設計範例報告

標題	***使用 LYTSwitch™ -4 LYT4322E 的 14.35 W 高效率 (高於 86%)、高功率因數 (大於 0.95)、可調光雙向閘流器 (TRIAC)、非隔離 Tapped-Buck LED 驅動器***
規格	195 VAC – 265 VAC 輸入； 41 V_{TYP}，350 mA 輸出
應用	PAR30 LED 驅動器
作者	應用工程部門
文件編號	DER-395
日期	2014 年 2 月 27 日
修訂	1.0

<u>摘要與功能</u>

- 結合 Single-stage 功率因數修正與定電流 (CC) 輸出
- 在 230 VAC 條件下，效率超過 86%
- 可調光雙向閘流器 (TRIAC)
    - 可使用廣泛的雙向閘流器 (TRIAC) 調光器
- 低成本、少元件、PCB 佔位面積小
- 快速啓動 (小於 200 ms) – 無可感延遲
- 整合式保護與信賴度特性
    - 藉由自動恢復功能提供輸出短路保護
    - 具有高磁滯時間的自動恢復回復過溫保護
    - 在電壓關閉情況下，不會發生任何損壞
    - 線電壓過壓保護
- 230 VAC 時功率因數 (PF) 大於 0.95
- 符合 EN55015 傳導性 EMI

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目錄

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重要事項：雖然此電路板的設計符合安全隔離要求，但工程原型尚未取得相關機構之認證。因此，執行所有測試應使用隔離變壓器才能提供 AC 輸入給原型板。

1 簡介

本文件說明非隔離式、高功率因數 (PF)、高效率、雙向閘流器 (TRIAC) 調光 LED 驅動器，其設計為輸入電壓範圍為 195 VAC 至 265 VAC (典型值 50 Hz) 時，於 350 mA 下驅動 41 V 的標準 LED 串電壓。

此設計使用 Single-stage 非隔離抽頭降壓式架構，以符合此設計的高功率因數、定電流調節和調光要求。

本文件包含 LED 驅動器規格、電路圖、PCB 詳情、物料清單、變壓器文件及典型效能特性。

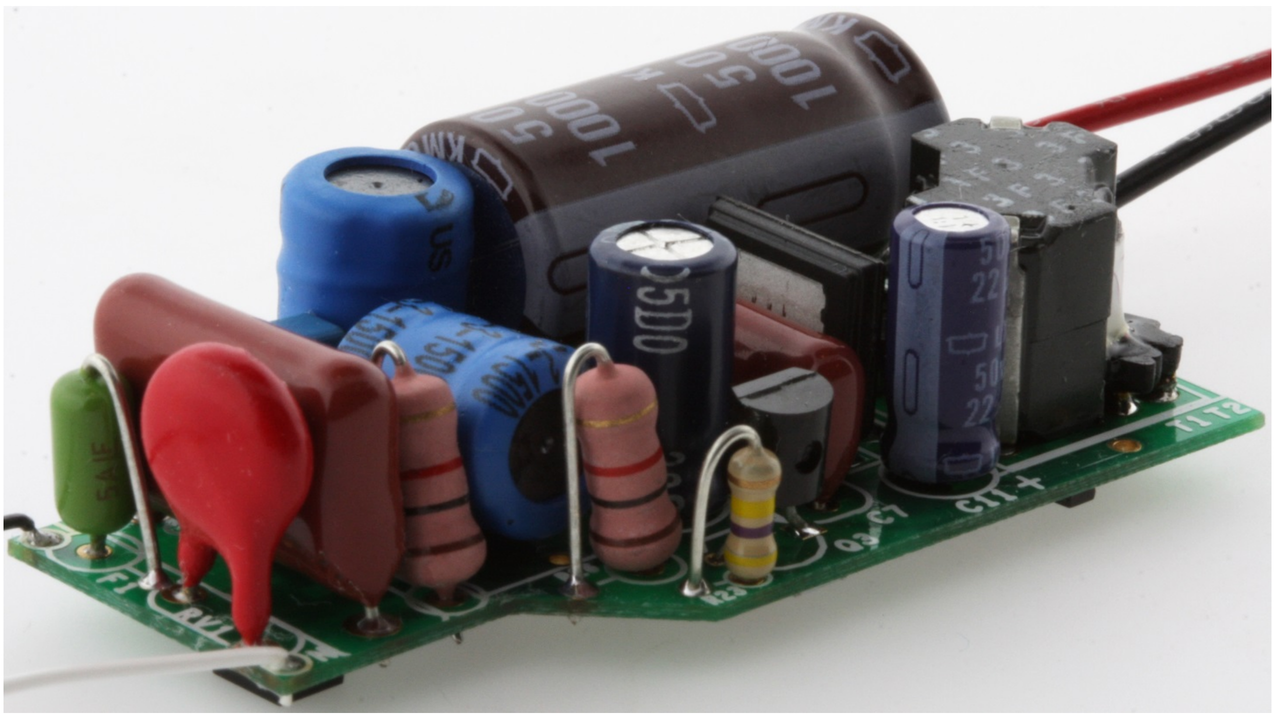

Figure 1 – Populated Circuit Board, Angle View.

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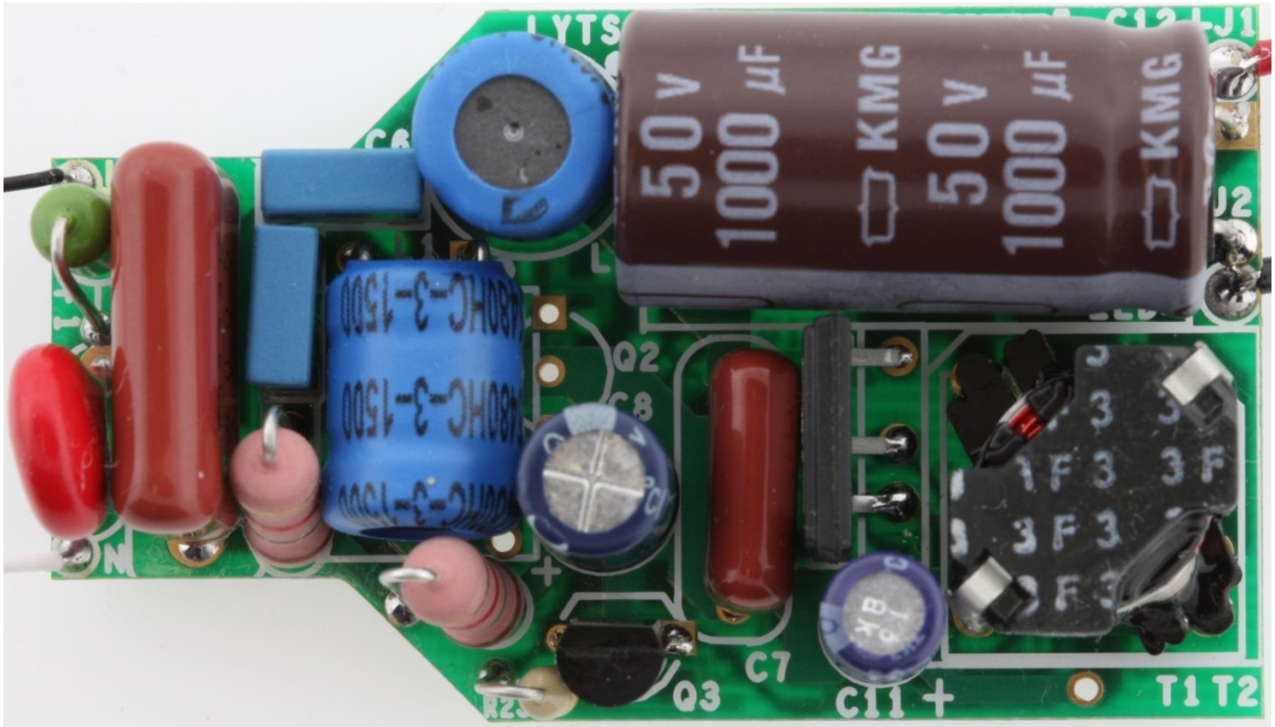

Figure 2 – Populated Circuit Board, Top View.

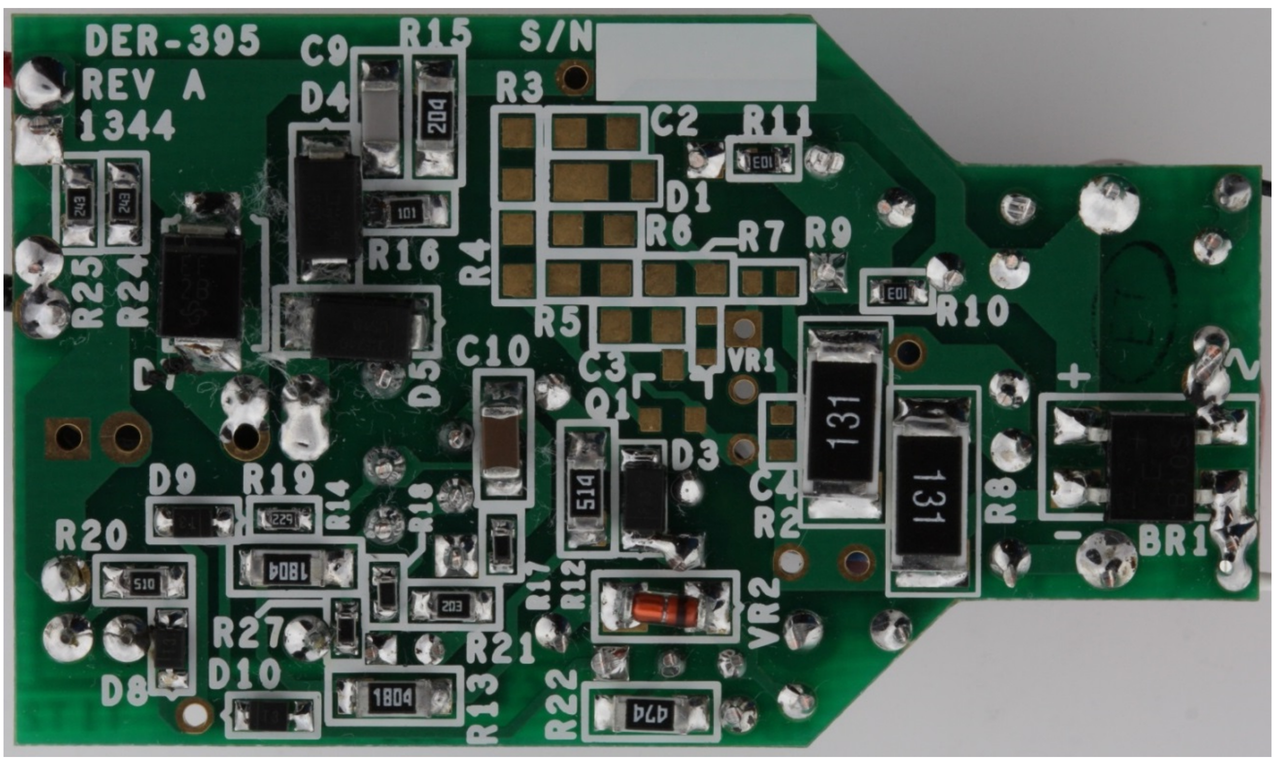

Figure 3 – Populated Circuit Board, Bottom View.

附註： 請參閱附錄以取得關於無載零件的詳細資料。

2 電源供應器規格

下表列出此設計可接受的最低效能。實際效能列在結果部分。

說明	符號	最小值	典型值	最大值	單位	註解
輸入						
電壓	V_{IN}	195	230	265	VAC	雙線 – 無 P.E.
頻率	f_{LINE}		50/60		Hz	
輸出						
輸出電壓	V_{OUT}	38	41	44	V	V_{OUT} = 41 V，V_{IN} = 230 VAC，25 ºC
輸出電流	I_{OUT}		350		mA	
總輸出功率						
連續輸出功率	P_{OUT}		14.35		W	
效率						
滿載	η		86		%	在 P_{OUT} 25 ºC 時測量
環境						
傳導性 EMI		CISPR 15B / EN55015B				
安全		非隔離式				
振盪波 (100 kHz)						
差模 (L1-L2)			2.5		kV	
共模 (L1/L2-PE)						
差模突波			500		V	
功率因數 (PF)		0.9				於 $V_{OUT(TYP)}$、$I_{OUT(TYP)}$ 及 230 VAC、50 Hz 條件下測量
諧波電流		EN 61000-3-2 C 級				
環境溫度	T_{AMB}		40		ºC	

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3 電路圖

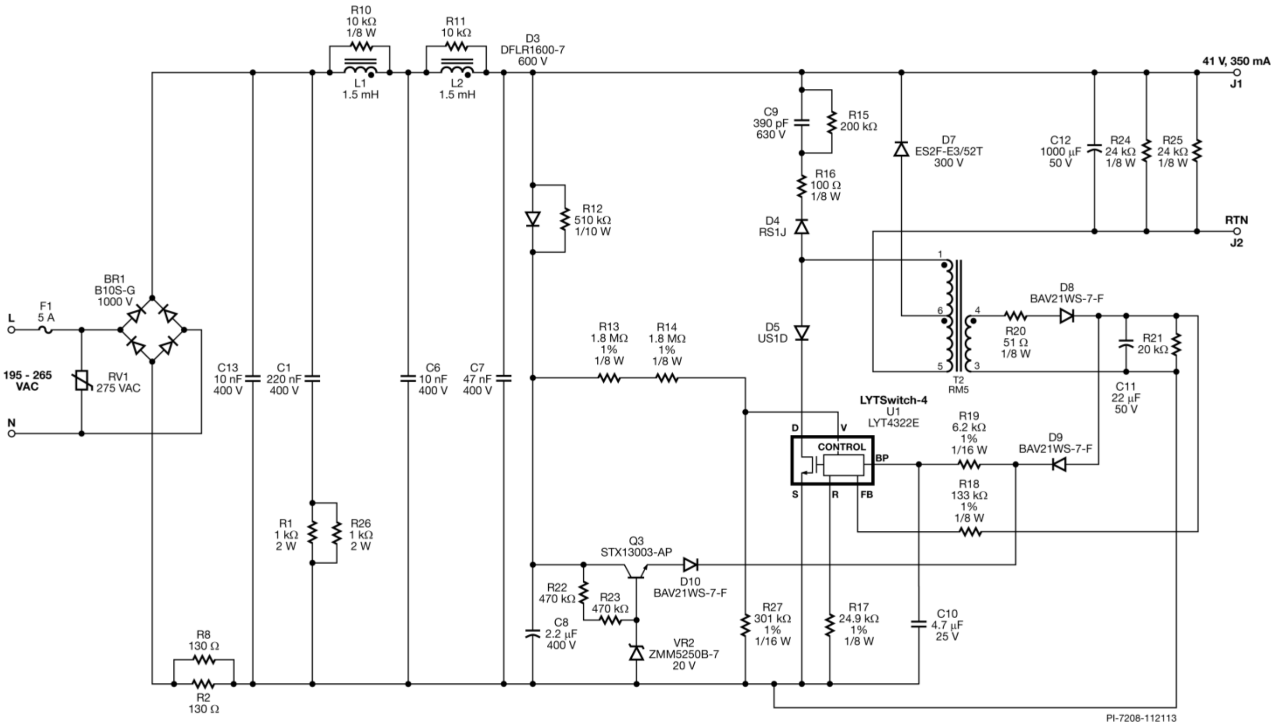

Figure 4 – Schematic.

4 電路說明

LYT4322E (U1) 是一個高度整合的一次側控制器，主要用於 LED 驅動器應用。它可以 Single-stage 轉換提供高功率因數 (PF)，同時還能在廣泛的輸入範圍 (195 VAC 至 265 VAC) 內調節輸出電流。所有負責這些功能的控制電路，加上高電壓功率 MOSFET 都整合到 IC 內。

4.1 輸入 EMI 濾波

保險絲 F1 可在發生元件故障時提供保護，而 RV1 可在發生線電壓突波活動期間進行箝制，以限制最大電壓。橋式整流器 BR1 可對 AC 線電壓進行整流。

EMI 濾波由電感器 L1和 L2，以及電容器 C6，C7 和 C13 提供。在 L1 和 L2 上的電阻器 R10 和 R11 會抑制電感器自身的諧振，以避免傳導性 EMI 圖中的雜訊在其諧振頻率下達到峰值。

選用的電感器不防磁，且彼此相鄰串聯連接；在佈局中，謹慎考量了 L1 與 L2 之間磁耦合的影響，以產出一致的 EMI 性能。在此設計中，L1 與 L2 垂直接合，且控制了繞組的起始和終止，並在電路圖和 PCB 中以圓點表示。(如需起始和終止繞組的相關資訊，請參閱電感器製造商產品規格型錄)

4.2 電源電路

此設計選用了低端抽頭降壓式架構，設定爲在 195 VAC 至 265 VAC 輸入電壓範圍內提供高功率因數 (PF) 和定電流輸出。

Tapped-Buck 式轉換器具有下列優勢：減小磁性元件的尺寸、主電源切換開關 U1 上的電流應力以及輸出二極體 D7 上的電壓應力。主電源切換開關上的電流應力減小後，便可使用較小的切換裝置，以提供具成本效益的設計。

電感器 T2 是降壓式轉換器的主要電感器。其包含三組繞組，即一次側繞組、二次側繞組和偏壓繞組。一次側與二次側圈數比選爲 3:1，這樣便可使用 300 V 輸出二極體，同時保持 U1 LYT4322E 的最大電壓遠低於其最大值。

每當 U1 關閉時，輸出二極體 D7 就會傳導，並將能量輸送到負載。需要使用二極體 D5，才能在 C7 上的電壓 (整流後的輸入 AC) 降到低於輸出電壓時防止反向電流流經 U1。還增加了電壓箝位電路，以限制由 T2 漏電感引起的電壓突波。電壓箝位網路由二極體 D4、電容器 C9 及電阻器 R15 和 R16 構成。

選用了輸出電容器 C12 以將輸出漣波降至最低 (低於 30%)。預載電阻器 R24 和 R25 會在移除 AC 時將輸出端快速放電至 LED 串電壓以下，並確保燈具完全熄滅 (而不是在移除 AC 後微弱地發光數秒鐘)。

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爲了提供峰値線電壓資訊給 U1，輸入整流 AC 峰值電壓會透過 D3 爲 C8 充電。然後，該電壓將以透過 R13 和 R14 的電流形式饋送至 U1 的電壓監測器 (V) 接腳。新增了 R27 以提供更嚴格的線間/負載調節。電阻器 R12 提供放電路徑，可讓 C8 上的電壓追蹤輸入 AC 的變化。

線間電壓過壓關機功能 (透過 V 接腳電流感測) 可讓整流後的線間電壓耐受度 (在突波和線間陡昇期間) 提高至內部功率 MOSFET 的 725 BV_{DSS} 額定值。

電容器 C10 會爲 U1 的 BYPASS (BP) 接腳 (內部控制器的供電接腳) 提供本機去耦合。在啓動期間，會從 U1 汲極 (D) 接腳連接的內部高電壓電流源將 C10 充電至約 6 V。選擇的電容器 C10 爲 4.7 μF，以讓裝置可以在全工模式下操作。

U1 的參考 (R) 接腳透過電阻器 R17 接地 (源極)。使用 24.9 kΩ 值以提供嚴格的定電流調節。

4.3 偏壓電源供應器和輸出回饋

T2 的偏壓繞組用於提供回饋和供電給 IC。偏壓繞組上的返馳式電壓會使用 D8 進行整流、C11 進行濾波，以使電壓平順，並使用 R20 減少從漏電感能量耦合的過量電壓。然後回饋電流會透過電阻器 R18 回饋到回饋 (FB) 接腳。二極體 D9 和 R19 會將 BP 接腳連結到偏壓繞組。啓動期間需要使用二極體 D9 來隔離 C10 與 C11，電阻器 R19 則限制從偏壓繞組供應給 BP 接腳的電流。電阻器 R21 提供偏壓供電的負載，以加快 C11 在 AC 週期期間的放電，並有助於實現較高的調光比。

4.4 TRIAC 相位調光控制相容性

爲了提供低成本的輸出調光功能，採用 TRIAC 的前緣和後緣相位調光器在設計時有許多取捨。

由於 LED 照明所消耗的功率小得多 (相較於傳統白熾燈泡)，因此燈具所汲取的電流會低於調光器內 TRIAC 的保持電流。這會導致發生不良情況，例如調光範圍受限及 (或) TRIAC 啓動不一致導致的閃爍。開啓 TRIAC 時，LED 燈具相對較大的阻抗會因對輸入電容充電的突波電流而導致大幅振盪。這同樣會引起不良狀況，因爲振盪可能導致 TRIAC 電流降至零 (並關閉 TRIAC)。

在設計中整合阻尼器、洩放器和線性調節器電路可以克服這些問題，而且幾乎不影響驅動器的效率。

電阻器 R2 和 R8 提供被動阻尼。

被動洩放器網路由電容器 C1 和 R1//R26 構成。這個網路會減弱輸入網路，但也會爲雙向閘流器 (TRIAC) 調光器提供所需的鎖定和保持電流。

新增的線性調節器電路 R22、R23、VR2、Q3 和 D10 可持續為 IC (BP 接腳) 穩定供電，可讓此 IC 在非常低的導通角或極低的輸入電壓下正常運作，並使該 IC 作為負載 (尤其是具有高漏電流的 TRIAC)。大多數高額定功率 (大於 600 W) 雙向閘流器 (TRIAC) 調光器均具有 LC 輸入濾波器。如果 RC 的電容大到足以提供能量來為 LED 驅動器的輸入階段充電，當 LED 負載通電時，LED 便會開啓，直到輸入放電。然後會重覆此循環，並導致 LED 負載閃爍，即使關閉了雙向閘流器 (TRIAC) 也是一樣。

當偏壓電壓高於 $Vz_{VR2}+Vt_{Q3}+Vf_{D10}$ 時，將不會啓動線性調節器。選擇電壓調節器 VR2 可讓線性調節器僅在偏壓電壓夠低情況下進行深度調光期間運作，將 Q3 功率消耗降至最低。Q3 採用低成本 BJT (400V) 和電阻器 R22 與 R23 提供充沛動力，即使輸入電壓在深度調光情況下偏低也是一樣。

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5 PCB 佈局

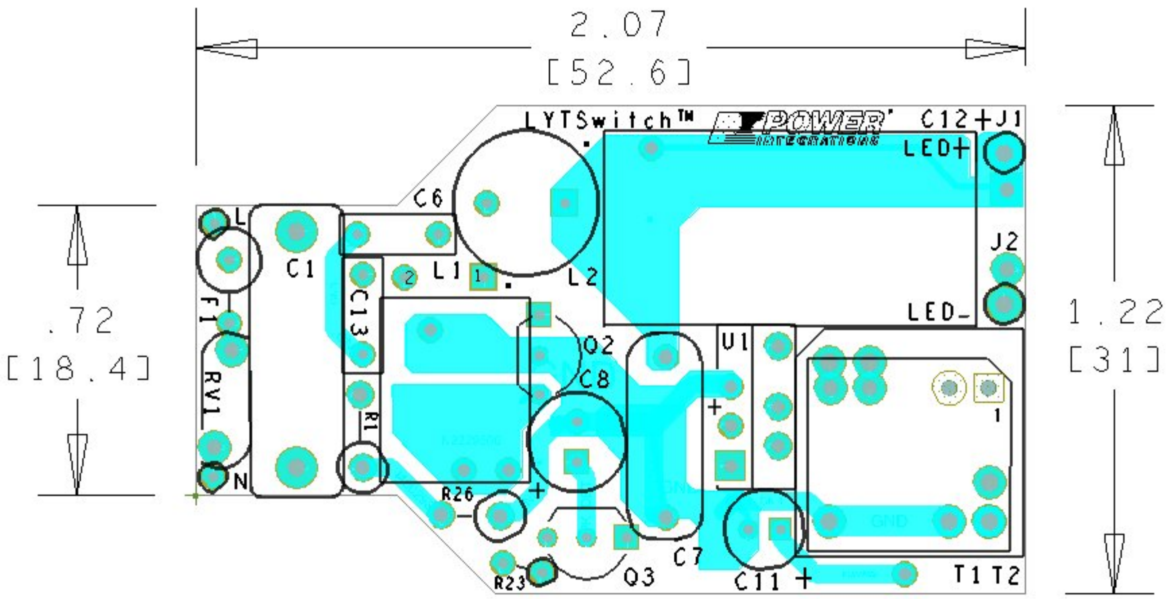

Figure 5 – Top Side.

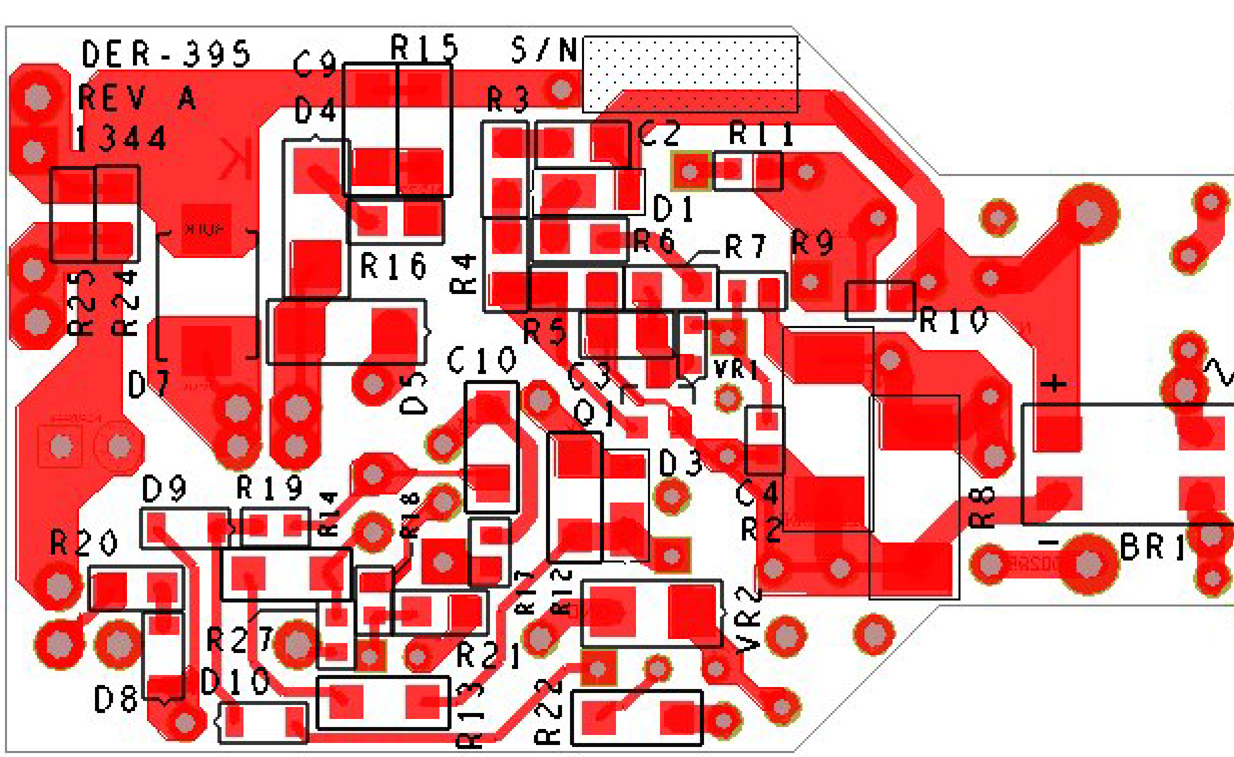

Figure 6 – Bottom Side.

6 物料清單

Item	Qty	Ref Des	說明	Mfg Part Number	Manufacturer
1	1	BR1	1000 V, 0.8 A, Bridge Rectifier, SMD, MBS-1, 4-SOIC	B10S-G	Comchip
2	1	C1	220 nF, 400 V, Film	ECQ-E4224KF	Panasonic
3	2	C6 C13	10 nF, 400 VDC, Metallized Polyester	B32529C6103K189	Epcos
4	1	C7	47 nF, 400 V, Film	ECQ-E4473KF	Panasonic
5	1	C8	2.2 μF, 400 V, Electrolytic, (6.3 x 11)	TAB2GM2R2E110	Ltec
6	1	C9	390 pF, 630 V, Ceramic, NPO, 1206	C3216C0G2J391J	TDK
7	1	C10	4.7 μF, 25 V, Ceramic, X7R, 1206	C3216X7R1E475K160AC	TDK
8	1	C11	22 μF, 50 V, Electrolytic, (5 x 11)	UPW1H220MDD	Nichicon
9	1	C12	1000 μF, 50 V, Electrolytic, Gen. Purpose, (12.5 x 25)	EKMG500ELL102MK25S	Nippon Chemi-Con
10	1	D3	600 V, 1 A, Rectifier, Glass Passivated, POWERDI123	DFLR1600-7	Diodes, Inc.
11	1	D4	600 V, 1 A, Fast Recovery, 250 ns, SMA	RS1J-13-F	Diodes, Inc.
12	1	D5	DIODE ULTRA FAST, SW, 200 V, 1 A, SMA	US1D-13-F	Diodes, Inc.
13	1	D7	300 V, 2 A, Ultrafast Recovery, 50 ns, SMB Case	ES2F-E3/52T	Vishay
14	3	D8 D9 D10	250 V, 0.2 A, Fast Switching, 50 ns, SOD-323	BAV21WS-7-F	Diode Inc.
15	1	F1	5 A, 250 V, Fast, Microfuse, Axial	0263005.MXL	Littlefuse
16	2	L1 L2	1.5 mH, 0.250 A, 10%	RL-5480HC-3-1500	Renco
17	1	Q3	NPN, Power BJT, 400 V, 1 A, TO-92	STX13003-AP	ST Micro
18	2	R1 R26	1 kΩ, 5%, 2 W, Metal Film	FMP200JR-52-1K	Yageo
19	2	R2 R8	130 Ω, 5%, 1 W, Thick Film, 2512	ERJ-1TYJ131U	Panasonic
20	2	R10 R11	10 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ103V	Panasonic
21	1	R12	510 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ514V	Panasonic
22	2	R13 R14	1.80 MΩ, 1%, 1/4 W, Thick Film, 1206	ERJ-8ENF1804V	Panasonic
23	1	R15	200 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ204V	Panasonic
24	1	R16	100 Ω, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ101V	Panasonic
25	1	R17	24.9 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF2492V	Panasonic
26	1	R18	133 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF1333V	Panasonic
27	1	R19	6.2 kΩ, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ622V	Panasonic
28	1	R20	51 Ω, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ510V	Panasonic
29	1	R21	20 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ203V	Panasonic
30	1	R22	470 kΩ, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ474V	Panasonic
31	1	R23	470 kΩ, 5%, 1/4 W, Carbon Film	CFR-25JB-470K	Yageo
32	2	R24 R25	24 kΩ, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ243V	Panasonic
33	1	R27	301 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF3013V	Panasonic
34	1	RV1	275 V, 23 J, 7 mm, RADIAL	V275LA4P	Littlefuse
35	1	T2	Bobbin, RM5, Vertical, 6 pins	P-501	Pin Shine
36	1	U1	LYTSwitch-4, eSIP-7C	LYT4322E	Power Integrations
37	1	VR2	20 V, 5%, 500 mW, DO-213AA (MELF)	ZMM5250B-7	Diodes, Inc.

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7 電感器規格

7.1 電氣圖

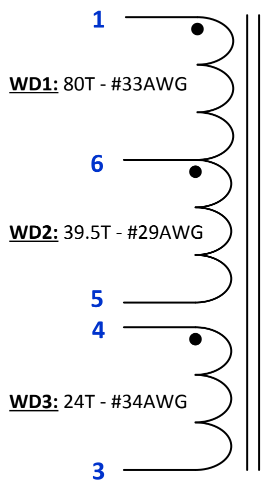

Figure 7 – Inductor Electrical Diagram.

7.2 電氣規格

Primary Inductance	Pins 1-5, all other windings open, measured at 100 kHz, 0.4 V_{RMS}.	1 mH ±3%
Resonant Frequency	Pins 1-5, all other windings open.	>1 MHz

7.3 材料

Item	說明
[1]	Core:RM5/**I**-3F3 Ferrox Cube.
[2]	Bobbin:RM5-Vertical, 6 pins (3/3).AllStar Magnetics P/N:CPV-RM5-1S-6P-G.
[3]	Clip:AllStar Magnetics P/N:CLI/P-RM4/5/**I**.
[4]	Magnet wire:#33 AWG - Double coated.
[5]	Magnet wire:#29 AWG - Double coated.
[6]	Magnet wire:#34 AWG - Double coated.
[7]	Tape:3M 1298 Polyester Film, 4.5 mm wide, 2.0 mils thick, or equivalent.
[8]	Varnish:Dolph BC-359 or equivalent.

7.4 電感構建圖

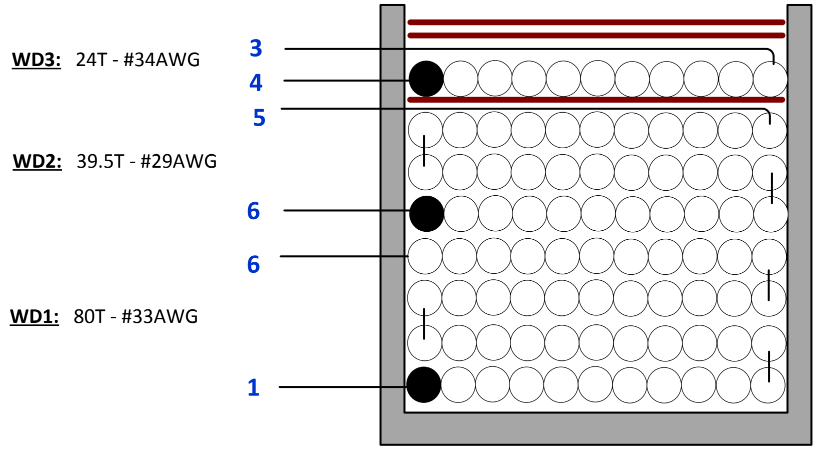

Figure 8 – Inductor Build Diagram.

7.5 電感器結構

Winding Preparation	Place the bobbin on the mandrel with the pin side is on the left side.Winding direction is clockwise direction.
WD1	Start at pin 1, wind 80 turns of wire item [4] and end at pin 6. Do not put tape in-between layer.
WD2	Start at pin 6, wind 39.5 turns of wire item [5] and end at pin 5.
Insulation	Place 1 layer of tape item [7].
WD3	Start at pin 4, wind 24 turns of wire item [6] from left to right in 1 layer.At the last turn bring the wire back to the left and end at pin 3.
Insulation	Place 2 layers of tape item [7].
Final Assembly	Grind, assemble, and secure core halves with clip item [3]. Varnish with item [7].
Cutting of extra pins	Cut pin 2 of the bobbin as well as the core clip which is closer to pin 5 and pin 6. Do not cut the other clip as this will be soldered onto PCB.

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8 電感器設計試算表

ACDC_LYTSwitch-4_Buck_102413; Rev.1.0; Copyright Power Integrations 2013	INPUT	INFO	OUTPUT	UNIT	ACDC_LYTSwitch_102413: LYTSwitch-4 Buck / Tapped Buck Design Spreadsheet
ENTER APPLICATION VARIABLES					
Topology Selection	**Tapped-Buck**				
Dimming required	**YES**		**YES**		Select "YES" option if dimming is required. Otherwise select "NO".
VACMIN	195.00		195	V	Minimum AC Input Voltage
VACNOM			230	V	Nominal AC Input Voltage
VACMAX			265	V	Maximum AC input voltage
fL			50	Hz	AC Mains Frequency
VO	41.00		41	V	Typical output voltage of LED string at full load
VO_MAX			44	V	Maximum LED string Voltage
VO_MIN			38	V	Minimum LED string Voltage
IO	0.35		0.35	A	Typical full load LED current
PO			14.35	Watts	Output Power
n	0.86		0.86		Estimated efficiency of operation
Feedback System	BIAS		BIAS		BIAS Supply
Bias Voltage			25	V	Bias Voltage
ENTER LYTSwitch VARIABLES					
LYTSwitch	**LYT4xx2**		LYT4322		Selected LYTSwitch device.
Current Limit Mode	**FULL**		FULL		Select "RED" for reduced Current Limit mode or "FULL" for Full current limit mode
ILIMITMIN			0.790	A	Minimum current limit
ILIMITMAX			0.920	A	Maximum current limit
fS			132000	Hz	Switching Frequency
fSmin			124000	Hz	Minimum Switching Frequency
fSmax			140000	Hz	Maximum Switching Frequency
IV			80.57	uA	V pin current
Rv			4	M-ohms	Voltage sense resistor
Rref			24.9	k-ohms	Reference Resistor Value
IFB			165	uA	FB pin current (90 uA < IFB < 210 uA)
RFB			133	k-ohms	IFB setting resistor
VDS			10	V	LYTSwitch on-state Drain to Source Voltage
VD			0.5	V	Output Winding Diode Forward Voltage Drop
VDB			0.7	V	Bias Winding Diode Forward Voltage Drop
CBP			4.7	uF	BP pin capacitor
Key Design Parameters					
L_TOTAL	1000.00		1000	uH	Total Inductance
N_RATIO	3.00		3.00		Turns Ratio (Np/Ns). For Buck Topology, N_RATIO=1
KP_VNOM			1.14		Ripple to Peak Current Ratio VACMIN peak)
KP_VMIN			1.11		Ripple to Peak Current Ratio VACMIN peak)
T_ON_MIN			1.91	us	Minimum T_ON at Maximum Input Voltage
Duty_Expected			0.33		Minimum duty cycle at peak of VACMIN
Expected IO			0.35	A	Expected Average Output Current

(average)					
IFB_VO_MAX			179	uA	FB pin current at VO_MAX
IFB_VO_MIN			152	uA	FB pin current at VO_MIN
STRESS PARAMETERS					
VDRAIN			562.77		Peak voltage at the Drain of LYTSwitch (assuming 100V leakage spike)
VDIODE			187.59		Peak voltage across freewheeling diode
IP			0.57	A	Peak Primary Current (calculated at minimum input voltage VACMIN)
ISP			1.71	A	Peak Secondary Current (calculated at minimum input voltage VACMIN)
PIVB			94.06	V	Bias Rectifier Maximum Peak Inverse Voltage (calculated at VO_MAX, excludes leakage inductance spike)
INPUT CURRENT PARAMETERS					
IAVG			0.07	A	Average Primary Current at VACMIN
IRMS			0.15	A	Primary RMS Current (calculated at minimum input voltage VACMIN)
DC INPUT VOLTAGE PARAMETERS					
VMIN			276	V	Peak input voltage at VACMIN
VMAX			375	V	Peak input voltage at VACMAX
VIN_OVP			495	V	Typical Line Overvoltage Protection Threshold
TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Core Type	**RM5/I**		RM5/I		Selected Core for inductor
Core		RM5/I		*P/N:*	RM5/I-3F3
Bobbin		RM5/I_BOBBIN		*P/N:*	CSV-RM5-1S-6P-G
AE			0.248	cm^2	Core Effective Cross Sectional Area
LE			2.32	cm	Core Effective Path Length
AL			1700	nH/T^2	Ungapped Core Effective Inductance
BW			4.68	mm	Bobbin Physical Winding Width
M			0	mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
NLAYER_PRI	4.00		4		Number of Primary Layers
NLAYER_SEC	3.00		3		Number of Secondary Layers
TRANSFORMER PRIMARY DESIGN PARAMETERS					
L_TOTAL			1000	uH	Total Inductance
N_RATIO			3		Turns Ratio (Np/Ns). For Buck Topology, N_RATIO=1
N_TOTAL	120.00		120		Total Number of Turns (primary + secondary)
NS			40		Secondary winding turns
NB			24		Bias number of turns
ALG			69	nH/T^2	Gapped Core Effective Inductance
BM			2047	Gauss	Maximum Flux Density at PO, VMIN (BM<3000)
BP			3091	Gauss	Peak Flux Density (BP<4200)
BAC			1024	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur			1266		Relative Permeability of Ungapped Core
LG			0.43	mm	Gap Length (Lg > 0.1 mm)
BWE			18.72	mm	Effective Bobbin Width

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OD			0.23	mm	Maximum Primary Wire Diameter including insulation
INS			0.05	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA			0.19	mm	Bare conductor diameter
AWG			33	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM			51	Cmils	Bare conductor effective area in circular mils
CMA			347	Cmils/Amp	Primary Winding Current Capacity (200 < CMA < 500)
TRANSFORMER SECONDARY DESIGN PARAMETERS **Lumped parameters**					
ISP			1.71	A	Peak Secondary Current
ISRMS			0.59	A	Secondary RMS Current
BWES			14.04	mm	Effective Bobbin Width
ODS			0.35	mm	Secondary Maximum Outside Diameter
INSS			0.06	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIAS			0.29	mm	Secondary Minimum Bare Conductor Diameter
AWGS			29.00	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
CMS			128.00	Cmils	Secondary Bare Conductor minimum circular mils
CMAS			210.68	Cmils/Amp	Secondary Winding Current Capacity (200 < CMAS < 500)
Estimated Input Current Harmonic Analysis					
Harmonic			Max Current (mA)	Limit (mA)	
1st Harmonic			69.64	N/A	Fundamental (mA)
3rd Harmonic			12.34	56.73	PASS. 3rd Harmonic current content is lower than the limit
5th Harmonic			2.57	31.70	PASS. 5th Harmonic current content is lower than the limit
7th Harmonic			0.90	16.69	PASS. 7th Harmonic current content is lower than the limit
9th Harmonic			2.28	8.34	PASS. 9th Harmonic current content is lower than the limit
11th Harmonic			2.70	5.84	PASS. 11th Harmonic current content is lower than the limit
13th Harmonic			2.61	4.94	PASS. 13th Harmonic current content is lower than the limit
15th Harmonic			2.24	4.28	PASS. 15th Harmonic current content is lower than the limit
THD			19.5	%	Estimated total Harmonic Distortion (THD)

9 效能資料

All measurements performed at room temperature using an LED load.The following data was taken measured using 3 sets of loads representing a load range of 38 V to 44 V (output voltage).Refer to the table in Section 9.6 for complete test data values.

9.1 效率

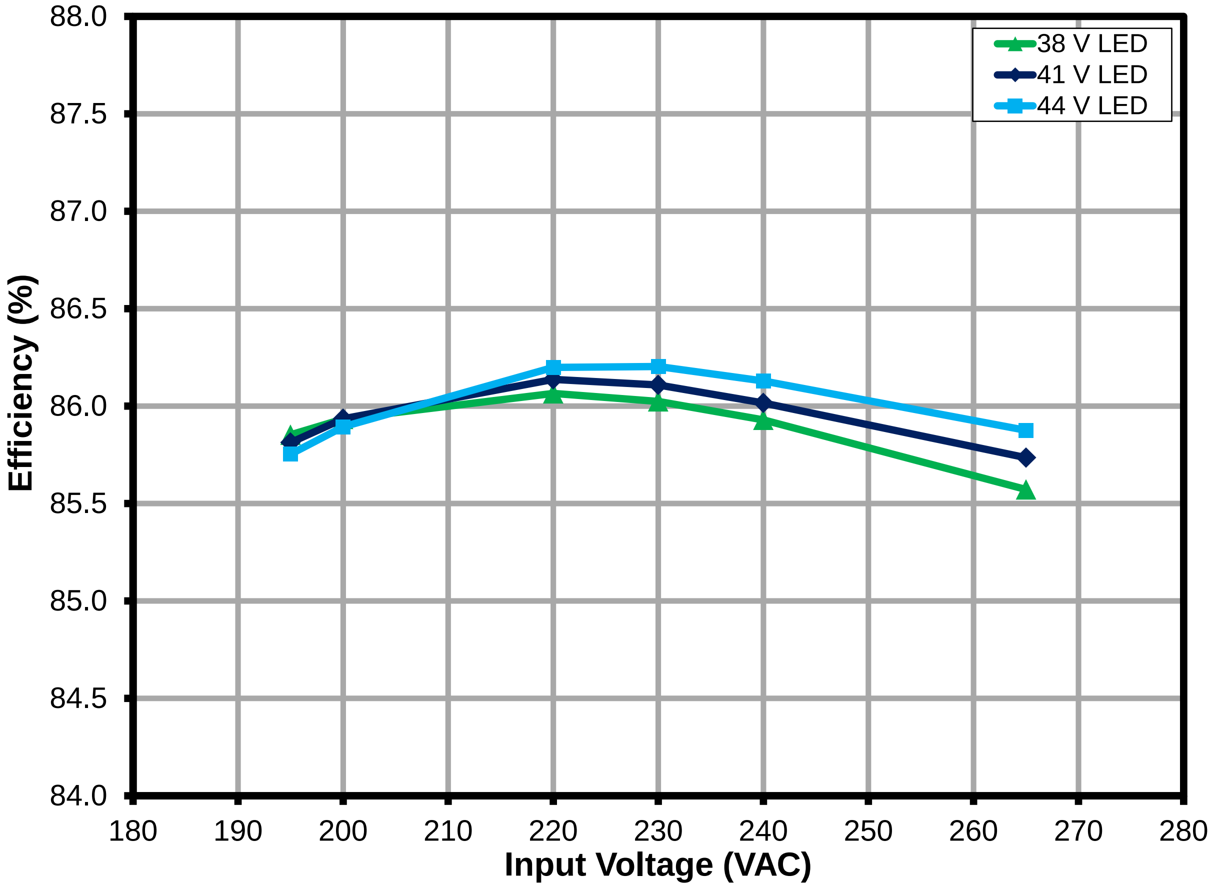

Figure 9 – Efficiency vs. Line and Load

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9.2 線電壓與負載穩定度關係圖

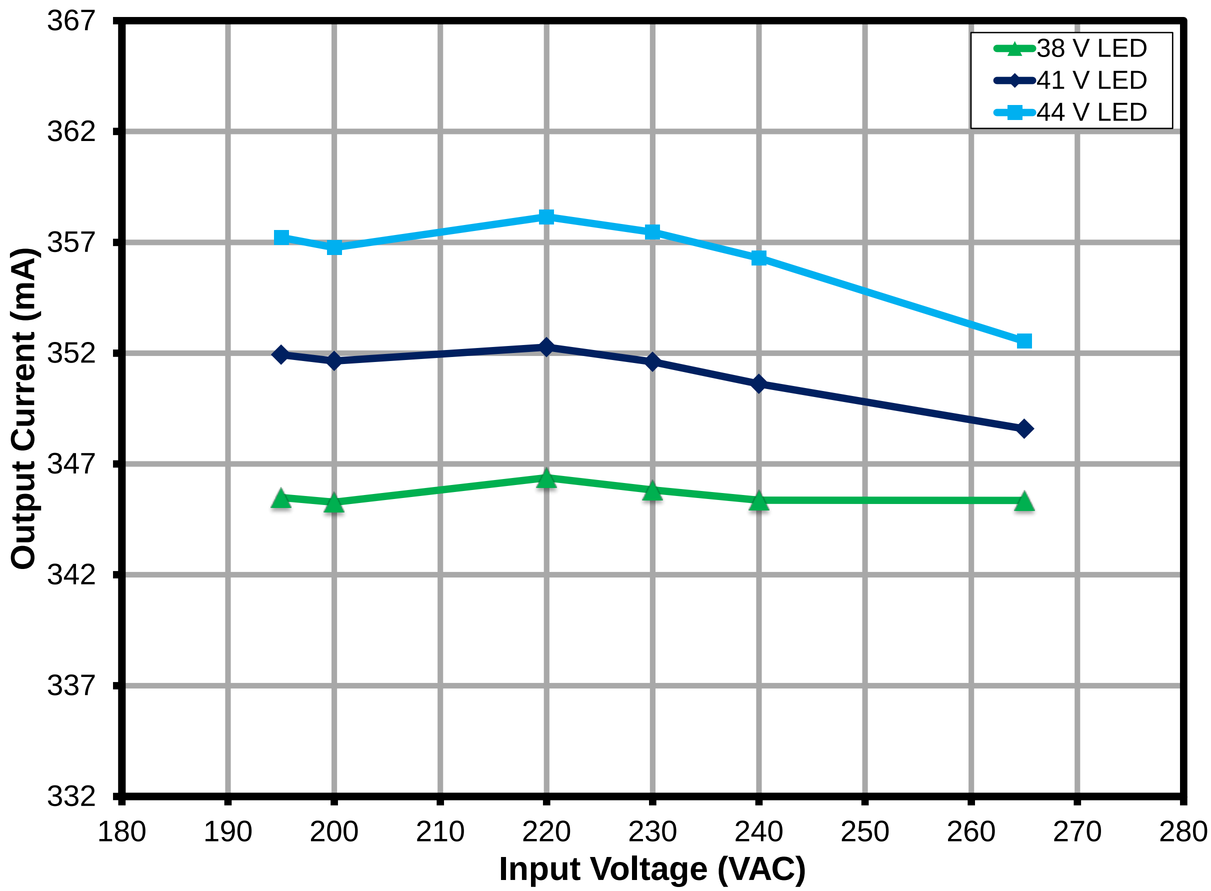

Figure 10 – Regulation vs. Line and Load

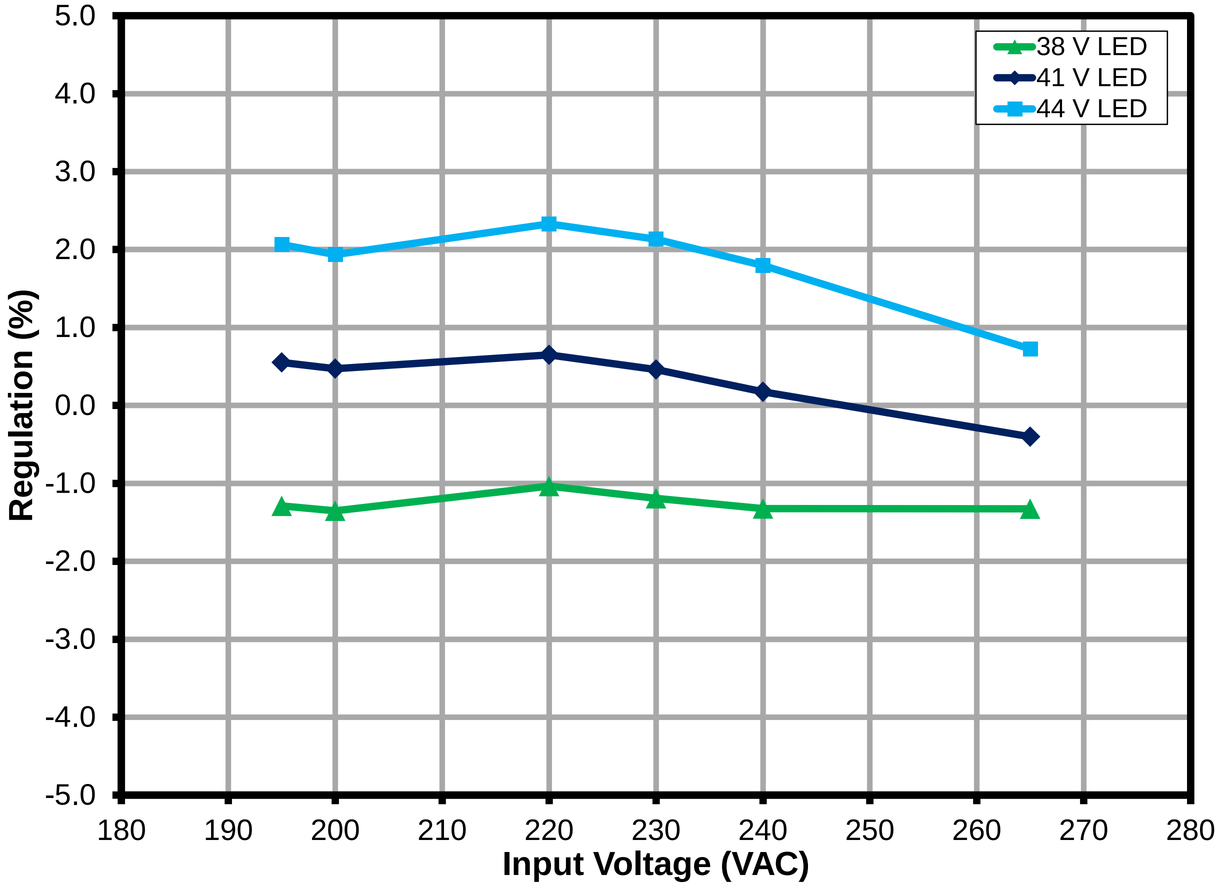

Figure 11 – % Regulation vs. Line and Load.

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9.3 功率因數 (PF)

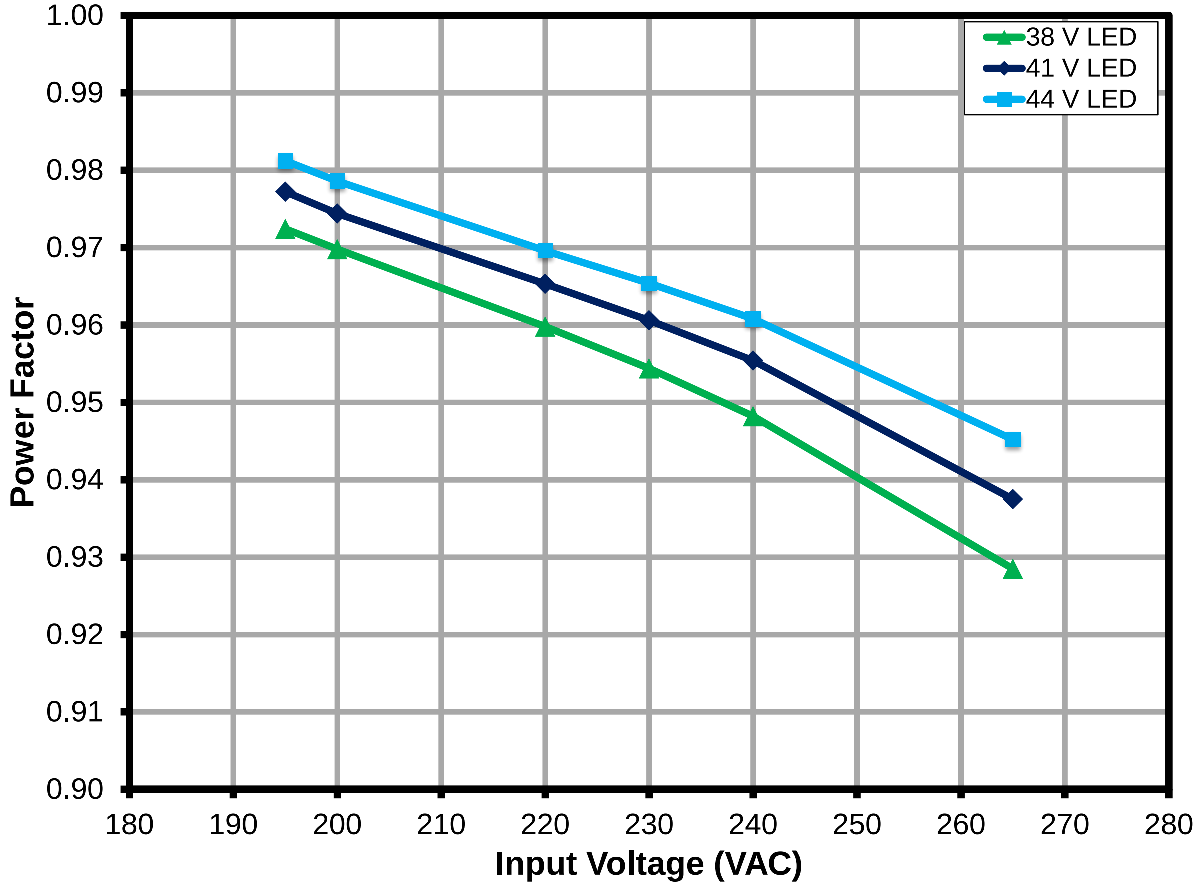

Figure 12 – Power Factor vs. Line and Load.

9.4 A-THD

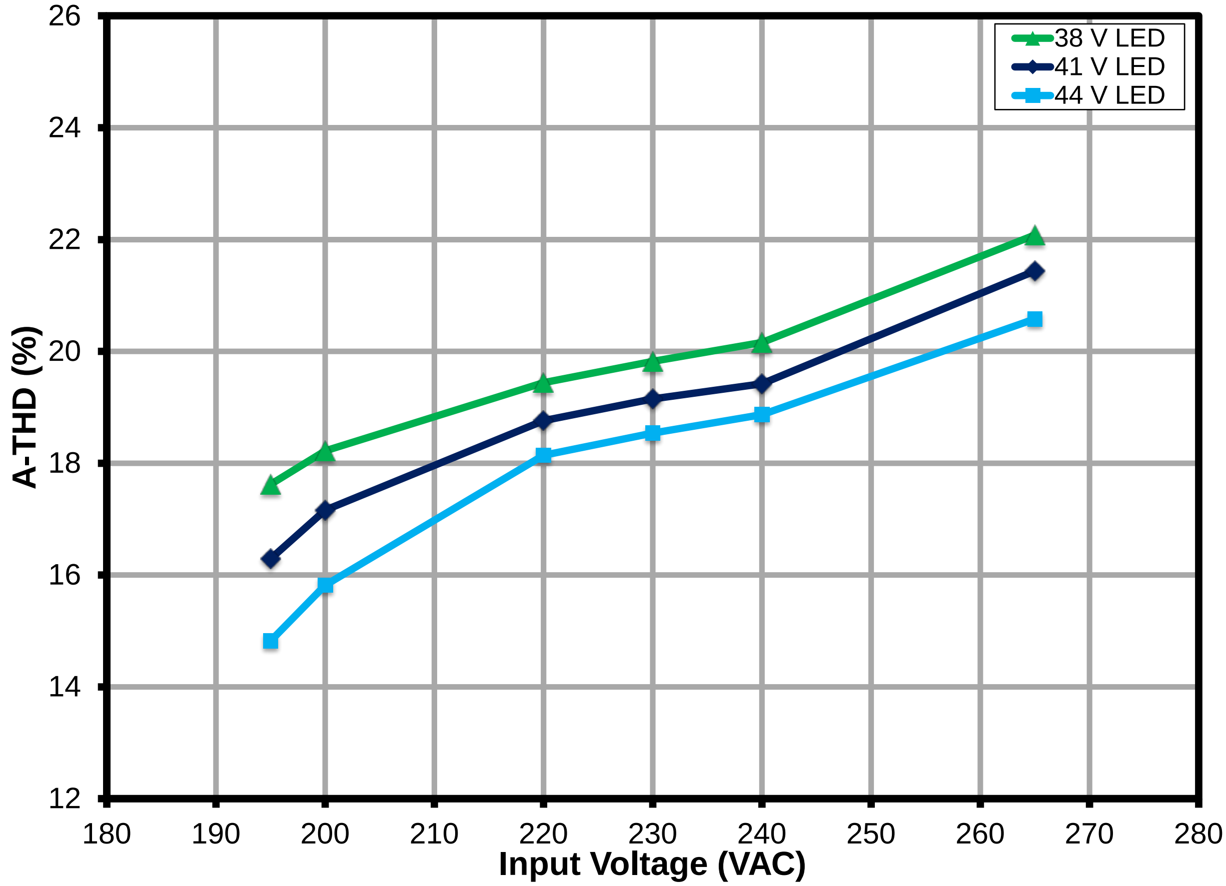

Figure 13 – A-THD vs. Line and Load.

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9.5 諧波

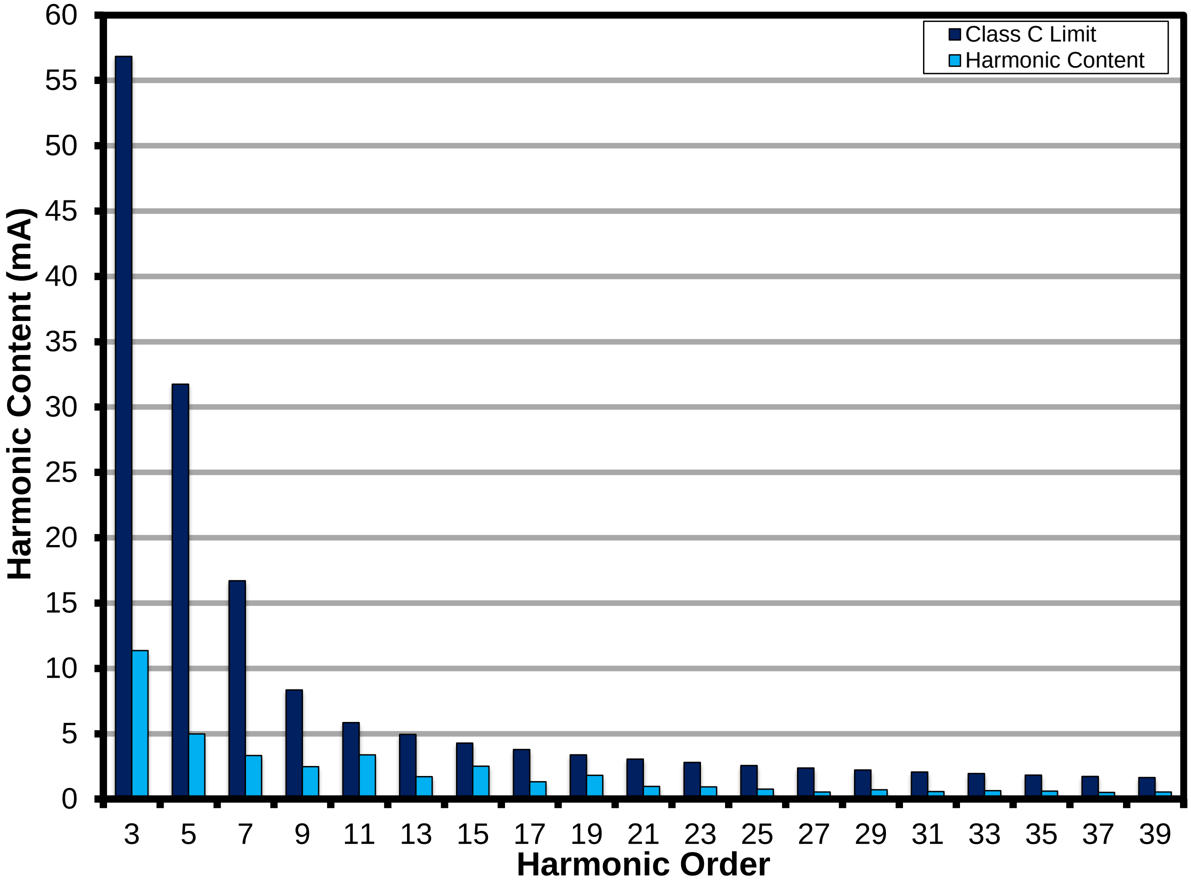

Figure 14 – 41 V LED Load Input Current Harmonics at 230 VAC, 50 Hz.

9.6 測試資料

All measurements were taken with the board at open frame, 25 ºC ambient, and 50 Hz line frequency.

9.6.1 測試資料，38 V LED 負載

輸入		Input Measurement					Load Measurement				
VAC (V_{RMS})	Freq (Hz)	V_{IN} (V_{RMS})	I_{IN} (mA_{RMS})	P_{IN} (W)	PF	%ATHD	V_{OUT} (V_{DC})	I_{OUT} (mA_{DC})	P_{OUT} (W)	Efficiency (%)	% Reg
195	50	194.94	80.88	15.332	0.972	17.62	38.0540	345.490	13.163	85.85	-1.29
200	50	199.92	78.92	15.300	0.970	18.22	38.0350	345.270	13.148	85.93	-1.35
220	50	219.98	72.56	15.322	0.960	19.44	38.0270	346.380	13.187	86.07	-1.03
230	50	229.93	69.71	15.298	0.954	19.82	38.0100	345.830	13.160	86.02	-1.19
240	50	239.97	67.19	15.288	0.948	20.16	37.9940	345.370	13.137	85.93	-1.32
265	50	264.94	62.38	15.346	0.929	22.0800	37.9820	345.360	13.132	85.57	-1.33

9.6.2 測試資料，41 V LED 負載

輸入		Input Measurement					Load Measurement				
VAC (V_{RMS})	Freq (Hz)	V_{IN} (V_{RMS})	I_{IN} (mA_{RMS})	P_{IN} (W)	PF	%ATHD	V_{OUT} (V_{DC})	I_{OUT} (mA_{DC})	P_{OUT} (W)	Efficiency (%)	% Reg
195	50	194.94	88.26	16.812	0.977	16.29	40.9500	351.930	14.427	85.81	0.55
200	50	199.92	86.06	16.766	0.974	17.16	40.9270	351.650	14.408	85.94	0.47
220	50	219.98	78.88	16.750	0.965	18.76	40.9130	352.270	14.428	86.14	0.65
230	50	229.93	75.68	16.715	0.961	19.15	40.8920	351.610	14.393	86.11	0.46
240	50	239.96	72.74	16.676	0.955	19.42	40.8690	350.610	14.344	86.02	0.17
265	50	264.94	66.92	16.622	0.938	21.4400	40.8400	348.590	14.251	85.74	-0.40

9.6.3 測試資料，44 V LED 負載

輸入		Input Measurement					Load Measurement				
VAC (V_{RMS})	Freq (Hz)	V_{IN} (V_{RMS})	I_{IN} (mA_{RMS})	P_{IN} (W)	PF	%ATHD	V_{OUT} (V_{DC})	I_{OUT} (mA_{DC})	P_{OUT} (W)	Efficiency (%)	% Reg
195	50	194.94	95.20	18.209	0.981	14.82	43.6670	357.220	15.615	85.75	2.06
200	50	199.92	92.76	18.148	0.979	15.82	43.6470	356.770	15.588	85.89	1.93
220	50	219.98	85.10	18.151	0.970	18.14	43.6410	358.150	15.646	86.20	2.33
230	50	229.93	81.57	18.106	0.965	18.54	43.6210	357.460	15.608	86.20	2.13
240	50	239.96	78.30	18.052	0.961	18.87	43.5980	356.290	15.548	86.13	1.80
265	50	264.94	71.47	17.898	0.945	20.5800	43.5590	352.540	15.370	85.88	0.73

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10 調光效能資料

TRIAC dimming results were taken with input voltage of 230 VAC, 50 Hz line frequency, room temperature, and nominal 41 V LED load.

10.1 使用前緣調光器的調光曲線

Taken using programmable AC source providing leading edge chopped AC input

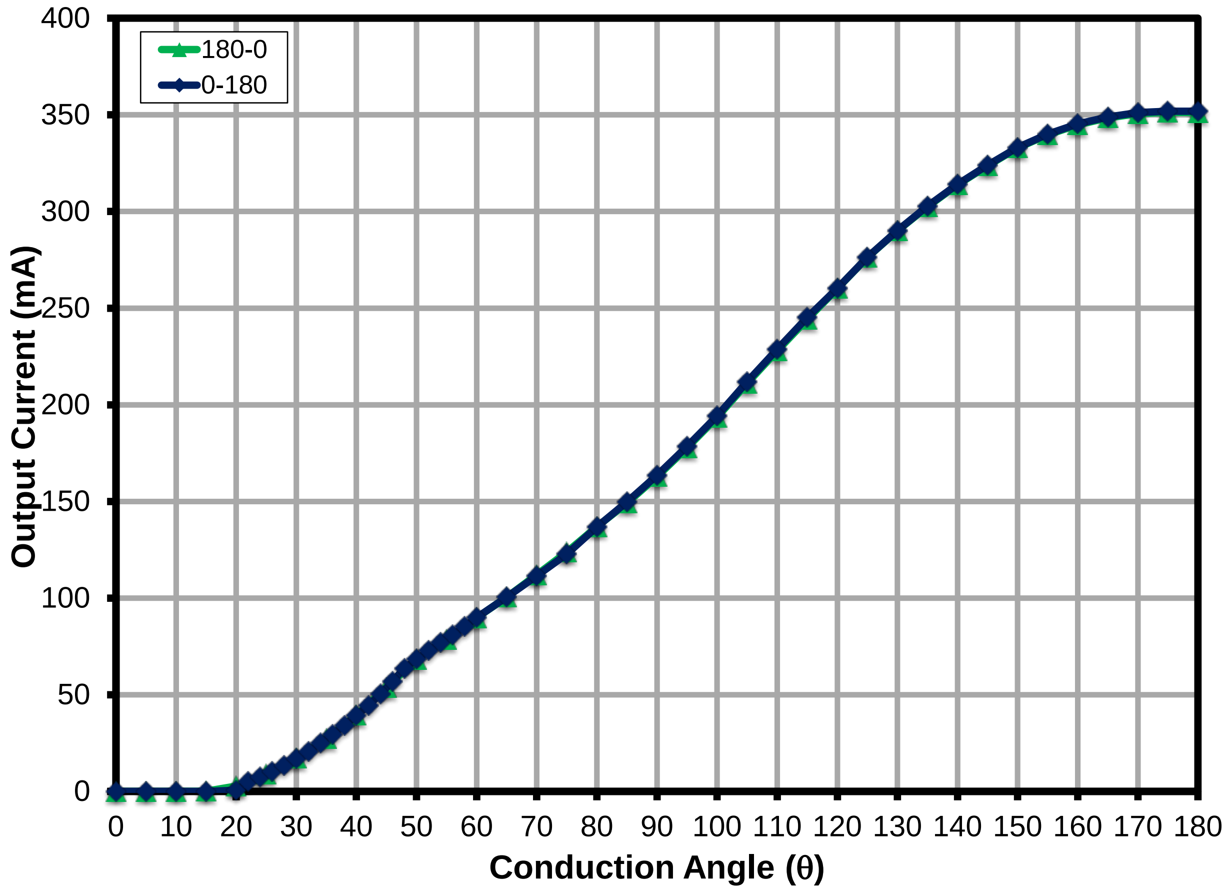

Figure 15 – Leading Edge Dimming Characteristics.

10.2 調光器相容性清單

The unit was tested with the following high-line dimmers at 230 VAC, 50 Hz input and 41 V LED load and using Agilent 6812B AC source.

Chinese Dimmers	Type	Maximum Setting I_{OUT} (mA)	Minimum Setting I_{OUT} (mA)	Dim Ratio
TCL 630 W	L	345	15	23
SEN BO LANG 300W	L	345	55	6
EBA HUANG	L	345	3	115
SB ELECT 600 W	L	334	3	115
MYONGBO	L	346	49	7
KBE 650W	L	345	4	86
CLIPMEI	L	345	3	115
MANK 200 W	L	346	63	5
Italian Dimmers				
RELCO RM34DMA 160W	L	341	38	9
RELCO RTM34LED DAXS 500W	L	276	25	11
RELCO RM34DMA 500W	L	346	48	7
RELCO RTS34.43 RLI 300W	L	346	9	38
RELCO RT34DSL 500W	L	347	45	8
MATIX AM5702 500W	L	277	58	5
Korean Dimmers				
SHIN SUNG 500W	L	343	71	5
FANTASIA 500W	L	340	84	4
SHIN SUNG	L	345	53	7
EU Dimmers				
NIKO 310-013	L	338	40	8
NIKO 310-014	L	338	62	5
NIKO-310-016	L	335	55	6
BERKER 2830 10	L	323	46	7
JUNG 225 NV DE	L	319	21	15
JUNG 266 G DE	L	323	35	9
BUSCH 2200 UJ-212	L	321	52	6
BUSCH 2250 U	L	330	23	14
BUSCH 2247 U	L	323	47	7
GIRA 2262 00 / IO1	L	325	14	23
GIRA 0300 00 / IO1	L	320	57	6
GIRA 0302 00 / IO1	L	324	37	9
BUSCH 2250	L	330	27	12
MERTEN 572499	L	339	12	28
BERKER 2875 600 W	L	324	34	10
KOPP 8033	L	301	33	9
Australian Dimmers				
32E450LM	L	306	4	77
32E450TM	T	311	34	9
32E2CFLDM	T	307	32	10
32E450UDM	T	326	45	7
Trailing Edge Dimmers				
PEHA 433HAB	T	316	90	4

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PEHA 433HAB oA	T	285	50	6
BUSCH 6513	T	341	99	3
BUSCH 6591U-101	T	330	93	4
GIRA 1176	T	330	109	3
NIKO 310-017	T	307	76	4

Figure 16 – Compatibility List.

11 散熱效能

11.1 開放式架構測量

Images captured after running for >30 minutes at room temperature (25 °C), open frame for the conditions specified.

11.1.1 非調光 V_{IN} = 195 VAC，50 Hz，41 V LED 負載

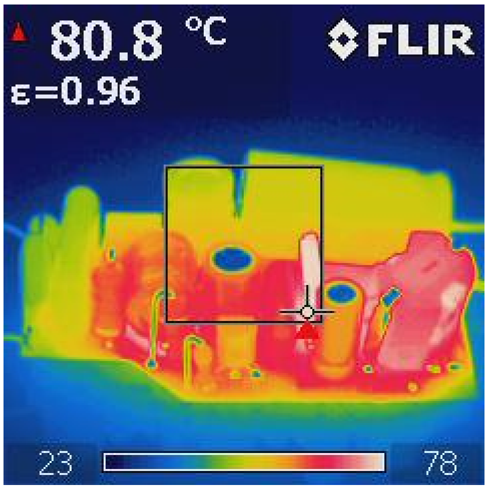

Figure 17 – Top Side.
U1-LYT4322E:80.8 ºC.

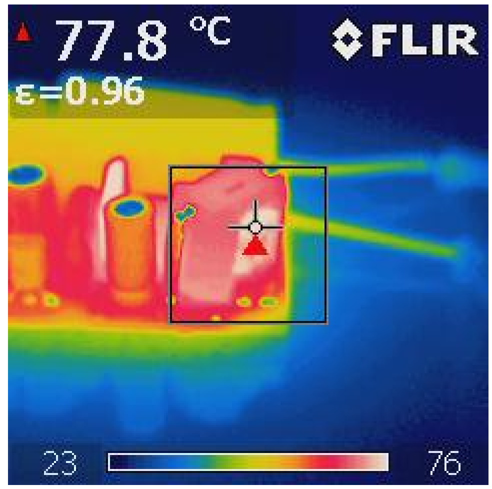

Figure 18 – Top Side.
T2:77.8 ºC.

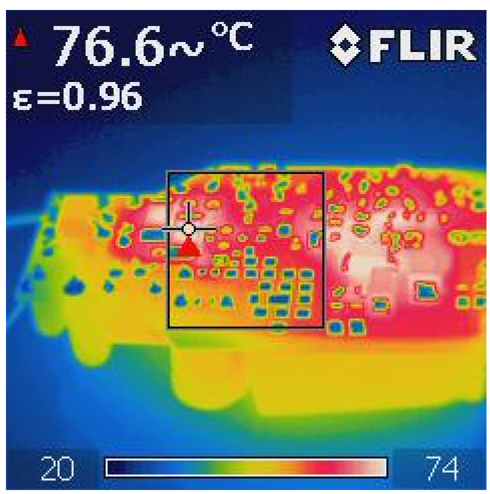

Figure 19 – Bottom Side.
PCB:76.6 ºC.

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11.1.2 非調光 V_{IN} = 265 VAC，50 Hz，41 V LED 負載

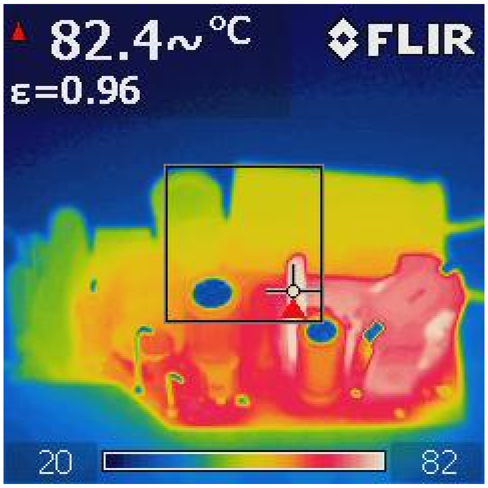

Figure 20 – Top Side.
U1-LYT4322E:82.4 ºC.

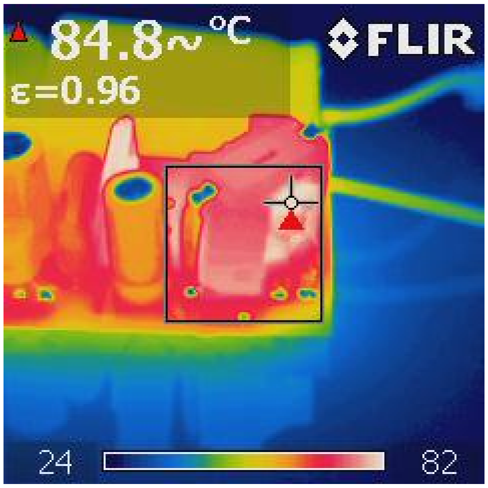

Figure 21 – Top Side, Inductor.
T2:84.8 ºC.

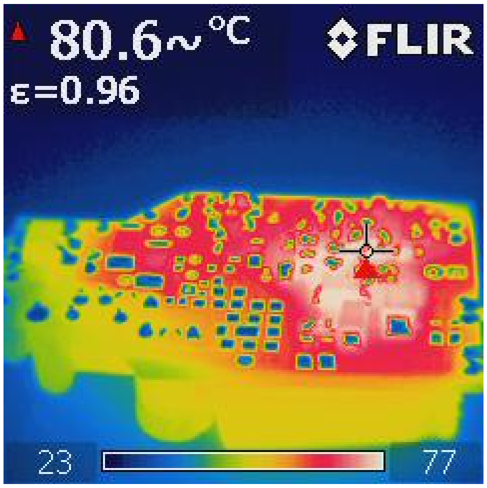

Figure 22 – Bottom Side.
PCB:80.6 ºC.

11.2 實際 LED 外殼中的散熱測量

Figure 23 – Actual LED Enclosure Used in Thermal Verification.

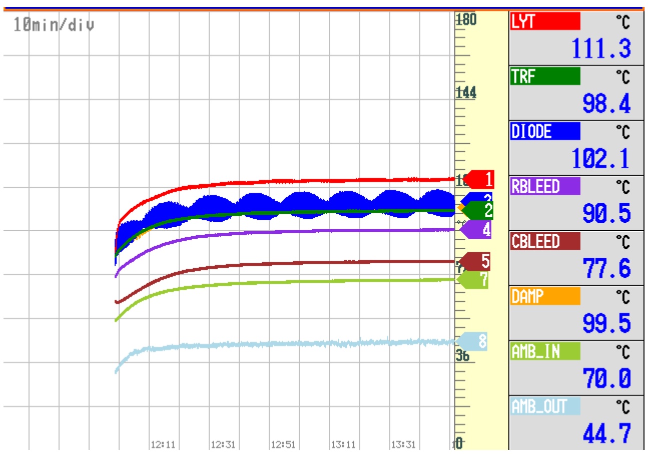

Figure 24 – V_{IN} = 195 VAC, Non-Dimming.

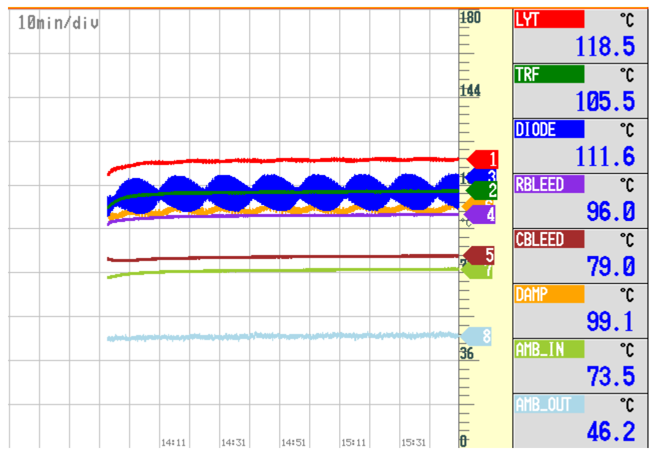

Figure 25 – V_{IN} = 265 VAC, Non-Dimming.

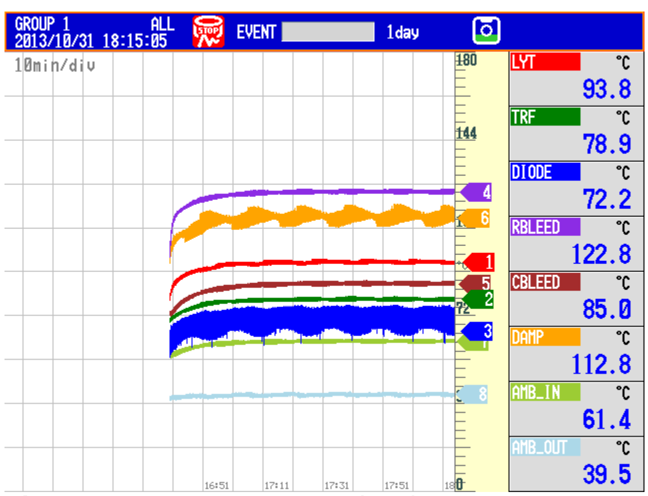

Figure 26 – V_{IN} = 230 VAC, Dimming at 90° Conduction Angle.

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12 非調光波形

12.1 輸入電壓和輸入電流波形

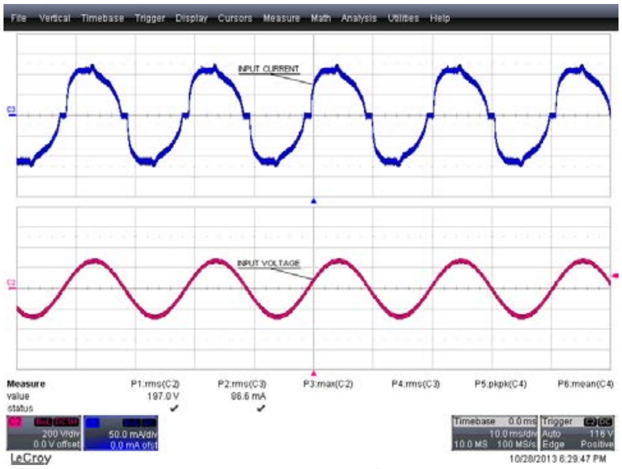

Figure 27 – 195 VAC, Full Load.
Upper:I_{IN}, 50 mA / div.
Lower:V_{IN}, 200 V, 10 ms / div.

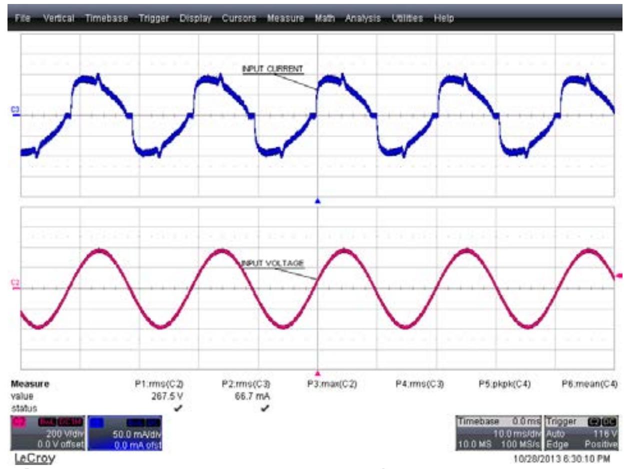

Figure 28 – 265 VAC, Full Load.
Upper:I_{IN}, 50 mA / div.
Lower:V_{IN}, 200 V, 10 ms / div.

12.2 正常運作下的輸出電流和輸出電壓

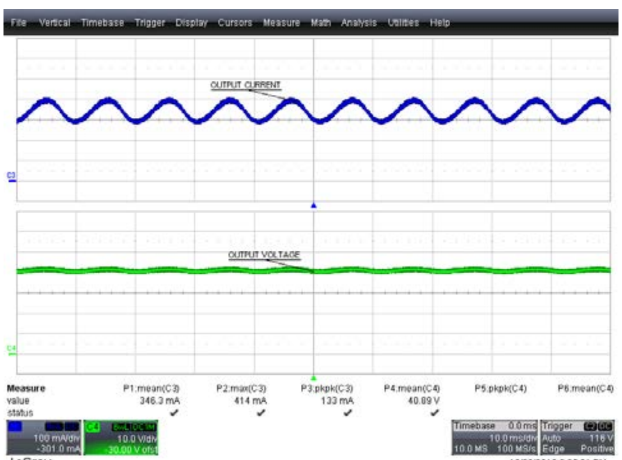

Figure 29 – 195 VAC, 50 Hz Full Load.
Upper:I_{OUT}, 100 mA / div.
Lower:V_{OUT}, 10 V, 10 ms / div.

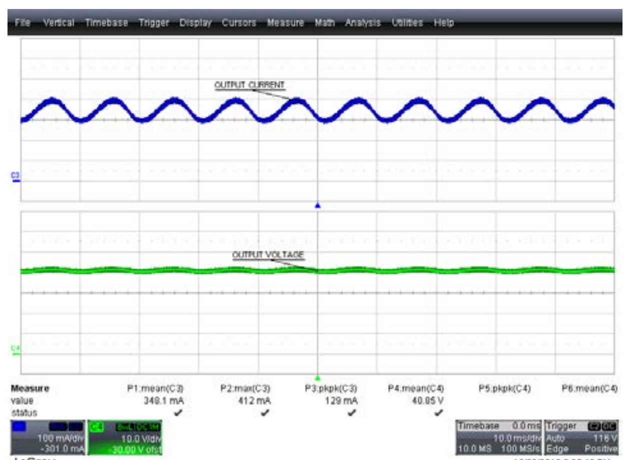

Figure 30 – 265 VAC, 50 Hz Full Load.
Upper:I_{OUT}, 100 mA / div.
Lower:V_{OUT}, 10 V, 10 ms / div.

12.3 啓動時的輸入電壓和輸出電流波形

Figure 31 – 195 VAC, 50 Hz.
Upper:I_{OUT}, 100 mA / div.
Lower:V_{IN}, 200 V, 100 ms / div.
Start-up Time:146 ms

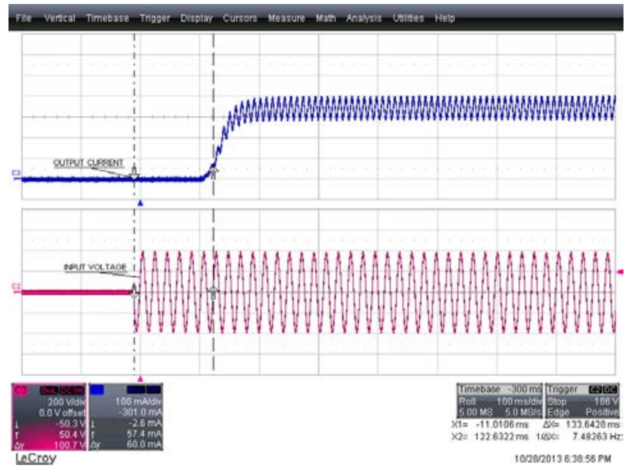

Figure 32 – 265 VAC, 50 Hz.
Upper:I_{OUT}, 100m A / div.
Lower:V_{IN}, 200 V, 100 ms / div.
Start-up Time:133 ms

12.4 正常運作下的汲極電壓和電流

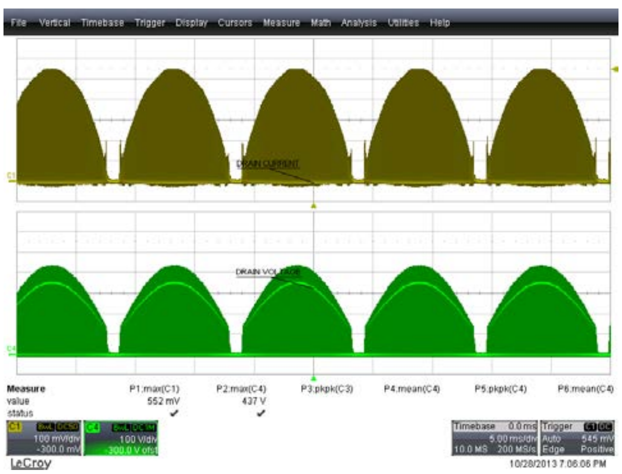

Figure 33 – 195 VAC, 50 Hz.
Upper:I_{DRAIN}, 100 mA / div.
Lower:V_{DRAIN}, 100 V, 5 ms / div.

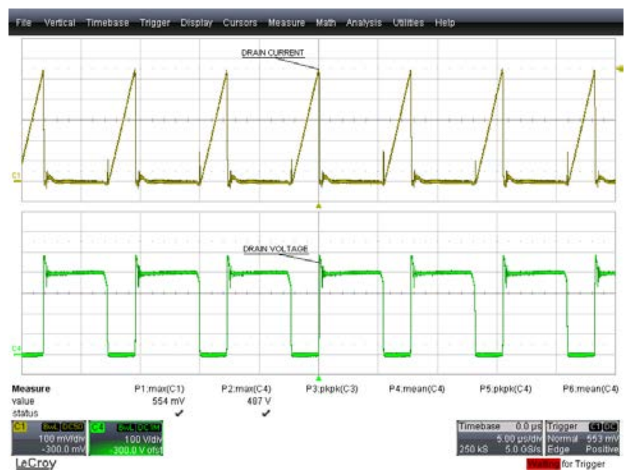

Figure 34 – 195 VAC, 50 Hz.
Upper:I_{DRAIN}, 100 mA / div.
Lower:V_{DRAIN}, 100 V / div., 5 μs / div.

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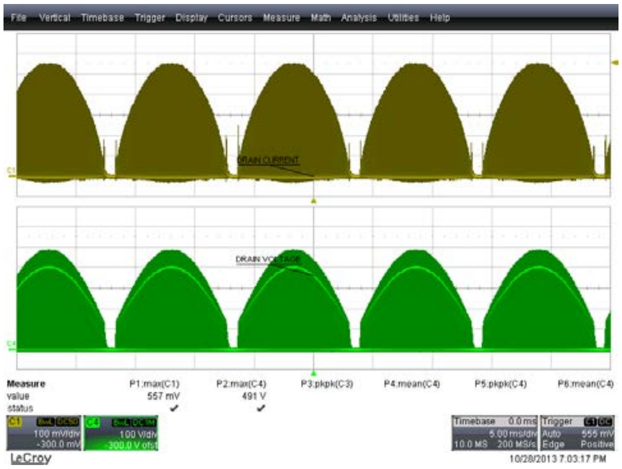

Figure 35 – 230 VAC, 50 Hz.
Upper:I_{DRAIN}, 100 mA / div.
Lower:V_{DRAIN}, 100 V, 5 ms / div.

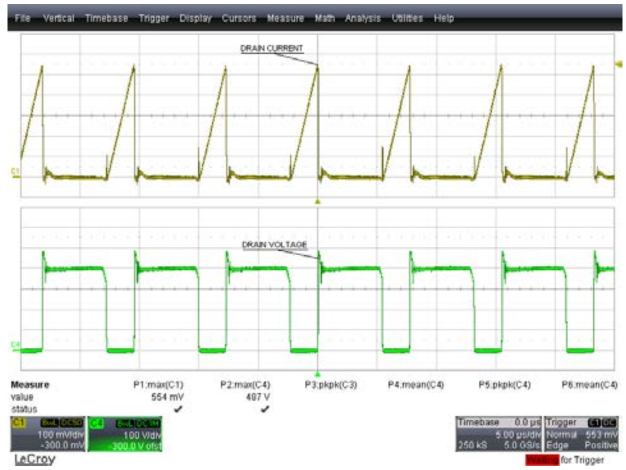

Figure 36 – 230 VAC, 50 Hz.
Upper:I_{DRAIN}, 100 mA / div.
Lower:V_{DRAIN}, 100 V / div., 5 μs / div.

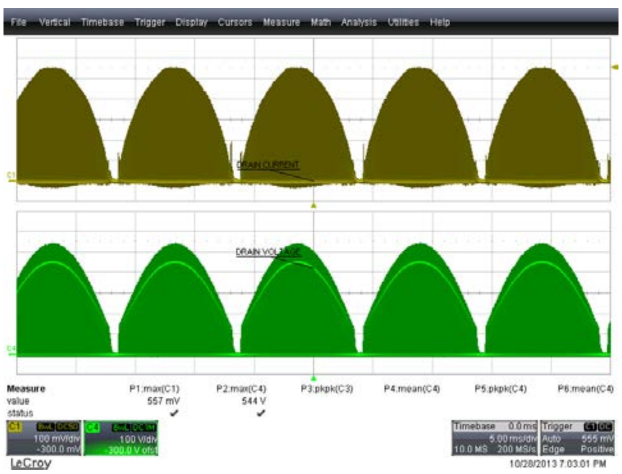

Figure 37 – 265 VAC, 50 Hz.
Upper:I_{DRAIN}, 100 mA / div.
Lower:V_{DRAIN}, 100 V, 5 ms / div.

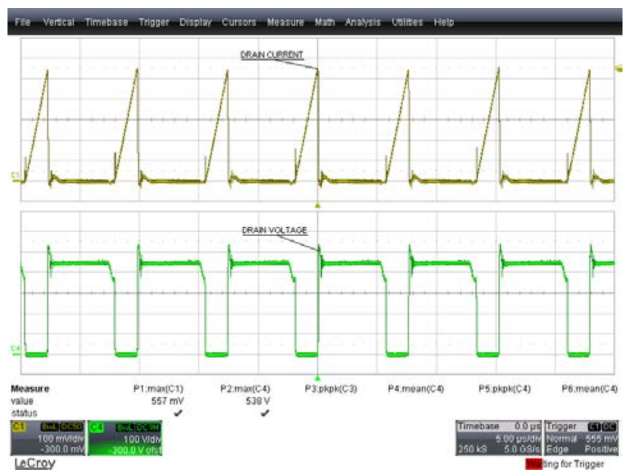

Figure 38 – 265 VAC, 50 Hz.
Upper:I_{DRAIN}, 100 mA / div.
Lower:V_{DRAIN}, 100 V / div., 5 μs / div.

12.5 啓動汲極電壓和電流

Figure 39 – 195 VAC, 50 Hz Start-up.
Upper:I_{DRAIN}, 200 mA / div.
Lower:V_{DRAIN}, 100 V, 2 ms / div.

Figure 40 – 195 VAC, 50 Hz Start-up.
Upper:I_{DRAIN}, 200 mA / div.
Lower:V_{DRAIN}, 100 V, 10 µs / div.

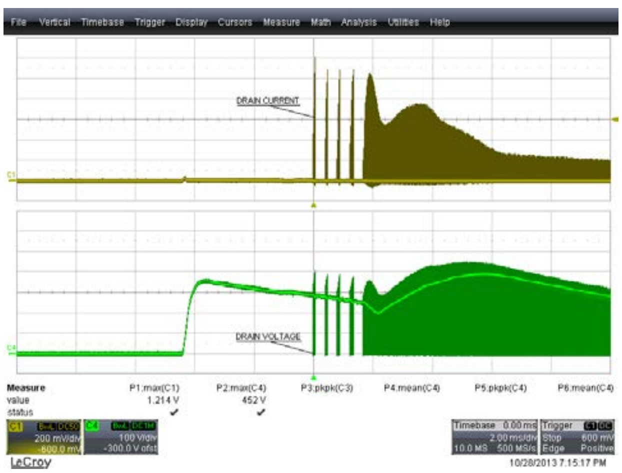

Figure 41 – 265 VAC, 50 Hz Start-up.
Upper:I_{DRAIN}, 200 mA / div.
Lower:V_{DRAIN}, 100 V, 2 ms / div.

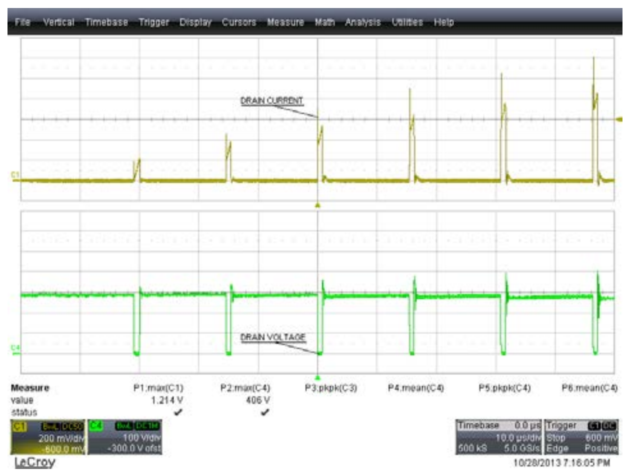

Figure 42 – 265 VAC, 50 Hz Start-up.
Upper:I_{DRAIN}, 200 mA / div.
Lower:V_{DRAIN}, 100 V, 10 µs / div.

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12.6 輸出短路情況下的汲極電流和汲極電壓

Figure 43 – 195 VAC, 50 Hz Output Short Condition.
Upper: I_{DRAIN}, 200 mA / div.
Lower: V_{DRAIN}, 100 V, 200 ms / div.

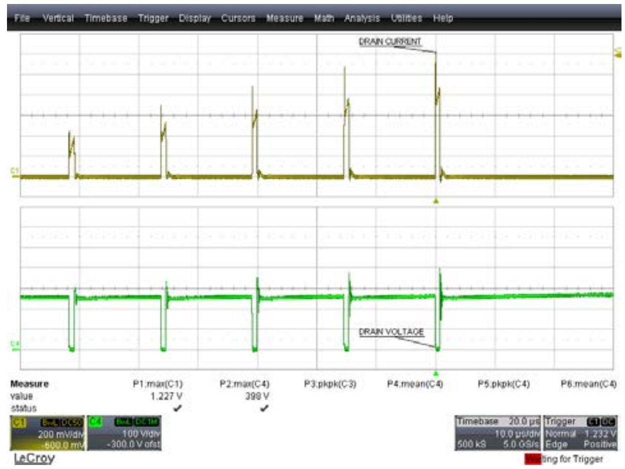

Figure 44 – 195 VAC, 50 Hz Output Short Condition.
Upper: I_{DRAIN}, 200 mA / div.
Lower: V_{DRAIN}, 100 V, 10 µs / div.

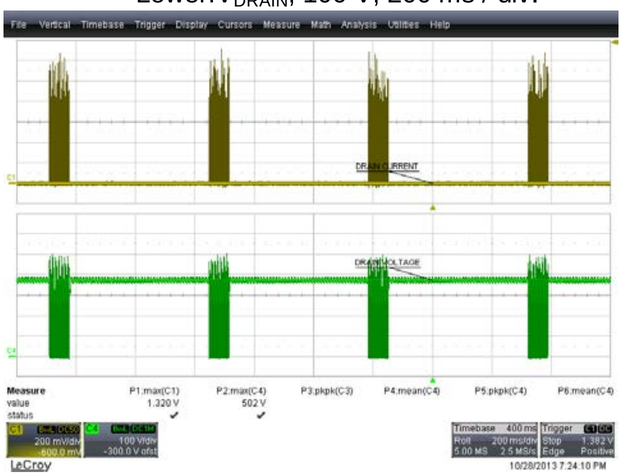

Figure 45 – 265 VAC, 50 Hz Output Short Condition.
Upper: I_{DRAIN}, 200 mA / div.
Lower: V_{DRAIN}, 100 V, 200 ms / div.

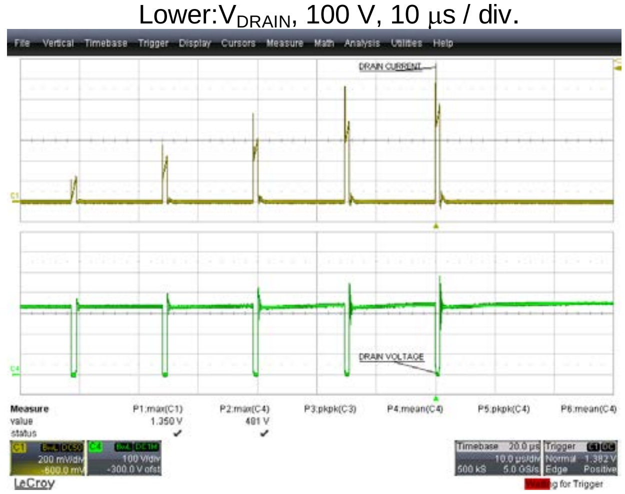

Figure 46 – 265 VAC, 50 Hz Output Short Condition.
Upper: I_{DRAIN}, 200 mA / div.
Lower: V_{DRAIN}, 100 V, 10 µs / div.

12.7 輸出二極體電流和電壓波形

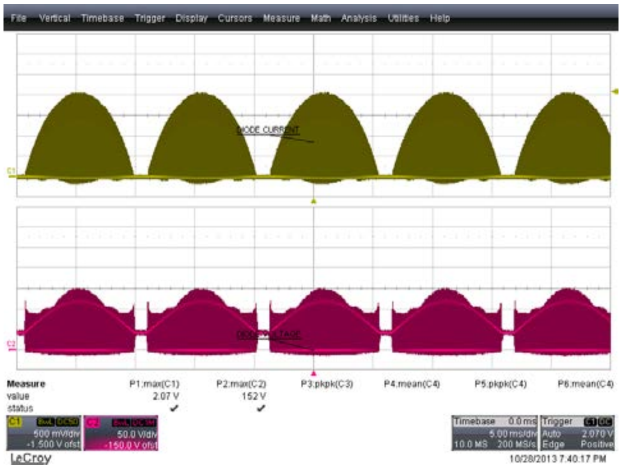

Figure 47 – 195 VAC, 50 Hz.
Upper:I_{D7}, 0.5 A / div.
Lower:V_{D7}, 50 V, 5 ms / div.

Figure 48 – 195 VAC, 50 Hz.
Upper:I_{D7}, 0.5 A / div.
Lower:V_{D7}, 50 V / div., 5 µs / div.

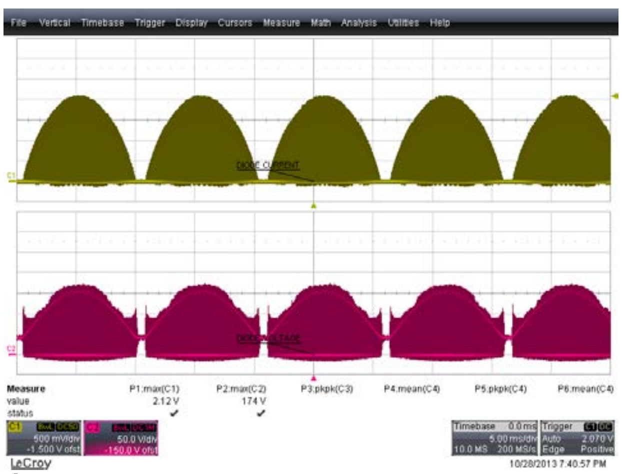

Figure 49 – 265 VAC, 50 Hz.
Upper:I_{D7}, 0.5 A / div.
Lower:V_{D7}, 50 V, 5 ms / div.

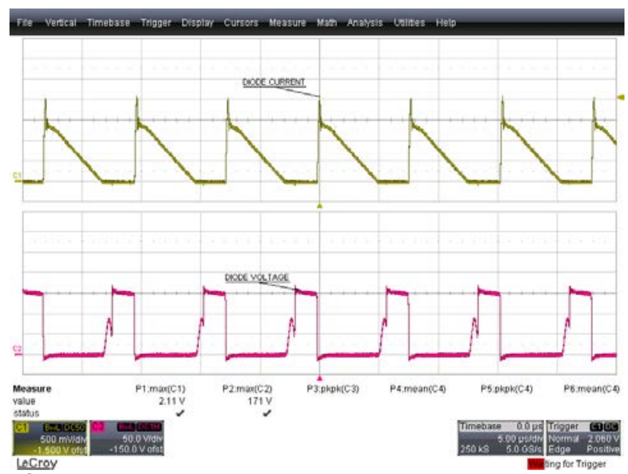

Figure 50 – 265 VAC, 50 Hz.
Upper:I_{D7}, 0.5 A / div.
Lower:V_{D7}, 50 V / div., 5 µs / div.

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12.8 輸出二極體電流和電壓啓動波形

Figure 51 – 195 VAC, 50 Hz.
Upper:I_{D7}, 1 A / div.
Lower:V_{D7}, 50 V, 2 ms / div.

Figure 52 – 265 VAC, 50 Hz.
Upper:I_{D7}, 1 A / div.
Lower:V_{D7}, 50 V / div., 2 ms / div.

12.9 輸出二極體電流和電壓短路波形

Figure 53 – 195 VAC, 50 Hz.
Upper:I_{D7}, 1 A / div.
Lower:V_{D7}, 50 V, 200 ms / div.

Figure 54 – 265 VAC, 50 Hz.
Upper:I_{D7}, 1 A / div.
Lower:V_{D7}, 50 V / div., 200 ms / div.

12.10 關閉

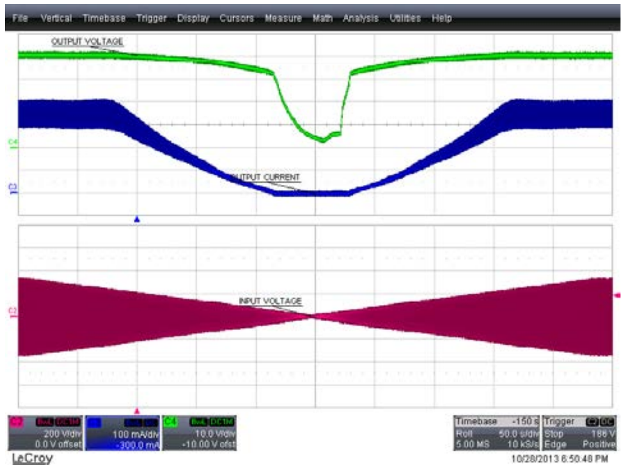

Figure 55 – 230 VAC, 50 Hz.
CH4:V_{OUT}, 10 V / div.
CH3:I_{OUT}, 100 mA / div.
CH2:V_{IN}, 200 V / div.

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12.11 線間暫態

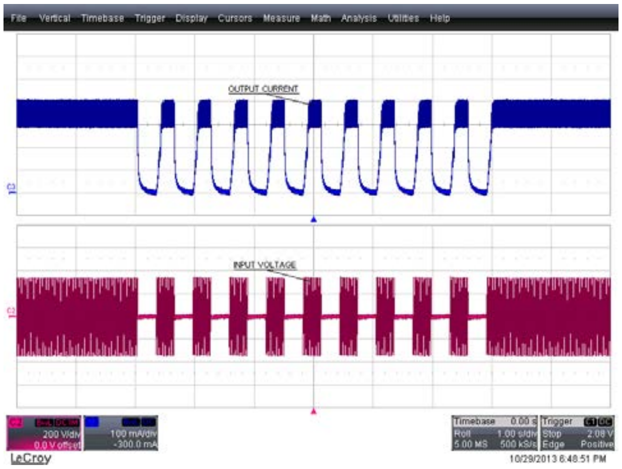

Figure 56 – 230 VAC, 50 Hz.
300 ms ON, 300 ms OFF.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 200 V /div, 1 s / div.

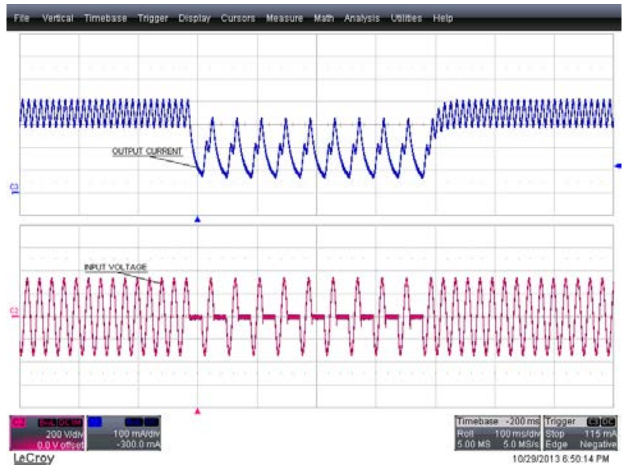

Figure 57 – 230 VAC, 50 Hz.
20 ms ON, 20 ms OFF.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 200 V /div, 100 ms / div.

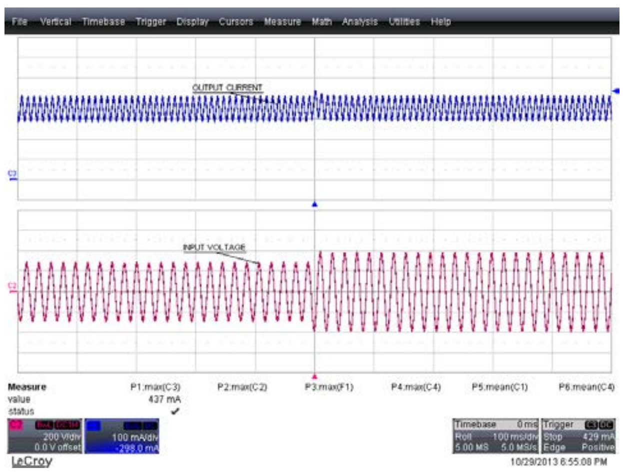

Figure 58 – 195 V to 265 V Step.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{IN}, 200 V, 100 ms / div.

13 調光波形

13.1 輸入電壓和輸入電流波形

Input:230 VAC, 50 Hz
Output:41 V LED Load
Dimmer:BUSCH 2250 600 W

Figure 59 – 160º Conduction Angle.
Upper:I_{IN}, 50 mA / div.
Lower:V_{IN}, 200 V, 5 ms / div.

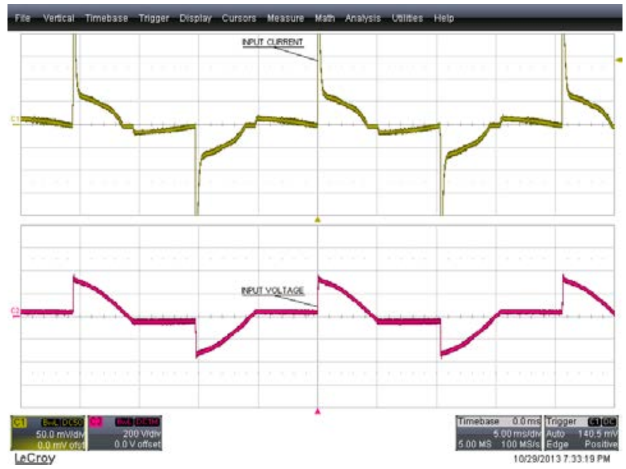

Figure 60 – 90º Conduction Angle.
Upper:I_{IN}, 50 mA / div.
Lower:V_{IN}, 200 V, 5 ms / div.

Figure 61 – 60º Conduction Angle.
Upper:I_{IN}, 50 mA / div.
Lower:V_{IN}, 200 V, 5 ms / div.

Figure 62 – 45º Conduction Angle.
Upper:I_{IN}, 50 mA / div.
Lower:V_{IN}, 200 V, 5 ms / div.

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13.2 輸出電流波形

Input:230 VAC, 50 Hz
Output:41 V LED Load
Dimmer:BUSCH 2250 600 W

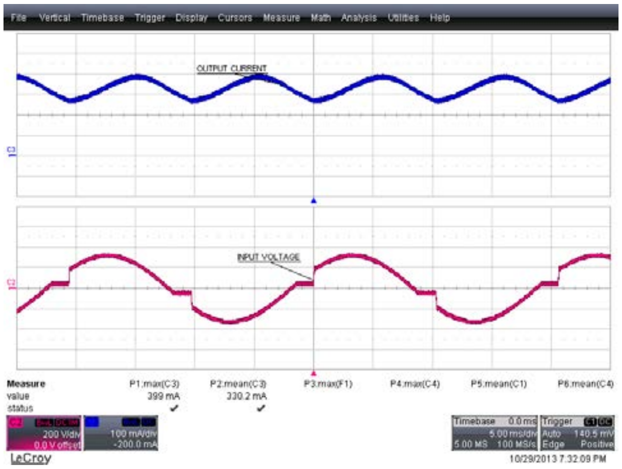

Figure 63 – 160º Conduction Angle.
Upper:I_{OUT}, 100 mA / div.
Lower:V_{IN}, 200 V, 5 ms / div.

Figure 64 – 90º Conduction Angle.
Upper:I_{OUT}, 100 mA / div.
Lower:V_{IN}, 200 V, 5 ms / div.

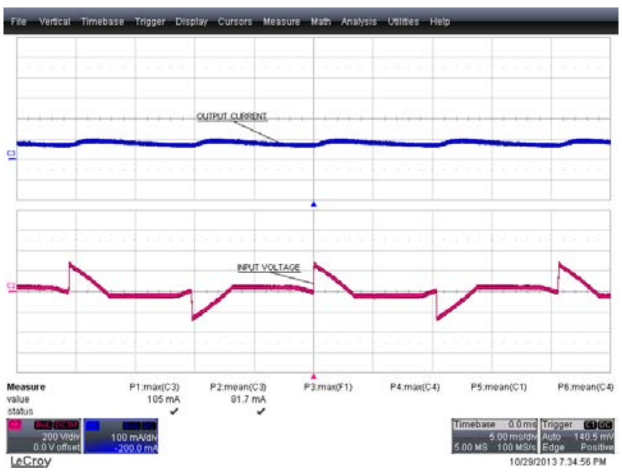

Figure 65 – 60º Conduction Angle.
Upper:I_{OUT}, 100 mA / div.
Lower:V_{IN}, 200 V, 5 ms / div.

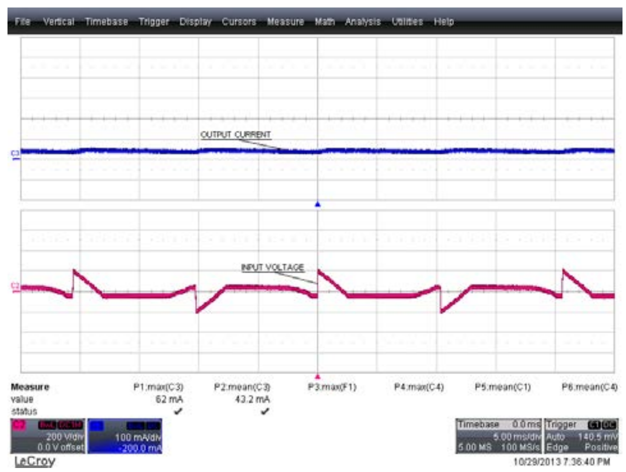

Figure 66 – 45º Conduction Angle.
Upper:I_{OUT}, 100 mA / div.
Lower:V_{IN}, 200 V, 5 ms / div.

14 傳導性 EMI

14.1 測試裝置

The unit was tested using LED load (~41 V V_{OUT}) with input voltage of 230 VAC, 60 Hz at room temperature.

Figure 67 – EMI Test Set-up with the Unit and LED Load Placed Inside the Cone.

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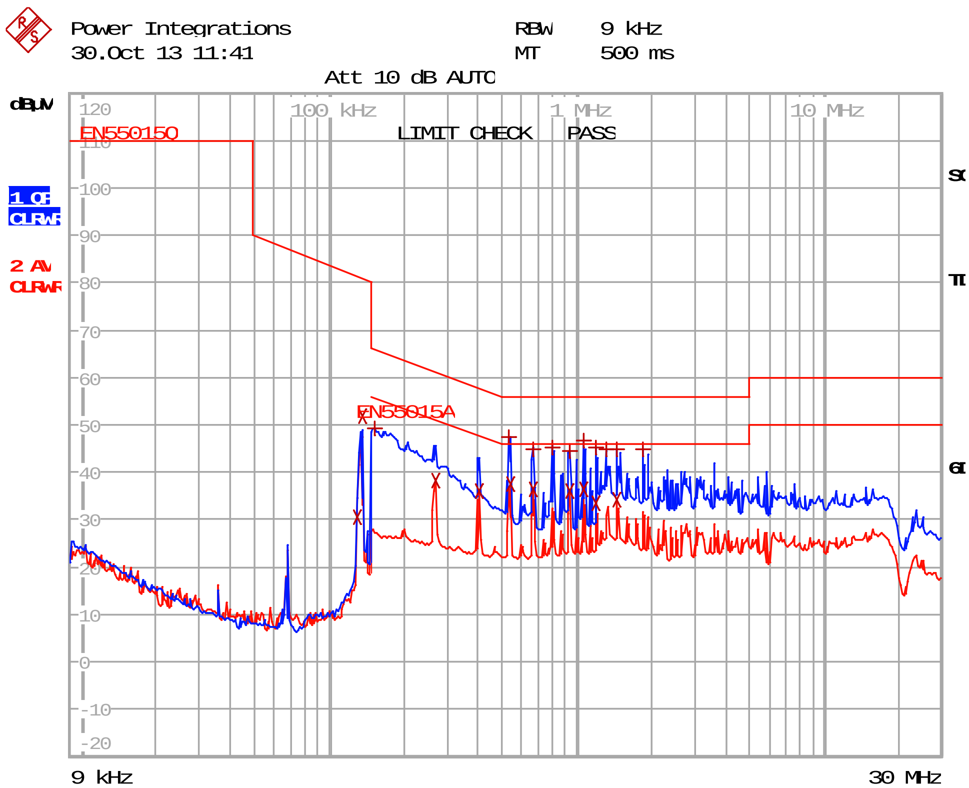
14.2 測試結果



EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55015Q
Trace2: EN55015A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV		DELTA LIMIT dB
2	Average	129.530094744 kHz	30.68	N gnd	
2	Average	136.137431366 kHz	51.84	L1 gnd	
1	Quasi Peak	153.015 kHz	49.36	L1 gnd	-16.46
2	Average	267.135089486 kHz	38.32	L1 gnd	-12.88
2	Average	401.705024172 kHz	35.94	L1 gnd	-11.87
1	Quasi Peak	530.769219795 kHz	47.46	L1 gnd	-8.53
2	Average	536.076911993 kHz	37.63	L1 gnd	-8.36
1	Quasi Peak	667.263434405 kHz	45.00	L1 gnd	-10.99
2	Average	667.263434405 kHz	36.42	L1 gnd	-9.57
1	Quasi Peak	798.145472681 kHz	45.40	L1 gnd	-10.59
1	Quasi Peak	935.888336808 kHz	44.48	L1 gnd	-11.51
2	Average	935.888336808 kHz	35.96	L1 gnd	-10.03
1	Quasi Peak	1.06512822736 MHz	46.53	L1 gnd	-9.46
2	Average	1.06512822736 MHz	36.28	L1 gnd	-9.71
1	Quasi Peak	1.20021314689 MHz	45.12	L1 gnd	-10.88
2	Average	1.20021314689 MHz	33.28	L1 gnd	-12.71
1	Quasi Peak	1.32578199726 MHz	44.71	L1 gnd	-11.28
1	Quasi Peak	1.46448812765 MHz	44.81	L1 gnd	-11.18
2	Average	1.46448812765 MHz	34.07	L1 gnd	-11.92
1	Quasi Peak	1.85951131803 MHz	45.00	L1 gnd	-11.00

Figure 68 – Conducted EMI, 41 V LED Load, 230 VAC, 60 Hz, and EN55015 B Limits.

15 線電壓突波測試

The unit was subjected to ±2500 V, 100 kHz ring wave and ±500 V differential surge at 230 VAC using 10 strikes at each condition.A test failure was defined as a non-recoverable interruption of output requiring supply repair or recycling of input voltage.

Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Type	Test Result (Pass/Fail)
+2500	230	L1, L2	0	100 kHz Ring Wave (500 A)	Pass
-2500	230	L1, L2	90	100 kHz Ring Wave (500 A)	Pass
+2500	230	L1, L2	0	100 kHz Ring Wave (500 A)	Pass
-2500	230	L1, L2	90	100 kHz Ring Wave (500 A)	Pass

Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Type	Test Result (Pass/Fail)
+500	230	L1, L2	0	Surge (2Ω)	Pass
-500	230	L1, L2	90	Surge (2Ω)	Pass
+500	230	L1, L2	0	Surge (2Ω)	Pass
-500	230	L1, L2	90	Surge (2Ω)	Pass

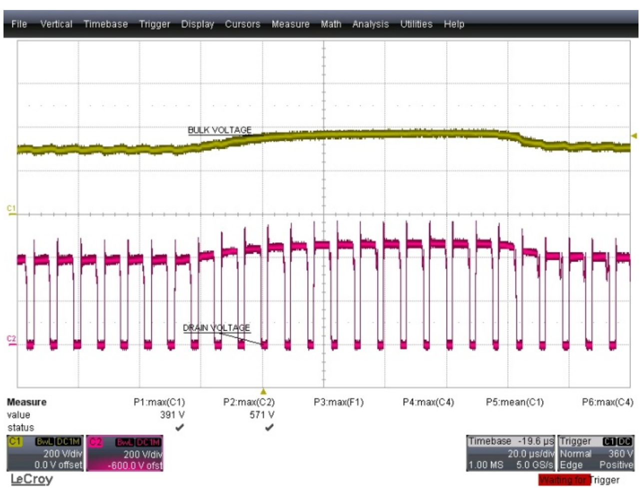


Figure 69 – (+)500 V Differential Surge, 90º.
Upper:V_{BULK}, 200 V / div.
Lower:V_{DRAIN}, 200 V, 20 µs / div.

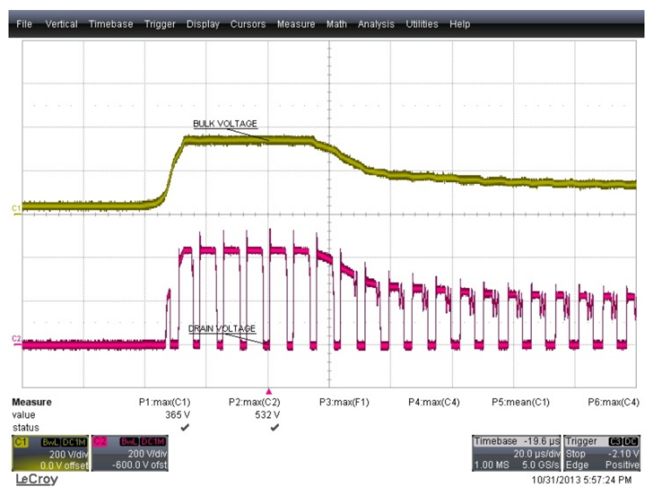


Figure 70 – (+)500 V Differential Surge, 0º.
Upper:V_{BULK}, 200 V / div.
Lower:V_{DRAIN}, 200 V, 20 µs / div.

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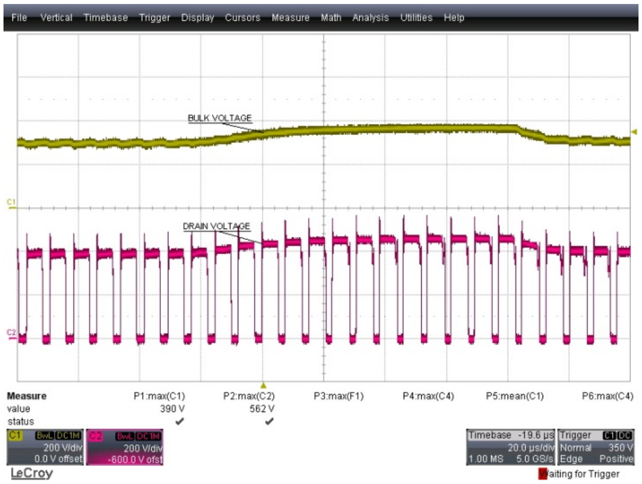

Figure 71 – (-)500 V Differential Surge, 270º.
Upper:V_{BULK}, 200 V / div.
Lower:V_{DRAIN}, 200 V, 20 µs / div.

Figure 72 – (-)500 V Differential Surge, 0º.
Upper:V_{BULK}, 200 V / div.
Lower:V_{DRAIN}, 200 V, 20 µs / div.

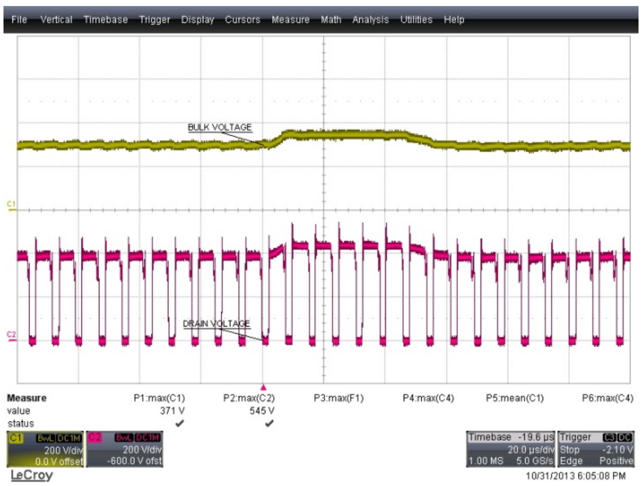

Figure 73 – (+)2.5 kV Ring Wave, 90º.
Upper:V_{BULK}, 200 V / div.
Lower:V_{DRAIN}, 200 V, 20 µs / div.

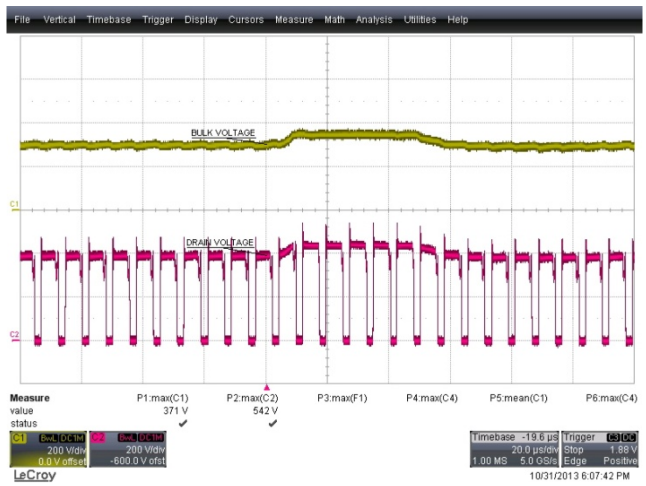

Figure 74 – (-)2.5 kV Ring Wave, 90º.
Upper:V_{BULK}, 200 V / div.
Lower:V_{DRAIN}, 200 V, 20 µs / div.

16 附錄

This section describes the operation of the optional active damper circuit that is incorporated in the pcb layout.

16.1 主動阻尼器電路圖

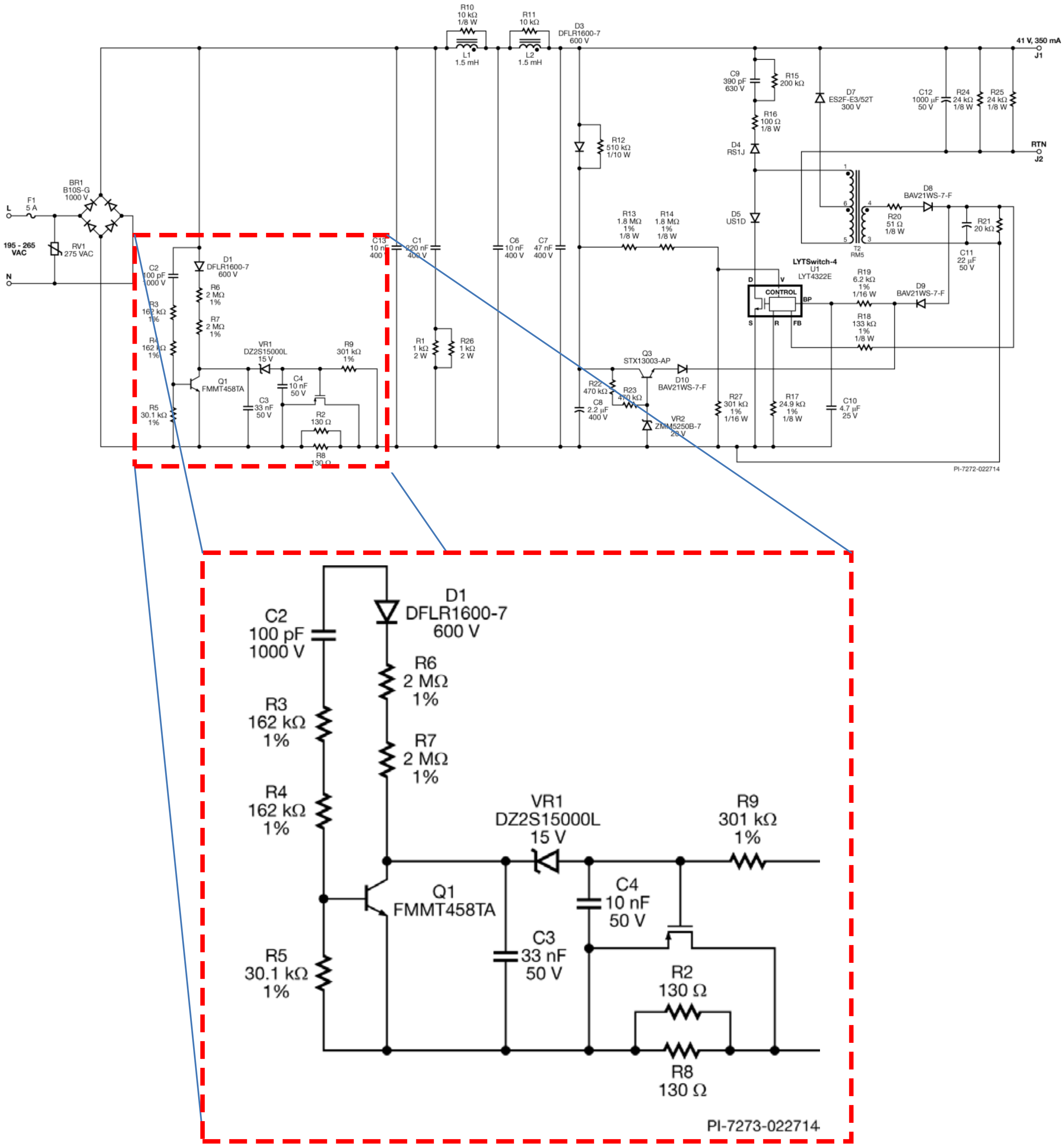

Figure 75 – Active Damper Schematic.

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16.2 電路說明

Resistors R2 and R8 provide passive damping and the surrounding circuit comprised of D1, R6, R7, C3, VR1, C4, Q2, and R9 minimize power dissipation of R2 and R8 by operating Q2 in linear mode approximately 2 ms after the TRIAC turns ON.Capacitor C2, R3, R4, R5 and Q1 provide a discharge path so that Q2 is initially turned OFF when the next TRIAC switching cycle begins.The values were also selected such that when there is no TRIAC connected, Q2 will be permanently ON which helps improve efficiency in non-dimming operation.

With this circuit, the values of R2 and R8 can be increased further for better dimmer compatibility but with less impact on the thermal performance of these resistors during dimming.

16.3 效率資料

With the active damper circuit, efficiency improves by as much as +2% over the one without the optional circuit.

16.3.1 無阻尼器

輸入		Input Measurement					Load Measurement			
VAC (V_{RMS})	**Freq (Hz)**	**V_{IN} (V_{RMS})**	**I_{IN} (mA_{RMS})**	**P_{IN} (W)**	**PF**	**%ATHD**	**V_{OUT} (V_{DC})**	**I_{OUT} (mA_{DC})**	**P_{OUT} (W)**	**Efficiency (%)**
195	50	194.95	87.09	16.600	0.978	15.86	42.0250	339.840	14.294	86.11
210	50	209.96	81.96	16.717	0.972	17.19	42.0210	342.990	14.425	86.29
220	50	220.00	79.41	16.901	0.967	17.79	42.0320	346.830	14.590	86.33
230	50	229.95	76.75	16.995	0.963	18.27	42.0280	348.660	14.666	86.30
240	50	239.98	74.05	17.021	0.958	18.75	42.0110	348.910	14.671	86.19
265	50	264.95	68.30	17.029	0.941	20.7200	41.9870	347.950	14.621	85.86

16.3.2 具有主動阻尼器

輸入		Input Measurement					Load Measurement				
VAC (V_{RMS})	**Freq (Hz)**	**V_{IN} (V_{RMS})**	**I_{IN} (mArms)**	**P_{IN} (W)**	**PF**	**%ATHD**	**V_{OUT} (V_{DC})**	**I_{OUT} (mA_{DC})**	**P_{OUT} (W)**	**Efficiency (%)**	**Effiency Improvement (%)**
195	50	194.95	85.87	16.314	0.975	16.77	42.1030	342.590	14.436	88.49	**2.38**
210	50	209.96	81.25	16.517	0.968	17.96	42.1070	346.400	14.598	88.38	**2.09**
220	50	219.99	78.59	16.672	0.964	18.32	42.1070	349.130	14.713	88.25	**1.92**
230	50	229.94	75.91	16.749	0.960	18.79	42.0950	350.030	14.747	88.05	**1.75**
240	50	239.98	73.25	16.773	0.954	19.25	42.0730	349.740	14.727	87.80	**1.61**
265	50	264.95	67.81	16.825	0.937	21.3300	42.0480	348.750	14.676	87.23	**1.37**

16.4 物料表 (主動阻尼器)

Item	Qty	Ref Des	說明	Mfg Part Number	Manufacturer
1	1	C2	100 pF, 1000 V, Ceramic, NPO, 0805	C0805C101MDGACTU	Kemet
2	1	C3	33 nF, 50 V, Ceramic, X7R, 0805	CC0805KRX7R9BB333	Yageo
3	1	C4	10 nF 50 V, Ceramic, X7R, 0603	C0603C103K5RACTU	Kemet
4	1	D1	600 V, 1 A, Rectifier, Glass Passivated, POWERDI123	DFLR1600-7	Diodes, Inc.
5	1	Q1	NPN, HP, 400 V, 225 mA, SOT23-3	FMMT458TA	Diodes, Inc.
6	1	Q2	600 V, 0.4 A, 8 Ω, N-Channel, TO-92	STQ2NK60ZR-AP	ST Micro
7	2	R2 R8	130 Ω, 5%, 1 W, Thick Film, 2512	ERJ-1TYJ131U	Panasonic
8	2	R3 R4	162 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF1623V	Panasonic
9	1	R5	30.1 kΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF3012V	Panasonic
10	2	R6 R7	2 MΩ, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF2004V	Panasonic
11	1	R9	301 kΩ, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF3013V	Panasonic
12	1	VR1	15 V, 5%, 150 mW, SSMINI-2	DZ2S15000L	Panasonic

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17 修訂記錄

日期	作者	修訂	**Description and Changes**	**Reviewed**
27-Feb-14	DS	1.0	Initial Release	Apps & Mktg

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專利資訊

本處所述的產品和應用 (包括 PI 裝置 IC 之外的變壓器結構和電路) 可能包含 Power Integrations 的一項或多項美國及國外專利，或是正在申請的美國及國外專利。www.powerint.com 上提供了 Power Integrations 專利的完整清單。Power Integrations 授予其客戶某些特定專利權的授權，詳情請參閱 <http://www.powerint.com/ip.htm>。

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