

# THE RESEARCH OF STABILITY OF SYNCHRONIZATION PROCESS WITH UNITROL 1000 APPLICATION

## SINHRONIZĀCIJAS PROCESA STABILITĀTES IZPĒTE IZMANTOJOT UNITROL 1000

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**Keywords:** Synchronization, generator

### Introduction

Modern electro technical progress now is determinable wherewith developing and initiating safe and economical alternating current electrical equipment is simply maintenance.

The UNITROL 1000-15 is an Automatic Voltage Regulator of the latest design for synchronous generators and synchronous motors. The implementation of the most advanced microprocessor technology together with IGBT semiconductors enables it to be used in a wide range of applications.

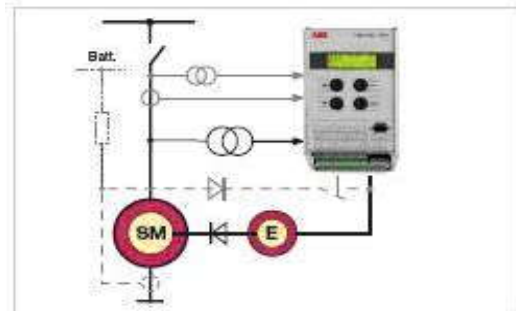
The maximum output current is 15 A and the power input can be from an AC or DC source.

The UNITROL 1000-15 has all the elements of excitation control built inside. A powerful signal processor running extensive control software guarantees excellent performance under all conditions. The chopper type power stage, which can be supplied from an AC or DC power source, enables the use in varied applications. The front panel serves for easy monitoring and configuring. The robust mechanical design guarantees a high reliability. The applications shown here are typical examples.

The UNITROL 1000 standard functions are:

- Voltage regulator with PID control algorithm;
- $\cos \varphi$  regulator with PID control algorithm;
- Reactive power regulator with PID control algorithm;
- Excitation current regulator (manual control) with PI control algorithm;
- Internal digital reference values;
- Bumpless changeover for all modes of operation;
- Soft-start function;
- Reactive current droop for network operation;
- Reactive power sharing between parallel machines by RS 485 bus;
- Modbus serial communication;
- Volts-per-Hertz limiter;
- Minimum excitation current limiter;

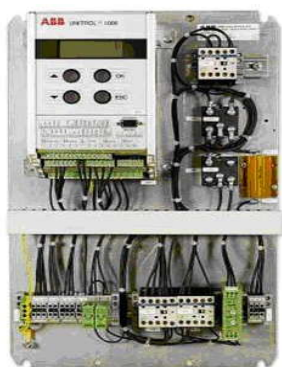
- Three-step delayed maximum excitation current limiter (temperature dependent);
- Reactive current limiter as a function of active power (P/Q);
- Stator voltage limiter;
- Stator current limiter (temperature dependent);
- Master/Slave reactive power sharing;
- Undervoltage detection to activate external current boost for short circuit support;
- Open-loop control of output voltage for test purposes;
- Built-in step test function;
- Stand-by mode for redundant backup channel system;
- Alarm and Trip signals.



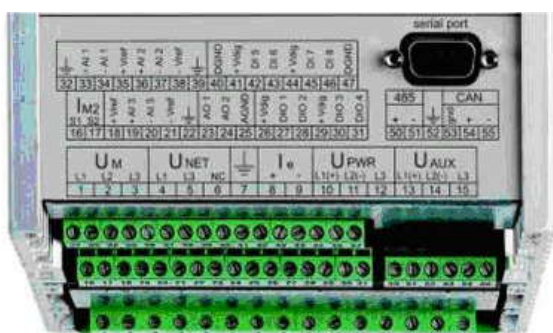
**Att.1.** Ierosmes šuntēšana.  
**Fig.1.** Shunt excitation with optional short circuit support.

All of the parameter settings for the UNITROL 1000 it is allow following how the changing of a parameter affects the overall behavior of the regulator by referring to the power chart and the oscilloscope function. This means, that the optimum settings are found within a short time. The single-channel solution, with all the necessary components installed on a mounting plate, is frequently used for the excitation of smaller synchronous machines, e.g. generators that are driven by hydro turbine or by a diesel

engine. This is also a commonly used solution for motor excitation.



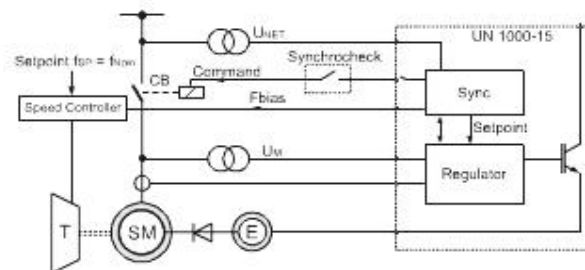
**Att.2.** Atsevišķo kanālu sistēma.  
**Fig.2.** Single-channel system.



**Att.3.** Unitrol 1000 ievadi.  
**Fig.3.** The Unitrol 1000 inputs.

The UNITROL 1000-15 is equipped with flexible interfaces:

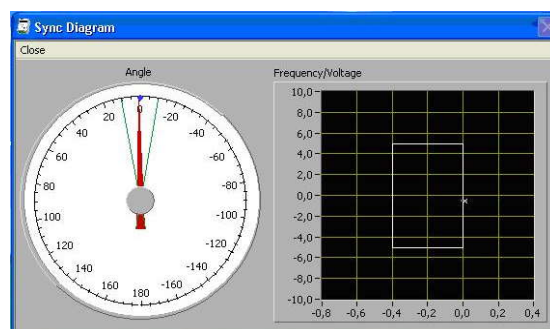
- 4 digital inputs, 4 digital outputs (or inputs), 3 analog inputs, 2 analog outputs.
- The four digital outputs can be individually redefined as digital inputs. An RS 232 serial interface is used for PC connection. An RS 485 link is used for Modbus serial communication or for reactive power sharing where two or more generators or motors are connected in parallel. A CAN bus is for controlling local extension devices.



**Att.4.** Unitrol 1000 elektriskā ķēde.  
**Fig.4.** The Unitrol 1000 circuit.

The automatic synchronization and paralleling of the synchronous machine with the line is achieved using the optional integrated synchronizing function. By settings a few simple parameters the Unitroll 1000 supplies the corresponding control signals for the speed governor and close the circuit breaker is released if all conditions are fulfilled.

To show serviceability of the exciting generator model we shall lead carry out the analysis of a synchronization regime with an infinite power network.

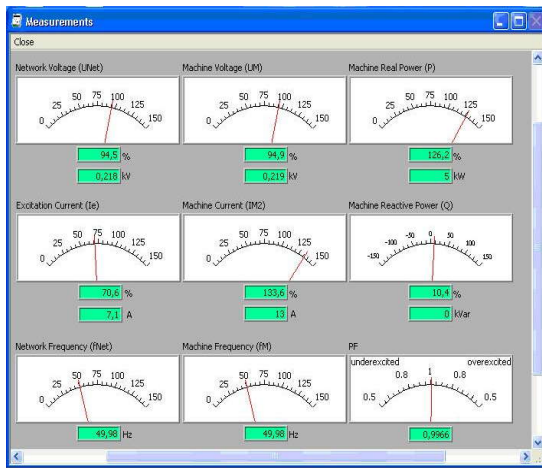


**Att.5.** Unitrol 1000 sinhronizācijas diagramma.  
**Fig.5.** The Unitrol 1000 sync Diagram.

On picture number 5 are given the Unitrol 1000 synchronization diagram program visualization results, where can see cases of coming into a synchronous work are resulted at a deviation from synchronization conditions.

On picture number 6 are given the Unitrol 1000 synchronization measurements program visualization results.

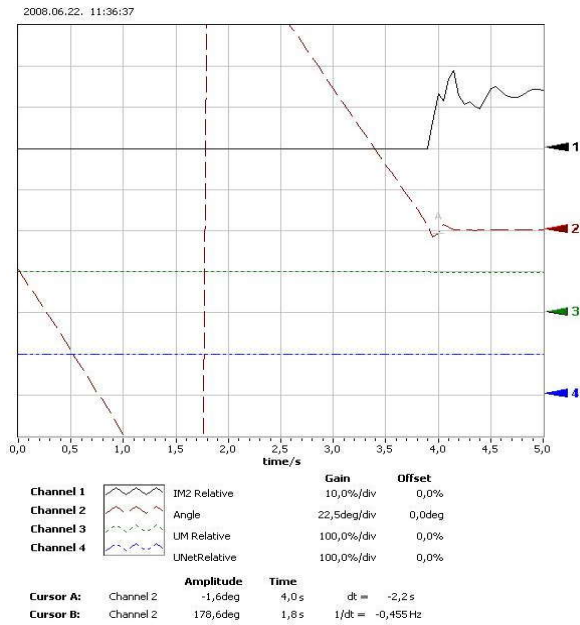
To show emergency conditions of the exciting generator model we shall lead carry out the analysis of a synchronization regime with an infinite power network.



**Att.6.** Unitrol 1000 mērīšanas lielumi.

**Fig.6.** The Unitrol 1000 sync measurements.

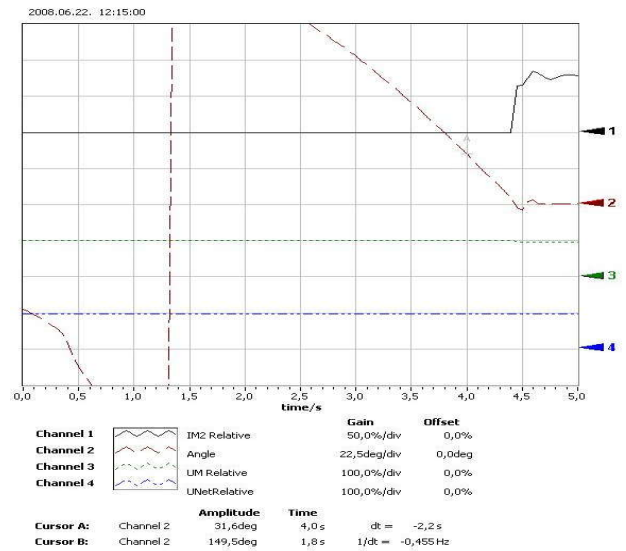
At the fig. 7 – 9 are given results for normal cases of coming into a synchronous work are resulted at a deviation from synchronization conditions generator-network, generator-load 2,2 A and generator- double as much load 4,4A.



**Att.7.** Sinchronizācijas rezultāti gadījumam ģeneratoru-tīkls.

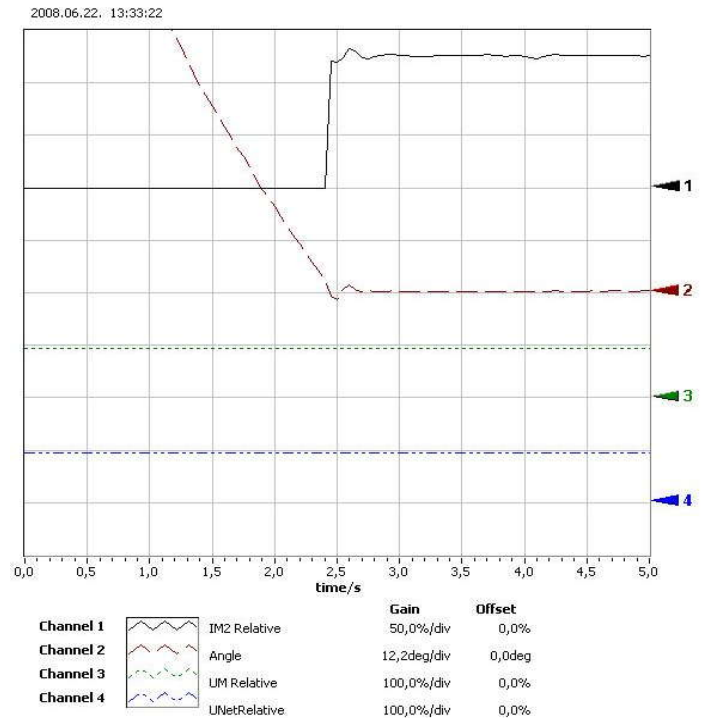
**Fig.7.** Results for cases of coming into a synchronous work are resulted at a deviation from synchronization

At the fig. 10 – 12 are given results for emergency situation's cases of coming into a synchronous work are resulted at a deviation from



**Att.8.** Sinchronizācijas rezultāti gadījumam ģeneratoru-slodze.

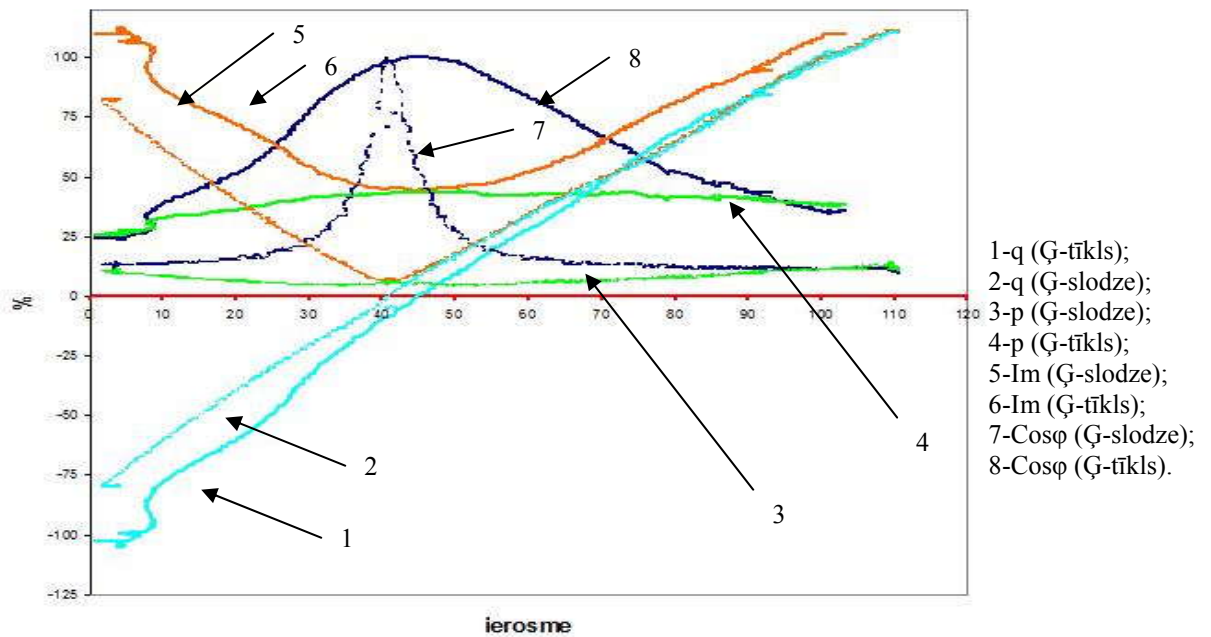
**Fig.8.** Results for cases of coming into a synchronous work are resulted at a deviation from synchronization conditions generator-load.



**Att.8.** Sinchronizācijas rezultāti gadījumam ģeneratoru - dubultā slodze.

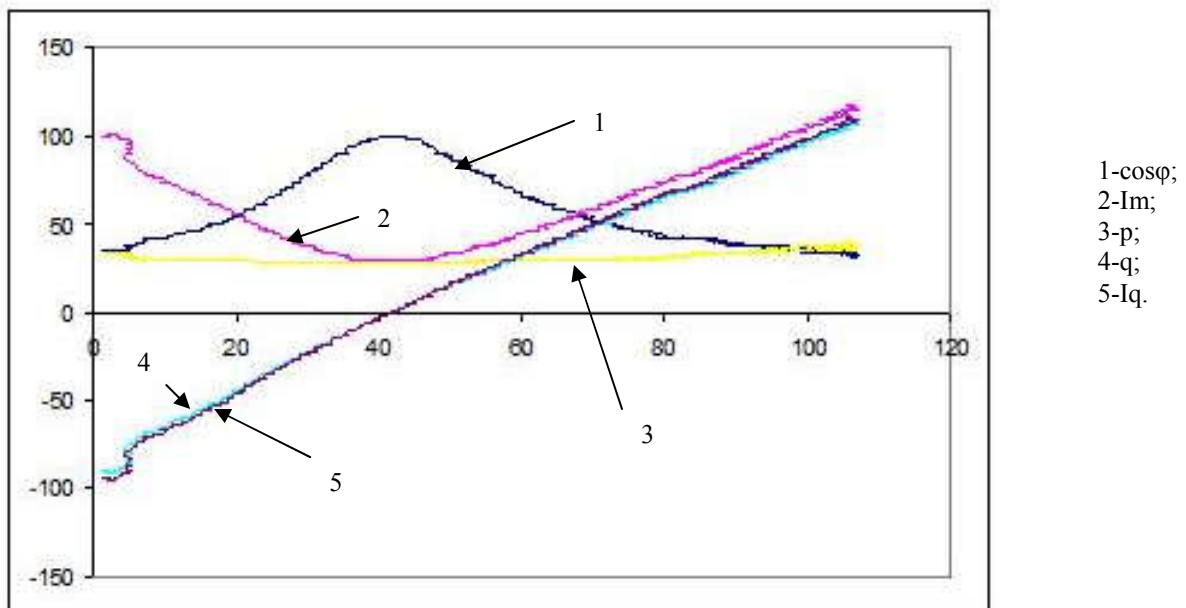
**Fig.9.** Results for cases of coming into a synchronous work are resulted at a deviation from synchronization conditions generator- double as much load.

synchronization conditions generator-network, generator-load and generator-load, when generator was initiated into engine conditions.



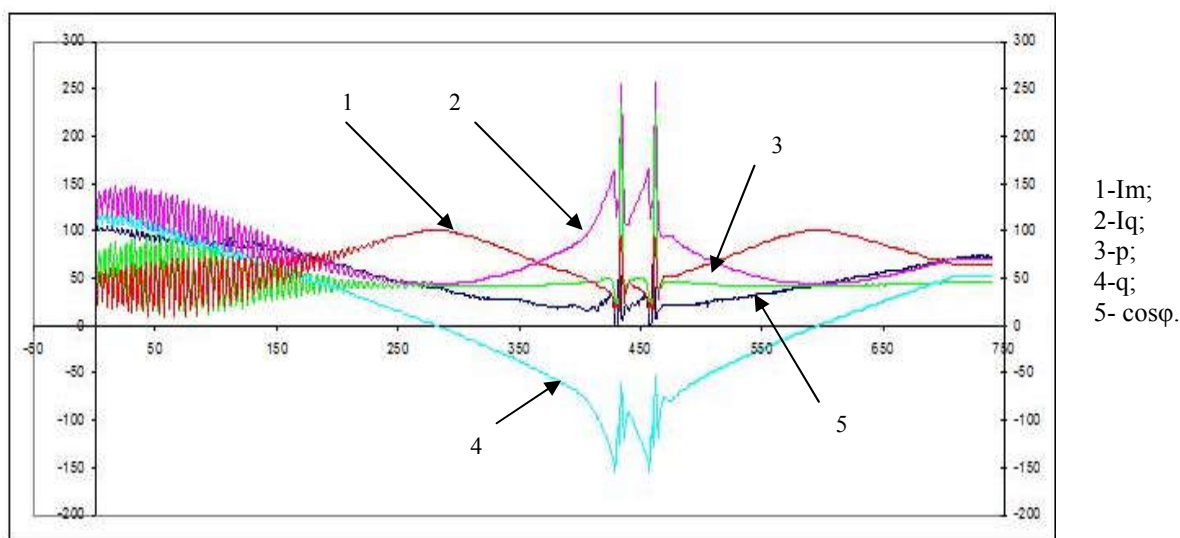
**Att.10.** Matemātiskās modeles sinhronizācijas rezultāti gadījumiem ģenerators – tīkls, (nepārtraukta līnija) un ģenerators - slodze (10A)(pārtrauktā līnija).

**Fig.10.** Results for cases of coming into a synchronous work are resulted at a deviation from synchronization conditions generator-network (line type) and generator-load (10A), (hidden line type).



**Att.11.** Matemātiskās modeles sinhronizācijas rezultāti gadījumiem ģenerators -slodze (5A), kad ģenerators dzīēja režīmā.

**Fig.11.** Results for cases of coming into a synchronous work are resulted at a deviation from synchronization conditions generator- load (5A), when generator was initiated into engine conditions.



**Att.12.** Matematisks modeles sinhronizācijas rezultāti gadījumiem ģenerators -slodze (6A), kad ģenerators dzinējā režīmā.

**Fig.12.** Results for cases of coming into a synchronous work are resulted at a deviation from synchronization conditions generator-load (6A), when generator was initiated into engine conditions.

## CONCLUSIONS

On the Unitrol's basis there is possible to define synchronization conditions of generator. To determine possible deviation limits on rotation frequency and mismatch corner of exact synchronization. It is easy to follow how the changing of a parameter affects the overall behavior of the regulator by referring to the power chart and the oscilloscope function. This means, that the optimum settings are found within a short time. The applied model has shown the serviceability. Also the device allows comparing the networks and generators currents and voltage in the real time. Four signals can be selected for graphic display parameter files and graphs can be saved in numerical form for later analysis the resolution of mismatch corner dependence from time.

The Unitrol 1000 make possible to control, analyze and compare theoretical current, power, mismatch corner results which was received from mathematical models and all components' practical results. It gives possible to check is the the oscilloscope is 50 ms, and a total of 20 channels are recorded.

At the publication was disclose results for emergency situation's cases of coming into a synchronous work are resulted at a deviation from

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**Ketnere E., Berzina K., Mesņajevs A., Orlovskis G.**  
**The research of stability of synchronization process with UNITROL 1000 application.**

UNITROL 1000 is an automatic voltage regulator of the latest design for synchronous generators and synchronous motors. The unit contains the most advanced microprocessor technology together with IGBT semiconductor technology (Insulated Gate Bipolar Transistor). In article is considered the problem of synchronization conditions execution on the synchronous generator with an infinite power network with UNITROL 1000 system application. All of the parameter settings for the UNITROL 1000 it is allow following how the changing of a parameter affects the overall behavior of the regulator by referring to the power chart and the oscilloscope function. This means, that the optimum settings are found within a short time.

On the Unitrol's basis there is possible to define synchronization conditions of generator. To determine possible deviation limits on rotation frequency and mismatch corner of exact synchronization.

At the publication are given results for normal cases of coming into a synchronous work are resulted at a deviation from synchronization conditions generator-network, generator-load, generator- double as much load and emergency situation's events, when synchronous generator was initiate into engine conditions.

**Ketnere E., Bērziņa K., Mesņajevs A., Orlovskis G.**  
**Sinhronizācijas procesa stabilitātes izpēte izmantojot UNITROL 1000.**

UNITROL 1000 ir jaunas paaudzes sinhrono ģeneratoru un sinhrono mašīnu automātiskais

sprieguma regulators. Rakstā apskatīts sprieguma regulators ietver sevī pusvadītāju mikroprocesoru tehnoloģiju, kā arī tika aprakstīts sinhrono ģeneratoru sinhronizācijas process ar UNITROL 1000 iekārtas palīdzību.

Doto iekārtu iespējas ļauj sekot ģeneratoru un tīklu parametru izmaiņām kā sinhronizācijas momentā, tā arī uzdotā laikā periodā. Iekārtā ir integrētas oscillografa funkcijas.

Ar UNITROL 1000 iekārtas palīdzību var noteikt ģenerātoru sinhronizācijas apstākļus. Ir iespējams noteikt novirzīšanas robežas rotēšanas frekvencei un sinhronizācijas leņķa nobīdei.

Rakstā ir vizualizēti un apskatīti sinhrono ģeneratoru ar tīklu, sinhrono ģeneratoru ar slodzi un sinhrono ģeneratoru ar dubulto slodzi sinhronizācijas rezultāti. Ievietoti arī sinhronizācijas avārijas režīmu vizualizēti dati.

Simulācijas rezultāti parādīja, ka izpētīta koģenerācijas sistēma strādā korekti zemā sprieguma sistēmā.

**Кетнере Е., Берзиня К., Месняев А., Орловский Г.**  
**Исследование устойчивости процесса синхронизации с использованием UNITROL 1000.**

UNITROL 1000 является автоматическим регулятором напряжения для усовершенствованных моделей синхронных генераторов и синхронных машин.

Рассматриваемый образец регулятора включает в себя встроенную микропроцессорную технологию на полупроводниковом базовом элементе.

В статье рассмотрена проблема выполнения условий синхронизации синхронного генератора с сетью бесконечной мощности при помощи UNITROL 1000. Параметры данного оборудования позволяют следить за изменениями данных генератора и сети как в момент синхронизации так и в определенный заданный период времени. UNITROL 1000 имеет встроенную функцию осциллографа.

При помощи программного обеспечения UNITROL 1000 возможно получить полную картину синхронизации генератора: получить данные отклонения угла вращения.

UNITROL 1000 дает возможность получить токи и напряжения сети и генератора в реальном времени.

В статье визуализированы и предоставлены результаты синхронизации синхронного генератора генератора с сетью, генератора с нагрузкой, генератора с удвоенной нагрузкой. Так же предоставлены результаты аварийных режимов синхронизации.