

GP49 ELECTRICAL QUALIFICATION AND TROUBLESHOOTING GUIDE

July 1983



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Electro-Motive Division Of General Motors La Grange, Illinois 60525

FOREWORD

In order to provide the customer with the best possible information, we solicit all comments relative to accuracy, continuity, and thoroughness of this publication. This publication will be revised or reissued after reviewing and evaluating your comments along with any data made available as a result of actual locomotive operation.

Please forward all comments to the attention of Service Publications, Department 700, Electro-Motive Division, La Grange, IL 60525.

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INTRODUCTION

This publication is provided as a guide in qualifying and troubleshooting the locomotive power control system. It is presented in three parts, Module Test Point Location and Description, Electrical Qualification, and Troubleshooting Guide. A brief description of the excitation and power control system is provided in the following paragraphs.

Main generator excitation is provided by the companion alternator through the SCR assembly and is directly proportional to average current through the SE module. Maximum excitation is provided when the SE module is fully turned on, and no excitation is provided when the SE module is turned off. The normal state of the SE module is at some intermediate level and it may be turned off by the LC, EN, or SW modules. Refer to the Block Diagram of the Excitation and Power Control System.

The purpose of the LC module is to control locomotive power levels during normal operation. Throttle signals are provided to the LC module. These throttle signals and the load regulator signal are used by the LC module to develop current, voltage, and kilowatt reference signals. Specific values of reference signals are developed for each throttle position.

Main generator output voltage is applied to the generator feedback module FG. The FG module provides output signals V_{MG} unfiltered and V_{MG} filtered which are proportional to main generator output voltage. The voltage output signal from the FG module has a ratio of one volt for each 125 volts output from the main generator. The V_{MG} filtered signal from the FG module is applied to the LC module where it is compared with the LC module voltage reference signal. The sensor string is opened at the LC module to turn off the SE module if main generator voltage tends to rise above the LC module voltage reference signal.

Main generator output current is also applied to the FG module. The FG module provides an output signal I_{MG} filtered which is proportional to main generator output current. The current output signal from the FG module has a ratio of one volt for each 600 amperes output from the main generator. The larger of the I_{MG} filtered signal from the FG module or the average motor current signal I_{AV} from the FM module is applied to the LC module where it is compared with the LC module current reference signal. The sensor string is opened at the LC module to turn off the SE module if I_{MG} filtered or I_{AV} tends to rise above the LC module current reference signal.

The main generator voltage and current input signals to the LC module are applied to a multiplier on the LC module to obtain a signal proportional to main generator kilowatts output from the main generator. This kilowatt signal is compared with the LC module kilowatt reference signal. The sensor string is opened at the LC module if the main generator kilowatt output signal tends to rise above the LC module kilowatt reference signal.

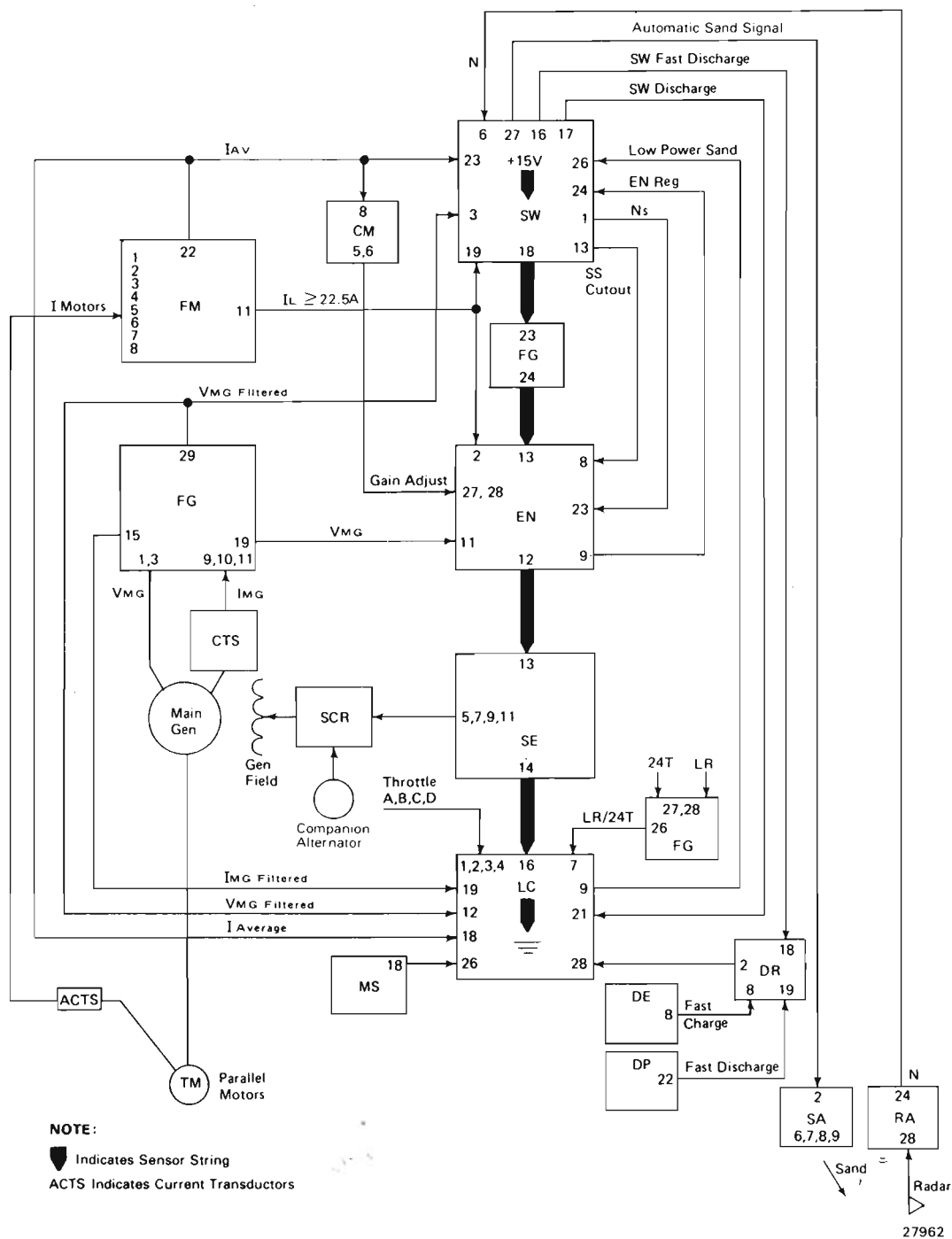
The sensor string is opened at the LC module to turn off the SE module as necessary to ensure that main generator voltage, current, or kilowatts do not rise above their respective LC module reference values. The sensor string at the LC module may also be opened by a signal from the DR module to the LC module during dynamic brake operation. The LC module provides a low power sand signal through the SW module to the SA module if both the current and kilowatt signals fall below about 90% of their respective LC module reference signals.

Refer to the Reference Signal Information Chart and the Feedback Signal Information Chart for signals, test points, range of the signal, and the scale factor or signal ratio. All test points on these charts are referenced to common (test point 25 on all modules except GC).

- 2 A signal proportional to current flowing through each motor is applied to the motor feedback module (FM103). The FM module provides output signals proportional to average motor current, lowest motor current, highest motor current, and lowest motor current above 22.5 amperes. These output signals have a ratio of one volt for 150 amperes of motor current. Some of these signals are not shown on the excitation and power control system block diagram.

The lowest motor current signal of a powered motor $I_L \geq 22.5A$ is applied to the EN module. The EN module uses this signal and the speed signal N to develop a motor voltage reference signal V. This signal represents the nominal voltage required to drive the motor at ground speed N. The EN module then limits wheel creep to some maximum value above ground speed. This allowable wheel creep results in an additional allowable voltage of ΔV above V. The $V + \Delta V$ motor voltage reference signal represents the voltage required to drive the motor at ground speed N plus the maximum allowable wheel creep. A signal from the CM module to the EN module may modify the gain of the EN module so that $V + \Delta V$ will be modified. The sensor string is opened at the EN module if wheel creep increases sufficiently to cause main generator voltage V_{MG} to rise above the $V + \Delta V$ motor voltage reference signal.

The average motor current signal I_{AV} and the lowest motor current above 22.5 amperes signal $I_L \geq 22.5A$ are applied to the SW module. These two signals are approximately equal during normal operation. However, the current of a motor driving a slipping wheel decreases as wheel slip increases. Therefore, during a wheel slip $I_L \geq 22.5A$ will be less than I_{AV} . The SW module compares the I_{AV} and $I_L \geq 22.5A$ signals to obtain a differential current signal. The sensor string is opened at the SW module if the differential current rises above a predetermined level.



Signal	Test Points	Signal Range		Signal Ratio
		Min.	Max.	
I _{MG} Filtered (Fld. Current in DB)	FG15, LC19, WO1, DR5, DE27	0	11V	600A/V
I _{MG} Unfiltered	FG18, DR28	0	-11V	600A/V
I _{AV} Motor Feedback (Grid Current in DB)	FM22, LC18, CM8, SW23, WO2, DP16	0	11V	150A/V
I _L Lowest Motor	FM12	0	11V	150A/V
I _L ≥ 22.5A Lowest Loading Motor	FM11, EN2, SW19, RA29	0	11V	150A/V
I _H Highest Motor	FM21, DR17, DP15, MS17, DE21	0	11V	150A/V
I _{M1} , M2, M3, M4	FM13, 14, 15, 16	0	11V	150A/V
V _{MG} Filtered	FG29, LC12, DP12, SW3, WO7, RA3, MS16	0	11V	125V/V
V _{MG} Unfiltered	FG19, EN11	0	11V	125V/V
LR/24T ^{LR Max.=OV=24T Min. LR Min.=10V=24T Max.}	FG26, LC7, DR16	0	10V	7.3V/V
Radar Train Speed	RA5	0	4V	22.5 mph/V
Recal. Radar Motor Speed :N	RA24, SW6	0	10V	**10 mph/V
Calc. Motor Speed :N _H (In power)	RA23, SW5	0	10V	**10 mph/V
kW Feedback	LC29	0	10V	198 kW/V
I _{MAIN GEN. FLD. AMPS}	EL21	0	10V	16.6A/V
Low Power	LC8, SW8	Digital*		Normal="0"* Low Power="1"*

*Digital "0" = 0 to 1.5V; "1" = 13.5 to 15V

**On units equipped with 40 inch wheels and 70:17 gear ratio this provides for 347 RPM/V.

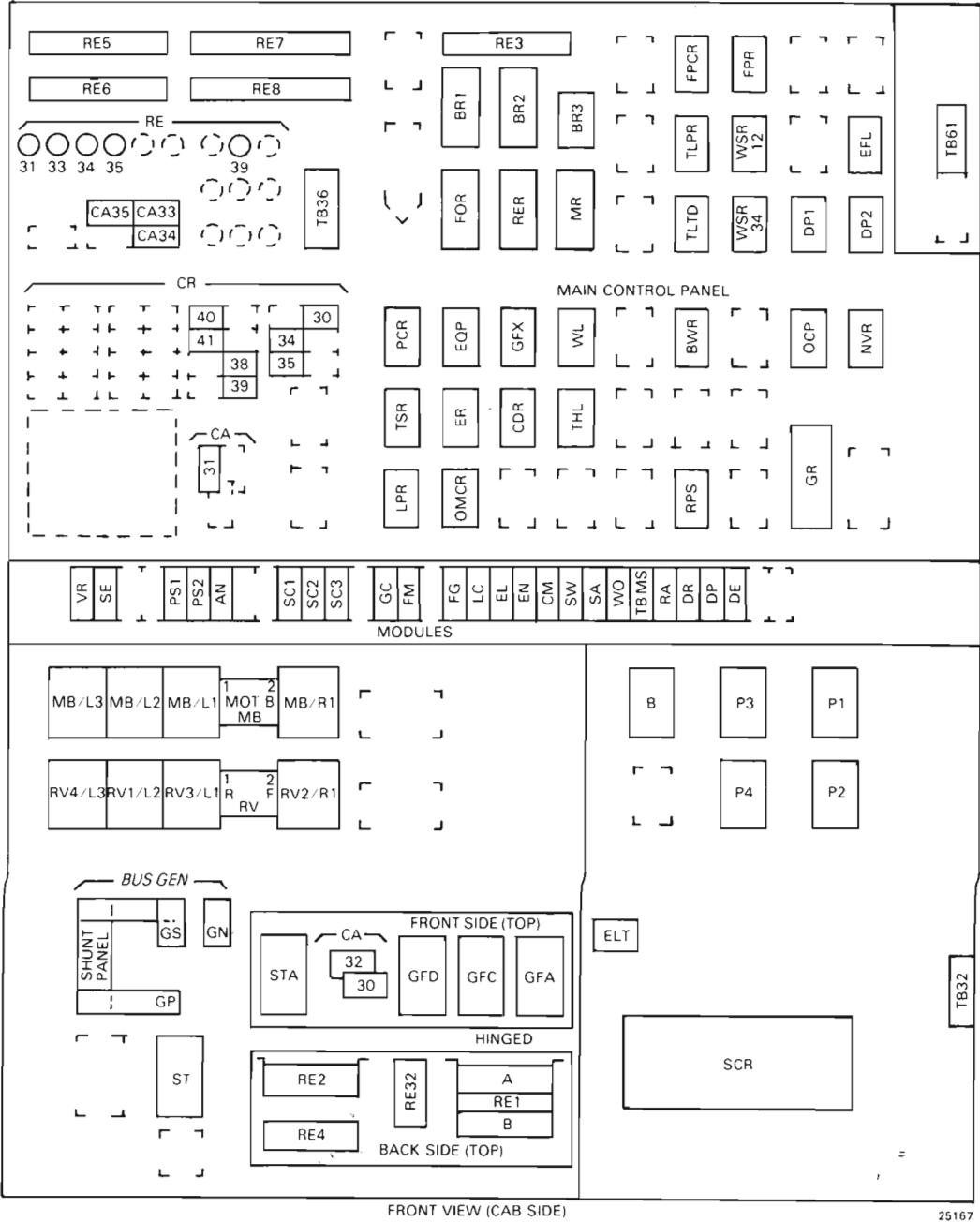
Feedback Signal Information

Signal	Test Points (Referenced To Common)	Signal Range		Signal Ratio
		Min.	Max.	
kW Ref.	LC10	0	10V	198 kW/V
I _{REF.}	LC14	0	11.08V	150 mtr. A/V 600 gen. A/V
V _{REF.}	LC15	0	11V	125 V/V
GF	LC5, SC2-13	Digital*		
V+ΔV Motor Voltage Reference	EN6, SW4	0	11V	125V/V
N+ΔN Motor Speed Reference	EN18	0	10V	*10 mph/V
DB Ref.	DR22	0	10V	A/V, ratio varies with speed
BR Input	SC1-9, LC13, FM19, SW29, RA18, DR13	Digital*		
$\overline{\text{BR}}$ Input	SC1-11, MS10, DP28	Digital*		
MR Input	SC2-3, FM29, DR12 SW7, EN16, RA4	Digital*		
A Gov. Valve	SC2-5, LC1,	Digital*		
B Gov. Valve	SC2-7, LC2, RA22	Digital*		
C Gov. Valve	SC2-9, LC3, SW28	Digital*		
D Gov. Valve	SC2-11, LC4	Digital*		

*Digital "0" = 0 to 1.5 V; "1" = 13.5 to 15 V

**On units equipped with 40 inch wheels and 70:17 gear ratio this provides for 347 RPM/V.

Reference Signal Information



GP49 – Electrical Cabinet, Front View

MODULE TEST POINT LOCATION AND DESCRIPTION

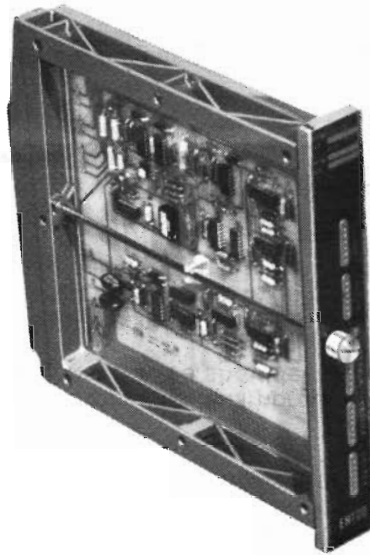
MODULAR ARRANGEMENT OF CIRCUITS

Most of the locomotive control and protective circuits are designed with solid state components, miniature relays, and miniature magnetic control devices mounted on circuit boards. The circuit boards are mounted in a support frame and equipped with a faceplate and pins or receptacles. The faceplate is designed to provide test points for circuit testing. Switches and indicating lights may be mounted on the faceplate. A nameplate is provided for identification purposes. The complete assembly is referred to as a control module.

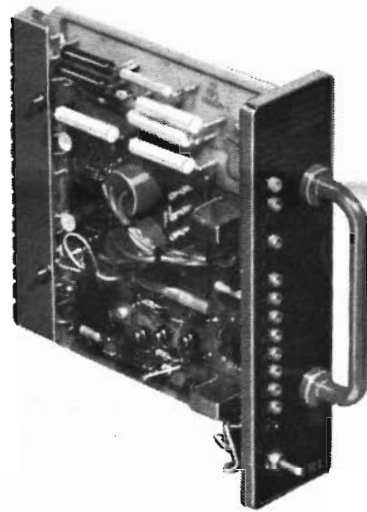
CAUTION

A test point at the faceplate does not necessarily connect to a like numbered pin or jack at the back of the module.

There are two general types of modules with minor variations within the two types. For reference purposes in this section the two types will be identified as the SS type module and the -2 type module illustrated below.



SS Type Module



22411

-2 Type Module

SS TYPE MODULES

These modules are equipped with 30 pairs of pins that mate with 30 pairs of receptacles mounted within the module compartment. The pins are connected in pairs to increase reliability. If more than 30 circuits are required, one or more pairs of pins and receptacles may be isolated to provide additional circuits.

The faceplate of the SS type modules contains 30 holes numbered from 1 to 30 that may be used as test points. There are five groups of six holes in each group. A test point may or may not be available at each hole. In this section, the test points are identified by a black circle adjacent to the numbers and the numbers are removed from the holes that have no test points. There are no receptacles for the test points. To make contact with the available test points it is necessary to use a special test pin 9324152. Insert the pin into the hole to make contact with the circuit board. The test points are not color coded. However, a brief description of the signal appearing at each test point is provided in this section. The faceplate may also be equipped with test switches and indicating lights.

CAUTION

Damage to SS type modules may result if improper size pins are inserted into the test points. Use only special test pin 9324152. These pins have a shoulder which prevents insertion deeper than 1/2 inch.

The SS type modules are not equipped with handles. When inserting the module, hold the module upright and place the module in the lower track, then carefully push in on module until resistance is felt. Turn knurled knob, extending out of faceplate, clockwise until module is in place. The knurled knob is attached to a jackscrew which pulls the module into place.

When removing the module, turn the knurled knob counter-clockwise to extract the module pins from the module receptacle. Continue to turn knurled knob counter-clockwise until the jackscrew is disengaged. The module may then be removed easily.

NOTE

To simplify the recorded data the designation "+15 VDC" (or "-15VDC") represents a range of +13 to +15 volts (-13 to -15 volts).

-2 TYPE MODULES

The modules are usually equipped with 14 receptacles that mate with pins mounted within the module compartment. Some of the modules are equipped with 28 receptacles instead of 14. The faceplates of most -2 modules are equipped with test point receptacles that accept the standard 0.185" banana plug. These receptacles are color coded to identify the type of signal appearing at the test point. Numbers from 1 through 14 or in some cases 1 through 28 appear on the faceplate. Test points are adjacent to some of these numerals. In this section, test points are identified by black circles adjacent to the numerals. A brief description of the signal appearing at each test point is provided in this section. The faceplate may also be equipped with test switches and indicating lights.

The test point color code is as follows.

Orange 72-76 VDC positive.

Blue Control circuits. Usually low voltage DC.

Yellow AC voltage, either from the companion alternator or from the main generator feedback transformers.

Red Main generator DC voltage output, or dynamic brake motor armature output.

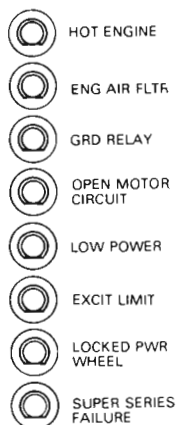
Black Control circuit 74 VDC negative.

Green Main generator field.

The -2 type modules are equipped with a handle to be used for insertion and removal of the module. When inserting the module, the module must be firmly pushed into place to ensure proper contact. Check alignment of module faceplates to ensure that module is properly inserted.

AN110 MODULE

The annunciator module receives signals from both 74 VDC and 15 VDC fault detecting devices. When a fault signal has been received, the applicable fault light remains on until the TEST/NORMAL switch is set to NORMAL after the fault signal has ceased. The AN module retains its memory if power is interrupted.



HOT ENGINE	Temperature at engine coolant inlet over 215° F.
ENG AIR FLTR	Plugged engine air filters.
GRD RELAY	High voltage path to locomotive ground or a group of failed diodes in the main generator.
OPEN MOTOR CIRCUIT	Operating with a motor open circuited.
LOW POWER	Engine developing low horsepower in 8th throttle.
EXCIT LIMIT	Excessive main generator field current.
LOCKED PWR WHEEL	Locked powered wheel.
SUPER SERIES FAILURE	Super series system failure.
TEST SWITCH	When the test switch is put in the TEST position all indicators on the module faceplate should go on. When the test switch is put in the RESET position all indicators on the module faceplate should go off.



AN110

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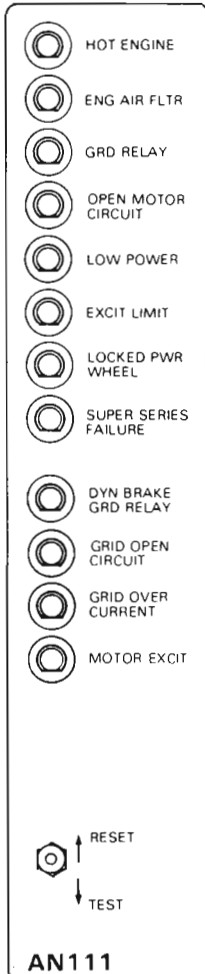
109T783

109T77

AN111 MODULE

AN111 MODULE

The annunciator module receives signals from both 74 VDC and 15 VDC fault detecting devices. When a fault signal has been received, the applicable fault light remains on until the TEST/NORMAL switch is set to NORMAL after the fault signal has ceased. The AN module retains its memory if power is interrupted.

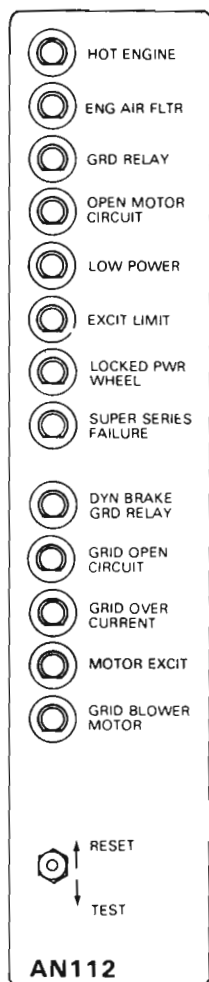


27963

HOT ENGINE	Temperature at engine coolant inlet over 215° F.
ENG AIR FLTR	Plugged engine air filters.
GRD RELAY	High voltage path to locomotive ground or a group of failed diodes in the main generator.
OPEN MOTOR CIRCUIT	Operating with a motor open circuited.
LOW POWER	Engine developing low horsepower in 8th throttle.
EXCIT LIMIT	Excessive main generator field current.
LOCKED PWR WHEEL	Locked powered wheel.
SUPER SERIES FAILURE	Super Series system failure.
DYN BRAKE GRD RELAY	While in dynamic brake a path is detected between dynamic braking grids and locomotive ground.
GRID OPEN CIRCUIT	Open dynamic braking resistor grid.
GRID OVER CURRENT	Excessive current in the dynamic braking resistor grids.
MOTOR EXCIT	Excessive current in motor fields or excessive voltage across the motor fields during dynamic braking.
TEST SWITCH	When the test switch is put in the TEST position all indicators on the module faceplate should go on. When the test switch is put in the RESET position all indicators on the module faceplate should go off.

AN112 MODULE

The annunciator module receives signals from both 74 VDC and 15 VDC fault detecting devices. When a fault signal has been received, the applicable fault light remains on until the TEST/NORMAL switch is set to NORMAL after the fault signal has ceased. The AN module retains its memory if power is interrupted.

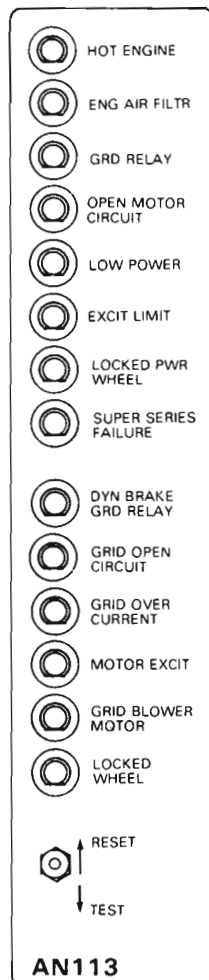


24964

HOT ENGINE	Temperature at engine coolant inlet over 215° F.
ENG AIR FLTR	Plugged engine air filters.
GRD RELAY	High voltage path to locomotive ground or a group of failed diodes in the main generator.
OPEN MOTOR CIRCUIT	Operating with a motor open circuited.
LOW POWER	Engine developing low horsepower in 8th throttle.
EXCIT LIMIT	Excessive main generator field current.
LOCKED PWR WHEEL	Locked powered wheel.
SUPER SERIES FAILURE	Super Series system failure.
DYN BRAKE GRD RELAY	While in dynamic brake a path is de-energized between the dynamic braking grids and locomotive ground.
GRID OPEN CIRCUIT	Open dynamic braking resistor grid.
GRID OVER CURRENT	Excessive current in the dynamic braking resistor grids.
MOTOR EXCIT	Excessive current in motor fields or excessive voltage across the motor fields during dynamic braking.
GRID BLOWER MOTOR	Current unbalance due to an open or short, or due to a stalled grid blower motor.
TEST SWITCH	When the test switch is put in the TEST position all indicators on the module faceplate should go on. When the test switch is put in the RESET position all indicators on the module faceplate should go off.

AN113 MODULE

The annunciator module receives signals from both 74 VDC and 15 VDC fault detecting devices.



24965

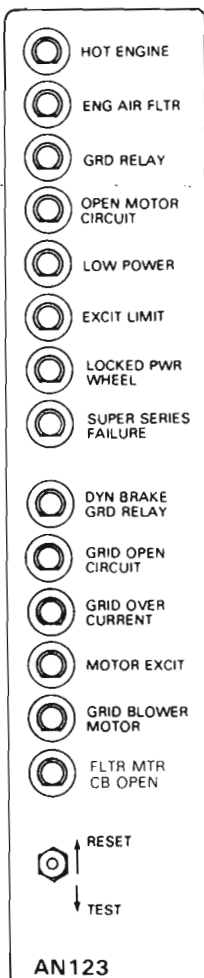
AN113 MODULE

The annunciator module receives signals from both 74 VDC and 15 VDC fault detecting devices. When a fault signal has been received, the applicable fault light remains on until the TEST/NORMAL switch is set to NORMAL after the fault signal has ceased. The AN module retains its memory if power is interrupted.

HOT ENGINE	Temperature at engine coolant inlet over 215° F.
ENG AIR FLTR	Plugged engine air filters.
GRD RELAY	High voltage path to locomotive ground or a group of failed diodes in the main generator.
OPEN MOTOR CIRCUIT	Operating with a motor open circuited.
LOW POWER	Engine developing low horsepower in 8th throttle.
EXCIT LIMIT	Excessive main generator field current.
LOCKED PWR WHEEL	Locked powered wheel.
SUPER SERIES FAILURE	Super Series system failure.
DYN BRAKE GRD RELAY	While in dynamic brake a path is detected between dynamic braking grids and locomotive ground.
GRID OPEN CIRCUIT	Open dynamic braking resistor grid.
GRID OVER CURRENT	Excessive current in the dynamic braking resistor grids.
MOTOR EXCIT	Excessive current in motor fields or excessive voltage across the motor fields during dynamic braking.
GRID BLOWER MOTOR	Current unbalance due to an open or short, or due to a stalled grid blower motor.
LOCKED WHEEL	Locked wheel condition indicated by traction motor sensor.
TEST SWITCH	When the test switch is put in the TEST position all indicators on the module faceplate should go on. When the test switch is put in the RESET position all indicators on the module faceplate should go off.

AN123 MODULE

The annunciator module receives signals from both 74 VDC and 15 VDC fault detecting devices. When a fault signal has been received, the applicable fault light remains on until the TEST/NORMAL switch is set to NORMAL after the fault signal has ceased. The AN module retains its memory if power is interrupted.



27964

HOT ENGINE	Temperature at engine coolant inlet over 215° F.
ENG AIR FLTR	Plugged engine air filters.
GRD RELAY	High voltage path to locomotive ground or a group of failed diodes in the main generator.
OPEN MOTOR CIRCUIT	Operating with a motor open circuited.
LOW POWER	Engine developing low horsepower in 8th throttle.
EXCIT LIMIT	Excessive main generator field current.
LOCKED PWR WHEEL	Locked powered wheel.
SUPER SERIES FAILURE	Super Series system failure.
DYN BRAKE GRD RELAY	While in dynamic brake a path is detected between dynamic braking grids and locomotive ground.
GRID OPEN CIRCUIT	Open dynamic braking resistor grid.
GRID OVER CURRENT	Excessive current in the dynamic braking resistor grids.
MOTOR EXCIT	Excessive current in motor fields or excessive voltage across the motor fields during dynamic braking.
GRID BLOWER MOTOR	Current unbalance due to an open or short, or due to a stalled grid blower motor.
FLTR MTR CB OPEN	Circuit breaker for inertial air filter blower ("dust bin" blower) is open.
TEST SWITCH	When the test switch is put in the TEST position all indicators on the module faceplate should go on. When the test switch is put in the RESET position all indicators on the module faceplate should go off.

CM100 MODULE

The current maximizer module looks for an increasing average traction motor current signal at terminal 8, it is intended to seek the peak (maximum level of traction effort, proportional to traction motor current) of the locomotive friction creep curve. By changing resistance between terminals 5 and 6 the locomotive slip limit can be modified and by detecting an increasing signal at terminal 8 the peak can be approached from either side. The module makes a change in the slip limit at terminals 5 and 6 and checks for an increase in current at terminal 8. If the current increases, the module makes another change in the same direction. If the current decreases or remains unchanged, the module makes the next change in the opposite direction. The output states are indicated by the LED's on the module faceplate.

TEST SWITCH: A functional check of the CM module may be performed by closing the test switch and observing the indicating lights.

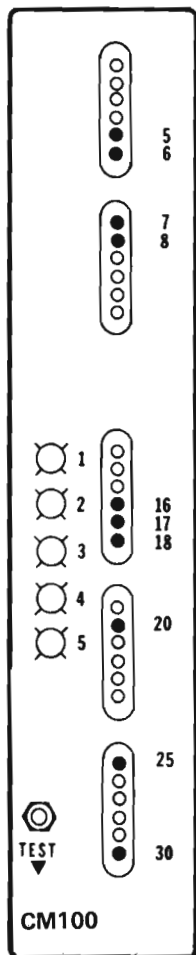
Close and hold the test switch as indicating lights move toward lowest number. The lights will sequence to the lowest number, then oscillate between the two lowest numbered lights (1 and 2). Open the test switch, the lights will go to the highest numbered light (5) within a few seconds.

NOTE

If the test switch does not cause the lights to sequence to number 1, then repeat the test a few times until the proper response is obtained.

INDICATING LIGHTS

The five indicating lights 1 through 5 correspond to 5 increasing slip levels respectively. LED5 on indicates that the slip limit is the maximum limit set by the EN module, LED1 indicates that the slip limit is the minimum limit established by modifying the EN module limit by a signal from the CM module. LED 2, 3, or 4 on indicates that the slip limit is being controlled between minimum and maximum. This control is the result of signals from the CM module being applied to the EN module.



22418

TEST POINT	SIGNAL DESCRIPTION	TYPICAL NORMAL VOLTAGE TO COMMON AT TEST POINT 25
5	Gain modifier output to terminal 27 of EN module.	0 to 0.3 volts maximum.
6	Gain modifier output to terminal 28 of EN module.	0 volt.
7	Test point only. Multiplexer enable signal.	0 volts in states 1 through 4, in state 5 signal oscillates between +15 V and 0 V in 1 second intervals.
8	Average traction motor current signal.	150A/V.

16, 17, and 18

Test points only. Binary indications of CM100 internal states.

State #16 #17 #18

16, 17,
and 18

Test points only. Binary indications
of CM100 internal states.

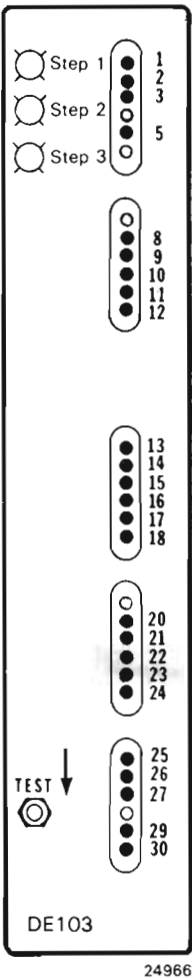
State #16 #17 #18

NOTE
0 indicates 0 volt.
1 indicates +15 volts.

1	0	0	0
2	0	0	1
3	0	1	0
4	0	1	1
5	1	0	0

20	+15 volts power supply input.	+15 volts.
25	±15 volts power supply common input.	0 volt.
30	-15 volts power supply input.	-15 volts.

DE103 MODULE



The DE module receives signals proportional to dynamic brake grid current and traction motor field current from the FM and FG modules. These signals are compared and the DC contactors which short out sections of the dynamic brake grids are properly sequenced to provide the extended range dynamic brake function.

When grid current drops below a level due to decreasing train speed, the DE module causes the proper DC contactor to pick up. The DE module also properly sequences the DC contactors to drop out as train speed increases. The DE module has its own built-in time delay function between extended range dynamic brake steps.

TEST SWITCH:

Operation of the test switch applies a false signal to the current comparison circuits in the DE module and causes the grid shorting contactors DC2 and DC1 to drop out in sequence.

STEP 1, STEP 2, and STEP 3

These green LED's on the module faceplate indicate pick up of grid shorting contactors DC1 and DC2. Step 1 indicates pick up of DC1. Step 2 indicates pick up of DC2. Step 3 indicates pick up of both DC1 and DC2 at the same time.

TEST POINT

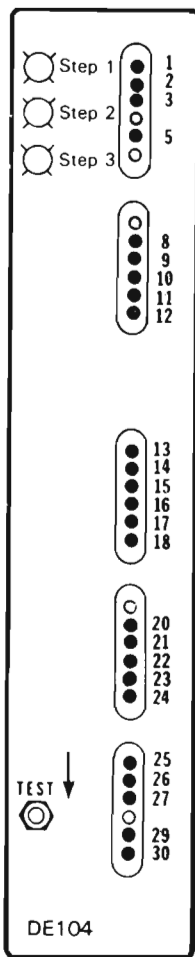
SIGNAL DESCRIPTION

- 1 Output to SC module. Results in pickup of pilot relay DP1 which picks up grid shorting contactor DC1.
- 2 Output to SC module. Results in pickup of pilot relay DP2 which picks up grid shorting contactor DC2.
- 3 Output to the DR module. Provides fast discharge of the dynamic brake reference signal (24T) each time a grid shorting contactor (DC) is picked up.
- 5 +5 VDC power supply.
- 8 Output to the DR module. Fast charge of the DR module 24T reference voltage.
- 9 Output to the DP module. Nullifies the response of the DP module during the transfer of the DC grid shorting contactors to help prevent cycling of the DC contactors during the rapid changes in current due to the insertion or removal of grid sections in the grid circuit.

- 10 Input from SC module indicating DC1 contactor is picked up

- 10 Input from SC module indicating DC1 contactor is picked up.
- 11 Input from SC module indicating DC2 contactor is picked up.
- 12 Output to the DR module. This signal is present when either the DC1 contactor or the DC2 contactor, or both, are energized. If the locomotive does not have grid current trainline control over the entire speed range, this input causes the DR module to transfer from FCTL to GCTL during the extended range portion of the dynamic brake operation.
- 13 Test point only. Indicates DE module circuit condition DP1 pickup (initiates output at term. & test point 1).
- 14 Test point only. Indicates DE module circuit condition DP2 pickup (initiates output at term. & test point 2).
- 15 Test point only. Indicates DE module circuit condition DP3 pickup (initiates output at terms. & test points 1 & 2).
- 16 Test point only. Indicates DE module circuit condition DP1 dropout (initiates ending term. & test point 1 signal).
- 17 Test point only. Indicates DE module circuit condition DP2 dropout (initiates ending term & test point 2 signal).
- 18 Test point only. Indicates DE module circuit condition DP3 dropout (initiates ending term & test points 1 & 2 signals).
- 20 +15 VDC power supply input to the DE module.
- 21 Input from the FM module. This signal is proportional to the highest traction motor armature current which is equivalent to grid current. This signal is used to determine the DC contactor transfer points and has a value of 150A/V.
- 22 Test point only. An output at this test point indicates that the DE Logic Control Circuit is providing the Step 1 signal.
- 23 Test point only. An output at this test point indicates that the DE Logic Control Circuit is providing the Step 2 signal.
- 24 Test point only. An output at this test point indicates that the DE Logic Control Circuit is providing the Step 3 signal.
- 25 ± 15 power supply common.
- 26 Output to the DR module. Fast discharge of the rate control circuit.
- 27 Input from the FG module. This signal is proportional to main generator current which is traction motor field current in dynamic brake. This signal is used to determine the DC contactor transfer points and has a value of 600A/V.
- 29 Input from the SC module. This signal is present when the independent brake pressure switch (IPS) is closed and the BR relay is energized and must be present for the DE module to operate. If independent air brake is used on the locomotive above a set level and the locomotive is operating in extended range dynamic brake, the IPS switch will open and the DC grid shorting contactors will drop out.
- 30 -15 VDC power supply input to the DE module.

DE104 MODULE



The DE module receives signals proportional to dynamic brake grid current and traction motor field current from the FM and FG modules. These signals are compared and the DC contactors which short out sections of the dynamic brake grids are properly sequenced to provide the extended range dynamic brake function.

When grid current drops below a level due to decreasing train speed, the DE module causes the proper DC contactor to pick up. The DE module also properly sequences the DC contactors to drop out as train speed increases. The DE module has its own built-in time delay function between extended range dynamic brake steps.

TEST SWITCH:

Operation of the test switch applies a false signal to the current comparison circuits in the DE module and causes the grid shorting contactors DC2 and DC1 to drop out in sequence.

STEP 1, STEP 2, and STEP 3

These green LED's on the module faceplate indicate pick up of grid shorting contactors DC1 and DC2. Step 1 indicates pick up of DC1. Step 2 indicates pick up of DC2. Step 3 indicates pick up of both DC1 and DC2 at the same time.

TEST POINT

SIGNAL DESCRIPTION

- | | |
|---|---|
| 1 | Output to SC module. Results in pickup of pilot relay DP1 which picks up grid shorting contactor DC1. |
| 2 | Output to SC module. Results in pickup of pilot relay DP2 which picks up grid shorting contactor DC2. |
| 3 | Output to the DR module. Provides fast discharge of the dynamic brake reference signal (24T) each time a grid shorting contactor (DC) is picked up. |
| 5 | +5 VDC power supply. |
| 8 | Output to the DR module. Fast charge of the DR module 24T reference voltage. |

Output to the DP module. Nullifies the response of the DP module during the transfer of the DC grid shorting

- 9 Output to the DP module. Nullifies the response of the DP module during the transfer of the DC grid shorting contactors to help prevent cycling of the DC contactors during the rapid changes in current due to the insertion or removal of grid sections in the grid circuit.
- 10 Input from SC module indicating DC1 contactor is picked up.
- 11 Input from SC module indicating DC2 contactor is picked up.
- 12 Output to the DR module. This signal is present when either the DC1 contactor or the DC2 contactor, or both, are energized. If the locomotive does not have grid current trainline control over the entire speed range, this input causes the DR module to transfer from FCTL to GCTL during the extended range portion of the dynamic brake operation.
- 13 Test point only. Indicates DE module circuit condition DP1 pickup (initiates output at term. & test point 1).
- 14 Test point only. Indicates DE module circuit condition DP2 pickup (initiates output at term. & test point 2).
- 15 Test point only. Indicates DE module circuit condition DP3 pickup (initiates output at terms & test points 1 & 2).
- 16 Test point only. Indicates DE module circuit condition DP1 dropout (initiates ending term. & test point 1 signal).
- 17 Test point only. Indicates DE module circuit condition DP2 dropout (initiates ending term & test point 2 signal).
- 18 Test point only. Indicates DE module circuit condition DP3 dropout (initiates ending term & test points 1 & 2 signals).
- 20 +15 VDC power supply input to the DE module.
- 21 Input from the FM module. This signal is proportional to the highest traction motor armature current which is equivalent to grid current. This signal is used to determine the DC contactor transfer points and has a value of 150A/V.
- 22 Test point only. An output at this test point indicates that the DE Logic Control Circuit is providing the Step 1 signal.
- 23 Test point only. An output at this test point indicates that the DE Logic Control Circuit is providing the Step 2 signal.
- 24 Test point only. An output at this test point indicates that the DE Logic Control Circuit is providing the Step 3 signal.
- 25 ± 15 power supply common.
- 26 Output to the DR module. Fast discharge of the rate control circuit.
- 27 Input from the FG module. This signal is proportional to main generator current which is traction motor field current in dynamic brake. This signal is used to determine the DC contactor transfer points and has a value of 600A/V.
- 29 Input from the SC module. This signal is present when the independent brake pressure switch (IPS) is closed and the BR relay is energized and must be present for the DE module to operate. If independent air brake is used on the locomotive above a set level and the locomotive is operating in extended range dynamic brake, the IPS switch will open and the DC grid shorting contactors will drop out.
- 30 -15 VDC power supply input to the DE module.

DG104 MODULE

The dynamic brake grid protection module monitors the equivalent resistance of the dynamic braking grids and the blower motor by comparing braking grid current with braking grid voltage. A "B" contactor dropout signal will be provided if the braking grid blower motor has failed.

LED1: Turn on of this light indicates that the grid blower motor has failed and the "B" contactor should drop out.

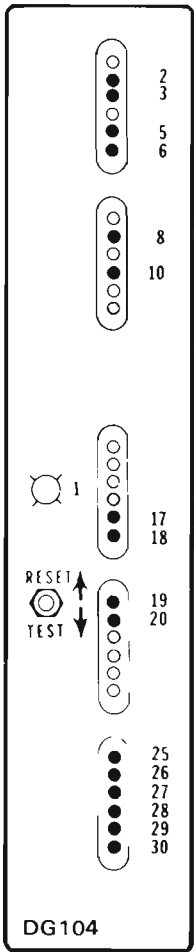
TEST SWITCH: When controls and switches are set up for load test, pushing the switch to test position simulates a grid blower motor failure.

When controls and switches are set up for dynamic brake, push the switch to the TEST position and hold it there for 5 seconds. After 5 seconds has elapsed, release the switch allowing it to return to the off position. Before two minutes has elapsed, again push the switch to the TEST position and hold it for 5 seconds. This also simulates a grid blower motor failure.

NOTE

A grid blower motor failure condition is indicated by turn on of the DG module light, dropout of the "B" contactor, the output voltage at DG terminal (and test point) 19 decreasing from +15 VDC to about +2 VDC, and turn on of the GRID BLOWER MOTOR light on the AN module.

Pushing the test switch to the RESET position resets the DG module which allows the "B" contactor to pick up, causes the voltage at DG terminal (and test point) 19 to go from about +2 VDC to +15 VDC, and turns off LED1. The GRID BLOWER MOTOR light on the AN module remains on until turned off by the AN reset switch.



27965

TEST POINTS**SIGNAL DESCRIPTION**

5 (or 6) to 2 (or 3)	Grid current input signal from the dynamic braking grid shunt. This signal is proportional to dynamic braking grid current. NOTE: Test points 5 and 6 are common and test points 2 and 3 are common.
5 (or 6) to 8	Grid voltage input signal. CAUTION: High voltages are present.
10	Test point only. Output signal from OP1B; at normal operating conditions this signal should be below +2.5 VDC.
17	Output signal. This is a fast discharge signal to the DR module.
18	Output signal to AN module GRID BLOWER MOTOR indicator.

- 18 Output signal to AN module GRID BLOWER MOTOR indicator.
- 19 Output signal. This signal results in dropout of the B contactor when a failed blower motor is detected. This signal is normally about +15 VDC, but goes to near +2 VDC when a failed blower motor is detected.
- 20 + VDC power supply input.
- 25 ± 15 VDC power supply input common.
- 26 Unused input. (Would have same effect on DG module as test point 28 & 29 signals.)
- 27 Input signal. This signal is +15 VDC when the BR1 relay is picked up.
- 28 Input signal. This is +15 VDC when the TEST SWITCH is in LOAD TEST 1 position.
- 29 Input signal. This signal is +15 VDC when the TEST SWITCH is in LOAD TEST 2 position.
- 30 -15 VDC power supply input.

DG105 MODULE

The dynamic brake grid protection module monitors the equivalent resistance of the dynamic braking grids and the blower motor by comparing braking grid current with braking grid voltage. A "B" contactor dropout signal will be provided if the braking grid blower motor has failed.

LED1: Turn on of this light indicates that the grid blower motor has failed and the "B" contactor should drop out.

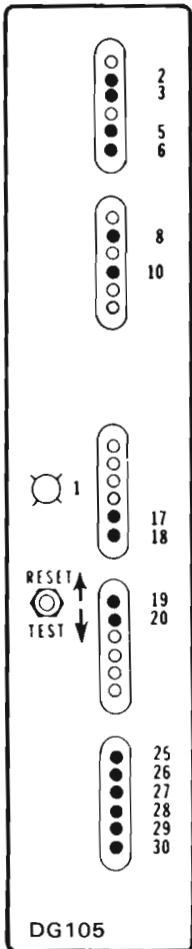
TEST SWITCH: When controls and switches are set up for load test, pushing the switch to test position simulates a grid blower motor failure.

When controls and switches are set up for dynamic brake, push the switch to the TEST position and hold it there for 5 seconds. After 5 seconds has elapsed, release the switch allowing it to return to the off position. Before two minutes has elapsed, again push the switch to the TEST position and hold it for 5 seconds. This also simulates a grid blower motor failure.

NOTE

A grid blower motor failure condition is indicated by turn on of the DG module light, dropout of the "B" contactor, the output voltage at DG terminal (and test point) 19 decreasing from +15 VDC to about +2 VDC, and turn on of the GRID BLOWER MOTOR light on the AN module.

Pushing the test switch to the RESET position resets the DG module which allows the "B" contactor to pick up, causes the voltage at DG terminal (and test point) 19 to go from about +2 VDC to +15 VDC, and turns off LED1. The GRID BLOWER MOTOR light on the AN module remains on until turned off by the AN reset switch.



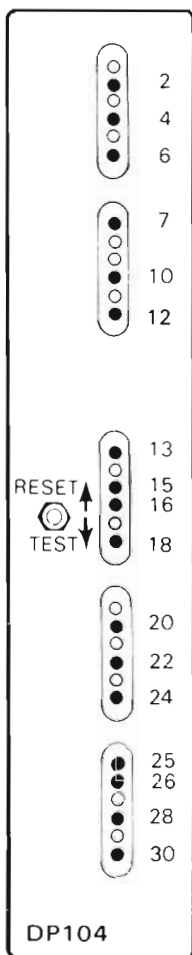
27966

TEST POINTS**SIGNAL DESCRIPTION**

- 5 (or 6) to 2 (or 3) Grid current input signal from the dynamic braking grid shunt. This signal is proportional to dynamic braking grid current. **NOTE:** Test points 5 and 6 are common and test points 2 and 3 are common.
- 5 (or 6) to 8 Grid voltage input signal. **CAUTION:** High voltages are present.
- 10 Test point only. Output signal from OP1B; at normal operating conditions this signal should be below +2.5 VDC.

- 17 Output signal. This is a fast discharge signal to the DR module.
- 18 Output signal to AN module GRID BLOWER MOTOR indicator.
- 19 Output signal. This signal results in dropout of the B contactor when a failed blower motor is detected. This signal is normally about +15 VDC, but goes to near +2 VDC when a failed blower motor is detected.
- 20 +15 VDC power supply input.
- 25 ± 15 VDC power supply input common.
- 26 Unused input. (Would have same effect on DG module as test point 28 & 29 signals.)
- 27 Input signal. This signal is +15 VDC when the BR1 relay is picked up.
- 28 Input signal. This signal is +15 VDC when the TEST SWITCH is in LOAD TEST 1 position.
- 29 Input signal. This signal is +15 VDC when the TEST SWITCH is in LOAD TEST 2 position.
- 30 -15 VDC power supply input.

DP104 MODULE



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The dynamic brake protection module provides the dynamic brake protection functions of grid over-current detection, motor over-excitation detection, and grid open-circuit detection.

The grid over-current function receives a signal equivalent to dynamic brake grid current and interrupts feed to the EQP relay when the limiting value is reached. This function provides back-up protection against a DR failure to regulate grid current.

The motor over-excitation function receives a signal equivalent to main generator voltage which represents traction motor field current in dynamic brake, and interrupts the feed to the EQP relay when the limiting value is reached. This function provides protection against open traction motor field circuit and against a DR failure to regulate traction motor field current.

The grid open-circuit function receives a signal from a resistor voltage divider in the dynamic brake grid circuit which is a result of an open circuit in the dynamic brake grid paths. This function energizes the OCP latching relay and in turn drops the B contactor which drops the GFC contactor.

TEST SWITCH: The test switch applies a false signal to the protective functions in the DP module. The test switch should be held five seconds to allow the annunciator time delay circuits in the DP module to time out. At the end of the five second delay, the GRID OPEN CIRCUIT, GRID OVER CURRENT, and MOTOR EXCIT LED's on the AN module should be turned on, and the OCP relay should be energized and electrically latched.

RESET SWITCH: The reset position discharges the time delay circuit capacitors in the grid over-current and motor over-excitation annunciator circuits. Allows immediate retest of module time delay after operating OCP reset switch on the circuit breaker panel and AN module reset switch.

NOTE

The BRAKE WARN light on the control stand will be on as long as the test switch is held in the TEST position.

**TEST
POINTS****SIGNAL DESCRIPTION**

- | | |
|---------|--|
| 2 | Output to SC module (normally low). Energizes OCP relay and turns on the grid open-circuit annunciator (+15V output). |
| 4 | Output to the AN module. Turns on the MTR EXCIT annunciator. |
| 6 and 7 | Input from the dynamic brake grid circuit voltage divider resistor. Used to detect an open-circuit fault condition in the dynamic brake parallel grid circuit. This signal has a high voltage potential to ground. |
| 10 | Unused main generator voltage signal input, intended for six-motor locomotives. |

- 12 Input from the FG module. This signal is proportional to main generator volts and provides the input signal for motor over-excitation protection. This signal has a value of 125V/V.
- 13 Input signal (+15V) from pick up of dynamic brake speed relay DBS. Pickup of DBS indicates increased grid or field current demand.
- 15 Input from the FM module. This input is proportional to the highest traction motor armature current and is used for grid over-current protection. This signal has a value of 150A/V.
- 16 Input from the FM module. This signal is proportional to the average traction motor armature current. This signal has a value of 150A/V.
- 18 Output to SC module. This output results in turn-on of the GRID OVER CURRENT annunciator on AN module.
- 20 +15 VDC power supply input to the DP module.
- 22 Output to the DR module. This signal causes a fast discharge of the DR module 24T reference voltage signal during back-up regulation by the DP module.
- 24 Output to SC module. This signal supplies the hold-in of the EQP relay during dynamic brake operation. During back-up regulation of the DP module for grid over-current or motor over-excitation conditions, the EQP relay is forced to pick up and drop out to provide coarse regulation.
- 25 ± 15 VDC power supply common.
- 26 Input from the DE module. This signal is present on extended range dynamic brake locomotives whenever a DC contactor is transferring. This prevents the DP module from functioning to interfere with an extended range dynamic brake step.
- 28 Input from SC module. This signal is present whenever the MR relay is energized and blocks the DP module from functioning in power. This signal is approximately +15 VDC in power and 0.0 in dynamic brake.
- 30 -15 VDC power supply input to the DP module.

DP109 MODULE

The dynamic brake protection module provides the dynamic brake protection functions of grid over-current detection, motor over-excitation detection, and grid open-circuit detection.

The grid over-current function receives a signal equivalent to dynamic brake grid current and interrupts feed to the EQP relay when the limiting value is reached. This function provides back-up protection against a DR failure to regulate grid current.

The motor over-excitation function receives a signal equivalent to main generator voltage which represents traction motor field current in dynamic brake, and interrupts the feed to the EQP relay when the limiting value is reached. This function provides protection against open traction motor field circuit and against a DR failure to regulate traction motor field current.

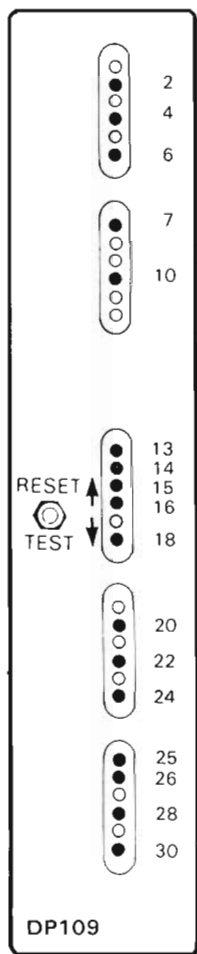
The grid open-circuit function receives a signal from a resistor voltage divider in the dynamic brake grid circuit which is a result of an open circuit in the dynamic brake grid paths. This function energizes the OCP latching relay and in turn drops the B contactor which drops the GFC contactor.

TEST SWITCH: The test switch applies a false signal to the protective functions in the DP module. The test switch should be held five seconds to allow the annunciator time delay circuits in the DP module to time out. At the end of the five second delay, the GRID OPEN CIRCUIT, GRID OVER CURRENT, and MOTOR EXCIT LED's on the AN module should be turned on, and the OCP relay should be energized and electrically latched.

RESET SWITCH: The reset position discharges the time delay circuit capacitors in the grid over-current and motor over-excitation annunciator circuits. Allows immediate retest of module time delay after operating OCP reset switch on the circuit breaker panel and AN module reset switch.

NOTE

The BRAKE WARN light on the control stand will be on as long as the test switch is held in the TEST position.



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**TEST
POINTS****SIGNAL DESCRIPTION**

- | | |
|---------|--|
| 2 | Output to SC module (normally low). Energizes OCP relay and turns on the grid open-circuit annunciator (+15V output). |
| 4 | Output to the AN module. Turns on the MTR EXCIT annunciator. |
| 6 and 7 | Input from the dynamic brake grid circuit voltage divider resistor. Used to detect an open-circuit fault condition in the dynamic brake parallel grid circuit. This signal has a high voltage potential to ground. |
| 10 | Unused main generator voltage signal input, intended for six-motor locomotives. |

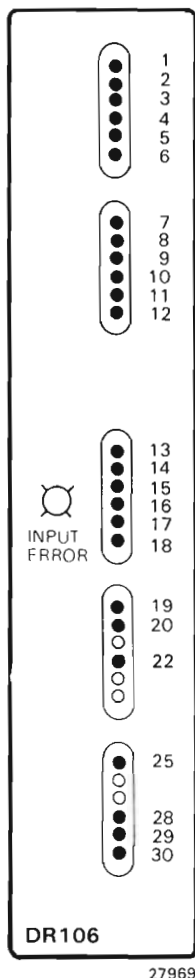
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109T

Input from the EG module. This signal is proportional to main generator volts and provides the input signal for

- 12 Input from the FG module. This signal is proportional to main generator volts and provides the input signal for motor over-excitation protection. This signal has a value of 125V/V.
- 13 Input signal (+15V) from pick up of dynamic brake speed relay DBS. Pickup of DBS indicates increased grid or field current demand.
- 14 Input from the RA module. This input is proportional to radar locomotive speed. It is scaled at 10 MPH/V.
- 15 Input from the FM module. This input is proportional to the highest traction motor armature current and is used for grid over-current protection. This signal has a value of 150A/V.
- 16 Input from the FM module. This signal is proportional to the average traction motor armature current. This signal has a value of 150A/V.
- 18 Output to SC module. This output results in turn-on of the GRID OVER CURRENT annunciator on AN module.
- 20 +15 VDC power supply input to the DP module.
- 22 Output to the DR module. This signal causes a fast discharge of the DR module 24T reference voltage signal during back-up regulation by the DP module.
- 24 Output to SC module. This signal supplies the hold-in of the EQP relay during dynamic brake operation. During back-up regulation of the DP module for grid over-current or motor over-excitation conditions, the EQP relay is forced to pick up and drop out to provide coarse regulation.
- 25 ± 15 VDC power supply common.
- 26 Input from the DE module. This signal is present on extended range dynamic brake locomotives whenever a DC contactor is transferring. This prevents the DP module from functioning to interfere with an extended range dynamic brake step.
- 28 Input from SC module. This signal is present whenever the MR relay is energized and blocks the DP module from functioning in power. This signal is approximately +15 VDC in power and 0.0 in dynamic brake.
- 30 -15 VDC power supply input to the DP module.

DR106 MODULE



The dynamic brake regulator module receives a signal from the dynamic brake rheostat established by the brake handle position (24T). This signal is converted to a traction motor field current reference signal for field current trainline control (FCTL) and to a traction motor armature current (grid current) reference signal for grid current trainline control (GCTL).

The DR module provides its own linear rate control for loading in dynamic brake operation and separate linear unloading rates for wheel slip control and DP module regulation. For locomotives with extended range dynamic brake, fast loading and unloading rates are provided to facilitate DC contactor transfer. The DR module provides field current trainline control (FCTL), grid current trainline control (GCTL) over the entire speed range or for extended range dynamic brake only, brake effort limiting, and 16 second grid current build-up rate; all depending on connections external to the module.

The DR module provides field current trainline control (FCTL) operation by comparing the 24T reference signal to a feedback signal proportional to main generator current (traction motor field current) from the FG module. During FCTL operation, the grid current reference is a fixed maximum limit. For grid current trainline control operation, the 24T reference signal is compared to a feedback signal proportional to the highest traction motor armature current (grid current) from the FM module.

The DR module provides all the regulation functions in dynamic brake by controlling the excitation current to the main generator through the LC (load control) module.

INDICATOR LIGHT:

The indicator light is on when the DR module receives input signals that both the MR and the BR relays are energized at the same time. This condition will cause the DR module to turn off the LC sensor control transistor and prevents excitation to the main generator.

TEST POINTS

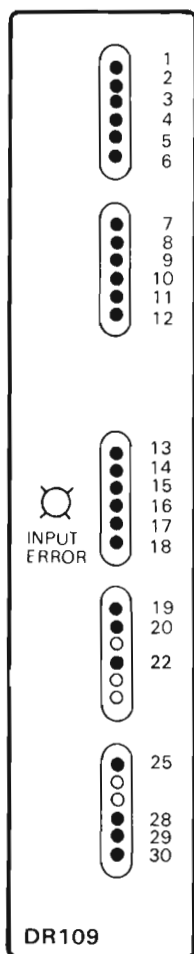
SIGNAL DESCRIPTION

- | | |
|---|---|
| 1 | Output for dynamic braking engine speed increase. 0 VDC for low grid current. +15 VDC when grid current exceeds a set level. (This output not used on basic GP49 locomotive.) |
| 2 | Output to the LC module. This signal is normally +15 VDC except when the DR module is regulating grid current or traction motor field current. This output controls the locomotive excitation level during dynamic brake operation. |
| 3 | Open circuit output of brake effort limit comparator. Not connected to module pin. |

- | | |
|---|---|
| 4 | Input from SC module for governor solenoid feedback. +15 VDC when engine is running at higher dynamic braking speed; 0 VDC for lower engine speed. (Not used on basic GP49 locomotive.) |
| 5 | Input from the FG module. This signal, I_{MGF} , is proportional to main generator current which is traction motor field current in dynamic brake. This signal has a value of 600A/V. |
| 6 | Unused input. Intended for radar speed input on other DR module types. |

- 7 Input signal. -15 VDC for FCTLC operation of DR module. For locomotives requiring GCTLC over the entire speed range, pin 7 is externally jumpered to pin 21 and +15 VDC will appear at this point at all times. For locomotives with extended range dynamic brake, +15 VDC will appear at this point after the DC1 contactor picks up.
- 8 Input from the DE module. This signal is normally 0.0 VDC except when the DE module is causing a DC contactor to pick up or drop out. During this transfer a +12 VDC or greater signal will be present which provides a fast loading rate to facilitate the DC contactor transfer.
- 9 Unused test point. Not connected to module pin.
- 10 Test point only. Positive grid current reference signal applied to grid current regulator. Scaled at 75A/V.
- 11 Test point only. Positive traction motor field current reference signal applied to field current regulator. Scaled at 99.3A/V.
- 12 Input signal from the SC module. This signal is present whenever the MR relay is energized and blocks the DR from regulating in power. This signal is approximately +15 volts in power and 0.0 volts in dynamic brake.
- 13 Input from SC module. This signal is present whenever the BR relay is energized and enables DR regulation output to the LC module. This signal is approximately +15 VDC in dynamic brake and 0.0 VDC in power.
- 14 Test point only. Negative grid current reference signal. Scaled at 75A/V; offset by -0.7 V.
- 15 Input signal. When the build up time for maximum grid current is required to be 16 seconds instead of the basic 10 seconds, pin 15 is externally connected to pin 26. This ties pin 15 to common of the ± 15 VDC power supply and changes the reference voltage for the grid anticipation circuit. (Test point 15 voltage is +15 VDC when module pin 15 is not connected externally.)
- 16 Input from FG module. This signal is proportional to 24T trainline voltage and is a function of brake handle position. This input signal has a value of 7.3 V (24T)/V. 0 to +10 VDC; +10 VDC = max. braking.
- 17 Input from FM module. This signal is proportional to the highest traction motor armature current which is equivalent to dynamic brake grid current. This feedback signal has the value of 150A/V.
- 18 Input from SW module. This signal is present only when a wheel slip occurs and is a correction function. This signal is +12 VDC or greater and causes a fast discharge of the reference voltages for GCTLC or FCTLC dynamic brake operation.
- 19 Input from either the DP or DE module. This signal is present when the dynamic brake back-up regulator DP module is regulating due to grid over-current or motor over-excitation conditions or when the DE module has caused any DC contactor to pick up. This signal is +12 VDC or greater and causes a fast discharge of the reference voltages for GCTLC or FCTLC dynamic brake operation. If the fast discharge input is not being provided, the test point 19 voltage will be -15 VDC.
- 20 +15 VDC power supply input. (Also available at module pin 21.)
- 22 Test point only. This is the dynamic brake reference voltage signal for traction motor field current and grid current. This signal follows the 24T voltage input, but at a controlled rate of change.
- 25 ± 15 VDC common. (Also available at module pin 26.)
- 28 Input from the FG module. This signal is proportional to unfiltered main generator current which is traction motor field current in dynamic brake. This signal has a value of 600A/V.
- 29 Test point only. Positive traction motor field current feedback signal. Scaled at 99.3A/V.
- 30 -15 VDC power supply input.

DR109 MODULE



The dynamic brake regulator module receives a signal from the dynamic brake rheostat established by the brake handle position (24T). This signal is converted to a traction motor field current reference signal for field current trainline control (FCTL) and to a traction motor armature current (grid current) reference signal for grid current trainline control (GCTL).

The DR module provides its own linear rate control for loading in dynamic brake operation and separate linear unloading rates for wheel slip control and DP module regulation. For locomotives with extended range dynamic brake, fast loading and unloading rates are provided to facilitate DC contactor transfer. The DR module provides field current trainline control (FCTL), grid current trainline control (GCTL) over the entire speed range or for extended range dynamic brake only, brake effort limiting, and 16 second grid current build-up rate; all depending on connections external to the module.

The DR module provides field current trainline control (FCTL) operation by comparing the 24T reference signal to a feedback signal proportional to main generator current (traction motor field current) from the FG module. During FCTL operation, the grid current reference is a fixed maximum limit. For grid current trainline control operation, the 24T reference signal is compared to a feedback signal proportional to the highest traction motor armature current (grid current) from the FM module.

The DR module provides all the regulation functions in dynamic brake by controlling the excitation current to the main generator through the LC (load control) module.

INDICATOR LIGHT:

The indicator light is on when the DR module receives input signals that both the MR and the BR relays are energized at the same time. This condition will cause the DR module to turn off the LC sensor control transistor and prevents excitation to the main generator.

TEST POINTS

SIGNAL DESCRIPTION

- | | |
|---|---|
| 1 | Output for dynamic braking engine speed increase. 0 VDC for low grid current. +15 VDC when grid current exceeds a set level. |
| 2 | Output to the LC module. This signal is normally +15 VDC except when the DR module is regulating grid current or traction motor field current. This output controls the locomotive excitation level during dynamic brake operation. |
| 3 | Open circuit output out of brake effort limit comparator. Not connected to module pin. |

- | | |
|---|--|
| 4 | Input from SC module for governor solenoid feedback. +15 VDC when engine is running at higher dynamic braking speed; 0 VDC for lower engine speed. |
| 5 | Input from the FG module. This signal is proportional to main generator current which is traction motor field current in dynamic brake. This signal has a value of 600A/V. |
| 6 | Unused input. Intended for radar speed input on other DR module types. |

- 7 Input signal. -15 VDC for FCTLC operation of DR module. For locomotives requiring GCTLC over the entire speed range, pin 7 is externally jumpered to pin 21 and +15 VDC will appear at this point at all times. For locomotives with extended range dynamic brake, +15 VDC will appear at this point after the DC1 contactor picks up.
- 8 Input from the DE module. This signal is normally 0.0 VDC except when the DE module is causing a DC contactor to pick up or drop out. During this transfer a +12 VDC or greater signal will be present which provides a fast loading rate to facilitate the DC contactor transfer.
- 9 Unused test point. Not connected to module pin.
- 10 Test point only. Positive grid current reference signal applied to grid current regulator. Scaled at 75A/V.
- 11 Test point only. Positive traction motor field current reference signal applied to field current regulator. Scaled at 99.3A/V.
- 12 Input signal from the SC module. This signal is present whenever the MR relay is energized and blocks the DR from regulating in power. This signal is approximately +15 volts in power and 0.0 volts in dynamic brake.
- 13 Input from SC module. This signal is present whenever the BR relay is energized and enables DR regulation output to the LC module. This signal is approximately +15 VDC in dynamic brake and 0.0 VDC in power.
- 14 Test point only. Negative grid current reference signal. Scaled at 75A/V; offset by -0.7 V.
- 15 Input signal. When the build up time for maximum grid current is required to be 16 seconds instead of the basic 10 seconds, pin 15 is externally connected to pin 26. This ties pin 15 to common of the ± 15 VDC power supply and changes the reference voltage for the grid anticipation circuit. (Test point 15 voltage is +15 VDC when module pin 15 is not connected externally.)
- 16 Input from FG module. This signal is proportional to 24T trainline voltage and is a function of brake handle position. This input signal has a value of 7.3 V (24T)/V.
- 17 Input from FM module. This signal is proportional to the highest traction motor armature current which is equivalent to dynamic brake grid current. This feedback signal has the value of 150A/V.
- 18 Input from SW module. This signal is present only when a wheel slip occurs and is a correction function. This signal is +12 VDC or greater and causes a fast discharge of the reference voltages for GCTLC or FCTLC dynamic brake operation.
- 19 Input from either the DP or DE module. This signal is present when the dynamic brake back-up regulator DP module is regulating due to grid over-current or motor over-excitation conditions or when the DE module has caused any DC contactor to pick up. This signal is +12 VDC or greater and causes a fast discharge of the reference voltages for GCTLC or FCTLC dynamic brake operation. If the fast discharge input is not being provided, the test point 19 voltage will be -15 VDC.
- 20 +15 VDC power supply input. (Also available at module pin 21.)
- 22 Test point only. This is the dynamic brake reference voltage signal for traction motor field current and grid current. This signal follows the 24T voltage input, but at a controlled rate of change.
- 25 ± 15 VDC common. (Also available at module pin 26.)
- 28 Input from the FG module. This signal is proportional to unfiltered main generator current which is traction motor field current in dynamic brake. This signal has a value of 600A/V.
- 29 Test point only. Positive traction motor field current feedback signal. Scaled at 99.3A/V.
- 30 -15 VDC power supply input.

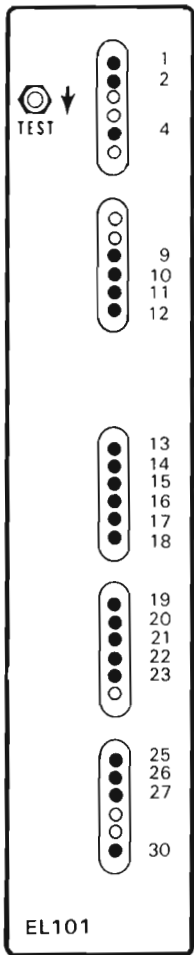
EL101 MODULE

The EL101 module receives an input from the ELT transducer. This signal is rectified, filtered, and amplified to a proportionality of 100 amperes of main generator field current per 6.02 volts dc filtered signal. The signal is compared to a predetermined maximum main generator field current reference to provide field current limiting. This backup excitation limit system will de-energize the EQP relay and annunciate excitation limit on the AN module.

The EL module also contains the primary main generator field current protection. This protection regulates field current to 95% of the maximum generator field current limit established for the backup system mentioned above. This primary limiting system regulates through the LC module.

TEST SWITCH:

Operation of the test switch (down) applies a false signal through the ELT test coil to simulate main generator field current over-excitation. The switch should annunciate excitation limit on the AN module after a 3-4 second time delay.



27971

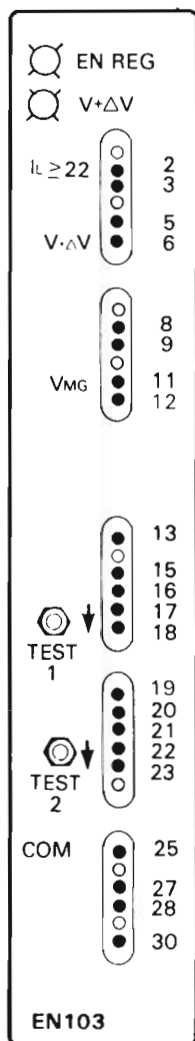
TEST
POINTS

SIGNAL DESCRIPTION

1	+74 VDC input.
2	Output to the ELT test coil when test switch is closed.
4	Unused output. 0 VDC.
9, 10 11 and 12	EL module excitation limit recalibration terminals for different types of generators. Terminal 12 will be jumpered to 9, 10, or 11 depending on type of generator.

- 13 and
15 Output to the EQP coil and the SC module respectively, to de-energize the EQP relay when over-excitation occurs.
- 14 -74 VDC input.
- 16 EL module excitation limit recalibration terminal. Terminal 16 is jumpered to terminal 17 when a single setting for the excitation limit is required.
- 17 +15 VDC source for recalibration jumpers.
- 18 and
19 Input from the ELT transducer. Represents the main generator field current feedback signal to the EL module.
- 20 +15 VDC power supply input.
- 21 Filtered main generator field current signal with a ratio of 6.02 VDC per 100 amperes of field current. (No external connection made to terminal 21.)
- 22 Output to the LC module. Used to regulate field current to 95% of the excitation limit setting.
- 23 Input from SC module. Used to recalibrate (lower) the excitation current limit setting as a result of failed main generator rectifier diode. (Not used on GP49 locomotive.)
- 25 ± 15 VDC common.
- 26 Input from WO module. This digital signal recalibrates the excitation limit setting to a lower value at higher locomotive speeds.
- 27 Output to AN module to turn on the EXCIT LIMIT light.
- 30 -15 VDC power supply input.

EN103 MODULE



27972

The E/N module generates the motor voltage reference signal that is the basis of the super series wheel control system. It also incorporates the regulator that establishes the ΔN slip limit regulation level of the motor voltage. The reference signal is generated from a lowest motor current signal and a train speed feedback signal using nominal motor characteristics and a specified ΔN function of speed. The slip limit reference is compared to motor voltage feedback and regulation is implemented by controlling main generator excitation.

TEST 1 SWITCH & EN REG INDICATOR

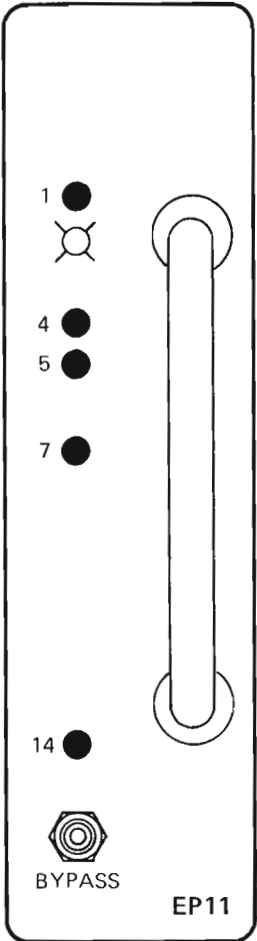
With throttle in idle or throttle 1 stall, pressing TEST 1 switch lever down should cause the EN REG indicator light to come on immediately and, if in throttle 1, the unit unloads. Operating the switch forces the normally positive V+ΔV input to the V+ΔV-vs.-V_{MG} comparator to be negative. The EN REG light should go off 1 or 2 seconds after the TEST 1 lever is released. The EN REG light comes on in normal creep operation.

TEST 2 SWITCH & V+ΔV TEST INDICATOR

With throttle in idle, pressing TEST 2 switch lever down and holding it there for at least two seconds should cause the V+ΔV TEST indicator light to come on. It applies specific false $I_L \geq 22$ and N+ΔN signals which the module should process to achieve a specific level V+ΔV signal, lighting the indicator. The indicator should go off when the lever is released. The indicator will come on whenever the module generates the test level V+ΔV signal in normal operation.

TEST POINTS	SIGNAL DESCRIPTION	TYPICAL NORMAL VOLTAGE TO COMMON AT TEST POINT 25
2	Lowest motor current input signal from FM module.	150A/V above 22.5 amperes. +12 to +15 volts with all motors below 22.5 amperes.
3	E/N output signal from internal E/N function generator.	0 to +10 volts as a function of the input signal at test point 2.
5	-I times R output signal as determined by lowest motor current signal and typical armature resistance.	-0.5 volts maximum with lowest motor current at 1650 amperes.
6	Slip limit reference voltage (V + ΔV) output signal for super series.	0 to +11 volts as determined by operating speed.
8	Super series cutout input signal from SW module.	-15 volts in super series motoring. +15 volts otherwise.
9	Super series system regulating	0 to -5 volts when not regulating

9	Super series system regulating output signal.	0 to -5 volts when not regulating in super series. +7 to +12 volts when regulating in super series.
11	Main generator volts unfiltered feedback input signal from FG module.	125V/V
12 13	SE sensor control output signal terminals.	+14 to +15 volts depending upon operating conditions. (This is a current signal.)
15	Ground speed input from RA module.	22.5 mph/V.
16	MR pickup input from SC2 module.	+15 volts when MR is picked up.
17	Output to enable SW module wheel slip system.	+15 volts when SW enable conditions are satisfied.
18	Test point only. $N + \Delta N$	0 to +12.5 volts as a function of speed; 10 mph/V.
19	Average traction motor input signal.	150A/V.
20	+15 volts power supply input.	+15 volts.
21	Input to ΔN function generator.	0 to +10 V.
22	Test point only. $E + \Delta E$.	0 to 12.5 volts depending upon operating conditions.
23	Speed signal (N) input from SW module.	10 mph/V.
25	± 15 volts power supply common input.	0 volt.
27	ΔN gain modifier input signal from CM module.	0 to +3 volts maximum. A function of speed and average motor current.
28	ΔN gain modifier input signal common from CM module.	0 volt.
30	-15 volts power supply input.	-15 volts.



22425

EP11 MODULE

The EP11 module monitors engine cranking speed by comparing starting motor voltage with starting motor current and inserts resistance in series with starting motors as necessary to limit engine cranking speed to less than 30 rpm during the first few seconds of cranking. This protects the engine in case of hydraulic lock.

- BYPASS SWITCH:

TEST LAMP:
- If module fails, this switch may be closed to by-pass the engine purge function.

This light will cycle on-off-on during the starting cycle to indicate that the module is functional.

TEST POINTS

SIGNAL DESCRIPTION

- | | |
|----|--|
| 1 | +74 VDC input to module. |
| 4 | Measure voltage across starting motors between 4 positive and 14 negative. |
| 5 | + voltage signal on timing capacitor of six seconds timer. |
| 7 | + Q2 collector voltage. |
| 14 | BN input (74 VDC negative side). |

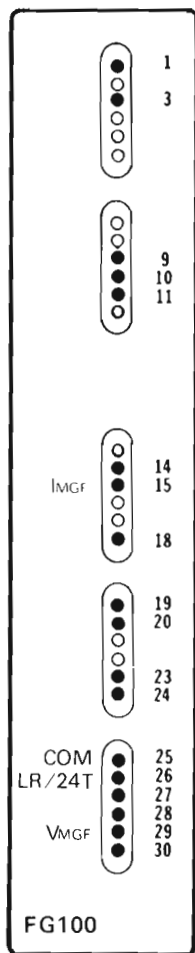
FG100 MODULE

The FG100 module receives high voltage dc feedback signals from the main generator and from the load regulator. These signals are electrically isolated, filtered, and adjusted for control usage. The main generator signal is 125V/V and the load regulator signal is 7.3V/V.

The FG100 module also receives the main generator current feedback signal from the main generator current transformers. These signals are rectified, filtered, and adjusted for control usage. The main generator current signal for four motor locomotives is 600A/V.

WARNING

Exercise caution when using test points 1 and 3. A fault in the system may result in high voltage at these test points.



27973

TEST
POINTS

SIGNAL DESCRIPTION

- | | |
|-----------------|---|
| 1 | Positive input signal from the main generator voltage divider resistor. The ratio of this signal is 125V/V. Nominal signal range between test points 1 positive and 3 negative is 0 to 10 volts dc. |
| 3 | Negative input signal from the main generator voltage divider resistor. |
| 9, 10
and 11 | Input signals from the main generator current transformers. |
| 14 | 74 VDC negative side. |

- 15 Filtered main generator current signal, I_{MGF} , 600A/V.
- 18 Negative unfiltered main generator current signal, (-) I_{MG} , 600A/V.
- 19 Unfiltered main generator voltage signal, (+) I_{MG} . This signal has as ratio of 125V/V.
- 20 +15 VDC power supply input.
- 23 and
24 Interlocking circuit to prevent loading of the locomotive when FG100 module is removed. Terminal 23 is jumpered to terminal 24. Removing FG100 module opens the sensor string.
- 25 ± 15 VDC power supply common.
- 26 Isolated load regulator signal during power operation or dynamic brake rheostat signal during dynamic brake. This signal ratio is 7.3V/V. +10VDC = minimum field load regulator position in power; +10 VDC = maximum braking signal in dynamic brake.
- 27 Input from load regulator wiper arm during power operation. This terminal is open during dynamic brake operation.
- 28 Input signal from top of load regulator during power operation or from dynamic brake rheostat wiper arm (24T signal) during dynamic brake operation.
- 29 Filtered main generator voltage output signal, V_{MGF} . This signal has a ratio of 125V/V.
- 30 -15 VDC power supply input.

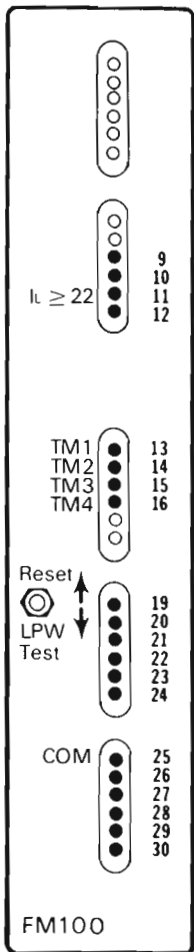
FM100 MODULE

The FM100 module receives an input signal from each armature current transducer and derives signals proportional to the current of each traction motor. The FM100 module provides output signals proportional to highest motor current, lowest motor current, lowest motor current above 22.5 amperes, and average motor current. The average motor current signal drives the ammeter both in power and in dynamic brake operation.

The FM100 module detects a locked powered wheel condition by comparing one-half of the highest motor current signal with the average motor current signal. A locked powered wheel condition is indicated on the AN module if one-half of the highest traction motor current signal is more than the average traction motor current signal.

The FM100 module detects an open circuit or traction motor cutout condition by comparing one-fourth average motor current signal with the lowest traction motor current signal. An open motor condition is indicated on the AN module if one-fourth of the average motor current signal is more than the lowest motor current signal.

LPW TEST SWITCH: Placing the switch in TEST position with unit at throttle 1 stall results in a false locked powered wheel condition after a 20 to 30 second delay. The wheel slip light will come on and a locked powered wheel indication is provided by the AN module. Placing the switch in RESET position (up) removes the false signal. The wheel slip light will go out, but the locked powered wheel indication on the AN module will remain until the AN module is reset.



27974

TEST
POINTS

SIGNAL DESCRIPTION

- | | |
|----|---|
| 9 | Locked powered wheel output signal, +15 VDC. 0VDC for normal condition. Same as terminal and test point 23. |
| 10 | Open motor circuit output signal, +15 VDC. 0 VDC for normal condition. |
| 11 | Lowest traction motor current signal (above 22.5 amperes), $I_L \geq 22$. The ratio of this signal is 150A/V. If no traction motor is above 22.5 amperes, this output will nominally be +12 VDC or higher. |
| 12 | Lowest traction motor current signal. This signal ratio is 150A/V. This signal is used internally to detect open circuit or motor cut out conditions. |

13 thru

- 16 Test points only. The filtered and rectified signal from the armature current transducers of TM1 through TM4 are available at these points. The ratio of these signals is 150A/V.
- 19 Input to indicate dynamic brake operation. This test point will be +15 VDC during dynamic brake operation.
- 20 +15 VDC power supply input.
- 21 This is the highest traction motor current output signal, I_H . The ratio of this signal is 150A/V.
- 22 Average traction motor current signal, I_{AVE} , 150A/V.
- 23 Locked powered wheel output signal.
- 24 Input signal from DP module for EQP energization circuit. +15 VDC for normal conditions. 0 VDC for following faults in dynamic braking detected by DP module: grid overcurrent, traction motor fields circuit open or overvoltage. "OR'ed" with pin 29 inputs to serve as source for pin 26 output.
- 25 ± 15 VDC power supply common.
- 26 EQP pickup output signal. +15 VDC for normal conditions. 0VDC for following fault conditions: locked powered wheel detected by FM module, dynamic braking fault detected by DP module (FM module pin 24 input).
- 27 Output signal to ammeter. +150A/V in power; -150A/V in dynamic braking.
- 28 Output signal. +15 VDC during normal operation. -15 VDC during locked powered wheel condition.
- 29 MR input for EQP energization circuit, +15 VDC in motoring, 0 VDC otherwise. "OR'ed" with pin 29 input to serve as source for pin 26 output.
- 30 -15 VDC power supply input.

GC104 MODULE

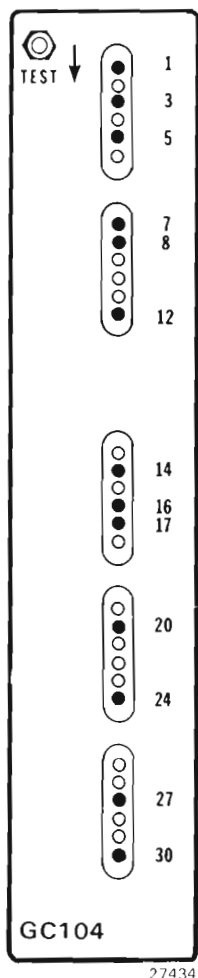
The governor control module performs interface functions between the governor solenoids and the throttle switches and other input signals to the governor solenoids.

The test point information given below applied to a basic GP49 locomotive with common extra equipment. The signal at some of the test points depends upon the desired engine speed for various operating conditions, and on locomotive equipment, which may vary. Refer to locomotive schematic for exact information.

TEST SWITCH: When closed, this switch provides a signal to governor overriding solenoid ORS. This results in driving the load regulator toward minimum field position.

CAUTION

Although this is a Super Series type module it uses +74 VDC as a power supply instead of ± 15 VDC. The 74 VDC reference (negative) is test point 14. Voltages at the other test points must be referenced to test point 14.

TEST
POINTS

SIGNAL DESCRIPTION

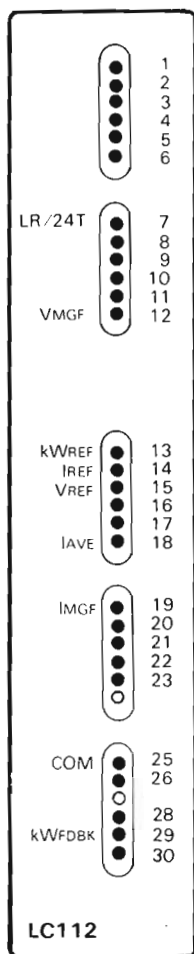
- | | |
|---|--|
| 1 | +74 VDC control voltage input for TEST SWITCH and for pin 2 output. |
| 3 | +74 VDC output to governor overriding solenoid ORS when an ORS signal is issued by the SW module or when test switch on the GC module is closed. Also +74 VDC when generator field contactor is dropped out while MR relay is picked up. 0 VDC otherwise. |
| 5 | +74 VDC output to governor "D" solenoid when set up for power operation and throttle is in STOP, IDLE, 5, or 6 or when throttle is in 5 through 8 and engine filter relay EFL or throttle limit relay THL is energized. Drop out of FPCR also provides +74 VDC to 5. |
| 7 | +74 VDC input when throttle is in STOP, 5 or 6 and unit is not isolated, and when FPCR is dropped out. |
| 8 | +74 VDC input to normal idle relay NIR, when NVR is de-energized, or when GFX and ER are both energized or |

- 8 +74 VDC input to normal idle relay NIR, when NVR is de-energized, or when GFX and ER are both energized or when low idle temp. sw. LITS is picked up with MR dropped out, or when main reservoir pressure relay MRPR is picked up.
- 12 +74 VDC output to governor "A" solenoid when in power and throttle is in IDLE, 2, 4, 6, or 8, or when low idle temp. sw. LITS is picked up with MR and shutdown relay SDR dropped out, or when unit is in active dynamic braking.
- 14 74 VDC control voltage negative.
- 16 +74 VDC output to governor "C" solenoid when in power and throttle is in 3 through 8.
- 17 +74 VDC output to governor "B" solenoid when in power and throttle is in 5 through 8.
- 20 +74 VDC input to ERA relay on module whenever power is applied to the ER relay.
- 24 +74 VDC input when set up for power operation and throttle is in 3 through 8.
- 25 Spare +74 VDC input parallel with pin 27 except pin 25 provided with input diode.
- 27 +74 VDC input during power when throttle is in 5 through 8.
- 30 +74 VDC input during power when throttle is in 2, 4, 6, or 8.

LC112 MODULE

The load control module provides the main load control characteristic of the locomotive. It provides throttle response and rate controlled load application; it also regulates current, voltage, and kilowatt levels at various points on the load control characteristic. The LC module also provides the following:

1. Automatic motor cut out power limit.
2. A low power sand output.
3. A low power annunciator output.
4. A switching start capability.
5. A wheel slip controlled current and kilowatt discharge input.
6. An additional regulating input for generator field current and dynamic brake regulation.
7. A motor temperature simulator input for lowering power limit levels when hot motors are simulated.



27975

TEST POINTS	SIGNAL DESCRIPTION
1, 2, 3, 4	Throttle valve inputs A, B, C, D respectively

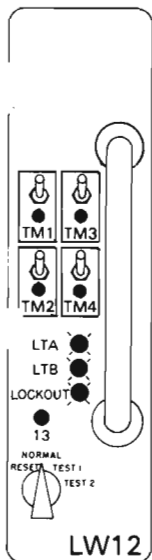
TYPICAL NORMAL VOLTAGE TO COMMON AT TEST POINT 25

TEST POINT	1	2	3	4
1	0	0	0	0
2	+15	0	0	0
3	0	0	+15	0
4	+15	0	+15	0
5	0	+15	+15	+15
6	+15	+15	+15	+15
7	0	+15	+15	0
8	+15	+15	+15	0

THROTTLE POSITION

5	GF input signal.	0V in idle. +14V with GF picked up.
6	Test point only. Rate controlled kW reference.	0V to +10V as a function of throttle position, time, load regulator, position and derating input.
7	LR or 24T input signal.	When in power LR is 0V at maximum field, and +10V at minimum field. When in brake 24T is 0V at minimum and +10V at maximum.
8	Low power annunciator output.	0V normal and +10 to +15V in low power.
9	Low power sand output signal.	0V normal and +10 to +15V when sand is required.

10	Test point only. kW reference.	0V to +10V as a function of throttle position, load regulator position, and derating input.
11	Load test over horsepower (load test No. 2) input.	Normally 0V; +14V for load test No. 2.
12	Filtered main generator voltage feedback signal input.	0V to +11V as a function of generator voltage, 125V/V.
13	Test point only. Modified rate controlled kW reference.	0V to +10V as a function of throttle position, time, load regulator position, and derating input. This signal immediately reflects load reductions by regulator.
14	Test point only. Rate controlled current reference.	0V to +11V as a function of throttle time, and load regulator position.
15	Test point only. Rate controlled voltage reference.	0V to +11.08V as a function of throttle.
16	Sensor control output.	
17	Test point only. kW multiplier scale factor.	+1.70 to 2.64 volts.
18	Average motor current feedback signal input, I_{AVE} .	Proportional to average traction motor current 150A/V.
19	Main generator current feedback signal input.	Proportional to main generator current. 600A/V.
20	+15 VDC power supply input.	+15 VDC.
21	Super series failure or wheel slip discharge input signal from SW module.	+15 VDC pulse or level for fault. 0 VDC otherwise.
22	Accelerated start input signal.	0 VDC in normal. +14 VDC in accelerated start mode.
23	LC module Q1 transistor base voltage. (Q1 is in sensor string.)	0 VDC opens sensor string.
25	± 15 VDC power supply common.	0 VDC.
26	Motor temperature simulator input signal.	0 VDC with hot motors, -10 VDC with cold motors.
28	External sensor control input signal for generator excitation limit in power, field and/or grid current control in dynamic braking.	+15 VDC when external circuits are not regulating. Less than +15VDC when external circuits are regulating.
29	Test point only. kW feedback signal output.	0 VDC to +10 VDC depending upon throttle position and generator kW output.
30	-15 VDC power supply input.	-15 VDC.



25479

LW12 MODULE

The locked wheel detection system provides both visual and audible alarms if one or more locomotive wheels become locked. A locked wheel condition will turn on the LOCK WHEEL light and energize the trainline wires for the alarm bell and wheel slip light.

A magnetic pickup mounted on each traction motor provides a traction motor speed signal for each axle. A traction motor speed signal represents wheel speed at that axle. These individual wheel speed signals are supplied to the locked wheel module which processes these signals to determine if a locked wheel condition exists.

INDICATOR LIGHTS:

The LTA light will be on only when all four wheel speed signals are below 4 mph.

The LTB light will be on only when all four wheel speed signals are above 1 mph.

The LOCKOUT light will be on only when one wheel speed signal is below 1 mph and one wheel speed signal is above 4 mph. Both of these conditions occurring at the same time cause the locked wheel indication.

TEST SWITCH:

NORMAL-LTA light on (at standstill).

TEST 1-LTA light off, LTB light on.

TEST 2-LOCKOUT light on, WHEEL SLIP light (control stand) and alarm bell on, and LOCK WHEEL light (engine control panel) on.

RESET-LTA light on.

TRACTION MOTOR

CUTOUT SWITCHES: In an emergency situation operating these switches will disconnect an individual traction motor's magnetic pickup from the locked wheel detection system.

TRACTION MOTOR

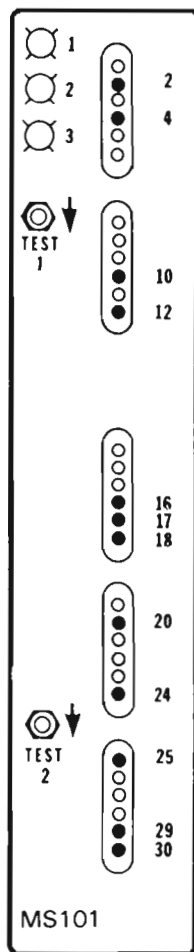
TEST POINTS:

Measure DC voltage at test points TM-1 thru TM-4 to TP13 with T.M. cutout switches open:

Less than 16 VDC at speeds of 1 mph or less.

More than 25 VDC at speeds of 4 mph or more.

MS101 MODULE



The motor simulator module receives signals proportional to highest motor current 150A/V and motor voltage 125V/V. It also receives cooling air proportional to and at the temperature of traction motor cooling air. The motor current and motor voltage signals heat the motor simulator block on the MS module proportional to motor temperature. Temperature of the block is monitored. When motor simulator block temperature rises above a predetermined temperature, the MS module provides an output signal to the LC module. This signal to the LC module results in reducing horsepower output of the locomotive.

LED 1: This LED turns on when the motor temperature simulator block indicates that traction motor temperature is within 5% of full hot condition.

LED 2: This LED turns on when the kilowatt heating circuit is functioning and TEST SWITCH 1 is closed.

LED 3: This LED turns on when the armature heating circuit is functioning and TEST SWITCH 1 is closed.

TEST SWITCH 1: When closed, this switch connects LED2 to the output of the kilowatt heating circuit transistor and connects LED3 to the output of the armature current heating circuit transistor.

TEST SWITCH 2: When closed, this switch provides a hot motor signal to the kilowatt heating circuit and to the armature current heating circuit.

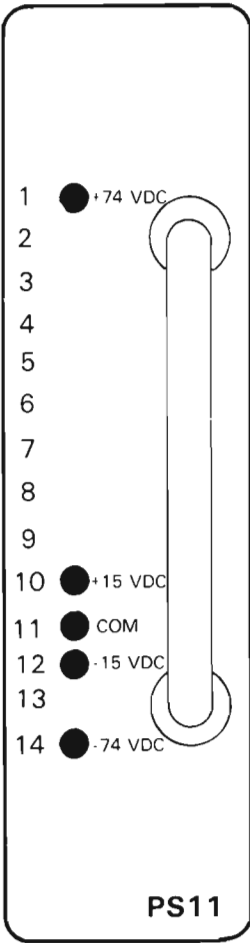
TEST
POINTS

SIGNAL DESCRIPTION

- | | |
|----|---|
| 2 | Test point only. This is the signal that is applied to the kilowatt heating circuit resistor. |
| 4 | Test point only. This is the signal that is applied to the armature current heating circuit resistor. |
| 10 | Input signal from SC1 indicating that relay BR1 is dropped out (+15 VDC). |
| 12 | Input signal from RA module indicating recalibrated radar motor speed; 347 rpm/V. |
| 14 | Output signal indicating a normal hot (approaching 180° C) motor condition. May not be used. |

16 Input signal from the FG module. This signal is proportional to filtered main generator voltage 125V/V.

- 16 Input signal from the FG module. This signal is proportional to filtered main generator voltage 125V/V.
- 17 Input signal from the FM module. This signal is proportional to highest traction motor current 150A/V.
- 18 Output signal to the LC module. This is the load control cut-back signal: -10 VDC when simulated motor temperature is below 170° C, increasing to 0 VDC as simulated motor temperature increases to 180° C.
- 20 +15 VDC power supply input.
- 24 Test point only. This is a negative signal representing temperature of the motor simulator block. This signal is -2.736 VDC at a block temperature of 0° C and decreases 0.01 V/°C rise. At a block temperature of 94.4° C (simulating 170° C motor temperature) the signal should be -3.68 VDC.
- 25 ±15 VDC power supply common.
- 29 Open motor circuit input signal from FM module. This signal is -5 VDC when operating with a motor cut out or with an open circuited motor.
- 30 -15 VDC power supply input.



27976

PS11 MODULE

The power supply module converts 74 VDC control voltage to closely regulated +15 volt and -15 volt output voltages when referenced to ± 15 volts common. Outputs of the 15 volt power supplies are provided to the super series control modules.

FUNCTIONAL CHECK:

TP10 to TP11 $+15 \pm 0.10$ volts
TP12 to TP11 -15 ± 0.10 volts

TEST POINTS SIGNAL DESCRIPTION

- | | |
|----|-----------------------------------|
| 1 | +74 VDC input. |
| 10 | +15 VDC power supply output. |
| 11 | ± 15 VDC power supply common. |
| 12 | -15 VDC power supply output. |
| 14 | 74 VDC negative. |

RA103 MODULE

Purpose of the radar module is to provide a ground speed reference signal to the super series control system which is independent of wheel slip. The RA module is automatically calibrated to the speed of the fastest non-slipping motor.

Secondary functions of the RA module are to provide an overspeed indication whenever an overspeed condition occurs and to provide a speed signal to the speed recorder and to the speedometer.

TEST

SWITCH 1:

(RADAR TEST) When the reverser is not centered, and MR and BR are de-energized, this switch may be closed to perform a radar system self test. The transceiver provides an approximately 1000 Hz signal to the RA module which processes the signal to provide a speed indication of 35 to 55 mph within 30 seconds. LED5 comes on after satisfactory completion of test.

TEST

SWITCH 2:

(DIVIDER TEST) When the reverser is not centered, and MR and BR are de-energized, this switch may be closed to perform an "N" function calculation check. LED6 comes on to indicate a normal "N" calculation during the check.

LED 1, 2,
3, and 4

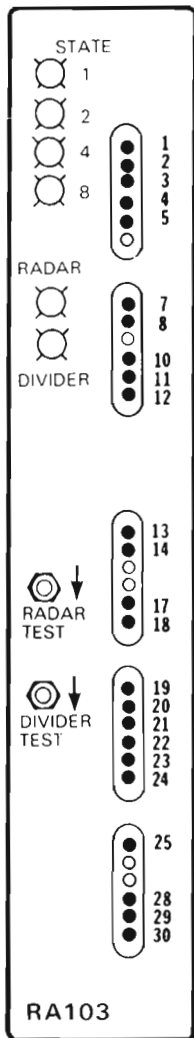
These indicating lights provide a visual indication of the state of the sixteen step digital radar recalibration circuit.

RADAR LED

This light provides a visual indication of satisfactory completion of radar system self test. This light comes on within 1 to 10 seconds after the RADAR TEST switch is closed when performing a radar system self test.

DIVIDER LED

This light provides a visual indication of satisfactory operation of the "N" calculation circuit when performing an "N" calculation check. This light comes on immediately after test switch 2 (DIVIDER TEST) is closed to indicate that the "N" calculation check is within limits.



27977

TEST
POINTS

SIGNAL DESCRIPTION

- 1 E/N input signal. Counter electromotive force per RPM of lowest current traction motor. An E/N of 1 provides a signal of 10 volts. Signal range is 0 to 10 volts.
- 2 $-I_L \times R$ input signal. A negative signal proportional to lowest motor current times typical armature resistance which represents voltage drop across the armature of the lowest current motor. This signal has a ratio of 125V/V. Signal range 0 to -10 volts.
- 3 V_{MGF} input signal. Main generator output voltage; An output voltage of 1250 volts provides a signal of 10 volts. Signal range 0 to 12 volts.

- 4 MR input signal. A logic "1" indicates that the MR relay is energized. A logic "0" indicates that the MR relay is de-energized. Signal range logic "1" or logic "0".
- 5 Speedometer drive output signal having a signal ratio of 1V/22.5 mph.
- 7 Test point only. Frequency of multiplexer recalibration clock. This is a 1 Hz signal.
- 8 Test point only. Count direction of UP/DOWN counter. Logic "1" results in COUNT UP. Logic "0" results in COUNT DOWN.
- 10 Test point only. Binary state of UP/DOWN counter channel Q4/multiplexer channel C4. Logic "1" level causes STATE 8 LED to light.
- 11 Test point only. Binary state of UP/DOWN counter channel Q3/multiplexer channel C3. Logic "1" level causes STATE 4 LED to light.
- 12 Test point only. Binary state of UP/DOWN counter channel Q2/multiplexer channel C2. Logic "1" level causes STATE 2 LED to light.
- 13 Test point only. Binary state of UP/DOWN counter channel Q1/multiplexer channel C1. Logic "1" level causes STATE 1 LED to light.
- 14 Unrecalibrated radar speed. 10 mph/V.
- 17 Test point only. Recalibrate enable signal. Logic "0" recalibrate, logic "1" hold.
- 18 Dynamic brake BR relay input signal. Logic "1" BR relay energized, logic "0" BR relay de-energized.
- 19 Overspeed trip output signal to overspeed relay OSR through SC module.
Normal = more than 10 volts, to energize OSR.
Overspeed = less than 1 volt, to drop out OSR.
- 20 +15 VDC power supply input.
- 21 Radar system calibration output signal is normally 0 VDC. Radar transceiver provides a calibrated 1000 Hz square wave signal to 28 when this signal is more than 10 volts.
- 22 "B" valve input signal. Logic "1" when "B" valve is energized, logic "0" when "B" valve is de-energized.
- 23 Calculated N output signal from multiplier/divider. Designated N_c or N_H. 6V=2079 rpm.
- 24 N recalibrated radar motor speed output signal. 6V=2079 rpm.
- 25 ±15 VDC power supply common input.
- 28 Radar input signal. 8 volt square wave, frequency proportional to track speed 22.2 Hz/mph.
- 29 Lowest loading motor current input signal. Ratio is 150A/V. Signal range is 0 to 10 volts.
- 30 -15 VDC power supply input.

SA100 MODULE

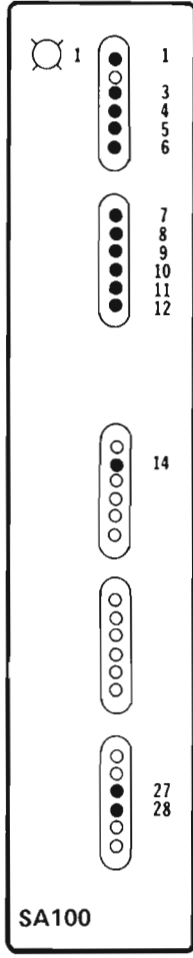
The sanding module directs the sanding signal to the proper magnet sanding valves during automatic sanding and manual sanding so that sand will be applied in front of each truck regardless of forward or reverse operation. During emergency sanding, sand is applied in front and in rear of all trucks. A signal from the SW module disables the manual sanding circuit under some conditions.

LED1 This indicating light comes on when automatic sand is being applied automatically.

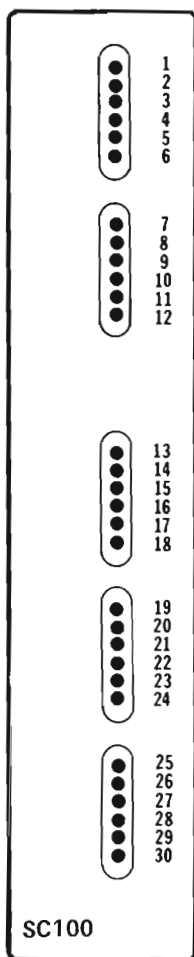
TEST
POINTS

SIGNAL DESCRIPTION

- | | |
|----|---|
| 1 | +74 VDC control voltage input. |
| 3 | +74 VDC output when manual sand cut out relay is energized. |
| 4 | +74 VDC output when manual sand cut out relay is de-energized. |
| 5 | +74 VDC input from LEAD TRUCK SAND SWITCH. |
| 6 | +74 VDC output to MV1-SR. |
| 7 | +74 VDC output to MV2-SR. |
| 8 | +74 VDC output to MV1-SF. |
| 9 | +74 VDC output to MV2-SF. |
| 10 | +74 VDC input signal from emergency sanding switch. |
| 11 | +74 VDC output to MV2-SF and, through module, to MV1-SF during emergency sanding or manual directional sanding. |
| 12 | +74 VDC output to MV1-SR and,through module, to MV2-SR during emergency sanding or manual directional sanding. |
| 14 | 74 VDC negative. |
| 27 | +74 VDC input from manual sand switch. |
| 28 | +74 VDC input when reverser is in reverse or when reverser handle is centered after being in reverse. |



SC100 MODULE



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SC100 MODULE

There are basically two signal conditioner modules on each locomotive which provide an electrically isolated interface between the 74 VDC controls and the 15 VDC controls. A third SC module is applied on locomotives equipped with extended range dynamic brakes.

There are two types of interface circuits (channels). The specific connections and function for each interface circuit is shown on the locomotive wiring diagram. Refer to the module locator chart on the locomotive wiring diagram to find the location of each SC100 channel on the diagram.

1. 74 VDC input to 15 VDC output.
2. 15 VDC input to 74 VDC output.

One SC module is connected in the CONTROL CIRCUIT and one is connected in the LOCAL CONTROL CIRCUIT.

CAUTION

74 VDC inputs or outputs from the CONTROL CIRCUIT and the LOCAL CONTROL CIRCUIT must not be connected to the same SC module.

When facing the front of the module compartment, the SC modules are designated from left to right as SC1, SC2, and SC3.

NOTE

With the exception of terminal 1 which is +74 VDC and terminal 20 which is +15 VDC, the even numbered terminals and test points are in the 74 VDC circuits and the odd numbered terminals and test points are in the 15 VDC circuits.

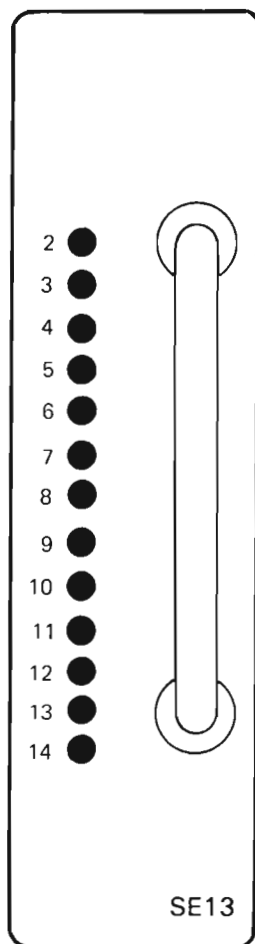
*INPUT	OUTPUT
1 Input +74 vdc supply	
2 Input 74 vdc logic	3 Output 15 vdc logic
4 Input 74 vdc logic	5 Output 15 vdc logic
6 Input 74 vdc logic	7 Output 15 vdc logic
8 Input 74 vdc logic	9 Output 15 vdc logic
10 Input 74 vdc logic	11 Output 15 vdc logic
12 Input 74 vdc logic	13 Output 15 vdc logic
14 Input -74 vdc supply	
15 Input 15 vdc logic	16 Output 74 vdc logic
17 Input 15 vdc logic	18 Output 74 vdc logic
20 Input +15 vdc supply	
21 Input 15 vdc logic	22 Output 74 vdc logic
23 Input 15 vdc logic	24 Output 74 vdc logic
25 Input ± 15 vdc supply common	
26 Input 74 vdc logic	27 Output 15 vdc logic
27 Input 15 vdc logic	28 Output 74 vdc logic
29 Input 15 vdc logic	30 Output 74 vdc logic

*NOTE

A logic input in the INPUT column results in the logic output specified in the OUTPUT column.

SE13 MODULE

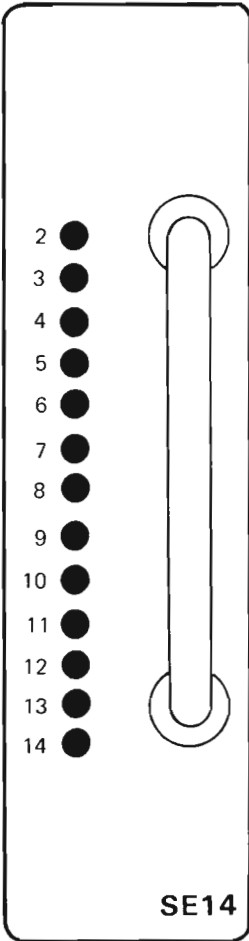
Provides gating pulses to the SCR at the proper time determined by the current in the control windings. Primary control windings are connected to terminals 13 & 14.

TEST
POINTS

SIGNAL DESCRIPTION

2	Provisional function; control or bias. (Used with terminal/test point 4.)
3	Input from main generator positive during dynamic braking (on locomotives so equipped). (Used with terminal/test point 12.)
4	Provisional function; control or bias. (Used with terminal/test point 2.)
5	Output to gate of SCR1.
7	Output to gate of SCR2.
9	Output to gate of SCR3.
6, 8, and 10	AC power supply from companion alternator.
11	Common point for gate outputs; cathodes of SCR's. (Return for outputs from terminals/test points 5, 7, and 9.)
12	Main generator negative during dynamic braking (on locomotives so equipped). (Used with terminal/test point 3.)
13	Input, excitation control windings. (Used with terminal/test point 14.)
14	Input, excitation control windings. (Used with terminal/test point 13.)

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SE14 MODULE

Provides gating pulses to the SCR at the proper time determined by the current in the control windings. Primary control windings are connected to terminals 13 & 14.

TEST POINTS

SIGNAL DESCRIPTION

2	Provisional function; control or bias. (Used with terminal/test point 4.)
3	Input from main generator positive during dynamic braking (on locomotives so equipped). (Used with terminal/test point 12.)
4	Provisional function; control or bias. (Used with terminal/test point 2.)
5	Output to gate of SCR1.
7	Output to gate of SCR2.
9	Output to gate of SCR3.
6, 8, and 10	AC power supply from companion alternator.
11	Common point for gate outputs; cathodes of SCR's. (Return for outputs from terminals/test points 5, 7, and 9.)
12	Main generator negative during dynamic braking (on locomotives so equipped). (Used with terminal/test point 3.)
13	Input, excitation control windings. (Used with terminal/test point 14.)
14	Input, excitation control windings. (Used with terminal/test point 13.)

SW100 MODULE

The SW100 module provides wheel slip protection when locomotive is not in Super Series, controls automatic sanding when in or out of Super Series, cuts out manual sanding capability when certain conditions of Super Series operation exist, provides a signal when in Super Series or in SW mode, provides a low power signal when unit is developing low power in throttle 8, detects Super Series failures and indicates the type of each failure that is detected. The wheel slip system provides corrective signals to the LC module, ORS, sensor string, or DR module (if in dynamic brake), and actuates the wheel slip light.

TEST

SWITCH 1:

Used to check SW wheel slip system (IN SW MODE), Super Series failure (on AN), radar signal input (NO RADAR SIGNAL), and SW automatic sand circuit (on SA).

INDICATING LIGHTS

"MANUAL SAND CUTOUT"

This light is on when manual sanding is cut out.

"IN SW MODE"

This light is on when the wheel control system is in the starting (or backup) wheel slip mode, as opposed to the Super Series mode.

"IN S.S. MODE"

This light is on when the wheel control system is in the Super Series mode.

"NO RADAR SIGNAL"

This light is on when no speed signal is available from the RA module. This condition is a Super Series failure.

"REGULATION FAILURE"

This light is on when the EN module has failed to regulate (limit) Super Series wheel creep. This condition is a Super Series failure.

"S.S. UNLOAD"

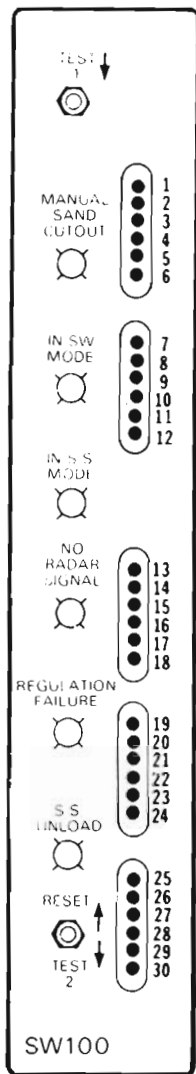
This light is on when the EN module has regulated (limited) Super Series wheel creep for an excessive time period. This condition is a Super Series failure.

TEST

SWITCH 2:

Used to check Super Series wheel creep system (IN S.S. MODE), SW sensor control, Super Series automatic sand (on SA), low power (on AN), and manual sand cutout operation (MANUAL SAND CUTOUT).

Used also to reset the latched-on LED's.



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TEST POINTS

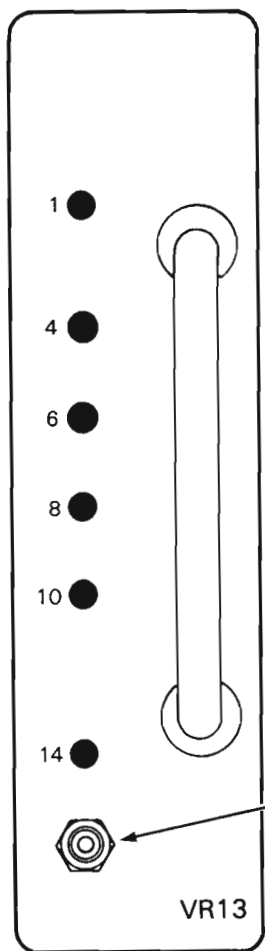
SIGNAL DESCRIPTION

- 1 Output signal. Super Series speed signal. This signal has a ratio of 10 mph/V.
- 2 Input signal. SW enable signal from EN module. Logic "1" enables SW.
- 3 Input signal. This signal, V_{MGF} , is proportional to filtered main generator voltage. It signal has a ratio of 125V/V.
- 4 Input signal. This signal is the voltage limit reference signal, $V + \Delta V$, developed by the EN module. This signal has a ratio of 125V/V.

- 5 Input signal. This signal, N_c (called N_H on some modules), is proportional to highest traction motor armature speed.
- 6 Input signal. This signal, N_R , is proportional to the radar analog speed signal.
- 7 Input signal. This signal, MR , is +15 VDC when locomotive is set up for power operation.
- 8 Input signal. This signal is +12 VDC or higher when power output of the unit is less than 75% of nominal throttle 8 position power in throttle 8 only.
- 9 Test point only. +15 VDC indicates a Super Series failure.
- 10 Test point only. About -15 VDC indicates normal operating conditions (no radar signal failure). A positive voltage (+15 VDC) indicates a radar signal failure.
- 11 Test point only. About -15 VDC indicates normal operating conditions (no regulation failure). A positive voltage (+15 VDC) indicates a regulation failure.
- 12 Test point only. About -15 VDC indicates normal operating conditions (no Super Series unload). A positive voltage (+15 VDC) indicates a Super Series unload condition.
- 13 This signal is positive when Super Series is cut out; negative when Super Series is engaged.
- 14 Test point only. Reference signal for first stage wheel slip correction.
- 15 Test point only. Sensor transistor control.
- 16 Test point only. Second stage wheel slip correction signal.
- 17 LC discharge output. Positive source of current to discharge negatively charged LC current and kW reference circuits. (-15 VDC except during discharge.)
- 18 Sensor string output signal.
- 19 Input signal. This signal is proportional to the lowest motor armature current greater than 22.5 amperes. The ratio is 150A/V. If none of the motors are drawing more than 22.5 amperes, this signal will be +15 VDC.
- 20 +15 VDC power supply input.
- 21 Test point only. Reference signal for second stage wheel slip correction.
- 22 Test point only. Level stage wheel slip correction signal.
- 23 Input signal. This signal, I_{AVE} , is proportional to average traction motor current.
- 24 Input signal. +15 VDC input from EN module that indicates regulation of wheel creep in Super Series.
- 25 ± 15 VDC power supply common input.
- 26 Input signal. Sand signal from LC module when actual kW and current levels are both less than 90% of their reference levels.
- 27 Output signal. +15 VDC is the automatic sand signal to SA module.
- 28 Input signal. +15 VDC when CV solenoid is energized.
- 29 Input signal. +15 VDC when BR1 picked up.
- 30 -15 VDC power supply input.

VR13 MODULE

Regulates auxiliary generator rectified voltage to 74 VDC by controlling the auxiliary generator field current.

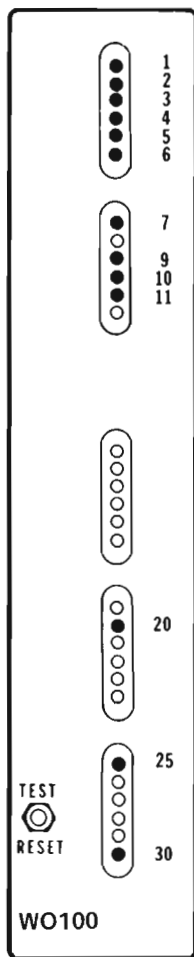


TEST POINTS SIGNAL DESCRIPTION

- | | |
|-------------|--|
| 1 | Input, 74 VDC. |
| 4, 6 and 10 | Aux. Gen. AC output. |
| 8 | Output to aux. gen. field (pilot exciter). |
| 14 | Aux. Gen. Negative. |

CAUTION

Do not install or remove VR module in locomotive unless engine is completely stopped.



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WO100 MODULE

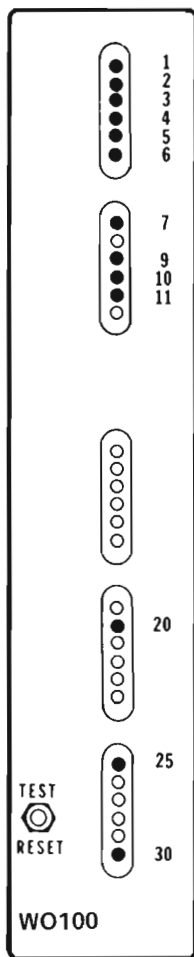
The WO100 module monitors wheel speed by comparing main generator voltage signal 125V/V with main generator current signal 600A/V and with average motor current signal 150A/V. The WO100 module provides a maximum field current limit recalibration signal to the EL module at some predetermined low speed (about 30 miles per hour). Provides a signal to the wheel slip light relay WL and to ORS and drops the feed to the EQP relay to protect the traction motors in case of wheel overspeed.

TEST SWITCH: This switch is used to perform a functional check on the module. It simulates a wheel overspeed condition when the test switch is closed.

TEST POINTS

SIGNAL DESCRIPTION

1	IMGF, main generator current input signal, 600A/V.
2	I _{AVE} , average motor current input signal, 150A/V.
3	+10 to +15 VDC output to wheel slip light relay during wheel overspeed.
4	+10 to +15 VDC output to ORS during wheel overspeed. (Not connected on this locomotive.)
5	RH1 output. Wheel overspeed setting.
6	RH2 output. EL module recalibration signal setting.
7	V _{MGF} , main generator voltage input signal, 125V/V.
9 to 11	Open circuit during wheel overspeed.
10	+10 to +15 VDC for EL module recalibration when operating above recalibration speed (about 30 miles per hour).
20	+15 VDC power supply input.
25	±15 VDC power supply common input.
30	-15 VDC power supply input.



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WO100 MODULE

The WO100 module monitors wheel speed by comparing main generator voltage signal 125V/V with main generator current signal 600A/V and with average motor current signal 150A/V. The WO100 module provides a maximum field current limit recalibration signal to the EL module at some predetermined low speed (about 30 miles per hour). Provides a signal to the wheel slip light relay WL and to ORS and drops the feed to the EQP relay to protect the traction motors in case of wheel overspeed.

TEST SWITCH: This switch is used to perform a functional check on the module. It simulates a wheel overspeed condition when the test switch is closed.

TEST POINTS

SIGNAL DESCRIPTION

1	IMGF, main generator current input signal, 600A/V.
2	I _{AVE} , average motor current input signal, 150A/V.
3	+10 to +15 VDC output to wheel slip light relay during wheel overspeed.
4	+10 to +15 VDC output to ORS during wheel overspeed. (Not connected on this locomotive.)
5	RH1 output. Wheel overspeed setting.
6	RH2 output. EL module recalibration signal setting.
7	V _{MGF} , main generator voltage input signal, 125V/V.
9 to 11	Open circuit during wheel overspeed.
10	+10 to +15 VDC for EL module recalibration when operating above recalibration speed (about 30 miles per hour).
20	+15 VDC power supply input.
25	±15 VDC power supply common input.
30	-15 VDC power supply input.

MODULE QUALIFICATION AT STANDSTILL

The electrical qualification guide provides a series of checks that may be performed when no specific trouble is reported or indicated. The checks may be used as a guide to qualify a locomotive for service.

NOTE

Green LED's on module faceplates indicate normal operation while red LED's signify faults.

WARNING

When performing standstill tests, always disconnect control jumper cables between units. When extensive checking of control circuit voltages is to be done, it is recommended that the ER relay be disabled whenever possible during high-throttle no-load testing.

Before removing or inserting modules, open the MODULE CONTROL circuit breaker on the No. 2 circuit breaker panel. This prevents damage to the modules by electrical transients and surges.

Do not disconnect a module during locomotive operation. Do not operate test switches during locomotive operation without a thorough understanding of the circuits involved and of the results of such action.

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
CM MODULE QUALIFICATION MAXIMIZING FUNCTION	UNIT SET UP FOR NORMAL POWER MODE OF OPERATION. ENGINE RUNNING. THROTTLE IDLE.	Observe indicating lights on CM module. Press and hold test switch on faceplate of CM module. Release test switch.	LED5 on CM faceplate should be on. The lighted LED's on CM faceplate should switch from 5 to 4 to 3 to 2 to 1 and then oscillate slowly (about 1/sec) between 1 and 2. NOTE If the test switch does not at first cause the lights to sequence to number 1, then repeat the test a few times until the proper response is obtained. LED5 should come on and all other LED's should go off within approximately 2 seconds.

DE MODULE QUALIFICATION EXTENDED RANGE DYNAMIC BRAKE DC CONTACTOR CONTROL	ENGINE RUNNING. CONTROLS AND SWITCHES SET FOR DYNAMIC BRAKE. REVERSER FORWARD. INDEPENDENT AIR BRAKES RELEASED.	Place dynamic brake handle in position No. 4. Operate and hold the DE module test switch. Release DE module test switch. Apply independent air brake. Release independent air brake. Return brake handle to set-up. Place brake handle in OFF position.	Engine speed increases from idle to dynamic brake speed. DE module LED's indicate in se- quence: Step 1, Step 2, and Step 3, with an interval between them. NOTE Step 1 indicates pickup of DC1 alone. Step 2 indicates pickup of DC2 alone. Step 3 indicates pickup of both DC1 and DC2 at the same time. DE module LED's go out in se- quence, Step 3, Step 2, and Step 1 with an interval between them. LED's sequence on. LED's all go out at same time. LED's sequence on. Engine speed returns to idle; LED's may remain on or they may se- quence off. LED's all go out at same time.

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
DG MODULE QUALIFICATION			
PROTECTION AGAINST NO GRID COOLING.	ENGINE RUNNING. CONTROLS AND SWITCHES SET UP FOR LOAD TEST. REVERSER CENTERED.	Operate test switch on DG module down to TEST position. Move throttle to No. 1 position.	DGX relay drops out, DG module LED on, and GRID BLOWER MOTOR light on AN module comes on.
		Release DG module test switch and press upward to RESET position.	LED on DG module goes out. GRID BLOWER MOTOR light on AN module remains on. DGX relay picks up.
		Raise AN module test switch lever to RESET position momentarily.	GRID BLOWER MOTOR light on AN module goes off.
	ENGINE RUNNING. CONTROLS AND SWITCHES SET UP FOR LOAD TEST AND REVERSER CENTERED. THROTTLE IDLE.	Connect a jumper be- tween test points 2 and 5 on DG. Load test loco- motive in throttle 8.	LED on DG module should go on within 30 seconds. GFX and GFC contactors drop out. GRID BLOWER MOTOR light on AN module turns on.
		Remove jumper. Reset AN.	
	ENGINE RUNNING. CONTROLS AND SWITCHES SET UP FOR DYNAMIC BRAKE.	Move dynamic brake handle to FULL 8 position. Operate test switch on DG module to TEST position and hold for 2 seconds. Release switch allowing it to return to normal position. Before 2 minutes have elapsed, again oper- ate DG test switch to TEST position and hold for 5 seconds.	B, GFX, and GFC contactors drop out. LED on DG module goes on. GRID BLOWER MOTOR light on AN module turns on.
		Reset DG and AN mod- ules.	

DP MODULE QUALIFICATION

DYNAMIC BRAKE PROTECTIVE FUNCTIONS

GRID OVER CURRENT.
MOTOR OVER
EXCITATION. GRID
OPEN CIRCUIT.

ENGINE RUNNING. AIR
BRAKES SET.
CONTROLS AND
SWITCHES SET FOR
DYNAMIC BRAKING.
REVERSER FORWARD.
DYNAMIC BRAKE
HANDLE IN SET-UP.

Connect jumper DP-TP20
and DP-TP26. (DP nullifi-
cation input.)

Place dynamic brake
handle in position 5.

Operate test switch on
faceplate of DP module
to TEST position (hold for
5 seconds, then release).

Reset OCP relay (on No. 2
circuit breaker panel) and
AN module.

Remove jumper between
DR-TP20 and DR-TP26.

Operate the DP module
test switch to TEST posi-
tion and hold for 10
seconds.

Engine speed increases from idle to
dynamic brake speed.

OCP relay should pick up. B con-
tactor should drop out. GFC con-
tactor should drop out.

Grid open circuit annunciator LED
on AN module should turn on.
(The connection between DP-TP20
and DP-TP26 should block grid over
current and motor over excitation
DP functions.)

OCP relay should pick up. B con-
tactor should drop out. GFC con-
tactor should drop out. EQP relay
should drop out. Grid open circuit
annunciator LED on AN module
should turn on immediately.

After a short delay, not to exceed 6
seconds, the grid over current and
motor over excitation annunciator
LED's on AN module should turn on
and brake warning light or buzzer
should turn on momentarily (while
switch is depressed only), but not
necessarily together.

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
DR MODULE QUALIFICATION			
DYNAMIC BRAKE LINEAR RATE AND TRACTION MOTOR FIELD CURRENT LIMIT	ENGINE RUNNING. AIR BRAKES SET. CONTROLS AND SWITCHES SET FOR DYNAMIC BRAKE. REVERSER FORWARD. DYNAMIC BRAKE HANDLE IN SET-UP.	Connect 0-20 VDC digital voltmeters between DR- TP25 (common) and DR- TP16, DR-TP22, and DR-TP5. Wipe brake handle to maximum.	NOTE Make sure that dynamic brake circuit breaker on control stand is reset. Engine speed increases to dynamic brake speed. Voltage at DR-TP16 rises immedi- ately from 0 VDC to 9.9 ± 0.2 VDC. Voltage at DR-TP22 slowly rises to 9.9 ± 0.2 VDC within 7 to 13 seconds (within 13 to 19 seconds if terminal/test point 15 is grounded by jumper to terminal 26). Voltage at DR-TP5 slowly rises to $1.46 \pm .08$ VDC, basic ($1.83 \pm$.10 VDC with high capacity grids). Engine speed returns to idle.
FAST CHARGE AND FAST DISCHARGE RATES	ENGINE RUNNING. AIR BRAKES SET. CONTROLS AND SWITCHES SET FOR DYNAMIC BRAKE. RE- VERSER FORWARD. DYNAMIC BRAKE HANDLE IN SET-UP.	Connect jumper between DR-TP20 and DR-TP8 (DE fast charge). Connect 0-20 VDC digital voltmeter between DR- TP22 and DR-TP25 (com- mon). Wipe brake handle to maximum.	Engine speed increases to dynamic brake speed. Voltage at DR-TP22 rises to $+9.9$ ± 0.2 VDC in 4 to 7 seconds.

Remove jumper between
DR-TP20 and DR-TP8

		Remove jumper between DR-TP8 and DR-TP20. Connect jumper between DR-TP18 and DR-TP20 (wheel slip fast discharge). Remove jumper from DR-TP18. Connect jumper between DR-TP19 and DR-TP20. Return brake handle to set-up. Remove all meters and jumpers.	Voltage at DR-TP22 drops to approximately 0 VDC in 1 to 3 seconds. Voltage at DR-TP22 returns to $+9.9 \pm 0.2$ VDC in 4 to 7 seconds. Voltage at DR-TP22 drops to approximately 0 VDC in 1 to 3 seconds. Engine speed returns to idle.
EL MODULE QUALIFICATION	UNIT SET UP FOR NORMAL POWER MODE OF OPERATION. ENGINE RUNNING AT THROTTLE 4. REVERSER CENTERED. AIR BRAKES SET.	Close and hold test switch on EL module. Release test switch. +74 VDC supply (test point 1) must be greater than +68 VDC. Connect 0-200 VDC digital voltmeter between EL-TP21 and EL-TP25, then close test switch on EL module. Release test switch. Return throttle to idle. Reset AN module.	While test switch is held, EXCIT LIMIT light on AN module should come on and EQP should drop out. EXCIT LIMIT light on AN module remains on. If voltage is not greater than +68 VDC, then verify VR module operation. Voltmeter indicates between 4.0 and 4.5 volts. If not, replace the EL module.

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
EN MODULE QUALIFICATION			
OUTPUT TO SENSOR STRING AND EN REG INDICATOR LIGHT	UNIT SET UP FOR THROTTLE 1 STALL TEST: ENGINE RUNNING, AIR BRAKES SET, REVERSER FORWARD, AND THROTTLE IN POSITION 1.	Push TEST 1 switch lever down and hold it there while observing the EN REG LED on the module and the load current indicating meter.	The EN REG LED should come on immediately, and the unit should unload.
		Release the TEST 1 switch lever.	Unit should begin to load, and EN REG LED should go off 1 or 2 seconds after switch is released.
E/N FUNCTION GEN. AND $V + \Delta V$ CIRCUIT	UNIT SET UP FOR POWER OPERATION: ENGINE RUNNING, THROTTLE IN IDLE POSITION, REVERSER FORWARD.	Press the TEST 2 switch lever down and hold it there for at least two seconds.	$V + \Delta V$ TEST LED should come on.
		Release the switch lever.	$V + \Delta V$ TEST LED should go off.
FG MODULE QUALIFICATION			
MAIN GENERATOR VOLTAGE FEEDBACK SIGNALS	UNIT SET UP FOR LOAD TEST. ENGINE RUNNING. THROTTLE IN IDLE POSITION. REVERSER CENTERED. AIR BRAKES SET.	Using 0-20 VDC digital voltmeter, measure voltage between: 1. FG-TP1 (pos) and FG-TP3. 2. FG-TP19 (pos) and FG-TP25. 3. FG-TP29 (pos) and FG-TP25. Connect 0-1000 VDC voltmeter between GP (pos) and GN (neg) on Test Panel to measure main generator voltage.	The voltage at these three points should be near zero.
		Advance throttle to position 1.	

MAIN GENERATOR CURRENT FEEDBACK SIGNALS	UNIT SET UP FOR NORMAL POWER MODE OF OPERATION. ENGINE RUNNING. THROTTLE IN IDLE POSITION. REVERSER FORWARD. AIR BRAKES SET.	Using a 0-20 VDC digital voltmeter, measure volt- age between: 1. FG-TP1 (pos) and FG-TP3. 2. FG-TP19 (pos) and FG-TP25. 3. FG-TP29 (pos) and FG-TP25. Return throttle to idle. Advance throttle to position 1. Measure signal between FG-TP18 and FG-TP25 (common), and between FG-TP15 and FG-TP25. Return throttle to idle and measure signals between points specified above.	The voltage at these three points should be equal, and should be equal to main generator voltage divided by 125. The signals should be between +1.50 and +1.75 VDC at FG-TP15 and between -1.50 and -1.75 VDC at FG-TP18. The signals should be 0 VDC.
LOAD REGULATOR FEEDBACK SIGNAL WITH THROTTLE IN IDLE	UNIT SET UP FOR NORMAL POWER MODE OF OPERATION. ENGINE RUNNING. THROTTLE IN IDLE POSITION.	Connect 0-100 VDC voltmeter between FG-TP28 and FG-TP27. Connect 0-20 VDC digital voltmeter between FG-TP26 and FG-TP25. Close test switch on GC module. Release test switch on GC module.	Voltmeter should indicate C +0.5 VDC with load regulator in maximum field position. Voltmeter should indicate 0 to -0.06 VDC. Voltmeter connected between FG-TP27 and FG-TP28 should increase to approximately 74 VDC, and voltmeter connected between FG-TP26 and FG-TP25 should increase to about +10 VDC.

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE								
FM MODULE QUALIFICATION	UNIT SET UP FOR NORMAL POWER MODE OF OPERATION. ENGINE RUNNING. THROTTLE IN IDLE POSITION. AIR BRAKES SET. REVERSER FORWARD.	Connect 0-20 VDC digital voltmeter between TP25 (common) and test points specified in column at right.	TP11: +12 to +15 VDC TP13: 0 VDC TP14: 0 VDC TP15: 0 VDC TP16: 0 VDC TP21: 0 VDC TP22: 0 VDC TP10: 0 VDC								
MOTOR CURRENT FEEDBACK SIGNALS		Advance to throttle 1 position and measure voltage at each test point in preceding step.	There should be +1.50 to +1.83 VDC at each test point except TP10 which should be 0 VDC.								
TM1, TM2, TM3, AND TM4 INPUT SIGNALS	UNIT SET UP FOR NORMAL POWER MODE OF OPERATION. ENGINE RUNNING. THROTTLE IDLE. AIR BRAKES SET.	Connect 0-20 VDC digital voltmeter between FM-TP25 and FM test points specified in column at right.	NOTE All FM module calibrations are 150A/V; a level of 1500 motor amperes results in a 10 VDC signal. <table border="1"> <tr> <td>TM1</td><td>TM2</td><td>TM3</td><td>TM4</td></tr> <tr> <td>FM-TP13</td><td>FM-TP14</td><td>FM-TP15</td><td>FM-TP16</td></tr> </table>	TM1	TM2	TM3	TM4	FM-TP13	FM-TP14	FM-TP15	FM-TP16
TM1	TM2	TM3	TM4								
FM-TP13	FM-TP14	FM-TP15	FM-TP16								
HIGHEST MOTOR CURRENT SIGNAL		Advance throttle to position 1 and record voltage signals for each traction motor.									
		Check highest current output signal between FM-TP21 and FM-TP25.	This signal should be equal to the highest of TM1, TM2, TM3, or TM4 signal.								

LOWEST MOTOR
CURRENT SIGNAL

Check lowest current
output signal between

This signal should be equal to the
lowest of TM1, TM2, TM3, or TM4

LOWEST MOTOR CURRENT SIGNAL	Check lowest current output signal between FM-TP12 and FM-TP25.	This signal should be equal to the lowest of TM1, TM2, TM3, or TM4 signal. An open motor circuit or an open input (ACT's) results in 0VDC at this point.
LOWEST LOADING MOTOR CURRENT SIGNAL	Check signal from lowest loading motor between FM-TP11 and FM-TP25.	This signal ratio should be 150A/V. This signal will be +12 VDC or more when all motors draw less than 22.5 amperes.
AVERAGE MOTOR CURRENT SIGNAL	Check average motor current signal between FM-TP22 and FM-TP25.	This signal should be equal to the signals of TM1 + TM2 + TM3 + TM4 divided by four.
AMMETER DRIVE SIGNAL	Check the load indicating meter drive signal be- tween FM-TP27 and FM-TP25.	This signal should be equal to the average motor current signal. Compare this signal with the load indicating meter indication using a ratio of 150A/V.
	Return throttle to idle.	The signal between FM-TP11 (pos) and FM-TP25 should be +12 to +15 VDC.
LOCKED POWERED WHEEL	Install jumper between SW-18 and SW-20 to prevent SW module cir- cuits from interfering with this test. Advance throttle to position 1, then close and hold test switch on faceplate of FM module.	LOCKED PWR WHEEL light on AN module and WHEEL SLIP light should come on and unit should unload after 10 to 30 seconds.
	Release test switch.	Lights should remain on and unit should not load.
	Remove jumper between SW-18 and SW-20.	

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
OPEN MOTOR OUTPUT SIGNAL		Reset test switch on face-plate of FM module. Return throttle to idle and reset AN module. NOTE If unit is equipped with motor cutout, cut out one motor and perform following steps. Connect a 0-20 VDC digital voltmeter between FM-TP12 and FM-TP25, then advance throttle to position 1. Return throttle to idle. Connect voltmeter between FM-TP10 and FM-TP25, then advance throttle to position 1 to check open motor output signal. Return throttle to idle and reconnect cut out motor. Reset AN module.	Unit should load and WHEEL SLIP light should go out. Voltmeter should indicate 0 VDC. Voltmeter should indicate +12 to +14 VDC within about one minute after advancing throttle to position 1. OPEN MOTOR CIRCUIT light on AN module will go on.

GC MODULE QUALIFICATION																																																																																																		
THROTTLE RESPONSE	UNIT SET UP FOR POWER MODE OF OPERATION. ENGINE RUNNING. THROTTLE IN IDLE POSITION.	Open generator field switch and advance throt- tle one step at a time from idle through throttle 8 position. Return throttle to idle.	Engine speed increases each time throttle advances, except from position 1 to position 2. Engine speed goes to idle.																																																																																															
LC MODULE QUALIFICATION	SET UP UNIT FOR POWER MODE OF OPERATION. ENGINE RUNNING OR STOPPED. THROTTLE IN IDLE POSITION. REMOVE SE MODULE.	Use three 0-20 VDC digital voltmeters with negatives at LC-TP25 and positives as specified in 1 through 3 below to determine level of current reference (I ref), voltage reference (V ref), and kilowatt reference (KW ref) signals. 1. KW ref LC-TP13. 2. I ref LC-TP14. 3. V ref LC-TP15. Advance throttle one position at a time and check meter readings against Table LC1 values. NOTE Engine speed in- creases as throttle advances, but unit will not load because SE module has been removed.	NOTE The voltages specified in the following table have a toler- ance of ± 0.2 VDC. Table LC1-LC112 Reference Voltages <table><tr><th>THROTTLE POSITION</th><th>KW ref LC-TP13</th><th>I ref LC-TP14</th><th>V ref LC-TP15</th></tr><tr><td>1</td><td>0.68</td><td>1.68</td><td>3.99</td></tr><tr><td>2</td><td>1.12</td><td>3.34</td><td>4.96</td></tr><tr><td>3</td><td>2.53</td><td>5.03</td><td>6.18</td></tr><tr><td>4</td><td>3.38</td><td>6.67</td><td>7.20</td></tr><tr><td>5</td><td>4.66</td><td>8.35</td><td>8.29</td></tr><tr><td>6</td><td>5.81</td><td>9.99</td><td>9.18</td></tr><tr><td>7</td><td>8.56</td><td>11.00</td><td>10.00</td></tr><tr><td>8</td><td>10.00</td><td>11.00</td><td>11.08</td></tr></table> <table><tr><th rowspan="2">THROTTLE POSITION</th><th colspan="5">TEST POINTS</th></tr><tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr><tr><td>1</td><td>OV</td><td>OV</td><td>OV</td><td>OV</td><td>15V</td></tr><tr><td>2</td><td>15V</td><td>OV</td><td>OV</td><td>OV</td><td>15V</td></tr><tr><td>3</td><td>OV</td><td>OV</td><td>15V</td><td>OV</td><td>15V</td></tr><tr><td>4</td><td>15V</td><td>OV</td><td>15V</td><td>OV</td><td>15V</td></tr><tr><td>5</td><td>OV</td><td>15V</td><td>15V</td><td>15V</td><td>15V</td></tr><tr><td>6</td><td>15V</td><td>15V</td><td>15V</td><td>15V</td><td>15V</td></tr><tr><td>7</td><td>OV</td><td>15V</td><td>15V</td><td>OV</td><td>15V</td></tr><tr><td>8</td><td>15V</td><td>15V</td><td>15V</td><td>OV</td><td>15V</td></tr></table> Table LC2-LC Throttle Input Signals	THROTTLE POSITION	KW ref LC-TP13	I ref LC-TP14	V ref LC-TP15	1	0.68	1.68	3.99	2	1.12	3.34	4.96	3	2.53	5.03	6.18	4	3.38	6.67	7.20	5	4.66	8.35	8.29	6	5.81	9.99	9.18	7	8.56	11.00	10.00	8	10.00	11.00	11.08	THROTTLE POSITION	TEST POINTS					1	2	3	4	5	1	OV	OV	OV	OV	15V	2	15V	OV	OV	OV	15V	3	OV	OV	15V	OV	15V	4	15V	OV	15V	OV	15V	5	OV	15V	15V	15V	15V	6	15V	15V	15V	15V	15V	7	OV	15V	15V	OV	15V	8	15V	15V	15V	OV	15V
THROTTLE POSITION	KW ref LC-TP13	I ref LC-TP14	V ref LC-TP15																																																																																															
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THROTTLE POSITION	TEST POINTS																																																																																																	
	1	2	3	4	5																																																																																													
1	OV	OV	OV	OV	15V																																																																																													
2	15V	OV	OV	OV	15V																																																																																													
3	OV	OV	15V	OV	15V																																																																																													
4	15V	OV	15V	OV	15V																																																																																													
5	OV	15V	15V	15V	15V																																																																																													
6	15V	15V	15V	15V	15V																																																																																													
7	OV	15V	15V	OV	15V																																																																																													
8	15V	15V	15V	OV	15V																																																																																													

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
LC MODULE QUALIFICATION THROTTLE RESPONSE RATE FUNCTIONS	SAME SETUP AS FOR REFERENCE SIGNAL FUNCTIONS IN PREVIOUS ITEM.	If the values given in Table LC1 cannot be verified, then check for voltages given in Table LC2. Voltage values are in reference to TP25. If the throttle inputs of Table LC2 are present but not the reference values of Table LC1, check the load regulator input, LC-TP7, and the derating input to LC pin 17. Both should be 0 VDC. If TP7 is not at 0 VDC, check the FG module and/or the load regulator/governor system. If the derating input is not 0 VDC, check its source. When either the load regulator input or the derating input level is more positive than 0 VDC, with respect to LC-TP25, some of the LC module reference levels will be lowered. If both load regulator and derating inputs are zero and the Table LC-2 throttle inputs are okay, but the reference values do not match Table LC1, replace the LC module. If voltages given in Table LC2 cannot be obtained, then check the SC2 and GC modules. Same voltmeter connections as for previous reference signal functions check.	

REGULATING FUNCTIONS AT THROTTLE 1 STALL

UNIT SET UP FOR POWER MODE OF OPERATION. ENGINE RUNNING. THROTTLE IN IDLE POSITION. AIR BRAKES SET.

Wipe throttle to position 8 and observe time required for signal to rise to the value specified.

Wipe throttle to idle.

Put unit in switching start mode if so equipped and wipe throttle to position 8.

Reduce throttle to idle.

Wipe throttle to position 8 and observe time required for signal to rise to the value specified.

Return throttle to IDLE.

Wipe throttle to position 8 and observe time required for signal to rise to the value specified.

Wipe throttle to idle.

Insert SE module.

Advance throttle to position 1.

Connect jumper between LC-TP15 and LC-TP25.

Remove jumper from between LC-TP15 and LC-TP25.

Connect jumper between LC-TP28 and LC-TP25.

Remove jumper from between LC-TP15 and LC-TP25.

Connect jumper between LC-TP13 and LC-TP25.

Remove jumper between LC-TP13 and LC-TP25.

I ref LC-TP14 signal should rise to the value specified in the preceding chart for throttle 8 position in 12 to 19 seconds.

I ref should decay to 0 VDC within 5 to 10 seconds.

I ref should rise to the value specified in the preceding chart for throttle 8 position within 5 to 15 seconds.

KW ref LC-TP13 signal should rise to 10 VDC within 27 to 45 seconds.

KW ref decays to 0 VDC within 6 to 12 seconds.

I ref LC-TP15 signal should rise to the value specified in the preceding chart for throttle 8 position in 5 to 20 seconds.

V ref should decay to 0 VDC within 5 to 20 seconds.

Load indicating ammeter should rise to between 200 and 300 amperes (Current Regulator).

Unit should unload and ammeter indication should fall to near 0 (Voltage Regulator).

Ammeter should indicate 200 to 300 amperes.

Ammeter indication should fall to near 0. (External Regulator: EL module excitation limit or DR module dyn. braking regulation.)

Ammeter indicates 200 to 300 amperes.

Ammeter indication should fall to near 0. (kW Regulator.)

Ammeter indicates 200 to 300 amperes.

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
LOW POWER FUNCTIONS	UNIT SET UP FOR POWER MODE OF OPERATION. ENGINE RUNNING. THROTTLE IN IDLE POSITION.	Connect jumper between LC-TP14 and LC-TP25.	Ammeter indication should fall to near 0. (Current Regulator.)
		Remove jumper between LC-TP14 and LC-TP25.	Ammeter indicates 200 to 300 amperes.
		Return throttle to idle.	
		Connect 0-20 VDC digital voltmeter between LC-TP9 and LC-TP25, then advance to throttle position 1.	Voltmeter should indicate -12 VDC or more negative.
		Return throttle to idle and remove SE module.	
		Advance throttle to position 3. (Engine speed increases, but unit will not load because SE module has been removed.) This checks low power sand output function.	Voltmeter should indicate -12 VDC or more negative. (Low Power Sand Output Function.)
		Return throttle to idle.	
		Disconnect 0-20 VDC digital voltmeter and reconnect between LC-TP8 and LC-TP25 (common).	Voltmeter should indicate -12 VDC or more negative.
		Advance throttle to position 8. This checks low power annunciator output.	Voltmeter at LC-TP8 should indicate +12 VDC or more positive. (Low Annunciator Function.)
		Return throttle to idle.	
		Re-install SE module.	

	UNIT SET UP FOR POWER MODE OF OPERATION. ENGINE RUNNING. THROTTLE IN IDLE POSITION.	Connect 0-20 VDC digital voltmeter between LC-TP7 and LC-TP25.	Voltmeter should indicate 0 VDC. Test ORS by operating test switch on GC module. Voltmeter should gradually increase to +10 VDC.
MS MODULE QUALIFICATION	UNIT SET UP FOR POWER MODE OF OPERATION. ENGINE RUNNING. THROTTLE IN IDLE POSITION. REVERSER CENTERED.	Press test switch 2 lever down to TEST position. Press and hold down test switch 2 lever, then press and hold down test switch 1 lever. Release both switches.	LED1 on MS faceplate should go on immediately. LED1 on MS faceplate should go on when test switch 2 is operated, then LED2 and LED3 on MS faceplate should go on.

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
PS MODULE #1 AND #2 QUALIFICATION	UNIT SET UP FOR NORMAL POWER MODE OF OPERATION. ENGINE RUNNING. THROTTLE IN ANY POSITION	Connect 0-20 VDC digital voltmeter between PS-TP10 (pos) and PS-TP11. Connect 0-20 VDC digital voltmeter between PS-TP12 (neg) and PS-TP11.	Voltmeter should indicate +15 $\pm$.10 VDC. If no indication is obtained, then make certain MODULE CONTROL circuit breaker is closed. Voltmeter should indicate -15 $\pm$.10 VDC. NOTE If any other steady voltages are obtained, then refer to "Preliminary Inspections And Testing" in the Troubleshooting Procedures section.
RA MODULE QUALIFICATION PROPER POWER SUPPLY INPUT RADAR TRANSCEIVER, FREQUENCY TO VOLTAGE CONVERTER, AND RADAR MOTOR SPEED CIRCUIT	UNIT SET UP FOR POWER MODE OF OPERATION. THROTTLE IN IDLE POSITION. REVERSER NOT CENTERED. ENGINE RUNNING OR STOPPED. SAME AS PREVIOUS SETUP.	Using a 0-20 VDC digital voltmeter check voltage between RA-TP20 and RA-TP25 (com) and between RA-TP30 and RA-TP25 (com). Press and hold test switch 1 (RADAR TEST) on RA module, until instructed to release.	Voltmeter indicates +15 VDC between RA-TP20 and RA-TP25 and -15 VDC between RA-TP30 and RA-TP25. If voltage is not correct, qualify PS module and wiring. After approximately 1 to 10 seconds LED5 on RA module should come on and radar operated speed indicator (if unit is so equipped) should indicate 35 to 55 miles per hour. 1. If LED5 comes on, but radar speed indicator does not indicate as specified, check for 1.5 to 2.5 VDC between RA-TP5 and RA-TP25. If present, check radar speed indicator and wiring. If not present, replace RA module and retest.

RA MODULE QUALIFICATION RADAR TRANSCEIVER, FREQUENCY TO VOLTAGE CONVERTER, AND RADAR MOTOR SPEED CIRCUIT (Cont'd)		Release test switch 1 (RADAR TEST) on RA module. Press and hold test switch 2 (DIVIDER TEST) on RA module. Release test switch 2 (DIVIDER TEST) on RA module.	2. If LED5 does not come on and radar speed indicator does indicate as specified, check for 3.0 to 5.0 volts radar speed input signal between RA-TP28 and RA-TP25. (An oscilloscope at these points should indicate a 7 to 9 volt square wave). a. If indication is as specified, replace RA module and retest. b. If indication is not as specified, check radar transceiver and associated wiring. LED5 should go out and radar speed indicator reading should fall to 0. LED6 on RA module should light. If LED6 does not light, replace RA module and retest. LED6 on RA module should go out.
SA MODULE QUALIFICATION MANUAL SAND LEAD TRUCK SAND	UNIT SET UP FOR POWER MODE OF OPERATION. ENGINE RUNNING. THROTTLE IN IDLE POSITION. REVERSER FORWARD. SAME AS PREVIOUS SETUP.	Close manual sand switch. Set reverser to reverse position and close manual sand switch. Close lead truck sand switch.	Sand light on control stand comes on and sand is applied to rails in front of each truck. Sand light on control stand comes on and sand is applied to rails behind each truck. Sand light on control stand comes on and sand is applied to rails in front of lead truck.

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
SW MODULE QUALIFICATION	ENGINE RUNNING. UNIT SET UP FOR POWER MODE OF OPERATION. REVERSER CENTERED. THROTTLE IN IDLE POSITION.	Press and hold down test switch 1.	The IN S.S. MODE light on the SW faceplate will go on immediately.
			a. After a short delay the AN module SUPER SERIES FAILURE light will go on.
			b. After another delay, the NO RADAR SIGNAL light on the SW module will go on.
			NOTE If the NO RADAR SIGNAL light does not go on, but the REGULATION FAILURE light goes on, then check that radar module RA is properly installed. If radar module is properly installed, then qualify it before proceeding.
		Release SW test switch 1.	c. The IN S.S. MODE light will go off.
			d. The IN SW MODE light will go on.
		Reset AN module.	All SW lights except NO RADAR SIGNAL will be off.
			AN module SUPER SERIES FAIL- URE light will go off.

SW MODULE
QUALIFICATION (Cont'd)

Push test switch 1 (RA-
DAR TEST) on radar
module. Wait for RADAR

The NO RADAR SIGNAL light will
go off. The IN S.S. MODE and
MANUAL SAND CUTOUT lights

SW MODULE QUALIFICATION (Cont'd)

Push test switch 1 (RADAR TEST) on radar module. Wait for RADAR LED on radar module to come on. Push test switch 1 on SW module.

Release RADAR TEST switch on RA module.

Release SW module test switch 1.

The NO RADAR SIGNAL light will go off. The IN S.S. MODE and MANUAL SAND CUTOUT lights should come on immediately. After about one second the REGULATION FAILURE light should come on and, about two seconds later, the IN S.S. MODE and MANUAL SAND CUTOUT light should go off and the IN SW MODE light should come on.

After a time delay:

- a. IN SW MODE light turns off.
- b. IN S.S. MODE light turns on.
- c. NO RADAR SIGNAL light turns on.
- d. IN S.S. MODE light turns off.
- e. IN SW MODE light turns on.
- f. REGULATION FAILURE light remains on.

IN SW MODE light turns off.

PURPOSE OF CHECK	GENERAL QUALIFICATION TEST SETUP	ACTION	RESPONSE
	ENGINE RUNNING. UNIT SET UP FOR POWER MODE OF OPERATION. REVERSER FORWARD OR REVERSE. THROTTLE IN IDLE POSITION. AIR BRAKES SET.	Advance throttle to posi- tion 1.	Unit will load immediately to throttle 1 stall. IN S.S. MODE light turns on. After a short time delay IN SW MODE light will turn on.
		Press and hold down SW module test switch 2.	a. NO RADAR SIGNAL light turns off. b. IN SW MODE light turns off. c. MANUAL SAND CUTOFF light turns on. d. Unit will unload: ammeter goes to zero. e. After a 20 minute time delay the LOW POWER light on AN will turn on.
		Release test switch.	Unit will load. IN SW MODE light turns on.
		Reset SW module test switch 2.	REGULATION FAILURE light turns off.
		Set throttle back to IDLE position.	
		Reset AN module.	

WARNING

When it is necessary to test a locomotive in throttle 2 stall with the independent air brake set, care should be taken that the locomotive does not move. The length of time in this condition should be limited to 30 seconds since cooling of the commutator segments is not optimum at standstill.

AUTOMATIC SAND FUNCTION	ENGINE RUNNING. UNIT SET UP FOR POWER MODE OF OPERATION. REVERSER FORWARD. THROTTLE IN IDLE POSITION. AIR BRAKES SET.	Put throttle in position 2 stall and allow adequate time for load current to stabilize. Press and hold down SW test switch 2. Release SW test switch 2. MOVE throttle to idle.	Sand light on SA module will go on momentarily and locomotive will unload. The light on the SA module will stay on only for a short period of time.
WO MODULE QUALIFICATION EL RECALIBRATION AND WHEEL OVER- SPEED PROTECTION	GENERATOR FIELD CIRCUIT BREAKER OFF. TEST SWITCH IN CIR- CUIT CHECK POSITION. CONTROLS AND SWITCHES SET UP FOR POWER MODE OF OPERATION.	Operate and hold test switch on WO module. Release test switch.	EQP and GFC drop out. WHEEL SLIP light comes on. ORS drives load regulator toward minimum field position. EQP and GFC pick up and WHEEL SLIP light goes out.

TROUBLESHOOTING PROCEDURES

Successful troubleshooting by a railroad electrician involves tracing a problem down to a fault in the locomotive wiring or in an individual module or component.

This section provides information for analyzing, locating, and correcting certain of the more common electrical control system faults. It is not intended to cover every problem.

Troubleshooting is usually performed when the locomotive is at a standstill with the engine running. Under these conditions the locomotive can be tested in:

- Idle
- Self Load Test (if so equipped)
- Throttle 1 Stall
- Dynamic Brake Setup

TROUBLESHOOTING INSTRUMENTS

A voltmeter and ohmmeter will be required for basic electrical troubleshooting. A 20,000 ohms per volt minimum sensitivity, 0.5% accuracy voltmeter may be used on the -2 type module. However, to obtain reliable indications, a digital meter must be used on the SS type modules.

CAUTION

Never use a test lamp, bell ringer, or megohmmeter for troubleshooting modular or solid state devices. A lamp may overload the circuits, and a bell ringer or megohmmeter may produce destructive voltages.

Open the MODULE CONTROL circuit breaker located on the No. 2 circuit breaker panel of the control cabinet before removing or inserting modules. Otherwise the module may be damaged.

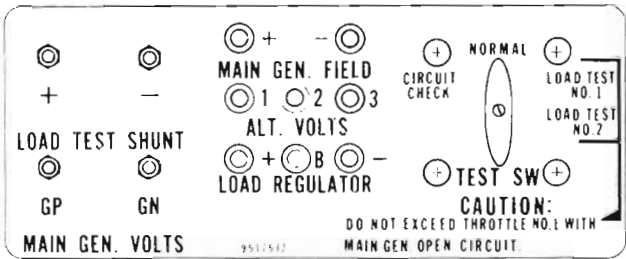
WARNING

Do not disconnect a module during locomotive operation. Do not operate test switches during locomotive operation without thoroughly understanding the circuits involved and the results of such action.

Always consider the specific set of conditions the locomotive is operating under before performing test on a moving locomotive.

When performing standstill tests, always disconnect control jumper cables between units. When extensive checking of control circuit voltages is to be done, disable the ER relay during high-throttle no-load testing, if possible.

The Circuit Check and Load Test positions of the test panel rotary switch do not cut out excitation of the main generator. The load test position will open circuit the main generator on units not equipped for automatic self loading. Do not exceed Throttle 1 with main generator open circuited. Never return test switch to normal position while unit is being loaded.



WARNING

Circuit check position does not prevent excitation of the main generator. On units NOT equipped for automatic self loading, load test position will open circuit the main generator, unless external load is connected. Do not exceed throttle No. 1 with main generator open circuited.

Do not return test switch to normal position while unit is under load.

Test Switch Positions

LOC	TERM	POSITION			
		CRT CHECK	NORMAL	LOAD TEST #1	LOAD TEST #2
852	1-2				
	1-3				
	1-4				
	1-5				
622	6-7				
	6-8				
	6-9				
	6-10				
625	11-12				
	11-13				
	11-14				
	11-15				
700	16-17				
	16-18				
	16-19				
	16-20				
462	21-22				
	21-23				
	21-24				
	21-25				
462	26-27				
	26-28				
	26-29				
	26-30				

NOTE

"LOC" refers to location on Locomotive P ... Schematic

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PRELIMINARY INSPECTIONS AND TESTING

1. Check setup of operating controls to ensure that an incorrectly positioned control, such as the generator field switch, is not causing the problem.
2. Look for fault indications on AN module. Note engine control panel and control stand indicator lights. Examine high voltage cabinet for resettable relays with exposed trip indicators. Check for tripped circuit breakers.
3. Measure the output voltage of both power supply modules (PS11). If the output voltage of either PS11 module is not ± 15 VDC then replace that PS11 module and requalify all other modules.

CAUTION

Any erratic output voltages from the PS11 modules necessitates requalifying all the modules.

The Troubleshooting Guide that follows provides specific trouble reports, possible causes, and recommended tests or corrective actions.

TROUBLESHOOTING GUIDE

NOTE

Green LED's on module faceplates indicate normal operation; red LED's signify faults.

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
ANNUNCIATOR REPORTS		
EXCITATION LIMIT	EL MODULE PROBLEMS.	Perform EL module Qualification Check. If EL module is satisfactory, the excitation limit transducer may have failed, or LC module problems may exist.
LOW POWER	LC MODULE PROBLEMS.	Perform LC module Qualification Check, check engine HP (refer to Locomotive Service Manual) or possible Super Series failure, and check EN and RA modules.
SUPER SERIES FAILURE	SW MODULE PROBLEMS.	Perform SW module Qualification Check.
	EN MODULE PROBLEMS.	Perform EN module Qualification Check.
	RA MODULE HAS NOT RE-CALIBRATED.	Under operating conditions set up RA recalibration conditions and allow RA to recalibrate.
	RA MODULE OR RADAR TRANSCEIVER PROBLEMS.	Perform RA module Qualification Check.
POWERED LOCKED WHEEL	FM MODULE PROBLEMS, SHORTED ARMATURE CURRENT TRANSDUCTORS, OR ACTUAL LOCKED WHEEL.	Have observer at trackside check for normal rotation of each wheel as locomotive moves slowly by.
		Perform FM module Qualification Check.
		Check for shorted armature current transducers.
GRID OPEN-CIRCUIT	DYNAMIC BRAKE GRIDS OPEN CIRCUIT	Check braking grid circuit for open circuit in grids or cabling.
	DP MODULE FAILURE	Perform "grid open-circuit (OCP)" portion of DP module DYNAMIC BRAKE PROTECTIVE FUNCTIONS Qualification Checks. (Test switch portion only.)

3. If 1 and 2 above are satisfactory, perform DP module GRID OPEN CIRCUIT IN LOAD TEST Qualification

MOTOR OVER-EXCITATION LIGHT ON (GRID CURRENT CYCLING)

DP MODULE FAILURE

3. If 1 and 2 above are satisfactory, perform DP module GRID OPEN CIRCUIT IN LOAD TEST Qualification Check. If OCP relay picks up low, replace DP module and retest.

Perform following preliminary set-up. Engine running; Control set for dynamic brakes; Reverser forward; Air brakes set; Brake handle in set-up.

1. Perform DP module DYNAMIC BRAKE PROTECTIVE FUNCTIONS Qualification Check. (Test switch portion only.)

2. If motor over-excitation annunciator will not reset, check for continuous output between DP-TP4 (pos) and DP-TP25. If voltage is always present at DP-TP4, replace DP module and retest.

DR or FG MODULE FAILURE

Perform DR module DYNAMIC BRAKE LINEAR LOADING RATE AND TRACTION MOTOR FIELD CURRENT LIMIT Qualification Check.

1. If cycling of EQP relay occurs (motor over-excitation annunciator light on) with voltage between DR-TP9 and DR-TP25, replace DR module and retest.

2. If cycling of EQP relay occurs (motor over-excitation annunciator light on) with no voltage between DR-TP9 and DR-TP25, replace FG module and retest.

UNIT NOT LOADING.
GRID BLOWER MOTOR
LIGHT ON.

GRID BLOWER MOTOR
FAILED. LOSS OF COOLING
AIR. LOSS OF CONNECTION
OF GRID VOLTAGE AND GRID
CURRENT WIRES. DG MOD-
ULE FAILURE.

1. Check grid blower motor connections.
2. Check grids and grid hatches for cause of overheating.
3. Reset the DG module by pushing the test switch to reset position.
4. Set up control and switches for load test, then advance throttle to position 1. Voltage between DG-TP5 and DG-TP2 should be 20 millivolts $\pm$ 10 millivolts. The voltage between DG-TP5 and DG-TP8 should be 86 ± 50 VDC.
5. Advance throttle to position 8 and load test for 15 minutes.
6. If proper response is obtained while performing Steps 1 through 4 above, but the DGX relay drops out during throttle 8 load test, then replace the DG module and retest.

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
MODULE ORIENTED PROBLEMS		
AMMETER INDICATES 0, BUT UNIT LOADS	AMMETER DRIVE SIGNAL AT FM-TP27 MISSING.	Compare the signal at FM-TP27 with the signal at FM-TP22. These signals should be equal in magnitude (opposite polarity in dynamic braking). If not, replace FM module.
ENGINE BOGS DOWN ON THROTTLE WIPE AT STALL	LC MODULE THROTTLE RESPONSE RATE FUNCTION PROBLEMS OR SWITCHING START CIRCUIT PROBLEMS ON UNITS SO EQUIPPED.	Perform LC module REFERENCE SIGNAL FUNCTIONS and THROTTLE RESPONSE RATE FUNCTIONS Qualification Check.
ENGINE BOGS DOWN ON THROTTLE INCREASE OR DECREASE	LC MODULE THROTTLE RESPONSE RATE FUNCTION PROBLEMS.	Perform LC module REFERENCE SIGNAL FUNCTIONS and THROTTLE RESPONSE RATE FUNCTIONS Qualification Check.
EL CYCLING AT HIGH SPEEDS	EL MODULE EXCITATION CURRENT REGULATING PROBLEMS.	Perform EL and LC module Qualification Check. Also check ELT and main generator.
LOADING OK IN POWER, BUT NOT IN LOAD TEST	LC MODULE (MAIN GENERATOR CURRENT FEEDBACK SIGNAL PROBLEMS) FG MODULE (CT PROBLEM) IMPROPER LOAD TEST SET-UP.	Perform LC module Qualification Check. Perform FG module Qualification Check. Check load test setup. Also check load test SC1 channels.
NOTE The kW limit reference signal is limited to 1% above normal engine horsepower when load test switch is set to LOAD TEST No. 1 position and is limited to 13% above normal engine horsepower when test switch is set to LOAD TEST No. 2 position. The load test switch should be set to LOAD TEST No. 2 position only when checking for excessive engine horsepower output. WARNING In LOAD TEST No. 2 position limit load testing to a maximum of 5 minutes then allow time for cooling before repeating.		
		23116

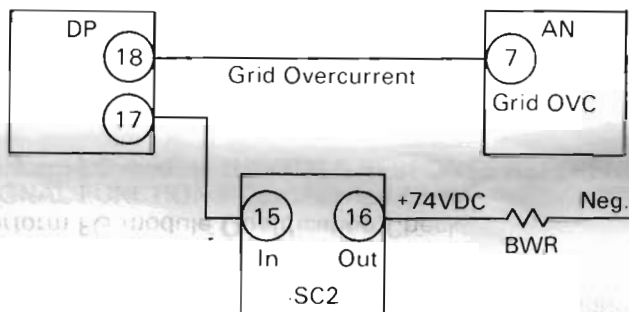
BRAKE WARNING LIGHT OR BUZZER (GRID OVERCURRENT)

DP MODULE FAILURE

Perform following preliminary set-up. Engine running; Controls set up for dynamic brake; Reverser forward; Air brakes set; Brake handle in set-up.

Perform DP module DYNAMIC BRAKE PROTECTIVE FUNCTIONS Qualification Test (test switch portion only).

1. If grid over-current annunciator will not reset, check for continuous output between DP-TP18 and DP-TP25 (common). If voltage is always present, replace DP module and retest.
2. If DP-TP18 voltage is satisfactory, check for failed SC module BWR relay channel. There should be an output voltage at SC2-TP16 only when there is an output voltage at DP-TP18. If this check is not satisfactory, replace SC2 module and retest.
3. If check in 1 and 2 are satisfactory, proceed to next check.



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TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
LOADING, UNIT FAILS TO LOAD.	GRID CURRENT FEEDBACK FAILURE (FM MODULE)	Perform the following preliminary test setup. Engine running; Controls set up for power; Reverser forward; Air brakes set; Throttle handle in position 1. 1. Load indicating ammeter should indicate 200 to 300 amperes. The voltage between DR-TP17 and DR-TP25 (common) should be between +1.3 VDC and +2 VDC. 2. If ammeter does not indicate between 200 and 300 amperes, perform LC module REGULATING FUNCTIONS AT THROTTLE 1 STALL Qualification Check. 3. If voltage at DR-TP17 is not between +1.3 VDC and +2.0 VDC, replace FM module and retest. 4. If the voltage at DR-TP17 and the ammeter indication are satisfactory, replace DR module.
	FG MODULE VOLTAGE FEEDBACK SIGNAL HIGH, CURRENT FEEDBACK SIGNAL HIGH, LOAD REGULATOR FEEDBACK SIGNAL HIGH.	Perform FG module Qualification Check.
	FM MODULE FEEDBACK SIGNALS HIGH OR POWERED LOCKED WHEEL CIRCUIT PROBLEMS.	Perform FM module Qualification Check.
	SENSOR STRING PROBLEMS	Refer to UNIT NOT LOADING TROUBLESHOOTING PROCEDURES. (Near end of this section.)
	1. EN MODULE Q1 OPEN, OPTO-ISOLATOR OPEN, OR REGULATING OPAMP HIGH SATURATION. 2. LC MODULE Q1 or CP2 PROBLEMS. 3. SW MODULE OPTO-ISOLATOR OPEN. 4. EL MODULE Q1 OPEN, OPTO-ISOLATOR OPEN, OR OP1 NEGATIVE SATURATION. 5. SE MODULE PROBLEMS.	

LOAD REGULATOR FAR OUT OF MAXIMUM FIELD POSITION.	LC MODULE THROTTLE REFERENCE FUNCTION PROBLEMS.	Perform LC module THROTTLE RESPONSE REFERENCE SIGNALS FUNCTION Qualification Check.
OVERLOADING IN SOME THROTTLE STEPS	LC MODULE THROTTLE RESPONSE PROBLEMS.	Perform LC module THROTTLE RESPONSE REFERENCE SIGNALS FUNCTION Qualification Check.
OVERLOADING ON GRID LOAD TEST	LC MODULE KW FUNCTION PROBLEMS.	Perform LC module THROTTLE RESPONSE REFERENCE SIGNALS FUNCTION Qualification Check.
OVERLOADING AT STALL THROTTLE ONE, BUT NOT IN GRID LOAD TEST	LC MODULE CURRENT REGULATOR OR CURRENT REFERENCE FUNCTION PROBLEM.	Perform LC module REGULATING FUNCTIONS AT STALL Qualification Check.
SANDING, NO AUTO SAND.	LC MODULE, EN MODULE OR SW MODULE SANDING SIGNAL PROBLEMS.	Perform EN module Qualification Check, LC module LOW POWER FUNCTIONS Qualification Check, and SW module AUTOMATIC SAND FUNCTION Qualification Check.
STALL CURRENT LIMITED TO 150 AMPERES MAXIMUM.	EL MODULE RECALIBRATION CIRCUIT LOW ONLY OR EL MODULE EXCITATION REGULATION PROBLEMS.	Perform EL, FM, and SW module Qualification Check.
	WO MODULE RECALIBRATION PROBLEMS.	Perform TR module Qualification Check.
THROTTLE STEPS MISSED OR IMPROPER THROTTLE RESPONSE.	LC MODULE THROTTLE RESPONSE REFERENCE SIGNALS PROBLEMS.	Perform LC module THROTTLE RESPONSE REFERENCE SIGNAL FUNCTIONS Qualification Check.
UNLOADS PERIODICALLY FOR NO APPARENT REASON.	CM MODULE (MULTIPLEXER PROBLEMS).	Perform CM module Qualification Check.
	RA MODULE or RADAR TRANSCEIVER PROBLEMS.	Perform RA module Qualification Check.
	NOTE E/N characteristic of one or more traction motors may be out of tolerance.	

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
UNDERLOADING CONSTANTLY	FM MODULE OPEN CIRCUIT OUTPUT AT FM-TP10 HIGH.	Perform FM module MOTOR CURRENT FEEDBACK SIGNALS Qualification Check to determine the TM1, TM2, TM3, and TM4 signal levels. 1. If any signal is less than 0.5 VDC, an open motor circuit exists and under loading is normal and should be expected. Replace open motor. 2. If all signals are above 1.0 VDC and the signal at FM-TP10 is more than 10 VDC, the FM module should be replaced.
UNCONTROLLED WHEEL SLIP	NOTE Locomotive wheels are allowed to creep above rail speed. Creep, limited to a maximum level or percentage of rail speed by the EN module, occurs normally if rail condi- tions are poor.	
	EN MODULE FAILURE.	Perform EN module Qualification Check.
	RA MODULE FAILURE.	Perform RA module Qualification Check.
	SW MODULE FAILURE.	Perform SW module Qualification Check.
AMMETER FLUCTUATES EXCESSIVELY		
	FM MODULE FAILURE.	Perform FM module Qualification Check.
CONTINUOUS SAND	SA MODULE FAILURE.	Perform SA module Qualification Check.
	SW MODULE FAILURE.	Perform SW module Qualification Check.
	LOW POWER SAND OR EN FAILURE.	Perform LC and EN module Qualification Check.
	SANDING MAGNET VALVES FAILURE.	The sanding magnet valves should be replaced if sand continues when the SA module is pulled out. (Open MODULE CONTROL circuit breaker before pulling module.)
CONTINUOUS SAND BELOW THROTTLE 3	SW MODULE OR SC MOD- ULE.	Unit set up for power mode of operation. Engine running. Throttle idle. Reverser forward or reverse. Air brakes set.

		Advance throttle to position 1 and using 0-20 VDC digital voltmeter, check voltage between SW-TP27 (pos) and SW-TP25 (common). 1. If voltage is not zero, replace SC2 module and retest. 2. If voltage is zero and AUTO. SAND light on SW module is on, replace SW module and retest. 3. If voltage is zero and AUTO. SAND light on SW module is not on, replace SC2 module and retest.
ERRATIC LOADING	LC MODULE FAILURE. SW MODULE FAILURE. EN OR RA MODULE FAILURE.	Perform LC module Qualification Check. Perform SW module Qualification Check. Perform EN and RA module Qualification Check.
ENGINE WILL NOT CRANK	STARTING FUSE OPEN. BATTERY LOW. LOOSE CONNECTION ON EP SHUNT. EP MODULE FAILURE.	Check for hydraulic lock before replacing fuse and attempting next start. Check battery and battery charging system. Check connections to EP shunt. Close BY-PASS switch on EP module. 1. If engine cranks, replace EP module. 2. If engine does not crank, check EPC relay, STA, and ST contactors.
EXCESSIVE BRAKING AT LOWER DYNAMIC BRAKE HANDLE POSITIONS ON UNITS WITH GRID CURRENT TRAINLINE CONTROL AND/OR EXTENDED RANGE DYNAMIC BRAKE	DR MODULE FAILURE.	Perform following preliminary setup. Engine running; Control set up for dynamic brake; Reverser forward; Independent air brakes released; Brake handle in maximum position. On units with grid current trainline control (GCTLC) with or without extended range dynamic brake, a jumper is installed at the back of the DR module between DR-21 and DR-7 to provide +15 VDC at DR-7. Excessive braking at lower braking handle positions will probably result if the jumper between DR-21 and DR-7 is open.

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
	DE MODULE FAILURE.	1. If voltage between DR-TP7 and DR-TP25 is not approximately +15 VDC, verify that a jumper is installed between DR-21 and DR-7 at the back of the module. 2. If voltage between DR-TP7 and DR-TP25 is approximately +15 VDC and excessive braking occurs at lower braking handle positions, replace DR module and retest. On units equipped with extended range dynamic brakes, but not equipped with full time GCTL, the voltage between DR-TP7 (pos) and DR-TP25 must be more than +10 VDC whenever the DC1 contactor is picked up. With brake handle in maximum position, all DC contactors should be picked up and the voltage between DE-TP12 (pos) and DR-TP25 must be more than +10 VDC. Press test switch on DE module faceplate and measure voltage between DR-TP7 (pos) and DR-TP25 and between DE-TP12 (pos) and DE-TP25. The voltage at DR-TP7 and at DE-TP12 should drop to zero when the DC1 contactor drops out. 1. If the voltage at DE-TP12 drops to zero, but the voltage at DR-TP7 does not drop to zero, check wiring between DR-7 and DE-12 at back of modules. 2. If voltage at DR-TP7 and at DE-TP12 drop to zero, replace DR module. 3. If voltage at DE-TP12 does not drop to zero, replace DE module and retest.

EXCESSIVE WHEEL NOISE

NOTE

A certain amount of wheel noise is expected and is perfectly normal when the Super Series control system enables wheel creep.

EN MODULE FAILURE.

Perform EN module Qualification Check.

NOTE

To completely qualify the E/N function curve, a bench test is required. Module bench testing is beyond the scope of this manual. Therefore, if the CM checks and RA checks are satisfactory and the EN module Qualification Check is satisfactory, the EN module may be out of calibration.

CM MODULE FAILURE.

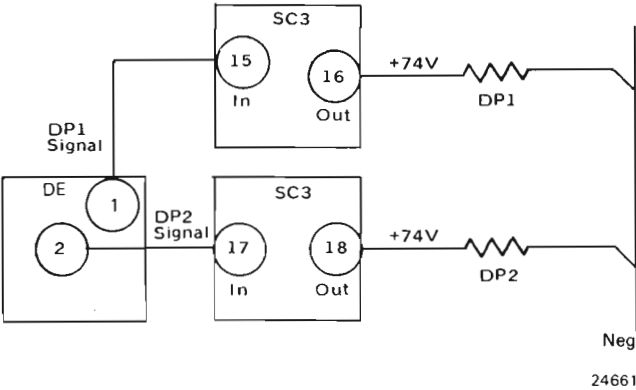
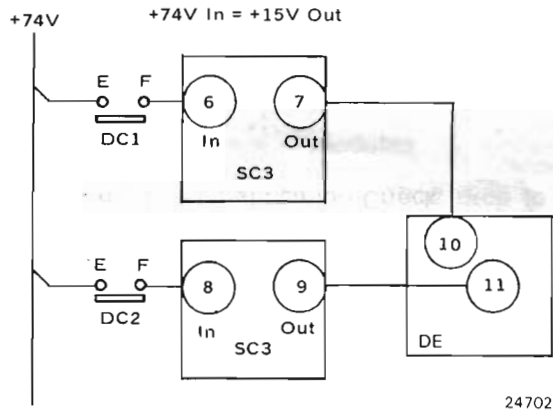
Perform CM module Qualification Check.

RA MODULE OR RADAR TRANSCEIVER FAILURE.

Perform RA module Qualification Check.

NOTE

The radar transceiver may pass the RA module Qualification Check, but fail to provide an accurate signal. Therefore, it may be advisable to operate the unit at a known speed and check the output between RA-5 (pos) and RA-6 (common) before replacing the radar transceiver. The signal at RA-5 has a ratio of 22.5 mph/V.

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
EXTENDED RANGE DYNAMIC BRAKE PARTIAL OR ERRATIC OPERATION. 	DE OR SC MODULE FAILURE.	Perform preliminary setup. Engine running; Controls setup for dynamic brake; Reverser forward; Independent air brakes released. Perform DE module EXTENDED RANGE DYNAMIC BRAKE DC CONTACTOR CONTROL Qualification Check. If DC contactor sequence is only partially successful, check the DP coil circuits through SC3, and the DC contactor pick up and dropout circuits through SC3. If SC module and coil circuits check satisfactory, replace DE module and retest. 

NO DYNAMIC BRAKE

SC MODULE FAILURE (Inter face between 74 VDC and

Perform following preliminary set-up.
Engine running; Controls set up for dynamic brake;
Reverser forward; Independent air brakes released.

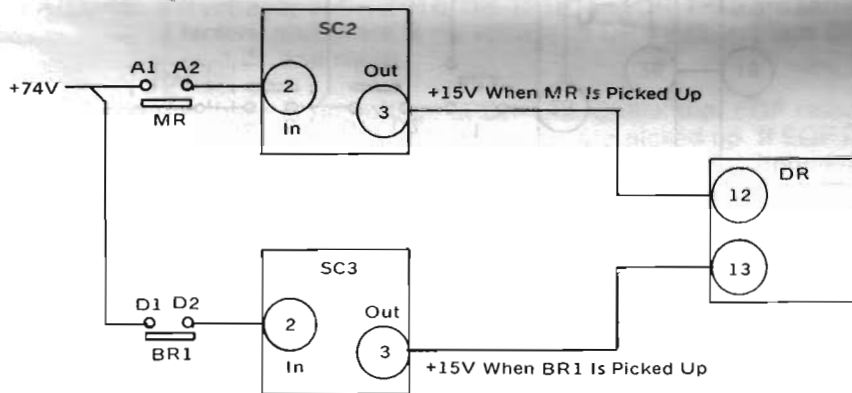
NO DYNAMIC BRAKE

SC MODULE FAILURE (Interface between 74 VDC and ± 15 VDC power supplies).

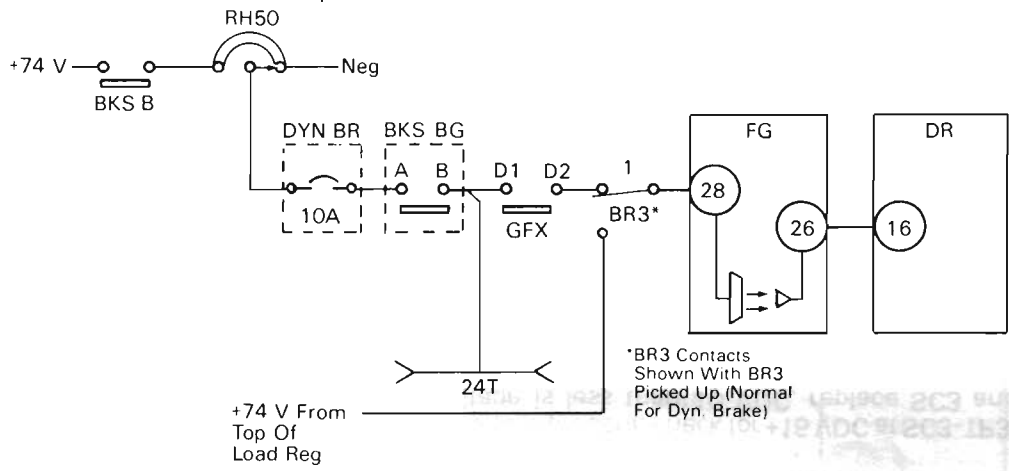
Perform following preliminary set-up.
Engine running; Controls set up for dynamic brake;
Reverser forward; Air brakes set; Brake handle in set-up
position.

Check that LED on DR faceplate is off. If LED is on, MR set-up signal at DR-TP12 and BR set-up signal at DR-TP13 are present at the same time.

1. Check for +74 VDC at SC2-TP2.
 - a. If voltage is present, the A1-A2 contacts of MR are closed. These contacts must be open.
 - b. If voltage is absent, check for +15 VDC at SC2-TP3. If voltage is present, replace SC2 and retest.
2. Check for +74 VDC at SC3-TP2.
 - a. If voltage is absent, D1-D2 contacts of BR1 are open. These contacts must be closed.
 - b. If voltage is present, check for +15 VDC at SC3-TP3. If voltage is less than 10 VDC, replace SC3 and retest.



22443

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
NO DYNAMIC BRAKE (Cont'd)	SUSPECTED DYNAMIC BRAKE EXCITATION FAILURE 1. No 24T VOLTAGE.  *BR3 Contacts Shown With BR3 Picked Up (Normal For Dyn. Brake)	Perform DR module DYNAMIC BRAKE LINEAR LOAD RATE AND TRACTION MOTOR FIELD CURRENT LIMIT Qualification Test and record voltage obtained at the specified test points. The results are to be used in the following checks. No voltage at DR-TP16 to DR-TP25. Check 24T trainline voltage circuit for possible FG module or BR interlock failure. Replace defective component and retest.

27979

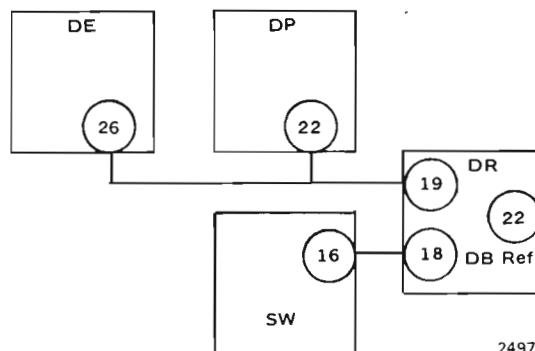
2. SW, DP, or DE MODULE FAILURE

No voltage at DR-TP22.

2. SW, DP, or DE MODULE FAILURE.

No voltage at DR-TP22.

1. Using digital DC voltmeter, check for fast discharge input between DR-TP18 and DR-TP25. If more than +10 VDC replace SW module and retest.
2. Using digital DC voltmeter, check for fast discharge input between DR-TP19 and DR-TP25. If more than +10 VDC, replace DP or DE module and retest.



24979

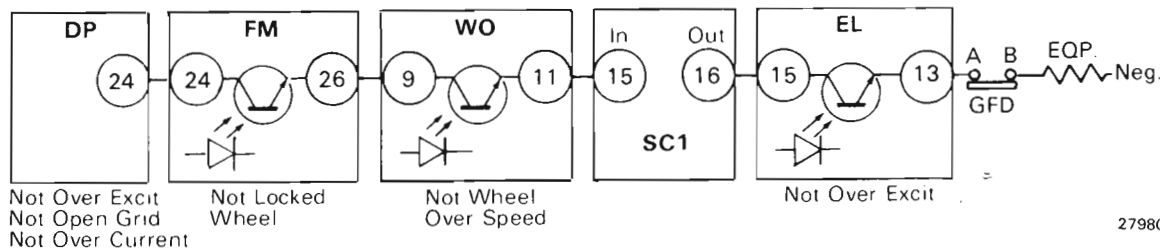
3. DR MODULE FAILURE.

If voltages at DR-TP16, DR-TP18, and DR-TP19 are satisfactory and there is no voltage at DR-TP22, replace DR module and retest.

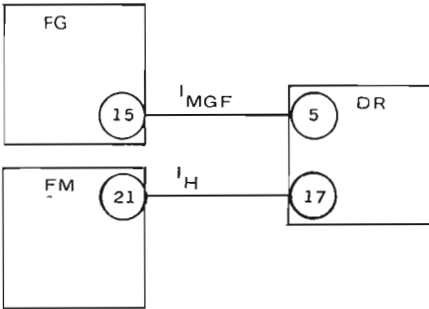
4. EQP NOT PICKED UP.

If there is no voltage at DR-TP5. Check that EQP relay, GFC contactor, and B contactor are picked up. If EQP is not picked up, check for more than +10 VDC between DP-TP24 (pos) and DP-TP25.

1. If voltage is less than +10 VDC, replace DR module and retest.
2. If voltage is more than +10 VDC, check the entire EQP relay coil string.



27980

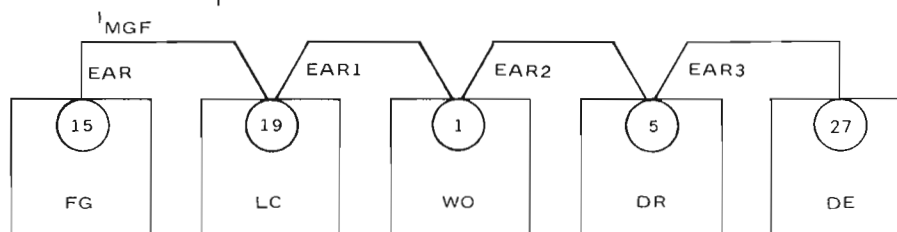
TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
	5. DR MODULE FAILURE. 6. FG or FM MODULE FAILURE.  22447	If voltages at DR-TP16, and DR-TP22 are satisfactory and voltage at DR-TP5 is unsatisfactory, replace DR module and retest. If all previous checks are satisfactory, perform the following checks. 1. Place brake handle in set-up position and check voltages between DR-TP5 (pos) and DR-TP25 and between DR-TP17 (pos) and DR-TP25. These voltages should be zero. 2. Place brake handle in maximum position and check voltage between DR-TP5 (pos) and DR-TP25. This voltage should be less than +2 VDC. Check voltage between DR-TP17 (pos) and DR-TP25. This voltage should be zero. 3. If the voltage between DR-TP5 and DR-TP25 is high, perform FG module Qualification Check. 4. If the voltage between DR-TP17 and DR-TP25 is high, perform FM module Qualification Check.
NO EXTENDED RANGE DYNAMIC BRAKE	DE, FG, or SC MODULE FAILURE.	Perform following preliminary setup. Engine running; Controls set up for dynamic brake; Reverser forward; Independent air brakes released. Perform DE module EXTENDED RANGE DYNAMIC BRAKE DC CONTACTOR CONTROL Qualification Check.

FG MODULE FAILURE.

If no DC contactor picks up, place brake handle in maximum position and check the traction motor field current feedback signal between DE-TP27 (pos) and DE-TP25. This signal should be $\approx 1.46 \pm 0.2$ VDC ($\approx 1.83 \pm 0.3$ VDC for high capacity dyn. brake system).

If signal is not present, check the signal between FG-TP15 and FG-TP25.

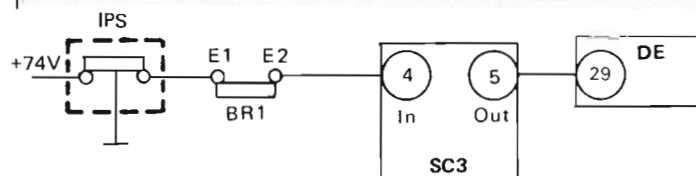
1. If this signal is absent, replace FG module and retest.
2. If this signal is present, check for continuity between FG-TP12 and DE-TP27. Replace defective wiring and retest.



24664

SC MODULE FAILURE.

If the signal at DE-TP29 is less than +10 VDC, check the SC3 channel. Replace defective component and retest.



24665

DE MODULE FAILURE.

If the FG and SC module checks are satisfactory, replace DE module and retest.

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
NO MANUAL SAND	NOTE Super Series locomotive wheel control system provides manual sand cutout when operating in super series above 5 mph. If unit has no manual sand below 5 mph, the SW, SA, or SC module may have failed to provide the proper signal. SW MODULE FAILURE. SA MODULE FAILURE. SC MODULE FAILURE.	Perform SW module Qualification Check. Perform SA module Qualification Check. Perform SC module Qualification Check.
NO AUTOMATIC SAND	SW MODULE FAILURE. LC MODULE FAILURE. EN MODULE FAILURE. SC MODULE FAILURE. SA MODULE FAILURE.	Perform SW module Qualification Check. Perform LC module Qualification Check. Perform EN module Qualification Check. Perform SC module Qualification Check. Perform SA module Qualification Check.

UNIT NOT LOADING

PS11 POWER SUPPLY FAIL-

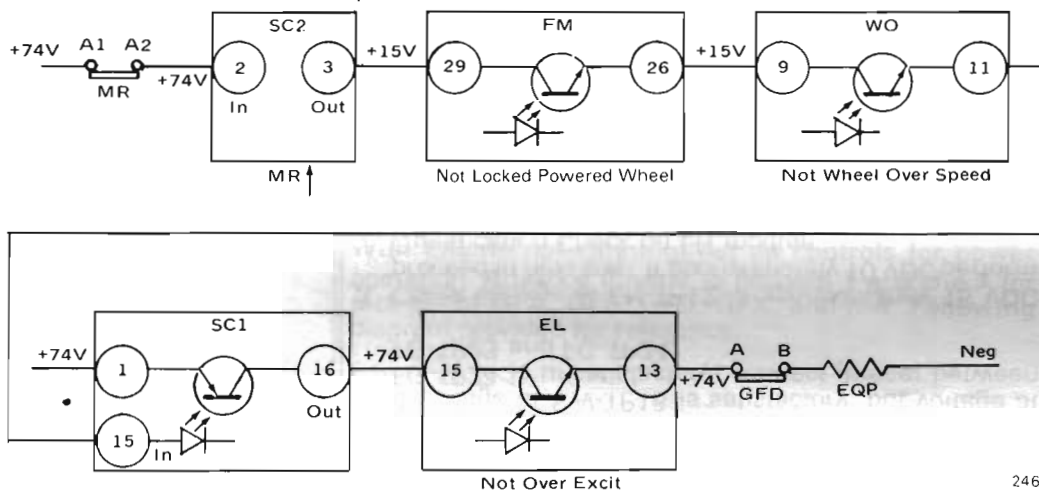
Perform PS11 module Qualification Check.

UNIT NOT LOADING

PS11 POWER SUPPLY FAILURE.

EQP NOT PICKED UP.

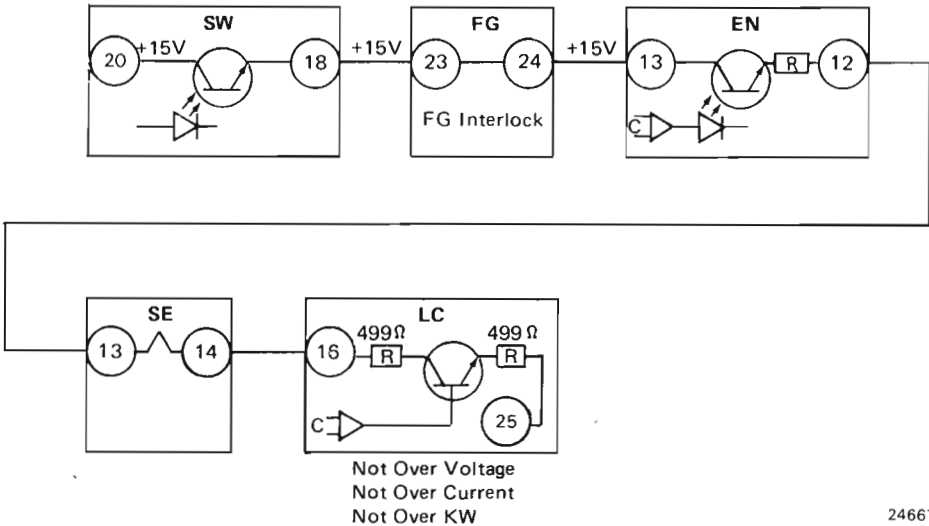
Perform PS11 module Qualification Check.

Perform throttle 1 stall setup to check the EQP string using following diagram. Voltage tolerance is ± 2 VDC.

SE MODULE OR SENSOR STRING FAILURE.

Perform throttle 1 stall setup to check the sensor string using the following diagram. Voltage tolerance is ± 2 VDC. Voltage at EN-TP12, SE-TP14, and LC-TP16 depends upon operating conditions.**NOTE**

Under some conditions, the voltages measured in the SENSOR STRING may go negative due to the induction of the SE module winding. This should be taken into consideration when measuring these voltages.

TROUBLE REPORT	POSSIBLE CAUSE	RECOMMENDED TEST OR CORRECTIVE ACTION
	 Not Over Voltage Not Over Current Not Over KW	24667 1. If voltage at SW-TP18 is unsatisfactory, perform Qualification Check on SW, FG, EN, RA, FM, and LC modules in order given. 2. If voltage at SW-TP18 is satisfactory, but voltage at FG-TP24 is unsatisfactory, connect jumper between FG-TP23 and FG-TP24. 3. Check voltage at EN-TP12; if approximately 15 VDC proceed to next step. If approximately 10 VDC perform Qualification Check on EN module. 4. Check voltage at SE-TP14; if approximately 15 VDC perform Qualification Check on LC module. If approximately 0 VDC replace SE module and retest. <i>If the locomotive is not loading while either going down the track in power or on load test, then the following procedure should be performed.</i>

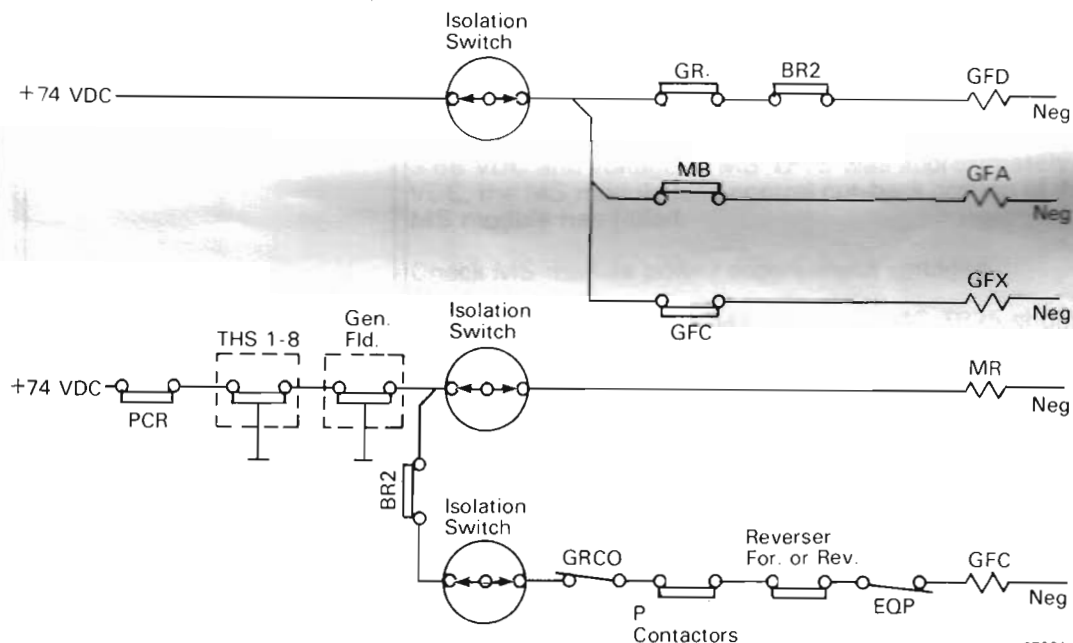
Isolate the module which is affecting the sensor string by by measuring the voltage across the following three pairs of module test points:

LC Module 16-25
EN Module 12-13
SW Module 18-20

One of these three measurements will be either non-zero or significantly larger than the other two measurements. The module with the large voltage value is the one which is affecting the string. This module should be closely checked to determine whether the failure to load is due to a malfunction in the module or a fault in one of its inputs.

CONTACTORS FAIL TO
UP.

With engine not running, set up controls for power operation. Advance throttle to position 1 and check for pick up of GFA, GFC, GFD, GFX, and MR. Following diagram provided for reference.



27981

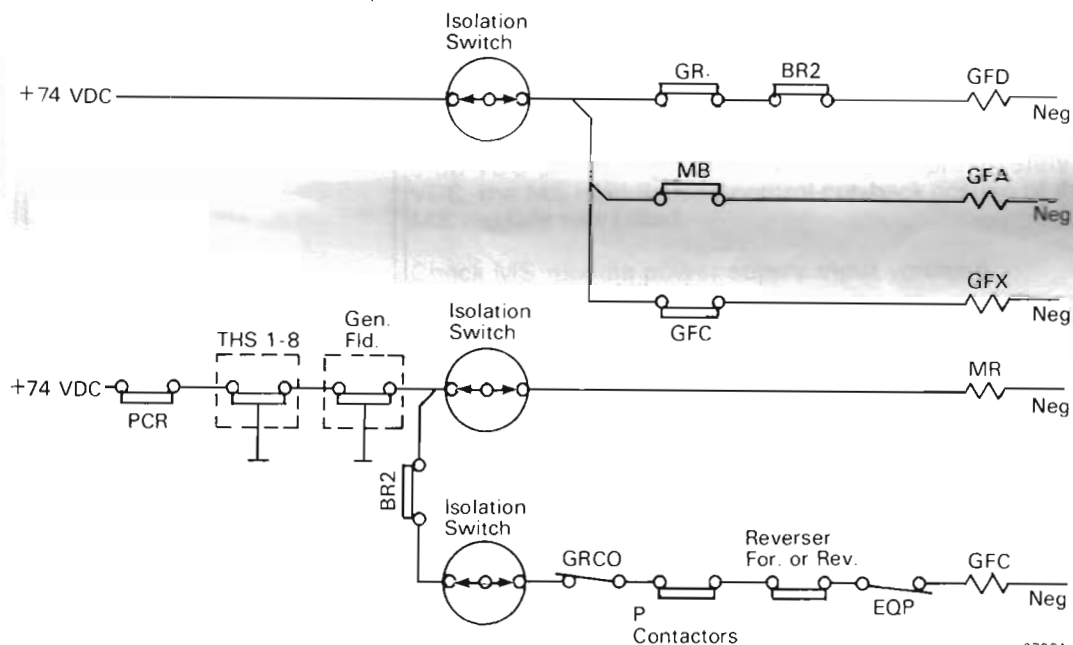
CONTACTORS FAIL TO
UP.

Isolate the module which is affecting the sensor string by
by measuring the voltage across the following three pairs
of module test points:

LC Module 16-25
EN Module 12-13
SW Module 18-20

One of these three measurements will be either non-zero
or significantly larger than the other two measurements.
The module with the large voltage value is the one which is
affecting the string. This module should be closely
checked to determine whether the failure to load is due to a
malfunction in the module or a fault in one of its inputs.

With engine not running, set up controls for power
operation. Advance throttle to position 1 and check for
pick up of GFA, GFC, GFD, GFX, and MR. Following
diagram provided for reference.



UNIT NOT LOADING ABOVE 1.5 MPH	EN MODULE FAILURE.	Perform EN module Qualification Check.
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UNIT NOT LOADING ABOVE 1.5 MPH.	EN MODULE FAILURE.	Perform EN module Qualification Check.
	RA MODULE OR RADAR TRANSCIVER FAILURE.	Perform RA module Qualification Check.
UNIT NOT LOADING BELOW 1.5 MPH.	SW MODULE FAILURE.	Perform SW module Qualification Check. If SW module operation is satisfactory, refer to UNIT NOT LOADING procedures.
UNIT UNDERLOADING WHEN MOTORS ARE COLD	MS MODULE PROVIDING FALSE HOT MOTORS SIGNAL.	Unit set up for power mode of operation. Engine running. Throttle idle. Traction motor temperature is lower than 170° C. Connect 0-20 VDC digital voltmeter between MS-TP18 (pos) and MS-TP25. 1. If voltmeter indicates approximately -10 VDC, motor temperature simulator is providing correct signal. 2. If voltmeter indicates approximately 0 VDC, motor temperature simulator is probably providing false hot motors signal. Connect 0-10 VDC digital voltmeter between MS-TP24 (neg) and MS-TP25. If voltage at MS-TP24 is less than 3.68 VDC and voltage at MS-TP18 was approximately 0 VDC, the MS module load control cut-back portion of the MS module has failed. Check MS module power supply input voltages. 1. The voltage between MS-TP20 and MS-TP25 should be +15 VDC. 2. The voltage between MS-TP30 and MS-TP25 should be -15 VDC. Close test switch 1 on MS module. Neither LED2 or LED3 should come on. If either comes on, one or both MS module heater circuits are receiving false signals. Connect 0-15 VDC digital voltmeter between MS-TP16 (pos) and MS-TP25. This signal should be 0 VDC; if not check FG module. Connect 0-15 VDC digital voltmeter between MS-TP17 (pos) and MS-TP25. This signal should be 0 VDC. If not zero, check FM module.

GP49 ELECTRICAL TROUBLESHOOTING GUIDE



ELECTRO-MOTIVE