2021

Solar Car Pre-Charge Motor Circuits Demonstration

INTRODUCTION TO PRE-CHARGE MOTOR CIRCUITS FOR EV CARS.

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RC Time Constant:
2200Ω and 1000µF = 2.2 Seconds

After 5 Time Constants the Capacitor is fully charged. The purple cursors measure the time (ΔX).
The x Axis = 2 Sec/division. After 5 time constants you can see the time = 10.16 seconds.

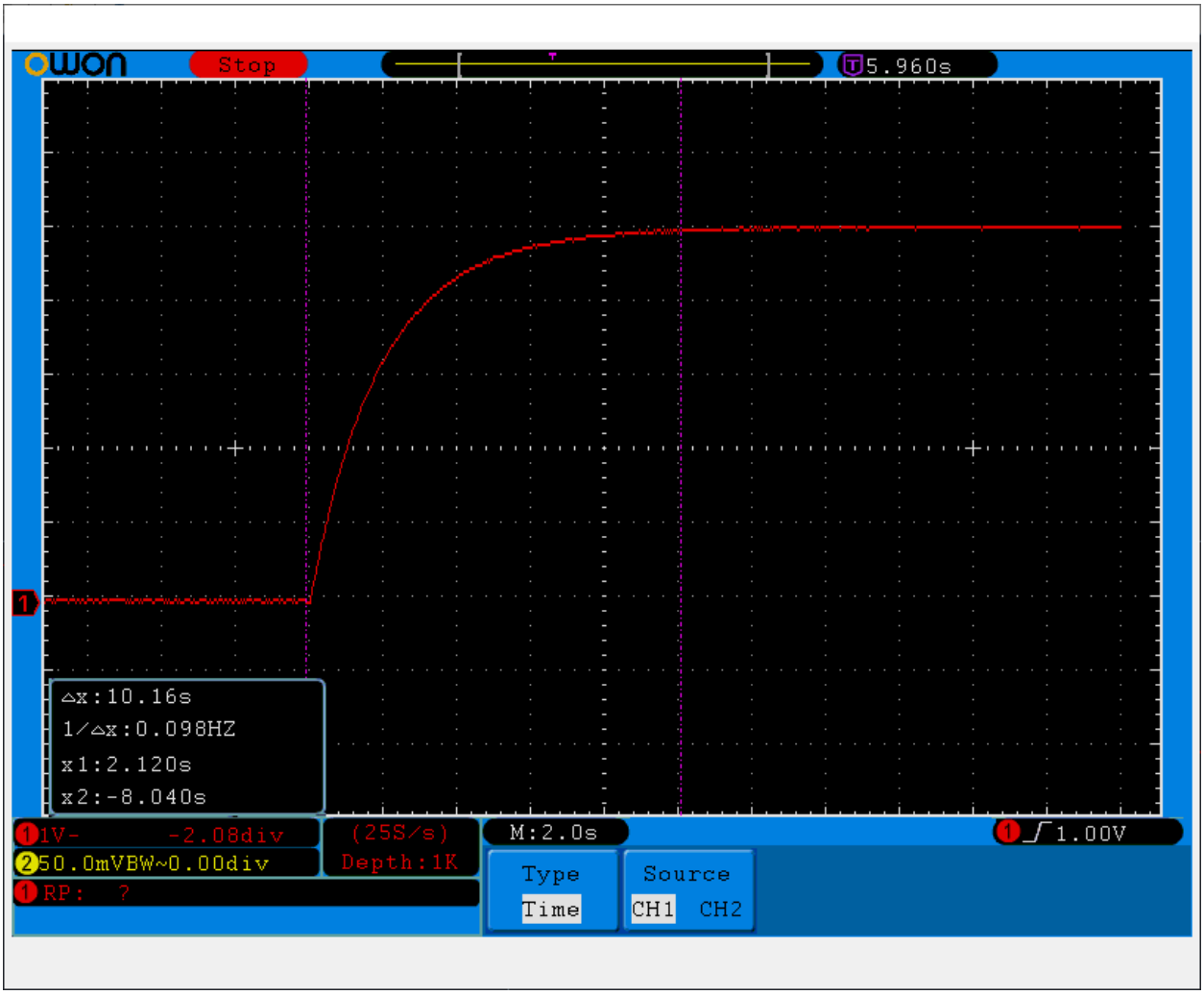

FIGURE 1: RC TIME CONSTANT SHOWS CHARGING TIME OF CAPACITOR.

RC Discharge Time is the same. It takes 5 time constants to completely discharge the capacitor.

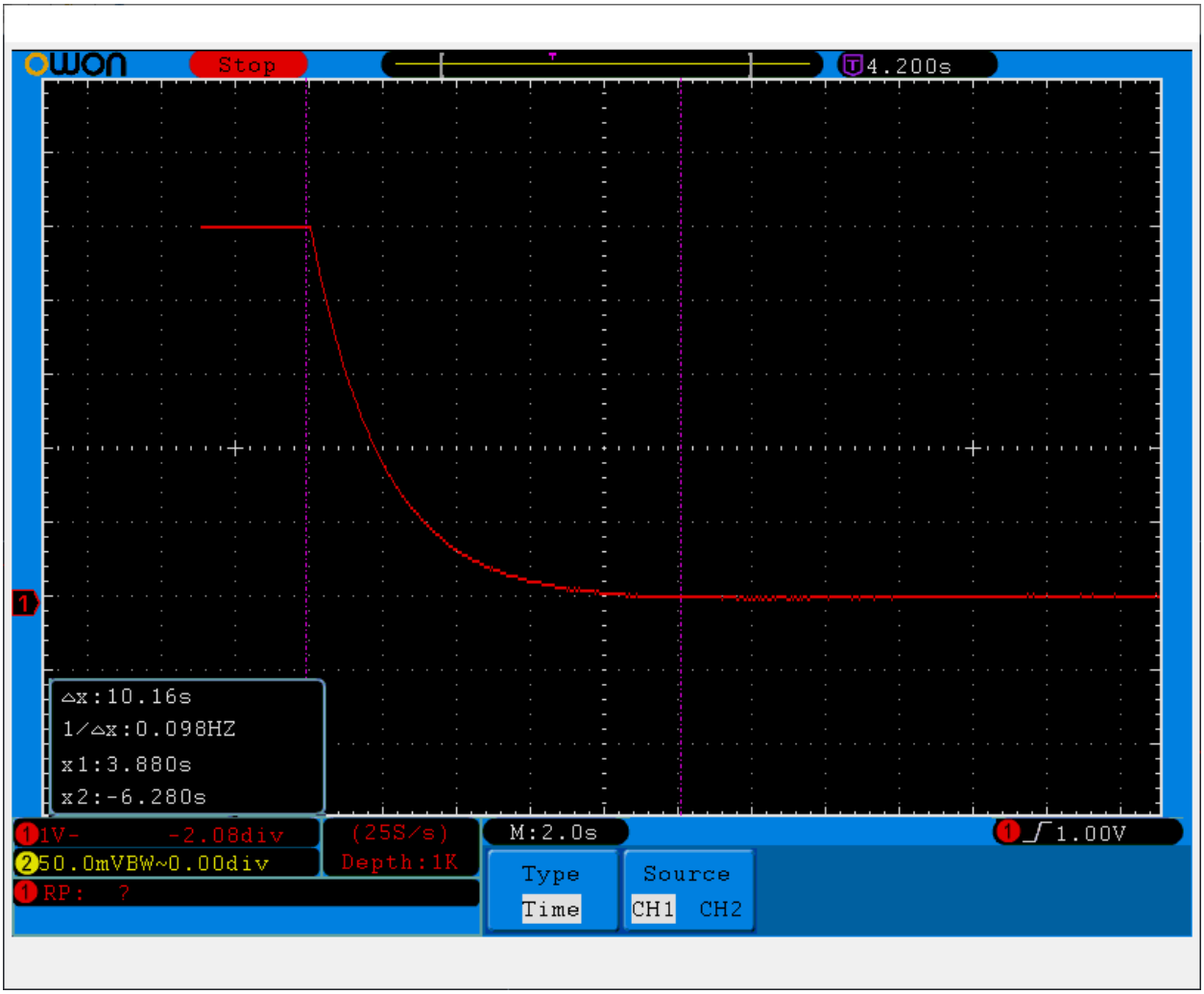

FIGURE 2: DISCHARGE CURVE FOR the SAME CAPACITOR.

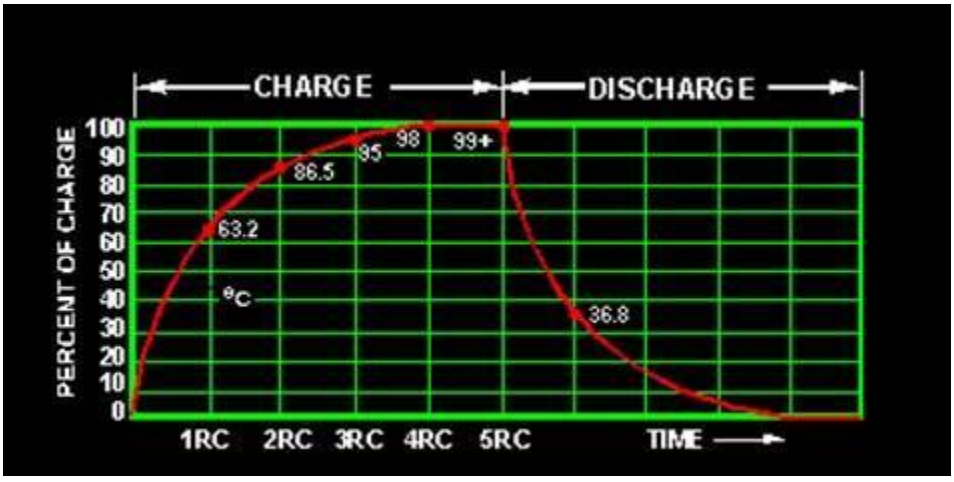

FIGURE 3: SUMMARY OF CHARGING AND DISCHARGING CIRCUIT OVER TIME

When the power is turned on, an inrush of current accumulating across the capacitor (yellow). The voltage (red) begins to rise as the electrons are stored on the capacitor's plates. When fully charged, the current returns to 0V. **[Scope settings for larger image: Current Channel 2: AC coupling, 1A/V current probe settings. 20M limit 100mABW. Channel 1: DC coupled 1V/Div Trigger: Channel 1: 1.2V rising edge]**

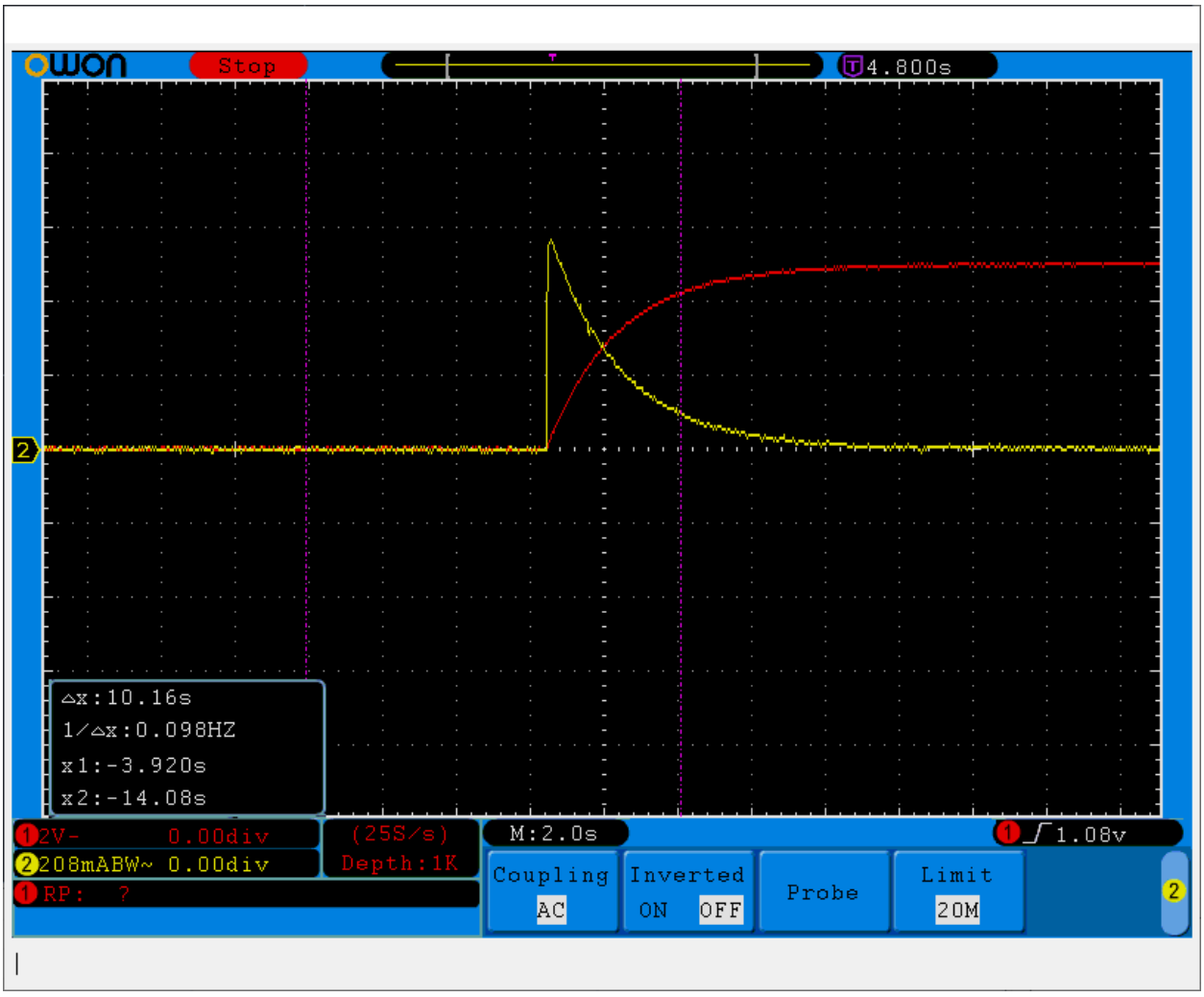

FIGURE 4: COMPARISON OF VOLTAGE (RED) AND CURRENT (YELLOW) AS THE CAPACITOR IS CHARGING.

When the capacitor is discharged, its stored energy is returned to the circuit slowly via the resistor. As soon as power is turned off, a large current flows in the opposite direction than the source voltage. Hence, the yellow trace is negative. As the current decays, the voltage slowly drops to zero. After 5 time constants, the voltage and current are back to 0 volts.

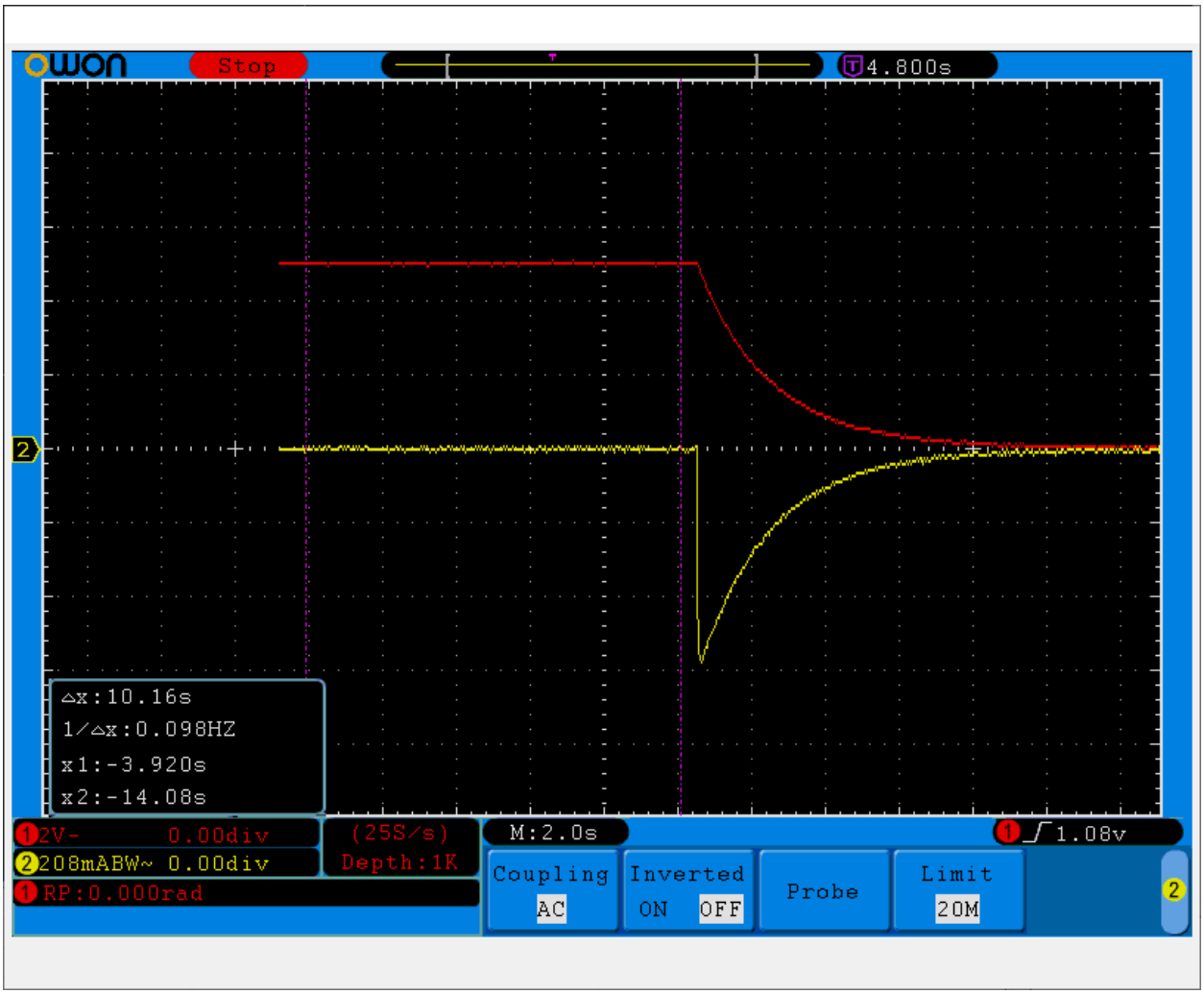

FIGURE 5: COMPARISON OF VOLTAGE (RED) AND CURRENT (YELLOW) AS THE CAPACITOR DISCHARGES

To summaraize, let's view the relationship between voltage and current as the cpacitor is charged and also when it is discharged. The red trace indicates voltage and the yellow shows the current flow.

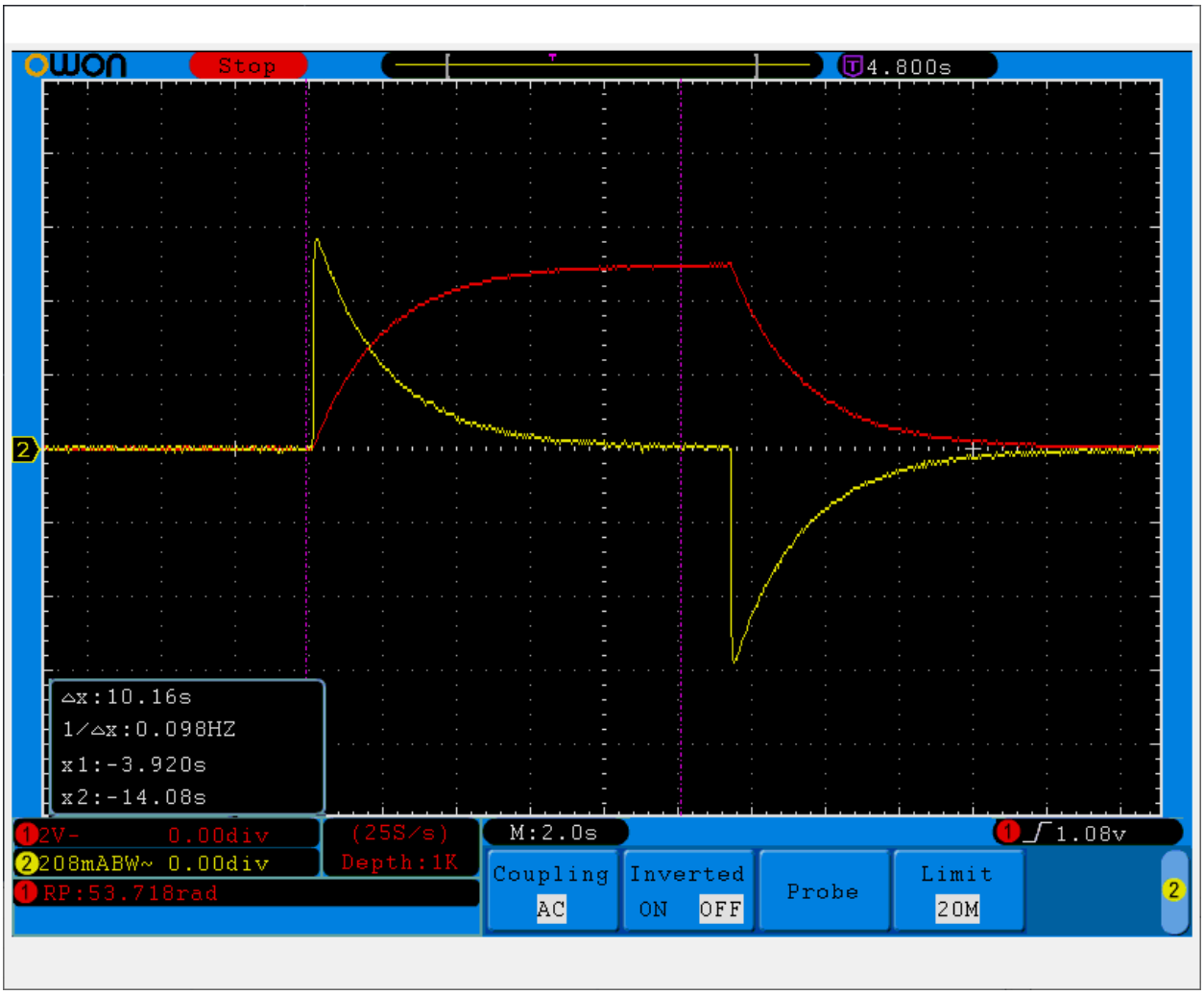

FIGURE 6: COMPARISON OF VOLTAGE VS CURRENT AS CAPACITOR IS CHARGED AND DISCHARGED.

Pre-Charge Circuits

The pre-charge circuit consists at the minimum of:

- A pre-charge resistor, to limit the inrush current (R1)
- A contactor (high power relay) across the pre-charge resistor (K2) to bypass the resistor during normal operation

Additionally, the pre-charge circuit may have:

- A pre-charge relay (K1), to keep the load from being powered through the pre-charge resistor when the system is off
- A contactor in line with the other end of the battery (K3) to isolate the load when the system is off.

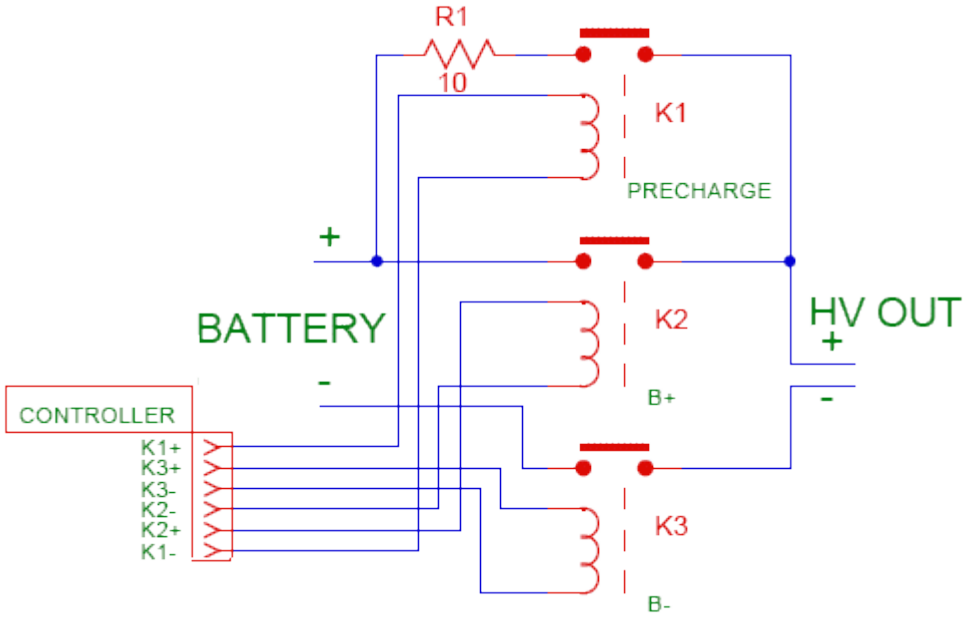

FIGURE 7: TYPICAL PRE-CHARGE CIRCUIT

In the most basic form, the pre-charge circuit is operated as follows:

- Off: When the system is off, all relays / contactors are off
- Pre-charge: When the system is first turned on, K1 and K3 are turned on, to pre-charge the load, until the inrush current has subsided
- On: After pre-charge, contactor K2 is turned on (relay K1 may be turned off to save coil power)

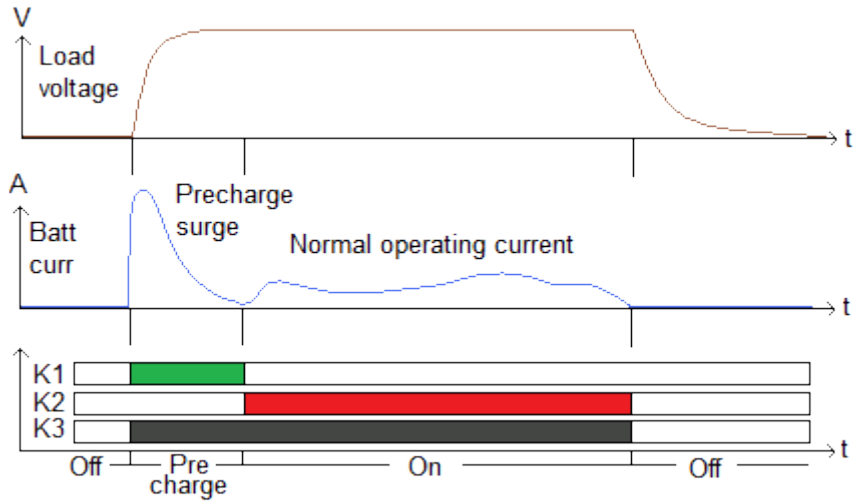

FIGURE 8: PRE-CHARGE AND DISCHARGE CIRCUIT TIMING DIAGRAM

Typical pre-charge waveforms.

Additionally, the pre-charge circuit may be used in combination with sensors to detect problems with ground isolation, short circuit across the load, and problems with components in the pre-charge circuit itself.
Such methods are specialized and are usually proprietary to the manufacturer.