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UCC28221 200-W Evaluation Module (EVM)

User's Guide

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EVM IMPORTANT NOTICE (CATEGORY B)

IMPORTANT: TI is providing the enclosed **HPA035A** evaluation module under the following conditions:

This evaluation module (EVM) being provided by Texas Instruments (TI) is intended for use for **ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY** and is not considered by Texas Instruments to be fit for commercial use. As such, this EVM may not be complete in terms of design and/or manufacturing related protective considerations including product safety measures typically found in the end–product incorporating the module. As a prototype, this product does not fall within the scope of the European Union Directive on electromagnetic compatibility and on low voltage and therefore may not meet the technical requirements of the directive. This EVM is not subject to the EU marking requirements.

- Should this EVM not meet the specifications indicated in the User's Guide the EVM may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY TI AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

- The user assumes all responsibility and liability for proper and safe handling of the EVM. The user acknowledge that the use of the EVM could present serious hazards and that it is the user's responsibility to take all precautions for the handling and use of the EVMs in accordance with good laboratory practices. Please be aware that the products received may not be regulatory compliant or agency certified (FCC, UL, etc.). Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

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- TI is currently dealing with various customers for products, and therefore our arrangement with the user **will not be exclusive**.

- TI assumes **no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein**.

- Please read the User's Guide and specifically the section in the User's Guide pertaining to warnings and restrictions prior to handling the product. This section contains important information regarding high temperature and voltages which TI recommends to be read before handling the EVMs. In case of any doubt regarding safety, please contact the TI application engineer.

- Persons handling the product should have electronics training and observe good laboratory practice standards.

- No license is granted under any patent right or other intellectual property right of TI covering or relating to any combination, machine, or process in which such TI products or services might be or are used.

- This Agreement is subject to the laws of the State of Texas, excluding the body of conflicts of laws and the United Nations Convention on the International Sale of Goods, and will be subject to the exclusive jurisdiction of the courts of the State of Texas.

DYNAMIC WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the maximum input voltage ranges specified in Table 1.

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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UCC28221 200-W Evaluation Module (EVM)

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ABSTRACT

The UCC28221 EVM is a 200-W power converter that converts 36-V to 76-V dc input voltage to a regulated 12-V dc output in a two-channel interleaved forward converter topology.

Contents

1   Introduction

The UCC28221 control device from Texas Instruments is used in a dual interleaved forward converter that enables the power supply designer to reduce output current ripple and reduce magnetic size per power stage allowing for improved transient response. The UCC28221 is a dual interleaved PWM controller with programmable maximum duty cycle per channel up to 90% for interleaved forward and interleaved flyback designs.

The power module has two isolated 100-W forward power stages operating at 500 kHz, which are operating 180 degrees out of phase with each other. This allows for smaller magnetic design and ripple current cancellation on the output. The ripple current cancellation on the output allows for a larger allowable equivalent series resistance (ESR) in your output capacitance.

The converter design also takes advantage of the on board 110-V internal JFET start up circuit of the UCC28221 that removes the need of an external trickle charge resistor for boot strapping. This circuit turns off after auxiliary power is supplied to the device conserving power. This saves the power supply designer one component and in high volume applications could be a considerable cost savings.

To correctly operate this EVM requires a minimum load of 50 W and a fan to keep the ambient temperature at or below 40°C. Not keeping the EVM's ambient temperature at or below 40°C could damage the EVM.

2   Caution

High voltage levels are present on this evaluation module whenever it is energized. Proper safety precautions must be taken when working with this power module. Before handling, power must be removed from the EVM and the input storage capacitance must be discharged below 50 V.

Figure 1. Typical Application Schematic

3   Electrical Characteristics

Table 1.

	MIN	TYP	MAX	UNITS
V_{IN}	36	48	76	V
Output	11.4	12	12.6	
P_{OUT}	50		200	W
Output ripple			500	mV

4   Performance

**EFFICIENCY
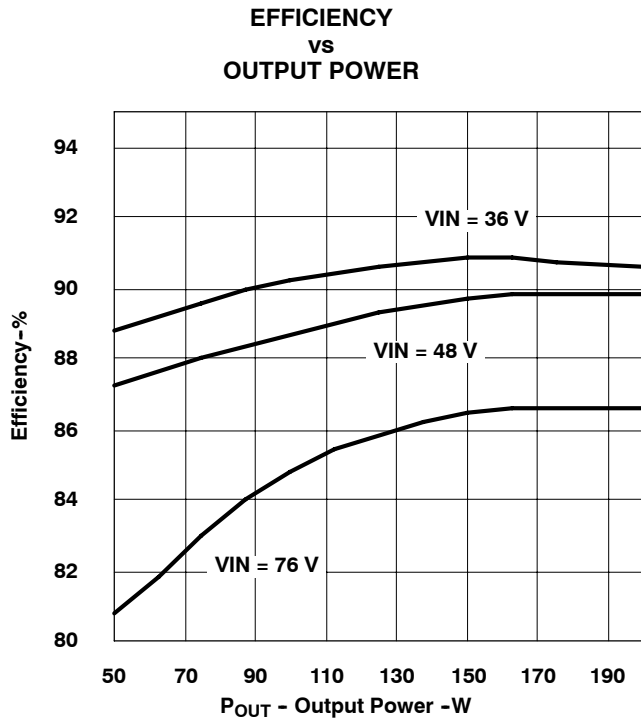vs
OUTPUT POWER**
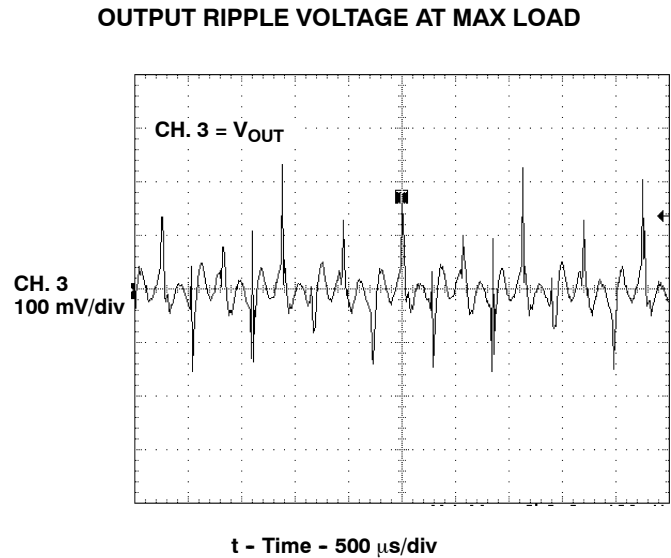

Figure 2

OUTPUT RIPPLE VOLTAGE AT MAX LOAD

Figure 3

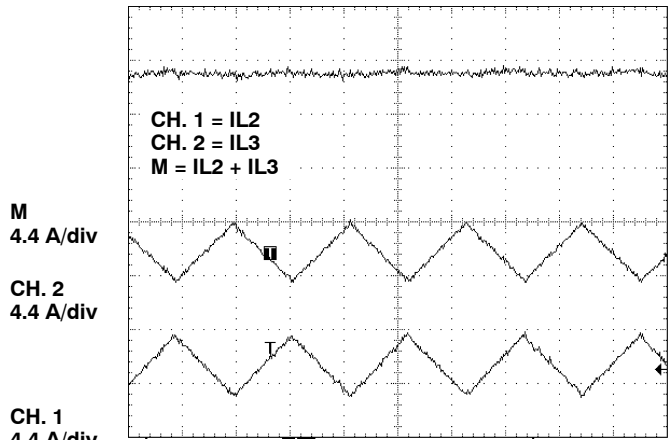**TRANSIENT RESPONSE WITH THE LOAD
STEPPED FROM 200 W TO 50 W**

CH. 3 = V$_{OUT}$

CH. 3
1 V/div
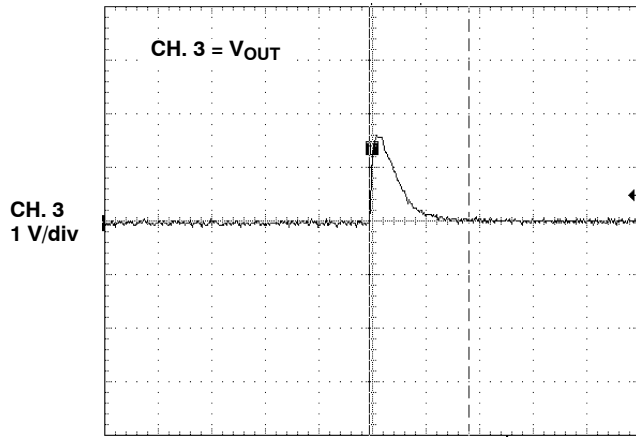
t – Time – 500 μs/div

Figure 4

**TRANSIENT RESPONSE WITH THE LOAD
STEPPED FROM 50 W TO 200 W**

CH. 3 = V$_{OUT}$

CH. 3
1 V/div
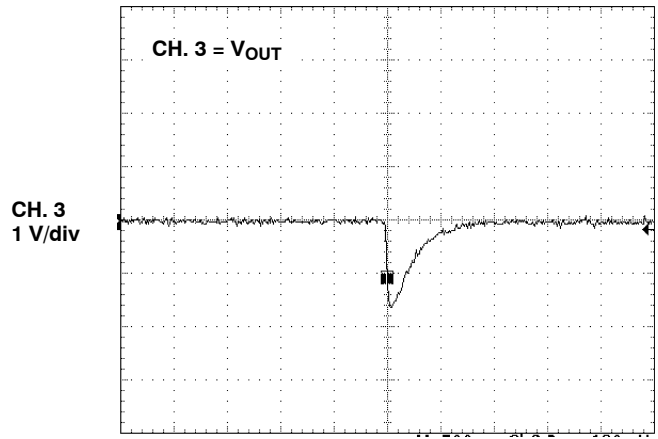
t – Time – 500 μs/div

Figure 5

**OUTPUT CURRENT RIPPLE CANCELLATION
(V$_{IN}$ = 36 V)**

CH. 1 = IL2
CH. 2 = IL3
M = IL2 + IL3

M
4.4 A/div

CH. 2
4.4 A/div

CH. 1
4.4 A/div

t – Time – 1 μs/div

Figure 6

**OUTPUT CURRENT RIPPLE CANCELLATION
(V$_{IN}$ = 76 V)**

CH. 1 = IL2
CH. 2 = IL3
M = IL2 + IL3

M
4.4 A/div

CH. 2
4.4 A/div

CH. 1
4.4 A/div

t – Time – 1 μs/div

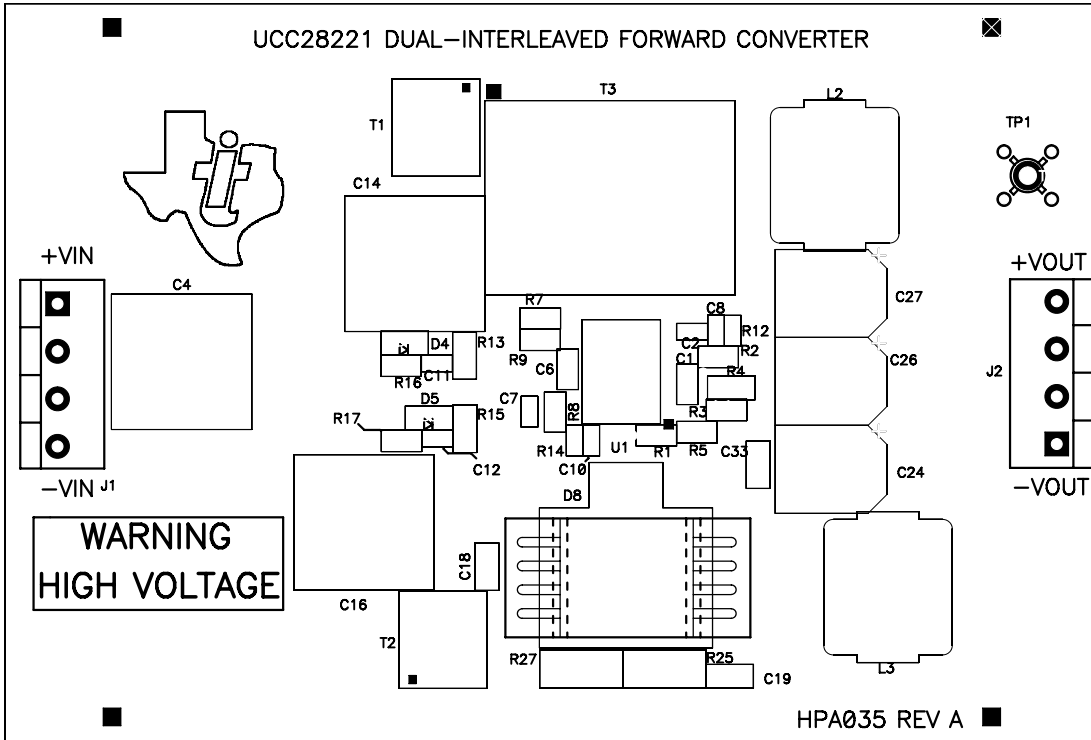**Figure 7**

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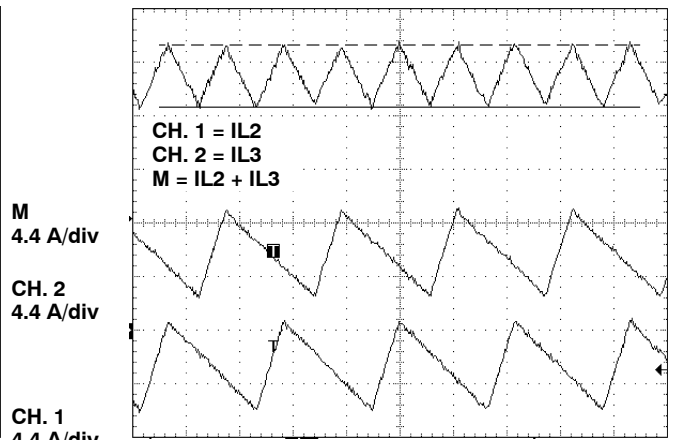
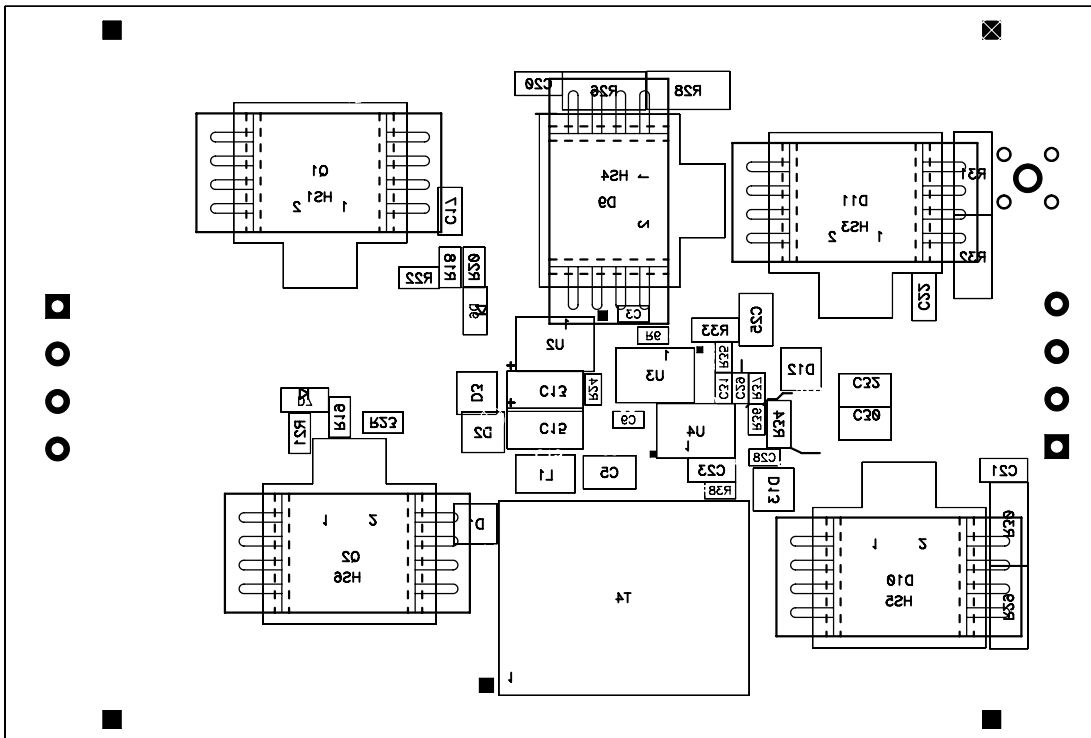# 5   Layout

Figure 8. Top View

Figure 9. Bottom View

6 List of Materials

The EVM list of materials is shown in Table 1.

Table 2. Evaluation Module List of Materials (HPA035)

REFERENCE	QTY	DESCRIPTION	MANUFACTURER	PART NUMBER
C1, C6	2	Capacitor, ceramic, 1.0 µF, 16 V, X7R, 10%, 805	Std	Std
C11, C12	2	Capacitor, ceramic, 47 pF, 50 V, X7R, 5%, 603	Kemet	C0603C470J5GACTU
C13, C15	2	Capacitor, tantalum Chip, 47 µF, 16 V, 0.281 x 0.126	Vishay	595D476X9016C2T
C17, C18, C19, C20, C21, C22	6	Capacitor, ceramic, 1000 pF, 200 V, X7R, 10%, 1206	Vishay	VJ1206Y102KXCA
C2	1	Capacitor, ceramic,0.47 µF, 50 V, X5R, 10%, 603	AVX	06036D474KAT
C23	1	Capacitor, ceramic, 0.01 µF, 500 V, X7R, 10%, 1206	Vishay	VJ1206Y103KXEA
C24, C26, C27	3	**Capacitor, OS–CON, 82 µF, 16 V, 40 mΩ, 20%, 8.3mm (E7)	Sanyo	16SVP82M
C28	1	Capacitor, ceramic, 0.01 µF, 25 V, X7R, 10%, 603	Kemet	C0603C104K3RACTU
C29	1	Capacitor, ceramic, 680 pF, 16 V, X7R, 10%, 603	Std	Std
C3	1	Capacitor, ceramic,180 pF, 50 V, X7R, 10%, 603	Std	Std
C30	1	Capacitor, ceramic, 1 µF, 50 V, X7R, 20%, 1210	Std	Std
C31	1	Capacitor, ceramic, 0.056 µF, 16 V, X7R, 10%, 603	Std	Std
C32	1	Capacitor, ceramic, 0.1 µF, 50 V, X7R, 20%, 1210	Std	Std
C33	1	Capacitor, ceramic, 0.47 µF, 16 V, X7R, 10%, 1206	Vishay	VJ1206Y474KXJA
C4, C14, C16	3	**Capacitor, MLP, 4.0 µF, 100 V	ITW PAKTRON	405K100CS4G
C5, C25	2	Capacitor, ceramic, 4.7 µF, 25 V, X7R, 10%, 1210	Vishay	Std
C7, C9	2	Capacitor, ceramic, 0.1 µF, 25 V, X7R, 10%, 603	Kemet	C0603C104K3RACTU
C8, C10	2	Capacitor, ceramic, 56 pF, 50 V, NPO, 5%, 603	Std	Std
D1, D2, D13	3	Diode, switching, 200 mA, 200 V, 330 mW, SOT23	Zetex	BAS21
D12	1	Diode, zener, 9.1 V, 350 mW, SOT23	Diodes, Inc.	BZX84C9V1T
D3	1	Diode, zener, 15 V, 350 mW, SOT–23	Diodes, Inc.	BZX84C15
D4, D5, D6, D7	4	Diode, schottky, 500 mA, 30 V, SOD123	ON Semiconductor	MBR0530
D8, D9, D10, D11	4	Diode, dual schottky, 20 A, 100 V, D2PAK/HS	International Rectifier	MBRB20100CTTRL
HS1, HS2, HS3, HS4, HS5, HS6	6	**Heatsink, surface mount heat sink, D2pak	Aavid	573300
J1, J2	2	Terminal block, 4 pin, 15 A, 5.1 mm, 0.80 x 0.35	OST	ED2227
L1	1	**Inductor, SMD, 470 µH, 62 mA, 26 mΩ, 0.177 x 0.126	TDK	NL453232T–471J
L2, L3	2	**Inductor, SMT, 3.2 µH, 18 A$_{RMS}$, 6.8 mΩ, 0.51 x 0.51		IHLP–5050FD–RZ–3R3–M–01
Q1, Q2	2	MOSFET, N-channel, 200 V, 0.030 Ω, D2PAK/HS	VISHAY	SUM65N20–30

REFERENCE	QTY	DESCRIPTION	MANUFACTURER	PART NUMBER
R1	1	Resistor, chip, 15.0 kΩ, 1/10 W, 1%, 805	Panasonic	ERJ–6ENF1502V
R12, R14	2	Resistor, chip, 1 kΩ, 1/16 W, 1%, 603	Panasonic	ERJ–3EKF1001V
R13, R15	2	Resistor, chip, 5.23 Ω, 1/8 W, 1%, 1206	Std	Std
R16, R17	2	Resistor, chip, 100 Ω, 1/10 W, 1%, 805	Std	Std
R18, R19	2	Resistor, chip, 5.23 Ω, 1/10 W, 1%, 805	Std	Std
R2	1	Resistor, chip, 22.6 kΩ, 1/10 W, 5%, 805	Std	Std
R20, R21	2	Resistor, chip, 0 Ω, 1/10 W, 5%, 805	Std	Std
R22, R23	2	Resistor, chip, 10 kΩ, 1/10 W, 1%, 805	Std	Std
R25, R26, R27, R28, R29, R30, R31, R32	8	Resistor, chip, 7.5 Ω, 1 W, 5%, 2512	Std	Std
R3	1	Resistor, chip, 604 kΩ, 1/10 W, 1%, 805	Panasonic	ERJ–6ENF6043V
R33, R34	2	Resistor, chip, 499 Ω, 1/8 W, 1%, 1206	Panasonic	
R35	1	Resistor, chip, 3.57 kΩ, 1/16 W, 1%, 603	Std	Std
R36	1	Resistor, chip,5.23 kΩ, 1/16 W, 1%, 603	Std	Std
R37	1	Resistor, chip, 1.37 kΩ, 1/16 W, 1%, 603	Std	Std
R38	1	Resistor, chip, 100 kΩ, 1/16 W, 1%, 603	Std	Std
R4	1	Resistor, chip, 20.0 Ω, 1/8 W, 1%, 1206	Panasonic	ERJ–8ENF10R0V
R5	1	Resistor, chip, 24.9 kΩ, 1/10 W, 1%, 805	Panasonic	ERJ–6ENF2492V
R6, R24	2	Resistor, chip, 750 Ω, 1/16 W, 1%, 603	Std	Std
R7	1	Resistor, chip, 15.4 kΩ, 1/10 W, 1%, 805	Std	Std
R8	1	Resistor, chip, 976 kΩ, 1/10 W, 1%, 805	Panasonic	ERJ–6ENF9763V
R9	1	Resistor, chip, 5.36 kΩ, 1/10 W, 1%, 805	Std	Std
T1, T2	2	**Transformer, current sense, 10 A, 500 kHz, 1:50, 0.330 x 0.360	Pulse	P8205T
T3, T4	2	**SMT transformer, 2 Primary, 1 Secondary, 500 kHz, 103 W, L_{MAG} = 35 μH, 0.787 x 0.984	Payton	50863
TP1	1	Adaptor, 3.5 mm probe clip (or 131–5031–00), 0.2	Tektronix	131–4244–00
U1	1	Dual Interleaved PWM Controller With Programmable Max Duty Cycle, SO16	TI	UCC28221D
U2	1	High Speed Low Side Power MOSFET Driver, SO8	Texas Instruments	UCC27324D
U3	1	Optocoupler, SO8	Motorola	MOC206
U4	1	Adj Shunt Regulator, 100 mA, 36 V, SO8	TI	TL431AID
– –	1	PCB, 0 In x 0 In x 0 In	Any	HPA035

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.

7   References

Datasheet, *UCC28220/1 Dual Interleaved PWM Controller with Programmable Maximum Duty Cycle*, TI Literature No. SLUS544