ADP1043A Evaluation Board Quarter Brick Full Bridge

Reference Design

PRD 1153

FEATURES

Full Bridge Switching Power Supply
Voltage Feedback Loop
Quarter Brick Size
Input Voltage Range from 38V to 72VDC
12V/25A DC Output from 48V DC Input
I2C serial interface to PC
Software GUI

DESCRIPTION

This Evaluation Board allows the ADP1043A to be quickly assessed in a switching power supply application. Using the evaluation board and its accompanying software, the ADP1043A can be interfaced to any PC running WindowsTM 2000, WindowsTM NT or WindowsTM XP via the computer's USB port.

The evaluation board allows all the input and output functions of the ADP1043A to be exercised without the need for external components. The software allows control and monitoring of the ADP1043A internal registers. The board is set up for the ADP1043A to act as an isolated switching power supply, outputting a 12V/25A DC voltage from a 38 to 72VDC input.

CAUTION

This eval board uses high voltages and currents. Extreme caution should be taken, especially on the primary side, to ensure safety of the user. It is strongly advised to switch off the eval board when not in use. It is recommended to use a current limited power supply as the input.

EVALUATION SYSTEM CONTENTS

The evaluation system package contains the following items:

- Application note
- ADP1043A evaluation board
- USB Interface cable
- Evaluation software on CD

EVALUATION EQUIPMENT

To evaluate this demo board, a PC, oscilloscope, electronic load and a power supply are required.

Rev. Prelim A, Oct 2009

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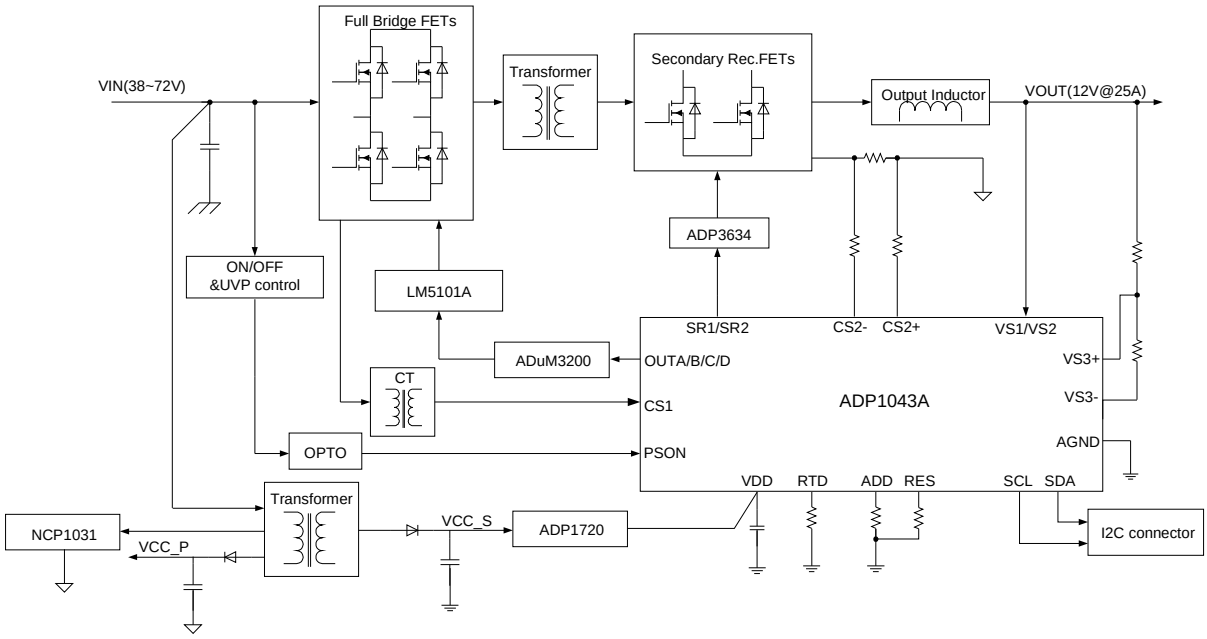
Figure 1. Power Module Block Diagram



EVALUATION BOARD HARDWARE

SPECIFICATIONS

- Nominal input voltage: 48 DC
- Input voltage range: 38-72V DC
- Nominal output voltage: 12V DC
- Max output voltage: 13.2V DC
- Max output current: 25A DC
- Switching frequency: 120kHz
- Efficiency: 95% at full load
- Cooling: 400 LFM (2.0 m/s)Air flow

TOPOLOGY AND OPERATION WAVEFORMS

A typical DC/DC switching power supply is the basis for the eval board. It is a full bridge topology. Figure 1 gives a block diagram of the main components on the board.

The primary side consists of the input terminals, full bridge switches and the main transformer. The gate signal for the switches comes from the ADP1043A, through the iCoupler and the drivers. This controls the switching of the

transformer. There is also a current sense transformer, to transmit the primary side current information to the ADP1043A on the secondary side.

The secondary side power stage consists of the synchronous rectifiers, output LC tank, sensing resistor. This provides 12V @ 25A at the output. The ADP1043A is also located on the secondary side. The ADP1043A provides the feedback signal that is used to regulate the voltage, limit the current, and allow current sharing and shutdown to be implemented. Low side current sensing is used. The ADP1043A also controls the share bus, which allows multiple power supplies to perform load sharing. The ADP1043A feedback to the primary side, through the iCoupler, consists of the voltage sense, current sense and share bus information.

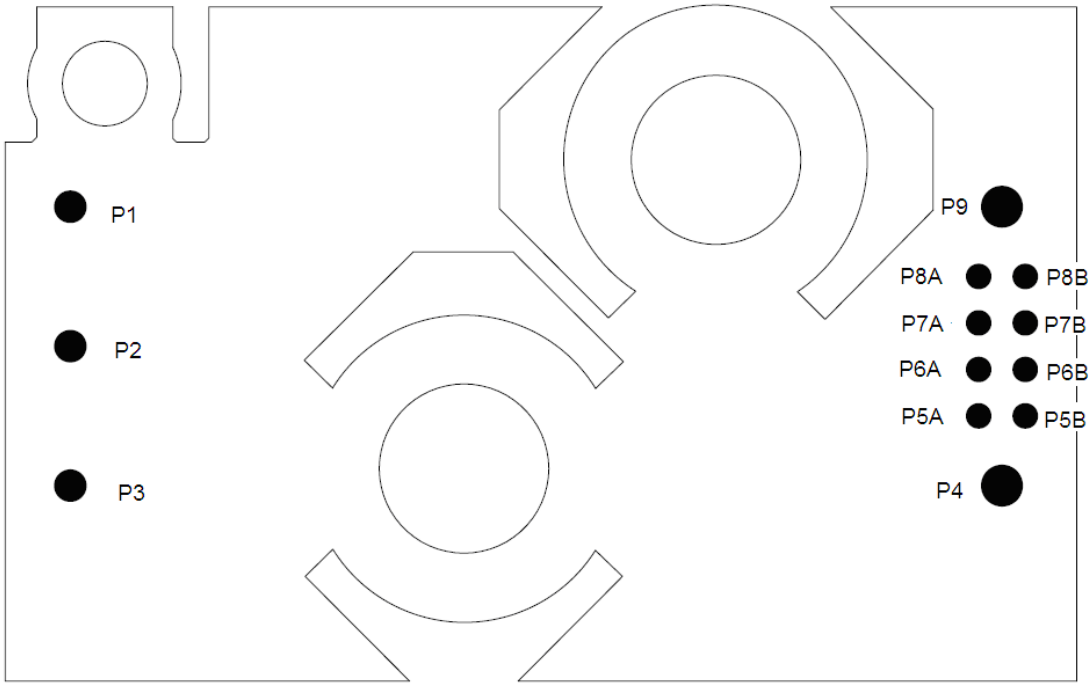
There is a 4 pins connector for I2C communication. This allows the PC software to communicate with the eval board (and with other eval boards through extra 4 pin connectors) through the USB port of the PC. The user can readily change register settings on the ADP1043A this way, and also monitor the status registers.

The eval board is designed with a 0.5 mOhm RSENSE resistor. The power supply is designed to support a maximum continuous output of 25 A. The current sense has been calibrated such that 25 A corresponds to 100% of output current rating.

A variable load is required to perform a thorough evaluation. The output voltage is available between P4 and P9, and this is also where the load should be connected.

The power supply will be in Continuous Conduction Mode. If the synchronous rectifiers are enabled, the power supply will remain in CCM mode over the full load range. The output voltage ripple is approx 100mVp-p.

Figure 2. Pin connection diagram (Top view)



CONNECTORS

The connections to the eval board are shown in Table 1.

Table 1. Power Module Pin Assignment

Pin	*Designation*	*Eval Board Function*
P1	Vin+	Positive Input
P2	On/Off	Remote Control
P3	Vin-	Negative Input
P4	Vo-	Negative Output
P5-P8	Table 2	Signal Pins
P9	Vo+	Positive Output

USB INTERFACE CONNECTOR

The signal pins are P5~P8 as shown in Table 2. Among them P5B, P6B, P7B and P8B are connected to USB dongle.

Table 2. Signal pins

Pin	*Designation*	*Pin*	*Designation*
P5A	PGOOD	P5B	Ground
P6A	Vsen+	P6B	SDA
P7A	Vsen-	P7B	SCL
P8A	ADD/Share	P8B	5V

Figure 3 shows the photo of eval board. Figure 4 provides a typical circuit diagram which details the filtering for normal operation and output ripple test.

Figure 3. Eval Board Picture

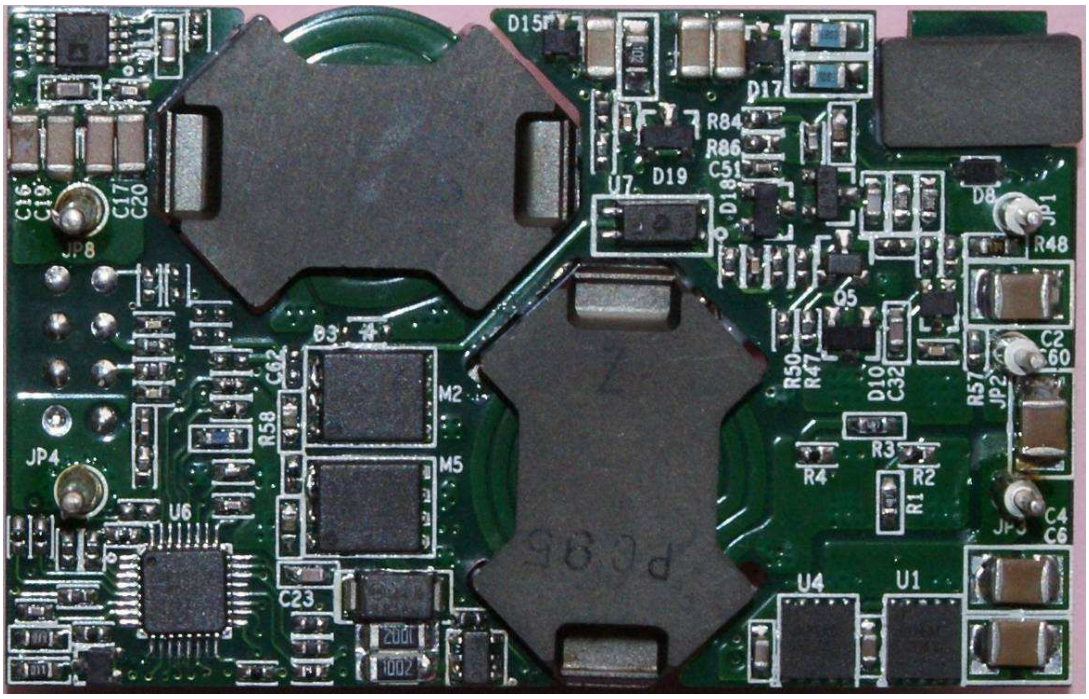
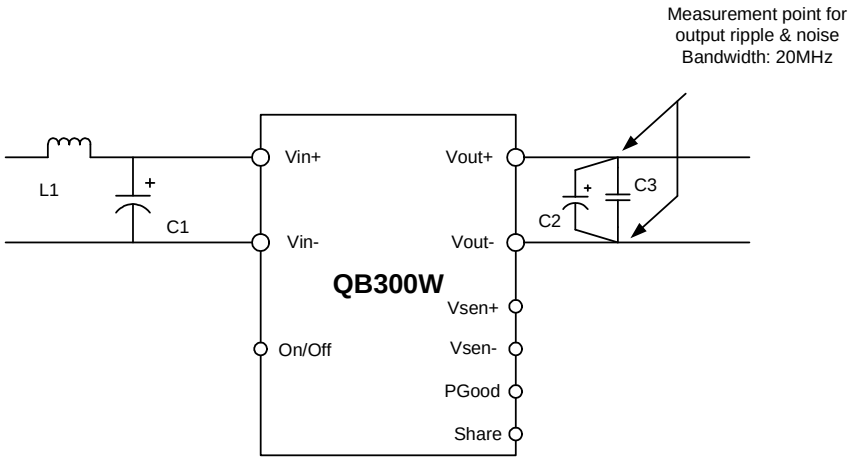


Figure 4. Test configuration for the Evaluation Board



Note:

1.C1 100uF×2 parallel
2.C2 560uF×2 parallel
3. C3 MLCC 10uF
4. L1 0.47uH

GETTING STARTED

EQUIPMENT

- DC Power Supply 0-100V

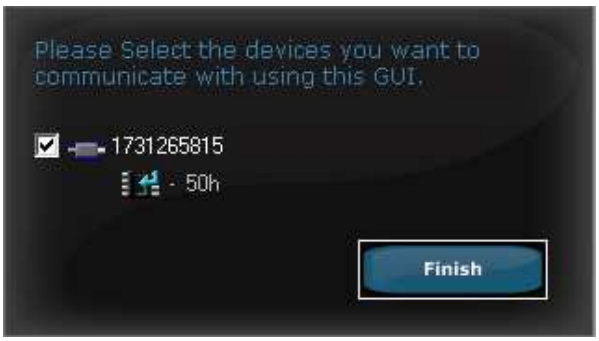
- Electronic Load capable of 12V/30A
- Oscilloscope
- PC with ADP1043A GUI installed
- Precision Digital Multimeters (HP34401 or equivalent - 6 digits)
- Portable DMM (Fluke) for measuring up to 30A DC current

SETUP

Note: Do not connect the usb cable to the eval board until after the software has been installed.

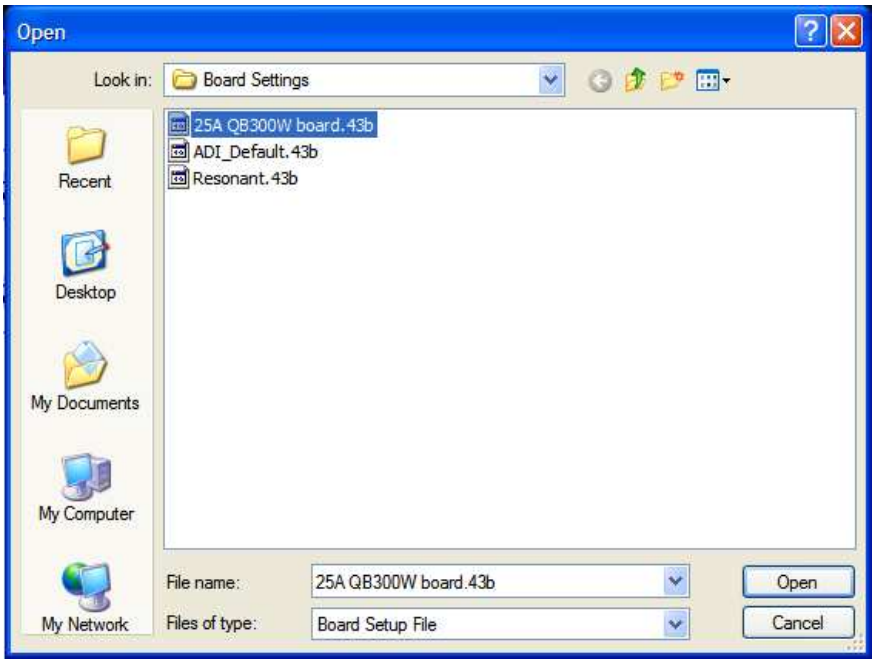
1. Install the ADP1043A software. Refer to the Quick Start Guide that comes on the CD (If already installed, skip to the next step).
2. Connect the evaluation board to the USB port on the computer, using the "USB to I2C interface" dongle. If the dongle driver was not previously installed, run the software from the Start Menu under "Programs/Analog Devices/ADP1043A".
3. The software should report that the ADP1043A has been located on the board. Click "Finish" to proceed to the Main Software Interface Window.

Figure 5. Getting Started



4. Click on the  icon: select the "25A QB300W board.43b file". This file contains all the board information including values of shunt and voltage dividers.

Figure 6. Load Board Setting



5. The ADP1043A is pre-programmed and calibrated, so there is no programming necessary.
6. Connect an electronic load at the output.
7. For the input voltage source, a DC power supply can be used. The input voltage range is 0 to 100 VDC (48VDC is recommended). This input voltage is the signal which will be regulated to provide a 12V/25A supply at the output. Set the voltage to 48VDC
8. The eval board should now up and running, and ready to evaluate. The output should be 12 VDC.

BOARD EVALUATION

The ADP1043A is optimized for improving the power supply design and evaluation process. The goal of this eval kit is to allow the user to get an insight into the flexibility offered by the extensive programming options offered by the ADP1043A.

The ADP1043A performs many monitoring and housekeeping functions in the power supply. The eval board allows the user to simulate various events that could affect the ADP1043A in a working system. The user can monitor how the ADP1043A handles this event in many ways. One way is to use an oscilloscope and/or multimeter, and probe the eval board, to see various conditions in the system. Many test points have been provided for this function. The user can also use the software to monitor the conditions of the ADP1043A, and how it has reacted to the event. The following section gives some experiments that the user might typically evaluate.

LINE AND LOAD VOLTAGE REGULATION

Vary the input voltage from 38 VDC to 72VDC. The output voltage remains 12V. Vary the load current from 0 to 25A. The output voltage remains 12V.

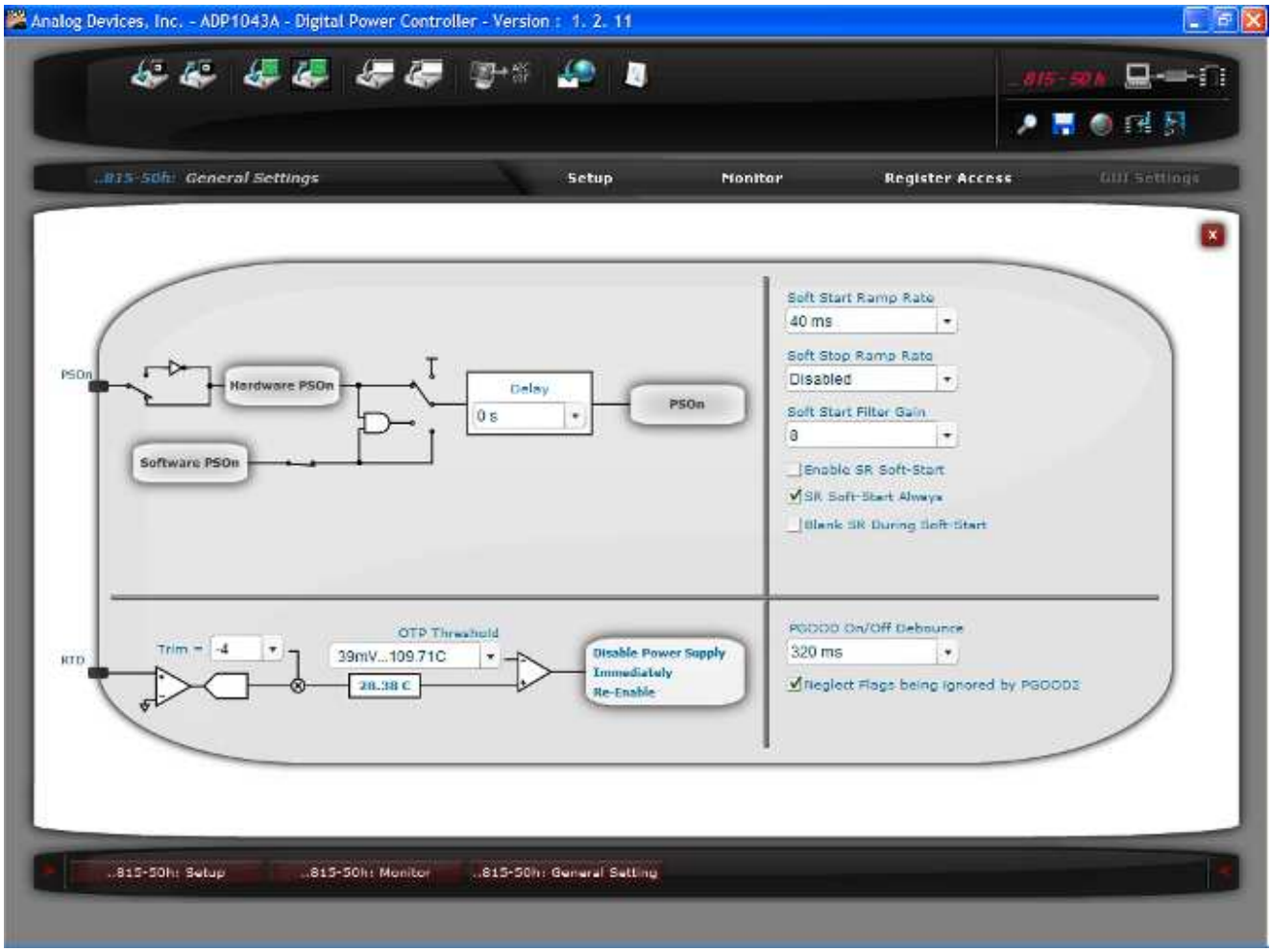
OUTPUT VOLTAGE SETTING

The output voltage setting is programmable. Using the Voltage setting window in the software, adjust the output voltage (using the o/p trim menu). Monitor the actual output voltage of the power supply using the software or a multimeter, or looking at the output voltage reading on the electronic load. It should match the programmed value. This will be used to calibrate the power supply in the production environment. By doing this evaluation, the user can see how the ADP1043A can be trimmed digitally to adjust the output voltage.

SOFT START

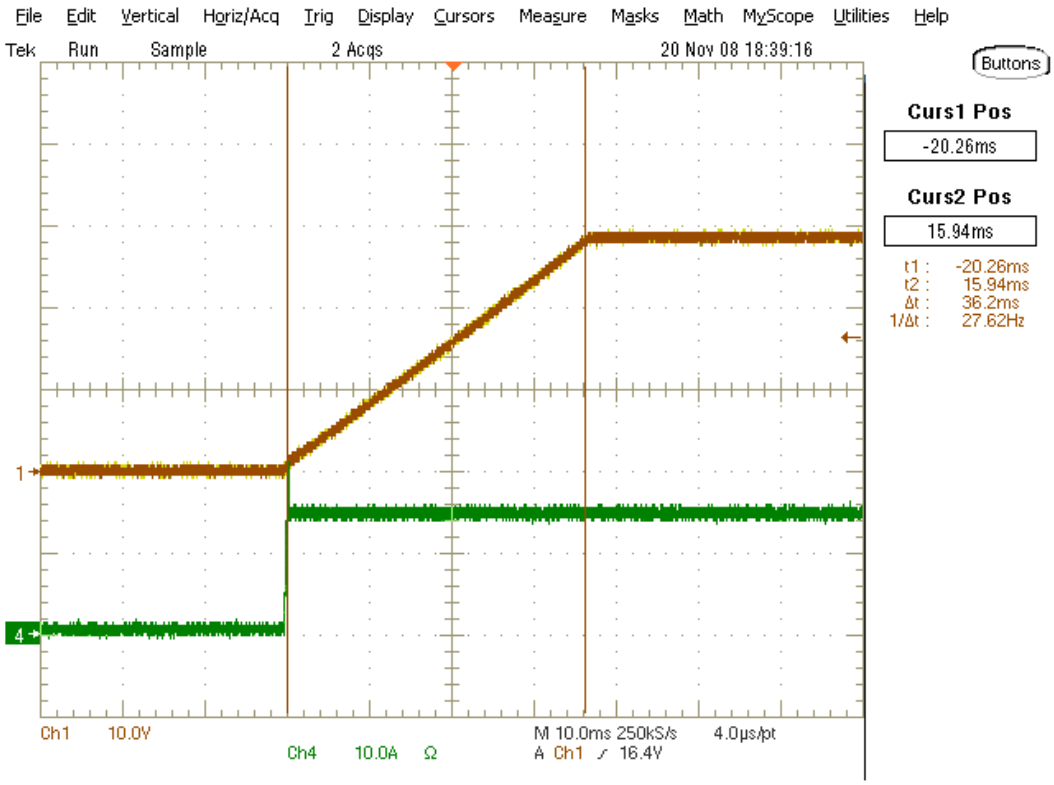
Once the input voltage is applied it is possible to test the Soft Start of the ADP1043A. The settings are located in the General Settings Window. Please refer to the Software Reference Guide for a detailed explanation of all the controls (EVAL-ADP1043A-GUI-RG).

Figure 7. General Settings Window



Soft Start is enabled and set to 40ms. You can experiment with different times.

Figure 8. SoftStart (Yellow VOUT – Green IOUT)



DIGITAL FILTER – TRANSIENT ANALYSIS

The digital filter can be changed using the software. The effect on transient analysis can be evaluated this way. Connect a switching electronic load to the output of the eval board. The load should be set to switch between 25%-50% or 50%-75%, changing every 10msecs. Set up an oscilloscope to capture the transient waveform of the power supply output.

Use a differential probe on the scope, connecting it to the eval board output. Turn on the load, and note the waveform response.

The scope should be ac-coupled, 200mV/division, with a timebase of 1msecs/division. Also connect a current probe, set up for 5A/div. Set the trigger at 9A on the current probe signal.

Figure 9. Transient Response – 75% to 50% load step

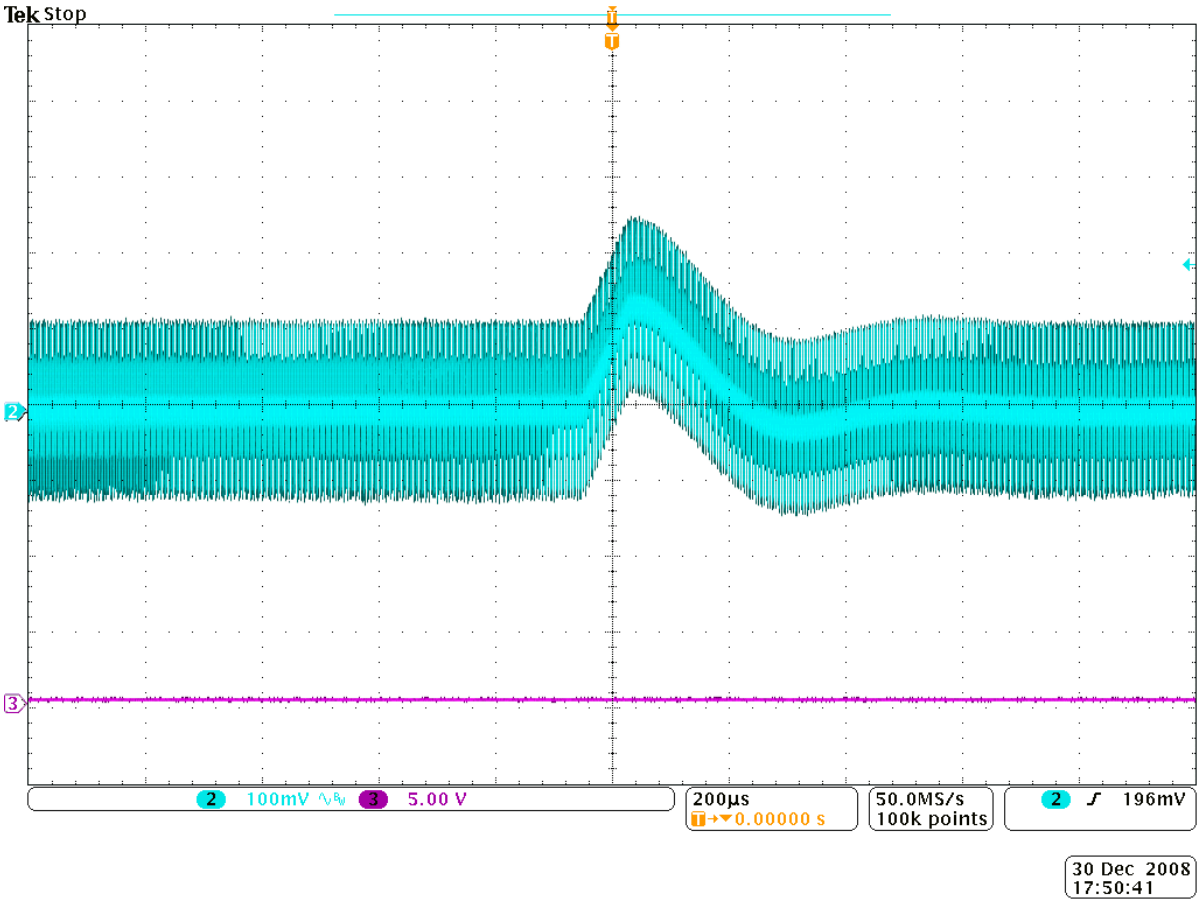
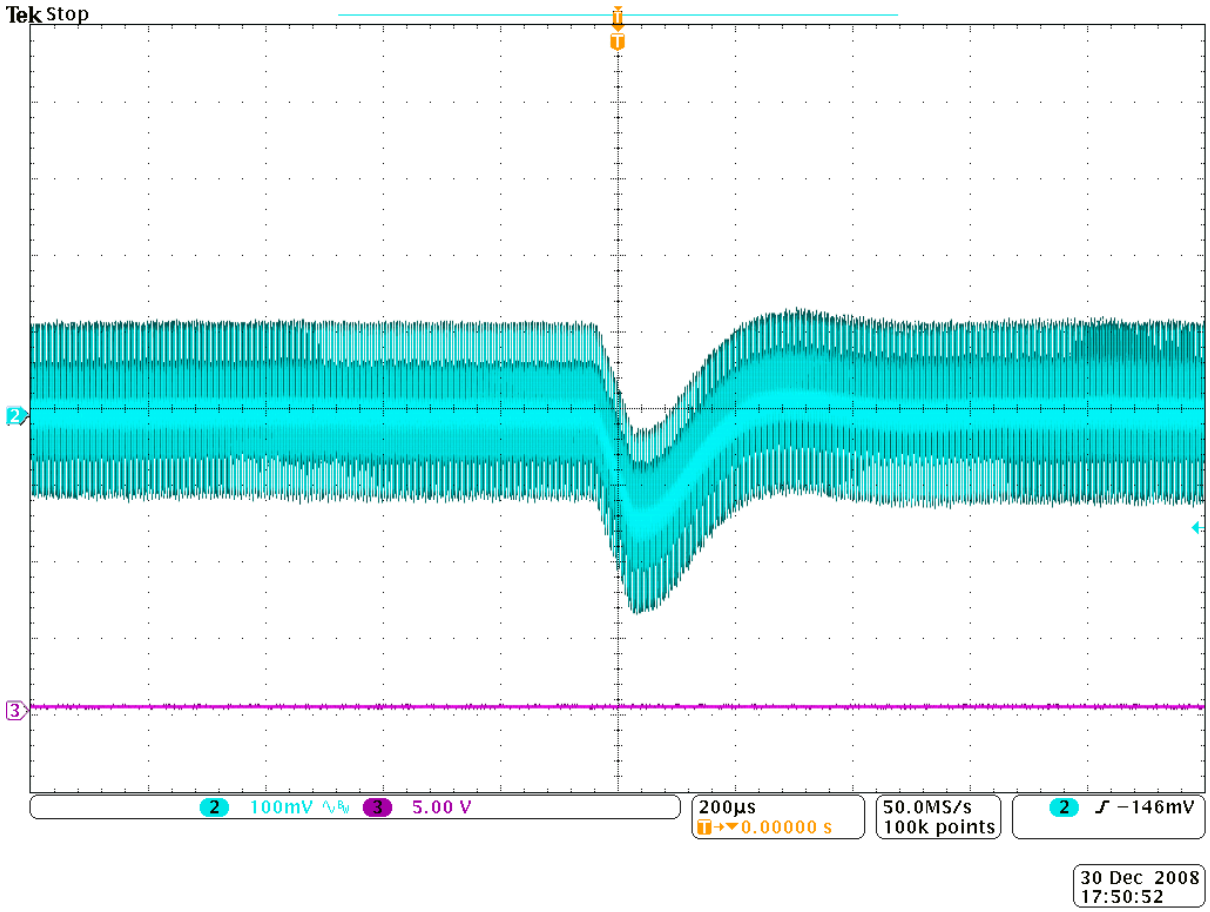
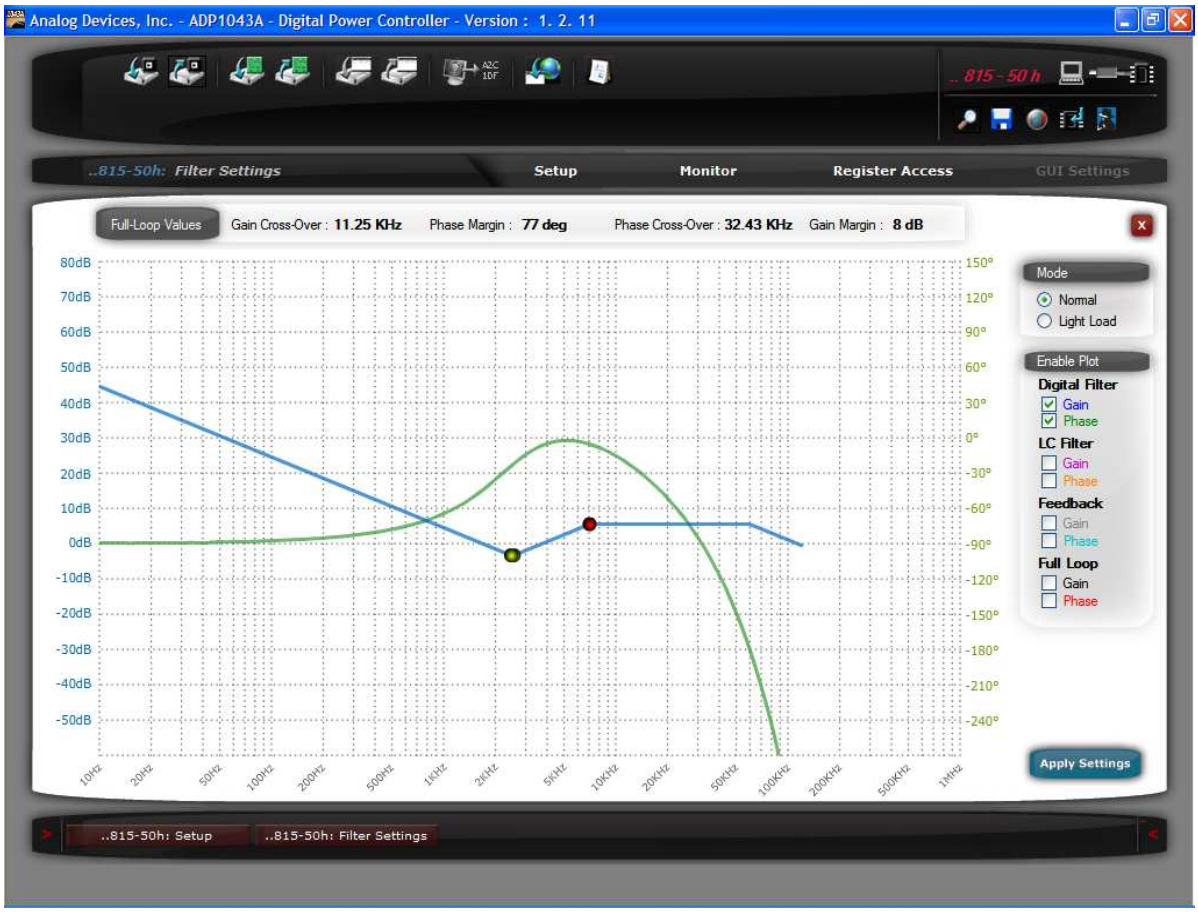


Figure 10. Transient Response – 50% to 75% load step



Now, vary the digital filter using the software. Click on “Filter Settings” the window shows the filter settings for Normal mode. Click on the curve to move position of poles, zeroes and gains.

Figure 11. Digital Filter window



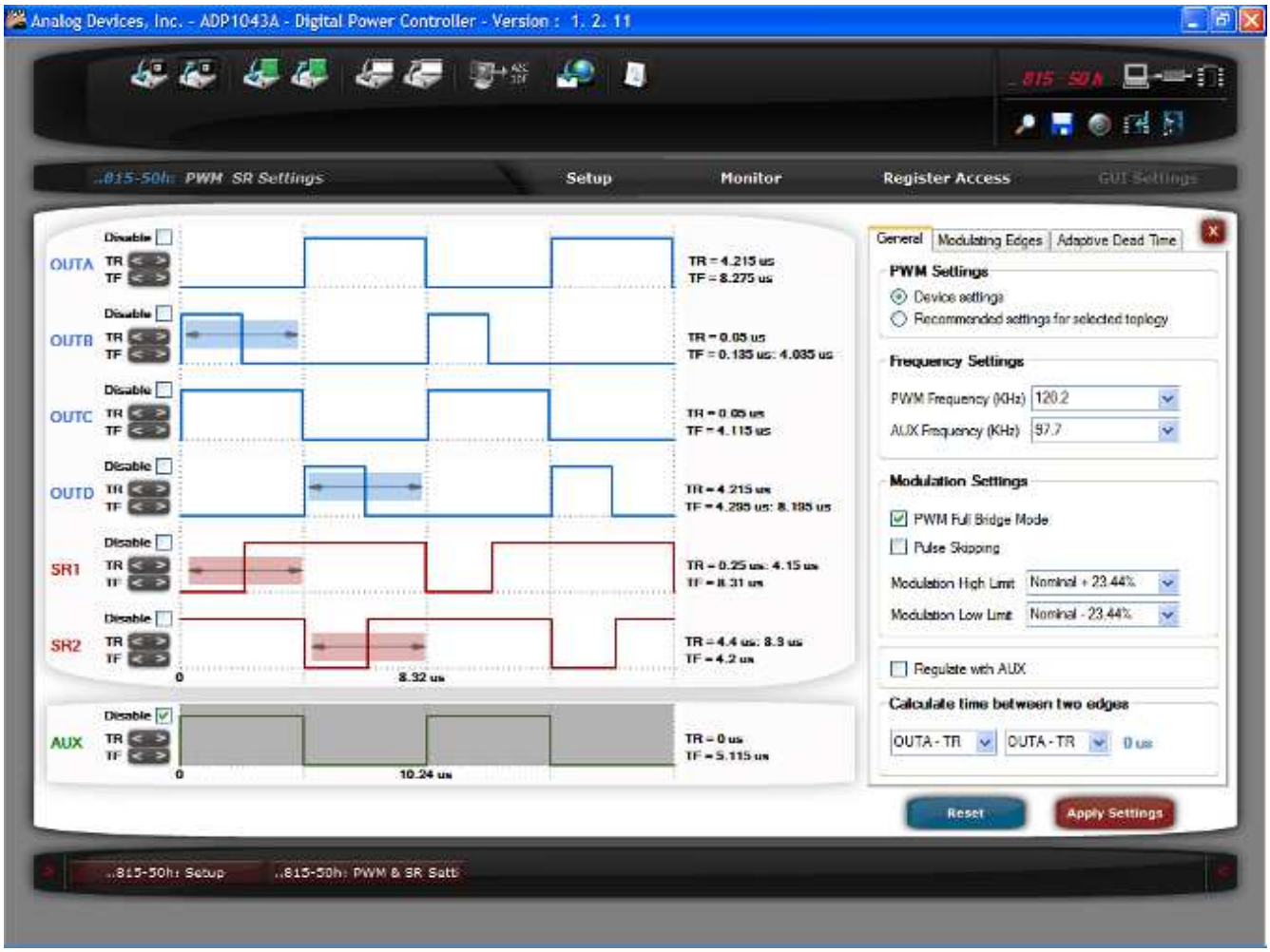
The transient response will change. This evaluation shows the user how the digital filter can easily be programmed to optimize the transient response of the power supply.

PWM – SWITCHING FREQUENCY

The converter switching frequency is programmable. In the “PWM & SR Settings” change the switching frequency.

The minimum and maximum modulation limits can also be modified.

Figure 12. PWM Timing Window



NOTE: It is recommended to evaluate this feature with the power supply turned off. This prevents the chance of damaging the power supply by introducing shoot-through.

LIGHT LOAD OPTIMIZATION

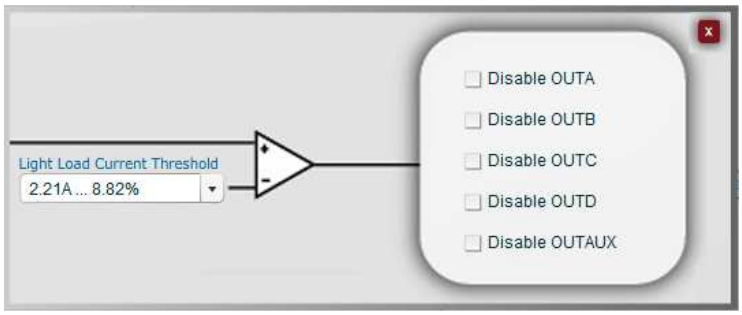
The ADP1043A can be programmed to optimize performance when a output current drops below a certain level.

The threshold for light load mode can be programmed in the “CS2 Settings” window.

Once the current will drop below this level the sync rectifiers (SR1 and SR2) will be disabled and the other five PWM can also be disabled by marking the corresponding checkboxes. The “Light Load Mode Settings” in “Filter Settings” will be used. The response time for the ADP1043A to switch from one mode to another is between 10 and 20ms.

The light load mode can be disabled by selecting a Light Load Current Threshold of 0%.

Figure 13. Light Load Mode Control Window



PRIMARY SIDE CURRENT SENSE AND SECONDARY SIDE CURRENT SENSE

Current sensing is available for both the primary side current and the secondary side current. Primary side current sensing is performed using the current transformer, T1. Secondary side current sensing uses a low-side sense resistor (R21, R29, R98 and R99).

Open the Flags and Readings window in the software. Adjust the load current from 0A to 25A. The input current and output current values will change in the software, matching the changes being made at the load.

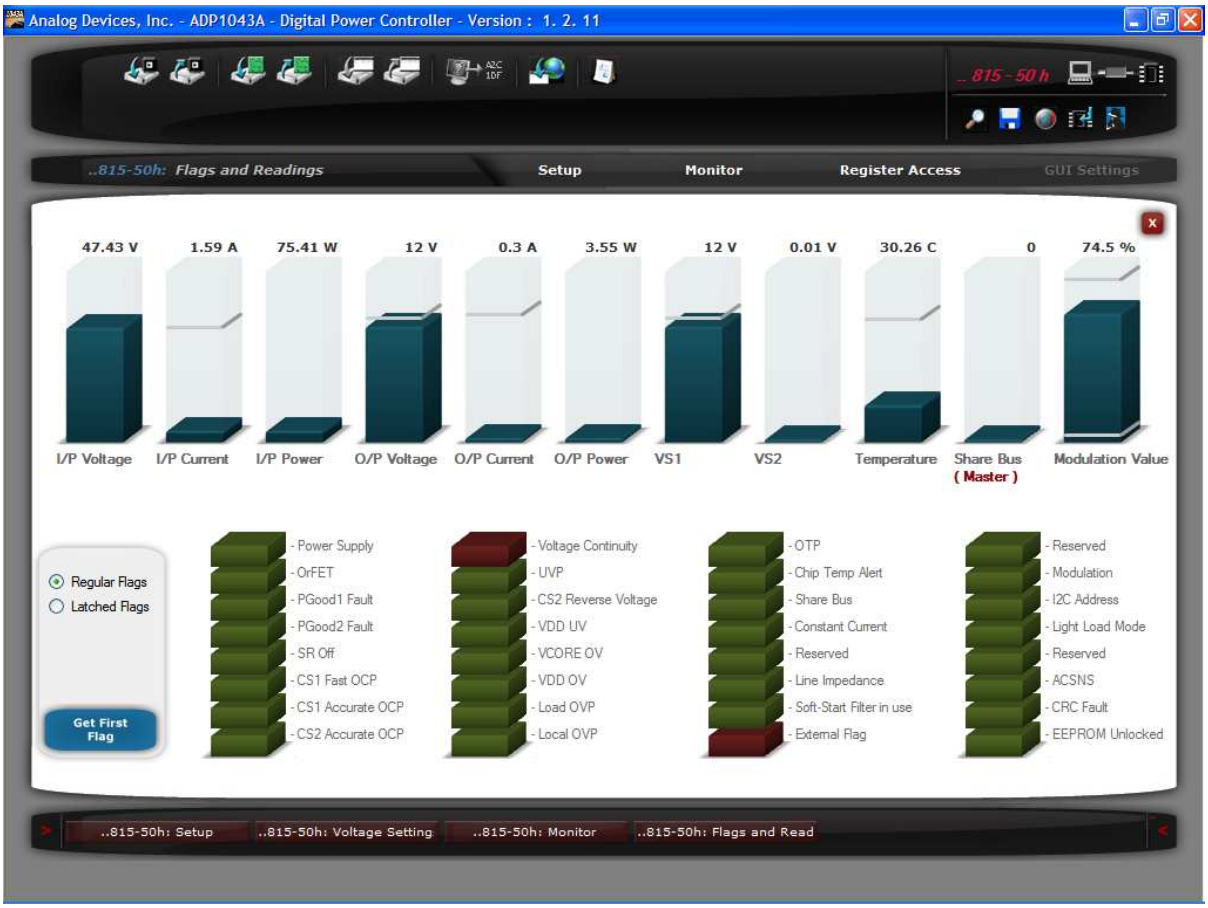
VOLT-SECOND BALANCE

The ADP1043A has an integrated Volt-Second Balance circuit. This means that there is no need for a dc blocking capacitor in the main power path on the primary side. Set the load current to 1A. Place a scope probe on the CS1 pin of the ADP1043A. Setup the scope to 200mV/div, 5usecs/div. A typical CT waveform should be on the scope. Using the software, toggle Reg 52h, Bit 1. To exaggerate an imbalance, use the PWM window in the software to intentionally place a timing mismatch. For example, move T3 from 2.5usecs to 2.51usecs.

FLAGS, AND FAULT CONFIGURATIONS

Open the Flags and Readings window in the software. The window will show all of the fault flags. If a flag is set, then there is a red box next to the flag. If the flag is ok, then there is a green box next to the flag.

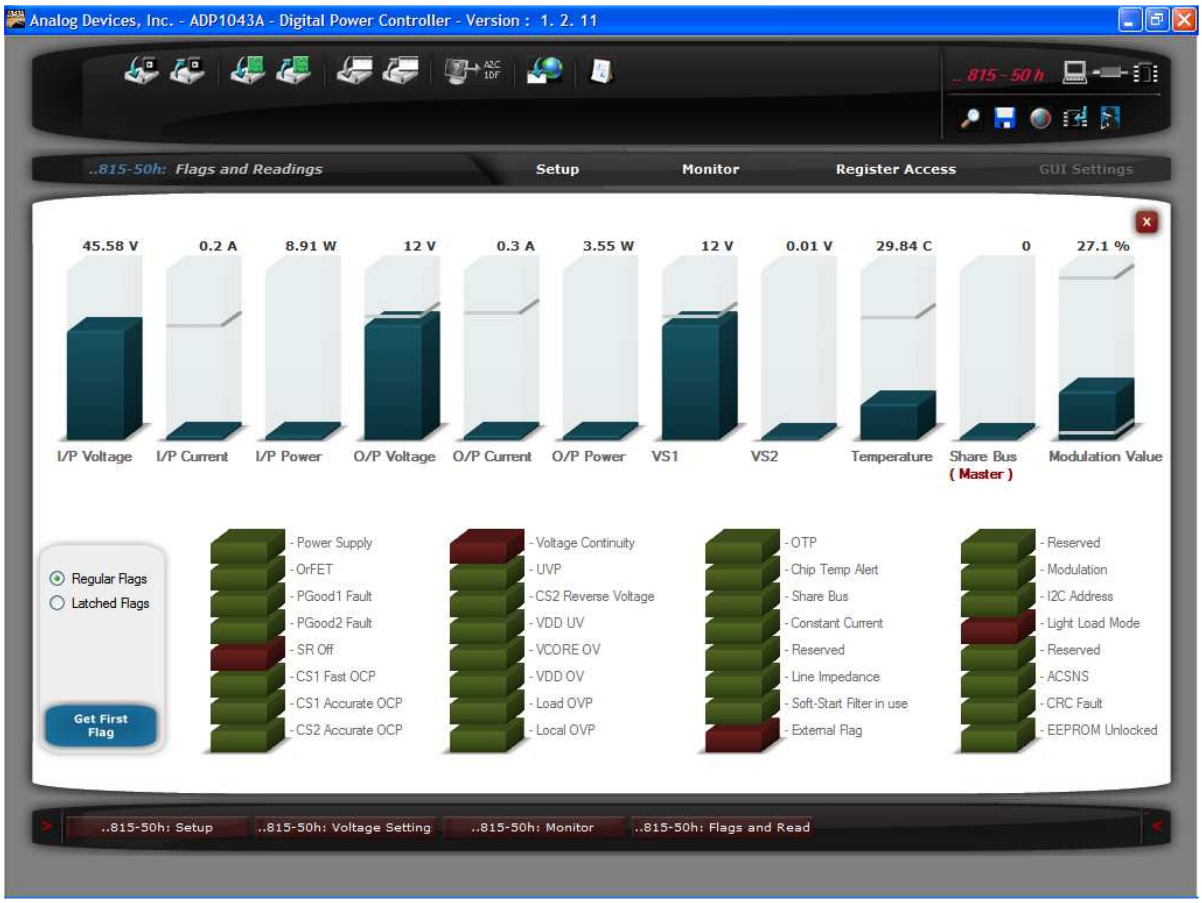
Figure 14. Flags and Readings



Set the load current to 0.3A. The CS2 OCP flag should be green.

Note that the SR flag and the Light load mode flags are red to indicate that the ADP1043A is in this state.

Figure 15. Flags in Light load mode



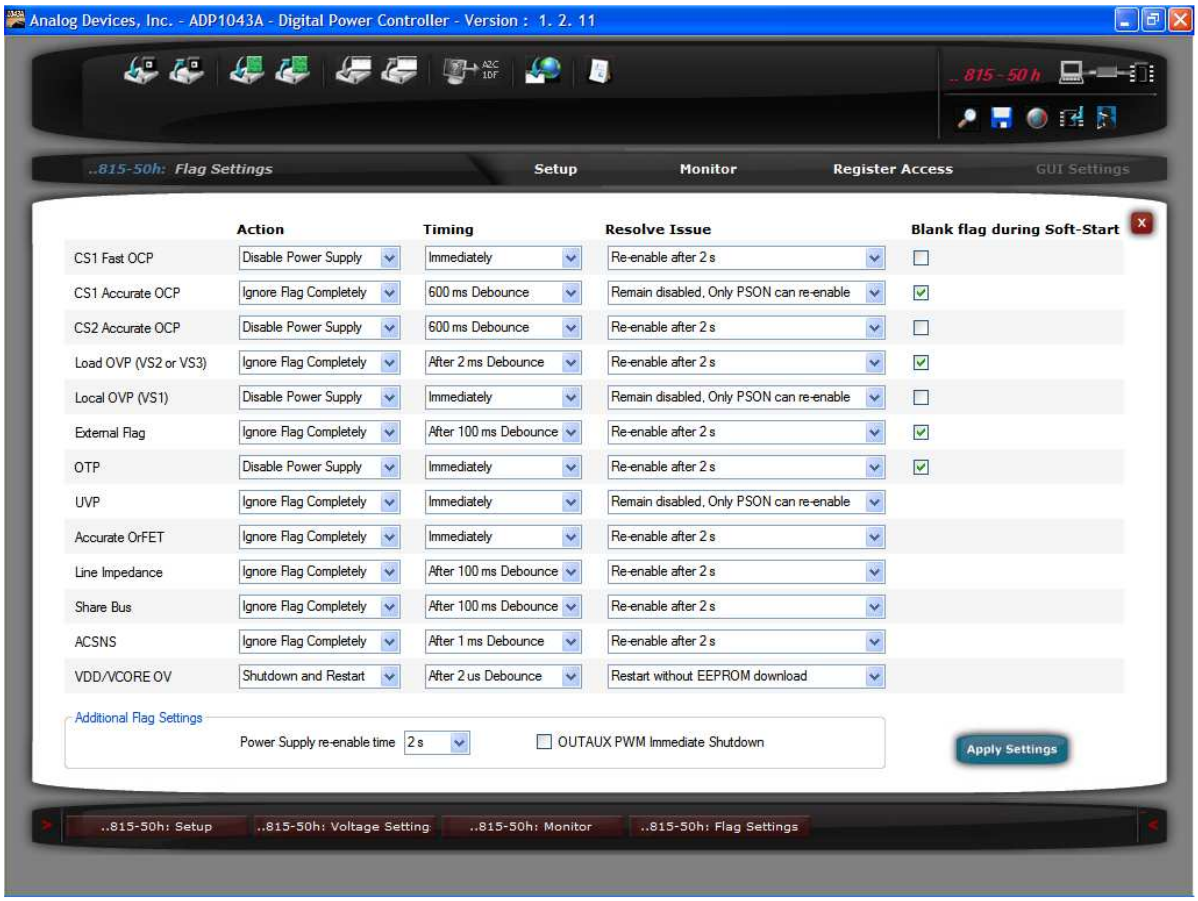
Now change the load to 28 A. The CS2 OCP flag should now have turned red, because the CS2 OCP threshold has been reached. The board wills ender in hiccup mode and try and restart.

Set the load back to 2A, and the flag turns green again. This shows how the user can easily monitor the health of the power supply by monitoring the status of the various flags.

FLAG & FAULT RESPONSE CONFIGURATION:

The ADP1043A is programmed to respond to the various fault conditions in the “Flag Settings” window.

Figure 16. Fault Configurations



You can change the resolve issue to “Remain Disabled”. If the overcurrent is applied again the ADP1043A will shut down and remain off until PSON is cycled.

This evaluation shows how it is quite easy to configure the response to a fault condition. Change the load back to 2A, then toggle the PS_ON switch to restart the power supply.

APPENDIX

Figure 17. Primary Side Power Stage Schematic

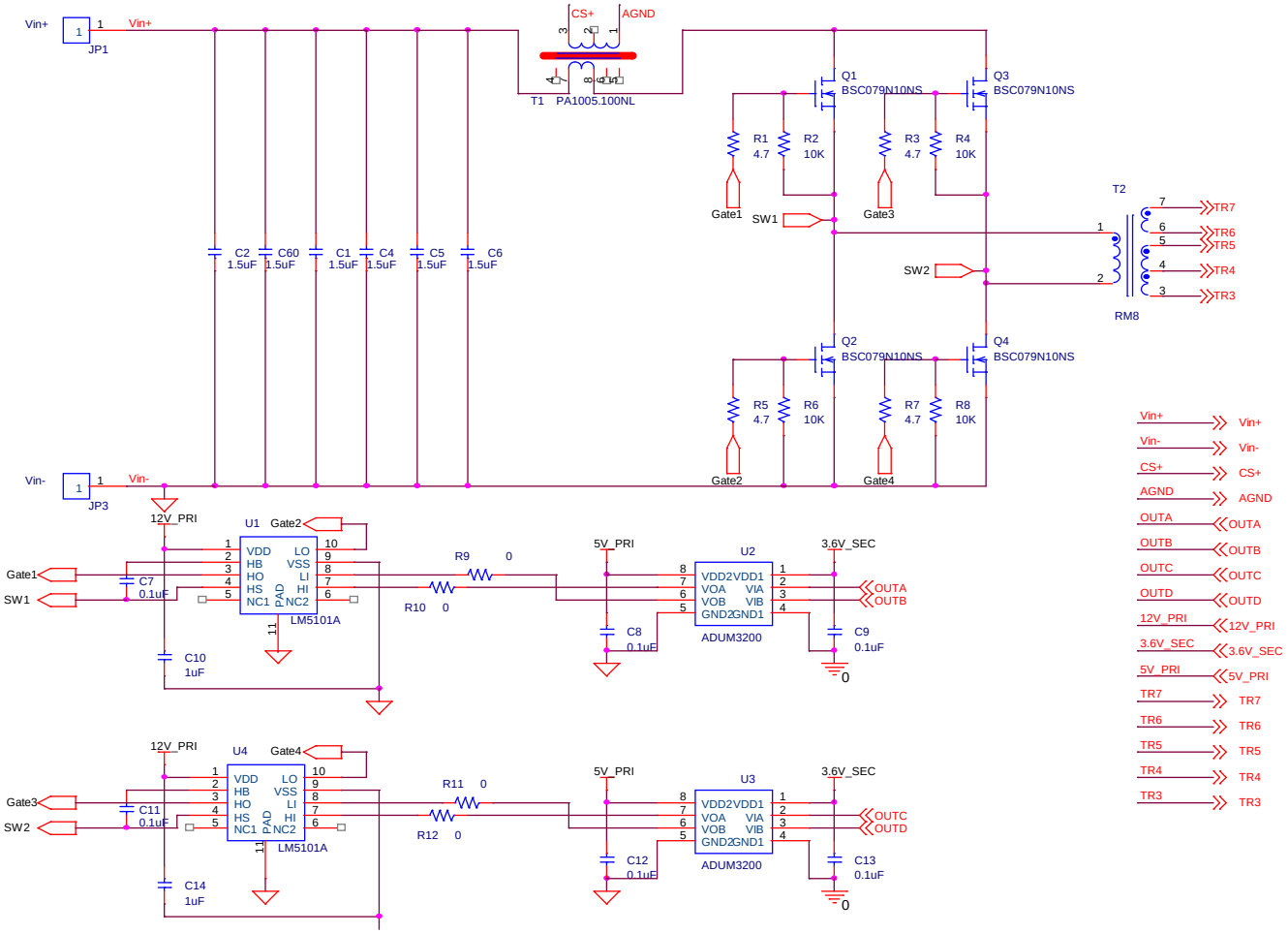


Figure 18. Secondary Side Power Stage Schematic

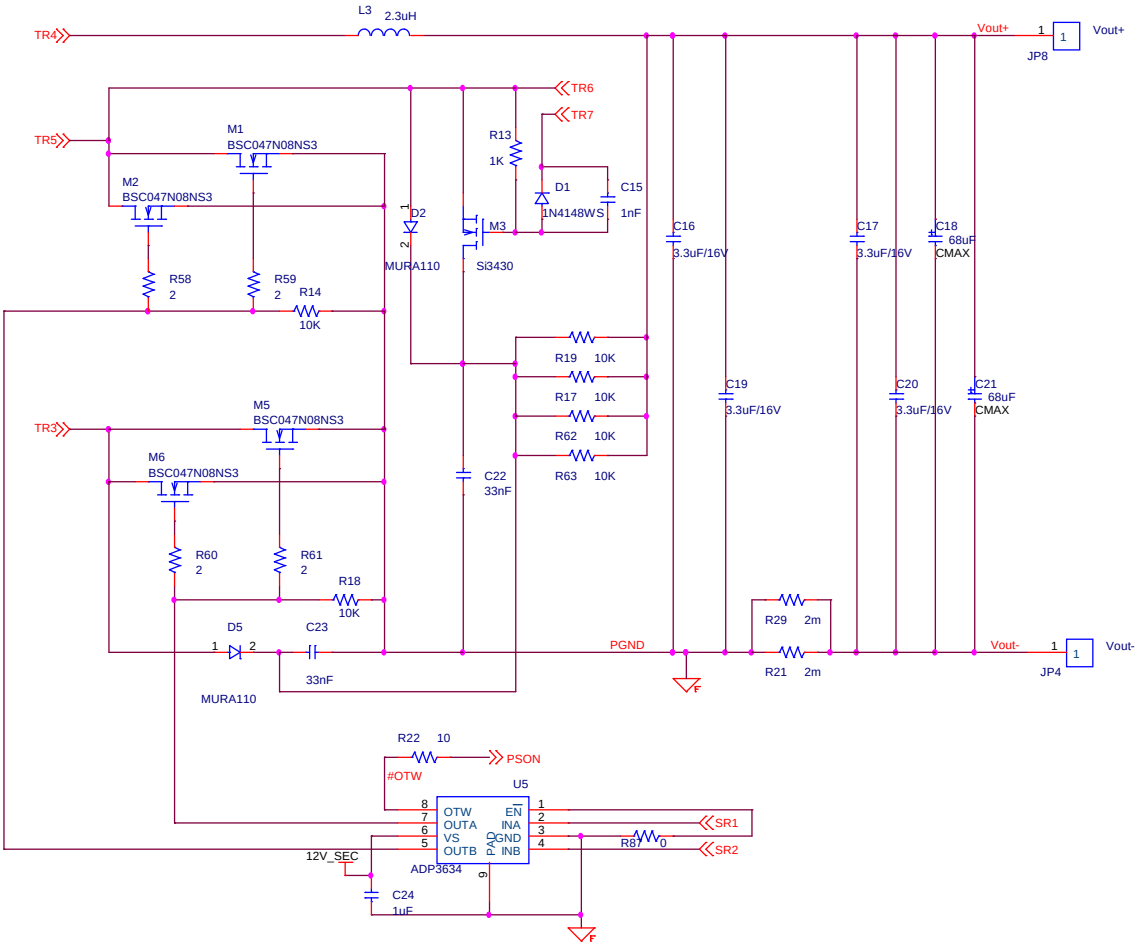


Figure 19. Control Circuit Schematic

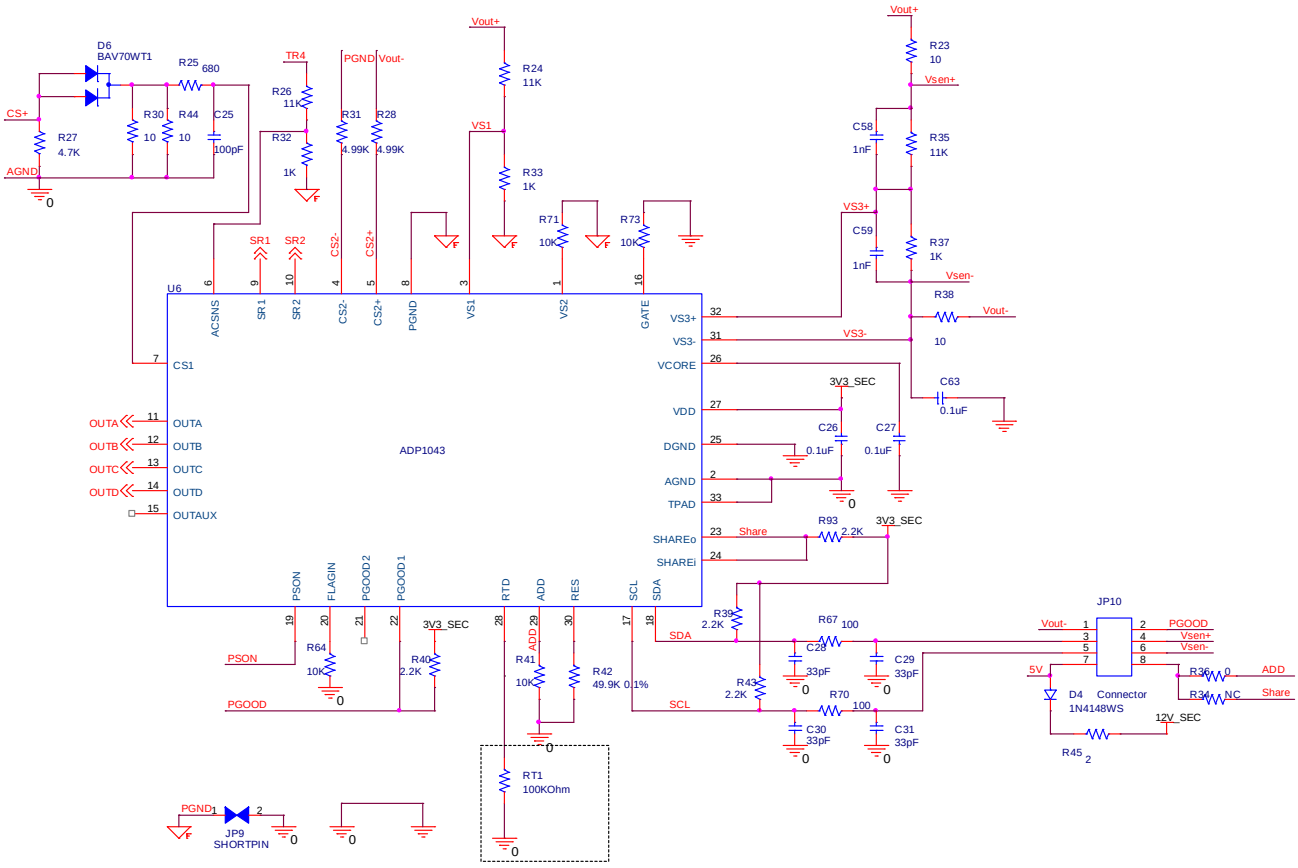


Figure 20. ON/OFF & UVP Control Schematic

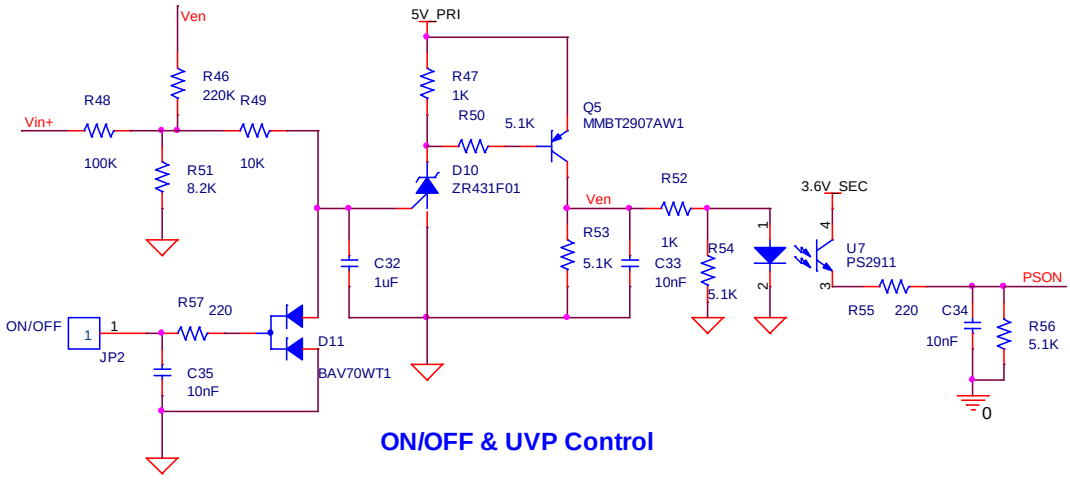


Figure 21. Auxiliary Power Schematic

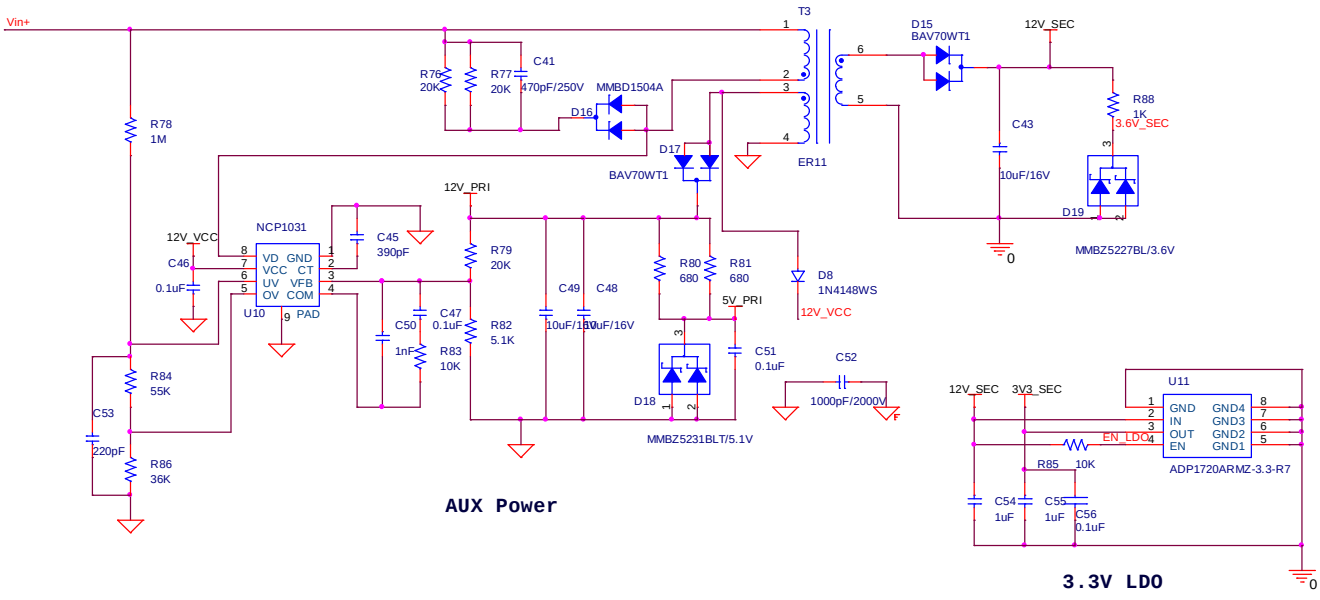


Figure 22. PCB Top View

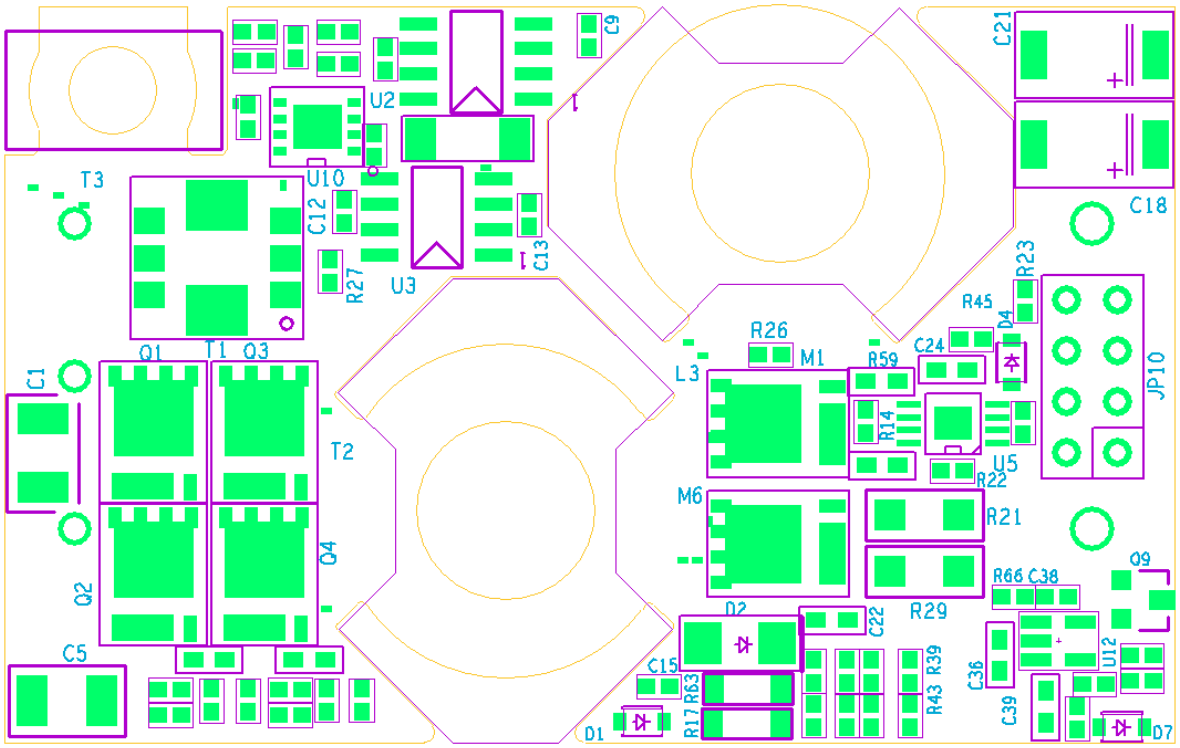
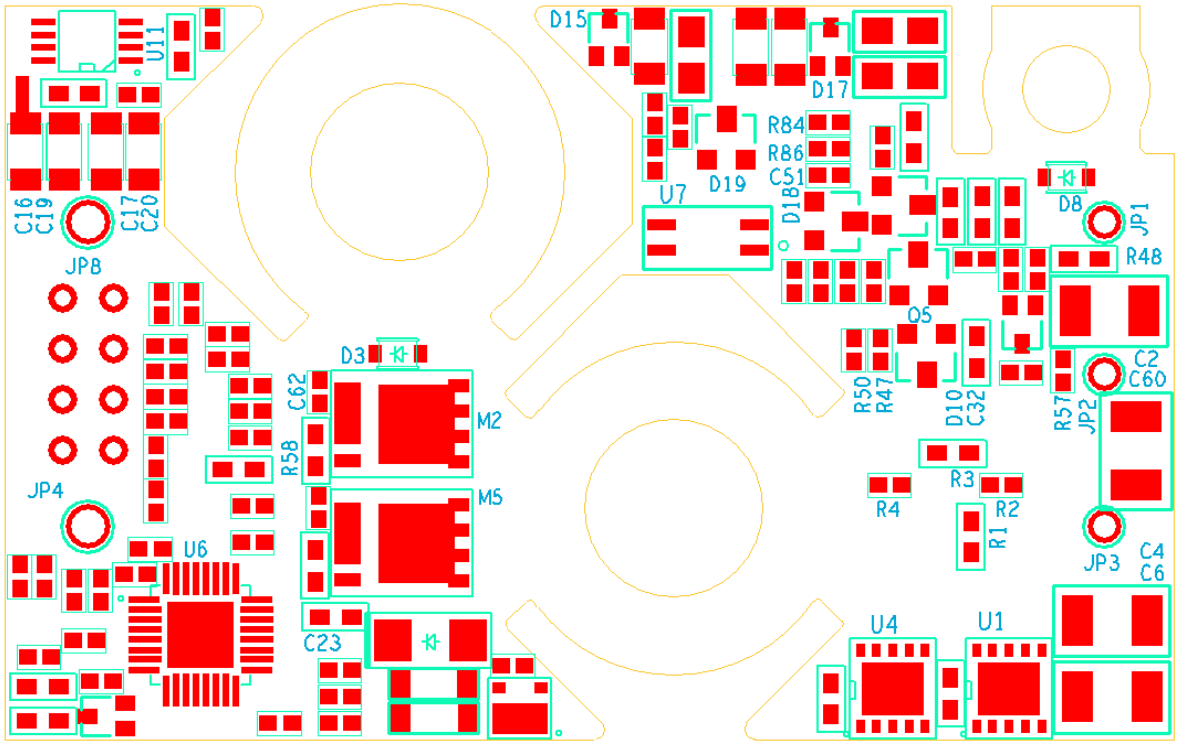


Figure 23. PCB Bottom View



BILL OF MATERIALS

Table 3. Bill of Materials

Item	Reference	Part Number	Description	Package	Qty	Mfg
1	C1,C2,C4,C5,C6,C60	C3225X7R2A155K	CAP 1.5uF/100V X7R	1210	6	TDK
2	C7,C8,C9,C11,C12,C13,C26, C27,C46,C47,C51,C56,C63	C1005X7R1C104K	CAP 0.1uF/16V X7R	0402	13	TDK
3	C10,C14,C24,C32,C54,C55	C1608X7R1C105K	CAP 1uF/16V X7R	0603	6	TDK
4	C15,C50,C58,C59	C1005X7R1H102K	CAP 1nF/50V X7R	0402	4	TDK
5	C16,C17,C19,C20	C3216X7R1C335K	CAP 3.3uF/16V X7R	1206	4	TDK
6	C18,C21	16TQC68M	CAP 68uF/16V	D3L	2	Sanyo
7	C22	C1608X7R2A223K	CAP 22nF/100V X7R	0603	1	TDK
8	C23	C1608X7R2A223K	CAP 33nF/100V X7R	0603	1	TDK
9	C25	C1005COG1H101J	CAP 100pF/50V C0G	0402	1	TDK
10	C28,C29,C30,C31	C1005COG1H330J	CAP 33pF/50V COG	0402	4	TDK
11	C33,C34,C35	C1005X7R1E103K	CAP 10nF/25V X7R	0402	3	TDK
12	C41	C1608C0G2E471J	CAP 470pF/250V COG	0603	1	TDK
13	C43,C48,C49	C3216X7R1C106K	CAP 10uF/16V X7R	1206	3	TDK
14	C45	C1005COG1H391J	CAP 390pF/50V COG	0402	1	TDK
15	C52	C4520X7R3D102K	CAP 1000pF/2000V X7R	1808	1	TDK
16	C53	C1005X7R1H221K	CAP 220pF/50V X7R	0402	1	TDK
17	D1,D4,D8	1N4148WS	Diode 150mA 75V	SOD323	3	Diodes
18	D2,D5	MURA110	Diode 1A 100V	SMA	2	Vishay
19	D6,D11,D15,D17	BAV70WT1	Diode 200mA 70V	SOT323	4	ON Semi
20	D10	ZR431F01	Adjustable precision shunt regulator	SOT23	1	ZETEX
21	D16	MMBD1504A	Diode 200mA 200V	SOT23	1	ON Semi
22	D18	MMBZ5231BLT	Zener 5.1V	SOT23	1	ON Semi
23	D19	MMBZ5227BL	Zener 3.6V	SOT23	1	ON Semi
24	JP1		PIN	HDR1X1	1	
25	JP2		PIN	HDR1X1	1	
26	JP3		PIN	HDR1X1	1	
27	JP4		PIN	HDR2x1	1	
28	JP8		PIN	HDR2x1	1	
29	JP9		PIN	shortpin	1	
30	JP10				1	
31	L3	Planar Transfomer	RM8_PC95	RM8	1	Vishay
32	M1,M2,M5,M6	BSC047N08NS3	MOSFET	SuperSO8	4	Infineon
33	M3	Si3430DV	MOSFET	TSOP-6-3	1	Vishay
34	Q1,Q2,Q3,Q4	BSC079N10NS	MOSFET	SuperSO8	4	Infineon
35	Q5	MMBT2907AWT1	PNP -800mA -40V	SOT23	1	ON Semi
36	RT1		THERMISTOR 1%	0603	1	Vishay
37	R1,R3,R5,R7		RES 4.7OHM 5% 1/10W	0603	4	Vishay
38	R2,R4,R6,R8,R14,R18,R49, R83,R85		RES 10KOHM 5% 1/16W	0402	9	Vishay
39	R9,R10,R11,R12,R36,R87		RES 0OHM 5% 1/16W	0402	6	Vishay

Item	Reference	Part Number	Description	Package	Qty	Mfg
40	R13,R47,R52		RES 1KOHM 5% 1/16W	0402	3	Vishay
41	R17		RES 10 KOHM 5% 1/4W	1206	1	Vishay
42	R21,R29,R98,R99		RES 2m OHM 1% 1/2W	1206	4	Vishay
43	R22,R23,R38		RES 10OHM 5% 1/16W	0402	3	Vishay
44	R24		RES 11KOHM 1% 1/16W	0402	1	Vishay
45	R25		RES 680OHM 5% 1/16W	0402	1	Vishay
46	R26,R35		RES 11KOHM 1% 1/16W	0402	2	Vishay
47	R27		RES4.7KOHM 5% 1/16W	0402	1	Vishay
48	R28,R31		RES 4.99KOHM 1% 1/16W	0402	2	Vishay
49	R30,R44		RES 10OHM 5% 1/10W	0603	2	Vishay
50	R32		RES 1KOHM 1% 1/16W	0402	1	Vishay
51	R33,R37		RES 1KOHM 1% 1/16W	0402	2	Vishay
52	R34		RES 10OHM 5% 1/16W	0402	1	Vishay
53	R39,R40,R43,R93		RES 2.2KOHM 1% 1/16W	0402	4	Vishay
54	R41,R64,R71,R73		RES 10KOHM 1% 1/16W	0402	4	Vishay
55	R42		RES 49.9KOHM 0.1% 1/16W	0402	1	Vishay
56	R45		RES 2OHM 1% 1/16W	0402	1	Vishay
57	R46		RES 220KOHM 1% 1/16W	0402	1	Vishay
58	R48		RES 100KOHM 5% 1/10W	0603	1	Vishay
59	R50,R53,R54,R56,R82		RES 5.1KOHM 5% 1/16W	0402	5	Vishay
60	R51		RES 8.2KOHM 1% 1/16W	0402	1	Vishay
61	R55,R57		RES 220OHM 5% 1/16W	0402	2	Vishay
62	R58,R59,R60,R61		RES 0OHM 5% 1/10W	0603	4	Vishay
63	R67,R70		RES 100OHM 5% 1/16W	0402	2	Vishay
64	R76,R77		RES 20KOHM 5% 1/10W	0603	2	Vishay
65	R78		RES 1MOHM 5% 1/10W	0603	1	Vishay
66	R79		RES 14KOHM 5% 1/16W	0402	1	Vishay
67	R80		RES 680OHM 5% 1/8W	0805	1	Vishay
68	R84		RES 55KOHM 5% 1/16W	0402	1	Vishay
69	R86		RES 36KOHM 5% 1/16W	0402	1	Vishay
70	R88		RES 1KOHM 5% 1/8W	0805	1	Vishay
71	T1	PA1005.100NL	20A 1:100	P820x	1	PULSE
72	T2	RM8	RM8_PC95	RM8	1	TDK
73	T3	ER11	Transformer ER11	ER11	1	TDK
74	U1,U4	LM5101A	Gate Driver	LLP-10	2	NS
75	U2,U3	ADuM3200	iCoupler	SO8	2	ADI
76	U5	ADP3634	Dual channel driver IC	8ld MSOP_ED	1	ADI
77	U6	ADP1043A	Secondary PWM Controller	LFCSP32	1	ADI
78	U7	PS2911-1	Optocoupler PS2911	4ld MSOP	1	Vishay
79	U10	NCP1031	TOP Switch	DFN8	1	ON Semi
80	U11	ADP1720ARMZ-3.3-R7	LDO	8ld MSOP	1	ADI
81	**R81**		**RES 820OHM 5% 1/8W**	**0805**	**1**	**Vishay**

NOTES