



# EVX2002-44018A-00A

## 120W, 2C1A Adapter Evaluation Board

**PRELIMINARY SPECIFICATIONS SUBJECT TO CHANGE**

### DESCRIPTION

The EVX2002-44018A-00A evaluation board is a 120W, 2C1A adapter designed to demonstrate the capabilities of the MP44018A and MPX2002.

The MP44018A is a critical conduction mode (CrM)/discontinuous conduction mode (DCM), multi-mode power factor correction (PFC) controller that provides simple and high-performance active PFC using minimal external components. The switching frequency ( $f_{sw}$ ) is reduced by dead time (DT) extension technology under light-load conditions, which improves light-load efficiency. The MP44018A also achieves reduced total harmonic distortion (THD) due to variable-on-time control in DCM compared to conventional constant-on-time (COT) control.

The MPX2002 is an all-in-one flyback controller with an integrated primary driving circuit, secondary controller, synchronous rectification driver, and safety-compliant feedback. The device offers the benefits of both primary-side regulation (PSR) and secondary-side regulation

(SSR). A feedback circuit is not required, as a synchronous rectifier (SR) can be matched with the driving signal of the primary-side MOSFET. The SR can operate safely in continuous conduction mode (CCM), which increases the overall efficiency and design flexibility.

The MPX2002 adopts novel quasi-resonant (QR) mode switching when it runs in DCM. Due to this feature, the power supply has improved efficiency. Under very light loads, the controller enters burst mode to achieve very low standby power consumption. The MPX2002 offers frequency jittering to help dissipate the energy generated by conducted noise.

The EVX2002-44018A-00A evaluation board provides a detailed reference design. This datasheet contains the complete specification of the power supply, a detailed circuit diagram, the entire bill of materials required to build the power supply, a drawing of the transformers, and performance testing.

### PERFORMANCE SUMMARY

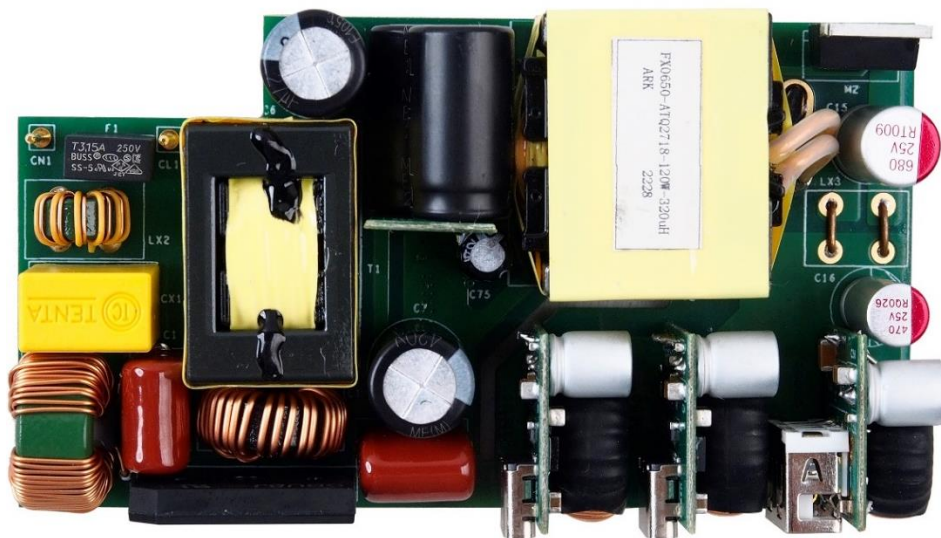
Specifications are at  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

| Parameters                                                                 | Conditions                 | Value                                   |
|----------------------------------------------------------------------------|----------------------------|-----------------------------------------|
| Input AC voltage ( $V_{AC}$ )                                              |                            | 90V <sub>AC</sub> to 264V <sub>AC</sub> |
| Input AC frequency                                                         |                            | 47Hz to 63Hz                            |
| Output voltage ( $V_{OUT}$ ) / output current ( $I_{OUT}$ ) <sup>(1)</sup> | USB-C1 / USB-C2            | 100W                                    |
|                                                                            | USB-C1 + USB-C2            | 60W + 60W                               |
|                                                                            | USB-C1 / USB-C2 + USB-A    | 87W + 30W                               |
|                                                                            | USB-C1 + USB-C2 + USB-A    | 60W + 30W + 30W                         |
| Maximum efficiency                                                         | USB-C1 + USB-C2: 60W + 60W | 93.58%                                  |

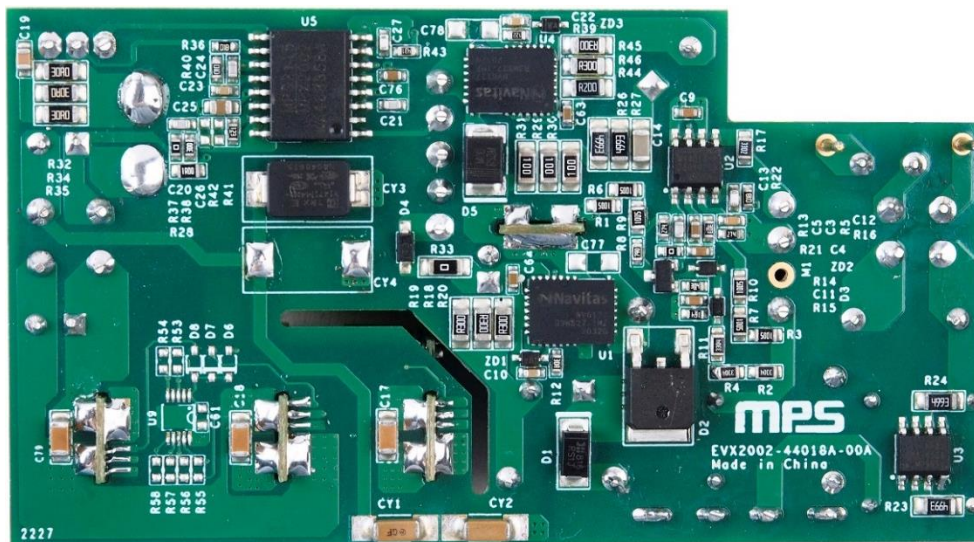
**Note:**

- 1) An additional microcontroller unit (MCU) is required to achieve power distribution.

## EVX2002-44018A-00A EVALUATION BOARD



Top Layer



Bottom Layer

LxWxH (92mmx50mmx23.5mm)

| Board Number       | MPS IC Number |
|--------------------|---------------|
| EVX2002-44018A-00A | MPX2002GY-Z   |
|                    | MP44018-AGS-Z |

## QUICK START GUIDE

1. Preset the AC input voltage ( $V_{AC}$ ) to be between  $90V_{AC}$  and  $264V_{AC}$ .
2. Turn the AC power supply off.
3. Connect the load to the Type-C connector or Type-A connector.
4. Connect the power supply's line and neutral terminals to the AC input.
5. Turn the power supply on. The board should start up automatically.

# EVALUATION BOARD SCHEMATICS

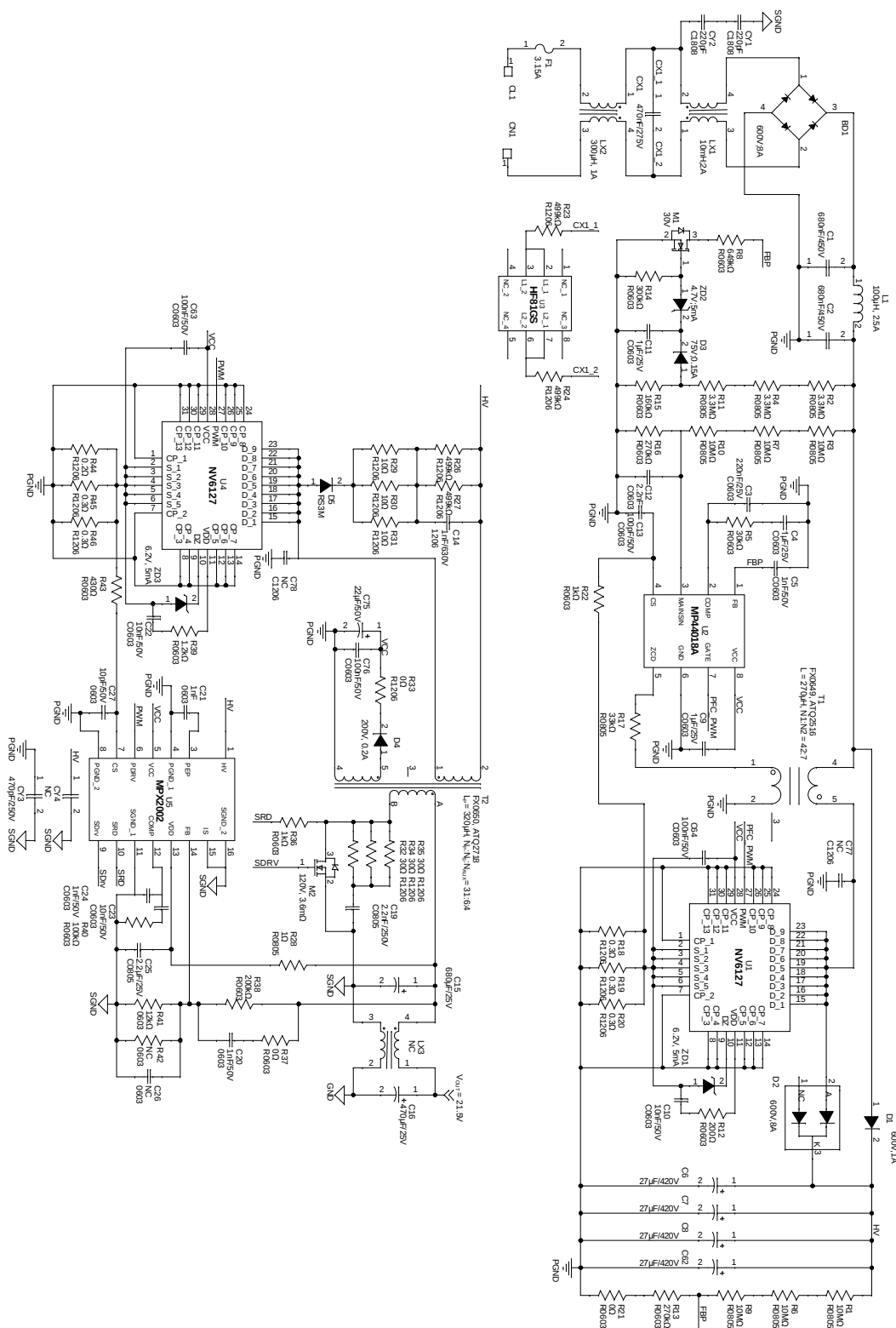
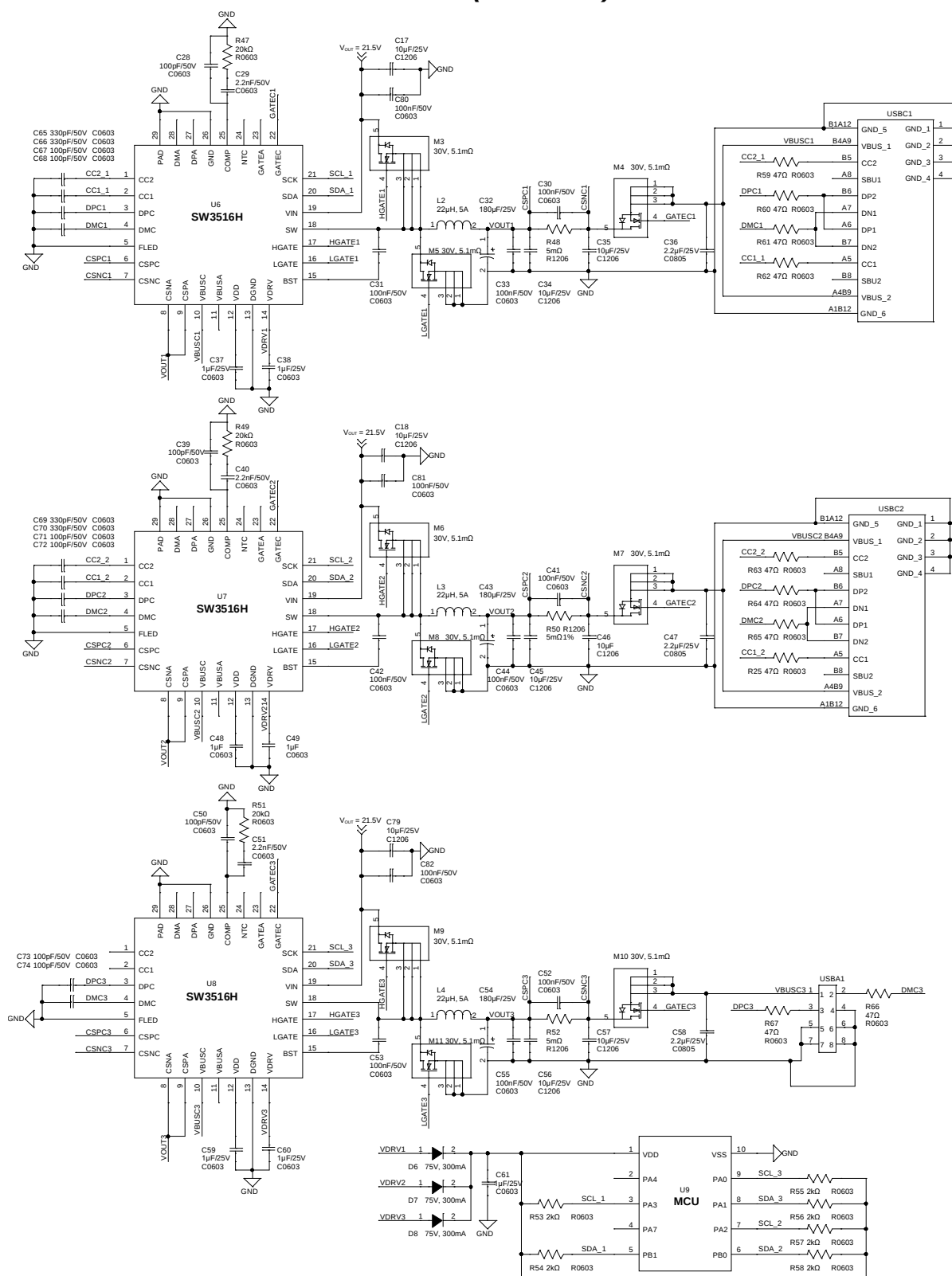


Figure 1: PFC and Flyback Controller

**EVALUATION BOARD SCHEMATICS (continued)**

**Figure 2: DC/DC and PD Controller**

**EVX2002-44018A-00A BILL OF MATERIALS**

| Qty | Ref                                                                       | Value | Description                     | Package | Manufacturer | Manufacturer PN    |
|-----|---------------------------------------------------------------------------|-------|---------------------------------|---------|--------------|--------------------|
| 1   | BD1                                                                       | 600V  | Bridge rectifier, 8A            | DIP     | FSC          | GBU8J              |
| 2   | C1, C2                                                                    | 680nF | CBB capacitor, 450V             | DIP     | CARLI        | TF684K2Y10BL270D9R |
| 1   | C3                                                                        | 220nF | Ceramic capacitor, 25V, X7R     | 0603    | Murata       | GRM188R71E224KA88  |
| 9   | C4, C9, C11, C37, C38, C48, C49, C59, C60                                 | 1μF   | Ceramic capacitor, 25V, X7R     | 0603    | Murata       | GCM188R71E105KA64D |
| 4   | C5, C20, C21, C24                                                         | 1nF   | Ceramic capacitor, 25V, C0G     | 0603    | Murata       | GRM1885C1E102JA01D |
| 4   | C6, C7, C8, C62                                                           | 27μF  | Electrolytic capacitor, 420V    | DIP     | Beryl        | ME 420V27uF 10X18  |
| 3   | C10, C22, C23                                                             | 10nF  | Ceramic capacitor, 50V, X7R     | 0603    | Murata       | GRM188R71H103KA01D |
| 4   | C12, C29, C40, C51                                                        | 2.2nF | Ceramic capacitor, 50V, X7R     | 0603    | Murata       | GRM188R71H222KA01D |
| 10  | C13, C28, C39, C50, C67, C68, C71, C72, C73, C74                          | 100pF | Ceramic capacitor, 50V, C0G     | 0603    | Murata       | GRM1885C1H101JA01D |
| 1   | C14                                                                       | 1nF   | Ceramic capacitor, 630V, U2J    | 1206    | Murata       | GRM31A7U2J102JW31D |
| 1   | C15                                                                       | 680μF | Electrolytic capacitor, 25V     | DIP     | Zhongyuan    | RT681M25F160       |
| 1   | C16                                                                       | 470μF | Electrolytic Capacitor, 25V     | DIP     | Zhongyuan    | RQ471M025E150      |
| 9   | C17, C18, C34, C35, C45, C46, C56, C57, C79                               | 10μF  | Ceramic capacitor, 25V, X7R     | 1206    | Murata       | GRM31CR71E106KA12  |
| 1   | C19                                                                       | 2.2nF | Ceramic capacitor, 250V, X7R    | 0805    | TDK          | C2012X7R2E222K     |
| 4   | C25, C36, C47, C58                                                        | 2.2μF | Ceramic capacitor, 50V, X7R     | 0805    | TDK          | C2012X7R1H225K     |
| 1   | C26                                                                       | NC    |                                 |         |              |                    |
| 1   | C27                                                                       | 10pF  | Ceramic capacitor, 50V, C0G     | 0603    | Murata       | GRM1885C1H100JA01  |
| 15  | C30, C31, C33, C41, C42, C44, C52, C53, C55, C63, C64, C76, C80, C81, C82 | 100nF | Ceramic capacitor, 50V, X7R     | 0603    | Murata       | GRM188R71H104KA93D |
| 3   | C32, C43, C54                                                             | 180μF | Electrolytic capacitor, 25V     | DIP     | YMIN         | NPXC0801E181ME     |
| 1   | C61                                                                       | NC    |                                 |         |              |                    |
| 4   | C65, C66, C69, C70                                                        | 330pF | Ceramic capacitor, 50V, X7R     | 0603    | Murata       | GRM188R71H331KA01D |
| 1   | C75                                                                       | 22μF  | Electrolytic capacitor, 50V     | DIP     | Jianghai     | CD281L-50V22       |
| 2   | C77, C78                                                                  | NC    |                                 |         |              |                    |
| 1   | CX1                                                                       | 470nF | X capacitor, 275V <sub>AC</sub> | DIP     | Huajia       | 275V470nF 12*13*8  |

**EVX2002-44018A-00A BILL OF MATERIALS (continued)**

| Qty | Ref                                  | Value | Description                     | Package          | Manufacturer    | Manufacturer PN   |
|-----|--------------------------------------|-------|---------------------------------|------------------|-----------------|-------------------|
| 2   | CY1, CY2                             | 220pF | Y capacitor, 250V <sub>AC</sub> | 1808             | Murata          | GA342DR7GF221KW02 |
| 1   | CY3                                  | 470pF | Y capacitor, 400V <sub>AC</sub> | SMD              | TRX             | TMY1471M          |
| 1   | CY4                                  | NC    |                                 |                  |                 |                   |
| 1   | D1                                   | 600V  | Diode, 1A                       | SMA              | Diodes, Inc.    | RS1J-13-F         |
| 1   | D2                                   | 600V  | Diode, 8A                       | TO-252           | WeEn            | BYV29D-600P       |
| 1   | D3                                   | 75V   | Diode, 0.15A                    | SOD-323          | Diodes, Inc.    | 1N4148WS          |
| 1   | D4                                   | 200V  | Diode, 0.2A                     | SOD-123          | Diodes, Inc.    | BAV21W            |
| 1   | D5                                   | 1000V | Diode, 1000V,3A                 | SMB              | Diodes, Inc.    | RS3MB             |
| 3   | D6, D7, D8                           | NC    |                                 |                  |                 |                   |
| 1   | F1                                   | 3.15A | Fuse, 250V <sub>AC</sub>        | DIP              | Cooper Bussmann | SS-5-3.15A        |
| 1   | LX1                                  | 10mH  | Common mode inductor, 2A        | DIP              | Emei            | TP4M10-01         |
| 1   | LX2                                  | 300μH | Common mode inductor, 1A,       | DIP              | Emei            | TP4U300-00        |
| 1   | LX3                                  | NC    |                                 |                  |                 |                   |
| 1   | L1                                   | 100μH | Inductor, 2A                    | DIP              | SANCI           | 13*10*5.5         |
| 2   | L2, L3                               | 22μH  | Inductor, 6A                    | DIP              | SANCI           | 13*10*5           |
| 1   | L4                                   | 22μH  | Inductor, 5A                    | DIP              | SANCI           | 12*9*4            |
| 1   | M1                                   | 30V   | N-channel MOSFET, 32mΩ          | SOT-23           | Analog Power    | AM2336N           |
| 1   | M2                                   | 120V  | N-channel MOSFET, 3.6mΩ         | TO-220           | Toshiba         | TK72E12N1         |
| 9   | M3, M4, M5, M6, M7, M8, M9, M10, M11 | 30V   | N-channel MOSFET, 5.1mΩ         | PowerPAK -1212-8 | Vishay          | SISHA14DN         |
| 6   | R1, R3, R6, R7, R9, R10              | 10MΩ  | Film resistor, 1%               | 0805             | Yageo           | RC0805FR-0710ML   |
| 3   | R2, R4, R11                          | 3.3MΩ | Film resistor, 1%               | 0805             | Yageo           | RC0805FR-073M3L   |
| 1   | R5                                   | 30kΩ  | Film resistor, 1%               | 0603             | Yageo           | RC0603FR-0730KL   |
| 1   | R8                                   | 649kΩ | Film resistor, 1%               | 0603             | Yageo           | RC0603FR-07649KL  |
| 1   | R12                                  | 200Ω  | Film resistor, 1%               | 0603             | Yageo           | RC0603FR-07200RL  |
| 2   | R13, R16                             | 270kΩ | Film resistor, 1%               | 0603             | Yageo           | RC0603FR-07270KL  |
| 1   | R14                                  | 300kΩ | Film resistor, 1%               | 0603             | Yageo           | RC0603FR-07300KL  |
| 1   | R15                                  | 160kΩ | Film resistor, 1%               | 0603             | Yageo           | RC0603FR-07160KL  |
| 1   | R17                                  | 33kΩ  | Film resistor, 1%               | 0805             | Yageo           | RC0805FR-0733KL   |
| 5   | R18, R19, R20, R45, R46              | 300mΩ | Film resistor, 1%               | 1206             | Yageo           | RL1206FR-070R3L   |
| 2   | R21, R37                             | 0Ω    | Film resistor, 1%               | 0603             | Yageo           | RC0603FR-070RL    |
| 2   | R22, R36                             | 1Ω    | Film resistor, 1%               | 0603             | Yageo           | RC0603FR-071KL    |
| 4   | R23, R24, R26, R27                   | 499kΩ | Film resistor, 1%               | 1206             | Yageo           | RC1206FR-07499KL  |
| 1   | R28                                  | 1Ω    | Film resistor, 1%               | 0805             | Yageo           | RC0805FR-071RL    |
| 3   | R29, R30, R31                        | 10Ω   | Film resistor, 1%               | 1206             | Yageo           | RC1206FR-0710RL   |
| 1   | R33                                  | 0Ω    | Film resistor, 1%               | 1206             | Yageo           | RC1206FR-070RL    |
| 3   | R32, R34, R35                        | 30Ω   | Film resistor, 1%               | 1206             | Yageo           | RC1206FR-0730RL   |
| 1   | R38                                  | 200kΩ | Film resistor, 1%               | 0603             | Yageo           | RC0603FR-07200KL  |

**EVX2002-44018A-00A BILL OF MATERIALS (continued)**

| Qty | Ref                                              | Value    | Description                   | Package          | Manufacturer | Manufacturer PN   |
|-----|--------------------------------------------------|----------|-------------------------------|------------------|--------------|-------------------|
| 1   | R39                                              | 1.2kΩ    | Film resistor, 1%             | 0603             | Yageo        | RC0603FR-071K2L   |
| 1   | R40                                              | 100kΩ    | Film resistor, 1%             | 0603             | Yageo        | RC0603FR-07100KL  |
| 1   | R41                                              | 12kΩ     | Film resistor, 1%             | 0603             | Yageo        | RC0603FR-0712KL   |
| 1   | R42                                              | NC       |                               |                  |              |                   |
| 1   | R43                                              | 430Ω     | Film resistor, 1%             | 0603             | Yageo        | RC0603FR-07430RL  |
| 1   | R44                                              | 200mΩ    | Film resistor, 1%             | 1206             | Yageo        | RL1206FR-070R2L   |
| 3   | R47, R49, R51                                    | 20kΩ     | Film resistor, 1%             | 0603             | Yageo        | RC0603FR-0720KL   |
| 3   | R48, R50, R52                                    | 5mΩ      | Film resistor, 1%             | 1206             | Yageo        | PA1206FRF070R005L |
| 6   | R53, R54, R55, R56, R57, R58                     | NC       |                               |                  |              |                   |
| 10  | R59, R60, R61, R62, R25, R63, R64, R65, R66, R67 | 47Ω      | Film resistor, 1%             | 0603             | Yageo        | RC0603FR-0747RL   |
| 1   | T1                                               | 270μH    | PFC inductor                  | ATQ2516          | ARK          | FX0649            |
| 1   | T2                                               | 320μH    | Flyback transformer           | ATQ2718          | ARK          | FX0650            |
| 2   | U1, U4                                           | 650V     | GaNFast™ power switch, 125mΩ  | QFN-30 (6mmx8mm) | Navitas      | NV6127            |
| 2   | U6, U7                                           | 36V      | PD controller                 | QFN-28           | ISMARTWARE   | SW3516H-C         |
| 1   | U8                                               | 36V      | PD controller                 | QFN-28           | ISMARTWARE   | SW3516H_A         |
| 1   | U10                                              | NC       |                               |                  |              |                   |
| 1   | USB-A1                                           | 4-pin    | Type-A connector              | DIP              | Jingtuo      | N/A               |
| 2   | USB-C1, USB-C2                                   | 16-pin   | Type-C connector              | DIP              | Yalian       | 93579102          |
| 2   | ZD1, ZD3                                         | 6.2V     | Zener diode, 5mA              | SOD-323          | Diodes, Inc. | BZT52C6V2S        |
| 1   | ZD2                                              | 4.7V     | Zener diode, 5mA              | SOD-323          | Diodes, Inc. | BZT52C4V7S        |
| 1   | U2                                               | MP44018A | CrM/DCM PFC controller        | SOIC-8           | MPS          | MP44018-AGS-Z     |
| 1   | U3                                               | HF81     | X capacitor bleeder           | SOIC-8           | MPS          | HF81GS-Z          |
| 1   | U5                                               | MPX2002  | All-in-one flyback controller | SOICW-16         | MPS          | MPX2002GY-Z       |

## EVb TEST RESULTS

Performance waveforms are tested on the evaluation board. <sup>(2)</sup>

**Table 1: Efficiency (USB-C1 = 100W, USB-C2 = 0W, USB-A = 0W)**

| $V_{IN}$<br>( $V_{AC}/Hz$ ) | Load                   | $V_{OUT1}$ (V) | $I_{OUT1}$ (A) | $P_{OUT}$ (W) | $P_{IN}$ (W) | Efficiency |
|-----------------------------|------------------------|----------------|----------------|---------------|--------------|------------|
| 115/60                      | 100%                   | 20.21          | 5.003          | 101.103       | 109.242      | 92.55%     |
|                             | 75%                    | 20.27          | 3.750          | 76.010        | 82.468       | 92.17%     |
|                             | 50%                    | 20.33          | 2.500          | 50.823        | 55.014       | 92.38%     |
|                             | 25%                    | 20.24          | 1.250          | 25.306        | 27.756       | 91.17%     |
|                             | Average Efficiency (%) |                |                |               |              | 92.07%     |
|                             | 10%                    | 20.20          | 0.500          | 10.108        | 11.852       | 85.29%     |
| 230/50                      | 100%                   | 20.18          | 5.001          | 100.926       | 108.564      | 92.96%     |
|                             | 75%                    | 20.24          | 3.751          | 75.910        | 81.930       | 92.65%     |
|                             | 50%                    | 20.30          | 2.501          | 50.760        | 55.166       | 92.01%     |
|                             | 25%                    | 20.22          | 1.250          | 25.267        | 28.006       | 90.22%     |
|                             | Average Efficiency (%) |                |                |               |              | 91.96%     |
|                             | 10%                    | 20.17          | 0.500          | 10.087        | 11.910       | 84.69%     |

**Table 2: Efficiency (USB-C1 = 60W, USB-C2 = 60W, USB-A = 0W)**

| $V_{IN}$<br>( $V_{AC}/Hz$ ) | Load                   | $V_{OUT1}$ (V) | $I_{OUT1}$ (A) | $V_{OUT2}$ (V) | $I_{OUT2}$ (A) | $P_{OUT}$ (W) | $P_{IN}$ (W) | Efficiency |
|-----------------------------|------------------------|----------------|----------------|----------------|----------------|---------------|--------------|------------|
| 115/60                      | 100%                   | 20.27          | 3.0025         | 20.28          | 3.0023         | 121.747       | 131.410      | 92.65%     |
|                             | 75%                    | 20.26          | 2.2504         | 20.24          | 2.2509         | 91.151        | 98.421       | 92.61%     |
|                             | 50%                    | 20.22          | 1.5005         | 20.18          | 1.5005         | 60.620        | 65.693       | 92.28%     |
|                             | 25%                    | 20.17          | 0.7509         | 20.13          | 0.7500         | 30.243        | 33.284       | 90.86%     |
|                             | Average Efficiency (%) |                |                |                |                |               |              | 92.10%     |
|                             | 10%                    | 20.14          | 0.3007         | 20.09          | 0.3001         | 12.085        | 14.129       | 85.53%     |
| 230/50                      | 100%                   | 20.28          | 3.0004         | 20.28          | 3.0014         | 121.717       | 130.290      | 93.42%     |
|                             | 75%                    | 20.26          | 2.2508         | 20.24          | 2.2503         | 91.147        | 97.855       | 93.15%     |
|                             | 50%                    | 20.21          | 1.5008         | 20.18          | 1.5009         | 60.619        | 65.856       | 92.05%     |
|                             | 25%                    | 20.17          | 0.7503         | 20.12          | 0.7505         | 30.234        | 33.597       | 89.99%     |
|                             | Average Efficiency (%) |                |                |                |                |               |              | 92.15%     |
|                             | 10%                    | 20.14          | 0.3003         | 20.09          | 0.3005         | 12.085        | 14.279       | 84.64%     |

**EVB TEST RESULTS (continued)**

 Performance waveforms are tested on the evaluation board. <sup>(2)</sup>
**Table 3: Efficiency (USB-C1 = 60W, USB-C2 = 30W, USB-A = 30W)**

| $V_{IN}$<br>( $V_{AC}/Hz$ ) | Load                   | $V_{OUT1}$<br>(V) | $I_{OUT1}$<br>(A) | $V_{OUT2}$<br>(V) | $I_{OUT2}$<br>(A) | $V_{OUT3}$<br>(V) | $I_{OUT3}$<br>(A) | $P_{OUT}$<br>(W) | $P_{IN}$ (W) | Efficiency |
|-----------------------------|------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|------------------|--------------|------------|
| 115/60                      | 100%                   | 20.29             | 3.009             | 20.16             | 1.501             | 20.02             | 1.501             | 121.359          | 130.860      | 92.74%     |
|                             | 75%                    | 20.28             | 2.244             | 20.14             | 1.125             | 20.02             | 1.126             | 90.706           | 97.914       | 92.64%     |
|                             | 50%                    | 20.23             | 1.511             | 20.11             | 0.751             | 20.03             | 0.751             | 60.705           | 65.780       | 92.28%     |
|                             | 25%                    | 20.19             | 0.746             | 20.07             | 0.375             | 20.02             | 0.375             | 30.095           | 33.882       | 88.82%     |
|                             | Average Efficiency (%) |                   |                   |                   |                   |                   |                   |                  |              | 91.62%     |
|                             | 10%                    | 20.16             | 0.298             | 20.06             | 0.151             | 20.06             | 0.151             | 12.066           | 14.207       | 84.93%     |
| 230/50                      | 100%                   | 20.29             | 3.009             | 20.17             | 1.501             | 20.03             | 1.501             | 121.401          | 130.090      | 93.32%     |
|                             | 75%                    | 20.28             | 2.246             | 20.14             | 1.125             | 20.03             | 1.125             | 90.740           | 97.615       | 92.96%     |
|                             | 50%                    | 20.23             | 1.511             | 20.11             | 0.751             | 20.03             | 0.751             | 60.705           | 66.205       | 91.69%     |
|                             | 25%                    | 20.19             | 0.748             | 20.08             | 0.375             | 20.03             | 0.375             | 30.159           | 33.732       | 89.41%     |
|                             | Average Efficiency (%) |                   |                   |                   |                   |                   |                   |                  |              | 91.84%     |
|                             | 10%                    | 20.15             | 0.298             | 20.05             | 0.1506            | 20.03             | 0.151             | 12.039           | 14.478       | 83.15%     |

**Table 4: Efficiency (USB-C1 = 100W, USB-C2 = 0W, USB-A = 0W)**

| $V_{IN}$<br>( $V_{AC}/Hz$ ) | $V_{OUT1}$ (V) | $I_{OUT1}$ (A) | $P_{OUT}$ (W) | $P_{IN}$ (W) | Efficiency |
|-----------------------------|----------------|----------------|---------------|--------------|------------|
| 90/60                       | 20.23          | 5.001          | 101.164       | 110.35       | 91.68%     |
| 115/60                      | 20.21          | 5.003          | 101.103       | 109.24       | 92.55%     |
| 230/50                      | 20.18          | 5.001          | 100.926       | 108.56       | 92.96%     |
| 264/50                      | 20.23          | 5.002          | 101.184       | 108.63       | 93.15%     |

**Table 5: Efficiency (USB-C1 = 60W, USB-C2 = 60W, USB-A = 0W)**

| $V_{IN}$<br>( $V_{AC}/Hz$ ) | $V_{OUT1}$ (V) | $I_{OUT1}$ (A) | $V_{OUT2}$ (V) | $I_{OUT2}$ (A) | $P_{OUT}$ (W) | $P_{IN}$ (W) | Efficiency |
|-----------------------------|----------------|----------------|----------------|----------------|---------------|--------------|------------|
| 90/60                       | 20.13          | 3.002          | 20.15          | 3.002          | 120.927       | 131.74       | 91.79%     |
| 115/60                      | 20.27          | 3.003          | 20.28          | 3.002          | 121.747       | 131.41       | 92.65%     |
| 230/50                      | 20.28          | 3.000          | 20.28          | 3.001          | 121.717       | 130.29       | 93.42%     |
| 264/50                      | 20.13          | 3.001          | 20.16          | 3.002          | 120.941       | 129.24       | 93.58%     |

**Table 6: Efficiency (USB-C1: 60W, USB-C2: 30W, USB-A: 30W)**

| $V_{IN}$<br>( $V_{AC}/Hz$ ) | $V_{OUT1}$<br>(V) | $I_{OUT1}$ (A) | $V_{OUT2}$<br>(V) | $I_{OUT2}$ (A) | $V_{OUT3}$<br>(V) | $I_{OUT3}$ (A) | $P_{OUT}$ (W) | $P_{IN}$ (W) | Efficiency |
|-----------------------------|-------------------|----------------|-------------------|----------------|-------------------|----------------|---------------|--------------|------------|
| 90/60                       | 20.09             | 3.003          | 20.08             | 1.511          | 20.04             | 1.502          | 120.763       | 131.62       | 91.75%     |
| 115/60                      | 20.29             | 3.009          | 20.16             | 1.501          | 20.02             | 1.501          | 121.359       | 130.86       | 92.74%     |
| 230/50                      | 20.29             | 3.009          | 20.17             | 1.501          | 20.03             | 1.501          | 121.401       | 130.09       | 93.32%     |
| 264/50                      | 20.09             | 3.004          | 20.08             | 1.511          | 20.03             | 1.502          | 120.764       | 129.29       | 93.41%     |

**Note:**

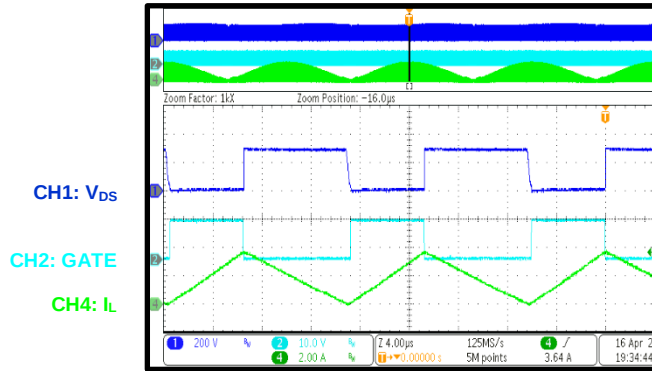
2) The measured efficiency is the board efficiency.

## EVB TEST RESULTS (continued)

Performance waveforms are tested on the evaluation board.

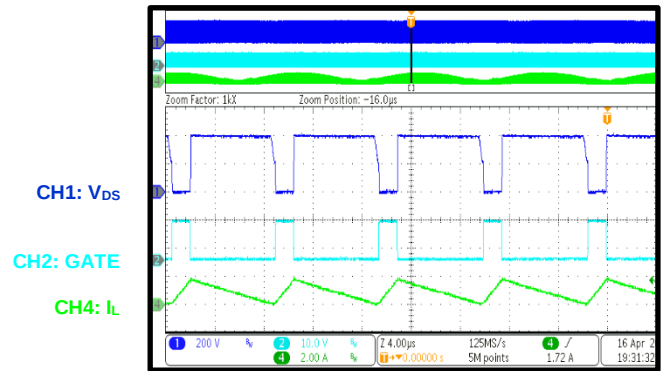
### PFC Steady State

$V_{IN} = 115V_{AC}/60Hz$ ,  $P_{OUT} = 120W$



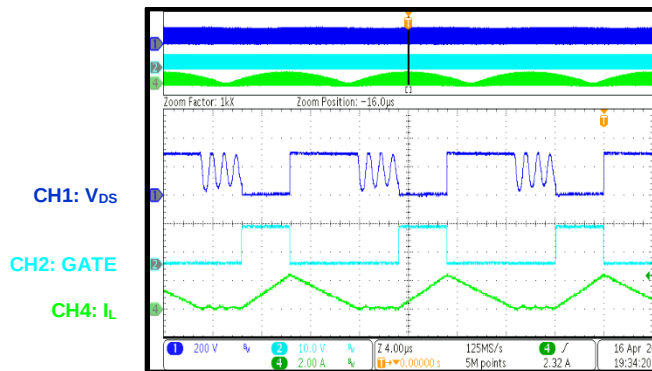
### PFC Steady State

$V_{IN} = 230V_{AC}/50Hz$ ,  $P_{OUT} = 120W$



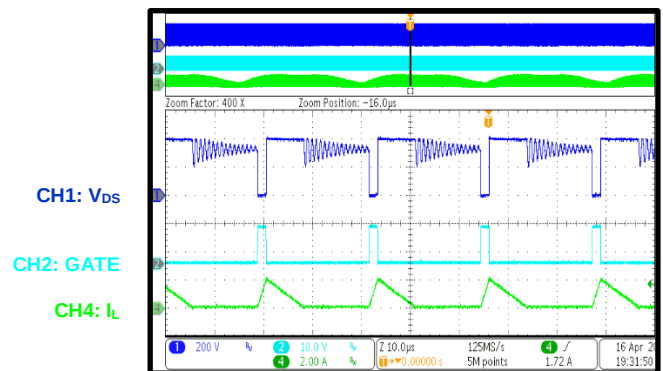
### PFC Steady State

$V_{IN} = 115V_{AC}/60Hz$ ,  $P_{OUT} = 60W$



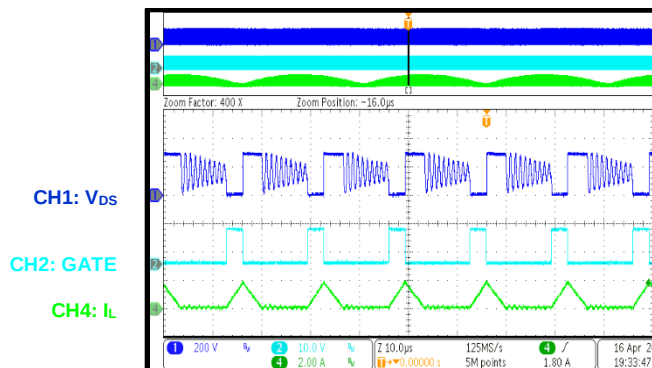
### PFC Steady State

$V_{IN} = 230V_{AC}/50Hz$ ,  $P_{OUT} = 60W$



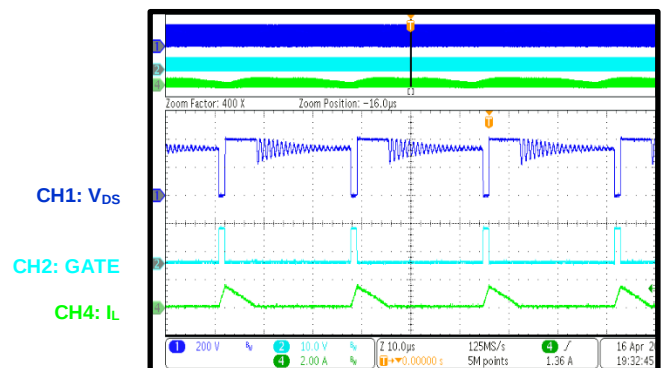
### PFC Steady State

$V_{IN} = 115V_{AC}/60Hz$ ,  $P_{OUT} = 30W$



### PFC Steady State

$V_{IN} = 230V_{AC}/50Hz$ ,  $P_{OUT} = 30W$

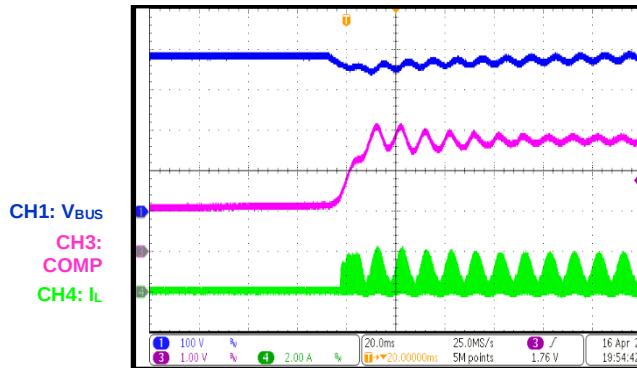


## EVB TEST RESULTS (continued)

Performance waveforms are tested on the evaluation board.

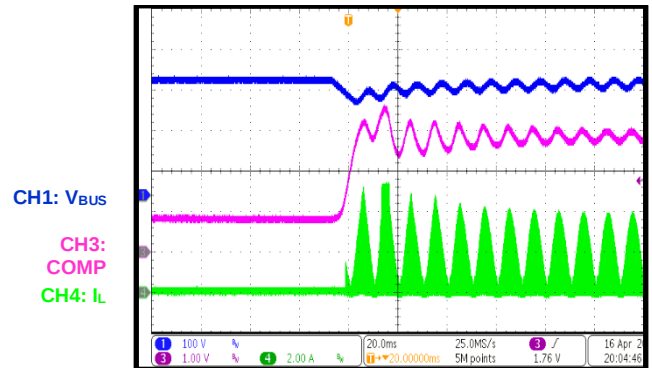
### PFC Load Transient

$V_{IN} = 115V_{AC}/60Hz$ ,  $P_{OUT} = 0W$  to  $120W$



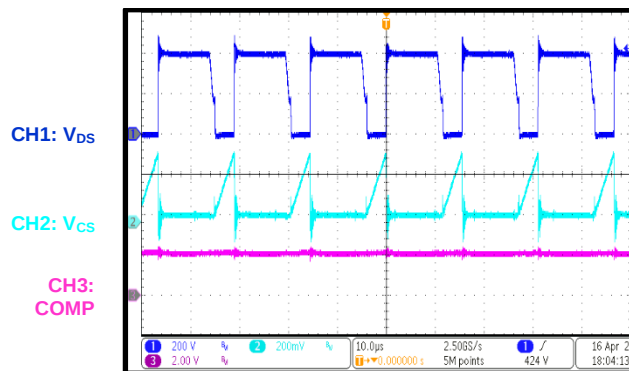
### PFC Load Transient

$V_{IN} = 230V_{AC}/50Hz$ ,  $P_{OUT} = 0W$  to  $120W$



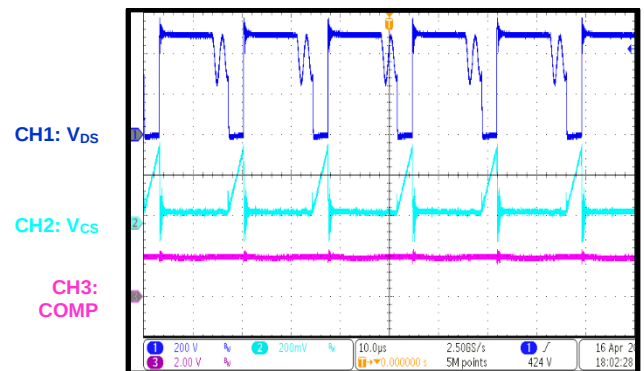
### Flyback Steady State

$V_{IN} = 115V_{AC}/60Hz$ ,  $P_{OUT} = 120W$



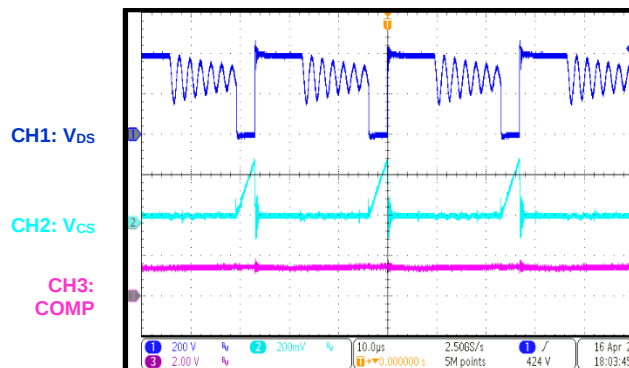
### Flyback Steady State

$V_{IN} = 230V_{AC}/50Hz$ ,  $P_{OUT} = 120W$



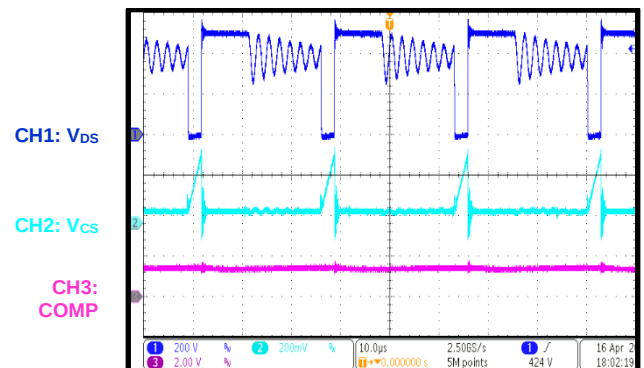
### Flyback Steady State

$V_{IN} = 115V_{AC}/60Hz$ ,  $P_{OUT} = 60W$



### Flyback Steady State

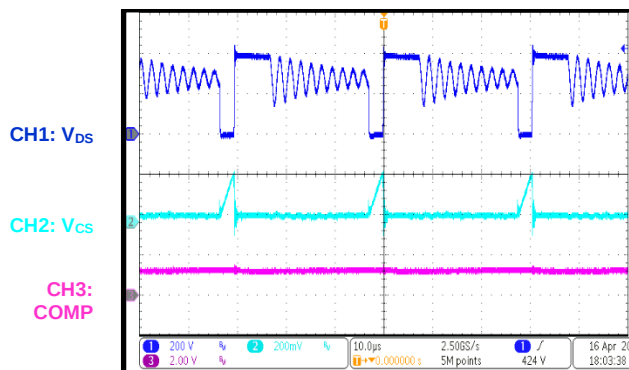
$V_{IN} = 230V_{AC}/50Hz$ ,  $P_{OUT} = 60W$



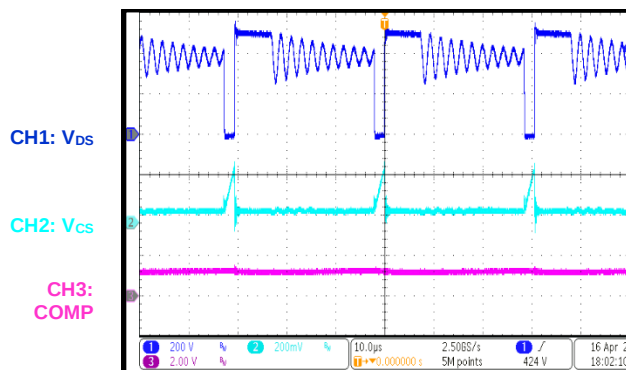
## EVB TEST RESULTS (continued)

Performance waveforms are tested on the evaluation board.

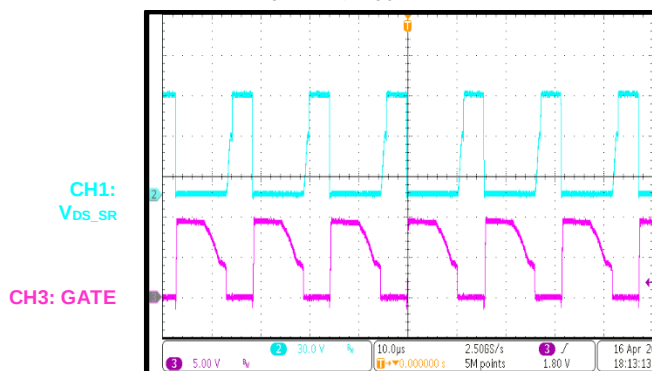
### Flyback Steady State

 $V_{IN} = 115V_{AC}/60Hz$ ,  $P_{OUT} = 30W$ 


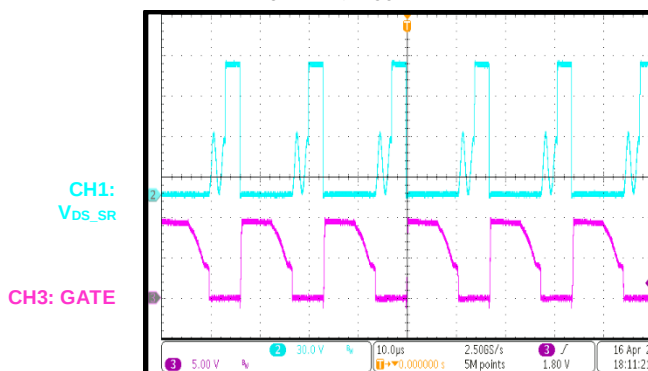
### Flyback Steady State

 $V_{IN} = 230V_{AC}/50Hz$ ,  $P_{OUT} = 30W$ 


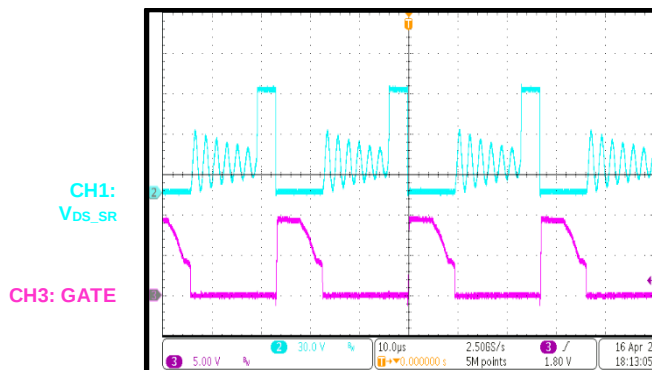
### Flyback SR Steady State

 $V_{IN} = 115V_{AC}/60Hz$ ,  $P_{OUT} = 120W$ 


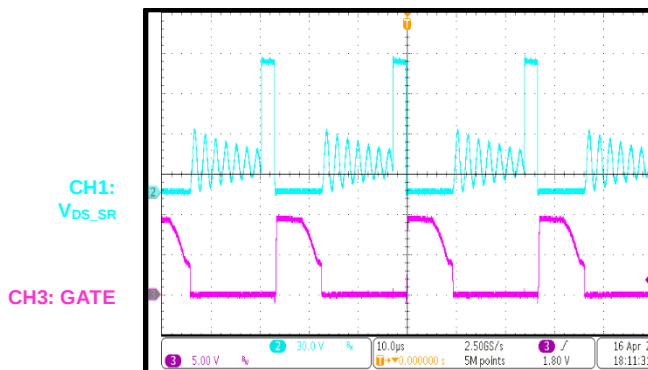
### Flyback SR Steady State

 $V_{IN} = 230V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ 


### Flyback SR Steady State

 $V_{IN} = 115V_{AC}/60Hz$ ,  $P_{OUT} = 60W$ 


### Flyback SR Steady State

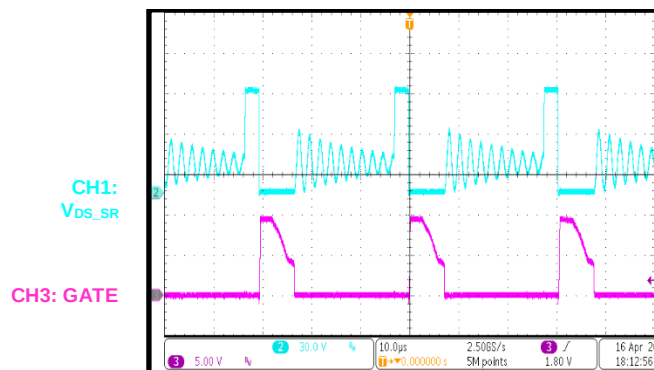
 $V_{IN} = 230V_{AC}/50Hz$ ,  $P_{OUT} = 60W$ 


## EVB TEST RESULTS (continued)

Performance waveforms are tested on the evaluation board.

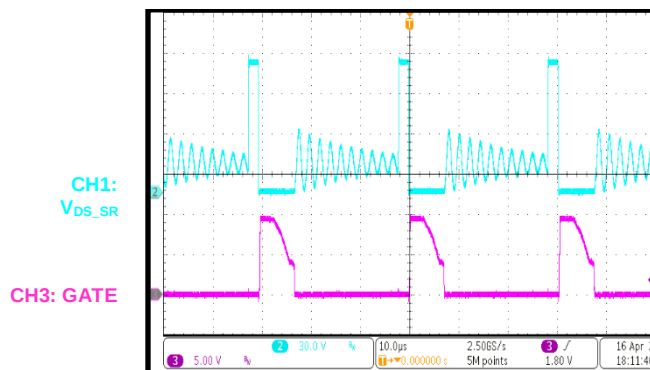
### Flyback SR Steady State

$V_{IN} = 115V_{AC}/60Hz$ ,  $P_{OUT} = 30W$



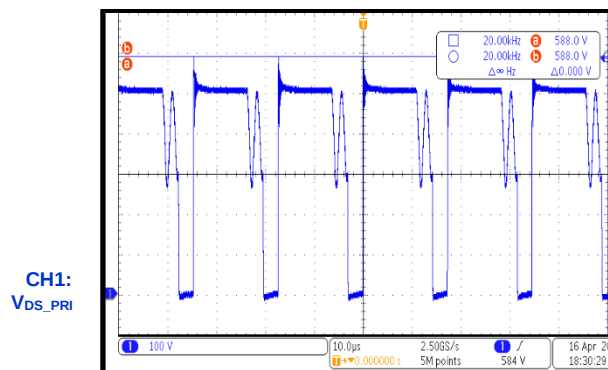
### Flyback SR Steady State

$V_{IN} = 230V_{AC}/50Hz$ ,  $P_{OUT} = 30W$



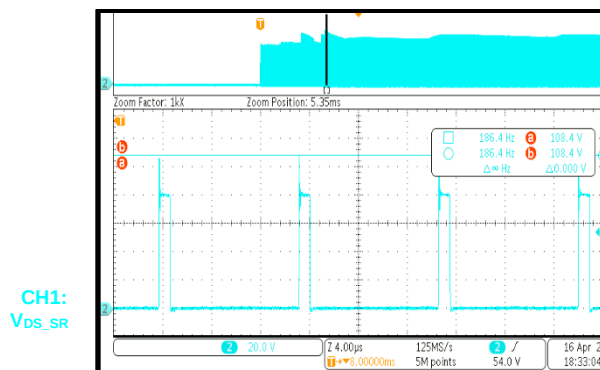
### Primary MOSFET Stress

$V_{IN} = 264V_{AC}$ ,  $P_{OUT} = 120W$ ,  $V_{MAX} = 588V$



### Secondary MOSFET Stress

$V_{IN} = 264V_{AC}$ , start up,  $P_{OUT} = 120W$ ,  $V_{MAX} = 108.4V$

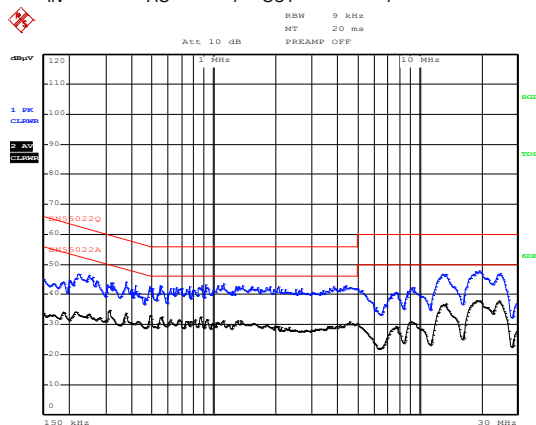


## EVB TEST RESULTS (continued)

Performance waveforms are tested on the evaluation board.

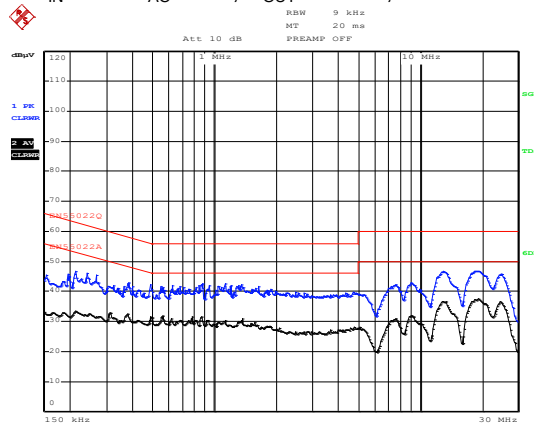
### Conducted EMI

$V_{IN} = 115V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , line L



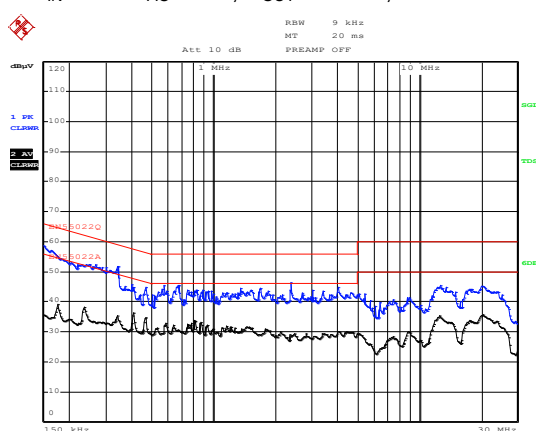
### Conducted EMI

$V_{IN} = 115V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , line N



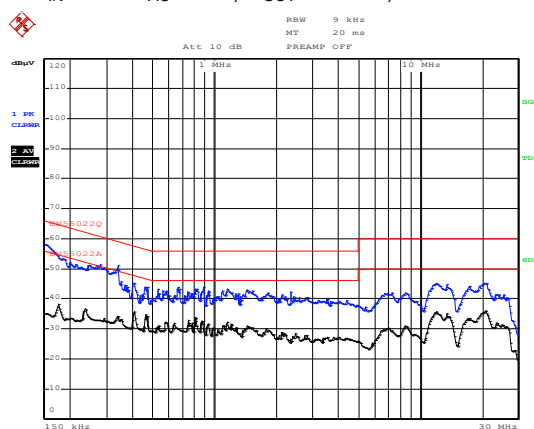
### Conducted EMI

$V_{IN} = 230V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , line L



### Conducted EMI

$V_{IN} = 230V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , line N

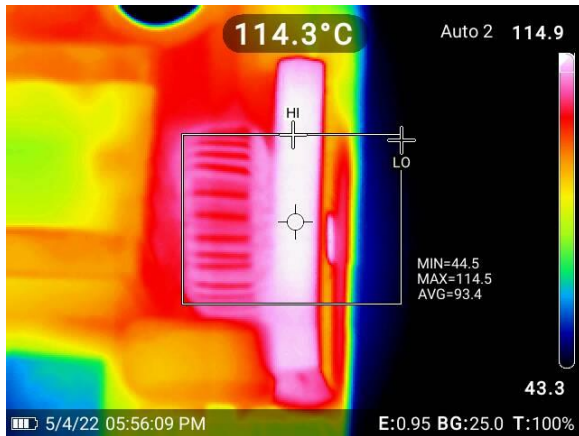


## EVB TEST RESULTS (continued)

Performance waveforms are tested on the evaluation board.

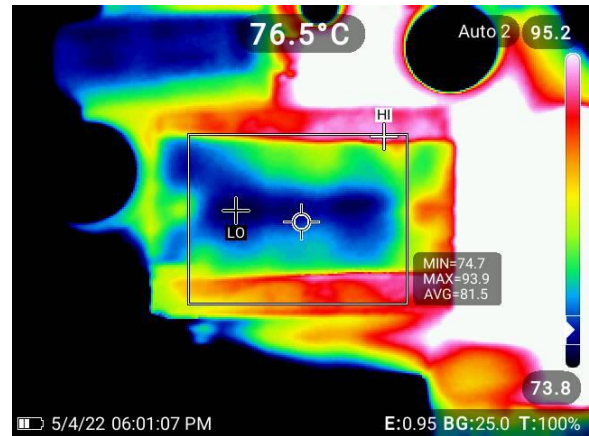
### Thermal Measurements

$V_{IN} = 90V_{AC}/60Hz$ ,  $P_{OUT} = 120W$ , bridge rectifier (BD1): 114.5°C



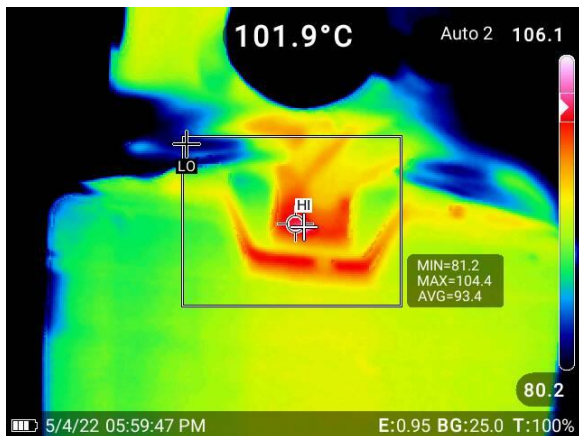
### Thermal Measurements

$V_{IN} = 90V_{AC}/60Hz$ ,  $P_{OUT} = 120W$ , PFC inductor (T1): 93.9°C



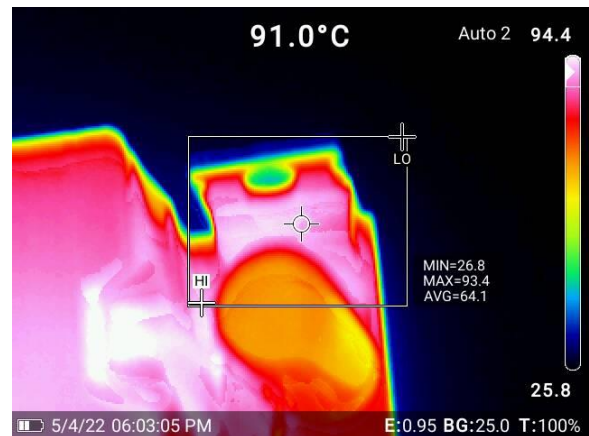
### Thermal Measurements

$V_{IN} = 90V_{AC}/60Hz$ ,  $P_{OUT} = 120W$ , flyback transformer (T2): 104.4°C



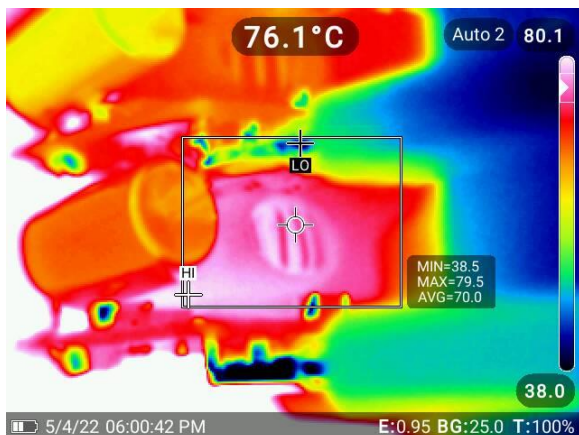
### Thermal Measurements

$V_{IN} = 90V_{AC}/60Hz$ ,  $P_{OUT} = 120W$ , SR MOSFET (M2): 93.4°C



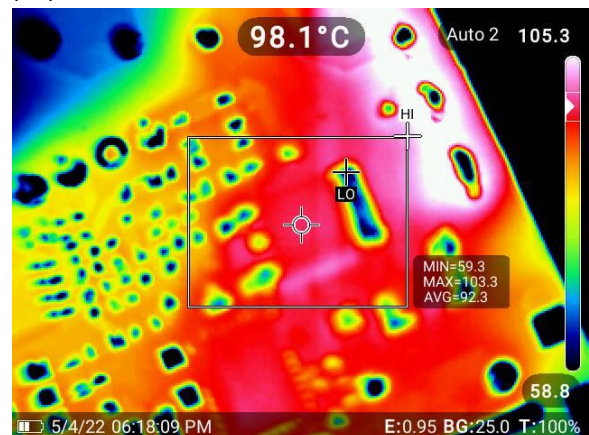
### Thermal Measurements

$V_{IN} = 90V_{AC}/60Hz$ ,  $P_{OUT} = 120W$ , DC/DC inductor (L2): 79.5°C



### Thermal Measurements

$V_{IN} = 90V_{AC}/60Hz$ ,  $P_{OUT} = 120W$ , PFC freewheeling diode (D1): 98.1°C

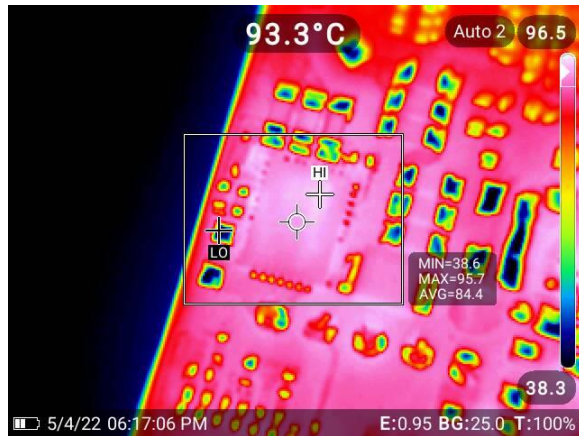


## EVB TEST RESULTS (continued)

Performance waveforms are tested on the evaluation board.

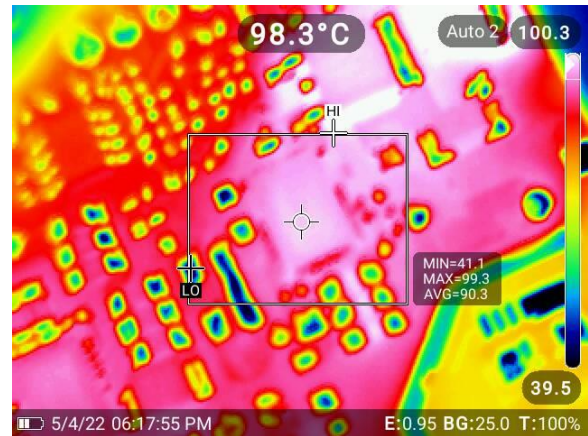
### Thermal Measurements

$V_{IN} = 90V_{AC}/60Hz$ ,  $P_{OUT} = 120W$ , flyback GaN (U4): 95.7°C



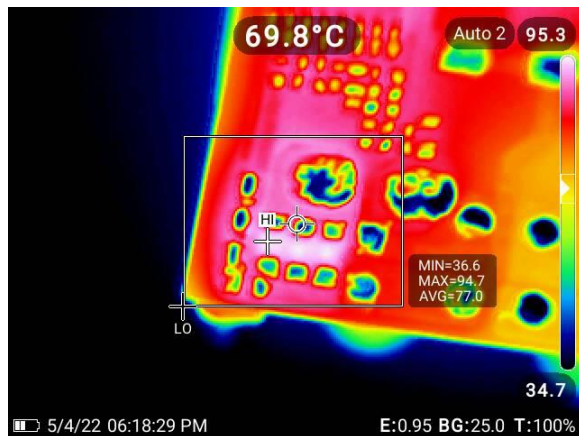
### Thermal Measurements

$V_{IN} = 90V_{AC}/60Hz$ ,  $P_{OUT} = 120W$ , PFC GaN (U1): 98.3°C



### Thermal Measurements

$V_{IN} = 90V_{AC}/60Hz$ ,  $P_{OUT} = 120W$ , SR snubber (R32, R34, R35): 94.7°C



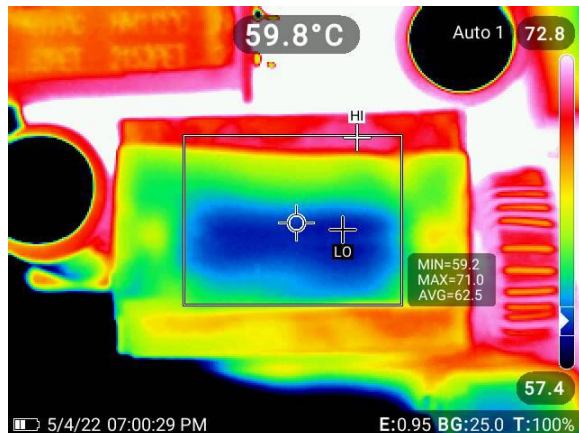
### Thermal Measurements

$V_{IN} = 264V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , bridge rectifier (BD1): 73.2°C



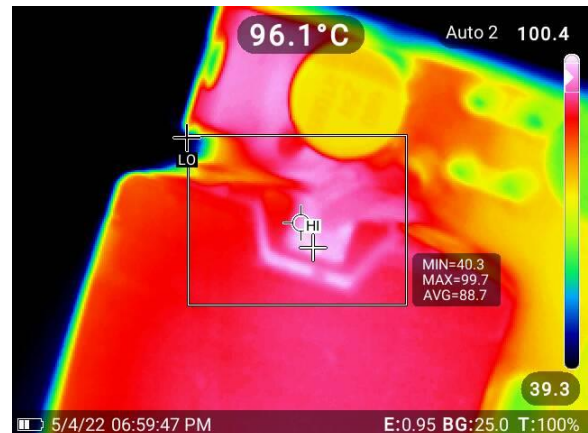
### Thermal Measurements

$V_{IN} = 264V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , PFC inductor (T1): 71°C



### Thermal Measurements

$V_{IN} = 264V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , flyback transformer (T2): 99.7°C

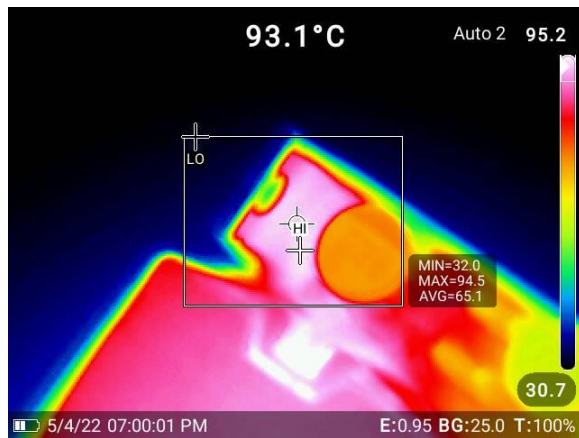


## EVB TEST RESULTS (continued)

Performance waveforms are tested on the evaluation board.

### Thermal Measurements

$V_{IN} = 264V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , SR MOSFET (M2): 94.5°C



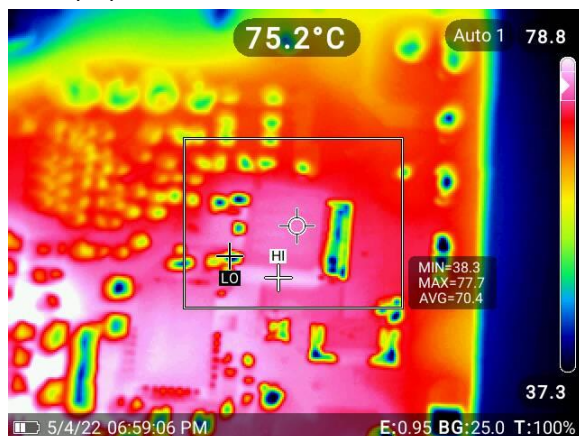
### Thermal Measurements

$V_{IN} = 264V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , DC/DC inductor (L2): 79.9°C



### Thermal Measurements

$V_{IN} = 264V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , PFC freewheeling diode (D1): 77.7°C



### Thermal Measurements

$V_{IN} = 264V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , flyback GaN (U4): 93.6°C



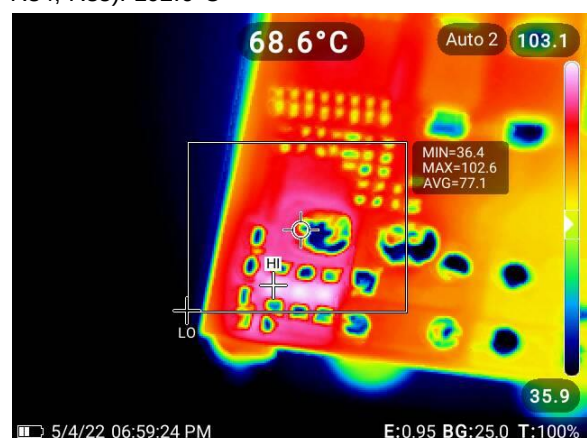
### Thermal Measurements

$V_{IN} = 264V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , PFC GaN (U1): 78.2°C

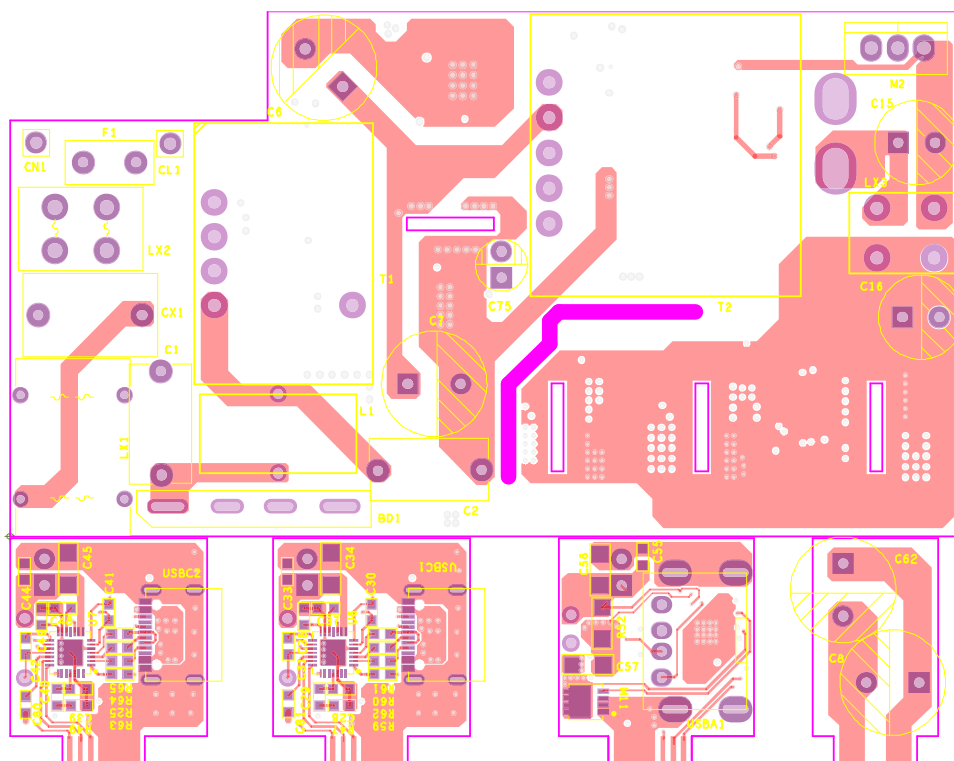


### Thermal Measurements

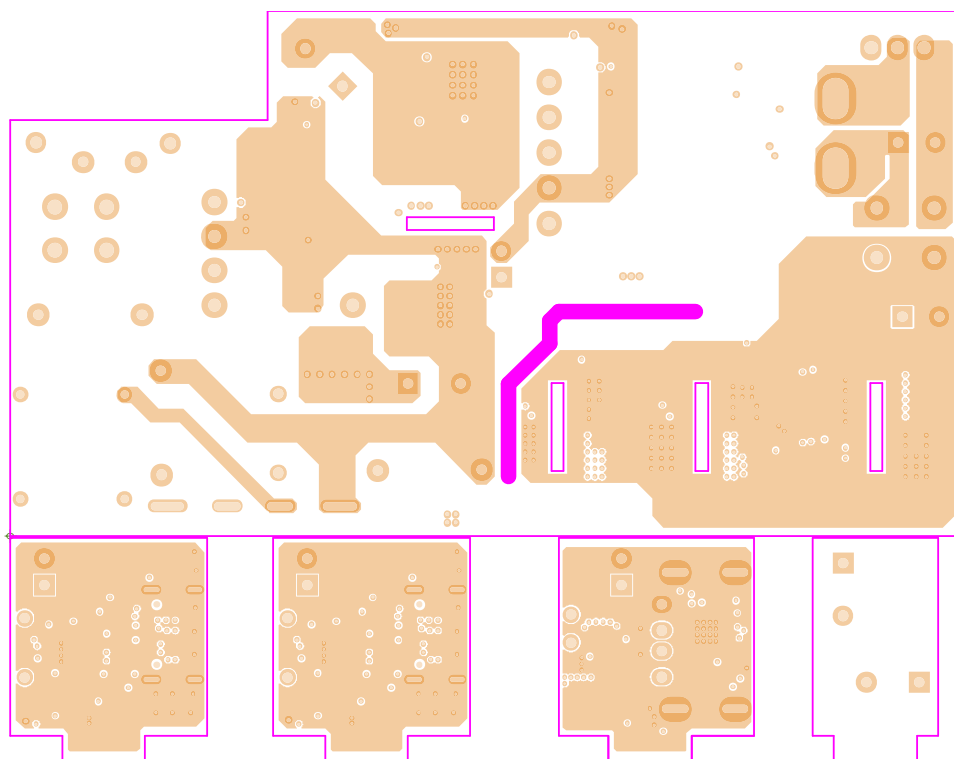
$V_{IN} = 264V_{AC}/50Hz$ ,  $P_{OUT} = 120W$ , SR snubber (R32, R34, R35): 102.6°C



## PCB LAYOUT

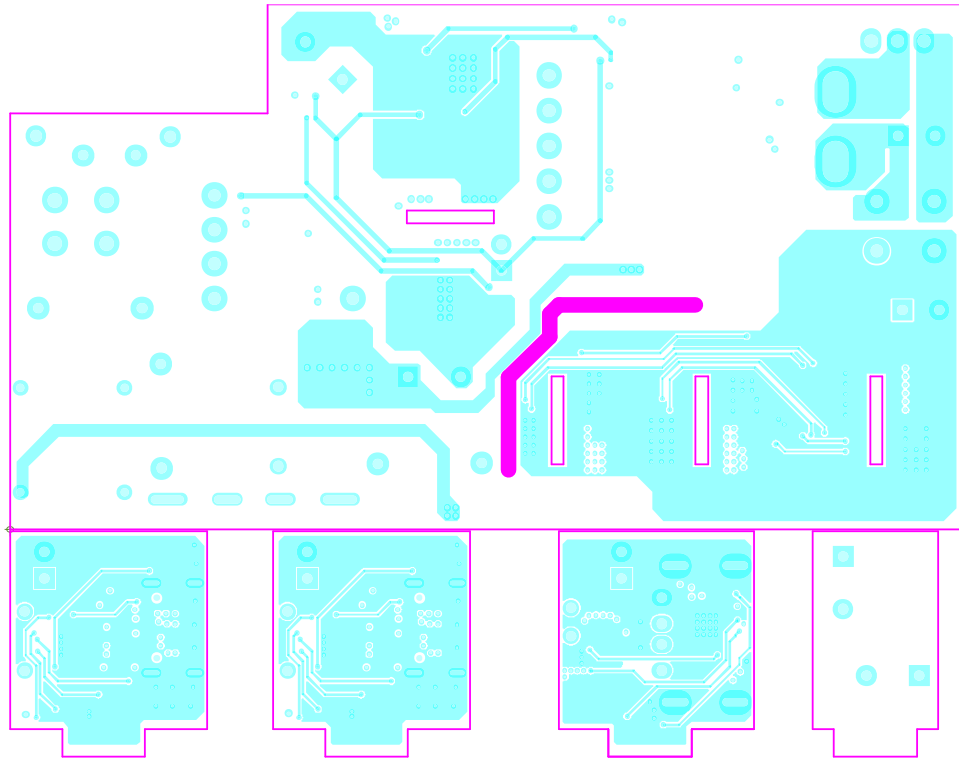


**Figure 3: Top Layer**

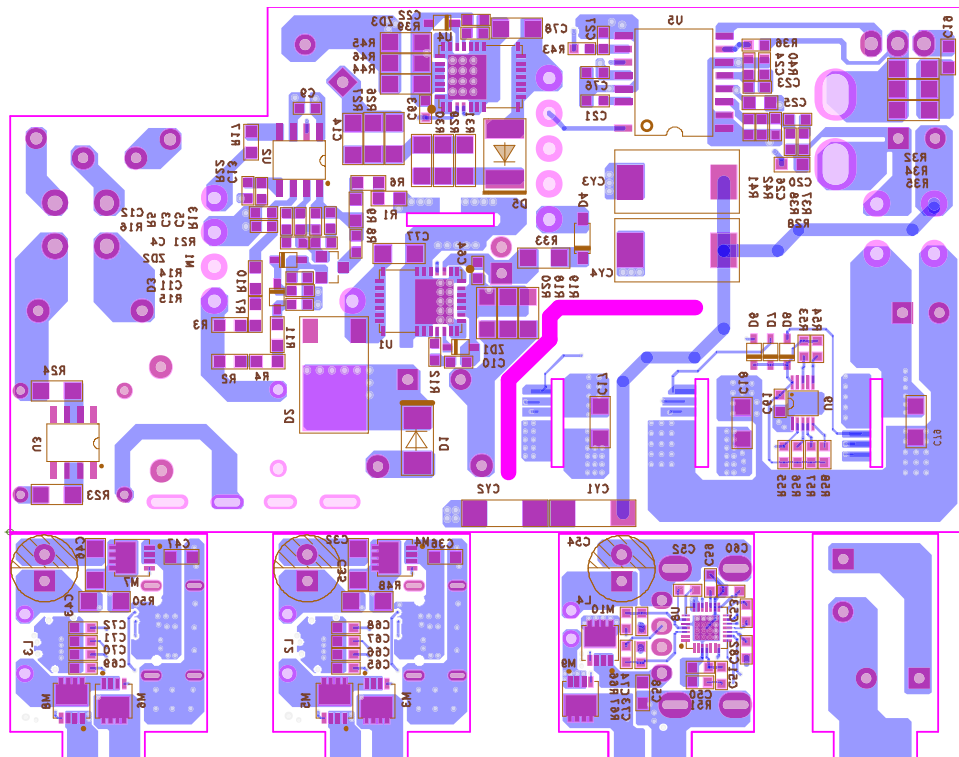


**Figure 4: Mid-Layer 1**

**PCB LAYOUT (continued)**



**Figure 5: Mid-Layer 2**



**Figure 6: Bottom Layer**

## APPENDIX 1: PFC INDUCTOR T1 SPECIFICATION

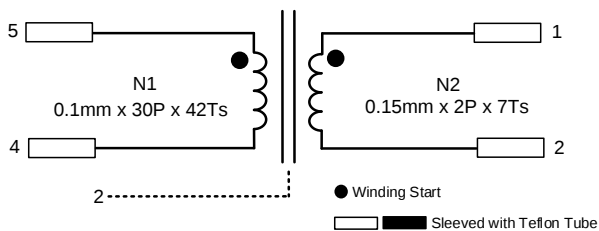


Figure 7: Electrical Diagram

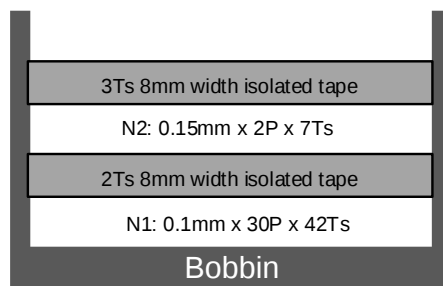


Figure 9: Winding Diagram

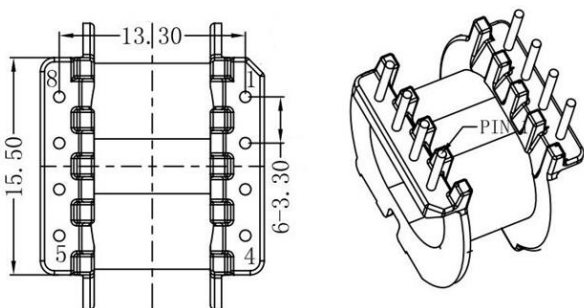


Figure 8: Pin Definition of Bobbin

Table 7: Electrical Characteristic

| Parameter     | Condition   | Value                  |
|---------------|-------------|------------------------|
| Inductance    | $L_P$ (4-5) | 270 $\mu$ H $\pm$ 3%   |
| Core          | -           | ATQ2516                |
| Bobbin        | -           | ATQ2516<br>(4 + 4) pin |
| Core material | -           | N95                    |
| Turn ratio    | N1:N2       | 42:7                   |

Table 8: Winding Specification

| Tape Turns                                                                                    | Winding No. | Start to End | Wire Diameter ( $\phi$ ) | Turns | Winding  | Tube |
|-----------------------------------------------------------------------------------------------|-------------|--------------|--------------------------|-------|----------|------|
|                                                                                               | N1          | 5 to 4       | 0.1mm x 30P              | 42Ts  | 5 layers | Yes  |
| 2Ts                                                                                           |             |              |                          |       |          |      |
| 3Ts                                                                                           | N2          | 1 to 2       | 0.15mm x 2P              | 7Ts   | 1 layer  | Yes  |
| Connect the core to GND (pin 2) via copper. The core center column is fixed with epoxy resin. |             |              |                          |       |          |      |

## APPENDIX 2: FLYBACK TRANSFORMER T2 SPECIFICATION

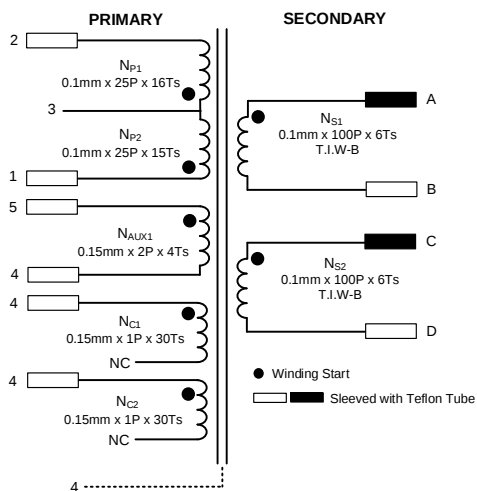


Figure 10: Electrical Diagram

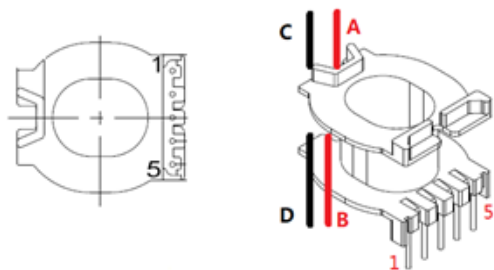


Figure 11: Pin Definition of Bobbin (View from Top)



Figure 12: Winding Diagram

Table 9: Electrical Characteristic

| Parameter          | Condition         | Value                |
|--------------------|-------------------|----------------------|
| Primary inductance | $L_P$ (1-2)       | 320 $\mu$ H $\pm$ 3% |
| Leakage inductance | $L_{LK}$ (1-2)    | 4 $\mu$ H max        |
| Core               | -                 | ATQ2718              |
| Bobbin             | -                 | ATQ2718 (5 + 0) pin  |
| Core material      | -                 | N95                  |
| Turn ratio         | $N_P:N_S:N_{AUX}$ | 31:6:4               |

Table 10: Winding Specification

| Tape Turns                                                                                    | Winding No. | Start to End | Wire Diameter ( $\phi$ ) | Turns | Winding | Tube |
|-----------------------------------------------------------------------------------------------|-------------|--------------|--------------------------|-------|---------|------|
| 2Ts                                                                                           | $N_{P1}$    | 1 to 3       | 0.1mm x 25P              | 16Ts  | 1 layer | Yes  |
| 2Ts                                                                                           | $N_{C1}$    | 4 to NC      | 0.15mm x 1P              | 30Ts  | 1 layer | Yes  |
| 2Ts                                                                                           | $N_{S1}$    | A to B       | 0.1mm x 100P (T.I.W)     | 6Ts   | 1 layer | Yes  |
| 2Ts                                                                                           | $N_{AUX}$   | 5 to 4       | 0.15mm x 2P              | 4Ts   | 1 layer | Yes  |
| 2Ts                                                                                           | $N_{P2}$    | 3 to 2       | 0.1mm x 25P              | 15Ts  | 1 layer | Yes  |
| 2Ts                                                                                           | $N_{C2}$    | 4 to NC      | 0.15mm x 1P              | 30Ts  | 1 layer | Yes  |
| 3Ts                                                                                           | $N_{S2}$    | C to D       | 0.1mm x 100P (T.I.W)     | 6Ts   | 1 layer | Yes  |
| Connect the core to GND (pin 4) via copper. The core center column is fixed with epoxy resin. |             |              |                          |       |         |      |

**REVISION HISTORY**

| Revision # | Revision Date | Description     | Pages Updated |
|------------|---------------|-----------------|---------------|
| 1.0        | 10/19/2022    | Initial Release | -             |

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