LLRF WP9

JRA1 – CARE 2007

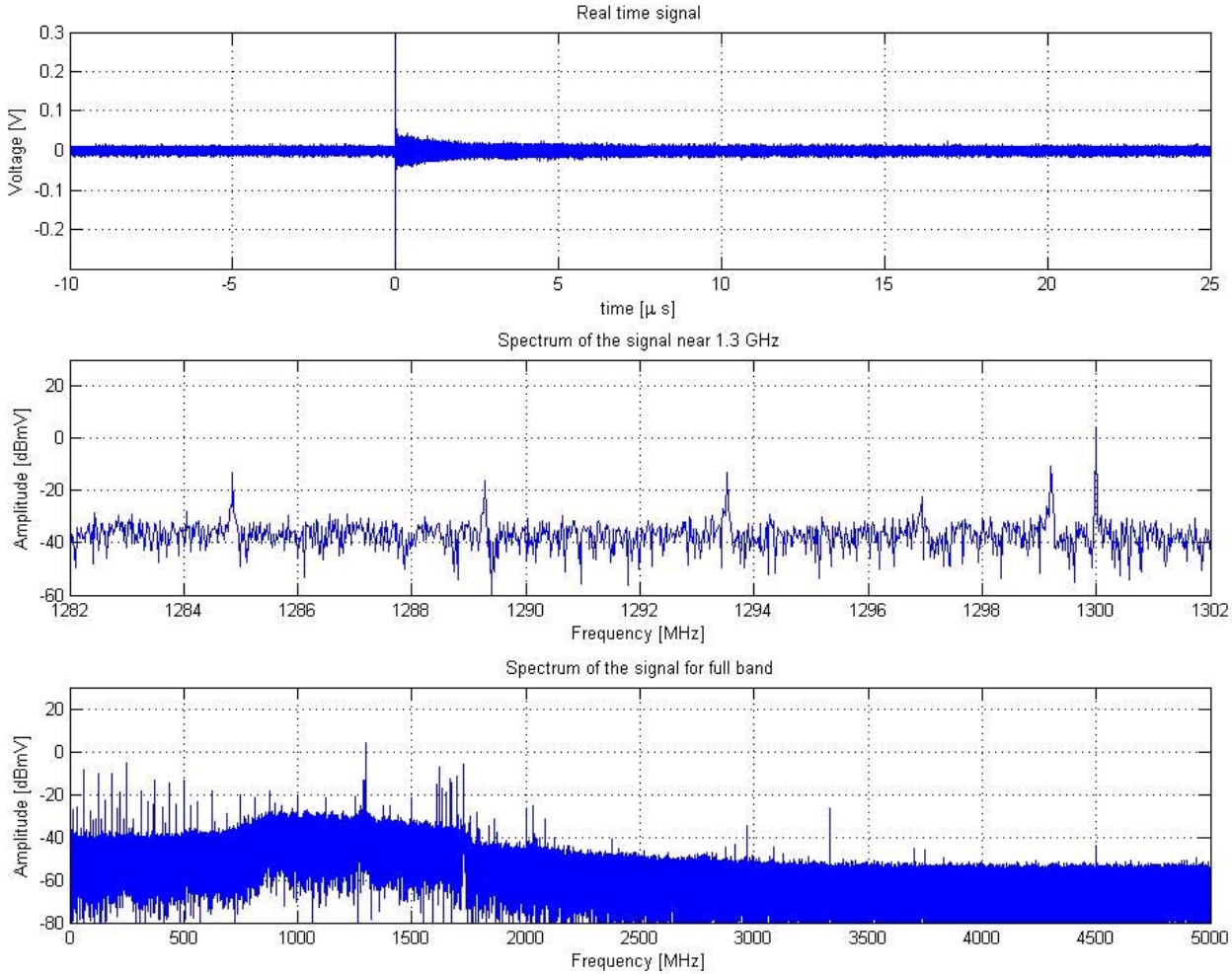
Warsaw 17-19 September 2007

9.1.1 Transient detector

The activities were focused on development of the cost-effective version of transient detection system and on improvements of the measurement accuracy.

Many measurements have been made to investigate the influence of signals coming from excitation of the other passband and higher order modes. The transient detection system measures the sum of transients at different resonant frequencies of cavity and therefore the measurement accuracy is limited.

The transients induced by single bunch

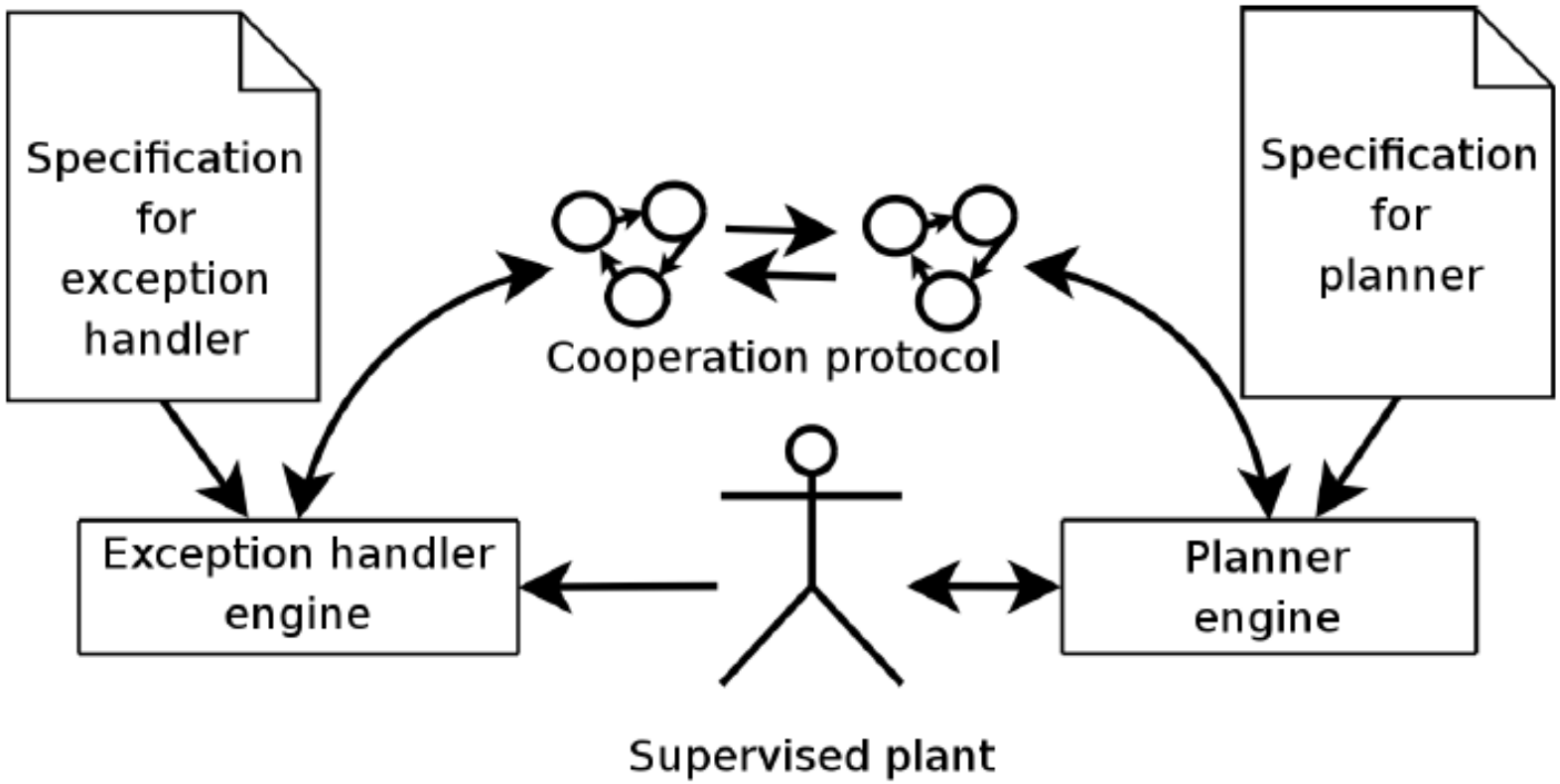


9.1.2 LLRF Automation

The activities were focused on improvements of general framework for designing and development of automation software for the FLASH. The ultimate goal of the framework is to systematize the way of automation software development and to improve its dependability.

- Formal verification of cooperation protocol between the planner and the exception handler.
- Introduction of automatic formal verification of the specification for the engines.
- Elaboration of the algorithm for conflict resolution for the exception handler.

Conceptual view of the automated accelerator subsystem



Single automation software installation

Integrated Formal Verification for the planner

NuSMV (New Symbolic Model Verifier) is used to verify formal properties of the specification. It is integrated with the automation toolkit. Definitions of formal properties which need to be fulfilled by the model close the specification file. Properties regarding reachability of the operation modes are generated automatically, remaining ones are translated from the original specification. All properties are finally expressed in the Computation Tree Logic CTL).

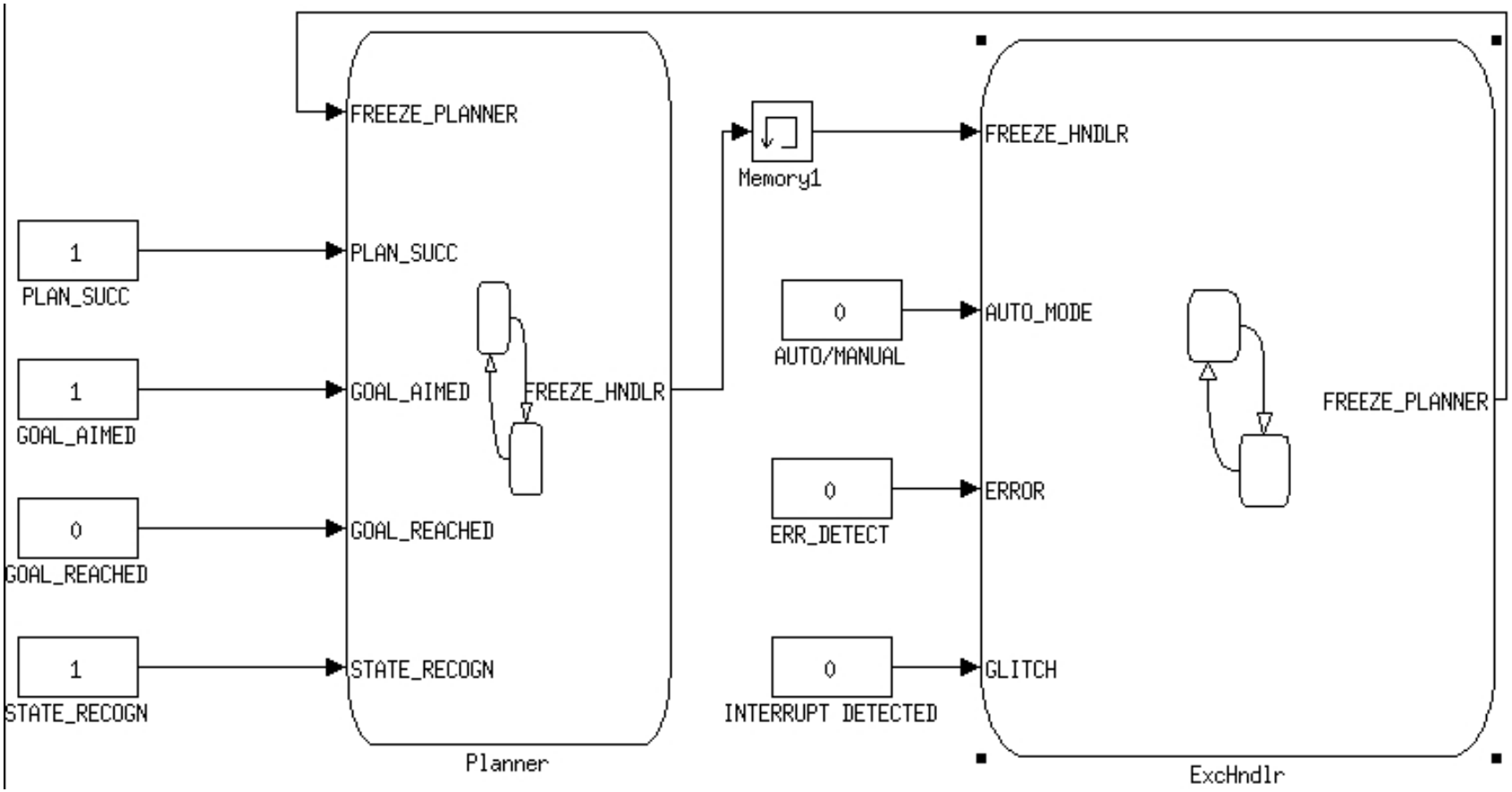
NuSMV application

ver_res.out

```
-- specification EF (((state.FORCE_MANUAL_MODE = FALSE & state.KLY_INTERLOCK_ST
ATUS = ALL_GREEN) & state.MOD_INTERLOCK_STATUS = ALL_GREEN) & state.MODULATOR_S
TATUS = OFF)  is true
-- specification EF (((((((state.MODULATOR_STATUS = ON & state.KLY_INTERLOCK_ST
ATUS = ALL GREEN) & state.MOD INTERLOCK STATUS = ALL GREEN) & state.FORCE MANUA
L_MODE = FALSE) & state.HV_SETPOINTS_AGREE = TRUE) & state.HV_EQUAL_SETPOINT =
TRUE) & state.IGCT_TIMING = CONNECTED) & state.LLRF_ALLOWED = TRUE)  is false
-- as demonstrated by the following execution sequence
Trace Description: CTL Counterexample
Trace Type: Counterexample
-> State: 1.1 <-
  state.FORCE_MANUAL_MODE = 0
  state.MODULATOR_STATUS = ON
  state.IGCT_TIMING = CUT_OFF
  state.LLRF_ALLOWED = 0
  state.MOD_INTERLOCK_STATUS = ALL_GREEN
  state.KLY_INTERLOCK_STATUS = ALL_GREEN
  state.HV_EQUAL_SETPOINT = 0
  state.HV_LEVEL = HIGH_LVL
  state.HV_SETPOINTS_AGREE = 0
```

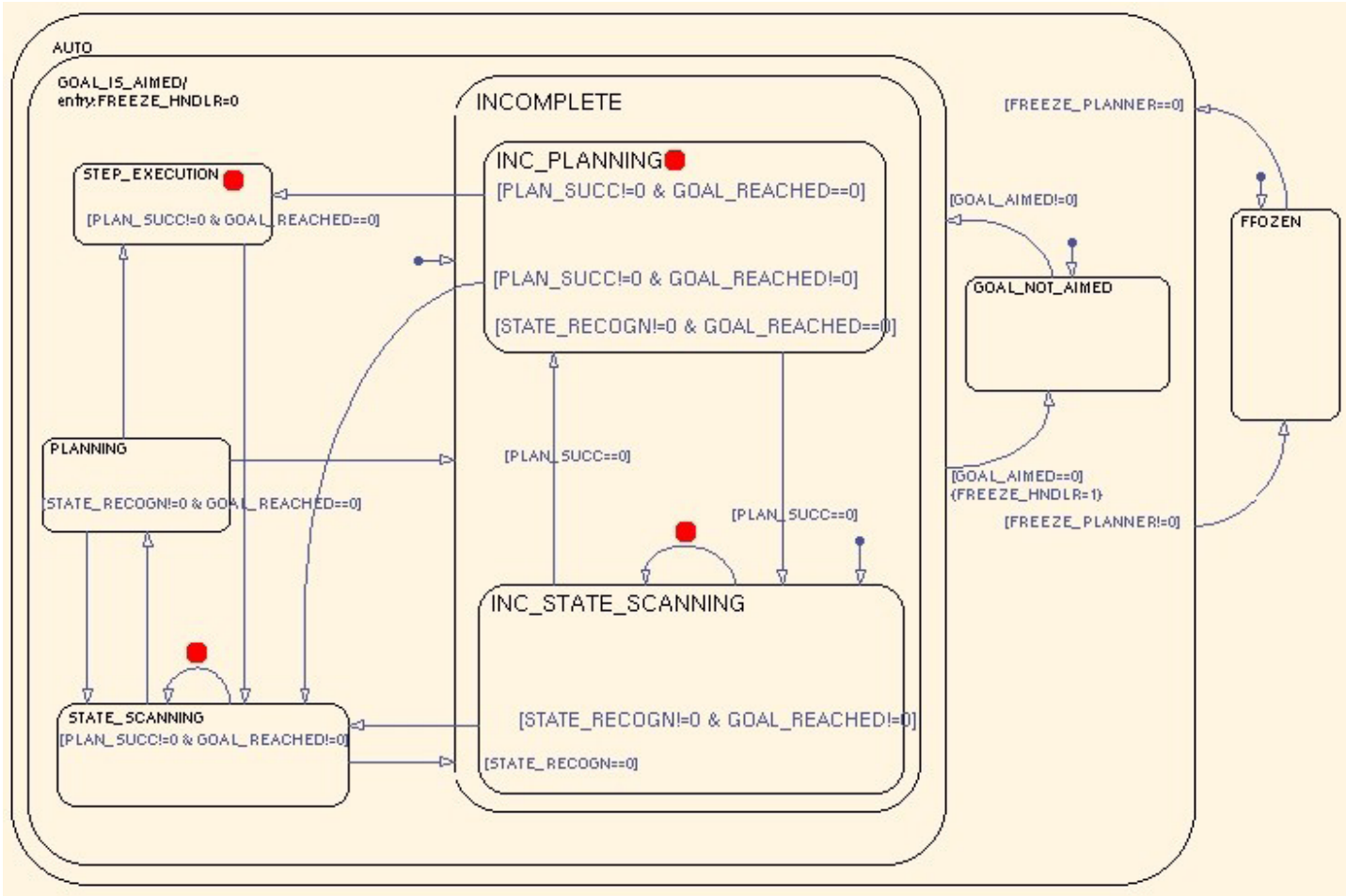
Output of the verifier. It points out that one of the operation modes is not reachable from the possible initial state (State: 1.1) and quotes corresponding counterexample.

Verification of Cooperation Protocol



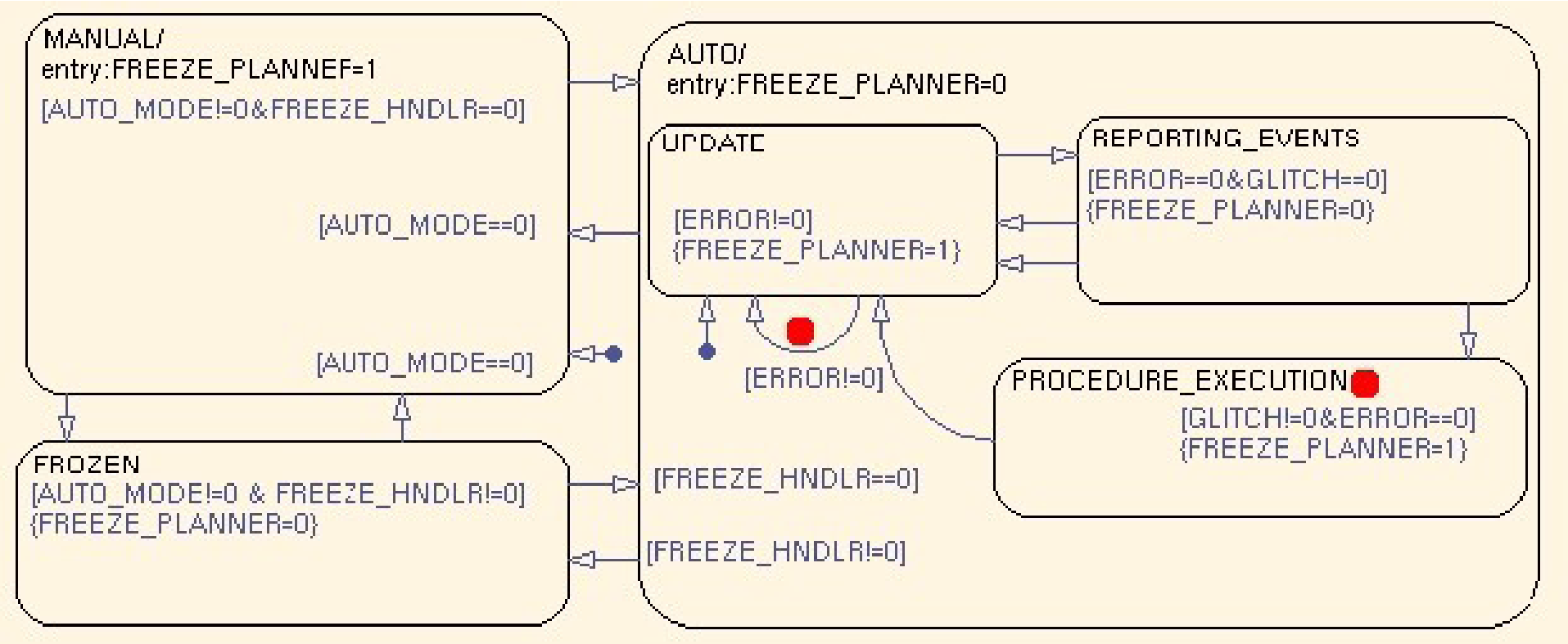
Input/output signals and communication channels for the cooperation protocol orchestrating mutual cooperation of the planner and exception handler.

Statecharts for the planner



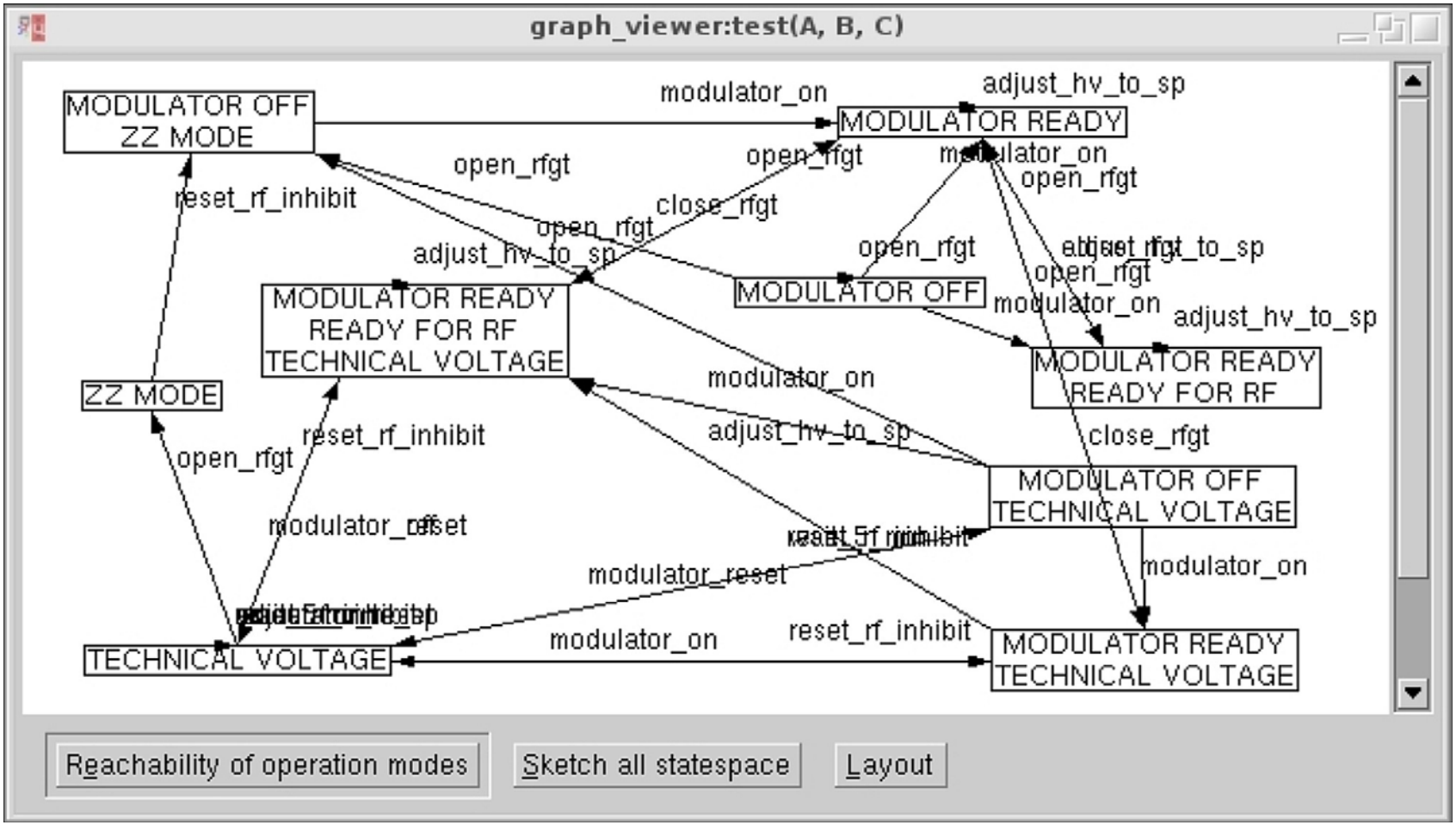
Red dots represent the progress points corresponding to the progres labels defined in corresponding promela model.

Statecharts for the exception handler



Red dots represent the progress points corresponding to the progress labels defined in corresponding promela model.

Ensuring Specification Consistency

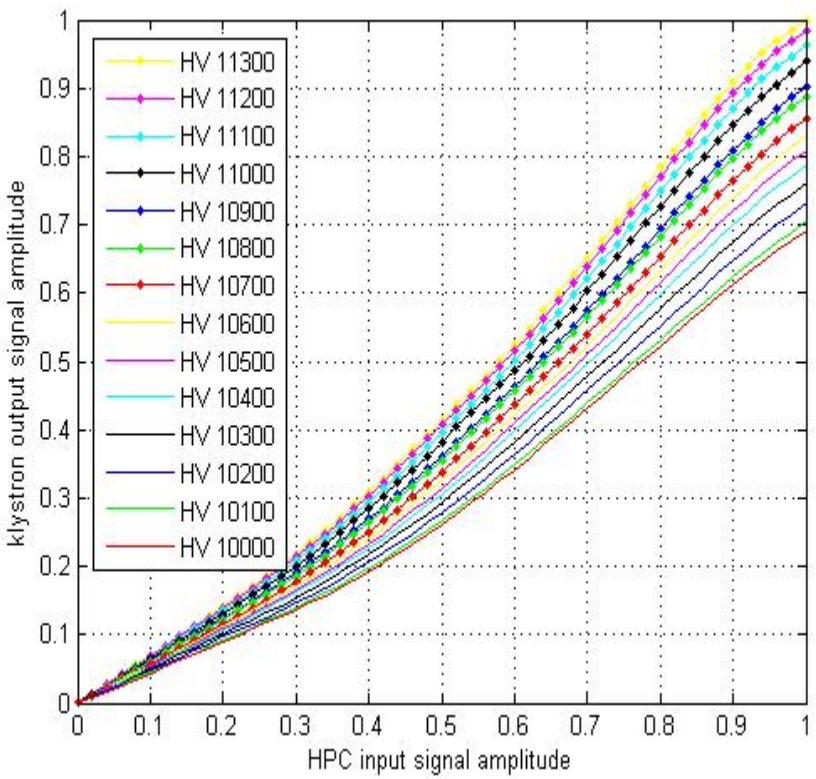


Valid transitions between RF-power station operation modes.

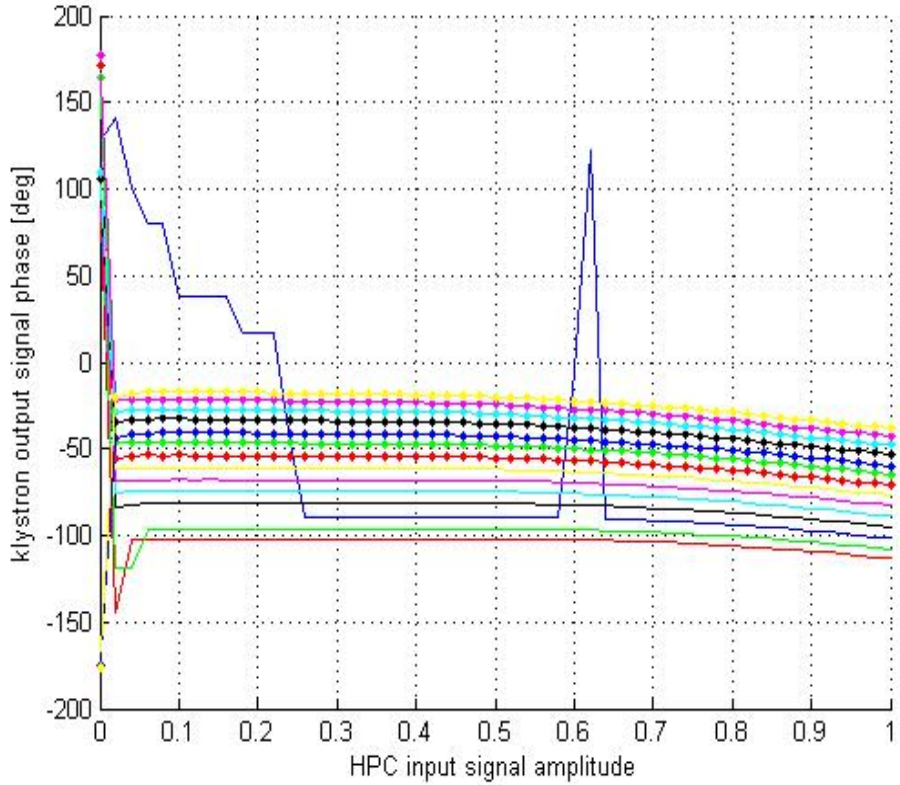
Linearization of the high power chain of the RF control system

- Klystron linearization method was proposed and implemented in the existing control system solution in order to achieve linear response of the klystron and its preamplifiers.
- The DOOCS panel allowing the characterisation and linearization of the high power components were designed and integrated with accelerator control system.

HV dependency of Klystron operation

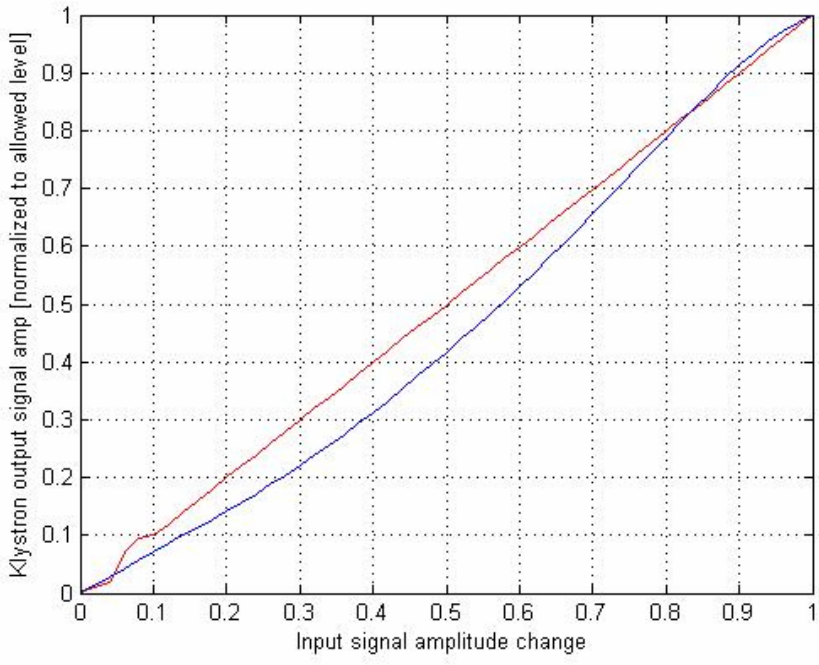


AM/AM

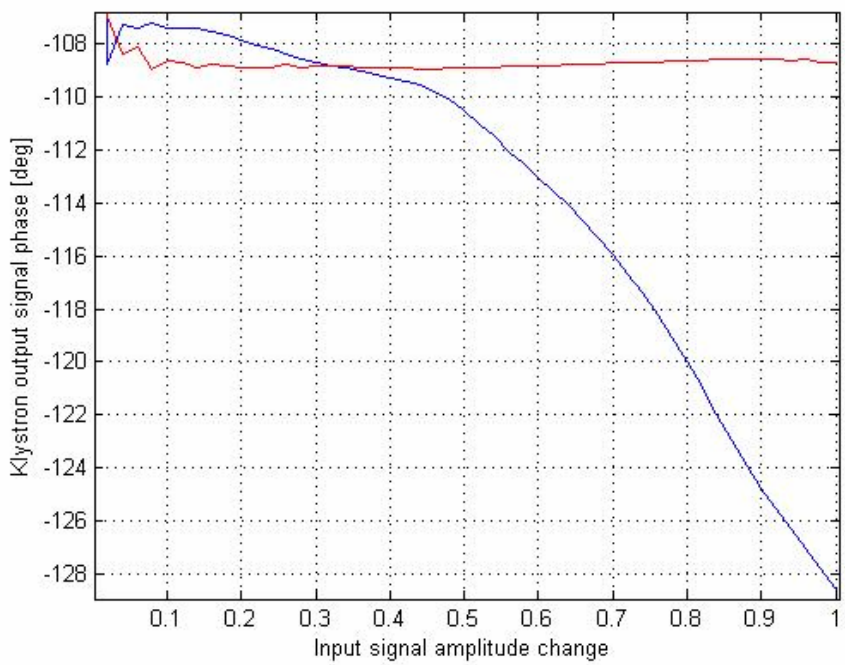


PM/AM

Results of klystron linearization

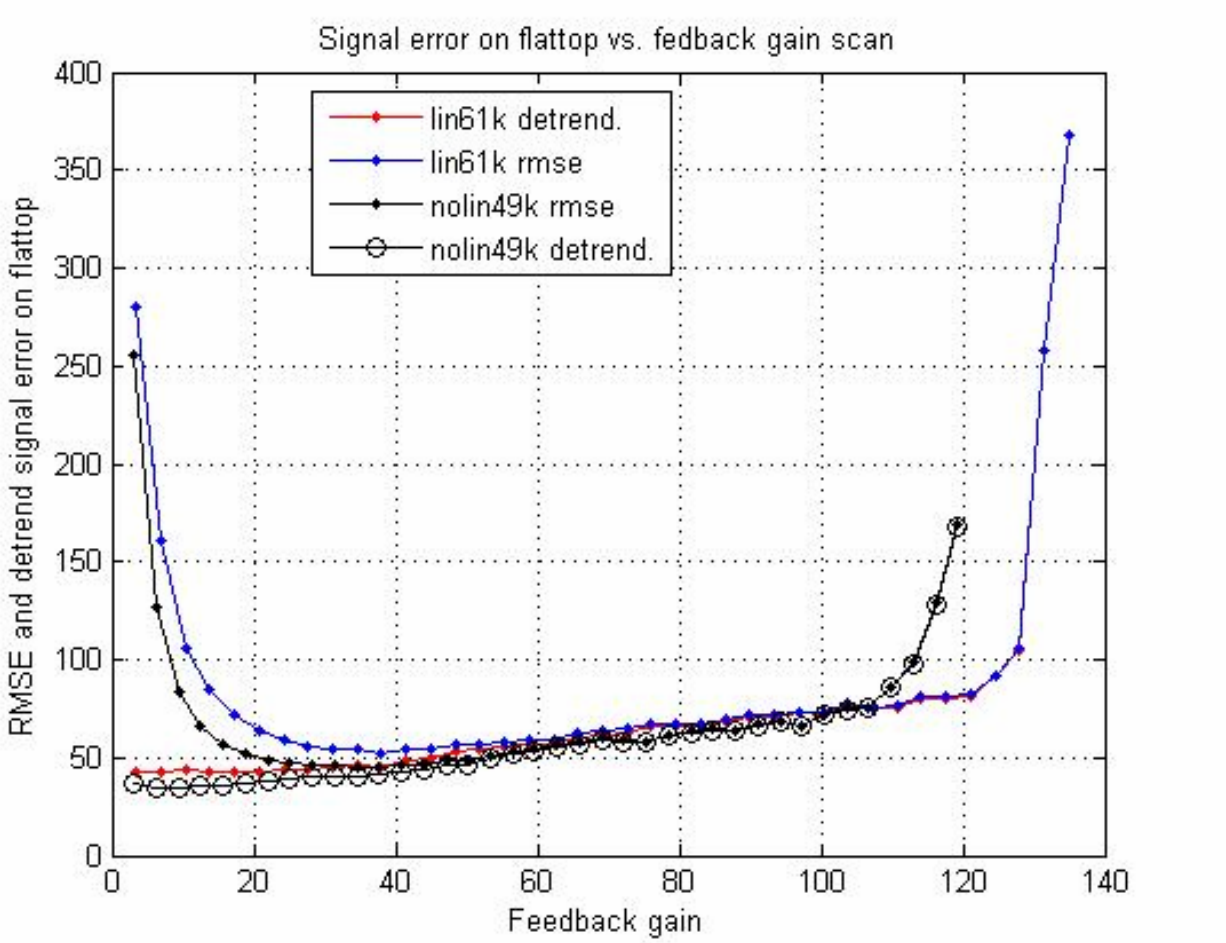


AM/AM char. (blue – nonlin, red - lin)



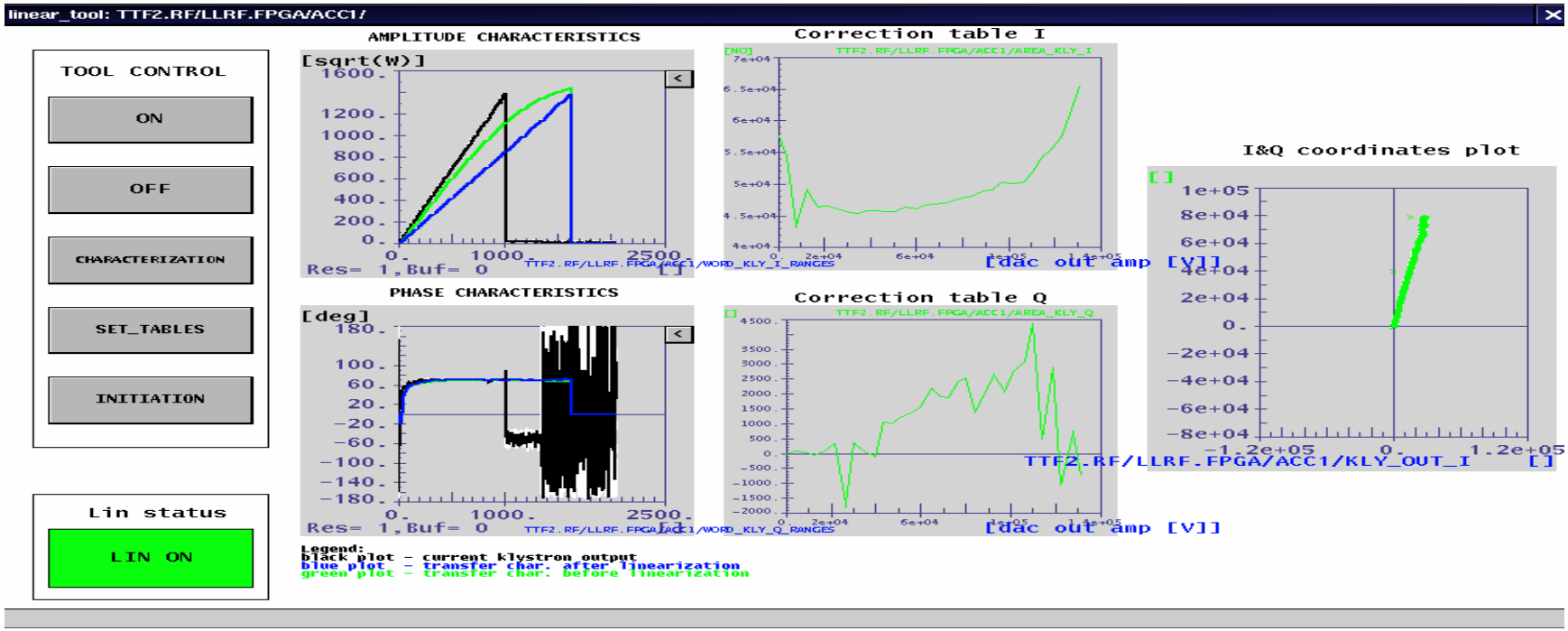
PM/AM .char (blue – nonlin, red - lin)

Results



Amplitude of the error signal in function of the feedback gain for 50% of the regular field gradient level set point (Black traces – non-linear case, blue and red traces – system with linearisation). Extension of operation range is visible.

DOOCS integration



Characterisation and linearization tool management panels for the klystron 2

9.2.1 Cost and reliability study

- Ways to reduce costs
  - Automation procedures using knowledge database (rule-based) reduce cost of operation.
  - ATCA or μTCA crates?
  - Cables from front or from back side of the crate?
  - Reduce number of signals?
  - Development in house or purchase?
- Ways to improve reliability
  - Algorithmic solutions for reliability improvement.

9.2.2 Radiation damage study

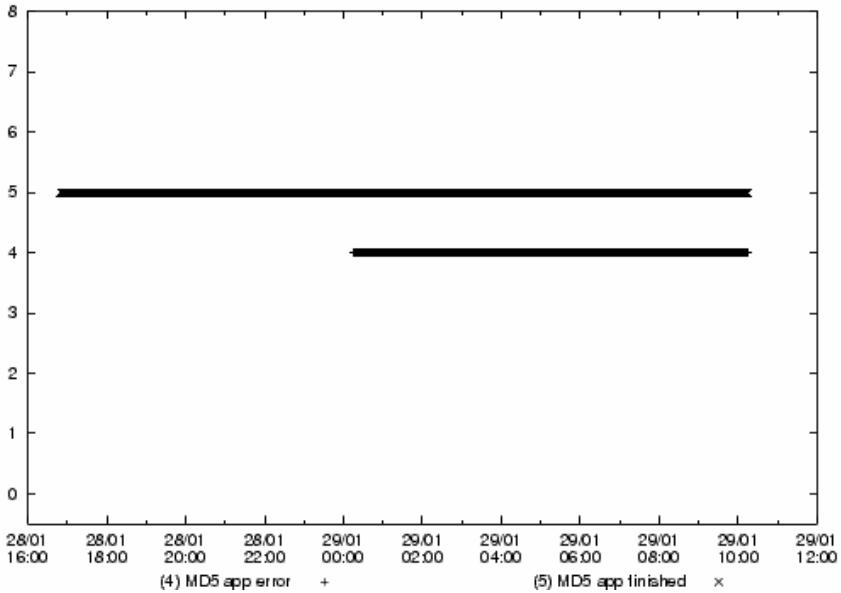
- During reported time period the radiation monitoring system RADMON installed in FLASH tunnel was extended (up to six permanently mounted sensors and two mobile) and tested. The radiation level is recorded on-line and stored for further processing.

Radmon

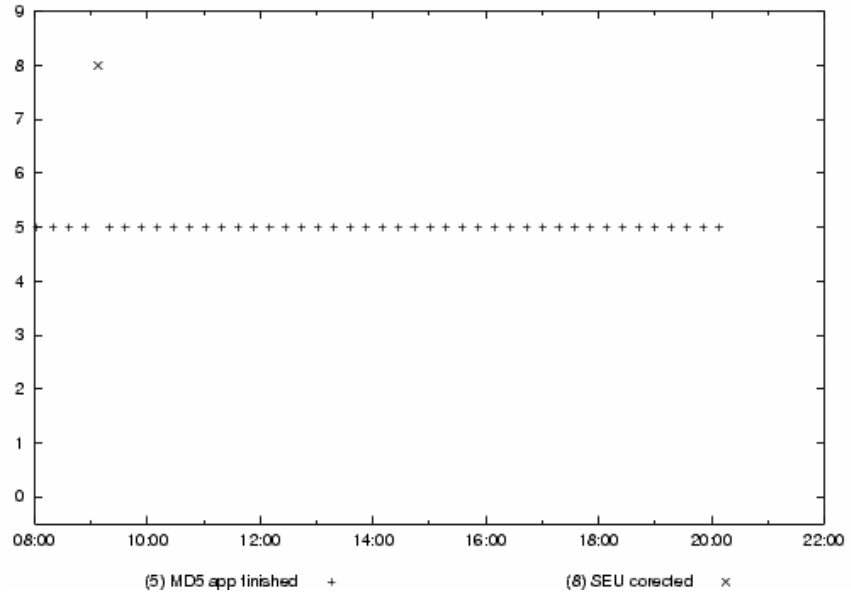
The sCore kernel was improved, optimized and ported to new hardware platforms. All changes were applied to single error protection algorithm based on virtual memory mechanisms (the algorithm was precisely described in previous reports). The sCore system was successful run on embedded PC104 board with the AMD Geode GX1-300 MHz processor and 256 MB of RAM module.

Results of experiments

- SEU-immunized operating system sCore was used together with ordinary (not immunized) program calculating MD5 sum
- Exit level=5 means proper execution, level=8 indicates succesful error detection and correction, other values indicates errors



without SEU protection

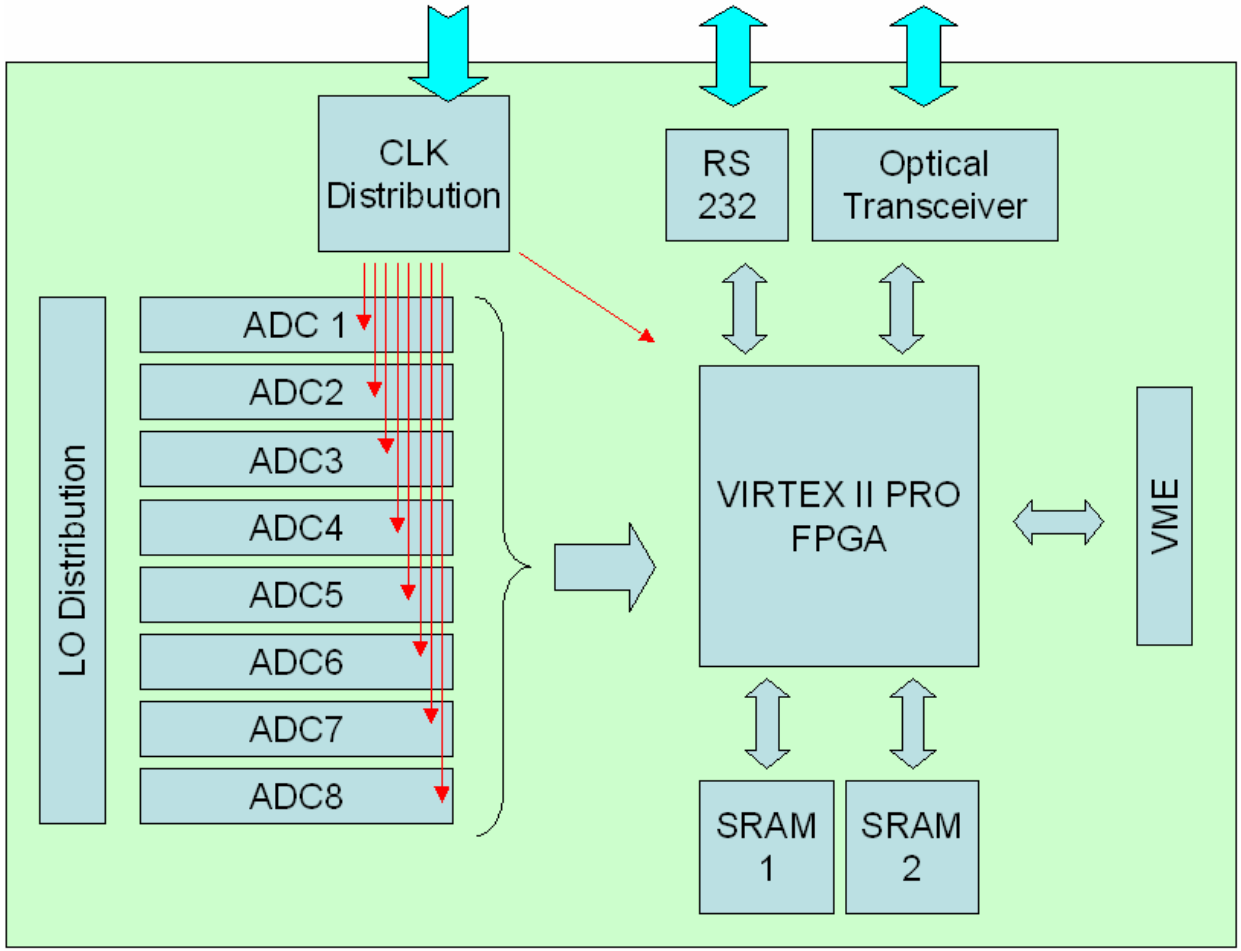


with algorithm against SEU

9.3.1 Multichannel downconverter

- During the reporting period a new carrier board were designed and manufactured. The digital motherboard can carry mezzanine boards. Different VME sized mezzanine boards for various applications are designed, namely
  - Analog frontend multi-channel downconverters with integrated ADCs,
  - Analog high resolution ADCs for new beam arrival monitors,
  - Analog high resolution ADCs for new beam position monitors.

Carrier board for DWNs & ADCs



Digital motherboard suited to carry mezzanine boards with downconverters and ADC

Carrier board for DWNs & ADCs

Digital motherboard suited to carry mezzanine boards with downconverters and ADC

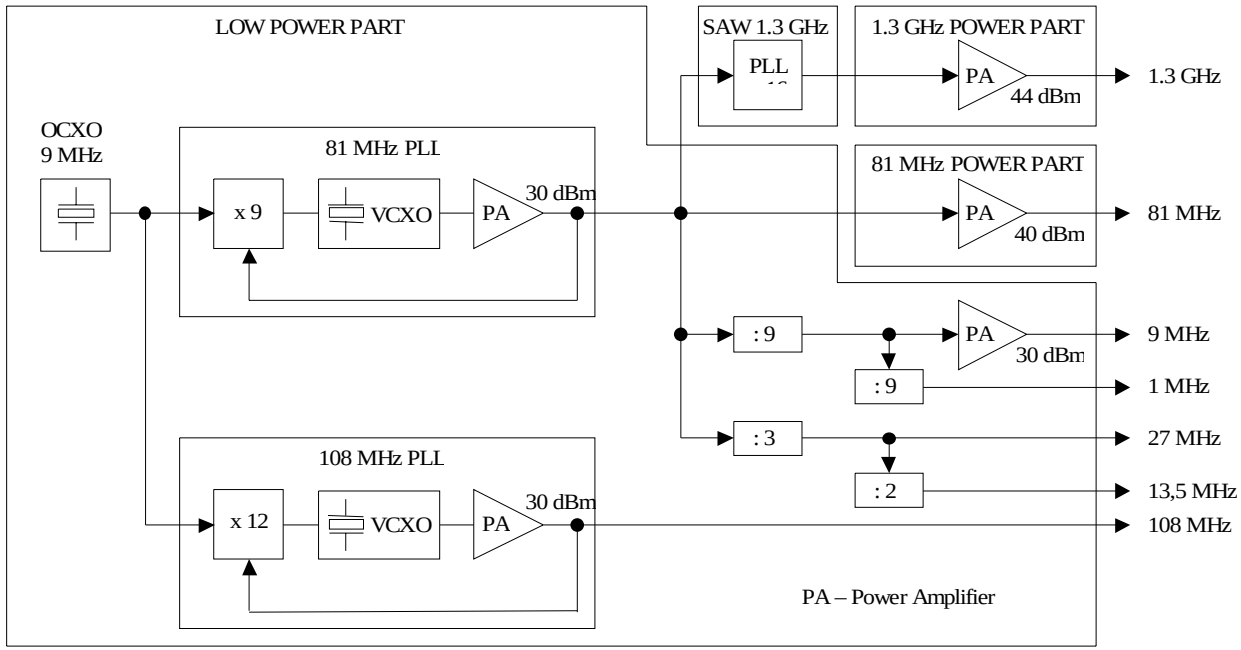
9.3.2 Third generation rf control

Control board SIMCON DSP

9.3.3 Stable frequency distribution

A new frequency distribution system was partially assembled and tested. The stability requirements of Master Oscillator were 100fs and 1ps for times shorter than 100ms and longer 1000s respectively. The frequency distribution system consist of MO supplying several reference frequencies and power amplifiers for signals distribution. The low level part of the system is already finished. The implementation and testing of the power part of the system is in progress.

Frequency distribution system



block diagram

Frequency generation and distribution boxes

9.4.1 Data management development

Task completed in 2005 and final report published. The database is currently under tests in DESY – Hamburg.

9.4.2 RF Gun control

- Task completed in 2006 and final report published.

LLRF Meetings/Workshops/Talks

- PAC
- IEEE-SPIE WILGA
- MIXDES
- LINAC
- IEEE Eurocon
- LLRF Workshop

CARE Publications

- **Measurement Science and Technology, IOP, London, vol.18, no.8, 2007**
- Radiation measurement in the environment of FLASH using passive dosimeters, B. Mukherjee, D. Rybka, D. Makowski, T. Lipka, S. Simrock,
- Application of Low Cost Gallium Arsenide Light Emitting Diodes as KERMA Dosemeter and Fluence Monitor for High Energy Neutrons, Radiation Protection Dosimetry, B. Mukherjee, S. Simrock, D. Rybka, R. Romaniuk, J. Khachan,
- Superconducting cavity control based onsystem model identification, Tomasz Czarski
- FPGA technology application in a fastmeasurement and control system for the TESLA superconducting cavity of a FLASH free electron laser, Krzysztof T Pozniak
- FPGA-based implementation of a cavityfield controller for FLASH and X-FEL, Przemyslaw Fafara, Wojciech Jalmuzna, Waldemar Koprek,Krzysztof Pozniak, Ryszard Romaniuk, Jaroslaw Szewinski and Wojciech Cichalewski,
- Radiation measurement in the environment of FLASH using passive dosimeters, B Mukherjee, D Rybka, D Makowski, T Lipka, and S Simrock,
- Measurements for low level RF control systems S Simrock,
- New method for beam induced transient measurement P Pawlik, M Grecki, S Simrock and A Napieralski,
- Measurement of static force at liquid helium temperature P Sekalski, A Napieralski, M Fouaidy, A Bosotti and R Paparella,
- Characterization and compensation for nonlinearities of high-power amplifiers used on the FLASH and XFEL accelerators W Cichalewski and B Koseda,
- Radiation monitoring system for X-FEL D Makowski, B Mukherjee, S Simrock, G Jablonski, A Napieralski and M Grecki SEU-tolerant IQ detection algorithm for LLRF accelerator system M Grecki
- Application of low cost gallium arsenide light-emitting-diodes as KERMA dosemeter and fluence monitor for high-energy neutrons, B.Mukherjee, S.Simrock, J.Khachan, D.Rybka, R.Romaniuk, Radiation Protection Dosimetry (2007), May, Vol. 123, No.5

CARE Conferences

- Radiation Field Unfolding at the Free Electron Laser in Hamburg (FLASH) using a Genetic Algorithm, B. Mukherjee, M. Valentan, D. Makowski, D. Rybka, S. Simrock, IEEE Eurocon 2007
- A Concept of Irradiation Experiments System, D. Rybka, S. Korolczuk, B. Mukherjee, R. Romaniuk, IEEE Eurocon 2007
- Linearization of downconversion for IQ detection purposes, M. Grecki, W. Koprek, S. Simrock, PAC 2007,
- Performance of the New Master Oscillator and Phase Reference System at FLASH, S. Simrock, M. Felber, Markus. Hoffmann, Matthias Hoffmann, H. C. Weddig, PAC 2007
- A Novel Approach for Hardware Implementation of a Detuning Compensation Control System for SC Cavities, K. Przygoda (Tech. Univ. Lodz , POLAND), R. Paparella (Univ. degli Studi di Milano, ITALY) MIXDES 2007
- In Situ Measurement of Neutron and Gamma Radiation Exposures During Intercontinental Flights Using Electronic Personal Dosimeter and Bubble Detectors, B. Mukherjee, D. Makowski, V. Mares, D. Rybka, S. Simrock, MIXDES 2007
- Integral Interface - Universal Communication Interface for FPGA-based Projects, A. Piotrowski, S. Tarnowski, G. Jabłoński, A. Napieralski, MIXDES 2007

CARE Conferences

- Low-latency Implementation of Coordinate Conversion in Virtex II Pro FPGA, G. Jabłoński, K. Przygoda, MIXDES 2007
- RadTest - Testing Board for the Software Implemented Hardware Fault Tolerance Research, A. Piotrowski, D. Makowski, S. Tarnowski, A. Napieralski, MIXDES 2007
- Sinusoidal Signal Synthesis from Vector Values with Small Quantity of Samples, S. Tarnowski, A. Piotrowski, A. Napieralski, MIXDES 2007
- Control system modeling for superconductive accelerator, Tomasz Czarski, Krzysztof Poźniak, Ryszard Romaniuk, IEEE Instrumentation and Measurement Conference, IMTC 2007, Warsaw,
- Measurement and control of field in RF GUN at FLASH, A.Brandt, M.Hoffman, W.Koprek, P.Pucyk, K.T.Pozniak, R.S.Romaniuk, WILGA 2007
- Multi-cavity complex controller with vector simulator for TESLA technology linear accelerator, T.Czarski, K.T.Pozniak, R.S.Romaniuk, J.Szewinski, WILGA 2007
- Versatile LLRF platform for FLASH laser, P.Strzalkowski, W.Koprek, K.T.Pozniak, R.S.Romaniuk, WILGA 2007

CARE Conferences

- FPGA based PCI mezzanine card with digital interfaces, K.Lewandowski, R.Graczyk, K.T.Pozniak, R.S.Romaniuk, WILGA 2007,
- Data acquisition module implemented on PCI mezzanine card, L.Dymanowski, L.Graczyk, K.T.Pozniak, R.S.Romaniuk, WILGA 2007
- Vector modulator board for X-FEL LLRF system, M.Smelkowki, P.Strzałkowski, K.T.Pozniak, WILGA 2007
- FPGA system development based on universal control module, R.Graczyk, K.T.Pozniak, R.S.Romaniuk, WILGA 2007
- DSP algorithms in FPGA – proposition of a new architecture, P.Kolasinski, W.Zabolotny, WILGA 2007
- Matlab script to C code converter for embedded processors; Application in LLRF system for FLASH laser, K.Bujnowski, A.Siemionczyk, P.Pucyk, J.Szewinski, K.T.Poźniak, R.S.Romaniuk, WILGA 2007
- Decomposition of Matlab script for FPGA implementation of real time simulation algorithms for the LLRF system in the European XFEL, K.Bujnowski, P.Pucyk, K.T.Pozniak, R.S.Romaniuk, WILGA 2007
- FPGA control utility in Java, P.Drabik, K.T.Pozniak, WILGA 2007
- Direct digital modulation system for LLRF, S.Tarnowski, A.Piotrowski, A.Napieralski, WILGA 2007