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A LADDERTRON MODULATION SYSTEM TO CORRECT A REPETITIVE CHARGING PATTERN

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A technique is described which has enabled a laddertron chain, which had a distinct charging pattern but was otherwise in good condition, to be used in the Daresbury tandem and still achieve excellent output beam energy stability. A phase timing marker from the laddertron was used to add a simple correction waveform to the upcharge power supply voltage each rotation and cancel out the charging pattern.

1. Stabilization system

Energy stabilization of the tandem is achieved in the usual manner using the signals from the energy defining slits to generate a signal which corrects the terminal voltage and maintains the output energy constant.

The Daresbury system differs from most other electrostatic machines in correcting the terminal voltage using laddertron downcharge.

This has the advantage of long term stability since it does not involve the use of corona but does have the disadvantage that the response speed is limited due to the 0.2 s delay in the response of the terminal to changes in downcharge.

It has always been the intention to install a stripper modulator to improve the feedback response. This has been constructed but is awaiting a suitable opportunity to be installed. At present, therefore, the response is severely limited.

2. Stabilization loop response

The open loop response of the slit feedback system presently in use on the Daresbury tandem is shown in fig. 1. Marked on the Bode plot is the frequency corresponding to the rotation period of the laddertron. It is seen that this is close to the frequency cutoff of the system. There is very little loop gain at this point and the system is operating at a phase shift near to 180° making it susceptible to stimulation at this frequency.

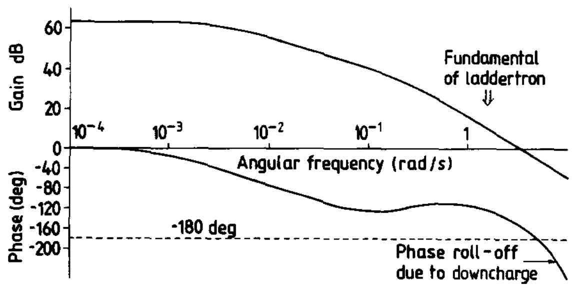

Fig. 1. Open loop response of the energy feedback stabilisation loop.

3. The effect of the laddertron pattern

Laddertron no 2, used recently in the tandem, was found to be stimulating the feedback loop into low level oscillation at the rotation frequency of the chain. It was shown subsequently that the chain had a charging pattern and that the amplitude of this was sufficient to induce a resonance at this frequency. Although the oscillation amplitude was small it was sufficient to affect the beam badly see fig. 4.

There were three ways of dealing with this problem, changing the chain, reducing the loop gain and severely limiting the performance of the stabiliser, and finding a way of removing the disturbance so that the loop could operate as normal. A method of achieving the latter is now described.

4. Suppression of the oscillation

A system was devised using a timing marker from the laddertron, see fig. 2, to superimpose a constant correction pulse waveform on to the charging current, see fig. 3. It was found sufficient to apply a low level pulse of one half the rotation period (hence simulating the fundamental) at the correct phase to suppress the oscillation. The amplitude of the correction was not critical within 25% of the optimum. An example of the "before" and "after" effect of the correction is shown in fig. 4 where the beam intensities transmitted through the analysing slits are compared for the two cases.

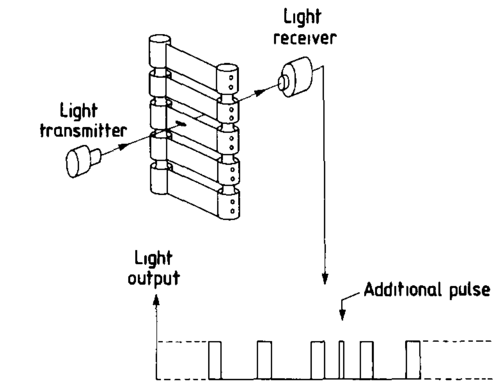

Fig. 2. Timing marker generation.

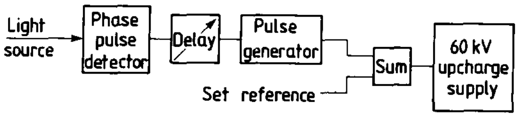

Fig. 3. Modulation generation system.

The system was used for a period of a year with great success enabling a chain which was almost unuseable to run for its full lifetime of 15000 h.

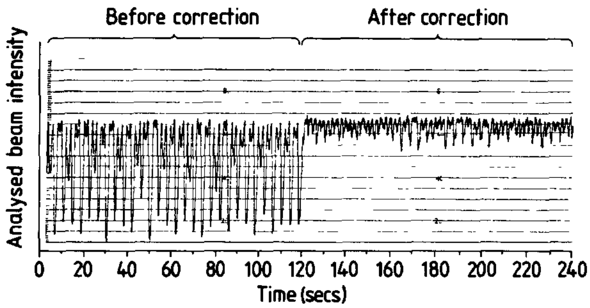

Fig. 4. Transmitted beam intensity before and after correction.

5. Conclusion

The technique described is capable of removing as a source of stimulation any charging pattern and hence allow normal feedback operation even with a very "bad" chain. The need to install a fast stripper modulator therefore becomes less urgent.

Future laddertron assemblies will hopefully not require this correction but the principle can be used if necessary. In fact a new chain installed recently did not require any correction.