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The MERLIN Induction Voltage Adder Radiographic Accelerator

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The MERLIN accelerator being commissioned at AWE in a new Technology Development Centre will provide one of the flash radiographic sources at a joint UK/French facility for hydrodynamic testing in support of the two nations' nuclear deterrents. The ten module Induction Voltage Adder (IVA) has been designed to provide a 60 ns long TerraWatt pulse to drive a Self Magnetic Pinch (SMP) electron beam diode at 7.5 MV. The design work for MERLIN was carried out by L3 Pulse Sciences in San Leandro, California and builds on previous IVA experience in the USA. Prototyping of sub-systems was also carried out by L3 to confirm that the performance and reliability requirements for the overall accelerator can be met. However, it is only now that all the components of the accelerator have been brought together and its overall function can be characterised and compared with predictions. Commissioning of the accelerator has involved setting to work the ancillary systems which provide and control oil, de-ionised water, sulphur hexa-fluoride gas, vacuum, control and instrumentation, diagnostics and data acquisition. With these operating satisfactorily testing of the pulsed power systems was able to commence.

Commissioning of the pulsed power systems started with a run up of the Marx generator into a resistive load to its operating voltage of 2.5 MV, including characterisation of the trigger systems and the diverter switches. These are intended to short the Marx output after it reaches peak voltage, or if a pre-fire occurs, in order to reduce the risk of electrical breakdowns. The waveforms produced during factory tests in the US were successfully reproduced and the jitter of the trigger systems shown to meet specification. This allowed the commissioning programme to proceed to the active commissioning phase where an X-ray output is generated.

Active commissioning is enabled by the Marx generator being connected via an oil insulated transfer line to the Pulse Forming Lines (PFLs). Each module of MERLIN comprises an induction cell driven by one of these PFLs. The upstream section of each PFL receives its 2.5 MV charge from the Marx generator on a microsecond timescale before its pulse forming action is initiated by a laser triggered gas switch. The laser triggering should provide nanosecond order synchronisation, and hence excellent pulse reproducibility, when the pulses are combined in the adder. The 60ns duration, 1.1 MV outputs of the PFLs are fed to their corresponding induction cells which act to perform voltage addition along a 28 metre long 80 Ohm MITL. This delivers an 11 MV forward going wave to the e-beam diode.

The pulsed radiographic source driven by MERLIN will be a SMP diode developed in an AWE led research programme in collaboration with US National Laboratories. This diode operates at approximately 40 Ohms with the result that re-trapping of the MITL sheath current occurs transforming the 11 MV forward wave down to ˜ 7.5 MV while increasing the load current to ˜ 200 kA. The PFL's configuration tailors the output pulse to compensate for the SMP diode's intra-pulse impedance droop and hence generate a relatively constant voltage during the X-ray flash. Since the SMP diode is a single shot device (due to the energy density incident at the anode/X-ray converter) a Large Area Diode (LAD) of similar impedance is utilised to allow repeated testing of the pulsed power systems. By mid-2017 the testing of the Pulsed Power systems and MITL with the LAD is due to have been completed and the optimisation of the SMP diode should be in progress.

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