EVAL-2HS01G-300W

300W LLC Evaluation Board with LLC controller ICE2HS01G

Power Management & Supply

Never stop thinking.

Edition 2012-05-07

Published by Infineon Technologies Asia Pacific,
168 Kallang Way,
349253 Singapore, Singapore

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EVAL2HS01G300W

Revision History:	**2012-05**	V2.0
Previous Version:	NA	

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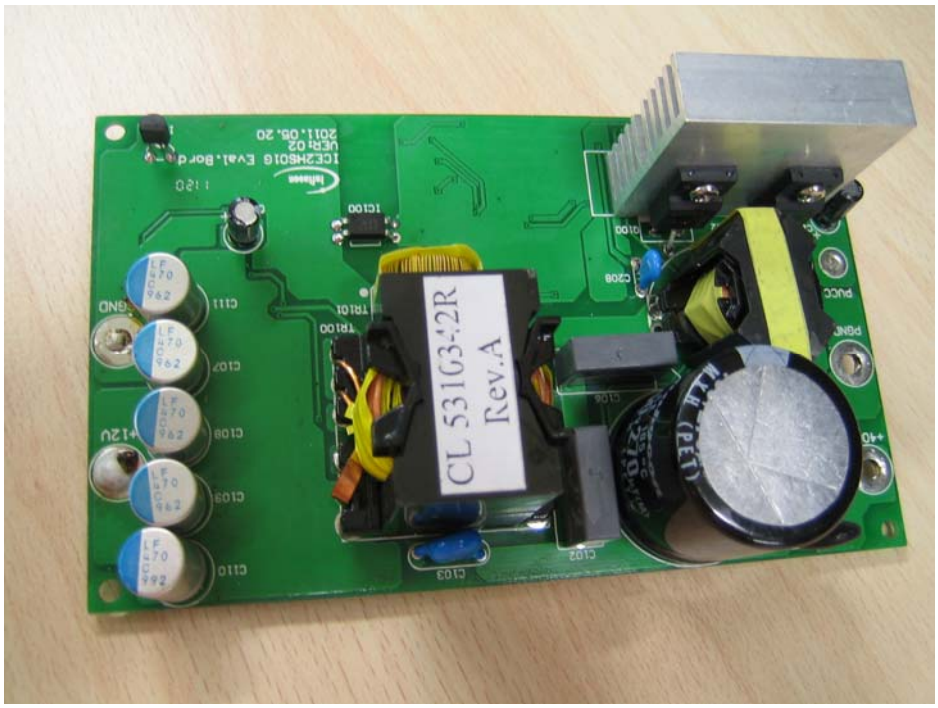
1 Introduction

The evaluation board presented is a 300W LLC Converter with 400VDC input and 12V output. It is controlled by Infineon's 2nd generation half-bridge LLC controller ICE2HS01G. The ICE2HS01G is designed especially for high efficiency application with its synchronous rectification (SR) control for the secondary side. With its new driving techniques, SR can be realized for half-bridge LLC converter operated with secondary switching current in both CCM and DCM conditions.

In this application note, the schematic circuit, PCB layout and BOM for the evaluation board are shared, followed by the performace of the board, such as the efficiency and operation waveforms. For the detailed step-by-step design procedure of this converter, please refer to our design guide.

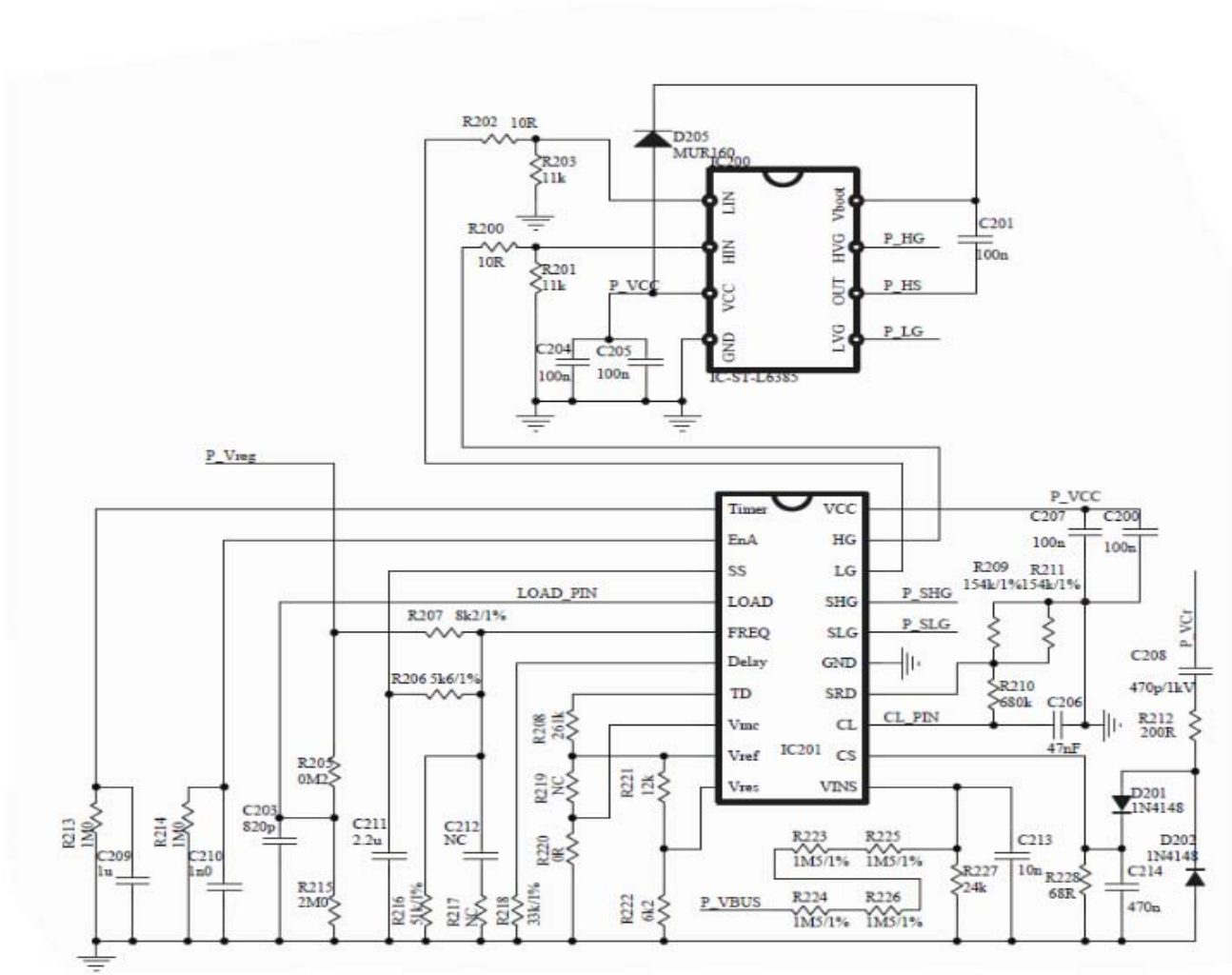
2 Evaluation Board



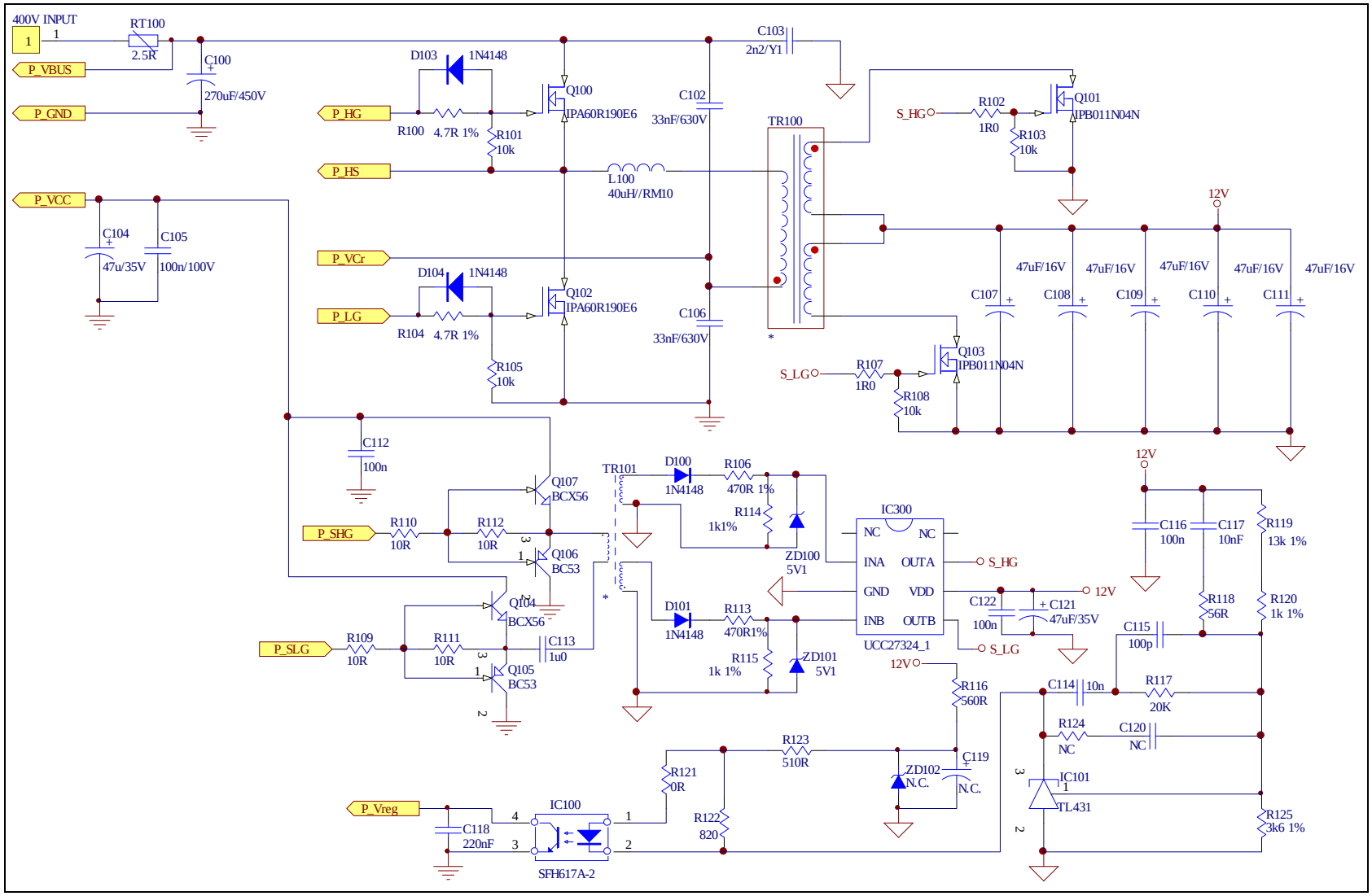
Technical Specifications

Input voltage V_{in}	400VDC
Output voltage and current V_o, I_o	12VDC, 25A
Output power P_{in}	~ 300W
Efficiency η	>97% at 100% load >97% at 50% load ~96% at 20% load
Resonant frequency f_r	85kHz

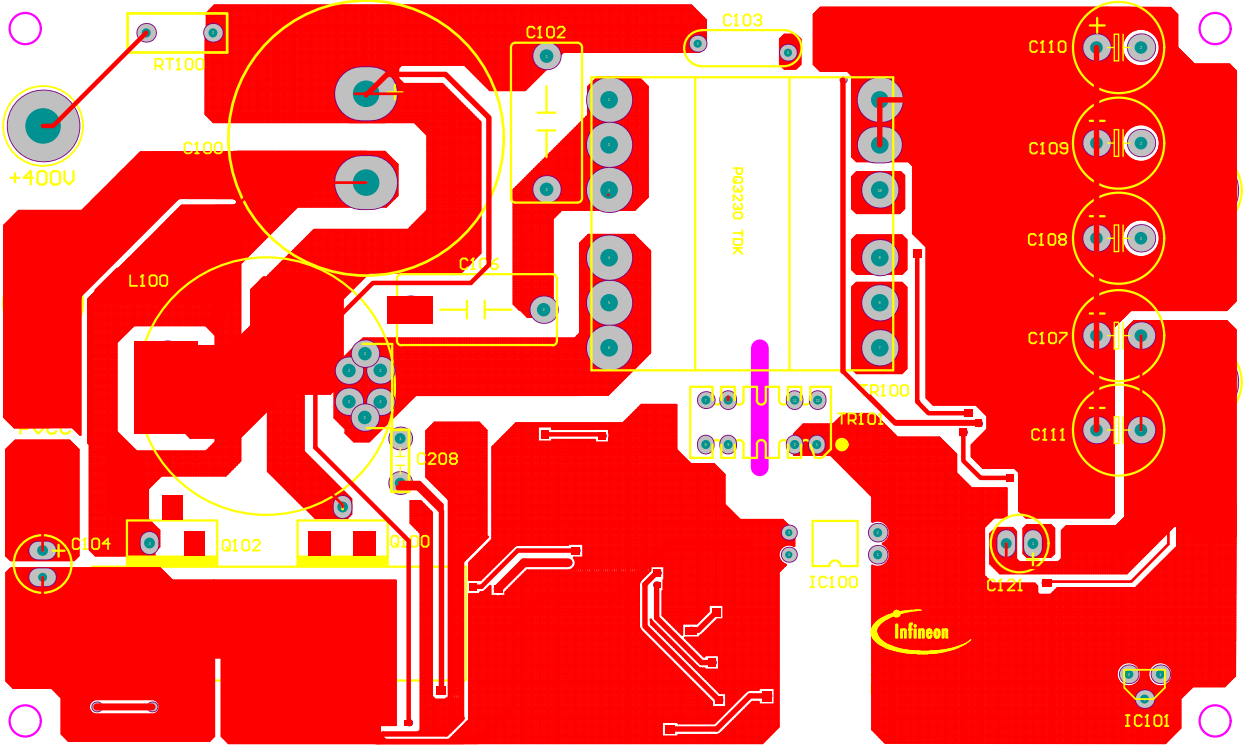
3 Control Circuit Diagram



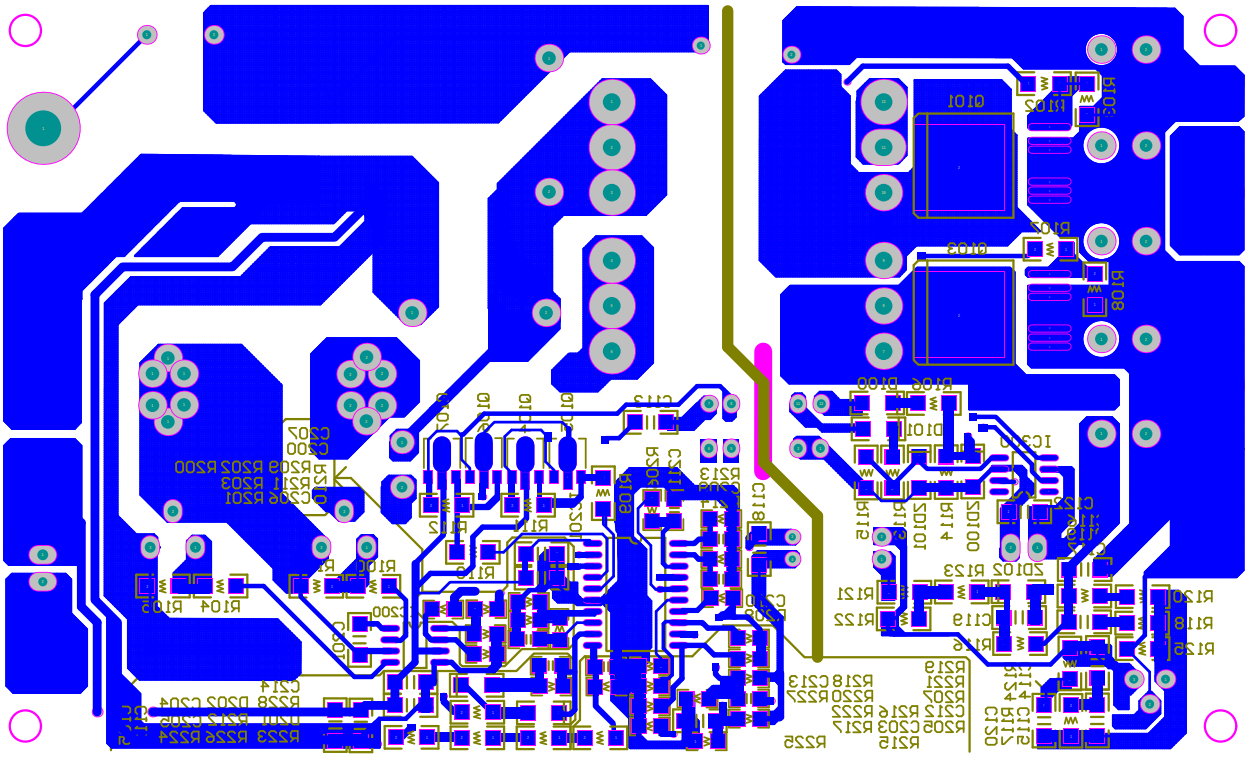
4 Power Circuit Diagram



5 PCB Layout – Top



6 PCB Layout – Bottom



7 Component List

Designator	Description	Footprint	Description	Quantity
PCB	Double Layer		2 ounce copper	1
C100	270uF/450V	RB30	Aluminum Electrolyte	1
C102, C106	33nF/630V	MKT6/13/10	CERAMIC	2
C103	2n2/Y1	CY10	CERAMIC	1
C104	47u/35V	RB6.5	Aluminum Electrolyte	1
C105	100n/100V	1206C	CERAMIC	1
C107, C108, C109, C110, C111	47uF/16V	RB10	Aluminum Electrolyte	5
C112, C116	100n	1206C	CERAMIC	2
C113	1u0	1206C	CERAMIC	1
C114	47n	1206C	CERAMIC	1
C115	100p	1206C	CERAMIC	1
C117, C118	10nF	1206C	CERAMIC	2
C119	1u	1206C	Aluminum Electrolyte	1
C120	NC	1206C		0
C121	47uF/35V	RB6.5	Aluminum Electrolyte	1
C122, C200, C205	100n	MKT2/7/5	CERAMIC	3
C201, C204, C207	100n	MKT2/7/5_0M8	CERAMIC	3
C203	820p	MKT2/7/5	CERAMIC	1
C206	47nF	0805C	CERAMIC	1
C208	220p/1kv	MKT2/7/5	CERAMIC	1
C209	1u	0805C	CERAMIC	1
C210	1n0	0805C	CERAMIC	1
C211	2.2u	0805C	CERAMIC	1
C212	NC	0805C	CERAMIC	1
C213	10n	0805C	CERAMIC	1
C214	220n	0805C	CERAMIC	1
D100, D101, D201, D202	1N4148	1206D	DIODE	4
IC100	SFH617A-2	DIP4/10	OPTO COUPLER	1
IC101	TL431	TO92-CBE		1
IC200	IC-ST-L6385	SO-8	Half-bridge driver	1

IC201	ICE2HS01G	SOL-20		1
IC300	UCC27324_1	SO-8	Resonant-Mode Controller	1
L100	40uH//RM10	RM10	CHOKE	1
Q100, Q102	IPA60R199C6	T0-220	MOSFET	2
Q101, Q103	IPB011N04N	TO-263	MOSFET	2
Q104, Q107	BCX56	SOT-89	NPN Transistor	2
Q105, Q106	BC53	SOT-89	PNP Transistor	2
R100, R104, R109, R111, R112	10R	1206R	RESISTOR	5
R101, R103, R105, R108	10k	1206R	RESISTOR	4
R102, R107	1R0	1206R	RESISTOR	2
R106, R113	2k0	1206R	RESISTOR	2
R110	10R	1206	RESISTOR	1
R114, R115	4k7	1206R	RESISTOR	2
R116	560	1206R	RESISTOR	1
R117	3k9	1206R	RESISTOR	1
R118	56R	1206R	RESISTOR	1
R119	11k	1206R	RESISTOR	1
R120	2k7	1206R	RESISTOR	1
R121	0R	1206R	RESISTOR	1
R122	820	1206R	RESISTOR	1
R123	2k2	1206R	RESISTOR	1
R124	NC	1206R	RESISTOR	1
R125	3k6	1206R	RESISTOR	1
R200, R202	10R	0805r	RESISTOR	2
R201, R203	11k	0805r	RESISTOR	2
R205	0M2	0805r	RESISTOR	1
R206	5k6/1%	0805r	RESISTOR	1
R207	12k/0.1%	0805r	RESISTOR	1
R208	240k	0805r	RESISTOR	1
R209	150k/1%	0805r	RESISTOR	1
R210	470k	0805r	RESISTOR	1

R211	110k/1%	0805r	RESISTOR	1
R212	200R	1206R	RESISTOR	1
R213, R214	1M0	0805r	RESISTOR	2
R215	2M0	0805r	RESISTOR	1
R216	24k/1%	0805r	RESISTOR	1
R217	NC	0805r	RESISTOR	1
R218	51k/1%	0805r	RESISTOR	1
R219	100k	0805r	RESISTOR	1
R220	820R	0805r	RESISTOR	1
R221	N.C.	0805r	RESISTOR	1
R222	0R	0805r	RESISTOR	1
R223, R224, R225, R226	1M5/1%	1206R	RESISTOR	4
R227	24k	0805R	RESISTOR	1
R228	62R	0805R	RESISTOR	1
RT100	2.5R	NTC7.5	NTC THERMISTOR	1
TR100		PQ3230	LLC Resonant Transformer	1
TR101		WNP12048LM4	Pulse Transformer	1
ZD100, ZD101	5V1	1206D	Zener Diode	2
ZD102	9v1	1206D	Zener Diode	1

8 Specifications for Magnetic components

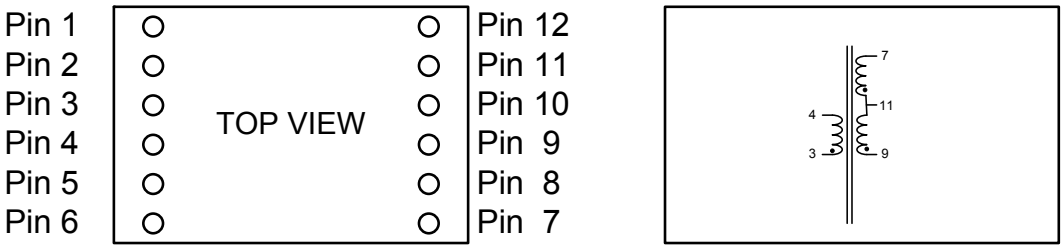
8.1 Main transformer

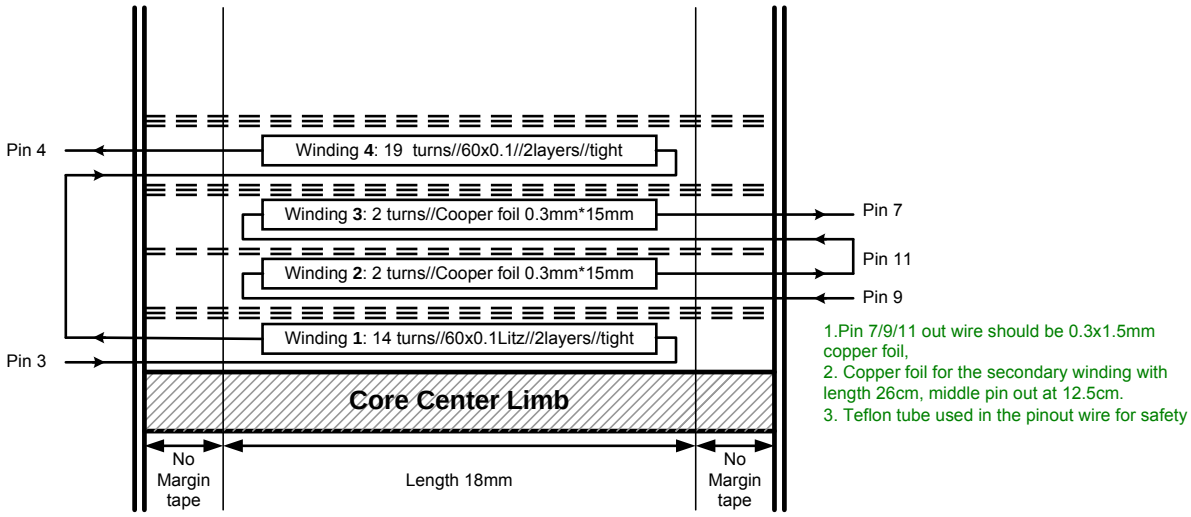
Core: PC95 PQ3230 (TDK)

Primary inductance Lp: 690uH±3% , between Pin 3 and Pin 4 (Gapped)

Leakage inductance: <2% of Lp with either Pin 7&11 shorted or Pin9&11 shorted

Teflon tube used for the pinout.





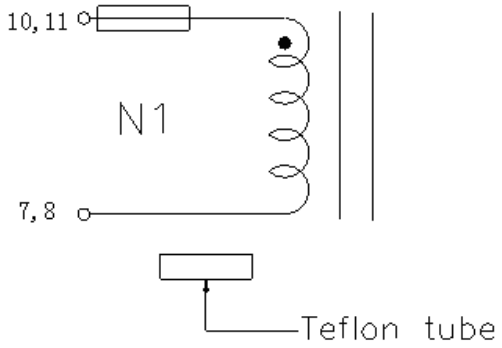
Windings	*Start*	*End*	*Wire*	*Turns*	*Layers*	*Method*
1	**3**	**float**	60x0.1mm Litz	14	2	Tight
2	**9**	**11**	0.3mm*15mm	2	NA	Tight
3	**11**	**7**	0.3mm*15mm	2	NA	Tight
4	**float**	**4**	60x0.1mm Litz	19	2	Tight

8.2 Resonant choke

Core: RM10

Material: N87

Inductance: L=40uH



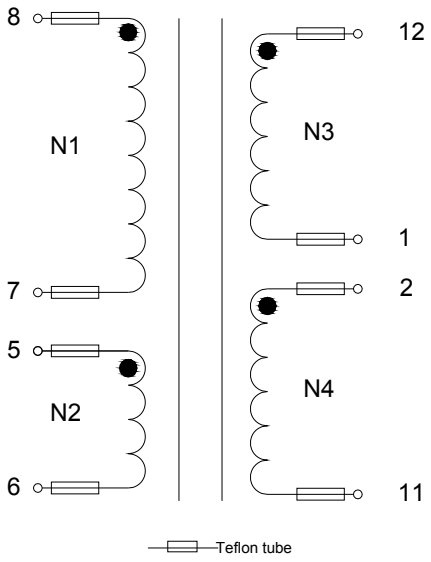
Wingdings	Start-End	Wire	Turns	Method
N1	10,11 — 7,8	2UEW,φ0.10mm *50p	44	tight

8.3 Pulse transformer

Core: T14*8*7

Material: Ferrite

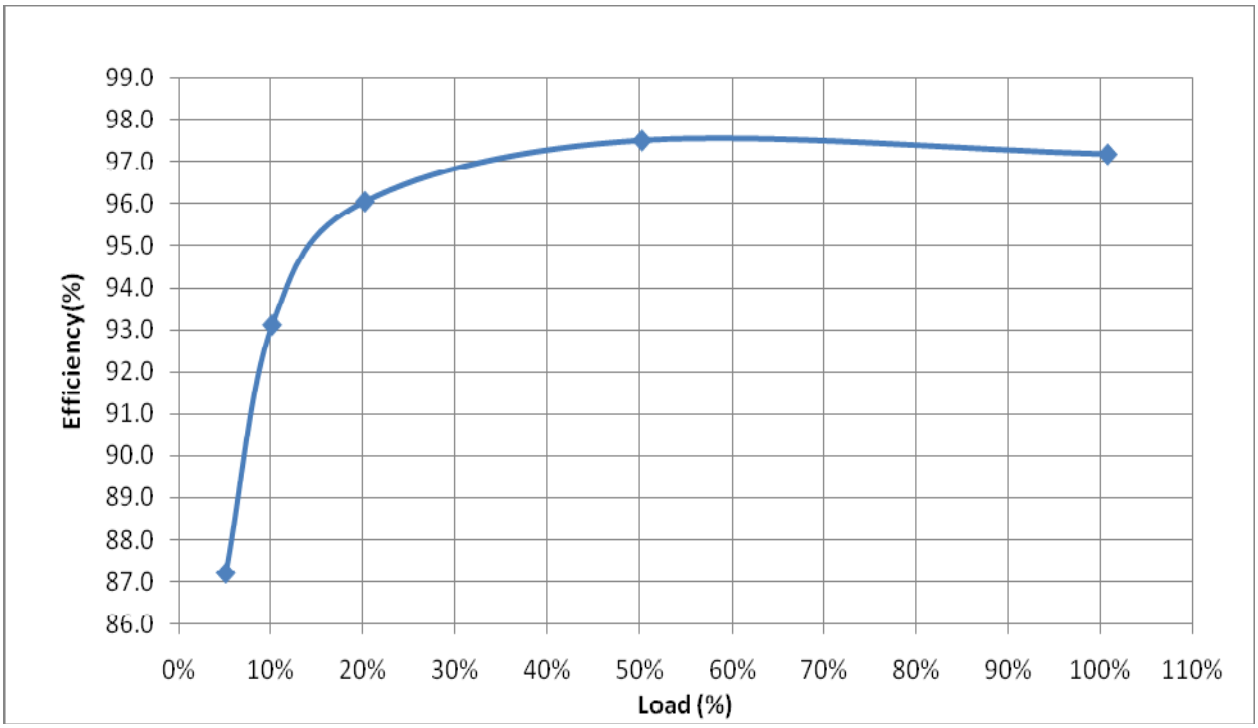
Inductance: 2.0mH Min (no gap)



Winding	Start	Finish	Wire	Turns(Ts)	Winding
N1	8	7	TLW-B, Φ0.20mm*1P	22TS	
N2	5	6	TLW-B, Φ0.20mm*1P	18TS	
N3	12	1	TLW-B, Φ0.20mm*1P	15TS	2 wires in parallel
N4	2	11	TLW-B, Φ0.20mm*1P	15TS	

9 Efficiency Test

V_{out}(V)	I_{out}(A)	P_{out}(W)	Load(%)	V_{in}(V)	I_{in}(A)	P_{in}(W)	Vcc(V)	Ivcc(A)	Pvcc(W)	Eff.(%)
12.17	1.25	15.21	5%	399.99	0.04	17.06	15.00	0.03	0.375	87.2
12.17	2.49	30.31	10%	399.89	0.08	32.17	15.00	0.03	0.375	93.1
12.17	4.98	60.59	20%	399.77	0.16	62.70	15.00	0.03	0.375	96.1
12.16	12.41	150.95	50%	399.34	0.39	154.46	15.00	0.03	0.375	97.5
12.16	24.87	302.42	101%	399.22	0.78	310.84	15.00	0.03	0.375	97.2

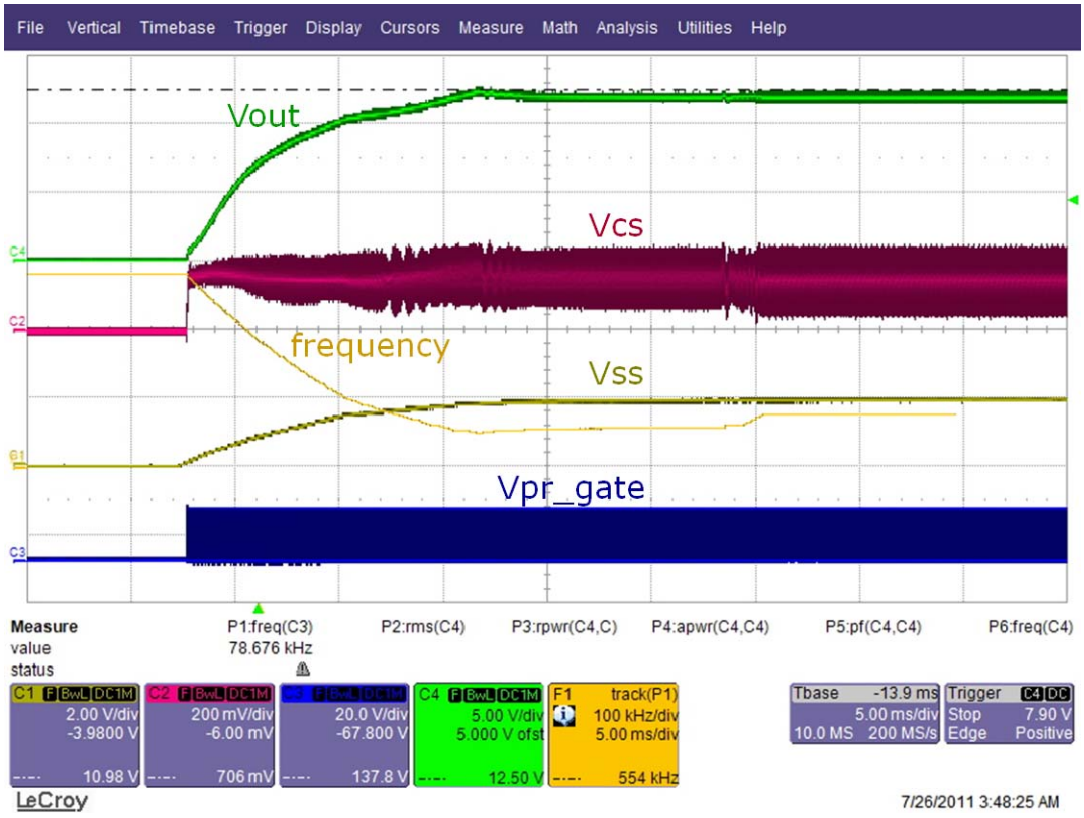


10 Test Waveforms

10.1 Soft start at full load and light load

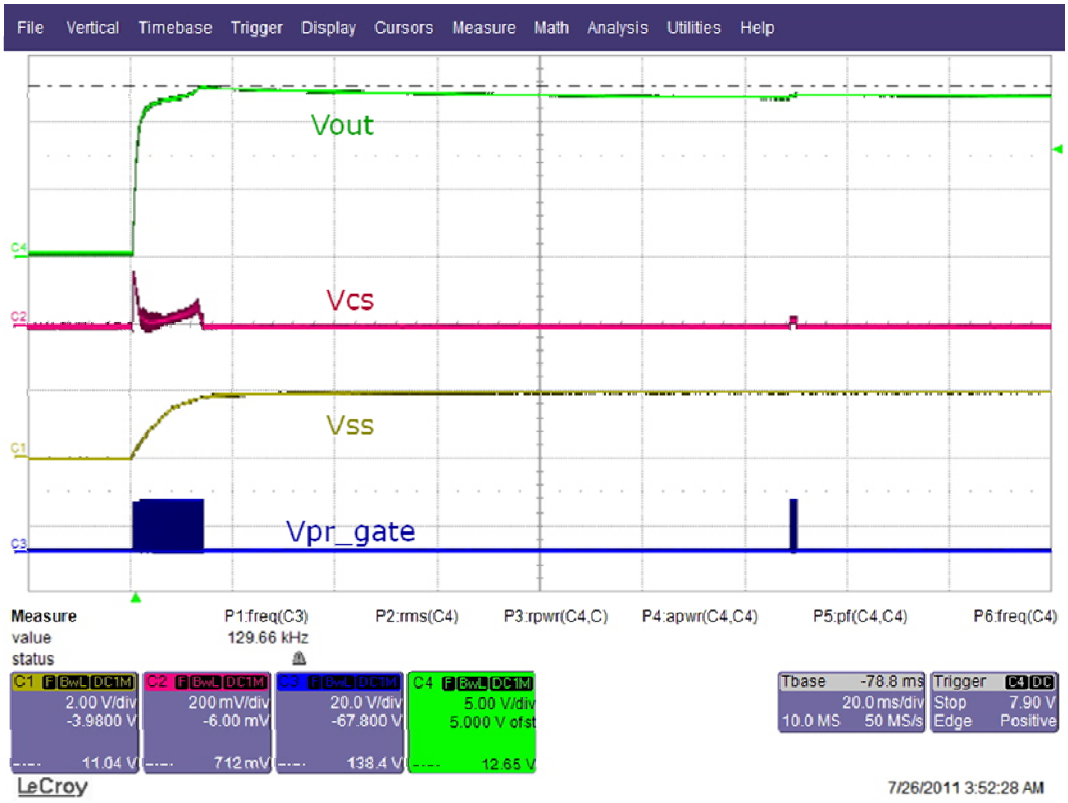
A. Full load

The output voltage rises up to nominal value in around 15ms. The overshoot is less than 5%. The soft start is achieved by decreasing the switching frequency gradually from 280 KHz to 80kHz until stable operation is reached.



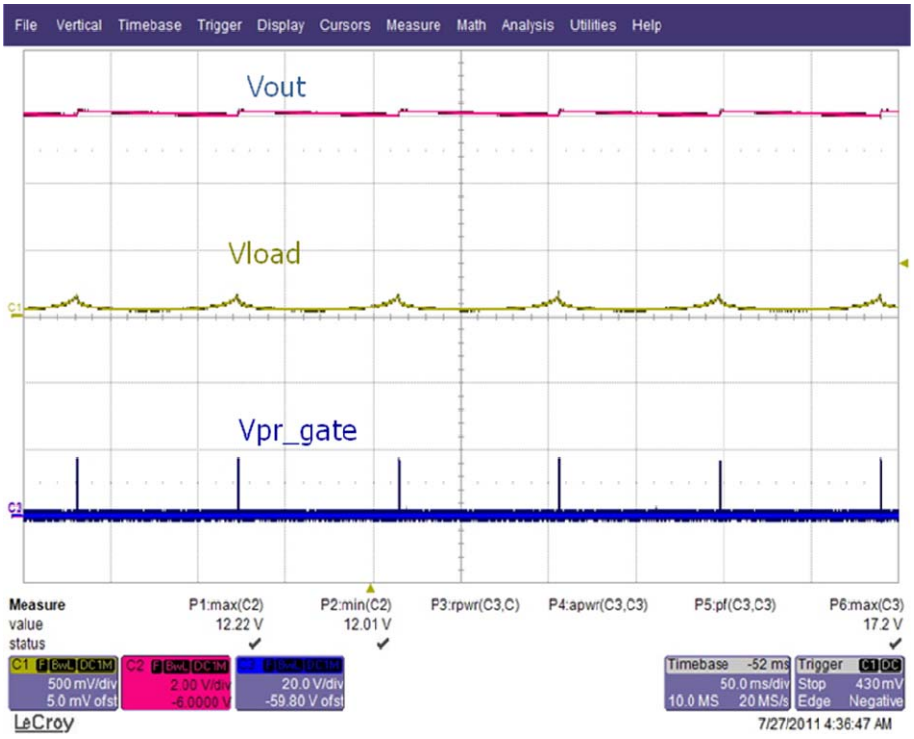
B. No load

The output voltage rises up to nominal value in around 15ms. The overshoot is less than 5%. IC operates in burst mode after softstart.



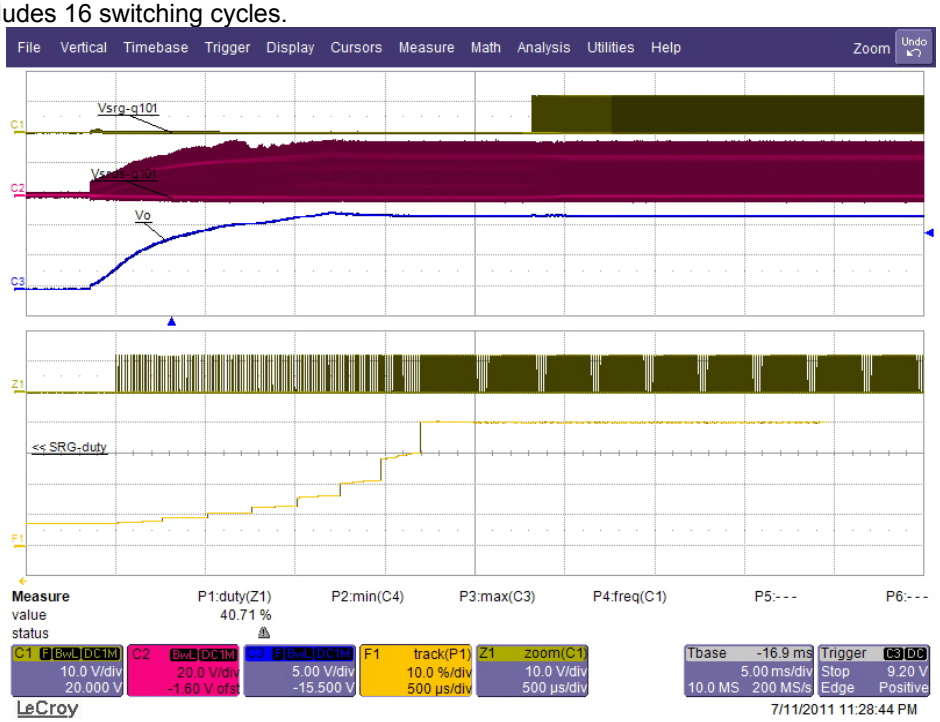
10.2 Burst mode operation at no load

When IC is operating in burst mode, the ripple of out voltage is less than 250mV.



10.3 SR soft start at full load

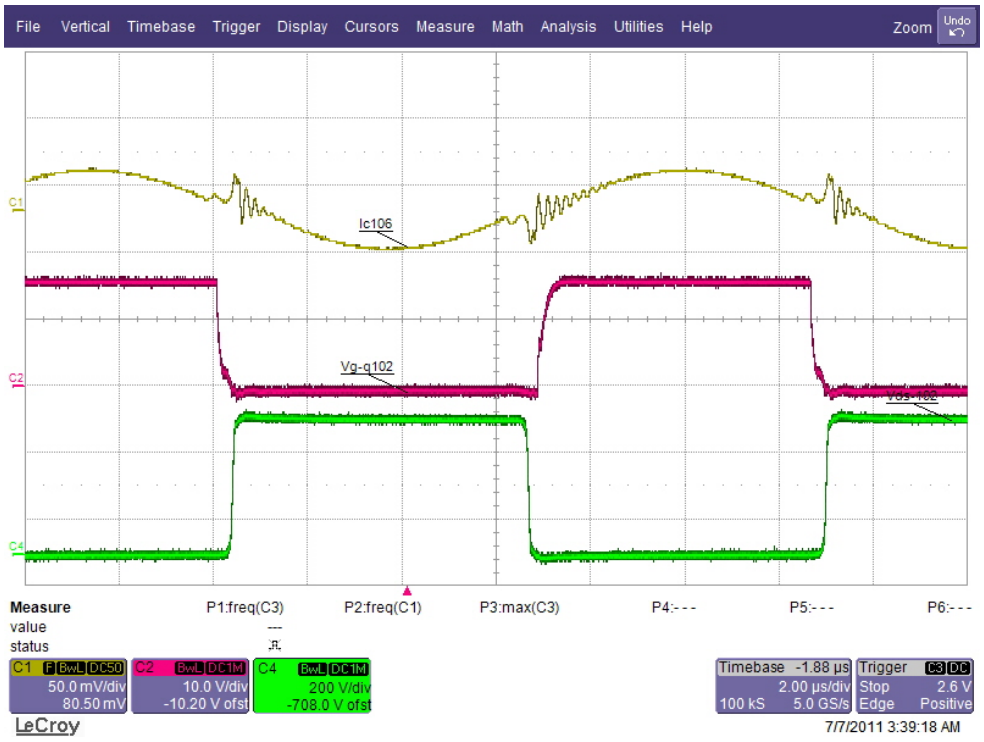
The SR operaton is enabled after the output voltage has been built up. In ICE2HS01G, SR operation will start with small duty, around one-tenth of its normal duty, which will be kept same for 16 consective switching cycles. Then, the duty is increased gradually step by step to the full duty. Total 7 steps are built for the softstart and each step includes 16 switching cycles.



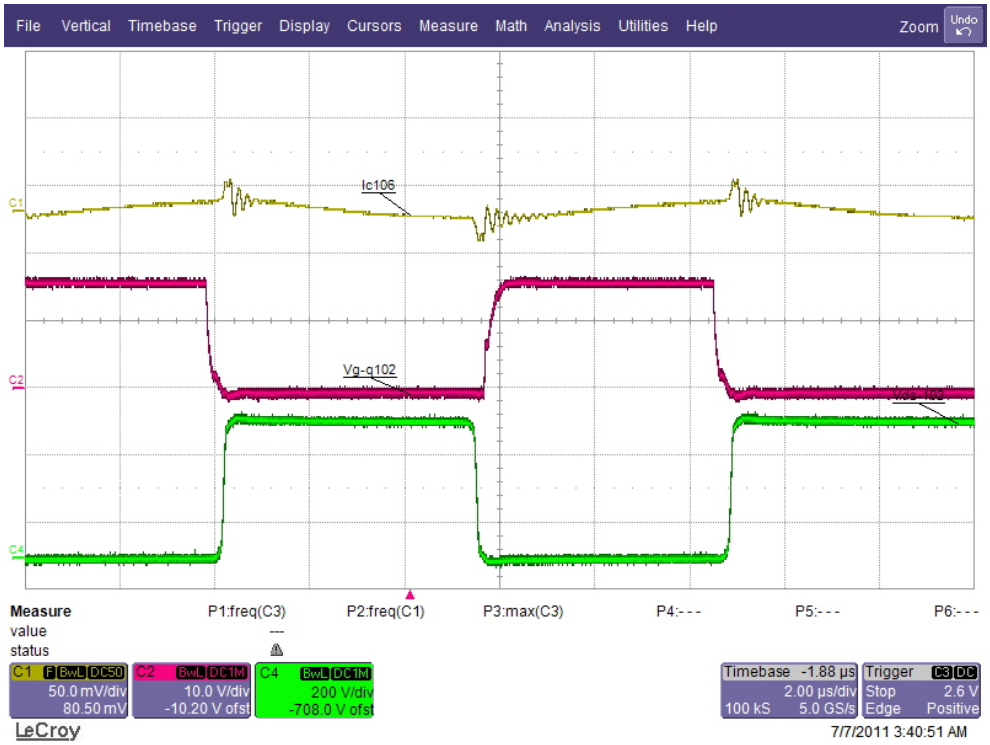
10.4 Zero Voltage Switching

With proper design of LLC converter, ZVS can be realized over all load range. Channel 1 shows the resonant current flowing through the resonant capacitor. Channel 2 and 4 represent the gate-source voltage and drain source voltage of Q102.

A. **Full load**

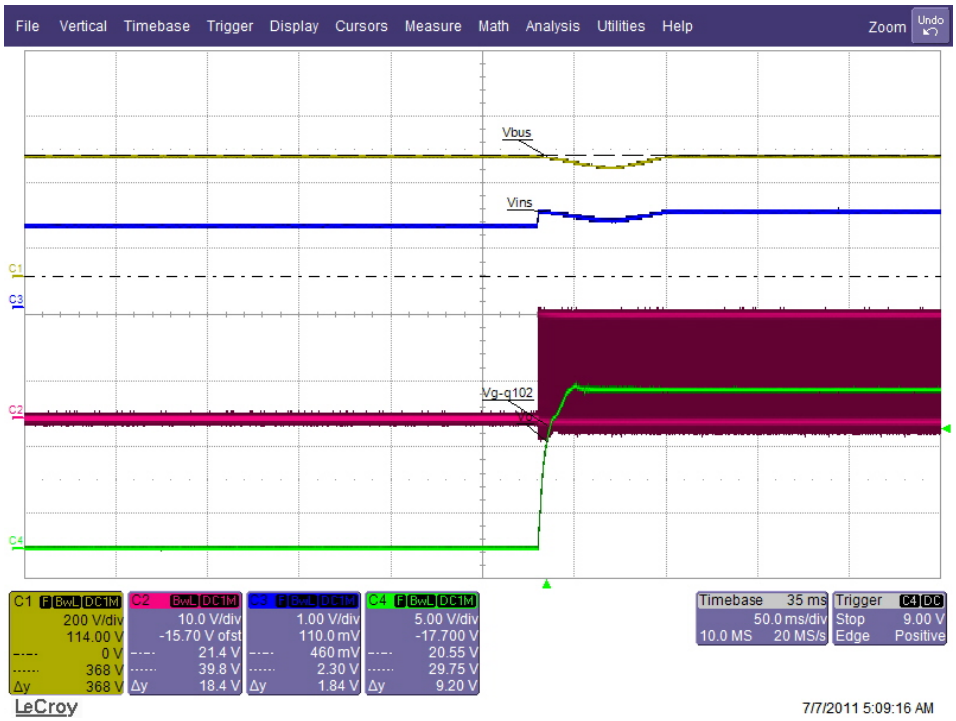


B. **Light load(Iout=1A)**

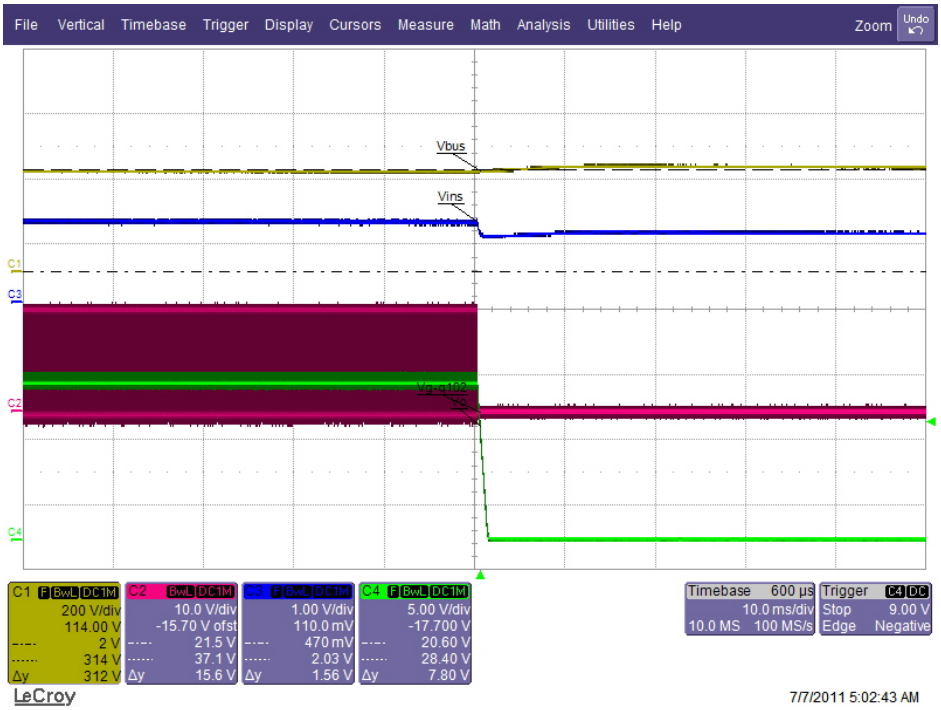


10.5 Main under voltage protection

A. IC starts operation when Vbus resumes to normal value Vbus-on=368Vdc.



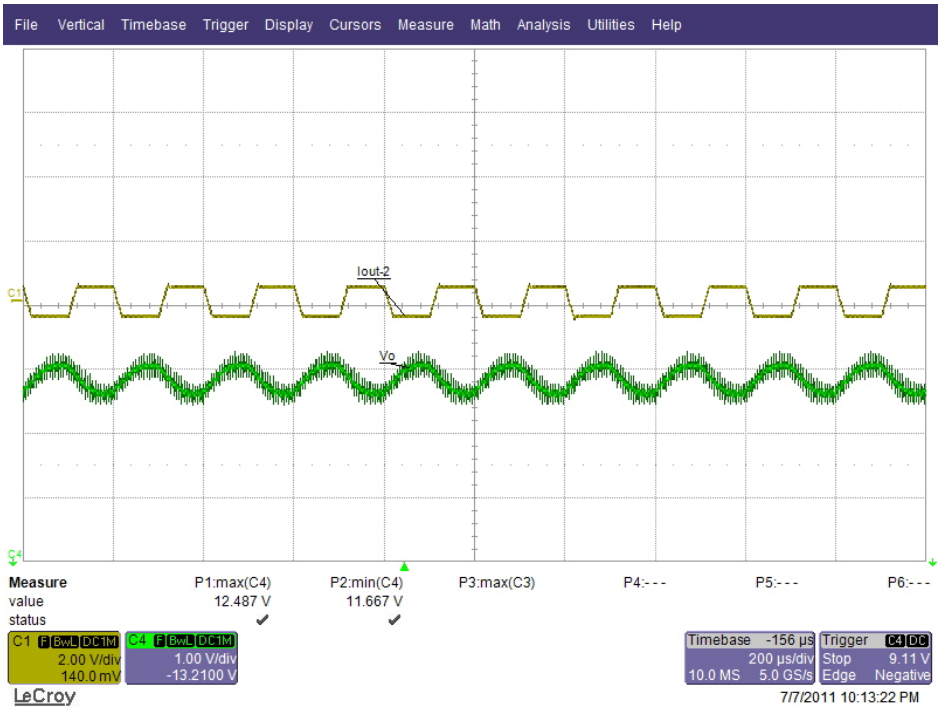
B. IC stop switching when Vbus drops to designed value Vbus-off=312V



10.6 Dynamic load response

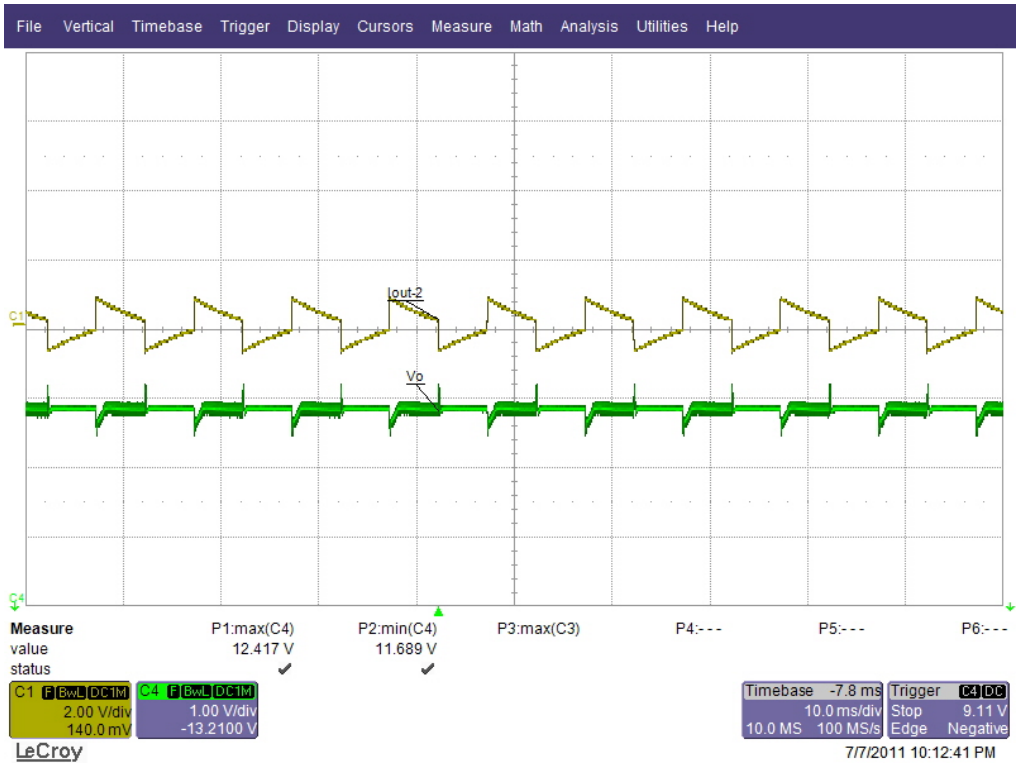
A. 12V@2.5A~20A, 5KHz, 800m A/u S

The ripple of output voltage is around 0.8V.



B. 12V@ 2.5A~20A, 100Hz, 800m A/u S

The ripple of output voltage is around 0.8V.



10.7 Hold up time test

The hold up time is about 22mS at full load after the input is disconnected from the board.