SiE-55

SERVICE ENGINEERING MANUAL OF INVERTER DRIVEN AIR–CONDITIONING SYSTEMS

VRV SYSTEMS

INVERTER

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CONTENTS

1. CHARACTERISTICS OF INVERTER DRIVEN AIR-CONDITIONING SYSTEMS

With inverter driven air-conditioning systems, cooling and heating can be adjusted freely in accordance with the load in any given room by controlling the rotational speed of compressors, while with non-inverter air-conditioning systems such adjustment is not possible because the rotational speed of compressors is fixed by the power supply frequency.

The primary differences between these two types of air-conditioning systems are shown in the following table:

Item	Air-conditioning system without inverter	Inverter air-conditioning system
1. Time required to reach the pre-set room temperature	Relatively long due to fixed cooling and heating capacity.	Short because of increased cooling and heating capacity.
2. Fluctuations after reaching the pre-set temperature	Major fluctuations due to stop/start operations.	Minor fluctuations due to load-adaptable operations.
3. Sudden current flow when the compressor is started	5 to 6 times rated value.	1.5 times rated value due to gradual frequency increase at the start.
4. Low temperature range during heating	Decrease in capacity.	Decrease in capacity compensated by increased rotational speed.
5. Defrosting time	Relatively long due to fixed cooling and heating capacity.	Short because of maximum capacity operations.
6. Unit composition	Relatively simple.	Extra parts required.
7. Trouble diagnosis	Relatively easy.	Complicated.

2. OUTLINE OF INVERTER FUNCTIONS

An inverter simply converts direct current to alternating current. In air-conditioning systems, inverters are largely referred to as devices which convert commercial AC electricity to alternating current with adjustable frequency and voltage. Converters which convert AC to DC form part of such devices.
The rotational speed of compressor can be altered freely by the inverter.

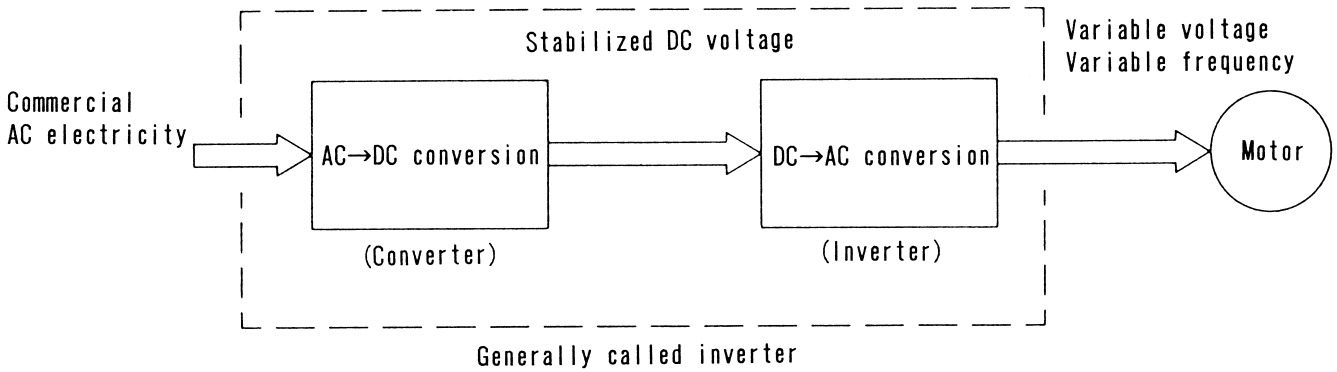

Fig.2-1 Block diagram of inverter

Fig.2-2 shows the general composition of an inverter in the air-conditioning system:

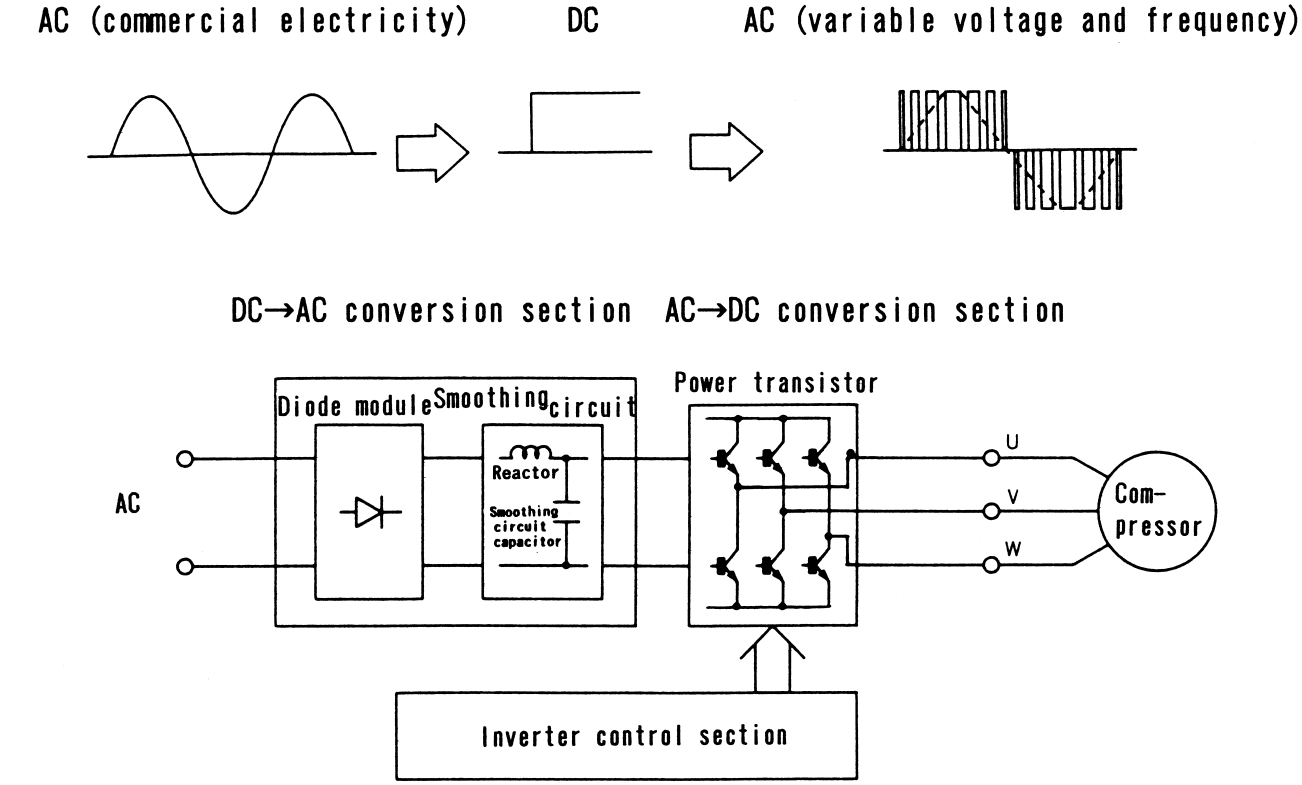

Fig.2-2 Basic composition of inverter

Table 2-1 Functions of main component parts

Name	Function
Diode module	Rectifies AC and converts it to DC. ⇒
Smoothing circuit Capacitor	Makes DC smoother by charging and discharging. ⇒
Reactor	Decreases ripples. ⇒
Power transistor	Makes AC of approximate sine waves by dividing DC. ⇒
Control section	Emits signals to switch on the power transistor when operation and frequency setting commands are received.

3. PRINCIPLES OF INVERTER OPERATIONS

The structure of the main circuit of the inverter is shown in Fig.3-1. In Fig.302, however, six transistors are replaced by switches, so that it is easier to explain the system.

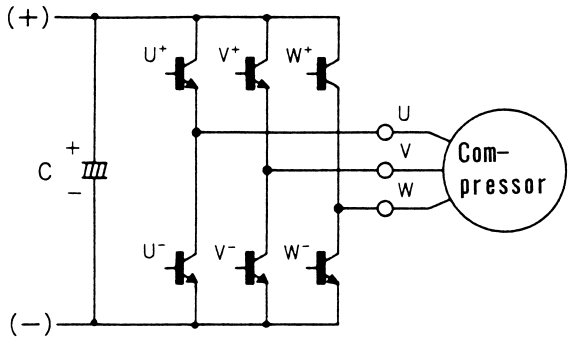

Fig.3-1 Inverter main circuit

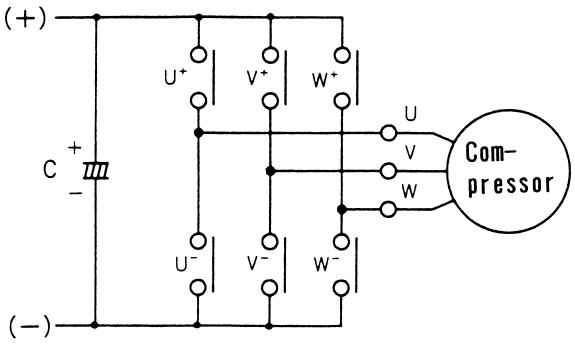

Fig.3-2 Circuit with switches replacing transistors

When the switches are changed over in the order of (1) to (6), the compressor will receive 3 phase AC.

For example,

(1) When U+, W+ and V+ are ON, potentials of output terminals U and V will be positive(+) and that of output terminal V will be negative(-).
(2) When W+ is OFF and W- is ON, output terminal W(+) will change to W(-).
(3) When V- is OFF and V+ is ON, output terminal V(-) will change to V(+).

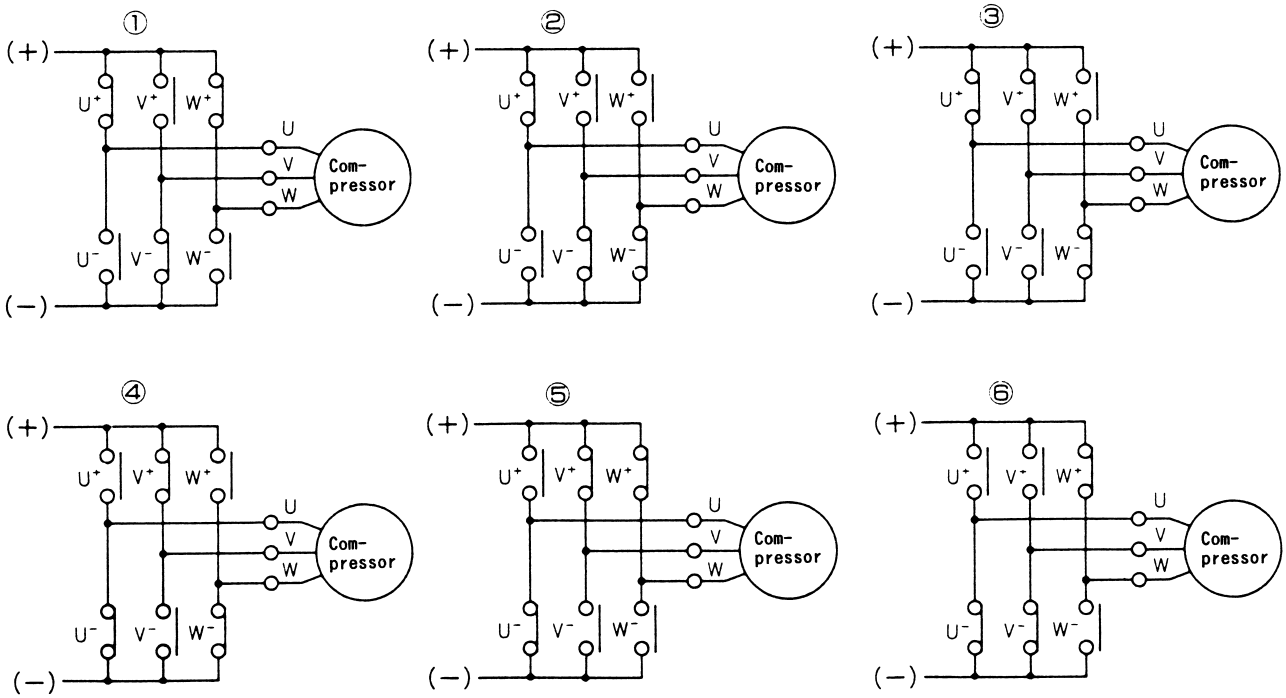

Fig.3-3 Switch Operations

By operating the on/off switches at a fixed interval as explained, output voltage and current of the inverter will become as shown in Fig.3-4.
The output frequency of the inverter is determined by the changeover cycle of the switches.

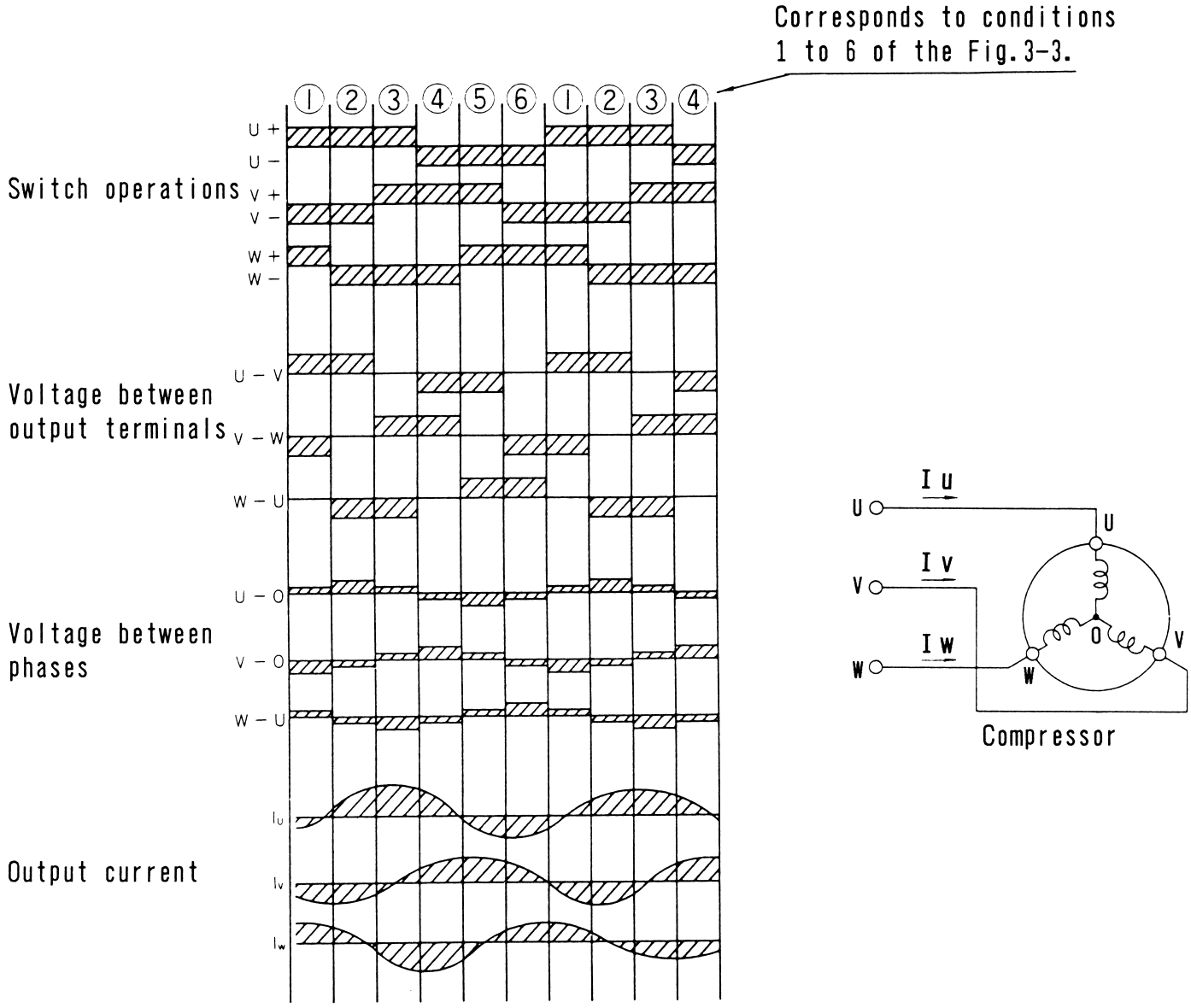

Fig.3-4 Output voltage and current of the inverter

In practice, transistors are turned on and off more frequently than the switches. Also, by changing the time ratio between 'ON' and 'OFF' periods, the voltage can be altered. Actual output voltage wave-forms and current wave-forms of the inverter are of approximate sine waves as shown in Fig.3-5 below.

Output voltage wave-form　　Output current wave-form

Fig.3-5 Actual wave-forms

4. OUTLINE OF INVERTER PROTECTIVE FUNCTIONS

4.1 Types, Purposes and Descriptions of Protective Functions

The protective functions of an inverter are shown below. Adopted functions vary depending on the model. Meanings of error codes, detection methods, set values and cancel methods may also vary depending on the model.

Error code	Protective function	Purpose	Description
L 0	Inverter system error	To protect inverter main circuit parts and compressor.	Inverter's micro-computer is out of control, or inverter's protective device is operating.
L 4	Heat discharging fin's temp. increase	To protect power transistor.	Stops when heat discharging fin's temperature exceeds the pre-set temperature.
L 5	Momentary excessive current	To protect power transistor.	Stops when DC output exceeds the prescribed value even momentarily.
L A	Power Transistor malfunction	To indicate power transistor failure.	After errors L5, L8 and L9 are detected, inverter's self-diagnosis device will check existence of errors in the power transistor. If errors are detected, the inverter will stop.

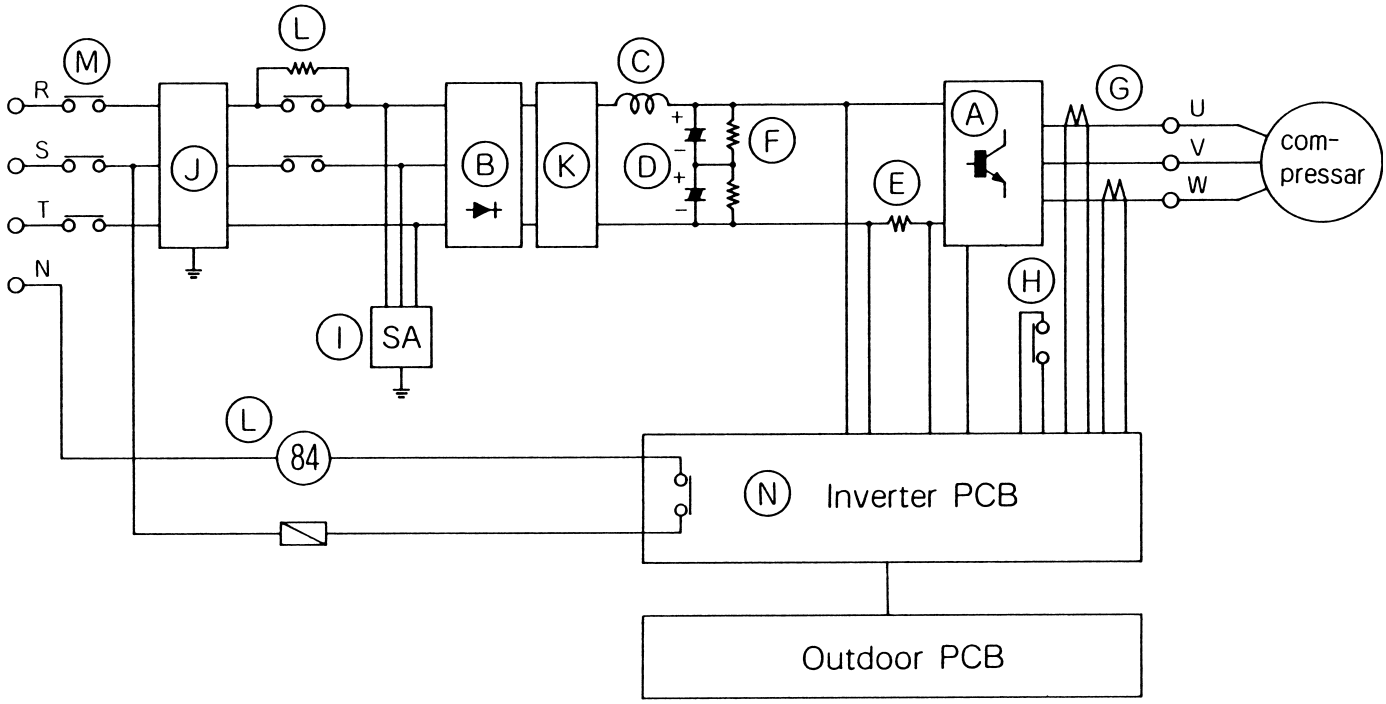

Fig.4-1 Inverter main circuit

Component parts

A. Power transistor	Produces AC voltage by dividing DC voltage.
B. Diode module	3 phase bridge diode module to rectify 3 phase AC voltage.
C. Reactor	Reduces ripples in the voltage and improves power ratio.
D. Smoothing circuit Capacitor	Large capacity electrolytic capacitor. Converts the rippled DC voltage rectified by the diode module to smooth DC voltage.
E. Shunt resistor	Detects DC output of the inverter and operates protective functions for excessive current depending on the detected intensity of the current.
F. Discharge resistor	Discharges electric load of the smoothing circuit capacitor and prevents electric shock when inverter operation stops.
G. CT (current transformer)	Detects AC output of the inverter and operates protective functions for excessive current and stalling as well as electronic thermal switch depending on the detected intensity of the current.
H. Thermal protector	Detects the temperature of heat discharging fin. When the temperature exceeds 90℃, the contact point will open, stopping the inverter, thus protecting the power transistor.
I. Surge absorber	Absorbs surge voltage of the power supply cable and prevents inverter's semi-conductors from being damaged by excessive voltage.
J. AC noise filter	Prevents inverter-generated noise from leaking into the power supply cable.
K. DC noise filter	Prevents inverter-generated noise from leaking into the power supply cable.
L. Limited current circuit	Turn on relay 84 after the electromagnetic switch (52C1) when starting up, thus charging the smoothing circuit capacitor via limited current resistor. In this matter, the sudden input of current at starting-up will be decreased.
M. Electromagnetic switch (52C1)	Switches the inverter's main circuit on and off. When the inverter is operating (including the thermostat off-period), this switch remains 'on' but when the inverter stops intentionally or due to errors, it switches 'off'.
N. Inverter PCB	Operates power transistor when operation and frequency commands from the outside PCB are received. It also protects component parts and capacitor of the inverter unit with various protective functions. No electrical charge when the electromagnetic switch (52C1) is OFF.

4.2 Details of Protective Functions

Remote controller display	Error description	Operating condition	No. of re-trials	Cancel method
L 0	Momentary excessive current	DC output exceeds 43A even momentarily.	0	Reset remote controller
	Electronic thermal switch	Overloading alarm. If excessive current passes through during operation, decrease the current by lowering the frequency to 40Hz. Excessive current 15A. If, under this condition, the alarm does not stop within 30 seconds the protective function will be initiated.	0	Reset remote controller
	Prevention of stalling	If, during the start-up acceleration phase, the following current passes through for 30 seconds the protective function will be initiated. 15A	0	Reset remote controller
	Heatdischarg-ing fin temp. increase	Temperature of the heat dischaging fin exceeds 90℃.	0	Reset remote controller
	Insufficient voltage	Terminal voltage of smoothing circuit is below DC 320V～DC 390V	0	Reset remote controller
	Transmission error between inverter and outdoor PCBs	To be judged on the outdoor PCB side when no signal is returned from the inverter control PCB.	Auto-return	Auto-return

5. INSPECTION METHOD OF "FORCED STOP BY LO"

Sensed Item	Cause of trouble	Features	Check Items
1. Activation of fin thermal	Insufficient cooling of Inverter thermal fins	In case of; ·High ambient temperature ·High amount of load ·Cooling operation If this function activates, operation will be prohibited for more than 5 min.	·The gallary (louver) for ventilation is obstructed or not. ·Thermal fins are polluted or not. Check the thermal protector.
2. Momentary over-current	Compressor is seized (=locked)	This error is not cancelled automatically. So when "LO" was senced, the operation bottun shall be "turn on" again all the time.	·Disconnect compressor from Inverter and check inverter output voltage.
3. Over-current for more than 30 sec just after compressor started	Compressor load is too large for starting	·It sometime occuers once this occured. ·Temperature difference between indoor and outdoor is large. (Because the high pressure and low pressure will hardly be equalized.) ·In case the compressor stop and start so often in a short period, it may occur.	·Check the pressure difference between HP and LP.
4. Over-current for more than 30 sec during operation	Over load	In case both ambient temperature and indoor temperature is high, it may occur. Running current is large. The voltage of power supply is low.	·Check the running current. ·Check the power voltage.
5. Insufficient voltage	Power voltage drops Momentary power drops	In case the power voltage drops extremery, it may occur.	·Check the power line size. ·Check the power line voltage.