

# ON Semiconductor

## Is Now



To learn more about onsemi™, please visit our website at  
[www.onsemi.com](http://www.onsemi.com)

onsemi and onsemi. and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "onsemi" or its affiliates and/or subsidiaries in the United States and/or other countries. onsemi owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of onsemi product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). onsemi reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as-is" and onsemi makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does onsemi assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using onsemi products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by onsemi. "Typical" parameters which may be provided in onsemi data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. onsemi does not convey any license under any of its intellectual property rights nor the rights of others. onsemi products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use onsemi products for any such unintended or unauthorized application, Buyer shall indemnify and hold onsemi and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that onsemi was negligent regarding the design or manufacture of the part. onsemi is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner. Other names and brands may be claimed as the property of others.



ON Semiconductor

TND6359/D

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 <sup>3</sup>
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:  $\pm 2\%$  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

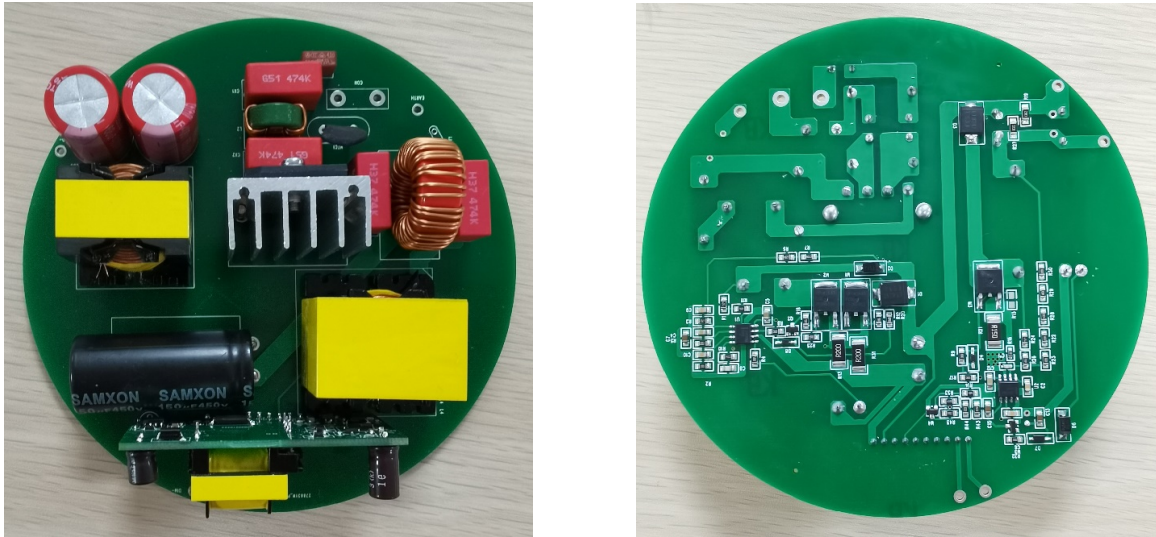


Figure 1. Demo Board Pictures

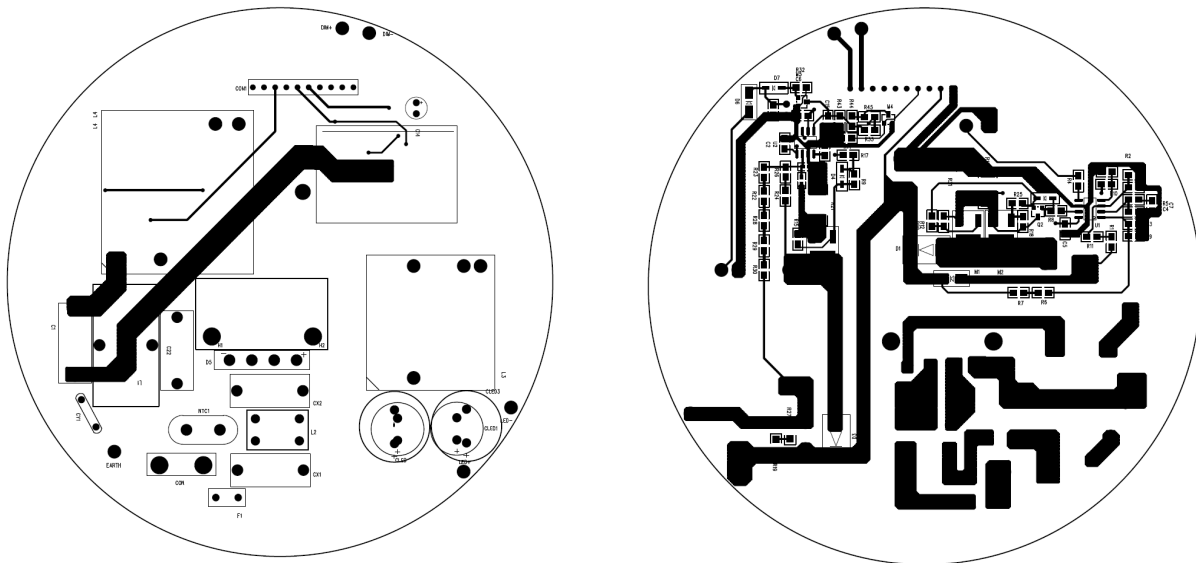


Figure 2. Main Board PCB

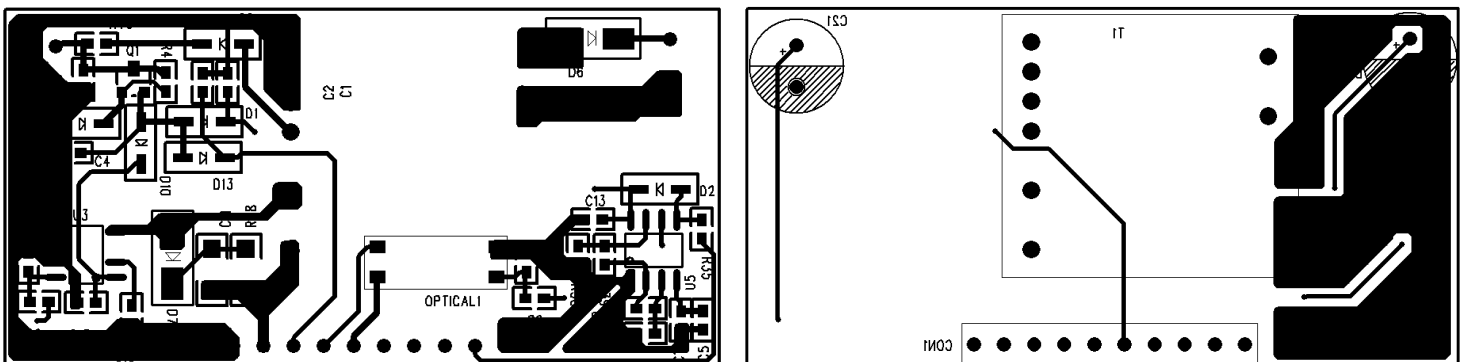
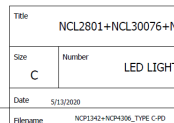
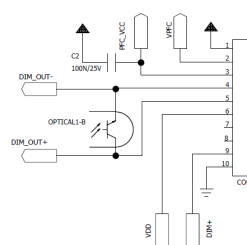
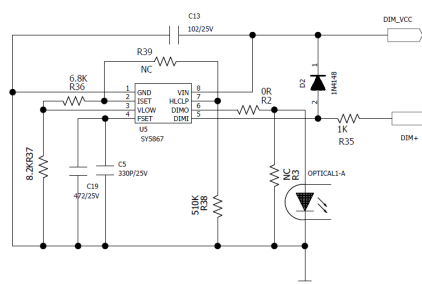
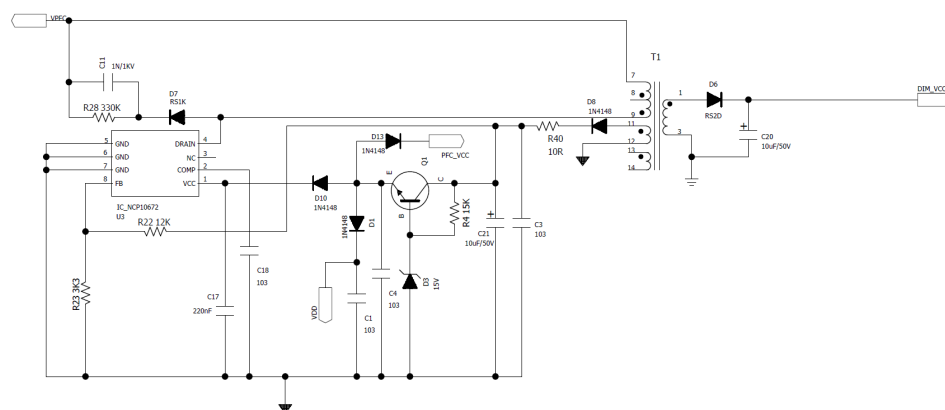


Figure 3. Auxiliary Vcc PCB

## Circuit Schematic



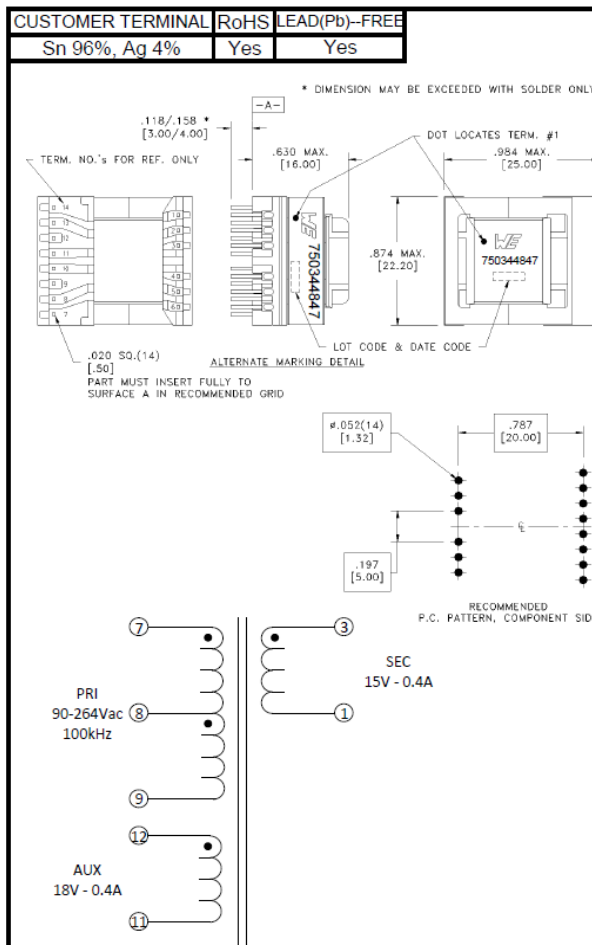
**TND6359/D**



Title		NCL2801+NCL30	
Size	C	Number	LED
Date		5/13/2020	
Filename		NCP1342+NCP406_TY	

# TND6359/D

## Auxiliary Vcc Power Transformer Design



### ELECTRICAL SPECIFICATIONS @ 25° C unless otherwise specified

PARAMETER	TEST CONDITIONS	MIN.	MAX.
D.C. RESISTANCE	7-9 @20°C	3.15	
D.C. RESISTANCE	12-11 @20°C	0.21	
D.C. RESISTANCE	3-1 @20°C	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	30	
DIELECTRIC	7-1 tie(9+11), 1500VAC, 1 second		
URNS RATIO	(7-9):(12-11)		
URNS 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 sample.

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

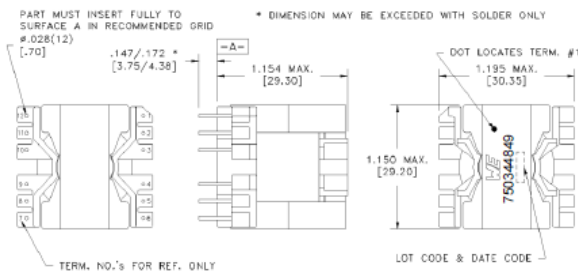
## PFC Choke Design

DFM		Packaging Specifications		 CONVENTION PLACEMENT	Tolerances unless otherwise specified:		DRAWING TITLE	PART NO.	
DATE		Method: Tray			Angles: $\pm 1^\circ$ Decimals: $\pm .005$ [13]				INDUCTOR
ENG		TLI			Fractions: $\pm 1/64$ Footprint: $\pm .001$ [03]				
REV.		03			This drawing is dual dimensioned. Dimensions in brackets are in millimeters.				
DATE		2020/12/4		www.wereonline.com/iscom		75034484		SPECIFICATION SHEET	

## Buck Choke Design

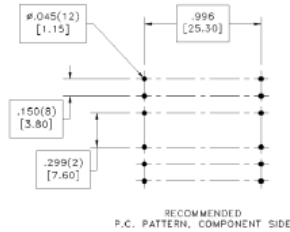
TND6359/D

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



### ELECTRICAL SPECIFICATIONS @ 25°C unless otherwise noted

PARAMETER	TEST CONDITIONS	VALUE
D.C. RESISTANCE	3-10 @20°C	0.50 ohms
D.C. RESISTANCE	8-7 @20°C	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 min
URNS 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	Packaging Specifications
DATE	Method: Tray
ENG	TLI
REV.	02
DATE	2020/12/3

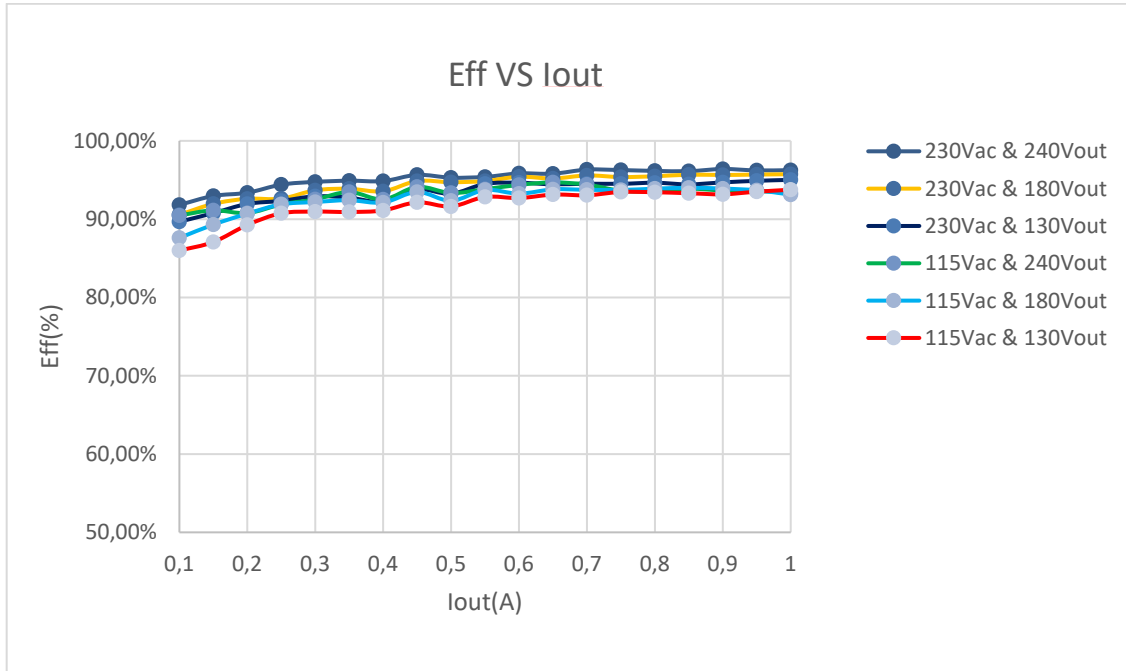


Tolerances unless otherwise specified:  
Angles: ±1°  
Decimals: ±.005 [0.13]  
Fractions: ±1/64 Footprint: ±.001 [0.03]  
This drawing is dual dimensioned. Dimensions in brackets are in millimeters.

DRAWING TITLE	PART NO.
INDUCTOR	7503448
	SPECIFICATION SHEET

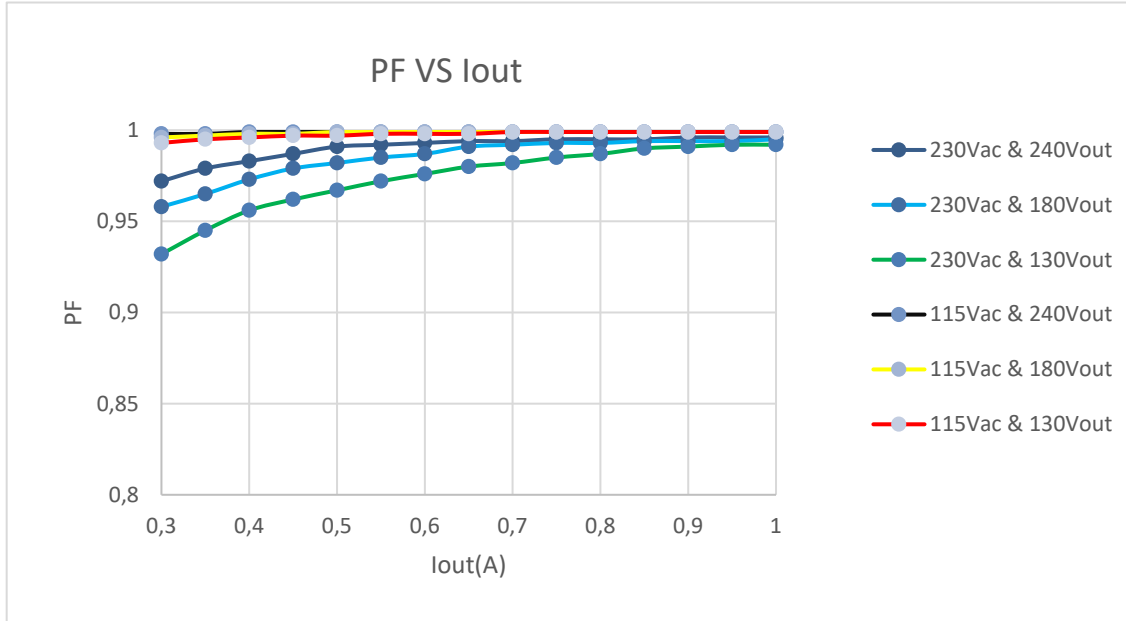
## Efficiency Curve in Different AC Input Voltage

Test condition: all efficiency are tested at board end



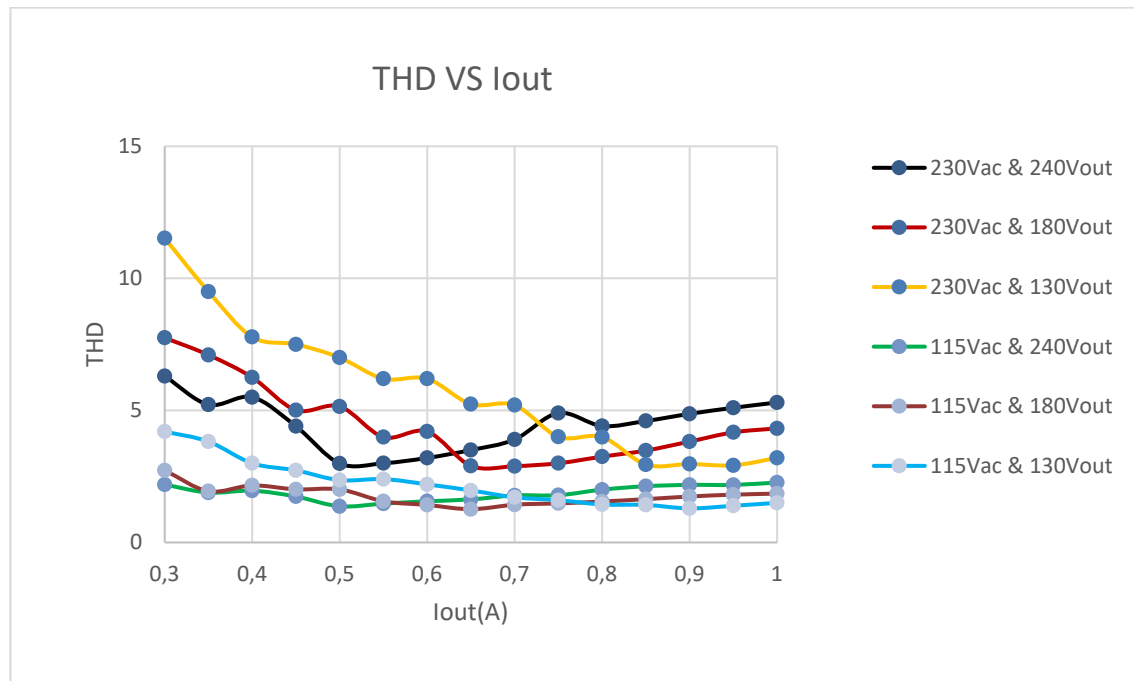
## PFC Value in Different Load:

Test condition: test in different load condition



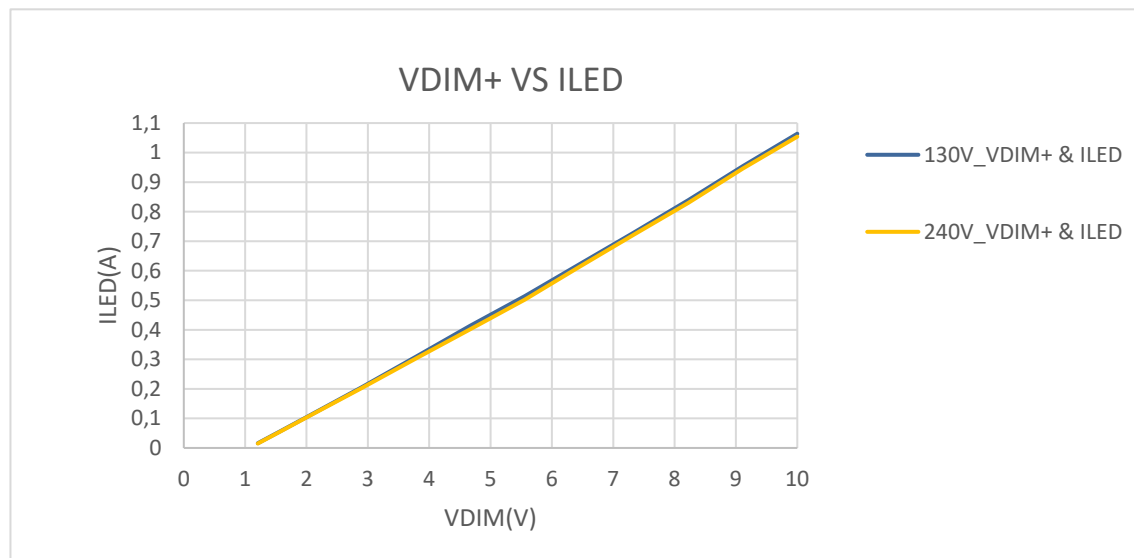
## THD in Different Load

Test condition: test in different load condition



## Dimming Curve:

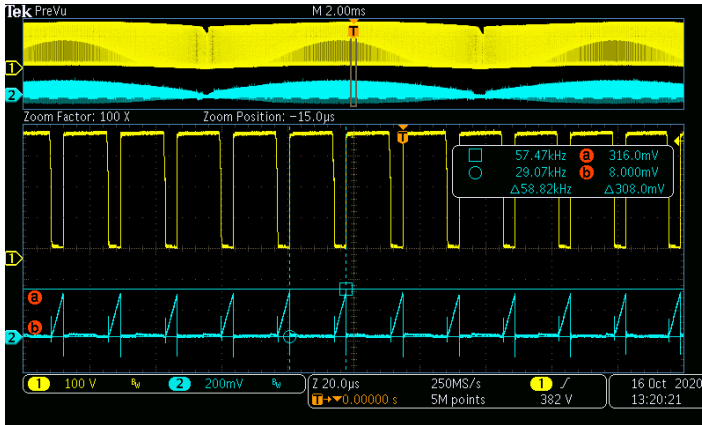
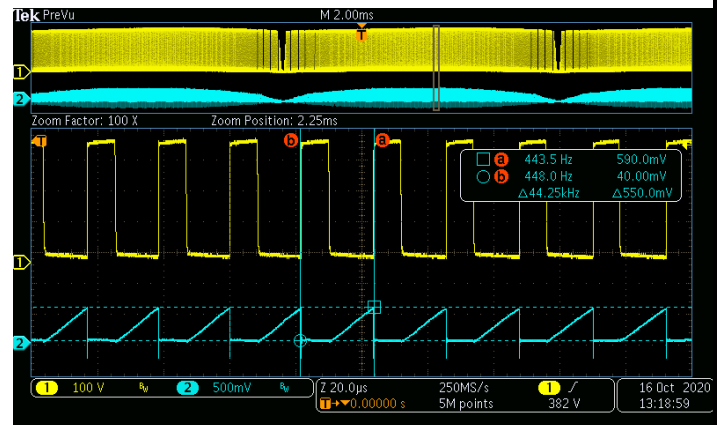
Test condition: test in 130V and 240V output voltage with CC mode



**PFC MOSFET D-S wave-form:**

(CH1: DS, CH2:CS)

(CH1: DS, CH2:CS)

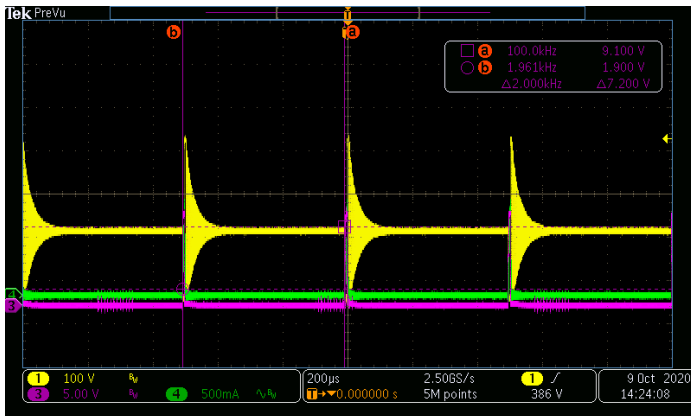
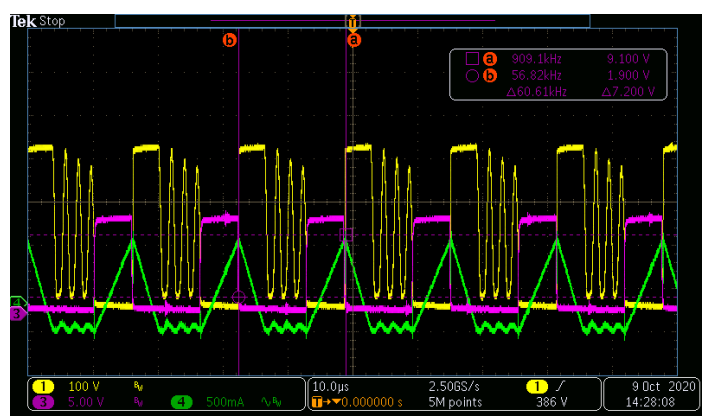
**230Vac input & full load****115Vac input & full load****Steady-State Wave form:**

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

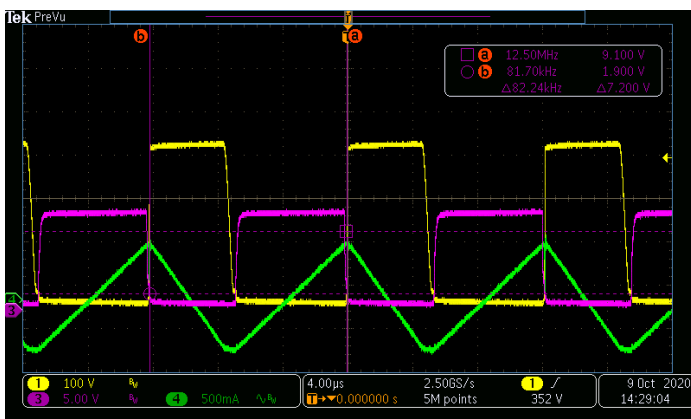
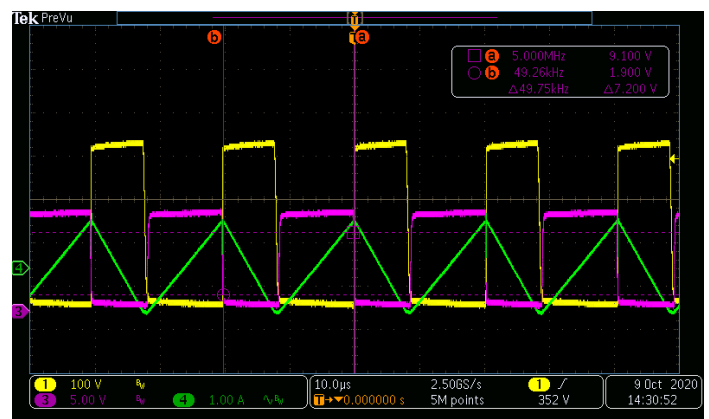
(CH1: MOS D-S, CH3:Driver CH4: LED current)

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

**VDIM+ = 1.38V,DCM Operation(open loop)****VDIM+ = 4V,DCM Operation**

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

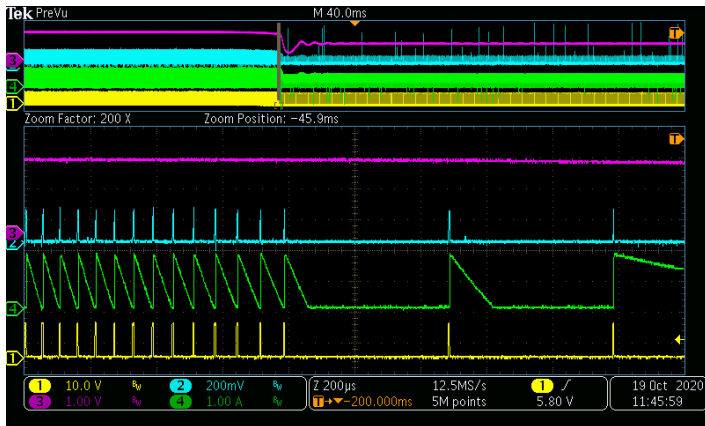
(CH1:MOS D-S, CH3:Driver CH4: LED current)

**VDIM+ = 4V,DCM Operation****VDIM+ = 9.2V,QR Operation**

## LED Short Circuit Protection

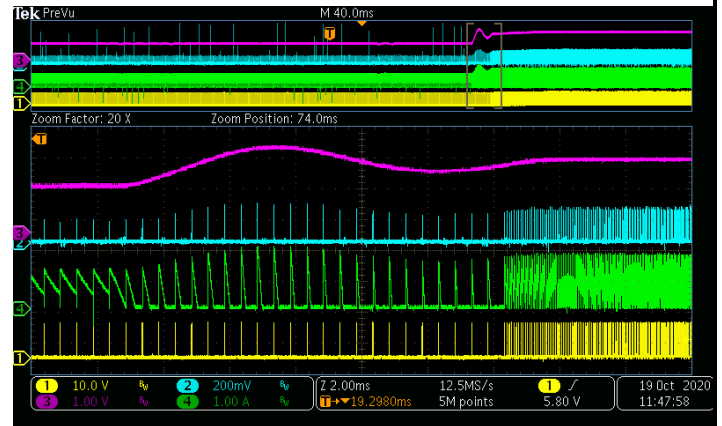
Test Condition -VOUT: 240V, ILED: 1A, VDIM+: 9.2V , LED Short and Release  
When LED is short circuited, T<sub>OFF.MAX</sub> protects system from damage.

(CH1: MOS D-S, CH2:CS,CH3:FB CH4: I<sub>buck</sub>)



Normal Operation to LED Short

(CH1: MOS D-S, CH2:CS,CH3:FB CH4: I<sub>buck</sub>)

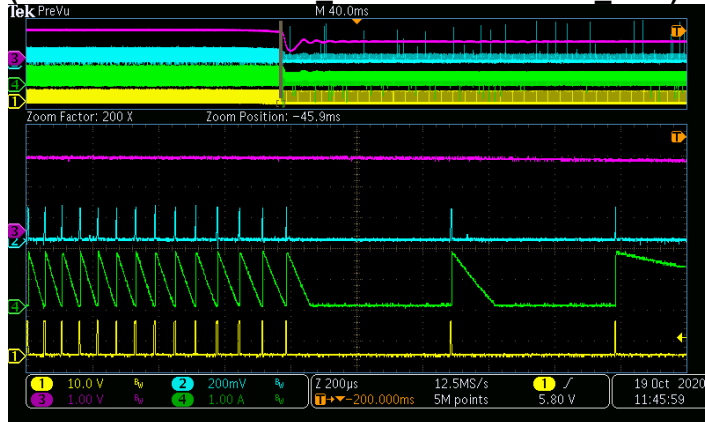


LED Short to Normal Operation

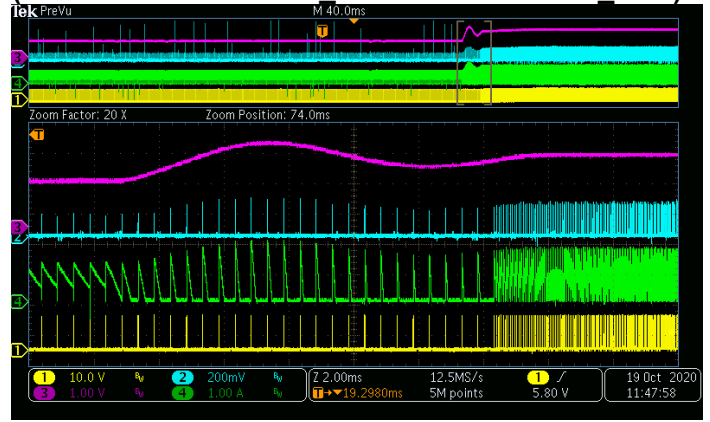
## Standby Condition

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<sub>DIM</sub> CH3: FB CH4:I<sub>LED</sub>)



(CH1:MOS D-S CH2: V<sub>DIM</sub> CH3: FB CH4:I<sub>LED</sub>)

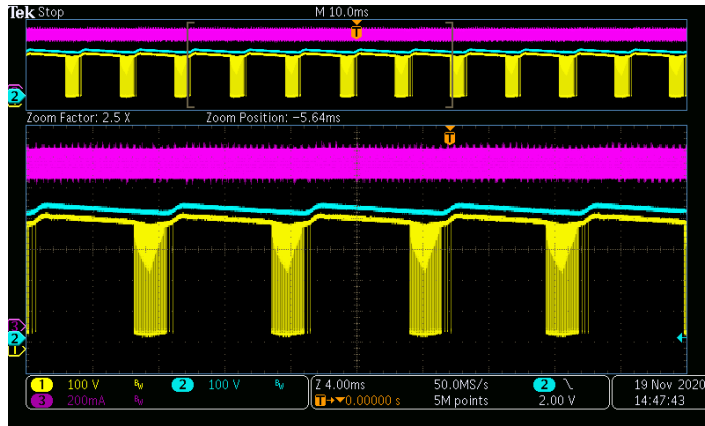


## The LED Current in 305V AC Input @ Full Load:

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

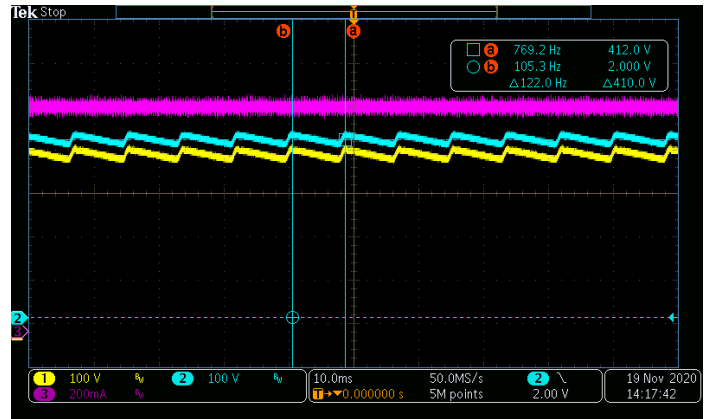
## TND6359/D

(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)

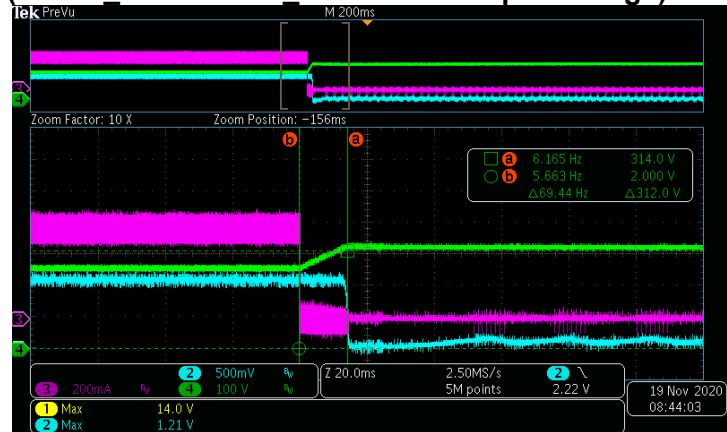


Test by LED load, 180V/1A load

## 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)



## TND6359/D

### BOM

Item	Qty	Reference	Type	Part Name	MFR	Value	Package
1	1	NTC1	NTC	SPNL09D1R5MBI	SUNLORD	1.5 $\Omega$	
2	1	F1	FUSE	3.15A/250VAC	Littelfuse	Micro Fuse 3.15 A/250 VAC	
3	1	L1	Filter		WE	90 $\mu$ H/4 A	
4	1	L4	PFC choke		WE	280 $\mu$ H	PQ3225
5	1	L2	Filter		WE	2*14 $\mu$ H/4 A	
6	1	L3	BUCK choke		WE	880 $\mu$ H	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

# TND6359/D

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 $\mu$ F	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		

# TND6359/D

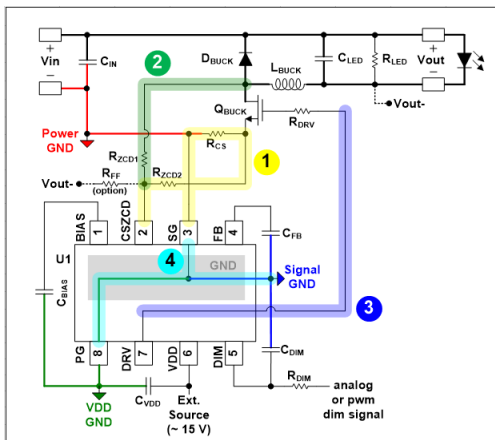
50	1	CON1	CONNECTOR	CONNECTOR,10PIN	WE	CONNECTOR,10PIN	10PIN
----	---	------	-----------	-----------------	----	-----------------	-------

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 $\mu$ F/50 V	E-cap
12	1	C20	E-cap		WE	10 $\mu$ F/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

**TND6359/D**

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 $\mu$ H	EE20

## Something about PCB Layout



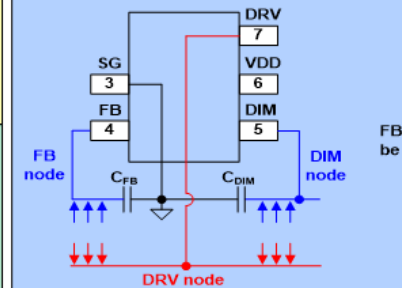
### Layout Guidance

#### Layout guidance 1 (most important)

Current sensing path (CSZCD -  $R_{ZCD2}$  -  $R_{CS}$  - SG)  
Should be **short**.  
This path and IC should be **away** from  $L_{BUCK}$ .

#### Layout guidance 2

1. CSZCD node should be **away** from Drain node.  
2.  $R_{ZCD1}$  resistors should be **close** each other.  
3.  $R_{ZCD1}$  type guidance  
- Two 0805 (2012) SMD resistors  
- One axial resistor



BIAS and VDD circuits are connected to VDD  
FB and DIM circuits are connected to Signal  
VDD GND and Signal GND join at the bottom

## References

ON Semiconductor datasheet for [NCL30076](#).

**Disclaimer:** ON Semiconductor is providing this reference design “AS IS” and does not assume any liability arising from its use; nor does ON Semiconductor convey any license to its or any third party’s intellectual property rights. This document is provided only to assist customers in evaluation of the referenced circuit implementation and the recipient assumes all liability and risk associated with its use, including, but not limited to, compliance with all regulatory standards. ON Semiconductor may change any of its products at any time, without notice.

Reference design created by; e-mail: [tom.zhang@onsemi.com](mailto:tom.zhang@onsemi.com)