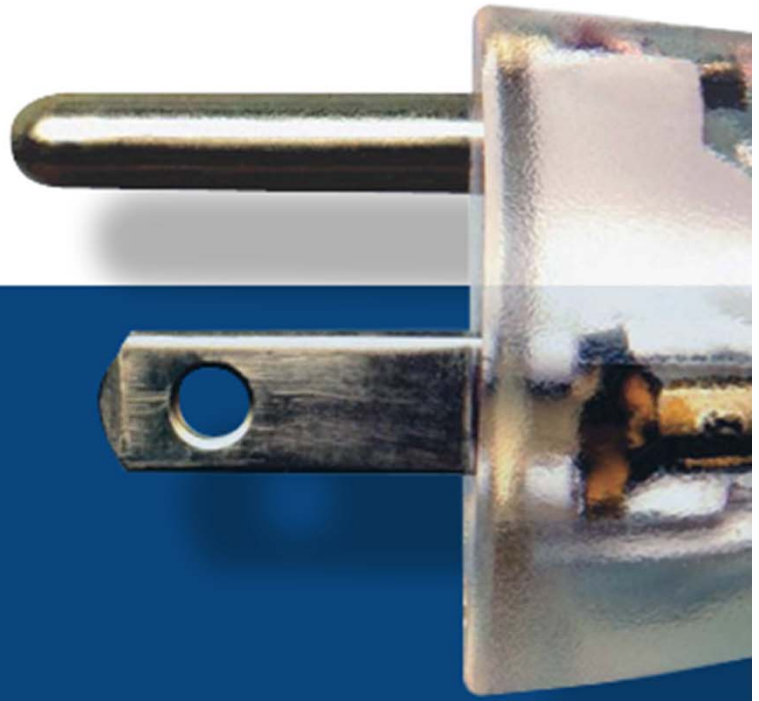
Design of 5V@1A Charger with LNK606DG (Rev-1)



Features

- No Y-cap design
- Build-in Internal HV Start-up circuit allow easy meeting 30mW no-load
- High EPA average efficiency (>74%).
- Low components count allow possible single sized PCB design

20 Mar, 2012

TH (PI-Shenzhen)

1. Power Supply Specification

Description	Symbol	Min	Typ	Max	Units	Comment/Conditions
INPUT						
Voltage	V_{IN}	90		265	V_{AC}	2 Wire no P.E
Frequency	f_{LINE}	47	50/60	63	Hz	
No-load Input Power	P_{IN}			30	mW	Input 230 V_{AC}
OUTPUT						
Output Voltage	V_{OUT}	4.75	5.0	5.25	V	Measured at the End of USB
Output Current	I_{OUT}	1			A	
Output Ripple Voltage	V_{RIPPLE}			80	mV_{P-P}	Measured at the End of USB cord 1.0m, 20 MHz Bandwidth
Total Output Power						
Continuous Output Power	P_{OUT}		5		W	
Peak Output Power	P_{OUT_PK}				W	
Conducted EMI Margin		6			dB	CISPR22B/EN55022 class B
Average Efficiency	η	68.17			%	115 and 230V_{AC}
Ambient Temprature	T_{AMB}	0		40	℃	Free convection, sea level
Surge Test			1		kV	Differential Mode:2Ω
ESD(Air Discharge)				8	kV	On each output terminals; +/-
Safety		Designed to meet IEC950, UL1950 Class II				

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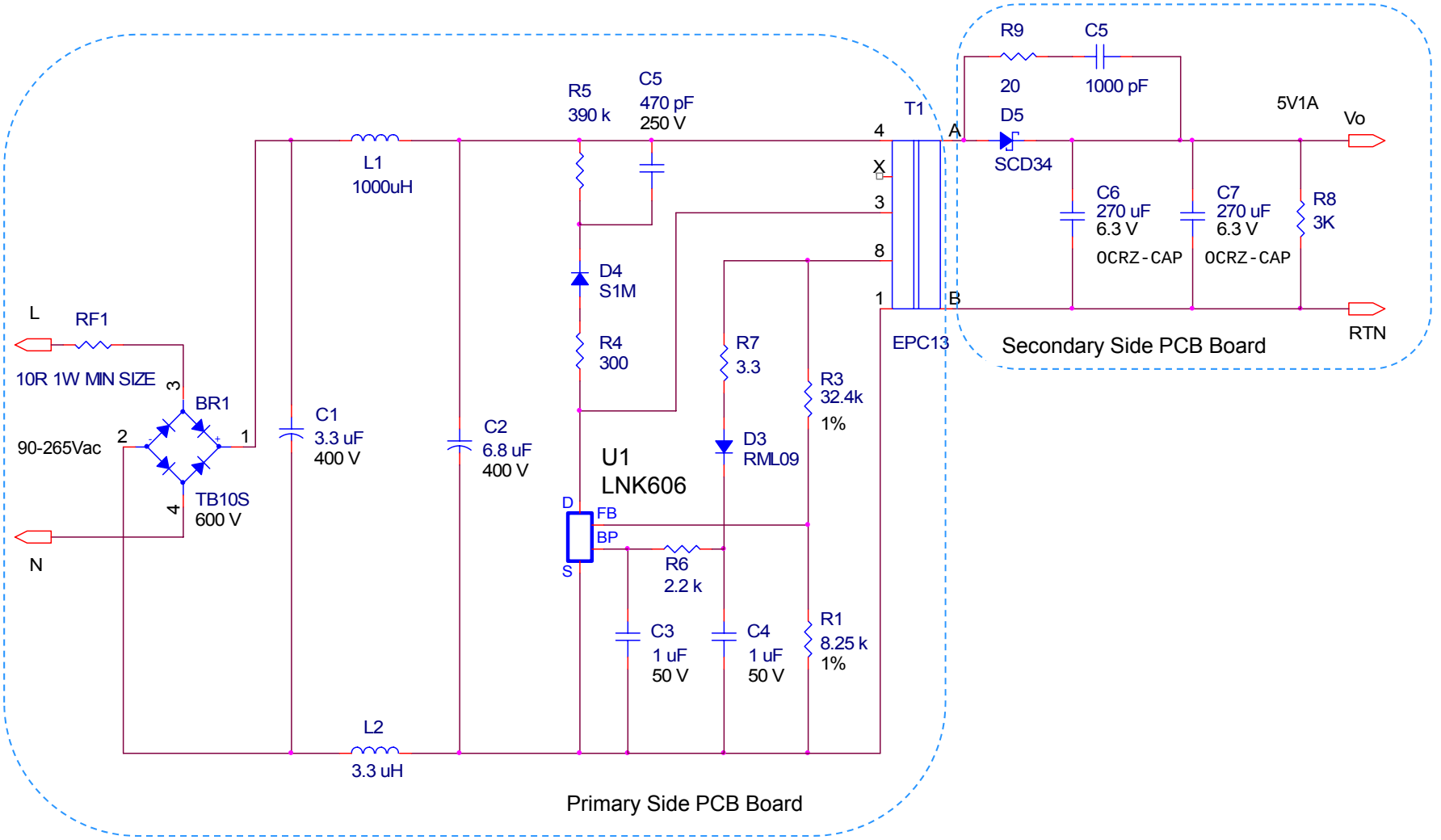
2. Schematic



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3. BOM

Item	Qty	Part Reference	Value	Description
1	1	BR1	MBCR10J	1000 V, 1 A, Bridge Rectifier, SMD, DFS
2	1	C1	3.3 uF	3.3 uF, 400 V, Electrolytic, (6 x 12.5)
3	1	C2	6.8 uF	6.8 uF, 400 V, Electrolytic, (8 x 13),
4	2	C3 C4	1 uF	1 uF, 25 V, Ceramic, X7R, 0805
5	1	C5	470 pF	470 pF, 250 V, Ceramic, X7R, 0805
6	2	C6 C7	270 uF	270 uF, 6.3 V, solid capacitor
7	1	D3	RML09	1000 V, 1 A, Fast Switching,
8	1	D4	S1M	1000 V, 1 A, Rectifier, Glass Passivated, DO-213AA (MELF)
9	1	D5	SCD34	40 V, 3 A, Schottky, SMD, DO-214AC low VF
10	1	L1	1000uH	1000 uH, 0.085 A, Color Inductor
11	1	L2	3.3uH	3.3 uH, 0.285 A, Color Inductor
12	1	R1	8.25k	8.25k, 1%, 1/8 W, Thick Film, 0805
13	1	R3	32.4 k	32.4 k, 1%, 1/16 W, Thick Film, 0603
14	1	R4	300	300 R, 5%, 1/16 W, Thick Film, 0603
15	1	R5	390 k	390 k, 5%, 1/4 W, Thick Film, 1206
16	1	R6	2.2 k	2.2 k, 5%, 1/8 W, Thick Film, 0805
17	1	R7	3.3	3.3 R, 5%, 1/8 W, Thick Film, 0805
18	1	R8	3 k	3 k, 5%, 1/8 W, Thick Film, 0805
19	1	R9	20	20 R, 5%, 1/8 W, Thick Film, 0805
20	1	RF1	10R 1W MIN SIZE	10 R, 1 W, Fusible/Flame Proof Wire Wound
21	1	T1	EPC13	EPC13 Horizontal 10 pins
22	1	U1	LNK606DG	LinkSwitch-II, LNK606D (0% Cable Drop Option), SMD-8B
23	1	PCB	PCB	TRFHYL-A018
Total	26			

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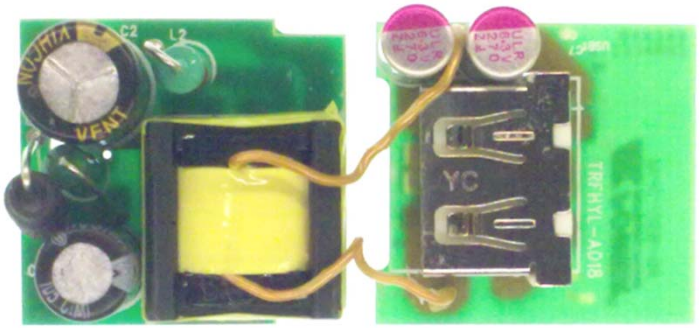
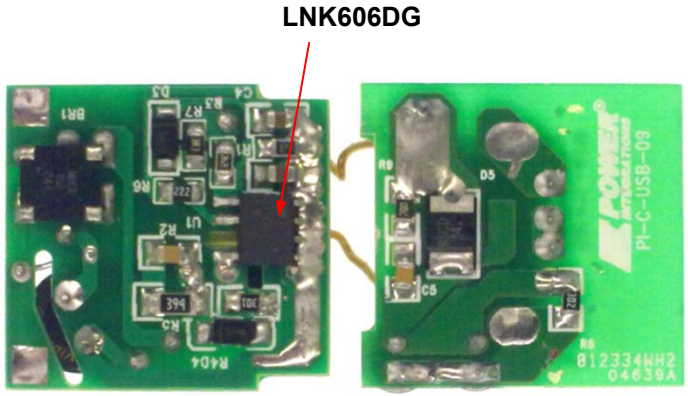
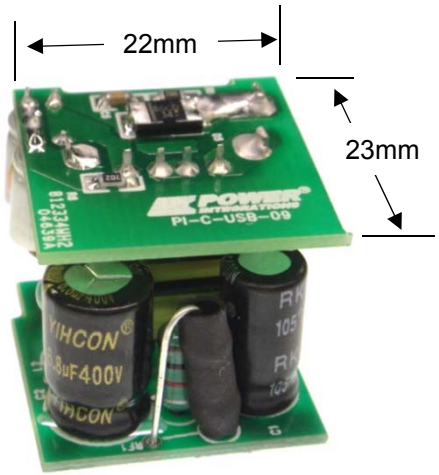
4. Circuit board

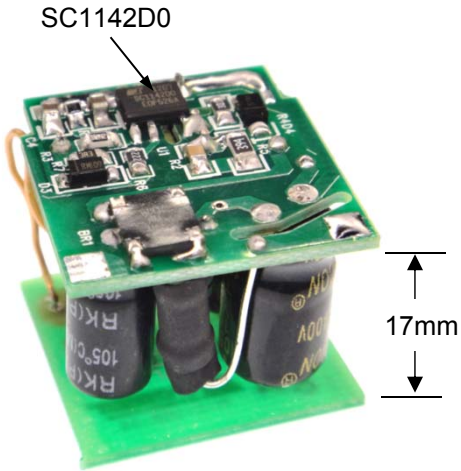


Component-Side view



Solder-Side view





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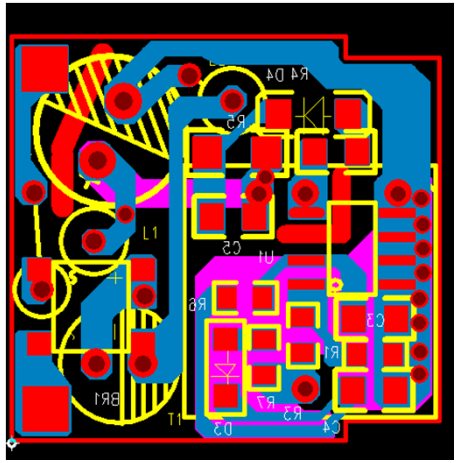
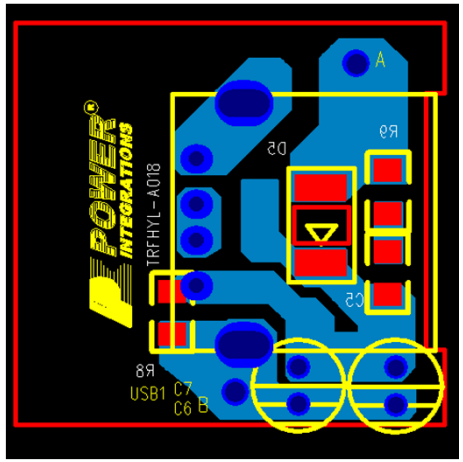
5. PCB Layout

Primary side



Secondary side



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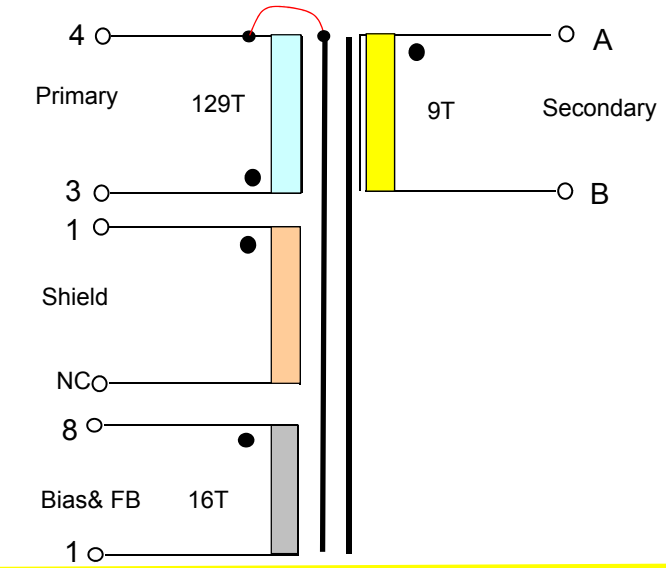
6. Transformer Information

SCHEMATIC



ELECTRICAL SPECIFICATIONS:

1. Primary Inductance (Lp) = 1.0mH± 7% @80KHz
2. Primary Leakage Inductance 50uH
3. Electrical Strength = 3KV, 50/60Hz,1Min

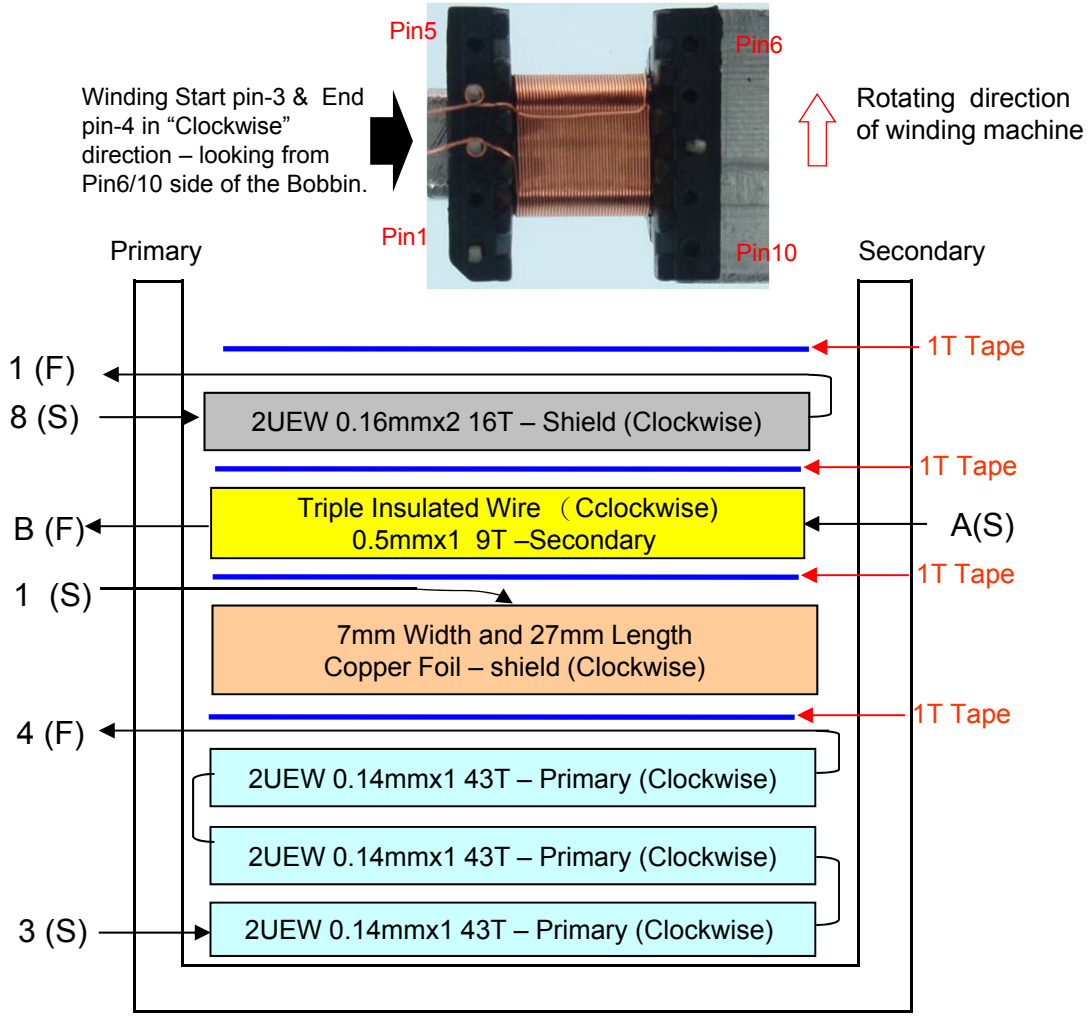
MATERIALS:

1. Core : EPC13 (Ferrite Material TDK PC40 or equivalent)
2. Bobbin : EPC13 **Horizontal** (5pin+5pin).
3. Magnet Wires (Pri) : Type 2-UEW
4. Magnet Wire (Sec) : Triple Insulated Wires

FINISHED :

1. Varnish the complete assembly
2. Made electrical connection between Ferrite core to PIN-4

Instruction for start of first winding…



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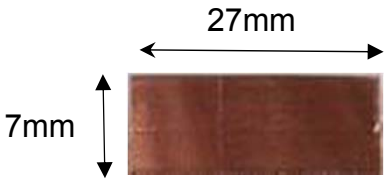
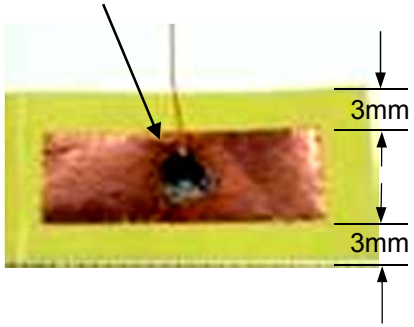
7. Transformer Copper Foil Assembly

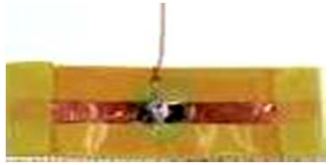
用2UEW-AWG30 wire 焊在铜箔的正中央，要焊的平整，无尖刺. 铜箔放在Mylar-Tape 的正中央，保证铜箔离每边Mylar-Tape边有3mm



准备厚度为0.05mm 的铜箔



Mylar-Tape (31 x 13) mm



把黄色 Mylar 折回外包铜箔，防止短路,如上图。

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8a. Transformer Spreadsheet

1	ACDC_LinkSwitch-II_011911; Rev.1.12; Copyright Power Integrations 2009	INPUT	INFO	OUTPUT	UNIT	ACDC_LinkSwitch-II_011911_Rev1-12; LinkSwitch-II Discontinuous Flyback Transformer Design Spreadsheet
2	**ENTER APPLICATION VARIABLES**					**Design Title**
3	VACMIN	90			V	Minimum AC Input Voltage
4	VACMAX	265			V	Maximum AC Input Voltage
5	fL	50			Hz	AC Mains Frequency
6	VO	5.00			V	Output Voltage (at continuous power)
7	IO	1.10			A	Power Supply Output Current (corresponding to peak power)
8	Power			5.50	W	Continuous Output Power
9	n	0.73		0.73		Efficiency Estimate at output terminals. Under 0.7 if no better data available
10	Z			0.50		Z Factor. Ratio of secondary side losses to the total losses in the power supply. Use 0.5 if no better data available
11	tC			3.00	ms	Bridge Rectifier Conduction Time Estimate
12	Add Bias Winding	YES		YES		Choose Yes to add a Bias winding to power the LinkSwitch-II.
13	CIN	9.40			uF	Input Capacitance
14						
15	**ENTER LinkSwitch-II VARIABLES**					
16	Chosen Device	LNK606		LNK606		Chosen LinkSwitch-II device
17	Package	PG		PG		Select package (PG, GG or DG)
18	ILIMITMIN			0.39	A	Minimum Current Limit
19	ILIMITTYP			0.41	A	Typical Current Limit
20	ILIMITMAX			0.45	A	Maximum Current Limit
21	FS	80.00		80.00	kHz	Typical Device Switching Frequency at maximum power
22	VOR			78.83	V	Reflected Output Voltage (VOR < 135 V Recommended)
23	VDS			10.00	V	LinkSwitch-II on-state Drain to Source Voltage
24	VD			0.50	V	Output Winding Diode Forward Voltage Drop
25	KP			1.78		Ensure KDP > 1.3 for discontinuous mode operation
26						
27	**FEEDBACK WINDING PARAMETERS**					
28	NFB			8.00		Feedback winding turns
29	VFLY			4.89	V	Flyback Voltage - Voltage on Feedback Winding during switch off time
30	VFOR			4.38	V	Forward voltage - Voltage on Feedback Winding during switch on time
31						
32	**BIAS WINDING PARAMETERS**					
33	VB			10.00	V	Bias Winding Voltage. Ensure that VB > VFLY. Bias winding is assumed to be AC-STACKED on top of Feedback winding
34	NB			10.00		Bias Winding number of turns
35	REXT			8.30	k-ohm	Suggested value of BYPASS pin resistor (use standard 5% resistor)
36	**DESIGN PARAMETERS**					
37	DCON			4.50	us	Output diode conduction time
38	TON			4.82	us	LinkSwitch-II On-time (calculated at minimum inductance)
39	RUPPER			18.13	k-ohm	Upper resistor in Feedback resistor divider
40	RLOWER			10.56	k-ohm	Lower resistor in resistor divider

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8b. Transformer Spreadsheet

1	ACDC_LinkSwitch-II_011911; Rev.1.12; Copyright Power Integrations 2009	INPUT	INFO	OUTPUT	UNIT	ACDC_LinkSwitch-II_011911_Rev1-12; LinkSwitch-II Discontinuous Flyback Transformer Design Spreadsheet
41						
42	**ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES**					
43	**Core Type**					
44	Core	EPC13		EPC13		Enter Transformer Core. Based on the output power the recommended core sizes are EE19 or EE22
45	Bobbin			EPC13_BOBBIN		Generic EPC13_BOBBIN
46	AE			12.50	mm^2	Core Effective Cross Sectional Area
47	LE			30.60	mm	Core Effective Path Length
48	AL			870.00	nH/turn^2	Ungapped Core Effective Inductance
49	BW			6.88	mm	Bobbin Physical Winding Width
50	M			0.00	mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
51	L	4.00		4.00		Number of Primary Layers
52	NS			9.00		Number of Secondary Turns. To adjust Secondary number of turns change DCON
53						
54	**DC INPUT VOLTAGE PARAMETERS**					
55	VMIN			70.56	V	Minimum DC bus voltage
56	VMAX			374.77	V	Maximum DC bus voltage
57						
58	**CURRENT WAVEFORM SHAPE PARAMETERS**					
59	DMAX			0.39		Maximum duty cycle measured at VMIN
60	IAVG			0.12	A	Input Average current
61	IP			0.39	A	Peak primary current
62	IR			0.39	A	Primary ripple current
63	IRMS			0.16	A	Primary RMS current
64						
65	**TRANSFORMER PRIMARY DESIGN PARAMETERS**					
66	LPMIN			872.31	uH	Minimum Primary Inductance
67	LPTYP			969.23	uH	Typical Primary inductance
68	LP_TOLERANCE			10.00	%	Tolerance in primary inductance
69	NP			129.00		Primary number of turns. To adjust Primary number of turns change BM_TARGET
70	ALG			58.24	nH/turn^2	Gapped Core Effective Inductance
71	BM_TARGET	2470.00		2470.00	Gauss	Target Flux Density
72	BM			2464.41	Gauss	Maximum Operating Flux Density (calculated at nominal inductance), BM < 2500 is recommended
73	BP			2981.93	Gauss	Peak Operating Flux Density (calculated at maximum inducatnce and max current limit), BP < 3000 is recommended
74	BAC			1232.20	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
75	ur			169.48		Relative Permeability of Ungapped Core
76	LG			0.28	mm	Gap Length (LG > 0.1 mm)
77	BWE			27.52	mm	Effective Bobbin Width
78	OD			0.21	mm	Maximum Primary Wire Diameter including insulation
79	INS			0.04		Estimated Total Insulation Thickness (= 2 * film thickness)
80	DIA			0.17	mm	Bare conductor diameter
81	AWG			34.00		Primary Wire Gauge (Rounded to next smaller standard AWG value)
82	CM			40.32	Cmils	Bare conductor effective area in circular mils

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8c. Transformer Spreadsheet

83	CMA			249.47	Cmils/A	Primary Winding Current Capacity (200 < CMA < 500)
84						
85	**TRANSFORMER SECONDARY DESIGN PARAMETERS**					
86	**Lumped parameters**					
87	ISP			5.58	A	Peak Secondary Current
88	ISRMS			2.19	A	Secondary RMS Current
89	IRIPPLE			1.90	A	Output Capacitor RMS Ripple Current
90	CMS			438.30	Cmils	Secondary Bare Conductor minimum circular mils
91	AWGS			23.00		Secondary Wire Gauge (Rounded up to next larger standard AWG value)
92						
93	**VOLTAGE STRESS PARAMETERS**					
94	VDRAIN			560.32	V	Maximum Drain Voltage Estimate (Assumes 20% clamping voltage tolerance and an additional 10% temperature tolerance)
95	PIVS			31.15	V	Output Rectifier Maximum Peak Inverse Voltage
96						
97	**FINE TUNING**					
98	RUPPER_ACTUAL			18.13	k-ohm	Actual Value of upper resistor (RUPPER) used on PCB
99	RLOWER_ACTUAL			10.56	k-ohm	Actual Value of lower resistor (RLOWER) used on PCB
100	Actual (Measued) Output Voltage (VDC)			5.00	V	Measured Output voltage from first prototype
101	Actual (Measured) Output Current (ADC)			1.10	Amps	Measured Output current from first prototype
102	RUPPER_FINE			18.13	k-ohm	New value of Upper resistor (RUPPER) in Feedback resistor divider. Nearest standard value is 18.2 k-ohms
103	RLOWER_FINE			10.56	k-ohm	New value of Lower resistor (RLOWER) in Feedback resistor divider. Nearest standard value is 10.5 k-ohms

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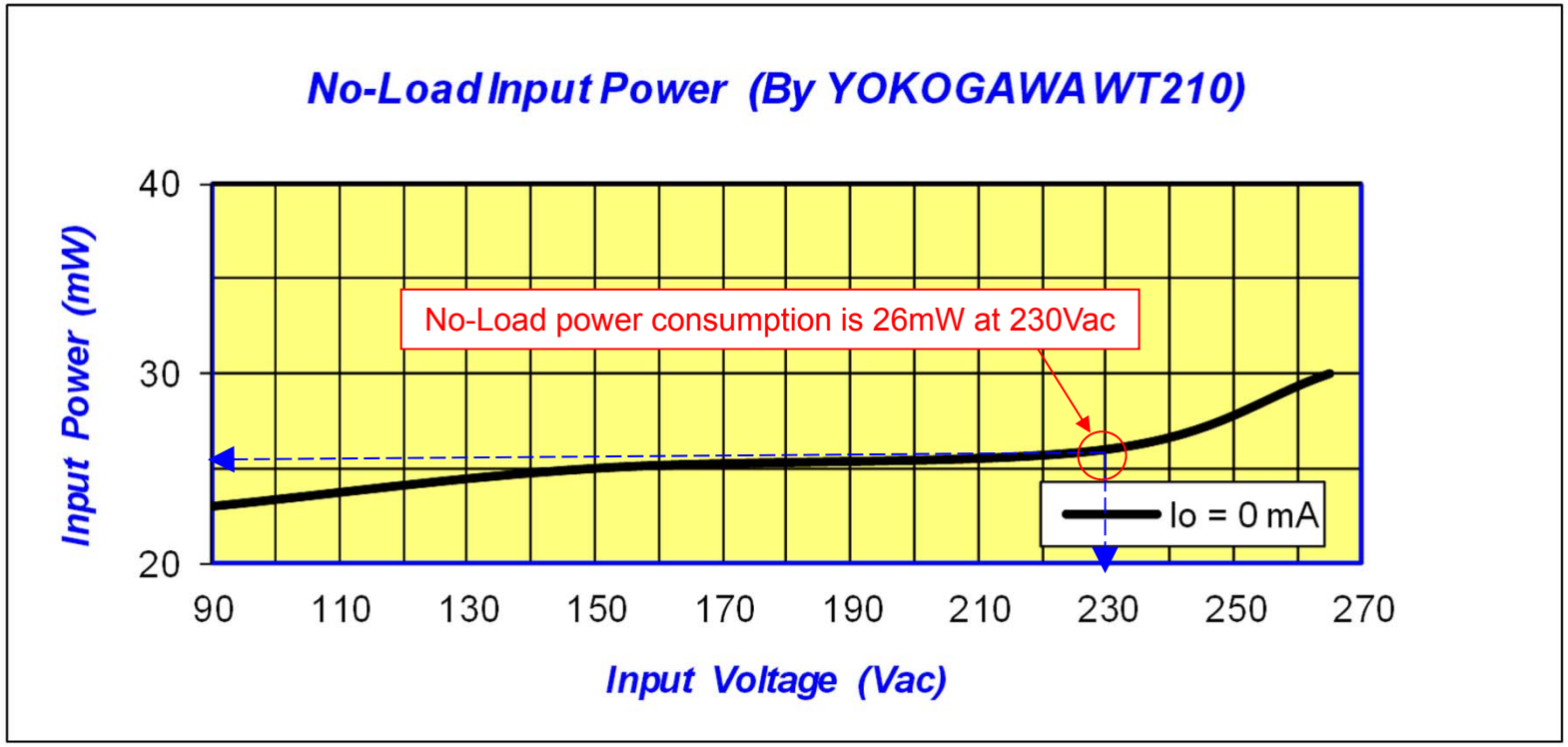
9. No Load Power Consumption



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10. Regulation, Ripple & Efficiency Measurement

*** Note: Output voltage is measured at end of PCB**

V_{IN} (V_{AC})	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (mA)	V_{RIPPLE} (mV_{P-P})	P_{OUT} (W)	η (%)	Average η(%)	EPA 2.0 η (%)
90	0.023	5.13	0	8			74.78	68.17
	1.654	5.04	250	54	1.26	76.18		
	3.326	4.99	500	64	2.50	75.02		
	5.026	4.98	750	58	3.74	74.31		
	6.753	4.97	1000	68	4.97	73.60		
115	0.024	5.13	0	8			75.98	
	1.656	5.04	250	36	1.26	76.09		
	3.267	4.98	500	64	2.49	76.22		
	4.918	4.98	750	60	3.74	75.95		
	6.569	4.97	1000	68	4.97	75.66		
230	0.026	5.09	0	10			76.05	
	1.720	5.04	250	42	1.26	73.26		
	3.244	4.98	500	64	2.49	76.76		
	4.848	4.98	750	60	3.74	77.04		
	6.444	4.97	1000	64	4.97	77.13		
264	0.029	5.18	0	10			75.34	
	1.757	5.04	250	42	1.26	71.71		
	3.260	4.98	500	66	2.49	76.38		
	4.876	4.98	750	60	3.74	76.60		
	6.481	4.97	1000	64	4.97	76.69		

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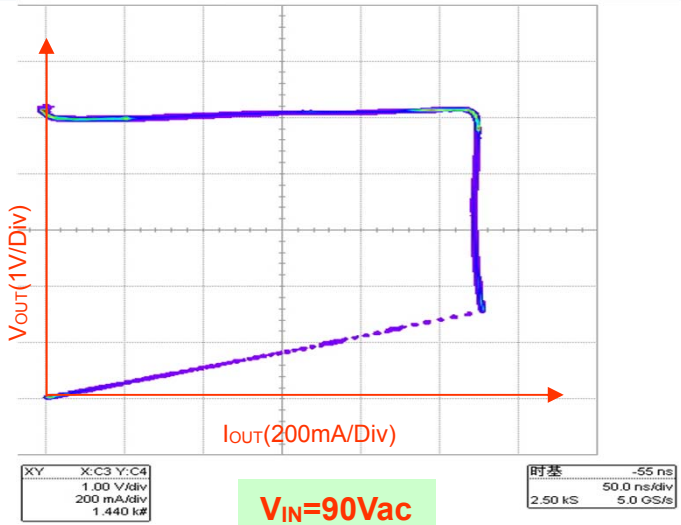
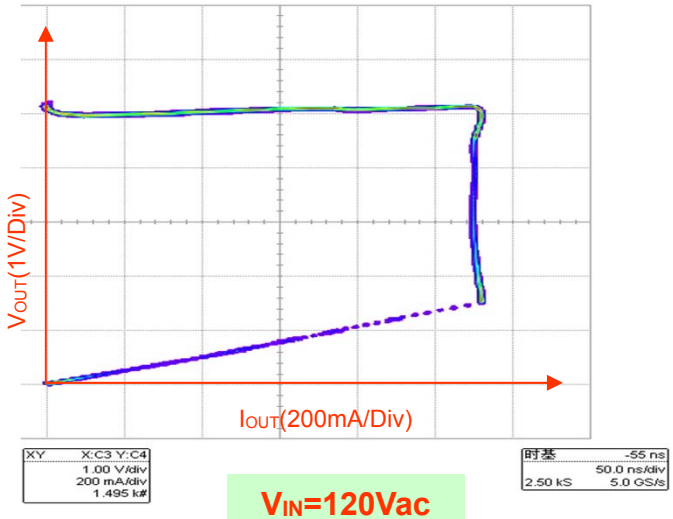
11. Output VI Characteristic

(Measured on USB end)



VIN=90Vac



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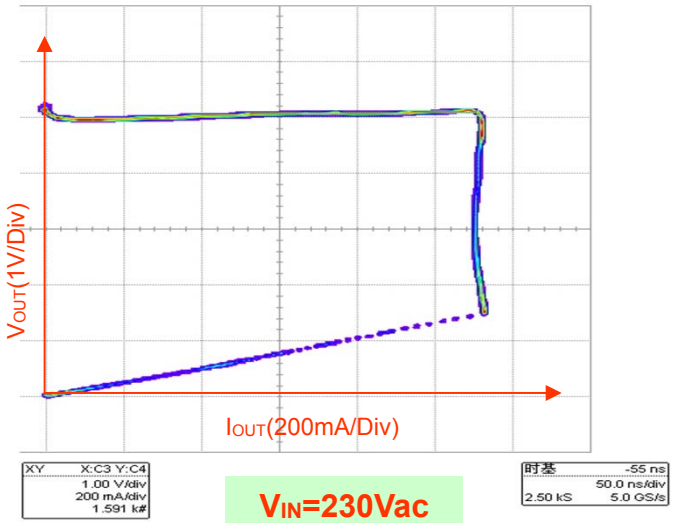

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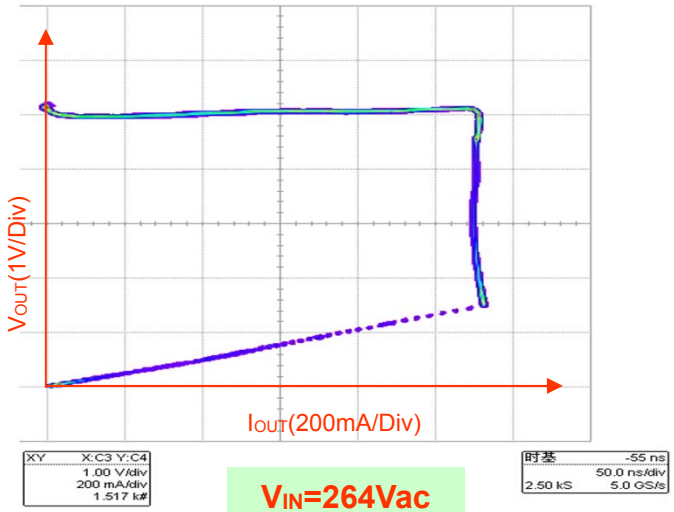

VIN=264Vac

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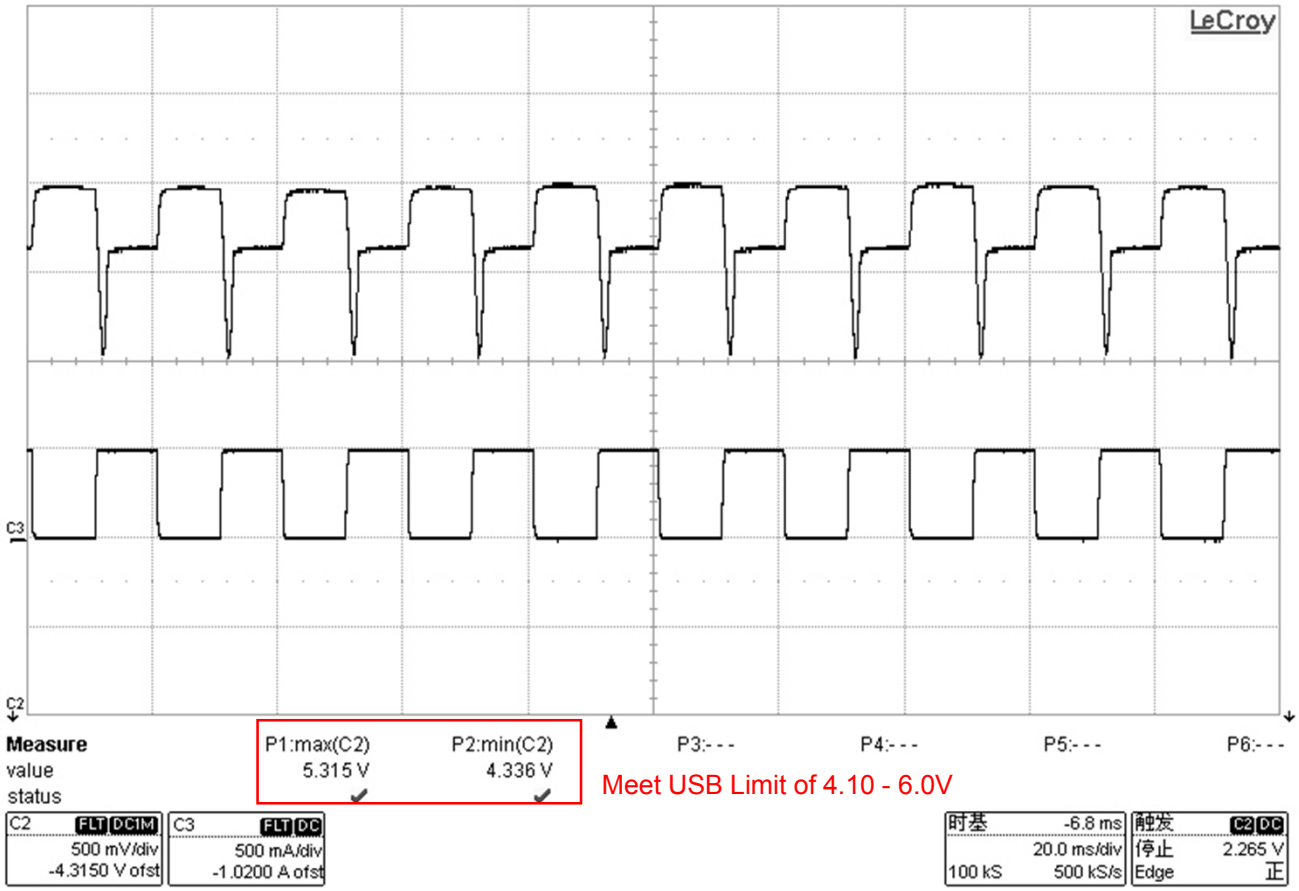
12a. Load Dynamic Response

(Measured on USB end)



Meet USB Limit of 4.10 - 6.0V

Test Conditions:

1. **Slew-Rate:0.25A/us;**
2. **VOUT is measured at USB End;**
3. **AC input = 90VAC**
4. **Freq:50 Hz**
5. **Load range, 0A-0.5A-0A**

CH2: Output Voltage, 0.5V/Div (offset -4.35V)
CH3: Output Current, 0.5A/Div

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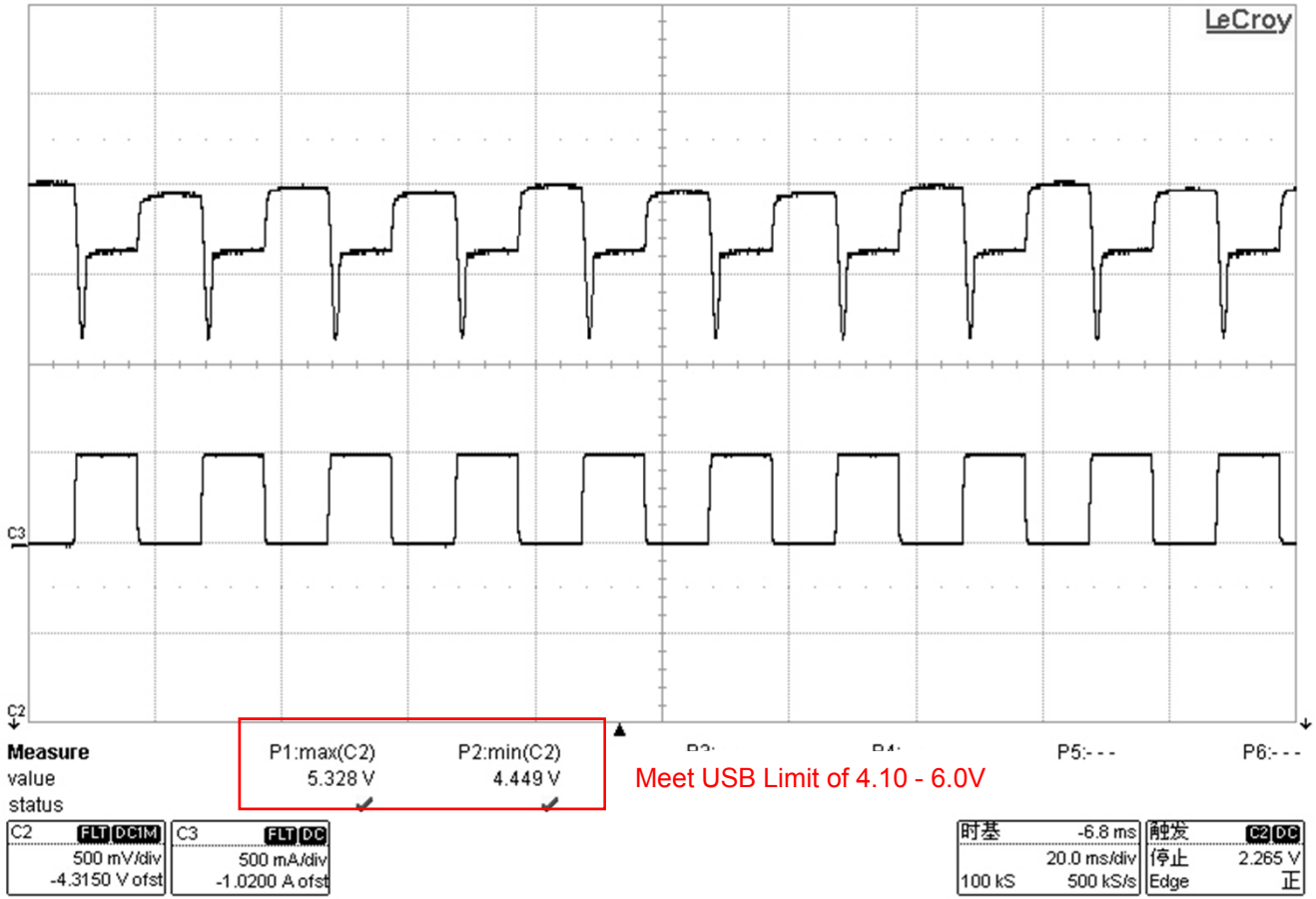
12b. Load Dynamic Response

(Measured on USB end)



Meet USB Limit of 4.10 - 6.0V

Test Conditions:

1. **Slew-Rate:0.25A/us;**
2. **VOUT is measured at USB End;**
3. **AC input = 264VAC**
4. **Freq:50 Hz**
5. **Load range, 0A-0.5A-0A**

CH2: Output Voltage, 0.5V/Div (offset -4.35V)
CH3: Output Current, 0.5A/Div

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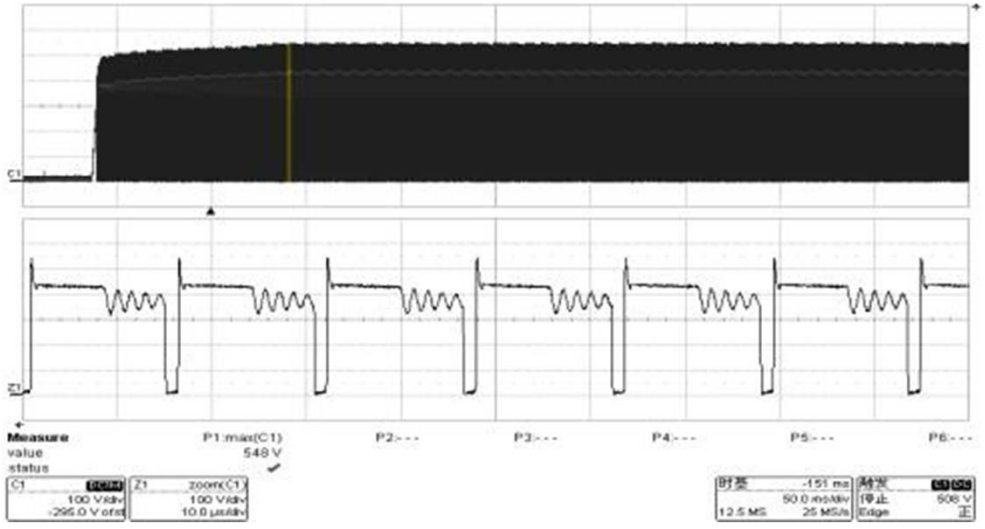
13. Maximum Drain voltage during start up



Test Condition:

V_{IN}=265V_{AC}, Iout=1A

Power ON

RESULT: V_{drain_max} = 548V

Absolute Maximum Rating from Datasheet(LNK606D0)

SC1142

Absolute Maximum Ratings(1,5)

DRAIN Voltage	-0.3 V to 700 V
DRAIN Peak Current:	654 mA
Peak Negative Pulsed Drain Current	-100 mA(2)
FEEDBACK Voltage	-0.3 V to 9 V
FEEDBACK Current	100 mA
BYPASS Pin Voltage	-0.3 V to 9 V
Storage Temperature	-65 °C to 150 °C
Operating Junction Temperature	-40 °C to 150 °C
Lead Temperature(4)	260 °C

Notes:
1. All voltages referenced to SOURCE, T_A = 25 °C.
2. Duration not to exceed 2 ms.
3. 1/16 in. from case for 5 seconds.
4. Maximum ratings specified may be applied, one at a time without causing permanent damage to the product. Exposure to Absolute Maximum ratings for extended periods of time may affect product reliability.

Thermal Impedance

Thermal Impedance: D Package:	
(θ_{JA})	100 °C/W(2); 60 °C/W(3)
(θ_{JC})(1)	30 °C/W

Notes:
1. Measured on pin 8 (SOURCE) close to plastic interface.
2. Soldered to 0.36 sq. in. (232 mm²), 2 oz. (610 g/m²) copper clad.
3. Soldered to 1 sq. in. (645 mm²), 2 oz. (610 g/m²) copper clad.

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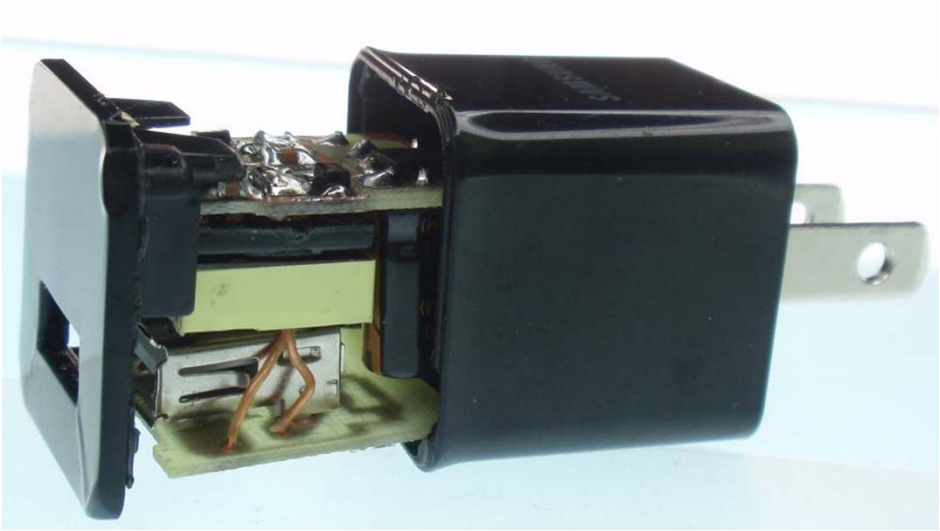
14. Temperature rise on PCB components

	Input:90Vac Amb:40℃	Input:264Vac Amb:40℃
Device	Temperature(℃)	Temperature(℃)
U1(LNK606D0)	100	98
T1(winding)	89	85
T1(core)	95	93
D2(SS34)	98	96

Note: Measure under an enclosed simulated plastic housing



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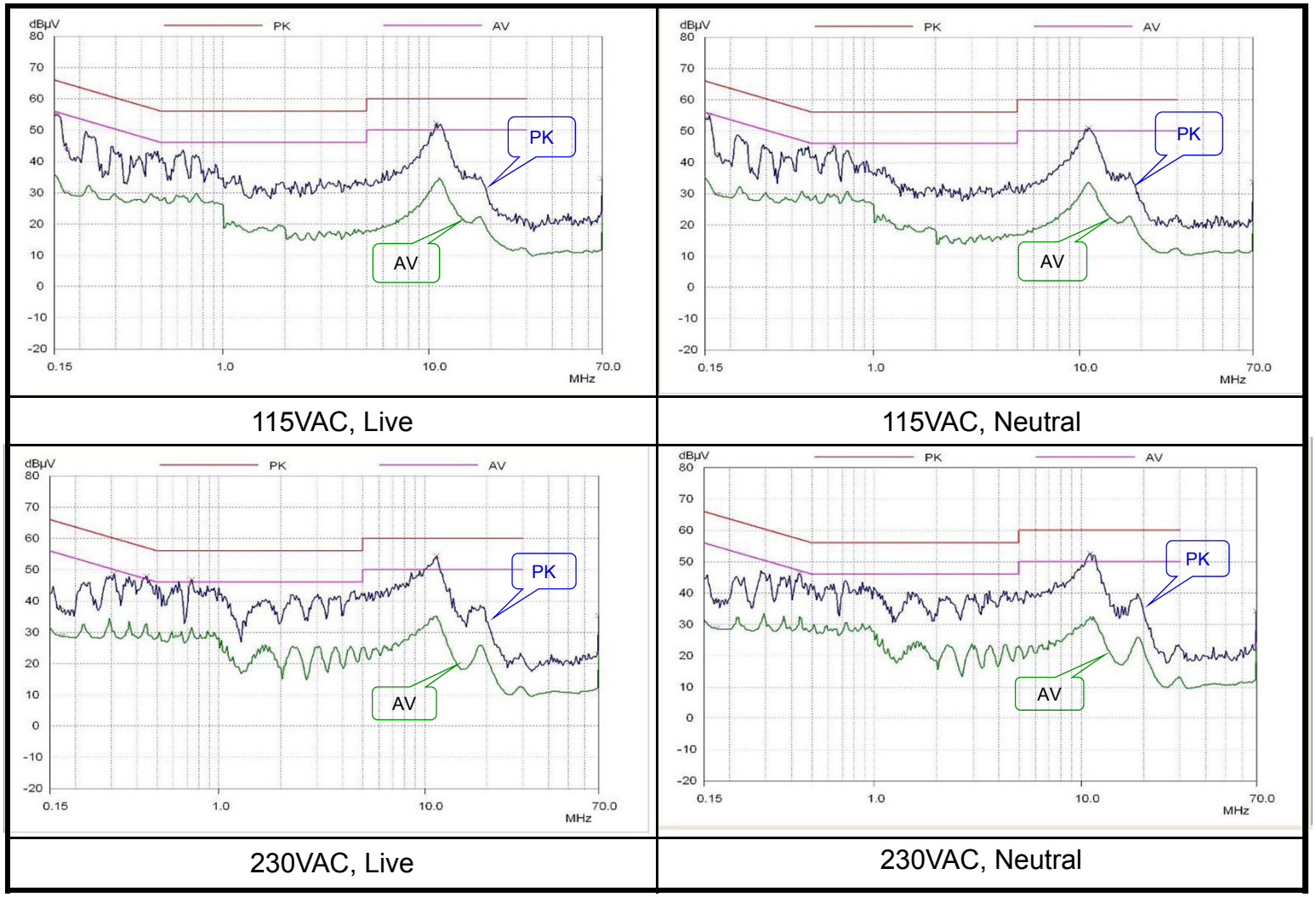
15. Conduction EMI (PK and AV)

(Output Connected to LISN's Artificial hand, Resistive Load)



115VAC, Live	115VAC, Neutral
230VAC, Live	230VAC, Neutral

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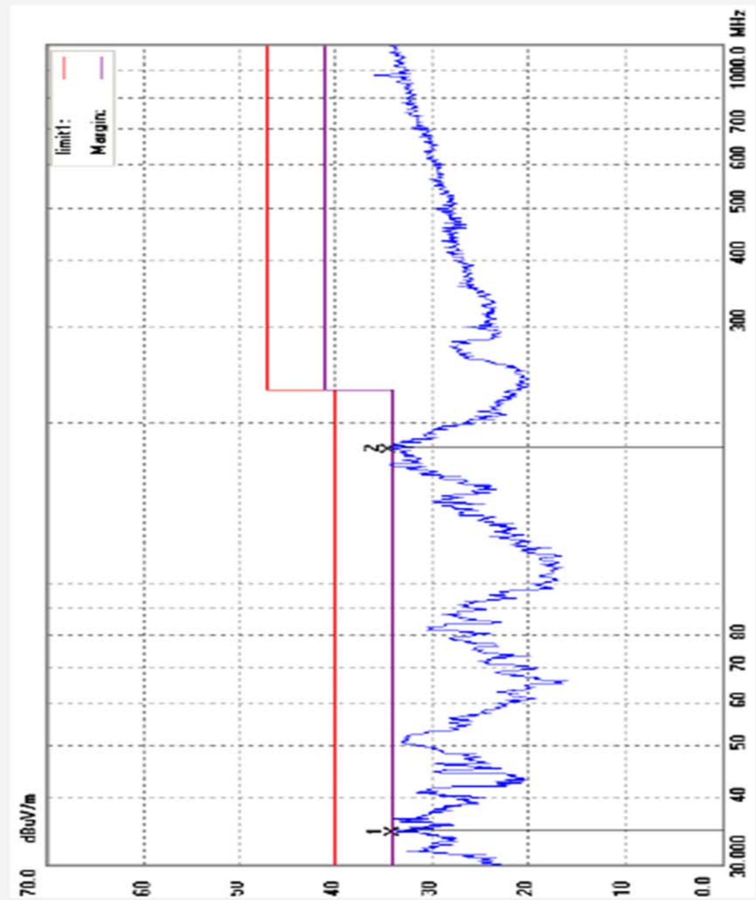
16. Radiated EMI

ACCURATE TECHNOLOGY CO., LTD.
F1,Bldg,A,Changyuan New Material Port Keyuan Rd,
Science & Industry Park,Nanshan Shenzhen,P.R.China

Site: 966 chamber
Tel:+86-0755-26503290
Fax:+86-0755-26503396

Job No.: PI #683	Polarization: Vertical
Standard: EN55022 ClassB Radiated	Power Source: AC 230V/50Hz
Test item: Radiation Test	Date: 2012/04/17
Temp.(C)/Hum.(%) 24 C / 48 %	Time: 15:47:48
EUT:	Engineer Signature:
Mode: ON	Distance: 3m
Model: 5V/1A--6-1	
Manufacturer: PI	

Note:



No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Degree (deg.)	Remark
1	34.7704	17.18	16.74	33.92	40.00	-6.08	peak			
2	179.3989	18.48	15.78	34.26	40.00	-5.74	peak			

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17. Common Mode Noise Verification Test

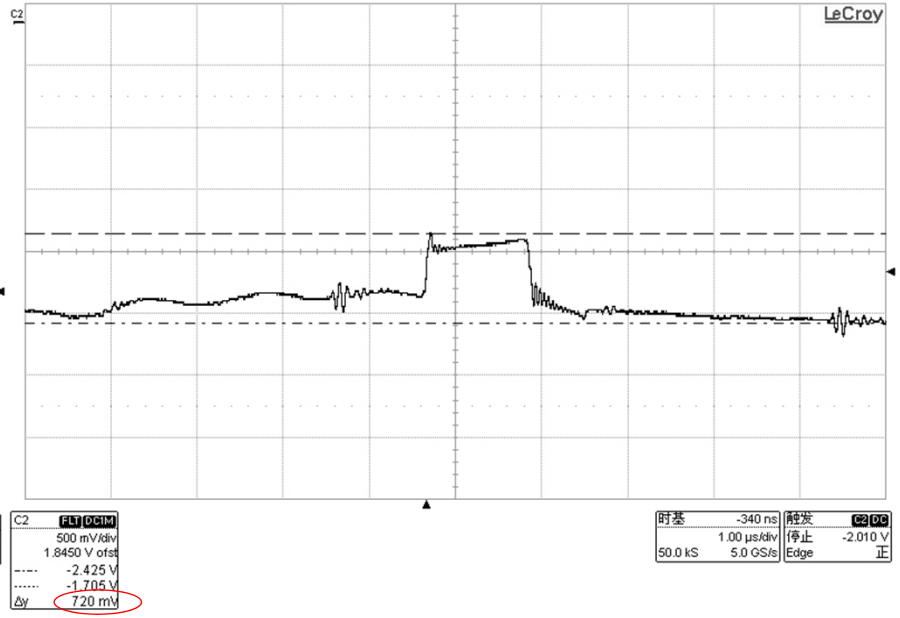
Test condition:

1.AC Input Test voltage : 264Vac/50Hz

2.Output Load : 10Ω resistive

3.Length of Output DC-Cable : 1.0 meter

AC frequency component
V_pp=59.8V



EPS switching frequency component
V_pp=720mV (Limit: 1000mV @<100kHz, EN62684)

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18. Major Features in SC1142

Advanced Performance Features

- Compensates for transformer inductance tolerances
- Compensates for input line voltage variations
- Compensates for cable voltage drop
- Compensates for external component temperature variations
- Very tight IC parameter tolerances using proprietary trimming technology
- Frequency jittering greatly reduces EMI filter cost
- Even tolerances achievable with external resistor selection/ trimming
- Programmable switching frequency up to 90 kHz to reduce transformer size
- Minimum operation frequency of ~1.4 kHz improves transient load response

Selectable Cable Drop Compensation (4 devices types)

Output Power Table

Product[3]	85-265 VAC	
	Adapter[1] 5.5 W	Open Frame[2] 6.1 W
SC1142	P/N Suffix	Cable Drop Compensation (Ratio to No-load Voltage Regulation)
	D0	1.00 (No Cable Drop Comp)
	D1	1.02
	D2	1.04
	D3	1.06

Table 1. Output Power Table.

Precision on-chip OTP projection

Thermal Shutdown Temperature	T_{SD}		135	142	150	°C
Thermal Shutdown Hysteresis	T_{SDH}			60		°C

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