European User's Group Meeting
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Obtaining the frequency responses of AVR and PSS using RTDS Simulator

Anton Kushnir, JSC «STC UPS»

«STC UPS» JSC is a sub-company of System Operator. One of the directions of work which are performed in «STC UPS» JSC is testing AVRs and PSSs

System Operator certificate

СИСТЕМА ДОБРОВОЛЬНОЙ СЕРТИФИКАЦИИ ОАО «СО ЕЭС»
(СДС «СО ЕЭС»)

Орган по добровольной сертификации СДС «СО ЕЭС» ОАО «НТЦ ЕЭС»
(ОДС СДС «СО ЕЭС» ОАО «НТЦ ЕЭС»)

194223, Санкт-Петербург, ул. Курчатова, д. 1, лит. А

Свидетельство о допуске к проведению добровольной сертификации ОАО «НТЦ ЕЭС»
№ NTC3.SO.RU.0513 дата регистрации 28 мая 2013 г.

СЕРТИФИКАТ СООТВЕТСТВИЯ

Настоящий сертификат удостоверяет, что автоматические регуляторы возбуждения сильного действия синхронных генераторов типа _____ производства _____ с установленной версией программного обеспечения _____, предназначенные для работы в составе _____ систем возбуждения синхронных генераторов,
указывается тип системы возбуждения

соответствуют требованиям стандарта ОАО «СО ЕЭС»
СТО 59012820.29.160.20.001-2012 «Требования к системам возбуждения и автоматическим регуляторам возбуждения сильного действия синхронных генераторов»

на основании решения _____.
указываются номер и дата решения о выдаче сертификата соответствия

Настоящий сертификат соответствия зарегистрирован в реестре сертифицированных объектов СДС «СО ЕЭС» «___» _____20__г. за регистрационным №_____.

Срок действия сертификата соответствия: _____.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ
–

Руководитель органа
по добровольной сертификации А.Х. Есипович

«___» _____20__г.

М.П.

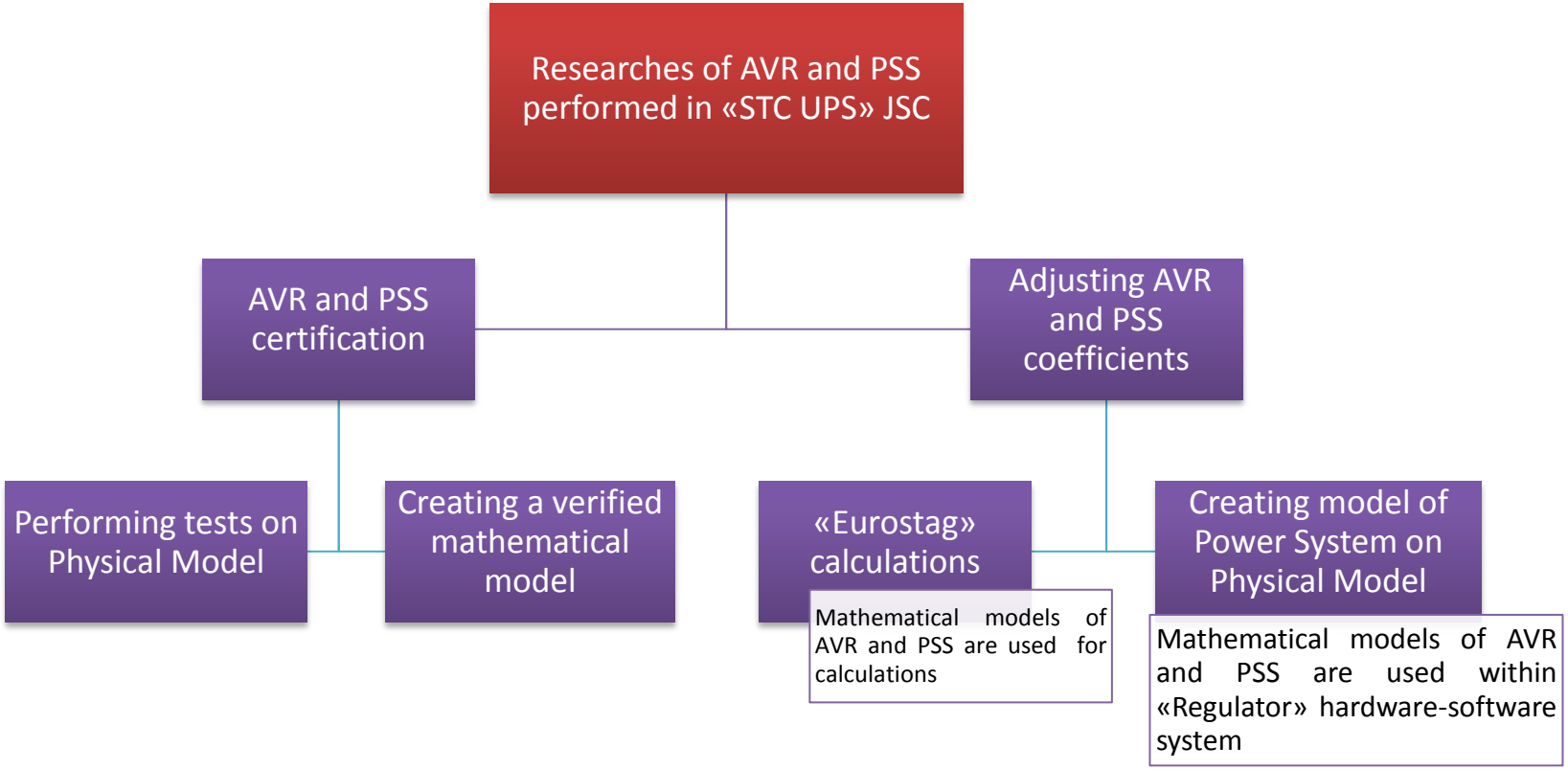
Presently certification is performed on «STC UPS» JSC **Physical Model**

Since year **2002** «STC UPS» JSC are doing researches of AVR and PSS

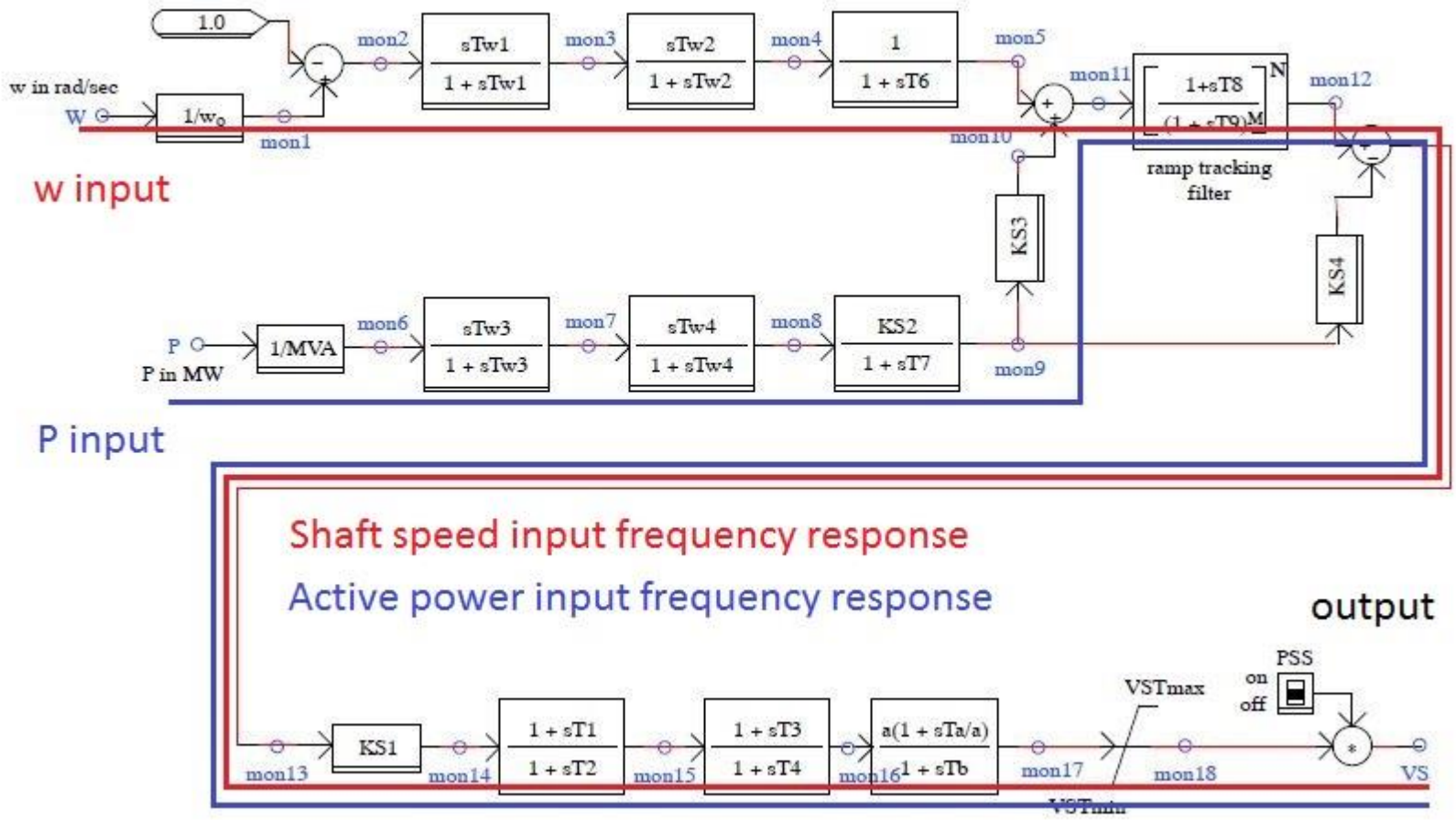
Since year **2011** «STC UPS» JSC are performing certification tests

AVRs which received System Operator certificate

AVR type	Manufacturer	Country	Date
Thyripol	Siemens	Germany	14.10.11
EX2100	General Electric	USA	27.10.11
EAA	Ansaldo Energia	Italy	14.12.11
THYNE1	Andritz Hydro	Austria	30.01.12
THYNE4/5/6	Andritz Hydro	Austria	06.02.12
MEC600	Mitsubishi	Japan	27.02.12
SEMIPOL	Converteam	Germany	01.06.12
DECS-2100	Basler Electric	USA	19.11.12
Unitrol 6000/6800	ABB	Switzerland	30.11.12
Unitrol 6080	ABB	Switzerland	30.11.12
EX2100-BR	General Electric	USA	13.12.12
AVR-2	Energocomplect	Russia	05.04.13


Researches of AVR and PSS performed in «STC UPS» JSC
AVR and PSS certification
Adjusting AVR and PSS coefficients
Performing tests on Physical Model
Creating a verified mathematical model
«Eurostag» calculations
Creating model of Power System on Physical Model
Mathematical models of AVR and PSS are used for calculations
Mathematical models of AVR and PSS are used within «Regulator» hardware-software system

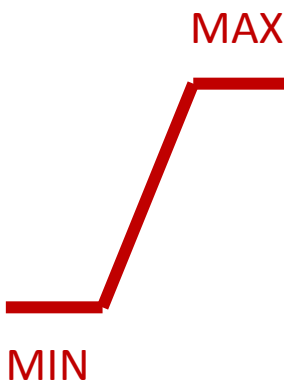
PSS2B model structure



Usually for measuring frequency responses of SISO liner time-irrelevant system following methods are applied:

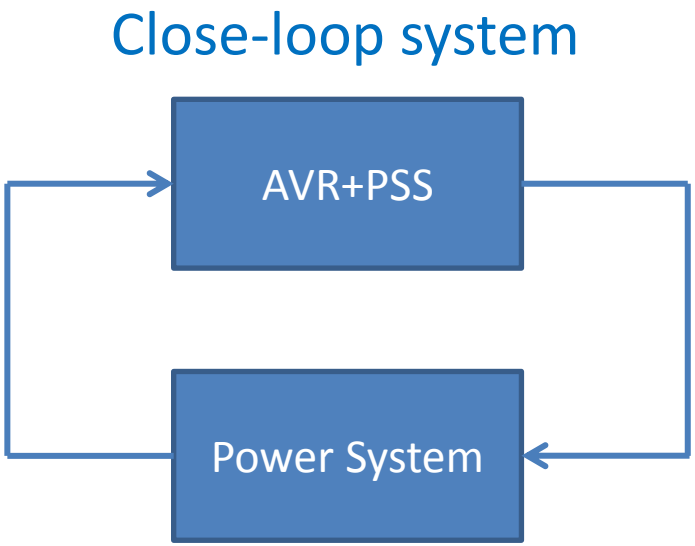
1. Sending on input of SISO system impulse and measuring its response
2. Applying a signal with a wide frequency spectrum
3. Sending a constant-amplitude pure tone through the bandwidth of interest and measuring the output level and phase shift relative to the input

Main problem – Limiters

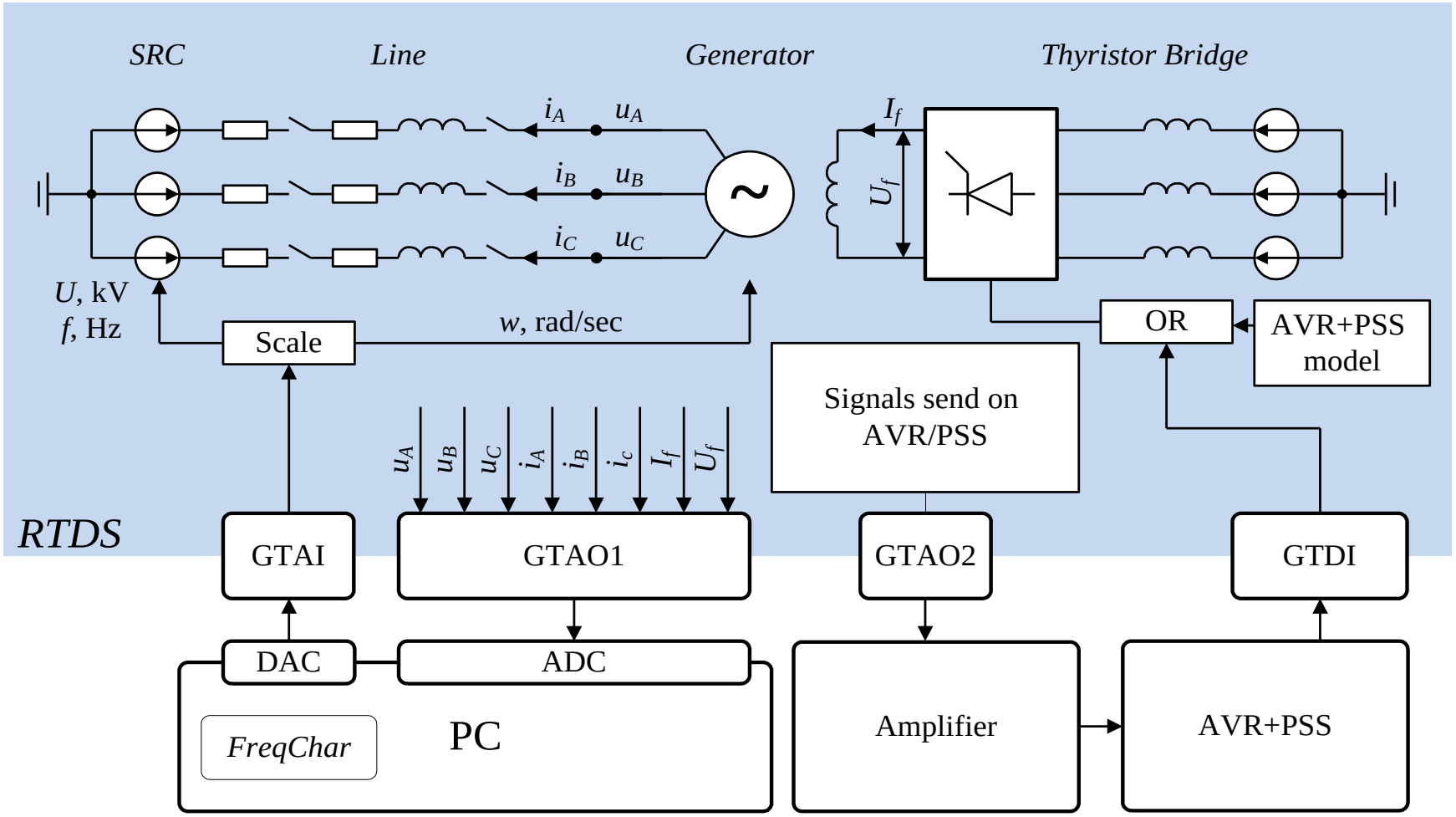


Other problems appear:

1. Input signals of AVR/PSS are instantaneous current and voltage
2. Most AVRs can't work without feedback signals
3. Some AVRs doesn't measure input parameters directly, instead of that those parameters are calculated from other signals(i.e. field current is calculated from instantaneous currents, which are measured before rectifier)
4. PSS can’t work without AVR



Scheme for obtaining the frequency responses of AVR/PSS full-scale specimens and AVR/PSS models

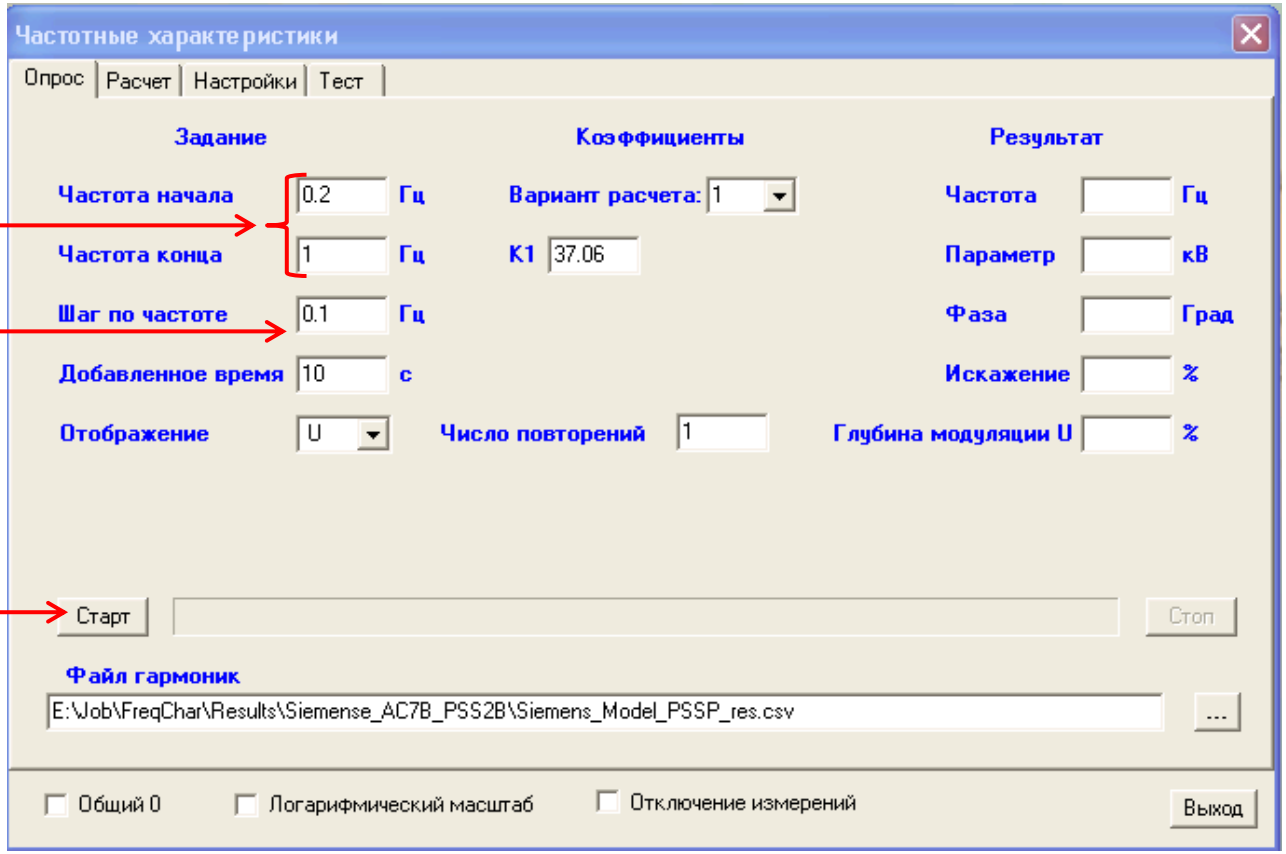


FreqChar software

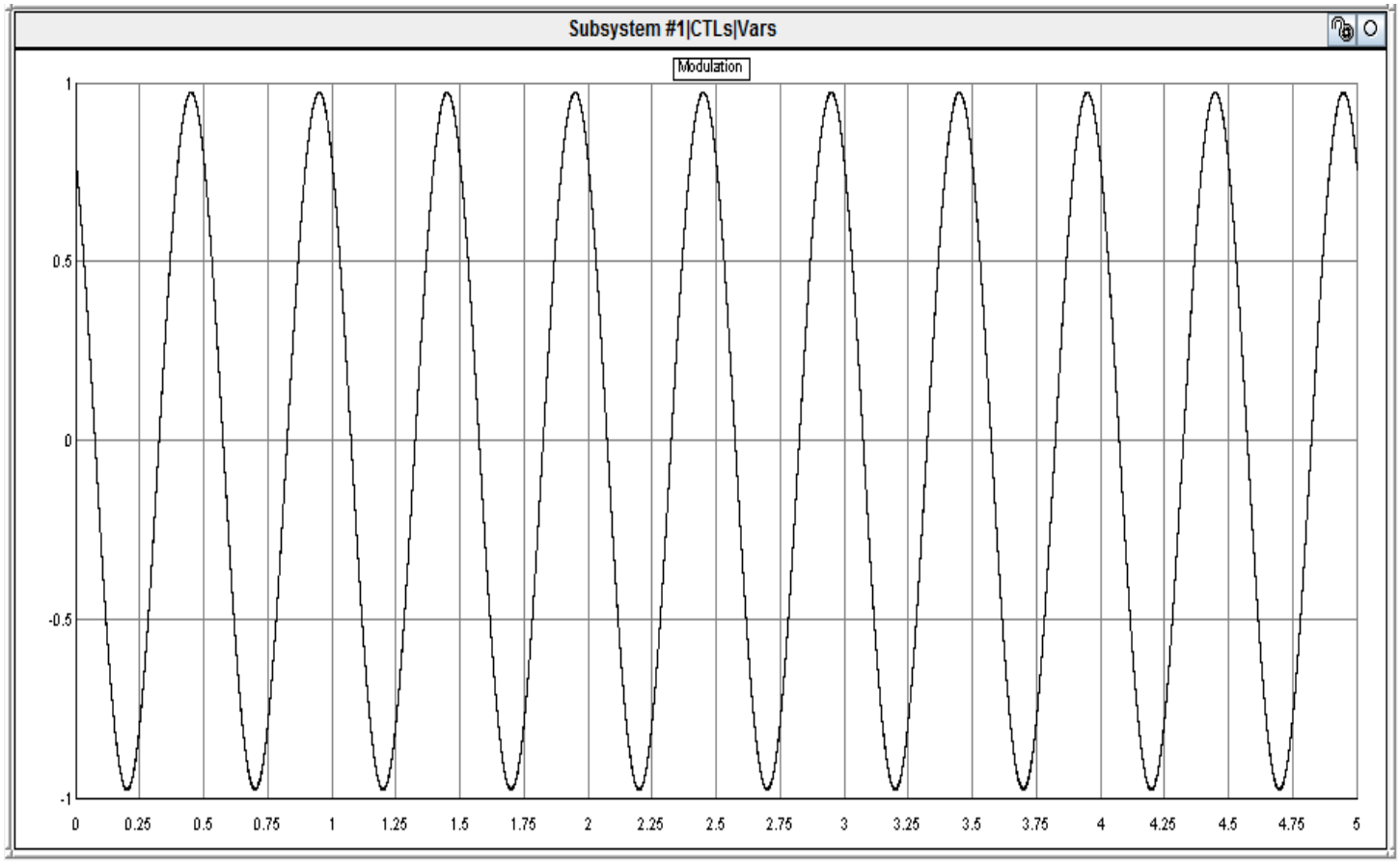
Bandwidth, Hz

Frequency step, Hz

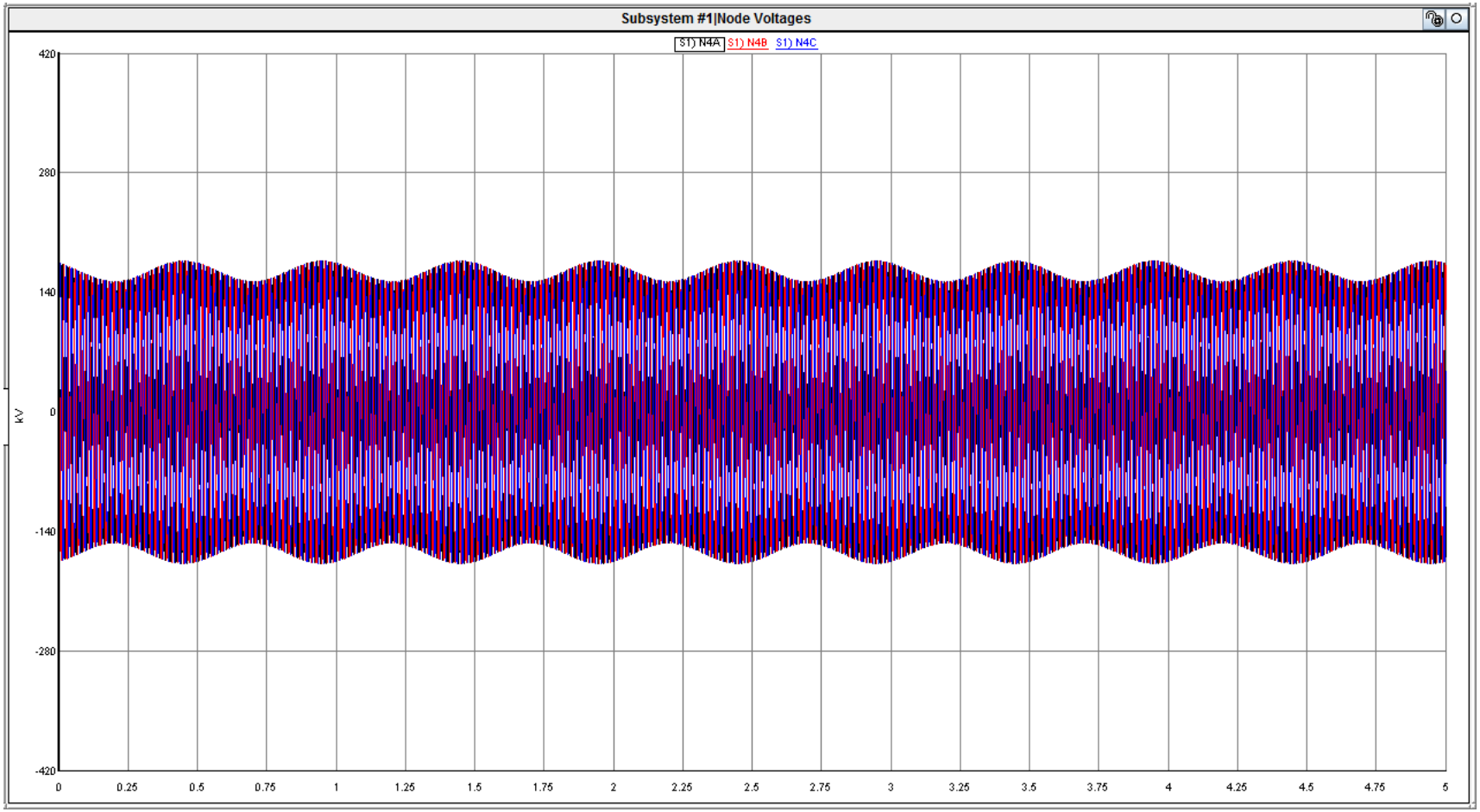
Start



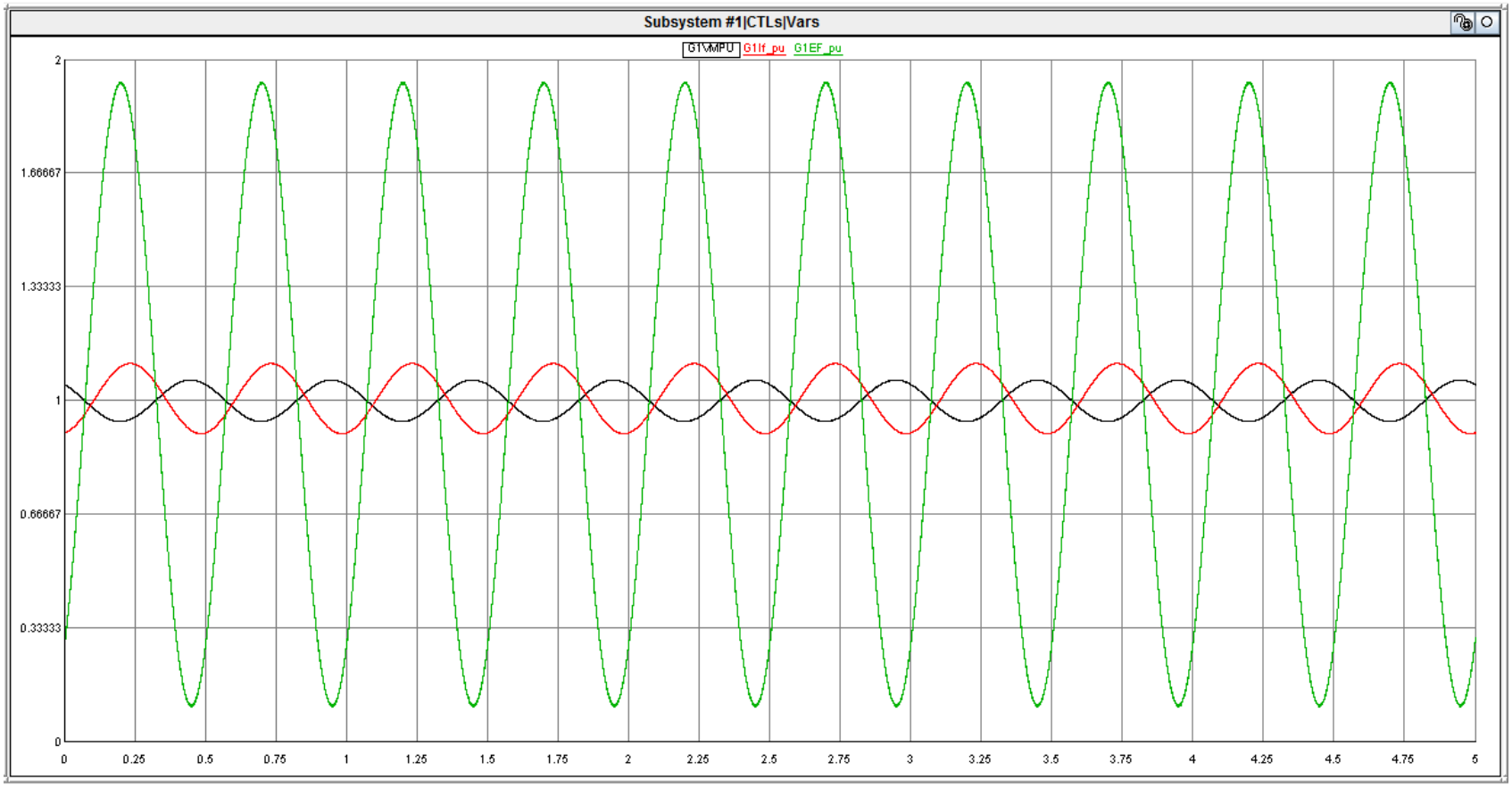
FreqChar send modulation signal



SRC voltage


Subsystem #1|Node Voltages
S1) N4A
S1) N4B
S1) N4C
420
280
140
0
-140
-280
-420
kV
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5
2.75
3
3.25
3.5
3.75
4
4.25
4.5
4.75
5

Terminal voltage, AVR output and field current

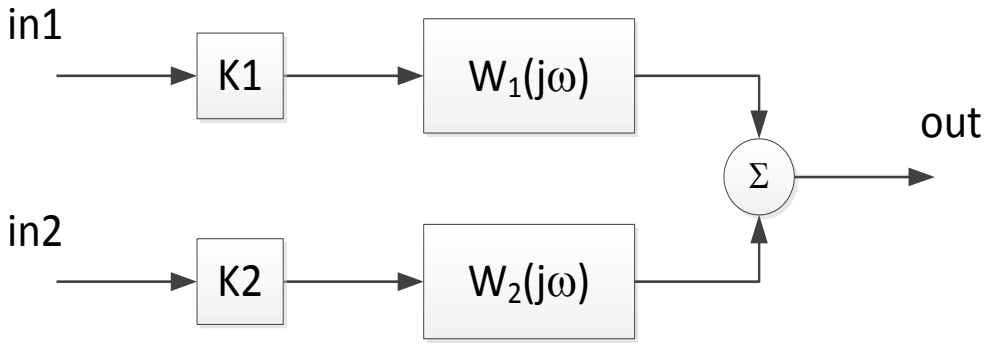


Assumption: AVR output = K*(Filtered field voltage)

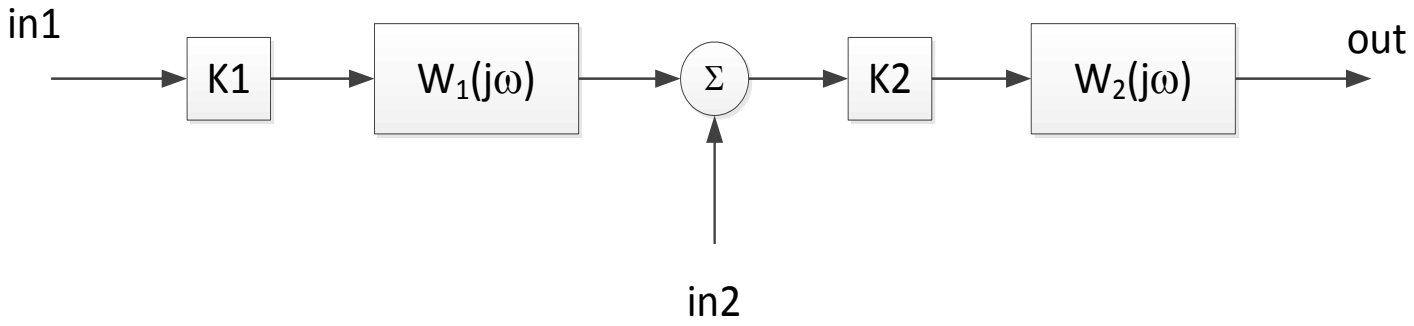
Sometimes it is impossible to disable one or more inputs

Two cases:

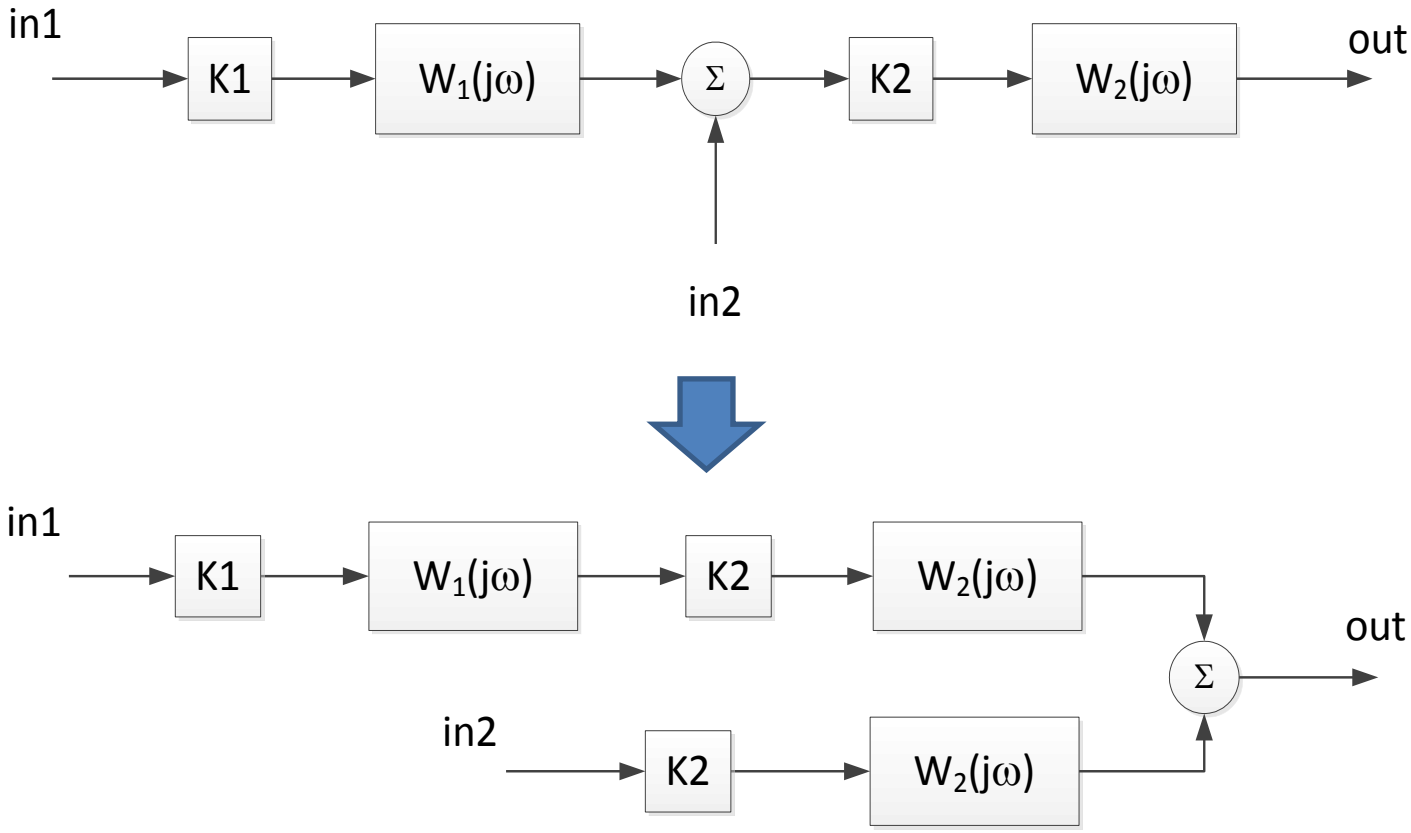
1)



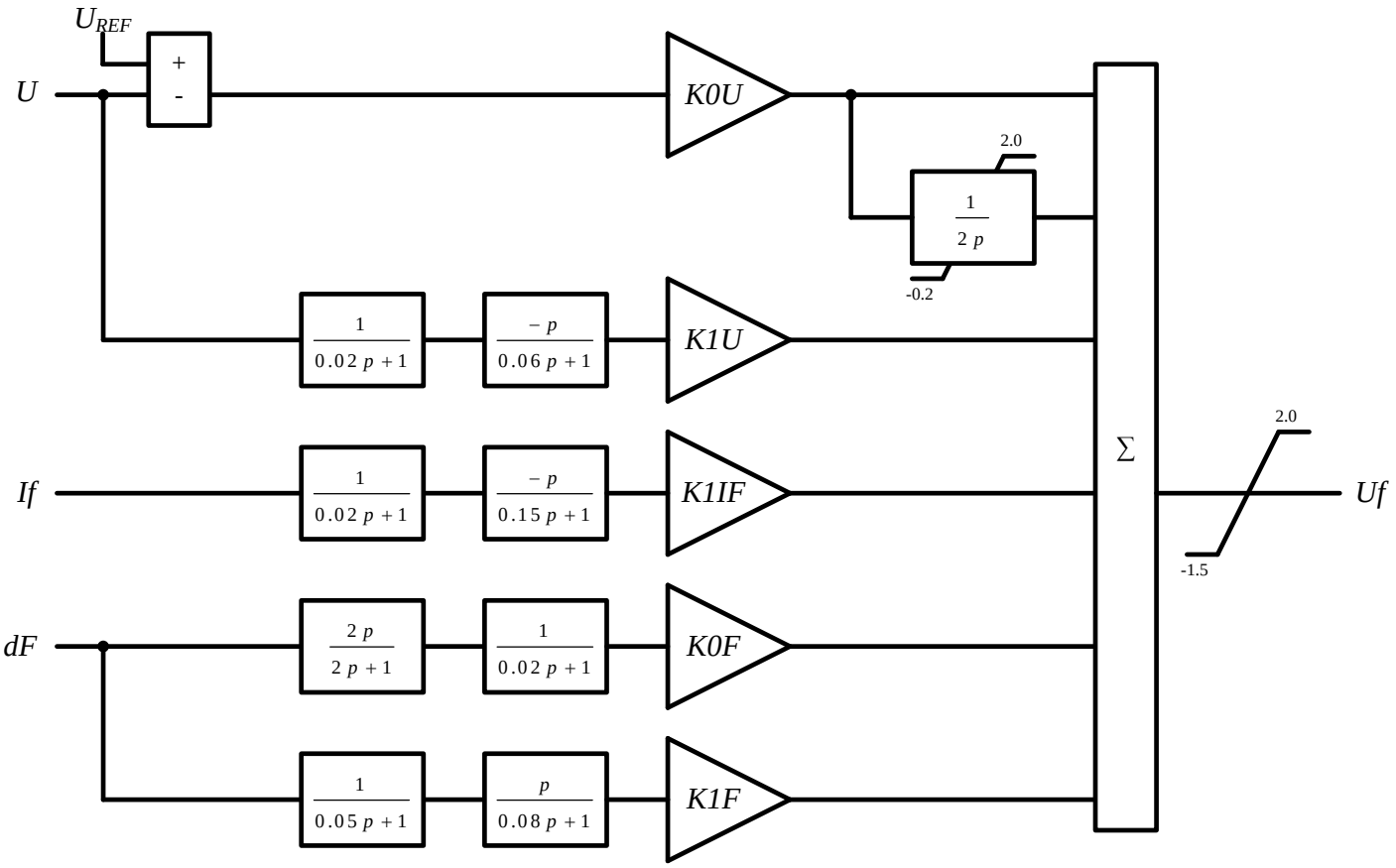
2)



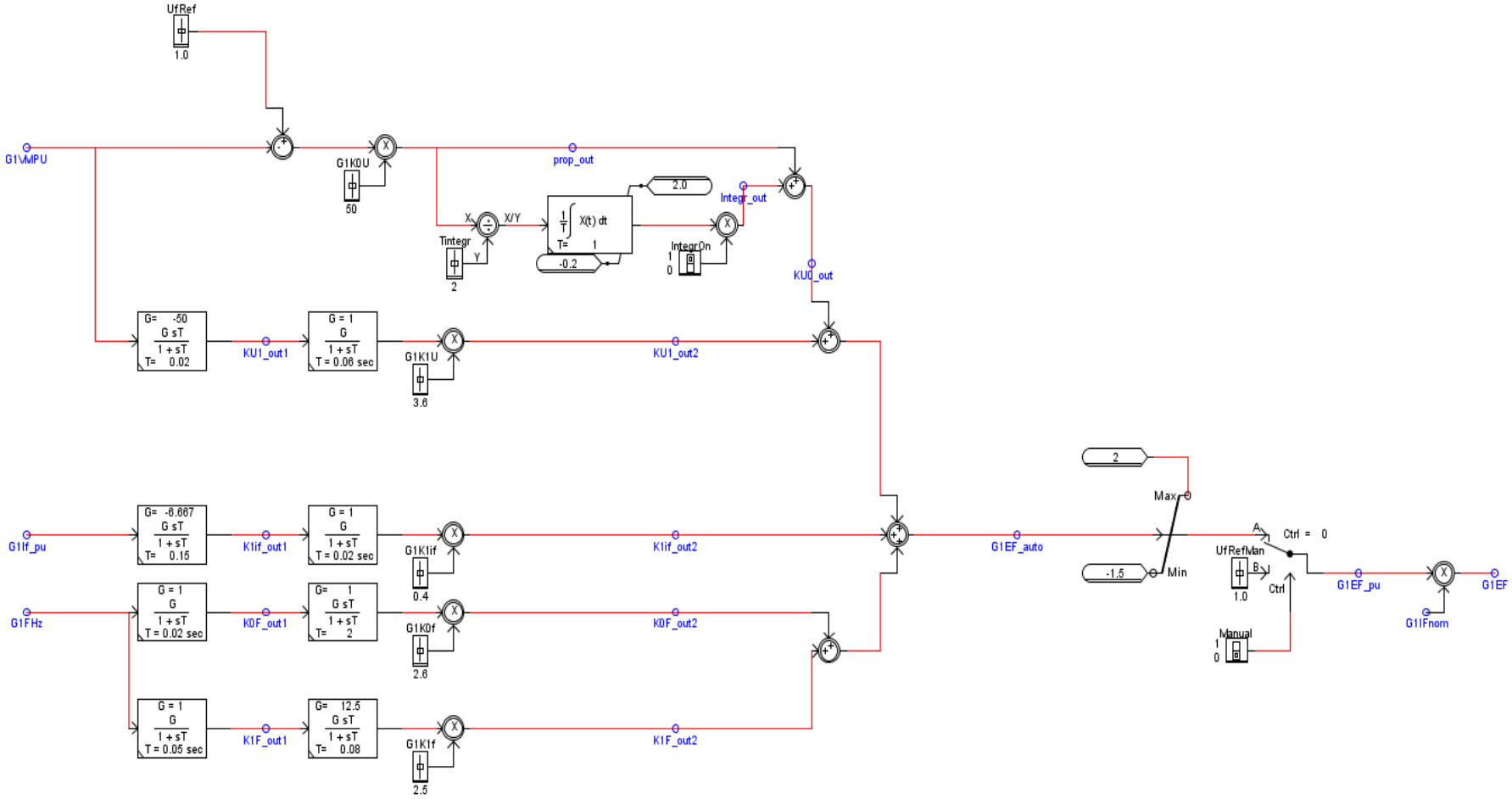
Well known from control theory



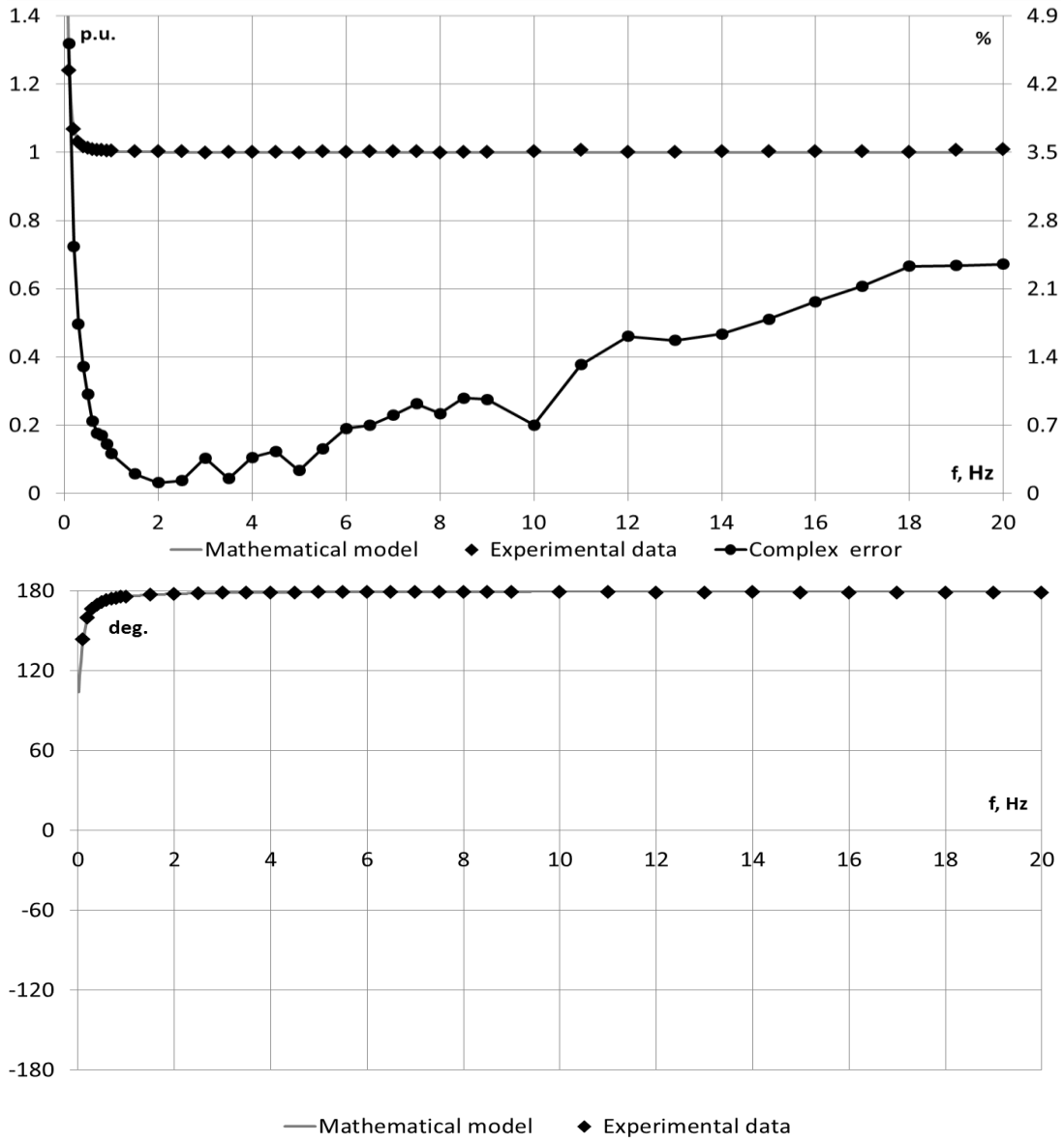
Method was approbated by obtaining the frequency responses of AVR and PSS mathematical models implemented in RTDS



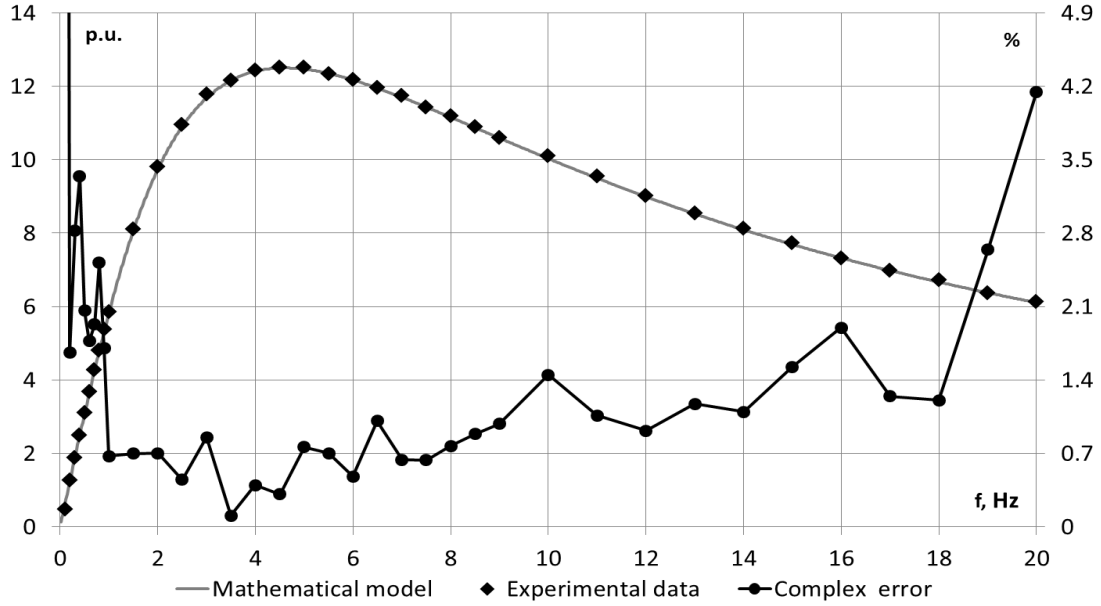
Structure implemented within RTDS Simulator

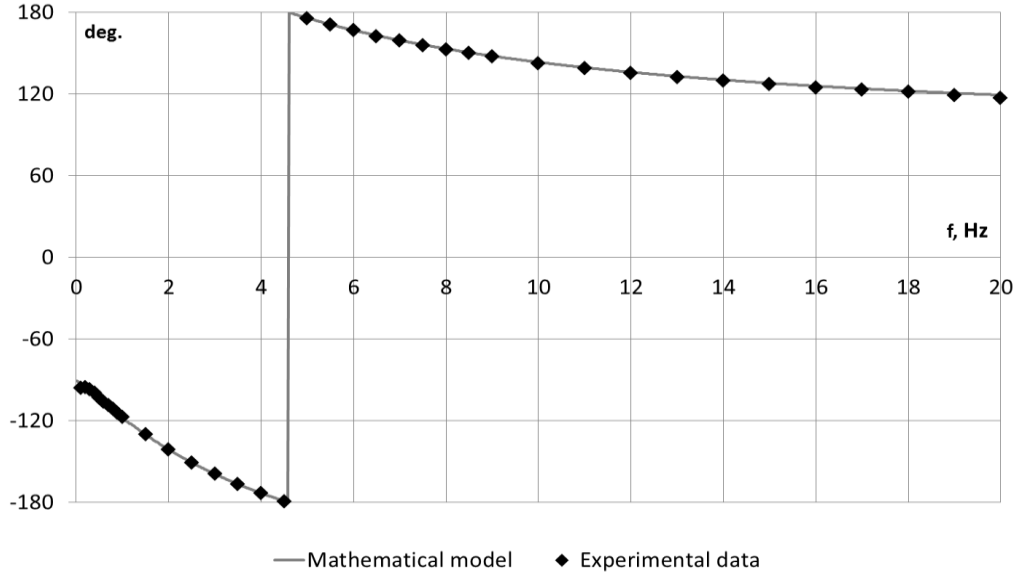


Frequency response of PI voltage regulator implemented within RTDS

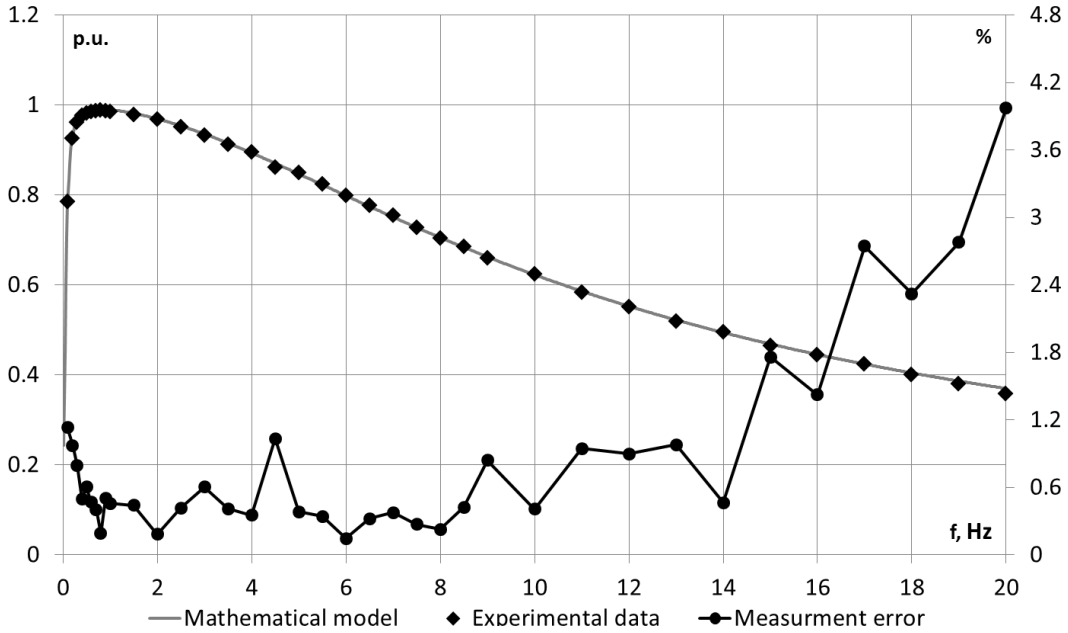


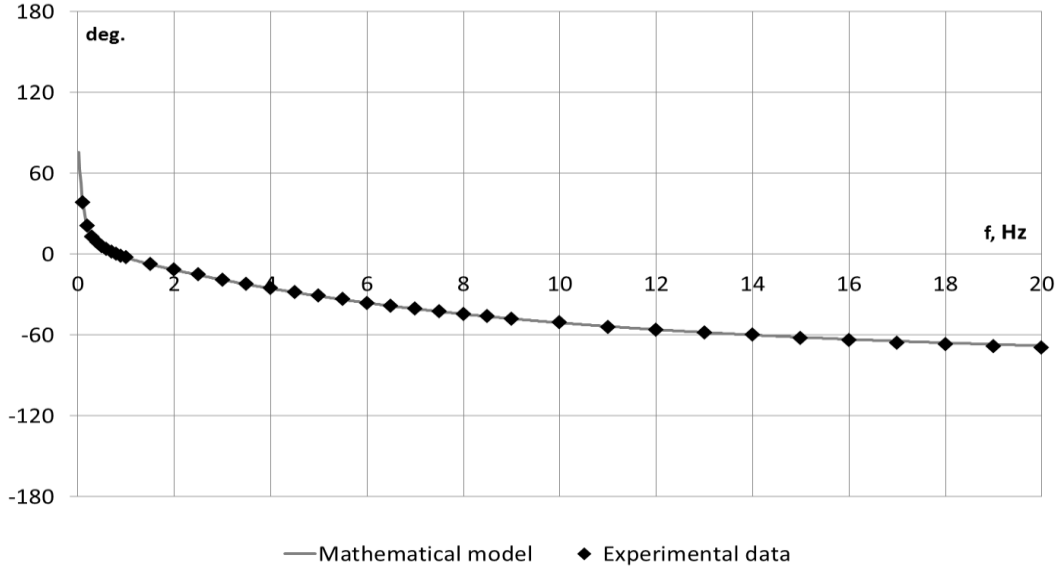
Derivative input



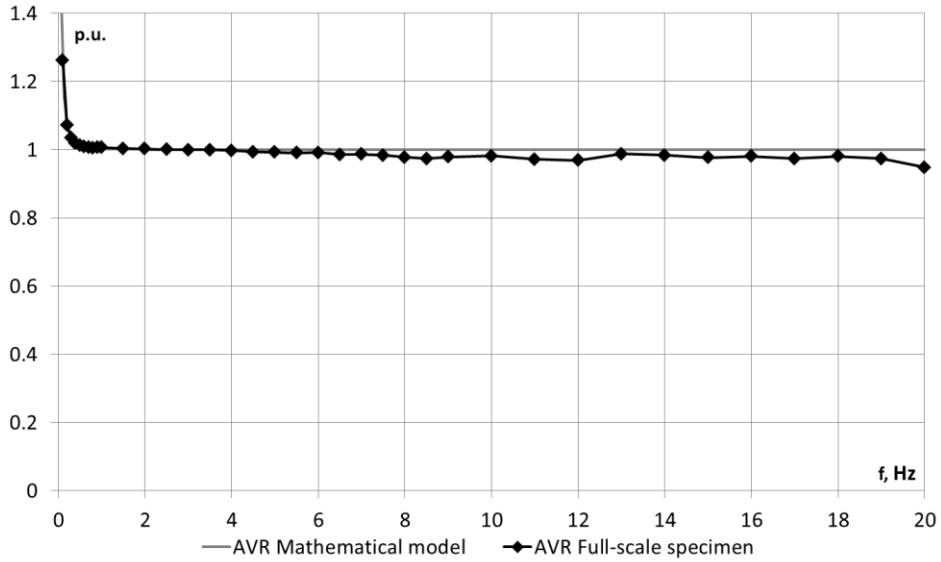


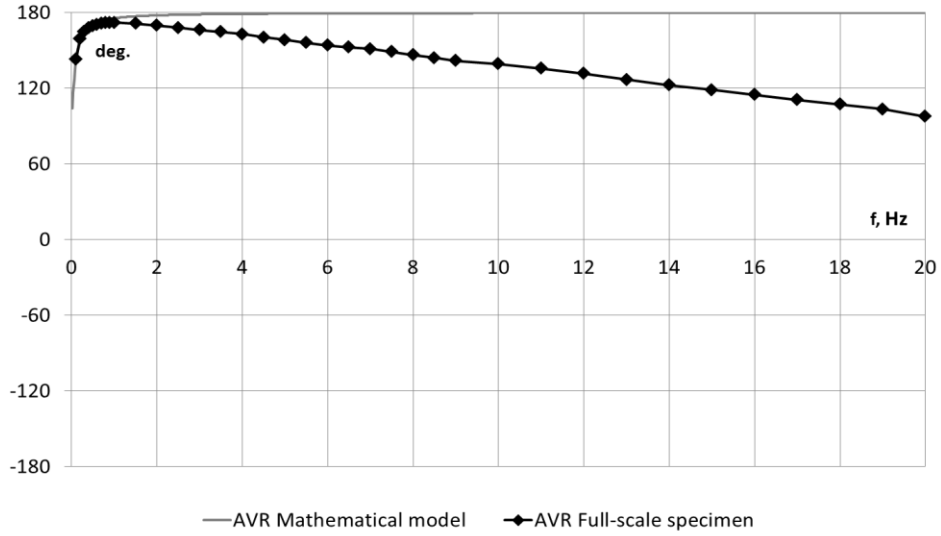
Frequency input

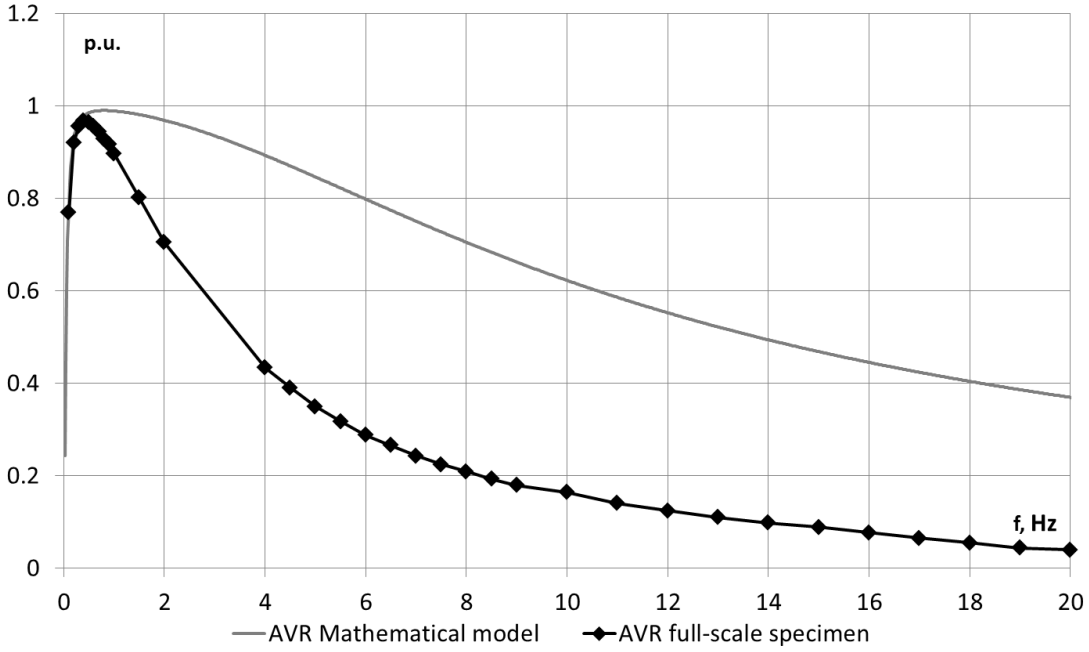


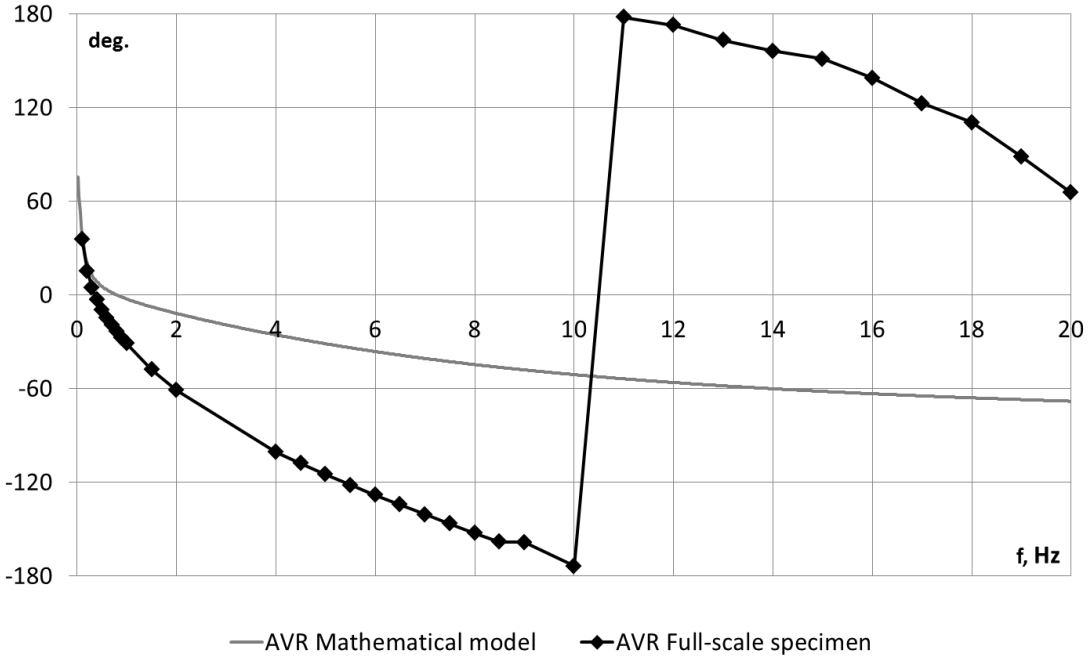


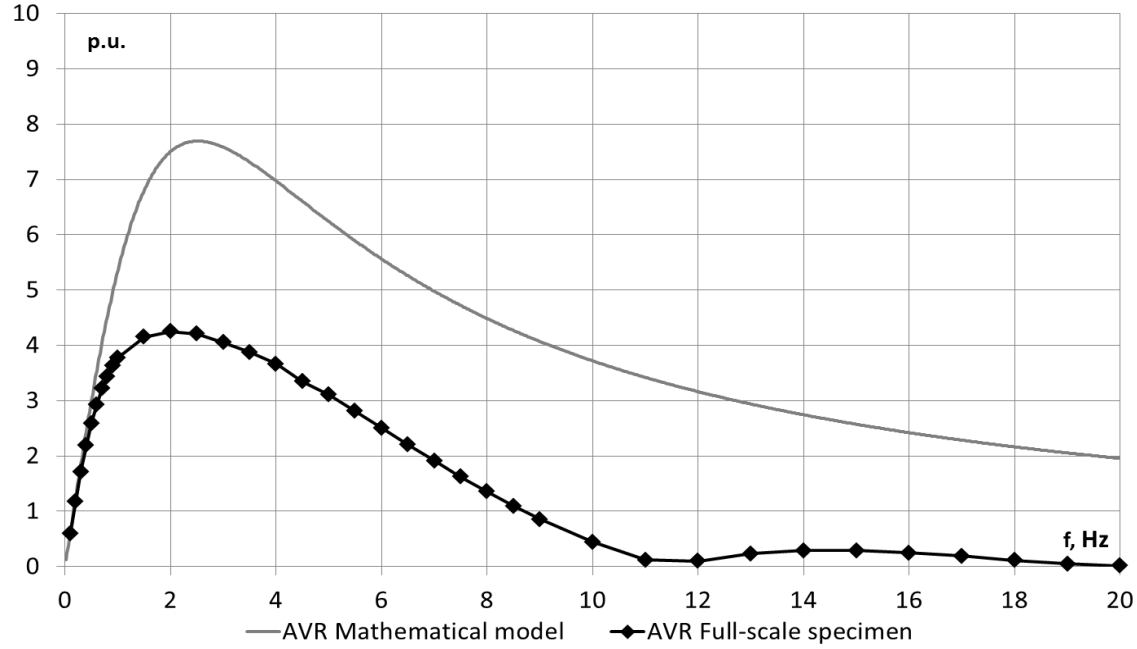
Some AVRs and PSSs have been already tested, and their frequency responses were obtained

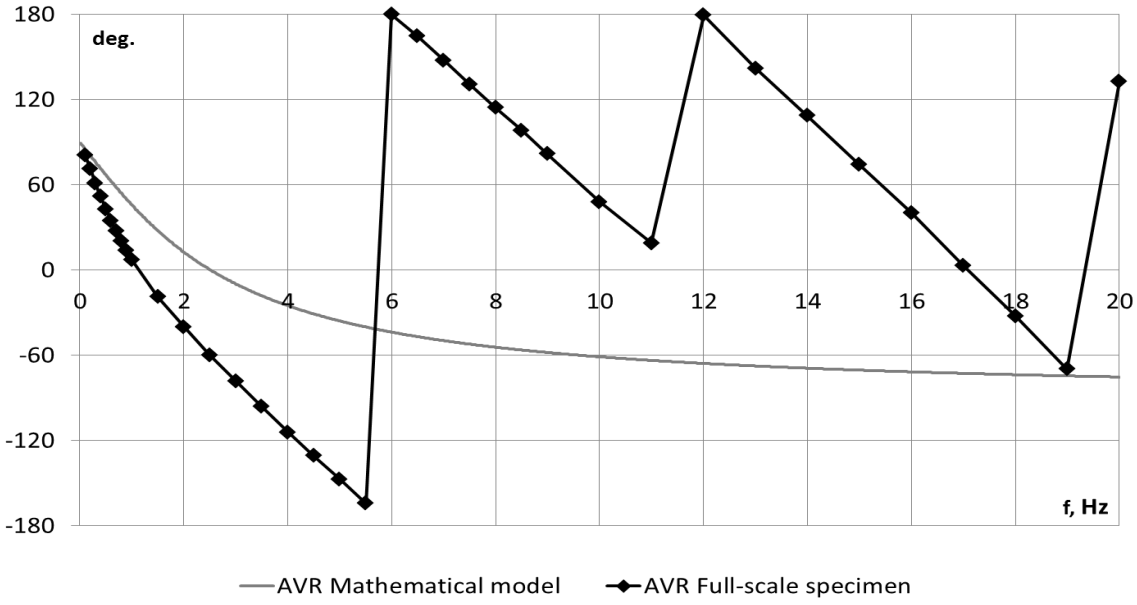





p.u.
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
16
18
20
f, Hz
AVR Mathematical model
AVR full-scale specimen


deg.
180
120
60
0
-60
-120
-180
0
2
4
6
8
10
12
14
16
18
20
f, Hz
AVR Mathematical model
AVR Full-scale specimen


p.u.
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10
12
14
16
18
20
f, Hz
AVR Mathematical model
AVR Full-scale specimen


deg.
180
120
60
0
-60
-120
-180
0
2
4
6
8
10
12
14
16
18
20
f, Hz
AVR Mathematical model
AVR Full-scale specimen

Conclusion

1. Described method can be used for obtaining the frequency responses of AVRs and PSSs
2. RTDS Simulator can be used for obtaining the frequency responses of AVRs and PSSs and for verification of its mathematical models
3. Described method and RTDS Simulator can be used for creating more refined mathematical models.