Rafael KAWECKI

Siemens AG, Power and Gas, Instrumentation and Electrical

doi:10.15199/48.2015.10.15

Modernization of excitation systems

***Abstract**. Sooner or later, the existing excitation system will reach the end of its active life. This may be because some modules have been discontinued or grid operators impose new requirements for control dynamics which the installed system is unable to meet. The article presents experiences and challenges during modernization projects and shows available solutions for existing power plants.*

Streszczenie.** Artykuł przedstawia przykłady modernizacji wyposażenia systemów zasilania. **Modernizacja systemów zasilania

Keywords: Excitation system, AVR, voltage regulator, modernization.
Słowa kluczowe: systemy zasilania, modernizacja

Introduction

Excitation system in a power plant plays a key role in ensuring long-term reliable operation of synchronous generators, since it significantly influences the operational readiness and dynamics of the generator. It also controls the reactive power response of the synchronous machine. Furthermore it keeps the current working point of generator in permissible range described by the generator envelope (s. picture 5).

As every technical component also excitation system will sooner or later reach the end of its life time. This may be because some modules have been discontinued, or simply because they can no longer operate economically. This is the case if, for example, spare parts costs have become prohibitive or grid operators impose new requirements for control dynamics which the installed system is unable to meet, or for some other reason the statistical risk of failures exceeds an acceptable level.

What is then required is a solution that perfectly fits in the existing situation in the power plant and ensures reliable, continuous, operation based on innovative technology. Modernization of aged excitation systems can be thus easily justified before the technical life span has been reached.

The following paper presents short overview of basic conditions and various technical requirements which need to be considered prior and during modernization of excitation system.

General requirements

One of the major reasons to modernize the excitation system is the availability of OEM support – availability of technical support and spare parts. On the other hand the knowledge of the installed system by operating personal needs to be considered as well. Until 1990 many analog excitation systems (Figure 1) were installed and nowadays, in the times of very fast changing technology, most of the technicians cannot handle analog technology. Those two points combined together are the most often reason for modernization of any installed system.

Before modernization project can be scheduled, certain basic parameters need to be determined such as:

- Rating of the excitation system and definition of interfaces – e.g. power supply
- Which parts of the excitation system should be replaced – e.g. with or without excitation transformer
- What type of technology should be applied
- How can the new system be integrated into the power plant – e.g. location of the excitation system, ambient temperature or transport way

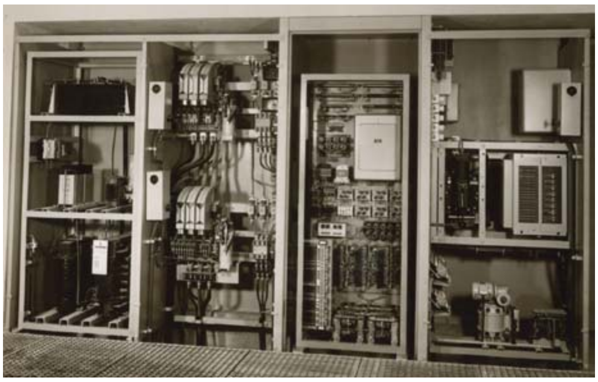


Fig. 1. Example of excitation system from 1930s.

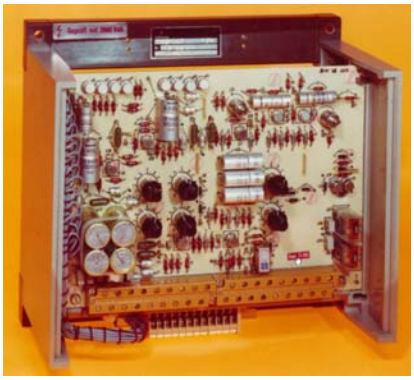


Fig. 2. Power factor and reactive power controller – 1980s.

Knowledge of the installed system is needed and a comparison between the present conditions and the desired changes needs to be specified. Most of those points can be specified based on the existing documentation. This is however very often also one of the main challenges – documentation does not exist or is of insufficient quality. In such a case inspection by experts of the installed system and generator is required.

Another essential consideration for the modification is the adaptability of a new excitation system with the existing or future (s. picture 3):

- control room
- protection system
- control system
- turbine automation

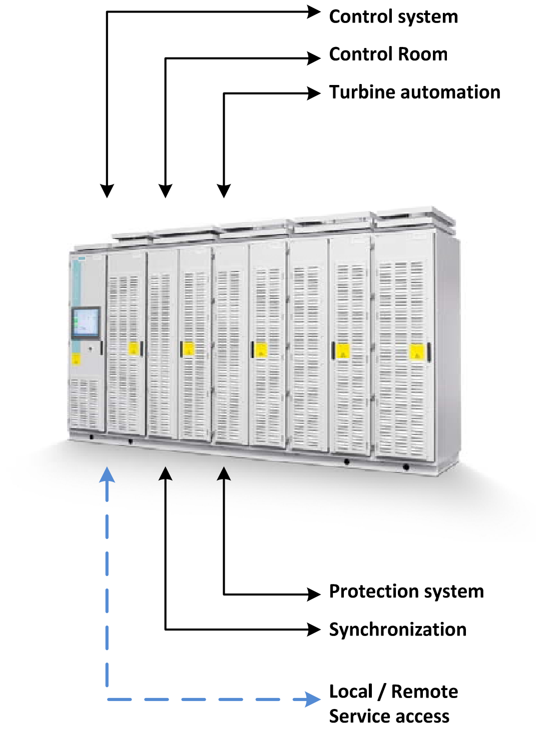


Fig. 3. Main interfaces to / from excitation system

With today's digital technology, digital excitation systems have become very versatile. They are equipped with operating modes necessary to control terminal voltage on the synchronous machine, power factor or reactive power. In the older systems very often additional components were used to fulfil such requirements. An example can be the Power System Stabilizer or power factor controller (s. Figure 2).

Nowadays in digital system in addition, a full complement of excitation limiters and Power System Stabilizer (PSS, [1]) are provided to ensure safe operation of the synchronous machine over a complete range of operating conditions.

Excitation systems offer also further functions like HMI, local and remote control, remote diagnose and service. With such functions the operator can adapt and check the system locally and remotely and thus has the necessary flexibility.

Modernization options

In modernization projects following typical options are available:

- Keep the type of the excitation system, e.g. static excitation system
- Change of the type, e.g. from brushless to static

A change from one type to another is reasonable only in case:

- the grid operators impose new requirements for control dynamics: change from brushless to static
- costs for maintenance of the entire system shall be minimized: change from static to brushless

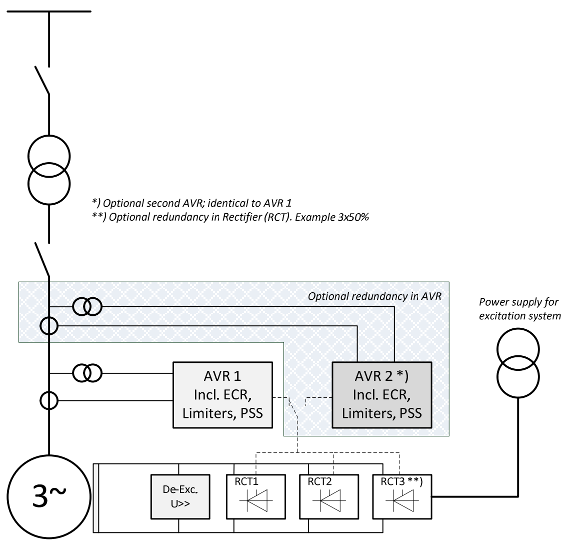
It needs to be considered that such modernization is combined also with feasibility study and mechanical modernization of the existing generator.

In most of the cases however the type of the excitation system will not be changed and a complete replacement of the existing excitation system by a new standardized system is the first choice. Keeping the type of the excitation system gives still further optimization options. Those can improve the transient response of the excitation system, reliability, serviceability of the system or simplicity of the operation. Example of improvements can be:

- increase in the ceiling voltage and current; this requires very often also change in the power supply, e.g. excitation transformer
- change of the redundancy concept – e.g. redundant automatic voltage regulator (AVR) and / or redundant rectifiers (picture 4)
- modern service functionality realized by remote access for service purposes

Other requirements to consider are type of the AVR incl. limiters, PSS and further functions. Today's AVR incl. limiters are well specified by international standard IEEE 421 [1] as well as national grid codes, e.g. [2]. In the development of modern digital AVRs such standards are already considered and tested accordingly.

Modern systems offers also additional features, just to mention the remote access for service purposes over a secured internet connection.



Picture 4. Full redundancy concept for a static excitation system

De-installation and installation

De-installation is the first step of modernization during the outage. In this phase all connections to and from existing excitation system will be dismantled and accordingly labeled. Depending on the modernization concept and on the shape of the cabling, some of them will be removed completely and replaced by new once. E.g. during replacement of the hardwired connection to the control system by a bus communication.

Second step is transport of the new excitation system inside of the plant and the installation of the system on the place where the old one was installed. In some cases the new excitation system will be installed at different location as the old one. This can be the case when for example the new system has a bigger footprint, e.g. because of the changed redundancy in rectifier.

Commissioning

After the installation of the new system was finished, commissioning can be performed. This stage is normally divided into following stages:

- cold commissioning – mainly signal check

• hot commissioning – optimization of the parameters as well as check of the performance of the new installed system

In this crucial step most of OEM have own procedures of testing, however the content is mostly very similar and includes following general points:

• optimization and check of basic functions, like AVR and ECR
• set, optimization and check of limiters, like under-excitation limiter; those limiters needs to be coordinated with generator parameters and setting of the protection system
• check of Power System Stabilizer (PSS) if installed
• optionally: additional tests required by grid operator
• setting and test of additional features, e.g. remote access for service purposes
• documentation of performed setting and tests

Especially the last point is very important for the operation of the plant in the future as it shows exactly the behavior of the excitation system during commissioning as well as set parameters. Thus it is also crucial for future stability studies.

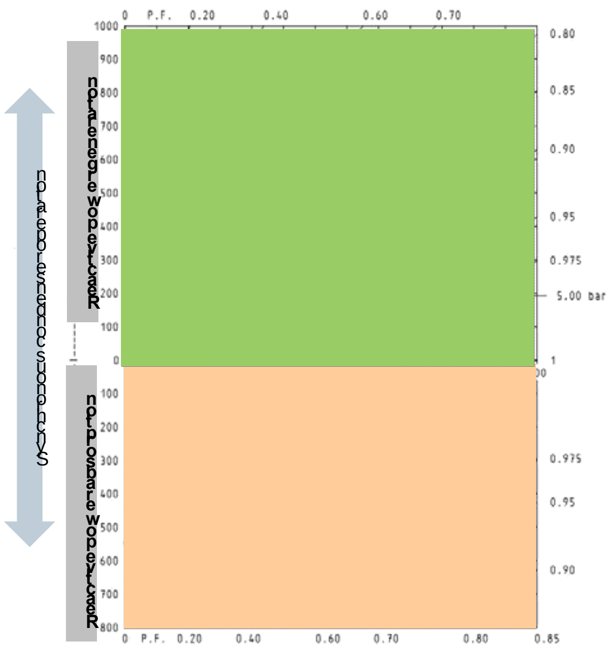


Fig. 5. Generator operating diagramm

Conclusion and outlook

Modernization of existing old excitation system is question of system reliability, serviceability requirements as well as new requirements in regards to system performance. In retrofit project many modernization aspects need to be considered and accordingly specified. The new system thus can differ in many points even if the rating does not change.

Modern, digital excitation systems offer solution for almost all needs and can be adapted to the existing situation in the power plant. They offer also significant increase in regards to system performance, serviceability and reliability. Especially high flexibility of digital system is benefit for power plant operators as it enables easy adaptation of system parameters according to the current needs.

REFERENCES

[1] IEEE 421-2005
[2] ENTSO-E Draft Network Code for Requirements for Grid Connection applicable to all Generators. European Network of Transmission System Operators for Electricity, 24 January 2012. https://www.entsoe.eu

Author: *Dr. Ing. Rafael Kawecki, Siemens AG Erlangen, Power and Gas, Instrumentation and Electircal, Freyeslebenstr. 1, 91058 Erlangen, Germany, E-mail: rafael.kawecki@siemens.com.*