भारत सरकार GOVERNMENT OF INDIA
रेल मंत्रालय MINISTRY OF RAILWAYS

OPERATION AND TROUBLE SHOOTING OF 25 KVA ON BOARD SIEMEN'S INVERTER FOR SG/AC COACHES

Target Group : AC Coach Mechanic/ Fitters

CAMTECH/E/2004/Inverter/1.0
कैमटेक/ई/2004/ईनवर्टर/1.0

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Centre for Advanced Maintenance TECHnology

Excellence in Maintenance

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1. INTRODUCTION

25 kVA inverters are provided on self generating (SG) type AC coached fitted with roof mounted AC package unit. These SG AC coaches are provided with 110V battery in parallel with belt driven alternator and rectifier cum regulator to supply input DC voltage 90V to 140V with 15% ripple to the inverter unit, which is giving 415V ± 5%, 3 phase, 50Hz ± 3% PWM supply as out put to feed air conditioning & 110V AC coach fan load of the coaches. Inverter is fitted with IGBT semiconductor power devices.

2. RATING

Dc Input

- Rated supply : 90Vto 140 V dc with 15% ripple
- Rated input current : 250A

AC output

- Output voltage : 3 phase,3 wire,415 V±5% PWM sine wave
- Output frequency : 50 Hz ± 3%
- Output power factor : 0.8
- Rated output current : 35A
- Rated output power : 25 kVA at 0.8 p.f.
- Sine filter output voltage : 415 V ± 5%

Nominal set limits

- Input overload 300A
- Input under voltage < 90V
- Input over voltage > 170V(154V + 15% ripple)
- DC link under voltage 350 Vdc
- DC link over voltage 700 Vdc
- Output overload 250A for 10 seconds

General

- Operating temperature range - 5° C to 55°C
- Cooling medium Forced air cooling by fan

3. FUNCTIONAL ELEMENTS

- Input dc choke
- Step up chopper
- Inverter
- Control and driver electronics
- DC – DC converter 110V/ 24V
- Earth leakage detector (ELD)
- Over Voltage Monitor (OVM)
- Display Card with LEDs
- Sine filter
- Switchgear

For heat dissipation, an axial flow fan is used. The cooling air for the power sections is drawn in through ventilation grills in the lower part of the rear wall of the panel and hot air is discharged through slots in the top cover with canopy arrangement**.**

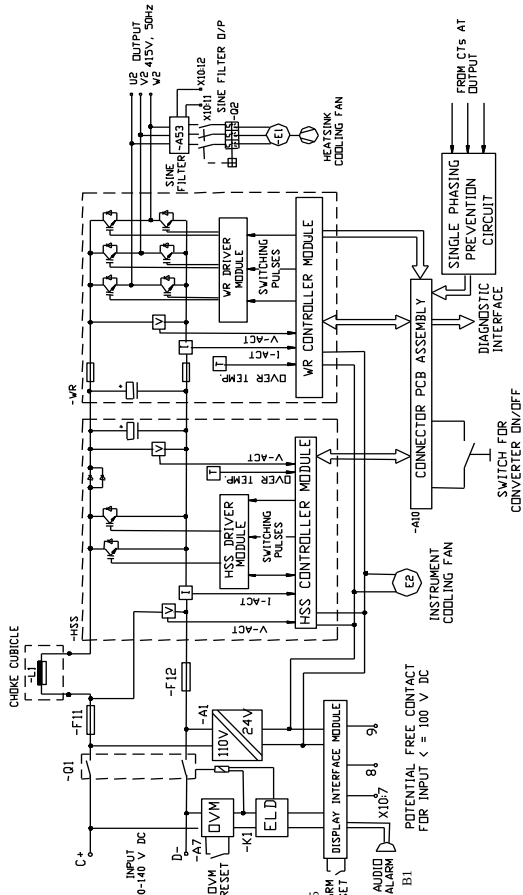

Figure 1. BLOCK DIAGRAM

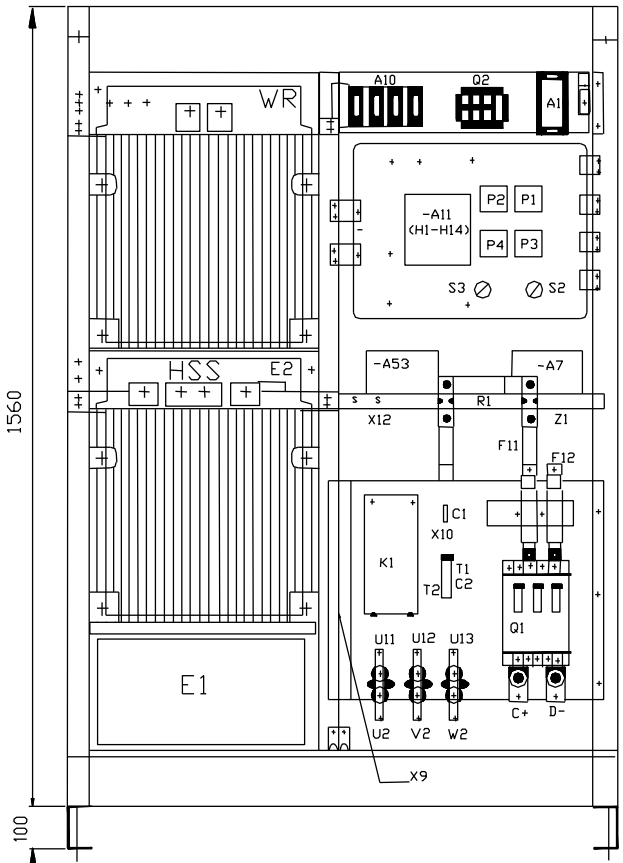

Figure 2. COMPONENT LAYOUT

DETAILS OF FIGURE 1 AND 2

Q1	DC MCCB	F11, F12	Input fuses 250A, 660V
T1, T2	Diodes in MCCB u/v coil circuit	F3	Fuse 2A for 24V circuit
K1	Earth leakage detector	HSS	Step up chopper
C1, C2	Capacitors for earth leakage detection circuit (4700μF, 400V)	WR	Inverter
P1	DC Voltmeter	P2	DC Ammeter
P3	AC Voltmeter	P4	AC Ammeter
A10	Connector PCB Assembly	A11	Display interface module
S1	Switch for inverter ON/OFF	S2	Selector switch for O/P AC voltmeter
S3	Selector switch for output AC Ammeter	S4	Reset switch for input over voltage monitoring circuit
E1	Cooling fan 415V, 3Ph	Q2	MCB for E1 fan
L1	Input DC choke	A2	Inverter controller module

X9	Terminal block for fan connections	X10	Terminal Block for control connections & 1ϕ Sine Filter O/P
Z1	Varistor	X12	Terminals Block for checking DC link Voltage
C+, D-	Input Busbar	U2, V2, W2	Output Busbar
A53	Sine filter (3 phase)	U11,U12, U13	Output CTs 50/1A
A6	Output single phasing protection circuit	A7	Input over voltage monitoring circuit (OVM)
R1	Shunt for input current meter (400A, 75mV)	E2	Instrument cooling fan 24V
A1	DC-DC converter	P1, Q2	Terminals for DC choke connection
B1	Audio Alarm	X8	Terminal block for E2 fan connection
S5	Audio alarm reset switch	X15	Terminal block for audio alarm connection

4. OPERATION

4.1 Indications, Control Switches and Protection Elements

4.1.1 Indications

The status as well as faults are indicated by meters and LED indications on the Display Interface Module, mounted in the converter and visible through a transparent acrylic sheet on the door. A list of all indications along with their functions is given below:

Nom	Indication	Function
P1	Input dc voltage	Voltmeter shows dc input voltage when Q1 is switched on.
P2	Input dc current	Ammeter shows dc input current Q1 is switched on.
P3	Output AC voltage	Voltmeter shows converter output line voltages.
P4	Output AC current	Ammeter shows converter output line currents.
H1	24V dc on	Indication shows 24V supply is available at the output of dc-dc converter (A1)

Nom.	Indication	Function
H2	Converter ON	Indication shows that the converter is ON.
H3	Input voltage ≤ 100V	LED indication shows that input to the converter is less than or equal to 100V. An Audio alarm is also provided to indicate that the input voltage is less than or equal to 100V.
H4	Input over-voltage	Indication shows that input voltage is greater than 170V.
H5	Input under voltage	Indication shows that input voltage is less than 90 V.
H6	Output single phasing	Indication shows that load currents are unbalanced due to single phasing or difference in load between phases.
H7	OVM Trip	Indication shows that Over Voltage Monitor (A7) has detected over voltage in input DC voltage (190V).

Nom.	Indication	Function
H8	Chopper fault	Indication shows that the step up chopper (HSS) is faulty.
H9	Inverter fault	Indication shows that the inverter section (WR) is faulty.
H10	Fuse failure	Indication shows that either one or both of the input fuses (F11, F12) have blown.
H11	Fan failure	Indication shows that the fan MCB (Q2) has tripped.
H12	Earth fault	Indication shows that the earth leakage detector (K1) has detected an earth leakage.
H13	Reverse polarity	Indication shows that the inverter input dc has been connected in reverse polarity.
H14	Group fault	Indication shows the occurrence of one or more of faults between H4, H5 and H8 to H11.

4.1.2 Control switches and protection elements

Nom	Description	Function
Q1	DC MCCB	Main switch for input dc ON/OFF. Short circuit protection at input. Reverse polarity protection at input.
F11 F12	Semi conductor fuses	Protection of semiconductor devices in case of reverse polarity at input.
S1	Switch, 2-way	Switch for converter ON/OFF, 24V instrument cooling fan ON/OFF.
S2	Voltmeter selector switch	Switch for selection of output line for voltage measurement and display.
S3	Ammeter selector switch	Switch for selection of output line for current measurement and display.
S4	Reset switch	Reset the input over voltage monitoring circuit.

Nom	Description	Function
S5	Alarm reset switch	Reset audio alarm
Q2	Miniature circuit breaker	Protection for internal fan (E1).
WR F1, WR F2	Semiconductor fuses	Protection of semiconductor devices in case of short-circuits in the power part of inverter section.

4.2 Starting the Converter

The sequence for switching 'ON' the converter should be as given below:

- Check whether Q1 and S1 are in off position. If not Q1 and S1 to be switched off.
- Ensure that dc input supply of correct voltage and polarity is available at input terminals C and D.
- Check whether OVM & ELD are in healthy condition.
- Switch on Q1. The input dc voltage can then be observed on voltmeter P1.

- Observe '24V dc on' LED (H1) on Display Interface module (A11) glowing.

- Check 'To earth' push-button on K1 is in pressed condition.

- Switch 'ON' S1. Observe converter on LED (H2) on the Display Interface module (A11) glowing. On receiving this switch on command, the step up chopper section builds up the dc link voltage. After the dc link voltage has reached above its minimum acceptable level, the inverter section ramps up and generates three phase 415V, 50 Hz PWM supply at the converter output terminals U2, V2, W2.

- Check 3 Phase line voltage on voltmeter P3.

- After approximately 30 seconds of switching S1 on (the time required for dc link voltage build up and ramp up of inverter), the loads can be switched on, through the AC control panel.

- Check the load current through each of the three phases on ammeter P4.

4.3 Precautions During Converter Operation

The following precautions should be taken when the converter is in running condition.

1. The converter starts the various motors of the AC unit, direct-on line. Hence it is preferable that the entire load of the A.C. unit is not switched on at the same time.

2. During converter operation on load, the dc input supply to the converter should not be disconnected.

3. The converter starts the various motors of the AC unit, direct-on-line. Due to thermal considerations, it is preferable if the compressor load of the A.C. unit is switched on max. 10 times in an hour.

4.4 Stopping the Converter

The sequence of switching the converter off should be as given below:

1. The entire load on the converter output should be switched OFF one by one.
2. Switch S1 should be switched OFF.
3. MCCB Q1 should be switched OFF.

5. SAFETY PRECAUTIONS

Hazardous voltages of over 650V are used in the operation of this converter, and can cause severe personal injury or loss of life.

The following precautions should be observed to reduce risk of injury or death.

- Only qualified service technicians of Railway/ Manufacturer's should be allowed to test and repair the converter or parts thereof.

- Keep all covers in place and doors closed during normal operation.

- Make sure that the voltage has dropped completely before touching any electrical contacts. Non-observance can lead to severe or fatal injury.

- Should it be necessary during commissioning to take measurements with the power turned 'ON', do not touch any electrical contacts during such work and keep one hand completely free and outside the electrical circuitry.

- Ensure that the test equipment is in good and safe operating condition.

- Stand on an ESD approved insulated surface while performing commissioning/ testing work with the power 'ON', being sure not to be grounded.

- When working on the connected motor or motor supply cable, ensure that the input MCCB of the converter is in 'OFF' position.

- All work on the converter and its installation must be carried out in accordance with locally applicable electrical wiring regulations. This includes proper grounding to ensure that no accessible part of the converter is at any hazardous potential.

- Failure to ground the converter properly can result in the surface of the converter carrying hazardous voltages, which may cause severe injury, loss of life or considerable damage to property.

6. FAULT DIAGNOSIS

Faults are indicated by the H4-H14 LEDs on the Display interface module and visible through the transparent window on the door of the converter cubicle. A list of all faults along with their functions is given below:

Nom.	Indication	Function
H4	Input over-voltage	Indication showing that input voltage is greater than 170V.
H5	Input under voltage	Indication showing that input voltage is less than 90V
H6	Output single phasing	Indication showing that load currents are unbalanced due to single phasing.
H7	OVM Trip	Indication showing that Over Voltage Monitor (A7) has detected over voltage in input DC voltage 190V)
H8	Chopper fault	Indication showing that the step-up chopper (HSS) is faulty.
H9	Inverter fault	Indication showing that the inverter section (WR) is faulty.

Nom.	Indication	Function
H10	Fuse failure	Indication showing that either one or both of the input fuses (F11, -F12) have blown.
H11	Fan failure	Indication showing that the fan MCB (Q2) has tripped (E1).
H12	Earth fault	Indication showing that the earth leakage detector (K1) has detected an earth leakage.
H13	Reverse polarity	Indication showing that the converter input dc has been connected in reverse polarity.
H14	Group fault	Indication showing that occurrence of one or more of faults between H4, H5 and H8 to H11.

A fault in the converter may be caused by internal faults as well as by external faults such as overload or short circuit at the output.

For each persisting fault indication, the possible causes are given below along with the suggested remedial measures.

6.1 Input Over-voltage

Description	Possible Causes	Remedial Measures
The display interface module detects an input voltage greater than 170V.	Over-charging of battery due to malfunctioning of Alternator/ Voltage regulator circuit.	Check the battery charging circuit i.e Alternator/Voltage regulator of the AC COACH.

6.2 Input under-voltage

Description	Possible Causes	Remedial Measures
The display interface module detects an input voltage less than 90V.	Battery is drained.	Check battery charging circuit of the AC COACH. Recharging or replacement of battery may be required.

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6.3 Output Single Phasing

Description	Possible Causes	Remedial Measures
Output Single Phasing LED on the Display Interface module glows indicating single phasing/unbalance in load currents in the three output phases. (Ignore 'Converter ON' Indication).	Un-balance in load currents due to single phasing.	Restart the inverter. While the converter is on load, check the currents in each of the three phases at the output of the converter. If the load currents differ from each other, check the load for single phasing. Tighten the load connections.

6.4 OVM Trip

Description	Possible Causes	Remedial Measures
The display interface module detects an input voltage more than 190V.	Over-charging of battery due to malfunctioning of Alternator/ Voltage regulator circuit.	Check the battery charging circuit i.e. Alternator/ Voltage regulator of the AC COACH.

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6.5 Chopper Fault

Description	Possible Causes	Remedial Measures
The step-up chopper detects a fault and the converter output ramps down to 0Hz.	1. The dc link voltage is out of its operating range.	1. In the step-up chopper a. Replace the chopper controller module (HSS, A1) b. Replace the voltage transducer (HSS, U2)
	2. The dc input voltage is out of its operating range.	2a. Check the dc input voltage b. Replace the chopper controller module (HSS, A1) c. Replace the voltage transducer (HSS, U1)

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Description	Possible Causes	Remedial Measures
	3.The power supply for electronics is out of its operating range.	3. Check 24V dc output from the DC- DC Converter (A1)
	4. The heat sink temperature monitoring circuit has detected over-temperature.	4a. Check proper functioning of E1 fan. b. Replace the chopper controller module (HSS, A1)

6.6 Inverter Fault

If there is a persisting inverter fault, diagnosis can be done with the help of RS 232 interface. Connection of the interface cable is as shown below between an input/ output port of the personal computer (PC) and the X12 connector on the Connector PCB module A10.

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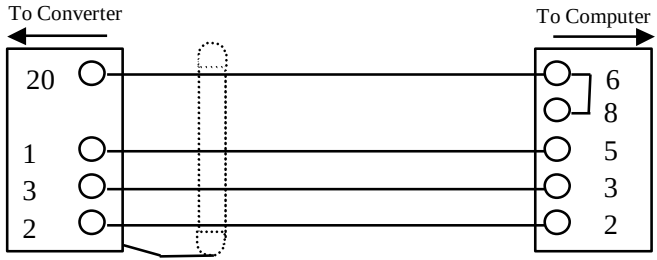

Any of the terminal programs, 'NEUMON' or 'SIMONIT', can be used to display the fault memory. The previous faults are displayed on the screen.

A fault is represented in the fault memory display as follows:

Representation for fault	'F'
Fault number	3 characters
The sign colon	;
Short form of faults	6 characters (max.)

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A list of fault strings is given below:

Fault string	Meaning
F010 : LT_KS	Short circuit in inverter power part
F011 : LT_KSA	Final switch off due to short circuit in inverter power part
F020 : ZK_UEU	Over-voltage in the dc link
F030 : ZK_UNU	Under voltage in the dc link
F040 : KK_UET	Over-temperature in the inverter heatsink
F100: 15_UNU	15V power supply too low
F120: KK_TMK	Fault in the temperature measuring circuit of inverter
F130: AD_CHK	Fault in the A/D converter test
F140: EP_CHK	Faulty checksum in EPROM
F150: EE_CHK	Fault in EEPROM
F160: RA_CHK	Fault in RAM test
F170:WD_UEL	Overflow of watchdog
F180: WD_OSZ	Oscillator fault

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F190: GK_CHK	Faulty unit code
F200: WD_FKT	Function fault of watchdog
D210:RS_485	Fault in communication over RS485
F220: WR_UEL	Overload in inverter section (>100% upto 250% for 10 Sec
F230:WR_UEI	Over-current in inverter section (>250% for 100 ms)
F255: UNBK_F	Unknown fault

Description	**Possible causes**	**Remedial measures**
The inverter section detects a fault and the converter output is disconnected from the load or ramps down to 0Hz	1. Short circuit in the power part of the inverter (F010, F011)	a. Check for short circuit at the output of the converter. b. Check for short circuit in the power section of the inverter. c. Check whether sine filter (A53) is faulty. d. Check whether the ac voltmeter (P3)/fan (E-1) is faulty.

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Description	Possible causes	Remedial measures
	2. The dc link voltage is out of its operating range (F020, F030).	a. Voltage sensor in inverter assembly is defective. b. Inverter controller card is defective.
	3. The heat sink temperature monitoring circuit has detected over-temperature (F040).	a. Check proper functioning of E1 fan. b. Replace the inverter controller module (HSS, A1).
	4. The power supply for electronics is low (F100).	a. Check the 24V dc output from the dc-dc converter (A2). b. Replace the inverter controller module (WR, A2).

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Description	Possible causes	Remedial measures
	5. The unit code is faulty (F190).	Check whether pins 14, 15, 17, 18 and 19 on X2 connector on inverter controller module (WR, A2) are shorted with each other. If not, then short them.
	6. Overload/ over-current at the output of converter (F220, F230).	Check the current in each phase, at the output of the converter.
	7. The inverter controller module (WR, A2) is defective (F120, F-130, F140, F150, F160, F170, F180, F200, F210, F255).	Replace the inverter controller module (WR, A2).

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6.7 Fuse Failure

Description	Possible causes	Remedial measures
Either one or both the input fuses (F11, F12) have blown.	A short circuit has occurred in the step-up chopper section.	Check whether one or both IGBTs (HSS, V1, HSS, V2) are shorted.

6.8 Fan Failure

Description	Possible causes	Remedial measures
The MCB (Q2) trips and the Display interface module indicates fan failure. (Ignore 'Converter ON' indication).	1.The fan (-E1) is faulty. 2.The MCB (Q2) is faulty.	1. Replace fan. 2. Replace MCB.

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6.9 Earth Fault

Description	Possible causes	Remedial measures
The earth leakage detector (K1) detects an earth leakage current in the output side of the converter and tripped MCCB (Q1).	1. There is an earth leakage current in the output side of the converter. 2. The earth leakage detector (K1) is faulty.	1. Switch on load part by part and localise the fault. Then the leakage can be confirmed by checking the insulation resistance of the suspected part in the load. 2. Replace K1.

6.10 Reverse Polarity

Description	Possible causes	Remedial measures
The MCCB (Q1) does not switch on and the display interface module indicates reverse polarity.	The dc input at terminal C+ and D- have been connected in reverse polarity.	Change the dc input terminal connections to correct polarity.

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OUR OBJECTIVE

To upgrade maintenance technologies and methodologies and achieve improvement in productivity, performance of all Railway assets and manpower which inter-alia would cover reliability, availability, utilisation and efficiency.

If you have any suggestions and any specific comments please write to us.

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