Application Note AN-1020

IR21571: T5 Lamp Ballast Using Voltage-Mode Filament Heating

By T. Ribarich, E. Thompson

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T5 lamps are becoming more popular due to their lower profile and higher lumen/watt output. These lamps, however, can be more difficult to control due to their higher ignition and running voltages. 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 IR21571 Ballast Control IC is used to program the ballast operating points and protect the ballast against conditions such as lamp strike failures, filament failures, low DC bus, thermal overload or lamp failure during normal operation.

International
IOR Rectifier

APPLICATION NOTE

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TOPICS COVERED

Introduction
Functional Description
Schematic Diagrams
Bill of Materials

INTRODUCTION

T5 lamps are becoming more popular due to their lower profile and higher lumen/watt output. These lamps, however, can be more difficult to control due to their higher ignition and running voltages. 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 IR21571 Ballast Control IC is used to program the ballast operating points and protect the ballast against conditions such as lamp strike failures, filament failures, low DC bus, thermal overload or lamp failure during normal operation.

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 C15. 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 C18 and C19. The DC blocking capacitor, C16, is also placed outside the under-damped resonant circuit loop such that it does not influence the natural resonance frequency of L3 and C15. The snubber capacitor, C14, also serves as a charge-pump for supplying the IR21571 and PFC IC.

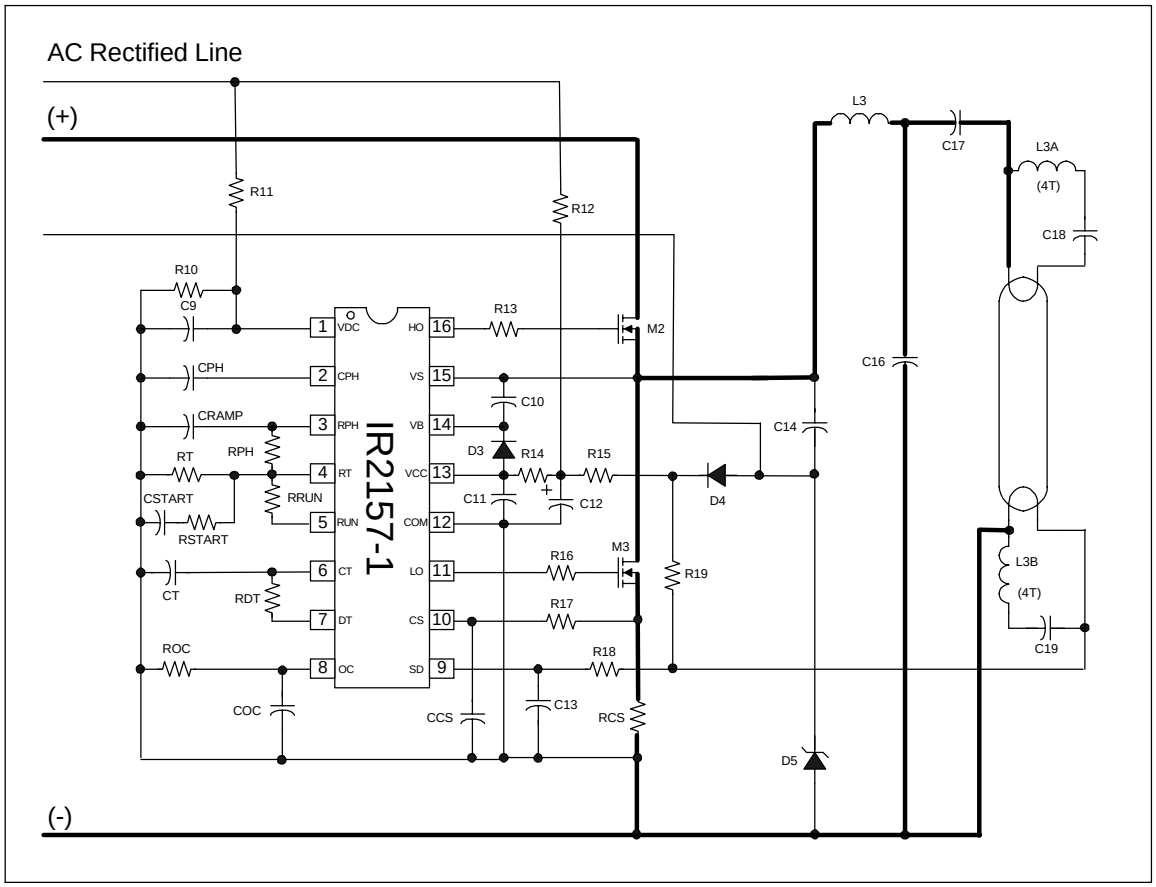
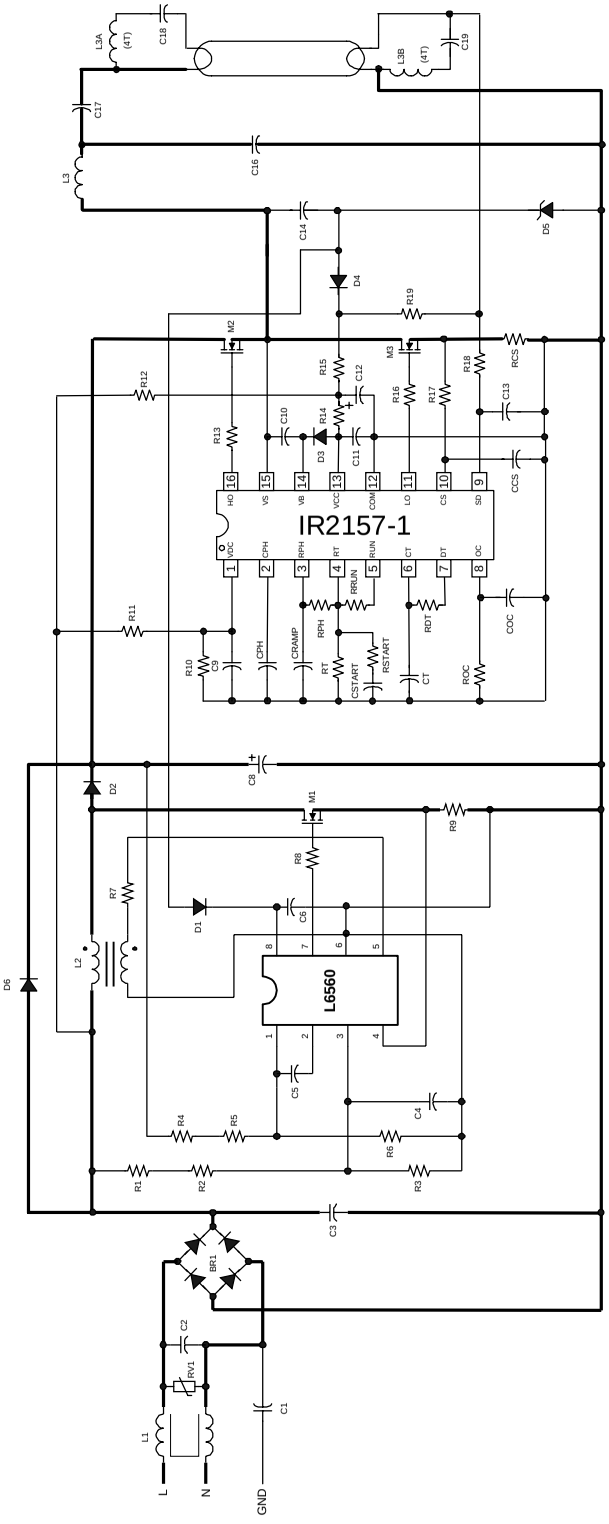


Figure 1. Ballast Output Stage with Voltage Mode Heating

Schematic Diagram



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

Bill of Materials

Lamp type: T5/35W/28W/14W

Line Input Voltage: 180..255 VAC/50..60 Hz

Item #	Qt	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 Cap	C1
3	1	RG Allen	275MKP334K	Capacitor, 0.33uF 275 VAC	C2
4	1	RG Allen	400MPS104K06A	Capacitor, 0.1uF 400 VDC	C3
5	2	RG Allen	S1206Z103K1HRN	Capacitor, 0.01uF SMT 1206	C4, CSTART
6	2	RG Allen	S1206Z474K1HRN	Capacitor, 0.47uF SMT 1206	C5,C6
7	1	RG Allen	2V10M350TB110X20	Capacitor, 10uF 350VDC 105C	C8
8	3	RG Allen	S1206Z104K1HRN	Capacitor, 0.1uF SMT 1206	C10, C11, COC
9	3	RG Allen	S1206Z224K1HRN	Capacitor, 0.22uF SMT 1206	CPH, C9, CRAMP
10	1	RG Allen	1H4R7M50TB15X11	Capacitor, 4.7uF 50VDC 105C	C12
11	1	RG Allen	S1812N152K3ARN	Capacitor, 1.5nF 1KV SMT 1812	C14
12	1	RG Allen	1600PPSA472K09A	Capacitor, 4.7nF,1600V	C16
13	1	RG Allen	400MEF224K08A	Capacitor, 0.22uF, 400V	C17
14	2	RG Allen	R15W334M1HA5R	Capacitor, 0.33uF, 50V	C18, C19
15	1	RG Allen	S1206N471K2ARN	Capacitor, 470pF SMT 1206	CT
16	1	RG Allen	S1206N101K2ARN	Capacitor, 100pF SMT 1206	CCS
17	2	Diodes	LL4148DICT-ND	Diode, 1N4148 SMT DL35	D1, D4
18	3	International Rectifier	10BF60	Diode, SMT SMB	D2, D3, D6
19	1	Diodes	ZMM5247BCT	Diode, Zener 17V SMT DL35	D5
20	1	ST	L6560	IC, Power Factor Controller	IC1
21	1	International Rectifier	IR21571	IC, Ballast Driver	IC2
22	1	Panasonic	ELF-15N007A	EMI Inductor, 1X10mH 0.7Apk	L1
23	1	RG Allen	RGA-K86960	PFC Inductor, 2.0mH 2.0Apk	L2
24	1	RG Allen	To be determined	Inductor, 4.0mH, 1.5Apk with 2 secondary windings of 4 turns	L3, L3A,L3B
25	3	International Rectifier	IRFBC30	Transistor, MOSFET	M1, 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	R4, R5
29	1	RG Allen	CR32C103JT	Resistor, 10K ohm SMT 1206	R6
30	2	RG Allen	CR32C223JT	Resistor, 22K ohm SMT 1206	R7, RSTART
31	3	RG Allen	CR32C220JT	Resistor, 22 ohm SMT 1206	R8, R13, R16
32	2	RG Allen	RSMF1/2W1R2FT	Resistor, 1.2 ohm ½ watt	R9, RCS
33	1	RG Allen	CR32C563JT	Resistor, 56K ohm SMT 1206	R10
34	1	RG Allen	R25G225JT	Resistor, 2.2M ohm ¼ watt	R11
35	1	RG Allen	CR32C102JT	Resistor, 1K ohm SMT 1206	R17
36	2	RG Allen	R25G394JT	Resistor, 390K ohm ¼ watt	R12, R18
37	1	RG Allen	R25G105JT	Resistor, 1.0M ohm ¼ watt	R19
38	1	RG Allen	CR32C243JT	Resistor, 24K ohm SMT 1206	ROC
39	1	RG Allen	CR32C273JT	Resistor, 27K ohm SMT 1206	RPH
40	1	RG Allen	CR32C104JT	Resistor, 100K ohm SMT 1206	RRUN
41	1	RG Allen	CR32C103JT	Resistor, 10K ohm SMT 1206	RDT
42	1	RG Allen	CR32C203JT	Resistor, 20K ohm SMT 1206	RT
43	1	RG Allen	RV05K300	Transient Suppressor	RV1
44	2	RG Allen	CR32C103JT	Resistor, 10 ohm SMT 1206	R14, R15
Total	64				

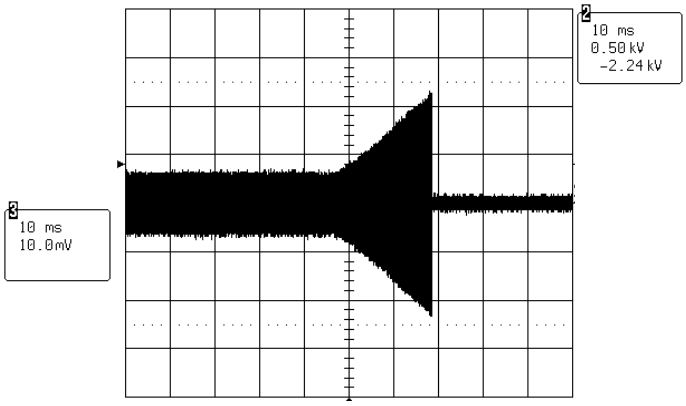


Figure 2, Inductor Current During Ignition
(500mA/div)

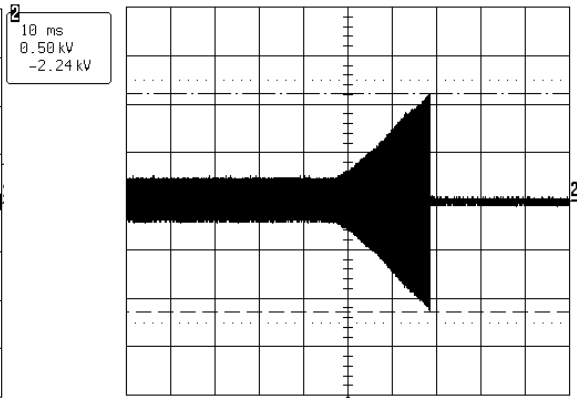


Figure 3, Lamp Voltage During Ignition
(500V/div)

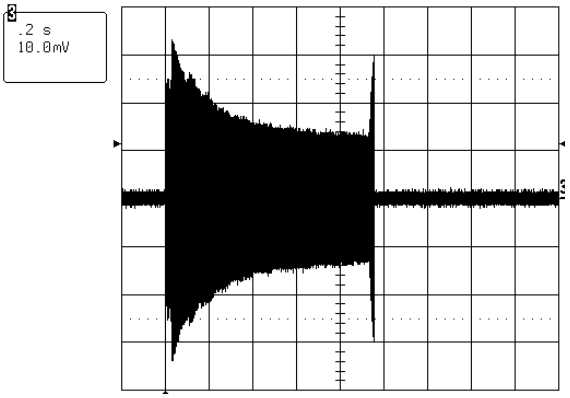


Figure 4, Filament current during Preheat
(T5/35W)

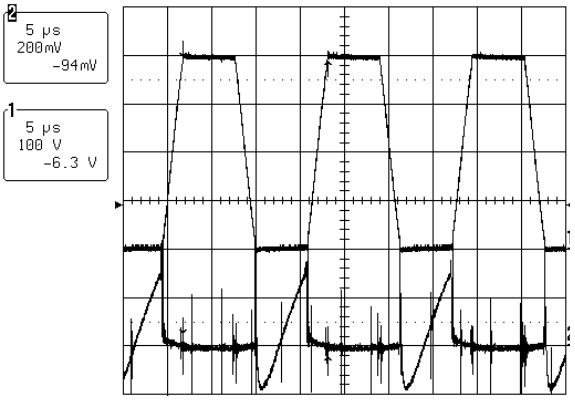


Figure 5, VS & CS during preheat
(T5/35W)

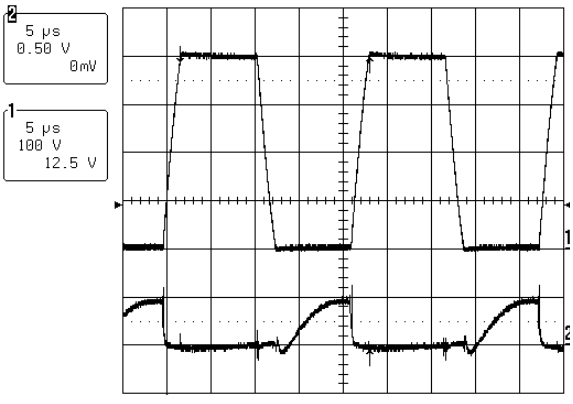


Figure 6, VS & CS during running
(T5/35W)

Parameter	T5/35W	T5/28W	T5/14W
Preheat Frequency	60 kHz	60 kHz	60 kHz
Lamp Preheat Voltage	350 Vpp	350 Vpp	350 Vpp
Lamp Ignition Voltage	2KVpp	2KVpp	2KVpp
Run Frequency	42 kHz	42 kHz	42 kHz
Ballast PF	0.99	0.99	0.95
Lamp Running Voltage	720 Vpp	575 Vpp	265 Vpp
Ballast Input Power	35W	28W	14W

Table 1. Ballast Input / Output Measurements