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Reference Design – TND6359/D

240 W Lighting Solution with NCL2801 and NCL30076

ON's Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCL2801 NCL30076 NCP10671	Lighting	90 to 305 Vac	240 W	BOOST PFC, BUCK, Flyback	Non-Isolated

	Output Specification
Output Voltage	130 Vdc-240 Vdc
Nominal Current	0-1 A
Max Current	1 A
Min Current	zero

Avg. Efficiency	>96% @ full load at board end, 230 Vac
Constant Current Tolerance	<2%
Standby Power	<0.5 W
Power Density	2.12 W/cm^3
Protection	OCP,OVP, output LED short circuit protection
Size	Round Size, Radius*High = 60 mm*35 mm

Circuit Description

This design used ON's PFC controller NCL2801CDA and BUCK controller NCL30076, with a high PF and low THD performance. The NCL30076 is DC-DC buck controller for wide analog dimming range down to 1%. ON Semiconductor's proprietary LED current calculation technique driven by zero input offset amplifiers performs precise constant current in the whole analog dimming range. PWM dimming is also provided to keep the constant LED color temperature.

There is also a Auxiliary power supply board using ON's NCP10671,which can be used to supply the Vcc power for NCL30076, NCL2801 and the Dimming circuit.

Key Features

- Wide analog dimming range: 1-100%
- Precise CC regulation: ±2% at 100% load
- QR operation at full load
- Low STBY current
- Protections:
  - Short LED protection
  - Over current protection
  - Thermal shutdown
- High PF and low THD

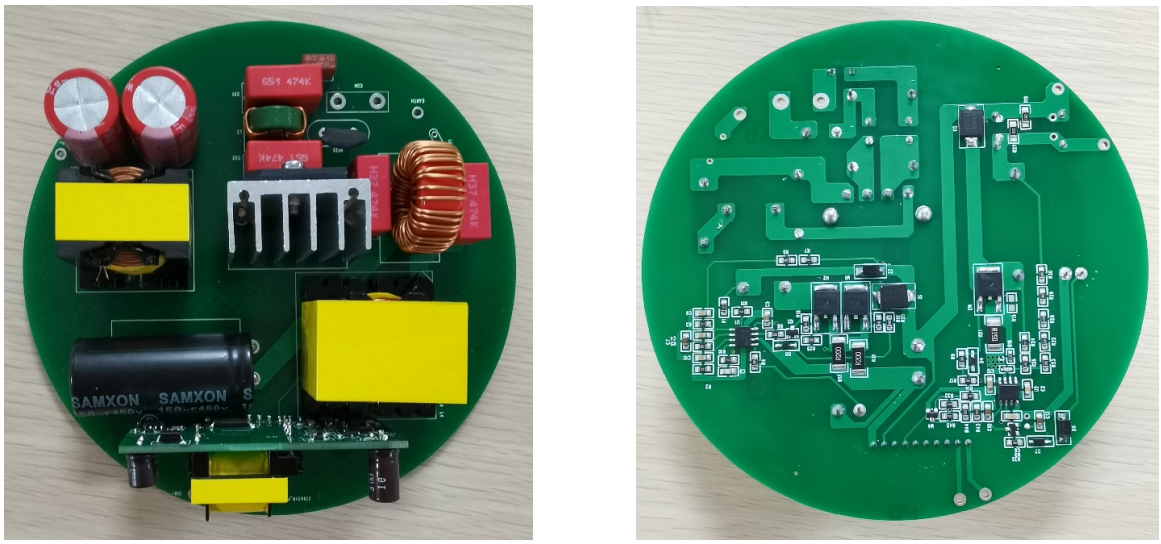


Figure 1. Demo Board Pictures

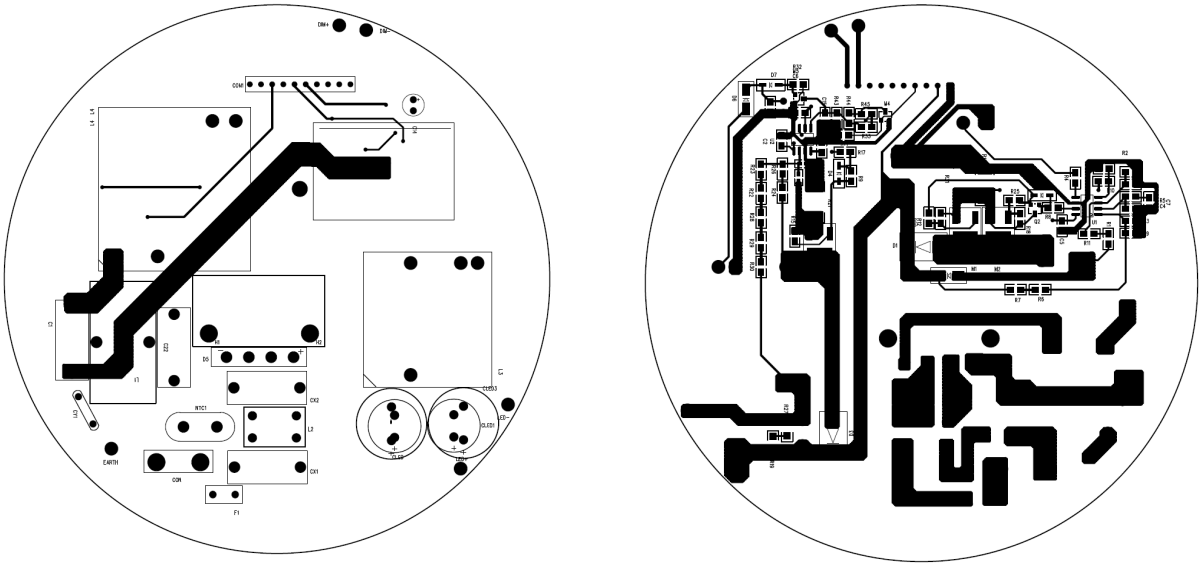


Figure 2. Main Board PCB

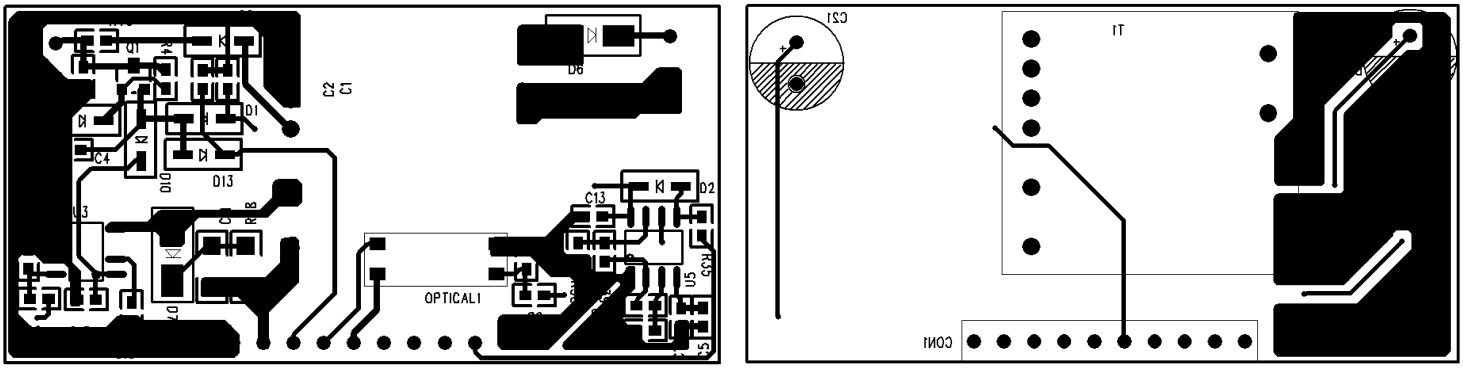
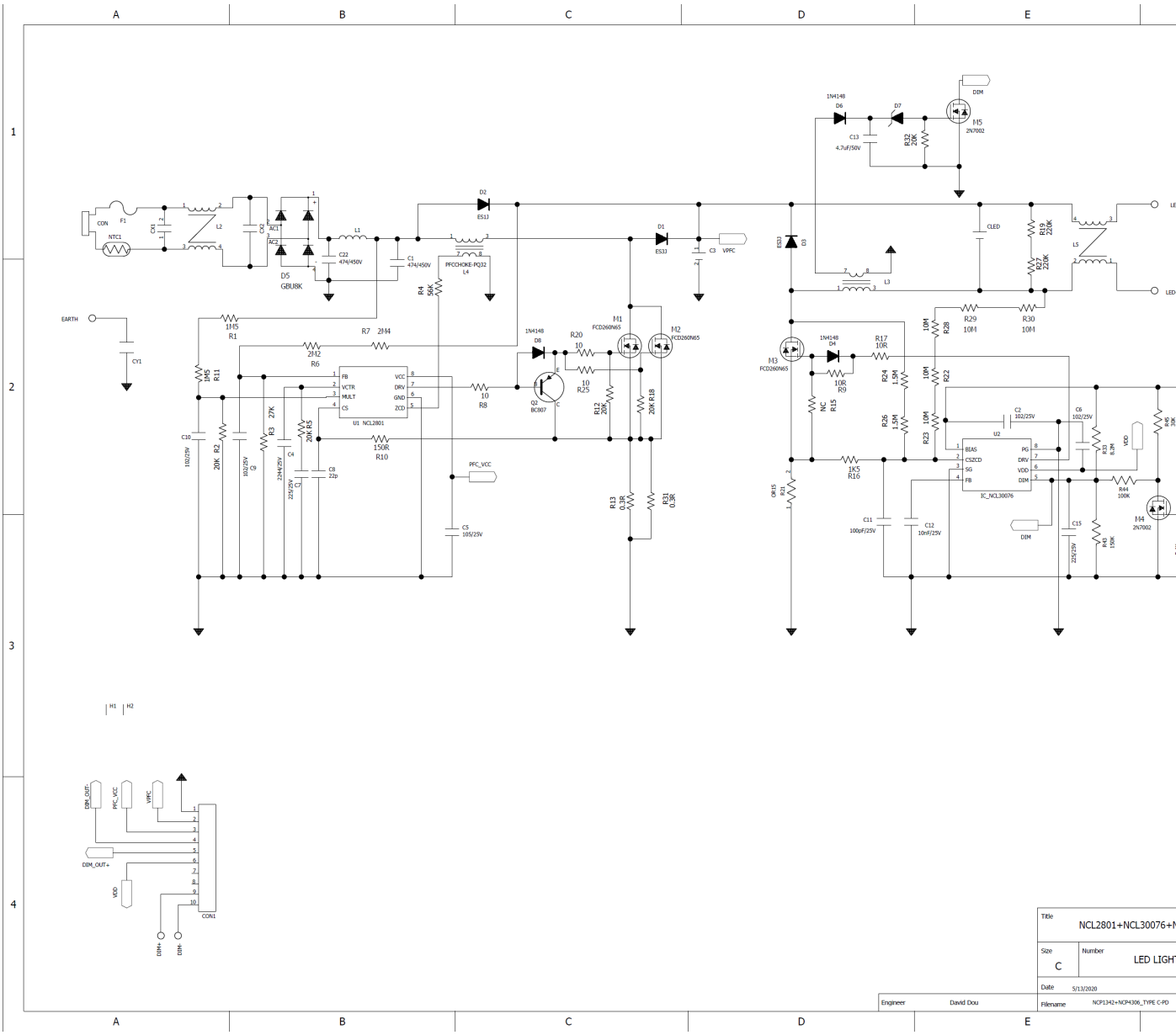
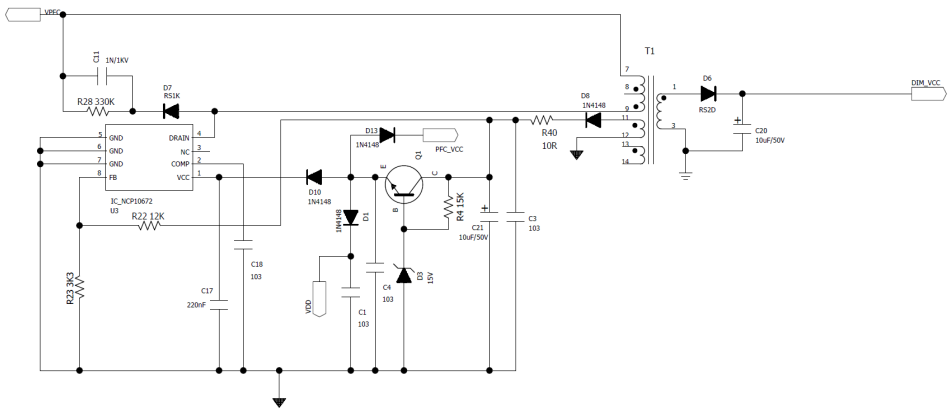
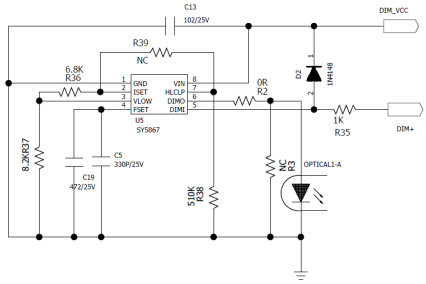


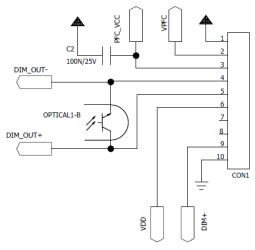
Figure 3. Auxiliary Vcc PCB

Circuit Schematic





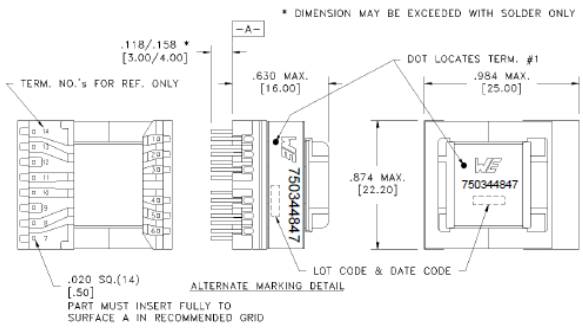


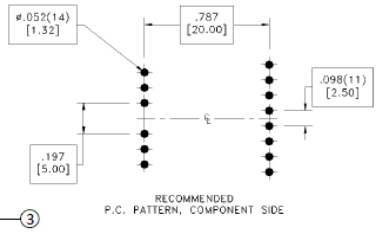


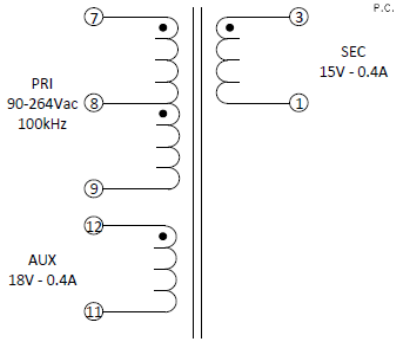
Title	NCL2801+NCL30
Size	C
Number	LED
Date	5/13/2020
Engineer	David Dou
Filename	NCP1342+NCP4306_TY

Auxiliary Vcc Power Transformer Design

CUSTOMER TERMINAL	RoHS	LEAD(Pb)--FREE
Sn 96%, Ag 4%	Yes	Yes







ELECTRICAL SPECIFICATIONS @ 25° C unless otherwi

PARAMETER		TEST CONDITIONS	
D.C. RESISTANCE	7-9	@20℃	3.15
D.C. RESISTANCE	12-11	@20℃	0.21
D.C. RESISTANCE	3-1	@20℃	0.11
INDUCTANCE	7-9	10kHz, 100mV, Ls	83
SATURATION CURRENT	7-9	20% rolloff from initial	
LEAKAGE INDUCTANCE	7-9	tie(1+3+11+12),100kHz, 100mV, Ls	3
DIELECTRIC	7-1	tie(9+11), 1500VAC, 1 second	
TURNS RATIO		(7-9):(12-11)	
TURNS RATIO		(7-9):(3-1)	

GENERAL SPECIFICATIONS:

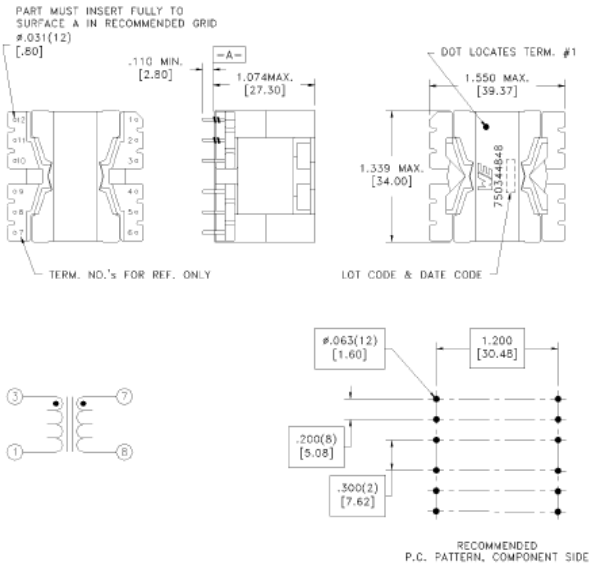
OPERATING TEMPERATURE RANGE: -40°C to +125°C including temp rise.

Wire insulation & RoHS status not affected by wire color. Wire insulation color may vary depending on availability. Marking detail font and color may vary on preproduction sam

DFM		Packaging Specifications	CONVENTION PLACEMENT	Tolerances unless otherwise specified:	DRAWING TITLE
DATE		Method: Tray		Angles: ±1° Decimals: ±.005 [.13]	TRANSFORMER
ENG	TLI	PKG-0736		Fractions: ±1/64 Footprint: ± .001 [.03]	PART NO. 7503
REV.	00			This drawing is dual dimensioned. Dimensions in brackets are in millimeters.	
DATE	2020/10/13	www.wa-online.com/midcom			SPECIFICAT

PFC Choke Design

CUSTOMER TERMINAL	RoHS	LEAD(Pb)--FREE
Sn 96%, Ag 4%	Yes	Yes



ELECTRICAL SPECIFICATIONS @ 25° C unless otherwise not

PARAMETER		TEST CONDITIONS	VALUE
D.C. RESISTANCE	3-1	@20℃	0.08 ohms ma
D.C. RESISTANCE	7-8	@20℃	0.15 ohms ma
INDUCTANCE	3-1	10kHz, 100mV, Ls	280µH ±10%
SATURATION CURRENT	3-1	20% rolloff from initial	7A
DIELECTRIC	1-7	625VAC, 1 second	500VAC, 1 min
TURNS RATIO		(3-1):(7-8)	10:1

GENERAL SPECIFICATIONS:

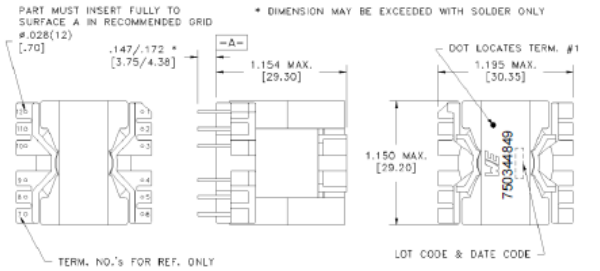
OPERATING TEMPERATURE RANGE: -40°C to +125°C including temp rise.

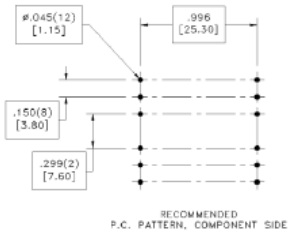
Wire insulation & RoHS status not affected by wire color. Wire insulation color may vary depending on availability. Marking detail font and color may vary on preproduction samples.

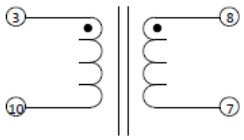
DFM		Packaging Specifications	Tolerances unless otherwise specified:	DRAWING TITLE	PART NO.
DATE		Method: Tray	Angles: ±1° Decimals: ±.005 [.13]	INDUCTOR	7503448
ENG	TLI	PKG-TBD	Fractions: ±1/64 Footprint: ± .001 [.03]		
REV.	03		This drawing is dual dimensioned. Dimensions in brackets are in millimeters.		SPECIFICATION SHEE
DATE	2020/12/4	www.we-online.com/midcom	CONVENTION PLACEMENT		

Buck Choke Design

CUSTOMER TERMINAL	RoHS	LEAD(Pb)–FREE
Sn 96%, Ag 4%	Yes	Yes







ELECTRICAL SPECIFICATIONS @ 25° C unless otherwise no

PARAMETER		TEST CONDITIONS	VALUE
D.C. RESISTANCE	3-10	@20℃	0.50 ohms
D.C. RESISTANCE	8-7	@20℃	0.17 ohms
INDUCTANCE	3-10	10kHz, 100mV, Ls	880µH ±1
SATURATION CURRENT	3-10	20% rolloff from initial	4A
DIELECTRIC	3-7	625VAC, 1 second	500VAC, 1 m
TURNS RATIO		(3-10):(8-7)	14.92:1

GENERAL SPECIFICATIONS:

OPERATING TEMPERATURE RANGE: -40°C to +125°C including temp rise.

Wire insulation & RoHS status not affected by wire color. Wire insulation color may vary depending on availability. Marking detail font and color may vary on preproduction samples.

DFM	
DATE	
ENG	TLI
REV.	02
DATE	2020/12/3

Packaging Specifications
Method: Tray
PKG-0807

CONVENTION PLACEMENT

Tolerances unless otherwise specified:
Angles: ±1° Decimals: ±.005 [.13]
Fractions: ±1/64 Footprint: ± .001 [.03]

This drawing is dual dimensioned. Dimensions in brackets are in millimeters.

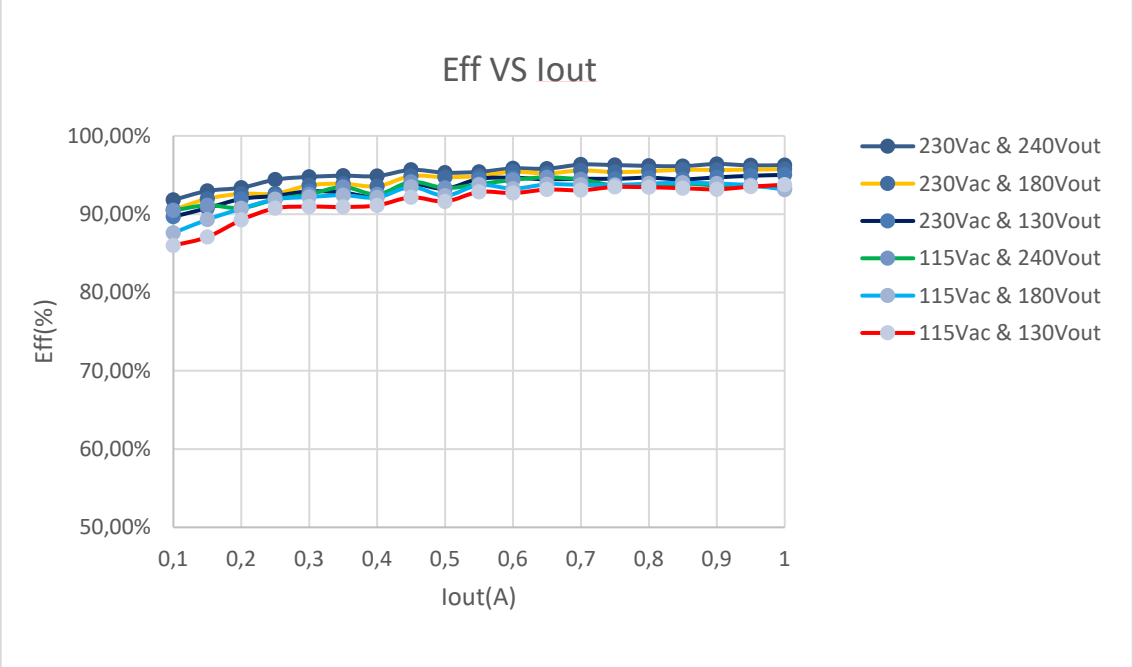
DRAWING TITLE
INDUCTOR

PART NO.
7503448

SPECIFICATION SHE

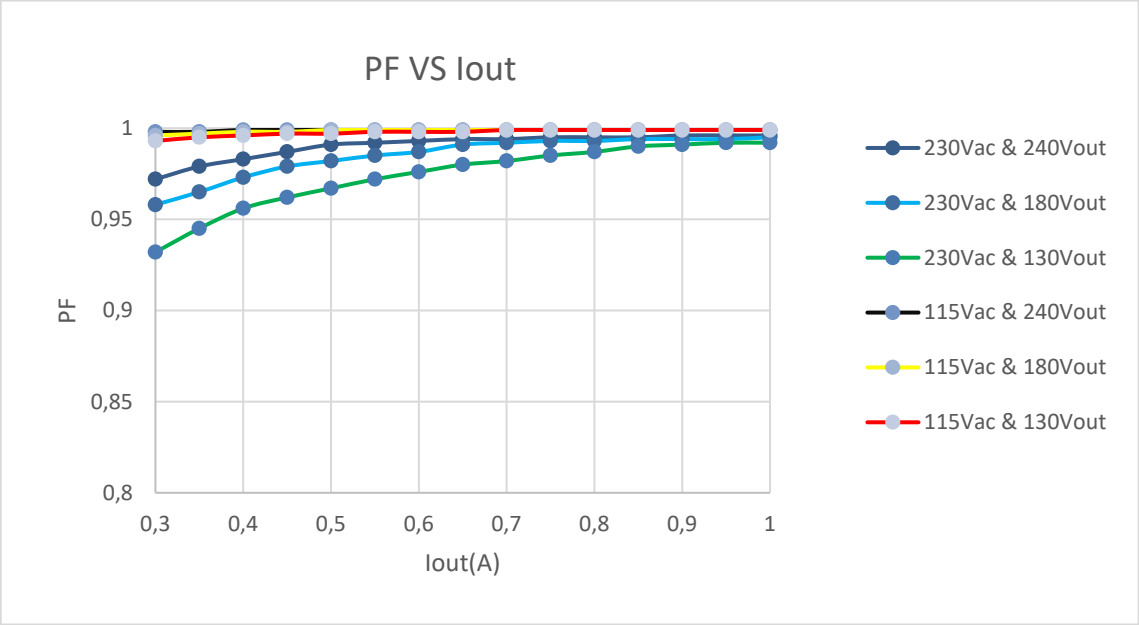
Efficiency Curve in Different AC Input Voltage

Test condition: all efficiency are tested at board end



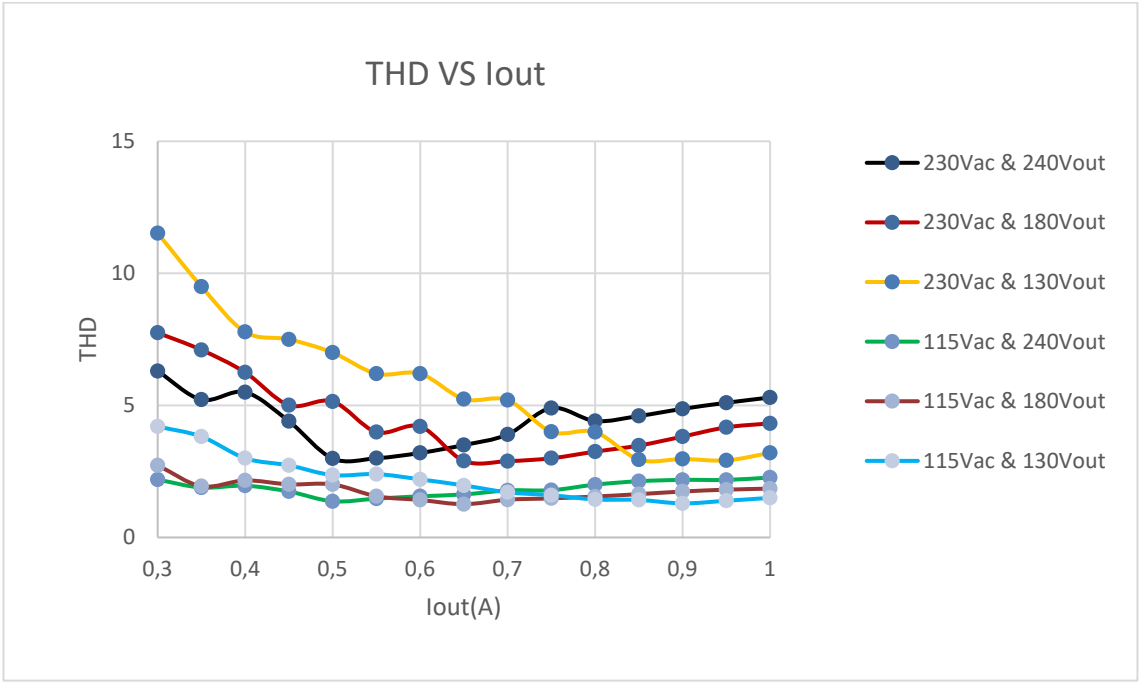
PFC Value in Different Load:

Test condition: test in different load condition



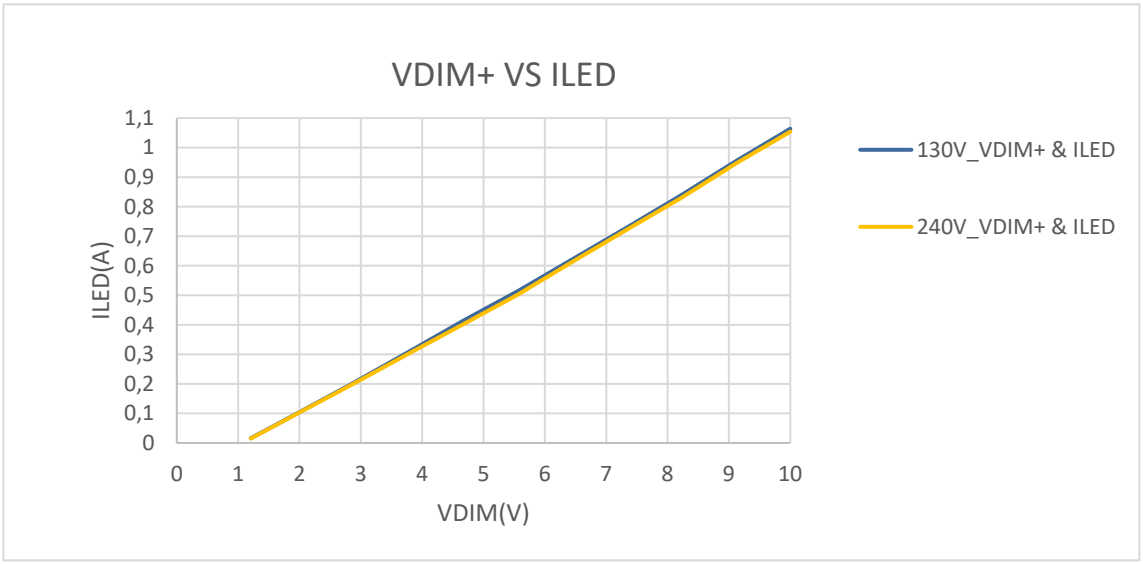
THD in Different Load

Test condition: test in different load condition



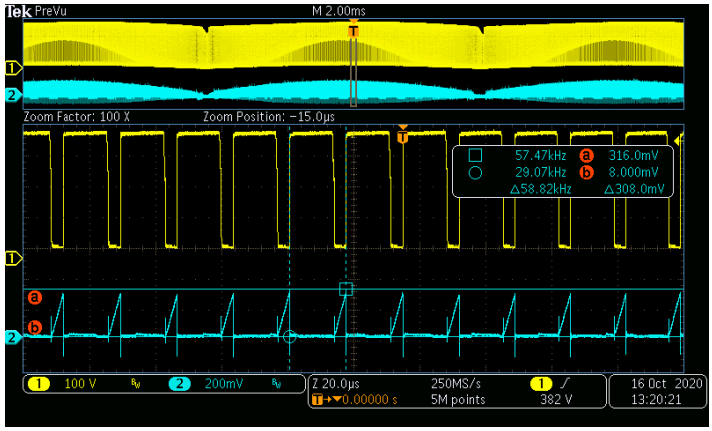
Dimming Curve:

Test condition: test in 130V and 240V output voltage with CC mode



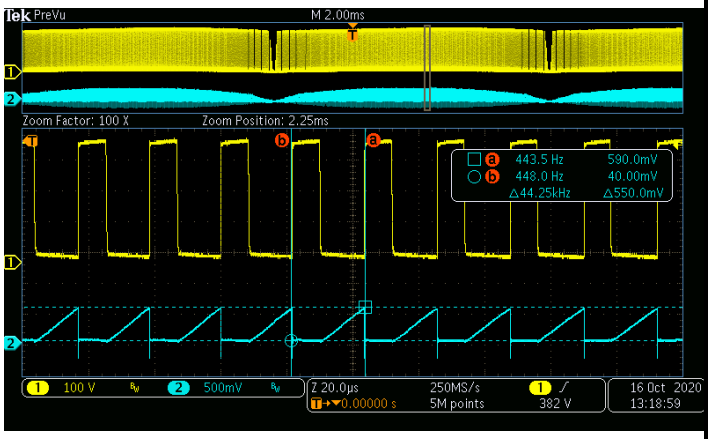
PFC MOSFET D-S wave-form:

(CH1: DS, CH2:CS)



230Vac input & full load

(CH1: DS, CH2:CS)



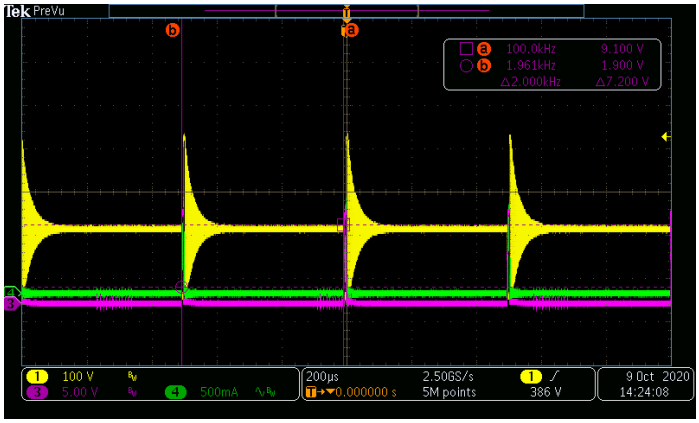
115Vac input & full load

Steady-State Wave form:

Test Condition – Vout : 240V, VDIM+: 9.2V/6.2V/4V/1.38V

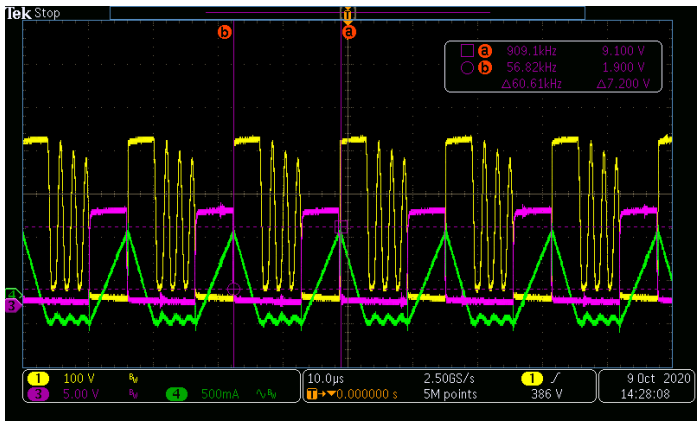
The NCL30076 Operate in multi-mode between CrM and DCM according to the Dimming condition

(CH1: MOS D-S, CH3:Driver CH4: LED current)



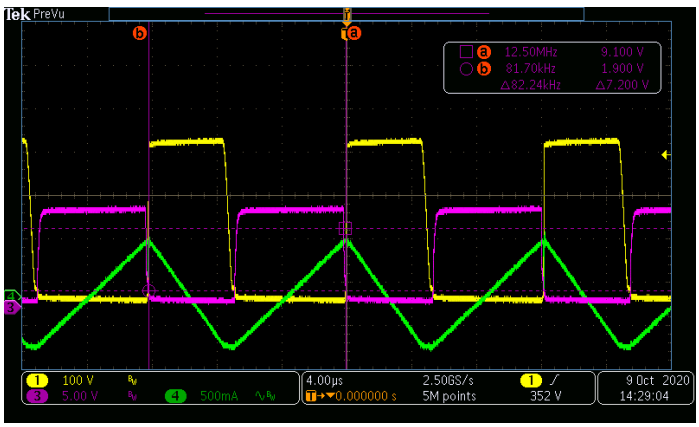
VDIM+ = 1.38V,DCM Operation(open loop)

(CH1: MOS D-S, CH3:Driver CH4: LED current)



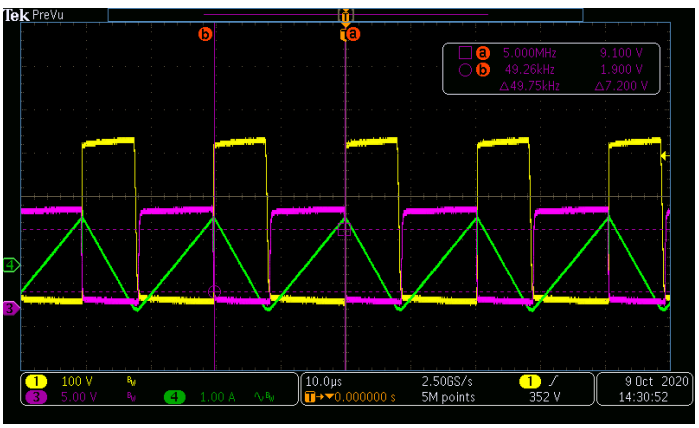
VDIM+ = 4V,DCM Operation

(CH1: MOS D-S, CH3:Dirver CH4: LED current)



VDIM+ = 4V,DCM Operation

(CH1:MOS D-S, CH3:Driver CH4: LED current)

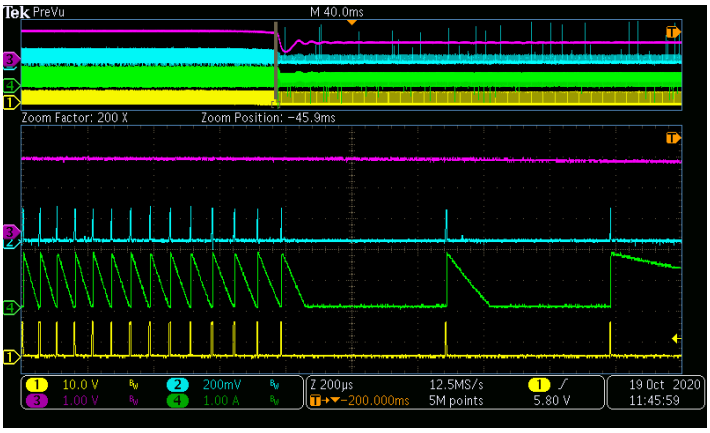


VDIM+ = 9.2V,QR Operation

LED Short Circuit Protection

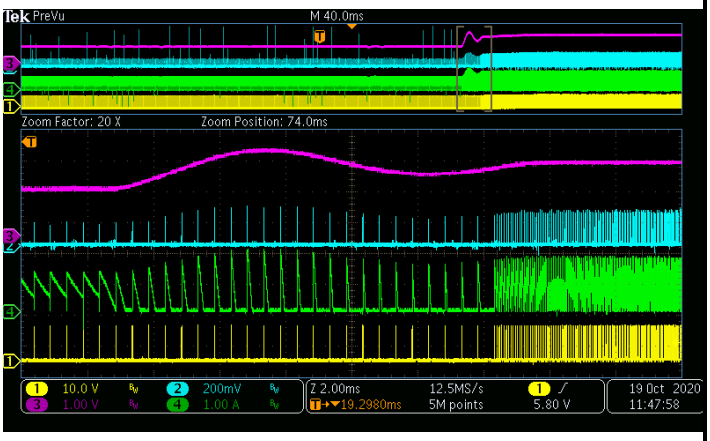
Test Condition -VOUT: 240V, ILED: 1A, VDIM+: 9.2V , LED Short and Release
When LED is short circuited, $T_{OFF.MAX}$ protects system from damage.

(CH1: MOS D-S, CH2:CS,CH3:FB CH4: I_buck)



Normal Operation to LED Short

(CH1: MOS D-S, CH2:CS,CH3:FB CH4: I_buck)

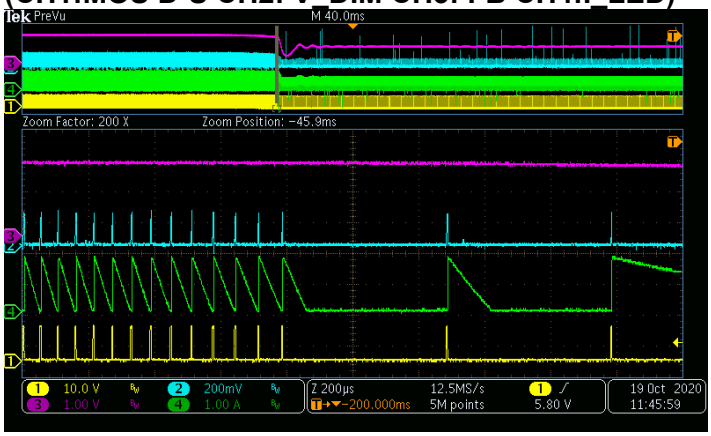


LED Short to Normal Operation

Standby Condition

NCL30076 will enter into a standby mode when V_{DIM} is lower than $V_{DIM(SB-EN)}$ for 10ms, and when V_{DIM} is higher than $V_{DIM(SB-DIS)}$, Standby mode will immediately terminated.

(CH1:MOS D-S CH2: V_DIM CH3: FB CH4:I_LED)

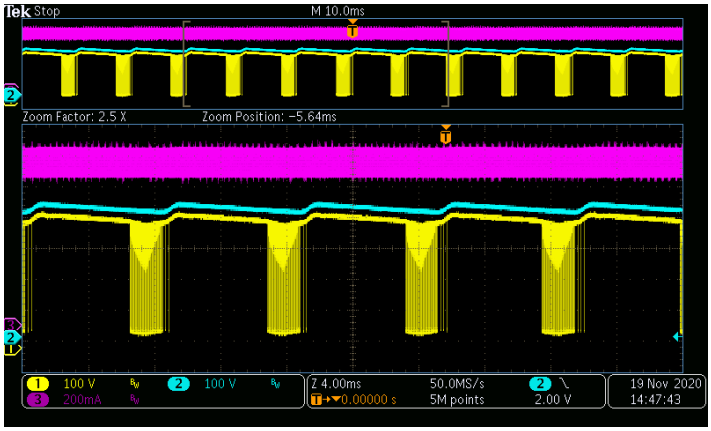


(CH1:MOS D-S CH2: V_DIM CH3: FB CH4:I_LED)

The LED Current in 305V AC Input @ Full Load:

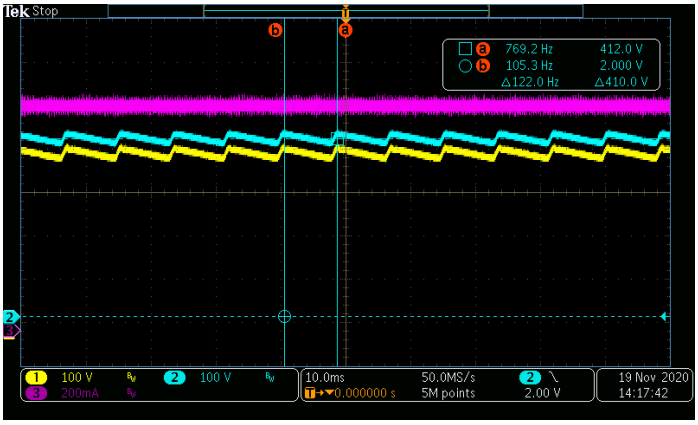
The LED current do not have bad current ripple even when the PFC voltage have a low frequency voltage ripple.

(CH1-PFC MOS D-S CH2- PFC Voltage CH4- I_LED)



Test by E-load CV mode,240V/1A load

(CH1-PFC MOS D-S CH2- PFC Voltage CH4- I_LED)

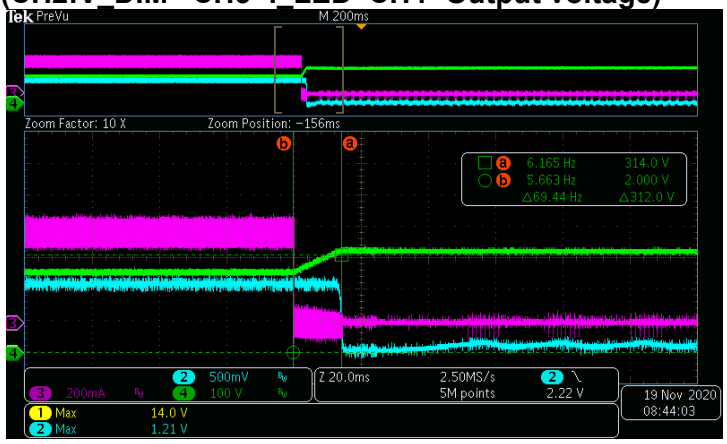


Test by LED load,180V/1A load

Output OVP Protection

Remove the LED or rise up the output voltage to 300V, the output voltage trigger the OVP protection.

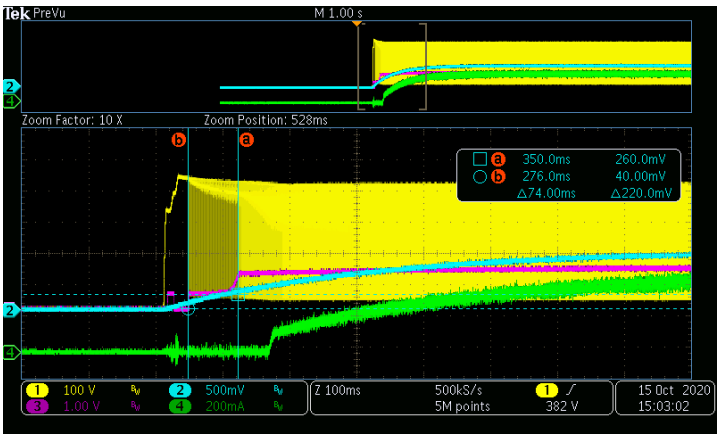
(CH2:V_DIM CH3- I_LED CH4- Output voltage)



When the Output voltage rise up, the OVP protection will be triggered, the output voltage will not exceed the OVP set point.

Start-up Timing

(CH1:MOS D-S CH2:V_DIM CH3:FB CH4:I_LED)



BOM

Item	Qty	Reference	Type	Part Name	MFR	Value	Package
1	1	NTC1	NTC	SPNL09D1R5MBI	SUNLORD	1.5 Ω	
2	1	F1	FUSE	3.15A/250VAC	Littelfuse	Micro Fuse 3.15 A/250 VAC	
3	1	L1	Filter		WE	90 μH/4 A	
4	1	L4	PFC choke		WE	280 μH	PQ3225
5	1	L2	Filter		WE	2*14 μH/4 A	
6	1	L3	BUCK choke		WE	880 μH	PQ3225
7	1	L5	Output common filter		WE	JUMP WIRE	
8	2	CX1,CX2	X-cap		WE	474/275 Vac	L*W:18*6cm, 脚距 15cm
9	1	R1,R11	Resistor	Std	Std	1M5/0805	0805
10	1	R2	Resistor	Std	Std	20 K/0805	0805
11	1	R3	Resistor	Std	Std	27 K/0805	0805
12	1	R4	Resistor	Std	Std	56 K/0805	0805
13	1	R5	Resistor	Std	Std	20 K/0805	0805
14	1	R6	Resistor	Std	Std	2M2/0805	0805
15	1	R7	Resistor	Std	Std	2M2/0805	0805
16	5	R8,R20,R25,R9,R17	Resistor	Std	Std	10/0805	0805
17	1	R10	Resistor	Std	Std	150 R/0805	0805
18	2	R12,R18， R32	Resistor	Std	Std	20 K/0805	0805
19	2	R13,R31	Resistor	Std	Panasonic	0R2	2512
20	1	R21	Resistor	Std	Panasonic	0R15	2512
21	2	R24,R26	Resistor	Std	Std	1.5 M/0805	0805
22	5	R22,R23,R28,R29,R30	Resistor	Std	Std	10 M/0805	0805

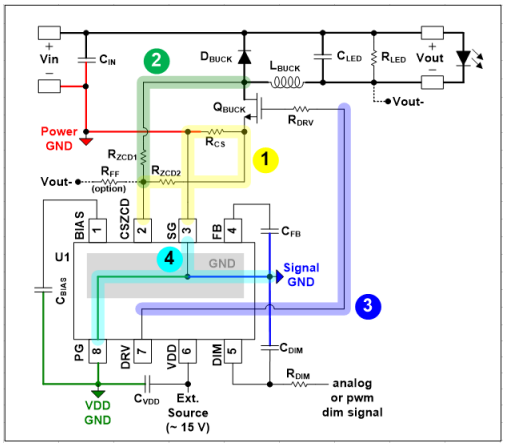
23	1	R33	Resistor	Std	Std	8.2 M/0805	0805
24	1	R16	Resistor	Std	Std	1K5/0603	0603
25	1	R14	Resistor	Std	Std	5.1 K/0805	0805
26	1	R45	Resistor	Std	Std	30 K/0805	0805
27	1	R44	Resistor	Std	Std	100 K/0805	0805
28	1	R43	Resistor	Std	Std	150 K/0805	0805
29	2	R19,R27	Resistor	Std	Std	220 K/0805	0805
30	2	C1,C22	Film capacitor	Std	WE	450 V/474	Film capacitor
31	2	C3,CLED	E-cap	Std	WE	450 V/180 μF	E-cap
32	4	C2,C6,C9,C10	Ceramic cap	Std	Std	102/25 V	0805
33	1	C13,C15	Ceramic cap	Std	Std	225/50 V	0805
34	1	C4	Ceramic cap	Std	Std	224/25 V	0805
35	1	C7	Ceramic cap	Std	Std	225/25 V	0805
36	1	C8	Ceramic cap	Std	Std	22P/25 V	0805
37	1	C5	Ceramic cap	Std	Std	105/25 V	0805
38	1	C11	Ceramic cap	Std	Std	100 pF/25 V	0603
39	1	C12	Ceramic cap	Std	Std	103/35 V	0805
40	1	Q2	BJT	BC807-40LT1G	ON	45 V/0.5 A	SO23
41	3	M1,M2,M3	MOSFET	FCD260N65	ON	650 V/260 mR	D-PARK
42	1	M4,M5	MOSFET	2N7002	ON	2N7002	SO23
43	2	D1,D3	Diode	MUR460	ON	600 V/4 A	SMC
44	2	D8,D4	DIODE	MMSD4148T1G	ON	100 V/0.2 A	SOD323
45	1	D2	Diode	ES1J	ON	1 KV/1 A	SMA
45	1	D6	Diode	RS1D	ON	200 V/1 A	SMA
45	1	D7	Zener	MMSZ15T1G	ON	15 V	SOD-123
46	1	D5	Diode bridge	GBU806	ON	800 V/6 A	Micro-DIP
47	1	U2	BUCK controller	NCL30076	ON	BUCK controller	SOIC-8
48	1	U1	PFC controller	NCL2801CDA	ON	PFC controller	SOIC-8
49	1	Heat-sink for D5		Heat-sink and screw	Std		

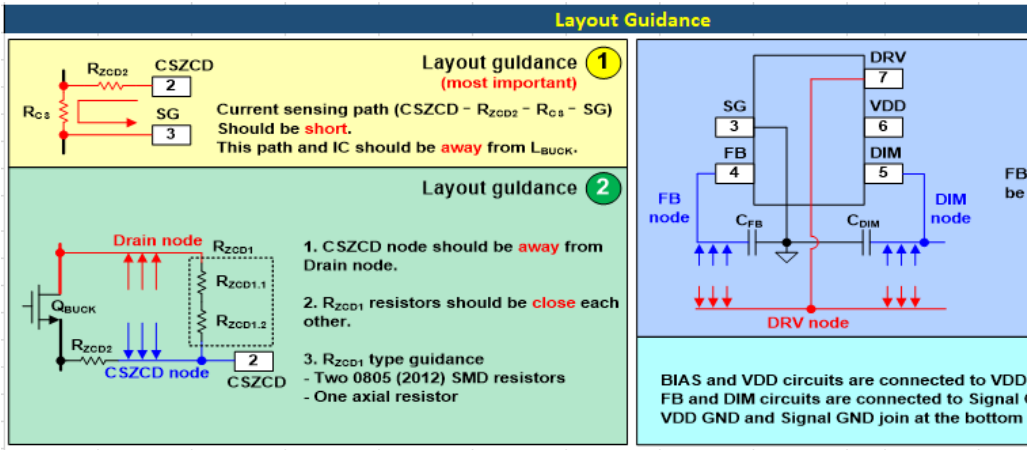
50	1	CON1	CONNECTOR	CONNECTOR,10PIN	WE	CONNECTOR,10PIN	10PIN

Item	Qty	Reference	Type	Part Name	MFR	Value	Package
1	1	R28	Resistor	Std	Std	330 K	1206
2	1	R22	Resistor	Std	Std	12 K	0603
3	1	R23	Resistor	Std	Std	3.3 K	0603
4	1	R4	Resistor	Std	Std	15 K	0603
5	1	R40	Resistor	Std	Std	10	0603
6	1	R36	Resistor	Std	Std	1M2	0603
7	1	R37	Resistor	Std	Std	300 K	0603
8	1	R38	Resistor	Std	Std	2M2	0603
9	1	R2	Resistor	Std	Std	0	0603
10	1	R35	Resistor	Std	Std	0	0603
11	1	C21	E-cap		WE	47 μF/50 V	E-cap
12	1	C20	E-cap		WE	10 μF/50 V	E-cap
13	1	C11	Ceramic cap	Std	WE	1 nF/1000 V	1206
14	1	C17	Ceramic cap	Std	Std	220 nF/25 V	0603
15	1	C18	Ceramic cap	Std	Std	103/25 V	0603
16	1	C1	Ceramic cap	Std	Std	103/25 V	0603
17	1	C4	Ceramic cap	Std	Std	103/25 V	0603
18	1	C3	Ceramic cap	Std	Std	103/25 V	0603
19	1	C13	Ceramic cap	Std	Std	102/35 V	0603
20	1	C19	Ceramic cap	Std	Std	472/25 V	0603
21	1	C5	Ceramic cap	Std	Std	330 P/25 V	0603
22	1	C2	Ceramic cap	Std	Std	104/25 V	0603
23	1	Q1	BJT	BC817-40LT1G	ON	45 V/0.5 A	SO23
24	5	D1,D2,D8,D10,D13	DIODE	MMSD4148T1G	ON	100 V/0.2 A	SOD323
25	1	D7	Diode	RS1K	ON	1 KV/1 A	SMA
26	1	D6	DIODE	RS2D	ON	200 V/1 A	SMA

27	1	D3	Zener	MMSZ15T1G	ON	15 V	SOD-123
28	1	U3	Flyback Switcher	NCP10671	ON	Flyback controller	SOIC-8
29	1	U1	Dimming controller	SY5867		Dimming controller	SOIC-8
30	1	OPTICAL1	Optical coupler	FODM1007	ON	Optical coupler	LSOP4
31	1	T1	Transformer		WE	800 μH	EE20

Something about PCB Layout





References

ON Semiconductor datasheet for NCL30076.

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