Digital Type Static Excitation Control System

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Keywords Digitization, Static excitation system, Hydropower station, RoHS application, AVR

Abstract

As a next-generation model to our conventional analog type static excitation control system (Type: YNEX97S Series), we developed a digital type static excitation control system (Type: YNEX11SD). The major features of the newly developed system are (1) multi-function, high performance, and compact design, (2) applicable up to a field current of 912A, (3) the adoption of the Restriction of Hazardous Substances (RoHS) directive- compliant parts, (4) improved operability with a large-sized display, and (5) the adoption of self-diagnostic functions. We especially realized a very compact excitation control unit: W225 × H311 × D175mm.

1 Preface

Recently, the digital system has become the dominant trend in control equipment. Even for a static excitation control system for a hydropower plant, demand for digital control is increasing. We have developed a digital control unit drawing on our digital technology of a brushless type excitation control system in which we have many records of supply. This paper introduces the features of the digital type static excitation control system (Type: YNEX11SD).

2 Features

Fig. 1 shows a human interface part of the digital type static excitation control system and Table 1 shows a comparison with a conventional model. The major features of this system are as follows:

(1) A multi-function, high performance, and compact design

Control functions of AVR primary and secondary circuits and gate phase control functions are digitized and concentrated in a single unit. As a result, we realized about a 10% size reduction (about 20% reduction of footprint space) compared with conventional model. For the excitation control unit in particular, we realized a very compact size: W225 × H311 × D175mm.

(2) Adoption of the Restriction of Hazardous Substances (RoHS) directive-compliant parts

All parts used in the unit are RoHS directive-compliant.

(3) Improved operability

Operational functions are sufficiently improved thanks to the adoption of a large-sized display and sheet switches.

(4) Redundancy of control power

We realized the redundancy of control power, both DC (110V) and AC (110V). The AC power source is obtained from the secondary circuit of the excitation transformer. For this reason, continuous operation is possible even though the DC control source is lost.

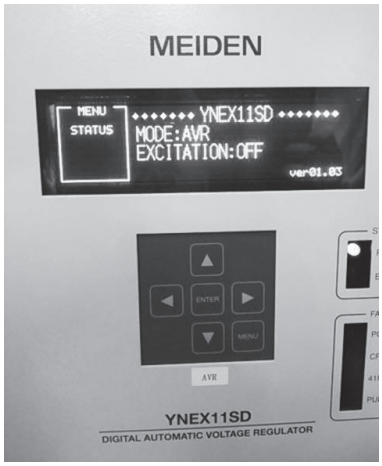

Fig. 1 Human Interface Part of Digital Type Static Excitation Control System

We realized a very compact design while improving the operability by using a large display.

Table 1 Comparison with the Conventional Model

By adopting the digital type, we increased such functions as the communication and secondary circuit regulation.

	New type of static excitation unit (YNEX11SD)	Conventional type of static excitation unit (YNEX97S)
Control method	Digital	Analog
Voltage control	Control range: 80～110%	Control range: 80～110%
	Control accuracy: within ±0.5%	Control accuracy: within ±0.5%
Field current control	Control range: 80～110%	Control range: 80～110%
	Control accuracy: within ±0.5%	Control accuracy: within ±0.5%
Voltage establishment control (Overshooting reduction control)	With overshooting reduction control	Without overshooting reduction control
	Smooth start or step start system	—
AVR/MVR control changeover	Capable of changeover during operation	Changeover is not possible during operation
Field overcurrent detection (51E)	○	○
Excitation undercurrent detection (37E)	○ (Used for backup protection of field loss relay "40")	×
Sync pulse monitoring for phase control	○	×
Gate pulse monitoring	○	○
Power supply major fault detection	○ (Undervoltage/overcurrent/overvoltage)	○ (Undervoltage/overcurrent)
Power supply minor fault detection	○ (Either power system disconnection detection)	×
41X dual contact monitoring	○ (Dual contact mismatch monitoring function)	×
VT/CT fault detection	○	×
Communication function	○ (TCP/UDP communication)	×
Fault trend function	○ (Dedicated tool required)	×
Secondary regulation function	Standard equipment	Available by optional unit

(5) Fault trend function

When a dedicated tool unit connected, is a fault trend analysis check at the time of a fault occurrence is possible.

(a) Measuring signals: 8 points

(b) Status and fault signals: 32 points

(c) Sampling period: 10～100ms (variable)

(d) No. of sampling points: 1500 before fault, 500 after fault

(6) Simplified maintenance

Except for the power supply board where electrolytic capacitors are accommodated, all other parts do not require any periodic replacement. Since the long-life type electrolytic capacitors are used, the lifetime of the power supply board has been extended to ten years.

(7) Productivity and application of component parts

We adopted the component parts which can provide stable and long-term production.

(8) Self-diagnostic functions

Functions of fault detection are available. This works by checking the soundness among CPUs through constant monitoring.

(9) Minimizing performance changes and deterioration

Any component parts liable to face aging detection (such as motor-powered setters and variable resistors) are not used. As a result, performance changes can be maintained at the minimum level. As such, inspection items are simplified and maintenance costs are reduced.

3 Automatic Voltage Regulator (AVR) Functions

Table 2 shows a list of AVR functions. The major functions are described below.

(1) AVR

Generator voltage is detected through a Voltage Transformer (VT) in order to obtain deviation data from the voltage setter (90R). A Proportional-Integral-Derivative (PID) controller is used for conversion to obtain phase control signals. By turning the thyristor gate ON, the AVR output is controlled.

(2) Automatic field current control (AIFR)

Exciting current is detected through a CT to determine the deviation from the field current setter (70E). The obtained data are converted into phase control signals by PID control. The AVR output is controlled by turning the thyristor gate ON.

(3) Voltage buildup control

(a) Step start

When excitation control begins, the preset field current output is immediately generated. When the detected generator voltage level attains the preset value, the circuit is switched over to the AVR.

(b) Smooth start

When excitation control starts, the field current value is linearly increased within the preset time. When the detected generator voltage attains the preset level, the circuit is switched over to the AVR. Thanks to this control, it is possible to reduce generator voltage overshooting at the initial excitation of the generator.

Table 2 AVR Functions

In addition to the standard functions required for the AVR, the PSS is also available.

Item	Specifications	
AVR	Voltage control range (90R)	80～110%
	Voltage control accuracy	Within ±1%
	Full-stroke time	60s
AIFR	Field current control range (70E)	0～110%I33
	Field current control accuracy	Within ±1%
	Full-stroke time	60s
Voltage establishment control function	Step start system (default)	—
	Smooth start system	0～100s
Cross current compensation function	Setting range	0～10%
V/Hz function	Voltage droop system Setup value (Drooping point to be set up)	70～100%F Default 85%
Field overcurrent function (#51E)	Operating value	105～130% Default 110%
Field undercurrent function (#37E)	Operating value	Default 5%
Power factor, reactive power control functions (APFR, AQR) Q = A + BP formula	Item A setting range	−1.0～1.0PU
	Item B setting range	−0.7～0.7 cos ϕ
	Reactive power control accuracy	Within ±2%
	Power factor control accuracy	Within ±2°
Reactive power limiting function (VARL)	OCL, OEL, UEL	
	OCL boundary setup	0～100%
	Lagging side setup	5 points Max.
	Leading side setup	5 points Max.
Power System Stabilizing (PSS) function	3-lead, lag/4-lead, lag	Default: 3-lead, lag
VT, CT fault detection function	Voltage and current difference detection between phases	10% 10s
Gate pulse error detection function	Pulse sequential order, open phase detection	Continuous alarming 10 times Continuous error 20 times Error: No pulse entry for 200ms to be sensed by #41XON
Dual contact mismatch detection function	Contact inputs #41Xa, b	1s

(4) Cross-current compensation function

In the case of parallel running with another generator, reactive currents (cross-currents) flow between both generators due to a difference between output voltages of these generators. This will result in the consumption of extra-reactive power. The cross-current compensation function of this system can suppress generation of reactive currents (cross-currents) by regulating the generator voltages according to the detected value of reactive power.

(5) Functions of the Automatic reactive power Regulator (AQR) and Automatic Power Factor Regulator (APFR)

During the parallel running of generators, the reactive power or power factor of the generators can be regulated to a constant level.

(6) Power System Stabilizer (PSS) function

Fluctuations in power can be suppressed by detecting such fluctuations in order to adjust the exciting currents.

(7) Communication function (LAN function)

One port of LAN interface is provided for use as a maintenance port.

4 Postscript

Our digital type static excitation control unit has been introduced.

Going forward, we will make efforts to increase functions and improve performance so that our products can meet various requirements of our customers.