Stripline Imagers for X-rays Introduction

These imagers use MCP gating to provide shuttering contrast. The phosphor is maintained at a constant potential behind the MCP. This technique offers very high speed operation (below 30ps has been achieved by some users), a high extinction ratio and good sensitivity, sometimes augmented by a second continuously run MCP behind the gated one. The main disadvantage of this system over the system of gating the MCP and phosphor together, is that the latter is more tolerant of gas entering the detector after the event as there are no DC potentials that can break down.

Kentech SLIX systems can offer slow phosphor gating (usually a gate off in a few milliseconds for 10 seconds after the event) but this may not be fast enough in some x-ray devices. Fast valves are also available from other suppliers which can open and close a line of sight to a source. Valves with both open-to-close and close-to-open-to-close are available.

In order to gate an MCP quickly, the MCP is produced without the regular electrodes and then strip line electrodes of copper or gold are laid down on the front surface. The rear is also coated with continuous conductor. The strips are then pulsed to achieve the gating. The characteristic impedance of the strips is typically in the range of a few Ω to 25Ω depending upon the strip width and MCP thickness. The lower the impedance then the more current is required. Also more strips require more current. Generally the total pulse power required to drive these systems depends upon the total image width (many strips for many channels) and the MCP thickness.

Most pulse generators and cabling are based upon a 50Ω impedance. In order to drive lower impedances efficiently many cables must be driven in parallel and then several of these will drive each channel on the MCP. Typically the final cabling up to the MCP will be in 25Ω cable. If gating speed is important it may be easier not to bother with matching and loss coupling efficiency but gain simplicity, flexibility and gating speed.

There are several ways to transform the pulse power from the generator 50Ω to the few ohms required on the strip. Firstly, mismatches may be used, these are inefficient but can offer simple and very fast changes to the drive impedance. The voltage on the output of such a discontinuity is calculated from:-

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     Output voltage/Input voltage =

2(output impedance)/(output impedance+input impedance)
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So for a 50Ω output pulser driving a 6.25Ω strip only 22% of the pulser voltage (5% energy efficiency) is transferred. This is inefficient when compared to the ideal case whereby we use an impedance matching transformer and achieve 35% transfer of the voltage (ideally 100% energy efficient). A mismatch is not just inefficient, also reflections occur at the mismatch which could arrive at the MCP later and cause double exposure problems. However, a single bad mismatch is probably the fastest way to operate such a system. This means that ~4.7kV may be required to drive 1kV into 6.25Ω.

The pulse impedance may be transformed from 50Ω to 6.25Ω with either a cable or tapered stripline transformer. The stripline transformers have been used down to 40ps. The cable transformer is good for long pulses. The stripline is good when the ratio of impedances to mate is not a multiple of 4 (cable systems are very good at a multiple of 4 and can be made with sub 100ps risetime to voltages > 10kV). Often some combination of transformers and mismatches is used. Note that two mismatches, suitably chosen (goemetric averages) is much better than a single one for efficiency; e.g. from 50Ω to 18Ω to 6Ω give 26% voltage transmission.

The gain of MCPs is a very strong function of the applied voltage. MCPs vary but typically 50 to 100volts will double the gain. Consequently this can be used firstly, to offer some variation of gain in the MCP and secondly, to manipulate the gate width. For long gate pulses, where the rise and fall times are short compared with the pulse length, adding or subtracting a DC bias to the pulse will adjust the gain. A forward (turn on) bias can be added until the SLIX system is just below detection threshold, offering total voltage on the MCP up to around 1200 volts for a 0.5mm thick device. Alternatively a reverse bias almost up to the gate voltage may be applied to reduce the gain. For short pulses the gate pulse tends to be triangular, gaussian or double exponential in shape. In this case adjusting the DC bias strongly affects the gate pulse length. Indeed this technique has been used down to about 40ps gate width for electronics only capable of around 100ps pulses FWHM. In this case the nonlinear response of the MCP is used to extend the system bandwidth.

Several configurations of the SLIX system exist. For very fast work it is best to make strips that go across the plate and apply the gate voltage to one end. The other end must then be terminated with a suitable impedance to prevent reflections.