

Commissioning AVR Direct Control

in the easYgen3000^{XT} system

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Introduction

This is an application note which shall help to handle the Exciter-10 module together with the easYgen3000XT device. Some easYgen3000XT controls (refer to the list end of the document) can be configured with a dedicated AVR algorithm to drive excitation modules.

This application note shall be an add-on document to the already existing easYgen manual and shall give hints how to commission such an easYgen / exciter module combination.

Prerequisites

- The operator has a general understanding about a synchronous generator and has the technical skill and education to interact with the according prime mover and synchronous generator machine.
- The easYgen is well known and the operator has well experience in commissioning a genset.
- There is an emergency stop installation available.
- There is an overvoltage monitoring installed and accordingly configured.
- The used excitation module is correctly dimensioned for the synchronous generator and the driving supply voltage.

Exciter 10 – Basic Settings

If the Woodward Exciter 10 module shall be commissioned following configuration is to establish.

Analog Output

Parameter ID	Name	Setting
5215	Selected hardware type	PWM
5217	Filter time constant	Off
5218	Source value at minimum level	0
5220	Source value at maximum level	100
5224	PWM output level	10,00 V

Parameter ID	Name	Setting
5214		

AVR Algorithm

Parameter ID	Name	Setting	Comment
5607	Voltage control	AVR	In comparison to PID analog the AVR algorithm is faster, has a different PID function and provides a special start up function.
5610	Proportional gain	1.00	Basic set up
5611	Integral gain	0.010	Basic set up
5612	Derivative ratio	0.01	Basic set up
5600	Int.voltage control setpoint 1	400V	Example of a desired voltage setpoint.
12938	Release V-Control	LogicsManager = TRUE	Only for double check: The voltage control must be released.
5496	Device	Exciter-10	
5624	Voltage filter time	0.00s	Basic set up -> Filter disabled
5632	Start voltage	50%	Basic set up
5633	Starting ramp	5%	Basic set up
5634	Max. starting excitation	20%	Basic set up
12037	AVR Enable V(f)	LogicsManager = FALSE	Basic set up -> For the first commissioning it should be disabled.

Doing the first start

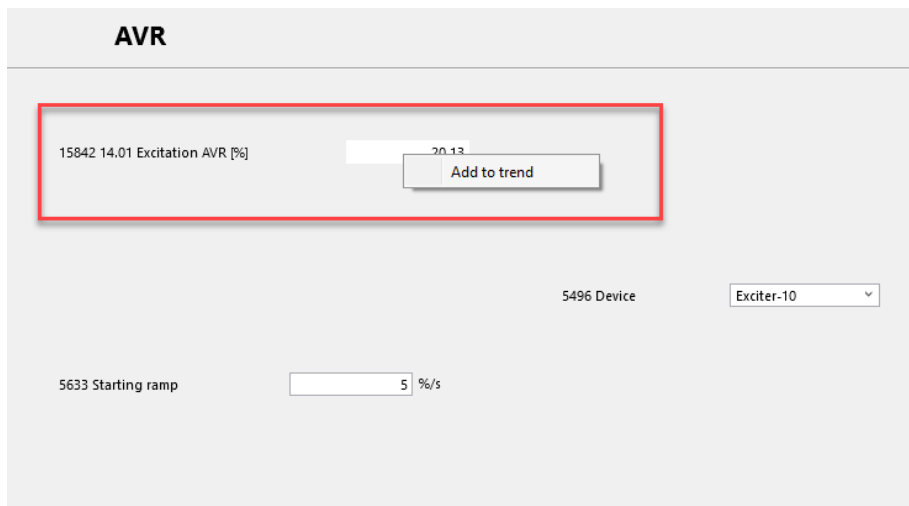
Basic Check

Before you are doing the first start you should check:

- The emergency stop button is functioning.
- The AVR module is well wired according to the technical descriptions
- The overvoltage monitor is enabled
- The closure of the GCB is inhibited
- There are no voltage critical consumer connected on the generator terminals.
- The prime mover (combustion engine) is correctly starting and ramps up its speed onto rated in the correct manner.

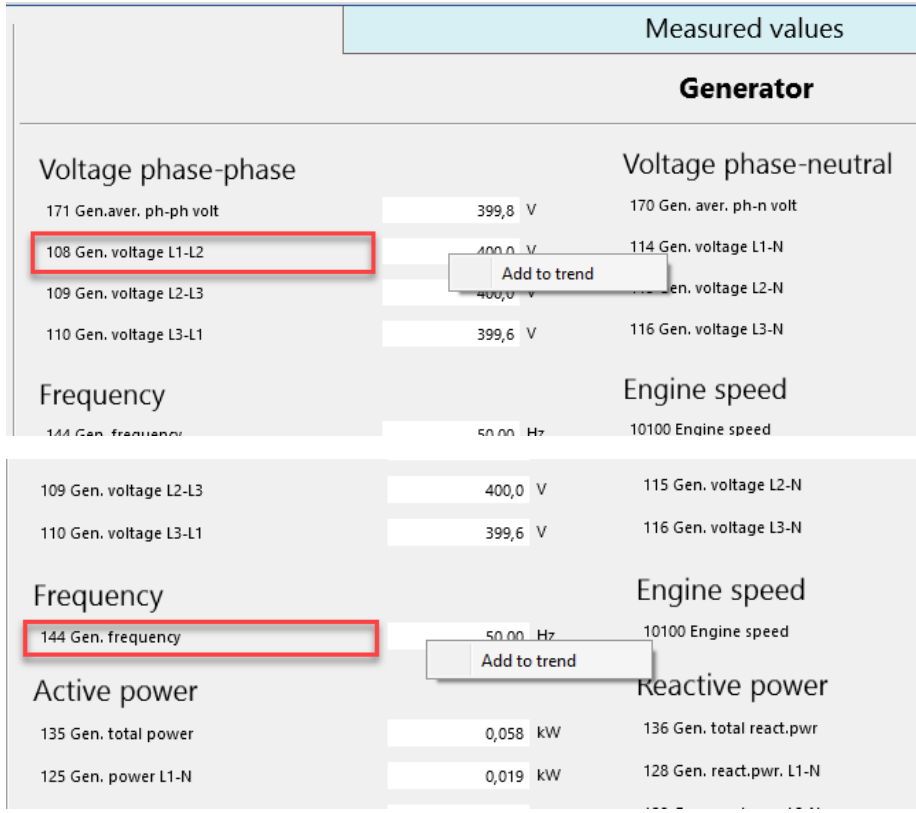
Establish a trending tool

To proper see how the synchronous generator is building up its voltage and the easYgen is guiding the exciter module you should install the easYgen ToolKit. ToolKit provides for such exercises a trending tool. The fastest way to bring a trending tool into operation is to click with right mouse click on the relevant data you want observe. At next is demonstrated a typical trending.



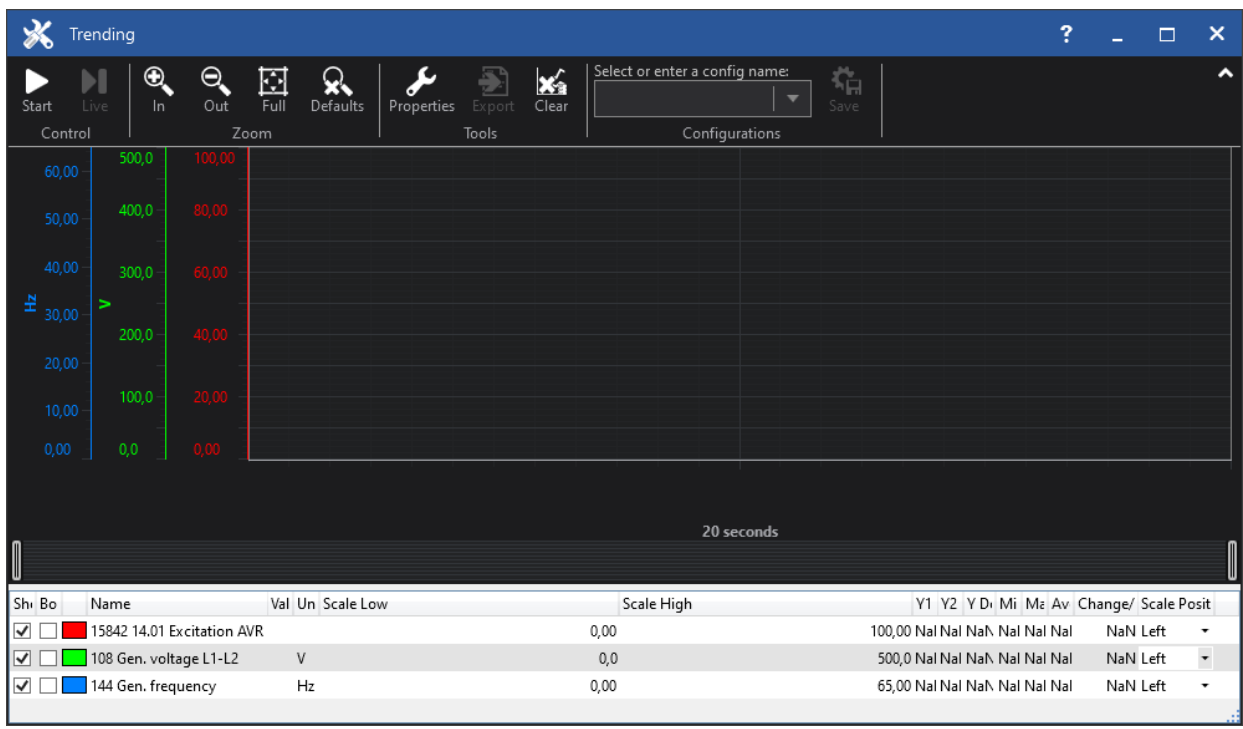
With right mouse click on the relevant data field you chose your data for the trending....

Interesting is the excitation signal going to the exciter module....



....the generator voltage L1-L2. This is the one which is regulated....

....and the electrical frequency.



Scaling Proposal

- Excitation AVR signal 0 to 100%
- Generator voltage 0 to 500V
- Generator frequency 0 to 65Hz

Start the engine

The trending tool is started and the easYgen or a PLC is starting the prime mover.

The trending tool should now record the excitation current signal going to the exciter module, it should show the generator frequency increasing and how the generator voltage increases.

Note: Please have in mind that the screen shots are created in a simulation. Your trended data could be very different. The application note shall help you to understand the configuration even the trending does not match your real application.

With the suggested settings there are now different situation imaginable:

The generator voltage is not raising

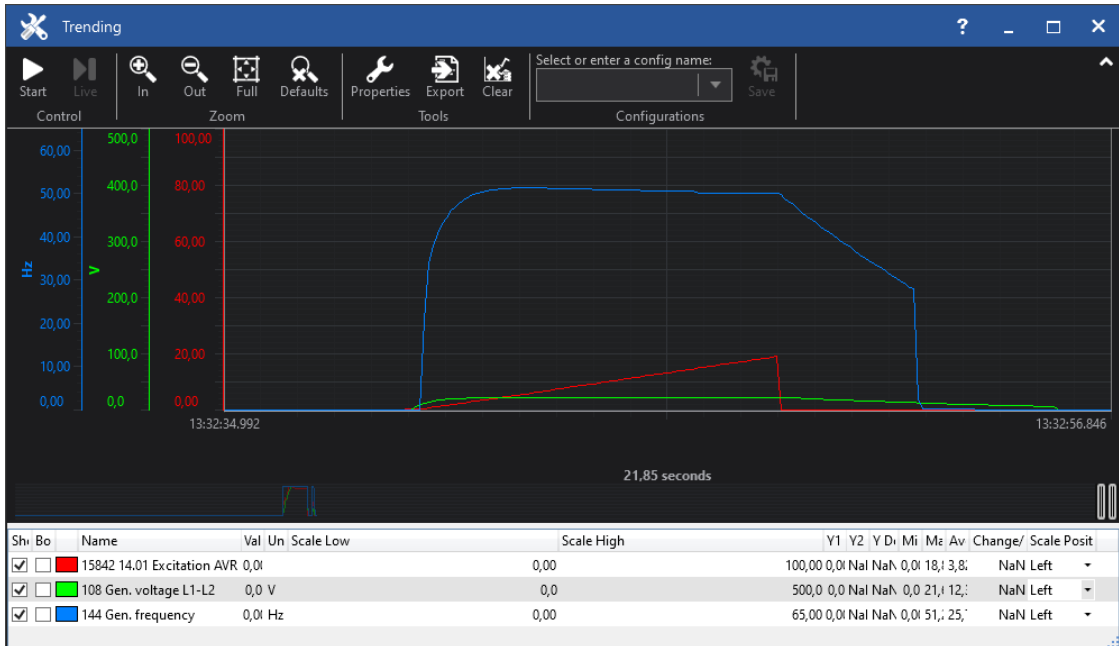


Figure 1.1: This is a trending example which shows that the generator voltage is not increasing. It could lead as well to a start failure if the electrical frequency cannot be measured. The engine is stopped.

The trend shows that the PID regulation is also not started because the generator voltage is not reaching the start voltage level (5632 Start voltage).

What can be done:

- If the generator voltage is not built up at all,
 - Recheck if the excitation module is wired correctly
 - Take care that the level “ID5634 Max. starting excitation” is reached faster by increasing the proportional gain of the AVR.

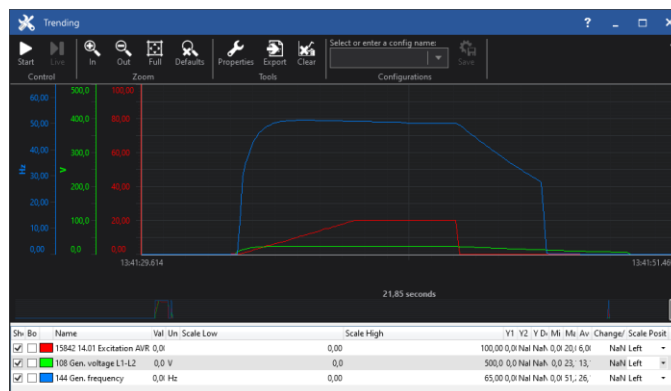


Figure 1.2:
The doubled gain increases the first ramp on max. starting excitation.
Still no improvement.

- The configuration “ID5634 Max. starting excitation” is too low and the value needs to be increased to a level which produces enough basic excitation to bring up the generator voltage.

The generator voltage is increasing but too slowly

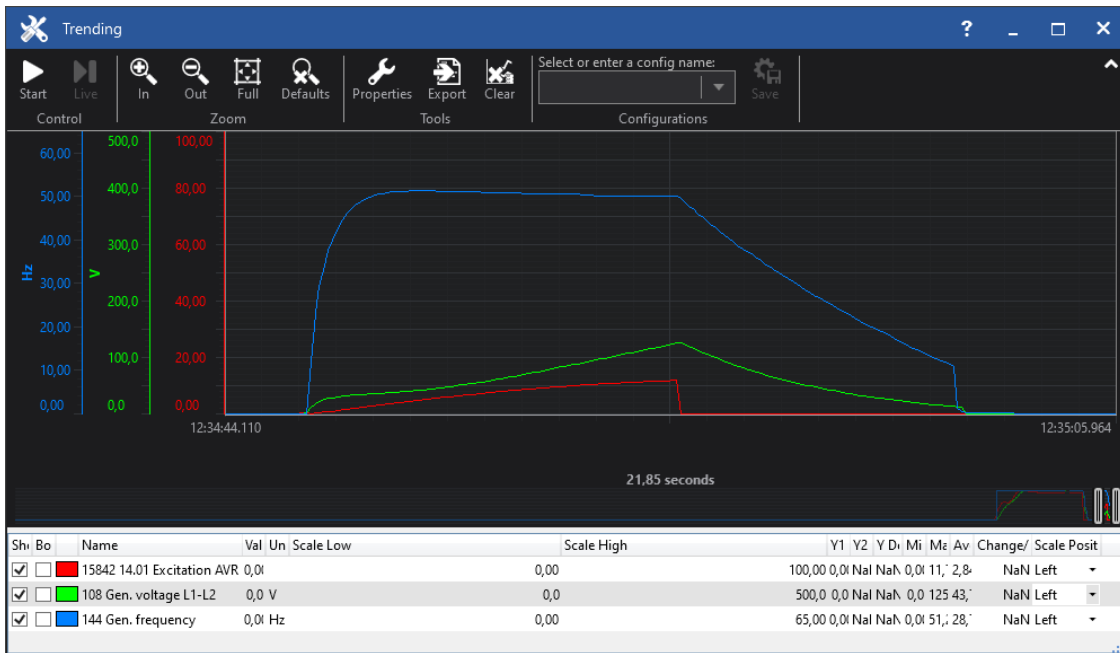


Figure 2.1: This is a trending example which shows that the excitation current has an influence on building up generator voltage, but the buildup of the generator voltage needs too long time so that the generator undervoltage monitor stops the engine.

The trend shows that the PID regulation is also not started because the generator voltage is not reaching the start voltage level (5632 Start voltage).

What can be done:

- If the generator voltage is not built up strong enough,
 - Take care that the level “ID5634 Max. starting excitation” is reached faster by increasing the proportional gain of the AVR.
 - The configuration “ID5634 Max. starting excitation” is not high enough and must be increased.



Figure 2.2: This is a trending example which shows that on one side the excitation current is strong enough to build up a generator voltage, but the generator voltage needs too long time to come into the generator operating range window. The generator undervoltage monitor stops the engine.

The trend here shows additionally that the PID regulation is started at the Starting voltage setpoint like configured (200V = 50%). The PID tries to ramp up the generator voltage with 5%/s up to 400V.

Hint: For test purposes you can delay the generator undervoltage monitor on approximately 30 seconds to be able to observe if the setpoint would be matched after some time.

- If not than you know that “ID5634 Max. starting excitation” is not high enough and must be increased.
- If yes than you know that “ID5634 Max. starting excitation” is high enough. In this case it is recommended to increase the ramp rate “ID5633 Starting ramp” on up to 100%. If it still needs to long time to reach the desired voltage setpoint you can begin to tune up the PID. Begin at first with only increasing proportional gain.

5633	Starting ramp	100%
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Figure 2.3: This is a trending example which shows that with fast ramping (“ID5633 Starting ramp” = 100%.) the generator voltage reaches the setpoint but also after too long time. It does not come to a shut down of the engine because the generator undervoltage monitor was delayed on 30 seconds.

The trend shows that the PID is not strong enough to bring the generator voltage up.

There is now a PID tuning required:

First change -> Increasing the proportional gain

5610	Proportional gain	5.00
5611	Integral gain	0.010
5612	Derivative ratio	0.01
5633	Starting ramp	100%



Figure 2.4:

Better, but still needs too long....

More proportional gain

Second change -> Increasing the proportional gain

5610	Proportional gain	20.00
5611	Integral gain	0.010
5612	Derivative ratio	0.01
5633	Starting ramp	100%

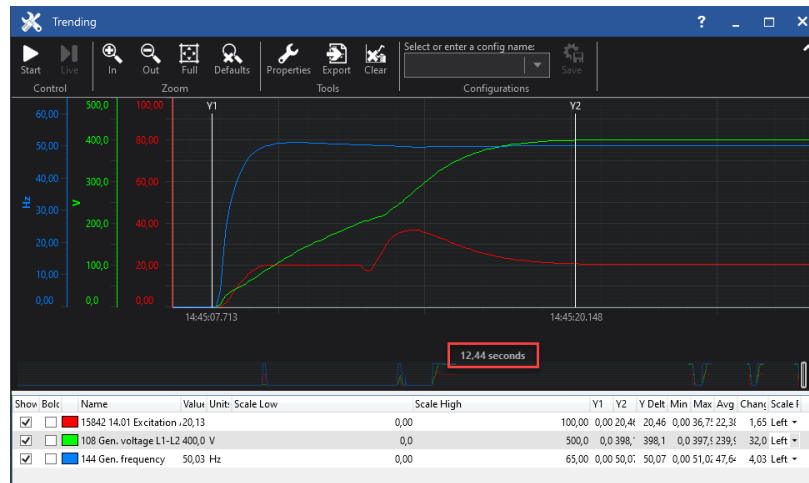


Figure 2.5:

Better, but still needs too long....

For sure here could be optimized more but this will not increase dramatical the start time which is estimated on under 10 seconds.

Third change -> Take a higher level for "ID5634 Max. starting excitation"

5610	Proportional gain	20.00
5611	Integral gain	0.010
5612	Derivative ratio	0.01
5633	Starting ramp	100%
5634	Max. starting excitation	30%

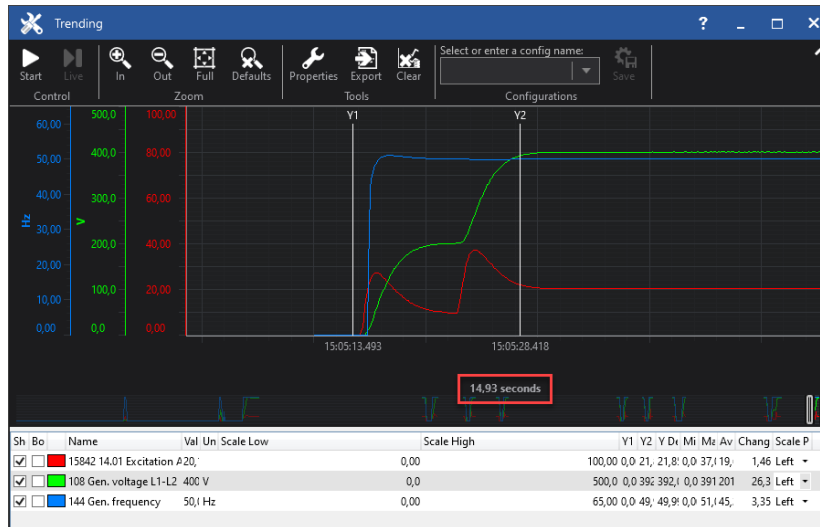


Figure 2.6:

Not better still needs too long....

First increase is okay but then it comes to a break time....

Fourth change

-> Take a higher level for "ID5634 Max. starting excitation"

-> Take a higher level for "ID5632 Start voltage"

5610	Proportional gain	20.00
5611	Integral gain	0.010
5612	Derivative ratio	0.01
5633	Starting ramp	100%
5634	Max. starting excitation	70%
5632	Start voltage	90%



Figure 2.7:

So far fine.

A further possibility to speed it up is the use of more integral gain....

Fifth change

- > Take a higher level for "ID5634 Max. starting excitation"
- > Take a higher level for "ID5632 Start voltage"

5610	Proportional gain	20.00
5611	Integral gain	0.050
5612	Derivative ratio	0.01
5633	Starting ramp	100%
5634	Max. starting excitation	70%
5632	Start voltage	90%

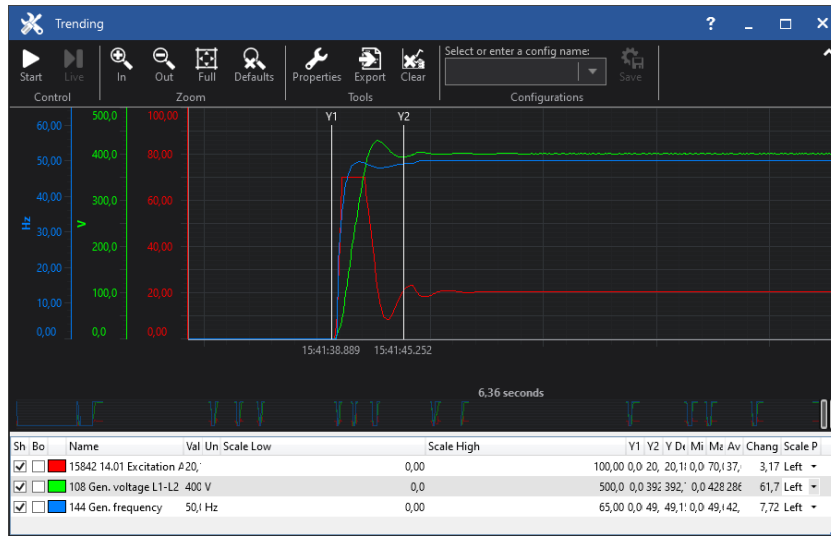


Figure 2.8:

In 6.3 seconds on rated voltage. Through more integral gain a small overshoot is to accept.

The generator voltage is raising too fast and too high

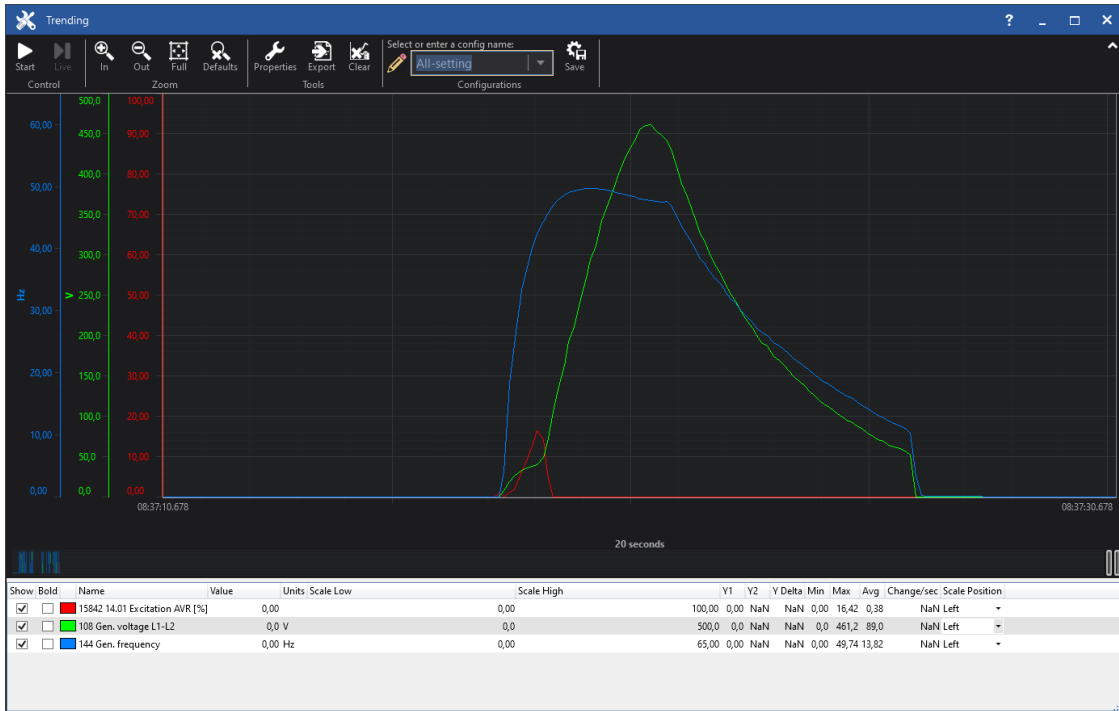


Figure 3.1: This is a trending example which shows that the generator voltage is increasing too much. The generator overvoltage monitor stops the engine.

The trend shows that the PID regulation is also reacting against the signal before the generator voltage has reached the start voltage level (5632 Start voltage).

What can be done:

- The level “ID5634 Max. starting excitation” seems to be too high. The synchronous generator is very sensitive on excitation current. -> Reducing the level.
- If you are still not successful: Measure out experimental wise what usual excitation current is needed (see special chapter). Take this value as “ID5634 Max. starting excitation”.



Figure 3.2 (Sketch): This is a trending example which shows that the generator voltage is clear influenced through the AVR but after some generator voltage swings it comes to a generator overvoltage. The engine is stopped.

The trend shows that the PID output reaches very fast the maximum starting excitation output (here 10%). Then after some time the synchronous generator builds up voltage. In that moment the generator passes the start voltage level (here 50%) the regulator signal begins to work. The PID tries to ramp up the generator voltage according to its ramp setting (ID5633 Starting ramp). But after some hunting it leads to a generator overvoltage situation.

What can be done:

- The “ID5611 Integral gain” seems to be to high. -> Reducing the Integral gain.
- If this is not successful begin to reduce as well the “ID5610 Proportional gain”
- If you are still not successful: Measure out experimental wise what usual excitation current is needed (see special chapter). Take this value as “ID5634 Max. starting excitation”.



Figure 3.3 (Sketch): This is a trending example which shows that the generator voltage is buildup not so bad but ends as well in an overvoltage situation. The engine is stopped.

The trend shows that the PID output reaches very fast the maximum starting excitation output (here 10%). Then after some time the synchronous generator builds up voltage. In that moment the generator passes the start voltage level (here 50%) the regulator signal begins to work. The PID tries to ramp up the generator voltage according to its ramp setting (ID5633 Starting ramp). But with reaching the rated speed the excitation needs to be more increased. The PID seems to react too slow, and its integral part seems to push him into an overshoot situation.

What can be done:

- Increase the “ID5610 Proportional gain”
- Decrease the “ID5611 Integral gain”
- Observe the curve. It should lead to the situation that the generator voltage is increased faster but with lesser overshoot.
- If you are still not successful: Measure out experimental wise what usual excitation current is needed (see special chapter). Take this value as “ID5634 Max. starting excitation”.

The generator voltage is raising but it stocks during buildup



Figure 3.4 (Sketch): This is a trending example which shows that the generator voltage is stocked during startup phase.

The trend shows that the generator voltage is relative fast reacting on the PID output. The excitation is not aggressive so that the generator signal must be guided very early.

What can be done:

- The “ID5633 Starting ramp” can be increased. This leads to a faster setpoint ramping beginning at the start voltage level.
- The “ID5632 Start voltage” can be increased. This brings the generator voltage to higher level at which the PID begins to regulate. Finally, the setpoint is faster reached.
- Finally, PID tuning with more proportional gain should help

Measure out experimental wise what usual excitation current is needed

Sometimes if there is no knowing about the amount of excitation current during running the rated generator voltage it is helpful to figure it out. A proper method could be as follows:

Based on the configuration mentioned in the chapter “Exciter 10 – Basic Settings” the excitation module will be controlled with constant percentage levels.

Navigate in ToolKit to the Analog manager “ID5214 AM Data source AO2” and configure it

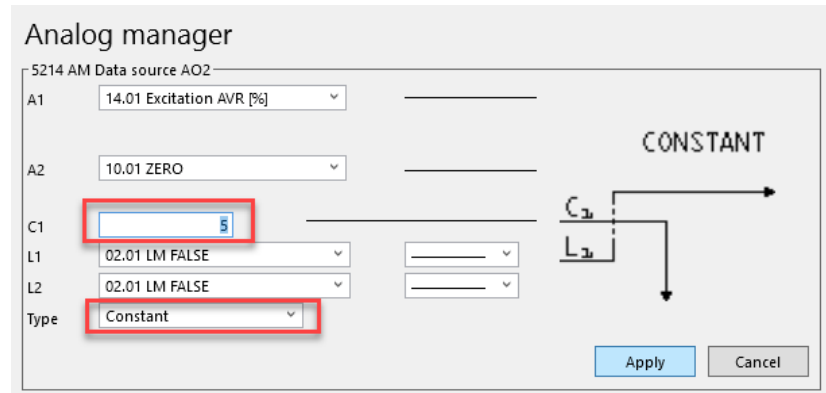


Figure 4: The picture shows the constant 5. It stands for 5% current.

... to a Constant type. This gives you now the possibility to set a constant current.

Note: Do not forget to apply the new setting.

After some start you can maybe figure out a current which leads to generator voltage buildup without any dramatical overshoot. Take this current for your setting “ID5634 Max. starting excitation” and begin again with Start tries.

If you cannot find a current which brings you into the operating range of the generator voltage than you know at least at which level it leads to an overshoot. Take a current for your setting “ID5634 Max. starting excitation” which will never bring you into the overshoot situation.

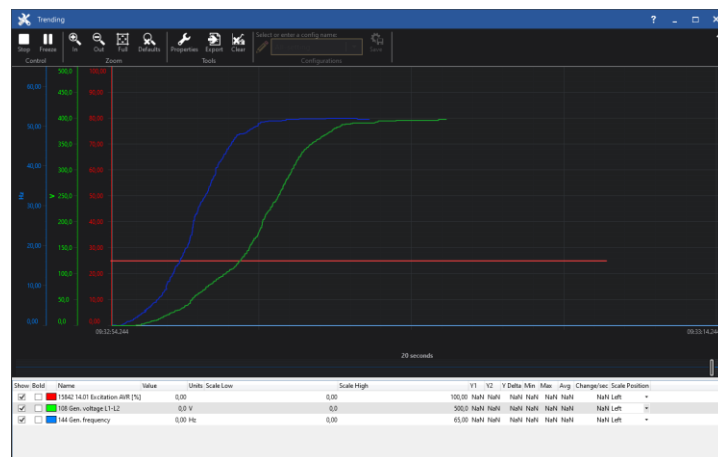


Figure 4.1: This seems to be the current which is needed to run the synchronous generator with rated voltage.

In the best situation he does not provoke any dramatical generator voltage overshoot during stating.

easYgen3000XT controls with AVR algorithm

- easYgen3400XT-P1
- easYgen3500XT-P1
- easYgen3400XT-P2
- easYgen3500XT-P2

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