International
IOR Rectifier

APPLICATION NOTE

AN-1021

International Rectifier • 233 Kansas Street El Segundo CA 90245 USA

IR2159: 40W/PL-L Lamp Dimmable Ballast

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TOPICS COVERED

Introduction
Functional Description
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Bill of Materials
Waveforms / Measurements

Please Note: This demoboard has been adjusted for the PL-L/40W lamp type.

INTRODUCTION

The following design is a fully-functional dimming ballast adjusted specifically for the PL-L/40W lamp type. The design includes EMI filter, rectifier, active PFC, ballast output stage and IR2159 Dimming Control IC. A typical ballast stage using current-mode filament heating (filaments placed inside L-C tank) will result in excessive lamp voltage during preheat and excessive filament current during running. The output stage has therefore been modified for voltage-mode filament heating using secondary windings off of the resonant inductor. The result is a more flexible ballast output stage necessary for fulfilling the lamp requirements. The IR2159 Dimming Control IC is used to regulate lamp power, set the minimum and maximum brightness levels and protect the ballast against conditions such as lamp strike failures, filament failures, low DC bus, thermal overload or lamp failure during normal operation***. Please note that this design does not include a complete EMI filter or an isolated dimming interface.***

FUNCTIONAL DESCRIPTION

The output stage has been modified for voltage-mode filament heating (Figure 1). The lamp has been placed outside the under-damped resonant circuit loop which consists of L3 and C13. The filament heating during preheat and dimming is achieved using voltage-mode filament heating with secondary windings off of the resonant inductor (L3A, L3B). The filament heating during preheat (see figure 4) can be adjusted with capacitors C15 and C16. The DC blocking capacitor, C13, is also placed outside the under-damped resonant circuit loop such that it does not influence the natural resonance frequency of L3 and C14. The snubber capacitor, C12, also serves as a charge-pump for supplying the IR2159 and PFC IC. Resistors RMIN and RMAX have been adjusted for each lamp type to set the minimum and maximum brightness levels (See Table 1).

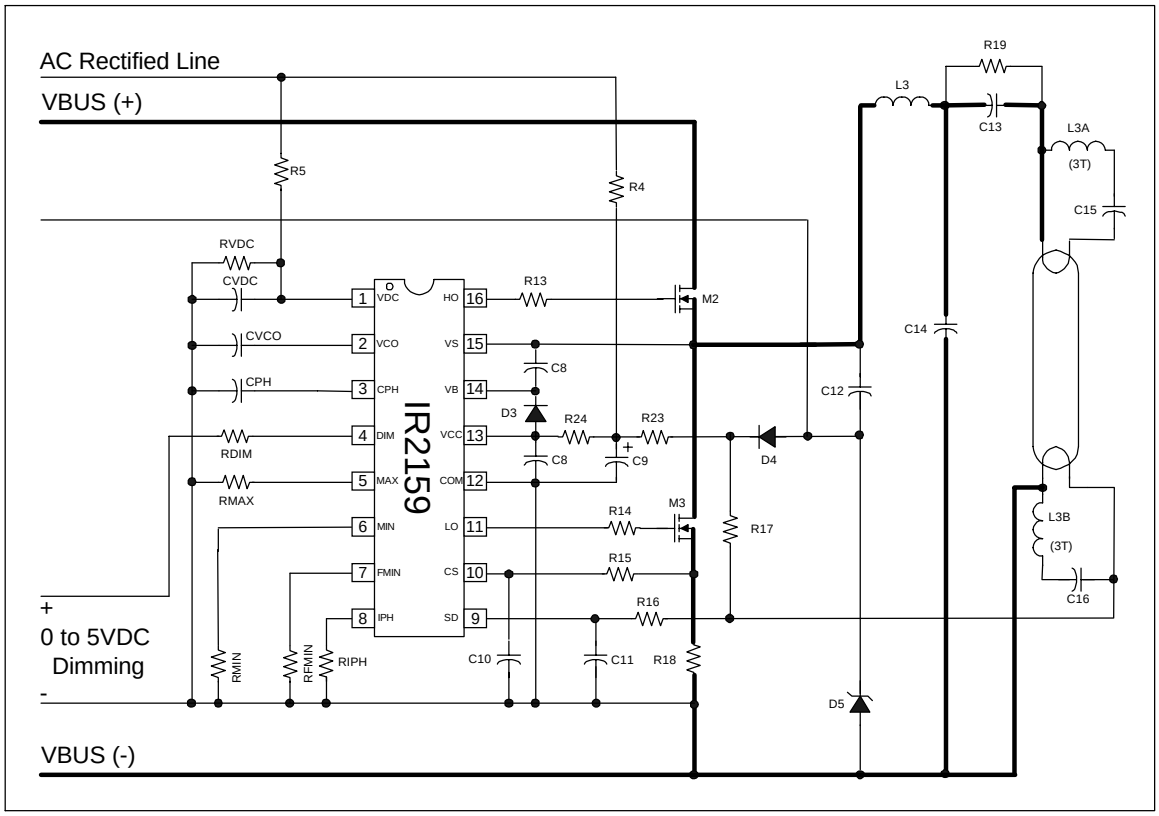
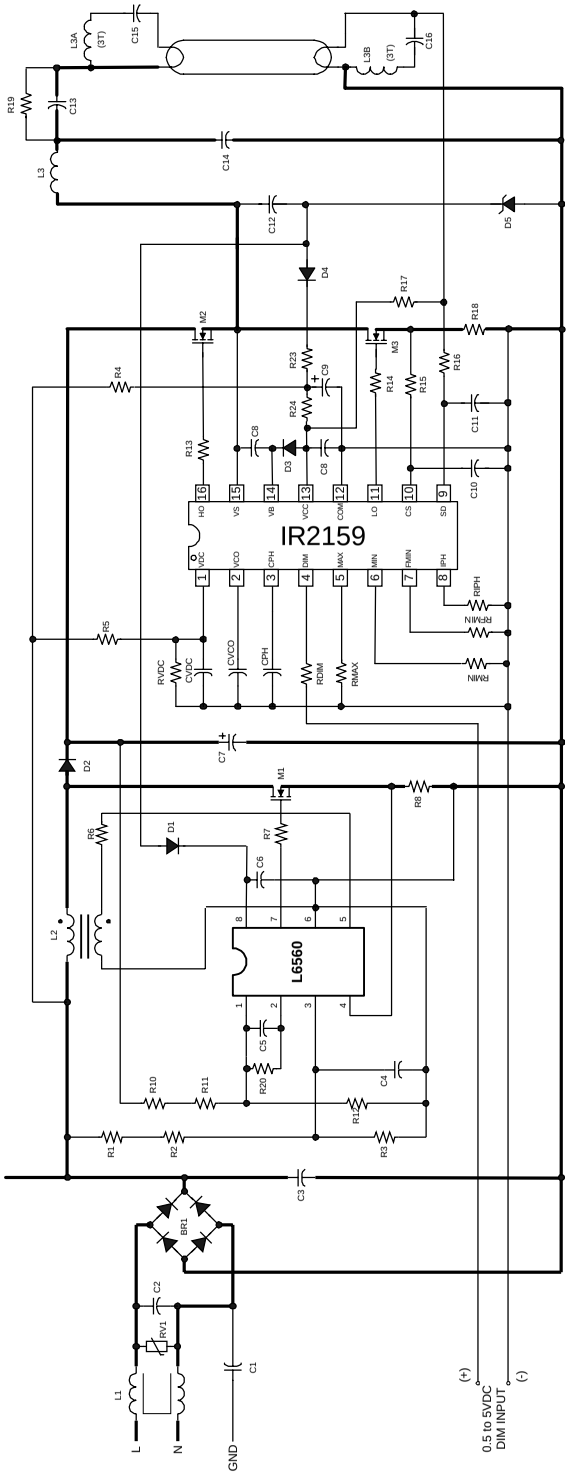


Figure 1: Ballast Output Stage with Voltage Mode Heating

Schematic Diagram



Note: Thick traces represent high-frequency, high-current paths. Lead lengths should be minimized to avoid high-frequency noise problems

Item #	Qty	Manufacturer	Part Number	Description	Reference
1	1	International Rectifier	DF10S	Bridge Rectifier, 1A 1000V	BR1
2	1	Roederstein	WY0222MCMBF0K	Capacitor, 2.2nF 275 VAC Y	C1
3	1	RG Allen	275MKP334K	Capacitor, 0.33uF 275 VAC	C2
4	2	RG Allen	400MPS104K06A	Capacitor, 0.1uF 400 VDC	C3, C13
5	1	RG Allen	S1206Z103K1HRN	Capacitor, 0.01uF SMT 1206	C4
6	3	RG Allen	S1206Z474K1HRN	Capacitor, 0.47uF SMT 1206	C5, C6, CVDC
7	1	RG Allen	2V10M350TB110X20	Capacitor, 10uF 450VDC 105C	C7
8	2	RG Allen	S1206Z104K1HRN	Capacitor, 0.1uF SMT 1206	C8, C11
9	1	RG Allen	S1206Z274K1HRN	Capacitor, 0.27uF SMT 1206	CPH
10	1	RG Allen	1H4R7M50TB15X11	Capacitor, 4.7uF 50VDC 105C	C9
11	1	RG Allen	S1812N152K3ARN	Capacitor, 1nF 1KV SMT 1812	C12
12	1	RG Allen	1600PPSA682K09A	Capacitor, 6.8nF,1600V	C14
13	2	RG Allen	R15W334M1HA5R	Capacitor, 0.22uF, 50V	C15, C16
14	1	RG Allen	S1206N222K2ARN	Capacitor, 22nF SMT 1206	CVCO
15	1	RG Allen	S1206N101K2ARN	Capacitor, 220pF SMT 1206	C10
16	2	Diodes	LL4148DICT-ND	Diode, 1N4148 SMT DL35	D1, D4
17	3	International Rectifier	10BF60	Diode, SMT SMB	D2, D3
18	1	Diodes	ZMM5247BCT	Diode, Zener 17V SMT DL35	D5
19	1	ST	L6560	IC, Power Factor Controller	IC1
20	1	International Rectifier	IR2159	IC, Ballast Driver	IC2
21	1	Panasonic	ELF-15N007A	EMI Inductor, 1X10mH 0.7Apk	L1
22	1	RG Allen	RGA-K86960	PFC Inductor, 2.0mH 2.0Apk	L2
23	1	RG Allen	To be determined	Inductor, 2.0mH, 2.5Apk with secondary windings of 3 turns	L3, L3A,L3B
24	1	International Rectifier	IRF820	Transistor, MOSFET	M1
25	2	International Rectifier	IRF820	Transistor, MOSFET	M2, M3
26	2	RG Allen	CR32C684JT	Resistor, 680K ohm SMT 1206	R1, R2
27	1	RG Allen	CR32C752JT	Resistor, 7.5K ohm SMT 1206	R3
28	2	RG Allen	CR32C824JT	Resistor, 820K ohm SMT 1206	R10, R11
29	3	RG Allen	CR32C103JT	Resistor, 10K ohm SMT 1206	RDIM, RIPH, R12
30	1	RG Allen	CR32C223JT	Resistor, 22K ohm SMT 1206	R6
31	3	RG Allen	CR32C220JT	Resistor, 22 ohm SMT 1206	R7, R13, R14
32	1	RG Allen	RSMF1/2W1R0FT	Resistor, 1 ohm ½ watt	R8
33	1	RG Allen	RSMF1/2WR91FT	Resistor, 0.91 ohm ½ watt	R18
34	1	RG Allen	CR32C273JT	Resistor, 27K ohm SMT 1206	RVDC
35	1	RG Allen	CR32C105JT	Resistor, 1.0M ohm SMT 1206	R17
36	1	RG Allen	CR32C102JT	Resistor, 1K ohm SMT 1206	R15
37	2	RG Allen	CR32C104JT	Resistor, 100K ohm SMT 1206	R16, R20
38	1	RG Allen	R25G105JT	Resistor, 1.0M ohm ¼ watt	R5
39	1	RG Allen	R25G283JT	Resistor, 28K ohm ¼ watt	RMAX
40	1	RG Allen	R25G163JT	Resistor, 16K ohm ¼ watt	RIPH
41	1	RG Allen	CR32C243JT	Resistor, 24K ohm SMT 1206	RMIN 1
42	3	RG Allen	R25G104JT	Resistor, 100K ohm ¼ watt	R4, R18, R20
43	1	RG Allen	CR32C303JT	Resistor, 30K ohm SMT 1206	RFMIN
44	1	RG Allen	RV05K300	Transient Suppressor	RV1
45	2	RG Allen	CR32C100JT	Resistor, 10 ohm SMT 1206	R23, R24
Total	**64**				

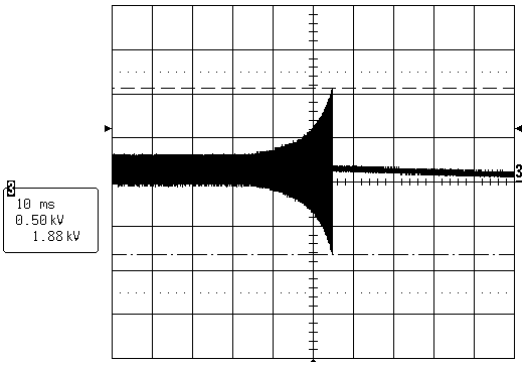


Figure 2: Lamp Voltage during Ignition (500V/div)

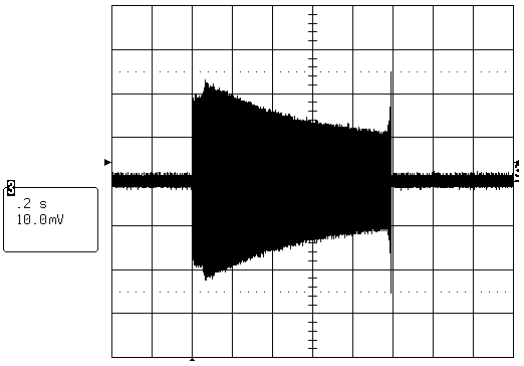


Figure 3: Filament Current during Preheat

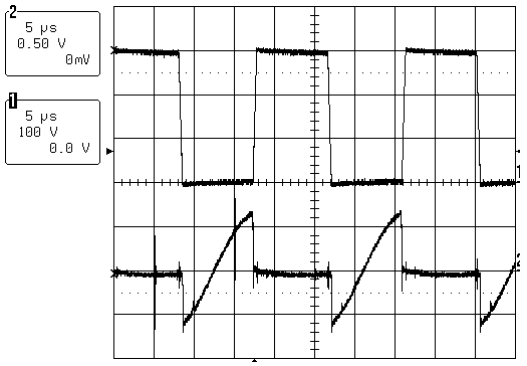


Figure 4: VS & CS during 10% Dimming

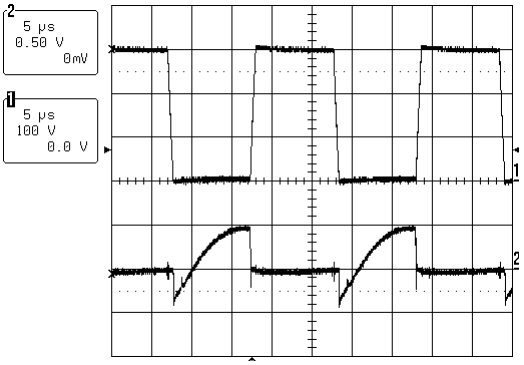


Figure 5: VS & CS during 100% Dimming

Parameter	Units	PL-L/40W
Preheat Frequency	**kHz**	58
Lamp Preheat Voltage Vpp	**Vpp**	520
Ignition Frequency KHz	**kHz**	46
Lamp Ignition Voltage	**kVpp**	2.0
100% Dimming Frequency	**kHz**	45
100% Lamp Voltage	**Vpp**	400
100% Ballast Input Power	**Watts**	40.0
100% Ballast Power Factor		0.99
5% Dimming Frequency	**kHz**	55
5% Lamp Voltage	**Vpp**	535
5% Ballast Input Power	**Watts**	11.0

Table 1: Ballast Measurement Summary