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SCT DETECTOR CONTROL SUBSYSTEM
structure and functions proposal

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Contents

1 Introduction

The detector control subsystem for the SemiConductor Tracker (SCT) is used for the operation and supervision of SCT subdetector and its infrastructure. The subsystem is one of several parts of the ATLAS Detector Control System (DCS), its data are transmitted to the DCS. Based on the data from all the DCS subsystems the global ATLAS status will generate and possibly broadcast automatic actions or suggestions for actions. Control commands issued by the user are in normal conditions transmitted to the every subsystem. The general conditions of the DCS functionality are defined in the ATLAS DCS User Requirements Document [1]. DCS for SCT can operate autonomously when testing or tuning procedures are performed with SCT subdetector itself.

The contents of subsystem data is the SCT status information, namely:

- SCT subdetector conditions (temperatures, humidity);
- apparatus functional parameters (high and low voltages, status signals)

and the status information of SCT surroundings - service equipment (cooling, power supplies, etc.).

A part of DCS for SCT, mainly the subdetector and apparatus sensing probes with limited monitoring electronics and front-end part of the control electronics, have to be implemented under radiation-hard and limited space conditions. The status data of Service equipment may be obtained by traditional methods of an industrial Slow Control (SC).

The SCT status data may be subdivided into two groups:

- Safety information of hardware (no damage danger);
- Validity information of physics data (no distortion danger).

The safety monitoring channels must have the local control feedbacks for high speed reaction in the case of hardware damage danger.

This document is based on the ideas that were described in [2-8] and on the materials of the ATLAS DCS and SCT meetings.

2 The main functions of DCS for SCT

The general functional structure of DCS for SCT is shown in Fig.1. The subsystem performs monitoring and control of:

- status of SCT front-end and readout electronics;
- microstrips bias "high" voltages (HV);
- power supply "low" voltages (LV);
- temperatures and cooling parameters;
- humidity and optoisolation conditions of microstrips;
- microstrips radiation dose;
- interlock system

for Barrel and both EndCaps constituents of the SCT subdetector.

The DCS for SCT has one (main for the subsystem) Local Control Station (LCS) and several Satellite Control Stations (SCS). The LCS (based on the power workstation) will be standardized among all the subdetectors in ATLAS. The LCS will be installed on the surface in a place where it is well accessible. The SCSs are situated in the SCT-crates

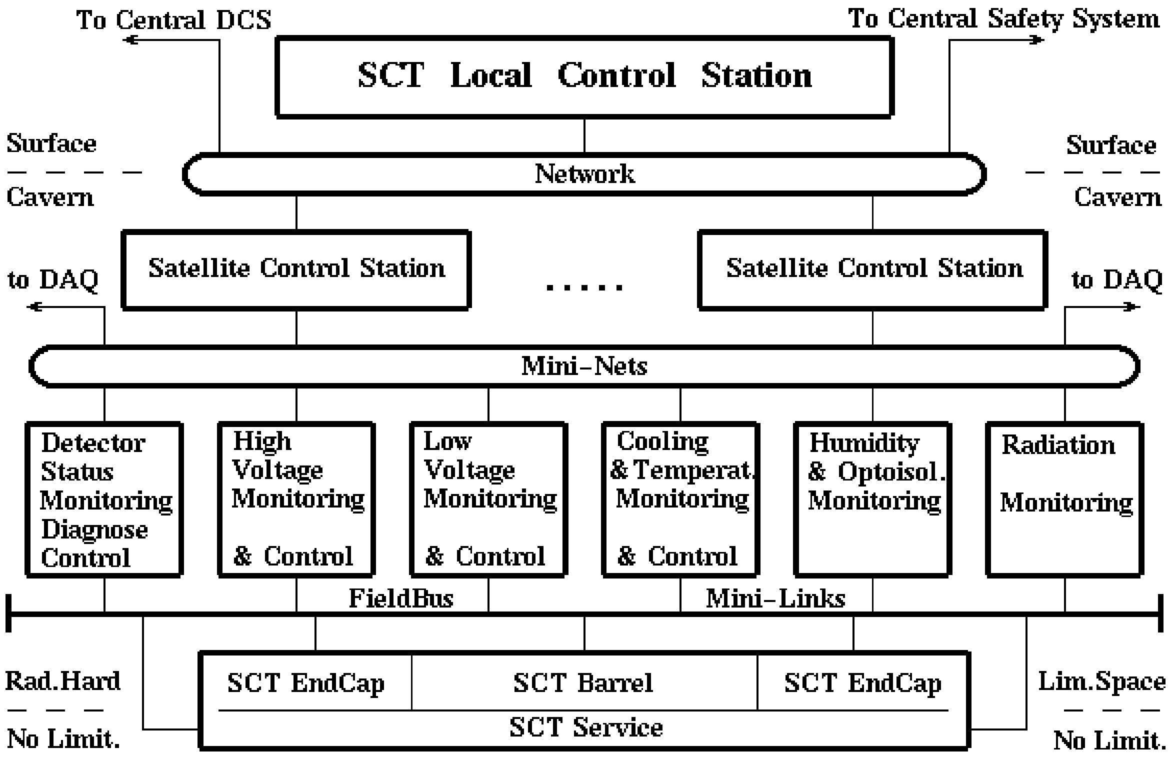

Figure 1: The general structure of DCS_SCT

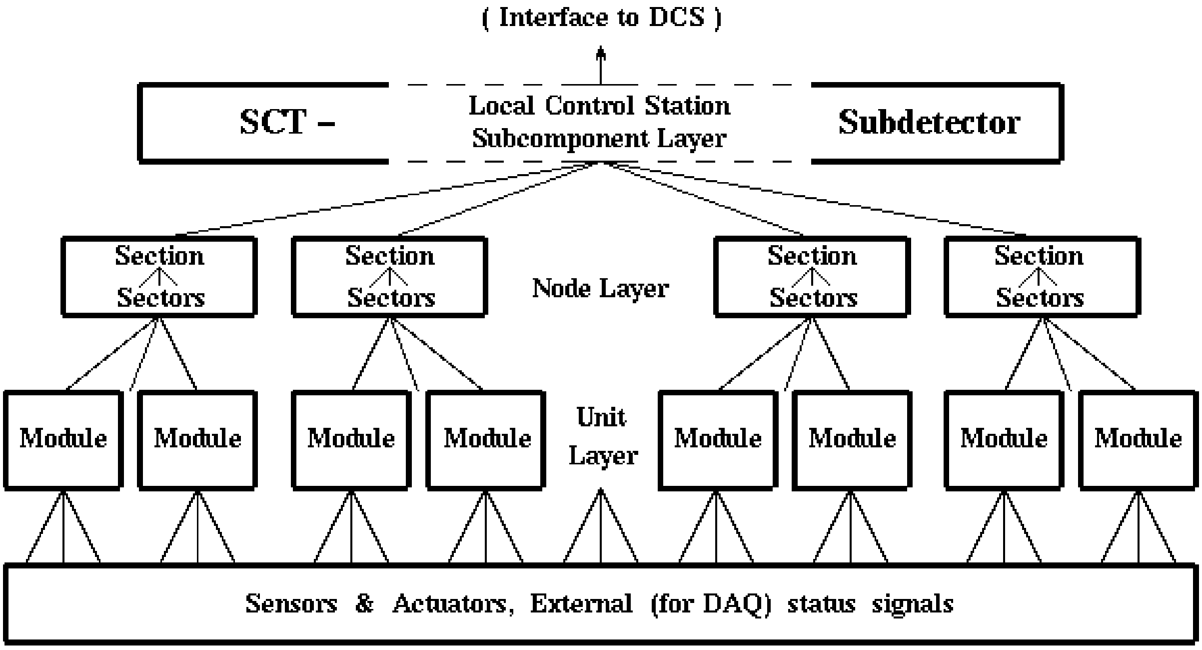

Figure 2: The ATLAS_SCT and DCS_SCT logical structures

located in the cavern close to the subdetector. Every control station (LCS or SCS) can be switched by the SC-expert of the SCT subdetector into local or stand-alone mode.

2.1 The subdetector and subsystem logical structures

The main components of SCT subdetector structure is shown in Fig.2; it has 4 hierarchial levels:

SCT subdetector - a part of ATLAS detector located between the Pixel detector and Transition Radiation Tracker; it has specific detecting function and can be used in stand-alone mode;
section - a (repeating) part of subdetector which can be installed and operated as one unit (a cylinder in the barrel or a disk in the forward detector);
sector (ladder) - a part of the barrel layer or a part of the disk which can be operated autonomously;
module - an element (the smallest part) of the detector, every sector may contain up to 10-12 modules.

The logical structure of DCS for SCT corresponds to the main layers of subdetector structure. It is described for user as a 4-level tree (see Fig.2 in the middle):

DCS subsystem - a part of DCS component, which corresponds to ATLAS subdetector layer and which has a certain autonomy, needs to be operated independently and has normally only loose connections to other subsystems;
node - a repeating part of subcomponent, corresponds to the ATLAS section;
unit - a functional element of node, corresponds to the ATLAS module;
sens/act - includes sensor/actuator sub- or zero-layer.

The logical structures are used for the definitions of names. Every item in the ATLAS DCS (and in the ATLAS Detector as well) has its own name as an identifier. The item name in the hierarchical structure may be ”full” or ”local”. The full name consists of the hierarchical chain of local names up to the highest level or up to a higher level which is an unique local name. The local name reflects the function of the part and is represented by an 3-5 letter abbreviation. Several parts of the DCS that realize the same function may have the same (common) local name. If only a local name is used it is preceded by indication of a higher ATLAS part.

The composition of names shall follow the general naming convention of the ATLAS DCS group which is yet to be defined. A example is that the local names in the chain with the higest level in the hiearchy written from the left are linked via ”_” sign. For instance, the name of DCS for SCT is DCS_SCT; the name of its Cooling node is DCS_SCT_Cool.

2.2 The main functions of the DCS subsystem for SCT

The main functions of the subsystem shown in Fig.1 are:

Monitoring	- read-out of the analogue and digital status signals;
Diagnose	- sending of the combination of the status-test signals and the analysis of the responses;
Control	- the assertion of the necessary analog and digital status signals;
Interface	to User, to DCS Component layer, to DAQ Subdetector electronics.

2.2.1 Subcomponent functions

The functional structure of SCT Subcomponent (see Fig.2) is shown in Fig.3. The satellite control stations perform short-term monitoring data storage (for the current week). Subsystem LCS deals with long-term SCT archives.

The subcomponent user interface software is based on the graphic user interface tools.

2.2.2 Node functions

The structure of the Node is shown in Fig.4. The main functional constituents of the SCT Node are:

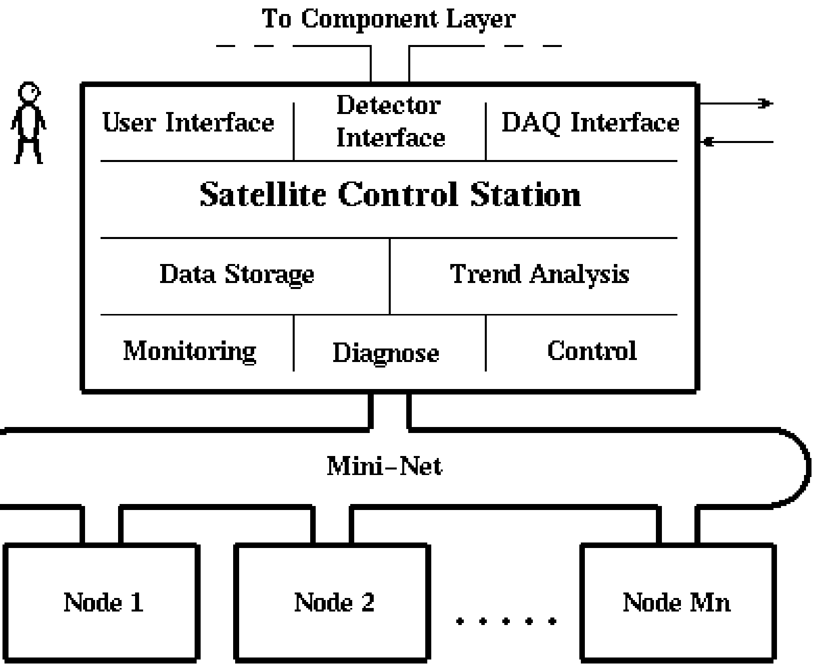

Figure 3: The structure of DCS_SCT Subcomponent layer

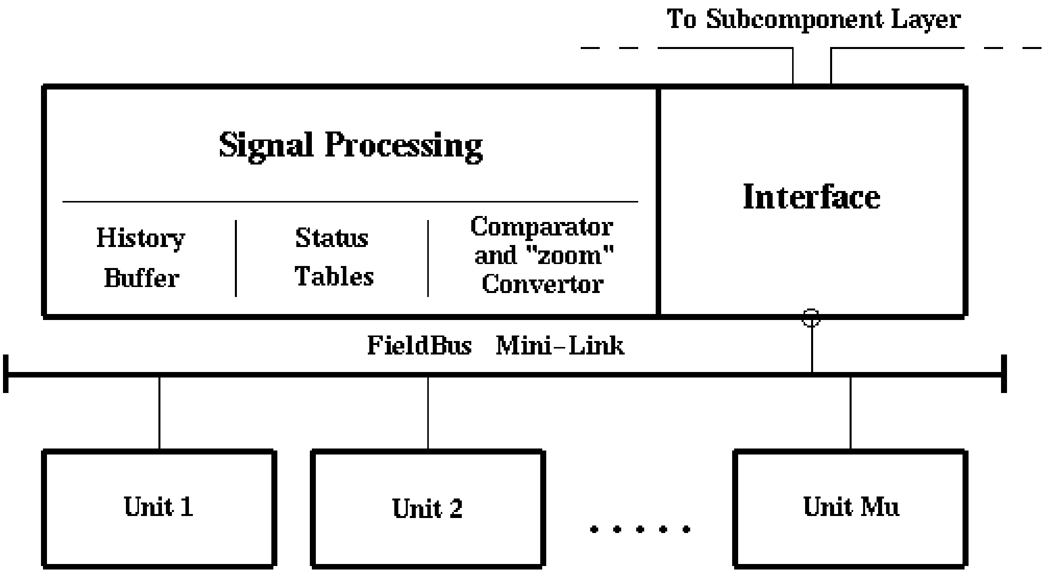

Figure 4: The structure of Node layer

interlayer interface	- multiplexing of the monitoring data and distribution of diagnose and control signals;
history buffer	- temporary storing of the state sequences;
status table	- (normal, warning, alarm) etalon quantities deposition;
comparator	- decision making for the current logical states.

A Portable Controller may be connected to the interface link in the stand alone mode (instead of Subcomponent).

2.2.3 Unit functions

The Monitoring, Diagnostic and Control (MDC) Unit has a generic structure and the functions that are shown in Fig.5. The monitor and control subunits are represented in the top and bottom correspondingly, they operate with both analogue and digital signals and perform the following:

monitoring subunit	- status data collection;
control subunit	- status signals fan-out.

The feedback about success or failure of the control operation is registered by the monitor subunit as the control_AK signals.

The MDC unit is an only interface for the monitoring and control signals; it has Fieldbus connection to the Node which performs Signal Processing functions (see Fig.4).

2.2.4 Test functions

The SCT testing procedures may be subdivided in two parts: calibration (analogue tests) and diagnose (binary tests).

The calibration may include Gain, Linearity, Pedestal and Thresold measuriment for the every channel by using a variable amplitude signal in the fixed point - Front-End (FE) of a channel. It is assumed that calibration is the function of SCT DAQ subsystem.

In a contrast, a diagnostic signal has a fixed amplitude but it puts in the variable points (from back- to front-end) of the channel for a localization the source of an error.

The points where diagnostic signals will be introduced are shown in Fig.6. The first source of the diagnostic signal is a test pulse on the backplane of the microstrips which covers all the readout lines in the module. The second source of diagnostic signal is an electrical pulse

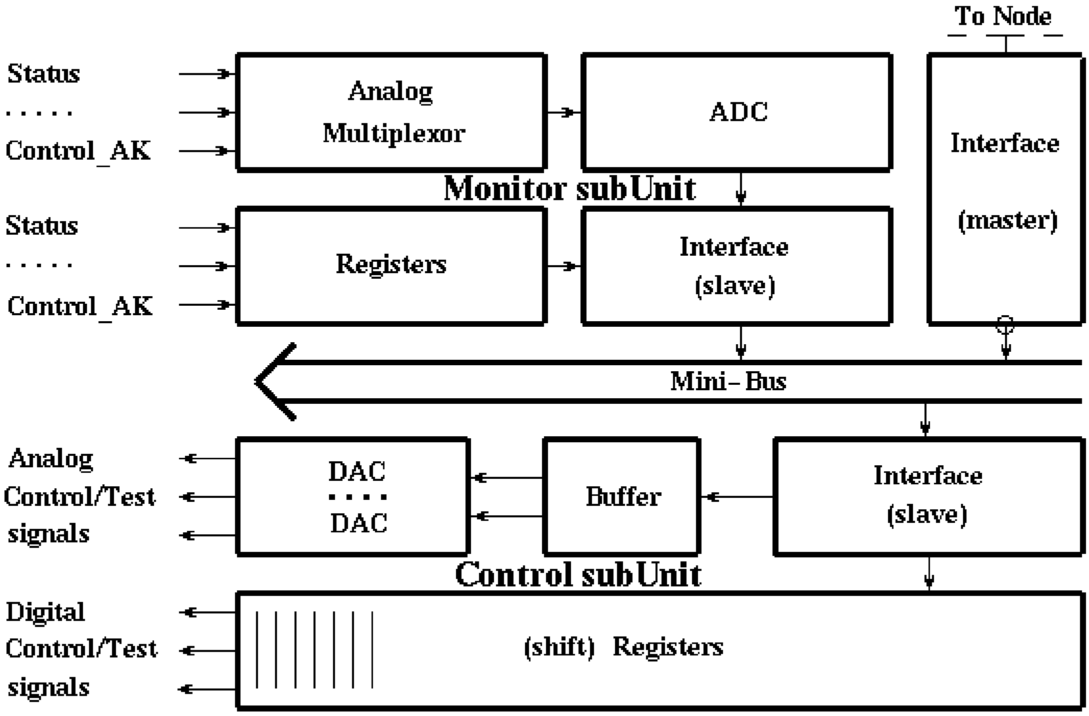

Figure 5: The generic structure of MDC Unit

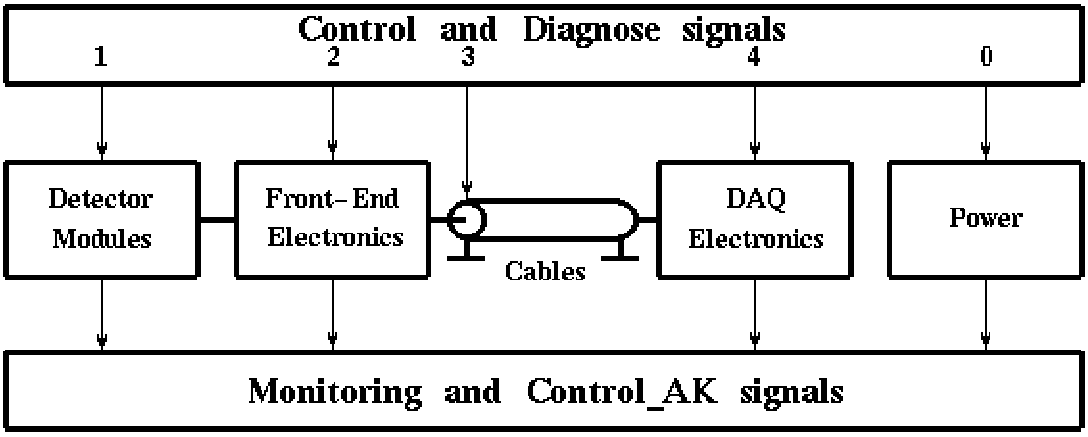

Figure 6: The sequent points of the control and diagnostic signals inputs

that applied as an analog signal on the FE-chip test-input. The third diagnostic signal is introduced in the inputs of the links (on the Node layer) and the last one - into the DAQ-channel input.

2.3 Interlock

The interlock is operated both trough software and hardware. The hardware interlock is closely connected to the cooling system. This interlock system will have its own monitoring sensors connected to a hardwired interlock logic for fast response. The interlock will operate on all voltage supplies of the SCT subdetector simultaneously.

The monitoring sensors for the software interlock is separated from the hardware interlock. The algorithm for the software interlock can be more complex than for the hardware interlock but the reaction time is slower. The software interlock can switch off a limited number of power supplies but the smallest part that will be operated is a section of the SCT subdetector.

3 The terms and definitions

The probable anomalies in the SCT may be subdivided into:

Fault - when after an anomaly appearance the apparatus remains in non-operable state until its repair;

Error - when non-operable state has a temporary (self-restortion) character;

see Supplement A for the details.

3.1 Types of anomalies in SCT

The categories of anomalies which are defined based on their nature and time spectrum are shown in the Table 1.

Table 1

Category number and the Nature of anomaly	Time spectrum
1. Ultra-slow variations of status parameters caused by - ageing, - degradation from an external radioactivity	1 - 10 years
2. Climatic variations caused by fluctuations of temperature, humidity, air pressure	1 - 100 hours
3. Electrical pulsations caused by power supply defects or an influence of external power setups	1 - 100 ms
4. Radio-frequency overcrosses and working point (baseline) shift due to loading variations	1 - 100 mcs
5. Random errors and noises	flat spectrum

3.2 SCT states and transitions

Every part of the SCT logical structure (of each layer) should have 4 logical "states" (see Supplement B for the details). These logical States are enumerated below in the function ability increasing ("up") order:

Off	- the part is absent or power off;
Unable	- power-on functional inability state;
Stand-by	- functional ability nonoperation (idle) state;
Run	- working state.

The "transitions" between the log-states form 2 kinds of loops: the "working" and "error" Transitions.

Every log-state of the part consists of several "substates". For Run state the logical Substates are:

Normal	- operation without errors;
Warning	- operation in spite of errors;
Alarm	- operation is blocked due to errors;
Fatal	- functional ability is lost.

More detailed description of the substates contains in Suppl.B.

3.2.1 The tree of SCT states

The state of whole SCT is a majority-AND function of it sections states. Every section state is an majority-AND function of the modules states. In the case of essential mixing the different log-states of parts the log-state of overall SCT may be represented as the 4-level tree of states.

The log-state information of SCT subdetector, section or module shall be accessed via their names. The information itself can be organized as 2-level structure of mnemocodes. For instance, the status message may be represented as follows:

SCT_PART: Run_Normal.

The term PART shall mean in the status message that ALL or near to ALL of the components in a lower layer (sections in this example) are in the Normal substate (majority-AND). In the opposite case the whole list of the states of lower layer components are represented.

3.3 Normalization of monitoring parameters

For essential reducing (about 2 times) the number of bits in monitoring parameters digital states a two-scope (”zoom”) linear conversion is used for the Normal-Warning and Alarm/Fatal substates; see Fig.11 in Suppl.A for the details. The assumed number of gradations are:
128 - in both of Normal and Warning substates (for the trend analysis);
64 - in the every of Alarm or Fatal substates.
”Zoom” normalization of monitoring parameters is implemented in the Node.

3.4 The designations for Monitoring and Control

The designations giving the needs for different monitoring and control functions are listed below:

Mm - number (Multitude) of Monitoring parameters;
Mc - number of parameters should be Controlled;
Mp - total number of the Parameters;
P - analogue value of the monitoring Parameter;
Pn - Nominal value of the monitoring parameter;
Ra - Range of the Alarm parameter quantities;
Rn - range of the Normal parameter quantities;

Rw - range of the Warning parameter quantities;
S - State (digital value) of the parameter;
Sz - Zoom normalized digital value of the parameter;
Td - maximum Time interval of an error Detecting;
Te - average duration of an Error interval (Te<Tr);
Ti - (Integral) filtering time constant for monitoring signal;
Tm - period of Monitoring;
Tn - average time interval of (Normal) operation of the system;
Tp - minimum (detectable) period of the Parameter variations;
Tr - average period of the errors Repetitions (Tr$\simeq$Tn);
Ts - duration of monitoring Strobe signal;
Tt - maximum time of diagnose (Testing) procedure;
Tv - maximum time of recoVery procedure.

The requirements on the transition times:

Tus - transition time from Unable to Stand-by state;
Tsr - transition time from Stand-by to Run state;
Trs - transition time from Run to Stand-by state;
Tru - transition time from Run to Unable state.

and some suggestions concerning

Nrs - permissible rate of the Error transitions (see Fig.13);
Nru - permissible rate of the Fault transitions;
Nsu - permissible rate of the Upset transitions

for the every layer are listed in the section 4.* (will be added).

The subsystem is able to detect the first three categories of anomalies and therefore two types of monitoring (see Suppl.A for the details) are performed in SCT:

- direct monitoring - when Tm<<Tp, then Td<= Tm;
- sampling monitoring - when Tm >Tp,
  but Ts<<Tp, then Td = 6Tm*Tr/Ts.

In the case of an error detecting the physics data, that were received in Td time interval, must be rejected because they *may be* corrupted.

4 The requirements for MDC parameters

DCS for SCT forms approximately 10-15 percent of DCS equipment.

4.1 The number of parts in DCS_SCT components

The general principle of SCT structure formation is as following: one LCS and 3-5 SCS, each of SCSs deals with 30-40 nodes, each node consists of 30-40 units; the number of monitoring parameters in every unit is about 6-10. The total number of DCS_SCT parts are represented in the Table 2.

Table 2

Layer :	**Parameters**	**Units**	**Nodes**	**SCS**
Mp - monit:	**35000**	**5000**	**150**	**4**
Mp - contr:	**15000**			

4.2 What shall be measured

The following parameters are monitored in the SCT subDetector itself:

1) power supply voltages (2 point/module, total 10000);
2) bias "high" voltage (1 point/module, total 5000);
3) module temperature (1 point/module, total 5000);
4) structure temperature (8 point/section total 800);
5) humidity (1 point/section, total 100);
6) optoisolation conditions (1 point/section, 50);
7) radiation dose (1 point/section, total 100).

The following parameters are monitored in the SCT Service:

1) power supply currents (2 point/module, total 10000);
2) bias HV current (1 point/module, total 5000);
3) flow of coolant (4 point/section total 400);
4) pressure of coolant (8 point/section total 800).

The list of FE-chip(s) parameters that may be monitored is:

1) pedestal and/or threshold status of the channels;
2) transition factor (gain) status of the channels;
3) the main Control and Status Registers (CSR) data;

these states are obtained from DAQ-subsystem.

The status of DAQ-electronics should be monitored; its status registers shall include the results of input cables test(s).

4.3 What shall be controlled

The following control functions is brought into the unit level in SCT subDetector:

1) module masking (1 point/module, total 5000);
2) FE-chip CSR-status preset.

For the first function realization an additional pin is used in the module connector. The second function is realized via DAQ request from SCS.

The following control functions is brought into the unit level in SCT Service:

1) power supply "masking" (1 point/module, total 5000);
2) high voltage "masking" (1 point/module, total 5000);

The (masking) Escape command - see Fig.13 should be used for FE-chips, High and Low voltages as a reserve control function in the case of DAQ-control fault.

4.4 What values shall be guaranted

The monitoring characteristics provided with the subDetector (D) modules are shown in the Table 3.

Table 3

D-module	Pn	Rw	Ra	Tp	Tr	Ts	Tm	Td
Low Volt.	3.5 V	0.2 V	0.3 V	2 ms	20 ms	1 ms*	1 s	120 s
	4.0 V	0.2 V	0.4 V	2 ms	20 ms	1 ms*	1 s	120 s
High Volt.								
from	10 V	0.5 V	1.0 V	?	-	100 ms	100 s	100 s
up to	300 V	15 V	30 V	?	-	100 ms	100 s	100 s
Temperat.	5‘C	2‘C	4‘C	20 s	-	1 s	10(!)s	10(!)s

Ts* - sampling monitoring (in other cases - direct monitoring);
(!) - for the Alarm substates Tm and Td are equal to 1 s.

The monitoring characteristics provided with the SCT Service are shown in Table 4.

Table 4

Service	**Pn**	**Rw**	**Ra**	**Tp**	**Tr**	**Ts**	**Tm**	**Td**
LV current	**0.8 A** **0.4 A**	**0.04 A** **0.02 A**	**0.08 A** **0.04 A**	**-** **-**	**-** **-**	**100 ms** **100 ms**	**100 s** **100 s**	**100 s** **100 s**
HV current	**6 mA**	**0.3 mA**	**0.6 mA**	**-**	**-**	**100 ms**	**100 s**	**100 s**

(!) - for the Alarm substates Tm and Td are equal to 1 s.

5 Subsystem hardware and software

The block-diagram of the main DCS_SCT hardware is shown in Fig.7.

”Per module” nested monitoring (LV, HV, temperature in D-module) is based on using rad-hard MDC-chips (one MDC for 2 D-modules). The same functions in SCT Service (LV and HV currents) may be realized on industrial Fieldbus MDC-chip or on the same nonrad-hard version of MDC-cheep (one MDC for 3 D-modules).

”Per section” distributed monitoring is based on the industrial multichannel ADC, DAC and IOR electronics (E) modules.

Fieldbus Interfaces, Net Interfaces and Signal Processors are the E-modules placed in VME (G64 ?) crates (E-nodes). These modules are used for D-sections and for S-sections as well.

5.1 MDC-chip general characteristics

The MDC Unit may be realized as a VLSI custom designed chip for all the ATLAS subDetector modules.

The following facilities shall be realized in MDC chip (see Fig.5):

1) number of analogue inputs - 9;
2) analogue inputs resolution - 12 bits;
3) number of digital inputs - 8 (Byte);
4) digital inputs levels - TTL compat.;
5) number of analogue outputs - 2;
6) analogue outputs resolution - 10 bits;
7) number of digital outputs - 4 (Byte/2);
8) digital output levels - TTL/OpColl.;
9) power supply voltages - +/- 4 V (?).

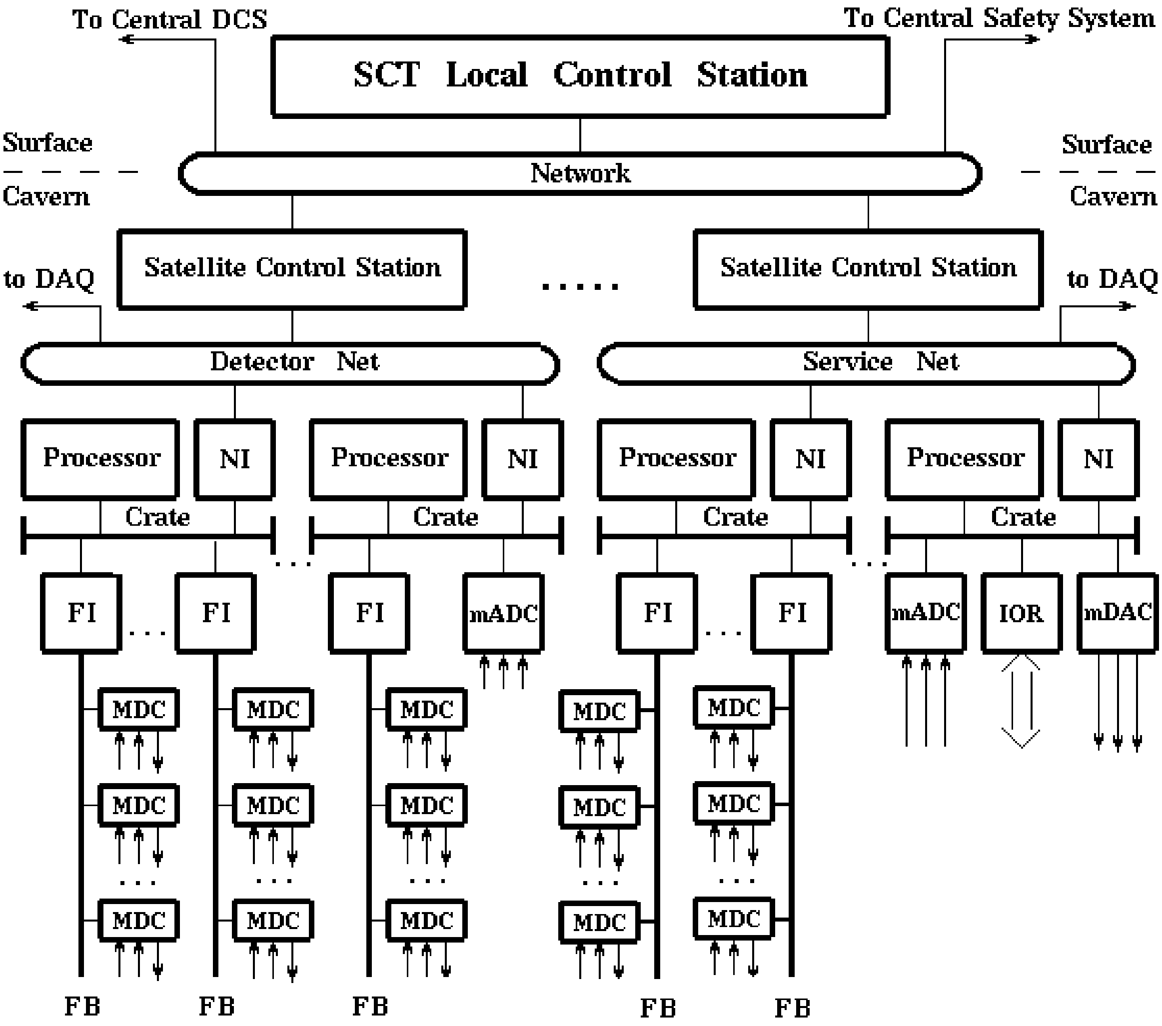

Figure 7: The DCS_SCT hardware realization: FB - FieldBus, FI - Fieldbus Interface, NI - Net Interface, MDC - Monitoring-Diagnose-Control chip, mADC - multiplexed ADC, mDAC - multiDAC, IOR - Input-Output Register

For D-modules in addition:

10) power consumtion	- 0.4 mW;
11) permissible radiation dose	as for FE-chips.

The assumed Fieldbus protocol for connection to the Node is CAN (?) [9].

5.2 The hardware numbers in DCS for SCT

The estimations of the number of MDC-chips, E-modules and crates are represented in the Table 5.

Table 5

MDCd	**MDCs**	**FI**	**NI**	**mADC**	**mDAC**	**IOR**	**Crates**
2500	**1700**	**150**	**20**	**50**	**20**	**30**	**20**

The proposal for software will be added to the next version of document.

6 Conclusion and Milestones

The general description of Slow Control for SemiConductor Tracker is presented in this document. Based on it the detailed proposals for the each subsubsystem (D-modules, Power, Cooling, etc.) should be done. After it the numerical values may be defined more precisely.

The milestones will be added to the next version of the document (after it discussion in SCT-community).

7 Supplement A. The monitoring features of DCS

Each DCS user wants to be sure that in every (!) act of physics data getting (in the every event) all the experiment status parameters (P) are in the certain working limits (Pw), see Fig.8,b.

In the large collider experiments the total amount of status parameters may reach a number of

$$\mathrm{Mp} \simeq 10^5, \tag{1,a}$$

the average intensity of primary physics events is approximately equal to

$$\mathrm{Np} \simeq 10^7 \ 1/\mathrm{s} \tag{1,b}$$

and maximum of P/dP ratio (the number of S gradations, see Fig.8,a) for the analogue parameters may be estimated as

$$\mathrm{P/dP} = 10^2 \text{ - } 10^3 \ . \tag{1,c}$$

It means that "user desirable" status data flow intensity

$$\mathrm{Ns} = \mathrm{Mp}{*}\mathrm{Np}{*}\log_2(\mathrm{P/dP}) \simeq 10^{12} \ \mathrm{Byte/s} \tag{2}$$

is too large.

As can be seen from (2) there are 3 possibilities for the essential reducing of Np in a real monitoring system:

- considerable decreasing of monitoring frequency (below Np value);
- the decreasing of Mp by means of transition a number of "natural" parameters for the certain part of an experiment apparatus (see Fig.8,a) to one general logical parameter, it needs an apparatus representation as a (logical) structure;
- a large number of natural states (S) of every parameter may be replaced by only the several logical states (see Fig.8,b) it may be done also for every Part and for the group(s) of parts (in a hierarchical structure) as well.

At last, aside (2) there is one additional possibility for the status data reduction. As any equipment must be the most of time under working conditions, it means that the most of its status data will contain a negligible amount of information (repeating states).

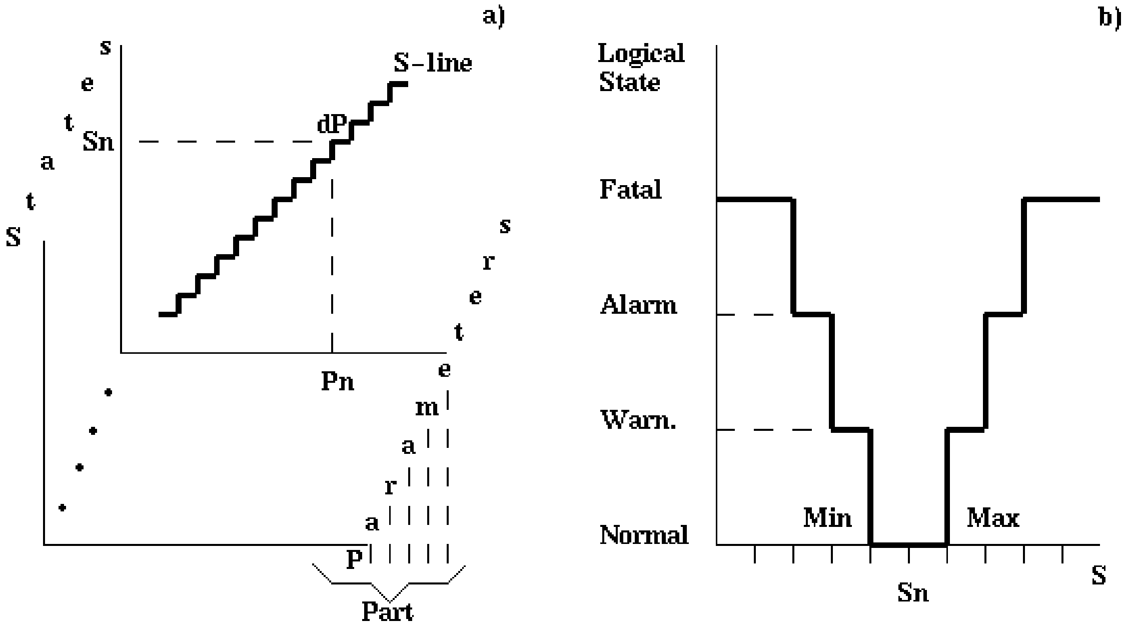

Figure 8: The states and logical states of the monitoring parameters

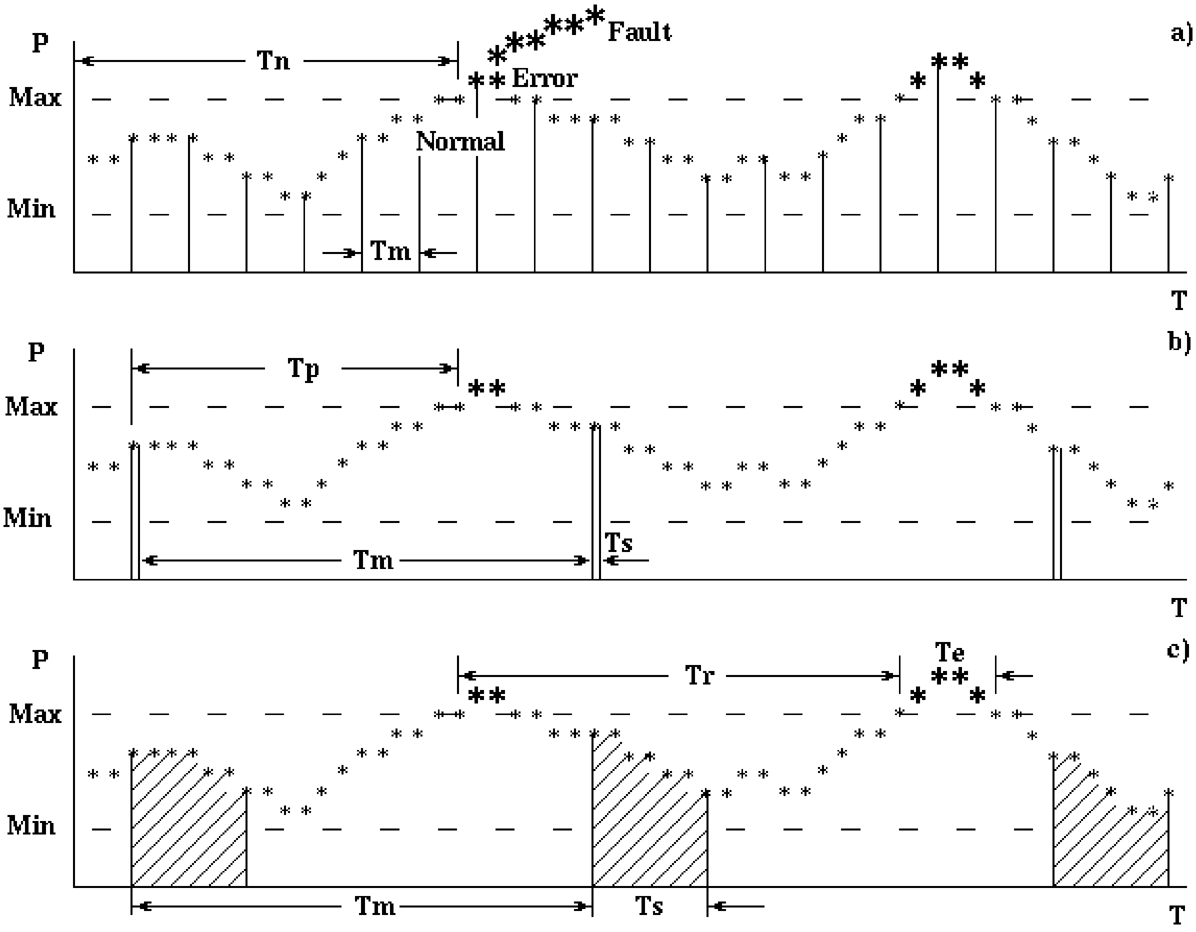

Figure 9: The kinds of the anomalies and their monitoring

7.1 Real (slow) monitoring

If monitoring period (Tm) will be increased over 1/Np value (1,b) it means, unfortunately, that a number of physics events may have (see Fig.9) some nondetected distortions in their data. Therefore, the aim of real monitoring of the status parameters is to have a time of any anomaly detection (Td) small enough in comparison with the average time interval of normal apparatus operation (Tn). The carrying out of the condition: $Td<<Tn$ is necessary, because in the case of some anomaly appearance the detection time must be excluded from the current Tn interval.

The real (slow) monitoring should take into account the time properties of possible sources of the anomalies. The 5 types of anomalies may be defined, as minimum, based on their nature and time spectrum (see Tabl.1). Ultra-slow variations of status parameters usual lead to the faults. Climatic variations may cause the faults and the errors as well. Electrical pulsations in the power supplies are the sources of errors.

The Fig.10 shows the time range of enumerated anomalies: the right edge corresponds to the maximum value of Tr or Tn (for all the possible types of anomalies of this kind), the left edge corresponds to the minimum value of Te for the errors or to the minimum value of Tn for the faults. As can be seen the possible sources of anomalies cover the extremely wide time range: from $3*10^{8}$ s (life time of the experiment) up to $3*10^{-7}$ s (a region of physics data signals) that is 15 decimal orders.

7.2 The kinds of monitoring

The possible kinds of monitoring depend on the correlations of Tp, Tm and Ts values:

- direct monitoring - when $Tm<<Tp$, see Fig.9,a;
- "sampling" monitoring- when $Tm>$ Tp, but $Ts<<Tp$, see Fig.9,b;
- "integral" monitoring - when $Ts >$ Tp (one count is an average meaning of parameter during the strobe interval, see Fig.9,c).

The advantageouses of direct monitoring are:

a) a relatively small detecting time - $Td<=Tm$;
b) the every error is detected, i.e. the detecting EFFIciency=1, see Fig.10,b (but not the every event with an error, see Fig.9,a).

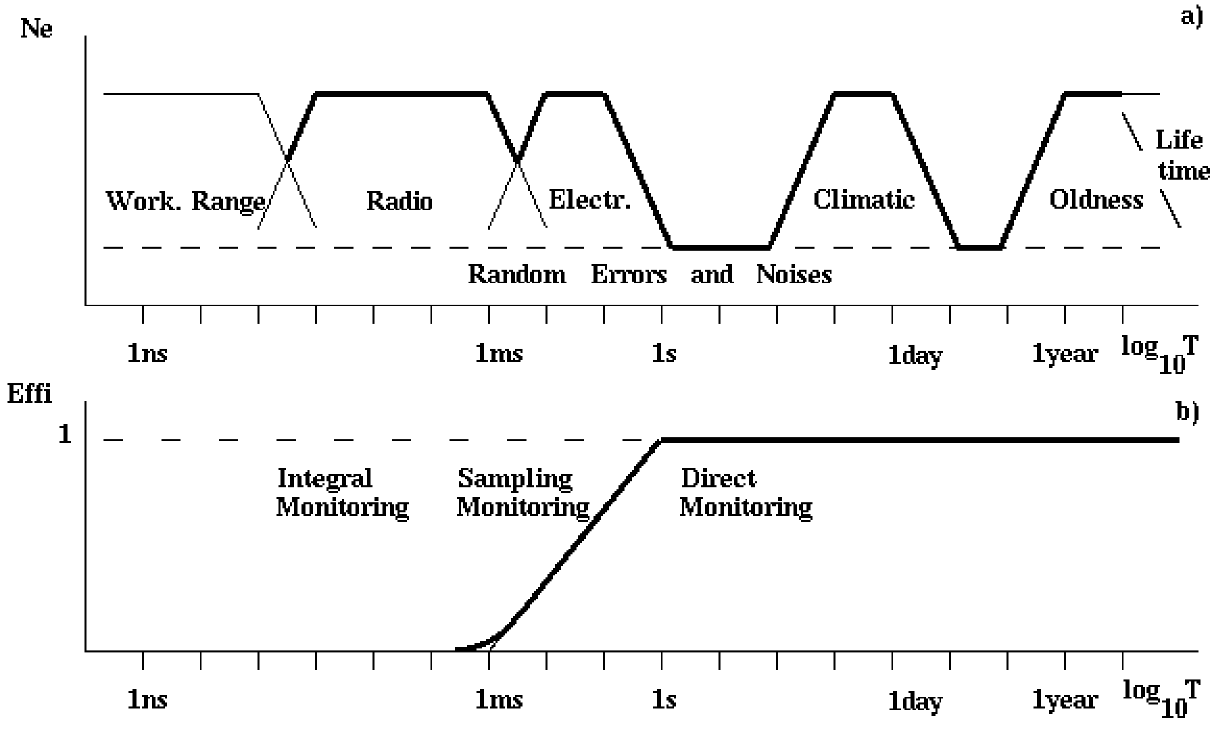

Figure 10: Time spectrum of the anomalies and the kinds of monitoring; sampling monitoring range is shown for Tm=1 s and Ts=1 ms

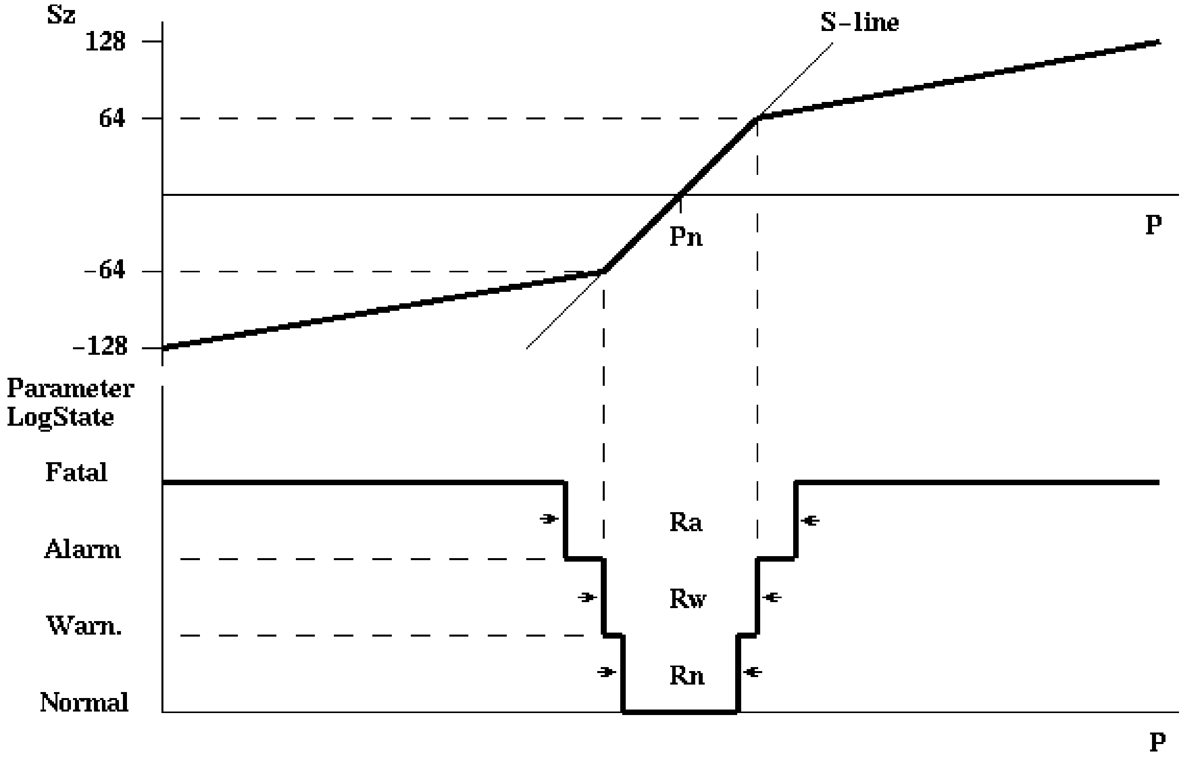

Figure 11: The graph of P ->S ->Sz conversion

In Sampling monitoring the error(s) is discovered due to random coincidence of the time intervals Te and Ts (Effi<1). According to the laws of statistics the intensity of random coincidences in the time interval Tc=Ts=Te of 2 processes with the intensities Nr=1/Tr (occasional errors) and Fm=1/Tm (regular strobes) is equal:

$$\mathrm{Nd} = 2\mathrm{Nr}*\mathrm{Fm}*\mathrm{Tc}. \qquad (3)$$

Then Td interval may be estimated (with a probability close to 1) from (3) as:

$$\mathrm{Td} = 3/\mathrm{Nd} = 6/\mathrm{Nr}*\mathrm{Fm}*\mathrm{Ts}, \qquad (4,a)$$

or

$$\mathrm{Td} = 6/\mathrm{Fm}*\mathrm{Nr}*\mathrm{Te}. \qquad (4,b)$$

It means that in sampling monitoring if Ts=Te the error(s) may be detected during the time interval that is higher in 6/Fm*Ts times than the average period between errors - Tr; or during the time interval that higher is in 6/Nr*Te times than the period of monitoring - Tm.

For instance, if Ts=2 ms and Tm=1 s the monitoring system will detect the electrical pulsations within a time (4,a):

$$\mathrm{Td} = 6/50*1*2*10^{-3} = 60\ \mathrm{s}. \qquad (5)$$

8 Supplement B. The LogStates and Transitions

The full logical structures of ATLAS detector and DCS are shown in Fig.12. The ATLAS logical state is a composition of the logical states of its parts.

8.1 The states and up/down transitions of a Part

Every part of each layer should have 4 logical "states":

Off - the part is absent or power off;
Unable - power-on functional inability state;
Stand-by - functional ability nonoperation (idle) state;
Run - working state.

These states are illustrated in Fig.13.

In the simple functional parts (for instance, power supply) the unable state may be absent and in the very simple ones (gas) the stand-by state may be absent also.

The possible "transitions" between the log-states form 2 kinds of loops: the "working" (left loops in Fig.13) and "error" (right loops) Transitions.

The Working transitions are:

Init - up-transition from Unable to Stand-by state;
Startup - up-transition from Stand-by to Run state;
Reset - down-transition from Run to Stand-by state;
Escape - down-transition from Run to Unable state.

The Error transitions are:

Error - down-transition from Run to Stand-by state;
Fault - down-transition from Run to Unable state;
Upset - down-transition from Standby to Unable state.

A common down-transition is "shutdown".

The requirements shall be imposed on Init/Startup/Reset/Escape transition times and some suggestions should be done concerning Error/Fault/ /Upset permissible rates for the every layer.

Every log-state of the part may consist of several "substates": For Run state the Substates are:

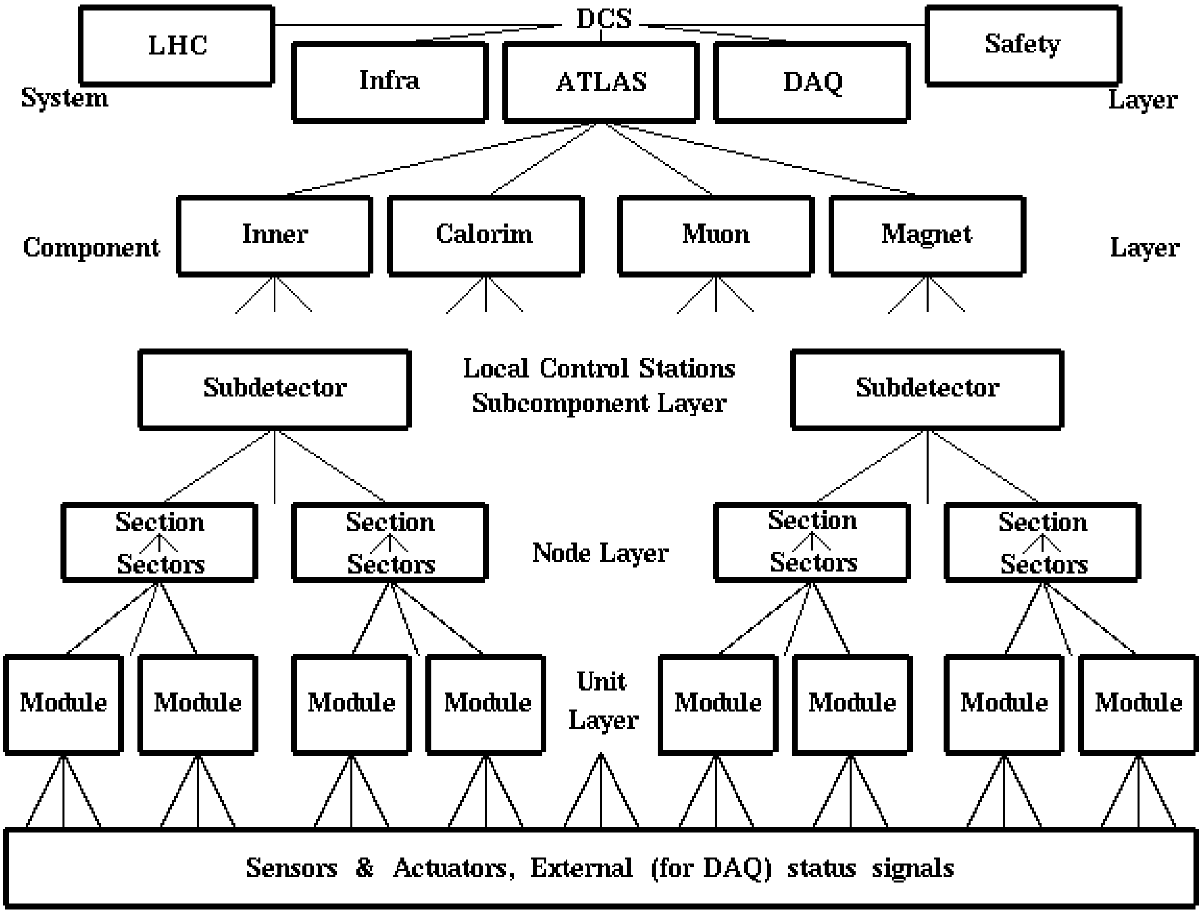

Figure 12: The ATALS/DCS logical structure

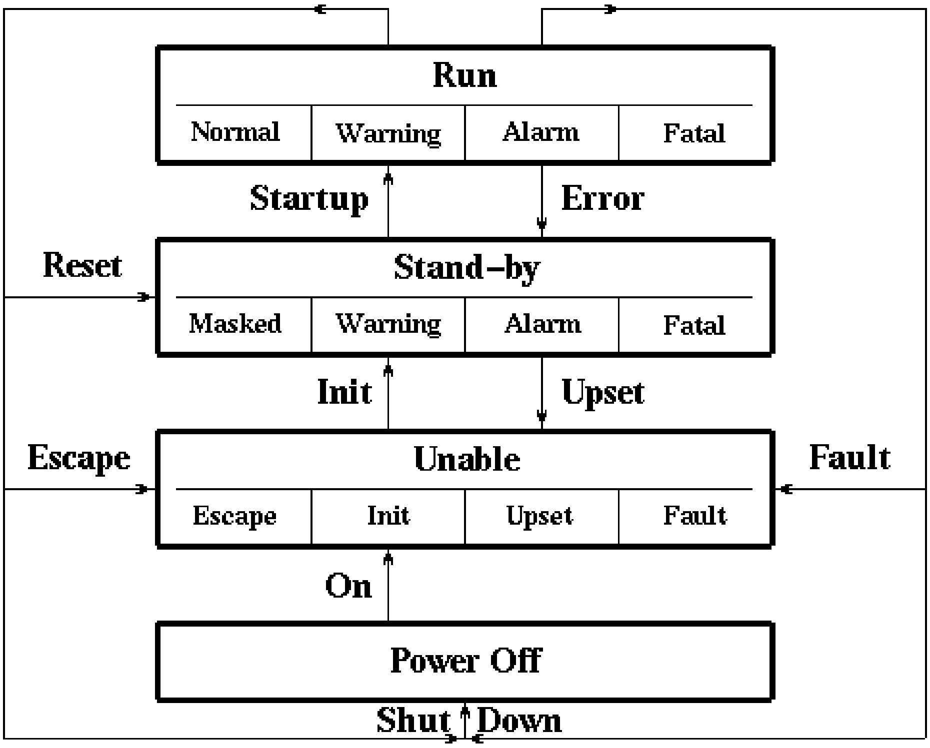

Figure 13: The state diagram of the every ATLAS part

Normal - operation without errors;
Warning - operation in spite of errors;
Alarm - operation is blocked due to errors;
Fatal - functional ability is lost.

For Stand-by state the logical substates are:

Masked (”reset mask” is startup command),
Warning,
Alarm,
Fatal.

For Unable state the substates are: ”escape”, ”init”, ”upset”, ”fault”, i.e. correspond to transitions of the part to Unable state.

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