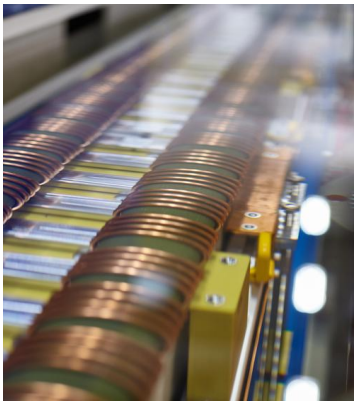
research instruments



ISP Workshop on Advanced Pulsed Power Technologies

Rise Time Improvements on a 20kV 50ns Solid State Switch Assembly by Impedance Adjustments

Michael Osemann, Nainpreet Kularia

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research instruments

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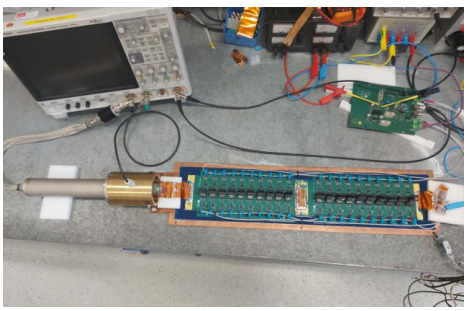
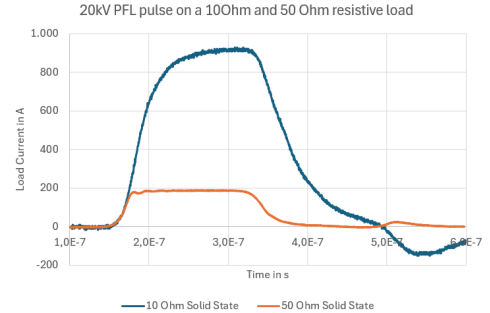


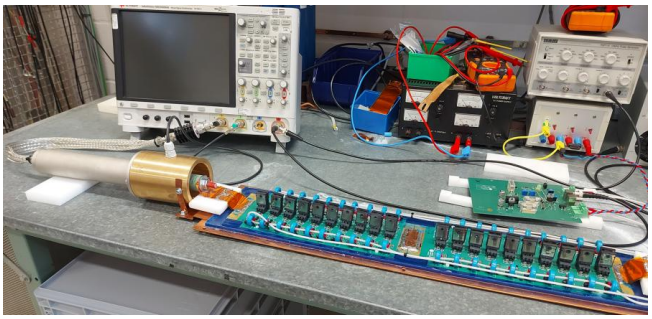


20kV / 1kA Solid State Switching Module

Introduction

Design goal
Solid state HV switch for fast Kicker Magnet applications

Approach
Thyristor based
Modular PCB design
20kV potential separated supply and trigger



Achieved parameters:

U_{switch}:	20kV (30kV peak)
I_{peak}:	1kA for
t_{rise}: at 10 Ohm	~50ns (1kA)
t_{rise}: at 50 Ohm	~25ns (200A)
f_{rep}:	10Hz

Max. test parameters

I_{peak_max}:	6kA for 10µ half sine
f_{rep_max}:	2Hz

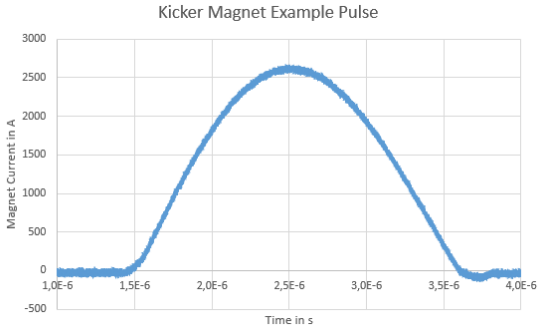
20kV / 1kA Solid State Switching Module

Example application project: Fast Kicker Magnet Pulser

Pulse generator parameters
Pulse shape: Half sine

U_{pulse}:	<8kV
I_{peak}:	< 3kA
t_{pulse}:	1.5µs fw/hm

Further project scope
Directly connected to the magnet
Radiation protection
Separate control system
Separate HV-power supply

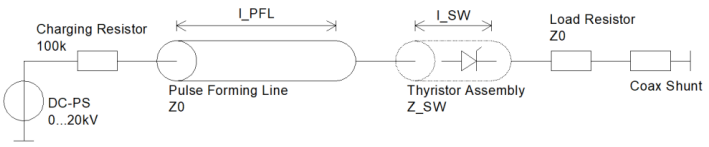


20kV / 1kA Solid State Switching Module

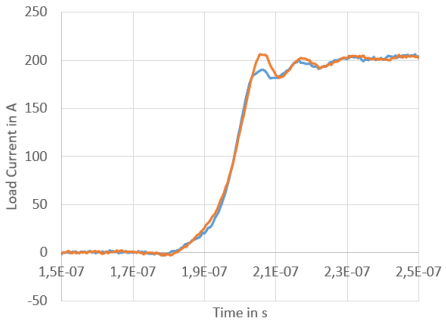
Impedance and Reflection Model

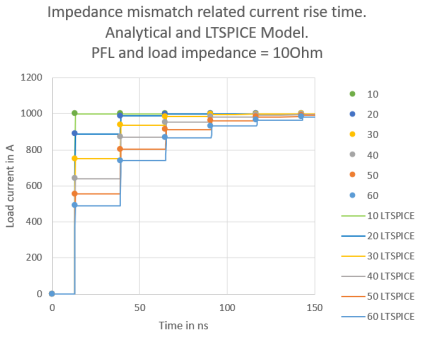
Expectation / Question
Will an impedance mismatch reduce the possible current gradient?

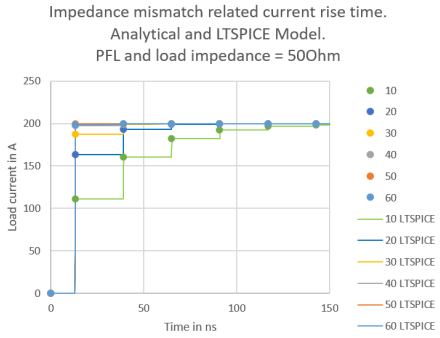
Assumption
$Z_{PFL} = R_{load}$
Switch module impedance ≠ Z_{PFL}



Experimental setup
Pulse Forming Line Pulser
1x 15m RG58 → R_{load}: 50 Ohm
5x 15m RG58 → R_{load}: 10 Ohm

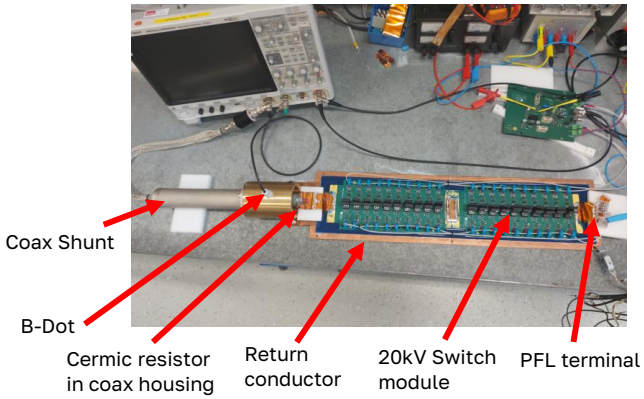




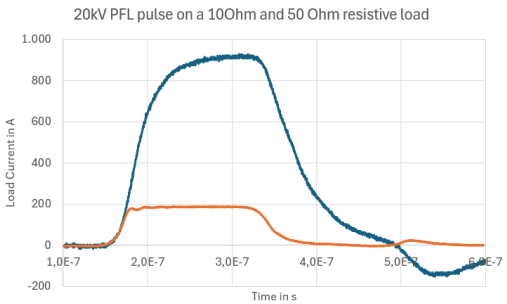


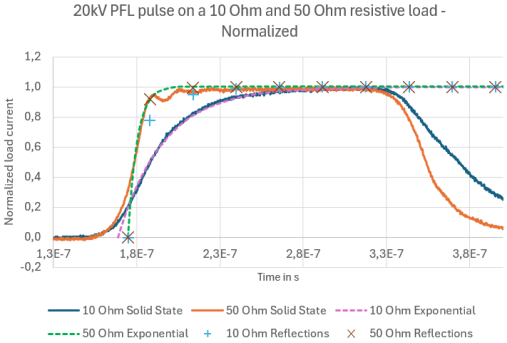
20kV / 1kA Solid State Switching Module

Experimental Results with Thyristors



$$\tau \sim \frac{L}{R};\ L = const.\quad R = 10\ Ohm/50\ Ohm$$

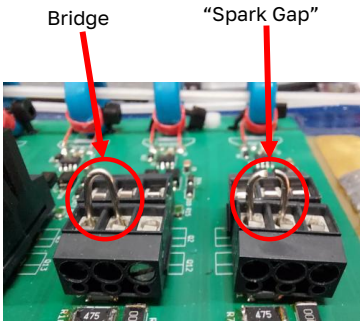




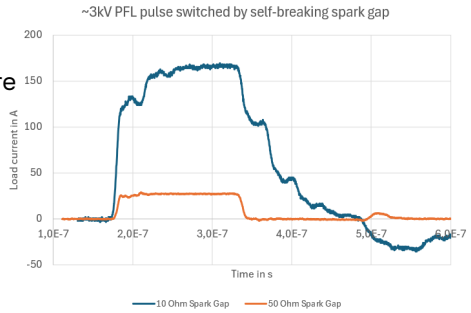
20kV / 1kA Solid State Switching Module

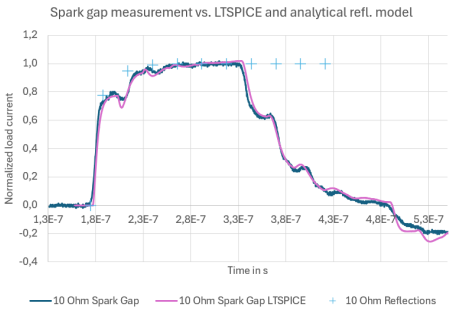
Experimental Results with Spark Gaps

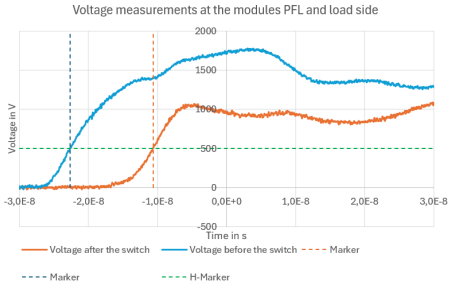
19 thyristors were replaced by wire bridges, the first thyristor at the PFL was replaced by spark gap.

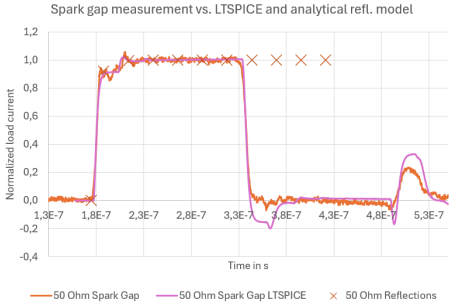


$t_{propagation}$ = 13ns
Z_{switch_module} = 28 Ohm









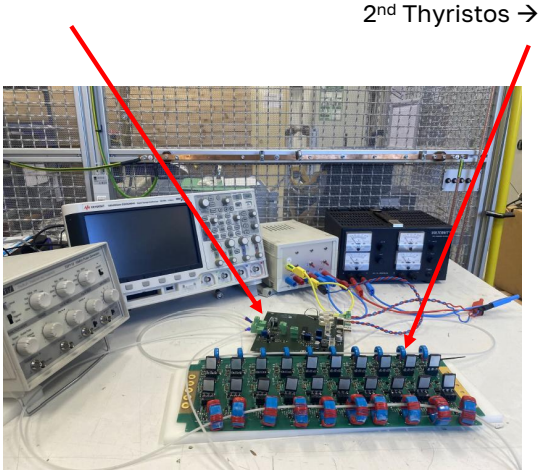
20kV / 1kA Solid State Switching Module

Outlook

Switch Module Impedance
1st Z_{switch} → 50 Ohm (almost done)
2nd Z_{switch} → 10 Ohm (open)

Driver upgrade
Repetition rates from ~10Hz → 1kHz (done)

Alternative semi conductors
1st Thyristors → IGBTs (almost done)
2nd Thyristos → MOSFETs (open)



Thanks for your attention

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- *Questions about the presentation?*

Feel free to contact us anytime.

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