TRANSIENT STUDIES OF THE STRIPLINE KICKER FOR BEAM EXTRACTION FROM CLIC DAMPING RINGS

C. Belver-Aguilar, M.J. Barnes, CERN, Geneva, Switzerland

ABSTRACT

Stripline kickers are generally assumed to have equal contributions from the electric and magnetic field to the total deflection angle, for ultra-relativistic beams. Hence parameters of the striplines, such as the characteristic impedance, the field homogeneity and the deflection angle are typically determined by simulating the striplines from an electrostatic perspective. However recent studies show that, when exciting the striplines with a trapezoidal current pulse, the magnetic field changes during the flat-top of the pulse, and this can have a significant effect upon the striplines performance. The transient solver of Opera2D has been used to study the magnetic field, for the striplines to be used for beam extraction from the CLIC Damping Rings (DRs), when exciting the electrodes with a pulse of 1 µs flat-top and 100 ns rise and fall times. The time dependence of the characteristic impedance, field homogeneity and deflection angle are presented in this paper. In addition, two solutions are proposed to improve the flatness of the magnitude of the magnetic field throughout the flat-top of the pulse, and the predicted results are also reported.

STUDIES IN THE TIME DOMAIN

Two RF baselines are considered for the CLIC DR operation [1]:

- 1 GHz RF structure, with one pulse containing two trains of 156 bunches each → current pulse of 560 ns rise/fall time and 900 ns flat-top.
- 2 GHz RF structure, with one pulse containing one single train of 312 bunches → current pulse of 1 µs rise/fall time and 160 ns flat-top.

The 1 GHz RF baseline has been considered for this study, but with pulse rise and fall times of 100 ns, in order to limit the electrical and thermal stresses on the kicker system [2].

The deflecting field of the striplines has been previously studied considering only an electrostatic field [3] and an AC magnetic field [4]. Now, transient simulations with Opera2D [5] have been carried out, and a pulse of 100 ns rise and fall time and 1 µs flat-top has been considered (Fig. 1).

The odd mode characteristic impedance, field inhomogeneity and deflection angle have been studied when considering the voltage/current pulse shown in Fig. 1:

- The increase of the odd mode characteristic impedance during the flat-top is 1.1%.
- The field inhomogeneity changes during the flat-top from ± 0.0028% to ± 0.0112%.
- The increase of the deflection angle during the flat-top is 0.73%.

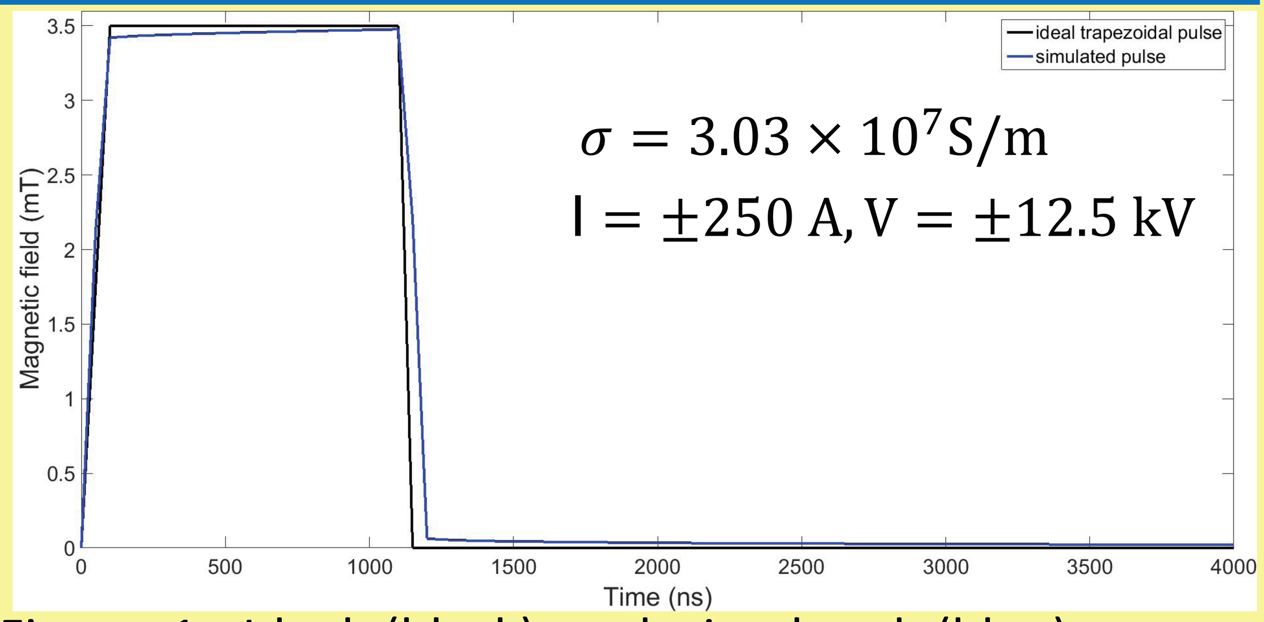

Figure 1: Ideal (black) and simulated (blue) current pulse when terminating each electrode with 50 Ω.

PROPOSALS FOR REDUCING THE PULSE VARIATION

In an attempt to reduce the increase of the "flat-top" field two proposals will be presented in the following:

- Using a thin silver coating on the electrodes
- Modulate the pulse to compensate for the variations in the field flat-top

SILVER COATING

The electrodes could be coated by a thin layer of silver in order to increase the electrical conductivity (σ_{silver}= 6.3× 10^7 S/m).

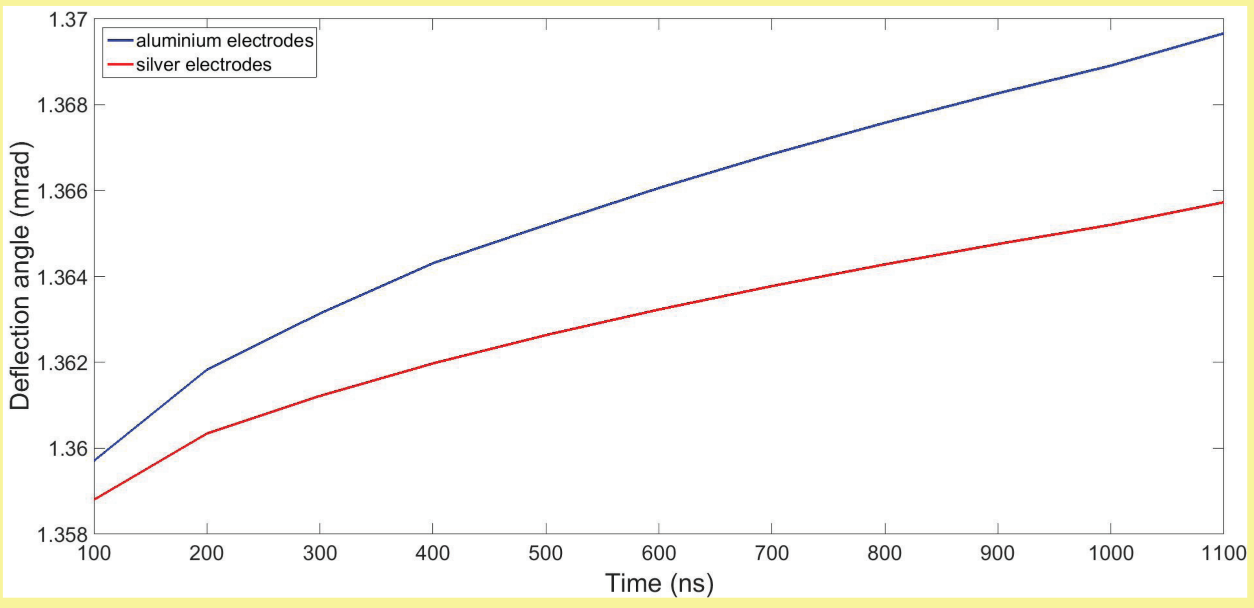

Figure 2: Flat-top deflection angle when considering electrodes made of aluminium (blue line) and silver (red line).

The variation of the deflection angle, along the flat top, is reduced from 0.73% to 0.5%.

Also the odd mode characteristic impedance variation is reduced from 1.1% to 0.8%.

PULSE MODULATION

The variation of the magnetic field, and therefore the total field during the pulse flat-top, can be also theoretically compensated by modulating the electrodes current/voltage during the flat-top of the pulse.

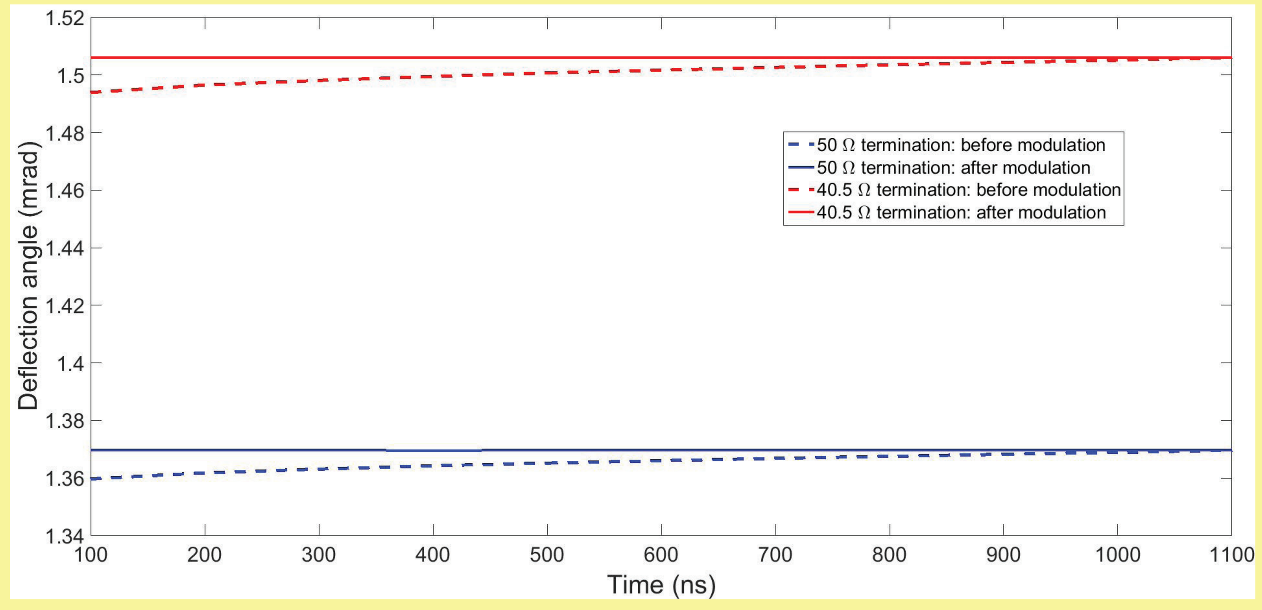

Figure 3: Total deflection angle before/after modulation, for 50 Ω (blue line) and 40.5 Ω (red line) terminating resistors.

After appropriate modulation, the increase of the deflection angle during the flat-top is reduced by more than a factor 100: from 0.73% to 0.006%.

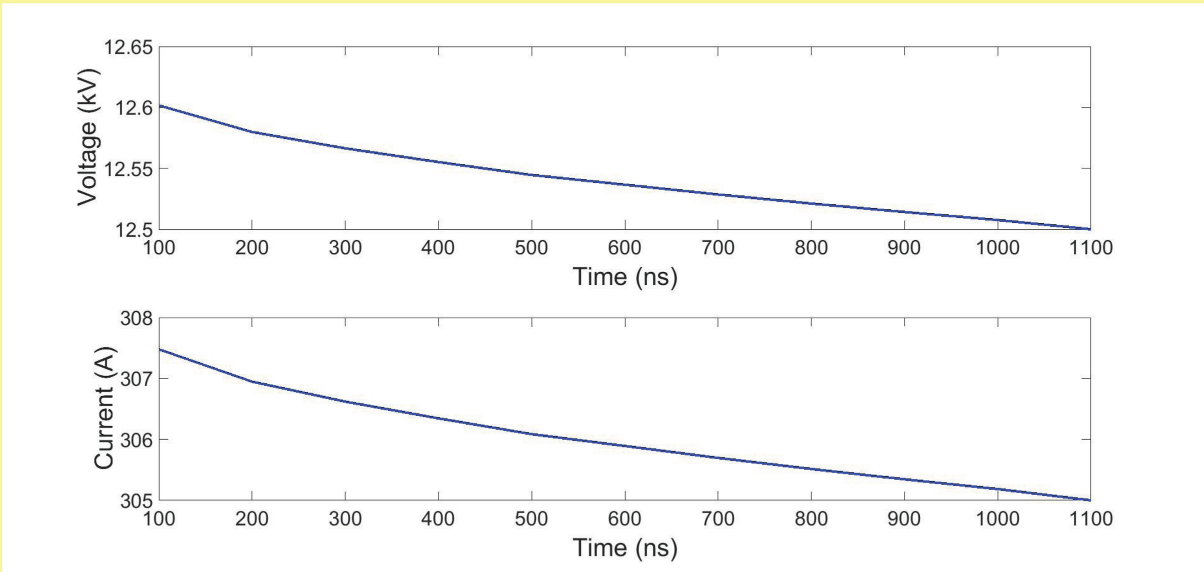

Figure 4: "Flat-top" voltage and current, in order to obtain a "constant" deflecting field (40.5 Ω terminators).

The voltage/current pulse shown in Fig. 4 has been specified as the flat-top of the driving waveforms in Opera2D.

CONCLUSIONS

Transient simulations have been carried out in order to consider the effects of 100 ns rise/fall time driving pulses, with a flat-top of 1 µs, upon the predicted characteristic impedance of the striplines and hence the total deflection angle. The magnetic field, and therefore the magnetic field contribution to the deflection angle, is not constant during the flat-top of a trapezoidal current pulse. Two means of improving the flatness of the total deflection angle have been proposed: coating the electrodes with silver or modulating the pulse created by the inductive adder. Silver electrodes give the required field homogeneity but do not result in the flat-top stability specifications being met. From the studies, the required output pulse shape from the inductive adder, to compensate the time dependence of the impedance of the striplines, has been derived for both 50 Ω and 40.5 Ω terminating resistors: these waveforms give the required flat-top of the total deflection pulses. However the field homogeneity is close to, but slightly outside, the specification of ±0.01%. Terminating resistors of 40.5 Ω provide the required deflection angle of 1.5 mrad, with a ±12.5 kV driving voltage: to achieve 1.5 mrad with 50 Ω terminating resistors requires that the nominal driving voltage is increased to ±13.7 kV. With 40.5 Ω terminating resistors it is not necessary to increase the nominal drive voltage, except for modulation. PSpice simulations to study reflections with 40.5 Ω and 50 Ω terminating resistors will be carried out next.

REFERENCES

[1] CLIC Conceptual Design Report (CDR), Volume 1, www.project-clic-cdr.web.cern.ch/project-clic-cdr/CDR-Volume1.pdf, 2012.
[2] J. Holma, M.J. Barnes, L. Ducimitière, "Measurements on Magnetic Cores for Inductive Adders with Ultra-flat Output Pulses for CLIC DR Kickers", Proceedings of IPAC 2016, THPMW032.
[3] C. Belver-Aguilar, "Development of Stripline Kickers for Low Emittance Rings: Application to the Beam Extraction Kicker for CLIC Damping Rings", PhD thesis, Universidad de Valencia, 2015.
[4] C. Belver-Aguilar, M.J. Barnes, L. Ducimitière, "Review on the Effects of Characteristic Impedance Mismatching in a Stripline Kicker', Proceedings of IPAC 2016, THPMW034.
[5] Opera2D User Guide, Version 17R1. Cobham Technical Services, Vector Fields Software, Oxfordshire, 2014.

Presented at International Beam Instrumentation Conference, MOPG05 **IBIC 2016, Barcelona, Spain, September 11-15**

mail: carolina.belver.aguilar@cern.ch