UNITROL® Stand-alone Power System Stabilizer

Improve network stability by refurbishing existing generator exciters!
Purpose and types of power system stabilizers

Causes and types of power oscillations

Network faults or network operation close to the stability limits cause active power oscillations between generators and the network. These electromechanical oscillations of the rotor can be reduced by controlled influence of the excitation current. Usually a distinction is made between:

- **Local oscillations** between a generator and other generators in a power station. Typical oscillation frequency: 0.8 to 2.0 Hz
- **Oscillations between neighboring power stations**, typical oscillation frequency: 1.0 to 2.0 Hz
- **Oscillations between network areas**, each comprising several generators. Typical oscillation frequency: 0.2 to 0.8 Hz
- **Global oscillations**, characterized by collective in-phase oscillations of all generators within a network area. Typical oscillation frequency: below 0.2 Hz.

The purpose of the power system stabilizer (PSS) is to measure these power oscillations and derive from these a signal, which influences the set point of the voltage regulator.

Increased reactive power consumption and improved network stability

Nowadays, new excitation systems for medium-power and high-power generators are almost always supplied with an integrated PSS. For existing power stations, where a complete replacement of the excitation systems is not planned, there are good reasons to equip the existing voltage regulators with PSS.

- Increasingly, network operators demand that the power producers make an active contribution to network stability
- In many cases, this can increase the working range of the generator, especially in terms of reactive power consumption capacity

The ABB stand-alone PSS was specially developed for these applications. This stabilizer is suitable for supplementing not only ABB Automatic Voltage Regulators (AVR) / Static Excitation Systems (SES), but also those of the other manufacturers.

In the past, a wide range of different types of power system stabilizers was in use. Recently, there is an increasing demand for types described below.

IEEE 2A/2B power system stabilizer

For most applications, a power system stabilizer, which uses the algorithm in accordance with IEEE Standard 421.5 PSS 2A/2B, is suitable. The electrical power $P_e$ and the rotor angular speed variation $\Delta \omega$ are calculated from the measured values for generator voltage and current. In stationary operation, deviations in the electrical power are used to generate the optimum stabilizing signal in terms of amplitude and phase relationship by means of a lead/lag filter. Without special measures, a PSS also reacts to changes in the turbine power. This undesired effect is suppressed by using the rotor angular speed as an additional variable (determination of acceleration power).

Multi-band power system stabilizer (MB-PSS)

In the MB-PSS, the influences on the stabilizing signal through changes in the turbine power are also suppressed. In contrast to the PSS described above, the stabilizing signal is derived from both the rotor angular speed variation and the electrical power. Furthermore, instead of using one filter, three independent lead/lag filters are applied, which are respectively optimized for the damping of local oscillations, oscillations between network areas and global oscillations.

The algorithm used in this power system stabilizer was developed by Hydro Quebec (Canada).

![Fig. 1: Simplified schematic representation of the signal processing in the multi-band power system stabilizer](image-url)

The optimum solution by ABB

The successful development of the ABB Power System Stabilizer was ensured by two major factors:

- ABB wisely used its more than 30 years long experience in the field of power oscillations damping via the excitation system
- The technical solution of the device is based on UNITROL F and UNITROL 5000 control platform, which have undergone a thorough and extensive testing.
Simple integration into existing excitation systems

This compact unit can be installed in the cubicle or in the vicinity of the existing AVR/SES. It can be supplied in two alternative versions with the transfer functions described above. Only one free analog input is required in the existing AVR/SES in order to connect the power system stabilizer. The necessary signal adaptation (impedance, level, polarity) takes place on the PSS side.

The 3-phase measured values for generator voltage and generator current are generally already available in the existing AVR and, since the additional load is low, the same can also be used for the stand-alone PSS without any problem.

Simple commissioning

Power system stabilizers are optimized for critical network configurations. These mostly rare configurations are the result of network faults; therefore they cannot generally be simulated during commissioning of the PSS. ABB strongly recommends, that the parameter values should not be set on trial and error basis.

ABB runs optimization programs that allow to determine the parameters off-line. The work required during commissioning is limited to verification of these pre-calculated parameter values and comparison of the power oscillations damping with and without the PSS.

Fig. 2: Block diagram showing the integration of the power system stabilizer into an existing static excitation system (SES) with automatic voltage regulator (AVR)

Static excitation system

Due to the direct influence on the rotor current of the generator, the power system stabilizer works very effectively. Power oscillations caused by sudden changes in load are quickly damped. Therefore, the contribution to network stability by generators with static excitation system is very high.

Automatic voltage regulator (with exciter machine)

Although the time constant of the exciter limits the effectiveness of the PSS, its application is still justified in many cases. The use of the PSS is especially effective for AC exciters with stationary or rotating diodes, whose frequencies are a multiple of the network frequency, which allows reducing the machine time constant.

Fig. 3: Mode of operation of the power system stabilizer. The data are taken from the integrated data logger and visualized using the CMT 5000 software (1 s/div)

Features of the ABB power system stabilizer

- Microprocessor-based digital power system stabilizer with transfer function in accordance with IEEE Standard 421.5 PSS 2A/2B or PSS 4B
- Self-activation on the basis of criteria that can be set individually
- Simple parameter setting with local operating unit (standard) or with laptop and Commissioning & Maintenance Tool CMT 5000 software (option)
- Integrated data logger with 6 channels, each with 1000 values
- Integrated event recorder with time stamp for 99 events
- Comprehensive self-monitoring
- Communication with higher-level control systems via bus coupler (optionally MODBUS or Profibus)
- LAN integration (TCP/IP) via Ethernet adapter for remote diagnostics (option)
Technical data

Voltage supply
Supply voltage \( U_s \) 24 V\textsubscript{DC}
Permissible voltage range 21.6 to 24.4 V
Current consumption 0.5 A
Power supply unit for other supply voltage Option

Inputs / outputs
Generator voltage input (3-phase)
Nominal voltage (phase to phase) 100 to 110 to 120 V\textsubscript{AC}
Permissible voltage range: 0 to 1.5 p.u. 0 to 180 V\textsubscript{AC}
Nominal frequency 16\textsuperscript{2/3}, 50, 60 Hz
Frequency range 10 to 120 Hz

Generator current input (3-phase)
Nominal current 1 A\textsubscript{AC} / 5 A\textsubscript{AC}
Permissible current range: 0 to 2.5 p.u. 2.5 / 12.5 A\textsubscript{AC}
Nominal frequency 16\textsuperscript{2/3}, 50, 60 Hz
Frequency range 10 to 120 Hz
Accuracy < 0.5 %

Analog input voltages
Nominal input voltage range \( U_n \) -10 to +10 V\textsubscript{DC}
Continuous permissible \( 1.5 \times U_n \)
Input resistance 220 kOhm
Nominal input current range \( I_n \) -20 to +20 mA\textsubscript{DC}
Continuous permissible \( 1.5 \times I_n \)

Digital inputs
Nominal input voltage 24 V\textsubscript{DC}
Input voltage range 20.5 to 28 V\textsubscript{DC}
Input voltage logical „0“ < 10 V\textsubscript{DC}
Input voltage logical „1“ > 18 V\textsubscript{DC}
Input current by 20.5 V 6 mA\textsubscript{DC} ± 10 %

Analog output
Output voltage range ± 10 V
Output current ≤ 4 mA
Measuring transducer with galvanic separation Option

Relay output
Switching voltage AC/DC ≤ 250 V
Inrush current ≤ 16 A
Continuous current ≤ 2 A

Current-limited +24 V output
Nominal input voltage \( U_s \) 24 V\textsubscript{DC}
Input voltage range 20.5 to 28 V\textsubscript{DC}
Output voltage \( U_s - 1 \text{ V} \)
Maximum continuous current +24 V Out ≤ 40 mA

Environmental conditions
Permissible ambient temperature
Compliance with technical data 0 to + 55 °C
Operable 0 to + 70 °C
Storage temperature - 25 to + 85 °C

Mechanical stability
Vibration test according to IEC 60255-21-1
Response test, Class 2 2 to 150 Hz, a=2 g
Endurance test, Class 2 2 to 150 Hz, a=2 g
Earthquake test 2 to 35 Hz according to IEC 60255-21-3, Class 2
and IEEE Std. 344-1987 2 g in each axis
IEEE Standard 344-1987 5 g in each axis

Protection class
According to DIN 40050 IP 20

Mechanical data
Dimensions (H x W x D) 420 x 273 x 195 mm

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