EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
European Laboratory for Particle Physics

Large Hadron Collider Project

LHC Project Report 575

ORCHESTRATING THE MEASUREMENTS ON TWELVE MAGNET TEST BENCHES

A. Rijllart[1], P. Coutinho-Ferreira[1], E. Gorskaia[2], A. Raimondo[1] and H. Reymond[1]

Abstract

The final LHC dipole series test set-up will consist of 12 benches, organised in 6 clusters of two benches sharing the largest and most expensive devices. This sharing is made possible by a deliberate de-phasing of the tests among magnets, ensuring an optimum use of resources, such as cryogenics and power equipment, without limiting the total throughput.

To orchestrate the measurements a Test Master is needed to organise the tests per cluster and a Resource Manager to centralise the booking of the resources.

1 CERN, Geneva, Switzerland
2 JINR, Dubna, Russia

Presented at the Eighth European Particle Accelerator Conference (EPAC)
3-7 June 2002 - La Villette, Paris, France

Administrative Secretariat
LHC Division
CERN
CH - 1211 Geneva 23
Switzerland

Geneva, 2 July 2002

ORCHESTRATING THE MEASUREMENTS ON TWELVE MAGNET TEST BENCHES

A. Rijllart, P. Coutinho-Ferreira, A. Raimondo, H. Reymond, CERN, Geneva, Switzerland
E. Gorskaia, JINR, Dubna, Russia

Abstract

The final LHC dipole series test set-up will consist of 12 benches, organised in 6 clusters of two benches sharing the largest and most expensive devices. This sharing is made possible by a deliberate de-phasing of the tests among magnets, ensuring an optimum use of resources, such as cryogenics and power equipment, without limiting the total throughput.

To orchestrate the measurements a Test Master is needed to organise the tests per cluster and a Resource Manager to centralise the booking of the resources.

1 INTRODUCTION

The next large accelerator project at CERN is the Large Hadron Collider [1] (LHC), which is foreseen to be installed in the existing LEP tunnel, and scheduled to be commissioned in 2007. For this project 1200, 15 metre long dipole magnets need to be tested at CERN in warm and cold conditions on dedicated test benches that are under development.

An important part of the test is the magnetic field mapping. Dedicated software has been developed to perform this measurement in the LHC magnets by means of the rotating coil method [2].

Rotating coils, mounted on a shaft driven by a motor, deliver signals proportional to the magnetic field and the rotation speed. The coil signals are integrated by digital integrators, which are triggered by an angular encoder. The integrators, on a VME bus, are configured and read-out by a computer through a VME interface. Figure 1 show a sketch of the measurement system.

From the raw data the software computes the main field, the main field direction, the higher order harmonics and the magnetic axis coordinates. To perform these measurements the computer controls motors, power supplies and measurement devices, and reads-out the acquired data. Finally, it analyses online the raw data and stores it for later offline treatment.

The ratio of measurement time versus preparation time allows a de-phasing of the tests without limiting the total throughput where the largest and most expensive resources, such as cryogenics and power supplies, can be shared into clusters of two benches for a total of 6 clusters.

To orchestrate the measurements a Test Master (TM) is needed to organise the tests per cluster and a Resource Manager (RM) to centralise the booking of the resources.

Each TM drives two VME based measurement systems that interface to the magnet test electronics. The first is a turnkey industrial DAQ system for magnet power tests and the second is an in-house developed magnetic measurement system based on industrially produced components. The TM's user interface has been designed to allow non-specialist operators to execute pre-defined tests.

The control architecture is organised in two levels, where the TMs are at the bottom level, driving the measurement for the clusters, and requesting the booking of required equipment to the RM at the top level.

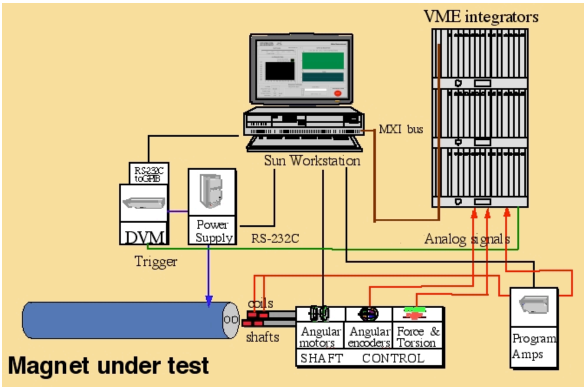

Figure 1: The magnetic field mapping system.

2 THE CONTROL ARCHITECTURE

We propose a control architecture with two levels [3]:

- the TM which drives the test for a cluster;
- the RM that allocates common devices and central resources.

In next sections we describe our implementation of this architecture in the LabVIEW™ environment.

2.1 The Test Master

The TM will be used to perform in an automatic way a predefined measurements cycle and should be a common interface for all the applications to be used in a cluster such as power supply control, magnetic measurements and energy loss measurements.

The aim is to simplify the way to perform the measurement allowing users with minimum experience to perform tests, and to minimise time and errors, during test definition.

To do this, the TM displays a synoptic panel that describes the cluster that is being controlled. In this diagram, the lines represent the communication between TM and the low-level programs that are located in different computers. The colour of these lines describes the communication status. The boxes that can be seen represent the programs status and indicate in which computer they are installed.

TM has several operating modes to configure the execution of measurements in a cluster.

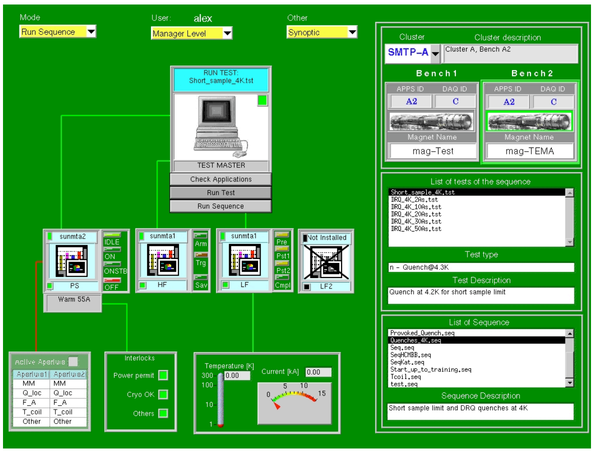

Figure 2: The *run sequence mode* synoptic

The first mode (*install mode*) is used to select the computers of the cluster that we want to control. In this mode, TM gets also the names of the configuration files present in the remote computers, which will be used to create the test files in the next mode (*define test mode*). These tests are in fact a list of commands written in a text file replacing the same operations that the user would do in the low-level programs, which operate the hardware and make the data acquisition.

In one test, the TM sends several command files, using FTP, to the program that performs the measurement and to the programs that make the low frequency and high frequency data acquisitions. These two types of programs are located in different computers.

To define a new test or to modify existing tests, the TM offers a specific editor that proposes a list of predefined commands. After creating the necessary tests, the user can build a sequence with these tests in the *build sequence mode*. Finally, in the *run sequence mode* the user can launch a sequence of tests. Figure 2 shows the *run sequence mode* cluster synoptic.

During a sequence execution the status of each measurement is shown and a log is being kept. For each test in the sequence, the TM configures and runs several applications in parallel (magnetic field mapping, temperature data acquisition, etc.) and communicates with the RM for status information and resource allocation.

The information coming from the remote programs launched by TM is obtained through a UDP socket. This type of communication doesn't need to have TM working nor a network, because it doesn't verify if the are being received.

2.2 The Resource Manager

The RM monitors the activity of TMs and the total power consumption. It shows the status of each test bench and handles the resource allocation on request of the TMs. It can refuse the use of a power supply if the total power consumption exceeds the limit.

The aim of the RM is to give an overview of all ongoing tests to the operators to help making decisions about the program in case it has to be changed depending on individual magnet test results. Normally a magnet will follow a standard program, but depending on results obtained during the test it may be necessary to shorten or extend the program. Such a change can influence the program on other clusters because of the common limited resources of cryogenics and electrical power.

2.3 Systems Interactions

When a measurement requires a particular power supply, the TM needs to reserve it and keeps control of it for the full time of the measurement. It is the RM that takes care of power supply reservation. The TM asks the RM if the needed device is available through a query on a UDP socket. The TM continues to send queries to the RM until an answer has been received.

Through another UDP socket the RM sends the answer allowing or not the measurement. With the reservation each TM gives an estimate of the total booking time that is updated during the measurement.

The measurement can start once the power supply is available. At the end, the TM sends to the RM the information to deallocate the device through a system as before. If the power supply cannot be used the RM gives an estimate of how much is the waiting time. Then the TM allows the user to take a decision to wait or to change the test sequence. Figure 3 shows the control architecture.

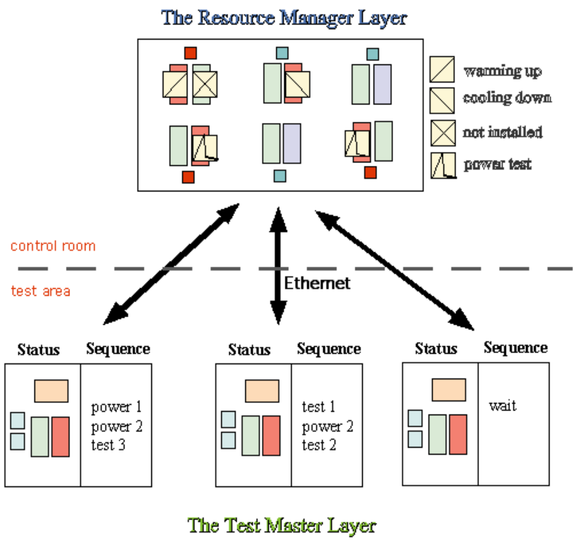

Figure 3: The control architecture.

The RM acquires the information through Ethernet by use of a UDP socket mechanism.

The use of UDP sockets is preferred over TCP because it does not need a permanent connection between the processes: this way, the TM can also run if the RM is not running or if there is no network communication with the RM. Only when needed, the communication takes place with a sort of simulation of TCP connection given that for every command sent the receipt is expected. During the measurement each bench sends status and usage information to the RM, which shows to a supervisor user the full installation.

3 CONCLUSIONS

For the LHC project 1200, 15 metre long dipole magnets need to be tested at CERN in warm and cold conditions on 12 dedicated test benches. The resources are shared in cluster of two benches, because of a deliberate de-phasing of the tests between magnets. This makes an optimum use of the resources, such as cryogenics and power equipment, without limiting the test throughput.

All measurement operations within a cluster can be controlled by measurement scheduler software called Test Master. The necessity of overall supervision software to share the total available electrical power is provided by the realisation of a Resource Manager.

4 REFERENCES

[1] The LHC Study Group, The LHC Conceptual Design Report, CERN/AC/95-05(LHC)

[2] L. Walckiers et al., "The Harmonic Coil Method", proc. of CAS, CERN 92-05, 1992

[3] A. Raimondo et al., "The Test Master", Note CERN IAS-LS-00-003