Operation of an Electromagnetic Trigger with a Short-circuit Ring

Dejan Križaj[1*], Zumret Topčagić[1], and Borut Drnovšek[1,2]
[1] Faculty of Electrical Engineering, University of Ljubljana, Ljubljana, Slovenia,
[2]RC NELA, Izlake, Slovenia

Introduction: Electromagnetic trigger is an essential constitutive part of circuit breakers, devices used to disconnect the load from electric appliance in case of an overload or short-circuit currents. A short-circuit ring in an electromagnetic trigger should reduce undesirable oscillations (vibrations) of a moving contact due to zero electromagnetic force between the anchor and the core at zero driving current .

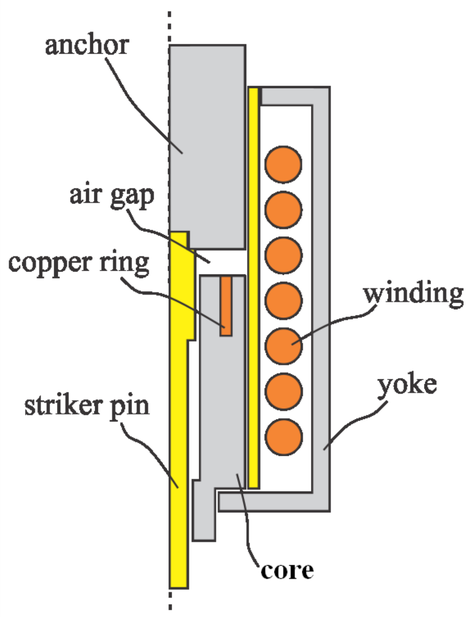


Figure 1. Cross section of a simulated structure with description of constitutive parts.

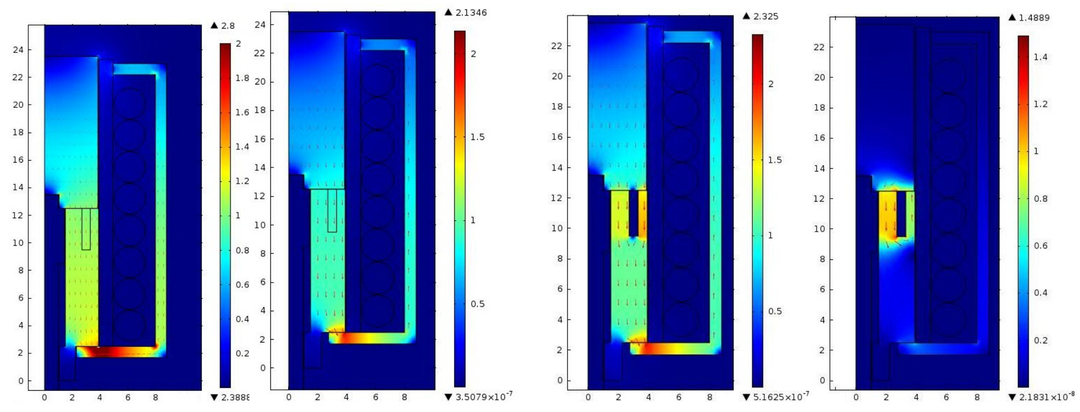
Computational Methods: Time domain AC/DC module in the form of Ampere's law

$$\sigma \frac{\sigma A}{\sigma t} + \nabla \times \boldsymbol{H} = \boldsymbol{J_e}$$

was used for numerical computation using Comsol Multyphysics Vers. 4.2a.

A sinusoidal current was imposed to the windings. Ferromagnetic materials were described through built-in B(H) tabulated values for soft iron. In order to improve (enable) convergence, the MUMPS direct solver was used with Jacobian update on every iteration and Maximum number of iterations set to 25. Also, absolute tolerances of variables was tuned to enable convergence.

Results: Numerical simulations reveal importance of inclusion of proper B(H) material properties (compare figure 3a and 3b) in order to take into acccount material saturation effects. Induced current in the ring is zero at maximal applied signal (figure 3c) and maximal when applied current crosses zero (figure 3d).



a) **b)** **c)** **d)**

Figure 3. Magnetic flux density without a ring for a) linear B(H curve), b) nonlinear B(H) curve and with a ring at c) maximal applied current and d) at zero crossing of applied current.

Induced current in the ring results in no-zero force during applied signal crossing zero reducing the unwated oscillations of the anchor and the striker pin.

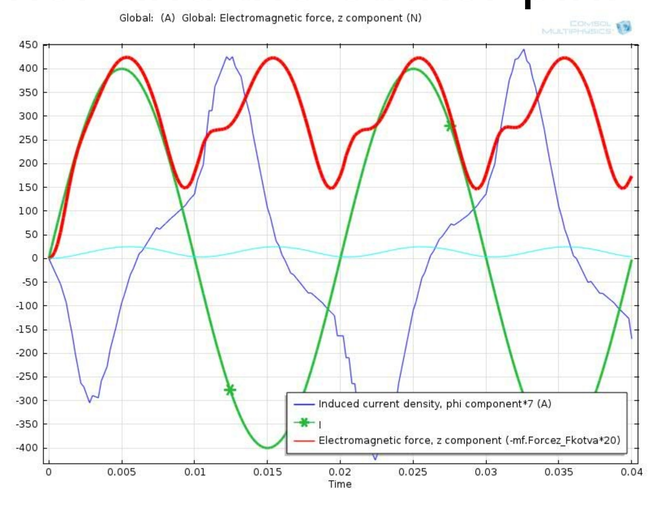


Figure 4. Applied (green) and induced (blue) current and force on an anchor in axial direction (red) as a function of time. The force and the induced current are scaled to fit in the graph (as seen in the legend).

Conclusions: Short-circuit ring should be used in future selective circuit breakers to reduce the oscillations of the striker pin and the moving contact.