Multioutput 30W Evaluation Board for DVD SMPS with ICE2A265

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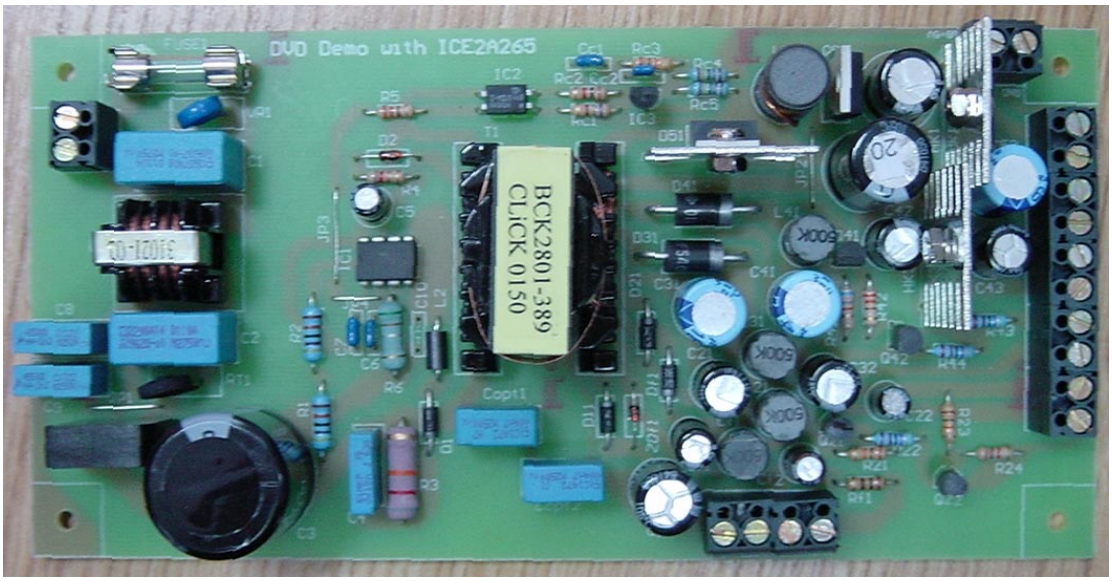
The board described here was designed as a typical power supply in flyback converter topology with multi output voltage and secondary control. This type of switch mode power supply is particularly suitable as an AC/DC power supply for DVD, VCD and VCR. The PWM controller **ICE2A265** chip used for this application is a current-controlled pulse width modulator with integrated CoolMOS™ power switch. **ICE2A265** is the second generation CoolSET™ which provides several special enhancements to satisfy the needs for low power standby and protection features. In standby mode frequency reduction is used to lower the power consumption and support a stable output voltage in this mode. In case of failure modes like open loop, overvoltage or overload due to short circuit the device switches in Auto Restart Mode which is controlled by the internal protection unit. By means of the internal precise peak current limitation the dimension of the transformer and the secondary diode can be lower which leads to more cost efficiency.

Evaluation board



Technical specifications:

Input voltage	85VAC~265VAC	
Input frequency	50Hz, 60Hz	
Output voltage and current		
Digital +5V	5V	1.5A
Digital +3.3V	3.3V	0.7A
Standby +5V	STB+5V	0.03A
Analog +5V	A+5V	0.3A
Audio +9V	+9V	0.2A
Audio -9V	-9V	0.2A
Motor +9V	M+9V	0.6A
	-25V	0.03A
VFD display 4.5V	Floating 4.5V	0.1A
Output power	23.9W	
Efficiency	70% excluding linear regulator	
Switching frequency	100KHz	
Standby load condition	STB+5V/0.03A only	
Standby power	<1W	

Circuit Description

Line Input

The AC line input side comprises the input fuse FUSE1 as overcurrent protection. The choke L1, X2-capacitors C1 and C2 and Y1-capacitor C8 and C9 as radio interference suppressors. After the bridge rectifier BR1 and the input capacitor C3, a voltage of 80 to 380 VDC depending on input voltage is available.

PWM Control and Power Stage

The PWM pulse is generated by 8-pin CoolSET™ **ICE2A265**. **ICE2A265** is an integrated power IC which includes both of the current mode PWM controller and power MOSFET with 650V breakdown voltage. The control IC and Power MOS are fabricated by the different optimized chip technologies respectively and no compromise like monolithic approaches is necessary. The control IC is fabricated by the reliable bipolar technology. Moreover, the power stage is handled by evolutionary CoolMOS™ technology.

Clamping Network

R3, C4 and D1 dissipate the energy of the leakage inductance.

Primary Current Sense

The primary current is sensed by the external shunt resistor R6. The sense voltage is fed into **ICE2A265** and compares to the internal control voltage for PWM control.

Output Stage

On the secondary side the power is coupled out via a group of fast-acting diodes Df1, D11, D21, D31, D41 and D51. The capacitors Cf1, C11, C21, C31, C41 and C51 provide energy buffering following with the LC filters to reduce the output voltage ripple considerably. Storage Cf1, C11, C21, C31, C41 and C51 are designed to have an internal resistance as small as possible (ESR). This minimizes the output voltage ripple caused by the triangular current characteristic. Q21, Q41 and Q51 are used to cut the current during the standby mode. Two linear regulators are used to provide A+5V and 3.3V with high accuracy.

Feedback Loop

The output voltage is sensed by the voltage divider of Rc4 and Rc5 and compare to TL431 internal reference voltage. The output voltage of TL431 is transferred to the primary via optocoupler for regulation control. The secondary regulation control is adopted with TL431 and optocoupler. The compensation network Cc1, Cc2, Rc3 constitutes the external circuitry of the error amplifier of TL431. This circuitry allows the feedback to be precisely matched to dynamically varying load conditions, thereby providing stable control. The maximum current through the optocoupler diode and the voltage reference is limited by the resistor Rc2. Optocoupler IC2 is used for floating transmission of the control signal to the "FB" input of the **ICE2A265**. The optocoupler meets DIN VDE 884 requirements.

Circuit Operation

Startup

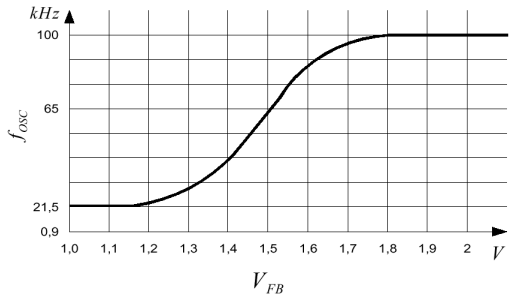
From the DC input voltage, the chip's starting current supply is derived using the resistors R1 and R2. Because of the low current less than 55uA, high-value resistors can be used. Series connection of the resistors is necessary for reasons of insufficient dielectric strength of the individual resistors. The IC remains inactive during the Vcc charge up. When the voltage on Vcc reaches 13.5V (typ.), the IC turn on threshold voltage, the SMPS is going to start. The Soft-Start function is realized by RC charging circuit of an internal resistor and the external capacitor C7. The pulse width is gradually increased during a soft start.

Normal Mode Operation

After startup, the secondary output voltage is built up. If the Stby input signal is high, the SMPS will go into in normal mode. The switches Q21, Q41 and Q51 are turned on and the IC is working in 100KHz switching frequency. During normal operation, the power supply is provided via a separate transformer winding with associated rectifier D2. Resistor R4 is used to limit the IC supply current.

Standby Mode Operation

If the Stby input signal is low, the switches Q21, Q41 and Q51 are off and the output voltages of 5V, 3.3V, A+5V, +9V and –9V are dropped to zero. The DVD microcontroller will switch off most of its function blocks and VFD display is inactive. There is almost no current from M+9V because DC motor does not work. During the standby mode, the voltage on the IC FB pin is low due to the negative feedback regulation. Because of the internal frequency course dependence on FB pin voltage, the switching frequency is reduced to 21.5KHz. It will help to lower the standby power due to the switching loss.



Protection Features

Overload & open loop protection in normal operation
The detection of open loop or overload is provided by two comparators. The detection is activated and IC will go to auto-restart mode when the voltage at pin SST exceeds 5.3V and feedback voltage V FB to exceed the threshold of 4.8V.

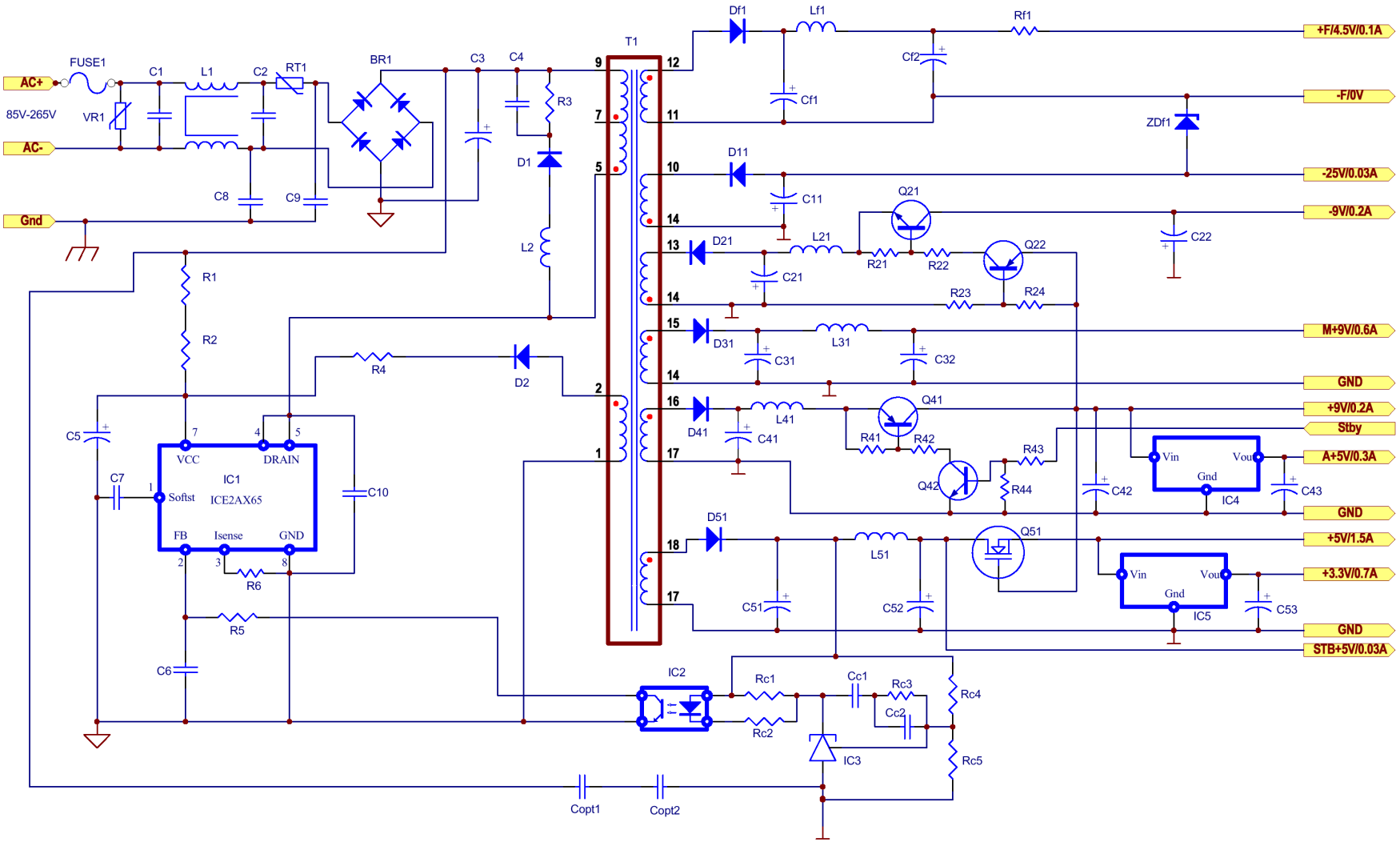
Open loop protection during start-up
The above open loop protection is not active in startup with softstart voltage is lower than 5.3V. The open loop protection is realized by Vcc overvoltage protection during startup when Soft-Start voltage is lower than 4.0V and the voltage at pin FB is above 4.8V. If Vcc exceeds 16.5V (typ.), IC will stop and go to auto-restart mode. This protection will help to prevent the extremely high voltages on secondary output in case of startup at no load condition with open loop fault.

Current Limiting
There is a cycle by cycle current limiting realized by the Current-Limit Comparator to provide the overcurrent detection. The source current of the integrated CoolMOS™ is sensed via an external sense resistor Rsense. By means of Rsense the source current is transformed to a sense voltage Vsense. When the voltage Vsense exceeds the internal threshold voltage Vcsth the Current-Limit-Comparator immediately turns off the gate drive. To prevent the Current Limiting from distortions caused by leading edge spikes a Leading Edge Blanking is integrated at the Current Sense.

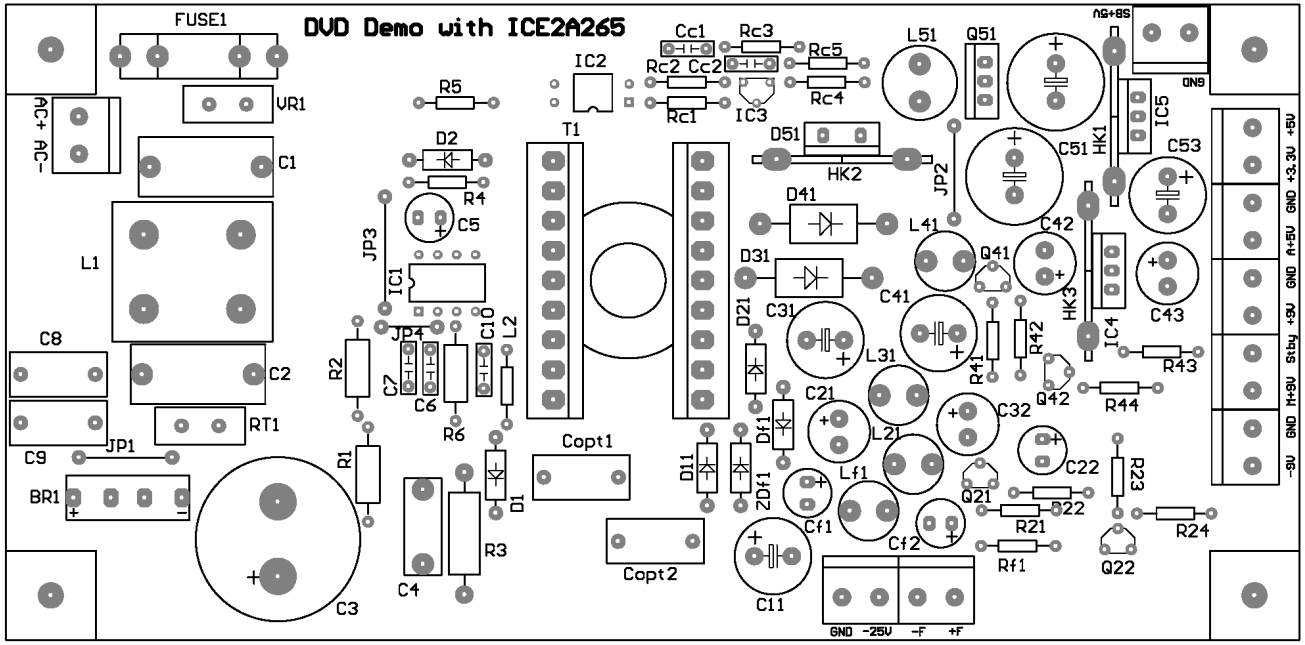
Current overshoot Minimization by propagation delay compensation
In case of overcurrent detection by current sense the shut down of CoolMOS™ is delayed due to the propagation delay of the circuit. This delay causes an overshoot of the peak current Ipeak which depends on the ratio of di/dt of the peak current. A propagation delay compensation is integrated to reduce the tolerance of the dependence on di/dt of the internal current limiting at ±5%.

Over temperature protection
Thermal Shut Down is latched by the Error-Latch when junction temperature Tj of IC is exceeding an internal threshold of 140°C. In that case the IC switches in Auto Restart Mode.

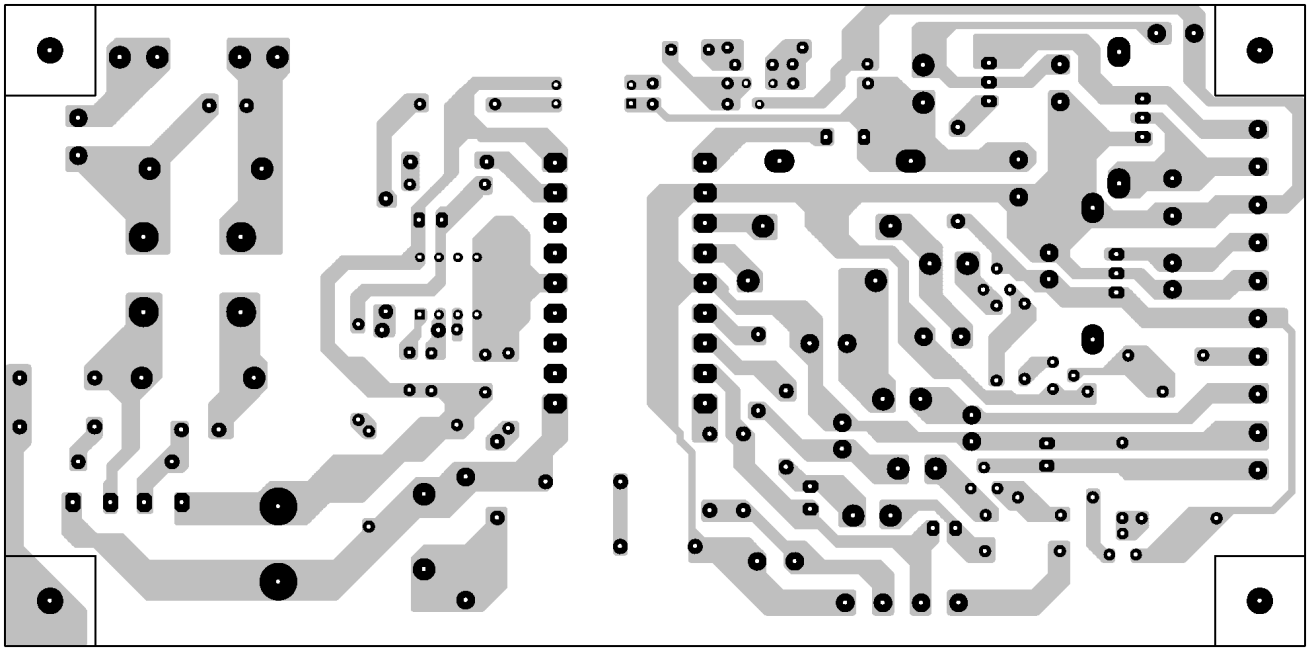
Circuit Diagram



PCB layout top layer



PCB layout Bottom:



Component List:

Designators	Type	Qty
BR1	RS204	1
C1	0.1uF/275V, X2	1
C10	Not connected	
C11	100uF/50V	1
C2	0.1uF/275V, X2	1
C21	220uF/16V	1
C22	100uF/16v	1
C3	47uF/400	1
C31	470uF/16V	1
C32	220uF/16V	1
C4	10nF/630V	1
C41	470uF/16V	1
C42	220uF/16V	1
C43	220uF/10V	1
C5	47uF/25V	1
C51	2200/10	1
C52	1000uF	1
C53	470uF/10V	1
C6	2.2nF	1
C7	1uF	1
C8	2200p/250, Y2	1
C9	2200p/250, Y2	1
Cc1	0.1uF	1
Cc2	6.8nF	1
Cf1	100uF/25V	1
Cf2	47uF/25V	1
Connector		9
Copt1	4.7nF/250V, Y2	1
Copt2	4.7nF/250V, Y2	1
D1	UF4006	1
D11	UF4003	1
D2	1N4148	1
D21	UF4002	1
D31	UF5401	1
D41	UF5401	1
D51	MBR760	1
Df1	UF4001	1
FUSE Holder		2
FUSE1	1A	1
HK1	Heat Sink	1
HK2	Heat Sink	1
HK3	Heat Sink	1
IC1	ICE2A265	1
IC2	SFH617A-3	1
IC3	TL431	1
IC4	L7805	1
IC5	LM1117	1
JP1	Jumper	1
JP2	Jumper	1

JP3	Jumper	1
JP4	Jumper	1
L1	Common mode choke, 50mH	1
L2	Ferrite Bead	1
L21	20uH	1
L31	20uH	1
L41	20uH	1
L51	20uH	1
Lf1	20uH	1
M3 Nut		3
M3 Screw		3
Q21	BC639	1
Q22	BC558	1
Q41	BC640	1
Q42	BC548	1
Q51	IPP15N03L	1
R1	470k, 1/2W	1
R2	470k, 1/2W	1
R21	10k	1
R22	4.7k	1
R23	10k	1
R24	1k	1
R3	82k, 2W	1
R4	8.2	1
R41	6.8k	1
R42	330	1
R43	4.7k	1
R44	4.7k	1
R5	22	1
R6	0.51ohm, 1/2W	1
Rc1	680	1
Rc2	1k	1
Rc3	10k	1
Rc4	2.4k, 1%	1
Rc5	2.4k, 1%	1
Rf1	10	1
RT1	S235/5	1
T1	ER28 Transformer	1
VR1	S07K275	1
ZDf1	5V1	1

Transformer construction:

Layer No.	Start	Stop	No. of Turns	Wire Size	
9	7	9	22	1 x Φ0.28mm	Primary
8	12	11	3	1 x Φ0.28mm	Secondary
7	14	10	11	1 x Φ0.28mm	
6	14	13	5	3 x Φ0.28mm	
5	15	14	5	3 x Φ0.28mm	
4	16	17	5	3 x Φ0.28mm	
3	18	17	3	8 x Φ0.28mm	
2	2	1	8	1 x Φ0.28mm	Primary
1	5	7	22	1 x Φ0.28mm	
Core Inside					

Core: ER28/N67
Primary Inductance, Lp=269µH, measured between pin 5 and pin 9
(Gapped to Inductance)

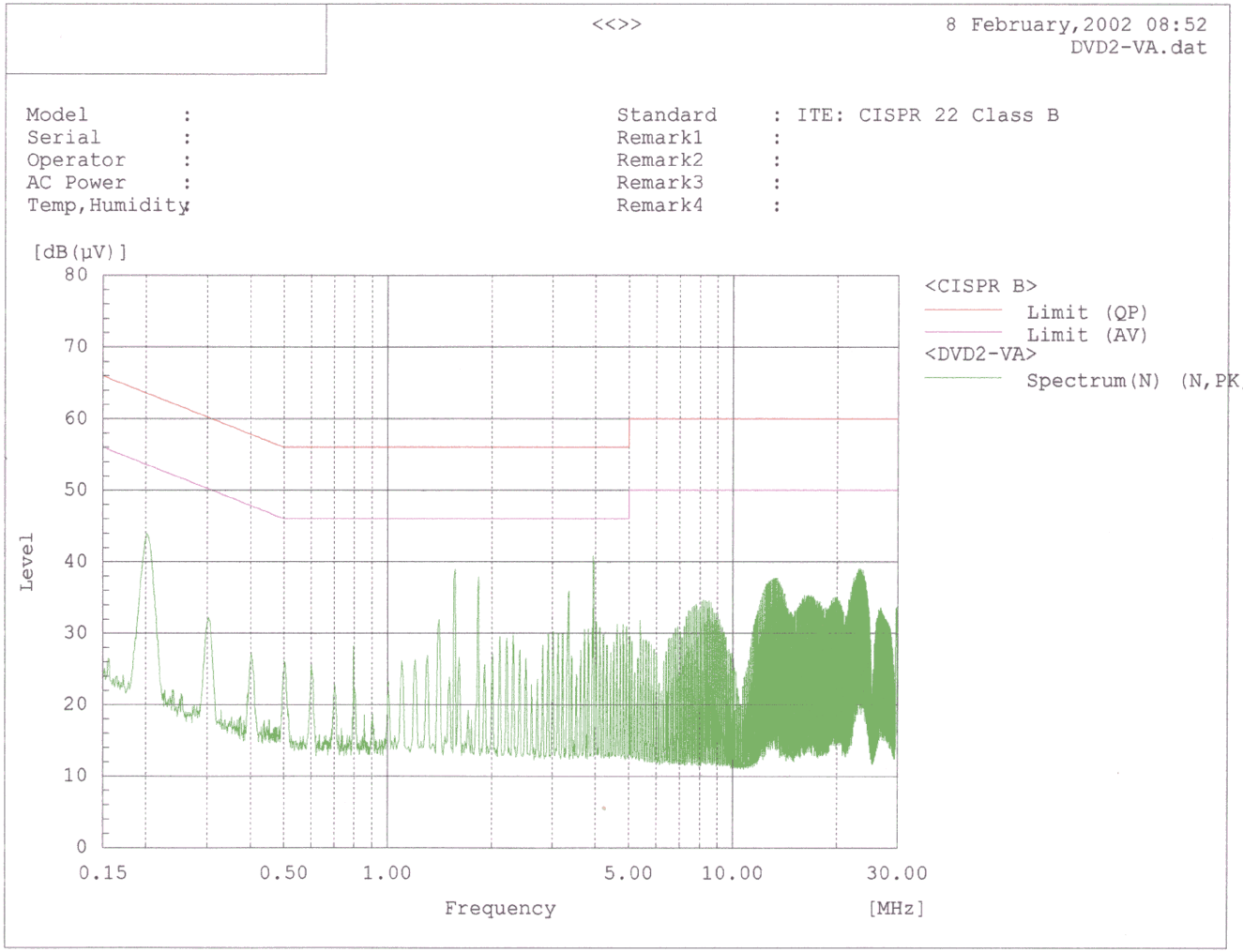
Test report:

full load	5V/1.3A, 3.3V/0.7A, A+5V/0.3A, +9V/0.2A, M+9V/0.6A, -9V/0.2A, -25V/0.03A, F+4.5V/0.1A, STB+5V/0.03A
med load	5V/0.6A, 3.3V/0.4A, A+5V/0.2A, +9V/0.1A, M+9V/0.3A, -9V/0.1A, -25V/0.03A, F+4.5V/0.1A, STB+5V/0.03A
light load	5V/0.2A, 3.3V/0.2A, A+5V/0.1A, +9V/0.1A, M+9V/0A, -9V/0.1A, -25V/0.03A, F+4.5V/0.1A, STB+5V/0.03A

Load Test															
Vin(V)		Pin(w)	SMPS Po(W) (Excluding Regulators)	Total Po(w) (Including Regulators)	Vo1 (+5V)	Vo2 (+3.3V)	Vo3 (A+5V)	Vo4 (+9V)	Vo5 (M+9V)	Vo6 (-9V)	Vo7 (-25V)	Vo8 (F4.5V)	Vo9 (STB+5V)	SMPS Efficiency (Excluding Regulators)	Total Efficiency (Including Regulators)
85	full load	32.8	22.87	20.53	4.92	3.26	4.92	8.85	9	-9.22	-25.51	4.42	4.96	70%	63%
	med load	17.3	12.46	11.01	4.97	3.27	4.92	8.78	8.9	-9.16	-23.41	4.16	4.99	72%	64%
	light load	7.8	5.77	5.07	5	3.28	4.93	8.56	9.5	-8.7	-21.75	3.84	5	74%	65%
110	full load	31.2	22.86	20.53	4.92	3.26	4.92	8.83	9	-9.22	-25.58	4.43	4.96	73%	66%
	med load	16.9	12.44	11.00	4.97	3.27	4.92	8.68	8.9	-9.16	-23.49	4.16	4.99	74%	65%
	light load	7.6	5.78	5.07	5	3.28	4.93	8.58	9.5	-8.72	-21.79	3.84	5	76%	67%
220	full load	29.8	22.90	20.55	4.92	3.26	4.92	8.86	9	-9.25	-25.97	4.46	4.96	77%	69%
	med load	16.4	12.49	11.03	4.97	3.27	4.92	8.8	8.9	-9.2	-23.65	4.20	4.99	76%	67%
	light load	7.9	5.78	5.07	5.01	3.28	4.93	8.6	9.6	-8.7	-21.66	3.81	5.01	73%	64%
265	full load	29.9	22.92	20.57	4.92	3.26	4.92	8.88	9	-9.28	-26.08	4.49	4.96	77%	69%
	med load	16.5	12.47	11.02	4.97	3.27	4.92	8.8	8.9	-9.17	-23.46	4.18	4.99	76%	67%
	light load	8.2	5.78	5.07	5.01	3.29	4.93	8.6	9.7	-8.7	-21.64	3.79	5.01	70%	62%

Standby Test:															
stby load: STB+5V/0.03A only															
Vin(V)		Pin(w)	SMPS Po(W) (Excluding Regulators)	Total Po(w) (Including Regulators)	Vo1 (+5V)	Vo2 (+3.3V)	Vo3 (A+5V)	Vo4 (+9V)	Vo5 (M+9V)	Vo6 (-9V)	Vo7 (-25V)	Vo8 (F4.5V)	Vo9 (STB+5V)	SMPS Efficiency (Excluding Regulators)	Total Efficiency (Including Regulators)
85	stby load	0.5	0.16	0.16	0	0	0	0	9.1	0	-23.87	6.40	5.04	32%	32%
110	stby load	0.5	0.16	0.16	0	0	0	0	9.1	0	-23.71	6.30	5.05	32%	32%
220	stby load	0.8	0.16	0.16	0	0	0	0	9.3	0	-24.64	6.68	5.11	20%	20%
265	stby load	0.9	0.16	0.16	0	0	0	0	9.3	0	-24.42	6.54	5.11	18%	18%

Conducted EMI spectrum at 240VAC input



References:

[1] Harald Zöllinger and Rainer Kling, ICE2AXXX for OFF-Line Switch Mode Power Supplies (SMPS), Application Note, Infineon Technologies.

[2] CoolSET™-II Off-line SMPS Current Mode Controller with High Voltage 650V/800V CoolMOS™ on Board Datasheet, Infineon Technologies.