AUTOMATIC CONDITIONING OF KICKER MAGNETS

C. Lolliot, M.J. Barnes, S. Pavis, N. Magnin, CERN, Geneva, Switzerland
C. Monier, INSA, Lyon, France

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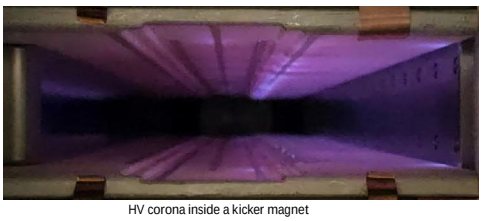
Introduction

Kicker magnets are used throughout the CERN accelerator chain to **inject or extract beam** from a ring. These kicker magnets generally have fast rise and/or fall times and are driven by high voltage pulses of up to 40~kV. To achieve fast field rise and/or fall times, transmission line kicker magnets are typically used: these magnets are installed in vacuum.
Kicker magnet conditioning is a process to prepare the magnet for **reliable operation** in the accelerators.



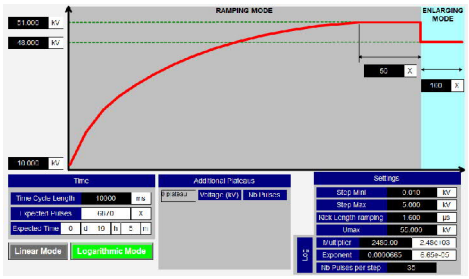
HV corona inside a kicker magnet

HV Pulse Conditioning

Dust, contaminants or small features increase locally the electric field and thus can cause High Voltage (HV) breakdown or corona. To condition the surfaces a voltage is applied: the value is incremented in small steps up to above the operating voltage. The phase of increasing pulse voltage is carried out with short pulse lengths: this limits the energy that is dissipated in the site of the breakdown and hence minimizes the possibility of damaging the surfaces.
Failure to properly condition the magnets can result in strong HV breakdown and may damage the surface of components.
A magnetic breakdown during operation can cause the beam to be mis-kicked.
During the conditioning, the kicker magnet is subject to gradually higher and higher pulse voltages (ramping mode), and subsequently greater pulse lengths (elongation mode), until the voltage holding capability is sufficiently beyond the nominal operating condition

Process Automatising

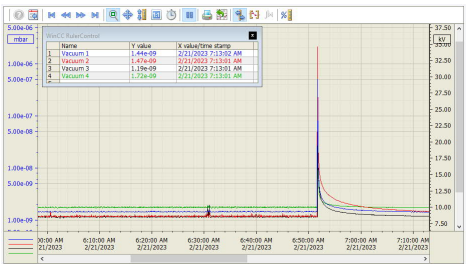
The kicker magnet conditioning control system has been developed on a Programmable Logic Controller (PLC). The program developed is called "new Automatic CONDitioning" (nACOND).
During the conditioning, the PLC will calculate the voltage strength (in kV) of the pulse sent to the magnet, and its duration (in µs).
Typically, the magnet is pulsed every ten seconds.



nACOND logarithmic ramping mode

Detection of HV breakdowns

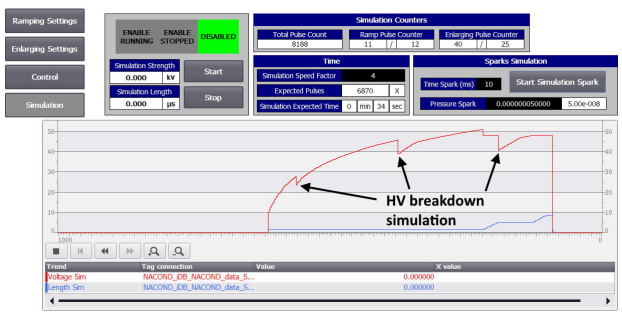
During the conditioning, the vacuum pressure inside the magnet is continuously monitored by the PLC.
If an HV breakdown occurs, the vacuum pressure will increase with the severity of the breakdown: the PLC will react to the breakdown and reduce the voltage according to vacuum pressure thresholds defined by the operator.



Vacuum increase in a magnet after an HV breakdown

Simulation Mode

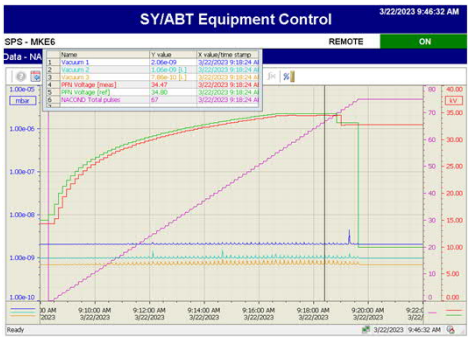
As there are many parameters available to define the conditioning, a simulation mode has been developed to allow operators to make sure the conditioning will behave as expected. This simulation results in a graph showing the voltage strength during ramping and the pulse duration during enlarging.
In addition, during this simulation, an operator can trigger an HV breakdown simulation to see how the system will react.



Simulated HV breakdown in Simulation mode

Conclusion

This automatic conditioning has been in use for two years. It is regularly used during kicker magnet HV conditioning and it has been proven to be reliable. In addition, it has greatly reduced the workforce and time needed to HV condition kicker magnets.
The nACOND is now available for many kickers across the various accelerators and test cages facilities. As the benefits are significant, it is being progressively deployed on all kicker systems at CERN.



Measurements done during a conditioning