Power Soft Start

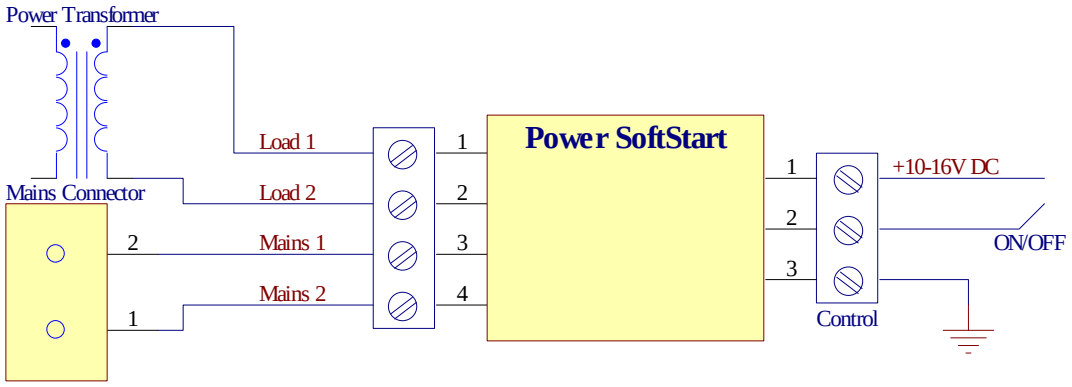
The **Power Soft Start Circuit** has the function to limit the inrush current which is drawn from the mains by the transformer of the amplifier during power ON sequence. When the power amplifier is switched on, the initial current drawn from the mains is few times higher than the maximum current which is drawn at the full power. There are two main reasons for this: one reason is because the transformers will draw a very heavy current at switch on, until the magnetic flux has stabilized. The effect is worst when power is applied as the AC voltage passes through zero, and is minimized if power is applied at the peak of the AC waveform. This is exactly the opposite of what you might expect. Another reason is that at power on, the filter capacitors are completely discharged, and act as a short circuit for a brief (but possibly destructive) period. The current is higher as the capacitors capacity and voltage is higher, and is proportional with the capacitor stored energy ($CU^2/2$).

Most of the high power amps used in PA and other industrial applications equipments use various types of Power Soft Start, although they are not commonly used in consumer equipment. Anyone who has a large power amp - especially one that uses a toroidal transformer - will have noticed a momentary dimming of the lights when the amp is powered up. The current drawn is so high that other equipment is affected, like computers, TV's or other equipment which are sensitive enough or have the hold-up time of the capacitors from the power supply too small to compensate the voltage fall during this transients. In addition to the unpleasant effects, the high inrush current (as it is known) is stressful on many components in your amp, especially the fuses which may blow if they are fast acting type or underrated, the transformer can be affected, the massive current stresses the windings mechanically and electrically. It is not uncommon to hear a diminishing mechanical buzz as the chassis and transformer react to the magnetic stress. The rectifier bridge must handle an initial current way beyond the normal, because it is forced to charge empty filter capacitors which look like a short circuit until a respectable voltage has been reached. The capacitors can be also damaged, as the inrush current is many times higher than the ripple current rating of the capacitors, and stresses the internal electrical connections, which may lead to premature failure. Due to this reason, some of amplifier failures occur at power on (unless the operator does something foolish). This is exactly the same problem that causes your lights at home to 'blow' as you turn on the light switch. You rarely see a light bulb fail while you are quietly sitting there reading, it almost always happens at the moment that power is applied. It is exactly the same with power amplifiers.

To avoid all the unpleasant effects which were showed above, the **Power Soft Start Circuit** must be used. The main role of the **Power Soft Start Circuit** is to limit inrush current to a safe value, which is 16A for 230V AC circuits and 8A for 110V circuits. The maximum current which the **Power Soft Start Circuit** can admit in normal operation is 20A RMS for 230V AC circuits and 24A RMS for 110V circuits. The maximum current thru the relays is limited at 30A, but because the power factor of the circuits is ≠ 1 this current have smaller value. A very important aspect is that the **Power Soft Start Circuit** must be used **ONLY** in AC current circuits, on the mains side and not on the secondary, or DC circuits. Misusages will lead to failure. Another important role of the **Power Soft Start Circuit** is that has the "remote" turn ON/OFF function, which means that the power circuit can be turned ON/OFF remote, by using a logic level control signal applied to the isolated control part of the **Power Soft Start Circuit**. This is particularly important when the **Power Soft Start Circuit** is used to control an Audio Power Amplifier which has remote turn ON/OFF function implemented or Stand-by for power saving. The idle current consumption is very small, and the power consumed is less than 0.8W at 230V AC and less than 0.65W at 110V AC. Although the soft start circuit can be added to any sized transformer, the winding resistance of 200VA and smaller transformers is generally sufficient to prevent a massive surge current. Use of a soft start circuit is definitely recommended for 300VA and larger transformers.

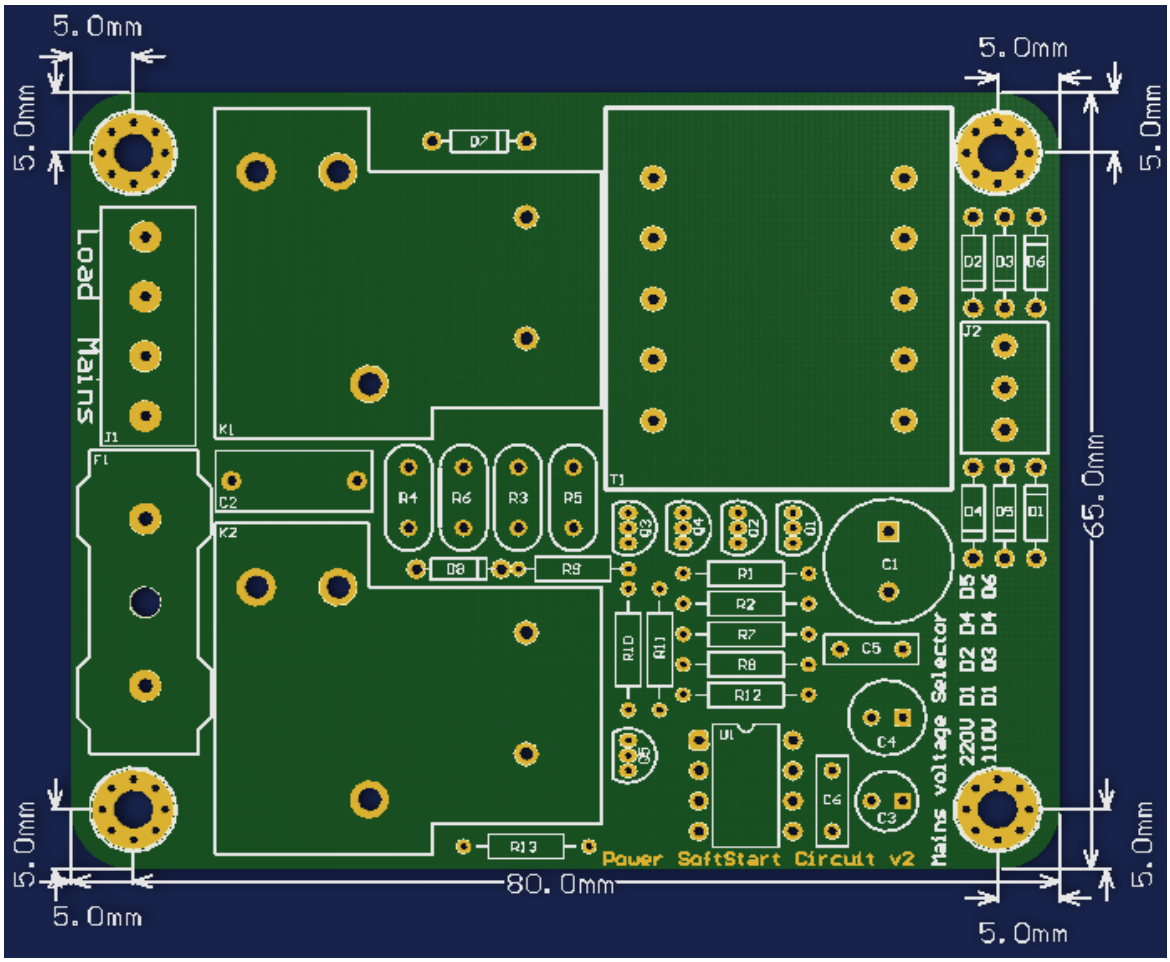
The principle of operation of the **Power Soft Start Circuit** is quite simple. When the power from the mains supply is applied to the mains transformer thru the connections 3 and 4 of the J1 connector, this will result in a secondary AC voltage which rectified and filtered will provide a DC voltage on the capacitor C1 and between pins 1 and 3 of the connector J2. This voltage have the value between 10-16 V DC, is unregulated, and can be used to power a control circuit like a remote control receiver, or any kind of small signal stage which will not draw more than 40mA from this voltage. Next, when on the pin 2 of the connector J2 is set to logic 1 (2.4 – 12 V DC) the relay K1 will close and the load (in our case the mains power transformer) will be connected to the mains thru the series/parallel thermistors R3-R6. The value of this thermistors group is 10Ω at 25˚C and is decreasing to 3.6Ω at 80˚C. This value will decrease in few hundreds milliseconds to few seconds, depending on the value of the current flowing thru them. If the current is large, the decrease time will be short (hundreds of milliseconds). If the current is small, the decrease time will be large (seconds). During this period, the main power transformer will stabilize the flux in the core and the secondary circuit filter capacitors will be able to charge to almost nominal working voltage. There are two reasons for using thermistors instead of resistors. One reason is that the thermistors can handle much higher current than equivalent value resistors, because they have negative temperature coefficient, (NTC) which means that their value decrease when the temperature increase, so the current handling will also increase up to a limit value. Another reason for using them is because in the next step, when the second relay will close, the load will see a smoother transition from the series connected resistor to the closed circuit relay. For example, if instead of the thermistors, resistors would be used which have larger value (>100Ω), then the flux in the main transformer may not be stabilized and the secondary capacitors may not be completely charged, so when the second relay will close, the current drawn will be high, almost as without the protective circuit. And one more important aspect is that most of the power resistors tend to blow if the current is too large. The thermistors do not have this behavior, as their resistance will fall close to zero and the fuse will blow in the event of an over current. Next, the U1 IC work as a timer, which will add few seconds delay for closing the second relay K2, which will connect the load to the mains directly. When the IC output will toggle to 1, the relay K2 will close and relay K1 will open, and the load will be connected directly to the mains. This will allow the transformer to work at rated power.

The **Power Soft Start Circuit** should be connected like in the following schematic. The mains voltage will be applied at the connector J1 pins 3 and 4, and the load (the amplifier mains power transformer) will be connected at the pins 1 and 2. Next, to switch the circuit ON/OFF, there are 2 ways: the most simple is to connect the pins 1 and 2 of the connector J2 together thru a simple unipolar switch. This will allow to use a low voltage, low current switch, which can withstand much longer than a mains switch. Another method, more elegant is to use a remote control circuit or remote power ON/OFF. This will allow turning ON/OFF the amplifier from another location, or in case of using a number of amplifiers, will allow turning them ON/OFF remotely and synchronized. One example is controlling the amplifier status from the preamplifier or signal source. For this, pins 2 and 3 of the connector J2 must be connected to a circuit which can provide voltage in rage of 2.4 – 12 V DC, with 10 mA max. current. When the signal source or the preamplifier is switched ON, and apply the control voltage to the **Power Soft Start Circuit**, it will start to operate as was described above. If the control circuit is mounted inside the amplifier case, and has a remote control receiver, this can be powered from the **Power Soft Start Circuit** if the required current does not exceed 40mA. Note that the voltage is unregulated, and will vary with the **Power Soft Start Circuit** status, when the relays are opened, the voltage will have the value between 14 to 16 V DC and will drop to about 10V when the relays are closed. When power is drawn, need to make sure that the voltage will not drop below 8.5-9 V DC, otherwise the relay may not close.



It is very important to know that mains voltage is present on the board and need to take all the caution measures when working with mains voltage, to not touch any part of the PCB, components, tracks, wires, and to not operate any modification to the circuits. The small mains transformer of the **Power Soft Start Circuit** is powered all the time when the mains voltage is applied to the board, and it's idle consumption is very low, less than 0.8W at 230V AC and less than 0.65W at 110V AC. It is recommended to use a bipolar, power mains switch connected before the **Power Soft Start Circuit** board, and which will be the main switch of the amplifier.

Size and the layout of the board:



Disclaimer:

The **Power Soft Start Circuit** shall be used according with the instructions provided in this document. The user should NOT attempt to modify or change any of the parameters of this product, which can lead to malfunction. The designer and manufacturer of the product, **PCBstuff**, and the official distributor, **Connexelectronic**, will not be liable for any kind of loss or damage, including but not limited to incidental or consequential damages. Due to the mains voltages of this board, the user should take all the caution measures needed when working with mains voltages, should not touch any unisolated part of the board or connectors, or short-circuit any part of the board or connectors. Any misusage will be made on user responsibility.

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