iW1689 Design for 3W LED Non-Isolated Driver

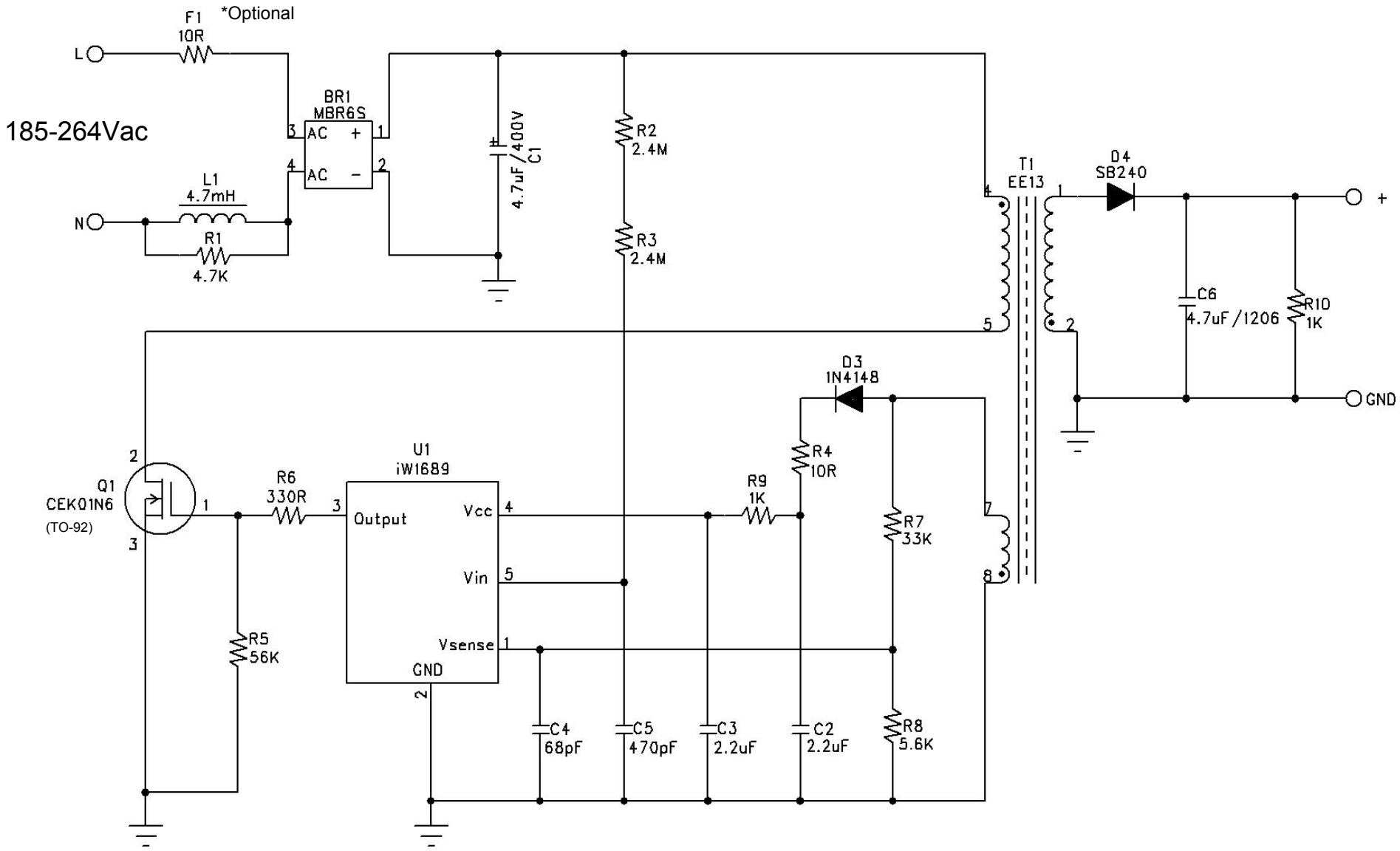
Summary and Features :

- **Simple transformer construction**
- **High efficiency**
- **Meets EN55015B EMI limit with >6dB margin**
- **Failure mode protects**
- **Constant-current LED drive (>1A is possible)**

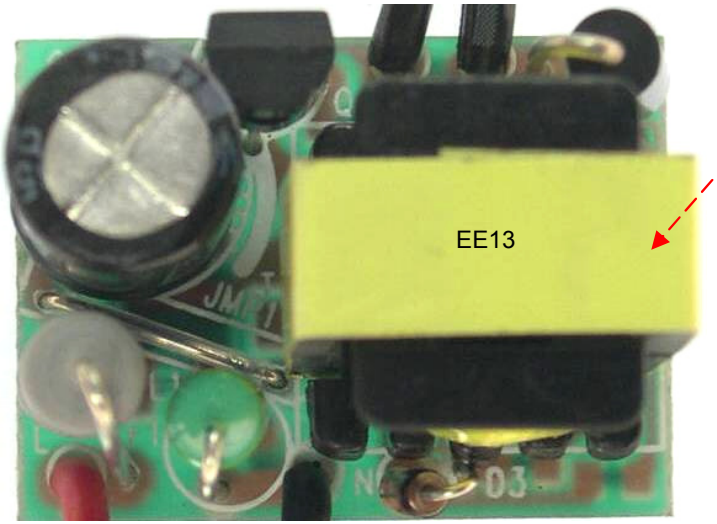
1. Specification

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 ($264V_{AC}$)						W	
Output							
Const Voltage	Output Voltage	V_{OUT_CV}	4.75	5.00	5.25	V	Measured at the end of PCB
	Output Current	I_{OUT_CV}	0		700	A	
Const Current	Output Voltage	V_{OUT_CC}		2.00		V	Min V_{OUT} is dependence of V_{CC} supply voltage
	Output Current	I_{OUT_CC}	600	700	800	A	
Total Output Power							
Continuous Output Power		P_{OUT}			3	W	
Over Current Protection		I_{OUT_MAX}				A	Auto-restart
Efficiency		η	65			%	Measured at end of PCB, V_{IN} = $90V_{AC}$ I_{OUT_CV} = 700mA. (T_A = 25 ℃)
Environmental							
Conducted EMI			Meets CISPR15B / EN55015B				
Safety			Designed to meet IEC950, UL1950 Class II				
Ambient Temperature		T_{AMB}	0		50	° C	Free convection, sea level

2. Schematic


F1
10R
*Optional
L
N
185-264Vac
L1
4.7mH
R1
4.7K
BR1
MBR6S
AC
AC
+
-
C1
4.7uF/400V
R2
2.4M
R3
2.4M
T1
EE13
D4
SB240
+
GND
C6
4.7uF/1206
R10
1K
D3
1N4148
R4
10R
R9
1K
R7
33K
R8
5.6K
U1
iW1689
Output
Vcc
Vin
Vsense
GND
Q1
CEK01N6
(TO-92)
R6
330R
R5
56K
C4
68pF
C5
470pF
C3
2.2uF
C2
2.2uF

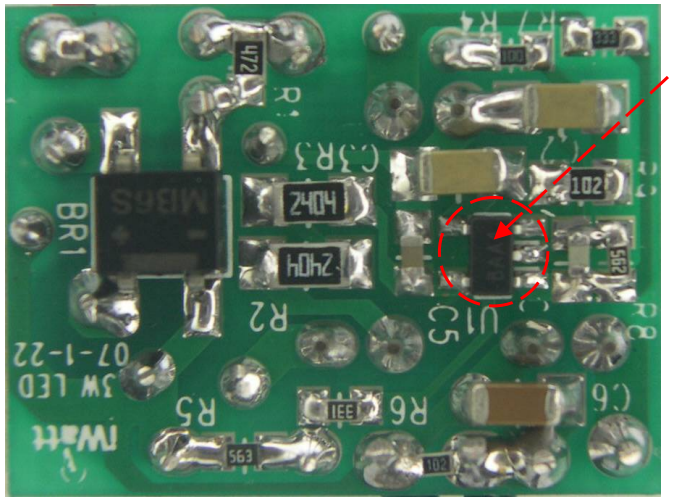
3. Circuit Board Photograph



Low Cost Transformer
-EE13 Core and Bobbin

Top side

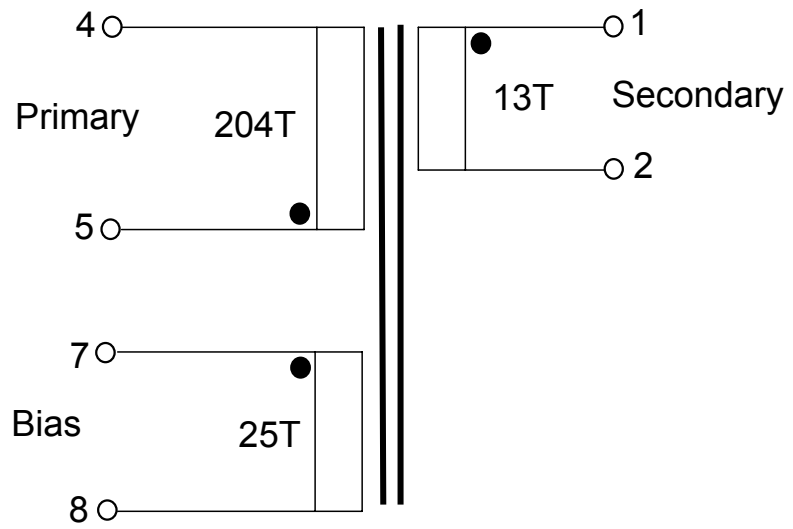
Primary PWM Controller-iW1689

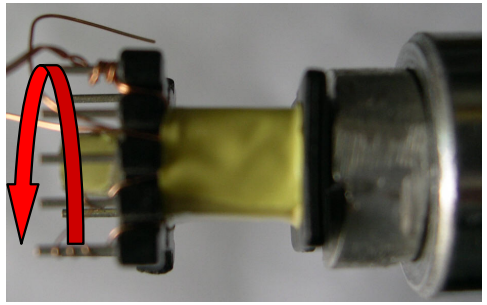


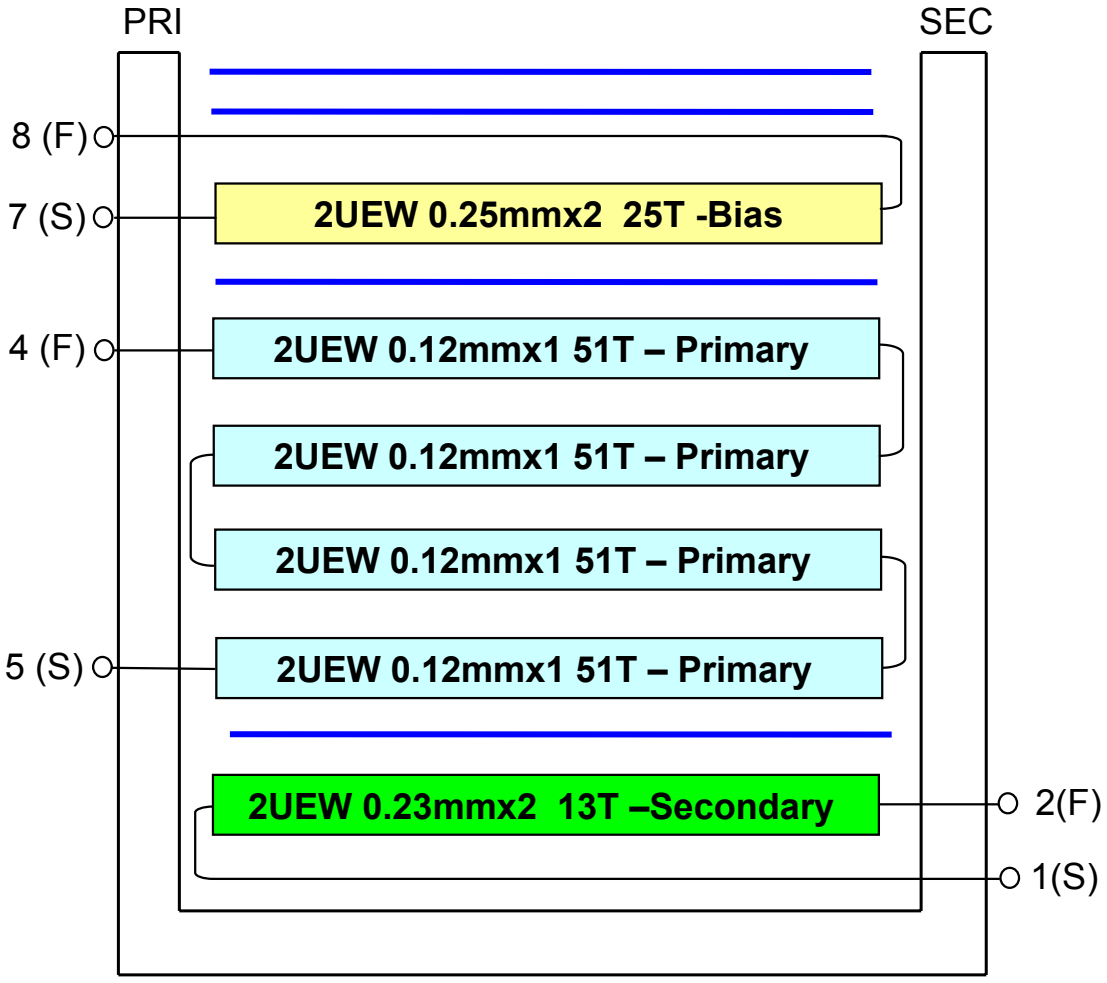
Bottom side

4 Transformer Design

SCHEMATIC







ELECTRICAL SPECIFICATIONS:

1. Primary Inductance (Lp) = 3.4mH @10KHz
2. Primary Leakage Inductance (Lk) = 36uH @10KHz

MATERIALS:

1. Core : EE13 (Ferrite Material TDK PC40 or equivalent)
2. Bobbin : EE13 Vertical.
3. Magnet Wires (Pri) : Type 2-UEW
4. Magnet Wire (Sec) : Triple Insulated Wires
5. Layer Insulation Tape : 3M1298 or equivalent.

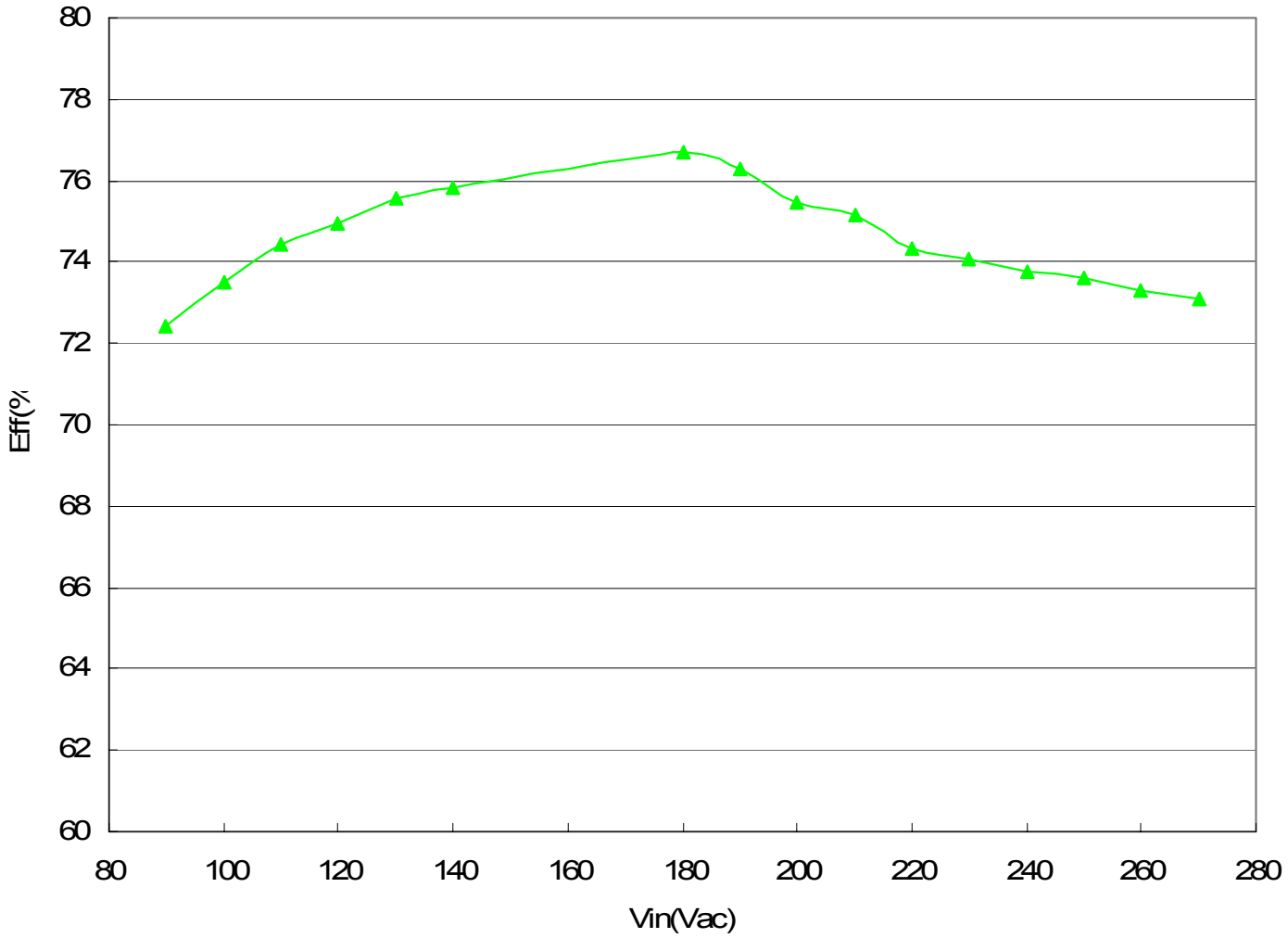
FINISHED :

1. Cut remained of Pin3,6,9,10 after wires termination
2. Varnish the complete assembly

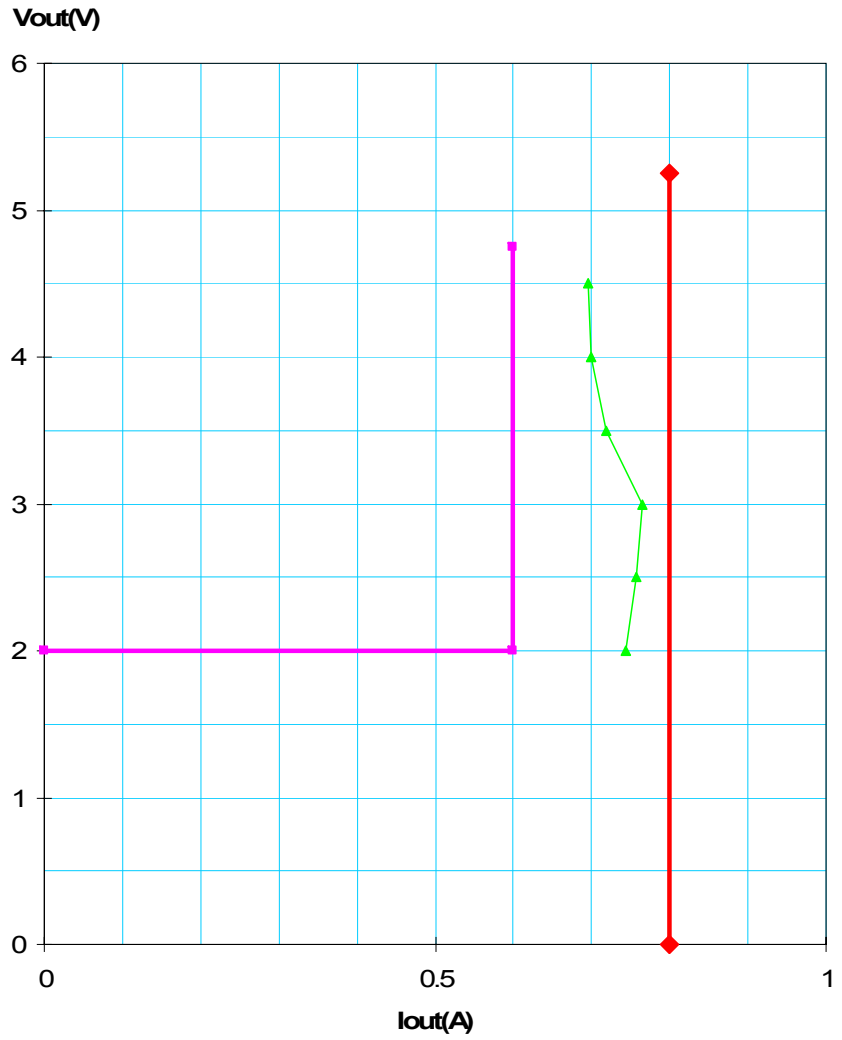
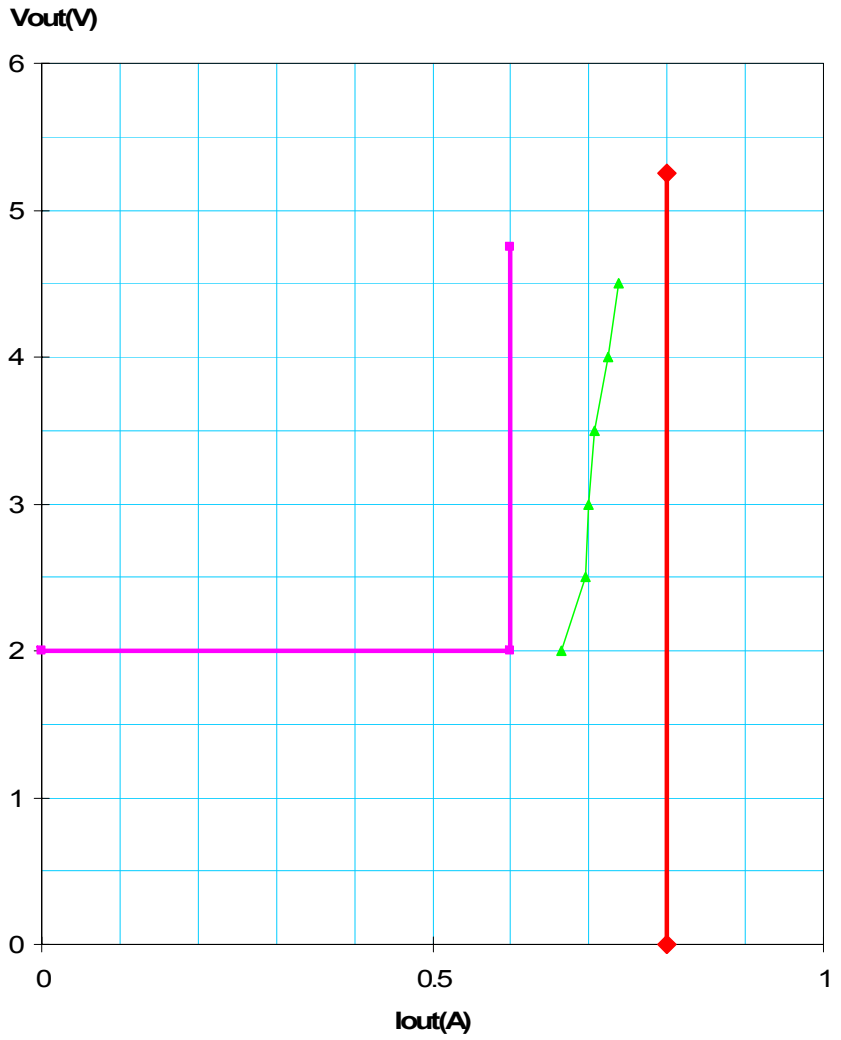
5. Bill of Material

Item	Qty.	Ref.	Description	Cost (US Cent) / unit	Sub-Total (Cent)
1	1	F1	10Ω, Fuse Resistor, 1W		
2	1	L1	4.7mH, Filter Inductor		
3	1	BR1	MBR6S		
4	1	C1	4.7uF, 400V, E-CAP, 8X10		
5	1	U1	iW1689, Off-line digital PWMController, SOT-5		
6	2	R2,R3	2.4MΩ±1%, SMD-1206		
7	1	C4	68pF, 25V, NPO, SMD-0603		
8	1	C5	470pF, 25V, NPO, SMD-0603		
9	2	C2,C3	2.2UF, 16V, X7R, SMD-1206		
10	1	R1	4.7KΩ±5%, SMD-0805		
11	1	R4	10Ω±5%, SMD-0603		
12	1	R5	56KΩ±5%, SMD-0603		
13	1	R6	330Ω±5%, SMD-0603		
14	1	R7	33KΩ±5%, SMD-0603		
15	1	R8	5.6KΩ±5%, SMD-0603		
16	1	R9	1KΩ±5%, SMD-0603		
17	1	Jump1	JUMP		
18	1	D3	1N4148,Fast rectifier diode, DL-35		
19	1	Q1	CEK01N6, RDS(ON)=15Ω, 0.2A/650V		
20	1	D7	SB240, Schotkky Diode, DO-201		
21	1	C6	4.7uF, 16V, SMD-1206		
22	1	R10	1KΩ±5%, SMD-0805		
23	1	T1	EE13, Transformer		
24	1	PCB	Single Board, FR-4, 24(L)x18(W)x1.6(T)		
			Total BOM(Based on 100K/Mvolume)		

6. Efficiency



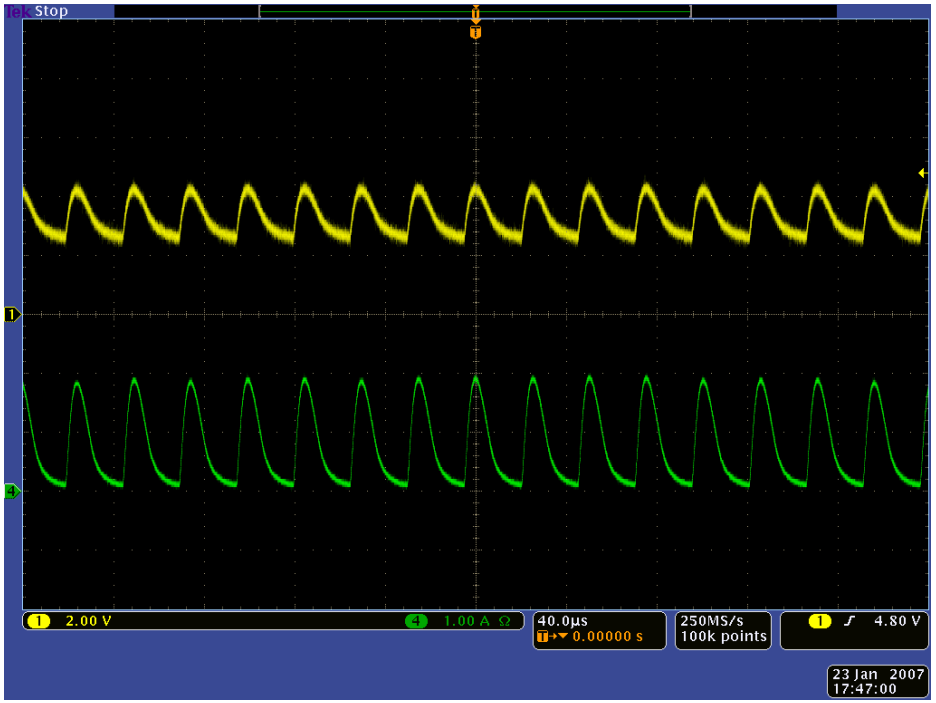
7. Output VI Characteristics

V_{IN}=90V_{AC}, T_{AMB}=25℃	V_{IN}=264V_{AC}, T_{AMB}=25℃
	

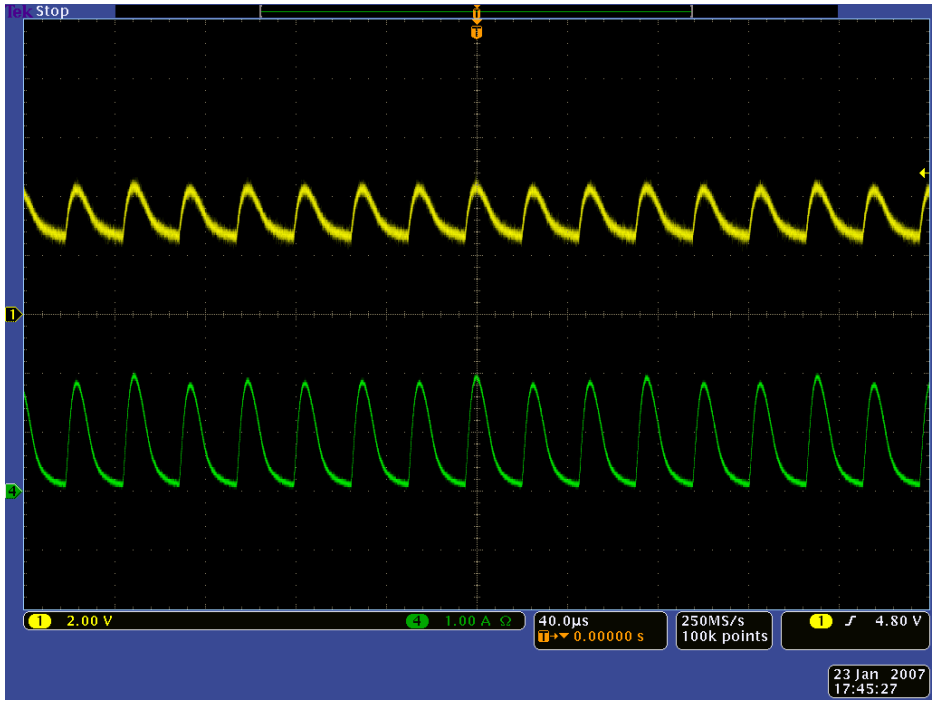
*Note: Output voltage measured at PCB end.

8. Output Waveform

90V Full Lold



264V Full Load

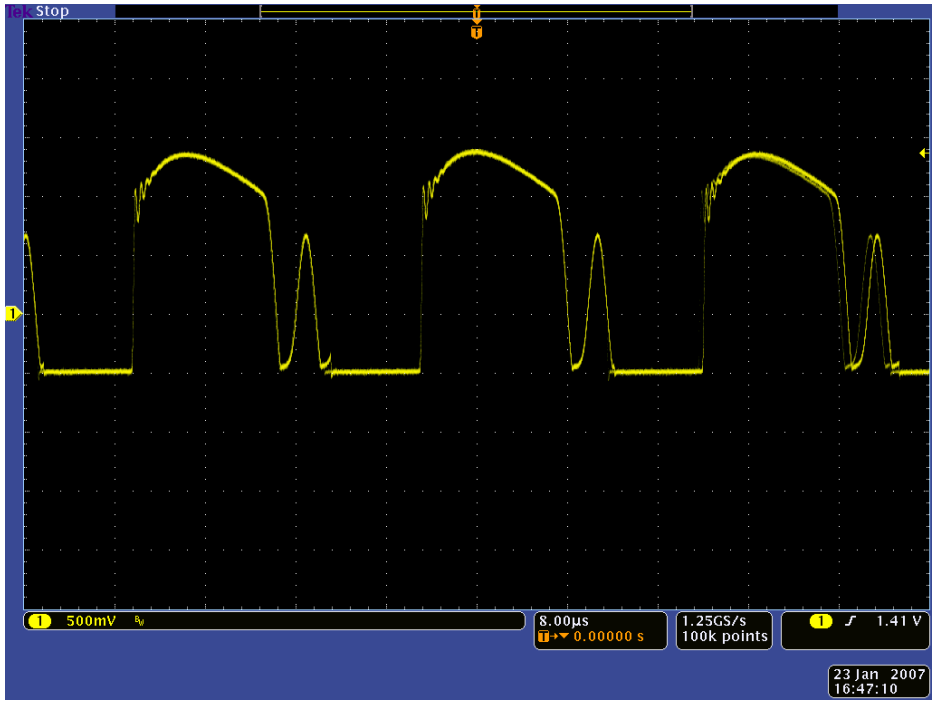


CH1: V_{OUT}, 2V/Div

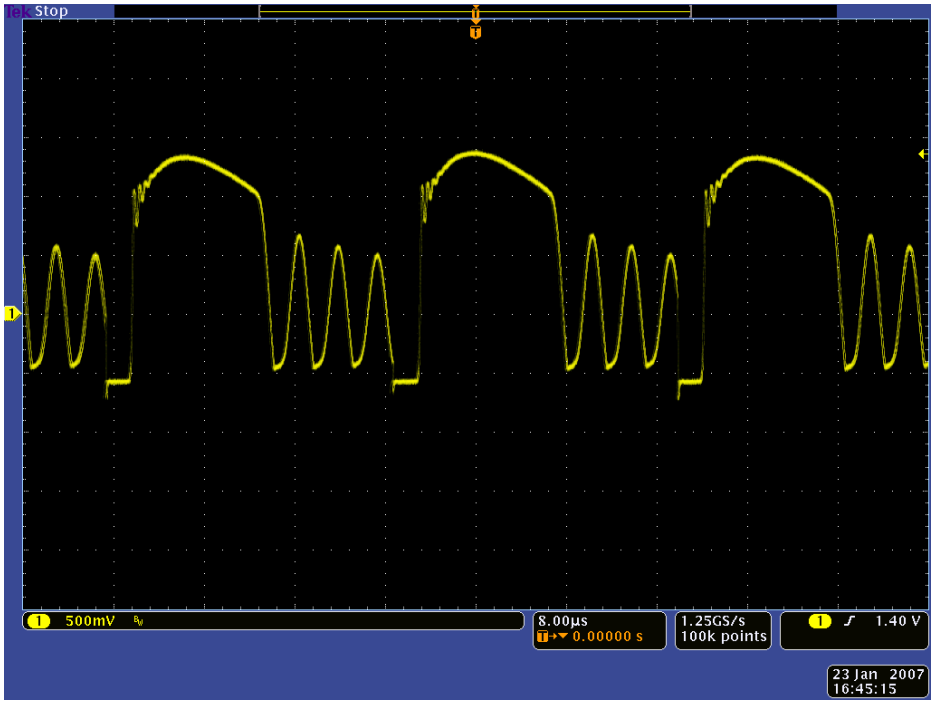
CH4: I_{OUT}, 1A/Div

9. V_{SENSE} Waveform

V_{IN}=90VAC, Full Load



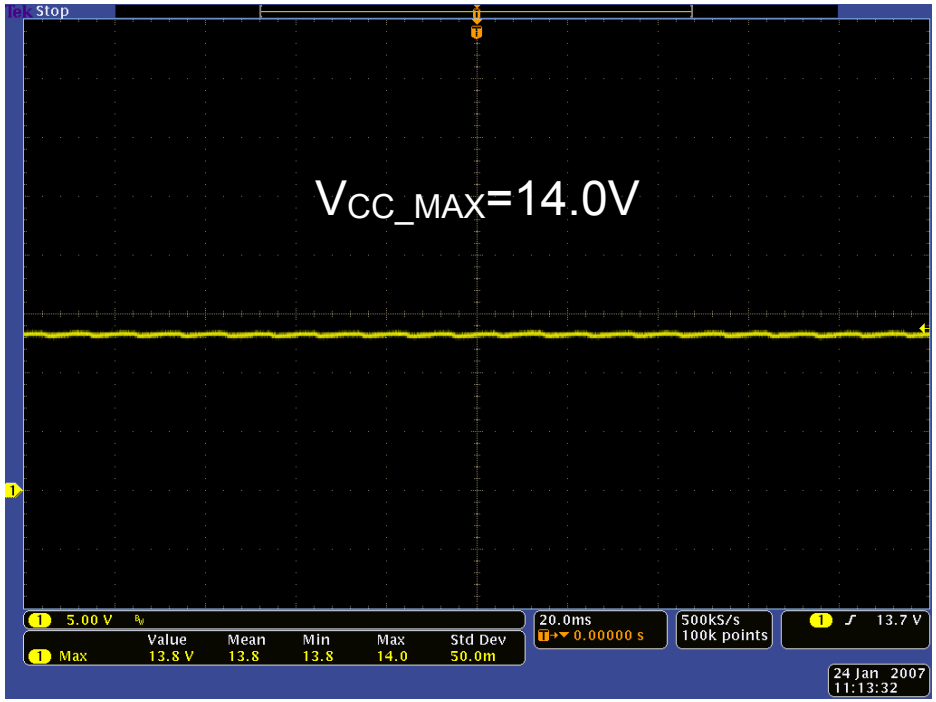
V_{IN}=264VAC, Full Load



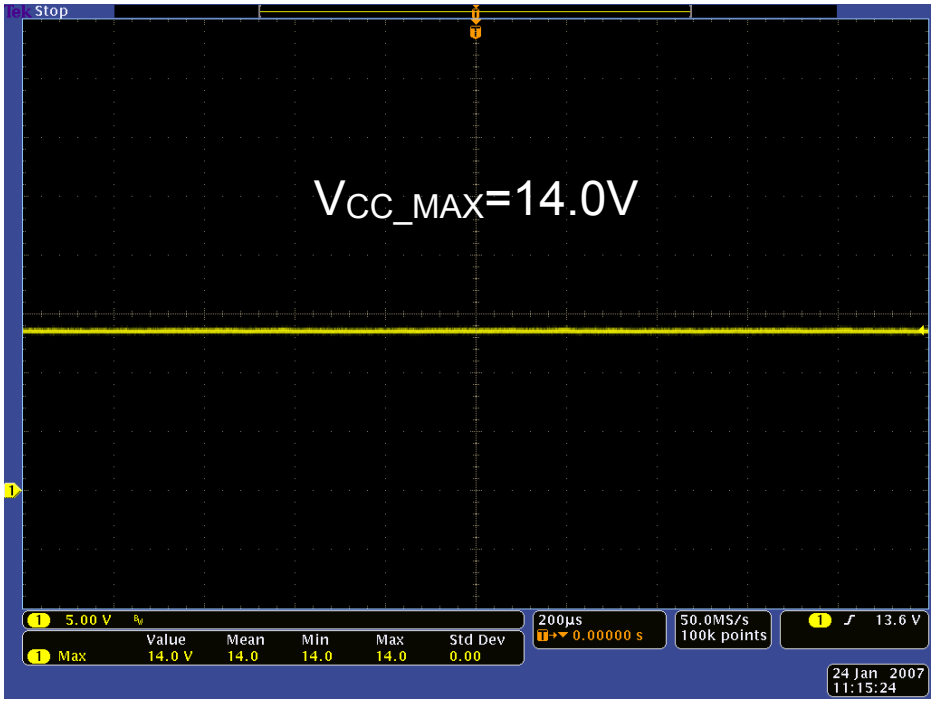
CH1: V_{SENSE}, 0.5V/Div

10. V_{CC} Waveform

V_{IN}=90VAC, Full Load

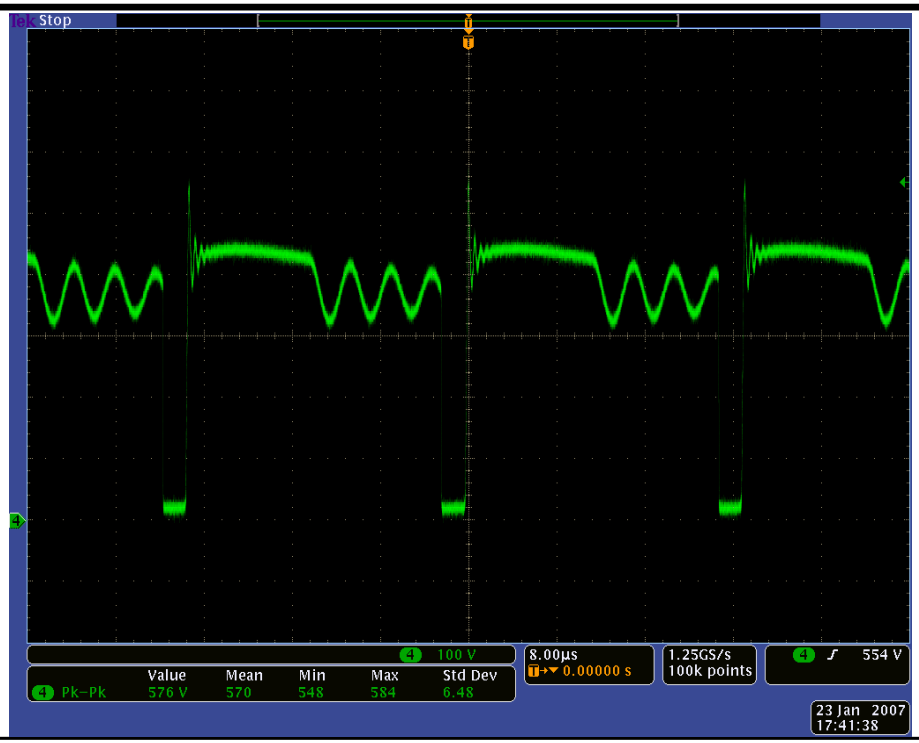


V_{IN}=264VAC, Full Load



CH1: VCC, 5V/Div

11. V_{DS} waveform



Test Condition:

V_{IN}=264VAC,Full Load

Result:

V_{DS_MAX}= **576 V**

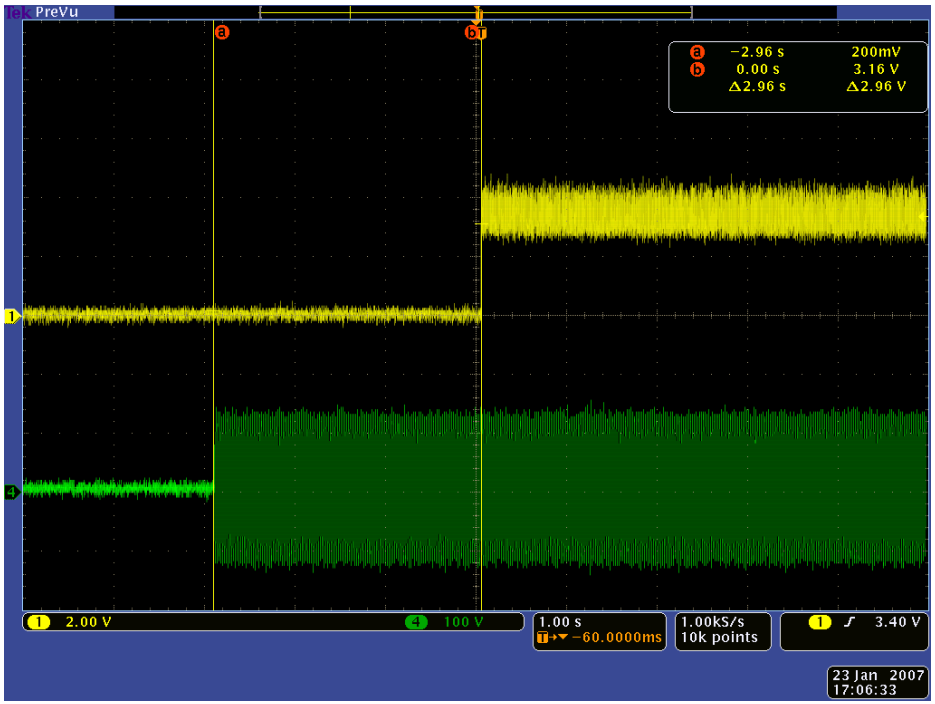
Appendix – Simple Specification for used MOSFET(CEK01N6)

Parameter	Symbol	Limit	Units
Drain-Source Voltage	V_{DS}	650	V
Gate-Source Voltage	V_{GS}	±30	V
Drain Current-Continuous	I_D	0.2	A
Drain Current-Pulsed [a]	I_{DM}	0.8	A
Maximum Power Dissipation	P_D	1.5	W
Operating and Store Temperature Range	T_J,T_{stg}	-55 to 150	°C
Thermal Resistance, Junction-to-Ambient [b]	$R_{\theta JA}$	85	°C/W

12. Start Up & Turn On Delay Time

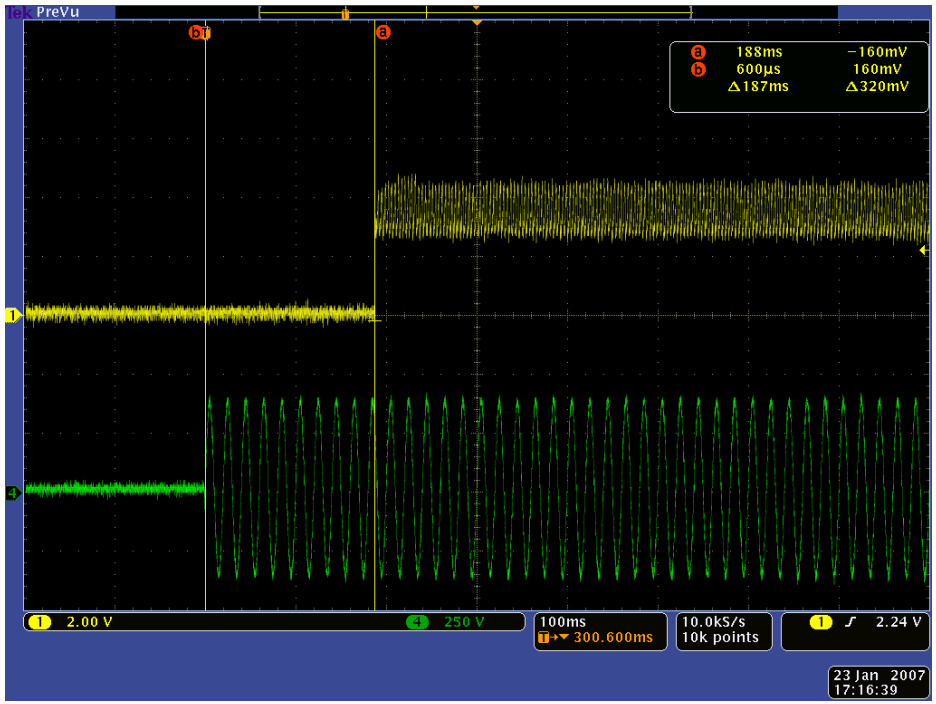
90V_{AC},Full Load

T_{ST_DELAY}= 2.98 S



264V_{AC},Full Load

T_{ST_DELAY}= 188 mS

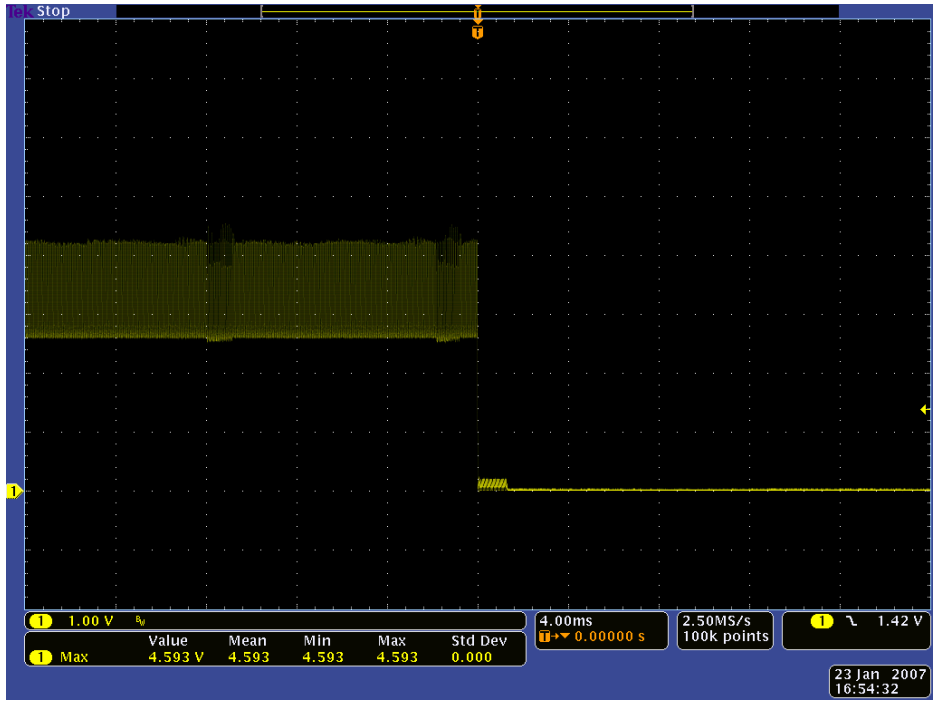


13. OVP Performance

-R8 is shorted, or R7 is opened.)

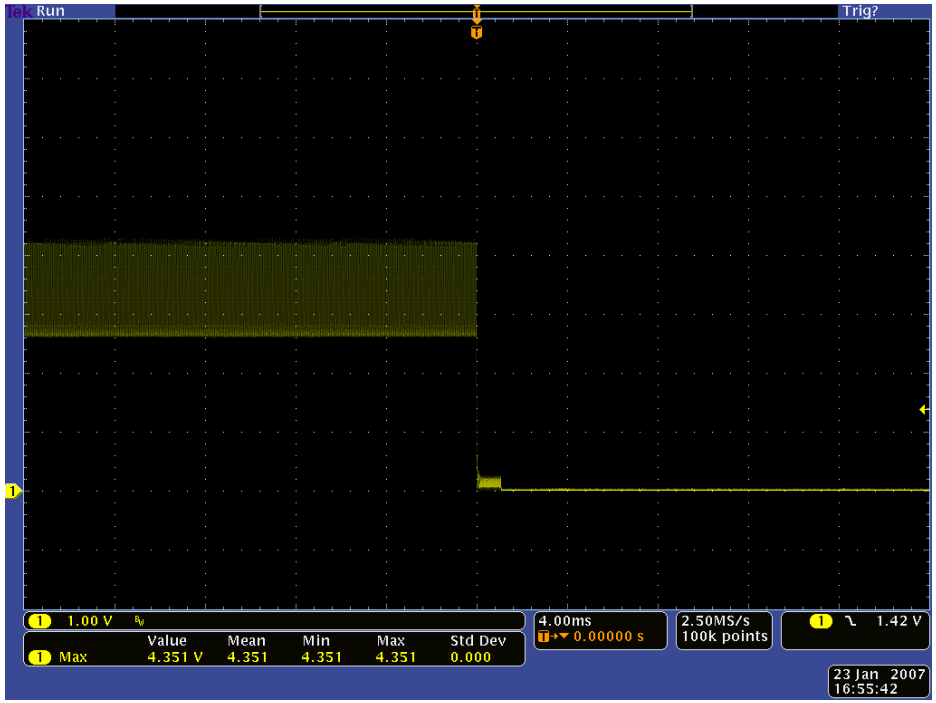
90V_{AC},Full Load

V_{OVP_MAX}= 4.593 V



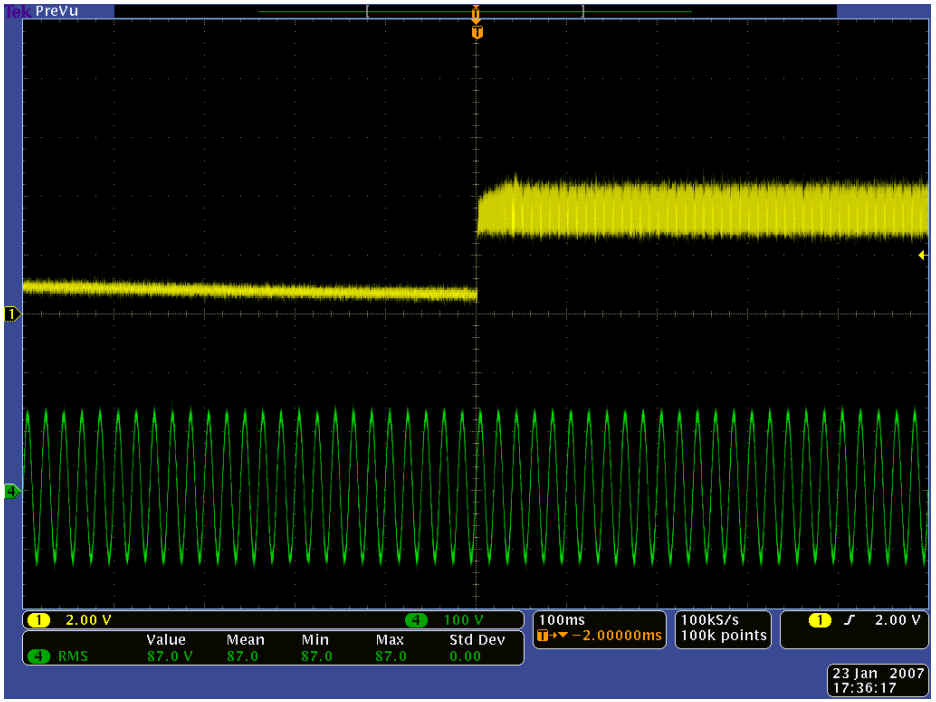
264V_{AC},Full Load

V_{OVP_MAX}= 4.351 V

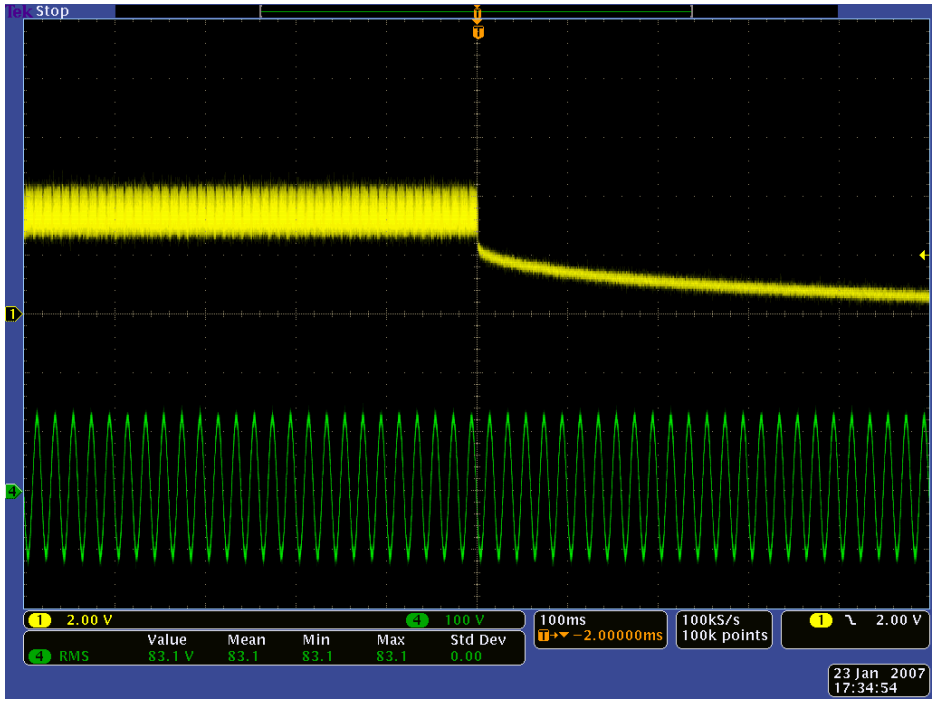


14. AC Startup & Shutdown Voltage Characteristic

$V_{IN\_STARTUP}$= 87.0 VAC, Full Load

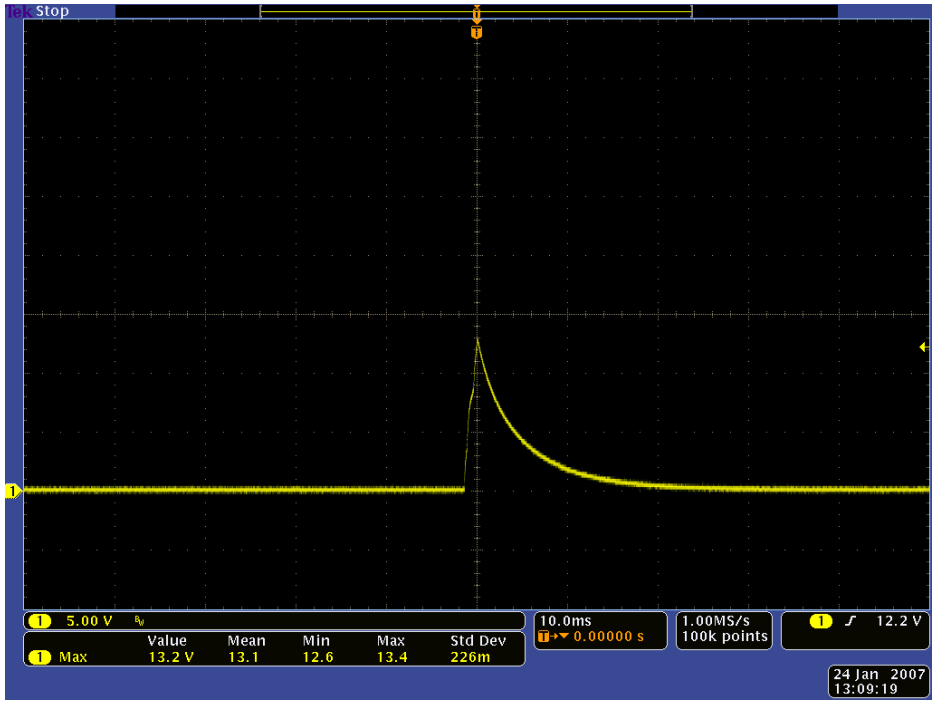


$V_{IN\_SHUTDOWN}$= 83.1 VAC, Full Load

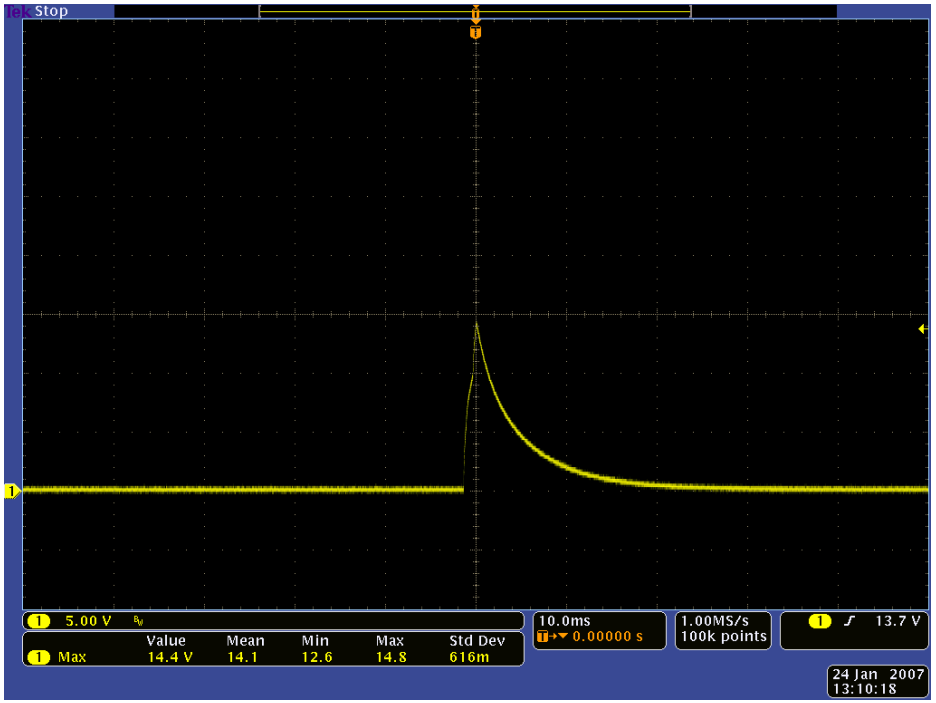


15. Output opened (Remove LED)

V_{IN}=90VAC, **V_{OUT_MAX}**= 13.2V



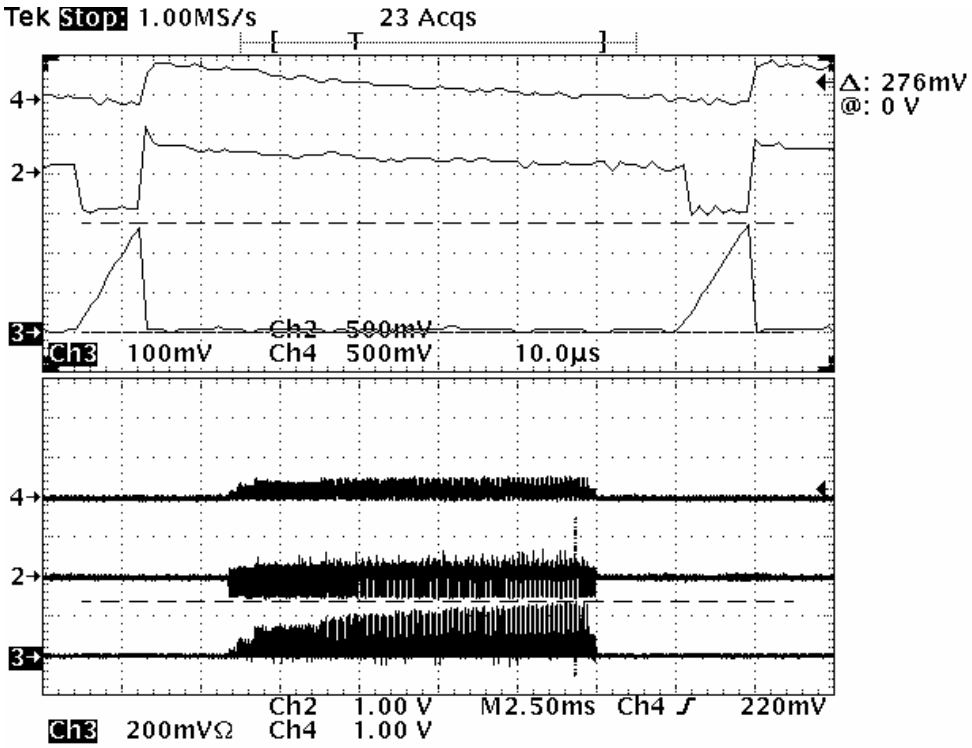
V_{IN}=264VAC, **V_{OUT_MAX}**= 14.4V



16. Output Short then Startup (Short at the PCB with a nipper)

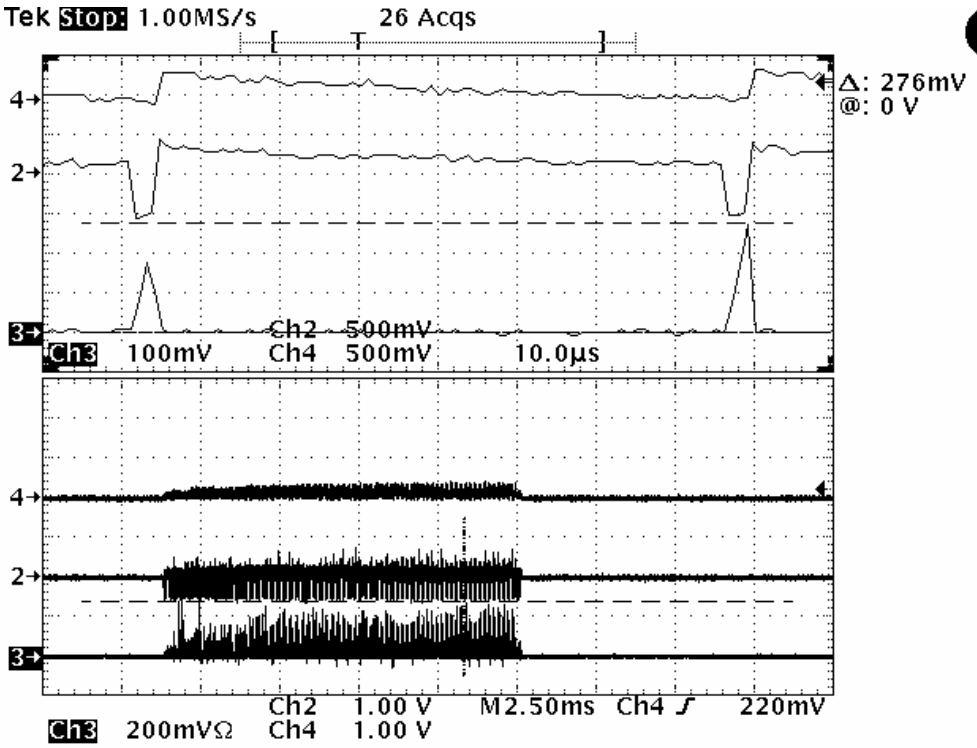
V_{IN}=90VAC, I_{PRI_MAX}=276mA

B_{MAX}=0.28Tesla, No Saturation



V_{IN}=264VAC, I_{PRI_MAX}=276mA

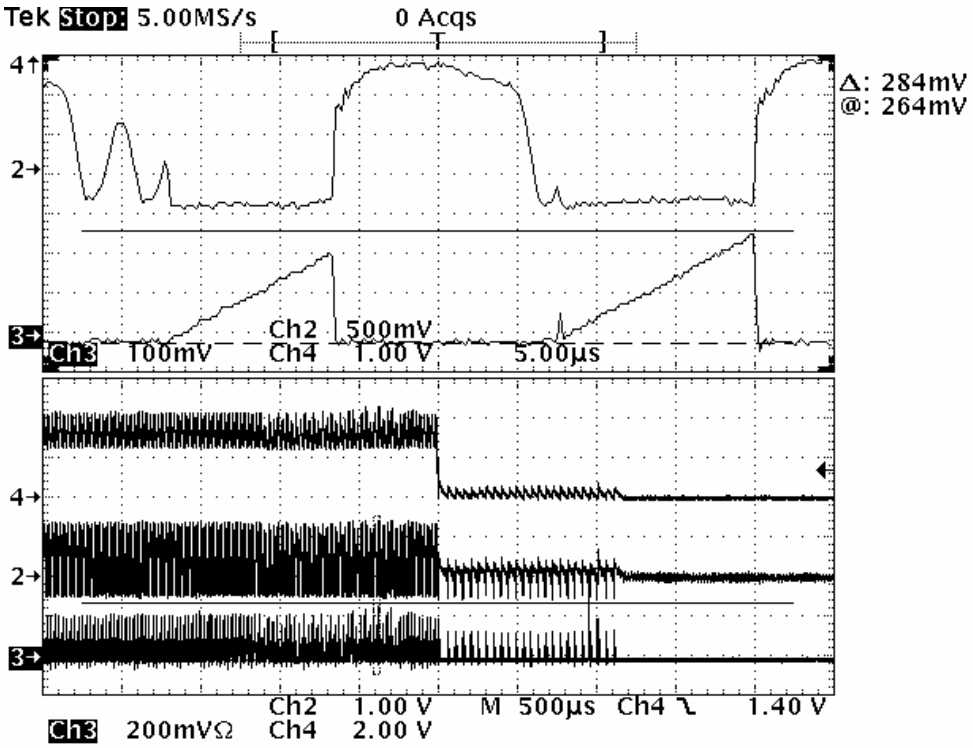
B_{MAX}=0.28Tesla, No Saturation



17. Output Short After Regulation (Short at the PCB with a nipper)

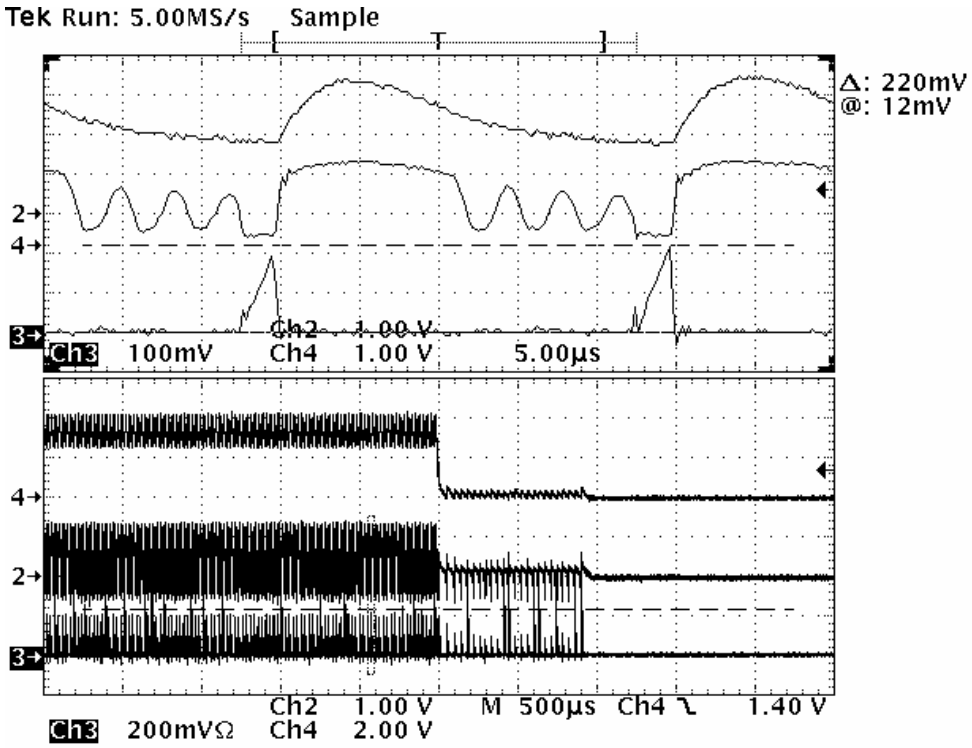
V_{IN}=90VAC, I_{PRI_MAX}=284mA

B_{MAX}=0.29Tesla, No Saturation



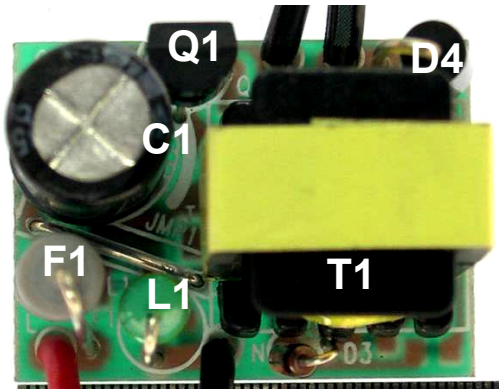
V_{IN}=264VAC, I_{PRI_MAX}=220mA

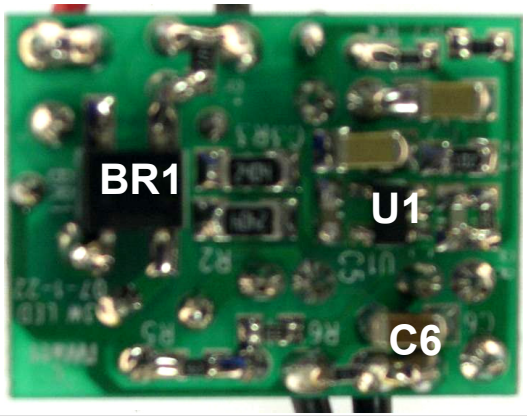
B_{MAX}=0.22Tesla, No Saturation



18. Thermal Test for Critical Component

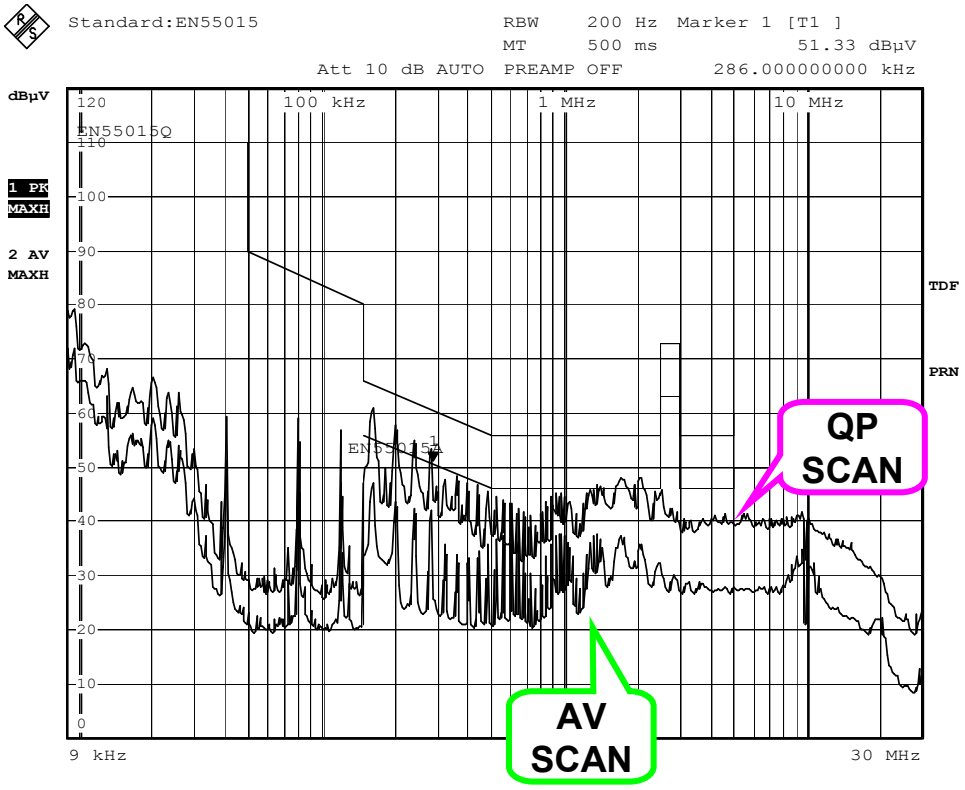
Item	CV MODE	V_{OUT_CV}=4.2V I_{OUT}=710mA
	V_{IN}=230V_{AC}	
	T(℃)	Tr(℃)
FUSE(F1,10R/1W)	75.7	35.0
DM Inductor(L1,4.7mH)	63.1	22.4
Input E-CAP(C1,4.7uF/400V)	67.6	26.9
Bridg(BR1, MBR6S)	69.5	28.8
Mosfet (Q1, CEK01N6)	77.2	36.5
Transformer(T1, EE13)	88.9	48.2
IC(U1 IW1689)	83.8	43.1
Output SK-Diode(D4, SB240)	94.2	53.5
Output CAP(4.7uF,C16)	74.9	34.2
Ambient Temperature	40.7	





19. Conducted EMI

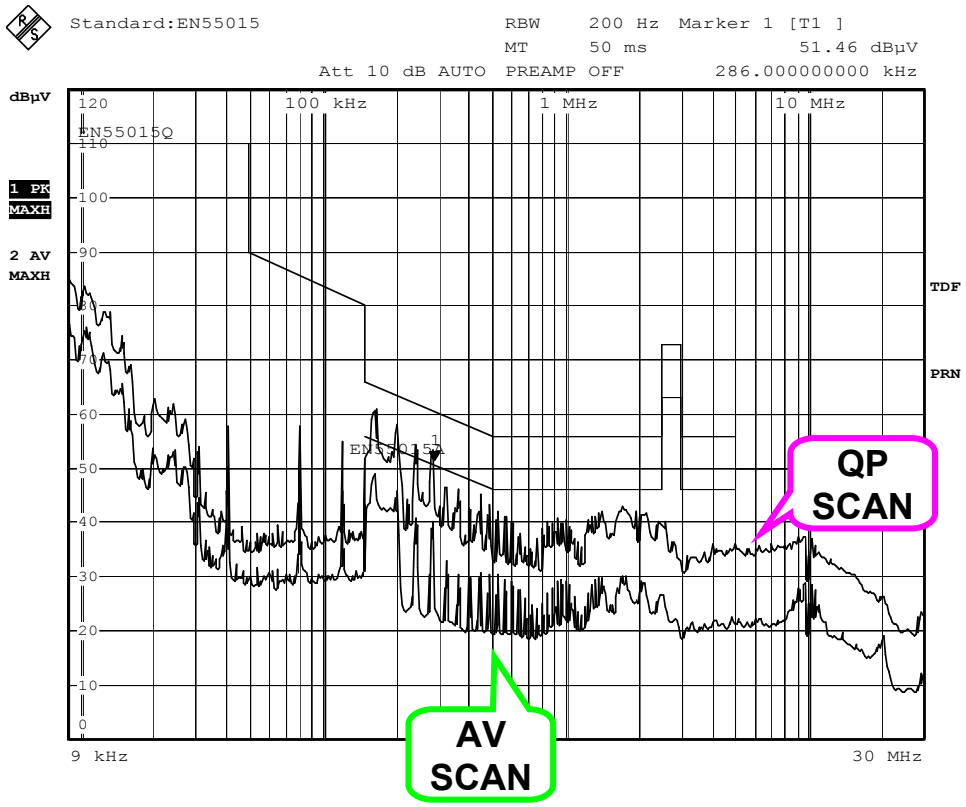
230V$_{AC}$/50Hz,Live



Comment B: Manuf:iwatt EUT:LED light M/N: Memo:ON Power:L 230V/50Hz

Date: 24.JAN.2007 14:41:26

230V$_{AC}$/50Hz,Neutral



Comment B: Manuf:iwatt EUT:LED light M/N: Memo:ON Power:N 230V/50Hz

Date: 24.JAN.2007 14:44:02

Test Conditions : Resistive Full load. Output Ungrounded.