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# A NEW UNIVERSAL DATA-ACQUISITION SYSTEM FOR AUTOMATION OF COMPLEX MEASURING AND CONTROL TASKS IN EXPERIMENTAL MECHANICS

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## Summary

Increasing demands for visualisation and control of large and/or complex mechanical structures, necessitate a new degree of performance for electronic data-acquisition equipment. A new data-acquisition system is discussed, which allows both conventional and advanced testprocedures within the same mainframe. Dynamic testing on the coupling-part of SPMT (Self Propelled Modular Transporter) modules is discussed in detail.

## General

The outcome of a marketsurvey, conducted some three years ago within the various fields of civil engineering, clearly indicated the immediate and future needs for sophisticated instrumentation to cope with the increasing demands for complex testing and control in experimental mechanics.

Conventional electronic equipment used in large scale testing facilities, is in many cases a compromise between "what is available" and "what is desirable". Although signal measurement methods and techniques may be adequate for the purpose, the analog signal interfaces lack the control possibilities to adapt to the more demanding needs.

Providing a better dynamic performance cannot be simply achieved by speeding up the measurement actions alone. It must be supported by improved methods of control to achieve enhanced, often real-time, properties s.a.: on-line monitoring, real-time load control, real-time analog/digital interaction (alarming) and on-line graphic presentation. A number of other desirable features may be added to satisfy the needs in complex testing.

During testing physical parameters have to remain within predetermined safety limits. Monitoring the relevant physical signals for safety limit checking may not be fast enough, when this is executed by a host-computer, interfaced to the measuring system (data-acquisition system). Valuable time is lost to transport the measured data to the host-computer, to let the running program decide and to return the limit control action back to the data-acquisition system.

Advanced control strategies must directly couple the physical quantities with the adjustable limits and the selectable control outputs, to function as a complete hardware/software operation in the data-acquisition system. The task of the host-computer is limited to defining the algorithm of the coupling and monitoring its operation, once it is up and running.
A further complication in large testing is, that quasi-static measurement procedures must function simultaneously with dynamic data-acquisition and/or load control actions. It is ofcourse possible to support each of these aspects by their own dedicated hardware and software, but synchronisation and interaction between static and dynamic events will be difficult to achieve and total equipment costs will be high.

Today's large scale testing require a universal, flexible and powerful data-acquisition system, that combines capabilities for a relatively large number of high precision measurements of lowlevel signals at low speeds with the means to measure an often smaller number of inputs at high dynamic speeds.

## A new data-acquisition system.

UNILOG 2500 is developed in response to the increasing demands for complex signal measurement and processing required in testing of mechanical structures. It allows universal static and high-dynamic measurements of a wide variety of analog signals, as well as multiple analog outputs for load- and deflection-control of testmachines and hydraulic cylinders.

To achieve these goals, it incorporates two powerful intelligent controllers, which are used to command and control the whole of the installed measuring hardware, supervise external load control and digital I/O-functioning.

The organisation of the various measurement facilities and I/O-control is shown in fig. 1.

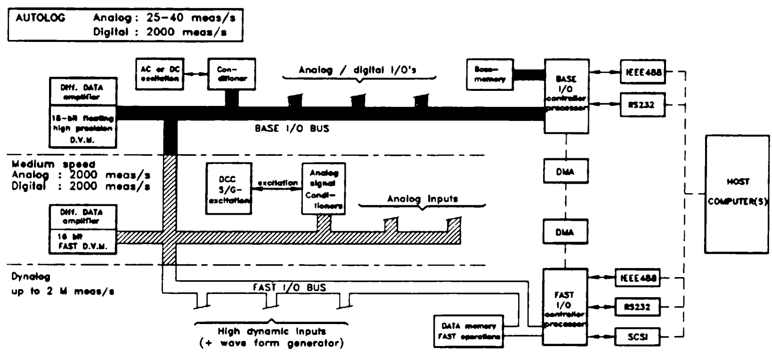


Fig.1 Organisation of UNILOG

The traditional signal scan-modules, the dual-slope integrating DVM, the signal conditioners and straingauge excitation modules are controlled from the BASE I/O-bus by the BASE I/O-controller. The BASE I/O-controller masters the digital I/O-modules as well. In fact all these modules are also used in the well-known and widely used quasi-static AUTOLOG measurement system.

High speed modules such as multiplexed A/D-converters, with and without Sample/Hold circuitry and parallel A/D-converters (4 each), including control electronics located on one module, are available for dynamic measurements. The second (and main) controller is the FAST I/O-controller, and one of its functions is to control these high speed measuring- and loadcontrol-modules over the FAST I/O-bus.

A number of other tasks are fulfilled by the FAST I/O-controller a powerful multi-tasking kernel is used, which can allocate enhanced functions in addition to the instruments measurement and control functions, such as datareduction, conversion to engineering-units, alarmlimit monitoring, sorting of data, waveform generation and signal analysis. Special functions can be downloaded by the hostcomputer into UNILOG, for execution of functions close to where data is measured and stored. In addition to driving the dynamic subsystem, the FAST I/O-controller controls associated devices, such as massmemory, for storage of measured dynamic data with DMA-procedures [1] (Ram-memory or large capacity internal harddisks with SCSI-interfacing).

A third measuring range has been added by including a new FAST DVM and opto-isolated solidstate switches, both controlled from the BASE I/O-controller. These modules enable scanningspeeds of upto

2000 measurements per second, including lowlevel straingauge inputs, using the DC-current balance method.

The advantages of DC-current technique over the AC-excitation technique are only meaningful with respect to the behaviour at high measuring speeds, e.g. with scanningspeeds in excess of 500 measurements per second [2,3,4].

Since the hardware and functional datalogging control is embedded in the firmware of UNILOG, the host-computer program can be focussed on supporting the interface to the users and operators of the system and hence highlight presentation and statusreporting of tests in progress [5].

To allow a number of users to access the datalogging equipment, a new userfriendly, multi-user/multi-tasking software structure has been developed. The organisation of UNIDRIVE, based on SCO-XENIX is shown in fig. 2.

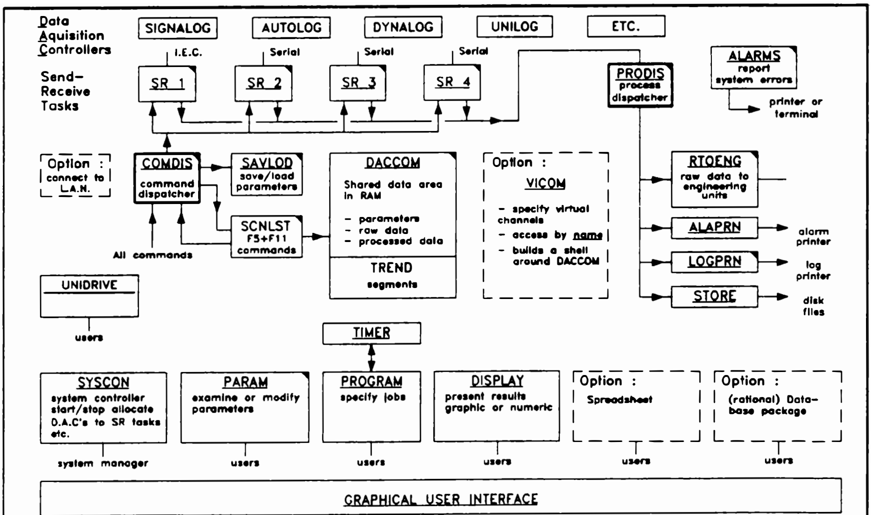

Fig.2 Organisation of UNIDRIVE

As a result a number of DAC's (UNILOG, DYNALOG, AUTOLOG, SIGNALOG programmable conditioners and amplifiers) or other suitable devices with RS232- or IEEE-interfacing can be controlled by any number of users or programs.

Users communicate with the COMMAND DISPATCHER, whereas one or more process-tasks are activated by the PROCESS-DISPATCHER. All standard datalogging functions are present as PROCESS-tasks, resulting in simple user-application programs. A compiler is available to generate application programs, which can be downloaded to the UNILOG's. This enables very high executionspeeds and reduces load on the hostcomputer.

Care has been taken to confirm with todays accepted standards, such as OPEN LOOK and the use of MSF-MOTIFS. This guarantees a transparent transportability from PC to any workstation as well (Sun, Apollo, Iris, etc.).

Both the hardware- and software-approach used in and with UNILOG, allows its use in large scale testing operations in experimental mechanics.

## Examples of applications:

Since its introduction UNILOG has seen a number of typical large scale testapplications.

- A large number of UNILOG's is used in the final static and dynamic tests of different parts of the AIRBUS 340 (body, wings, landinggear). Mediumspeed scanning (approx. 1000 measurements/sec.) is used to speed up evaluation time of the numerous flight movements. The open and universal structure of the firmware was highly appreciated; it allowed typical aeronautic tests and testsequences to be carried out.

- A monitoring- and diagnostic system, consisting of various AUTOLOG- and UNILOG mainframes, is being installed in the new NPP-Temelin, Czechoslovakia. The data-acquisition system collects data from several thousands of inputs (temperatures, flows, pressures, etc. and of course digital I/O's). UNILOG takes care about more demanding applications: e.g. it samples 32 pressure-fluctuating signals on-line for fatigue information; static pressure and variance are calculated every 2 seconds at 1000 Hz/channel. The same UNILOG samples at 1000 Hz a one-out-of-twenty signal, representing the position of valve opening and -closing.

- Investigating the coupling-parts of SPMT-modules.

  Mammoet-Breda, Netherlands is on off the leading companies in the world, when is comes to huge and heavy transports. Handling concerns both sea- and landtransports.

  A SMPT (Self Propelled Modular Transporter) is a 4- or 6-axial flat transportcarrier. These modules can be coupled both in length as well as in width, in order to arrive at large carriersurfaces. A computerized system controls drivingspeed and elevation level of each of the supportinglegs; ideally the SPMT shall operate completely levelled. In the past several damages have occurred to the coupling parts; wringing of the couplingfins, broken fixingbold and deformed splines. A series of testruns have recently been carried out to simulate and evaluate possible causes (fig. 3):

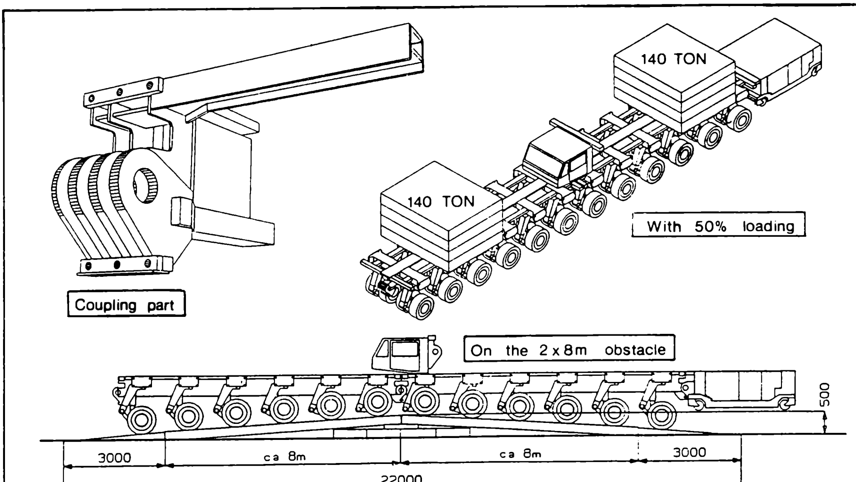

Fig.3 Impressions of SPMT–testing

* loaddowns from ships were simulated by driving over a 2x8m. wedge (max. elevation 50 cm)

* uneven sites were simulated by crossing a 2x5m. wedge with central height of 20cm. The testruns included: trial runs (full and half axial) at different speeds, combined with 0%, 50% and 60% (340 Tons) loading; braking, turning, crab and circular motion. In total 48 channels were connected; 8 pressure transducers, 40ea. ¼-bridges, of which 4 ea. 45°/90° rosettes. Measuringspeed was maintained at 25 measurements/s/channel. Per run approx. 6000 datavalues/channels were collected.

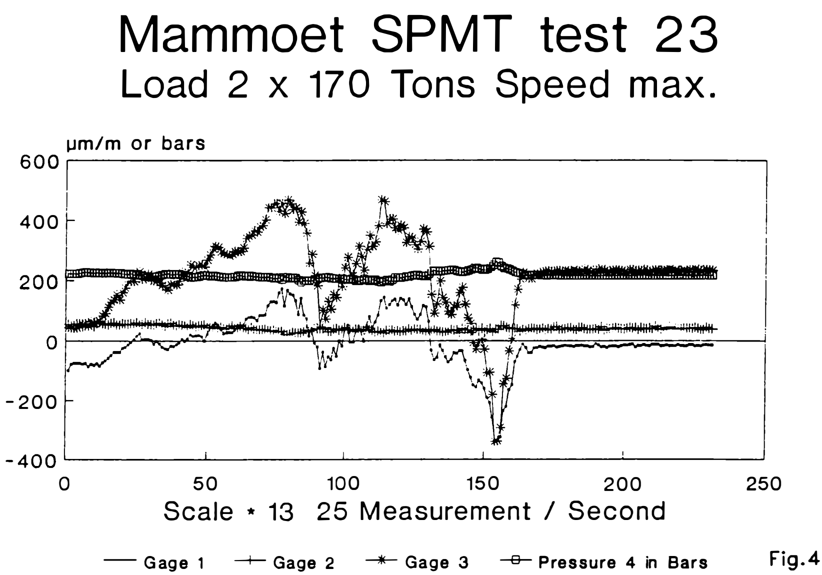

Fig.4

Fig. 4 shows a run at 60% load, at max. speed over the 2x5m. wedge. Gauge 1,2 and 3 form a 45/90° on the couplingfin (gauge 1-vertical, gauge 2-horizontal). The curves are averaged for every 13 readings, however gauge 1 and 3 indicate a substantial dynamic straincontribution.

Complete post-analysis were in progress at the time of writing this paper; conclusions will be given when presenting this paper.

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