iW1706-00 for 9V600mA Network Adapter Design

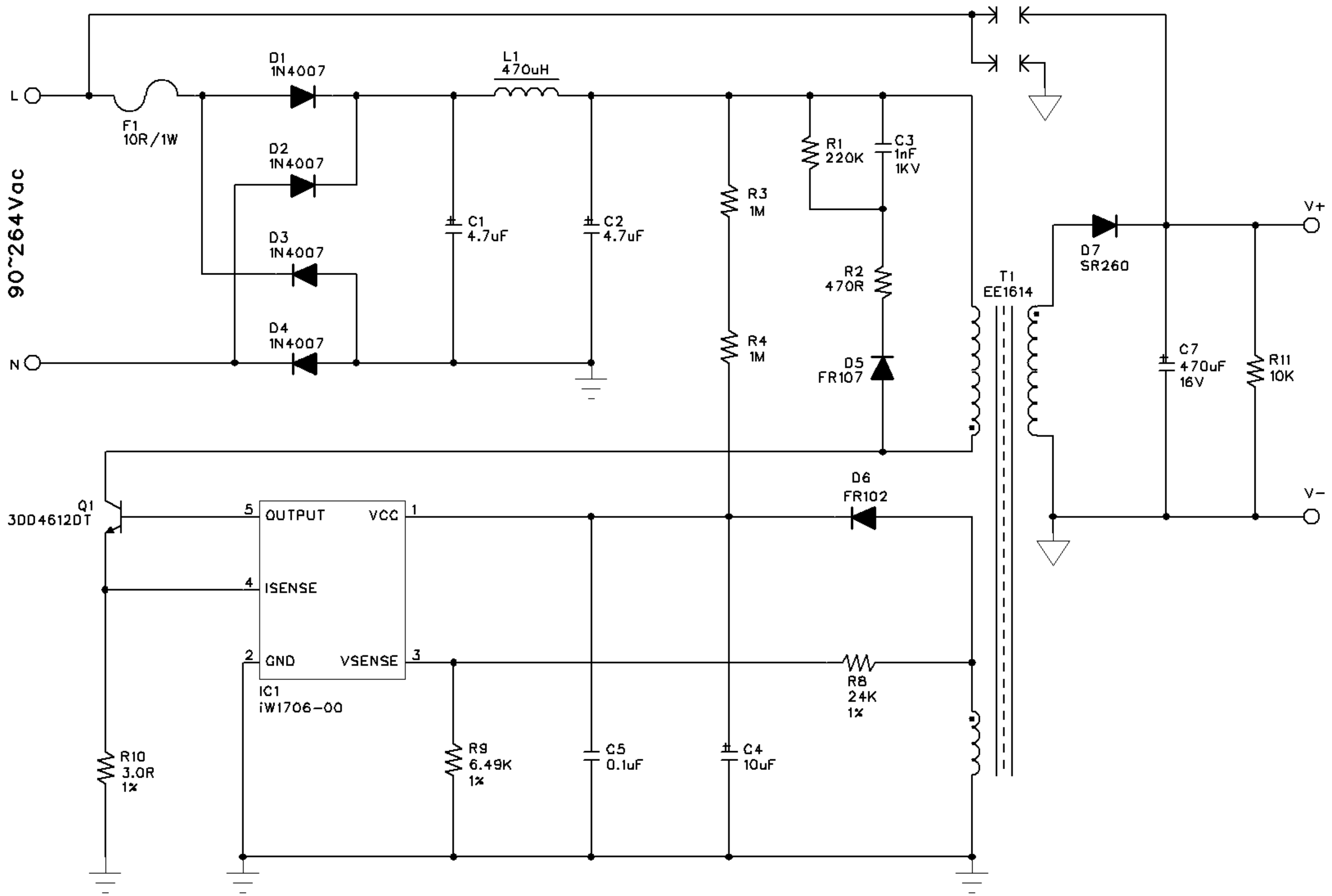
General Design Specification :

1. AC Input Range 90-264Vac
2. DC Output 9V,600mA
3. Meet *"150mW"* No-Load Standby Power Consumption Requirement
4. Meet *"EPA_2.0"* Requirement at end of Output DC-Cable
5. Max Ripple <200mV$_{P_P}$
6. No Y-CAP Design

1. Specification

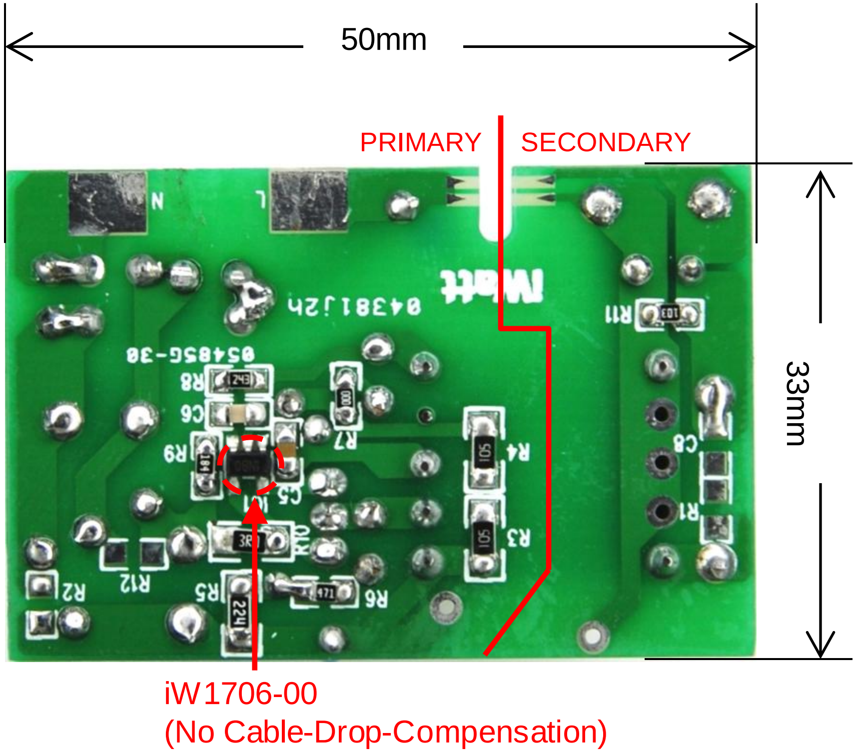
Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	90		264	V_{AC}	2 Wire
Frequency	f_{LINE}	63	50/60	47	Hz	
No-load Input Power (230V_{AC})				150	mW	
Output						
Output Voltage	V_{OUT}	8.55	9.00	9.45	V	Measured at the end of Output DC-Cable
Output Current	I_{OUT}	0		0.6	A	
Output Ripple Voltage	V_{RIPPLE}			200	mV_{P_P}	Measured at the end of Output DC-cable I_{OUT}=0.6A @T_A = 25 ℃ 20 MHz Bandwidth
Total Output Power						
Continuous Output Power	P_{OUT}	5.4			W	
Over Current Protection	*OCP*			0.9	A	Auto-restart
Active Mode Efficiency (Meet EPA2.0 Requirement)	η	72.8			%	Measured at end of Output DC-Cable, V_{IN} = 115VAC and 230VAC (T_{AMB} = 25 ℃).
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Safety		Designed to meet IEC950, UL1950 Class II				
Ambient Temperature	T_{AMB}	0		40	° C	Free convection, sea level

2. Schematic



L
N
90~264Vac
F1
10R/1W
D1
1N4007
D2
1N4007
D3
1N4007
D4
1N4007
L1
470uH
C1
4.7uF
C2
4.7uF
R3
1M
R4
1M
R1
220K
C3
1nF
1KV
R2
470R
D5
FR107
T1
EE1614
D7
SR260
C7
470uF
16V
R11
10K
V+
V-
Q1
3DD4612DT
5
OUTPUT
VCC
1
4
ISENSE
2
GND
VSENSE
3
IC1
iW1706-00
D6
FR102
R8
24K
1%
R9
6.49K
1%
C5
0.1uF
C4
10uF
R10
3.0R
1%

3. Circuit Board Photograph



4. Bill of Material

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Item	Qty.	Ref.	Description
1	1	IC1	iW1706-00, Off-line Digital PSR & PWM & VMS Controller, SOT23-5
2	2	C1,C2	4.7uF/400V, E-Cap, Φ8mmX12mm
3	1	C3	1nF/1KV, Ceramic Capacitor
4	1	C4	10uF/50V,Low ESR E-Cap, Φ5mmX11.5mm
5	1	C5	0.1uF/25V, X7R, SMD-0603
6	1	C7	470uF/16V, Low ESR E-Cap, Φ8mmX12mm
7	4	D1,D2,D3,D4	1N4007, 1A1000V, Rectifier Diode, DO-41
8	1	D5	FR107, 1A1000V, Fast Recovery Rectifier (Trr=500nS), DO-41
9	1	D6	FR102 1A100V, Fast Recovery Rectifier (Trr=150nS), DO-41
10	1	D7	SR260, 2A60V, Schottky Diode, DO-15
11	1	L1	470uH, Color Ring Inductor, 0510
12	2	R3,R4	1MΩ ±5%, SMD-1206
13	1	R1	220KΩ±5%, SMD-1206
14	1	R2	470Ω±5%, SMD-0805
15	1	R8	24KΩ±1%, SMD-0805
16	1	R9	6.49KΩ±1%, SMD-0603
17	1	R10	3.0Ω ±1%, SMD-0805
18	1	R11	22KΩ±5%, SMD-0805
19	1	F1	10Ω, Fusible Resistor, 1W
20	1	Q1	3DD4612DT, 1.5A800V, NPN Transistor, TO-92
21	1	T1	EE1614, Horizontal Taye
22	1	PCB	Single Side Board, 94V0

5. Transformer Design

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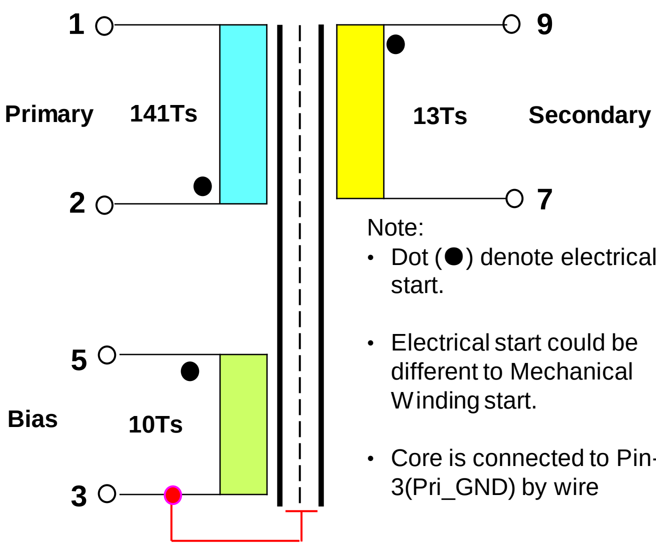
SCHEMATIC

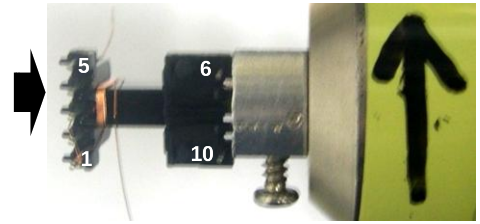


Note:
- Dot (●) denote electrical start.
- Electrical start could be different to Mechanical Winding start.
- Core is connected to Pin-3(Pri_GND) by wire

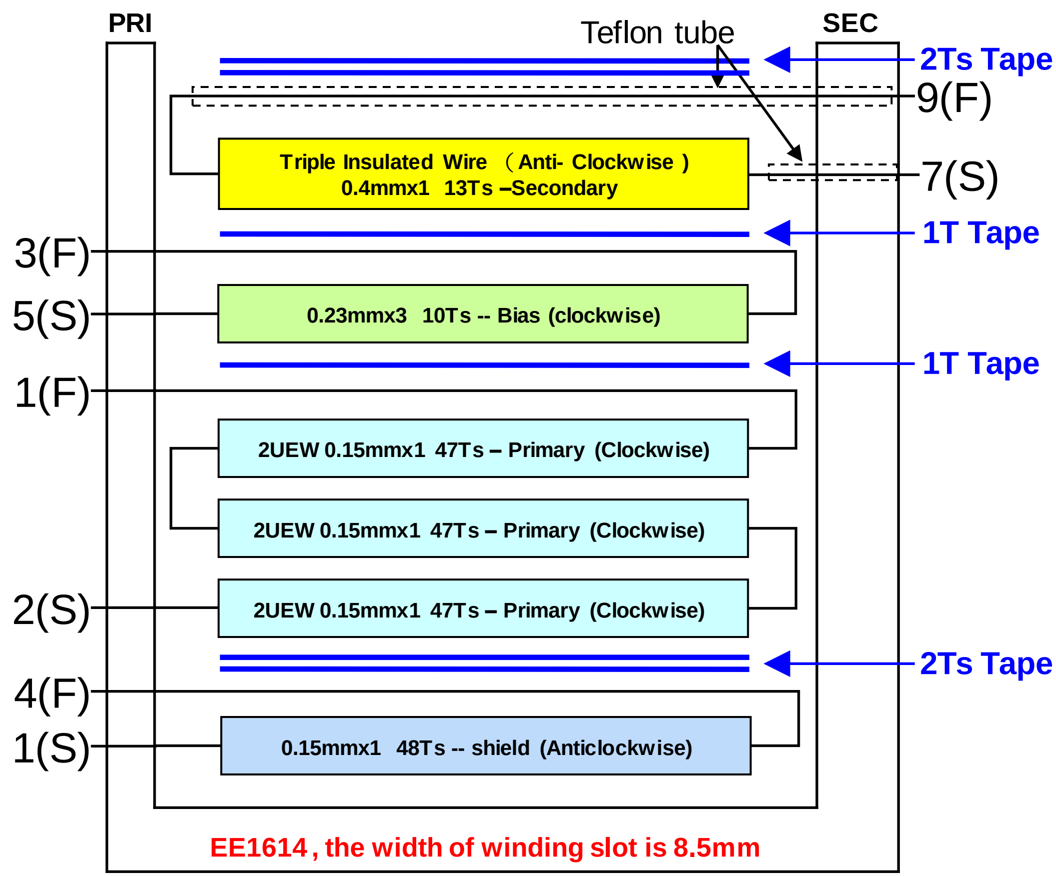
Core to be connected to Pin-3

Instruction for start of first winding…

Winding Start pin-1 & End pin-4 in "Clockwise" direction – looking from Pin 1/5side of the Bobbin.



Rotating direction of winding machine



ELECTRICAL SPECIFICATIONS:

1. Primary Inductance (Lp) =2.3mH±7% @10KHz
2. Primary Leakage Inductance (L_K) <5%*Lp
3. Electrical Strength = 3KV, 50/60Hz,1Min

MATERIALS:

1. Core : EE16 (Ferrite Material TDK PC40 or equivalent)
2. Bobbin : EE1614 Horizontal.
3. Magnet Wires (Pri) : Type 2-UEW
4. Magnet Wire (Sec) : Triple Insulated Wires
5. Layer Insulation Tape :3M1298 or equivalent.

FINISHED :

1. Varnish the complete assembly

6. Regulation, Ripple and Efficiency Measurement

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* Note: Output voltage is measured at PCB Terminal.

V_{IN} (V_{AC})	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (mA)	V_{RIPPLE} (mV_{P-P})	P_{OUT} (W)	η (%)	OCP (mA)	Average η(%)
90	0.065	9.10	0	20			669	76.85
	1.74	9.10	150	50	1.37	78.45		
	3.52	9.11	300	62	2.73	77.64		
	5.41	9.13	450	74	4.11	75.92		
	7.27	9.14	600	176	5.48	75.39		
115	0.070	9.09	0	18			676	78.89
	1.75	9.10	150	48	1.36	77.99		
	3.42	9.11	300	56	2.73	79.89		
	5.18	9.13	450	74	4.11	79.29		
	7.00	9.14	600	82	5.49	78.37		
230	0.105	9.08	0	18			689	77.19
	1.88	9.10	150	64	1.36	72.44		
	3.54	9.11	300	64	2.73	77.24		
	5.19	9.13	450	62	4.11	79.14		
	6.86	9.14	600	92	5.48	79.95		
264	0.115	9.13	0	20			690	75.57
	1.94	9.09	150	48	1.36	70.46		
	3.63	9.11	300	50	2.73	75.29		
	5.29	9.13	450	64	4.11	77.64		
	6.95	9.14	600	82	5.48	78.91		

7. EPA_2.0 Requirement

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Table 1: Energy-Efficiency Criteria for Ac-Ac and Ac-Dc External Power Supplies in Active Mode: Standard Models

Nameplate Output Power (P_{no})	Minimum Average Efficiency in Active Mode (expressed as a decimal) [2]
0 to ≤ 1 watt	≥ 0.480 * P_{no} + 0.140
> 1 to ≤ 49 watts	≥ [0.0626 * Ln (P_{no})] + 0.622
> 49 watts	≥ 0.870

Table 2: Energy-Efficiency Criteria for Ac-Ac and Ac-Dc External Power Supplies in Active Mode: Low Voltage Models

Nameplate Output Power (P_{no})	Minimum Average Efficiency in Active Mode (expressed as a decimal) [2]
0 to ≤ 1 watt	≥ 0.497 * P_{no} + 0.067
> 1 to ≤ 49 watts	≥ [0.0750 * Ln (P_{no})] + 0.561
> 49 watts	≥ 0.860

EPA2.0 (Final) for Low Voltage Model (P_{no}=3.75W)

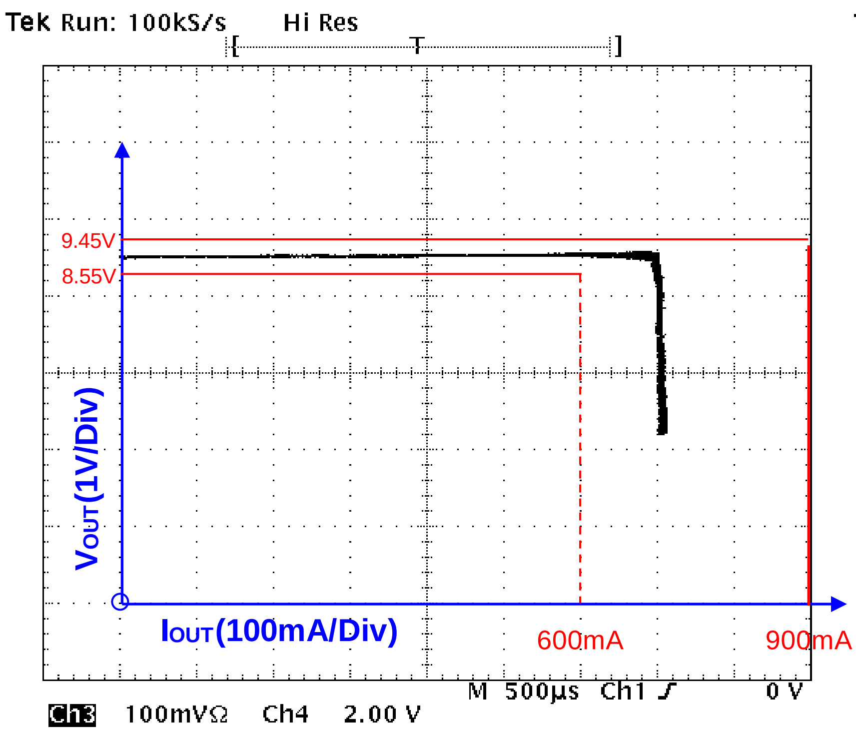
$$0.0626 \times Ln(5.4W) + 0.622 = 72.8\%$$

Meet EPA2.0 with lots of Margin!

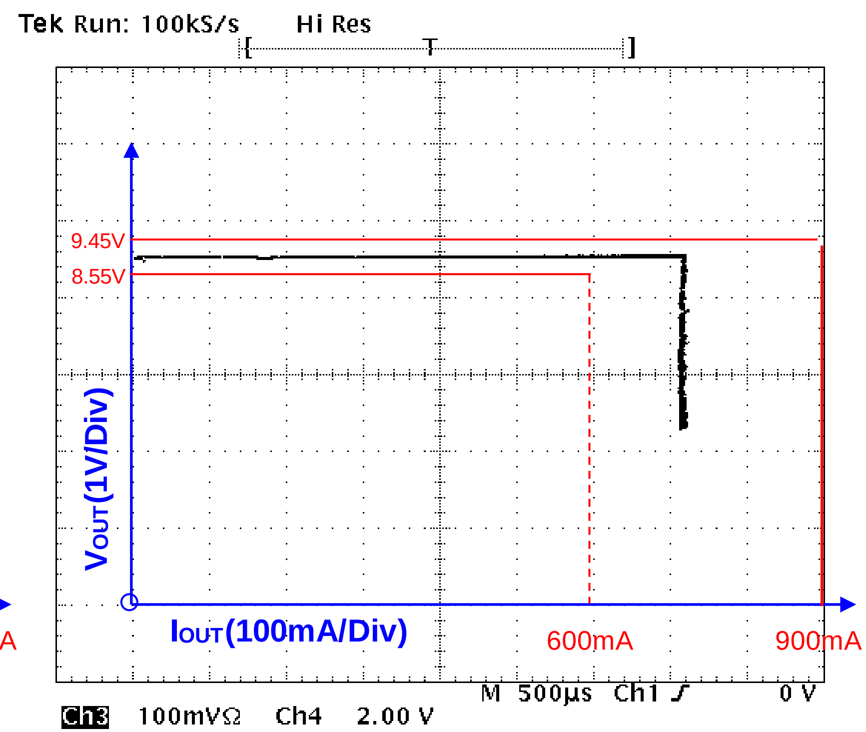
V_{IN} (VAC)	I_{OUT} (mA)	P_{IN} (W)	Measure at end of PCB				Measure at end of Cable 26AWG/1.8m, R_{Cable}=0.51Ω			
			$V_{OUT\ PCB}$ (V)	$P_{OUT\ PCB}$ (W)	EFF_{PCB} (%)	$AV\text{-}EFF_{PCB}$ (%)	$V_{OUT\ Cable}$ (V)	$P_{OUT\ Cable}$ (W)	EFF_{Cable} (%)	$AV\text{-}EFF_{Cable}$ (%)
115	150	1.770	9.24	1.39	78.31	79.51	9.16	1.37	77.66	77.87
	300	3.440	9.25	2.78	80.67		9.10	2.73	79.33	
	450	5.210	9.26	4.17	79.98		9.03	4.06	78.00	
	600	7.040	9.28	5.57	79.09		8.97	5.38	76.48	
230	150	1.870	9.24	1.39	74.12	78.39	9.16	1.37	73.50	76.75
	300	3.540	9.26	2.78	78.47		9.11	2.73	77.18	
	450	5.200	9.26	4.17	80.13		9.03	4.06	78.15	
	600	6.880	9.27	5.56	80.84		8.96	5.38	78.17	

8. Output VI Characteristics

V_{IN}=90Vac/50Hz

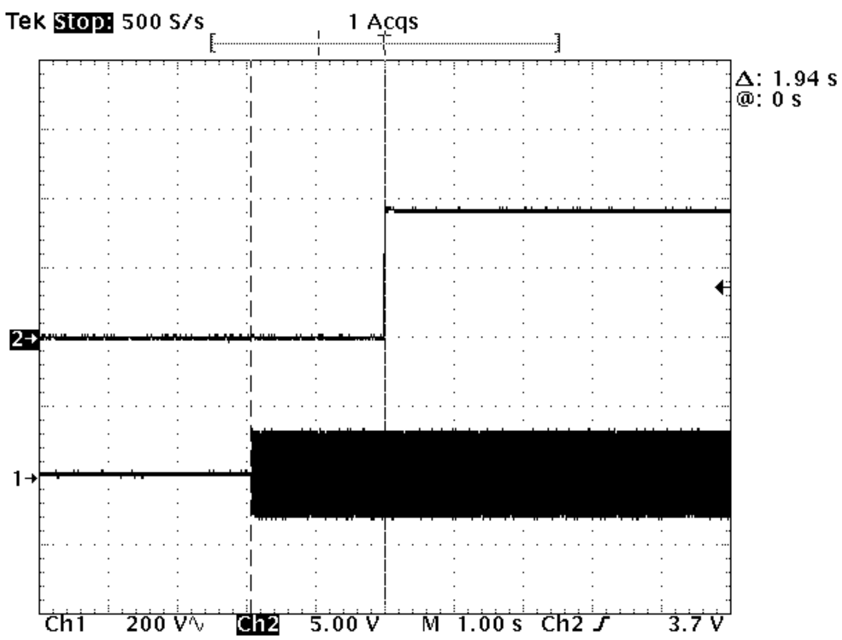


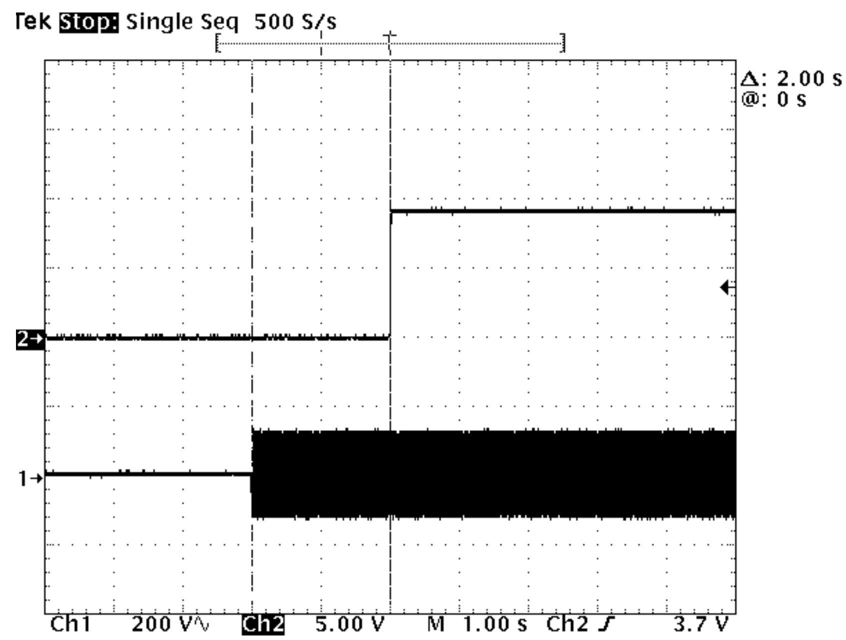
V_{IN}=264Vac/50Hz



Note: Output voltage is monitored at end of PCB

9. Turn-On Delay Time





90VAC,No Load

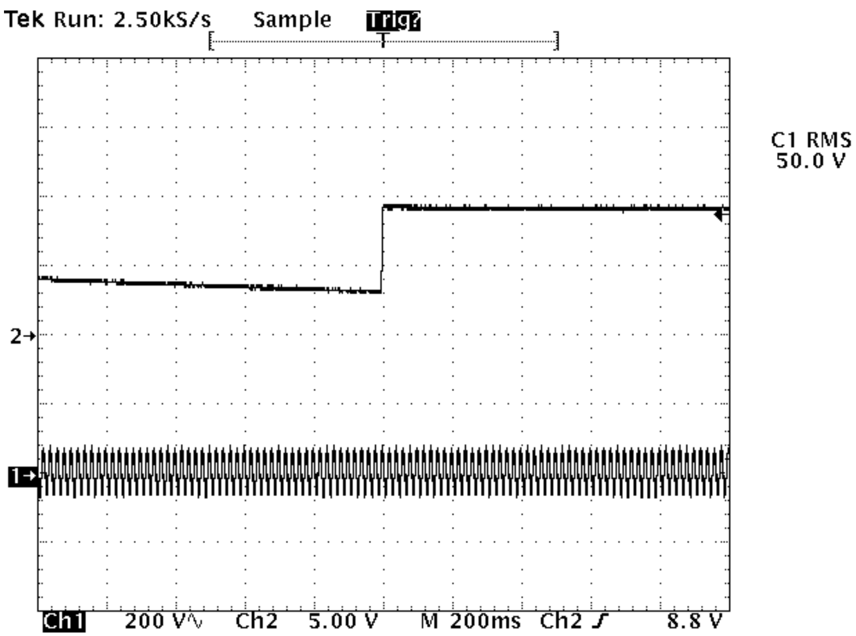
TST_DELAY=1.94S

90VAC,Full Load

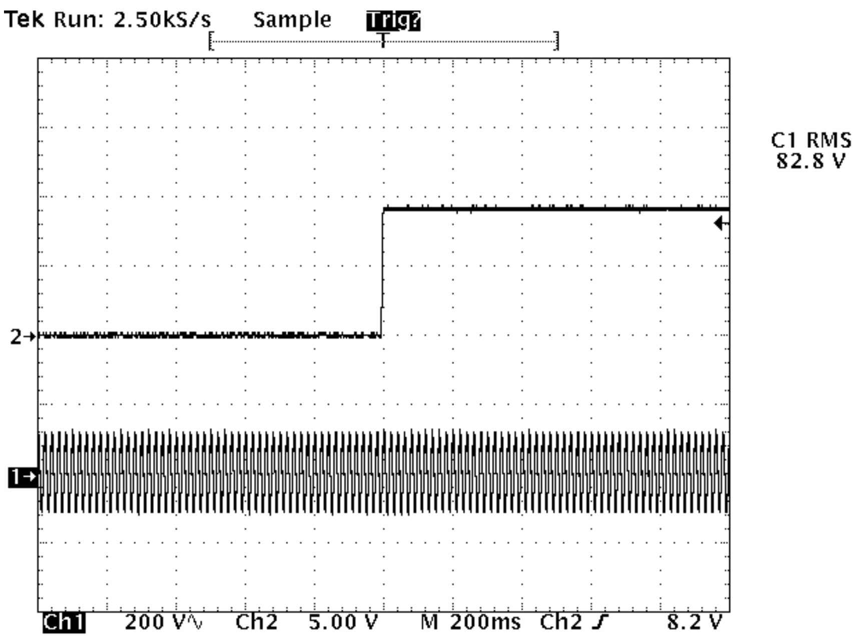
TST_DELAY=2.0S

10. AC Startup Voltage Characteristic

No Load, $V_{IN\_STARTUP}$ =50V_{AC}



Full Load, $V_{IN\_STARTUP}$=82.8V_{AC}



11. AC Brownout Voltage Characteristic

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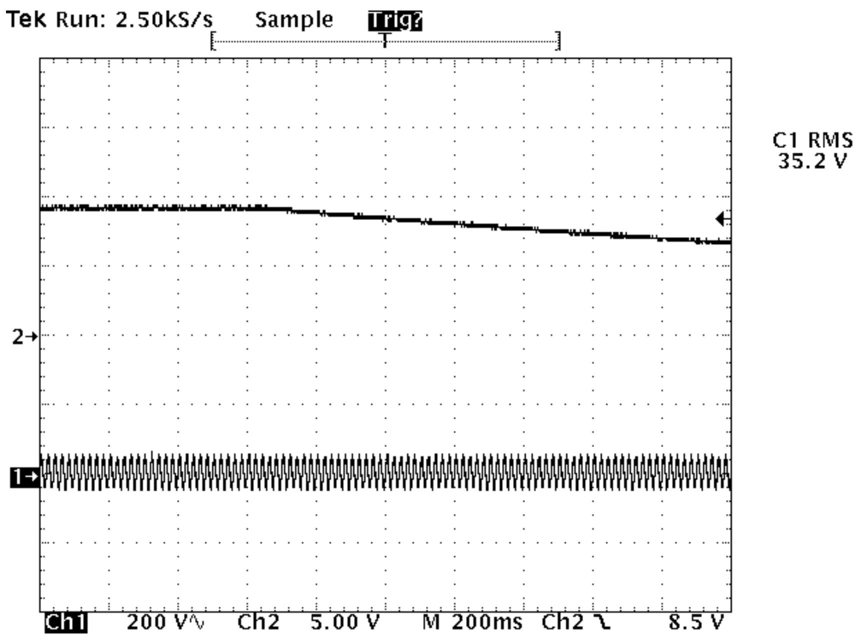
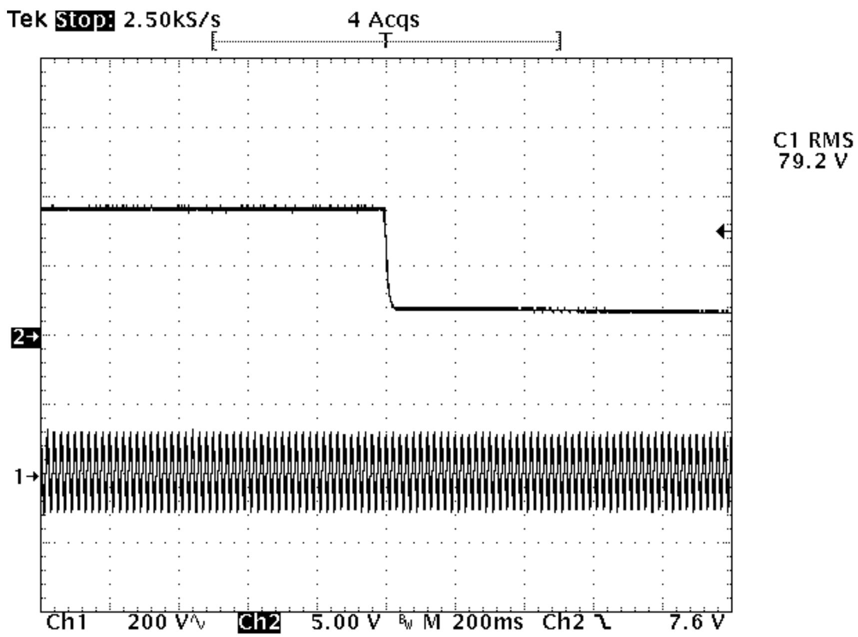
No Load, $V_{IN\_BROWNOUT}$ =35.2V_{AC}



Full Load, $V_{IN\_BROWNOUT}$=79.2V_{AC}



12. Transformer Flux Density

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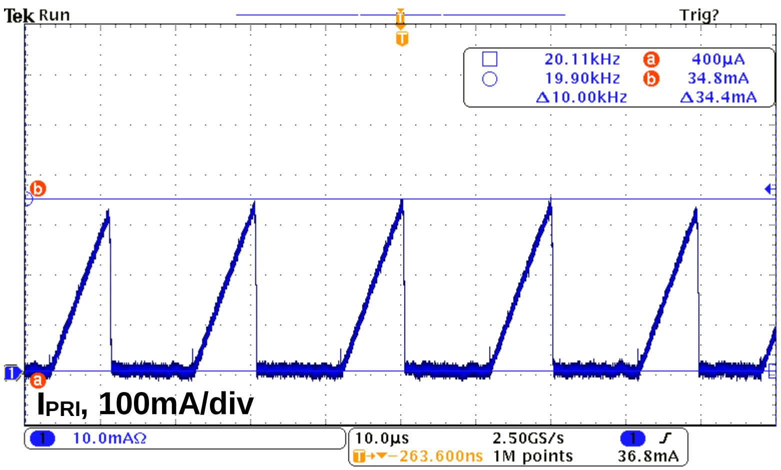
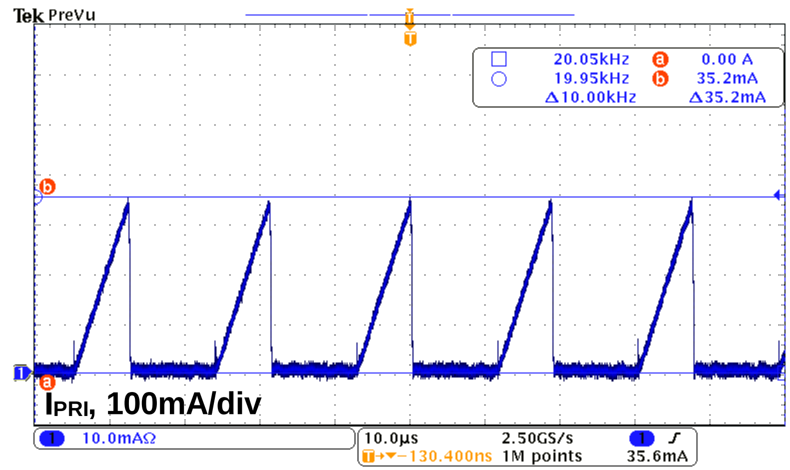
(N_P=141Ts, L_{P_MAX}=2.46mH, Ae=19.1mm^2-EE1614)





I_{PRI} is monitored at 90Vac and *600mA* load

I_{PRI} =344mA

B_{MAX} =(I_{PRI} *L_{P_MAX}) / (N_P*A_E)

=(344*2.46) / (141*19.1)

=0.314Tesla

I_{PRI} is monitored at 90Vac and 7*00mA* load (Max Output Power).

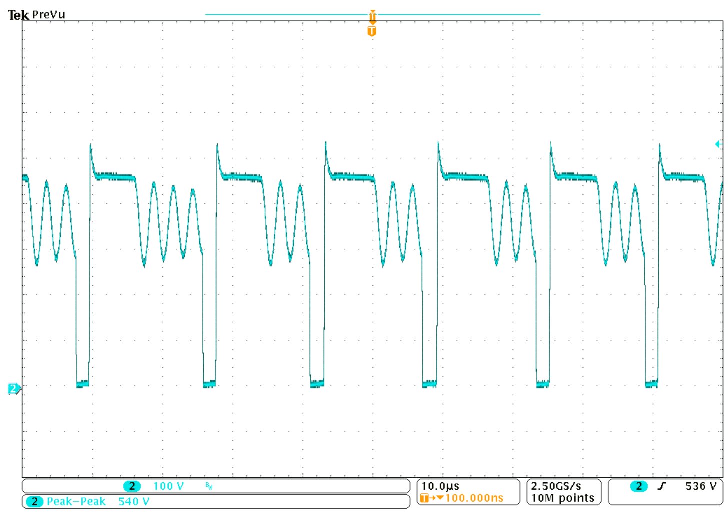
I_{PRI} =352mA

B_{MAX} =(I_{PRI} *L_{P_MAX}) / (N_P*A_E)

=(352*2.46) / (128*19.1)

=0.322 Tesla

13. V_{CE} Waveform



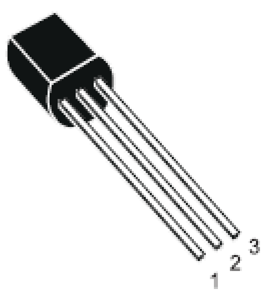
Test Condition:

V_{IN}=264V_{AC}, I_{OUT_CV}=600mA

Result:

V_{CE_MAX}=540V

Appendix – Simple Specification for used Transistor(3DD4612DT)

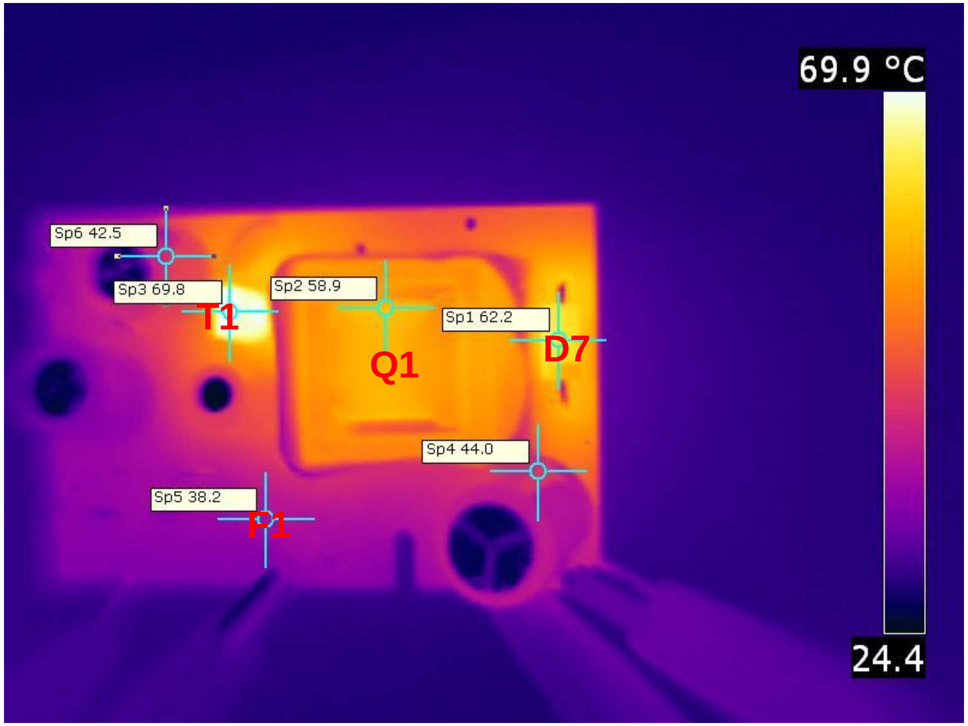


TO-92

Except for Other Prescription, T_a= 25℃

Parameter Note		Symbol	Rating	Unit
Collector-Base Breakdown Voltage		V_{CBO}	800	V
Collector-Emitter Breakdown Voltage		V_{CEO}	450	V
Emitter-Base Breakdown Voltage		V_{EBO}	9	V
Collector Current		I_C	1.5	A
Power Dissipation	T_a=25℃	P_{tot}	0.8	W
Junction Temperature		T_j	150	℃
Storage Temperature		T_{stg}	−55～150	℃

14. Thermal Test for Critical Components



Item	V_{IN}=90Vac, I_{OUT}=0.6A		V_{IN}=264Vac, I_{OUT}=0.6A	
	Temp.(℃)	Rising Temp. (℃)	Temp.(℃)	Rising Temp. (℃)
Input Fuse(F1)	54.2	28.5	38.2	13.8
Transformer(T1)	58.6	32.9	58.9	34.5
Power Transistor(Q1, 3DD4612DT	81.9	56.2	69.8	45.4
Output Schotty Diode(D7,SR260)	68.6	42.9	62.2	37.8
U1(iW1706-00)	65.7	40.0	51.5	27.1
Ambient (Chamber) Temp.	25.7		24.4	

15. Conducted EMI

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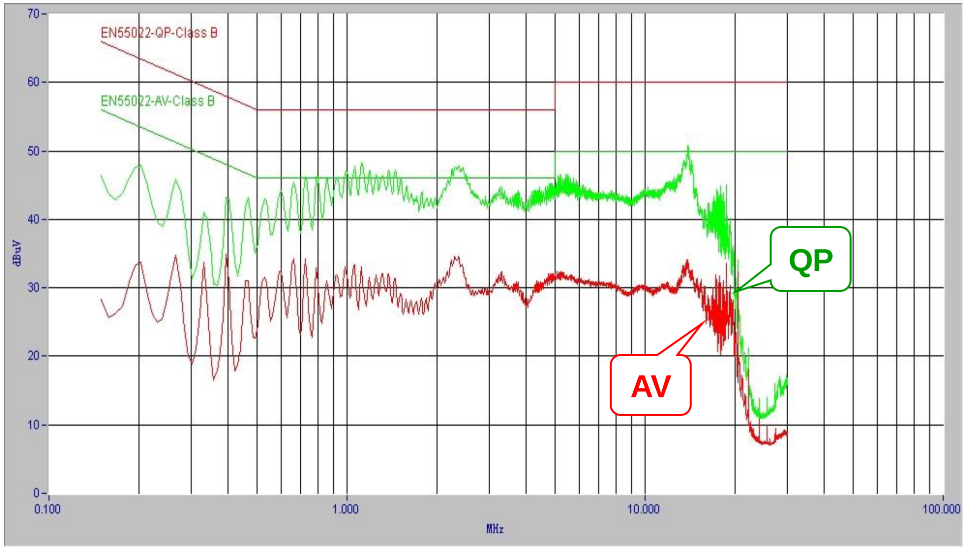
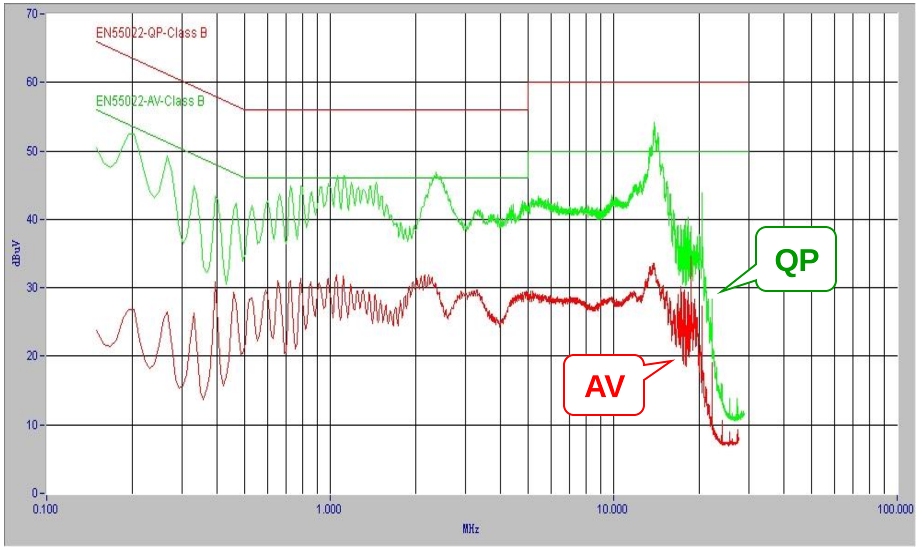
V_{IN}=230Vac/50Hz, Live



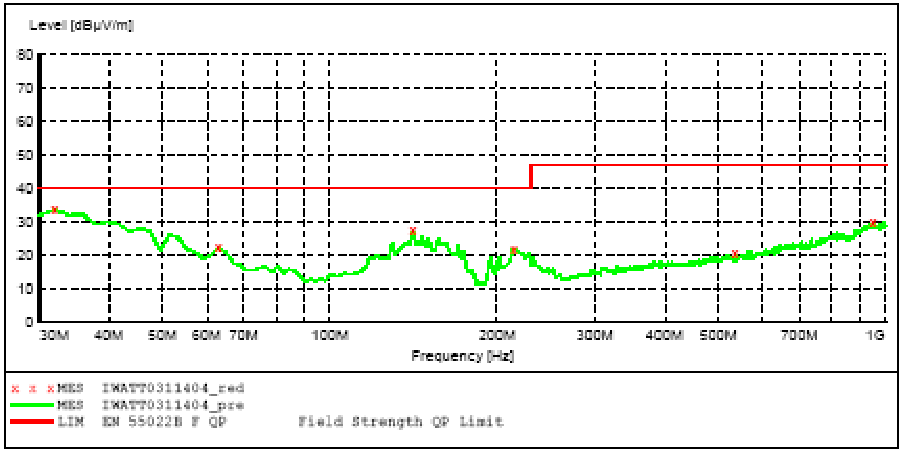
V_{IN}=230Vac/50Hz, Neutral



Note: Resistive & Full load; output (-) is connected to Earth.

16. Radiated EMI

Vin=230Vac/50Hz, HORIZONTAL

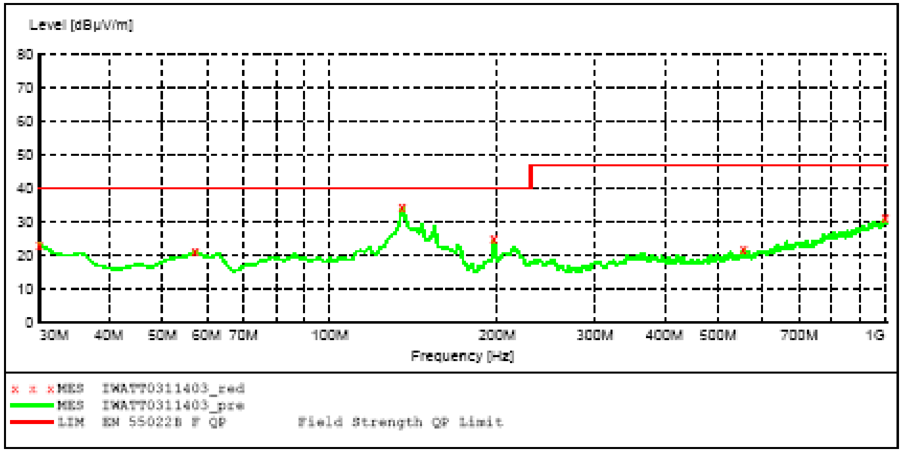


MEASUREMENT RESULT: "IWATT0311404_red"

3/11/2011 2:02PM

Frequency MHz	Level dBµV/m	Transd dB	Limit dBµV/m	Margin dB	Det.	Height cm	Azimuth deg	Polarization
31.943888	33.60	-11.2	40.0	6.4	---	100.0	77.00	VERTICAL
63.046092	22.40	-24.9	40.0	17.6	---	100.0	29.00	VERTICAL
140.801603	27.30	-21.3	40.0	12.7	---	100.0	0.00	VERTICAL
214.669339	22.00	-21.0	40.0	18.0	---	100.0	173.00	VERTICAL
535.410822	20.60	-13.9	47.0	26.4	---	100.0	220.00	VERTICAL
947.515030	30.00	-5.2	47.0	17.0	---	100.0	62.00	VERTICAL

Vin=230Vac/50Hz, VERTICAL



MEASUREMENT RESULT: "IWATT0311403_red"

3/11/2011 2:00PM

Frequency MHz	Level dBµV/m	Transd dB	Limit dBµV/m	Margin dB	Det.	Height cm	Azimuth deg	Polarization
30.000000	23.40	-10.2	40.0	16.6	---	300.0	97.00	HORIZONTAL
57.214429	21.00	-24.1	40.0	19.0	---	300.0	320.00	HORIZONTAL
134.969940	34.60	-20.4	40.0	5.4	---	300.0	73.00	HORIZONTAL
197.174349	25.00	-21.5	40.0	15.0	---	100.0	156.00	HORIZONTAL
554.849699	22.10	-13.3	47.0	24.9	---	100.0	200.00	HORIZONTAL
998.056112	31.00	-4.9	47.0	16.0	---	300.0	201.00	HORIZONTAL

Note: Resistive & Full load; output (-) is floating.

17. ESD (IEC 61000-4-2)

Test condition:

V_{IN}=230VAC/50Hz, No_Load and Full_Load (Resistive Load)

Air-Discharged		Result (no-load)	Result (full-load)
15KV	+	PASS	PASS
	-	PASS	PASS
16KV	+	PASS	PASS
	-	PASS	PASS
17KV	+	PASS	PASS
	-	PASS	PASS
18KV	+	PASS	PASS
	-	PASS	PASS
19KV	+	PASS	PASS
	-	PASS	PASS
20KV	+	PASS	PASS
	-	PASS	PASS