iW1788-00 For 12V/1.25A, 9V/1.67A, 5V/1.67A QC2.0 and MTK_PE+ Quick Charge Design

General Design Specification:

1. AC Input Range 90-264V_{AC}
2. DC Output 12V/1.25A, 9V/1.67A, 5V/1.67A
3. Meet ***"75mW@5V"*** No-Load standby Power Consumption Requirement
4. Max Output Ripple & Noise < 120mV

May 26, 2014

...personal
...portable
...connected

1.1. QC2.0 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							
5V/1.67A	Output Voltage	V_{OUT}	4.75	5.0	5.25	V	Measured at the end of USB-A
	Output Current	I_{OUT}	0		1.67	A	
	Over Current Protection	I_{OCP}		1.8		A	
	Ripple & Noise	V_{RIPPLE}			80	mV_{P_P}	Note1
	Average Efficiency	η	77.43			%	Refer to DoE
9V1.67A	Output Voltage	V_{OUT}	8.55	9.0	9.45	V	Measured at the end of USB-A
	Output Current	I_{OUT}	0		1.67	A	
	Over Current Protection	I_{OCP}		1.8		A	
	Ripple & Noise	V_{RIPPLE}			120	mV_{P_P}	Note1
	Average Efficiency	η	79.16			%	Refer to EPA2.0
12V1.25A	Output Voltage	V_{OUT}	11.4	12.0	12.6	V	Measured at the end of USB-A
	Output Current	I_{OUT}	0		1.25	A	
	Over Current Protection	I_{OCP}		1.5		A	
	Ripple & Noise	V_{RIPPLE}			120	mV_{P_P}	Note1
	Average Efficiency	η	79.15			%	Refer to EPA2.0
Environmental							
Conducted EMI			Meets CISPR22B / EN55022B				Output (-) is connected to Earth
Safety			Designed to meet IEC60950, UL1950 Class II				
Ambient Temperature		T_{AMB}	0		40	° C	Free convection, sea level

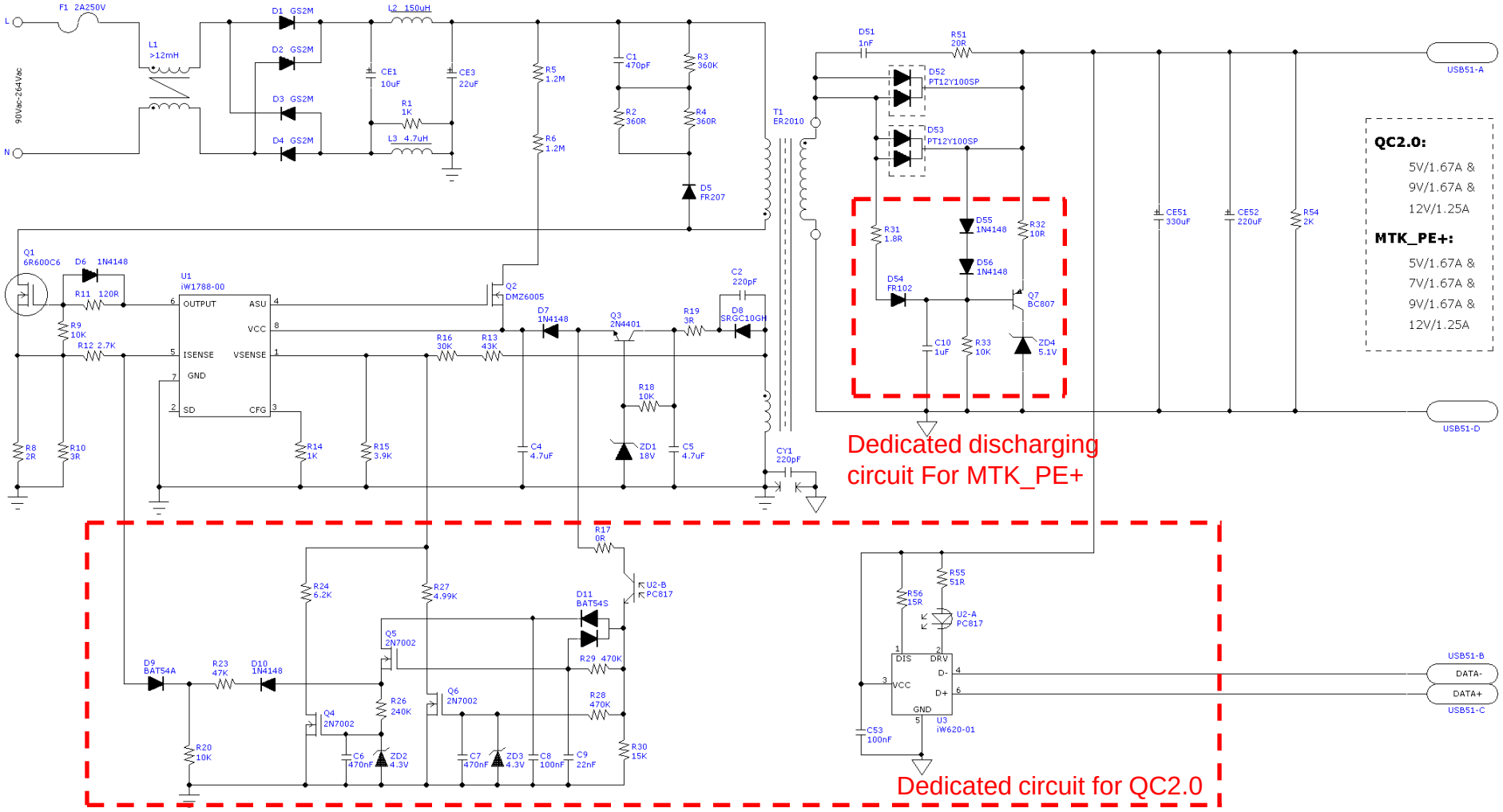
Note1: Add 0.1uF Ceramic capacitor and 10uF E-cap at the end of connector and set oscilloscope at 20MHz bandwidth.

1.2. MTK_PE+ 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							
5V/1.67A	Output Voltage	V_{OUT}	4.75	5.0	5.25	V	Measured at the end of USB-A
	Output Current	I_{OUT}	0		1.67	A	
	Over Current Protection	I_{OCP}		1.8		A	
	Ripple & Noise	V_{RIPPLE}			80	mV_{P_P}	Note1
	Average Efficiency	η	77.43			%	Refer to DoE
7V1.67A	Output Voltage	V_{OUT}	6.65	7.0	7.35	V	Measured at the end of USB-A
	Output Current	I_{OUT}	0.25		1.67	A	
	Over Current Protection	I_{OCP}		1.8		A	
	Ripple & Noise	V_{RIPPLE}			120	mV_{P_P}	Note1
	Average Efficiency	η	77.59			%	
9V1.67A	Output Voltage	V_{OUT}	8.55	9.0	9.45	V	Measured at the end of USB-A
	Output Current	I_{OUT}	0.25		1.67	A	
	Over Current Protection	I_{OCP}		1.8		A	
	Ripple & Noise	V_{RIPPLE}			120	mV_{P_P}	Note1
	Average Efficiency	η	79.16			%	Refer to EPA2.0
12V1.25A	Output Voltage	V_{OUT}	11.4	12.0	12.6	V	Measured at the end of USB-A
	Output Current	I_{OUT}	0.25		1.25	A	
	Over Current Protection	I_{OCP}		1.5		A	
	Ripple & Noise	V_{RIPPLE}			120	mV_{P_P}	Note1
	Average Efficiency	η	79.15			%	Refer to EPA2.0
Environmental							
Conducted EMI			Meets CISPR22B / EN55022B				Output (-) is connected to Earth
Safety			Designed to meet IEC60950, UL1950 Class II				
Ambient Temperature		T_{AMB}	0		40	° C	Free convection, sea level

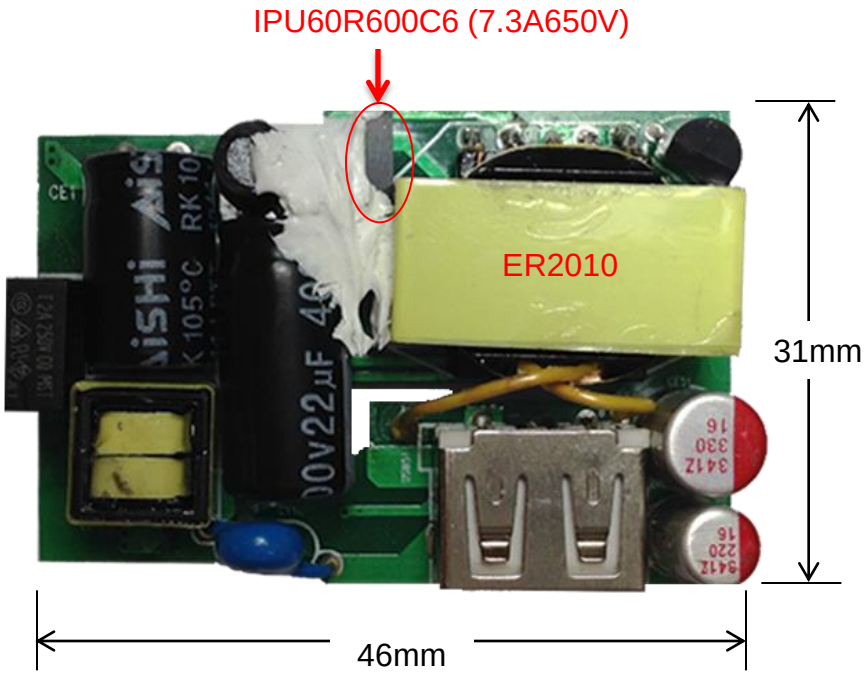
Note1: Add 0.1uF Ceramic capacitor and 10uF E-cap at the end of connector and set oscilloscope at 20MHz bandwidth.

2. Schematic

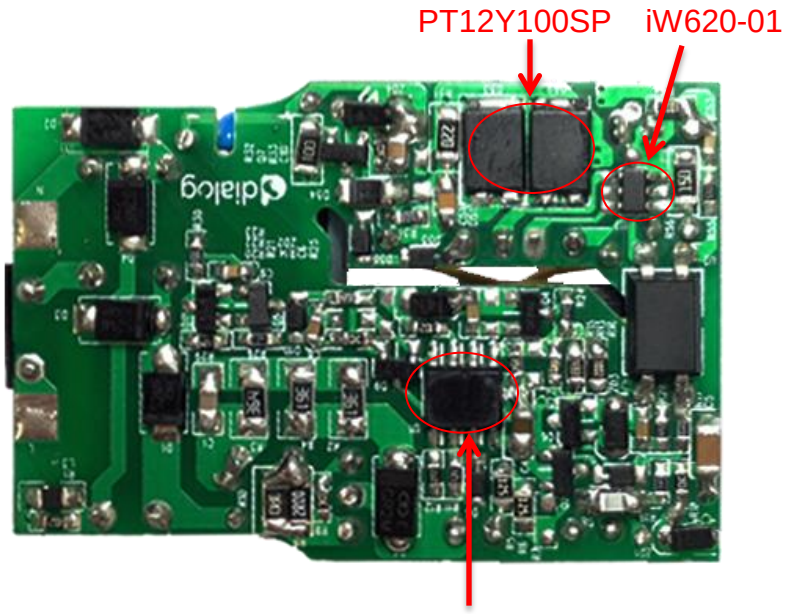


3. Circuit Board Photograph

Top View



Bottom View



4.1. Bill of Material

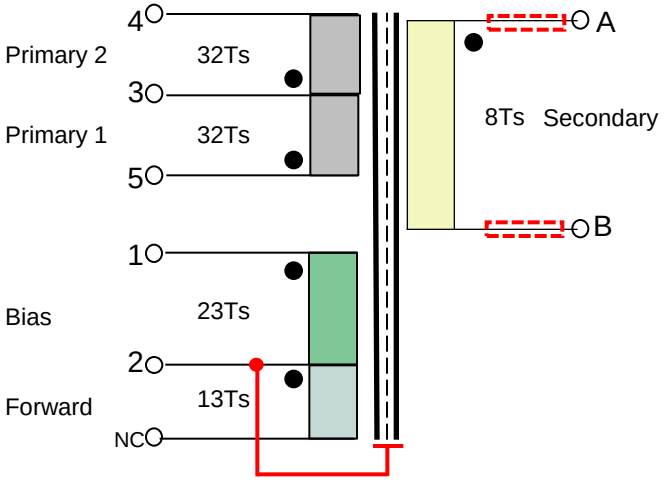
Item	Qty.	Ref.	Description
1	1	U1	iW1788-00, Off-line Digital PSR & PWM & VMS Controller, SOIC-8
2	1	F1	T2A250V, Fuse ,4*8
3	1	L1	12mH,CM-inductor, Core: EE8.3, Wire: 0.16mmX51Ts
4	1	L2	150uH,DM-inductor, Core: 4*6, Wire: 0.16mmX90Ts
5	1	L3	4.7uH,MPH201210S4R7MT,SUNLORD
6	4	D1-D4	S2MF,2A/1000V, Rectifier Diode,SMD
7	1	D5	FR207, 2A1000V,Fast Recovery Rectifier (Trr=500ns), SMD
8	2	D6,D7	1N4148, Fast Rectifier Diode,,SMD-323
9	1	D8	SRGC10GH, 1A400V, Fast switching diode(Trr=150nS), SMD-1206S
10	2	D52,D53	PT12Y100SP, 12A100V, Schottky Diode, TO-227 PFC
11	1	ZD1	ZVS,18±5%V,SMD-123
12	1	Q1	IPU60R600C6, TO-251
13	1	Q2	DMZ6005, 12mA600V, Depletion Mode MOSFET, SOT23
14	1	Q3	2N4401,NPN Transistor, TO-92
15	1	T1	ER2010 Transformer Vertical Type
16	1	CE1	10uF, 400V, Low-ESR E-Cap, Φ8mm X 12mm Aishi
17	1	CE3	22uF, 400V, Low-ESR E-Cap, Φ8mm X 16mm Aishi
18	1	CE51	330uF,16V, Solid-Cap, ULR 6.3*11,艾华科技
19	1	CE52	220uF,16V, Solid-Cap, ULR 5*11,艾华科技
20	1	D51	1nF, 100V, X7R, SMD-0805
21	1	C1	470pF, 250V, X7R, SMD-0805
22	1	C2	220pF, 250V, X7R, SMD-0805
23	1	C4	4.7uF, 25V, X7R, SMD-0805
24	1	C5	4.7uF, 50V, X7R, SMD-1206
25	1	CY1	220pF,Y-Cap
26	2	R1,R14	1KΩ ±5%, SMD-0603
27	2	R2,R4	360Ω ±5%, SMD-1206
28	1	R3	360KΩ ±5%, SMD-1206
29	2	R5,R6	1.2MΩ ±5%, SMD-0805
30	1	R8	2.0Ω ±1%, SMD-1206
31	2	R9,R18	10KΩ ±5%, SMD-0603
32	1	R10	3.0Ω ±1%, SMD-1206
33	1	R11	120Ω±5%, SMD-0603
34	1	R12	2.7KΩ ±5%, SMD-0603
35	1	R13	43KΩ ±1%, SMD-0805

4.2. Bill of Material

Item	Qty.	Ref.	Description
36	1	R15	3.9KΩ ±1%, SMD-0603
37	1	R16	30KΩ ±1%, SMD-0805
38	1	R19	3.0Ω ±5%, SMD-0603
39	1	R51	20Ω ±5%, SMD-1206
40	1	R54	2KΩ ±5%, SMD-0805
41	1	USB	USB,Horizontal,2A current
42	1	PCB	Double Side Board, FR-4,46X31mm
Dedicated discharging circuit For MTK_PE+			
43	1	C10	1uF, 25V, X7R, SMD-0603
44	1	D54	SRGC10DH, 1A200V, Fast switching diode(Trr=150nS), SMD-1206S
45	2	D55,D56	1N4148, Fast Rectifier Diode,,SMD-323
46	1	ZD4	ZVS,4.3±1%V,SMD-123
47	1	Q7	BC807,PNP Transistor, SOT-23
48	1	R31	1.8Ω ±5%, SMD-0603
49	1	R32	10Ω ±5%, SMD-1206
50	1	R33	10KΩ ±5%, SMD-0603
Dedicated circuit for QC2			
51	1	U2	Light coupling,PC817,SMD
52	1	U3	iW620-01,SOT23
53	2	ZD2,ZD3	ZVS,4.3±1%V,SMD-123
54	1	D9	BAT54A,SOT23
55	1	D10	1N4148, Fast Rectifier Diode,,SMD-323
56	1	D11	BAT54S,SOT23
57	3	Q4,Q5,Q6	2N7002, 60V,1.2ohm, SOT-23
58	2	C6,C7	470nF, 25V, X7R, SMD-0603
59	2	C8,C53	100nF, 25V, X7R, SMD-0603
60	1	C9	22nF, 25V, X7R, SMD-0603
61	1	R17	0Ω ±5%, SMD-0603
62	1	R20	10KΩ ±1%, SMD-0603
63	1	R23	47KΩ ±5%, SMD-0603
64	1	R24	6.2KΩ ±1%, SMD-0603
65	1	R26	240KΩ ±1%, SMD-0603
66	1	R27	4.99KΩ ±1%, SMD-0603
67	2	R28,R29	470KΩ ±1%, SMD-0603
68	1	R30	15KΩ ±1%, SMD-0603
69	1	R55	51Ω ±5%, SMD-0603
70	1	R56	15Ω ±5%, SMD-1206

5. Transformer Drawing

SCHEMATIC



ELECTRICAL SPECIFICATIONS:

1. Primary Inductance (Lp) =800±7%uH @10KHz/1V
2. Electrical Strength = 3KV, 50/60Hz,1Min(pins1~5 to pins A~B)

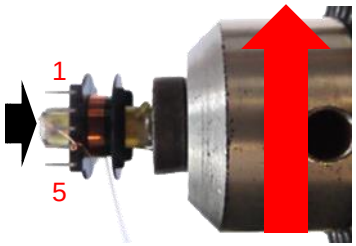
MATERIALS:

1. Core : ER2010(Ferrite Material JP95 or equivalent)
2. Bobbin :ER2010 Vertical
3. Magnet Wires (pri): Type 2-UEW
4. Magnet wires(sec): Triple Insulated Wire
5. Layer Insulation Tape :3M1298 or equivalent.

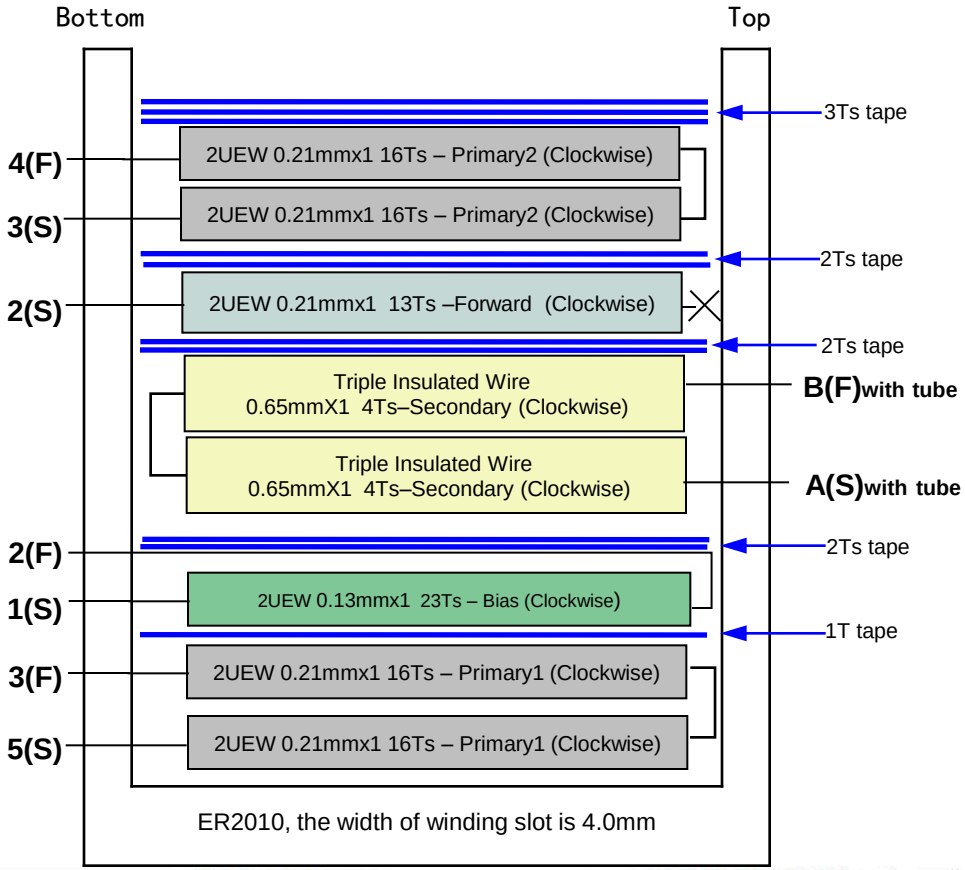
FINISHED :

1. Varnish the complete assembly
2. Core is connected to pin2

Winding Start pin-5& End pin-3 in "Clockwise" direction – looking from Top side of the Bobbin



Rotating direction of winding machine



6.1. Regulation, Ripple and Efficiency Measurement

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(%)	DOE η(%)
90	0.029	5.049	0	25			1.87	83.19	77.43
	2.58	5.072	0.418	46	2.12	82.17			
	5.08	5.088	0.835	37	4.25	83.63			
	7.59	5.093	1.250	49	6.37	83.88			
	10.24	5.093	1.670	64	8.51	83.06			
115	0.031	5.043	0	25			1.87	83.49	
	2.58	5.074	0.418	40	2.12	82.21			
	5.08	5.084	0.835	37	4.25	83.57			
	7.56	5.094	1.250	45	6.37	84.23			
	10.14	5.099	1.670	59	8.52	83.98			
230	0.043	5.040	0	32			1.80	81.28	
	2.68	5.074	0.418	47	2.12	79.14			
	5.25	5.085	0.835	43	4.25	80.88			
	7.77	5.097	1.250	44	6.37	82.00			
	10.23	5.092	1.670	52	8.50	83.12			
264	0.046	5.066	0	32			1.80	80.13	
	2.73	5.077	0.418	47	2.12	77.74			
	5.33	5.085	0.835	46	4.25	79.66			
	7.88	5.099	1.250	46	6.37	80.89			
	10.35	5.096	1.670	55	8.51	82.23			

* Note: Output voltage is monitored at end of PCB

6.2. Regulation, Ripple and Efficiency Measurement (QC2.0)

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(%)	EPA η(%)
90		9.207	0	35			1.86	84.34	79.16
	4.58	9.039	0.418	39	3.78	82.50			
	8.90	9.060	0.835	44	7.57	85.00			
	13.28	9.064	1.250	52	11.33	85.32			
	17.87	9.045	1.670	96	15.11	84.53			
115		9.212	0	38			1.86	85.16	
	4.57	9.040	0.418	36	3.78	82.69			
	8.84	9.056	0.835	40	7.56	85.54			
	13.13	9.064	1.250	55	11.33	86.29			
	17.56	9.055	1.670	63	15.12	86.12			
230		9.208	0	46			1.83	84.18	
	4.71	9.046	0.418	38	3.78	80.28			
	9.01	9.055	0.835	37	7.56	83.92			
	13.20	9.068	1.250	44	11.34	85.87			
	17.45	9.055	1.670	56	15.12	86.66			
264		9.196	0	50			1.82	83.33	
	4.78	9.050	0.418	40	3.78	79.14			
	9.14	9.057	0.835	38	7.56	82.74			
	13.30	9.070	1.250	52	11.34	85.24			
	17.56	9.065	1.670	66	15.14	86.21			

* Note: Output voltage is monitored at end of PCB

6.3. Regulation, Ripple and Efficiency Measurement (QC2.0)

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(%)	EPA η(%)
90		12.15	0	33			1.48	82.95	79.15
	4.75	11.98	0.313	36	3.75	78.94			
	8.98	12.00	0.625	52	7.50	83.52			
	13.32	12.01	0.938	78	11.27	84.57			
	17.71	12.01	1.25	75	15.01	84.77			
115		12.15	0	37			1.50	83.61	
	4.76	11.99	0.313	44	3.75	78.84			
	8.92	12.00	0.625	43	7.50	84.08			
	13.17	12.01	0.938	57	11.27	85.54			
	17.46	12.01	1.25	67	15.01	85.98			
230		12.16	0	38			1.49	82.57	
	4.94	11.99	0.313	34	3.75	75.97			
	9.07	12.00	0.625	37	7.50	82.69			
	13.23	12.01	0.938	43	11.27	85.15			
	17.36	12.01	1.25	45	15.01	86.48			
264		12.14	0	34			1.49	81.84	
	5.00	11.99	0.313	55	3.75	75.06			
	9.19	12.00	0.625	36	7.50	81.61			
	13.32	12.01	0.938	47	11.27	84.57			
	17.45	12.02	1.25	39	15.03	86.10			

*Note: Output voltage is measured at the end of USB Connector.

6.4. Regulation, Ripple and Efficiency Measurement (MTK_PE+)

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(%)	EPA η(%)
90	3.58	7.119	0.418	38	2.98	83.12	1.84	84.34	77.59
	7.02	7.132	0.835	43	5.96	84.83			
	10.50	7.140	1.25	46	8.93	85.00			
	14.12	7.136	1.67	67	11.92	84.40			
115	3.58	7.124	0.418	44	2.98	83.18	1.84	84.91	
	6.99	7.134	0.835	38	5.96	85.22			
	10.41	7.140	1.25	40	8.93	85.73			
	13.94	7.136	1.67	56	11.92	85.49			
230	3.70	7.118	0.418	47	2.98	80.41	1.83	83.45	
	7.18	7.129	0.835	49	5.95	82.91			
	10.52	7.134	1.25	53	8.92	84.77			
	13.93	7.151	1.67	50	11.94	85.73			
264	3.75	7.118	0.418	50	2.98	79.34	1.81	82.48	
	7.28	7.127	0.835	48	5.95	81.75			
	10.65	7.138	1.25	44	8.92	83.78			
	14.03	7.145	1.67	52	11.93	85.05			

* Note: Output voltage is monitored at end of PCB

6.5. Regulation, Ripple and Efficiency Measurement (MTK_PE+)

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(%)	EPA η(%)
90	4.59	9.141	0.418	37	3.82	83.24	1.88	84.66	79.15
	8.97	9.162	0.835	39	7.65	85.29			
	13.41	9.166	1.25	49	11.46	85.44			
	18.06	9.157	1.67	80	15.29	84.67			
115	4.58	9.142	0.418	42	3.82	83.44	1.88	85.43	
	8.91	9.159	0.835	42	7.65	85.83			
	13.28	9.168	1.25	55	11.46	86.30			
	17.76	9.164	1.67	60	15.30	86.17			
230	4.72	9.146	0.418	50	3.82	81.00	1.84	84.58	
	9.07	9.156	0.835	46	7.65	84.29			
	13.31	9.172	1.25	52	11.47	86.14			
	17.62	9.166	1.67	57	15.31	86.87			
264	4.78	9.152	0.418	48	3.83	80.03	1.82	83.80	
	9.20	9.157	0.835	52	7.65	83.11			
	13.41	9.174	1.25	58	11.47	85.51			
	17.70	9.173	1.67	58	15.32	86.55			

* Note: Output voltage is monitored at end of PCB

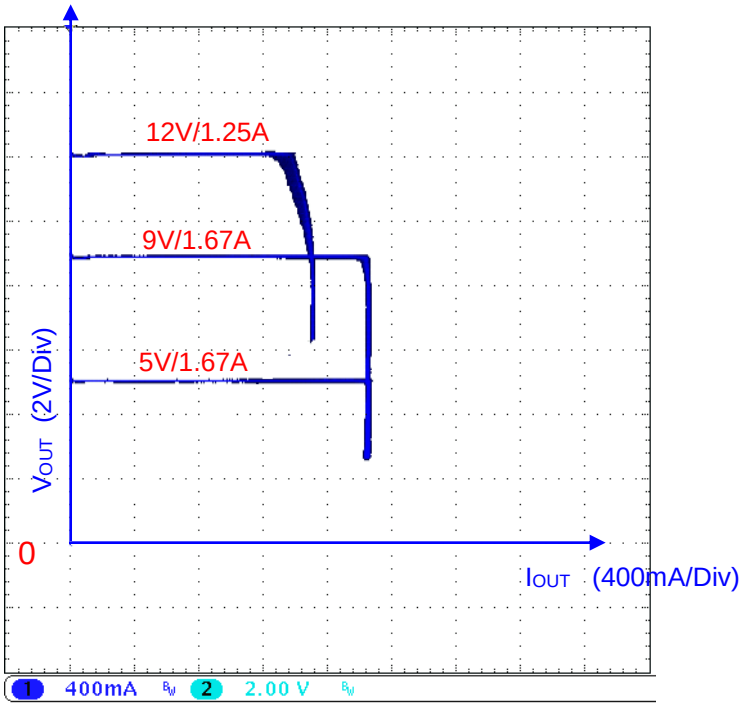
6.6. Regulation, Ripple and Efficiency Measurement (MTK_PE+)

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(%)	EPA η(%)
90	4.69	12.18	0.313	39	3.81	81.29	1.42	84.11	79.16
	9.02	12.20	0.625	40	7.63	84.53			
	13.43	12.21	0.938	44	11.45	85.28			
	17.90	12.22	1.25	60	15.28	85.34			
115	4.68	12.18	0.313	44	3.81	81.46	1.41	84.82	
	8.96	12.20	0.625	39	7.63	85.10			
	13.30	12.21	0.938	54	11.45	86.11			
	17.64	12.22	1.25	49	15.28	86.59			
230	4.81	12.19	0.313	48	3.82	79.32	1.39	84.04	
	9.10	12.20	0.625	45	7.63	83.79			
	13.33	12.21	0.938	48	11.45	85.92			
	17.53	12.22	1.25	64	15.28	87.14			
264	4.87	12.19	0.313	49	3.82	78.35	1.38	83.28	
	9.21	12.20	0.625	46	7.63	82.79			
	13.43	12.21	0.938	67	11.45	85.28			
	17.62	12.22	1.25	78	15.28	86.69			

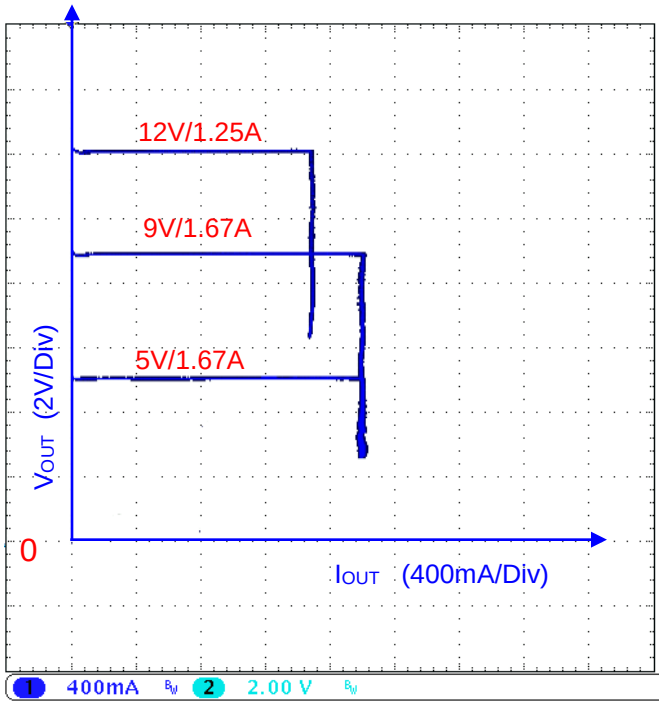
*Note: Output voltage is measured at the end of USB Connector.

7.1. QC2.0 Output VI Characteristics

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



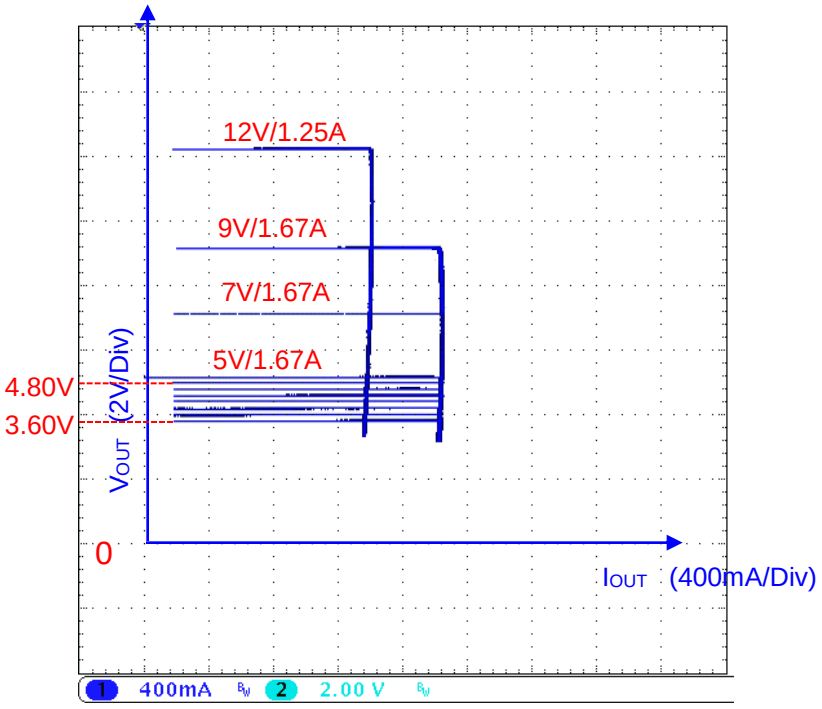
V_{IN}=264V_{AC}/50Hz



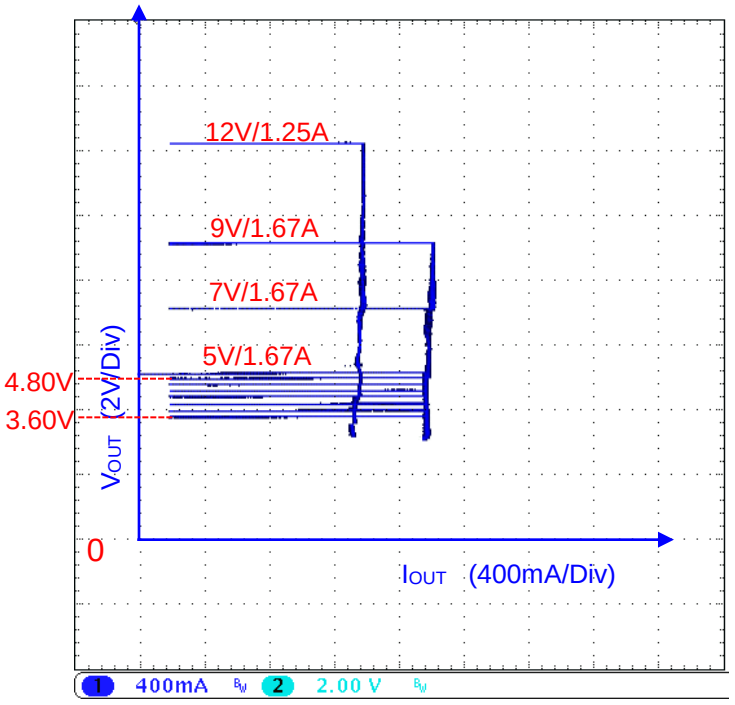
* Note: Output voltage is monitored at end of PCB

7.2. MTK_PE+ Output VI Characteristics

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



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

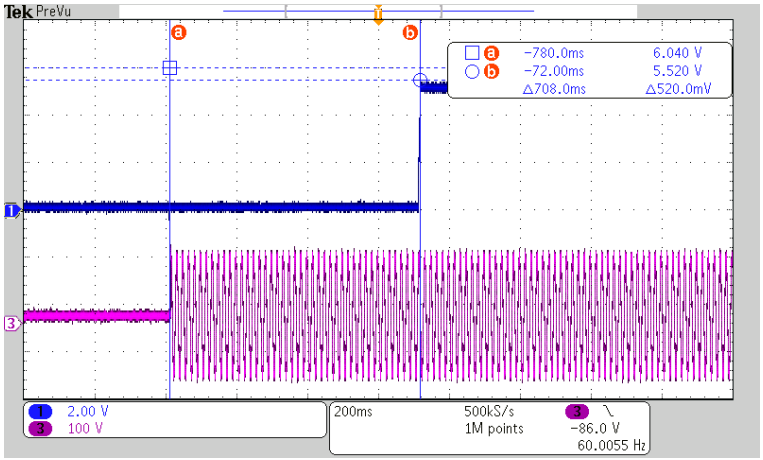


* Note: Output voltage is monitored at end of PCB

8. Turn-on Delay Time

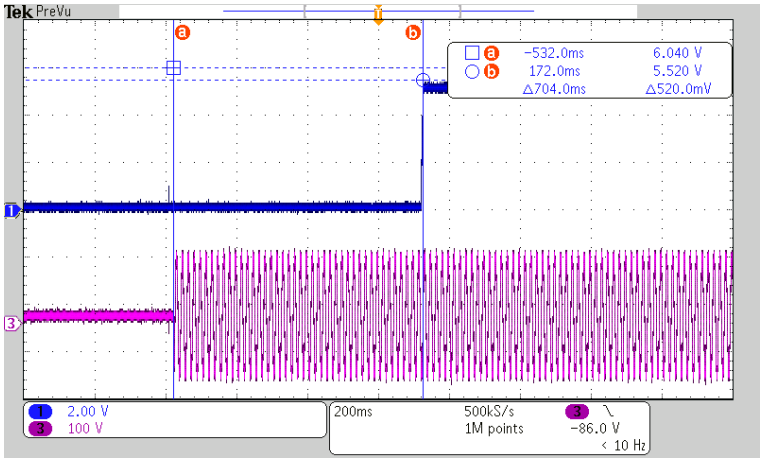
90V_{AC},No Load

T_{ST_DELAY}=0.708S



90V_{AC},Full Load

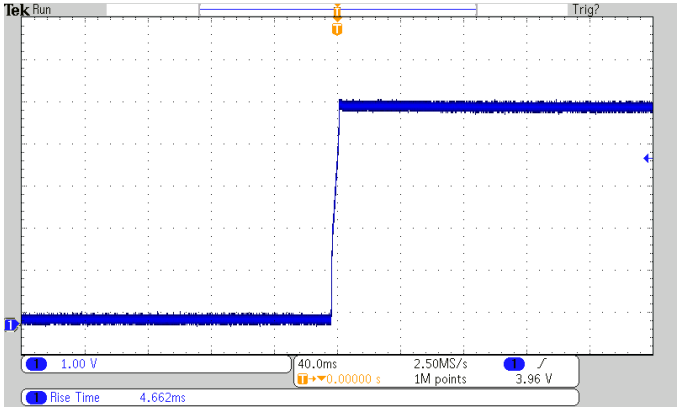
T_{ST_DELAY}=0.704S



9. Output Rise Time

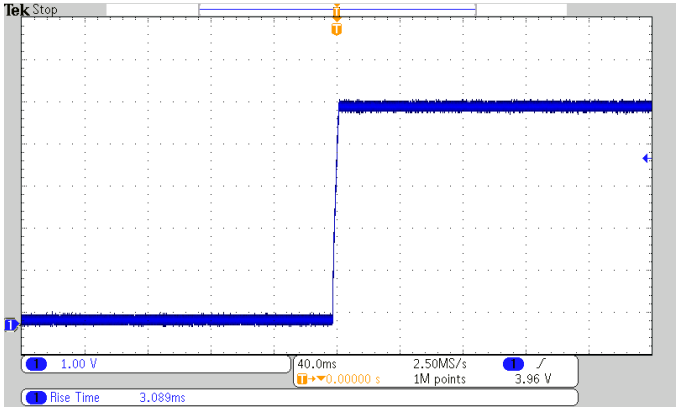
90Vac, No Load

T_{RISE}=4.662mS



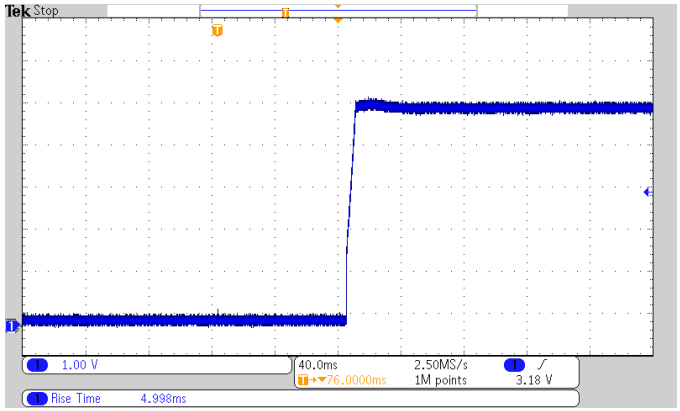
90Vac, Full Load

T_{RISE}=3.089mS



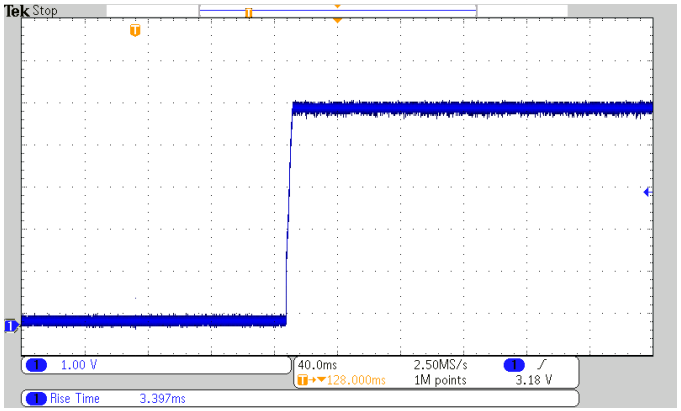
264Vac, No Load

T_{RISE}=4.998S



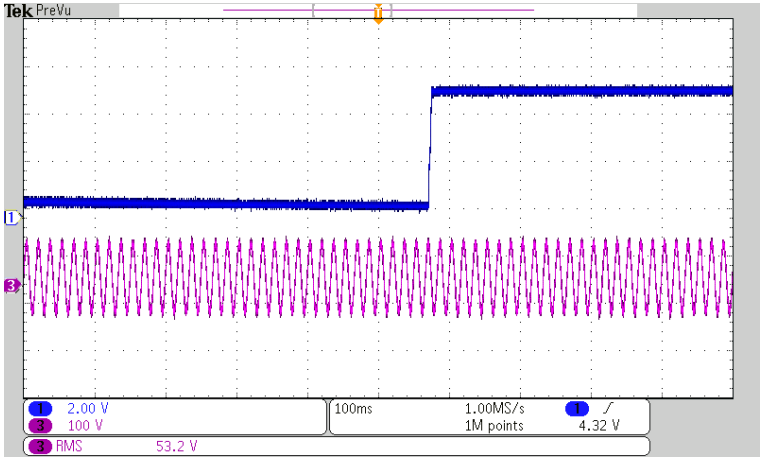
264Vac, Full Load

T_{RISE}=3.397mS

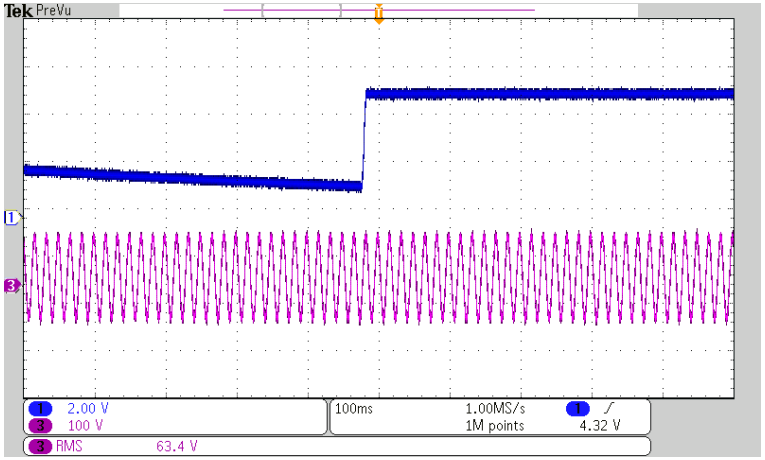


10. AC Startup Voltage

No Load, $V_{IN\_STARTUP}$ =53.2V_{AC}

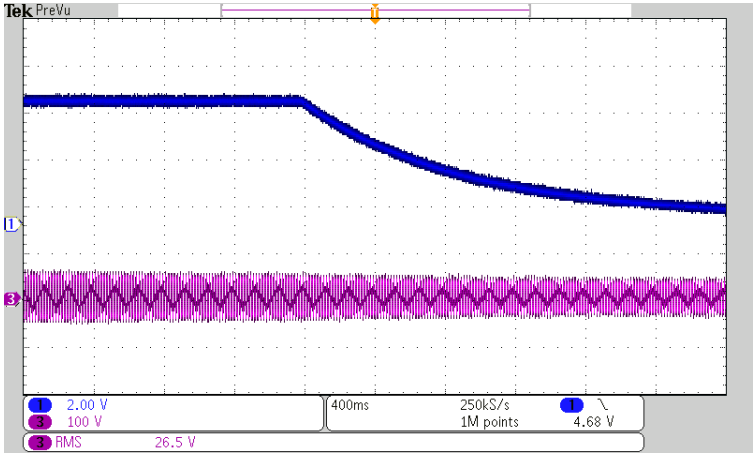


Full Load, $V_{IN\_STARTUP}$=63.4V_{AC}

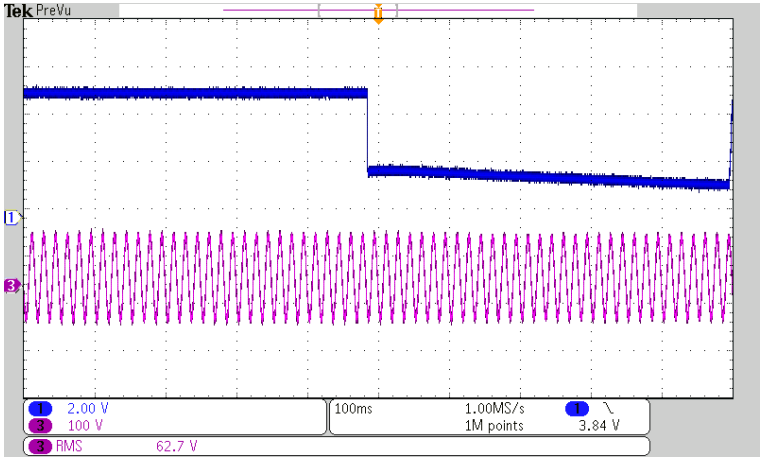


11. AC Brownout Voltage

No Load, $V_{IN\_BROWNOUT}$ =26.5V_{AC}



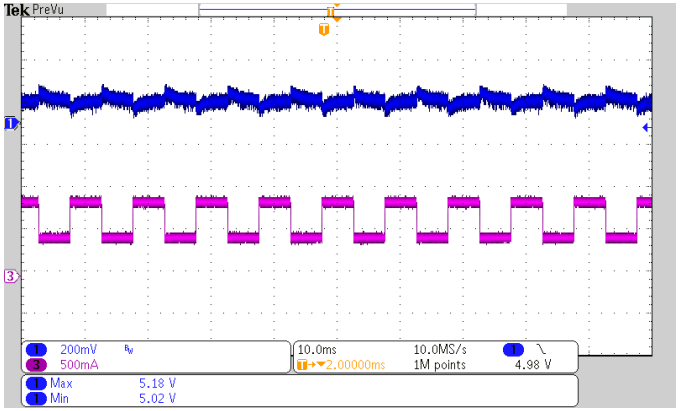
Full Load, $V_{IN\_BROWNOUT}$=62.7V_{AC}



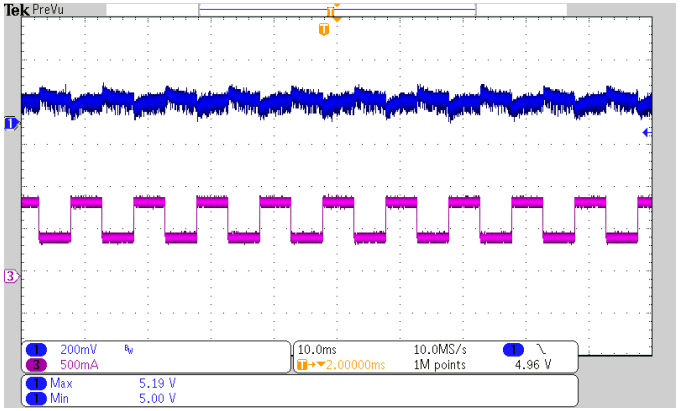
12.1. Dynamic Load Response (@5V)

Test Conditions: 1). Load: *25%-50%-25%* 2). Frequency: *100HZ*
3). Duty-Cycle: *50%* 4). Slew-Rate: *0.2A/us*

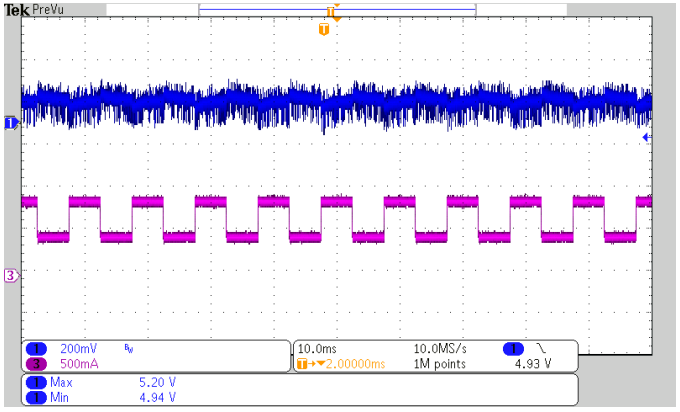
V_{IN}=90V_{AC},
V_{O_MAX}=5.18V, V_{O_MIN}=5.02V



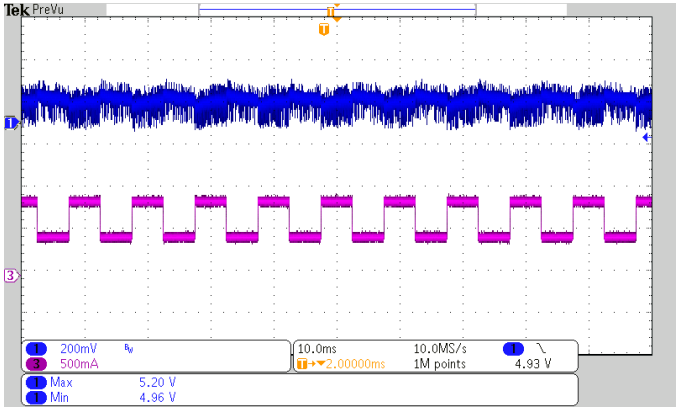
V_{IN}=115V_{AC},
V_{O_MAX}=5.19V, V_{O_MIN}=5.00V



V_{IN}=230V_{AC},
V_{O_MAX}=5.20V, V_{O_MIN}=4.94V



V_{IN}=264V_{AC},
V_{O_MAX}=5.20V, V_{O_MIN}=4.96V

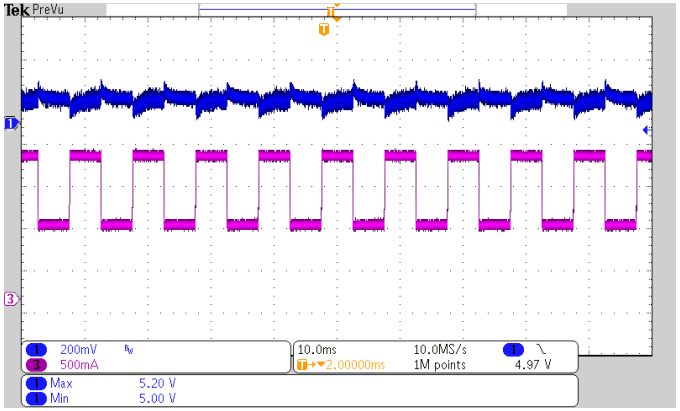


* Note: Output voltage is monitored at end of PCB

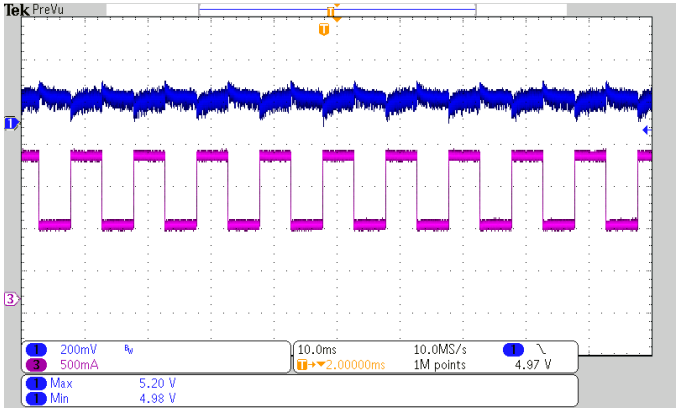
12.2. Dynamic Load Response (@5V)

Test Conditions: 1). Load: *50%-100%-50%A* 2). Frequency: *100HZ*
3). Duty-Cycle: *50%* 4). Slew-Rate: *0.2A/us*

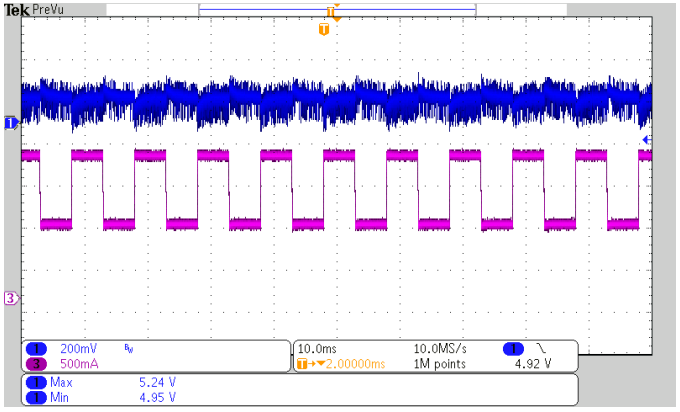
V_{IN}=90V_{AC},
V_{O_MAX}=5.20V, V_{O_MIN}=5.00V



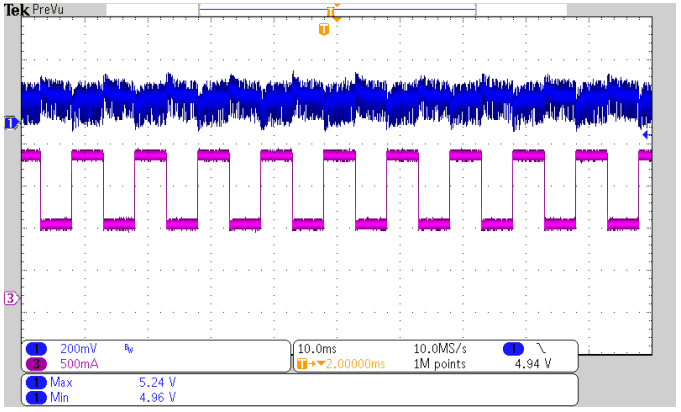
V_{IN}=115V_{AC},
V_{O_MAX}=5.20V, V_{O_MIN}=4.98V



V_{IN}=230V_{AC},
V_{O_MAX}=5.24V, V_{O_MIN}=4.95V



V_{IN}=264V_{AC},
V_{O_MAX}=5.24V, V_{O_MIN}=4.96V

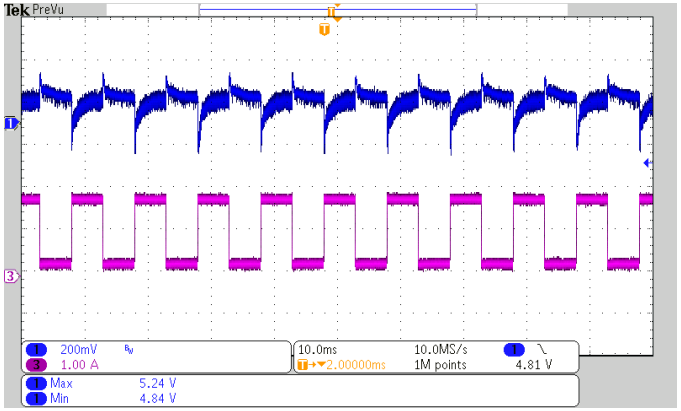


* Note: Output voltage is monitored at end of PCB

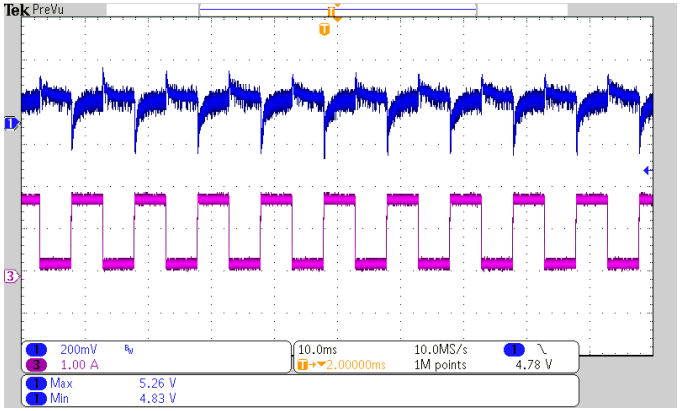
12.3. Dynamic Load Response (@5V)

Test Conditions: 1). Load: *10%-100%-10%* 2). Frequency: *100HZ*
3). Duty-Cycle: *50%* 4). Slew-Rate: *0.2A/us*

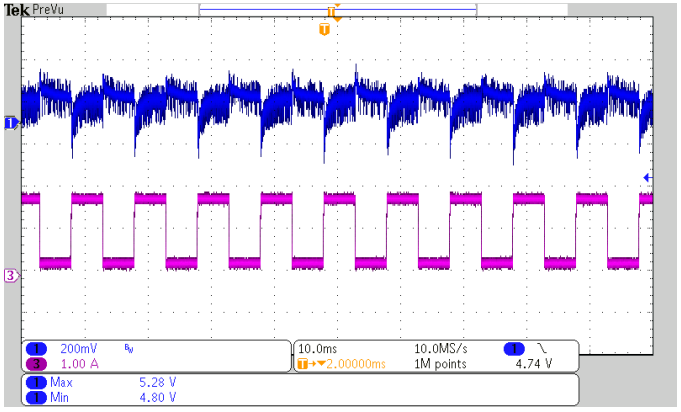
V_{IN}=90V_{AC},
V_{O_MAX}=5.24V, V_{O_MIN}=4.84V



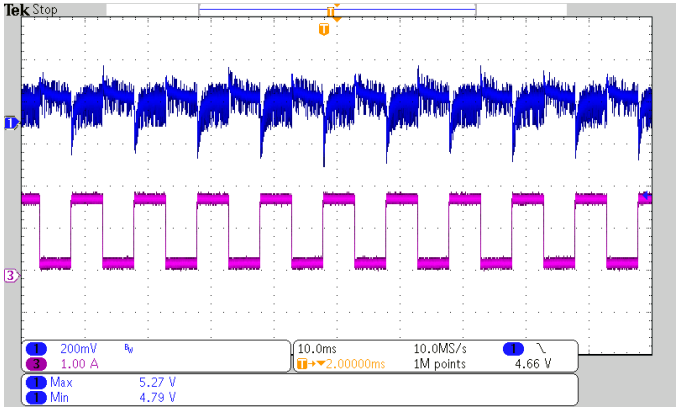
V_{IN}=115V_{AC},
V_{O_MAX}=5.26V, V_{O_MIN}=4.83V



V_{IN}=230V_{AC},
V_{O_MAX}=5.28V, V_{O_MIN}=4.80V



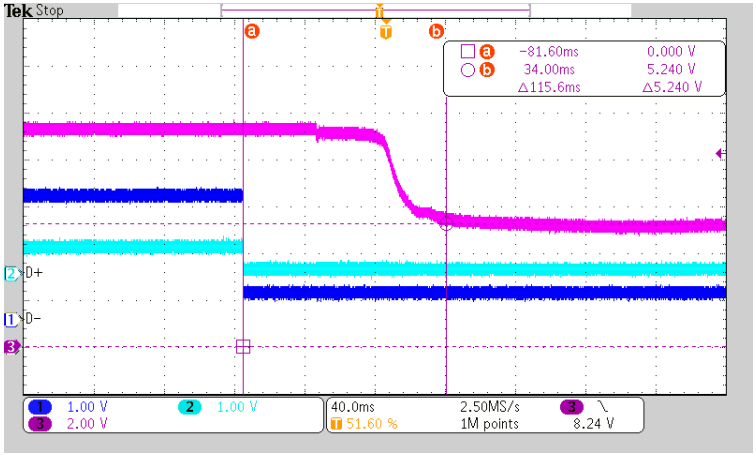
V_{IN}=264V_{AC},
V_{O_MAX}=5.27V, V_{O_MIN}=4.79V



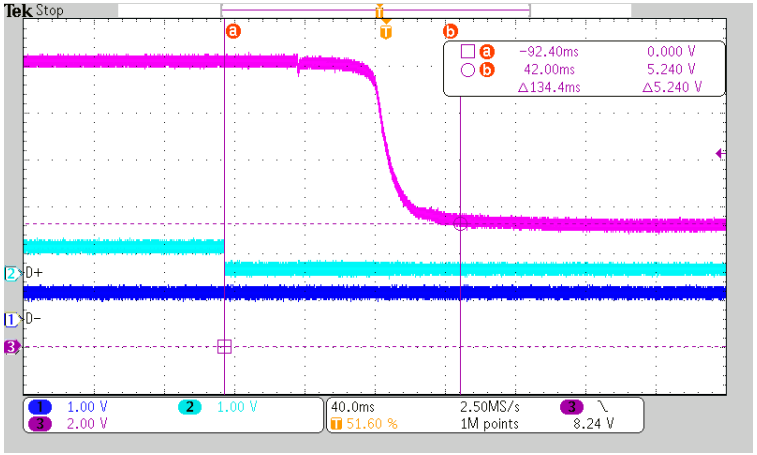
* Note: Output voltage is monitored at end of PCB

13. QC2.0 Output Voltage Transition Delay time

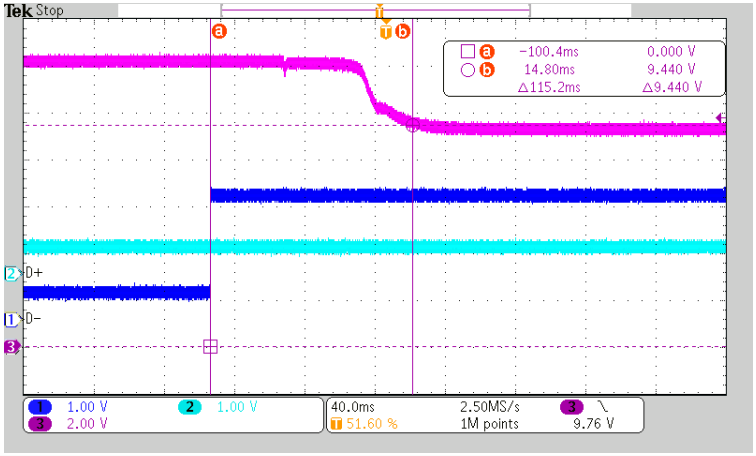
9 -> 5V, No Load
Tdelay time =115.6mS



12V ->5V, No Load
Tdelay time=134.4mS



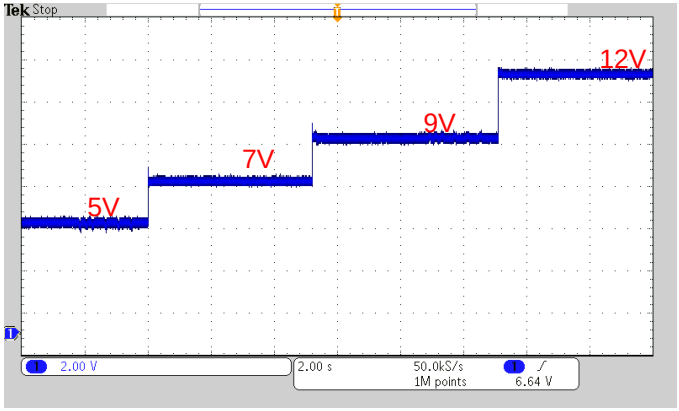
12V -> 9V, No Load
Tdelay time=115.2mS



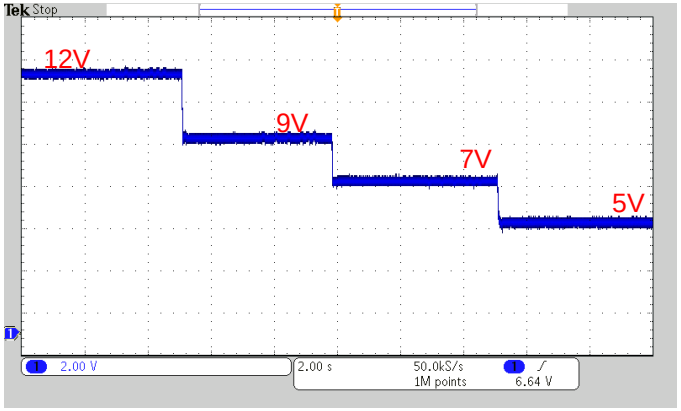
- Note: CH1,D-; CH2,D+; CH3,Vout

14.1. MTK_PE+ Output Voltage Transition and Discharge

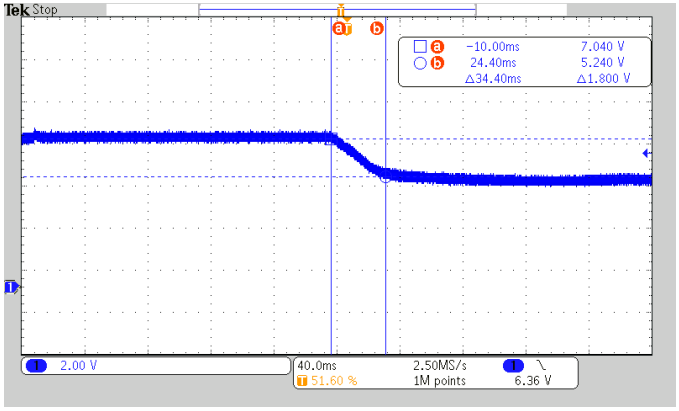
5V -> 7V ->9V ->12V, No Load



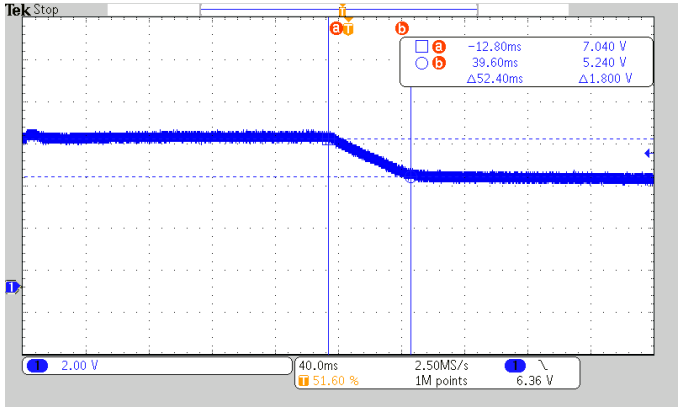
12V -> 9V ->7V ->5V, No Load



90V_{AC}, No Load
7V ->5V Tf=34.4mS

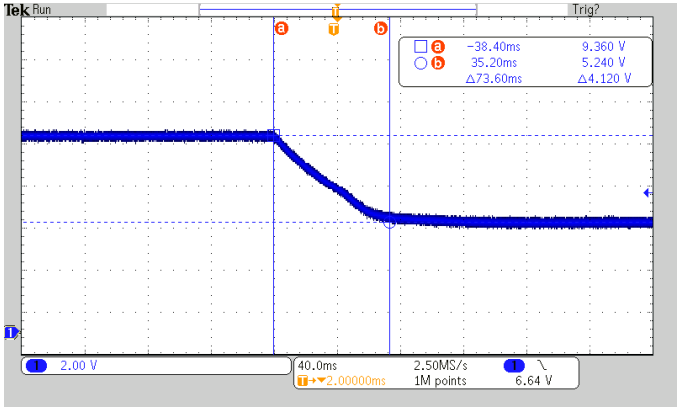


264V_{AC}, No Load
7V ->5V Tf=52.4mS

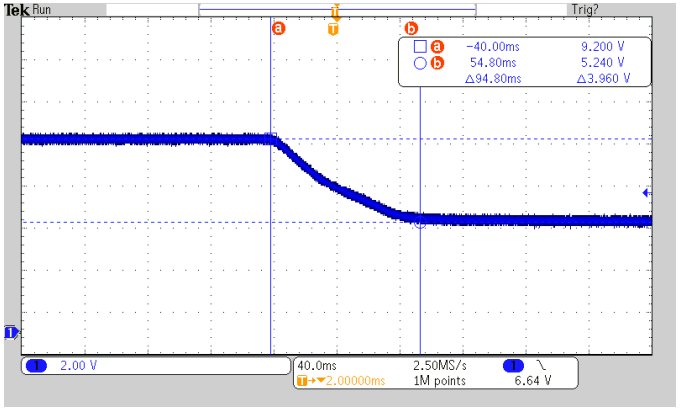


14.2. MTK_PE+ Output Voltage Transition and Discharge

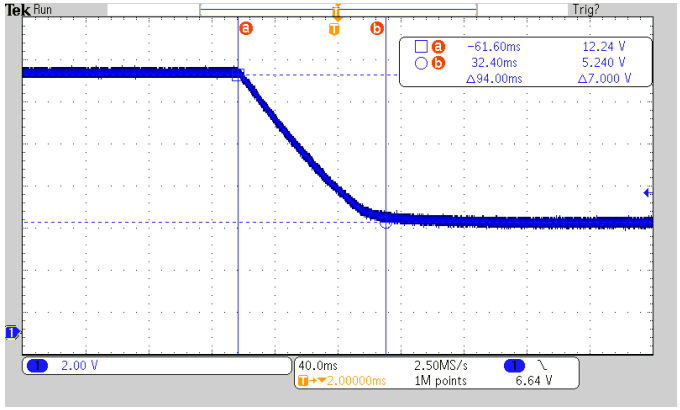
90V_{AC}, No Load
9V ->5V Tf=73.6mS



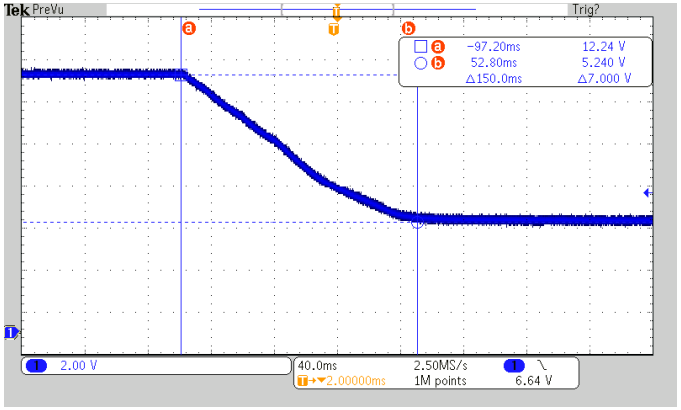
264V_{AC}, No Load
9V ->5V Tf=94.8mS



90V_{AC}, No Load
12V ->5V Tf=94.0mS

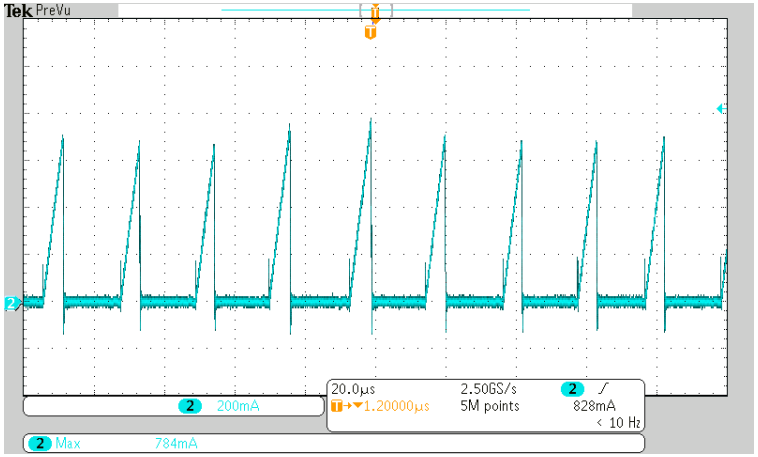


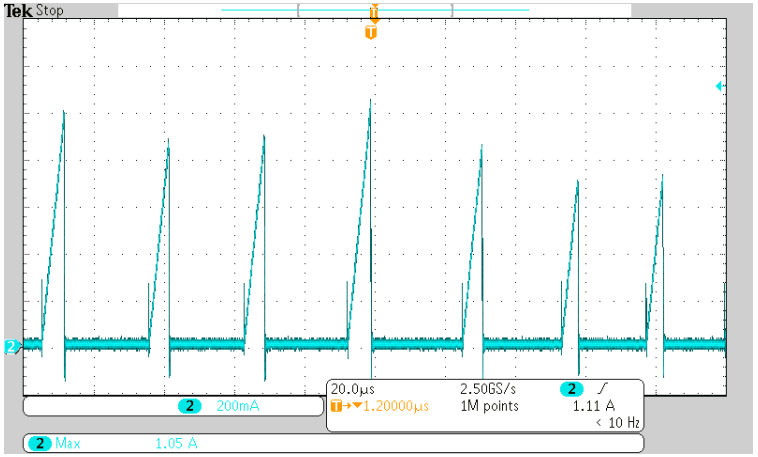
264V_{AC}, No Load
12V ->5V Tf=150.0mS



15.1. Transformer Flux Density (@5V)

(Np=64Ts, Lm-max=0.856mH, Ae=40.88mm^2-ER2010





CH1: I_{PRI} ,200mA/div

I_{PRI} *is monitored at* 90*Vac and* 1.67*A (full load)*

$I_{PRI} = 784mA$

$$B_{MAX} = \frac{L_{PRI} \times I_{PRI}}{N_P \times A_e} = \frac{0.856 \times 784}{64 \times 40.88} = 0.256(Tesla)$$

CH1: I_{PRI} ,200mA/div

I_{PRI} *is monitored at* 90*Vac*

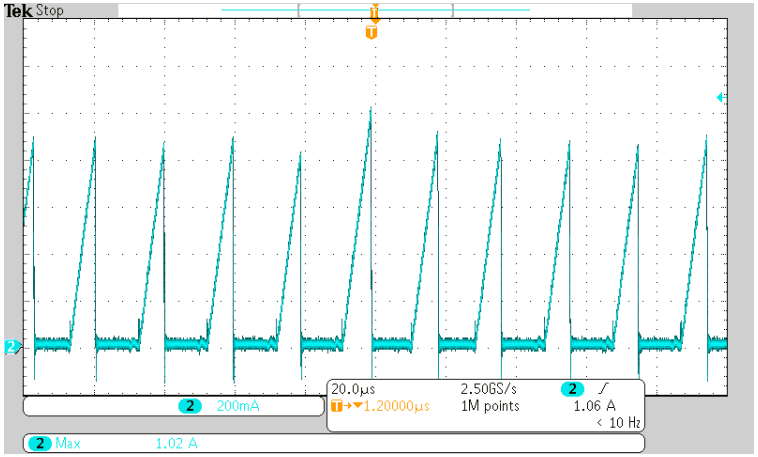
(*Worst Case under DLR@* 0*A* – 1.67*A* – 0*A*)

$I_{PRI} = 1050mA$

$$B_{MAX} = \frac{L_{PRI} \times I_{PRI}}{N_P \times A_e} = \frac{0.856 \times 1050}{64 \times 40.88} = 0.343(Tesla)$$

15.2. Transformer Flux Density (@9V)

(Np=64Ts, Lm-max=0.856mH, Ae=40.88mm^2-ER2010)

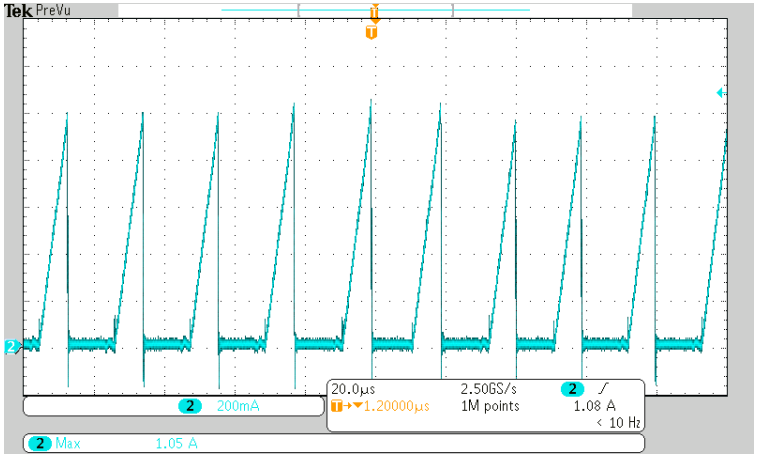


CH1: I_{PRI} ,200mA/div

I_{PRI} *is monitored at* 90*Vac and* 1.67*A (full load)*

$I_{PRI} = 1020mA$

$$B_{MAX} = \frac{L_{PRI} \times I_{PRI}}{N_P \times A_e} = \frac{0.856 \times 1020}{64 \times 40.88} = 0.334(Tesla)$$



CH1: I_{PRI} ,200mA/div

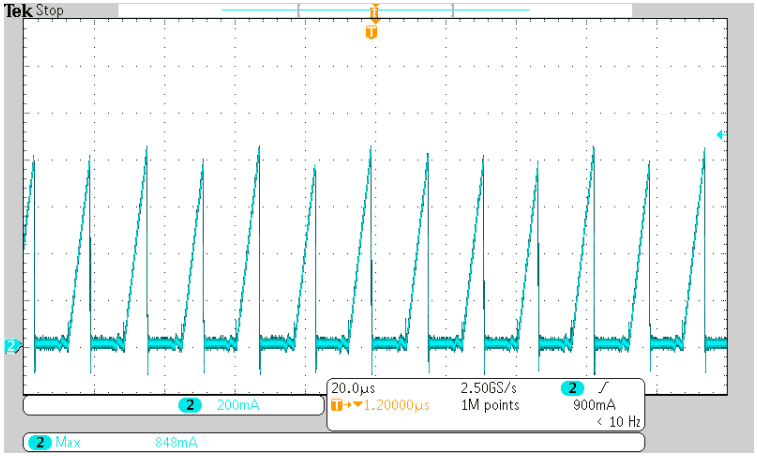
I_{PRI} *is monitored at* 90*Vac and* 1.8*A (Max* P_{OUT} *)*

$I_{PRI} = 1050mA$

$$B_{MAX} = \frac{L_{PRI} \times I_{PRI}}{N_P \times A_e} = \frac{0.856 \times 1050}{64 \times 40.88} = 0.343(Tesla)$$

15.3. Transformer Flux Density (@12V)

(Np=64Ts, Lm-max=0.856mH, Ae=40.88mm^2-ER2010)

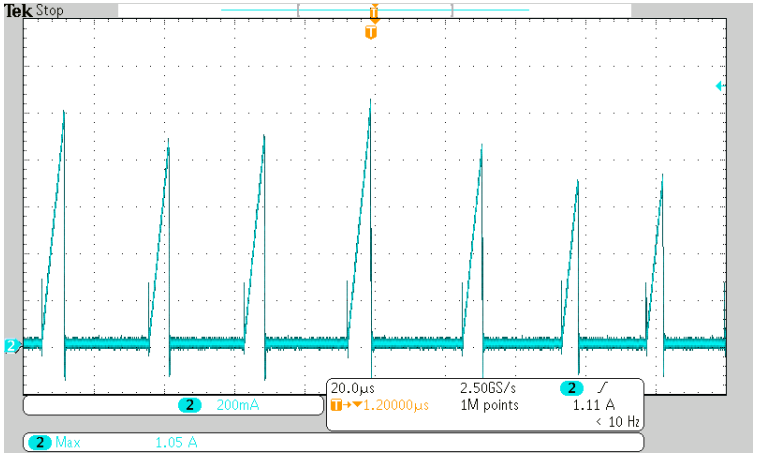


CH1: I_{PRI} ,200mA/div

I_{PRI} *is monitored at* 90*Vac and* 1.25*A (full load)*

$I_{PRI} = 848mA$

$$B_{MAX} = \frac{L_{PRI} \times I_{PRI}}{N_P \times A_e} = \frac{0.856 \times 848}{64 \times 40.88} = 0.277(Tesla)$$



CH1: I_{PRI} ,200mA/div

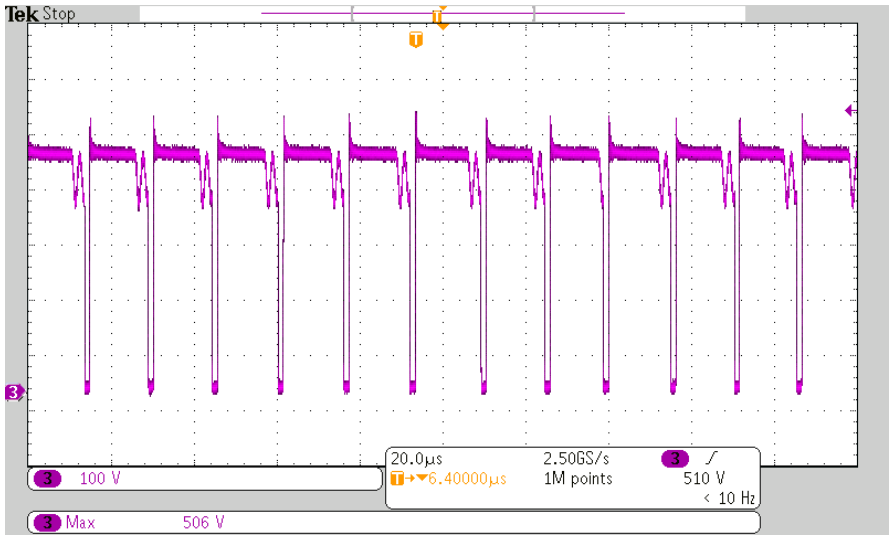
I_{PRI} *is monitored at* 90*Vac*

(*Worst Case under DLR@* 0*A* – 1.25*A* – 0*A*)

$I_{PRI} = 1050mA$

$$B_{MAX} = \frac{L_{PRI} \times I_{PRI}}{N_P \times A_e} = \frac{0.856 \times 1050}{64 \times 40.88} = 0.343(Tesla)$$

16.1. V_{DS} Waveform (@5V)



Test Condition (Worst Case):

V_{IN}=264V_{AC},I_{OUT}=1.67A(Startup)

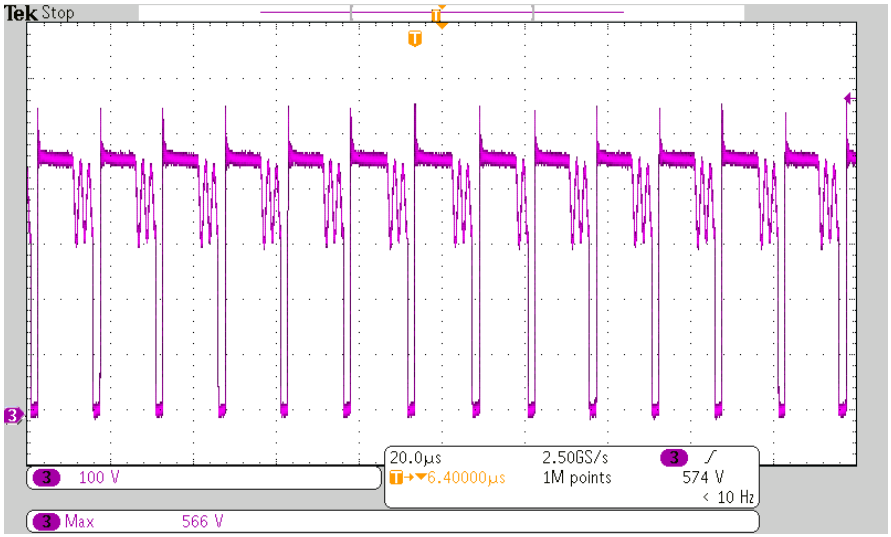
Result:

V_{DS_MAX}=**506V**

Appendix – Simple Specification for used MOSFET (IPU60R600C6)

Parameter	Value	Unit
V_{DS} @ $T_{j\ max}$	650	V
RDS(on),max	0.6	Ω
Qg,typ	20.5	nC
ID,pulse	19	A
Eoss @ 400V	1.9	µJ
Body diode di/dt	500	A/µs

16.2. V_{DS} Waveform (@9V)



Test Condition (Worst Case):

V_{IN}=264V_{AC},I_{OUT}=1.67A

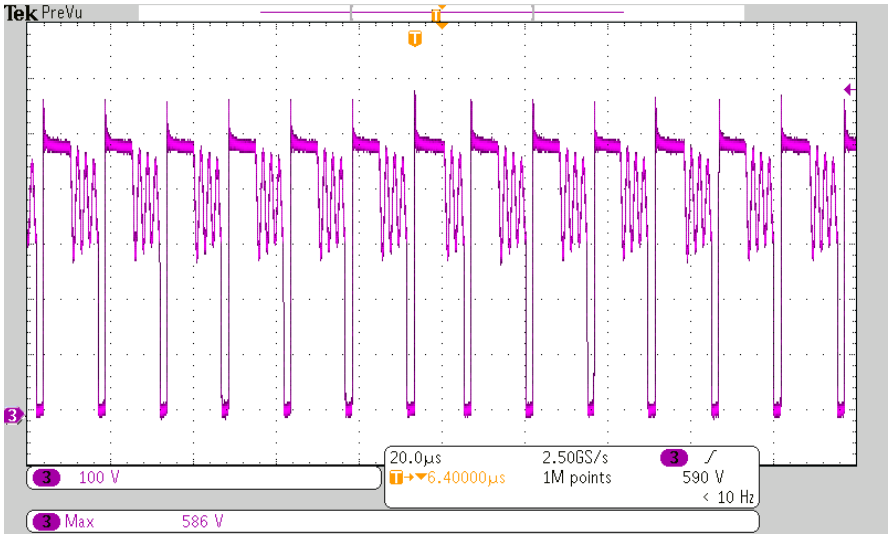
Result:

V_{DS_MAX}=**566V**

Appendix – Simple Specification for used MOSFET (IPU60R600C6)

Parameter	Value	Unit
V_{DS} @ $T_{j\ max}$	650	V
RDS(on),max	0.6	Ω
Qg,typ	20.5	nC
ID,pulse	19	A
Eoss @ 400V	1.9	µJ
Body diode di/dt	500	A/µs

16.3. V_{DS} Waveform (@12V)



Test Condition (Worst Case):

V_{IN}=264V_{AC},I_{OUT}=1.25A

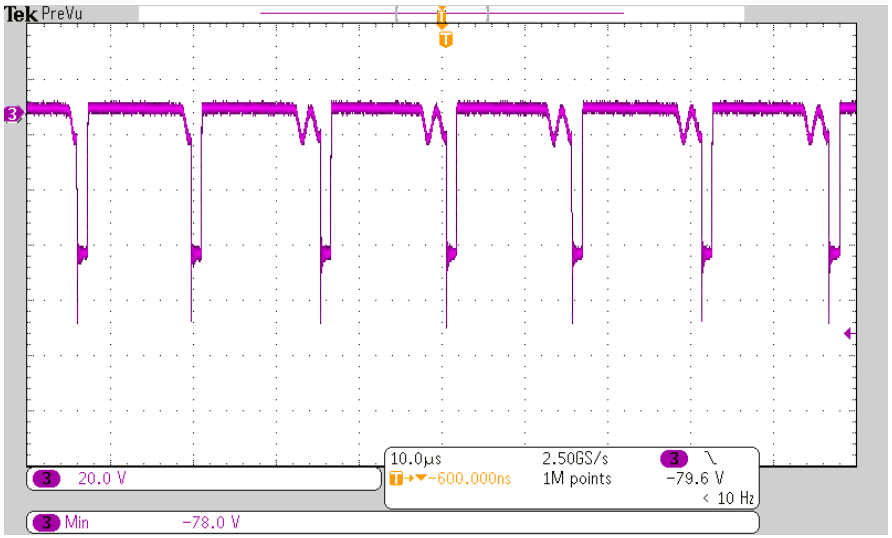
Result:

V_{DS_MAX}=**586V**

Appendix – Simple Specification for used MOSFET (IPU60R600C6)

Parameter	Value	Unit
V_{DS} @ $T_{j\ max}$	650	V
RDS(on),max	0.6	Ω
Qg,typ	20.5	nC
ID,pulse	19	A
Eoss @ 400V	1.9	µJ
Body diode di/dt	500	A/µs

17.1. Schottky Diode Waveform (@5V)



Test Condition:

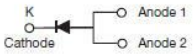
V_{IN}=264V_{AC},I_{OUT}=1.67A

Result:

V_{R_MAX}=**78.0V**

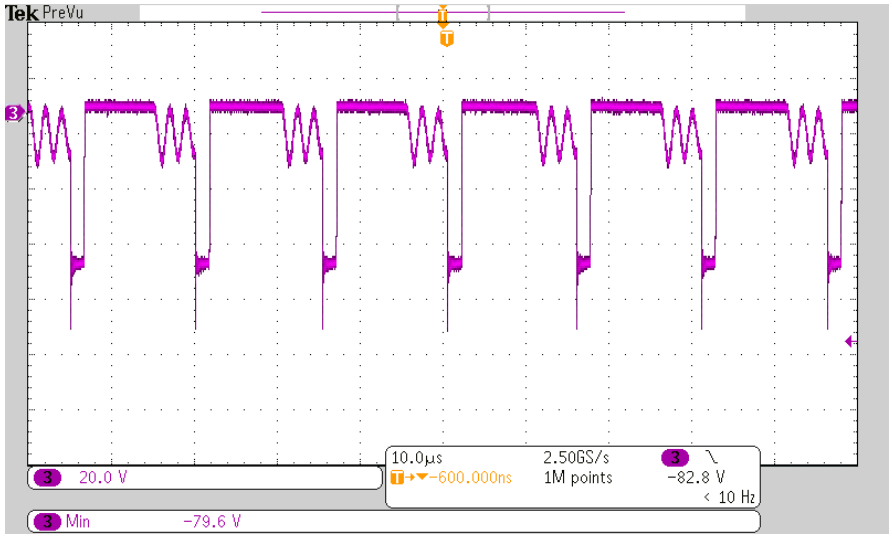
Appendix – Simple Specification for used Schottky diodes (PT12Y100SP)

TO-277A (SMPC)



PRIMARY CHARACTERISTICS	
$I_{F(AV)}$	12 A
V_{RRM}	100 V
I_{FSM}	200 A
E_{AS}	100 mJ
V_F at I_F = 12 A	0.58 V
T_J max.	150 °C

17.2. Schottky Diode Waveform (@9V)



Test Condition:

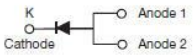
V_{IN}=264V_{AC},I_{OUT}=1.67A

Result:

V_{R_MAX}=**79.6V**

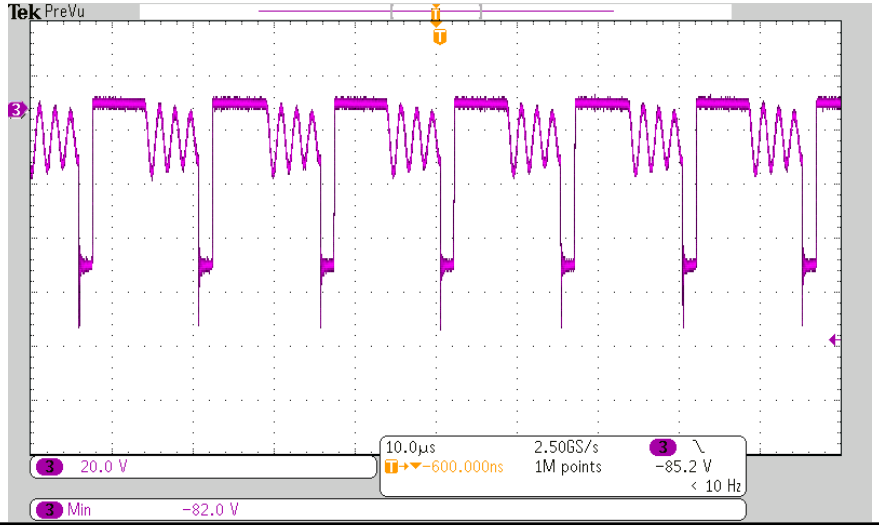
Appendix – Simple Specification for used Schottky diodes (PT12Y100SP)

TO-277A (SMPC)



PRIMARY CHARACTERISTICS	
$I_{F(AV)}$	12 A
V_{RRM}	100 V
I_{FSM}	200 A
E_{AS}	100 mJ
V_F at I_F = 12 A	0.58 V
T_J max.	150 °C

17.3. Schottky Diode Waveform (@12V)



Test Condition:

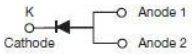
V_{IN}=264V_{AC},I_{OUT}=1.25A

Result:

V_{R_MAX}=**82.0V**

Appendix – Simple Specification for used Schottky diodes (PT12Y100SP)

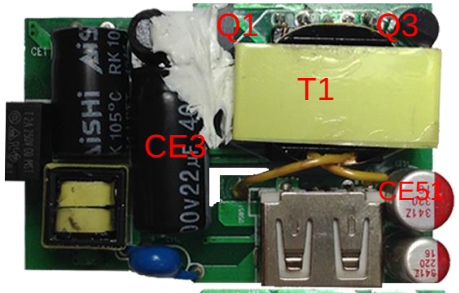
TO-277A (SMPC)

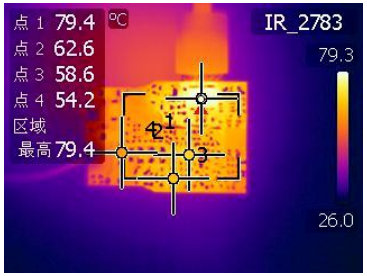


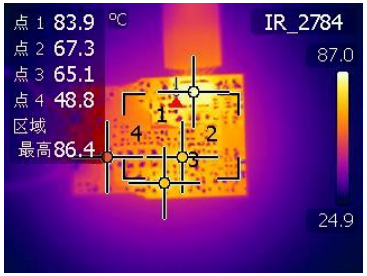
PRIMARY CHARACTERISTICS	
$I_{F(AV)}$	12 A
V_{RRM}	100 V
I_{FSM}	200 A
E_{AS}	100 mJ
V_F at I_F = 12 A	0.58 V
T_J max.	150 °C

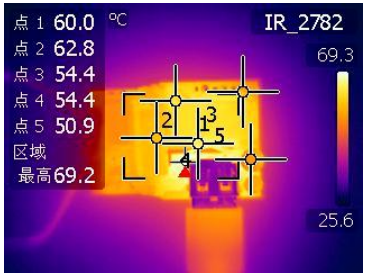
18.1. Thermal Test for Critical Component (@5V)

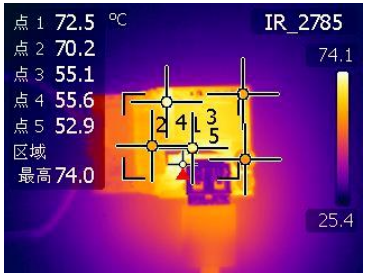
Item	V_{IN}=90V_{AC}, Vout=5V I_{OUT}=1.67A		V_{IN}=264V_{AC},Vout=5V I_{OUT}=1.67A	
	Temp.(°C)	Rising Temp. (°C)	Temp.(°C)	Rising Temp. (°C)
Input Bulk_Cap(CE3, 22uF/400V)	54.4	29.4	55.6	30.6
Input Rectifier Rectifier (D1, GS2M)	54.2	29.2	48.8	23.8
MOSFET(Q1, IPU60R600C6)	60	35	72.5	47.5
Transformer(T1, ER2010)	62.8	37.8	70.2	45.2
Schottky Diode(D52, PT10Y100SP)	79.4	54.4	83.9	58.9
PWM IC(U1, iW1788)	62.6	37.6	67.3	42.3
NPN transistor(Q3,2N4401)	54.4	29.4	55.1	30.1
Solid capacitor(CE51, 330uF/16V)	50.9	25.9	52.9	27.9
Fast Rectifier Rectifier (D5, FR207)	58.6	33.6	65.1	40.1
Ambient (Chamber) Temp.	25		25	





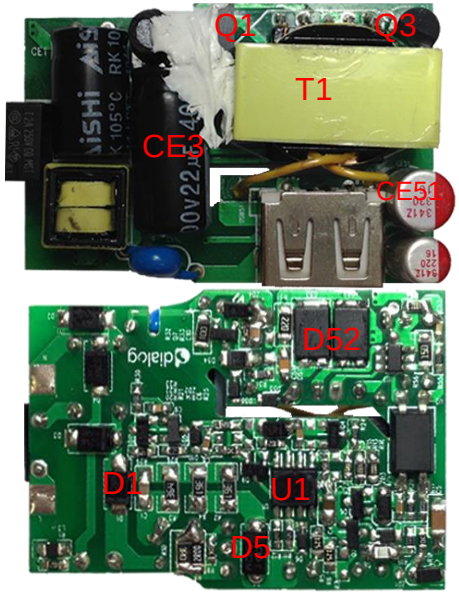


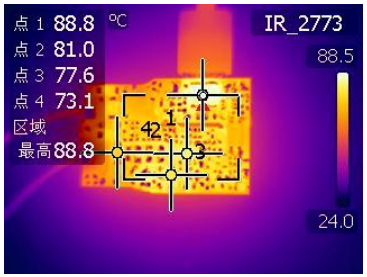


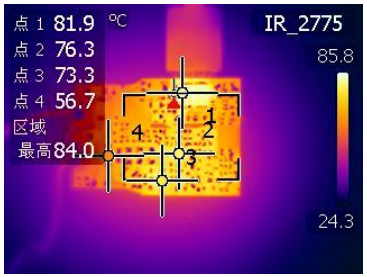


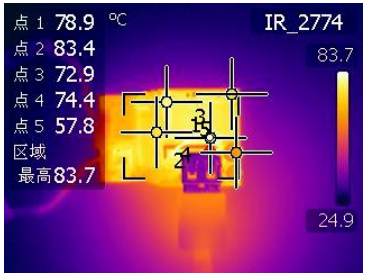
18.2. Thermal Test for Critical Component (@9V)

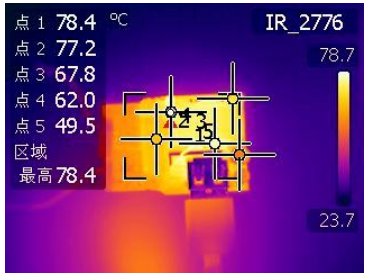
Item	V_{IN}=90V_{AC}, Vout=9V I_{OUT}=1.67A		V_{IN}=264V_{AC},Vout=9V I_{OUT}=1.67A	
	Temp.(°C)	Rising Temp. (°C)	Temp.(°C)	Rising Temp. (°C)
Input Bulk_Cap(CE3, 22uF/400V)	74.4	49.4	62	37
Input Rectifier Rectifier (D1, GS2M)	73.1	48.1	56.7	31.7
MOSFET(Q1, IPU60R600C6)	78.9	53.9	78.4	53.4
Transformer(T1, ER2010)	83.4	58.4	77.2	52.2
Schottky Diode(D52, PT10Y100SP)	88.8	63.8	81.9	56.9
PWM IC(U1, iW1788)	81	56	76.3	51.3
NPN transistor(Q3,2N4401)	72.9	47.9	67.8	42.8
Solid capacitor(CE51, 330uF/16V)	57.8	32.8	49.5	24.5
Fast Rectifier Rectifier (D5, FR207)	77.6	52.6	73.3	48.3
Ambient (Chamber) Temp.	25		25	





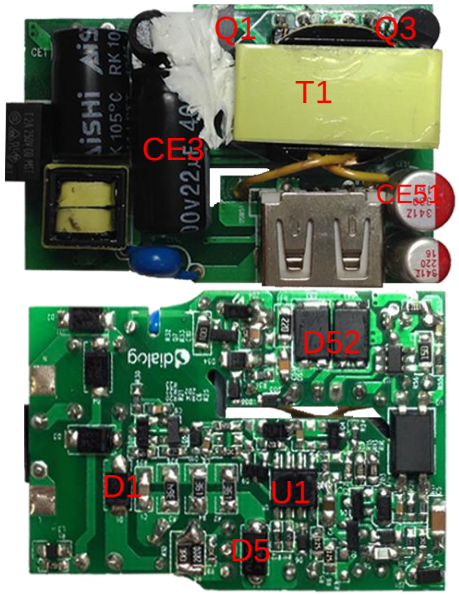


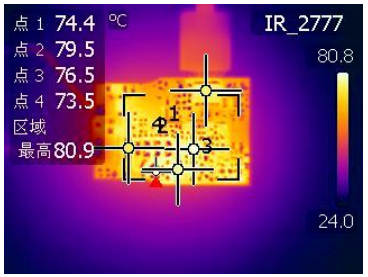


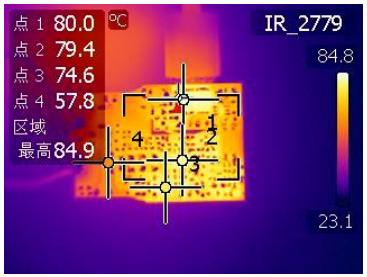


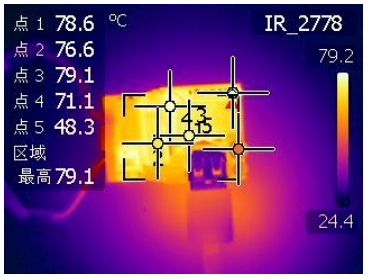
18.3. Thermal Test for Critical Component (@12V)

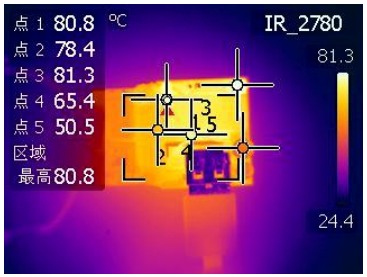
Item	V_{IN}=90V_{AC}, Vout=12V I_{OUT}=1.25A		V_{IN}=264V_{AC},Vout=12V I_{OUT}=1.25A	
	Temp.(°C)	Rising Temp. (°C)	Temp.(°C)	Rising Temp. (°C)
Input Bulk_Cap(CE3, 22uF/400V)	71.1	46.1	65.4	40.4
Input Rectifier Rectifier (D1, GS2M)	73.5	48.5	57.8	32.8
MOSFET(Q1, IPU60R600C6)	78.6	53.6	80.8	55.8
Transformer(T1, ER2010)	76.6	51.6	78.4	53.4
Schottky Diode(D52, PT10Y100SP)	74.4	49.4	80	55
PWM IC(U1, iW1788)	79.5	54.5	79.4	54.4
NPN transistor(Q3,2N4401)	79.1	54.1	81.3	56.3
Solid capacitor(CE51, 330uF/16V)	48.3	23.3	50.5	25.5
Fast Rectifier Rectifier (D5, FR207)	76.5	51.5	74.6	49.6
Ambient (Chamber) Temp.	25		25	





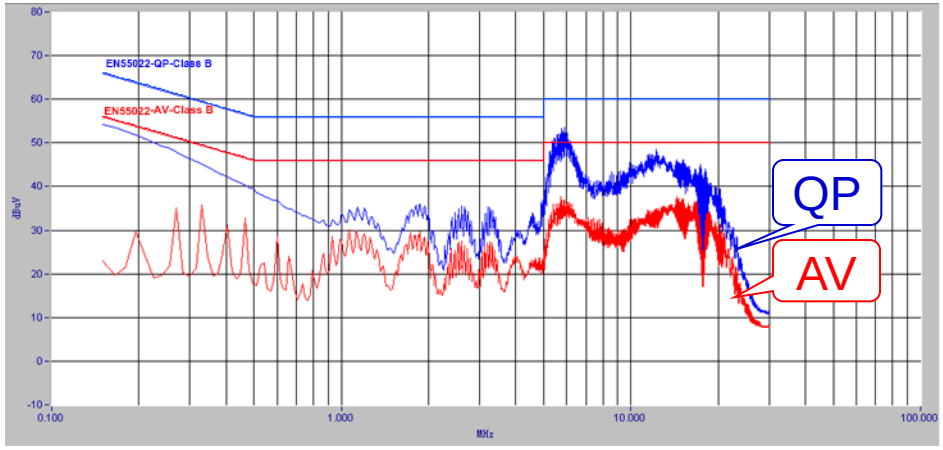




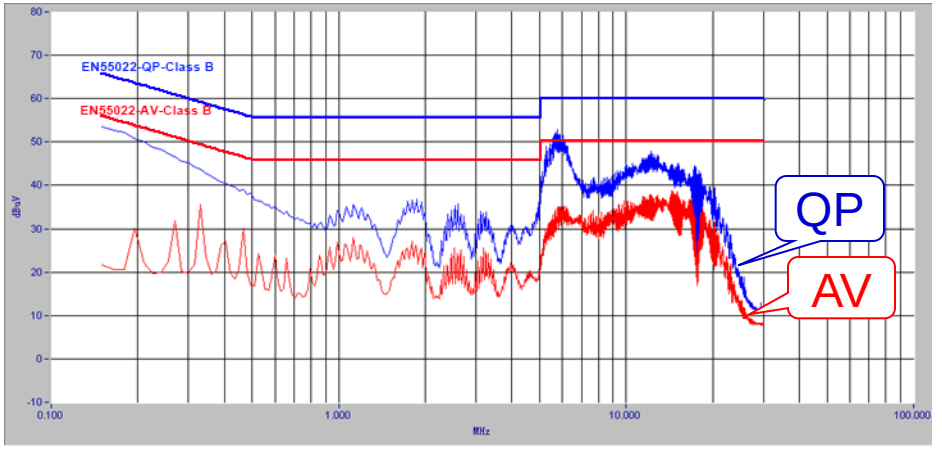


19.1. Conducted EMI (@5V)

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



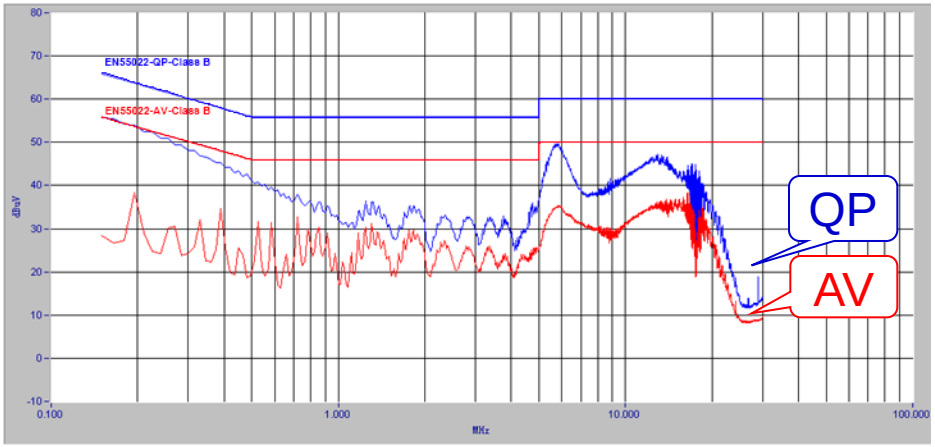
V_{IN}=230V_{AC}/50Hz, Natural



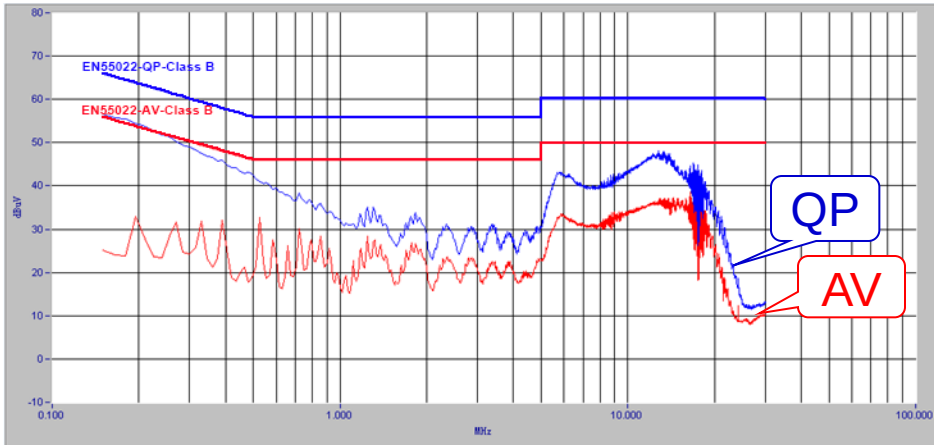
*Note: Resistive & Full load; output (-) is connected to Earth .

19.2. Conducted EMI (@9V)

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



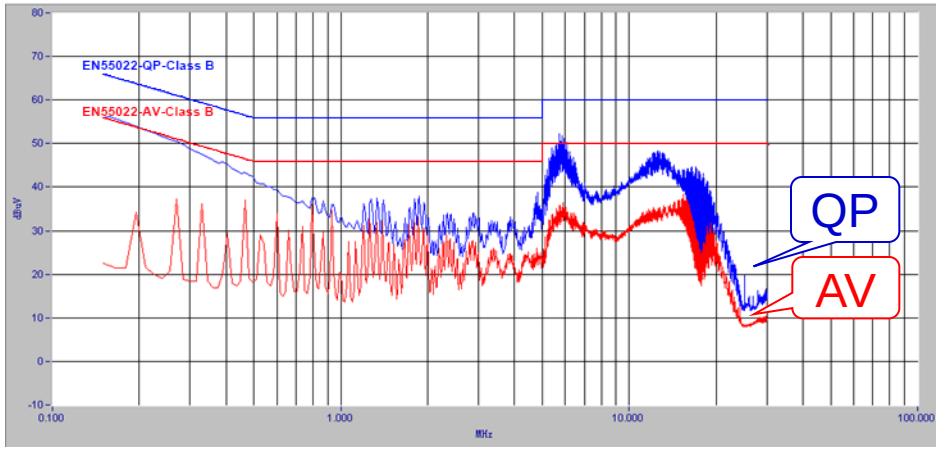
V_{IN}=230V_{AC}/50Hz, Natural



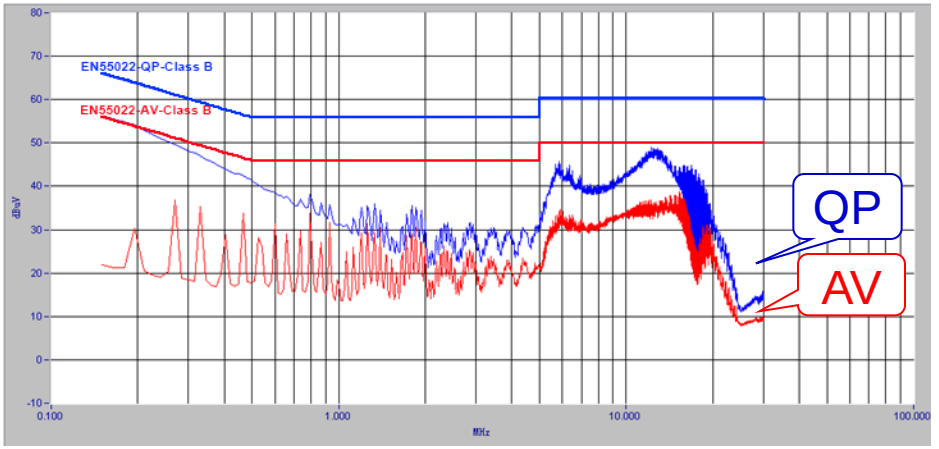
*Note: Resistive & Full load; output (-) is connected to Earth .

19.3. Conducted EMI (@12V)

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



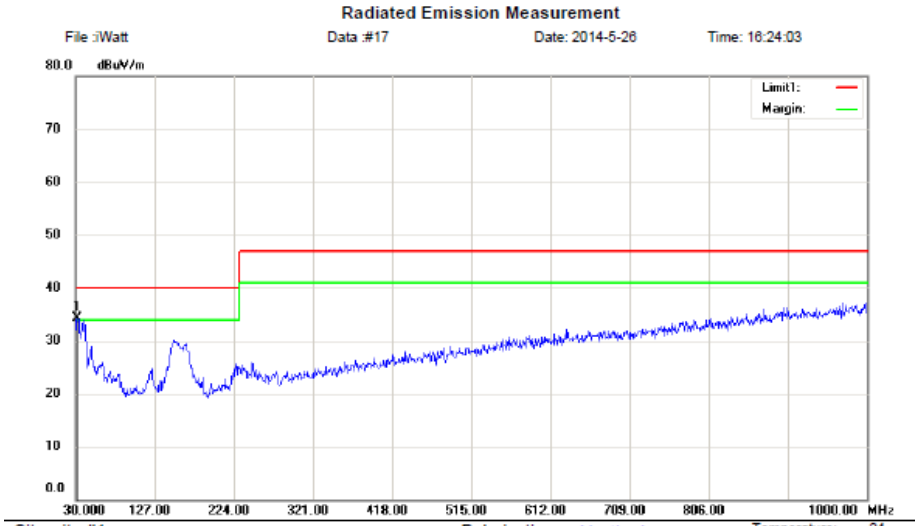
V_{IN}=230V_{AC}/50Hz, Natural



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

20.1. Radiated EMI(@5V)

Vin=230Vac/50Hz, VERTICAL



Site site #1 Polarization: *Vertical* Temperature: 24

Limit: EN55022 class B _ 3M Radiation Power: AC 230V/50Hz Humidity: 53 %

EUT:

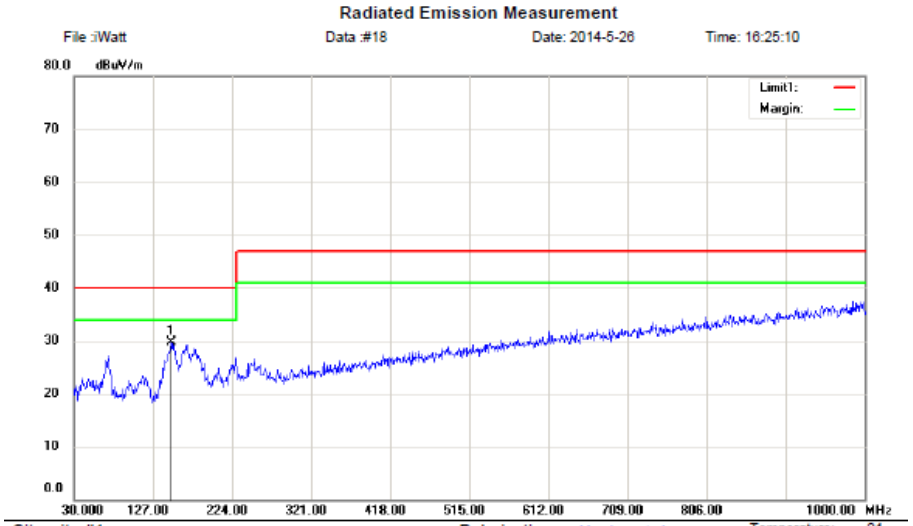
M/N: 5V/1.67A

Mode:FULL LOAD

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	31.9400	43.28	-9.01	34.27	40.00	-5.73	peak			

Vin=230Vac/50Hz, HORIZONTAL



Site site #1 Polarization: *Horizontal* Temperature: 24

Limit: EN55022 class B _ 3M Radiation Power: AC 230V/50Hz Humidity: 53 %

EUT:

M/N: 5V/1.67A

Mode:FULL LOAD

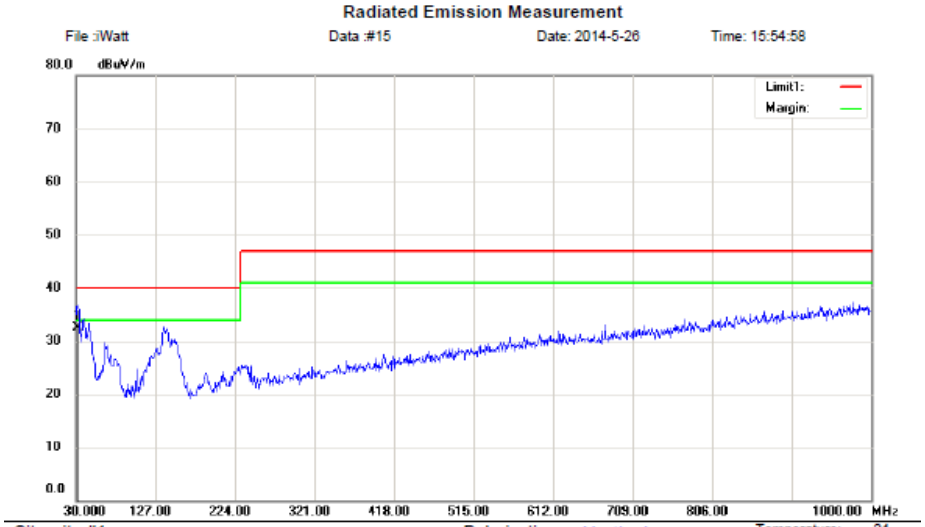
Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	149.3100	40.82	-11.12	29.70	40.00	-10.30	peak			

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

20.2. Radiated EMI(@9V)

Vin=230Vac/50Hz, VERTICAL



Site site #1 Polarization: *Vertical* Temperature: 24

Limit: EN55022 class B _ 3M Radiation Power: AC 230V/50Hz Humidity: 53 %

EUT:

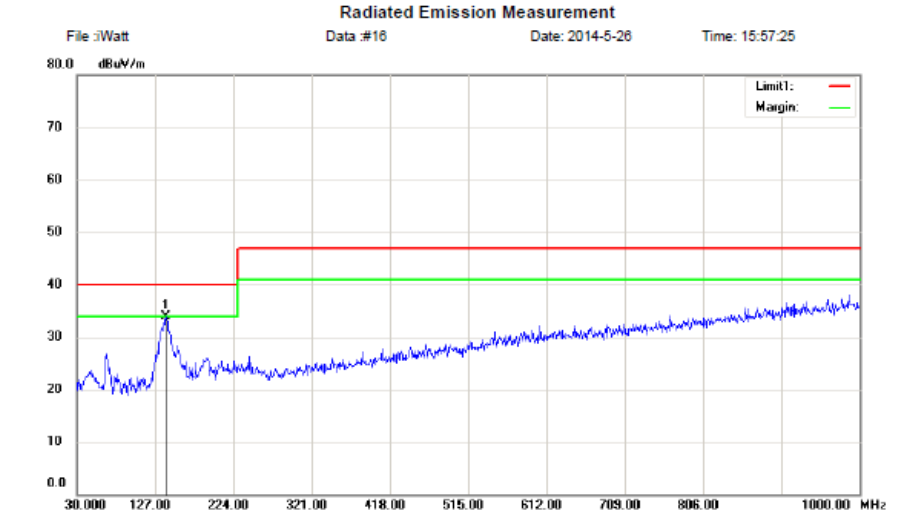
M/N: 9V/1.67A

Mode:FULL LOAD

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	31.9400	41.51	-9.01	32.50	40.00	-7.50	QP			

Vin=230Vac/50Hz, HORIZONTAL



Site site #1 Polarization: *Horizontal* Temperature: 24

Limit: EN55022 class B _ 3M Radiation Power: AC 230V/50Hz Humidity: 53 %

EUT:

M/N: 9V/1.67A

Mode:FULL LOAD

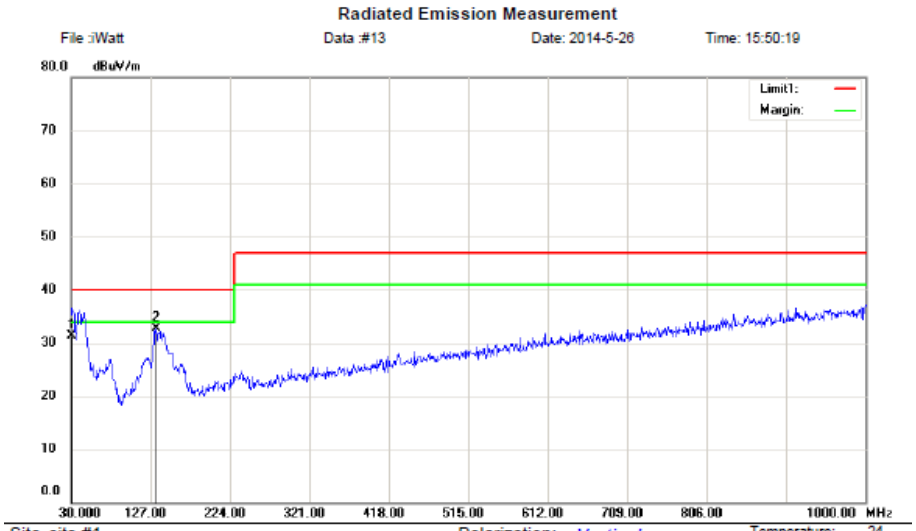
Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	140.5800	45.47	-11.47	34.00	40.00	-6.00	peak			

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

20.3. Radiated EMI(@12V)

Vin=230Vac/50Hz, VERTICAL



Site site #1 Polarization: *Vertical* Temperature: 24

Limit: EN55022 class B _ 3M Radiation Power: AC 230V/50Hz Humidity: 53 %

EUT:

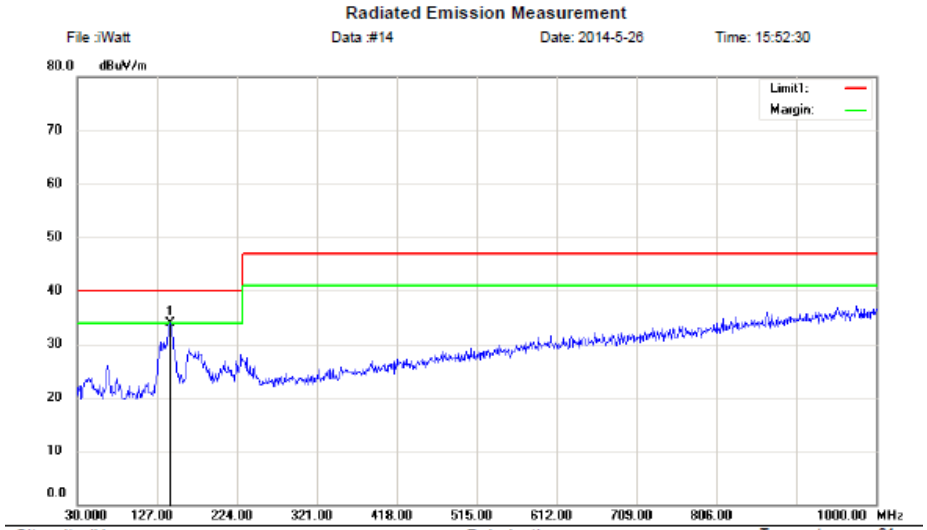
M/N: 12V/1.25A

Mode:FULL LOAD

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		30.9700	40.37	-9.07	31.30	40.00	-8.70	QP			
2	*	133.7900	43.82	-11.20	32.62	40.00	-7.38	peak			

Vin=230Vac/50Hz, HORIZONTAL



Site site #1 Polarization: *Horizontal* Temperature: 24

Limit: EN55022 class B _ 3M Radiation Power: AC 230V/50Hz Humidity: 53 %

EUT:

M/N: 12V/1.25A

Mode:FULL LOAD

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	143.4900	45.21	-11.36	33.85	40.00	-6.15	peak			

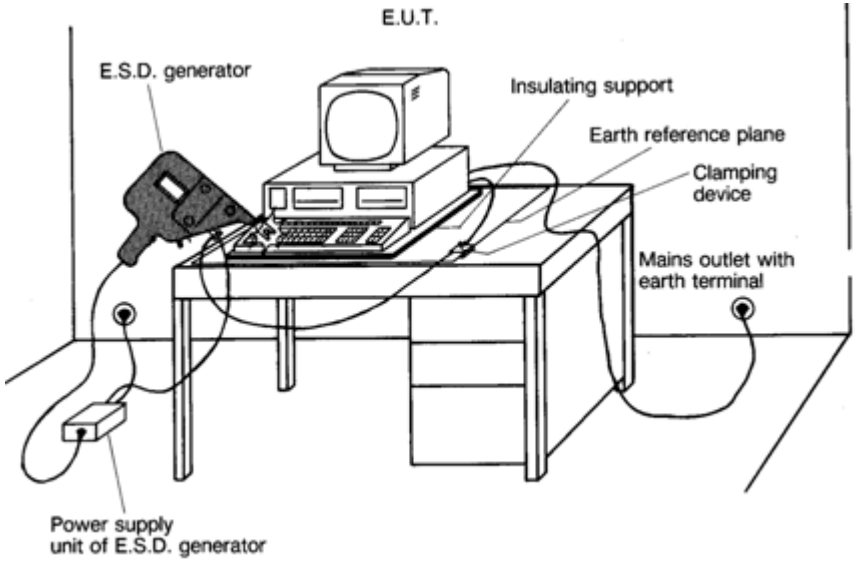
Note: Resistive & Full load; output (-) is floating.

21. ESD (IEC 61000-4-2) (@5V)

Test condition:

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

Air-Discharge		Result (no-load)	Result (full-load)
10KV	+	PASS	PASS
	-	PASS	PASS
12KV	+	PASS	PASS
	-	PASS	PASS
14KV	+	PASS	PASS
	-	PASS	PASS
15KV	+	PASS	PASS
	-	PASS	PASS
16KV	+	PASS	PASS
	-	PASS	PASS
18KV	+	PASS	PASS
	-	PASS	PASS
20KV	+	PASS	PASS
	-	PASS	PASS



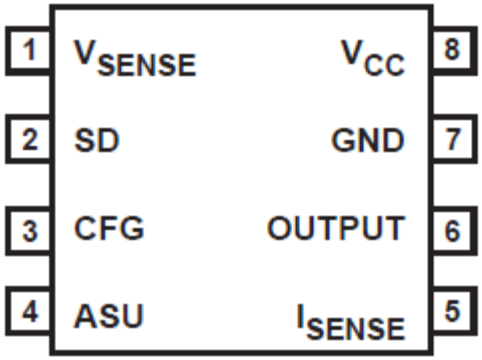
Appendix-1. V_{CC} Supply Voltage (@5V)

The purpose of this test is to verify range of V_{CC} voltage under different loading conditions.

Item	V_{CC} range [Max:20V, Min:5.5V]			
Input V_{AC}	V_{IN}=90V_{AC}	V_{IN}=115V_{AC}	V_{IN}=230V_{AC}	V_{IN}=264V_{AC}
Output No-load	12.1V	12.1V	12.1V	12.3V
Output Full-load (1.67A)	16.7V	16.5V	17.1V	17.3V
Max load (CC/CV corner)	17.1V	16.9V	17.3V	17.5V

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

iW1788



V_{CC} SECTION (Pin 8)						
Operating voltage (Note 2)	V_{CC}				20	V
Start-up threshold	$V_{CC(ST)}$	V_{CC} rising	12.7	13.7	14.7	V
Under-voltage lockout threshold	$V_{CC(UVL)}$	V_{CC} falling	5.2	5.5	5.8	V
Latch release threshold	$V_{CC(RLS)}$	V_{CC} falling	4.2	4.5	4.8	V
Start-up current	$I_{IN(ST)}$	V_{CC} = 12V		7.6		µA

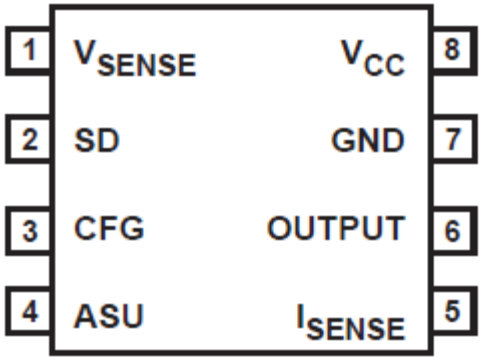
Appendix-2. V_{CC} Supply Voltage (@9V)

The purpose of this test is to verify range of V_{CC} voltage under different loading conditions.

Item	V_{CC} range [Max:20V, Min:5.5V]			
Input V_{AC}	V_{IN}=90V_{AC}	V_{IN}=115V_{AC}	V_{IN}=230V_{AC}	V_{IN}=264V_{AC}
Output No-load	17.2V	17.6V	18.0V	17.7V
Output Full-load (1.67A)	18.6V	18.8V	18.8V	18.6V
Max load (CC/CV corner)	18.6V	18.8V	18.8V	18.6V

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

iW1788



V_{CC} SECTION (Pin 8)						
Operating voltage (Note 2)	V_{CC}				20	V
Start-up threshold	$V_{CC(ST)}$	V_{CC} rising	12.7	13.7	14.7	V
Under-voltage lockout threshold	$V_{CC(UVL)}$	V_{CC} falling	5.2	5.5	5.8	V
Latch release threshold	$V_{CC(RLS)}$	V_{CC} falling	4.2	4.5	4.8	V
Start-up current	$I_{IN(ST)}$	V_{CC} = 12V		7.6		µA

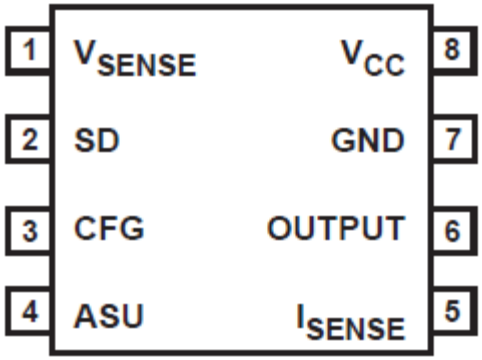
Appendix-3. V_{CC} Supply Voltage (@12V)

The purpose of this test is to verify range of V_{CC} voltage under different loading conditions.

Item	V_{CC} range [Max:20V, Min:5.5V]			
Input V_{AC}	V_{IN}=90V_{AC}	V_{IN}=115V_{AC}	V_{IN}=230V_{AC}	V_{IN}=264V_{AC}
Output No-load	19.0V	19.0V	19.0V	19.0V
Output Full-load (1.25A)	18.8V	19.0V	19.0V	19.0V
Max load (CC/CV corner)	18.8V	19.0V	19.0V	19.0V

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

iW1788



V_{CC} SECTION (Pin 8)						
Operating voltage (Note 2)	V_{CC}				20	V
Start-up threshold	$V_{CC(ST)}$	V_{CC} rising	12.7	13.7	14.7	V
Under-voltage lockout threshold	$V_{CC(UVL)}$	V_{CC} falling	5.2	5.5	5.8	V
Latch release threshold	$V_{CC(RLS)}$	V_{CC} falling	4.2	4.5	4.8	V
Start-up current	$I_{IN(ST)}$	V_{CC} = 12V		7.6		µA

dialog SEMICONDUCTOR

The power to be...

...personal
...portable
...connected