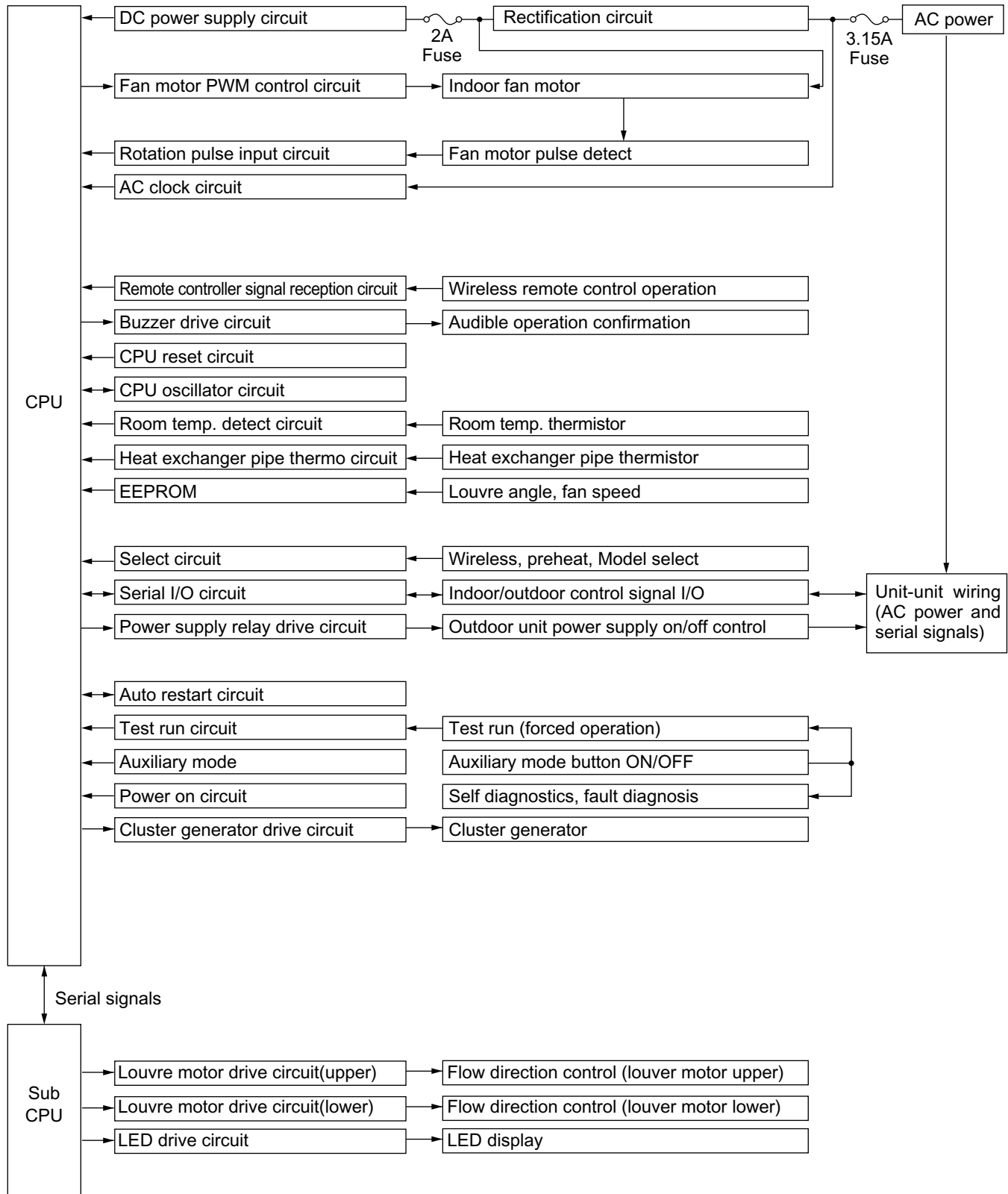
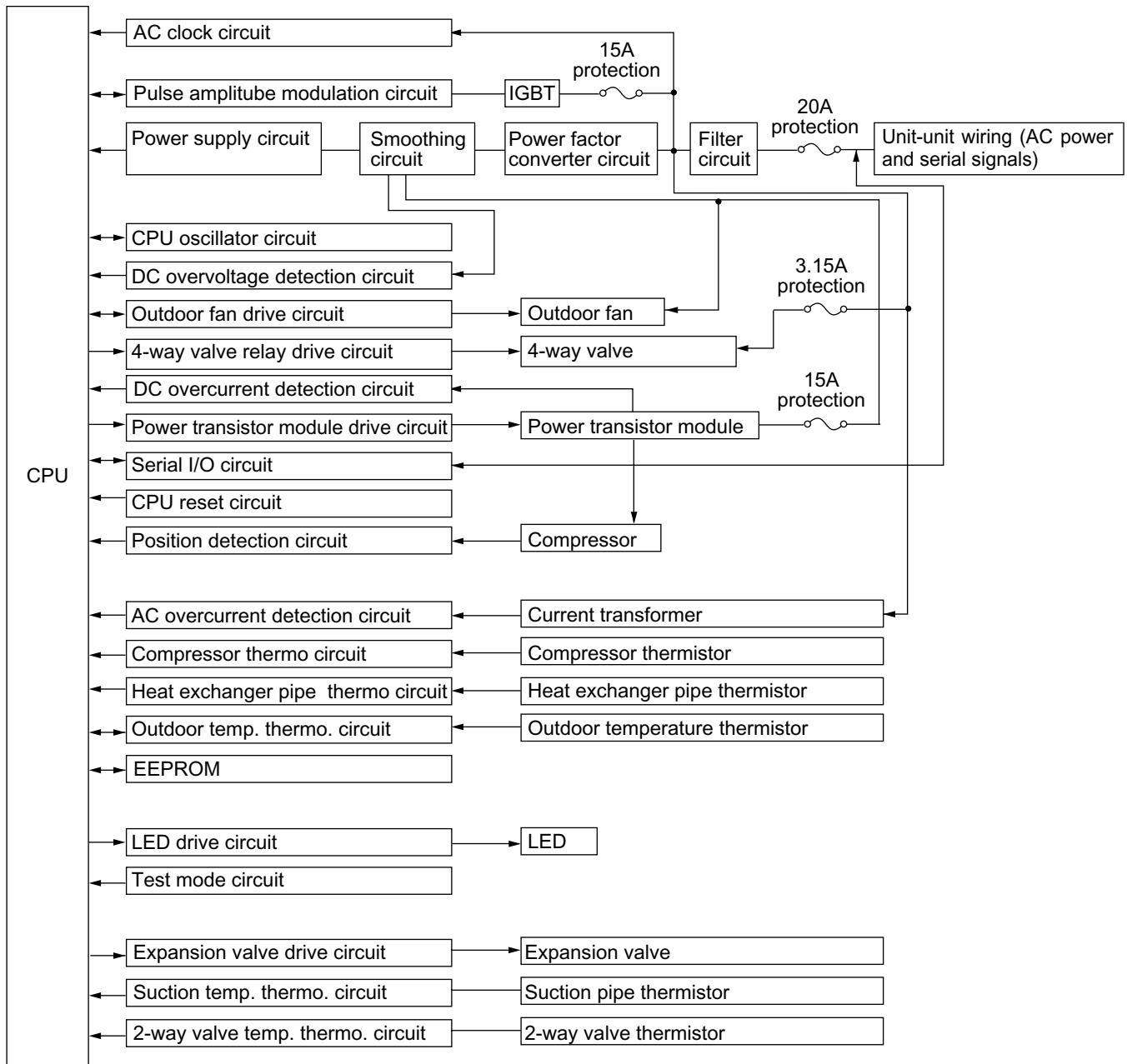


[1] BLOCK DIAGRAMS

1. Indoor unit

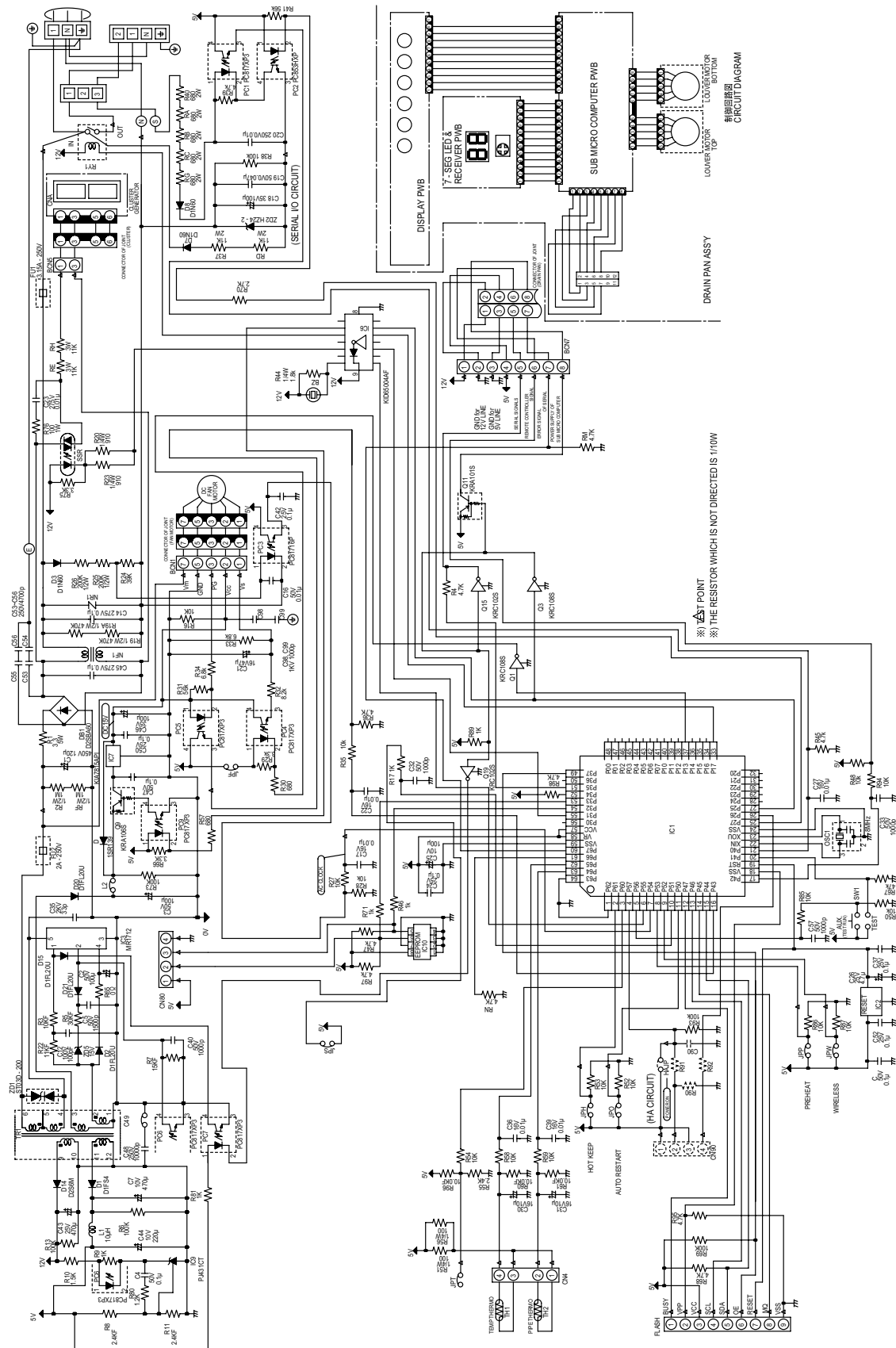


2. Outdoor unit

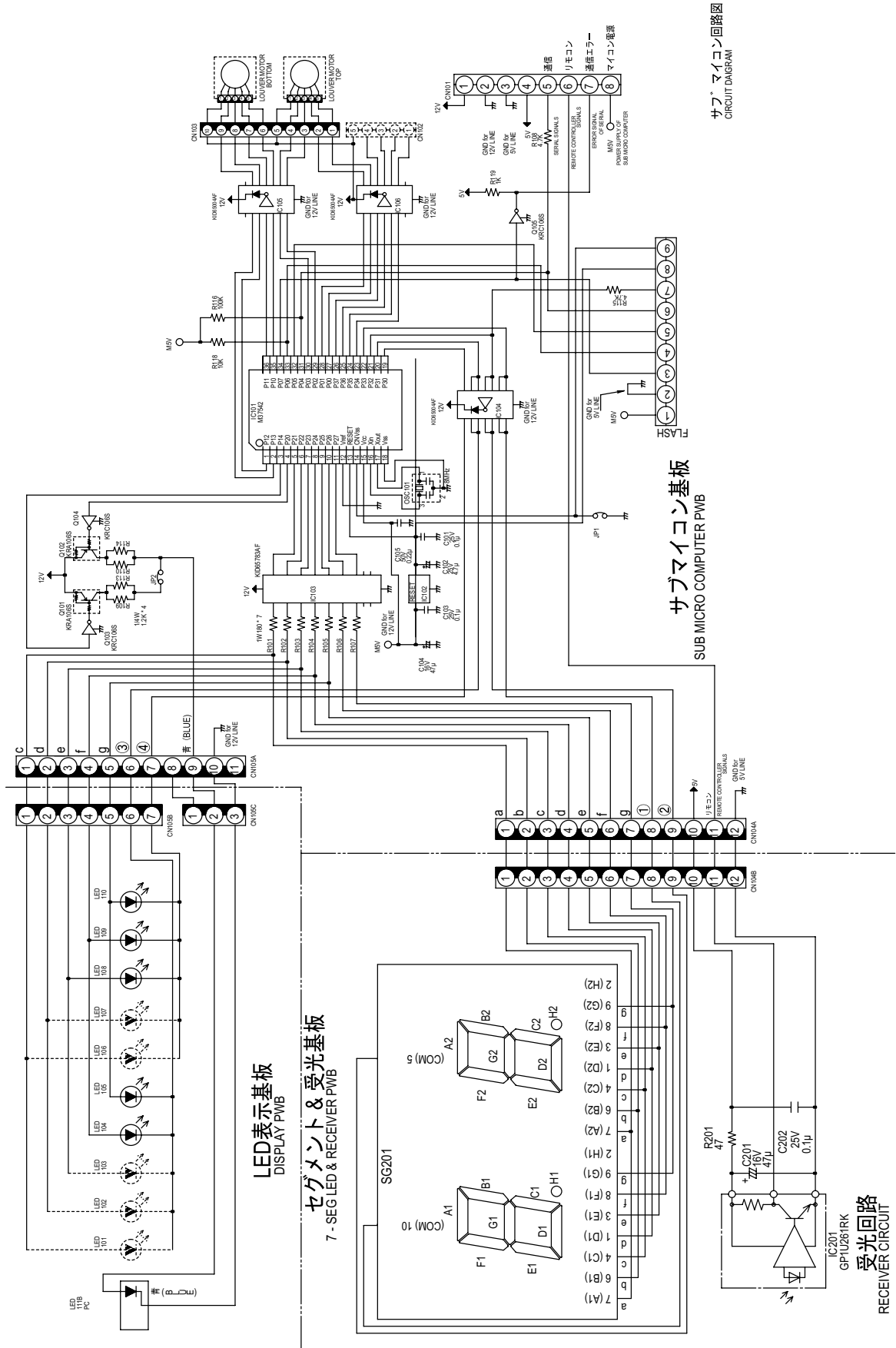


1. Indoor unit

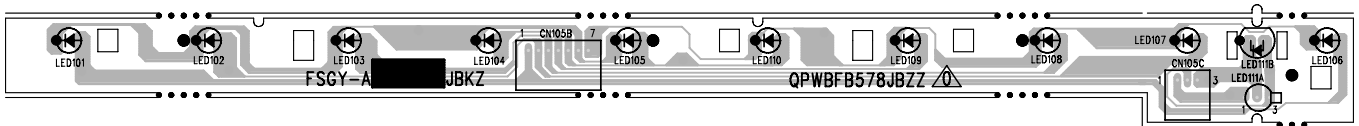
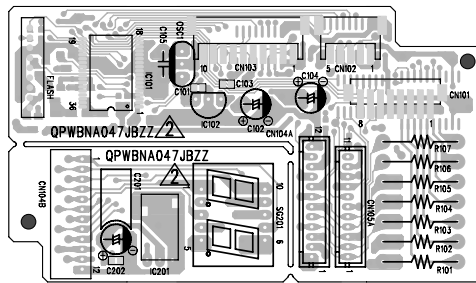
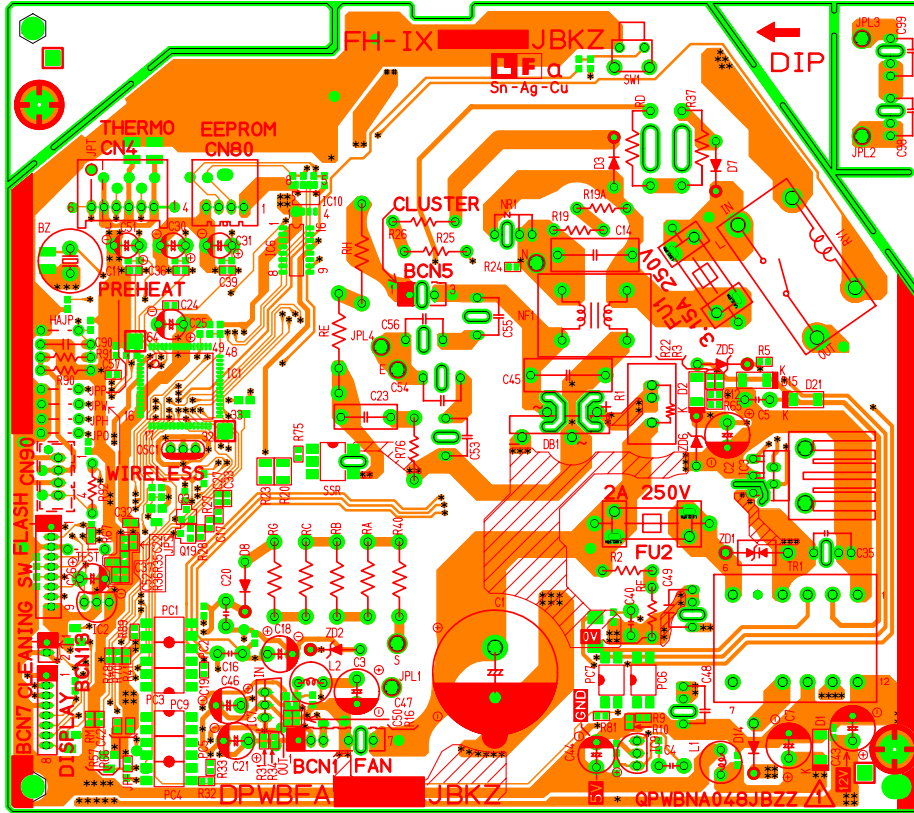
1.1. Electronic control circuit diagram



1.2. Display circuit diagram

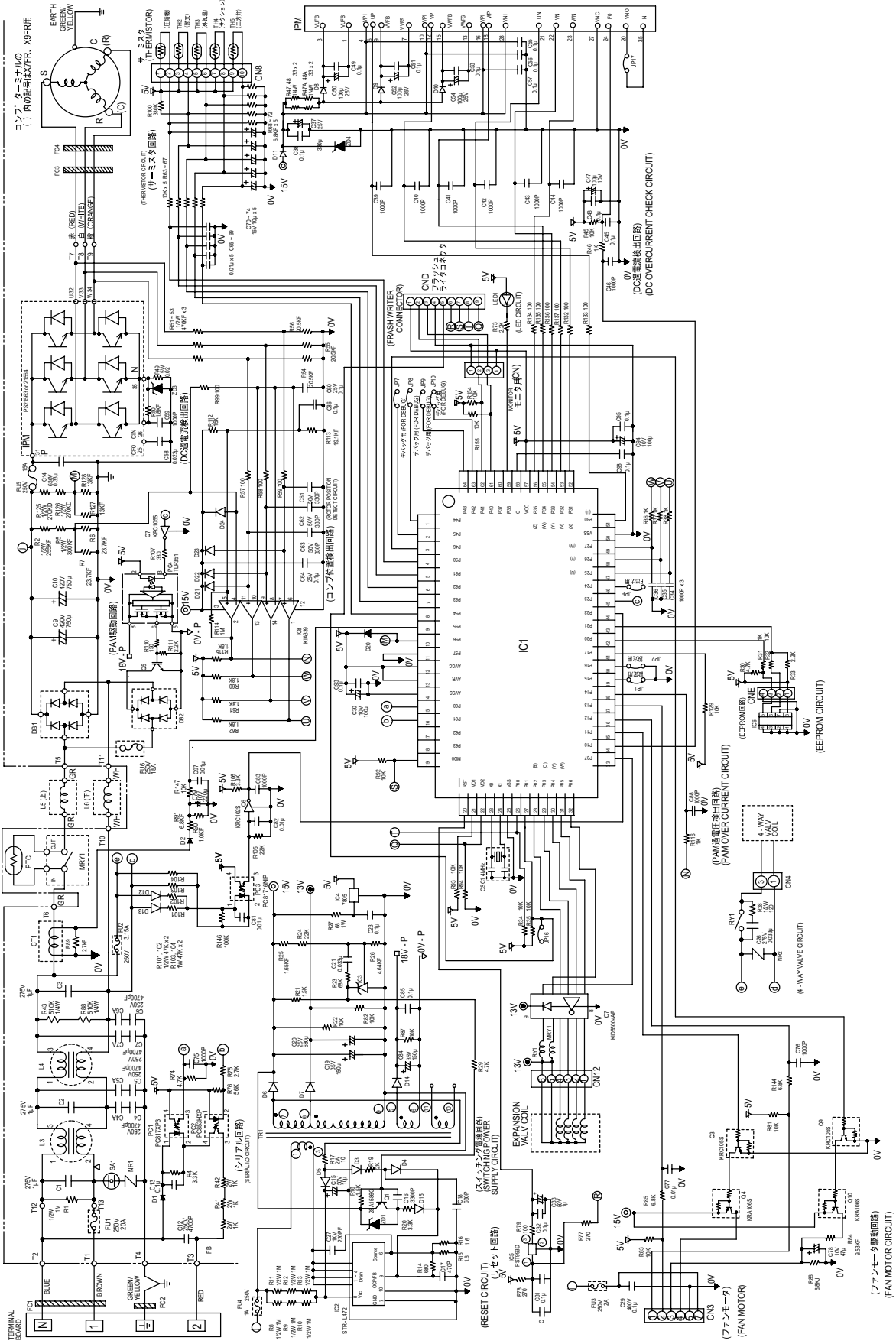


SHARP AY-XP9FR MARK3COMPI 1313+88595888-1313-YAYLDB12021202 9999X-YA 9999H2

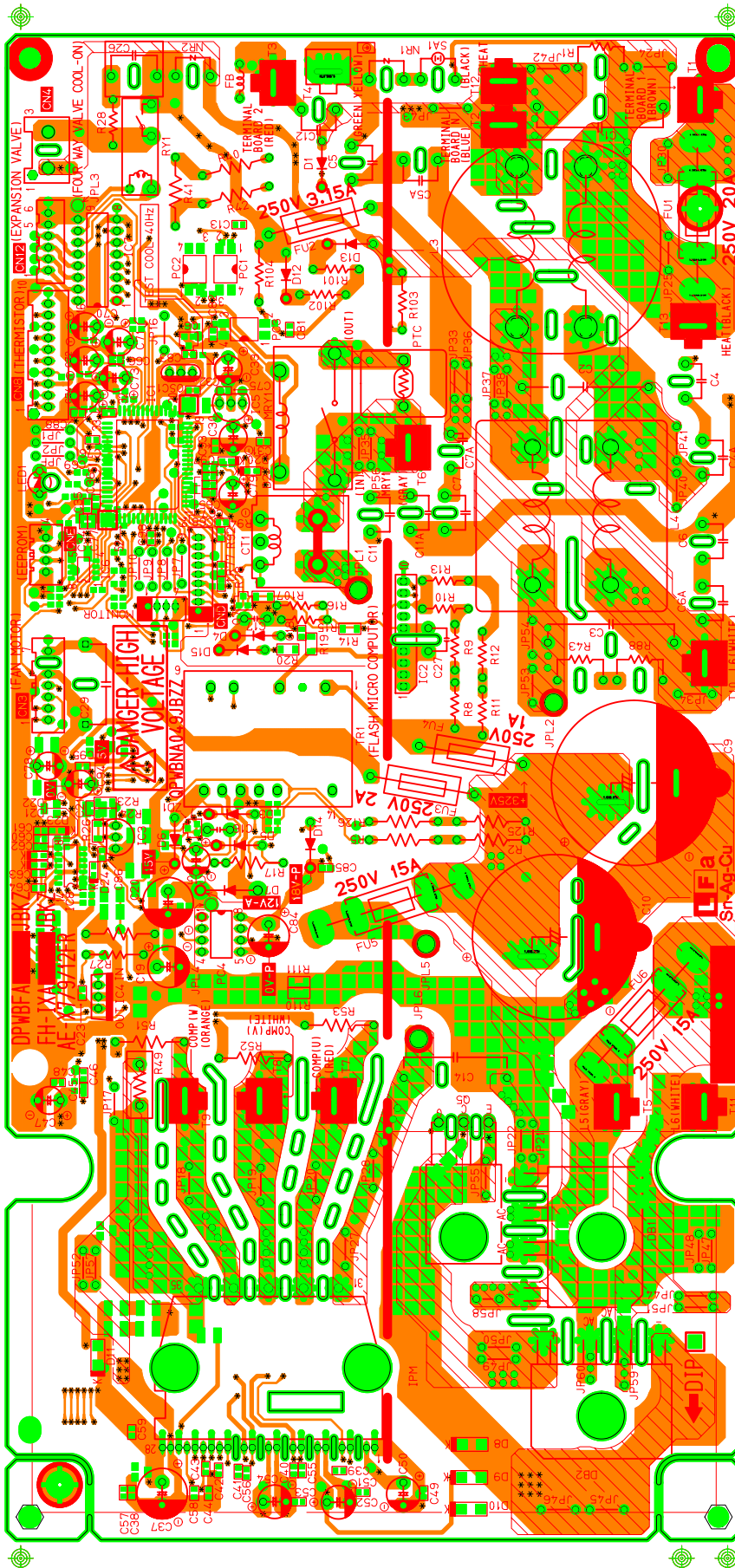


2. Outdoor unit

2.1. Electronic control circuit diagram



SHARP AE-XTRF REFRIGCOMP-F 313189909



SHARP AE-XTRF REFRIGCOMP-F 313189909

[3] FUNCTION

1. Function

1.1. Startup control

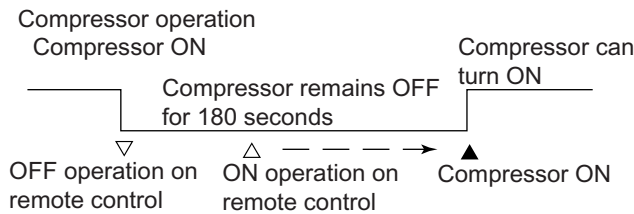
The main relay remains off during the first 45 seconds (first safety time) immediately after the power cord is plugged into an AC outlet in order to disable outdoor unit operation and protect outdoor unit electric components.

1.2. Restart control

Once the compressor stops operating, it will not restart for 180 seconds to protect the compressor.

Therefore, if the operating compressor is shut down from the remote control and then turned back on immediately after, the compressor will restart after a preset delay time.

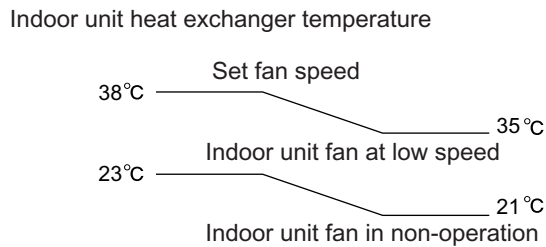
(The indoor unit will restart operation immediately after the ON switch is operated on the remote control.)



1.3. Cold air prevention control

When the air conditioner starts up in heating mode, the indoor unit fan will not operate until the temperature of the indoor unit heat exchanger reaches about 23°C in order to prevent cold air from blowing into the room.

Also, the indoor unit fan operates at low speed until the temperature of the indoor unit heat exchanger reaches about 38°C so that people in the room will not feel chilly air flow.



1.4. Odor prevention control

When the air conditioner starts up in cooling mode, the discharged air temperature is lowered slightly, and for the reduction of unpleasant odors the operation of the indoor unit fan is delayed 60 seconds if the automatic fan speed mode in cooling mode is set.

1.5. Indoor unit heat exchanger freeze prevention control

If the temperature of the indoor unit heat exchanger remains below 0°C for 4 consecutive minutes during cooling or dehumidifying operation, the compressor operation stops temporarily in order to prevent freezing.

When the temperature of the indoor unit heat exchanger rises to 2°C or higher after about 180 seconds, the compressor restarts and resumes normal operation.

1.6. Outdoor unit 2-way valve freeze prevention control

If the temperature of the outdoor unit 2-way valve remains below 0°C for 10 consecutive minutes during cooling or dehumidifying operation, the compressor operation stops temporarily in order to prevent freezing.

When the temperature of the 2-way valve rises to 10°C or higher after about 180 seconds, the compressor restarts and resumes normal operation.

1.7. Indoor unit overheat prevention control

During heating operation, if the temperature of the indoor unit heat exchanger exceeds the indoor unit heat exchanger overheat prevention temperature (about 45 to 54°C) which is determined by the operating frequency and operating status, the operating frequency is decreased by about 4 to 15 Hz. Then, this operation is repeated every 60 seconds until the temperature of the indoor unit heat exchanger drops below the overheat protection temperature.

Once the temperature of the indoor unit heat exchanger drops below the overheat protection temperature, the operating frequency is increased by about 4 to 10 Hz every 60 seconds until the normal operation condition resumes.

If the temperature of the indoor unit heat exchanger exceeds the overheat protection temperature for 60 seconds at minimum operating frequency, the compressor stops operating and then restarts after about 180 seconds, and the abovementioned control is repeated.

1.8. Outdoor unit overheat prevention control

During cooling operation, if the temperature of the outdoor unit heat exchanger exceeds the outdoor unit heat exchanger overheat prevention temperature (about 55°C), the operating frequency is decreased by about 4 to 15 Hz. Then, this operation is repeated every 60 seconds until the temperature of the outdoor unit heat exchanger drops to about 54°C or lower.

Once the temperature of the outdoor unit heat exchanger drops to about 54°C or lower, the operating frequency is increased by about 4 to 10 Hz every 60 seconds until the normal operation condition resumes.

If the temperature of the outdoor unit heat exchanger exceeds the outdoor unit heat exchanger overheat protection temperature for (120 sec : outdoor temperature $\geq 40^\circ\text{C}$ • 60 sec : outdoor temperature $< 40^\circ\text{C}$) at minimum operating frequency, the compressor stops operating and then restarts after about 180 seconds, and the abovementioned control is repeated.

1.9. Compressor overheat prevention control

If the temperature of the compressor exceeds the compressor overheat prevention temperature (110°C), the operation frequency is decreased by about 4 to 10 Hz. Then, this operation is repeated every 60 seconds until the temperature of the compressor drops below the overheat protection temperature (100°C).

Once the temperature of the compressor drops below the overheat protection temperature, the operating frequency is increased by about 4 to 10 Hz every 60 seconds until the normal operation condition resumes.

If the temperature of the compressor exceeds the overheat protection temperature (for 120 seconds in cooling operation or 60 seconds in heating operation) at minimum operating frequency, the compressor stops operating and then restarts after about 180 seconds, and the abovementioned control is repeated.

1.10. Startup control

When the air conditioner starts in the cooling or heating mode, if the room temperature is 2°C higher than the set temperature (in cooling operation) or 3.5°C lower (in heating operation), the air conditioner operates with the operating frequency at maximum. Then, when the set temperature is reached, the air conditioner operates at the operating frequency determined by fuzzy logic calculation, then enters the normal control mode after a while.

1.11. Peak control

If the current flowing in the air conditioner exceeds the peak control current (see the table below), the operation frequency is decreased until the current value drops below the peak control current regardless of the frequency control demand issued from the indoor unit based on the room temperature.

Model	Peak control current	
	Cooling operation	Heating operation
AY-XP9GHR	Approx. 3.8 A	Approx. 6.4 A
AY-XP12GHR	Approx. 6.4 A	Approx. 7.5 A

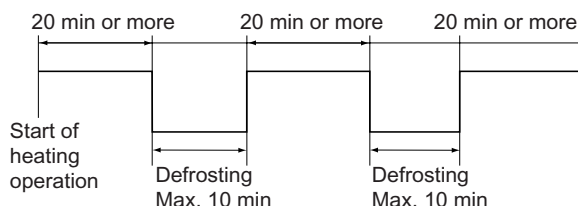
1.12. Outdoor unit fan delay control

The compressor stops immediately after cooling, dehumidifying or heating operation is shut down, but the outdoor unit fan continues operation for 50 seconds before it stops.

1.13. Defrosting

1.13.1 Reverse defrosting

The defrost operation starts when the compressor operating time exceeds 20 minutes during heating operation, as shown below, and the outside air temperature and the outdoor unit heat exchanger temperature meet certain conditions. When the defrost operation starts, the indoor unit fan stops. The defrost operation stops when the outdoor unit heat exchanger temperature rises to about 13C or higher or the defrosting time exceeds 10 minutes.



1.14. ON timer

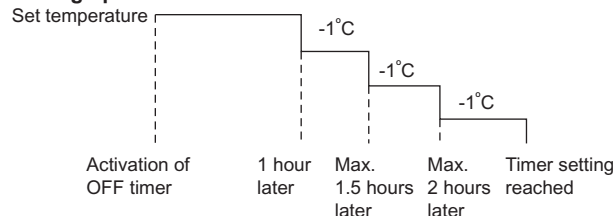
The ON timer can be activated by pressing the ON timer button. When the ON timer is activated, the operation start time is adjusted based on fuzzy logic calculations 1 hour before the set time so that the room temperature reaches the set temperature at the set time.

1.15. OFF timer

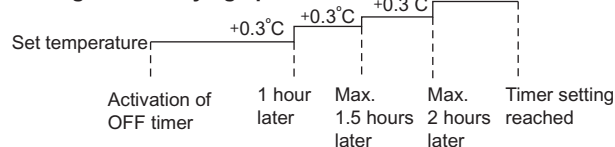
The OFF timer can be activated by pressing the OFF timer button. When the OFF timer is set, the operation stops after the set time.

When this timer is set, the compressor operating frequency lowers for quieter operation, and the room temperature is gradually varied after one hour (reduced 1°C three times (max. 3°C) in heating, or increased 0.3°C three times (max. 1°C) in cooling or dehumidifying operation) so that the room temperature remains suitable for comfortable sleeping.

Heating operation



Cooling/dehumidifying operation



1.16. Power ON start

If a jumper cable is inserted in the location marked with HAJP on the indoor unit control printed circuit board (control PCB), connecting the power cord to an AC outlet starts the air conditioner in either cooling or heating mode, which is determined automatically by the room temperature sensor.

When a circuit breaker is used to control the ON/OFF operation, please insert a jumper as described above.

1.17. Self-diagnostic malfunction code display

1.17.1 Indoor unit

1) When a malfunction is confirmed, all relays turn off and a flashing malfunction code number is displayed to indicate the type of malfunction.

When the air conditioner is in non-operating condition, holding down AUX button for more than 5 seconds activates the malfunction code display function.

The operation continues only in the case of a serial open-circuit, and the main relay turns off after 30 seconds if the open-circuit condition remains.

In the case of a serial short-circuit, the air conditioner continues operating without a malfunction code display, and the main relay turns off after 30 seconds if the short-circuit condition remains.

The malfunction information is stored in memory, and can be recalled later and shown on display.

2) The self-diagnostic memory can be recalled and shown on the display by stopping the operation and holding down AUX button for more than 5 seconds.

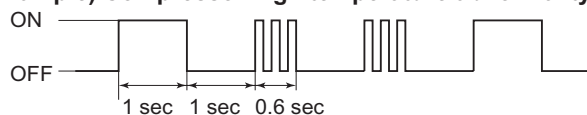
3) The content of self-diagnosis (malfunction mode) is indicated by a flashing number.

(For details, refer to the troubleshooting section.)

1.17.2 Outdoor unit

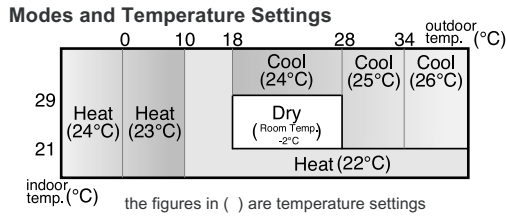
If a malfunction occurs, LED1 on the outdoor unit flashes in 0.2-second intervals as shown below.

(Example) Compressor high temperature abnormality



1.18. Information about auto mode

In the AUTO mode, the temperature setting and mode are automatically selected according to the room temperature and outdoor temperature when the unit is turned on.



During operation, if the outdoor temperature changes, the temperature settings will automatically slide as shown in the chart.

1.20. Difference of operation in Auto and Manual modes

In the Auto mode, the temperature setting is automatically determined based on the outside air temperature. In addition, the air conditioner operation differs from the operation in the Manual mode as explained below.

1.20.1 Difference relating to set temperature

	Auto mode			Manual mode		
	Cooling	Heating	Dehumidifying	Cooling	Heating	Dehumidifying
Temperature setting method	Automatic temperature setting based on outside air temperature. Can be changed within $\pm 2^\circ\text{C}$ using remote control.			Can be changed between 18 and 32°C using remote control.	Can be changed between 18 and 32°C using remote control.	Automatic setting. Can be changed within $\pm 2^\circ\text{C}$.

1.21. Dehumidifying operation control

If the room temperature is 26°C or higher when dehumidifying operation starts, the dehumidifying operation provides a low cooling effect in accordance with the room temperature setting automatically determined based on the outside air operation. (The setting value is the same as the set temperature for cooling operation in the auto mode.)

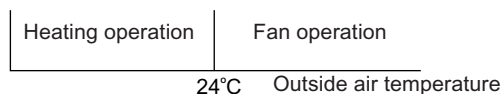
If the room temperature is lower than 26°C when dehumidifying operation starts, the dehumidifying operation minimizes the lowering of the room temperature.

1.22. Self Clean operation

Heating or Fan operation and Cluster operation are performed simultaneously.

The judgment of whether Heating or Fan operation is used is based on the outside air temperature at 3 minutes after the start of internal cleaning.

The operation stops after 40 minutes. (The air conditioner shows the remaining minutes: 40 → 39 → 38 ... 3 → 2 → 1)



1.23. Plasmacluster Ion function

Operating the Plasmacluster Ion button while the air conditioner is in operation or in non-operation allows the switching of the operation mode in the following sequence: "Air Clean operation" → "Stop".

- "Self Clean operation" generates about equal amounts of (+)ions and (-)ions from the cluster unit to provide clean air.

If the Plasmacluster Ion generation function is operated together with the air conditioner operation, the indoor unit fan speed and louver direction are in accordance with the air conditioner settings.

If the Plasmacluster Ion generation function is used without operating the air conditioning function, the indoor unit fan operates at a very low speed and the upper louver is angled upward and the lower louver remains horizontal. (The airflow volume and direction can be changed by using the remote control.)

1.19. Airflow control

The airflow control holds the two upper and lower louvers at special positions during operation to prevent discharged air from directly blowing into people in the room.

1.19.1 Cooling/dehumidifying operation

When the airflow button is pressed the upper louver is set at an upward angle to send the air along the ceiling.

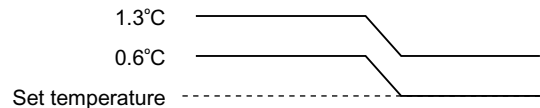
1.19.2 Heating

When the airflow button is pressed the lower louver is set at a downward angle to send the air directly toward the floor.

1.24. Hot keep

When the room temperature rises above the set temperature by 0.6°C or more, the ON/OFF operation of the compressor and indoor unit fan is controlled in order to lower the room temperature.

(The values indicated below, such as "0.6°C" and "1.3°C," vary depending on the outside air temperature.)



1.24.1 Hot keep zone 1

With the compressor frequency at the lowest, if the room temperature is higher than the set temperature by 0.6°C but no more than 1.3°C, the following processes will be activated.

- The compressor stops temporarily, and restarts after 2 minutes.
- If the room temperature remains in the hot keep zone, the compressor is turned OFF and ON in 3-minute intervals.
- The indoor unit fan turns OFF and ON with a delay of 30 seconds from the compressor OFF/ON.
- After the above operation in 3-minute intervals is repeated four times, the interval extends to 6 minutes.

1.24.2 Hot keep zone 2

If the compressor ON/OFF in hot keep zone 1 fails to bring the room temperature within 1.3°C above the set temperature, the following processes will be activated.

- The compressor repeats a cycle of 8-minute OFF and 6-minute ON.
- After the second time, the compressor remains completely OFF and only the indoor unit fan repeats OFF-ON in set intervals.
- While the compressor is completely OFF in 2), the louvers are set horizontally to prevent cold air from blowing.

The zone transition and the end of hot keep operation (room temperature lower than the set temperature) are judged when the compressor ON period ends.

* This function cannot be repeated.

1.25. Winter cool

Cooling operation is available during the winter season by the built in winter cool function.

Lower limit of outdoor temperature range is -10°C DB.

When the outside air temperature is low, the outdoor unit fan operates at slower speed.

NOTE: Built-in protect device may work when outdoor temperature falls below 21°C DB., depending on conditions.

1.26. Auto restart

When power failure occurs, after power is recovered, the unit will automatically restart in the same setting which were active before the power failure.

1.26.1 Operating mode (Cool, Heat, Dry)

- Temperature adjustment (within 2°C range) automatic operation
- Temperature setting

- Fan setting
- Air flow direction
- Power ON/OFF
- Automatic operation mode setting
- Swing louvre
- Plasmacluster mode

1.26.2 Setting not memorized

- Timer setting
- Full power setting
- Internal cleaning

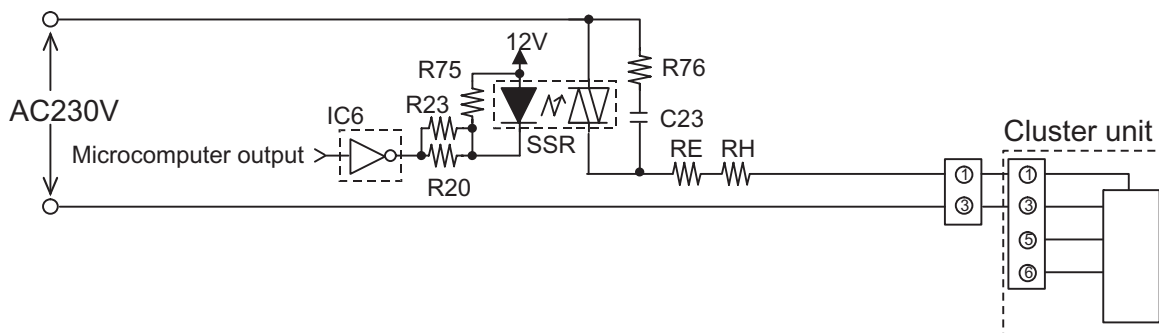
1.26.3 Disabling auto restart function

By removing (cutting) jumper J (JPJ) on the printed circuit board (PCB), the auto restart function can be disabled.

2. Explanation of cluster circuit

The cluster unit generates cluster ions, which are circulated throughout the room by the air flow created by the blower fan (indoor unit fan motor) in the air conditioner unit.

1) When microcomputer output turns "H," the IC6 output changes to "Lo," turning ON the SSR and applying 230 V to the cluster unit for the generation of cluster ions (positive and negative ions).

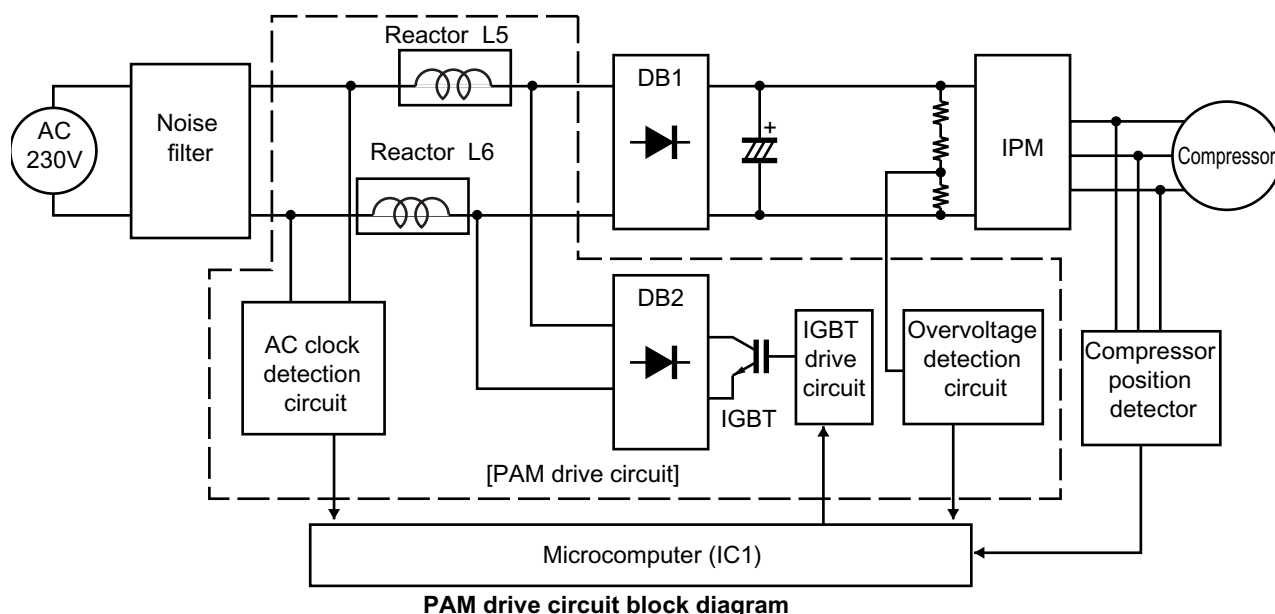


3. Outline of PAM circuit

3.1. PAM (Pulse Amplitude Modulation)

The PAM circuit varies the compressor drive voltage and controls the rotation speed of the compressor.

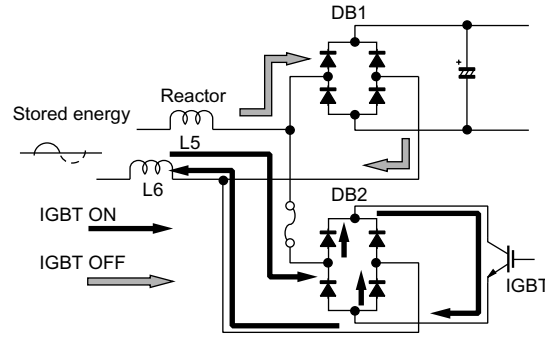
The IGBT shown in the block diagram charges the energy (electromotive force) generated by the reactor to the electrolytic capacitor for the inverter by turning ON and OFF.



When the IGBT is ON, an electric current flows to the IGBT via the reactor (L5), (L6) and diode bridge (DB2).

When the IGBT turns OFF, the energy stored while the IGBT was ON is charged to the voltage doubler capacitor via the diode bridge (DB1).

As such, by varying the ON/OFF duty of the IGBT, the output voltage is varied.



3.2. High power factor control circuit

This circuit brings the operating current waveform closer to the waveform of commercial power supply voltage to maintain a high power factor.

Because of the capacitor input, when the PAM circuit is OFF, the phase of the current waveform deviates from the voltage waveform as shown below.

To prevent this deviation, a current is supplied during the periods indicated by "O" in the diagram.

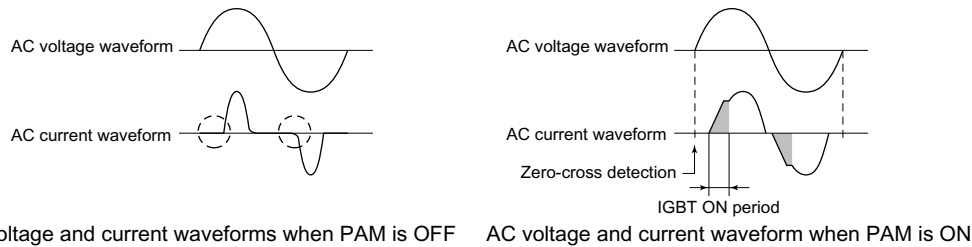
To determine the length of period to supply a current, the zero-cross timing of the AC input voltage is input to the microcomputer via the clock circuit.

The power source frequency is also determined at the same time.

The IGBT turns ON after the time length determined by the zero-cross point to supply a current to the IGBT via the reactor.

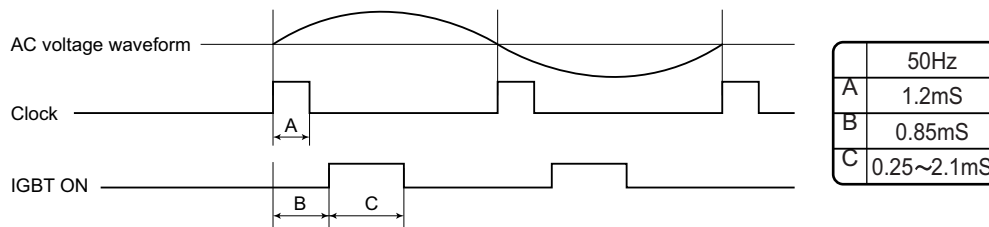
This brings the current waveform closer to the voltage waveform in phase.

As described above, the ON/OFF operation of the IGBT controls the increase/decrease of the compressor power supply voltage (DC voltage) to improve the compressor efficiency and maintain a high power factor by keeping the current phase closer to that of the supply voltage.



AC voltage and current waveforms when PAM is OFF AC voltage and current waveform when PAM is ON

3.2.1 Detailed explanation of PAM drive circuit sequence



3.2.2 AC clock (zero-cross) judgment

- The clock circuit determines the time from one rising point of the clock waveform to the next rising point. The detected clock waveform is used to judge the power source frequency (50Hz).
- The zero-cross of the AC voltage is judged as the rising of the clock waveform, as shown in the diagram above.

3.2.3 IGBT ON start time (delay time B)

- Based on the zero-cross of the AC voltage, the IGBT turns ON after a delay time set according to the power source frequency.

3.2.4 IGBT ON time (C)

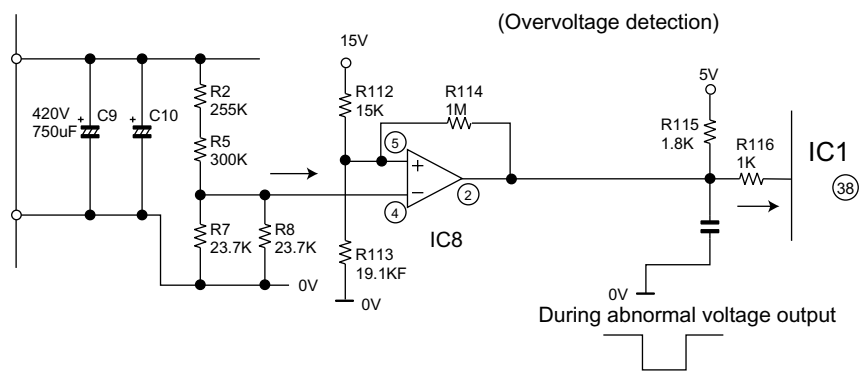
- After the above delay time, the IGBT turns ON to supply a current to the reactor.
- The ON time of the IGBT determines the amount of energy (level of DC voltage rise) supplied to the reactor. DC voltage level in each operation mode (varies depending on external load conditions)
 - Cooling operation --- 220 to 240 V
 - Heating operation --- 220 to 280 V

3.3. PAM protection circuit

To prevent excessive voltage of PAM output from damaging the IPM and electrolytic capacitor as well as the control printed circuit board (PCB), this circuit monitors the PAM output voltage and turns off the PAM control signal and PAM drive immediately when an abnormal voltage output is generated. At the same time, it shuts off the compressor operation.

The PAM output voltage is distributed to pin (4) of the comparator (IC8). If this voltage exceeds the reference voltage at pin (5) of the IC8, the output of the comparator (IC8) reverses (from H to L) and it is input to pin (38) of the microcomputer (IC1) to halt the PAM drive.

The protection voltage level is as follows.



3.3.1 Details of troubleshooting procedure for PAM

1) PAM shutdown due to error

1) When the DC voltage detection circuit sends a signal exceeding the specified voltage to the microcomputer

DC voltage of 350 V or higher (detection circuit input voltage of about 9.2 V or higher) [IC8 pin (4)]

- When an error is detected
 - PAM IGBT turns OFF.
 - Compressor turns OFF.
 - All units shut down completely when the error occurs four times.

2) When the outdoor unit clock waveform differs from the specified value immediately before the PAM IGBT turns ON

When there is no clock waveform input

When a clock signal of other than specified power source frequency (50/60 Hz) is input

- When an error is detected
 - PAM IGBT does not turn ON.
 - Compressor operates normally.
 - Complete shutdown does not occur.

2) PAM error indication

In case of error “1”

- An error signal is sent to the indoor unit as soon as an error is generated.
 - Malfunction No. 14-0 is indicated when the error code is called out by the indoor unit's self-diagnosis function.
- The LED on the outdoor unit flashes 14 times when an error is generated.
 - The LED continues flashing in the 14-time cycle even after the compressor stops operating.
 - The LED turns off (data is deleted from the memory) when the outdoor unit power is turned off.

In case of error “2”

- An error signal is sent to the indoor unit as soon as an error is judged.
 - Malfunction No. 14-1 is indicated when the error code is called out by the indoor unit's self-diagnosis function.
- The LED on the outdoor unit flashes 14 times when an error is judged.
 - The LED on the outdoor unit flashes in normal pattern when the compressor stops operating.
(Compressor OFF or Thermostat OFF from remote control)

* When a user complains that the air conditioner does not provide sufficient cool air or warm air

In addition to conventional error-generating reasons, there is a possibility that the PAM IGBT does not turn ON even if the compressor is operating. In that case, the DC voltage does not rise even though the compressor is operating, and lowers to the 180-VDC level.

- Check items
 - Clock circuit check
 - PAM IGBT check
 - Fuse (Fu6) open-circuit check

4. Explanation of IPM drive circuit

The IPM for compressor drive is made by Mitsubishi Electric.

The power supply for the IPM drive, the shunt resistance for overcurrent detection, etc., are provided outside the IPM (control PCB).

4.1. IPM drive power supply circuit

The power supply for the upper-phase IGBT (HU, HV, HW) drive employs a bootstrap system, and provides power to the upper-phase IC.

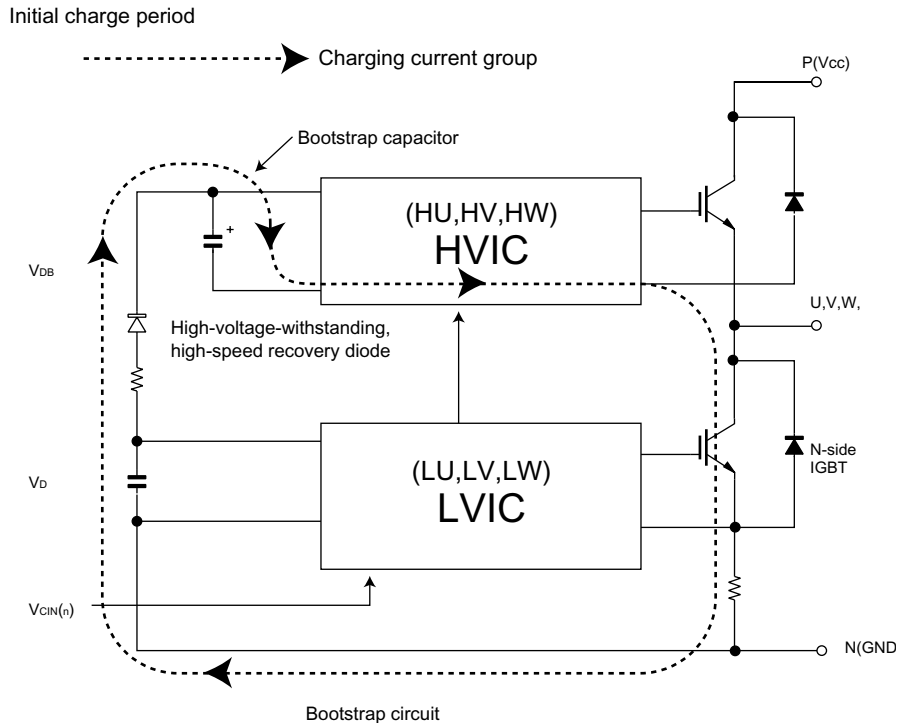
The 15-V power supply for the lower-phase IC is provided by the control printed circuit board (PCB).

4.1.1 Brief explanation of bootstrap system (single power drive system)

To supply power to the upper-phase IC, the microcomputer (IC1) turns ON the lower-phase IGBT (LU, LV, LW).

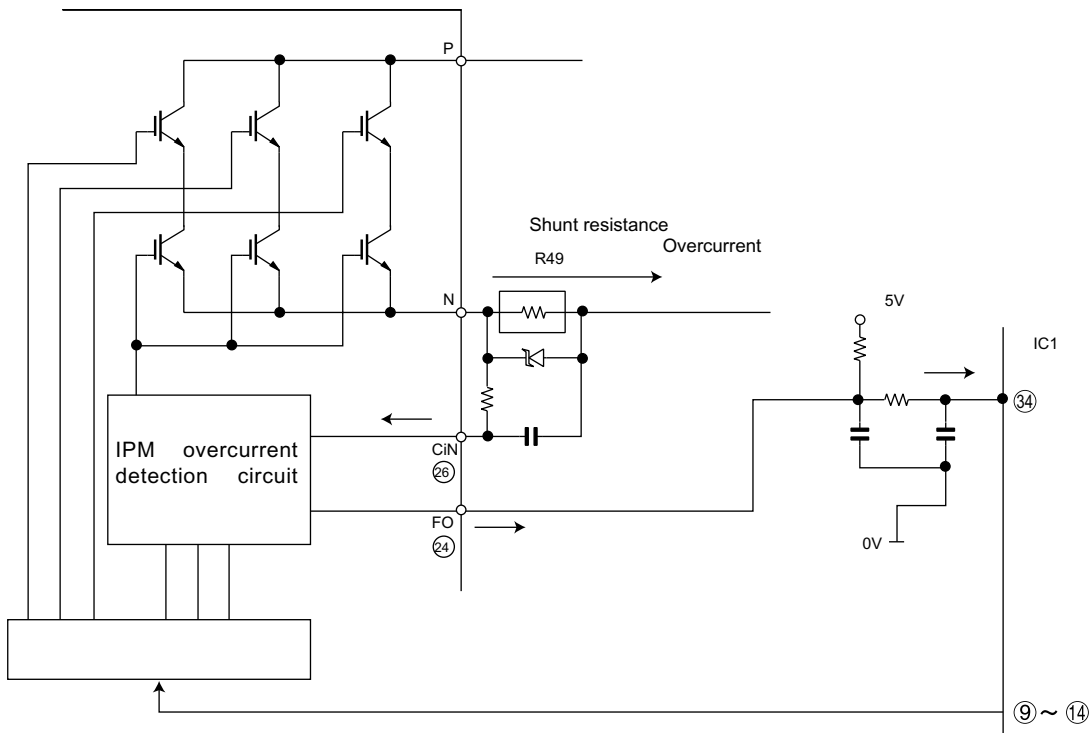
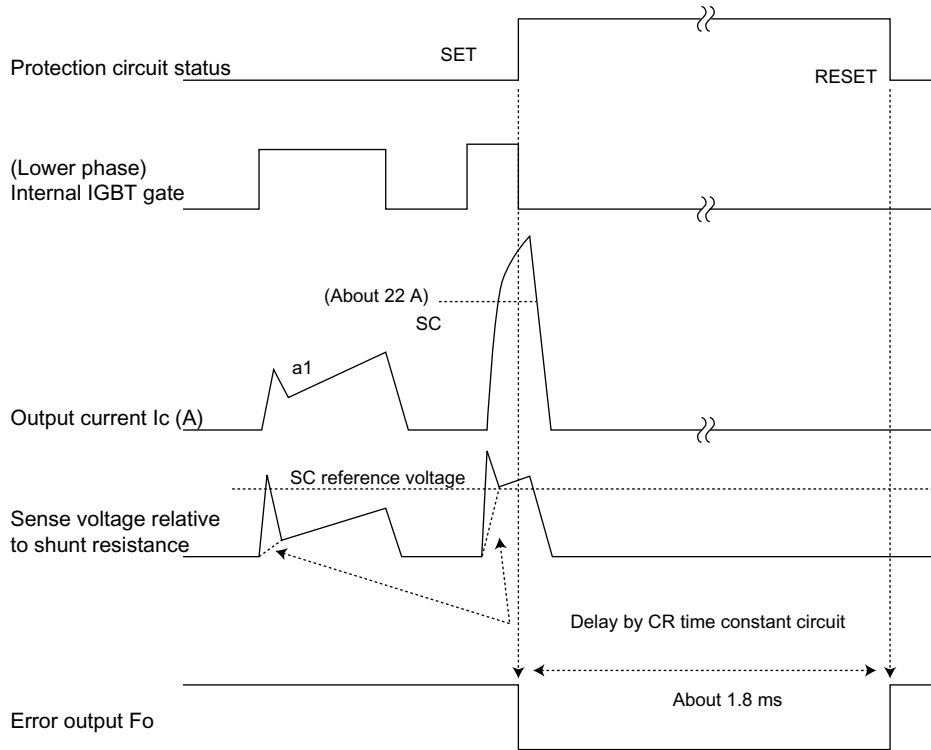
This results in a charging current that flows to the electrolytic capacitor of each upper-phase IC input and charges the bootstrap capacitor with a 15-V current.

The power supply for the subsequent stages is charged while the lower-phase IGBT is ON in ordinary compressor drive control.



4.1.2 DC overcurrent detection circuit

When a current of about 25 A or higher flows through the shunt resistance (R49) on the control printed circuit board (PCB), the voltage at this resistance is input to IPM CIN pin (26). Then, the gate voltage of the lower-phase IGBT (LU, LV, LW) inside the IPM turns OFF to cut off the overcurrent. At the same time, an L output of about 1.8 ms is generated from IPM Fo pin (24), and this results in an L input to overcurrent detection input pin (34) of the microcomputer (IC1) and turns OFF the PWM signal output (IC1 pins (51) through (56)) to the IGBT gate.



5. 120° energizing control (digital position detection control)

This control system detects the digital position detection signal and adjusts the rate of acceleration/deceleration accordingly.

The motor's induced voltage waveform is input to the comparator in the form of PWM-switched pulse waveform, and a position detection signal is generated as a reference voltage equaling 1/2 of 280 VDC. However, since there is no induced voltage waveform when the PWM waveform is OFF, the microcomputer performs internal processing so that detection is enabled only when it is ON. Based on the detected position signal, actual PWM waveform output timing is determined. Since it does not use a filter circuit, the detection accuracy is high.

The microcomputer performs internal processing to cancel spike voltage during the regenerative process.

Furthermore, even if the induced voltage is low, position detection is still possible, thus allowing sensor-less operation at low rotation speed in the initial stage of operation. This reduces the starting current and improves the IPM reliability.

