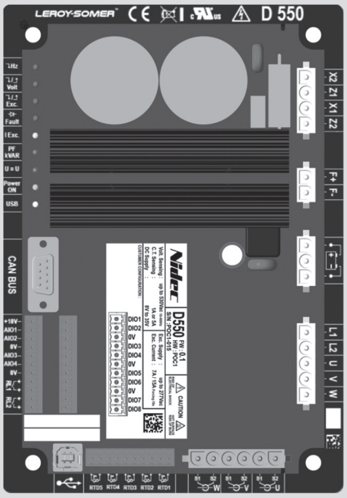

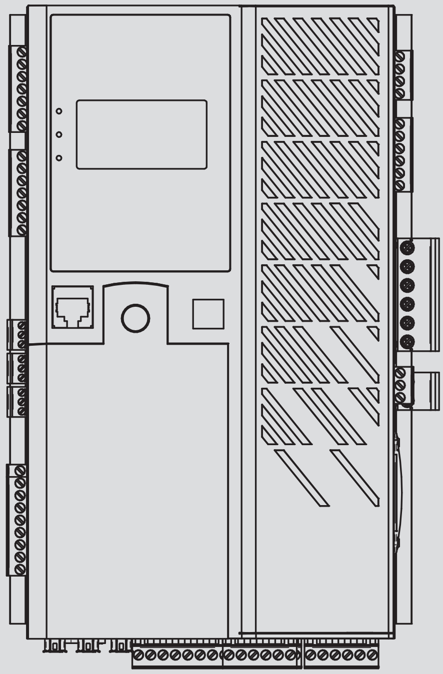

Power System Stabilizer for D550 and D700

Digital voltage regulator

Installation and maintenance

LEROY-SOMER™

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All for dreams

Power System Stabilizer for D550 and D700

This manual concerns the alternator AVR which you have just purchased.
We wish to draw your attention to the contents of this maintenance manual.

SAFETY MEASURES

Before using your machine for the first time, it is important to read the whole of this installation and maintenance manual.

All necessary operations and interventions on this machine must be performed by a qualified technician.

Our technical support service will be pleased to provide any additional information you may require.

The various operations described in this manual are accompanied by recommendations or symbols to alert the user to potential risks of accidents. It is vital that you understand and take notice of the following warning symbols.

WARNING

Warning symbol for an operation capable of damaging or destroying the machine or surrounding equipment.

Warning symbol for general danger to personnel.

Warning symbol for electrical danger to personnel.

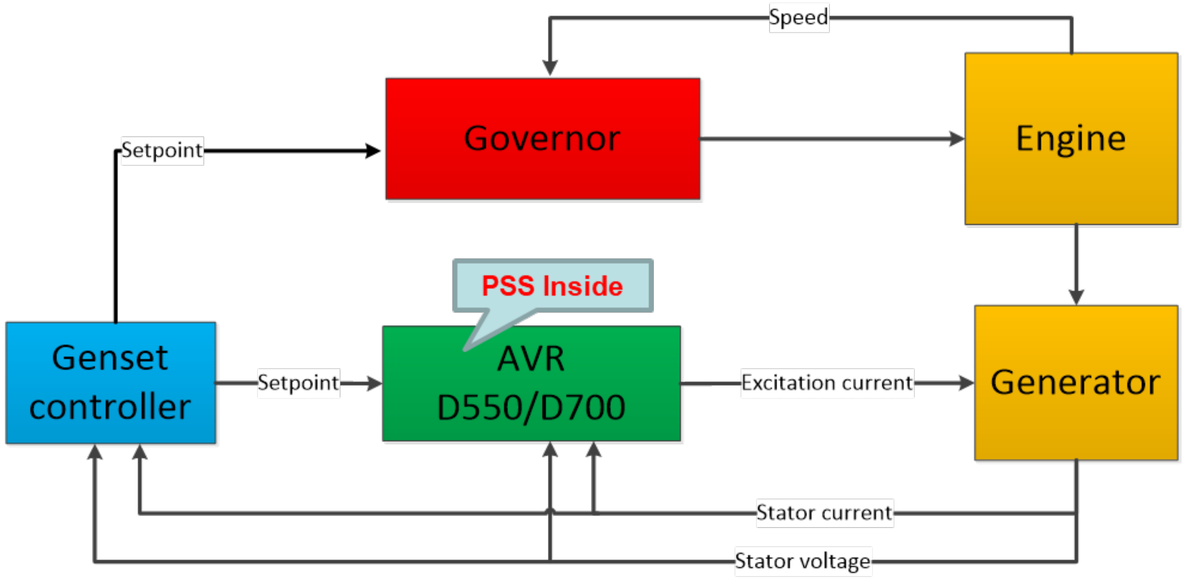
All servicing or repair operations performed on the AVR should be undertaken by personnel trained in the commissioning, servicing and maintenance of electrical and mechanical components.

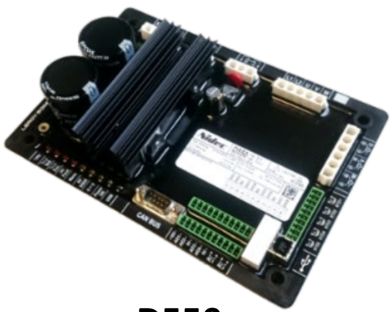
WARNING

This AVR can be incorporated in a EC-marked machine.
This manual is to be given to the end user.

Power System Stabilizer for D550 and D700

Power System Stabilizer for D550 and D700 digital voltage regulator





D550

D700

Table of contents

Introduction

Overall, AVRs, or Automatic Voltage Regulators, allow to obtain more stable power generation system due to their fast dynamics. However, these very fast regulations may create, in certain operating conditions, oscillations of the rotor angle of the machines. This leads to ripple on the output frequency and electrical power of the machines.

The oscillation frequency range of these perturbations may be divided into three different groups, linked with the origin of the corresponding oscillations:

- The range 0.1Hz to 1Hz corresponds to the low-frequency inertial mode;
- The range 1Hz to 2Hz corresponds to the local mode or interarea mode;
- And the range 2Hz to 3Hz corresponds to the intra plant mode.

To limit the negative effects of these oscillations, it is possible to use an additional functionality of the AVR called PSS (Power Stabilizer System) which, depending on the active power and the frequency variations, will act on the generator excitation level to limit the undesired oscillations of the system.

1. PSS Description

Several PSS structures exist and the one named PSS2C has been implemented into the D550 and the D700 digital AVRs.

As mentioned above, a PSS aims to increase the damping level of the global power system over a certain frequency range. For that purpose, the idea is to measure signals that are representative of the power oscillations (generally frequency, speed or active power) and to optimally combine them to act on the voltage regulator setpoint. Indeed, a bias added to the voltage setpoint will tend to change the excitation level of the generator, and therefore to increase or decrease the magnetic link between stator and rotor. If these excitation level modifications are optimally determined, then they will counteract the rotor speed oscillation, thus increasing the stability of the global system.

According to its topology, a PSS is generally composed of two main parts arranged in different orders:

- The first part deals with the input signals processing. The different inputs of the system are indeed adequately scaled, shifted and arranged to serve the purposes of the PSS.
- The second part is the output stage of the PSS. It consists in phase shifting the output of the PSS in order to apply the right correction on the voltage setpoint. A scaling is applied as well to obtain the expected level of damping.

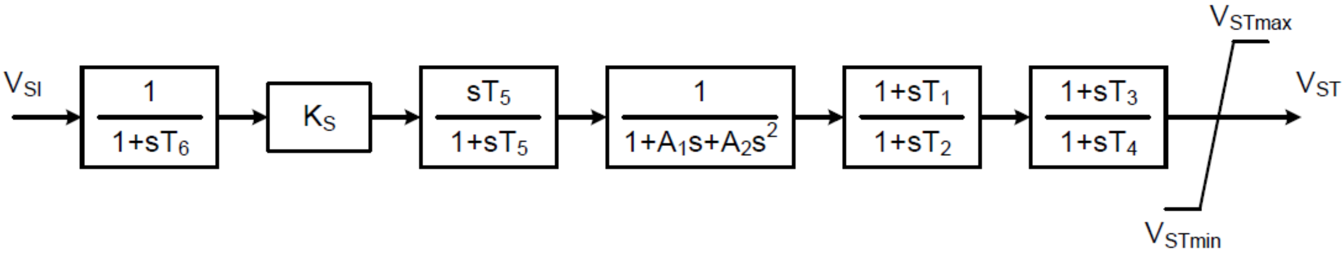
1.1. IEEE PSS structures

The IEEE committee has defined different types of standard PSS structures. These structures represent different level of complexity and therefore have different characteristics. Following the application and the needs regarding the additional damping required by the system, the user can choose one appropriate structure that will offer sufficient degrees of freedom to achieve the expected behaviour. The different structures proposed in the IEEE 421.5 2016 are briefly described in the following subsections.

1.1.1. PSS1A

The PSS1A is the simplest structure that can be implemented. The single input is generally connected to a rotating velocity signal (speed or frequency) or to the electrical power. This structure is composed of:

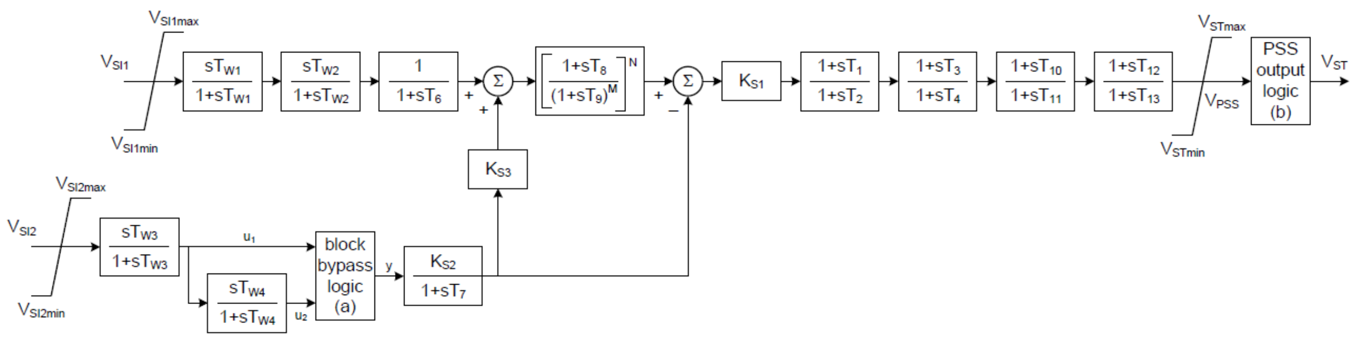
- A transducer block (T6 time constant) representing the signal measurement dynamic;
- A global gain block of the PSS Ks;
- A washout filter (T5 time constant) for suppressing the signal DC bias;
- A second-order filter accounted for refining the input or output signal shaping;
- Two lead-lag filters (T1 to T4) for adjusting the phase shift of the PSS output signal.



1.1.2. PSS2C

The PSS2C is a widely used structure, providing a very good compromise between efficient system damping and implementation complexity. Its dual-input is generally connected to a speed-representing signal (Vsi1) and to the electrical power of the generator (Vsi2). The PSS then combines these signals to calculate the integral of accelerating power, that gives a good image of mechanical power changes in the system. This structure is composed of:

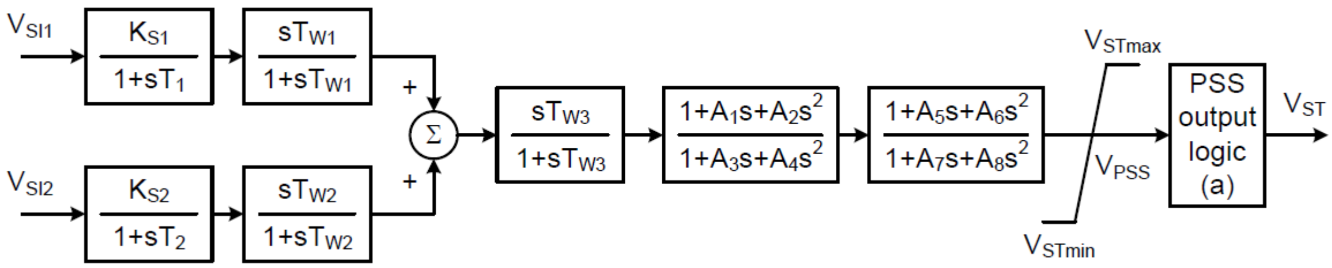
- Washout filters (Tw1, Tw2, Tw3 and Tw4) for suppressing the very low frequency components in the input signals;
- A transducer block (T6);
- A low-pass filter (T7) together with two scaling gains (Ks2 and Ks3) for adjusting the electrical power input;
- A Ramp Tracking Filter (T8 and T9) used for preventing the PSS from reacting to slow electrical power changes;
- A global PSS gain Ks1;
- Four lead-lag filters (T1, T2, T3, T4, T10, T11, T12 and T13) for adjusting the phase shift of the output signal.



1.1.3. PSS3C

The PSS3C is a dual-input PSS, generally connected to the electrical power (Vsi1) and rotor angular speed deviation (Vsi2). The global structure is quite simple, the inputs are processed and composed to generate an accelerating power signal. It is composed of:

- Two transducer blocks (T1 and T2) with Ks1 and Ks2 gains;
- Three washout blocks (Tw1, Tw2 and Tw3) for the inputs and the accelerating power signal;
- Two second-order filters for output signal phase compensation (A1 to A8).

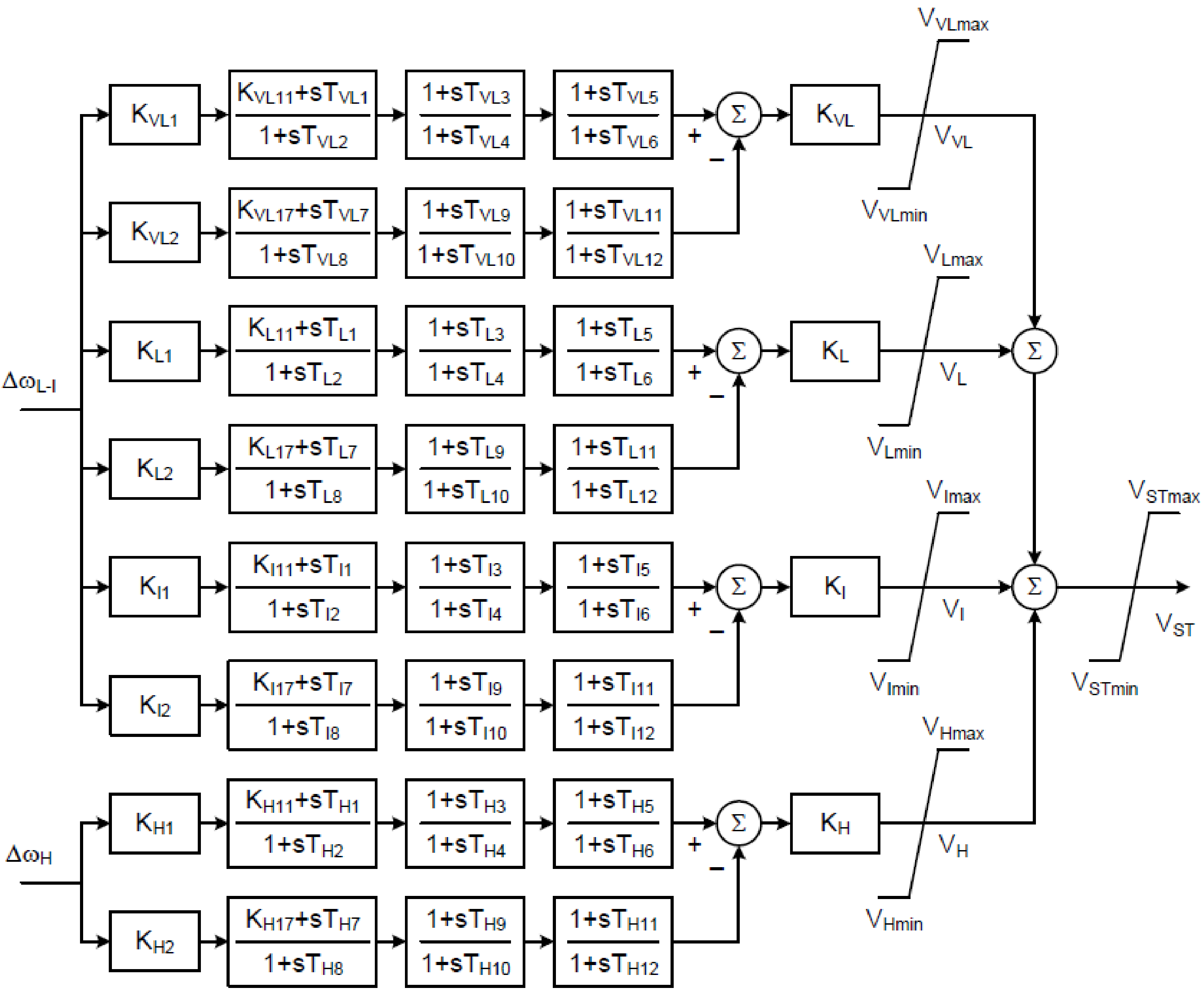


1.1.4. PSS4C

The PSS4C has been created to seperately deal with the low- medium- and high-frquency bands related to the power oscillations of the system. The rotor speed deviation is measured differently for low and intermediate frequencies on one side and high-frequencies on the other. Each band is composed of:

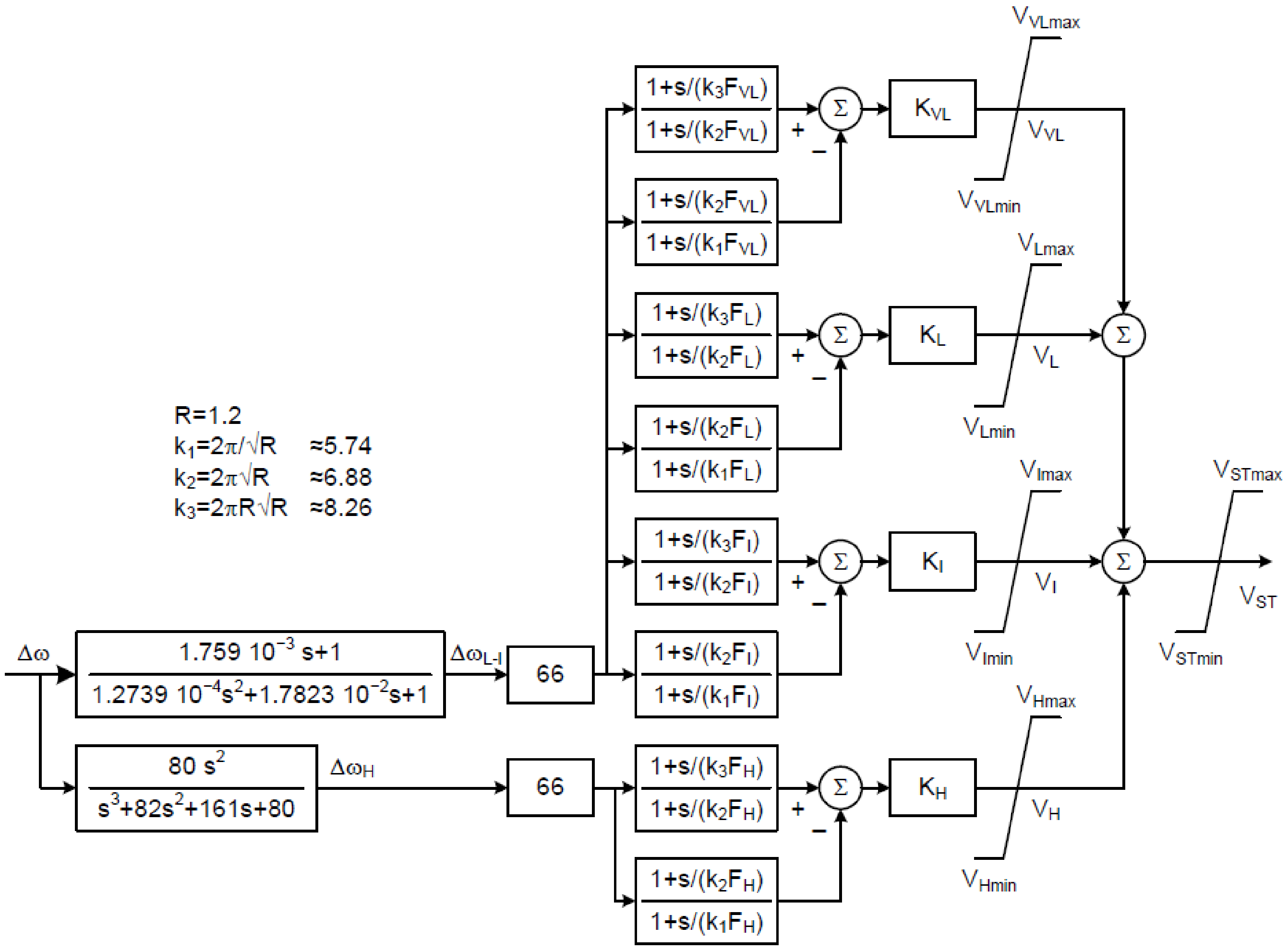
- A differential filter (blocks before the summing points ;
- A gain;
- A limiter.

All the outputs are summed and limited to provide the PSS output signal.



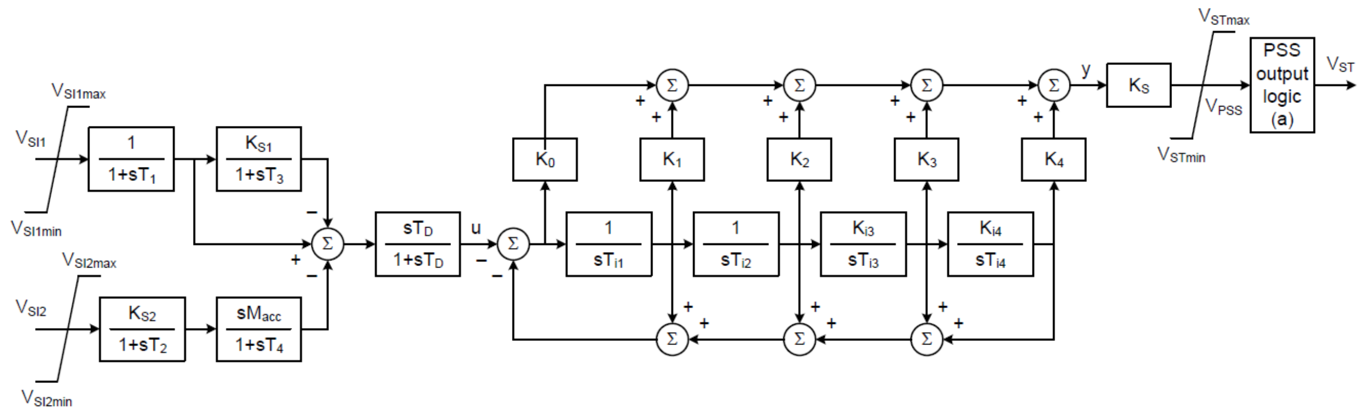
1.1.5. PSS5C

The PSS5C is a kind of simplified PSS4C with a single input. The processing of this input is then separated and provides two signals for the different frequency bands. As for the PSS4C, the aim is here to provide a specific response of the PSS with regards to the band in which the input frequency lies.



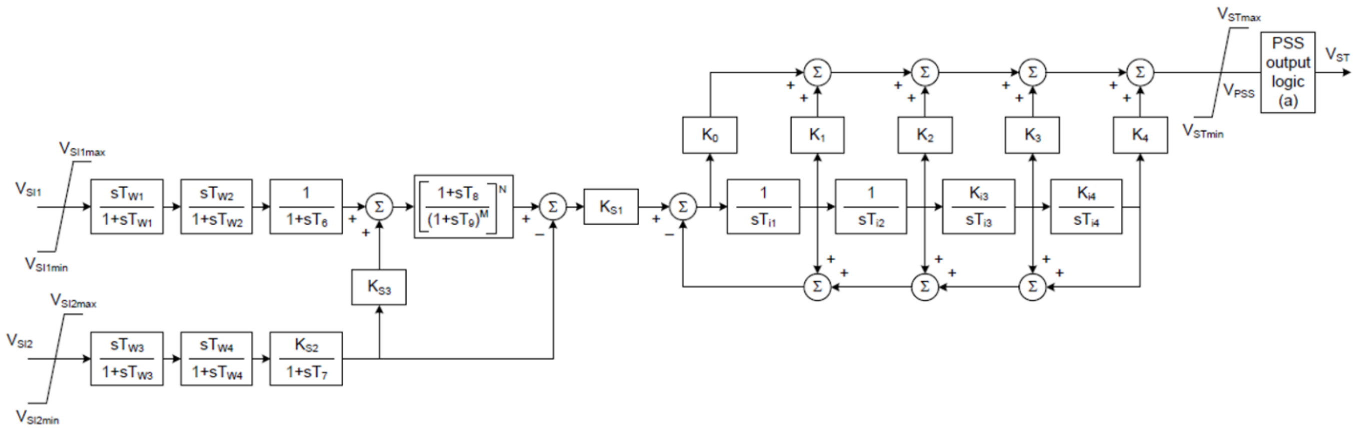
1.1.6. PSS6C

The structure of the PSS6C is derived from the PSS3C one with a dual input (typically generator electrical power output and rotor angular speed deviation) to produce a signal proportional to the accelerating power. A conversion between PSS3C and PSS6C is possible.



1.1.7. PSS7C

Finally, the PSS7C is a hybrid between PSS2C and PSS6C. It has the same structure as the PSS2C but the phase compensation is provided by a canonical state equation, as for PSS6C. It is possible to transform PSS2C into PSS7C parameters.



1.2. PSS2C detailed description

The PSS integrated in the D550 and the D700 follows the PSS2C structure. This section details the different parts of this structure and the associated parameters.

1.2.1. Input signals

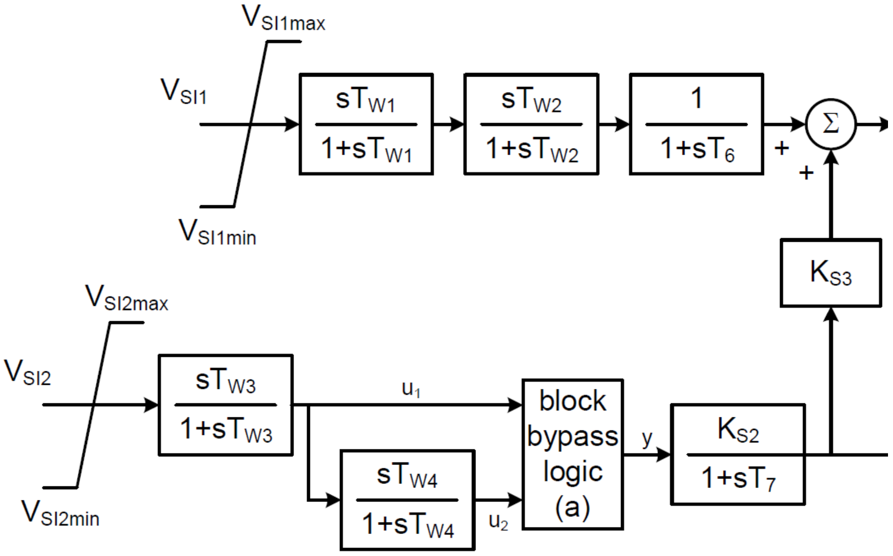
The PSS2C has two input signals:

- Vsi1 is the electrical frequency deviation. It is limited between Vsi1max and Vsi1min, typically 2 and -2;
- Vsi2 is the generator electrical active power. It is limited between Vsi2max and Vsi2min, typically 2 and -2.

1.2.2. Input signal processing

The input signals are pre-processed in order to isolate the significant part for PSS operation. This pre-processing stage consists in different filters:

- For Vsi1 input (frequency deviation)
  - A transducer filter (unity gain low-pass filter) that takes into account the measurement system time constant T6;
  - Two washout filters for deleting the very low frequencies of the signals. These filters consist in unity gain high-pass filters (Tw1 and Tw2).
- For Vsi2 input (electrical active power)
  - A low-pass filter with Ks2 gain (T7 time constant) to cut off the high-frequency components compared to the relevant frequency range;
  - Two washout filters for deleting the very low frequencies of the signals (Tw3 and Tw4). One of the two washout filters may be bypassed thanks to a logic block.



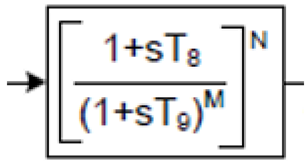
The gain Ks3 is generally set to 1 and the two input signals are combined to create the integral of the mechanical power. The previous relation is derived from:

$$P_m = 2Hs\omega + P_e \Rightarrow \int P_m = 2H\omega + \int P_e$$

1.2.3. Ramp Tracking Filter

The integral of the mechanical power is then sent to a Ramp Tracking Filter. This high-order filter aims to allow low-frequency mechanical power changes to pass through and prevent the system from reacting when submitted to fast changes in the electrical power. Indeed, the electrical power produced by the generator may change very fast, that is not the case for the mechanical power. Therefore, this filter enables to obtain a good image of the real modification of the mechanical power from changes in the electrical power. Typical values for this filter are:

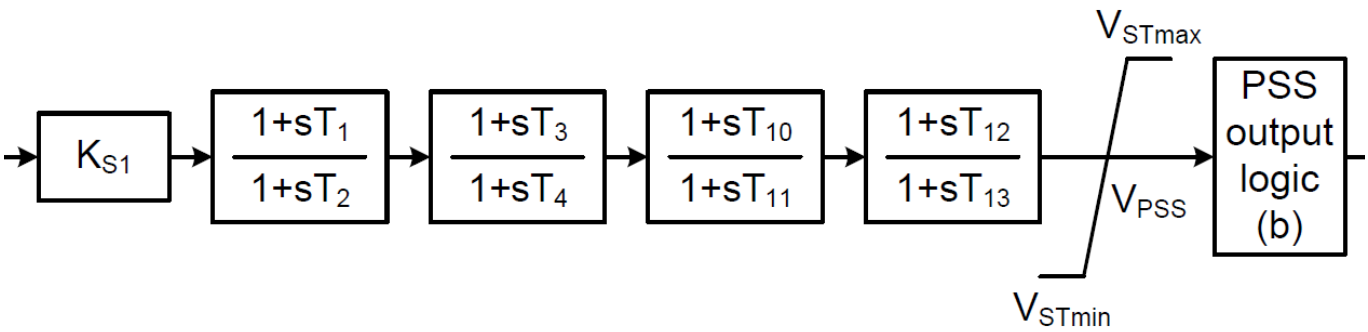
- M = 5;
- N = 1;
- T8 = 0.5s;
- T9 = 0.1s.



The filtered signal coming from the Ramp Tracking Filter is then combined with the integral of the electrical power in order to obtain the integral of the accelerating power.

1.2.4. Output stage

Finally, the integral of the accelerating power is scaled by the global PSS gain Ks1 and is submitted to a phase compensation stage. Indeed, in order to compensate the phase shift created by all the electrical and mechanical phenomena between the PSS output and the torque applied on the shaft, four lead-lag filters are present in the PSS structure. This phase compensation can be accurately configured thanks to eight parameters (T1, T2, T3, T4, T10, T11, T12 and T13 time constants).



The output signal is finally limited between V_{STmax} and V_{STmin} (typically 0.1 and -0.1) and an output logic bloc enables to activate or disactivate the PSS.

2. PSS2C implementation in D550 and D700

In the D550 and D700 AVR products, PSS is embedded in application firmware. To integrate this function in the firmware, a discretization of the PSS has been used and the corresponding functional diagram is given below. The Output of PSS is a saturated bias integrated in the list of setpoints.

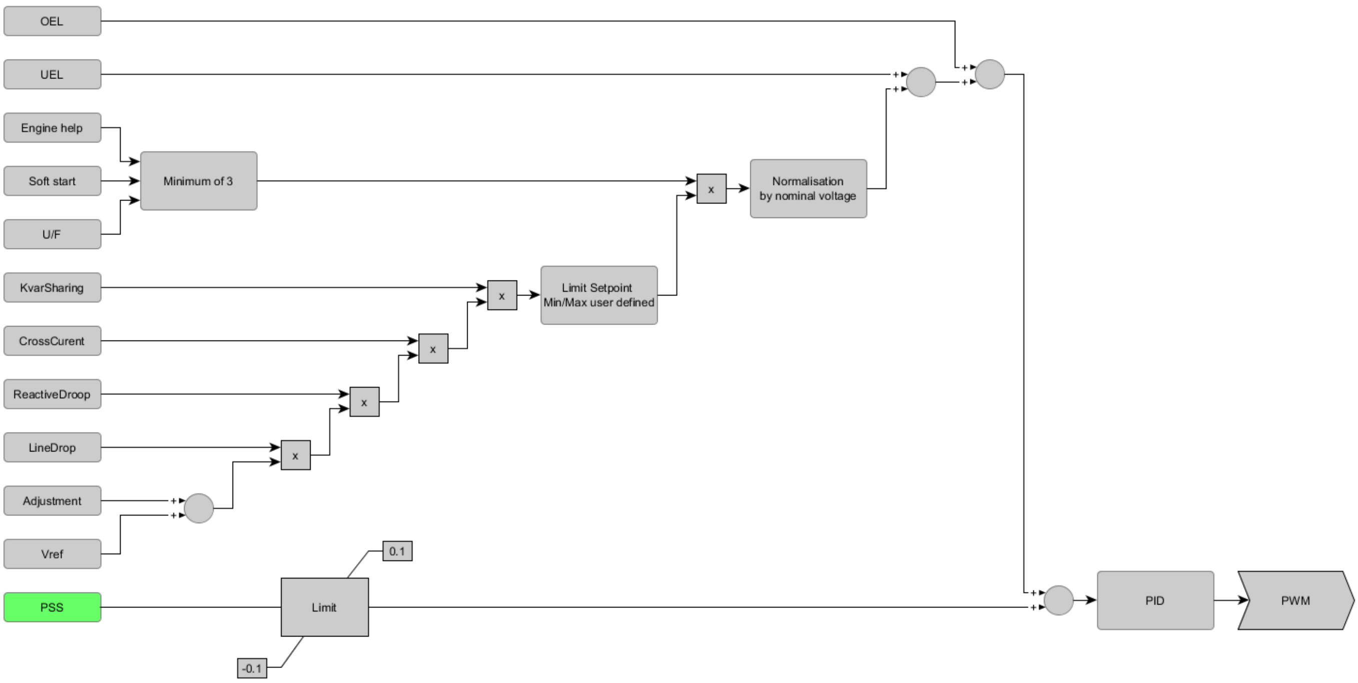


Figure 1 - PSS setpoint integration

PSS Filters integration part is described hereunder:

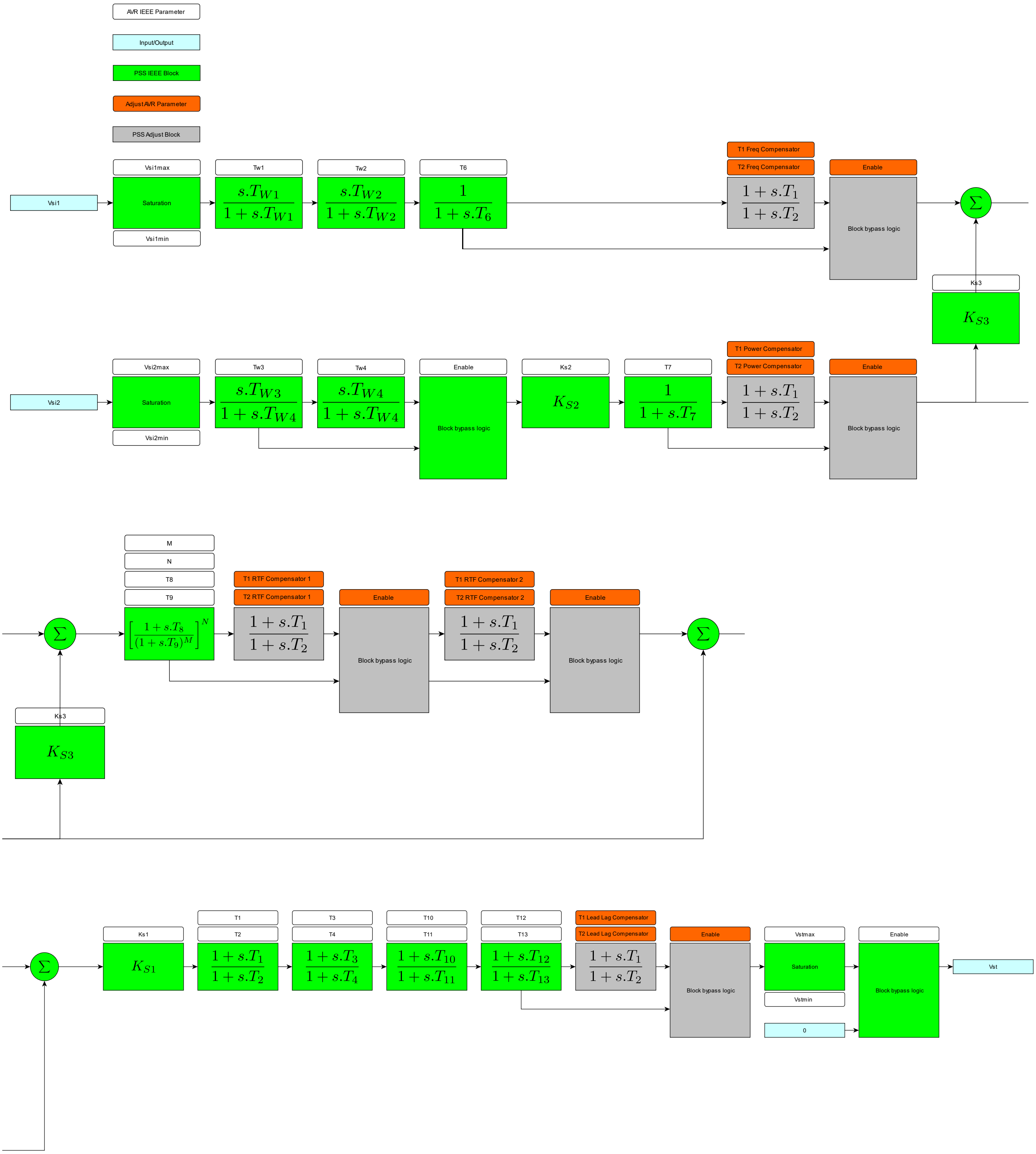


Figure 2 - Full PSS2C Integration

In Figure 2 - Full PSS Integration is described. Based on the IEEE model, all filters embedded in the product to achieve the PSS2C functionality may be found in the picture. However, other filters (in grey) are added and not defined by the standard model, these filters must be configured to optimize the filter block phase.

3. PSS Activation and configuration in EasyReg Advanced

To configure PSS function in EasyReg Advanced, an Add-on must be installed to unlock the configuration page.

3.1. Unlock function PSS

After this installation, go in Add-on page to see new button:

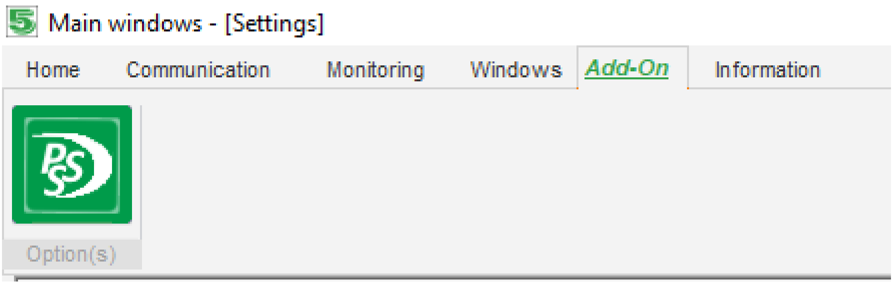


Figure 3 - Add on page

In this menu click on PSS option, the page hereunder will appear:

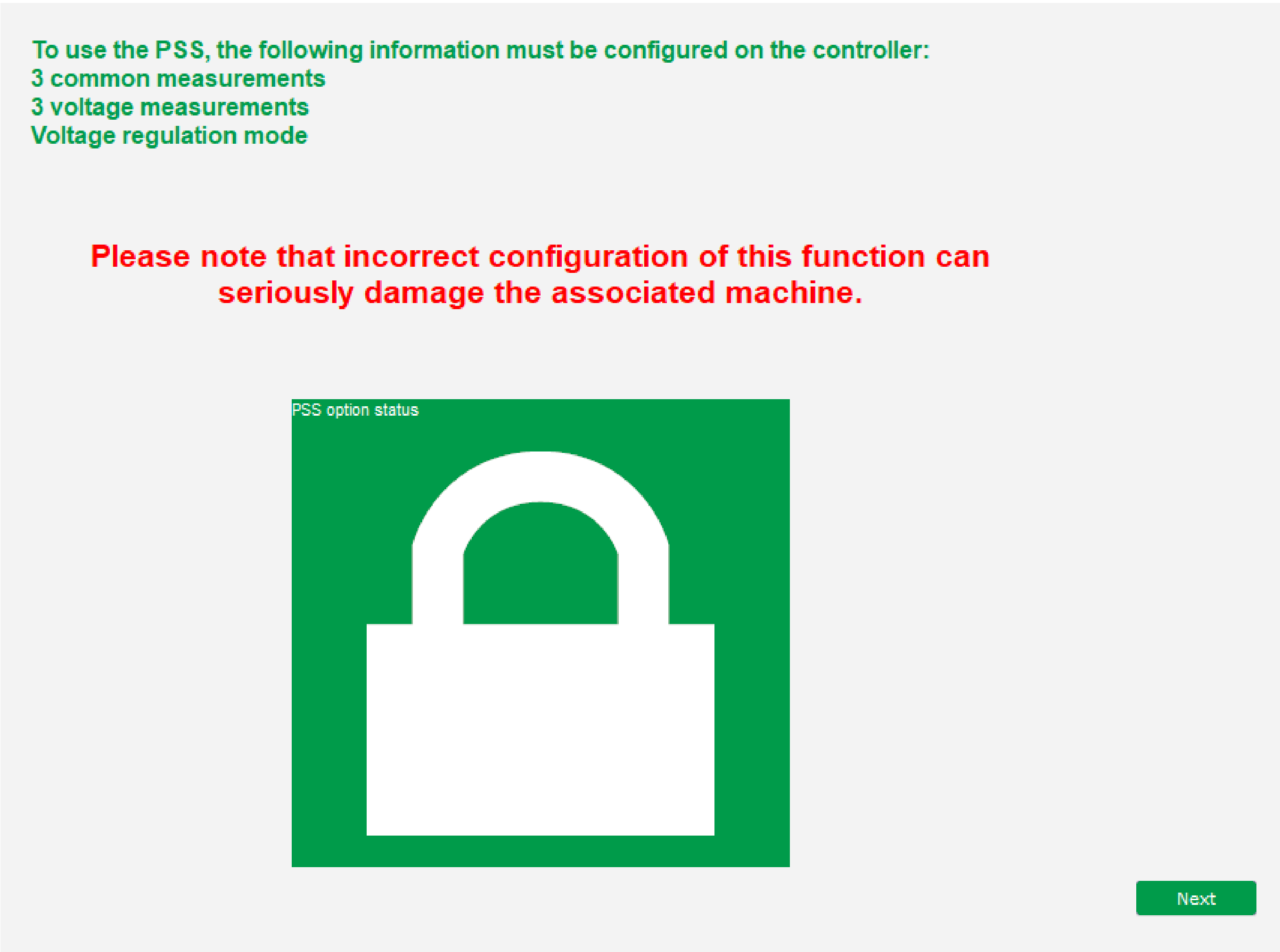


Figure 4 - PSS unlock function page

On this page, if the connected AVR does not embed PSS function or no AVR is connected to your computer, the padlock will appear closed. However, if the function is already unlocked, the padlock will appear open.

If the option is locked, you can set the password by clicking on the padlock:

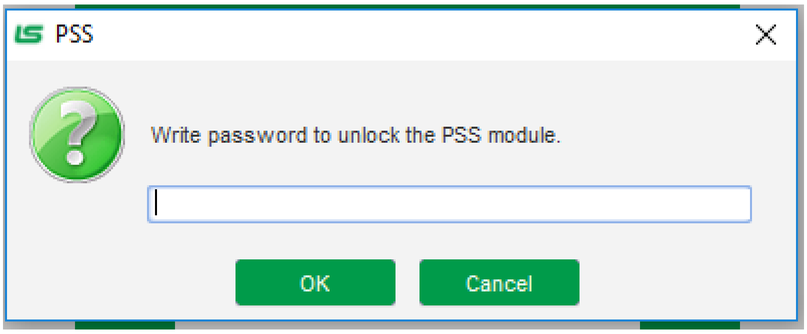


Figure 5 - Password PSS page

3.2. PSS configuration

After enabling the PSS function, by clicking on the next button, a new page appears with a first set of filters defined in the IEEE standard.

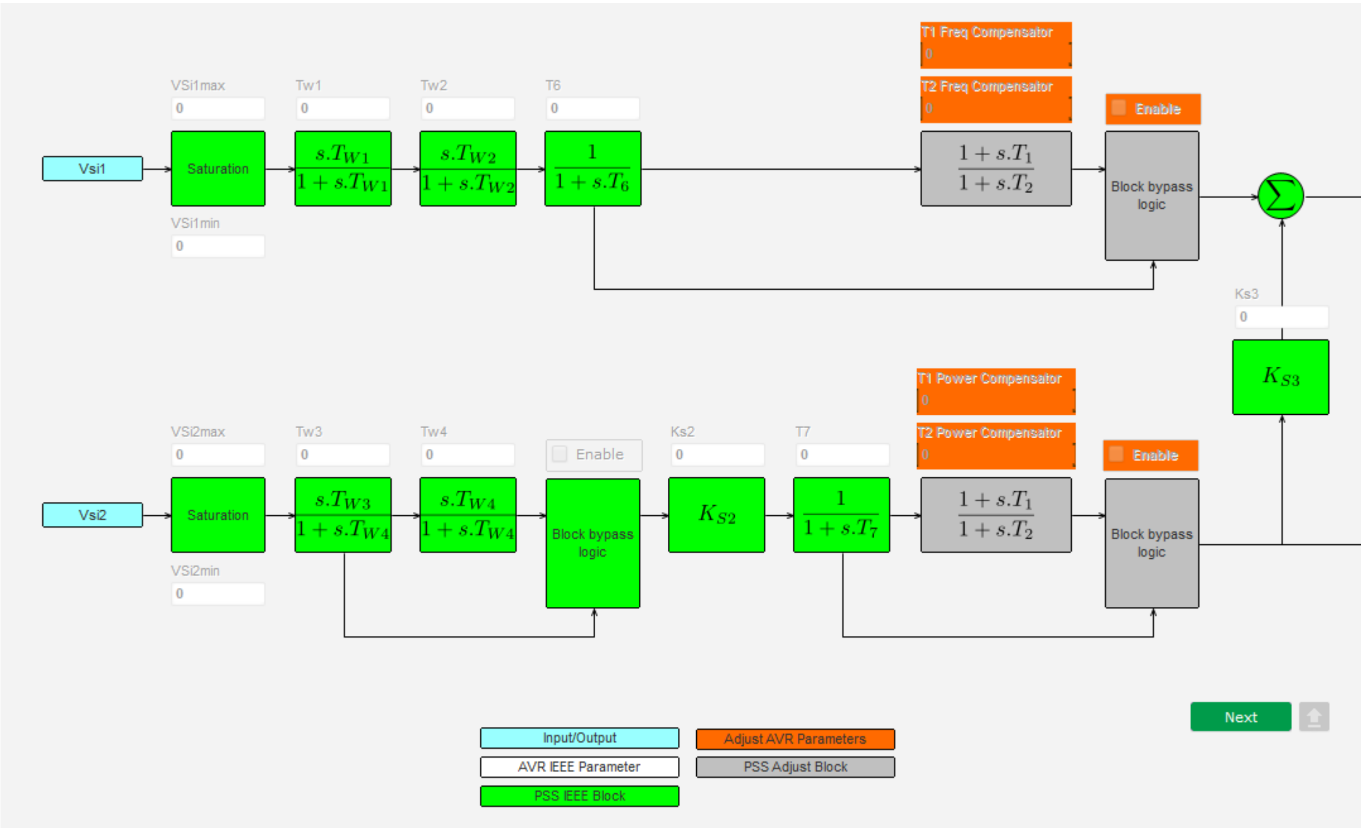


Figure 6 - PSS input part

In this page, all parameters should be set with values given by Leroy-Somer. Please contact service.epg@leroy-somer.com for assistance.

By clicking on the next button, a new page of configuration will appear.

This page is used to configure the RTF filter:

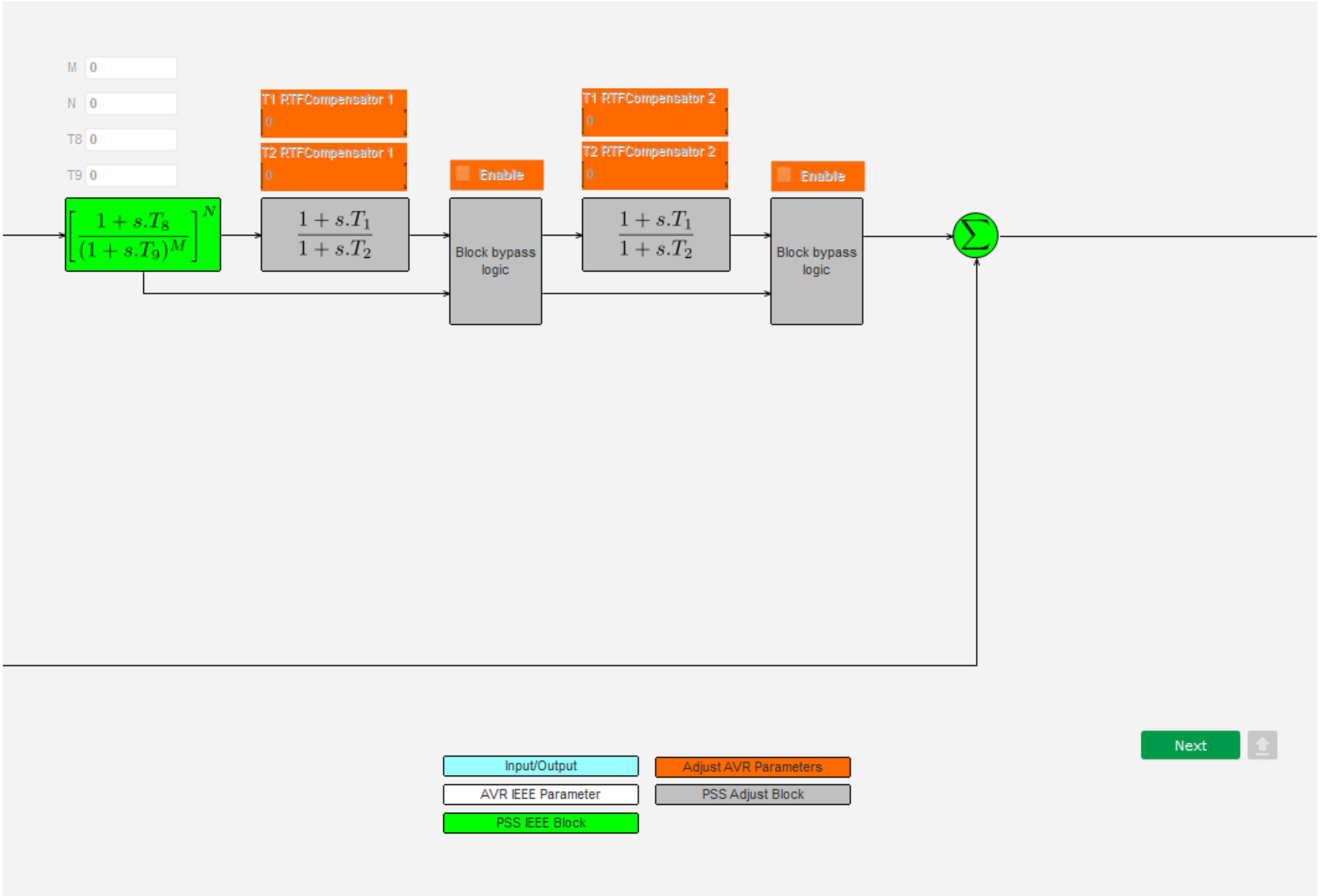


Figure 7 - PSS RTF Part

Here again, all parameters should be set with values given by Leroy-Somer.

By clicking on the next button, a new page of configuration will appear.

This page is used to configure the output filters (Lead-Lag):

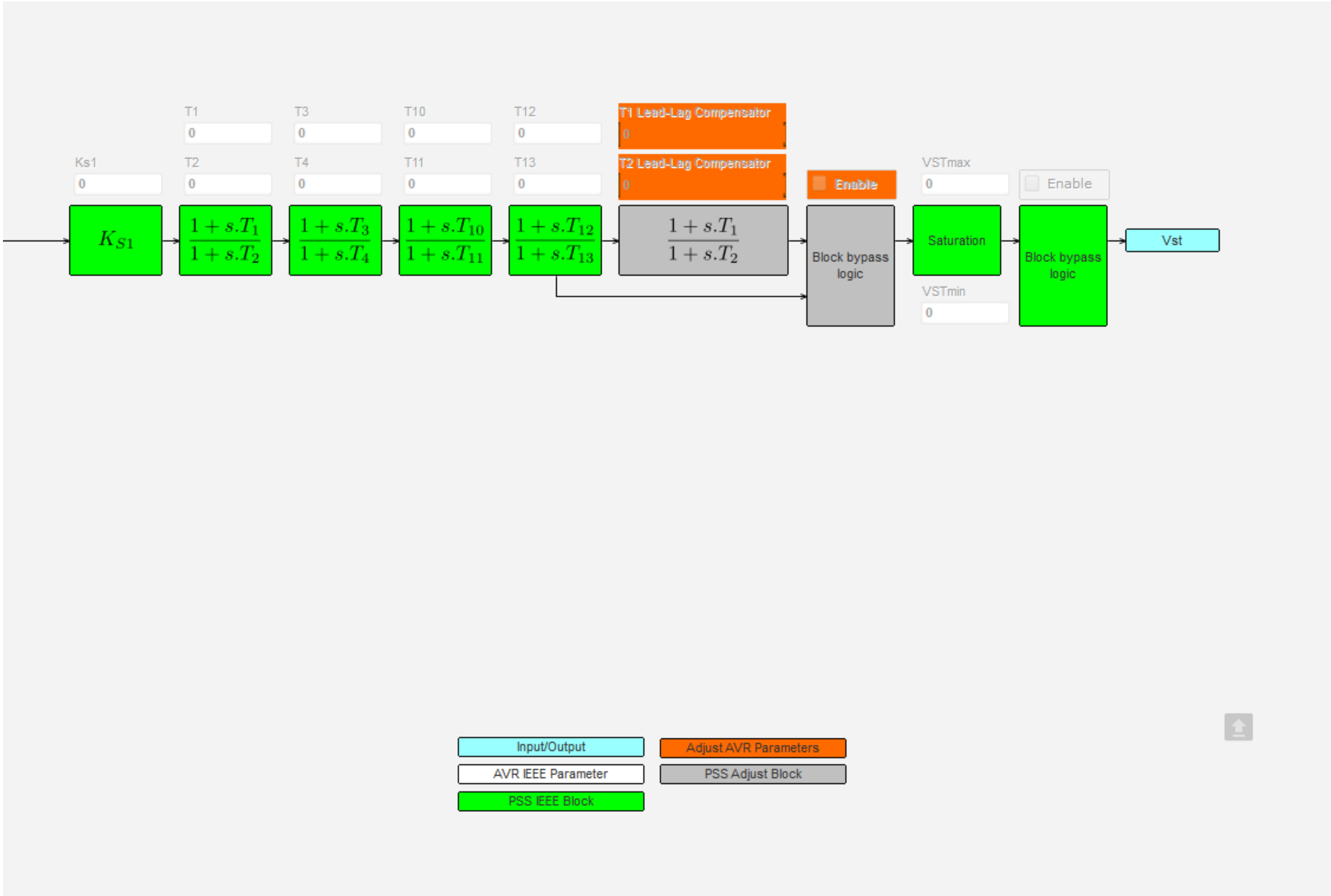


Figure 8 - PSS Output part

All parameters should be set with values given by Leroy-Somer.

After full parameter set, the configuration can be uploaded into the AVR.

Service & Support

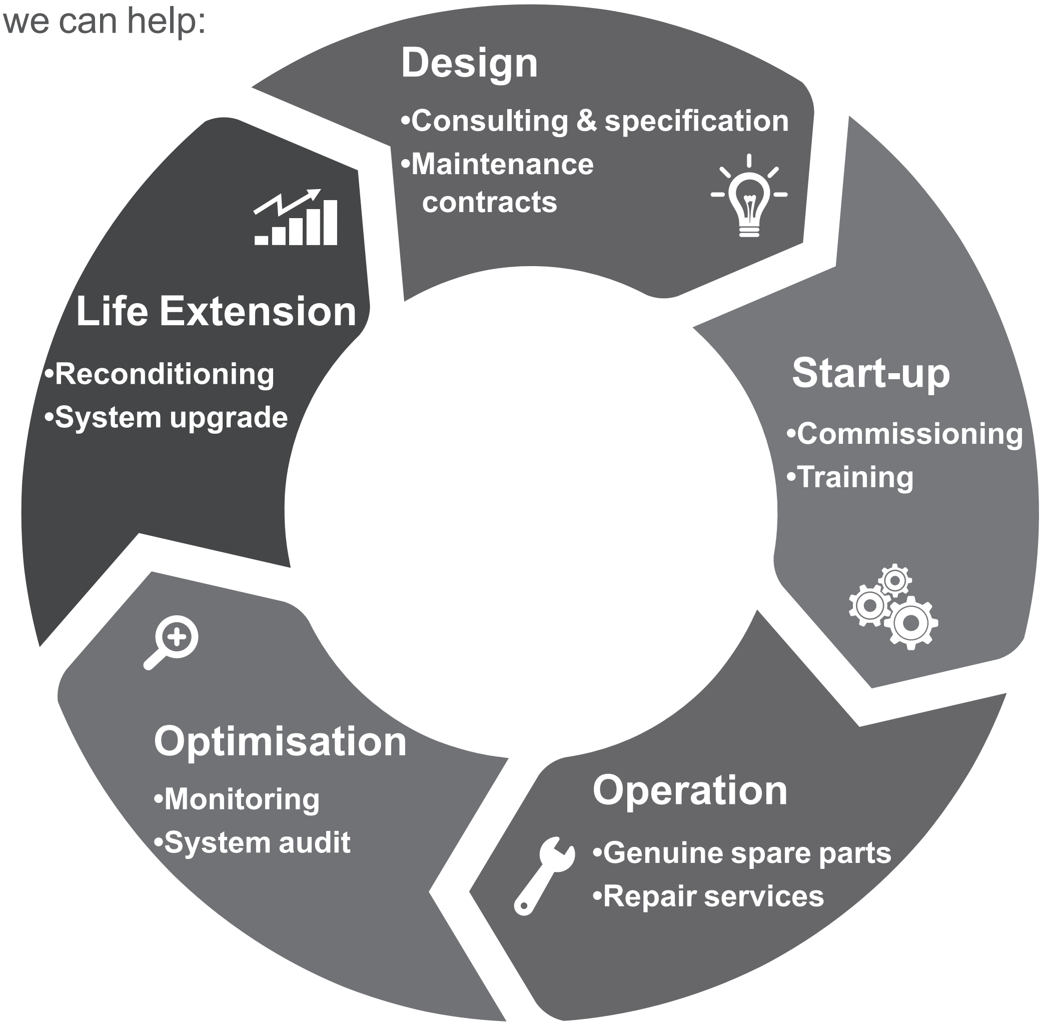
Our worldwide service network of over 80 facilities is at your service.

This local presence is our guarantee for fast and efficient repair, support and maintenance services.

Trust your alternator maintenance and support to electric power generation experts. Our field personnel are 100% qualified and fully trained to operate in all environments and on all machine types.

We have a deep understanding of alternator operation, providing the best value service to optimise your cost of ownership.

Where we can help:



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