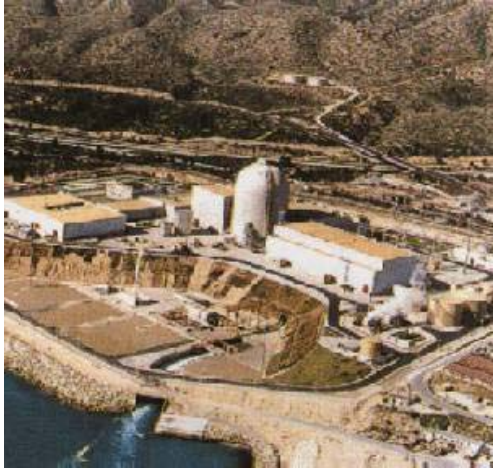
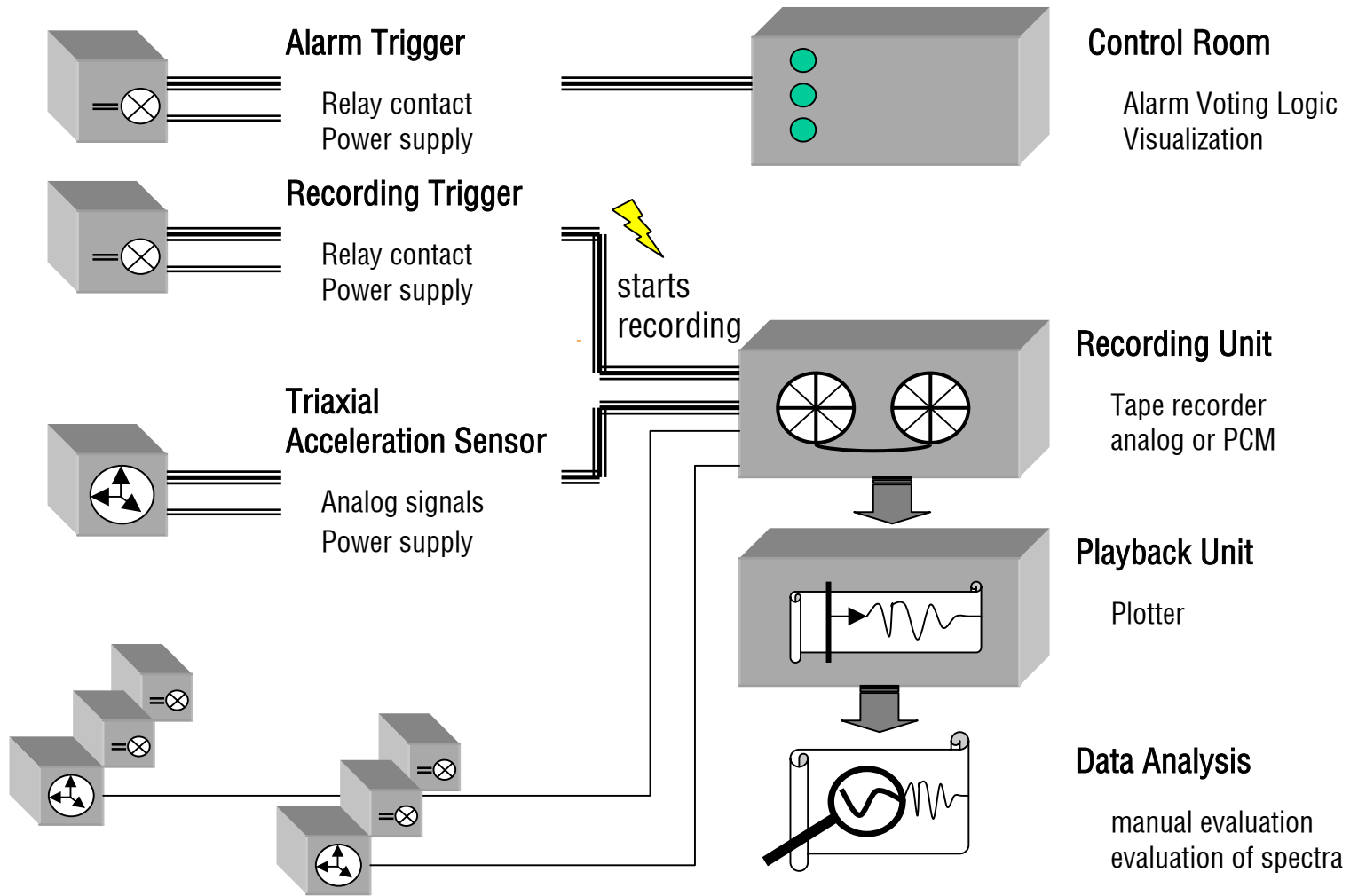


Seismic Monitoring Systems SMS for NPP

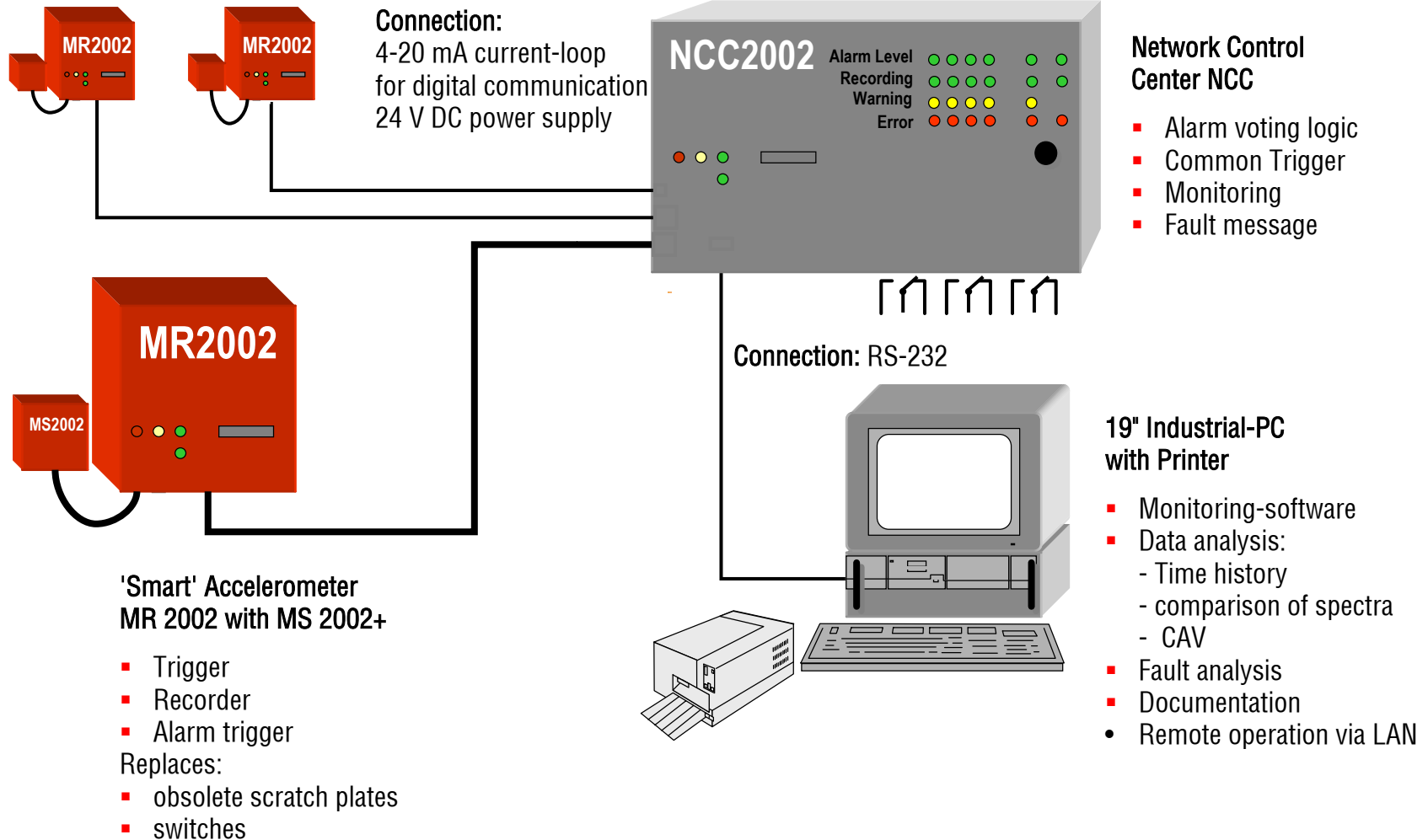
Seismic Instrumentation SI for NPP



Obsolete Seismic Instrumentation



'State-of-the-art' Seismic Instrumentation



Measuring Point Inside Containment



Junction Box

- Termination of (existing) field cables and system pig tails

MR 2002 'Smart' Accelerometer

- Digitizing and recording (built-in trigger)
- Alarm trigger

MS 2002+

- MEMS technology
- triaxial acceleration sensor with protective cover

Measuring Point Free Field at Neckarwestheim NPP Germany



Separate MR 2002 for each unit

Different trigger and alarm levels

Data transmission via fiber-optic cable

Central Cabinet (Standard Design)



NCC Network Control Center

- Up to 32 Recording Stations
- Common Trigger / Common Timing
- Voting Logic
- Indicator Panel (Recorder and Network Status)
- Alarm Output (3 Relays)

Laptop PC (Windows)

- Near Real Time Analysis
- Automatic Alerting
- Peak Acceleration Display

Printer

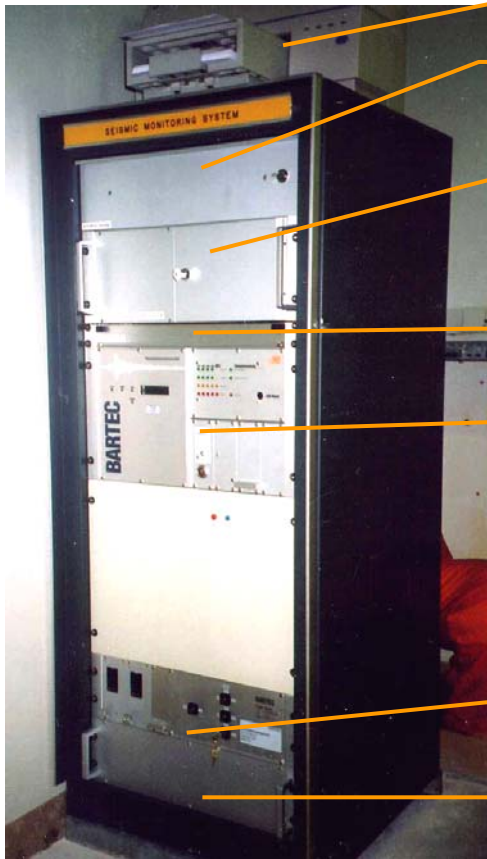
Power Supply Unit

- Industrial AC/DC Converter

Battery Back Up

- Autonomy approx. 36 hours

Central Cabinet (re-use of existing cabinet)



Printer

LC-Display (in drawer)

Analysis PC (Windows)

- Near Real Time Analysis
- Automatic Alerting
- Peak Acceleration Display

Keyboard

NCC Network Control Center

- Up to 32 Recording Stations
- Common Trigger / Common Timing
- Voting Logic
- Indicator Panel (Recorder and Network Status)
- Alarm Output (3 Relays)

Power Supply Unit

- Industrial AC/DC Converters

Battery back up

- Autonomy approx. 36 hours

RED BOX



MR 2002-16 Strong Motion Recorder

MR 2002-24 Seismic Recorder

- High performance digitizer/recorder/seismic switch
- Rugged and modular design
- Excellent reliability
- Designed for use in networks
- Economical memory handling
- Superior quality
- Low maintenance

RED BOX MR 2002 Permanent Self-Test

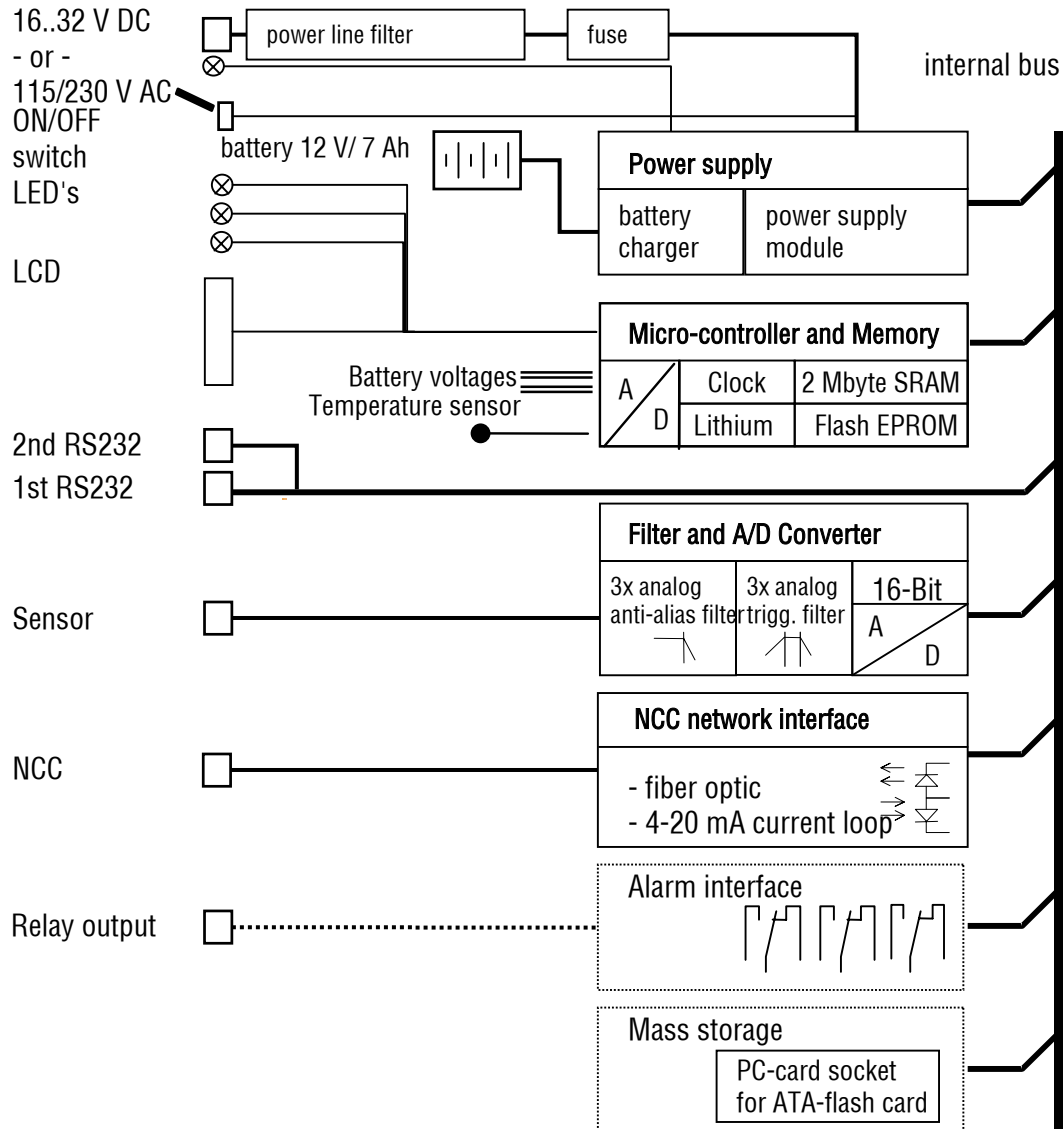
- Power interruption:
the MR2002 works with the internal battery for at least another 2 days, time and date of the power interruption is registered
 - Primary battery low
 - No sensor detected or sensor cable broken
 - No memory detected (memory card is missing)
 - Memory full
 - Processor (different tests)
- ➔ The permanent self test immediately creates a warning or an error message after identifying the irregularity

RED BOX MR 2002 Periodic Self-Test

- Noise test on each channel
 - Zero level test on each channel (offset)
 - Filter response test on each channel
 - Trigger test on each channel
 - AD converter value resolution
 - AD conversion time test
 - EPROM and EEPROM checksum test
 - Memory test (read/write, format)
 - Data checksum and consistency test
 - Battery test for each battery
 - Real-time clock test
 - Sensor link test on each channel (test-pulse generated in the sensor)
- ➔ The periodic self test immediately creates a warning or an error message after identifying the irregularity

MR 2002

**Block-
diagram**



RED BOX MR 2002 Maintenance

- Every month
 - Periodic self-test is carried out automatically (including sensor-test pulse) and derivations get messaged
- Every 6 months
 - Erase local trigger files
 - Check and clear system flags (and reset counters)
- Every year:
 - Inspection with maintenance manual (visual, function and fault conditions)
 - Battery capacity test
- Every 3-5 years
 - Prophylactic replacement of batteries

MS 2002+



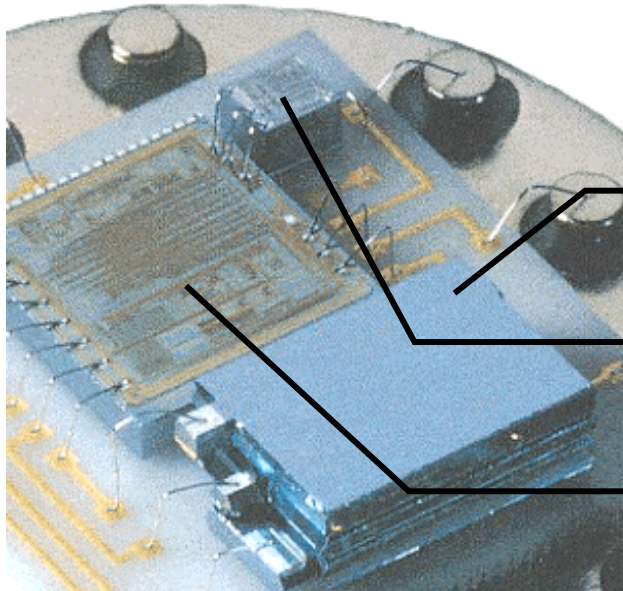
Triaxial Acceleration Sensor

- Small high precision accelerometer
- MEMS technology
- Environmental and reliability performance similar to integrated circuits
- Very low short- and long-term drift
- Data requires no post-processing
- Factory calibrated, no re-calibration required
- Fully comprehensive self-test function
- Linear phase and frequency response
- No hysteresis

The superior alternative against traditionally used FBA's

Sensor MS 2002+

Overview

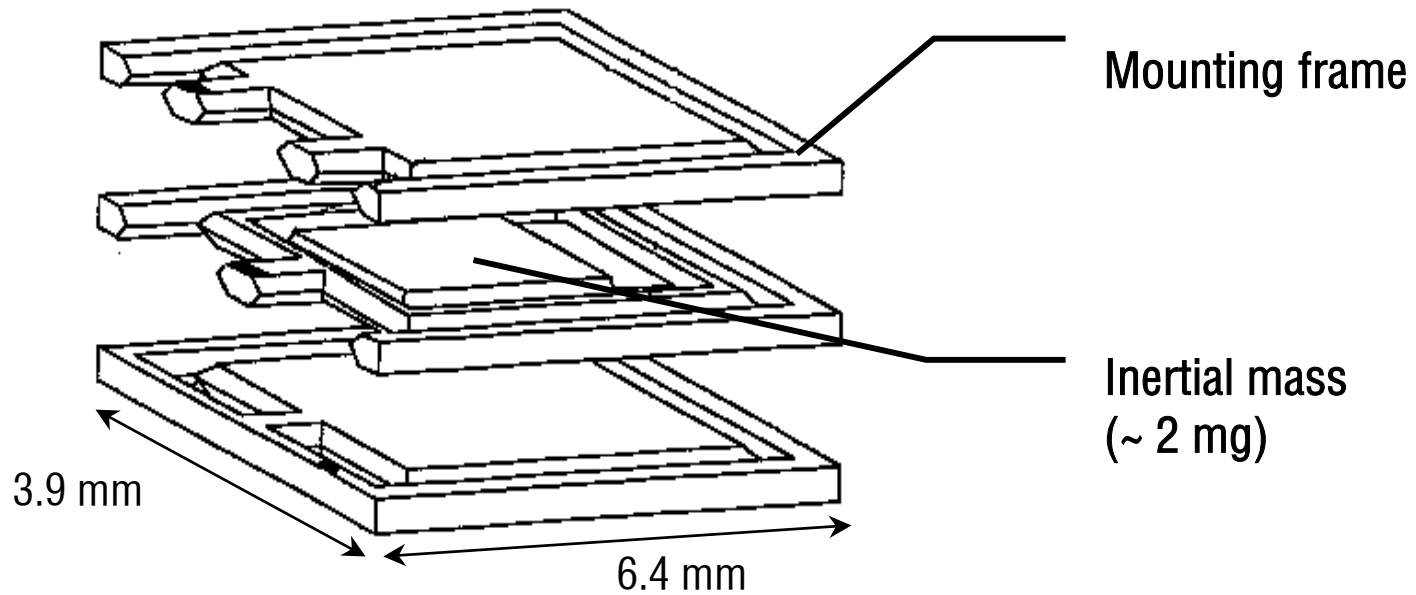


Micromachined Sensor

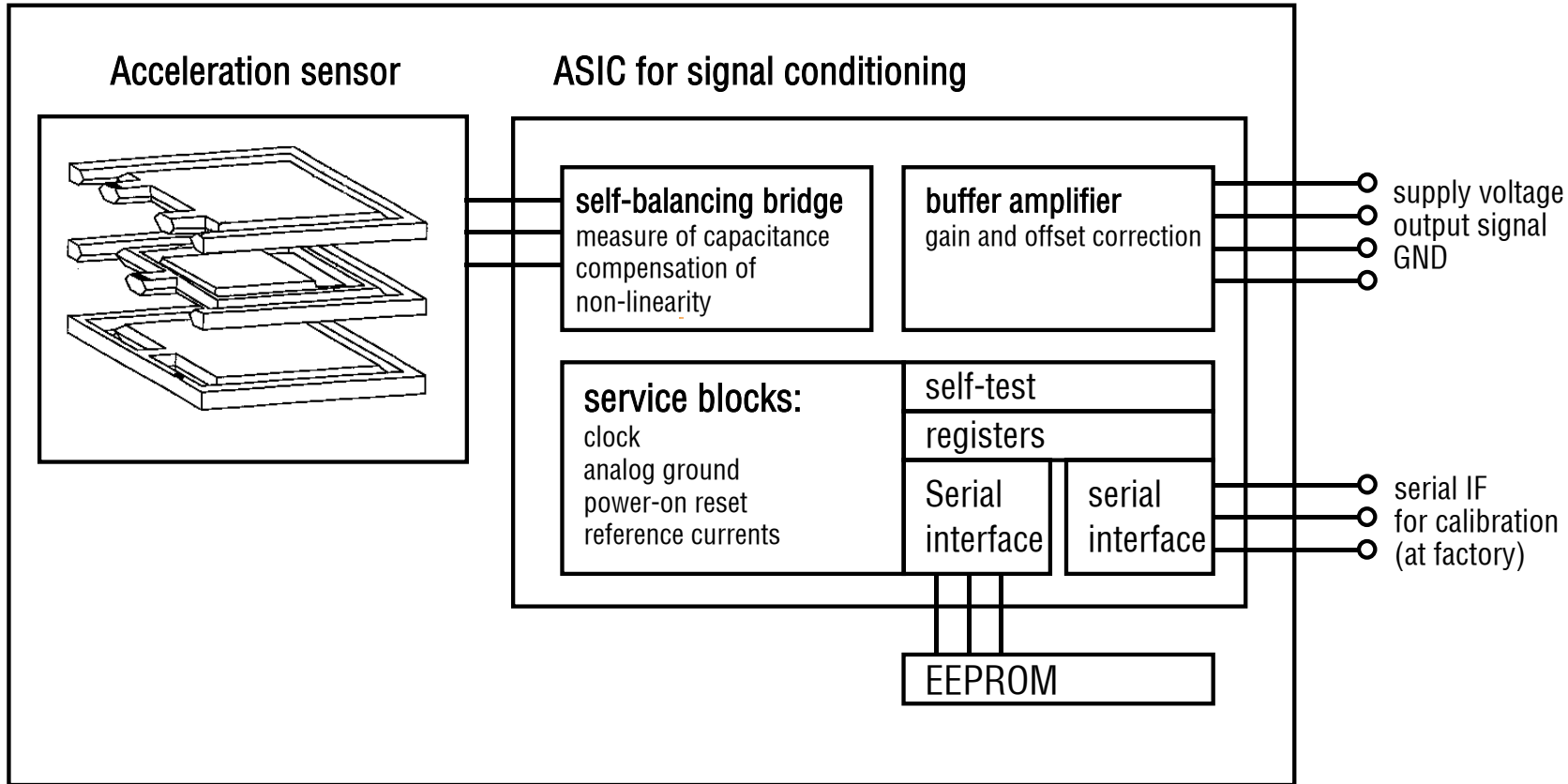
EEPROM
storage of calibration data

ASIC
contains driving electronics

Sensor MS 2002+ Mechanical Part



Sensor MS 2002+ Block-diagram



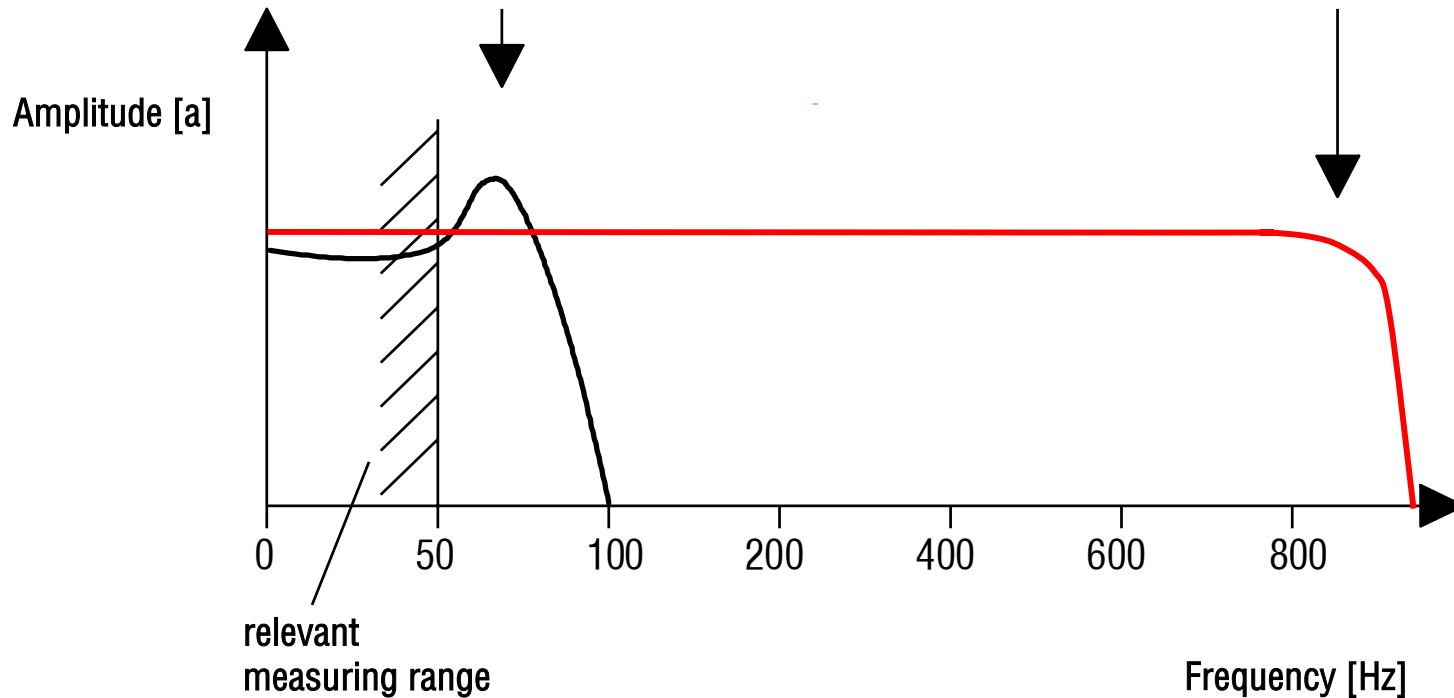
Sensor MS 2002+ Resonant Frequency

FBA

Frequency range: 0-50 Hz
Resonant frequency: ~55 Hz

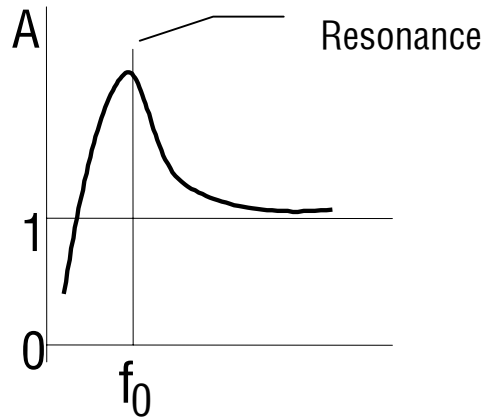
MS 2002+

Frequency range: 0-150 Hz
Resonant frequency: >800 Hz

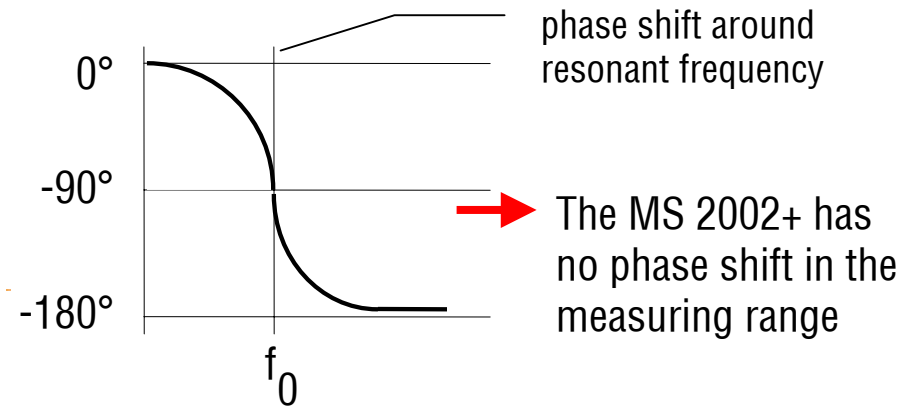


Sensor MS 2002+ Resonance - theoretical background

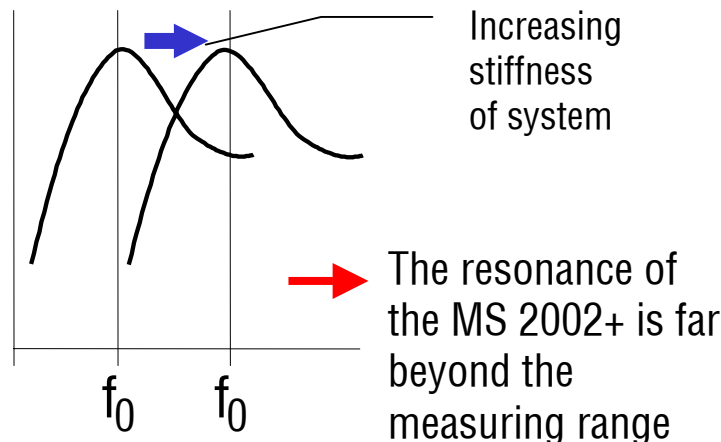
Undamped system



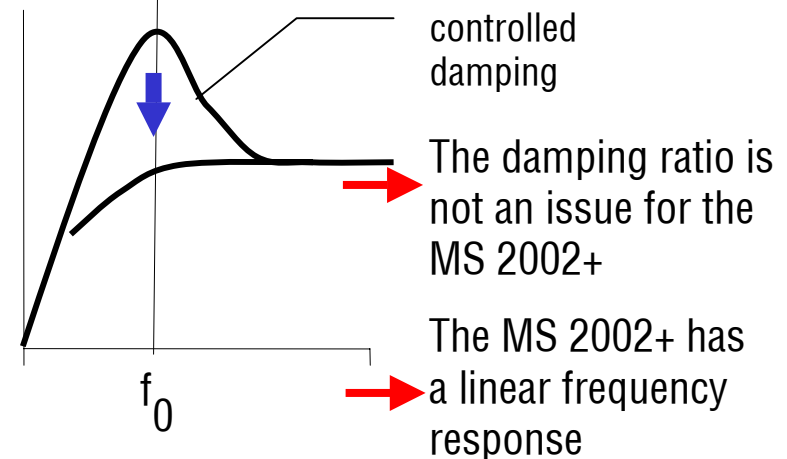
Problem: Phase Shift



Problem: Resonance in measuring range



Problem: Damping / Non-Linearity



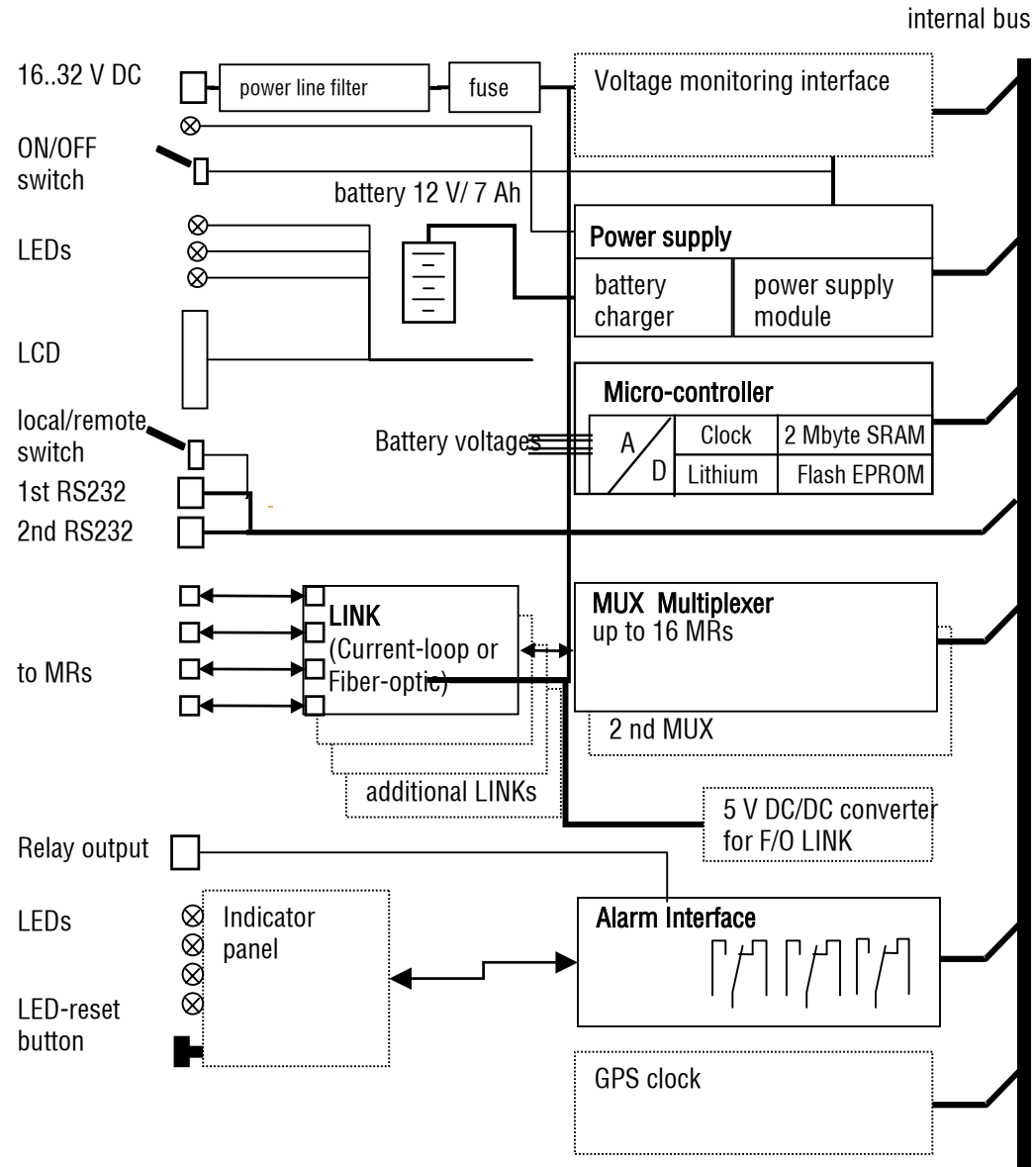
NCC Network Control Center



- Interconnection and coordination of up to 32 distributed MR2002s in a star topology network
- On-line monitoring of each MR operation status
- Automatic download of the recordings
- Individually programmable common trigger, time synchronization, high- and low level alarm activation
- Data retrieval and parameter setting in all connected MR 2002
- Direct link to optional central analysis computer
- Optional timing from master clock or GPS
- Shake-table tested up to 5 g

NCC

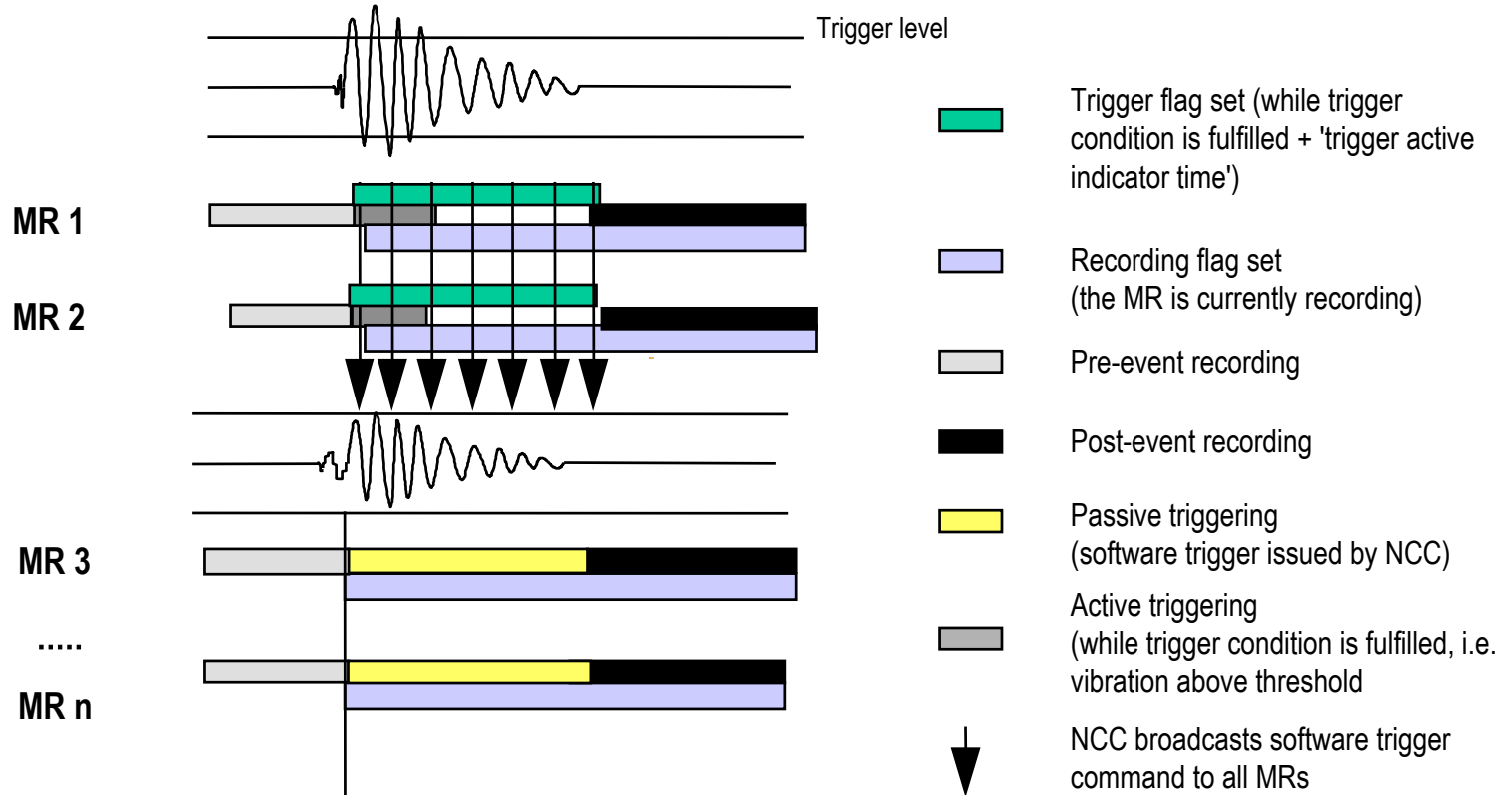
**Block-
diagram**



NCC Maintenance

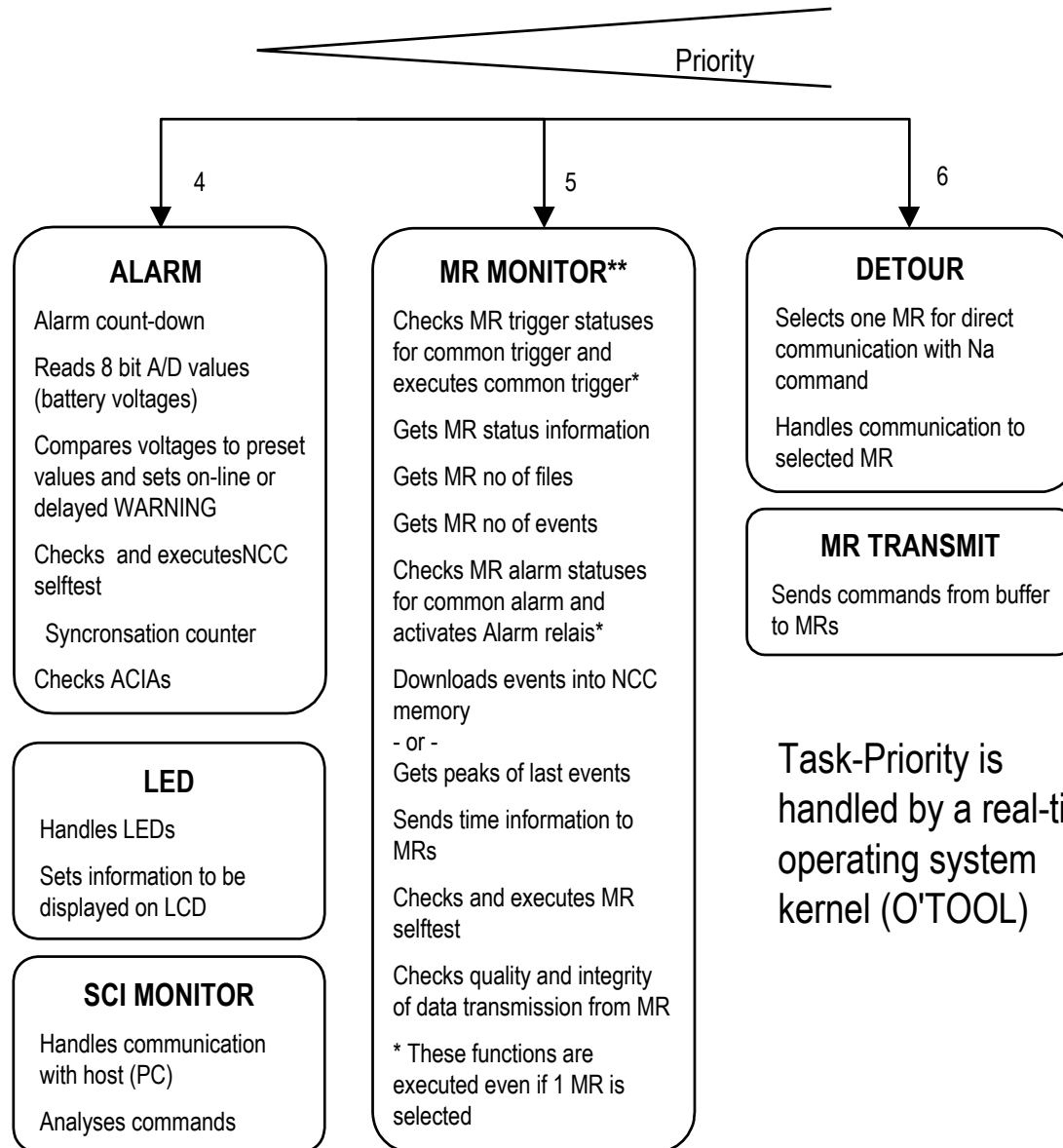
- In case of a message
 - Check / reset LEDs (to be prepared for next event)
 - In case a WARNING-flag is set - reset it manually
- Every month
 - Periodic self-test is carried out
- Every 6 months
 - Check and reset communication-error counters
- Every year:
 - Inspection based on maintenance manual (visual, function and fault conditions)
 - Battery capacity test
- Every 3-5 years
 - Prophylactic replacement of batteries

NCC Common Trigger



NCC

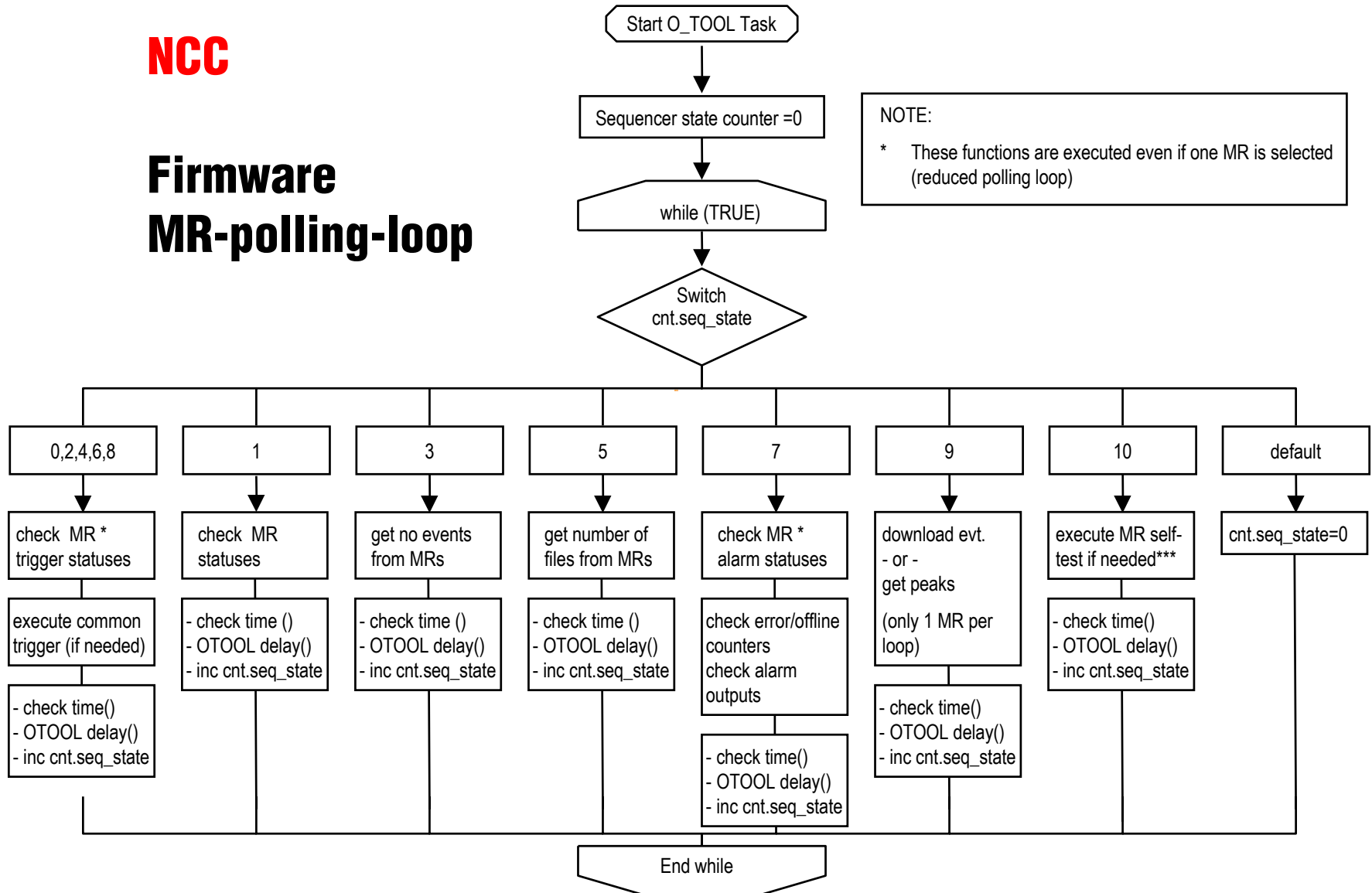
Firmware Overview



Task-Priority is handled by a real-time operating system kernel (O'TOOL)

NCC

Firmware MR-polling-loop

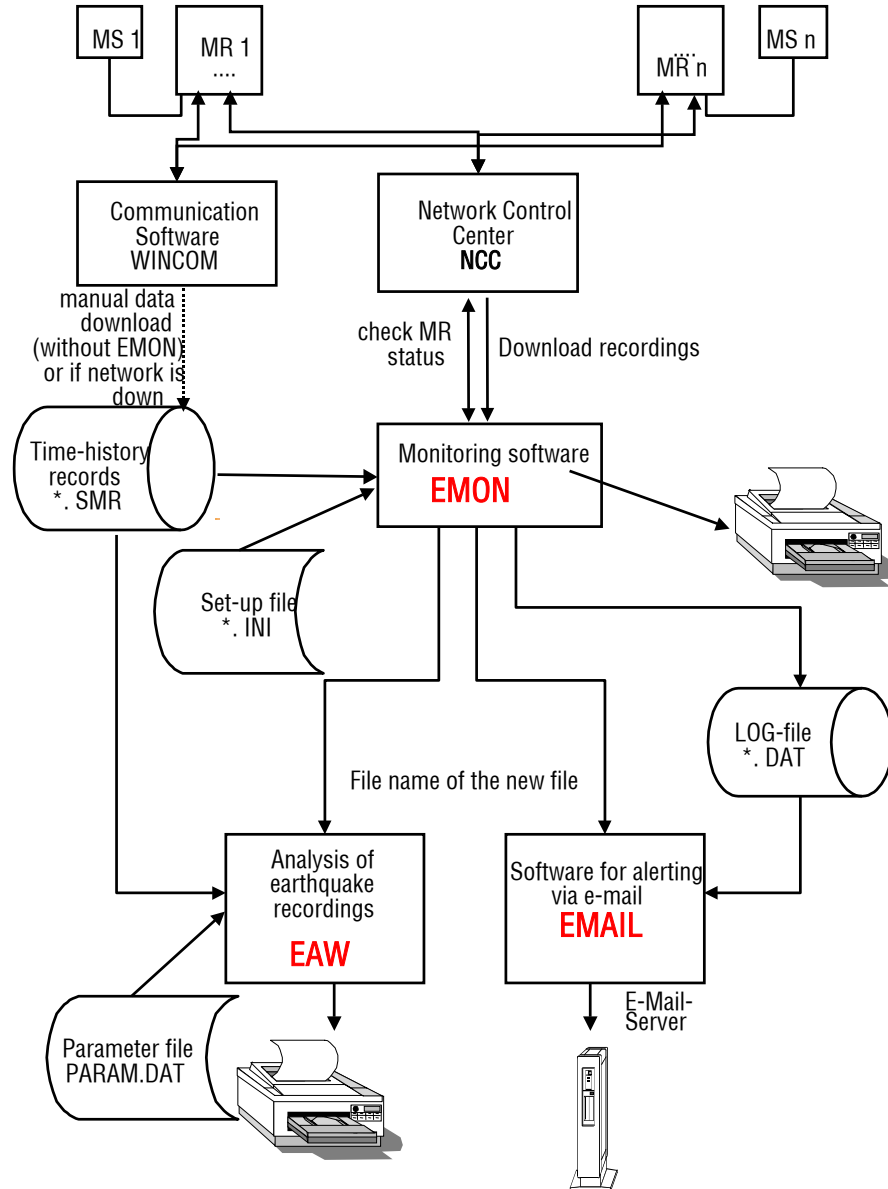


**NPP
Software
Package**

**EMON
EAW
EMAIL**

Overview

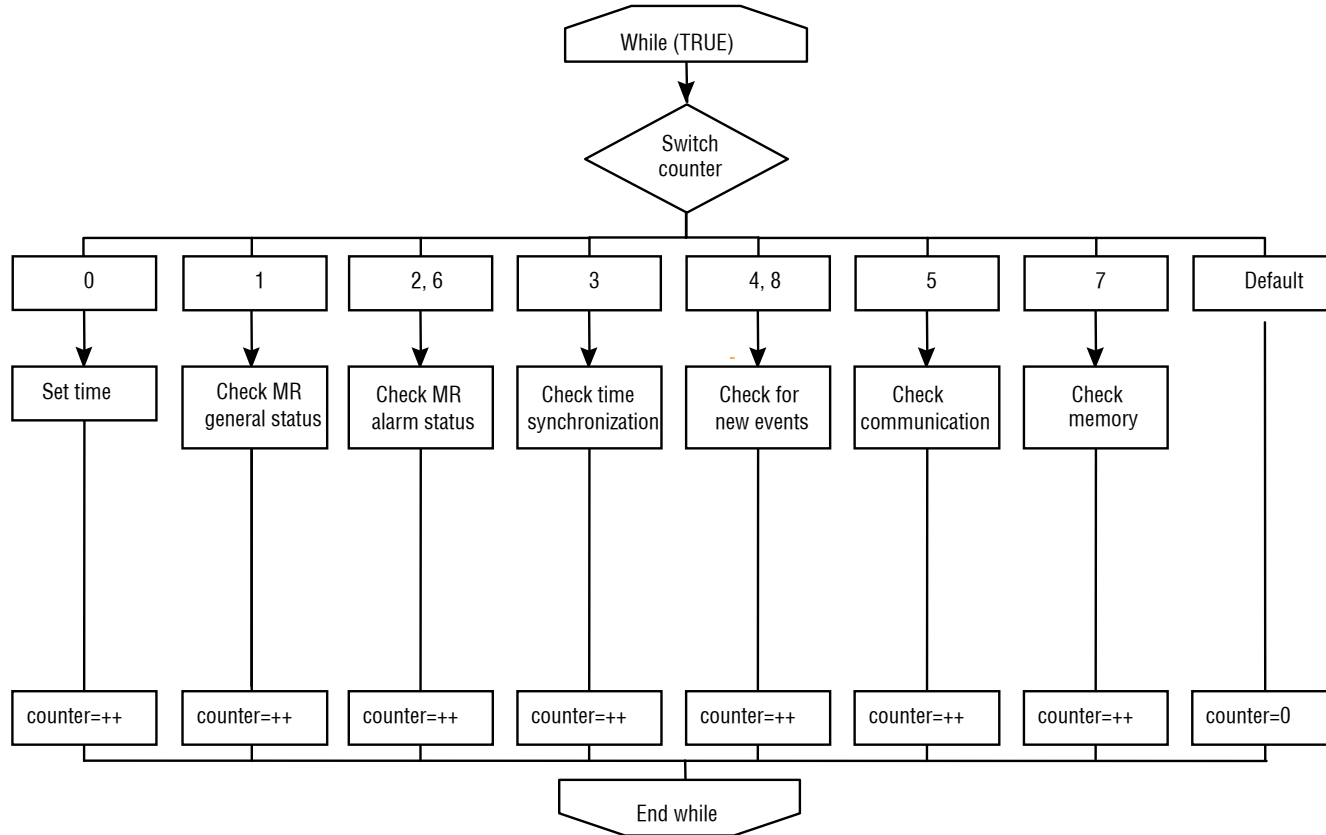
- **Type tested algorithms**
- **Near real-time analysis**
- **Automatic alerting**
- **Source code available**



NPP Software Package EMON

- Automates data retrieval and analysis
- Full system state-of-health history with
 - LOG- files (messages)
 - TRACE-files (communication)
- Helps trouble shooting
- Prepared for remote operation
- Data-mirroring on file-server
- Archiving function for files
- Email messaging (requires **EMAIL**)
- Prevents tampering with system

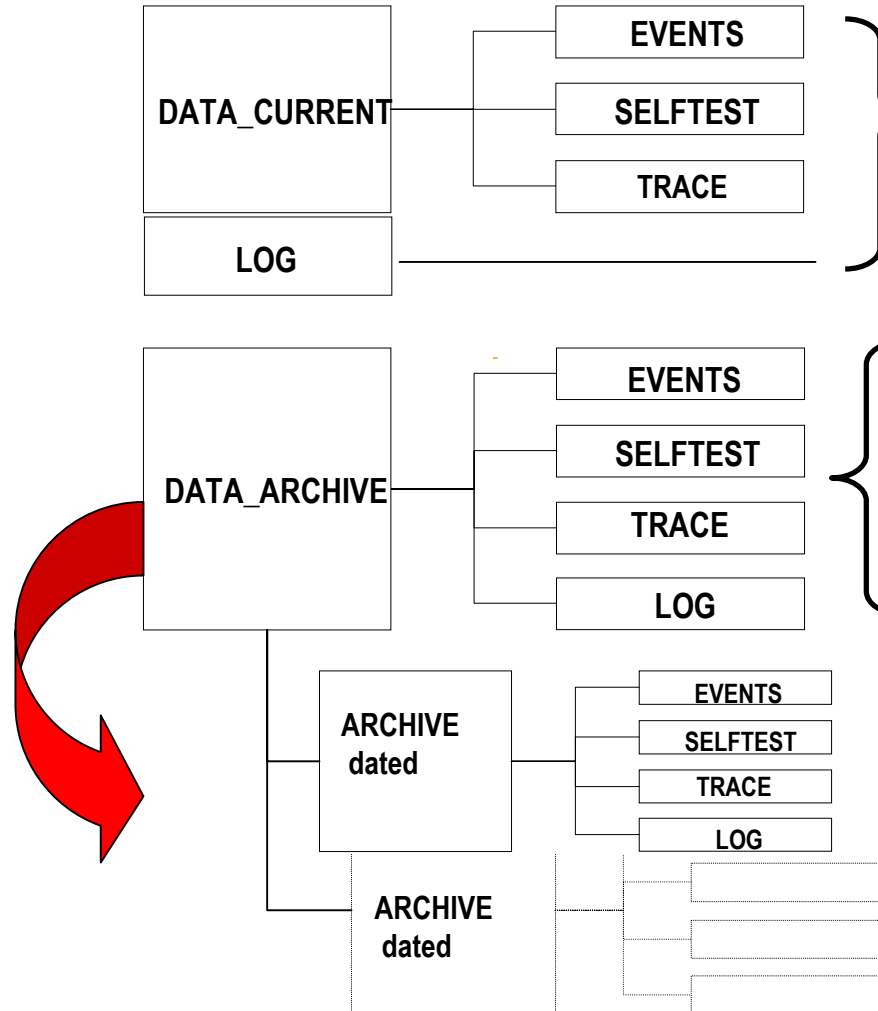
EMON Polling-Loop



EMON Archiving

1.

contents
of current
archive
is moved
to a dated
archive



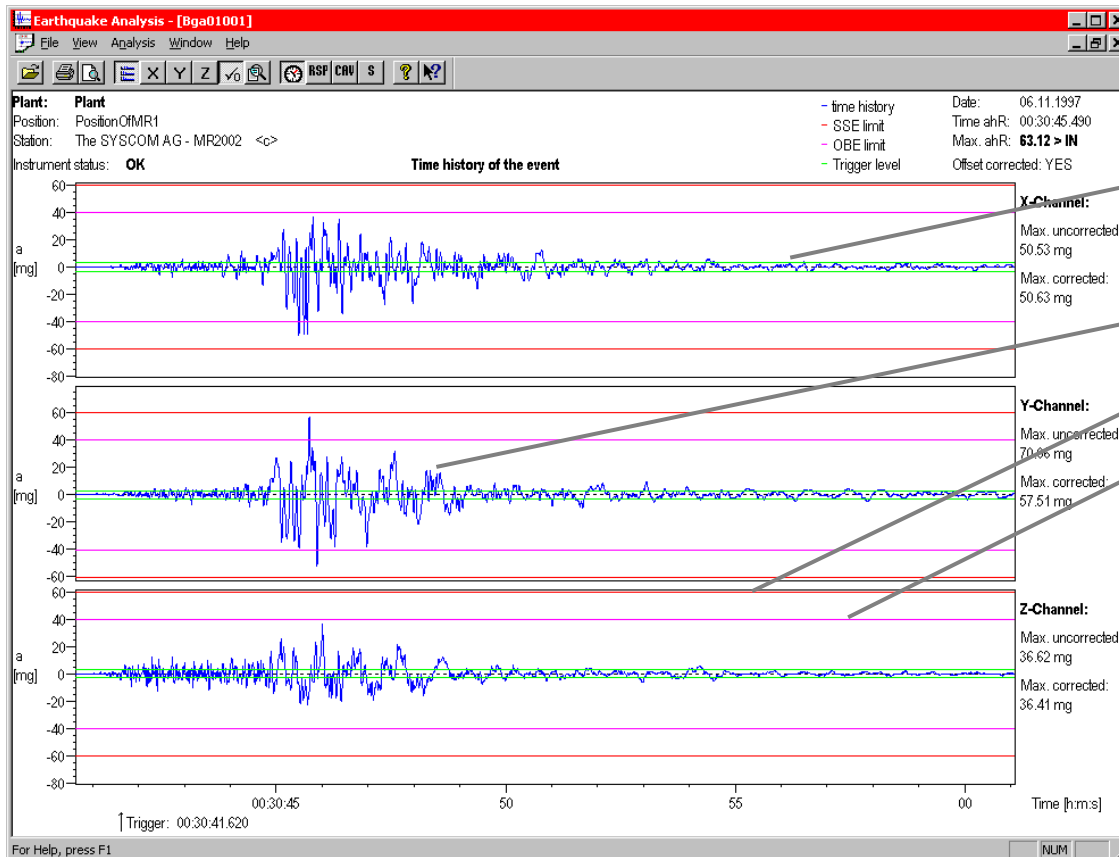
2.

contents
of current
directory
is moved
to archive

NPP Software Package EAW

- In accordance with the requirements of the U.S. Reg. guide 1.12 and German KTA 2201.6
- Algorithms are approved by TÜV Germany
- Interactive and batch-mode (analyze recording and print report)
- Features:
 - Display of the time-history $a(t)$ for each location, for each axis together with the trigger- and OBE/SSE alarm levels
 - Computation and display of peak value of the resultant horizontal acceleration in for each location with time mark.
 - Computation and display of the response spectra for each location, for each axis with a given damping value and graphical comparison with the user specified reference spectra for OBE and SSE
 - Computation and display of the time-history of the CAV-value (Cumulative Absolute Velocity) for each location, for each axis and graphical comparison with the user specified limit values.

EAW Time History



Trigger Level

Time History

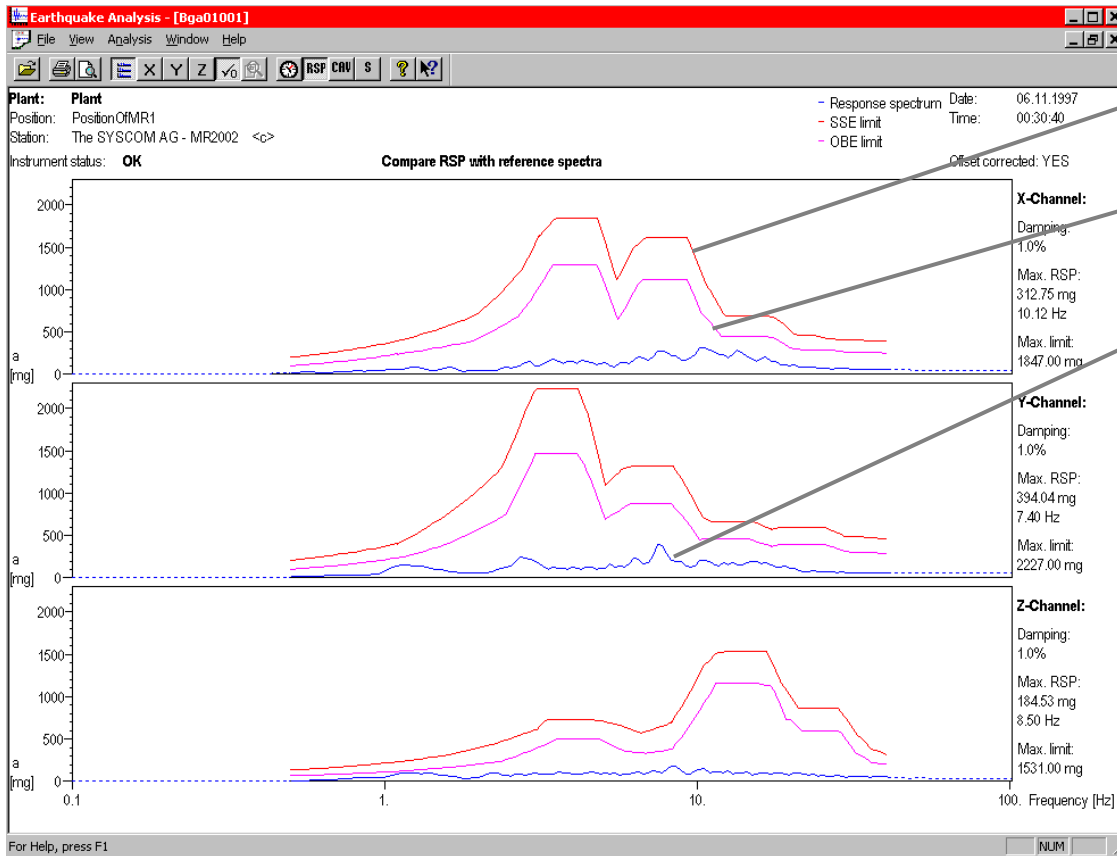
High Alarm

Low Alarm

Additional Features:

- Zoom
- Single channel display
- Instrument status

EAW Comparison of Response Spectrum with Reference Spectrum



SSE Reference-Spectrum

OBE Reference-Spectrum

Response-Spectrum

Analysis and printout for each location and axis available within minutes after event trigger

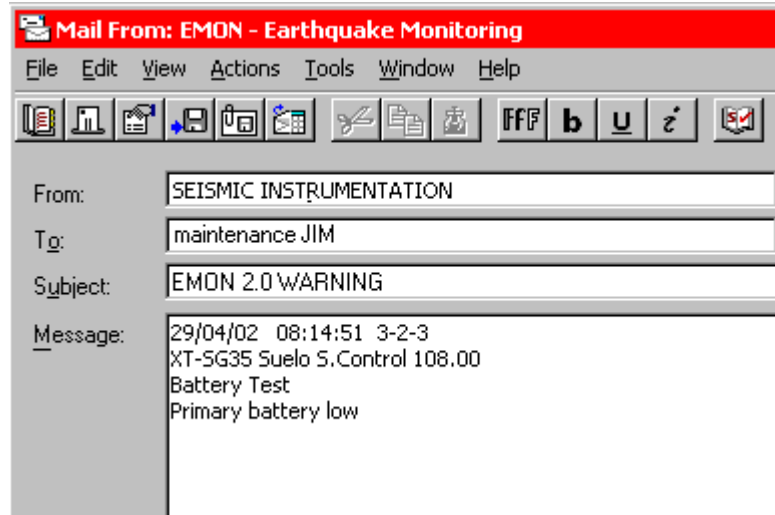
NPP Software Package **EMAIL**

- Reads the Log-File of EMON..

```

29/04/02 08:09:41 3-6-2 Message XT-SG33 Contencion 114.00
           Data Retrieval          CNV03001.SMR - Test-file transferred
29/04/02 08:13:07 3-6-2 Message XT-SG34 Base Ed. Control 91.00
           Data Retrieval          CNV04001.SMR - Test-file transferred
29/04/02 08:14:20 1-6-6 ** WARNING ** XT-SG35 Suelo S.Control 108.00
           General System Condition Supply power loss
29/04/02 08:14:51 3-2-3 ** WARNING ** XT-SG35 Suelo S.Control 108.00
           Battery Test           Primary battery low
30/04/02 08:30:11 3-2-1 Message A47 Sala Control Vandellos II
           General System Condition System works fine
    
```

-and sends e-mail messages to designated persons



Main advantages

- Distributed recording > data backup
- Digital data transmission > no loss of raw signal information
- MEMS accelerometers > linear phase / frequency behaviour
- Reusing existing cables for substitution > project cost reduction
- System integrated voting logic > safe autonomous ESD function
- Near real-time analysis > immediate load evaluation
- Comprehensive software > log; remote; message and archive function
- Comprehensive system documentation
- Turn key project management
- No re-calibration of sensors > low maintenance costs
- Full compliance with U.S. Reg. Guide / German KTA

SYSCOM Instruments

A pleasure to measure

BARTEC protection of people and environment by safety of components, system and plants