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# ***UCC28521 EVM User's Guide***

*User's Guide*

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It is important to operate this EVM within the maximum input voltage ranges specified in section 6.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 50°C. The EVM is designed to operate properly with certain components above 50°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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# **UCC28521 EVM User's Guide**

*Power Supply Control Products*

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## **1 Introduction**

The UCC28521 module is a 100-W offline ac-to-dc voltage converter with power factor correction (PFC). The prototype was designed to show how the UCC28521 could be configured to control a dc-regulated output offline with one control integrated circuit. The module was designed to operate over a universal input range of 85 V to 265 V with a regulated 12-V, 100-W output.

To correctly operate this EVM a fan is required to keep the component temperature at or below 60°C. Not keeping the temperature at or below 60°C could damage the EVM.

## **2 Caution**

High-voltage levels are present on the evaluation module whenever it is energized. Proper precautions must be taken when working with the module. The evaluation module has a large energy storage capacitor and must be completely discharged before the module can be handled. Serious injury can occur if proper safety precautions are not followed.

### 3 Schematic

The schematic can be found in Figure 1, 2 and 3.

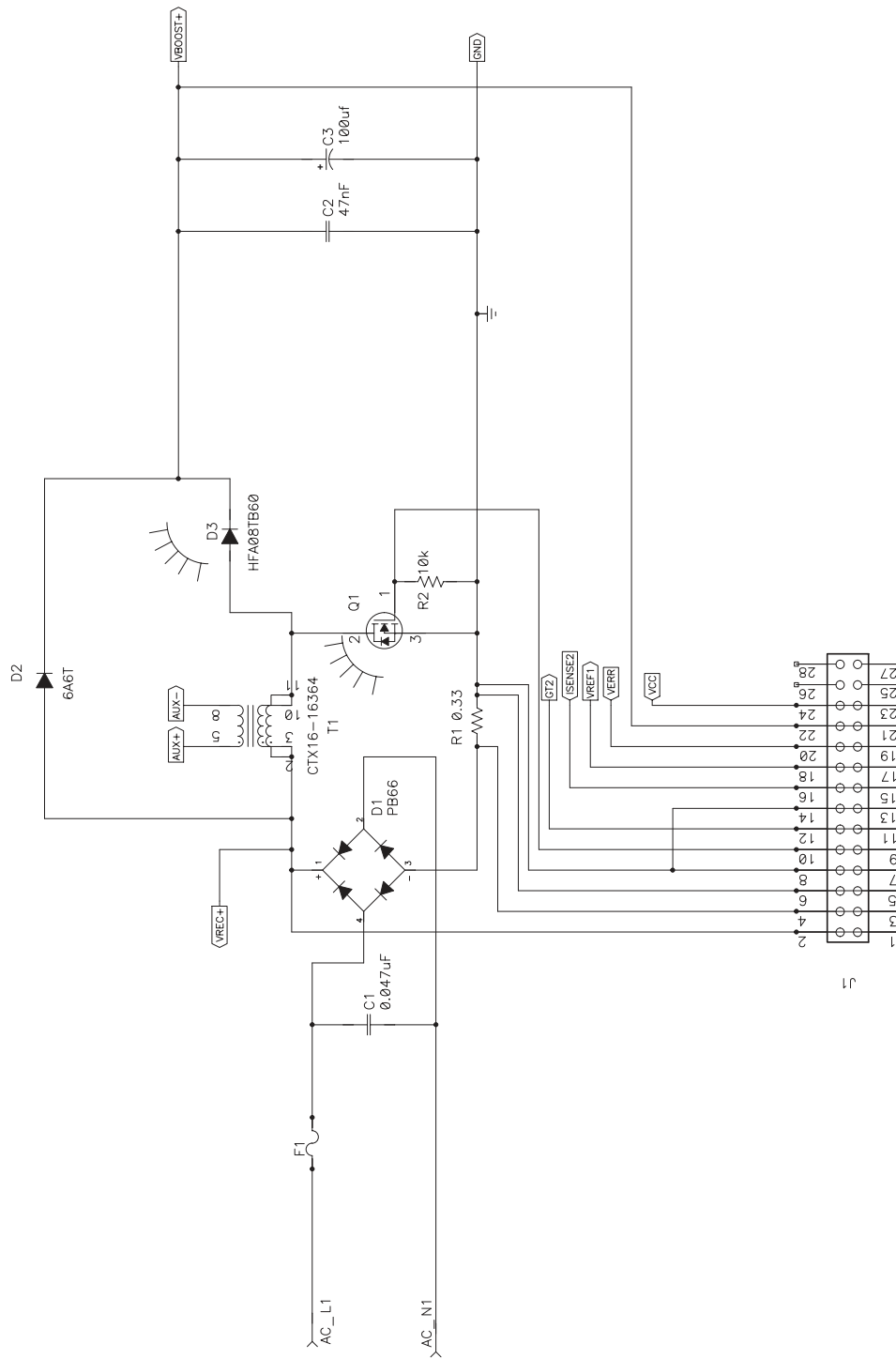


Figure 1. Mother Board Part 1

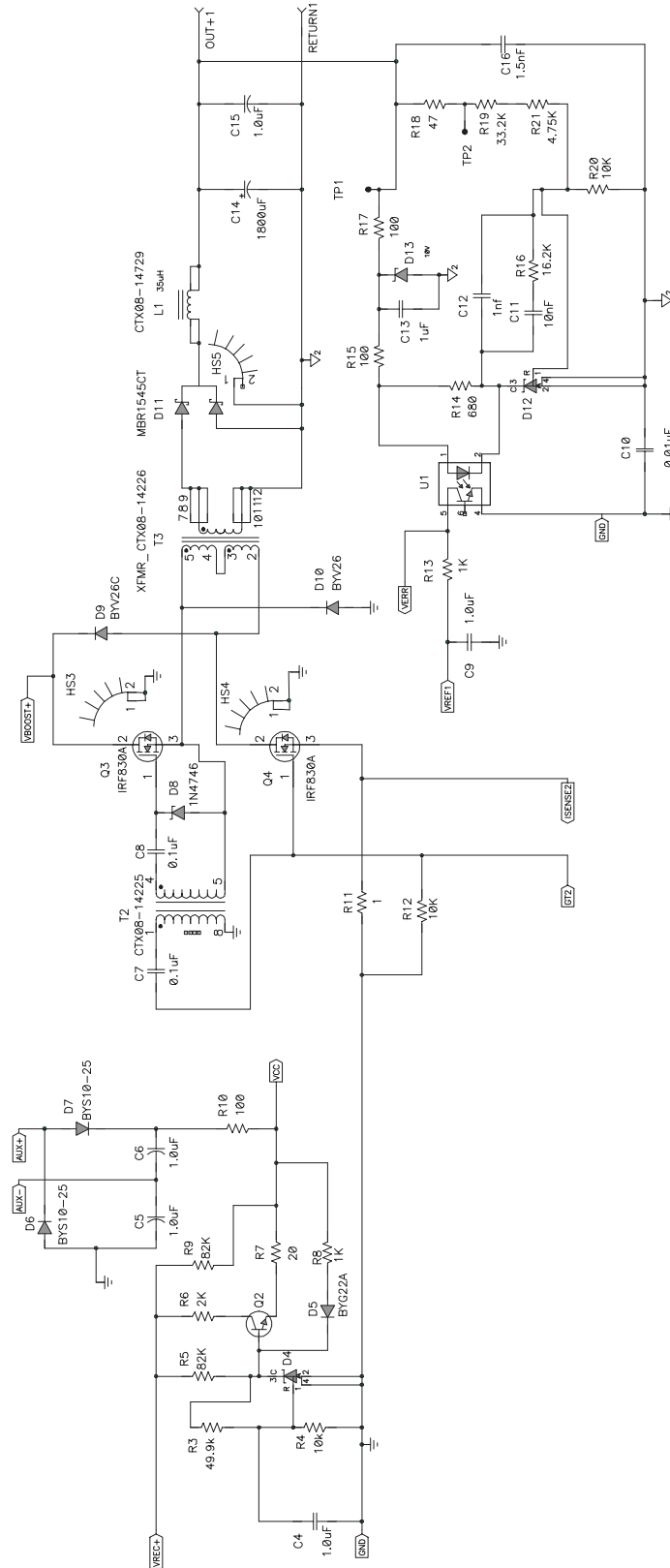


Figure 2. Mother Board Part 2

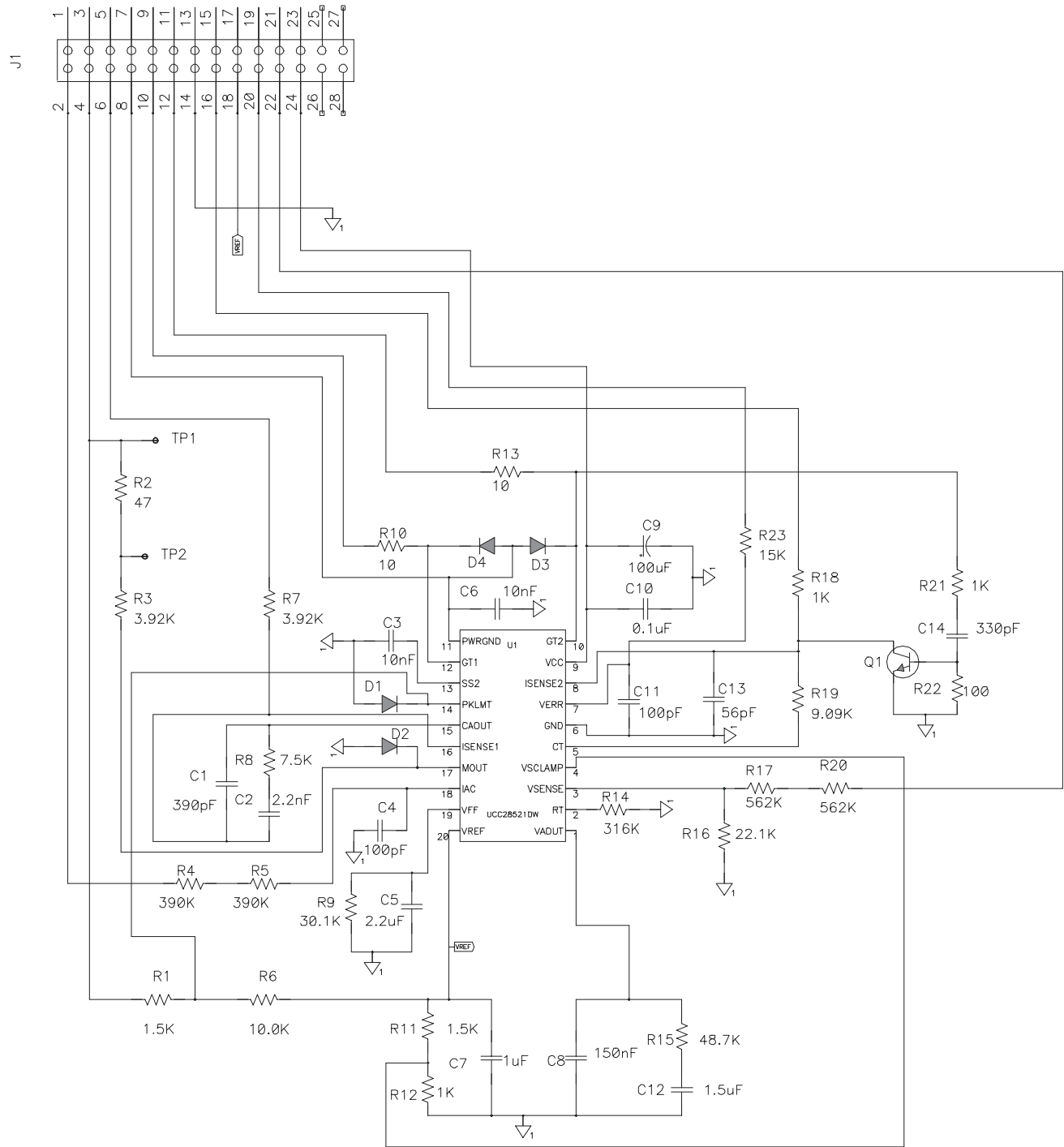


Figure 3. Daughter Board

## 4 List of Materials

Table 1 lists the components used in this design. With minor component tweaks this design could be modified to meet a wide range of applications.

**Table 1. HPA114 Mother Board List of Materials**

| REFERENCE               | QTY | DESCRIPTION   | MANUFACTURER            | PART NUMBER        |
|-------------------------|-----|---|-------------------------|--------------------|
| AC_L1                   | 0   | Connector, binding post, insulated, for standard banana plug, black, 15 A, 141860 | Johnson                 | 111-0703-001       |
| AC_N1                   | 0   | Connector, binding post, insulated, for standard banana plug, red, 15 A, 141860   | Johnson                 | 111-0702-001       |
| C1                      | 1   | Capacitor, film, 0.047 $\mu$ F, 300 V <sub>AC</sub> , $\pm$ 20%, 0.236 x 0.591    | Panasonic               | ECQU3A473MG        |
| C2                      | 1   | Capacitor, polyester, .047 $\mu$ F, 630 V, 10%, 0.256 x 0.650                     | Panasonic               | ECQ-E6473KZ        |
| C3                      | 1   | Capacitor, electrolytic, 100 $\mu$ F, 450 V, TS series                            | Panasonic               | ECO-S2WB101BA      |
| C4, C9                  | 2   | Capacitor, ceramic, 1 $\mu$ F, 25 V, X7R, 10%, 1206                               | Panasonic               | ECJ-3YB1E105K      |
| C5, C6, C15             | 3   | Capacitor, film, 1.0 $\mu$ F, 50 V, 5%, 7380                                      | Panasonic               | ECQ-V1H105JL       |
| C7, C8                  | 2   | Capacitor, ceramic, 0.1 $\mu$ F, 50 V, X7R, $\pm$ 10%, 43200                      | Panasonic               | ECU-S1H104KBB      |
| C10                     | 1   | Capacitor, film, 0.01 $\mu$ F, 300 V <sub>AC</sub> , $\pm$ 20%, 0.197 x 0.591     | Panasonic               | ECQU3A103MG        |
| C11                     | 1   | Capacitor, ceramic, 0.01 $\mu$ F, 50 V, X7R, 10%, 1206                            | Panasonic – ECG         | ECU-V1H103KBM      |
| C12                     | 1   | Capacitor, ceramic, 1 nF, 50 V, X7R, 10%, 0805                                    | Panasonic               | ECU-V1H102KBN      |
| C13                     | 1   | Capacitor, ceramic, 1 $\mu$ F, 50 V, X7R, 10%, 1206                               | Panasonic               | ECJ-3YB1E105K      |
| C14                     | 1   | Capacitor, electrolytic, 1800 $\mu$ F, 35 V,                                      | Panasonic               | EEUFC1E1825C       |
| C16                     | 1   | Capacitor, ceramic, 0.0015 $\mu$ F, 50 V, X7R, 10%, 0805                          | Panasonic               | ECJ-2VB2D152K      |
| Daughter Board Assembly | 1   | Controller board plugs into J1  | Any                     | HPA115             |
| D1                      | 1   | Bridge rectifier, 6 A, 600 V, GBJ series  | General Semiconductor   | PB66               |
| D2                      | 1   | Diode, 600 V, 6 A, 400 A peak surge, 252000                                       | Diodes Inc              | 6A6-T              |
| D3                      | 1   | Diode, ultra fast, 8 A, 600 V, 5 mA   | International Rectifier | HFA08TB60          |
| D4, D12                 | 2   | Adjustable precision shunt regulator, SOT-89                                      | Texas Instruments       | TL431CPK           |
| D5                      | 1   | Diode, rectifier, 2 A, 50 V, SMA  | Vishay                  | BYG22A             |
| D7, D6                  | 2   | Diode, schottky, 1.5 A, 25 V, SMA   | Vishay                  | BYS10-25           |
| D8                      | 1   | Diode, zener, 18 V, 83 mA, 1 W, DO-41   | On Semi                 | 1N4746             |
| D10, D9                 | 2   | Diode, fast recovery, SOD-57  | Phillips                | BYV26              |
| D11                     | 1   | Diode, dual schottky, 15 A, 45 V, TO220   | OnSemi                  | MBR1545            |
| D13                     | 1   | Diode, zener, 10 V, 35 mA, 350 mW, SOT23  | Diodes Inc              | BZX84C10-7         |
| F1                      | 1   | Fuseholder, 1/4 fuses, 0.42   | Cooper/Bussman          | BK/1A1907-06       |
| Fuse at F1              | 1   | 6 A, 250 V, 3AG Glass Fast Acting *Cartridge Type, 1.25" x 0.25"                  | Littlefuse              | 312 006            |
| HS1                     | 1   | Heatsink, TO-220, vertical mount, 5°C/W, 0.5 x 1.38in.                            | Aavid                   | 513201             |
| HS2                     | 1   | Heatsink, TO-220, Vertical mount, 0.98 x 0.44                                     | Aavid                   | 579402B00000       |
| HS3, HS4, HS5           | 3   | Heatsink, TO-220, Vertical mount, 15°C/W, 0.5" x 0.95"                            | Aavid                   | 593002B33402       |
| J1**                    | 1   | Receptacle, female 28 pins, 0.197 x 1181  | Hirose Electric         | DF11-28DS-2DSA(xx) |
| L1**                    | 1   | Inductor, 35 $\mu$ H, 9 A   | Cooper                  | CTX08-14729        |
| OUT+1                   | 0   | Connector, binding post, insulated, for standard banana plug, black, 15 A, 141860 | Johnson                 | 111-0703-001       |
| PCB                     | 1   | Mother board  | Any                     | HPA013             |
| Q1, Q3, Q4**            | 3   | MOSFET, N-channel, 500 V, 5 A, 1500 m $\Omega$ , TO-220                           | International Rectifier | IRF830A            |
| Q2**                    | 1   | Bipolar, NPN, 400 V, 1 A, 15 W, DPAK  | On Semi                 | MJD50              |



| REFERENCE                | QTY | DESCRIPTION   | MANUFACTURER        | PART NUMBER       |
|--------------------------|-----|---|---------------------|-------------------|
| R1                       | 1   | Resistor, wirewound, 3 W, axial, 187500   | Huntington Electric | ALSR-3-.33-1%     |
| R2, R4                   | 2   | Resistor, chip, 10 k $\Omega$ , 1/4 W, 1%, 1210                                   | Panasonic           | ERJ-14NF1002U     |
| R3                       | 1   | Resistor, chip, 49.9 k $\Omega$ , 1/4 W, 1%, 1210                                 | Panasonic           | ERJ-14NF4992U     |
| R5                       | 1   | Resistor, power metal film, 500 V, 3 W, 5 $\pm$ %, 1,000 X 0.200                  | BCcomponents        | 5093NW82K00J08AFX |
| R6                       | 1   | Resistor, power metal film, 2 k $\Omega$ , 3 W, 5 $\pm$ %, 1,000 X 0.200          | BCcomponents        | 5093NW2K00J08AFX  |
| R7                       | 1   | Resistor, chip, 20 $\Omega$ , 1/4 W, 5%, 1210                                     | Panasonic           | ERJ-14YJ200U      |
| R8, R13, R20             | 3   | Resistor, chip, 1 k $\Omega$ , 1/10 W, 1%, 0805                                   | Panasonic           | ERJ-6ENF1001V     |
| R9                       | 1   | Resistor, power metal film, 82 k $\Omega$ , 3 W, 5 $\pm$ %, 1,000 X 0.200         | BCcomponents        | 5093NW82K00J08AFX |
| R10                      | 1   | Resistor, chip, 100 $\Omega$ , 1/4 W, 5%, 1210                                    | Panasonic           | ERJ-14YJ101U      |
| R11                      | 1   | Resistor, metal oxide, 1.0 $\Omega$ , 1 W, 5%, 0.150 x 0.700                      | Yageo               | RSF100JB-1R0      |
| R12                      | 1   | Resistor, chip, 10 k $\Omega$ , 1/10 W, 1%, 0805                                  | Panasonic           | ERJ-6ENF1002V     |
| R14                      | 1   | Resistor, chip, 680 $\Omega$ , 1/10 W, 1%, 0805                                   | Yageo America       | 9C8052A6800FKHFT  |
| R15, R17                 | 2   | Resistor, chip, 100 $\Omega$ , 1/10 W, 1%, 0805                                   | Std                 | Std               |
| R16                      | 1   | Resistor, chip, 16.2 k $\Omega$ , 1/10 W, 1%, 0805                                | Std                 | Std               |
| R18                      | 1   | Resistor, chip, 47 $\Omega$ , 1/10 W, 1%, 0805                                    | Panasonic           | ERA-S27J470V      |
| R19                      | 1   | Resistor, chip, 33.2 k $\Omega$ , 1/10 W, 1%, 0805                                | Std                 | Std               |
| R21                      | 1   | Resistor, chip, 4.75 k $\Omega$ , 1/10 W, 1%, 0805                                | Std                 | Std               |
| RETURN1                  | 0   | Connector, binding post, insulated, for standard banana plug, black, 15 A, 141860 | Johnson             | 111-0703-001      |
| T1**                     | 1   | Boost Inductor, 20 primary, 1 secondary, 1.7 mH, 2.5 A, 1,260 x 1,220             | Cooper              | CTX16-16364       |
| T2**                     | 1   | XFMR, 100 kHz, 750 $\mu$ H, toroid, ferrite                                       | Coiltronics, Inc    | CTX08-14225       |
| T3**                     | 1   | Transformer, 10.8 primary, 1 secondary  | Cooper              | CTX08-14226       |
| TP1, TP2                 | 0   | Jack, test point, circle  | Farnell             | 240-3xx           |
| U1**                     | 1   | Optocoupler, 5300 V, 100% center, SMD   | Fairchild           | 4N36S             |
| X1 at HS1, HS3, HS4, HS5 | 4   | Thermal pad silicon TO220   | BERQUIST            | 3223-07FR-51      |
| X1 at HS1, HS3, HS4, HS5 | 4   | Nut #6X32 (steel)   |                     |                   |
| X1 at HS1, HS3, HS4, HS5 | 4   | Split lock washer #6(steel)   |                     |                   |
| X1 at HS1, HS3, HS4, HS5 | 4   | Flat washer #6 (steel)  |                     |                   |
| X1 at HS1, HS3, HS4, HS5 | 4   | Nylon shoulder washer #6  | Keystone            | 3122              |
| X1 at HS1, HS3, HS4, HS5 | 4   | Pan head screw #6-32X7/16 (steel)   |                     |                   |
| Mother Board             | 1   | PCB   | Any                 | HPA114            |

- NOTES: (1) These assemblies are ESD sensitive, ESD precautions shall be observed.  
 (2) These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.  
 (3) These assemblies must comply with workmanship standards IPC-A-610 Class 2.  
 (4) Reference designators marked with an asterisk (\*\*\*) cannot be substituted. All other components can be substituted with equivalent MFG's components.

**Table 2. HPA115 Daughter Board List of Materials**

| REFERENCE      | QTY | DESCRIPTION  | MANUFACTURER      | PART NUMBER       |
|----------------|-----|--|-------------------|-------------------|
| C1             | 1   | Capacitor, ceramic, 390 pF, 50 V, X7R, 10%, 0805             | Panasonic         | ECU-V1H391KBN     |
| C2             | 1   | Capacitor, ceramic, 2.2 nF, 50 V, X7R, 10%, 0805             | Panasonic         | ECJ-2VB1H222K     |
| C3, C6         | 2   | Capacitor, ceramic, 10 nF, 50 V, X7R, 10%, 0805              | Panasonic         | ECJ-2VB1H103K     |
| C4, C11        | 2   | Capacitor, ceramic, 100 pF, 50 V, X7R, 10%, 0805             | Panasonic         | ECJ-2VC1H101J     |
| C5             | 1   | Capacitor, ceramic, 2.2 $\mu$ F, 16 V, X7R, 10%, 1206        | muRata            | ECJ-3YB1C225K     |
| C7             | 1   | Capacitor, ceramic, 1 $\mu$ F, 50 V, X7R, 10%, 1206          | Panasonic         | ECJ-3YB1E105K     |
| C8             | 1   | Capacitor, ceramic, 150 nF, 50 V, X7R, 10%, 0805             | Panasonic         | ECJ-2YB1E154K     |
| C9             | 1   | Capacitor, aluminum, 100 $\mu$ F, 25 V, 20% (FC Series), 0.2 | Panasonic         | EEU-FC1E101S      |
| C10            | 1   | Capacitor, ceramic, 0.1 $\mu$ F, 50 V, X7R, 10%, 0805        | Panasonic         | ECJ-2YB1H104K     |
| C12            | 1   | Capacitor, ceramic, 1.5 $\mu$ F, 16 V, X7R, 10%, 1206        | Panasonic         | ECJ-3YB1C155K     |
| C13            | 1   | Capacitor, ceramic, 56 pF, 50 V, X7R, 10%, 0805              | Panasonic         | ECJ-2VC1H560J     |
| C14            | 1   | Capacitor, ceramic, 330 pF, 50 V, X7R, 10%, 0805             | Yageo America     | 08052R331K9B20D   |
| D1, D2, D3, D4 | 4   | Diode, schottky, 500 mA, 25 V, SMA                           | Vishay Telefunken | BYS10-25          |
| J1             | 1   | Header, right angle 100 mil, 12 pin , 0.495 x 1,200          | Hirose Electronic | DF11-28DP-2DS(22) |
| Q1             | 1   | Bipolar, NPN, SOT23  | Vishay Telefunken | MMBT2222A         |
| R1, R11        | 2   | Resistor, chip, 1.5 k $\Omega$ , 1/10 W, 1%, 0805            | Panasonic         | ERJ-6ENF1501V     |
| R2             | 1   | Resistor, chip, 47 $\Omega$ , 1/10 W, 1%, 0805               | std               | std               |
| R3, R7         | 2   | Resistor, chip, 3.92 k $\Omega$ , 1/10 W, 1%, 0805           | Panasonic         | ERJ-6ENF3921V     |
| R4, R5         | 2   | Resistor, chip, 390 k $\Omega$ , 1/2 W, 1%, 2010             | Std               | Std               |
| R6             | 1   | Resistor, chip, 10 k $\Omega$ , 1/10 W, 1%, 0805             | Panasonic         | ERJ-6ENF1002V     |
| R8             | 1   | Resistor, chip, 7.5 k $\Omega$ , 1/10 W, 1%, 0805            | Panasonic         | ERJ-6ENF7501V     |
| R9             | 1   | Resistor, chip, 30.1 k $\Omega$ , 1/10 W, 1%, 0805           | Panasonic         | ERJ-6ENF3012V     |
| R10, R13       | 2   | Resistor, chip, 10 $\Omega$ , 1/4 W, 1%, 1210                | Panasonic         | ERJ-14NF10R0U     |
| R12, R18, R21  | 3   | Resistor, chip, 1 k $\Omega$ , 1/10 W, 1%, 0805              | Panasonic         | ERJ-6ENF1001V     |
| R14            | 1   | Resistor, chip, 316 k $\Omega$ , 1/10 W, 1%, 0805            | Std               | Std               |
| R15            | 1   | Resistor, chip, 48.7 k $\Omega$ , 1/10 W, 1%, 0805           | Panasonic         | ERJ-6ENF4872V     |
| R16            | 1   | Resistor, chip, 22.1 k $\Omega$ , 1/4 W, 1%, 1210            | Panasonic         | ERJ-14NF2212U     |
| R17, R20       | 2   | Resistor, chip, 562 k $\Omega$ , 1/4 W, 1%, 1210             | Panasonic         | ERJ-8ENF5623V     |
| R19            | 1   | Resistor, chip, 9.09 k $\Omega$ , 1/10 W, 1%, 0805           | Std               | Std               |
| R22            | 1   | Resistor, chip, 100 $\Omega$ , 1/10 W, 1%, 0805              | std               | std               |
| R23            | 1   | Resistor, chip, 15 k $\Omega$ , 1/10 W, 1%, 0805             | std               | std               |
| TP1, TP2       | 0   | Jack, test point, Clr,                                       | Farnell           | 240-3xx           |
| U1             | 1   | IC, Bi CMOS PFC\PWM Controller, 273600                       | TI                | UCC28521DW        |

- NOTES: (1) These assemblies are ESD sensitive, ESD precautions shall be observed.  
(2) These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.  
(3) These assemblies must comply with workmanship standards IPC-A-610 Class 2.  
(4) Ref designators marked with an asterisk (\*\*\*) cannot be substituted. All other components can be substituted with equivalent MFG's components.

## 5 Reference Design Layout

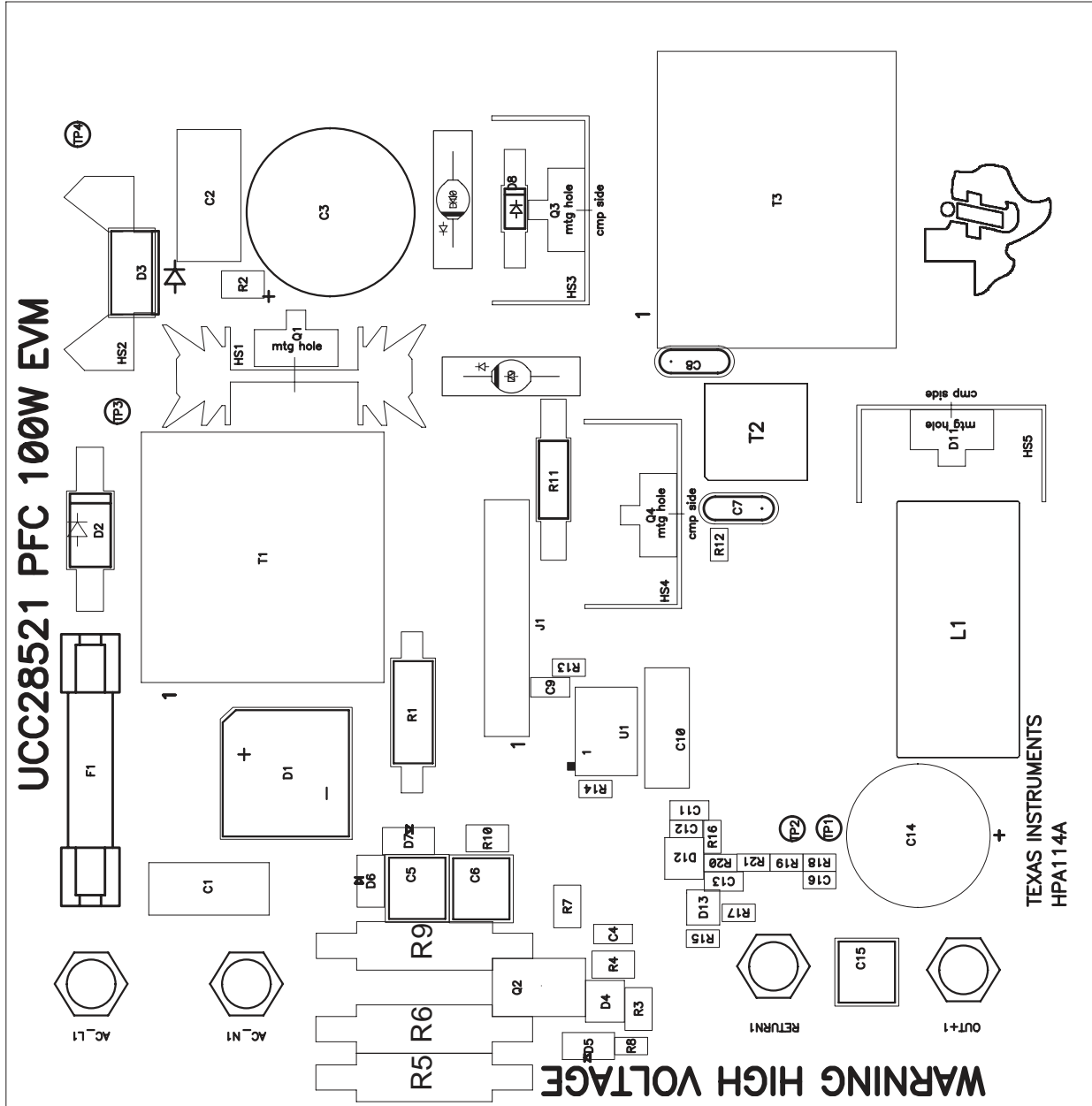
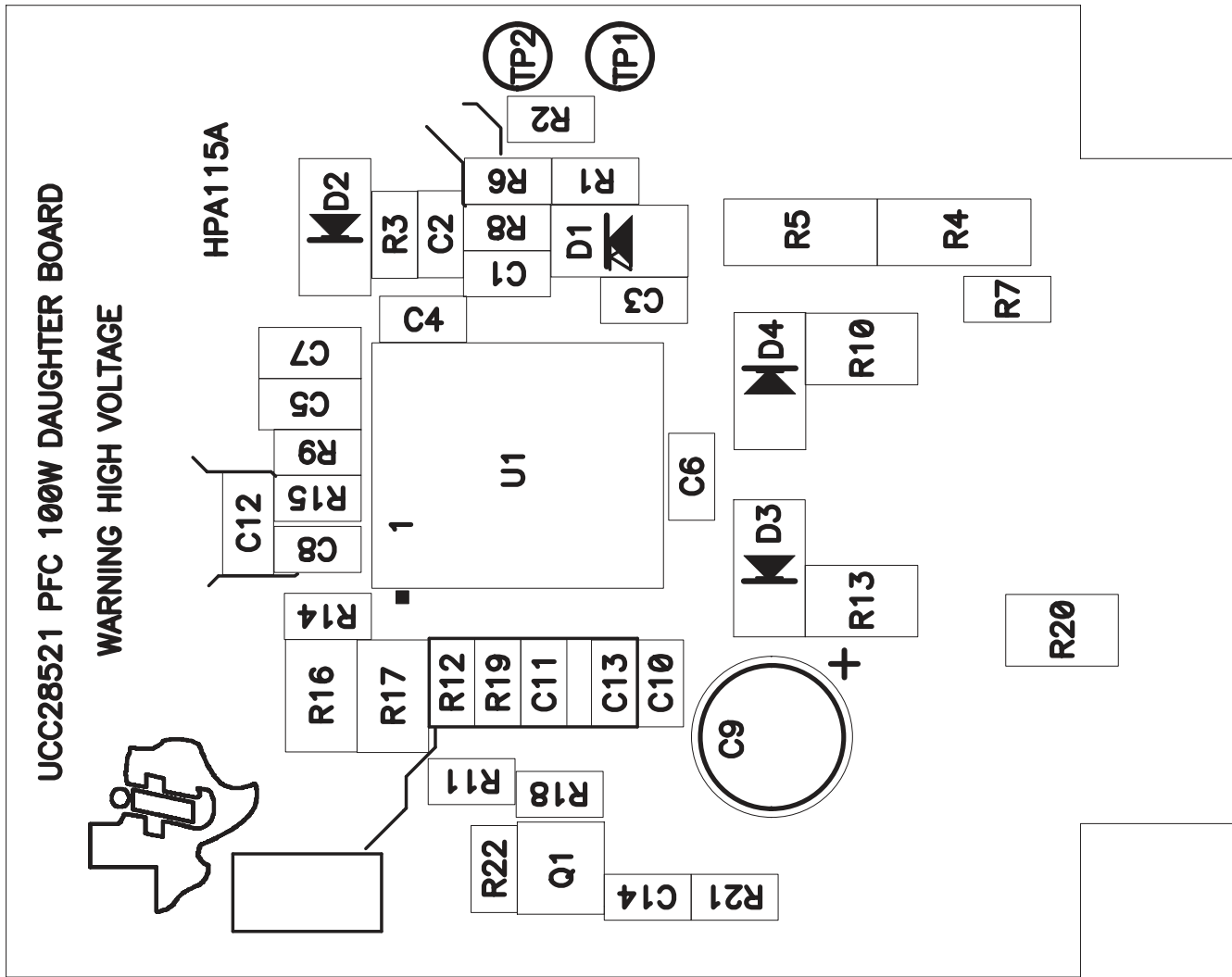


Figure 4. Mother Board



NOTE: R23 can be found on the back of the daughter board.

Figure 5. Daughter Board

## 6 Electrical Characteristics

|                  | MIN  | TYP | MAX  | UNITS            |
|------------------|------|-----|------|------------------|
| V <sub>IN</sub>  | 85   |     | 265  | V <sub>RMS</sub> |
| Output           | 11.4 | 12  | 12.6 | V                |
| P <sub>OUT</sub> | 10   |     | 100  | W                |
| Output Ripple A  |      |     | 500  | mV               |

## 7 Reference Design Performance

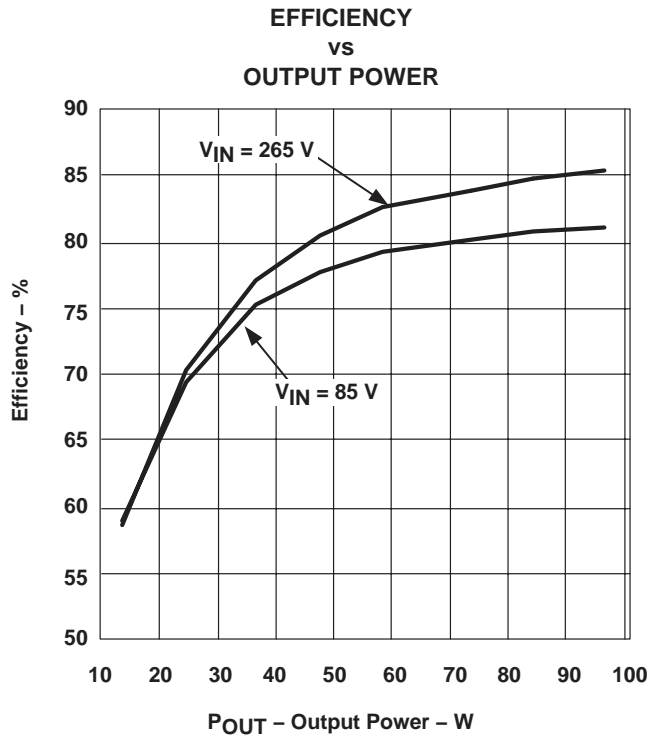


Figure 6

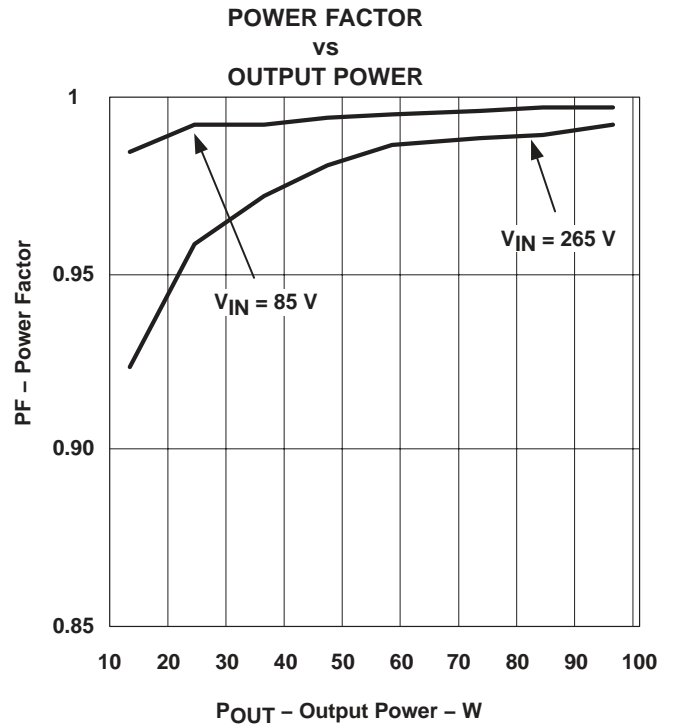


Figure 7

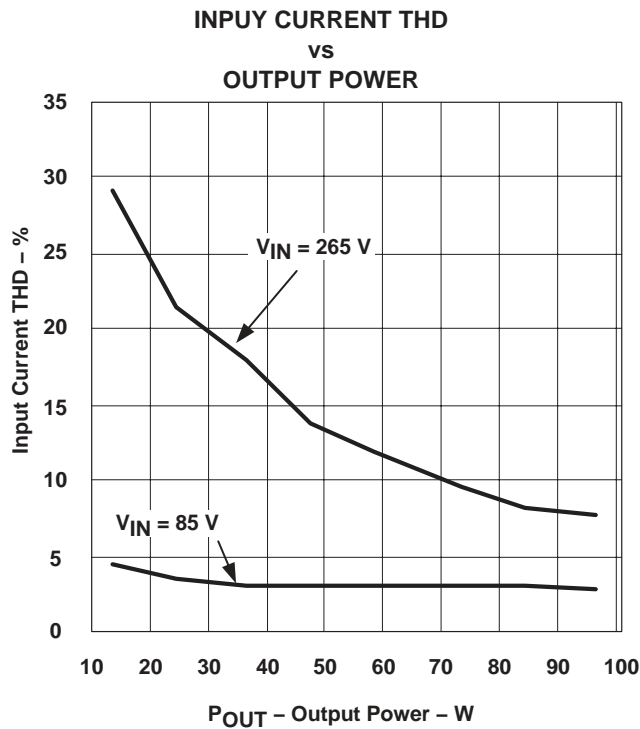


Figure 8

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| DSP              | <a href="http://dsp.ti.com">dsp.ti.com</a>                         | Broadband           | <a href="http://www.ti.com/broadband">www.ti.com/broadband</a>           |
| Interface        | <a href="http://interface.ti.com">interface.ti.com</a>             | Digital Control     | <a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a> |
| Logic            | <a href="http://logic.ti.com">logic.ti.com</a>                     | Military            | <a href="http://www.ti.com/military">www.ti.com/military</a>             |
| Power Mgmt       | <a href="http://power.ti.com">power.ti.com</a>                     | Optical Networking  | <a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a> |
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