6

POWER SYSTEMS
"LINEAGE"® 2000 RECTIFIER CIRCUIT
INPUT: 208 OR 240 VOLTS, 60 Hz
OUTPUT: 24 VOLTS OR 48 VOLTS
125 AMPERES
J85502C

TABLE OF CONTENTS

SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

1.01 This rectifier circuit charges and floats or equalizes storage batteries by providing regulated dc power from an ac source.

1.02 The ferroresonant rectifier converts an ac input voltage into a filtered and regulated dc output voltage of either 24 or 48 volts, of either polarity, at any current between zero and the rated output current.

2. GENERAL DESCRIPTION OF OPERATION

RECTIFIER CIRCUIT

2.01 The rectifier consists of a ferroresonant transformer, two rectifying diodes, dc filter capacitors, and a filter inductor. The dc output is obtained by connecting the secondary winding of the transformer to the full-wave rectifier feeding the output filter.

FERROCONTROL CIRCUITS

2.02 The ferrocontrol circuit consists of an ac capacitor, an ac inductor, a triac, a triac firing circuit, and an error amplifier. The switching action of the triac simulates the saturation of the transformer at flux levels below magnetic saturation and thereby controls the output voltage of the transformer. The error amplifier senses the output voltage of the rectifier and compares it with a reference voltage. The error voltage is the difference between the output voltage and the reference voltage. The error voltage is then amplified and compared with a synchronizing signal obtained from the secondary winding of the transformer. The comparator output signal fires the triac sooner or later in the half-cycle, depending on the magnitude of the error voltage. The sensed output voltage is thereby regulated for changes in load, line voltage and frequency, and temperature.

AUXILIARY POWER SUPPLY

2.03 The auxiliary power supply consists of an energy-limited transformer, rectifying diodes, filter capacitors, and series transistor regulators. This power supply furnishes the positive and negative 12 volts that power the control circuits and the +27 volts that energize the relays for the alarm circuits. The positive and negative 5-volt supplies, derived from the regulated positive and negative 12-volt supplies, consist of positive and negative 3-terminal series voltage regulators and filter capacitors.

CURRENT-LIMIT CIRCUIT

2.04 The current-limit circuit limits the output of the rectifier under overcurrent conditions. This circuit consists of an operational amplifier, a zener diode, and a potentiometer. When the output current increases above a set limit, the operational amplifier overrides the voltage-regulating error voltage (paragraph 2.02) and decreases the output voltage of the rectifier.

WALK-IN CIRCUIT

2.05 This circuit consists of a resistance-capacitance (RC) network that controls the rampingup of the rectifier after the power switch has been turned on. The walk-in circuit is reset each time the K1 input contactor of the rectifier releases.

HIGH-VOLTAGE SHUTDOWN CIRCUITS

2.06 Three separate high-voltage shutdown circuits are provided. The first circuit, called selective, selectively accepts a high-voltage signal from the plant. If the plant does not provide a high-voltage shutdown signal, a second shutdown is provided. An internal selective shutdown circuit can be actuated by connecting either option Q (24 volts) or option T (48 volts) and disconnecting option M on the CM 1 option board. The third circuit, called backup, senses the output voltage of the rectifier and, when this voltage exceeds the specified value, shuts off the rectifier. Operation of the selective high-voltage shutdown circuit depends on two conditions: First, the rectifier must deliver at least 10 percent of its rated output current; and second, the rectifier must receive a high-voltage shutdown signal from the plant. If no signal is available from the plant (option M), then the internal selective high-voltage shutdown circuit can be connected to take the place of the plant high-voltage shutdown circuit.

REMOTE SHUTDOWN CIRCUIT

2.07 This circuit consists of a relay and a current-limiting resistor. The presence of a plant ground signal on the relay coil shuts off the rectifier, and its absence allows the rectifier to restart.

FUSE ALARM CIRCUITS

2.08 The internal V+ and V- are guarded by alarm fuses. When the fuse alarm circuits operate, they actuate the FA and the RFA relays, which shut down the rectifier. The FA and RFA circuits are also actuated when the output circuit breaker trips.

RESTART CIRCUIT

2.09 The restart circuit restarts the rectifier with an external signal. The restart circuit is a one-shot multivibrator that switches states when the restart signal is applied. The multivibrator output turns off the transistor that holds the RFA relay on. Then the rectifier restarts and stays on if the original cause of the shutdown has been cleared. The rectifier will try to restart once for each application and removal of the external restart signal.

DIGITAL METER CIRCUIT

2.10 The CM 3 digital meter circuit pack displays the output current, output voltage, or battery voltage of the rectifier selected by a 3-position switch.

CONTROL BOARD

2.11 The circuits listed below are located on the CM 2 circuit pack (205A1 control board circuit module):

(a) local power supplies

(b) feedback regulator, ferrocontrol

(c) walk-in circuit

(d) current-limit circuit

(e) high-voltage shutdown circuits

(f) remote shutdown circuit

(g) restart circuit

(h) fuse alarm circuit

(i) isolated current measuring circuit

(j) equalize circuit.

OPTION BOARD

2.12 The CM 1 option board (FS 2) is used as an interface between the CM 2 and CM 3 circuit packs and the cabinet-mounted components. It also contains certain optional components and all the wiring straps of the rectifier. The CM 1 option board is manufactured with all optional resistors and straps in place. Superfluous straps and resistors must be removed before the rectifier is placed in service.

SECTION II - DETAILED DESCRIPTION

1. RECTIFIER CIRCUIT

1.01 Ferroresonant transformer T1 isolates the output of the rectifier from the ac input source and provides the required voltage level at the output terminals. The primary winding of T1 is connected to the ac input source through make-contacts on input contactor K1.

1.02 The output winding of T1 is connected to CR1 and CR2.

1.03 The C1 through C8 capacitors and the L2 inductor filter the output of the full-wave center-tap rectifier. The CR3 and CR4 diodes are in parallel with the L2 inductor, and they provide a path for the inductor current when the CBA1 circuit breaker opens, which inhibits the appearance of the inductive kick.

1.04 The total output current passes through the R3 shunt, which provides a signal for the output current meter. Bleeder resistor R1 discharges the output filter capacitors when the rectifier is turned off and disconnected from the battery.

1.05 Setting the S1 POWER switch to the ON position applies power to the rectifier circuit. The switch closure operates the K2 relay from the +27 volt auxiliary supply located on the CM 2 circuit pack. The +27 volt supply is routed to terminal A of the K2 relay through the S1 switch. Terminal 7 of connector J6 connects to the ground of the +27 volt supply through break-contacts 12 and 14 of the TR relay and break-contacts 3 and 5 of the RFA2 relay on CM 2. The CR1 diode on the CM 1 option board suppresses the transient voltage across the coil of the K2 relay.

1.06 When K2 operates, its make-contacts 4 and 7 close and connect the ac input voltage across the coil of input contactor K1. When K1 operates, it connects the primary winding of transformer T1 to the ac input source.

1.07 The DS3 POWER light-emitting diode (LED), in series with the R8 current-limiting resistor on the FS 2 option board, is in parallel with the coil of the K2 relay. Therefore, the POWER light is on whenever the K1 contactor is closed and the ac line is applied to the primary winding of the T1 transformer.

1.08 The S2 RECT TEST switch is used to check the ability of the rectifier to regulate. When the switch is moved to the NL position, the output of the rectifier should decrease; with the switch in the FL position, the output should increase. The plant connector must be in and wired for remote sense for this feature to operate.

1.09 The T2 transformer is the source of the internal power supplies of the rectifier.

1.10 Contacts 6 and 9 of the K2 relay interrupt the power to the digital meter when the rectifier is off.

FERROCONTROL CIRCUITS

1.11 An ordinary ferroresonant transformer is capable of regulating its output voltage to a fixed value, compensating for line and load variations. A controlled ferroresonant transformer provides a controllable regulated output voltage. Controllability is achieved by means of the ferrocontrol circuit.

1.12 The control circuit for the T1 ferroresonant transformer consists of capacitors C10 and C11, inductor L1, and triac (bidirectional thyristor) Q1. When the Q1 triac turns on, the L1 inductor is placed in parallel with the C10 and C11 capacitors. The resonant discharge that results reverses the capacitor voltage. This action simulates saturation of the T1 transformer and thus limits its output voltage. By varying the timing of the Q1 gate pulses, and thus the timing of the Q1 turnon, the level of the T1 output voltage can be controlled. The gate pulses are generated in the CM 2 circuit pack and are controlled by the feedback amplifier.

1.13 The C9 capacitor and R6 resistor form a snubber network across Q1 to reduce the rate of rise of voltage when Q1 turns off. The C12 capacitor suppresses noise at the gate of the triac.

1.14 Terminals 11 and 12 of the T1 transformer furnish a voltage that is used to synchronize the triac gate pulses with the voltage developed by the transformer.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.01 Input Requirements

Phases: single phase

Frequency: 57 through 63 Hz

Line-to-Line Voltage:

Nominal	Allowable Limits
208	184 through 220
240	212 through 254

Fusing and Wire Size

Refer to Information Note 309 on SD-82659-01.

1.02 Output

The output voltage is adjustable as follows:

Option	Full Load	Max at No Load
W	43 - 54 volts	60 volts
V	21.5 - 28 volts	30 volts

Voltage regulation is ±1/2 percent for line, load, and temperature changes.

1.03 Electrical Noise

Electrical noise is less than 32 dBrnc when measured at the terminals of a battery that has an ampere-hour capacity of four times the rectifier rating.

1.04 Radio Frequency Interference

The rectifier meets the FCC Part 15J requirements for Class A equipment.

1.05 Ambient Temperature

Normal: 40° to 100° F

Short term: 35° to 120° F

(Short term refers to a period of not more than 72 consecutive hours and a total of not more than 15 days in one year.)

1.06 Relative Humidity

20% through 55%

Short term

20% minimum

80% maximum and not to exceed 0.024 lbs of water per lb of dry air.

2. FUNCTIONAL DESIGNATIONS

2.01 Relays

Designation	Meaning
RFA1, RFA2	Rectifier failure (shutdown and lockout of operation, caused by a high-voltage condition, a connector not mating properly, a fuse has operated)
FA	Indicates a fuse alarm or CBA1 trip
TR	Remote shutdown
EQ	To change from float mode to equalize

2.02 Switches

Designation	Meaning
RECT TEST	No-load, full-load regulation test switch
RECT V/AMPS/ BATT V	Output voltage, output current, or battery voltage selector

3. FUNCTIONS

3.01 The J85502C rectifier circuit charges and floats lead-acid batteries at 2.17 to 2.25 volts per cell, with a maximum 2-volt battery feeder loop drop, and with the following number of cells:

(a) 12 cells, option V

(b) 24 cells, option W.

3.02 It provides for connections to:

(a) a conventional power plant

(b) a LINEAGE 2000 power plant.

3.03 It provides for manually turning the rectifier on or off by operating the POWER switch.

3.04 It provides the POWER light to indicate that the K1 line contactor is closed and that the ac line is applied to the power transformer. It provides for manually setting the output voltage for both the float and the equalize modes by means of the OUTPUT VOLTS ADJ and the EQUALIZE ADJ potentiometers.

3.05 It increases its output current gradually at turnon.

3.06 It limits its output current:

(a) inherently, to about 125 percent of full load if the output is shorted

(b) electronically, to an adjustable 90 percent to 110 percent of full load.

3.07 It provides the RECT TEST switch to verify that the feedback regulator is working.

3.08 It provides the REG+ and REG- test jacks to observe the output voltage at the point of regulation.

3.09 It provides digital metering for measuring:

(a) output current at 2.5 percent initial accuracy

(b) output voltage at ±0.02 volt initial accuracy at less than 10 percent load.

(c) battery voltage at ±0.02 volt initial accuracy.

3.10 It automatically transfers to internal voltage sensing if an external sensing lead (R+ or R-) opens. The ZA internal sensing option is provided for applications where external sensing is impractical.

3.11 It provides for an automatic reduction of output voltage if both internal and external sensing circuits fail.

3.12 It shuts down and locks out on high voltage if:

(a) The rectifier is delivering output current (greater than 10% load) and receives a high-voltage shutdown signal from the plant. This is called the selective high-voltage shutdown.

(b) The output voltage increases:

(1) to 27.5 ±0.1 volts in float and greater than 10% load

(2) to 55.0 ±0.2 volts in float and greater than 10% load.

This is called the adjustable internal selective high-voltage shutdown (options T and Q) and is used when the plant does not provide a high-voltage shutdown signal.

(c) The output voltage increases:

(1) to 32.90 ±0.63 volts (option V)

(2) to 64.5 ±1.5 volts (option W).

This is called the backup high-voltage shutdown.

3.13 It shuts down and locks out if a fuse fails.

3.14 It provides for shutting down the rectifier remotely.

3.15 It provides for restarting the rectifier remotely.

3.16 It provides for visible and remote indications of the rectifier failure.

3.17 It provides isolation between the rectifier input and output.

3.18 It provides an optional output circuit breaker that provides an alarm when tripped.

3.19 It interfaces direct with all the conventional and the Microprocessor Controlled System (MCS) LINEAGE 2000 battery plants.

4. CONNECTING CIRCUITS

4.01 Connecting circuit information can be found in the AT&T Practice (802 Series) Equipment Design Requirements for the specific plant.

4.02 This circuit has been designed to function with the following circuits:

SD-82588-01	MCS LINEAGE® 2000 Controller
SD-82603-01	LINEAGE® 2000 Charge and Discharge Circuit
SD-82646-01	"LINEAGE"® XCS Controller
SD-82649-01	LINEAGE® 2000 Charge and Discharge Ckt
SD-83104-01	LINEAGE® 2000 Charge and Discharge Circuit

5. TAKING EQUIPMENT OUT OF SERVICE

5.01 To take the rectifier out of service, move the CBA1 circuit breaker to the OFF position, remove the ac input fuses, and disconnect the J2A connector.

SECTION IV - REASONS FOR REISSUE

B. Changes in Apparatus

B.1

Removed	Replaced By
CBA1 Circuit Breaker KS-22012 L70, 150A - App Fig 1	CBA1 Circuit Breaker KS-22012 L75, 150A - App Fig 1
CR3 Diode, IR 85HFR20 - App Fig 1	CR3 Diode, AEG D75N400B-Mod 1 - App Fig 1
CR4 Diode, IR 85HF20 - App Fig 1	CR4 Diode, AEG D75NR400B-Mod 1 - App Fig 1
K1 Relay, Arrow-Hart ACC430-8072C - Comcode 405589433 - App Fig 1 - V Option	K1 Relay, Arrow-Hart ACC430-8070C - Comcode 405589433 - App Fig 1 - V Option
K1 Relay, Arrow-Hart ACC430-8082C - Comcode 405577305 - App Fig 1 - W Option	K1 Relay, Arrow-Hart ACC430-8076C - Comcode 405577305 - App Fig 1 - W Option
Q1 Thyristor, Motorola MAC-10 - App Fig 1	Q1 Thyristor, Motorola MAC25A-10 - App Fig 1

B.2 Added

K1 Relay, Telemechanique 2200EB330BA-63-11-9 - Comcode 405589433 - App Fig 1 - V Option

K1 Relay, Telemechanique 2200EB530BA-9 - Comcode 405577305 - App Fig 1 - W Option

D. Description of Changes

D.1 In FS 1, wire gauges and reference to Information Note 314 have been added.

D.2 In FS 2, Sheet Note 1 has been added; the wiring to P15 and P16 has been changed and reference to Sheet Note 1 has been added; and the charge position shown on P14, P15, and P16 has been changed.

D.3 In App Fig 1, the KS-22012 L70, 150A identifying number for circuit breaker CBA1 has been removed and replaced by KS-22012 L75, 150A.

D.4 In App Fig 1, the IR 85HFR20 identifying number for diode CR3 has been removed and replaced by AEG D75N400B-Mod 1.

D.5 In App Fig 1, the IR 85HF20 identifying number for diode CR4 has been removed and replaced by AEG D75NR400B-Mod 1.

D.6 In App Fig 1, the Arrow-Hart ACC430-8072C identifying number for option V relay K1 has been removed and replaced by Arrow-Hart ACC430-8070C.

D.7 In App Fig 1, the Arrow-Hart ACC430-8082C identifying number for option W relay K1 has been removed and replaced by Arrow-Hart ACC430-8076C.

D.8 In App Fig 1, the Motorola MAC25-10 identifying number for thyristor Q1 has been removed and replaced by Motorola MAC25A-10.

D.9 In App Fig 1, Telemechanique 2200EB330BA-63-11-9, Comcode 405589433, has been added as the preferred option V relay K1.

D.10 In App Fig 1, Telemechanique 2200EB530BA-9, Comcode 405577305, has been added as the preferred option W relay K1.

D.11 Page Notes 1, 2, and 3 have been added in App Fig 1.

D.12 Note 1 has been added to K2 in App Fig 1.

D.13 Page Note 1 has been changed in App Fig 2.

D.14 Circuit Note 102 has been completely changed.

D.15 Information Notes 306, 309, and 316 on the drawing have been changed.

D.16 Designations EQA and EQAR have been removed from Table A on the drawing.

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