

ON Semiconductor

Is Now

onsemi™

To learn more about onsemi™, please visit our website at
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. **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.

TND6288/D



50 W / 60 W Direct AC LED Driver Analog Dimming

ON Semiconductor®

www.onsemi.com

50 W / 60 W Direct AC LED Driver Analog Dimming

This reference design covers the specification, theory of operation, testing and construction of a design based on the NCL30170. The design demonstrates 50 W / 60 W analog dimming with accurate current regulation and low THD performance.

REFERENCE DESIGN

Table 1.

Input Voltage	108–132 Vac	Low line ADIM
	198–264 Vac	High line ADIM
Line Frequency	50 Hz / 60 Hz	
Output Power	50 W / 60 W	Low line: 50 W High line: 60 W
Power Factor (Maximum LED Output)	0.95	Min
THD (Nominal Input Voltage)	13%	Max
Line Regulation	±2%	
Analog Dimming Range	< 5 %	
Start Up Time	< 200 ms	Typ.
Percent Flicker	< 30%	With E-cap
Lighting Surge	CM: ±2.0 kV (Line to PE) DM: ±2.0 kV (Line to Neutral)	ANSI/IEEE C62.41–1991 Class A
EMI	Conducted	9 kHz–30 MHz

Key Features

- Accurate Constant LED Current across Input Voltage Range
- Selectable LED Channel Counts using Advanced Topology
- Excellent Power Factor and THD with Sinusoidal Current Shape
- Wide Analog dimming range < 5 %
- Excellent Phase-cut dimmer compatibility
- Protections
 - ◆ Input Over Voltage Protection
 - ◆ Thermal Shut Down
 - ◆ Sensing Resistor Short Protection

TND6288/D

Schematic for Low Line 50 W ADIM

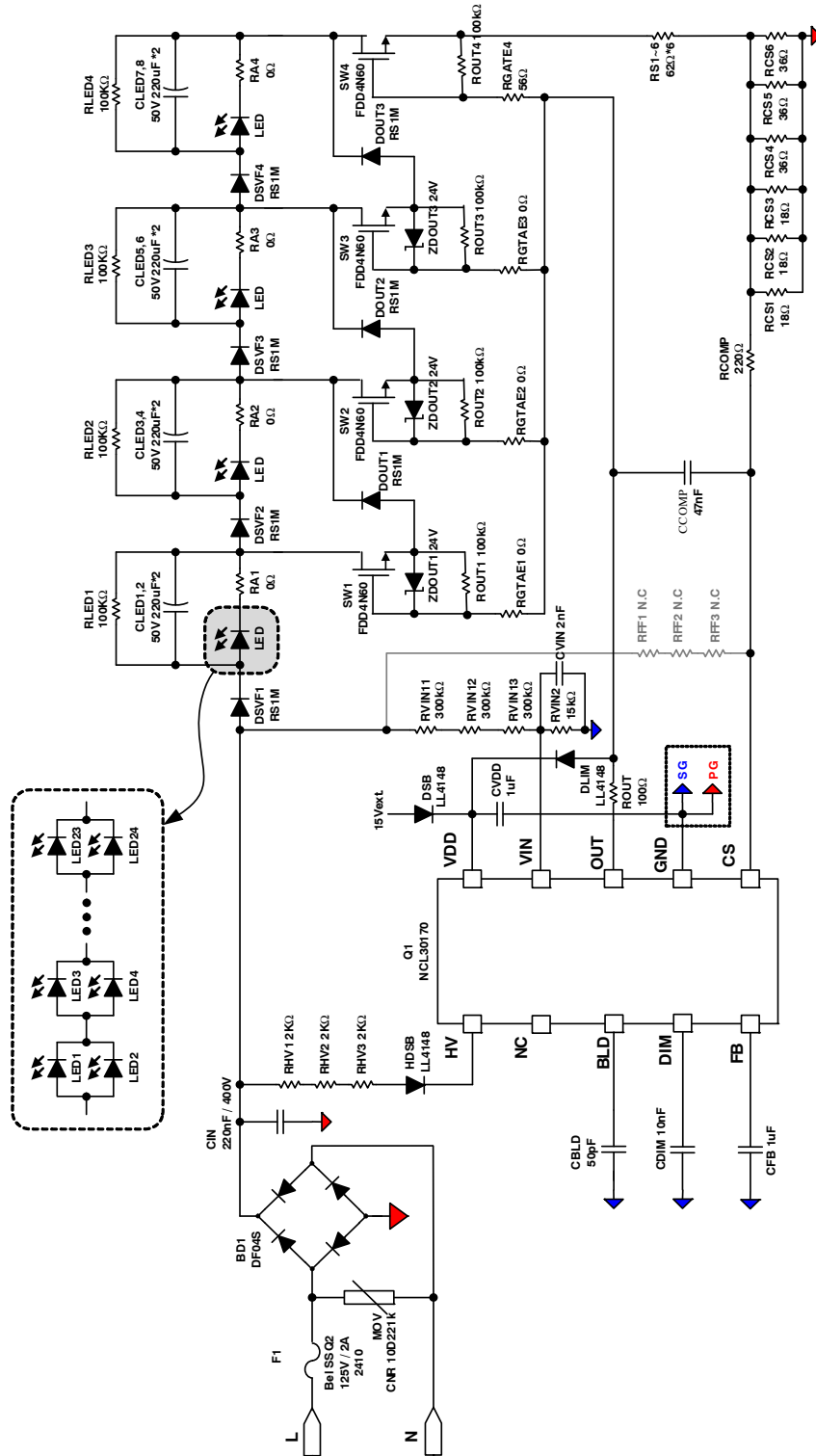


Figure 1. Schematic for Low Line 50 W ADIM

TND6288/D

Table 2. BILL OF MATERIALS FOR LOW LINE (BOM)

Part Reference	Part Description	Q'ty	Vendor	Value
Q1	NCL30170 / IC SOIC 10	1	ON Semiconductor	NCL30170
F1	fast Acting 125 V, 2 A, SSQ2 2410	1	Bel fuse	
MOV	CNR10D221K	1	ANY	
RCS1, RCS2, RCS3	RES, SMD, 1/2 W, 3216	3	Yageo	18 Ω
RCS4, RCS5, RCS6	RES, SMD, 1/2 W, 3216	3	Yageo	36 Ω
RHV1, RHV2, RHV3	RES, SMD, 1/2 W, 3216	3	Yageo	2 KΩ
RVIN11, RVIN12	RES, SMD, 1/2 W, 3216	2	Yageo	300 KΩ
RVIN13	RES, SMD, 1/2 W, 3216	1	Yageo	220 KΩ
RVIN2	RES, SMD, 1/2 W, 3216	1	Yageo	13 KΩ
RLED1 ~ RLED4, ROUT1 ~ ROUT4	RES, SMD, 1/2 W, 3216	8	Yageo	100 KΩ
ROUT	RES, SMD, 1/2 W, 3216	1	Yageo	100 Ω
RGATE4	RES, SMD, 1/2 W, 3216	1	Yageo	56 Ω
RCOMP	RES, SMD, 1/2 W, 3216	1	Yageo	220 Ω
RS1 ~ RS6	RES, SMD, 1/2 W, 3216	6	Yageo	62 Ω
CVIN	220nF / 400 V	1		220 nF
CLED1 ~ CLED8	220 μF / 50 V	8	Samwha	220 μF
CVDD	Cap, 3216 SMD, Ceramic, 50 V, X7R	1	Kemet	1 μF
CBLD	Cap, 2012 SMD, Ceramic, 25 V, X7R	1	Kemet	50 pF
CDIM	Cap, 2012 SMD, Ceramic, 25 V, X7R	1	Kemet	10 nF
CFB	Cap, 2012 SMD, Ceramic, 25 V, X7R	1	Kemet	1 μF
CCOMP	Cap, 3216 SMD, Ceramic, 50 V, X7R	1	Kemet	47 nF
CVIN2	Cap, 3216 SMD, Ceramic, 50 V, X7R	1	Kemet	2 nF
DLIM	Diode, 100 V, 150 mA, Fast recovery	1	ON Semiconductor	LL4148
DSVF1 ~ DSVF4, DOUT1 ~ DOUT3	Diode, 1000 V, 1 A, Fast recovery	7	ON Semiconductor	RS1M
DSB, HDSB	Diode, 100 V, 150 mA , Fast recovery	2	ON Semiconductor	LL4148
ZDOUT1, ZDOUT2, ZDOUT3	ZENER Diode 24 V	3	ON Semiconductor	24 V
BD1	Bridge Diode 400 V, 1 A	1	ON Semiconductor	DF04S
LED1 ~ LED96	MP-3030-1100-30-80	96	LUMINUS	3 V / 240 mA
SW1, SW2, SW3, SW4	MOSFET, 600 V, 4 A	4	ON Semiconductor	FDD4N60NZ
RGATE1 ~ 3, RA1 ~ 4	RES, SMD, 1/2 W, 3216	30	Yageo	0 Ω
RFF1 ~ RFF3		3		Open

Schematic for High Line 60 W ADIM

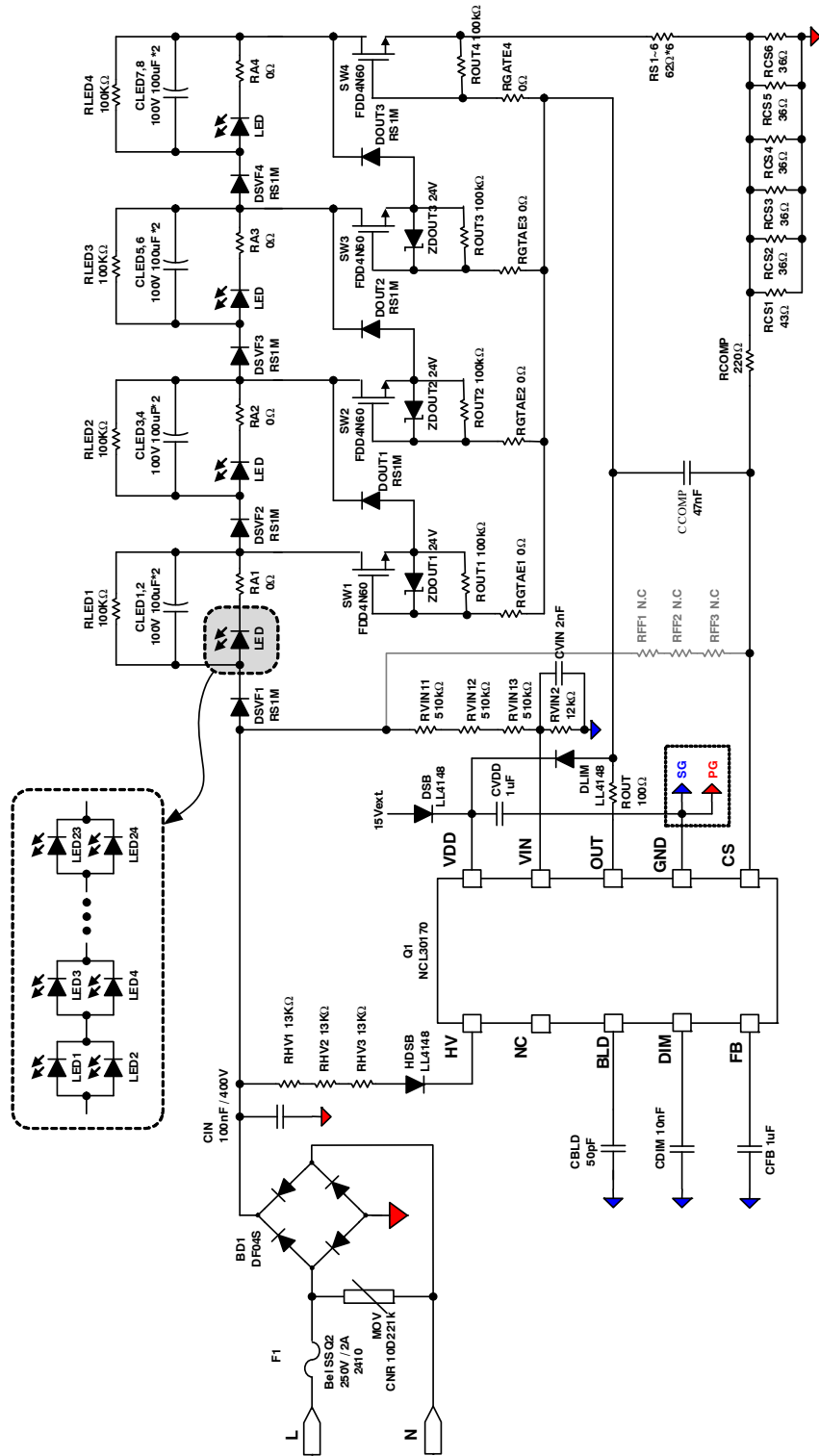


Figure 2. Schematic for High Line 60 W ADIM

TND6288/D

Table 3. BILL OF MATERIALS FOR HIGH LINE (BOM)

Part Reference	Part Description	Q'ty	Vendor	Value
Q1	NCL30170 / IC SOIC 10	1	ON Semiconductor	NCL30170
F1	2 A, 250 Vac MF2410F2.000TM	1	AEM	SMD
MOV	STF 10D391K	1		10φ
RCS1	RES, SMD, 1/2 W, 3216	1	Yageo	43 Ω
RCS2 ~ RCS6	RES, SMD, 1/2 W, 3216	5	Yageo	36 Ω
RHV1, RHV2, RHV3	RES, SMD, 1/2 W, 3216	3	Yageo	13 KΩ
RVIN11, RVIN12, RVIN13	RES, SMD, 1/2 W, 3216	3	Yageo	510 KΩ
RVIN2	RES, SMD, 1/2 W, 3216	1	Yageo	12 KΩ
RLED1 ~ RLED4, ROUT1 ~ ROUT4	RES, SMD, 1/2 W, 3216	8	Yageo	100 KΩ
ROUT	RES, SMD, 1/2 W, 3216	1	Yageo	100 Ω
RCOMP	RES, SMD, 1/2 W, 3216	1	Yageo	220 Ω
RS1 ~ RS6	RES, SMD, 1/2 W, 3216	6	Yageo	62 Ω
CVIN	100 nF / 600 V	1		100 nF
CLED1 ~ CLED8	100 μF / 100 V	8	Samwha	100 μF
CVDD	Cap, 3216 SMD, Ceramic, 50 V, X7R	1	Kemet	1 μF
CBLD	Cap, 2012 SMD, Ceramic, 25 V, X7R	1	Kemet	50 pF
CDIM	Cap, 2012 SMD, Ceramic, 25 V, X7R	1	Kemet	10 nF
CFB	Cap, 2012 SMD, Ceramic, 25 V, X7R	1	Kemet	1 μF
CCOMP	Cap, 3216 SMD, Ceramic, 50 V, X7R	1	Kemet	47 nF
CVIN2	Cap, 3216 SMD, Ceramic, 50 V, X7R	1	Kemet	2 nF
DLIM	Diode, 100 V, 150 mA, Fast recovery	1	ON Semiconductor	LL4148
DSVF1 ~ DSVF4, DOUT1 ~ DOUT3	Diode, 1000 V, 1 A, Fast recovery	7	ON Semiconductor	RS1M
DSB, HDSB	Diode, 100 V, 150 mA, Fast recovery	2	ON Semiconductor	LL4148
ZDOUT1, ZDOUT2, ZDOUT3	ZENER Diode, 24 V	3	ON Semiconductor	24 V
BD1	Bridge Diode 400 V, 1 A	1	ON Semiconductor	DF04S
LED1 ~ LED96	MP-3030-2100-30-80	96	LUMINUS	6 V / 240 mA
SW1, SW2, SW3, SW4	MOSFET, 600 V, 4 A	4	ON Semiconductor	FDD4N60NZ
RGATE1 ~ 4, RA1 ~ 4	RES, SMD, 1/2 W, 3216	30	Yageo	0 Ω
RFF1 ~ 3		5		Open

TND6288/D

PERFORMANCE

Test Data – Analog Dimming Mode

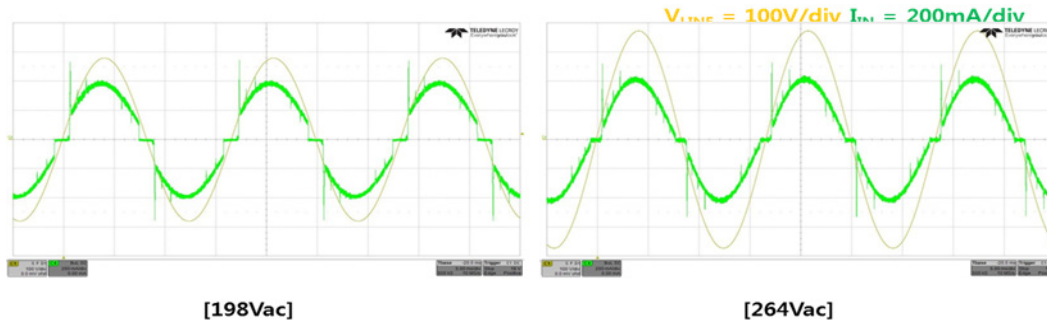


Figure 3. Normal Operation for High Line ADIM

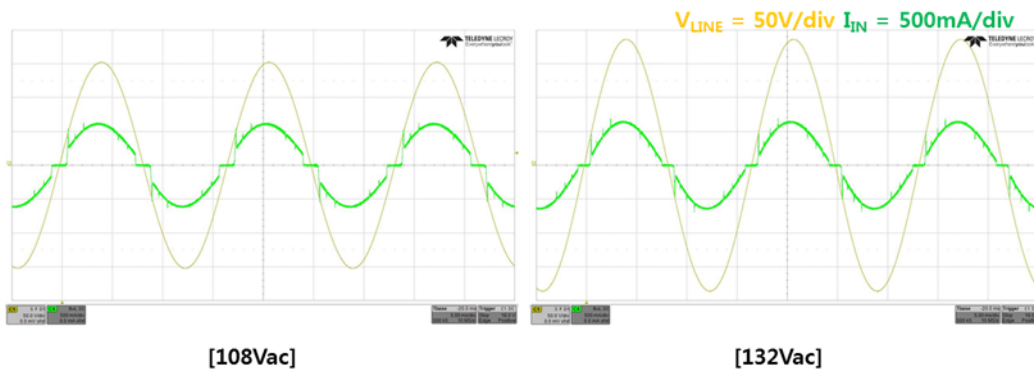


Figure 4. Normal Operation for Low Line ADIM

Table 4. POWER FACTOR AND THD FOR INPUT VOLTAGE

60 W High Line EVB				50 W Low Line EVB			
Input Voltage [Vac]	Input Power [W]	PF	THD [%]	Input Voltage [Vac]	Input Power [W]	PF	THD [%]
198	56.41	0.991	12.967	108	45.523	0.991	11.162
230	64.01	992	10.336	120	50.727	0.992	9.737
264	74.5	0.992	9.638	132	56.032	0.992	9.654

TND6288/D

High line 60W ADIM

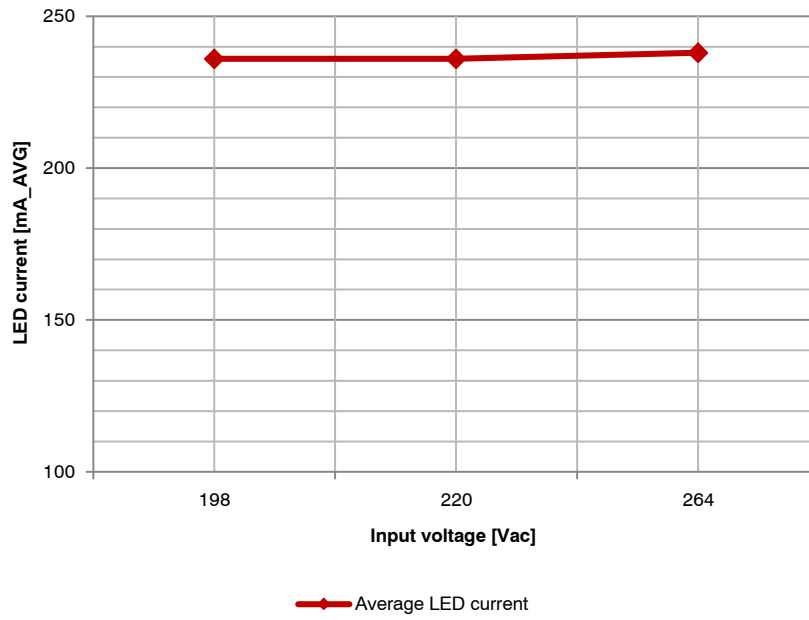


Figure 5. Line Regulation Performance for High Line (ADIM)

Low line 50W ADIM

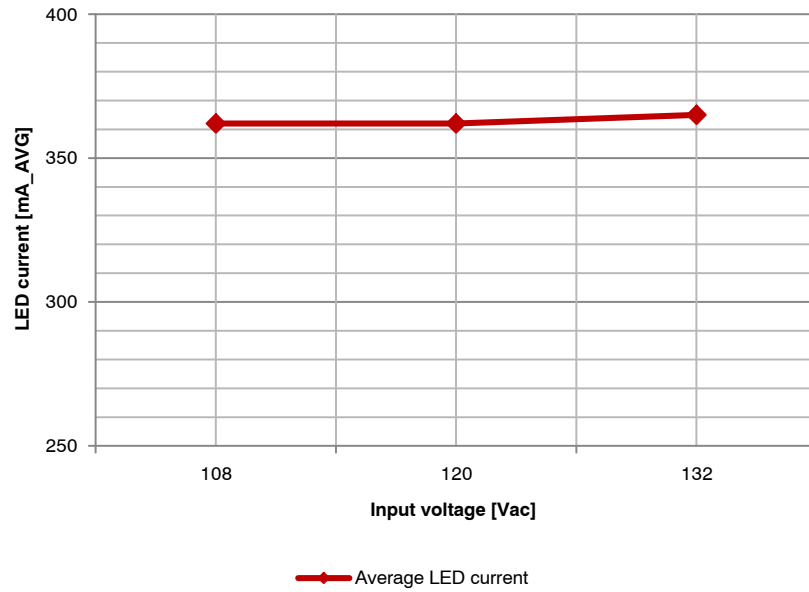


Figure 6. Line Regulation Performance for Low Line (ADIM)

TND6288/D

Dimming Performance

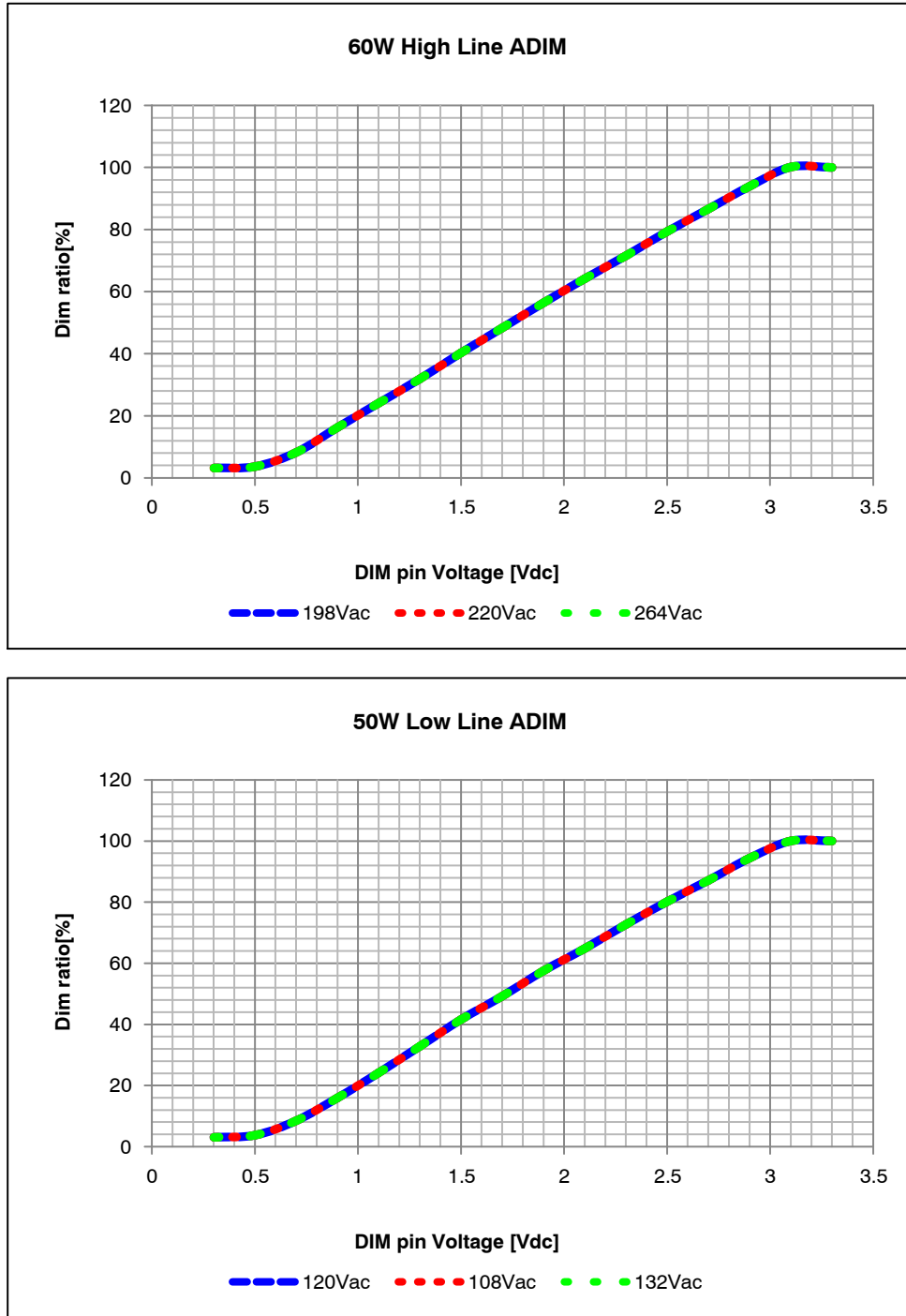


Figure 7. Dimming Curve for Analog Dimming

Percent Flicker with Electrolytic Capacitor

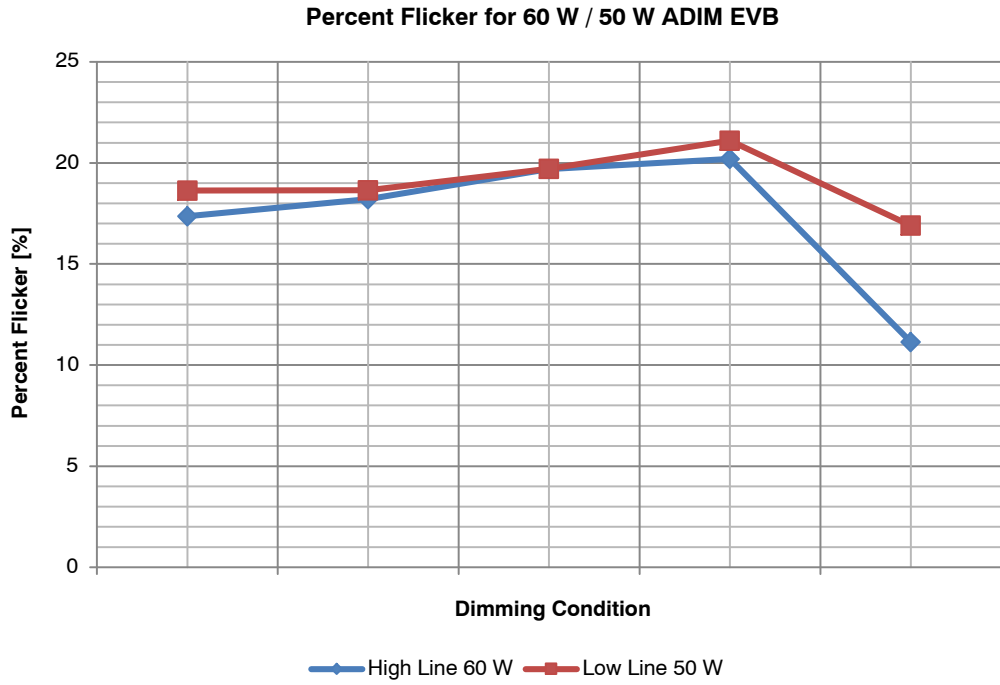
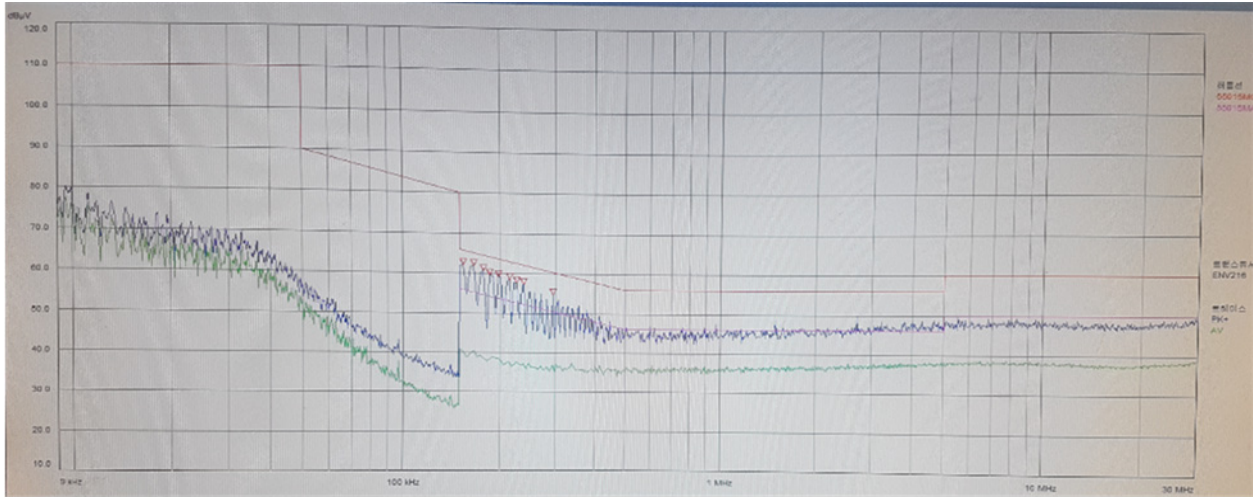
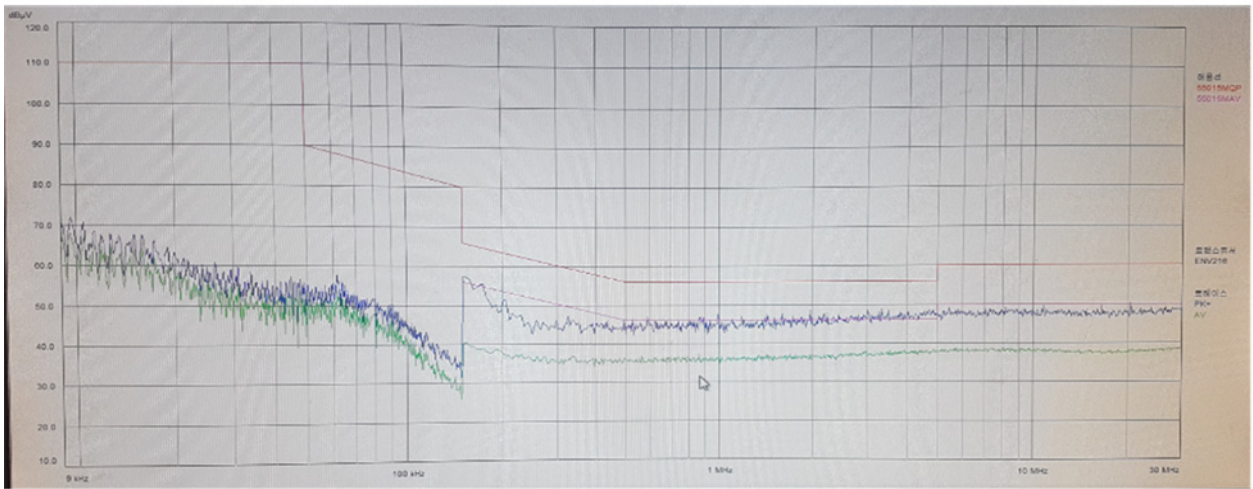


Figure 8. Percent Flicker Performance

Conducted EMI



[60W High Line ADIM]



[50W Low Line ADIM]

Figure 9. EMI Test Result for NCL30170 60 W / 50 W EVB

TND6288/D

Surge Test

Test condition:

Boards mounted to 25 cm x 18 cm x 4.5 cm heatsink

Heatsink connected to Earth ground


DM: Differential Mode test applies surge between Line and Neutral

CM: Common Mode test applies surge between Line + Neutral connected and Earth ground

Combination wave: 3 strikes

Table 5. TEST RESULT FOR COMBINATION WAVE

Test EVB	Test Result	Surge Immunity Component
60 W High Line	±2 kV passed	MOV 10D221K (10pi)
50 W Low Line	±2 kV passed	MOV 10D391K (10pi)

ON Semiconductor and  are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor 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 ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor 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. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor 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 ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor 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 ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor
19521 E. 32nd Pkwy, Aurora, Colorado 80011 USA
Phone: 303-675-2175 or 800-344-3860 Toll Free USA/Canada
Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800-282-9855 Toll Free
USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910

ON Semiconductor Website: www.onsemi.com
Order Literature: <http://www.onsemi.com/orderlit>

For additional information, please contact your local Sales Representative