Application Note AN-1013

IR21571: Dual Lamp Series Configuration

By T. Ribarich, E. Thompson, A. Mathur

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Dual lamps connected in series is the popular conventional magnetic ballast retrofit configuration for the U.S. lighting market. The center lamp filaments are connected in parallel which results in six connections to the lamps from the output of the ballast. This retrofit configuration is accomplished using the IR21571 and some modifications to the ballast output stage. Through externally programmable components, the IR21571 affords flexibility of various features such as preheat time and frequency, ignition ramp characteristics, and running mode operating frequency. Comprehensive protection features protect the circuit against conditions such as lamp strike failures, filament failures, low DC bus, thermal overload, or ramp failure during normal operation. *This circuit switches off both lamps when one is taken out, and automatically restarts when both lamps are in place.*

International
IOR Rectifier

APPLICATION NOTE

AN-1013-A

International Rectifier • 233 Kansas Street El Segundo CA 90245 USA

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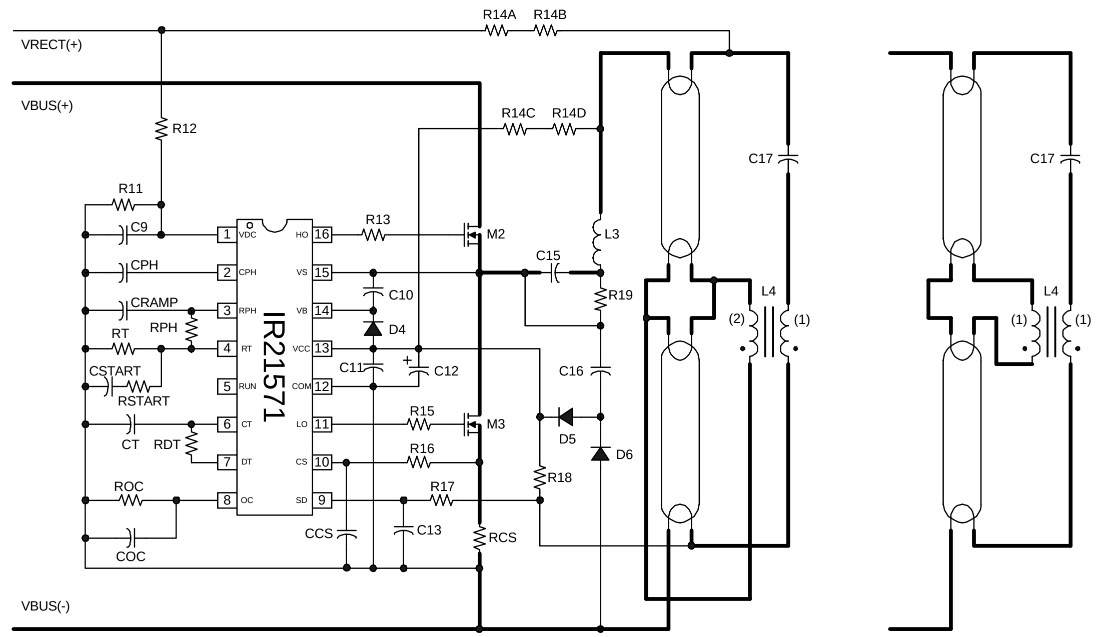
TOPICS COVERED

Introduction
Functional Description
Schematic Diagrams
Waveforms
Bill of Materials

Dual lamps connected in series is the popular conventional magnetic ballast retrofit configuration for the U.S. lighting market. The center lamp filaments are connected in parallel which results in six connections to the lamps from the output of the ballast. This retrofit configuration is accomplished using the IR21571 and some modifications to the ballast output stage. Through externally programmable components, the IR21571 affords flexibility of various features such as preheat time and frequency, ignition ramp characteristics, and running mode operating frequency. Comprehensive protection features protect the circuit against conditions such as lamp strike failures, filament failures, low DC bus, thermal overload, or ramp failure during normal operation. *This circuit switches off both lamps when one is taken out, and automatically restarts when both lamps are in place.*

FUNCTIONAL DESCRIPTION

The output stage circuitry for the series configuration is shown in Figures 1 and 2. The configuration is similar to that for a single lamp except the middle filaments must be heated as well. The configuration in Fig. 2a shows the middle filaments connected in parallel. The primary to secondary turns ratio for transformer L4 is 1:2, which doubles the current for the two middle filaments. As filament current flows during preheat, the filament with the smaller resistance draws more current. However, as the filament heats up the resistance also increases which causes more current to flow through the second filament. As the second filament heats up then current flows again through the first filament. This positive temperature coefficient effect keeps the currents balanced in the filaments continuously such that they are heated equally during the preheat mode. The configuration in Fig. 2b shows the filaments connected in series which may be a desirable configuration as well. The same current flows through each filament resulting in a turns ratio for L4 of 1:1. For either configuration, if one of the middle cathodes is removed, an over-current condition is sensed at the current sense pin. This causes a fault condition and the IC shuts down. The micro-power current supply resistor is connected to VCC from the AC rectified line through the upper filament. When the upper filament is removed, the micro-power current is no longer supplied to the IC and VCC falls below under voltage lockout (UVLO). When the lamp is re-inserted, VCC increases again above the UVLO+ threshold and the IC returns to the preheat mode. When the lower cathode is in place, the Shutdown Pin (SD) is kept low through resistor R17. When the lower filament is removed, VCC pulls SD high through resistor R18. At this point, both IR21751 half-bridge outputs are pulled low, and the IC enters micro-power mode. When the lower filament is reinserted, SD is pulled low again and the IC returns to the preheat mode. Additional protection features such as low-line conditions, over-temperature and near-resonance detection are also provided by the IC. (For additional information on these protection features please see the IR21571 datasheet.)



Note: Thick traces represent high-frequency, high-current paths. Lead lengths should be minimized to avoid high-frequency noise problems. The above configuration shows the middle filaments connected in parallel. The configuration at the right shows the middle filaments connected in series with the secondary windings of L4.

Figure 1, Ballast output stage for dual lamp series connection (both parallel and series middle filament configurations).

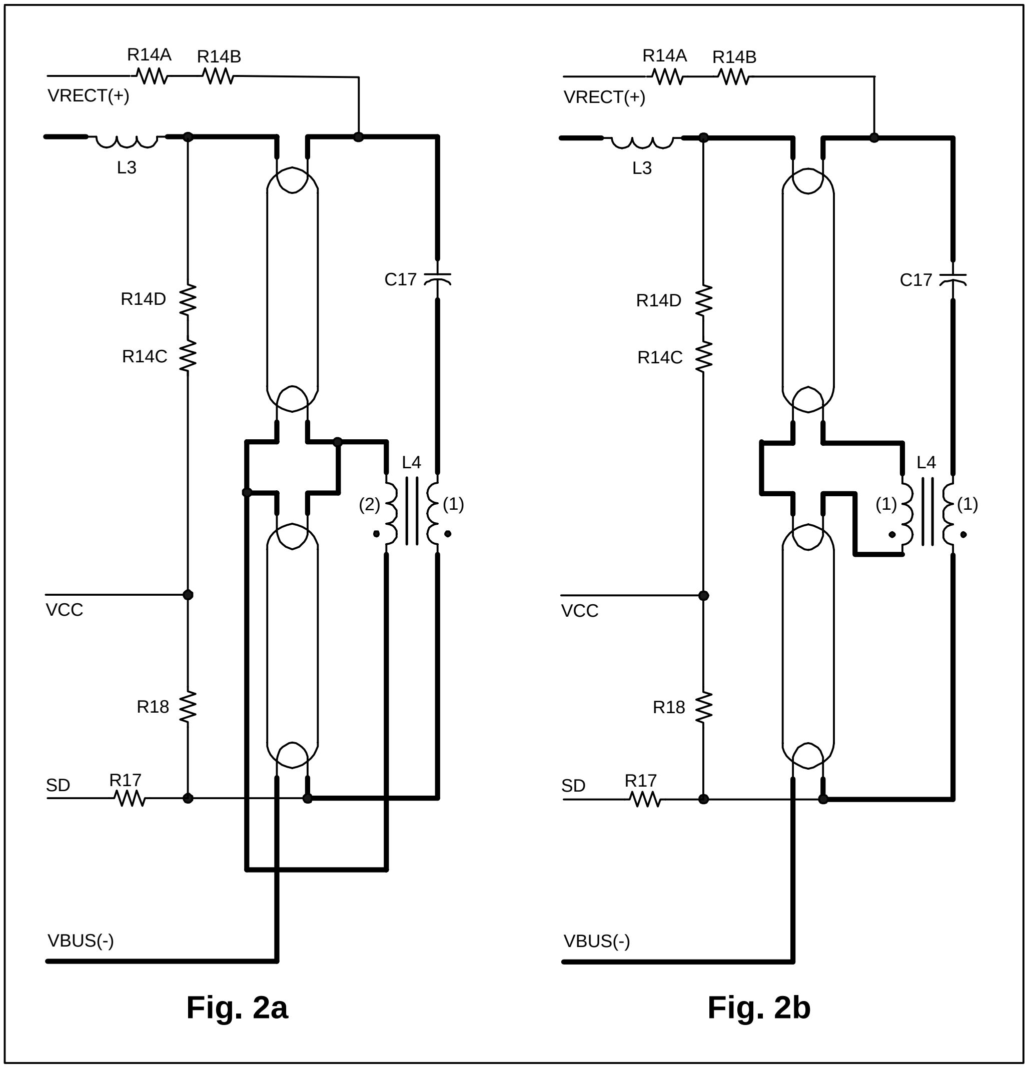


Figure 2, Series lamp connection showing both parallel and series filament configurations.

MEASUREMENTS

Figures 3 and 4 show the lamp filament currents during preheat mode for the parallel center filament configuration. The middle filament current is twice the upper and lower filaments due to the 2:1 winding ratio of transformer L4. Figures 5 and 6 show equal heating in all filaments.

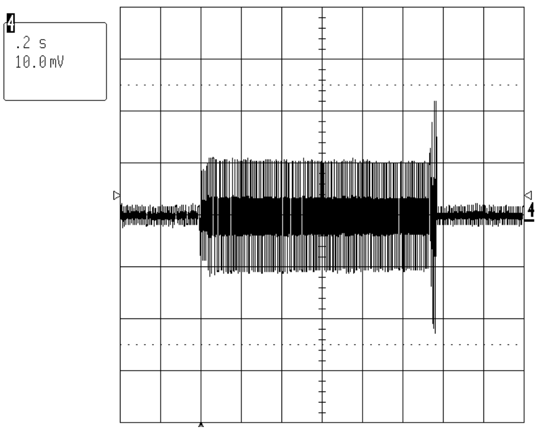


Figure 3. Upper and Lower Filament Currents (1A/Div)

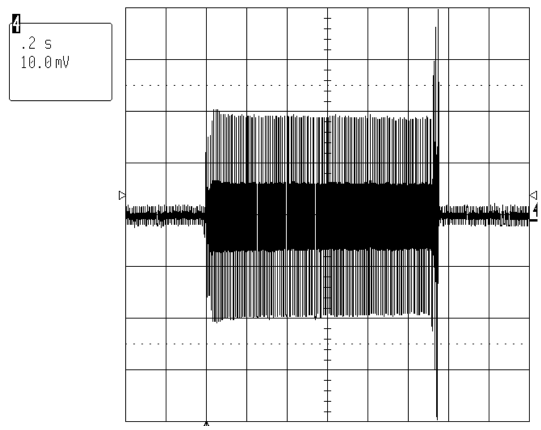


Figure 4. Middle Filament Currents (1A/div)

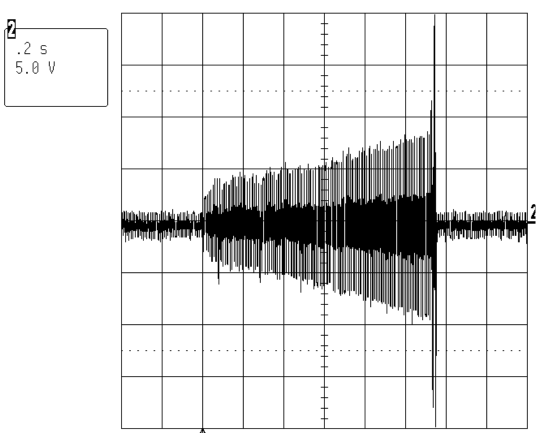


Figure 5. Upper and Lower Filament Voltages

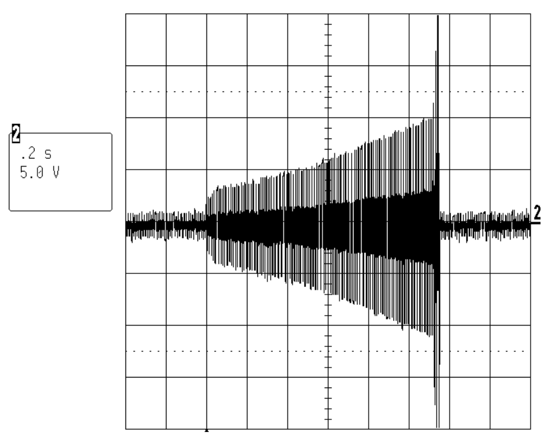


Figure 6. Middle Filament Voltages

MEASUREMENTS (Cont.)

Figure 7 and 8 show the lamp filament currents during ignition for the parallel center filament configuration. The middle filament current is twice the upper and lower filaments due to the 2:1 winding ratio of transformer L4. Figure 9 shows the ignition voltage across both lamps. For dual lamps in series, this voltage is usually set at least 1.5 times the required ignition voltage for a single lamp.

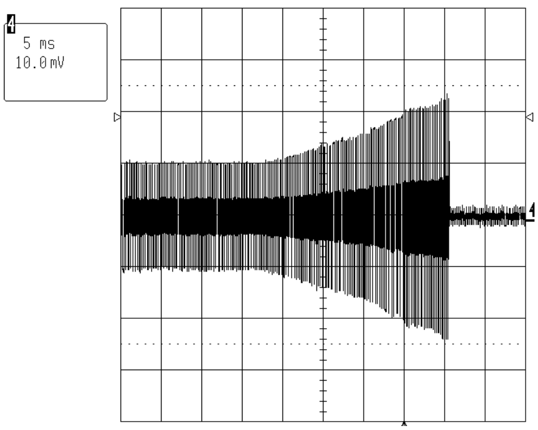


Figure 7. Upper and Lower Filament Ignition Currents (1A/Div)

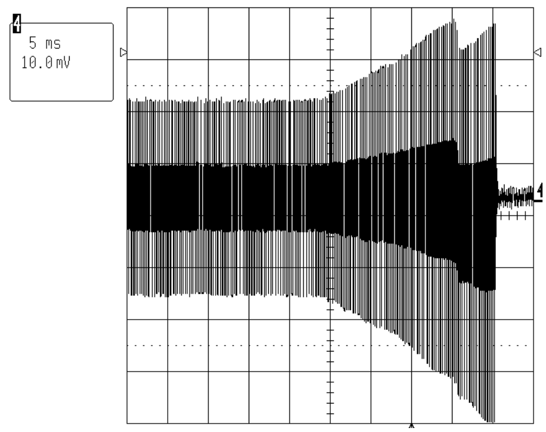


Figure 8. Middle Filament Ignition Current (1A/Div)

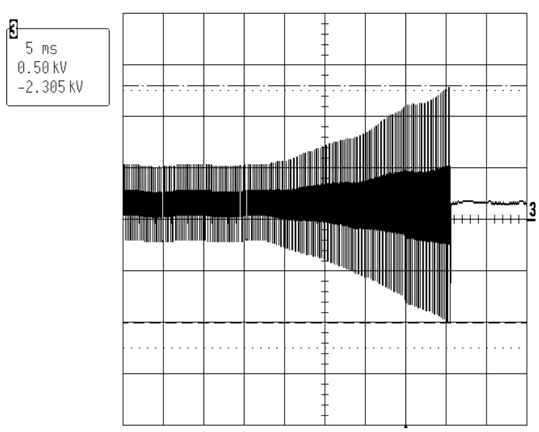


Figure 9, Lamp Ignition Voltage

MEASUREMENTS (Cont.)

Figures 10 and 11 show the lamp filament currents during preheat, ignition and running modes for the parallel center filament configuration. The middle filament current is twice the upper and lower filament currents due to the 2:1 winding ratio of transformer L4. Figure 12 shows the total lamp voltage over both lamps during normal preheat, ignition and running modes

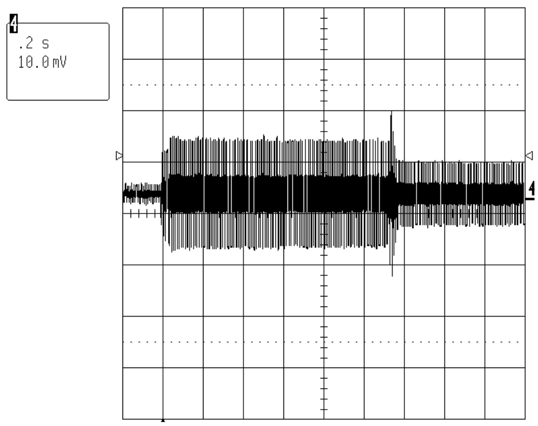


Figure 10. Upper and Lower Filament Current (1A/Div)

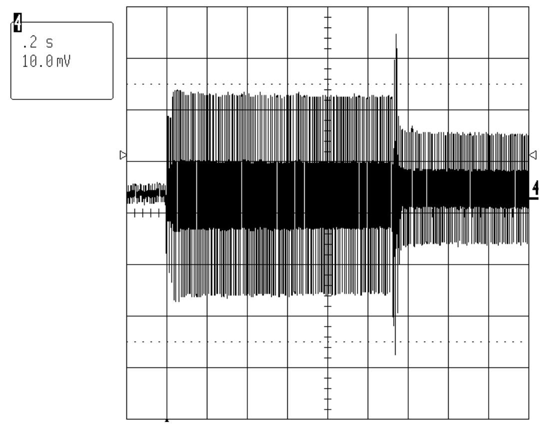


Figure 11. Middle Filament Current (1A/div).

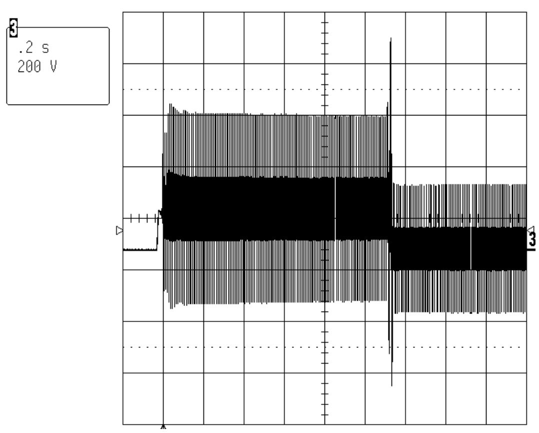
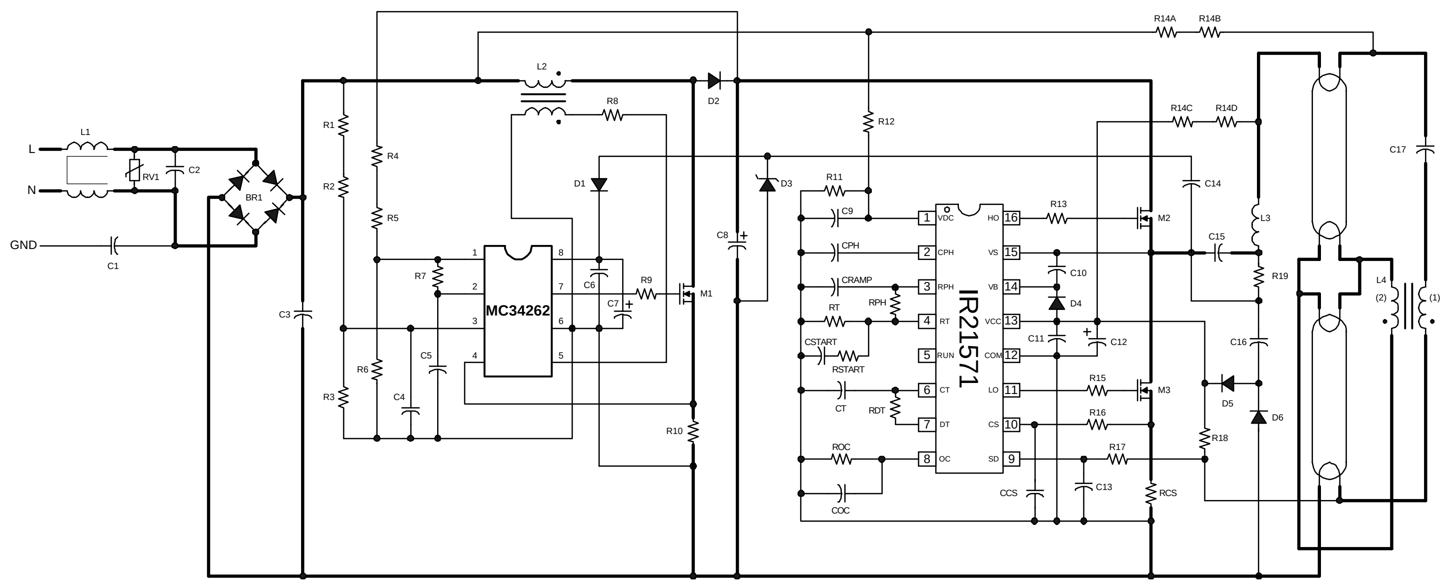


Figure 12. Lamp Voltage



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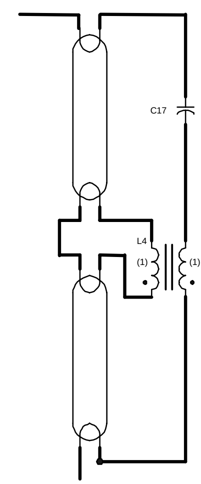

The schematic above shows the middle filaments connected in parallel. In this configuration, L4 is wound in a 1:2 ratio.
The schmatic at the right shows the middle filaments connected in series with the secondary winding of L4. In this configuration, L4 is wound in a 1:1 ratio.

BILL OF MATERIALS

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 Cap	C1
3	1	Roederstein	F1772433-2200	Capacitor, 0.33uF 275 VAC	C2
4	2	Wima	MKP10	Capacitor, 0.01uF 400 VDC	C3, C15
5	2	Panasonic	ECU-V1H103KBM	Capacitor, 0.01uF SMT 1206	C4, CSTART
6	3	Panasonic	ECJ-3YB1E474K	Capacitor, 0.47uF SMT 1206	C5, C6, C13
7	4	Panasonic	ECU-V1H104KBM	Capacitor, 0.1uF SMT 1206	C9, COC, C10, C11
8	1	Panasonic	EEU-EB2V100	Capacitor, 10uF 350VDC 105C	C8
9	1	Panasonic	ECU-V1H471KBM	Capacitor, 470pF SMT 1206	CT
10	1	Panasonic	ECJ-3VB1E334K	Capacitor, 0.33uF SMT 1206	CRAMP
11	1	Panasonic	ECJ-3VB1E274K	Capacitor, 0.27uF SMT 1206	CPH
12	1	Panasonic	ECE-A1HGE010	Capacitor, 1uF 50VDC 105C	C12
13	1	Vitramon	1812A152KXE	Capacitor, 1.5nF 1KV SMT 1812	C14
14	1	Vitramon	1812A102KXE	Capacitor, 1nF 1KV SMT 1812	C16
15	1	Panasonic	ECW-H16682JV	Capacitor, 6.8nF 1.6KV	C17
16	1	Panasonic	ECU-V1H101KBM	Capacitor, 100pF SMT 1206	CCS
17	3	Diodes	LL4148DICT-ND	Diode, 1N4148 SMT DL35	D1, D5, D6
18	2	International Rectifier	10BF60	Diode, SMT SMB	D2, D4
19	1	Diodes	ZMM5250BCT	Diode, Zener 20V SMT DL35	D3
20	1	Motorola	MC34262	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	R.G. Allen	RGA-K86960	PFC Inductor, 2.0mH 2.0Apk	L2
24	1			Inductor, 2mH 3.0Apk	L3
25	1			Inductor, 1:2, EF20, no gap	L4
				50 Turns:100 Turns, AWG 28	
				Inductor, 1:1, EF20, no gap	
				100 Turns:100 Turns, AWG 28	
26	3	International Rectifier	IRF840	Transistor, MOSFET	M1, M2, M3
27	5	Panasonic	ERJ-8GEYJ680K	Resistor, 680K ohm SMT 1206	R1, R2, R4, R5, R17
28	2	Panasonic	ERJ-8GEYJ10K	Resistor, 10K ohm SMT 1206	R3, RSTART
29	1	Panasonic	ERJ-8GEYJ8.2K	Resistor, 8.2K ohm SMT 1206	R6
30	1	Panasonic	ERJ-8GEYJ100K	Resistor, 100K ohm SMT 1206	R7
31	1	Panasonic	ERJ-8GEYJ22K	Resistor, 22K ohm SMT 1206	R8
32	3	Panasonic	ERJ-8GEYJ22	Resistor, 22 ohm SMT 1206	R9, R13, R15
33	1	Dale	CW-1/2	Resistor, 0.5 ohm ½ watt	R10
34	1	Panasonic	ERJ-8GEYJ56K	Resistor, 56K ohm SMT 1206	R11
35	1	Yageo	2.2MQBK-ND	Resistor, 2.2megohm ¼ watt	R12
36	1	Dale	CW-1/2	Resistor, 0.68 ohm ½ watt	RCS
37	1	Panasonic	ERJ-8GEYJ6.8K	Resistor, 6.8K ohm SMT 1206	RDT
38	1	Panasonic	ERJ-8GEYJ30K	Resistor, 30K ohm SMT 1206	ROC
39	1	Panasonic	ERJ-8GEYJ68K	Resistor, 68K ohm SMT 1206	RPH
40	1	Panasonic	ERJ-8GEYJ20K	Resistor, 20K ohm SMT 1206	RT
41	4	Yageo	110KQBK-ND	Resistor, 110K ohm ¼ watt	R14A, R14B, R14C, R14D
42	1	Panasonic	ERJ-8GEYJ1K	Resistor, 1K ohm SMT 1206	R16
43	1	Panasonic	ERJ-8GEYJ1.0M	Resistor, 1.0megohm SMT 1206	R18
44	1	Yageo	100KQBK-ND	Resistor, 100K ohm ¼ watt	R19
45	1	Panasonic	ERZ-V05D471	Transient Suppressor	RV1
Total	67				

Data and specifications subject to change without notice. 10/30/2000