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***UCC3580EVM Flyback Converters,  
Active Clamp vs Hard-Switched  
Evaluation Board and List of  
Materials***

***User's Guide***

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During normal operation, some circuit components may have case temperatures greater than 60°C. The EVM is designed to operate properly with certain components above 125°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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# **UCC3580EVM**

## **Flyback Converters, Active Clamp vs Hard-Switched Evaluation Board and List of Materials**

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*Power Supply Control Products*

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## 1 Introduction

This user's guide describes the UCC3580EVM flyback converter evaluation board for comparing an active-clamp configuration with a hard-switched configuration. The UCC3580EVM is originally configured as an active-clamp flyback converter. Instructions and parts list are included in order to reconfigure the UCC3580EVM as a hard-switched flyback converter. Both configurations use the UCC3580 PWM controller. The active clamp configuration operates noticeably more efficiently than the hard switched configuration. Most of the efficiency differences will be seen in the primary-side components.

## 2 Features

- Provides auxiliary-switch activation complementary to main-power switch drive
- Programmable dead time (turnon delay) between activation of each switch
- Voltage mode control with feedforward operation
- Programmable limits for both transformer volt-second product and PWM duty cycle
- High-current gate driver for both main and auxiliary outputs
- Multiple protection features with latched shutdown and soft restart
- Low supply current (160- $\mu$ A startup, 2.5-mA operation)

## 3 Description

### 3.1 Operating Guidelines

**WARNING:**

***DANGER: HIGH VOLTAGE! This evaluation board is intended for professional use only. It has exposed high voltages. Do not operate this board without proper isolation and high-voltage/high-current safety practices.***

Refer to the recommended test setup, as shown in Figure 1, and the test points in Table 1. Connect the UCC3580EVM, configured for either active clamp operation or hard-switched operation, as shown in Figure 1. Close the ac line switch and verify that the UCC3580EVM is operating correctly (12 V should be measured by the hand-held DVM on the converter output). Using the appropriate oscilloscope probes, observe the main transistor drain source voltage (TP14 to TP13) and the cathode to anode voltage of the output rectifier (TP6 to TP8). The active clamp implementation will have crisp, clamped voltages and no overshoot on the output rectifier. Converter dynamics can be observed [1] using TP3, 4 and 5.

Other test points are included to observe voltages and currents that are of interest for a specific application. Table 1 describes the intended purpose of the test points that are installed in the board and how they should be used.

### 3.2 Added Features

Flyback converters require a voltage clamp in order to limit the main switch voltage at turnoff. The effect is due to energy that is stored in the primary leakage inductance of the power transformer. Older hard-switched technology captures the excess leakage inductance energy at turnoff and merely dissipates it in a resistor. In contrast, the active clamp uses the leakage inductance energy to facilitate zero voltage transitions. Efficient ZVS transitions occur at turnon of both the main MOSFET and the auxiliary MOSFET.

Active-clamp technology is made possible here with the UCC3580 single ended active clamp/reset PWM controller. Essentially, this controller is a voltage mode PWM controller with complementary outputs and programmable delay between output transitions. The controller also includes over-current protection, volt-seconds protection and a soft-start feature. The programmable delay is set to be long enough for the leakage inductance energy to forward bias the power MOSFETs before their respective turnon, thus achieving zero voltage switching.

The schematic for the active clamp configuration is shown in Figure 2 and its parts list is in Table 2. The schematic for the hard-switched configuration is shown in Figure 3. Both configurations operate with the same input voltage (110 VAC  $\pm$  10%) and produce the same output voltage (12 V) and current (10 A). Heat sink HS1 is selected to accommodate the hard-switched configuration and it is thus over-sized for active clamp operation. The thermal resistance of HS1 is 6.5°C/W, which is required for hard-switched operation. In contrast, heat sink HS1 only needs a thermal resistance of 10°C/W for active-clamp operation, which was verified in the laboratory. Thus transistor QM operates more efficiently, and it requires a smaller heat sink in the active-clamp configuration. Also, notice that the active-clamp configuration does not require secondary rectifier snubber components (R31 and C30). These features are the result of efficient active clamp technology.

For more information, pin descriptions and specifications for the UCC3580 single ended active clamp/reset PWM, please refer to the UCC3580 data sheet.

### 3.3 Re-Configuration Instructions

#### **WARNING:**

***Danger: Remove power from the UCC3580EVM before removing or installing components.***

These instructions describe how to reconfigure the UCC3580EVM from the active clamp configuration to the hard switched configuration. This section requires components, de-soldering, soldering, and assembly equipment and skills. The components are listed in Table 4.

Begin with an UCC3580EVM in the active-clamp configuration (original configuration). Refer to Table 3 and Table 4 for the components to remove and add, respectively in order for the UCC3580EVM to match the schematic in Figure 3. The additional components in Table 4 are supplied in the kit that is included with the UCC3580EVM.

De-solder the components listed in Table 3. Solder the components listed in Table 4.

Conversion is now complete and comparisons can be made using the test setup in Figure 1 and the test points in Table 1.

## 4 Test Setup and Test Points

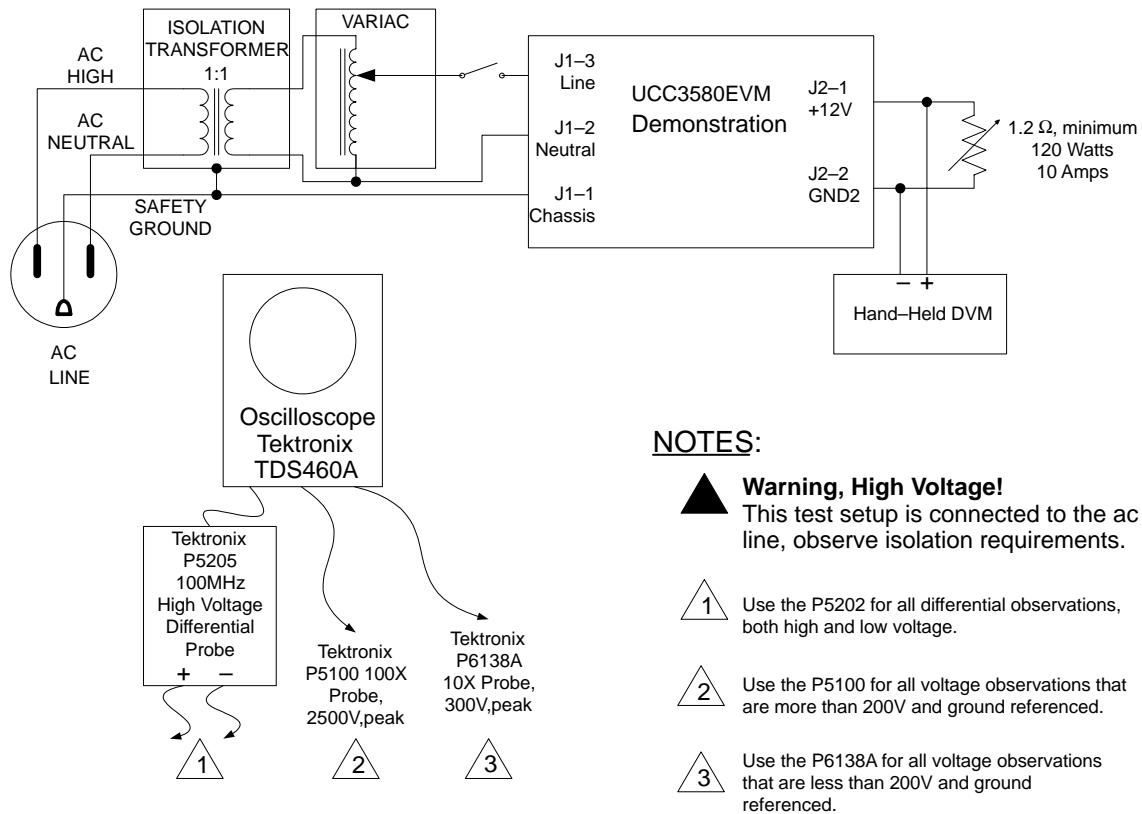


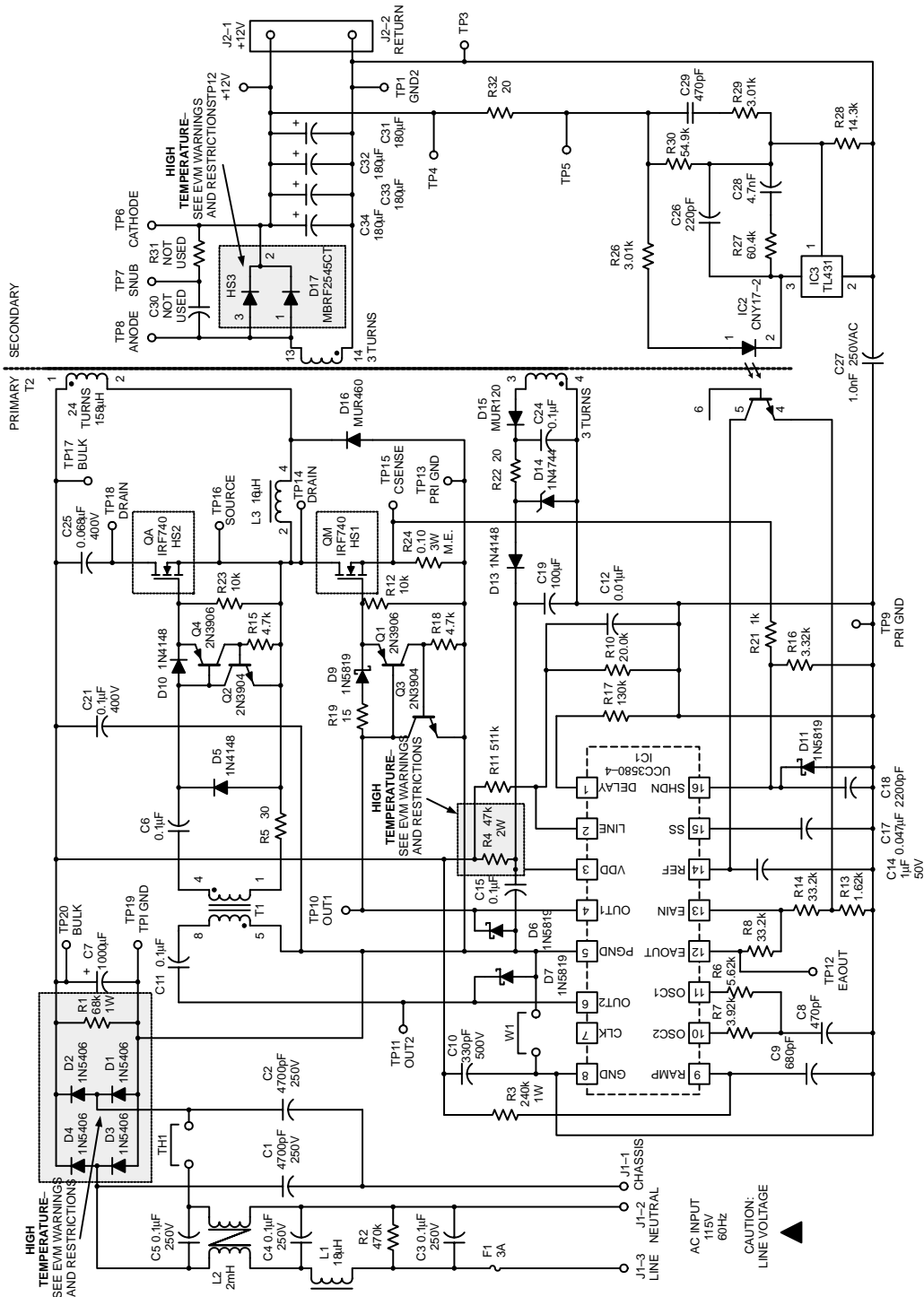
Figure 1. Recommended Test Setup for the UCC3580EVM

Table 1. List of Test Points

Test Point	Signal Name	Voltage Range	GND REF	Measurement
TP1	GND2		SEC	Secondary ground
TP2	12 V	12 V	SEC	12 V, observe relative to TP1
TP3 TP4 TP5		12 V, 0.1 VAC	SEC	Injection and observation points for control loop. Refer to [1]
TP6 TP7 TP8		12 V 50 V 50 V	SEC	Differentially observe V(D17) between TP6 and TP8. Differentially observe snubber power between TP6 and TP7.
TP9	PRI GND		PRI	Primary ground for controller observations
TP10	OUT1	12 V	PRI	Main MOSFET (QM) gate control signal
TP11	OUT2	12 V	PRI	Auxiliary MOSFET (QA) gate control signal
TP12	EAOUT	5 V	PRI	Error amplifier output to PWM comparator
TP13	PRI GND		PRI	PRI GND reference for QM and CSense observations
TP14	DRAIN	300 V	PRI	Observe QM drain voltage relative to PRI GND
TP15	CSense	1 V	PRI	Observe drain current of QM
TP16 TP17 TP18	SOURCE BULK DRAIN	300 V 300 V 300 V	PRI	Differentially observe QA drain-source voltage between TP18 and TP16 Differentially observe clamp voltage, V(C25) between TP18 and TP17
TP19 TP20	PRI GND BULK	200 V	PRI	Observe bulk capacitor voltage ( the dc input voltage to the converter)

## 5 Application Drawings and Parts List

### 5.1 Active Clamp Configuration



UDG-00014

Note: High-temperature component. See EVM Warnings and Restrictions at the front of this document.

Figure 2. Flyback Converter Populated for Active Clamp Operation

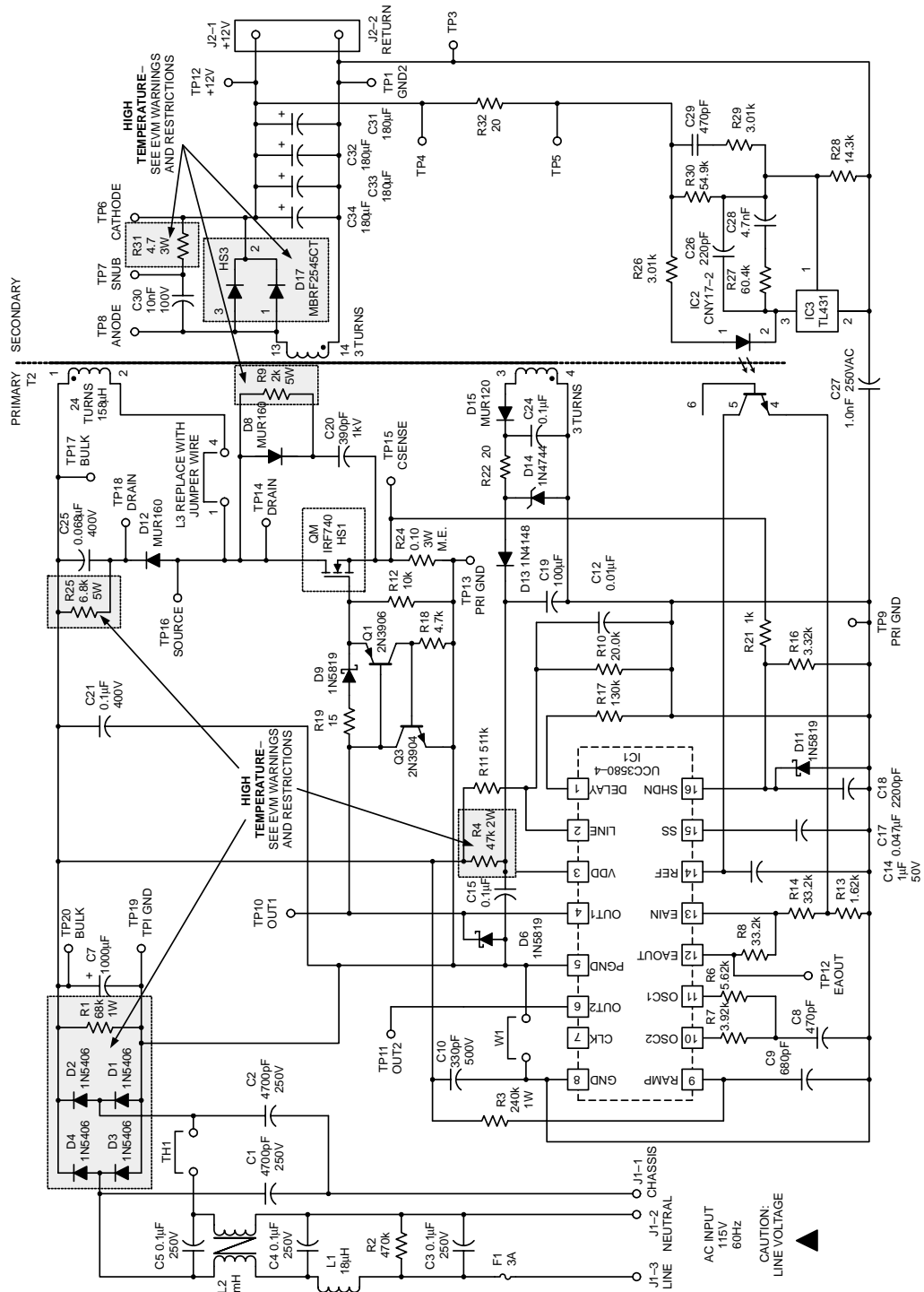


**Table 2. Parts List for Active Clamp Configuration**

	Ref Des	Qty	Description	MFG	Size	Part Number
Capacitor	C1,2	2	Y Cap, 4700 pF, 250 Vac	Sprague	6.5 mm	5GAD47
	C3 – C5	3	X Film Cap, 0.1 $\mu$ F, 250 Vac	Philips	15 mm	222 330 40104
	C6, C11, C15, C24	4	Ceramic, 0.1 $\mu$ F, 50 V	Panasonic	5 mm	ECU–S1H104KBB
	C7	1	Aluminum electrolytic, 1000 $\mu$ F, 200 V	United Chemi–con	10 mm	KMH200VN102M35X35 T2
	C8	1	Ceramic, 470 pF, 50 V	Panasonic	2.5 mm	ECU–S1H471JCA
	C9	1	Ceramic, 680 pF, 50 V	Panasonic	2.5 mm	ECK–F1H681KB
	C10	1	Ceramic Disk, 330 pF, 500 V	Philips	5 mm	D331K20Y5PLAAEU
	C12	1	Ceramic, 0.01 $\mu$ F, 50 V	Panasonic	2.5 mm	ECU–S1H103KBA
	C14	1	Ceramic, 1 $\mu$ F, 50 V	Panasonic	5 mm	ECU–S1H105MEB
	C17	1	Ceramic, 47 nF, 50 V	Panasonic	2.5 mm	ECU–S1H473MEA
	C18	1	Ceramic, 2200 pF, 50 V	Panasonic	2.5 mm	ECK–F1H222KB
	C19	1	Aluminum Electrolytic, 100 $\mu$ F, 25 V	Panasonic	2 mm	ECE–A1EU101
	C21	1	Foil, 0.1 $\mu$ F, 400 V	Panasonic	20 mm	ECQ–P4104JU
	C25	1	Foil, 0.068 $\mu$ F, 400 V	Panasonic	20 mm	ECQ–P4683JU
	C26	1	Ceramic, 220 pF, 50 V	Panasonic	2.5 mm	ECU–S1H221JCA
	C27	1	Y1 Ceramic, 1000 pF, 250 Vac	Panasonic	10 mm	ECK–DNA102MB
	C28	1	Ceramic, 4.7 nF, 50 V	Panasonic	2.5 mm	ECU–S1H472KBA
	C29	1	Ceramic, 470 pF, 50 V	Panasonic	7.5 mm	ECU–S1H471JCA
C31 – C34	4	Os–Con, 180 $\mu$ F, 20 V	Sanyo	5 mm	20SP180M	
Diode	D1 – D4	4	General Purpose, 3 A, 600 V		DO–201AD	1N5406
	D5, D10, D13	3	Switching, 75 mA, 75 V		DO–35	1N4148
	D6, D7, D9, D11	4	Schottky, 1 A, 40 V		DO–41	1N5819
	D14	1	Zener, 15 V, 1 W		DO–41	1N4744A
	D15	1	Ultra Fast, 1 A, 200 V		DO–41	MUR120
	D16	1	Ultra Fast, 4 A, 400 V		DO–201AD	MUR460
	D17	1	Schottky, Dual, 25 A, 45 V		ITO–220AB	MBRF2545CT
Fuse	F1	1	3 A, AGC3A Buss, 3 A	Buss	31.75 mm	AGC3A
Fuse clips	FCa,b	2	2 required, spacing per dwg	Keystone	7.62 mm	3510
Heatsink	HS1	1	For QM, 6.5 C/W	Thermalloy	50.44 mm	7022B–MT
	HS2	1	For QA, 13 C/W	Thermalloy	24.38 mm	6021PB
	HS3	1	For D53, 4.4 C/W	Thermalloy	27.94 mm	7023B–MT
PWM	IC1	1	IC control	TI–Unitrode	DIL–16	UCC3580N–4
Optocoupler	IC2	1	CNY17–2		DIL–6	CNY17–2
Voltage Reference	IC3	1	2.495 V	TI	TO–226AA	TL431CLP
Connector	J2	1	2 pos, 5.08 mm spacing	Phoenix Contact	5.08 mm	1730612
Choke	L1	1	Toroid, 18 $\mu$ H	Magnetek	12.06 mm	FIT68–7
	L2	1	Common mode, 2 mH	Panasonic	10X16.5 mm	ELF–18N032A
	L3	1	E25/10/6–3F3 core, 10-pins, 16 $\mu$ H	Century Magnetics	5.1X15.6 mm	CMI–2408
MOSFET	QA, QM	2	400 V, 0.55 $\Omega$ , 10 A	IR	TO–220AB	IRF740

	Ref Des	Qty	Description	MFG	Size	Part Number
Screw		3	#4–40 x 3/8" round head, philips, for QA, QM & D17			
Nut		3	#4–40 hex for QA, QM & D17			
Washer		3	#4, flat for QA, QM & D17			
Washer		3	#4, split lock, for QA, QM & D17			
Heat sink pad		2	TO220, for QA, QM	Bergquist	3.18 mm hole	SP600–58
Shoulder washer		2	Hi temp plastic, for QA, QM & D17	Bivar	for #4 screw	SW–031–145
Transistor	Q1, Q4	2	PNP, 40 V, 200 mA		TO–226AA	2N3906
	Q2, Q3	2	NPN, 40 V, 200 mA		TO–226AA	2N3904
Resistor	R1	1	1 W, Metal Oxide, 68 k $\Omega$ , 5%	Panasonic	20 mm	P68kW–1BK–ND
	R2	1	1/4 W, carbon comp, 470 k $\Omega$ , 5%	Multicomp	15.24 mm	RC1/4G474JT
	R3	1	1 W, Metal Oxide, 240 k $\Omega$ , 5%	Panasonic	20 mm	P240kW–1BK–ND
	R4	1	2 W, 47 k $\Omega$ , 5%	Panasonic	25.4 mm	P47kW–2BK–ND
	R5	1	1/4 W, 30 $\Omega$ , 5%		10.16 mm	
	R6	1	1/4 W, 5.62 k $\Omega$ , 1%		10.16 mm	
	R7	1	1/4 W, 3.92 k $\Omega$ , 1%		10.16 mm	
	R8	1	1/4 W, 33.2 k $\Omega$ , 1%		10.16 mm	
	R10	1	1/4 W, 20.0 k $\Omega$ , 1%		10.16 mm	
	R11	1	1/4 W, 511 k $\Omega$ , 1%		10.16 mm	
	R12, R23	2	1/4 W, 10 k $\Omega$ , 5%		10.16 mm	
	R13	1	1/4 W, 1.62 k $\Omega$ , 1%		10.16 mm	
	R14	1	1/4 W, 33.2 k $\Omega$ , 1%		10.16 mm	
	R15	1	1/4 W, 4.7 k $\Omega$ , 5%		10.16 mm	
	R16	1	1/4 W, 3.32 k $\Omega$ , 1%		10.16 mm	
	R17	1	1/4 W, 130 k $\Omega$ , 1%		10.16 mm	
	R18	1	1/4 W, 4.7 k $\Omega$ , 5%		10.16 mm	
	R19	1	1/4 W, 15 $\Omega$ , 5%		10.16 mm	
	R21	1	1/4 W, 1 k $\Omega$ , 1%		10.16 mm	
	R22, R32	2	1/4 W, 20 $\Omega$ , 5%		10.16 mm	
	R24	1	3 W, Metal Element, 0.1 $\Omega$ , 1%	IRC	20 mm	LOB–3–0.10 $\Omega$
R26, R29	2	1/4 W, 3.01 k $\Omega$ , 1%		10.16 mm		
R27	1	1/4 W, 60.4 k $\Omega$ , 1%		10.16 mm		
R28	1	1/4 W, 14.3 k $\Omega$ , 1%		10.16 mm		
R30	1	1/4 W, 54.9 k $\Omega$ , 1%		10.16 mm		
Transformer	T1	1	Gate drive, 8-pins	Coiltronics	2.5X8 mm	CTX08–14086–X1
	T2	1	PC40EER35 core, 12-pins, 158 $\mu$ H pri, 24:3	Century Magnetics	5X22.5 mm	CMI–2409
Thermistor	TH1	1	Jumper, insulated, 20AWG		10.16 mm	
Test Point	TP1 to TP20	20	White, 0.063 inch dia.	Keystone	1.6 mm	5012
Jumper	W1	1	2 holes		7.62 mm	
Support Post		4	Nylon, in PWB corner holes	Richco	156"hole, 15.9 mm	SP3–10–01
PCB	—	1	2-Layer, 2 oz, 9.00"(L) x 6.00"(W) x 0.062"(T)			SLUP054

## 5.2 Hard-Switched Configuration



UDG-00015

Note: High-temperature component. See EVM Warnings and Restrictions at the front of this document.

Figure 3. Flyback Converter Populated for Hard-Switched Operation

**Table 3. Conversion From Active Clamp to Hard-Switched Configuration: Remove List**

	Ref Des	Qty	Description	MFG	Size	Part Number
Capacitor	C6, C11	2	Ceramic, 0.1 $\mu$ F, 50 V	Panasonic	5 mm	ECU-S1H104KBB
Diode	D5, D10	2	Switching, 75 mA, 75 V		DO-35	1N4148
	D7, D11	2	Schottky, 1 A, 40 V		DO-41	1N5819
	D16	1	Ultra Fast, 4 A, 400 V		DO-201AD	MUR460
Heatsink	HS2	1	For QA, 13 C/W. Remove as an assembly with QA and all of the mounting hardware attached to HS2.	Thermalloy	24.38 mm	6021PB
Choke	L3	1	E25/10/6-3F3 core, 10-pins, 16 $\mu$ H	Century Magnetics	5.1X15.6 mm	CMI-2408
MOSFET	QA	1	400 V, 0.55 $\Omega$ , 10 A (removed with HS2)	IR	TO-220AB	IRF740
Transistor	Q2	1	NPN, 40 V, 200 mA		TO-226AA	2N3904
	Q4	1	PNP, 40 V, 200 mA		TO-226AA	2N3906
Resistor	R5	1	30 $\Omega$ , 1/4 w, 5%		10.16 mm	
	R15	1	1/4 W, 4.7 k $\Omega$ , 5%		10.16 mm	
	R23	1	1/4 W, 10 k $\Omega$ , 5%		10.16 mm	
Gate	T1	1	xfmr, 8-pins	Coiltronics	2.5X8 mm	CTX08-14086-X1

**Table 4. Conversion From Active Clamp to Hard-Switched Configuration: Add List**

	Ref Des	Qty	Description	MFG	Size	Part Number
Capacitor	C20	1	Ceramic disk, 390 pF, 1 kV	Panasonic	5 mm	ECK-D3A391KBN
	C30	1	Polyester, 0.01 $\mu$ F, 100 V	Panasonic	5 mm	ECQ-E1103KF
Diode	D8, D12	2	Ultra fast, 1 A, 600 V		DO-41	MUR160
Jumper	L3	1	Pin 1 to pin 4, 20AWG, insulated		14 mm	
Resistor	R9	1	5 W, wire, vertical, 1 k $\Omega$ , 5%	Ohmite	5 mm	TWM-5J1K0
	R25	1	5 W, wire, vertical, 6.8 k $\Omega$ , 5%	Ohmite	5 mm	TWM-5J6K8
	R31	1	5 W, wire, vertical, 4.7 $\Omega$ , 5%	Ohmite	5 mm	TWM-5J4R7

## 6 Traces and silkscreen

Figures 4, 5, and 6 show the traces and silkscreen for the UCC3580EVM.

### 6.1 Traces

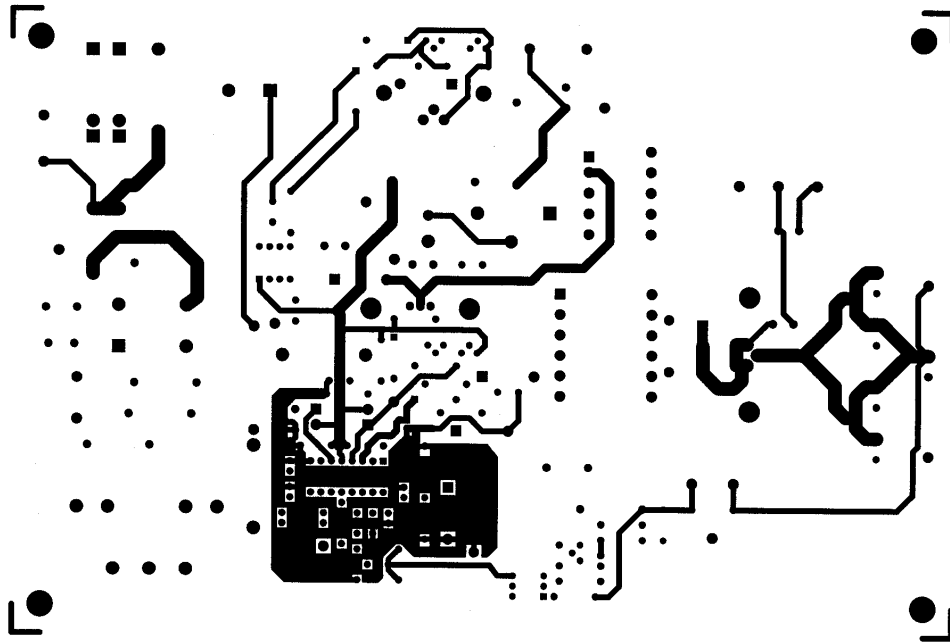


Figure 4. UCC3580EVM Layout, Top Traces

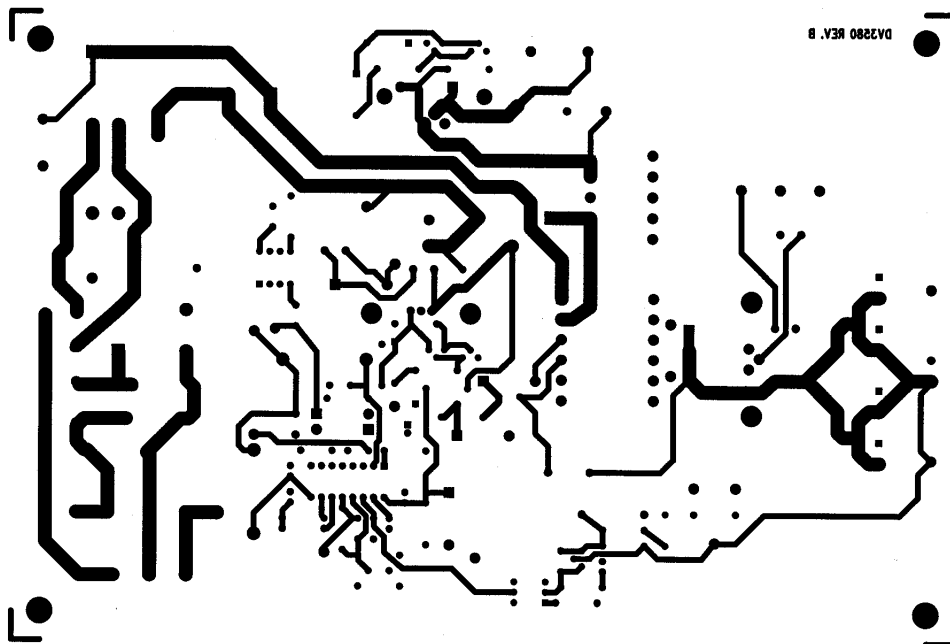


Figure 5. UCC3580EVM Layout, Bottom Traces

## 6.2 Silkscreen

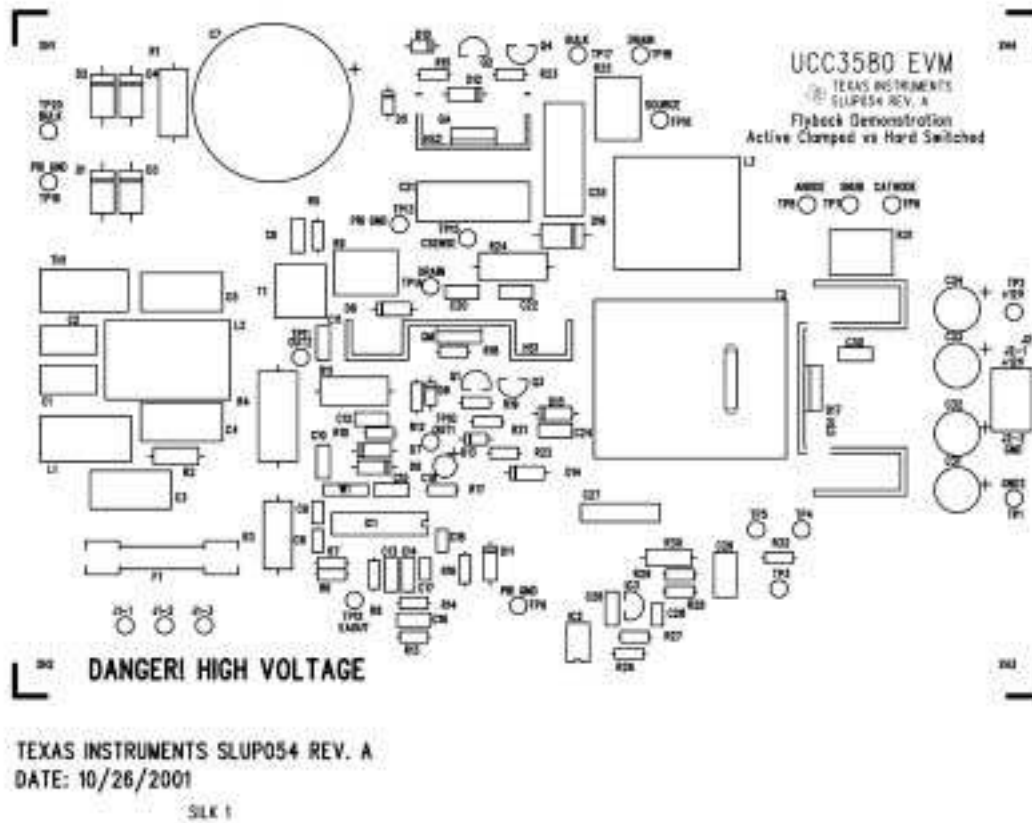


Figure 6. UCC3580EVM Silks Screen (only top layer has a silks screen)

## 7 Reference

[1] R.B. Ridley, Switching power supply design information, design tips, frequency response analyzers, and educational material for power supplies. See web site located at <http://www.ridleyengineering.com>.

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