

STANGENES INDUSTRIES, INC.

The Best In Custom Transformers



**A NEW TYPE HIGH VOLTAGE FAST
RISE/FALL TIME SOLID STATE MARX
PULSE MODULATOR**

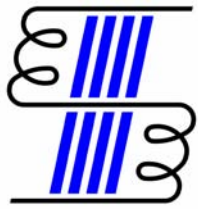
R.L. Cassel Sherry Hitchcock

Stangenes Industries

1052 East Meadow Circle

Palo Alto, CA, USA

6/16/05

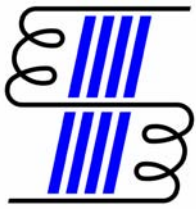


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**Stangenes fast dynamic waveform
solid-state Marx modulator**



Stangenes Industries has developed a Fast Rise/Fall time dynamic waveform solid-State modulator base on the Marx Generator :

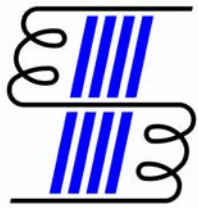
- Pulsed Voltage 14kV
- Pulse Width total 0.2 to 2 μ sec
- Pulse rise/fall time <120 nSec
- Pulse rate >25kHz



Why use a Marx design!

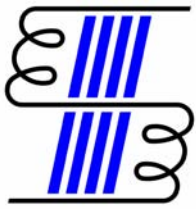
The present pulsed modulators such as hard tube modulator or Solid State equivalents or induction modulators have a number of limitation which can be overcome by use of the solid state Marx approach.

- 1) Dynamic Pulse width and Amplitude**
- 2) Fast Rise time and fall time**
- 3) High pulse voltage with low power supply voltage.**
- 4) Capable of driving high capacitance load**



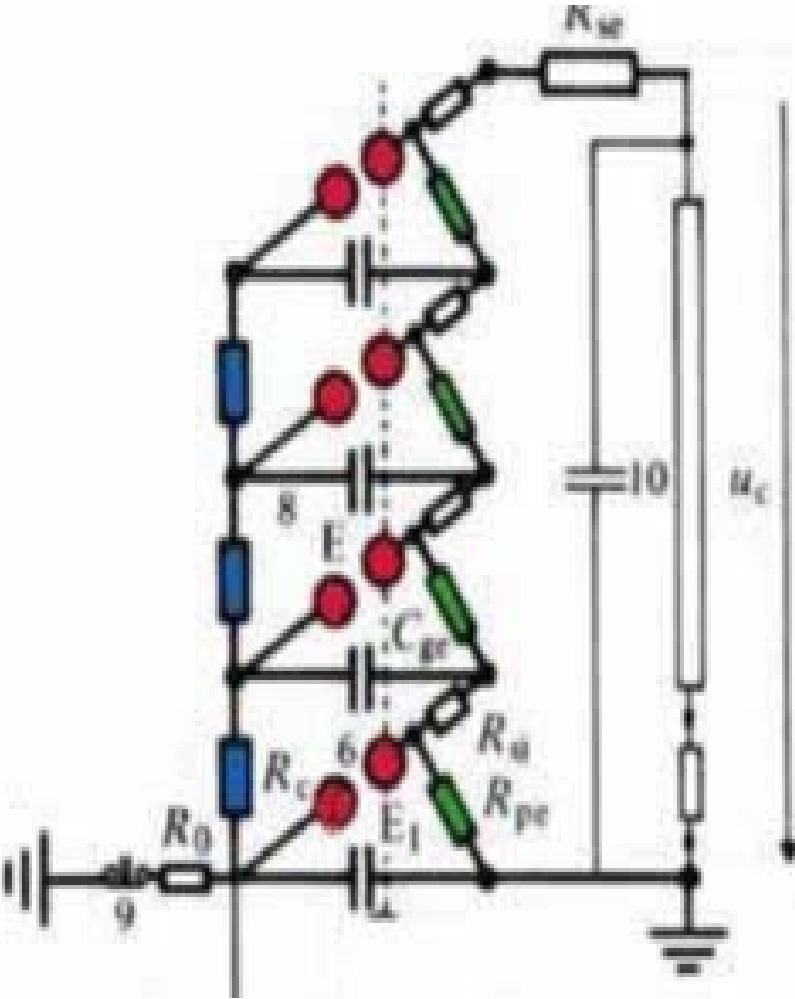
Advantages of solid-state Marx for dynamic pulses

- **1) Rise time and fall time** The output impedance of a Marx is very low limited only by the capacitor and switch impedance on both rise and fall. Turn on and off time of the switch is the major limit to rise time.
- **2) The Marx allows for discrete dynamic amplitude control.** Depending on the number of stages the amplitude of the pulse can be time varying by discrete steps.

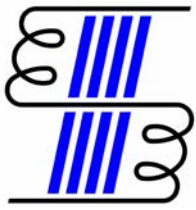


Classic Marx generator

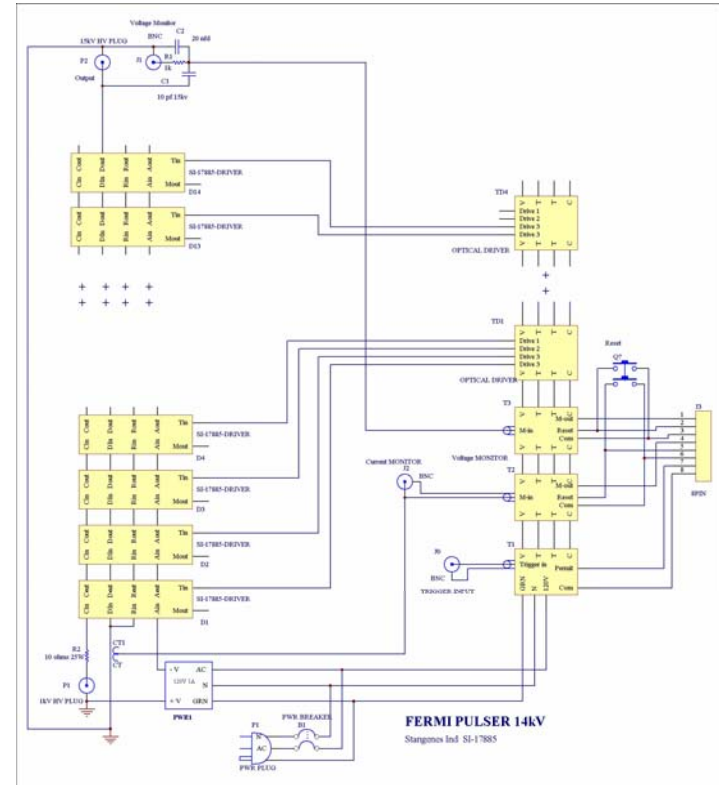
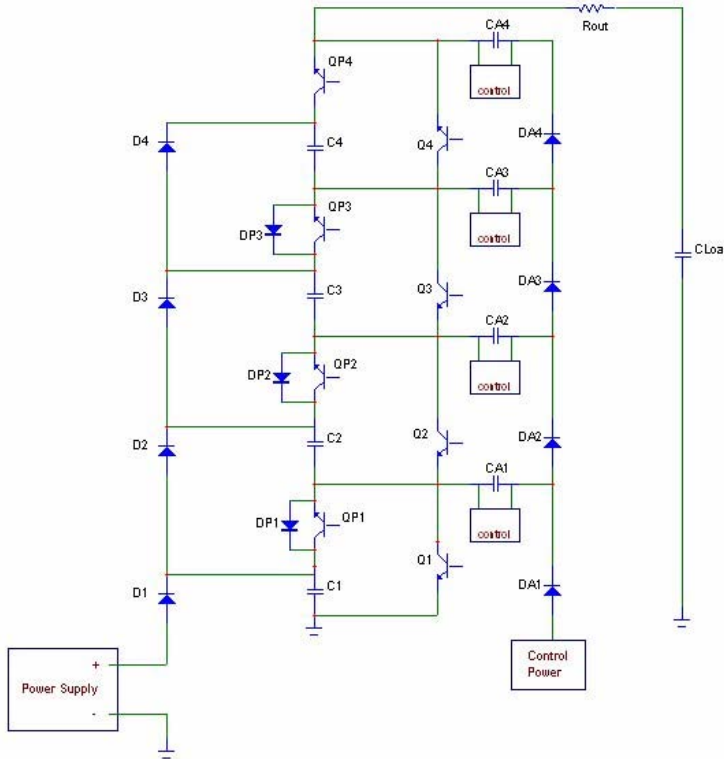
The Marx generator modulator has the advantage of **lower DC voltages and multiple stages**. Typically it used **inductor, resistor, or transformers** to supply the charging capacitors voltage and control power to the stages



Classic Marx generator



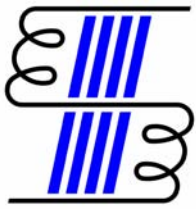
Stangenes solid-State Marx



**Replace resistor/ inductors
with solid state switch**

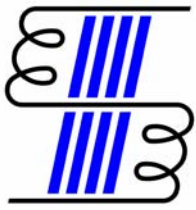
Note: charging and auxiliary by way of
diodes and switches

**Modular design for
Modulator and drivers**



Prototype modulator

- A prototype, **14 stage multistage modulator** was fabricated and tested and supplied to Fermi Lab
- Each stage was operated at a nominal one kilovolt with a producing a **14 kV pulse. Rise times was less than 150 ns with pulse width adjustable for 0.2 μs to 2 μs .**
- **Spark down testing** using spark gaps demonstrated its ability to recover from load break down.

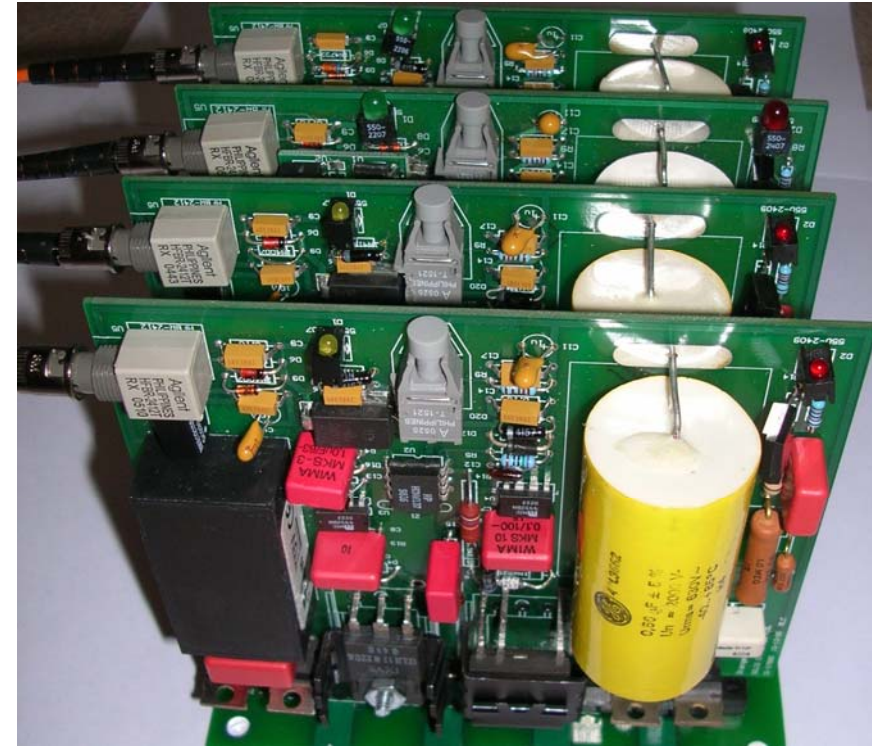
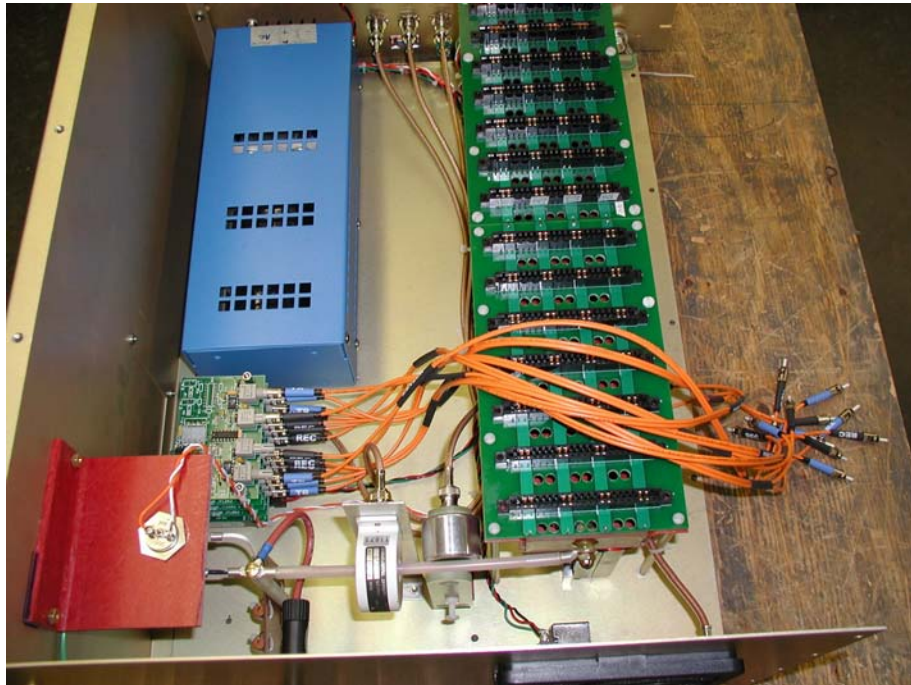


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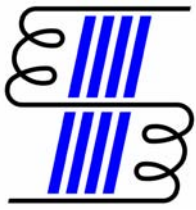
Stangenes Marx Modulator

14 stage Marx modulator
14 kV pulse Rise times **< 120ns**
Pulse width adjustable
Fiber optic triggered



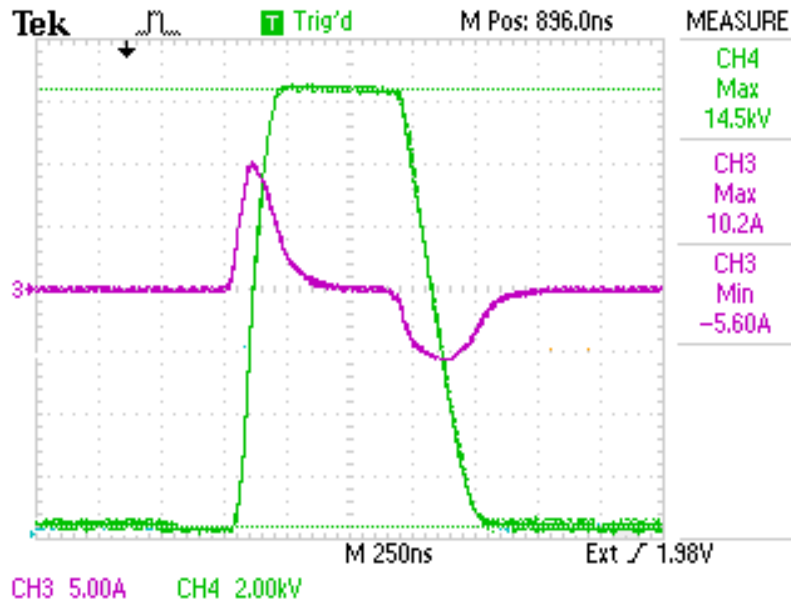
**Pulse Driver
Stages**

**Mother board and
trigger Driver**

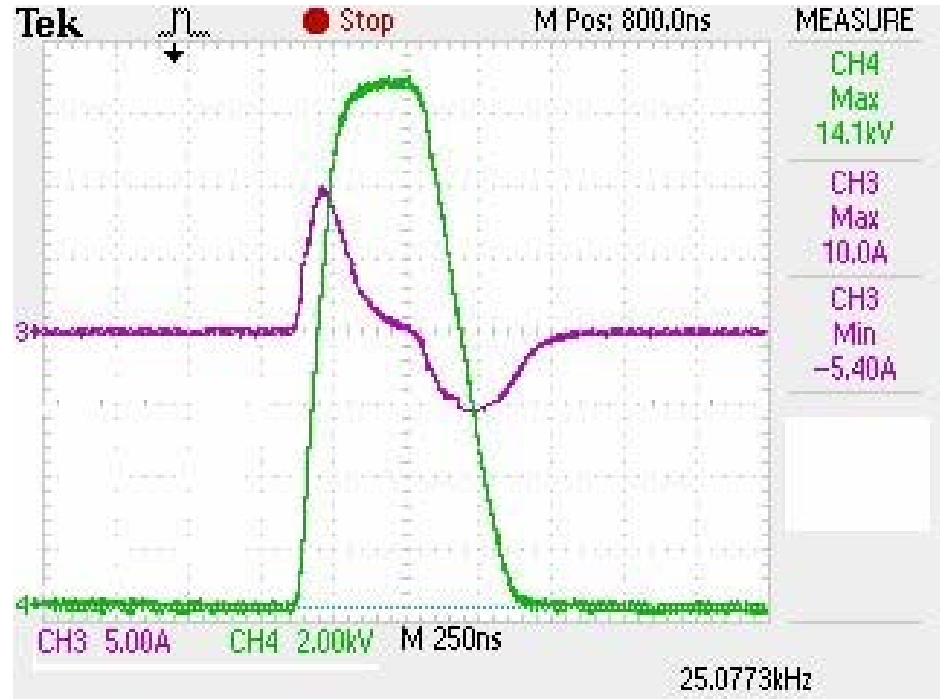


Stangenes Marx modulator driver

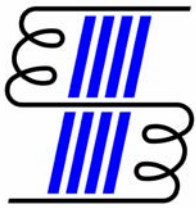
**2.2kV IGBTs
operating at 1 kV**



Longer pulse

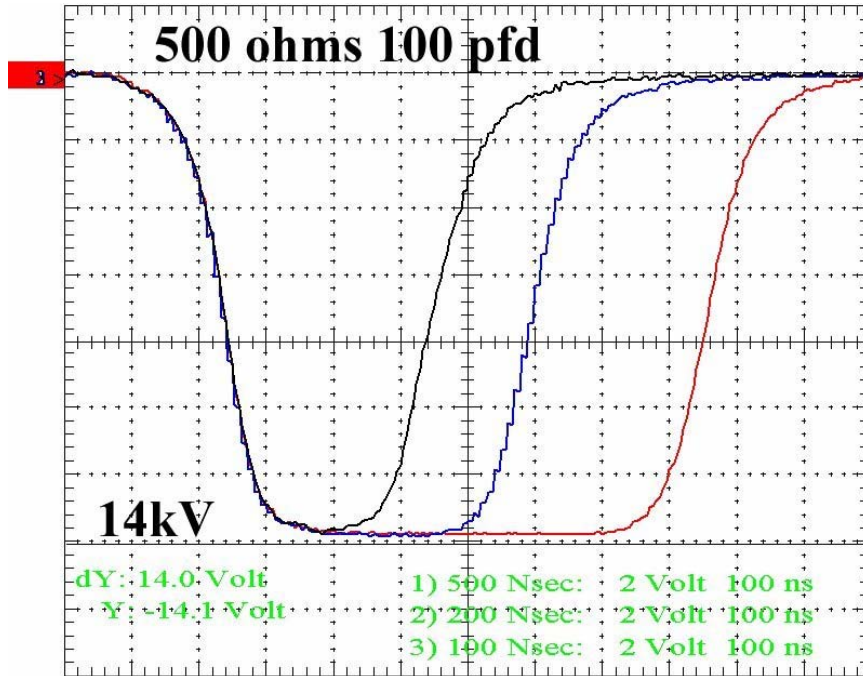


**Short Pulse
IGBT limits Rise time**

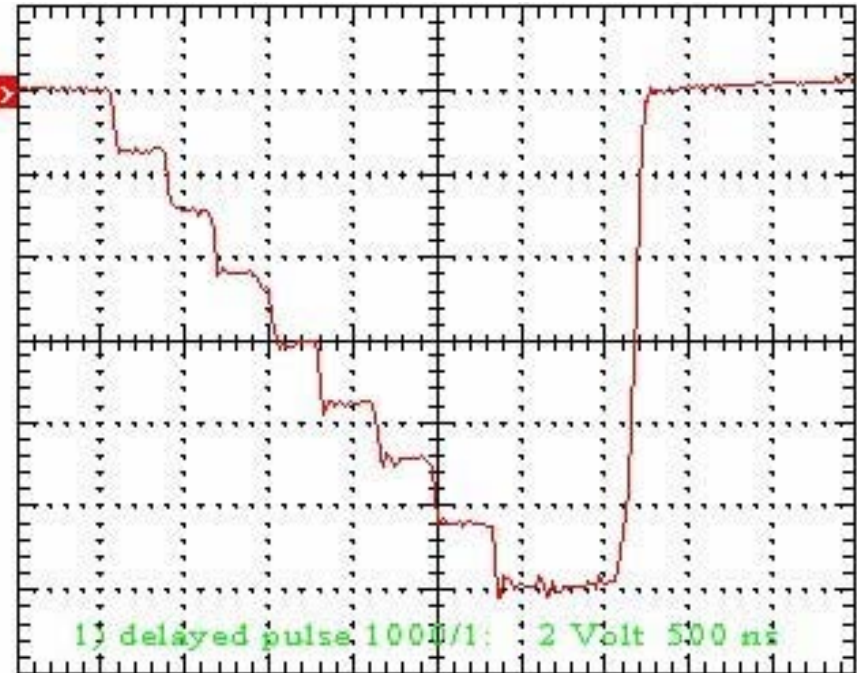


Stangenes Marx modulator

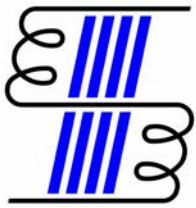
Adjustment flexibility of modulator



Short pulses 200 η sec

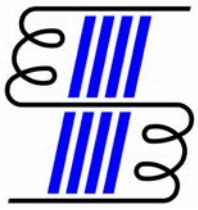


Step Voltage
Amplitude Pulses



Stangenes Marx modulator driver

A Second Generation Modulator has been designed and is under fabrication to 14kV, at 50 kHz with discrete dynamically adjustable output voltage. The new modulator will have improved cooling. It is capable of using high voltage FETs to improve the rise time and fall time of the modulator. The IGBT/FETs are water cooled to allow for greater than 50 kHz operation.

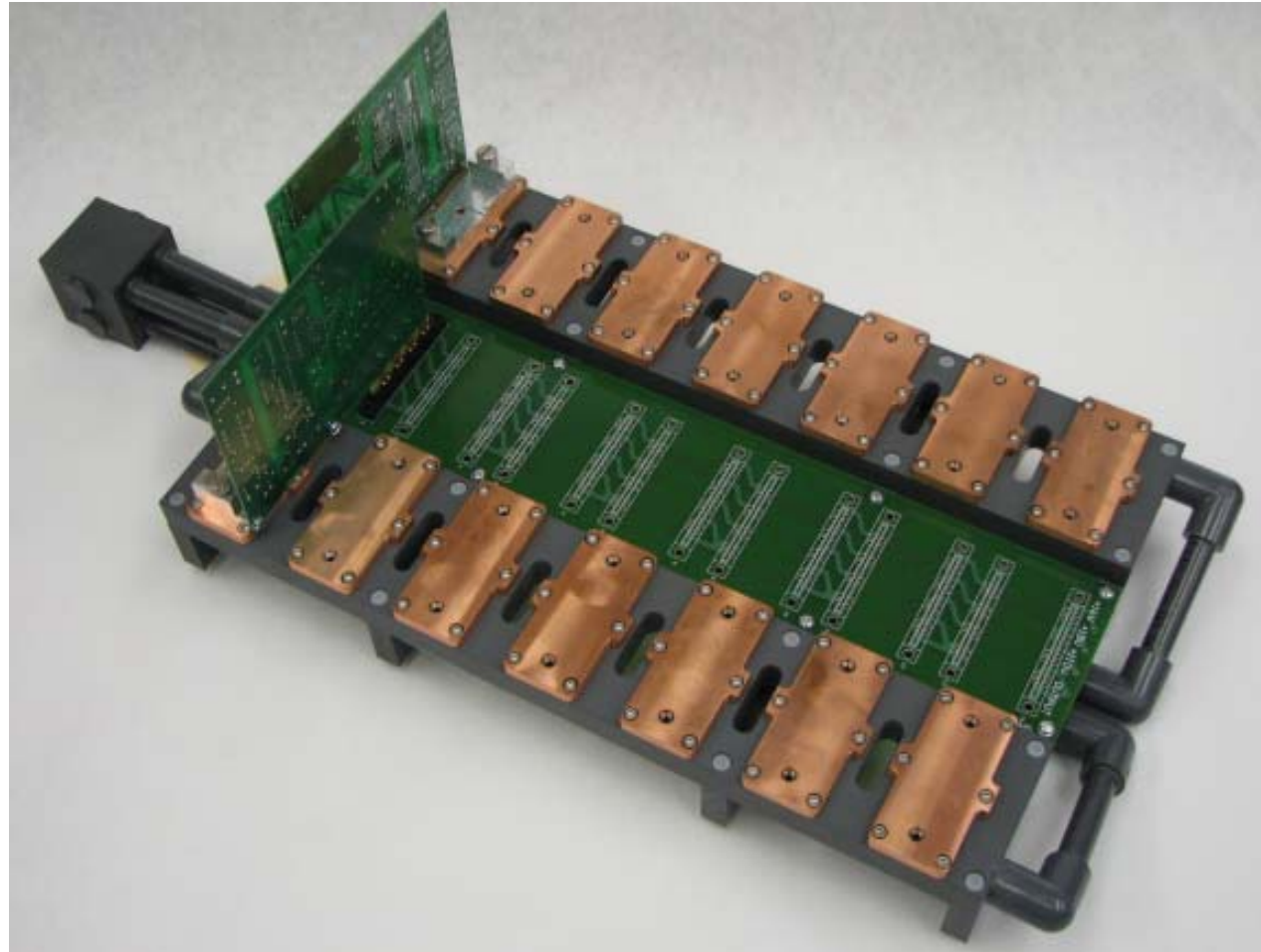


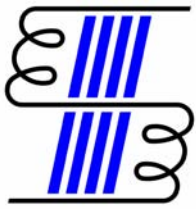
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Stangenes Marx modulator driver

**Water
cooled
heat sink
and
modular
stages**





SUMMARY

- The **Stangenes** designed **Solid-State Marx** modulator has demonstrated that it can be used to provide a fast rise and fall time at high repetition rate. In addition, it can produce a dynamic amplitude and pulse duration at high voltages. With the improved cooling, it well is capable of higher repetition rates. If the IGBTs are replaced with FETs, the modulator can have a faster rise and fall time at a lower output voltage