Instruction Manual

Installation
Operation
Maintenance

Voltage Regulators
Magnetic Amplifier - Single Phase

P/N 800-84132-xx
09
20-21
27
32

Publication
351-01052-00 (April 1995)

Nidec
KATO ENGINEERING™

Kato Engineering, Inc. | P.O. Box 8447 | Mankato, MN USA 56002-8447 | Tel: 507-625-4011
KatoEngineering@mail.nidec.com | www.KatoEngineering.com | Fax: 507-345-2798

SECTION 1
INTRODUCTION AND THEORY OF OPERATION

INTRODUCTION

The magnetic amplifier voltage regulator is designed to operate with brushless synchronous 400 Hz generators. The voltage regulator controls generator voltage by regulating the amount of current it supplies the exciter field.

SPECIFICATIONS

Input Power: single phase, 400 Hz, 120 Vac
Sensing: single phase, 400 Hz, 120-139, or 208-240 Vac
Output: continuous maximum: 55 Vdc, 4 amperes

THEORY OF OPERATION

Note: Refer to drawings

A. Sensing

A sample of the generator output voltage is applied to regulator sensing terminals E1 and E3. Tap setting H2 for 120 or 208 Vac and H3 for 139 or 240 Vac. This voltage is applied to sensing transformer T1 which proportionally reduces the voltage. Regulators equipped for parallel operation also include transformer T4. This circuit does not affect voltage regulator operation in single unit operation if the CT leads are shorted. (See B below.)

The reduced AC voltage is then fed to a rectifier consisting of diodes D1 through D6. The rectifier output, which is proportional to the sensing voltage, is filtered by capacitor C1. It is then impressed across a voltage divider circuit consisting of resistors R2 and R4, voltage range set adjust potentiometer R3, and the externally mounted voltage adjust rheostat. A portion of this voltage is applied to the base of transistor Q1 in the error detector circuit.

B. Sensing Circuit During Parallel Generator Operation in Parallel Cross-Current Compensation Mode

Parallel cross-current compensation allows two or more parallel generators to share reactive loads and maintain constant system output voltage. The reactive error signal developed in the external paralleling circuit is added vectorially to the sensing voltage by transformer T4. The circuit is phased such that a generator with excessive excitation will decrease excitation and an under-excited generator will increase excitation. At balance, each generator will carry its share of reactive load.

C. Error Detector

The error detector is a differential amplifier. Resistors R11 and R14 in the emitter circuit of transistors Q1 and Q2 are of equal value. Therefore, when the base voltage of Q1 is equal to the base voltage at transistor Q2, Q1 and Q2 conduction will be equal. Transistor Q2 is the reference voltage side of the error detector. Its base voltage is kept constant by zener diode Z1. The base voltage of Q1 is proportional to the sensing voltage and the setting of the voltage adjust rheostat. Q1 base voltage will therefore increase and decrease in direct proportion to any increase or decrease in the sensing voltage or change in the setting of the voltage adjust rheostat. Operation of the error detector (Q1, Q2), second stage differential amplifier (Q3, Q4), and amplifier Q5, Q6 is as follows.

An increase of Q1 base voltage will decrease Q1's collector voltage and increase Q2's collector voltage. The differential collector voltage is directly connected to the bases of Q3 and Q4. This voltage increases Q3's collector current and decreases Q2's collector current. The increase in Q3's collector current is also an increase in base drive to the control current amplifier transistors Q5 and Q6. The collector current of Q5 and Q6 and the magnetic amplifier control current increases, resulting in decreased magnetic amplifier output. Conversely, a decrease in sensing voltage results in lower conduction of transistors Q1, Q3, Q5, and Q6, a decrease in control current and an increase in magnetic amplifier output.

D. Power Stage

The output power stage of the voltage regulator rectifies 400 Hz power and feeds a regulated amount of dc power to the exciter field. The power output stage consists of an electromagnetic filter (RFI), two full-wave rectifiers (BR1 AND BR2) and two toroid magnetic amplifiers (MA-1 and MA-2). The magnetic amplifiers contain two windings wound about a ferromagnetic core. The windings are: a power or "gate" winding and a control winding C1 and C2. Field excitation is controlled by operation of the magnetic amplifiers as described in the paragraphs that follow

The single phase, 400 Hz, 120 Vac power applied to regulator terminals L1 and L2 magnetizes the magnetic amplifier core. During the time the core is being magnetized, it creates a back e.m.f. across the gate

winding, limiting current flow. As magnetism of the core increases, the rate of change in flux decreases, resulting in a decrease in back e.m.f. This action continues until the core becomes fully magnetized (saturation). At this point no further change in flux density occurs. Resistance across the gate winding is then limited by the series resistance of the gate winding and field winding, and current flow is maximum. Control and regulation are accomplished by resetting the core of the magnetic amplifier at some point below saturation during the half-cycle the gate winding is not conducting. This is done by applying dc control current to magnetic amplifier control winding (C1-C2) and is referred to as magnetic reset or bias. Increasing the control current resets the magnetic amplifier core further below saturation. The further the core is reset below saturation the more back e.m.f. will be present across the gate winding. Thus, the less current will flow through the gate winding and exciter field. The magnetic amplifier reacts in an opposite manner when control current is decreased.

E. Stability

The voltage regulator includes a negative feedback system stability circuit designed to prevent oscillation (hunting) of the generator output voltage. The circuit consists of capacitors C2, C5, resistors R5, R6, R16 and a stability adjust potentiometer R7 .

F. EMI Suppression

Filter RFI is included in the voltage regulator input power circuit to reduce conducted EMI to negligible levels.

SECTION 2
INSTALLATION

SAFETY SUMMARY

WARNING
To prevent injury to personnel or damage to equipment, this unit shall be installed only in accordance with installation instructions and wiring diagrams contained in the instruction manual provided with this unit.

WARNING
When this unit is operating, 120 VAC and 120-139 or 208-240 VAC is present at the voltage regulator assembly terminal board and internal circuitry. To avoid accidental contact with lethal voltage, de-energize the generator set starting circuit while making electrical connections or repairs to this equipment.

CAUTION
Meggers and high potential test equipment should not be used. Incorrect use of such equipment could destroy the rectifiers, transistors and capacitors in the regulator.

LOCATION

The voltage regulator may be mounted in the generator terminal box or remotely mounted. The enclosure in which the regulator is to be mounted should be of sufficient size to permit flow of air about all sides of the regulator.

MOUNTING

Mounting holes are incorporated in the regulator base. The regulator can be mounted in any position without affecting its operating characteristics.

ELECTRICAL CONNECTIONS

The regulator must be connected to the generator system as instructed in the paragraphs that follow and as shown on the diagrams for the generator and control system. Number 14 gauge or larger wire should be used for all connections to the voltage regulator.

A. Regulator Input Power Terminals L1 and L2. The nominal voltage applied to the regulator input power stage (terminals L1 and L2) must be single phase, 400 hertz, 120 volt ac. The input power may be taken from any generator lines that provide the correct voltage (line-to-line or line-to-neutral).

NOTE: When the generator output is different from the preceding value, a power transformer must be used to match the generator voltage to the required regulator input. If excessive voltage is applied to the regulator input terminals L1 and L2), destruction of the rectifiers in the regulator could occur.

B. Fuse F1. The voltage regulator contains a 250 volt, 5 amp., ABC-5 type fuse located within a fuse holder that is mounted on the voltage regulator chassis. Replacement fuse must be a normal break fuse of the same capacity. A time delay type fuse should not be used.

C. Grounding. The dc output circuit to the exciter field must not be grounded. Regulator chassis grounding can be accomplished by solidly mounting the voltage regulator onto a metal cubicle which in turn is grounded, or by connecting a ground wire from the regulator case to ground.

D. Regulator Sensing (Terminals E1 and E3). The voltage regulator is designed for single phase, 400-Hz, 120-139 or 208-240 Vac sensing. Follow the interconnection diagram provided with the generator set.

E. Sensing Transformer (T1). Verify that the sensing transformers located in the voltage regulator are connected as follows: Tap H2 for 120 or 208 Vac and Tap H3 for 139 or 240 Vac.

F. Voltage Regulator dc output Terminals F+ and F-. This circuit provides DC excitation to the exciter field. Observe correct polarity. F- connects to exciter field lead F1 (-) and F+ to exciter field lead F2 (+). In applications where field wires are longer than a foot or two, shielding by running the field lead through one-half inch conduit is recommended.

G. Externally Mounted Voltage Adjust Rheostat (Terminals R1 and R2). Connect the voltage adjust rheostat as shown on the wiring diagram provided with the generator set. Make certain rheostat contains a jumper wire between its slider terminal 2 and the rheostat end terminal 1. When correctly connected, turning the rheostat clockwise increases generator voltage output.

H. Paralleling Terminals (Terminals CT1 and CT2). On voltage regulators with paralleling, connect these terminals to the paralleling circuit as shown on the system drawing. If used for single unit operation, short terminal CT1 to CT2.

SECTION 3
CONTROLS ADJUSTMENT PROCEDURES AND VOLTAGE REGULATOR OPERATING PROCEDURES

SAFETY PRECAUTIONS

The precautions described in Section 2 must be followed when inspecting, making internal adjustments, or making repairs to this equipment.

VOLTAGE REGULATING SYSTEM CONTROLS

The voltage regulating system includes the external voltage adjust rheostat for adjustment of generator output voltage, a voltage range potentiometer R3 located on the circuit board that extends either the minimum voltage limit or maximum voltage of the voltage adjust circuit, and a stability control potentiometer R7 located on the circuit board that provides means of increasing or decreasing a stabilizing signal to attain optimum response and system stability. Adjustment procedures are as described in the paragraphs that follow.

A. Voltage Adjustment. This adjustment is made while the generator is running at rated frequency and while no-load is applied. Turning the externally mounted voltage adjust rheostat clockwise increases generator output voltage. When it is turned in a counterclockwise direction, a decrease in generator output voltage should occur. Voltage is measured during the adjustment procedure by observing the generator voltmeter.

B. Voltage Range Adjustment. This adjustment extends either the minimum voltage limit or the maximum voltage limit of the external voltage adjust rheostat. It is normally factory set at about 1/2 its maximum travel. To limit maximum voltage adjust as follows:

NOTE: In applications that include overvoltage protection circuitry the maximum voltage setting should be lower than the overvoltage trip setting.

1. Operate generator at rated frequency with no-load applied. Turn the external voltage adjust to its maximum clockwise position.

NOTE: Turning R3 clockwise raises the maximum voltage while turning it counterclockwise decreases the maximum voltage.

2. Measure generator voltage using the generator outputvoltage. If voltage is not the required maximum, turnpotentiometer R3 in the appropriate direction until 3' voltmeter indicates output voltage is the required maximum. This is the final adjustment of R3.

3. Turn external voltage adjust counterclockwise to position where output voltage decreases to rated value.

C. Stability Adjustment R7. This control is located on the regulator printed circuit board. Adjust R7 only if during operation oscillating voltage or slow response occurs.

1. Slow Response. Turn R7 clockwise to position where response is satisfactory. Test with load applied and also with no-load applied. If oscillating voltage occurs turn R7 clockwise past the point where oscillation stops.

2. Voltage Oscillating. Turn R7 clockwise past the position where oscillations stop. Test no-load and with load applied.

NOTE: Slow response, loss of sensitivity and poor regulation could occur if R7 is turned too far counterclockwise.

OPERATING PROCEDURES

The instructions that follow describe the procedures to be followed during initial operation and during subsequent operation of the unit. The preceding chapters as well as the following procedures should be reviewed and understood before system operation is attempted. The system operator should also locate all controls and adjustments pertinent to system operation before attempting to operate the equipment.

A. Initial operation

1. Open output circuit breaker or contactor. Initial start-up should be made with no-load.

2. In applications where system includes overvoltage devices or a field circuit breaker, make certain the field circuit breaker and overvoltage circuit is not "tripped" open.

3. In applications where system includes both automatic voltage control, and manual voltage control set

mode selector switch to AUTO position for automatic regulation.

4. Start the generator set and bring up to rated speed.

5. Verify generator voltage. Any of the following conditions may occur:

a) Overvoltage — If this condition occurs adjust the auto voltage adjust rheostat as described in paragraph A, Voltage Adjustment. If condition persists, stop the prime mover and determine cause of malfunctions.

b) Undervoltage — If condition occurs adjust the auto voltage adjust rheostat as described in paragraph A, Voltage Adjustment. If condition persists, stop the prime mover and determine cause of malfunction.

c) No voltage buildup — If this condition exists and an auto/manual switch is incorporated, stop the prime mover, set auto/manual switch to manual position, start generator set and see if voltage builds up.

NOTE: Alternative methods of testing to isolate faulty operation and a troubleshooting chart are given in Chapter 4.

d) Oscillating Voltage (Hunting) — If this condition exists adjust stability control as described in paragraph C, Stability Adjustment R7. If problem persists, refer to troubleshooting procedures. Voltage hunting can be caused by an unstable prime mover .

e) Voltage Unstable or Slow Response — Adjust Stability Adjust R7 as described in paragraph C.

6. Turn auto voltage adjust rheostat to obtain desired voltage.

7. The voltage regulator is now ready for load test.

8. Close output circuit breaker and apply load to generator.

9. Verify that the voltage regulation is within + or - 1%. If it is not within these limits, refer to troubleshooting procedures.

10. Alternately remove and apply load to determine whether the generator voltage is stable and response is satisfactory.

11. If the generator voltage becomes unstable or response is slow, adjust stability adjust R7.

a) Instability may occur when the no-load field requirements of the exciter are near the minimum working voltage of the regulator.

b) On engine driven or dc motor driven generator sets, unstable speed governors are frequently the cause of generator voltage instability. If a stability problem still exists after performing the procedure as described in paragraph C, check the governor.

12. After satisfactory initial operation has been determined, remove load, open output circuit breaker and stop generator set.

B. General Procedure for Subsequent Operation of Unit

1. Verify that overvoltage circuitry and field circuit breakers, when included in generating system, are not tripped open.

2. In applications where generating system includes both automatic voltage control and manual voltage control, set the mode selector switch to AUTO position.

3. Start generator set and bring up to rated speed.

4. Verify generator voltage. If voltage is not correct adjust the voltage control rheostat as described in Voltage Regulating Controls, paragraph A in this section.

5. Close output circuit breaker or contactor and apply load.

6. During operation periodically check system meters to ensure that generator set is operating satisfactorily.

7. Before stopping generator set, remove load and open output circuit breaker.

SECTION 4
MAINTENANCE

SAFETY SUMMARY

The precautions described in Section 2 must be followed when inspecting, testing or making repairs to this equipment.

PREVENTIVE MAINTENANCE INSPECTION

Semiannual inspection should be made on this unit to insure that it is kept free of dirt and moisture. Wiring should be inspected for satisfactory condition (absence of frayed or broken insulation) and all connections should be inspected and tightened.

TROUBLESHOOTING PROCEDURES

Troubleshooting is the process of recognizing malfunctions of the system, intelligently analyzing the malfunction, and making the necessary corrections to place the unit back into proper operation. The more common generator system malfunctions and the appropriate repair procedures are listed in the following Troubleshooting Chart. Following the chart are methods of isolating system malfunctions and instructions for voltage regulator test.

TABLE 4-1 TROUBLE SHOOTING CHART	
Voltage does not build-up to rated value	
Probable Cause	**Probable Remedy**
Voltage adjust rheostat not set correctly.	Adjust rheostat.
Voltage regulator fuse (F1) blown.	Install new fuse.
No field flashing voltage.	Verify flashing assy. output. Refer to wiring diagrams provided with the generator.
Circuit breaker in incoming power to voltage regulator open.	Ascertain cause of circuit breaker trip. Correct abnormal condition and reset circuit breaker.
Improper voltage or loose connections to regulator power terminals L1 & L2.	Check connections. Check input voltage. Voltage should be 120 Vac, 400 HZ, nominal.
Generator output heavily loaded or shorted.	Remove short or excessive load.
Regulator rectifier assembly BR1 or BR2 open or shorted.	Test rectifiers.
Magnetic amplifier MA-1 or MA-2 open.	Check continuity of magnetic amplifier windings. Replace amplifiers if windings are open.
Loose connections to exciter field (terminals F+ F-)	Check connections.
Defective exciter or generator.	See generator manual.
Low Voltage	
Open Rectifier in assembly BR1 or BR2.	Test. Replace if any of its rectifiers are defective.
Preamplifier (PC board) failure.	Replace PC board.
Voltage adjust not properly adjusted.	Adjust rheostat.
Voltage range adjust R3 requires adjustment.	Adjust for minimum voltage while external voltage adjust is turned to complete counterclockwise position.
High Voltage	
Voltage adjust rheostat not properly adjusted.	Adjust rheostat.
Voltage range adjust R3 requires adjustment.	Adjust for maximum voltage while voltage adjust is turned to complete clockwise position.
Preamplifier (PC board) defective.	Replace PC board.
Magnetic amplifier MA-1, MA-2 shorted.	Check for shorts.

Sensing open or wrong sensing taps.	Check wiring. If correct check for open sensing transformer T1.
Excessive voltage applied to regulator power input (terminals L1 & L2).	Check wiring. Voltage should be 120 Vac, 400 HZ, nominal.
Voltage Unstable	
Stability adjust potentiometer R7 not properly set. (Stability insufficient).	Adjust R7 as described in chapter 3.
Slow Response	
Excessive load.	Remove excessive load.
Stability adjust R7 not properly set.	Adjust R7 as described in Chapter 3.
Poor Regulation	
Excessive load.	Remove excessive load.
Stability adjust R7 not properly set.	Adjust R7 as described in chapter 3.

SINGLE PHASE SENSING		
Magnetic Amplifier Regulator Part No.	**Sensing Volts AC**	**Paralleling**
800-84132-21	120/139	No
800-84132-32	120/139	No
800-84132-09	208/240	No
800-84132-20	208-240	Yes
800-84132-27	208/240	No

Kato Engineering Support

The brand you trust, the power you depend on. Include the serial number and model number for your machine in the email subject line.

Field Service	KatoService@mail.nidec.com
Parts	KatoParts@mail.nidec.com
Remanufacturing	KatoRemanufacturing@mail.nidec.com
Warranty/Quality Assurance	KatoWarranty@mail.nidec.com

Nidec
KATO ENGINEERING™

Kato Engineering, Inc. | P.O. Box 8447 | Mankato, MN USA 56002-8447 | Tel: 507-625-4011
KatoEngineering@mail.nidec.com | www.KatoEngineering.com | Fax: 507-345-2798