QPS Sunglasses - filter

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This is implemented in the DQQDS board used for the DQLPU type S protection crate for Main Dipoles and for Main Quadrupoles circuits

Problem
During the first few hundred milliseconds after a Fast Power Abort (FPA), the circuit is subject to voltage oscillations and fast changing voltages.

The voltage drop over the magnet in response to transients and its oscillations varies from magnet to magnet (due to physical differences in the magnets).

These differences between the magnet voltages might be large enough to cross the programmed *symmetric quench detection threshold*. (a typical thresholds is 500mv, DQQDS threshold - for main dipole)

(Explanation of the symmetric quench detection algorithm implemented in the DQQDS board)

If nothing is done, the DQQDS boards in the LHC circuit (several) which detects the crossing of the *symmetric quench detection threshold* will trigger the discharge of their Heater Power Supplies on their surveyed magnet, forcing a quench to protect it.

With this behavior, a single quench correctly detected and protected will carry on several forced quenches derivated from the artifact of the energy extraction switch opening.

Solution - Sunglasses filter

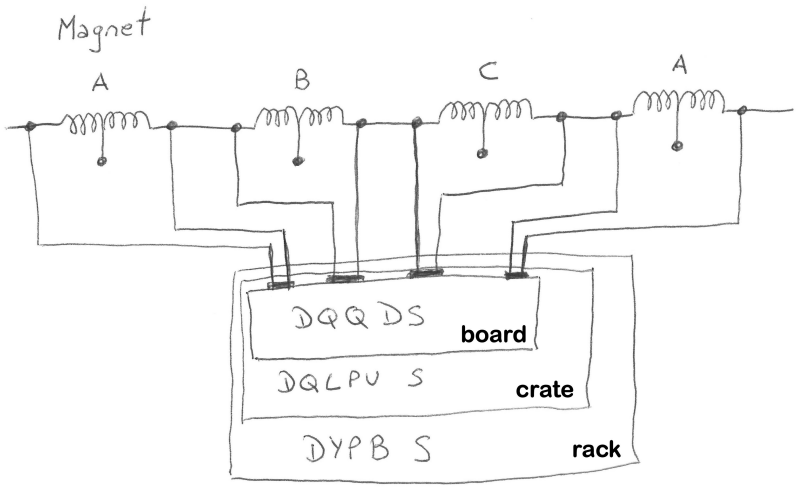
To avoid triggering on these transient signals, an adaptive filter was introduced, the so called "sunglasses filter".

The "sunglasses filter" mode becomes active

if any of the four magnet voltages (U_DIODE_RB) monitored by the DQQDS board pass below the *sunglasses mode threshold* (typical value for this threshold is about -1.55V, DQQDS threshold - for main dipole).

This "big" voltage across the magnet is not expected under normal conditions. But it is expected in the case of energy extraction activation which builds a big di/dt (and in consequence a "big" voltage across de magnet).

Note: this "big" voltage is expected to be present in each magnet of the circuit (same current → same di/dt for all) so ALL the sunglasses filters of ALL the DQLPU type S crates of the LHC circuit are expected to be activated.



Once activated the sunglasses filter mode the normal *symmetric quench detection threshold* is raised to an bigger value (eg. from 500mV to 700mV) for the duration programmed with **T**sunglasses (usually 1 to 1.3s).

After the **T**sunglasses the *symmetric quench detection threshold* is restored to its original value.

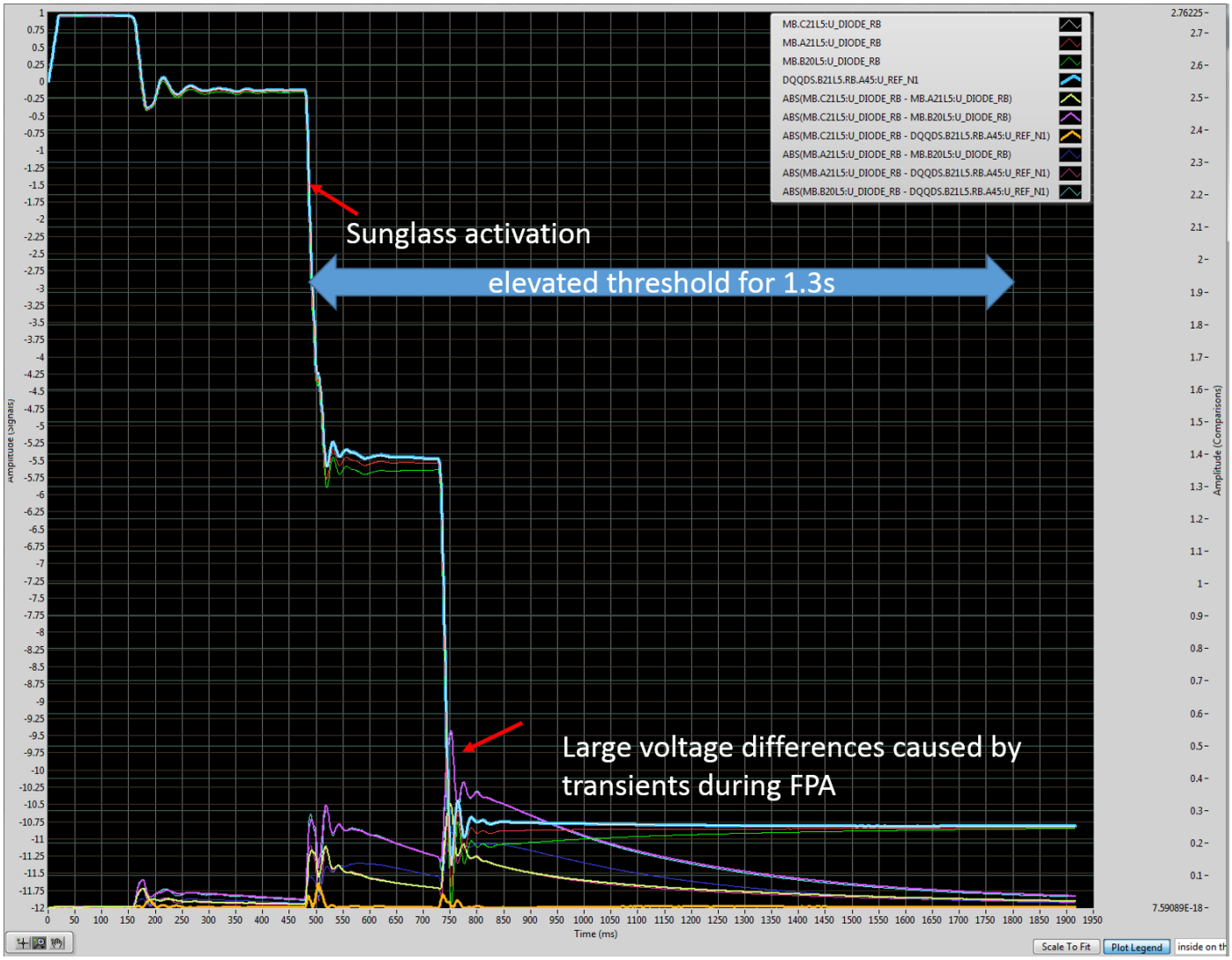
Any cross of the *symmetric quench detection threshold*, the normal value (during normal operation) or the enlarged value (during the sunglasses filter mode), at any moment, will be acknowledged and the Heaters Power Supplies (DQHDS) fired (if were not already fired). The sunglasses filter mode does not remove the protection, it just relax it a bit during a short moment.

The activation of the sunglasses filter mode will open the power interlock loop (which initiates a FPA of the circuit). This is a safe measure in the case where the sunglasses filter is erroneously triggered. In normal conditions the sunglasses filter is activated by the big di/dt build by the opening of the energy extraction system so there was already a FPA in first place that activated the energy extraction, this second FPA should not produce any new action.

As a side effect of this behavior is that ALL the DQQDS board in the circuit needs to be reset after a FPA to close the power interlock loop again (because if all works correctly all the DQQDS boards should detect the "big" voltage across the magnet and enter in the sunglasses filter mode which results in the opening of their interlocks).

The activation of the sunglasses filter mode is one-shot. Once activated and expired (after **T**sunglasses) it can not be activated again without doing a system reset of the the DQLPU type S. (The system reset is needed anyway to close the power interlock loop).

The event below illustrates that large transient voltage differences (over 500mv, scale at the right side) does not trigger the symmetric quench detection because the sunglasses filter mode has been activated by the voltage across the magnet (the 3 U_DIODE_RB and the U_REF_N1, we don't really known which one crossed first) going below 1.5V (scale at the left)



This event happens some long ago, at that moment the delays for the opening of the Energy Extraction System was 340ms and 600ms, now we are using 100ms and 600ms (EE switches opening delay and analysis windows)

DQQDS command and control parameters v6

DQQDS command and control parameters v7

mp3