TPS68000EVM-161

This user's guide describes the characteristics, operation, and use of the TPS68000EVM evaluation module (EVM). This EVM is designed to help the user easily evaluate and test the operation and functionality of the TPS68000. This document includes setup instructions for the hardware, a schematic diagram, a bill of materials (BOM), and PCB layout drawings for the EVM.

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1 Introduction

The Texas Instruments TPS68000EVM-161 evaluation module (EVM) helps designers evaluate the operation and performance of the TPS68000 cold cathode fluorescent lamp (CCFL) controller. The TPS68000EVM-161 EVM is a fully functional DC/AC inverter module used to drive a single CCFL lamp. The upper section demonstrates a small layout whereas the larger lower section allows access to all features of the TPS68000. This EVM operates from an input supply of 8 V to 22 V and generates up to 600 Vrms at 6 mArms. Lamp current is fixed at 6 mArms by resistor value, and output voltage is determined by CCFL. This output is typical of a 300-mm length CCFL, reference JKL Components BF3300-208.

Note: As with all CCFL inverters, high AC voltages are present on outputs, and care should be taken to avoid shock hazards and equipment damage.

1.1 Background

The TPS68000EVM-161 uses the TPS68000 version. Other versions with additional features are available; consult the data sheet. The input voltage range of the TPS68000 is greater than the limits of this EVM. Additional lower input voltage configurations are also possible. Output voltage and current are a function of transformer and circuit design

1.2 Performance Specification

Table 1 provides a summary of the TPS68000EVM-161 performance specifications. All specifications are given for an ambient temperature of 25°C.

Table 1. Performance Specification Summary

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input voltage		8		22	V
Input current		200		500	mA
Output current			6		mArms
Output voltage			665		Vrms
Efficiency			80%		
Strike voltage			1500		Vrms
Open-lamp delay			1.6		s
Operating frequency			56		kHz
Burst dimming frequency			100		Hz
Burst dimming range		0		2	V
Analog dimming range		0		2.3	V

1.3 Modifications

The U2 lower section has the option for two additional outputs at TP21 and TP22. These outputs do not have voltage applied until C31 and C30 are installed. TP21 and TP22 are used to demonstrate a dual-lamp configuration with a common return at TP12.

Typical values for C31 and C30 are 33 pF to 15 pF, respectively. Input voltage range of the IC is 8 V to 30 V but is limited to a Vin of 22 V due to the voltage ratings of input capacitors and switch FETs.

1.3.1 Burst Dimming Adjustment

R7 adjusts the burst dimming of U2 to increase or decrease brightness. On-time of the lamp is changed at a fixed frequency to vary brightness. C17 sets the frequency at 100 Hz. Full counter-clockwise setting of R7 is maximum brightness and full clockwise is minimum brightness. Voltage can be monitored at J5. Dimming voltage range is 2 V to 0 V. Note that at low settings of the lamp, on-time flicker may appear due to lamp strike characteristics.

1.3.2 Analog Dimming Adjustment

R8 adjusts the analog dimming of U2 to increase or decrease brightness. The lamp current regulation point is changed to vary brightness. R16 sets the lamp current is to normally 6 mArms. A full counter-clockwise setting of R8 is maximum brightness and full clockwise setting of R8 is minimum brightness. Voltage can be monitored at J6. The dimming voltage range is 3.3 V to 0 V. Note that typically when the lamp current is reduced to less than 3 mArms, performance is degraded.

2 Setup and Results

This section describes how to properly use the TPS68000EVM-161.

2.1 Input/Output Connector and Header Descriptions

J1–Vin	Power supply positive input for U1
J2 – GND	Power supply return input for U1
TP3–HV	High-voltage AC output to lamp, U1
TP4–HV	RTN high-voltage lamp return from lamp, U1
TP1–BC	Burst dimming input, U1
TP2–FAULT	Fault output open-collector signal, U1
JP1–EN	Enable input, OFF and ON setting, no jumper is ON, U1
TP15–OCP	Overcurrent protection test point, transformer primary current, U1
TP17–VSEN	Voltage-sense test point, output voltage divider sample voltage, U1
TP16–CSEN	Current-sense test point, lamp return current-sense resistor, U1
TP20–GND	Ground test point for TP15, TP16, and TP17, U1
J3–Vin	Power supply positive input for U2
J4–GND	Power supply return input for U2
TP11–HV	High-voltage AC output to lamp, U2
TP12–HV	RTN high-voltage lamp return from lamp, U2
J5–BBR	Burst dimming voltage set by R7 or input, U2
J6–ABR	Analog burst dimming voltage set by R8 or input, U2
TP6–BC	Burst dimming input, U2
TP5–GND	Ground located near TP6,U2
TP9–SYNC	Synchronous output from U2
TP8–GND	Ground located near TP9, U2
JP7–FAULT	Fault output open-collector signal, U2
JP2–EN	Enable input, OFF and ON setting, no jumper is ON, U2
TP10–OCP	Overcurrent protection test point, transformer primary current, U2
TP14–VSEN	Voltage-sense test point, output voltage divider sample voltage, U2
TP13–CSEN	Current-sense test point, lamp return current-sense resistor, U2
TP7–GND	Ground test point for TP10, TP14, and TP13, U2
TP18–SA	Transformer primary, U2
TP19–SC	Transformer primary, U2
TP21–HV	HV to lamp if C31 is installed, U2
TP22–HV	HV to lamp if C30 is installed, U2

2.2 Setup

CAUTION

High AC voltage is present at the output terminals when input voltage is applied; all connections should be made with the input supply off.

Do not place the EVM or the lamp on a conductive surface. Do not run output leads across the EVM or input voltage leads.

The power supply input should be at J1/J2 for U1 top section. The lower section U2 power input is J3/J4.

Each section is power-independent of the other. The minimum setup requires an input power supply and load. The input supply range is 10 V to 20 V. Lamp loads can be as short as 100 mm or up to 300 mm.

JP1 or JP2 EN can be used to turn the unit ON or OFF.

2.3 Power Up

During power up, the lamp will strike, then go into a current regulation mode. During lamp strike, the lamp has a high resistance because there is no ionization of gas. The voltage required to strike the lamp is 2X normal operation. Once current is flowing in the lamp, the TPS68000 transitions to a current regulation mode.

Figure 1. Turn ON Into 330-mm Lamp, Voltage at 500 V/div

2.4 Output Current and Voltage

Output current and voltage during normal operation see from the lamp. Also from Vsen and Csen test points.

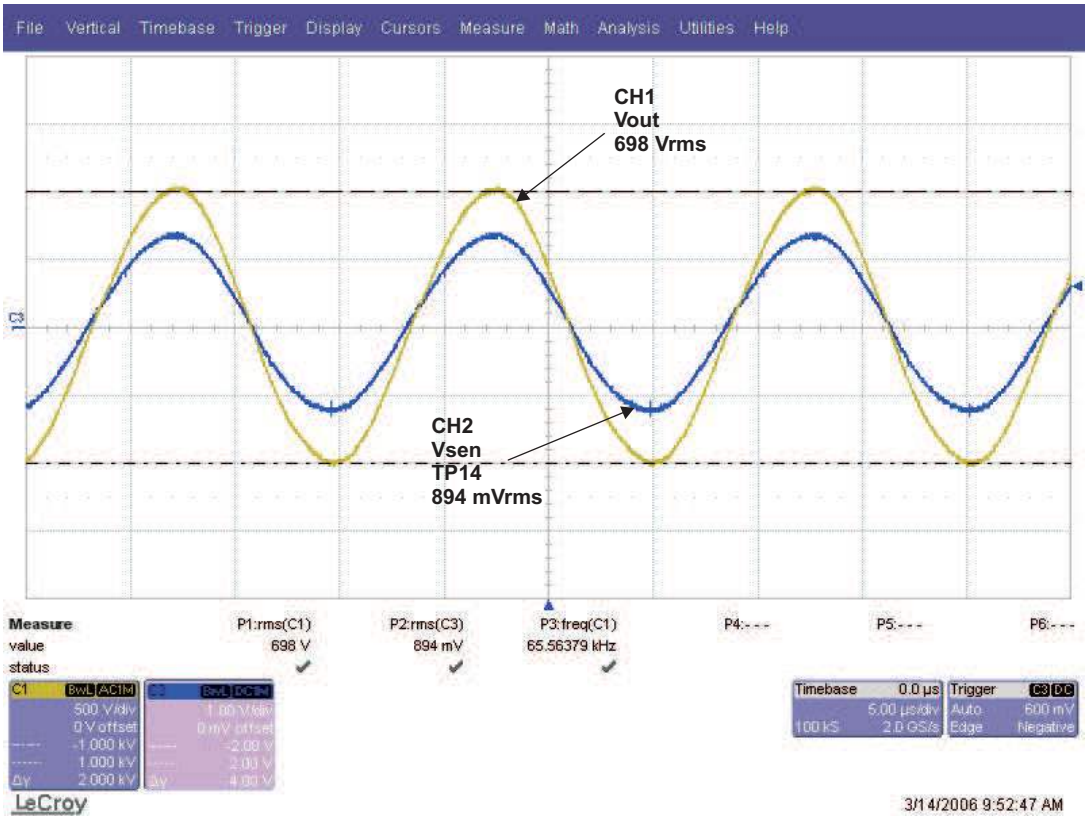

Figure 2. Output Voltage and Vsen Test Point 14, Divide Ratio 1:820

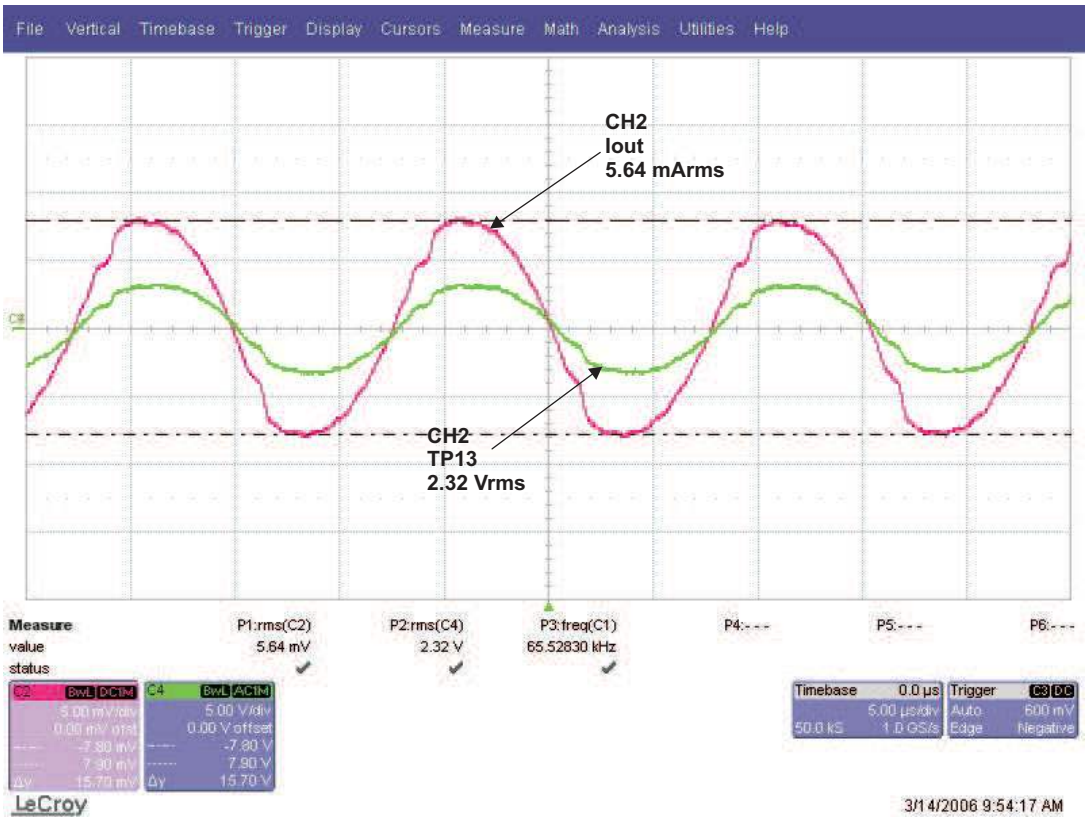

Figure 3. Output Current and Csen Test Point 13, Divide Ratio 1 V:2.55 mA

2.5 Efficiency/Power Dissipation

With high efficiency, the power to be dissipated is low.

Table 2. U1 With 300-mm Lamp

Vin	Iin	Vout	Iout	PWR IN	PWR OUT	Efficiency
12	0.364	609	5.63	4.37	3.43	78.50
8	0.545	607	5.63	4.36	3.42	78.38
22	0.202	607	5.68	4.44	3.45	77.58

Table 3. U2 With 360-mm Lamp

Vin	Iin	Vout	Iout	PWR IN	PWR OUT	Efficiency
12	0.432	721	5.63	5.18	4.06	78.30
18	0.285	722	5.62	5.13	4.06	79.10
22	0.234	720	5.62	5.15	4.05	78.60

2.6 Burst Dimming

R7 controls burst dimming. Adjustment range is 2 V to 0 V. Below setting is 1 V for 50% duty cycle. Note the reduced soft start at turn on.

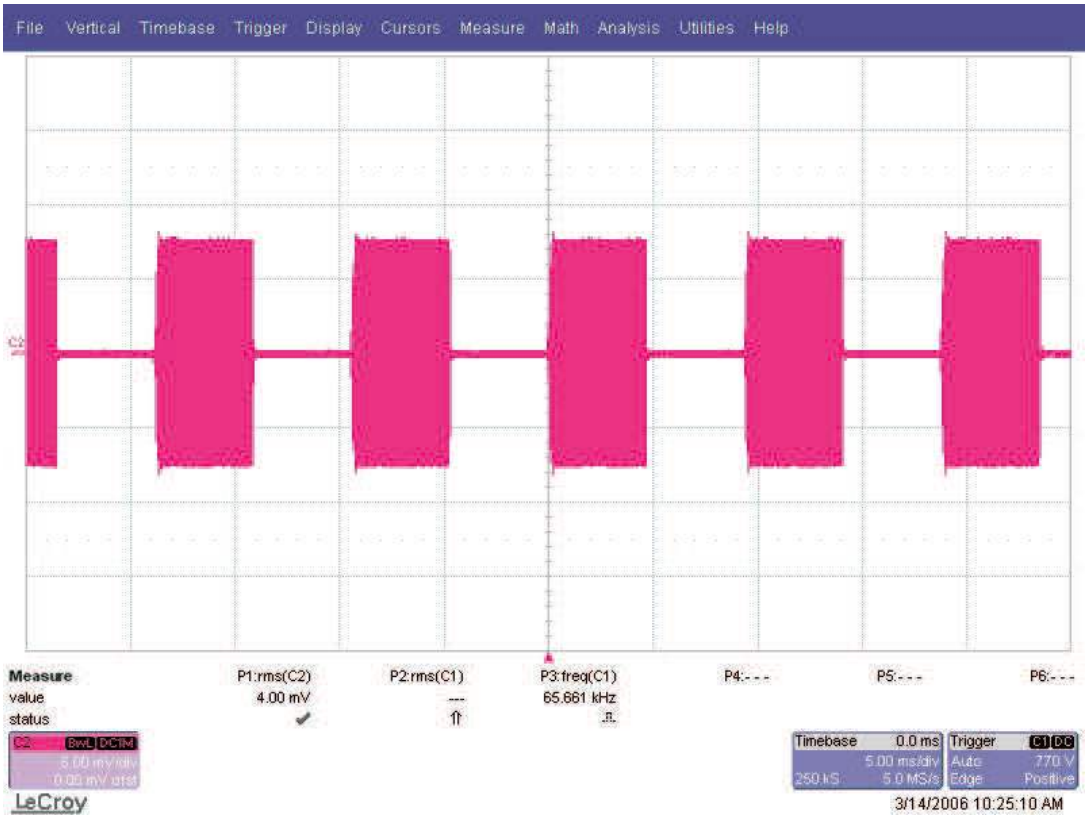

Figure 4. Burst Dimming Current at 50% Duty Cycle

3 Board Layout

This section provides the TPS68000EVM-161 board layout and illustrations.

3.1 Layout

Figure 5, Figure 6, and Figure 7 show the board layout for the TPS68000EVM-161 PCB.

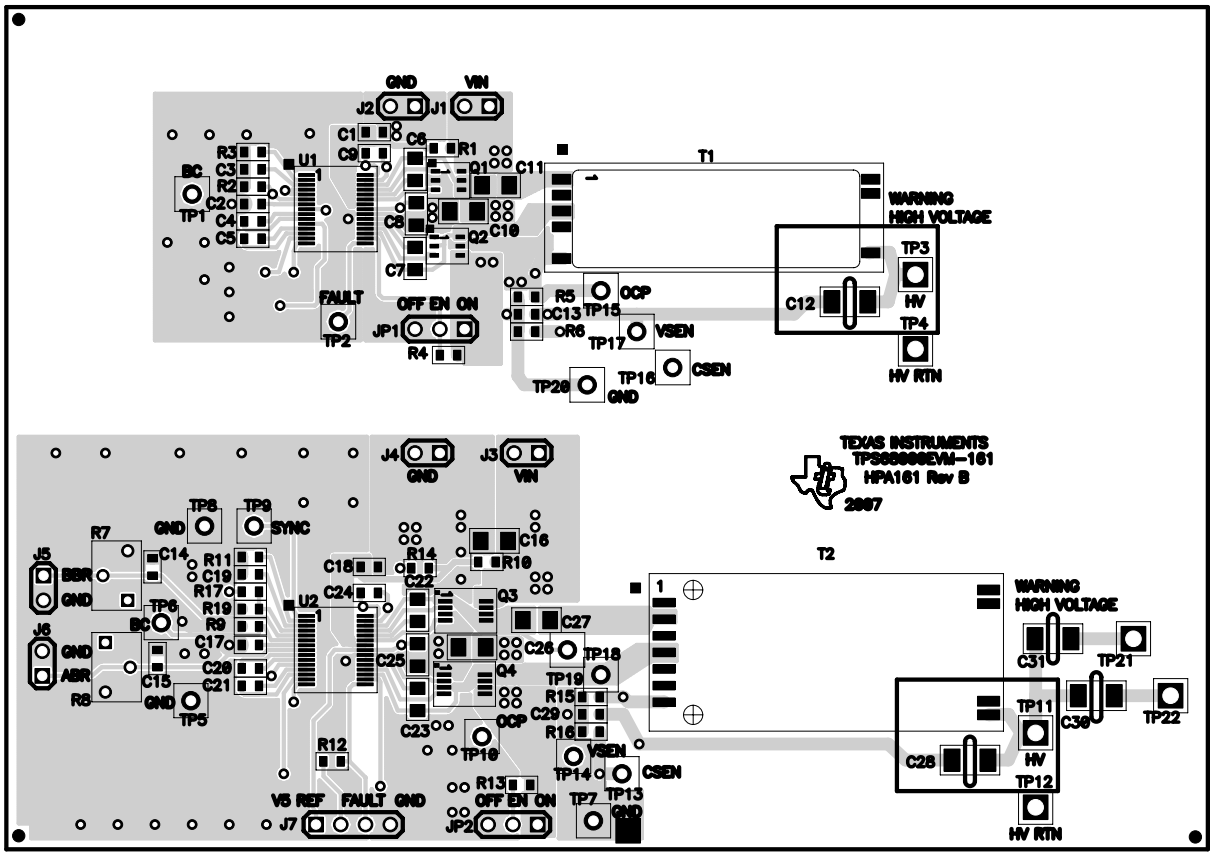

Figure 5. Assembly Layer

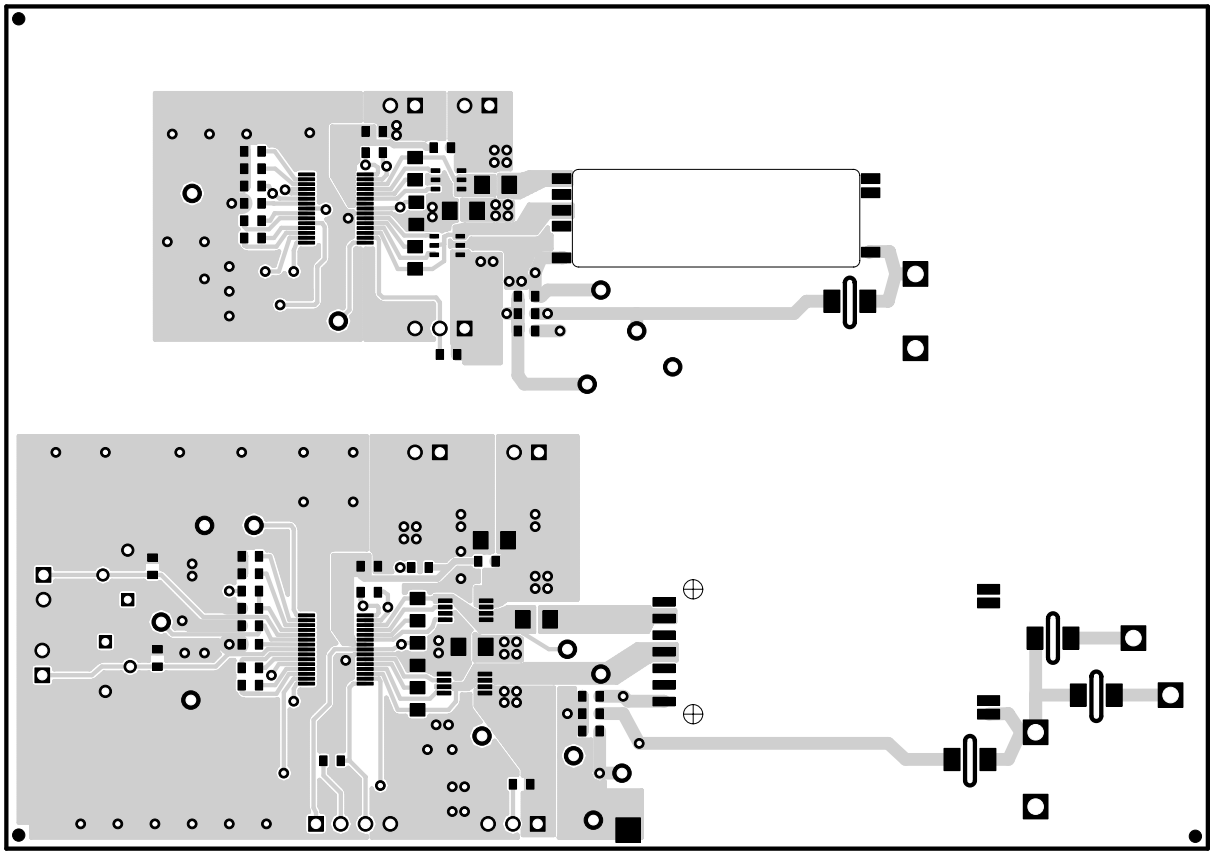

Figure 6. Top Layer Routing

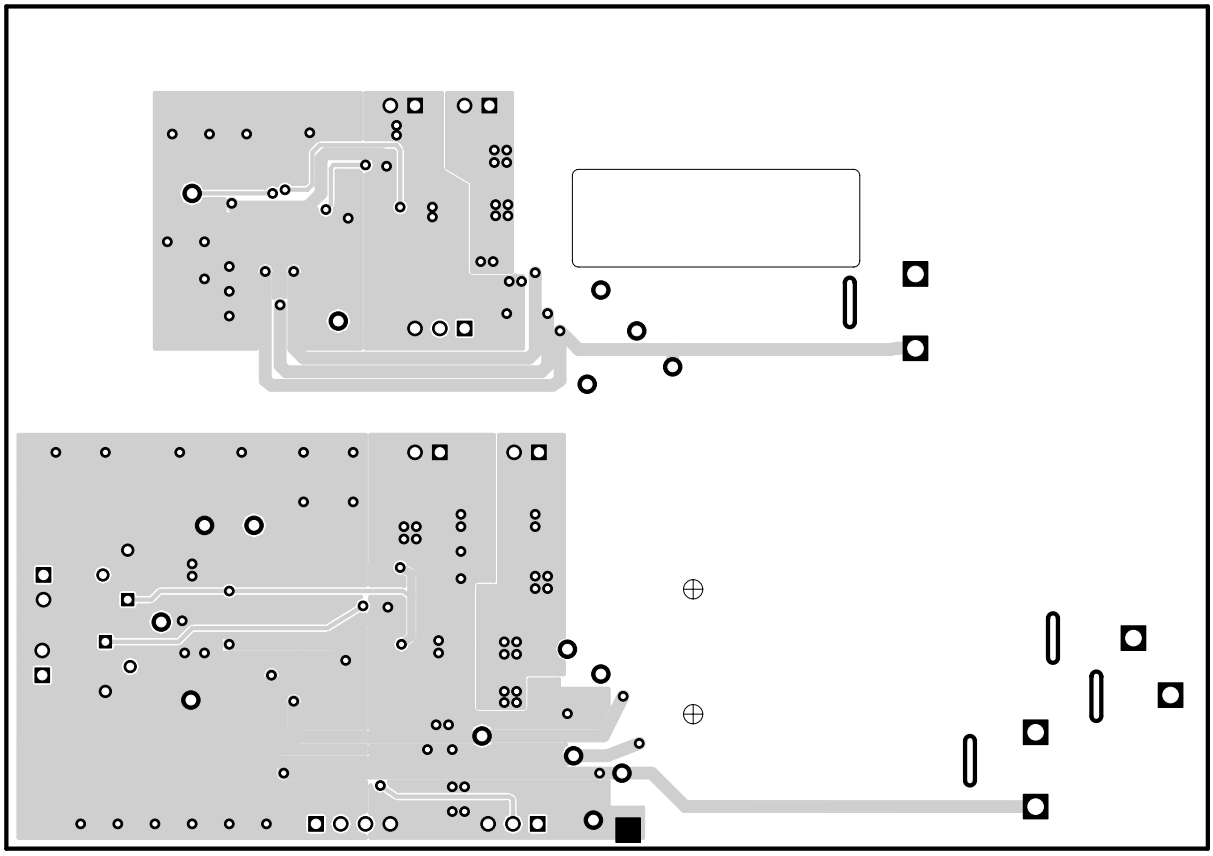

Figure 7. Bottom Layer Routing

4 Schematic and Bill of Materials

This section provides the TPS68000EVM-161 schematic and bill of materials.

4.1 Schematic

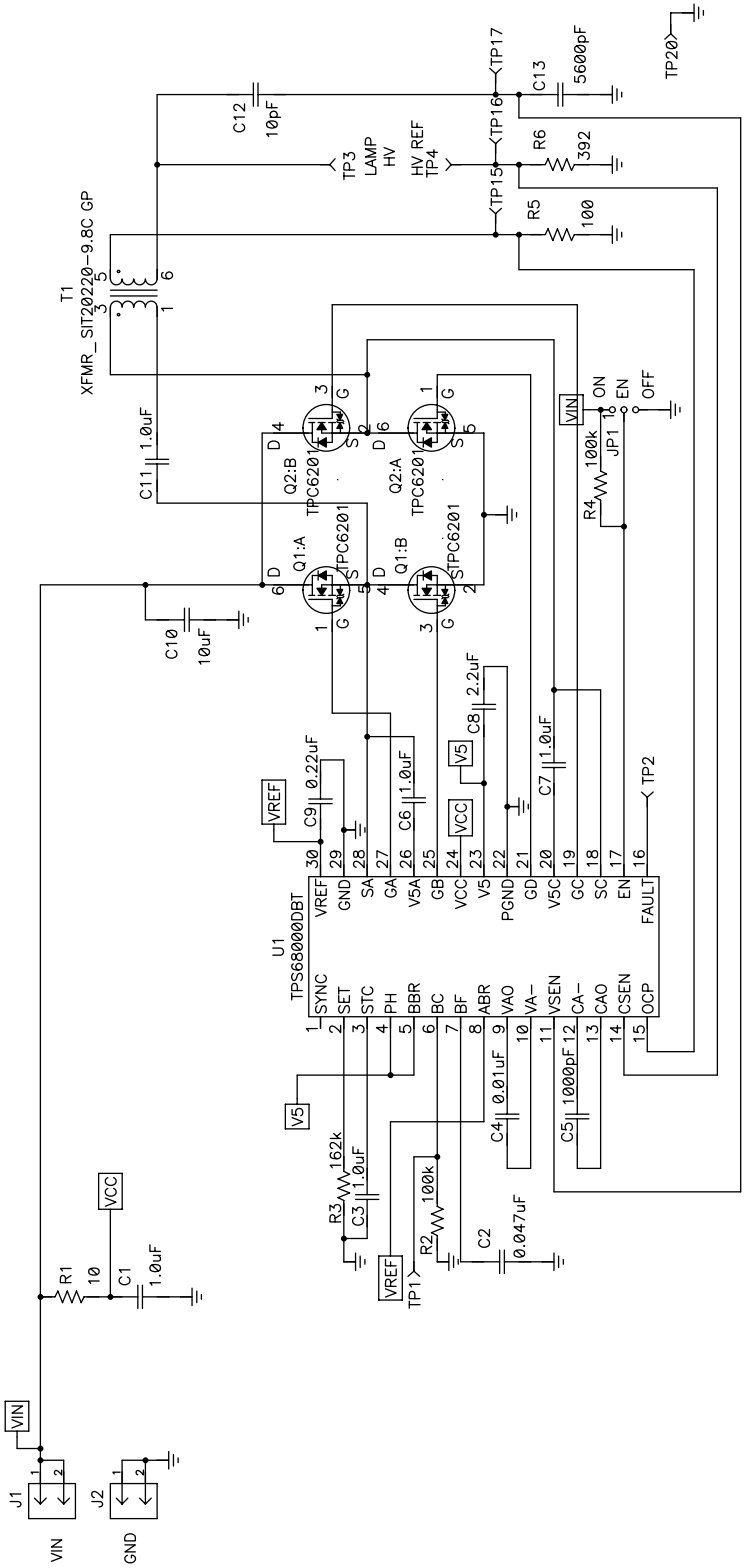

Figure 8. TPS68000EVM-161, U1 Schematic

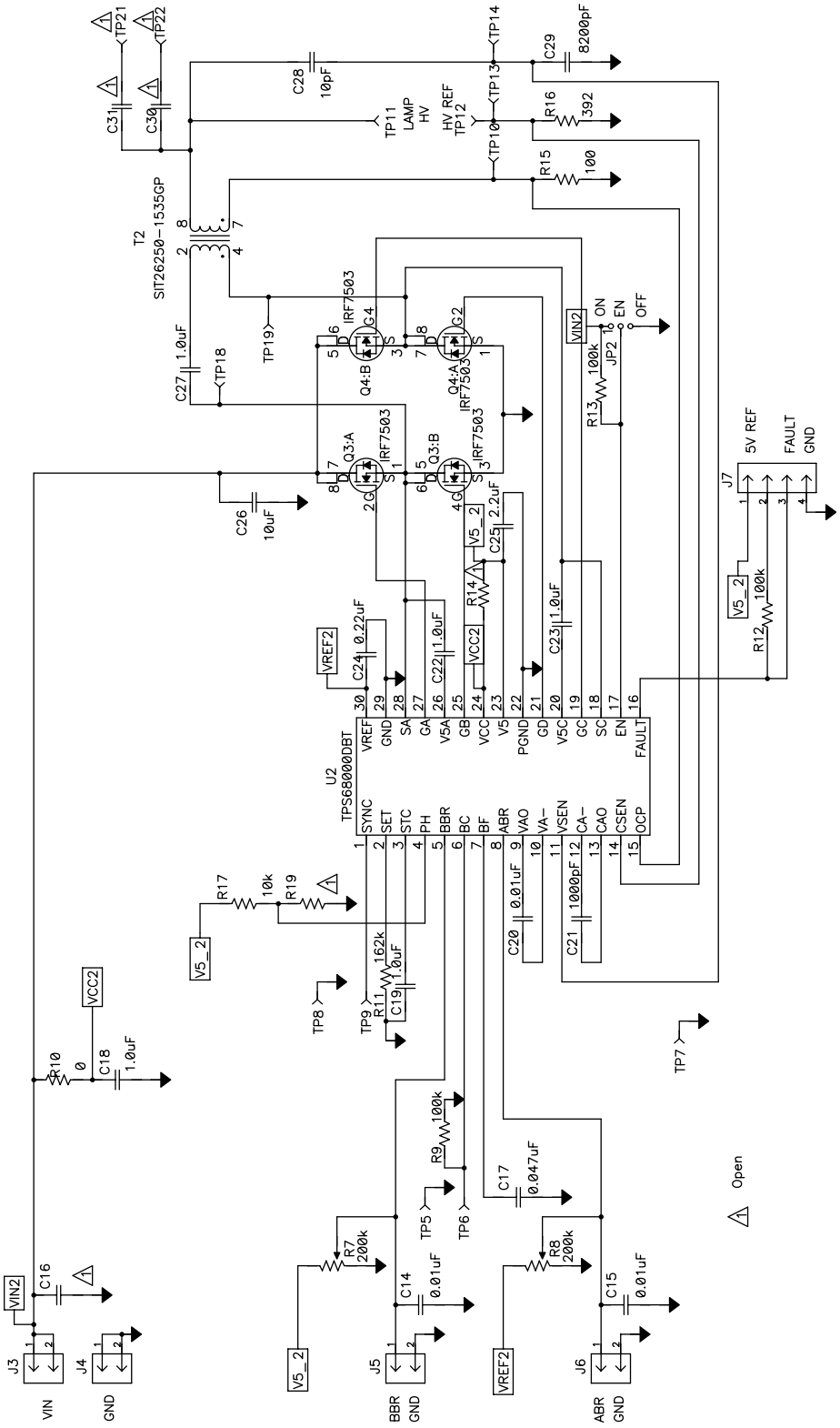

Figure 9. TPS68000EVM-161, U2 Schematic

4.2 Bill of Materials

Table 4. TPS68000EVM-161 Bill of Materials

Count	Ref Des	Value	Description	Size	Part Number	MFR
4	C1, C3, C18, C19	1 µF	Capacitor, ceramic, 25-V, X5R, 10%	0603	C1608X5R1E105K	TDK
2	C10, C26	10 µF	Capacitor, ceramic, 25-V, X5R, 10%	1206	C3216X5R1E106K	TDK
2	C11, C27	1 µF	Capacitor, ceramic, 50-V, X7R, 10%	1206	C3216X7R1H105K	TDK
2	C12, C28	10 pF	Capacitor, 3-kV, C0G, ±1 pF		C4520C0G3F100F	TDK
1	C13	5600 pF	Capacitor, ceramic, 50-V, X7R, 10%	0603	GRM188R71H562KA01	Murata
4	C4, C14, C15, C20	0.01 µF	Capacitor, ceramic, 25-V, X5R, 10%	0603	C1608X5R1E103KB	TDK
0	C16	Open	Capacitor, ceramic, vvV	1206		
2	C2, C17	0.047 µF	Capacitor, ceramic, 50-V, X7R, 10%	0603	C1608X7R1H473KB	TDK
1	C29	8200 pF	Capacitor, ceramic, 50-V, X7R, 10%	0603	GRM188R71H822KA01	Murata
0	C30, C31		Capacitor			
2	C9, C24	0.22 µF	Capacitor, ceramic, 16-V, X5R, 10%	0603	C1608X5R1C224KB	TDK
2	C5, C21	1000 pF	Capacitor, ceramic, 50-V, X5R, 10%	0603	C1608X5R1H102KB	TDK
4	C6, C7, C22, C23	1 µF	Capacitor, ceramic, 25-V, X7R, 10%	0805	C2012X7R1E105K	TDK
2	C8, C25	2.2 µF	Capacitor, ceramic, 25-V, X5R, 10%	0805	C2012X5R1E225K	TDK
6	J–J6		Header, 2-pin, 100-mil spacing, (36-pin strip)		PTC36SAAN	Sullins
1	J7		Header, 4 pin, 100-mil spacing, (36-pin strip)		PTC36SAAN	Sullins
2	JP1, JP2		Header, 3 pin, 100-mil spacing, (36-pin strip)		PTC36SAAN	Sullins
2	Q1, Q2		MOSFET, N-Ch, 30-V, 2.5-A	2-3T1B	TPC6201	Toshiba
2	Q3, Q4		XSTR, MOSFET, N-Ch, 30-V, 2.4-A, Rds 0.135-Ω	TSSOP8-MICRO8	IRF7503	IR
1	R1	10 Ω	Resistor, chip, 1/16-W, 1%	0603	Std	Std
1	R10	0 Ω	Resistor, chip, 1/16-W, 1%	0603	Std	Std
0	R14, R19	Open	Resistor, chip, 1/16-W, 1%	0603		
1	R17	10 kΩ	Resistor, chip, 1/16-W, 1%	0603	Std	Std
5	R2, R4, R9, R12, R13	100 kΩ	Resistor, chip, 1/16-W, 1%	0603	Std	Std
2	R3, R11	162 kΩ	Resistor, chip, 1/16-W, 1%	0603	Std	Std
2	R5, R15	100 Ω	Resistor, chip, 1/16-W, 1%	0603	Std	Std
2	R6, R16	392 Ω	Resistor, chip, 1/16-W, 1%	0603	Std	Std
2	R7, R8	200 kΩ	Potentiometer, 1/4 cermet	12-turn	3266W-1-204	Bourns
1	T1		Transformer, inverter LCD backlight		SIT20220-9.8C GP or G064199LF	Taipei Multipower or GCI Technologies
1	T2		Transformer, EFDL15 inverter		SIT26250-1535 GP or G064200LF	Taipei Multipower or GCI Technologies
12	TP1, TP2, TP6, TP9, TP10, TP13–TP19		Test point, red, thru-hole, color-keyed		5000	Keystone
0	TP21, TP22		Test point			
2	TP3, TP11		Test point, red, thru-hole, compact style		5005	Keystone
2	TP4, TP12		Test point, black, thru-hole, compact style		5006	Keystone
4	TP5, TP7, TP8, TP20		Test point, black, thru-hole, color keyed		5001	Keystone
2	U1, U2		IC, high efficient phase shift full bridge CCFL controller	TSSOP-30	TPS68000DBT	TI
1			PCB, 4.85-in. × 3.4-in. × 0.062-in. (12.32 cm × 8.64 cm × 1.58 mm)		HPA161	Any
2			Shunt, 100-mil (2.54-mm), black		929950-00	3M
4			Bumpon, transparent		SJ5303	3M

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 8 V to 22 V and the output voltage range of 500 V to 1500 V.

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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