AN2115

460VAC Survival

RediSem PPFC drivers are very tolerant of high voltage operation due to the 700V transistors used in the half-bridge. A typical driver is able to operate up to 320VAC operation for 1 hour and with minor modifications it can operate at up to 400VAC for 1 hour. In a worst case scenario, a driver is connected between phases which can reach 460VAC (264VAC x √3). For this high voltage the driver can be made to shut down, so that it is able withstand 460VAC for a long time. This application note presents the options available and suggests possible driver modifications to make it survive very high input voltages.

Before designing or testing high voltage operation please pay special attention to safety as high voltages are much more lethal and most equipment is only designed for lower voltage operation. Take care to read the safety section later in this document.

320VAC Operation

PPFC LED drivers designed using RediSem's technology are usually capable of withstanding 320VAC without any modifications. Test your driver to find out how it performs at 320VAC. It will most likely continue to operate normally. Be careful to check for hot components, especially the transistors and L2. In addition, depending on the choice of capacitor, make sure that the X-capacitors C1 & C2 are good quality and check the voltage rating of the main HT capacitor C10. A standard RediSem driver should not need an MOV to meet 1kV surge requirements, but if an MOV has been added, check that it can withstand operation at 320VAC. The circuit below shows a 5mm diameter 510V MOV.

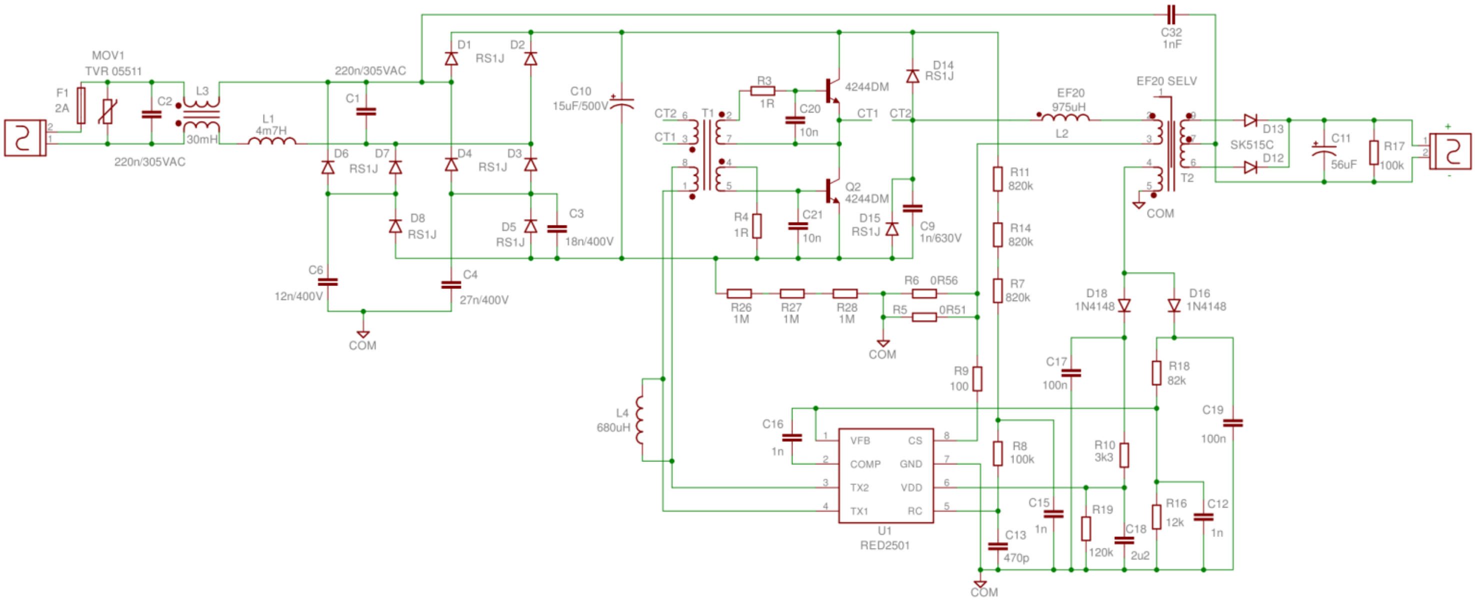

Figure 1: Standard 42W schematic for 320VAC operation

400VAC Operation

The driver can be made to operate at voltages up to 400VAC for a short time. To survive this voltage some component changes are required. If the withstand requirement is short, then no component should become hot, but some of the components will be above their rating so it is necessary to change them.

Component	Change
C10	The 500V HT capacitor will be over its rating. Replace it with two 350V capacitors in series. Shown as C5 in series with C10 in the schematic. Note that with two capacitors in series the capacitance value should be doubled.
D1, D2, D3, D4, D7, D8	These diodes will be subjected to >600V, so change them to 1000V rated diodes such as ES1M. Do not use RS1M because they are slow and THD will be worse.
C1, C2	X2 rated capacitors can usually withstand a higher voltage operation for a short duration. Consult the manufacturers data and use X1 rated capacitors if necessary.
F1	Check the voltage rating of this fuse. Also for higher voltage surge requirements increase the rating to 5A.
MOV1	Increase the voltage rating to 560V or higher. Shown as 680V in the schematic.

Table 1: Modifications for 400VAC operation

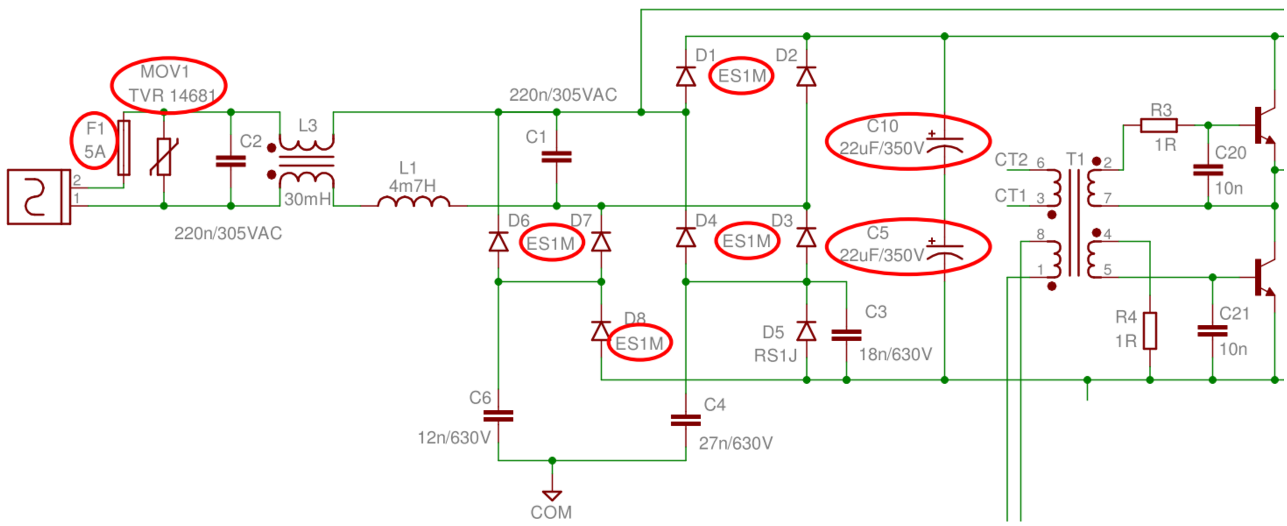

Figure 2: Modifications for 400VAC operation

460VAC survival – turn off > 360VAC

High voltage survival is usually required because an installation has lost the Neutral connection or an installer has connected the driver between two phases. So, to avoid damage, the driver should be able to withstand up to 460VAC for a short period. To achieve this high voltage withstand, the following circuit is shown that that turns the BJT Half-Bridge off above 360VAC. When the high voltage condition is removed, the driver re-starts.

Component	Value	Reason
U1	RED2511	The RED2511 has a shutdown function when VFB is pulled high. RED2501 does not have this feature.
D9	19V Zener	The main element that turns the driver off. Select the value depending on where you want to set the turn-off voltage.
R26, R27, R28	560k	Imbalance the midpoint so that there is hysteresis. There will be a period of flashing as the voltage rises, but increase it more and the driver turns off.
R19	82k	Bleeding resistor for driver turn off
C12	220pF	Keep the time constant R18, R16, C12 the same.
R18	470k	Increase R18 and R16 to reduce the current drawn from the HT resistors through the Zener diode.
R16	62k	
R8	200k	A higher value makes it easier to select the Zener value. It also improves accuracy.
C15	22n	A higher value reduces the flashing as the AC voltage rises.

Table 2: Modifications for 460VAC survival

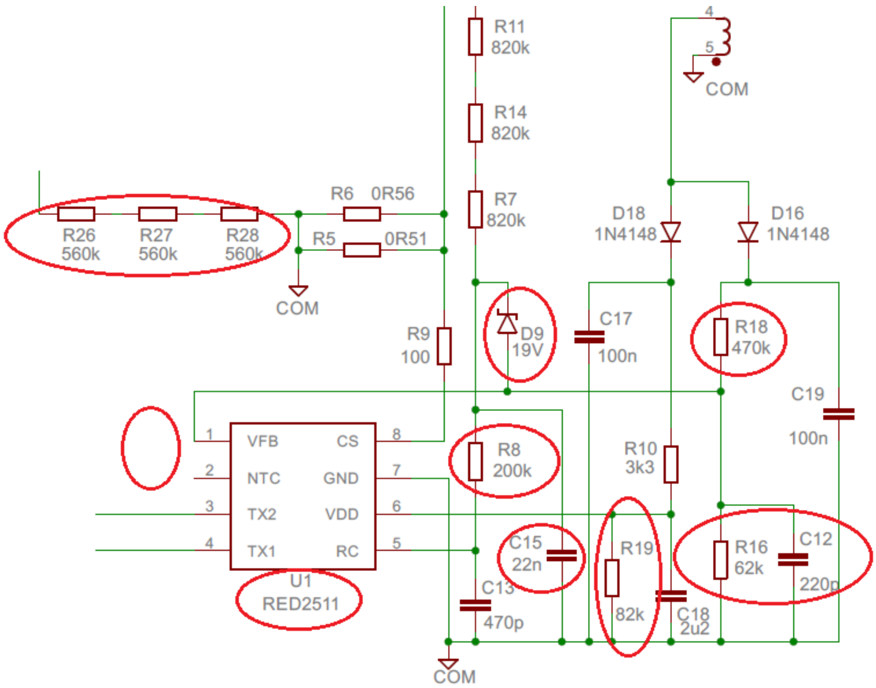

Figure 3: Changes required to turn the IC off at high voltages

The main part of the circuit is the addition of a Zener, D9. The potential divider connected to the HT bus (R26, R27, R28, R8, R7, R14, R11) generates a voltage across R8. When this voltage increases the Zener starts to act and pulls the VFB pin of the IC high. As the voltage rises the IC enters burst as it attempts to regulate the VFB pin, but as the VFB pin rises further the driver eventually turns off. The IC re-starts but as the VFB pin is held high, it does not re-start the BJT bridge. The driver therefore remains off. Even when directly powered with 460VAC, the driver will not attempt to start. When the mains voltage drops below 360VAC, the driver turns on again. Please note that the RED2501 will not completely shut the driver off, but RED2401 or RED2511 are able to.

Surge requirements

RediSem's PPFC designs are very tolerant to surges due to the high voltage half-bridge, but if the shutdown circuit has been added, care should be taken, otherwise the driver could shut down during a surge test. An MOV should be added across the input between the Live and Neutral connections, after the fuse to help reduce the surge voltage. If high voltage operation / survival is required, then this MOV voltage must be higher than normal, depending on the high voltage operation requirement. With a high voltage MOV, the BJT half-bridge is not as well protected against surges, so if 6kV surge is required, it is recommended that the driver is allowed to shut down in order to survive the surge.

On RediSem's standard 42W driver design, with a 14mm 680V MOV, such as Thinking's TVR14681 is suitable for 6kV differential operation.

The effect of the surge will depend on many factors such as the EMI components used and the HT capacitor (C10). Some other ideas to reduce the surge voltage and possibly avoiding shutdown are:

- Use 2 MOV's, one either side of the Common Mode inductor
- Increase the size of the MOV to 20mm diameter
- Increase the HT capacitor so that it absorbs the surge voltage better
- Add more inductance / resistance in series with the input fuse to reduce the currents surge in the combination wave generator used in surge testing
- Add more inductance between the MOV and the HT capacitor
- Reduce the shutdown voltage (lower voltage Zener) so that the bridge shuts down earlier during the surge

Safety

RediSem's driver designs are intended for operation up to 264VAC and they should be rated as such. Survival at these higher voltages is possible, but extreme caution should be taken when designing products for operation above 264VAC. Check the applicable safety standard for high voltage operation and make sure that you adhere to them. Apart from the far more lethal voltage, the energy available is far higher.

Fusing (explosions), thermals (fire) and electric shock all pose hazard. Fuses for example might be rated for 250VAC, so they might not be able to break a high current at 440VAC. Connector isolation, shrouding, cable sheaths etc. all pose safety threats. Please take extra caution when designing and testing high voltage operation.

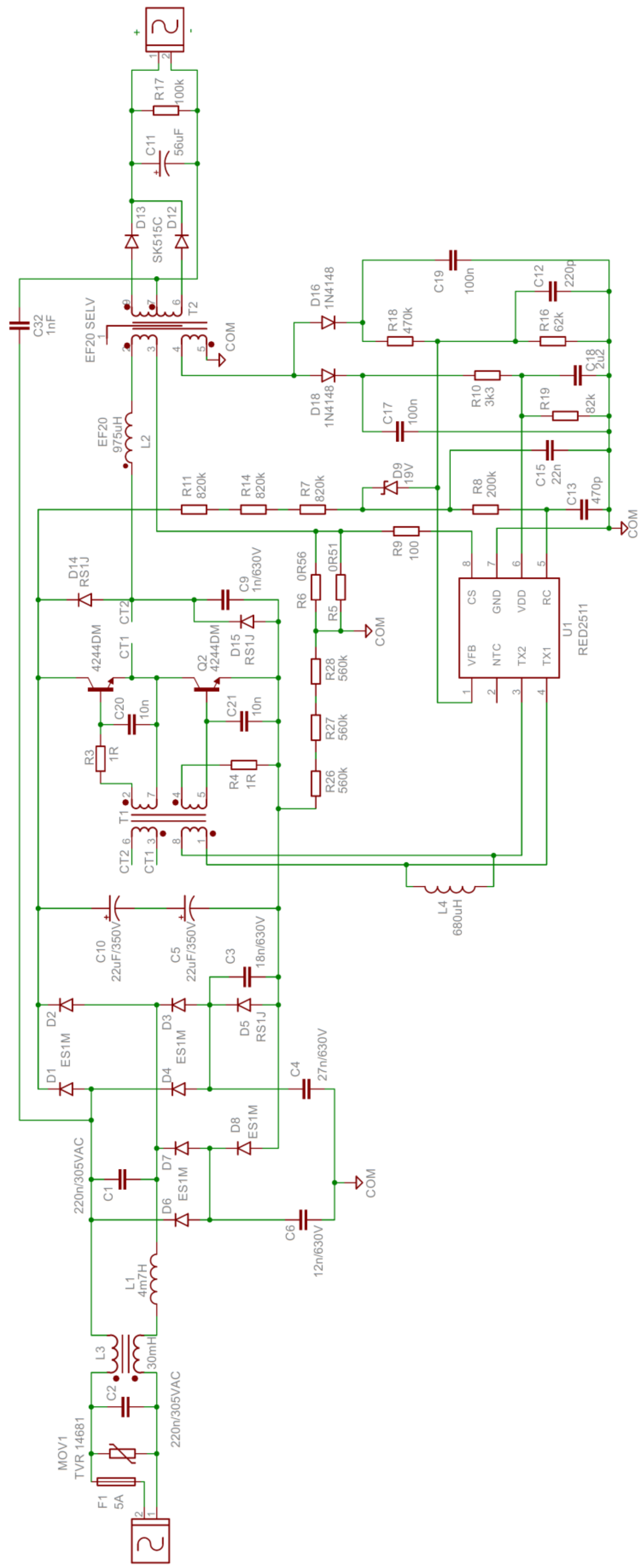

Figure 4: Full schematic to support 460VAC survival and 6kV surge

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RediSem designs and supplies semiconductor ICs for energy efficient power management applications. RediSem uniquely combines extensive experience in power electronics with in-depth knowledge of IC design and manufacturing and works with the world's top suppliers and customers. RediSem's unique patented IC and converter technologies deliver maximum efficiency and performance, while reducing overall bill of materials cost through the use of bipolar transistors.

RediSem's range of LED control ICs can be used with RediSem's patented single stage LED control solution to provide very high efficiencies with low EMI – all with a single IC. When combined, these features deliver a low cost, high performance LED driver solution.

RediSem's fluorescent driver controller ICs achieve the advanced performance of MOSFET drivers by using bipolar transistors at a fraction of the BOM cost. RediSem's range of SMPS (Switched Mode Power Supply) control ICs enables low-cost LLC converters with bipolar transistors that deliver very high efficiencies already meeting DoE Level VI regulations, have low standby power and have much lower EMI compared to flyback converters.

All RediSem ICs are supported by comprehensive turn-key application designs enabling rapid time to market. For further information please use our contact details below

Contact Details

RediSem Ltd.
301-302 IC Development Centre
No 6 Science Park West Avenue
Hong Kong Science & Technology Park
Shatin, New Territories
Hong Kong

Tel. +852 2607 4141
Fax. +852 2607 4140
Email: info@redisem.com
Web: www.redisem.com

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