

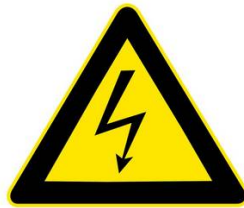
# High voltage power supply (1 to 20 KV)

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This documentation is divided into two parts, the first part provides a brief overview about the key features and specifications that the user needs to know to effectively use the product. This section is labeled under the **Getting Started** heading. The second part of the documentation provides more detailed information, which is intended to give a better understanding about the internal circuit of the power supply.

**Please be sure that you read the warning at the beginning of this document, as high voltages can cause serious injuries and burns. So it is absolutely essential that the user is careful.**

## Warning:



**High voltage can be very dangerous, even at low currents. Please ensure the following:**

- **Do not open the power supply casing, as some capacitors may still be charged, so never open the casing unless you are qualified to do so.**
- **Never go close to the high voltage probe when the power supply is ON, any adjustments that need to be made to the placement of the probes must only be done when the power supply is OFF.**
- **Always wear gloves, and shoes when handling the high voltage probes, even when the power supply is OFF.**

## **Getting Started:**

The power supply is designed to provide large output voltages (dc), at low currents. The output can be regulated using the variable resistor on the outside of the box. Here are the important specifications.

**Output voltage range: 1000 – 20000 V dc**

**Maximum output current: 20 mA**

**Input voltage: 210 - 250 V ac**

**Input current: 0.5-1 amperes.**

**Average power of device: 40 – 60 watts**

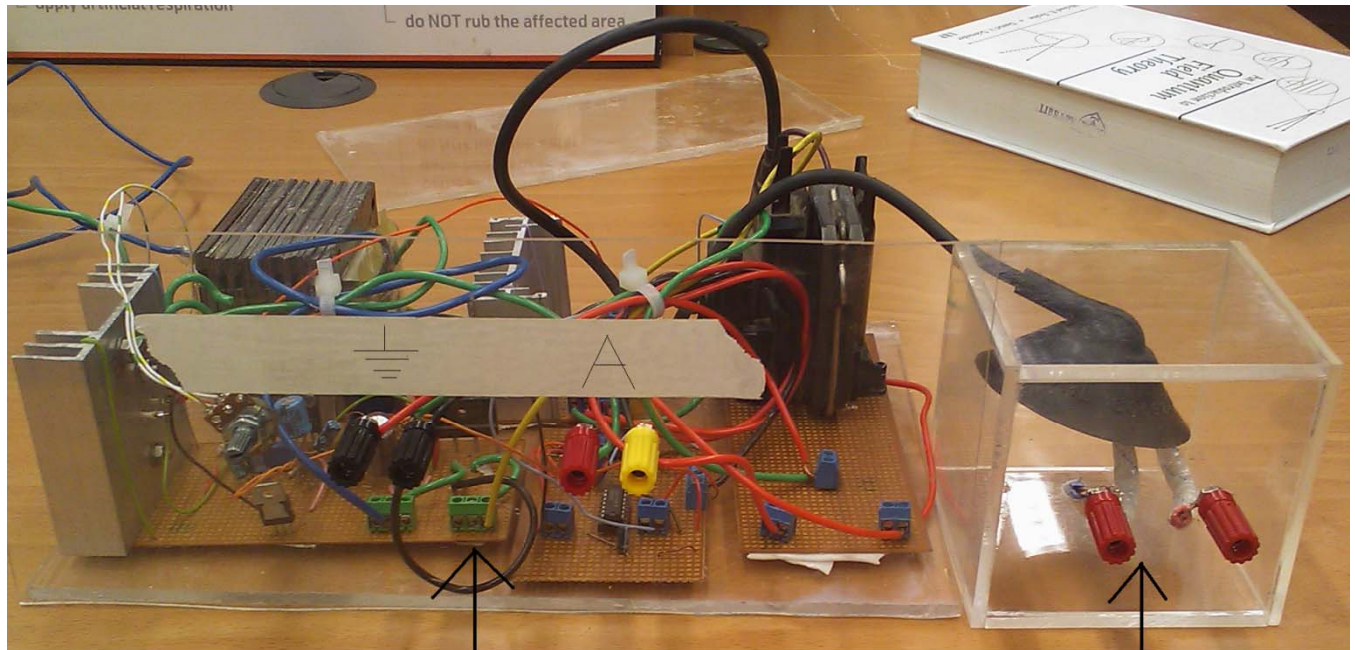
To power up the power supply, connect it to the ac-mains. Make sure that before powering up, the variable resistor knob is tuned to its lowest value, this must be ensured in order to minimize the risk of injury, as high voltages can be very dangerous.

To use the power supply to get high voltages, connect probes to the positive and negative sockets provided on the auxiliary extension box. The potential difference will exist between these two probes. They can be connected in necessary places in various apparatuses used in high voltage experiments.

There is no permanent display to show the output voltages in the power supply itself. This is because common voltmeters available in labs cannot measure voltages more than 1000-1500 volts. So, to measure the output voltages, the user will have to use a variable resistor (EMCO V1G). This device is basically a high voltage step-down resistor, which allows the user to see output voltages across its terminals that are stepped down by a factor of 1000, e.g., if a multimeter connected to the output of the EMCO device shows 20 V, it means that there is actually a voltage of 20000 V at the output of the high voltage power supply. So, simply connect the resistor to one of the high voltage outputs, and then observe the voltage on a multimeter. To do so, connect the high voltage input wire of the emco device to the high voltage output, and connect the mutlimeter between the ground of the power supply and the positive output of the emco device.

To vary the output voltage, you will have to use the variable resistor knob provided I the outside of the box. Using this knob, you can vary the output voltage between 1-20 KV.

A picture of the power supply can be seen below:



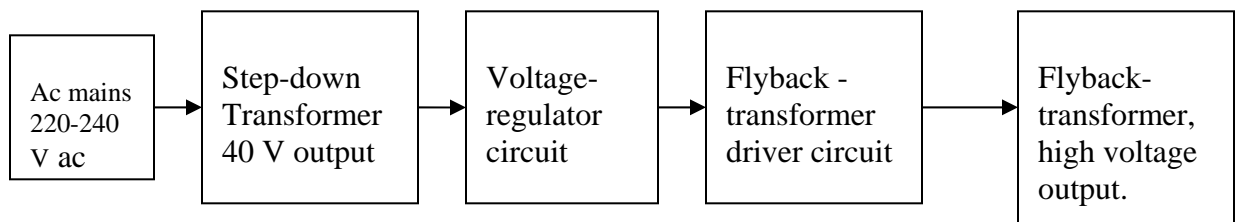
Main Box

Auxiliary Box

- ) The two black knobs are grounds.
- ) The red and yellow sockets are to be shorted, they are useful for measuring the input current.
- ) The two red sockets on the auxiliary box are the high voltage outputs.

### Detailed information:

Block diagram:



- **Step-down Transformer:** This is basically a transformer that connects to the ac – main, steps the voltage down, and gives an output voltage of approximately 40 V. The core is made up of f-type plates. The primary contains about 1000 turns of insulated copper wire, with a thickness of about 30 swg. The secondary contains about 200 turns of copper wire, with a thickness of 28 swg. The secondary wire is thicker because more current will flow through the secondary than at the primary, as this is a step-down transformer.
- **Voltage regulator circuit:** This is a simple circuit that as the main source of power for the flyback transformer and its driver. The circuit contains 3 outputs, one 5 V, one 12 V, and a regulated output, between 1-30 V dc. The output voltage of the regulated output can be changed from the variable resistor, and this is the main voltage that is given to the input of the flyback transformer, and hence it controls the output voltage.
- **Flyback-transformer driver circuit:** This is a circuit that basically drives the flyback transformer. The main function of this circuit is to simulate a pulsed (square-wave), high frequency input for the flyback transformer, which then allows it to work. The square wave generated typically has a frequency between 25-100 kHz, in our case it was about 26 kHz, but the exact value can vary from one flyback transformer to another.

The circuit contains a 55-timer, which is put in the astable mode, this generates a square wave. The output of the 555-timer is fed into the input of a hex-inverter buffer. The output of this buffer acts as an open-collector, a sink for the 12 Vdc from the regulated circuit. Periodic transitions of the output of the buffer from open, to a short sink, allow it to switch the transistor on and off. The transistor being switched on and off is an n-channel mosfet, in our case it is an IRF-540. We chose this particular transistor because of its low drain-source resistance, so it heats up less.

The transistor is connected in a heavy-side driver configuration, in which the primary of the flyback transformer is placed between the drain and the regulated input from the voltage regulator circuit.

- **Flyback-transformer:** A flyback transformer is a very interesting transformer. Normal transformers, simply transfer energy from their inputs to their outputs. Flyback transformers, however, not only transfer energy to their secondary, but they also store energy for a considerable amount of time. In fact, flyback transformers act as pure inductors during half a cycle, and then they act as a pure transformer in the other half. This behavior is made possible by an air gap in the ferrite core. This air gap increases the reluctance of the core, which thereby increases its ability to store magnetic energy.

Flyback transformers are high frequency transformers, and their low output power and small size make them very useful in generating high output voltages, at

relatively low currents. Their main applications are in televisions, monitors, and high voltage power supplies, like this one. The maximum attainable output voltage varies from transformer to transformer, but it is possible to get voltages as high as 50 KV, although the one we used generates 20 KV maximum.

The basic working of the transformer is as follows:

- a) During the time in which a current flows through the primary coil, no current flows through the secondary, due to a diode on the secondary, the energy is stored.
- b) When the input current in the primary is switched off, an emf is induced in the secondary, and this time the diode conducts, as its polarities are different. This induces a voltage, which is then rectified, and smoothed with a capacitor, giving us a dc output. The rectifier and smoothing circuit is built into the transformer, so we don't have to worry about it.

It can be tricky to find the correct pins on the flyback transformer, as there are multiple inputs. Also, we need to find the high voltage ground. It is recommended that you try to find a datasheet for the transformer, as it will save a lot of time. Otherwise, you can use this very useful website, which provides a very useful way of finding all the pins. ( <http://lifters.online.fr/lifters/labhvps/tht.htm>).

The complete circuit diagram is on the next page:

