

## 設計範例報告

|      |                                                                                       |
|------|---------------------------------------------------------------------------------------|
| 標題   | 使用 <b>LinkSwitch™-PH LNK419EG</b> 的 <b>92% 效率、24 W T10、非隔離式、升降壓式架構、功率因數修正 LED 驅動器</b> |
| 規格   | 90 VAC – 265 VAC 輸入；134 V、180 mA 輸出                                                   |
| 應用   | T10 燈管燈泡 LED 驅動器                                                                      |
| 作者   | 應用工程部門                                                                                |
| 文件編號 | DER-356                                                                               |
| 日期   | 2012 年 12 月 6 日                                                                       |
| 修訂   | 1.0                                                                                   |

### 摘要與功能

- 大幅簡化了已執行功率因數修正之離線式 LED 驅動器的設計
  - Single-stage 結合功率因數修正 (PFC) 與定電流 (CC) 輸出，非隔離式 LED 驅動器
  - 體積小巧，所需元件極少
  - 免除所有控制迴路補償
  - 不需要輸出電流感測
  - 於 230 VAC 時可達 92% 以上的高效率
  - 線電壓和負載範圍內的功率因數 (PF) 高 (大於 0.95)
  - 總諧波失真 (THD) 低，230 VAC 時小於 25%
  - 符合 IEC61000-3-2 C 級標準
- 進階效能特色
  - 可補償電感公差
  - 可補償輸入電壓變異
  - 可補償輸出電壓變異
  - 頻率抖動功能可大幅降低 EMI 濾波器成本
- 進階保護和安全功能
  - 自動重新啟動可提供短路保護
  - 磁滯回復過溫保護

### Power Integrations

5245 Hellyer Avenue, San Jose, CA 95138 USA.

Tel: +1 408 414 9200 Fax: +1 408 414 9201

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**重要附註：**

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

本文件說明非隔離式、功率因數修正且低 THD 的高效 LED 驅動器。該設計能在 90 VAC 至 265 VAC 的輸入電壓範圍內，以 180 mA 驅動相當於 134 V LED 燈串。

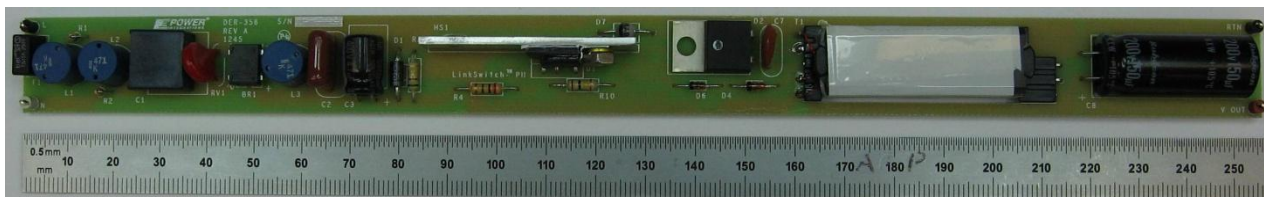
本公司所開發的 LinkSwitch-PH，能以符合成本效益的方式實作 Single-stage 功率因數修正 LED 驅動器，並結合一次側定電流控制。LinkSwitch-PH 控制器經過最佳化，最適合 LED 驅動器應用，且所需的外部零件極少。這個裝置不需借助光耦合器，可直接透過 LED 負載控制輸出電流。

LinkSwitch-PH 將 725 V 功率 MOSFET 和控制器整合到單一晶片上。這個控制器功能包含振盪器、PWM、6 V 調整器、過溫保護、頻率抖動、逐週期限電流 (cycle-by-cycle current limit) 以及其他保護功能，加上充電控制器，用於輸出 CC (定電流) 控制。

LinkSwitch-PH 提供多種額外的精密保護功能，其中包括控制迴路開路/短路故障和輸出短路狀況時的自動重新啟動。精確的磁滯回復過溫保護功能可確保 PCB 在所有情況下皆可保持在安全的溫度。

本報告所呈現的非隔離式功率因數修正升降壓式設計，顯示 LinkSwitch-PH 如何以極少量的零件，大幅簡化離線式高效、且具功率因數修正的 LED 驅動器設計，並實現符合 EN 61000-3-2 C 級諧波電流標準的優越效能、高輸出電壓設計實作。

本文件包含 LED 驅動器規格、電路圖、PCB 圖、物料清單、傳導性 EMI 測量、散熱測量、電感器文件以及典型的效能特性。



**Figure 1 – Populated Circuit Board Photograph.**  
(L: 10" [254 mm] x W: 0.78" [19.8 mm].  
Heat Sink Highest Component: 0.36" [9.14 mm])



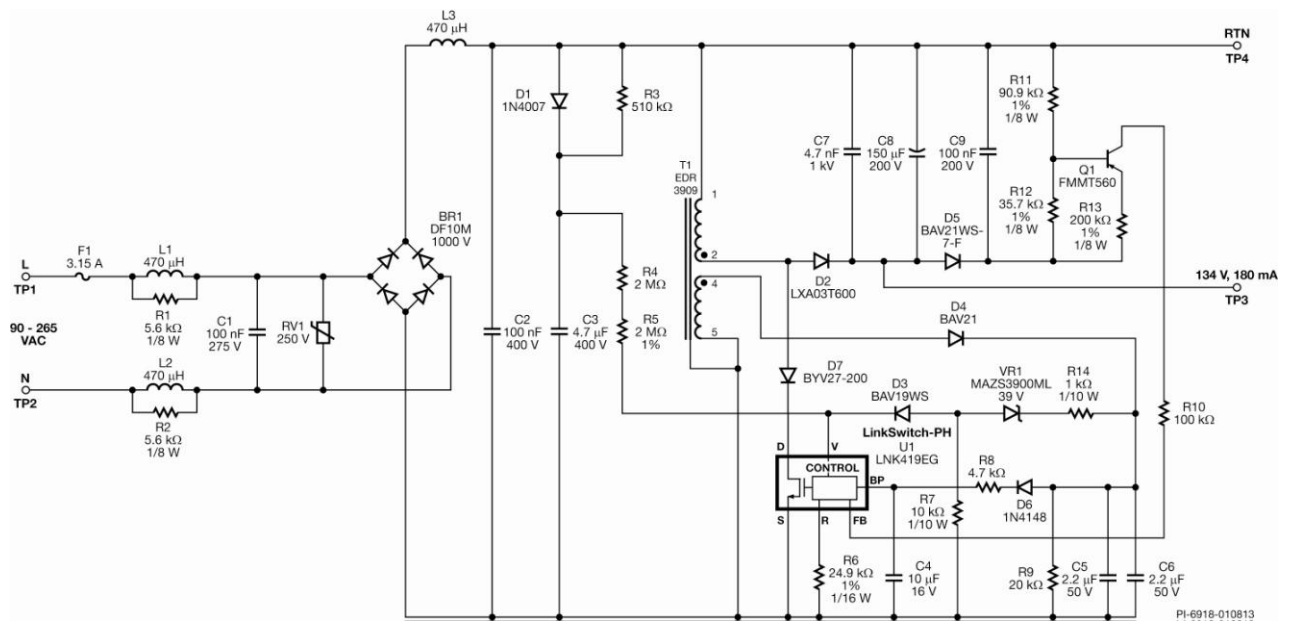
## 2 電源供應器規格

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<br>電壓<br>頻率                                                         | $V_{IN}$<br>$f_{LINE}$         | 90               | 50/60                                | 265 | VAC<br>Hz    | 雙線 – 無 P.E.                                                |
| 輸出<br>LED 電壓<br>LED 電流<br>總輸出功率<br>連續輸出功率                              | $V_{OUT}$<br><br><br>$P_{OUT}$ |                  | 134<br>180<br>24                     |     | V<br>mA<br>W |                                                            |
| 環境<br>傳導性 EMI<br>安全<br>振盪波 (100 kHz)<br>差模 (L1-L2)<br>差動突波 (1.2/50 μs) |                                |                  | 符合 EN55015B 標準<br>非隔離式<br>2.5<br>500 |     | kV<br>V      |                                                            |
| 效率                                                                     |                                |                  | 92                                   |     | %            | 於 230 VAC、25 °C 條件下測量                                      |
| 諧波電流                                                                   |                                | EN 61000-3-2 C 級 |                                      |     |              |                                                            |
| 功率因數                                                                   |                                |                  | 0.97                                 |     |              | 於 $V_{OUT(TYP)}$ 、 $I_{OUT(TYP)}$<br>及 230 VAC、50 Hz 條件下測量 |
| 環境溫度                                                                   | $T_{AMB}$                      |                  | 40                                   |     | °C           |                                                            |



### 3 電路圖



## 4 電路說明

LinkSwitch-PH (U1) 是一個高度整合的一次側控制器，主要應用於 LED 驅動器。LinkSwitch-PH 以 Single-stage 轉換架構提供高功率因數，同時會在典型 LED 驅動器環境中所預期的輸入和輸出電壓範圍內，調整輸出電流。所有負責這些功能的控制電路，加上高電壓功率 MOSFET 都會整合到裝置內。

電容器 C1、C2、差模電感器 L1、L2 和 L3 會一起執行 EMI 濾波，且大小可以維持高功率因數。電阻器 R1 和 R2 則用於箝制 L1 和 L2 的 Q，以防止 EMI 頻中產生諧振峰值。

具浮接輸出的升降壓式(buck-boost)功率電路是由 U1 (電源開關 + 控制)、輸出二極體 D2、輸出電容器 C7 和 C8，以及輸出電感器 T1 所組成。電感器 T1 在返馳式配置中配置有第二個繞組，用於提供偏壓電源給 U1。二極體 D7 是用於防止 U1 汲源極間，接近輸入電壓過零處出現負電壓。二極體 D1 和 C3 會偵測峰值 AC 線電壓。在 C3 上的電壓以及 R4 和 R5 會設定饋入電壓監測器 (V) 接腳的輸入電流。此電流會由 U1 用於控制線電壓欠壓 (UV)、過壓 (OV) 及前饋電流，並與回授 (FB) 接腳電流一起，將定電流提供給 LED 負載。

U1 用於調節輸出電流的 FB 接腳電流則由電壓至電流轉換器網路提供，這個網路是使用 R10、R11、R12、R13、Q1、C9 和 D5 構成。輸出電壓與回授電流的關係公式如下：

$$I_{FB} \approx I_{R13} = \frac{V_{OUT} \times \frac{R12}{R11 + R12} - V_{BE}}{R13}$$

為消除或盡量降低溫度效應，以及 Q1 之  $V_{BE}$  電壓的  $V_{CE}$  相依性，選用了 R12 上的電壓。

電容器 C4 會為 U1 的 BYPASS (BP) 接腳 (內部控制器的供電接腳) 提供本機去耦合。在啟動期間，會從 U1 汲極 (D) 接腳連接的內部高電壓電流源將 C4 充電至約 ~6 V。選擇的電容器 C4 為 10  $\mu$ F，以讓裝置可以在全工模式下操作。採用外部偏壓供電 (透過 D6 和 R8)，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。輸出過壓 (開路) 保護透過 V 接腳和 VR1、R14 及 D3 提供。一旦偏壓供電的電容器 C6 上的電壓因為開路情況而超過 VR1 臨界值，電流將會流入 V 接腳，直到到達線間電壓過壓臨界值 ( $I_{OV}$ ) 為止，然後 IC 會立即終止切換，藉此防止輸出電壓再次升高。



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## 5 PCB 佈局

Copper: 2 oz. / 70  $\mu\text{m}$  thickness used.

**Figure 3 – Printed Circuit Layout, Top and Bottom.**

**Figure 4 – Printed Circuit Layout, Top.**

**Figure 5 – Printed Circuit Layout, Bottom.**

## 6 物料清單

### 6.1 電氣物料清單

| Item | Qty | Ref Des  | Description                                                   | Mfg Part Number      | Mfg                |
|------|-----|----------|---------------------------------------------------------------|----------------------|--------------------|
| 1    | 1   | BR1      | 1000 V, 1 A, Bridge Rectifier, DF-M, Glass Passivated, 4-EDIP | DF10M                | Diodes, Inc.       |
| 2    | 1   | C1       | 100 nF, 275 VAC, Film, X2                                     | LE104-M              | OKAYA              |
| 3    | 1   | C2       | 100 nF, 400 V, Film                                           | ECQ-E4104KF          | Panasonic          |
| 4    | 1   | C3       | 4.7 $\mu\text{F}$ , 400 V, Electrolytic, (8 x 11.5)           | SHD400WV 4.7uF       | Sam Young          |
| 5    | 1   | C4       | 10 $\mu\text{F}$ , 16 V, Ceramic, X5R, 0805                   | GRM21BR61C106KE15L   | Murata             |
| 6    | 2   | C5 C6    | 2.2 $\mu\text{F}$ , 50 V, Ceramic, Y5V, 1206                  | GRM31MF51H225ZA01L   | Murata             |
| 7    | 1   | C7       | 4.7 nF, 1 kV, Thru Hole, Disc Ceramic                         | 562R5GAD47           | Vishay             |
| 8    | 1   | C8       | 150 $\mu\text{F}$ , 200 V, Electrolytic, (12.5 x 30)          | 200KXW150MEFC12.5X30 | Rubycon            |
| 9    | 1   | C9       | 100 nF, 200 V, Ceramic, X7R, 1206                             | VJ1206Y104KXCAT      | Vishay             |
| 10   | 1   | D1       | 1000 V, 1 A, Rectifier, DO-41                                 | 1N4007-E3/54         | Vishay             |
| 11   | 1   | D2       | 600 V, 3 A, TO-220AC                                          | LXA03T600            | Power Integrations |
| 12   | 1   | D3       | 100 V, 0.2 A, Fast Switching, 50 ns, SOD-323                  | BAV19WS-7-F          | Diodes, Inc.       |
| 13   | 1   | D4       | 250 V, 250 mA, Fast Switching, DO-35                          | BAV21                | Vishay             |
| 14   | 1   | D5       | 250 V, 0.2 A, Fast Switching, 50 ns, SOD-323                  | BAV21WS-7-F          | Diodes, Inc.       |
| 15   | 1   | D6       | 75 V, 300 mA, Fast Switching, DO-35                           | 1N4148TR             | Vishay             |
| 16   | 1   | D7       | 200 V, 2 A, Ultrafast Recovery, 25 ns, SOD57                  | BYV27-200-TR         | Vishay             |
| 17   | 1   | F1       | 3.15 A, 250 V, Slow, RST                                      | 507-1181             | Belfuse            |
| 18   | 1   | HS1      | Heat Sink, Custom, Al, 3003, 0.062" Thk                       |                      | Custom             |
| 19   | 3   | L1 L2 L3 | 470 $\mu\text{H}$ , 0.38 A, Radial                            | TSL0808RA-471KR38-PF | TDK                |
| 20   | 1   | Q1       | PNP, Small Signal BJT, 500 V, 0.15 A, SOT23                   | FMMT560TA            | Zetex              |
| 21   | 2   | R1 R2    | 5.6 k $\Omega$ , 5%, 1/8 W, Carbon Film                       | CFR-12JB-5K6         | Yageo              |
| 22   | 1   | R3       | 510 k $\Omega$ , 5%, 1/4 W, Carbon Film                       | CFR-25JB-510K        | Yageo              |
| 23   | 1   | R4       | 2.0 M $\Omega$ , 5%, 1/4 W, Carbon Film                       | CFR-25JB-2M0         | Yageo              |
| 24   | 1   | R5       | 2.00 M $\Omega$ , 1%, 1/4 W, Thick Film, 1206                 | ERJ-8ENF2004V        | Panasonic          |
| 25   | 1   | R6       | 24.9 k $\Omega$ , 1%, 1/16 W, Thick Film, 0603                | ERJ-3EKF2492V        | Panasonic          |
| 26   | 1   | R7       | 10 k $\Omega$ , 5%, 1/10 W, Thick Film, 0603                  | ERJ-3GEYJ103V        | Panasonic          |
| 27   | 1   | R8       | 4.7 k $\Omega$ , 5%, 1/4 W, Thick Film, 1206                  | ERJ-8GEYJ472V        | Panasonic          |
| 28   | 1   | R9       | 20 k $\Omega$ , 5%, 1/4 W, Thick Film, 1206                   | ERJ-8GEYJ203V        | Panasonic          |
| 29   | 1   | R10      | 100 k $\Omega$ , 5%, 1/4 W, Carbon Film                       | CFR-25JB-100K        | Yageo              |
| 30   | 1   | R11      | 90.9 k $\Omega$ , 1%, 1/8 W, Thick Film, 0805                 | ERJ-6ENF9092V        | Panasonic          |



|    |   |     |                                                  |               |                        |
|----|---|-----|--------------------------------------------------|---------------|------------------------|
| 32 | 1 | R13 | 200 k $\Omega$ , 1%, 1/8 W, Thick Film, 0805     | ERJ-6ENF2003V | Panasonic              |
| 33 | 1 | R14 | 1 k $\Omega$ , 5%, 1/10 W, Thick Film, 0603      | ERJ-3GEYJ102V | Panasonic              |
| 34 | 1 | RV1 | 250 V, 21 J, 7 mm, RADIAL LA                     | V250LA4P      | Littlefuse             |
| 35 | 1 | T1  | Bobbin, EDR-3909, Horizontal, 8 pins Transformer | SNX-R1681     | SBEF<br>Santronics USA |
| 36 | 1 | U1  | LinkSwitch-PH, eSIP                              | LNK419EG      | Power Integrations     |
| 37 | 1 | VR1 | 39 V, 5%, 150 mW, SSMINI-2                       | MAZS39000L    | Panasonic              |
| 32 | 1 | R13 | 200 k $\Omega$ , 1%, 1/8 W, Thick Film, 0805     | ERJ-6ENF2003V | Panasonic              |

## 7 T1 變壓器規格

### 7.1 電氣圖

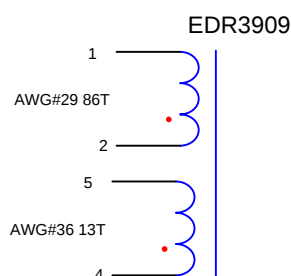


Figure 6 – Electrical Diagram.

### 7.2 電氣規格

|                           |                                                                               |                 |
|---------------------------|-------------------------------------------------------------------------------|-----------------|
| <b>Primary Inductance</b> | Pins 1-2, all other windings open, measured at 66 kHz, 0.4 V <sub>RMS</sub> . | 2.8 mH $\pm$ 2% |
| <b>Resonant Frequency</b> | Pins 1-2, all other windings open.                                            | 1 MHz (Min.)    |

### 7.3 材料

| Item | Description                                |
|------|--------------------------------------------|
| [1]  | Core: EDR3909.                             |
| [2]  | Bobbin: EDR3909, Horizontal, 8 pins, 5/3.  |
| [3]  | Magnet Wire: #29 AWG.                      |
| [4]  | Magnet Wire: #36 AWG.                      |
| [5]  | Tape: 3M 1298 Polyester Film, 4.5 mm wide. |
| [6]  | Copper Tape: 0.125" wide, 2 mil thick.     |

## 7.4 變壓器建構圖

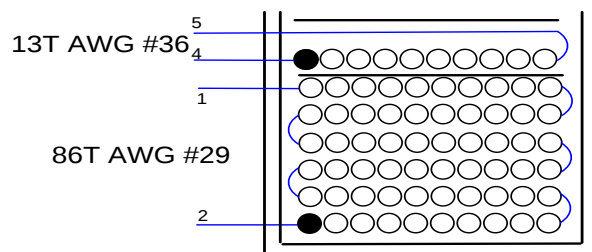


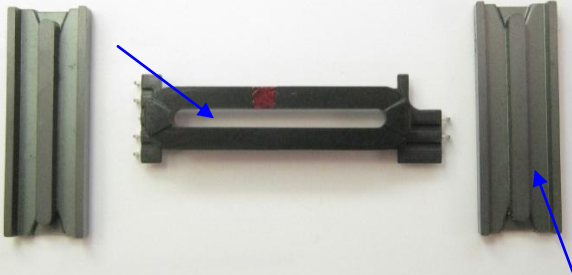
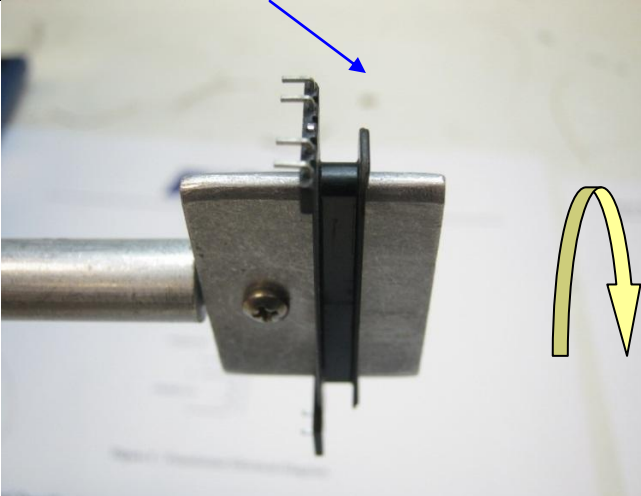
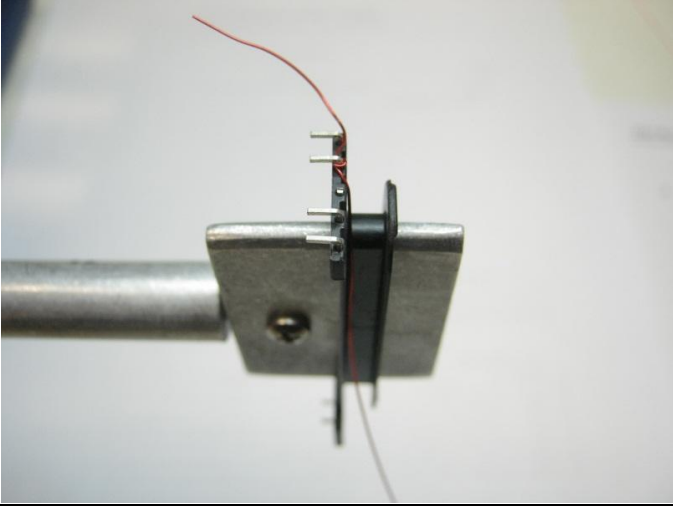
Figure 7 – Transformer Build Diagram.

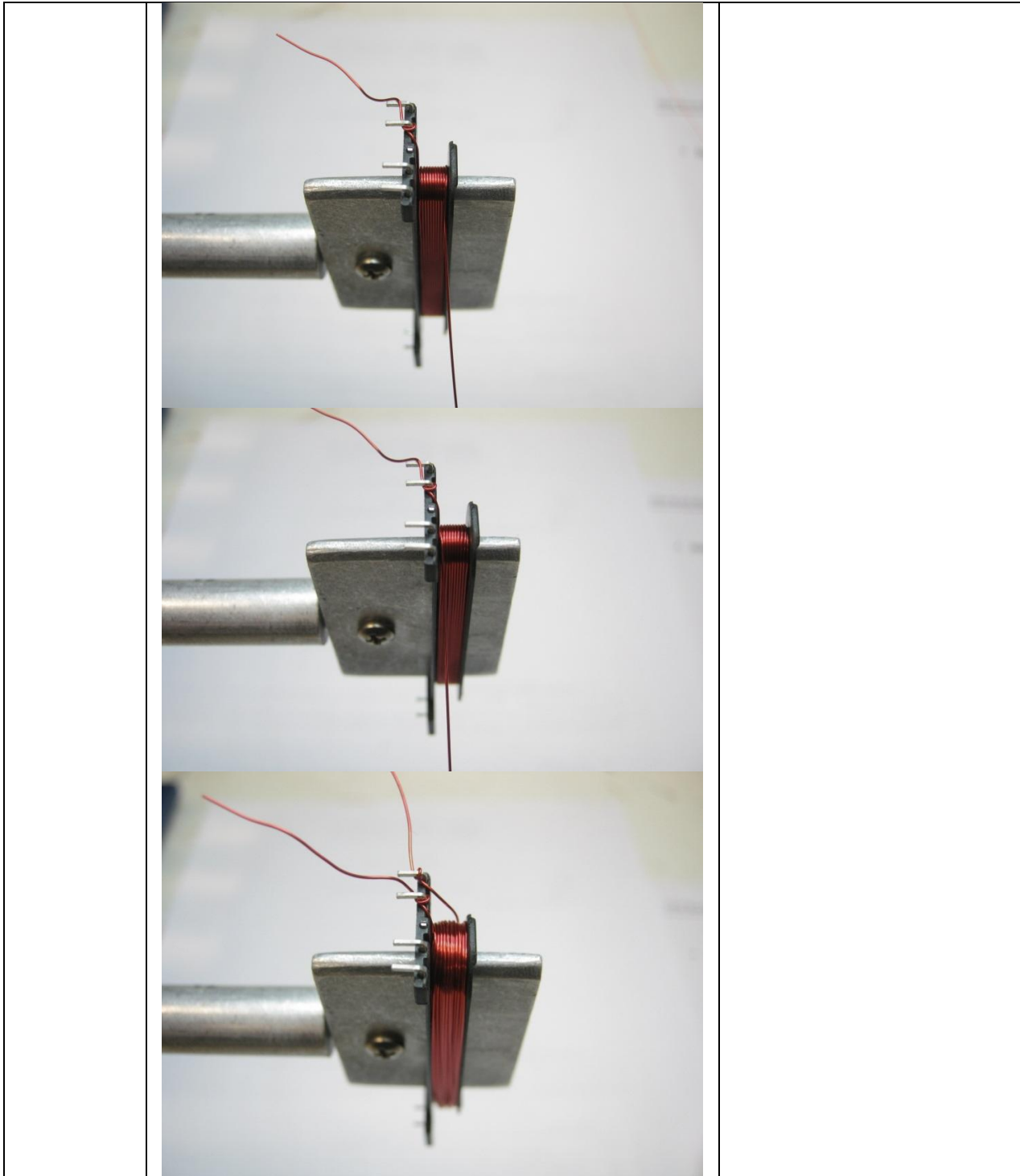
## 7.5 變壓器結構

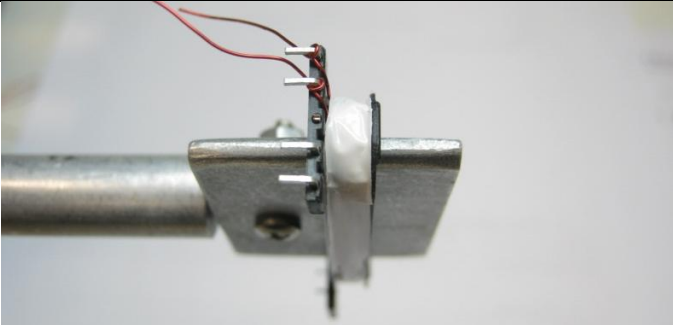
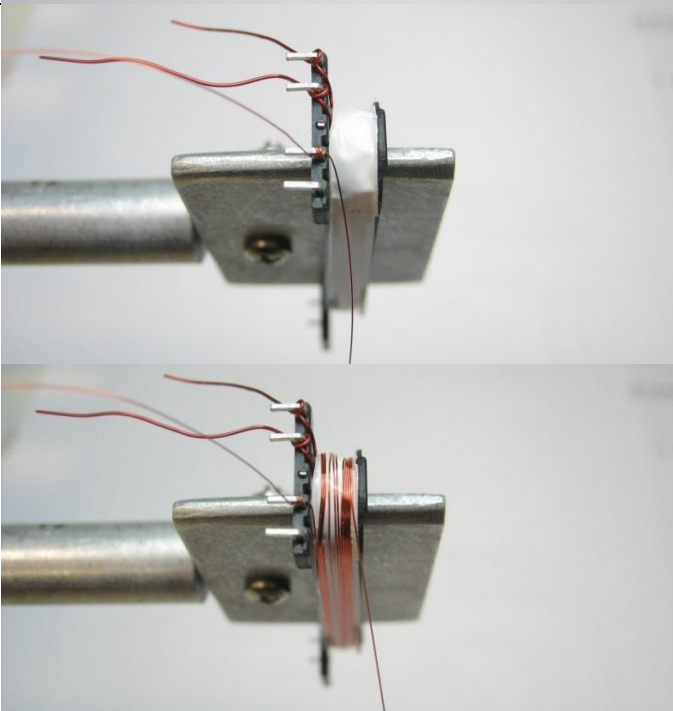
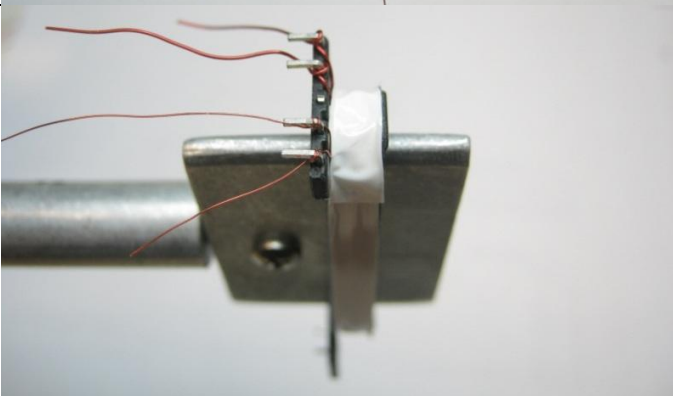
|                           |                                                                                                                                                                                                                                                                              |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Bobbin Preparation</b> | Pull-out pin number 3 and 6.                                                                                                                                                                                                                                                 |
| <b>General Note</b>       | For the purpose of these instructions, Bobbin is oriented on winder such that pin 1 side is on the left side (see illustration). Winding direction as shown is clockwise.                                                                                                    |
| <b>WDG1<br/>Primary 1</b> | Start at pin 2; wind with firm tension 86 turns of item [3] in 7 layers from left to right. At the end of 1st layer, continue to wind the next layer from right to left. On the final layer, spread the winding evenly across entire bobbin. Finish this winding on pin(s) 1 |
| <b>Insulation</b>         | 1 layer of tape [5] for insulation.                                                                                                                                                                                                                                          |
| <b>WDG2<br/>Bias</b>      | Start on pin(s) 4 and wind 13 turns of item [4]. Wind in same rotational direction as primary winding. Spread the winding evenly across entire bobbin. Finish this winding on pin(s) 5.                                                                                      |
| <b>Insulation</b>         | 2 layers of tape [5] for insulation.                                                                                                                                                                                                                                         |
| <b>Assemble Core</b>      | Assemble and secure the cores.                                                                                                                                                                                                                                               |
| <b>Flux Band</b>          | Construct a flux band by wrapping a single shorted turn of item [6] around the outside of windings and core halves with tight tension. Make an electrical connection to pin(s) 5 using wire. Add 3 layers of tape, item [4], for insulation.                                 |
| <b>Finish</b>             | Varnish transformer assembly.                                                                                                                                                                                                                                                |

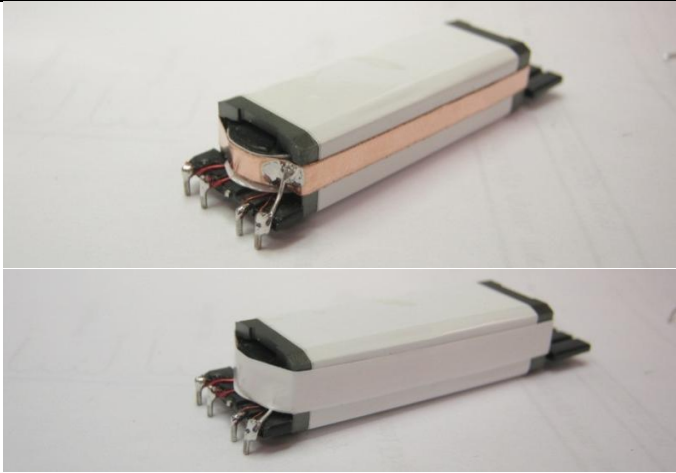


## 7.6 變壓器繞組示意圖

|                           |                                                                                      |                                                                                                                                                                                                                                                                                     |
|---------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Bobbin Preparation</b> |    | <p>Pull-out pin number 3 and 6.</p>                                                                                                                                                                                                                                                 |
| <b>General Note</b>       |   | <p>For the purpose of these instructions, Bobbin is oriented on winder such that pin 1 side is on the left side (see illustration). Winding direction as shown is clockwise.</p>                                                                                                    |
| <b>WDG1 Primary 1</b>     |  | <p>Start at pin 2; wind with firm tension 86 turns of item [3] in 7 layers from left to right. At the end of 1st layer, continue to wind the next layer from right to left. On the final layer, spread the winding evenly across entire bobbin. Finish this winding on pin(s) 1</p> |



|               |                                                                                      |                                                                                                                                                                                         |
|---------------|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Insulation    |    | 1 layer of tape [5] for insulation.                                                                                                                                                     |
| WDG2 Bias     |   | Start on pin(s) 4 and wind 13 turns of item [4]. Wind in same rotational direction as primary winding. Spread the winding evenly across entire bobbin. Finish this winding on pin(s) 5. |
| Insulation    |  | 1 layer of tape [5] for insulation.                                                                                                                                                     |
| Assemble Core |  | Assemble and secure the cores.                                                                                                                                                          |

|                  |                                                                                   |                                                                                                                                                                                                                                                     |
|------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Flux Band</b> |  | <p>Construct a flux band by wrapping a single shorted turn of item [6] around the outside of windings and core halves with tight tension. Make an electrical connection to pin(s) 5 using wire. Add 3 layers of tape, item [4], for insulation.</p> |
| <b>Finish</b>    |  | <p>Varnish transformer assembly.</p>                                                                                                                                                                                                                |

## 8 電感器設計試算表

Buck-boost inductor parameters can be calculated using LinkSwitch-PH PIXIs spreadsheet using  $VO \equiv VOR$ .

| ACDC_LinkSwitch-PH_071112; Rev.1.8; Copyright Power Integrations 2012 | INPUT    | INFO   | OUTPUT   | UNIT      | LinkSwitch-PH_071112: Flyback Transformer Design Spreadsheet                          |
|-----------------------------------------------------------------------|----------|--------|----------|-----------|---------------------------------------------------------------------------------------|
| <b>ENTER APPLICATION VARIABLES</b>                                    |          |        |          |           |                                                                                       |
| Dimming required                                                      | NO       |        | NO       |           | Select 'YES' option if dimming is required. Otherwise select 'NO'.                    |
| VACMIN                                                                |          |        | 90       | V         | Minimum AC Input Voltage                                                              |
| VACMAX                                                                |          |        | 265      | V         | Maximum AC input voltage                                                              |
| fL                                                                    |          |        | 50       | Hz        | AC Mains Frequency                                                                    |
| VO                                                                    | 140.00   |        | 140      | V         | Typical output voltage of LED string at full load                                     |
| VO_MAX                                                                |          |        | 154.00   | V         | Maximum expected LED string Voltage.                                                  |
| VO_MIN                                                                |          |        | 126.00   | V         | Minimum expected LED string Voltage.                                                  |
| V_OVP                                                                 |          |        | 169.40   | V         | Over-voltage protection setpoint                                                      |
| IO                                                                    | 0.18     |        | 0.18     | A         | Typical full load LED current                                                         |
| PO                                                                    |          |        | 25.2     | W         | Output Power                                                                          |
| n                                                                     | 0.90     |        | 0.9      |           |                                                                                       |
| VB                                                                    | 20       |        | 20       | V         | Bias Voltage                                                                          |
| <b>ENTER LinkSwitch-PH VARIABLES</b>                                  |          |        |          |           |                                                                                       |
| LinkSwitch-PH                                                         | LNK419   |        | LNK419   | Universal | 115 Doubled/230V                                                                      |
| Chosen Device                                                         |          | LNK419 |          |           |                                                                                       |
| Current Limit Mode                                                    | RED      |        | RED      |           | Select "RED" for reduced Current Limit mode or "FULL" for Full current limit mode     |
| ILIMITMIN                                                             |          |        | 2.35     | A         | Minimum current limit                                                                 |
| ILIMITMAX                                                             |          |        | 2.73     | A         | Maximum current limit                                                                 |
| fS                                                                    |          |        | 66000    | Hz        | Switching Frequency                                                                   |
| fSmin                                                                 |          |        | 62000    | Hz        | Minimum Switching Frequency                                                           |
| fSmax                                                                 |          |        | 70000    | Hz        | Maximum Switching Frequency                                                           |
| IV                                                                    |          |        | 38.7     | uA        | V pin current                                                                         |
| RV                                                                    |          |        | 3.909    | M-ohms    | Upper V pin resistor                                                                  |
| RV2                                                                   |          |        | 1.402    | M-ohms    | Lower V pin resistor                                                                  |
| IFB                                                                   |          |        | 155.8    | uA        | FB pin current (85 uA < IFB < 210 uA)                                                 |
| RFB1                                                                  |          |        | 109.1    | k-ohms    | FB pin resistor                                                                       |
| VDS                                                                   |          |        | 10       | V         | LinkSwitch-PH on-state Drain to Source Voltage                                        |
| VD                                                                    |          |        | 0.50     | V         | Output Winding Diode Forward Voltage Drop (0.5 V for Schottky and 0.8 V for PN diode) |
| VDB                                                                   |          |        | 0.70     | V         | Bias Winding Diode Forward Voltage Drop                                               |
| <b>Key Design Parameters</b>                                          |          |        |          |           |                                                                                       |
| KP                                                                    | 0.46     |        | 0.46     |           | Ripple to Peak Current Ratio (For PF > 0.9, 0.4 < KP < 0.9)                           |
| LP                                                                    |          |        | 2820     | uH        | Primary Inductance                                                                    |
| VOR                                                                   | 135.00   |        | 135      | V         | Reflected Output Voltage.                                                             |
| Expected IO (average)                                                 |          |        | 0.18     | A         | Expected Average Output Current                                                       |
| KP_VACMAX                                                             |          |        | 0.76     |           | Expected ripple current ratio at VACMAX                                               |
| TON_MIN                                                               |          |        | 4.01     | us        | Minimum on time at maximum AC input voltage                                           |
| PCLAMP                                                                |          |        | 0.29     | W         | Estimated dissipation in primary clamp                                                |
| <b>ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES</b>                  |          |        |          |           |                                                                                       |
| Core Type                                                             | Custom   |        | EDR 3909 |           | Transformer core                                                                      |
| Custom Core                                                           | EDR 3909 |        |          |           | If using a custom core - Enter part number here                                       |
| AE                                                                    | 1.0400   |        | 1.04     | cm^2      | Core Effective Cross Sectional Area                                                   |



|                                                                           |        |  |      |                   |                                                                                                             |
|---------------------------------------------------------------------------|--------|--|------|-------------------|-------------------------------------------------------------------------------------------------------------|
| LE                                                                        | 2.0000 |  | 2    | cm                | Core Effective Path Length                                                                                  |
| AL                                                                        | 5000.0 |  | 5000 | nH/T <sup>2</sup> | Ungapped Core Effective Inductance                                                                          |
| BW                                                                        | 3.7    |  | 3.7  | mm                | Bobbin Physical Winding Width                                                                               |
| M                                                                         |        |  | 0    | mm                | Safety Margin Width (Half the Primary to Secondary Creepage Distance)                                       |
| L                                                                         | 7.00   |  | 7    |                   | Number of Primary Layers                                                                                    |
| NS                                                                        | 90     |  | 90   |                   | Number of Secondary Turns                                                                                   |
| <b>DC INPUT VOLTAGE PARAMETERS</b>                                        |        |  |      |                   |                                                                                                             |
| VMIN                                                                      |        |  | 127  | V                 | Peak input voltage at VACMIN                                                                                |
| VMAX                                                                      |        |  | 375  | V                 | Peak input voltage at VACMAX                                                                                |
| <b>CURRENT WAVEFORM SHAPE PARAMETERS</b>                                  |        |  |      |                   |                                                                                                             |
| DMAX                                                                      |        |  | 0.54 |                   | Minimum duty cycle at peak of VACMIN                                                                        |
| IAVG                                                                      |        |  | 0.29 | A                 | Average Primary Current                                                                                     |
| IP                                                                        |        |  | 0.97 | A                 | Peak Primary Current (calculated at minimum input voltage VACMIN)                                           |
| IRMS                                                                      |        |  | 0.42 | A                 | Primary RMS Current (calculated at minimum input voltage VACMIN)                                            |
| <b>TRANSFORMER PRIMARY DESIGN PARAMETERS</b>                              |        |  |      |                   |                                                                                                             |
| LP                                                                        |        |  | 2820 | uH                | Primary Inductance                                                                                          |
| NP                                                                        |        |  | 86   |                   | Primary Winding Number of Turns                                                                             |
| NB                                                                        |        |  | 13   |                   | Bias Winding Number of Turns                                                                                |
| ALG                                                                       |        |  | 377  | nH/T <sup>2</sup> | Gapped Core Effective Inductance                                                                            |
| BM                                                                        |        |  | 3032 | Gauss             | Maximum Flux Density at PO, VMIN (BM<3100)                                                                  |
| BP                                                                        |        |  | 3669 | Gauss             | Peak Flux Density (BP<3700)                                                                                 |
| BAC                                                                       |        |  | 697  | Gauss             | AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)                                                   |
| ur                                                                        |        |  | 765  |                   | Relative Permeability of Ungapped Core                                                                      |
| LG                                                                        |        |  | 0.32 | mm                | Gap Length (Lg > 0.1 mm)                                                                                    |
| BWE                                                                       |        |  | 25.9 | mm                | Effective Bobbin Width                                                                                      |
| OD                                                                        |        |  | 0.30 | mm                | Maximum Primary Wire Diameter including insulation                                                          |
| INS                                                                       |        |  | 0.05 | mm                | Estimated Total Insulation Thickness (= 2 * film thickness)                                                 |
| DIA                                                                       |        |  | 0.25 | mm                | Bare conductor diameter                                                                                     |
| AWG                                                                       |        |  | 31   | AWG               | Primary Wire Gauge (Rounded to next smaller standard AWG value)                                             |
| CM                                                                        |        |  | 81   | Cmils             | Bare conductor effective area in circular mils                                                              |
| CMA                                                                       |        |  | 191  | Cmils/Amp         | !!! INCREASE (200 < CMA < 600) Increase L(primary layers),decrease NS,larger Core                           |
| LP_TOL                                                                    |        |  | 10   |                   | Tolerance of primary inductance                                                                             |
| <b>TRANSFORMER SECONDARY DESIGN PARAMETERS (SINGLE OUTPUT EQUIVALENT)</b> |        |  |      |                   |                                                                                                             |
| <b>Lumped parameters</b>                                                  |        |  |      |                   |                                                                                                             |
| ISP                                                                       |        |  | 0.93 | A                 | Peak Secondary Current                                                                                      |
| IS RMS                                                                    |        |  | 0.36 | A                 | Secondary RMS Current                                                                                       |
| IRIPPLE                                                                   |        |  | 0.31 | A                 | Output Capacitor RMS Ripple Current                                                                         |
| CMS                                                                       |        |  | 72   | Cmils             | Secondary Bare Conductor minimum circular mils                                                              |
| AWGS                                                                      |        |  | 31   | AWG               | Secondary Wire Gauge (Rounded up to next larger standard AWG value)                                         |
| DIAS                                                                      |        |  | 0.23 | mm                | Secondary Minimum Bare Conductor Diameter                                                                   |
| ODS                                                                       |        |  | 0.04 | mm                | Secondary Maximum Outside Diameter for Triple Insulated Wire                                                |
| <b>VOLTAGE STRESS PARAMETERS</b>                                          |        |  |      |                   |                                                                                                             |
| VDRAIN                                                                    |        |  | 647  | V                 | Estimated Maximum Drain Voltage assuming maximum LED string voltage (Includes Effect of Leakage Inductance) |
| PIVS                                                                      |        |  | 559  | V                 | Output Rectifier Maximum Peak Inverse Voltage (calculated at VOVP, excludes leakage inductance spike)       |



|                                                           |  |  |                  |                 |                                                                                                     |
|-----------------------------------------------------------|--|--|------------------|-----------------|-----------------------------------------------------------------------------------------------------|
| PIVB                                                      |  |  | 82               | V               | Bias Rectifier Maximum Peak Inverse Voltage (calculated at VOVP, excludes leakage inductance spike) |
| <b>FINE TUNING (Enter measured values from prototype)</b> |  |  |                  |                 |                                                                                                     |
| <b>V pin Resistor Fine Tuning</b>                         |  |  |                  |                 |                                                                                                     |
| RV1                                                       |  |  | 3.91             | M-ohms          | Upper V Pin Resistor Value                                                                          |
| RV2                                                       |  |  | 1.40             | M-ohms          | Lower V Pin Resistor Value                                                                          |
| VAC1                                                      |  |  | 115.0            | V               | Test Input Voltage Condition1                                                                       |
| VAC2                                                      |  |  | 230.0            | V               | Test Input Voltage Condition2                                                                       |
| IO_VAC1                                                   |  |  | 0.18             | A               | Measured Output Current at VAC1                                                                     |
| IO_VAC2                                                   |  |  | 0.18             | A               | Measured Output Current at VAC2                                                                     |
| RV1 (new)                                                 |  |  | 3.91             | M-ohms          | New RV1                                                                                             |
| RV2 (new)                                                 |  |  | 1.40             | M-ohms          | New RV2                                                                                             |
| V_OV                                                      |  |  | 318.3            | V               | Typical AC input voltage at which OV shutdown will be triggered                                     |
| V_UV                                                      |  |  | 70.8             | V               | Typical AC input voltage beyond which power supply can startup                                      |
| <b>FB pin resistor Fine Tuning</b>                        |  |  |                  |                 |                                                                                                     |
| RFB1                                                      |  |  | 109              | k-ohms          | Upper FB Pin Resistor Value                                                                         |
| RFB2                                                      |  |  | 1E+012           | k-ohms          | Lower FB Pin Resistor Value                                                                         |
| VB1                                                       |  |  | 17.9             | V               | Test Bias Voltage Condition1                                                                        |
| VB2                                                       |  |  | 22.1             | V               | Test Bias Voltage Condition2                                                                        |
| IO1                                                       |  |  | 0.18             | A               | Measured Output Current at Vb1                                                                      |
| IO2                                                       |  |  | 0.18             | A               | Measured Output Current at Vb2                                                                      |
| RFB1 (new)                                                |  |  | 109.1            | k-ohms          | New RFB1                                                                                            |
| RFB2(new)                                                 |  |  | 1.00E+12         | k-ohms          | New RFB2                                                                                            |
| <b>Input Current Harmonic Analysis</b>                    |  |  |                  |                 |                                                                                                     |
| <b>Harmonic</b>                                           |  |  | <b>% of Fund</b> | <b>Limit(%)</b> |                                                                                                     |
| 1st Harmonic                                              |  |  |                  |                 |                                                                                                     |
| 3rd Harmonic                                              |  |  | 17.14            | 27.00           | PASS. %age of 3rd Harmonic is lower than the limit                                                  |
| 5th Harmonic                                              |  |  | 6.3              | 10.00           | PASS. %age of 5th Harmonic is lower than the limit                                                  |
| 7th Harmonic                                              |  |  | 3.2              | 7.00            | PASS. %age of 7th Harmonic is lower than the limit                                                  |
| 9th Harmonic                                              |  |  | 1.92             | 5.00            | PASS. %age of 9th Harmonic is lower than the limit                                                  |
| 11th Harmonic                                             |  |  | 1.34             | 3.00            | PASS. %age of 11th Harmonic is lower than the limit                                                 |
| 13th Harmonic                                             |  |  | 1.02             | 3.00            | PASS. %age of 13th Harmonic is lower than the limit                                                 |
| 15th Harmonic                                             |  |  | 0.82             | 3.00            | PASS. %age of 15th Harmonic is lower than the limit                                                 |
| THD                                                       |  |  | 18.4             | %               | Estimated total Harmonic Distortion (THD)                                                           |



9 U1 散熱片組裝

9.1 散熱片製造圖

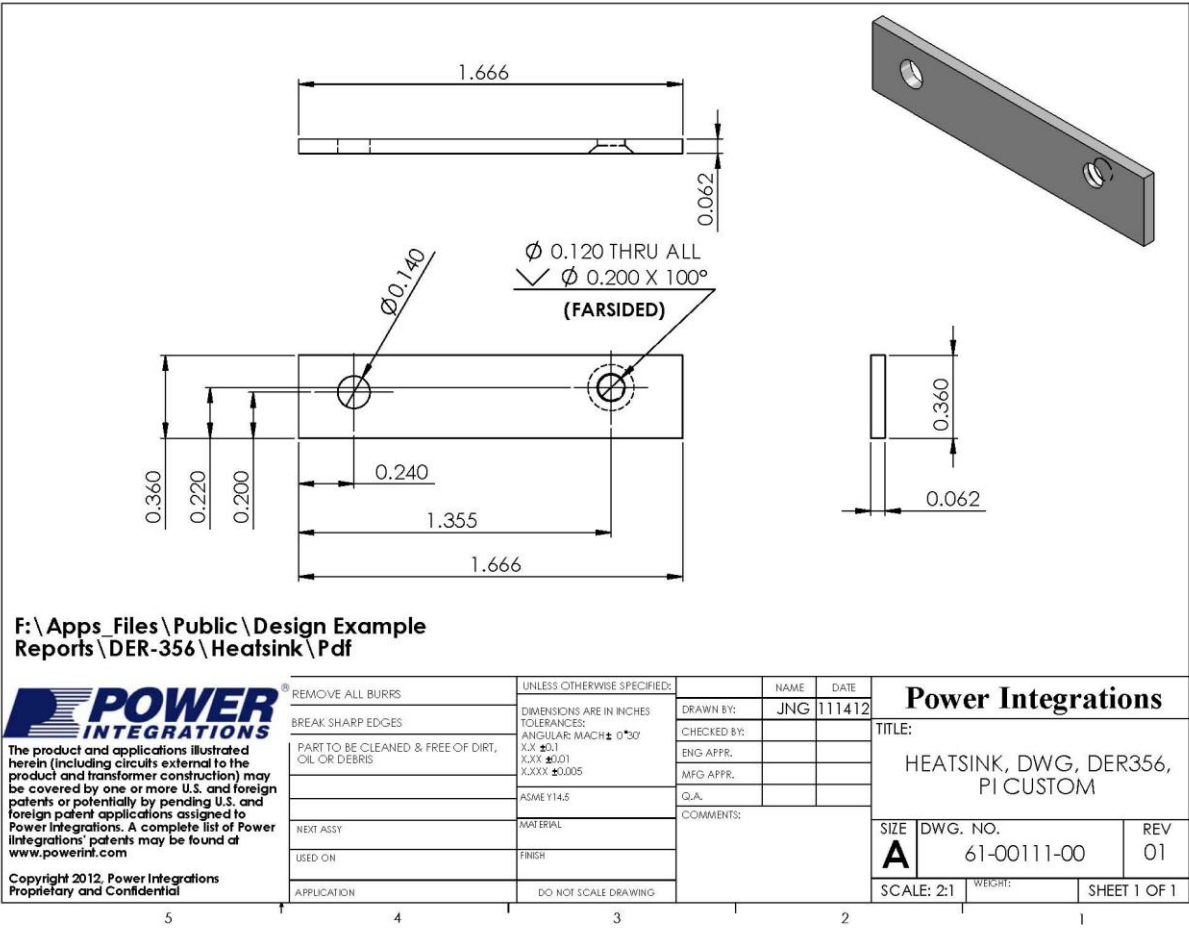


Figure 8 – U1 Heat Sink Dimensions.



## 9.2 散熱片組裝圖

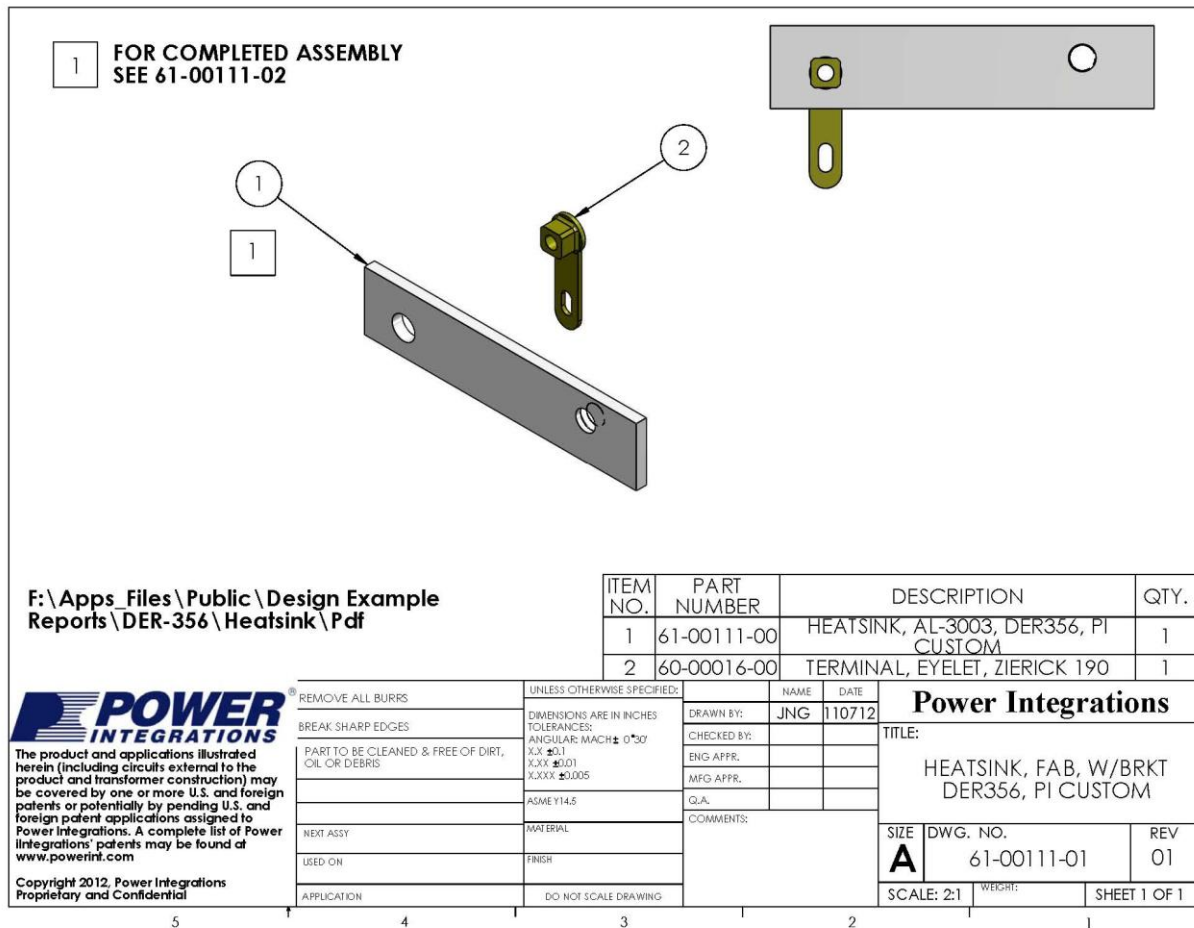


Figure 9 – U1 Heat Sink Fabrication Drawing.



9.3 散熱片和U1 組裝圖

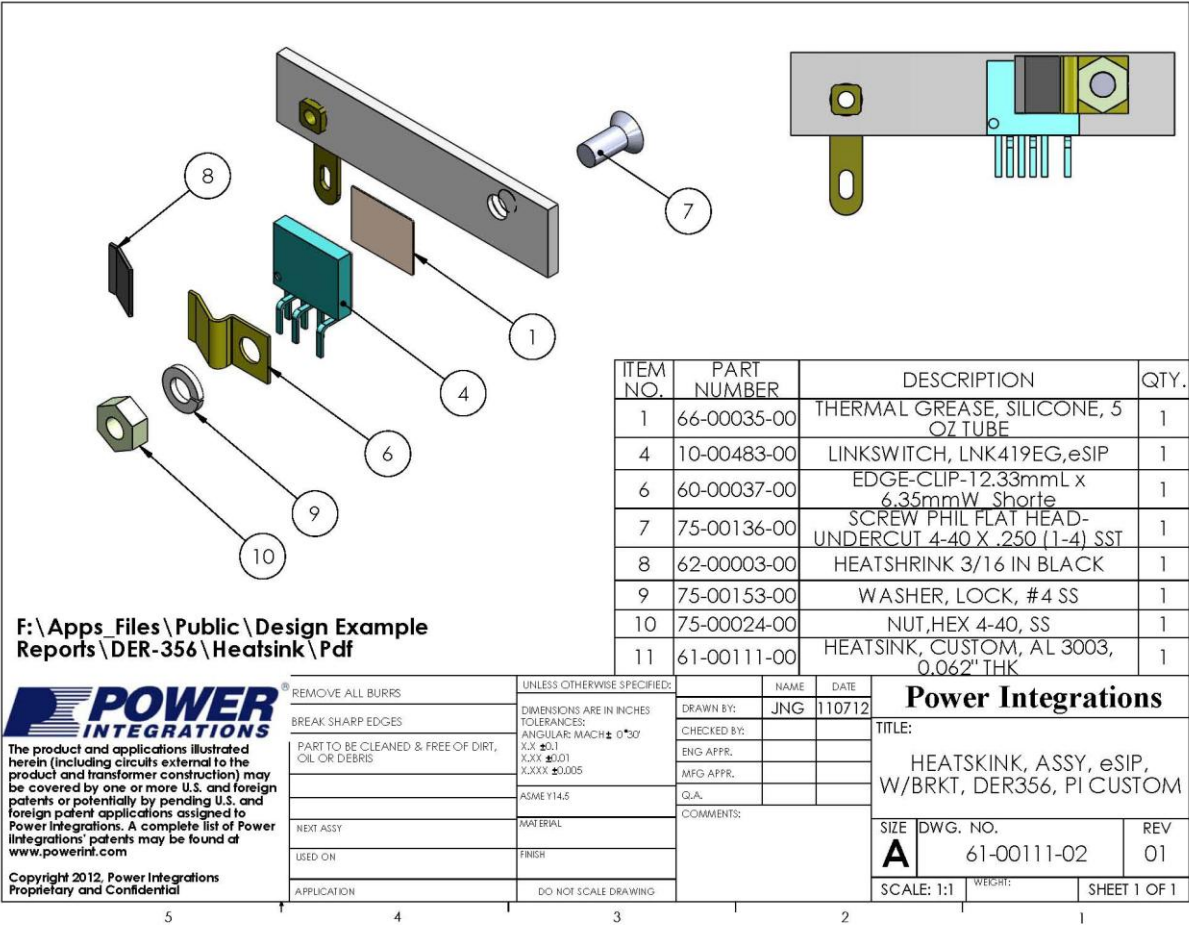


Figure 10 – U1 Heat Sink Assembly Drawing.

## 10 效能資料

The following data was compiled using 3 sets of load (121 V, 134 V, and 142 V LED strings). All measurements were performed at room temperature.

### 10.1 效率

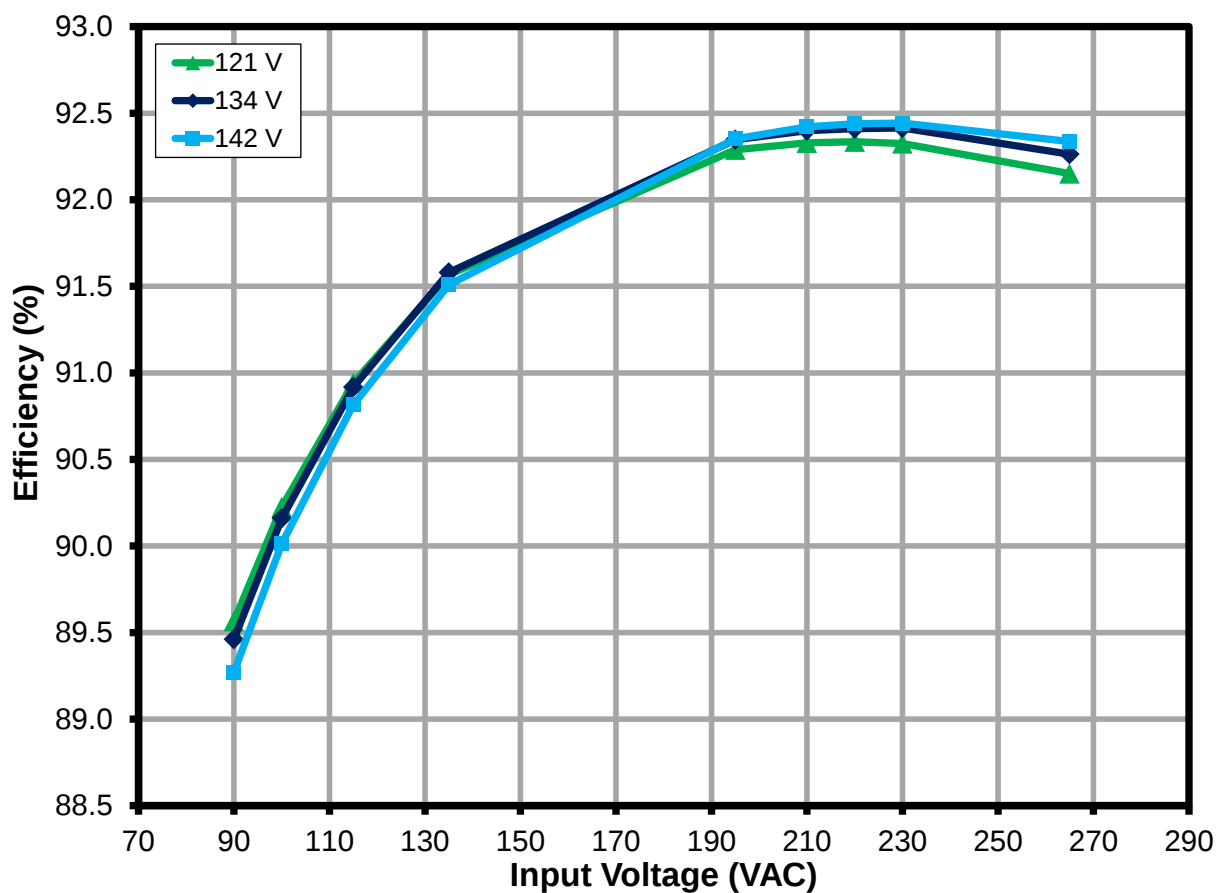


Figure 11 – Efficiency vs. Line and Load.

## 10.2 線電壓與負載穩定度關係圖

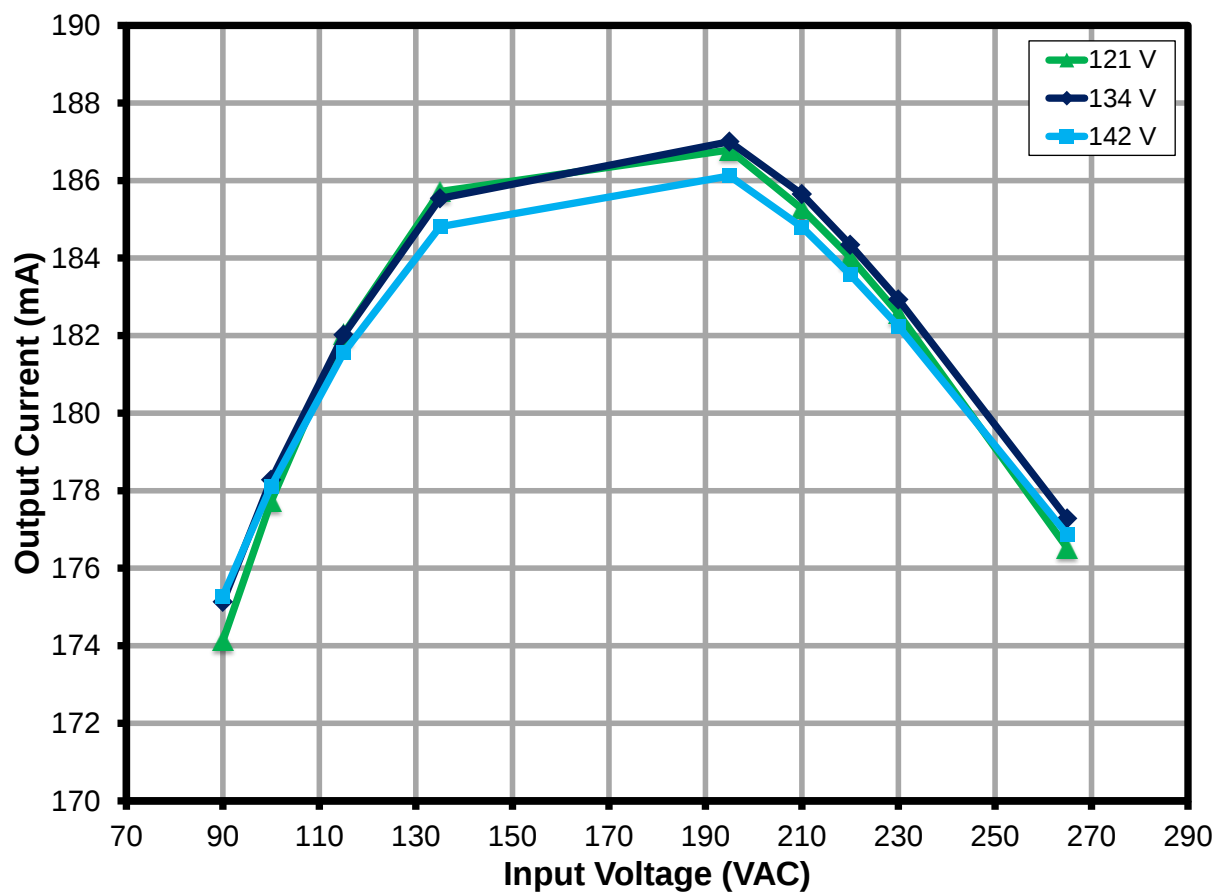


Figure 12 – Regulation vs. Line and Load.

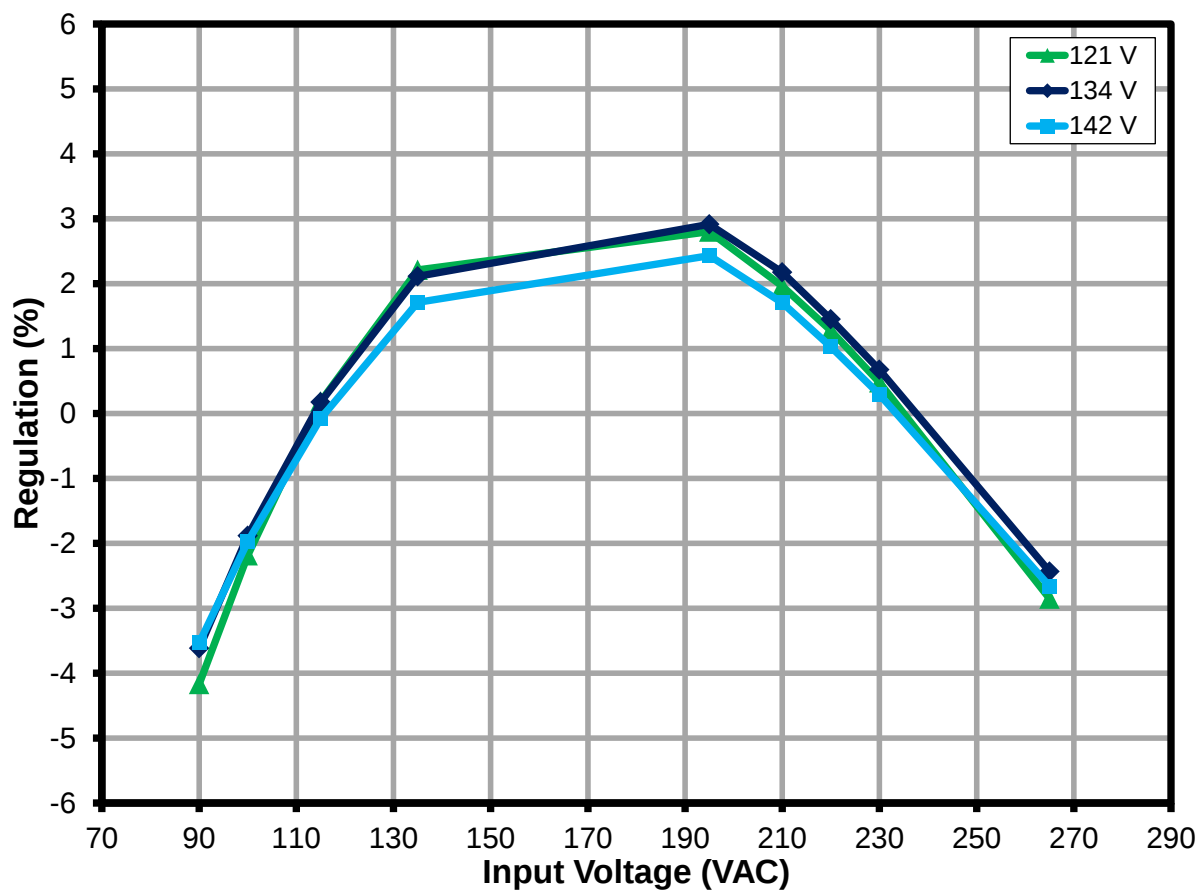


Figure 13 – Percent Line/Load Regulation.



### 10.3 功率因數

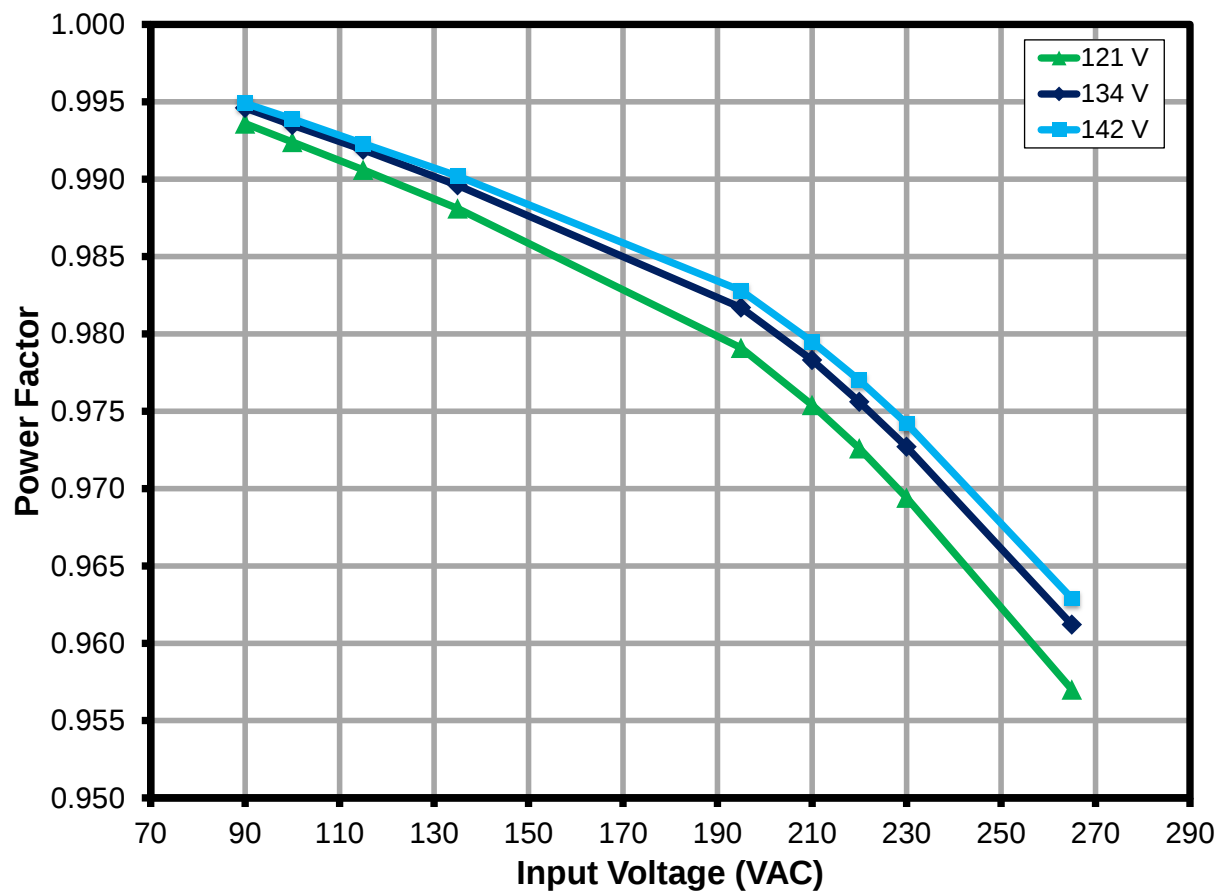
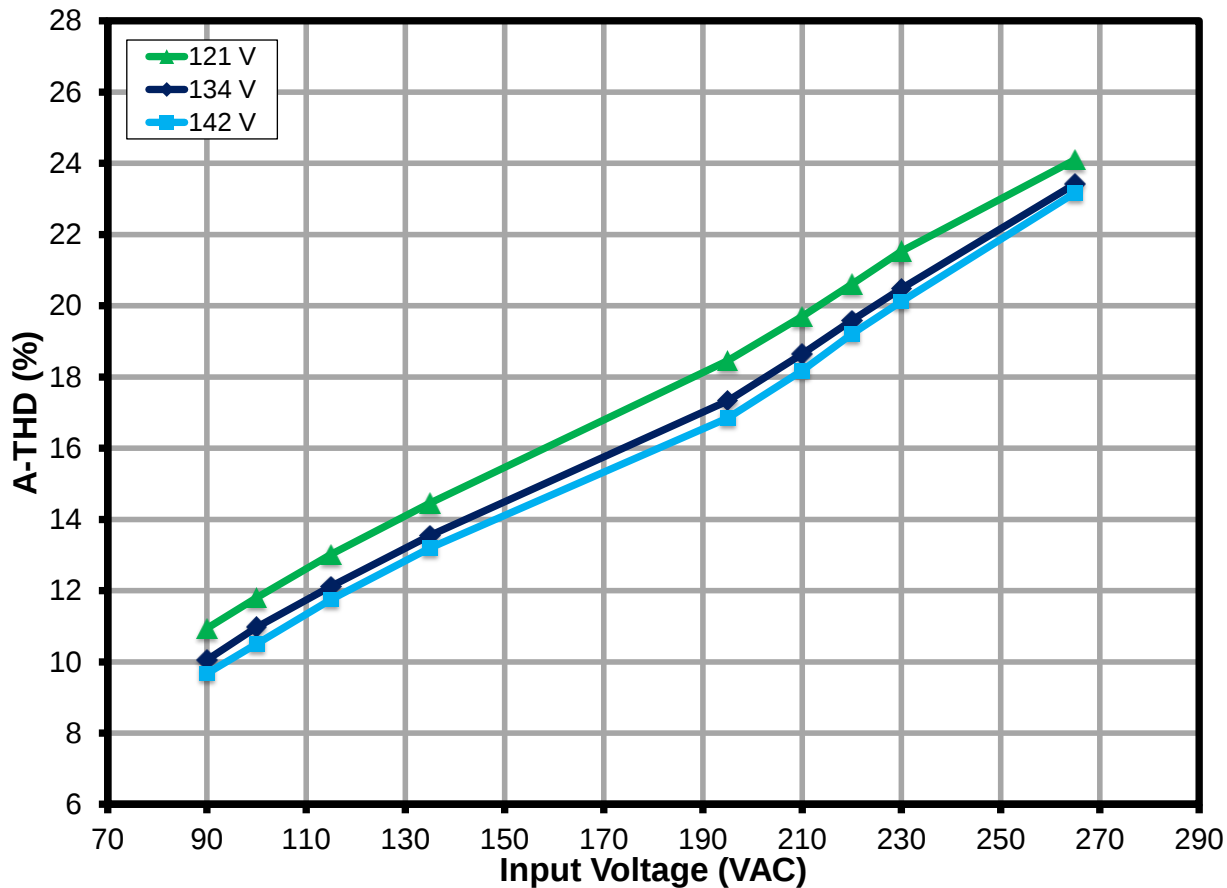


Figure 14 – Power Factor vs. Line and Load.



**10.4 A-THD****Figure 15 – A-THD vs. Line and Load.**

## 10.5 諧波

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.

### 10.5.1 115 V、60 Hz 輸入條件下的 134 V LED 負載

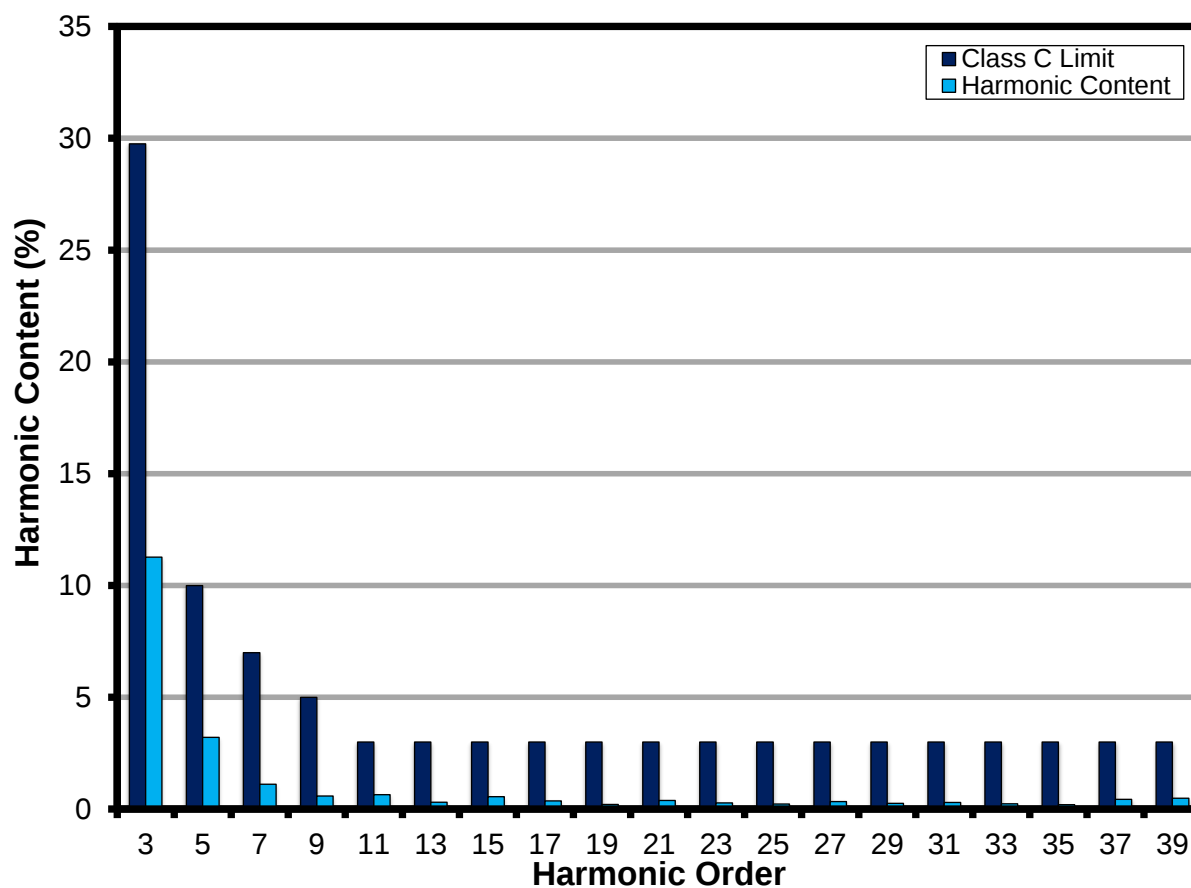


Figure 16 – 134 V LED Load Input Current Harmonics at 115 VAC, 60 Hz.

## 10.5.3 230 V、50 Hz 輸入條件下的 134 V LED 負載

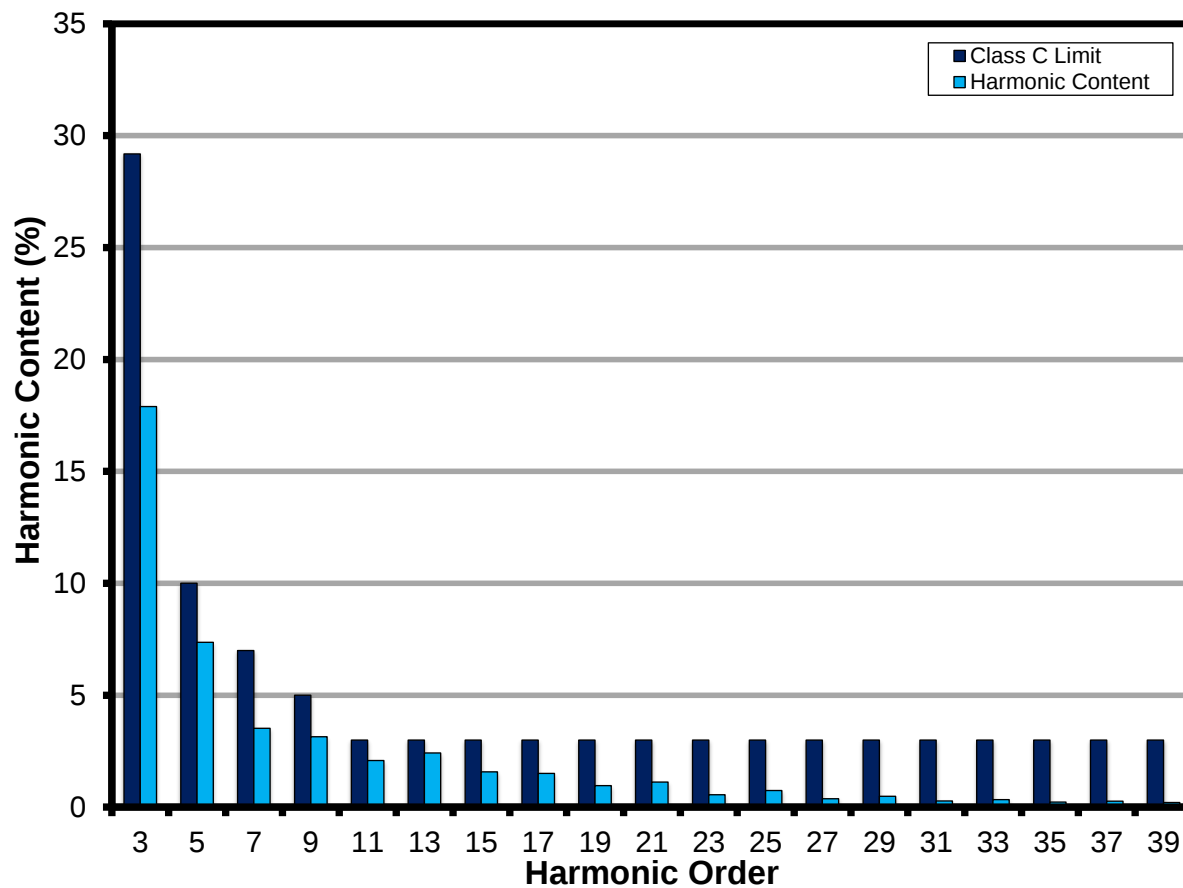


Figure 17 – 134 V LED Load Input Current Harmonics at 230 VAC, 50 Hz.



## 10.6 測試資料

All measurements were taken with the board in open frame configuration, and 25 °C ambient.

### 10.6.1 測試資料，121 V LED 負載

| Input                     |              | Input Measurement                      |                                         |                        |       |       | Load Measurement                       |                                         |                         | Calculation             |                   |             |          |
|---------------------------|--------------|----------------------------------------|-----------------------------------------|------------------------|-------|-------|----------------------------------------|-----------------------------------------|-------------------------|-------------------------|-------------------|-------------|----------|
| V <sub>RMS</sub><br>(VAC) | Freq<br>(Hz) | V <sub>IN</sub><br>(V <sub>RMS</sub> ) | I <sub>IN</sub><br>(mA <sub>RMS</sub> ) | P <sub>IN</sub><br>(W) | PF    | %ATHD | V <sub>OUT</sub><br>(V <sub>DC</sub> ) | I <sub>OUT</sub><br>(mA <sub>DC</sub> ) | P <sub>OUT</sub><br>(W) | P <sub>CAL</sub><br>(W) | Efficiency<br>(%) | Loss<br>(W) | %<br>Reg |
| 90                        | 60           | 89.91                                  | 264.01                                  | 23.584                 | 0.994 | 10.94 | 121.0700                               | 174.130                                 | 21.123                  | 21.08                   | 89.56             | 2.46        | 4.17     |
| 100                       | 60           | 99.95                                  | 241.02                                  | 23.907                 | 0.992 | 11.8  | 121.1200                               | 177.730                                 | 21.570                  | 21.53                   | 90.22             | 2.34        | 2.18     |
| 115                       | 60           | 114.97                                 | 213.43                                  | 24.308                 | 0.991 | 13.02 | 121.2000                               | 182.040                                 | 22.106                  | 22.06                   | 90.94             | 2.20        | 0.19     |
| 135                       | 60           | 134.96                                 | 184.78                                  | 24.642                 | 0.988 | 14.46 | 121.2600                               | 185.720                                 | 22.564                  | 22.52                   | 91.57             | 2.08        | 2.21     |
| 195                       | 50           | 195.00                                 | 128.85                                  | 24.601                 | 0.979 | 18.46 | 121.2500                               | 186.790                                 | 22.704                  | 22.65                   | 92.29             | 1.90        | 2.80     |
| 210                       | 50           | 209.94                                 | 119.04                                  | 24.377                 | 0.975 | 19.7  | 121.1900                               | 185.270                                 | 22.507                  | 22.45                   | 92.33             | 1.87        | 1.96     |
| 220                       | 50           | 219.98                                 | 113.11                                  | 24.200                 | 0.973 | 20.61 | 121.1500                               | 184.020                                 | 22.345                  | 22.29                   | 92.33             | 1.86        | 1.28     |
| 230                       | 50           | 230.02                                 | 107.62                                  | 23.999                 | 0.969 | 21.53 | 121.0900                               | 182.570                                 | 22.157                  | 22.11                   | 92.32             | 1.84        | 0.48     |
| 265                       | 50           | 265.04                                 | 91.53                                   | 23.215                 | 0.957 | 24.1  | 120.9500                               | 176.520                                 | 21.393                  | 21.35                   | 92.15             | 1.82        | -2.85    |

### 10.6.2 測試資料，134 V LED 負載

| Input                     |              | Input Measurement                      |                                         |                        |       |       | Load Measurement                       |                                         |                         | Calculation             |                   |             |          |
|---------------------------|--------------|----------------------------------------|-----------------------------------------|------------------------|-------|-------|----------------------------------------|-----------------------------------------|-------------------------|-------------------------|-------------------|-------------|----------|
| V <sub>RMS</sub><br>(VAC) | Freq<br>(Hz) | V <sub>IN</sub><br>(V <sub>RMS</sub> ) | I <sub>IN</sub><br>(mA <sub>RMS</sub> ) | P <sub>IN</sub><br>(W) | PF    | %ATHD | V <sub>OUT</sub><br>(V <sub>DC</sub> ) | I <sub>OUT</sub><br>(mA <sub>DC</sub> ) | P <sub>OUT</sub><br>(W) | P <sub>CAL</sub><br>(W) | Efficiency<br>(%) | Loss<br>(W) | %<br>Reg |
| 90                        | 60           | 89.90                                  | 294.78                                  | 26.358                 | 0.995 | 10.05 | 134.4100                               | 175.130                                 | 23.580                  | 23.54                   | 89.46             | 2.78        | -3.62    |
| 100                       | 60           | 99.94                                  | 268.15                                  | 26.626                 | 0.994 | 10.97 | 134.4200                               | 178.280                                 | 24.006                  | 23.96                   | 90.16             | 2.62        | -1.88    |
| 115                       | 60           | 114.96                                 | 236.46                                  | 26.964                 | 0.992 | 12.12 | 134.4500                               | 182.020                                 | 24.515                  | 24.47                   | 90.92             | 2.45        | 0.18     |
| 135                       | 60           | 134.96                                 | 204.35                                  | 27.292                 | 0.990 | 13.55 | 134.4800                               | 185.540                                 | 24.994                  | 24.95                   | 91.58             | 2.30        | 2.11     |
| 195                       | 50           | 194.99                                 | 142.53                                  | 27.282                 | 0.982 | 17.33 | 134.4400                               | 187.000                                 | 25.194                  | 25.14                   | 92.35             | 2.09        | 2.92     |
| 210                       | 50           | 209.93                                 | 131.71                                  | 27.051                 | 0.978 | 18.65 | 134.3500                               | 185.650                                 | 24.995                  | 24.94                   | 92.40             | 2.06        | 2.17     |
| 220                       | 50           | 219.98                                 | 125.06                                  | 26.839                 | 0.976 | 19.59 | 134.2700                               | 184.340                                 | 24.802                  | 24.75                   | 92.41             | 2.04        | 1.45     |
| 230                       | 50           | 230.02                                 | 118.96                                  | 26.616                 | 0.973 | 20.48 | 134.1900                               | 182.930                                 | 24.597                  | 24.55                   | 92.41             | 2.02        | 0.68     |
| 265                       | 50           | 265.04                                 | 101.26                                  | 25.797                 | 0.961 | 23.42 | 134.0200                               | 177.280                                 | 23.801                  | 23.76                   | 92.26             | 2.00        | -2.43    |

### 10.6.3 測試資料，142 V LED 負載

| Input                     |              | Input Measurement                      |                                         |                        |       |       | Load Measurement                       |                                         |                         | Calculation             |                   |             |          |
|---------------------------|--------------|----------------------------------------|-----------------------------------------|------------------------|-------|-------|----------------------------------------|-----------------------------------------|-------------------------|-------------------------|-------------------|-------------|----------|
| V <sub>RMS</sub><br>(VAC) | Freq<br>(Hz) | V <sub>IN</sub><br>(V <sub>RMS</sub> ) | I <sub>IN</sub><br>(mA <sub>RMS</sub> ) | P <sub>IN</sub><br>(W) | PF    | %ATHD | V <sub>OUT</sub><br>(V <sub>DC</sub> ) | I <sub>OUT</sub><br>(mA <sub>DC</sub> ) | P <sub>OUT</sub><br>(W) | P <sub>CAL</sub><br>(W) | Efficiency<br>(%) | Loss<br>(W) | %<br>Reg |
| 90                        | 60           | 89.90                                  | 312.51                                  | 27.951                 | 0.995 | 9.67  | 142.1300                               | 175.280                                 | 24.952                  | 24.91                   | 89.27             | 3.00        | -3.53    |
| 100                       | 60           | 99.94                                  | 283.66                                  | 28.177                 | 0.994 | 10.5  | 142.1700                               | 178.120                                 | 25.363                  | 25.32                   | 90.01             | 2.81        | -1.97    |
| 115                       | 60           | 114.97                                 | 249.48                                  | 28.462                 | 0.992 | 11.75 | 142.1400                               | 181.560                                 | 25.848                  | 25.81                   | 90.82             | 2.61        | -0.08    |
| 135                       | 60           | 134.96                                 | 215.32                                  | 28.774                 | 0.990 | 13.2  | 142.2700                               | 184.810                                 | 26.331                  | 26.29                   | 91.51             | 2.44        | 1.71     |
| 195                       | 50           | 195.00                                 | 149.83                                  | 28.713                 | 0.983 | 16.85 | 142.2000                               | 186.120                                 | 26.517                  | 26.47                   | 92.35             | 2.20        | 2.43     |
| 210                       | 50           | 209.94                                 | 138.39                                  | 28.459                 | 0.980 | 18.18 | 142.0600                               | 184.800                                 | 26.302                  | 26.25                   | 92.42             | 2.16        | 1.71     |
| 220                       | 50           | 219.98                                 | 131.44                                  | 28.249                 | 0.977 | 19.21 | 141.9900                               | 183.570                                 | 26.113                  | 26.07                   | 92.44             | 2.14        | 1.03     |
| 230                       | 50           | 230.02                                 | 125.08                                  | 28.028                 | 0.974 | 20.12 | 141.9200                               | 182.240                                 | 25.910                  | 25.86                   | 92.44             | 2.12        | 0.30     |
| 265                       | 50           | 265.04                                 | 106.55                                  | 27.194                 | 0.963 | 23.17 | 141.7500                               | 176.870                                 | 25.110                  | 25.07                   | 92.34             | 2.08        | -2.66    |



## 10.6.4 115 VAC、60 Hz 輸入條件下的 134 V LED 負載諧波資料

| V   | Freq         | I (mA)        | P            | PF            | %THD    |
|-----|--------------|---------------|--------------|---------------|---------|
| 115 | 60.00        | 236.46        | 26.9640      | 0.9919        | 12.12   |
|     | nth<br>Order | mA<br>Content | %<br>Content | Class C Limit | Remarks |
|     | 1            | 234.47        |              |               |         |
|     | 2            | 0.18          | 0.08%        | 2.00%         |         |
|     | 3            | 26.43         | 11.27%       | 29.76%        | PASS    |
|     | 5            | 7.53          | 3.21%        | 10.00%        | PASS    |
|     | 7            | 2.61          | 1.11%        | 7.00%         | PASS    |
|     | 9            | 1.38          | 0.59%        | 5.00%         | PASS    |
|     | 11           | 1.52          | 0.65%        | 3.00%         | PASS    |
|     | 13           | 0.73          | 0.31%        | 3.00%         | PASS    |
|     | 15           | 1.30          | 0.55%        | 3.00%         | PASS    |
|     | 17           | 0.87          | 0.37%        | 3.00%         | PASS    |
|     | 19           | 0.49          | 0.21%        | 3.00%         | PASS    |
|     | 21           | 0.92          | 0.39%        | 3.00%         | PASS    |
|     | 23           | 0.66          | 0.28%        | 3.00%         | PASS    |
|     | 25           | 0.54          | 0.23%        | 3.00%         | PASS    |
|     | 27           | 0.80          | 0.34%        | 3.00%         | PASS    |
|     | 29           | 0.60          | 0.26%        | 3.00%         | PASS    |
|     | 31           | 0.69          | 0.29%        | 3.00%         | PASS    |
|     | 33           | 0.56          | 0.24%        | 3.00%         | PASS    |
|     | 35           | 0.46          | 0.20%        | 3.00%         | PASS    |
|     | 37           | 1.02          | 0.44%        | 3.00%         | PASS    |
|     | 39           | 1.14          | 0.49%        | 3.00%         | PASS    |



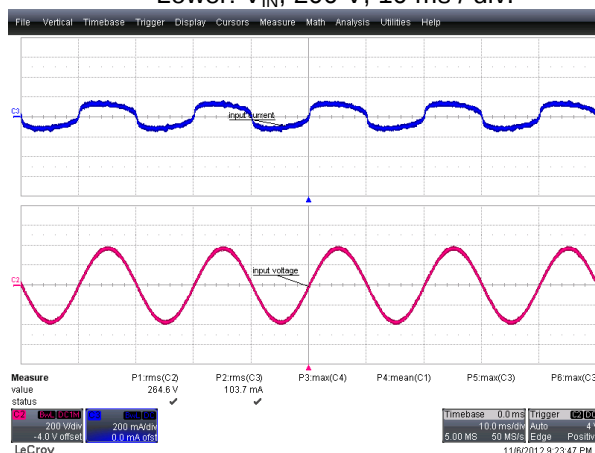
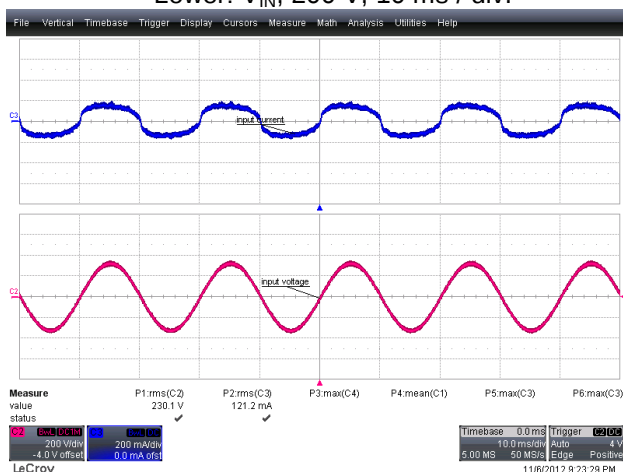
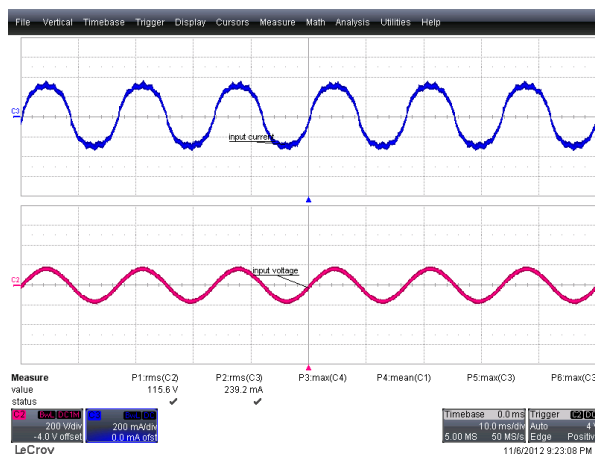
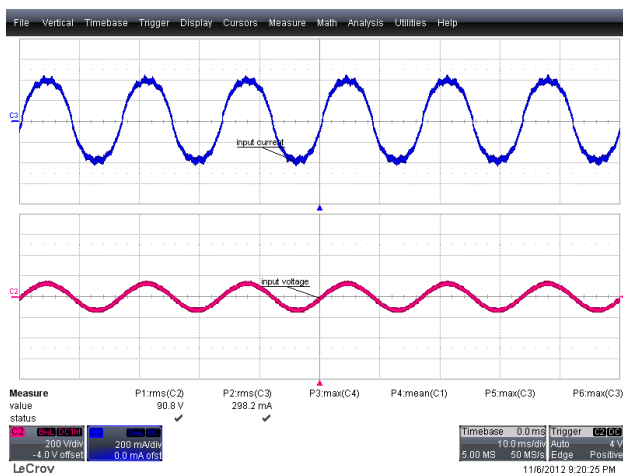
## 10.6.5 230 VAC、50 Hz 輸入條件下的 134 V LED 負載諧波資料

| V   | Freq         | I (mA)        | P            | PF             | %THD    |
|-----|--------------|---------------|--------------|----------------|---------|
| 230 | 50.00        | 118.96        | 26.6160      | 0.9727         | 20.48   |
|     | nth<br>Order | mA<br>Content | %<br>Content | Limit<br>>25 W | Remarks |
|     | 1            | 116.30        |              |                |         |
|     | 2            | 0.12          | 0.10%        | 2.00%          |         |
|     | 3            | 20.81         | 17.89%       | 29.18%         | PASS    |
|     | 5            | 8.56          | 7.36%        | 10.00%         | PASS    |
|     | 7            | 4.10          | 3.53%        | 7.00%          | PASS    |
|     | 9            | 3.66          | 3.15%        | 5.00%          | PASS    |
|     | 11           | 2.42          | 2.08%        | 3.00%          | PASS    |
|     | 13           | 2.81          | 2.42%        | 3.00%          | PASS    |
|     | 15           | 1.83          | 1.57%        | 3.00%          | PASS    |
|     | 17           | 1.75          | 1.50%        | 3.00%          | PASS    |
|     | 19           | 1.12          | 0.96%        | 3.00%          | PASS    |
|     | 21           | 1.30          | 1.12%        | 3.00%          | PASS    |
|     | 23           | 0.64          | 0.55%        | 3.00%          | PASS    |
|     | 25           | 0.87          | 0.75%        | 3.00%          | PASS    |
|     | 27           | 0.44          | 0.38%        | 3.00%          | PASS    |
|     | 29           | 0.56          | 0.48%        | 3.00%          | PASS    |
|     | 31           | 0.32          | 0.28%        | 3.00%          | PASS    |
|     | 33           | 0.39          | 0.34%        | 3.00%          | PASS    |
|     | 35           | 0.26          | 0.22%        | 3.00%          | PASS    |
|     | 37           | 0.31          | 0.27%        | 3.00%          | PASS    |
|     | 39           | 0.24          | 0.21%        | 3.00%          | PASS    |

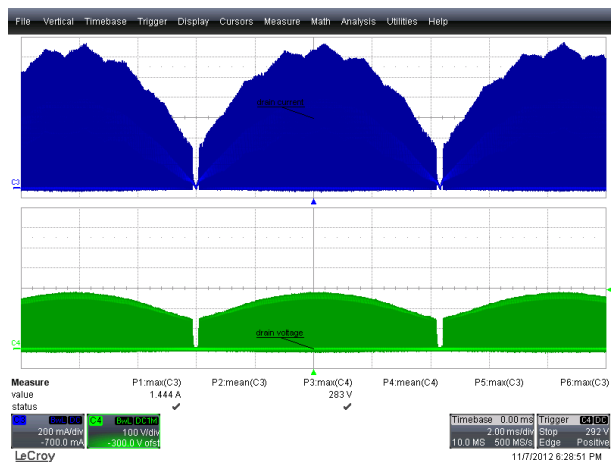


## 11 波形

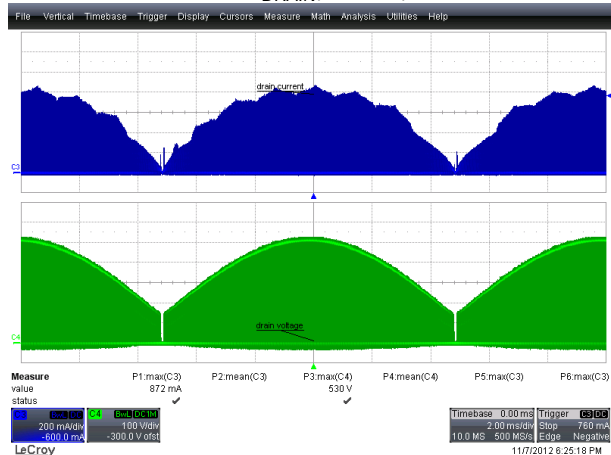
### 11.1 輸入線電流



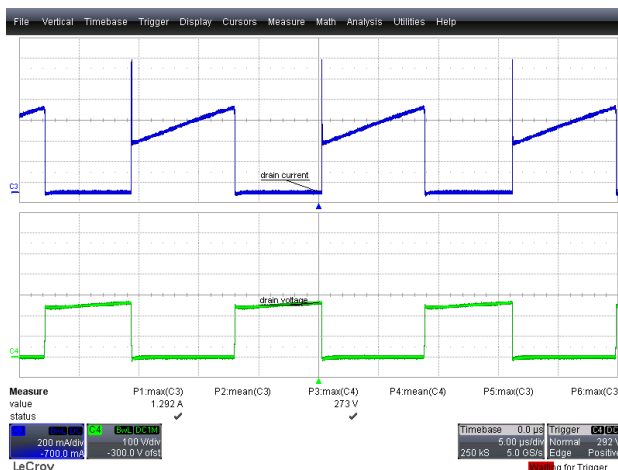
## 11.2 汲極電壓和電流與正常操作



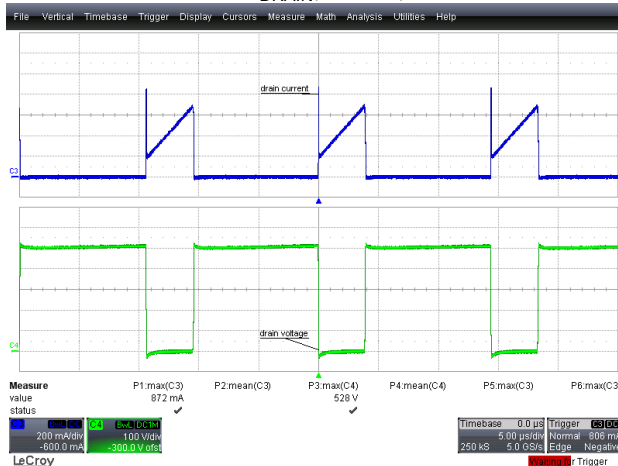
**Figure 22 – 90 VAC 60 Hz, Full Load.**  
Upper:  $I_{DRAIN}$ , 200 mA / div.  
Lower:  $V_{DRAIN}$ , 100 V, 2 ms / div.



**Figure 24 – 265 VAC 50 Hz, Full Load.**  
Upper:  $I_{DRAIN}$ , 200 mA / div.  
Lower:  $V_{DRAIN}$ , 100 V, 2 ms / div.

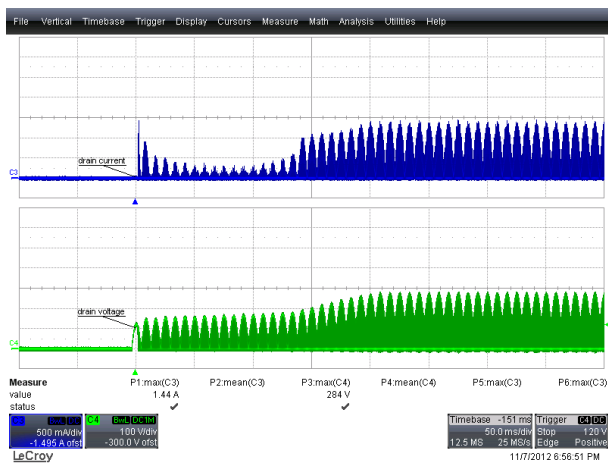


**Figure 23 – 90 VAC 60 Hz, Full Load.**  
Upper:  $I_{DRAIN}$ , 200 mA / div.  
Lower:  $V_{DRAIN}$ , 100 V, 5  $\mu$ s / div.

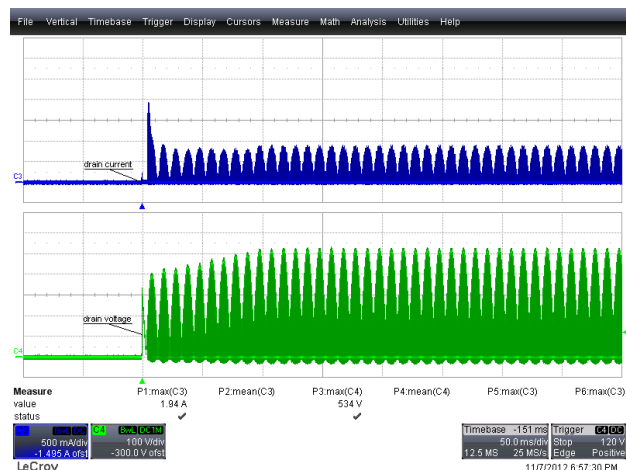


**Figure 25 – 265 VAC 50 Hz, Full Load.**  
Upper:  $I_{DRAIN}$ , 200 mA / div.  
Lower:  $V_{DRAIN}$ , 100 V, 5  $\mu$ s / div.

### 11.3 汲極電壓和電流啟動操作



**Figure 26** – 90 VAC 60 Hz, Full Load Start-up.  
Upper:  $I_{DRAIN}$ , 500 mA / div.  
Lower:  $V_{DRAIN}$ , 100 V, 50 ms / div.



**Figure 27** – 265 VAC 50 Hz, Full Load Start-up.  
Upper:  $I_{DRAIN}$ , 500 mA / div.  
Lower:  $V_{DRAIN}$ , 100 V, 50 ms / div.



## 11.4 輸出電流與輸出電壓

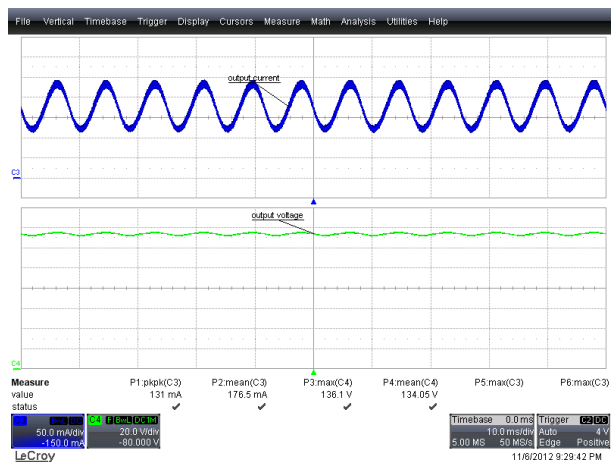


Figure 28 – 90 VAC 60 Hz, Full Load.

Upper:  $I_{OUT}$ , 50 mA / div.

Lower:  $V_{OUT}$ , 20 V, 10 ms / div.

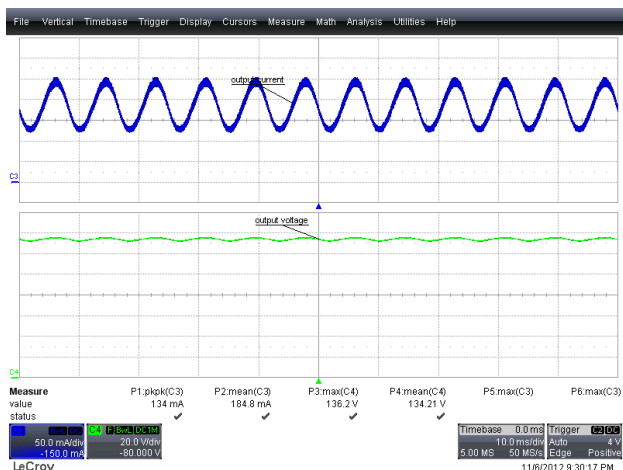


Figure 29 – 115 VAC 60 Hz, Full Load.

Upper:  $I_{OUT}$ , 50 mA / div.

Lower:  $V_{OUT}$ , 20 V, 10 ms / div.

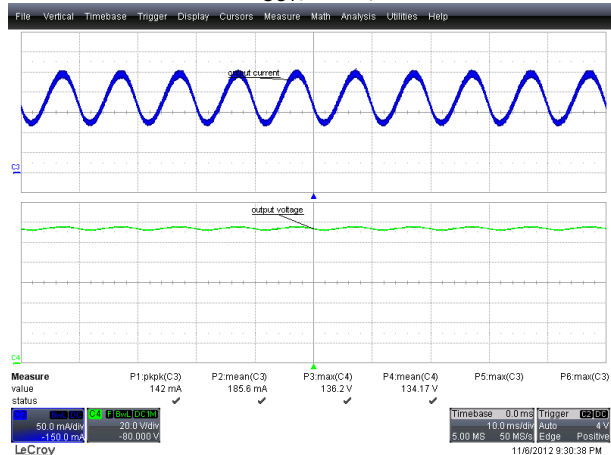


Figure 30 – 230 VAC 50 Hz, Full Load.

Upper:  $I_{OUT}$ , 50 mA / div.

Lower:  $V_{OUT}$ , 20 V, 10 ms / div.

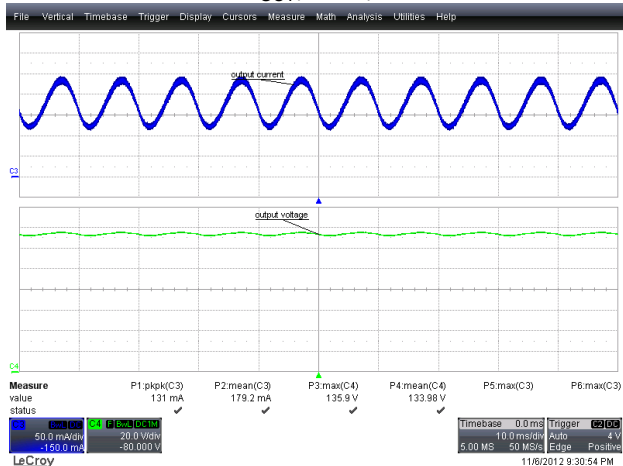


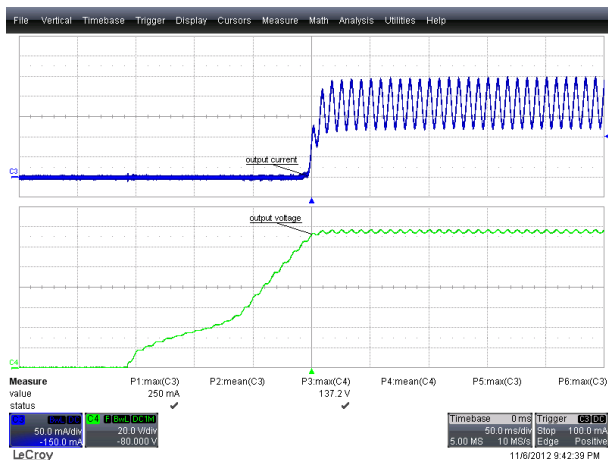
Figure 31 – 265 VAC 50 Hz, Full Load.

Upper:  $I_{OUT}$ , 50 mA / div.

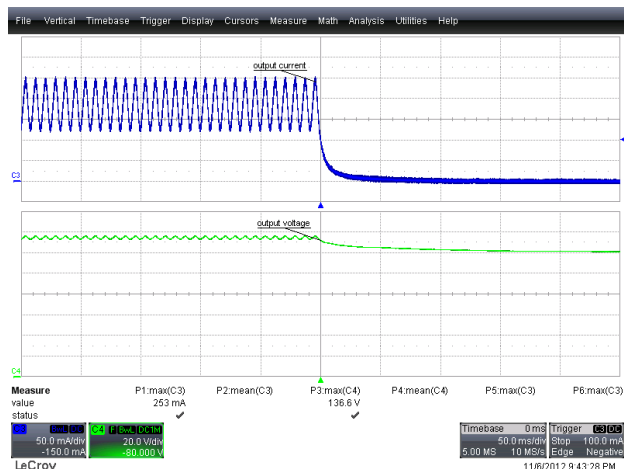
Lower:  $V_{OUT}$ , 20 V, 10 ms / div.



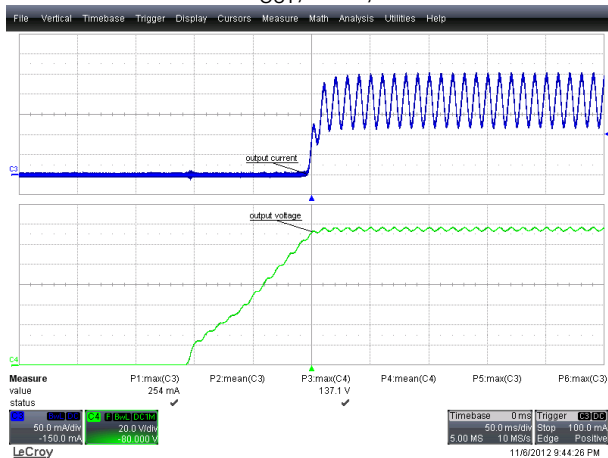
## 11.5 開機、關機時的輸出電流與電壓



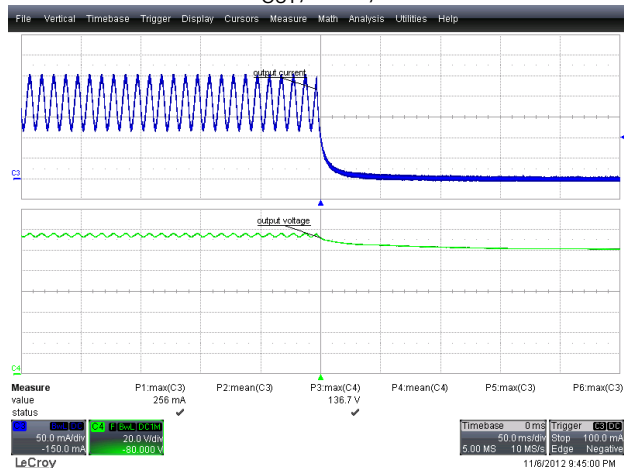
**Figure 32 – 115 VAC 60 Hz, Output Rise.**  
Upper:  $I_{OUT}$ , 50 mA / div.  
Lower:  $V_{OUT}$ , 20 V, 50 ms / div.



**Figure 33 – 115 VAC 60 Hz, Output Fall.**  
Upper:  $I_{OUT}$ , 50 mA / div.  
Lower:  $V_{OUT}$ , 20 V, 50 ms / div.



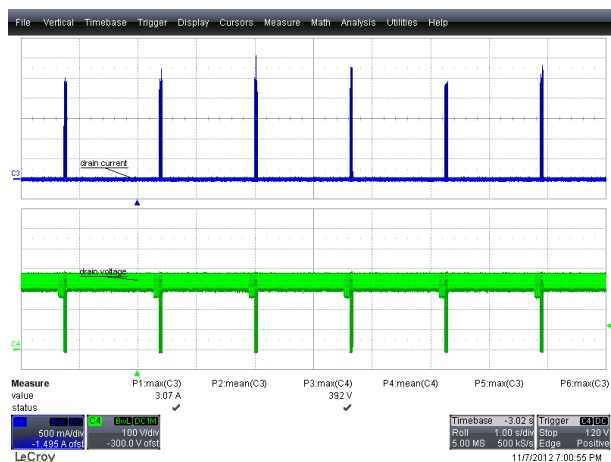
**Figure 34 – 230 VAC 50 Hz, Output Rise.**  
Upper:  $I_{OUT}$ , 50 mA / div.  
Lower:  $V_{OUT}$ , 20 V, 50 ms / div.



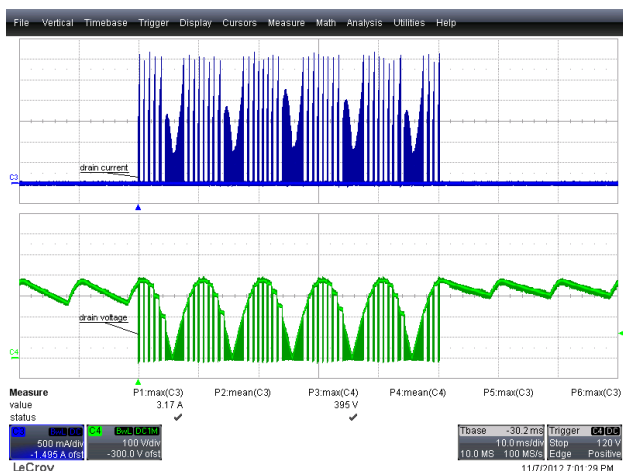
**Figure 35 – 230 VAC 50 Hz, Output Fall.**  
Upper:  $I_{OUT}$ , 50 mA / div.  
Lower:  $V_{OUT}$ , 20 V, 50 ms / div.



## 11.6 輸出短路



**Figure 36** – 265 VAC 50 Hz, Output Short.  
Upper:  $I_{DRAIN}$ , 0.5 A / div.  
Lower:  $V_{DRAIN}$ , 100 V, 1 s / div.



**Figure 37** – 265 VAC 50 Hz, Output Short.  
Upper:  $I_{DRAIN}$ , 0.5 A / div.  
Lower:  $V_{DRAIN}$ , 100 V, 10 ms / div.

## 11.7 開路負載



**Figure 38** – 265 VAC 50 Hz, Open Load.  
Upper:  $V_{DRAIN}$ , 100 V / div.  
Lower:  $V_{OUT}$ , 50 V, 200 ms / div.



**Figure 39** – 265 VAC 50 Hz, Open Load Start-up  
Upper:  $V_{DRAIN}$ , 100 V / div.  
Lower:  $V_{OUT}$ , 50 V, 200 ms / div.



## 12 散熱測量

Thermal measurements were done with the EUT operated at room temperature, 134 V LED Load

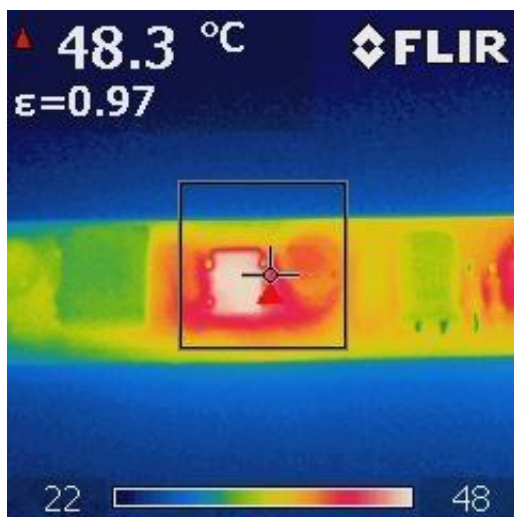


Figure 40 – Input Area, 110 VAC, 60 Hz

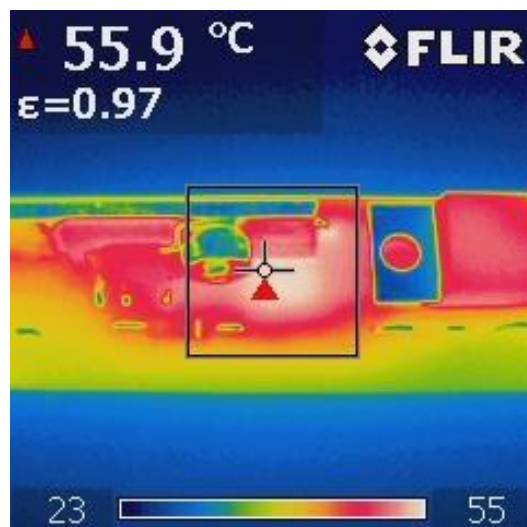


Figure 41 – LNK419EG Area, 110 VAC, 60 Hz

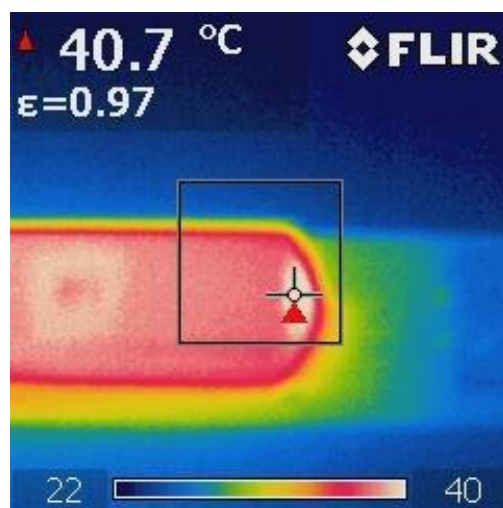
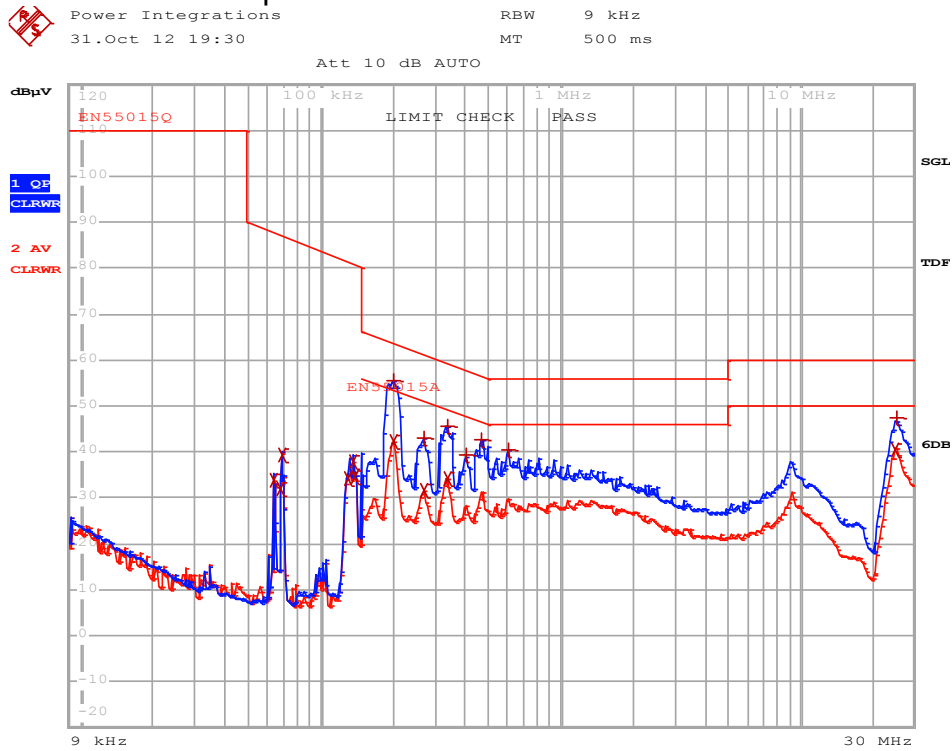


Figure 42 – Output Area, 110 VAC, 60 Hz

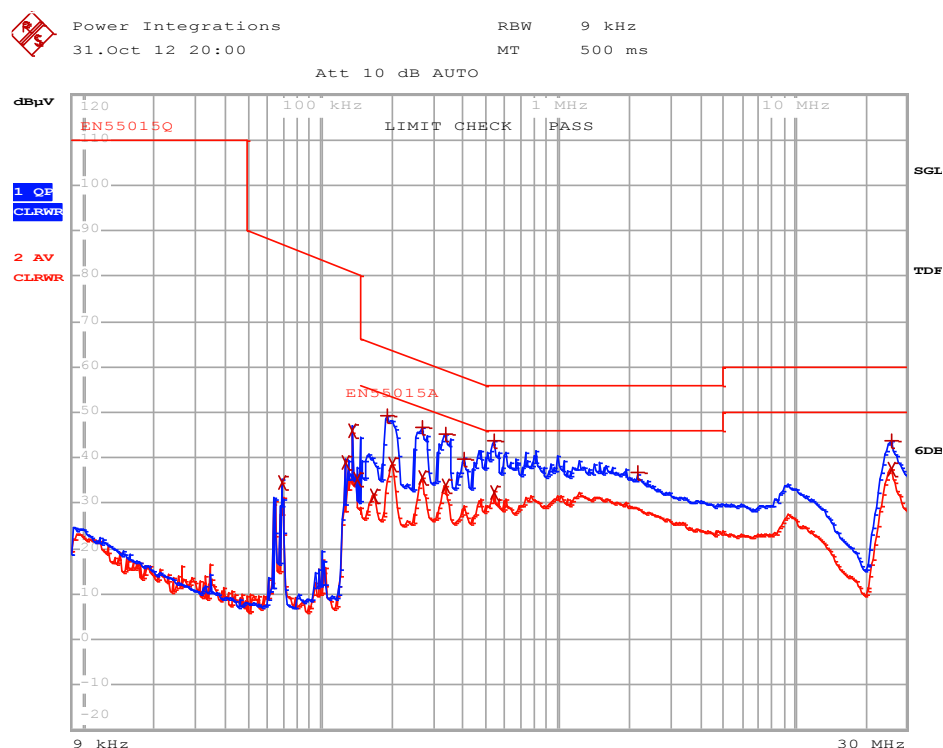
13 傳導性 EMI 測量

The unit was tested using ~ 134 V LED strings as load with an input voltage of 230 VAC, 60 Hz at room temperature.



| EDIT PEAK LIST (Final Measurement Results) |                   |            |                |        |  |
|--------------------------------------------|-------------------|------------|----------------|--------|--|
| Trace1:                                    | EN55015Q          |            |                |        |  |
| Trace2:                                    | EN55015A          |            |                |        |  |
| Trace3:                                    | ---               |            |                |        |  |
| TRACE                                      | FREQUENCY         | LEVEL dBμV | DELTA LIMIT dB |        |  |
| 2 Average                                  | 63.9076936414 kHz | 34.01      | L1 gnd         |        |  |
| 2 Average                                  | 67.1676282959 kHz | 31.88      | N gnd          |        |  |
| 2 Average                                  | 68.5176976246 kHz | 39.49      | L1 gnd         |        |  |
| 2 Average                                  | 129.530094744 kHz | 34.19      | N gnd          |        |  |
| 2 Average                                  | 136.137431366 kHz | 37.75      | L1 gnd         |        |  |
| 2 Average                                  | 138.873793737 kHz | 34.40      | L1 gnd         |        |  |
| 1 Quasi Peak                               | 200.175581485 kHz | 55.37      | L1 gnd         | -8.23  |  |
| 2 Average                                  | 200.175581485 kHz | 42.37      | L1 gnd         | -11.22 |  |
| 1 Quasi Peak                               | 267.135089486 kHz | 43.02      | L1 gnd         | -18.18 |  |
| 2 Average                                  | 267.135089486 kHz | 31.62      | L1 gnd         | -19.58 |  |
| 1 Quasi Peak                               | 335.832355405 kHz | 45.66      | L1 gnd         | -13.64 |  |
| 2 Average                                  | 335.832355405 kHz | 34.29      | L1 gnd         | -15.01 |  |
| 1 Quasi Peak                               | 401.705024172 kHz | 39.28      | L1 gnd         | -18.52 |  |
| 1 Quasi Peak                               | 466.367062279 kHz | 42.56      | N gnd          | -14.01 |  |
| 1 Quasi Peak                               | 604.06488251 kHz  | 40.46      | N gnd          | -15.53 |  |
| 2 Average                                  | 24.9618853035 MHz | 40.45      | L1 gnd         | -9.54  |  |
| 1 Quasi Peak                               | 25.2115041566 MHz | 47.61      | L1 gnd         | -12.38 |  |

Figure 43 – Conducted EMI, 134 V LED Load, 115 VAC, 60 Hz, EN55015B Limits.



## EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55015Q

Trace2: EN55015A

Trace3: ---

|   | TRACE      | FREQUENCY         | LEVEL dBpV |        | DELTA LIMIT dB |
|---|------------|-------------------|------------|--------|----------------|
| 2 | Average    | 68.5176976246 kHz | 34.65      | L1 gnd |                |
| 2 | Average    | 126.977840157 kHz | 38.88      | L1 gnd |                |
| 2 | Average    | 136.137431366 kHz | 45.83      | L1 gnd |                |
| 2 | Average    | 141.665156991 kHz | 35.36      | N gnd  |                |
| 2 | Average    | 167.350252 kHz    | 31.78      | N gnd  | -23.30         |
| 1 | Quasi Peak | 190.46019728 kHz  | 49.13      | L1 gnd | -14.88         |
| 2 | Average    | 200.175581485 kHz | 38.67      | L1 gnd | -14.92         |
| 1 | Quasi Peak | 267.135089486 kHz | 46.62      | L1 gnd | -14.58         |
| 2 | Average    | 267.135089486 kHz | 35.71      | L1 gnd | -15.49         |
| 1 | Quasi Peak | 335.832355405 kHz | 45.10      | L1 gnd | -14.19         |
| 2 | Average    | 335.832355405 kHz | 33.96      | L1 gnd | -15.33         |
| 1 | Quasi Peak | 401.705024172 kHz | 39.85      | N gnd  | -17.96         |
| 1 | Quasi Peak | 536.076911993 kHz | 43.86      | L1 gnd | -12.13         |
| 2 | Average    | 536.076911993 kHz | 32.50      | L1 gnd | -13.49         |
| 1 | Quasi Peak | 2.18042326152 MHz | 36.71      | L1 gnd | -19.28         |
| 1 | Quasi Peak | 25.4636191981 MHz | 43.61      | L1 gnd | -16.38         |
| 2 | Average    | 25.4636191981 MHz | 37.36      | L1 gnd | -12.63         |

Figure 44 – Conducted EMI, 134 V LED Load, 230 VAC, 60 Hz, EN55015B Limits.

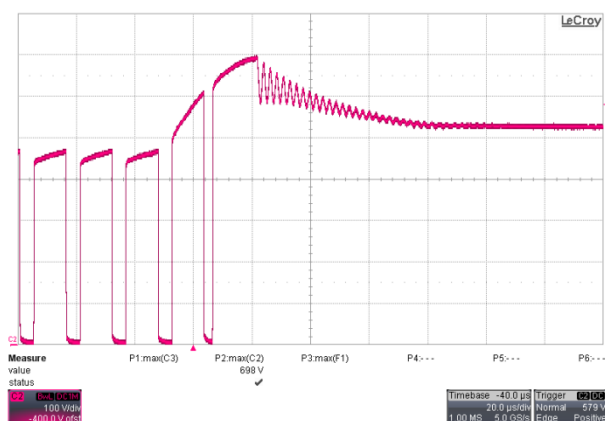


## 14 線電壓突波測試

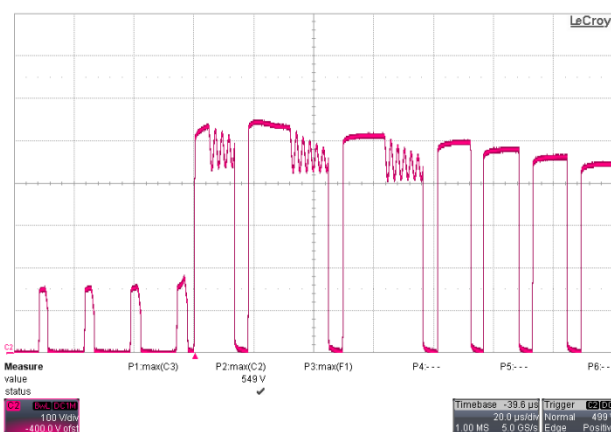
The unit was subjected to  $\pm 2500$  V, 100 kHz ring wave and  $\pm 500$  V differential surge at 230 VAC using 10 strikes at each condition. A test failure was defined as a non-recoverable interruption of output requiring supply repair or recycling of input voltage.

| 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                    |

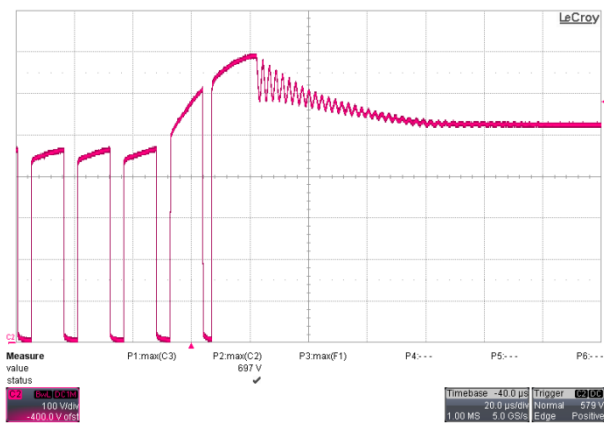
| Level (V) | Input Voltage (VAC) | Injection Location | Injection Phase (°) | Type                | Test Result (Pass/Fail) |
|-----------|---------------------|--------------------|---------------------|---------------------|-------------------------|
| +500      | 230                 | L1, L2    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



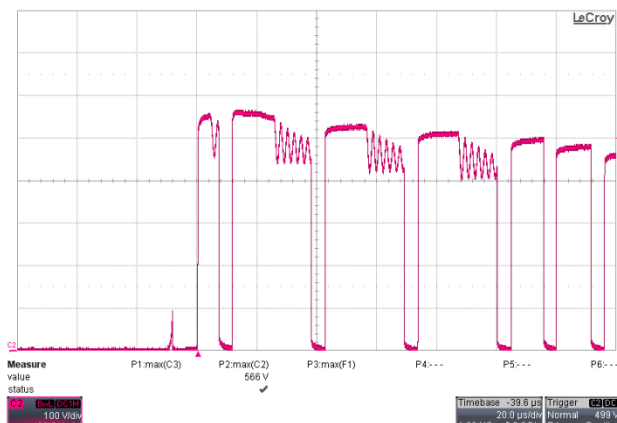
**Figure 45 – (+) 500 V Differential Surge, 90°**  
 $V_{DRAIN}$ , 100 V, 20  $\mu$ s / div.



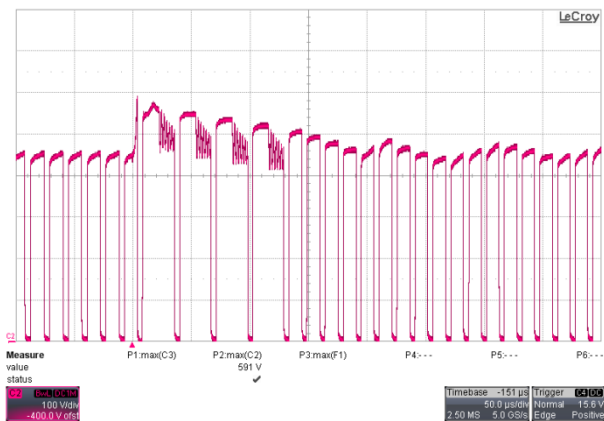
**Figure 46 – (+) 500 V Differential Surge, 0°**  
 $V_{DRAIN}$ , 100 V, 20  $\mu$ s / div.



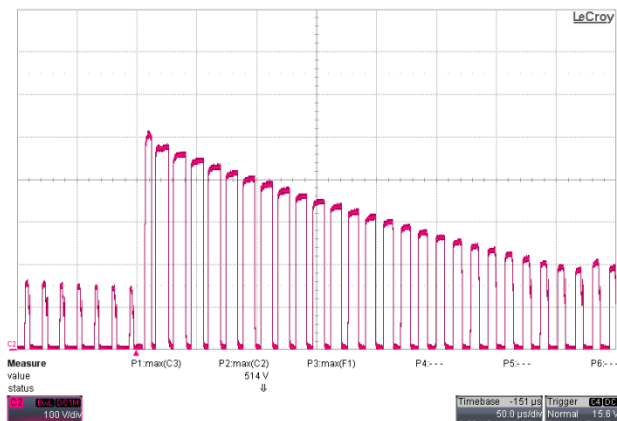
**Figure 47 – (-) 500 V Differential Surge, 90°**  
 $V_{DRAIN}$ , 100 V, 20  $\mu$ s / div.



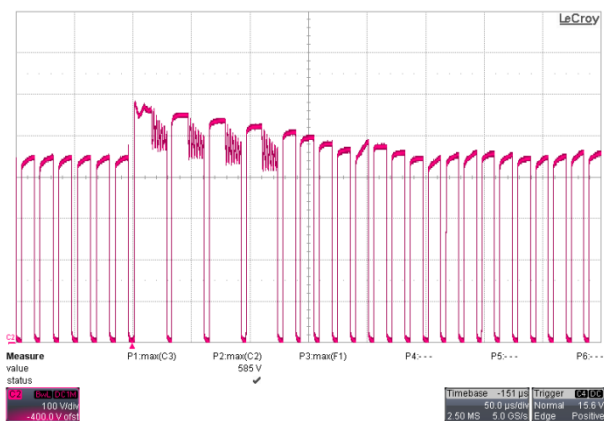
**Figure 48 – (-) 500 V Differential Surge, 0°**  
 $V_{DRAIN}$ , 100 V, 20  $\mu$ s / div.



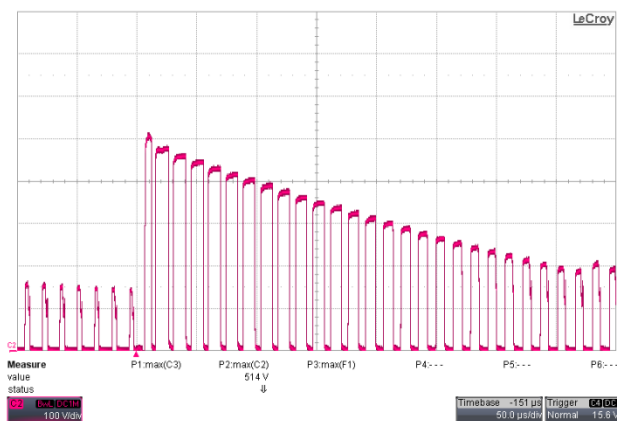
**Figure 49 – (+) 2.5 kV Ring Wave, 90°**  
 $V_{DRAIN}$ , 100 V, 50  $\mu$ s / div.



**Figure 50 – (+) 2.5 kV Ring Wave, 0°**  
 $V_{DRAIN}$ , 100 V, 50  $\mu$ s / div.



**Figure 51 – (-) 2.5 kV Ring Wave, 90°**  
 $V_{DRAIN}$ , 100 V, 50  $\mu$ s / div.



**Figure 52 – (-) 2.5 kV Ring Wave, 0°**  
 $V_{DRAIN}$ , 100 V, 50  $\mu$ s / div.

**15 修訂記錄**

| Date     | Author | Revision | Description and Changes | Reviewed      |
|----------|--------|----------|-------------------------|---------------|
| 6-Dec-12 | DS     | 1.0      | Initial Release         | Apps and Mktg |
|          |        |          |                         |               |



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### Power Integrations 全球銷售支援地點

#### 全球總部

5245 Hellyer Avenue  
San Jose, CA 95138, USA.  
總機：+1-408-414-9200  
客戶服務：  
電話：+1-408-414-9665  
傳真：+1-408-414-9765  
電子郵件：[usasales@powerint.com](mailto:usasales@powerint.com)

#### 德國

Lindwurmstrasse 114  
80337, Munich  
Germany  
電話：+49-895-527-39110  
傳真：+49-895-527-39200  
電子郵件：[eurosales@powerint.com](mailto:eurosales@powerint.com)

#### 日本

Kosei Dai-3 Building  
2-12-11, Shin-Yokohama,  
Kohoku-ku, Yokohama-shi,  
Kanagawa 222-0033  
Japan  
電話：+81-45-471-1021  
傳真：+81-45-471-3717  
電子郵件：[japansales@powerint.com](mailto:japansales@powerint.com)

#### 台灣

5F, No. 318, Nei Hu Rd.,  
Sec. 1  
Nei Hu District  
Taipei 11493, Taiwan R.O.C.  
電話：+886-2-2659-4570  
傳真：+886-2-2659-4550  
電子郵件：[taiwansales@powerint.com](mailto:taiwansales@powerint.com)

#### 中國 (上海)

Rm 1601/1610, Tower 1,  
Kerry Everbright City  
No. 218 Tianmu Road West,  
Shanghai, P.R.C. 200070  
電話：+86-21-6354-6323  
傳真：+86-21-6354-6325  
電子郵件：[chinasales@powerint.com](mailto:chinasales@powerint.com)

#### 印度

#1, 14<sup>th</sup> Main Road  
Vasanthanagar  
Bangalore-560052  
India  
電話：+91-80-4113-8020  
傳真：+91-80-4113-8023  
電子郵件：[indiasales@powerint.com](mailto:indiasales@powerint.com)

#### 韓國

RM 602, 6FL  
Korea City Air Terminal B/D,  
159-6  
Samsung-Dong, Kangnam-Gu,  
Seoul, 135-728 Korea  
電話：+82-2-2016-6610  
傳真：+82-2-2016-6630  
電子郵件：[koreasales@powerint.com](mailto:koreasales@powerint.com)

#### 歐洲總部

1st Floor, St. James's House  
East Street, Farnham  
Surrey GU9 7TJ  
United Kingdom  
電話：+44 (0) 1252-730-141  
傳真：+44 (0) 1252-727-689  
電子郵件：[eurosales@powerint.com](mailto:eurosales@powerint.com)

#### 中國 (深圳)

3rd Floor, Block A,  
Zhongtuo International Business  
Center, No. 1061, Xiang Mei Rd,  
FuTian District, ShenZhen,  
China, 518040  
電話：+86-755-8379-3243  
傳真：+86-755-8379-5828  
電子郵件：[chinasales@powerint.com](mailto:chinasales@powerint.com)

#### 義大利

Via Milanese 20, 3<sup>rd</sup> Fl.  
20099 Sesto San Giovanni  
(MI) Italy  
電話：+39-024-550-8701  
傳真：+39-028-928-6009  
電子郵件：[eurosales@powerint.com](mailto:eurosales@powerint.com)

#### 新加坡

51 Newton Road,  
#19-01/05 Goldhill Plaza  
Singapore, 308900  
電話：+65-6358-2160  
傳真：+65-6358-2015  
電子郵件：[singaporesales@powerint.com](mailto:singaporesales@powerint.com)

#### 應用服務專線

全球 +1-408-414-9660

#### 應用服務傳真

全球 +1-408-414-9760

