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DESIGN, DEVELOPMENT AND INITIAL RESULTS OF SOLID STATE MAGNETRON MODULATOR

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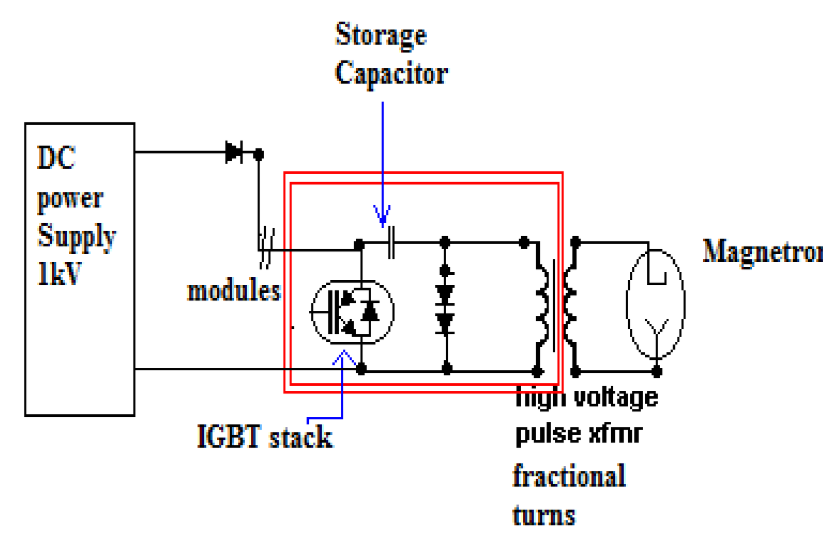
A prototype solid state pulse modulator based on Induction Adder Topology has been designed and is currently being tested on an S Band Pulsed magnetron rated for 3.2MW Peak RF Power. After successful lab tests the modulator is intended for use in cargo scanning and radiography applications. Currently the topology consists of 4 nos. of single turn primaries driven independently at voltages not more than 1000V. The secondary encircles all the four primaries to generate the desired pulsed voltage across the magnetron. The designed output pulse parameters are 50kV, 120A, 4 micro s, at a pulse repetition rate of 250 pps. The paper describes the design and development of the Epoxy Cast Pulse transformer and the Low Inductance Primary Circuit. The rise time measured was < 400ns, and the reverse voltage at the end of the pulse was less than 12kV (at 43k V pulse). The testing was done at low PRF, on two different magnetrons having different operating points to demonstrate fairly good impedance independent operating characteristic of the magnetron modulator. Initial test results on the Resistive load and Magnetron load is also discussed.

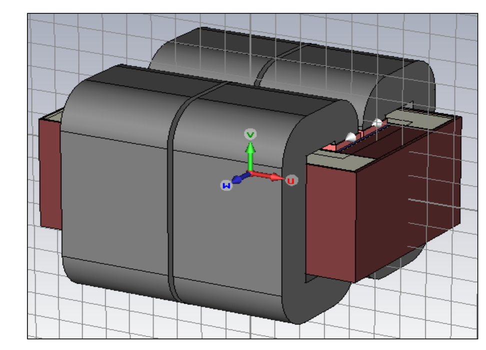
Various low power linear electron accelerators designed for cancer treatment, radiography, cargo scanning and related applications use pulsed magnetrons as RF Source. The magnetrons are typically rated for 3.2MW peak RF Power and. 3kW average RF Power. 1000's of such machines are available worldwide. The pulse modulators required to power these magnetrons are traditionally Line type-modulators. Though these modulators are very rugged, they are being replaced by Solid state modulators due to various reasons which are elaborated in various references [1, 4, 5, 6].

The paper describes a solid state magnetron modulator being developed in our lab. The output specifications towards with the modulator is designed are listed in the table.

Output Pulse Voltage	-52kV
Peak Current	120A
Pulse width	4µs (flat top)
Rise time	<400ns
Backswing	< 5kV
Pulse Droop	< 1%
Pulse to Pulse Stability	1%
Max Pulse Repetition Rate	250 pps



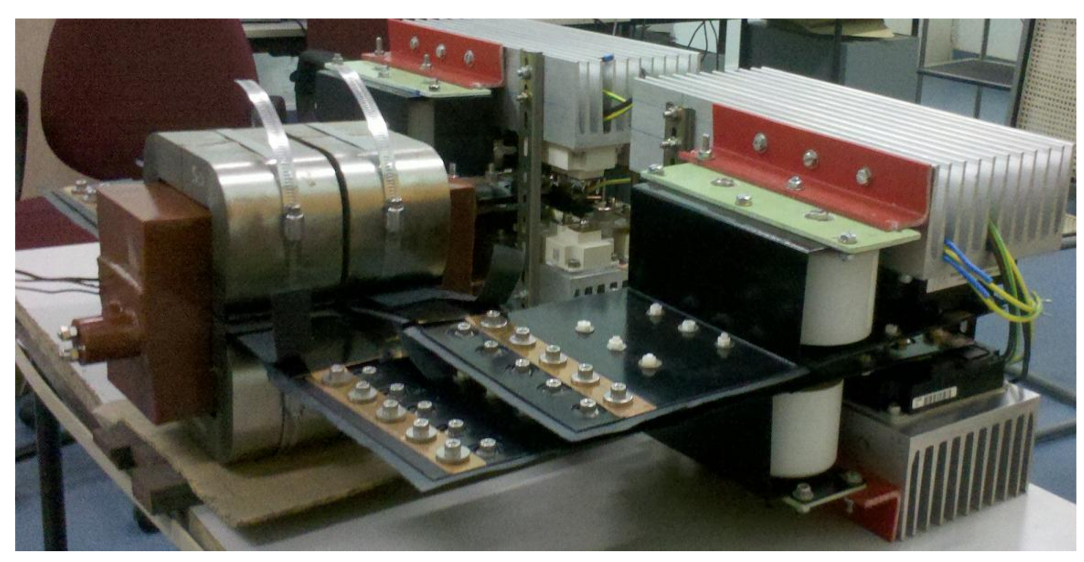
Basic Schematic

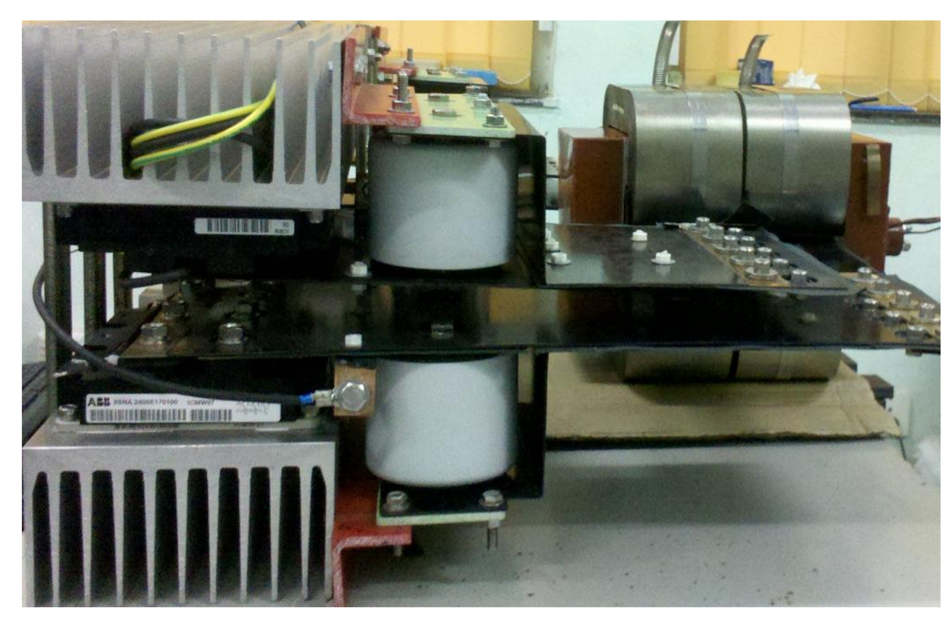


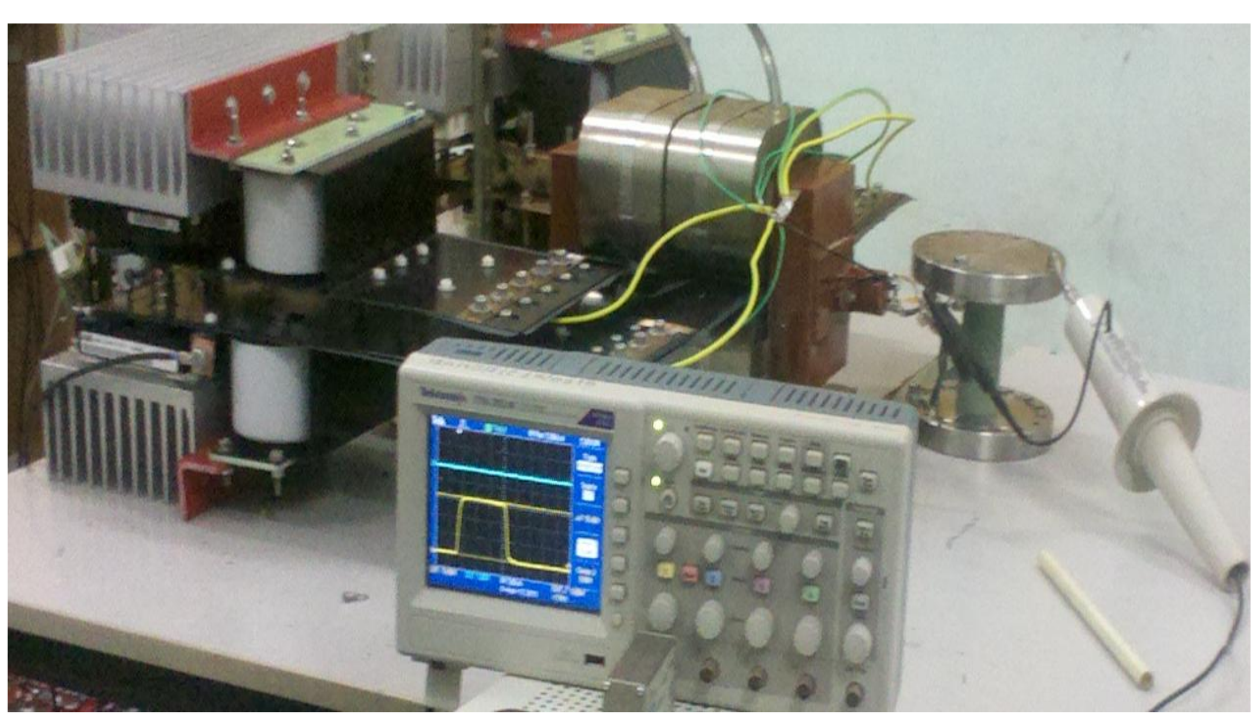
CST EM Modeling of Fractional turns Pulse Transformer

Construction of Epoxy Cast Secondary Winding

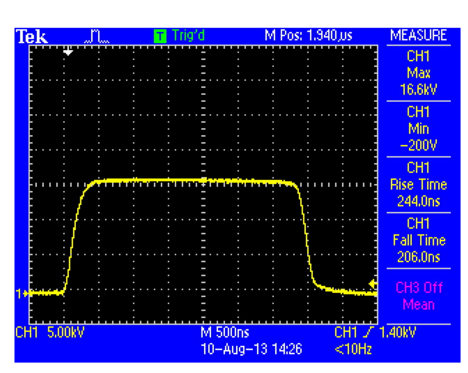
Different Views of the Discharging Circuit of the Prototype Modulator without the Load



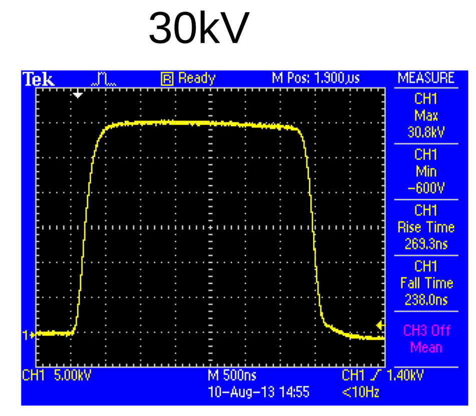




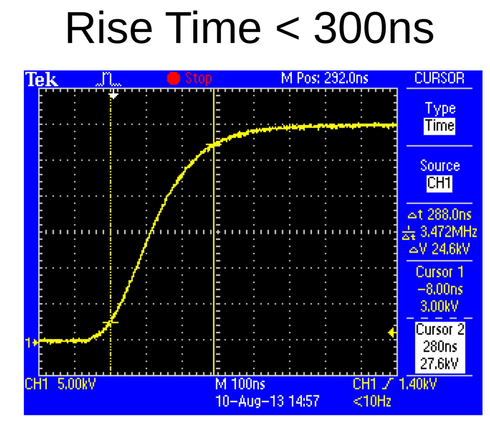
15kV



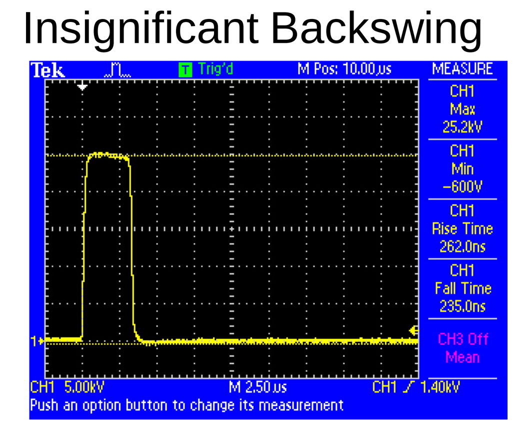
30kV



Rise Time < 300ns



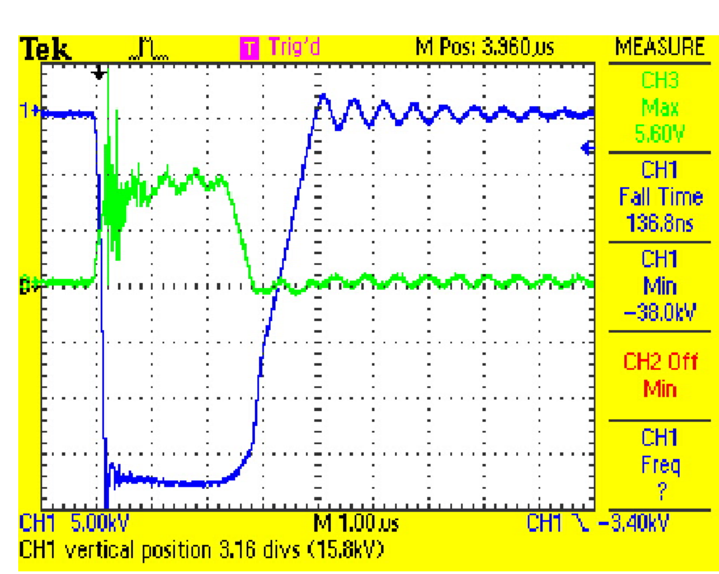
Insignificant Backswing



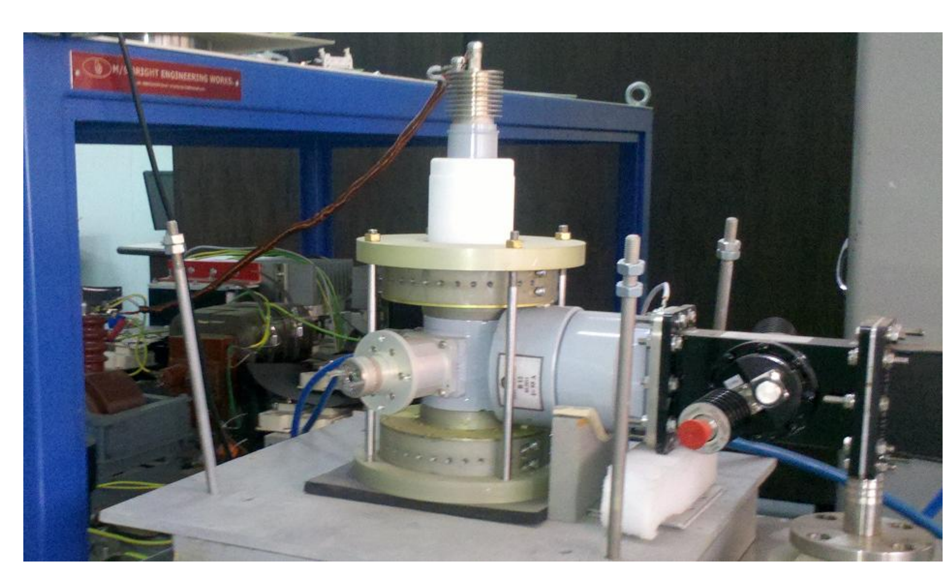
The testing on resistive load Indicates that the rise time is fairly independent of the voltage swing. The rise time is < 300ns & the backswing is negligible.. This will be used with opposite polarity

Solid State modulator used for powering the e2v make magnetron MG5028 used for buncher Linac Conditioning.

PULSE SHAPE ON MG5028



Ch1 (Blue): Magnetron Voltage
Ch3 Green: CT for magnetron Current
As seen the rise time is < 400ns, very important for magnetron
Back swing < 3kV



Modulator tested on FAZA make (Russia) magnetron MI456A with operating point of 55kV/110A

FUTURE SCOPE

Commercially available gate drives were used for this testing. These commercially available Gate drives were slightly modified to restrict the ARC current, however they are not suitable. An improved Gate Drive has been designed, fabricated and is being tested. The CCPS for the modulator has been designed and is under fabrication, Water cooled heat sinks will be used for more compactness, and based on the results, we may finally freeze the design to 2 IGBTS only.

CONCLUSION

Indigenous design and development of a Proof of Principle Solid State Modulator has been successful. It has been tested on actual magnetron Load and the required rise time has been achieved. It is also concluded that the modulator performance is largely load independent, as the modulator was successful tested on two different magnetrons. The experience gained is very useful for the development of similar modulators for higher power klystrons.