EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE

CERN - ST Division

CERN-ST-2001-013
30 January 2001

BE 400/18 KV SUBSTATION RENOVATION PROJECT

M. Delidais and A. Vairo

Abstract

The 400/18 kV SPS main substation was designed for the 400 GeV SPS project and was commissioned in 1974. It has been upgraded several times to form the present 400/66/18 kV SPS and LEP transmission power comprising 490 MVA and 240 MVAR installed power. The beginning of the LHC project and the obsolescence of the main elements, and consequently limited reliability, made it necessary to begin a complete renovation program. The new configuration of the substation will integrate the new compensator of reactive power efficiently into the 18 kV pulsed network. In this way the new compensator will facilitate the functioning of the pulsed network with the new loads and it will improve the performance of the electrical substation. The renovation program consists in a global reorganisation of the substation, with the total replacement of the 18 kV power equipment, a set up of new control and protection systems for the 18 kV and 400 kV section and the reconditioning of all the 400 kV equipment.

Presented at the 4th ST Workshop
Chamonix, France, 30 January - 2 February 2001

1 INTRODUCTION

The CERN site is powered by the Swiss 130 kV network via the ME10 130/18 kV substation, mainly dedicated to the surface installations, and by the French EDF (Electricité de France) 400 kV network via the BE 400/18 kV substation, dedicated to the accelerators powering. Therefore the BE substation plays a major role in the CERN network. It consists of: one income line, two power lines 110 MVA dedicated to the LEP/LHC network and three power lines 90 MVA dedicated to the SPS pulsed network (12 double power converters for the dipole bending magnets, 2 power-converters for the quadrupoles and the SPS 18 kV pulsed loop). At the BE substation there are also two reactive power compensators (total installed power 240 MVAR) that have the task of maintaining the voltage variations within the power converters working limits and filtering the harmonics.

2 REASONS FOR THE RENOVATION

In the LHC functioning configuration the SPS will operate at 450 GeV, this means that both the SPS Principal Compensator and the North Area Compensator, as well as the 90 MVA transformers supplying the SPS and North Area, must be fully operational. The renovated BE substation will thus consist of three 400/18 kV supply groups, each one comprising of a 90 MVA, 400/18 kV transformer and a compensator. Two of these will suffice for SPS and LHC, the third will be stand by. Moreover the renovation of the BE substation is necessary in order to assure a good level of reliability at the electrical network powering the accelerators during the LHC era. This renovation project involves the 18 kV pulsed network side as well as the 400 kV side, with the aim, not only to renovate the equipment, but also to re-structure the control and protection system and to reorganise the power distribution for the pulsed loads.

2.1 New loads

With the LHC project there will be load distribution changes with new loads that will need dedicated feeders. Particularly the Injection Tunnel TI2 and TI8 request 45 MVA via two separated lines that have to be connected at the main 18 kV distribution switchboard. But the composition of the existing switchboard does not allow these modifications.

2.2 Ageing of the components

The pulsed components are ageing much more than the rest, since 1975 they have been submitted to about 50 million high power pulses during 500,000 hours of operation.

The most worrying situation concerns the two compensators. If a major breakdown occurs in any of these it means a repair outage in the factory of about one year. The transformer T1 is in the worst condition, it was submitted to four successive short-circuits in 1979 and it has several important oil leaks, about 200 litres/month.

The 18 kV main switchboard air-blast circuit-breakers are submitted to heavy service conditions and necessitate expensive maintenance each year. It will be replaced with SF6 breakers. The ageing of the main components of the substation (power transformers, reactive power compensator, etc.) imposes the need to have, in case of default, different configurations allowing the powering of the loads. The present configuration of the MV distribution switchboard does not allow this flexibility. Moreover this switchboard is 30 years old and it is not possible to modify it because this type of equipment is no longer in production, and itself is a weak point in the reliability of the substation.

2.3 Rationalisation of the protection and control system

At present time the protection and control functions of the BE substation is entrusted to an old electromechanical system. This obsolete installation will be replaced with a new control system, consisting of numerical relays, that will allow a more efficient protection of the electrical network. At the same time the set up of a completely new monitoring and control system of the BE substation will centralise the control and protection functions, avoiding the presence of different control centres acting in an independent way, and to integrate it with the global control system of the CERN network.

2.4 Auxiliary supply systems

The structure of the present auxiliary supply, with one single 110 Vdc battery for feeding the 18 kV and 400 kV devices and both the protection systems of the 400 kV level and of the 18 kV, is too primitive to be sufficiently reliable for such a strategic installation. To conform with present CERN standards, it will be necessary set up a double battery feeding system 48 Vdc. One battery supply system, rated at 160 Ah, will be dedicated to the 400 kV equipment, while for the 18 kV equipment and control and protection systems will be installed two 230 Ah battery supply systems.

2.5 Integration of the third compensator

A third reactive power compensator (Compensator n° 2) will be installed in order to allow the functioning of the whole 18 kV pulsed network, even in case of breakdown of one of the other two compensators. There is the need to be able to connect the main 18 kV switchboard the three compensators, as well as the three feeding transformers, in such a way as act as an exchangeable system. The existing switchboard does not allow neither the connection of the new compensator, nor the set up of the different configurations needed in order to allow this exchange.

3 DESCRIPTION OF THE PROJECT

3.1 Reconditioning and maintenance of the 400 kV equipment

The 400 kV circuit breakers of the power lines feeding the 18 kV pulsed network have been in active service for 30 years and during this time they have been subjected to maintenance on site only. For this reason, in order to assure safe operation during the next many years, they will be completely reconditioned at the factory. The other circuit breakers, that have been installed more recently, and all the line insulators will be subjected to maintenance interventions on site. Because of the renovation of the auxiliary supply system in the BE substation, changing from 110 Vdc to 48 Vdc in order to be made it uniform with the present CERN standard, it is necessary to modify all the control and auxiliary systems of the 400 kV equipment.

The other main intervention on the 400 kV installation is the replacing of the existing command and signal cables for all the high voltage equipment of the power lines. The replacing of these cables is necessary to properly interface the high voltage equipment of the power lines with the new control and protection system. Concerning the 400/18 kV 90 MVA transformers the investigations on the status of the active parts (windings, insulation, etc.) carried out by an EDF specialised team, have given reassuring results. So there is no need for heavy interventions on the active parts of these. Anyway there is the urgent need to carry out reconditioning interventions replacing the gaskets in order stop the oil leaks. The first maintenance intervention will be carried out on the transformer T1, that is in the worst conditions.

3.2 Replacement of the 18 kV equipment

The interventions on the 18 kV side is one of the major points of the project. The existing main distribution switchboard, as explained in the reasons for the renovation, does not allow the functioning of the 18 kV pulsed network as necessary with the LHC operation. For this reason it will be completely replaced.

3.2.1 Substation lay out and distribution diagram

The new 18 kV distribution switchboard will be composed of several sections that will feed all the pulsed loads as shown in figure 1. The configuration of this switchboard will make possible (see fig.2) the feeding of all the 18 kV pulsed loads even with one transformer or compensator out of order, with just two power transformers and two compensators in service, that are sufficient to power all the pulsed loads. This has been possible by the structure of the switchboard that allows to group in different ways the loads, on the different sections of the switchboard, and by the busbar links connecting the two extreme sections of the switchboard, realising in this way a “triangle” distribution schema.

3.2.2 Technical characteristics of the MV switchboard

The 18 kV CERN pulsed network has special characteristics, compared to a standard medium voltage industrial network. These special characteristics are mainly due to:

- the particularity of the pulsing loads, with a high reactive power demanded in a non constraint way
- to the presence of reactive power compensators and capacitive filters with a high power rating, functioning as voltage regulators together with the tap changers of the transformers.

In all the possible configurations each section of the medium voltage switchboard is fed by only one transformer in order to limit the short circuit current, on the 18 kV main distribution switchboard, at 20 kA and the rated current at 3150 A.

The exchange of reactive inductive power between the reactors and the reactive capacitive power of the filters, directly on the switchboards of the compensators, limits the current on the main switchboard. The switchboard must be able to operate in several different degraded conditions. In case of a break down of the thyristor controlled reactor of the new compensator, the capacitive reactive power of the filters will be not compensated, this fact will cause the increase of the voltage (about 22.4 kV) with a capacitive current of about 1300 A.

The circuit breakers of the compensator switchboard must be able to operate in these no standard conditions. Another special condition is when the pulsing mode of the loads stops from a condition of functioning at maximum power. In this case there will be the tap changer of the transformer in the highest position, for 10 min awaiting the restart of the pulsing mode, in this situation the reactive power of the reactor is not compensated, this will cause an high current on the busbar, around 4000 A. In this functioning condition no intervention of the 18 kV circuit breakers is possible, in case of an emergency it is possible to intervene with the 400 kV circuit breakers, but the switchboard must be able to operate with this current, that is 1.27 In, for 10 min.

4 CONTROL AND PROTECTION SYSTEM

The new substation will be managed by a centralised system, avoiding the present time structure with different control and protection system installed in different places and manually interlocked. The new system will be placed in an suitable safe room and it will be structured in three different functional systems:

- 18 kV voltage control and protection. All the switchgear will be equipped with programmable protection relays controlling the operation of the switchgear, following the status of the installation and the inputs coming from the other control systems.
- 400 kV control and protection. The incoming line and each 400 kV feeder is managed by an integrate system composed by numerical relays and bay controllers. The numerical relays assure the electrical protection; the bay controllers, specific PLCs for the command and control of HV installations, control all of the equipment forming the power feeder.
- Reactive power compensator regulation. This system is integrated with the control system of the electrical substation, because besides to command the tap changers of the transformers and the regulation devices of the compensators, it controls the configuration of the network, coupling transformer-compensator, in order to correctly compensate the pulsing loads.

These functional systems are interfaced to each other and managed by a top level control system set up by a PLC, controlling the configuration of the substation, following the operation conditions and to interface correctly the control systems of the substation with the control system of the power converters stations feeding the magnets. The general lay out of the control and interface system of the BE substation is shown in fig. 3.

5 PLANNING

The duration of the realisation of this project is 25 weeks, from the 26th of November 2000 until the 1st of June 2001, in conformity with the scheduling of the SPS accelerator. This period includes the dismantling activities, the civil engineering modification of the existing building, the set up of the new installation and the functioning tests. All these activities must be carried out in separate periods, it is not possible to superpose them. This fact makes each activity critical for the respect of the whole planning of the project.

REFERENCES

[1] O. Bayard – J. Pedersen, The CERN 400/66/18 kV main substation and its associated compensators and filters. October 1993.

[2] O. Bayard, CERN’s electrical power supply. January 1996.

[3] GEC Switchgear Limitad, Reactive power compensator for the 300 GeV accelerator.

[4] K. Kahle, Technical Specification for the supply of a 150 MVA, 18 kV Static Var Compensator. February 2000.

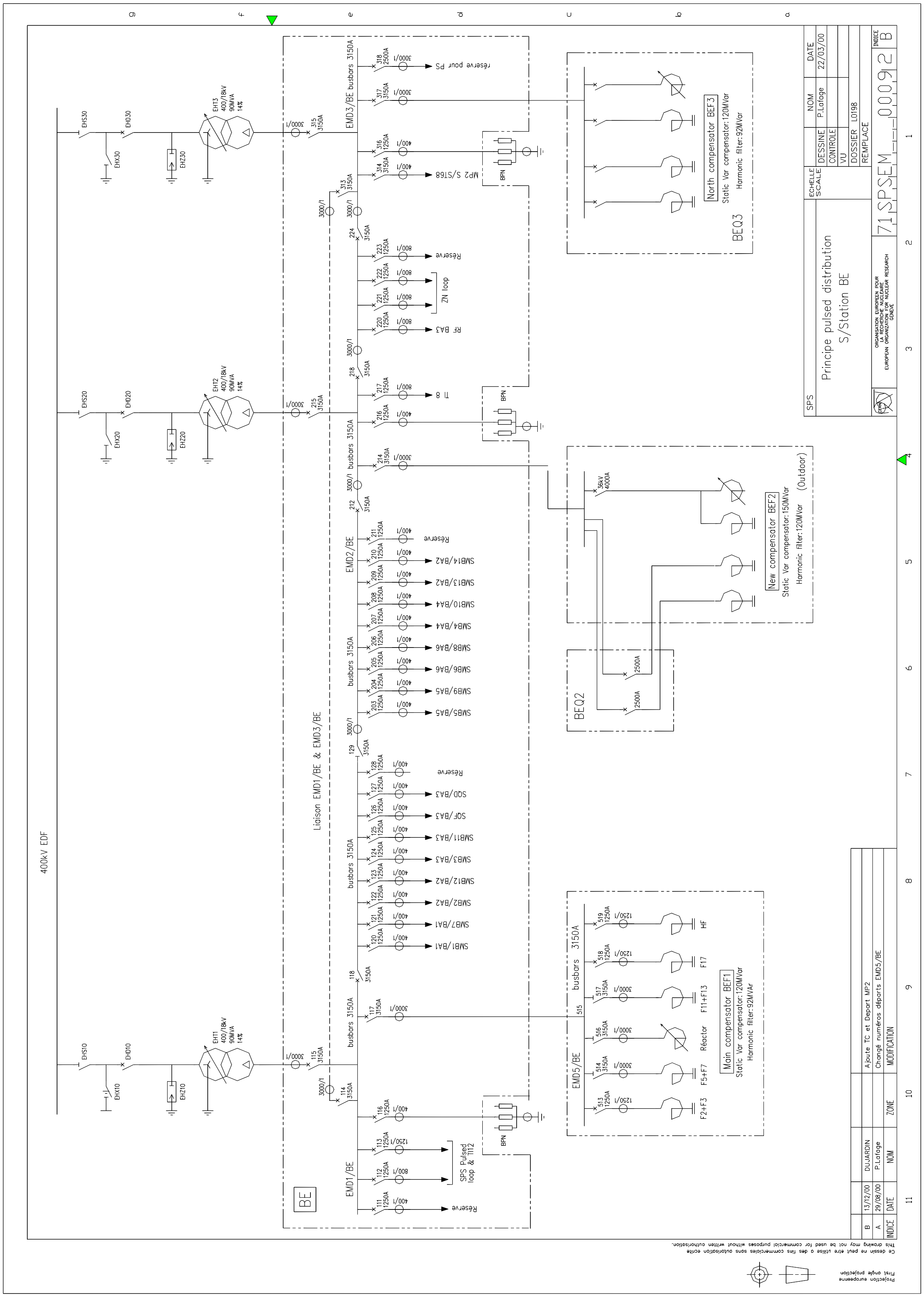

Figure 1 - BE Distribution diagram.

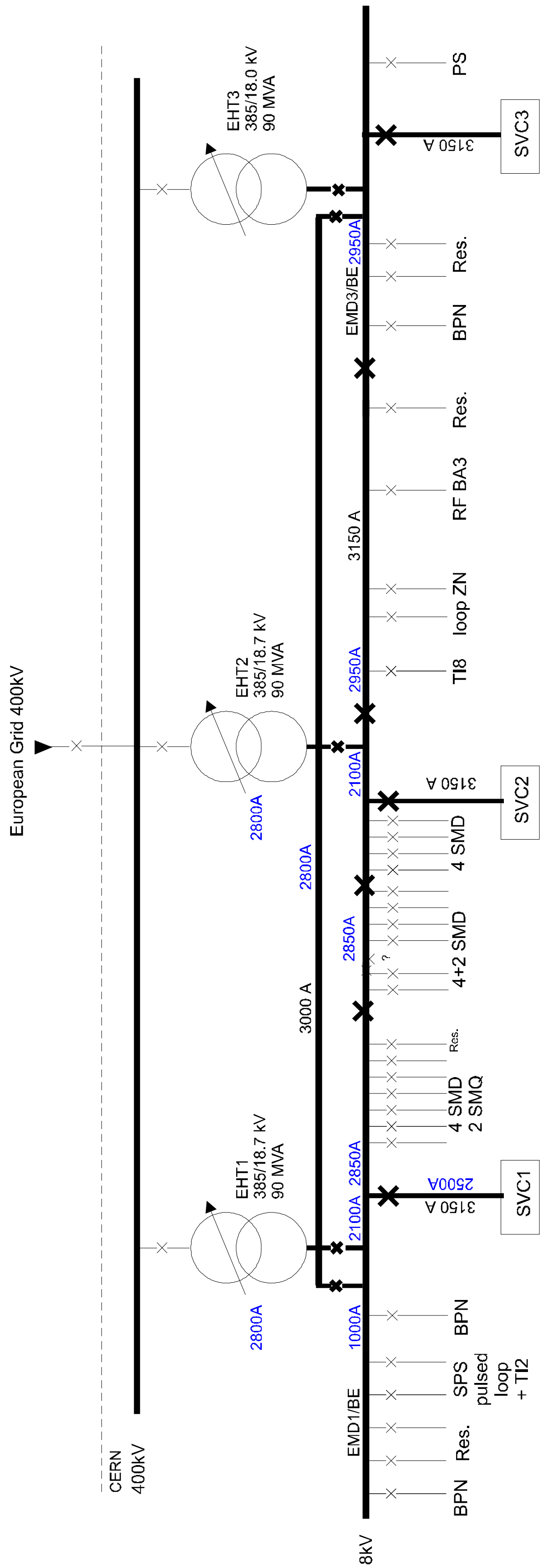

Figure 2 – Configuration of the main 18 kV switchboard.

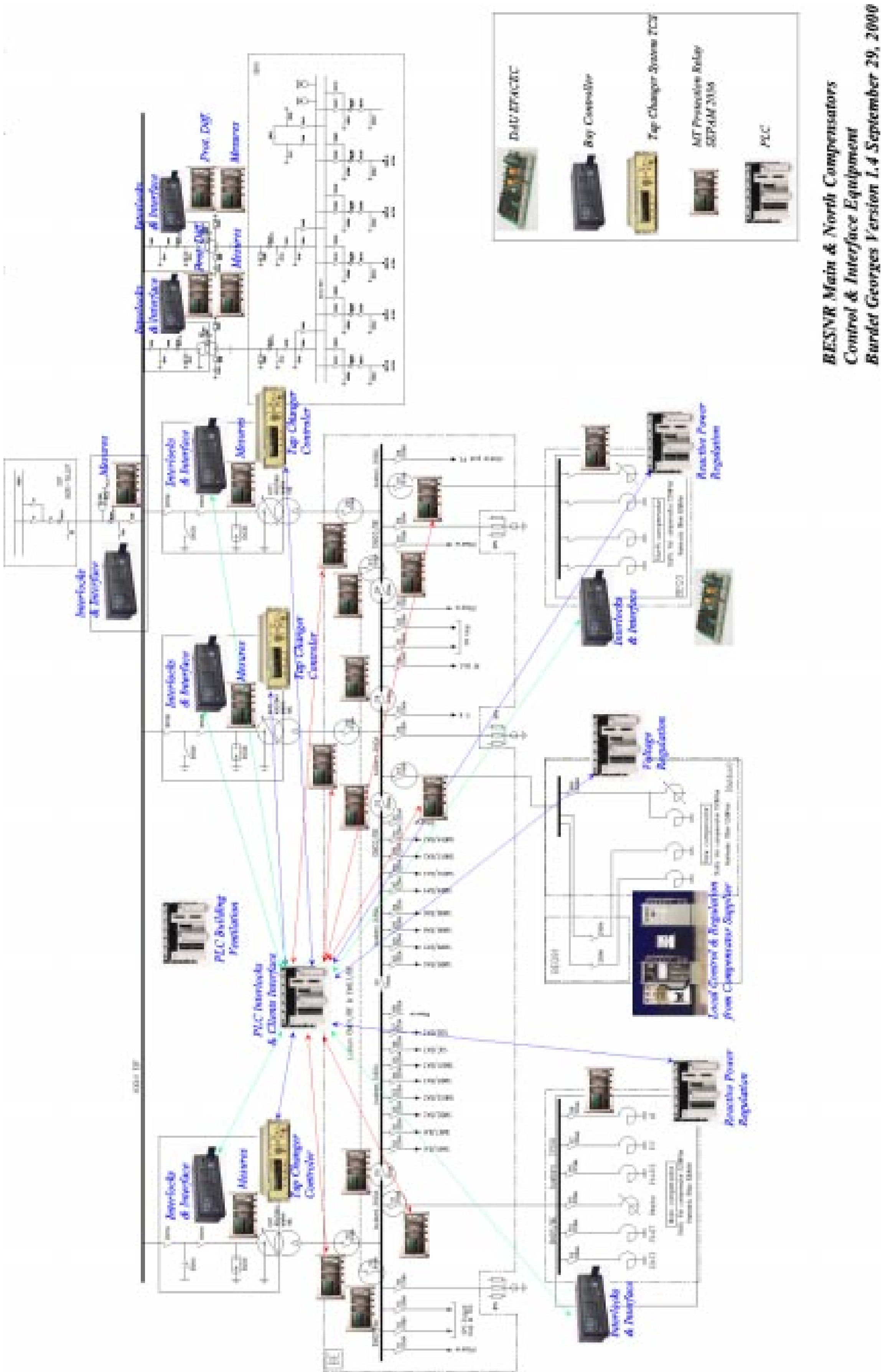

Figure 3 – General lay out of control and interface equipment BE substation.