AL-2006
User's Guide
Ref. 6210-004.1
Rev. A 01/03

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The industrial automation equipment manufactured by ALTUS is robust and reliable due to a rigid quality control program. However, electronic equipment for industrial control (programmable controllers, numeric controls, etc.) can cause damage to machinery or processes controlled by them in the case of a part defect and programming or installation errors, and may even cause death.

The user should analyze the possible consequences of these defects and add security safeguards to protect system security, mainly in cases of initial installation and tests when problems are more likely to happen.

The user should thoroughly read the user's guides and/or Technical Features before installation and use.

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Preface

User's Guide Description

This user's guide describes the AL-2006 Brother Processor for Redundancy and remote I/O Stations, its installation, programming and operation. It consists of six chapters and two appendices.

Chapter 1, **Introduction**, presents the main characteristics and advantages of using the AL-2006 Brother Processor.

Chapter 2, **Technical Description,** presents detailed characteristics of the product and its operation limitations.

Chapter 3, **System Principles**, describes the possible methods of use of remote I/O stations and redundancy, with specific details of each.

Chapter 4, **Programming**, refers to the method of configuring the AL-2006 Brother and remote stations in the program modules of the programmable controller.

Chapter 5, **Installation**, contains the necessary procedures for the correct installation and connection of the AL-2006 Brother with the other components of the control system.

Chapter 6, **Maintenance**, presents the correct method of use and error diagnostics of the control system with redundancy or remote I/O stations.

Appendix A, **Quick Reference Guide**, contains abridged information related to the programming and configuration of the systems.

Appendix B, **Error Messages**, supplies a list of error messages used in the AL-2006 Brother.

Appendix C, Glossary, presents a glossary of terms, including words and expressions that may be unknown or that have a specific meaning in this guide.

This user's manual was created assuming the reader is familiar with the programming and operation of the Altus Programmable Controllers, as well as the ALNET II communications network. In case of doubts over specific details related to these topics, the guides cited in the following section can be consulted.

Related Guides

For more information on the use of the AL-2006 Brother processor, the following guides can be consulted:

- AL-3830 User's Guide
- MasterTool User's Guide
- AL-2000/MSP-C User's Guide
- AL-2002/MSP User's Guide
- AL-2003 User's Guide
- QK800, QK801 and QK2000/MSP User's Guide
- ALNET II User's Guide
- FOCOS User's Guide
- AL-2401 User's Guide
- QK2401 User's Guide
- AL-1000/AL-2000 Technical Specifications Guide

Terminology

The following expressions are frequently used in the text of this guide. Because of this, they need to be recognized and understood.

- **PC** (Programmable Controller) - equipment made up of one CPU, input and output modules and power source.
- **CPU** (Central Processing Unit) - the main module of the PC, which executes data processing.
- **AL-3830 -** ALTUS program for a standard IBM-PC® microcomputer or compatible, which allows the development of program modules for the AL-2000/MSP-C and AL-2002/MSP PCs, among others. Throughout the

guide this program will be referred to by its acronym or as AL-3830 programmer.

- **MasterTool -** ALTUS program for a standard IBM-PC® microcomputer or compatible, used in a WINDOWS® environment, which allows the development of program modules for the AL-2000/MSP-C, AL-2002/MSP and AL-2003 PCs, among others. Throughout the guide, this program will be referred to by its acronym or as MasterTool programmer.
- The word **module**, when referring to hardware, describes components of equipment.
- The word **module**, when referring to software, describes components of an application program.

Other expressions can be found in appendix B, Glossary.

Conventions

The utilized symbols throughout this guide have the following meanings:

- This bullet indicates a list of items or topics.

SMALL CAPS indicate names of keys, for example ENTER.

KEY1+KEY2 is used for keys to be pressed simultaneously. For example, the simultaneous typing of the CTRL and END keys is indicated as CTRL+END.

KEY1, KEY2 is used for keys to be pressed sequentially. For example, a message Type ALT, F10 means that the ALT key should be pressed and released and then the F10 key pressed and released.

LARGE CAPS indicate names of files and directories.

Italics indicate words and characters that are typed on the keyboard or seen on the screen. For example, if you are asked to type *C-UCP1.000*, these characters should be typed exactly as they appear in the guide.

BOLD is used for names of commands or options, or to emphasize important parts of the text.

Warning messages present the following formats and meanings:

➲**DANGER:**
The DANGER label indicates that risk of life, serious personal injury or substantial material damage will result if the necessary precautions are not taken.

✍CAUTION:
The CAUTION label indicates that risk of life, serious personal injury or substantial material damage can result if the necessary precautions are not taken.

ATTENTION:
The ATTENTION label indicates that personal injury or minimal material damage can result if the necessary precautions are not taken.

Contains important information about the product, its operation or a part of text to which special attention should be paid.

Technical Support

ALTUS EXPRESS: get information by calling +55 51 337-3633

INTERNET:

- website: http://www.altus.com.br
- e-mail: altus@altus.com.br

If the equipment is already installed, it is advisable to have the following information available before contacting Technical Support:

- equipment modules used and configuration of the system installed
- CPU serial number, equipment revision and operating system version, shown on a fixed tag on the lateral part of the equipment
- information on the CPU mode of operation, obtained from the AL-3830 programmer or MasterTool
- contents of program module obtained from the AL-3830 programmers or MasterTool
- version of programmer used

Manual Revisions

Reference code, revision and date of the current user's guide are indicated on the cover. A change in revision can mean alterations in the functional specification or user's guide improvements.

The following report lists the corresponding alterations to every revision of this guide:

Revision A Date 10/02

- Initial revision of the user's guide.

Introduction

The AL-2006 Brother Processor

The AL-2006 Brother module is used as a coprocessor in the AL-2002/MSP (Multi-Station Processors) and AL-2003 programmable controllers to execute the following functions:

- remote input and output control of the AL-2002/MSP or AL-2003 programmable controller, using the Remote I/O Network, which uses the same protocol as the proprietary ALNET II network;
- implementation of programmable controller architectures with hot standby CPU redundancy.

Throughout the text of this guide there are various references to the AL-2002/MSP programmable controller. All of these references are also valid for the AL-2003 programmable controller, except when the contrary is explicitly emphasized.

The AL-2006 coprocessor and the I/O remote stations can be connected using a standard EIA 485 cable, a simple fiber-optic cable or redundant fiber-optic cable.

The remote I/O stations can be made up of AL-2000/MSP-C, QK2000/MSP PCs or even other AL-2002/MSP or AL-2003 PCs, running a special control program.

AL-2006 control is done using software, through the F-2006.019 function, inserted into a program module of the AL-2002/MSP CPU through the MasterTool or AL-3830 programming software.

Figure 1-1 shows a typical redundant system application with remote input and output, using an AL-2006 Brother processor.

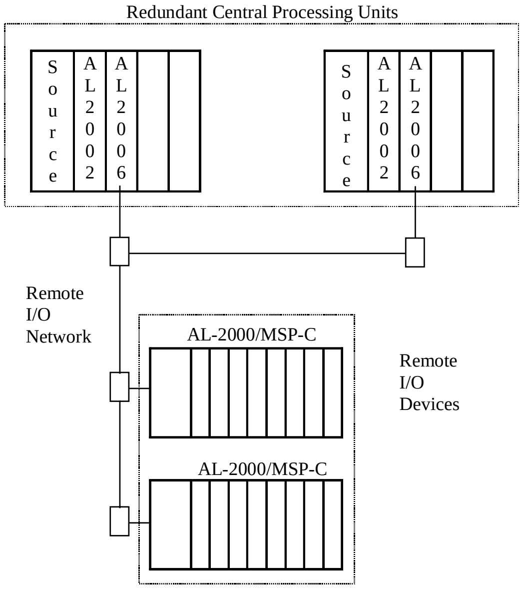


Figure 1-1 – Example of a Redundant System with Remote I/O Stations

Hot Standby Redundancy

With the use of an AL-2006 module, systems with CPU hot standby redundancy can be implemented.

This configuration is built using two CPUs with identical controllers, both with the same program module. However, only one of them controls the system (active CPU), while the other remains in standby mode (backup CPU), verifying that the first one is working correctly.

In case of a failure in the controlling CPU, the backup CPU assumes control of the system, avoiding interruptions to the process. The CPU swap is done very quickly, so that the absence of control during the change is as short as possible.

The AL-2006 Brother processors are used to transfer the main operand values from the active to the backup CPUs at each program scan cycle, assuring that both CPUs are synchronized if a switchover is needed.

The hot standby method of redundancy control is acceptable for processes that allow short periods of absence of control, in the range of hundreds of milliseconds. Many industrial processes allow periods of this magnitude in case of failures, and can be controlled by redundant systems using this method.

AL-2006 Brother Applications

- Control system and energy distribution
- Security interlocking systems
- Control system of continuous processes, such as chemical plants, refineries, cellulose production, etc.
- Oil extraction platforms
- Systems with points of input and output distributed over a large area

Technical Description

The AL-2006 Brother processor was designed for safe operation in rigorous industrial environments. It is composed of a multilayer circuit board with SMD (Surface Mounting Devices) technology, double height Eurocard, containing a high-integration processor, EPROM and RAM memories, interfaces for communication with ALNET I protocol and with remote I/O networks.

Front Panel

Figure 2-1 shows AL-2006 Brother front panel.

The upper part of the front panel has 9 LEDs showing the operating status and the communications activities of the AL-2006 Brother, identified by the following codes:

- **EX - Execution -** shows that the AL-2006 Brother processor is in normal operating conditions, ready to communicate with the AL-2002 CPU through the F-2006.019 program module.
- **PG - Programming -** not used.
- **PC - Programmable Controller -** this LED flashes continuously when the AL-2002 CPU is communicating with the AL-2006 Brother processor through the F-2006.019 module.
- **ER - Error -** this LED indicates that the AL-2006 Brother processor has detected some hardware or software malfunction.
- **WD - Watchdog -** shows that the watchdog circuit of the AL-2006 Brother is activated. This circuit continuously monitors the execution of the 80C152 microcontroller, disabling it in case of failure.
- **TX ALNET I -** indicates that the AL-2006 Brother is sending messages over the serial channel of ALNET I network (ALNET I connector on the front panel).

- **RX ALNET I -** shows that the AL-2006 Brother is receiving messages over the serial channel of ALNET I network (ALNET I connector on the front panel).
- **TX REMOT I/O -** shows that the AL-2006 Brother is sending messages over the remote I/O network channel (REMOTE I/O connector on the front panel).
- **RX REMOT I/O -** indicates communication on the remote I/O network bus, not necessarily addressed to this processor (REMOTE I/O connector on the front panel).

The front panel also has three standard DB9 female connectors:

- **REDUND -** redundancy communication connector for connection with the AL-2006 Brother of the redundant CPU, if applicable.
- **ALNET I -** ALNET I communications connector allows the connection of MasterTool or AL-3830 programmers so that the operation and the communications status of the Remote I/O network can be examined in detail.
- **REMOTE I/O -** connector to ALNET II network, dedicated to the connection of remote I/O stations and redundant CPU, if applicable.

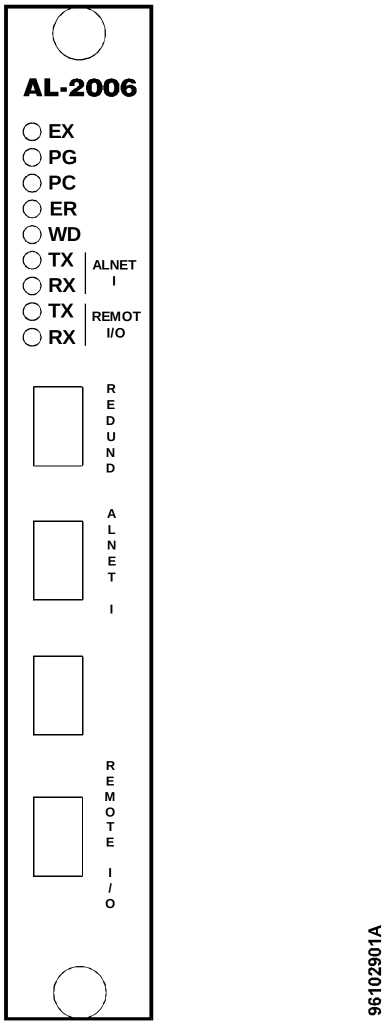


Figure 2-1 – AL-2006 Brother Front Panel

Technical Features

Below, several features identify and determine the operating limits of this product, regarding its hardware, software, and mechanics.

General Features

- Modes of use:
  - single CPU with remote I/O
  - redundant CPU with remote I/O
- Number of digital I/O points: up to 512 per remote processor, total of 1,024 (AL-2002/MSP) or of 2,048 (AL-2003)
- Number of analog I/O points: up to 72 per remote processor
- Maximum number of remote I/O processors: 8
- Supports hot swap of I/O modules, individually or by bus in remote I/O processors that have such feature
- Hot stand-by redundancy with transfer of up to 2,016 bytes of operand values to the backup CPU upon each scanning of the application program of the active CPU (1,008 M operands or 1,008 TM table positions or 504 D operands or 504 TD table positions). Several types of operands can be simultaneously configured for the transfer, observing the total limit of 2,016 bytes.
- Interface for integrated high-speed communications network, multimaster system, dedicated ALNET II protocol, EIA 485 standard (Remote I/O)
- LEDs showing the processor status on the front panel
- Intel® 80C152 microcontroller as main processor
- Clock frequency: 15 MHz
- Watch dog timer
- Capacity to operate with the AL-2002/MSP or AL-2003 CPUs
- Ambient air temperature: 0 to 60°C
  exceeds IEC 1131 standard
- Storage temperature: -25 to 75°C
  according to IEC 1131 Standard
- Relative humidity: 5 to 95% non-condensing, according to
  IEC 1131 standard level RH2

- Weight:
  packed: 570 g
  unpacked: 420 g
- MTBF: 40,000 hours @ 40°C
  calculated according to MIL-HDBK-217F standard
- Protection: IP30, against accidental access by tools, without protection against water, according to IEC Pub.144 standard (1963), considering the installed product

Electrical Features

- Supply voltages received from backplanet:
  +5 VDC ±5%
  +15 VDC ±5%
  -15 VDC ±5%
  +5 Vbb ±10% (battery voltage)

- Consumption:
  300 mA @ +5 VDC
  250 mA @ +15 VDC
  30 mA @ -15 VDC
  70 mA @ +5 Vbb
  30 µA @ battery, when the system is not powered

  Note: the battery is located in the power source. Its lifetime depends on the total consumption of all modules connected to the bus that can retain memory.
- Module dissipation: 11 W
- Severity level of electrostatic discharge (ESD):
  according to IEC 1131 standard, level 3.
- Immunity to radiated electromagnetic field: 10V/m @ 140 MHz
  according to IEC 1131 standard
- Protection against electric shock:
  according to IEC 536 standard (1976), class I.

Software Features

- Configuration and communication with remote I/O and redundant backup CPU through the F-2006.019 module, called by the AL-2002/MSP CPU application program

- F-2006.019 runtime ranging from 2 to 25 ms, depending on the amount of data to be transferred between redundant CPUs and remote I/O processors.
- Hot standby redundancy algorithm, implemented in a relay diagram
- Programmers:
  MasterTool - version 1.20 or higher
  AL-3830 - version 3.50 or higher

Software Components

A floppy disk containing the following software modules, necessary for the operation of the AL-2006 Brother, is provided with the product:

- AL-2002 subdirectory: F-2006.019, F-END2.082, P-TEMPO.032, P-2006.000, P-2006_1.000, P-2006_2.000, F-REMOT.069
- AL-2003 subdirectory: F-2006.019, F-END2.082, P-TEMPO.032, P-2006.000, P-2006_1.000, P-2006_2.000, F-REMOT.069
- AL-2000 subdirectory: F-REMOT.069
- QK2000 subdirectory: F-REMOT.069

Remote I/O Networks

The AL-2006 Brother processor has a high-speed network interface dedicated to the communication with remote I/O processors and with the redundant CPU, based on ALNET II protocol. It features determinism, high performance and easy installation of ALNET II network with quick processing of commands dedicated to the remote I/O by the AL-2006 Brother processor. It is possible to connect up to 8 I/O remote processors, in addition to a redundant CPU, in the same sub-network or in different sub-networks.

The fundamental features of the remote I/O network are:

- bus topology
- connection of up to 2 redundant CPUs plus 8 I/O remote stations, distributed in up to 3 sub-networks
- maximum range with no repeater: 2 km with RS-485, 3 km with optical fiber
- programmable baud rate from 64 kbit/s to 1 Mbit/s
- access method: deterministic, multimaster
- physical standard: EIA 485 with galvanic insulation

- automatic retransmission control and error check
- capacity to be used over optical fiber, through fiber-optic modem, with greater rate and range

Although the communications network, with remote I/O and redundant CPU, uses the same format as that of ALNET II network, it is exclusive for this purpose. On this network, communication is controlled by the AL-2006 Brother, and the execution of ECR or LTR instructions in I/O remote processors is not allowed. It is also not allowed to connect gateways or CPUs that have such instructions to the network.

Related Equipment and Documents

	Name	Function
AL-2300	Branch cable	Cable used to connect the CPU to the AL-2600 branch
AL-2301	EIA 485 Cable	Physical medium used for ALNET II network
AL-2600	Branch and termination	Module for connection of ALNET II physical medium with AL-2300 branch cables
AL-3830	Programming Software	Programmer of PC series 2000, 3000 and 600
MT4000 or MT4100	MasterTool Programming Software	Programmer of PC series 2000, 3000 and 600 in Windows™ environment. MT4000 was designed for WINDOWS 3.1X, WINDOWS 95/98, and MT4100 was designed for WINDOWS NT and 2000.
AL-1342	Cable for connection of AL-2006 to programmer	Used to interconnect the AL-2006 with a DB9 serial interface of a microcomputer that runs AL-3830 or MT4000 / MT4100.
AL-1343	Cable connection AL-2006 to programmer	Used to interconnect the AL-2006 with a DB25 serial interface microcomputer
AL-1366	Cable connection between two AL-2006	Used to interconnect the AL-2006 processors of redundant CPUs, through the REDUND connector.
MAN/AL-2006-UT	User Manual AL-2006	Manual with instructions for the operation of the AL-2006

Operating Principles

The first three sections of this chapter present the possible system types that can be implemented with the AL-2006 Brother processor and the basic operating principles of remote I/O stations and redundancy, respectively.

The sections that follow present more detailed information on the different aspects of remote I/O devices and redundancy. For systems that do not have these characteristics, these sections can be disregarded.

System Configurations

Two basic system types can be implemented with the AL-2006 Brother processor:

- Single CPU with remote I/O stations
- Redundant CPU with remote I/O stations

The first type consists of a single CPU, without redundancy, and an AL-2006 Brother processor, which communicates with the I/O modules distributed in remote units. Local I/O modules can also be used, if necessary. Figure 3-1 shows a typical architecture of this type of system, where the AL-2006 Brother processor does not execute the redundancy function, but only communication with the remote I/O stations.

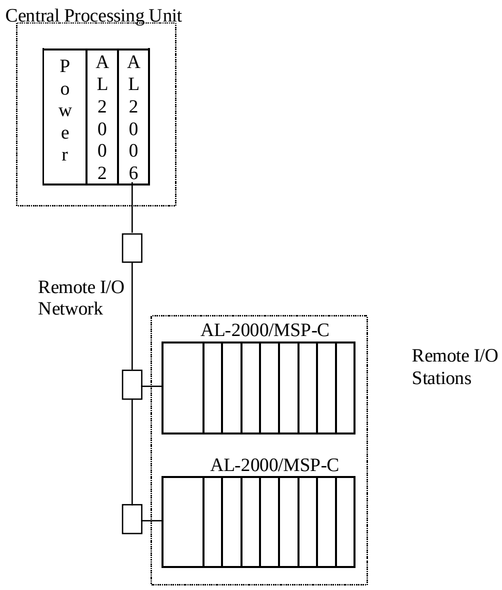


Figure 3-1 – System with Single CPU and Remote I/O Station

The second type contains two AL-2002/MSP processors, each with an AL-2006 Brother, composed of a redundant CPU. The two AL-2006 Brother processors are connected to each other and with the remote stations that contain the I/O points. Figure 3-2 shows an example of system with this configuration, where the redundancy functions and communication with remote I/O stations of the AL-2006 Brother are used together.

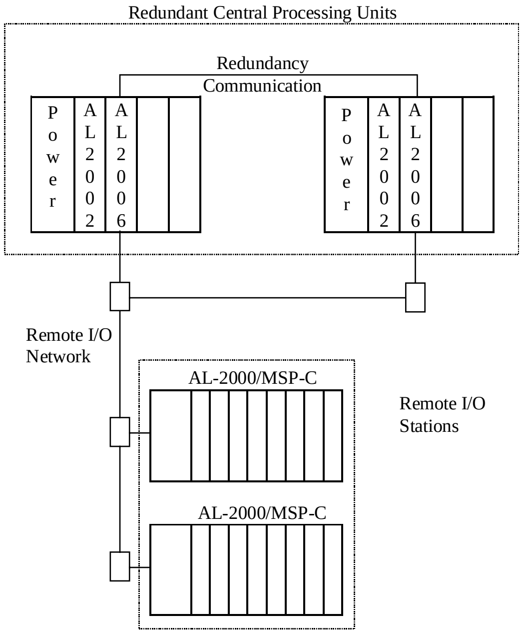


Figure 3-2 – System with Redundant CPU and Remote I/O Stations

Remote I/O Stations

This section presents a general overview of the remote I/O station processing using the AL-2006 Brother. The sections that follow give more detailed information on different aspects related to this processing.

The AL-2006 Brother processor uses a segment of the dedicated ALNET II network (network of remote I/O stations) for reading and writing I/O values in up to 8 remote stations. These remote stations can be AL-2000/MSP-C, QK2000/MSP, AL-2003 or AL-2002/MSP controllers.

The AL-2006 Brother communicates with the remote stations at the same time the AL-2002 CPU executes the application program. The F-2006.019 program module provides communication between the AL-2002/MSP CPU application program and the AL-2006 Brother processor.

When the F-2006.019 function is called by the application program, the AL-2006 Brother copies the values read from the remote station inputs to the CPU operands, and also searches for the CPU operand values to be written in the remote outputs. After the transfer of these operand values between the processors, the AL-2002/MSP begins to execute a new cycle of the application program while the AL-2006 Brother writes the output values and continuously reads the remote station input values to supply the most current values to the CPU, on the next F-2006.019 module call. Figure 3-3 shows the basic processing of the remote I/O stations by the AL-2006 Brother processor and AL-2002 CPU.

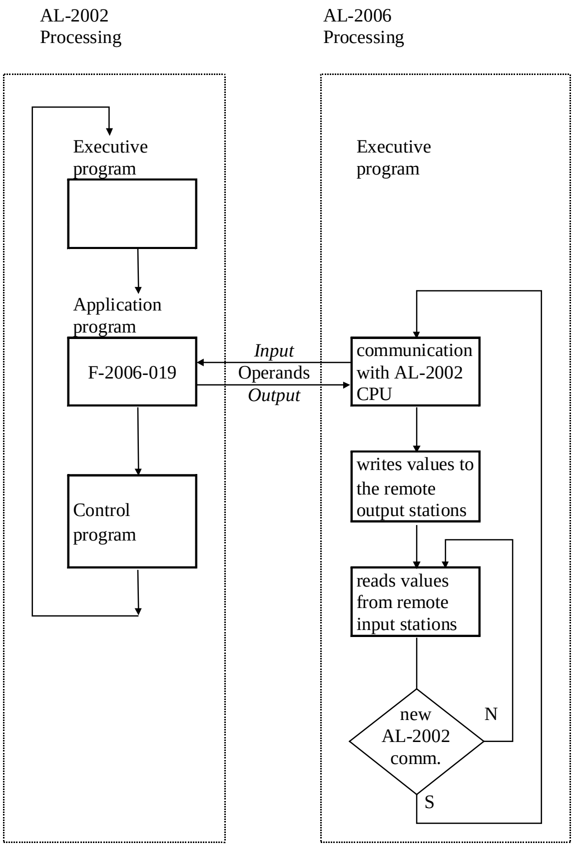


Figure 3-3 – Processing of the Remote I/O Stations by the AL-2006 Brother

If the execution of the AL-2002/MSP application program finishes before the AL-2006 Brother communicates with all of the remote stations, a new program cycle is not executed, and the F-2006.019 function is continuously called until the AL-2006 Brother finishes all communications with the I/O stations.

The AL-2006 Brother allows reading E (digital inputs) and M (analog inputs and special modules) remote station operands to the CPU M operands. It can also write CPU M operand values for the S (digital outputs) and M (analog outputs and special modules) operands of the remote stations. The operands of the remote stations are always transferred from/to M operands in the AL-2002/MSP CPU.

Redundancy

This section presents a general overview of the redundancy process using the AL-2006 Brother. The sections that follow present more detailed information for several aspects related to this process.

The AL-2006 Brother allows the implementation of redundant systems in hot stand-by configuration. In this redundancy architecture, the control CPUs are duplicated, where one is the **active** CPU and the other one is the **backup** CPU. The active CPU executes the application program, controlling the process. The backup CPU only executes a small part in the beginning of the program, supervising the operation of the active CPU.

If the backup CPU detects a failure in the operation of the active CPU, the latter is turned off and the backup CPU goes into the active mode, assuming control of the system. In order for this switchover be carried out without disturbing the control of the process (bumpless transfer) at each scan cycle of the application program, the active CPU copies the contents of its main operands to the same operands in the backup CPU.

The AL-2006 Brother processors are used to transfer these “redundant operand values” from the active CPU to the backup CPU, and at the same time the active CPU executes the application program. Thus, the backup CPU can assume control of the process with the most currently available status of the active CPU.

Figure 3-4 shows the normal continuous operation of the redundant CPUs. Figure 3-5 shows the system after an active CPU failure.

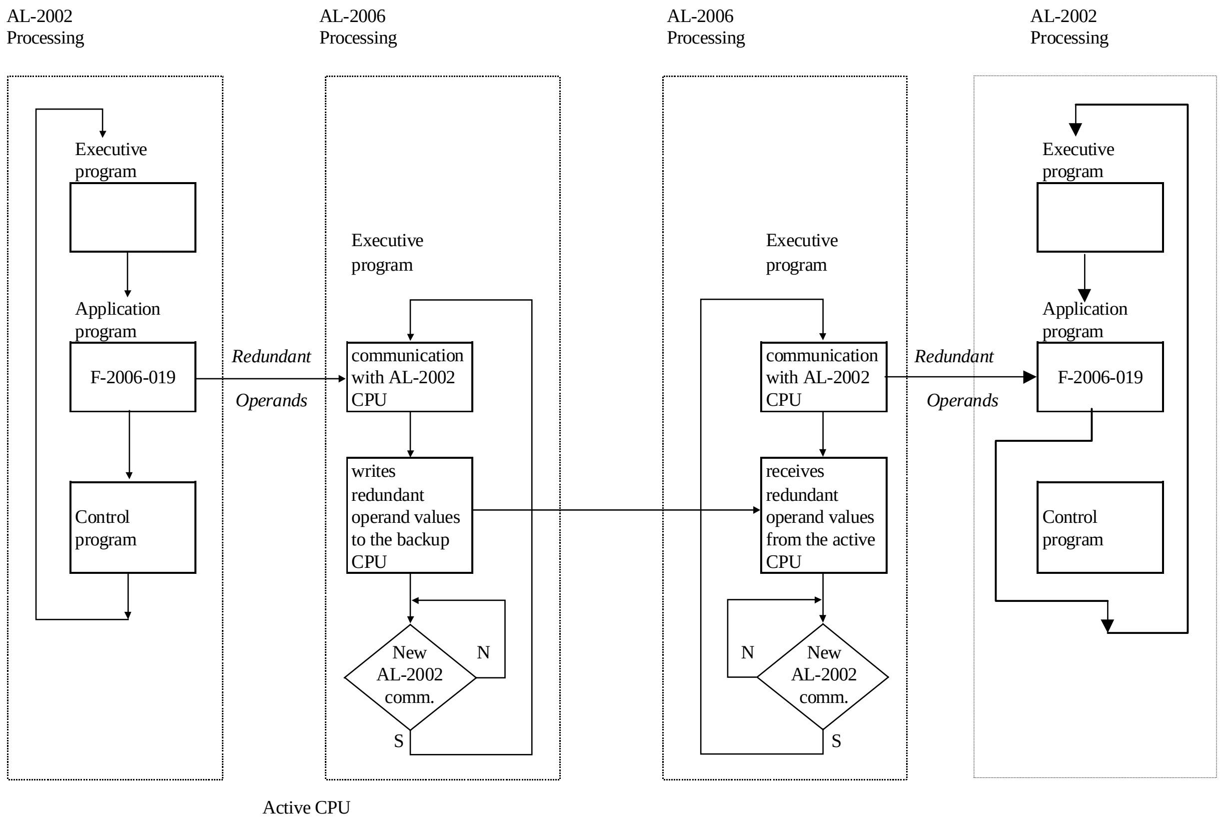


Figure 3-4 – Redundant System in Continuous Operation

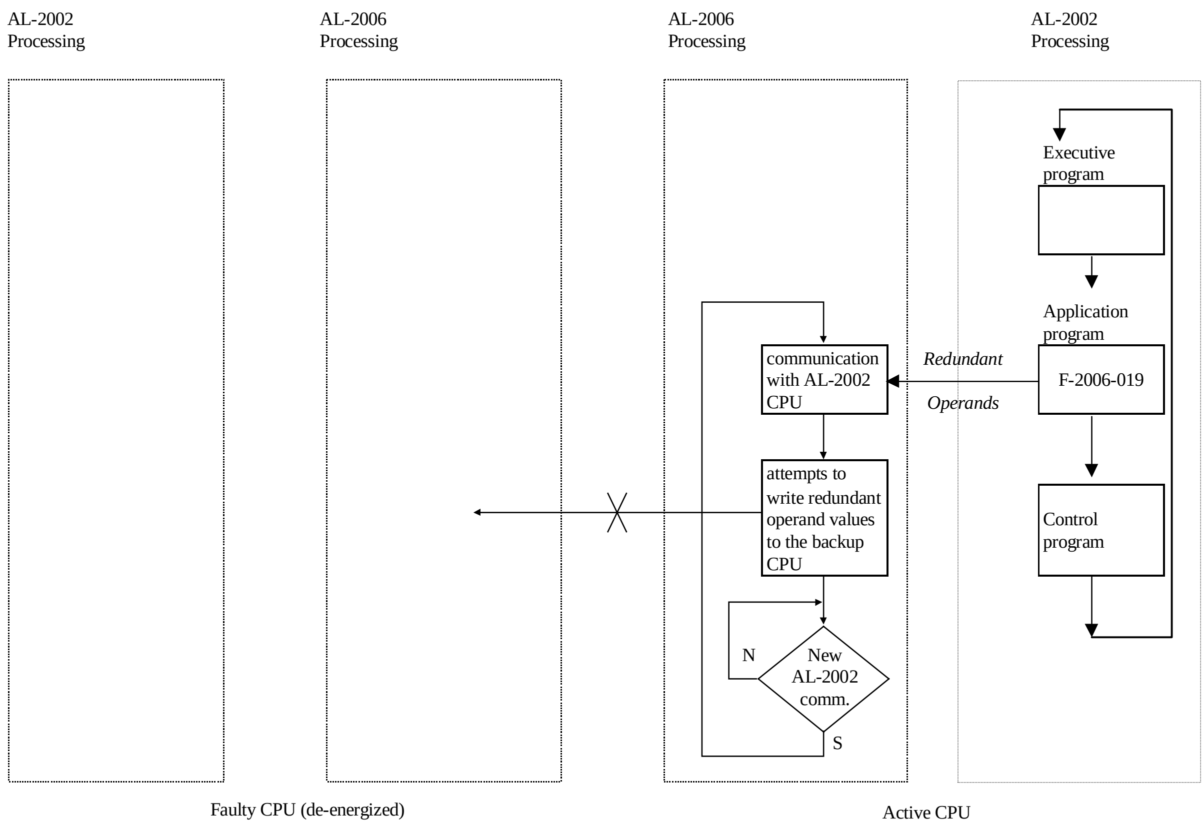


Figure 3-5 – Redundant System after Active CPU Failure

After automatic de-energization, the faulty CPU can be fixed and re-energized, then operating in standby mode, because the redundant CPU is already in active mode (figure 3-6).

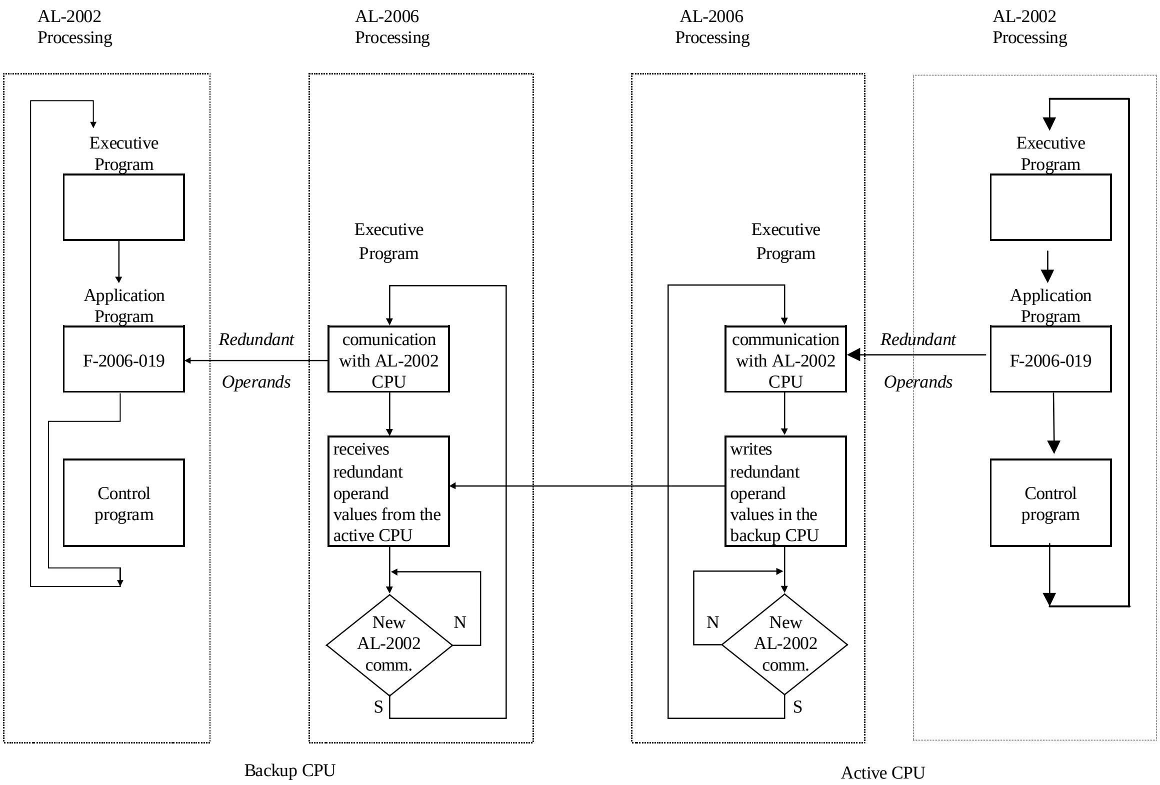


Figure 3-6 – Redundant System after Failure Repair

Application program

The F-2006.019 application program configures and exchanges data with the AL-2006 Brother processor. This F module is called within the P-2006_1.000 and P-2006_2.000 procedure modules, which configure the AL-2006 Brother processor, control access to the points of remote I/O stations, the redundancy logic and the execution of the control program.

Each P module, P-2006_1.000 and P-2006_2.000, is destined for one of the two redundant CPUs. These modules accompany the AL-2006 Brother and are programmed in relay diagram language (ladder) and should be used in the application programs of the redundant CPUs after the necessary modifications are made, as explained in the **Customized Use** section in chapter 4, **Programming**.

The P-2006_1.000 or P-2006_2.000 module should be the first procedure called in the E-.001 cyclic execution module. It can enable or disable the execution of the main control program, using a skip instruction present in the E-.001 module, according to the result of AL-2006 Brother module processing.

The entire main control program should remain under the command of the skip coil operated by the P-2006_1.000 or P-2006_2.000 module, except the instructions that cannot be skipped, such as ECR and LTR.

Figure 3-7 shows the structure of the application program of one of the AL-2002/MSP redundant CPUs for use with the AL-2006 Brother processor.

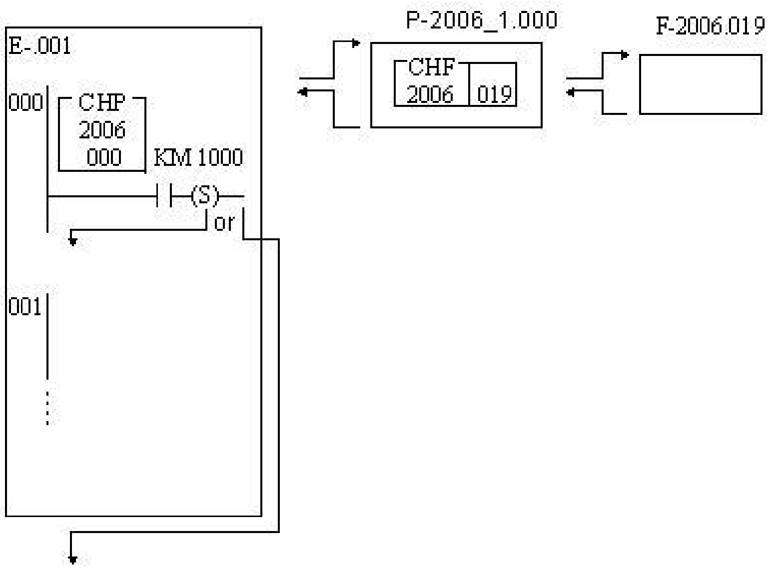


Figure 3-7 – Structure of the AL-2002/MSP Application program

➲DANGER:
The P-2006_1.000 and P-2006_2.000 modules, supplied with the AL-2006 Brother, were created and tested for correct hot standby redundancy control of the CPUs. The use of other control procedures or even the improper modification of these modules can cause the poor operation of the system and consequent implications.

For more details on P control modules for remote I/O stations and redundancy, refer to chapter 4, **Programming**.

AL-2006 Brother Processing

Operating Modes

The AL-2006 Brother processor, after activation, can work in four different operating modes, shown in figure 3-8:

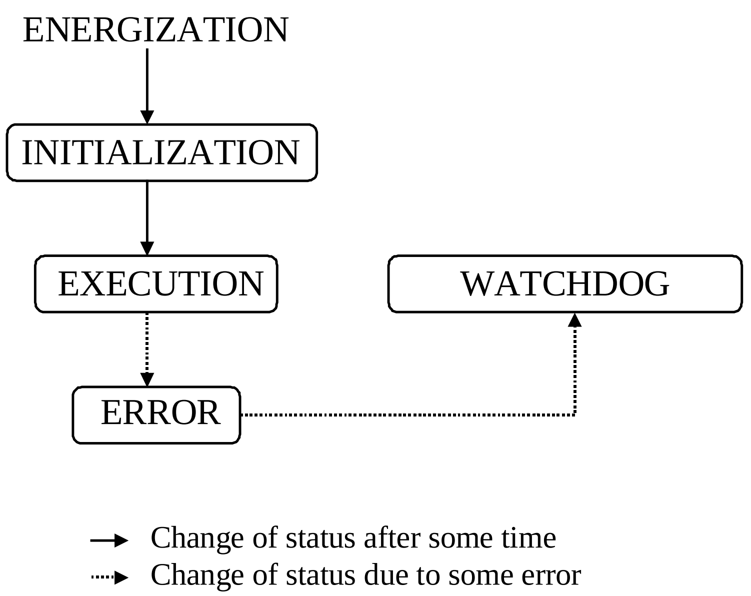


Figure 3-8 – Operating Modes of the AL-2006 Brother

- **Initialization Mode** – the EX, PG, PC and ER LEDs are lit on the front panel, indicating that the AL-2006 Brother is initializing its processing variables. This mode occurs soon after the programmable controller is powered up, taking about 3 seconds, and then passing to the execution or error mode.
- **Execution Mode** –the LED EX is lit on the front panel. In this mode, the AL-2006 Brother is operating normally, and is able to communicate with the AL-2002 CPU using the F-2006.019 module. When this communication is taking place, the PC LED flashes continuously.
- **Error Mode** – the ER LED is lit. This mode indicates that there was some kind of malfunction in the PC during processing, either a program checksum error or the maximum cycle time was exceeded. You can find out the specific cause of the error by connecting AL-3830 or MasterTool programmers on the ALNET I channel and opening the PC status information window. In this mode, the AL-2006 Brother does not allow communication with the AL-2002 CPU using the F-2006.019 module.
- **Watchdog Mode** – the WD LED is lit. This indicates that there was an AL-2006 Brother hardware error. In this mode, processing is interrupted, and communication with the AL-2002 CPU and the programmers using the ALNET I channel is impossible.

When in normal operation, in execution mode, the AL-2006 Brother can operate in three different modes, determined by the P-2006_1.000 or P-2006_2.000 module, and transferred to the AL-2006 Brother using the F-2006.019 function:

- **Active** – after communicating with the AL-2002 CPU, reading the operand values using the AL-2002 backplane, the AL-2006 Brother writes the output operand values to the remote stations and writes the redundant operand values to the AL-2006 Brother processor of the backup CPU, using the ALNET II communications network. Figure 3-9 shows this sequence of events.

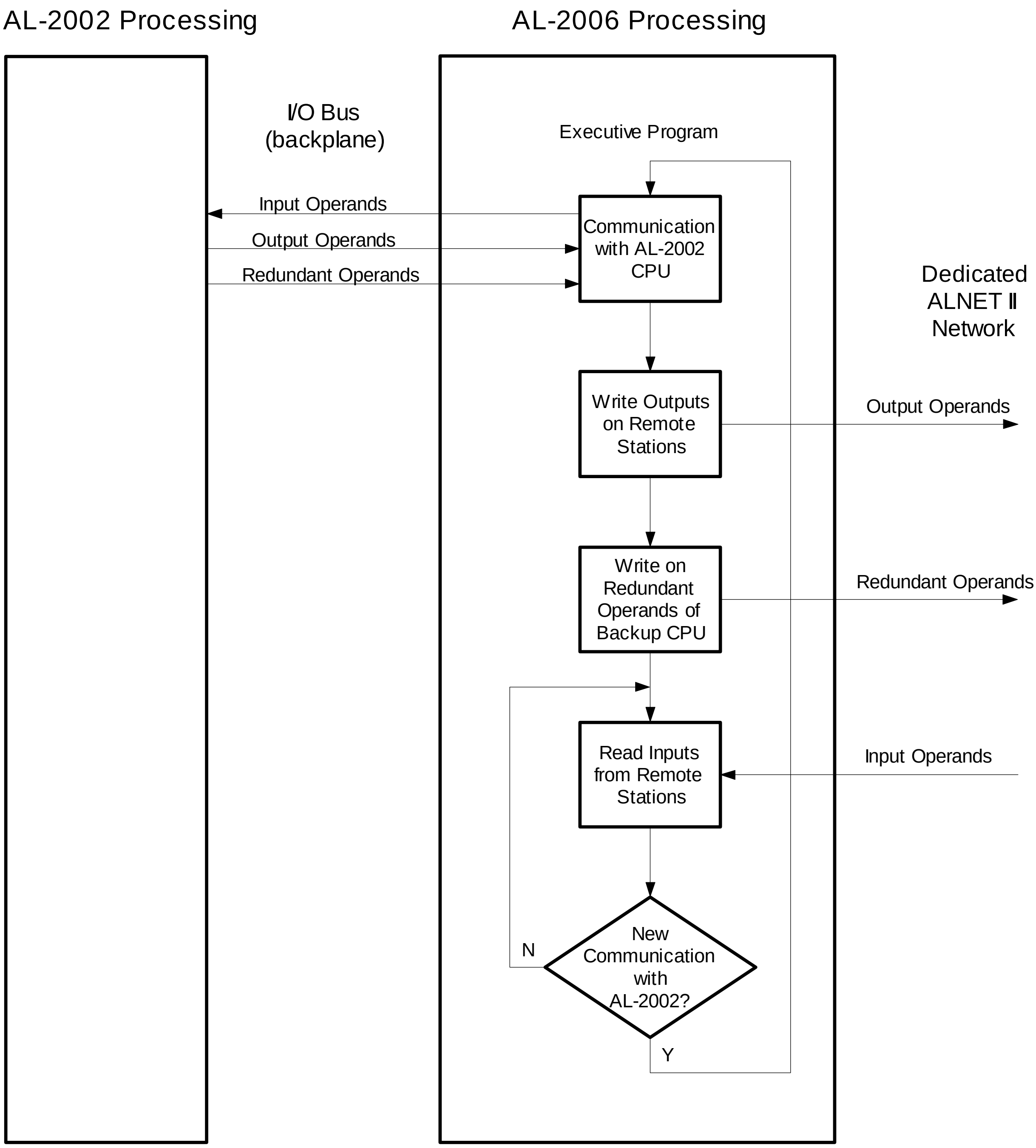


Figure 3-9 – AL-2006 Brother Processing in Active Mode

- **Backup -** the AL-2006 Brother processor continuously waits for the communication of the redundant operand values coming from the AL-2006 Brother of the active PC. After receiving all of the redundant operand values from the active PC's previous scan cycle, the AL-2006 Brother writes them to the operands of the backup CPU in the next communications interruption created by the backup CPU (F-2006.019 procedure call). Figure 3-10 shows the behavior of the AL-2006 Brother in backup mode.

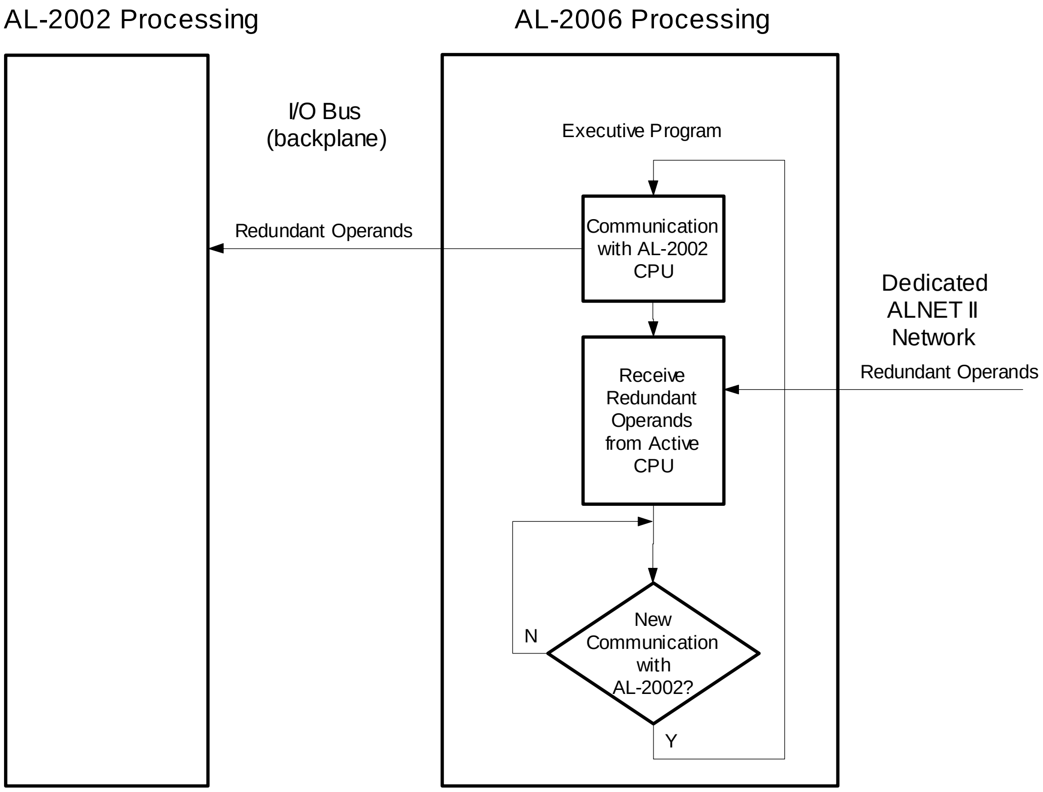


Figure 3-10 – AL-2006 Brother Processing in Backup Mode

- **Configuration -** the AL-2006 Brother processor examines the contents of the parameters programmed in the CHF instruction of the F-2006.019 module call, verifying its consistency and initializing its control variables for the new configuration. In this mode, the AL-2006 Brother does not communicate with the remote stations nor with the AL-2006 Brother of the redundant CPU.

Before operating in the active or backup modes, the AL-2006 Brother processor should have been configured at least once after the PC has been energized.

In any of these three operating modes, the AL-2006 Brother can process commands in the ALNET I protocol received from its corresponding connector and serially exchange information with the AL-2006 Brother of the redundant CPU.

Communications Network with Remote Stations

Exchange of information between redundant CPUs and remote I/O stations is carried out by the remote I/O network. This network uses the same physical media, the same connection method and configuration as the ALNET II network. In addition, the optical media for the connection of one or more remote stations can be used.

Even though a communications network with remote stations has all the potential of the ALNET II network, the number of possible sub-networks is limited to 3 (maximum of 2 bridge processors).

In the communications network with remote stations only the AL-2006 Brother processors of the same redundant PC, the respective remote I/O stations and at most 2 bridge processors can be connected. Gateway processors or ALNET II channels of any other elements cannot be connected. Furthermore, the application programs of the remote stations cannot contain ECR or LTR instructions.

Each element connected to this network has node and sub-network addresses: the AL-2006 Brother processors, the remote stations and any bridges. The AL-2006 Brother addresses and data rate are defined using the F-2006.019 application program. In remote stations these parameters are defined by the

F-REMOT.069 module. More information can be found in chapter 4, **Programming**.

The bridge processors are configured using R modules. This configuration is described in detail in AL-2401 or QK2401Technical Specifications.

For addressing of the communications networks with remote stations, the same configuration principles applicable to the ALNET II networks are valid: all the elements connected to the same network segment should be configured with the same sub-network address (from 1 to 63); all the elements connected to the same segment of the network should be configured with different node addresses (from 1 to 31).

For more specific details on the configuration and use of the ALNET II networks, refer to the ALNET II User's Guide.

Use of FOCOS Optical Network

A group of I/O remote stations, or even all the remote stations, can be connected over long distances through the optical fibers of the FOCOS system, taking advantage of the characteristics of the great immunity to electromagnetic interference and electric insulation.

Optical channels can be simple or redundant, guaranteeing a high availability in environments with risk of damage to the cables.

For more information on the use and configuration of the FOCOS optical system, refer to the FOCOS User's Guide.

Specific Aspects of Redundancy

States of Redundant CPUs

The P-2006_1.000 (CPU 1) and P-2006_2.000 (CPU2) modules of the application program determine the operating state of each CPU, supervise the active CPU and control the execution of the main control program. If the CPU is powered-up and in execution mode, it can be in one of the three following states:

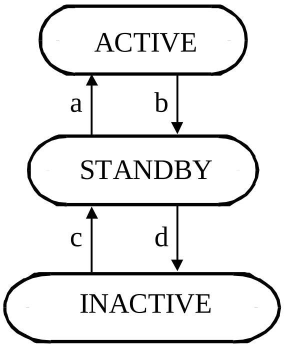
- **Active** – the CPU is controlling the process and sends the contents of the main program operands to the backup CPU on every execution cycle of its application program. It also updates the remote I/O station points, if applicable.
- **Standby -** the CPU is not in control of the process, but receives the operand values of the active CPU and supervises the active CPU state. In case of failure of the active CPU, it switches to active and takes control of the process, de-energizing the other CPU. If there are remote I/O station points in the system, the backup CPU does not access them.
- **Inactive** – the CPU neither controls the process nor supervises the status of the active CPU. As a result, it will not take control of the process in case of active CPU failure. This state is used for configuring the AL-2006 Brother processor and to make maintenance on the CPU.

The P-2006_1.000 and P-2006_2.000 modules determine the mode of the CPUs using two basic principles, fundamental for implementing hot-standby redundant systems:

- A single CPU is always active, controlling the system. The other one can be used as backup, or be inactive during maintenance.
- The time a CPU remains inactive, in programming mode or de-energized should be as short as possible, because the system could have no control if a failure in the active CPU occurs while the other CPU is in these states.

Changes of CPU States

The change of CPU states is carried out by the P-2006_1.000 or P-2006_2.000 modules, and can occur due to the detection of failures on the active CPU or commands activated by the user through local input points on the CPUs. On each CPU there are input points that should be connected to buttons so that the CPU can be switched to standby and inactive modes. Figure 3-11 presents the possible changes of CPU states.



a – Failure or Standby button pressed on Active CPU.

b - Standby button pressed on Active CPU.

c - Standby button pressed on Inactive CPU, or power-on of a CPU while another is already active

d - Inactive button pressed on Backup CPU.

Figure 3-11 – Changes of Redundant CPU States

Detection of Active CPU Failure

The backup (or standby) CPU supervises the operation of the active CPU to detect failures. This supervision is done using a redundant procedure, using two simultaneous methods, avoiding change of state without a real active CPU failure, as shown in figure 3-12.

- Communication between the AL-2006 Brother processors using a redundancy serial channel (AL-1366 cable) – using this dedicated communications channel, a CPU receives information about the current status of the other redundant CPU in a quick and efficient way.
- Communication using the Remote I/O network (dedicated ALNET II) –the backup CPU should periodically receive communication from the active CPU.

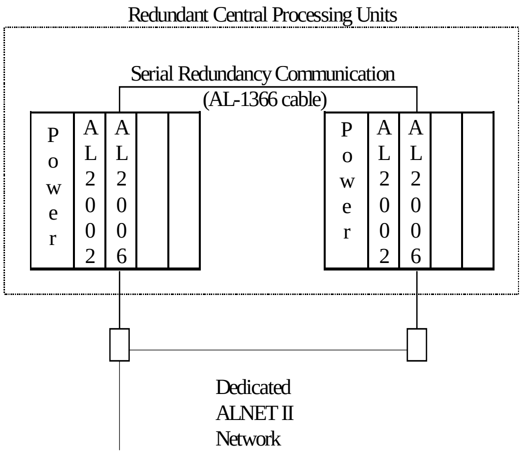


Figure 3-12 – Communications Channels between Redundant CPUs

If the backup CPU detects active CPU failure simultaneously using the two communications channels, it takes control of the process, becoming active and de-energizing the redundant CPU. The de-energization of the CPU in which the failure was detected guarantees the absence of this CPU in the control process.

The two existing ways for the detection of failures in the active CPU increases the security of the control system, allowing it to support single failures, such as serial interface damage in the backup PC or disconnection of cables, without attempting to change the state since the active CPU is in good conditions.

The time necessary for detecting a failure and changing the backup CPU to active mode depends on the maximum cycle time for the application program configured in the C module of the CPUs. For the P-2006_1.000 or P-2006_2.000 modules supplied, these times are shown in table 3-1.

Maximum cycle time for the program configured in the C module	Maximum time for the backup CPU to become active
100 ms	400 ms
200 ms	500 ms
300 ms	600 ms
400 ms	700 ms
500 ms	900 ms
600 ms	1,100 ms
700 ms	1,300 ms
800 ms	1,500 ms

Table 3-1 – Time of Failure Detection and Change of State between CPUs

When the backup CPU becomes active, the AL-2006 Brother processor reads all the input operands of the remote stations, before the first execution of its application program, so that the program can be executed with the most current process values.

Transfer Operands from the Active CPU to the Backup CPU

In order for the backup CPU to continue the control process starting from the same situation in the active CPU after the occurrence of a failure in the latter, two conditions are fundamental: the application programs of the two CPUs should be identical and the main operand values of the active CPU should be copied to the backup CPU at every scan cycle.

The latter condition is carried out by the AL-2006 Brother processors. During each scan cycle of the application program of the active CPU, its AL-2006 Brother processor transmits the operand values configured for redundancy to the redundant AL-2006 Brother, so that they are copied to the identical operands of the backup CPU. If the active AL-2006 Brother cannot communicate with the backup AL-2006 Brother due to absence, deactivation or failure, a new cycle of the active CPU program is executed, maintaining control of the process.

The E, S, A, M, D, TM and TD operands can be transferred to the redundant CPU, within the limits presented in table 3-2.

Operand Type	Maximum number of redundant operands
E	64
S	64
A	96
M	1008
D	504
TM	1008 positions
TD	504 positions

Table 3-2 – Maximum Number of Operands Configurable for Redundancy

The configuration of the redundancy of numeric operands (M, D, TM and TD) as a whole should not exceed the maximum number of 2,016 bytes. The number of operands shown in table 3-2 refers to the maximum value that can be configured for a determined type when no other type has been declared. The redundancy of the S operands is reserved for future use, and should not be used.

To determine whether a configuration is valid, the number of bytes occupied by each numeric operand should be multiplied by the number stated for redundancy, then added and the result should be less or equal to the maximum number of bytes possible (2,016). This restriction is not applied to the digital operands (S and A), which can be configured for any amount. Table 3-3 presents the number of bytes occupied by each numeric operand.

Operand type	Number of bytes
M	2 bytes per operand
D	4 bytes per operand
TM	2 bytes per position
TD	4 bytes per position

Table 3-3 – Maximum Number of Operands Configurable for Redundancy

Example of Calculation of Configuration Limit

Six hundred M operands, 100 D operands, 80 TM table positions and 20 TD table positions are to be transferred to the backup CPU. The total number of bytes for redundancy communication would be:

Number of total redundancy bytes = 600 x 2 + 100 x 4 + 80 x 2 + 20 x 4

Number of total redundancy bytes = 1,840

The total number of bytes calculated is less than the 2,016 byte limit. Therefore, the configuration is valid.

Cycle Time of the Application program of Redundant CPUs

The backup CPU only executes the redundancy control routine found in the P-2006_1.000 or P-2006_2.000 module, and always skips over the main program instructions of the control (skip coil on first logic of E-.001 module). Because of this, the runtime of the program of this CPU is short, approximately 5 to 30 ms, depending on the amount of redundant operands configured.

In addition to the P-2006_1.000 or P-2006_2.000 redundancy control module, the active CPU also executes the application program of the process control, and the process time can range from a few tens to hundreds of milliseconds. While the AL-2006 Brother processor executes this program, it also communicates with the remote I/O stations and with the backup CPU. A new control program scan cycle can only start after its end, and after the end of the AL-2006 Brother communication with remote I/O stations and redundant AL-2006 Brother.

Regarding the program cycle time, the active CPU can operate in two distinct ways, depending on the cycle time of the main control program of the AL-2002 and the number of redundant operands and remote stations configured in the AL-2006 Brother:

- The cycle time of the AL-2002 control program is bigger than the processing time of the AL-2006 Brother. When the AL-2002 control program ends, the AL-2006 Brother has already ended its tasks. So, a new AL-2002 cycle can start immediately.
- The cycle time of the AL-2002 control program is shorter than the processing time of the AL-2006 Brother. When the AL-2002 control program ends, the AL-2006 Brother has not ended its tasks yet. So, the AL-2002 control program must wait until AL-2006 Brother ends its tasks.

The first case resembles a controller with local I/O stations, where the time spent to read local I/O is irrelevant.

The second case typically occurs with small application programs and many redundant operands configured. The execution of the program waits until the end of the AL-2006 Brother processing. The instantaneous runtime indication varies between small and large values and the average time tends to be shorter than the maximum time.

In the two types of operation , the process control is executed normally, since the maximum cycle time is acceptable for the type of process controlled.

The instantaneous, maximum, average and minimum application program execution cycle times can be found using the MasterTool programmer.

ALNET II Communication with Redundant Controller

The redundant programmable controller, which consists of an active CPU and backup CPU, can be connected to an ALNET II network, communicating with a supervisory program or with other programmable controllers.

✎CAUTION: The ALNET II network for communication with a redundant programmable controller, connected to the AL-2002 CPUs, is completely independent from the ALNET II network dedicated to communication with the remote I/O stations, connected to the AL-2006 Brother processors. These two networks cannot be interconnected directly or through a bridge processor.

Both CPUs that make up a redundant PC are connected to the ALNET II network, each one having a communications address (node address) within the local sub-network segment.

The redundancy mechanisms of the CPUs used allow the change of the active CPU, so either CPU1 or CPU2 can be in active mode, controlling the process. This change can cause a problem for the rest of the elements connected to the network that need to communicate with the active CPU, because they would not know which node address corresponds to the active CPU for use in communication.

To solve this problem, a dynamic node mechanism changes the addresses of CPUs 1 and 2, according to their states. Thus, the CPU that is in active state always has the same node address, while the inactive or backup CPU always has another address, no matter to which CPU (1 or 2) they physically correspond.

For example, suppose a supervisory system connected to an ALNET II network using an AL-2400/S-C gateway, where a redundant programmable controller is also connected, whose CPUs have the node addresses of 7 and 8, with a local sub-network address of 5, as shown in figure 3-13.

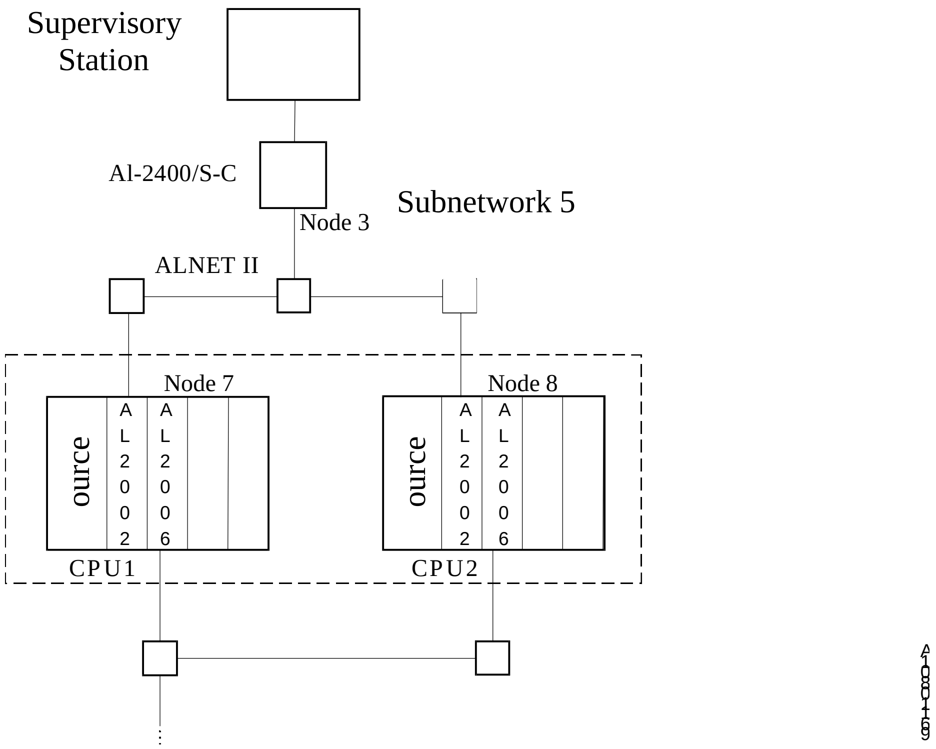


Figure 3-13 – Example of ALNET II Communication with a Redundant PC

If CPU 1 is in active state, it has a node address of 8, while CPU 2, in backup state, has a node address of 7.

If CPU 1 is in backup state, it has a node address of 7, while CPU 2, in active state, has a node address of 8.

All of the remote stations are configured with a sub-network address of 5. Thus, communications with the supervisory program are transmitted to address 8, which always corresponds to the active CPU, which controls the process, no matter if this CPU is physically 1 or 2.

The F-END2.082 function module changes the address of the CPU according to its state.

Normally, successive addresses are used for CPUs of the same redundant controller, using an even-number address for the active CPU and an odd-number address for the backup CPU. The normal node address of the ALNET II network (address1 to 31) can be used within the same sub-network.

The active CPU swapping process, either manually or by active CPU failure, can cause some transient failures in the network operation, with possible loss of some communication, and some errors are shown in the ALNET II communication status window, seen in the MasterTool or AL-3830 programmer.

The node address of the ALNET II network configured in the C modules of the two CPUs should be the same, with the same value as the backup CPU should have (odd address). When the system is initialized, one of the CPUs becomes active and the F-END2.082 module changes its address to the even-number value. Thus, the C module can be modified and loaded in any CPU, as long as it is in backup status, so both the C modules are configured with the backup address. The C module **should not be directly loaded into the active CPU**, because loading it could cause a change in the CPU address.

In the example shown in figure 3-13, the C modules on both CPUs should be configured for a node address of 7 and a sub-network address of 5.

Specific Aspects of Remote I/O Stations

Remote Station Processing

Up to eight remote stations can be connected to a simple programmable controller (one CPU) or a redundant controller (two CPUs) using AL-2006 Brother processors. The stations consist of AL-2000/MSP-C, QK2000/MSP, AL-2003 or AL-2002/MSP controllers executing a small application program, where the F-REMOT.069 function module is called. This function manages data transfer between the E and S operands of the remote station and the AL-2006 Brother processors, also commanding the enabling of the local I/O buses.

During each scan cycle of the AL-2002 CPU application program, the AL-2006 Brother processor copies the input point values of the remote stations to the CPU, also transferring the CPU output point values to the stations. This transfer is done between the CPU M operands and the remote station M operands. In the latter, the F-REMOT.069 module copies the values between the M operands and the E and S operands. Figure 3-14 shows a diagram with this transfer.

In addition to the digital I/O point values, the remote station numeric values are also transferred to the CPU and vice versa, making the use of analog and special I/O modules possible, such as fast counters, interfaces for thermocouples, communication interfaces, among others. The instructions to access these modules, when used, should be inserted into the application program of the remote stations because they are not processed by the F-REMOT.069 function.

The exact correspondence between the CPU operands and those of the remote stations is presented in the Remote Stations section in this chapter.

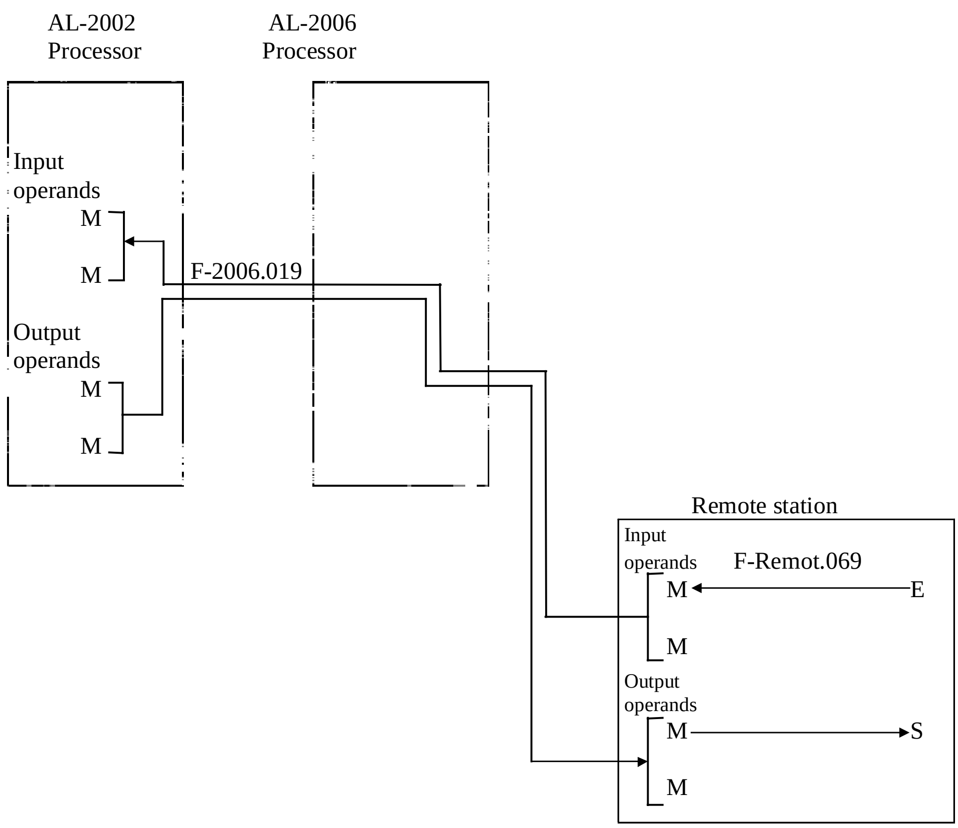


Figure 3-14 – Transfer of Remote I/O Station Values

Declaration of Remote Stations for the AL-2006 Brother

Each existing remote I/O station should be declared to the AL-2006 Brother processor. This is done using a table memory (TM) operand, programmed as the second parameter called by the F-2006.016 application program. Table 3-4 shows the meaning of each position in this table, to configure two remote stations.

TM declaration of remote I/O stations in F-2006.019 – General definitions		
Position	Values	Contents
0	0	Table type identifier
1	0	Table type identifier
2	1 to 31	Node address of the AL-2006
3	1 to 63	Sub-network address of the AL-2006
4	1000, 500, 250, 125, 64	Data rate of the AL-2006
5	-	Not used (reserved)

TM declaration of remote I/O stations in F-2006.019 – Optical channel definitions		
Position	Values	Contents
6	0 to 31	Node address of the controller channel of the first optical connection
7	0 to 63	Sub-network address of the first optical connection
8	0 to 31	Node address of the controller channel of the second optical connection
9	0 to 63	Sub-network address of the second optical connection

TM declaration of remote I/O stations in F-2006.019 - Remote 0 definitions		
Position	Values	Contents
10	1 to 31	Remote station node address
11	1 to 63	Remote station sub-network address
12	1000, 500, 250, 125, 64	Remote station data rate
13	0 to 9999	First M operand of the area that receives/sends remote station values on the local CPU
14	0 to 64	Number of remote station E operands to be read
15	0 to 64	Number of remote station S operands to be written
16	0 to 108	Number of remote station M operands to be read

17	0 to 112	Number of remote station M operands to be written

TM declaration of remote I/O stations in F-2006.019 - Remote 1 Definitions		
Position	Values	Contents
18	1 to 31	Remote station node address
19	1 to 63	Remote station sub-network address
20	1000, 500, 250, 125, 64	Remote station data rate
21	0 to 9999	First M operand of the area that receives/sends remote station values on the local CPU
22	0 to 64	Number of remote station E operands to be read
23	0 to 64	Number of remote station S operands to be written
24	0 to 108	Number of remote station M operands to be read
25	0 to 112	Number of remote station M operands to be written

Table 3-4 – Contents of the Definition Table for the Remote I/O Stations in F-2006.019

The declaration of the remote stations is done from position 10 in the table, each remote station occupying 8 positions, as shown in table 3-5. The function of each one of the 8 positions is identical for all of the 8 remote stations.

declaration of remote I/O stations in F-2006.019	
Positions	Contents
10 to 17	Definitions of remote station 0
18 to 25	Definitions of remote station 1
26 to 33	Definitions of remote station 2
34 to 41	Definitions of remote station 3
42 to 49	Definitions of remote station 4
50 to 57	Definitions of remote station 5
58 to 65	Definitions of remote station 6
66 to 73	Definitions of remote station 7

Table 3-5 – Configuration Positions of the I/O Remote Stations

The declaration table should contain the correct number of positions to define the remote stations to be used. For example, if the system has 3 remote stations, the table should be declared with 34 positions (positions 0 to 33) in the C module of the PC application program.

Additional information on the use of the F-2006.019 module or on the configuration process of the AL-2006 Brother can be found in chapter 4, **Programming**.

Remote Station Configuration

Each remote I/O station should be configured so that the AL-2006 Brother processor can properly communicate with it. This configuration is done using the contents of a table memory (TM) operand, programmed as the first parameter called by the module of the F-REMOT.069 application program. Table 3-6 shows the meaning of each position of this table.

TM – configuration of remote I/O stations in F-REMOT.069		
Position	Values	Contents
0	0	Table type identifier
1	0	Table type identifier
2	1 to 31	Remote station node address
3	1 to 63	Remote station sub-network address
4	1000, 500, 250, 125, 64	Remote station data rate
5	0 to 9999	First M operand of the area that receives/sends remote station values on the local CPU
6	0 to 64	Number of remote station E operands to be read
7	0 to 64	Number of remote station S operands to be written
8	0 to 108	Number of remote station M operands to be read
9	0 to 112	Number of remote station M operands to be written

Table 3-6 – Contents of the Remote Station Configuration Table in F-REMOT.069

The parameter values of the table used in F-REMOT.069 (remote application program) should be identical to the table used in the F-2006.019 function of the CPU application program, in the part referring to the same remote station.

For example, in a system with 3 remote stations, the TM009 for definition of the stations on the CPU has 34 positions, remote station 1 is defined in positions 18 to 25. This table is processed by the F-2006.019 function module to the configuration of the AL-2006 Brother of the CPU.

Remote station 1 is configured by the TM000, with 10 positions, processed by the F-REMOT.069 function module, called by the station. The values of positions 2 to 9 of TM000 of remote station 1 should be identical to positions

18 to 25 in the CPU's TM009 table. Table 3-7 shows the values used in this example.

TM009 – configuration of the CPU remote stations							
Position	Value	Position	Value	Position	Value	Position	Value
0	0	10	2	18	3	26	4
1	0	11	1	19	1	27	1
2	1	12	1000	20	1000	28	1000
3	1	13	100	21	200	29	300
4	1000	14	20	22	24	30	14
5	0	15	16	23	22	31	12
6	0	16	8	24	12	32	0
7	0	17	6	25	10	33	0
8	0						
9	0						

TM000 – configuration of remote station 1	
Position	Value
0	0
1	0
2	3
3	1
4	1000
5	200
6	24
7	22
8	12
9	10

Table 3-7 – Contents of the Configuration Table of the I/O in an Example System

CPU Operand Equivalence -- Remote Stations

Based on the configuration values of the remote station, the F-REMOT.069 module copies the input and output operand values, plus status indications to the two areas of M operands for communication with the AL-2006 Brother processor. One area corresponds to the input operands, which are read by the AL-2006 Brother. The other area corresponds to the output operands, which are written by the AL-2006 Brother. Figure 3-15 shows the structure of these two areas.

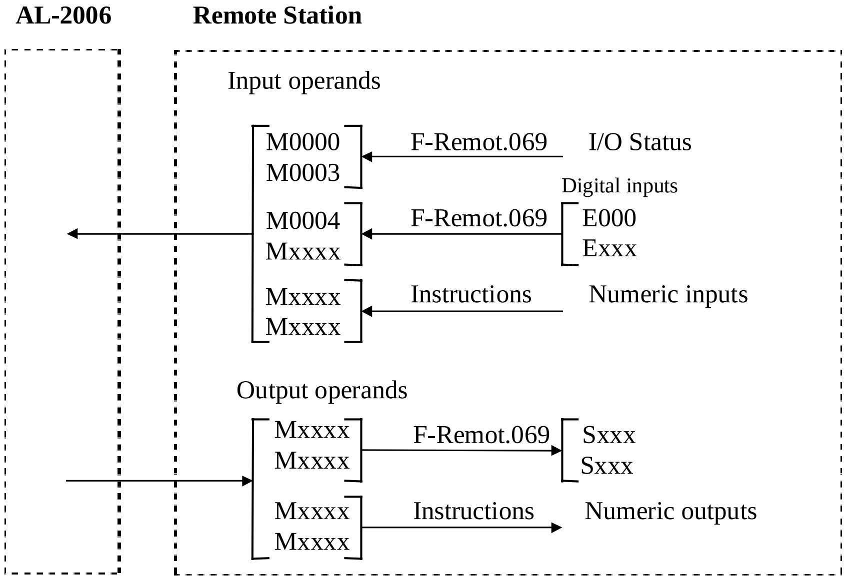


Figure 3-15 – Communications Areas of the Remote I/O Stations

Area of the Input Operands in the Remote Stations

The area of the input operands in the remote stations always begins with the M0000 operand, and is divided into three regions:

- Status of I/O operands – occupies the first four operands in the input area (M0000 a M0003), contains the status of each of the 64 E and S operands of the remote station. The status of each E or S octet is indicated using a bit corresponding to the M status operands, where the value 0 means normal operating status of the octet and the value 1 means failure or hot swapping status. Tables 3-8 and 3-9 show the bits of the M status operands corresponding to the E and S operands of the remote stations. The S operands are represented in the tables as E operands, because the first S address depends on the configuration used.

Status Operand	I/O Operand	Status Operand	I/O Operand
M0000.0	E0000	M0001.0	E0016
M0000.1	E0001	M0001.1	E0017
M0000.2	E0002	M0001.2	E0018
M0000.3	E0003	M0001.3	E0019
M0000.4	E0004	M0001.4	E0020

M0000.5	E0005	M0001.5	E0021
M0000.6	E0006	M0001.6	E0022
M0000.7	E0007	M0001.7	E0023
M0000.8	E0008	M0001.8	E0024
M0000.9	E0009	M0001.9	E0025
M0000.A	E0010	M0001.A	E0026
M0000.B	E0011	M0001.B	E0027
M0000.C	E0012	M0001.C	E0028
M0000.D	E0013	M0001.D	E0029
M0000.E	E0014	M0001.E	E0030
M0000.F	E0015	M0001.F	E0031

Table 3-8 – Remote Station Status Operands

Status Operand	I/O Operand	Status Operand	I/O Operand
M0002.0	E0032	M0003.0	E0048
M0002.1	E0033	M0003.1	E0049
M0002.2	E0034	M0003.2	E0050
M0002.3	E0035	M0003.3	E0051
M0002.4	E0036	M0003.4	E0052
M0002.5	E0037	M0003.5	E0053
M0002.6	E0038	M0003.6	E0054
M0002.7	E0039	M0003.7	E0055
M0002.8	E0040	M0003.8	E0056
M0002.9	E0041	M0003.9	E0057
M0002.A	E0042	M0003.A	E0058
M0002.B	E0043	M0003.B	E0059
M0002.C	E0044	M0003.C	E0060
M0002.D	E0045	M0003.D	E0061
M0002.E	E0046	M0003.E	E0062
M0002.F	E0047	M0003.F	E0063

Table 3-9 – Remote Station Status Operands

- E operand image – a copy of the E operand values of the remote station is stored beginning from the M0004 operand. The number of E operands copied is determined by the value of position 6 of the TM000 table of the remote station configuration, used by the F-REMOT.069 function. Each M operand receives the value from two E operands, using the number of M operands sufficient to contain all the E operands defined in TM000. Byte 0 of the M operand receives the E operands with the lowest address, while byte 1 receives the E operand with the highest address. For example, if position 6 of the TM000 table were 15, the F-REMOT.069 function copies the E000 to E014 octet values to the M0004 to M0011 operands in the positions shown in table 3-10.

Operand	byte 1	byte 0
M0004	E0001	E0000
M0005	E0003	E0002
M0006	E0005	E0004
M0007	E0007	E0006
M0008	E0009	E0008
M0009	E0011	E0010
M0010	E0013	E0012
M0011	-	E0014

Table 3-10 – Example of Image Area of Operands E in the Remote

- Input M operands – this group of operands is used to transfer analog values or special input modules (fast counter, for example) from the remote station to the CPU. The number of reserved operands is determined by the value of position 8 of the TM000 table of the remote station configuration, while the first M input operand corresponds to the following operand after the last M operand of the image area of the E operands.

> The F-REMOT.069 function does not modify the value of these operands during its processing, because they are updated by special instructions or functions, that access these input modules in the I/O bus.

These operands can also be used to transfer any other remote station values to the CPU.
For example, if position 8 TM000 table has a value of 20 and the image area of the E operands occupies up to the M0011, the M0012 to M0031 operands will be used to store the values to be copied to the CPU using the AL-2006 Brother processor.

> The number of M operands allocated for the whole input area should not exceed 112. That is, the area of input operands in each remote station should not exceed the M0111 operand (it always begin in M0000).

Area of the Output Operands in Remote Stations

The area of the output operands in the remote stations always starts in the first M operand after the last operand used in the input area, and is divided into two regions:

- S operand image – the values to be copied to the S operands of the remote station are obtained starting with the first M operand of the output area. The number of S operands updated is determined by the value in position 7 of the TM000 table of the remote station configuration, used by the F-REMOT.069 function. Each M operand carries values for two S operands. A sufficient number of M operands are allocated to store all of the S operands defined in TM000. Byte 0 of the M operand is copied to the S operand with the lowest address, while byte 1 is copied to the S operand with the highest address. For example, if position 7 of the TM000 table is 9, the last M input operand is M0031 and the first S operand is S020, the F-REMOT.069 function copies the values of the M0032 to M0036 operands to the S020 to S028 octets, according to the equivalence shown in table 3-11.

Operand	byte 1	byte 0
M0032	S0021	S0020
M0033	S0023	S0022
M0034	S0025	S0024
M0035	S0027	S0026
M0036	-	S0028

Table 3-11 – Example of Image Area of Operands S in a Remote Station

- M output operands – this group of operands is used to transfer analog values or special output modules (IHMs for example) from the CPU station to the remote station. The number of reserved operands is determined by the value in position 9 of the TM000 table of the remote station configuration, while the first M output operand corresponds to the following operand after the last of the S operand image area.

The F-REMOT.069 function does not use the value of these operands during its processing. They must be used by special instructions or functions that access these output modules in the I/O bus.

These operands can also be used to transfer any other values from the CPU to the remote stations.
For example, if position 9 of the TM000 table has a value of 12 and the S operand image area occupied up to the M0036 operand, the M0037 to

M0048 operands will be used to transfer CPU values to the remote station, using the AL-2006 Brother processor.

The number of M operands allocated for the whole output area should not exceed 112.

Area of the Input and Output Operands on the CPUs

The AL-2006 Brother processor transfers the areas of input operands from the remote stations to the CPU and the areas of output operands from the CPU to the remote stations.

The CPU and remote station areas have the same operand distribution and size, only the initial addresses of location on the CPU are modified. In the remote station, the initial address is always the M0000 operand.

The initial address of the areas of each remote station on the CPU is determined in the F-2006.019 module I/O configuration table. Figure 3-16 presents the equivalence between the CPU and remote station areas, also showing the positions of the CPU configuration tables (used by F-2006.019) and of the remote stations (used by F-REMOT.069) corresponding to each area.

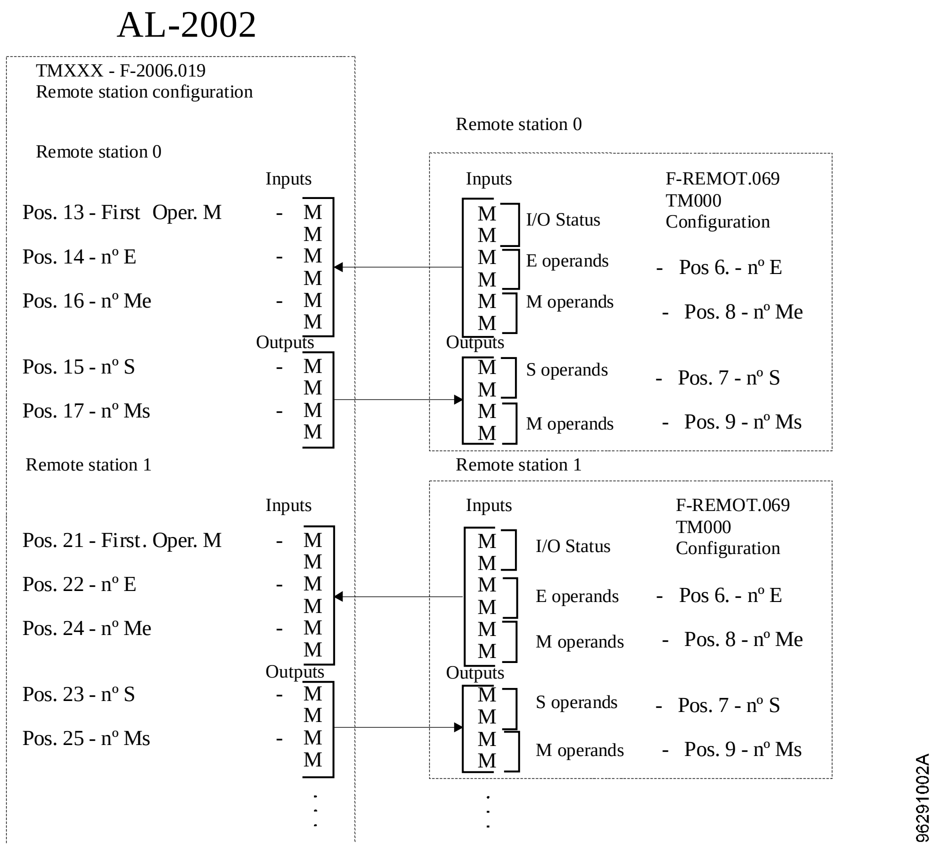


Figure 3-16 – Equivalence of Areas of Input and Output Operands between the CPU and the Remote Stations

The values declared in the TM000 tables of the remote stations, processed by the F-REMOT.069 module, should be identical to the corresponding areas in the remote station configuration table on the CPU, processed by the F-2006.019 module. In figure 3-16, for example, the contents of position 14 of the CPU TMXXX should be equal to position 6 of the remote station TM000, position 16 of TMXXX should be equal to position 8 of TM000 and so on.

Example of Operand Mapping CPU – Remote Stations

Suppose the example system has a single CPU, not redundant, and has 3 remote stations connected only using electrical connections, not using optical media. The CPU TM003 table is used by the F-2006.019 function to configure the remote stations. The data rate is 1 Mbit/s, the CPU and the remote stations have the same sub-network addresses (1) and the node addresses are 1,10,11 and 12, respectively, as shown in figure 3-17. Tables 3-12 and 3-13 show the CPU and remote station configuration tables.

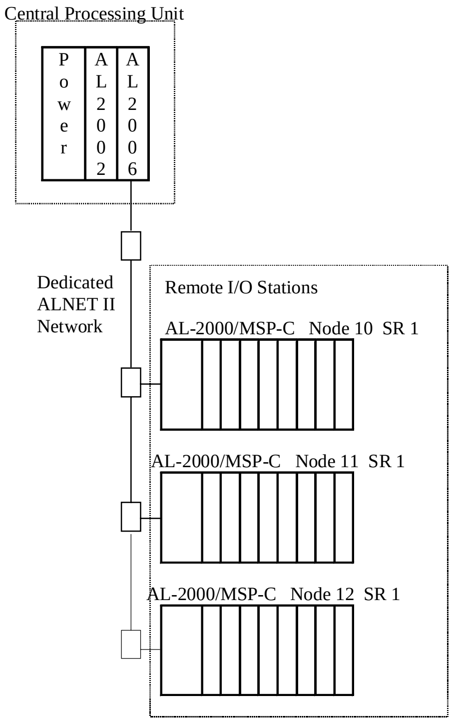


Figure 3-17 – Example of a System with Remote I/O Stations

TM003 – Remote I/O station configuration table on CPU (F-2006.019)

Position	Value	Position	Value
0	0	17	2
1	0	18	11
2	1	19	1
3	1	20	1000
4	1000	21	150
5	0	22	15
6	0	23	8
7	0	24	0
8	0	25	0
9	0	26	12

10	10	27	1
11	1	28	1000
12	1000	29	170
13	120	30	94
14	20	31	33
15	14	32	24
16	6	33	18

Table 3-12 – Remote I/O Station Configuration Table in an Example System

TM000 – Remote station 0 configuration table (F-REMOT.069)

Position	Value	Position	Value
0	0	5	120
1	0	6	20
2	10	7	14
3	1	8	6
4	1000	9	2

TM000 - Remote station 1 configuration table (F-REMOT.069)

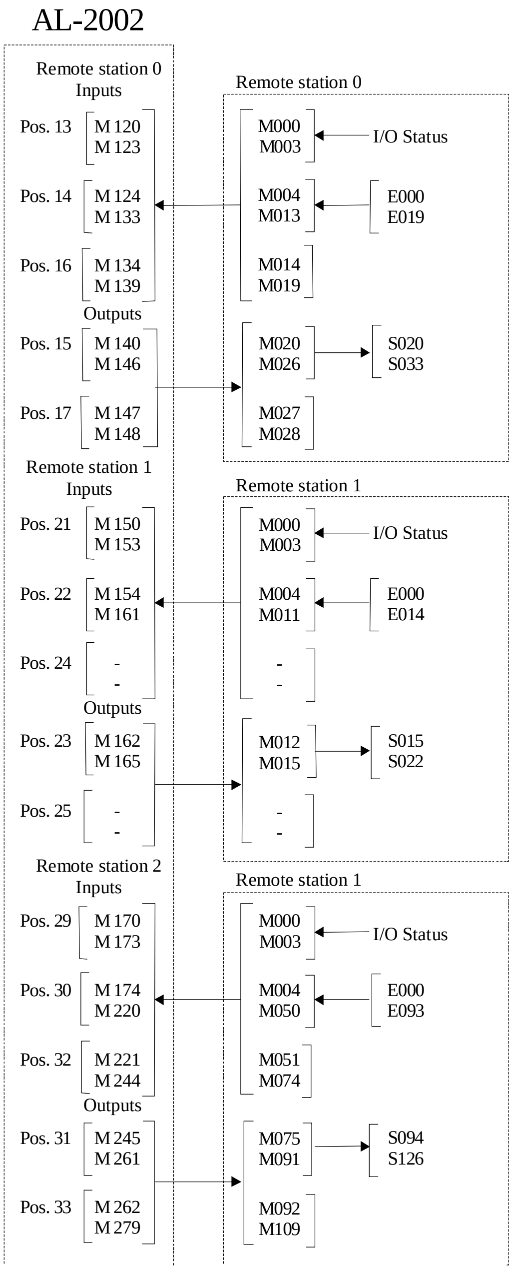
Position	Value	Position	Value
0	0	5	150
1	0	6	15
2	11	7	8
3	1	8	0
4	1000	9	0

TM000 - Remote station 2 configuration table (F-REMOT.069)

Position	Value	Position	Value
0	0	5	170
1	0	6	94
2	12	7	33
3	1	8	24
4	1000	9	18

Table 3-13 – Remote Station Configuration Table in an Example System

Figure 3-18 shows the equivalence operands obtained between the CPU and remote stations.



A

Figure 3-18 – Equivalence of CPU Operands - Remote Stations for the Example System

Declaration of Optical Connections

In positions 6 to 9 in the declaration table of the remote I/O stations of F-2006.019, up to two optical connections can be specified, redundant or not, for the remote I/O station system. The first optical connection is configured in positions 6 and 7, while the second one is configured in positions 8 and 9, as shown in table 3-14.

TM declaration of remote I/O stations in F-2006.019 – Optical channel definitions		
Position	Values	Contents
6	0 to 31	Node address of the controller channel of the first optical connection
7	0 to 63	Sub-network address of the first optical connection
8	0 to 31	Node address of the controller channel of the second optical connection
9	0 to 63	Sub-network address of the second optical connection

Table 3-14 – Transfer of Remote I/O Station Values

In a system with a redundant optical connection, the bridge processor channel connected to fiber-optic modem controls the redundancy of the two connections. This channel executes periodical tests to verify the status of the two optical connections and chooses the connection to be used for communication. With the address of this channel declared to F-2006.019, the AL-2006 Brother periodically reads the statuses of the two optical connections, providing them to the application program by means of the status indication operands. It also allows the application program to select the active connection at the moment.

Similarly, in systems with simple optical connections, not redundant, the status indication of the optical connection can also be read by the AL-2006 Brother processor and used by the application program.

For more details, refer to the **Status Indicators of Optical Connection** section in chapter 4, **Programming**, in the ALNET II User's Guide and the FOCOS User's Guide.

Update Time of Remote I/O Stations

The time the AL-2006 Brother occupies in each cycle to access all the remote stations and transfer the operands to the redundant CPU can be found using the MasterTool or AL-3830 programmers. Simply connect the programmer serial channel cable to the AL-2006 Brother ALNET I connector of the active CPU and open the CPU status information window. The AL-2006 Brother minimum, maximum, average and instantaneous cycle runtimes are presented (to access the remote I/O stations and the redundant AL-2006 Brother).

Instantaneous time refers to the last execution cycle. The minimum and maximum times are the lowest and highest instantaneous time obtained, reinitializing each 25 seconds. The average time corresponds to the arithmetic mean of the last 256 instantaneous times obtained.

These times directly depend on the number of redundant operands and on the number of remote I/O station operands configured.

Programming

This chapter introduces the modules, procedures and functions used in the implementation of systems with the AL-2006 Brother processor. It also provides information on programming precautions, the use of redundant operands and on the diagnosis of failures.

Systems with Remote I/O and no Redundancy

Systems of this type consist of one CPU and up to 8 remote stations with I/O points. The procedure and function modules described in this user's guide are used in the following manner:

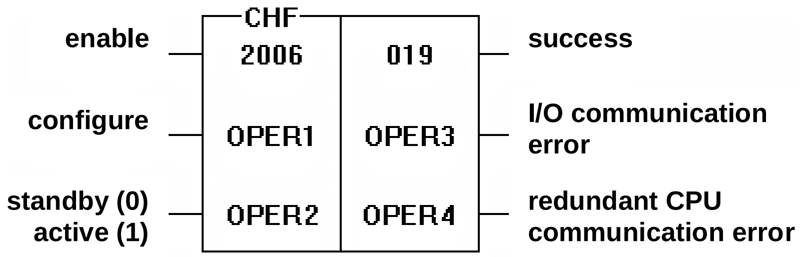
- The CPU application program must call the module P-2006.000, and this module calls the function F-2006.019.
- The remote station CPU application programs must call the module F-REMOT.069.

Systems with Remote I/O and Redundancy

Systems of this type consist of two CPUs operating redundantly and up to 8 remote stations with I/O points. The procedure and function modules described in this user's manual are used in the following manner:

- The redundant CPUs application programs must call, respectively, the modules P-2006_1.000 and P-2006_2.000, and each one of these two modules calls the F-2006.019 and F-END2.082 functions, and the P-TEMPO.032 procedure.
- The remote station CPU application programs must call the module F-REMOT.069.

F-2006.019 – Communication with AL-2006 Brother function



Introduction

The F-2006.019 function is executed on the AL-2002/MSP CPU, enabling it to communicate with the AL-2006 Brother processor, and performing the information exchange necessary for its configuration and operation.

Programming

Operands

The CHF instruction cells used to call the function are programmed in the following manner:

- **OPER1** – Specifies the number of parameters to be passed to the function in OPER3. This operand must be a memory constant with value 4 (KM+00004).
- **OPER2** – Must be a memory constant operand with value 0 (KM+00000). Specifies the number of parameters allowed to be programmed in the edit window of OPER4. As this function requires no parameters in OPER4, the value of OPER2 is 0.
- **OPER3 –** Contains the parameters that are passed to the function. They are declared in an edit window when the CHF instruction is edited. The number of editable parameters is specified in OPER1 – being fixed at 4 for this module:

- **RXXXX -** Bus address where the AL-2006 Brother module is housed.

- **TMXXXX** – Table operand containing the configurations of the remote I/Os being used. Must have at least 10 positions in order for the function to be correctly executed. The contents of each position in this table are defined in the section “Remote I/O Configuration” below.

- **TMXXXX** – Operand table containing CPU redundancy configurations. Should have at least 16 positions in order for redundancy to be configured. In the event it has fewer than 16 positions redundancy will not be used. The contents of each position in this table are defined in the section “Redundancy Configuration” below.

- **MXXXX** – Specifications of the operands that will receive status information on communications with the remote I/O stations, with the redundant CPU and on the optical channels, if employed. The status values are read from or written to the memory address declared and the subsequent 23 addresses. These 24 operands should be declared in the C module of the application program. The contents of each operand are defined in the “Status Indicators” section.
- **OPER4** – Not used.

Inputs and Outputs

Description of inputs:

- **enable** – when this input is energized the function is called, and the parameters programmed in the CHF instruction are analyzed. If these are incorrect the **I/O communications error** and **redundant CPU communications error** outputs of the instruction are permanently energized and the **success** output is de-energized. If they are correct, the communication with the AL-2006 Brother processor is proceeded.
- **configure** – when energized, the AL-2006 Brother processor configuration procedure is launched, with the parameters programmed in the CHF instruction. This process can require several scans of the AL-2002/MSP CPU application program, energizing the **success** output in the event that configuration has been successful. If errors occur, the **I/O communications error** or **redundant CPU communications error** outputs are permanently energized and the **success** output is de-energized.

The AL-2006 Brother processor configuration procedure must be run by calling the F-2006.019 module with the **configure** input activated until the **success** output or one of the error outputs returns energized. After that, the **configure** input must remain deactivated so that the AL-2006 Brother cyclic functions can be executed. If any of the error outputs is energized, the CHF instruction parameters, the values on the configuration table and system installation should be verified.

The AL-2006 Brother processor configuration procedure must be launched every time the CPU application program starts (power-on or change to execution mode), or after a change on the values of the I/O or redundancy configuration tables. Modifications to configuration table values will only take effect after the configuration procedure.

The attempt to call F-2006.019 in operating mode (configure input de-energized) without previous configuration of the AL-2006 Brother activates both error outputs and returns the corresponding error code to the redundant CPU communications status operand.

- **standby(0) / active(1) -** selects the mode of operation of the AL-2006 Brother processor, after completion of the configuration process launched by the **configure** input.

Description of outputs:

- **success** - with the AL-2006 Brother in configuration mode, this indicates the successful completion of the configuration process. After configuration, with the AL-2006 Brother in active mode (**standby(0) / active(1)** input energized), this output is energized for a single scan (pulse) at the end of every communication with the remote I/Os and the standby redundant CPU. With the AL-2006 Brother in standby mode (**standby(0) / active(1)** input de-energized), this output is energized for a single scan (pulse) every time the AL-2006 Brother receives communications with the operand values of the active redundant CPU. So, in operating mode (configure input de-energized) it is expected that **success** output is always energized, because in each scan cycle communication must take place between the active CPU and standby CPU, and with all remote I/O processors.
- **I/O communication error -** with the AL-2006 Brother in configuration mode, this indicates unsuccessful completion of the configuration process

with an error in the specifications for the remote I/Os. After configuration, with the AL-2006 Brother in active mode (**standby(0) / active(1)** input energized), this output is energized for a single scan (pulse) in the event of errors in communications with any of the remote I/Os With the AL-2006 Brother in standby mode (**standby(0) / active(1)** input de-energized), this output is not energized.

- **redundant CPU communication error -** with the AL-2006 Brother in configuration mode, this indicates unsuccessful completion of the configuration process with an error in the redundancy specifications. After configuration, with the AL-2006 Brother in active mode (**standby(0) / active(1)** input energized), this output is energized for a single scan (pulse) in the event of errors in communications with the redundant CPU. With the AL-2006 Brother in standby mode (**standby(0) / active(1)** input de-energized), this output is not energized.

If both error outputs are activated simultaneously and continuously, one of the following errors has occurred:

- the number of parameters in OPER1 is not four
- one of the parameters programmed in OPER3 is of an invalid type
- one of the parameters programmed in OPER3 is not defined in the C module of the application program
- the address R defined in the first parameter is invalid
- there is no AL-2006 Brother processor at the bus address declared in the first parameter

Remote I/O Configuration

The specification of the remote input and output stations is accomplished through a TM operand, programmed as the second parameter for the F-2006.019 function. This table should have at least 10 positions. If there are fewer than 10 positions, a configuration error occurs. The contents of each position in this TM table are specified in table 4-1.

TM declaration of Remote I/O stations in F-2006.019 – General Definitions		
Position	Values	Contents
0	0	Table type identifier
1	0	Table type identifier
2	1 to 31	AL-2006 node address
3	1 to 63	AL-2006 sub-net address
4	1000, 500, 250, 125, 64	AL-2006 data rate
5	-	Not used (reserved)

TM declaration of Remote I/O stations in F-2006.019 - Optical Channel Definitions		
Position	Values	Contents
6	0 to 31	Node address of the controller channel of the first optical connection
7	0 to 63	Sub-net address of the controller channel of the first optical connection
8	0 to 31	Node address of the controller channel of the second optical connection
9	0 to 63	Sub-net address of the controller channel of the second optical connection

TM declaration of Remote I/O stations in F-2006.019- Remote 0 Definitions		
Position	Values	Contents
10	1 to 31	Remote station node address
11	1 to 63	Remote station sub-net address
12	1000, 500, 250, 125, 64	Remote station data rate
13	0 to 9999	First M operand of the area that sends/receives remote station values on the local CPU
14	0 to 64	Number of remote station E operands to be read
15	0 to 64	Number of remote station S operands to be written
16	0 to 108	Number of remote station M operands to be read
17	0 to 112	Number of remote station M operands to be written

TM declaration of Remote I/O stations in F-2006.019- Remote 1 Definitions		
Position	Values	Contents
18	1 to31	Remote station node address
19	1 to 63	Remote station sub-net address
20	1000, 500, 250, 125, 64	Remote station data rate
21	0 to 9999	First M operand of the area that sends/receives remote station values on the local CPU
22	0 to 64	Number of remote station E operands to be read
23	0 to 64	Number of remote station S operands to be written
24	0 to 108	Number of remote station M operands to be read
25	0 to 112	Number of remote station M operands to be written

Table 4-1 – Contents of the Remote I/O Definition Table in F-2006.019

Remote stations are declared from table position 10 onwards, with each remote occupying 8 positions. The function of each of the eight positions is identical for all 8 remote stations.

TM declaration of Remote I/O stations in F-2006.019	
Positions	Contents
10 to 17	Definitions of remote station 0
18 to 25	Definitions of remote station 1
26 to 33	Definitions of remote station 2
34 to 41	Definitions of remote station 3
42 to 49	Definitions of remote station 4
50 to 57	Definitions of remote station 5
58 to 65	Definitions of remote station 6
66 to 73	Definitions of remote station 7

Table 4-2 – I/O Remote Station Configuration Positions

The remaining remote stations are configured in the subsequent positions, each occupying 8 positions, as shown in table 4-2.

The declaration table should contain the correct number of positions to define the number of remote stations that will be used. For example, if the system has 3 remote stations then the table should be declared with 34 positions (positions 0 through 33) in the C module of the CPU application program.

Redundancy Configuration

The definitions necessary for CPU redundancy operation are achieved through a TM operand, programmed as the third parameter for the F-2006.019 function and specified in table 4-3. This table should have at least 16 positions for redundancy to be implemented. If there are fewer than 16 positions, the table will not be processed. No error occurs, but the AL-2006 Brother only accepts the I/O configuration. If there are more than 16 positions, the additional positions will be ignored.

TM declaration of Redundancy F-2006.019		
Position	Values	Contents
0	0	Table type identifier
1	0	Table type identifier
2	1 to 31	Redundant CPU AL-2006 node address
3	1 to 63	Redundant CPU AL-2006 sub-net address
4	0 to 63	First redundant S operand
5	0 to 64	Number of redundant S operands
6	0 to 95	First redundant A operand
7	0 to 96	Number of redundant A operands
8	0 to 9999	First redundant M operand
9	0 to 1,008	Number of redundant M operands
10	0 to 9999	First redundant D operand
11	0 to 504	Number of redundant D operands
12	0 to 255	First redundant TM operand
13	0 to 1,008	Number of redundant TM operand positions
14	0 to 255	First redundant TD operand
15	0 to 504	Number of redundant TD operand positions

Table 4-3 – Redundancy Configuration Positions

The Redundancy Configuration table should contain 16 positions. For operands types not used in redundancy processing, the table positions that refer to the number of positions should be filled in with zero.

Redundancy configuration of S operands is reserved for future use and so positions 4 and 5 of the table must contain value zero.

> The total number of redundant bytes to be transferred must not exceed 2016 bytes (excluding S and A operands). So, the following equation must be true:
> position 9 * 2 + position 11 * 4 + position 13 * 2 + position 15 * 4 < 2016

Status Indicators

The AL-2006 Brother processor communicates cyclically with the redundant CPU, with the remote I/O stations and with the controller channels of the optical connection. The status indicators for these communications are stored in a 23 M operand area, beginning in the operand M specified in the fourth parameter of the F-2006.019 function. These status indicators are shown in table 4-4. These operands can also indicate table definition programming errors at the end of the configuration process. The first two operands in this area are used for the exchange of redundancy status information between CPUs.

Status indication operands in F-2006.019	
Operands	Contents
MXXXX	Transmits redundancy status to the other CPU. Possible values are defined in chapter “Maintenance”, section “Procedures in Case of Failure”.
MXXXX + 1	Receives redundancy status from the other CPU. Possible values are defined in chapter “Maintenance”, section “Procedures in Case of Failure”.
MXXXX + 2	General status of AL-2006 processor and of communication with redundant CPU through remote I/O network. Possible values are defined in chapter “Maintenance”, section “Procedures in Case of Failure”.
MXXXX + 3	First optical connection selected (1 or 2)
MXXXX + 4	First optical connection – status of connection 1 (0 - normal or 1 - failure)
MXXXX + 5	First optical connection – status of connection 2 (0 - normal or 1 - failure)
MXXXX + 6	First optical connection - forced connection (0 - not forced, 1 or 2)
MXXXX + 7	Forced status of connection 1 – first optical connection (0 - normal or 1 - failure)
MXXXX + 8	Forced status of connection 2 – first optical connection (0 - normal or 1 - failure)
MXXXX + 9	Second optical connection selected (1 or 2)
MXXXX + 10	Second optical connection - status of connection 1 (0 - normal or 1 - failure)
MXXXX + 11	Second optical connection - status of connection 2 (0 - normal or 1 - failure)
MXXXX + 12	Second optical connection - forced connection (0 - not forced, 1 or 2)
MXXXX + 13	Forced status of connection 1 – second optical connection (0 - normal or 1 - failure)
MXXXX + 14	Forced status of connection 2 – second optical connection (0 - normal or 1 - failure)
MXXXX + 15	Not used (reserved)
MXXXX + 16	Communications status of remote I/O 0
MXXXX + 17	Communication status of remote I/O 1
MXXXX + 18	Communications status of remote I/O 2
MXXXX + 19	Communications status of remote I/O 3
MXXXX + 20	Communications status of remote I/O 4
MXXXX + 21	Communications status of remote I/O 5
MXXXX + 22	Communications status of remote I/O 6

MXXXX + 23	Communications status of remote I/O 7

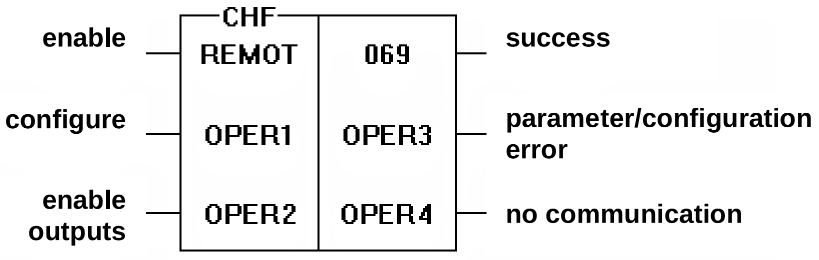
Table 4-4 – Status Indicator Operands in F-2006.019

For more details, refer to the **Optical Link Status Indicators** section in chapter 4, **Programming**. Also refer to the **Procedures in Case of Failure** section in chapter 6, **Maintenance**, for interpreting error codes in some status indicators.

Usability

This function can be used on AL-2002/MSP CPUs, from version 1.50 onwards. It can also be used on any version of AL-2003 CPU.

F-REMOT.069 – Remote I/O Stations Processing Function



Introduction

The F-REMOT.069 function is run on the remote I/O stations and makes copies of the values and status of local S and E operands for areas of communication with the main CPU. It also allows the execution of the filtering process on the input point values and the deactivation of output points in the event of a failure of communication with the main CPU.

Low Band Filtering Processing

Low band filtering processing consists of an increase in the response delay time required before an input point changes its status.

For example, if a remote station programmed with a delay time of 2 seconds has an input point configured for filtering in logical state 0 then this point must remain in logical state 1 for a minimum of 2 seconds for its state at the CPU to change from 0 to 1. In the event that the input value changes to 1 and returns to 0 in less than two seconds then the status of the CPU reception point will remain fixed at 0.

In opposite states the behavior is identical, i.e. if the input has value 1 then this point must remain at value 0 for a minimum of 2 seconds for its state at the CPU to change from 1 to 0.

The F-REMOT.069 function allows the input points subject to filtering to be selected individually. However, the same delay time configuration applies to all points.

Programming

Operands

The CHF instruction cells used to call the function are programmed in the following manner:

- **OPER1** – Specifies the number of parameters to be passed to the function in OPER3 edit window. This operand must be a memory constant with value 3 (KM+00003).
- **OPER2 - OPER2** – Should be a memory constant operand with value 0 (KM+00000). Specifies the number of parameters allowed to be programmed in the edit window of OPER4. As this function requires no parameters in OPER4, the value of OPER2 is 0.
- **OPER3 -** Contains the parameters that are passed to the function. They are declared in an edit window when the CHF instruction is edited. The number of editable parameters is specified in OPER1 – being fixed at 3 for this module.
    - **TM000 -** Operand table containing the configuration of the remote I/O. Should have at least 10 positions in order for the function to be correctly executed. The contents of each position are defined in table 4-5.

The values for positions 2 to 9 in this table should be identical to those declared in the remote I/O configuration table of F-2006.019 function, for the same remote I/O station.

TM declaration of Remote I/O stations in F-REMOT.069		
Position	Values	Contents
0	0	Table type identifier
1	0	Table type identifier
2	1 to31	Remote station node address
3	1 to 63	Remote station sub-net address
4	1000, 500, 250, 125, 64	Remote station data rate
5	0 to 9999	First M operand of the area that sends/receives remote station values on the local CPU
6	0 to 64	Number of remote station E operands to be read
7	0 to 64	Number of remote station S operands to be written
8	0 to 108	Number of remote station M operands to be read
9	0 to 112	Number of remote station M operands to be written

Table 4-5 – Contents of the Remote I/O Definition Table in F-REMOT.069

- **KM+XXXXX** – Constant operand specifying the filtering time, in tenths of a second, to be applied to the I/O points where filtering is enabled. Possible values range from 0 to 200, corresponding to results from no effect up to 20 seconds of filtering.

- **MXXXX** – This operand, and the following 31 operands, specify which of the input points processed by the function should be subject to filtering. Each bit that is ON at one of these M operands enables filtering at a corresponding E operand. Bits that are OFF deactivate the filtering process. Table 4-6 illustrates the correlation between M and E operands with the purpose of defining filtering points.

Operands for filtering definition			
Operands	Filtering definition	Operands	Filtering definition
MXXXX	E001, E000	MXXXX + 16	E033, E032
MXXXX + 1	E003, E002	MXXXX + 17	E035, E034
MXXXX + 2	E005, E004	MXXXX + 18	E037, E036
MXXXX + 3	E007, E006	MXXXX + 19	E039, E038
MXXXX + 4	E009, E008	MXXXX + 20	E041, E040
MXXXX + 5	E011, E010	MXXXX + 21	E043, E042
MXXXX + 6	E013, E012	MXXXX + 22	E045, E044
MXXXX + 7	E015, E014	MXXXX + 23	E047, E046
MXXXX + 8	E017, E016	MXXXX + 24	E049, E048
MXXXX + 9	E019, E018	MXXXX + 25	E051, E050
MXXXX + 10	E021, E020	MXXXX + 26	E053, E052
MXXXX + 11	E023, E022	MXXXX + 27	E055, E054
MXXXX + 12	E025, E024	MXXXX + 28	E057, E056
MXXXX + 13	E027, E026	MXXXX + 29	E059, E058
MXXXX + 14	E029, E028	MXXXX + 30	E061, E060
MXXXX + 15	E031, E030	MXXXX + 31	E063, E062

Table 4-6 – Filtering Process Configuration Operands

Each M operand allows the definition of two E operands. The E operands listed on the right hand side of the column (E000, E002, ...) correspond to bits 0 through 7 of the M operand (byte L). The E operands listed on the left hand side of the column (E001, E003, ...) correspond to bits 8 through F of the M operand (byte H).

For example, if the M0030 operand is programmed in module F-REMOT.069, then to **enable** filtering for point E027.2, bit M0043.A (M0030+13, bit 2 + 8 - byte H) should be ON. To disable filtering for E024.5, bit M0042.5 (M0030+12, bit 5 + 0 - byte L) should be OFF.

- **OPER4 -** Not used.

Inputs and Outputs

Description of inputs:

- **enable** – when this input is energized the function is called, and the parameters programmed in the CHF instruction are analyzed. If these are incorrect the **parameter/configuration error** output is permanently energized and the **success** output is de-energized. If they are correct, the function is processed.

- **configure** – when energized, the values programmed in the CHF instruction are analyzed. If these are incorrect the **parameter/configuration error** output is energized and the **success** output is de-energized. If they are correct the **success** output is energized. When the **configure** input is de-energized the module executes the remote station functions.

The remote I/O station is configured by calling the F-REMOT.069 module with the **configure** input activated until the **success** output or the error output returns energized. After that, the **configure** input should be deactivated so that the module can execute the remote station functions. If the **parameter/configuration error** output is energized, the CHF instruction parameters and the configuration values should be verified.

The remote station configuration procedure should be carried out every time the CPU application program starts (power on or mode changing to execution), or after each change on the values of the configuration table.

- **enable outputs** – when energized, it deactivates outputs if the remote station does not receive communication from the AL-2006 Brother processor for 3 seconds. If this input is de-energized, the output points remain permanently enabled.

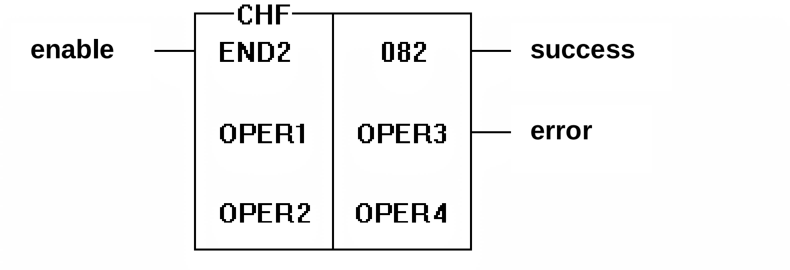
Description of outputs:

- **success** – with the **configure** input energized, this indicates the successful configuration of the remote station. With the **configure** input de-energized, this indicates that the function was processed correctly.
- **parameter/configuration error** – indicates an error in one of the CHF parameters (incorrect number of parameters, invalid parameter type or parameter not defined in the C module of the application program), or that one of the values specified in the remote configuration table is incorrect.
- **no communication** – if the **enable outputs** input is energized, this indicates the absence of communications with the CPU's AL-2006 Brother processor. If the **enable outputs** input is de-energized, then this output remains de-energized permanently.

Usability

This function can be used on the following CPUs: AL-2003, AL-2000/MSP (from version 1.42 onwards), AL-2000/MSP-C (from version 1.12 onwards), QK2000/MSP (from version 1.12 onwards) and AL-2002/MSP (from version 1.50 onwards).

F-END2.082 – Modification of ALNET II Node Address



Introduction

The F-END2.082 function allows the modification of the PC node address on the ALNET II network to values different from those originally configured in the C module, under application program control. This characteristic is used in redundant systems to maintain the same communications address for the active CPU, allowing the active CPU to be referred easily in communications from other stations on the network (PCs, supervisor stations). For further details refer to the **ALNET II Communication with Redundant Controller** section in chapter 3, **Operating Principles**.

Programming

Operands

The CHF instruction cells used to call the function are programmed in the following manner:

- **OPER1** - Specifies the number of parameters to be passed to the function in OPER3. This operand must be a memory constant with value 1 (KM+00001).

- **OPER2 -** Should be a memory constant operand with value 0 (KM+00000). Specifies the number of parameters allowed to be programmed in the edit window of OPER4. As this function requires no parameters in OPER4, the value of OPER2 is 0.
- **OPER3 -** Contains the parameters that are passed to the function. They are shown in an edit window when the CHF instruction is edited. The number of editable parameters is specified in OPER1 – being fixed at 1 for this module

    - **KM+XXXXX or MXXXX** – Operand specifying the new node address to be assumed by the PC. If this is programmed as a constant, and values from 1 to 31 can be defined. If it is programmed as an M operand, its contents should be within the interval 1 to 31.

- **OPER4** – Not used.

Inputs and Outputs

Description of inputs:

- **enable** – when this input is energized, the function is called and the parameters programmed in the CHF instruction are analyzed. If these are incorrect the **error** output is energized and the **success** output is de-energized. If they are correct, the node address is changed to the programmed value.

Description of outputs:

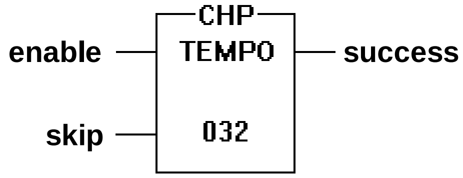
- **success -** indicates that the node address has been successfully modified.
- **error** – indicates an error in one of the CHF instruction parameters (incorrect number of parameters, invalid parameter type or parameter not defined in the C module of the application program), or that the address value specified is outside of the range 1 to 31.

Usability

This function can be used on AL-2002/MSP and AL-2003 CPUs.

This function should be employed in the same manner as programmed in the P-2006_1.000 and P-2006_2.000 modules. Improper use of this function can cause malfunction in the ALNET II processing on the PC.

P-TEMPO.032 – Auxiliary Time Base Control



Introduction

The P-TEMPO.032 is called by the P-2006_1.000 and P-2006_2.000 modules which are responsible for redundancy control and communication with the remote I/O stations. It controls the time base for timing instructions within the application program, avoiding delays in these instructions when the application program is skipped due to a redundancy logic decision. The application program is always skipped in the backup CPU, and sometimes may also be skipped in the active CPU when its scan cycle is faster than the cycle needed to communicate with remote I/O processors and redundant CPU.

Programming

Inputs and Outputs

Description of inputs:

- **enable** – when this input is energized the function is processed.
- **skip** – this input is activated by the application program skip condition. When the application program is skipped it must be energized, and when the program is being executed, this input must be de-energized. The application program is skipped in the backup CPU.

Description of outputs:

- **success** – indicates the successful execution of the procedure.

Usability

This function can be used on AL-2000/MSP CPU (from version 1.42 onwards) and AL-2003 CPU.

This function should be employed in the same manner as programmed in the P-2006_1.000 and P-2006_2.000 modules. Improper use of this function can cause malfunction in application program timing instructions.

P-2006.000 – Communication with Remote I/Os

The P-2006.000 procedure module is a routine written in relay diagram language which is provided with the AL-2006 Brother product for use in systems with Remote I/Os and a single CPU without redundancy. This module performs the following functions:

- configures the AL-2006 Brother processor
- exchanges I/O operand values with the AL-2006 Brother processor

This P module should be called at every scan cycle of the CPU application program.

Before being used within the CPU application program, this module should be modified in accordance with the recommendations contained in the **Customized Use** section**,** in this chapter.

The P-2006.000 should be the first procedure to be called in the cyclical execution module E-.001. It updates the I/O operands of the CPU with the remote station values.

Operands Used

The tables 4-7 and 4-8 show the operands used in the P-2006.000 module which is provided with the AL-2006 Brother Processor.

Operands used in the P-2006.000 module	
Operand	Contents

TM001	Remote I/O Configuration Table
TM002	Redundancy Configuration Table
M0008	Transmission of redundancy status to other CPU. Even though redundancy is not used, this operand is passed to F-2006.019 function called inside P-2006.000 module.
M0009	Reception of redundancy state from other CPU. Even though redundancy is not used, this operand is passed to F-2006.019 function called inside P-2006.000 module.
M0010	Status of communication with redundant CPU via remote I/O network. Even though redundancy is not used, this operand is passed to F-2006.019 function called inside P-2006.000 module.
M0011	Primary optical link selected
M0012	Status of primary optical link connection 1
M0013	Status of primary optical link connection 2
M0014	Primary optical link forced connection
M0015	Forced status of primary optical link connection 1
M0016	Forced status of primary optical link connection 2
M0017	Secondary optical link selected
M0018	Status of secondary optical link connection 1
M0019	Status of secondary optical link connection 2
M0020	Secondary optical link forced connection
M0021	Forced status of secondary optical link connection 1
M0022	Forced status of secondary optical link connection 2
M0023	Not used (reserved)
M0024	Communications status of remote 0, and also general status for all remote stations.
M0025	Communications status of remote 1
M0026	Communications status of remote 2
M0027	Communications status of remote 3
M0028	Communications status of remote 4
M0029	Communications status of remote 5
M0030	Communications status of remote 6
M0031	Communications status of remote 7
M0032	Memory status of communication with remote stations

Table 4-7 – TM and M Operands Used in the P-2006.000 module

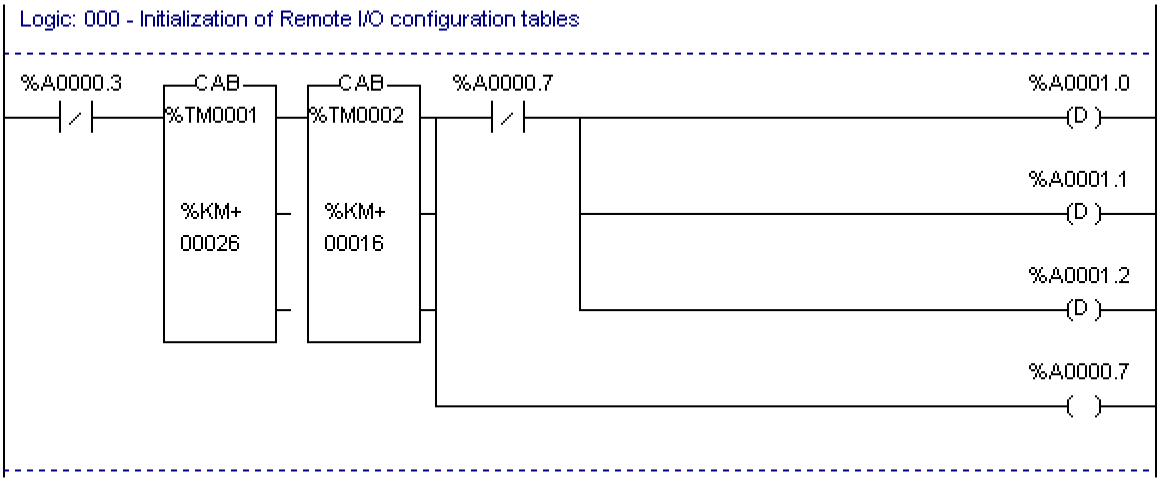
Operands used in the P-2006.000 module	
Operand	Contents
A0000.0	F-2006 success output
A0000.1	F-2006 redundancy output error
A0000.2	F-2006 remote I/O output error

A0000.3	AL-2006 in active or standby mode
A0000.7	Configuration start pulse
A0001.0	AL-2006 configured OK
A0001.1	Redundancy configuration error
A0001.2	Remote I/O configuration error
A0001.6	Launch switch to standby mode

Table 4-8 – A Operands Used in the P-2006.000 Module

Contents of Module P-2006.000

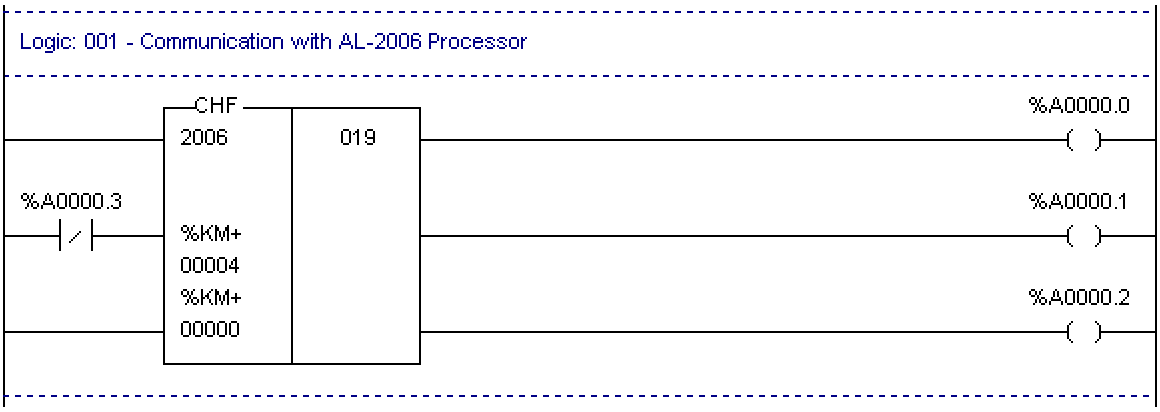
The logics that make up the P-2006.000 module are shown below.



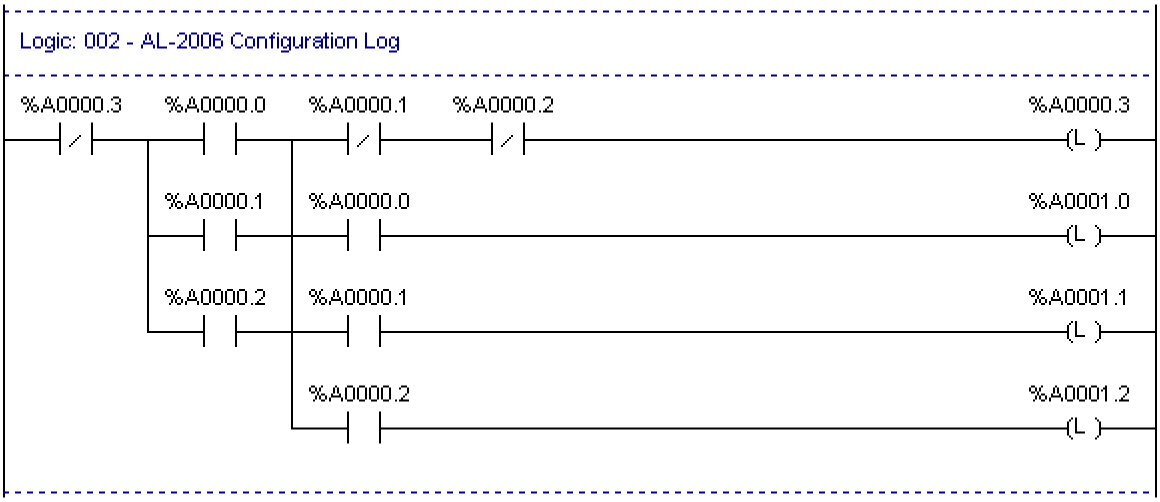
TM001					
Position	Value	Position	Value	Position	Value
0	00000	9	00000	18	00004
1	00000	10	00003	19	00002
2	00001	11	00001	20	01000
3	00001	12	01000	21	00130
4	01000	13	00100	22	00006
5	00000	14	00006	23	00004
6	00030	15	00004	24	00010
7	00002	16	00010	25	00008
8	00000	17	00008		

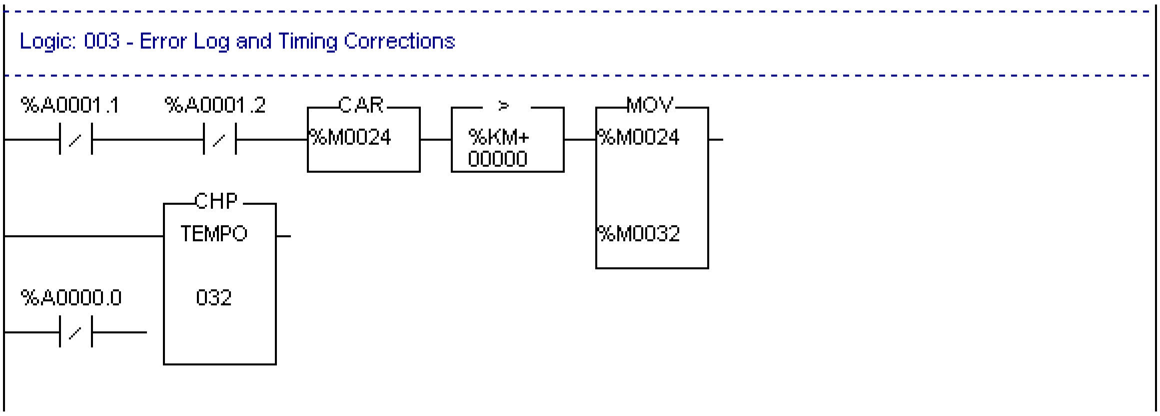
TM002			
Position	Value	Position	Value
0	00000	8	00000
1	00000	9	00000
2	00002	10	00000
3	00001	11	00000
4	00000	12	00000
5	00000	13	00000

6	00000	14	00000
7	00000	15	00000



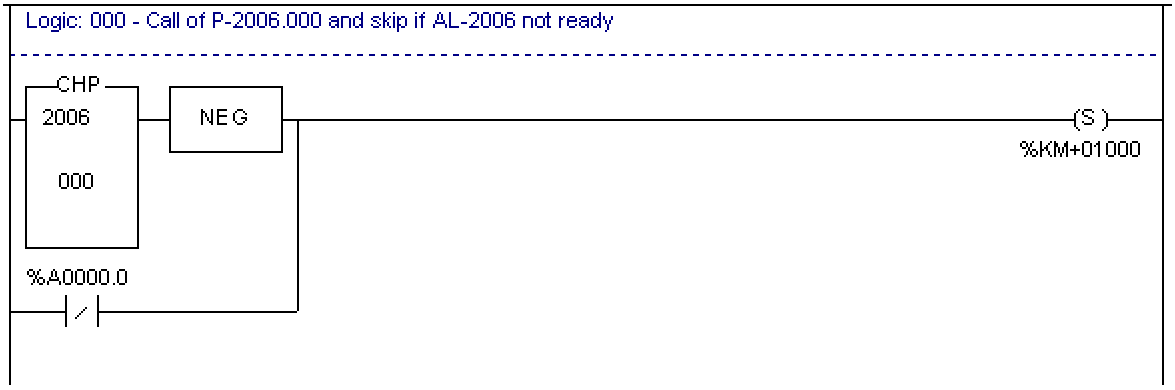
CHF instruction parameters
%R0000
%TM0001
%TM0002
%M0008





E-.001 Module Contents

The first logic of the main module of the CPU, E-.001 application program, containing the call to the P-2006.000 module, is shown below. The main process control program should be inserted into the following logics (001 ...).



Customized Use

The P-2006.000 module provided with the AL-2006 Brother product has the following characteristics:

- implementation in system architectures with a non-redundant CPU and 2 remote I/O stations

- data rate at 1 Mbaud with the CPU and remote stations
- remote station 0 with 6 input octets, 4 output octets, 10 input M operands and 8 output M operands
- remote station 1 with 6 input octets, 4 output octets, 10 input M operands and 8 output M operands
- use of TM001 and TM002, M0008 to M0032, A000 and A001 operands
- AL-2006 Brother processor located at position 0 on the I/O module bus

For use in applications with different characteristics, this P module should be modified, as specified below.

- If the control application program has already used any of the operands mentioned before, a new set of unused operands of the same types should be allocated for programming the P-2006.000 module. Two TM operands, 21 M operands and two A operands are required.

None of the operands used by the P-2006.000 module can be used in any other application program module

For example, if the application program is already using operands M0008 through M0012 and has operands M0188 through M192 free, M0188 can replace M0008, M0189 can replace M0009, and so on.

- Declare the AL-2006 Brother at the bus position in which it will be used. In the module declaration window, the R address used to access this position is displayed in the corresponding position. Modify the logic 1 CHF instruction to use this address.
- Within logic 0 CAB instruction, modify the values loaded into tables TM001 and TM002 to the I/O and redundancy configurations desired. The meaning of each table position is described at section **F-2006.019 – Communication with AL-2006 Brother Function** earlier in this chapter.
- Even if AL-2006 Brother redundancy processing is not being used, the relevant table should still be declared for the module to function correctly (TM002 in P-2006.000). This table must have at least 16 positions with correct values entered. The quantities of redundant operands must be zero.
- The maximum cycle time allowed for execution of the application program (C module) should be configured with a 50-ms margin in relation to the actual runtime needed by the program, rounding up to the next time period allowed. For example, if the program requires a maximum of 80 ms for execution, the time limit configured in the C module should be 200 ms (80ms + 50ms = 130ms, using the next allowed time period = 200ms). Exaggerated margins should be avoided (100, 200 ms or greater) when

configuring the maximum cycle time, since this results in an unnecessary increase in response time for the backup CPU to detect active CPU failures.

P-2006_1.000 and P-2006_2.000 – Redundancy Control and Communication with Remote I/Os

The P-2006_1.000 and P-2006_2.000 procedure modules are routines written in relay diagram language, provided with the AL-2006 Brother product for use in systems with Remote I/Os and CPU redundancy. These modules perform the following functions:

- configure the AL-2006 Brother processor
- exchange I/O and redundancy operand values with the AL-2006 Brother processor
- determine the CPU operating status with relation to redundancy (active, standby, inactive)
- enable execution of the main control program, depending on momentary conditions.
- change the addresses of the CPUs on the ALNET II network, to maintain the same communications address for the active and backup CPUs, thus allowing easier communication with supervisory programs and other CPUs.

Each P module is used in one of the two redundant CPUs, defined as CPU 1 and CPU 2, respectively. These P modules should be called at the beginning of every scan cycle of the application program in on each CPU (see the **Application Program** section in chapter 3, **Operating Principles**).

Before being implemented within the CPU application programs, these modules should be modified in accordance with the recommendations contained in the **Customized Use** section**,** in this chapter.

Either the P-2006_1.000 or the P-2006_2.000 module should be the first procedure to be called in the cyclical execution module E-.001. It can then enable, or not, execution of the main control program, using a skip instruction within the E-.001 module, depending on the results of the AL-2006 Brother module processing.

The whole control program should be under the control of the skip coil, activated by either the P-2006_1.000 or the P-2006_2.000 module, with the exception of instructions which do not accept skipping them, such as ECR and LTR. See **Contents of the E-.001 Module** later in this chapter.

Operands Used

Tables 4-9 and 4-10 show the operands used in the P-2006_1.000 and P-2006_2.000 modules which are provided with the AL-2006 Brother.

Operands used in P-2006_1.000 and P-2006_2.000 modules	
Operand	Contents
TM001	Remote I/O Configuration Table
TM002	Redundancy Configuration Table
M0000	AL-2006 initialization delay
M0001	Delay on failure to receive redundant operands
M0002	Delay on activation of button for switching to standby mode
M0003	Delay in switching to standby mode when both CPUs are in active state
M0004	Holding time for switching to standby mode
M0005	Delay on activation of button for switching to inactive mode
M0006	Delay in switching to inactive mode
M0007	Delay on activation of button for re-energizing redundant CPU
M0008	Transmission of redundancy status to other CPU
M0009	Reception of redundancy status from other CPU
M0010	Status of communication with redundant CPU through remote I/O network
M0011	Primary optical link selected
M0012	Status of primary optical link connection 1
M0013	Status of primary optical link connection 2
M0014	Primary optical link forced connection
M0015	Forced status of primary optical link connection 1
M0016	Forced status of primary optical link connection 2
M0017	Secondary optical link selected
M0018	Status of secondary optical link connection 1
M0019	Status of secondary optical link connection 2
M0020	Secondary optical link forced connection
M0021	Forced status of secondary optical link connection 1

M0022	Forced status of secondary optical link connection 2
M0023	Not used (reserved)
M0024	Communications status of remote 0, and also general status for all remote stations.
M0025	Communications status of remote 1
M0026	Communications status of remote 2
M0027	Communications status of remote 3
M0028	Communications status of remote 4
M0029	Communications status of remote 5
M0030	Communications status of remote 6
M0031	Communications status of remote 7
M0032	Memory status of communication with redundant CPU
M0033	Memory status of communication with remote stations

Table 4-9 – TM and M Operands Used in P-2006_1.000 and P-2006_2.000 modules

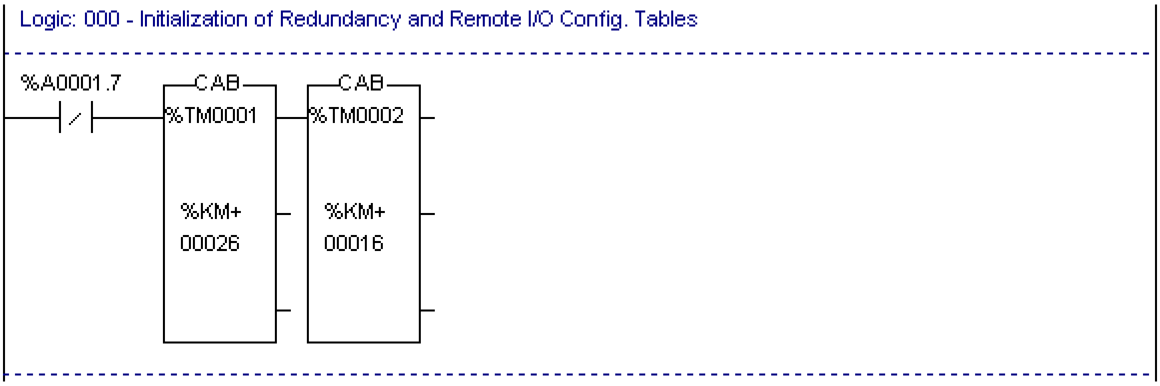
Operands used in P-2006_1.000 and P-2006_2.000 modules	
Operand	Contents
E0000.1	Button for switching to standby mode
E0000.2	Button for switching to inactive mode
E0000.3	Button for re-energizing redundant CPU
S0008.0	Active mode lamp
S0008.1	Standby mode lamp
S0008.2	Inactive mode lamp
S0008.3	De-energizes redundant CPU
A0000.0	F-2006.019 “success” output
A0000.1	F-2006.019 “redundancy error” output
A0000.2	F-2006.019 “remote I/O error” output
A0000.3	AL-2006 must be configured, when A0000.3 = 0.
A0001.0	AL-2006 was configured successfully
A0001.1	Redundancy configuration error
A0001.2	Remote I/O configuration error
A0001.6	Switching to standby mode is occurring
A0001.7	Operand Initialization complete
A0002.0	Pulse - redundant CPU re-energize button
A0002.1	Pulse - switch to inactive mode button
A0002.2	Pulse - AL-2006 communications error
A0002.3	Pulse - switch to standby mode button
A0002.5	Pulse - switch to active mode
A0002.6	Pulse - switch to standby or inactive mode
A0002.7	Skip control of application program execution

A0002.4	Pulse - Configuration start
A0003.0	Active mode
A003.1	Standby mode
A003.2	Inactive mode
A003.3	Redundant CPU de-energized due to error
A003.4	Redundancy communication channel error

Table 4-10 – S and A Operands Used in P-2006_1.000 and P-2006_2.000 modules

Contents of the P-2006_1.000 Module

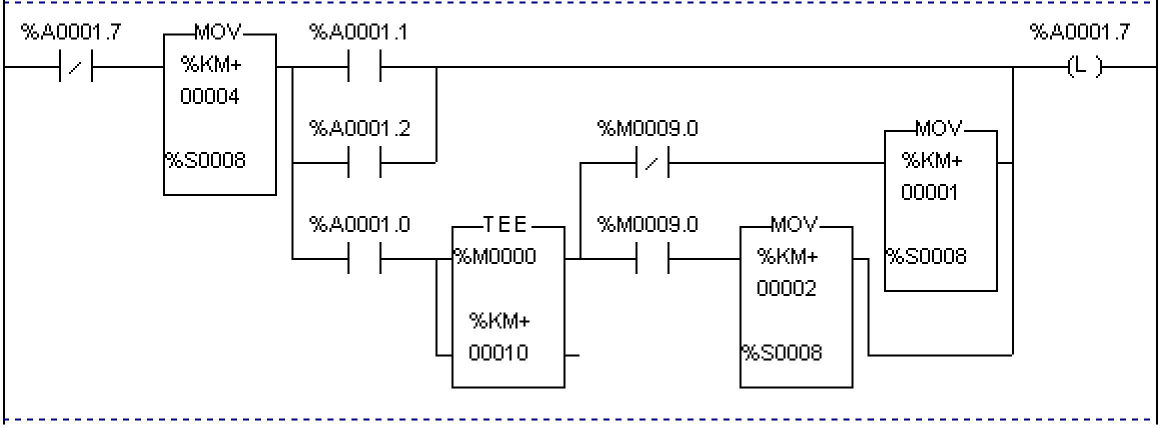
The logics that make up the P-2006_1.000 module are shown below.



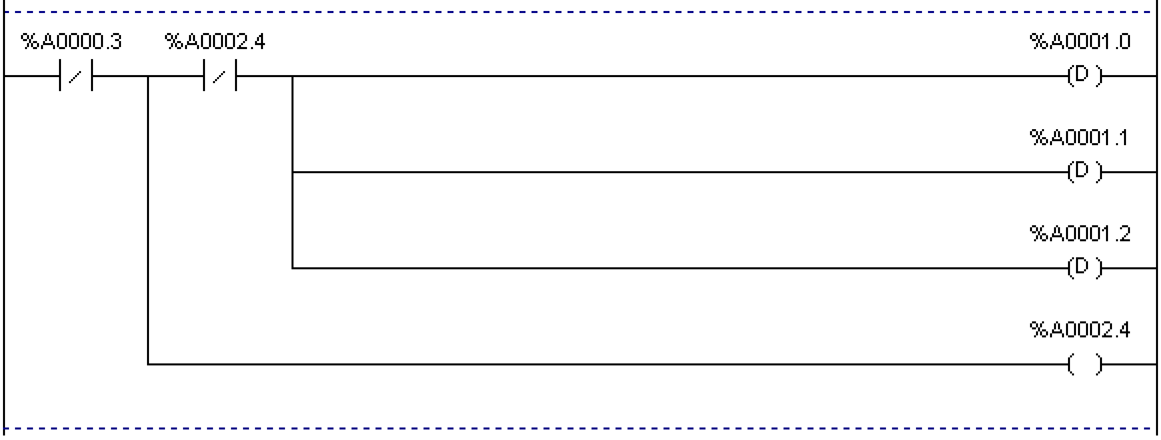
TM001					
Position	Value	Position	Value	Position	Value
0	00000	9	00000	18	00004
1	00000	10	00003	19	00002
2	00001	11	00001	20	01000
3	00001	12	01000	21	00130
4	01000	13	00100	22	00006
5	00000	14	00006	23	00004
6	00030	15	00004	24	00010
7	00002	16	00010	25	00008
8	00000	17	00008		

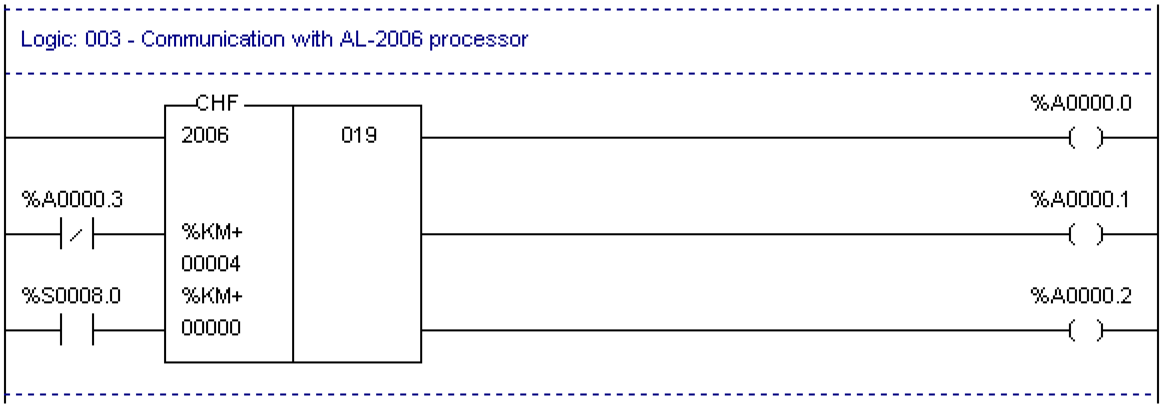
TM002			
Position	Value	Position	Value
0	00000	8	01000
1	00000	9	00900
2	00002	10	00000
3	00001	11	00000
4	00000	12	00000
5	00000	13	00000
6	00010	14	00000
7	00080	15	00000

Logic: 001 - CPU Initial State Definition

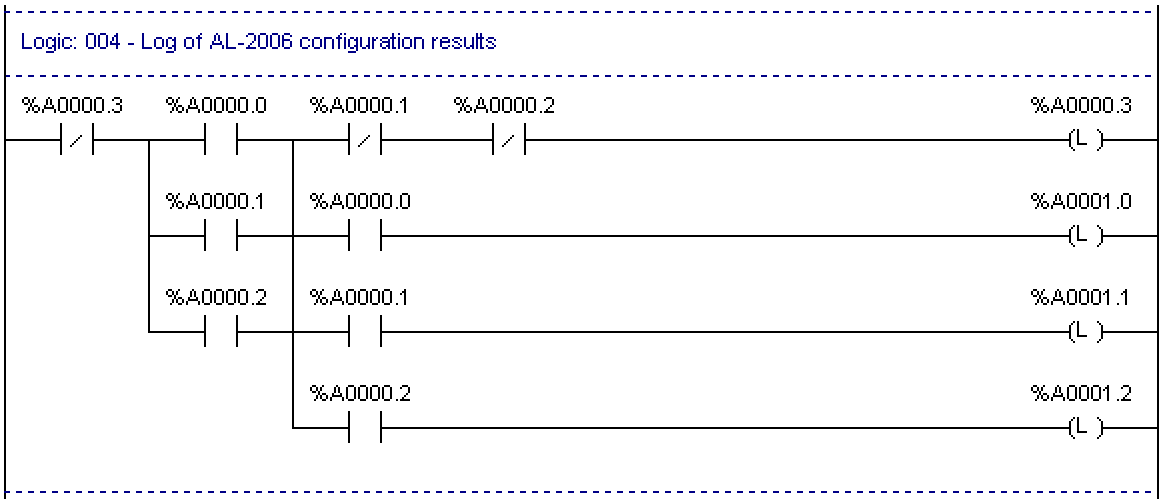


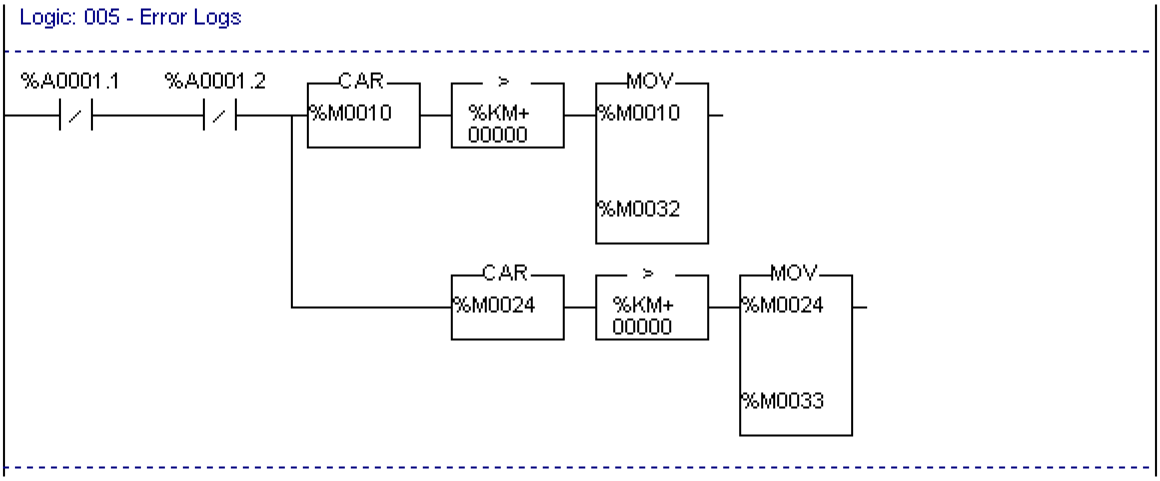
Logic: 002 - Initialization of AL-2006 results of configuration

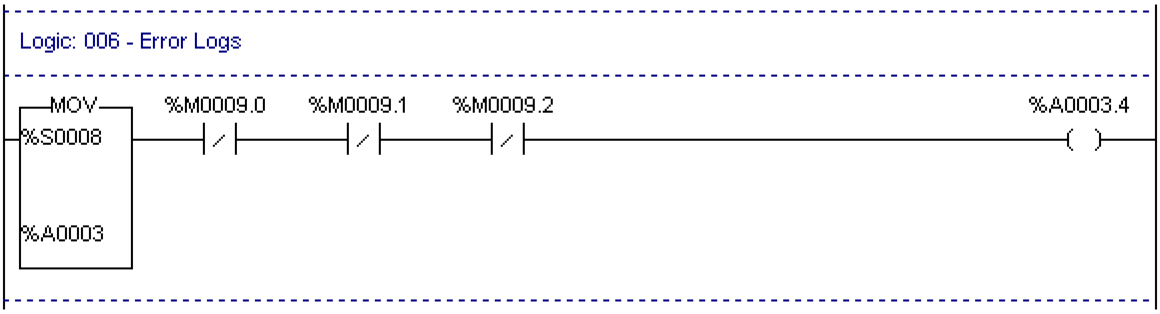


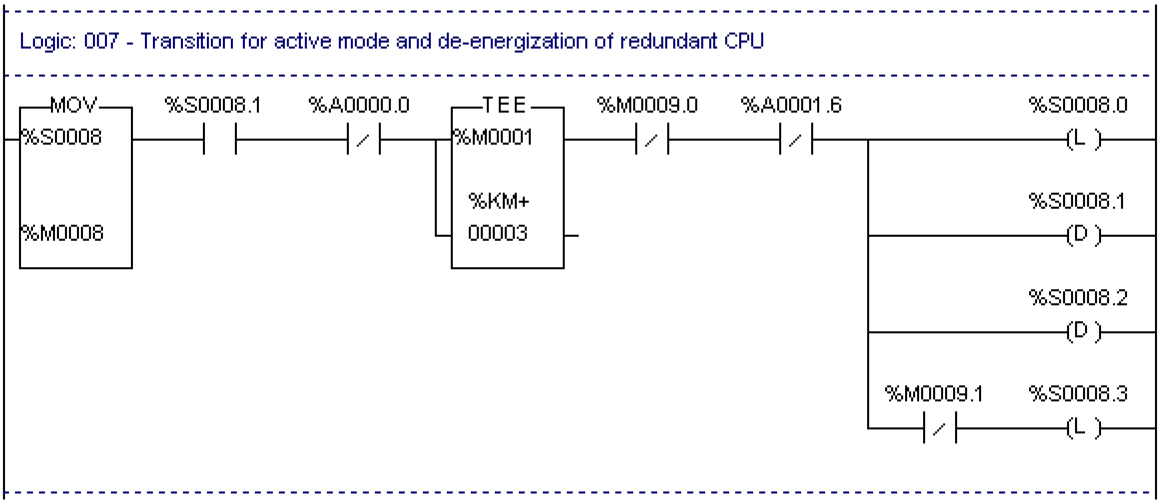


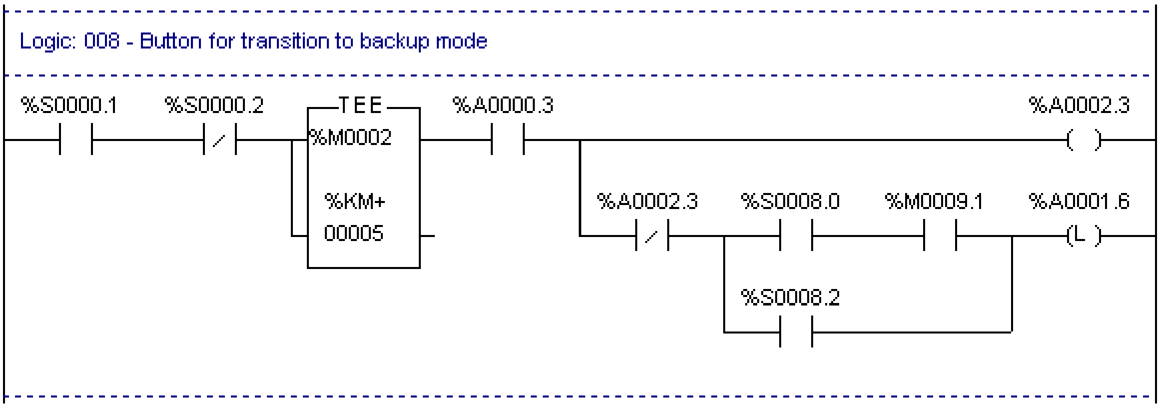
CHF instruction parameters
%R0000
%TM0001
%TM0002
%M0008

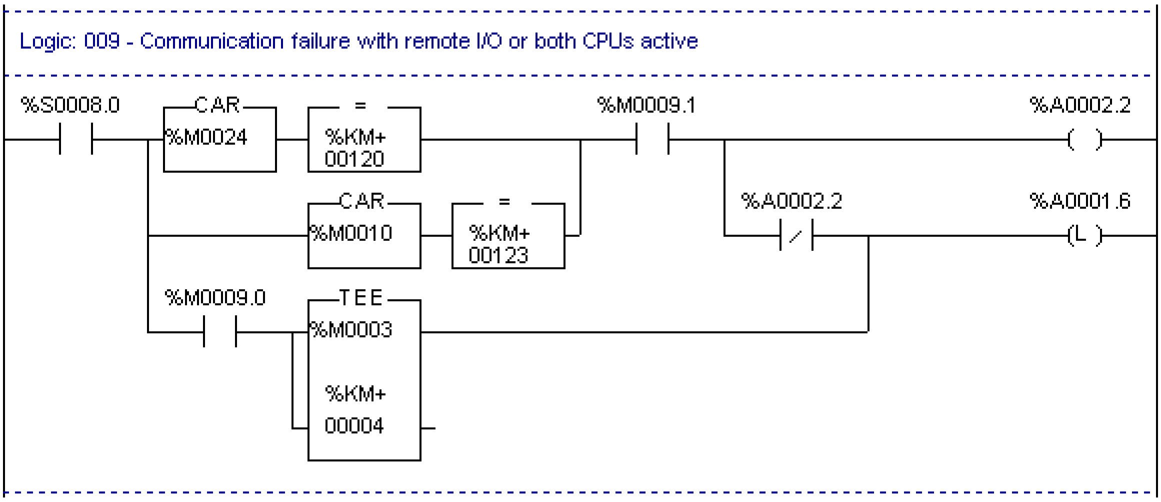


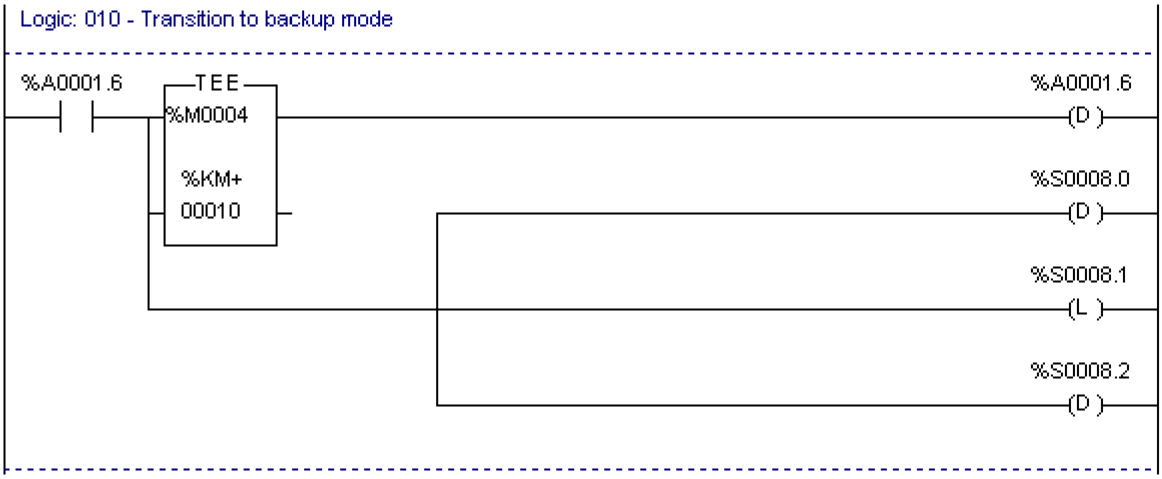

Logic: 005 - Error Logs
%A0001.1
%A0001.2
CAR
%M0010
>
%KM+
00000
MOV
%M0010
%M0032
CAR
%M0024
>
%KM+
00000
MOV
%M0024
%M0033

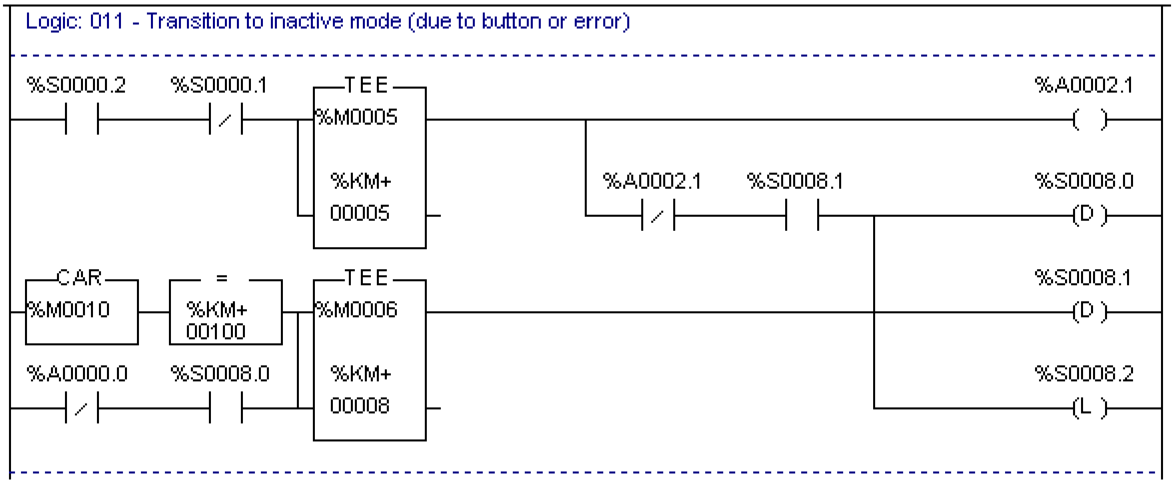

Logic: 006 - Error Logs
MOV
%S0008
%A0003
%M0009.0
%M0009.1
%M0009.2
%A0003.4

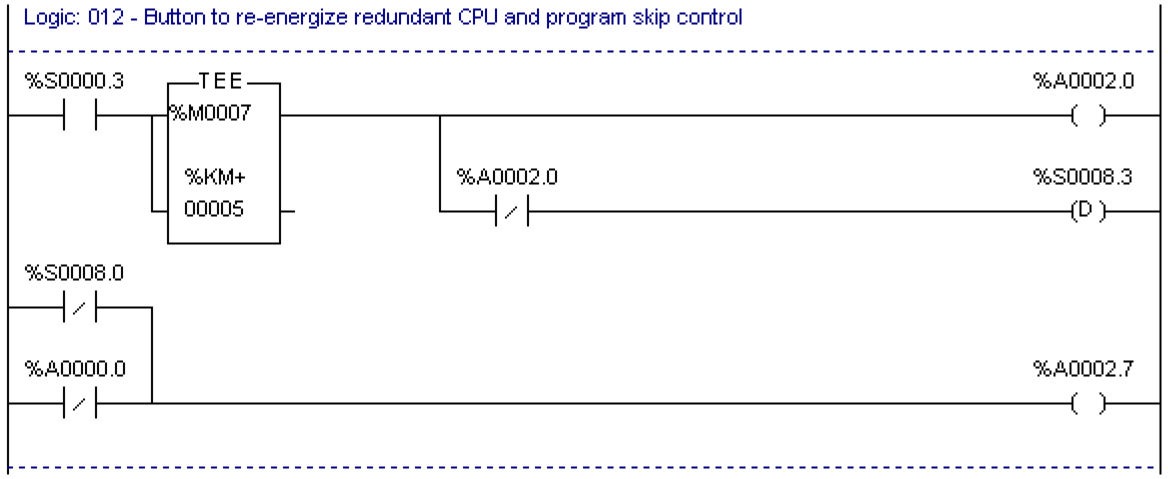

Logic: 007 - Transition for active mode and de-energization of redundant CPU
MOV
%S0008
%M0008
%S0008.1
%A0000.0
TEE
%M0001
%KM+
00003
%M0009.0
%A0001.6
%S0008.0
L
%S0008.1
D
%S0008.2
D
%M0009.1
%S0008.3
L

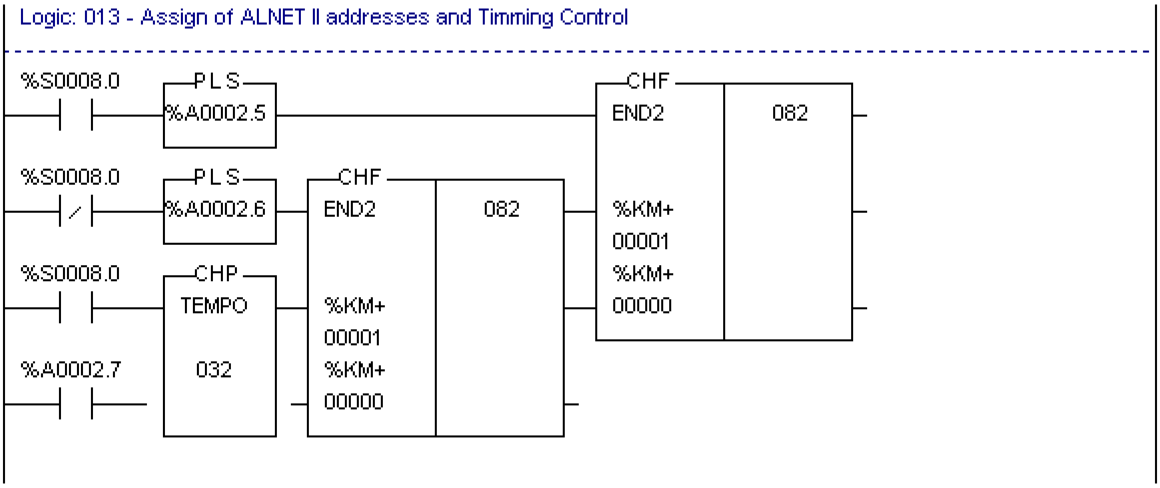

Logic: 008 - Button for transition to backup mode
%S0000.1
%S0000.2
TEE
%M0002
%KM+
00005
%A0000.3
%A0002.3
%A0002.3
%S0008.0
%M0009.1
%A0001.6
L
%S0008.2


Logic: 009 - Communication failure with remote I/O or both CPUs active
%S0008.0
CAR
%M0024
=
%KM+
00120
%M0009.1
%A0002.2
( )
CAR
%M0010
=
%KM+
00123
%A0002.2
%A0001.6
(L)
%M0009.0
TEE
%M0003
%KM+
00004


Logic: 010 - Transition to backup mode
%A0001.6
TEE
%M0004
%KM+
00010
%A0001.6
(D)
%S0008.0
(D)
%S0008.1
(L)
%S0008.2
(D)


Logic: 011 - Transition to inactive mode (due to button or error)
%S0000.2
%S0000.1
TEE
%M0005
%KM+
00005
%A0002.1
%A0002.1
%S0008.1
%S0008.0
D
CAR
%M0010
=
%KM+
00100
TEE
%M0006
%KM+
00008
%S0008.1
D
%A0000.0
%S0008.0
%S0008.2
L


Logic: 012 - Button to re-energize redundant CPU and program skip control
%S0000.3
TEE
%M0007
%KM+
00005
%A0002.0
%A0002.0
%S0008.3
D
%S0008.0
%A0000.0
%A0002.7

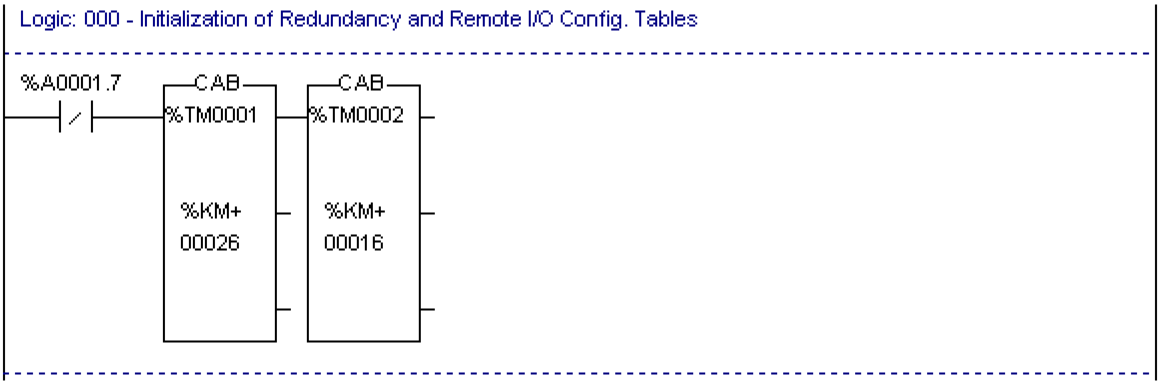


Left-hand CHF instruction parameter
KM00001

Right-hand CHF instruction parameter
KM00002

Contents of the P-2006_2.000 Module

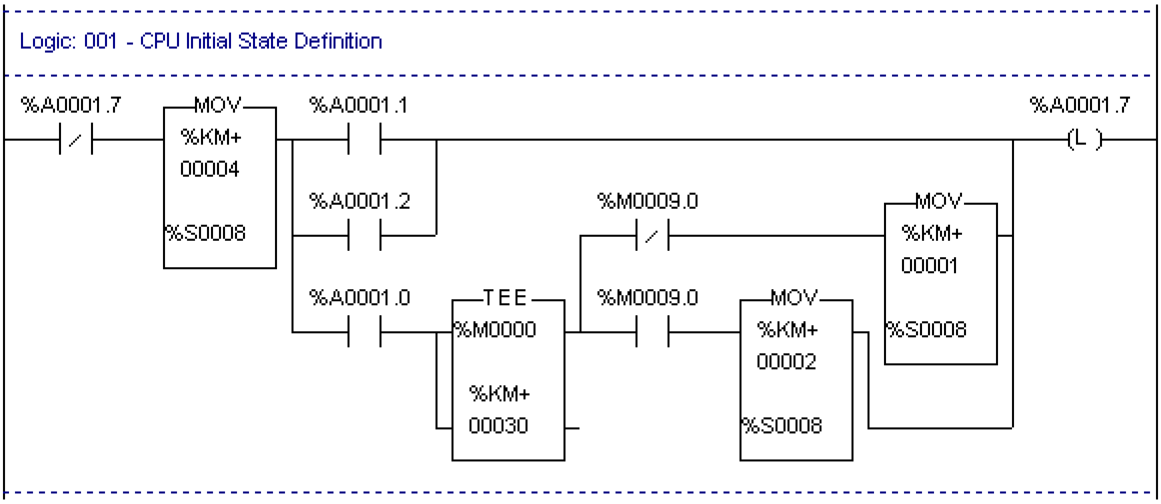
The P-2006_2.000 module is identical to the P-2006_1.000 module, with the exception of the contents of logics 0, 1 and 9, illustrated below.

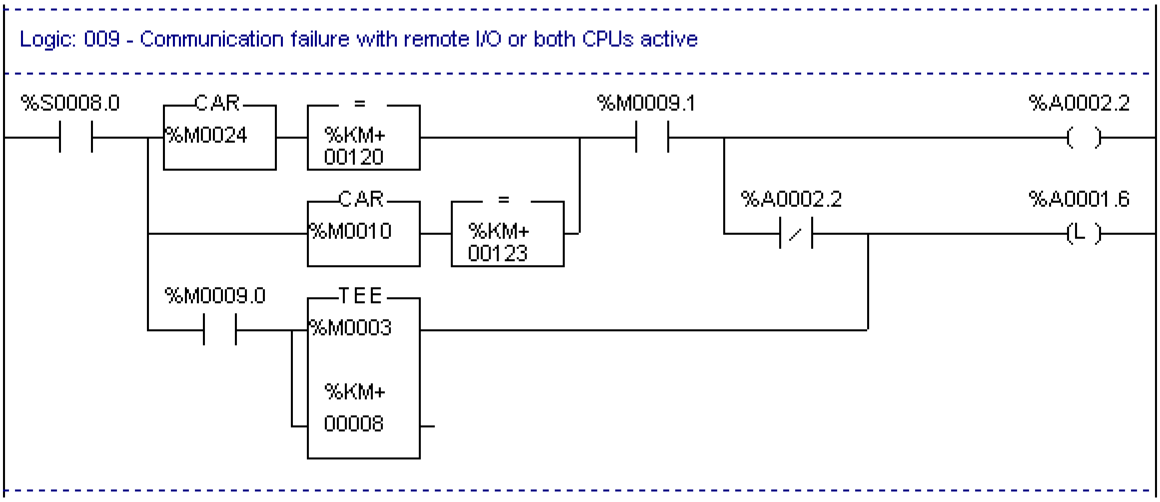


TM001					
Position	Value	Position	Value	Position	Value
0	00000	9	00000	18	00004
1	00000	10	00003	19	00002
2	00002	11	00001	20	01000
3	00001	12	01000	21	00130
4	01000	13	00100	22	00006
5	00000	14	00006	23	00004
6	00030	15	00004	24	00010
7	00002	16	00010	25	00008
8	00000	17	00008		

TM002			
Position	Value	Position	Value
0	00000	8	01000
1	00000	9	01000
2	00001	10	00000
3	00001	11	00000
4	00000	12	00000
5	00000	13	00000

6	00010	14	00000
7	00080	15	00000



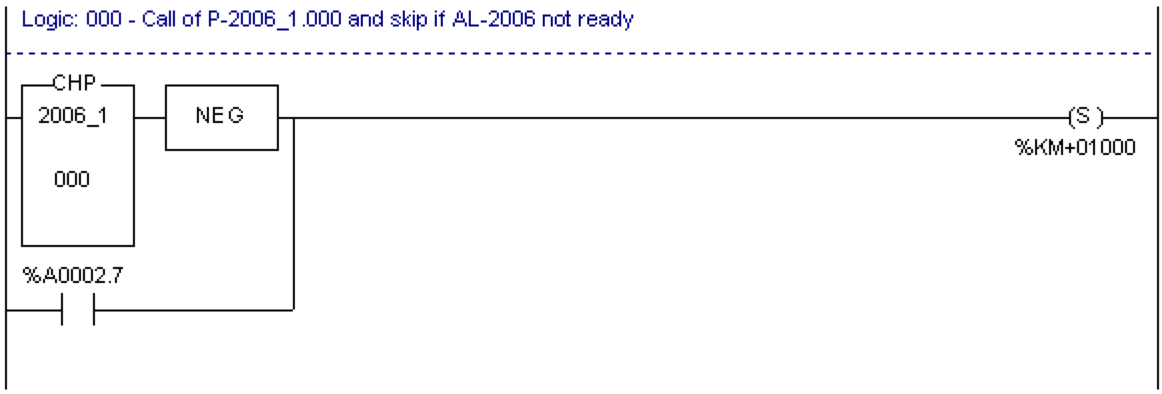


Contents of the E-.001 Module

The first logic in the main module of the E-.001 application program of CPU 1 is illustrated below. It contains the call to the P-2006_1.000 module. The main process control program should be inserted into the following logics, and should be subject to enable/disable control by the skip coil contained in logic 0, activated by a contact controlled by the P module.

The E-.001 module for CPU 2 should be identical to that for CPU1, with the single exception of a change of name of the module called in the logic 0 CHP instruction to 2006_2.

If the control program contains instructions such as ECR or LTR which can't be skipped then these instructions should be transferred to logics before the call of module P-2006_1.000 or P-2006_2.000. Refer to the **Customized Use** section in this chapter for more details. Such instructions should not be initiated when the CPU is not in active mode, but if the CPU switches from active to standby or inactive, then the instructions must be ended without skipping them.



Customized use

The P-2006_1.000 and P-2006_2.000 modules provided with the AL-2006 Brother product have the following characteristics:

- implementation in system architectures with redundant CPU and 2 remote I/O stations
- communication at 1 Mbaud with the redundant CPU and remote stations
- remote station 0 with 6 input octets, 4 output octets, 10 input M operands and 8 output M operands

- remote station 1 with 6 input octets, 4 output octets, 10 input M operands and 8 output M operands
- 1000 M and 90 A operand redundancy
- for use with application programs with a 600 ms maximum cycle time
- uses TM001 and TM002, M0000 to M0033, E000, S008, and A000 to A003 operands
- AL-2006 Brother processor located at position 0 on the I/O module bus
- ALNET II network node address with value 2 for the active CPU, and value 1 for the CPU in standby or inactive modes, or undergoing configuration

To enable their use in a range of applications with different characteristics, these P modules should be modified, as specified below.

- If the control application program is already using any of the operands used in programming the P-2006_1.000 and P-2006_2.000 modules, a new set of unused operands of the same types should be allocated, and the P modules modified to use the new operands. Two TM operands, 34 M operands, 1 E operand, 1 S operand and 4 A operands are required.

None of the operands used by either the P-2006_1.000 or the P-2006_2.000 modules can be used in any other application program module.

For example, if the application program is already using operands M0000 through M0010 and has operands M0180 through M213 free, M0000 can be replaced with M0180, M0011 by M0181, and so on.

- Declare the AL-2006 Brother at the bus position in which it will be utilized. In the module declaration window, the R address used to access this position is displayed in the corresponding position. Modify the logic 3 CHF instruction to use this address.
- Within logic 0 CAB instruction, modify the values loaded into tables TM001 and TM002 to the I/O and redundancy configurations desired. The meaning of each table position is described in **F-2006.019 – Communication with AL-2006 Brother function** earlier in this chapter.
- The maximum cycle time allowed for execution of the application program (C module) should be configured with a 50ms margin in relation to the actual runtime needed by the program, rounding up to the next time period allowed. For example, if the program requires a maximum of 80 ms to execute, the time limit configured in the C module should be 200 ms (80ms + 50ms = 130ms, using the next allowed time period = 200ms). Exaggerated margins should be avoided (100, 200 ms or greater) when

configuring the maximum cycle time, since this results in an unnecessary increase in response time for the backup CPU to detect active CPU failures.

- If the maximum cycle time allowed for execution of the application program is to be configured at a value greater than 600 ms, then the value constant KM+00008 should be modified to KM+00012 in the TEE instruction with the operand M0006, in logic 11 of both modules P-2006_1.000 and P-2006_2.000.
- If AL-2002 CPUs are connected to an ALNET II communications network, the values of the call to F-END2.082 module instruction parameters should be modified within logic 13 of the P-2006_1.000 and P-2006_1.000 modules. In this logic, the left-hand CHF instruction configures the node address which the CPU assumes in standby or inactive state, and should be an odd value. The right-hand CHF instruction configures the node address which the CPU assumes in the active mode, and should be an even value subsequent to the odd value in the left-hand CHF instruction.

The values chosen for node addresses in the CHF instruction should be unique on the sub-net, and between 1 and 31.

The C modules for CPU 1 and CPU 2 should be configured with the same node address. This address should be the same as the odd address chosen in the left-hand CHF instruction in logic 13 of the P-2006_1.000 and P-2006_2.000 modules.

Example

Consider a system with 3 redundant PCs connected on sub-net 1 of an ALNET II network.

redundant PC A:

- CPU 1 - sub-net address configured in the C module = 1
  node address configured in the C module = 1
  address programmed in the left-hand CHF (standby) = 1
  address programmed in the right-hand CHF (active) = 2

- CPU 2 - sub-net address configured in the C module = 1
  node address configured in the C module = 1
  address programmed in the left-hand CHF (standby) = 1

address programmed in the right-hand CHF (active) = 2

redundant PC B:

- CPU 1 - sub-net address configured in the C module = 1
  node address configured in the C module = 3
  address programmed in the left-hand CHF (standby) = 3
  address programmed in the right-hand CHF (active) = 4

- CPU 2 - sub-net address configured in the C module = 1
  node address configured in the C module = 3
  address programmed in the left-hand CHF (standby) = 3
  address programmed in the right-hand CHF (active) = 4

redundant PC C:

- CPU 1 - sub-net address configured in the C module = 1
  node address configured in the C module = 5
  address programmed in the left-hand CHF (standby) = 5
  address programmed in the right-hand CHF (active) = 6

- CPU 2 - sub-net address configured in the C module = 1
  node address configured in the C module = 5
  address programmed in the left-hand CHF (standby) = 5
  address programmed in the right-hand CHF (active) = 6

A gateway connected to the network could be configured with node address 31 and sub-net address 1. Supervisory communications connected to the gateway could be sent to node addresses 2, 4 and 6, for communicating with the active CPUs of PCs A, B and C, respectively.

For further details refer to the section entitled **ALNET II Communication with Redundant Controller** in chapter 3, **Operating Principles**.

General Programming Precautions

This section describes certain essential precautions which should be taken when preparing the application programs for the CPUs and remote I/O stations, in order to ensure the correct operation of the system.

Central Processing Units

Precautions when programming:

- Declare the AL-2006 Brother module in the program configuration module (C module) at the bus position it occupies.
- The same R address which corresponds to the module's position on the bus should be employed in the CHF instruction of the call to the F-2006.019 module.
- The values programmed for redundancy and remote I/O configuration should be correct, in accordance with the specifications found in chapter 3, **Operating Principles**, and chapter 4, **Programming.**
- Redundancy configuration should follow the recommendations contained in the **Specification of Redundant Operands** section to follow, in this chapter.
- The F-2006.019 module should be included in the programmable controller.
- Use program modules P-2006_1.000 and P-2006_2.000 for redundancy control.
- Before operating in either active or standby mode, the AL-2006 Brother processor should be configured at least once after the PC has been powered up. The AL-2006 Brother does not lose its configuration on switching the AL-2002 CPU to programming mode. However, it is advisable to reconfigure the AL-2006 Brother at every time the AL-2002 CPU application program begins (power-on or switching to execution mode). The redundancy control modules P-2006_1.000 and P-2006_2.000 are prepared to configure the AL-2006 Brother processor.
- The application programs and the C configuration modules for the two redundant CPUs should be exactly identical, with the exception of the redundancy control modules P-2006_1.000 and P-2006_2.000.
- It is suggested that the M operands in the application program are separated into 4 distinct areas:
  - operands used by the modules P-2006_1.000 and P-2006_2.000
  - operands with remote I/O values
  - redundant operands for processing the program
  - non-redundant operands for processing the program
- The ALNET II network node addresses configured in the C modules of the two CPUs should be identical, with the same value (odd) for the backup CPU. Refer to the **ALNET II Communication with Redundant Controller** section, in chapter 3, **Operating Principles**.

- During execution of the F-2006.019 module, the call to module E-.018 remains disabled. The execution of E-.018 is postponed until the end of the processing of F-2006.019, if it should have been called during its execution. The time taken to process F-2006.019 depends on the number of redundant operands and remote stations with which it is configured to operate.

The E-.018 module should not employ call periods of less than 25 ms within the application program of the CPU using the AL-2006 Brother processor.

In application program configurations with more than 500 redundant operands or more than 4 remote stations, E-.018 module call periods of less than 50 ms should not be employed within the application program of the AL-2002 CPU.

- Important points for verification in the remote I/O configuration tables:
  - The values in the configuration table positions should be within the limits specified in tables 3-4 and 3-6 in chapter 3, **Operating Principles**.
  - Each AL-2006 and remote I/O processor must have a unique ALNET II address, composed by a node address and a sub-net address.
  - The ALNET II sub-net address and baudrate should be the same for both the AL-2006 and all the remote stations when optical communications are not being employed.
  - The values in the TM000 table for the remote stations should be the same as the corresponding positions in the remote configuration TM table for the CPU, i.e. the following positions should contain the same values:

Remote I/O Configuration TM positions at CPU (F-2006.019)	TM000 positions for remote stations which should contain identical values
Positions 10 to 17 of the CPU TM	Positions 2 to 9 in TM000 of remote 0
Positions 18 to 25 of the CPU TM	Positions 2 to 9 in TM000 of remote 1
Positions 26 to 33 of the CPU TM	Positions 2 to 9 in TM000 of remote 2
Positions 34 to 41 of the CPU TM	Positions 2 to 9 in TM000 of remote 3
Positions 42 to 49 of the CPU TM	Positions 2 to 9 in TM000 of remote 4
Positions 50 to 57 of the CPU TM	Positions 2 to 9 in TM000 of remote 5
Positions 58 to 65 of the CPU TM	Positions 2 to 9 in TM000 of remote 6
Positions 66 to 73 of the CPU TM	Positions 2 to 9 in TM000 of remote 7

Table 4-11 – Equivalence of Remote I/O and CPU Configuration Tables

Remote I/O Stations

Programming precautions:

- The module F-REMOT.069 should be present in the remote station.
- The remote I/O stations should preferably be configured with hot-swap enabled for the I/O modules. This avoids the need to de-energize the entire remote station if there is an error in one of the I/O modules.
- The application program cycle time should be as short as possible, preferably less than 15 ms, in order to avoid increasing the cycle time of the main CPU application program. An excessive increase in the cycle time of the main CPU application program can cause problems for the control system, or even prevent its operation.

Specification of Redundant Operands

In redundant systems, the active CPU transfers the values of the operands defined in the redundancy configuration table to the backup CPU at every scan cycle. This transfer is necessary so that the backup CPU is able to assume control of the system in the same state as the active CPU, if there is a failure in the active CPU, or if a switchover takes places for another reason.

It is not necessary to transfer all the operands of the active CPU application program to the redundant CPU at every scan cycle. In order to optimize system performance, only those operands essential to the operation of redundancy should be transferred.

Each application program should be analyzed and the operands which should be transferred must be defined and grouped in contiguous addresses to avoid the communication of unused operands.

As a general rule, to decide whether an operand should be declared as redundant, an analysis should be made of whether a modification in its value will have any influence on the way the application program will behave when it runs the next cycle.

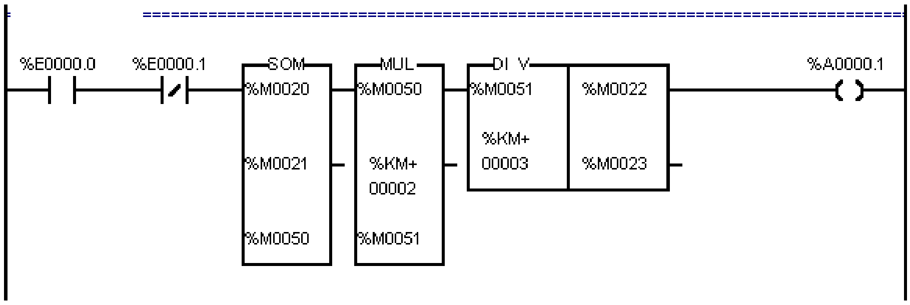
Those M operands which receive input values from the remote I/O stations do not need to be configured as redundant, since the AL-2006 Brother in the backup CPU will automatically read the input points when it becomes the active CPU, before executing the application program for the first time.

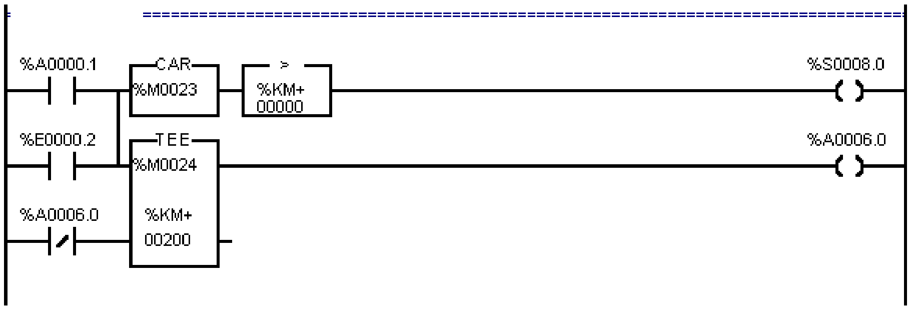
The operands utilized by the redundancy control modules P-2006_1.000 and P-2006_2.000 cannot be configured as redundant.

In redundant systems, at least one operand must be configured as redundant.

Example of Definition of Redundant Operands

As an example, we will take an application program comprising the E-.001 module containing the following logics.





- The operands E0000.0, E0000.1 and E0000.2 do not need to be configured as redundant because they are input points.

- The operand A0000.1 does not need to be configured as redundant. It is calculated in logic 000 and used in logic 001, so its initial value at the beginning of the application program does not matter.
- The operand A0006.0 must be configured as redundant, because it is used in logic 001, before being altered. So its initial value at the beginning of the application program does matter.
- The operands M0050 and M0051 do not need to be configured as redundant. As in the previous cases, they are altered before being read. Sometimes they are not altered (if E0000.0 = 0 or E0000.1 = 1), but in these cases, they also are not read.
- The operands M0020 and M0021 must be configured as redundant, since, if the mathematical instructions in logic 0 are enabled, any alteration in their values can change the result of the calculation in logic 0 (M0022 and M0023) and the activation of the output point (S008.0).
- The operands M0022, M0023 must be configured as redundant, since, if the mathematical instructions in logic 0 are disabled, any change in their values can alter the activation of the output point (S008.0).
- The operand M0024 must be configured as redundant, since an alteration in its value can cause the activation of the coil A006.0.

Therefore, for this example, the operands M0020 to M0024 and A006 should be defined as redundant.

Usual Declarations of Redundant Operands

In the majority of cases, the decision on whether to configure an operand as redundant is based upon certain tendencies, depending on the instruction in which the operand will be utilized.

The two following sections describe these tendencies. They are included in order to orient the user and not as a substitute for the analysis of every operand in accordance with the criteria described above.

Operands which should Normally be Declared as Redundant

- Operands used in counting instructions (counters and timers).
- Operands which are modified by instructions which can be disabled or skipped.
- A or S operand points activated by on/off coils.
- A operand points used in pulse-relay instructions.

- Operands which are not modified by instructions within the application program, but which are written over the communications network by other PCs or either by programming or supervisory stations.

Operands which do not Normally need to be Declared as Redundant

- Operands which are always modified by an instruction before being used by another (scratchpad operands). The first instruction, which writes the value to the operand should always be executed (should always be enabled, can't be skipped). This category includes operand points activated by single coils, operands which receive values in movement, mathematical or conversion functions. The operand A000.1 in the previous example is always written with a value at the end of logic 0, coil before being used in logic 1.

Failure Diagnostics

The identification of failures is a topic of fundamental importance in any control system. Alarm signals should be generated in order that the operators execute the appropriate maintenance procedures. Diagnostics assume a special importance in redundant systems, in which the process control frequently proceeds normally, even when an isolated fault has occurred in one of its component parts. Despite the appearance of normal operation, this failure should be signaled and corrected to guarantee the safety and availability of the system.

This section describes the mechanisms for identifying errors related to redundancy processing or the remote I/Os. For each type of error, the procedures for setting alarms which should be included in the supervisory station and/or application program, in order that the operators may perform the necessary corrective action. Depending on the failure, the PC application program may take some automatic corrective actions, like shutting down the system to a safe state.

The way to correct these errors is described in the section **Procedures in Case of Failure**, in chapter 6, **Maintenance**.

Error diagnostics and correction procedures relating to the basic functions of the CPUs, the I/O stations and the power sources can be found in the AL-2002/MSP User's Guide, in the AL-2000/MSP-C User's Guide, in the QK800, QK801 and QK2000/MSP User's Guides and in the Technical Specifications documentation of the respective I/O modules.

AL-2002 CPU General Status Indicators

In the redundancy control modules P-2006_1.000 and P-2006_2.000, the operand A003 stores the current status of the CPU at its bits, as described immediately below:

- A003.0 – active
- A003.1 – standby
- A003.2 – inactive

These points should be monitored at both CPUs by the supervisory program in order to display their current status to the operator.

Point A0003.2 should cause an alarm, because indicates that this CPU is not able to assume as active in case of a failure in the active CPU.

De-energization of the Redundant CPU

In redundant systems, if the active CPU fails then it is de-energized by the backup CPU which takes over control of the process and switches to active. The occurrence of this failure is signaled by the activation of the point A003.3 in the redundancy control module of the CPU which has become active; either P-2006_1.000 or P-2006_2.000.

The activation of point A003.3 in either CPU 1 or CPU 2 should set an alarm for the system operator.

If the CPUs are connected via the network to a supervisory system, then it is recommended that the supervisory system monitor these auxiliary points periodically and display alarm messages to the operator if they are activated.

The CPU in which the fault occurred remains de-energized and should be re-energized as defined in the **Procedures in Case of Failure** section, in chapter 6, **Maintenance**. The operand A003.3 is deactivated on re-energization of the CPU.

Redundancy Communication Failure

The auxiliary point A003.4 is energized when one of the CPUs fails to receive the information that the redundant CPU is in active, standby or inactive over the communication channels.

The activation of point A003.4 in either CPU 1 or CPU 2 should set an alarm for the system operator.

This alarm occurs in one of the CPUs when the other is de-energized or the communication among both CPU is not working.

AL-2006 Brother General Status Indicators

In the fourth parameter of the call to module F-2006.019 instruction (CHF instruction) an area of M operands is defined. These operands receive a number of status indicators (see item **F-2006.019 – Communication with AL-2006 Brother function** in this chapter).

Within this area, two M operands provide the general status of the configuration and operation of the AL-2006 Brother processor and of its communications with the redundant CPU and the remote I/Os. These operands are shown in table 4-13.

Status indicator operands in F-2006.019	
Operands	Contents
MXXXX + 2	General status of AL-2006 processor and of communication with redundant CPU
MXXXX + 16	General status of communication with remote I/Os and also of remote I/O 0

Table 4-12 – General Status Indicator Operands in F-2006.019

In these operands, the value zero means normal operation, no errors. Values other than zero indicate faults.

In the redundancy control modules P-2006_1.000 and P-2006_2.000 provided with the AL-2006 Brother product, the last non-zero values on these operands are memorized by the operands M0032 (for MXXXX + 2) and M0033 (for MXXXX + 16).

The presence of values other than zero in the operands M0032 and M0033 which memorize status should set an alarm for the system operator and display the error identification code.

If the CPUs are connected via the network to a supervisory system, then it is recommended that the supervisory program monitor these operands periodically and display an alarm message to the operator if either of their values is different from zero, and show the error identification value together with its explanatory text. Supervisory system may write zero on these two operands after acknowledging their alarms and fixing their causes.

The operand M0032 should always be monitored by the supervisory system, even in systems without redundancy which use the P-2006.000 module, since it indicates general AL-2006 Brother processor errors.

The error identification values allowed for these operands are described in appendix A, **Error Codes**. Errors which occur should be corrected in accordance with the recommendations contained in the section **Procedures in Case of Failure** , in chapter 6, **Maintenance**.

Once the problem has been corrected, the supervisor can force the operand to the value zero. If the problem has been repaired the alarm operand will not return to zero unless the supervisory system writes zero on it.

Communication with Remote Station Indicators

In the fourth parameter of the call to module F-2006.019 instruction (CHF instruction) an area of M operands is defined. These operands receive a number of status indicators (see item **F-2006.019 – Communication with AL-2006 Brother function** in this chapter).

Table 4-14 shows the status operands related to communication between the AL-2006 Brother processor and the remote I/O stations.

Status indicator operands in F-2006.019	
Operands	Contents
MXXXX + 16	Communications status of remote I/O 0 (also a general status for all remote I/O stations)
MXXXX + 17	Communications status of remote I/O 1
MXXXX + 18	Communications status of remote I/O 2
MXXXX + 19	Communications status of remote I/O 3

MXXXX + 20	Communications status of remote I/O 4
MXXXX + 21	Communications status of remote I/O 5
MXXXX + 22	Communications status of remote I/O 6
MXXXX + 23	Communications status of remote I/O 7

Table 4-13 – Remote I/O Status Indicator Operands in F-2006.019

In the redundancy control modules P-2006_1.000 and P-2006_2.000 provided with the AL-2006 Brother product, these operands are in the range M0024 through M0031.

In these operands, the value zero indicates normal operation, no errors. Values other than zero indicate faults.

The presence of values other than zero at these operands should set an alarm for the system operator and display the error identification value.

If the CPUs are connected via the network to a supervisory system, then it is recommended that the supervisory system monitor these operands periodically and display alarm messages for the operands if any of their values is different from zero, and show the error identification value or its explanatory text.

The supervisory system should monitor only those operands which correspond to existing remote stations. For example, if the system has just three remote stations, the supervisory system should monitor operand MXXXX+16, MXXXX+17 and MXXXX+18 only.

The error identification codes allowed for these operands are described in appendix A, **Error Codes**. Errors which occur should be corrected in accordance with the recommendations contained in the section **Procedures in Case of Failure** , in chapter 6, **Maintenance**.

Optical Link Status Indicators

In the fourth parameter of the call to module F-2006.019 instruction (CHF instruction) an area of M operands is defined. These operands receive a number of status indicators (see item **F-2006.019 – Communication with AL-2006 Brother function** in this chapter).

Up to two optical links can be used for communication with the remote stations, each of which can be either simple (only 1 connection) or redundant (2 alternative connections). If redundant optical links are being employed, the status of these links are stored in the operands shown in table 4-15. These values are read and written by the bridge processors (QK2401) which control the optical links.

Status indicator operands in F-2006.019	
Operands	Contents
MXXXX + 3	Primary optical link selected (1 or 2)
MXXXX + 4	Status of primary optical link connection 1 (0 - normal or 1 - fail)
MXXXX + 5	Status of primary optical link connection 2 (0 - normal or 1 - fail)
MXXXX + 6	Primary optical link forced connection (0 - not forced, 1 or 2)
MXXXX + 7	Forced status of primary optical link connection 1 (0 - normal or 1 - fail)
MXXXX + 8	Forced status of primary optical link connection 2 (0 - normal or 1 - fail)
MXXXX + 9	Secondary optical link selected (1 or 2)
MXXXX + 10	Status of secondary optical link connection 1 (0 - normal or 1 - fail)
MXXXX + 11	Status of secondary optical link connection 2 (0 - normal or 1 - fail)
MXXXX + 12	Secondary optical link forced connection (0 - not forced, 1 or 2)
MXXXX + 13	Forced status of secondary optical link connection 1 (0 - normal or 1 - fail)
MXXXX + 14	Forced status of secondary optical link connection 2 (0 - normal or 1 - fail)

Table 4-14 – Optical Link Status Indicators in F-2006.019

> The operands MXXXX+4, MXXXX+5 and MXXXX+10 and MXXXX+11 contain the connection status of the optical links. In these operands, the value zero indicates normal operation, no errors. Values other than zero indicate faults in the optical connections that should set an alarm for the system operator. If the CPUs are connected via the network to a supervisory system, then it is recommended that the supervisory system monitor these operands periodically and display alarm messages to the operator if any of their values is different from zero. The operands MXXXX+3 and MXXXX+9 can also be monitored in redundant systems to indicate which connections are selected.

If an error in one of the optical connections is detected, it should be corrected in accordance with the recommendations contained in the section **Procedures in Case of Failure** , in chapter 6, **Maintenance**.

> After correcting the connection fault, the corresponding operand (MXXXX+7, MXXXX+8, MXXXX+13 or MXXXX+14) should be forced to the value 1000 at the active CPU. The connection will once more be considered as in a normal status as a result of this forcing, and the equivalent status indicator operand (MXXXX+4, MXXXX+5 and MXXXX+10 and MXXXX+11) will return to the value zero. If there is still an error after the repair, the connection will return to the error status in a few moments due to the tests that the bridge processor performs periodically.

The operands MXXXX+7, MXXXX+8, MXXXX+13 or MXXXX+14 are only used for forcing. Their monitoring value always returns to zero.

> If the CPUs are connected to a supervisory system it is recommended that this system include commands to force the operands corresponding to the optical connections employed to zero (MXXXX+7, MXXXX+8, MXXXX+13, MXXXX+14). In this way the operator is able to reset the connections to the normal status as soon as repairs have been made.

The operands MXXXX+6 and MXXXX+12 can be forced to the value 1001 or 1002 in order to force a change in which redundant connection is in use, for maintenance of one of the connections.

> After being forced to the value 1001 or 1002 the operand MXXXX+6 or MXXXX+12 should be forced back to 1000, in order that connection switching is re-enabled, i.e., so that the system switches connections automatically if there is a failure in the connection being used at the time.

For example, if communications are using connection 1 and it is necessary to perform maintenance on it, the use of connection 2 can be selected by forcing the operand MXXXX+6 to the value 1002. The switch will only be accomplished if connection 2 is in the normal status (MXXXX + 5 = 0). The switching can be confirmed at operand MXXXX+3, which should indicate value 2 after switching from connection 1 to connection 2. After the switching, the operand MXXXX+6 should be forced to the value 1000.

The operands MXXXX+3 through MXXXX+8 and MXXXX+9 through MXXXX+14 correspond to positions 34 through 40 of the TM000 for the channels of the bridge processors connected to the system’s fiber-optic modems. Forcing the application program operands MXXXX+3 to MXXXX+8 and MXXXX+9 to MXXXX+14 to the values 1000, 1001 and 1002 will make the AL-2006 Brother processor launch commands to force positions 34 to 40 in the TM000 of the corresponding bridge processor channel.

Further details can be found in the sections entitled **Status Indicators of Optical Connection** in chapter 4, **Programming** in the AL-2401 User’s Guide and the FOCOS User’s Guide.

Remote Station Octet Status Indicators

The first four M operands of the input area of each remote station contain the status of each I/O octet of the station, one bit per octet, as described in tables 3-7 and 3-8 of the section **Area of Input Operands in Remote Stations**, in chapter 3, **Operating Principles**. The value 0 indicates normal operation of the octet, while value 1 indicates that the octet is deactivated for hot swapping or that there is a fault in the module or bus.

If the CPUs are connected via the network to a supervisory system it is recommended that this system periodically monitor the status of the octets of each remote and display an alarm message to the operator if they return values other than zero.

Installation

This chapter introduces the procedures necessary for the correct installation of the AL-2006 Brother processor, introducing hardware and software aspects and verifications necessary for smooth operation.

Installation in the Rack

The AL-2006 Brother was designed to be used with the AL-2003 and AL-2002/MSP CPU, mounted in the same rack.

There are 3 models of racks:

- AL-3630: it has room for the power-supply, CPU AL-2002 or AL-2003, and 4 other modules. The first 3 of these 4 positions may receive special modules, which require an “extended bus” for communicating with CPU using DMA (direct memory access).
- AL-3632: it has room for the power-supply, CPU AL-2002 or AL-2003, and 8 other modules. The first 5 of these 8 positions may receive special modules, which require an “extended bus” for communicating with CPU using DMA (direct memory access).
- AL-3634: it has room for the power-supply, CPU AL-2002 or AL-2003, and other 16 modules. The first 5 of these 16 positions may receive special modules, that require an “extended bus” for communicating with CPU using DMA (direct memory access).

The special modules that must be installed in the first three (AL-3630) or five (AL-3632 and AL-3634) positions, for DMA access to CPU, are the following at this time:

- AL-2006 (Brother Coprocessor)
- AL-2005 (Communication Coprocessor)

- AL-3405 (Ethernet TCP/IP Interface)
- AL-3406 (Profibus DP Master Interface)
- AL-2008 (High Performance DSP Coprocessor)

Figure 5-1 shows the positions where the AL-2006 may be installed in an AL-3632 rack (power-supply, CPU and eight other modules).

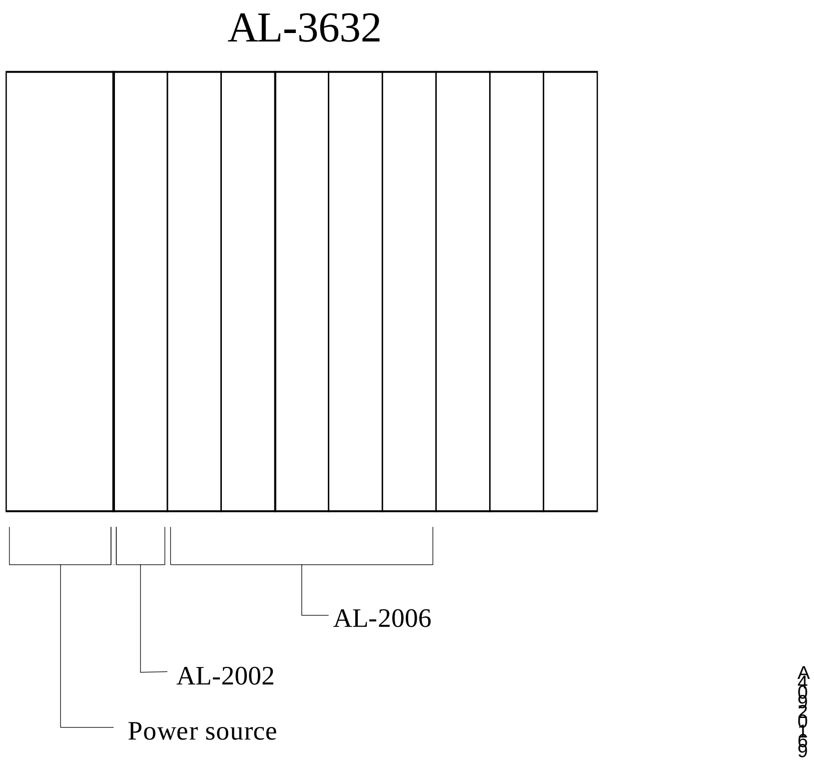


Figure 5-1 – AL-2006 Brother Positioning in AL-3632 Rack

To be installed in the rack, the AL-2006 Brother module must be inserted into the plastic guides until it is totally connected into the rack backplane connector. After insertion, the fastening screws on the front panel of the module must be firmly tightened. Figures 5-2 and 5-3 show installation procedures in detail.

During the rack installation procedure, modules should only be handled by their front panels. Fingers should never come into contact with the printed circuit board or its components, in order to avoid possible damage by electrostatic discharge (ESD).

The power source of the rack must be switched off before installing the AL-2006 Brother and the other modules (except for hot-swappable I/O modules).

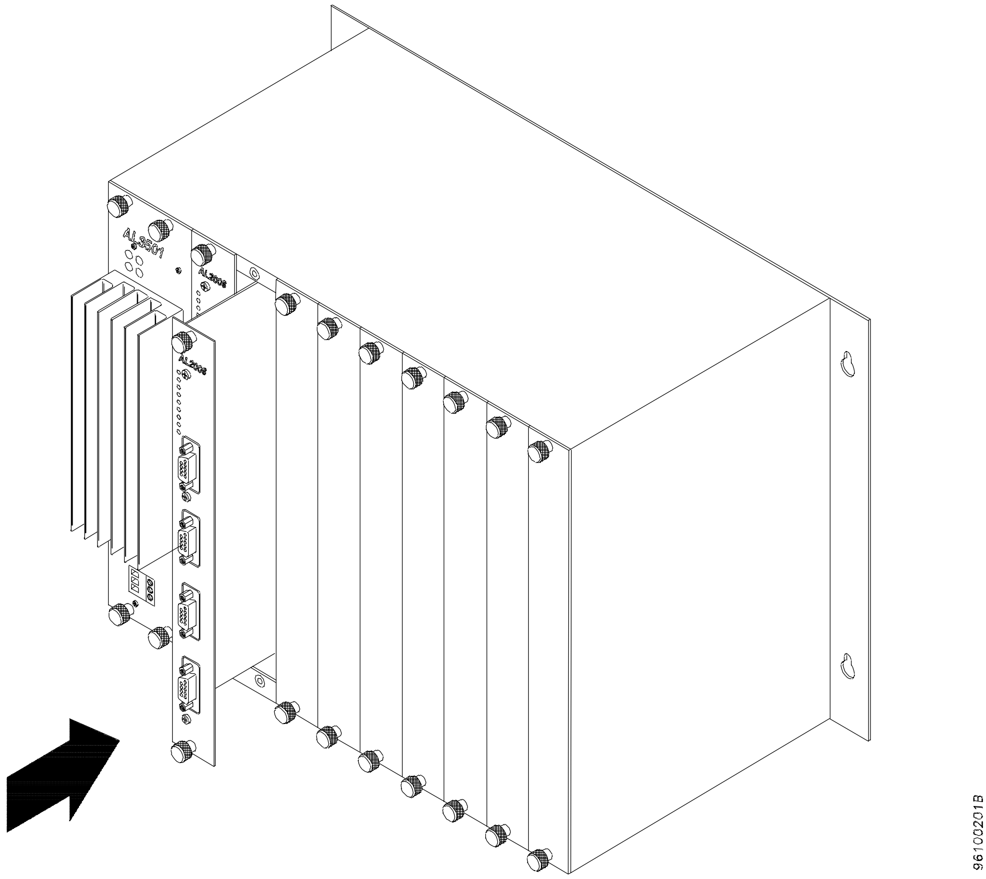


Figure 5-2 – Insertion of the AL-2006 Brother into the AL-3632 Rack

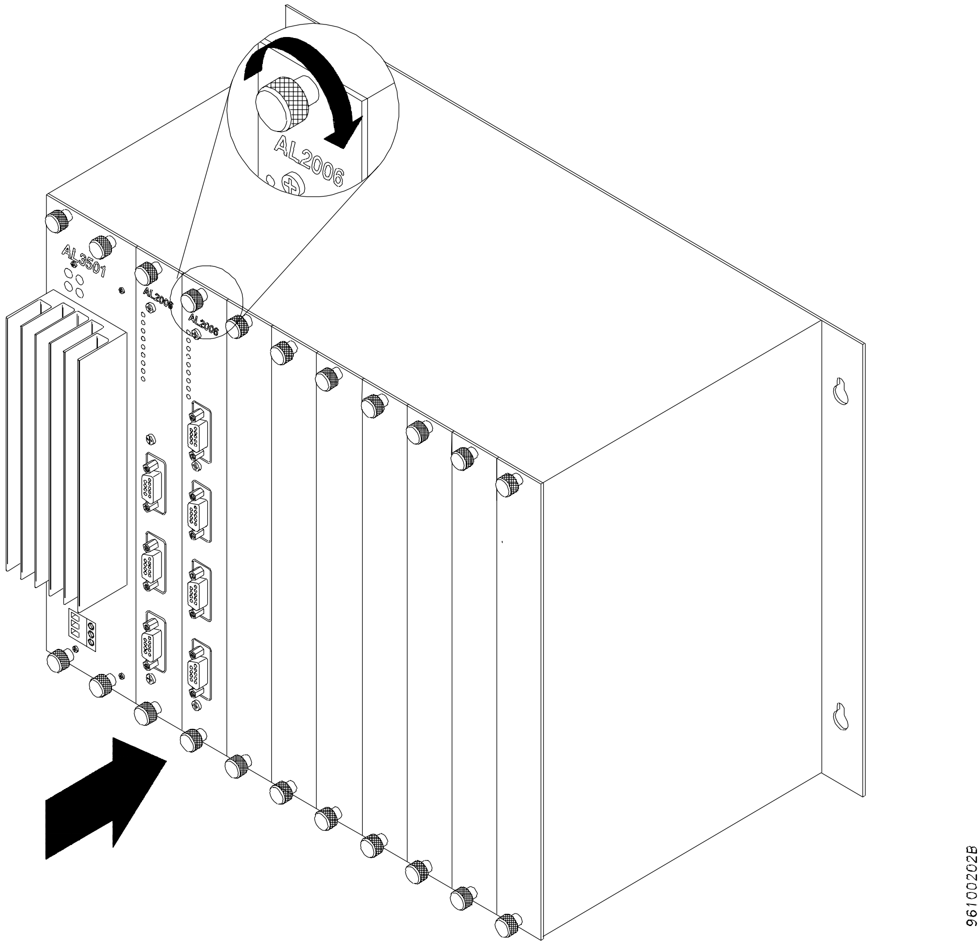


Figure 5-3 – AL-2006 Brother Fastening Screws

Installation in the Mounting Panel

General Precautions

The AL-2006 Brother is considered part of the AL-2002 programmable controller, since it is installed in the same rack.

The procedures and the necessary precautions for the correct installation of the controller in the mounting panel are described in the AL-2002/MSP User's Guide.

Redundancy Control Panel

For systems with redundant CPUs, a small control panel must be installed close to the CPUs, in a place that can be easily accessed by the operator.

The existence of this panel is extremely important for system operation, allowing quick awareness of the status of the redundant CPUs and the execution of maintenance tasks by the operator.

This panel consists of eight buttons with integrated light indicators arranged in two rows of four. These indicators allow the operator to view the current operating status of the CPUs, to request a change of status, and re-energize the CPUs in case of failure, as shown in figure 5-4.

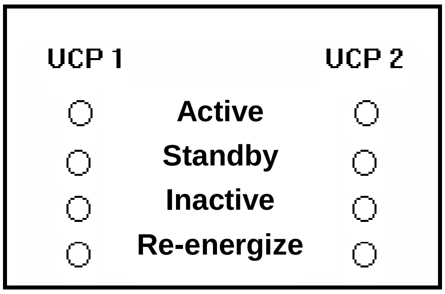


Figure 5-4 – Redundancy Control Panel

Each row refers to a CPU and each button activates an input point. The three upper buttons have built-in lamp indicators which are activated by output points in order to indicate the current status of each CPU. These input and output points are processed by the P-2006.000 redundancy control module, as described in chapter 4, **Programming**. Table 5-1 shows the addresses of the input and output points used by the P-2006.000 module that should be connected to the buttons and indicators on the redundancy control panel.

CPU 1	Status	CPU 2
button - not connected lamp - S008.0	active	button - not connected light - S008.0
button - E000.1 lamp - S008.1	standby	button - E000.1 lamp - S008.1
button - E000.2 lamp - S008.2	inactive	button - E000.2 lamp - S008.2
button - E000.3 lamp – not connected	re-energize	button - E000.3 lamp – not connected

Table 5-1 – I/O Addresses for Buttons and Lamps on Redundancy Control Panel

The I/O addresses shown in table 5-1 are used in the P-2006_1.000 and P-2006_2.000 modules, provided with the AL-2006 Brotherproduct. These addresses may be modified according to the configuration of the I/O modules used in the system. Refer to **Customized Use** section in chapter 4, **Programming**.

The operation of the redundancy control buttons is described in the **Change of Redundant CPU Status by Operator**, in chapter 6, **Maintenance**.

Redundant CPU Control Relays

In redundant systems, each CPU should have control over the other CPU's power supply, de-energizing it in case of failure. This control is accomplished through a normally closed relay contact, which controls the supply of energy to the other CPU, as shown in figure 5-5.

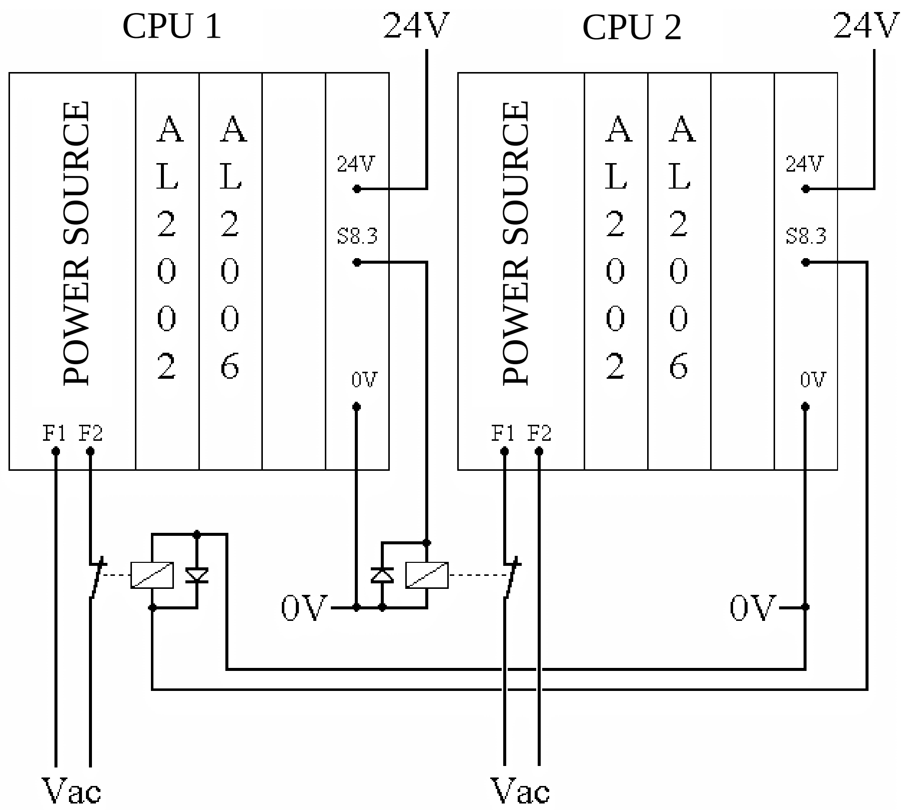


Figure 5-5 – Redundant CPU Control Relay Connections

The output point that activates the contact of each CPU uses address S0008.3 in the P-2006_1.000 and P-2006_2.000 modules provided with the AL-2006 Brother product. This address may be modified according to the configuration of the I/O modules used in the system. Refer to **Customized Use** section in chapter 4, **Programming**.

Only relays or contacts which have a control current capacity that is sufficient to control the power supply used for the CPUs should be employed. The use of adequate noise suppressors on the relay or contacts, in accordance with the recommendations in the AL-2002 User's Guide is indispensable.

Installation of the Communications Network

The AL-2006 Brother processor communicates with the remote I/O stations and with the redundant CPU through a dedicated ALNET II network.

Even though it has a specific purpose, this network uses the same elements of ALNET II communications network as a physical media among programmable controllers. The elements are listed below.

Electrical physical media:

- AL-2300 – branch cable for the connection of a station to the network
- AL-2600 – module for connection of branches and network termination
- AL-2301 – network cable

Optical physical media - FOCOS:

- AL-2401 – bridge processor for the interconnection of sub-networks
- AL-2410 – modem for the connection of optical channels
- AL-2513 – power source for fiber-optic modems
- AL-2610 – rack for 16 fiber-optic modems
- AL-2611 – rack for 3 fiber-optic modems
- AL-2320 – cable for connection of fiber-optic modem to bridge processor or PCs.

Network architecture may be quite flexible, as allowed by the ALNET II standard, but for Brother application it is limited to 3 sub-networks. Figure 5-6 shows an architecture using electrical media, with 2 remote stations. Figure 5-7 shows an architecture with the maximum number of sub-nets and optical connections, with 4 remote stations.

For greater data exchange efficiency between CPUs and remote I/O stations, a data rate of 1 Mbit/s should be used. In consequence, the total length of electrical sub-nets should be less than 100 meters. When longer networks are used, optical media should be used to keep the 1 Mbit/s rate.

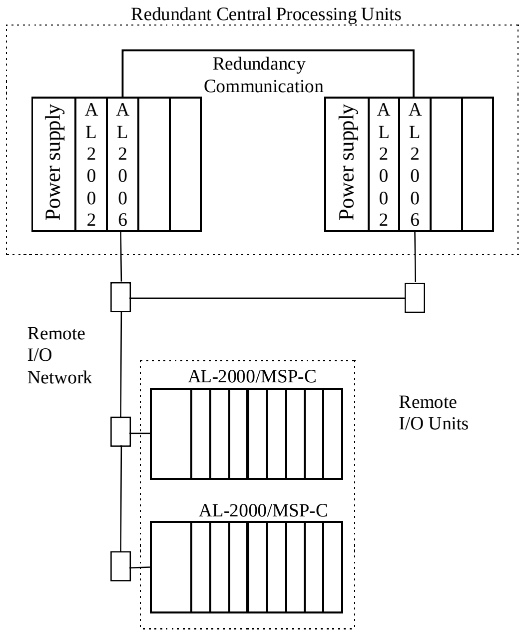


Figure 5-6 –Typical Architecture of a Simple System

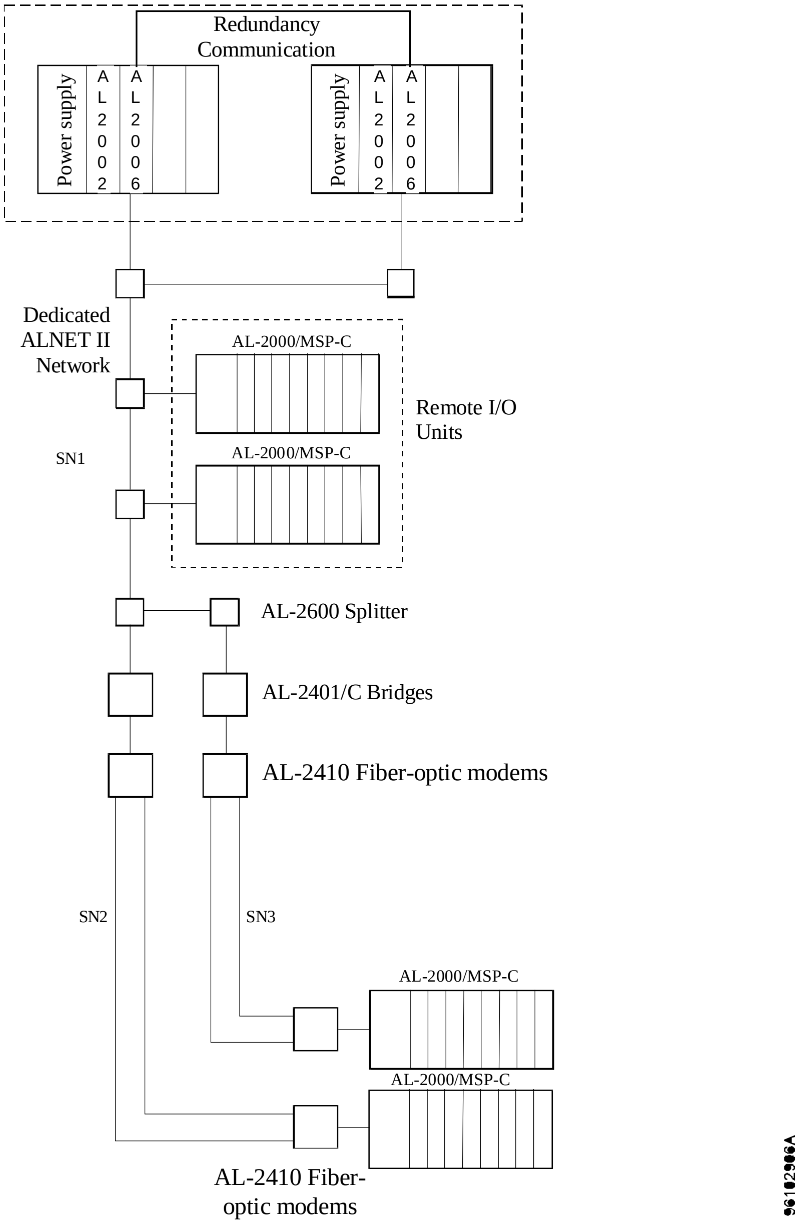


Figure 5-7 – Architecture of a System with an Optical Network

The procedures for the installation of network components, such as architecture information, operational limits and the specific characteristics of ALNET II networks can be found in the ALNET II User's Guide.

Installation of Redundancy Communication

When redundant CPUs are used, the AL-2006 Brother processors of both CPUs communicate through the AL-1366 cable to exchange information on the redundancy status among the CPUs.

The AL-1366 cable has two DB9 male connectors that must be connected to the REDUND connectors on the front panel of the AL-2006 Brother processors. The connectors must be tightened using the screws.

Commissioning

The commissioning test consists of the final debugging of the control system when the programs of all remote stations and CPUs are executed together, after being developed and verified individually. The commissioning test must be performed when all the equipment of the system has already been correctly installed, according to the previous recommendations in this chapter and to the guidelines presented in the respective guides.

The commissioning test is carried out as follows:

1. Installation of application programs in the I/O remote stations
2. Installation of the application programs on the CPUs
3. Commissioning of the application program

Before installing application programs, it is necessary to check whether the recommendations presented in the **General Programming Precautions** section**,** in chapter 4, **Programming**, have been followed. Also check whether the versions of the execution software for the CPUs and I/O remote stations allow for the execution of the F-2006.019 and F-REMOT.069 modules (Refer to **Usability** in the sections that describe each module in chapter 4, **Programming)**.

The installation of the application programs must be executed according to the procedures described in the following sections, starting with the I/O remote stations. The loading and execution of the CPU programs can only be carried out after the application programs of the remote stations have been loaded.

The operations of changing the CPU status, loading the program modules, monitoring and forcing the variables mentioned in the following sections are described in the AL-3830 User's Guide and in the MasterTool User's Guide.

➲DANGER:
When the commissioning test begins, before energizing any element of the control system, the output points whose inadequate function may cause any harm to people or to the controlled system itself must be disconnected. As the control system is debugged, the output points must be checked and may be connected to the elements.

Installation of Application Programs on the Remote I/O Stations

- Connect the programming terminal to the ALNET I connector in the remote station.
- Power up the remote station.
- Switch the remote station to programming mode.
- Delete any previous version of the program from RAM. Also erase the FLASH EPROM.
- Send the application program to the remote station.
- Switch the remote station to execution mode.
- Check the CPU status with the programmer. If an error is detected, check the cause, correct it and restart the loading procedure.
- If the remote station is in execution mode, check whether there are warning messages and correct the indicated problem.
- Activate the points of digital input modules and check, through monitoring, whether the values of the points are being copied to the correct M operands of the input communications area of the remote station, which will be read by the CPU. Test whether the programmed filtering time for the input points configured with this feature is working. If the values are not being

correctly copied or the filtering is not working, check the configuration and the F-REMOT.069 module call.

- Repeat the previous procedure for the special and analog input points. If the values are not being correctly copied, check the instructions of the A/D conversion or the function modules used in the access to the special modules.
- Force the M operands of the output communications area of the remote station, which will be written by the CPU, checking the activation of the points in the associated output modules. Check the activation of the digital, analog and special modules.
- Check the runtime of the remote station program. The runtime must be shorter than 15 milliseconds. If not, try to shorten the runtime by distributing the execution of A/D – D/A instructions and the access to the special modules in several scanning cycles.
- When the corrections have been carried out, transfer the program to FLASH EPROM.

Installation of Application Programs on the CPUs

The loading procedure must be carried out separately for each CPU in redundant systems, keeping the other redundant CPU de-energized. After both redundant CPUs have been loaded and tested, they can be simultaneously energized and operated together.

The remote stations must be energized and connected to the remote I/O network, so that the installation of the application programs on the CPUs may be carried out. The programs of remote I/O station must have been previously installed and debugged, and must be running.

- Connect the programming terminal to the ALNET I connector on the CPU.
- Power up the CPU.
- Switch the CPU to programming mode.
- Delete any previous version of the program from RAM, and erase the FLASH EPROM.
- Send the application program to the CPU.
- Switch the CPU to execution mode.
- Check the CPU status with the programmer. If an error is detected, check the cause, correct it and restart the loading procedure.

- If the CPU is in execution mode, wait for five seconds and check whether it is active or not, monitoring the output operands that define the status in the P-2006 module on the CPU (P-2006_1.000 or P-2006_2000).
- If the CPU remains inactive, a configuration error has occurred in the AL-2006 Brother processor. Check the error output indicated (logic 004) and the error code indicated (logic 005, operands M0032 and M0033), correct the error and restart the loading procedure. The guidelines for error correction may be obtained, according to its code, in **Procedures in Case of Failure**, in chapter 6, **Maintenance**.
- If the CPU becomes active, check the contents of the operands that indicate error. If they have values different from zero, the respective error must be corrected. Refer to the **Procedures in Case of Failure** section, in chapter 6, **Maintenance**.
- With the CPU in active mode the TX and RX REMOT I/O LEDs on the AL-2006 Brother front panel should be flashing quickly and continuously. If they remain off, the whole installation process must be reviewed, according to the recommendations presented earlier in this chapter.
- Connect the programming terminal to the ALNET I connector of the AL-2006 Brother processor and check the ALNET II communications status (Refer to the **ALNET II Communications Status** section, in chapter 6, **Maintenance**). Reset the error counters, wait for five minutes and check the communications status again. If errors have occurred, they are due to a problem on the physical installation of the redundant I/O network or to a de-energized station. Refer to the ALNET II User's Guide for correcting the problem.
- If there are no error indications either in the P-2006 module operands or in the ALNET II communications status window, check whether the contents of the input and output operands are being read and written correctly from/to the respective operands in the remote stations.
- Check whether the local I/O points on the CPU (buttons and indicators of status on the redundancy control panel) are operating correctly.
- De-energize the CPU and carry out the previous procedures for the redundant CPU, if they have not been executed yet.
- After the programs have been loaded on both CPUs, de-energize and re-energize them simultaneously. One of the CPUs must assume as active, while the other must assume as standby. If the CPUs keep changing status constantly, check the contents of the tables, the initialization parameters of the AL-2006 Brother processors, the differences between the P-2006 1.000 and P-2006 2.000 modules of both CPUs, and the logics of status control of the CPUs in these modules (logics 7,8,9 and 10).

- Check whether the status of one CPU is being transmitted to the other one, monitoring the M0008 and M0009 operands of each CPU. These operands must be different from zero. If they are not different from zero, check the AL –1366 cable that connects the AL-2006 Brother on both CPUs.
- Test the change of status of the CPUs by activating the standby and inactive buttons on the redundancy control panel. When a CPU is switched to the standby mode by pressing the button, the other CPU must automatically become active. A CPU can only assume as inactive if it is in the standby mode. If this does not work fine, check the correct reading of the buttons of the panel, monitoring their inputs, and check the logics from 7 to 10 of the P-2006_1.000 and P-2006_2.000 modules.
- When one CPU is active and the other one is in standby, switch the active CPU to programming mode with the AL-3830 programmer or the MasterTool, thus simulating a failure in it. Check whether this CPU has been de-energized by the other in standby mode and also check whether the latter becomes active. The de-energized CPU should become energized again by pressing the **re-energize** button of the active CPU. Repeat the test by starting with the other CPU in the active mode. If this does not work fine, check the correct reading of the buttons on the panel, monitoring their inputs, and check the logics from 7 to 10 of the P-2006_1.000 and P-2006_2.000 modules. Check also the connection of the NC relays that de-energizes CPUs.
- When one CPU is active and the other is in standby, switch the backup CPU to programming mode with the AL-830 or MasterTool processor, thus simulating a failure in it. This CPU should not be de-energized, while the other CPU must remain active. Repeat the test by reversing the status of the CPUs.
- Check whether the declared redundant operands are being transmitted from the active CPU to the backup CPU, forcing and monitoring the values on both. Reverse the status of the CPUs and repeat the test for the other CPU. If the operands are not being transmitted, check the configuration tables and parameters of the F-2006.019 functions in the P-2006_1.000 and P-2006_2.000 modules.

Debugging of the Application Program

- While keeping the I/O remote stations and the two CPUs energized, monitor and force the variables of the application program of the active CPU, testing whether it is working. If errors occur, make the necessary changes and load the modified modules in the active CPU, whenever possible. After the errors are corrected, load the modified modules also in the backup CPU.

- When the corrections have been made, transfer the program to FLASH EPROM on both CPUs

Maintenance

This chapter introduces essential operation and maintenance precautions for a redundant system or one with remote I/Os.

Change of Redundant CPU Operating Mode by the Operator

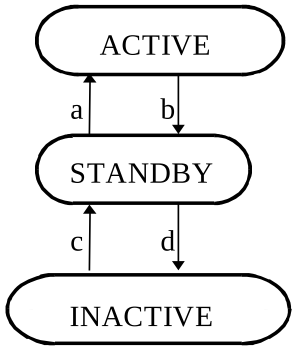
Each CPU in the system can be in one of three operating modes, defined by the P-2006_1.000 and P-2006_2.000 redundancy control modules: active, standby or inactive. The description of each mode and their allowed transitions is in **Specific Aspects of Redundancy** in chapter 3, **Operating Principles**.

The change of operating mode occurs automatically due to a failure on the CPU which is in the active mode, described in the same section, or manually by pressing buttons on the control panel.

The current status of each CPU is indicated by light indicators in the control panel, as specified in chapter 5, **Installation**. Using the buttons on this panel, the operator can request a change of status of one of the redundant CPUs.

For a request of change of status, the button should be pressed for at least 0.5 seconds. Only one button should be pressed at a time in a CPU. No action will be performed if more than one button is pressed at the same time.

Possible changes of CPU status are shown in figure 6-1.



a - redundant CPU is not active, due to failure or manual switch to standby mode.

b - Activation of the standby button.

c - Activation of the standby button or CPU was re-energized.

d - Activation of the inactive button.

Figure 6-1 – Change of Status of Redundant CPUs

It is not always possible to perform a change of status that has been requested by the activation of a button, since certain changes depend upon specific conditions. Table 6-1 shows possible changes made with the buttons and the conditions upon which they will be performed.

Current Status	Button activated (new status)	Conditions for change of current status to new status
active	standby	The redundant CPU is in the standby mode, able to assume control of the process.
active	inactive	The change cannot be made directly, the CPU should first be switched to standby and then to inactive mode.
standby	inactive	This change is always possible.
inactive	standby	The AL-2006 module must have been configured correctly.

Table 6-1 – Conditions for Change of Redundant CPU Status by the Operator

There is no button to request the switch to active mode. A CPU switches to active mode when the redundant CPU is changed to standby mode or when a failure occurs. For example, if CPU 2 is required to switch to active mode, it is simply necessary to switch CPU 1 to standby mode, or else a failure may occur in CPU1.

De-energization of the active CPU causes the backup CPU to switch to active mode. However, it is not advisable to de-energize the active CPU directly. To de-energize a CPU, the procedures contained in **De-energizing or Switching CPUs to Programming Mode** in this chapter should be followed.

De-energizing or Switching CPUs to Programming Mode

If it is necessary to de-energize one of the CPUs, the following steps should be followed, in this order:

- if the CPU is in active mode, switch it to standby and then to inactive mode
- if the CPU is in standby mode, switch it to inactive mode
- de-energize the CPU, or switch it to programming mode

A redundant CPU should only be de-energized or switched to programming mode if it is in inactive mode.

In non-redundant systems using only one CPU, this can be de-energized or switched to programming mode from the active mode.

Modifications to the Application Program

Minor alterations to the application program, involving only one of its modules, can be carried out by loading the modified module while the CPU remains in execution mode (online module loading). Details of this procedure can be found in the MasterTool User’s Guide or in the AL-3830 User’s Guide.

Certain types of modification to the application program, however, need the program modules to be loaded with the CPU in programming mode, and can’t be loaded with the CPU in execution mode (on line):

- modification of the number of simple operands or tables in the C module
- modification of any of the parameters of the F-2006.019 module call or of the contents of the redundancy or I/O remote configuration tables

The redundancy control modules P-2006_1.000 and P-2006_2.000 only configure the AL-2006 Brother processors during the switch from programming mode to execution mode, or when the CPU powers up.

- modifications which must be performed simultaneously in one or more program modules

In redundant systems, in order to carry out these modifications with no interruption to the process control, the following procedure should be used:

- switch the CPU from standby to inactive mode, by activating the corresponding button on the redundancy control panel
- switch the same CPU to programming mode, using the corresponding command on the AL-3830 or MasterTool programmer
- load the new program modules with the programmer
- switch the CPU to execution mode with the programmer. It should automatically enter standby mode, after a few seconds in inactive mode, performing initialization
- switch the other CPU (which had been active during the process, controlling the system) to standby , so that the CPU with the new program modules switches to active mode and takes control of the system

During program updating, the CPU whose program is being changed should remain as short as possible in programming mode and in the inactive mode. For this reason it is advisable that the new modules are already modified and ready for loading before starting the process of program switching.

The behavior of the new modules can then be analyzed and tested. If it is desirable to go back to the previous program, just switch the active CPU (with the new modules) to standby and the CPU with the original program will take control of the system once more.

If the new program is correct, the same modification process should be repeated for the other CPU, and both CPUs will have the same program, with the exception of the redundancy control modules P-2006_1.000 and P-2006_2.000.

Swapping I/O Modules on the Local Bus

Non-redundant Systems

In non-redundant systems the swapping of I/O modules on the local bus is achieved in one of two ways:

- de-energizing the CPU, for I/O modules which do not permit hot swapping
- with the CPU energized, for I/O modules which permit hot swapping

The swapping of modules should be performed according to the procedures contained in the AL-2002/MSP User's Guide.

Redundant Systems

For redundant systems, if the module to be switched does not allow hot swapping, then the CPU should be de-energized in accordance with the procedure defined in **De-energizing or Switching CPUs to Programming Mode**, in this chapter. After this, replace the module and re-energize the CPU once again.

If the module allows hot swapping, switching the CPU to standby mode is recommended in order to change the module. After the swap, the CPU can be returned to its active mode or be kept in standby. This way the system will continue to be controlled by the other CPU with the corresponding active I/O module.

Swapping Remote I/O Modules

In remote stations, the I/O modules can be switched in the same way as those on the CPU local bus:

- de-energizing the remote station, for I/O modules which do not permit hot swapping
- with the remote station energized, for I/O modules which permit hot swapping

Modules which do not allow hot swapping should be changed with the following procedure:

- de-energize the remote station
- disconnect the module from field wiring
- remove the module from the bus
- configure the jumpers (if applicable) of the new module to the address used by the old module
- insert the new module into the bus
- reconnect the new module to field wiring
- re-energize the remote station

On de-energizing a remote station to change a module which is not hot-swappable, the active CPU will keep frozen the values of the input operands (E) and the memory operands (M) last read from that station, until it is re-energized.

The remote station should only remain de-energized for the time necessary to change the module, which should be as short as possible.

WARNING:
The remote station should not be re-energized without the new module having been inserted into the same bus position. The new module must have been configured for the same address as the original, if there are jumpers.

Remote I/O Communications Network

The TX and RX REMOT I/O LEDs on the AL-2006 Brother processor front panel should flash rapidly, during normal operation.

The communications status can be checked in greater detail using the MasterTool or AL-3830 programmers, making sure that the remote I/O network has been installed and is operating correctly. For this, do as follows:

- Connect the programming terminal communications cable to the ALNET I connector on the AL-2006 Brother processor
- Check the ALNET II communication status in the corresponding window of the AL-3830 or MasterToll programmers.
- Reset error and communications counters.

- Wait 5 minutes.
- Check the communications status once again.

If errors have occurred during this period, refer to the ALNET II User's Guide for diagnostics and correction procedures.

In correctly specified and installed systems with low noise levels, the error level should remain at 0 for long periods of time.

It is recommended that this test be carried out periodically for all AL-2006 Brother processors and remote stations, to ensure the proper installation of the ALNET II network.

Procedures in Case of Failure

This section introduces the most common errors that may happen during the use of the AL-2006 Brother processor, and includes explanations for their probable causes and the procedures to be carried out for correcting them. In addition, it informs the basic error location procedures to be executed on devices with processors.

The procedures for correcting errors specific to the CPUs, to the I/O modules, the power supplies and to the ALNET II network components can be found in the User's Guides or the Technical Specifications of the equipment concerned.

The errors have been grouped into two categories:

- configuration errors – those which occur during system debugging and prevent the AL-2006 Brother from operating;
- execution errors – those which occur after the AL-2006 Brother has been correctly configured, during its operation.

Despite being considered an execution error, the de-energization of the active CPU by the backup CPU is described in a separate section due to the extensive description of the procedures to be followed upon its occurrence.

Basic Tests in the Event of Errors

If errors occur or there is a suspicion of malfunction in CPUs, remote stations or bridges, the following basic procedure should be applied:

- Check the status of the LEDs on the front panel, the LEDs WD and ER should be OFF and the EX LED should be ON for correct operation.

- Connect the AL-3830 or MasterTool programmer and check the general status window for the PC: the device should be in execution mode, with no error messages.
- Using the programmer, check the status of ALNET II communications: verify the node addresses, sub-net and data rate. Check whether communication is being processed, and whether the receive and transmit counters are continually incrementing. Observe any communication errors. Check the network installation, the condition of cables, connectors and ground connections.
- Check whether cable connections, connections between system components, fastening screws, supply voltage and ground cables are all in good conditions.

If an error is detected, attempt to solve it according to the instructions found in the User's Guide or Technical Specifications of the system component on which a problem has been found.

Configuration Errors

The errors described next are reported during the AL-2006 Brother configuration process.

- Error: error code 101 in one of the memory addresses programmed for F-2006 status indication.

  Description: remote I/O or redundancy network data rate configuration error.

  Procedure: locate the remote I/O (or redundant CPU) indicated by the error, depending on the address of the M operand where the error code is stored. Check that the correct data rate value is programmed into the correct position of the table used in the F-2006.019 module configuration. Check that all data rate configurations within this table are correct.

- Error: error code 102 in one of the memory addresses programmed for F-2006 status indication.

  Description: remote I/O or redundancy network node address configuration error.

  Procedure: locate the remote I/O (or redundant CPU) indicated by the error, depending on the address of the M operand where the error code is stored. Check that the correct node address value is programmed into the correct position of the table used in the F-2006.019 module configuration. Check that all node address configurations within this table are correct.

- Error: error code 103 in one of the memory addresses programmed for F-2006 status indication.

  Description: remote I/O or redundancy network sub-net address configuration error.

  Procedure: locate the remote I/O (or redundant CPU) indicated by the error, depending on the address of the M operand where the error code is stored. Check that the correct sub-net address value is programmed into the correct position of the table used in the F-2006.019 module configuration. Check that all sub-net address configurations within this table are correct.

- Error: error code 104 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

  Description: S operand address redundancy configuration error.

  Procedure: check the value that has been programmed for the first redundant S operand in the redundancy configuration table used in the F-2006.019 module. An existing address should be used. Refer to the output module declarations at the programmable controller bus.

- Error: error code 105 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

  Description: configuration error in the number of redundant S operands.

  Procedure: check the value that has been programmed for the number of redundant S operands in the redundancy configuration table used in the F-2006.019 module. Check that the last redundant S operand (first operand plus number of operands) is defined in the programmable controller. Refer to the output module declarations at the programmable controller bus.

- Error: error code 106 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

  Description: A operand address redundancy configuration error.

Procedure: check the value that has been programmed for the first redundant A operand in the redundancy configuration table used in the F-2006.019 module. An existing controller address should be used.

- Error: error code 107 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

  Description: configuration error in the number of A operands.

  Procedure: check the value that has been programmed for the number of redundant A operands in the redundancy configuration table used in the F-2006.019 module. Check that the last redundant A operand (first operand plus number of operands) is defined in the programmable controller.

- Error: error code 108 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

  Description: M operand address redundancy configuration error.

  Procedure: check the value that has been programmed for the first redundant M operand in the redundancy configuration table used in the F-2006.019 module. An existing controller address should be used. Refer to the declaration of operands in the C module.

- Error: error code 109 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

  Description: configuration error in the number of M operands.

  Procedure: check the value that has been programmed for the number of redundant M operands in the redundancy configuration table used in the F-2006.019 module. Check that the last redundant M operand (first operand plus number of operands) is defined in the programmable controller. Refer to the declaration of operands in the C module.

- Error: error code 110 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

  Description: D operand address redundancy configuration error.

  Procedure: check the value that has been programmed for the first redundant D operand in the redundancy configuration table used in the F-2006.019 module. An existing controller address should be used. Refer to the declaration of operands in the C module.

- Error: error code 111 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

  Description: configuration error in the number of D operands.

  Procedure: check the value that has been programmed for the number of redundant D operands in the redundancy configuration table used in the F-2006.019 module. Check that the last redundant D operand (first operand plus number of operands) is defined in the programmable controller. Refer to the declaration of operands in the C module.

- Error: error code 112 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

  Description: TM operand address redundancy configuration error.

  Procedure: check the value that has been programmed for the first redundant TM operand in the redundancy configuration table used in the F-2006.019 module. An existing controller address should be used. Refer to the declaration of operands in the C module.

- Error: error code 113 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

  Description: configuration error in the number of redundant TM operands.

  Procedure: check the value that has been programmed for the number of redundant TM positions in the redundancy configuration table used in the F-2006.019 module. Check that the last redundant TM position (first TM operand plus number of positions) is defined in the programmable controller. Refer to the declaration of operands in the C module.

- Error: error code 114 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

  Description: TD operand address redundancy configuration error.

  Procedure: check the value that has been programmed for the first redundant TD operand in the redundancy configuration table used in the F-2006.019 module. An existing controller address should be used. Refer to the declaration of operands in the C module.

- Error: error code 115 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

Description: configuration error in the number of TD operand positions.

Procedure: check the value that has been programmed for the number of redundant TD positions in the redundancy configuration table used in the F-2006.019 module. Check that the last redundant TD position (first TD operand plus number of positions) is defined in the programmable controller. Refer to the declaration of operands in the C module.

- Error: error code 116 in one of the F-2006 memory addresses programmed for redundant CPU status indication.

  Description: configuration error - total number of operand bytes exceeded.

  Procedure: calculate the total number of bytes defined for redundancy operands and check against the limit allowed. If this limit has been exceeded, reduce the number of declared redundancy operands.

- Error: error code 117 in one of the memory addresses programmed for F-2006 status indication.

  Description: configuration error - maximum number of remote stations exceeded.

  Procedure: check that the redundancy configuration table used in the F-2006.019 module contains the correct number of positions.

- Error: error code 118 in one of the memory addresses programmed for F-2006 status indication.

  Description: address configuration error in the first M operand used as input area by the remote station.

  Procedure: locate the remote I/O indicated by the error, depending on the address of the M operand where the error code is stored. Check that the correct remote station value is programmed for the first M operand of the remote station input area. This operand should be declared in the programmable controller. Refer to the declaration of operands in the C module.

- Error: error code 119 in one of the memory addresses programmed for F-2006 status indication.

Description: there are not enough M operands for the input or output areas of the remote station.

Procedure: increase the number of M operands declared at CPUs 1 and 2. It is also possible to reduce the number of operands used by the input and output areas of the remote station affected by changing the values in the remote I/O configuration table used by the F-2006.019 module.

Execution Errors

The errors described next are reported while the AL-2006 Brother processor is in either active or standby mode.

- Error: error code 8 in one of the memory addresses programmed for F-2006 status indication. F-2006.

  Description: communications time-out error.

  Procedure: locate the remote I/O (or redundant CPU) indicated by the error, depending on the address of the M operand where the error code is stored. Perform the procedures in **Basic Tests in the Event of Errors**, earlier in this section. Attempt to locate possible sources of electromagnetic noise, isolating them from the communications network.

- Error: error code 9 in one of the memory addresses programmed for F-2006 status indication.

  Description: no reply from the station to which communication was transmitted.

  Procedure: locate the remote I/O (or redundant CPU) indicated by the error, depending on the address of the M operand where the error code is stored. Perform the procedures in **Basic Tests in the Event of Errors**, earlier in this section. Attempt to locate possible sources of electromagnetic noise, insulating them from the communications network.

- Error: error code 100 in one of the memory addresses programmed for F-2006 status indication.

  Description: communications error with AL-2006 Brother processor.

  Procedure: Perform the procedures in **Basic Tests in the Event of Errors**, earlier in this section, for the AL-2002/MSP CPU and the AL-2006 Brother processor.

- Error: error code 120 in one of the memory addresses programmed for F-2006 status indication.

  Description: inactive communications error.

  Procedure: locate the remote I/O (or redundant CPU) indicated by the error, depending on the address of the M operand where the error code is stored. Perform the procedures in **Basic Tests in the Event of Errors**, earlier in this section. If the system has more than one sub-net or optical fibers, perform the basic tests for the bridges and check that optical fibers and the fiber-optic modems are in good repair.

- Error: error code 121 in one of the memory addresses programmed for F-2006 status indication.

  Description: attempt to use the AL-2006 Brother without configuring it.

  Procedure: perform the AL-2006 Brother configuration procedure, making sure that it is completed without errors

- Error: error code 122 in one of the memory addresses programmed for F-2006 status indication.

  Description: multiple reception of redundancy operands.

  Procedure: check the configuration of the two CPUs, reconfigure both CPUs making sure that configuration is completed without errors.

- Error: error code 123 in one of the memory addresses programmed for F-2006 status indication.

  Description: reception of redundancy communication in active mode.

  Procedure: check the application programs and the configuration parameters of the two CPUs, making sure that configuration is completed without errors. Check the connections and proper operation of the redundancy data exchange channel connections.

- Error: the diagnostic operand for communication of status between CPUs (A0003.4) has value 1.

  Description: this CPU is not receiving redundancy status communications from the redundant CPU.

Procedure: check that the redundant CPU is energized and in either active, standby or inactive mode. If so, check that the AL-1366 cable which connects the AL-2006 Brother processors is in good condition and correctly connected. Monitor the operands M0008 and M0009 (or their equivalents after modification of modules P-2006_1.000 and P-2006_2.000) for both CPUs. The operand M0008 should contain the status of the CPU being monitored and the M0009 the status of the remote CPU. If none of the previous tests reveals an error, replace the cable with another identical one. If the error continues, substitute the AL-2006 Brother in the backup CPU. If it still continues, switch the active CPU to standby and replace its AL-2006 Brother processor.

- Error: the diagnostic operands for the optical connections have value 1 (M0012, M0013, M0018, M0019 in the original P-2006_1.000 and P-2006_2.000 modules).

  Description: failure detected in one of the optical fibers.

  Procedure: locate the optical fiber which is causing the problem, depending on the address of the M operand where the error code is stored. Check its general condition, its connections and the fiber-optic modems to which it is connected. Follow the recommendations contained in the FOCOS User's Guide, the AL-2401 (QK2401) User's Guide, and the ALNET II User's Guide.

- Error: one of the remote station I/O octet status operands has value 1.

  Description: one of the modules of the remote station is de-energized for replacement, or the corresponding bus has a fault.

  Procedure: each bit of these operands corresponds to the status of an octet at a remote station. Locate the C module which corresponds to the octet and check whether it is in hot-swapping mode, switching it back to normal operation if necessary. If all the bits for all octets on the bus are energized, check whether the bus is in hot-swapping mode, checking its power supply, if applicable. Perform the procedures in **Basic Tests in the Event of Errors**, earlier in this section on the remote station, noting any errors reported for the bus.

Active CPU Failure

If the CPU which is in standby mode detects a failure in the active CPU, the backup CPU switches to active mode, taking control of the process. Simultaneously, it de-energizes the CPU in which the failure has been detected, guaranteeing that the error will not interfere with the control process.

After the failure, one of the CPUs remains in the active mode, controlling the process, and the other is de-energized. The procedures described below should be performed in order to locate the failure on the CPU which has been de-energized, and this CPU must be switched back to standby mode.

The repair of the failure in the de-energized CPU should be performed as quickly as possible, so that the system can return to its redundant status with one CPU in active and the other one in standby mode. While there is no CPU in standby, the system will be operating non-redundantly, i.e., if a failure occurs in the active CPU there would be no standby to take over.

In redundant systems, the security of the system is fundamentally based on the existence of spare components in stock, for the rapid replacement of defective system elements.

Procedures to be performed on the de-energized CPU:

- Remove the cables plugged into the ALNET II connectors on the AL-2002 processors and the REMOTE I/O on the AL-2006 Brother. From the AL-2006 Brother processor, also remove the cable plugged into the REDUND connector. These cables should remain disconnected throughout this procedure, until an item explicitly requests its reconnection.
- Check that the power cables and grounding leads are in good conditions. Check the fuses in the power supply. If they are burnt out replace them with fuses of the correct value.
- Loosen the fixing screws and disconnect all of the modules on the CPU bus.
- Re-energize the CPU, pressing the “re-energize” button of the another CPU on the redundancy control panel.
- Check that the input voltages for the power supply are within the limits specified in its Technical Specifications.
- Check that the LEDs on the power supply indicate the existence of all voltages and absence of failures. If any of the voltage LEDs is not energized, but the input voltages are correct, replace the power supply.
- De-energize the power supply, reconnect the module at the rightmost position of the bus and re-energize the power supply. Repeat this procedure for each module on the bus, from right to left, finishing with the AL-2002 processor, checking that the power supply voltage LEDs remain energized.

As each module is inserted, check that it snaps into place correctly and check the fixing screws and connectors. If the insertion of one of the modules causes one of the power supply voltages to fail, replace it with a spare.

If a module with an application program is replaced, the program must be loaded to the new module, according to the instructions contained in its User's Guide. The module which has been removed should be sent to Altus Support.

- Once all the modules have been inserted, check the WD LEDs of the system modules. If any of the LEDs are lit, replace the corresponding module.
- Connect the AL-3830 or MasterTool programmer to the AL-2002 and check the general status window of the programmable controller: the device should be in execution mode, with no error messages displayed. If there is an error, try to solve the problem following the error description and instructions contained in the AL-2002/MSP User's Guide.
- On the programmer, refer to the module directory window and check the integrity of the CPU application program, verifying the presence of all program modules and their sizes. If any of the modules are missing, load it and transfer it to Flash EPROM memory.
- Check the status of the LEDs of the AL-2006 Brother: the WD, ER and PR LEDs should be de-energized and the EX LED should be permanently energized. If this is not the case, replace the module. The FC LED should be flashing, denoting that there is communication with the AL-2002. If it is not flashing, perform the tests contained in **General Programming Precautions** in chapter 4, **Programming** on the AL-2002 application program.
- Check the status of the remaining modules on the bus. On modules with ER or ERR LEDs, these should be de-energized. In modules with processors, check that they are communicating with the AL-2002, flashing the relevant LEDs. If there is a fault, check that the correct application program, if there is one, is loaded onto the module.
- The ACTIVE LEDs of the I/O modules should be flashing. If they are not, check that they have been declared in the CPU application program C module and that the hot-swap switch is not in standby. If they are active, check the input module readings, monitoring E operand values, and activating output points, forcing S operand values. Check the condition of connectors, power supplies, fuses and grounding. If any error is detected, replace the module.

> Before forcing values to test output points, these should be disconnected from process components, avoiding accidents.

- After all the previous tests, de-energize the CPU, connect the ALNET II communications cable to the AL-2002 and re-energize the CPU. With the programmer, check the status of ALNET II communications: check the node addresses, sub-net and data rate. Check if there are communications being processed, and that the reception and transmission counters are incrementing continually. Observe any wrong communications. Check the condition of the network installation, the cables, connectors and grounding leads.
- De-energize the CPU, connect the redundancy status communications cable to the REDUND connector of the AL-2006 Brother and re-energize the CPU. The CPU should enter standby mode. Monitoring logic 7 of the P-2006_1.000 or P-2006_2.000 module, the bit of the M operands which appears at the leftmost contact of the logic should have value 1 and that furthest to the right, value 0, indicating that this CPU is correctly reading the status information of the other CPU (active mode). If this is not the case, perform the tests contained in **General Programming Precautions** in chapter 4, **Programming**. If the problem persists, replace the AL-2006 Brother processor.
- De-energize the CPU, plug the communications cable into the REMOTE I/O connector of the AL-2006 Brother processor and re-energize the CPU. The CPU should enter the standby mode. Connect the AL-3830 or MasterTool programmer to the ALNET I channel of the AL-2006 Brother and check the status of ALNET II communications: check the node addresses, sub-net and data rate against those declared in the remote I/O configuration tables. Check if there are communications being processed, and that the reception and transmission counters are incrementing continually. Observe any wrong communications. Check the condition of the remote I/O network installation, the cables, connectors and grounding leads. If the addresses, data rate and network installation are correct and no OK reception is indicated, replace the AL-2006 Brother processor.

Quick Reference Guide

This appendix contains abbreviated information related to the programming and configuration of the systems, for quick access. Detailed explanations are not included in this section, but can be found in the specific sections throughout the user's guide.

Remote I/O Networks

General characteristics of the remote I/O networks (dedicated ALNET II)	
Parameter	Values
Node address	1 to 31
Sub-network address	1 to 63
Maximum number of sub-networks	3 (maximum of 2 bridge processors)
Data rate	1,000, 500, 250, 125, 64

All the elements connected to the same network segment must be configured with the same sub-network address.

All the elements connected to the same network segment must be configured with different node addresses.

In the communications network with remote stations, only the AL-2006 Brother processors of the same redundant PC, its I/O remote stations and any eventual bridge processors can be connected. Gateway processors or ALNET II channels of any other elements cannot be connected. The program modules of the remote stations cannot contain ECR or LTR communications instructions.

Declaration of Redundant Operands for the AL-2006 Brother Processor

Operand Type	Maximum number of configurable redundant operands
E	64
S	64
A	96
M	1,008
D	504
TM	1,008 positions
TD	504 positions

The configuration of the redundancy of numeric operands (M, D, TM and TD) as a whole may not exceed the maximum number of 2,016 bytes. The number of operands represented in the previous table refers to the maximum value possible that can be configured for a determined type when no other type has been declared.

Operand Type	Number of bytes
M	2 bytes per operand
D	4 bytes per operand
TM	2 bytes per position
TD	4 bytes per position

TM of redundancy declaration in F-2006.019		
Position	Values	Contents
0	0	Table type identifier
1	0	Table type identifier
2	1 to 31	Node address of the other AL-2006 on the redundant CPU
3	1 to 63	Sub-network address of the other AL-2006 on the redundant CPU
4	0 to 63	First redundant S operand
5	0 to 64	Number of redundant S operands
6	0 to 95	First redundant A operand
7	0 to 96	Number of redundant A operands
8	0 to 9,999	First redundant M operand
9	0 to 1,008	Number of redundant M operands
10	0 to 9,999	First redundant D operand
11	0 to 504	Number of redundant D operands
12	0 to 255	First redundant TM operand
13	0 to 1,008	Number of redundant positions of TM operands
14	0 to 255	First redundant TD operand
15	0 to 504	Number of redundant positions of TD operands

The redundancy configuration table must have 16 positions. The positions of the table referring to the number of operands or number of positions should contain zero for the operands not used in the redundancy process. Redundancy configuration of the S operands is reserved for future use, providing that positions 4 and 5 contain the value zero.

Declaration of Remote Stations for the AL-2006 Brother Processor

TM declaration of remote I/O stations in F-2006.019 – General definitions		
Position	Values	Contents
0	0	Table type identifier
1	0	Table type identifier
2	1 to 31	Node address of this AL-2006
3	1 to 63	Sub-network address of this AL-2006
4	1,000, 500, 250, 125, 64	Data rate of the AL-2006
5	-	Not used (reserved)

TM declaration of remote I/O stations in F-2006.019 – Optical channel definitions		
Position	Values	Contents
6	1 to 31	Node address of the controller channel of the first optical connection
7	1 to 63	Sub-network address of the first optical connection
8	1 to 31	Node address of the controller channel of the second optical connection
9	1 to 63	Sub-network address of the second optical connection

TM declaration of remote I/O stations in F-2006.019 - Remote 0 definitions		
Position	Values	Contents
10	1 to 31	Remote station node address
11	1 to 63	Remote station sub-network address
12	1,000, 500, 250, 125, 64	Remote station data rate
13	0 to 9,999	First M operand of the area that receives/sends remote station values on the local CPU
14	0 to 64	Number of remote station E operands to be read
15	0 to 64	Number of remote station S operands to be written
16	0 to 108	Number of remote station M operands to be read
17	0 to 112	Number of remote station M operands to be written

TM declaration of remote I/O stations in F-2006.019 - Remote 1 Definitions		
Position	Values	Contents
18	1 to 31	Remote station node address
19	1 to 63	Remote station sub-network address
20	1,000, 500, 250, 125, 64	Remote station data rate
21	0 to 9,999	First M operand of the area that receives/sends remote station values on the local CPU
22	0 to 64	Number of remote station E operands to be read
23	0 to 64	Number of remote station S operands to be written
24	0 to 108	Number of remote station M operands to be read
25	0 to 112	Number of remote station M operands to be written

TM declaration of remote I/O in F-2006.019 – Definition positions of all the remotes	
Positions	Contents
10 to 17	Definitions of remote station 0
18 to 25	Definitions of remote station 1
26 to 33	Definitions of remote station 2
34 to 41	Definitions of remote station 3
42 to 49	Definitions of remote station 4
50 to 57	Definitions of remote station 5
58 to 65	Definitions of remote station 6
66 to 73	Definitions of remote station 7

The number of possible M operands for all the input areas should not exceed 112 in each remote station. Or, the area of input operands in each remote station should not exceed the M0111 operand.

The number of M operands possible for all of the output areas should not exceed 112 in each remote station.

Status Indication Operands for the AL-2006 Brother Processor

Indication of status operands in F-2006.019	
Operands	Contents
MXXXX	Transmits redundancy status to the other CPU
MXXXX + 1	Receives redundancy status from the other CPU
MXXXX + 2	General status of the AL-2006 processor and of the communication with the redundant CPU by the Remote I/O network
MXXXX + 3	Selected connection of the first optical connection (1 or 2)
MXXXX + 4	Status of connection 1 of the first optical connection (0 - normal or 1 - failure)
MXXXX + 5	Status of connection 2 of the first optical connection (0 - normal or 1 - failure)
MXXXX + 6	Forced connection of the first optical connection (0 - not forced, 1 or 2)
MXXXX + 7	Forced status of connection 1 of the first optical connection (0 - normal or 1 - failure)
MXXXX + 8	Forced status of connection 2 of the first optical connection (0 - normal or 1 - failure)
MXXXX + 9	Selected connection of the second optical connection (1 or 2)
MXXXX + 10	Status of connection 1 of the second optical connection (0 - normal or 1 - failure)
MXXXX + 11	Status of connection 2 of the second optical connection (0 - normal or 1 - failure)
MXXXX + 12	Forced connection of the second optical connection (0 - not forced, 1 or 2)
MXXXX + 13	Forced status of connection 1 of the second optical connection

	(0 - normal or 1 - failure)
MXXXX + 14	Forced status of connection 2 of the second optical connection (0 - normal or 1 - failure)
MXXXX + 15	Not used (reserved)
MXXXX + 16	Communications status with remote I/O device 0
MXXXX + 17	Communications status with remote I/O device 1
MXXXX + 18	Communications status with remote I/O device 2
MXXXX + 19	Communications status with remote I/O device 3
MXXXX + 20	Communications status with remote I/O device 4
MXXXX + 21	Communications status with remote I/O device 5
MXXXX + 22	Communications status with remote I/O device 6
MXXXX + 23	Communications status with remote I/O device 7

Configuration of Remote Stations

TM000 – Declaration of remote I/O stations in F-REMOT.069		
Position	Values	Contents
0	0	Table type identifier
1	0	Table type identifier
2	1 to 31	Remote station node address
3	1 to 63	Remote station sub-network address
4	1,000, 500, 250, 125, 64	Remote station data rate
5	0 to 9,999	First M operand of the area that receives/sends remote station values on the local CPU
6	0 to 64	Number of remote station E operands to be read
7	0 to 64	Number of remote station S operands to be written
8	0 to 108	Number of remote station M operands to be read
9	0 to 112	Number of remote station M operands to be written

The parameter values of the table used in F-REMOT.069 (remote program module) should be identical to the table used in the F-2006.019 function of the CPU program module, in the part referring to the associated remote station.

Operands for debouncing definition			
Operands	Debouncing definition	Operands	Debouncing definition
MXXXX	E001, E000	MXXXX + 16	E033, E032
MXXXX + 1	E003, E002	MXXXX + 17	E035, E034
MXXXX + 2	E005, E004	MXXXX + 18	E037, E036
MXXXX + 3	E007, E006	MXXXX + 19	E039, E038
MXXXX + 4	E009, E008	MXXXX + 20	E041, E040
MXXXX + 5	E011, E010	MXXXX + 21	E043, E042
MXXXX + 6	E013, E012	MXXXX + 22	E045, E044
MXXXX + 7	E015, E014	MXXXX + 23	E047, E046
MXXXX + 8	E017, E016	MXXXX + 24	E049, E048
MXXXX + 9	E019, E018	MXXXX + 25	E051, E050
MXXXX + 10	E021, E020	MXXXX + 26	E053, E052
MXXXX + 11	E023, E022	MXXXX + 27	E055, E054
MXXXX + 12	E025, E024	MXXXX + 28	E057, E056
MXXXX + 13	E027, E026	MXXXX + 29	E059, E058
MXXXX + 14	E029, E028	MXXXX + 30	E061, E060
MXXXX + 15	E031, E030	MXXXX + 31	E063, E062

Glossary

This appendix presents a glossary of terms and abbreviations used in this guide.

- **Active CPU.** In a redundant system, it is the CPU that controls the system, by reading the values of the input points, executing the application program, and updating the output points.
- **Backup CPU.** In a redundant system, it is the CPU that supervises the active CPU. It is not controlling the system, but is ready to take control of the system in case of active CPU failure.
- **Bit.** Basic unit of information, can be either 0 or 1.
- **Bridge.** Equipment that connects two communications networks with similar protocols. The AL-2401 or QK2401 bridges connect two ALNET II sub-networks.
- **Bus.** A collection of logically grouped electrical signals that transfer information and controls between different elements in a subsystem.
- **Byte.** Unit of information composed of eight bits.
- **CPU.** Central processing unit. Element that controls the flow of information, interprets and executes instructions of a program module.
- **EPROM.** Nonvolatile memory erasable by ultraviolet rays.
- **Executive software.** It controls the basic functions of the programmable controller and the execution of program modules in a PC.
- **Flash EPROM.** Electronically erasable nonvolatile memory.

- **Gateway.** Equipment that connects two communication networks with different protocols. The AL-2400/S-C or QK2400 gateways allow the connection of the ALNET I network with the ALNET II network.
- **Hardware.** Pieces of equipment used in data processing, where programs (software) are normally executed.
- **Hot swap.** Procedure of module replacement of a system without having to turn off the system. Normally used in I/O module swaps.
- **Inactive CPU.** CPU that is not active (controlling the system) nor standby (backup, supervising the active CPU), and is unable to take control of the system.
- **Instruction.** Element that defines an operation to be executed over a group of operands within a program.
- **Interface.** Device that electrically or logically adapts the signal transfer between two pieces of equipment.
- **Jumper.** Selection key of configuration addresses, composed of pins on the circuit board and a small removable connector, used for selection.
- **LED (Light Emitting Diode).** Type of semiconductor diode that emits light when stimulated by electricity. Used as a light indicator.
- **Operands.** Elements over which the instructions act. They can represent constants, variables or groups of variables.
- **P-2006_1.000.** Module programmed in a relay diagram language (ladder) which controls the redundancy and communication with remote stations on CPU 1.
- **P-2006_2.000.** Module programmed in a relay diagram language that controls the redundancy and communication with remote stations on CPU 2.
- **PC.** Abbreviation of Programmable Controller.
- **Program.** Group of properly ordered instructions that instruct a specific machine to operate over data in order to obtain a result.
- **Programmable Controller.** Digital electronic equipment with hardware and software that is compatible with industrial applications.

- **Programming.** The act of preparing a program in all of its steps for a computer or similar piece of equipment.
- **Programming Language.** A group of rules, conventions and syntax used to create a program. A group of symbols used to represent and communicate information or data between people and machines.
- **RAM.** Memory where all the addresses can be randomly and directly read or written. It is volatile, and needs a battery in order to avoid data loss when power is turned off.
- **Redundant CPU.** Corresponds to the other CPU of the system in relation to the one the text of the user's guide is referring to. For example, the redundant CPU of CPU 2 is CPU 1, and vice versa.
- **Redundant System.** System that contains backup or duplicated elements for the execution of certain tasks, which can tolerate determined types of failure without affecting the execution of the task.
- **Remote Station.** Pieces of equipment that allows the reading and writing of input and output points of the controlled process, communicating their values with the active CPU.
- **Serial Channel.** Device that allows the connection and communication of data between two or more pieces of equipment using a common standard.
- **Software.** Computer programs, procedures and rules related to the operation of a data processing system.
- **Scan cycle.** A complete execution of an operating system and of the application program of a PC.
- **Commissioning test.** Final debugging procedure of the control system, when the programs of all the remote stations and CPUs are executed together, after having been developed and verified individually.
- **Watchdog.** Electronic circuit used for verifying the integrity of the operation of a piece of equipment.

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