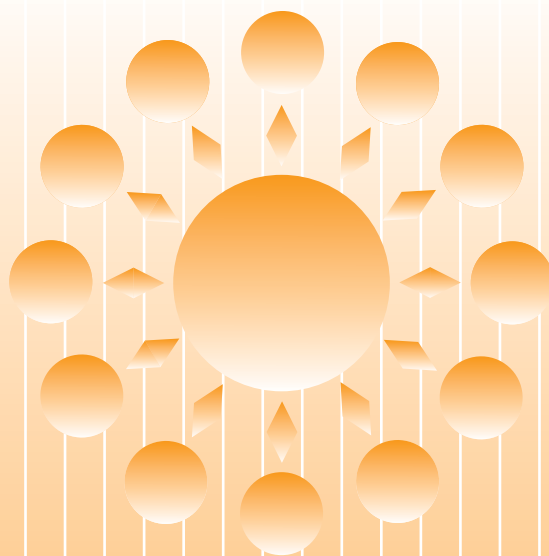


Multi-drop Network Provides One Shared Memory

Let's Try!
CUnet

How to Use MKY43/MKY46

For Beginners
For Field Engineers





Preface

Sending/receiving data between CPUs and personal computers (PCs) usually uses a method called "communications".

Networks established over public and private communication lines facilitate file transfer between PCs.

However, in a control system using many CPUs, system engineers have difficulties in evaluating network items, describing problems such as "LAN puts a heavy load on each CPU", "RS-232C baud rate is too slow", and "Using RS-485 requires programming of all applications from collision management to communication procedures".

What is necessary for an ideal sending/receiving data?

Let's say if memory were shared between all CPUs...?

In this 21st century, a very modern data exchange system, CUnet, has appeared, providing "multi-shared memory".

All you need is connect a multi-drop cable like an RS-485.

No protocol processing needed. Required data read and written performed when needed. Any CPU on network can read shared memory. Very fast data sharing achievable.

The CUnet allows the user to control real-time distributed processing and to simply develop sophisticated systems using multiple CPUs.

● CUnet

"CUnet" is a coined word combining "Collective Unconscious" (psychological term) and "Network".

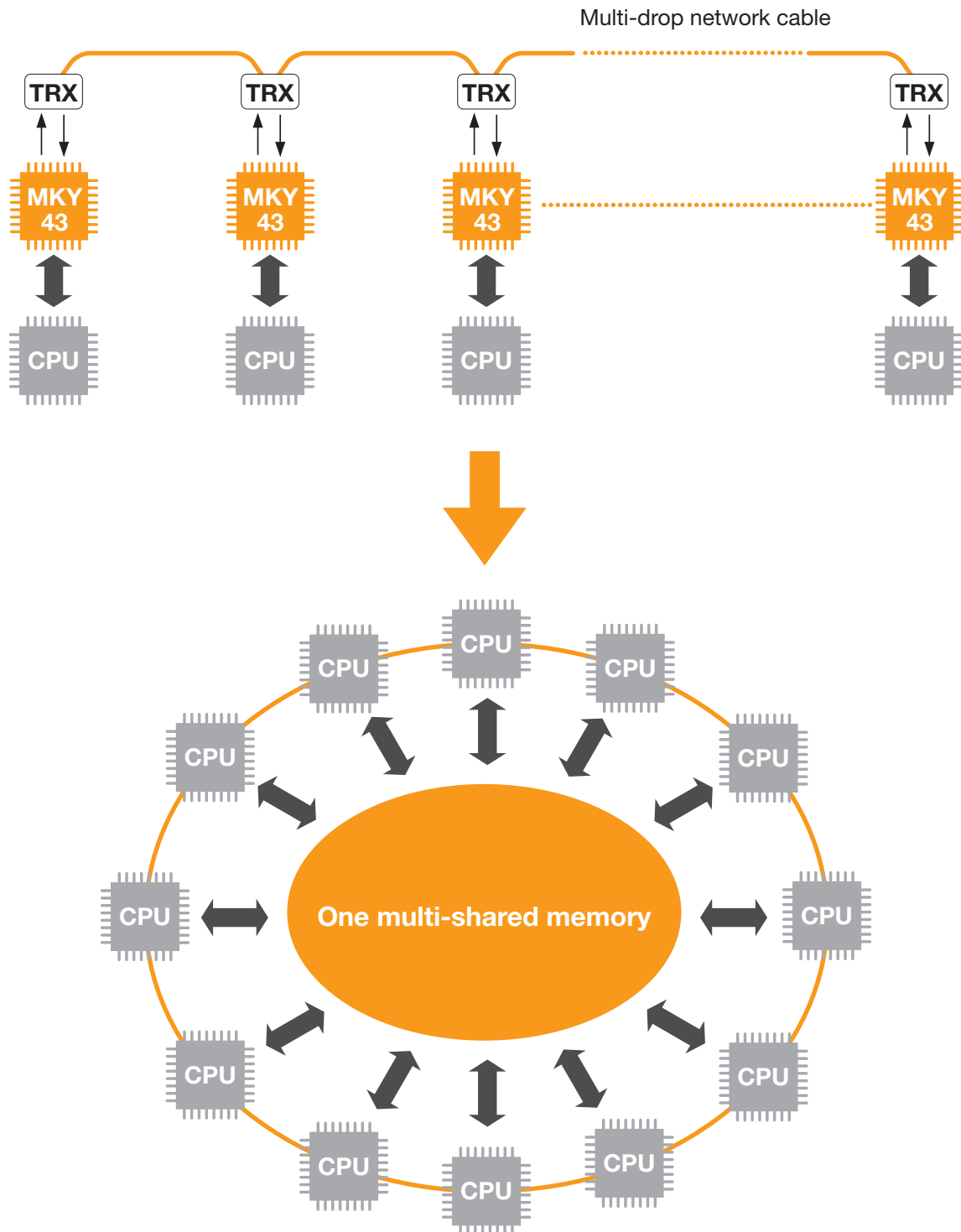
"CUnet" is a registered trademark of StepTechnica Co., Ltd.



"Multi-Shared Memory" due to Multi-drop Communications

In a system consisting of several equipment, connecting the MKY43 to the CPU in each equipment and connecting it to each other MKY43 using a multi-drop network cable provides one "multi-shared memory" that

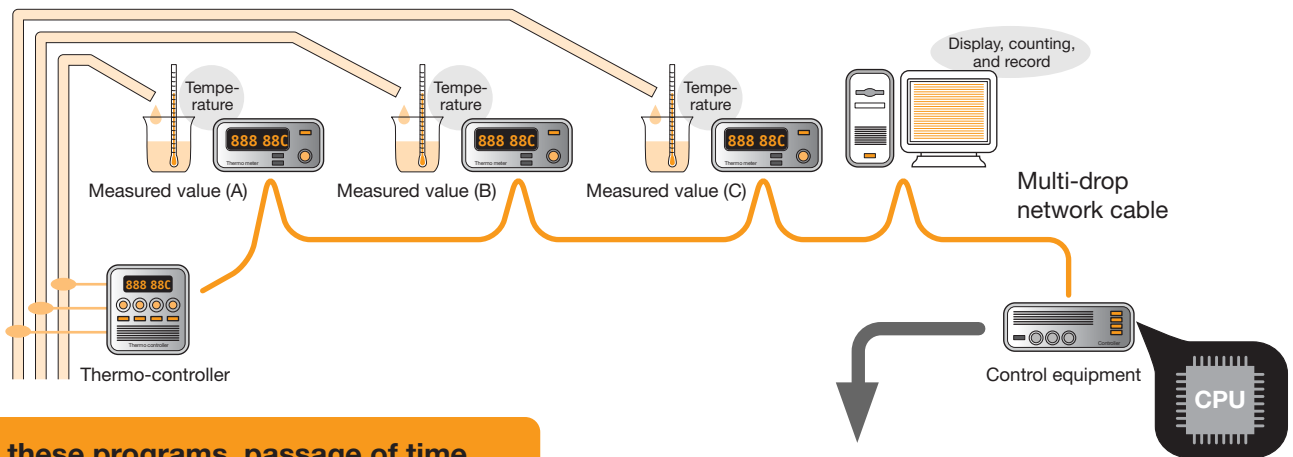
can be accessed from all equipment. With this system, data written by one CPU to the MKY43 can be read from any CPU on the system.



When Compared with Other Systems...

The figure below shows an example of counting and control based on data from three thermometers. In the current program-controlled communications systems, most CPU performance must be assigned to communication processing, preventing any increase in the control speed of the entire system. The algorithm in the figure below also shows that most communication programs are installed on each equipment.

Moreover, existing communications require consideration of communications time and program debugging at the destination equipment after completion of the program. This increases the degree of difficulty in designing the entire system, which mainly performs communication processing. There are some cases where problems, such as excessively low baud rate, occur only after all equipment are connected for communications.

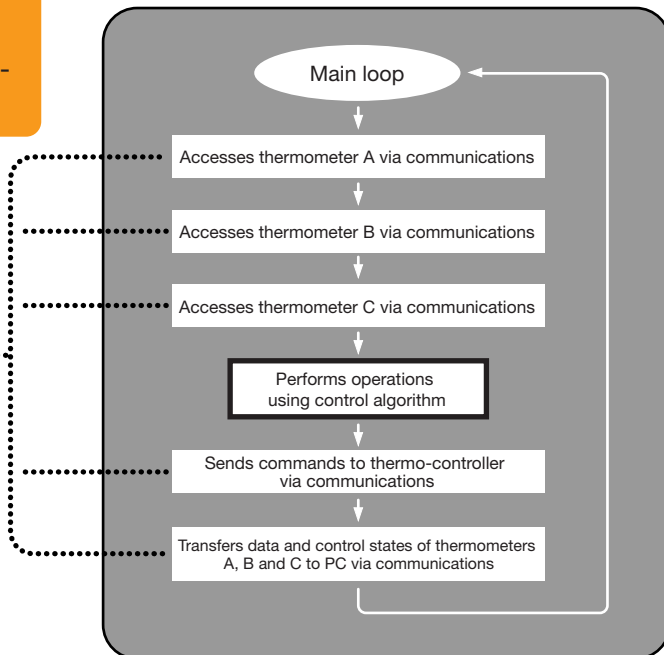


In all these programs, passage of time and labor costs must be considered.

(Even a simple system can only be built by intermediate or higher-level system engineers!)

● Communications Processing

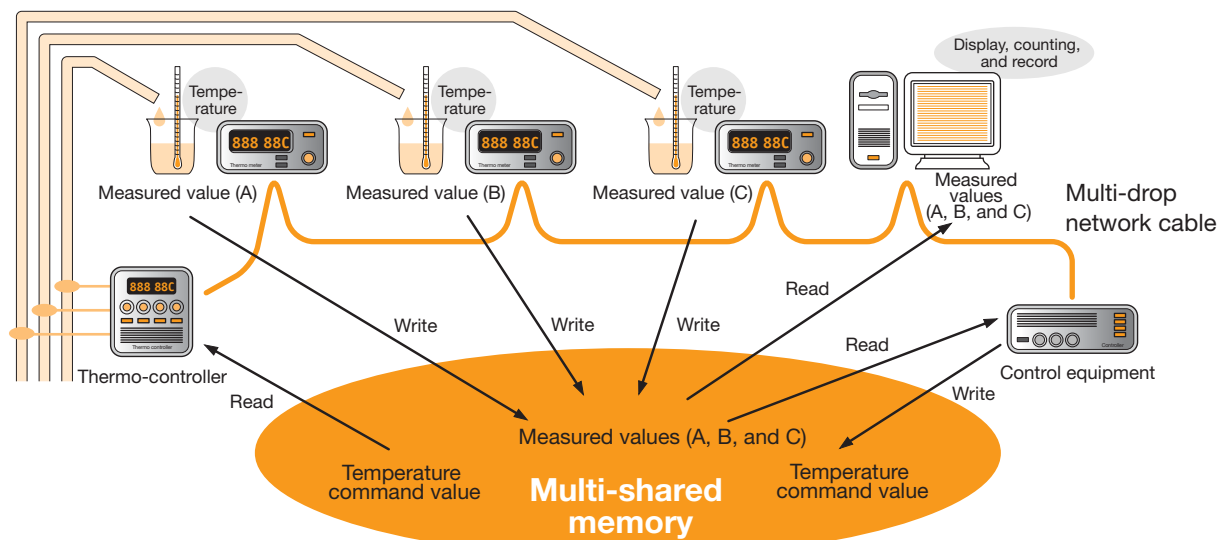
- Calls and sends to equipment
- Waits for responses from equipment
- Sends data and commands to equipment
- Waits for reception of data from equipment
- Completes communication with one equipment (checks for data quality and time-out)



Greatly-Reduced Communication Processing Overhead and Clearly-Achieved Functional Separation

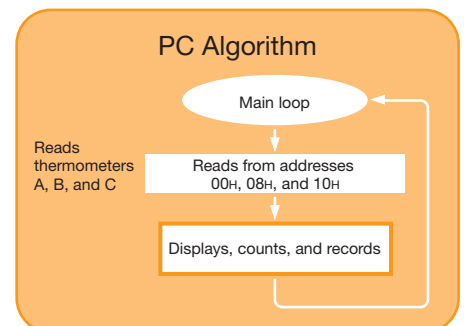
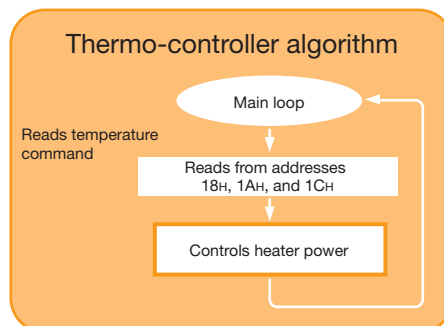
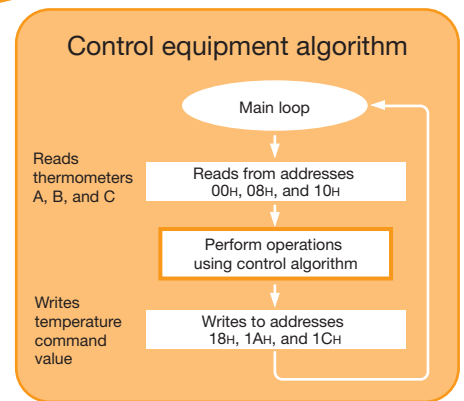
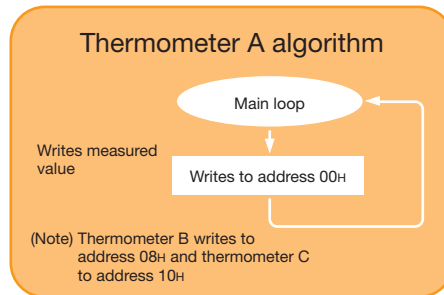
Let's say you build a system with the same configuration as on the previous page but using CUnet. Using CUnet greatly reduces the need to consider communications overhead when developing programs installed on each equipment. Using CUnet allows communications to be established just by read/write access to shared memory. Data of each equipment corresponds to each address in shared memory. Implementing CUnet memory sharing in this system of three thermometers, one control equipment, one ther-

mo-controller and one PC via a communication cable requires a processing time of only 210 μ s. As each algorithm below shows, each function can be separated clearly in the system implementing CUnet. (For example, when debugging only the algorithm of the control equipment, the user has only to install CUnet on a development PC and generate dummy data for other equipment, facilitating simulation. This allows debugging to be completed even if not all equipment constituting a system are not available.)



● Data definition map in shared memory (Each value is given as 16-bit data.)

Address	Content
00H	Measured value A
02H	
04H	
06H	Measured value B
08H	
0AH	
0CH	Measured value C
0EH	
10H	
12H	Temperature command value A
14H	
16H	
18H	Temperature command value B
1AH	
1CH	Temperature command value C
1EH	

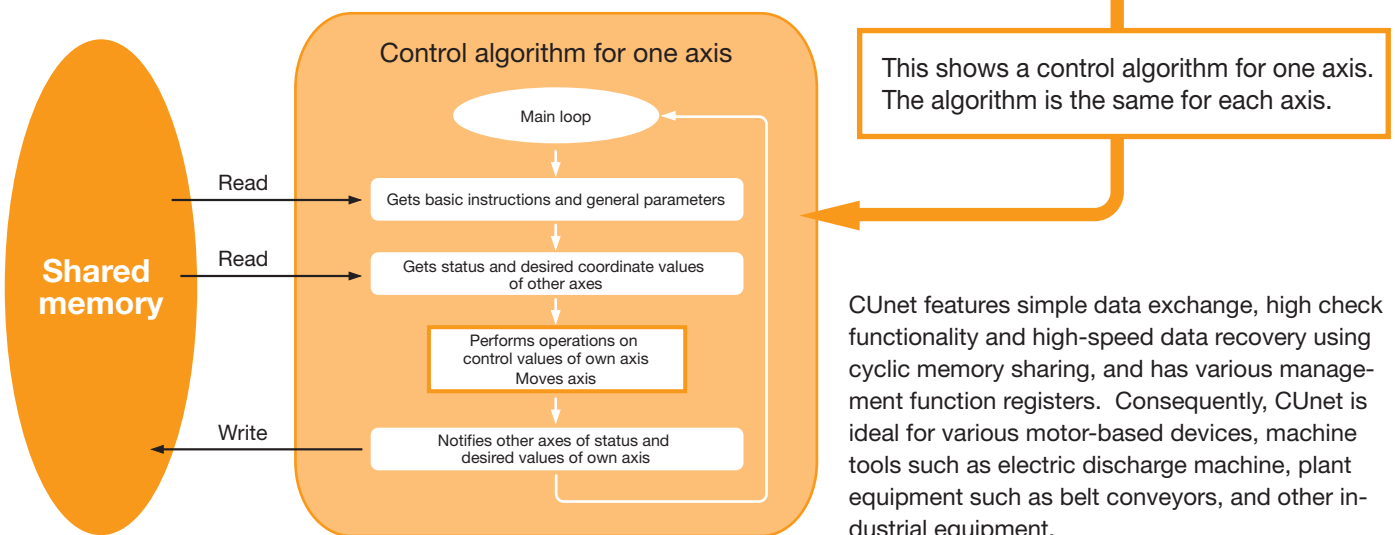
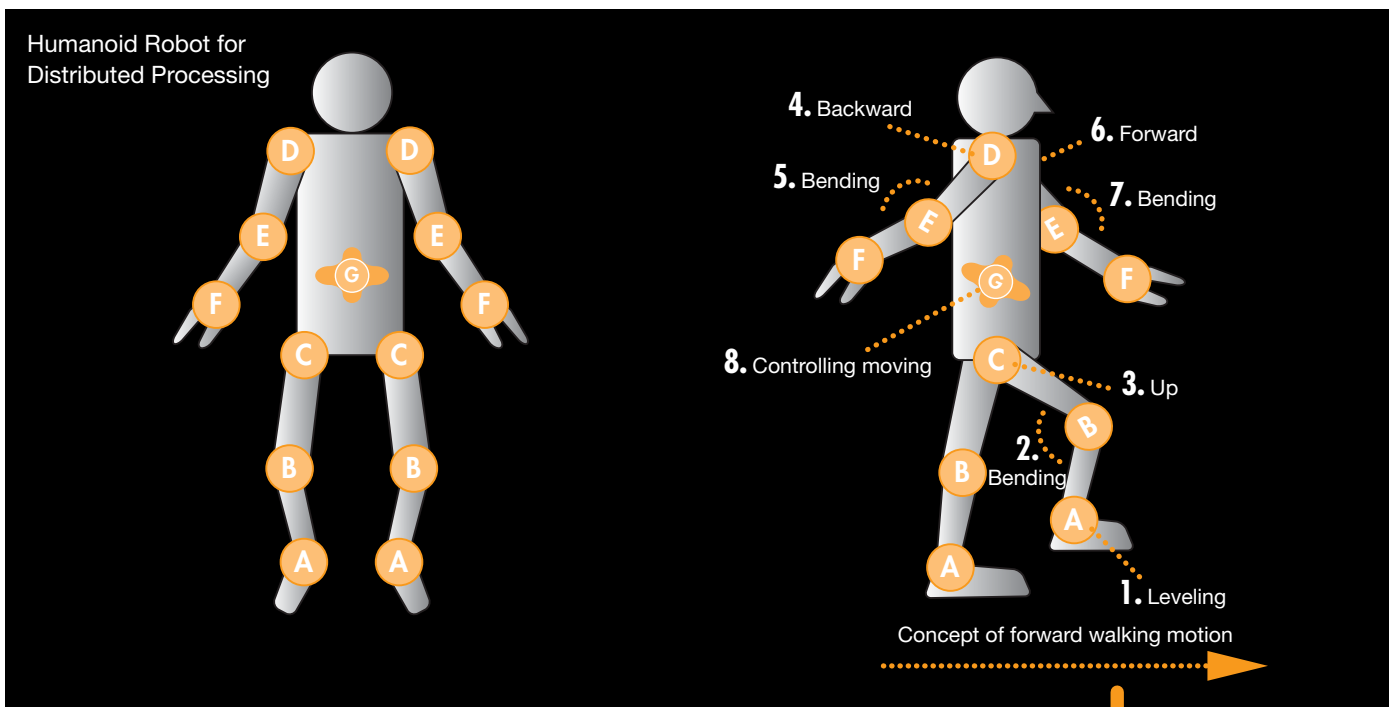


Implementing Real-time Distributed Processing Control (Highly effective for control of robots and multi-axis motion)

Controlling robots and multi-axis motion requires extremely fine and quick operation. Furthermore, the control algorithm also requires cooperative operation while tracking the operating status of other axes as data. On the other, due to the need to reduce the many data cables, many companies are attempting to achieve "real-time distributed processing control". However, this can be a difficult obstacle to overcome because there is no communications method that meets the needs.

CUNet provides a solution to this problem with optimum efficiency.

The figure below shows a schematic for a bipedal walking robot. Joints A to F and G have brains (dedicated CPUs) controlling joint status while recognizing the overall balance. Using CUNet in this robot reduces the individual processing (controls) and facilitates processing to make the bipedal walking more sophisticated.

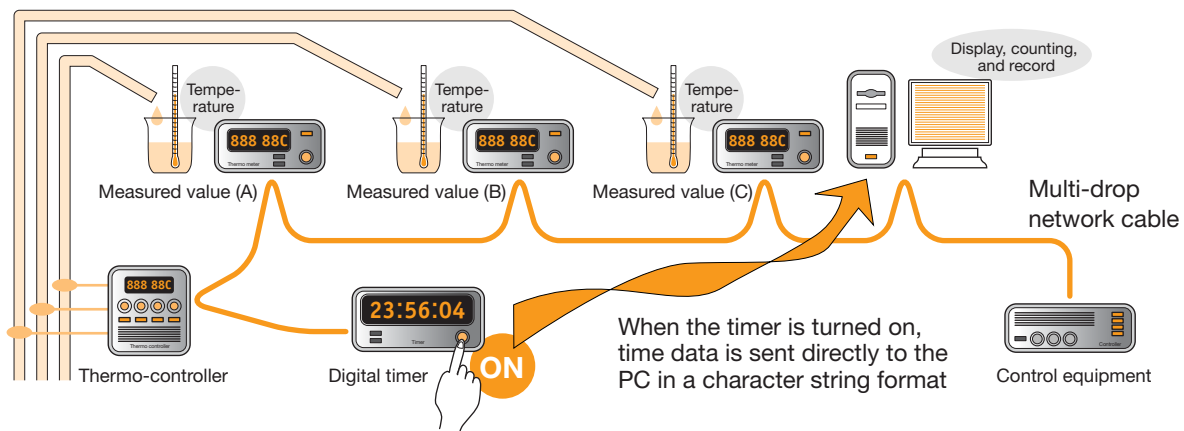


Mail Sending/Receiving of Datasets during Memory Sharing

► Mail Function

CUnet has a mail sending and receiving function. It is useful for sending/receiving of datasets that are sometimes required in a system. In the figure shown below, a timer is added for recording time data temporarily to a thermo-controller data. This figure shows a mechanism in which the time is sent directly to the PC as a dataset in a character string format as soon as the added digital timer is turned on. In addition to operating as one "multi-shared memory", CUnet can send and receive datasets using a peer-to-peer mail function. The mail function works independently of operating as

one "multi-shared memory". Therefore, the datasets sent and received by the mail function do not appear in the shared memory and are transferred directly to the mail receive buffers of the destination station (equipment). The speed and quality of real-time shared memory are unaffected. CUnet has protocols to overcome communication interference caused by external noise. Use of mail function of CUnet is very simple. Interrupt triggers can also be generated at the mail receiving side. A CUnet-dedicated IC, has mail send buffer and mail receive buffer in addition to multi-shared memory.

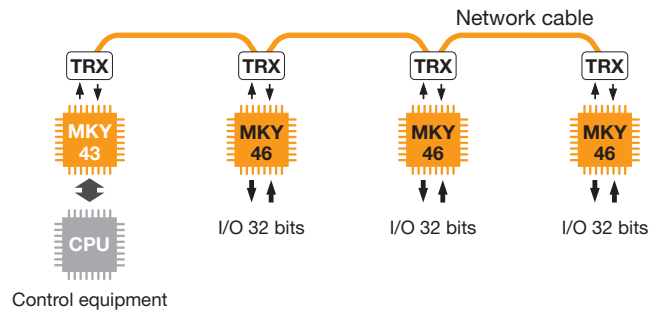
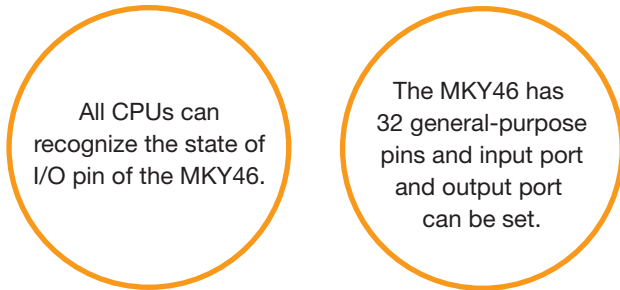


Remote I/O Equipment on Network

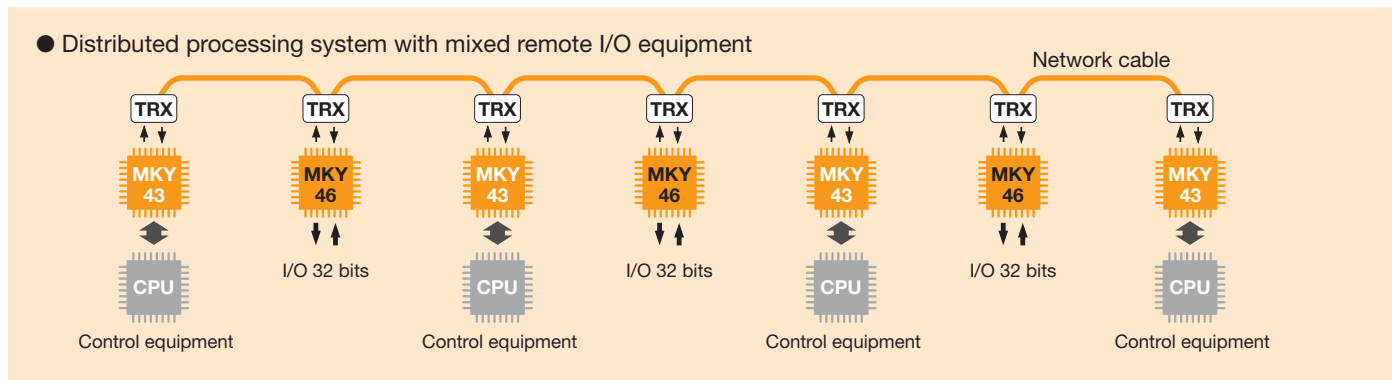
IO Mode

Using the MKY46, CUnet-dedicated I/O-IC, allows remote I/O equipment without CPUs to be mixed in CUnet (all equipment use the state of I/O pin).

● Remote I/O system with "1 station" : "several I/O terminals"



● Distributed processing system with mixed remote I/O equipment



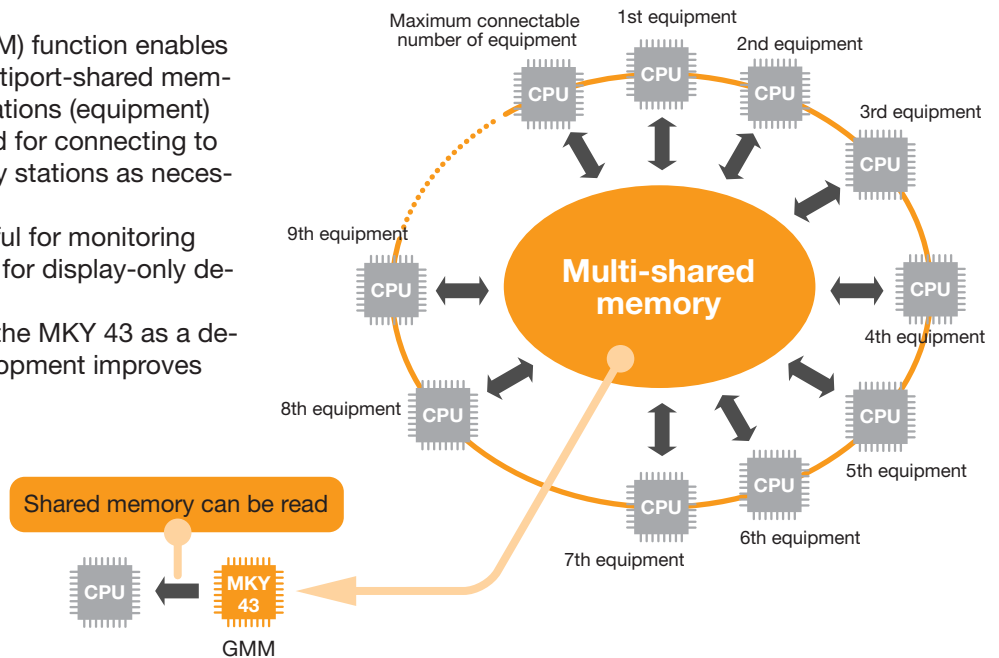
Monitoring of Multi-Shared Memory

GMM Function

The Global Memory Monitor (GMM) function enables CUnet to monitor data in one multipoint-shared memory. The maximum number of stations (equipment) for which this function is specified for connecting to CUnet is not counted, so as many stations as necessary can be connected.

The monitoring equipment is useful for monitoring system operation and is effective for display-only devices without "input".

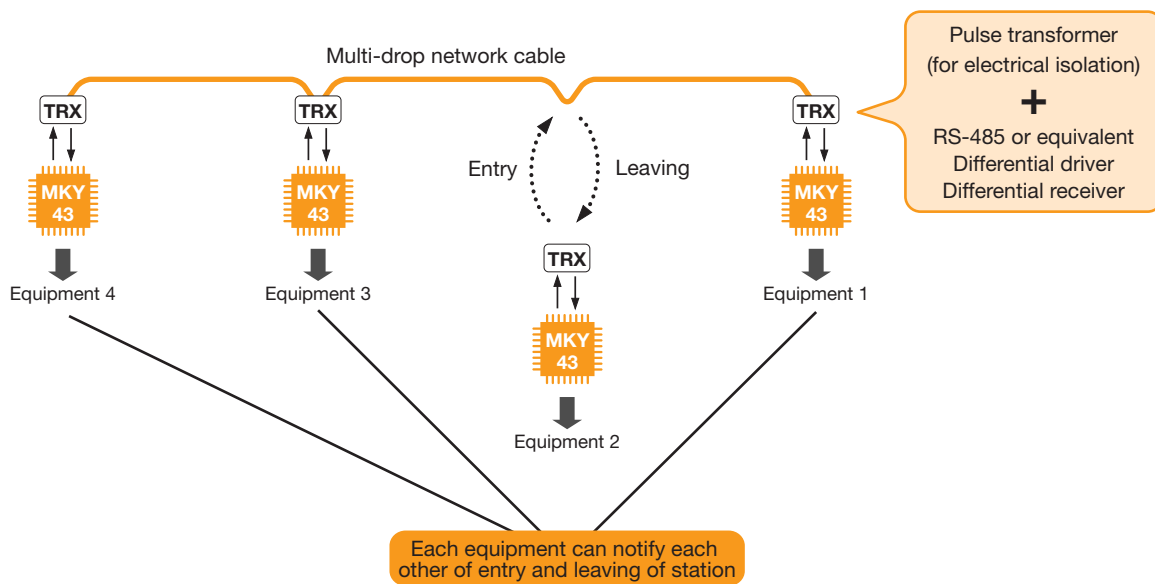
In addition, using the board with the MKY 43 as a debug monitor during system development improves development efficiency.



Entering into and Leave Network

An RS-485 (or equivalent) multi-drop connection and electrical isolation using a pulse transformer are usually recommended for a CUnet network.

Setting the management function registers of the MKY43 allows the user CPU to simply recognize that stations (equipment) enter into and leave network. (Generation of interrupt triggers due to the entry and leaving, can be set.)



How to Use MKY43/MKY46

For the MKY43 and MKY46, LSIs used to build a CUNet, basic memory sharing and other functions are introduced below in a question-and-answer format.

● For Beginners

- 10** Step01 How many MKY43 units can be connected? What is the size of shared memory?
- 11** Step02 Is it necessary to connect four MKY43s to a CPU when writing 32 bytes of data to multi-shared memory?
- 12** Step03 Does the MKY43 have to be initialized? Is it necessary to understand all registers?
- 13** Step04 When sending and receiving general (conventional communication) datasets using mail function, what is the size of datasets to be sent and received?
- 14** Step05 Does memory sharing assure real-timeness? How long does mail sending/receiving take?
- 15** Step06 What CPUs can be connected to MKY43?
- 16** Step07 What length of network cable is supported?
- 16** Step08 What kind of cables and drivers/receivers are supported?

● For Field Engineers

[Note] Prior knowledge of the CUNet memory sharing mechanism is required to understand this section.

- 19** Step09 What is the state of data in unused Global Memory (GM) areas? Does data in GM have to be initialized?
- 20** Step10 How does the user know whether the destination equipment enters the network? How does the user know the shared status of a GM area?
- 21** Step11 Does the user need to know that the program always monitor which part of the GM area is shared?
- 22** Step12 Is it necessary to always read GM to monitor that the destination equipment rewrites data?
- 23** Step13 What happens when an error occurs on a network?
- 24** Step14 What methods are available for application tests for noisy environments and evaluation of the network environment quality?
- 25** Step15 How does the user know that memory sharing in self-station is stopped?
- 26** Step16 How does added equipment behave after memory is shared?
- 27** Step17 What should the user consider in using shared memory?
- 28** Step18 How to avoid data hazards
- 29** Step19 Another pair of "hazard protection function" — WHPB1/WHCR1 and RHPB1/RHCR1
- 30** Step20 How to "monitor" GM during operation?
- 31** Step21 Can remote I/O equipment handling only the bit ON/OFF operation be placed on the network?
- 32** Step22 Can a CUNet be built by using only remote IO equipment without CPU and program?
- 33** Step23 Can all equipment be synchronized?
- 33** Step24 Can the user reset the CPU of a runaway equipment on a network?
- 34** Step25 How are data quality and reliability assured in CUNet?
- 34** Step26 Can program detect that a MKY43 is mounted?
- 35** Step27 What are the required settings of the MKY43?
- 35** Step28 How can the user know the mode of other equipment?
- 36** Step29 Can the user build a system with more than 64 stations?

How to Use MKY43/MKY46



For Beginners

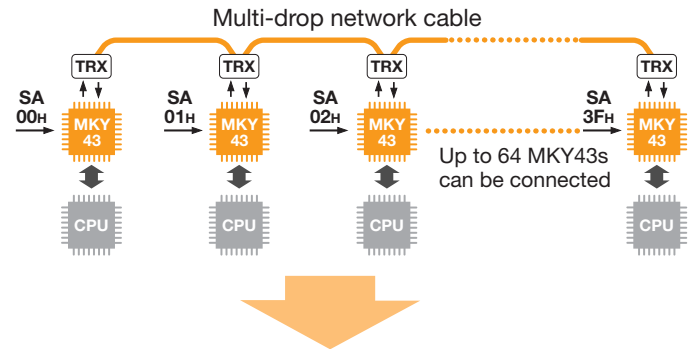
This section describes the basics for understanding and operating CUnet.

CUnet

Step 01

How many MKY43 units can be connected? What is the size of shared memory?

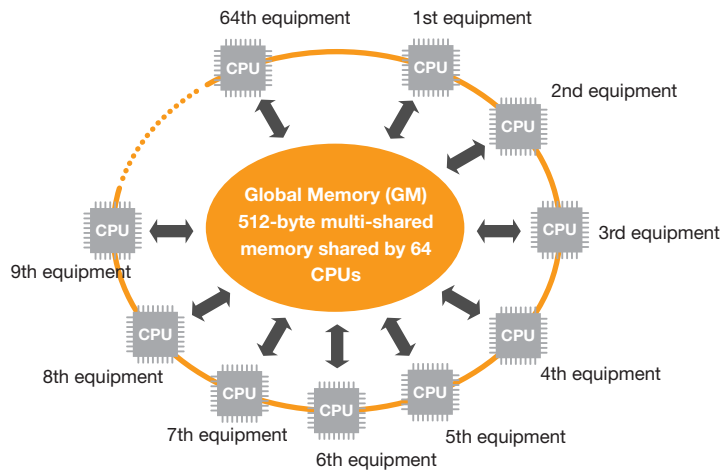
Up to 64 MKY43s can be connected. Each MKY43 is assigned a Station Address (SA) that identifies it. The value ranges from 0 to 63 (00H to 3FH).



The multi-shared memory is 512 bytes. The CPUs of all equipment can read the multi-shared memory. This multi-shared memory is called "Global Memory (GM)".

● Concept of CUNet

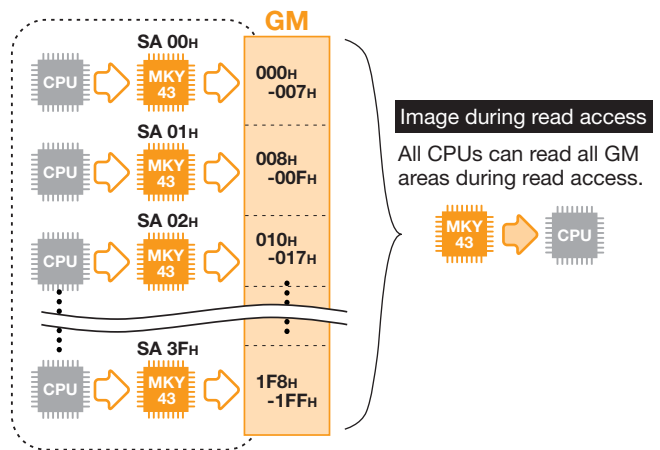
All CPUs can share data in one shared memory in real time.



● Access concept as seen from CPU

Area image during write access

The GM has 64 8-byte areas corresponding to each SA.



- The station with SA at address 0 (00H) can write data to the GM area at addresses 000H to 007H.
- The station with SA at address 1 (01H) can write data to the GM area at addresses 008H to 00FH.
- The station with SA at address 63 (3FH) can write data to the GM area at addresses 1F8H to 1FFH.

All stations can read all GM areas.

For example,

- All equipment can read the GM area at addresses 000H to 007H to get the data written by the station at address 0 (00H).
- All equipment can read the GM area at addresses 1F8H to 1FFH to get the data written by the station at address 63 (3FH).

Point

1. The size of one multi-shared memory is 512 bytes. Up to 64 MKY43s can be connected.
2. The GM is divided into 64 8-byte areas, corresponding to each SA. Addresses in the multi-shared memory correspond to each SA.
3. One station can write 8 bytes of data to the multi-shared memory.

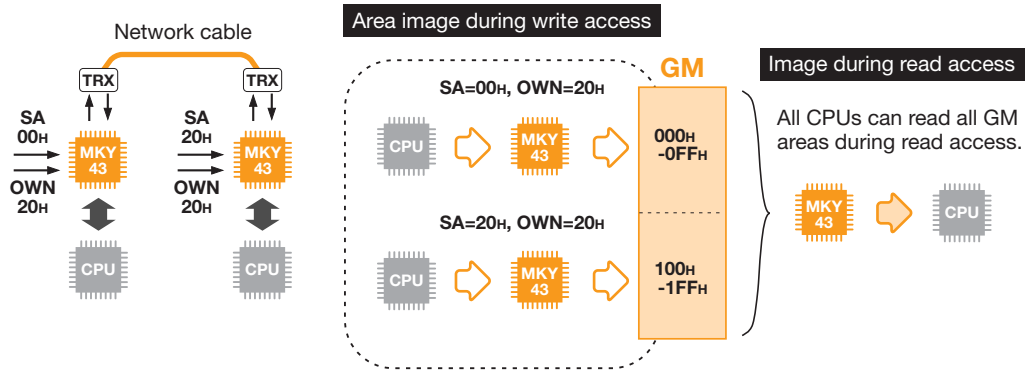
Step 02 Is it necessary to connect four MKY43s to a CPU when writing 32 bytes of data to multi-shared memory?

No, there is no problem with connecting just one MKY43 to a CPU. The MKY43 has an OWN Width (OWN) setting, meaning "how many 8-byte areas does the MKY43 own?" When writing 32 bytes of data to the multi-shared memory, set the OWN value to "4", which enables 32 bytes of data to be written to the multi-

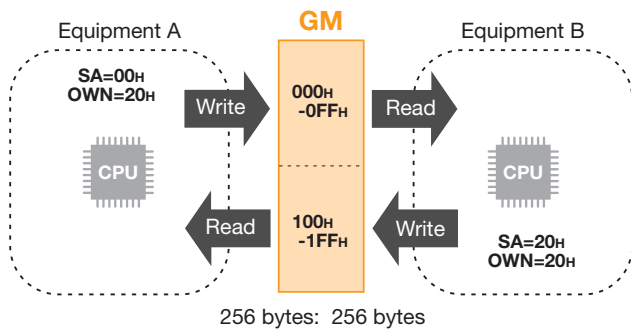
shared memory.

Therefore, when sharing 32 bytes of data, the user does not have to connect four MKY43s to a CPU.

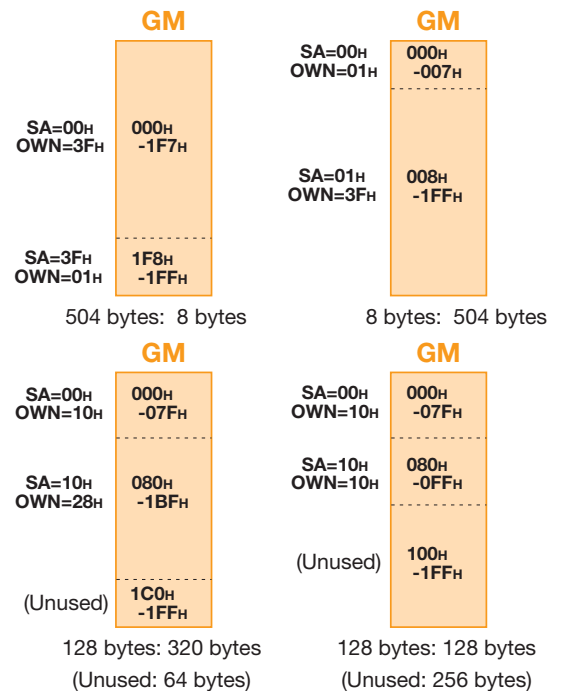
When connecting two stations (equipment) using the MKY43, the multi-shared memory can be divided into 256 bytes each (half size) as shown below.



● Data processed using GM in the middle of two stations (equipment)



● GM can be divided into any size as shown below. Unused areas may be allocated.



Note

1. Even when "0" is set to the OWN value, it is read as "1".
2. It is impossible to set SA and OWN that own the same memory area in two or more stations. (For example, a station with setting of "SA = 00H" and "OWN = 02H" and a station with setting of "SA = 01H" and "OWN = 01H" cannot exist within the same system.)
3. If the sum of setting values of SA and OWN is greater than "64", the area exceeding "63" will not be owned. (For example, a station with SA = 63 (3FH) cannot own more than 8 bytes, even if any OWN setting value is set.)

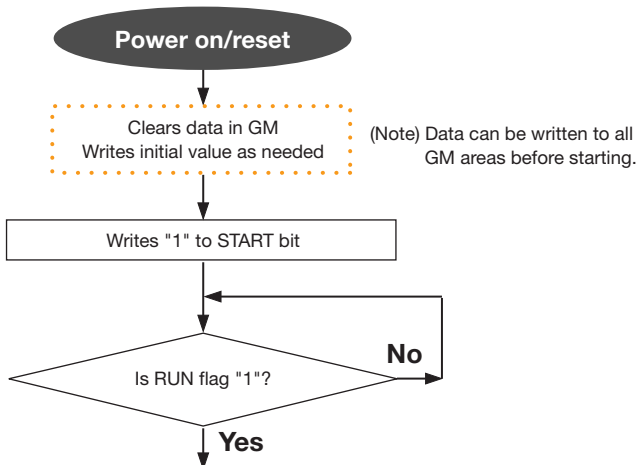
Step 03

Does the MKY43 have to be initialized? Is it necessary to understand all registers?

The MKY43 does not share memory after reset. Starting a network requires to operate only one bit (START bit). When the network is started and changes to a state where GM is shared, the RUN flag changes from "0" to "1". The MKY43 has various registers supporting sophisticated applications. The user should understand them as necessary.

Each register usually remains at reset by default, requiring no operation. When GM can be shared stably (, meaning link is stable), the MON pin of MKY43 is kept Low. The stable state of link can be checked visually by connecting an LED to the MON pin.

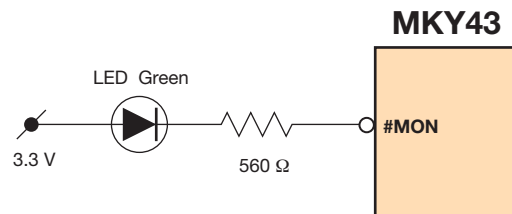
● Procedure for starting basic network



State where GM can be shared:

- Data can be written to the areas owned by the self-station (equipment).
- Data written by other stations (equipment) to GM can be read.

● Connection of LED indicating stable state of link

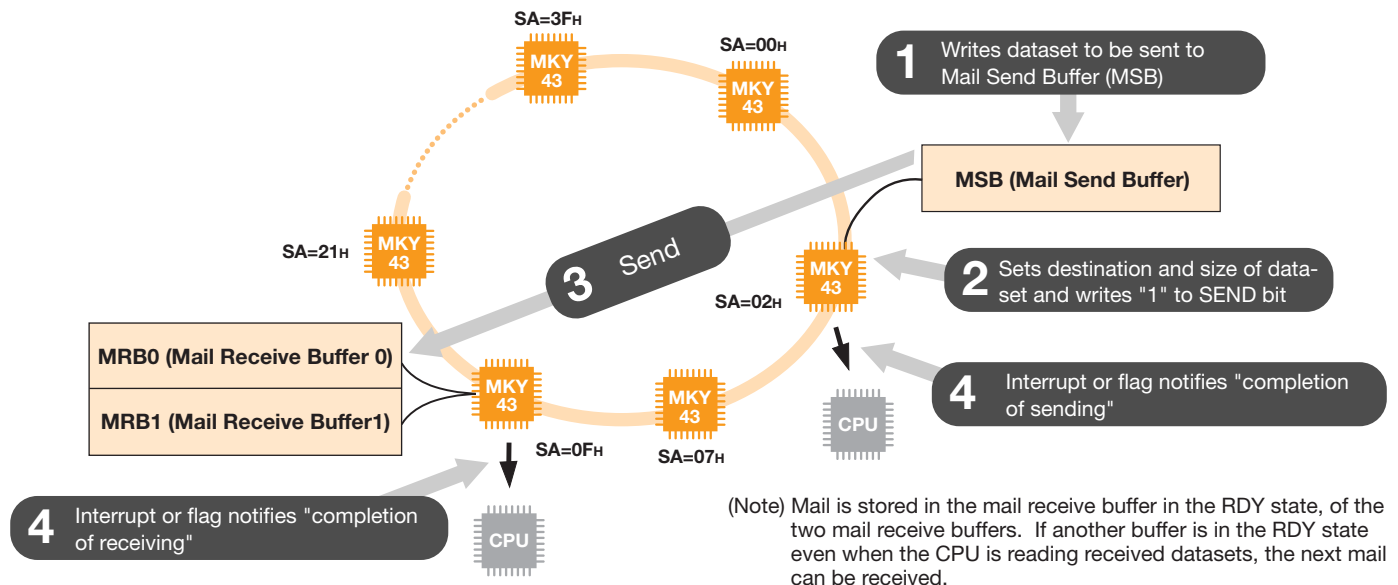


Step 04 When sending and receiving general (conventional communication) datasets using mail function, what is the size of datasets to be sent and received?

The MKY43 has mail sending/receiving function for peer-to-peer sending/receiving of mail. Up to 256-byte mail can be sent/received at a time. It has one 256-byte mail send memory and two 256-byte mail receive memory.

Actual mail sending/receiving is performed in the background and does not affect data in the multi-shared memory or the response speed.

● When sending mail from station (equipment) at "SA = 02H" to station (equipment) at "SA = 0FH"



Interrupts can be generated in MKY43 by "completion of mail receiving" and "completion of mail sending". When mail sending is stopped by an error, the error type can be referenced. In addition, the user can set time-out for sending and can know a time required for the actual mail sending.

▶ Error types in mail sending

- No destination
- Mail receive buffer on destination is not in RDY state
- Time-out
- Illegal setting
- Line interruption

Point

1. Write any dataset to the mail send memory and set the destination (equipment) and the size of datasets to write "1" to SEND bit. Mail sending starts.
2. All mail sending/receiving protocols including retry are performed by the MKY43.
3. Mail can be sent/received even when using GM.

Note

1. Broadcast mailing is not supported. (The CUnet protocol does not adopt broadcast mailing because it does not guarantee that the destination equipment receives data).
2. The station address (SA) owned and expanded by OWN setting cannot be specified as a mailing address. (If that address is specified accidentally, mail sending is terminated with "destination does not exist".)

Step
05

Does memory sharing assure real-timeness? How long does mail sending/receiving take?

The time required for all equipment to read the data that any equipment writes to GM corresponds to cycle time in the mechanism of the CUNet memory sharing. The cycle time in the CUNet memory sharing is very short (see the figure below), assuring real-timeness.

The cycle time is determined based on the baud rate and Final Station (FS) value. Baud rates of 12, 6 and 3 Mbps are recommended for MKY43. The FS value is a setting value to determine how many areas can be shared and valid from the beginning of 512-byte shared memory. (The FS value at reset default is "63" (3FH).)

● **Cycle time at typical FS values**

	FS value (Final Station)	Cycle time			Connectable number of stations
		12 Mbps	6 Mbps	3 Mbps	
Fastest →	1	102.0 μs	204.0 μs	408.0 μs	2
	3	155.0 μs	310.0 μs	620.0 μs	4
	7	265.0 μs	530.0 μs	1.060 ms	8
	15	501.0 μs	1.002 ms	2.004 ms	16
	31	1.037 ms	2.074 ms	4.148 ms	32
	47	1.659 ms	3.317 ms	6.634 ms	48
Reset default →	63	2.365 ms	4.730 ms	9.460 ms	64

Time required for mail sending/receiving depends on the baud rate, FS value and size of datasets to be sent. The sending/receiving time at a baud rate of 12 Mbps and a FS value of "63" (3FH) is about 27 ms for a 64-byte sending and about 83 ms for a 256-byte sending. This is equivalent to about 3 kilobytes/second (about 34 kbps) compared to RS-422 or RS-485 data transfer. (The mail sending/receiving time is much faster in a system with small FS values.)

● **Typical estimated mail sending/receiving time**

Size of dataset	Estimated sending/receiving time
64 bytes	27 ms
256 bytes	83 ms

Point

The estimated cycle time and mail sending/receiving time can be calculated using the equation described in the manual.

Operation of FS: Resizing

In CUNet, changing an FS value (by the user) is called "resizing". Writing the change value to the New Final Station Register (NFSR) of the MKY43 updates the FS values of all stations connected via the cable.

Resizing is terminated when the MKY43 finishes sending the resizing instruction packet four times. The NFSR also changes to 00H.

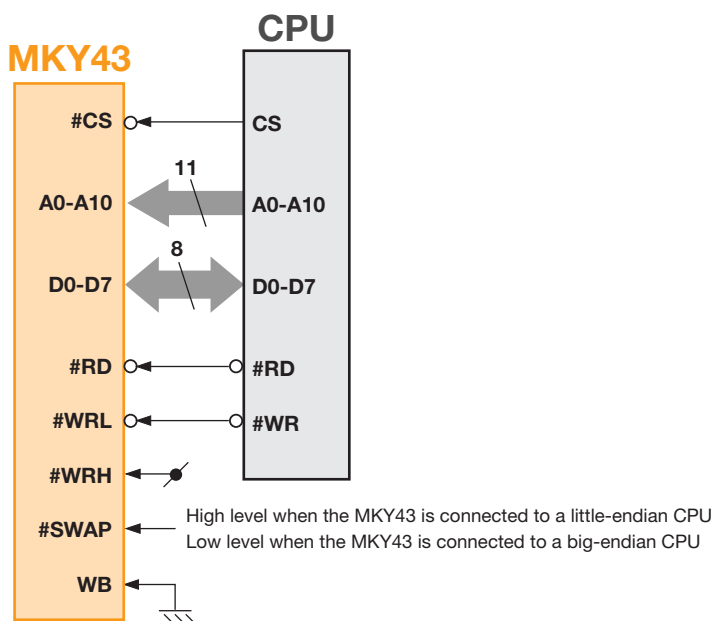
Step 06

What CPUs can be connected to MKY43?

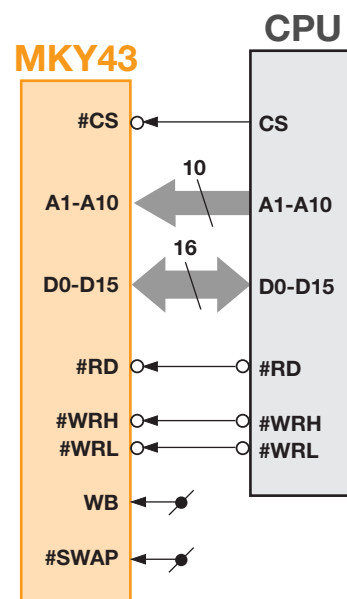
The MKY43 is assumed to be static RAM. Therefore, the CPU and MKY43 are connected by bus signal lines (address, data, read, and write). The access speed is 89 ns. The CPU interface of the MKY43 is 5-V tolerant type and can be connected to bus signal lines of a 5-V CPU.

The MKY43 has two pins to generate interrupt trigger signals to a CPU when it detects the state transition of a network and data transition in GM. Several interrupt factors can be set for one output pin of an interrupt trigger signal. The interrupt factors are set using the internal registers of the MKY43. At reset, an interrupt trigger signal is set not to generate by default.

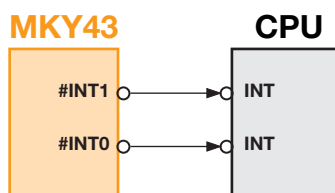
● CPU Connection via 8-bit bus



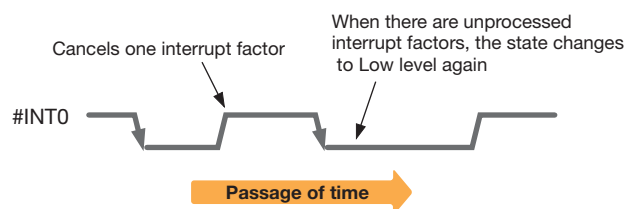
● CPU Connection via 16-bit bus



● 2 output pins of interrupt trigger signals (Several interrupt factors can be set for each pin.)



● #INT0 and #INT1 pins with retrigger function



The MKY43 has a retrigger function. Using this function, when any uncancelled interrupt factors are still left for the pin when the interrupt trigger signals for which several interrupt factors are set are cancelled, the MKY43 can output valid interrupt trigger signals again.

Step 07

What length of network cable is supported?

The cable length to be used varies with the baud rate. The table on the right shows the network cable lengths when the number of connection points of a multi-drop network cable is 32.

Inserting a CUnet-dedicated HUB into the network cable allows the supported length to be extended several times.

Baud rate	Network cable length
12 Mbps	100 m
6 Mbps	200 m
3 Mbps	300 m

Note

The cable length depends on the kinds and number of driver/receiver components multi-drop connected as terminals, and the cabling environment. Therefore, the above values are provided as a guide for stable use under prevailing conditions. (Performance is not guaranteed.) The recommended differential driver/receiver is an RS-485-based driver/receiver. Therefore, the branch count "32" stipulated in the RS-485 specification is used as a guide in the above table.

Up to 64 CUnet stations can be connected to the CUnet, enabling connection of "64" branches in terms of the function. This recommended network is isolated electrically by a pulse transformer and the format of signals propagated through the network is RZ (Return to Zero). Consequently, "64" branches can be connected using a standard RS-485-based driver/receiver without using DC component signals. In this case, the cable length is likely to be shorter than the value in the above table (due to increase of dispersion of propagated signal energy).

StepTechnica recommends about half the limit length in our practical experiment as the recommended length shown in the above table.

Step 08

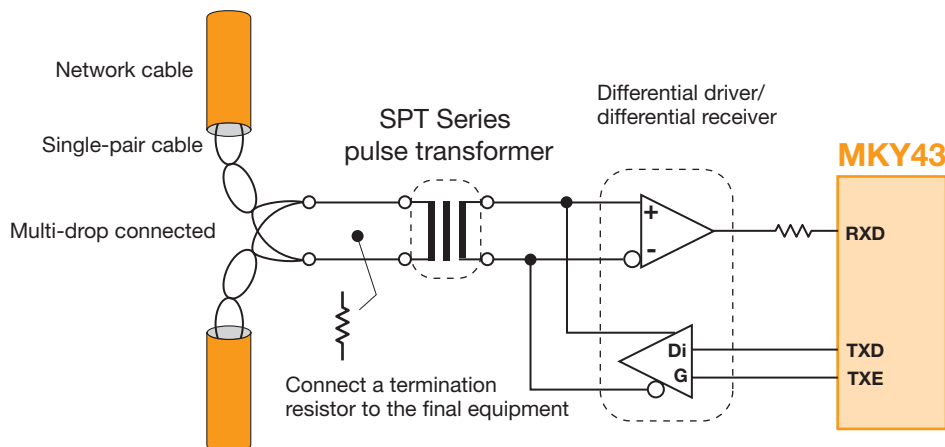
What kind of cables and drivers/receivers are supported?

Network cables

StepTechnica recommends cables equivalent to or better than Ethernet LAN cables (Category 3 or higher) be used. StepTechnica also recommends shielded cables providing high transmission performance and high workability (ZH series). (Contact your sales agent.)

Drivers/receivers

Use a differential driver/differential receiver for RS-485. (Select a type available for the baud rate set to the MKY43.)



Pulse transformer

StepTechnica recommends a pulse transformer be used to provide electrical isolation between the network cable and equipment. For the SPT series of pulse transformers, contact your sales agent.

How to Use MKY43/MKY46



For Field Engineers

This section answers questions from field engineers who have technical network experience.

What should we do if equipment is unexpectedly disconnected while using the network?

Who manages it and when?

How do we perform phase matching, at startup, between equipment that cannot be turned on concurrently?

Management and processing for the system are required.

The degree of difficulty of system development increases as the network is growing faster and data is processed more and more frequently.

CUnet can significantly reduce these problems.

CUnet has a very fast data transmission speed over the network cable. It requires a CPU running at tens of MIPS to constantly manage the network states using the program because one item must be executed in several microseconds. Under such circumstances, there is nothing about using a network.

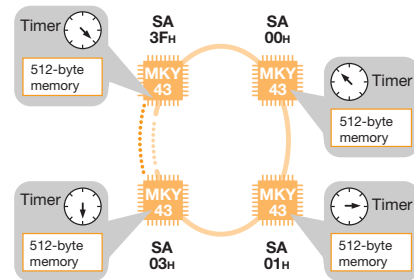
The MKY43 has various network management functions, allowing users to focus on system operation and releasing them from the duty of network management.

Note: This section describes only useful functions of the MKY43.

Prior knowledge

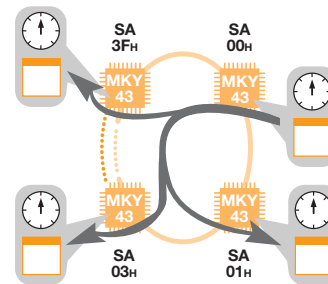
► CUnet Memory sharing mechanism

1. MKY43 has its own timepiece (timer) and 512-bytes of shared memory.
2. The timer is calibrated by network packets. As a result, all timers of MKY43s connected to the network tick the same time at the same speed and they keep the same state. One cycle of time of this timer is a cycle time.
3. When the time is "0", the packet with 8-byte data at memory addresses 000H to 007H is sent from the station (equipment) at SA [00H] to the network. All stations connected to the network receive this packet and read the received 8-byte data into their memory addresses 000H to 007H.
4. When the time is "1" immediately after the operation (of when the time is "0"), the packet with 8-byte data at memory addresses 008H to 00FH is sent from the station (equipment) at SA [01H] to the network. All stations connected to the network, as in the case of above, read the received 8-byte data into their memory addresses 008H to 00FH.
5. When the time reaches "63", 8-byte data at memory addresses 1F8H to 1FFH is sent from the 64th station at SA [3FH] and is read into memory addresses 1F8H to 1FFH of all stations.
6. Next, the timer of the MKY43 passes through two system management timers (public frames) to reach the time "0".
7. Continuing the operations in the steps 3 to 6 above for constant circulation makes data in the 512-byte memory of each station identical in all stations, providing a situation similar to the existence of one multi-shared memory. This is the CUnet memory sharing mechanism.
8. If anything other than "0" or "1" is set to an OWN width (OWN), one station has the right to send data of its owned width, expanding its owned area. For example, when the station at SA [00H] has an OWN value of "4", it acts as the station at SA [01H] to send data when the time is "1"; it acts as the station at SA [02H] to send data when the time is "2"; and it acts as the station at SA [03H] to send data when the time is "3".
9. In addition to 512-byte memory used as the above shared memory, each MKY43 has one 256-byte mail send buffer and two 256-byte mail receive buffers for mail function. Executing the mail function uses two system management timers (public frames) at the final position of one cycle of the timer. Therefore, a constant cycle time is guaranteed even during mail sending and receiving without disturbing the shared-memory mechanism.



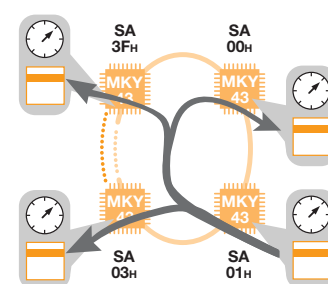
On starting, times are all different.
All times are set to the same time when receiving a packet.

3. Operation in the step 3



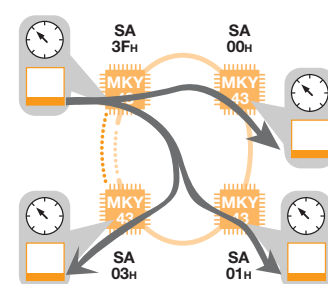
Data at memory addresses 000H to 007H is sent to all equipment from the station at SA = 00H.

4. Operation in the step 4



Data at memory addresses 008H to 00FH is sent to all equipment from the station at SA = 01H.

5. Operation in the step 5



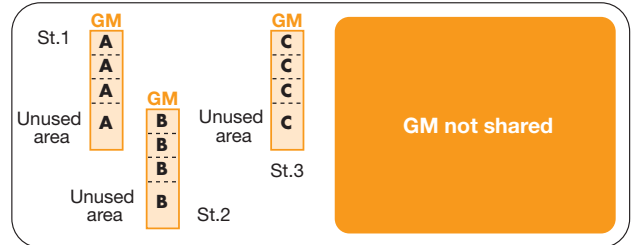
Data at memory addresses 1F8H to 1FFH is sent to all equipment from the station at SA = 3FH.

Step 09

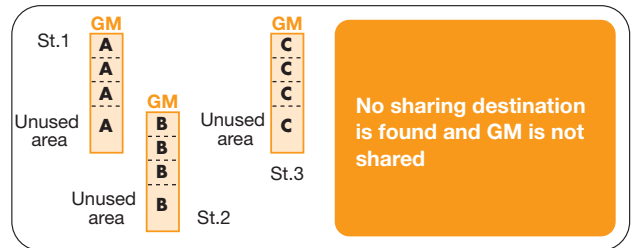
What is the state of data in unused Global Memory (GM) areas? Does data in GM have to be initialized?

Data in GM is undefined after power-on. MKY43 can write data to all GM areas before the START bit of the System Control Register (SCR) is "ON". Data in GM should usually be cleared to 00H by initialization after power-on. All areas other than the owned area of the self-station specified by SA and OWN are write-protected after the START bit of the SCR is "ON". Unused GM areas do not change from the value cleared as mentioned above. When the network starts operating, the data in the area specified by SA and OWN of each station (equipment) is shared. When specific initial data is required, write the specific initial data before the START bit is "ON".

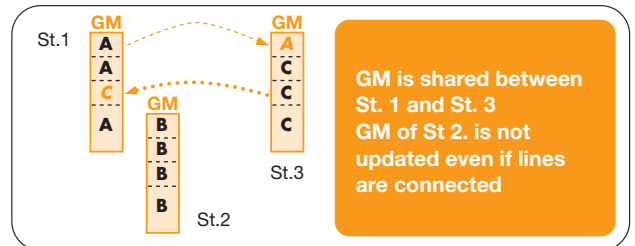
● Data transition in each GM area for start operation in system consisting of three stations (St)



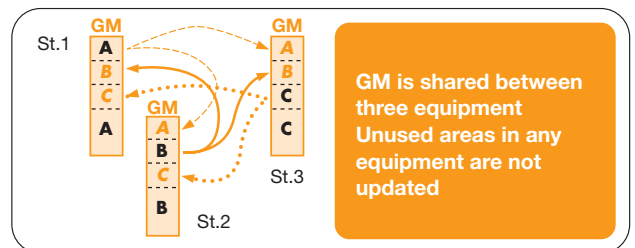
When the START flag of St. 1 is "ON"



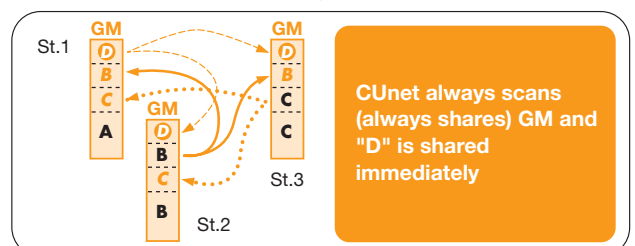
When the START flag of St. 3 is "ON", the RUN flags of St. 1 and St. 3 are set to "1"



When the START flag of St. 2 is "ON", the RUN flag of St. 2 is set to "1"



St. 1 writes data "D" to the self-area



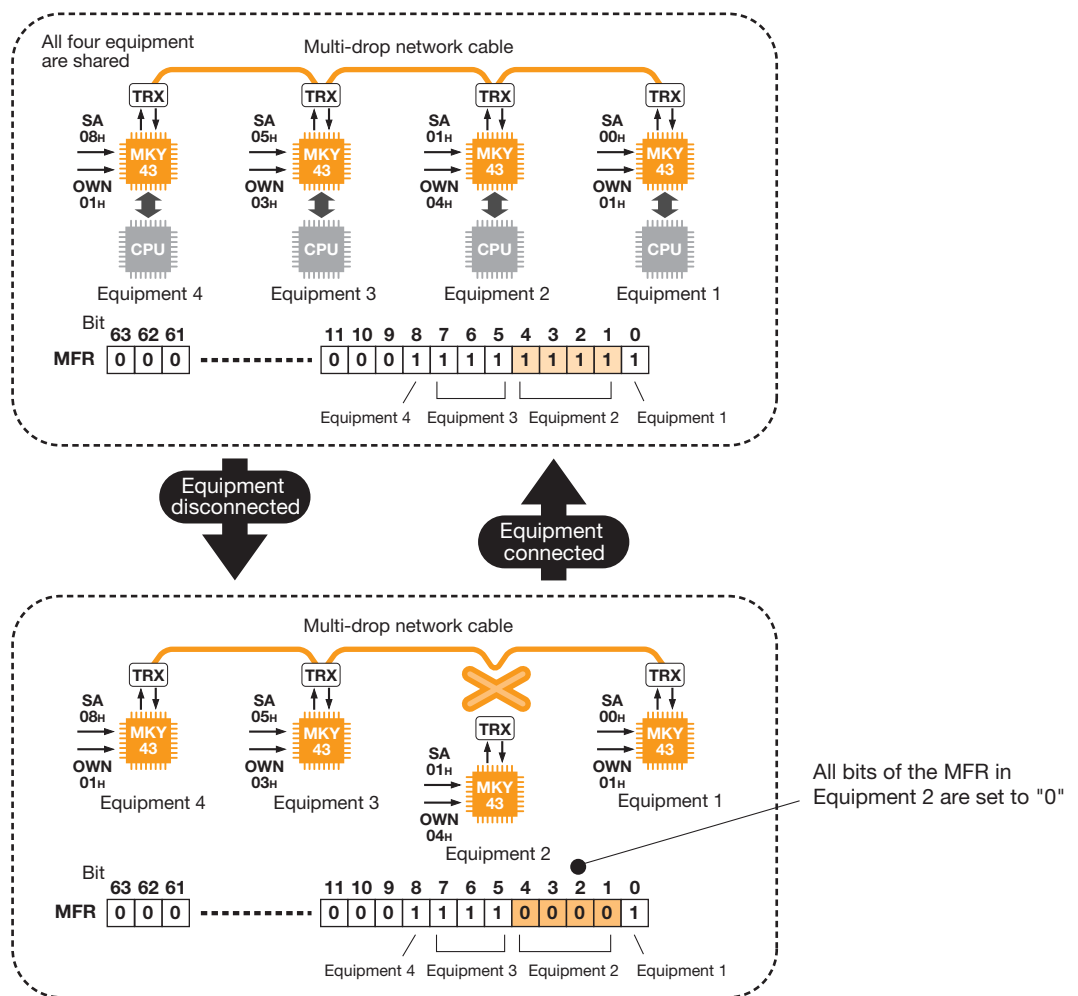
Step 10

How does the user know whether the destination equipment enters the network? How does the user know the shared status of a GM area?

The MKY43 has several types of registers with 64-bit flags corresponding to SA addresses 0 to 63 (64 addresses: 00H to 3FH). One of them is a Member Flag Register (MFR) where the bit of the SA area in which GM is shared, is set to "1".

Using the MFR allows the user to know whether the destination equipment enters (is connected to) the network and whether GM is shared. This will help the user recognize the state of individual stations (equipment) corresponding to the SA addresses. The bits of the MFR for the owned area of the self-station are always "1" while the system is in the RUN state.

● Behavior of MFR in four equipment



Point

The area where the member flag in the MFR is set to "1" means memory is shared.

Note

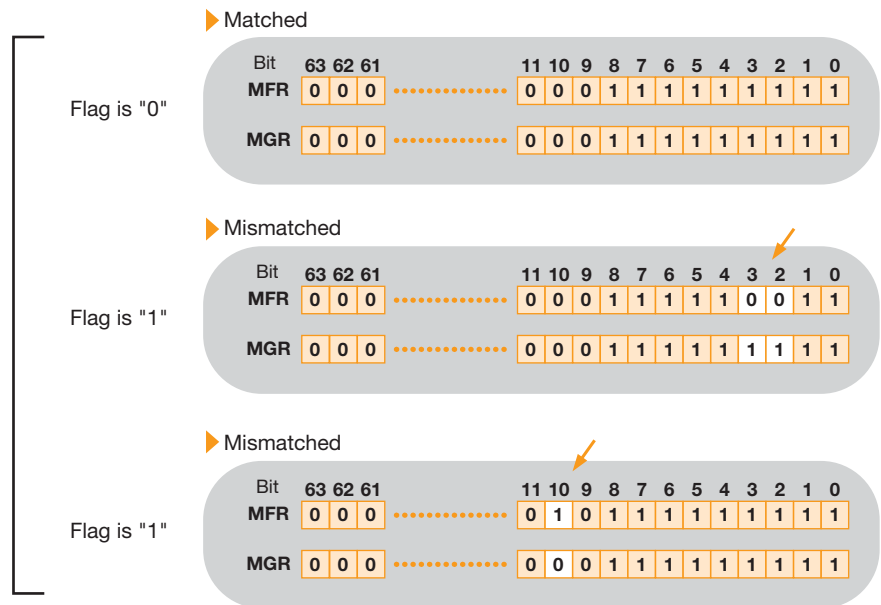
In CUnet, GM is always scanned at every cycle time. The member flag is set to "1" when the connection can be checked in consecutive three cycles, and is set to "0" when the connection cannot be checked in consecutive three cycles.

Step 11 Does the user need to know that the program always monitor which part of the GM area is shared?

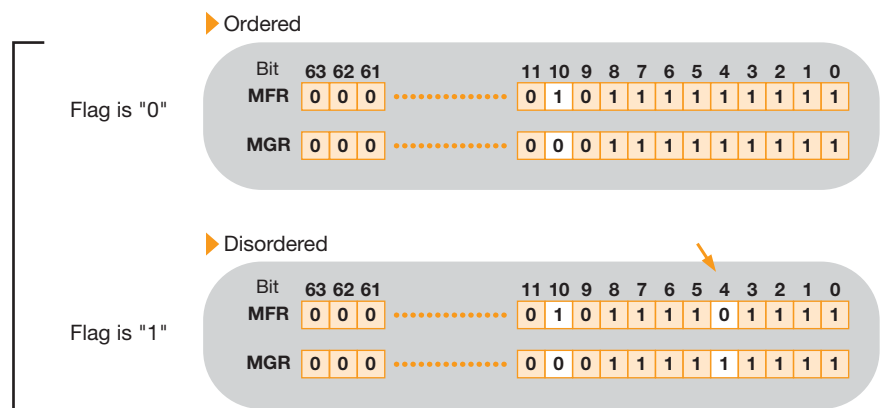
The MKY43 has a Member Group Register (MGR) paired with MFR. The MGR is a 64-bit register like the MFR. The MFR is a read-only register and the MGR can read and write. The area where the sharing state is to be monitored is set to the MGR beforehand. This enables batch monitoring of the "matched/mismatched" state or the "ordered/disordered" state between the MFR and MGR. An interrupt can be generated "when the mismatched state occurs" and "when the disordered state occurs".

This interrupt generation eliminates the need for management programs. A System Status Register (SSR) of the MKY43 has a bit to be set to "1" when the mismatched state occurs and a bit to be set to "1" when the disordered state occurs. Monitoring the bits enables a system not using an interrupt to manage the sharing state of areas collectively stored in the MGR. At reset, the MGR is all set to "0" where no areas to be monitored are set.

● Flag indicating match/mismatch Bit 4 of SSR (Member Group Not Equal)



● Flag indicating order/disorder Bit 5 of SSR (Member Group Not Collect)



**Step
12**

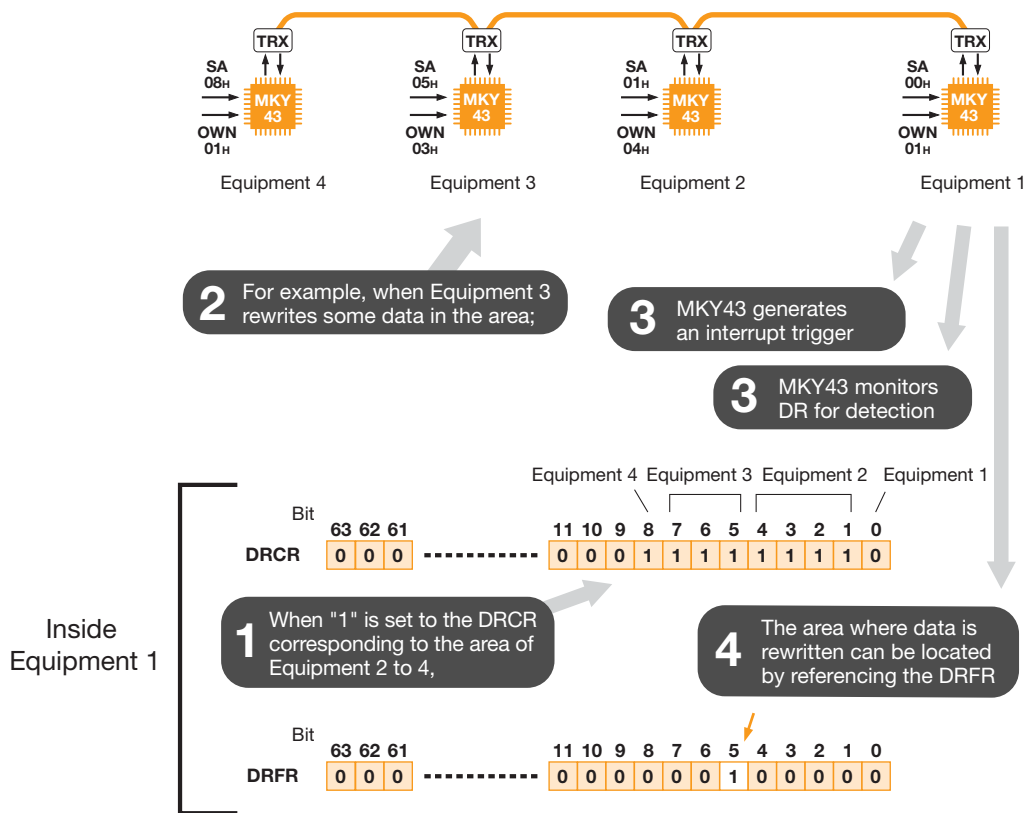
Is it necessary to always read GM to monitor that the destination equipment rewrites data?

The MKY43 can be set to detect that data in the GM area has been rewritten using the Data Renewal Check (DRC), which is performed by a 64-bit Data Renewal Check Register (DRCR). When data in the SA area where "1" is set to the DRCR is written, the MKY43 can output an interrupt trigger signal. The SSR of the MKY43 has a "Data Renewal (DR)" bit that is set to "1" when data in the destination equipment set in the DRCR is rewritten. This enables a system not using interrupts to perform batch monitoring.

An SA area in the destination equipment set in the DRCR where data is rewritten can be located by referencing a 64-bit Data Renewal Flag Register (DRFR) paired with the DRCR register.

The DRFR and DR bit are refreshed every CUnet cycle for subsequent data renewal. When a data renewal interrupt is generated, the DRFR and DR bit freeze until the interrupt is terminated.

● **Flow of data renewal detection**



Note

To generate a data renewal interrupt trigger signal, the user must set the timing of signal generation during a CUnet cycle to the Interrupt Timing 0 Control Register (IT0CR) or IT1CR. This prevents generation of interrupt trigger signals so frequently (at intervals of several tens to hundreds of microseconds) that ordinary CPUs and programs cannot follow.

Step 13

What happens when an error occurs on a network?

Possible network problems include the three items described on the right. To avoid these problems, CUnet monitors and manages equipment in the sharing state by handshaking individually with all stations (equipment).

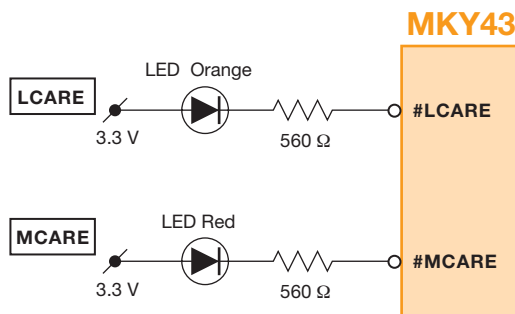
The MKY43s handle each of the following events.

1. Instantaneous communication interference caused by external noise
2. Disconnection of network cable or connector, equipment disconnection, and equipment power-off
3. Driver/receiver failure

1. Instantaneous communication interference caused by external noise

- ▶ The MYK43 determines whether to discard the packet being received immediately after receiving noise. If the data quality is poor, the received packet is discarded.
- ▶ In this case, an LED driving pulse is output from an LCARE pin of the MKY43. During this period, data from the preceding cycle remains in GM until updated in the next cycle. The presence or absence of data in one preceding cycle can be recognized by referencing the Link Flag Register (LFR) and Receive Flag Register (RFR).

● Connecting LED pins



(Note) The LED lights for about 50 ms

2. Disconnection of network cable or connector, equipment disconnection, and equipment power-off

- ▶ A station disconnected from the network cannot share memory with other stations and the RUN bit and START bit return to "0", stopping the sharing memory. The user can know it by accepting the interrupt trigger signal and detecting flag transition.
- ▶ In a station sharing memory correctly, an LED driving pulse is output from the MCARE pin of MKY43. The bit for station disconnection in the MFR is set to "0" (see Step10). The user can know it by accepting the interrupt trigger signal and detecting flag transition.

3. Driver/receiver failure

- ▶ In a station where the driver/receiver fails, sharing is stopped like 2. described above. A station that the user starts to share without noticing the failure cannot cooperate with other stations. We call this faulty station "Jammer", and when Jammer exists, other stations that are sharing correctly notify the user of the existence of Jammer by outputting an interrupt trigger signal or by flag transition.
- ▶ A station sharing memory correctly operates the same as 2. described above.

Step 14

What methods are available for application tests for noisy environments and evaluation of the network environment quality?

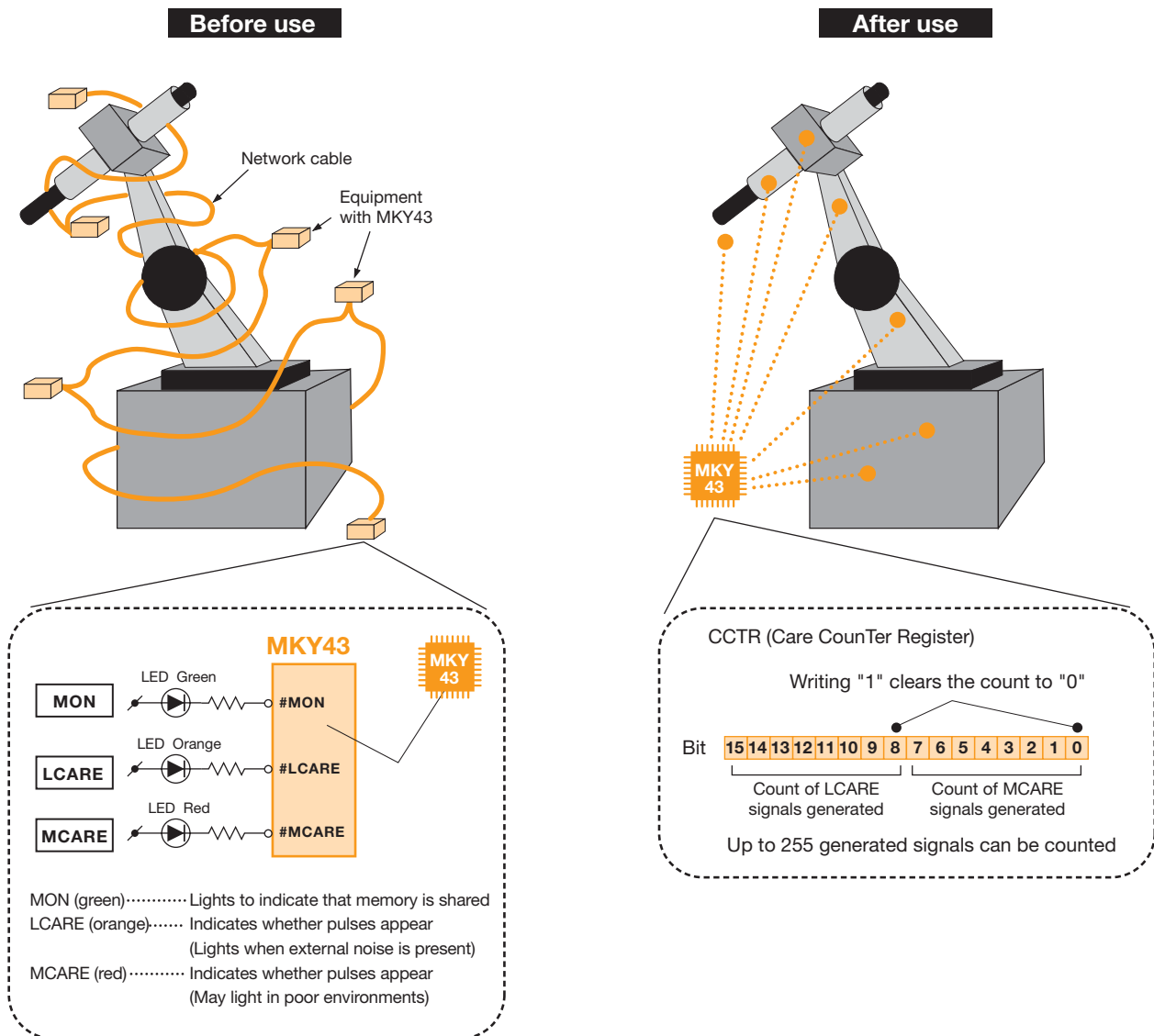
The LCARE and MCARE signals described in Step13 can be used. When external noise causes a communication error, MKY43 outputs the LCARE signal. If the error occurs frequently and is bad, MKY43 can output the MCARE signal, too.

The user can check whether these signals are generated by the LED lighting.

Use CUnet in noisy environments where machine tools are in full operation and the network cables longer than the actual cables (for example, 12- or 20-m cables if

the actual cables are 10 m) to check whether these signals are generated.

The MKY43 counts generation of up to 255 signals using the Care CounTer Register (CCTR). The user can also check the count of generated signals by reading the CCTR, which helps the user determine the quality of communication environments at various installation locations. The values of the CCTR can be reset individually.



Point

In CUnet, garbage data is discarded after powerful checks even when external noise occurs. At this point, garbage data is not updated, and is updated correctly in the next cycle.

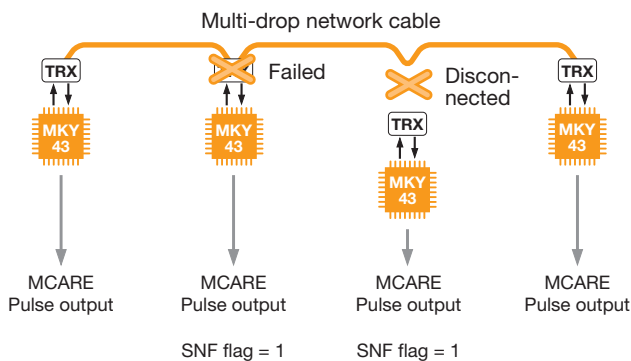
Step 15 How does the user know that memory sharing in self-station is stopped?

The RUN and START bits of the self-station (equipment) return to "0" under the following circumstances (memory sharing is continued between other stations). The MKY43 can generate an interrupt trigger signal when memory sharing is stopped under the following conditions 2, 3, 4, and 5.

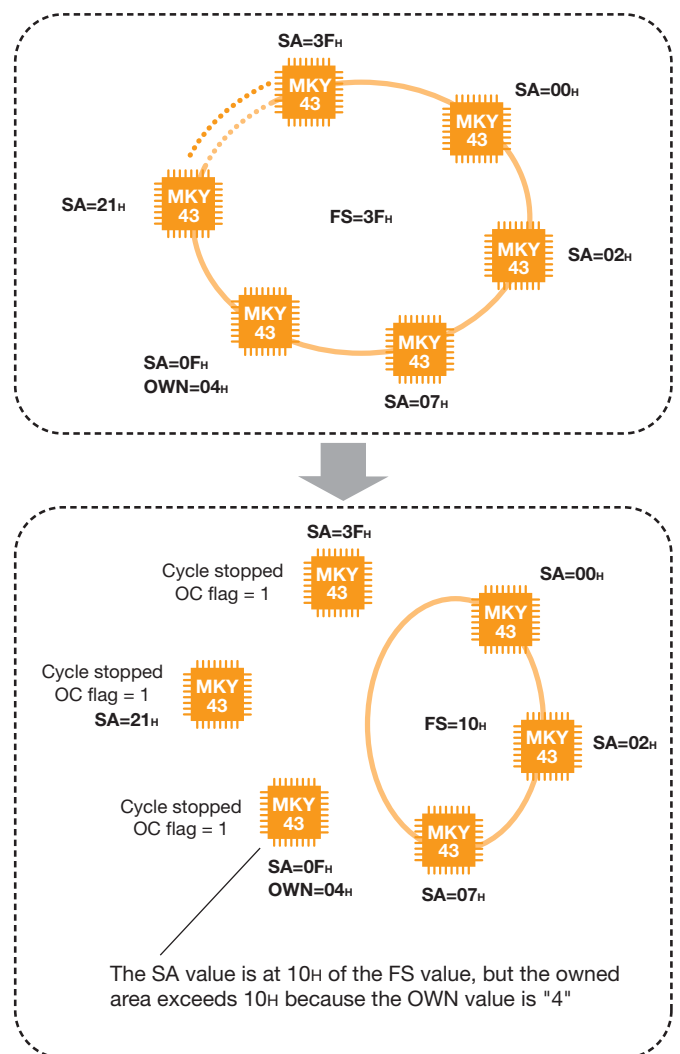
When the system state of RUN stops under the following conditions 2, 3 and 5, the Station Not Found (SNF) bit of the System Control Register (SCR) of the MKY43 is set to "1". At the system state of RUN stops under the following condition 4, the Out of Cycle (OC) bit of the SCR is set to "1". (The SNF and OC bits return to "0" when "1" is written to the START bit).

1. When "0" is written to the START bit of the SCR of the self-station to stop sharing
2. When the equipment is disconnected from the network cable (see the figures in Step10)
3. When a driver/receiver fails (same as disconnection)
4. When the equipment is out of cycle due to resizing (see Resizing in Step05)
5. When the station cannot share memory with other stations 32 consecutive times due to a poor network environment (same as disconnection)

● Cycle stop due to disconnection or TRX failure



● Cycle stop by resizing (FS = 3FH → FS = 10H)



Step 16

How does added equipment behave after memory is shared?

The behavior of the added equipment depends on whether the owned area based on the setting of SA and OWN of the MKY43 mounted in the added equipment,

is within the Final Station (FS) value in operation (see Step05 for FS and resizing).

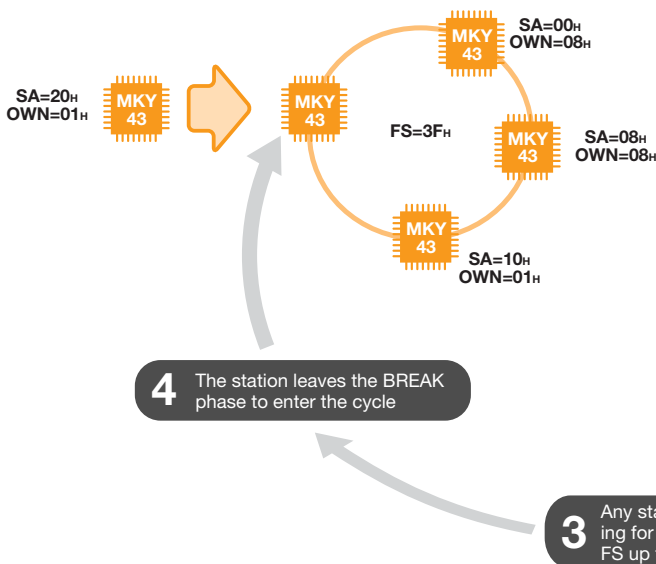
► When owned area is within FS value

Setting "1" to the START bit of the SCR enables immediate entry into the cycle sharing memory (see "Equipment disconnected" and "Equipment connected" in the figures in Step10).

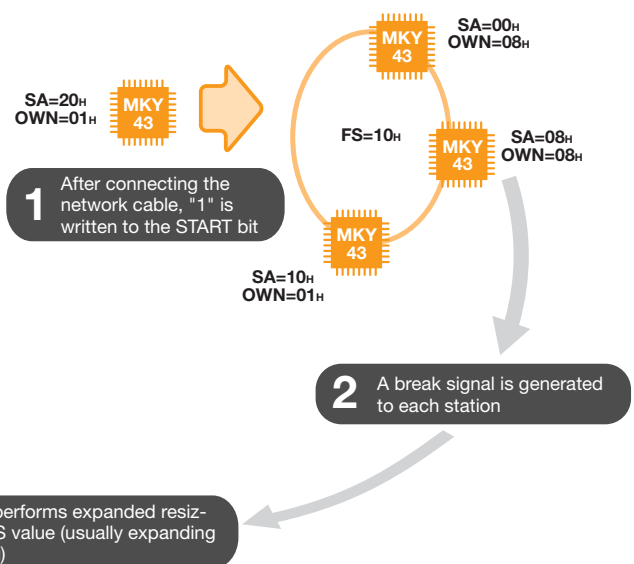
► When owned area exceeds FS value

The MKY43 mounted in the added equipment enters a BREAK phase. During the BREAK phase, the added station (equipment) issues a break signal to operating stations to wait for entry to CUnet. When an operating station detects the break signal, it notifies the user of a request for new entry by flag transition or by outputting an interrupt trigger signal. After that, when an expanded resizing is performed for the FS value, the added equipment enters the memory sharing cycle.

● Within FS value



● More than FS value



Point

1. A station with owned area within the FS value can enter the cycle anytime and immediately.
2. A station with owned area outside the FS value enters the BREAK phase. This station can enter the cycle when the operating station that detected the BREAK phase performs expanded resizing.

Note

Not always only one station is in the BREAK phase. Therefore, the operating station cannot know the SA and OWN values of the station in the BREAK phase. The operating station generally accepts a new station in the BREAK phase after performing expanded resizing as "FS to 3FH" and recognizing the new station based on the newly changed Member Flag (MF).

Step 17

What should the user consider in using shared memory?

In a hardware logic circuit, an unexpected output result is called "hazard". For example, the High level output cannot appear in the output of a 2-input AND gate connected to a counter during carry counting. However, an "unexpected logic result" may appear momentarily depending on a slight difference in arrival time caused by different wiring lengths of two input signals (see the figure below).

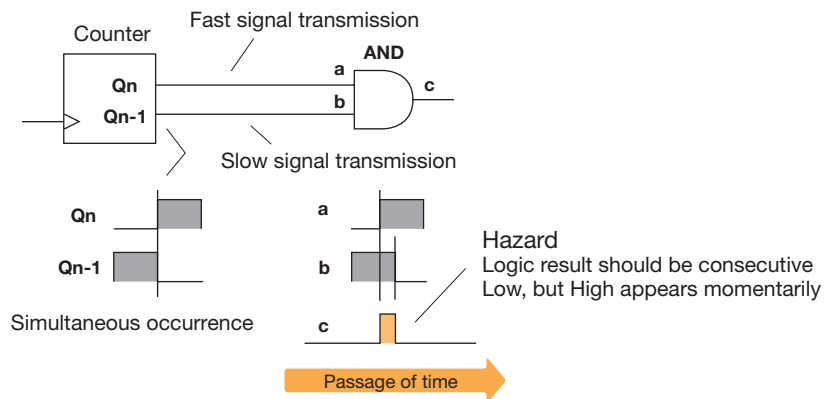
Similarly, "unexpected data" may appear momentarily when shared memory transfers data. This is defined as a "data hazard" (see the figure below).

A data hazard occurs when the bit width of data exceeds the bus width.

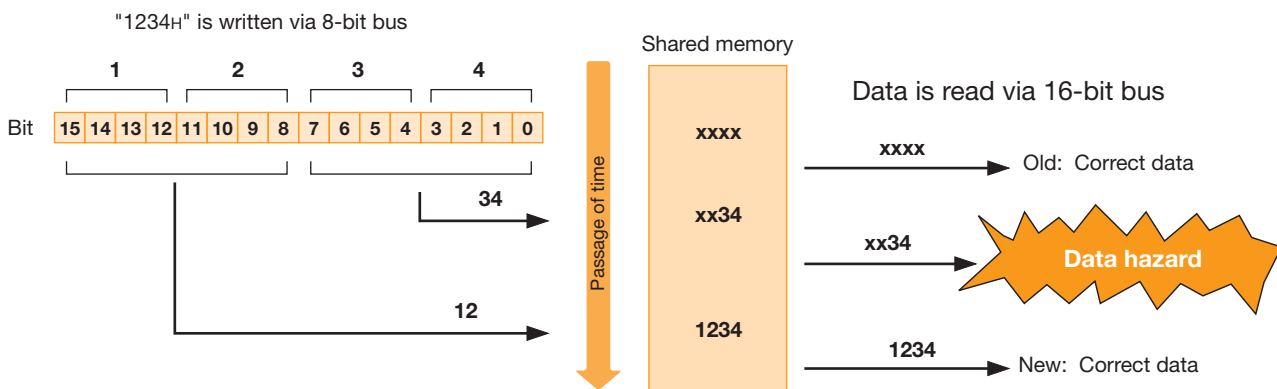
A data hazard does not occur "when 16-bit data is written/read to and from each other via the 16-bit buses" or "when 8-bit data is written via the 8-bit bus and the 8-bit data is read via the 16-bit bus".

In other words, there is no need to consider a data hazard when the bit width of data does not exceed the bus width when reading/writing. However, a data hazard occurs "when 16-bit data written via the 8-bit bus is read via the 16-bit bus". Conversely, a data hazard also occurs "when updated data is written via the 16-bit bus while 16-bit data is read via the 8-bit bus". When using shared memory, the user should consider the occurrence of data hazards.

● Hazard in hardware



● Data hazard in shared memory



Step 18

How to avoid data hazards

The MKY43 has a function called "hazard protection function" to avoid data hazards by absorbing differences in data bus width.

The MKY43 has 64-bit (8-byte) buffer which is equivalent to one independent Memory Block (MB). 64-bit data in a buffer can be written collectively to GM by using the dedicated control register.

How to use write hazard protection

The buffer used by users at write access is WHPB0 (Write Hazard Protection Buffer 0).

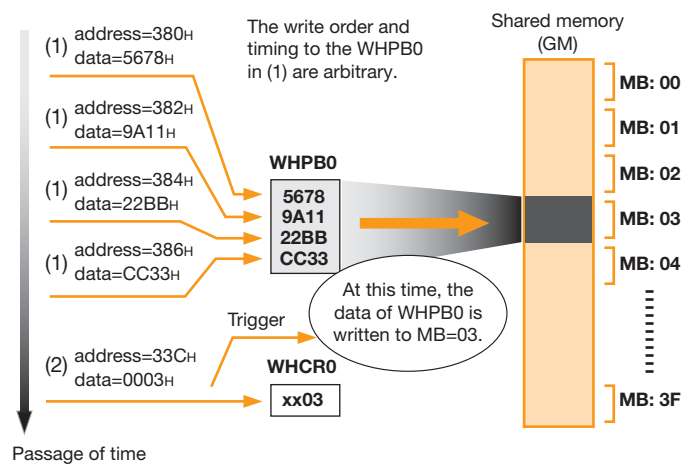
The WHPB0 is controlled by the WHCR0 (Write Hazard Control Register 0). The WHPB0 and the WHCR0 are used by the following procedure.

- (1) The user writes all data (8 bytes, that is, 64 bits) for one MB to the WHPB0 at any time.
- (2) Write the MB value to be written, to the WHCR0. Thanks to the write, all data of the WHPB0 is written to the specified MB collectively.
- (3) When writing data to another MB, repeat the steps (1) and (2) above.

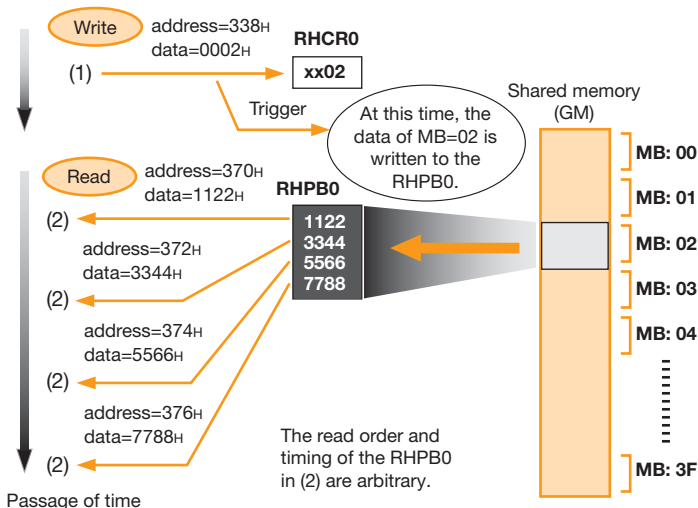
The figure on the right shows an example of writing the 64-bit data "56789A1122BBCC33H" to the memory block "03H".

Also, 64-bit data in GM can be copied collectively to a buffer by using the dedicated control register. This function enables the users to handle 64-bit data, avoiding data hazards.

64-bit data write procedure



64-bit data read procedure



How to use read hazard protection

The buffer used by users at read access is RHPB0 (Read Hazard Protection Buffer 0).

The RHPB0 is controlled by the RHCR0 (Read Hazard Control Register 0). The RHPB0 and RHCR0 are used by the following procedure.

- (1) The user writes the MB value to be read, to the RHCR0 at any time. Thanks to the write, the data of the specified MB is read from the GM collectively and is stored to the RHPB0.
- (2) The user can read the data from the RHPB0 at any time.
- (3) When reading another MB, repeat the steps (1) and (2) above.

The figure on the left shows an example of reading the 64-bit data "1122334455667788H" from the memory block "02H".

► Supplementary explanation of hazard protection function

The WHPB0 (Write Hazard Protection Buffer 0) and the RHPB0 (Read Hazard Protection Buffer 0) operate independently. Therefore, data are never mixed even if data in GM is copied to the RHPB0 while writing data to the WHPB0.

Data hazards can be avoided by recognizing the timing when the CUnet cycle proceeds to access data. (See "Prior knowledge ► CUnet Memory sharing mechanism" (p.18). The timing when the cycle proceeds can be recognized by reading the System Control Register (SCR) in the MKY43.)

Note

1. In "**How to use write hazard protection**", if all of the 8-byte (64-bit) data has not been written to the WHPB0 during the operation of the step (1), the previous data remains in the byte area where the write had not been performed. In this state, if the operation of the step (2) is performed, a mixed data of the newly written data and the previous data remaining in the buffer is written to the specified MB.
2. When handling data with a bit configuration larger than 64 bits (8 bytes) that exceeds the capacity of the MKY43 hazard protection function, avoid data hazards by recognizing the timing when the CUnet cycle proceeds to access data.

Step 19

Another pair of "hazard protection function" — WHPB1/WHCR1 and RHPB1/RHCR1

The MKY43 has another pair of "hazard protection function" using WHPB1/WHCR1 and RHPB1/RHCR1. This pair allows two tasks to use the hazard protection function simultaneously.

For example, assume that an interrupt is generated during read using the RHPB0. Also, assume that it is necessary to read data in GM by using "hazard protection function" even during interrupt handling. In this case, the RHPB0 is used for the interrupt handling, and

consequently, the data contents in the RHPB0 have been changed from those before the interrupt even if the continued program, which returned from the interrupt handling, reads the RHPB0 later.

In such cases, there is no problem if the interrupt handling program uses the RHPB1 to read GM. Similarly, there is no problem if the interrupt handling program uses the WHPB1 to write data to GM.

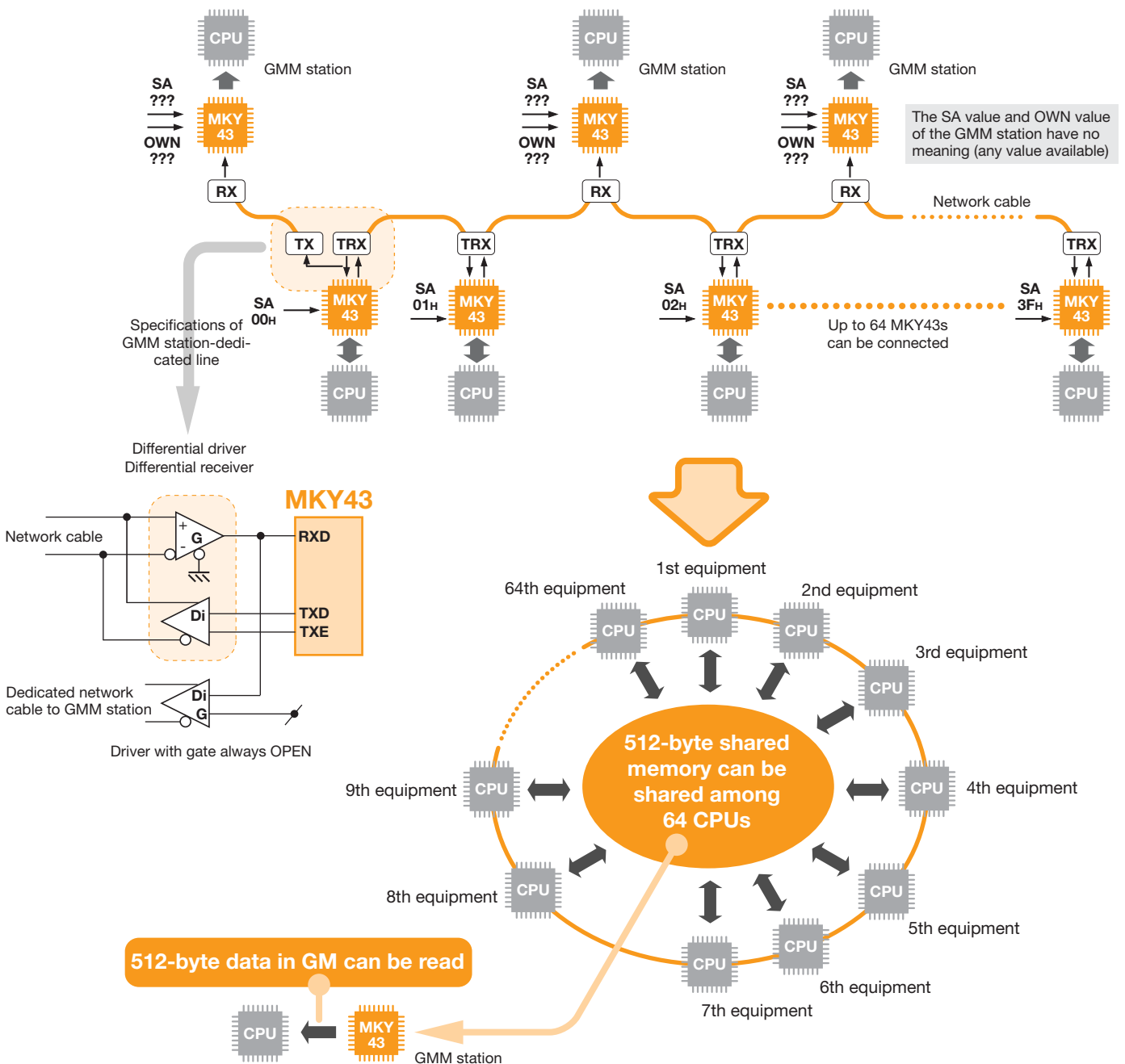
Step 20

How to "monitor" GM during operation?

The MKY43 has a Global Memory Monitor (GMM) function to monitor GM without entering the network. Any number of the GMM stations can be connected to a network cable as long as network quality can be maintained.

Instead of not connecting the GMM station directly to the network cable, the user can connect an input signal from the RXD pin of the station entering the network to the GMM station as a signal driven by the driver that is not active-controlled.

- Any number of GMM stations can be connected to network cable as long as network quality can be maintained



Note

Mail sending to/from the GMM station and rewriting of data in the GMM station are not supported.

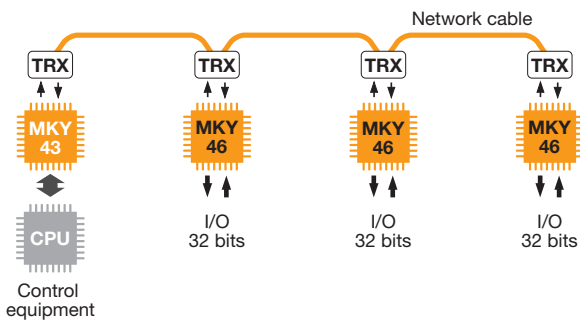
Step 21 Can remote I/O equipment handling only the bit ON/OFF operation be placed on the network?

The MKY46 is a CUnet-dedicated I/O-IC that can handle 32-bit I/O signals. A system can be configured freely, as shown in the figure below, by using the MKY43 and MKY46 for the CUnet configuration. The I/O pin state set to "input" of the MKY46 is always (at every cycle) input to the GM area corresponding to the SA set to the MKY46. This allows all stations to reference this input data.

The MKY46 can specify, by the settings of the Data Out Station Address (DOSA) pin and Data Out Hi-bit Lo-bit (DOHL) pin, what data in a GM area is output to I/O pins set to "output".

The number of "inputs" and "outputs" for 32 I/O pins of the MKY46 can be selected by the setting of In Out Select (IOS) pins as shown in the table below.

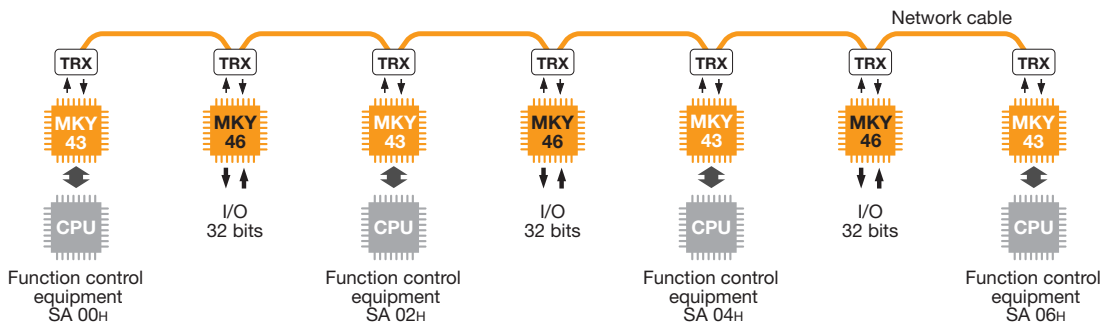
● System that controls several MKY46s (remote I/O) by one CPU



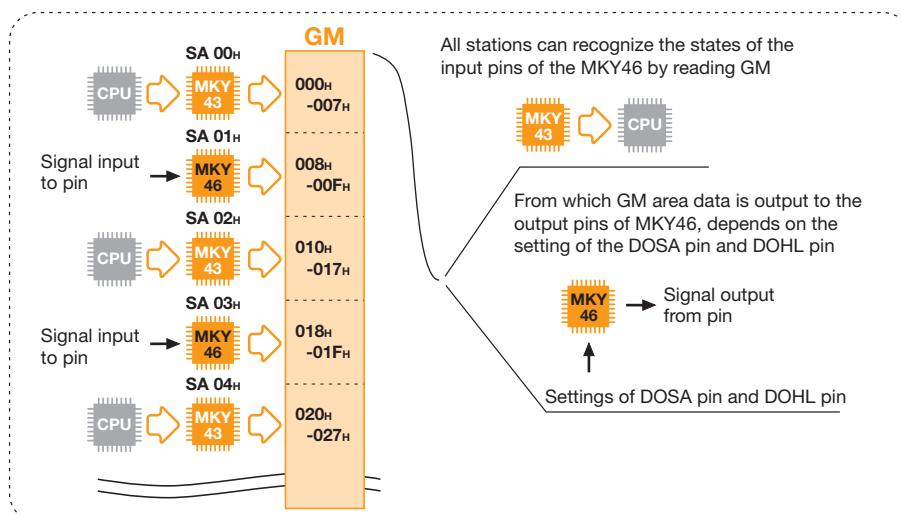
● Selection of number of input/output pins by setting MKY46 IOS pin

IOS2	IOS1	IOS0	Inputs	Outputs
Lo	Lo	Lo	32	0
Lo	Lo	Hi	28	4
Lo	Hi	Lo	24	8
Lo	Hi	Hi	20	12
Hi	Lo	Lo	16	16
Hi	Lo	Hi	12	20
Hi	Hi	Lo	8	24
Hi	Hi	Hi	0	32

● System using mixedly several CPUs and several MKY46s (distributed processing system that can cooperate)



Example when OWNs of all stations is set to "1"
(OWN setting is not supported in the MKY46.)



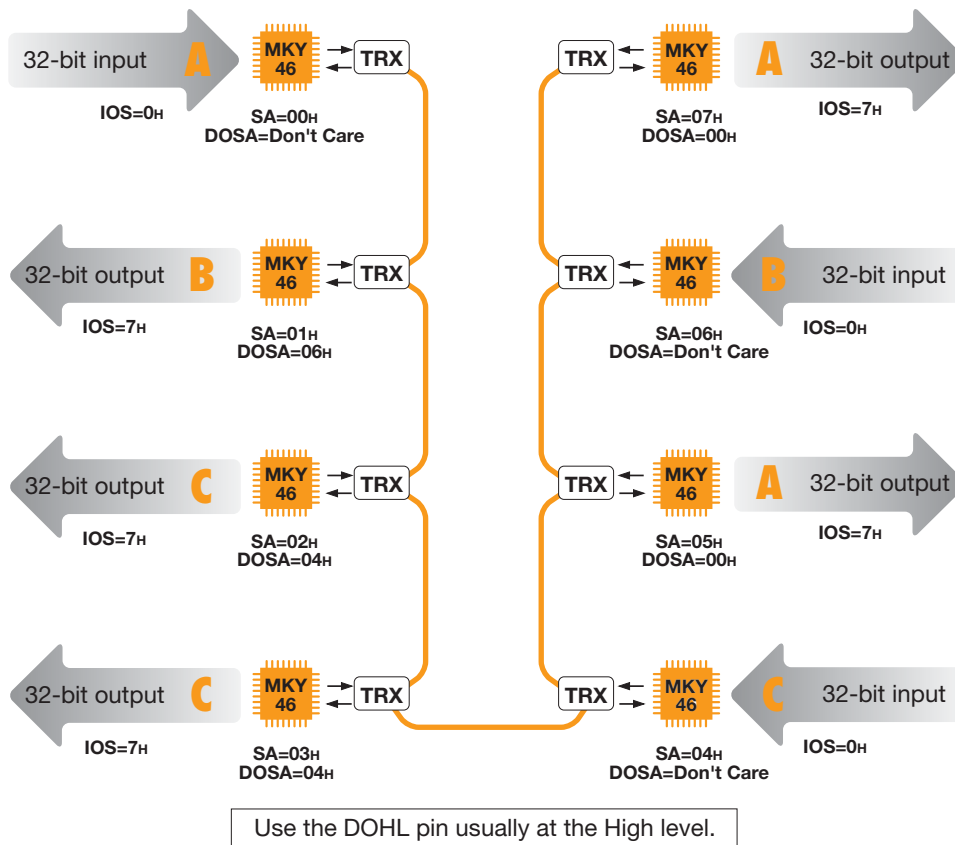
**Step
22**

Can a CUnet be built by using only remote IO equipment without CPU and program?

Yes. CUnet can be built by using only the MKY46s comprising the remote I/O equipment without any CPUs and programs. As shown in the figure below, many I/O signals can be connected to one another via just one network cable. The various setting pins (SA, DOSA, DOHL, IOS, IOS-

WAP, and INV) of the MKY46 offers many applications, such as outputting an input signal from one MKY46 to several MKY46 pins (in the figure below, e.g., the input signal "A" at SA = 00H shown is output from the pins at SA = 05H and SA = 07H), and reverse logic on the I/O pin signal.

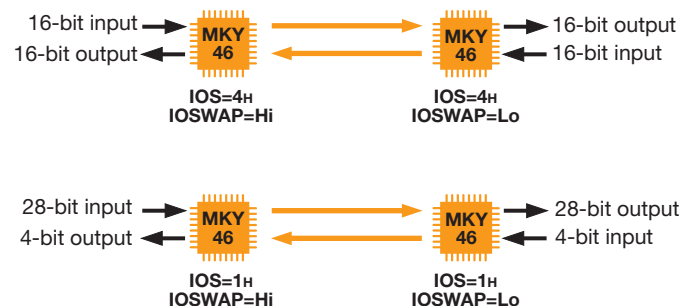
● Connection of many I/O signals via one network cable



► Other features

1. Connecting a GMM equipment to a network cable allows the user to monitor the I/O signals.
2. The output can be forcibly reset when a network cable fails.
3. Timing notification signals (STB1 pin and STB2 pin) are output, indicating when to update of data of output pins and when to sample data of input pins.

● I/O setting available at every 4 bits



Reverse the I/O setting to set the IOSWAP pin

Step 23

Can all equipment be synchronized?

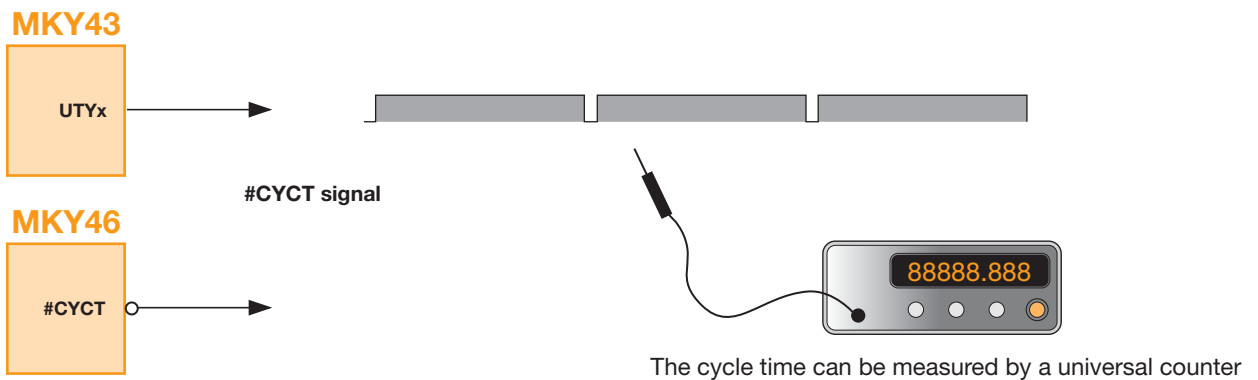
When the MKY43 and MKY46 are in the RUN phase (normal state of CUnet), the start periods of the cycle time are synchronized. These start periods of the cycle time are notified by a #CYCT signal (pulse signal).

The MKY43 can output the #CYCT signal from the

UTY1 pin or the UTY2 pin. In the MKY46, the #CYCT signal is output from the #CYCT pin.

Using this #CYCT signal allows all equipment to be synchronized. In addition, using the interrupt setting of the MKY43 enables to issue an interrupt trigger signal to the CPU at a specific period of the cycle time.

- The MKY43 and the MKY46 output the #CYCT signal indicating the start of one cycle to the UTYx pin and to the #CYCT pin respectively



The cycle time can be measured by a universal counter

Note

Synchronization is not guaranteed in a period that is not in the RUN phase or in a CUnet that performs resizing. CUnet is synchronized in cooperation with each station (equipment). The accuracy of the accumulated cycle time is not guaranteed. Therefore, the #CYCT signal is inappropriate to be used as a signal source for time-measuring applications.

Step 24

Can the user reset the CPU of a runaway equipment on a network?

The MKY43 and MKY46 have pins that can output a PING signal. The PING signal goes High when the PING instruction is received from a network and returns to Low after it receives data from other devices. Any equipment can issue the PING instruction using the Query Control Register (QCR) in the MKY43.

The PING signal destination and purpose are unspecified. Therefore, for example, if a CPU connected to a MKY43 runs away, the PING signal can be output as long as the MKY43 operates correctly. In this case, the user can use this signal as a CPU reset signal.

The MKY43 can output the #PING signal from the UTY1 pin or the UTY2 pin. In the MKY46, the #PING signal is output from the #PING pin.

**Step
25**

How are data quality and reliability assured in CUnet?

CUnet performs the following three tests concurrently to test packets transmitted over the network cable. The calculated CRC-16 test for 17-bit garbage data is 99.99695% at worst. Moreover, CUnet checks the format (validity) and always monitors the validity of bit-wise RZ signal format.

Data received from other equipment is discarded unless the data passes all these three tests. The combination of these three tests gives CUnet a complete capability to assure quality and reliability under any circumstance.

1. CRC-16 Test

Officially recognized test in digital communications

2. Format test

Examines whether or not CUnet format is established

3. Validity test of RZ signal format (RZ test)

Examines RZ (Return to Zero) format that using "01" as a code representing "data 1", and "10" as a code representing "data 0" (In normal data representation, three consecutive RZ codes, such as "111" or "000", are not available)

	M = Length of CRC
	B = Count of error bits
CRC capability	
When $B \leq M$	100%
When $B = M + 1$	$(1 - (1/(2^{M-1}))) \times 100\%$
When $B > M + 1$	$(1 - (1/(2^M))) \times 100\%$
CRC16 capability	
16-bit max. errors	100%
17-bit error	99.99695%
18-bit min. errors	99.99847%

**Step
26**

Can program detect that a MKY43 is mounted?

Place the MKY43 in the CPU memory space. When the MKY43 is connected properly, the CPU can read the chip code from a Chip Code Register (CCR) of the MKY43 by performing read access to the MKY43.

When a MKY43 is connected to a little-endian CPU, the ASCII character string "MKY43_v0" can be read. (When connected to a big-endian CPU, the character sequence on the address is reversed.)

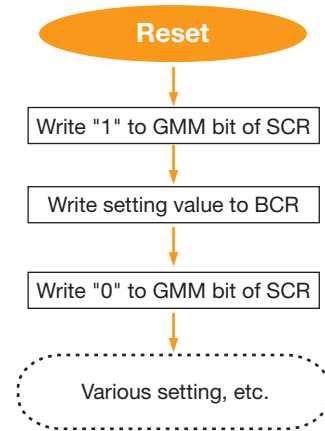
Step 27

What are the required settings of the MKY43?

The required MKY43 settings are SA, OWN and BPS, and set each of them to the Basic Control Register (BCR) in the MKY43. Usually, the BCR is a read-only register, but can be written when the GMM bit of the SCR is "1". The BCR values are left after the GMM bit returns to "0".

The initial values set by BCR hardware reset are SA = 0, OWN = 1 and BPS = 3 (12 Mbps).

● Procedure for writing required setting values



Step 28

How can the user know the mode of other equipment?

In most cases, the operation mode and SA of each equipment connected to CUnet are predetermined. However, even when equipment was added later, the user program can detect the operation mode of the added equipment from the system in operation. The MKY43 has a function to check the mode of other equipment.

When the SA value and execution flag to be checked are written to the Query Control Register (QCR), the type code for the check result is returned to the QCR. Using this function allows the user to know the operation mode of the checked area, whether the area to be checked is owned and expanded, and whether the long frame (LFS = 1: bit 15 of BCR) is set in the area.

▶ Type code for check result

00H	MEM Mode
01H	MEM Mode LFS=ON
02H	IO Mode
03H	IO Mode LFS=ON
04H	Owned (Owned and expanded)
05H to 1FH	Reserved for manufacturer

Note

When an area to be checked is not in the memory sharing state, the check cannot be completed and the query flag does not return to "0". In this case, stop the check and write "0" to the query flag. The same applies to the self-owned area. The monitoring equipment does not enter a network and is not checked.

**Step
29**

Can the user build a system with more than 64 stations?

To build a system consisting of more than 64 stations, either use a system composed of several CUnets, or use another system for simple control. StepTechnica recommends our Hi-speed Link System (HLS) family be used for simple control.

The Hi-speed Link System (HLS) family enables "1 : N" real-time bit control.

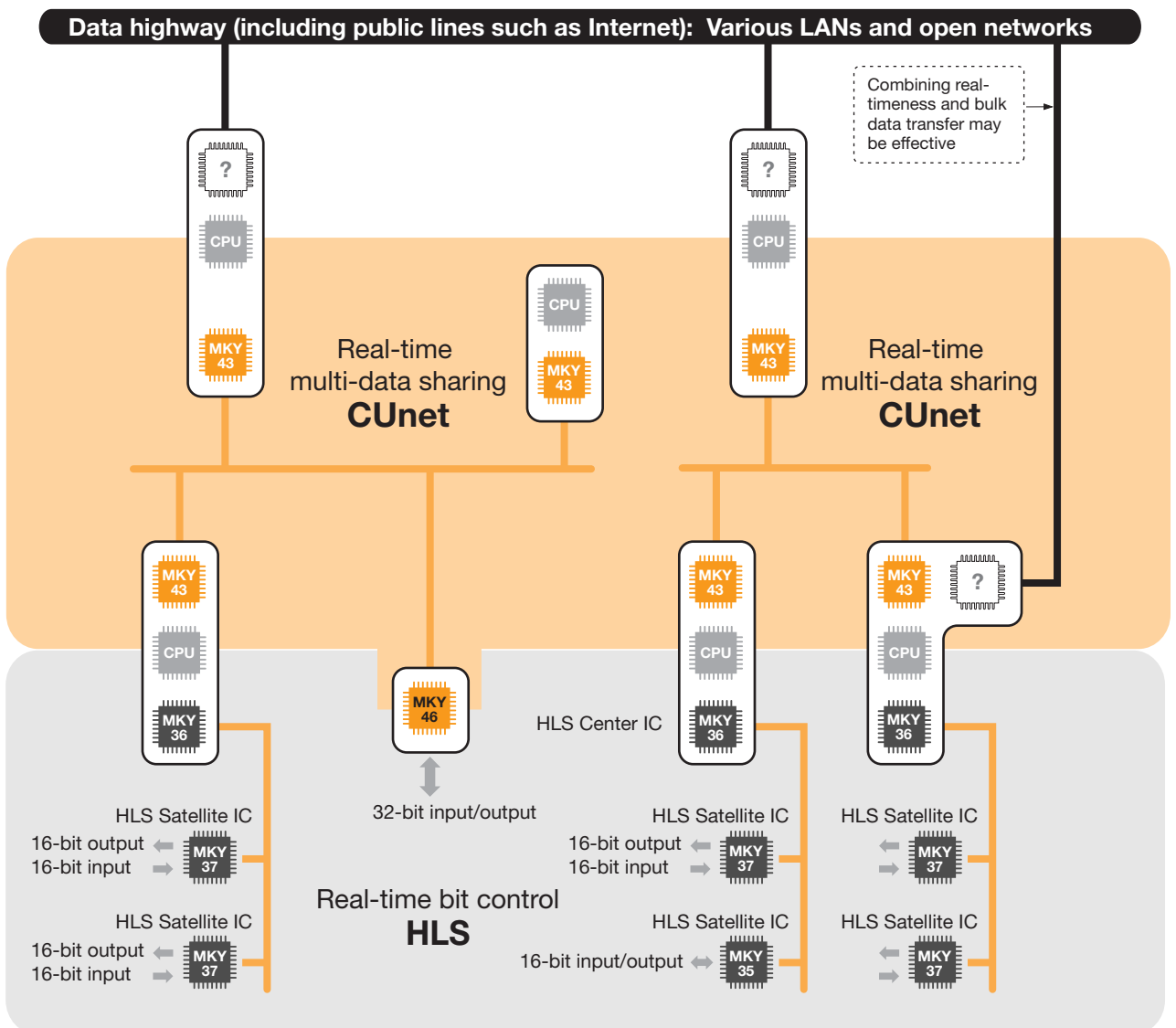
As shown in the figure below, using various communication items (such as Ethernet networks, LANs, open buses, and field buses) and our product family allows the user to build medium- to large-scale systems.

► **Hi-speed Link System (HLS) family**

- ◆ **Center IC: MKY36**
- ◆ **Satellite IC: MKY37 and others**

Features of HLS family

The HLS family offers "1 : N" faster and cheaper remote I/O systems than remote I/O systems comprised of CUnets.



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Let's Try! **CUnet**

How to Use MKY43/MKY46

For Beginners
For Field Engineers

