Reference Design

EBC941

iWatt
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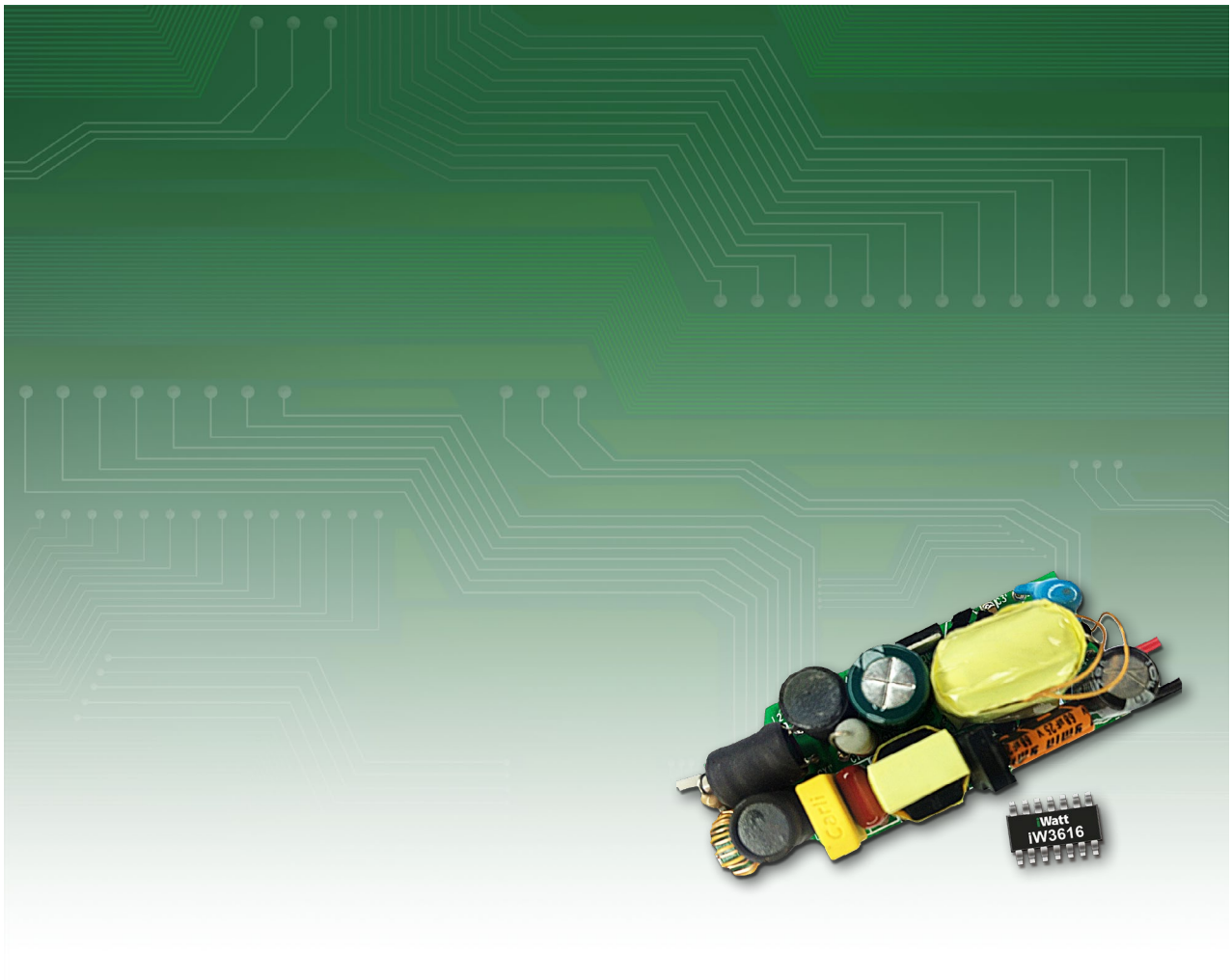

Dimmable LED Driver with iW3616-01

(AC input 180V–264V_{AC}, Output 30V 350mA)

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1.0 Introduction

This reference design describes a 9 LEDs output at 350mA current, high line input (180–264V_{AC}) power supply for phase-cut dimmable LED applications. For this design the iW3616-01 is used. This document contains the design features of the phase-cut dimmable LED driver, a detailed circuit diagram, an entire bill of materials required to build the LED driver, a drawing of the power transformer, and test data of the most important performance.

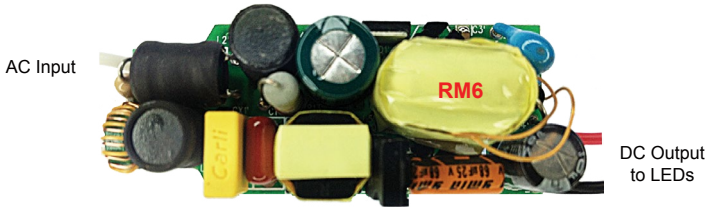


Figure 1.1 PCB Top View

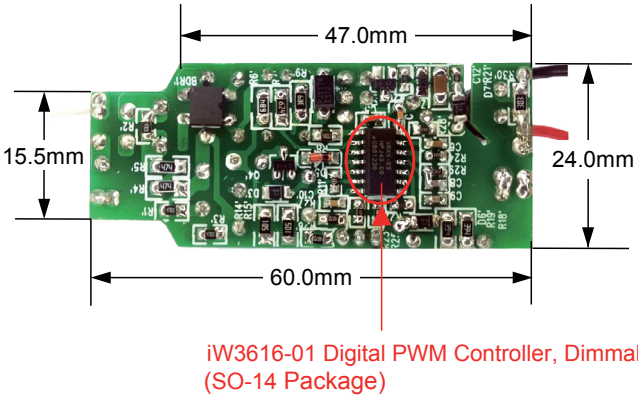


Figure 1.2 PCB Bottom View

2.0 Design Features

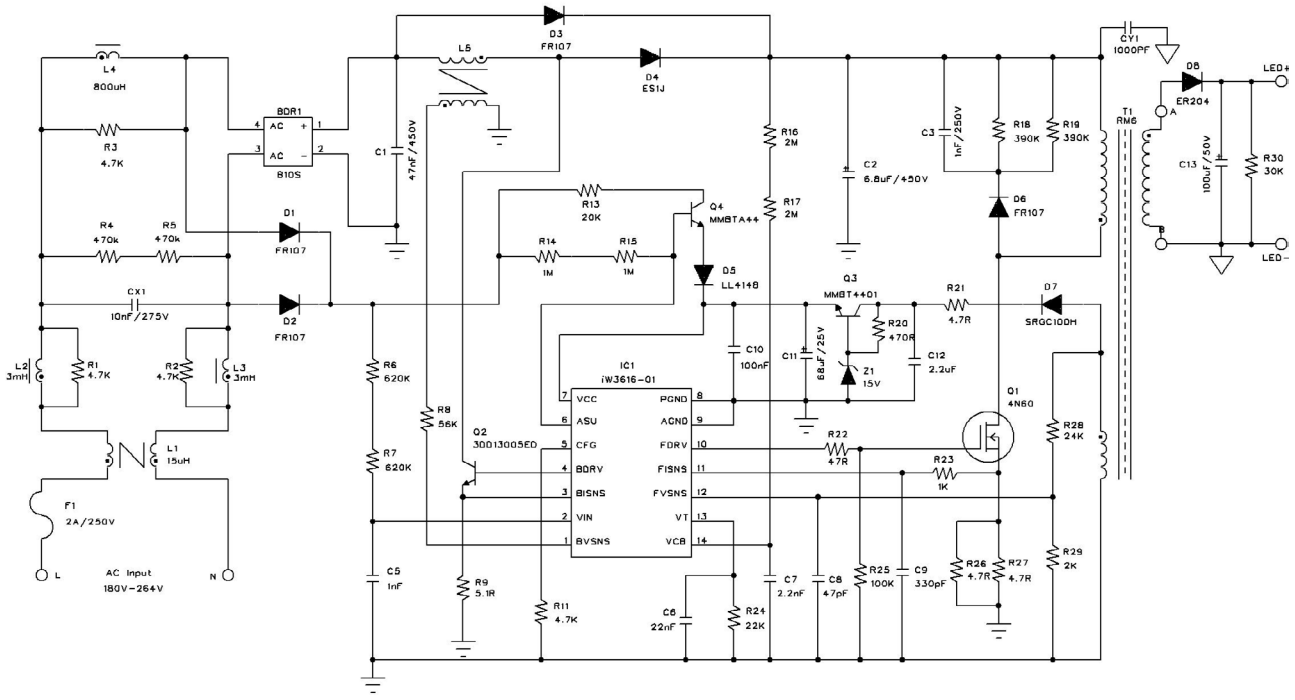
- Isolated AC/DC offline, input 230 V_{AC}
- Output 9 LEDs at 350mA
- Intelligent wall dimmer detection
  - » Leading-edge dimmer
  - » Trailing-edge dimmer
  - » No dimmer
- Multiple dimming control scheme
  - » Hybrid dimming scheme
  - » PWM dimming scheme, 630Hz
  - » Amplitude dimming scheme
- Wide dimming range from 1% up to 100%
- No visible flicker
- Resonant control to achieve high efficiency
- High Power Factor, 0.9 without dimmer
- Temperature degradation control to adjust the LED current
- Primary-only eliminates opto-isolator feedback and simplifies design

3.0 Design Specification

The information in the table below represents the minimum acceptable performance of the design.

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	180		264	V_{AC}	2 wire
Frequency	f_{LINE}	47	50/60	63	Hz	
Output						
Output voltage	V_{OUT}		30		V	Measured at the end of PCB
Output current	I_{OUT}		0.35		A	
Output ripple current	I_{RIPPLE}		30		mA_{P_P}	Set oscilloscope at 20MHz bandwidth
Total Output Power						
Continuous output power	P_{OUT}		10.5		W	
Power factor	*PF*		0.98			V_{IN} = 230V_{AC}
Efficiency	η		84		%	Measured at end of PCB V_{IN}=230V_{AC} (T_{AMB}=25°C)
Environmental						
THD	*THD*			15	%	V_{IN} = 230V_{AC}
Conducted EMI		Meets CISPR22B/EN55022B				
Safety		Designed to meet IEC950, UL1950 Class II				
Ambient temperature	T_{AMB}	0		40	°C	Free convection, sea level

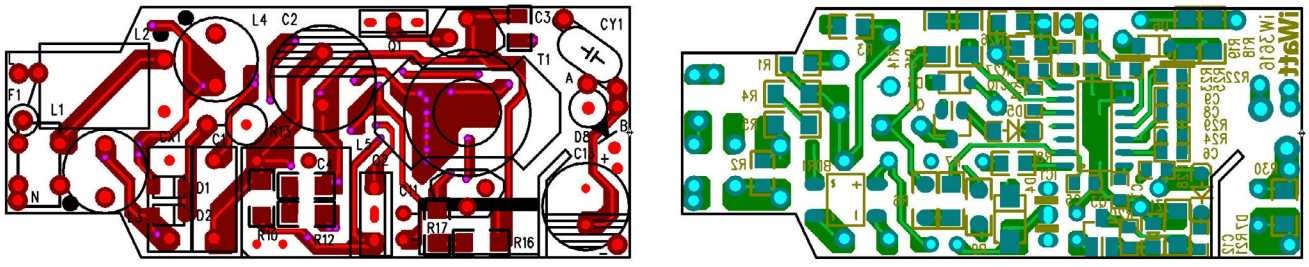
4.0 Schematic



CFG PIN5(R11)		
00	CC_PFM	0 - 6.65KΩ (4.7KΩ ±5%)
01	PWM	8.45 - 9.31KΩ(9.1KΩ±1%)

Figure 4.1 Design Schematic

5.0 PCB Layout



a) PCB Top

b) PCB Bottom

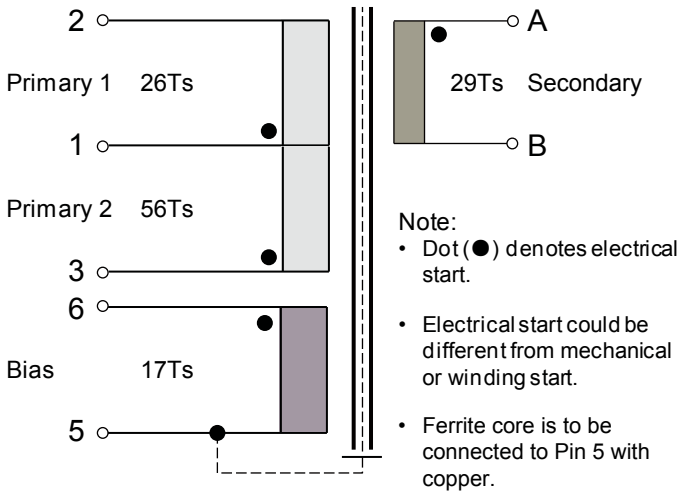
Figure 5.1 PCB Layout 60.0 mm x 24.0 mm

6.0 Bill of Materials

Item	Qty.	Ref.	Description	Manufacturer P/N	Manufacturer
1	1	IC1	iW3616-01, digital PWM controller, dimmable, SO-14	iW3616-01	iWatt, Inc
2	1	CX1	10nF, 275V, X2, P=7.5mm	GPX103K3IB19L200D9R0	Kwoktran
3	1	C1	47nF, 450V, CBB21, P=7.5mm	GPF473J2Y079L250D9R0	Kwoktran
4	1	C2	6.8µF, 450V, E-Cap	6.8MFLK450V	Yongming
5	1	C11	68µF, 25V, E-Cap	68MFLK25V	Yongming
6	1	C13	100µF, 50V, E-Cap	100MFLK50V	Yongming
7	1	C7	2.2nF, 25V, X7R, SMD-0603	06033C222KAT2A	AVX Corporation
8	1	C5	1nF, 25V, X7R, SMD-0603	06033C102JAT2A	AVX Corporation
9	1	C8	47pF, 25V, X7R, SMD-0603	06033C470KAT2A	AVX Corporation
10	1	C9	330pF, 25V, X7R, SMD-0603	06033C331KAT2A	AVX Corporation
11	1	C6	22nF,25V, X7R, SMD-0603	06033C223KAT2A	AVX Corporation
12	1	C10	100nF,25V, X7R, SMD-0603	06033C104KAT4A	AVX Corporation
13	1	C3	1nF, 250V, X7R, SMD-0805	0805PC102KAT1A	AVX Corporation
14	1	C12	2.2µF, 25V, X7R, SMD-1206	ESD63C225K4T2A-30	AVX Corporation
15	1	R11	4.7kΩ, ±5%, SMD-0603	RC0603JR-074K7L	Yageo
16	1	R21	4.7Ω, ±5%, SMD-0603	RC0603JR-074R7L	Yageo
17	1	R22	47Ω, ±5%, SMD-0603	RC0603JR-0747RL	Yageo
18	1	R20	470Ω, ±5%, SMD-0603	RC0603JR-07470RL	Yageo
19	1	R25	100kΩ, ±5%, SMD-0603	RC0603JR-07100KL	Yageo
20	1	R24	22kΩ, ±5%, SMD-0603	RC0603JR-0722KL	Yageo
21	1	R8	56kΩ, ±5%, SMD-0805	RC0805JR-0756KL	Yageo
22	3	R1,R2,R3	4.7kΩ, ±5%, SMD-0805	RC0805JR-074K7L	Yageo
23	1	R30	30kΩ, ±5%, SMD-1206	RC1206JR-0730KL	Yageo
24	2	R14,R15	1MΩ, ±5%, SMD-1206	RC1206JR-071ML	Yageo
25	2	R18,R19	390kΩ, ±5%, SMD-1206	RC1206JR-07390KL	Yageo
26	2	R4,R5	470kΩ, ±5%, SMD-1206	RC1206JR-07470KL	Yageo
27	1	R9	5.1Ω, ±1%, SMD-1206	RC1206FR-075K1L	Yageo
28	2	R6,R7	620kΩ, ±1%, SMD-1206	RC1206FR-07620KL	Yageo
29	1	R16	1.8MΩ, ±1%, SMD-1206	RC1206FR-071M8L	Yageo
30	1	R17	2MΩ, ±1%, SMD-1206	RC1206FR-072ML	Yageo
31	1	R23	1kΩ, ±1%, SMD-0603	RC0603FR-071KL	Yageo
32	1	R29	2kΩ, ±1%, SMD-0603	RC0603FR-072KL	Yageo
33	1	R28	24kΩ, ±1%, SMD-0603	RC0603FR-0724KL	Yageo
34	2	R26,R27	4.7Ω, ±1%, SMD-0805	RC0805FR-074R7L	Yageo
35	1	R13	MOF, 20kΩ, 1W	MOF20K1W	YAGEO
36	1	F1	Fuse, T2A250V	CRUPMP2A250V	GONGDE
37	1	BDR1	B10S, 0.5A, 1000V, MDI	B8S	PANJIT Semiconductor
38	1	D7	1A, 200V, fast recovery rectifier, 1206-S	WSRGC10DH	ZOWIE
39	4	D1,D2,D3,D6	1A, 1000V, fast recovery rectifier, 1206-S	WSRGC10MH	ZOWIE
40	1	D4	ES1J, 1A, 600V, SMA	ES1J	PANJIT Semiconductor
41	1	D8	ER204, 2A, 400V, DO-15	ER204	PANJIT Semiconductor
42	1	D5	LL4148, 0.15A, 100V, LL-34	LL4148	PANJIT Semiconductor
43	1	Z1	Zener, MM3Z15, 15V, SOD-323	ZMM15B	ST
44	1	Q1	4N60, 4A, 600V, TO-251	FTA04N60B	ARK
45	1	Q4	MMBTA44, NPN, 0.3A, 500V, SOT-23	MMBT4401	NXP
46	1	Q3	MMBT4401, NPN, SOT-23	MMBTA44	NXP
47	1	Q2	3DD13005ED, NPN, 4A, 700V, T0-126S	BTR13005GD	IPS
48	2	L2,L3	Drum choke, I-shaped 8X10mm, 3mH	8X10MM3MH	Xin Yuan Yang
49	1	L4	Drum choke, I-shaped 8X10mm, 800µH	2X10MM800UH	Xin Yuan Yang
50	1	L1	Common mode inductor T8*3*3 15µH	B29 T8*4*3 15UH	Xin Yuan Yang
51	1	L5	EE10, L=2.2mH	EE10	Xin Yuan Yang
52	1	CY1	Y1, 1000pF, 400V	RM6	Xin Yuan Yang
53	1	T1	Transformer, RM6, Lp=2.2mH	1000PF/400V	STE
54	1	PCB	Two-layer, 24mm*60mm		

7.0 Transformer Drawing

Schematic:



Note:
- Dot (●) denotes electrical start.
- Electrical start could be different from mechanical or winding start.
- Ferrite core is to be connected to Pin 5 with copper.

Electrical Specifications:

1.	Primary inductance (Lp) = 2.2mH @10KHz
2.	Primary leakage inductance (Lk) < 30µH @60KHz
3.	Electrical strength = 3KV, 50/60Hz, 1min

Materials:

1.	Core: RM6 (ferrite material TDK PC40 or equivalent)
2.	Bobbin: RM6 Vertical. Primary=3, Secondary=3
3.	Magnet wires (pri): type 2-UEW
4.	Magnet sire (sec): triple insulated wires
5.	Layer insulation tape: 3M1298 or equivalent

Finished:

1.	Cut remained of Pin 1, 4 after wires termination
2.	Core should be connected to PRI-GND Pin 5
3.	Varnish the complete assembly

8.0 Performance

8.1 Constant Current and Efficiency

* Note: V_{IN}=180V_{AC}-264V_{AC}/50Hz; Loading with 9LEDS 350mA

V_{IN} (V_{AC})	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (mA)	Ripple(PK) (mA)	η (%)	Power Factor	V_{bulk} (V)
180	12.75	30.37	354	17.4	84.27%	0.996	278
190	12.74	30.35	354	16.2	84.26%	0.996	302
200	12.74	30.35	354	15.8	84.33%	0.996	313
210	12.74	30.33	354	15.2	84.28%	0.996	330
220	12.72	30.32	355	14.8	84.52%	0.995	347
230	12.72	30.31	355	14.6	84.52%	0.995	357
240	12.74	30.30	355	14.2	84.50%	0.994	364
250	12.76	30.29	355	13.6	84.37%	0.993	386
264	12.73	30.28	356	13.4	84.58%	0.992	394

8.2 Harmonic and Current Waveform

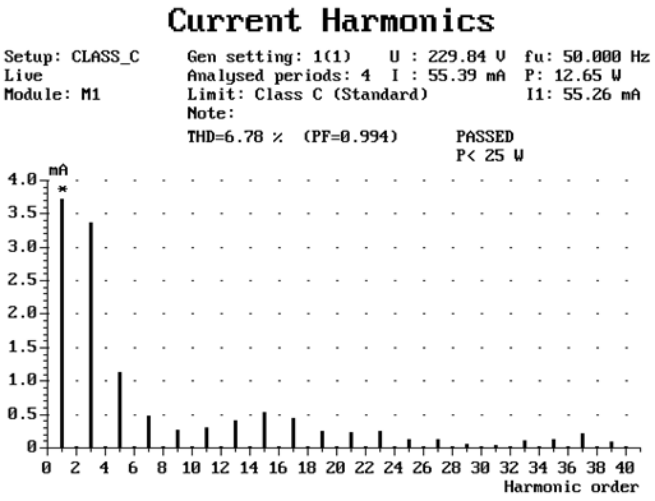


Figure 8.2.1 Current Harmonics

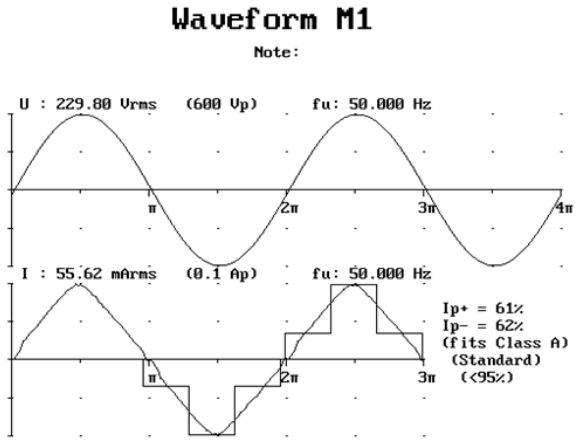
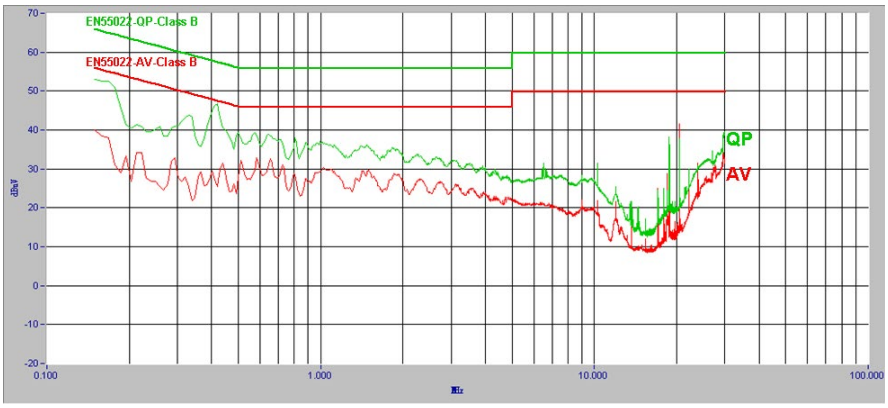


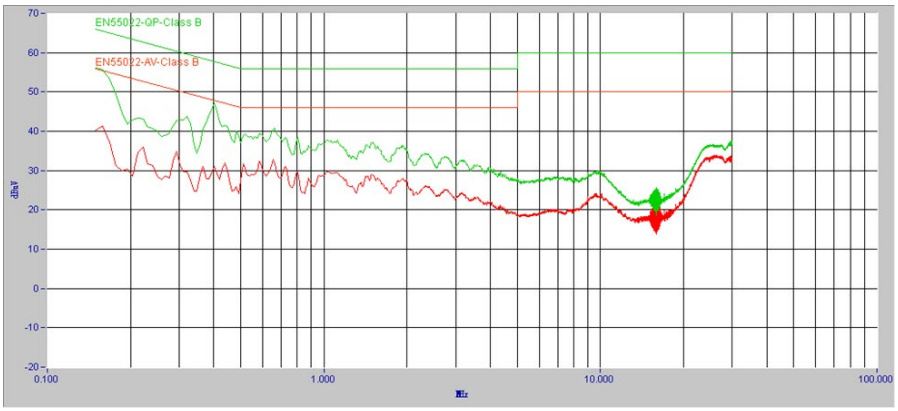
Figure 8.2.2 AC Current Waveform

8.0 Performance (Cont.)

8.3 Conducted EMI



a) QP & AV Scan L



b) QP & AV Scan N

Figure 8.3 EMI Results

Trademark Information

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