設計範例報告

標題	***使用 LYTSwitch™ LYT4313E 的 14 W 可調光雙向閘流器 (TRIAC)，達 85% 以上的高效率，非隔離降壓式轉換器，功率因數修正 (大於 0.95) LED 驅動器***
規格	90 VAC – 132 VAC 輸入；41 V、350 mA 輸出
應用	PAR20 LED 驅動器
作者	應用工程部門
文件編號	DER-364
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修訂	1.0

摘要與功能

- 於 120 VAC 時可達 85%以上的高效率
- 廣泛的調光器相容性 (符合 NEMA SSL6 調光曲線)，以美國 TRIAC 爲基礎的各種調光器可供選擇
  - 超過 1000:1 的高調光比
- 增強的使用者體驗
  - 無閃爍、單向調光，
  - 快速單向啓動 (小於 200 ms) – 無可感延遲
  - 幾乎以相同的調光角開啓和關閉 (無驟開效應)
- 高度整合的低成本的解決方案
  - Single-stage 結合 PFC 與精準的一次側調節定電流 (CC) 輸出
- 整合式保護與可靠性功能
  - 藉由自動恢復功能提供輸出短路保護
  - 快斷型線間輸入過壓關機，擴大了線路故障時的耐壓程度
    - ±2500 V 振盪波和 ±500 V 差動突波 (未使用 MOV)

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  - 具有高磁滯時間的自動恢復回復過溫保護，同時保護元件和 PCB
- 符合 IEC 61000-4-5 振盪波、IEC 61000-3-2 C THD 和 IEC CISPR 15 / EN55015 B 傳導性 EMI 標準

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重要事項：雖然此電路板的設計滿足安全隔離需求，但其工程原型未經相關機構核准。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

本文件說明隔離式高功率因數 (PF) 且雙向閘流器 (TRIAC) 調光的 LED 驅動器，其設計爲輸入電壓範圍爲 90 VAC 至 132 VAC 時，用於驅動 41 V (350 mA) 的標準 LED 串電壓。此 LED 驅動器採用 LYTSwitch IC 系列中的 LYT4313E。

所使用的架構是 Single-stage 功率因數修正降壓式轉換器，用於實現高效能、高功率因數、低 THD，以及低元件數。

高功率因數和低 THD 是透過採用 LYTSwitch IC 來達成，此裝置也提供眾多而完整的保護功能，包括開路控制迴路與輸出短路狀況的自動重新啓動。線電壓過壓可提高線路故障與突波承受度，而精確的磁滯回復過溫保護功能可確保 PCB 在各種狀況下皆可保持在安全的平均溫度。

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

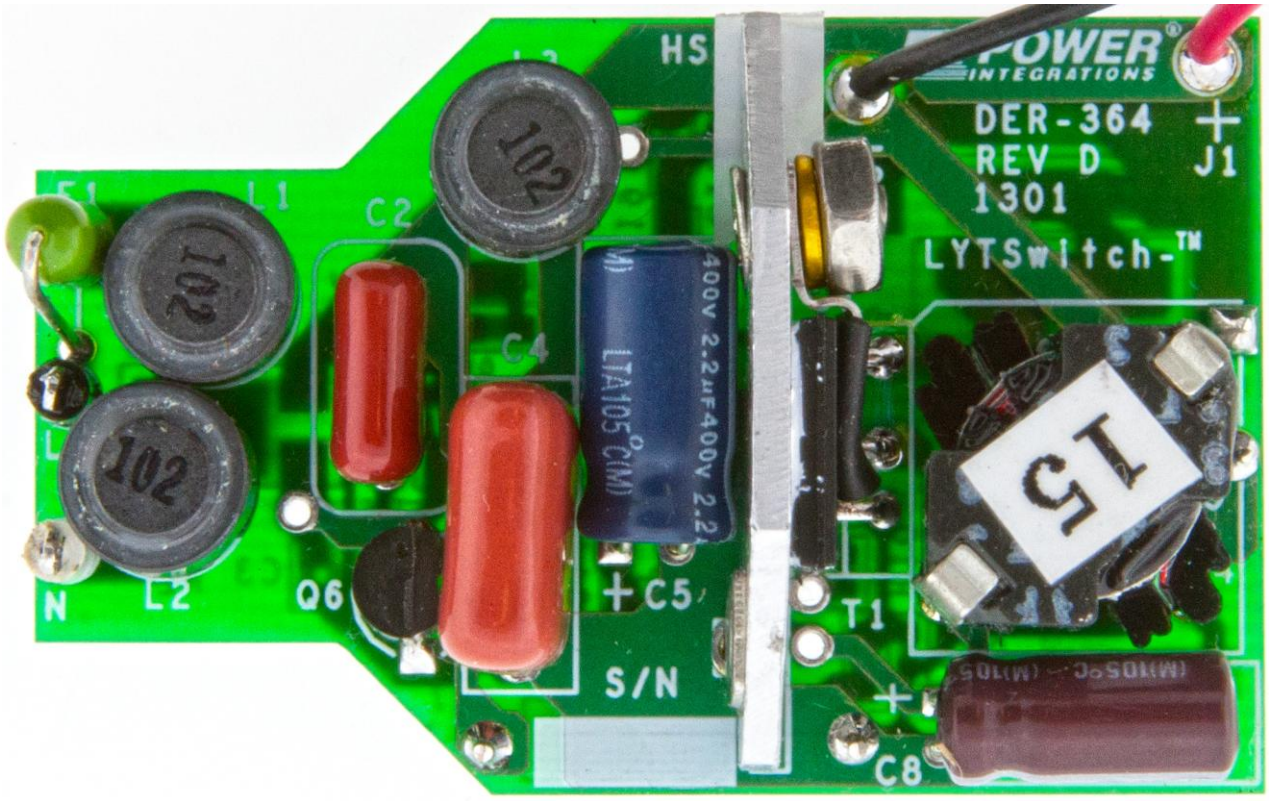

Figure 1 – Populated Circuit Board Photograph (Top).

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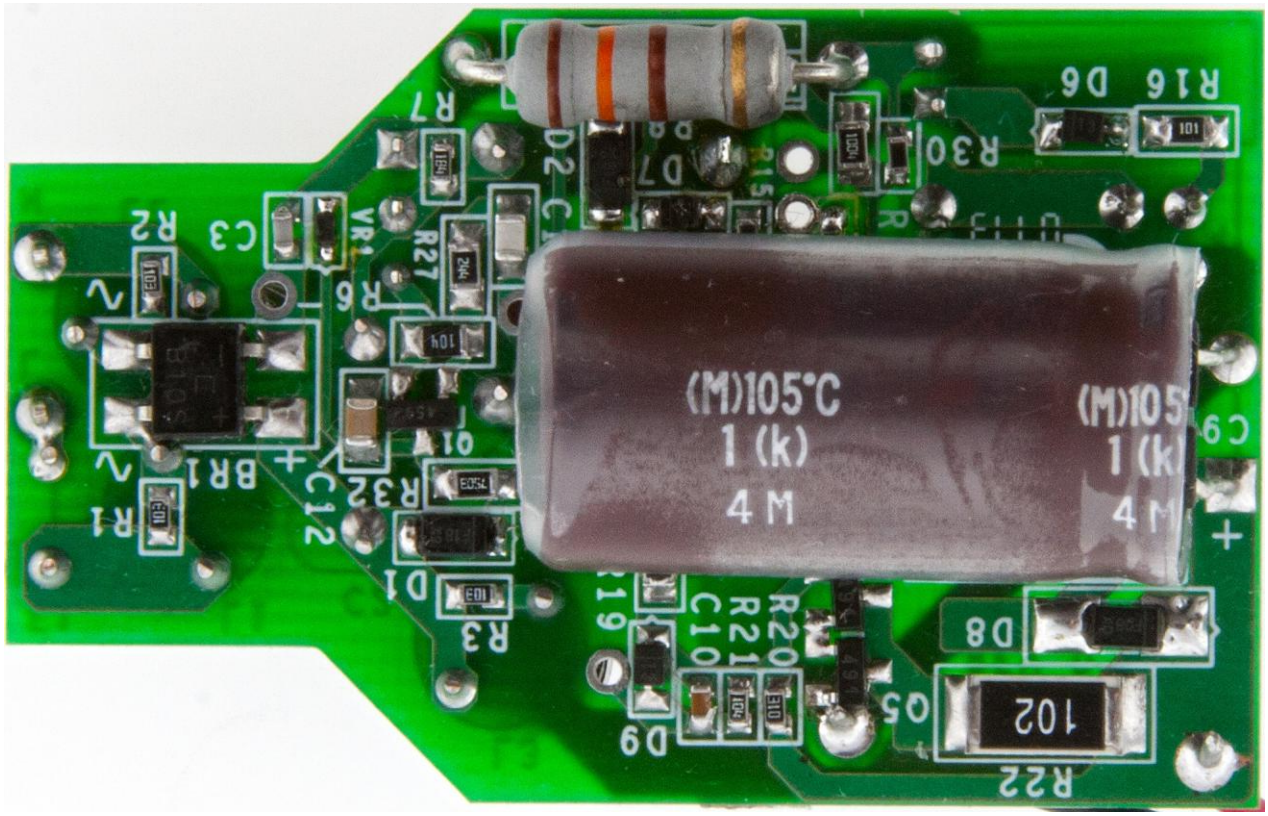

Figure 2 – Populated Circuit Board Photograph (Bottom).

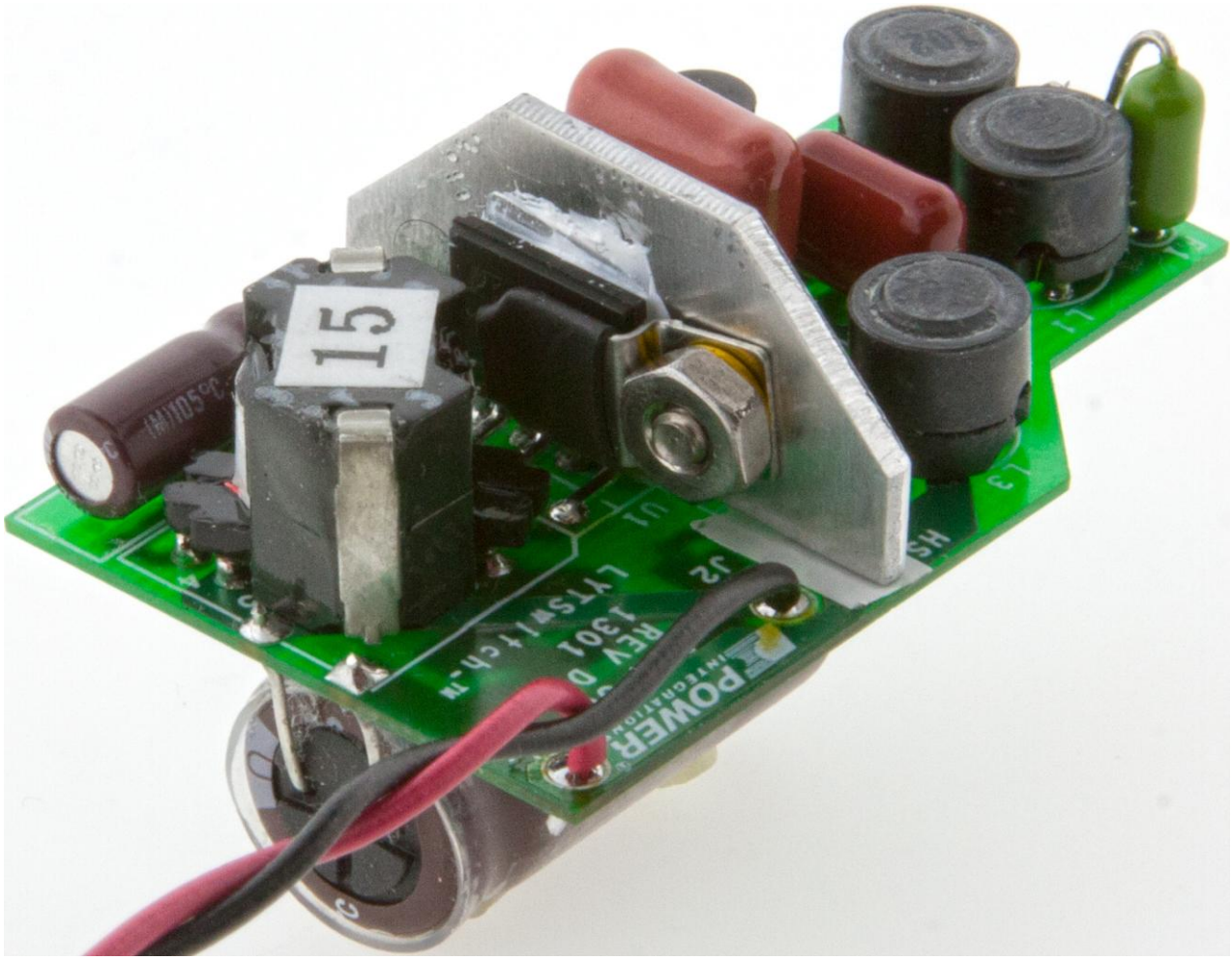

Figure 3 – Populated Circuit Board Photograph (Angle).
Dimensions: 1.99 in [50.6 mm] L x 1.26 in [32 mm] W x 1.19 in [30.2 mm] H.

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2 電源供應器規格

下表展示設計的最低可接受效能。實際效能列在結果部分。

說明	符號	最小值	類型	最大值	單位	註解
輸入						
電壓	V_{IN}	90	120	132	VAC	
頻率	f_{LINE}		60		Hz	
輸出						
輸出電壓	V_{OUT}	38	41	44	V	
輸出電流	I_{OUT}		350		mA	
總輸出功率						
連續輸出功率	P_{OUT}		14		W	
效率						
滿載	η		85		%	V_{OUT} = 41,V_{IN} = 120 VAC，環境溫度爲 25 °C
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	
差動突波 (1.2 / 50 μs)			500		V	
功率因數			0.99			於 $V_{OUT(TYP)}$、$I_{OUT(TYP)}$ 及 120 VAC、60 Hz 條件下測量
諧波電流		EN 61000-3-2 D 級 (C)				C 級規範 P_{IN} 小於 25 W 時的 D 級限值
環境溫度	T_{AMB}		45		°C	自然對流，海平面

3 電路圖

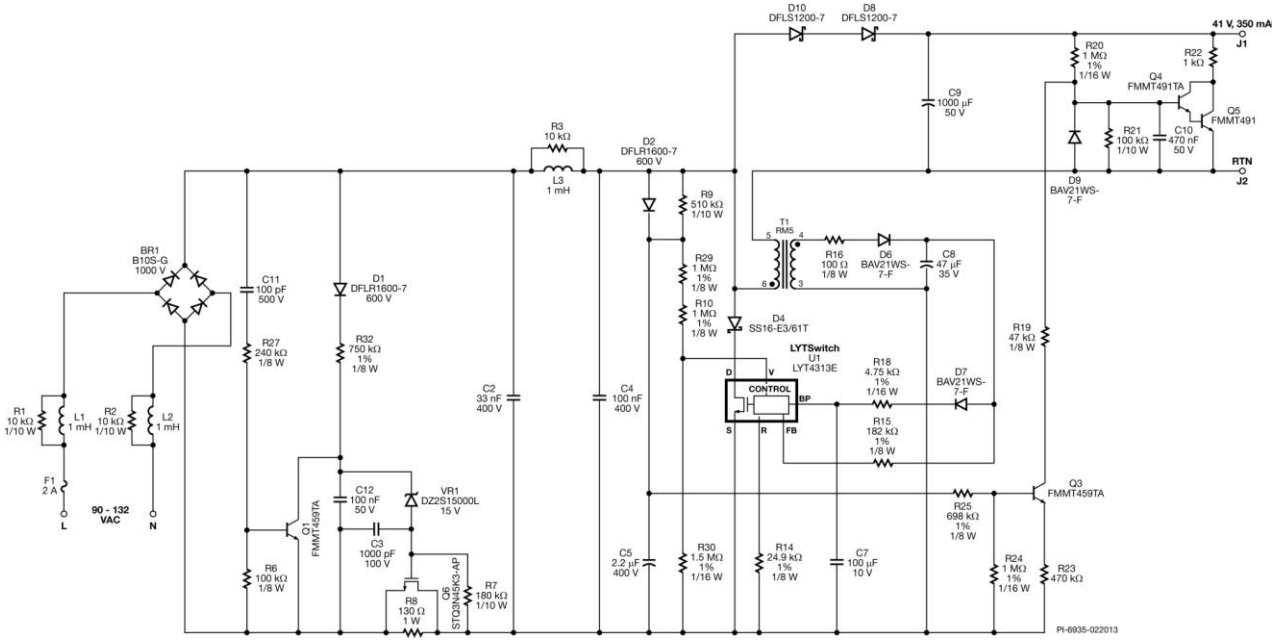

Figure 4 – Schematic.

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4 電路說明

LYTSwitch 裝置是一種控制器，採用整合式 670 V 功率 MOSFET，用於 LED 驅動器應用。LYTSwitch 設定用於 Single-stage 降壓式轉換器結構，具備已調整的一次側定電流輸出，同時保持 AC 輸入端的高功率因數。

4.1 輸入濾波功能

保險絲 F1 可防止元件發生故障。爲防止線電壓高壓 (1.2 µs / 50 µs) 突波，已選用極高的電流額定值。橋式整流器 BR1 可利用電容器 C4 對 AC 線電壓進行整流，來爲一次側切換電流提供低阻抗路徑 (去耦合)。

EMI 濾波由電感器 L1、L2 和 L3，以及電容器 C2 和 C4 提供。L1、L2 和 L3 上的電阻器 R1、R2 和 R3 會分別抑制因濾波元件和 AC 線間阻抗而產生的 LC 任何 LC 諧振，否則會導致傳導性 EMI 測量增加。

4.2 LYTSwitch 一次側

此設計中所選擇的結構是低壓降壓式轉換器，設定爲在 90 VAC 至 132 VAC 輸入電壓範圍內提供低 THD、一致的功率因數，以及定電流輸出。

電感器 T1 是降壓式轉換器的主要電感器。其包含兩組繞組，即一次側繞組和偏壓繞組。一次側繞組是主要降壓式電感器，偏壓繞組則是 IC 的供應器，可協助防止特別會在深度調光期間發生的閃爍及閃光。

每當 U1 關閉時，輸出二極體 (串接的 D8 和 D10) 就會執行，並將能量輸送到負載。這些二極體可已換成一個額定電壓大於 200 V 的蕭特基二極體。二極體 D4 是 C4 (整流後輸入 AC) 上的電壓降到低於輸出電壓時，防止反向電流流經 U1 的必要裝置。

爲了提供峰值線電壓資訊給 U1，輸入整流 AC 峰值電壓會透過 D2 爲 C5 充電。然後該電壓將以透過 R10 和 R29 的電流形式饋送至 U1 的電壓監測器 (V) 接腳。存在線間弛波使 V 接腳對減少功率更快回應時，電阻器 R9 會成爲 C5 的放電路徑。

線電壓過壓關機功能 (透過 V 接腳電流感應) 可讓整流線電壓的承受度 (在突波和線間陡昇期間) 提高至內部功率 MOSFET 的 650 BV_{DSS} 額定值。LYTSwitch 的快斷型線間過壓偵測加上搭配使用 D2 和 C5 峰值偵測器電容器，可提供箝位來限制線間突波期間 IC 的功率 MOSFET 上的最大電壓應力。C5 上值 2.2 µF 可承受 500 V 突波，而 4.7 µF 則可承受 1 kV 突波。如果需要大於 1000 V 線電壓高壓突波，可使用其他選用的 140 VAC 額定 MOV (金屬氧化物可變電阻)。

電容器 C7 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 C7 充電至約 ~6 V。建議使

用外部偏壓供電 (透過 D7 和 R18) 以提供最低的裝置消耗功率，並在深度調光情況下，充裕供電給 U1。

在內部使用 V 接腳電流和回授 (FB) 接腳電流，以控制平均輸出 LED 電流。對於相位角調光應用，在參考接腳 (R14) 上使用了 49.9 kΩ 電阻器，同時在 V 接腳上使用 2 MΩ (R10+R29) 電阻，以便使輸入電壓和輸出電流之間形成線性關係。這可在與 TRIAC 調光器搭配使用時，使調光範圍最大。但是，此設計使用 24.9 kΩ 值，以達成較嚴格的定電流穩壓。使用輸出端上的主動預載來達成高調光比。

4.3 回授

使用偏壓繞組電壓可間接感測輸出電壓，而不再需要二次側回授元件。偏壓繞組電壓與輸出電壓成正比 (由偏壓繞組和一次側繞組之間的圈數比設定)。偏壓繞組上的返馳電壓會使用 D6 進行整流，使用 R16 和 C8 進行濾波。電阻器 R15 會將偏壓電壓轉換成電流，再將該電流饋送至 U1 的 FB 接腳。U1 的內部引擎會結合 FB 接腳電流、V 接腳電流及內部汲極電流資訊，以便提供恆定的輸出電流，同時維持高輸入功率因數。

二極體 D7 和 R18 提供偏壓供應給 BP 接腳的路徑。啓動期間會使用二極體 D7 來隔離 C7 與 C8，電阻器 R18 則限制從偏壓繞組供應給 BP 接腳的電流。

4.4 輸出整流

變壓器二次側繞組由 D8 和 D10 進行整流，由電容器 C9 進行濾波。針對像是這個設計一樣要求低漣波的設計，應該使用高電容值，否則值可能遭到降低。

4.5 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 的上升邊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，因此燈具所汲取的電流會低於調光器內 TRIAC 的吸持電流。這會引起不良狀況，例如燈具在調光器控制範圍結束之前關閉及/或在 TRIAC 啓動時不一致地閃爍。開啓 TRIAC 時，LED 燈相對較大的阻抗會因對輸入電容充電的浪湧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。

爲了克服這些問題，加入了主動阻尼器和主動預載電路。接在火線和地線之間保險絲後面的被動 RC 洩放器電路也可以使用。這些電路的缺點是會增大功耗，進而降低電源供應器的效率。對於非調光應用，省略這些元件即可。

新的 PI 專利主動阻尼器由主要元件 D1、R32、C11、R27、R6、Q1、C12、VR1、Q6、R7、C3 和 R8 組成。其中 Q6 會在沒有連接 TRIAC 時完全導通，以繞過 R8，這將會保持低功率消耗，進而使系統效率提高。TRIAC 會透過 C11、R27 和 R6 偵測，這將會短暫地驅動 Q1，使 C3 接地和閘極 Q6 維持低值，以便讓 R8 能與 TRIAC 串接，在 TRIAC 每次啓動時，用作電流振盪的阻尼元件。

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4.6 主動預載

此驅動器的主動預載，會用於塑造調光曲線並增加調光比，同時維持正常操作下的高效率。此電路也可用於非隔離式轉換器，像是降壓式、升降壓式、抽頭降壓式。

主動預載電路透過分壓器 R25 和 R24 偵測來自 C5 的輸入峰值電壓，分壓器與調光器導通角成正比；透過 Q3、R23、R19 和 C10 處理資訊，以提供一個平均訊號，再使用此訊號線性驅動達靈頓 (Q4、Q5) 以透過電阻器 (R22) 載入輸出。

在非調光操作 (全導通) 期間，輸出上的主動洩放器不會連接，藉此維持高效率操作。洩放器會開啓在設定好的調光角度。主動洩放器將會線性施加偏壓降至 TRIAC 可運作的最低導通角，藉此提高調光比。

此電路也會用作洩漏 TRIAC 的洩放器，因達靈頓 (Darlington) 將透過 R20 施加偏壓，在輸出端，因 TRIAC 洩漏少量能量而電壓累積時載入 R22。

5 PCB 佈局

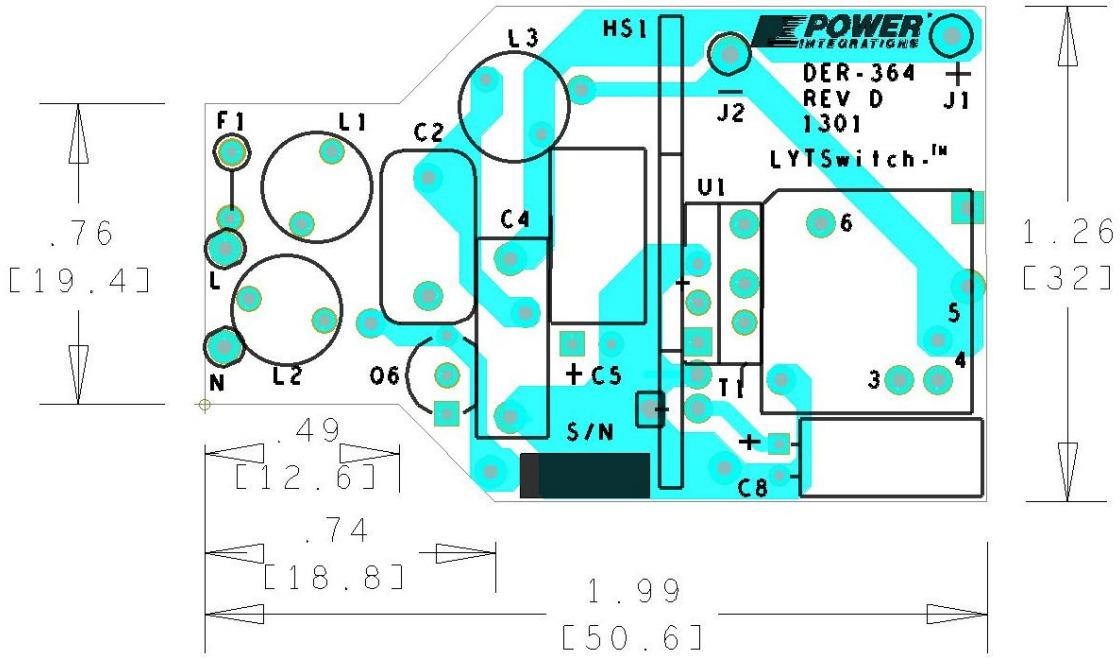

Figure 5 – Top Side.

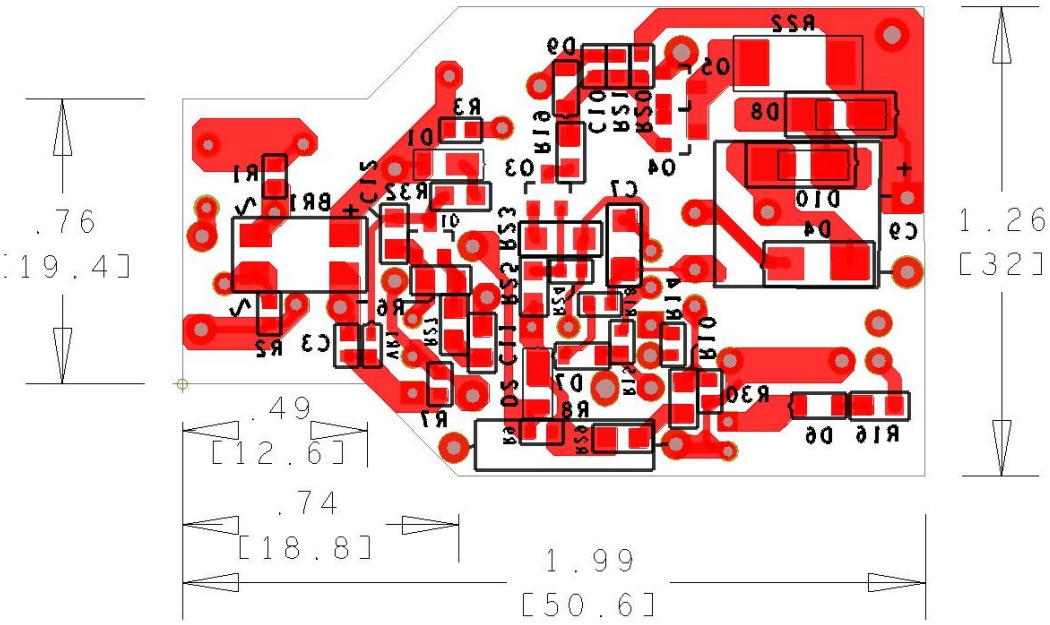

Figure 6 – Bottom Side.

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6 物料表

6.1 電氣物料表

Item	Qty	Ref Des	Description	Mfg Part Number	Mfg
1	1	BR1	1000 V, 0.8 A, Bridge Rectifier, SMD, MBS-1, 4-SOIC	B10S-G	Comchip
2	1	C2	33 nF, 400 V, Film	ECQ-E4333KF	Panasonic
3	1	C3	1000 pF, 100 V, Ceramic, COG, 0603	C1608C0G2A102J	TDK
4	1	C4	100 nF, 400 V, Film	ECQ-E4104KF	Panasonic
5	1	C5	2.2 □F, 400 V, Electrolytic, (6.3 x 11)	TAB2GM2R2E110	Ltec
6	1	C7	100 □F, 10 V, Ceramic, X5R, 1206	C3216X5R1A107M	TDK
7	1	C8	47 □F, 35 V, Electrolytic, Gen. Purpose, (5 x 11)	EKMG350ELL470ME11D	Nippon Chemi-Con
8	1	C9	1000 □F, 50 V, Electrolytic, Gen. Purpose, (12.5 x 25)	EKMG500ELL102MK25S	Nippon Chemi-Con
9	1	C10	470 nF, 50 V, Ceramic, X7R, 0603	UMK107B7474KA-TR	Taiyo Yuden
10	1	C11	100 pF, 500 V, Ceramic, NPO, 0805	501R15N101KV4T	Johanson Dielectrics
11	1	C12	100 nF, 50 V, Ceramic, X7R, 0805	CC0805KRX7R9BB104	Yageo
12	2	D1 D2	600 V, 1 A, Rectifier, Glass Passivated, POWERDI123	DFLR1600-7	Diodes, Inc.
13	1	D4	60 V, 1 A, Schottky, DO-214AC	SS16-E3/61T	Vishay
14	3	D6 D7 D9	250 V, 0.2 A, Fast Switching, 50 ns, SOD-323	BAV21WS-7-F	Diodes, Inc.
15	2	D8 D10	200 V, 1 A, Diode Schottky 1 A 200 V PWRDI 123	DFLS1200-7	Diodes, Inc.
16	1	F1	Fuse, Pico, 2 A, 250V, Fast, Axial	0263002.MXL	Littlefuse Inc.
17	1	HS1	Heat sink, Custom, Al, 3003, 0.062" Thk (See Heat sink Spec)		Custom
18	2	L N	Test Point, BLK, Miniature THRU-HOLE MOUNT	5001	Keystone
19	3	L1 L2 L3	1 mH, 0.23 A, Ferrite Core	CTSCH875DF-102K	CT Parts
20	2	Q1 Q3	NPN, Small Signal BJT, 450 V, 0.5 A, 150MA ,SOT-23	FMMT459TA	Diodes, Inc.
21	2	Q4 Q5	NPN,60 V 1000 MA, SOT-23	FMMT491TA	Zetex Inc
22	1	Q6	450 V, 0.6 A, 3.8 Ohms, N-Channel, TO-92	STQ3N45K3-AP	ST Micro
23	3	R1 R2 R3	10 k□, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ103V	Panasonic
24	1	R6	100 k□, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ104V	Panasonic
25	1	R7	180 k□, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ184V	Panasonic
26	1	R8	130 □, 5%, 1 W, Metal Oxide	RSF100JB-130R	Yageo
27	1	R9	510 k□, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ514V	Panasonic
28	2	R10 R29	1 M□, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF1004V	Panasonic
29	1	R14	24.9 k□, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF2492V	Panasonic
30	1	R15	182 k□, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF1823V	Panasonic
31	1	R16	100 □, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ101V	Panasonic
32	1	R18	4.7 k□, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ472V	Panasonic
33	1	R19	47 k□, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ473V	Panasonic
34	2	R20 R24	1 M□, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ105V	Panasonic
35	1	R21	100 k□, 5%, 1/10 W, Thick Film, 0603	ERJ-3GEYJ104V	Panasonic
36	1	R22	1 k□, 5%, 1 W, Thick Film, 2512	ERJ-1TYJ102U	Panasonic
37	1	R23	470 k□, 5%, 1/4 W, Thick Film, 1206	ERJ-8GEYJ474V	Panasonic
38	1	R25	698 k□, 1%, 1/8 W, Thick Film, 0805	ERJ-6ENF6983V	Panasonic
39	1	R27	240 k□, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ244V	Panasonic
40	1	R30	1.50 M□, 1%, 1/16 W, Thick Film, 0603	ERJ-3EKF1504V	Panasonic
41	1	R32	750 k□, 5%, 1/8 W, Thick Film, 0805	ERJ-6GEYJ754V	Panasonic

42	1	T1	See Inductor Spec	SNX-R1687 TSD-3200	Santronics USA Premier Magnetics
43	1	U1	LYTSwitch, eSIP-7C	LYT4313E	Power Integrations
44	1	VR1	15 V, 5%, 150 mW, SSMINI-2	DZ2S15000L	Panasonic

6.2 散熱片組裝物料表

Item	Qty	Description
1	1	HEAT SINK, AL-3003, DER364,PI CUSTOM
2	1	RIVET, Al, 0.93 DIA x 0.187 C'sunk
3	1	POST, HEAT SINK, SS, Nickel Plated, 5 mm W x 9.1 mm L
4	1	THERMAL GREASE, SILICONE, 5 OZ TUBE
5	1	EDGE-CLIP-12.33 mm L x 6.35 mm W
6	1	HEAT SHRINK 3/16 IN X 4 FT BLACK
7	1	WASHER, LOCK, #4 SS
8	1	NUT, HEX 4-40, SS
9	1	SCREW PHIL FLAT, HEAD, UNDERCUT 4-40 X .250 (1-4) SST

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7 電感器規格

7.1 電氣圖

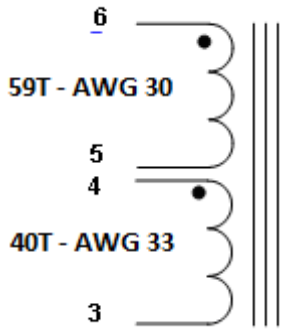

Figure 7 – Inductor Electrical Diagram.

7.2 電氣規格

Primary Inductance	Pins 5-6 all other windings open, measured at 132 kHz, 0.4 $V_{RMS.}$	380 □H ±2%
Resonant Frequency	Pins 5-6, all other windings open.	2.1 MHz (Min.)

7.3 材料

Item	Description
[1]	Core: RM5/I-3F3 or equivalent.
[2]	Bobbin: B-RM5-V 6 pins 3/3.
[3]	Magnet Wire, #30 AWG, solderable double coated.
[4]	Magnet Wire, #33 AWG, solderable double coated.
[5]	Tape: 3M 1298 Polyester Film, 4.8 mm wide, 2.0 mil thick, or equivalent.
[6]	Varnish: Dolph BC-359, or equivalent.
[7]	CLI/P-RM4/5 or equivalent.

7.4 電感構建圖

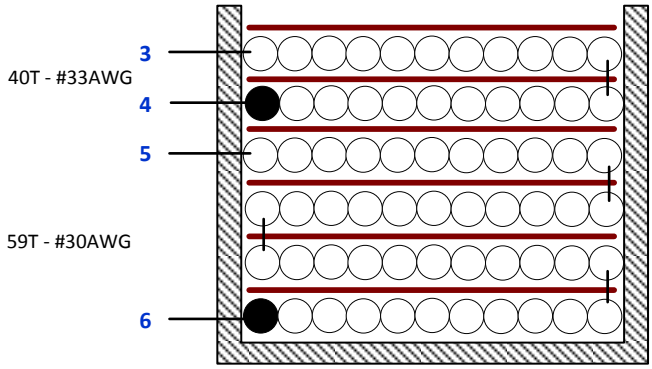

Figure 8 – Inductor Build Diagram.

7.5 電感結構

General Note	For the purpose of these instructions, bobbin is oriented on winder such that pin 1 side is on the left.
WD1	Start at pin 6. Wind 59 turns of item [3] as shown in Figure 8. Put 1 layer of tape item [5] every layer. Terminate at pin 5.
WD2	Start at pin 4. Wind 40 turns of item [4]. Put 1 layer of tape item [5] every layer. Terminate the other end at pin 3.
Insulation	Place 2 layers of tape item [5] to secure windings.
Finish	Grind the core to get the specified inductance. Secure with clip item [7]. Varnish with item [6]. Cut pin 1 and pin 2 of the bobbin. Cut transformer clip pin near pin 5 and 6. Refer to Figure 9.

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7.6 附錄

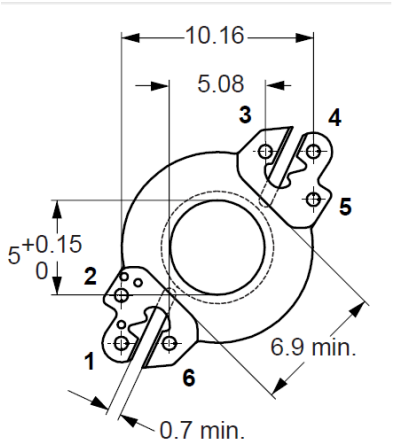

Figure 9 – Bottom View, Transformer Pin Illustration.

Figure 10 – Sample Choke Illustration for Bottom Actual View.

8 變壓器設計試算表

ACDC_LYTSwitch_Buck_010913; Rev.0.8; Copyright Power Integrations 2012	INPUT	INFO	OUTPUT	UNIT	ACADC_LYTSwitch_010913: LYTSwitch Buck Design Spreadsheet
ENTER APPLICATION VARIABLES					
Dimming required	NO		NO		Select "YES" option if dimming is required. Otherwise select "NO".
VACMIN	90		90	V	Minimum AC Input Voltage
VACMAX	132		132	V	Maximum AC input voltage
fL			50	Hz	AC Mains Frequency
VO	41			V	Typical output voltage of LED string at full load
VO_MAX			51.25	V	Maximum LED string Voltage. Ensure that the maximum LED string voltage is below VO_MAX
VO_MIN			30.75	V	Minimum LED string Voltage. Ensure that the minimum LED string voltage is above VO_MIN
V_OVP			56.375	V	Overvoltage setpoint
IO	0.35				Typical full load LED current
PO			14.35	Watts	Output Power
n			0.85		Estimated efficiency of operation
ENTER LYTSwitch VARIABLES					
LYTSwitch	LYT4313				Selected LYTSwitch device. If Dimming is required, select device from LNK42XX family, Otherwise select device from LNK43XX family
Current Limit Mode	RED		RED		Select "RED" for reduced Current Limit mode or "FULL" for Full current limit mode
ILIMITMIN			1	A	Minimum current limit
ILIMITMAX			1.16	A	Maximum current limit
fS			132000	Hz	Switching Frequency
fSmin			124000	Hz	Minimum Switching Frequency
fSmax			140000	Hz	Maximum Switching Frequency
IV			79.8173	uA	V pin current
Rv			2	M-ohms	Upper V pin resistor
VB			25	V	Bias winding voltage
IFB			155.959	uA	FB pin current (75 uA < IFB < 250 uA)
RFB				k-ohms	FB pin resistor (assuming Bias winding feedback)
VDS			10	V	LYTSwitch on-state Drain to Source Voltage
VD	0.6			V	Output Winding Diode Forward Voltage Drop
VDB	0.7			V	Bias Winding Diode Forward Voltage Drop
Key Design Parameters					
KP			0.5		Ripple to Peak Current Ratio (0.4 < KRP < 1.3)
LP			378.185	uH	Primary Inductance
KP Expected			0.78636		Ripple to Peak Current Ratio (0.4 < KRP < 1.3)
Expected IO (average)			0.35006	A	Expected Average Output Current
ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Core Type	RM5		RM5		Selected Core for inductor
Core		#N/A		P/N:	#N/A
Bobbin		#N/A		P/N:	#N/A
AE	0.25		0.25	cm^2	Core Effective Cross Sectional Area
LE	2.32		2.32	cm	Core Effective Path Length

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AL	1700		1700	nH/T^2	Ungapped Core Effective Inductance
BW	4.7		4.7	mm	Bobbin Physical Winding Width
M			0	mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L			4		Number of Primary Layers
DC INPUT VOLTAGE PARAMETERS					
VMIN			127.279	V	Peak input voltage at VACMIN
VMAX			186.676	V	Peak input voltage at VACMAX
CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			0.32213		Minimum duty cycle at peak of VACMIN
IAVG			0.35006	A	Average input Current
IP			0.88437	A	Peak Current (calculated at minimum input voltage VACMIN)
IP_VMAX			1.01736	A	Peak Current (calculated at maximum input voltage VACMAX)
INDUCTOR PRIMARY DESIGN PARAMETERS					
LP			378.185	uH	Primary Inductance
NP	59		59		Primary Winding Number of Turns
ALG			108.643	nH/T^2	Gapped Core Effective Inductance
BM			2608.46	Gauss	Maximum Flux Density at PO, VMIN (BM<3000)
BP			3421.42	Gauss	Peak Flux Density (BP<4200)
BAC			652.116	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur			1255.41		Relative Permeability of Ungapped Core
LG			0.27069	mm	Gap Length (Lg > 0.1 mm)
BWE			18.8	mm	Effective Bobbin Width
OD			0.31864	mm	Maximum Primary Wire Diameter including insulation
INS			0.0539	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA			0.26475	mm	Bare conductor diameter
AWG			30	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM			101.594	Cmils	Bare conductor effective area in circular mils
CMA			290.216	Cmils/Amp	Primary Winding Current Capacity (200 < CMA < 500)

9 U1 散熱片組裝

9.1 U1 散熱片製造圖

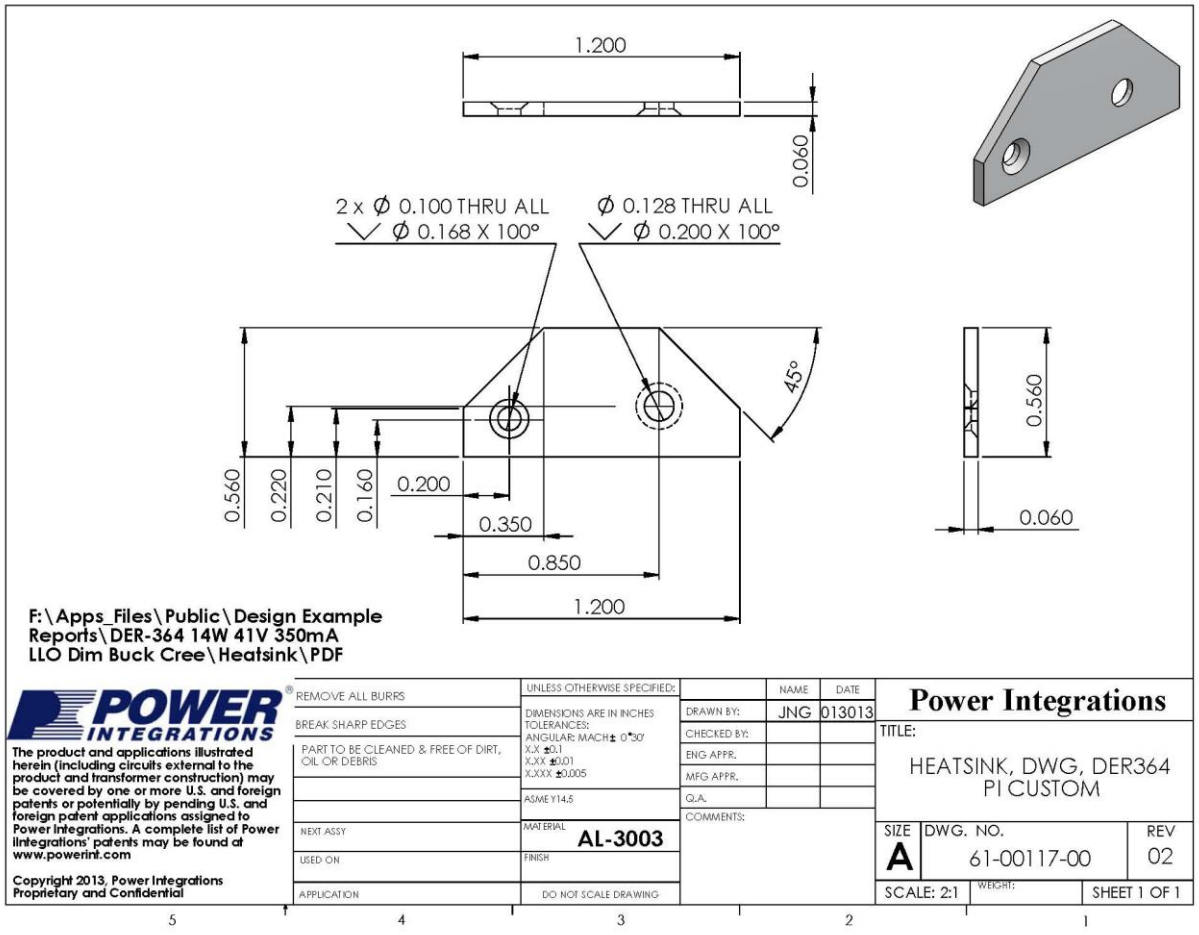

Figure 11 – Heat Sink Fabrication Drawing.

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9.2 U1 散熱片組裝圖

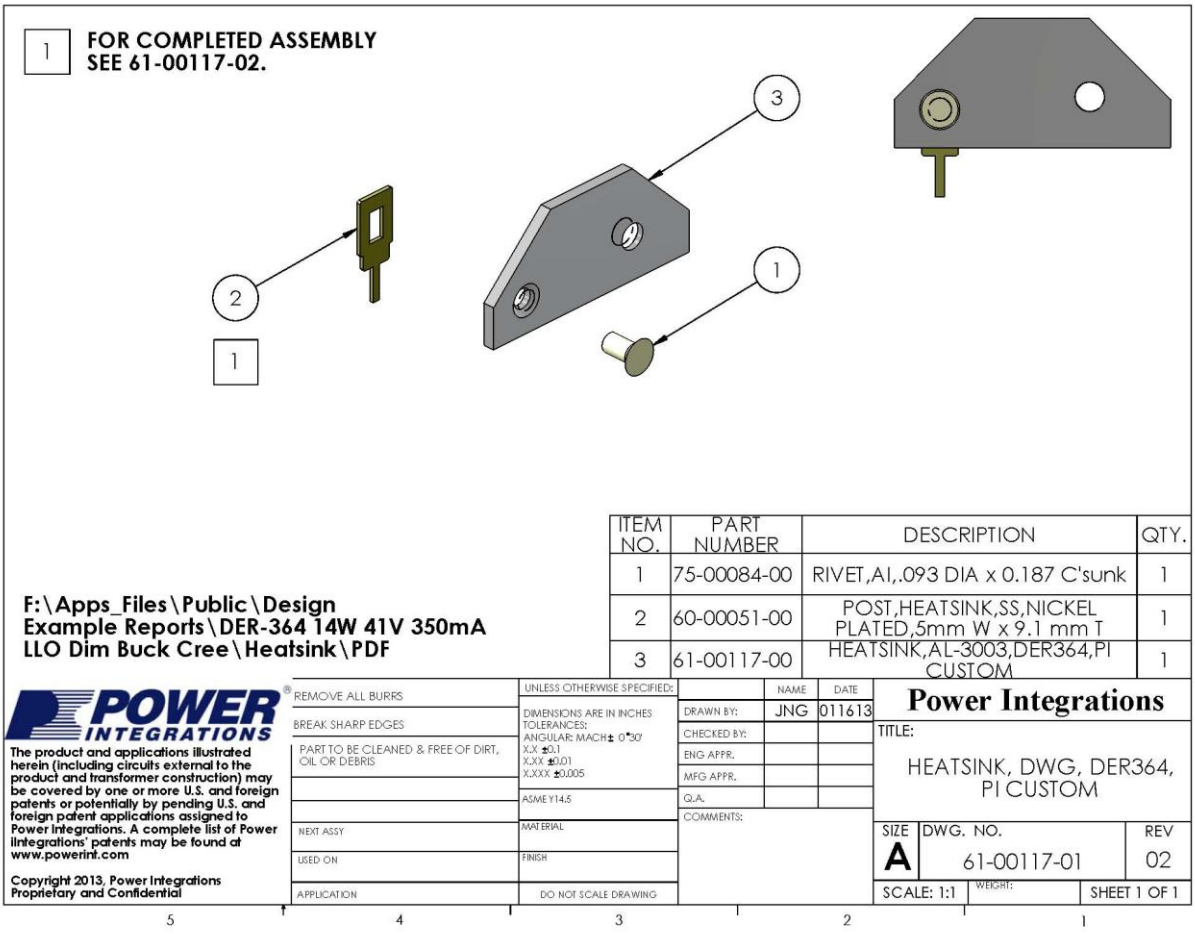

Figure 12 – U1 Heat Sink Assembly Drawing.

9.3 U1 和散熱片組裝圖

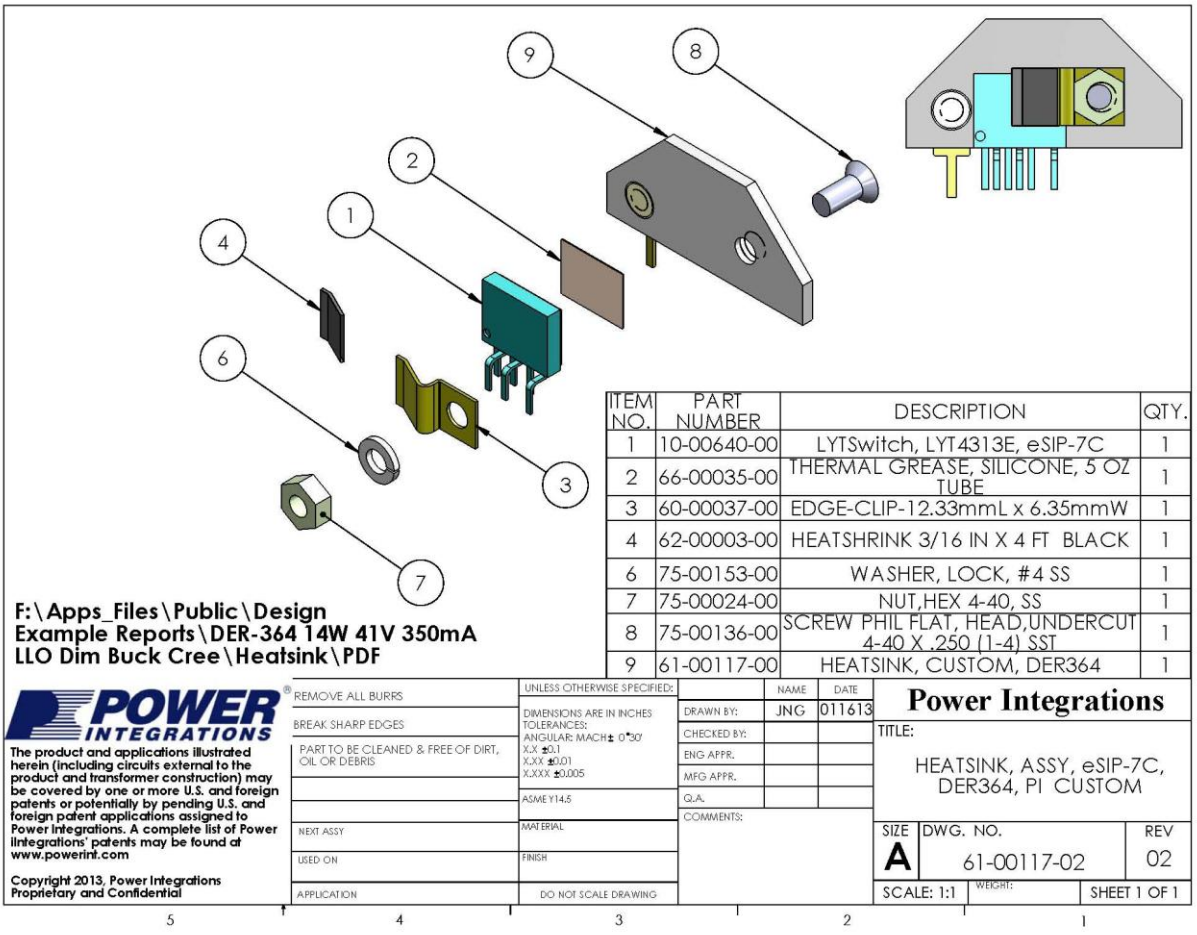

Figure 13 – U1 and Heat Sink Assembly Drawing.

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10 效能資料

All measurements performed at room temperature using an LED e-load. The table in Section 10.6 shows complete test data values.

10.1 效率

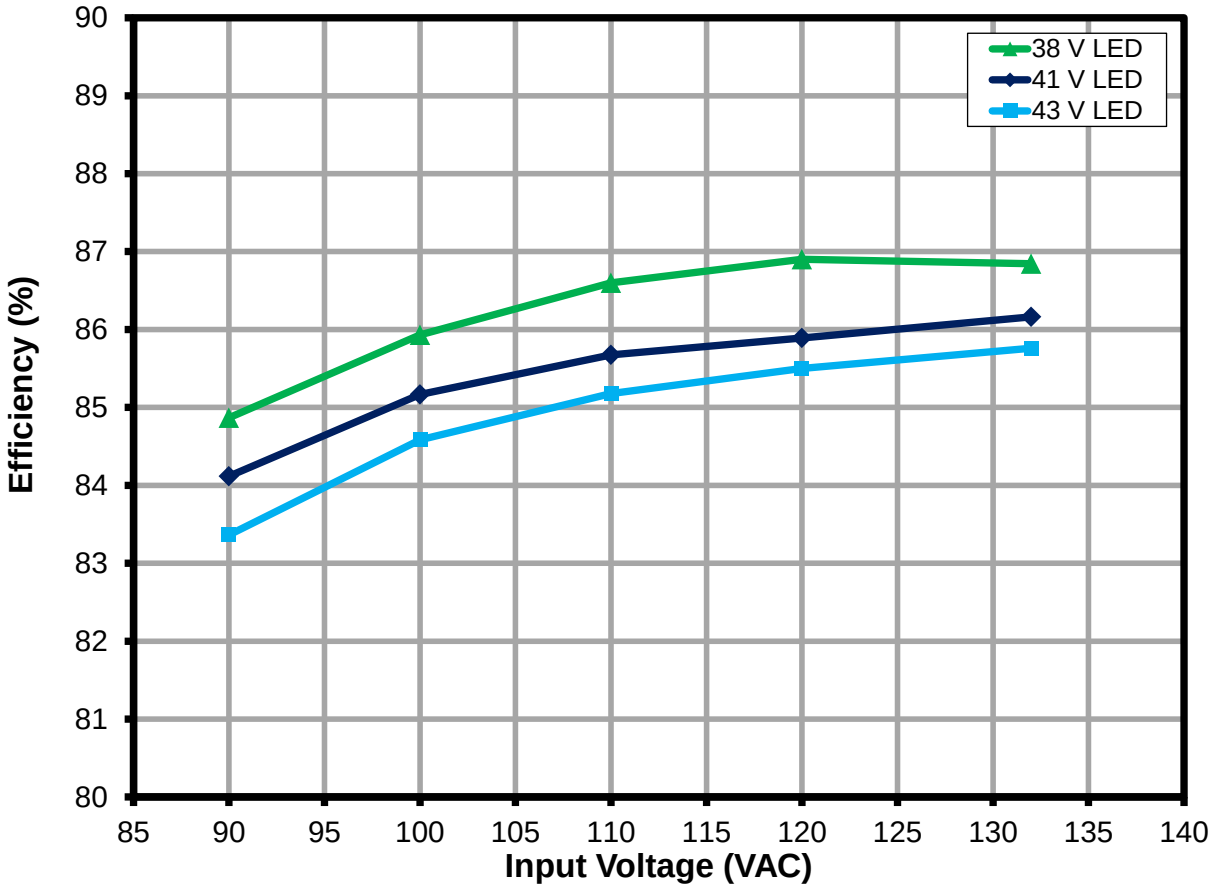

Figure 14 – Efficiency vs. Line.

10.2 線電壓與負載穩定度關係圖

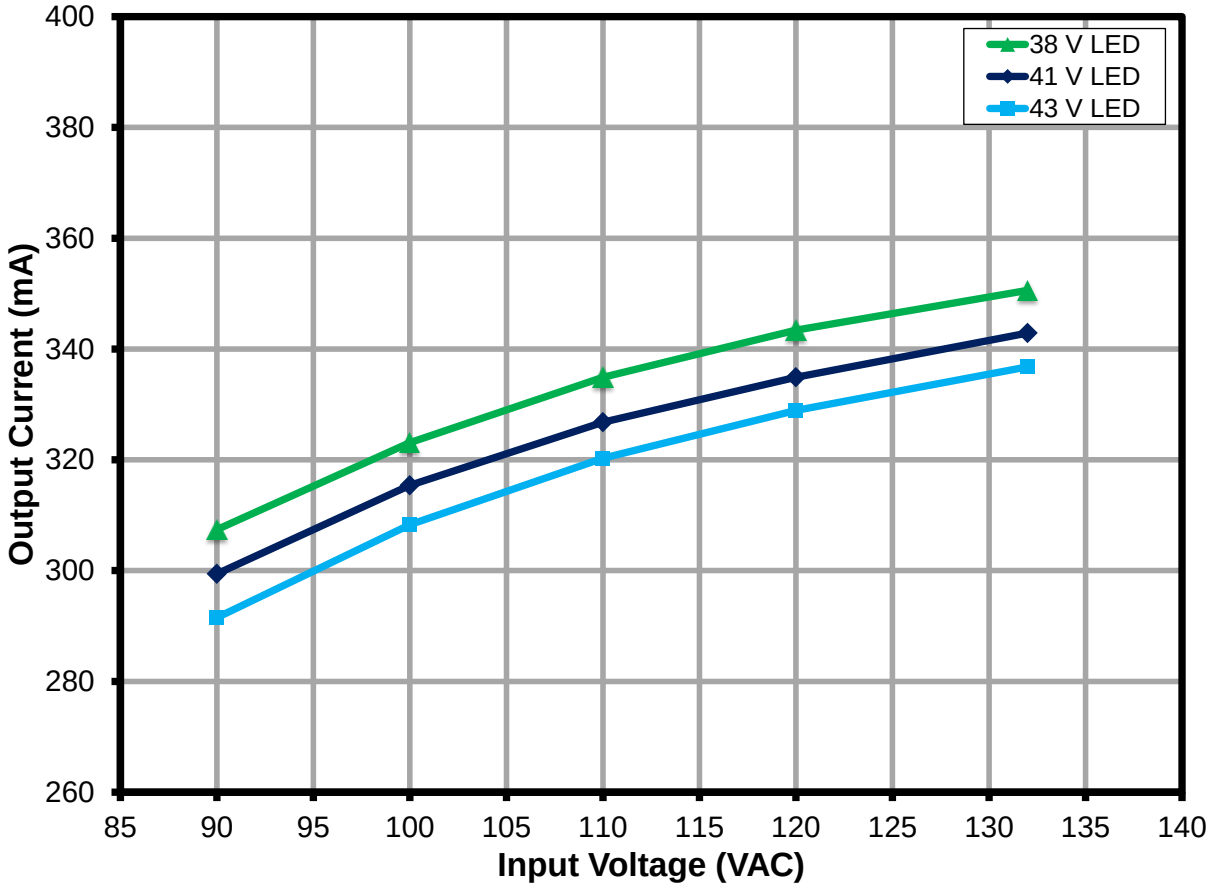

Figure 15 – Regulation vs. Line and Load.

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10.3 功率因數

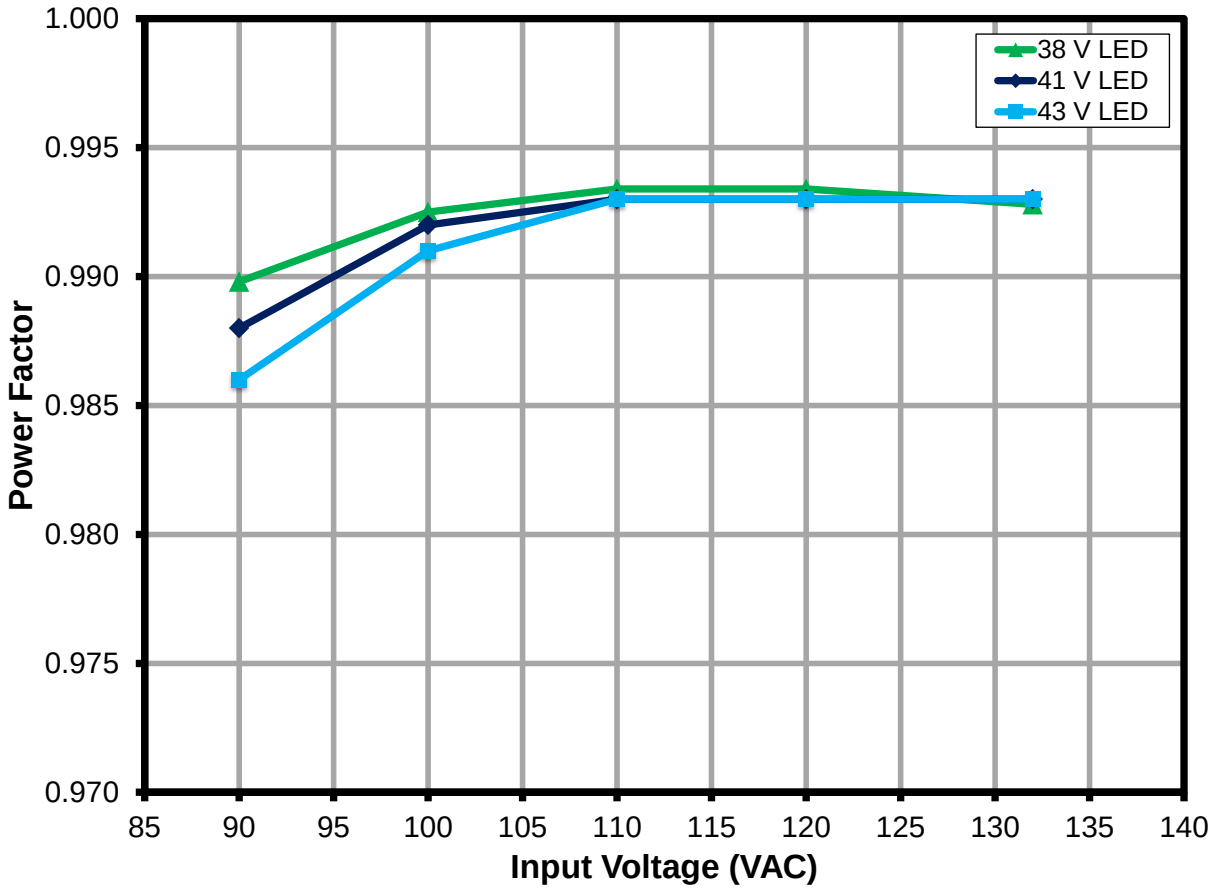

Figure 16 – Power Factor vs. Line and Load.

10.4 A-THD

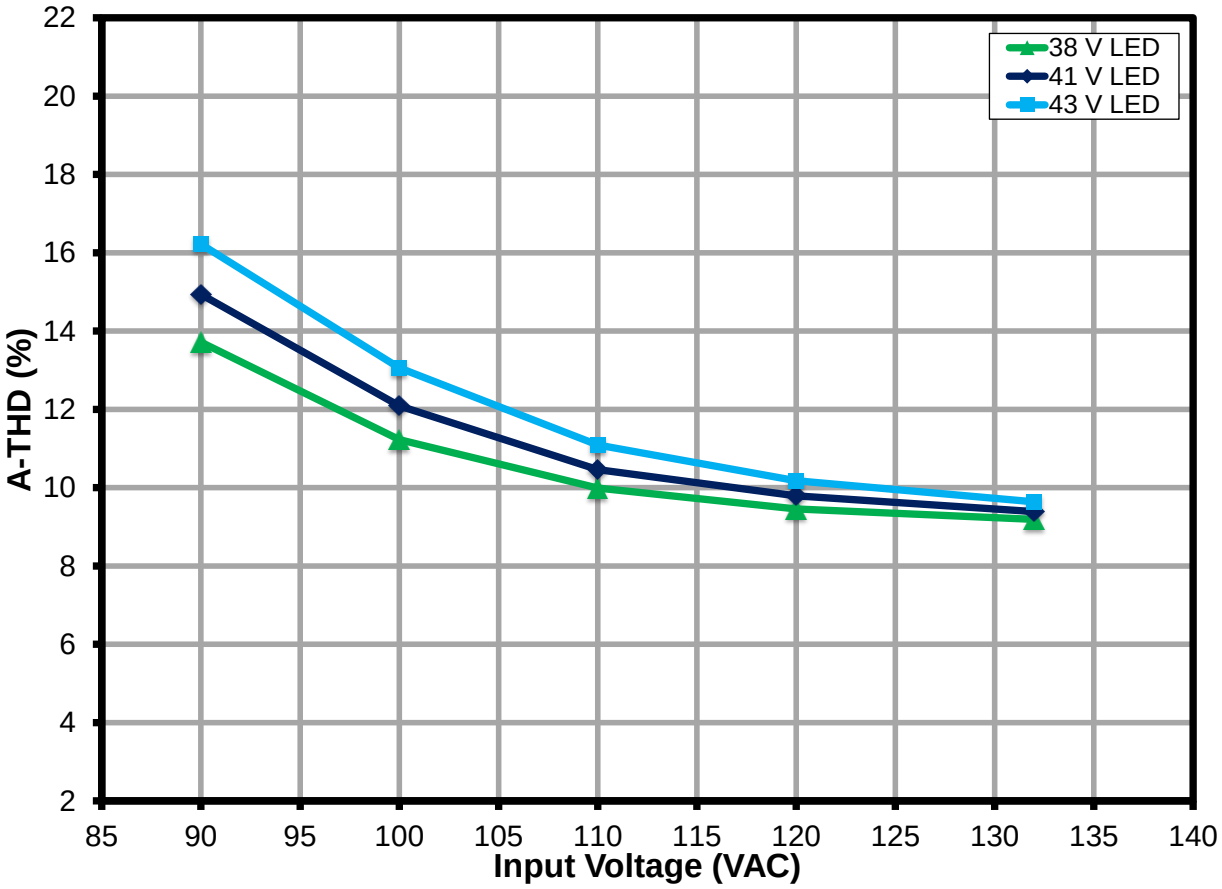

Figure 17 – A-THD vs. Line and Load.

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10.5 諧波電流

The design met the IEC61000-3-2 Limits for Class C equipment (section 7.3-a) for an active input power of <25 W, which states that the harmonic currents shall not exceed the related limits given in Table 2 - Limits for Class C equipment.

10.5.1 38 V LED 負載

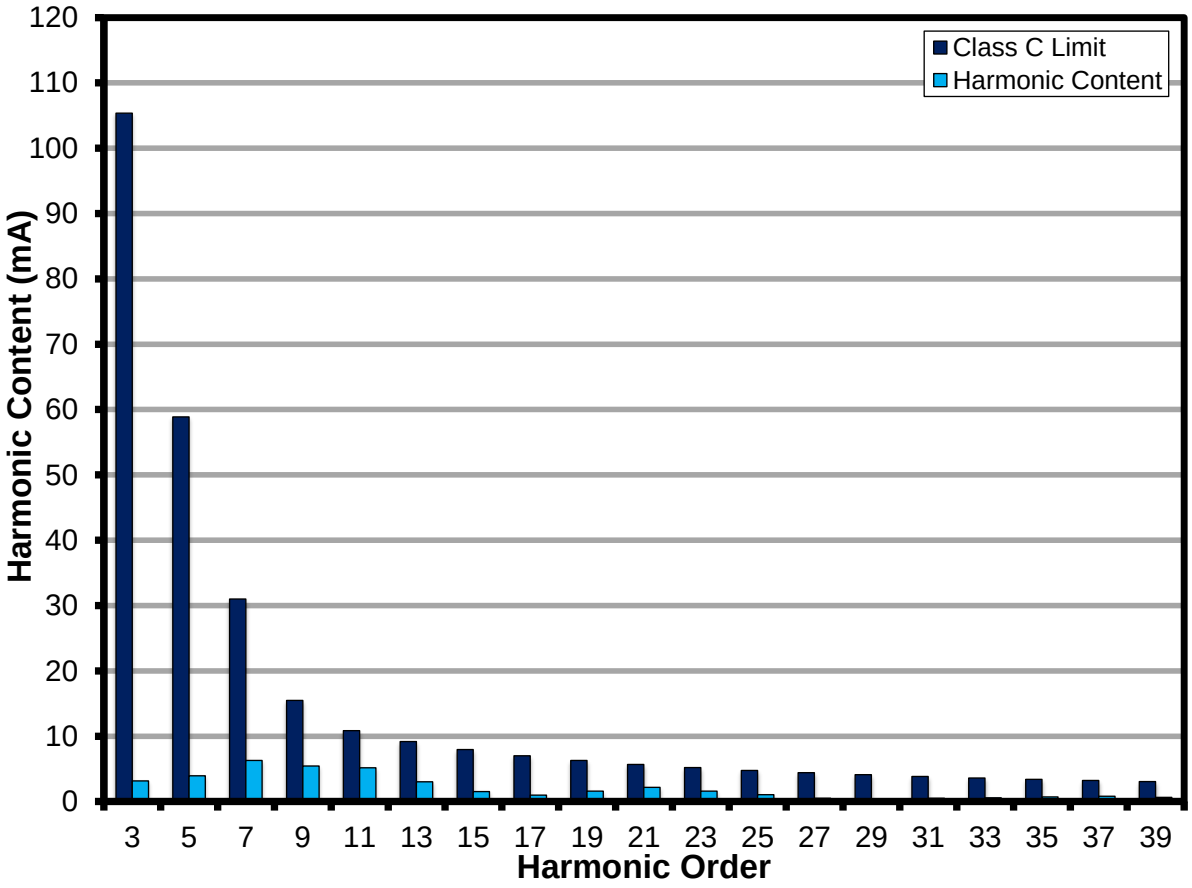

Figure 18 – 38 V LED Load Input Current Harmonics (IEC61000-3-2) at 120 VAC, 60 Hz.

10.5.2 41 V LED 負載

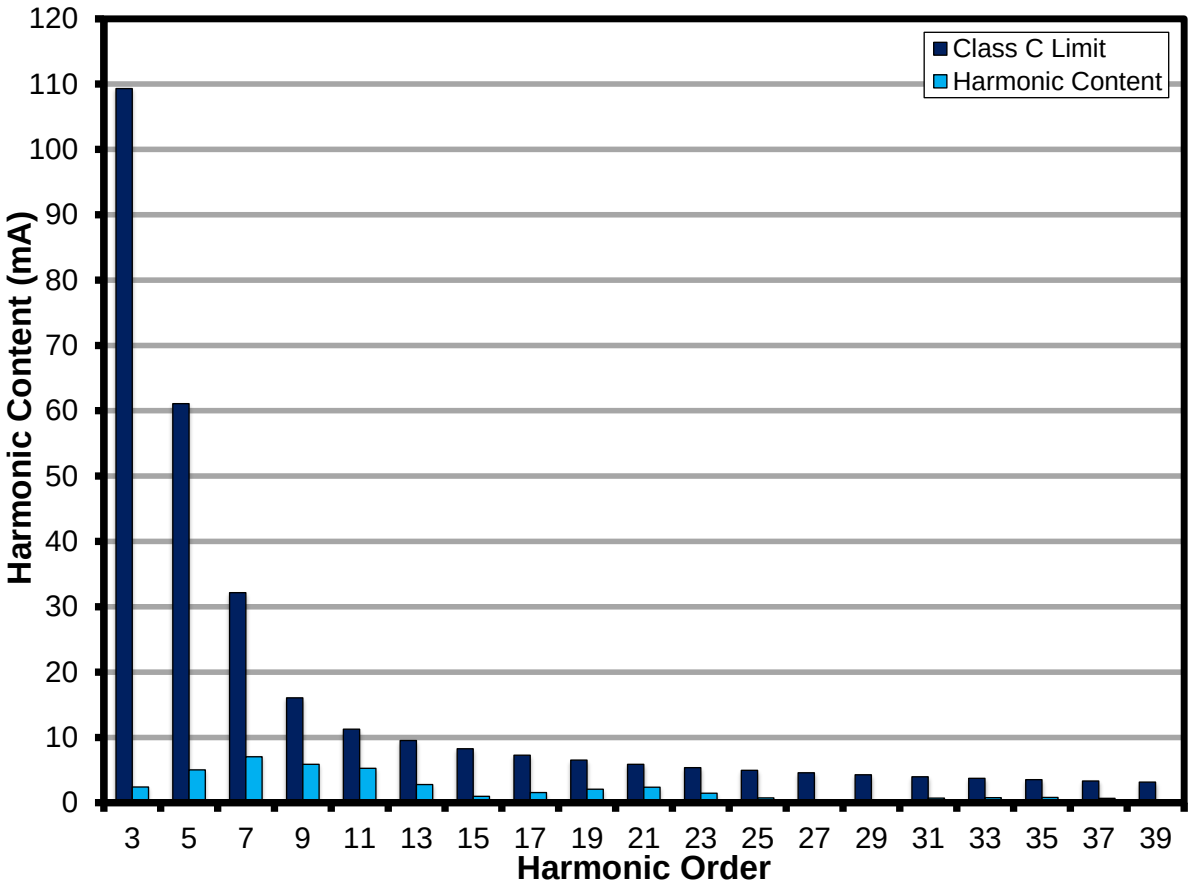

Figure 19 – 41 V LED Load Input Current Harmonics Case (IEC61000-3-2) at 120 VAC, 60 Hz.

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10.5.3 43 V LED 負載

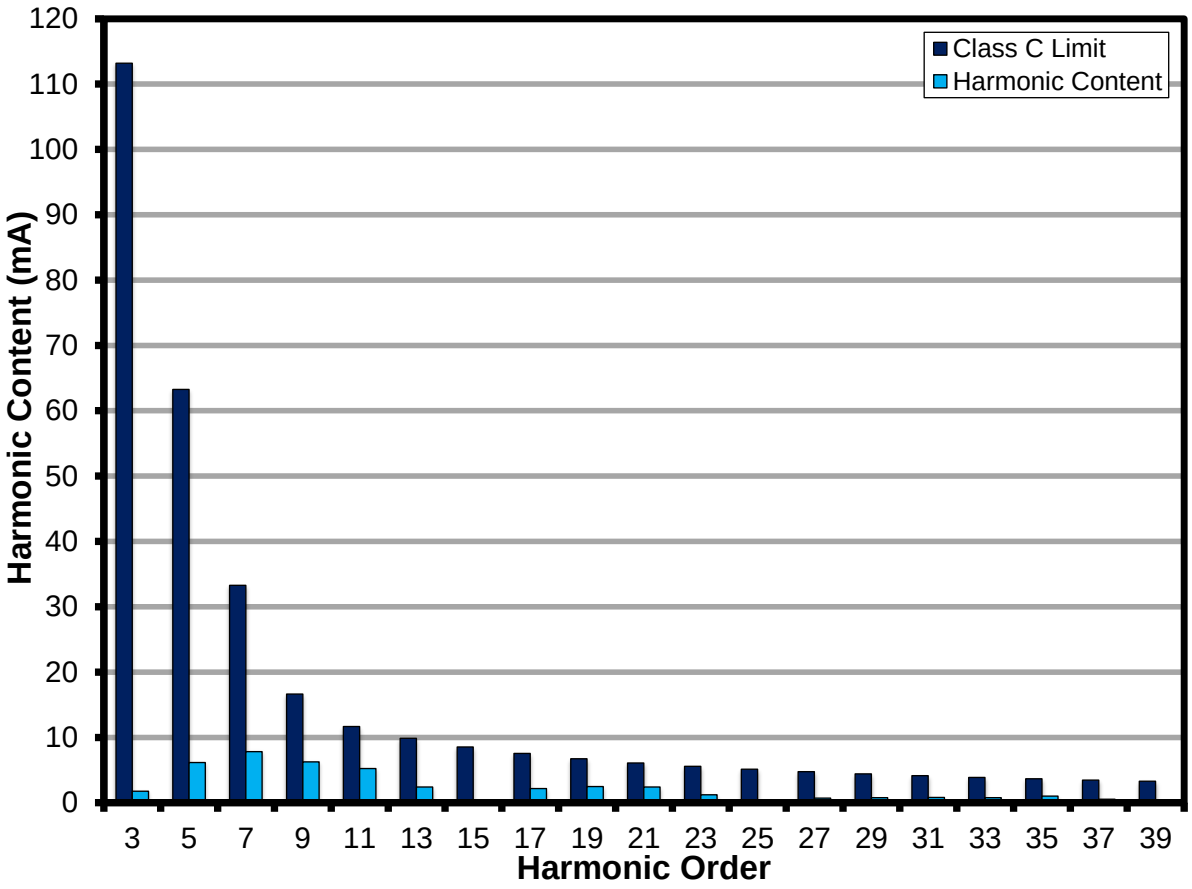

Figure 20 – 43 V LED Load Input Current Harmonics (IEC61000-3-2) at 120 VAC, 60 Hz.

10.6 測試資料

All measurements were taken with the board at open frame, 25 °C ambient, and 60 Hz line frequency.

10.6.1 測試資料，38 V LED 負載

Input		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 (%)
90	60	90.09	158.51	14.135	0.990	13.72	38.9740	307.400	11.996	84.87
100	60	100.12	147.98	14.705	0.993	11.23	39.0610	323.100	12.636	85.93
110	60	110.15	138.44	15.149	0.993	9.99	39.1250	334.900	13.119	86.60
120	60	120.15	129.84	15.497	0.993	9.46	39.1710	343.400	13.467	86.90
132	60	132.16	120.79	15.849	0.993	9.19	39.2130	350.600	13.764	86.84

10.6.2 測試資料，41 V LED 負載

Input		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 (%)
90	60	90.09	164.06	14.605	0.988	14.94	40.9800	299.400	12.285	84.12
100	60	100.11	153.38	15.228	0.992	12.09	41.0720	315.400	12.969	85.17
110	60	110.15	143.63	15.712	0.993	10.46	41.1380	326.800	13.461	85.67
120	60	120.16	134.68	16.076	0.993	9.79	41.1870	334.900	13.808	85.89
132	60	132.19	125.16	16.427	0.993	9.39	41.2320	342.900	14.154	86.16

10.6.3 測試資料，43 V LED 負載

Input		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 (%)
90	60	90.10	169.38	15.050	0.986	16.22	42.9910	291.500	12.546	83.36
100	60	100.11	158.57	15.725	0.991	13.06	43.0960	308.300	13.301	84.59
110	60	110.12	148.68	16.252	0.993	11.09	43.1690	320.300	13.843	85.18
120	60	120.15	139.52	16.647	0.993	10.18	43.2220	328.900	14.233	85.50
132	60	132.19	129.60	17.010	0.993	9.64	43.2700	336.800	14.588	85.76

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10.6.4 120 VAC 60 Hz，33 V LED 負載諧波資料

Current Harmonics Limits for IEC61000-3-2

V	Freq	I (mA)	P	PF	%THD
120	60	129.84	15.497	0.993	9.46
nth Order	**mA Content**	**% Content**	**Limit <25 W**	**Limit >25 W**	**Remarks**
1	128.96				
2	0.03	0.02%		2.00%	
3	3.16	2.45%	105.3796	29.80%	Pass
5	3.96	3.07%	58.8886	10.00%	Pass
7	6.28	4.87%	30.9940	7.00%	Pass
9	5.43	4.21%	15.4970	5.00%	Pass
11	5.16	4.00%	10.8479	3.00%	Pass
13	3.04	2.36%	9.1790	3.00%	Pass
15	1.54	1.19%	7.9551	3.00%	Pass
17	0.99	0.77%	7.0192	3.00%	Pass
19	1.58	1.23%	6.2804	3.00%	Pass
21	2.18	1.69%	5.6822	3.00%	Pass
23	1.58	1.23%	5.1881	3.00%	Pass
25	1.04	0.81%	4.7731	3.00%	Pass
27	0.52	0.40%	4.4195	3.00%	Pass
29	0.20	0.16%	4.1147	3.00%	Pass
31	0.49	0.38%	3.8493	3.00%	Pass
33	0.59	0.46%	3.6160	3.00%	Pass
35	0.72	0.56%	3.4093	3.00%	Pass
37	0.81	0.63%	3.2251	3.00%	Pass
39	0.65	0.50%	3.0597	3.00%	Pass

10.6.5 120 VAC 60 Hz，41 V LED 負載諧波資料

Current Harmonics Limits for IEC61000-3-2

V	Freq	I (mA)	P	PF	%THD
120	60	134.68	16.0760	0.9933	9.79
nth Order	**mA Content**	**% Content**	**Limit <25 W**	**Limit >25 W**	**Remarks**
1	133.75				
2	0.04	0.03%		2.00%	
3	2.42	1.81%	109.3168	29.80%	Pass
5	5.02	3.75%	61.0888	10.00%	Pass
7	7.05	5.27%	32.1520	7.00%	Pass
9	5.88	4.40%	16.0760	5.00%	Pass
11	5.28	3.95%	11.2532	3.00%	Pass
13	2.78	2.08%	9.5219	3.00%	Pass
15	0.99	0.74%	8.2523	3.00%	Pass
17	1.55	1.16%	7.2815	3.00%	Pass
19	2.07	1.55%	6.5150	3.00%	Pass
21	2.39	1.79%	5.8945	3.00%	Pass
23	1.47	1.10%	5.3820	3.00%	Pass
25	0.74	0.55%	4.9514	3.00%	Pass
27	0.46	0.34%	4.5846	3.00%	Pass
29	0.45	0.34%	4.2685	3.00%	Pass
31	0.70	0.52%	3.9931	3.00%	Pass
33	0.77	0.58%	3.7511	3.00%	Pass
35	0.81	0.61%	3.5367	3.00%	Pass
37	0.69	0.52%	3.3455	3.00%	Pass
39	0.34	0.25%	3.1740	3.00%	Pass

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10.6.6 120 VAC 60 Hz，43 V LED 負載諧波資料

Current Harmonics Limits for IEC61000-3-2

V	Freq	I (mA)	P	PF	%THD
120	60	139.52	16.6470	0.9931	10.18
nth Order	**mA Content**	**% Content**	**Limit <25 W**	**Limit >25 W**	**Remarks**
1	138.46				
2	0.03	0.02%		2.00%	
3	1.77	1.28%	113.1996	29.79%	Pass
5	6.17	4.46%	63.2586	10.00%	Pass
7	7.82	5.65%	33.2940	7.00%	Pass
9	6.27	4.53%	16.6470	5.00%	Pass
11	5.25	3.79%	11.6529	3.00%	Pass
13	2.41	1.74%	9.8601	3.00%	Pass
15	0.41	0.30%	8.5455	3.00%	Pass
17	2.16	1.56%	7.5401	3.00%	Pass
19	2.48	1.79%	6.7464	3.00%	Pass
21	2.40	1.73%	6.1039	3.00%	Pass
23	1.23	0.89%	5.5731	3.00%	Pass
25	0.36	0.26%	5.1273	3.00%	Pass
27	0.71	0.51%	4.7475	3.00%	Pass
29	0.77	0.56%	4.4201	3.00%	Pass
31	0.81	0.59%	4.1349	3.00%	Pass
33	0.77	0.56%	3.8843	3.00%	Pass
35	1.00	0.72%	3.6623	3.00%	Pass
37	0.55	0.40%	3.4644	3.00%	Pass
39	0.20	0.14%	3.2867	3.00%	Pass

11 調光效能資料

TRIAC dimming results were taken at an input voltage of 120 VAC, 60 Hz line frequency, room temperature, and a nominal 41 V LED load.

The output current High Limit I_{OUT} (HL) and Low Limit I_{OUT} (LL) were incorporated based on the USA NEMA publication SSL6-2010 section 4 page 9 for dimming performance system requirements for reference. The standard however refers to 120 VAC operating input voltage and pertains to the limits as relative light output. The limits incorporated on the succeeding graphs assumes that 100% relative light output falls on the maximum operating output current of 360 mA and 0 mA as 0% light output, and input line of 120 VAC, 60 Hz.

11.1 使用模擬 (使用 Agilent 6812B 交流電源) 上升邊緣調光器的調光曲線

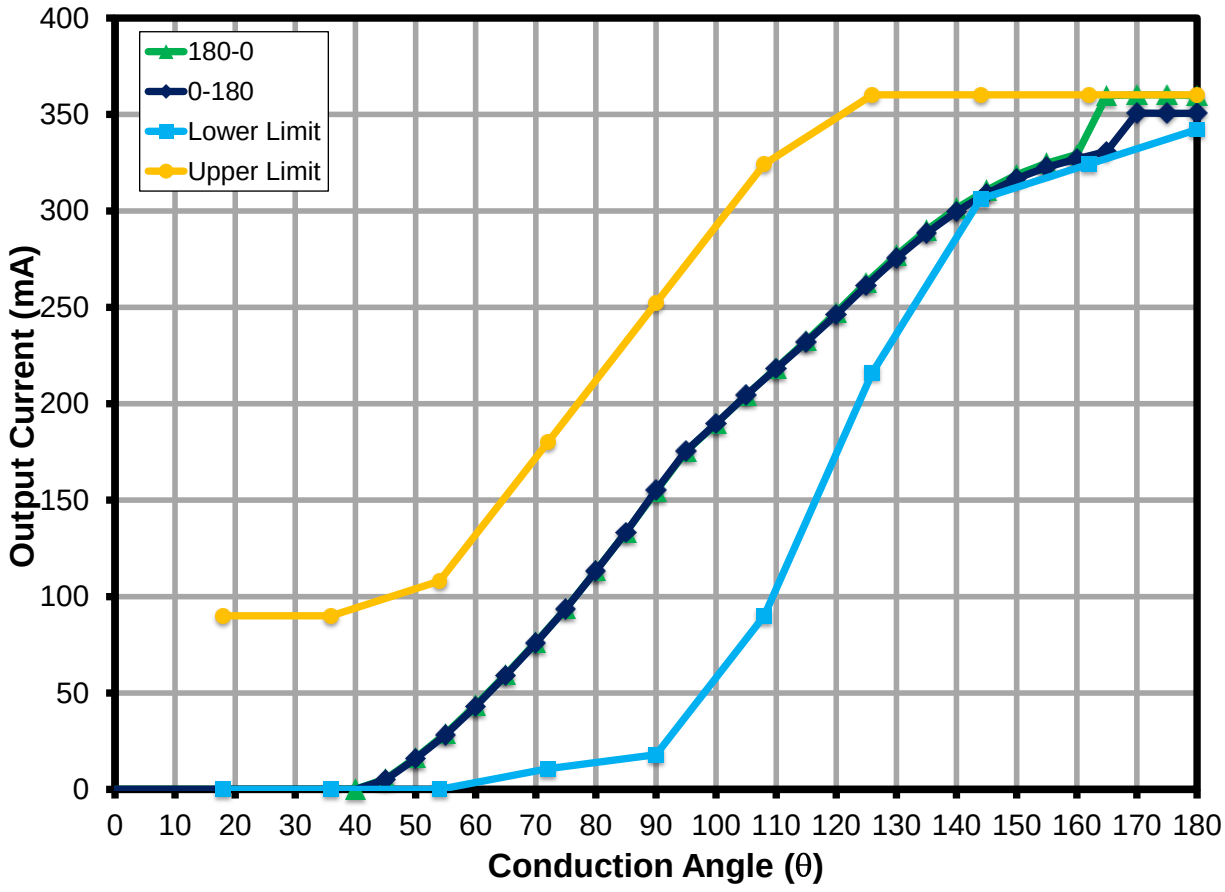

Figure 21 – Dimming Curve at 120 VAC, 60 Hz Input.

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11.2 使用以 TRIAC 爲基礎的調光器的快速啓動 (不到 200 ms)

Using a TRIAC-based U.S. dimmer model NT-600 (Lutron) with thumb-wheel adjust set to minimum turn-on (i.e. <30 degrees) which guarantees the LED driver is off when it is switched to ON position. The test was made by turning/sliding the dimmer knob as quickly as possible from minimum to maximum position then measuring the time from the point the dimmer started conducting to the point the output current started rising.

Input voltage: 120 VAC / 60 Hz

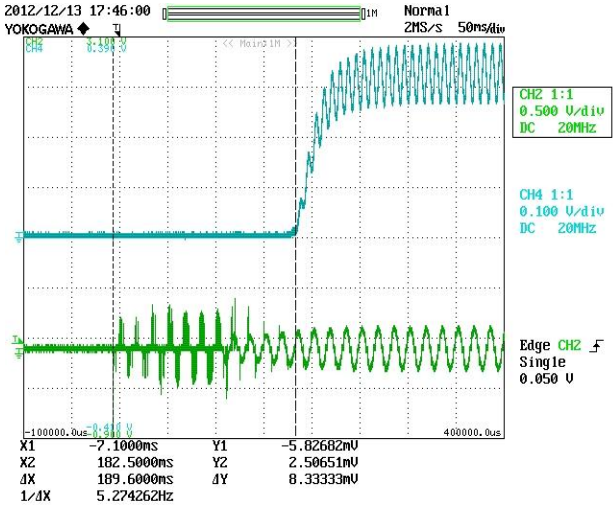

Figure 22 – Measured Start-up Time 189 ms.
Flicking the Switch ON, Dimmer at Full Conduction.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 500 mA, 50 ms / div.

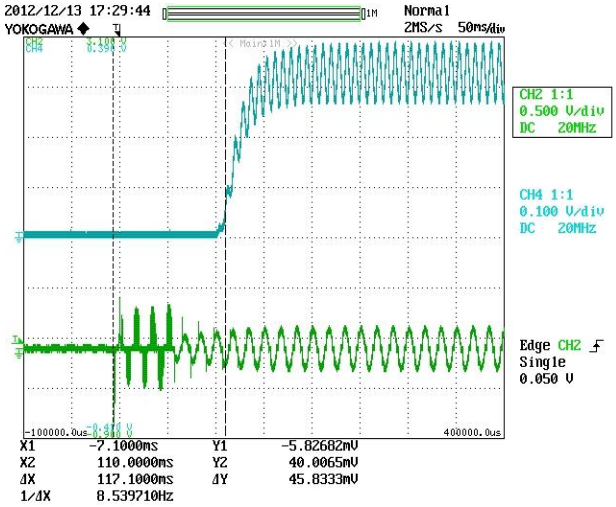

Figure 23 – Measured Start-up Time 117 ms.
Quickly Sliding the Knob from Minimum to Full Conduction.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 500 mA, 50 ms / div.

*11.3 使用以 **TRIAC** 爲基礎的調光器的驟開點*

Pop-on per NEMA SSL-6 definition is lowest dimmer setting above minimum at which the lamp transitions from off to dimmed.

This particular test was conducted using 120 V / 60 Hz TRIAC dimmer model NT-600 (LUTRON dimmer).

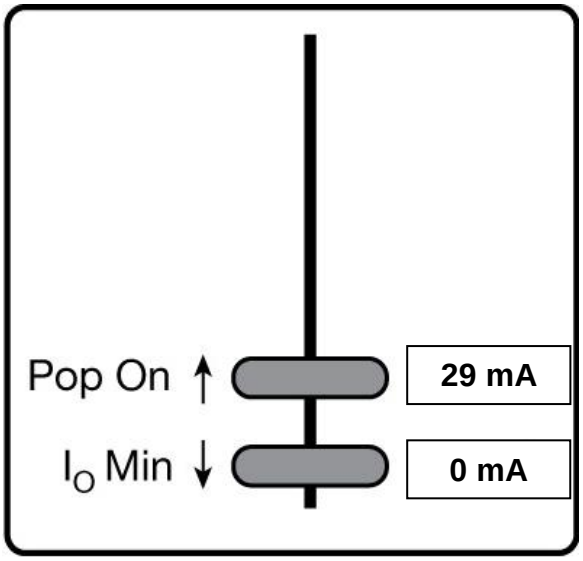

Figure 24 – 42º Conduction Angle was Measured at Pop-on Point.

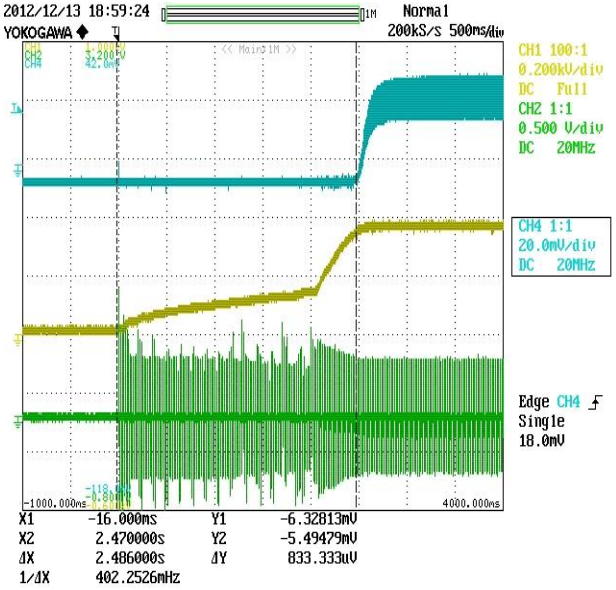

Figure 25 – 42º Conduction Angle at Pop-on Point.
Upper: I_{OUT}, 20 mA / div.
Middle: V_{OUT}, 200 V / div.
Lower: I_{IN}, 0.5 A / div., 500 ms / div.

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11.4 使用調光器的輸出電流和輸入電流波形

Input: 120 VAC, 60 Hz Utility Line
Output: 41 V LED Load
Dimmer: LUTRON NT-600

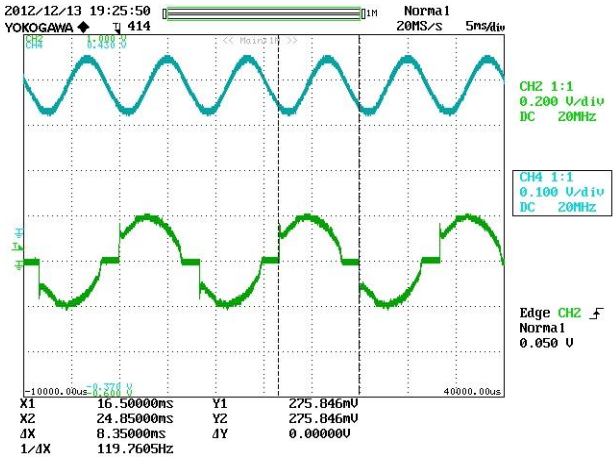

Figure 26 – 144º Conduction Angle.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 200 mA, 5 ms / div.

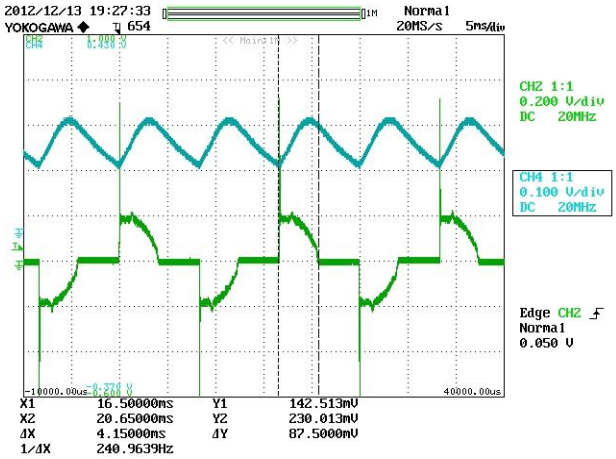

Figure 27 – 90º Conduction Angle.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 200 mA, 5 ms / div.

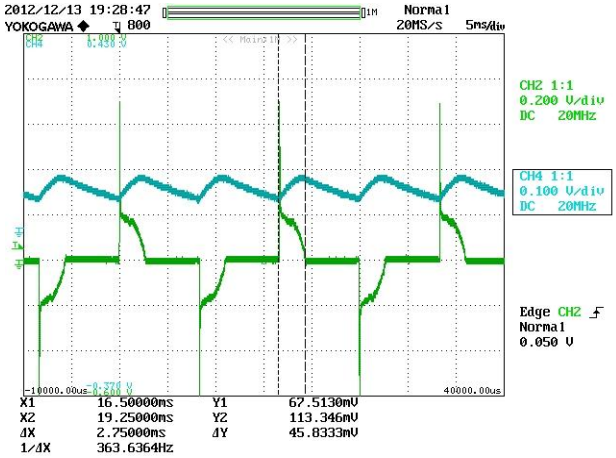

Figure 28 – 60º Conduction Angle.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 200 mA, 5 ms / div.

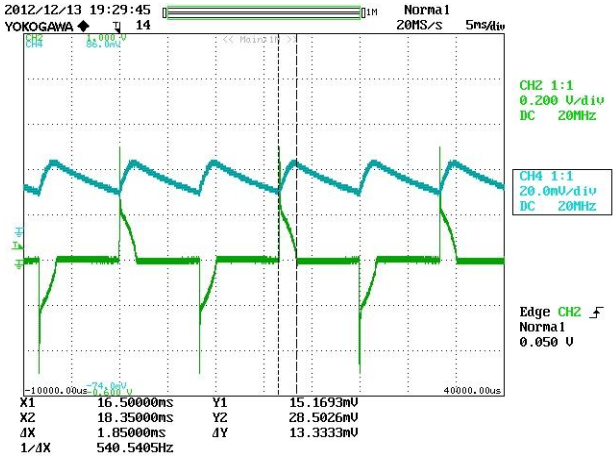

Figure 29 – 40º Conduction Angle.
Upper: I_{OUT}, 20 mA / div.
Lower: I_{IN}, 200 mA, 5 ms / div.

11.5 相容性清單

The following U.S. TRIAC-based dimmers were tested with programmable AC source (120 VAC, 60 Hz) and 41 V LED load.

Dimmer Brand	Type	Remarks	Power	Part Number	I_{MIN} (mA)	I_{MAX} (mA)	Dim Ratio
LUTRON	L	Lutron 600-Watt Slide Dimmer LG-600PH-LA	600W	LG-600PH-WH	0.1	277	2700
LUTRON	L	Lutron Skylark Incandescent 600W 3-Way Preset Dimmer with On/Off	600W	S-603P-WH	0.1	293	2930
LUTRON	T	Lutron SLV-600P-WH 600-Watt Skylark Magnetic Low-Voltage Single-Pole Dimmer	600W	SLV600P-WH	0.1	291	2910
LUTRON	L	Slide-to-Off Single Pole Skylark Dimmer Switch (RFI suppression)	600W	S-600-WH	0.1	318	3180
LUTRON	L	Lutron Skylark 5-Amp White Gloss Dimmer	600W	S-600PH-WH	0.1	296	2960
LUTRON	L	Cfl&led Dimmer, Paddle/slide, 120V, 600W	600W	DVWCL-153-PLH-WH	14	302	21
LUTRON	L	600W Diva Dimmer, 3-Way - Ivory	600W	DV-603P-WH	0.1	278	2780
LUTRON	L	Lutron Diva DV-600P-WH Incand 600 Watt Single Pole Light Dimmer in White	600W	DV-600P-WH	0.1	278	2780
LUTRON	L	Ivry Toggle Dimmer 1p Preset	600W	TG-600PH-WH	0.1	287	2870
LUTRON	T	Lutron Ariadni AY-600P-WH Incand Preset 600 Watt Single Pole Light Dimmer in White	600W	AY-600P-WH	15	305	20
LUTRON	L	Glyder Incandescent Single Pole 600 Watts Preset Dimmer, White	600W	GL-600P-WH	0.1	290	2900
LEVITON	L	SureSlide 600W Incandescent Dimmer	600W	R62-06633-1LW	0.1	325	3250
LEVITON	L	SureSlide 600W Incandescent Slide Dimmer, Single-Pol	600W	R62-06631-1LW	0.1	310	3100
LEVITON	L	IllumaTech Incandescent Preset Slide Dimmer	600W	R60-IPI06-1LM	62	326	5
LEVITON	Electronic	I 500 W, 120 VAC, Decora Brand Style 4 Level Dimmer	500W	R52-06161-00W	41	312	8
LEVITON	L	IllumaTech Rotary Controls 120V AC 60Hz	600W	R52-RPI06-1LW	0.1	334	3340
LEVITON	L	A Push On and Push Off Dimmer	600W	R60-06681-0LW	0.1	269	2690
LEVITON	L	Leviton 600-Watt 3-Way Lighted White/Ivory Push Dimmer	600W	R60-06684-1LW	0.1	354	3540
LEVITON			600W	6683	0.1	354	3540
LEVITON	L	SURESLIDE" MAGNETIC LOW VOLTAGE DIMMER *600VA, 120V AC, 60Hz	450W	R02-06613-PLW	0.1	322	3220
COOPER				SLC03P-W-K-L	0.1	302	3020
LUTRON	L	Lutron 15-Amp White Slide Dimmer	600W	GL-600-WH	0.1	317	3170
LUTRON	L	Diva, Screw Base Compact Fluorescent Dimming with Philips® DIMMABLE Energy Saver CFL, Single Pole/3-Way, 200W, White	200W	DVPDC-203P-WH	148	322	2
LUTRON	L	Lyneo Lx Single Pole Dimmer 600W	500W	LX-600PL-wh	31	312	10
LUTRON	L	Single Pole - Incandescent - Push On/Off - 600 Watt - White	600W	D-600P-WH	0.1	292	2920
LUTRON			600W	CTCL-153PDH	9	301	34
LUTRON			600W	S-600P	0.1	294	2940
LUTRON				TGLV-600P	0.1	292	2920
LUTRON			450W	TGLV-600PR	0.1	288	2880
LUTRON	L	Lutron Diva Satin 5-Amp Desert	300W	TT-300NLH-WH	0.1	316	3160

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		Stone Preset Dimmer					
LUTRON	L	Lutron Credenza 300-Watt White Lamp Dimmer	300W	TT-300H-WH	0.1	316	3160
LUTRON				S-600P	0.1	298	2980
LUTRON				S-600P	0.1	323	3230
COOPER				S106P	0.1	307	3070
LUTRON		Skylark, Dimmers with On/Off Switch, Incandescent/Halogen, 3-Way, 1000W, White	1000	S-103P-WH	55	315	5
LUTRON		Skylark, Dimmers with On/Off Switch, Incandescent/Halogen, Single Pole, 1000W, White	1000	S-10P-WH	35	312	9
LUTRON		Skylark, Dimmers with On/Off Switch & Locator Light, Incandescent/Halogen, Single Pole, 600W, White	600	S-600PNLH-WH	0.1	300	3000
LUTRON		Skylark, Dimmers with On/Off Switch & Locator Light, Incandescent/Halogen, 3-Way, 600W, White	600	S-603PNL-WH	0.1	300	3000
LUTRON		Skylark, Dimmers with On/Off Switch, Magnetic Low Voltage, 3-Way, 600VA, White	600	SLV-603P-WH	0.1	287	2870
LUTRON		Skylark, Slide-To-Off Dimmers, Incandescent/Halogen, Eco-Dim, Single Pole/3-Way, 600W, Clamshell Packing, White	600	S-603PGH-WH	0.1	225	2250
LUTRON		Ariadni, Dimmers, Magnetic Low Voltage, Single Pole, 600VA, White	600	AYLV-600P-WH	0.1	291	2910
LUTRON		Ariadni, Dimmers, Magnetic Low Voltage, 3-Way, 600VA, White	600	AYLV-603P-WH	0.1	280	2800
LUTRON		Ariadni, Dimmers with Locator Light, Incandescent/Halogen, 3-Way, 1000W, White	1000	AY-103PNL-WH	32	310	9
LUTRON		Ariadni, Dimmers, Incandescent/Halogen, 3-Way, 1000W, White	1000	AY-103P-WH	30	310	10
LUTRON		Ariadni, Dimmers with Locator Light, Incandescent/Halogen, Single Pole, 1000W, White	1000	AY-10PNL-WH	44	330	7
LUTRON		Ariadni, Dimmers, Incandescent/Halogen, Single Pole, 1000W, White	1000	AY-10P-WH	50	311	6
LUTRON		Ariadni, Dimmers with Locator Light, Incandescent/Halogen, 3-Way, 600W, White	600	AY-603PNL-WH	0.1	268	2680
LUTRON		Ariadni, Dimmers, Incandescent/Halogen, Eco-dim, Single Pole/3-Way, 600W, White	600	AY-603PG-WH	0.1	194	1940
LUTRON		Ariadni, Dimmers, Incandescent/Halogen, 3-Way, 600W, White	600	AY-603P-WH	0.1	275	2750
LUTRON		Ariadni, Dimmers with Locator Light, Incandescent/Halogen, Single Pole, 600W, White	600	AY-600PNL-WH	0.1	283	2830
LUTRON		Diva, Dimmers with Locator Light, Magnetic Low Voltage, Single Pole, 1000VA, White	1000	DVLV-10P-WH	0.1	273	2730
LUTRON		Diva, Dimmers with Locator Light, Magnetic Low Voltage, 3-Way, 1000VA, White	1000	DVLV-103P-WH	0.1	277	2770
LUTRON		Diva, Dimmers with Locator Light, Magnetic Low Voltage, 3-Way, 600VA, White	600	DVLV-603P-WH	0.1	278	2780

LUTRON		Skylark, Slide-To-Off Dimmers, Incandescent/Halogen, Single Pole, 1000W, White	1000	S-1000-WH	0.1	315	3150
LUTRON		Skylark, Dimmers with On/Off Switch, Incandescent/Halogen, Single Pole, 600W, White	600	S-600P-WH	0.1	290	2900
LUTRON		Skylark, Dimmers with On/Off Switch & Locator Light, Incandescent/Halogen, 3-Way,1000W, White	1000	S-103PNL-WH	52	317	6
LUTRON		Glyder, Slide-To-Off Dimmers, Magnetic Low Voltage, Single Pole, 600W, White	600	GLV-600-WH	0.1	313	3130

Figure 30 – U.S. TRIAC-Based Dimmers Compatibility List.

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12 散熱效能

12.1 IR 散熱模式

Images captured after running for more than 2 hours (25 °C), open frame for the conditions specified.

Non-Dimming V_{IN} = 90 VAC, 60 Hz, 41 V LED Load.	Non-Dimming V_{IN} = 132 VAC, 60 Hz, 41 V LED Load.
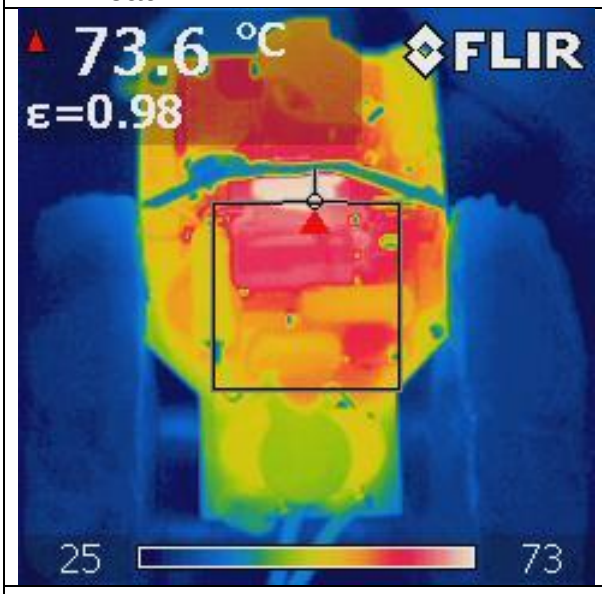	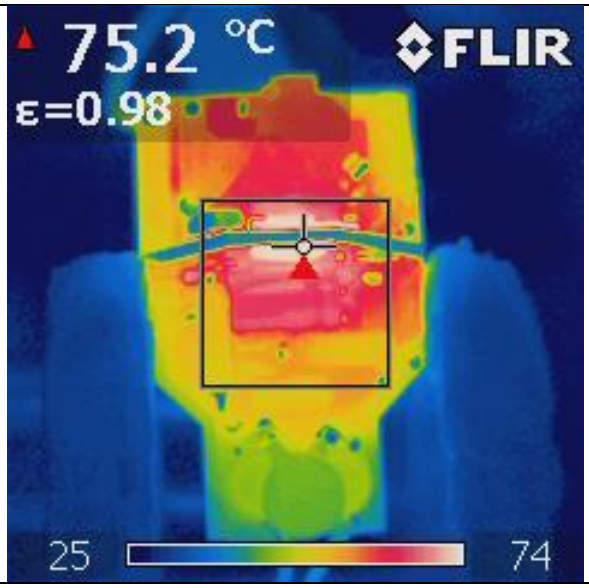
Figure 31 – U1 was Hottest Device.	**Figure 32 –** U1 was Hottest Device.

TRIAC Dimmer Connected V_{IN} = 120 VAC, 60 Hz, 41 V LED Load.

With TRIAC: V_{IN} = 120 VAC, 60 Hz, 41 V LED Load at Full Conduction.
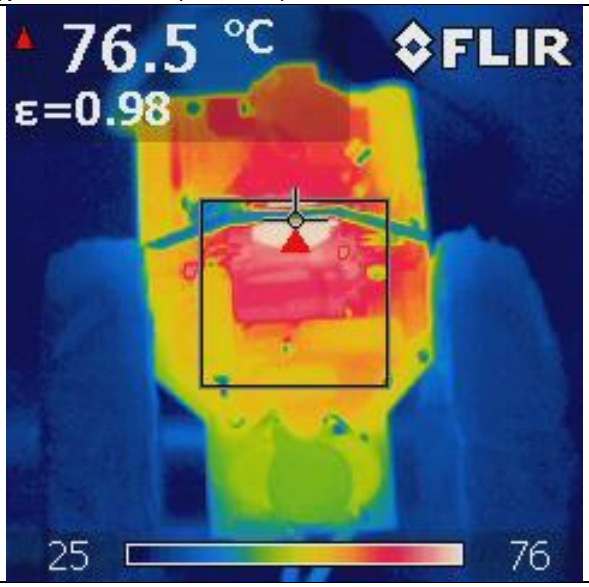
Figure 33 – U1 was Hottest Device.

12.2 正常運作下的輸出電流和輸出電壓波形

Input Condition	I_{OUT}, Mean (mA)	I_{OUT}, Peak to Peak (mA)	I_{OUT} Ripple (%)
90 VAC, 60 Hz	310	133	±21.4
120 VAC, 60 Hz	344	138	±20
132 VAC, 60 Hz	353	142	±20.1

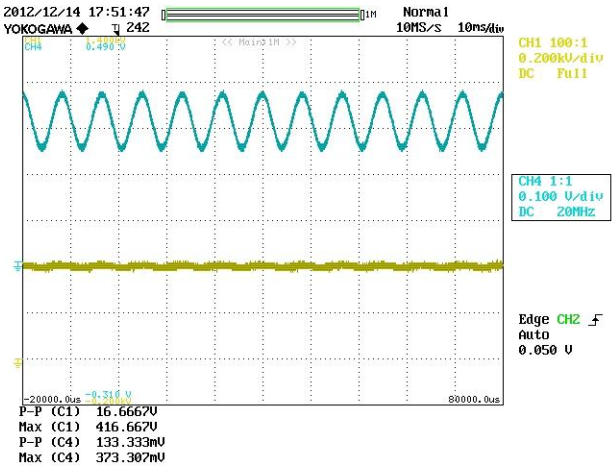

Figure 34 – 90 VAC, 60 Hz Full Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 200 V, 10 ms / div.

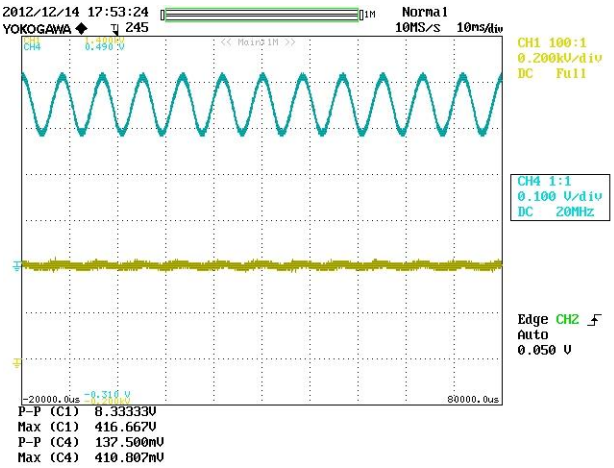

Figure 35 – 120 VAC, 60 Hz Full Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 200 V, 10 ms / div.

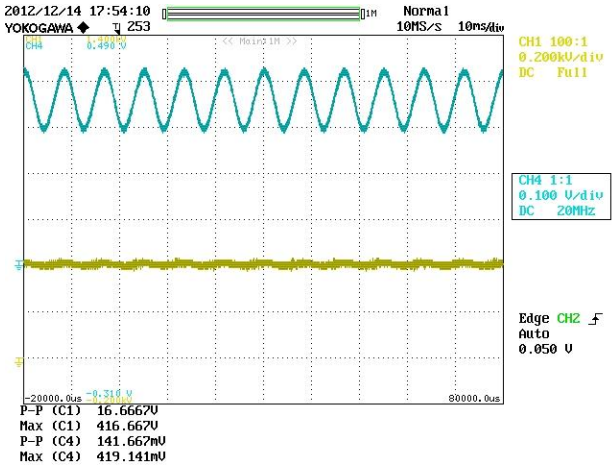

Figure 36 – 132 VAC, 60 Hz Full Load.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 200 V, 10 ms / div.

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12.3 啓動時的輸出電壓和輸出電流波形

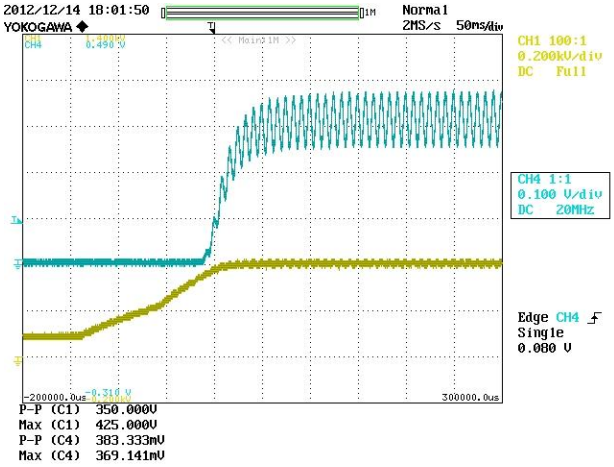

Figure 37 – 90 VAC, 60 Hz.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 200 V, 50 ms / div.

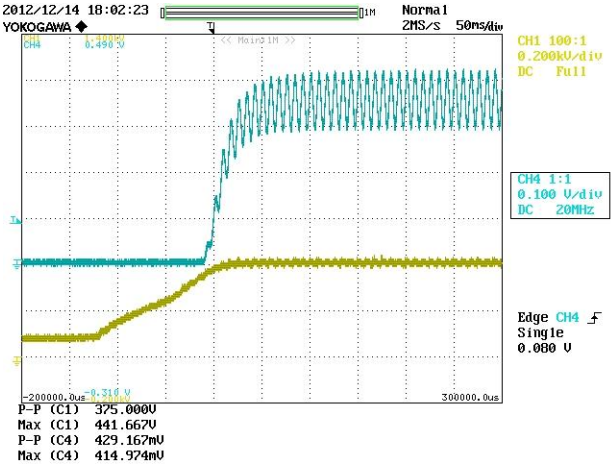

Figure 38 – 132 VAC, 60 Hz.
Upper: I_{OUT}, 100 mA / div.
Lower: V_{OUT}, 200 V, 50 ms / div.

12.4 正常運作下的汲極電壓和電流

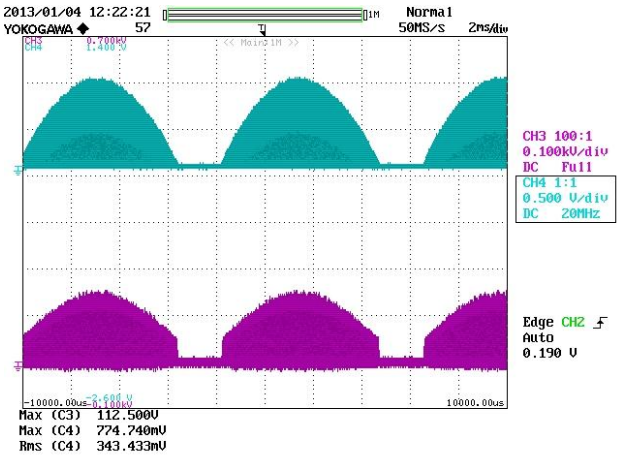

Figure 39 – 90 VAC, 60 Hz.
Upper: I_{DRAIN}, 0.5 A / div.
Lower: V_{DRAIN}, 100 V, 2 ms / div.

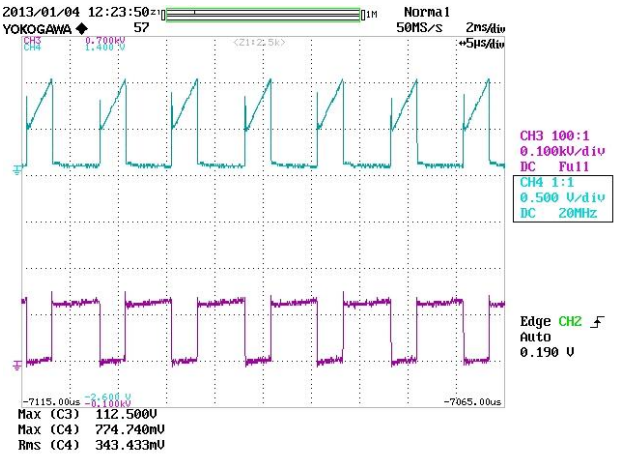

Figure 40 – 90 VAC, 60 Hz.
Upper: I_{DRAIN}, 0.5 A / div.
Lower: V_{DRAIN}, 100 V / div., 5 □s / div.

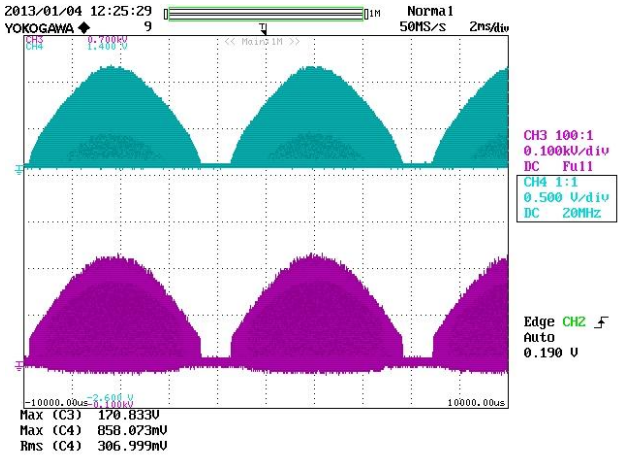

Figure 41 – 132 VAC, 60 Hz.
Upper: I_{DRAIN}, 0.5 A / div.
Lower: V_{DRAIN}, 100 V, 2 ms / div.

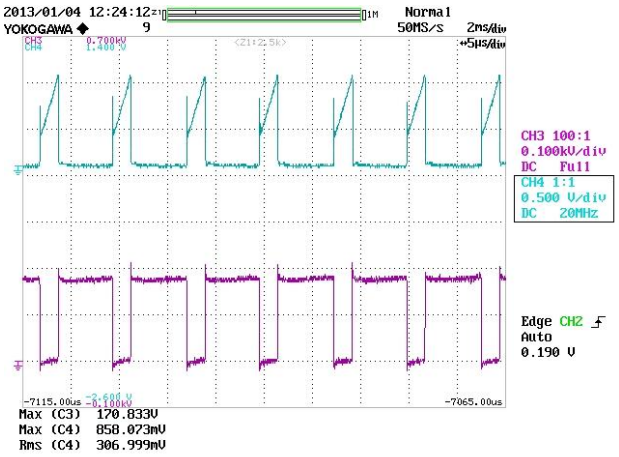

Figure 42 – 132 VAC, 60 Hz.
Upper: I_{DRAIN}, 0.5 A / div.
Lower: V_{DRAIN}, 100 V / div., 5 □s / div.

12.5 啓動時的汲極電壓和電流

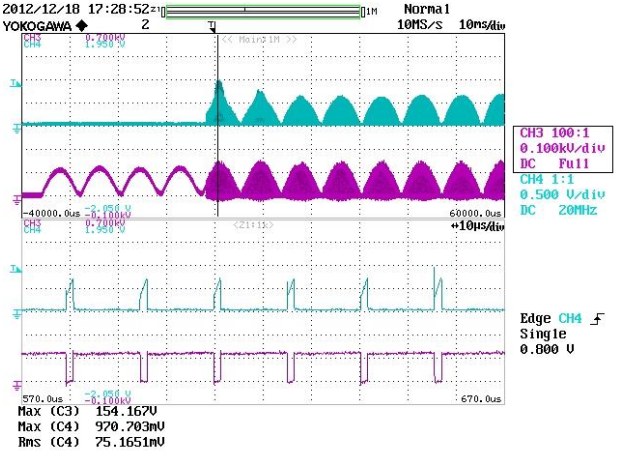

Figure 43 – 90 VAC, 60 Hz Start-up.
Upper: I_{DRAIN}, 500 mA / div.
Lower: V_{DRAIN}, 100 V,10 ms / div.

Figure 44 – 90 VAC, 60 Hz Start-up.
Upper: I_{DRAIN}, 500 mA / div.
Lower: V_{DRAIN}, 100 V, 10 □s / div.

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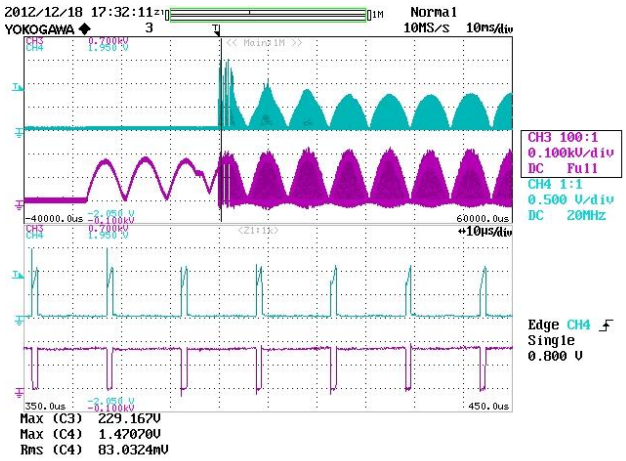

Figure 45 – 132 VAC, 60 Hz Start-up.
Upper: I_{DRAIN}, 500 mA / div.
Lower: V_{DRAIN}, 100 V, 10 ms / div.

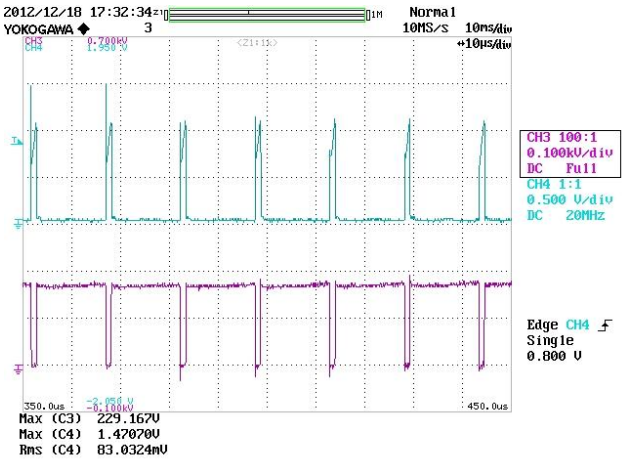

Figure 46 – 132 VAC, 60 Hz Start-up.
Upper: I_{DRAIN}, 500 mA / div.
Lower: V_{DRAIN}, 100 V, 10 □s / div.

12.6 輸出短路情況下的汲極電壓和電流輸出

During output short condition, the I_{FB} current falls below the $I_{FB(AR)}$ threshold and enters the auto-restart condition. During this condition, to minimize power dissipation on the power components, the auto-restart circuit turns the power supply on and off at an auto-restart duty cycle of typically DC_{AR} for as long as the fault condition persists.

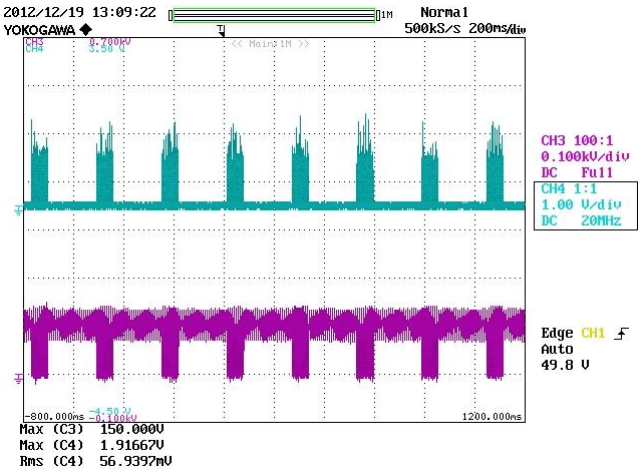

Figure 47 – 90 VAC, 60 Hz Output Short Condition.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V, 200 ms / div.

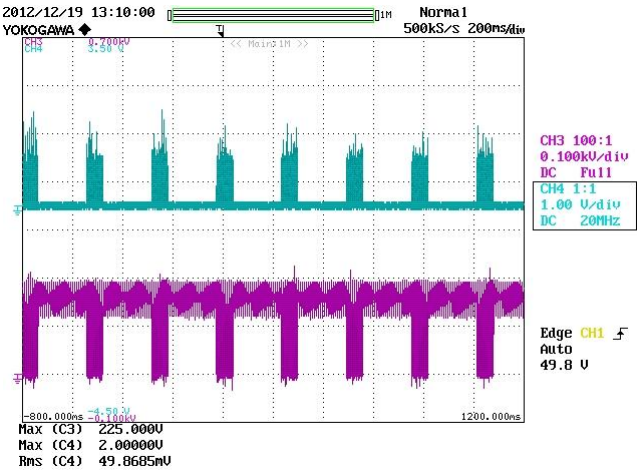

Figure 48 – 132 VAC, 60 Hz Output Short Condition.
Upper: I_{DRAIN}, 1 A / div.
Lower: V_{DRAIN}, 100 V, 200 ms / div.

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12.7 正常運作下的輸出二極體電壓和電流波形

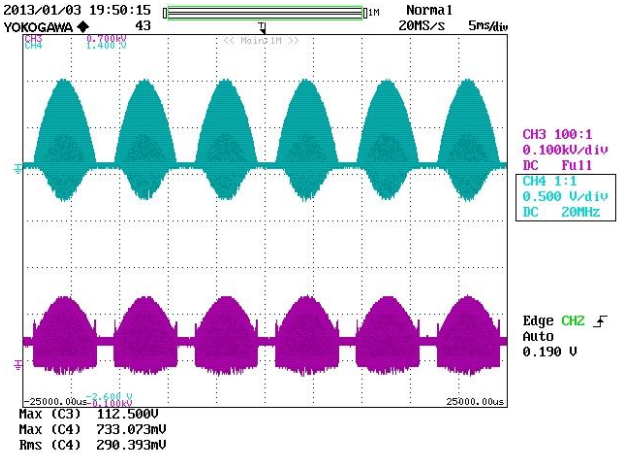

Figure 49 – 90 VAC, 60 Hz.
Upper: I_{D7}, 500 mA / div.
Lower: V_{D7}, 100 V, 5 ms / div.

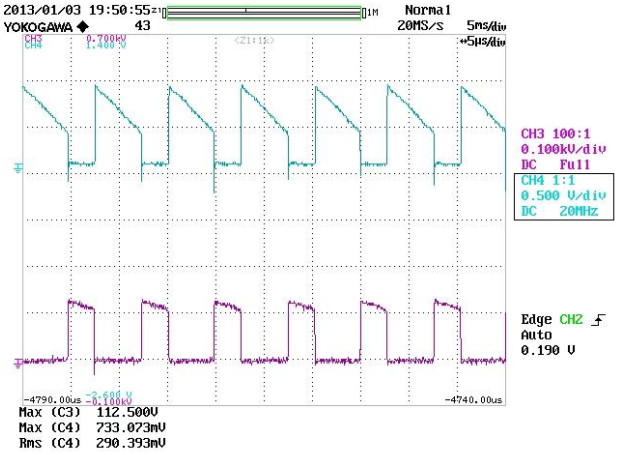

Figure 50 – 90 VAC, 60 Hz.
Upper: I_{D7}, 500 □A / div.
Lower: V_{D7}, 100 V, 5 □s / div

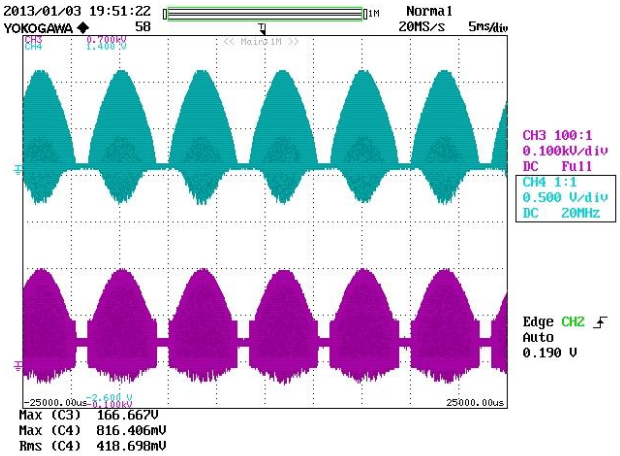

Figure 51 – 132 VAC, 60 Hz.
Upper: I_{D7}, 500 mA / div.
Lower: V_{D7}, 100 V, 5 ms / div

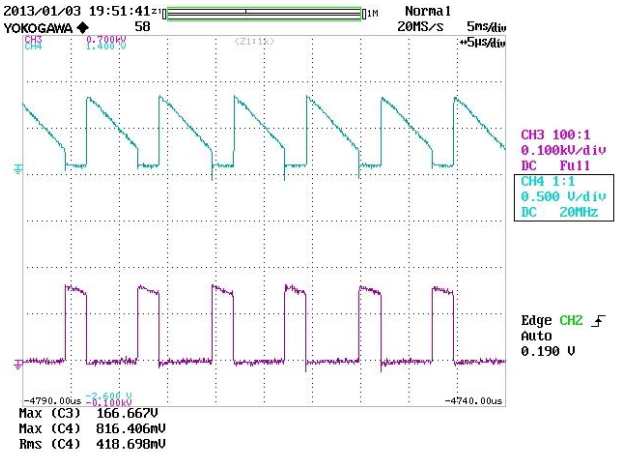

Figure 52 – 132 VAC, 60 Hz.
Upper: I_{D7}, 500 mA / div.
Lower: V_{D7}, 100 V, 5 □s / div.

12.8 啓動時的輸出電壓和電流輪廓

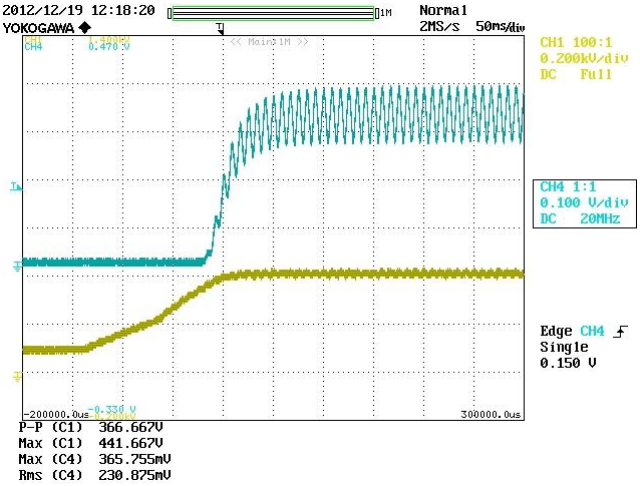

Figure 53 – 90 VAC, 60 Hz Start-up Condition.
Upper: I_{D5}, 0.1 A / div.
Lower: V_{D5}, 200 V, 50 ms / div.

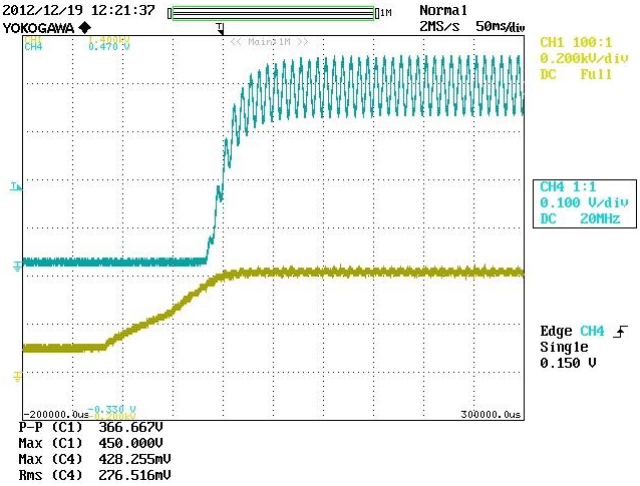

Figure 54 – 132 VAC, 60 Hz Output Short Condition.
Upper: I_{D5}, 0.1 A / div.
Lower: V_{D5}, 200 V, 50 ms / div.

13 非調光波形

13.1 輸出電流和輸入電流波形

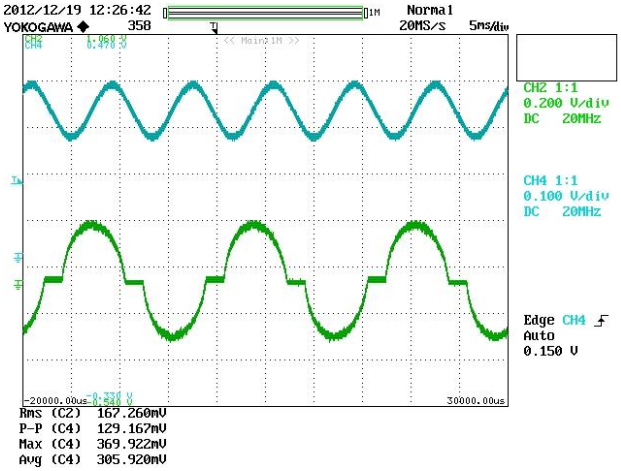

Figure 55 – 90 VAC, 41 V LED Load.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 200 mA, 5 ms / div.

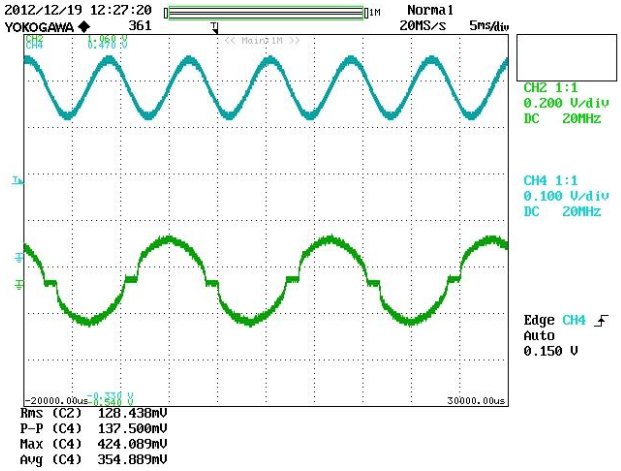

Figure 56 – 132 VAC, 41 V LED Load.
Upper: I_{OUT}, 100 mA / div.
Lower: I_{IN}, 200 mA, 5 ms / div.

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14 傳導性 EMI

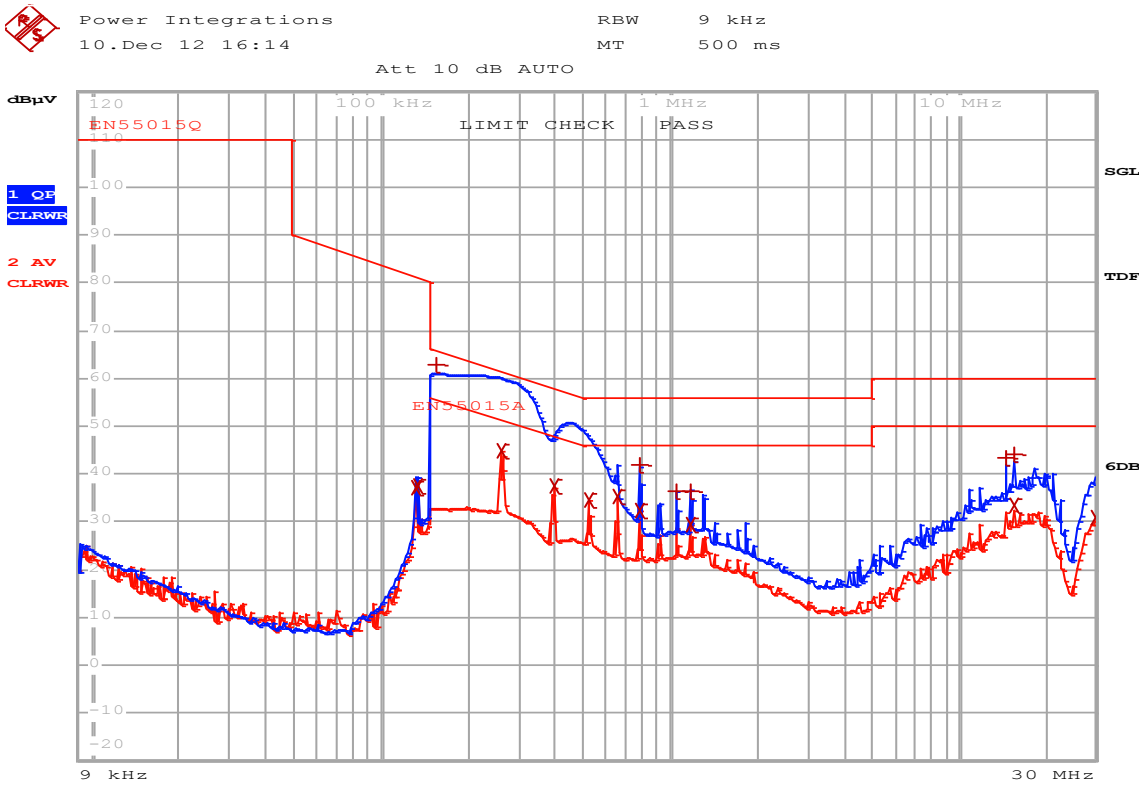
The design met the limits for conducted electromagnetic emission (EMI) with frequency range of 9 kHz to 30 MHz as per described in the CISPR 15 / IEC: 2005 Standard.

14.1 測試裝置

The unit was tested using 41 V LED load at input voltage of 120 VAC, 60 Hz at room temperature. The unit was placed inside a conical metal housing as shown in Figure 57.

Figure 57 – EMI Test Set-up with the Unit and LED Load Placed Inside a Conical Metal Housing as Described in CISPR 15 / IEC: 2005 Standard.

14.2 測試裝置



EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55015Q
Trace2: EN55015A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV		DELTA LIMIT dB
2	Average	130.825395691 kHz	37.10	N gnd	
2	Average	133.454986145 kHz	37.53	N gnd	
1	Quasi Peak	154.54515 kHz	62.86	L1 gnd	-2.89
2	Average	261.871472881 kHz	45.01	L1 gnd	-6.35
2	Average	393.789848222 kHz	37.53	N gnd	-10.45
2	Average	525.514079005 kHz	34.65	L1 gnd	-11.34
2	Average	654.11570866 kHz	35.15	N gnd	-10.84
1	Quasi Peak	782.418853721 kHz	41.74	N gnd	-14.25
2	Average	782.418853721 kHz	32.34	N gnd	-13.65
1	Quasi Peak	1.04414099339 MHz	36.45	L1 gnd	-19.54
1	Quasi Peak	1.17656420634 MHz	36.51	L1 gnd	-19.48
2	Average	1.17656420634 MHz	29.34	L1 gnd	-16.65
1	Quasi Peak	14.4411515385 MHz	43.37	N gnd	-16.62
1	Quasi Peak	15.4828690896 MHz	44.08	N gnd	-15.91
2	Average	15.4828690896 MHz	33.47	N gnd	-16.52
2	Average	29.8580960942 MHz	31.03	N gnd	-18.96

Figure 58 – Conducted EMI, 41 V LED Load, 120 VAC, 60 Hz, and EN55015 B Limits.

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15 線電壓突波

The unit was subjected to ±2500 V 100 kHz ring wave and ±500 V differential surge at 120 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.

The unit tested passed both ±2500 V 100 kHz ring wave and ±500 V differential surge with and without MOV (see Figures 59 and 60). In both conditions unit passed.

Level (V)	Input Voltage (VAC)	Injection Location	Injection Phase (°)	Type	Test Result (Pass/Fail)
+2500	120	L1, L2	0	100 kHz Ring Wave (500 A)	Pass
-2500	120	L1, L2	0	100 kHz Ring Wave (500 A)	Pass
+2500	120	L1, L2	90	100 kHz Ring Wave (500 A)	Pass
-2500	120	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	120	L1, L2	0	Surge (2 □)	Pass
-500	120	L1, L2	0	Surge (2 □)	Pass
+500	120	L1, L2	90	Surge (2 □)	Pass
-500	120	L1, L2	90	Surge (2 □)	Pass

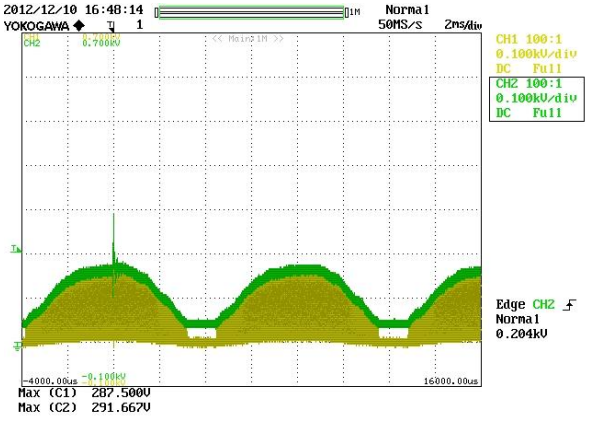

Figure 59 – +2500 V 100 kHz Differential Ring Wave.

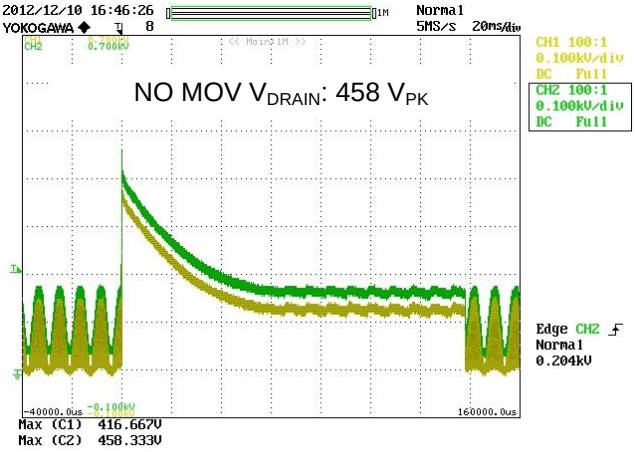

Figure 60 – No MOV +500 V 1.2 □s / 50 □s Differential Surge.

16 修訂記錄

Date	Author	Revision	Description and Changes	Reviewed
04-Apr-13	RM	1.0	Initial release	Apps and Mktg

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