EVALCOMBI-ICE1CS02

300W PFC/PWM COMBI High Efficiency Evaluation Board with ICE1CS02

Power Management & Supply

Never stop thinking.

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Revision History:	**2009-04**	V1.0
Previous Version: V1.0		
Page	Subjects (major changes since last revision)	

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Liu Jianwei

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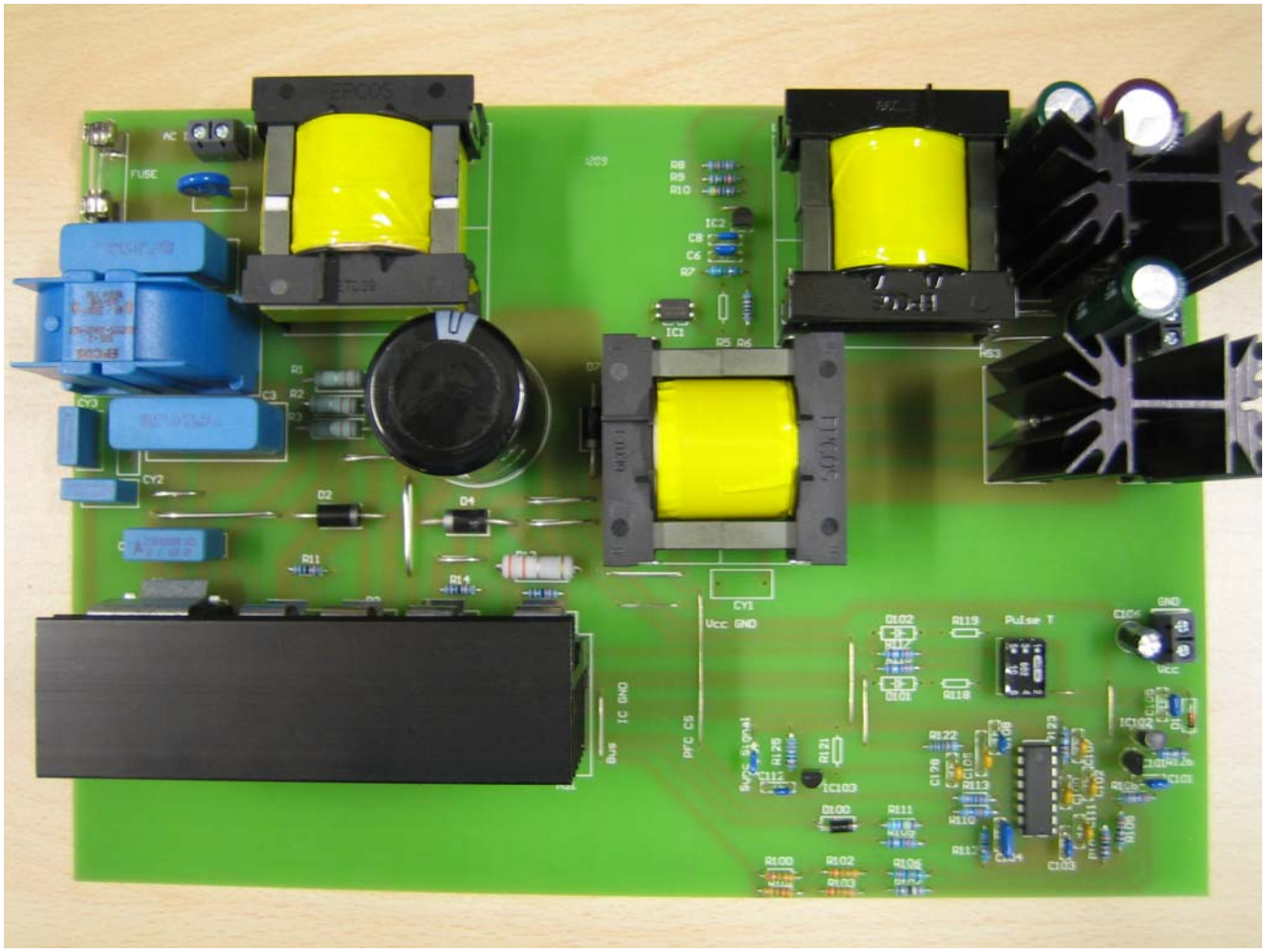
Table of Content

1 Abstract

The evaluation board presented is a 300W CCM PFC/PWM Combi circuit employing the new combi controller IC **ICE1CS02.** The circuit can operate from 85~265VAC universal input and achieve high efficiency. The PFC section achieves near unity power factor and provides 390VDC to the down-stream forward converter, which outputs 12V and 5VDC. The detailed application circuit, PCB drawing and component list are included. Important specifications such as power factor and efficiency are tested and some important features are demonstrated.

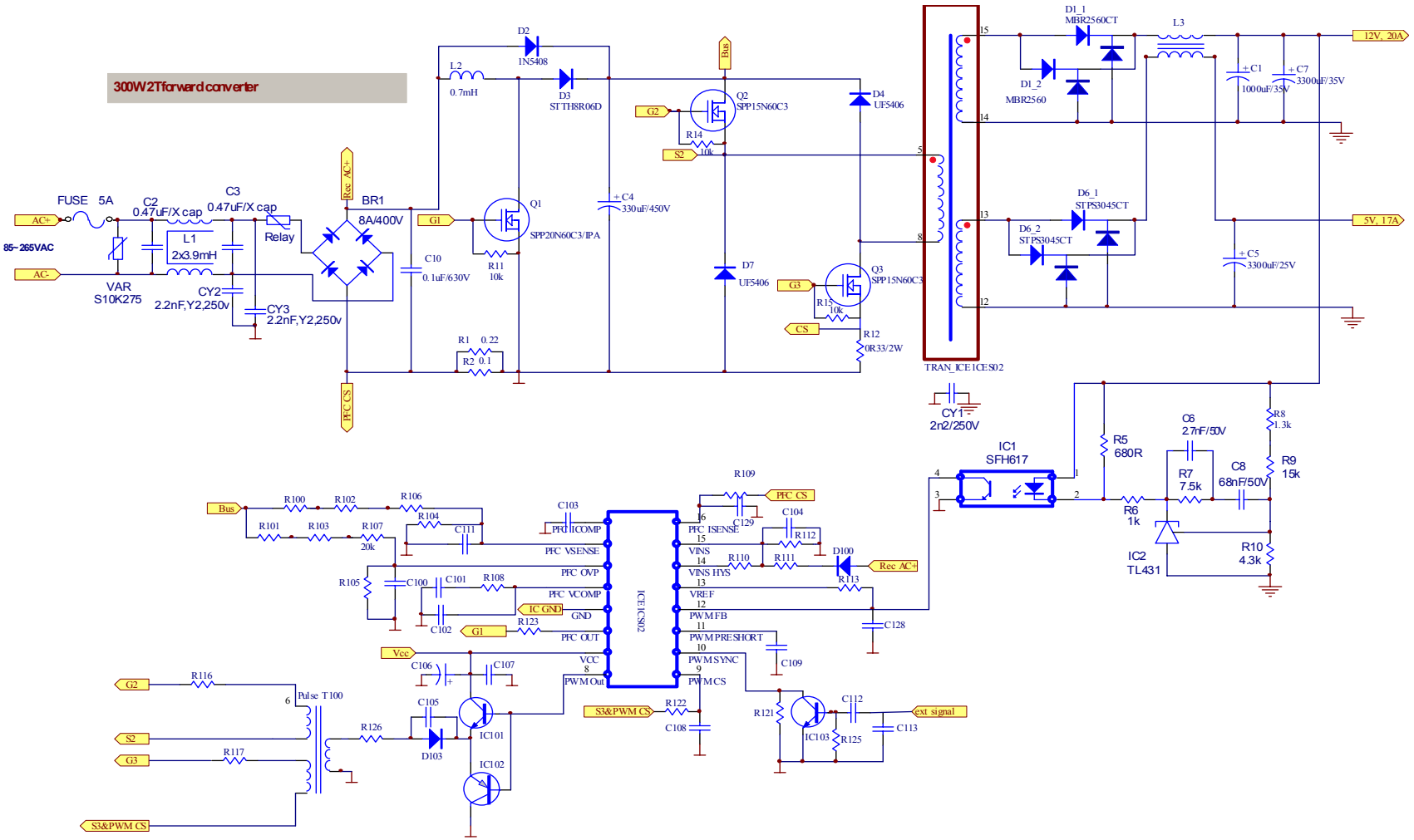
2 Evaluation Board



3 Technical Specifications

Input voltage	85VAC~265VAC
Input frequency	50Hz
Output voltage	12VDC
	~ 5VDC
Output power	300W
Switching Frequency (internal)	65kHz PFC / 130kHz PWM
Efficiency at 115Vac	83.3% at full load 86.5% at half load 85.8% at 20% load

4 Circuit Diagram



5 Circuit Description

Line Input

The high frequency current ripple and radio interference is suppressed by the choke L1, X2-capacitors C2 and C3 and Y1-capacitor CY2 and CY3. NTC is placed in series to limit inrush current during power on.

PFC Converter

The CCM boost type PFC converter consists of L2, Q1, D3 and C4. Bulk capacitor C4 provides energy buffering to reduce the output voltage ripple (100Hz) to the acceptable level.

The PFC brown-out voltage is set at 59VAC. The recover voltage is 68VAC. The values can be adjusted by changing the components at 14 and 15 pin.

The **CoolMOS™ C3** series MOSFET SPP20N60 is usedas main switch in this boost type PFC circuit.

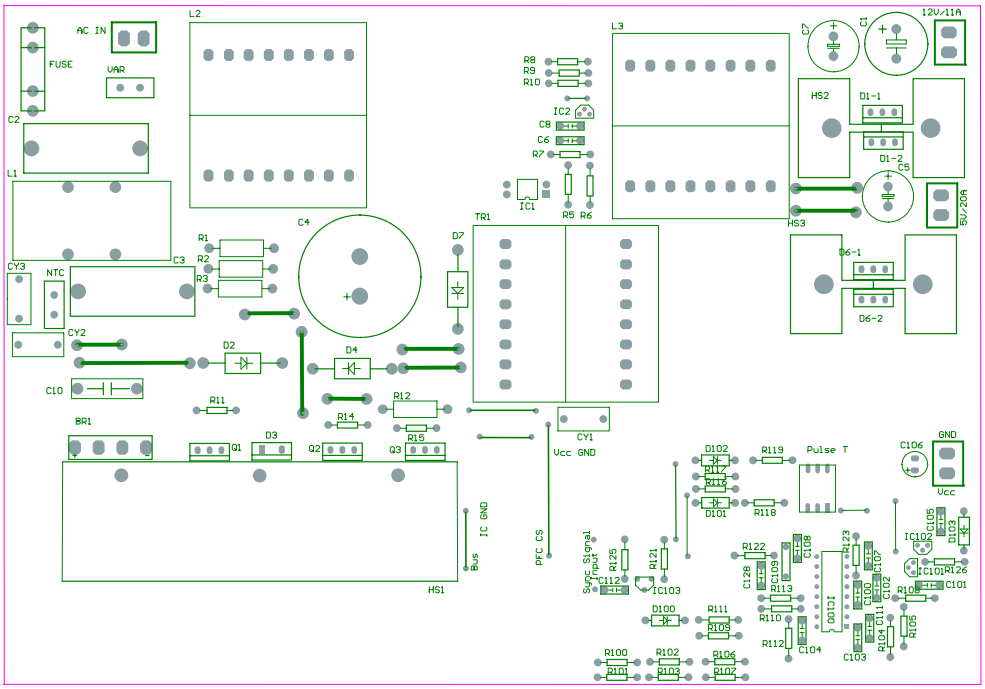
PWM Converter

This stage is a two_transistor (Q2 and Q3) forward converter. The two ultra-fast diodes D4 and D7 consists of the magnetic resetting circuit. The output inductors are coupled to improve cross regulation and reduce phase-ripple current for transient response.

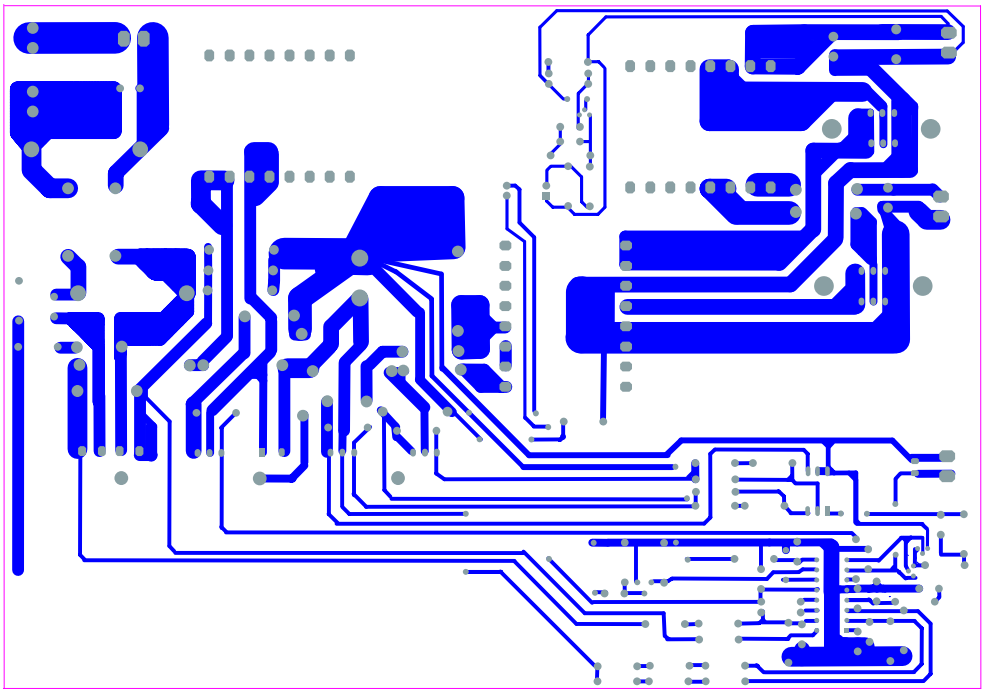
The pre-short protection blanking time is set as 10ms.

The **CoolMOS™ C3** series MOSFET SPP15N60 are used.

6 PCB Layout Top Layer



7 PCB layout Bottom Layer



8 Components

8.1 Bill of Material

		Part Type
1	C1	2200uF/35V
2	C2	0.47uF
3	C3	0.47uF
4	C4	220uF/450V
5	C5	2200uF/25V
6	C6	2.7nF
7	C7	1000uF/35V
8	C8	68nF
9	C10	0.1uF
10	C100	0.1uF
11	C101	1uF
12	C102	0.1uF
13	C103	3.3nF
14	C104	680nF
15	C105	1u/50V
16	C106	47uF/50V
17	C107	0.1uF
18	C108	1nF
19	C109	0.1uF
20	C111	0.1uF
21	C112	0.47nF
22	C113	Empty
23	C128	0.1uF
24	C129	1nF
25	CY2	2.2nF,Y2,250v
26	CY3	2.2nF,Y2,250v
27	D1_1	MBR2560CT
28	D1_2	MBR2560CT
29	D2	1N5408
30	D3	STTH8R06D
31	D4	UF5406
32	D6_1	STPS3045CT
33	D6_2	STPS3045CT
34	D7	UF5406
35	D100	1N4007
36	D103	1N4148
37	L1	2x3.9mH
38	L2	0.71mH
39	Q1	SPP20N60C3
40	Q2	SPP15N60C3
41	Q3	SPP15N60C3

		Part Type
46	IC1	SFH617
47	IC2	TL431
48	R1	0.22/1W
49	R2	0.1/1W
50	R5	Empty
51	R6	1k
52	R7	7.5k
53	R8	1.3k
54	R9	15k
55	R10	4.3k
56	R11	10k
57	R12	0.33 /2W
58	R14	10k
59	R15	10k
60	R100	2M
61	R101	2M
62	R102	2M
63	R103	2M
64	R104	33k
65	R105	33k
66	R106	270k
67	R107	390k
68	R108	33k
69	R109	3.3
70	R110	470k
71	R111	5.6M
72	R112	82k
73	R113	3.6k
74	R116	3.3
75	R117	3.3
76	R118	Empty
77	R119	Empty
78	R121	Empty
79	R122	1k
80	R123	3.3
81	R125	180
82	R126	6.8
83	BR1	8A/400V
84	FUSE	5A
85	NTC	Shorted
86	TR	TRAN_ICE1CES02

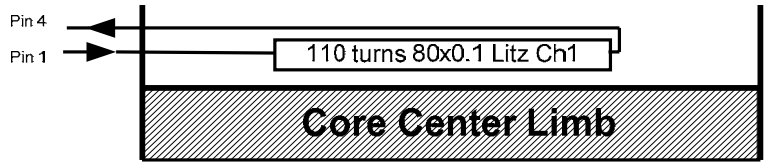
42	IC101	BC548
43	IC102	BC557
44	IC103	BC548
45	IC104	ICE1CS02

87	VAR	S10K275
88	Pulse T100	CD602
89	Heatsink1	3.6C/W
90	Heatsink2	2.9C/W

8.2 PFC Boost Choke Layout

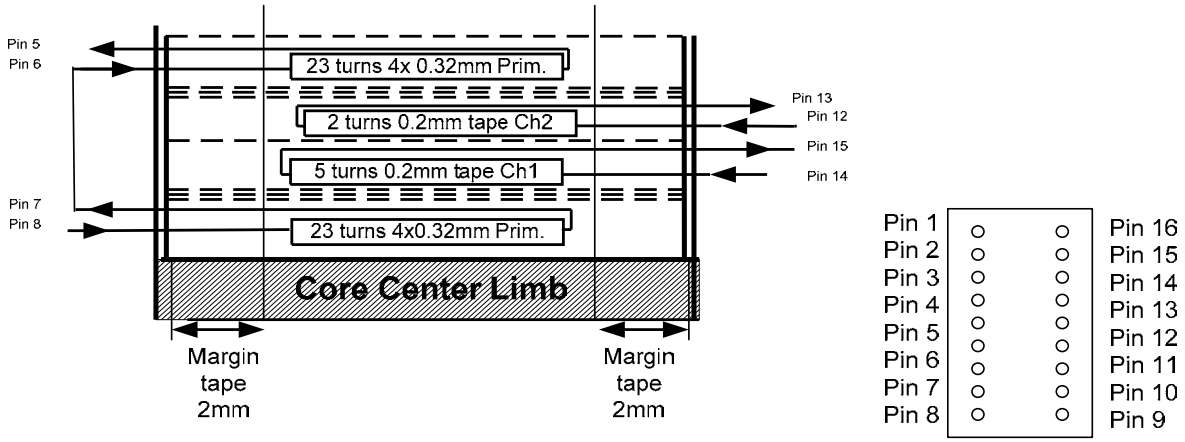
Core size: ETD39 Core material N97 (Epcos)
Bobbin: ETD39 (16pin) Horizontal Version
Litz Wire: 80x0.1mm

Primary Inductance, Lp=710uH, measured between pin 1 and pin 4 (air gap)



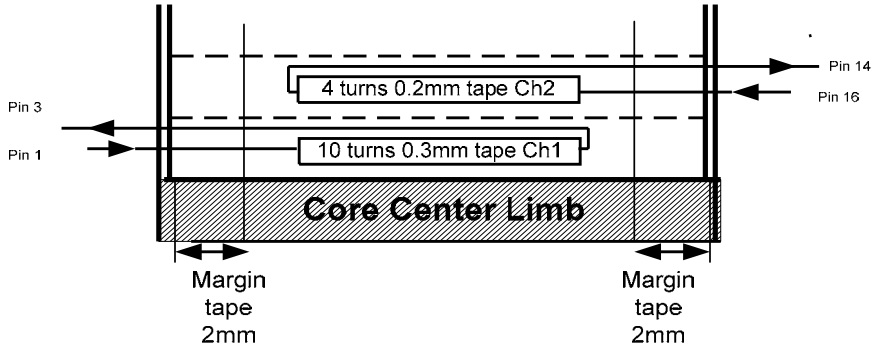
8.3 Forward Converter Transformer

Core size: ETD39 Core material N97 (Epcos)
Bobbin: ETD39 (16pin) Horizontal Version
Primary Inductance, Lp=5.9mH, measured between pin 8 and pin 5 (no air gap)



8.4 Output choke

Core size: ETD39 Core material N97 (Epcos)
Bobbin: ETD39(16pin) Horizontal Version
Primary Inductance, Lp=12.4uH, measured between pin 1 and pin 3 (air gap)

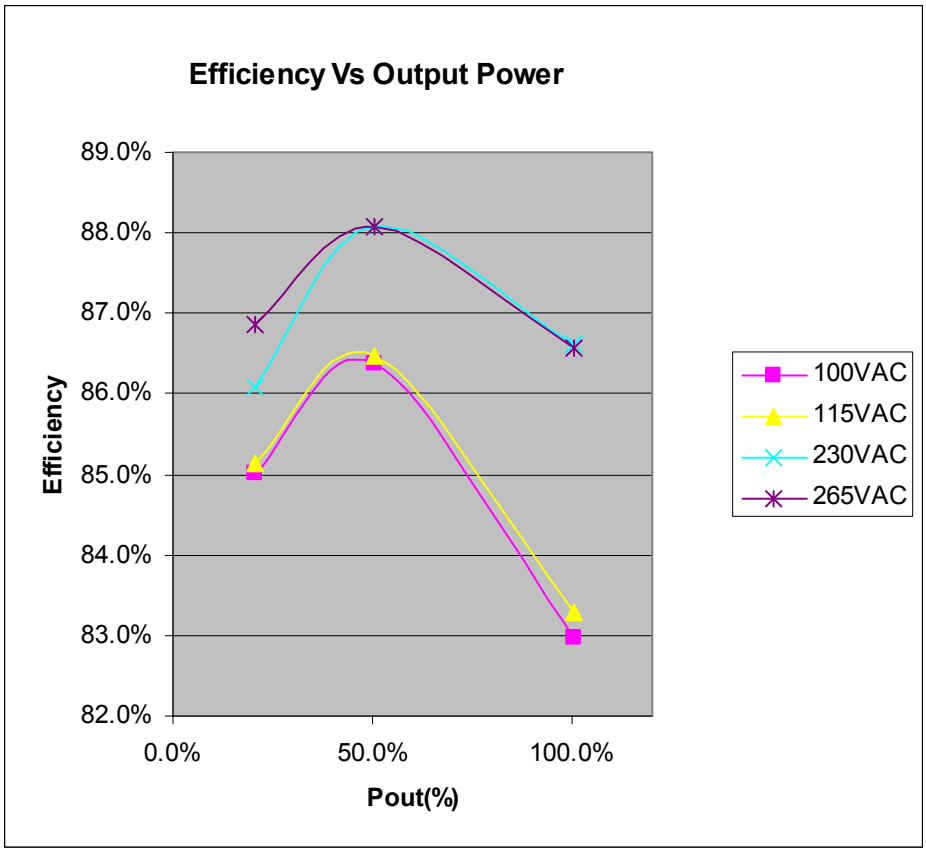


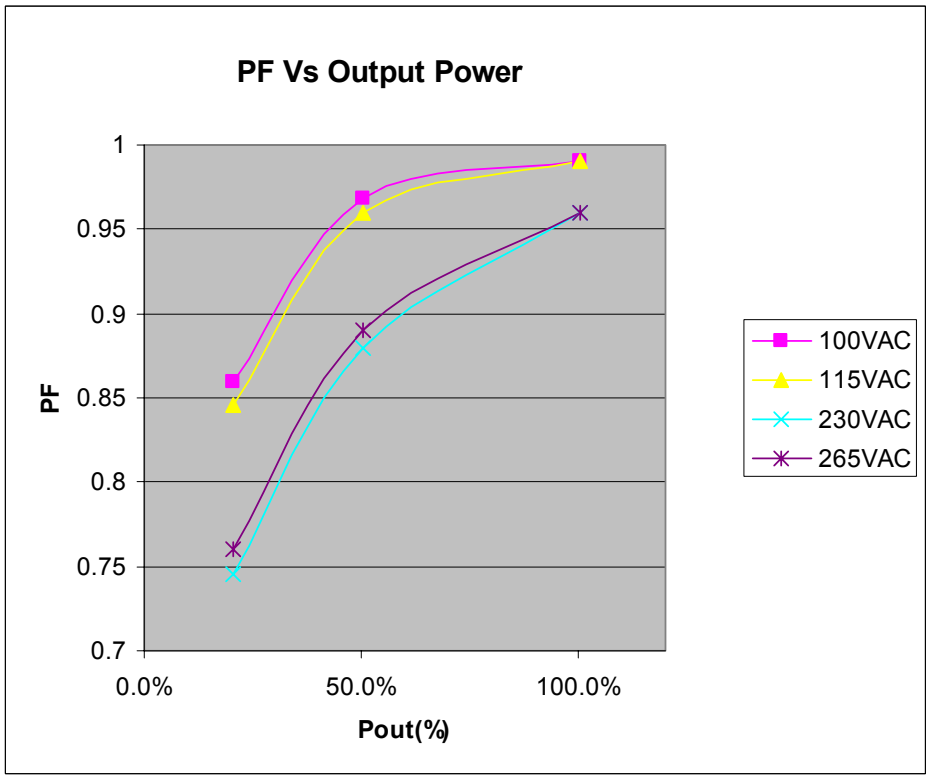
9 Test report

Please note an electric fan (say of 11W) is used to help dissipate heat, otherwise the devices may get overheated and damaged.

9.1 Load test (NTC shorted)

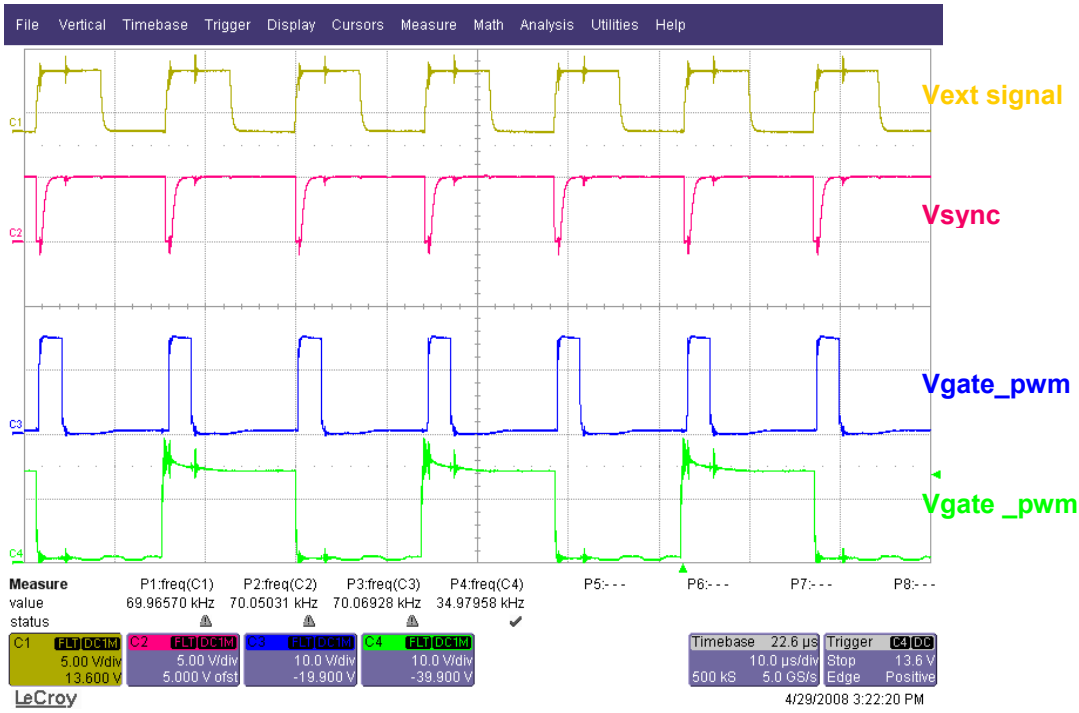
Vin(VAC)	Vout1(V)	Iout1(A)	Vout2(V)	Iout2(A)	Pout(W)	Pin(W) (read)	Pin(W) (overall)	Efficiency	PF
100VAC	11.94	18.94	4.4	16.94	300.7	357.3	362.4	83.0%	0.991
	11.95	8.98	4.44	9.95	151.5	174.8	175.4	86.4%	0.968
	11.94	3.98	4.55	2.99	61.1	71.3	71.9	85.0%	0.86
115VAC	11.94	18.96	4.4	16.94	300.9	356.2	361.3	83.3%	0.99
	11.95	8.98	4.43	9.954	151.4	174.5	175.1	86.5%	0.96
	11.94	3.98	4.55	2.99	61.1	71.2	71.8	85.1%	0.846
230VAC	11.94	18.94	4.4	16.94	300.7	346.5	347.1	86.6%	0.96
	11.95	8.98	4.44	9.95	151.5	171.4	172	88.1%	0.88
	11.94	3.98	4.55	2.99	61.1	70.4	71	86.1%	0.745
265VAC	11.94	18.95	4.4	16.94	300.8	346.9	347.5	86.6%	0.96
	11.95	8.98	4.44	9.95	151.5	171.4	172	88.1%	0.89
	11.94	3.98	4.56	2.99	61.2	69.8	70.4	86.9%	0.76


Efficiency Vs Output Power
89.0%
88.0%
87.0%
86.0%
85.0%
84.0%
83.0%
82.0%
Efficiency
0.0%
50.0%
100.0%
Pout(%)
100VAC
115VAC
230VAC
265VAC

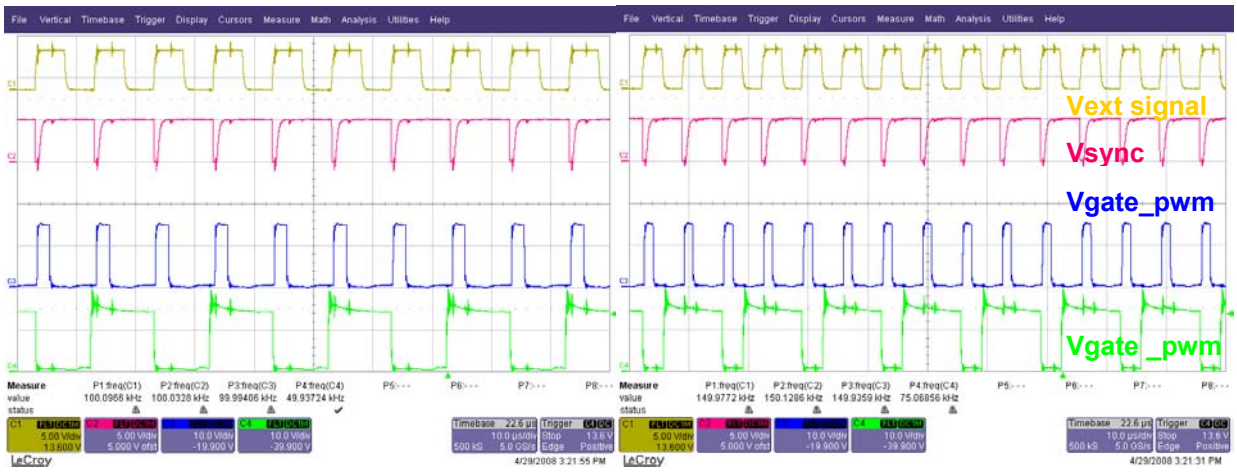

PF Vs Output Power
1
0.95
0.9
0.85
0.8
0.75
0.7
PF
0.0%
50.0%
100.0%
Pout(%)
100VAC
115VAC
230VAC
265VAC

9.2 Waveforms

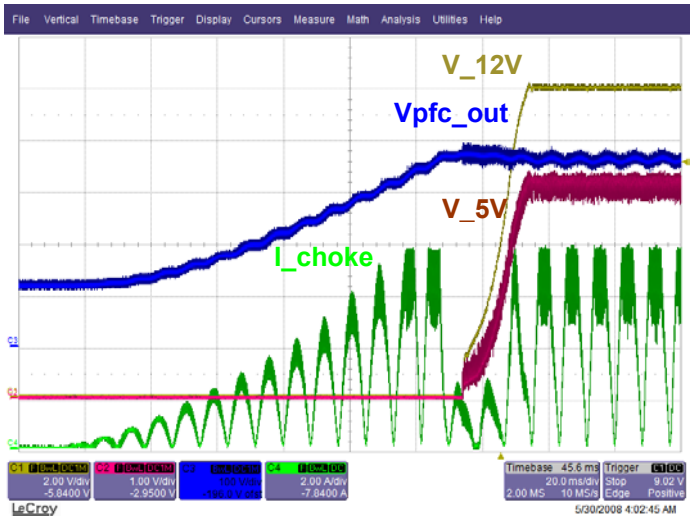
External Synchronization at 70kHz



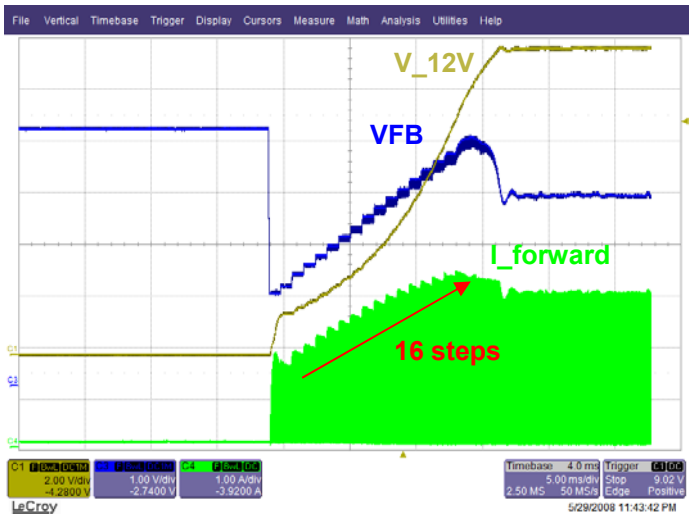
External Synchronization at 100kHz and 150kHz



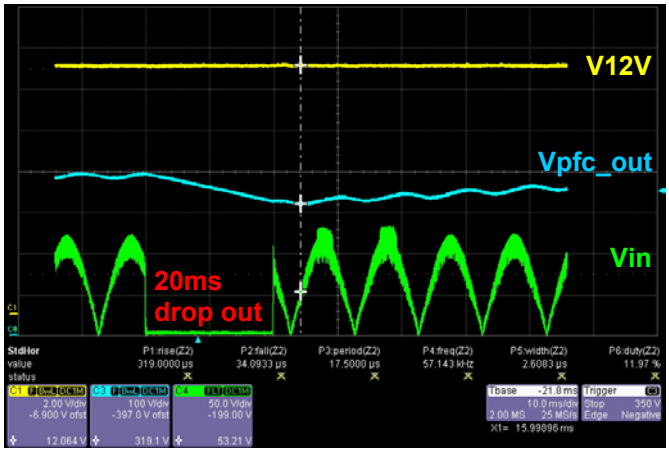
85Vac, Full load (300W) PFC softstart



Full load (300W) PWM softstart



Output 12V stable during the 20ms cycle drop out under full load



10 References:

[1] Combi PFC/PWM Controller ICE1CS02 datasheet Preliminary datasheet; Infineon Technologies; Munich

[2] Liu Jianwei, Luo Junyang, Jeoh Meng Kiat, Design Guide for Boost Type CCM PFC with ICE2PCSxx, Application note, Infineon Technologies, Munich, Germany, Feb. 2007