iWatt
Intelligent AC-DC and LED Power™

iW1677-00 for 5V2A Adapter Design

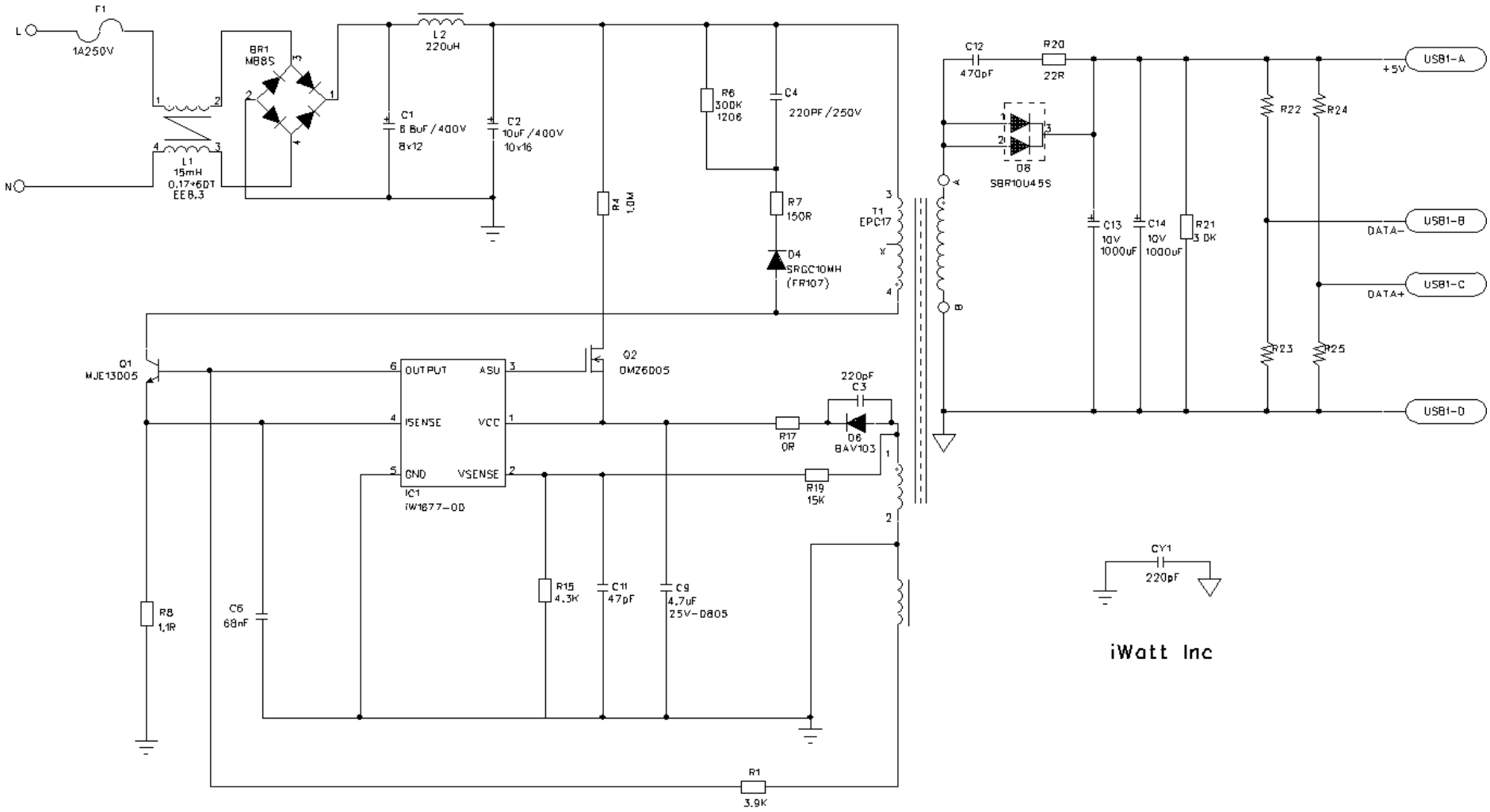
General Design Specification:

1. AC Input Range 90-264Vac
2. DC Output 5V, 2.0A
3. Meet *"30mW"* No-Load standby Power Consumption Requirement
4. Max Ripple <150mV$_{P_P}$

1. Specification

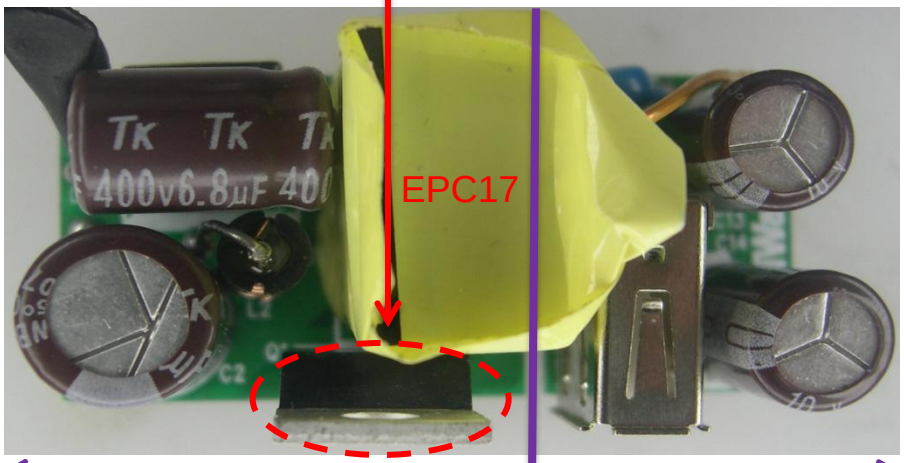
Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	90		264	V_{AC}	2 Wire
Frequency	f_{LINE}	47	50/60	63	Hz	
No-load Input Power (230V_{AC})				30	mW	
Output						
Output Voltage	V_{OUT_CV}	4.75		5.25	V	Measured at the end of Cable
Output Current	I_{OUT_CV}		2.0		A	
Output Ripple Voltage	V_{RIPPLE}			150	mV_{P_P}	Measured at the End of DC Output cable I_{OUT}=2.0A @T_A = 25℃ 20 MHz Bandwidth add 0.1uF+1uF
Total Output Power						
Continuous Output Power	P_{OUT}			10	W	
Over Current Protection	I_{OUT_MAX}			2.5	A	Auto-restart
Efficiency	η	73.37			%	Measured at end of PCB, V_{IN} = 115V_{AC} and 230Vac I_{OUT}= 2.0A. (T_A = 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


F1
1A250V
L
N
BR1
MB8S
L1
15mH
0.17*6DT
EE8.3
L2
220uH
C1
6.8uF/400V
8x12
C2
10uF/400V
10x16
R4
1.0M
R6
300K
1206
C4
220PF/250V
R7
150R
D4
SRGC10MH
(FR107)
T1
EPC17
Q1
MJE13005
Q2
OMZ6005
IC1
iW1677-00
OUTPUT
ASU
ISENSE
VCC
GND
VSENSE
R8
1.1R
C6
68nF
R15
4.3K
C11
47pF
C9
4.7uF
25V-0805
R17
0R
C3
220pF
D6
BAV103
R19
15K
R1
3.9K
C12
470pF
R20
22R
D8
SBR10U45S
C13
10V
1000uF
C14
10V
1000uF
R21
3.0K
R22
R24
R23
R25
USB1-A
+5V
USB1-B
DATA-
USB1-C
DATA+
USB1-D
CY1
220pF
iWatt Inc

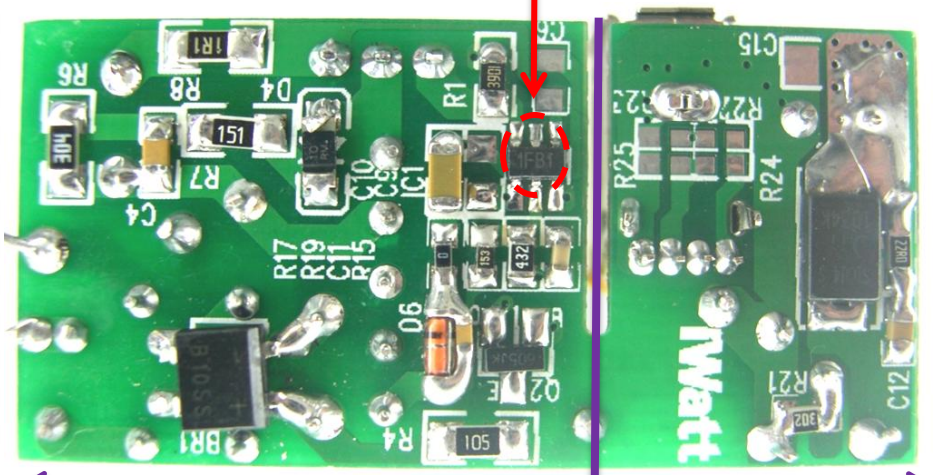
3. Circuit Board Photograph

BJT MJE13005 4A 700V TO-220



Top side

iW1677-00 Primary Sensing Controller
(No Cable-Drop-Compensation)



Bottom side

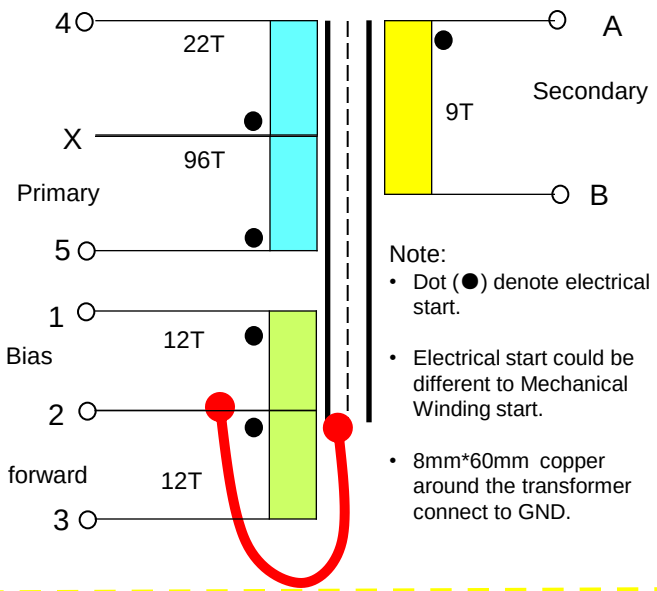
Note: L:45mm W:22.0mm H:22.0mm

4. Bill of Material

Item	Qty.	Ref.	Description
1	1	U1	iW1677-00, Off-line digital PWM Controller, SOT-23-6
2	1	C1	6.8uF, 400V, E-CAP 8*12.5 TK
3	1	C2	10uF, 400V, E-CAP 10*16 TK
4	2	C3,C4	220PF, 250V,SMD-0805
5	1	C6	68nF 25V, X7R,SMD-0805
6	1	C9	4.7uF 25V, X7R,SMD-0805
7	1	C11	47pF,25V,X7R,SMD-0603
8	1	C12	470PF, 250V,SMD-0805
9	1	C13	1000uF/10V, E-CAP, 8x12
10	1	C14	1000uF/10V, LOW-ESR,E-CAP,8X16,
11	1	CY1	220pF/250V, Y1
12	1	BD1	1A800V, MB8S,Bridge Diode, Panjit
13	1	D4	SRGC10MH(FR107),1A800V, Fast Rectifier Diode,SOD-123
14	1	D6	BAV103, 0.2A250V,Rectifier Diode, LL-34
15	1	D8	SBR10U45SP5, Schottky Diode, pow er DI@5, DIODES
16	1	F1	1A/250V, Fuse
17	1	L1	>15mH,CM Inductor, EE8.3, 0.17x60T
18	1	L2	220uH,LM Inductor,5*10 0.25*110Ts
19	1	Q1	MJE13005, 700V/4A, TO-220
20	1	Q2	DMZ6005, Depletion Mode MOSFET, 500V/30mA, SOT23
21	1	R1	3.9K ±5％, SMD-0805
22	1	R4	1M ±5％, SMD-1206
23	1	R5	300K ±5％, SMD-1206
24	1	R7	150R ±5％, SMD-1206
25	1	R8	1R1 ±1％, SMD-1206
26	1	R15	4.3KΩ ±5％, SMD-0603
27	1	R17	0Ω ±5％, SMD-0603
28	1	R19	15K ±1％, SMD-0603
29	1	R20	22Ω ±5％,SMD-0805
30	1	R21	3K ±5％, SMD-0805
31	1	USB	USB Connector,Vertical
32	1	T1	EPC17, Transformer,Vertical
33	1	PCB	Double Side Board, FR-4, 22mmX45mm

5. Transformer Design

SCHEMATIC



ELECTRICAL SPECIFICATIONS:

1. Primary Inductance (Lp) =0.9mH±5% @10K Hz/1.0V
2. Primary Leakage Inductance (L_K) <5%*Lp Short pinA-pinB
3. Electrical Strength = 3KV,1Min (Primary&Secondary)

MATERIALS:

1. Core : EPC17 (Ferrite Material TDK PC40 or equivalent)
2. Bobbin : EPC17
3. Magnet Wires (Pri) : Type 2-UEW
4. Magnet Wire (Sec) : Triple Insulated Wires
5. Layer Insulation Tape :3M1298 or equivalent.

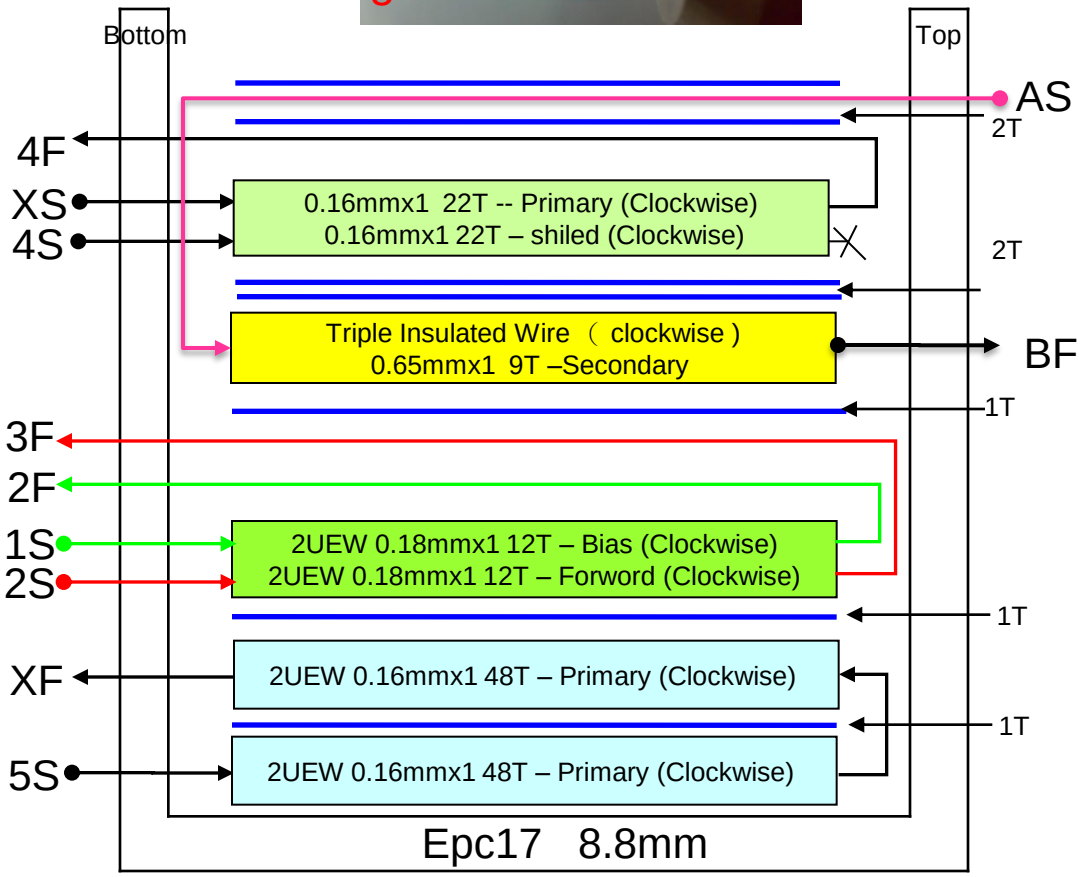
FINISHED :

1. Varnish the complete assembly

Instruction for start of first winding…

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

Rotating direction of winding machine



6. Regulation, Ripple and Efficiency Measurement

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Note: Output voltage measured at end of PCB

V_{IN} (V_{AC})	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	V_{RIPPLE} (mV_{P-P})	P_{OUT} (W)	η (%)	OCP (A)	Average η (%)	EPA2.0 η(%)
90	0.019	5.09	0	10.4			2.24	80.9	
	3.15	5.10	0.500	48	2.55	80.95			
	6.29	5.11	1.000	68	5.11	81.24			
	9.48	5.13	1.500	78	7.70	81.17			
	12.83	5.15	2.000	108	10.30	80.28			
115	0.019	5.07	0	10.4			2.24	81.8	73.37
	3.13	5.10	0.500	60	2.55	81.47			
	6.25	5.12	1.000	68	5.12	81.92			
	9.38	5.13	1.500	75	7.70	82.04			
	12.58	5.15	2.000	98	10.30	81.88			
230	0.027	5.07	0	12			2.23	81.3	
	3.18	5.10	0.500	46	2.55	80.19			
	6.30	5.11	1.000	58	5.11	81.11			
	9.41	5.13	1.500	64	7.70	81.77			
	12.53	5.15	2.000	88	10.30	82.20			
264	0.032	5.11	0	12			2.23	80.8	
	3.22	5.10	0.500	54	2.55	79.19			
	6.33	5.12	1.000	66	5.12	80.88			
	9.47	5.13	1.500	74	7.70	81.26			
	12.59	5.15	2.000	86	10.30	81.81			

7. EPA_2.0 Requirement

*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}=10W)

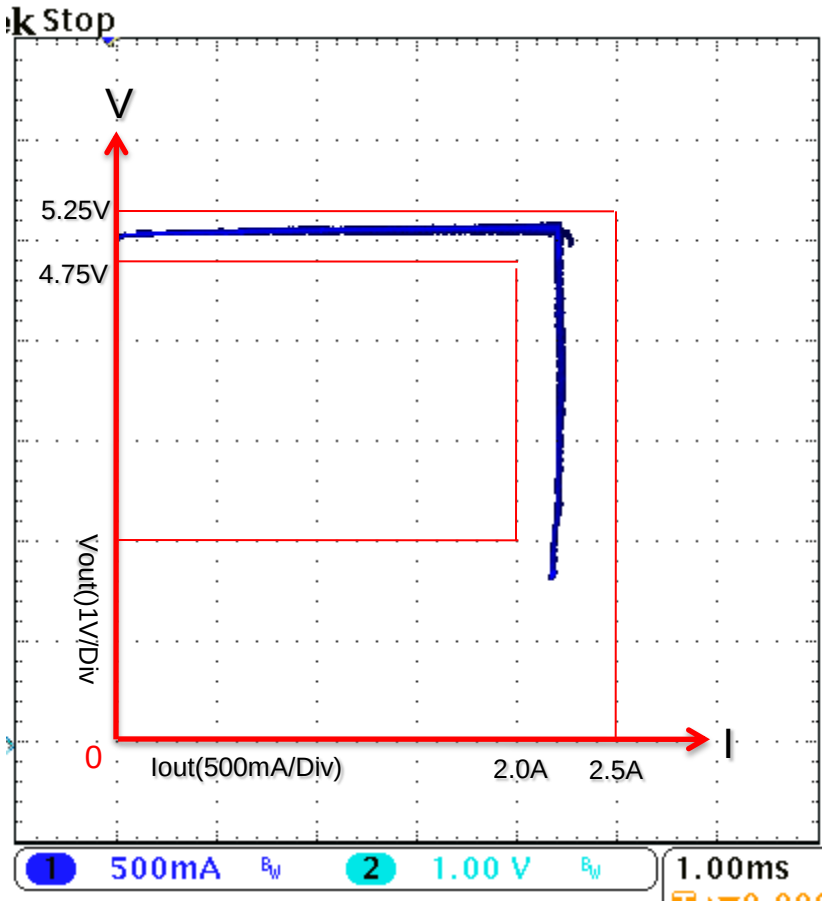
$$0.075 \times Ln(10W) + 0.561 = 73.7\%$$

Meet EPA2.0 with lots of Margin!

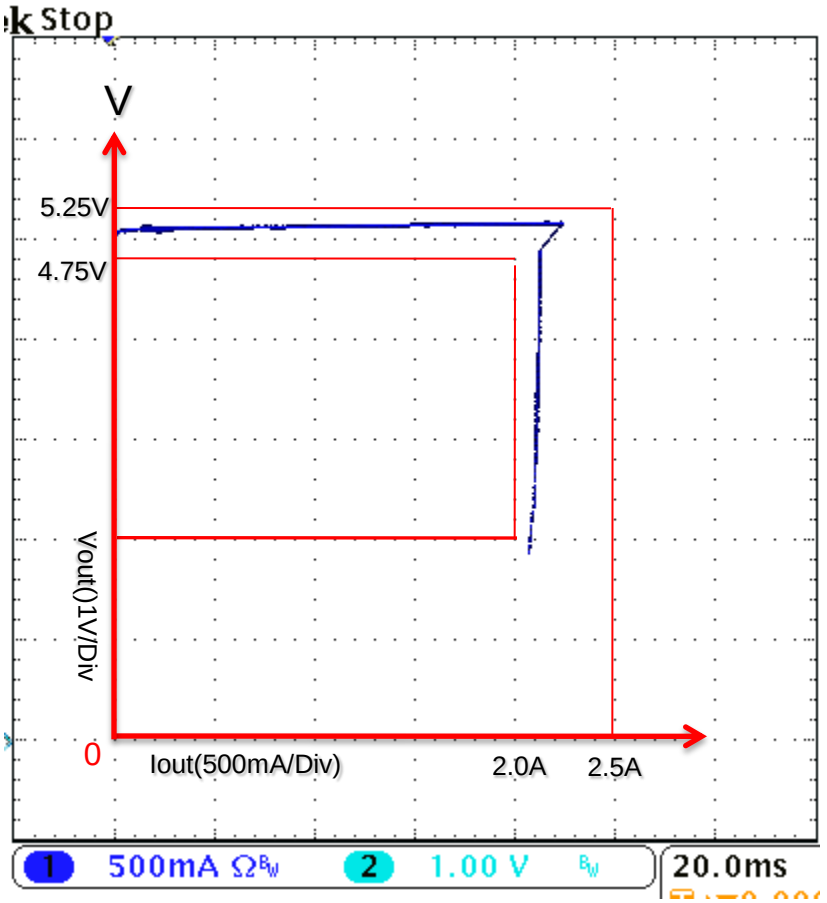
V_{IN} (VAC)	I_{OUT} (mA)	P_{IN} (W)	Measure at end of PCB				Measure at end of Cable 24AWG/1.0m, R_{Cable}=0.18Ω			
			$V_{OUT\ PCB}$ (V)	$P_{OUT\ PCB}$ (W)	EFF_{PCB} (%)	AV-EFF_{PCB} (%)	$V_{OUT\ Cable}$ (V)	$P_{OUT\ Cable}$ (W)	EFF_{Cable} (%)	AV-EFF_{Cable} (%)
115	500	3.13	5.10	2.55	81.47	81.83	5.01	2.51	80.03	78.24
	1000	6.25	5.12	5.12	81.92		4.94	4.94	79.04	
	1500	9.38	5.13	7.70	82.04		4.86	7.29	77.72	
	2000	12.58	5.15	10.30	81.88		4.79	9.58	76.15	
230	500	3.18	5.10	2.55	80.19	81.32	5.01	2.51	78.77	77.74
	1000	6.30	5.11	5.11	81.11		4.93	4.93	78.25	
	1500	9.41	5.13	7.70	81.77		4.86	7.29	77.47	
	2000	12.53	5.15	10.30	82.20		4.79	9.58	76.46	

8. Output VI Characteristics

V_{IN}=90Vac/50Hz

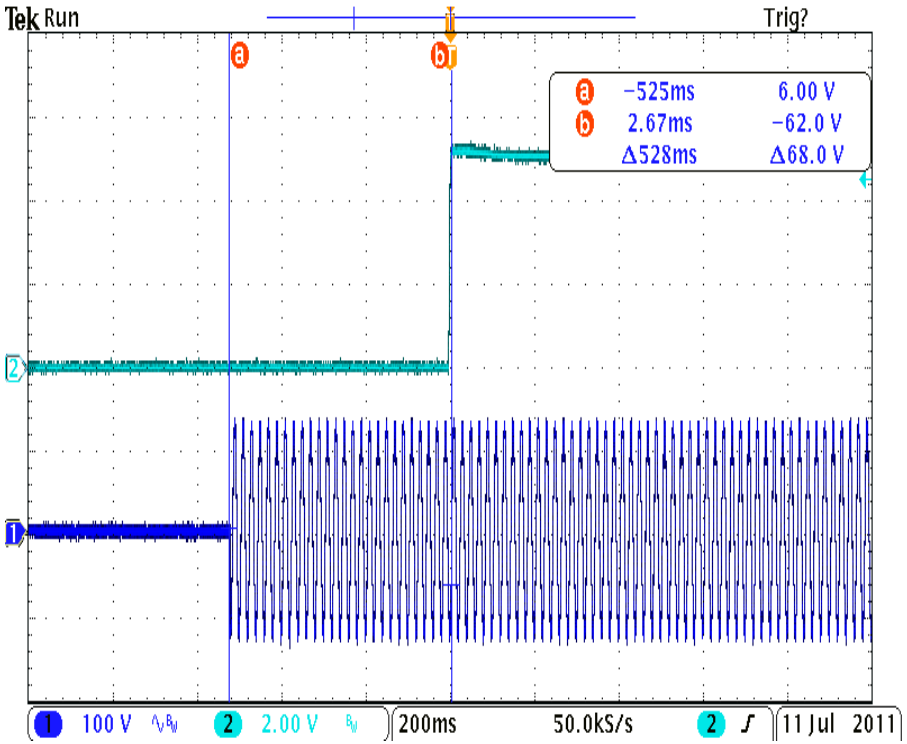


V_{IN}=264Vac/50Hz



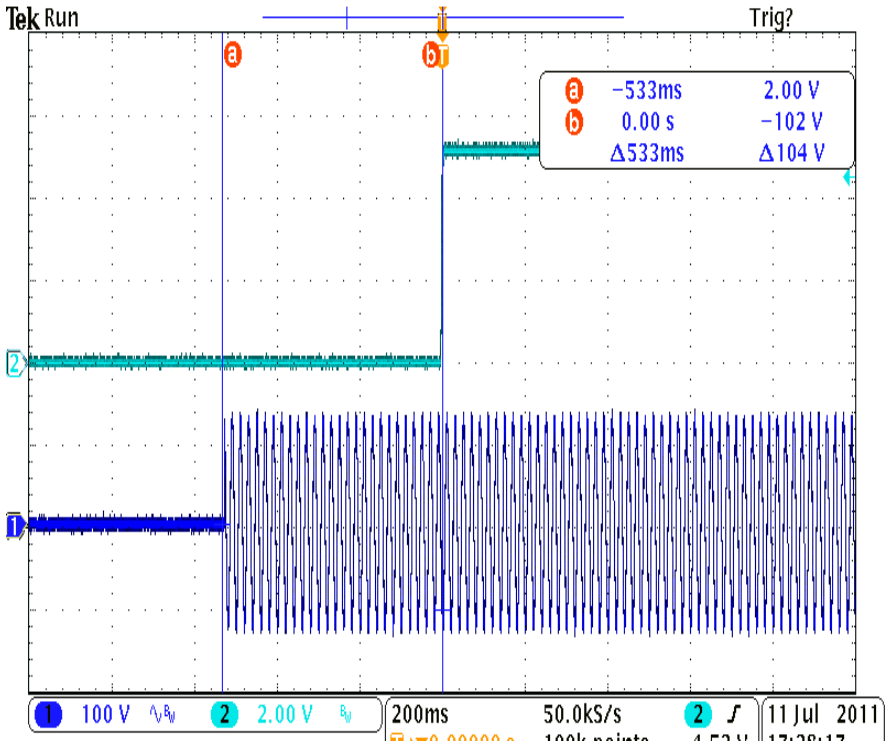
* Note: Output voltage is monitored at end of PCB

9. Turn On Delay Time



90V_{AC},No Load

T_{ST_DELAY}=528mS

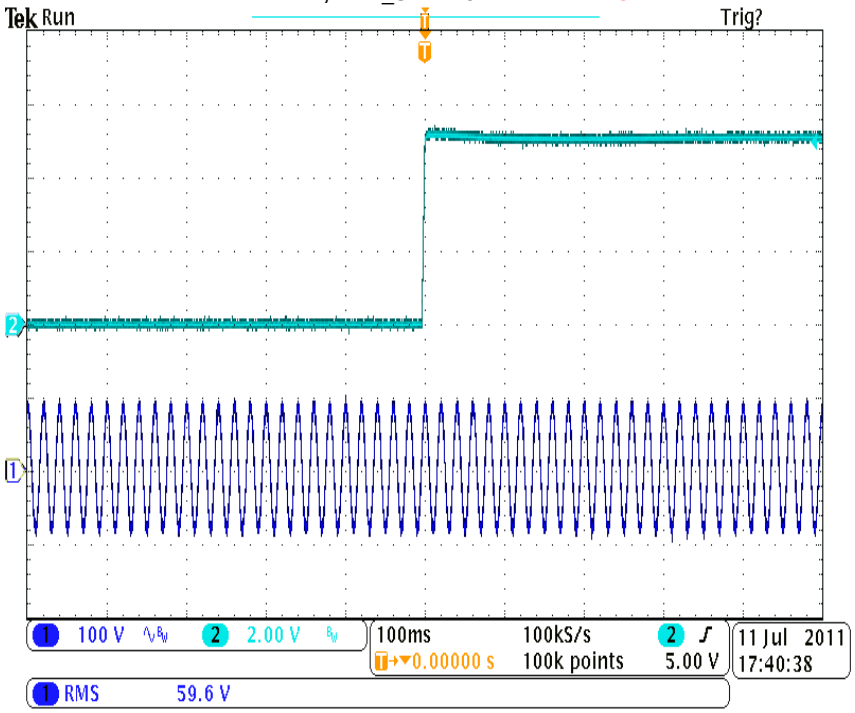


90V_{AC},Full Load

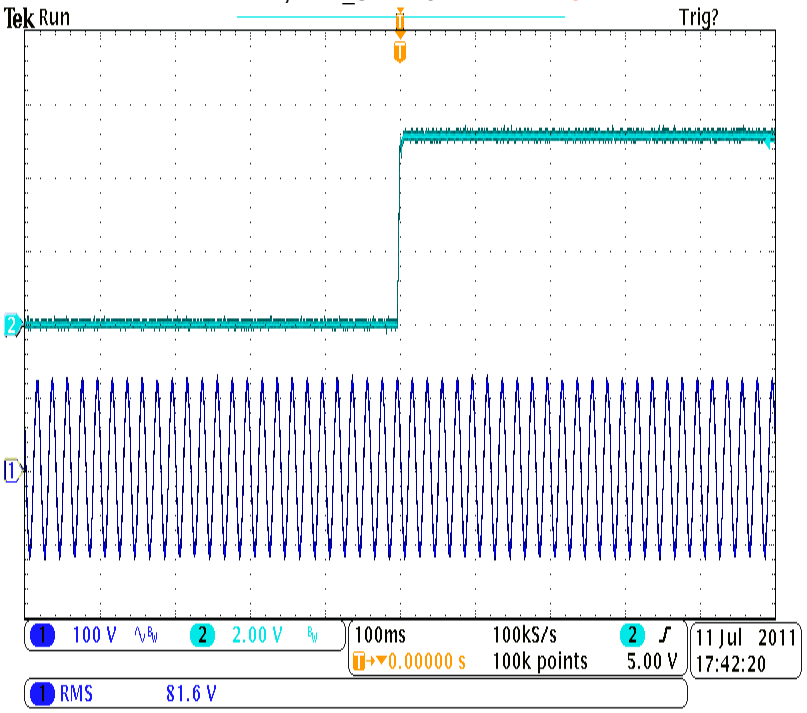
T_{ST_DELAY}=533S

10. AC Startup Voltage Characteristic

No Load, $V_{IN\_STARTUP}$ =59.6V_{AC}



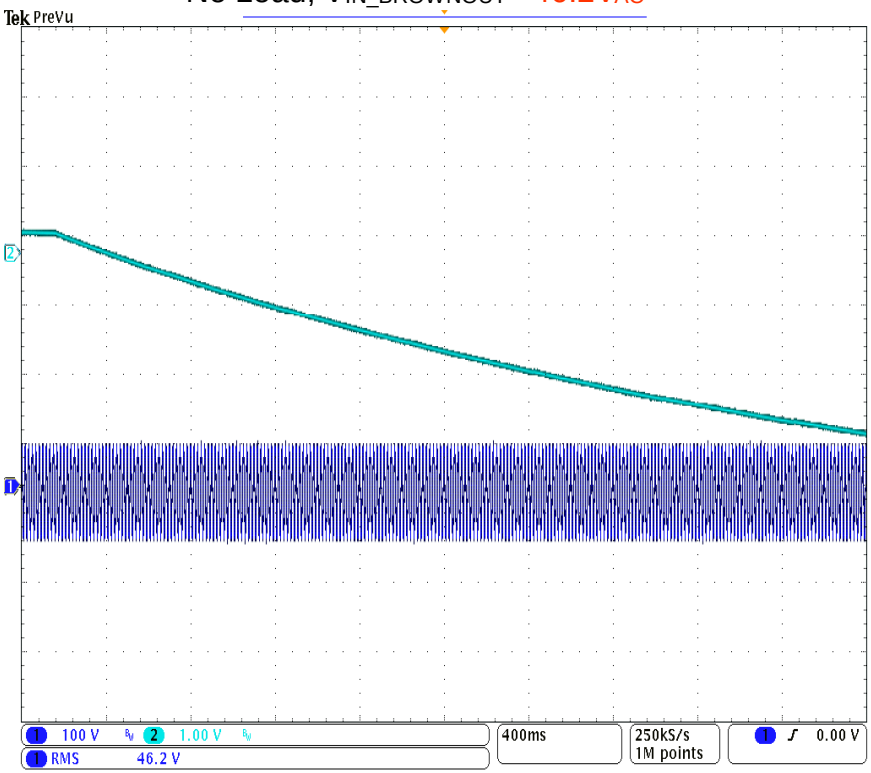
Full Load, $V_{IN\_STARTUP}$=81.6V_{AC}



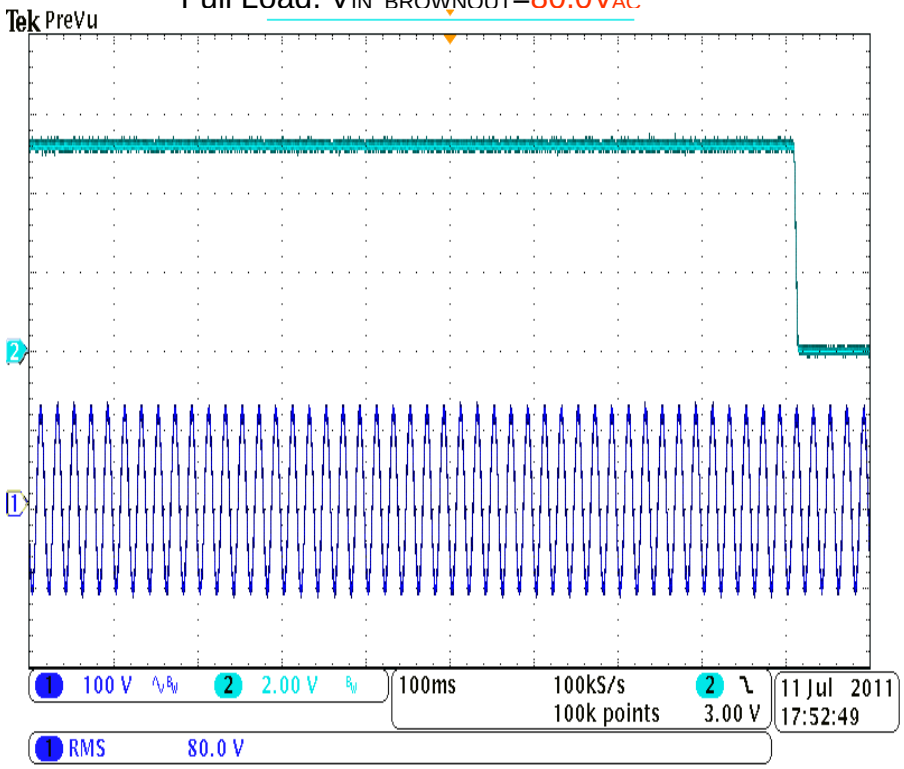
CH1: Input Voltage, 100V/Div CH2: Output Voltage, 2V/Div

11. AC Brownout Voltage Characteristic

No Load, $V_{IN\_BROWNOUT}$ =46.2V_{AC}



Full Load. $V_{IN\ BROWNOUT}$=80.0V_{AC}



CH1: Input Voltage, 100V/Div CH2: Output Voltage, 2V/Div

12. Output Voltage Rise Time

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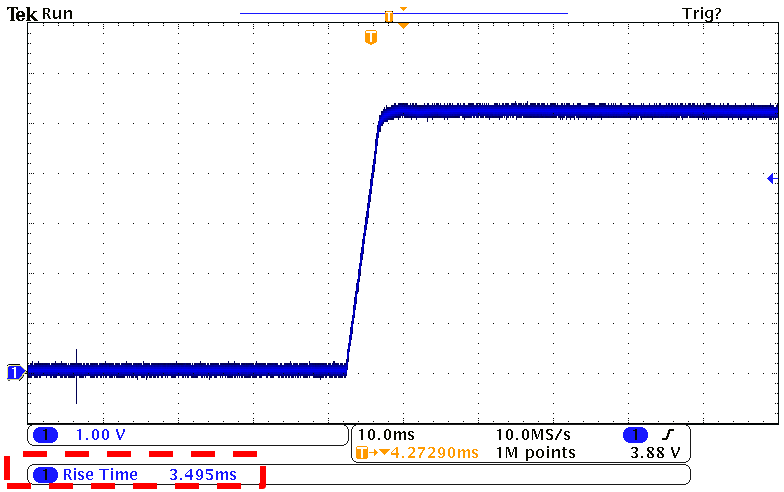
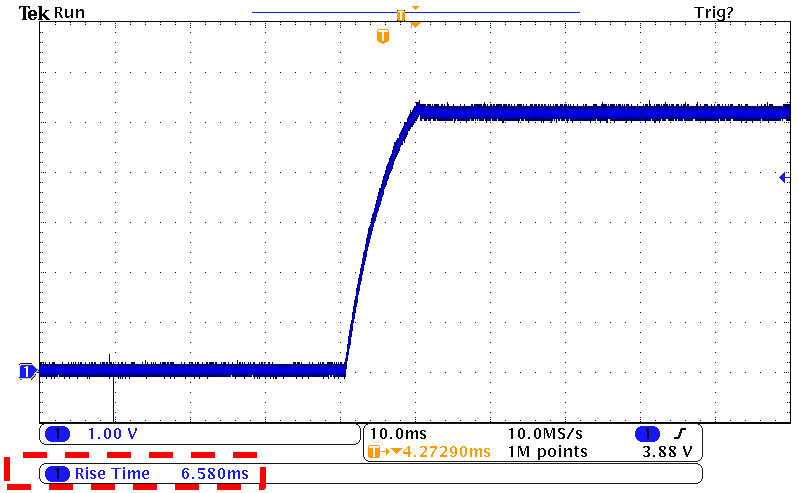
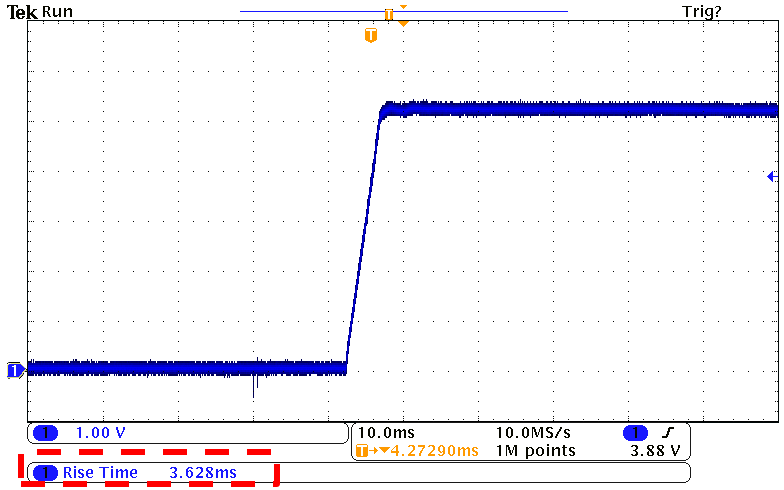
90VAC, No Load



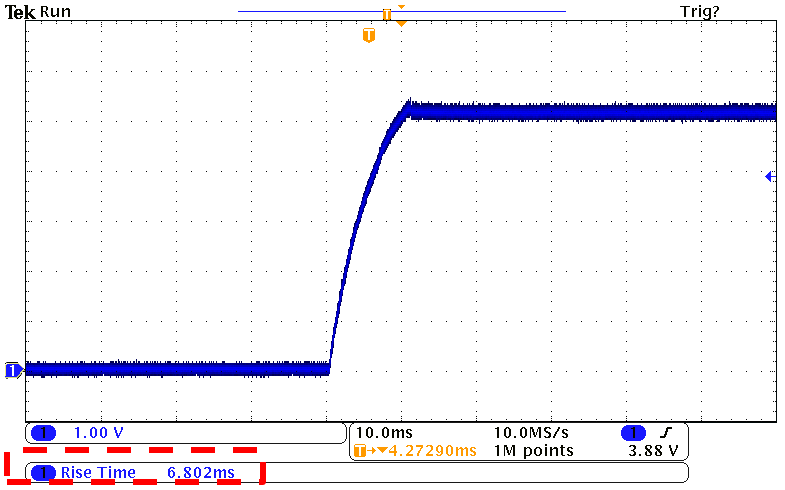
90VAC, Full Load



264VAC, No Load



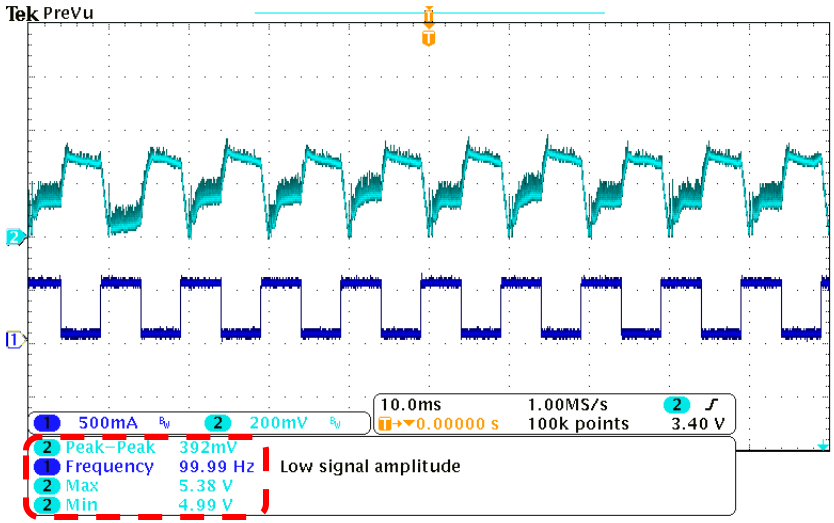
264VAC, Full Load



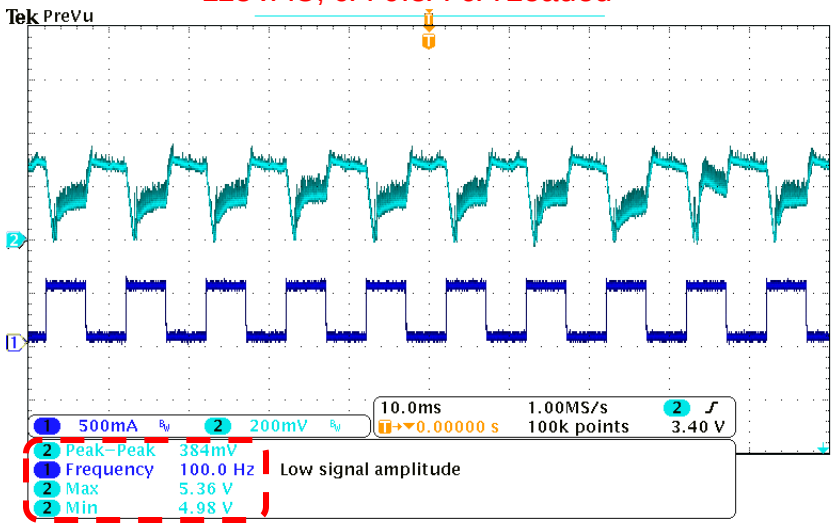
13.1 Load Dynamic Response(Freq:100Hz)

Test Condition: 1).Slew-Rate:0.5A/us; 2).Duty-Cycle:50%; 3).V_{OUT} is measured at PCB End

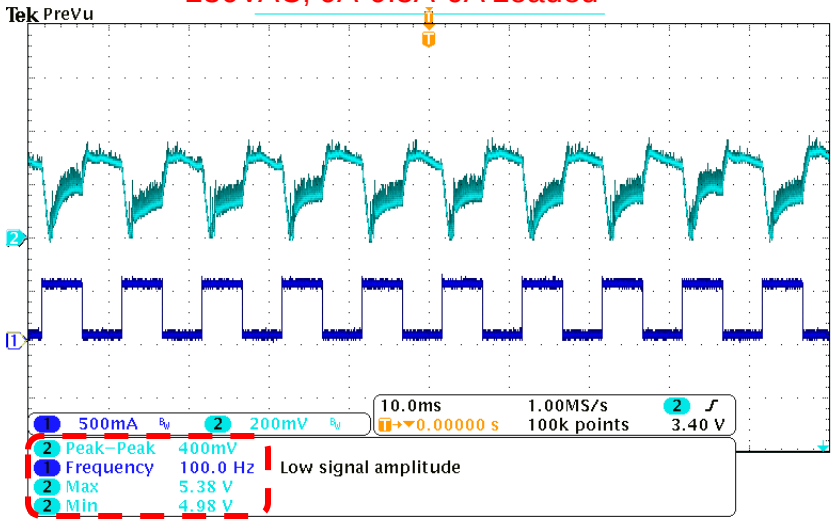
90VAC, 0A-0.5A-0A Loaded



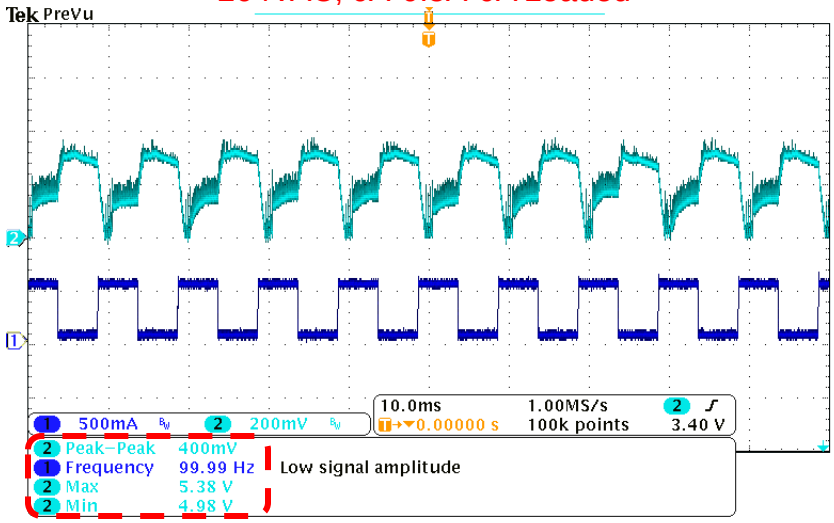
115VAC, 0A-0.5A-0A Loaded



230VAC, 0A-0.5A-0A Loaded



264VAC, 0A-0.5A-0A Loaded



13.2 Load Dynamic Response(Freq:100Hz)

Test Condition: 1).Slew-Rate:0.5A/us; 2).Duty-Cycle:50%; 3).V_{OUT} is measured at PCB End

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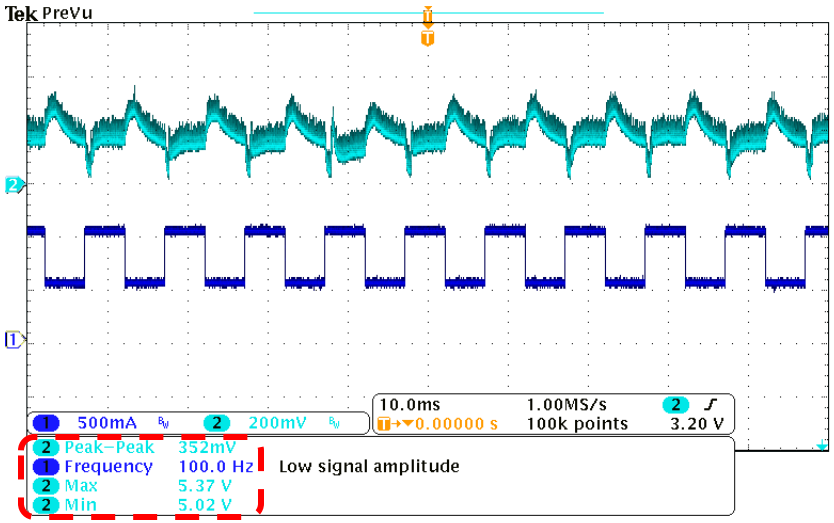
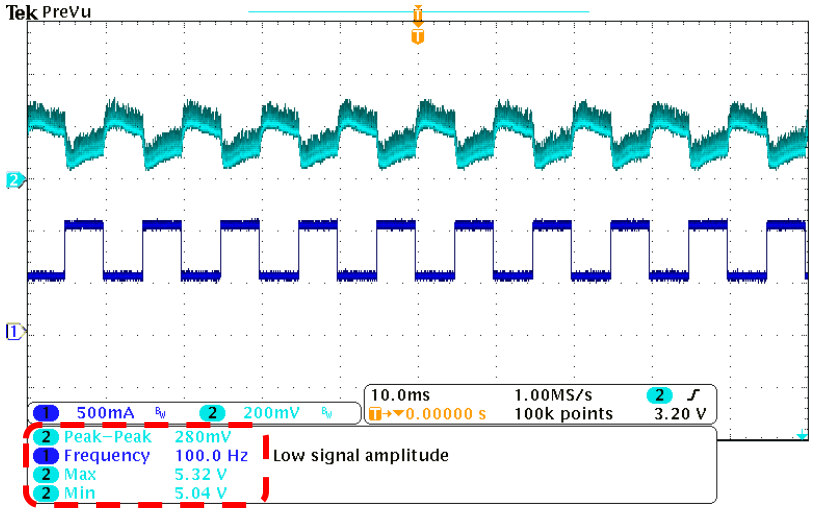
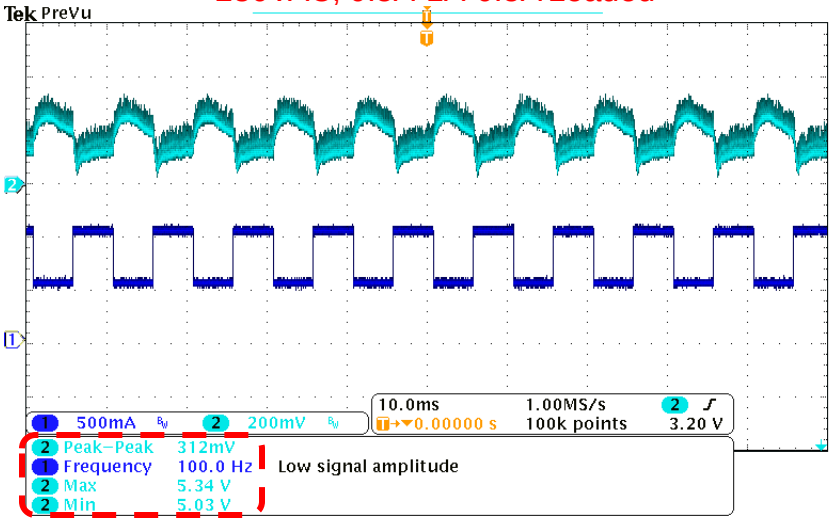
90VAC, 0.5A-1A-0.5A Loaded



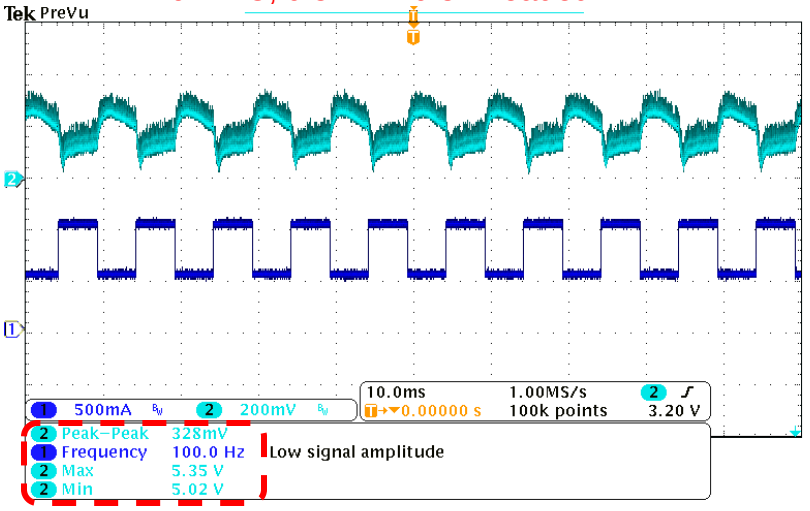
115VAC, 0.5A-1A-0.5A Loaded



230VAC, 0.5A-1A-0.5A Loaded



264VAC, 0.5A-1A-0.5A Loaded



13.3 Load Dynamic Response(Freq:100Hz)

Test Condition: 1).Slew-Rate:0.5A/us; 2).Duty-Cycle:50%; 3).V_{OUT} is measured at PCB End

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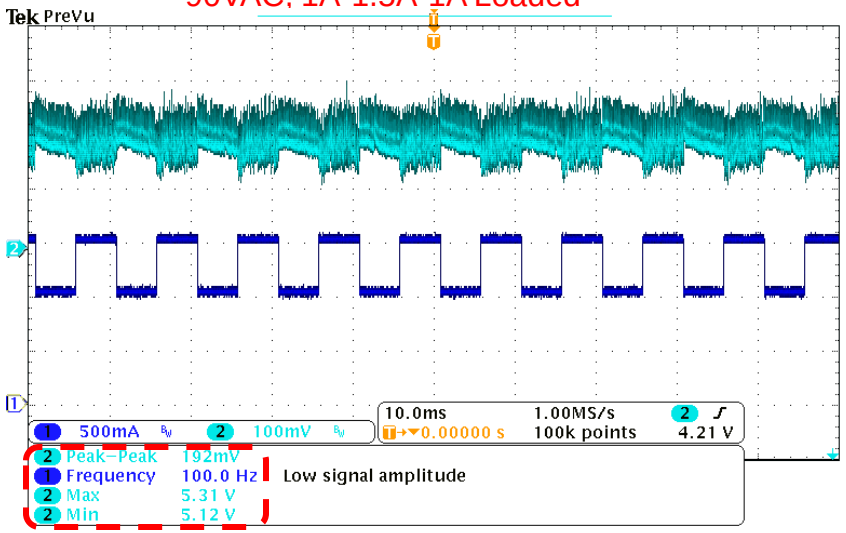
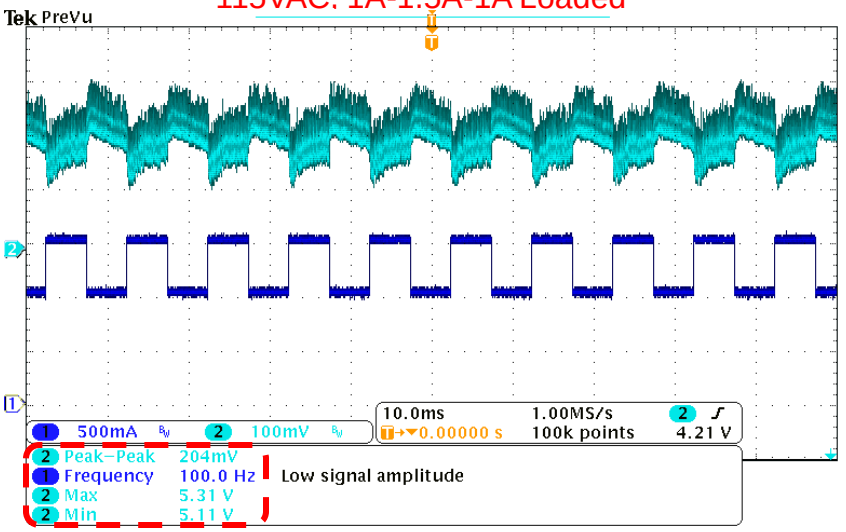
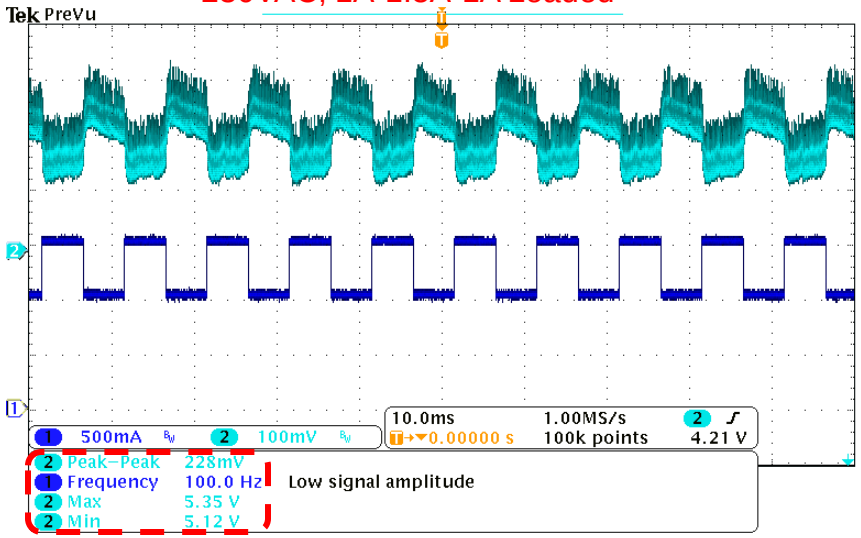
90VAC, 1A-1.5A-1A Loaded



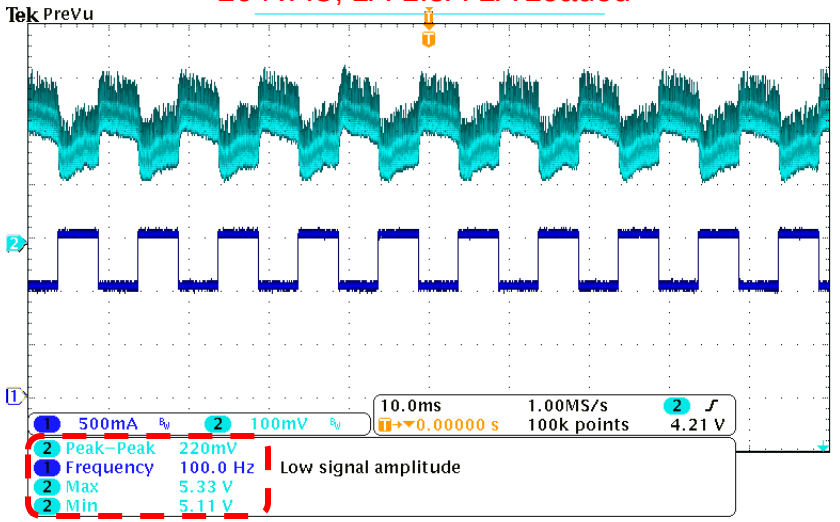
115VAC, 1A-1.5A-1A Loaded



230VAC, 1A-1.5A-1A Loaded



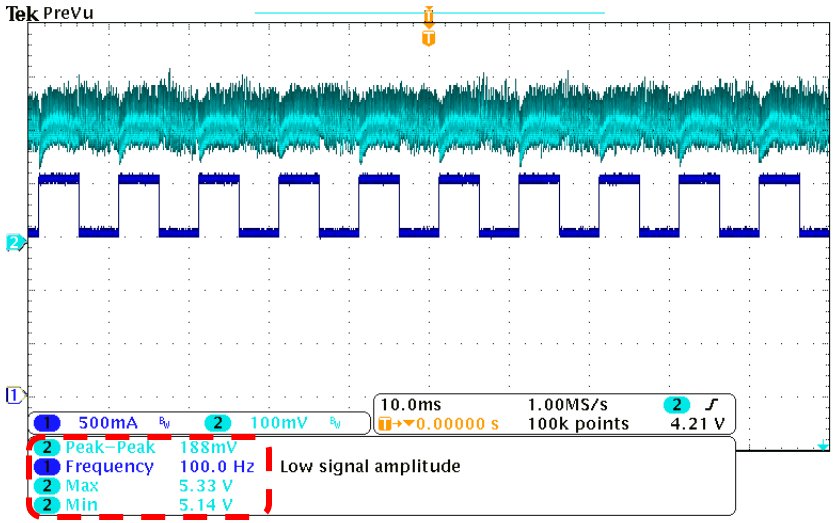
264VAC, 1A-1.5A-1A Loaded



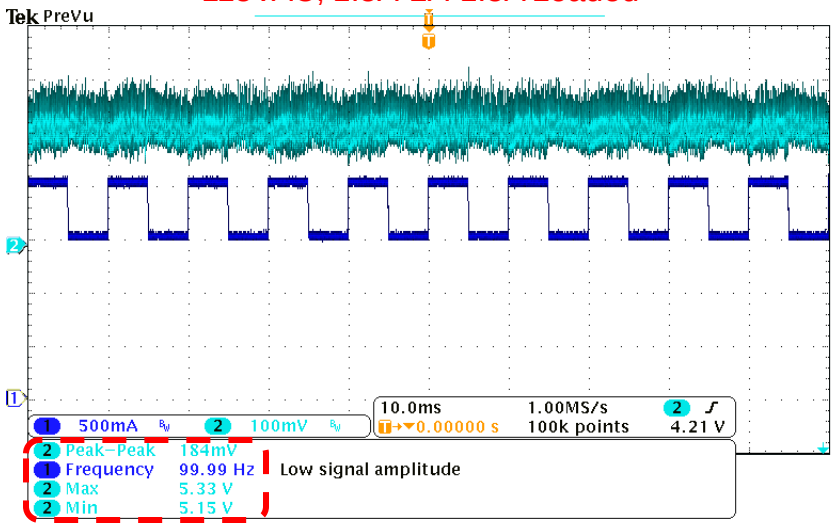
13.4 Load Dynamic Response(Freq:100Hz)

Test Condition: 1).Slew-Rate:0.5A/us; 2).Duty-Cycle:50%; 3).V_{OUT} is measured at PCB End

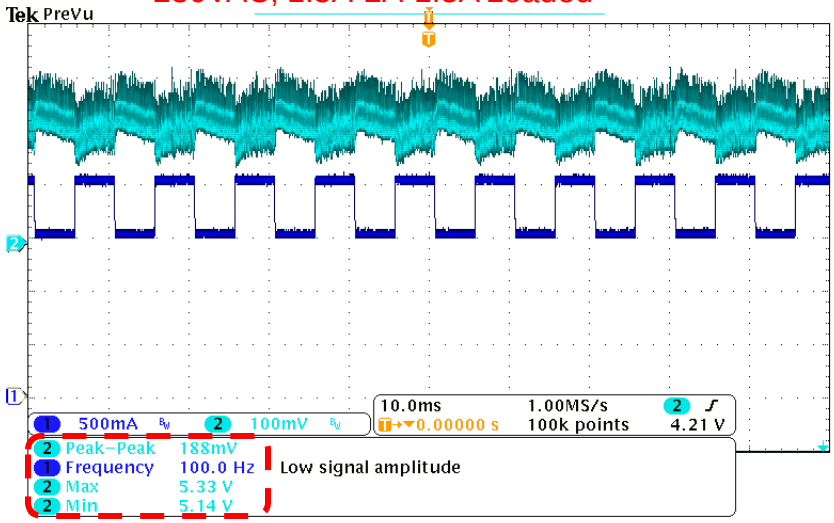
90VAC, 1.5A-2A-1.5A Loaded



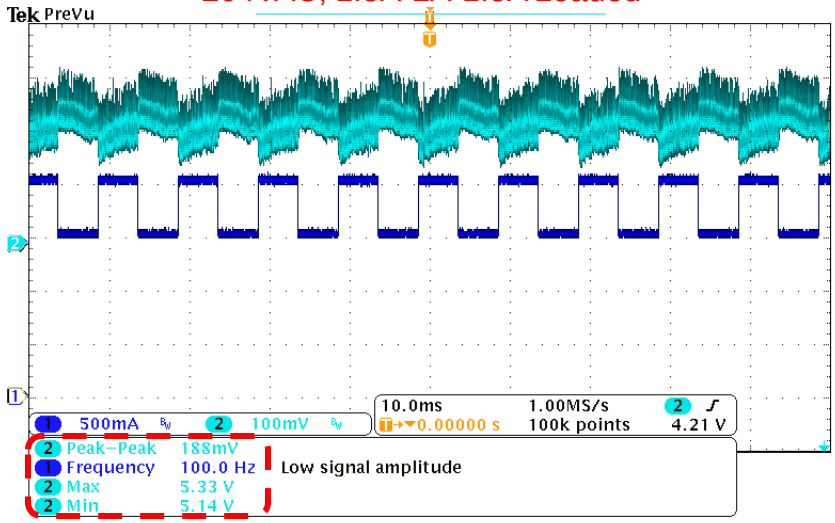
115VAC, 1.5A-2A-1.5A Loaded



230VAC, 1.5A-2A-1.5A Loaded



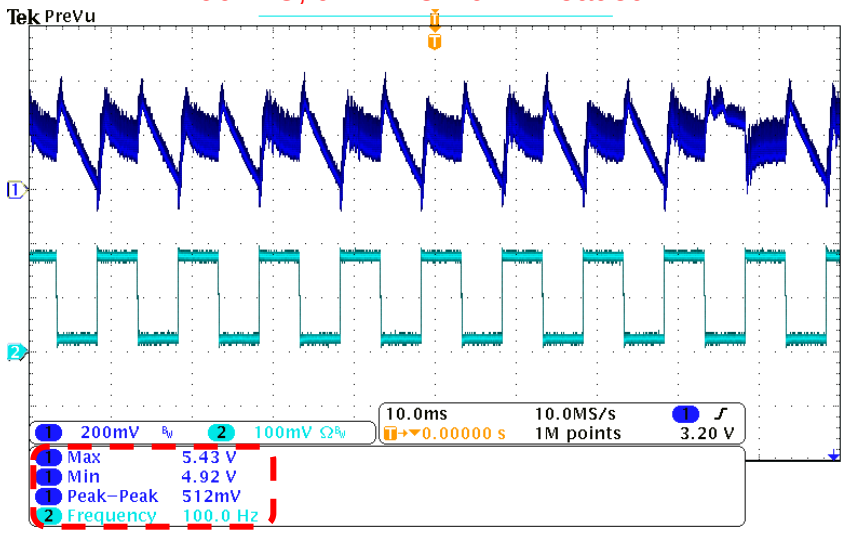
264VAC, 1.5A-2A-1.5A Loaded



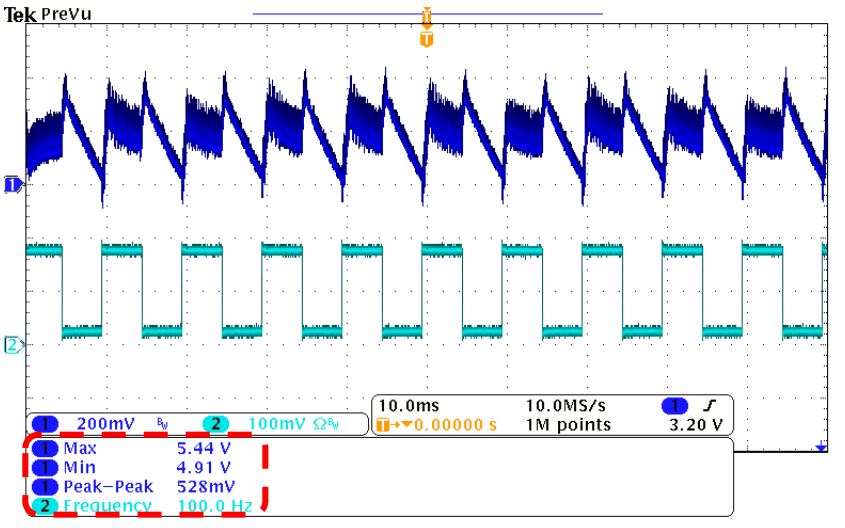
13.5 Load Dynamic Response(Freq:100Hz)

Test Condition: 1).Slew-Rate:0.5A/us; 2).Duty-Cycle:50%; 3).V_{OUT} is measured at PCB End

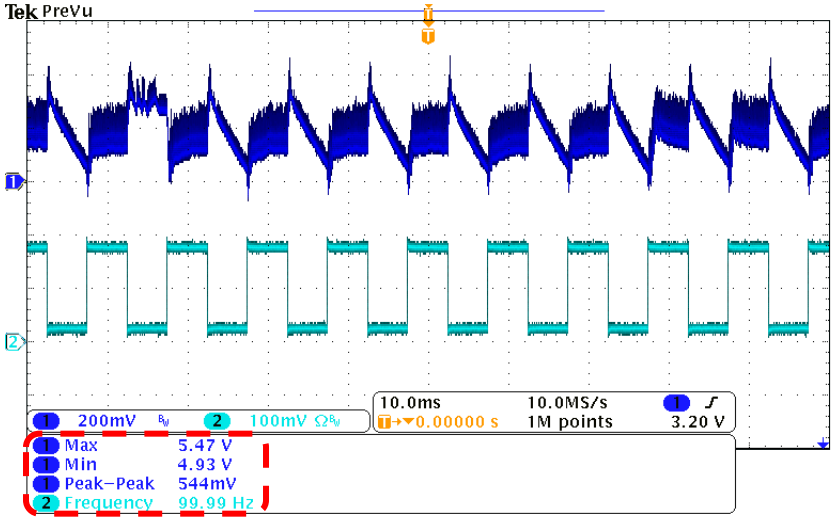
90VAC, 0.2A-1.8A-0.2A Loaded



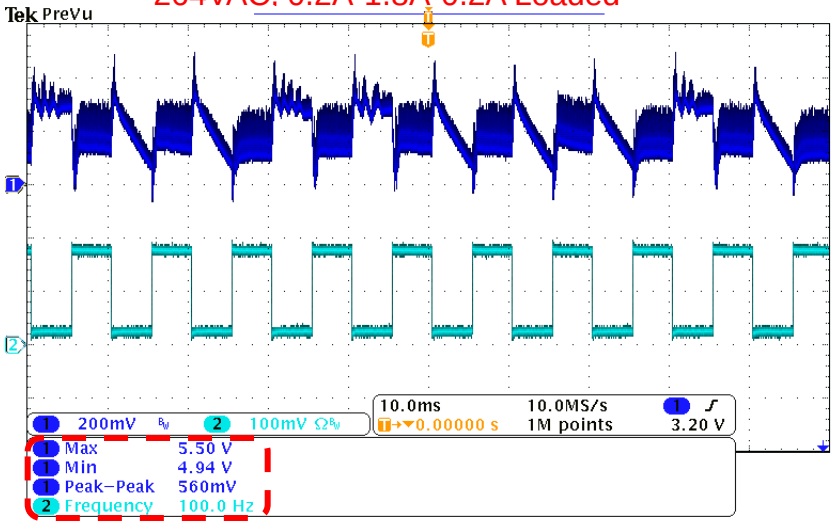
115VAC, 0.2A-1.8A-0.2A Loaded



230VAC, 0.2A-1.8A-0.2A Loaded

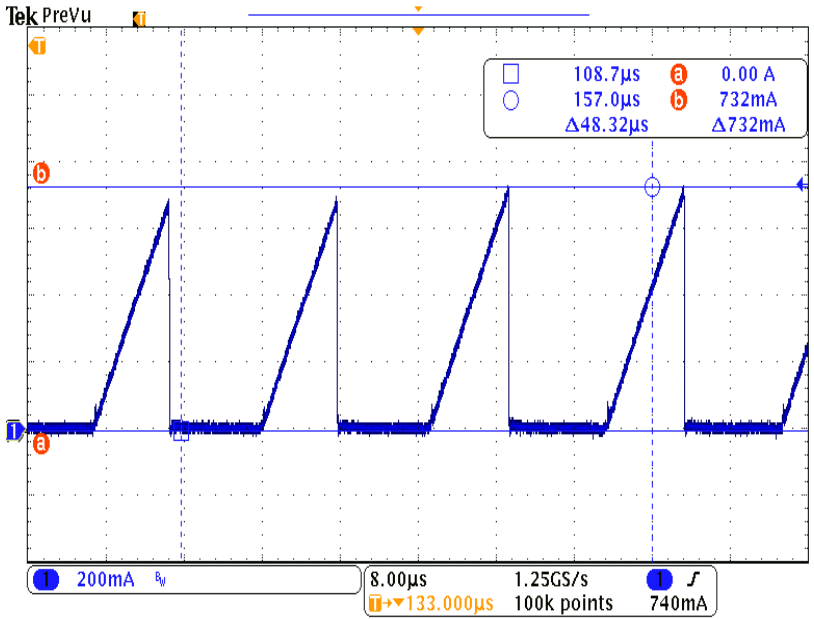


264VAC, 0.2A-1.8A-0.2A Loaded



14. Transformer Flux Density

(Np=118Ts, Lm=940uH, Ae=22.5mm^2-EPC17)



CH1: I_{PRI} ,200mA/div

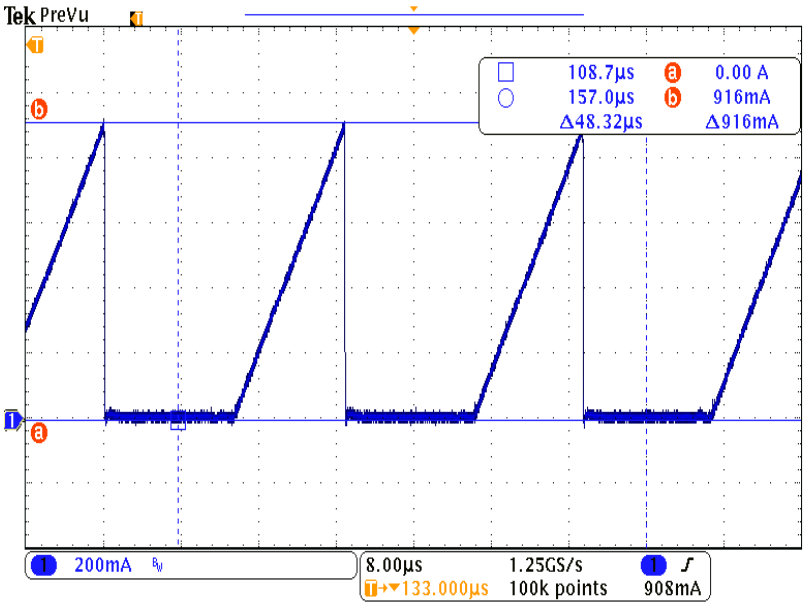
I_{PRI} is monitored at 90Vac and *2.0A* load

I_{PRI}=732mA

$B_{MAX} = I_{PRI} * L_{PRI} / (N_P * A_e)$

=(732*0.94)/(118*22.5)

=0.26Tesla



CH1: I_{PRI} ,200mA/div

I_{PRI} is monitored at 90Vac and *2.2A* load (Max Output Power).

I_{PRI}=916mA

$B_{MAX} = I_{PRI} * L_{PRI} / (N_P * A_e)$

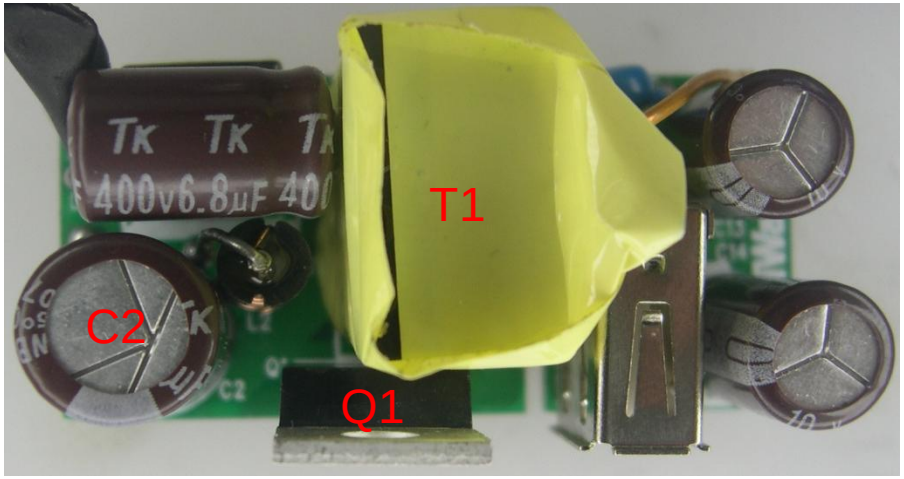
=(916*0.94)/(118*22.5)

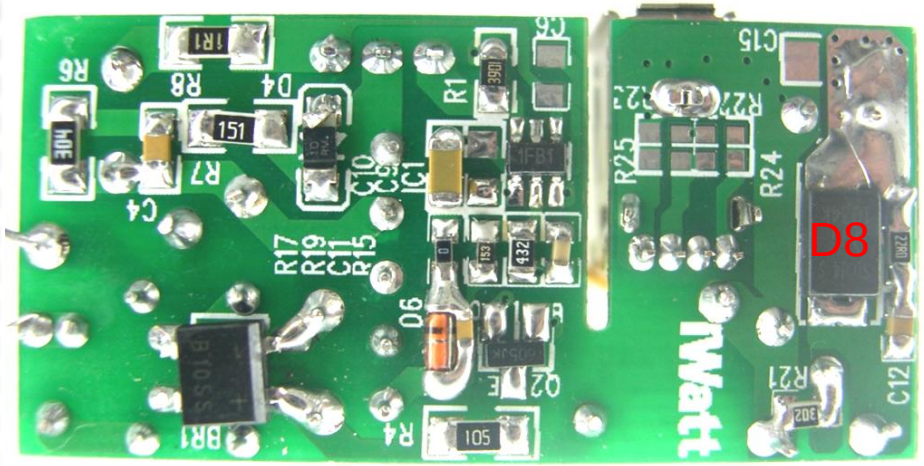
=0.324Tesla

16. Thermal Test for Critical Component

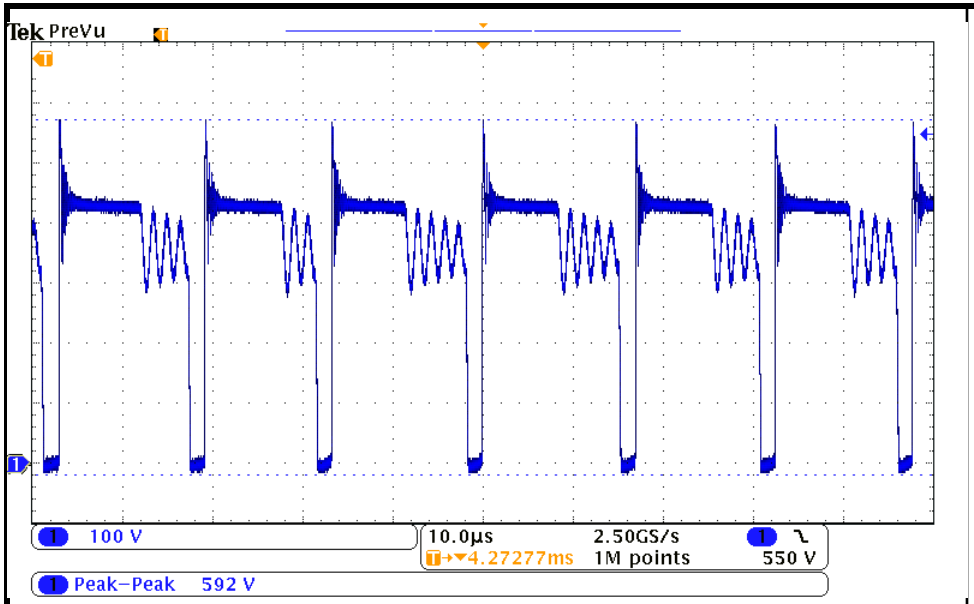
Note: The UUT is assembled with case and placed in a temperature Chamber.

Item	I_{OUT}=2000mA			
	V_{IN}=90V_{AC}		V_{IN}=264V_{AC}	
	T(℃)	Tr(℃)	T(℃)	Tr(℃)
Input Capacitors (C2,10uF/400V)	89.2	54.0	88.4	53.1
Transistor (Q1,MJE13005)	92.3	57.1	94.3	59.0
Transformer wire(T1, EPC17)	100.5	65.3	96.7	61.4
Transformer core(T1, EPC17)	99.4	64.2	92.1	56.8
Schottky Diode(D8, SBR10U45)	103.1	67.9	102.5	67.2
Ambient Temperature	35.2℃		35.3℃	





16. V_{ce} Waveform



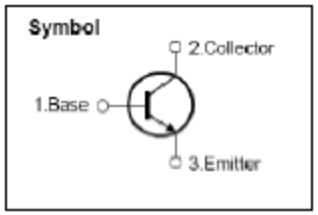
Test Condition:

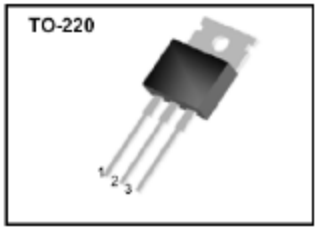
V_{IN}=264VAC,I_{OUT}=2.0A

Result:

V_{ce_MAX}=**592V**

Appendix – Simple Specification for used Transistor (MJE13005)

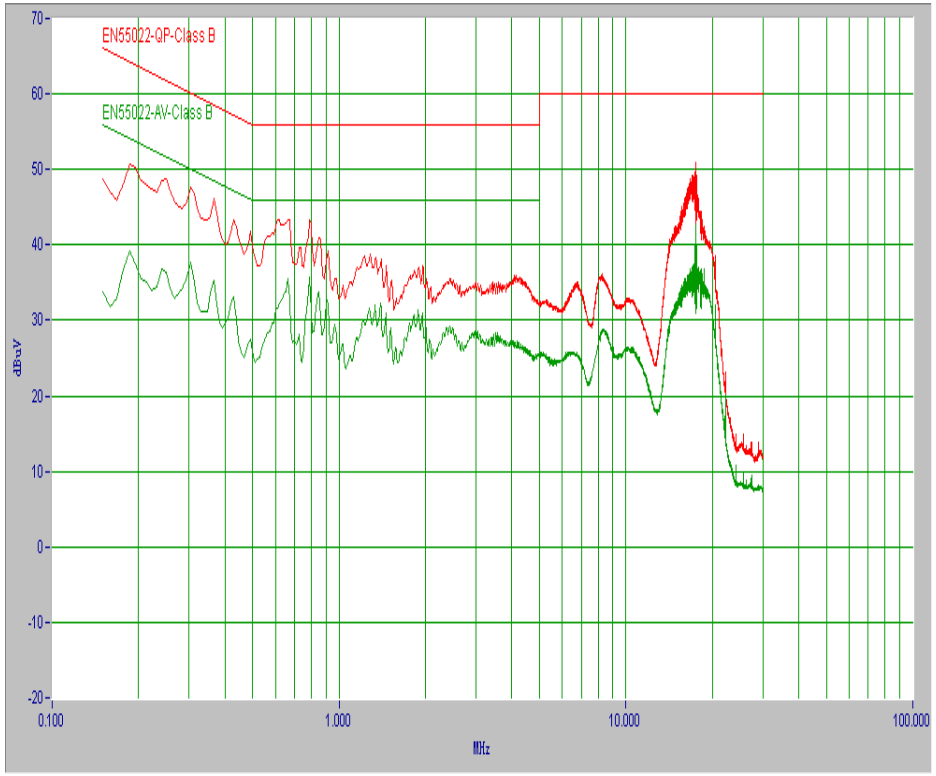




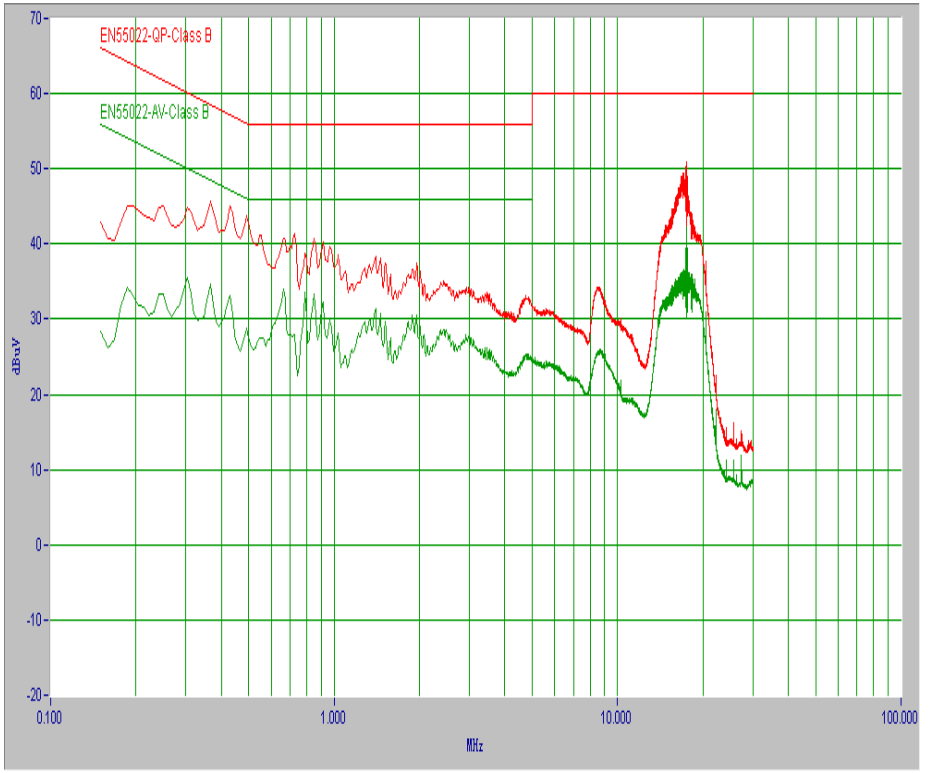
参数名称		符号	额定值	单位
集电极-基 极电压		V_{CBO}	700	V
集电极-发射极电压		V_{CEO}	400	V
发射极-基 极电压		V_{EBO}	9	V
集电极电流		I_C	4	A
耗散功率	Ta=25℃	P_{tot}	2	W
	Tc=25℃		75	
结温		T_j	150	℃
贮存温度		T_{stg}	-55～150	℃

17. Conducted EMI

Vin=230Vac/50, Live



Vin=230Vac/50Hz, Neutral



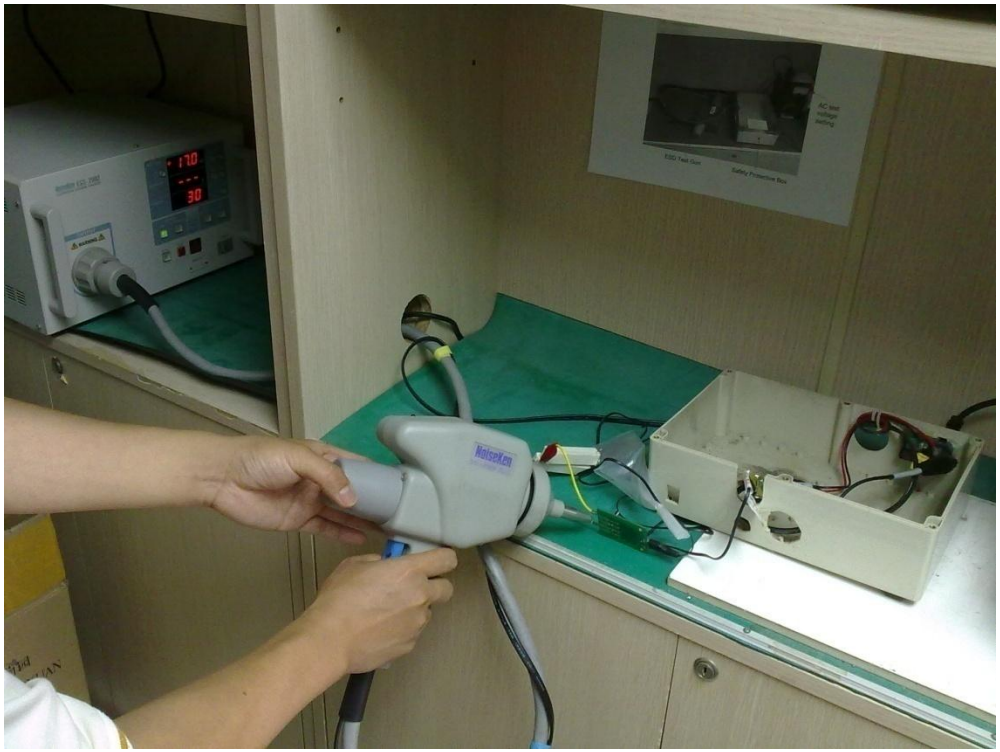
QP Scan

AV Scan

Note: Resistive full-load(2.5R), output (-) is grounded.

18. ESD Test (IEC 61000-4-2)

Air-Discharge		Result (no-load)	Result (full-load)
12KV	+		PASS
	-		PASS
13KV	+		PASS
	-		PASS
14KV	+		PASS
	-		PASS
15KV	+		PASS
	-		PASS
16KV	+		PASS
	-		PASS
17KV	+		PASS
	-		PASS
18KV	+		PASS
	-		PASS

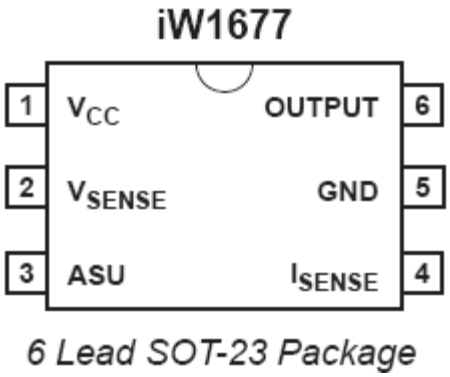


19.Appendix. V_{CC} Supply Voltage

The purpose of this test is to verify range of Vcc voltage under different loading conditions.

Item	Vcc range [Max: 16V, Min: 4.2V]			
Input Vac	Vin=90Vac	Vin=115Vac	Vin=230Vac	Vin=264Vac
Output No-load	6.22	6.21	6.18	6.18
Output Full-load (2000mA)	13.18	13.87	14.12	14.28
Max load (CC/CV corner)	13.44	14.42	14.63	14.71

Above test result show all voltage measuring points is within normal operating range.



6 Lead SOT-23 Package

V_{CC} SECTION (Pin 1)						
Maximum operating voltage (Note 1)	$V_{CC(MAX)}$				16	V
Start-up threshold	$V_{CC(ST)}$	V_{CC} rising	10.0	11.0	12.0	V
Undervoltage lockout threshold	$V_{CC(UVL)}$	V_{CC} falling	3.8	4.0	4.2	V
Start-up current	$I_{IN(ST)}$	V_{CC} = 10 V	1.0	1.7	3.0	µA
Quiescent current	I_{CCQ}	No I_B current		2.7	4.0	mA
Zener breakdown voltage	V_{ZB}	Zener current = 5 mA T_A=25°C	18.5	19.5	20.5	V