AN-EVAL3BR4765J

12W 5.0V SMPS Evaluation Board with CoolSET^{TM} F3R ICE3BR4765J

Power Management & Supply

Never stop thinking.

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12W 5V Demoboard using ICE3BR4765J on board

Revision History:	**2008-06-04**	V1.3
Previous Version:	1.2	

Page	Subjects (major changes since last revision)
1, 5, 7	Change demo board name to EVAL3BR4765J

12W 5.0V SMPS Evaluation Board with CoolSET^{TM} F3R ICE3BR4765J:
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Kok Siu Kam Eric
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1 Abstract

This document is an engineering report of an universal input 5V 12W off line flyback converter power supply utilizing IFX F3R CoolSET™[13] ICE3BR4765J. The application demo board is operated in Discontinuous Conduction Mode (DCM) and is running at 65 kHz switching frequency. It has a one output voltage with secondary side control regulation. It is especially suitable for small power supply such as DVD player, set-top box, game console, charger and auxiliary power of high power system, etc. The ICE3BR4765J is the latest version of the CoolSET™. Besides having the basic features of the F3 CoolSET™ such as Active Burst Mode, propagation delay compensation, soft gate drive, auto restart protection for serious fault (Vcc over voltage protection, Vcc under voltage protection, over temperature, over-load, open loop and short opto-coupler), it also has the BiCMOS technology design, built-in soft start time, built-in and extendable blanking time, frequency jitter feature with built-in jitter period and external auto-restart enable, etc. The particular features needs to be stressed are the best in class low standby power and the good EMI performance.

2 Evaluation Board

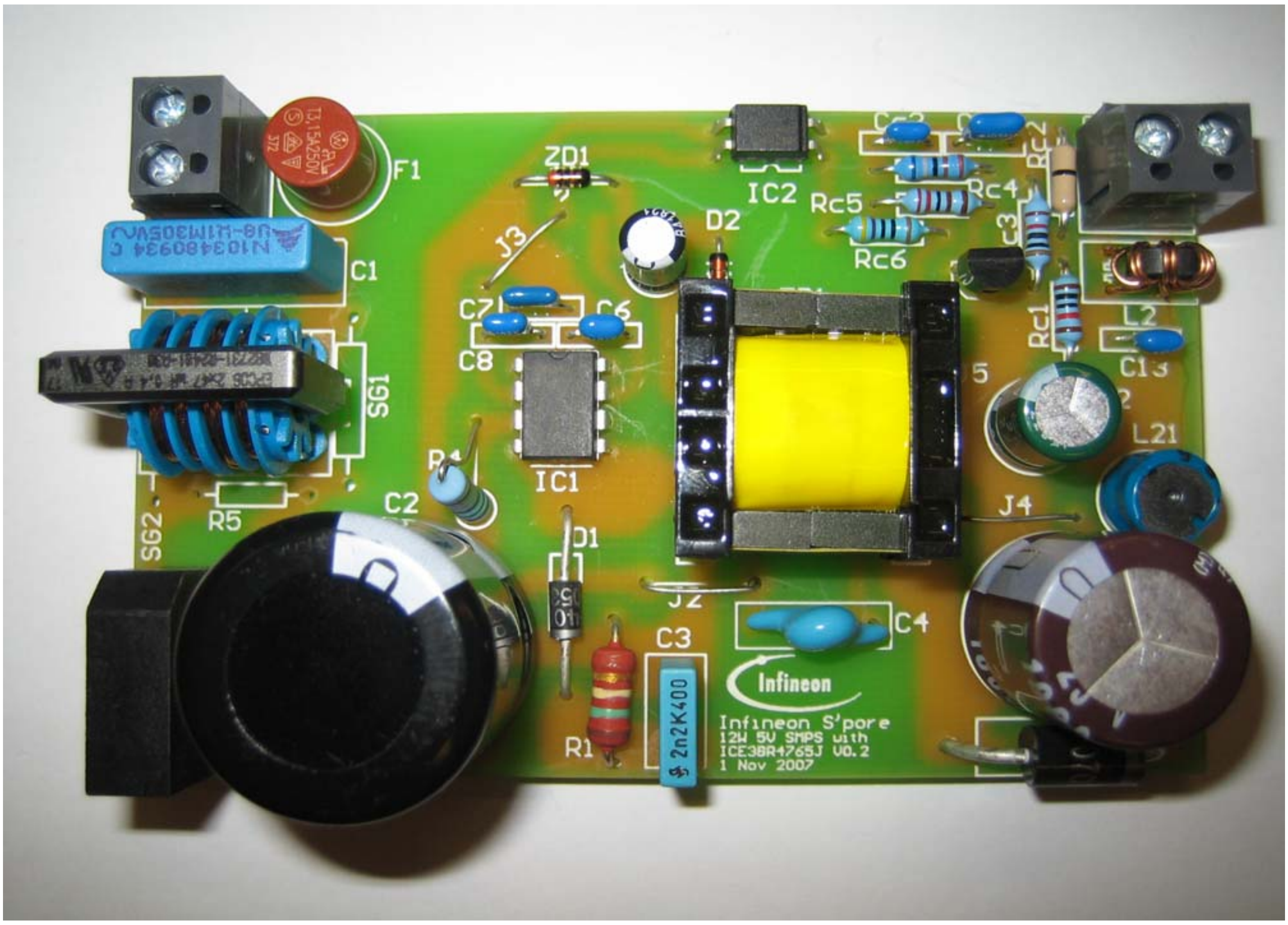


Figure 1 – EVAL3BR4765J

This document contains the list of features, the power supply specification, schematic, bill of material and the transformer construction documentation. Typical operating characteristics such as performance curve and scope waveforms are showed at the rear of the report.

[13] CoolSET™ is a trade mark of Infineon which is a PWM control IC integrated with CoolMOS™ in one package.

3 List of Features

650V avalanche rugged CoolMOS™ with built-in Startup Cell
Active Burst Mode for lowest Standby Power
Fast load jump response in Active Burst Mode
65 kHz internally fixed switching frequency
Auto Restart Protection Mode for Over-load, Open Loop, Vcc Undervoltage, Over-temperature & Vcc Over-voltage
Built-in Soft Start
Built-in blanking window with extendable blanking time for short duration high current
External auto-restart enable
Max Duty Cycle 75%
Overall tolerance of Current Limiting < ±5%
Internal PWM Leading Edge Blanking
BiCMOS technology provides wide VCC range
Built-in Frequency jitter feature and soft driving for low EMI

4 Technical Specifications

Input voltage	85VAC~265VAC
Input frequency	50Hz, 60Hz
Input Standby Power	< 40mW @ no load; < 0.7W @ 0.5W load
Output voltage and current	5V +/- 2%
Output current	2.4A
Output power	12W
Efficiency	>75% at full load
Output ripple voltage	< 50mVp-p (exclude high frequency spike)

5 Circuit Description

5.1 Introduction

The EVAL3BR4765J demoboard is a low cost off line flyback switch mode power supply (SMPS) using the ICE3BR4765J system IC from the CoolSET^{TM}-F3R family. The circuit, shown in Figure 2, details a 5.0V, 12W power supply that operates from an AC line input voltage range of 85Vac to 265Vac, suitable for applications in open frame supply or enclosed adapter.

5.2 Line Input

The AC line input side comprises the input fuse F1 as over-current protection. The choke L1, X2-capacitors C1 and Y1-capacitor C4 act as EMI suppressors. Spark gap device SG1 and SG2 can absorb high voltage stress during lightning surge test. After the bridge rectifier BR1 and the input bulk capacitor C2, a voltage of 100 to 380 V_{DC} is present which depends on input voltage.

5.3 Start up

Since there is a built-in startup cell in the ICE3BR4765J, there is no need for external start up resistor. The startup cell is connecting the drain pin of the IC. Once the voltage is built up at the Drain pin of the ICE3BR4765J, the startup cell will charge up the Vcc capacitor C5 and C6. When the Vcc voltage exceeds the UVLO at 18V, the IC starts up. Then the Vcc voltage is bootstrapped by the auxiliary winding to sustain the operation.

5.4 Operation mode

During operation, the Vcc pin is supplied via a separate transformer winding with associated rectification D2 and buffering C5, C6. Resistor R2 is used for current limiting. In order not to exceed the maximum voltage at Vcc pin, an external zener diode ZD1 and resistor R3 are added.

5.5 Soft start

The Soft-Start is a built-in function and is set at 20ms.

5.6 Clamper circuit

The circuit R1, C3 and D1 clamp the DRAIN voltage spike caused by transformer leakage inductance to a safe value below the drain source break down voltage V_{DSBR} = 650V[14] maximum.

5.7 Peak current control of primary current

The CoolMOS^{TM} drain source current is sensed via external shunt resistors R4 and R4A. An accurate value of the shunt improves the peak power limitation shown in the curve peak power limitation in the rear of this report.

5.8 Output Stage

On the secondary side the power is coupled out by a schottky diode D21. The capacitor C21 provides energy buffering following with the LC filter L21 and C22 to reduce the output voltage ripple considerably. Storage

[14] V_{DSBR} = 650V @ Tj = 110°C

capacitor C21 is selected to have an internal resistance as small as possible (ESR) to minimize the output voltage ripple. The Common mode choke L2 can suppress ESD stress from output.

5.9 Feedback and regulation

The output voltage is controlled using a TL431 (IC3). This device incorporates the voltage reference as well as the error amplifier and a driver stage. Compensation network Cc1, Cc2, Rc1, Rc2, Rc4 constitutes the external circuitry of the error amplifier of IC3. This circuitry allows the feedback to be precisely matched to dynamically varying load conditions and provides stable control. The maximum current through the optocoupler diode and the voltage reference is set by using resistors Rc5 and Rc6. Optocoupler IC2 is used for floating transmission of the control signal to the “Feedback” input via capacitor C8 of the ICE3BR4765J control device. The optocoupler used meets DIN VDE 884 requirements for a wider creepage distance.

5.10 Blanking Window for Load Jump / Active Burst Mode

In case of Load Jumps the Controller provides a Blanking Window before activating the Over-Load Protection and entering the Auto Restart Mode. The blanking time is built-in at 20ms. If a longer blanking time is required, a capacitor, C7 can be added to BA pin to extend it. The extended time can be achieved by an internal 13uA constant current at BA pin to charge C7 from 0.9V to 4.0V. Thus the overall blanking time is the addition of 20ms and the extended time. The voltage at Feedback pin can rise above 4V without switching off due to Over-load Protection within this blanking time frame. During the operation the transferred power is limited to the maximum peak current defined by the value of the current sense resistor, R4 and R4A.

The blanking time to enter the Active Burst Mode is built-in at 20ms with no extension. If a low load condition is detected when V_{FB} is falling below 1.35V, the system will only enter Active Burst Mode after 20ms blanking time while V_{FB} is still below 1.35V.

5.11 Active Burst Mode

At light load condition, the SMPS enters into Active Burst Mode. At this start, the controller is always active and thus the V_{CC} must always be kept above the switch off threshold $V_{CCoff} \geq 10.5V$. During active burst mode, the efficiency increases significantly and at the same time it supports low ripple on V_{OUT} and fast response on load jump. When the voltage level at FB falls below 1.35V, the internal blanking timer starts to count. When it reaches the built-in 20ms blanking time, it will enter Active Burst Mode. The Blanking Window is generated to avoid sudden entering of Burst Mode due to load jump.

During Active Burst Mode the current sense voltage limit is reduced from 1V to 0.34V so as to reduce the conduction losses and audible noise. All the internal circuits are switched off except the reference and bias voltages to reduce the total V_{CC} current consumption to below 0.45mA. At burst mode, the FB voltage is changing like a sawtooth between 3.0 and 3.5V. To leave Burst Mode, FB voltage must exceed 4V. It will reset the Active Burst Mode and turn the SMPS into Normal Operating Mode. Maximum current can then be provided to stabilize V_{OUT}.

5.12 Jitter mode

The ICE3B4765J has frequency jittering feature to reduce the EMI noise. The jitter frequency is internally set at 65kHz (+/-2.6kHz) and the jitter period is set at 4ms.

5.13 Protection modes

Protection is one of the major factors to determine whether the system is safe and robust. Therefore sufficient protection is necessary. ICE3BR4765J provides all the necessary protections to ensure the system is operating safely. The protections include Vcc over-voltage, over-temperature, over-load, open loop, Vcc under-voltage, short opto-coupler, etc. When those faults are found, the system will go into auto-restart which means the system will stop for a short period of time and re-start again. If the fault persists, the system will stop again. It is then until the fault is removed, the system resumes to normal operation. A list of protections and the failure conditions are showed in the below table.

Protection function	Failure condition	Protection Mode
Vcc Over-voltage	1. Vcc > 25.5V or 2. Vcc > 20.5V & FB > 4.0V & during soft start period	Auto Restart
Over-temperature (controller junction)	T_J > 130°C	Auto Restart
Over-load / Open loop	V_{FB} > 4.0V and V_{BA} > 4.0V (Blanking time counted from charging V_{BA} from 0.9V to 4.0V)	Auto Restart
Vcc Under-voltage / short Opto-coupler	Vcc < 10.5V	Auto Restart
Auto-restart enable	V_{BA} < 0.33V	Auto Restart

6 Circuit Diagram

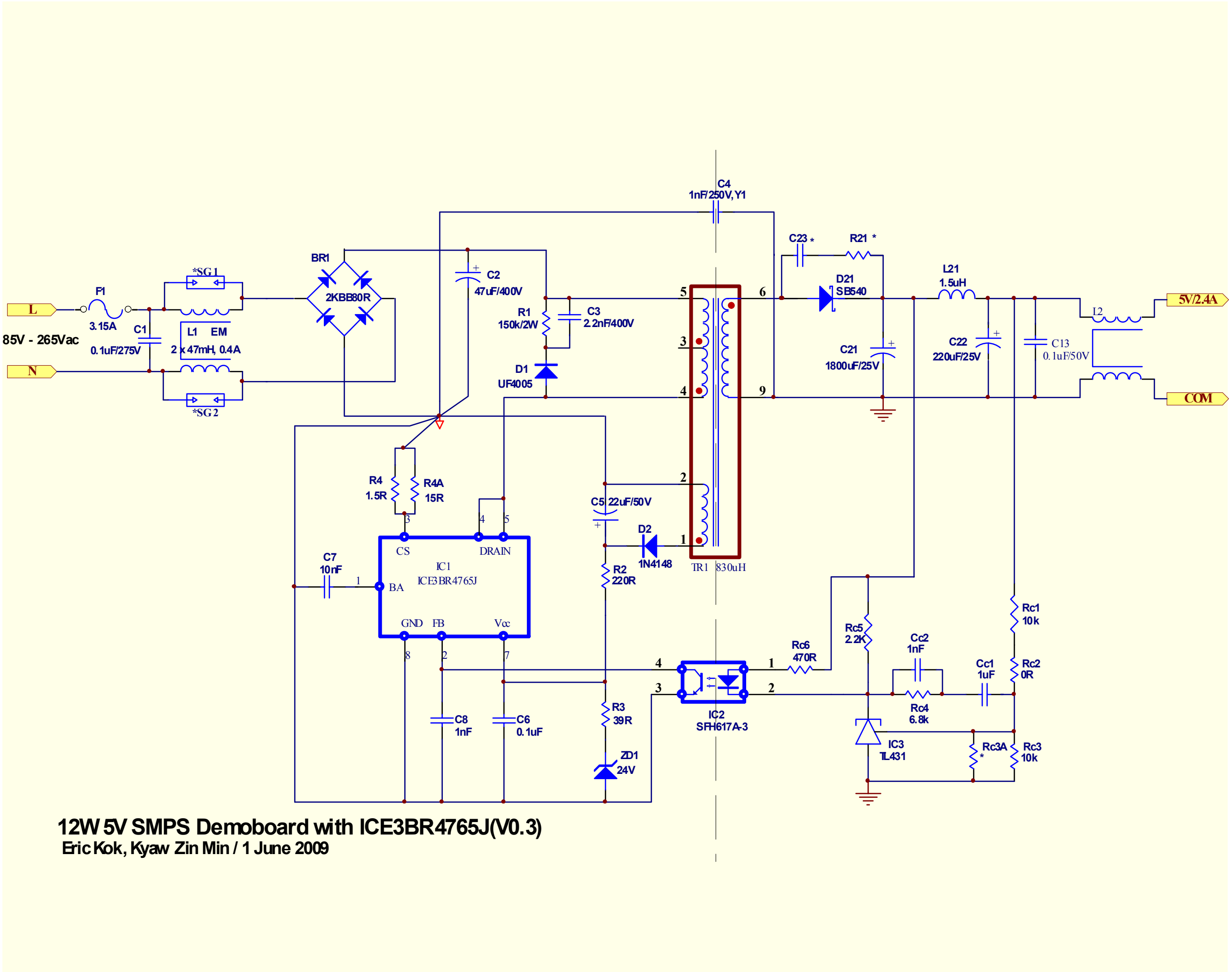


Figure 2 – 12W 5.0V ICE3BR4765J power supply Schemetic

N.B. : In order to get the optimized performance of the CoolSET™, the grounding of the PCB layout must be connected very carfefully. From the circuit diagram above, it indicates that the grounding for the CoolSET™ can be split into several groups; signal ground, Vcc ground, Current sense resistor ground and EMI return ground. All the split grounds should be connected to the bulk capacitor ground separately.

- Signal ground includes all small signal grounds connecting to the CoolSET™ GND pin such as filter capacitor ground, C6, C7, C8 and opto-coupler ground.
- Vcc ground includes the Vcc capctior ground, C5 and the auxiliary winding ground, pin 2 of the power transformer.
- Current Sense resistor ground includes current sense resistor R4 and R4A.
- EMI return ground includes Y capacitor, C4.

7 PCB Layout

7.1 Component side component legend

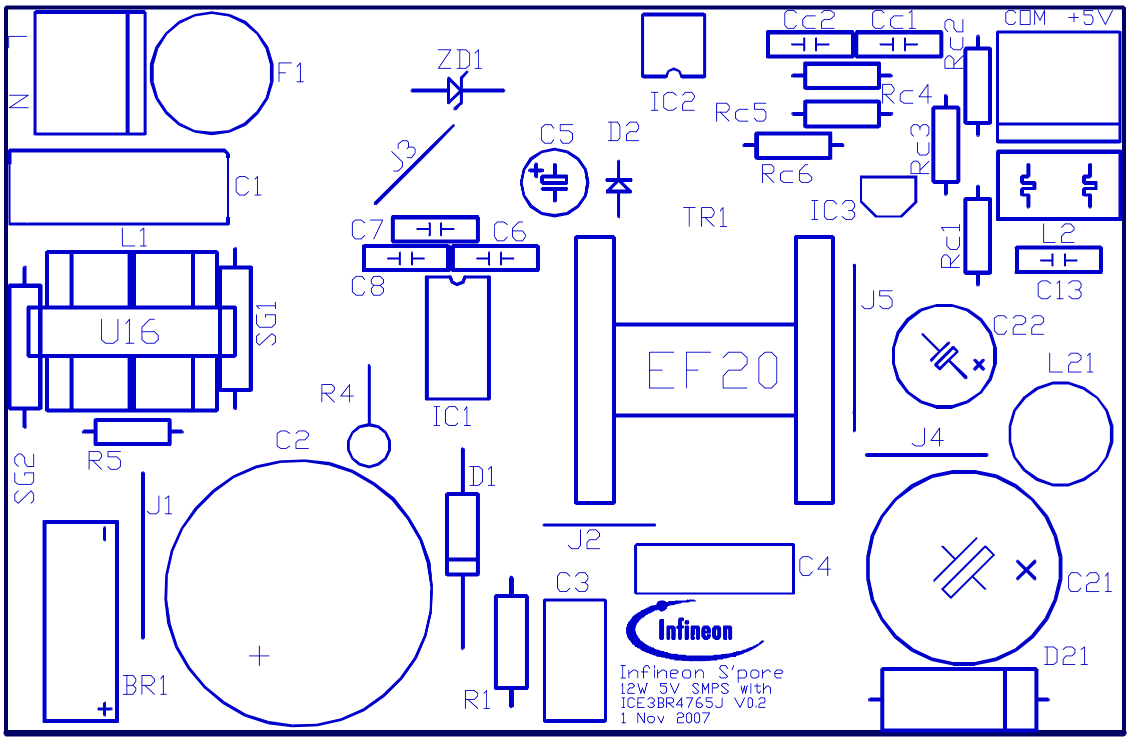


Figure 3 – Component side Component Legend – View from Component Side

7.2 Solder side copper & component legend

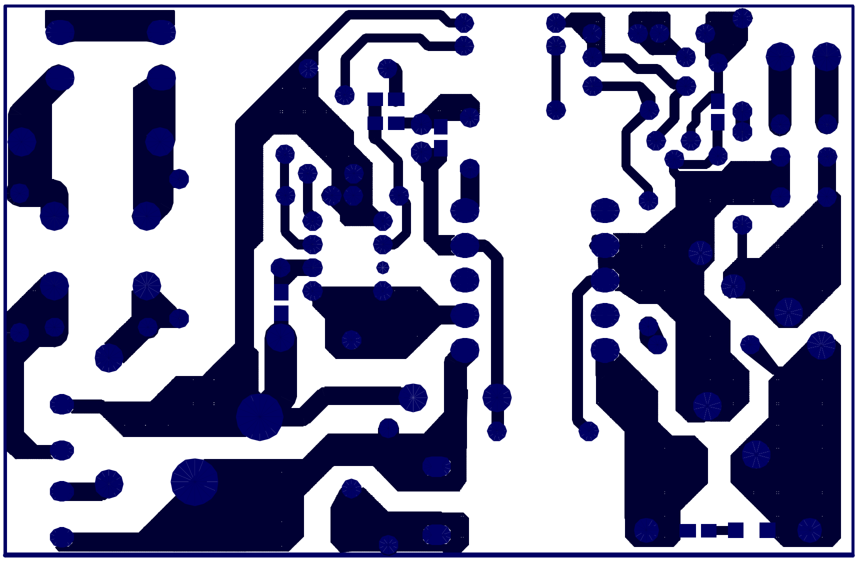


Figure 4 – Solder side copper – View from Component Side

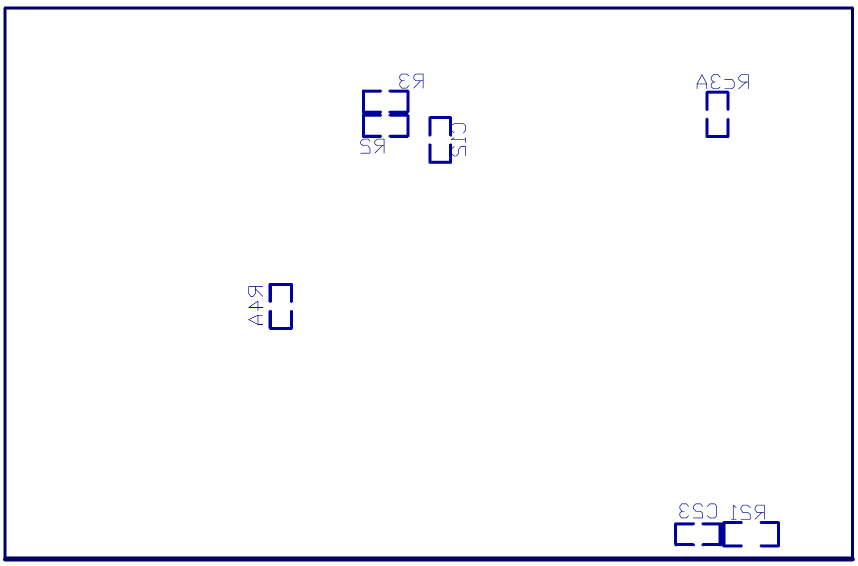


Figure 5 – Solder side component Legend – View from Component Side

8 Component List

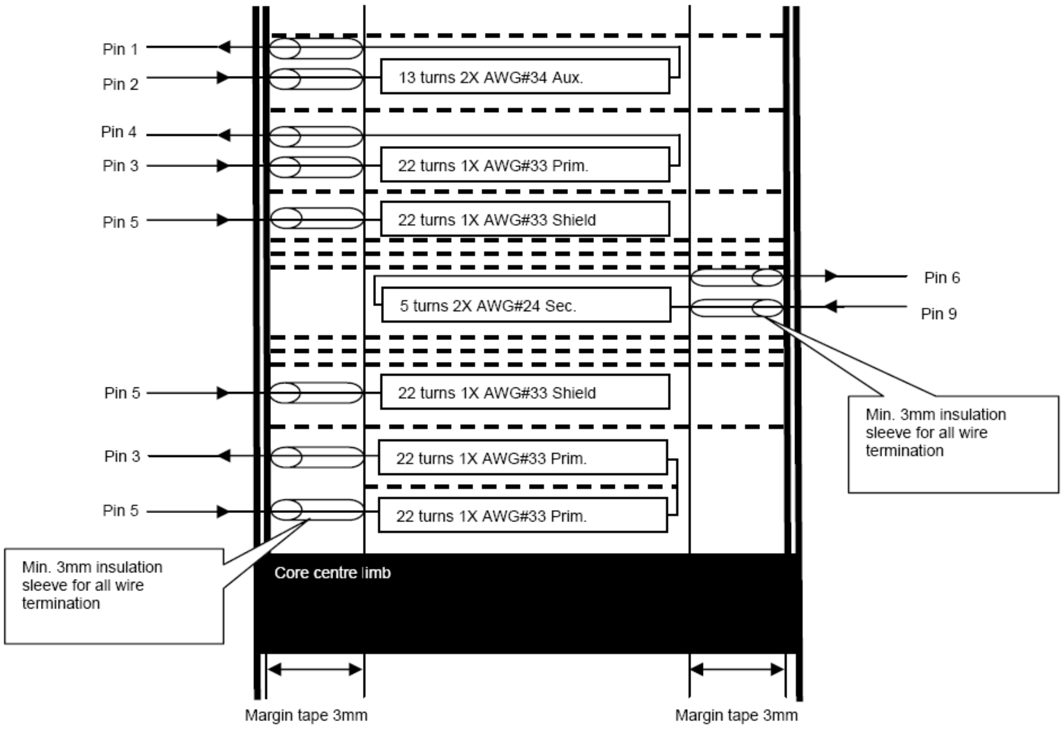
Items	Part	Type	Manufacturer / Part No.
1	BR1	2KBB80R	
2	C1	0.1uF/275V, X2 capacitor	EPCOS / B32922C3104M
3	C2	47uF/400V	EPCOS / B43504A9476M
4	C3	2n2F/400V	EPCOS / B32560J8222M
5	C4	1nF/250V, Y1 capacitor	Murata
6	C5	22u/50V	EPCOS / B41851A6226M
7	C6	0.1u/50V	Murata
8	C7	10n/50V	Murata
9	C8	1nF/50V	Murata
10	C13	0.1u/50V	Murata
11	C21	1800uF/25V	
12	C22	220uF/25V	
13	Cc1	1uF/50V	Murata
14	Cc2	1nF/50V	Murata
15	D1	UF4005	
16	D2	1N4148	
17	D21	SB540	
18	F1	3.15A 250V	
19	IC1	ICE3BR4765J (IFX)	Infineon
20	IC2	SFH617A-3	Vishay
21	IC3	TL431CLP	
22	J1, J2, J3, J4, J5	Jumper	
23	L1	2 x 47mH, 0.4A	EPCOS / B82731R2401A30
24	L2	2 x 100µH,(µi=10000,T38,R 6.30) (EPCOS)	
25	L21	1.5uH	NEC-Tokin
26	PCB	V0.2	
27	R1	150K, 2W, 5%	
28	R2	220R, 5%(0805 SMD)	ROHM
29	R3	39R, 5% (0805 SMD)	ROHM
30	R4	1.5R, 0.5W, 1%	
31	R4A	15R, 0.1W, 1% (0805 SMD)	ROHM
32	Rc1	10K, 0.25W, 1%	
33	Rc2	0R	
34	Rc3	10K, 0.25W, 1%	
35	Rc4	6.8K, 0.25W, 5%	
36	Rc5	2.2K, 0.25W, 5%	
37	Rc6	470R, 0.25W, 5%	
38	TR1	EF20, N87, Lp=830uH (EPCOS)	EPCOS / B66206A1110T001
39	ZD1	24V zener diode	
40	SG1*[15]	DSP-301N-S008	Mitsubishi
41	SG2 *[16]	DSP-301N-S008	Mitsubishi

*[15/16] Option Component

9 Transformer Construction

Core: EF20/10/6, N87
Bobbin: Horizontal Version
Primary Inductance, Lp : 0.83mH (+/-2%) measured between pin 4 and pin 5 (Gapped to Inductance)

Transformer structure :



Note : Sleeves are added to each wire termination to increase the insulation from primary to secondary wire.

Figure 6 – Transformer structure

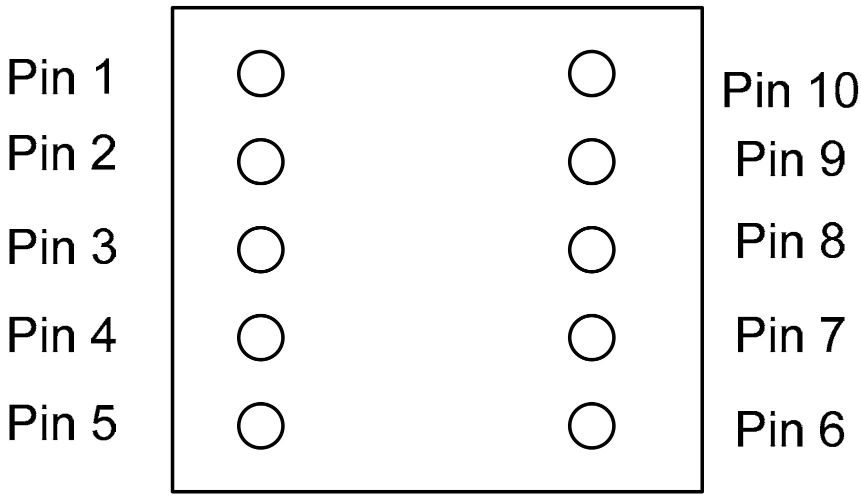


Figure 7 – Transformer complete – top view

Wire size requirement :

Start	Stop	No.of turns	Wire size	layer
2	1	13	2X AWG#34	Auxiliary
3	4	22	1X AWG# 33	½ primary
5	float	22	1X AWG#33	Shield
9	6	5	2X AWG#24	Secondary
5	float	22	1X AWG#33	Shield
5	3	44 (22+22)	1X AWG#33	½ primary

10 Test Results

10.1 Efficiency

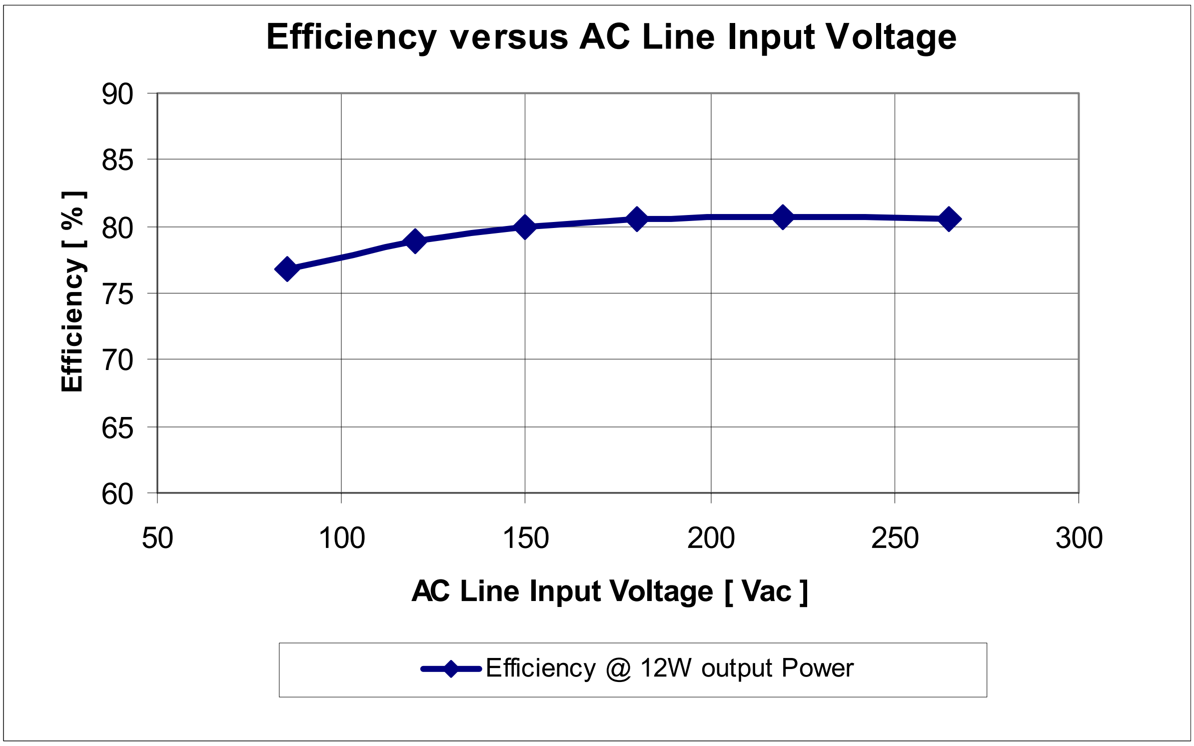


Figure 8 – Efficiency Vs. AC Line Input Voltage

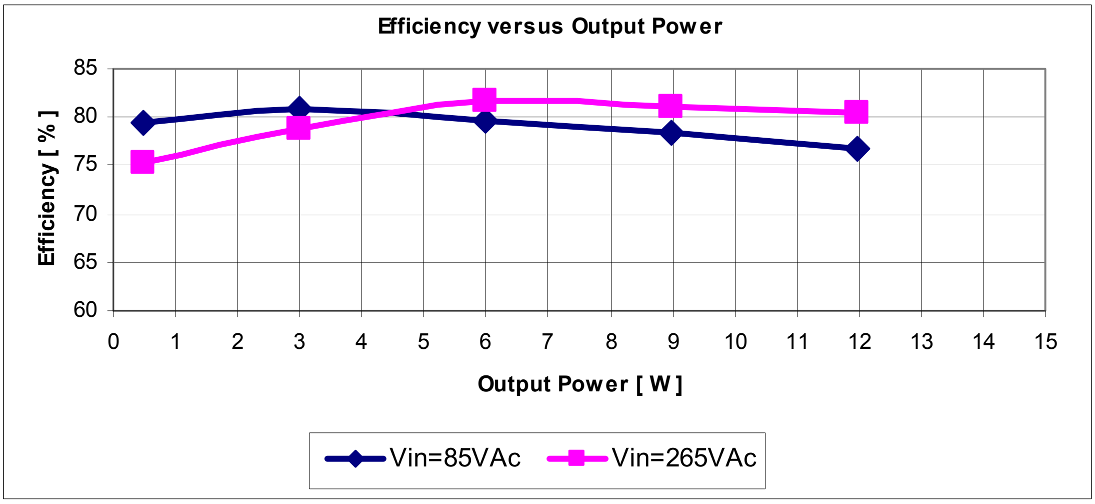


Figure 9 – Efficiency Vs. Output Power @ Low and High Line 50Hz

10.2 Input Standby Power

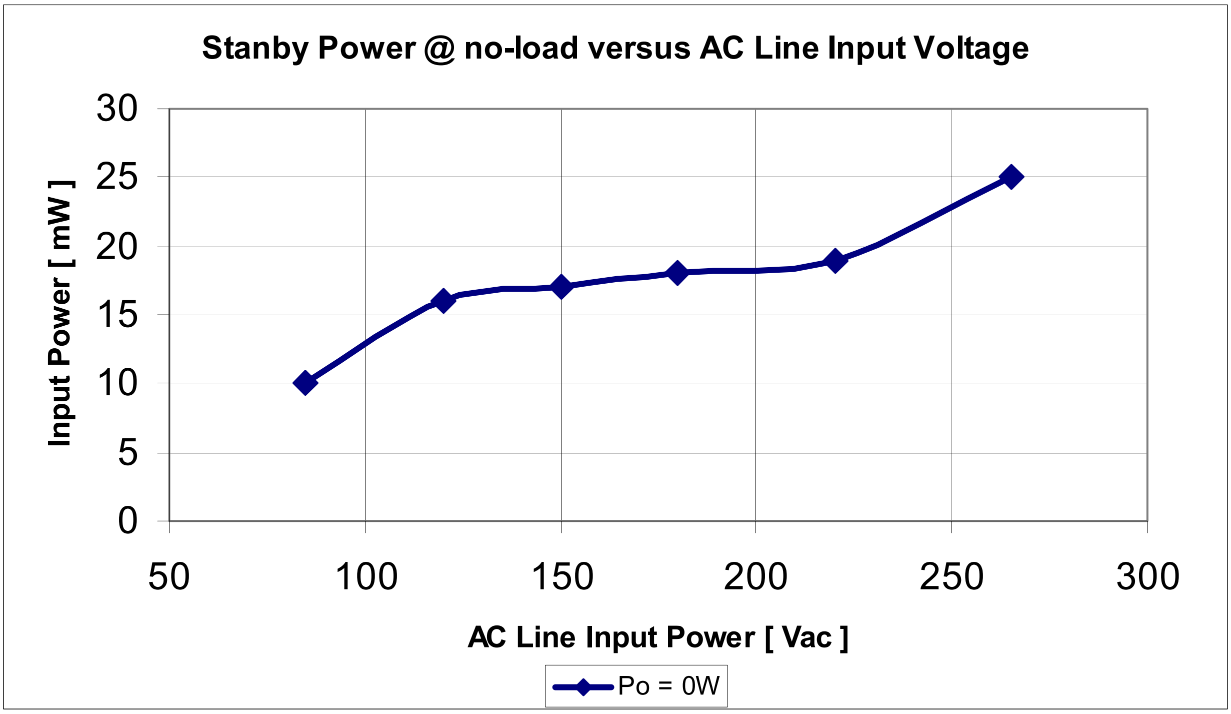


Figure 10 – Input Standby Power @ no load Vs. AC Line Input Voltage (measured by Yokogawa WT210 power meter - integration mode)

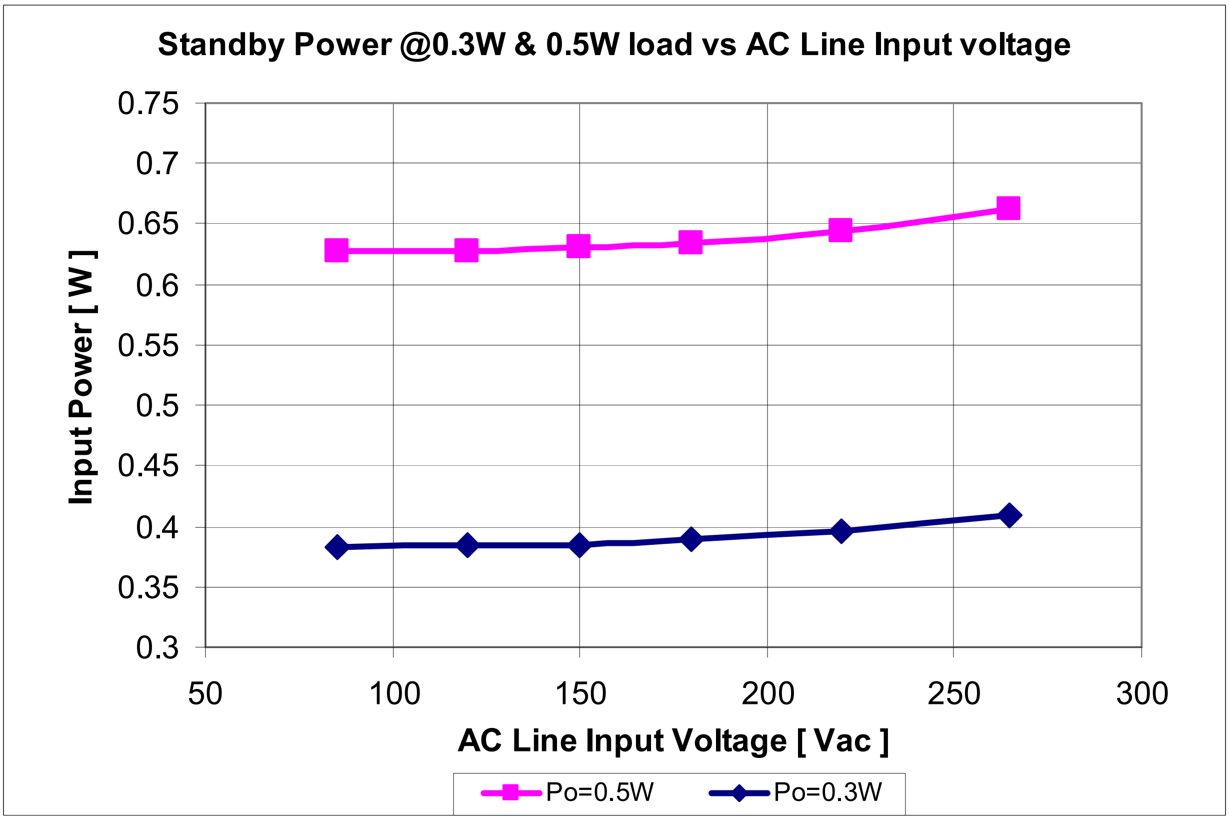


Figure 11 – Input Standby Power @ 0.3W & 0.5W Vs. AC Line Input Voltage (measured by Yokogawa WT210 power meter - integration mode)

10.3 Line Regulation

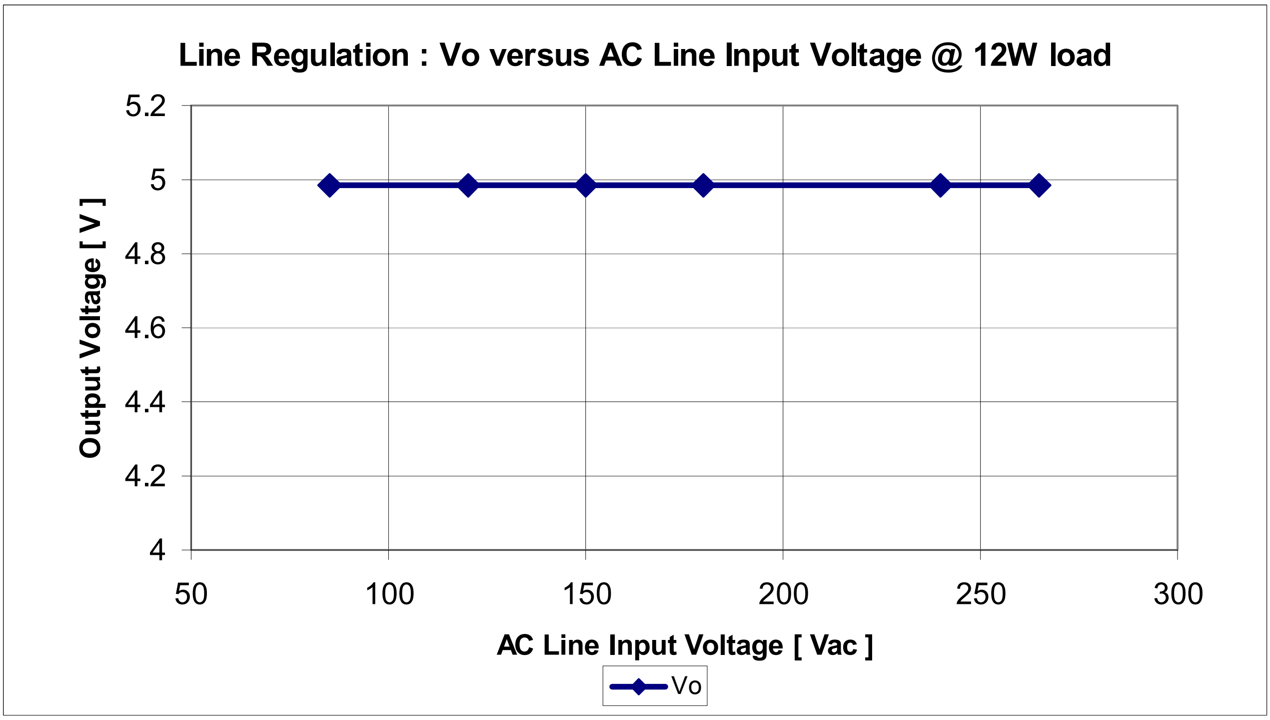


Figure 12 – Line Regulation Vo vs. AC Line Input Voltage

10.4 Load Regulation

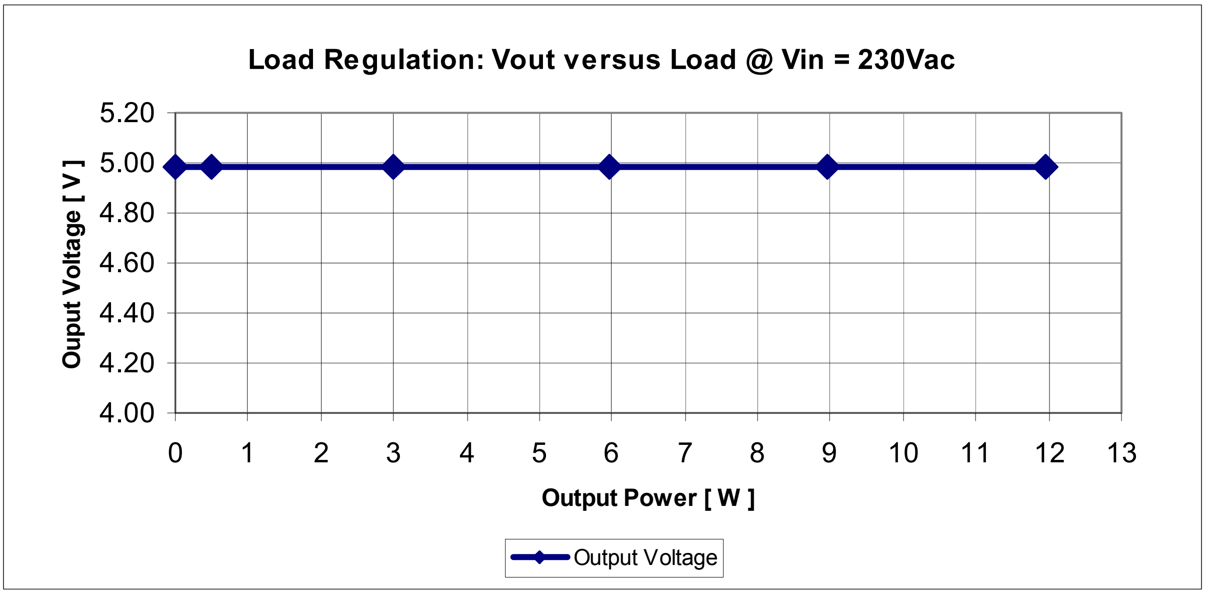


Figure 13 – Load Regulation Vo Vs. Output Power

10.5 Max. Output Power

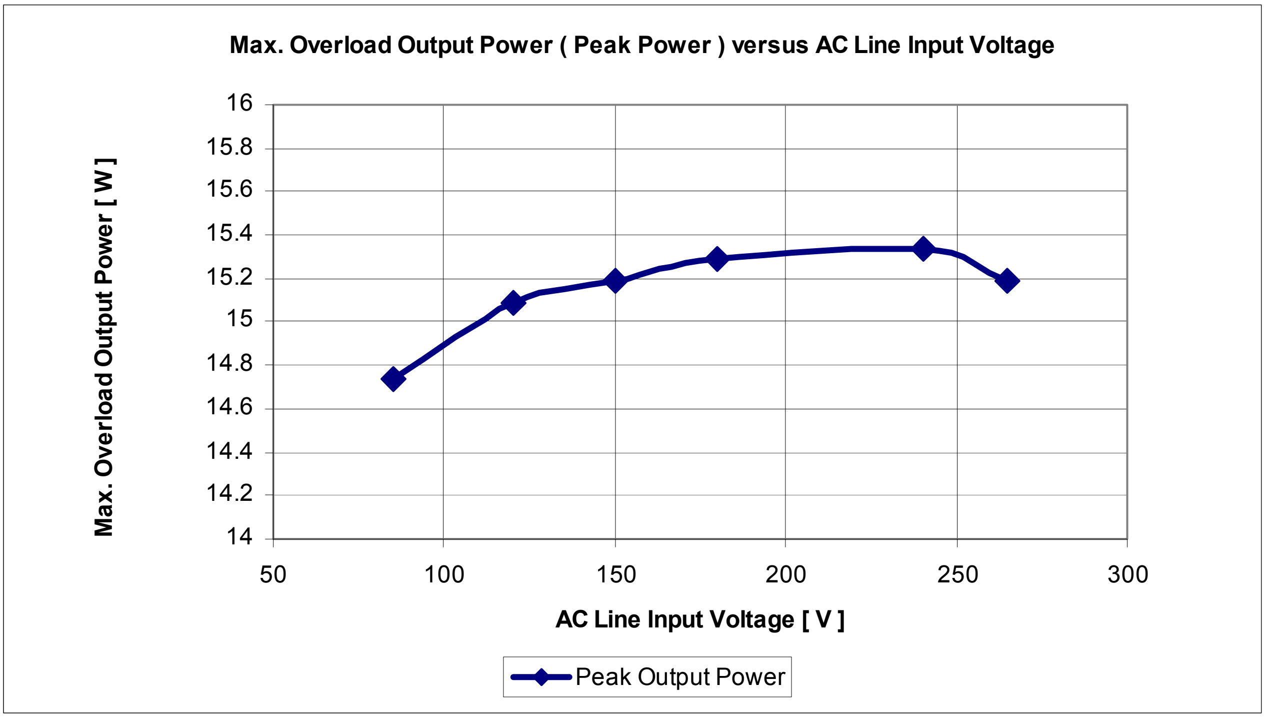


Figure 14 – Max. Output Power (before over-load protection) Vs. AC Line Input Voltage

10.6 ESD Test

Pass EN61000-4-2 Level 4: 8kV for contact discharge

10.7 Lightning Surge Test

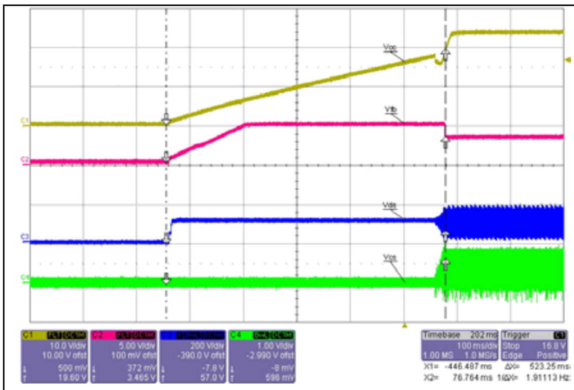
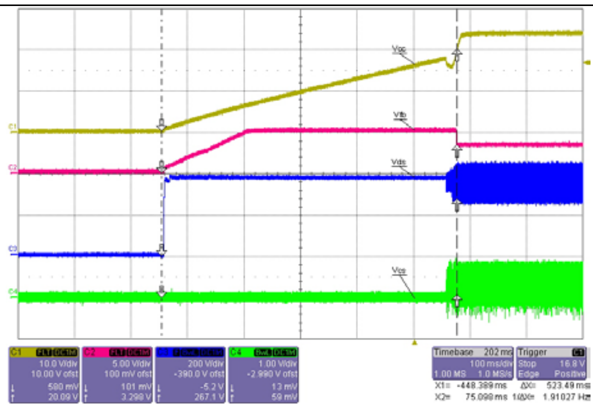
Pass EN61000-4-5 Level 3: 1kV for line to line and 2kV for line to earth

*Adding SG1 & SG2 can pass EN61000-4-5 Level 4: 4kV for line to earth

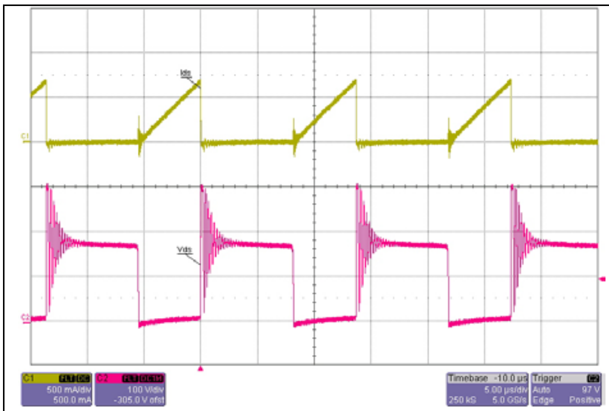
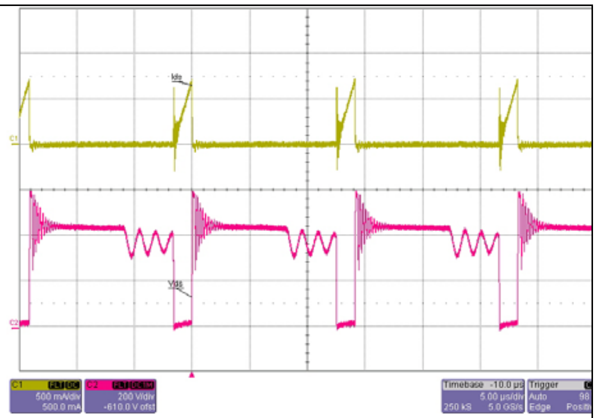
11 Waveforms and Scope Plots

All waveforms and scope plots were recorded with a LeCroy 6050 oscilloscope

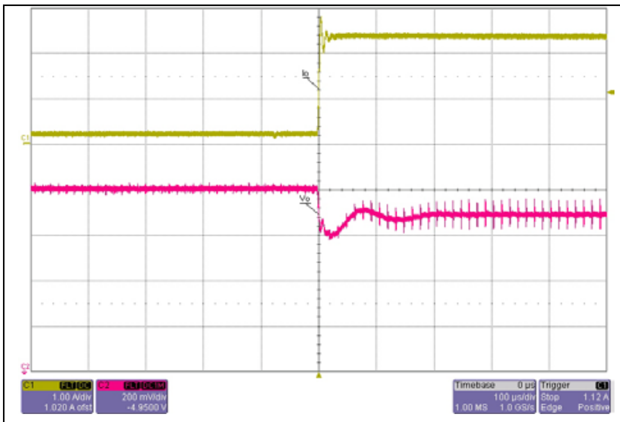
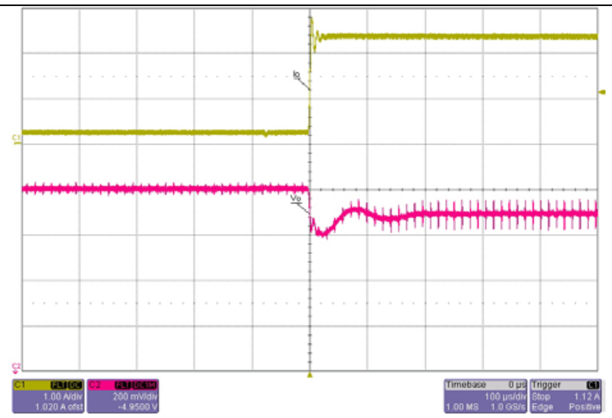
11.1 Startup @ Low and High AC Line Input Voltage and 12W load

	
Channel 1; C1 : Supply Voltage (V_{CC}) Channel 2; C2 : Feedback Voltage (V_{FB}) Channel 3; C3 : Drain Source Voltage (V_{DS}) Channel 4; C4 : Current Sense Voltage (V_{CS})	Channel 1; C1 : Supply Voltage (V_{CC}) Channel 2; C2 : Feedback Voltage (V_{FB}) Channel 3; C3 : Drain Source Voltage (V_{DS}) Channel 4; C4 : Current Sense Voltage (V_{CS})
Startup time = 0.52s, Soft start time = 18ms	Startup time = 0.52s, Soft start time = 18ms
Figure 15 – Startup @ Vin=85Vac and 12W load	**Figure 16** – Startup @ Vin=85Vac and 12W load

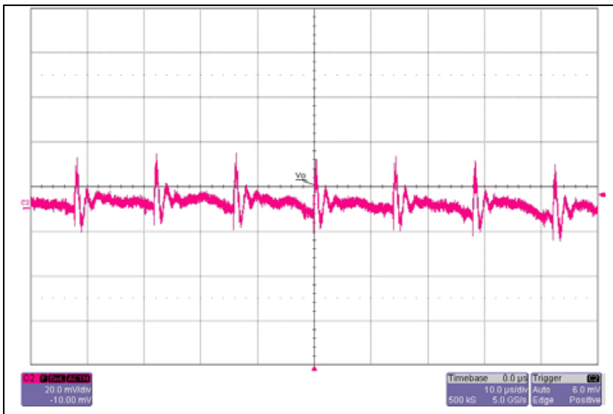
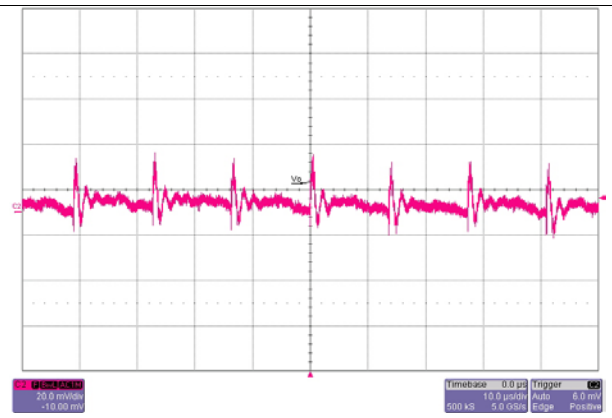
11.2 Drain Source Voltage and Current During 12W load Operation

	
Channel 1; C1 : Drain Current (I_{DS}) Channel 2; C2 : Drain Source Voltage (V_{DS})	Channel 1; C1 : Drain Current (I_{DS}) Channel 2; C2 : Drain Source Voltage (V_{DS})
Duty cycle = 36.42%	Duty cycle = 11.73%
Figure 17 – Operation @ Vin = 85Vac and 12W load	**Figure 18** – Operation @ Vin = 85Vac and 12W load

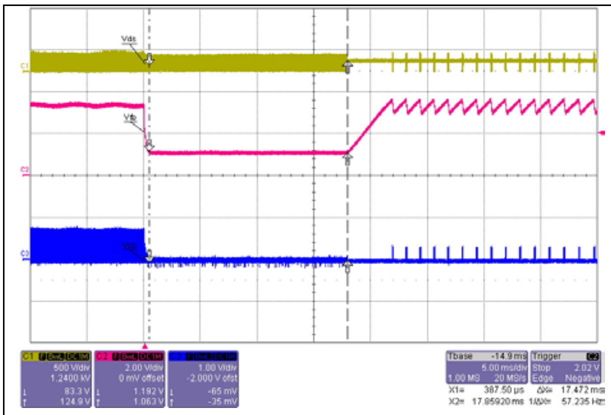
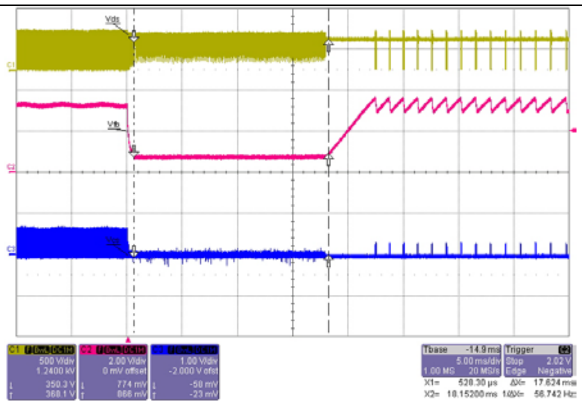
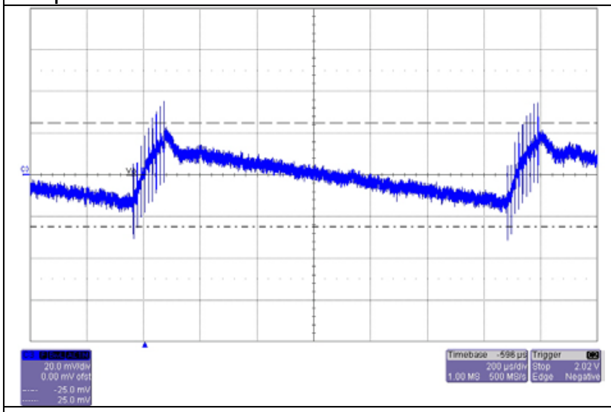
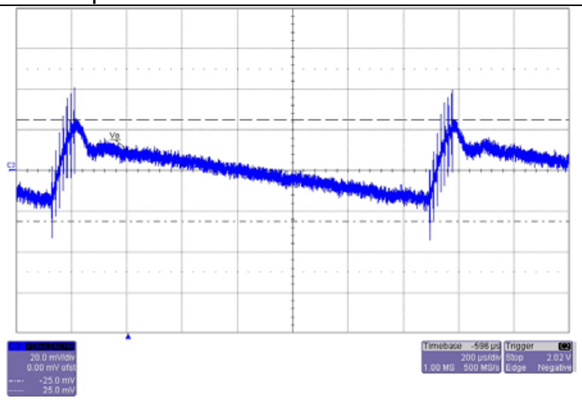
11.3 Load Transient Response (Load jump from 10% to 100% Load)

	
Channel 1; C1 : Output Current (I_o) Channel 2; C2 : Output Voltage (V_o)	Channel 1; C1 : Output Current (I_o) Channel 2; C2 : Output Voltage (V_o)
Current step slew rate = 0.4A/us	Current step slew rate = 0.4A/us
Figure 19 – Loadjump @ Vin=85Vac from 1.2W to 12W load	**Figure 20** – Loadjump @ Vin=265Vac from 1.2W to 12W load

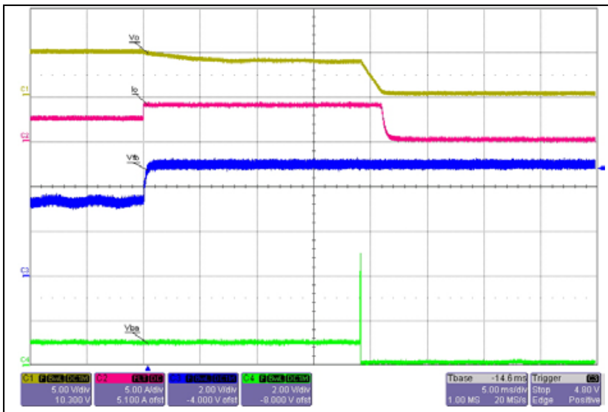
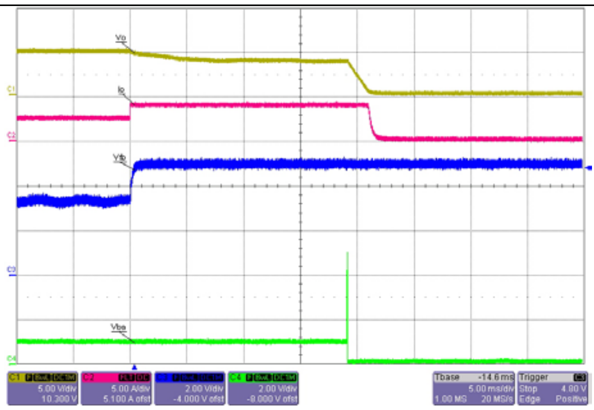
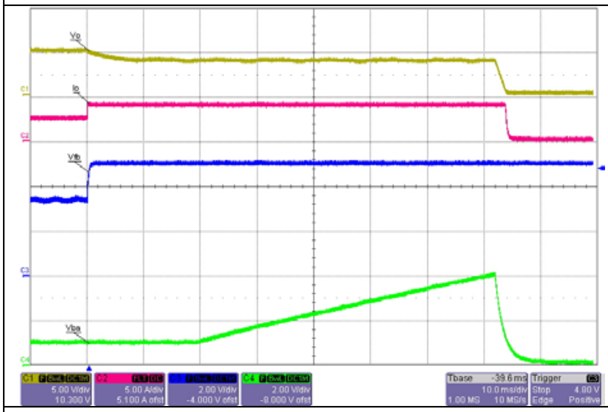
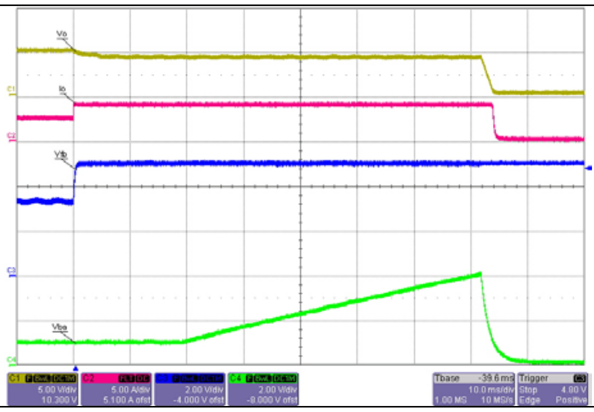
11.4 AC Output Ripple at 12W load

	
Channel 2; C2 : Output Ripple Voltage (V_{o_ripple})	Channel 2; C2 : Output Ripple Voltage (V_{o_ripple})
V_{o_ripple} =+/-10mV(exclude high frequency ripple) Terminal with decoupling capacitor of 0.1uF +1uF	V_{o_ripple} =+/-10mV(exclude high frequency ripple) Terminal with decoupling capacitor of 0.1uF +1uF
Figure 21 – AC output ripple @ Vin=85Vac and 12W load	**Figure 22** – AC output ripple @ Vin=265Vac and 12W load

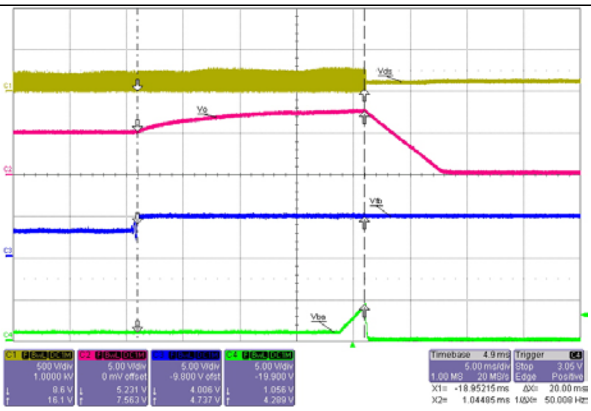
11.5 Active Burst Mode @ 0.25W load

	
Channel 1; C1 : Drain Source Voltage (V_{DS}) Channel 2; C2 : Feedback voltage (V_{FB}) Channel 3; C3 : Current Sense Voltage (V_{CS})	Channel 1; C1 : Drain Source Voltage (V_{DS}) Channel 2; C2 : Feedback voltage (V_{FB}) Channel 3; C3 : Current Sense Voltage (V_{CS})
Blanking time to enter burst mode : 17.4ms	Blanking time to enter burst mode : 17.6ms
Figure 23 – Active burst mode @ Vin=85Vac and step from 2.4A to 0.05A	**Figure 24** – Active burst mode @ Vin=265Vac and step from 2.4A to 0.05A
	
Channel 4; C4 : Output Voltage (V_o)	Channel 4; C4 : Output Voltage (V_o)
Output ripple : app. 50mV	Output ripple : app. 50mV
Figure 25 – Output ripple at active burst mode @ Vin=85Vac and 0.25W load	**Figure 26** – Output ripple at active burst mode @ Vin=265Vac and 0.25W load

11.6 Over load protection (with and without extended blanking; C7) – auto-restart

	
Channel 1; C1 : Output Voltage (V_o) Channel 2; C2 : Output current (I_o) Channel 3; C3 : Feedback Voltage (V_{FB}) Channel 4; C4 : BA voltage (V_{BA})	Channel 1; C1 : Output Voltage (V_o) Channel 2; C2 : Output current (I_o) Channel 3; C3 : Feedback Voltage (V_{FB}) Channel 4; C4 : BA voltage (V_{BA})
Blanking time to enter auto-restart mode : 18ms	Blanking time to enter auto-restart mode : 18ms
Figure 27 – Over load protection without extended blanking time;C7=100pF @ Vin=85Vac and output power step from 2.4A to 4A load	**Figure 28** – Over load protection without extended blanking Time;C7=100pF @ Vin=265Vac and output power step from 2.4A to 4A load
	
Channel 1; C1 : Output Voltage (V_o) Channel 2; C2 : Output current (I_o) Channel 3; C3 : Feedback Voltage (V_{FB}) Channel 4; C4 : BA voltage (V_{BA})	Channel 1; C1 : Output Voltage (V_o) Channel 2; C2 : Output current (I_o) Channel 3; C3 : Feedback Voltage (V_{FB}) Channel 4; C4 : BA voltage (V_{BA})
Blanking time to enter auto-restart mode : 72ms	Blanking time to enter auto-restart mode : 72ms
Figure 29 – Over load protection with extended blanking time;C7 = 220nF @ Vin=85Vac and output power step from 2.4A to 4A load	**Figure 30** – Over load protection with extended blanking time; C7 = 220nF @ Vin=265Vac and output power step from 2.4A to 4A load

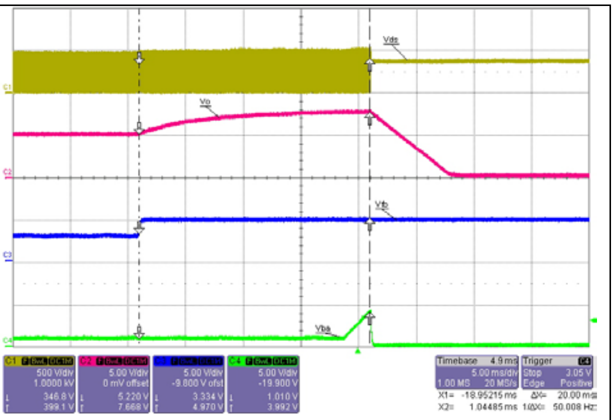
11.7 Open loop protection-auto-restart



Channel 1; C1 : Drain Source voltage (V_{DS})
Channel 2; C2 : Output Voltage (V_o)
Channel 3; C3 : Feedback Voltage (V_{FB})
Channel 4; C4 : BA voltage (V_{BA})

Blanking time to enter auto-restart mode : 20ms; System enters auto-restart when V_{FB}>4V, V_{BA} > 4V with defined blanking time.

Figure 31 – Open loop protection @ Vin=85Vac; Rc1 disconnected during test

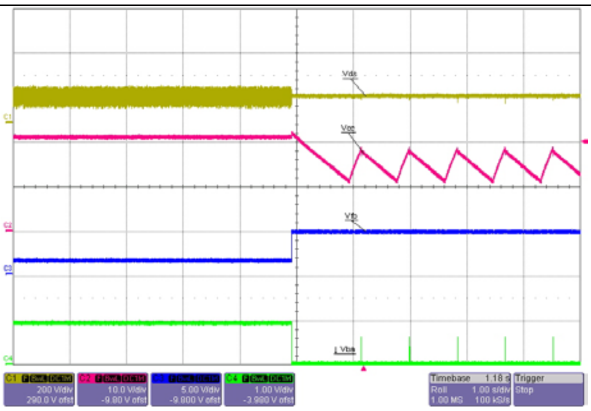


Channel 1; C1 : Drain Source voltage (V_{DS})
Channel 2; C2 : Output Voltage (V_o)
Channel 3; C3 : Feedback Voltage (V_{FB})
Channel 4; C4 : BA voltage (V_{BA})

Blanking time to enter auto-restart mode : 19.8ms; System enters auto-restart when V_{FB}>4V, V_{BA} > 4V with defined blanking time.

Figure 32 – Open loop protection @ Vin=265Vac; Rc1 disconnected during test

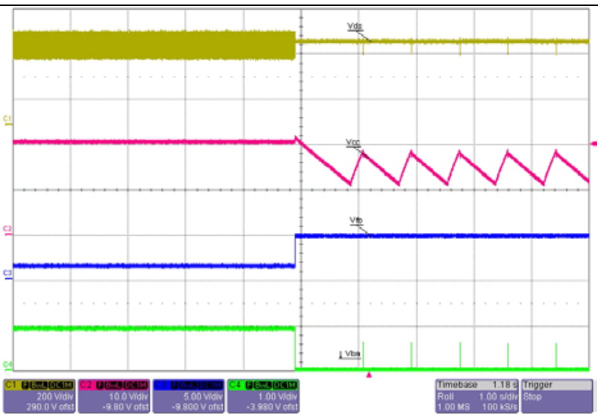
11.8 Auto-restart enable



Channel 1; C1 : Drain Source voltage (V_{DS})
Channel 2; C2 : Supple voltage (V_{CC})
Channel 3; C3 : Feedback Voltage (V_{FB})
Channel 4; C4 : BA voltage (V_{BA})

System enters auto restart mode when V_{BA}< 0.33V

Figure 33 – Auto restart by trigger BA pin @ Vin=85Vac; adding 10kΩ resistor at BA pin after system start up.

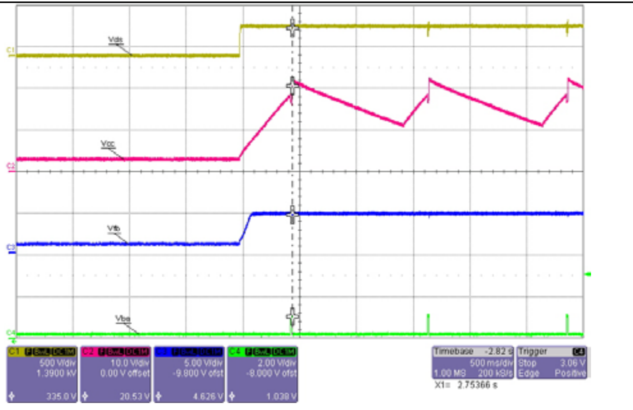
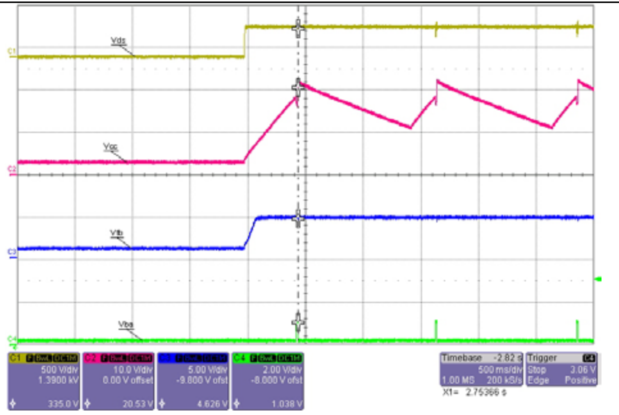
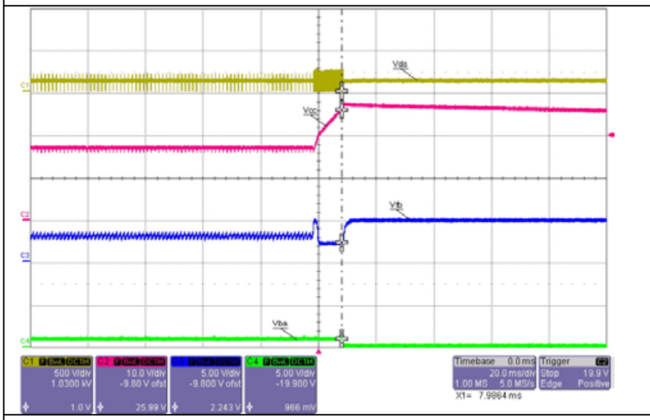
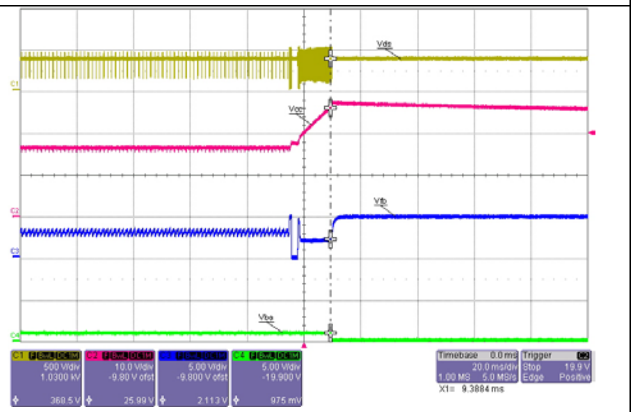


Channel 1; C1 : Drain Source voltage (V_{DS})
Channel 2; C2 : Supple voltage (V_{CC})
Channel 3; C3 : Feedback Voltage (V_{FB})
Channel 4; C4 : BA voltage (V_{BA})

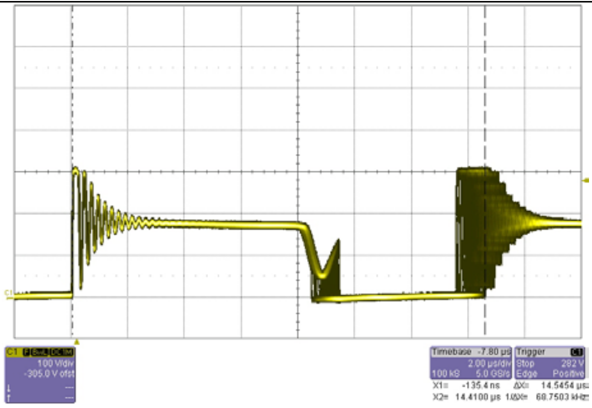
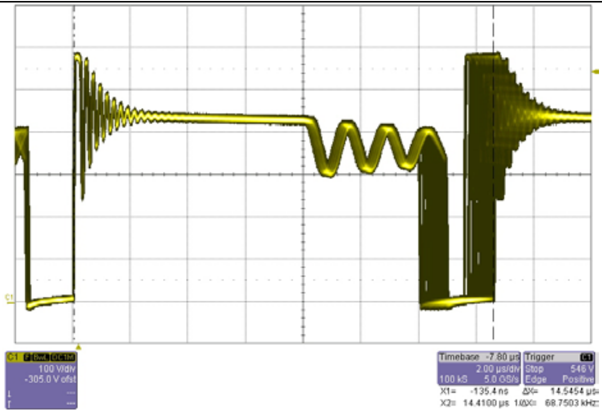
System enters auto restart mode when V_{BA}< 0.33V

Figure 34 – Auto restart by trigger BA pin @ Vin=265Vac; adding 10kΩ resistor at BA pin after system start up.

11.9 Vcc overvoltage protection- auto-restart

	
Channel 1; C1 : Drain Source voltage (V_{DS}) Channel 2; C2 : Supple voltage (V_{CC}) Channel 3; C3 : Feedback Voltage (V_{FB}) Channel 4; C4 : BA voltage (V_{BA})	Channel 1; C1 : Drain Source voltage (V_{DS}) Channel 2; C2 : Supple voltage (V_{CC}) Channel 3; C3 : Feedback Voltage (V_{FB}) Channel 4; C4 : BA voltage (V_{BA})
System enters auto restart mode when V_{CC}>20.5V & V_{FB} >4V during soft start period	System enters auto restart mode when V_{CC}>20.5V & V_{FB} >4V during soft start period
Figure 35 – Vcc overvoltage protection @ Vin=85Vac; Rc1 disconnected at startup with light load	**Figure 36** – Vcc overvoltage protection @ Vin=265Vac; Rc1 disconnected at startup with light load
	
Channel 1; C1 : Drain Source voltage (V_{DS}) Channel 2; C2 : Supple voltage (V_{CC}) Channel 3; C3 : Feedback Voltage (V_{FB}) Channel 4; C4 : BA voltage (V_{BA})	Channel 1; C1 : Drain Source voltage (V_{DS}) Channel 2; C2 : Supple voltage (V_{CC}) Channel 3; C3 : Feedback Voltage (V_{FB}) Channel 4; C4 : BA voltage (V_{BA})
System enters auto restart mode when VCC>25.5V	System enters auto restart mode when VCC>25.5V
Figure 37 – Vcc overvoltage protection @ Vin=85Vac; Rc1 disconnected after startup time with light load	**Figure 38** – Vcc overvoltage protection @ Vin=265Vac; Rc1 disconnected after startup time with light load

11.10 Frequency Jittering

	
Channel 1; C1 : Drain Source voltage (V_{DS})	Channel 1; C1 : Drain Source voltage (V_{DS})
Frequency changing from 68.7kHz ~ 73kHz, Jitter period is set at 4ms internally (taken from untrimmed sample)	Frequency changing from 68.7kHz ~ 73kHz, Jitter period is set at 4ms internally (taken from untrimmed sample)
Figure 39 – Frequency change shown at V_{DS} @ Vin=85Vac and 12W Load	**Figure 40** – Frequency change shown at V_{DS} @ Vin=265Vac and 12W Load

12 Appendix

12.1 Slope compensation for CCM operation

This demo board is designed in Discontinuous Conduction Mode (DCM) operation. If the application is designed in Continuous Conduction Mode (CCM) operation where the maximum duty cycle exceeds the 50% threshold, it needs to add the slope compensation network. Otherwise, the circuitry will be unstable. In this case, three more components (2 ceramic capacitors C17 / C18 and one resistor R19) is needed to add as shown in the circuit diagram below.

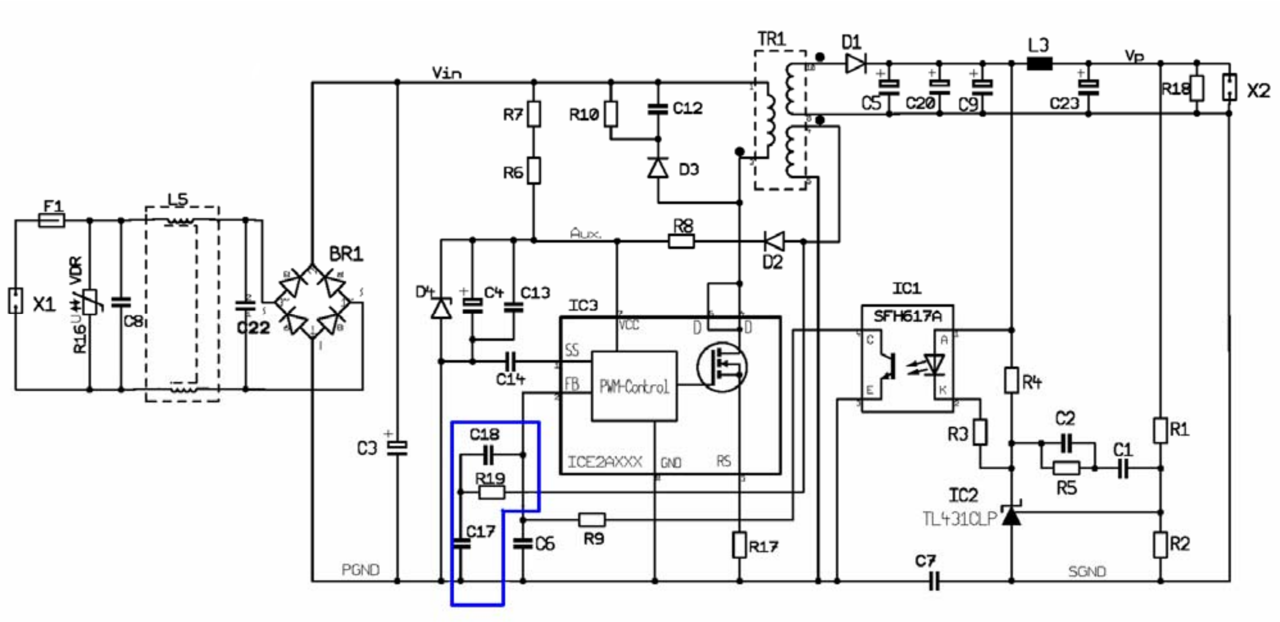


Figure 41 – Circuit Diagram Switch Mode Power Supply with Slope Compensation

More information regarding how to calculate the additional components, see application note AN_SMPS_ICE2xXXX – available on the internet: www.infineon.com (directory : Home > Power Semiconductors > Integrated Power ICs > **CoolSET® F2**)

13 References

[1] Infineon Technologies, Datasheet "CoolSET™-F3R ICE3BR4765J Off-Line SMPS Current Mode Controller with Integrated 650V Startup Cell / Depletion CoolMOS™ (Frequency Jitter Mode) in DIP-8"

[2] Eric Kok Siu Kam, Kyaw Zin Min, Infineon Technologies, Application Note "ICE3ARxx65J /ICE3BRxx65J CoolSET™ F3R Jitter version Design Guide"

[3] Harald Zoellinger, Rainer Kling, Infineon Technologies, Application Note "AN-SMPS-ICE2xXXX-1, CoolSET™ ICE2xXXXX for Off-Line Switching Mode Power supply (SMPS)"