

EMC issues in LLRF signal distribution system

actions planned for 1.5 months:

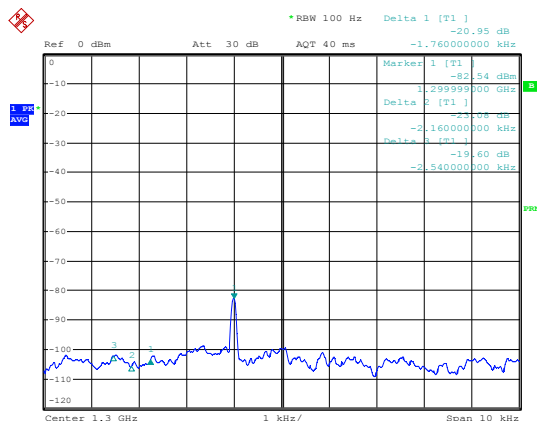
- 1 Results of measurements of the signals in LLRF system by means of spectrum and signal analyzers (oscilloscope).
- 2 Comparison of the measured signals with signals observed in DOOCS.
- 3 Conclusions concerning artifacts and real problems in LLRF system.
- 4 Identification of distortion sources and suggestions for their elimination.

Done:

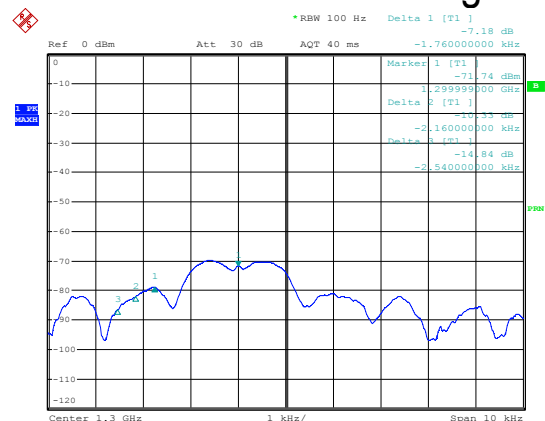
1. measurements (signal analyzer replaced by oscilloscope) -2 w. in DESY
2. signals collected via DOOCS transformed and analyzed but direct comparison with measured spectra shows very small convergence
3. „inter-system ground noise” is probably the source of problems observed as unstable level of signals in DOOCS
4. main source: an high current electric motor, some other sources like power supply regulators are identified

Main facts:

-observations showed sudden jumps of the noise floor on measured signals



Date: 16.SEP.2008 21:24:57



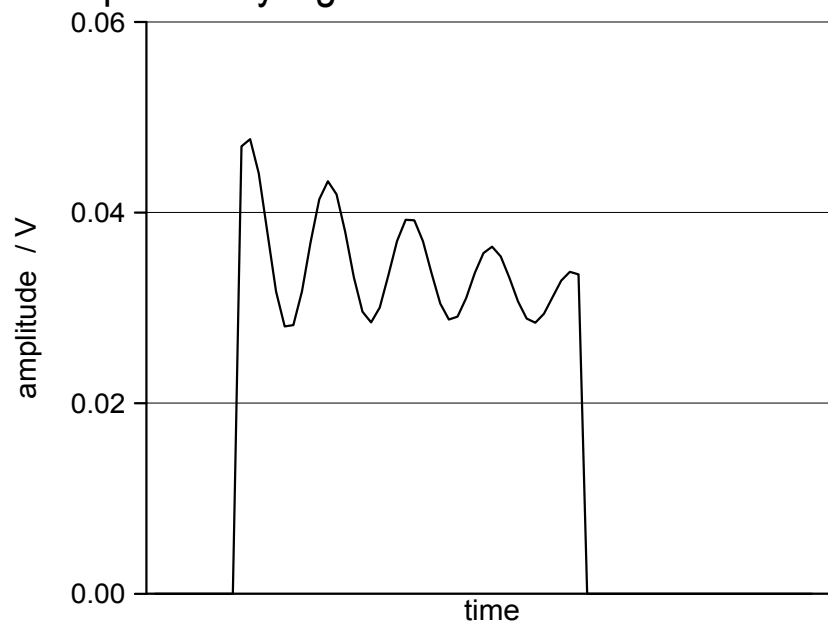
Date: 16.SEP.2008 21:25:53

1.5 m wire with one end connected to the input of spectrum analyzer and the other end touching front panel of IQ 31.

1300 MHz signal can be seen and relatively low noise level (left), several seconds later (right).

- oscilloscope measurements showed noise and distortions up to 30 mV rms present on the ground line (such a high level is present in quite short time)

intervals, typically noise is on the 1.5 mV level), this distortions can be easily transfered to the output of any signal in LLRF distribution and control system



The shape of the signals observed as remembered by me.

This shape is typical for electric motors (air condition, heating/cooling ?)

Main conclusions

Problems with stability of the measured signals are probably related to „inter-system ground noise” which is different from „differential” (normal) and „common” mode noise and distortions present in any supply. Both „differential” and „common” mode noise are well attenuated by the voltage regulators (although frequency characteristics are important). CMRR and PSRR are usually such that decrease the noise significantly.

The „inter-system ground noise” exists between ground lines of connected subsystems. The main causes of the problem are the presence of ground loops, ground noise injection, ground faults, strong ground currents and induced voltages.

Signals observed in DOOCS are averaged thus depending on the presence and length of the distortions like in figure above observed signals change suddenly and unexpectedly

The jumps of the signals in DOOCS do not reflect a stable operation of FLASH nor the amplitude and phase characteristics of signals generated and distributed in LLRF.

For me there is still a question how the control loops work in a proper way but I am still not very familiar with the system.

What to do now:

For checking all the subsystems can be supplied through UPS - this should help although probably will not remove the problem completely.

Better grounding is difficult to provide but better **filtering** of the supply (especially ground line) is possible and will not be expensive. There are companies providing ground line noise filters.

For the future:

XFEL facility ground proposed and designed now will not solve the problems, separate ground system for LLRF will be too expensive and may be also influenced with the distortions generated by the high power supply.

Design of components and subsystems (especially detectors and ADC boards) should be revised from the view point of supply possibly transferring noise and distortions.

If possible all pulse regulators in subsystems should be replaced with linear regulators.

A space for ground line filters should be reserved.

Maybe interconnection lines between distributed subsystems should be realized with optical or Ethernet like connections (immune to ground line noise).

Measurements with Real-Time Spectrum Analyzer (e.g. Tektronix RSA6100A making 48000 spectrum measurements/second) can be helpful in finding the source of the distortions.

Elimination of the distortions will improve the quality of the signals thus the operation of FLASH.