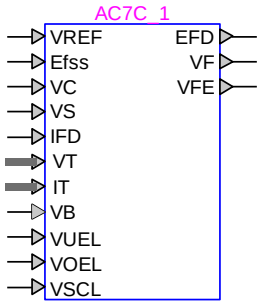
Exciters and Governors: Exciter AC7C



Exciter AC7C

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1 Description

This device is an implementation of the IEEE type AC7C excitation system model. This device is implemented as described in [1]. Implementation details can be viewed by inspecting the subcircuit of this device.

1.1 Pins

This device has 13 pins:

Pin name	Type	Description	Units
VREF	Input	Reference voltage of the stator terminal voltage	pu
Efss	Input	Steady-state field voltage at t = 0, for initialization	pu
VC	Input	Terminal voltage of synchronous machine, transducer output	pu
VS	Input	Power System Stabilizer signal	pu
IFD	input	Field current	pu
VT	Input, bundle	Terminal voltage (phasor) of synchronous machine (magnitude and phase)	pu
IT	Input, bundle	Current (phasor) of synchronous machine (magnitude and phase)	pu
VB	Input	Available exciter voltage	pu
VUEL	Input	Under Excitation Limiter signal	pu
VOEL	Input	Over Excitation Limiter signal	pu
VSCL	Input	Stator Current Limiter signal	pu
EFD	Output	The field voltage signal	pu

VF	Output	The excitation system stabilizer signal	pu
VFE	Output	Signal proportional to exciter field current	pu

1.2 Parameters

The default set of parameters can be found in [1].

1.2.1 Data tab

The parameters on the Data tab are:

1. **Gain K_{PA}**: Field current regulator proportional gain
2. **Gain K_{IA}**: Field current regulator integral gain
3. **Maximum regulator output V_{Amax}**: Maximum field current regulator output
4. **Minimum regulator output V_{Amin}**: Minimum field current regulator output
5. **Gain K_{PR}**: Voltage regulator proportional gain
6. **Gain K_{IR}**: Voltage regulator integral gain
7. **Gain K_{DR}**: Voltage regulator derivative gain
8. **Time constant T_{DR}**: Lag time constant for derivative channel of PID controller
9. **Maximum regulator output V_{Rmax}**: Maximum regulator output
10. **Minimum regulator output V_{Rmin}**: Minimum regulator output
11. **Gain K_L**: Gain related to negative exciter field current capability
12. **Gain coefficient K_P**: Potential circuit gain coefficient
13. **Phase angle $Theta_p$**: Potential circuit phase angle (degrees)
14. **Gain K_I**: Potential circuit (current) gain coefficient
15. **Reactance X_L**: Reactance associated with potential source
16. **Gain K_{C1}**: Rectifier loading factor proportional to commutating reactance
17. **V_{Bmax}**: Maximum available exciter field voltage
18. **Gain K_R**: Gain related to regulator and alternator field power supply
19. Excitation Type option: see explanations below.
20. Voltage Regulator power option: see explanations below.
21. Under Excitation Limiter option: see explanations below.
22. Over Excitation Limiter option: see explanations below.
23. Stator Current Limiter option: see explanations below.

There are two possible selections for the Excitation Type option:

1. Excitation system is self-excited: VT and IT inputs must be connected.
2. Excitation system comes from a separate source: VB input must be connected

There are two possible selections for the Current Control Type option:

1. Feedback from generator field voltage E_{FD}.
2. Feedback from exciter field current V_{FE}.

There are three possible selections for the Under Excitation Limiter option:

1. VUEL not available or added to the reference voltage: this option can be selected when the VUEL input signal is zero (not connected) or when it is connected and added to the reference voltage.
2. VUEL connected to the first high value gate (HV gate).
3. VUEL connected to the second high value gate (HV gate).

There are three possible selections for the Over Excitation Limiter option:

1. VOEL not available or added to the reference voltage: this option can be selected when the VOEL input signal is zero (not connected) or when it is connected and added to the reference voltage.
2. VOEL connected to the first low value gate (LV gate).
3. VOEL connected to the second low value gate (LV gate).
4. VOEL connected to the third low value gate (LV gate).

There are five possible selections for the Stator Current Limiter option:

1. VSCL not available or added to the reference voltage: this option can be selected when the VSCL input signal is zero (not connected) or when it is connected and added to the reference voltage.
2. VSCL connected to the first high value gate (HV gate).
3. VSCL connected to the first low value gate (LV gate).
4. VSCL connected to the second high value gate (HV gate).
5. VSCL connected to the second low value gate (LV gate).

1.2.2 Exciter tab

The exciter tab allows to input:

1. **Gain K_E**: Exciter gain
2. **Time constant T_E**: Exciter time constant
3. **Gain K_{F1}**: Excitation control system stabilizer gain
4. **Gain K_{F2}**: Excitation control system stabilizer gain
5. **Gain K_{F3}**: Excitation control system stabilizer gain
6. **Time constant T_F**: Excitation control system stabilizer time constant
7. **Field current limit V_{FEmax}**: Exciter field current limit
8. **Voltage V_{Emin}**: Minimum of exciter voltage back of commutating reactance
9. **Demagnetizing factor K_D**: Demagnetizing factor, function of exciter alternator reactances
10. **Rectifier loading factor K_C**: Rectifier loading factor proportional to commutating reactance
11. **Field voltage V_{E1}**: The exciter voltage point which is near the exciter ceiling voltage
12. **Field voltage V_{E2}**: The exciter voltage point which is near 75% of V_{E1}
13. **Saturation function output SE_V_{E1}**: The exciter saturation function value at V_{E1}
14. **Saturation function output SE_V_{E2}**: The exciter saturation function value at V_{E2}

There are two possible selections for the Under Excitation Limiter option:

The exciter saturation function is defined as

$$S_E = A_{EX} e^{B_{EX} E_{FD}} \tag{1}$$

which gives the approximation saturation for any E_{FD} (exciter output voltage). According to [2] (see pages 562 and 563), the coefficients A_{EX} and B_{EX} can be found from:

$$A_{EX} = \frac{S_{V_{E2}}^4}{S_{V_{E1}}^3} \tag{2}$$

$$B_{EX} = \frac{4}{V_{E1}} \ln\left(\frac{S_{V_{E1}}}{S_{V_{E2}}}\right) \tag{3}$$

In the literature [2] $V_{E1} = V_{E_{max}}$ and $V_{E2} = V_{E_{0.75max}}$.

2 Initial conditions

The reference voltage VREF can be manually or automatically set by connecting or not connecting the input signal VREF, respectively. When VREF is not connected (the signal is zero), the reference voltage is internally found from the steady-state solution. When VREF is connected, its initial value must match the per unit steady-state voltage of the stator terminal voltage, since otherwise the generator voltage will not start at the actual steady-state.

3 References

[1] "IEEE Recommended Practice for Excitation System Models for Power System Models for Power System Stability Studies," IEEE Standard 421.5-2016.

[2] P. M. Anderson and A. A. Fouad, “Power system control and stability”, second edition, IEEE Press, Wiley Interscience, 2003.