Development of the Super Link II Communication System for Building Air Conditioners

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There is increasing demand for high-capacity indoor and outdoor units for multi-unit air conditioning systems that have reduced space requirements, improved functionality, and reduced equipment costs. In particular, the requirement will grow for air conditioning systems that consist of one outdoor unit and 100 or more indoor units. The new Super Link II air conditioner communication system plays an important role in supporting the further development of air conditioning systems. While maintaining interchangeability and compatibility with previous communication systems, Super Link II has a new automatic polarity and protocol adjustment algorithm that permits the mixed operation of conventional and new air conditioners with automatic address setting of up to 128 indoor units.

1. Introduction

In 1990, Mitsubishi Heavy Industries, Ltd. (MHI) developed and brought to market the Super Link communication system for controlling air conditioners used in stores and office buildings. The system's installation workability, expandability, and reliability were of such a high level that it has been used as the communication system for all new multi-unit air conditioner models developed since its introduction.

There is increasing demand for high-capacity indoor and outdoor units with reduced space requirements, improved functionality, and reduced life-cycle costs. In particular, the requirement will grow for air conditioning systems that consist of one outdoor unit and 100 or more indoor units. Such large air conditioning systems require a communication system capable of interconnecting 100 or more air conditioning units.

This paper describes the features and technology of the Super Link II air conditioner communication system used in MHI's multi-unit air conditioners.

2. Communication circuit configuration

The Super Link communication system used in MHI's conventional multi-unit air conditioner systems has a communication transceiver with excellent resistance to noisy environment and reliability that meets the RS-485 standards for multi-node, long-distance communication. In addition, previous Super Link uses MHI's unique communication circuit configuration and polarity adjustment algorithm that depolarizes its two communication lines[1] to reduce problems with incorrect connections during installation.

The primary goal of this development was to enable the mixed operation of new and previous systems that would be encountered when new units replace old ones in a building on either an individual or a group by group basis.

For compatibility purposes, Super Link II uses a transceiver that meets the same RS-485 specifications as Super Link. The communication system, which is developed according to MHI's own method and criteria of evaluation, is capable of connecting up to 172 units, composed of 128 indoor units, 32 outdoor units, and 12 central controllers. **Table 1** compares the outline specifications of the new and previous systems.

Interconnecting a larger number of units requires an increase in the volume of communications. The central controller that manages the air conditioning accounting system checks the status of each indoor unit every minute. The communications speed has been quadrupled in the new system to maintain this one-minute status checking interval for an increased number of units.

A faster communication speed means that the effect of reflected waves on the communications waveform is a more important issue, and communications are impossible if the distance is too great. **Figure 1** shows the communication waveforms under such conditions. We found that reflected waves were caused by the capacitor in the over-voltage protection circuit. We solved this problem by redesigning the over-voltage protection circuit, which was provided for protection in the event that the main power line was incorrectly connected to a communication terminal.

We performed a number of tests to confirm our predictions of communications performance under various branching and connection scenarios. The system is capable of communicating over wiring runs of up to 2000 m, with a maximum of 1000 m to the furthest end. Due to their increased capacitance, shielded cables were restricted to a maximum run of 1500 m.

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Table 1 Specifications of new and conventional communication systems

Item	Specification		Remarks
	Super Link II	Super Link	
Wiring medium	2-conductor cable	2-conductor cable	Vinyl cabtire cable: 0.75–2.0 mm^2 Shielded cable: 0.75 mm^2 or 1.25 mm^2
Number of devices	172 (maximum)	100 (maximum)	
Maximum cable length	2000 m (unshielded cable) 1500 m (shielded cable, 0.75 mm^2) 1000 m (shielded cable, 1.25 mm^2)	1000 m	
Baud rate	38400 bps	9600 bps	4 x as fast as conventional system
Interface	RS-485	RS-485	EIA standard
Access control	CSMA/CD	CSMA/CD	

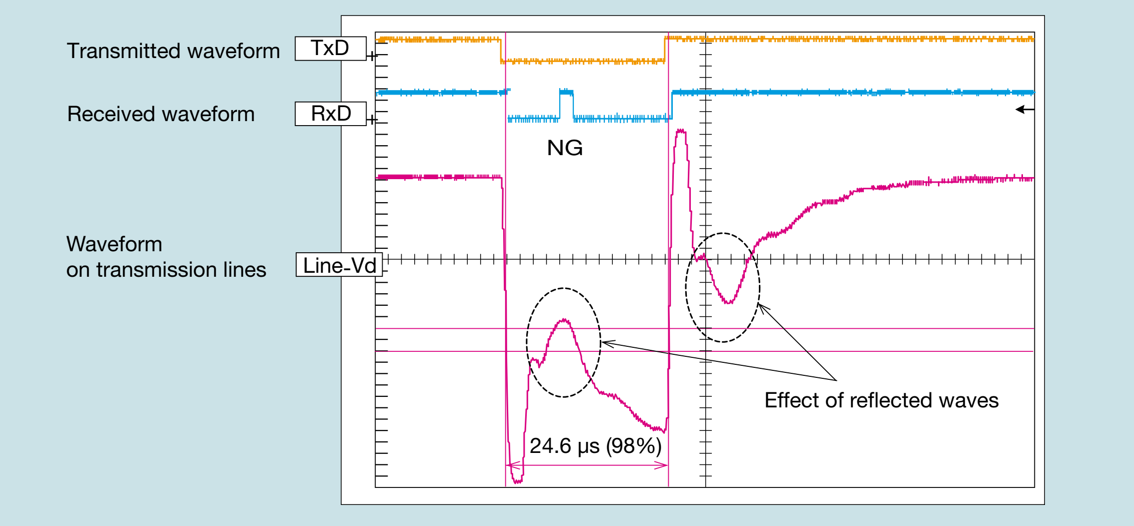

Fig. 1 Distortion of received waveforms due to reflections on transmission channels
The branching pattern of transmission channels and the number of units connected makes the effect of the reflection a serious problem, distorting the received waveforms to the point of disrupting normal communication.

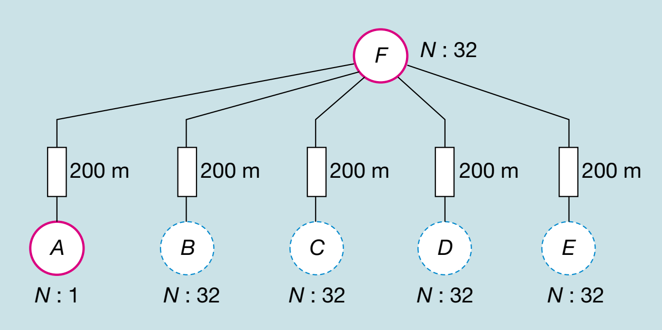

Fig. 2 Example of branching patterns where *N* is the number of units connected
A is a central controller, *B–E* are indoor units, and *F* is an outdoor unit. Communication cables 200 m in length are connected to blocks *A–F*.

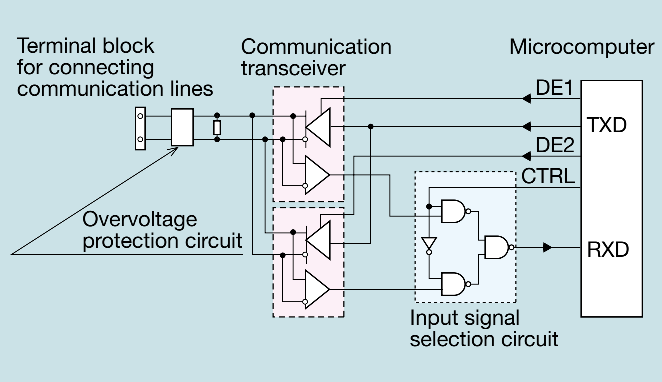

Fig. 3 Communication circuit configuration
Two communication transceivers enable this configuration to communicate in positive as well as negative polarity.

Figure 2 shows an example of typical connections and **Fig. 3** shows the configuration of a Super Link II communication circuit with two transceivers and one received signal selection circuit. With this arrangement, the circuit detects the polarity of the communication network regardless of which way it is connected, and selects the appropriate polarity for the transmitting and receiving circuits to enable intercommunication.

3. Communication procedure

3.1 Media access control (CSMA/CD)

Super Link uses MHI's own protocol, which is a type of carrier sense multiple access with collision detection (CSMA/CD) system.

It is a bus contention system where two or more communication terminals share one transmission line, and when necessary, the terminals compete to use the transmission line. It is also a "1-persistent" access control in that when one terminal is about to start communication it checks the transmission line to see if it is already in use, in which case it continues to wait until the line is free before using it.

Due to the increased number of expected data collisions caused by the significant increase in the possible number of devices, Super Link II uses a "non-persistent" access control where, if the transmission line is being used, the transmitter waits for a random time before retrying the transmission. Furthermore, the average length of this random wait interval has been adjusted to prevent the increased number of units (up to 128 indoor units for Super Link II instead of 48 for previous Super Link) from causing a deterioration in the responsibility and line availability factor of the communications.

3.2 Automatic polarity and protocol adjustment algorithm

It is important to ensure interoperability of old and new units when they are being replaced. In a building with an centrally controlled system in particular, the indoor units are usually replaced progressively in phases rather than all at once. When this happens, both the new units and the old units must be connected simultaneously to the centralized control system so that the management of energy saving and air conditioning fee will continue without interruption.

The new auto polarity and protocol adjustment algorithm allows the previous Super Link system to operate if it detects at least one older unit when the system is turned on.

The previous Super Link auto polarity adjustment algorithm[1] determines the polarity of the communication circuit. If there is already one air conditioner with an established polarity on the network, than any newly installed air conditioners adopt this same polarity. The Super Link II auto polarity and protocol adjustment algorithm is capable of automatically switching between the previous and new protocols by adding the previous/new data to the data for determining polarity.

As the new algorithm gives precedence to the previous protocol in detection, the most time-consuming configuration would be with 128 indoor units and 32 outdoor units all of which meet the new specifications. In this extreme configuration with all units turned on simultaneously, it would take about 20 s to switch all the units to the new protocol.

4. Automatic address-setting function

Each controller must have its own address when one network covers two or more controllers. Multi-unit air conditioners for buildings have indoor units installed in living spaces, and outdoor units installed outdoors; these are interconnected by refrigerant piping. The indoor and outdoor units communicate with each other to produce the intended air conditioning performance, and each unit must know the other's address for this to happen.

The addressing switches mounted on the controller are not easily accessible in many cases as the indoor units in a building are built into the ceiling or the ceiling void. Therefore, previous Super Link-compliant products have an address-assignment function[2] that automatically assigns an address to each indoor unit. The function was expanded from 48 units to a maximum of 128 in Super Link II.

Pairing the indoor and outdoor units for each refrigerant system is important when one network covers two or more refrigerant systems that managed by a central controller as shown in **Fig. 4**.

The pairing of the indoor and outdoor units connected by the refrigerant piping must match the pairing of the indoor and outdoor units connected by the communication network configured by the crossover wiring. A mismatch between the pairs linked by the refrigerant piping and by the communication network can cause accidents, such as mechanical failures or water leaks. MHI has developed and brought to market an automatic address setting function for two or more refrigerant systems to avoid such pairing problems.

The following subsections describe the technologies used in the automatic address-setting function for multiple refrigerant systems.

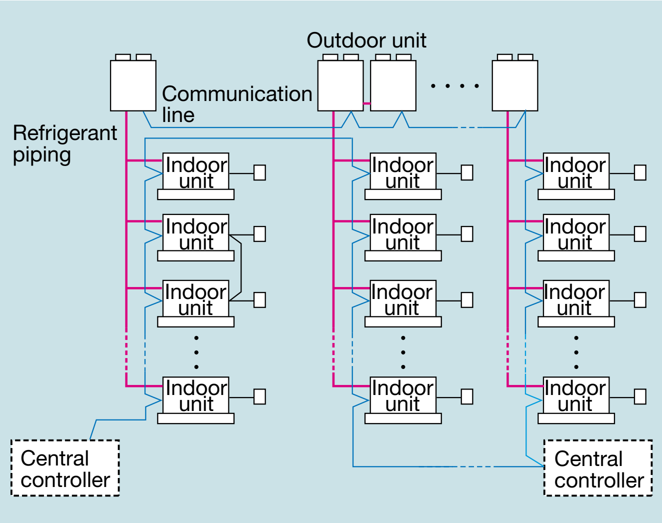

Fig. 4 Refrigerant piping and communication lines
The pairing of indoor and outdoor units connected by the refrigerant piping must match the pairing of the indoor and outdoor units connected by communication lines.

4.1 Network connector

Automatically and electrically establishing the correct pairing of indoor and outdoor units for each refrigerant system requires isolating the communication network for each refrigerant system and having the units within each single network segment communicate on the network so they recognize the presence of the others. A communication line connector called a network connector is used to isolate the communication lines conveniently. **Figure 5** shows a conceptual connection diagram for connecting two or more refrigerant systems for communications purposes. **Figure 6** is a schematic diagram of the network connector.

The communication lines and the refrigerant piping in a multi-unit air conditioning system usually run parallel through the building, and are covered by insulation as they connect with rooftop outdoor units. Network connectors are used to isolate the communication network for each refrigerant system. **Figure 7** shows the procedure for automatically setting the addresses in a system with two or more refrigerant systems.

4.2 Procedure for setting tentative addresses

As the address information determined through the automatic address setting procedure is stored in the nonvolatile memory of the indoor control circuit board, it remains intact even if the power supply is cut off as would happen in a power blackout. This address information is not present when the unit is shipped from the factory. The system follows a special procedure for setting tentative indoor unit addresses when the power is turned on for the first time. This particular tentative address setting function has been expanded to handle a maximum of 128 indoor units in Super Link II, and expansion from the previous limit of 48.

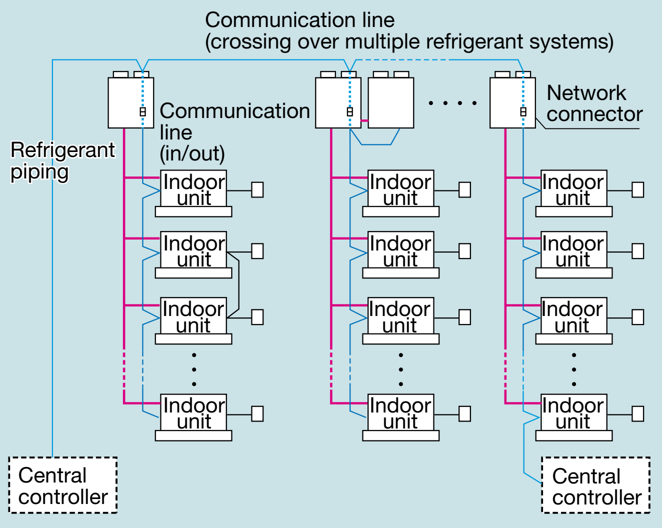

Fig. 5 Configuration of system with automatic address setting for multiple refrigerant systems
The communication line runs parallel to its associated refrigerant system. The outdoor units are wired in crossover mode to connect two or more refrigerant systems. The network connectors isolate the communication lines for each refrigerant system.

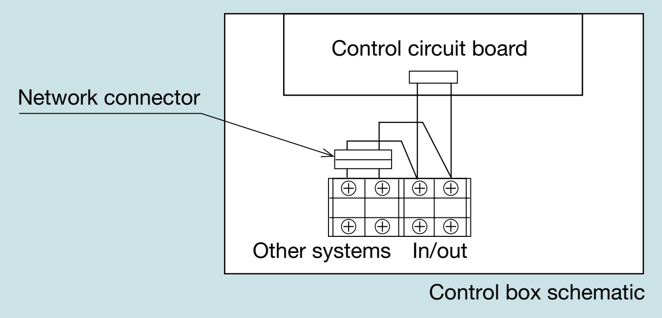

Fig. 6 Schematic diagram of network connector layout
Terminal blocks are provided for separate connection of units associated with a particular refrigerant system and for crossover electrical wiring with other refrigerant systems.

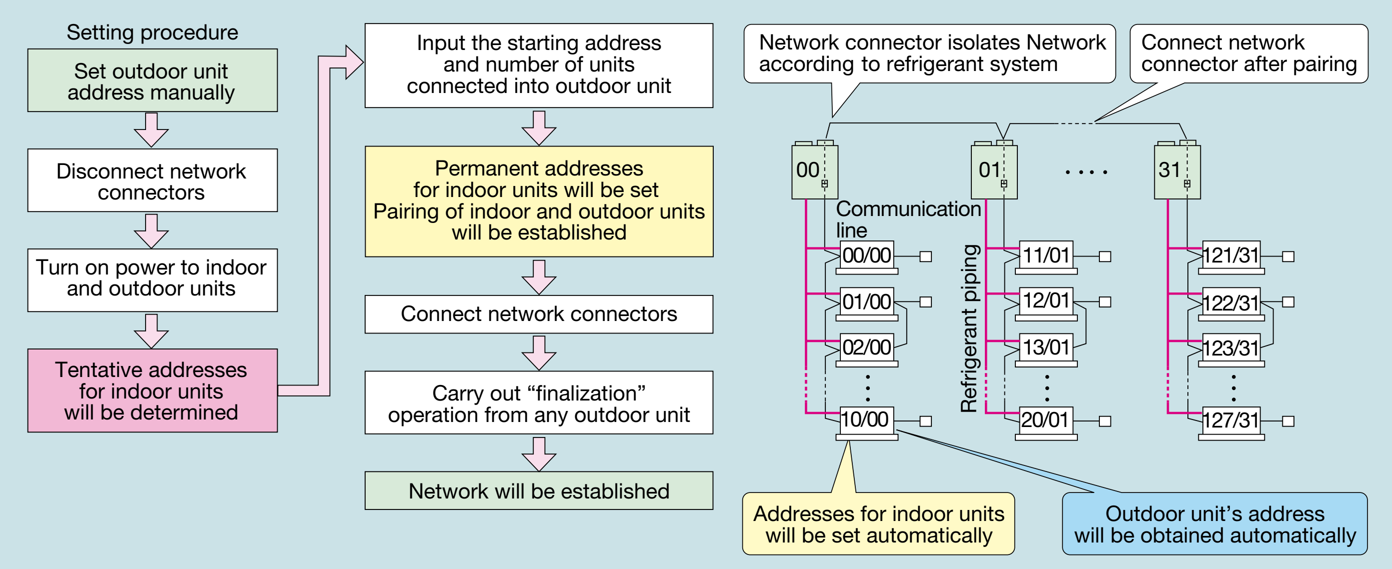

Fig. 7 Procedure for automatic address setting of multiple refrigerant systems

4.3 Procedure for setting permanent addresses

The tentative address numbers are assigned in ascending order starting from 000 to 127 for each refrigerant system. MHI has developed an algorithm that works as follows. The outdoor unit is given the number of indoor units connected and the starting address number. Based on the tentative addresses, the permanent addresses for the indoor units are automatically determined from the starting address number and the number of units connected.

4.4 Pairing indoor and outdoor units

When the indoor units obtain the starting address number from the outdoor unit, they simultaneously obtain the outdoor unit address number. The outdoor unit obtains the address numbers of two or more indoor units using the procedure for requesting registration of the permanent address numbers from the indoor units. This series of procedures establishes the pairing of the indoor and outdoor units sharing the same refrigerant system.

4.5 Matching polarity

Finally network connectors connect all the refrigerant systems to one communication network. However, as the network connectors isolate the different segments during startup, the communication polarity that was established independently for any refrigerant system does not necessarily agree with the polarity established for the others. The system is designed such that a “finalization” process takes place on the outdoor unit of one selected refrigerant system so that the devices associated with other refrigerant systems adopt the communication polarity of the selected system.

4.6 Automatic address setting time

Testing showed that automatic address setting took 1 min to obtain tentative addresses for the maximum of 128 indoor units, and less than 5 min from startup to complete the permanent address number assignment of 128 indoor units and one outdoor unit simultaneously.

5. Conclusion

MHI is progressively expanding its range of multi-unit air conditioner models for buildings and centralized controllers equipped with Super Link II. MHI expects to see an increase in business for new and replacement installations given the increased expandability provided by the improved Super Link II communication system described here.

MHI is committed to developing innovative air conditioning products to satisfy the diversified market needs of its customers. These products not only provide the sophisticated functions that customers demand, but they are also easy and quick to install, and reduce installation errors.

References

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