

# Modified design of Existing Trigger Module for Series Ignitron Crowbar System of ITER-India Gyrotron Test Facility (IIGTF)

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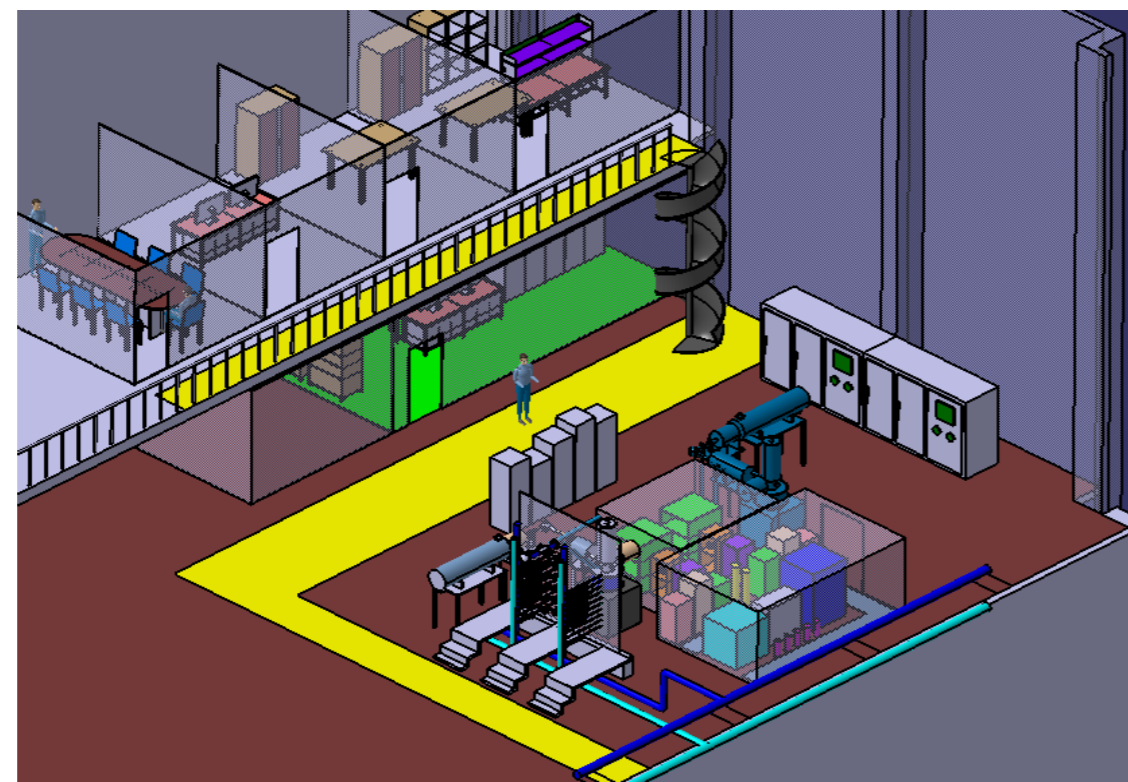
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- Indian domestic agency (IN-DA) has the responsibility to supplying 2 high power gyrotron sources (1MW, 170 GHz) for EC heating & current drive (EC H&CD) system on ITER.
- To establish gyrotron system integration, integrated system performance and any routine testing/conditioning of other gyrotrons require a dedicated gyrotron test facility.
- The ITER-India Gyrotron Test Facility (IIGTF) is in development stage at IPR campus.

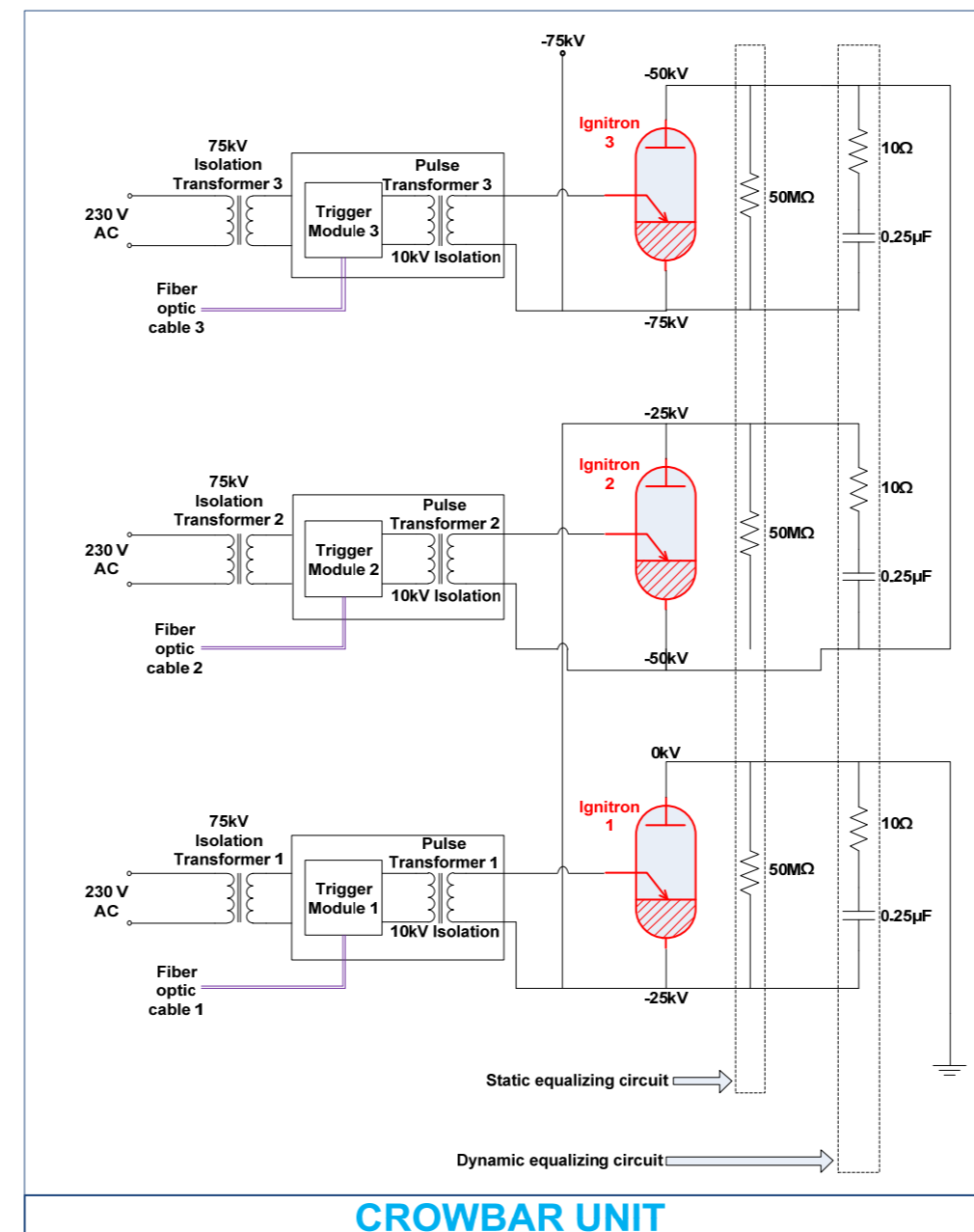
- IIGTF shall have high voltage power supplies, Auxiliary power supplies, Local control unit, water cooling and crowbar protection system to test the gyrotron.
- High power microwave tubes (gyrotron) require crowbar protection when high voltage power supply energy is greater than the critical crater energy (in gyrotron case it is < 10 joules) of microwave tubes.
- Crowbar protection is mandatory to qualify those high voltage power supplies for gyrotron testing.



ITER-India Lab Building

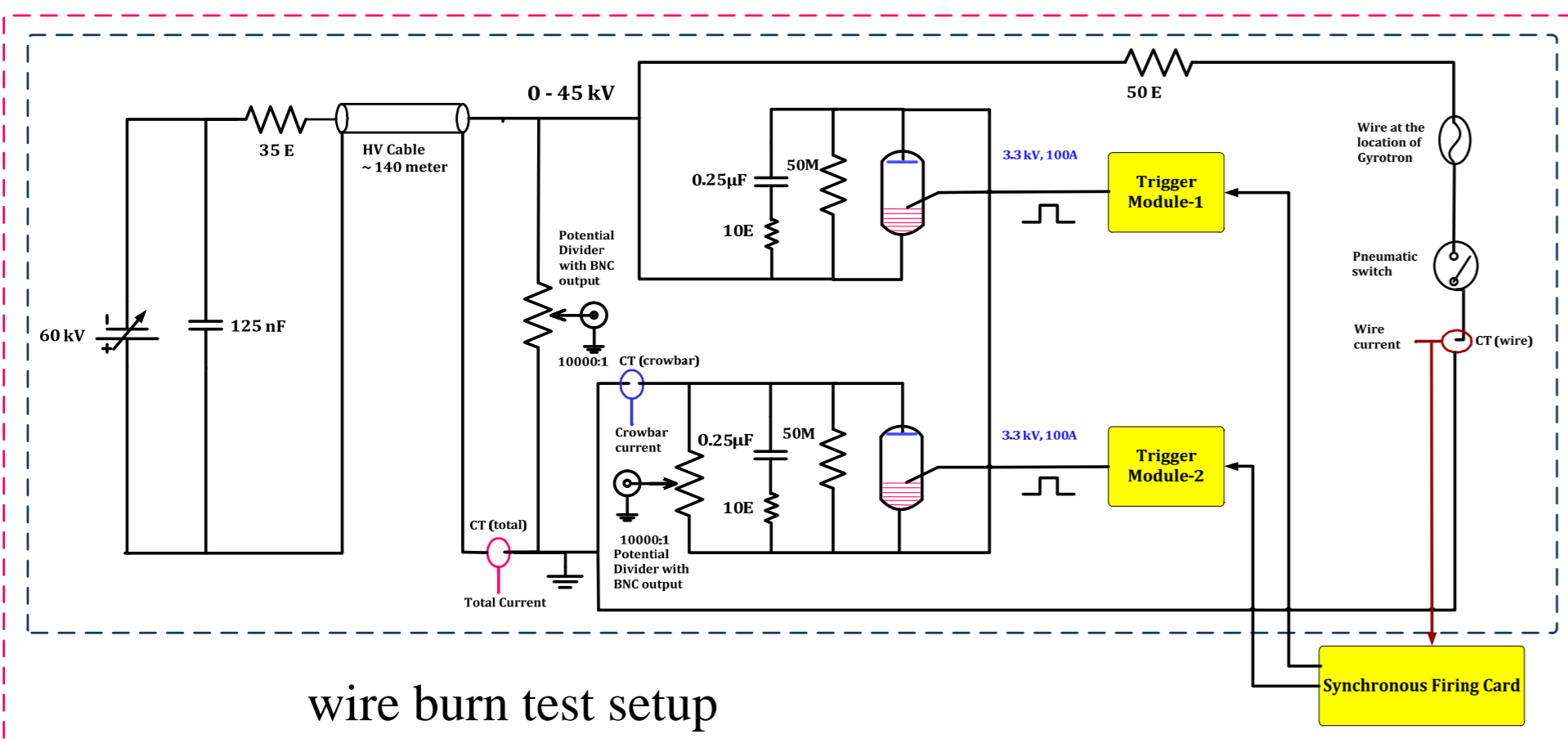


ITER-India Gyrotron Test Facility (IIGTF)

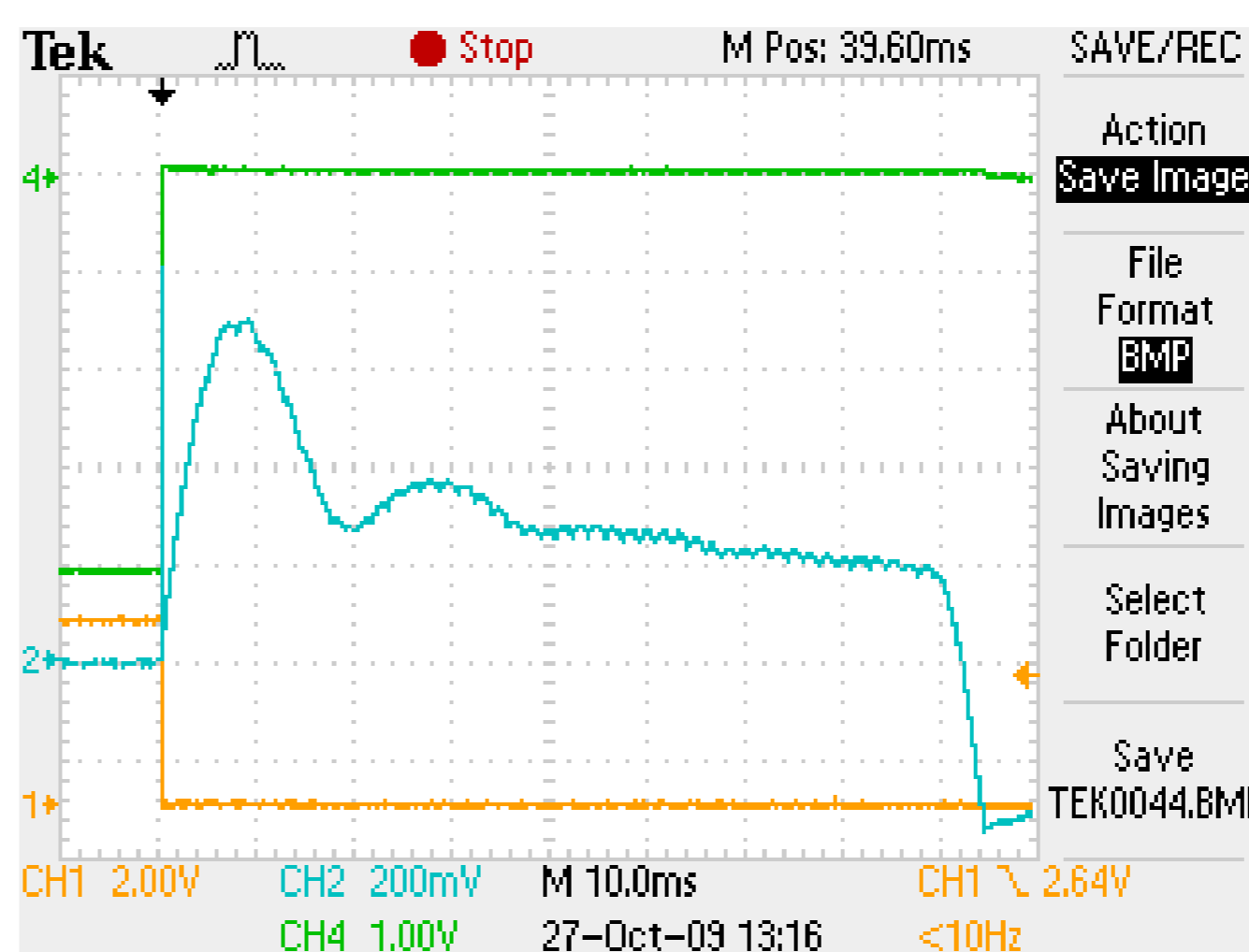


Technical issues in seriesing of ignitrons:

- Voltage should be divided equally at each stage.
- Simultaneous firing of all series connected ignitrons.
- Jitter of the ignitrons between the stages should be minimized.
- Sufficient dynamic compensation for taking care of ignitrons jitter.
- Capacitor for dynamic compensation should be short circuit proof.

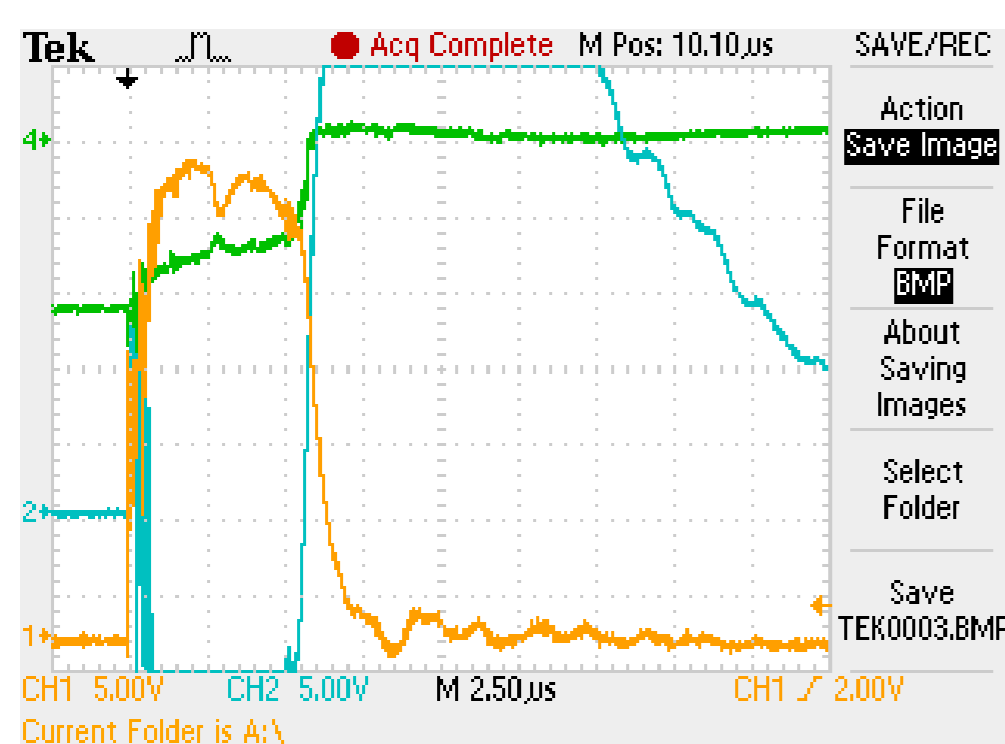


wire burn test setup



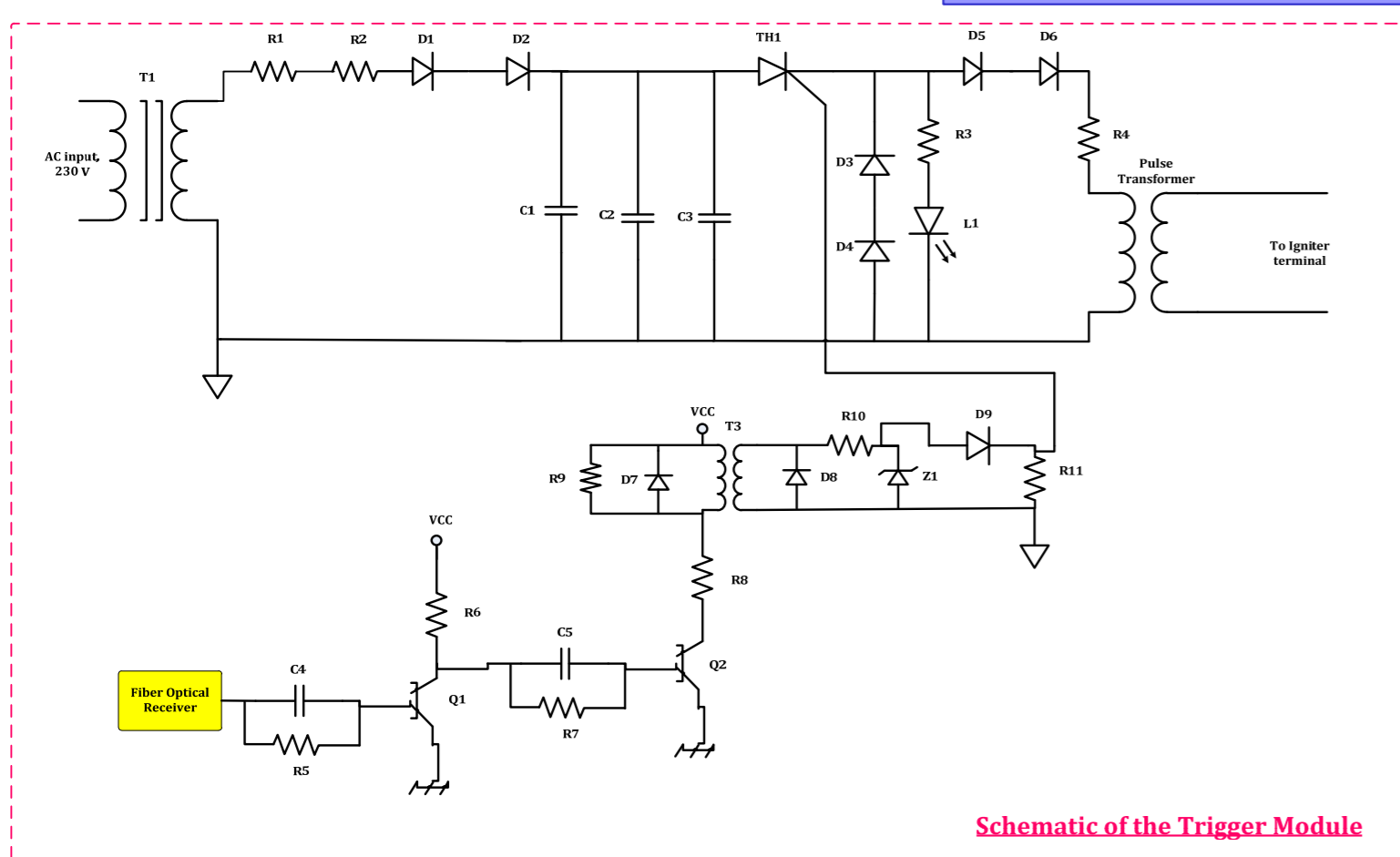
Orange trace: Trigger Pulse  
Blue trace: Crowbar current  
Green trace: Voltage across crowbar

The data was recorded in long time scale to monitor the power supply follow-through current. It is highlighted that crowbar current continue for ~ 80ms but the high voltage remains zero.

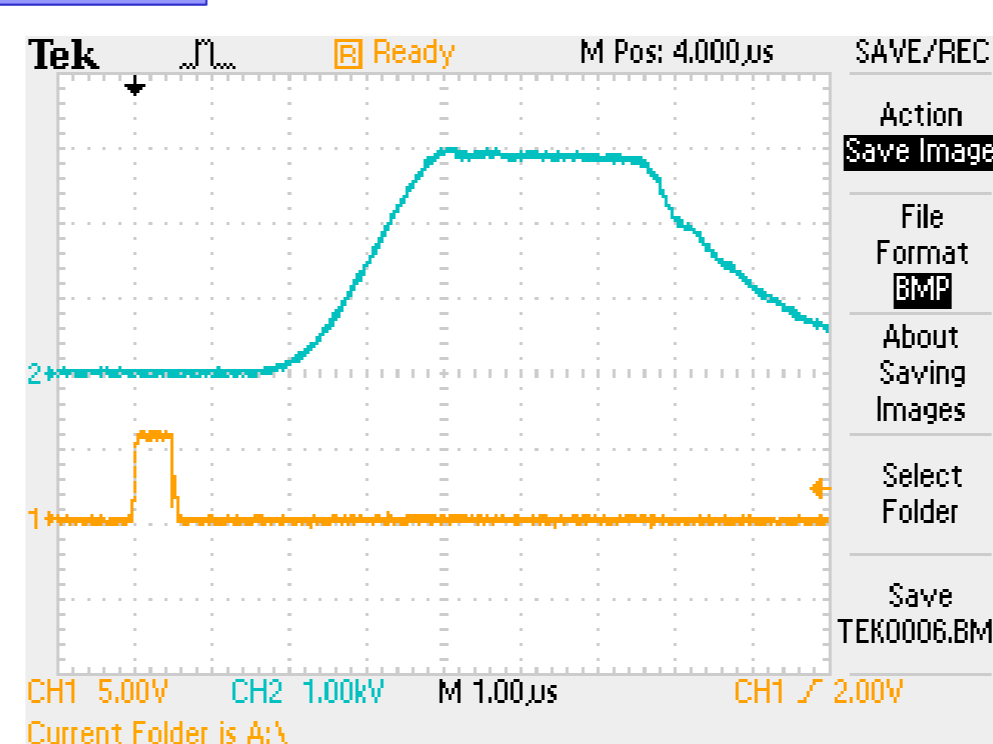


Orange trace: Wire current  
Blue trace: Crowbar current  
Green trace: Voltage across crowbar

This shot was taken at 20kV, the wire current is flowing till the crowbar fired. After crowbar firing wire current become zero and crowbar take over the power supply current.



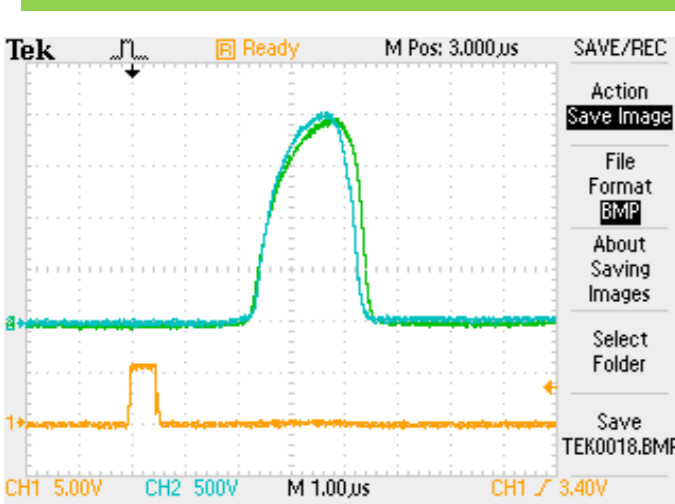
Schematic of the Trigger Module



Trigger module open circuit voltage  
Orange Trace: Trigger pulse  
Blue trace: Voltage at Ignitor-1

The output of the trigger module is approximately 3.5kV for ~ 3.5μs. The total measured delay of the triggered module is ~ 4.0μs, which is well below the required time for crowbar operation.

- Trigger module generate the sharp rise high voltage pulse of specified voltage, current, and time duration.
- The jitter of the ignitrons can also be minimized by proper optimization of trigger module voltage.

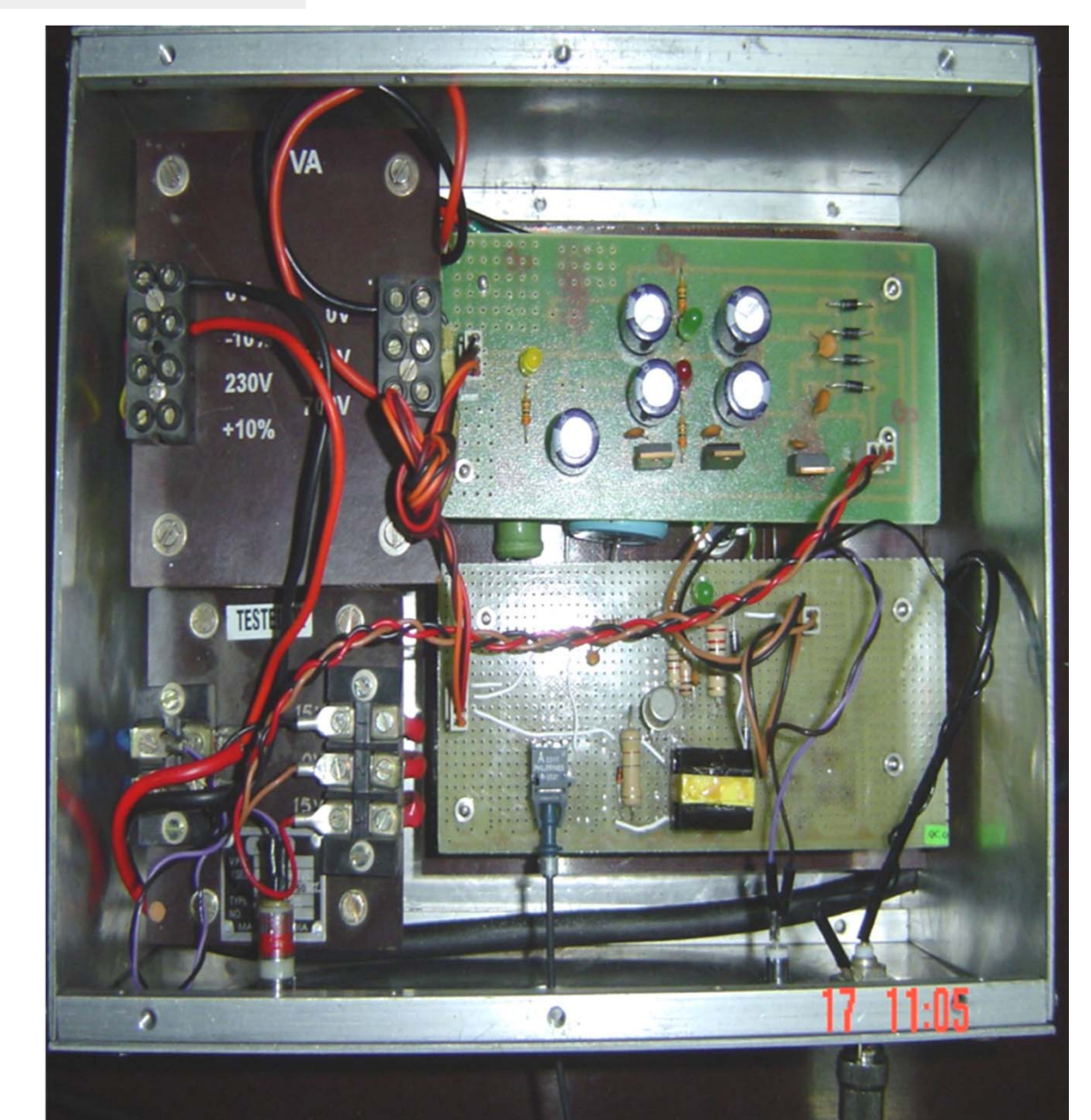


Trigger modules voltage at Ignitors  
Orange Trace: Trigger pulse  
Blue trace: Voltage at Ignitor-1  
Green trace: Voltage at Ignitor-2

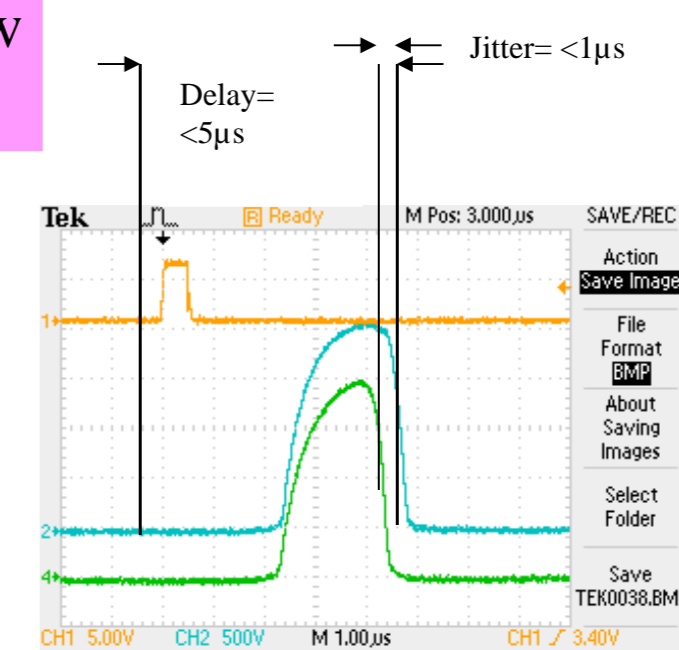
Output of two trigger Modules connected to ignitrons with negligible jitter.

Main features of modified design

- High current capacity
- Long duration pulse
- Precise voltage adjustment
- Higher reliability



Trigger Module



Trigger modules voltage at Ignitors  
Orange Trace: Trigger pulse  
Blue trace: Voltage at Ignitor-1  
Green trace: Voltage at Ignitor-2

Output of two trigger Modules connected to ignitrons for jitter & delay measurement.