FAST KICKERS FOR THE NEXT GENERATION LIGHT SOURCE *

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Abstract

The Next Generation Light Source (NGLS) under development at Lawrence Berkeley Laboratory is a 2.4 GeV linear accelerator with up to ten FELs. Each of the FELs require a fast kicker, with the exception of the final one which can use a normal dipole bend magnet. The requirements for the kickers are to deflect the linac beam by an angle of 3 mrad with a magnetic length of 2 m, and an aperture size of 17 by 17 mm. A strip line magnet with an impedance of 50 Ohms being feed from the opposite direction as the beam has been selected for prototyping. The modulator requirements to drive such a magnet are +/-15 kV and +/-300 A, with rise and fall times of 5 ns and a flat top of 10 ns. The pulse to pulse stability must be better than 0.01% of the peak value. The design of the modulator is a transmission line adder with 20 cells, each driven by 12 power MOSFETs. This paper describes details of the design as well as present preliminary test data.

REQUIREMENTS

The NGLS is designed to have ten FELs, each fed from the same linac operating at 2.4 GeV [1]. Bunches with a frequency of 1 MHz will be kicked into the FEL lines using fast kicker magnets operating at 100 kHz. The overall requirements for the kickers are shown in Table 1.

Table 1. Parameter list for NGLS kicker requirements.

Beam Energy	2.4 GeV
Bend Angle	3.0 mrad
Magnetic Length	2.0 m
Aperture	17x17 mm
B Field	600 Gauss
E Field	1.8 MV/m
Pulse Width	10 ns
Rise/Fall Times	<5 ns
PRF	100 kHz
Average Power	5.6 kW
Repeatability	<0.01 % error FS
Interpulse Ripple	<0.01 % FS

MAGNET DESIGN

The magnet design is a 50 Ω stripline kicker feed with bipolar pulses from the opposite end as the beam direction. The cross section of the prototype magnet and the lines of flux in the magnet are shown in Figure 1. The structure is made by splitting a copper pipe along its length to form the busses. The vacuum vessel is made from stainless steel and has an upper and lower pole piece attached to provide for a low impedance return path for the beam image currents. Figure 2 shows the magnitude of the magnetic field across the center of the aperture, when driven by ±1 A current. This magnet has a magnetic gain of 0.19 G/A and an inductance of 327 nH/m.

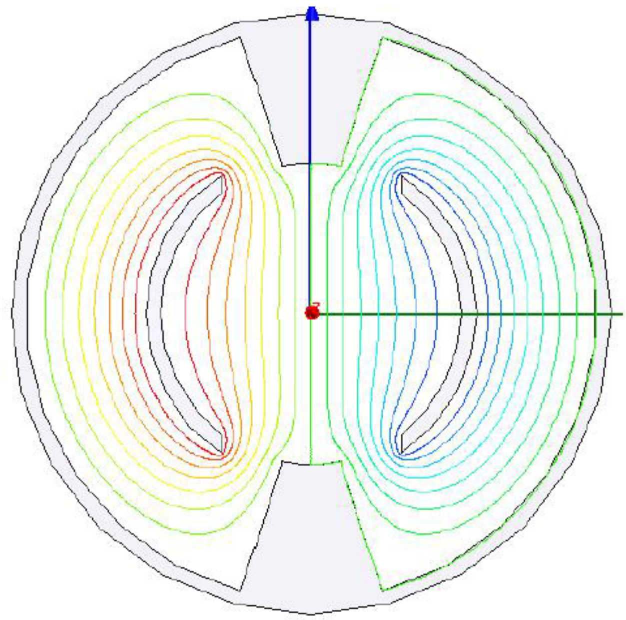

Figure 1. Cross section of magnet and flux lines.

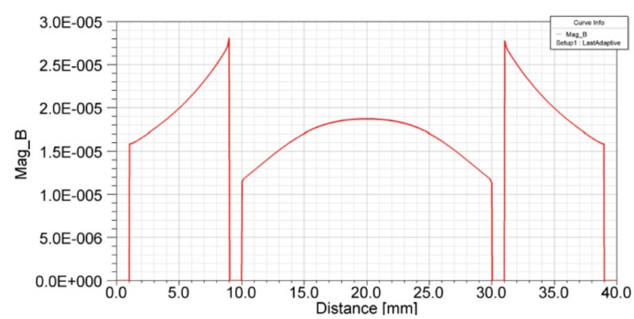

Figure 2. B field magnitude across center of aperture.

MODULATOR DESIGN

Several modulator topologies were investigated, a conventional inductive adder [2], a transmission line adder [3] and a drift step recovery diode (DSRD) circuit [4]. DSDR modulators were ruled out early because of an unavoidable pre-pulse required for diode pumping. A conventional inductive adder design was investigated but abandoned in favour of the transmission line adder because of complexity and cost of the mechanical assemblies. A simplified schematic of the transmission line adder circuit is shown in Figure 3. The design uses 20 switch PCBs, each consisting of 6 MOSFETs, driving a 2.5 Ω stripline transmission line for each polarity. The grounds of the striplines are all isolated using ferrite cores to allow addition of the output signals. Bipolar pulses can be created by a single adder by connecting one adder as

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shown in the figure while tying the high voltage output of the other set of cables to ground and the braids to the magnet.

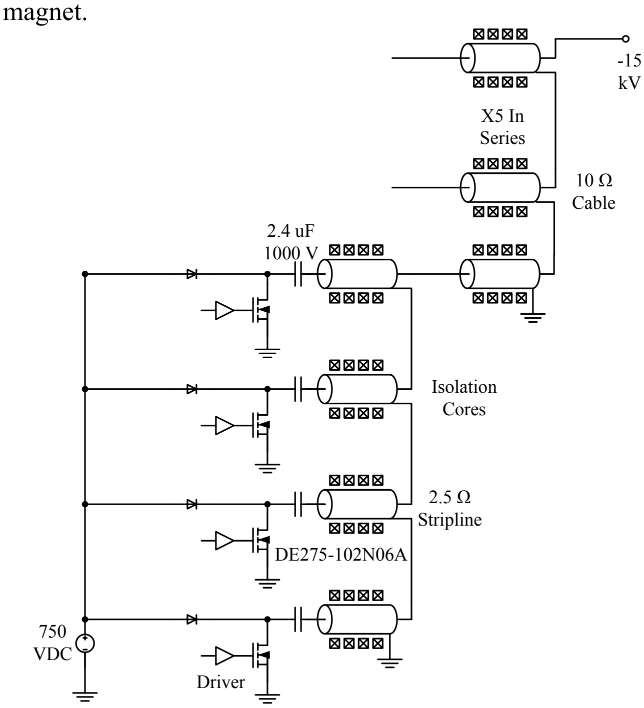

Figure 3. Simplified schematic of a transmission line adder.

A two stage adder design using flexible PCBs for the 2.5 Ω transmission lines was chosen in order to reduce the number of coaxial cables and connectors required. The flexible PCB striplines will be clamped to the switch PCBs and provide a smooth mechanical transition between the switch boards and the adder structure. Each stripline passes through a ferrite core for ground isolation. The adder structure for the striplines consists of a clamp holding the striplines together and contacting the top layer of one flex line with the bottom of the next, and five 50 Ω coax cables which compromise the second stage of the adder. The five coax cables also pass through a nanocrystalline core then are connected to a PCB that acts as the adder structure, again clamping the signal side of one board to the return side of the next, and feeding a single RG-214 cable center conductor through the structure with the return connected to the top board to add the voltages. A mechanical assembly drawing of the adder is shown in Figure 4. A drawing for the entire system with magnet is shown in Figure 5.

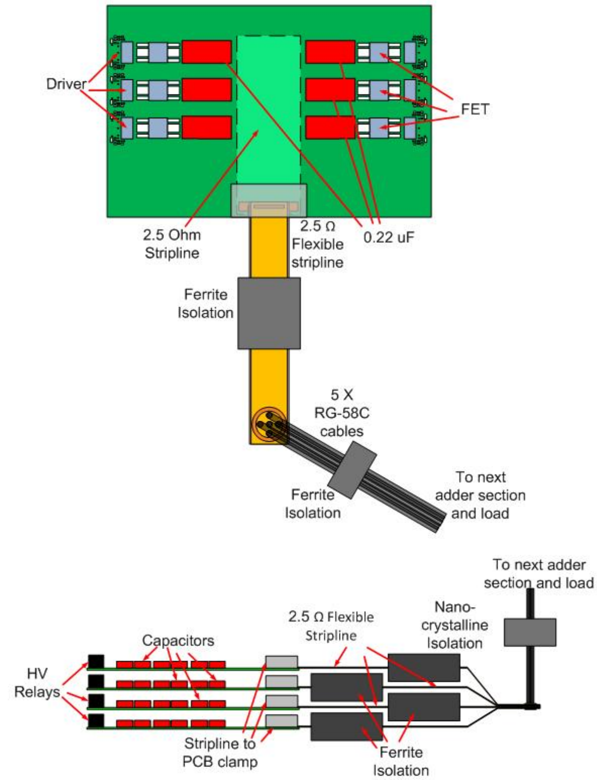

Figure 4. Drawing of the switch PCBs and adders.

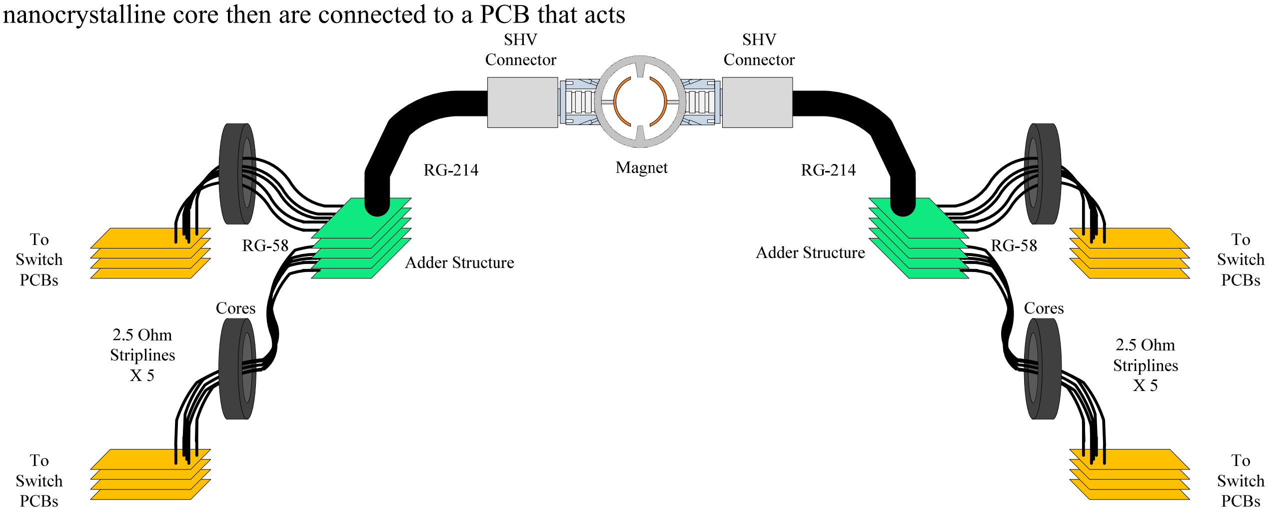

Figure 5. Drawing of assembled transmission line adder.

LOAD DESIGN

The loads are 50 Ω resistive loads made from an array of tubular bulk carbon ceramic resistors immersed in oil. The oil is circulated through the structure and cooled with a liquid to liquid heat exchanger. A drawing of the resistive load and oil vessel is shown in Figure 6. A linear taper is provided to transition from 50 Ω at the input of the load to a short at the end, to avoid reflections of the high frequency components of the pulse.

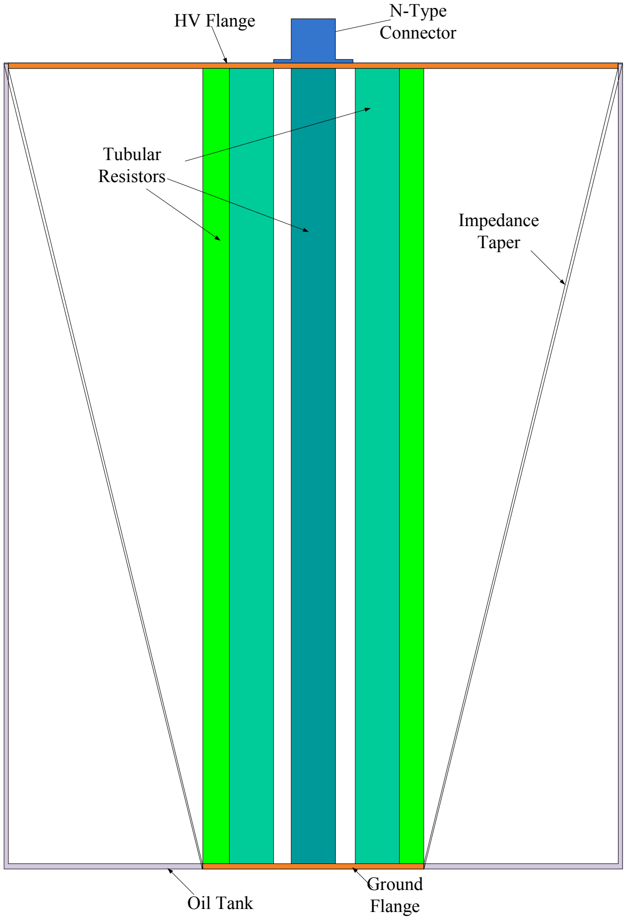

Figure 6. Drawing of the resistive load.

STATUS

The details of the modulator electronics are complete and most parts are either in house or on order. The first prototype PCBs for the switching circuits and the stripline are built and being stuffed. Low voltage testing of the electronics should begin soon. Mechanical design of modulator components, such as clamps for the adder structures have begun. The design of a prototype, non-vacuum compatible, magnet is in progress, and should be complete in several weeks. Resistors for the load are on order, however the mechanical design of the tank and impedance taper have not yet begun. High voltage testing of the modulator is probably one or two months away.

REFERENCES

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