Monolithic Power Systems

EV0019

MP1018 Flat Panel Monitor CCFL Inverter Module

EVALUATION BOARD

General Description

The EV0019 Evaluation Board is designed to demonstrate MPS' MP1018 multiple lamp driving capability. The EV0019 is configured to drive four (4) Cold Cathode Lamps. The MP1018 is a Cold Cathode Florescent Lamp (CCFL) driver controller optimized for flat panel monitor applications. Designed to run off 12 or 15V input supplies, the MP1018 can drive up to 30 lamps (150W) via four (4) external N Channel MOSFETs. Its full bridge architecture converts unregulated DC input voltages to the nearly pure sine waves required to ignite and operate CCF Lamps.

The MP1018 supports analog and burst dimming without the use of external components. It has soft on and off burst waveform shaping, lamp current regulation, transformer secondary current regulation, output over voltage protection and a dual mode fault timer.

The MP1018 is available in the 28 lead TSSOP package.

Absolute Maximum Ratings

Input Voltage V_{PRR}, V_{PRL}	18.5V
Logic Inputs	-0.3V to 6.5V
Junction Temperature	150°C

Recommended Operating Conditions

Input Voltage V_{PRR}, V_{PRL}	8V to 17.5V
Analog Brightness Voltage V_{ABRT}	0V to 1.9V
Digital Brightness Voltage V_{DBRT}	0V to 1.8V
Enable Voltage V_{EN}	0V to 5.0V

Ordering Information

Board Number	MPS Part Number
EV0019	MP1018EM

Figure 1: EV0019 Evaluation Board

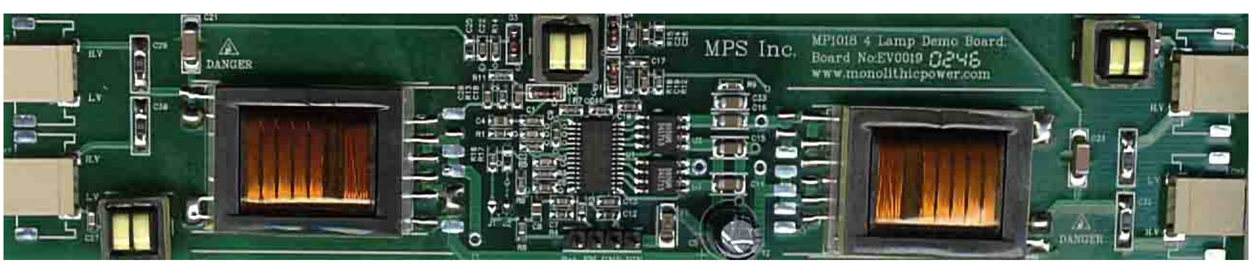


Figure 2: EV0019 Schematic

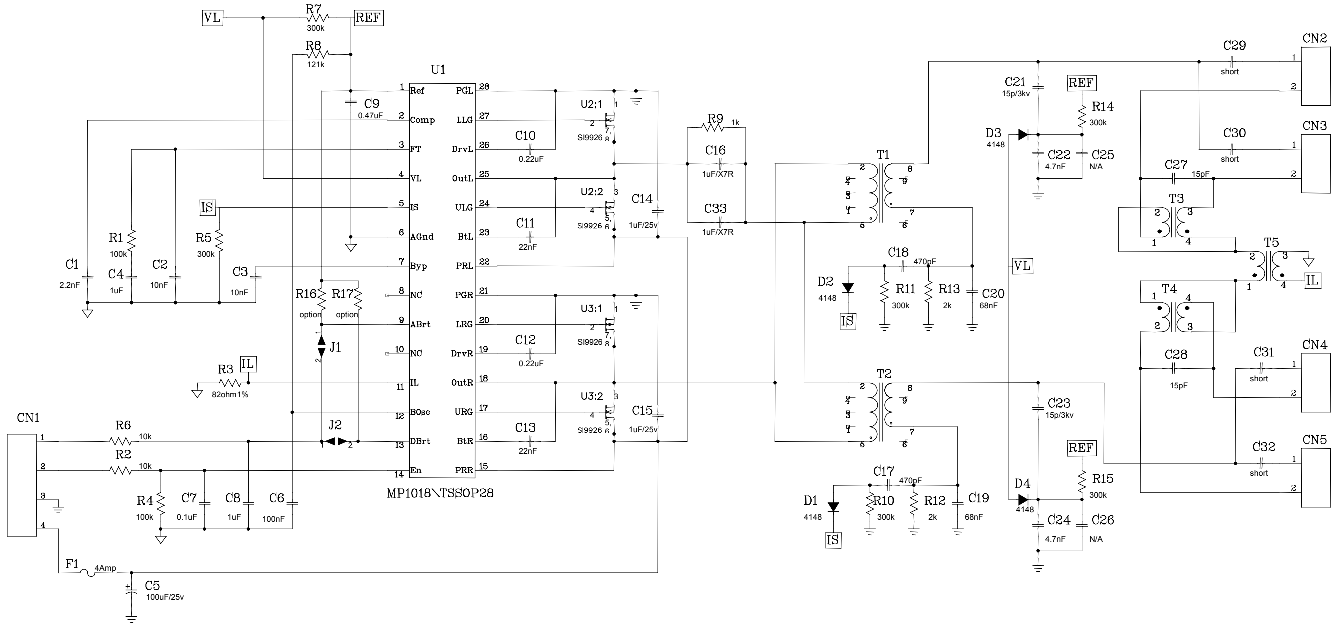
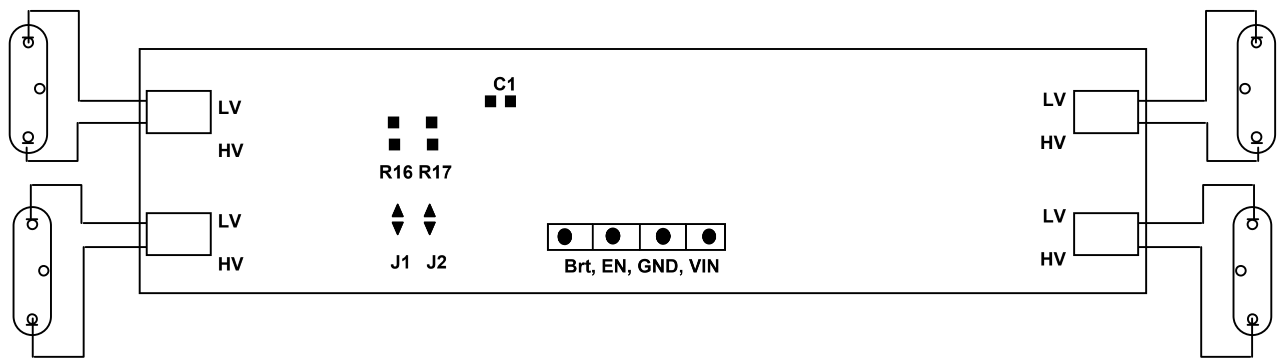


Table 1: EV0019 Bill of Materials

Parts	Component	QTY
ICs		
MP1018	U1	1
SI9926/SO-8	U2,U3	2
Capacitors		
N/A	C25,C26	2
100uF/25V CAP	C5	1
0.1uF/0603	C7	1
0.22uF/0603	C10,C12	2
0.47uF/0603	C9	1
1uF/0805	C4,C8	2
2.2nF/0603	C1	1
4.7nF/0603	C22,C24	2
10nF/0603	C2,C3	2
15pF/0603	C27,C28	2
22nF/0603	C11,C13	2
68nF/0603	C19,C20	2
100nF/0603	C6	1
470pF/0603	C17,C18	2
1uF/25V/1206	C14,C15,C16,C33	4
15P/3KV/1810	C21,C23	2
0Ω/1808	C29,C30,C31,C32	4
Resistors		
N/A	R17	1
1KΩ/0603	R9	1
2KΩ/0603	R12,R13	2
10KΩ/0603	R2,R6,R16	3
82Ω/1%/0603	R3	1
100KΩ/0603	R1,R4	2
121KΩ/0603	R8	1
300KΩ/0603	R5,R7,R10,R11,R14,R15	6
Diodes		
YST-A266910	T3,T4,T5	3
EEL-19	T1,T2	2
4148/1206	D1,D2,D3,D4	4
Miscellaneous		
PCB	FR-4	1
SM02B-BHSS	CN1~CN4	4
Input connector	CN5	1
FUSE/1206/4Amp	F1	1

Figure 4: EV0019 Board Layout



Operation

The EV0019 is set up to drive four (4) lamps and is set for Digital Burst Mode dimming.

1. Attach low voltage and high voltage end of lamps to LV and HV pins respectively.
2. Attach input voltage 8V $\leq V_{IN} \leq$17.5V and input ground to VIN and GND pins respectively.
3. To enable the MP1018 apply a voltage, 0V $\leq V_{EN} \leq$ 5V, to the EN pin. To disable the MP1018 connect the EN pin to ground.
4. The Brt pin is used to control brightness via with Digital Burst Mode or Analog mode.

   To use the Brt pin in Analog mode:
   a. Short jumper J1
   b. Leave jumper J2 open
   c. Leave R16 open
   d. Change R17 to a 10KΩ resistor
   e. Change C1 to a 15nF capacitor

   To use the Brt pin in Burst mode:
   a. Short jumper J2
   b. Leave jumper J1 open
   c. Leave R17 open
   d. Change R16 a 10KΩ resistor
   e. Change C1 to a 2.2nF capacitor

   To adjust the brightness vary the amplitude or frequency of the Brt signal.

2 Lamp Application with Current Balancing

Fig.1 is the traditional, 2 CCFL circuit that is used in most of Royer inverters. C2 & C3 (ballast capacitors) provide extra impedance that can cancel the impedance difference between the 2 lamps. But this circuit has 2 problems.

1. Because capacitors are the frequency related impedance, higher the operation frequency, lower the impedance, poorer the balancing performance.

2. When operates in analog mode dimming, the lamp impedance increases with lamp current decreases. The lamp impedance will increases almost at the same rate with dimming ratio. This also increases the importance of the impedance difference between lamps.

There is one method to improve these 2 problems: reduce the capacitance of these 2 ballast capacitors. But this will bring out another problem: the voltage stress of transformer secondary winding will be increased. This will reduce transformer reliability.

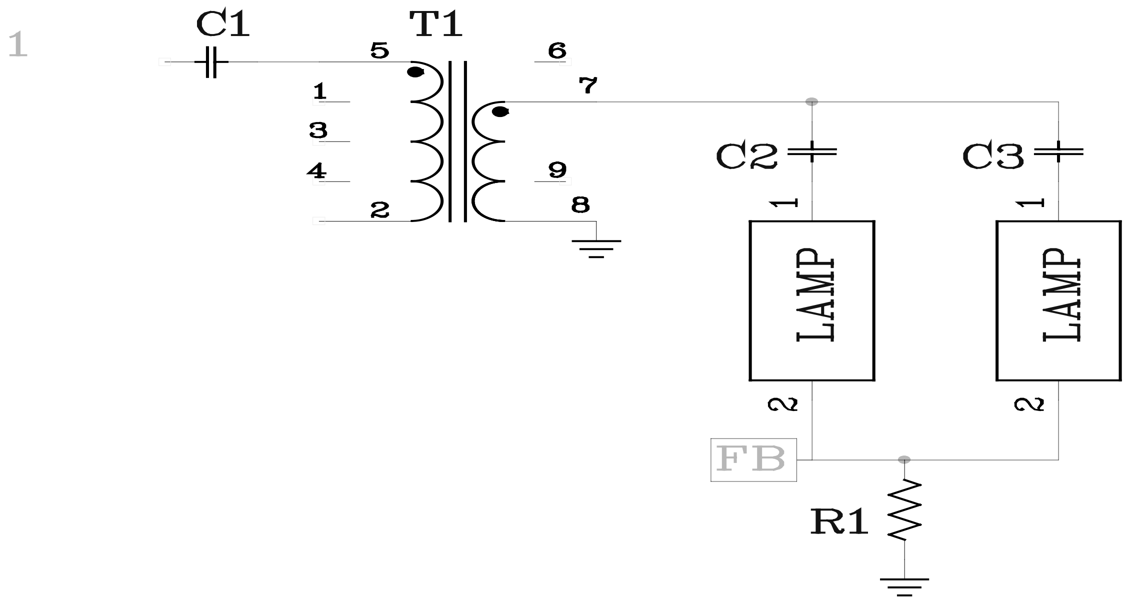


Figure 1: Traditional 2 CCFL circuit used in most Royer inverters

Fig. 2 is the application using a common-mode transformer (T2). This is similar theory to Fig. 1: by adding extra impedance in series with each lamp to cancel the impedance difference between lamps, one different point is the impedance of each winding of a transformer is related to the other winding of the same transformer, this improve current balancing a little. But we know the impedance of an inductor is also frequency related, higher the operation frequency, higher the impedance. Normal application requires few hundreds mH of each coil to achieve current balancing.

1.1

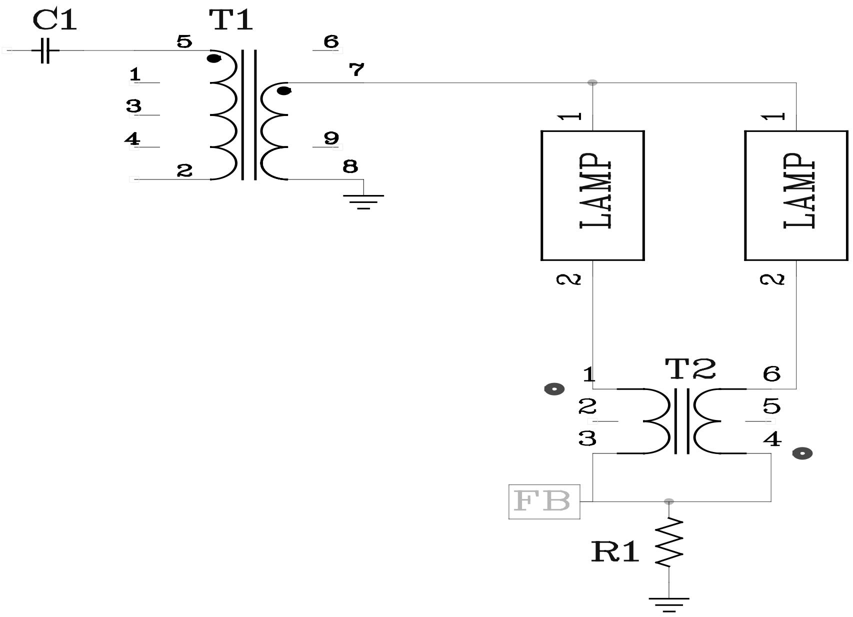


Figure 2: Application using a common-mode transformer (T2)

Fig. 3 is a **patent pending technology of MPS**. Only one power transformer can drives 2 lamps in parallel with very good lamp current balancing. By adding a resonant capacitor (C2) between pin 1 & 6 of T2, the impedance of this capacitor- transformer network increases dramatically high around the resonate frequency, and the setting of resonant frequency is free by changing capacitance of C2. This won't require extremely high inductance of common-mode transformer or low capacitance of ballast capacitor, and can still balance lamp current. The resonant frequency of this network is: Fo = 1/ (2*pi*sqrt(4L*C2)), while L is the inductance of each winding of T2.

Normal application requires about 75mH on each coil, but unfortunately, the existing common-mode transformers must have about 400 turns to get such inductance. This generates a huge stray capacitor in each coil and the Self Resonance Frequency (SRF) of this transformer do effect the resonant frequency of C2-T2 network, and the calculation of resonant frequency above become incorrect. There is one method to find out the actual resonant frequency with inductor's stray capacitors.

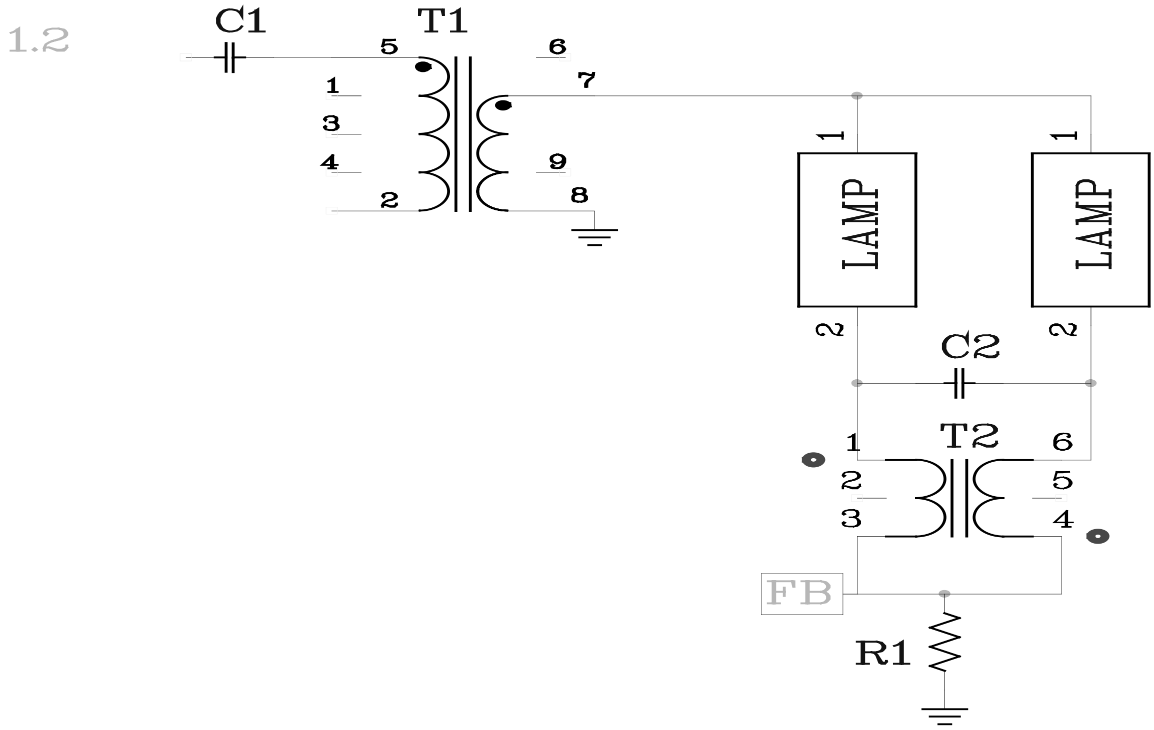


Figure 3: Adding a resonant capacitor (C2) to increase capacitor-transformer network impedance

Refer to Fig. 3.1, the impedance of C2-T2 network vs. frequency can be measured as this circuit. The gain = Vo/ Vin, of this network should be around 0.9 at resonant frequency, and the resonant frequency can be easily changed by change capacitance of C2 or inductance of T2. Also the bandwidth of C2-T2 network can be measured by changing the frequency of input signal, you can judge how to match this network with MP1018 during operation.

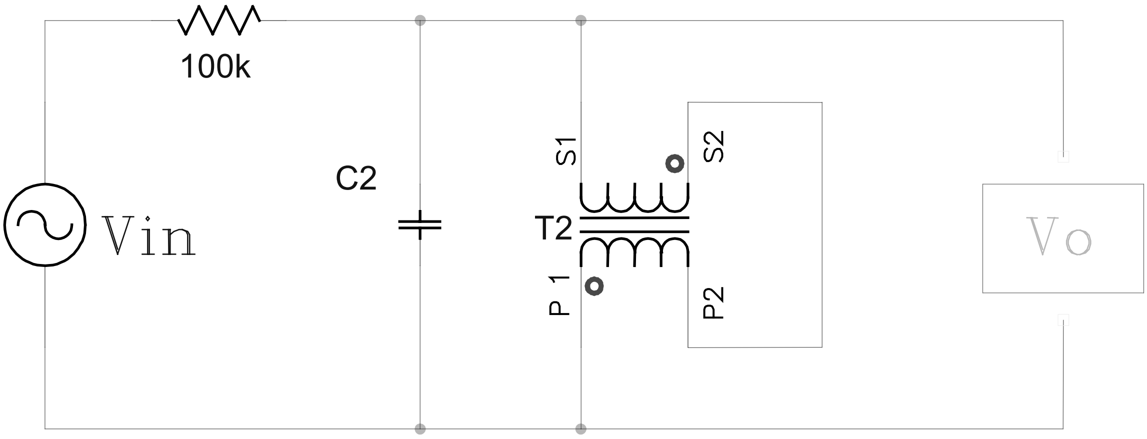


Figure 3.1: Measuring the impedance of C2-T2 network vs. frequency

The magnetic flux inside the core of T2 is canceled by each other because the same current from individual lamps flows in opposite direction into T2. So there is one method to detect one-lamp-open situation by adding a few turns winding (normally 2 or 3 turns is enough) on anywhere of transformer's magnetic loop. If any one lamp is off by any reason, the flux density in the transformer core increases a lot, and the additional coil can pick up a high level signal, this can be used to either turn inverter off or to reduce output power, the safety issues can be solved. Refer to Fig. 3.2 & 3.3.

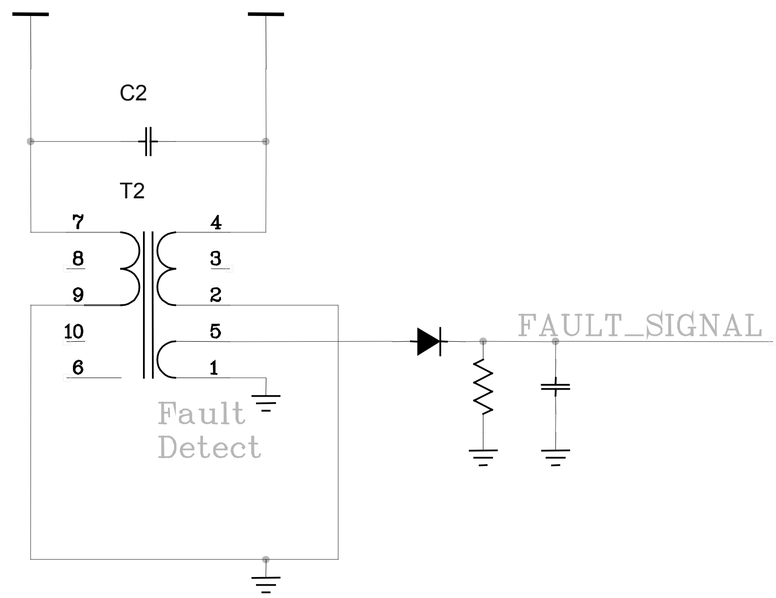


Figure 3.2: Fault Detection Coil Method

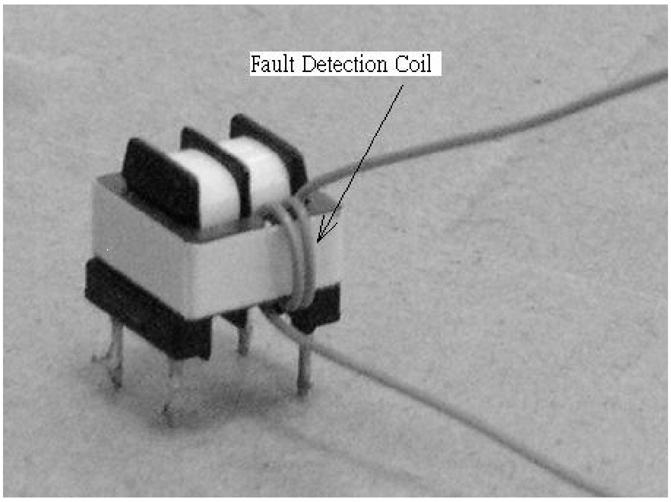


Figure 3.3: Fault Detection Coil Method

4 Lamp Application with Current Balancing

If you are using 2 power transformers for 4 lamps, few circuits are available. Fig 4 shows 2 groups of lamps in series, with center node high impedance to ground. Primary winding of each transformer is opposite connected to the other. This can generate the opposite voltage between 2 transformers' outputs, and allow lamp current flows in these 2 groups. Lamp current is detected by a current transformer which is located in between 2 lamp groups. The only requirement of this current transformer is the impedance of each winding must be higher than current detection resistor with lamp operation frequency. The turns ratio of each common-mode & current transformers should be 1: 1.

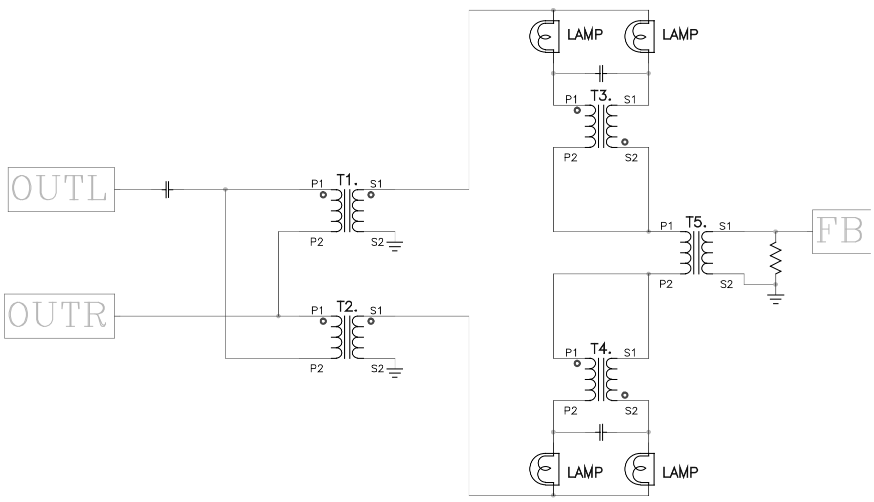


Figure 4: 2 Groups of Lamps in Series with center node high impedance to ground

Some other people is doing similar connection as Fig. 4, the only difference is most of people set a low impedance between center node of lamps to ground. This allows current flows between this node and ground, and break current balancing.

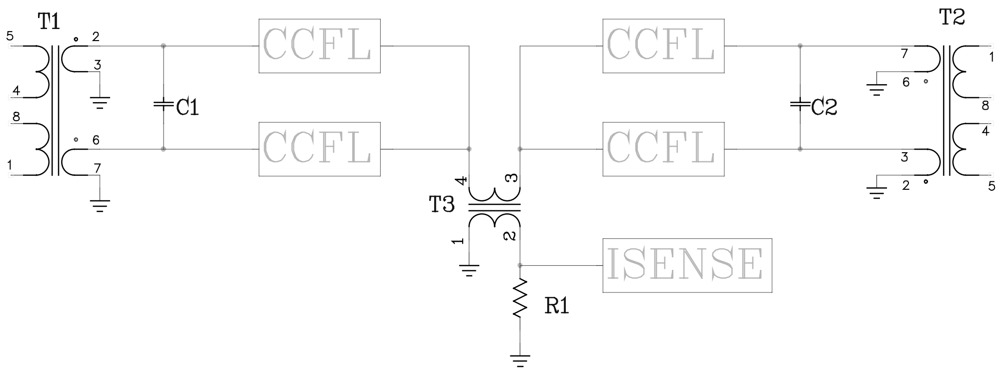


Figure 5: Typical 4 Lamp Application

Fig. 5 shows the other method for lamp current balancing. T1, T2 both have 2 secondary windings and each secondary winding has a leakage inductance. Refering to Figure 5.1, assuming both output voltage of 2 secondary windings of T1 are the same, so pin 2 & 6 of T1 looks connected, Lk1-1, Lk1-2 & C1 become a similar resonant network as shown on Fig. 3, the only difference is Lk1-1 & Lk1-2 are not coupled to each other, so the resonant frequency is: F = 1/(2*pi*sqrt((LK1-1 + Lk1-2)*C1)). But unfortunately, most of these kinds of transformer got too much stray capacitance with secondary windings, the SRF is always too low for inverter operation.

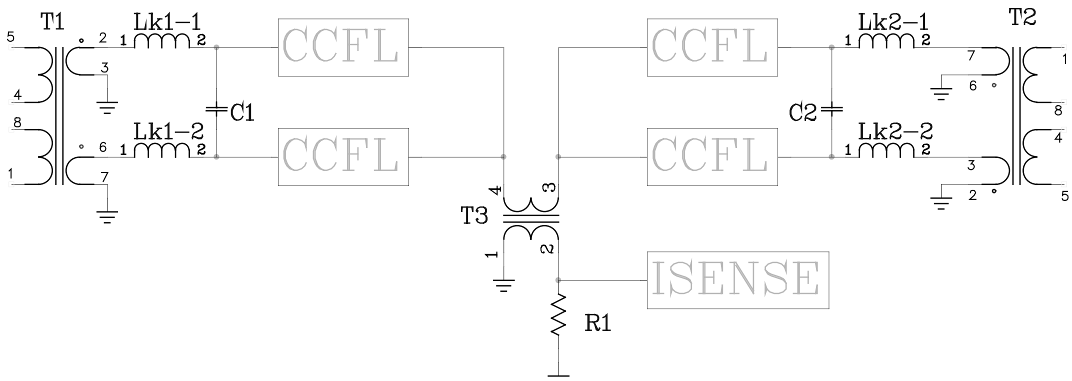


Figure 5.1: 4 Lamp Application with Output Voltages of both Secondary Windings Equivalent

Fig. 6 is for 6 lamps application. T11, T12, T14 & T16 are common-mode transformers, and the capacitors around them are trying to resonant with the inductor of each common-mode transformers to get high impedance in order to balance lamp currents. Notice that the inductance of each coil of these transformers must be around 150mH to 200mH for wider bandwidth.

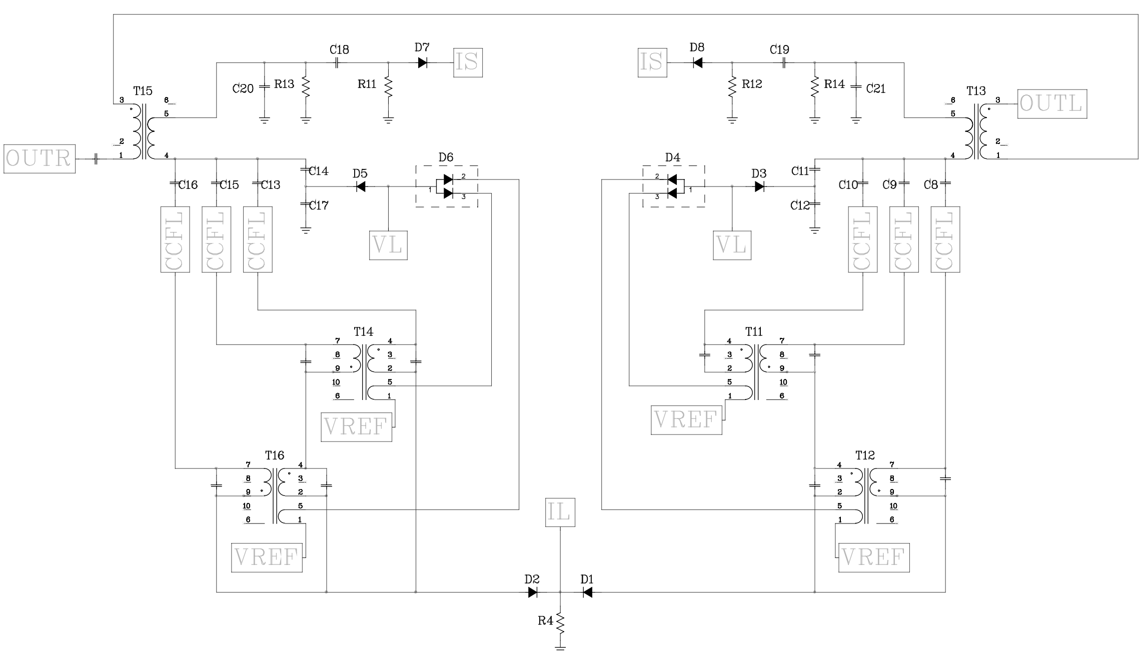


Figure 6: 6 Lamp Application

Figure 7: EV0019 Top Silk Layer

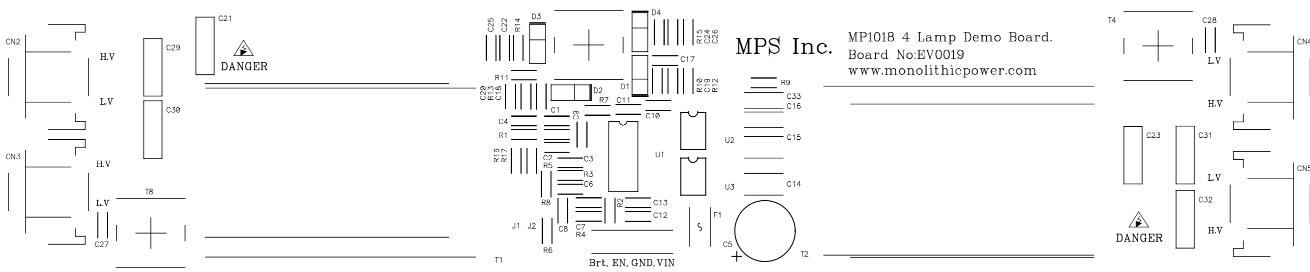


Figure 8: EV0019 Top Layer

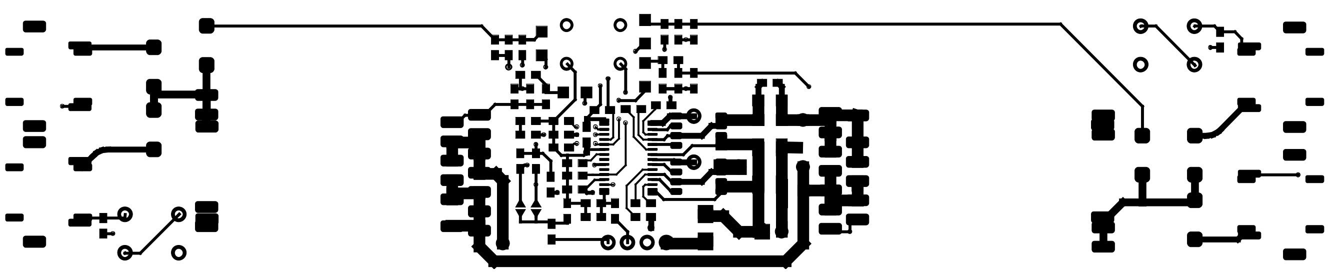


Figure 6: EV0019 Bottom Layer