iW1781-30+iW676-00+iW656-45-08
For 45W USB-PD Design
EBC10211

General Design Specification:

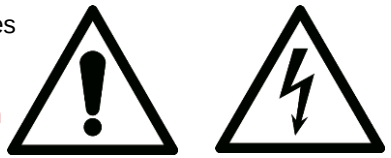
1. **AC Input Range 90-264Vac**
2. **DC Output 5V/3A, 9V/3A, 15V/3A, 20V2.25A**
3. **Meet *"75mW@5V"* No-Load standby Power Consumption Requirement**
4. **Max Output Ripple & Noise < 150mV**
5. **Support PD2.0**

June 23, 2017

…personal
…portable
…connected

Warning

Disclaimer for High Voltage (Mains Powered) Evaluation Boards



Warning
This evaluation board is powered by AC mains voltage. When powered, this evaluation board generates non-insulated high voltages which may produce electrical shock, burn, and/or fire hazards, resulting in risk of property damage, personal injury, and/or death.

When the evaluation board is powered, never touch the board or its electrical circuits since they may be operating at high voltages that can cause an electrical shock hazard.

TO BE USED FOR EVALUATION PURPOSES ONLY
This board is intended for evaluation purposes only and not intended for commercial use in an end product. Any other use is strictly prohibited by Dialog Semiconductor.

WORK AREA AND PERSONAL SAFETY
This board should be used in a test area/laboratory specifically designed and designated for working with, and evaluating high-voltage electrical devices. Only trained and qualified professional personnel with experience, knowledge and training in the use of high-voltage electrical circuits should use this evaluation board. Trained personnel must use required personal protective equipment and required laboratory equipment when working with the evaluation board.

The professional personnel operating this evaluation board and the test area/laboratory in which it is operated must be qualified according to the local regulations, guidelines and labor laws applicable to working with non-isolated mains voltages and high voltage circuits.

An isolated housing is highly recommended when using this evaluation board.

Use this evaluation board at your own risk.

NOT AGENCY APPROVED
This evaluation board has not been agency tested or approved for safety, technical performance, and/or regulatory requirements, such as electromagnetic interference or other technical regulatory or safety requirements.

1.1 Specification

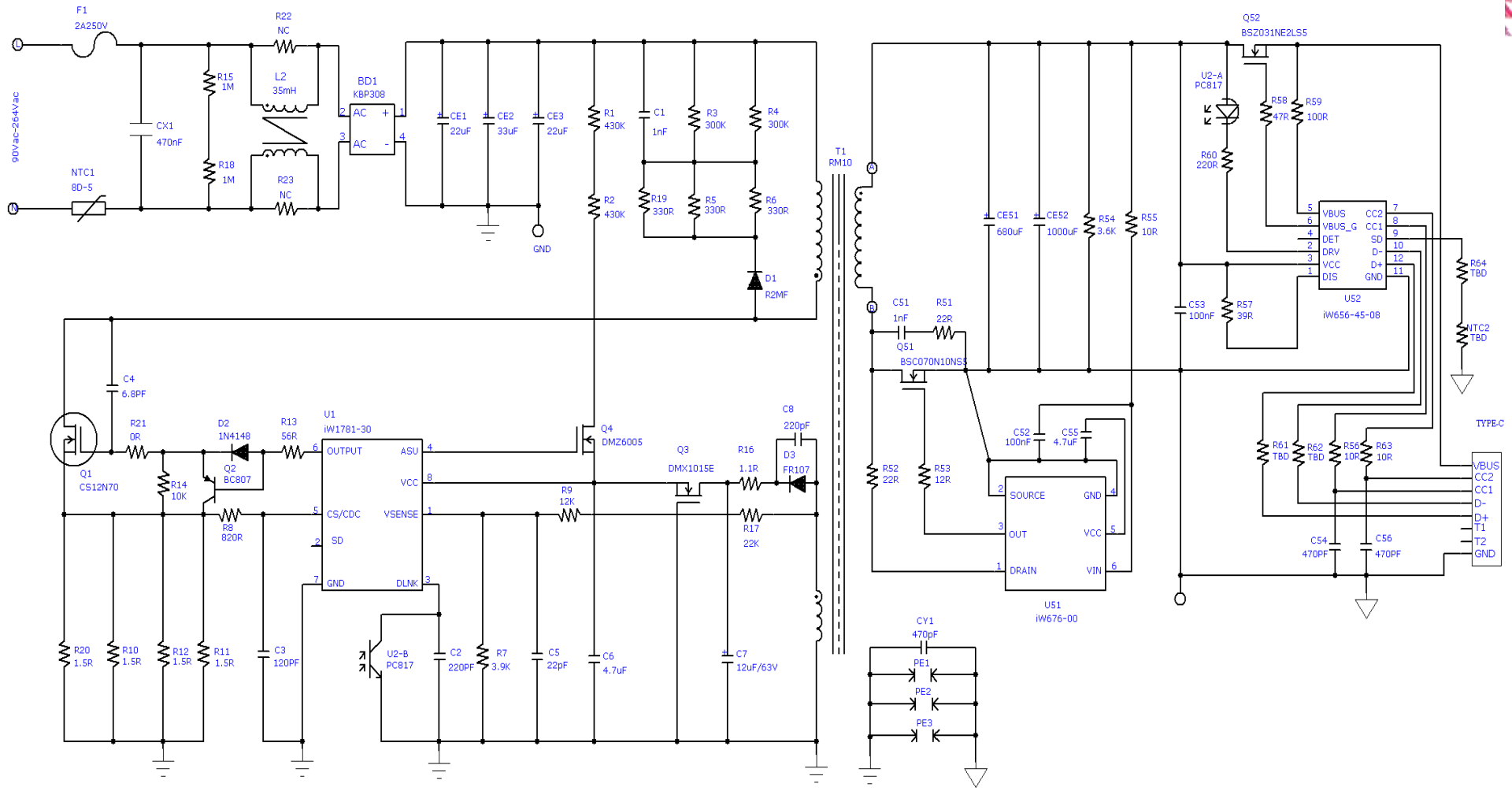
Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	90		264	V_{AC}	2 Wire
Frequency	f_{LINE}	47	50/60	63	Hz	
No-load Input Power (230V_{AC})				75	mW	Measured under 5V output
Output	V_{OUT}				V	See the next page
Protocol		Meets PD2.0 (4PDOs)				
Environmental						
Conducted EMI		Meets FCC Part 15B / EN55032B				Output is Floating
Safety		Designed to meet IEC60950, UL1950 Class II				
Ambient Temperature	T_{AMB}	0		40	° C	Free convection, sea level

1.2 Specification

Description		Symbol	Min	Typ	Max	Units	Comment
Output							
5V/3A	Output Voltage	V_{OUT}	4.75	5.00	5.25	V	Measured at PCB-End
	Output Current	I_{OUT}	0		3	A	
	Over Current Protection	I_{OCP}		3.3	3.6	A	
	Ripple & Noise	V_{RIPPLE}			150	mV_{P_P}	Note1
	Average Efficiency	η	81.84			%	Refer to CoC_V5_Tier2
9V3A	Output Voltage	V_{OUT}	8.55	9.00	9.45	V	Measured at PCB-End
	Output Current	I_{OUT}	0		3.0	A	
	Over Current Protection	I_{OCP}		3.3	3.6	A	
	Ripple & Noise	V_{RIPPLE}			150	mV_{P_P}	Note1
	Average Efficiency	η	87.3			%	Refer to CoC_V5_Tier2
15V3A	Output Voltage	V_{OUT}	14.25	15.0	15.75	V	Measured at PCB-End
	Output Current	I_{OUT}	0		3.0	A	
	Over Current Protection	I_{OCP}		3.3	3.6	A	
	Ripple & Noise	V_{RIPPLE}			150	mV_{P_P}	Note1
	Average Efficiency	η	88.85			%	Refer to CoC_V5_Tier2
20V3A	Output Voltage	V_{OUT}	19.00	20.00	21.00	V	Measured at PCB-End
	Output Current	I_{OUT}	0		2.25	A	
	Over Current Protection	I_{OCP}		2.45	2.7	A	
	Ripple & Noise	V_{RIPPLE}			150	mV_{P_P}	Note1
	Average Efficiency	η	88.85			%	Refer to CoC_V5_Tier2

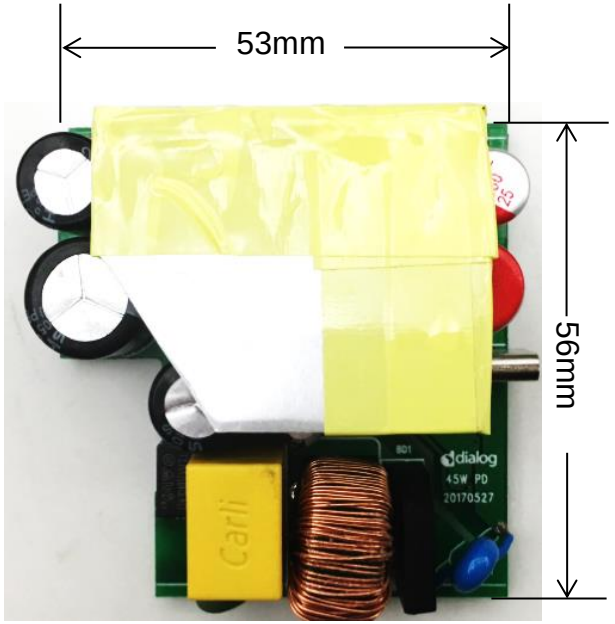
*Note1: Add 0.1uF Ceramic capacitor and 10uF E-cap at the end of connector and set oscilloscope at 20MHz bandwidth.

3. Schematic

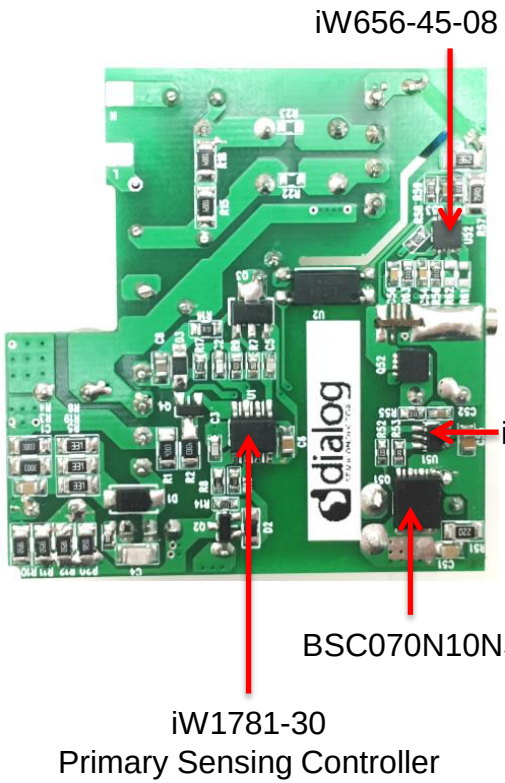

F1
2A250V
R22
NC
L
N
90Vac-264Vac
CX1
470nF
R15
1M
R18
1M
L2
35mH
R23
NC
NTC1
8D-5
BD1
KBP308
AC
AC
+
-
CE1
22uF
CE2
33uF
CE3
22uF
GND
R1
430K
R2
430K
C1
1nF
R19
330R
R3
300K
R5
330R
R4
300K
R6
330R
D1
R2MF
T1
RM10
Q52
BSZ031NE2LS5
U2-A
PC817
R58
47R
R59
100R
R60
220R
CE51
680uF
CE52
1000uF
R54
3.6K
R55
10R
C53
100nF
R57
39R
U52
iW656-45-08
VBUS
VBUS_G
DET
DRV
VCC
DIS
CC2
CC1
SD
D-
D+
GND
R64
TBD
NTC2
TBD
TYPE-C
VBUS
CC2
CC1
D-
D+
T1
T2
GND
C51
1nF
R51
22R
Q51
BSC070N10NS5
C52
100nF
C55
4.7uF
R52
22R
R53
12R
U51
iW676-00
SOURCE
GND
OUT
VCC
DRAIN
VIN
R61
TBD
R62
TBD
R56
10R
R63
10R
C54
470PF
C56
470PF
C4
6.8PF
Q1
CS12N70
R21
0R
R14
10K
D2
1N4148
Q2
BC807
R13
56R
R8
820R
U1
iW1781-30
OUTPUT
ASU
VCC
CS/CDC
VSENSE
SD
GND
DLNK
Q4
DMZ6005
Q3
DMX1015E
R16
1.1R
R17
22K
R9
12K
C8
220pF
D3
FR107
R20
1.5R
R10
1.5R
R12
1.5R
R11
1.5R
C3
120PF
U2-B
PC817
C2
220PF
R7
3.9K
C5
22pF
C6
4.7uF
C7
12uF/63V
CY1
470pF
PE1
PE2
PE3

3. Circuit Board Photograph

Top View

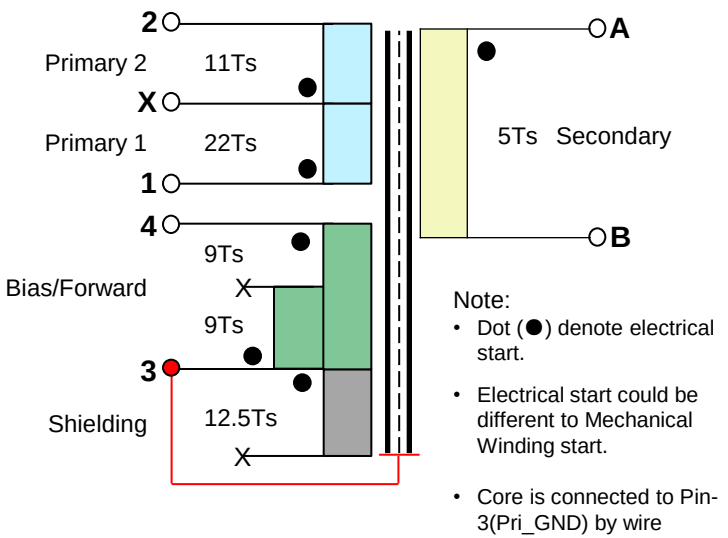


Bottom View



4. Transformer Drawing

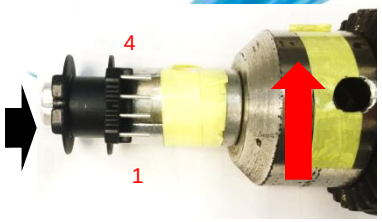
SCHEMATIC

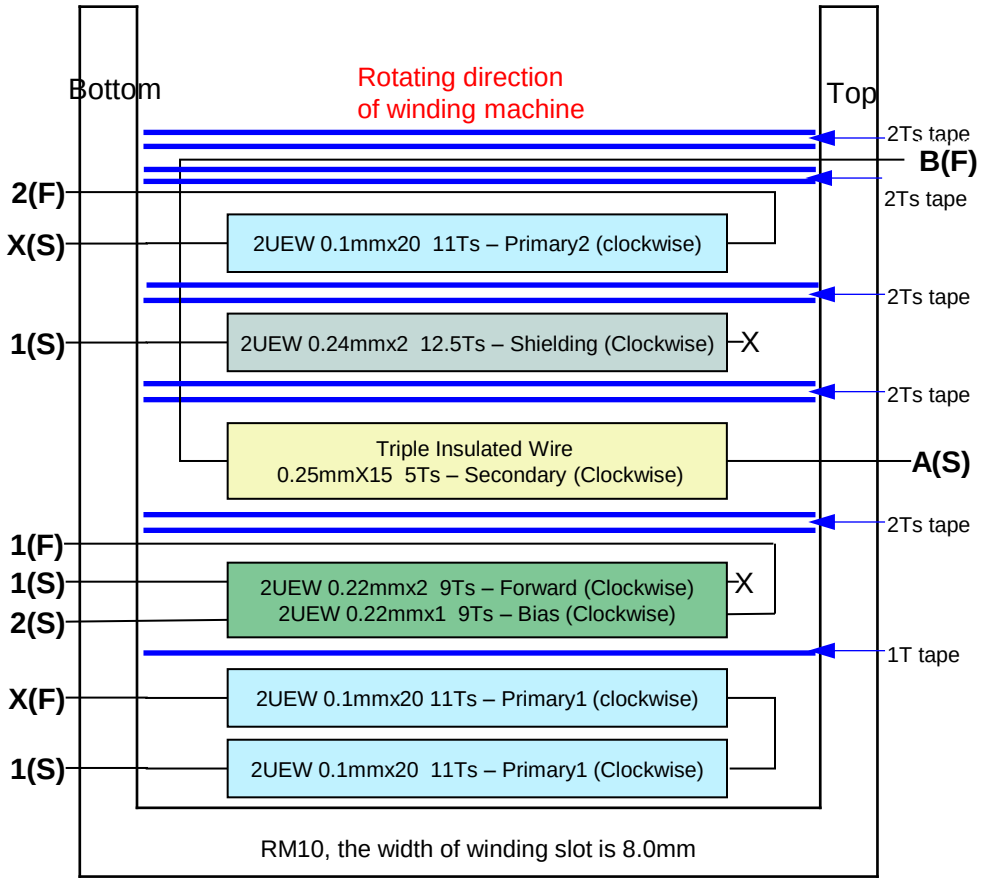


Note:

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

Winding Start pin-1& End pin-2 in "Clockwise" direction-looking from bottom side of the Bobbin





ELECTRICAL SPECIFICATIONS:

1. Primary Inductance (Lp) =450±5%uH @10KHz
2. Electrical Strength = 3KV, 50/60Hz,1Min(pins1~4to pins A~B)

MATERIALS:

1. Core : RM10(Ferrite Material JP95 or equivalent)
2. Bobbin :RM10,Vertical
3. Magnet Wires (pri): Type 2-UEW
4. Magnet wires(sec): Triple Insulated Wire
5. Layer Insulation Tape :3M1298 or equivalent.

FINISHED :

1. Varnish the complete assembly
2. Core is connected to pin3

5. Bill of Material

Item	Qty.	Ref.	Description
1	1	U1	iW1781-30, Off-line Digital PSR & PWM & VMS Controller, SOIC-8
2	1	U2	LTV1008, CTR:130%-260%, Photo-coupler
3	1	U51	iW676-00, SR Controller, SOT23-6
4	1	U52	iW656-45-08, USB-PD Controller, TDFN12, 3x3mm
5	1	F1	2A250V, Fuse, size: 4mmX8mmX7mm
6	1	L2	35mH, Common-mode choke, T16X9X8, Core Material:15K, Wire:0.4mmX60T
7	1	BD1	KBP308, 3A800V, KBPF
8	1	Q1	CS12N70F A9H, 700V0.64R, N-channel MOSFET, TO-220F
9	1	Q2	BC807, PNP Transistor, Vceo-45V,Ic -500mA, SOT-23
10	1	Q3	DMX1015E, depletion mode MOSFET, SOT-89
11	1	Q4	DMZ6005, 600V12mA, depletion mode MOSFET, SOT23
12	1	Q51	BSC070N10NS5, 100V, 7mΩ, N-Channel MOSFET, DFN5X6
13	1	Q52	BSZ031NE2LS5, 20V40A, 3.1mΩ, N-Channel MOSFET, DFN3X3_EP
14	1	T1	RM10, Transformer, Vertical type, Height: 16mm, Core Material: JP95
15	2	CE1, CE3	22uF, 400V, Low-ESR E-Cap, Φ10mmX16mm
16	1	CE2	33uF, 400V, Low-ESR E-Cap, Φ13mmX16mm
17	1	C1	1nF, 250V, X7R, SMD-0805
18	1	C2	220pF, 25V, X7R, SMD-0603
19	1	C3	120pF, 25V, X7R, SMD-0603
20	1	C4	6.8pF, 1000V, X7R, SMD-1206
21	1	C5	22pF, 25V, X7R, SMD-0603
22	1	C6	4.7uF, 25V, X7R, SMD-0805
23	1	C7	12uF, 63V, E-cap, Φ5mmX8mm
24	1	C8	220pF, 250V, X7R, SMD-0805
25	1	CE51	1000uF, 25V, Solid-cap, Φ10mmX16mm
26	1	CE52	680uF, 25V, Solid-cap, Φ8mmX16mm
27	1	C51	1nF, 100V, X7R, SMD-0805
28	2	C52, C53	100nF, 25V, X7R, SMD-0603
29	2	C54, C56	470pF, 25V, X7R, SMD-0603
30	1	C55	4.7uF, 25V, X7R, SMD-0805
31	1	CY1	470pF, Y-Cap
32	1	D1	FR207, 2A1000V, Fast Recovery Rectifier
33	1	D2	1N4148, Fast Rectifier Diode, SMD-323
34	1	D3	FR107, 1A1000V, Fast switching diode(Trr=500nS), SOD-123

5. Bill of Material(Cont.)

Item	Qty.	Ref.	Description
35	1	NTC1	SCK08053MSY, 8D-5ohm
36	2	R1, R2	430KΩ ±5%, SMD-1206
37	2	R3, R4	300KΩ ±5%, SMD-1206
38	3	R5, R6, R19	330Ω ±5%, SMD-1206
39	1	R7	3.9KΩ ±5%, SMD-0603
40	1	R8	820Ω ±5%, SMD-0603
41	1	R9	12KΩ ±1%, SMD-0603
42	4	R10, R11, R12, R20	1.5Ω ±1%, SMD-1206
43	1	R13	56Ω ±5%, SMD-0603
44	1	R14	10KΩ ±5%, SMD-0603
45	2	R15, R18	1MΩ ±5%, SMD-1206
46	1	R16	1.1Ω ±5%, SMD-0805
47	1	R17	22KΩ ±1%, SMD-0603
48	1	R21	0Ω ±1%, SMD-0603
49	1	R51	22Ω ±5%, SMD-1206
50	1	R52	22Ω ±5%, SMD-0603
51	2	R53	12Ω ±5%, SMD-0603
52	1	R54	3.6KΩ ±5%, SMD-1206
53	3	R55, R56, R63	10Ω ±5%, SMD-0603
54	1	R57	39Ω ±5%, SMD-1206
55	1	R58	47Ω ±5%, SMD-0603
56	1	R59	100Ω ±5%, SMD-0603
57	1	R60	220Ω ±5%, SMD-0603
58	1	USB51	USB Type-C connecter , Vertical type

6.1 Regulation and Efficiency Measurement (@5V)

V_{IN} (V_{AC})	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	V_{RIPPLE} (mV_{P-P})	P_{OUT} (W)	η (%)	Average η(%)	OCP (A)	CoC_V5_Tier2 Requirement
90	**0.027**	5.116	0.000	24				3.47	1. Minimum Efficiency in Active Mode at 10% load of full rated output current is 72.48%. 2. Minimum Four Point (25%, 50%, 75% and 100%) Average Efficiency in Active Mode is 81.84%.
	4.26	5.106	0.750	102	3.83	89.89	90.15		
	8.48	5.105	1.500	27	7.66	90.30			
	12.69	5.102	2.250	35	11.48	90.46			
	17.02	5.102	3.000	53	15.31	89.93			
115	**0.032**	5.117	0.000	26				3.46	
	1.74	5.111	0.300	51	1.53	88.12			
	4.26	5.106	0.750	110	3.83	89.89	90.45		
	8.49	5.106	1.500	29	7.66	90.21			
	12.64	5.103	2.250	34	11.48	90.84			
	16.85	5.103	3.000	45	15.31	90.85			
230	**0.065**	5.115	0.000	29				3.51	
	1.85	5.105	0.300	48	1.53	82.78			
	4.49	5.106	0.750	111	3.83	85.29	87.12		
	8.88	5.104	1.500	83	7.66	86.22			
	13.12	5.104	2.250	48	11.48	87.53			
	17.12	5.104	3.000	48	15.31	89.44			
264	**0.081**	5.114	0.000	32				3.50	
	4.60	5.101	0.750	122	3.83	83.17	85.70		
	9.05	5.102	1.500	102	7.65	84.56			
	13.22	5.103	2.250	37	11.48	86.85			
	17.36	5.105	3.000	38	15.32	88.22			

*Note: Output voltage is measured at PCB-End.

6.2 Regulation and Efficiency Measurement (@9V)

V_{IN} (V_{AC})	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	V_{RIPPLE} (mV_{P-P})	P_{OUT} (W)	η (%)	Average η(%)	OCP (A)	CoC_V5_Tier2 Requirement
90	**0.073**	9.206	0.000	29				3.43	1. Minimum Efficiency in Active Mode at 10% load of full rated output current is 77.3%. 2. Minimum Four Point (25%, 50%, 75% and 100%) Average Efficiency in Active Mode is 87.3%.
	7.67	9.193	0.750	78	6.89	89.89	90.27		
	15.23	9.196	1.500	29	13.79	90.57			
	22.83	9.193	2.250	41	20.68	90.60			
	30.62	9.189	3.000	54	27.57	90.03			
115	**0.078**	9.208	0.000	29				3.43	
	3.13	9.196	0.300	57	2.76	88.14			
	7.63	9.196	0.750	75	6.90	90.39	91.10		
	15.12	9.196	1.500	32	13.79	91.23			
	22.64	9.194	2.250	39	20.69	91.37			
	30.17	9.193	3.000	46	27.58	91.41			
230	**0.109**	9.207	0.000	48				33.44	
	3.23	9.194	0.300	57	2.76	85.39			
	7.86	9.195	0.750	95	6.90	87.74	89.74		
	15.55	9.199	1.500	32	13.80	88.74			
	22.75	9.194	2.250	39	20.69	90.93			
	30.12	9.192	3.000	45	27.58	91.55			
264	**13.000**	9.207	0.000	34				3.43	
	7.98	9.194	0.750	86	6.90	86.41	88.71		
	15.80	9.199	1.500	39	13.80	87.33			
	22.96	9.195	2.250	40	20.69	90.11			
	30.31	9.193	3.000	45	27.58	90.99			

*Note: Output voltage is measured at PCB-End.

6.3 Regulation and Efficiency Measurement (@15V)

V_{IN} (V_{AC})	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	V_{RIPPLE} (mV_{P-P})	P_{OUT} (W)	η (%)	Average η(%)	OCP (A)	CoC_V5_Tier2 Requirement
90	**0.157**	15.334	0.000	25				3.34	1. Minimum Efficiency in Active Mode at 10% load of full rated output current is 78.85%. 2. Minimum Four Point (25%, 50%, 75% and 100%) Average Efficiency in Active Mode is 88.85%.
	12.95	15.316	0.750	32	11.49	88.70	89.59		
	25.36	15.262	1.500	49	22.89	90.27			
	38.22	15.250	2.250	104	34.31	89.78			
	51.03	15.243	3.000	142	45.73	89.61			
115	**0.161**	15.339	0.000	25				3.35	
	5.30	15.328	0.300	61	4.60	86.76			
	12.80	15.327	0.750	29	11.50	89.81	91.06		
	25.05	15.270	1.500	36	22.91	91.44			
	37.54	15.259	2.250	56	34.33	91.46			
	50.00	15.254	3.000	76	45.76	91.52			
230	**0.194**	15.331	0.000	25				3.35	
	5.47	15.324	0.300	53	4.60	84.04			
	13.14	15.325	0.750	54	11.49	87.47	90.56		
	25.27	15.276	1.500	37	22.91	90.68			
	37.44	15.266	2.250	48	34.35	91.74			
	49.55	15.256	3.000	52	45.77	92.37			
264	**0.219**	15.334	0.000	25				3.35	
	13.34	15.321	0.750	55	11.49	86.14	89.87		
	25.50	15.279	1.500	38	22.92	89.88			
	37.64	15.259	2.250	49	34.33	91.21			
	49.61	15.254	3.000	55	45.76	92.24			

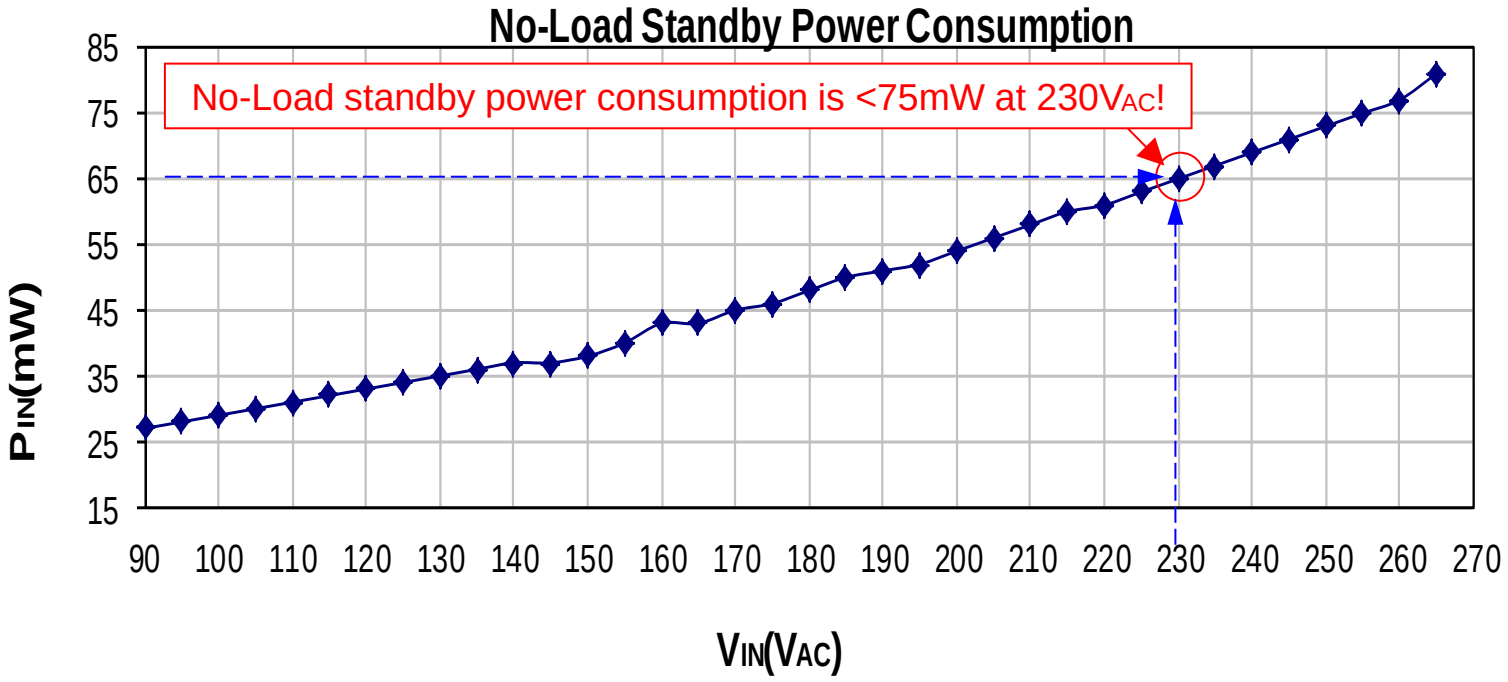
*Note: Output voltage is measured at PCB-End.

6.4 Regulation and Efficiency Measurement (@20V)

V_{IN} (V_{AC})	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	V_{RIPPLE} (mV_{P-P})	P_{OUT} (W)	η (%)	Average η(%)	OCP (A)	CoC_V5_Tier2 Requirement
90	**0.264**	20.469	0.000	20				2.46	1. Minimum Efficiency in Active Mode at 10% load of full rated output current is 78.85%. 2. Minimum Four Point (25%, 50%, 75% and 100%) Average Efficiency in Active Mode is 88.85%.
	13.20	20.460	0.563	32	11.52	87.27	89.32		
	25.40	20.404	1.125	46	22.95	90.37			
	38.17	20.371	1.688	75	34.39	90.09			
	51.13	20.354	2.250	138	45.80	89.57			
115	**0.264**	20.475	0.000	20				2.46	
	5.53	20.471	0.225	49	4.61	83.29			
	13.10	20.462	0.563	34	11.52	87.94	90.40		
	25.16	20.406	1.125	39	22.96	91.24			
	37.66	20.374	1.688	53	34.39	91.32			
	50.30	20.365	2.250	78	45.82	91.10			
230	**0.291**	20.477	0.000	20				2.47	
	5.67	20.470	0.225	52	4.61	81.23			
	13.43	20.473	0.563	48	11.53	85.83	90.08		
	25.37	20.420	1.125	43	22.97	90.55			
	37.50	20.376	1.688	45	34.39	91.72			
	49.70	20.368	2.250	54	45.83	92.21			
264	**0.328**	20.418	0.000	21				2.47	
	13.63	20.480	0.563	52	11.53	84.59	89.35		
	25.55	20.427	1.125	39	22.98	89.94			
	37.80	20.382	1.688	41	34.40	91.02			
	49.90	20.370	2.250	55	45.83	91.85			

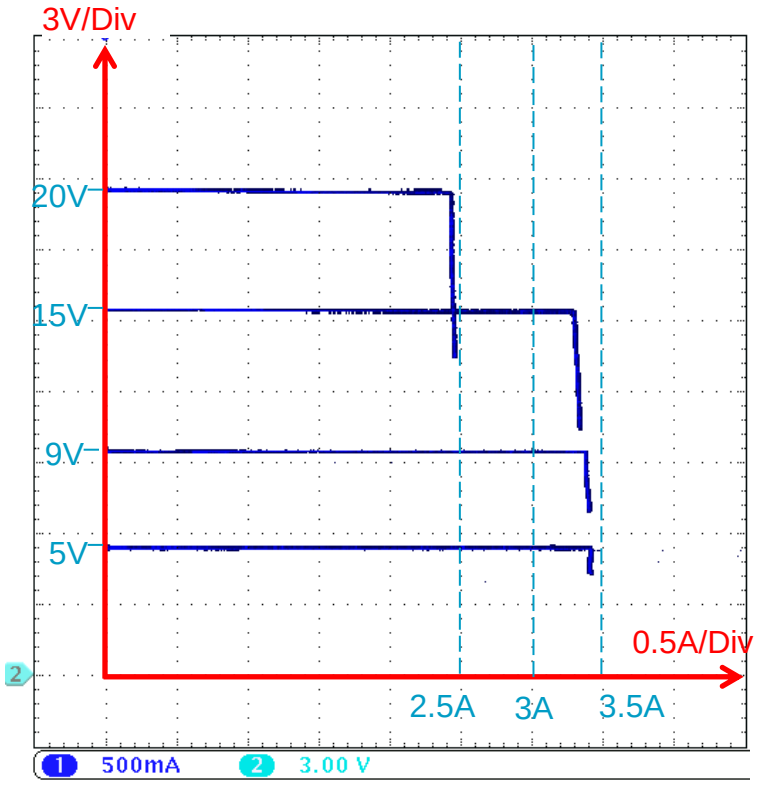
*Note: Output voltage is measured at PCB-End.

7. No-Load Standby Power Consumption(@5V)

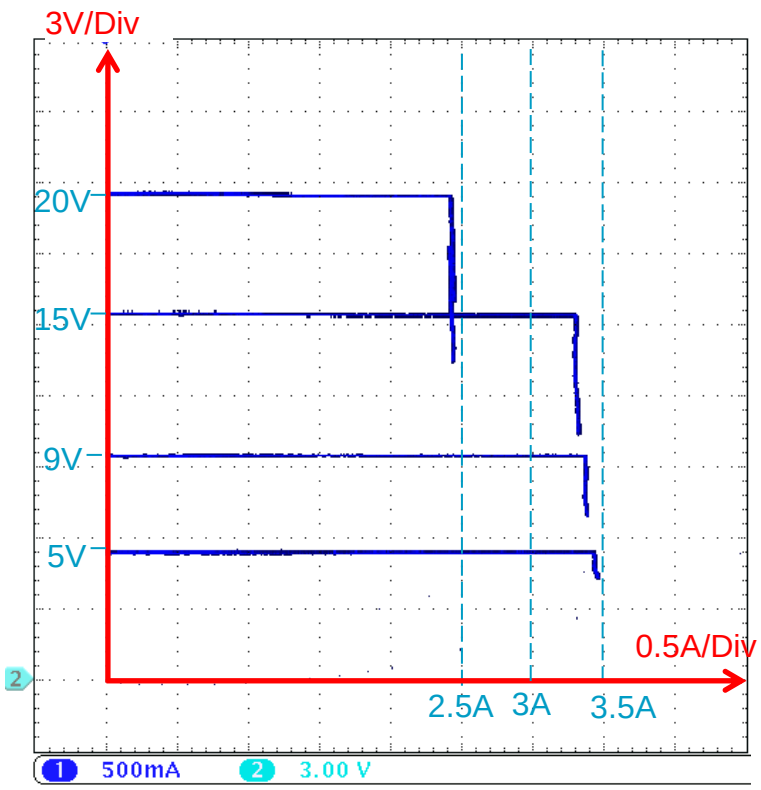


8. Output VI Characteristics

V_{IN}=90V_{AC}/60Hz



V_{IN}=264V_{AC}/50Hz

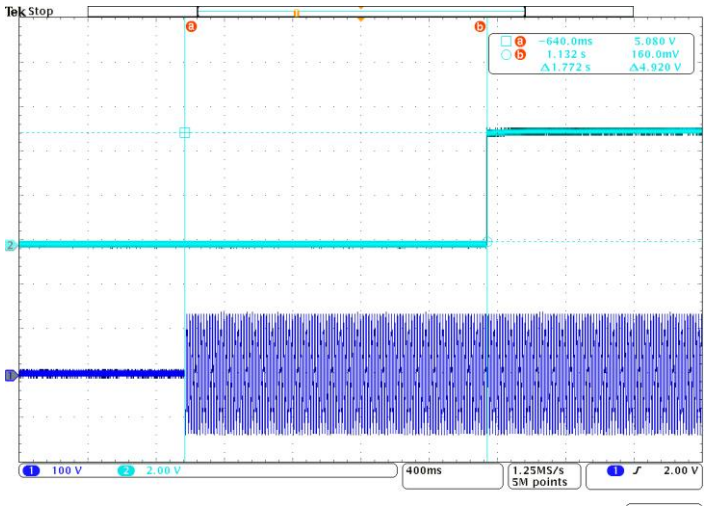


*Note: Output voltage is monitored at PCB-End

9. Turn-on Delay Time

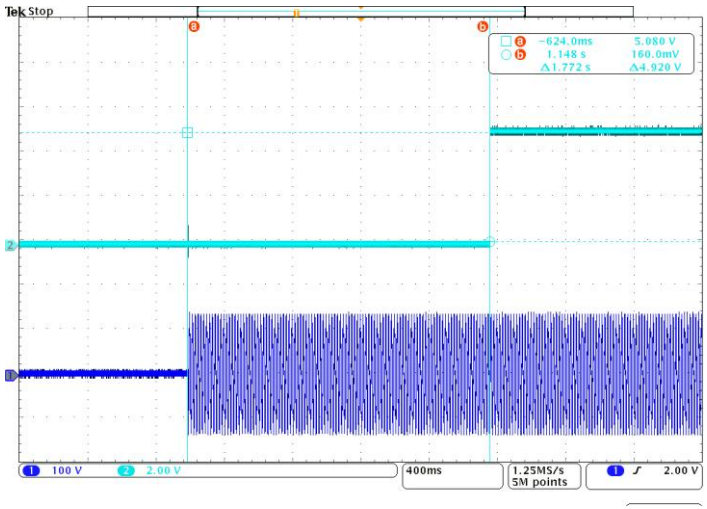
$90V_{AC}$, No Load

T_{ST_DELAY}=1.772S



$90V_{AC}$, Full Load

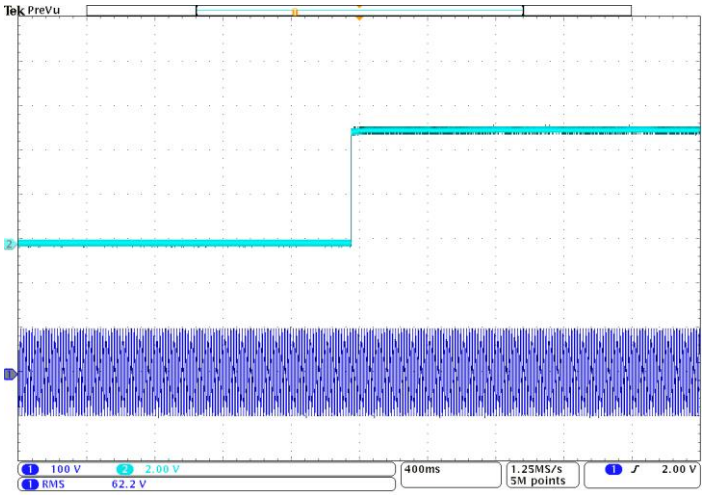
T_{ST_DELAY}=1.772S



10. AC Startup Voltage

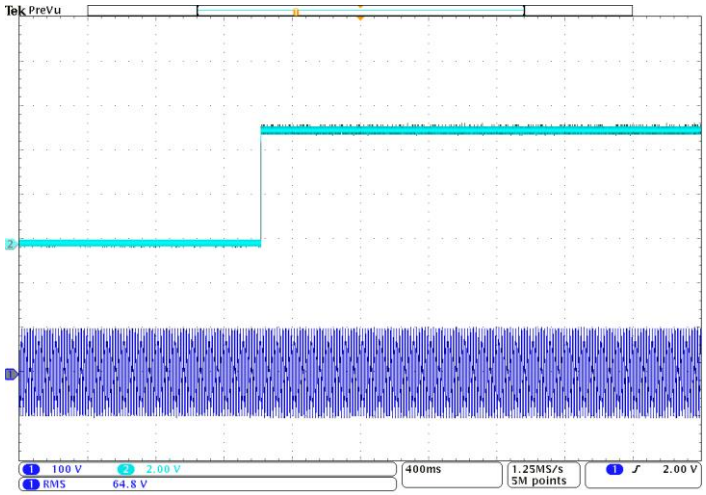
No Load

$V_{IN\_STARTUP}$ =62.2V_{AC}



Full Load

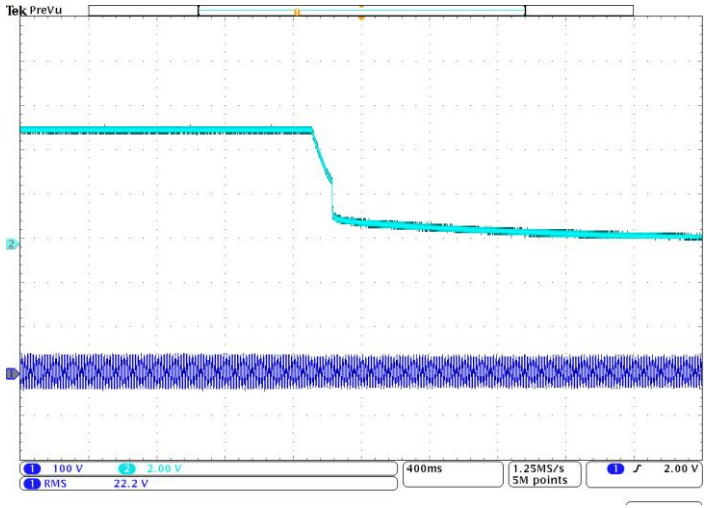
$V_{IN\_STARTUP}$=64.8V_{AC}



11. AC Brownout Voltage

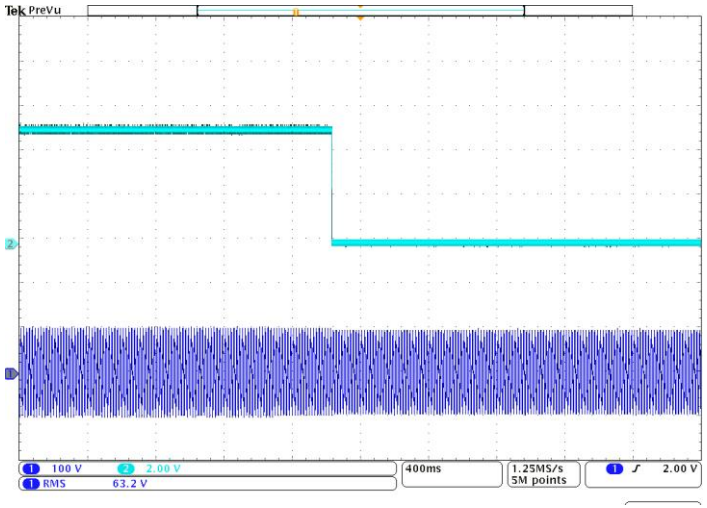
No Load

$V_{IN\_BROWNOUT}$ =22.2V_{AC}



Full Load

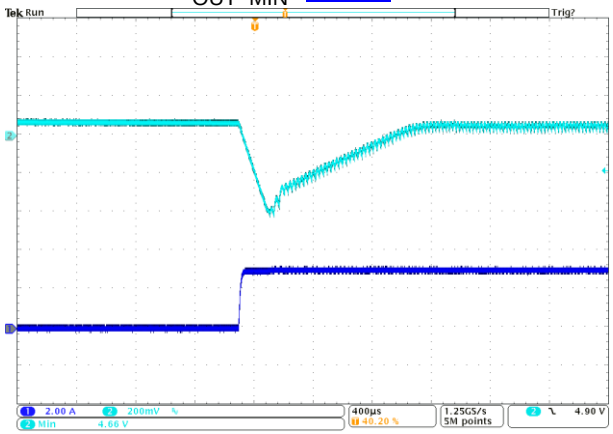
$V_{IN\_BROWNOUT}$=63.2V_{AC}



12.1 One-time DLR(@5V)

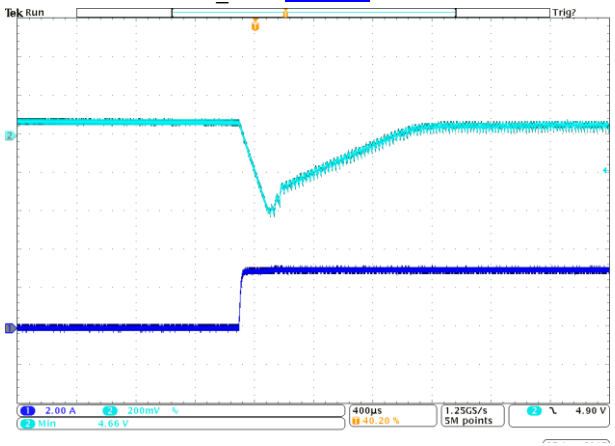
V_{IN}=90V_{AC}/60Hz, I_{OUT}=0A→3A

V_{OUT_MIN}=4.66V



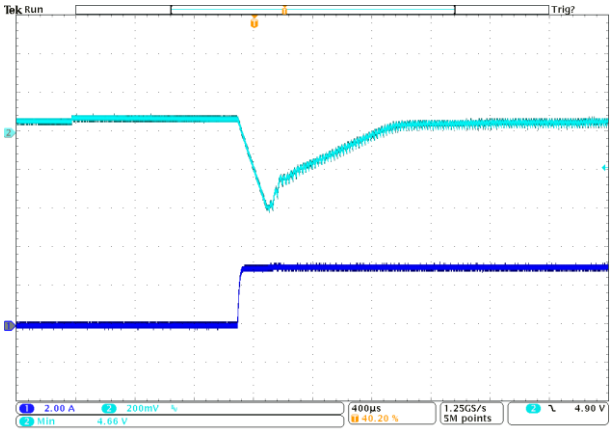
V_{IN}=115V_{AC}/60Hz, I_{OUT}=0A→3A

V_{OUT_MIN}=4.66V



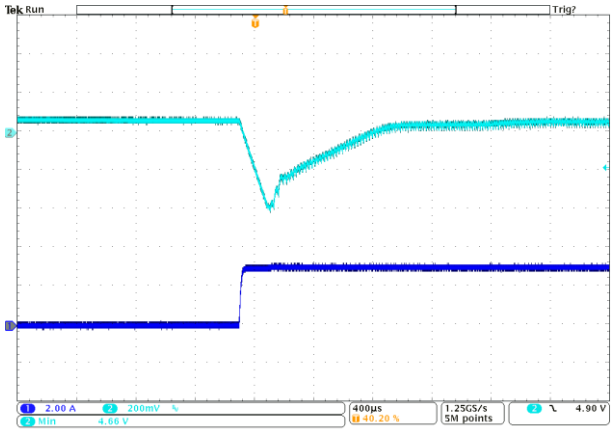
V_{IN}=230V_{AC}/50Hz, I_{OUT}=0A→3A

V_{OUT_MIN}=4.66V



V_{IN}=264V_{AC}/50Hz, I_{OUT}=0A→3A

V_{OUT_MIN}=4.66V

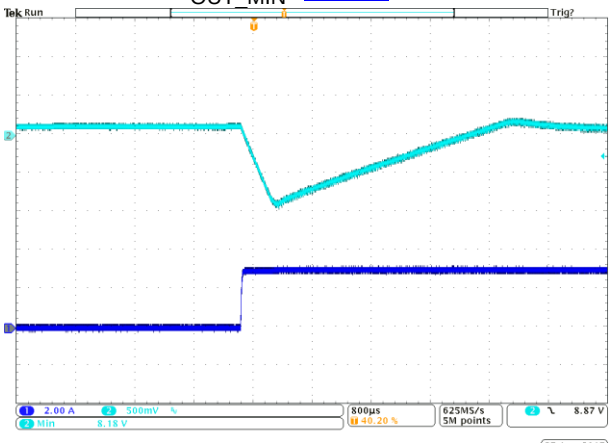


* Note: Output voltage is monitored at PCB-End

12.2 One-time DLR(@9V)

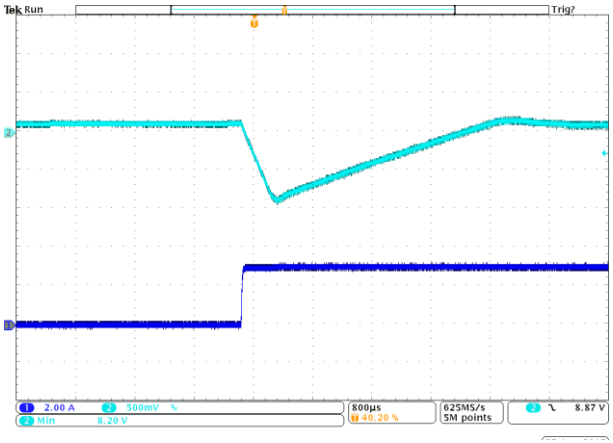
V_{IN}=90V_{AC}/60Hz, I_{OUT}=0A→3A

V_{OUT_MIN}=8.18V



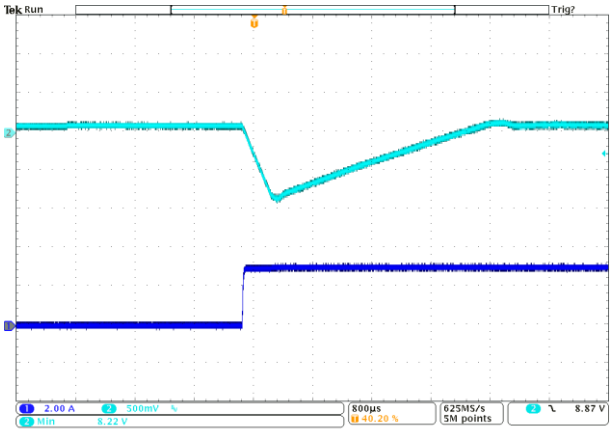
V_{IN}=115V_{AC}/60Hz, I_{OUT}=0A→3A

V_{OUT_MIN}=8.2V



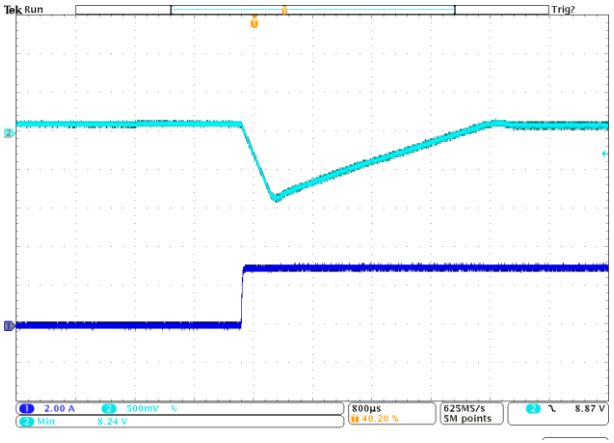
V_{IN}=230V_{AC}/50Hz, I_{OUT}=0A→3A

V_{OUT_MIN}=8.22V



V_{IN}=264V_{AC}/50Hz, I_{OUT}=0A→3A

V_{OUT_MIN}=8.24V

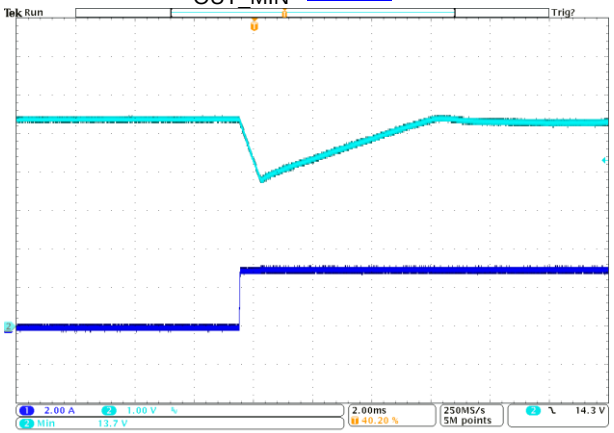


* Note: Output voltage is monitored at PCB-End

12.3 One-time DLR(@15V)

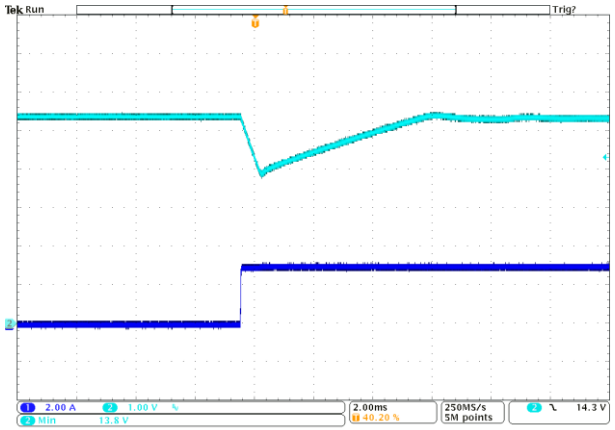
V_{IN}=90V_{AC}/60Hz, I_{OUT}=0A→3A

V_{OUT_MIN}=13.7V



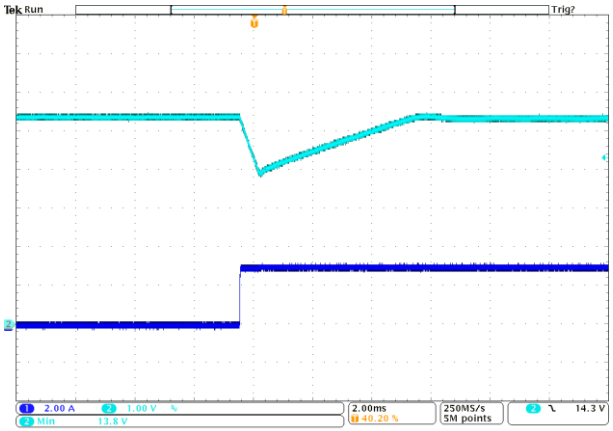
V_{IN}=115V_{AC}/60Hz, I_{OUT}=0A→3A

V_{OUT_MIN}=13.8V



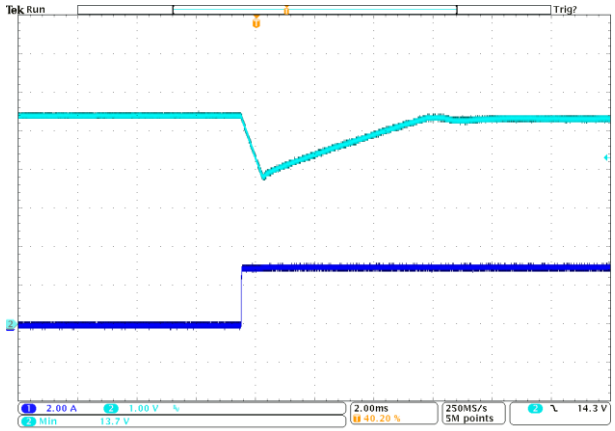
V_{IN}=230V_{AC}/50Hz, I_{OUT}=0A→3A

V_{OUT_MIN}=13.8V



V_{IN}=264V_{AC}/50Hz, I_{OUT}=0A→3A

V_{OUT_MIN}=13.7V

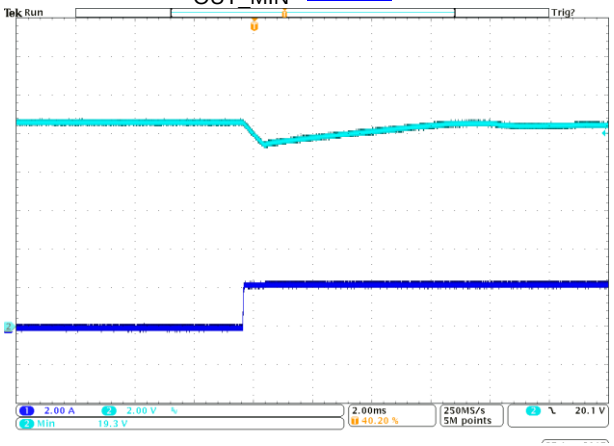


* Note: Output voltage is monitored at PCB-End

12.4 One-time DLR(@20V)

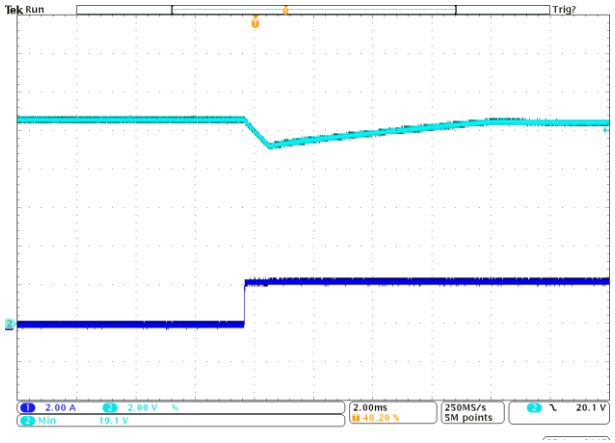
V_{IN}=90V_{AC}/60Hz, I_{OUT}=0A→2.25A

V_{OUT_MIN}=19.3V



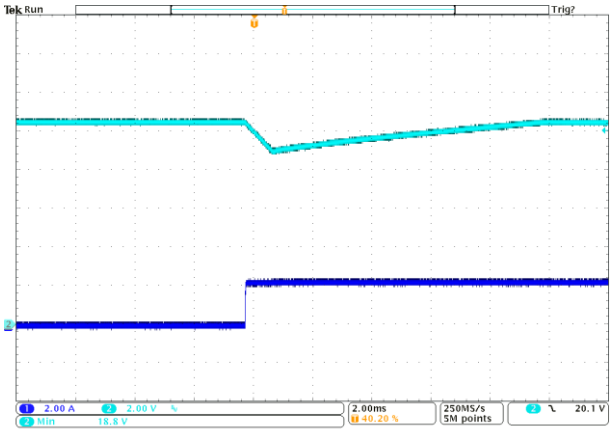
V_{IN}=115V_{AC}/60Hz, I_{OUT}=0A→2.25A

V_{OUT_MIN}=19.1V



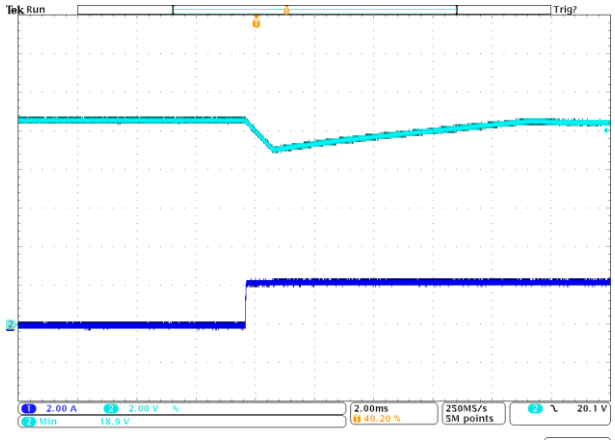
V_{IN}=230V_{AC}/50Hz, I_{OUT}=0A→2.25A

V_{OUT_MIN}=18..8V



V_{IN}=264V_{AC}/50Hz, I_{OUT}=0A→2.25A

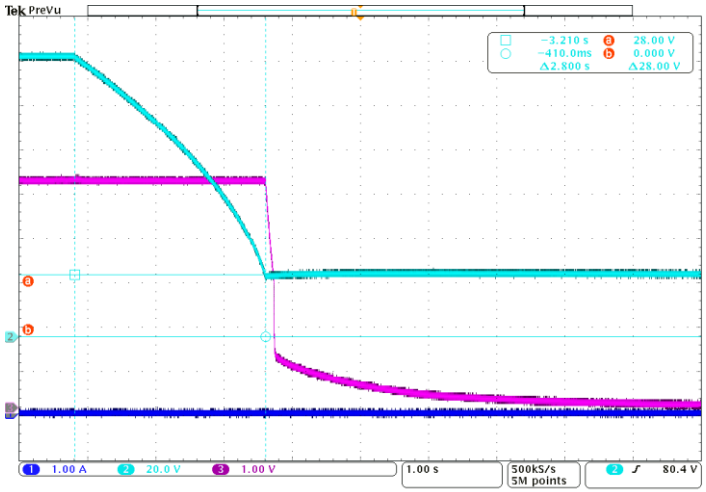
V_{OUT_MIN}=18.9V



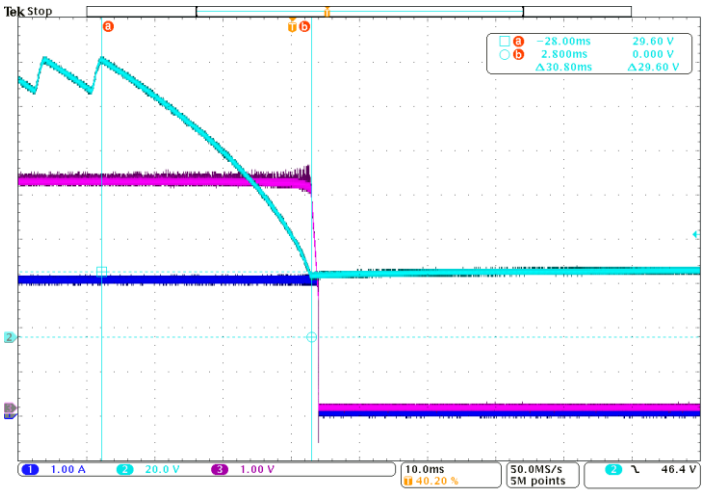
* Note: Output voltage is monitored at PCB-End

13. Bulky Capacitor Discharging

No Load, V_{IN_BULK}=28V



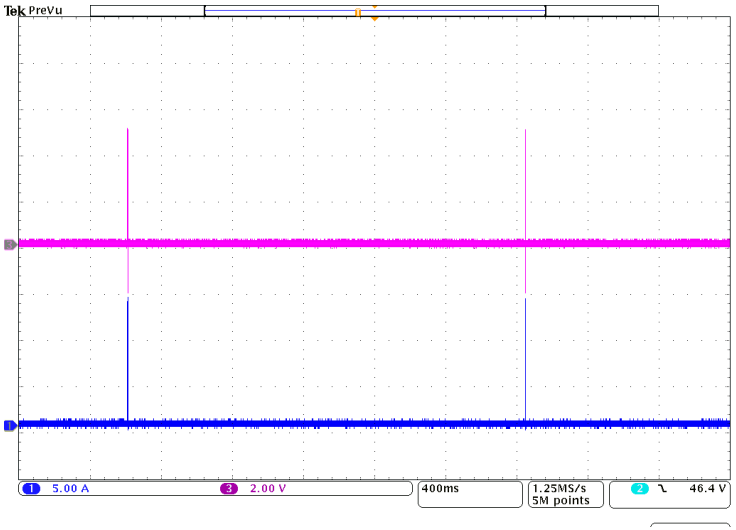
Full Load, V_{DC_BULK}=29.6V



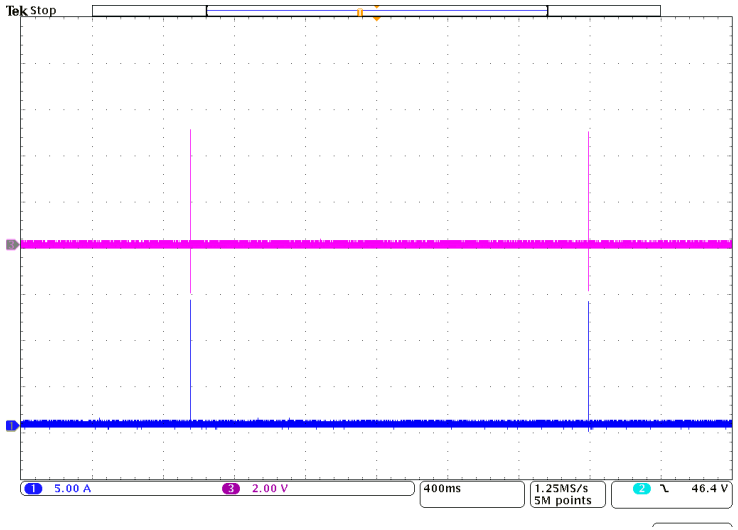
*Note: CH1: IOUT, 1A/Div; CH2: VBULK, 20V/Div; CH3: VOUT, 1V/Div

14. Output Short Circuit

V_{IN}=90V_{AC}, $P_{IN\_S/C}$=56mW



V_{IN}=264V_{AC}, $P_{IN\_S/C}$=120mW

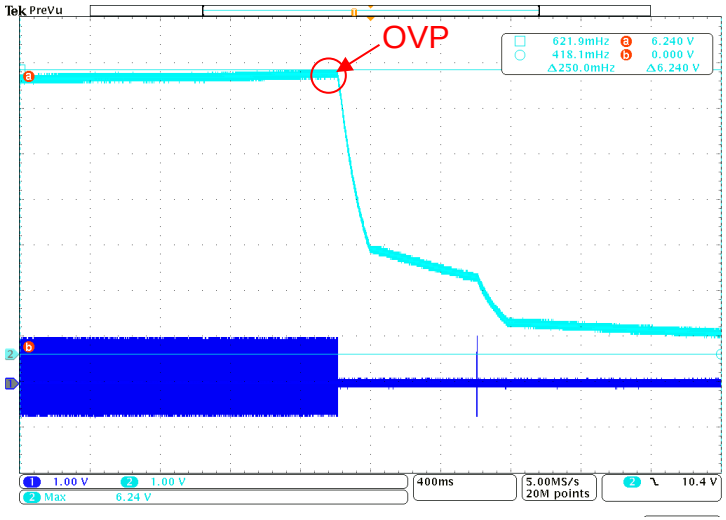


*Note: CH1: IOUT, 5A/Div, CH3: V_{OUT}, 2V/Div

15.1 Output Over Voltage Protection (@5V)

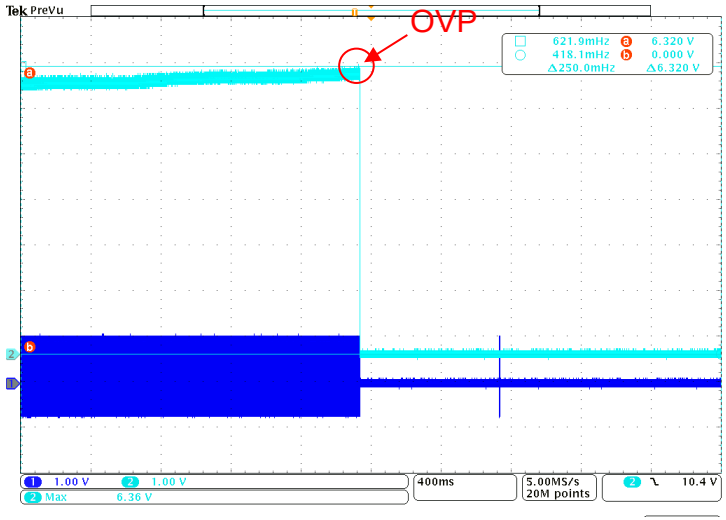
V_{IN}=90V_{AC}/60Hz

No-load, V_{OUT_OVP}=6.24V



V_{IN}=264V_{AC}/60Hz

No-load, V_{OUT_OVP}=6.32V

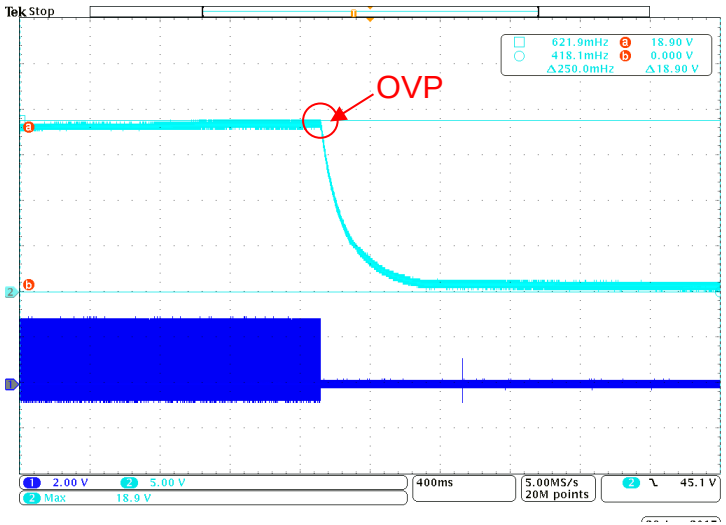


*Note: CH1: V_{SENSE}, 1V/Div; CH2: V_{OUT}, 1V/Div

15.2 Output Over Voltage Protection (@15V)

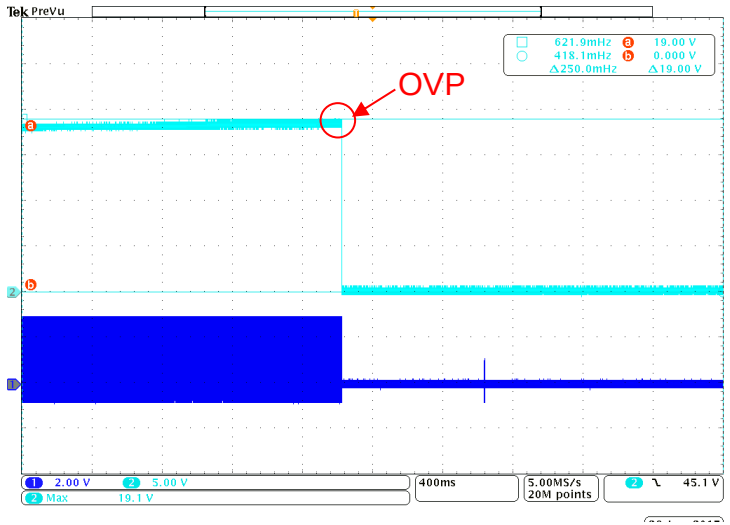
V_{IN}=90V_{AC}/60Hz

No-load, V_{OUT_OVP}=18.9V



V_{IN}=264V_{AC}/60Hz

No-load, V_{OUT_OVP}=19V

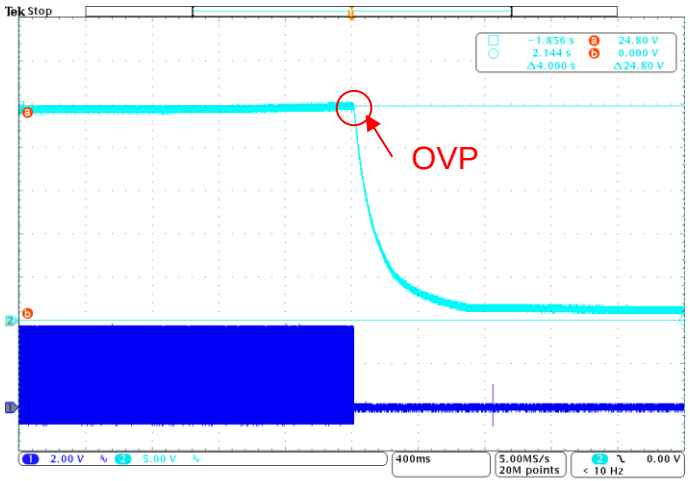


*Note: CH1: V_{SENSE}, 2V/Div; CH2: V_{OUT}, 5V/Div

15.3 Output Over Voltage Protection (@20V)

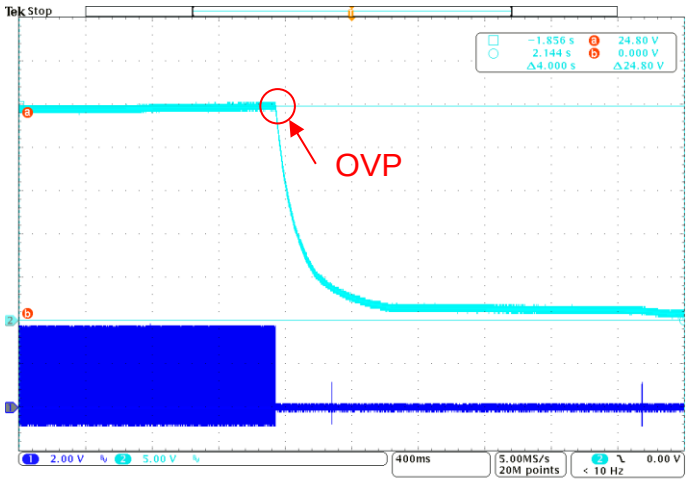
V_{IN}=90V_{AC}/60Hz

No-load, V_{OUT_OVP}=24.8V



V_{IN}=264V_{AC}/60Hz

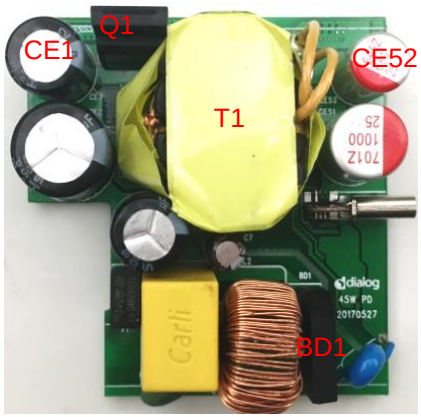
No-load, V_{OUT_OVP}=24.8V



*Note: CH1: V_{SENSE}, 2V/Div; CH2: V_{OUT}, 5V/Div

16.1 Thermal Test for Critical Component (@15V)

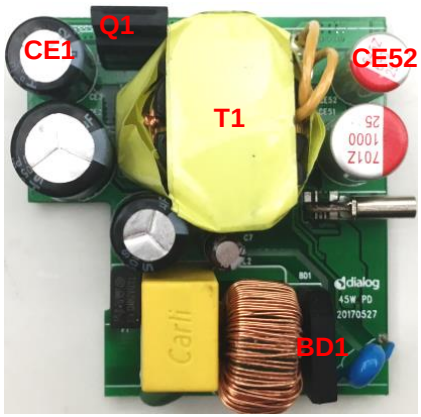
Item	V_{IN}=90V_{AC}, V_{OUT}=15V I_{OUT}=3A		V_{IN}=264V_{AC}, V_{OUT}=15V I_{OUT}=3A	
	Temp.(℃)	Rising Temp.(℃)	Temp.(℃)	Rising Temp.(℃)
Bridge Diode(BD1, KBP308)	113.9	73.9	78.7	38.7
PWM IC(U1, iW1781-30)	103.6	63.6	96.6	56.6
Vcc LDO(Q5, DMX1015E)	102.6	62.6	93.2	53.2
Transformer(T1,Wire)	108.2	68.2	100.8	60.8
Transformer(T1, Core)	105.4	65.4	98.4	58.4
MOSFET(Q1,CS12N70)	99.3	59.3	92.0	52.0
Input Bulk_Cap(CE1, 22uF/400V)	90.6	50.6	80.7	40.7
MOSFET(Q51, BSC070N10NS5)	109.2	69.2	104.4	64.4
Solid capacitior(CE52, 680uF/25V)	93.9	53.9	89.6	49.6
Ambient(Chamber) Temp.	40.0		40.0	



* Note: The UUT is assembled with case and placed in a temperature chamber.

16.2 Thermal Test for Critical Component (@20V)

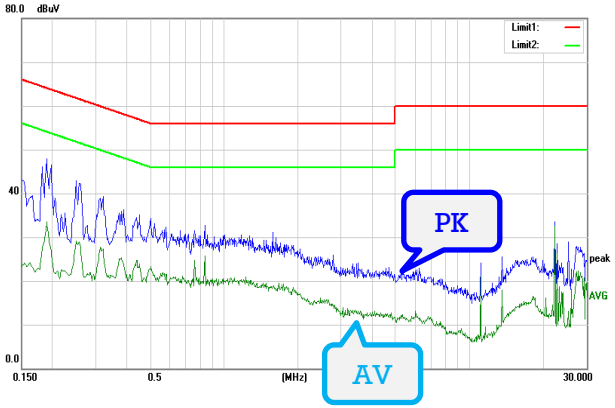
Item	V_{IN}=90V_{AC}, V_{OUT}=20V I_{OUT}=2.25A		V_{IN}=264V_{AC}, V_{OUT}=20V I_{OUT}=2.25A	
	Temp.(℃)	Rising Temp.(℃)	Temp.(℃)	Rising Temp.(℃)
Bridge Diode(BD1, KBP308)	113.3	73.3	79.5	39.5
PWM IC(U1, iW1781-30)	101.8	61.8	98.6	58.6
Vcc LDO(Q5, DMX1015E)	105.7	65.7	99.6	59.6
Transformer(T1,Wire)	102.3	62.3	100.2	60.2
Transformer(T1, Core)	101.0	61.0	99.1	59.1
MOSFET(Q1,CS12N70)	94.6	54.6	92.4	52.4
Input Bulk_Cap(CE1, 22uF/400V)	88.0	48.0	82.1	42.1
MOSFET(Q51, BSC070N10NS5)	99.3	59.3	99.9	59.9
Solid capacitior(CE52, 680uF/25V)	86.6	46.6	86.7	46.7
Ambient(Chamber) Temp.	40.0		40.0	



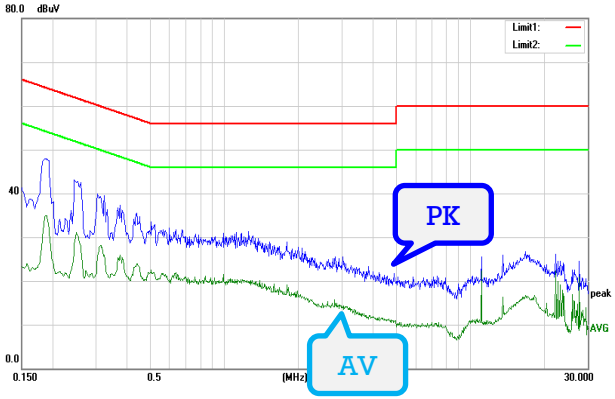
* Note: The UUT is assembled with case and placed in a temperature chamber.

17.1 Conducted EMI (@5V)

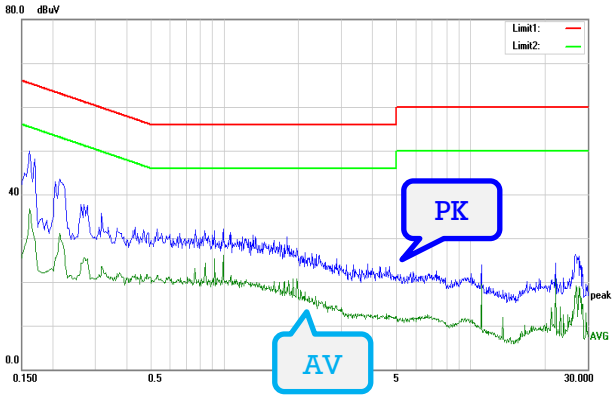
V_{IN}=230V_{AC}/50Hz, Live



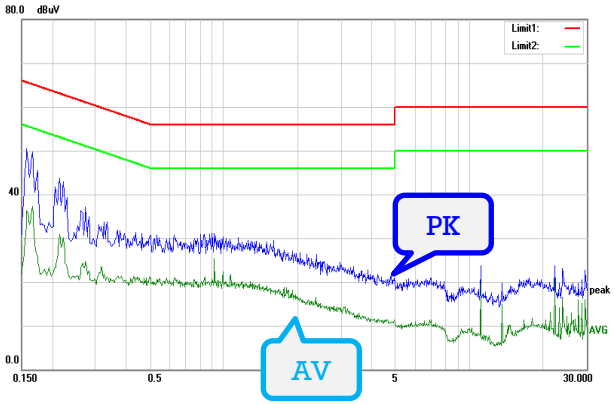
V_{IN}=230V_{AC}/50Hz, Natural



V_{IN}=110V_{AC}/60Hz, Live



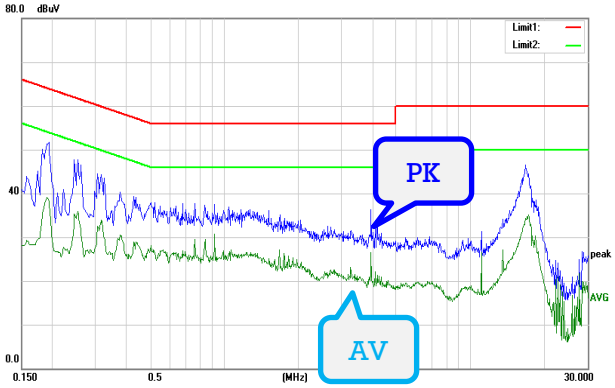
V_{IN}=110V_{AC}/60Hz, Natural



*Note: Resistive & Full load; output is floating.

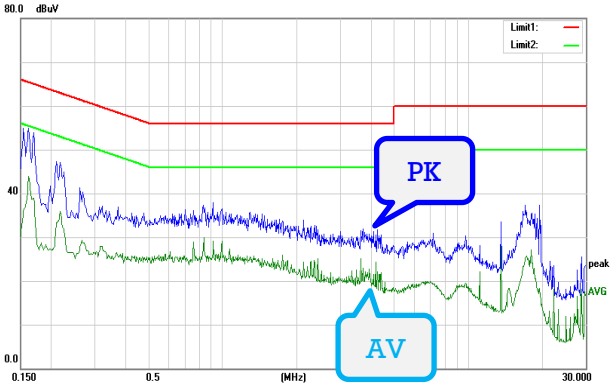
17.2 Conducted EMI (@5V)

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

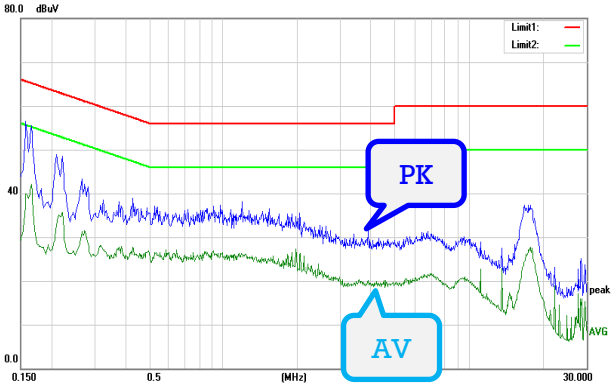


V_{IN}=230V_{AC}/50Hz, Natural

V_{IN}=110V_{AC}/60Hz, Live



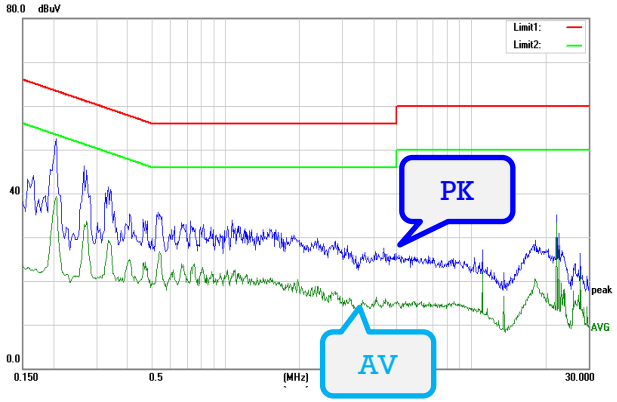
V_{IN}=110V_{AC}/60Hz, Natural



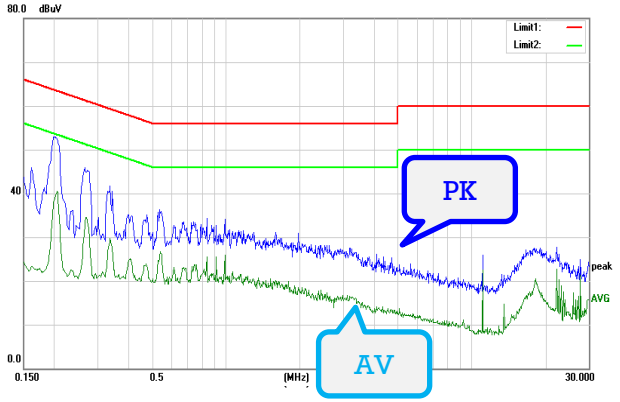
*Note: Resistive & Full load; output is connected to GND.

17.3 Conducted EMI (@15V)

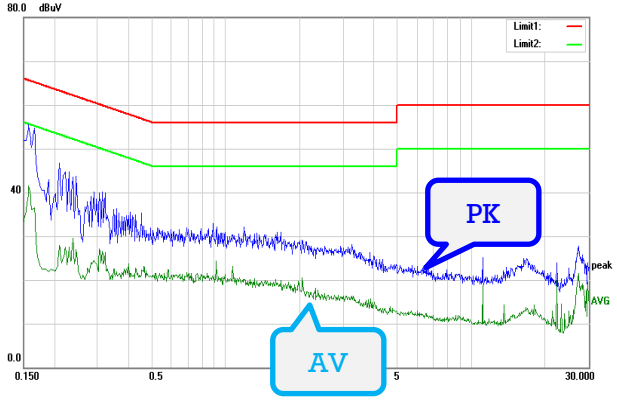
V_{IN}=230V_{AC}/50Hz, Live



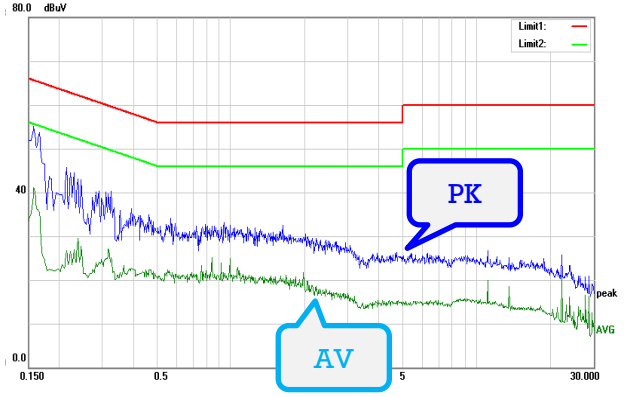
V_{IN}=230V_{AC}/50Hz, Natural



V_{IN}=110V_{AC}/60Hz, Live



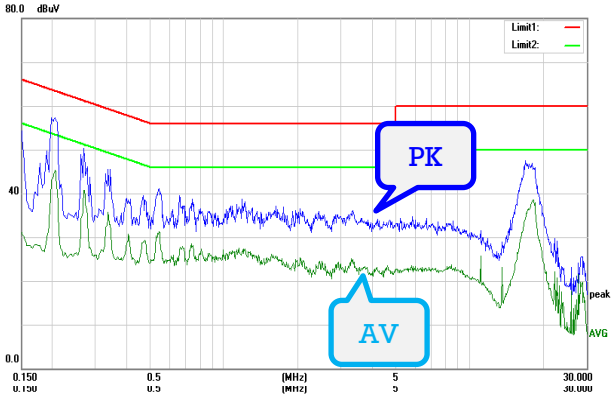
V_{IN}=110V_{AC}/60Hz, Natural



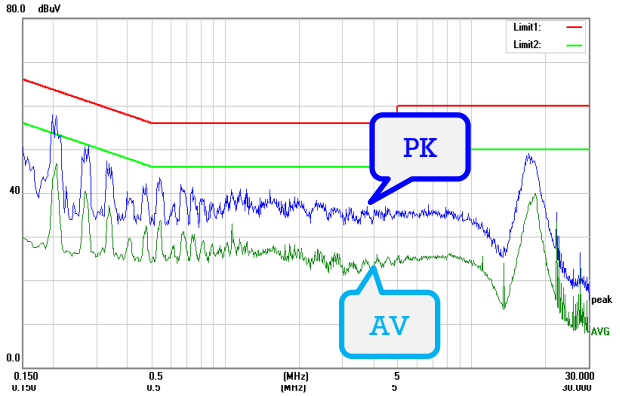
*Note: Resistive & Full load; output is floating.

17.4 Conducted EMI (@15V)

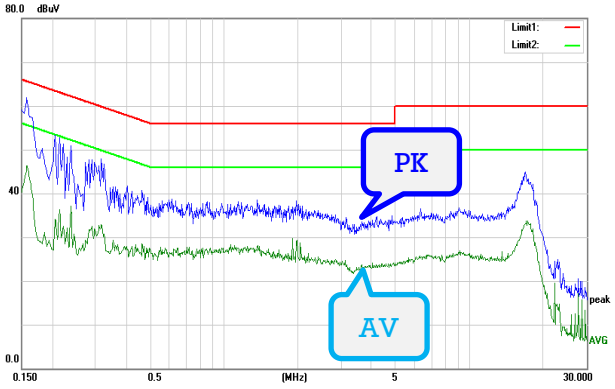
V_{IN}=230V_{AC}/50Hz, Live



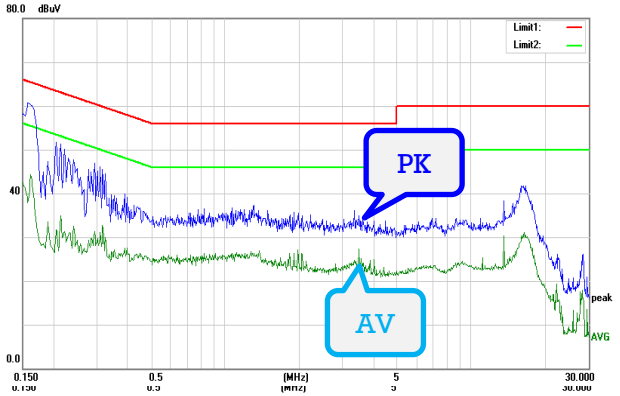
V_{IN}=230V_{AC}/50Hz, Natural



V_{IN}=110V_{AC}/60Hz, Live



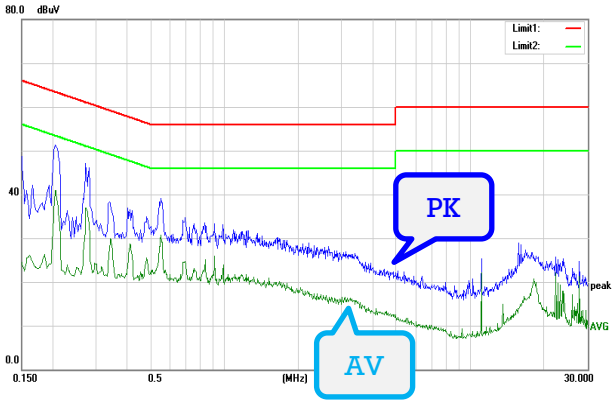
V_{IN}=110V_{AC}/60Hz, Natural



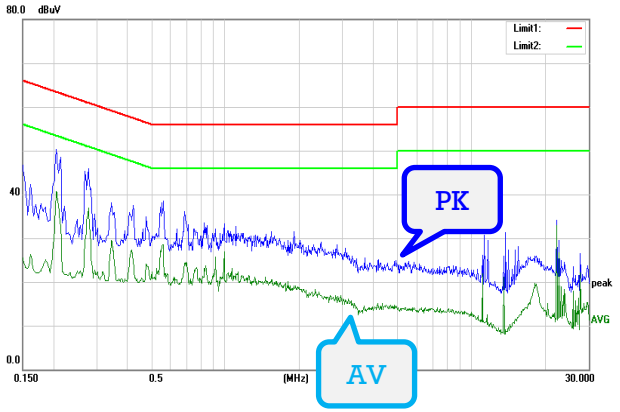
*Note: Resistive & Full load; output is connected to GND.

17.5 Conducted EMI (@20V)

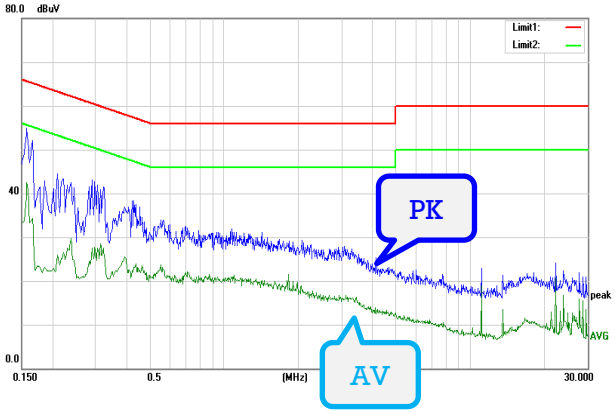
V_{IN}=230V_{AC}/50Hz, Live



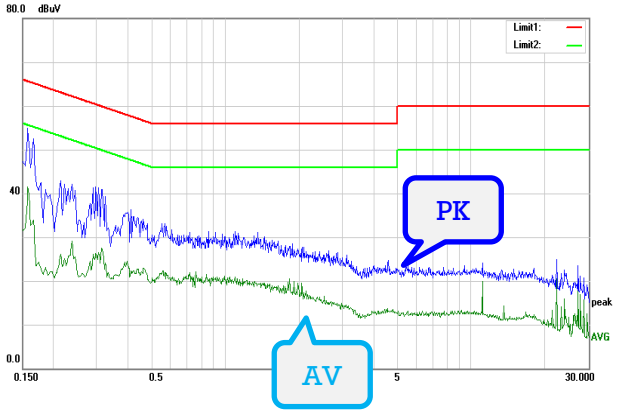
V_{IN}=230V_{AC}/50Hz, Natural



V_{IN}=110V_{AC}/60Hz, Live



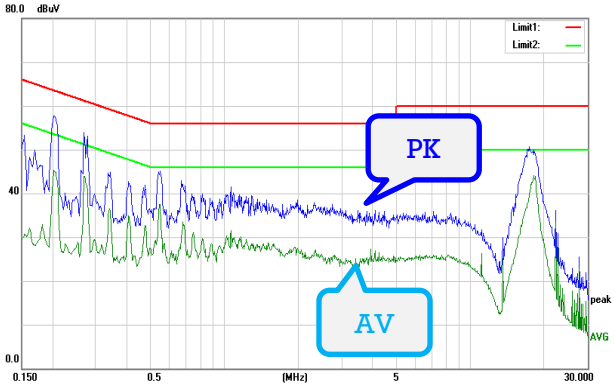
V_{IN}=110V_{AC}/60Hz, Natural



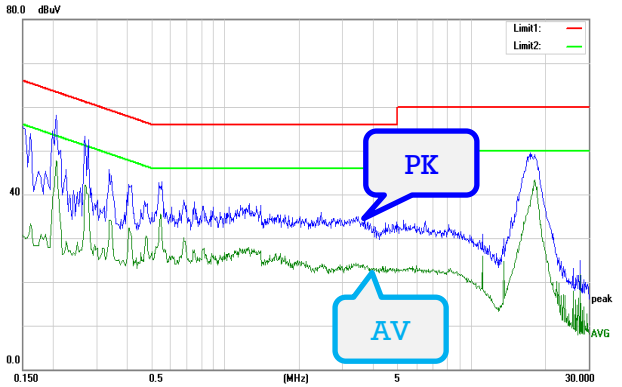
*Note: Resistive & Full load; output is floating.

17.6 Conducted EMI (@20V)

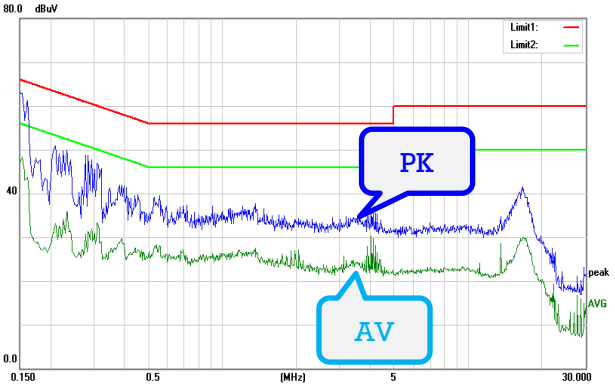
V_{IN}=230V_{AC}/50Hz, Live



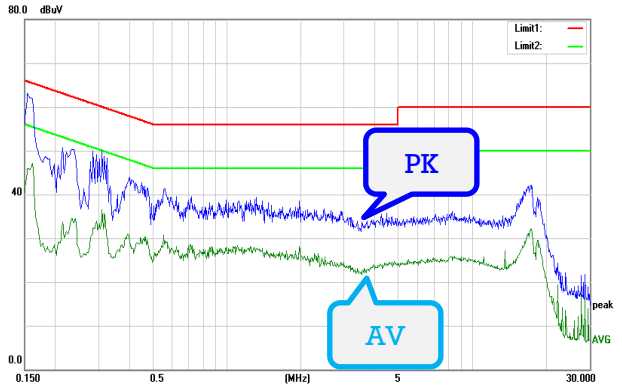
V_{IN}=230V_{AC}/50Hz, Natural



V_{IN}=110V_{AC}/60Hz, Live



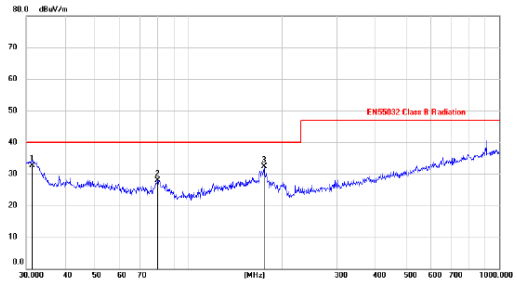
V_{IN}=110V_{AC}/60Hz, Natural



*Note: Resistive & Full load; output is connected to GND.

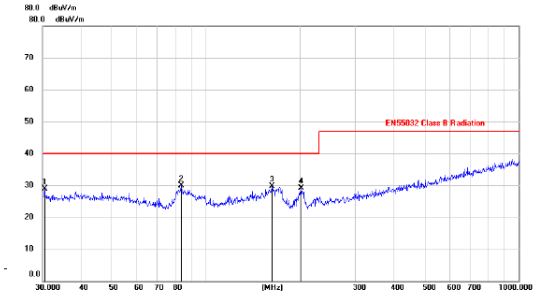
18.1 Radiated EMI (@5V)

V_{IN}=230V_{AC}/50Hz, Vertical



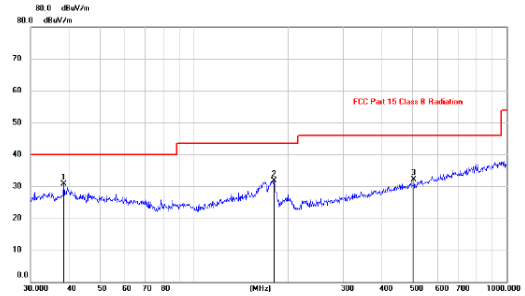
No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	31.2893	19.44	13.36	32.80	40.00	-7.20	QP			
2		79.5209	18.53	9.47	28.00	40.00	-12.00	peak			
3		175.0368	19.42	12.95	32.37	40.00	-7.63	peak			

V_{IN}=230V_{AC}/50Hz, Horizontal



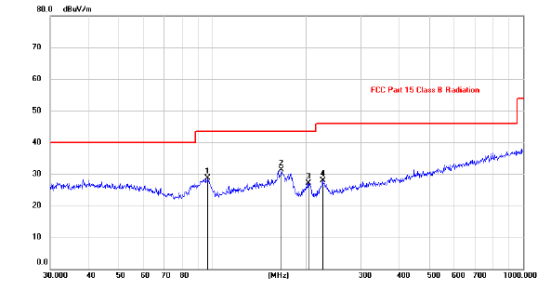
No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		30.4238	15.54	13.30	28.84	40.00	-11.16	peak			
2	*	83.2298	20.31	9.59	29.90	40.00	-10.10	peak			
3		163.1818	15.32	14.32	29.64	40.00	-10.36	peak			
4		201.3930	18.80	10.38	29.18	40.00	-10.82	peak			

V_{IN}=110V_{AC}/60Hz, Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	38.3462	16.71	13.95	30.66	40.00	-9.34	peak			
2		180.0165	19.49	12.15	31.64	43.50	-11.86	peak			
3		504.7062	14.91	17.28	32.19	46.00	-13.81	peak			

V_{IN}=110V_{AC}/60Hz, Horizontal

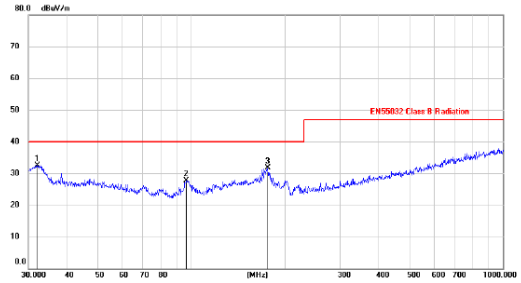


No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		96.4362	18.39	10.31	28.70	43.50	-14.80	peak			
2	*	167.2368	17.29	14.00	31.29	43.50	-12.21	peak			
3		203.5228	16.73	10.46	27.19	43.50	-16.31	peak			
4		226.0994	16.30	11.61	27.91	46.00	-18.09	peak			

*Note: Resistive & Full load; output is floating.

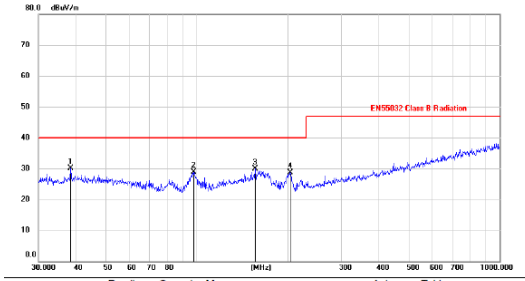
18.2 Radiated EMI (@5V)

V_{IN}=230V_{AC}/50Hz, Vertical



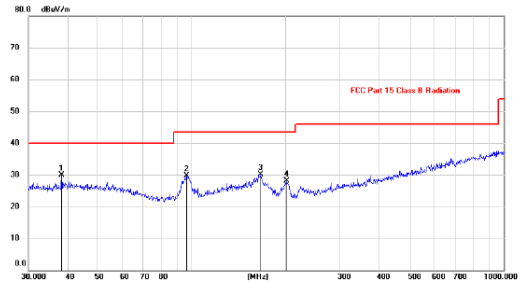
No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	32.0667	19.21	13.39	32.60	40.00	-7.40	peak			
2		96.4362	17.47	10.31	27.78	40.00	-12.22	peak			
3		176.2686	18.94	12.75	31.69	40.00	-8.31	peak			

V_{IN}=230V_{AC}/50Hz, Horizontal



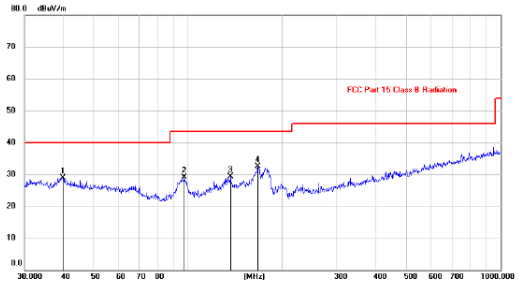
No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	38.3462	16.07	13.95	30.02	40.00	-9.98	peak			
2		97.4560	18.54	10.33	28.87	40.00	-11.13	peak			
3		155.9101	15.37	14.57	29.94	40.00	-10.06	peak			
4		203.5228	18.24	10.46	28.70	40.00	-11.30	peak			

V_{IN}=110V_{AC}/60Hz, Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	38.3462	15.89	13.95	29.84	40.00	-10.16	peak			
2		96.4362	19.34	10.31	29.65	43.50	-13.85	peak			
3		167.2368	16.11	14.00	30.11	43.50	-13.39	peak			
4		201.3930	17.75	10.38	28.13	43.50	-15.37	peak			

V_{IN}=110V_{AC}/60Hz, Horizontal

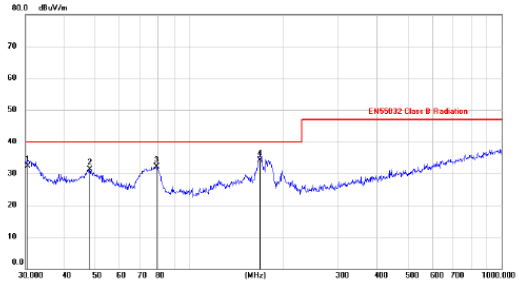


No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		39.8542	14.68	14.23	28.91	40.00	-11.09	peak			
2		97.1148	18.67	10.35	29.02	43.50	-14.48	peak			
3		136.4598	15.73	13.62	29.35	43.50	-14.15	peak			
4	*	167.8243	18.47	13.95	32.42	43.50	-11.08	peak			

*Note: Resistive & Full load; output is connected to GND.

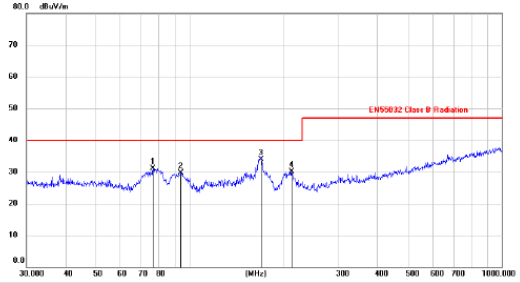
18.3 Radiated EMI (@15V)

V_{IN}=230V_{AC}/50Hz, Vertical



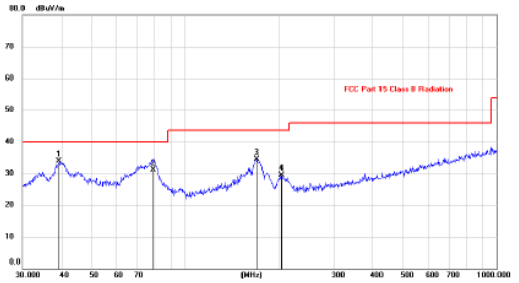
No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		30.4238	19.00	13.30	32.30	40.00	-7.70	QP			
2		48.3318	17.59	13.67	31.26	40.00	-8.74	peak			
3		78.6888	22.56	9.64	32.20	40.00	-7.80	peak			
4	*	169.0054	20.25	13.85	34.10	40.00	-5.90	QP			

V_{IN}=230V_{AC}/50Hz, Horizontal



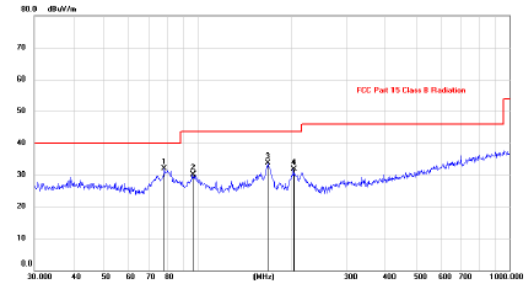
No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		76.2442	21.10	10.08	31.18	40.00	-8.82	peak			
2		94.0979	19.58	10.05	29.63	40.00	-10.37	peak			
3	*	169.5990	20.10	13.80	33.90	40.00	-6.10	QP			
4		212.2695	19.24	10.83	30.07	40.00	-9.93	peak			

V_{IN}=110V_{AC}/60Hz, Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	39.4371	19.72	14.22	33.94	40.00	-6.06	peak			
2		78.6888	21.56	9.64	31.20	40.00	-8.80	AVG			
3		169.5990	20.80	13.80	34.60	43.50	-8.90	peak			
4		203.5228	18.99	10.46	29.45	43.50	-14.05	peak			

V_{IN}=110V_{AC}/60Hz, Horizontal



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	78.4133	22.12	9.74	31.86	40.00	-8.14	peak			
2		96.4362	19.80	10.31	30.11	43.50	-13.39	peak			
3		168.4138	19.73	13.90	33.63	43.50	-9.87	peak			
4		203.5228	21.31	10.46	31.77	43.50	-11.73	peak			

*Note: Resistive & Full load; output is floating.

18.4 Radiated EMI (@15V)

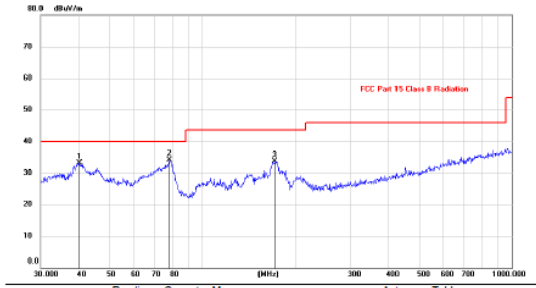
V_{IN}=230V_{AC}/50Hz, Vertical

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		32.9791	19.49	13.44	32.93	40.00	-7.07	peak			
2		47.9940	19.34	13.69	33.03	40.00	-6.97	peak			
3		77.8654	22.37	9.89	32.26	40.00	-7.74	peak			
4	*	169.0054	20.15	13.85	34.00	40.00	-6.00	QP			

V_{IN}=230V_{AC}/50Hz, Horizontal

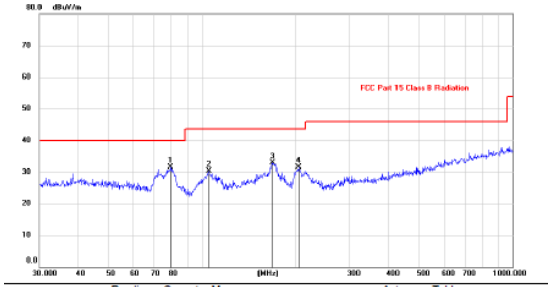
No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	38.3462	16.07	13.95	30.02	40.00	-9.98	peak			
2		97.4560	18.54	10.33	28.87	40.00	-11.13	peak			
3		155.9101	15.37	14.57	29.94	40.00	-10.06	peak			
4		203.5228	18.24	10.46	28.70	40.00	-11.30	peak			

V_{IN}=110V_{AC}/60Hz, Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		39.9942	18.95	14.24	33.19	40.00	-6.81	peak			
2	*	78.4133	24.31	9.74	34.05	40.00	-5.95	peak			
3		170.7926	20.12	13.64	33.76	43.50	-9.74	peak			

V_{IN}=110V_{AC}/60Hz, Horizontal



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	78.9652	21.92	9.53	31.45	40.00	-8.55	peak			
2		105.2718	19.28	11.09	30.37	43.50	-13.13	peak			
3		169.0054	19.05	13.85	32.90	43.50	-10.60	peak			
4		204.2377	20.95	10.48	31.43	43.50	-12.07	peak			

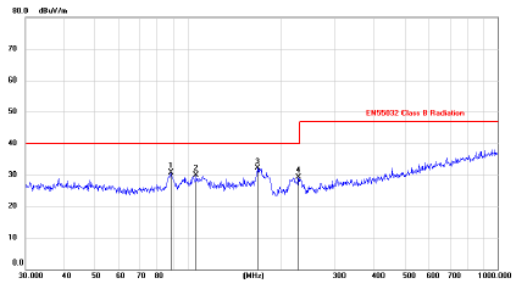
*Note: Resistive & Full load; output is connected to GND.

18.5 Radiated EMI (@20V)

V_{IN}=230V_{AC}/50Hz, Vertical

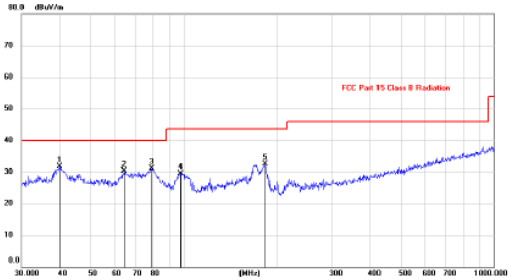
No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		31.3992	19.43	13.37	32.80	40.00	-7.20	QP			
2		78.4133	22.35	9.74	32.09	40.00	-7.91	peak			
3	*	169.0054	20.15	13.85	34.00	40.00	-6.00	QP			

V_{IN}=230V_{AC}/50Hz, Horizontal



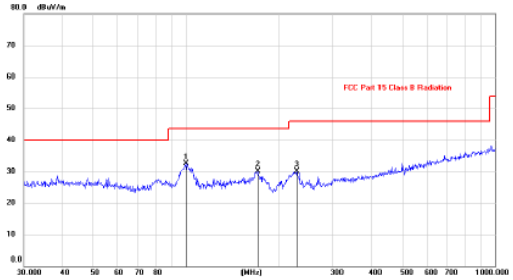
No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		88.0329	20.96	9.73	30.69	40.00	-9.31	peak			
2		106.3850	18.66	11.19	29.85	40.00	-10.15	peak			
3	*	168.4138	18.14	13.90	32.04	40.00	-7.96	peak			
4		227.6906	17.63	11.68	29.31	40.00	-10.69	peak			

V_{IN}=110V_{AC}/60Hz, Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	39.8542	17.50	14.23	31.73	40.00	-8.27	peak			
2		64.2074	18.18	12.14	30.32	40.00	-9.68	peak			
3		78.6888	21.42	9.64	31.06	40.00	-8.94	peak			
4		97.4560	19.17	10.33	29.50	43.50	-14.00	peak			
5		182.5592	20.64	11.84	32.48	43.50	-11.02	peak			

V_{IN}=110V_{AC}/60Hz, Horizontal

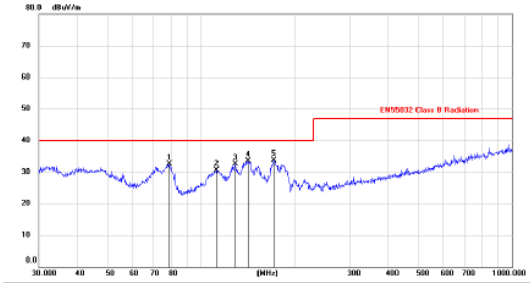


No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	99.8777	21.85	10.60	32.45	43.50	-11.05	peak			
2		170.7926	16.39	13.64	30.03	43.50	-13.47	peak			
3		228.4904	18.45	11.71	30.16	46.00	-15.84	peak			

*Note: Resistive & Full load; output is floating.

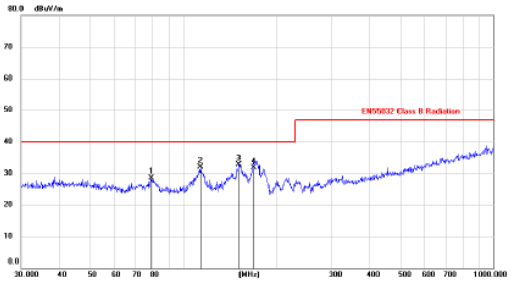
18.6 Radiated EMI (@20V)

V_{IN}=230V_{AC}/50Hz, Vertical



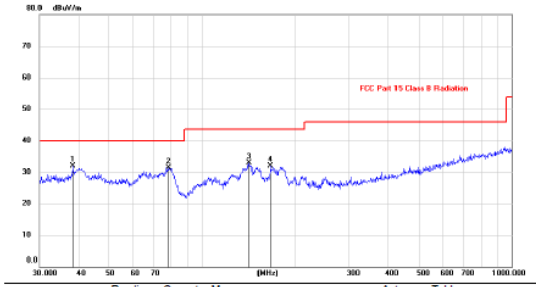
No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		78.6888	22.94	9.64	32.58	40.00	-7.42	peak			
2		112.1305	18.73	11.75	30.48	40.00	-9.52	peak			
3		129.0146	19.38	13.17	32.55	40.00	-7.45	peak			
4		141.3298	19.54	13.93	33.47	40.00	-6.53	peak			
5	*	170.7926	19.97	13.64	33.61	40.00	-6.39	peak			

V_{IN}=230V_{AC}/50Hz, Horizontal



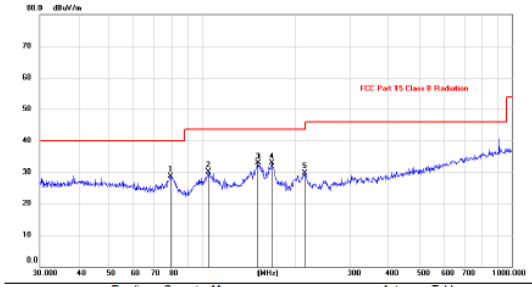
No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		78.6888	18.95	9.64	28.59	40.00	-11.41	peak			
2		113.3163	20.02	11.87	31.89	40.00	-8.11	peak			
3	*	151.0666	18.24	14.56	32.80	40.00	-7.20	peak			
4		169.0054	17.85	13.85	31.70	40.00	-8.30	QP			

V_{IN}=110V_{AC}/60Hz, Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	38.3462	17.90	13.95	31.85	40.00	-8.15	peak			
2		78.4133	21.53	9.74	31.27	40.00	-8.73	peak			
3		141.8262	18.85	13.96	32.81	43.50	-10.69	peak			
4		167.2368	17.88	14.00	31.88	43.50	-11.62	peak			

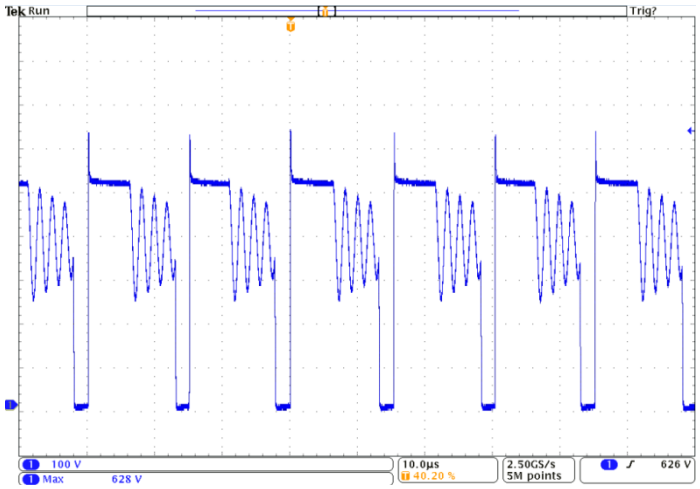
V_{IN}=110V_{AC}/60Hz, Horizontal



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		78.9652	19.18	9.53	28.71	40.00	-11.29	peak			
2		104.9033	19.01	11.05	30.06	43.50	-13.44	peak			
3	*	151.5972	18.38	14.56	32.94	43.50	-10.56	peak			
4		168.4138	18.98	13.90	32.88	43.50	-10.62	peak			
5		214.5143	18.75	10.97	29.72	43.50	-13.78	peak			

*Note: Resistive & Full load; output is connected to GND.

19. Maximum Drain Voltage of HV MOSFET (@20V)



Test Condition(Full Load):

V_{IN}=264V_{AC}, I_{OUT}=2.25A

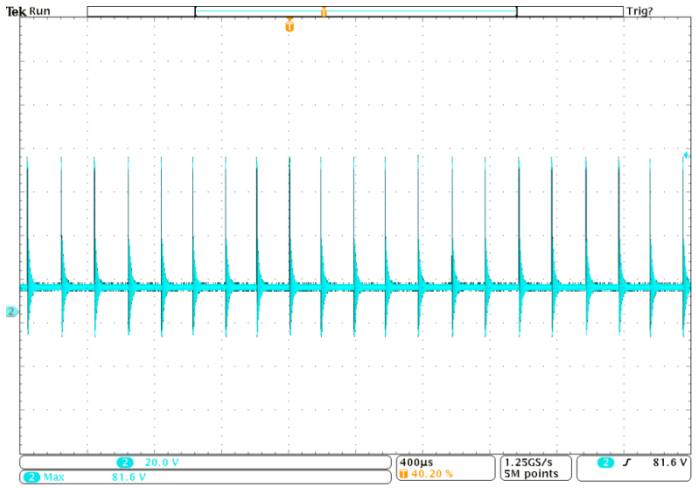
Result:

V_{DS_MAX}=**628V**

Appendix – Simple Specification for used MOSFET (CS12N70F A9H, 12A/700V)

V_{DSS}	700	V
I_D	12	A
P_D (T_C=25℃)	55	W
$R_{DS(ON)Typ}$	0.64	Ω

20. Maximum Drain Voltage of SR MOSFET (@20V)



Test Condition:

V_{IN}=264V_{AC}, I_{OUT}=0A

Result:

V_{DS_MAX}=**81.6V**

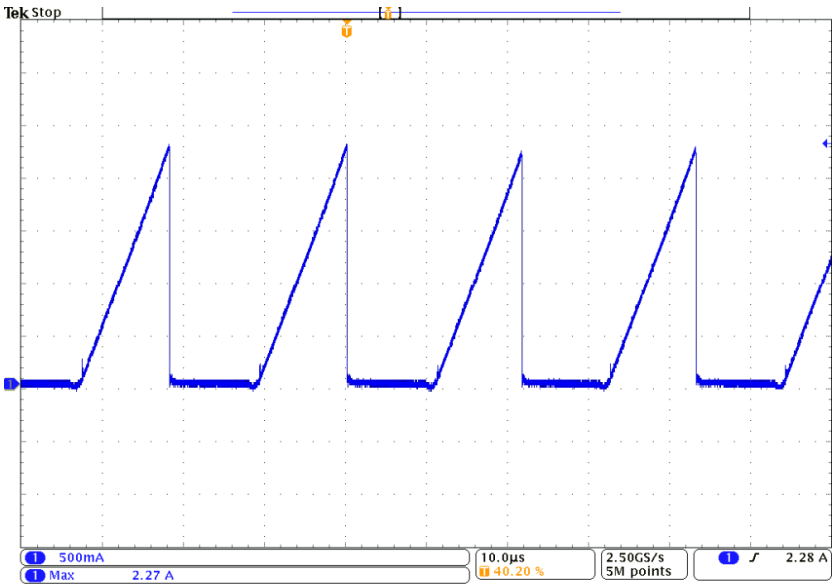
Appendix – Simple Specification for used N-MOS (BSC070N10NS5)

Table 1 Key Performance Parameters

Parameter	Value	Unit
V_{DS}	100	V
$R_{DS(on),max}$	7.0	mΩ
I_D	80	A
Q_{oss}	41	nC
Q_G(0V..10V)	30	nC

21. Transformer Flux Density (@15V)

(Np=33Ts, Lm=0.450mH, Ae=98mm^2-RM10)

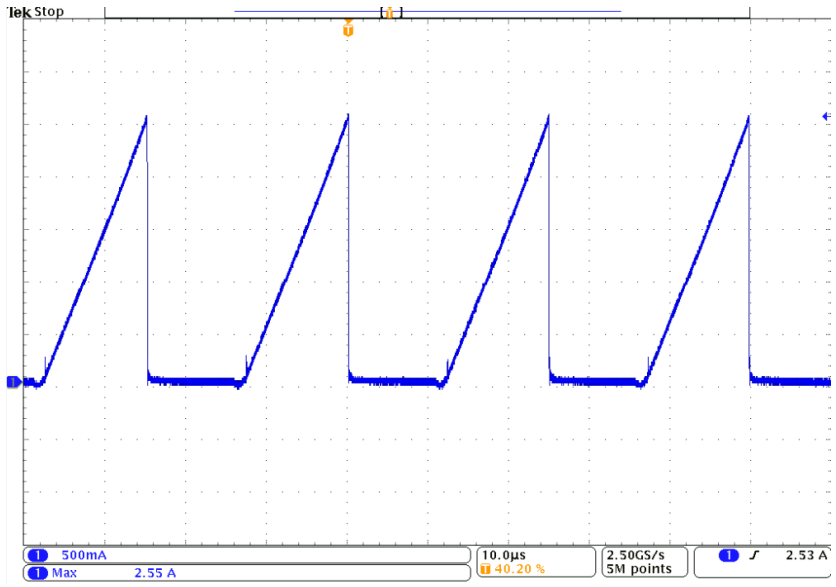


CH1: I_P ,500mA/div

I_P *is monitored at* 90*Vac and* 3*A (full load)*

$I_P = 2270mA$

$$B_{MAX} = \frac{L_{PRI} \times I_P}{N_P \times A_e} = \frac{0.45 \times 2270}{33 \times 98} = 0.315(Tesla)$$



CH1: I_P ,500mA/div

I_P *is monitored at* 90*Vac and* 3.3*A (Max* P_{OUT}*)*

$I_P = 2550mA$

$$B_{MAX} = \frac{L_{PRI} \times I_P}{N_P \times A_e} = \frac{0.45 \times 2550}{33 \times 98} = 0.37(Tesla)$$

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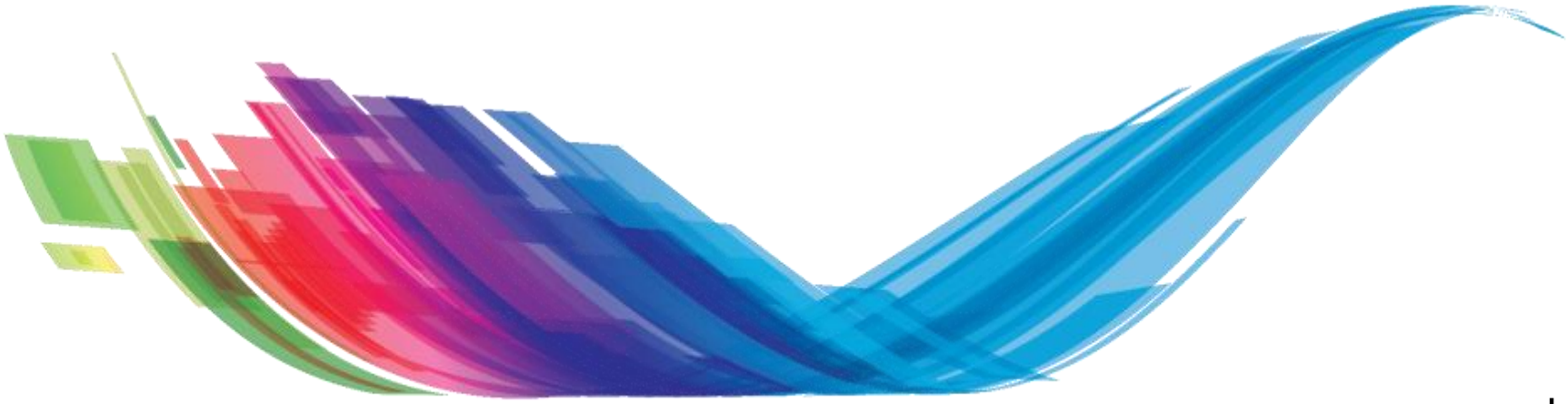

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