MITSUBISHI ELECTRIC
FACTORY AUTOMATION

FX Family

Programmable Logic Controllers

Training Manual

GX IEC Developer

About this Manual

The texts, illustrations and examples in this manual only explain the installation, operation and use of the *GX IEC Developer* programming package.

.

If you have questions about the programming and operation of the programmable logic controllers mentioned in this manual please contact your dealer or one of our distributors (see back cover). Up-to-date information and answers to frequently-asked questions can be found on the Mitsubishi website at www.mitsubishi-automation.com.

MITSUBISHI ELECTRIC EUROPE B.V. reserves the right to make changes to this manual or the technical specifications of its products at any time without notice.

Training Manual
GX IEC Developer Programming Software Package
Art.-no.:

Version	Changes / Additions / Corrections
A 06/2007 pdp	First edition

Safety Information

For qualified staff only

This manual is only intended for use by properly trained and qualified electrical technicians who are fully acquainted with automation technology safety standards. All work with the hardware described, including system design, installation, setup, maintenance, service and testing, may only be performed by trained electrical technicians with approved qualifications who are fully acquainted with the applicable automation technology safety standards and regulations.

Proper use of equipment

The programmable logic controllers are only intended for the specific applications explicitly described in this manual. Please take care to observe all the installation and operating parameters specified in the manual. All products are designed, manufactured, tested and documentated in agreement with the safety regulations. Any modification of the hardware or software or disregarding of the safety warnings given in this manual or printed on the product can cause injury to persons or damage to equipment or other property. Only accessories and peripherals specifically approved by MITSUBISHI ELECTRIC may be used. Any other use or application of the products is deemed to be improper.

Relevant safety regulations

All safety and accident prevention regulations relevant to your specific application must be observed in the system design, installation, setup, maintenance, servicing and testing of these products. The regulations listed below are particularly important. This list does not claim to be complete; however, you are responsible for knowing and applying the regulations applicable to you.

- VDE Standards
  - VDE 0100
    (Regulations for electrical installations with rated voltages up to 1,000V)
  - VDE 0105
    (Operation of electrical installations)
  - VDE 0113
    (Electrical systems with electronic equipment)
  - VDE 0160
    (Configuration of electrical systems and electrical equipment)
  - VDE 0550/0551
    (Regulations for transformers)
  - VDE 0700
    (Safety of electrical appliances for household use and similar applications)
  - VDE 0860
    (Safety regulations for mains-powered electronic appliances and their accessories for household use and similar applications)
- Fire prevention regulations
- Accident prevention regulations
  - VBG No. 4 (Electrical systems and equipment)

Safety warnings in this manual

In this manual special warnings that are important for the proper and safe use of the products are clearly identified as follows:

DANGER:
Personnel health and injury warnings. Failure to observe the precautions described here can result in serious health and injury hazards.

CAUTION:
Equipment and property damage warnings. Failure to observe the precautions described here can result in serious damage to the equipment or other property.

General safety information and precautions

The following safety precautions are intended as a general guideline for using the PLC together with other equipment. These precautions must always be observed in the design, installation and operation of all control systems.

CAUTION:

- ***Observe all safety and accident prevention regulations applicable to your specific application. Installation, wiring and opening of the assemblies, components and devices may only be performed with all power supplies disconnected.***
- ***Assemblies, components and devices must always be installed in a shockproof housing fitted with a proper cover and protective equipment.***
- ***Devices with a permanent connection to the mains power supply must be integrated in the building installations with an all-pole disconnection switch and a suitable fuse.***
- ***Check power cables and lines connected to the equipment regularly for breaks and insulation damage. If cable damage is found, immediately disconnect the equipment and the cables from the power supply and replace the defective cabling.***
- ***Before using the equipment for the first time check that the power supply rating matches that of the local mains power.***
- ***Residual current protective devices pursuant to DIN VDE Standard 0641 Parts 1-3 are not adequate on their own as protection against indirect contact for installations with positioning drive systems. Additional and/or other protection facilities are essential for such installations.***
- ***EMERGENCY OFF facilities pursuant to EN 60204/IEC 204 VDE 0113 must remain fully operative at all times and in all control system operating modes. The EMERGENCY OFF facility reset function must be designed so that it cannot cause an uncontrolled or undefined restart.***
- ***You must also implement hardware and software safety precautions to prevent the possibility of undefined control system states caused by signal line cable or core breaks.***
- ***All relevant electrical and physical specifications must be strictly observed and maintained for all the modules in the installation.***

Table of Contents

1 Course Overview and Requirements

1.1 Modular PLC Training Hardware 1-1

2 The Hardware

2.1 General Introduction to PLCs 2-1
2.1.1 History & Development 2-1
2.1.2 The initial specification for the PLC 2-1
2.1.3 Comparison of PLC and Relay Systems 2-1
2.1.4 Programming 2-2
2.1.5 Human Machine Interfaces 2-2
2.2 What is a PLC? 2-3
2.3 How PLCs Process Programs 2-4
2.4 The MELSEC FX Family 2-6
2.5 Selecting the Right Controller 2-7
2.6 Controller Design 2-8
2.6.1 Input and output circuits 2-8
2.6.2 Layout of the MELSEC FX1S base units 2-8
2.6.3 Layout of the MELSEC FX1N base units 2-9
2.6.4 Layout of the MELSEC FX2N base units 2-9
2.6.5 Layout of the MELSEC FX2NC base units 2-10
2.6.6 Layout of the MELSEC FX3U base units 2-10
2.7 Wiring 2-11
2.7.1 Power Supply 2-11
2.7.2 Wiring of Inputs 2-12
2.7.3 Wiring of Outputs 2-13
2.8 Extending the Range of Digital Inputs/Outputs 2-15
2.8.1 Extension Boards 2-15
2.8.2 Compact Extension Units 2-15
2.8.3 Modular Extension Blocks 2-16
2.9 Extending for Special Functions 2-17
2.9.1 Analog Modules 2-18
2.9.2 High-Speed Counter Module and Adapters 2-20
2.9.3 Positioning Modules 2-21
2.9.4 Network Modules for ETHERNET 2-22
2.9.5 Network Modules for Profibus/DP 2-23
2.9.6 Network Modules for CC-Link 2-25
2.9.7 Network Module for DeviceNet 2-26

2.9.8 Network Module for CANopen 2-26
2.9.9 Network Module for AS-Interface 2-27
2.9.10 Interface Modules and Adapters 2-28
2.9.11 Communication Adapters 2-29
2.9.12 Setpoint Adapter Boards 2-30
2.10 System Configuration 2-31
2.10.1 Connection of Special Adapters (FX3U only) 2-32
2.10.2 Basic Rules for System Configuration 2-34
2.10.3 Quick Reference Matrixes 2-35
2.11 I/O Assignment 2-37
2.11.1 Concept of assigning 2-37
2.11.2 Special function module address 2-38

3 Programming

3.1 Concepts of the IEC61131-3 Standard 3-1
3.2 Software Structure and Definition of Terms 3-2
3.2.1 Definition of Terms in IEC61131-3 3-2
3.2.2 System Variables 3-9
3.2.3 System Labels 3-10
3.3 Programming Languages 3-11
3.3.1 Text Editors 3-11
3.3.2 Graphic Editors 3-12
3.4 Data Types 3-15
3.4.1 Simple Types 3-15
3.4.2 Complex Data Types 3-16
3.4.3 MELSEC Timers and Counters 3-20

4 Building a Project

4.1 Starting GX IEC Developer 4-2
4.2 Application Program 4-4
4.2.1 Example: Carousel Indexer 4-4
4.2.2 Creating a New Project 4-6
4.2.3 Creating a new “POU” 4-8
4.2.4 Assigning the Global Variables 4-9
4.2.5 Programming the POU Body 4-14
4.2.6 Creating a new Task 4-29
4.2.7 Program Documentation 4-33
4.2.8 Checking and Building the Project Code 4-34
4.2.9 Illustration: Guided Ladder Entry Mode 4-36

4.3 Project Download Procedures 4-37
4.3.1 Connection with Peripheral Devices 4-37
4.3.2 Communications Port Setup 4-37
4.3.3 Downloading the project 4-41
4.4 Monitoring the Project 4-43
4.4.1 Split / Multi Window Monitoring 4-44
4.4.2 Adjusting Monitor Visibility 4-46
4.5 Cross Reference List 4-47
4.6 PLC Diagnostics 4-50
4.7 Project Documentation 4-51

5 Program Example

5.1 QUIZMASTER 5-1
5.1.1 Method. 5-2
5.1.2 Quizmaster - Principle of Operation 5-5
5.1.3 Quizmaster Program Description 5-5

6 Functions and Function Blocks

6.1 Functions 6-1
6.1.1 Example: Creating a Function 6-1
6.1.2 Processing Real (Floating Point) Numbers 6-10
6.2 Creating a Function Block 6-14
6.3 Execution options of Function Blocks 6-21
6.3.1 Macrocode execution 6-21
6.3.2 Enable / EnableOutput (EN/ENO) 6-22

7 Advanced Monitoring Functions

7.1 Entry Data Monitoring 7-1
7.1.1 Customising the EDM 7-2
7.1.2 Monitor Limitations 7-4
7.1.3 Toggling Boolean Variables 7-5
7.2 Monitoring Headers 7-6
7.3 Monitor Mode Essentials 7-7
7.4 Monitoring Mitsubishi “Transfer Form” Objects 7-9
7.5 Modifying Variable Values from the POU Body 7-10
7.6 Monitoring “Instances” of Function Blocks. 7-11

8 Forcing Inputs and Outputs

9 Device Edit

10 Online Mode

10.1 Online Change Mode. 10-1
10.2 Online Program Change 10-3

11 Data Unit Types (DUT)

11.1 Example use of a DUT 11-2
11.2 Automatic Filling, Variables 11-5
11.3 Assigning DUT Variables to Function Blocks 11-8

12 Arrays

12.1 Overview 12-1
12.2 Array Example: Single Dimension Array 12-2

13 Working with Libraries

13.1 User Defined Libraries. 13-1
13.1.1 Example – Creating a new Library 13-1
13.1.2 Opening the Library. 13-3
13.1.3 Moving a POU “Function Block” to an open Library 13-4
13.2 Special Note about Libraries 13-7
13.3 Importing Libraries into Projects 13-8
13.3.1 Example: Importing a Mitsubishi Library Function Block 13-11
13.3.2 Library Function Block Help: 13-14

14 Security

14.1 Password 14-1
14.1.1 Setting the Password. 14-1
14.1.2 Changing the Security Level 14-2
14.1.3 Modifying POU Password Access. 14-3

15 Sequential Function Chart - SFC

15.1 What is SFC? 15-1
15.2 SFC Elements 15-2
15.2.1 SFC Transitions 15-2
15.2.2 Initial Step 15-2
15.2.3 Termination Step 15-2
15.3 SFC configuration examples 15-4
15.4 SFC Actions 15-5
15.5 Complex Transitions 15-7

16 IEC Instruction List

16.1 Example of IEC Instruction List (IL) 16-1
16.1.1 Some useful tips 16-1
16.2 Mixing IEC IL and Melsec IL in POUs 16-2

17 IEC Structured Text

17.1 Structured Text Operators 17-1
17.2 Structured Text Program Example 17-2

18 PROFIBUS/DP Communication

18.1 Configuring the PROFIBUS/DP Network 18-1

19 Ethernet Communications

19.1 Configuring a FX3U Eternet Module by Parameter 19-1
19.1.1 Configuring the PLC (using initial set up PC) 19-2
19.2 Configuring the PC on the Ethernet 19-8
19.3 Configuring GX Developer to access the PLC on Ethernet 19-9
19.4 Setting up the HMI 19-13
19.5 Communication via MX Component 19-16

A Appendix

A.1 Special Relays A-1
A.1.1 PLC Status Diagnostic Information (M8000 to M8009) A-1
A.1.2 Clock Devices and Real Time Clock (M8011 to M8019) A-2
A.1.3 PLC Operation Mode (M8030 to M8039) A-2
A.1.4 Error Detection (M8060 to M8069) A-3

A.1.5 Extension Boards (Dedicated to FX1S and FX1N) A-3
A.1.6 Analog Special Adapter for FX3U (M8260 to M8299) A-3
A.2 Special Registers A-4
A.2.1 PLC Status Diagnostic Information (D8000 to D8009) A-4
A.2.2 Scan Information and Real Time Clock (D8010 to D8019) A-5
A.2.3 PLC Operation Mode (D8030 to D8039) A-5
A.2.4 Error Codes (D8060 to D8069) A-6
A.2.5 Extension Boards (Dedicated to FX1S and FX1N) A-6
A.2.6 Analog Special Adapter for FX3U (D8260 to D8299) A-6
A.3 Error Code List A-7
A.3.1 Error codes 6101 to 6409 . . . . . A-7
A.3.2 Error codes 6501 to 6510 . . . . . A-8
A.3.3 Error codes 6610 to 6632 . . . . . A-9
A.3.4 Error codes 6701 to 6710 . . . . . A-10
A.4 Number of Occupied Input/Output Points and Current Consumption A-11
A.4.1 Interface Adapter Boards and Communication Adapter Boards A-11
A.4.2 Special Adapters A-12
A.4.3 Extension Blocks A-12
A.4.4 Special Function Modules A-13
A.5 PLC Components Glossary A-14

1 Course Overview and Requirements

This course has been specially produced as an introduction to Mitsubishi's FX family utilising the GX IEC Developer Version 7 software package.

The course content has been selectively produced to provide an introduction into the functionality of the Mitsubishi range of FX PLC's, together with the GX IEC Developer programming system. The second section deals with the PLC hardware configuration and operation, whilst the remainder covers the use of Mitsubishi's IEC61131-3 programming system, which is illustrated using worked examples.

It is assumed that student will have a sound working knowledge of the Microsoft Windows operating environment.

1.1 Modular PLC Training Hardware

There are various models of training rigs for Mitsubishis FX family. Most exercises within this training manual are based around use of the facilities offered in these training systems. The examples used in these course notes assume the following configuration:

- 6 Digital input simulator switches: X0-X5
- Variable clock input (1–100 Hz and 0.1– 10 kHz): X7
- 6 Digital output LED indicators: Y0-Y5
- 1 Special function block FX2N-5A with 4 analog inputs and 1 analog output
- 1 Temperature acquisition special adapter FX3U-4AD-PT-ADP

Thus, adjustments according to other training simulators may be accommodated with appropriate address alterations to the example code provided this training document.

2 The Hardware

2.1 General Introduction to PLCs

2.1.1 History & Development

Bedford Associates, founded by Richard Morley introduced the first Programmable Logic Controller in 1968. This PLC was known as the Modular Digital Controller from which the MODICON Company derived its name.

Programmable Logic Controllers were developed to provide a replacement for large relay based control panels. These systems were inflexible requiring major rewiring or replacement whenever the control sequence was to be changed.

The development of the Microprocessor from the mid 1970's have allowed Programmable Logic Controllers to take on more complex tasks and larger functions as the speed of the processor increased. It is now common for PLC's to provide the heart of the control functions within a system often integrated with SCADA (Supervisory Control And Data Acquisition), HMI (Human Machine Interfaces), Expert Systems and Graphical User Interfaces (GUI). The requirements of the PLC have expanded to providing control, data processing and management functionality.

2.1.2 The initial specification for the PLC

- Easily programmed and reprogrammed in plant to enable its sequence of operations, to be altered.
- Easily maintained and repaired – preferably using 'plug-in' cards or modules.
- Able to withstand the rigorous Environmental, Mechanical and Electrical conditions, found in plant environments.
- Smaller than its relay and "discrete solid state" equivalents.
- Cost effective in comparison with "discrete solid state" and relay based systems.

2.1.3 Comparison of PLC and Relay Systems

Characteristic	PLC	Relay
Price per function	Low	Low - If equivalent relay program uses more than 10 relays
Physical size	Very compact	Bulky
Operating speed	Fast	Slow
Electrical noise immunity	Good	Excellent
Construction	Easy to program	Wiring - time consuming
Advanced instructions	Yes	No
Changing the control sequence	Very simple	Very difficult – requires changes to wiring
Maintenance	Excellent PLC's rarely fail	Poor - relays require constantmaintenance

2.1.4 Programming

Ladder Logic

PLC's had to be maintainable by technicians and electrical personnel. To support this, the programming language of Ladder Logic was developed. Ladder Logic is based on the relay and contact symbols technicians were used to through wiring diagrams of electrical control panels.

The documentation for early PLC Programs was either non existent or very poor, just providing simple addressing or basic comments, making large programs difficult to follow. This has been greatly improved with the development of PLC Programming packages such as Mitsubishi's Windows based, **GX Developer** (covered in detail later in this document).

Until recently there has been no formal programming standard for PLC's. The introduction of the **IEC 61131-3** Standard in 1998 provides a more formal approach to coding. Mitsubishi Electric has developed a programming package, "**GX-IEC Developer**". This enables IEC compliant coding to be adopted.

2.1.5 Human Machine Interfaces

The early programmable logic controllers interfaced with the operator in much the same way as the relay control panel, via push-buttons and switches for control and lamps for indication.

The introduction of the Personal Computer (PC) in the 1980's allowed for the development of a computer based interface to the operator, these where initially via simple Supervisory Control And Data Acquisition (SCADA) systems and more recently via Dedicated Operator Control Panels, known as Human Machine Interfaces (HMI). It is now common place to see PLC's heavily integrated with these products to form user friendly control system solutions.

Mitsubishi offer a very wide range of HMI and SCADA products to suit a variety of operator Interface applications.

It is now commonplace to find HMI's integrated into PLC based control systems, providing the operator interface functionality.

2.2 What is a PLC?

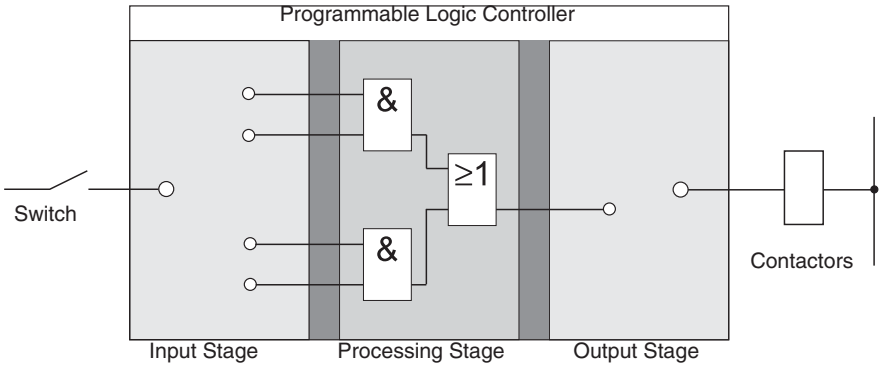
In contrast to conventional controllers with functions determined by their physical wiring the functions of programmable logic controllers or PLCs are defined by a program. PLCs also have to be connected to the outside world with cables, but the contents of their program memory can be changed at any time to adapt their programs to different control tasks.

Programmable logic controllers input data, process it and then output the results. This process is performed in three stages:

- an input stage,
- a processing stage

and

- an output stage



The input stage

The input stage passes control signals from switches, buttons or sensors on to the processing stage.

The signals from these components are generated as part of the control process and are fed to the inputs as logical states. The input stage passes them on to the processing stage in a pre-processed format.

The processing stage

In the processing stage the pre-processed signals from the input stage are processed and combined with the help of logical operations and other functions. The program memory of the processing stage is fully programmable. The processing sequence can be changed at any time by modifying or replacing the stored program.

The output stage

The results of the processing of the input signals by the program are fed to the output stage where they control connected switchable elements such as contactors, signal lamps, solenoid valves and so on.

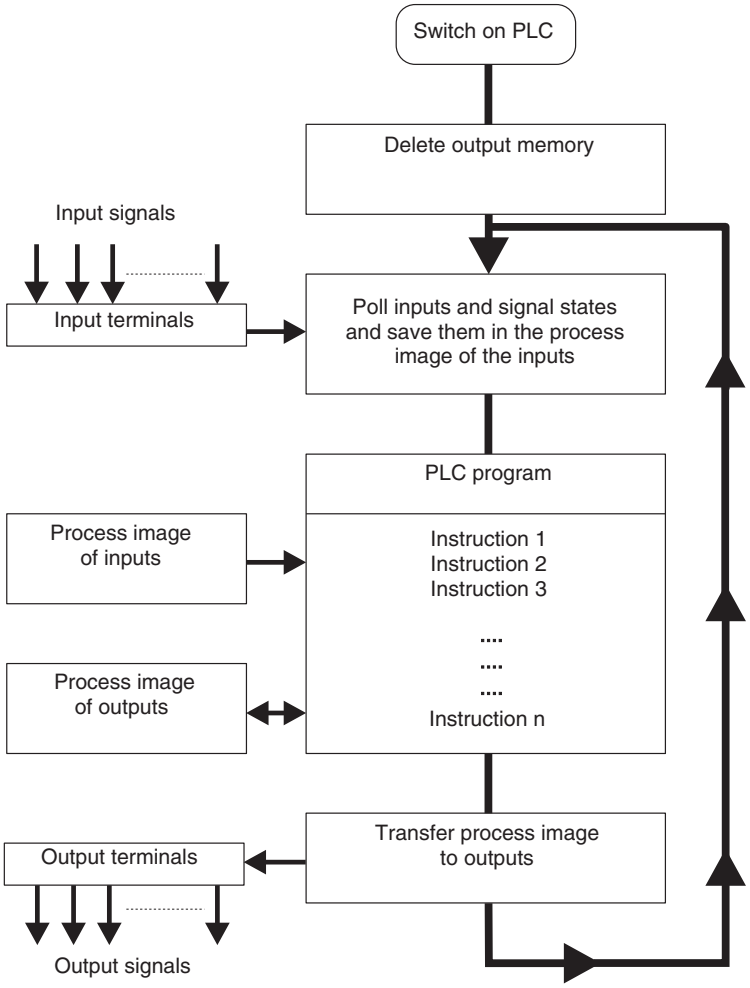
2.3 How PLCs Process Programs

A PLC performs its tasks by executing a program that is usually developed outside the controller and then transferred to the controller's program memory. Before you start programming it is useful to have a basic understanding of how PLCs process these programs.

A PLC program consists of a sequence of instructions that control the functions of the controller. The PLC executes these control instructions sequentially, i.e. one after another. The entire program sequence is cyclical, which means that it is repeated in a continuous loop. The time required for one program repetition is referred to as the program cycle time or period.

Process image processing

The program in the PLC is not executed directly on the inputs and outputs, but on a "process image" of the inputs and outputs:



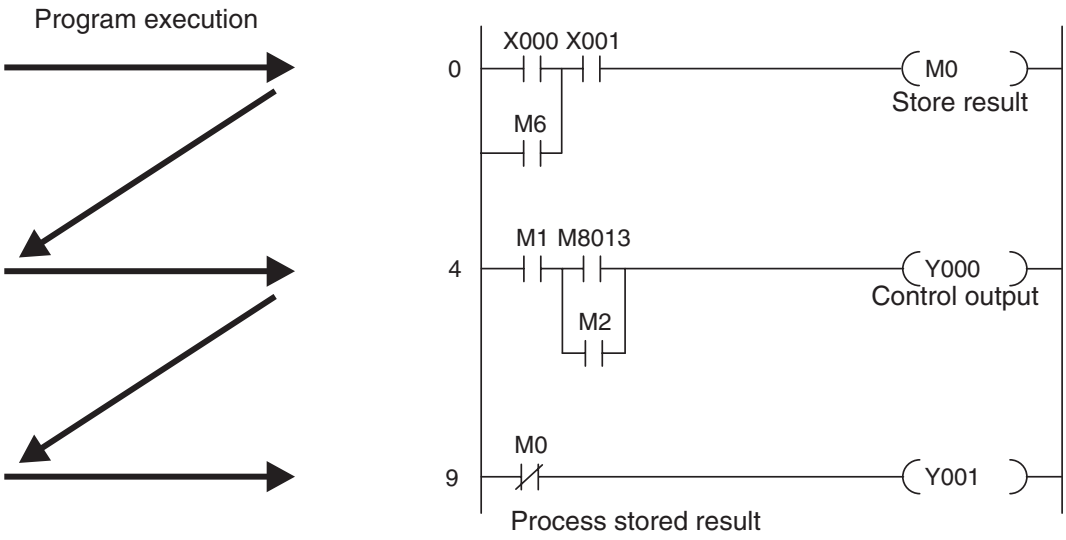
Input process image

At the beginning of each program cycle the system polls the signal states of the inputs and stores them in a buffer, creating a "process image" of the inputs.

Program execution

After this the program is executed, during which the PLC accesses the stored states of the inputs in the process image. This means that any subsequent changes in the input states will not be registered until the **next** program cycle!

The program is executed from top to bottom, in the order in which the instructions were programmed. Results of individual programming steps are stored and can be used during the current program cycle.



Output process image

Results of logical operations that are relevant for the outputs are stored in an output buffer – the output process image. The output process image is stored in the output buffer until the buffer is rewritten. After the values have been written to the outputs the program cycle is repeated.

Differences between signal processing in the PLC and in hard-wired controllers

In hard-wired controllers the program is defined by the functional elements and their connections (the wiring). All control operations are performed simultaneously (parallel execution). Every change in an input signal state causes an instantaneous change in the corresponding output signal state.

In a PLC it is not possible to respond to changes in input signal states until the next program cycle after the change. Nowadays this disadvantage is largely compensated by very short program cycle periods. The duration of the program cycle period depends on the number and type of instructions executed.

2.4 The MELSEC FX Family

MELSEC means **M**ITSUBISHI **EL**ECTRIC **SE**QUEN**C**ER. The compact micro-controllers of the MELSEC FX series provide the foundation for building economical solutions for small to medium-sized control and positioning tasks requiring 10 to 256 integrated inputs and outputs in applications in industry and building services.

With the exception of the FX1S all the controllers of the FX series can be expanded to keep pace with the changes in the application and the user's growing requirements.

Network connections are also supported. This makes it possible for the controllers of the FX family to communicate with other PLCs and controller systems and HMIs (Human-Machine Interfaces and control panels). The PLC systems can be integrated both in MITSUBISHI networks as local stations and as slave stations in open networks like PROFIBUS/DP.

In addition to this you can also build multi-drop and peer-to-peer networks with the controllers of the MELSEC FX family.

The FX1N, FX2N and FX3U have modular expansion capabilities, making them the right choice for complex applications and tasks requiring special functions like analog-digital and digital-analog conversion and network capabilities.

All the controllers in the series are part of the larger MELSEC FX family and are fully compatible with one another.

Specifications	FX1S	FX1N	FX2N	FX2NC	FX3U
Max integrated I/O points	30	60	128	96	128
Expansion capability (max. possible I/Os)	34	132	256	256	384
Program memory (steps)	2000	8000	16000	16000	64000
Cycle time per logical instruction (µs)	0.55 – 0.7	0.55 – 0.7	0.08	0.08	0.065
No. of instructions (standard / step ladder / special function)	27 / 2 / 85	27 / 2 / 89	27 / 2 / 107	27 / 2 / 107	27 / 2 / 209
Max. special function modules connectable	—	2	8	4	8 right 10 left

2.5 Selecting the Right Controller

The base units of the MELSEC FX family are available in a number of different versions with different power supply options and output technologies. You can choose between units designed for power supplies of 100–240 V AC, 24 V DC or 12–24 V DC, and between relay and transistor outputs.

Series	I/Os	Type	No. of inputs	No. of outputs	Power supply	Output type
FX1S	10	FX1S-10 M□-□□	6	8	24 V DC or 100 – 240 V AC	Transistor or relay
	14	FX1S-14 M□-□□	8	6		
	20	FX1S-20 M□-□□	12	8		
	30	FX1S-30 M□-□□	16	14		
FX1N	14	FX1N-14 M□-□□	8	6	12 – 24 V DC or 100 – 240 V AC	Transistor or relay
	24	FX1N-24 M□-□□	14	10		
	40	FX1N-40 M□-□□	24	16		
	60	FX1N-60 M□-□□	36	24		
FX2N	16	FX2N-16 M□-□□	8	8	24 V DC or 100 – 240 V AC	Transistor or relay
	32	FX2N-32 M□-□□	16	16		
	48	FX2N-48 M□-□□	24	24		
	64	FX2N-64 M□-□□	32	32		
	80	FX2N-80 M□-□□	40	40		
	128	FX2N-128 M□-□□	64	64		
FX2NC	16	FX2NC-16 M□-□□	8	8	24 V DC	Transistor or relay
	32	FX2NC-32 M□-□□	16	16		
	64	FX2NC-64 M□-□□	32	32		
	96	FX2NC-96 M□-□□	48	48		
FX3U	16	FX3U-16 M□-□□	8	8	24 V DC or 100 – 240 V AC	Transistor or relay
	32	FX3U-32 M□-□□	16	16		
	48	FX3U-48 M□-□□	24	24		
	64	FX3U-64 M□-□□	32	32		
	80	FX3U-80 M□-□□	40	40		
	128	FX3U-128 M□-□□	64	64	100 – 240 V AC	Transistor or relay

Here are some considerations that should be taken into account when configuring a system:

- Power supply requirements

  Supply voltage: 24 V DC or 100 – 240 V AC

- Input/Output requirements
  - How many signals (external switch contacts, buttons and sensors) do you need to input?
  - What types of functions do you need to switch, and how many of them are there?
  - How high are the loads that the outputs need to switch? Choose relay outputs for switching high loads and transistor outputs for switching fast, trigger-free switching operations.

- **Special Function Modules**
  - Number of modules in system
  - External power supply requirements

2.6 Controller Design

All the controllers in the series have the same basic design. The main functional elements and assemblies are described in the glossary in section 2.5.7.

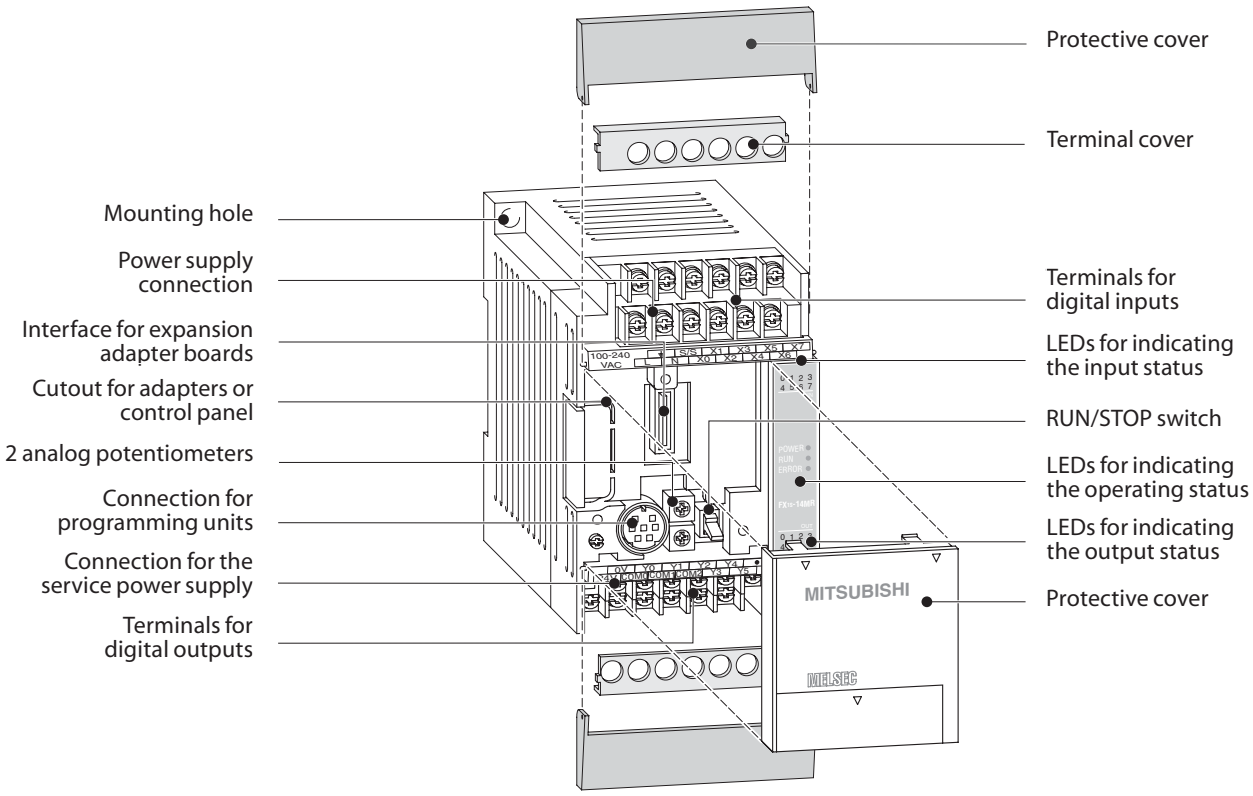
2.6.1 Input and output circuits

The **input circuits** use floating inputs. They are electrically isolated from the other circuits of the PLC with optical couplers. The **output circuits** use either relay or transistor output technology. The transistor outputs are also electrically isolated from the other PLC circuits with optical couplers.

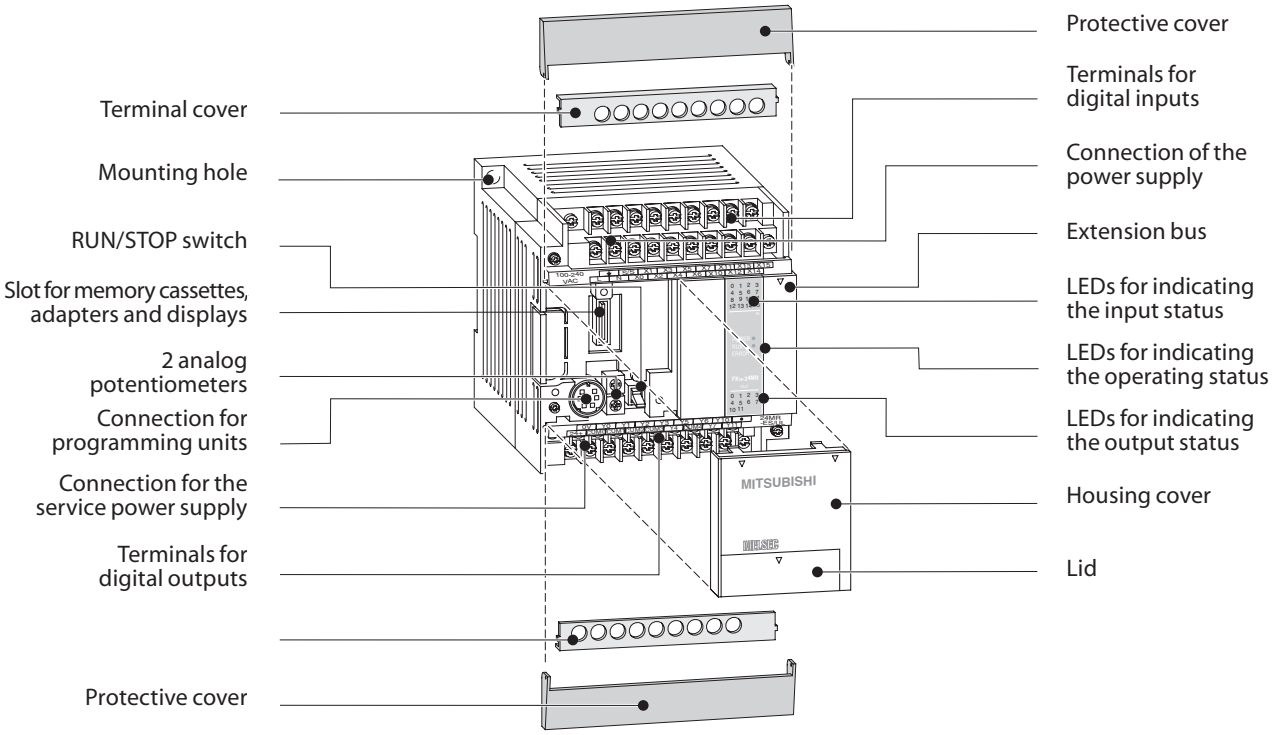
The switching voltage at all the digital inputs must have a certain value (e.g. 24 V DC). This voltage can be taken from the PLC's integrated power supply unit. If the switching voltage at the inputs is less than the rated value (e.g. <24 V DC) then the input will not be processed.

The maximum output currents are 2 A on 250 V three-phase AC and non-reactive loads with relay outputs and 0.5 A on 24 V DC and non-reactive loads.

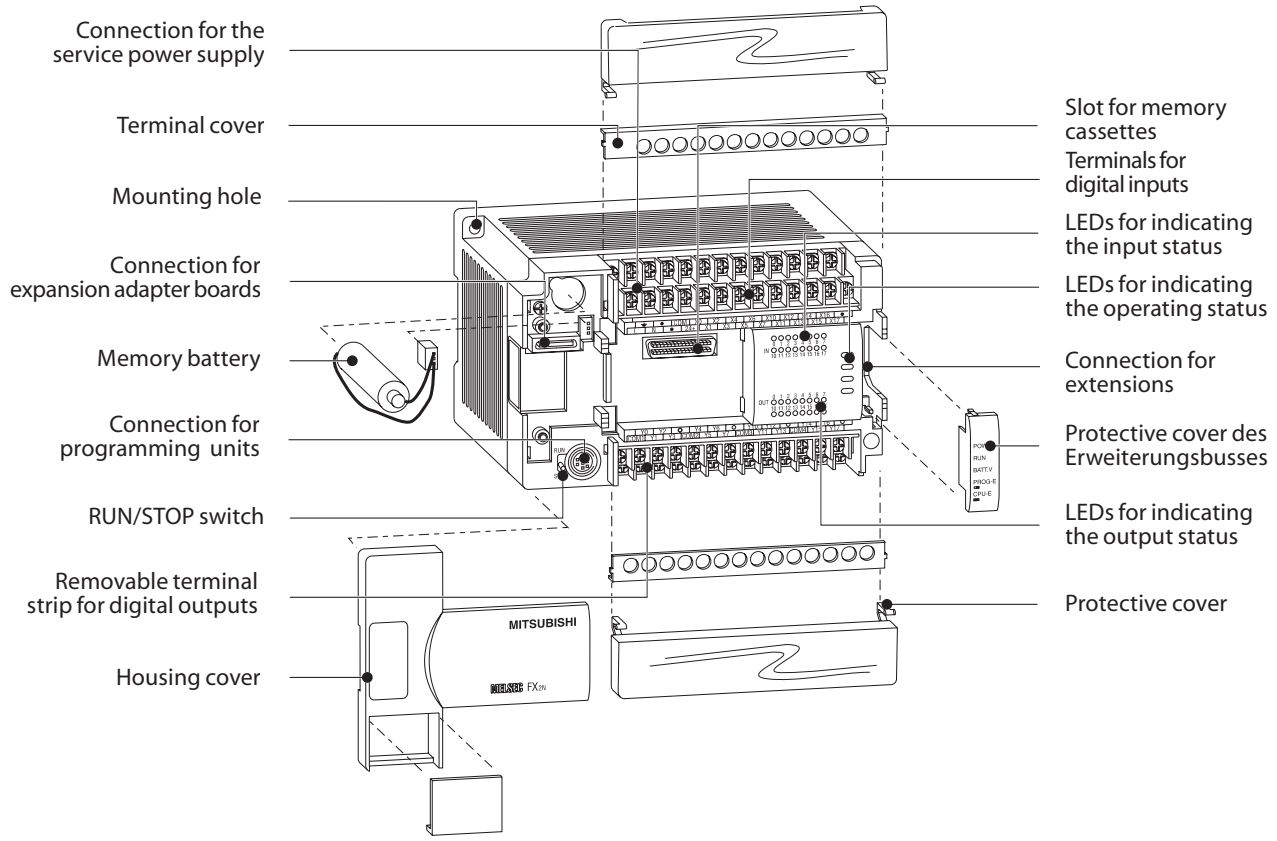
2.6.2 Layout of the MELSEC FX1S base units



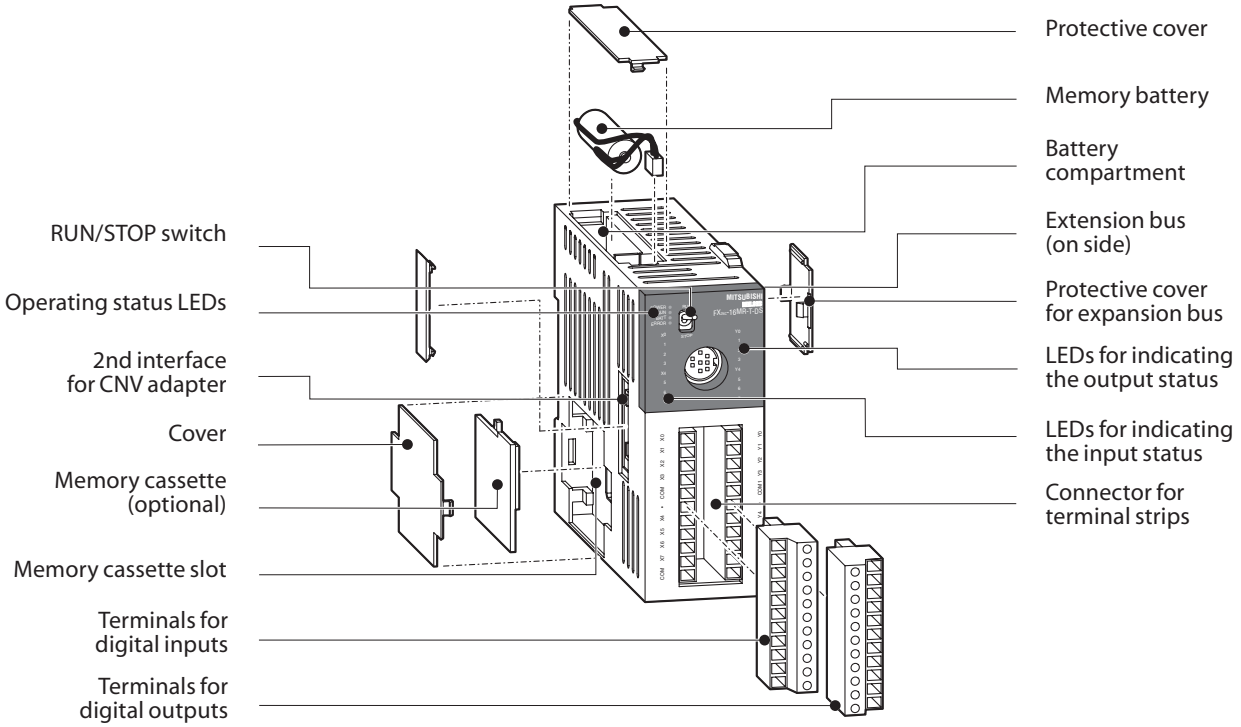
2.6.3 Layout of the MELSEC FX1N base units



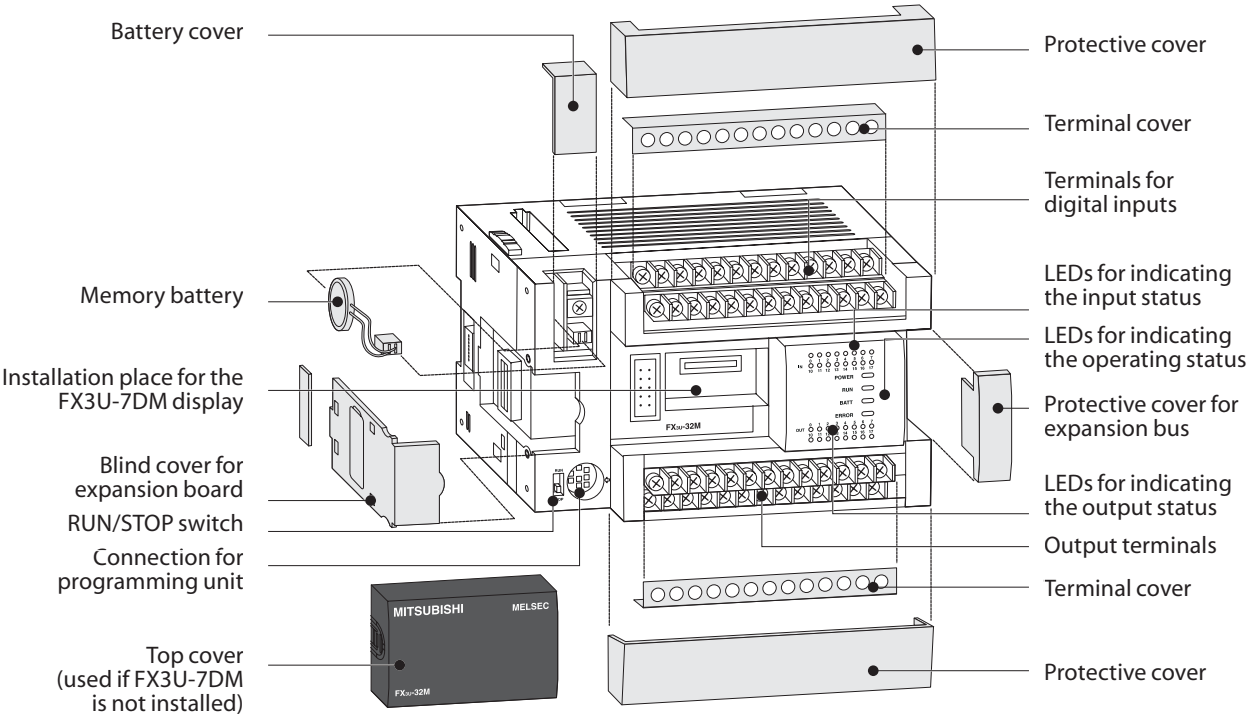
2.6.4 Layout of the MELSEC FX2N base units



2.6.5 Layout of the MELSEC FX2NC base units



2.6.6 Layout of the MELSEC FX3U base units



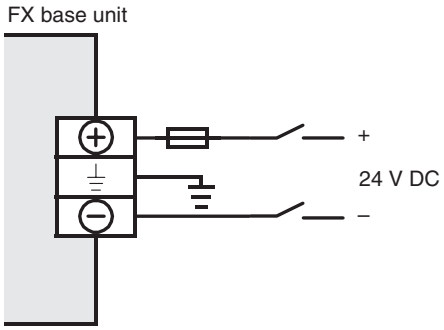
2.7 Wiring

2.7.1 Power Supply

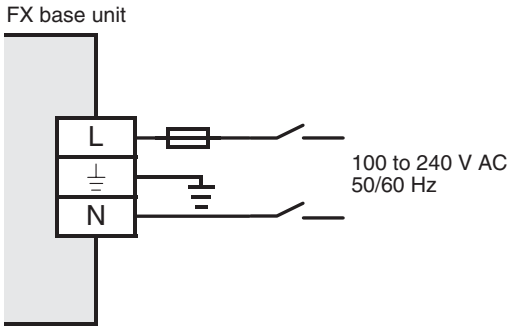
Power Supply Specifications

Specification	Units for DC Power Supply		Units for AC Power Supply
Rated voltage	12 to 24 V DC	24 V DC	100 to 240 V AC
Voltage range	10.2 to 26.4 V DC	20.4 to 26.4 V DC	85 to 264 V AC
Allowable momentary power failure time	5 ms		20 ms

Connection of units with DC power supply



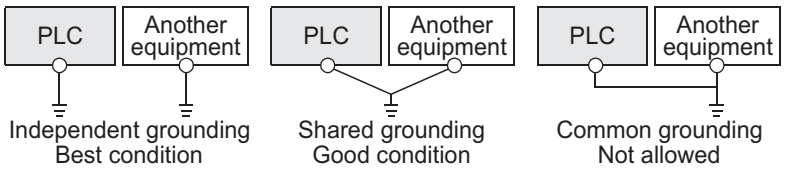
Connection of units with AC power supply



Grounding

The PLC should be grounded.

- The grounding resistance should be 100 Ω or less.
- The grounding point should be close to the PLC. Keep the grounding wires as short as possible.
- Independent grounding should be performed for best results. When independent grounding is not performed, perform "shared grounding" of the following figure.

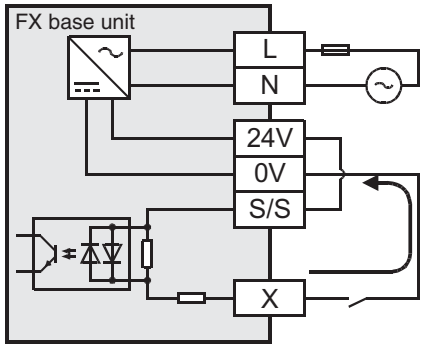


- The ground wire size should be at least 2 mm^2.

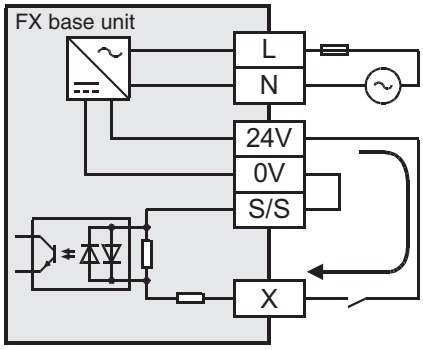
2.7.2 Wiring of Inputs

Connecting sink or source devices

The base units of the FX family series can be used with sink or source switching devices. The decision is made by the different connections of the "S/S" terminal.



In the case of the **sink input type**, the S/S terminal is connected to the 24V terminal of the service power supply or, when a DC powered main unit is used, to the positive pole of the power supply.
Sink input means that a contact wired to the input (X) or a sensor with NPN open collector transistor output connects the input of the PLC with the **negative** pole of a power supply.

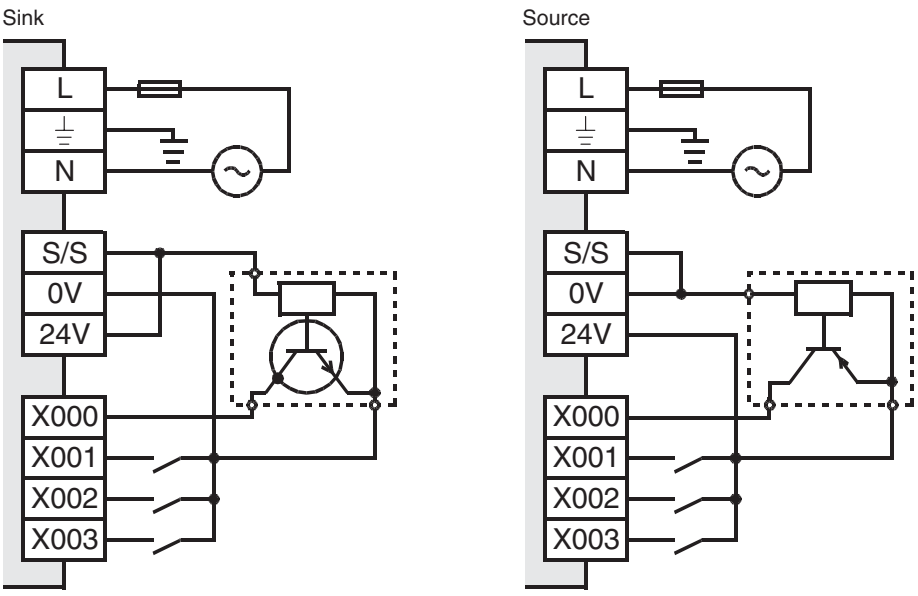


In the case of the **source input type**, the S/S terminal is connected to the 0V terminal of the service power supply or, when a DC powered main unit is used, to the negative pole of the power supply.
Source input means that a contact wired to the input (X) or a sensor with PNP open collector transistor output connects the input of the PLC with the **positive** pole of a power supply.

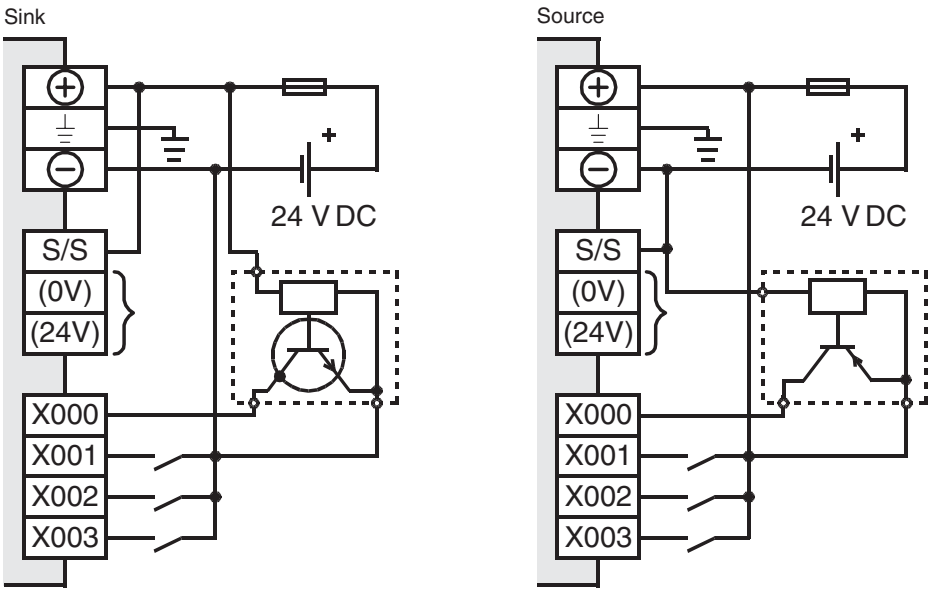
All inputs of a base unit or an extension unit can be either used as sink or source inputs, but it is not possible to mix sink and source inputs in one unit. Separate units in one PLC however can be set as sink or source inputs types, since the base unit and input/output powered extension units are individually set to sink or source input mode.

Examples for input types

AC powered base units



DC powered base units



2.7.3 Wiring of Outputs

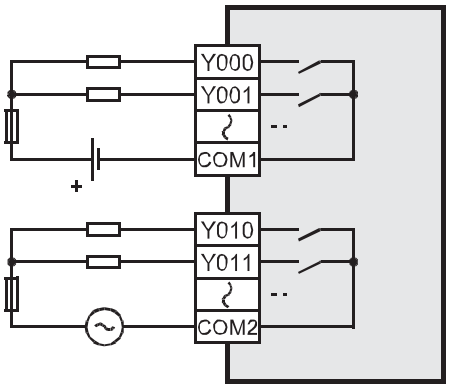
In case of the FX3U-16M□ each output can be connected separately. In case of the main units FX3U-32□M to FX3U-128M□ the outputs are pooled into groups of 4 or 8 outputs. Each group has a common contact for the load voltage. These terminals are marked "COM□" for main units with relais outputs or transistor outputs of the sink type and "+V□" for main units with source transistor outputs. "□" stands for the number of the output group e. g. "COM1".

Because the outputs groups are isolated against each other, one main unit can switch several voltages with different potentials. Main units with relay outputs can even switch AC and DC voltages.

FX3U base unit with relay outputs

The first group of outputs is used to switch a DC voltage.

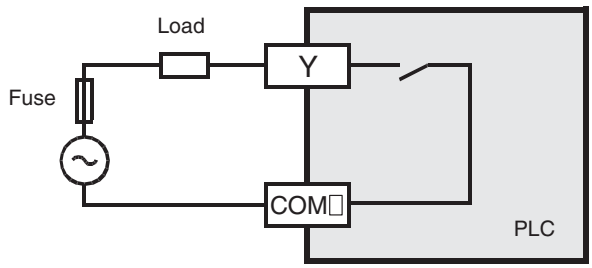
The second group of relays controls AC powered loads.



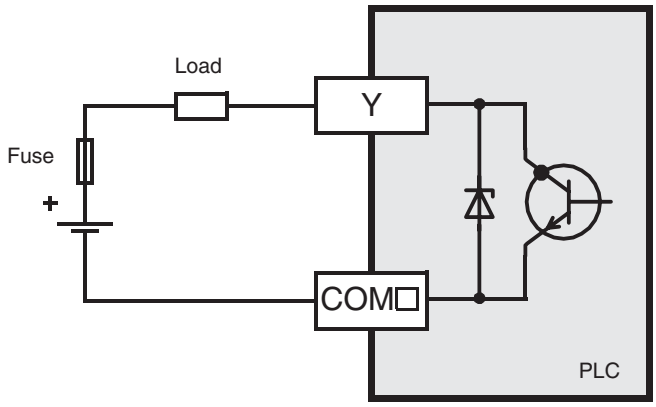
The selection of sink and source output type is done by the selection of a correspondent base unit. Both types are available with DC or AC power supply. The output type is given in the model designation code: base units with the code "MT/□S" provide transistor sink type outputs (e. g. FX3U-16MT/ES) while main units with the code "MT/□SS" provide transistor source type outputs (e. g. FX3U-16MT/ESS).

Examples of output wiring

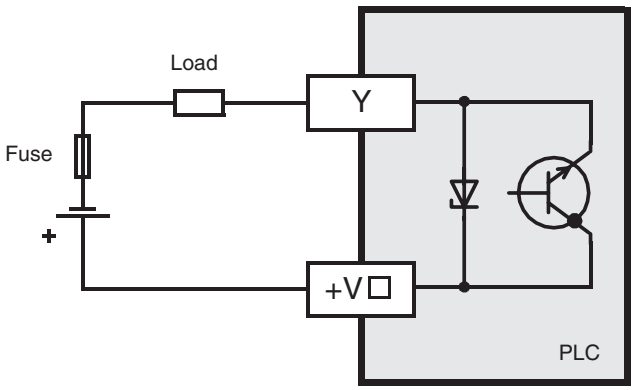
Relay output



Transistor output (sink)



Transistor output (source)

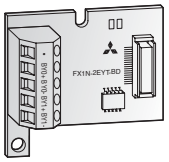


2.8 Extending the Range of Digital Inputs/Outputs

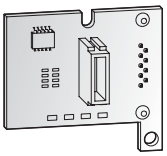
For the MELSEC FX family of PLCs several ways and means are available to provide a base unit with additional inputs and outputs.

2.8.1 Extension Boards

FX1N-2EYT-BD with two digital outputs



Connector side

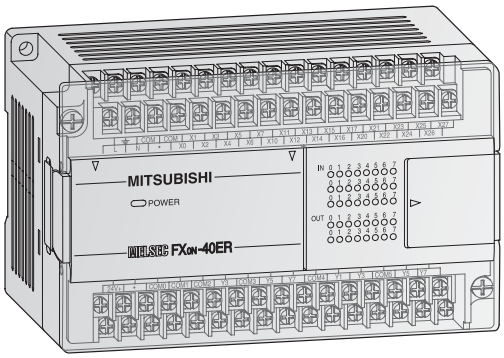


For a small number of I/O (2 to 4) an extension adapter board can be installed directly in a FX1S or FX1N base unit. Extension boards therefore do not require any additional installation space.
The state of the additional input and outputs is reflected in special relays in the PLC (see section A.1.5). In the program these relays are used instead of X and Y devices.

Designation	Number of I/O			Output type	Power supply	FX1S	FX1N	FX2N FX2NC	FX3U
	Total	No. of inputs	No. of outputs						
FX1N-4EX-BD	4	4	—	—	From base unit	●	●	○	○
FX1N-2EYT-BD	2	—	2	Transistor					

● : The extension board can be used with a base unit of this series.
○ : The extension board cannot be used with this series.

2.8.2 Compact Extension Units



The powered compact input/output extension units have their own power supply. The integrated service power supply (24 V DC) of AC powered extension units can be used for the supply of external devices.
It is possible to choose between relay and transistor (source) output type.

Compact Extension Units of the FX0N Series

Designation	Number of I/O			Output type	Power supply	FX1S	FX1N	FX2N FX2NC	FX3U
	Total	No. of inputs	No. of outputs						
FX0N-40ER/ES-UL	40	24	16	Relay	100–240 V AC	○	●	○	○
FX0N-40ER/DS	40	24	16	Relay	24 V DC				
FX0N-40ET/DSS	40	24	16	Transistor					

● : The extension unit can be used with a base unit of this series.
○ : The extension unit cannot be used with this series.

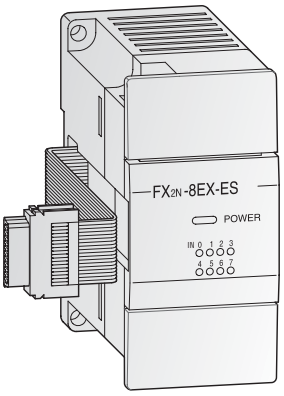
Compact Extension Units of the FX2N Series

Designation	Number of I/O			Output type	Power supply	FX1S	FX1N	FX2N FX2NC	FX3U
	Total	No. of inputs	No. of outputs						
FX2N-32ER-ES/UL	32	16	16	Relay	100–240 V AC	○	●	●	●
FX2N-32ET-ESS/UL	32	16	16	Transistor					
FX2N-48ER-ES/UL	48	16	16	Relay					
FX2N-48ET-ESS/UL	48	24	24	Transistor					
FX2N-48ER-DS	48	24	24	Relay	24 V DC				
FX2N-48ET-DSS	48	24	24	Transistor					

● : The extension unit can be used with a base unit of this series.

○ : The extension unit cannot be used with this series.

2.8.3 Modular Extension Blocks



Modular extension blocks have no build-in power supply but very compact dimensions. The FX2N series modular extension blocks are available with 8 or 16 input/output points. It is possible to choose between relay and transistor (source) output type.

Designation	Number of I/O			Output type	Power supply	FX1S	FX1N	FX2N FX2NC	FX3U
	Total	No. of inputs	No. of outputs						
FX2N-8ER-ES/UL	16*	4	4	Relay	100–240 V AC	○	●	●	●
FX2N-8EX-ES/UL	8	8	—	—					
FX2N-16EX-ES/UL	16	16	—	—					
FX2N-8EYR-ES/UL	8	—	8	Relay					
FX2N-8EYT-ESS/UL	8	—	8	Transistor	24 V DC				
FX2N-16EYR-ES/UL	16	—	16	Relay					
FX2N-16EYT-ESS/UL	16	—	16	Transistor					

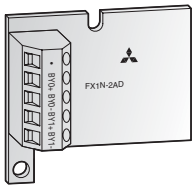
* The extension block FX2N-8ER-ES/UL occupies 16 input/output points of the PLC. Four inputs and four outputs are occupied but cannot be used.

2.9 Extending for Special Functions

A variety of hardware for special functions are available for the MELSEC FX family.

Adapter Boards

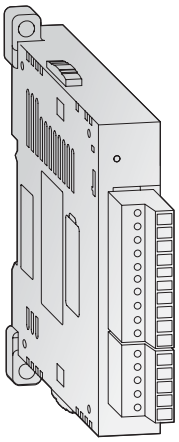
Adapter boards are small circuit boards that are installed directly in the FX1S or FX1N controllers, which means that they don't take up any extra space in the switchgear cabinet.



In the case of analog adapter boards, the digital values generated from the signals coming from the analog input adapter's two input channels are written directly to special registers D8112 and D8113, which makes it particularly easy to process them.
The output value for the analog output adapter is written by the program to special register D8114 and then converted by the adapter and sent to the output.

Special Adapter

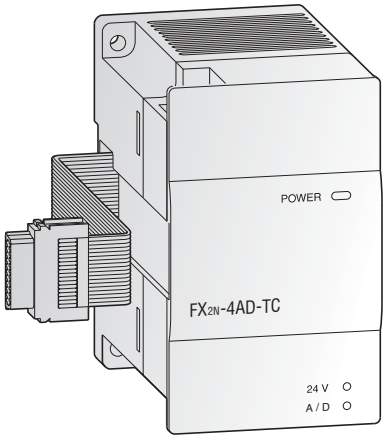
Special adapters can only be connected on the left side of a base unit of the MELSEC FX3U series. You can install up to a maximum of ten special adapters.



Special adapters do not use any input or output points in the base unit. They communicate directly with the base unit via special relays and registers (see section A.1.5 and A.2.6). Because of this, no instructions for communication with special function modules are needed in the program (see below).

Special function modules

Up to eight special function modules can be connected on the right side of a single base unit of the MELSEC FX family.



In addition to analog modules the available special function modules include communication modules, positioning modules and other types. Each special function module occupies eight input points and eight output points in the base unit.

Communication between the special function module and the PLC base unit is carried out via the memory buffer of the special function module with the help of FROM and TO instructions.

2.9.1 Analog Modules

Without additional modules the base units of the MELSEC FX family can only process digital input and output signals (i.e. ON/OFF data). Additional analog modules are thus required for inputting and outputting analog signals.

Modul Type		Designation	No. of channels	Range	Resolution	FX1S	FX1N	FX2N FX2NC	FX3U
Analog Input Modules	Adapter Board	FX1N-2AD-BD	2	Voltage: 0 V to 10 V DC	2.5 mV (12 bits)	●	●	○	○
				Current: 4 mA to 20 mA DC	8 µA (11 bits)				
	Special Adapter	FX3U-4AD-ADP	4	Voltage: 0 V to 10 V DC	2.5 mV (12 bits)	○	○	○	●
				Current: 4 mA to 20 mA DC	10 µA (11 bits)				
	Special Function Modules	FX2N-2AD	2	Voltage: 0 V to 5 V DC 0 V to 10 V DC	2.5 mV (12 bits)	○	●	●	●
				Current: 4 mA to 20 mA DC	4 µA (12 bits)				
		FX2N-4AD	4	Voltage: -10 V to 10 V DC	5 mV (with sign, 12 bits)	○	●	●	●
				Current: 4 mA to 20 mA DC -20 mA to 20 mA DC	10 µA (with sign, 11 bits)				
		FX2N-8AD*	8	Voltage: -10 V to 10 V DC	0.63 mV (with sign, 15 bits)	○	●	●	●
				Current: 4 mA to 20 mA DC -20 mA to 20 mA DC	2.50 µA (with sign, 14 bits)				
		FX3U-4AD	4	Voltage: -10 V to 10 V DC	0.32 mV (with sign, 16 bits)	○	○	○	●
				Current: 4 mA to 20 mA DC -20 mA to 20 mA DC	1.25 µA (with sign, 15 bits)				
Analog Output Modules	Adapter Board	FX1N-1DA-BD	1	Voltage: 0 V to 10 V DC	2,5 mV (12 bits)	●	●	○	○
				Current: 4 mA to 20 mA DC	8 µA (11 bits)				
	Special Adapter	FX3U-4DA-ADP	4	Voltage: 0 V to 10 V DC	2.5 mV (12 bits)	○	○	○	●
				Current: 4 mA to 20 mA DC	4 µA (12 bits)				
	Special Function Block	FX2N-2DA	2	Voltage: 0 V to 5 V DC 0 V to 10 V DC	2.5 mV (12 bits)	○	●	●	●
				Current: 4 mA to 20 mA DC	4 µA, (12 bits)				
		FX2N-4DA	4	Voltage: -10 V to 10 V DC	5 mV (with sign, 12 bits)	○	●	●	●
				Current: 0 mA to 20 mA DC 4 mA to 20 mA DC	20 µA (10 bits)				
		FX3U-4DA	4	Voltage: -10 V to 10 V DC	0.32 mV (with sign, 16 bits)	○	○	○	●
				Current: 0 mA to 20 mA DC 4 mA to 20 mA DC	0.63 µA (15 bits)				

* The special function block FX2N-8AD is able to measure voltage, current and temperature.

Modul Type		Designation	No. of channels	Range	Resolution	FX1S	FX1N	FX2N FX2NC	FX3U
Combined Analog Input & Output Modules	Special Function Modules	FX0N-3A	2 inputs	Voltage: 0 V to 5 V DC 0 V to 10 V DC	40 mV (8 bits)	○	●	●	●
				Current: 4 mA to 20 mA DC	64 µA (8 bits)				
			1 output	Voltage: 0 V to 5 V DC 0 V to 10 V DC	40 mV (8 bits)				
				Current: 4 mA to 20 mA DC	64 µA (8 bits)				
		FX2N-5A	4 inputs	Voltage: -100 mV to 100 mV DC -10 V to 10 V DC	50 µV (with sign, 12 bits) 0.312 mV (with sign, 16 bits)	○	●	●	●
				Current: 4 mA to 20 mA DC -20 mA to 20 mA DC	10 µA/1,25 µA (with sign, 15 bits)				
			1 output	Voltage: -10 V to 10 V DC	5 mV (with sign, 12 bits)				
				Current: 0 mA to 20 mA DC	20 µA (10 bits)				
Temperature Acquisition Modules	Special Adapter	FX3U-4AD-PT-ADP	4	Pt100 resistance thermometer: -50 °C to 250 °C	0.1 °C	○	○	○	●
		FX3U-4AD-TC-ADP	4	Thermocouple type K: -100 °C to 1000 °C	0.4 °C	○	○	○	●
				Thermocouple type J: -100 °C to 600 °C	0.3 °C				
	Special Function Modules	FX2N-8AD*	8	Thermocouple type K: -100 °C to 1200 °C	0.1 °C	○	●	●	●
				Thermocouple type J: -100 °C to 600 °C	0.1 °C				
				Thermocouple type T: -100 °C to 350 °C	0.1 °C				
		FX2N-4AD-PT	4	Pt100 resistance thermometer: -100 °C to 600 °C	0.2 to 0,. °C	○	●	●	●
		FX2N-4AD-TC	4	Thermocouple type K: -100 °C to 1200 °C	0.4 °C	○	●	●	●
				Thermocouple type J: -100 °C to 600 °C	0.3 °C				
Temperature Control Module (Special Function Modules)		FX2N-2LC	2	For example with a thermocouple type K: -100 °C to 1300 °C	0.1 °C or 1 °C (depends on temperature probe used)	○	●	●	●
				Pt100 resistance thermometer: -200 °C to 600 °C					

* The special function block FX2N-8AD is able to measure voltage, current and temperature.

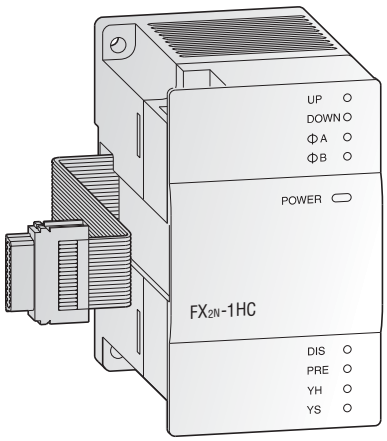
● The adapter board, special adapter or special function module can be used with a base unit or expansion unit of this series.

○ The adapter board, special adapter or special function module cannot be used with this series.

2.9.2 High-Speed Counter Module and Adapters

FX2N-1HC

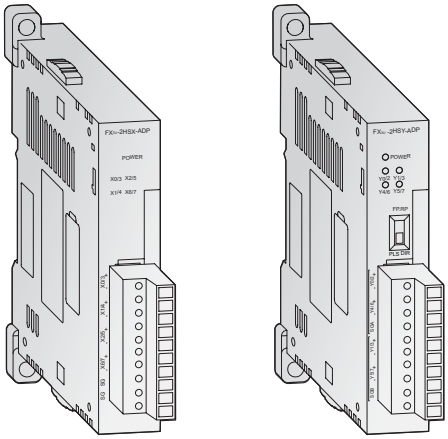
In addition to the internal high-speed MELSEC FX counters, the high-speed counter module FX2N-1HC provides the user with an external counter. It counts 1- or 2-phase pulses up to a frequency of 50 kHz. The counting range covers either 16 or 32 bit.



The two integrated transistor outputs can be switched independently of one another by means of internal comparison functions. Hence, simple positioning tasks can also be realized economically. In addition, the FX2N-1HC can be used as a ring counter.

FX3U-4HSX-ADP and FX3U-2HSY-ADP

These adapter modules allow direct processing of positioning application data.



The FX3U-4HSX-ADP (far left) provides four high speed counter inputs up to 200 kHz while the FX3U-2HSY-ADP (left) delivers two channels of pulse train outputs up to 200 kHz.

Overview of High-Speed Counter Modules/Adapters

Modul type	Designation	Desciption	FX1S	FX1N	FX2N FX2NC	FX3U
Special function module	FX2N-1HC	1-ch high speed counter	○	○	●	●
Special adapter	FX3U-4HSX-ADP	Differential line driver input (high-speed counter)	○	○	○	●
	FX3U-2HSY-ADP	Differential line driver input (positioning output)				

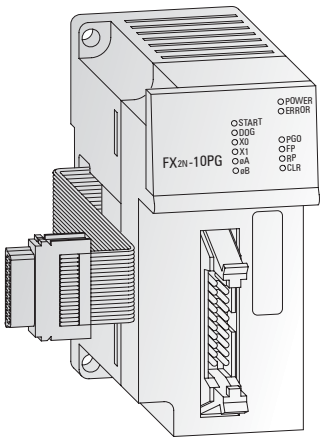
● The special adapter or special function module can be used with a base unit or expansion unit of this series.

○ The special adapter or special function module cannot be used with this series.

2.9.3 Positioning Modules

FX2N-1PG-E, FX2N-10PG

The positioning modules FX2N-1PG-E and FX2N-10PG are extremely efficient single-axis positioning modules for controlling either step drives or servo drives (by external regulator) with a pulse chain.



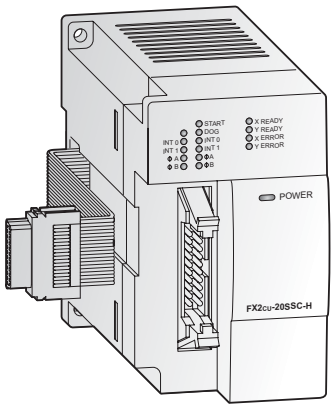
They are very suitable for achieving accurate positioning in combination with the MELSEC FX series. The configuration and allocation of the position data are carried out directly via the PLC program.

The FX2N-1PG-E provides an 100 kHz open collector output while the FX2N-10PG is equipped with a 1 MHz differential line driver output.

A very wide range of manual and automatic functions are available to the user.

FX3U-20SSC-H

The SSCNET* module FX3U-20SSC-H can be used in combination with a FX3U programmable controller to achieve a cost effective solution for high precision, high speed positioning. The plug-and-play fiber optic SSCNET cabling reduces setup time and increases control distance for positioning operations in a wide range of applications.



Servo parameters and positioning information for the FX3U-20SSC-H are easily set up with an FX3U base unit and a personal computer. For parameter setting, monitoring and testing the easy programming software FX Configurator-FP is available.

* SSCNET: **S**ervo **S**ystem **C**ontroller **Net**work

Overview of Positioning Modules

Modul type	Designation	Desciption	FX1S	FX1N	FX2N FX2NC	FX3U
Special function modules	FX2N-1PG-E	Pulse output for independent 1-axis control	○	○	●	●
	FX2N-10PG		○	○	●	●
	FX3U-20SSC-H	Simultaneous 2-axis (independent 2-axis) control (Applicable to SSCNET III)	○	○	○	●

● The special function module can be used with a base unit or expansion unit of this series.
○ The special function module cannot be used with this series.

2.9.4 Network Modules for ETHERNET

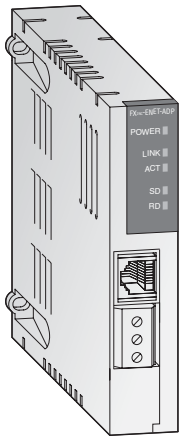
ETHERNET is the most widespread network for connection of information processors such as personal computers and work stations. By loading an ETHERNET interface into the PLC, production-related management information can be transmitted rapidly to personal computers or work stations.

ETHERNET is a platform for a very wide range of data communications protocols. The combination of ETHERNET and the extremely widespread TCP/IP protocol enables high-speed data communications between process supervision systems and the MELSEC PLC series. TCP/IP provides logical point-to-point links between two ETHERNET stations.

The programming software GX Developer provides function blocks or setup routines for the PLCs, making the configuration of one or more TCP/IP links a quick and easy process.

FX2NC-ENET-ADP

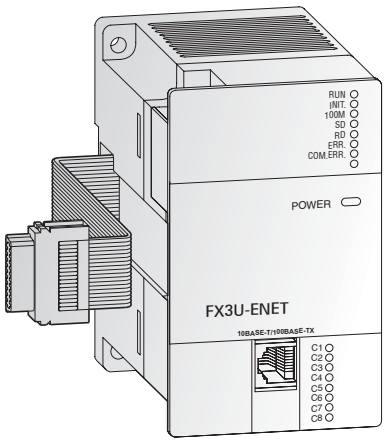
The FX2NC-ENET-ADP communications adapter is an Ethernet interface with 10BASE-T specifications for the FX1S, FX1N, FX2NC and FX2N series*.



* Note: When connecting this adapter module to a FX1S or FX1N PLC the communications adapter FX1N-CNV-BD is required. When connecting this adapter module to a FX2N PLC the communications adapter FX2N-CNV-BD is required.

FX3U-ENET

The FX3U-ENET communications module provides the FX3U with a direct connection on to an Ethernet network.



Overview of Network Modules for ETHERNET

Modul type	Designation	Desciption	FX1S	FX1N	FX2N FX2NC	FX3U
Special function modules	FX2NC-ENET-ADP	ETHERNET network modules	●	●	●	○
	FX3U-ENET		○	○	○	●

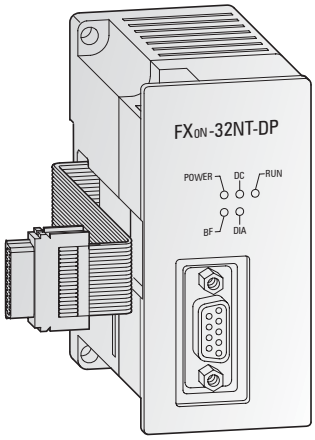
2.9.5 Network Modules for Profibus/DP

The Profibus/DP network enables communication between a master module and decentralised slave modules, with data transfer rates of up to 12 Mbps. With a MELSEC PLC as master, PROFIBUS/DP allows quick and simple connection of sensors and actuators, even from different manufacturers.

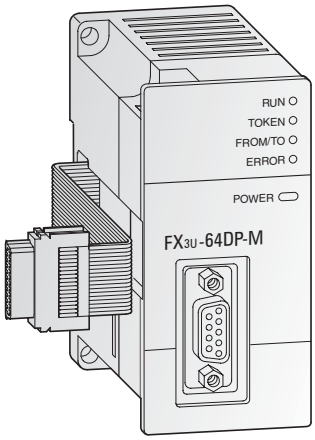
A MELSEC PLC, serving as slave in a PROFIBUS/DP network, can execute decentralised control tasks and simultaneously exchange data with the PROFIBUS/DP master.

To help reduce costs PROFIBUS/DP uses RS485 technology with shielded 2-wire cabling.

FX0N-32NT-DP

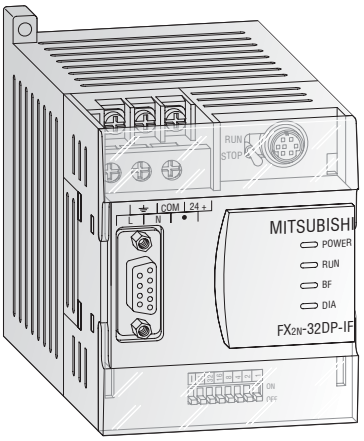


FX3U-64DP-M



FX2N-32DP-IF

The remote I/O station FX2N-32DP-IF forms an extremely compact communication unit and provides a connection of I/O modules with up to 256 I/O points and/or up to 8 special function modules as an alternative.



Overview of Profibus/DP modules

Modul type	Designation	Desciption		FX1S	FX1N	FX2N FX2NC	FX3U
Special function modules	FX0N-32NT-DP	PROFIBUS/DP slave		●	●	●	●
	FX3U-64DP-M	PROFIBUS/DP master		○	○	○	●
—	FX2N-32DP-IF	PROFIBUS/DP remote I/O station	Power supply: 100–240 V AC	Compatible with PROFIBUS/DP masters			
	FX2N-32DP-IF-D		Power supply: 24 V DC				

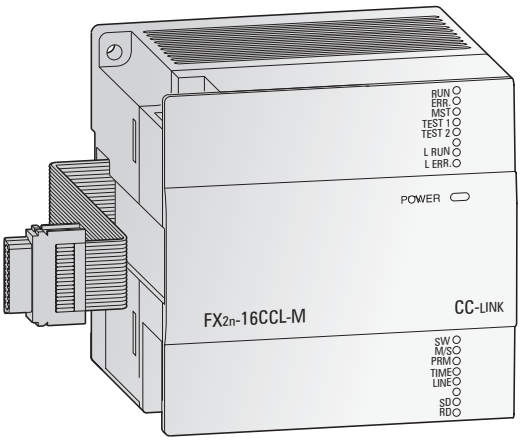
● The special function module can be used with a base unit or expansion unit of this series.
○ The special function module cannot be used with this series.

2.9.6 Network Modules for CC-Link

CC-Link Master Module FX2N-16CCL-M

The CC-Link network enables the controlling and monitoring of decentralized I/O modules at the machine.

The CC-Link master module FX2N-16CCL-M is a special extension block which assigns an FX series PLC as the master station of the CC-Link system.



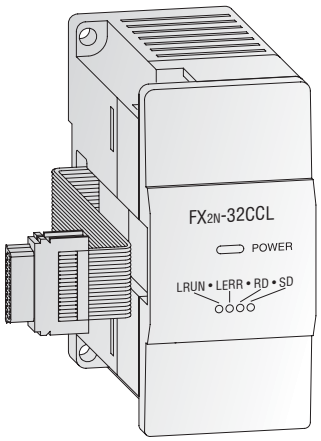
The setting of all modules within the network is handled directly via the master module.

Up to 15 remote stations and remote device stations can be connected to the master station as decentralized I/O stations. These remote stations can be up to 7 I/O modules and up to 8 intelligent modules. Two master modules can be connected to one FX1N or FX2N base unit.

The maximum communications distance is 1200 m without repeater.

CC-Link Communication Module FX2N-32CCL

The communication module FX2N-32CCL enables the user to connect to the CC-Link network with a superior PLC system as master CPU. This gives him access to the network of all MELSEC PLC systems and frequency inverters and to additional products from other suppliers.



Thus the network is expandable via the digital inputs/outputs of the FX modules to a maximum of 256 I/Os.

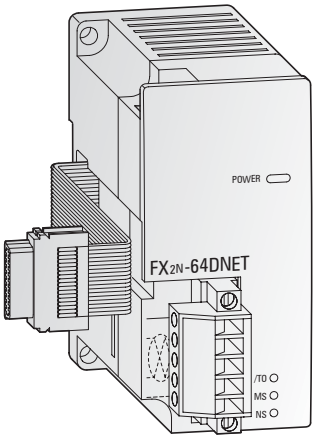
Overview of Network Modules for CC-Link

Modul type	Designation	Desciption	FX1S	FX1N	FX2N FX2NC	FX3U
Special function modules	FX2N-16CCL-M	Master for CC-Link	○	●	●	●
	FX2N-32CCL	Remote device station for CC-Link	○	●	●	●

● The special function module can be used with a base unit or expansion unit of this series.
○ The special function module cannot be used with this series.

2.9.7 Network Module for DeviceNet

DeviceNet represents a cost-effective solution for the network integration of low-level terminal equipment. Up to 64 devices including a master can be integrated in one network. For the data exchange a cable with two shielded twisted-pair cables is used.



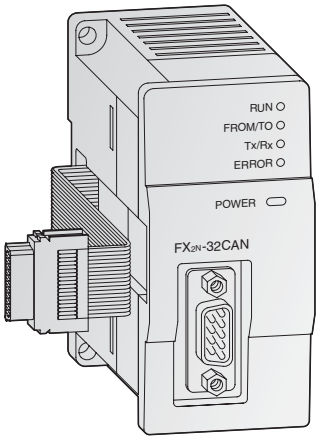
Modul type	Designation	Desciption	FX1S	FX1N	FX2N FX2NC	FX3U
Special function module	FX2N-64DNET	DeviceNet slave module	○	○	●	●

● The special function module can be used with a base unit or expansion unit of this series.
○ The special function module cannot be used with this series.

2.9.8 Network Module for CANopen

CANopen is an “open” implementation of the Controller Area Network (CAN), which is defined in the EN50325-4 standard. CANopen offers cost effective network communications with fault-resistant network structure where components of different manufacturers can be integrated quickly and easily.

CANopen networks are used for connecting sensors, actuators and controllers in a variety of applications. The bus uses inexpensive twisted-pair cabling.

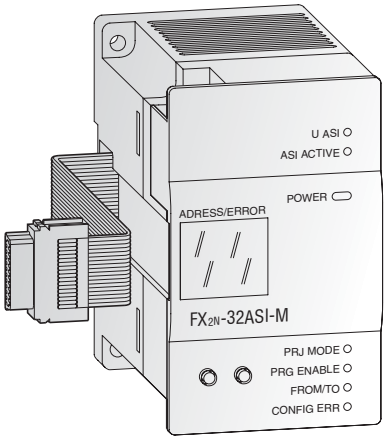


Modul type	Designation	Desciption	FX1S	FX1N	FX2N FX2NC	FX3U
Special function module	FX2N-32CAN	CANopen module	○	○	●	●

● The special function module can be used with a base unit or expansion unit of this series.
○ The special function module cannot be used with this series.

2.9.9 Network Module for AS-Interface

The Actuator Sensor interface (AS interface or ASi) is an international standard for the lowest field bus level. The network suits versatile demands, is very flexible and particularly easy to install. The ASi is suitable for controlling sensors, actuators and I/O units.



The FX2N-32ASI-M serves as master module for the connection of the FX1N/FX2N and FX3U PLC to the AS-Interface system. Up to 31 slave units with up to 4 inputs and 4 outputs can be controlled.

For status and diagnosis messages a 7-segment display is integrated.

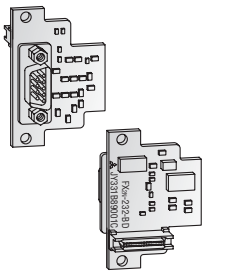
Modul type	Designation	Desciption	FX1S	FX1N	FX2N FX2NC	FX3U
Special function module	FX2N-32ASI-M	Master for AS-i system	○	●	●	●

● The special function module can be used with a base unit or expansion unit of this series.
○ The special function module cannot be used with this series.

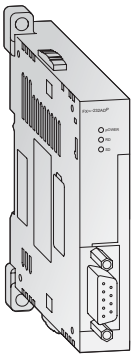
2.9.10 Interface Modules and Adapters

For serial data communication a large range of interface modules/adapters is available. Shown below are only some examples, but the following table covers all available interfaces.

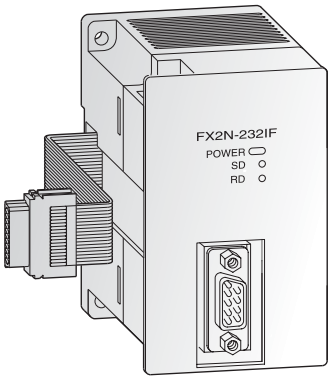
RS232C interface adapter board FX2N-232-BD



Connector side



Communication special adapter FX3U-232ADP (RS232C interface)



Interface Module FX2N-232IF

The interface module FX2N-232IF provides an RS232C interface for serial data communications with the MELSEC FX2N, FX2NC and FX3U.

Communication with PCs, printers, modems, barcode readers etc. is handled by the PLC program. The send and receive data are stored in the FX2N-232IF's own buffer memory.

Overview of Interface Modules and Adapters

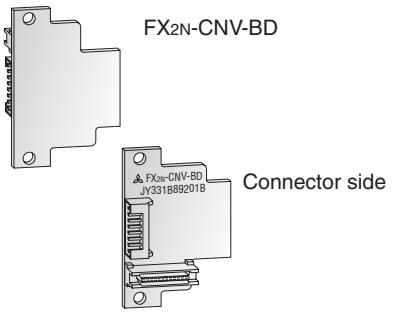
Modul type	Designation	Desciption	FX1S	FX1N	FX2N FX2NC	FX3U
Adapter boards	FX1N-232-BD	RS232C interfaces	●	●	○	○
	FX2N-232-BD		○	○	●	○
	FX3U-232-BD		○	○	○	●
Special adapter	FX2NC-232ADP*		●	●	●	○
	FX3U-232ADP		○	○	○	●
Special function module	FX2N-232IF		○	○	●	●
Adapter boards	FX1N-422-BD	RS422 interfaces	●	●	○	○
	FX2N-422-BD		○	○	●	○
	FX3U-422-BD		○	○	○	●
Adapter boards	FX1N-485-BD	RS485 interfaces	●	●	○	○
	FX2N-485-BD		○	○	●	○
	FX3U-485-BD		○	○	○	●
Special adapter	FX2NC-485ADP*		●	●	●	○
	FX3U-485ADP		○	○	○	●
Adapter board	FX3U-USB-BD	USB interface	○	○	○	●

① The FX2NC-232ADP and the FX2NC-485ADP require a FX2N-CNV-BD or FX1N-CNV-BD interface adapter when connecting to a FX1S, FX1N or FX2N base unit.

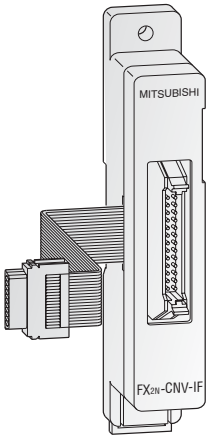
2.9.11 Communication Adapters

Communication adapters boards

Communication adapters boards (product code FX□□-CNV-BD) are are installed directly in a base unit. They are needed to connect special adapters (FX□□-□□□ADP) to the left-hand side of base units.



FX2N-CNV-IF



Overview of Communication Adapters

Modul type	Designation	Desciption	FX1S	FX1N	FX2N FX2NC	FX3U
Adapter boards	FX1N-CNV-BD	Communication adapters for connection of special adapters	●	●	○	○
	FX2N-CNV-BD		○	○	●	○
	FX3U-CNV-BD		○	○	○	●
Adapter	FX2N-CNV-IF	Communication adapter for connection of FX series modules	○	○	●	○

● The adapter can be used with a base unit or expansion unit of this series.
○ The adapter cannot be used with this series.

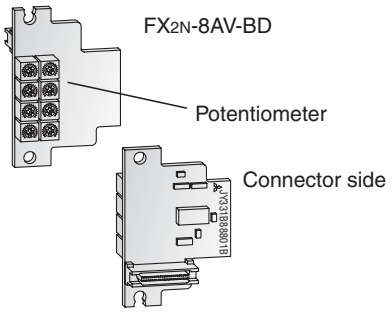
2.9.12 Setpoint Adapter Boards

These analog setpoint adapters enable the user to set 8 analog setpoint values. The analog values (0 to 255) of the potentiometers are read into the controller and used as default setpoint values for timers, counters and data registers by the user's PLC programs.

Each potentiometer value can also be read as an 11 position rotary switch (positions 0 to 10).

Setpoint value polling is performed in the PLC program using the dedicated instruction VRRD. The position of an rotary switch is read using the VRSC instruction.

The analog setpoint adapters are installed in the expansion slot of the base unit. No additional power supply is required for operation.



Modul type	Designation	Desciption	FX1S	FX1N	FX2N FX2NC	FX3U
Adapter boards	FX1N-8AV-BD	Analog setpoint adapters	●	●	○	○
	FX2N-8AV-BD		○	○	●	○

● The adapter board can be used with a base unit or expansion unit of this series.
○ The adapter board cannot be used with this series.

2.10 System Configuration

A basic FX PLC system can consist of a stand alone base unit, with the functionality and I/O range increased by adding extension I/O and special function modules. An overview of available options is given in sections 2.8 and 2.9.

Base Units

Base units are available with different I/O configurations from 10 to 128 points but can be expanded to 384 points depending upon the FX range selected.

Extension Boards

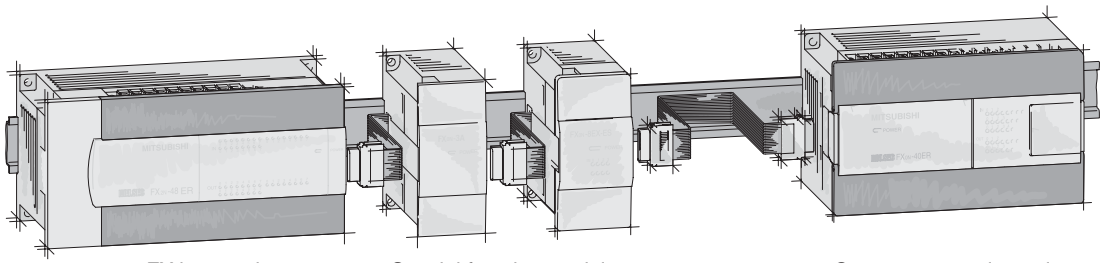
Extension adapter boards can be installed directly into the base unit and therefore do not require any additional installation space. For a small number of I/O (2 to 4) an extension adapter boards can be installed directly into the FX1S or FX1N controller. Interface adapter boards can also provide the FX PLC with additional RS232 or RS485 interfaces.

Extension I/O Modules

Unpowered modular extension blocks and powered compact extension units modules can be added to the FX1N, FX2N and FX3U PLCs. For modular extension blocks powered by the base unit, the power consumption has to be calculated as the 5 V DC bus can only support a limited number of expansion I/O.

Special Function Modules / Special Adapters

A wide variety of special function modules are available for the FX1N, FX2N and FX3U PLCs. They cover networking functionality, analog control, pulse train outputs and temperature inputs (for further details please refer to section 2.9).



FX base unit Special function modules Compact extension unit

Expansion Options

PLC	Number of modules on the left side of base unit	Number of boards in expansion board port of base unit	Number of modules on the right side of base unit
FX1S	The modules FX0N-485ADP and FX0N-232ADP can be mounted in combination with a communication adapter FX1N-CNV-BD.	1 (product code FX□□-□□□-BD)	—
FX1N			Up to 2 special function modules of the FX2N series.
FX2N			Up to 8 special function modules of the FX2N series.
FX2NC	The modules FX0N-485ADP and FX0N-232ADP can be mounted on the left side directly. An adapter is not required.		Up to 4 special function modules of the FX2N series.
FX3U	Up to 10 adapter of the FX3U series can be directly mounted on the left side of the base unit.		Up to 8 special function modules of the FX2N or FX3U series.

The difference between a base unit, extension unit and extension block is described as follows:

- A base unit is made up of 4 components i.e. power supply, inputs, outputs and CPU.
- An extension unit is made up of 3 components i.e. power supply, inputs and outputs.
- An extension block is made up of 1or 2 components i.e. inputs and/or outputs.

It can be seen that the extension block does not have a power supply. It therefore obtains its power requirement from either the base unit or extension unit.

Hence it is necessary to determine how many of these unpowered units can be connected before the 'On Board' power supply capacity is exceeded.

2.10.1 Connection of Special Adapters (FX3U only)

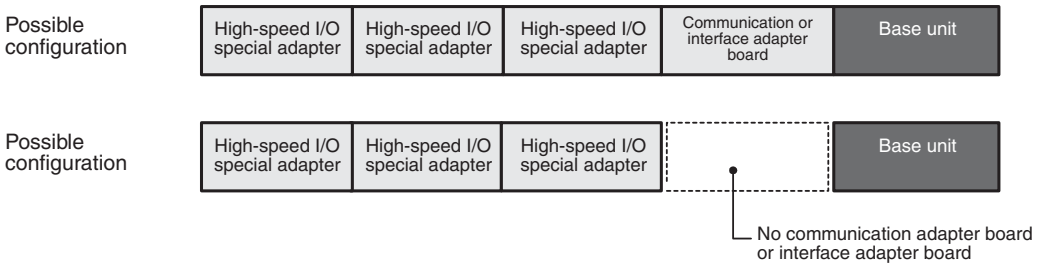
Up to 10 special adapters can be directly mounted on the left side of a FX3U base unit. Please obey the following rules.

High-speed input/output special adapters

Up to two high-speed input special adapters FX3U-4HSX-ADP and up to two high-speed output special adapters FX3U-2HSY-ADP can be connected to a base unit.

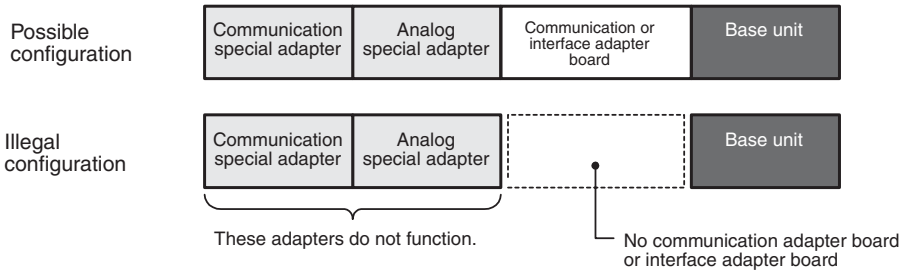
Connect all high-speed I/O special adapters before connecting other special adapters when they are used in combination. A high-speed I/O special adapter can not be mounted on the left side of a communication or analog special adapter.

When only high-speed input/output special adapters are connected, the adapters can be used without a communication or interface adapter board installed in the base unit.



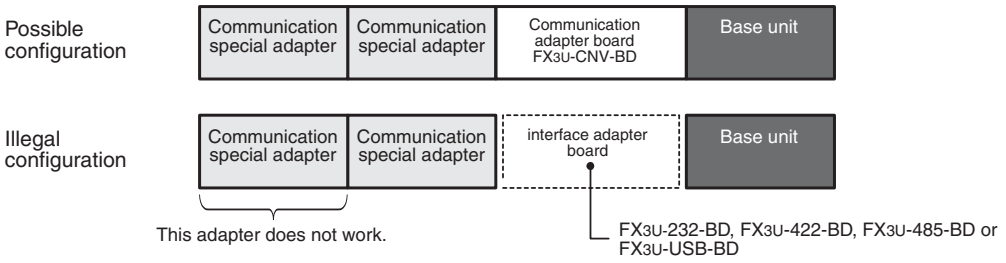
Combination of analog and communication special adapters

Analog and communication special adapters must be used with a communication adapter board or an interface adapter board installed in the base unit.



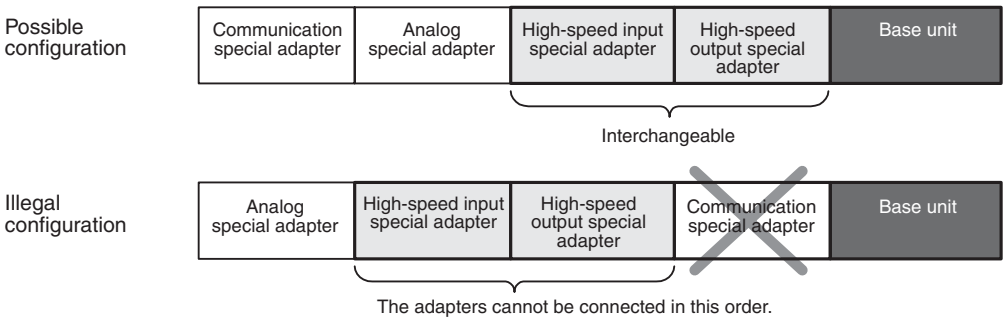
Combination of communication special adapters and an interface adapter board

When instead of a communication adapter board FX3U-CNV-BD an interface adapter board FX3U-232-BD, FX3U-422-BD, FX3U-485-BD, or FX3U-USB-BD is mounted, one communication special adapter FX3U-232ADP or FX3U-485ADP may be used.



Combination of high-speed input/output, analog and communication special adapters

When these adapters are used, connect the high-speed input/output special adapters on the left side of the main unit. The high-speed input/output special adapters cannot be connected on the downstream side of any communication/analog special adapter.



Summary

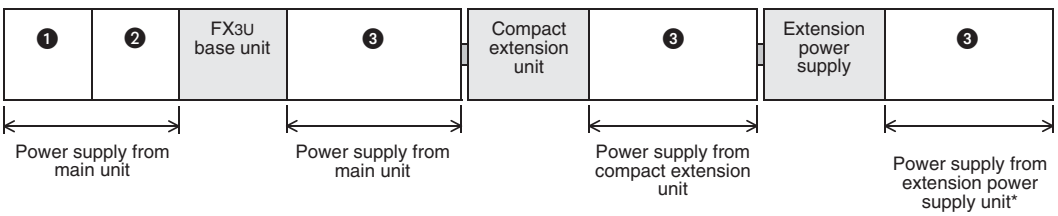
Mounted communication adapter board or interface adapter board	Number of connectable special adapters			
	Communication special adapter	Analog special adapter	High-speed input special adapter	High-speed output special adapter
No adapter board installed	These special adapters cannot connected.		2	2
FX3U-CNV-BD	2	4	2	2
FX3U-232-BD FX3U-422-BD FX3U-485-BD FX3U-USB-BD	1	4	2	2

2.10.2 Basic Rules for System Configuration

The following considerations should be taken into account when configuring a system with extension units or special function modules:

- Current consumption from 5 V DC backplane bus
- 24 V DC current consumption
- The total number of inputs and outputs point must be smaller than the number of max. I/Os.

The following figure shows the distribution of the power supply in case of an FX3U.



❶: Special adapter
❷: Communication board or interface board
❸: Modular extension block or special function module

* When connecting an **input** extension block on the downstream side of an extension power supply unit, this input extension block is supplied from the base unit or from an input/output powered extension unit which is mounted between base unit and extension power supply unit.

Calculation of current consumption

The power is supplied to each connected device from the built-in power supply of the main unit, the input/output powered extension unit or – for FX3U only– the extension power supply unit.

There are three types of built-in power supplies

– 5V DC

– 24V DC (for internal use)

– 24V DC service power supply (only in AC powered base units).

The following table shows the capacities of the built-in power supplies:

Model		5 V DC built-in power supply	24 V DC built-in power supply (internal / service power supply
Base units	FX1N	Suitable to power all connected modules	400 mA
	FX2N	290 mA	250 mA (FX2N-16M□, FX2N-32M□) 460 mA (all other base units)
	FX3U	500 mA	400 mA (FX3U-16M□, FX3U-32M□) 600 mA (all other base units)
Compact extension unit	FX2N	690 mA	250 mA (FX2N-32E□) 460 mA (FX2N-48E□)

When only input/output extension blocks are added, a quick reference matrix can be used.

When also special function modules are added, calculate the current consumption to ensure that the total current to be consumed by the additional modules can be supplied by the built-in power supply. For details of the power consumption please refer to section A.4.

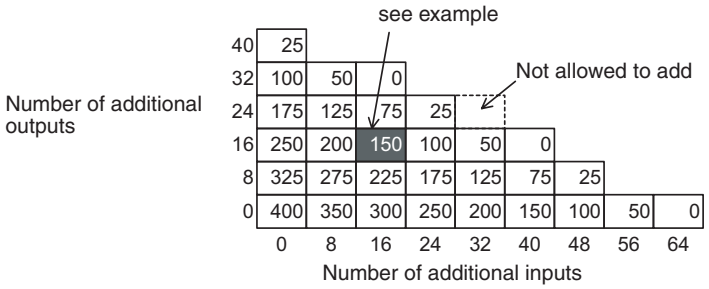
2.10.3 Quick Reference Matrixes

When only input/output extension blocks without a built-in power supply are added to a base unit, a quick reference matrix can be used. The following examples are valid for base units of the FX3U series.

AC powered base units

In the following quick reference matrixes, the value at the intersection of the number of input points to be added (horizontal axis) with the number of output points to be added (vertical axis) indicates the remaining power supply capacity.

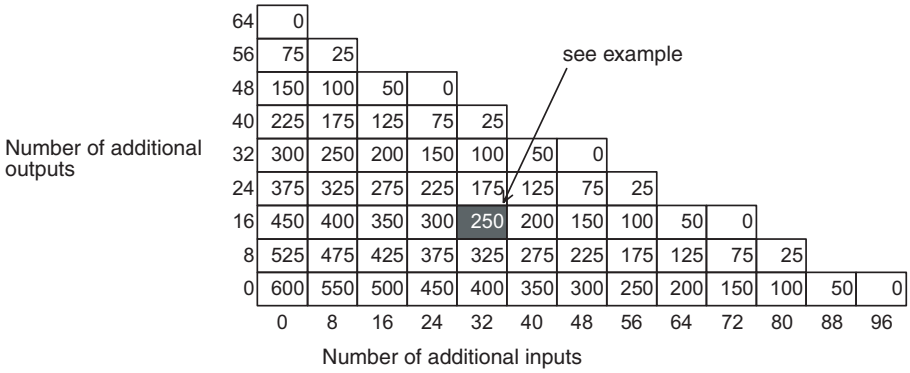
For FX3U-16MR/ES, FX3U-16MT/ES, FX3U-16MT/ESS, FX3U-32MR/ES, FX3U-32MT/ES or FX3U-32MT/ESS:



- Example

  When a 16-input and a 16-output point extension block are connected to a base unit FX3U-16M□ or FX3U-32M□, the residual current of the 24V DC service power supply is 150 mA.

For FX3U-48MR/ES, FX3U-48MT/ES, FX3U-48MT/ESS, FX3U-64MR/ES, FX3U-64MT/ES, FX3U-64MT/ESS, FX3U-80MR/ES, FX3U-80MT/ES, FX3U-80MT/ESS, FX3U-128MR/ES, FX3U-128MT/ES or FX3U-128MT/ESS:



- Example

  When a 32-input and a 16-output point extension block are connected to an AC powered base unit with 48, 64, 80 or 128 I/Os, the 24 V DC service power supply can still deliver a maximum current of 250 mA to other devices.

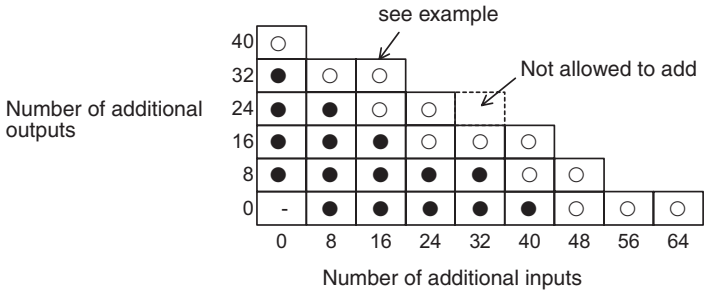
Confirm the current capacity of 24 V DC service power supply from the value shown in the quick reference matrix. This remaining power supply capacity (current) can be used as a power supply to external loads (sensors or the like) by the user. When special function modules are connected, it is necessary to consider whether they can be powered by the remaining power supply capacity.

DC powered base units

The DC power type main units have restrictions in expandable I/O points since they lack a built-in service power supply.

The following matrixes show the expandable units up to the ○ mark, where the desired inputs (horizontal axis) and outputs (vertical axis) intersect. System are expandable up to the ● mark when the supply voltage is 16.8 V to 19.2 V.

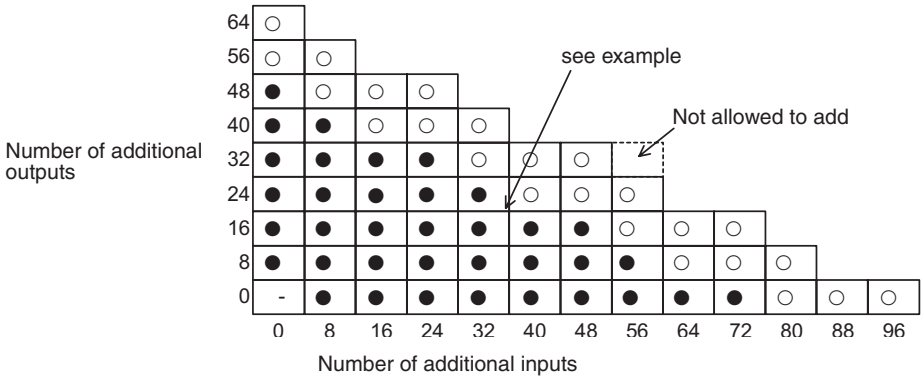
For FX3U-16MR/DS, FX3U-16MT/DS, FX3U-16MT/DSS, FX3U-32MR/DS, FX3U-32MT/DS or FX3U-32MT/DSS:



- Example

  When adding 16 inputs to a DC powered base unit with 16 or 32 I/O, a maximum of 32 outputs are expandable. When adding 16 inputs under the supply voltage 16.8 V to 19.2 V, a maximum of 16 outputs are expandable.

For FX3U-48MR/DS, FX3U-48MT/DS, FX3U-48MT/DSS, FX3U-64MR/DS, FX3U-64MT/DS, FX3U-64MT/DSS, FX3U-80MR/DS, FX3U-80MT/DS or FX3U-80MT/DSS:



- Example

  When adding 32 inputs to a DC powered base unit with 48, 64, or 80 I/Os, a maximum of 40 outputs are expandable. But when adding 32 inputs under the supply voltage 16.8 V to 19.2 V, a maximum of 24 outputs are expandable.

2.11 I/O Assignment

The assignment of the inputs and outputs in a PLC of the MELSEC FX family is fixed and can not be altered.

When power is turned on after input/output powered extension units/blocks have been connected, the main unit automatically assigns the input/output numbers (X/Y) to the units/blocks.

Therefore, it is unnecessary to specify the input/output numbers with parameters.

Input/output numbers are not assigned to special function units/blocks.

2.11.1 Concept of assigning

Input/output numbers (X/Y) are octal

The inputs and outputs of a PLC of the MELSEC FX family are counted in the octal numeral system. This is a base-8 number system and uses the digits 0 to 7.

The following table shows a comparison between some decimal and some octal numbers:

Decimal	Octal
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	10
9	11
10	12
11	13
12	14
13	15
14	16
15	17
16	20
:	:

Octal numbers are assigned as input/output numbers (X/Y) as shown below.

– X000 to X007, X010 to X017, X020 to X027....., X070 to X077, X100 to X107...

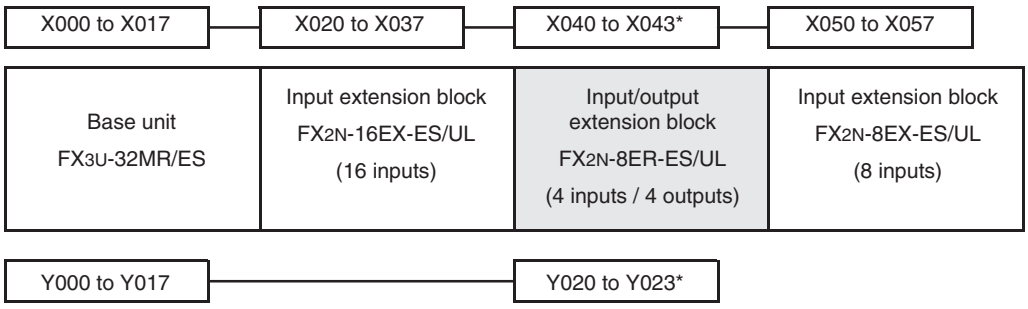
– Y000 to Y007, Y010 to Y017, Y020 to Y027....., Y070 to Y077, Y100 to Y107...

Numbers for added input/output unit/block

To an added input/output powered extension unit/block, input numbers and output numbers following the input numbers and output numbers given to the preceding device are assigned.

The last digit of the assigned numbers must begin with 0.

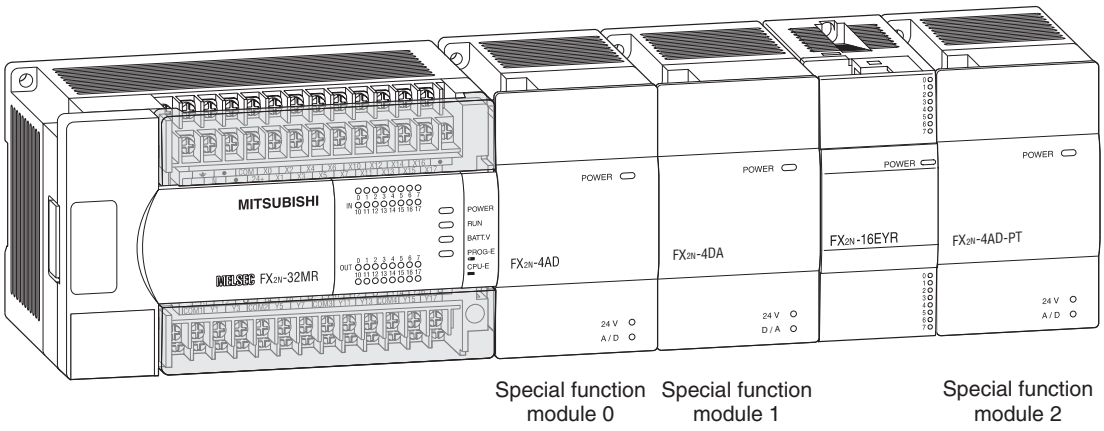
For example, when the last number on the preceding device is Y43, the output numbers are assigned to the next device starting from Y50.



* The inputs from X044 to X047 and the outputs from Y024 to Y027 are occupied by the FX2N-8ER-ES/UL, but they can not used.

2.11.2 Special function module address

Since you can attach multiple special function modules to a single base unit each module needs to have a unique identifier so that you can address it to transfer data to and from it. Each module is automatically assigned a numerical ID in the range from 0 – 7 (you can connect a maximum of 8 special function modules). The numbers are assigned consecutively, in the order in which the modules are connected to the PLC.



Special function module addresses are **not** assigned to the following products:

– Input/output powered extension units (e. g. FX2N-32ER-ES/UL or FX2N-48ET-ESS/UL)
– Input/output extension blocks (e. g. FX2N-16EX-ES/UL or FX2N-16EYR-ES/UL)
– Communication adapter (e.g. FX3U-CNV-BD)
– Interface adapter (e. g. FX3U-232-BD
– Special adapter (e. g. FX3U-232ADP)
– Extension power supply unit FX3U-1PSU-5V

3 Programming

3.1 Concepts of the IEC61131-3 Standard

IEC 61131-3 is the international standard for PLC programs, defined by the International Electromechanical Commission (IEC). It defines the programming languages and structuring elements used for writing PLC programs.

This system enables structured programs to be created using a high degree of modularisation. This provides increased efficiency, where tested programs and routines may be reused with a reduction of the number of programming errors.

Through use of structured programming techniques, IEC1131-3 eases fault finding procedures as individual operational program elements may be examined independently.

One important advantage of IEC61131-3 is that at assists in project management and quality control procedures. In particular, the structured methods encompassed within IEC61131-3 aid the **Validation** of processes incorporating PLC's. In fact, in some industries it is now considered mandatory to adopt this approach of structured programming. This is commonplace in the Pharmaceutical and Petrochemical industries where some processes can be considered safety critical.

It is considered, in some quarters that the IEC method of programming requires excessive work to create the final code. However, it is generally accepted that the advantages a structured approach has to offer over "un-structured" and "open" programming techniques makes IEC61131-3 a worthwhile advantage.

PLCopen

PLCopen is an independent vendor and product organisation that has been established in order to further the use of IEC61131-3 throughout users of Industrial Control Systems. This organisation has defined 3 levels of compliancy for the design and implementation of systems to IEC61131-3.

PLCopen has established:

- an accreditation procedure
- accredited test institutes
- development test software, shared amongst members
- a defined certification procedure
- members with certified products

This assures compliancy now, and in the future.

PLCopen Certification

IEC 61131-3

Mitsubishi's GX-IEC Developer is fully compliant with PLCopen to "**Base Level IL**" (Instruction List) and "**Base Level ST**" (Structured Text) and has been fully certified to these standards.

3.2 Software Structure and Definition of Terms

In the following section, the primary terms used within GX-IEC Developer will be defined:

- POU's
- GLOBAL VARIABLES
- LOCAL VARIABLES
- USER DEFINED FUNCTIONS & FUNCTION BLOCKS
- TASK POOL
- PROGRAM EDITORS:
  - Instruction List
  - Ladder Diagram
  - Function Block Diagram
  - Sequential Function Chart
  - Structured Text
  - MELSEC Instruction List

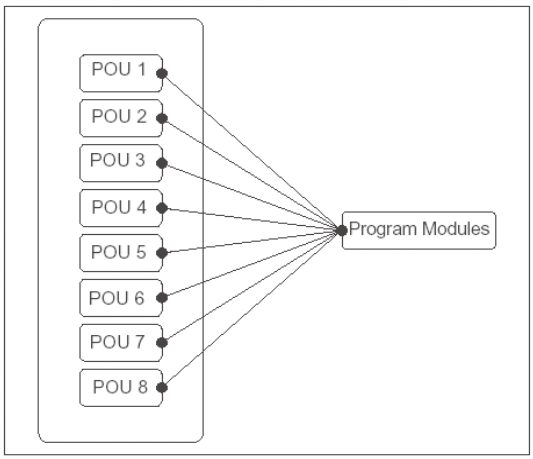
3.2.1 Definition of Terms in IEC61131-3

Projects

A Project contains the programs, documentation and parameters needed for an application.

POU - Program Organisation unit

The structured programming approach replaces the former unwieldy collection of individual instructions with a clear arrangement of the program into program modules. These modules are referred to as Program Organisation Units (POU's), which form the basis of the new approach to programming PLC systems.



Program organisation units (POU's) are used to implement **all** programming tasks.

There are three different classes of POU's, classified on the basis of their functionality:

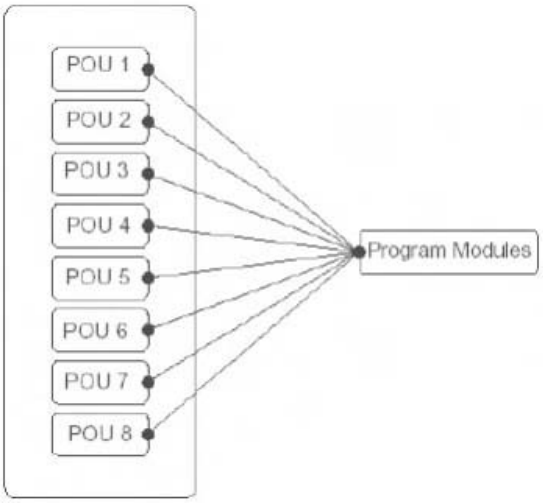
- Programs

- Functions
- Function Blocks

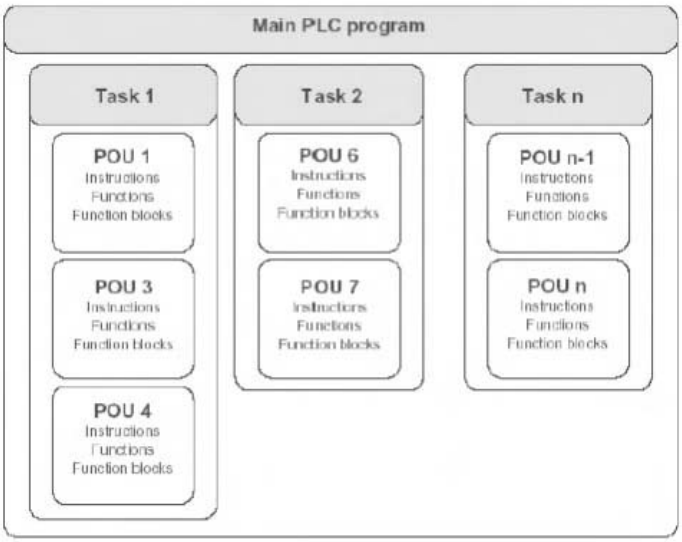
POU's declared as Function Blocks can be considered as **programming instructions in their own right** and they can be used as such in every module of your programs.

The final program is compiled from the POU's that you define as programs. This process is handled by the task management, in the Task Pool. Program POU's are put together in groups referred to as "**Tasks**".

Tasks

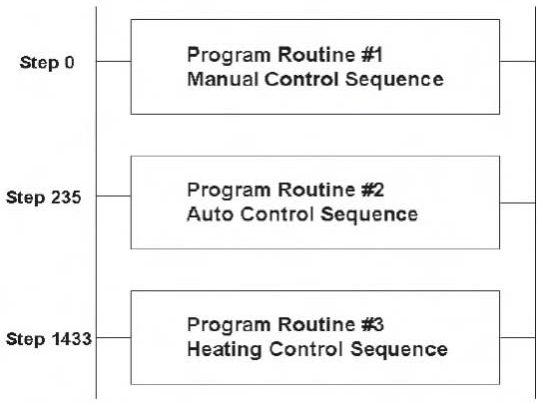


The Program POU's are grouped together in tasks



In turn, all the tasks are grouped together to form the actual PLC program.

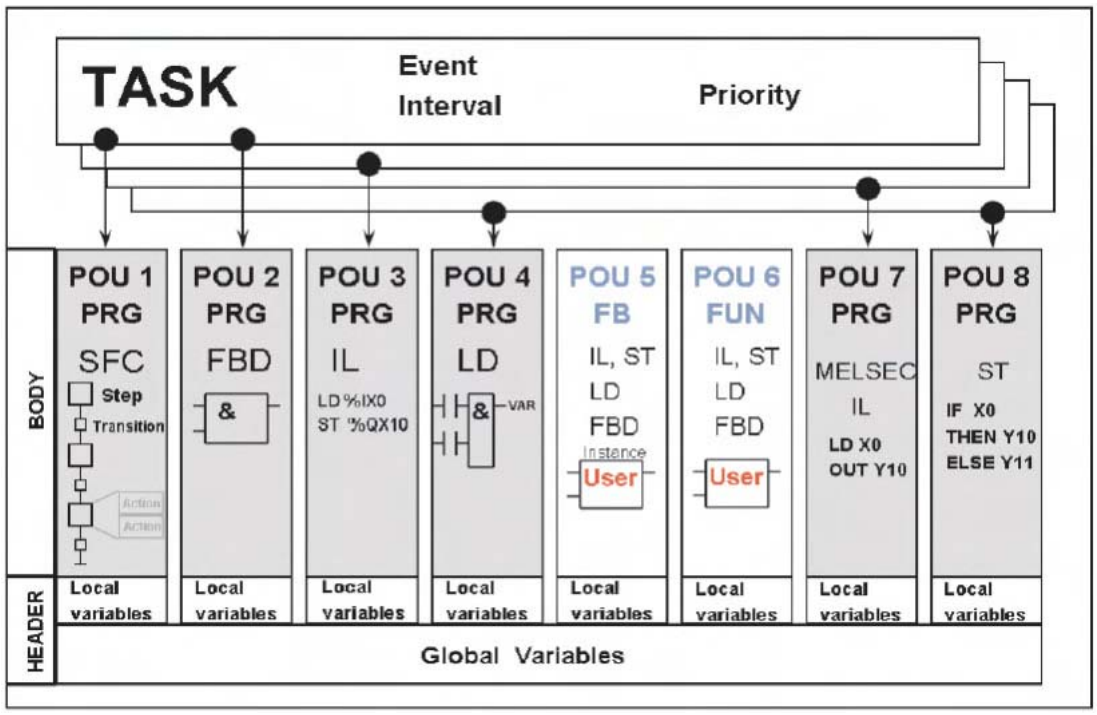
Most PLC programs consist of areas of code which perform specific tasks.They may form part of one large program, or be written in sub-routines, with program control instructions to select the current routine i. e. CALL, CJ etc.



Typical PLC program event sequence

In the above program, GX IEC Developer considers that each program routine which carries out a specific task to be a POU or program organisation unit.

Each POU can be written using any of the supported editors i.e. LD, IL, FBD, SFC, ST as shown below:



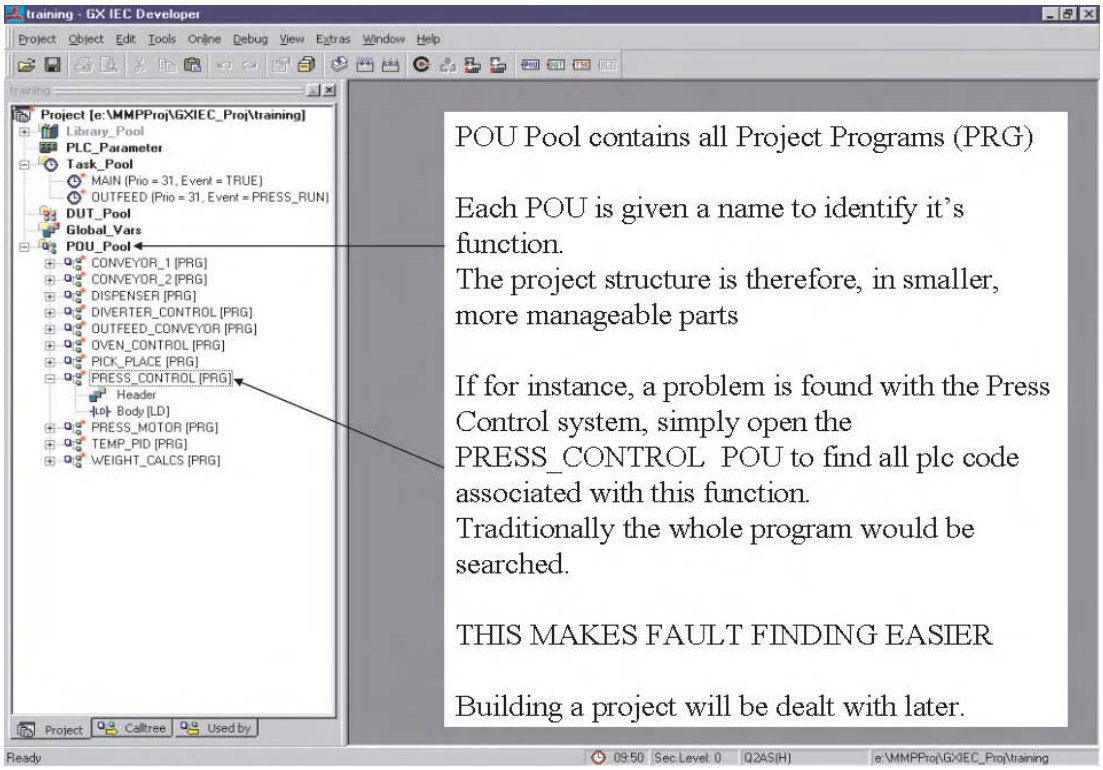
Overall Project Configuration illustrating POU integration using SFC, FBD, IL, LD and MELSEC IL and ST format programs.

POU Pool

A Project will consist of many POU's, each providing a dedicated control function and held in a POU Pool. Each POU could be written in any of the IEC editors. Therefore in any given project, the best language for the required function can be chosen. The compiler will assemble the project into code the PLC can understand but the user interface remains as written.

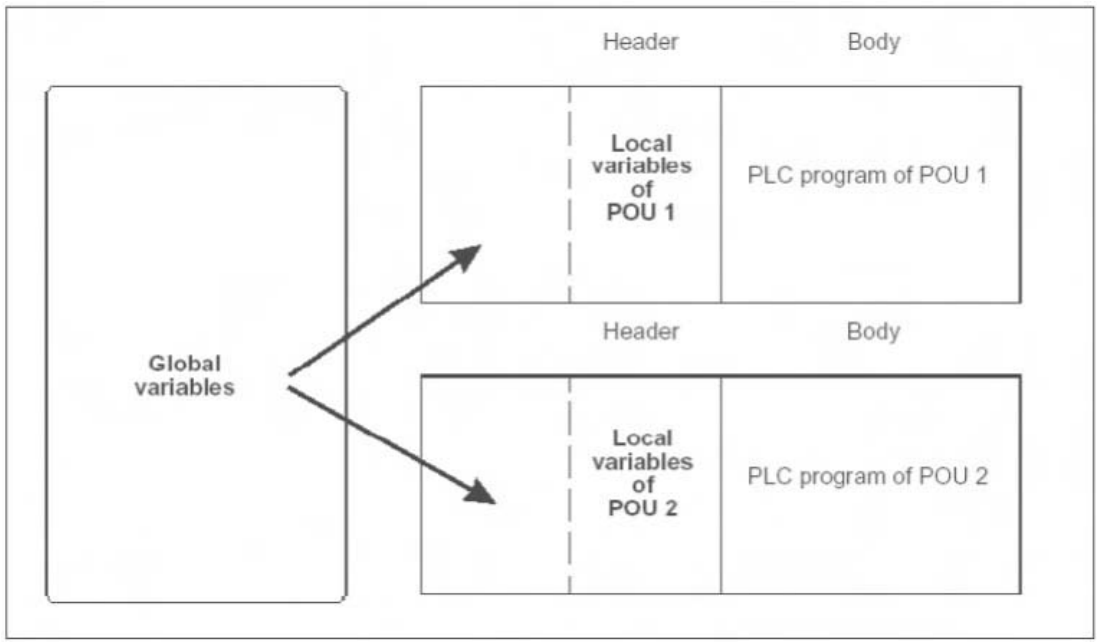
In this way, perhaps complicated interlocking routines, could be written in a ladder POU, whilst complex calculations or algorithms, might be better suited to one of the textual, or FDB editors.

It is the choice of the designer/user but this environment allows flexibility.



Above an example of the GX-Developer display is shown illustrating an example POU Pool.

Composition of a POU



Definition of Variables – GLOBAL and LOCAL

- Variables

  Before a program can be constructed, it must be decided what variables are going to be required in each particular program module. Each POU has a list of Local Variables, which are defined and declared for use only for use within a particular POU. Global Variables can be used by all the POU's in the program and are declared in a separate list.

- Local Variables

  When program elements are declared as Local Variables, GX IEC Developer, automatically, uses some of its System Variables, as appropriate storage devices within a specific POU. These variables are exclusive to each POU and are not available to any other routine within a project.

- Global Variables

  Global Variables can be regarded as "shared" variables and are the interface to physical PLC devices. They are made available to all POU's and reference an actual physical PLC I/O or named internal devices within the PLC. External HMI and SCADA devices may interface with the user program using Global Variables.

IEC61131-3 Verses MELSEC Variables

GX IEC Developer supports program creation, using either symbolic declarations (tag names), or absolute Mitsubishi addresses (X0, M0 etc), assigned to the program elements.

The use of symbolic declarations complies with IEC 61131.3.

If symbolic declarations are used, then the tag names must be cross referenced to real PLC addresses.

Local Variable List

For a particular POU to access a Global Variable, it must be declared in its Local Variable List (LVL), in the POU Header.

The LVL can be made up of both Global Variables and Local Variables.

A Local Variable can be thought of as an intermediate result, i.e. if the program performs a five stage calculation, using three values and ending with one result, traditionally, the programmer would construct software, which produced several intermediate results, held in data registers before ending with the final register result.

It is likely that these intermediate results, serve no purpose other than for storage and only the final result is used elsewhere.

With GX IEC Developer, the intermediate results can be declared, as Local Variables and in this case, only the original three numbers and the result, declared as Global Variables.

The Global Variable List

The Global Variable List (GVL) provides the interface for all names, which relate to real PLC addresses, i.e. I/O data registers etc.

The GVL is available and can be read by all POU's created in the project.

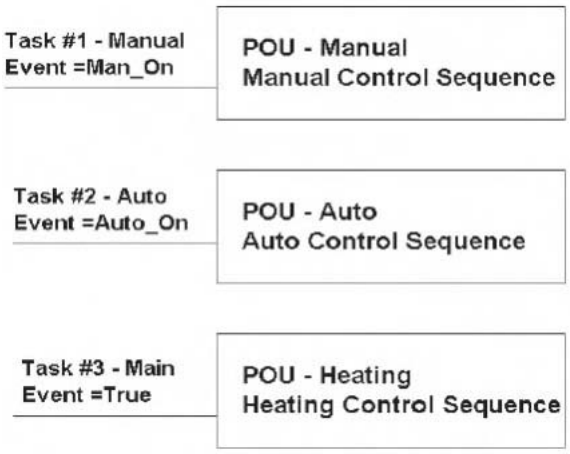
Task Pool and Task Manager

If we now think of our routines as POU's written for each function and given names, we can create a Task for each of our assigned POU's.

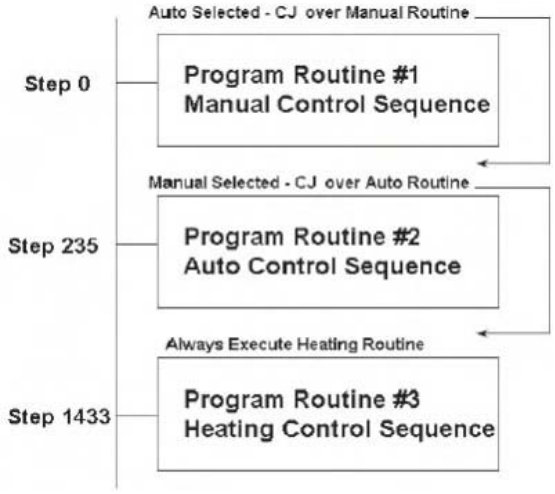
Each Task can have different operating conditions, or events.

- Task #1 only runs when a tag named, 'Man_On' is true.
- Task #2 only runs when a tag, named, 'Auto_On' is true.
- Task #3 runs all the time (event = True denotes this)

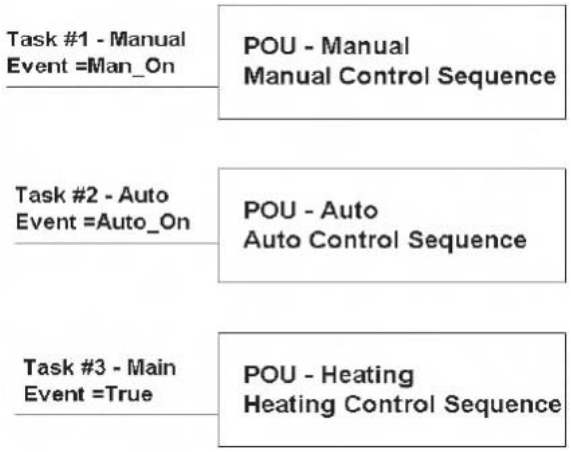
These tag names would be declared as Global Variables and assigned to PLC bit devices (they could be addresses i.e. X0).



Consider our original control program. Conditional Jump (CJ) instructions could be used to isolate, either routines #1 or #2, when not in use. The Heating control routine is always required to run.



If these routines are considered as tasks, then routines #1 & #2, are driven by event, i.e. when either auto or manual is selected, whereas, routine #3 is always on.



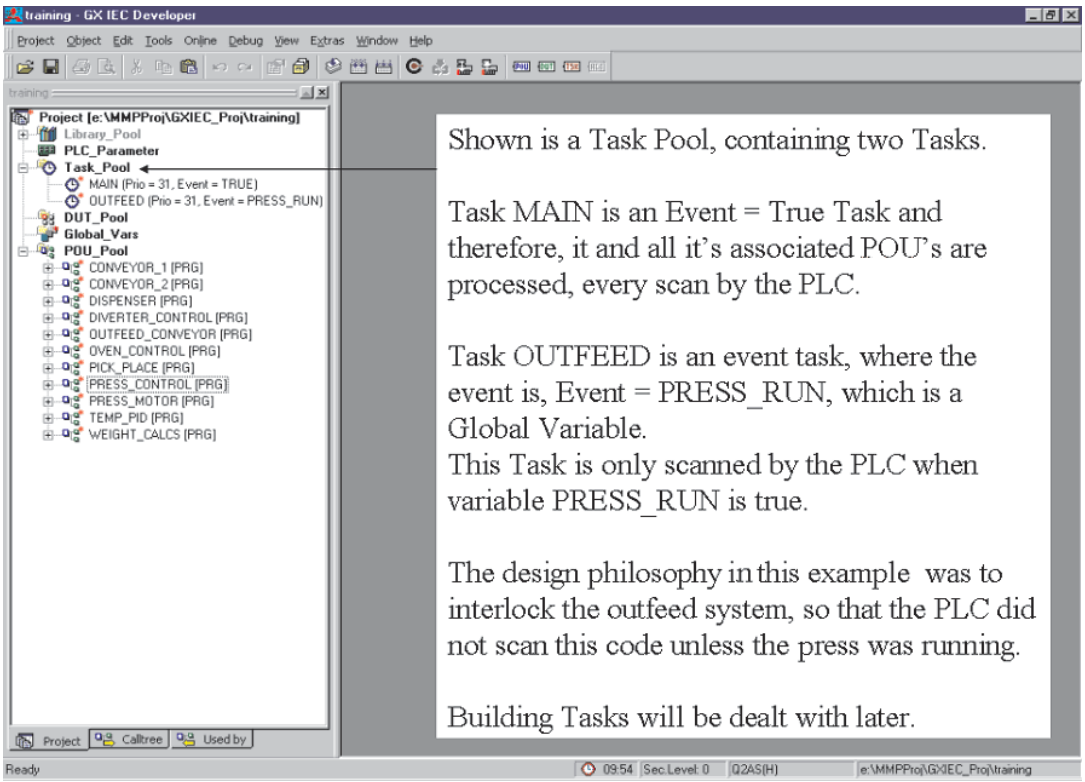
When GX IEC Developer compiles the project, it automatically inserts, program branching instructions, into the program, in line with event driven tasks.

A Task can have more than one POU assigned to it, typically, a task where Event = True, would contain all POU's which needed to operate every scan of the PLC. A POU of a particular name cannot be assigned to more than one task in any one project.

NOTE

Any POU's **not** assigned to Tasks, ARE NOT SENT TO THE PLC during program transfer. Don't forget – this applies to the default download. Tasks can be prioritised, either on a time or interrupt basis.

The **Task Pool** contains all the assigned tasks in the project.



The **Task Manage**r allows the user to efficiently manage the PLC scan, ensuring that only the routines that require scanning are executed. It also provides an easy method of allocating specific routines to events and timed or priority interrupts.

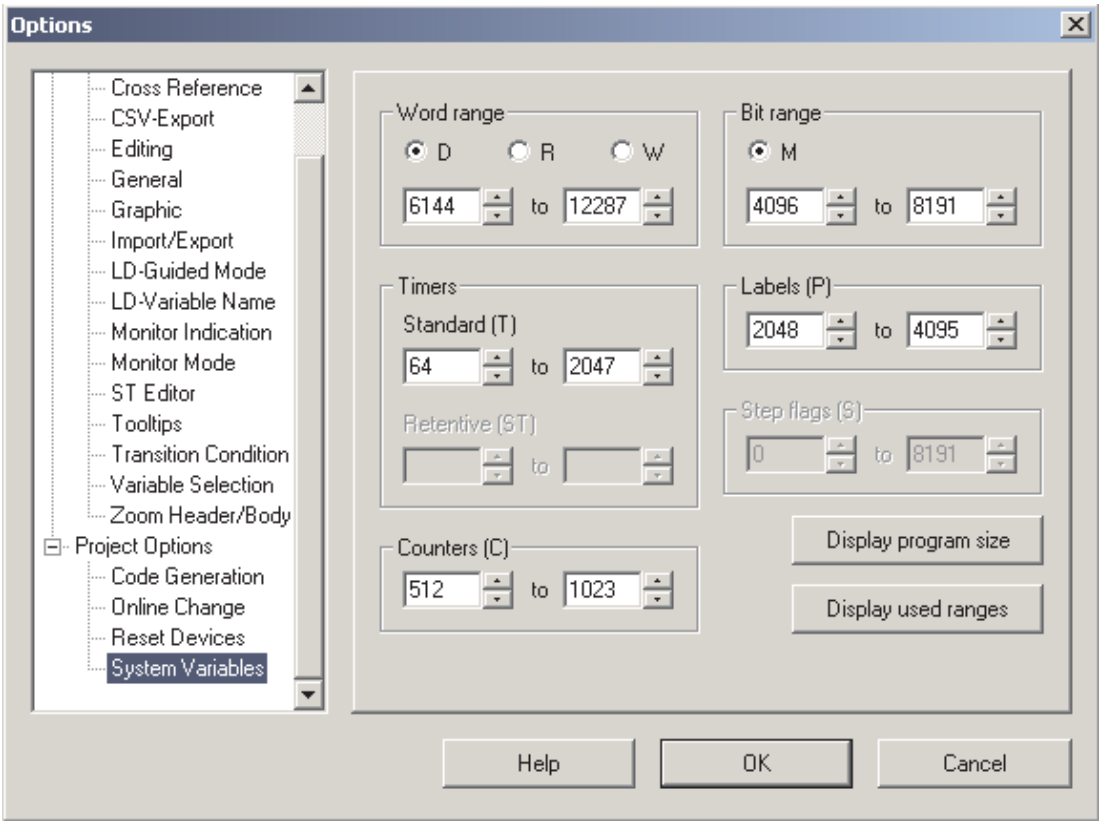
The software engineer need only be concerned about the program content, not whether the branch instructions are correct and obey the rules.

Machines/processes, consisting of standard parts, can have individual POU's written for each part. The full machine may consist of many POU's.

For each variant of the machine, the supplier can choose to assign to the Task Manager, only the relevant POU's, for that machine, as only POU's assigned will be transferred to the plc on download.

3.2.2 System Variables

The device ranges that GX IEC Developer allocated to system variables can be edited here. This feature is displayed using the ***Options*** command under the ***Extras*** menu:



Systen variable ranges for the actual project. Available if an Q/QnA project is open.

- Word range

  D: D devices are used as word system variables.

  R: R devices are used as word system variables.

  W: W devices are used as word system variables.

  From/to: PLC type dependant, as defined in the parameters.

- Timers

  Standard (T) – From/to: PLC type dependant, as defined in the parameters.

  Retentive (ST) – From/to: PLC type dependant, as defined in the parameters.

- Counters (C)

  From/to: PLC type dependant, as defined in the parameters.

- Bit range

  M: M devices are used as bit system variables.

  From/to: PLC type dependant, as defined in the parameters.

- Labels (P)

  From/to: PLC type dependant, as defined in the adequate CNF file

- Step flags (S)

  From/to: PLC type dependant, as defined in the adequate TYP file

- Display program size

  A summary of the used program size is displayed on a separate dialog box. If the program is not compiled the dialog shows a "?" character instead of the program size. If SFC or SUB programs are not available for this CPU, the correspondent line will be grayed.

- Display used ranges

  A summary of the used system variables ranges is displayed on a a separate dialog box.

3.2.3 System Labels

System Labels, shown in the system variable list in chapter 3.2.2 are used by GX IEC Developer for internal management of the project. GX IEC Developer allocates system labels for the following:

- Network Labels
- Event Driven Task (not EVENT = TRUE)
- User Defined Function blocks (one per function block - unless Macro Code)
- System Timers (These are used by the Task Manager, for interval triggered tasks and local Timers.)

Used System Devices

To read GX IEC Developer's device allocation to system variables usage, the ***Display used ranges*** button should be clicked and the following notification will be displayed:

3.3 Programming Languages

GX IEC Developer provides separate editors for all the following programming languages, which can be used to program the bodies of your programs:

Text Editors

- Instruction List (IEC and MELSEC)
- Structured Text

Graphic Editors

- Ladder Diagram
- Function Block Diagram
- Sequential Function Chart

With the exception of the Sequential Function Chart language, all the editors divide PLC programs into sections, referred to as "Networks". These Networks can be given names (labels), which can consist of up to a maximum of 8 characters terminated with a colon (:). These networks are numbered consecutively and can be used as destinations for branching commands.

3.3.1 Text Editors

Instruction List (IL)

The Instruction List (IL) work area is a simple text editor with which the instructions are entered directly.

An Instruction List consists of a sequence of statements or instructions. Each instruction must contain an operator (function) and one or more operands. Each instruction must begin in a new line. You can also add optional Labels, Modifiers and comments to each instruction.

Two different types of Instruction List are used:

- IEC Instruction List

  IEC Instruction Lists are entered and edited in exactly the same way as MELSEC Instruction Lists. The following programming differences need to be observed, however:

  – MELSEC networks in IEC IL

    You can include MELSEC networks in IEC Instruction Lists, thus providing access to the MELSEC system instructions.

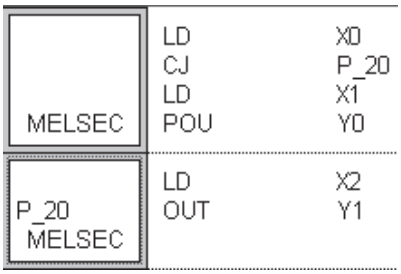
  – The accumulator

    The accumulator is a result management system familiar from high-level languages. The result of every operation is stored in the bit accumulator directly after execution of the instruction. The accumulator always contains the operation result of the last instruction executed. You do not need to program any input conditions (execution conditions) for the operations; execution always depends on the content of the accumulator.

For more information about IEC Instruction List, please refer to chapter 16.

- MELSEC Instruction List

  MELSEC Instruction Lists are entered and edited in exactly the same way as IEC Instruction Lists. However, you can only use the MELSEC instruction set; IEC standard programming is not possible.



Example of a MELSEC Network

Structured Text

Structured Text is a helpful tool. Especially programmers coming from the PC world will enjoy this tool. If they program carefully and think about the way of working by PLC, they will be glad with this editor.

The Structured Text editor is compatible to the IEC 61131-3, all requirements are fulfilled.

```
(*Example showing Structured Text*)

Y00:=X00;
Y01:=X01 AND X02 OR X03;
M0:=(M1 AND (M2 OR M3)) OR X04;
```

Example for Structured Text

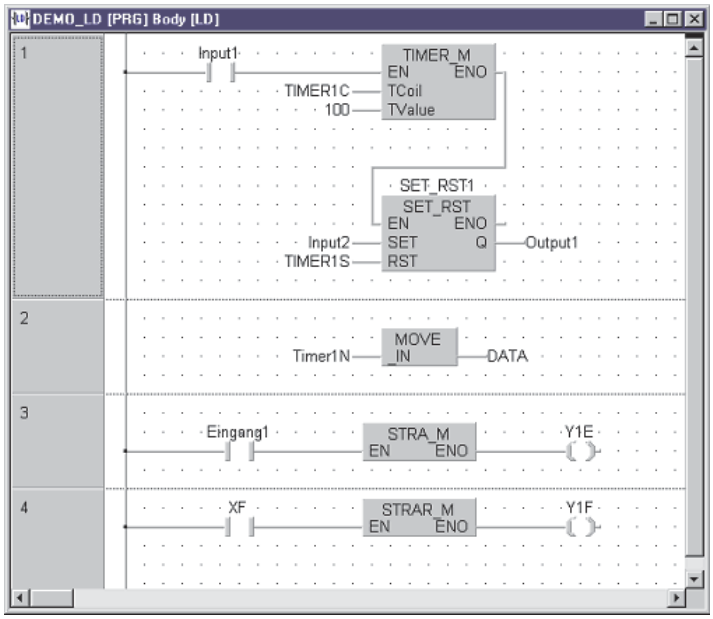
An example of Structured Text programming is given in chapter 17.

3.3.2 Graphic Editors

Ladder Diagram

A Ladder Diagram consists of input contacts (makers and breakers), output coils, function blocks and functions. These elements are connected with horizontal and vertical lines to create circuits. The circuits always begins at the bus bar (power bar) on the left.

Functions and function blocks are displayed as blocks in the diagram. In addition to the normal input and output parameters, some blocks also have a Boolean input (EN = ENable) and output (ENO = ENable Out). The status at the input always corresponds to that at the output.



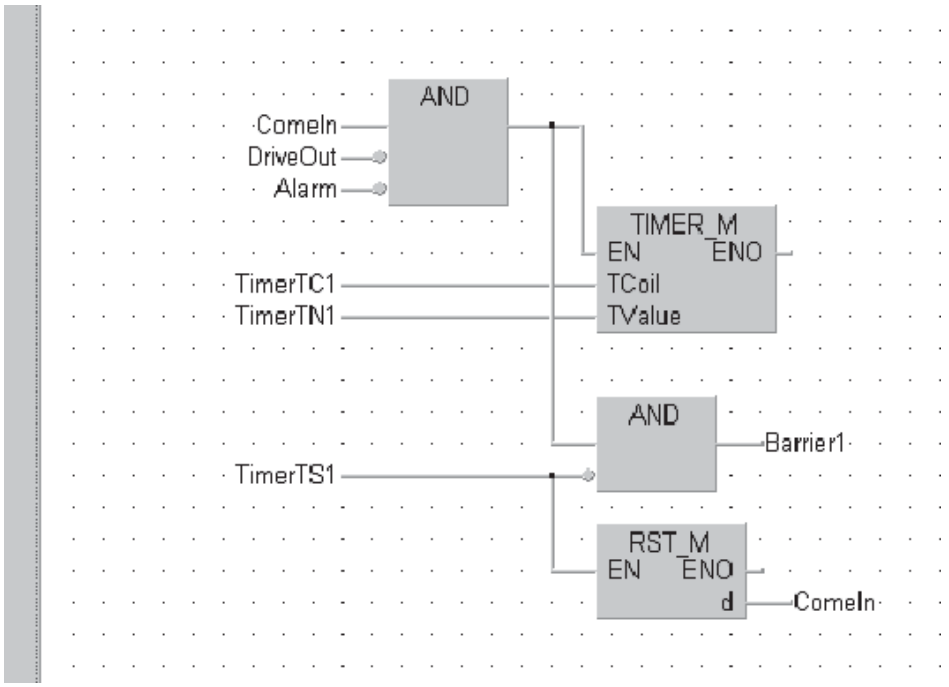
Example for Ladder diagram

Function Block Diagram

All instructions are implemented using blocks, which are connected with one another with horizontal and vertical connecting elements. There are no power bars.

In addition to the normal input and output parameters, some blocks also have a Boolean input (EN = ENable) and output (ENO = ENable Out). The status of the input always corresponds to the output status.

Example for Function Block Diagram:

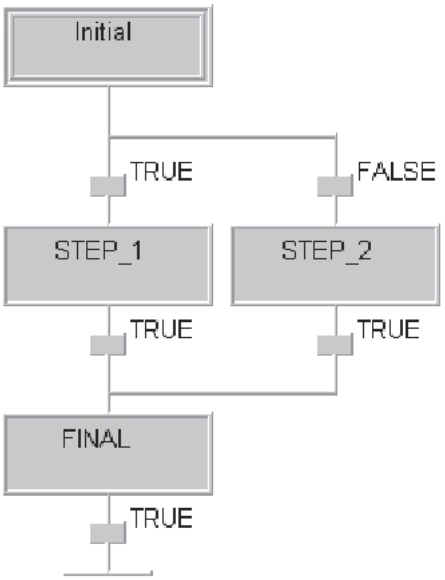


Sequential Function Chart

Sequential Function Chart is one of the graphical languages. It can be regarded as a structuring tool with which the sequential execution of processes can be represented clearly and comprehensible.

The only possible program organisation unit in SFC is the program.

Sequential Function Chart has two basic elements, Steps and Transitions. A sequence consists of a series of steps, each step separated from the next by a transition. Only one step in the sequence can be active at any one time. The next step is not activated before the previous step has been completed and the transition is satisfied.



Example for Sequential Function Chart

3.4 Data Types

GX IEC Developer supports the following data types.

3.4.1 Simple Types

Data type		Value range		Size	Applicable Devices / PLCs
BOOL	Boolean	Bit Device	0 (False), 1 (True)	1 bit	X, Y, M, B
INT	Integer	Register	-32768 to +32767	16 bit	D, W, R
DINT	Double Integer		-2,147,483.648 to 2,147,483,647	32 bit	
WORD	Bit String	K4M0	0 to 65,535	16 bit	X, Y, M. B
DWORD		K8M0	0 to 4,294,967,295	32 bit	
REAL	Floating point value	7 digits		32 bit	FX2N, FX3U
STRING	Character String	20 Characters (default)		32 bit	FX3U
TIME	Time value	-T#24d0h31m23s64800ms to T#24d20h31m23s64700 ms		32 bit	All controllers of the FX family

3.4.2 Complex Data Types

ARRAYS

An array is a field or matrix of variables of a particular type.

For example, an **ARRAY [0..2] OF INT** is a one dimensional array of three integer elements (0,1,2). If the start address of the array is D0, then the array consists of D0, D1 and D2.

Identifier	Address	Type	Length
Motor_Volts	D0	ARRAY	[0...2] OF INT

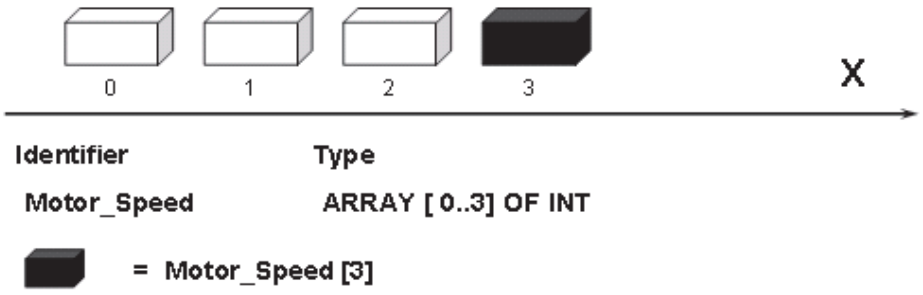
In software, program elements can use: Motor_Volts[1] and Motor_Volts[2], as declarations, which in this example mean that D1 and D2 are addressed.

Arrays can have up to three dimensions, for example: ARRAY [0...2, 0...4] has three elements in the first dimension and five in the second.

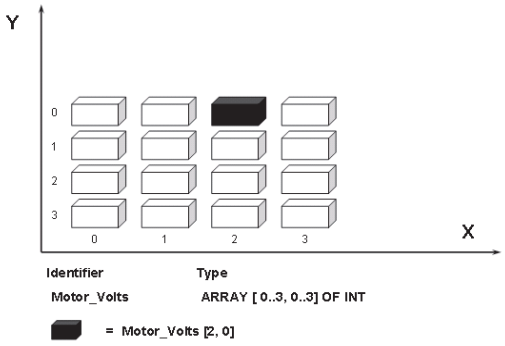
Arrays can provide a convenient way of 'indexing' tag names, i.e. one declaration in the Local or Global Variable Table can access many elements.

The following diagrams illustrate graphical representation of the three array types.

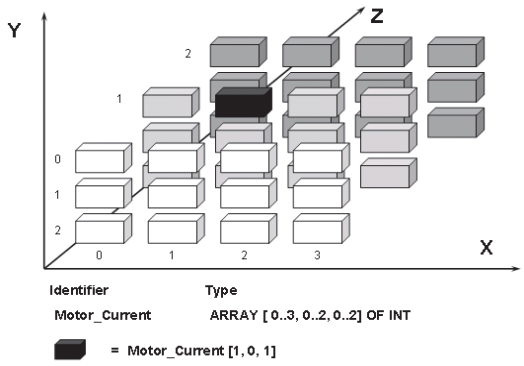
Single Dimensional Array



Two Dimensional Array



Three Dimensional Array



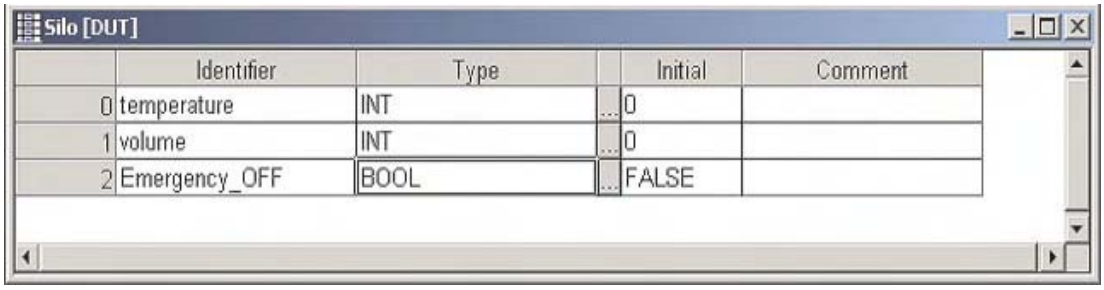
Data Unit Types (DUT)

User defined Data Unit Types (DUT), can be created. This can be useful for programs which contain common parts, for example; the control of six identical silos. Therefore a data unit type, called ‘Silo’ can be created, composing patterns of different elements, i.e. INT, BOOL etc.

When completing a global variable list, identifiers of type Silo can be used. This means that the predefined group called ‘Silo’ can be used with the elements defined as required for each silo, thus reducing design time and allowing re-use of the DUT.

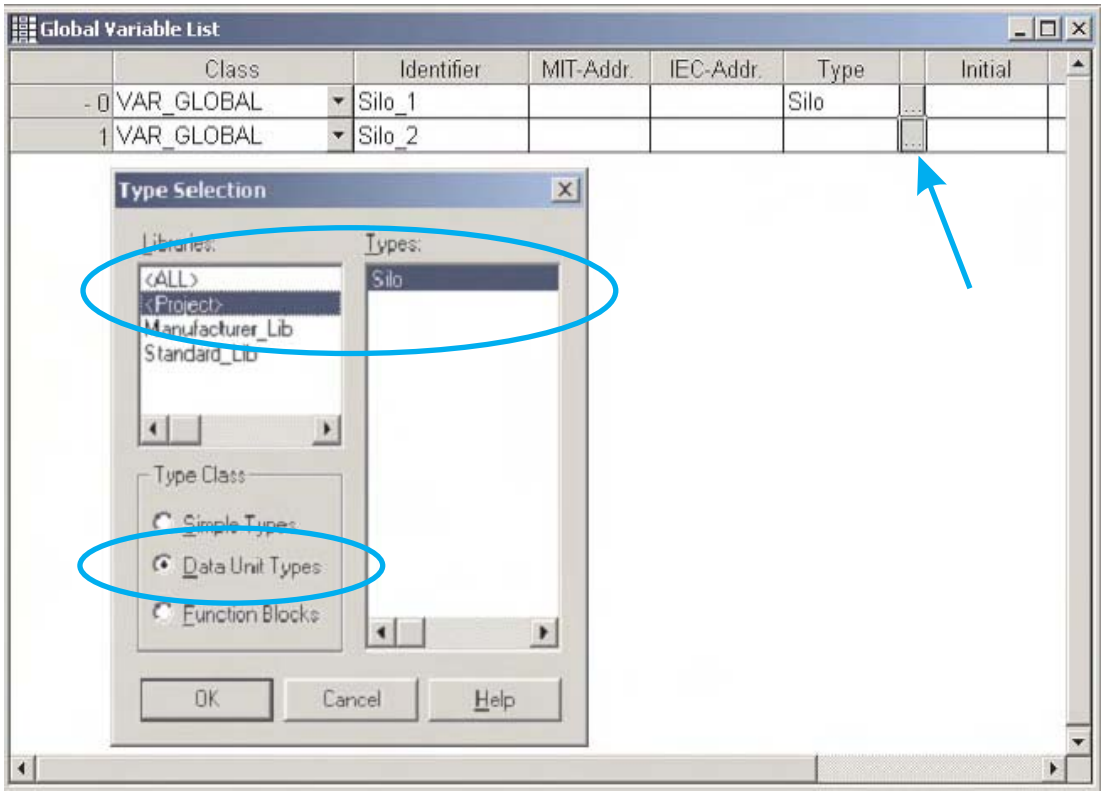
Example use of a DUT

The following example shows the creation of a data type called Silo. The variable collection of Silo contains two variables of the INT and one variable of the type BOOL.

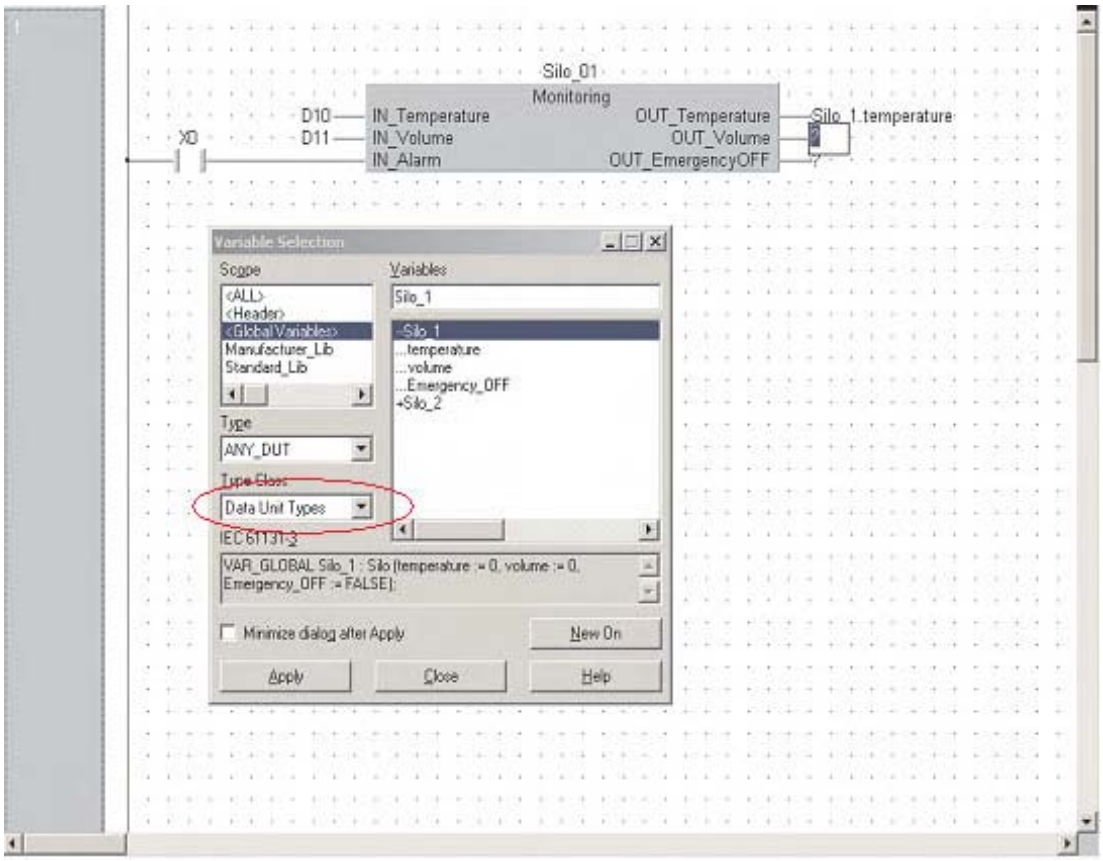


How to declare the DUT

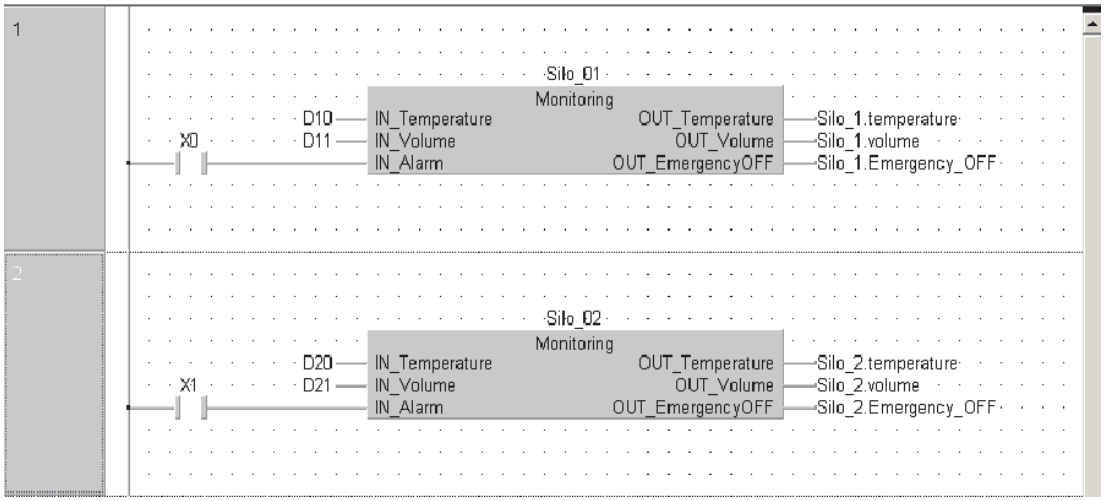
Double-click on ***Global_Vars*** in the Project Navigator window and enter the following lines in the global variables declaration table.



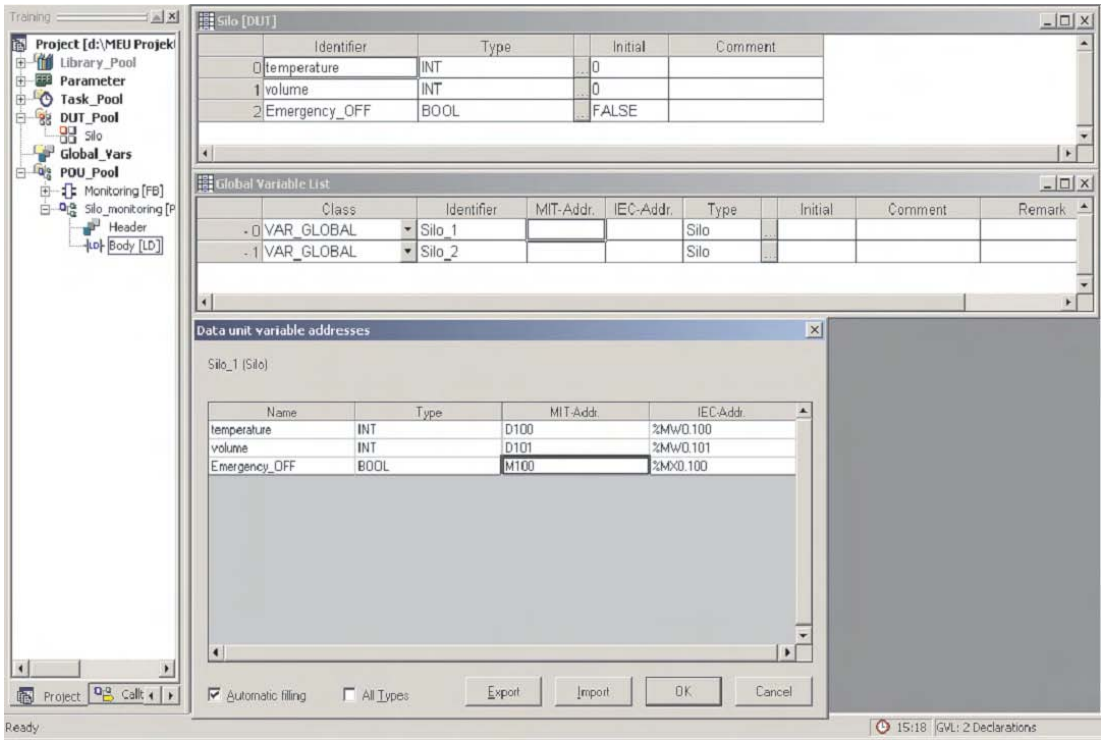
The variables are stored in the Global Variable List. The structure of both variables, Silo_1 and Silo_2, is identical, so to reference the individual variable of each DUT you only need to prefix their names with the name of the respective global variable.



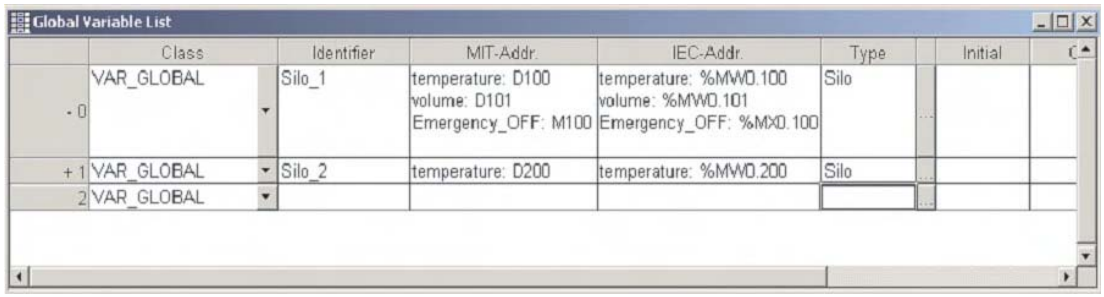
In this example a function block of the type “Monitoring” has been programmed for assigning the register value and the Boolean input to the elements of the DUTs. Two separate instances (Silo_01 and Silo_02) of this function blocks were then created for two silos.



The GVL has been extended to define addresses for all elements of data unit types. Not defined addresses are handled by the system.



To view all definitions at once (if more than one definition is available), DUT entries in the GVL can be expanded by double-clicking the row number field.



3.4.3 MELSEC Timers and Counters

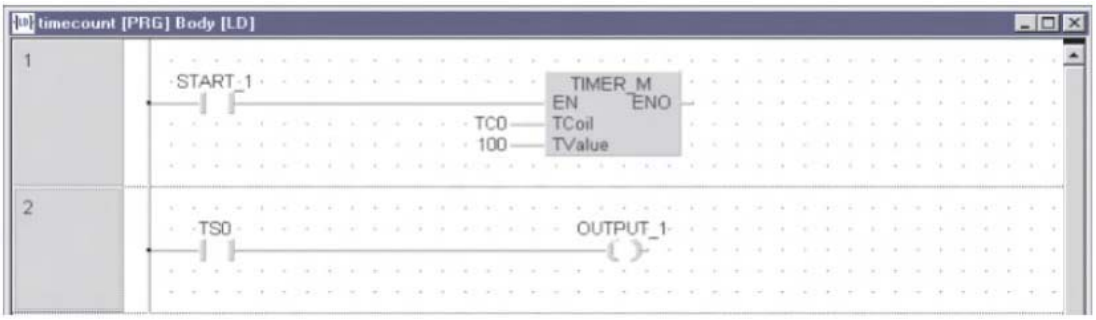
When programming standard Timers/Counters, an IEC convention must be observed:

Timer/Counter **Coil** is programmed: **TCn / CCn**

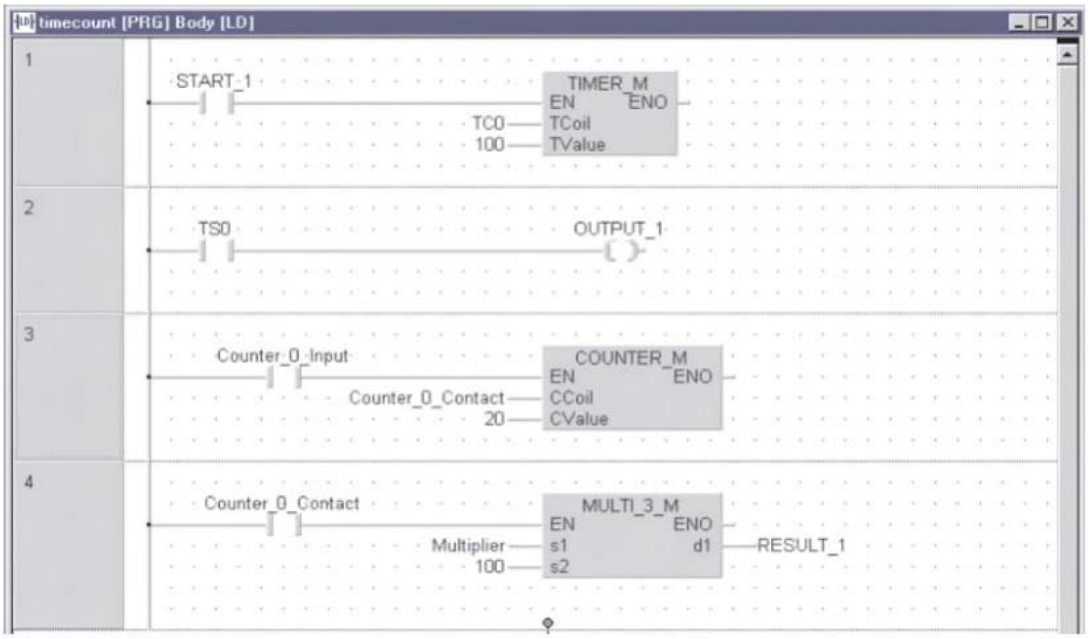
Timer/Counter **Contact** is programmed: **TSn / CSn**

Timer/Counter **Value** is programmed: **TNn / CNn**

In the following example T0 becomes TC0 and TS0. In this case Mitsubishi addresses have been used, it is therefore vital to check the System Variable default T/C usage:



In the following example, the counter has been programmed using identifiers which would have to be declared in the Global and Local Variable tables:



4 Building a Project

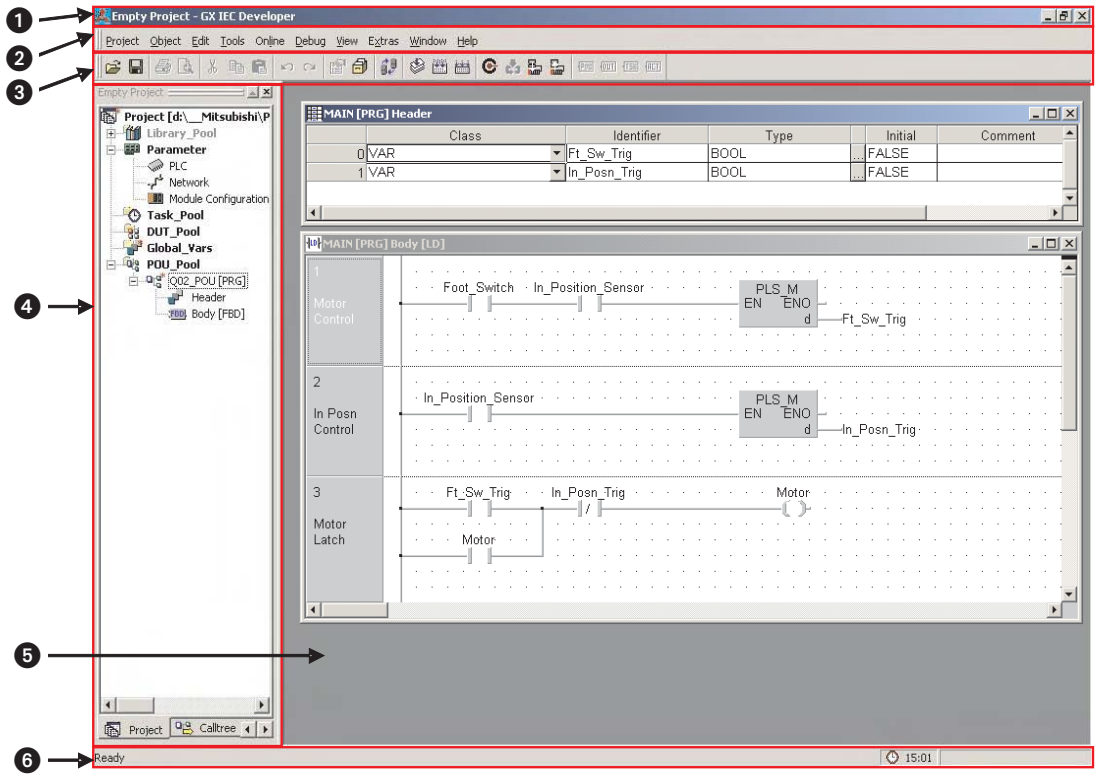
In the next section, we will build our first project, initially using the Ladder Diagram editor.

Topics covered

- Using the Project Navigator
- Using the GVL with identifiers
- Declaring variables in the Program Header
- Creating programs with the IEC ladder editor
- Programming IEC Timers/Counters
- Commenting and Documentation
- Downloading and Monitoring

4.1 Starting GX IEC Developer

After starting GX-IEC Developer from Windows, the following window will be displayed:



❶ Application Title Bar

The Application title bar gives you the name of the open project.

❷ Menu Bar

The Menu Bar provides access to all the menus and commands used to control GX IEC Developer. When you select one of the entries in the bar by clicking with the mouse, a menu of options drops down. Options marked with an arrow contain submenus, which are displayed with additional options when you click on them. Selecting commands normally opens a dialog or entry box.

GX IEC Developer' menu structure is context-sensitive, changing depending on what you are currently doing in the program. Commands displayed in light grey are currently unavailable.

❸ Tool Bar

The Tool Bar icons give you direct access to the most-used commands with a single mouse click. The Tool Bar is context-sensitive, displaying a different collection of icons depending on what you are currently doing in the program.

❹ Project Navigator Window

The Project Navigator is the control centre of GX IEC Developer. The Project Navigator window is not displayed until you open an existing project or create a new one.

❺ Editor (Body)

In this area the POUs can be edited. Each POU consists out of a Header and a Body.

– Header

  A header is an integral part of a program organisation unit (POU). It is the place where the variables to be used in the POU must be declared.

– Body

  A body is an integral part of a program organisation unit (POU). It contains the code elements and syntax of the actual program, function block or function.

❻ Status Bar

This bar displayed at the bottom of the screen gives you useful information on the current status of your project. Status Bar display can be enabled or disabled, and you can also configure the individual display options to suit your needs.

4.2 Application Program

4.2.1 Example: Carousel Indexer

The following application program will be used to illustrate the creation of a simple program using the tools of GX IEC Developer.

Operational Sequence

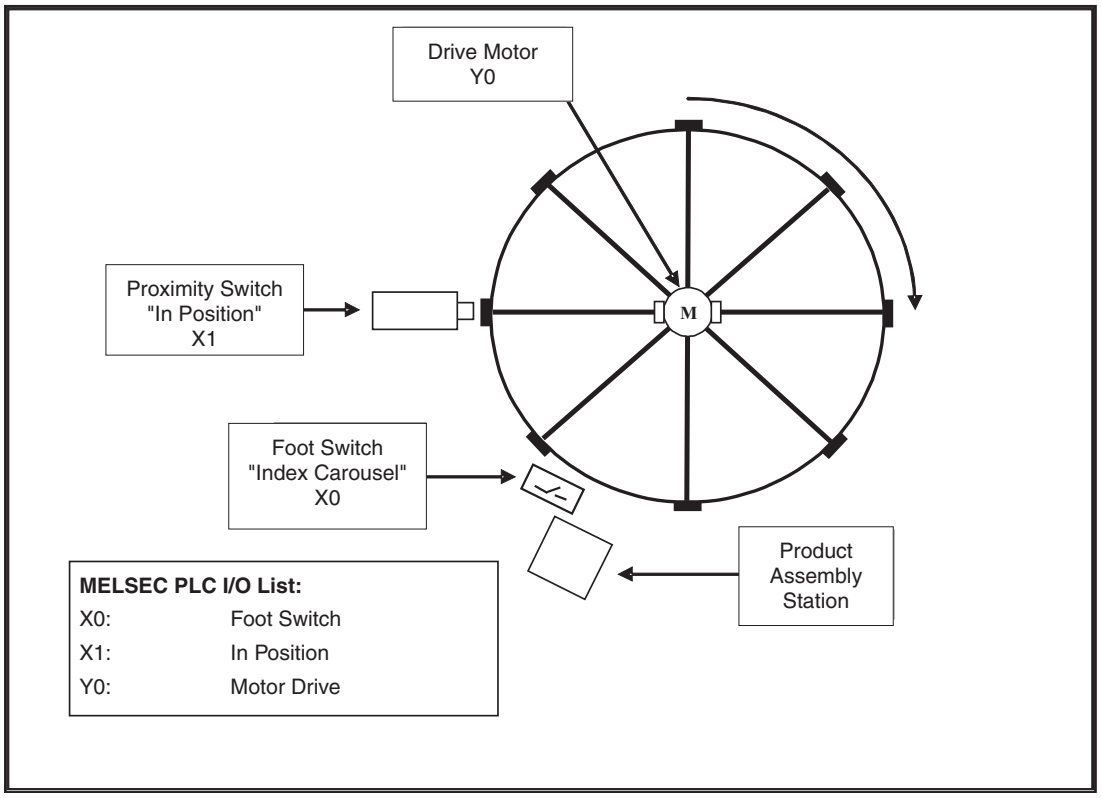
① Momentarily operate foot switch to index carousel.

② Carousel rotates – 'In-Position' sensor turns OFF as carousel begins rotating.

③ 'In-Position' sensor turns ON when carousel reaches index position.

④ Assemble product

⑤ Repeat process (Go back to ①.)



There are a number of issues that must be addressed when designing a PLC program for the above application. Using a standard Start / Stop circuit is not possible without modification due to the following difficulties:

- The foot switch may be operated at random. Once activated, it may be possible for the operator to forget to release the switch which may cause the table to continue to rotate past its index position.
- Once "In-Position" X1 operates, it remains on, thus the table is prevented from re-indexing.

The design must therefore contain interlocks to prevent miss-operation as described above. An alternative approach to the design would suggest the use of 'Pulse Transition Logic' by means of the IEC or MELSEC "Edge Triggered" configurations.

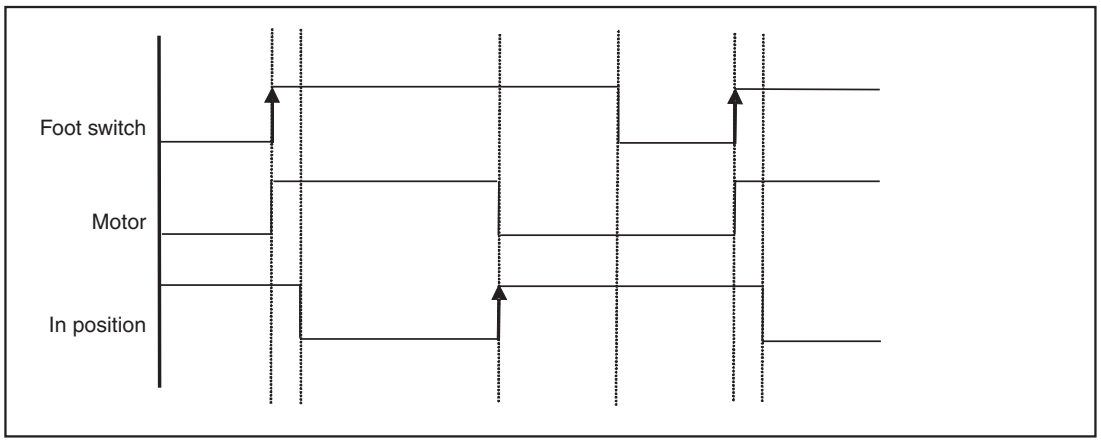
The most appropriate command to use in this application is the MELSEC ‘PLS’ (Rising edge Pulse). It has been adopted here instead of the IEC instruction R_TRIG (Rising edge Trigger) instruction, which would also be suitable.

The following diagram illustrates the order of sequencing of the carousel control. Note that the rising edge of the foot switch triggers the motor ON, irrespective of the “In Position” sensor being ON.

When the table begins rotating, the “In position” sensor turns OFF a little later. The motor continues to drive the carousel conveyer until the rising edge of the “In Position” sensor is detected; this turns the motor OFF. Note that the foot switch continues to be held on.

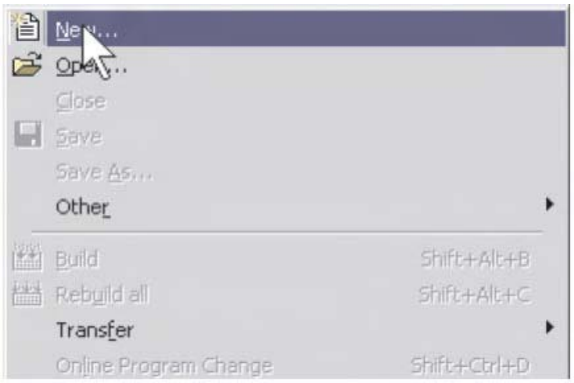
The Motor can only start rotation when the foot switch is released and subsequently reactivated. Hence the motor starts again on the rising edge of the Foot Switch being operated.

Timing Diagram of Carousel Control Logic:

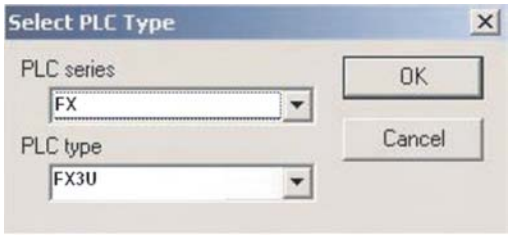


4.2.2 Creating a New Project

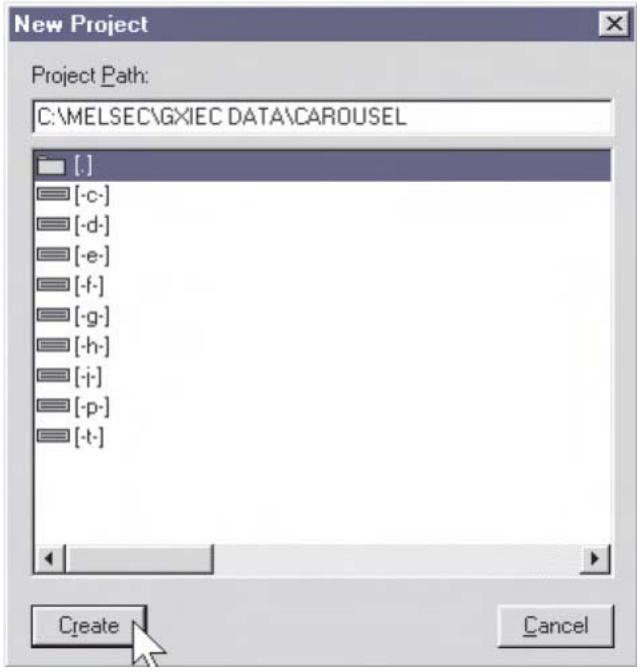
① From the ***Project*** menu, select ***New***.



② Choose the appropriate ***PLC type*** from the selection:

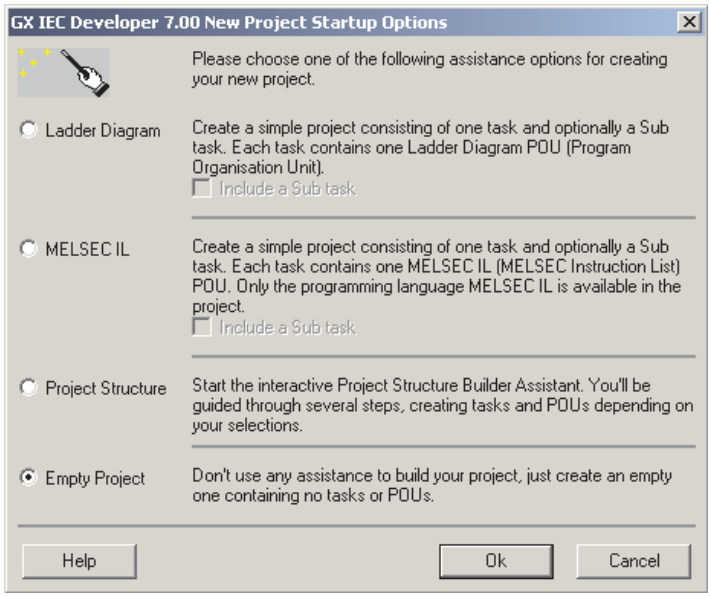


③ Provide a name for the project in the project path field. In this case use "\GX-IEC DATA\CAROUSEL" and click on ***Create*** – as in the following illustration:



The Wizard

The Project Startup Wizard will be displayed:

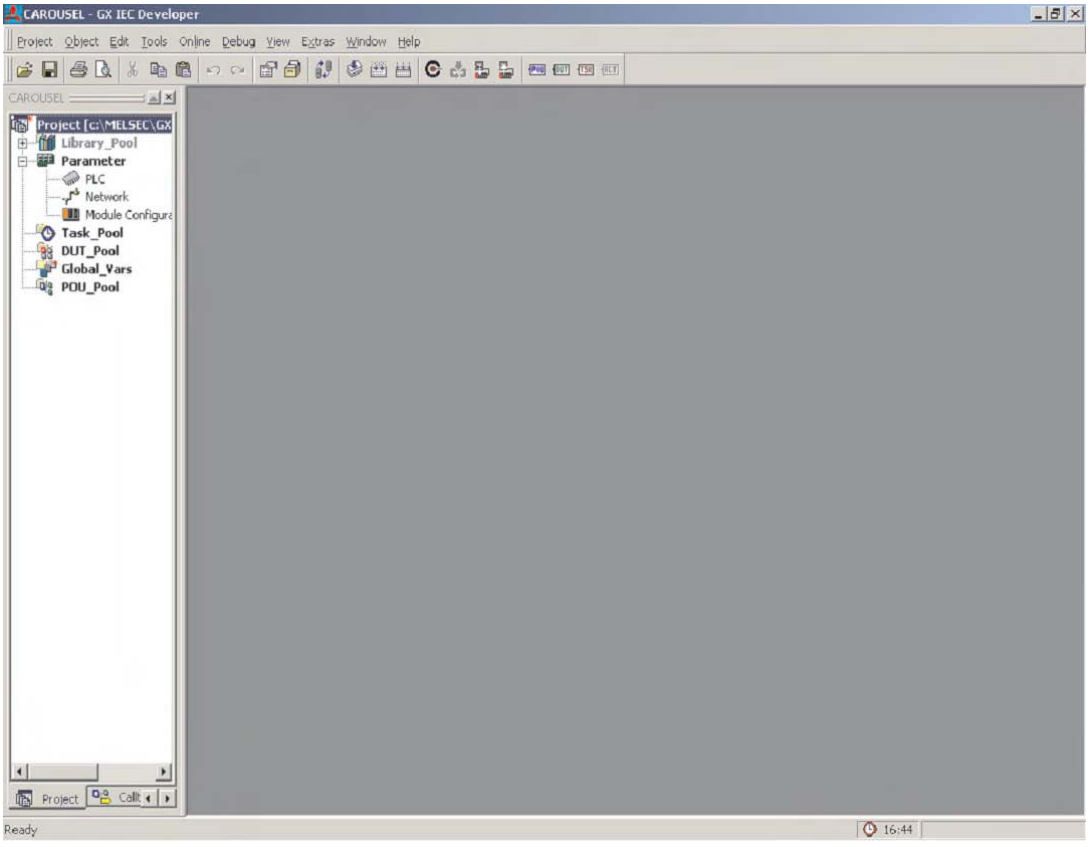


The Wizard provides a quick way to begin projects. It will thus create the basic starting structures for simple projects.

Select the Option, ***Empty Project*** and click ***OK***.

This effectively inhibits the Wizard from creating any project elements. Of course, the Wizard may be used if desired, but in order to fully explore the primary functions of GX-IEC Developer, for training purposes we will use manual operations to create a program.

The project display screen is shown as illustrated below:

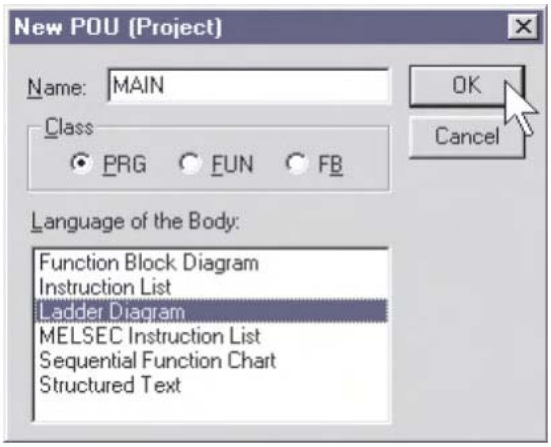


This is the primary display of the project.

The project navigation window on the left hand side of the screen enables the user to rapidly access any portion of the project by double clicking on the selection.

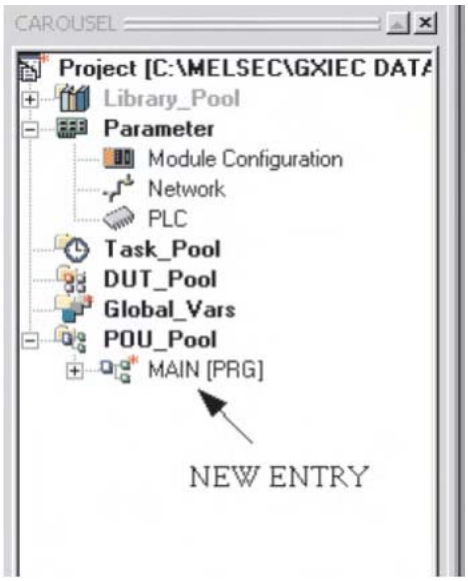
4.2.3 Creating a new "POU"

① Click on the "New POU" button (or "Right Click" on POU Pool) on the tool bar. The new POU specifications are to be entered as follows:

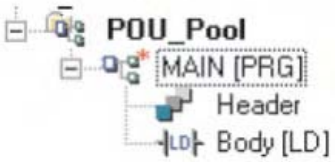


The name of the POU will be 'MAIN' and it should be specified as a **Ladder Diagram** of type ***PRG*** (Program).

② Click ***OK*** and note the addition to the POU Pool in the 'Project navigation window':



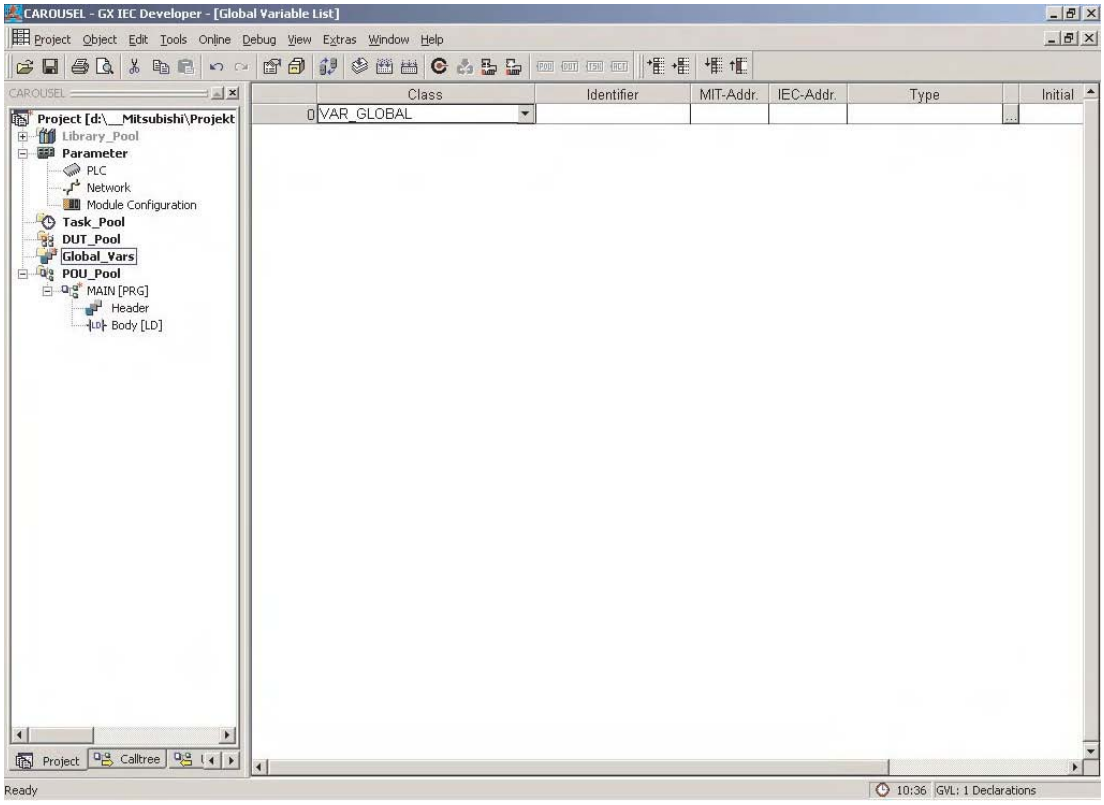
③ Double click on ***MAIN*** program icon or click the symbol on the POU Pool in order to expand the directory branch and display the Header and Body entries:



4.2.4 Assigning the Global Variables

Before any program code can be created, it is necessary to specify and assign all pre-allocated physical PLC inputs and outputs including any shared variables that are to be used in the project.

Double Click the mouse pointer on ***Global_Vars*** to open the Editor for the Global Variables. This is called the Global Variable List - GVL.



Global Variables are the link to the physical PLC devices.

As discussed previously, if IEC conventions are to be applied, then symbolic identifiers (names) must be used instead of discreet addresses in our program. These addresses must therefore be declared in the Global Variable List (GVL). The identifier must be filled in, using its' PLC address (either using Mitsubishi or IEC notation) and its' type, for example; whether it is a 'bit' or 'word' device. Once completed, this list can be used by all of the POU's that will be created.

Declaring Variables

As can be seen from the GVL field list, each variable has a set of elements as follows:

- Class

  The class keyboard assigns the variable a specific property that defines how it is to be used in the project

- Identifier

  Each variable is given a symbolic address, i.e. a name. This is referred to as the identifier. It consists of a string of alphanumeric characters and 'underscore' characters. The identifier must always begin with a letter or an underscore character. Spaces and mathematical operator characters (e.g. +,-,*) are not permitted.

- MIT-Addr

  This is the absolute address referenced in the PLC.

- IEC-Addr

  The IEC syntax of the address.

- Type

  Referrers to the data type, i.e. BOOL, INT, REAL, WORD etc.

- Initial

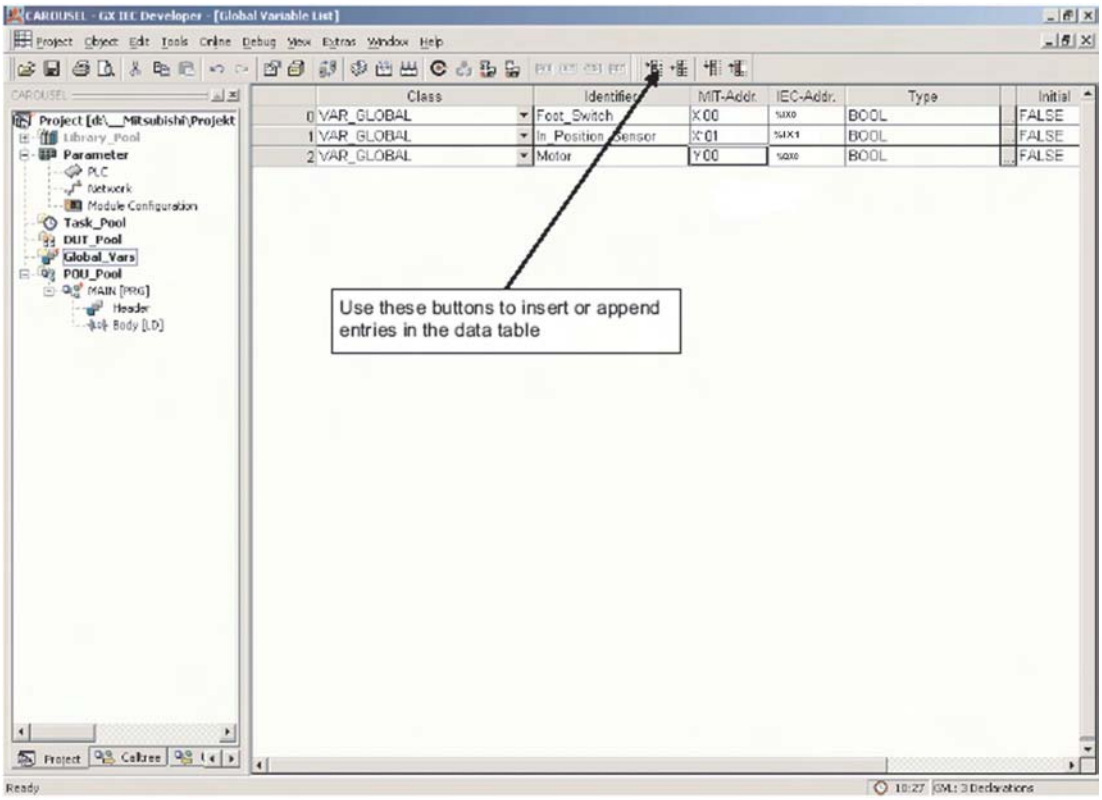
  The initial values are set automatically by the system and cannot be changed by the user.

- Comment

  Comments up to 64 characters may be added for each variable

If symbolic identifiers are not to be used in the program but only Mitsubishi addresses, then there is no need to fill out the Global Variable List (GVL). However the program will no longer be truly IEC61131-3 compliant.

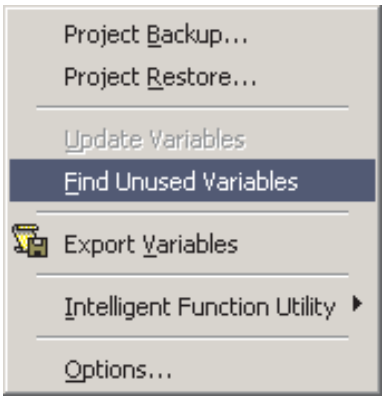
Fill out the table as shown in the following illustration. The variable “Type Selection” is automatically recognised and placed by GX IEC Developer upon entry of the ‘Address’ but can be input manually or modified by clicking on the type select arrow in the ***Type*** field area. When the Mitsubishi address is entered, the system automatically converts and enters the IEC equivalent.



These are the Global Variables specified for the project.

Find unused variables

By using the function ***Extra*** -> ***Find Unused Variables*** you can find and delete all unused global and local variables that are declared but not used in a project. Unused global and local variables will be detected in the whole project, excluding the user libraries.



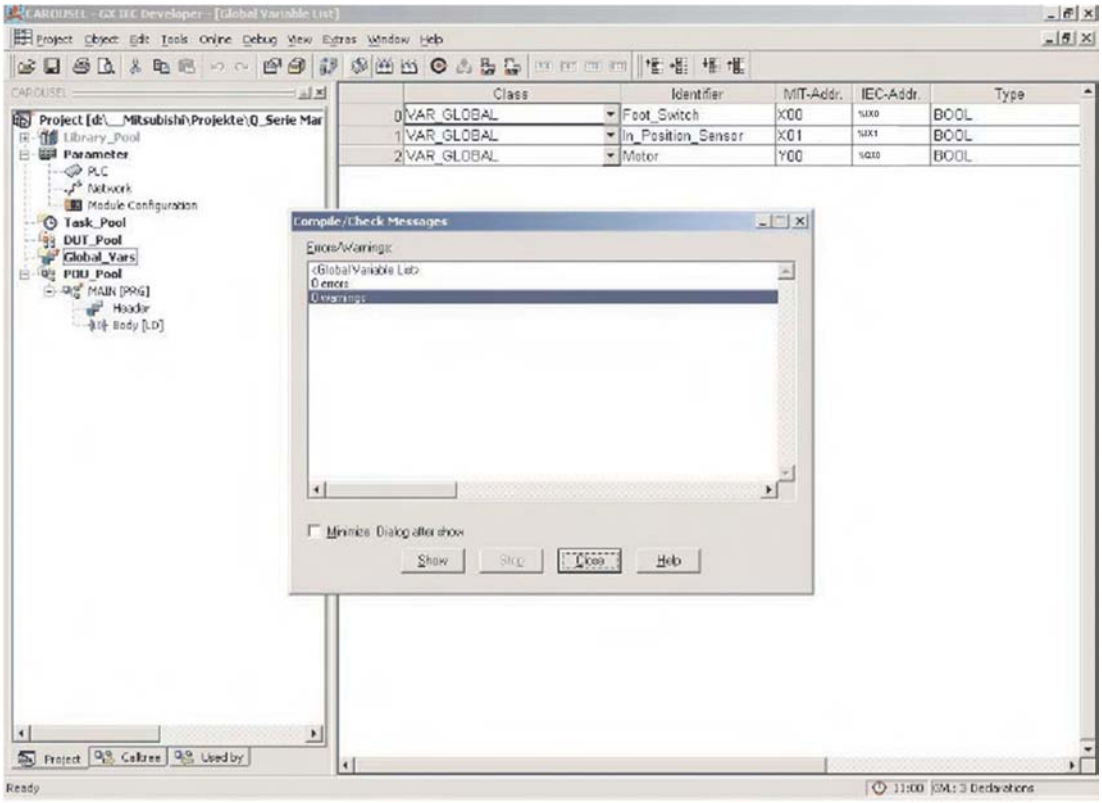
NOTE Finding unused variables can only be performed if the project has been built and was not changed since then. Otherwise a warning message will be displayed.

NOTES

The Global Variable List incorporates an “Increment new declarations” feature. If the GVL contains entries i.e. for a number of valves, ‘Valve_1’ to ‘Valve_n’ then if the first entry is made for Valve_1 and new rows are declared either via the tool bar icons or “Shift+Enter” then both the identifier and address fields are incremented. This feature is enabled by default. If this is not required it can disabled via the ***Extras*** menu (***Extras\Options\Editing***), to be described later. All or selected POU’s can be selected and all or selected variables can be deleted. When invoked, all unused Global Variables in POU’s are deleted. This feature will be explored later when appropriate.

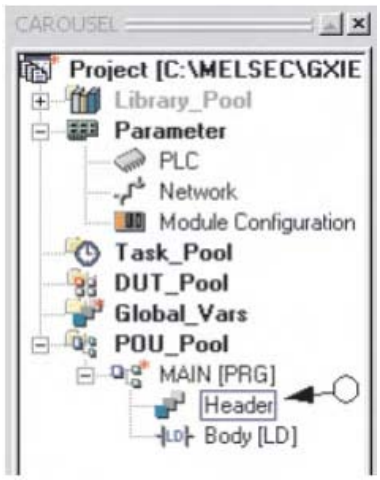
For all FX2N, FX3U, Q & AnA(S) type CPU’s or better, IEC Type REAL (Floating Point) values are fully supported.

When the data entry in the GVL has been completed, click the ‘Check’ button  as shown:

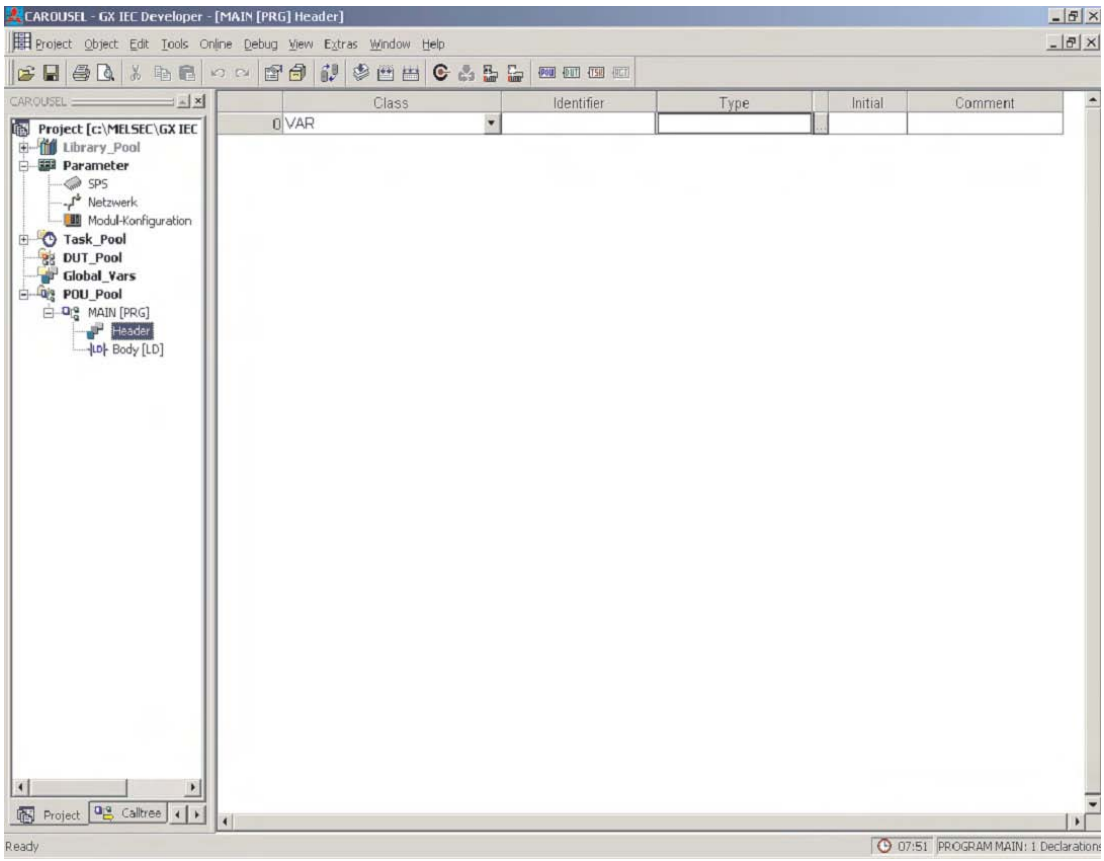


Opening the POU Header

From the Project Navigation window, double click on the **Header** on the POU ***MAIN***.



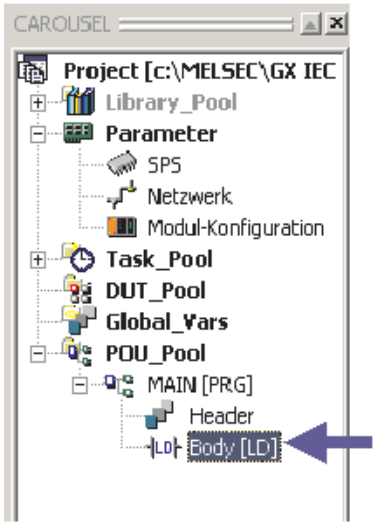
The following screen will be displayed:



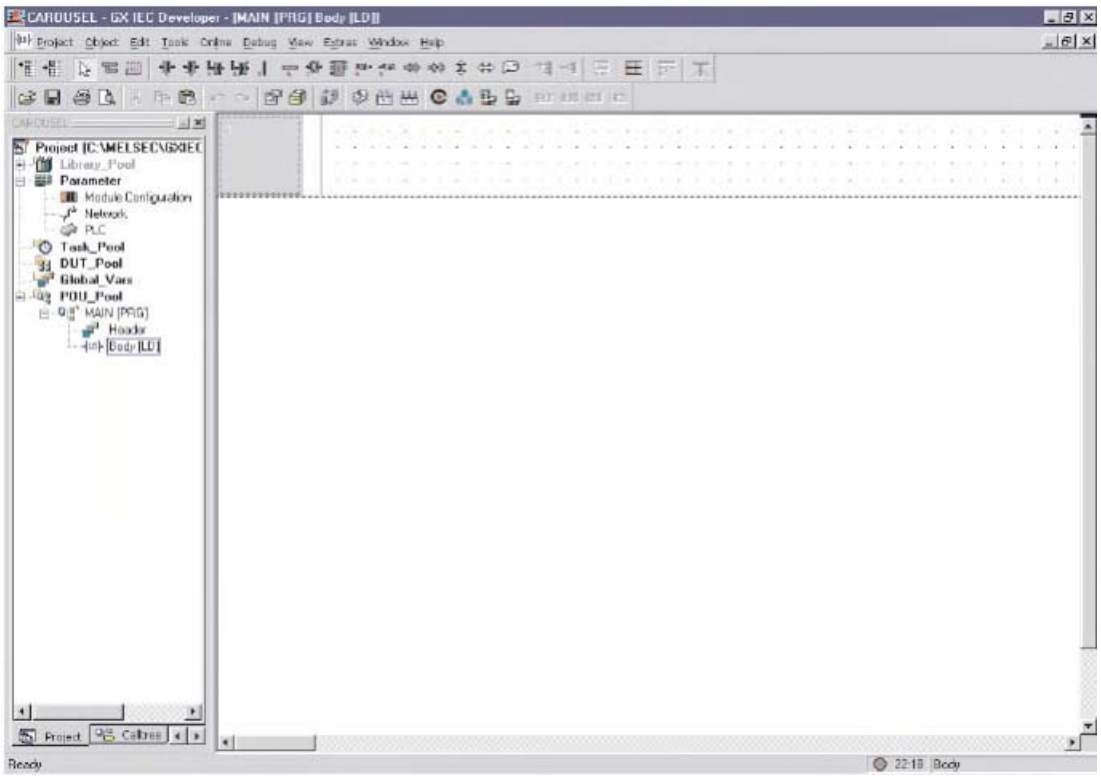
Close this POU Header display.

4.2.5 Programming the POU Body

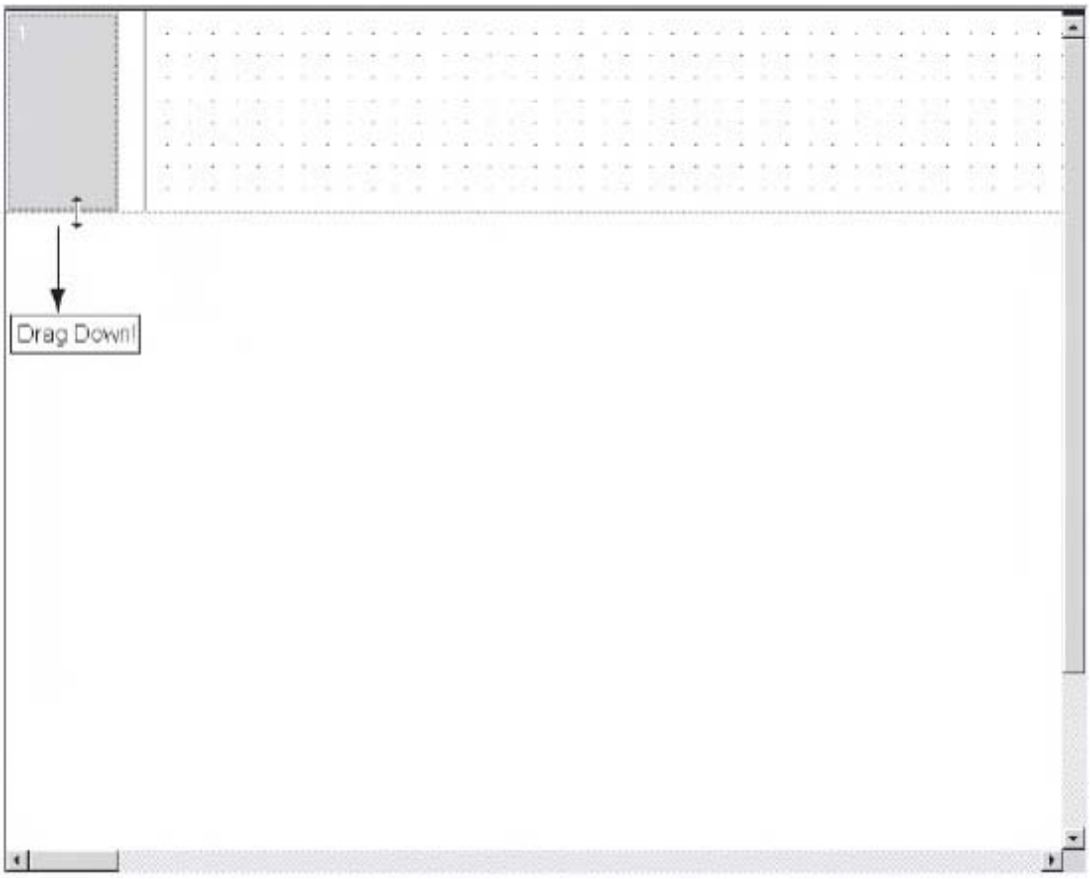
① To open the Ladder diagram editor, double click on the Body selection under the POU pool in the project navigation window:



The following window is displayed:



② With the pointer over the window boundary, click and drag downwards to increase the vertical size of the network:



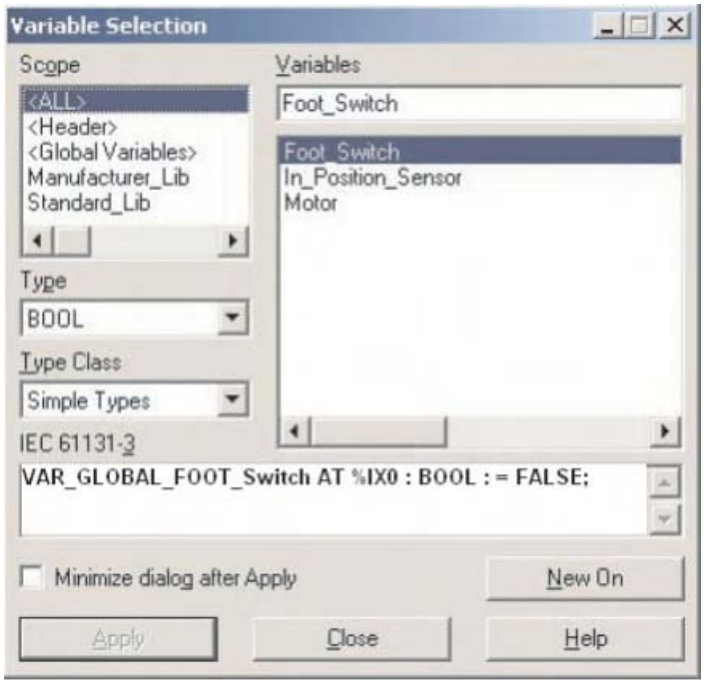
Using the Toolbar Ladder Symbol Selection

③ With the editor in “Selection Mode”, select the ‘Normally Open’ contact from the toolbar:

④ Move the mouse pointer over the work area and click to fix the drop position on the window:

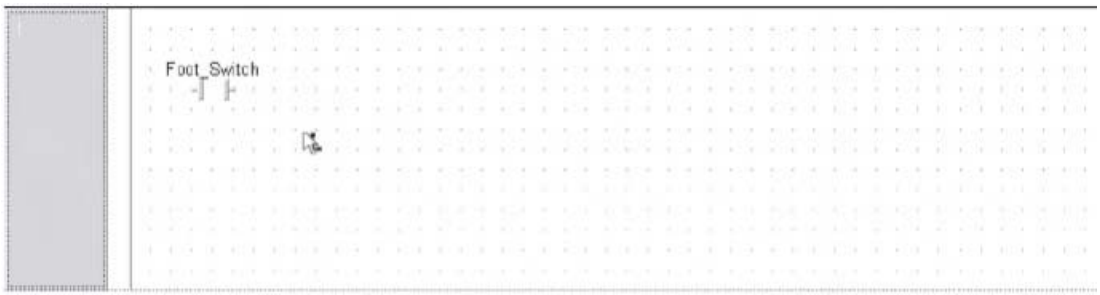
Selecting variables from the POU Header

① Press the “F2” button on the keyboard or click on the  button on the tool bar to call up the variables selection window and the display will be as shown below:



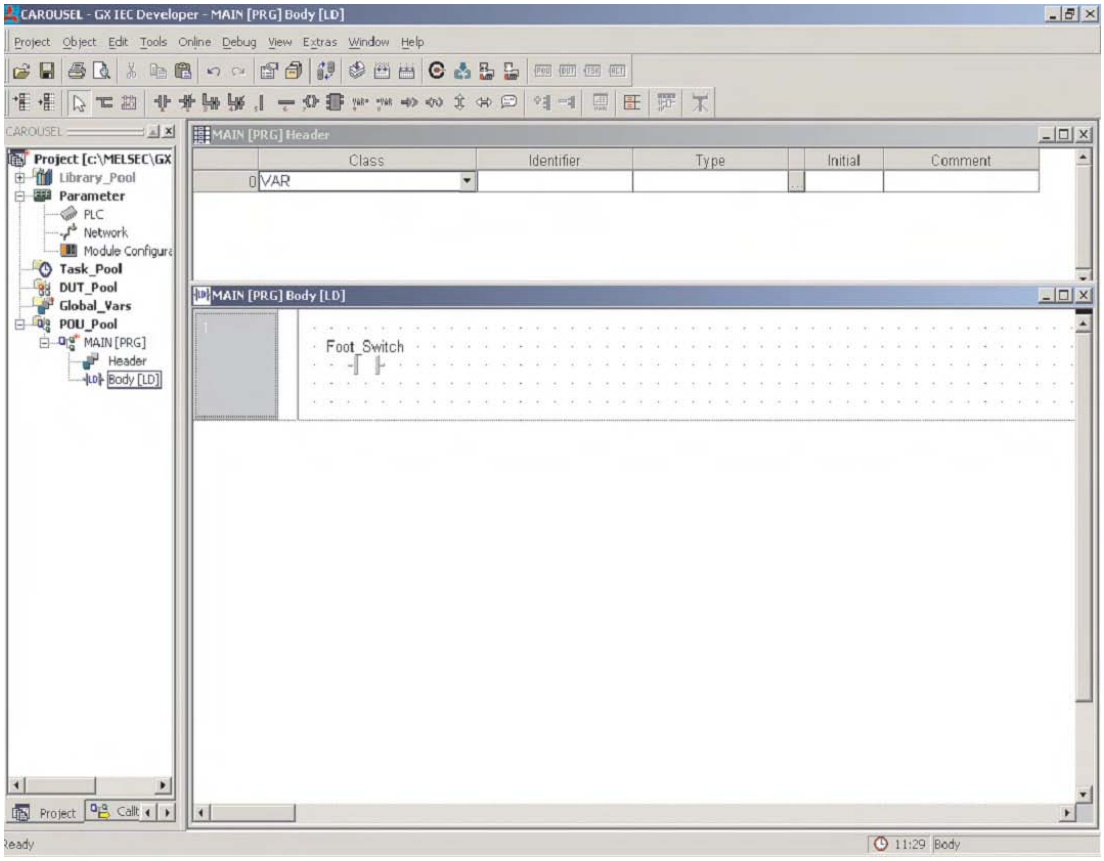
Note that the current ‘Header’ should be selected under the ***Scope*** dialogue area.

② Click “Foot_Switch” to highlight that variable and click the ***Apply*** button. Then close the Variable Selection box.



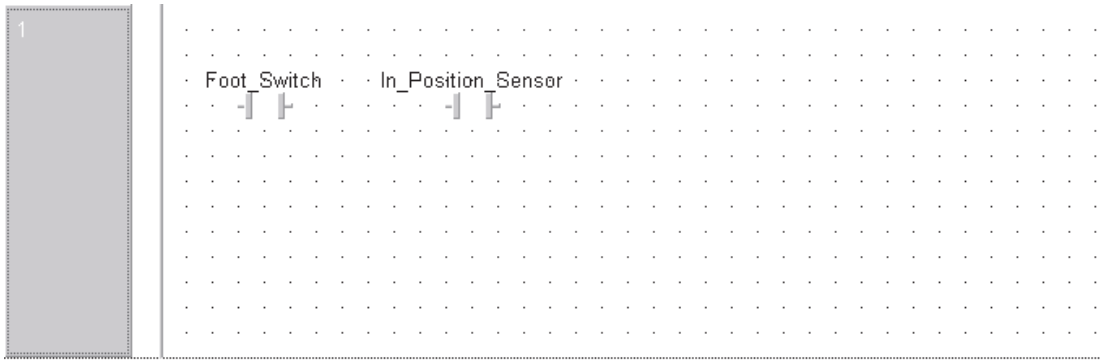
Alternative Variable Specification Method: Editing in Split Screen

Split screen viewing of POU Ladder diagram and Header is possible by opening both the header and the ladder and selecting “Tile Horizontally.”



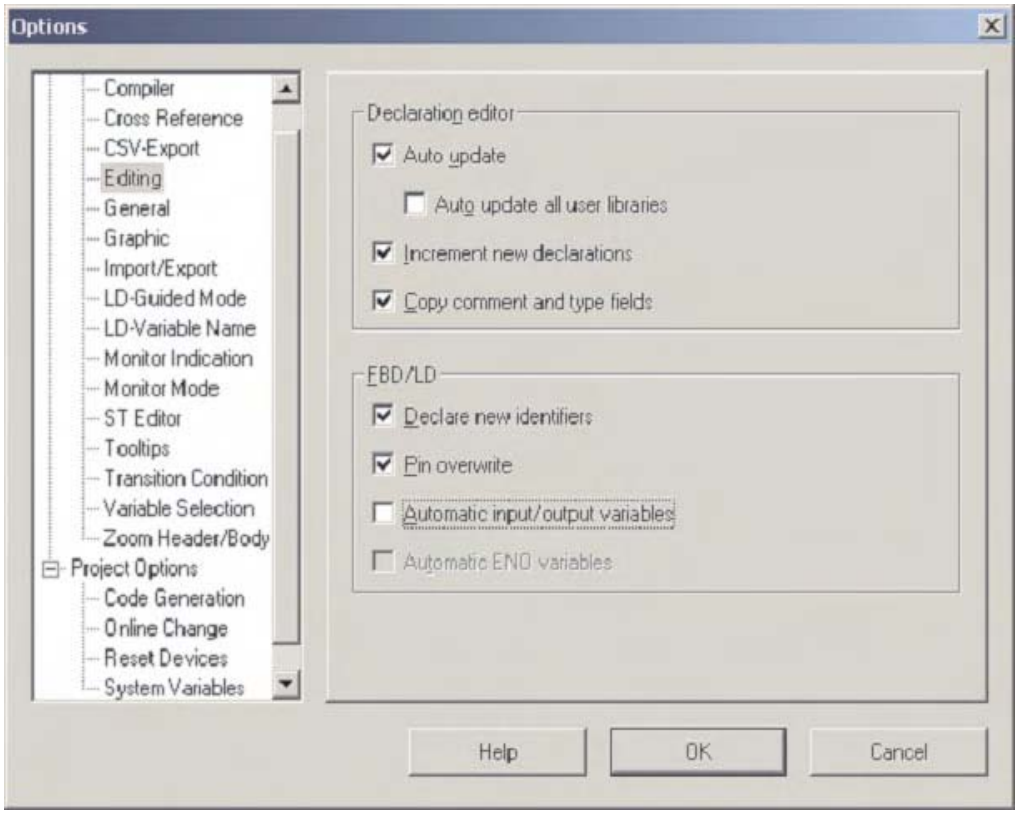
Continue editing Project ‘Carousel’

Enter the normally open contact of the “In_Position_Sensor" in the position shown on the current screen in the same manner, as shown below:



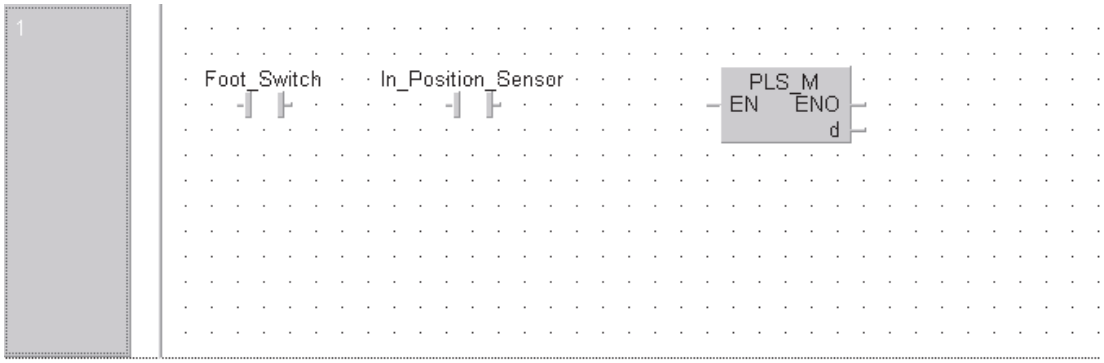
Entering a Function Block command into the Ladder program

Before continuing, it is recommended for the remainder of this course, that the ***Automatic input/output variables*** facility be "**Disabled**" by de-selecting this option. This facility is found under the ***Extras*** menu using the ***Options*** selection and selecting ***Editing***, as shown below:



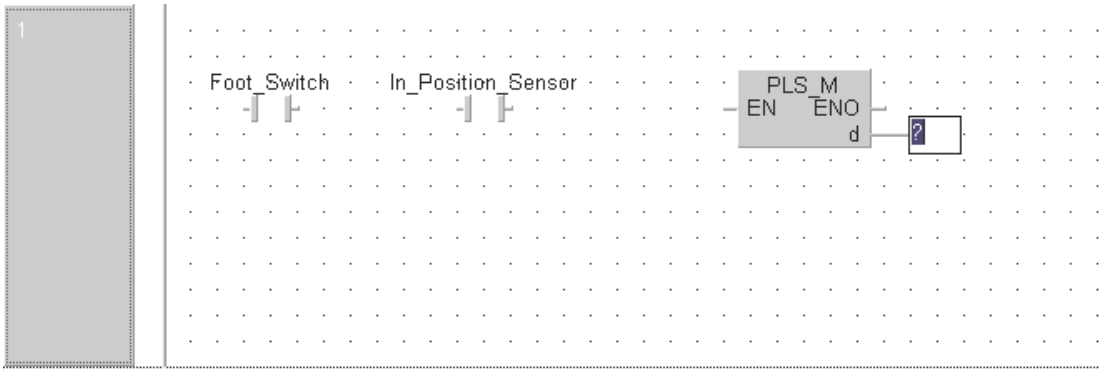
The MELSEC Function Block command, 'PLS_M' will be added to the program as the output function.

① Click on the Function / Function block  selection button on the tool bar. On the ***Operator type*** click ***Functions*** and type "PLS_M" into the ***Operators*** prompt box thus:



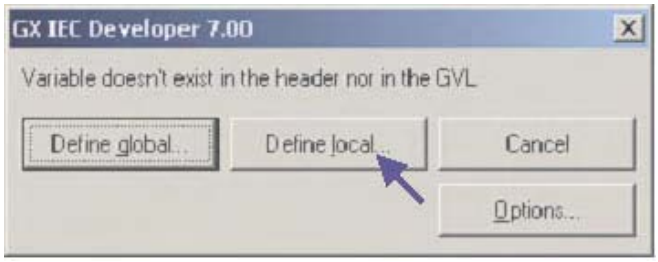
Assigning a Variable to an Instruction

② Click on the output variable prompt from the toolbar. Click on the ‘d’ destination, output function from the PLS_M to drop the variable prompt field.

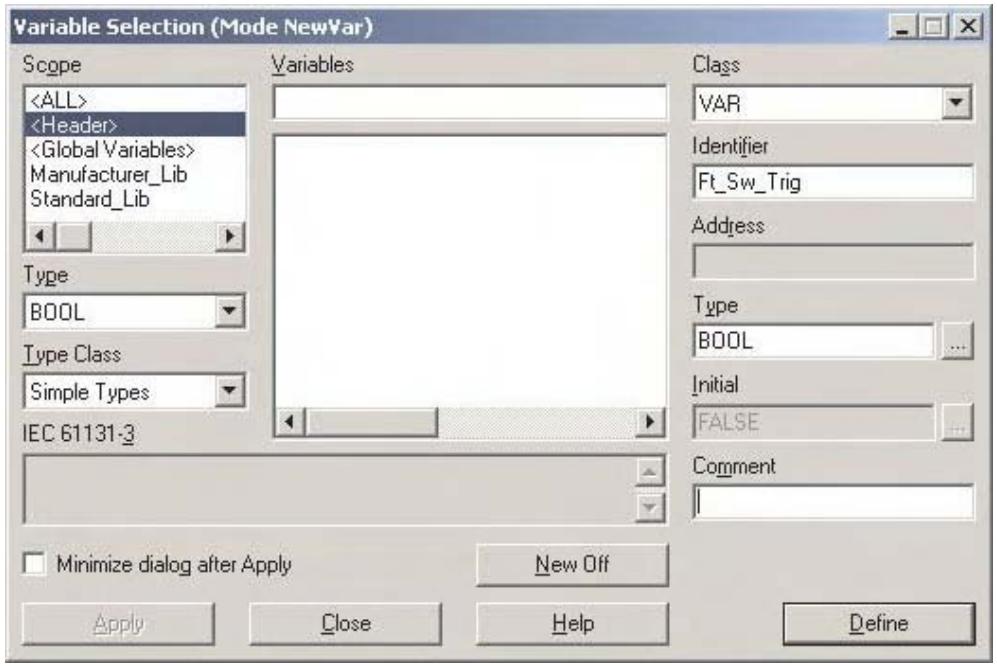


③ Enter the variable name Ft_Sw_Trig into the empty ‘?’ box.

The following prompt is displayed if the variable does not exist in the Local Variable List ‘LVL’ (Local Header) or the Global Variable List ‘GVL’:



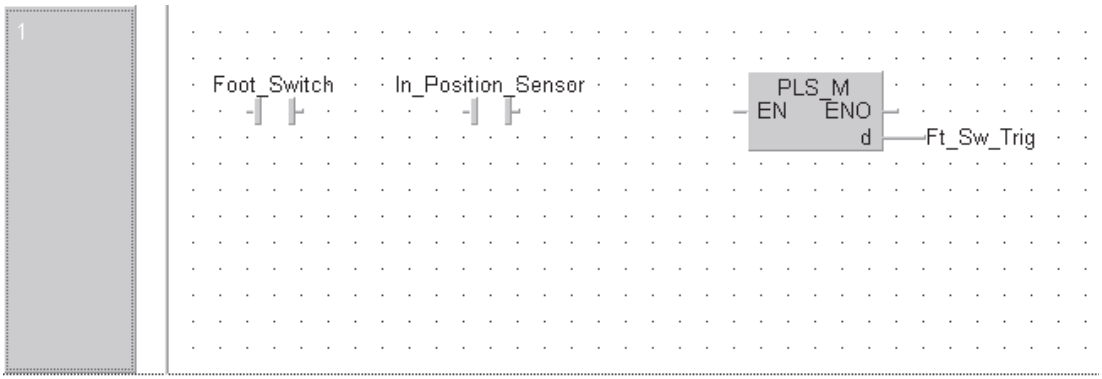
④ Click on ***Define Local*** to define a new Local Variable ‘LVL’. The ***Variable Selection*** window is displayed, prompting a new variable to be defined:



⑤ Click ***Define*** to enter the new variable into the LVL (Local Header).

NOTE To confirm the above operation, check the local header!!

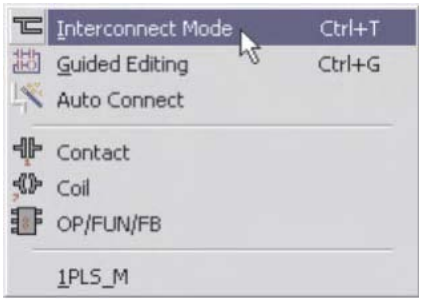
The display should be as follows:



Finally, the ladder network must be finalised by connecting up the elements as follows.

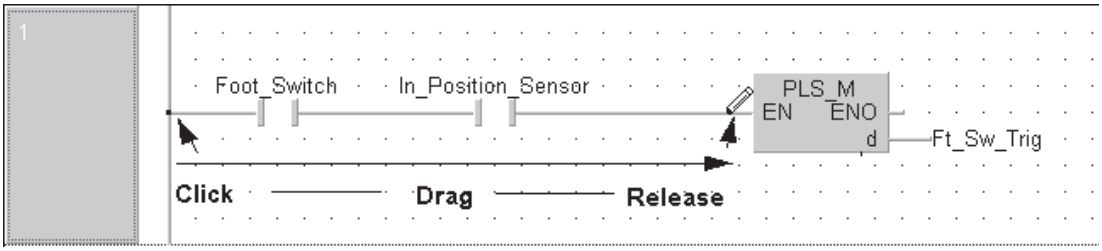
⑥ Right click the mouse anywhere in the edit window area and de-select the ***Auto connect*** function.

⑦ In the same manner, click to select ***Interconnect Mode***.



Note that the Pointer now changes to a small pencil icon.

⑧ On the Ladder diagram click on the left point on the ladder diagram and “Click – Drag” across the diagram and release on the ‘EN’ input on the ‘PLS_M’ function as shown below:



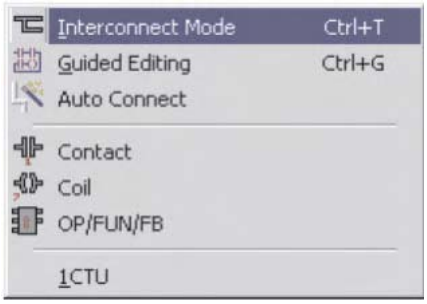
The circuit is now complete.

Changing the cursor mode

Before continuing with the worked example, it is necessary to understand the operation of the cursor control and the various edit modes that are available.

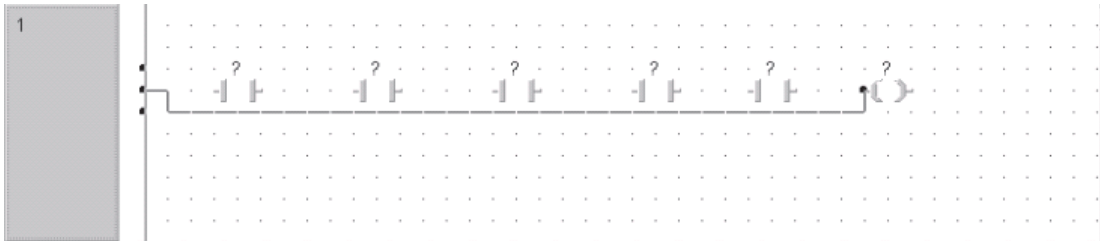
The following text is for illustration purposes only:

While in the ladder edit screen, Right clicking the mouse button pops up a small selection window as shown below. Clicking on ***Auto Connect*** toggles this feature on/off; it is also the method for switching between pen and arrow, other than via toolbar icons.

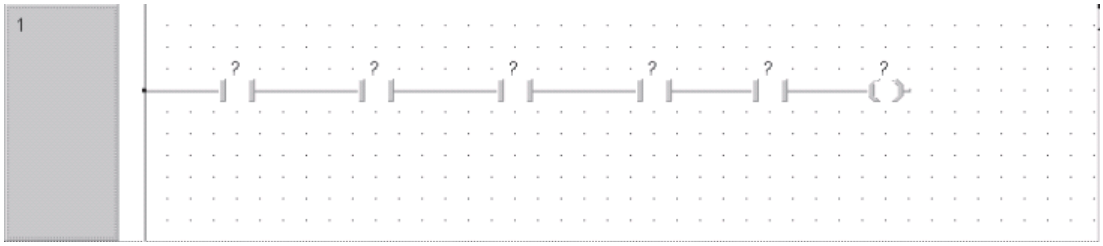


Precautions when using the Ladder Editor

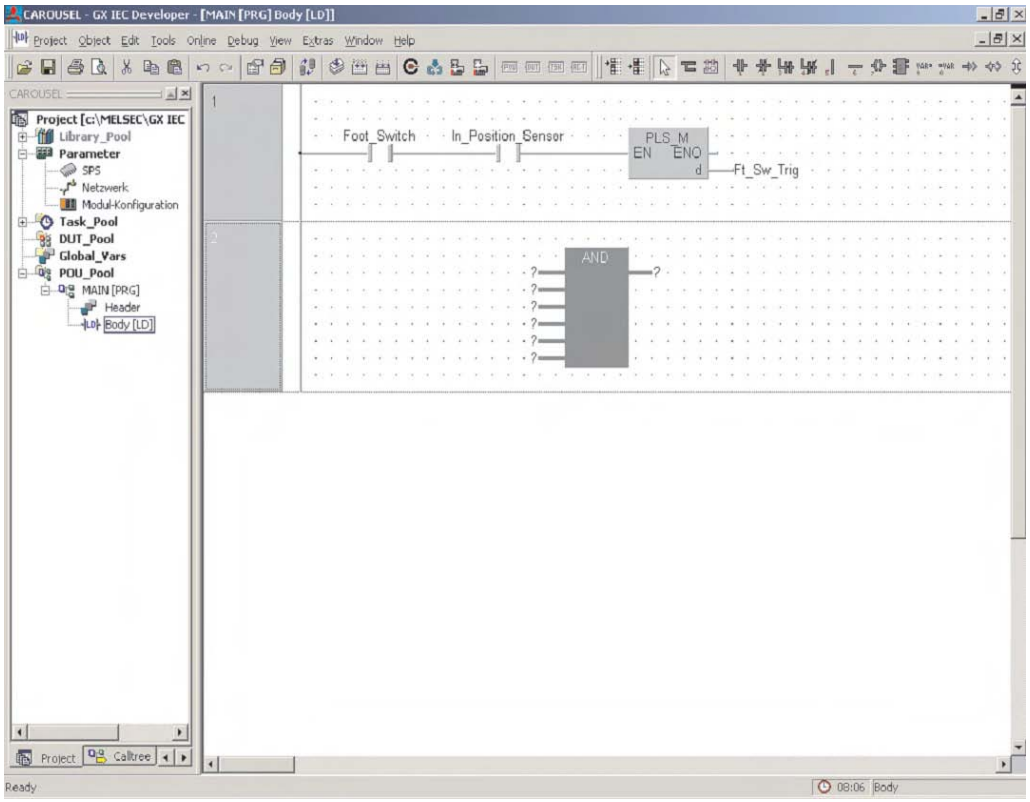
As can be seen from the screen below, because ***Auto Connect*** connects between two points, for a row of contacts the line tries to connect as shown. With ***Auto Connect*** on, the only way to connect these contacts is to connect between each individual pair:



The pen can then strike through all contacts, from the bus bar, to the coil. In the Ladder Editor the suggestion is to invoke the ***Auto Connect*** feature when dropping elements onto the POU body or connecting parallel elements. It should however be disabled when connecting a row of contacts as shown in the following screen, or inserting a contact into an existing network.

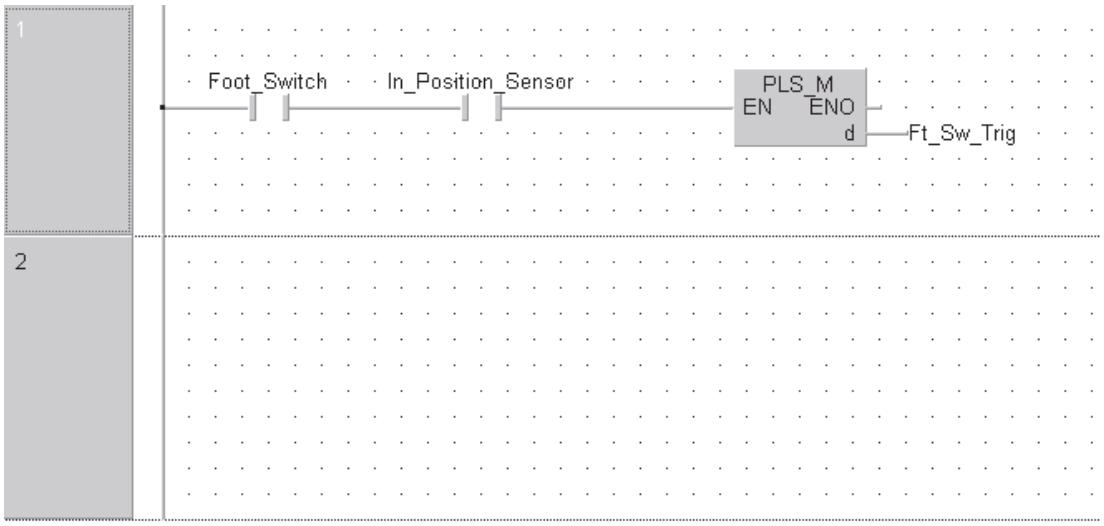


When using multi-legged or 'pinned' functions such as MUL, the number of input parameter legs, can be incremented/decremented by using the special toolbar, icons shown. This can also be achieved by placing the cursor at the bottom edge of the function, holding down the left hand mouse button and then dragging away as shown below:

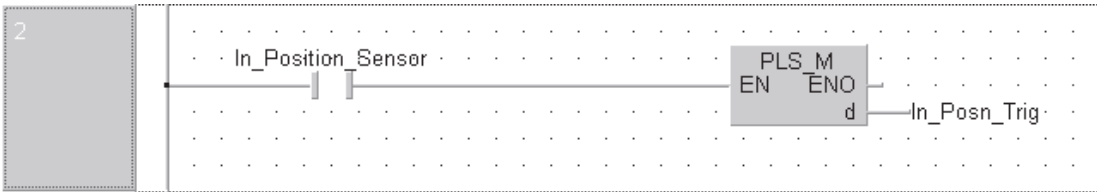


Creating a new Program Network

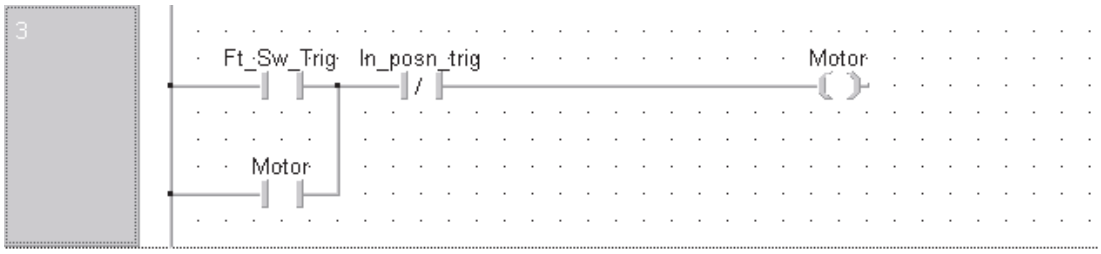
① To create a network below the current one, click the 'insert after' button. A blank network space will appear:



② Enter the second network in the same format as previously described with the following attributes:

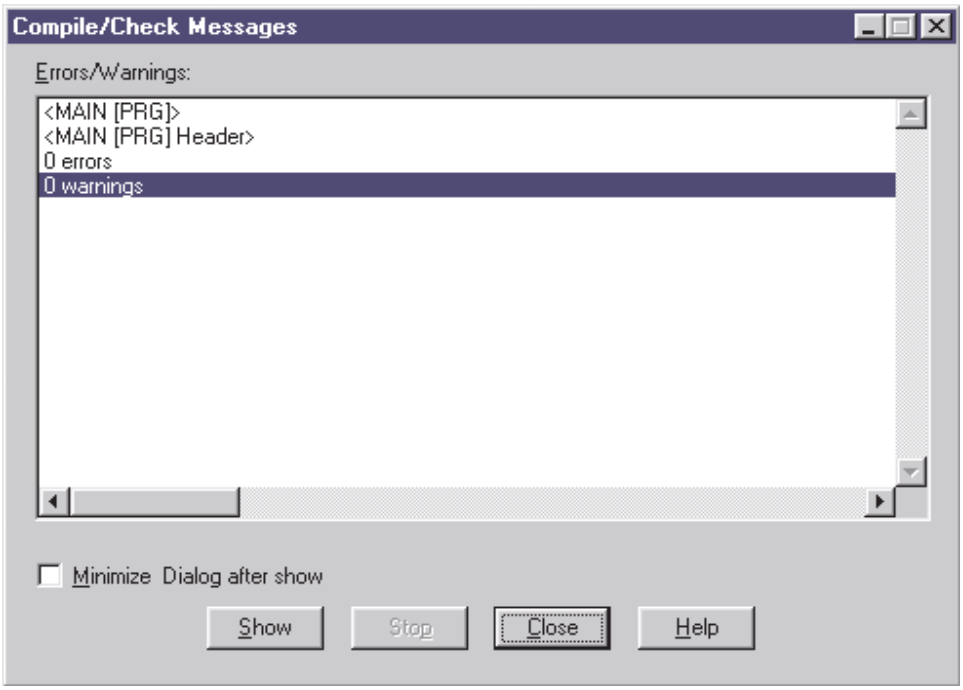


③ Finally, enter the following network as shown:



Checking the entered Program

When the three networks have been entered, complete click the Check button and if all is well, the following dialogue is displayed:



Adding new POU's – Counters and Timers

Continuing with the Carousel example; Additional routines will now be added to illustrate the use of timing and counting functions.

– Counting number of operations (Product Batch Counter)

– Create an additional POU to provide a batch counting function.

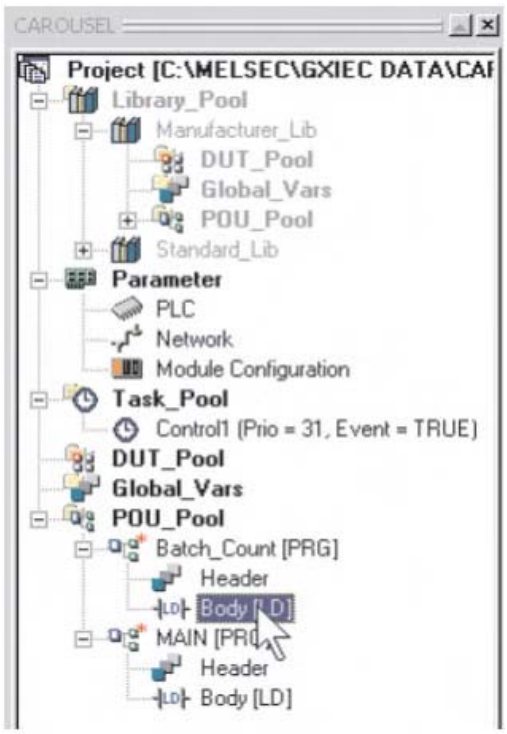
Task:

An additional POU will now be added to the project in order to count the number of times the motor is activated, i.e. product batch counter.

When ten products have been counted, the PLC will flash an output at a 1 Second 'time-base' until a button is operated to reset the batch counter.

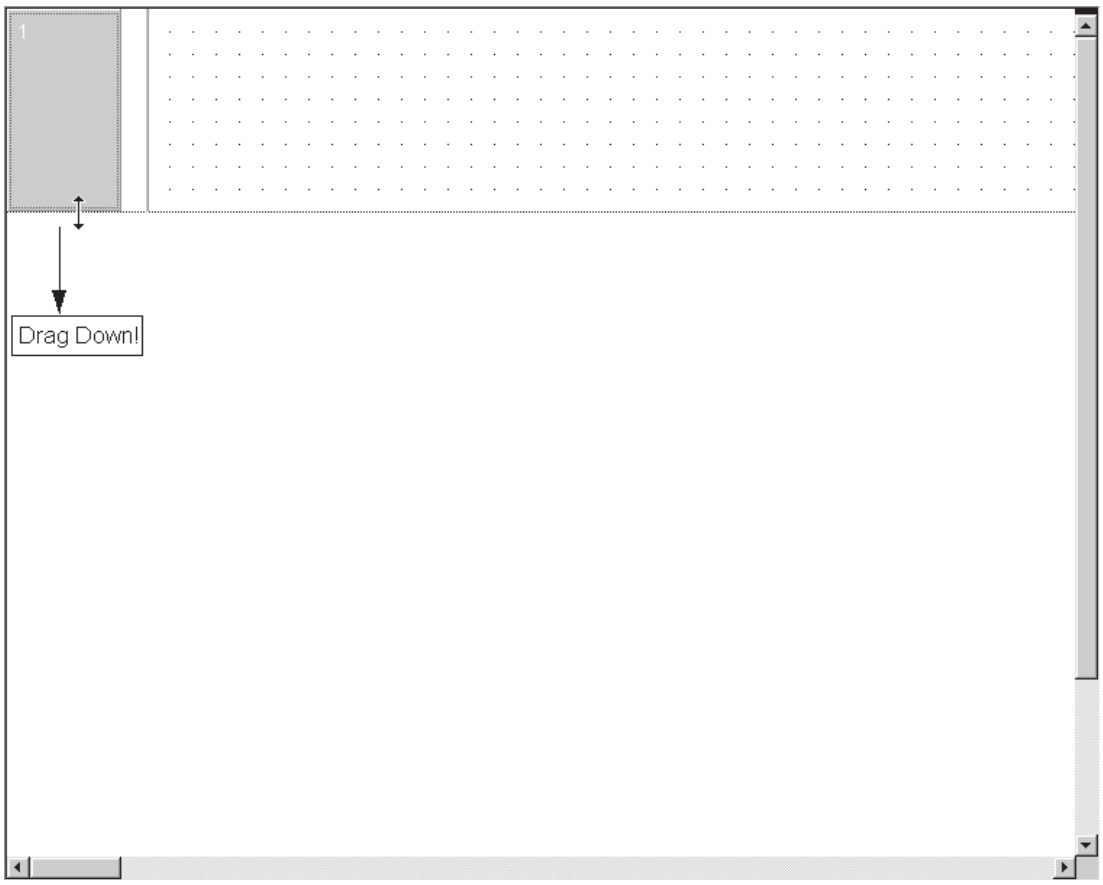
Enter the following POU ladder routine, using the 'free-form' editors as shown:

① Create a new POU by clicking on the POU button.



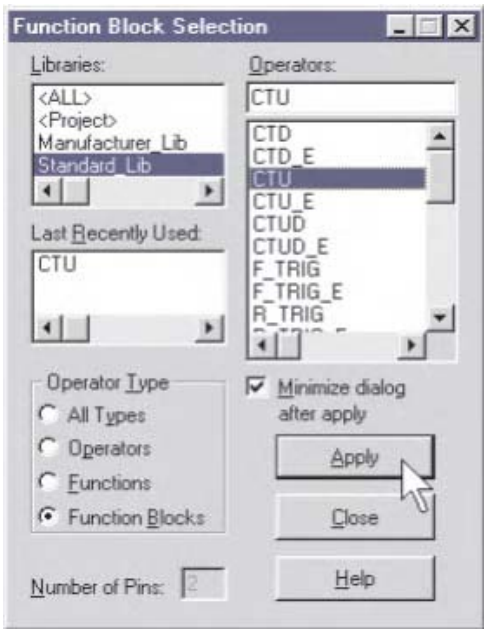
② Select the Body of the new POU by opening the newly created entry in the Project Navigation Window.

As discussed previously, the ladder network may be re-sized by moving the mouse pointer to the lower boundary of the network header and 'click-hold' dragging downward to increase the vertical size:

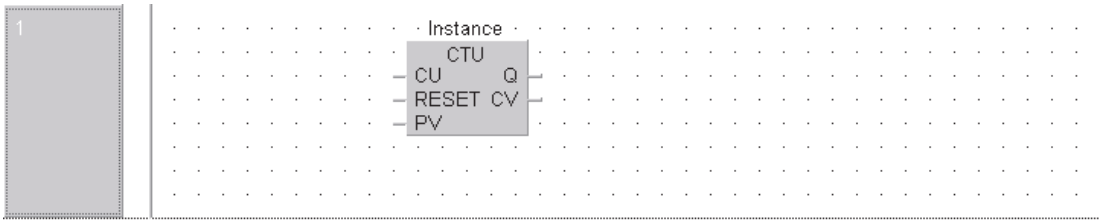


Counting function

Using the editor in “select” mode, enter the instruction CTU (Count Up) into the ladder network:



Drop the IEC Function Block onto the empty Ladder network:

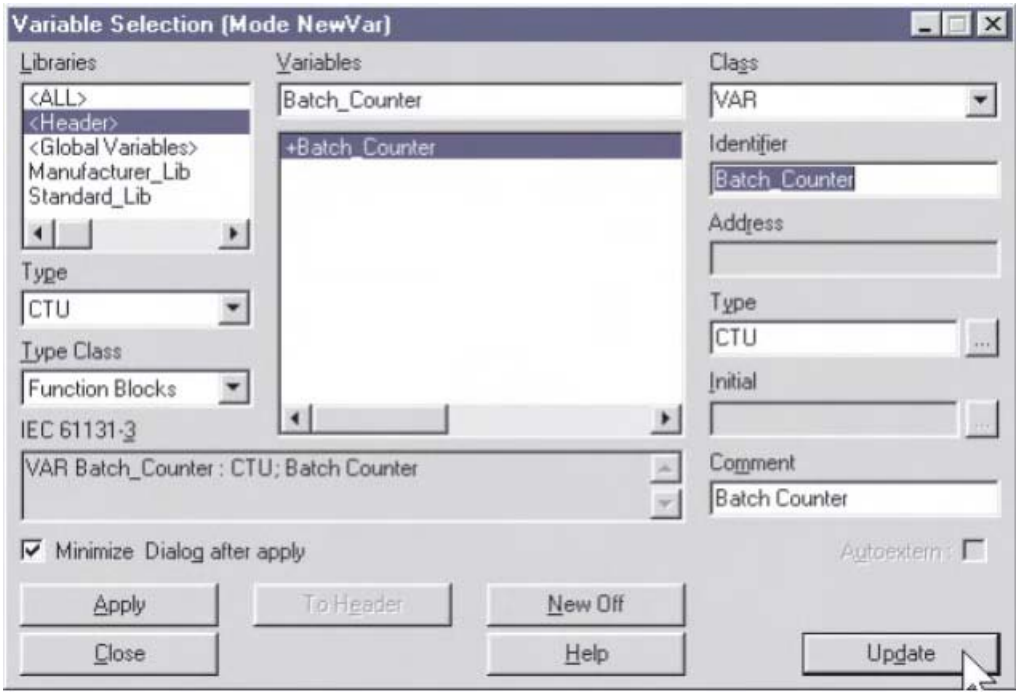


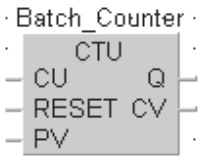
Instances of Function Blocks

Function Blocks can only be called as “**Instances.**” The process of “Instancing,” or making a copy of a function block, is performed in the header of the POU in which the instance is to be used. In this header the function block will be declared as a variable and the resulting instance is given a name. It is possible to declare multiple instances with different names from one and the same function block within the same POU. The instances are then called in the body of the POU and the ‘**Actual’** parameters are passed to the ‘**Formal’** parameters. Each instance can be used more than once.

Entering IEC Function Block CTU

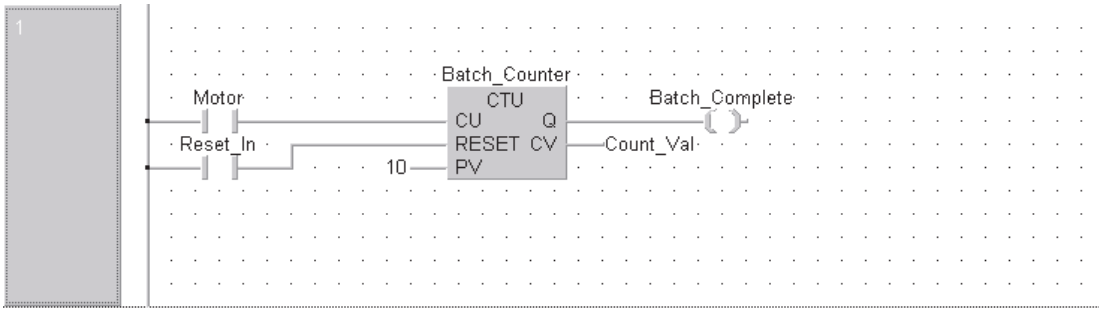
① To create a new name for this instance of the CTU Function Block in this POU, click on the variable name ***Instance*** above the CTU function block. And press F2 to bring up the ***Variable selection*** dialogue. Fill in the resulting window as shown on the next page.





② Click on ***Apply***, then ***Update*** and the variable name will change as shown on the left.

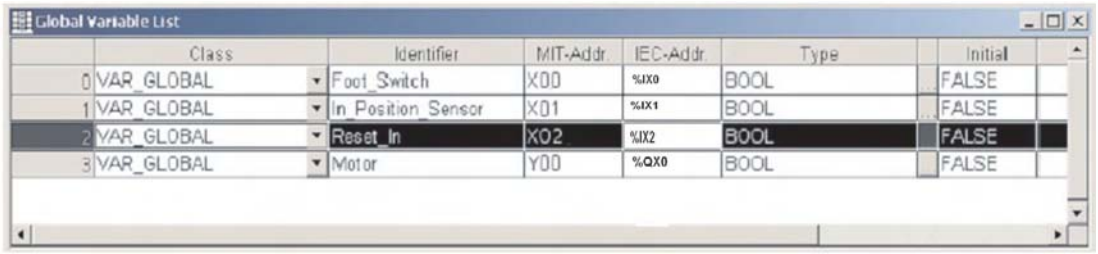
③ Continue to enter the program as previously described so that the following display is achieved:



When entering the PV and CV values, use the variable  buttons respectively.

Adding entries to the GVL

Note, in particular: “Reset_In” (Global) - is a new Input mapped from the MELSEC boolean address X02 or IEC %IX2. This requires a new entry into the GVL as follows:

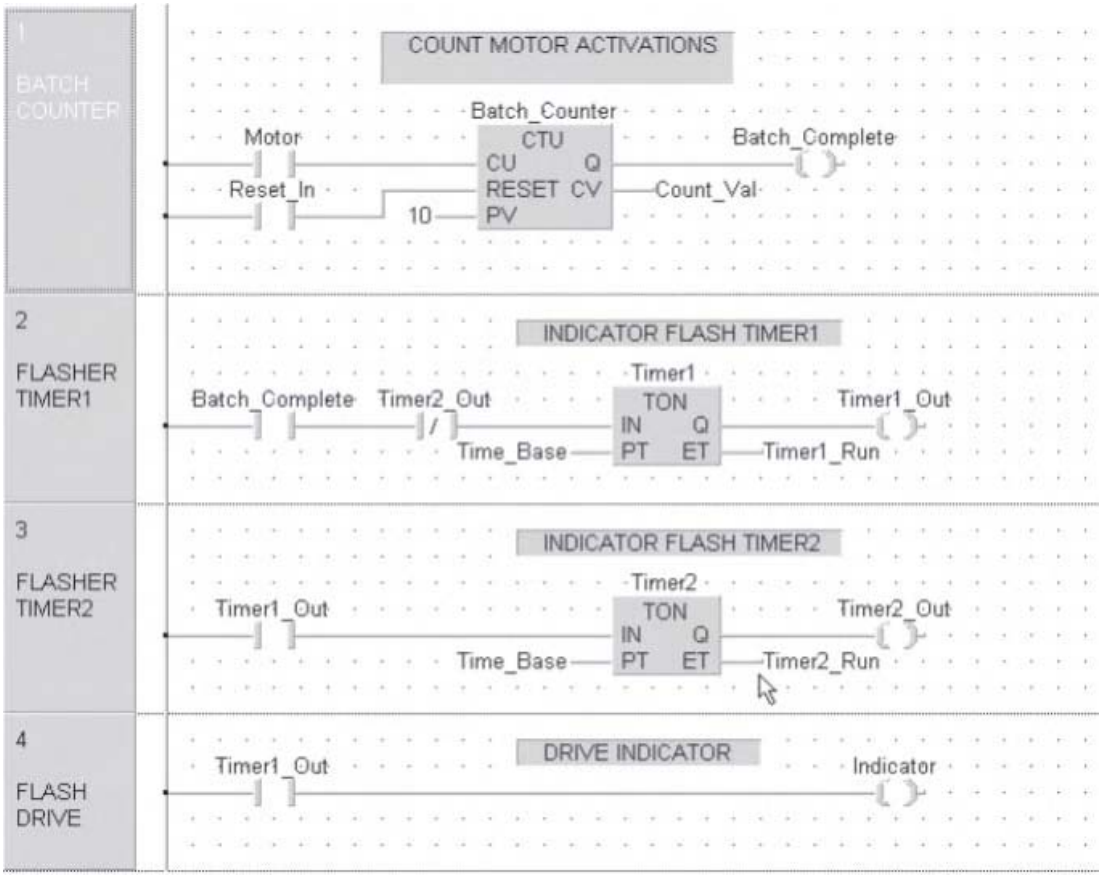


	Class	Identifier	Type		Initial	Comment
0	VAR	Batch_Counter	CTU	...		Batch Counter
1	VAR	Batch_Complete	BOOL	...	FALSE	Batch Complete
2	VAR	Batch_Complete1	BOOL	...	FALSE	
3	VAR	Count_Val	INT	...	0	

When all new entries are complete, click the check button then the 'Rebuild All' button to check and assemble the project.

Timing Function

Create the following Ladder Networks below the batch counting routine in the Batch_Count POU as shown:



When the editing task has been completed, the GVL should appear thus:

Global Variable List

	Class	Identifier	MIT-Addr	IEC-Addr	Type		Initial
0	VAR_GLOBAL	Foot_Switch	X00	%IX0	BOOL	...	FALSE
1	VAR_GLOBAL	In_Position_Sensor	X01	%IX1	BOOL	...	FALSE
2	VAR_GLOBAL	Reset_In	X02	%IX2	BOOL	...	FALSE
3	VAR_GLOBAL	Motor	Y02	%QX2	BOOL	...	FALSE
4	VAR_GLOBAL	Indicator	Y21	%QX17	BOOL	...	FALSE

The header (LVL) for the above program "Batch_Count" should now appear as shown:

	Class	Identifier	Type		Initial	Comment
0	VAR	Batch_Counter	CTU	...		Batch Counter
1	VAR	Batch_Complete	BOOL	...	FALSE	Batch Complete
2	VAR	Count_Val	INT	...	0	
3	VAR	Timer1	TON	...		Time Base Timer1
4	VAR	Timer1_Out	BOOL	...	FALSE	
5	VAR	Timer2_Out	BOOL	...	FALSE	
6	VAR	Timer2	TON	...		Time Base Timer2
7	VAR_CONSTANT	Time_Base	TIME	...	T#0.5s	
8	VAR	Timer1_Run	TIME	...	T#0s	
9	VAR	Timer2_Run	TIME	...	T#0s	

When all new entries are complete, click the check  button then the 'Rebuild All'  button to check and assemble the project.

For the POU, "Batch_Count" header

Batch_Count [PRG] Header

	Class	Identifier	Type		Initial	Comment
0	VAR	Batch_Counter	CTU	...		Batch Counter
1	VAR	Batch_Complete	BOOL	...	FALSE	Batch Complete
2	VAR	Count_Val	INT	...	0	
3	VAR	Timer1	TON	...		Time Base Timer1
4	VAR	Timer1_Out	BOOL	...	FALSE	
5	VAR	Timer2_Out	BOOL	...	FALSE	
6	VAR	Timer2	TON	...		Time Base Timer2
7	VAR_CONSTANT	Time_Base	TIME	...	T#0.5s	
8	VAR	Timer1_Run	TIME	...	T#0s	
9	VAR	Timer2_Run	TIME	...	T#0s	

For the POU, "MAIN" header:

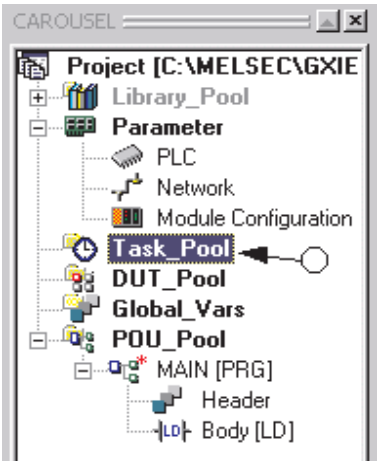
MAIN [PRG] Header

	Class	Identifier	Type		Initial	Comment
0	VAR	In_posn_trig	BOOL	...	FALSE	
1	VAR	Ft_Sw_Trig	BOOL	...	FALSE	

4.2.6 Creating a new Task

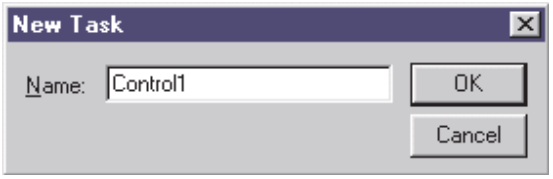
In order for the POUs “MAIN” and "Batch_Count" to be assembled and executed in the PLC, they must be specified as valid tasks in the ***Task Pool***.

① Click once to highlight the ***TASK_Pool*** icon in the Project Navigation area.

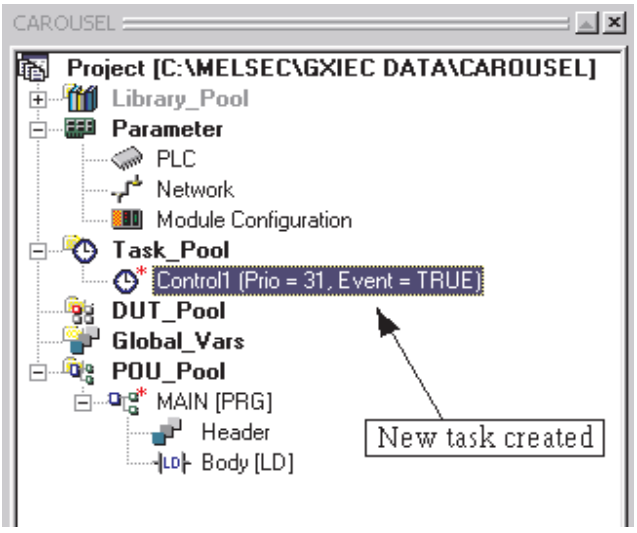


② Then click on the Task button  on the Toolbar. Alternatively, ‘Right Click’ the task pool icon in the Project navigation window and select the ***New Task*** option from the menu.

③ Enter the name of the new task ("Control1") in the prompt window.



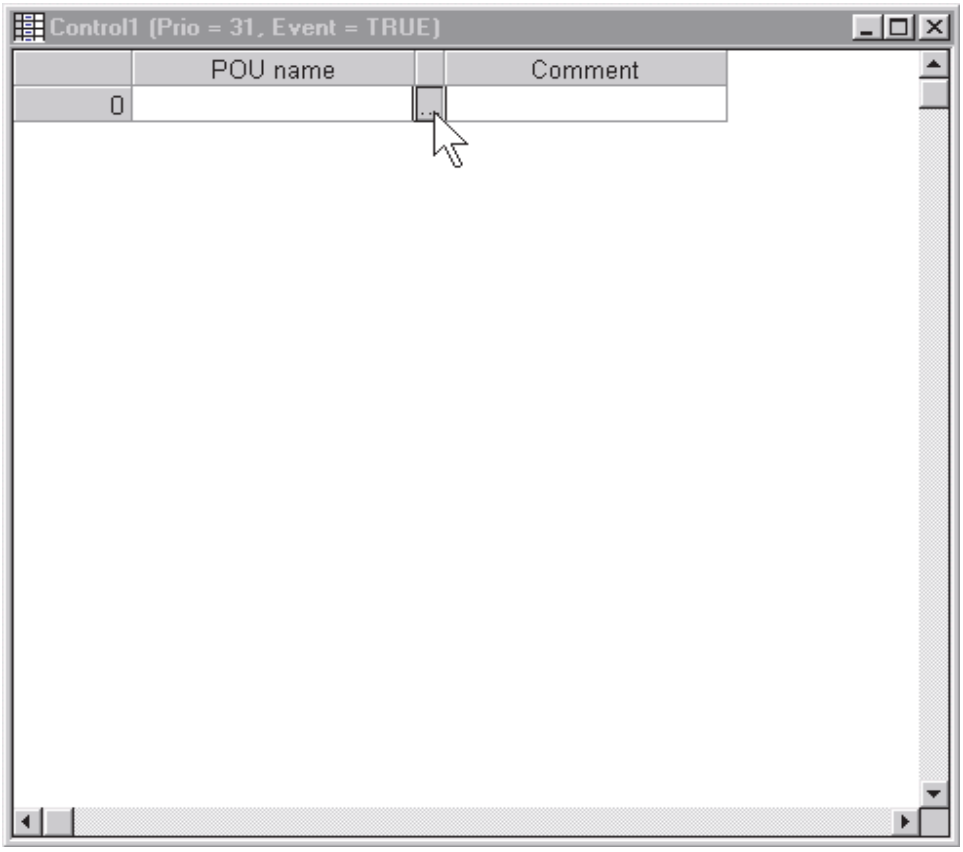
④ Click ***OK*** and the Project Navigation window now shows the newly created task called “Control1”:



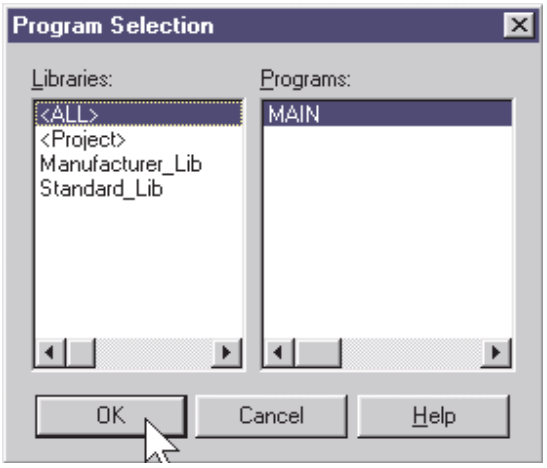
Assigning the POU to Task

The newly created task “Control1” must now reference a POU.

① Double click the ***Control1*** Task icon in the Project Navigation Window; the ‘task event list’ window will be displayed:



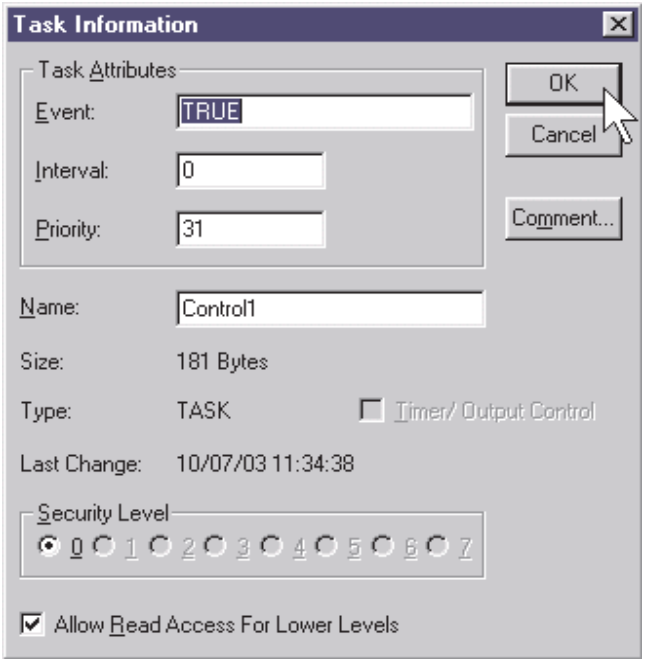
② Click on the centre ‘choice browse’ ellipsis as shown above. The following prompt dialogue is displayed:



③ Choose MAIN and click ***OK*** to complete the assignment operation.

Task Properties

The properties for the task can be displayed by right clicking the mouse on the required task pool entry (i.e. Control1) and selecting ***Properties*** from the menu. The following task settings window is displayed:



- Task Attributes
  - Event = TRUE: Always execute
  - Interval = 0: Set to zero because ***Event*** is always true.
  - Priority = 31: 31 is lowest priority i.e. is scanned last.

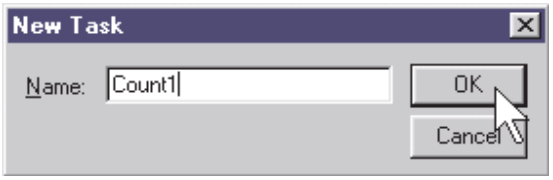
Before continuing, it is a good idea to “SAVE” the project; click on the Save Button.

Creation of a new task for the POU "Batch-Count"

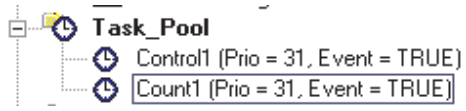
The POU "Batch-Count" needs also to be referenced (called) by a task in the ‘Task Pool’.

① To create a new task, Right Click on the ‘Task_Pool’ icon on the Project Navigation Window (PNW) and select ***New Task*** from the presented menu. Alternatively, follow the previous procedure, clicking once on the Task_Pool Icon to highlight it on the PNW and click the ‘New Task’ icon on the toolbar.

② Enter the name "Count1" into the prompt window as illustrated:



The new task will appear under the previous Task “Control1” in the task Pool:



③ Double click on the new task icon, ‘Count1’ in the PNW.

④ Assign the remaining POU to this task:

	POU name		Comment
0	Batch_Count	...	

When complete, click the check button then the ‘Rebuild All’ button to check and assemble the project.

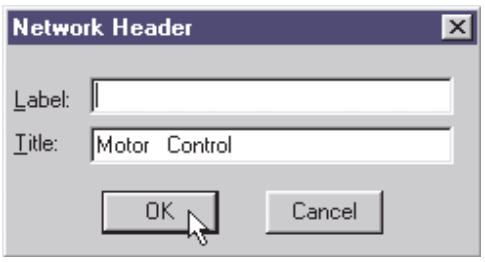
Save the project using the save button. The project is now complete and must therefore be transferred to the PLC.

4.2.7 Program Documentation

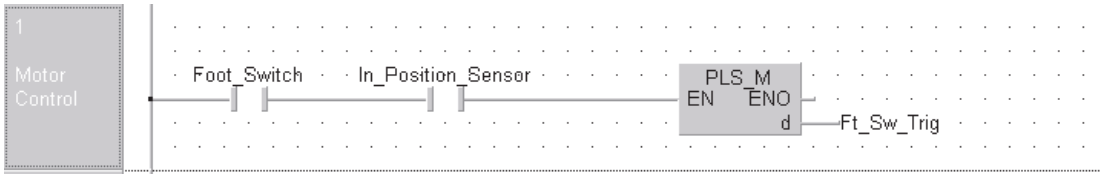
Network Header

Titling the network header is optional and provides a means to identify the program network with a descriptive title of up to 22 characters. This can assist handling projects where large numbers of networks are present.

① With Network 1 selected, click the ***Network Header*** button  or double click the mouse pointer over the network header area and enter the following data into the Title field **ONLY** – leave the ***Label*** field **Blank** as this has another function:



② Click ***OK*** and the network header will be displayed on the left hand side of the screen:



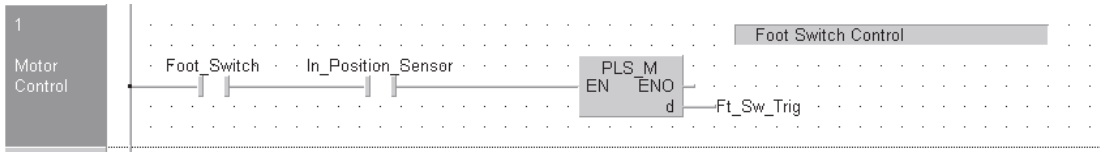
Note that the title may require pre-formatting (Padding with spaces), depending on the screen resolution set, to read correctly as the text auto wraps to fit into the horizontal space available (22 characters max).

Network Comments

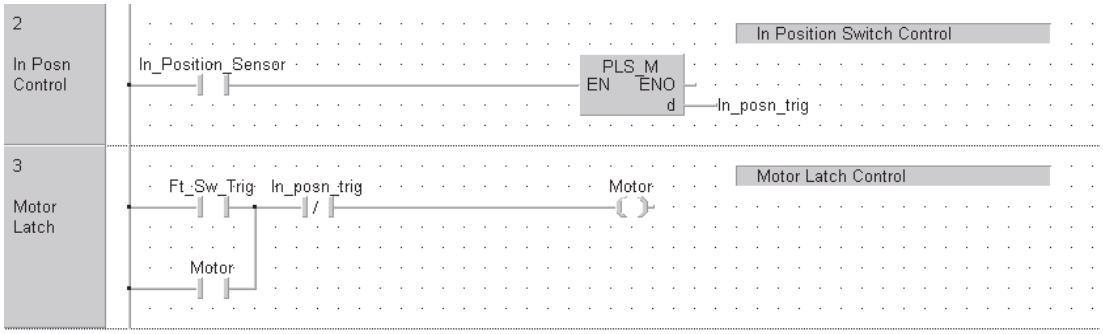
Comments enable virtually freehand text descriptors to be added anywhere inside the ladder network area. This is vital to provide descriptions of the operation of the program.

① To create a comment, press the 'Comment Button'  on the toolbar.

② The mouse pointer changes to  , click the left mouse button wherever the comment is to be placed and type the required text and press <Enter>:



Continue to complete the program documentation as follows:



Moving the position of a comment

With the cursor in 'Select Mode', it is possible to grab and move the comments around the ladder network area. To achieve this, click and hold on the left part of the comment dialogue area. Drag the comment anywhere on the screen and release the mouse button.

Deleting a comment

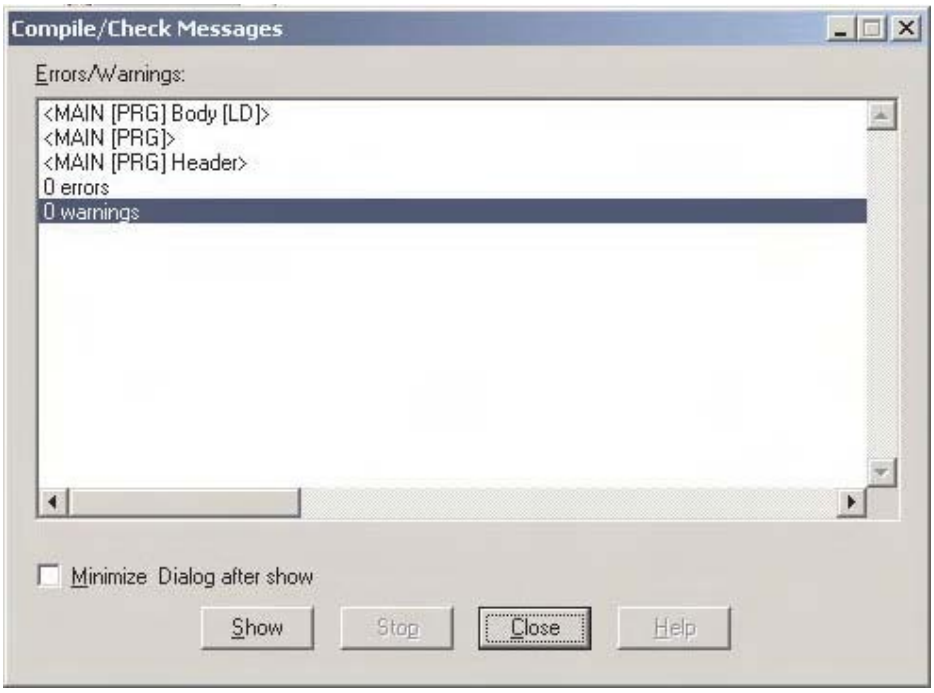
Click once on the comment to highlight and press the <Delete> key on the keyboard.

Cutting / Copying a comment

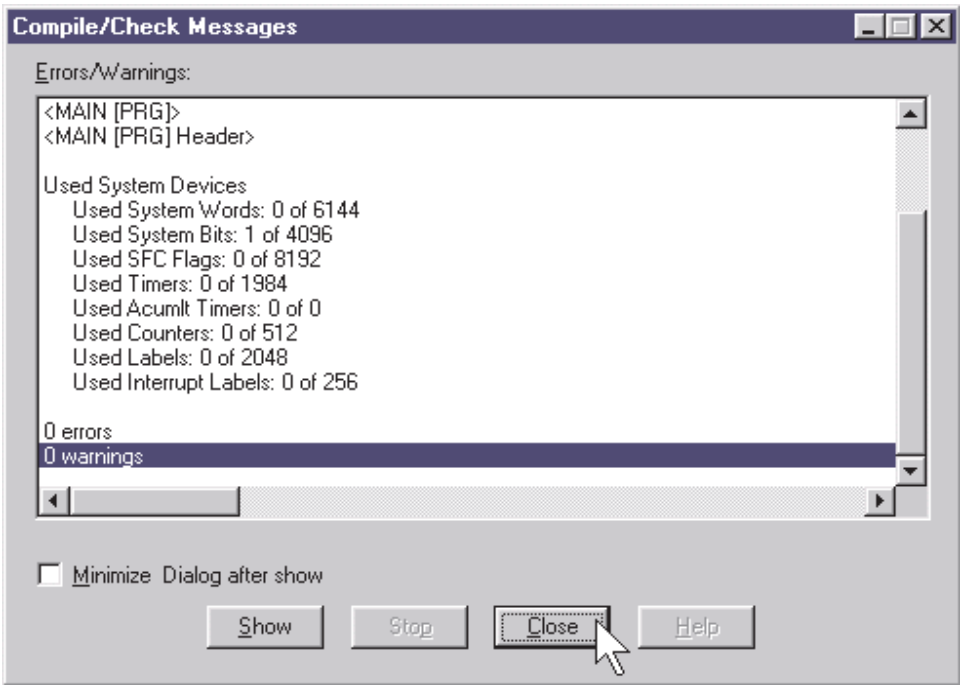
Duplication of comments is achieved by clicking on the left hand end of the source comment to highlight it. Use windows cut/copy – paste procedure and click the mouse once again to set position of destination comment in another network.

4.2.8 Checking and Building the Project Code

① When the Ladder Diagram is complete and task has been specified in the Task Pool, once again press the "Check" button on the tool bar to check the program for errors; the following dialogue should be displayed:



② Click either the 'Build' button or the 'Rebuild All' button on the toolbar and if all is well, the following compiler messages are reported:

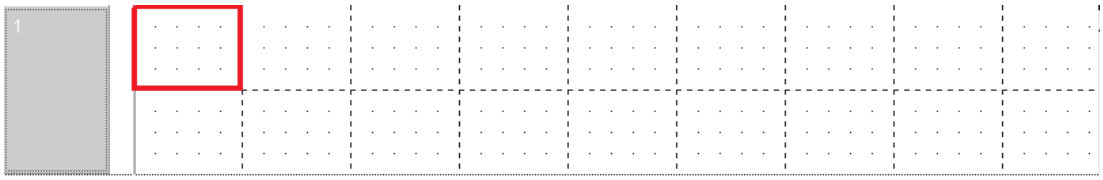


③ Click ***Close*** to exit this display.

4.2.9 Illustration: Guided Ladder Entry Mode

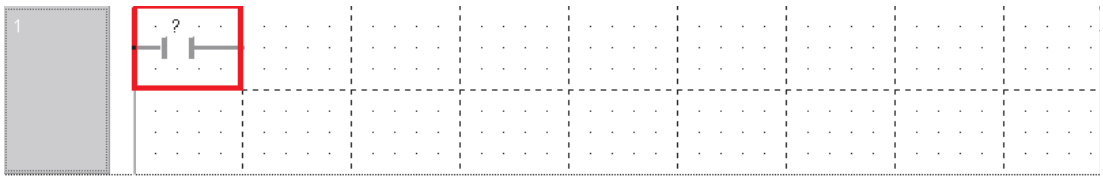
In addition to the freehand ladder entry methods, GX-IEC Developer Version 6 **onward** features a ***Guided Ladder Entry*** Monitor method which may be used to aid Ladder program entry. This entry method may prove to be helpful to those wishing to make the transition to GX-IEC Developer who have had previous familiarity with Mitsubishi's MEDOC package and GX-Developer.

① Enter the ***Guided Entry Monitor*** mode by pressing the button on the tool bar. The following matrix is placed into the edit area:



② Use the following buttons on the toolbar to select the ladder symbols. The corresponding number may be pressed to select the appropriate symbol from the keyboard, thus eliminating the need to use the mouse:

③ Select the 'Normally Open' Contact symbol "1" and the following will be displayed:

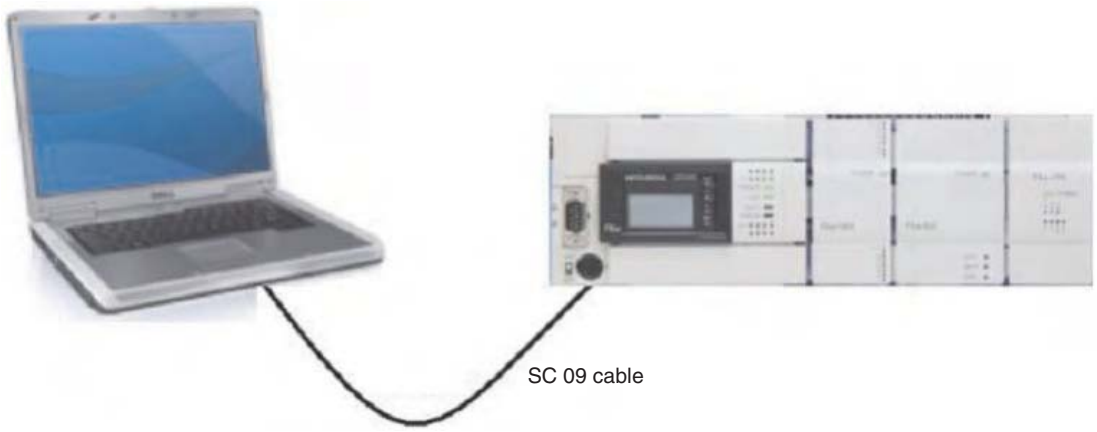


The program may continue to be entered using the "F2" button on the keyboard or click on the button on the tool bar to call up the variables selection window as previously described.

4.3 Project Download Procedures

4.3.1 Connection with Peripheral Devices

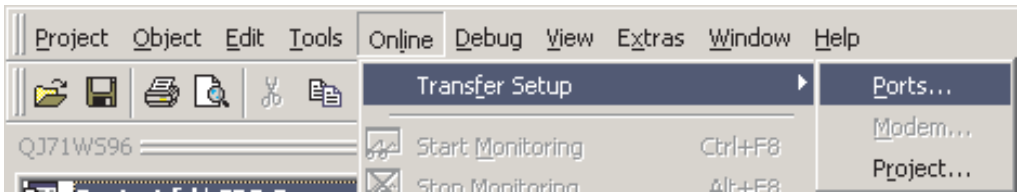
The following notes describe how the project is downloaded to a FX PLC. To connect a controller of the FX family and a PC, the SC 09 converter is used to convert the RS232 common mode serial signals 'to and from' the computer to the RS 422 serial-differential format required by the PLC.



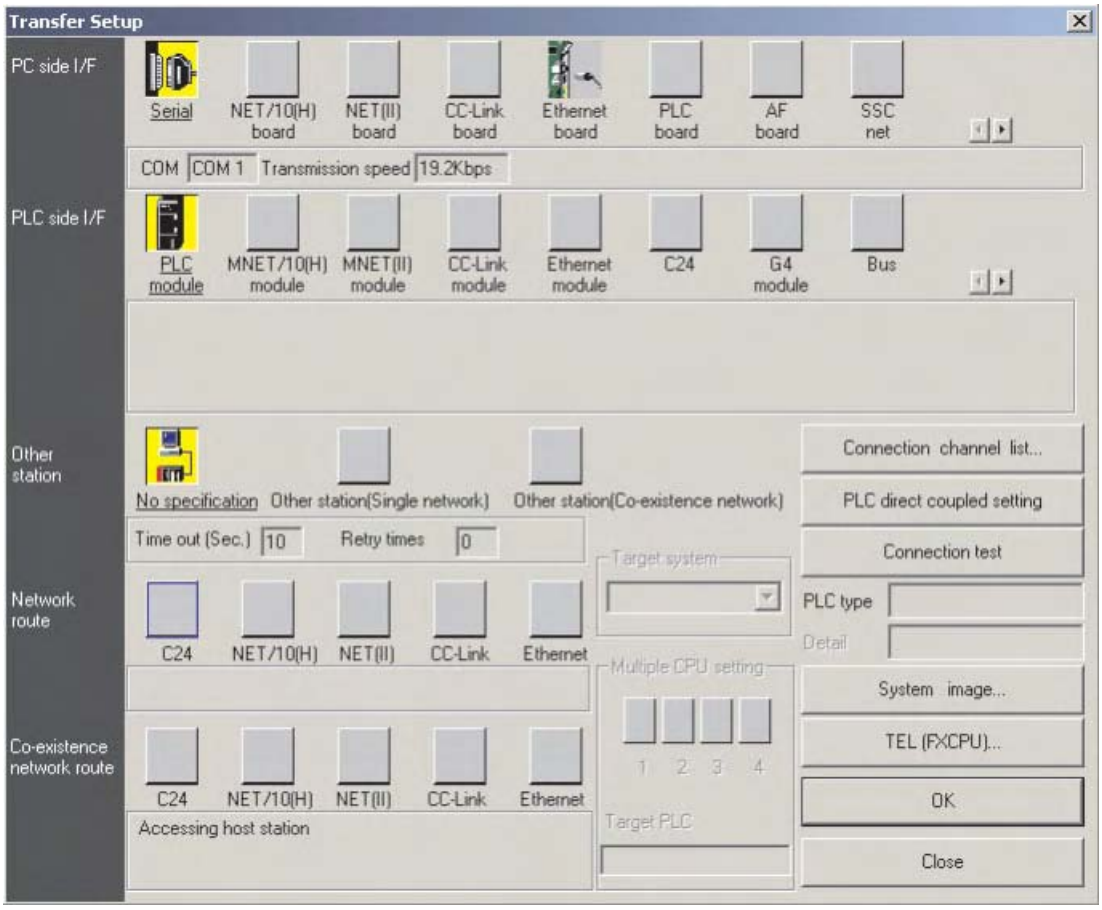
4.3.2 Communications Port Setup

Before the project can be downloaded into the PLC CPU for the first time, the communication and download settings must be configured.

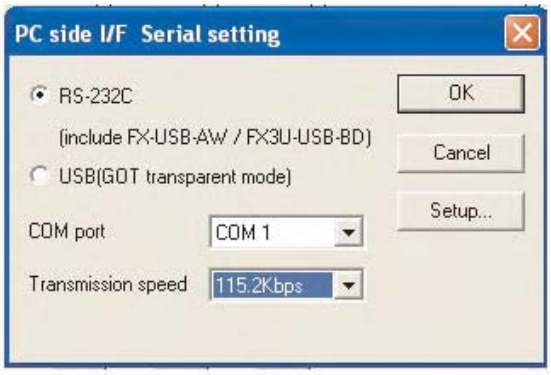
① From ***Online*** Menu, select ***Transfer Setup*** and then ***Ports***:



The ***Connection Setup*** window shown on the next page will be displayed.

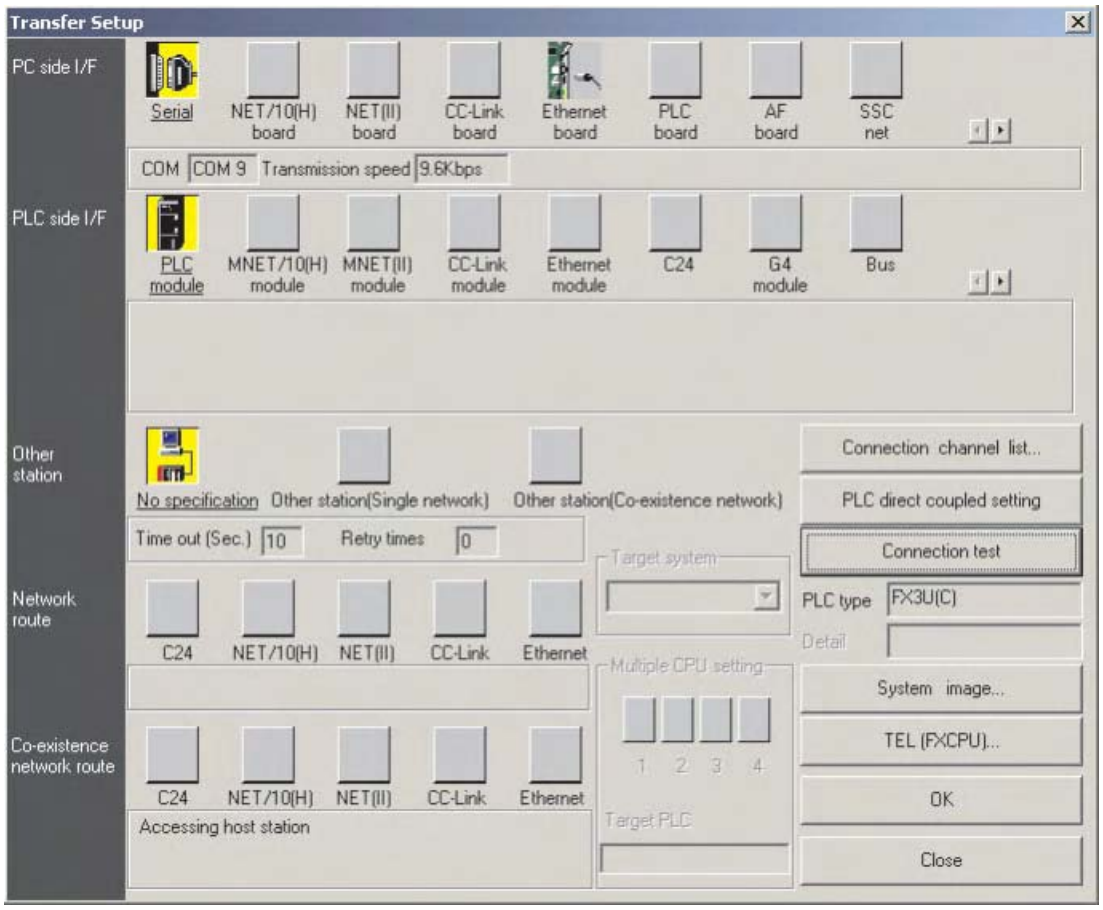


② Double click the mouse on the yellow ***PC side I/F*** – ***Serial*** button and the following dialogue window is displayed:



③ Select ***RS232C*** as shown above and click ***OK***.

④ Click on the ***Connection Test*** button to check PC-PLC communications are ok:



⑤ The following message should be displayed:

⑥ Click ***OK*** to close this message.

If an error message is displayed, check connections and settings with the PLC.

Connection Setup Route

① To obtain a pictorial view of the Connection setup route, select the ***System Image*** button

② Click ***OK*** to clear the display.

NOTE

When using a standard RS232 Serial Port to communicate with the PLC, if another device is already connected to the selected COM (n) interface, for example a serial mouse; Select another free serial port.

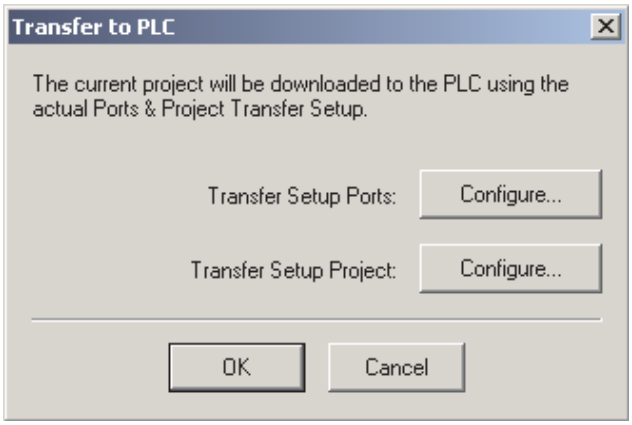
③ Select ***OK*** to close the ***System image*** display and return to the ***Connection setup*** display. Than click the ***OK*** button to close the ***Connection Setup*** window. If you leave the ***Connection Setup*** window using the ***Close*** button, the settings are not saved.

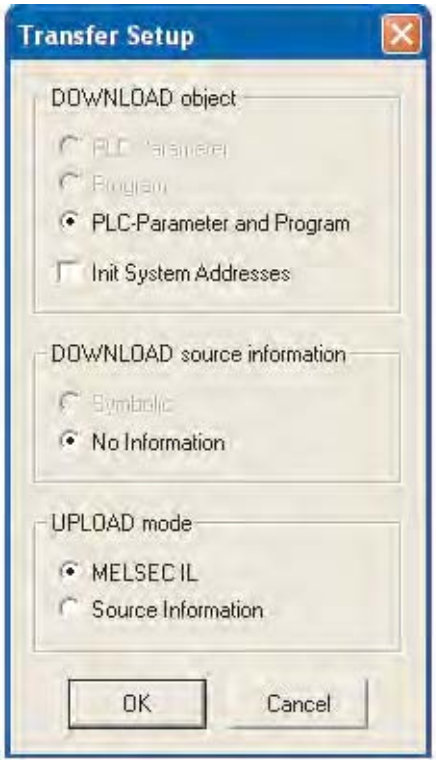
4.3.3 Downloading the project

① Once the setting up procedures is complete, click on the “Download Project” icon on the toolbar.

Transfer Setup

② Click the ***Configure*** button to setup the “Transfer parameters” for the project.

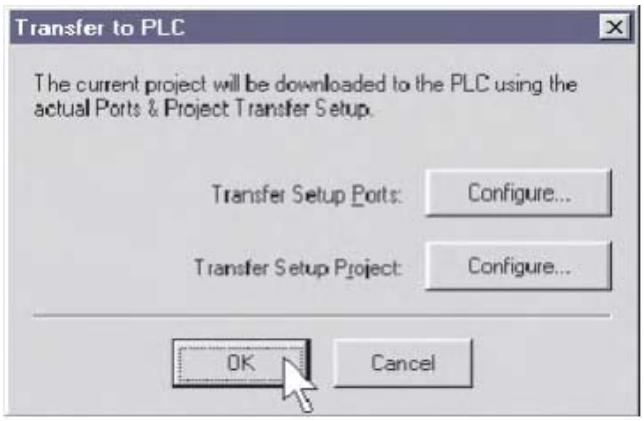




② Click on ***PLC-Parameter and Program***

③ Click on ***OK*** to confirm the selection.

④ To send the project to the PLC, click the ***OK*** button to execute the transfer.

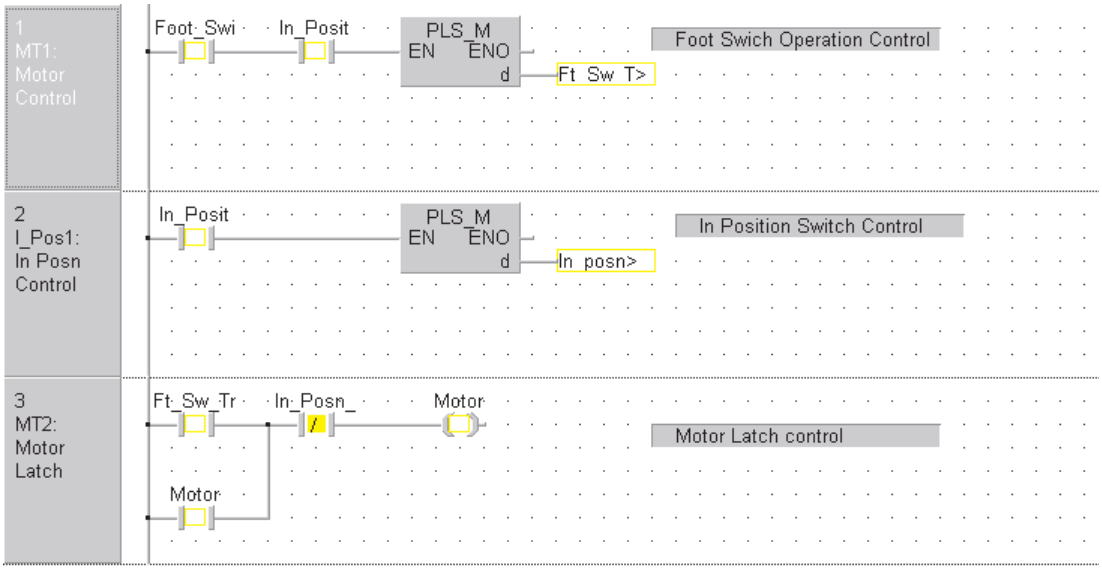


4.4 Monitoring the Project

Ensure that the PLC is switched to RUN and no errors are present.

Display the body of the MAIN ladder program.

Click on the Monitor Mode Icon  on the toolbar and observe the ladder display:



NOTE

Depending on the colour attributes set, monitored variables will be displayed with a coloured surround (Default: Yellow). Values of any analogue variable will be displayed on the monitored networks as appropriate.

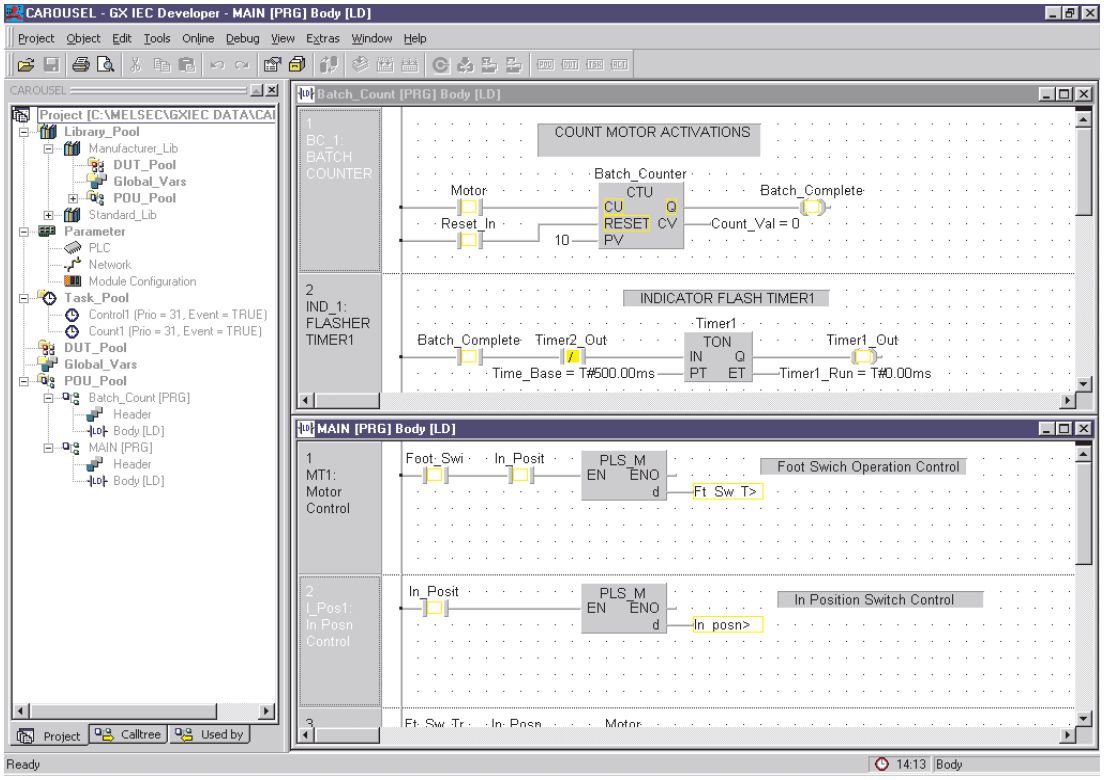
4.4.1 Split / Multi Window Monitoring

To monitor both of the project' POU's simultaneously, open both POU bodies and select ***Tile Horizontally*** from the ***Window*** menu.

NOTE

Important: It should be noted that when initially entering monitor mode with  , only the screen in focus will be monitored. This is to avoid unneeded communication traffic occurring from other screens that have been opened but are not necessarily in the focus (i.e. opened but behind).

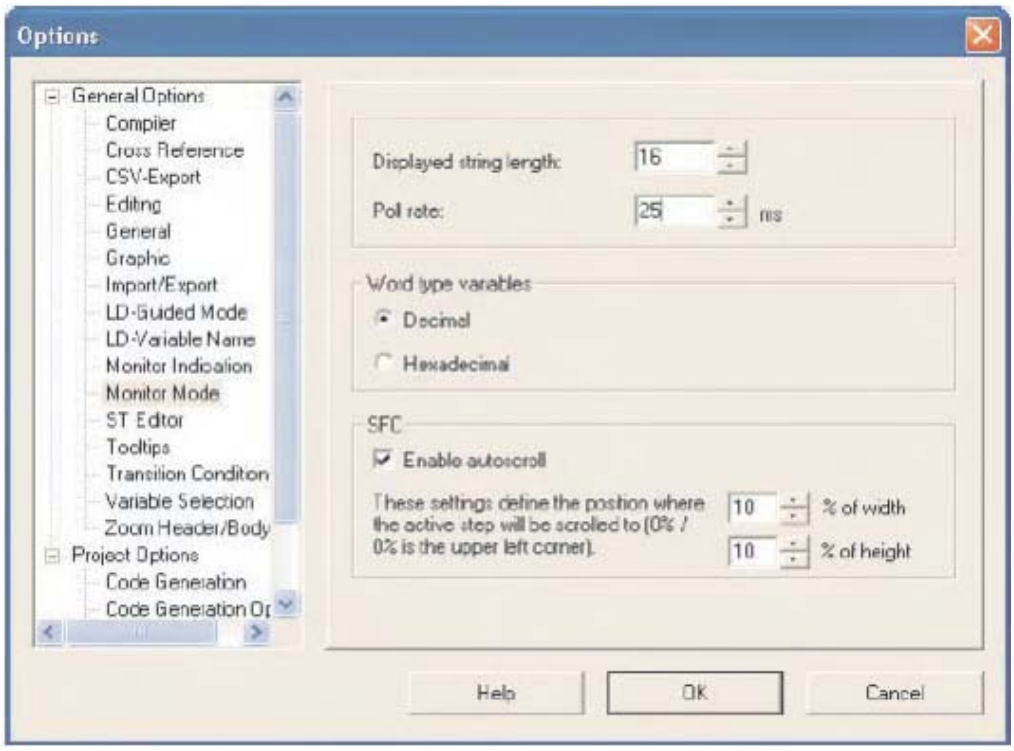
To begin monitoring the content of additional windows, click inside that window and select ***Start Monitoring*** from the ***Online*** Menu:



NOTE

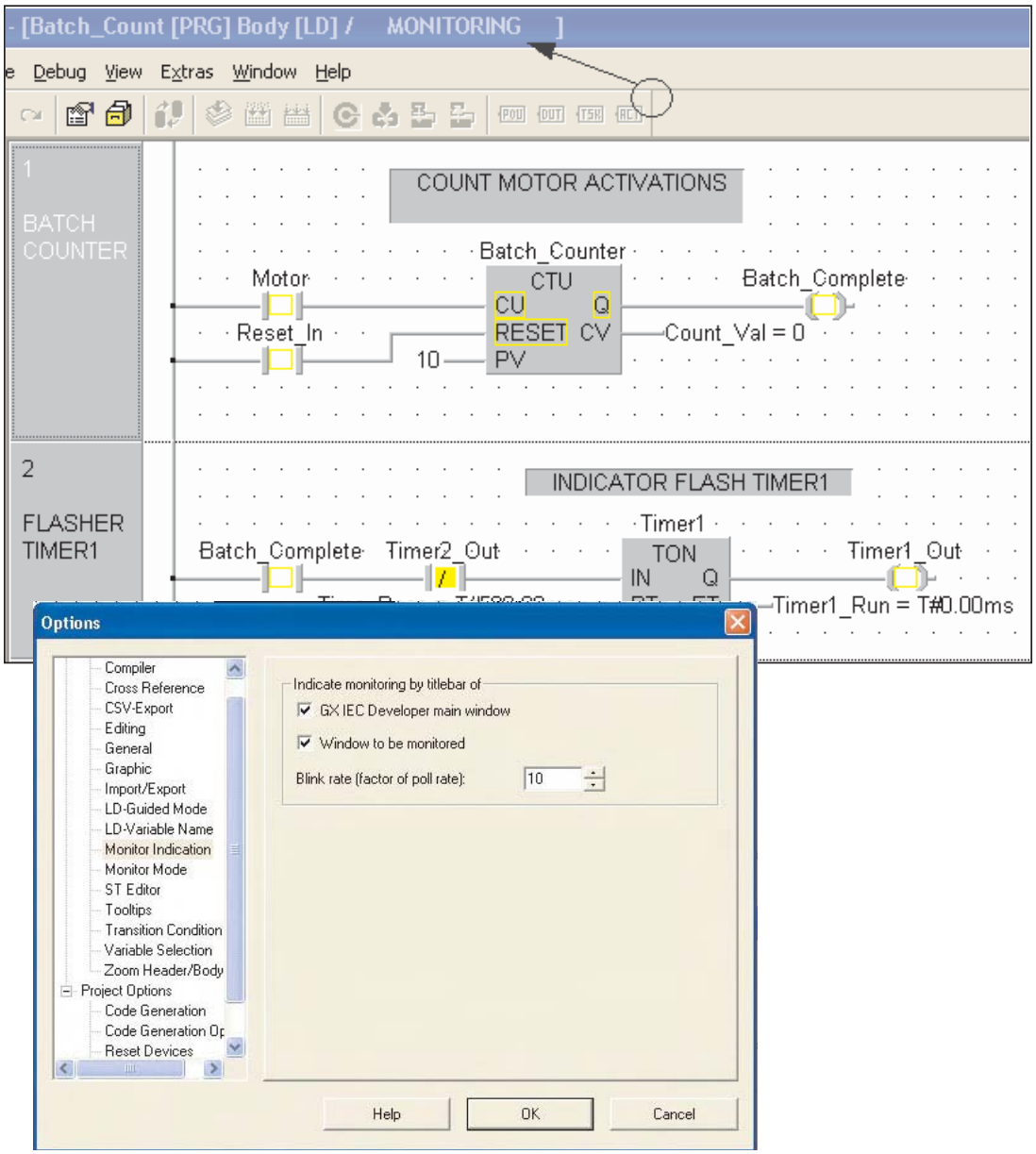
Due to the serial communications handshake, be prepared to wait a few seconds for the monitor information to be registered between GX IEC Developer and the PLC.

The rate of communication polling from GX IEC Developer to the PLC may be increased by adjusting the following parameters from the ***Extras*** / ***Options*** menu and select ***Monitor Mode***; alter the poll rate setting:



4.4.2 Adjusting Monitor Visibility

To adjust the visibility of the monitor mode, select ‘Extras/Options/Monitor Indication’ and a flashing message can be enabled, to appear where chosen. The blink rate of the “Monitoring” banner can be set by the User:

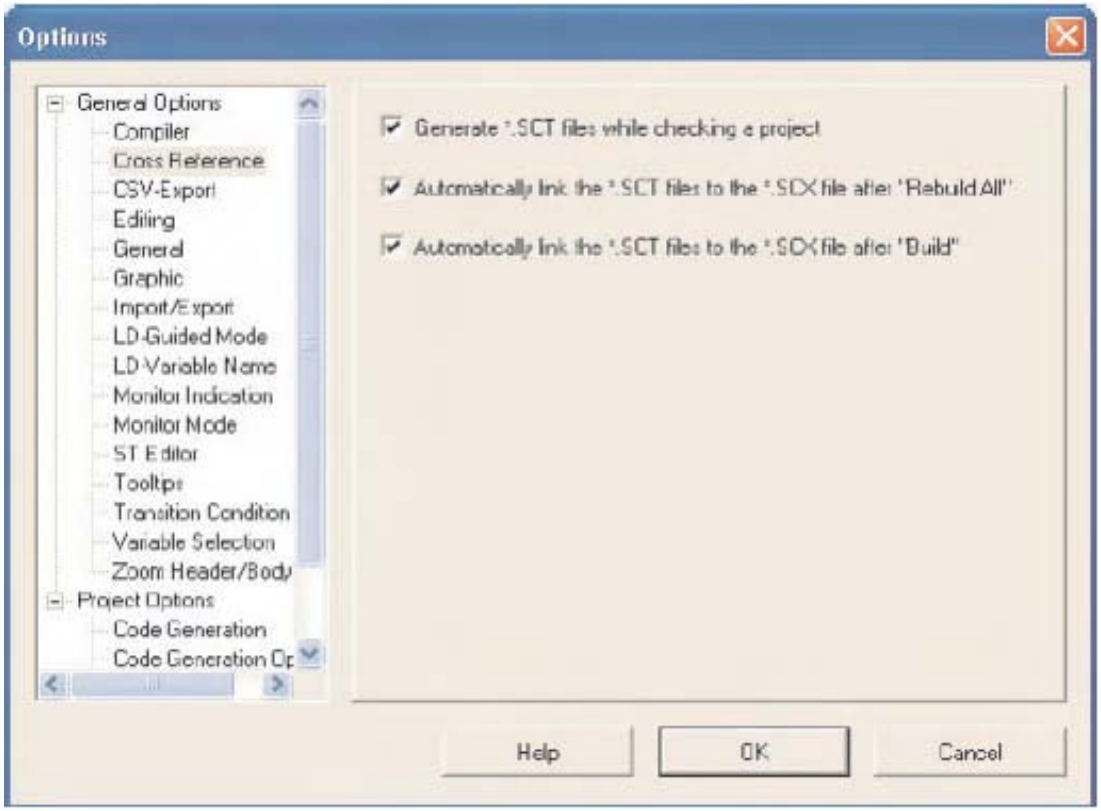


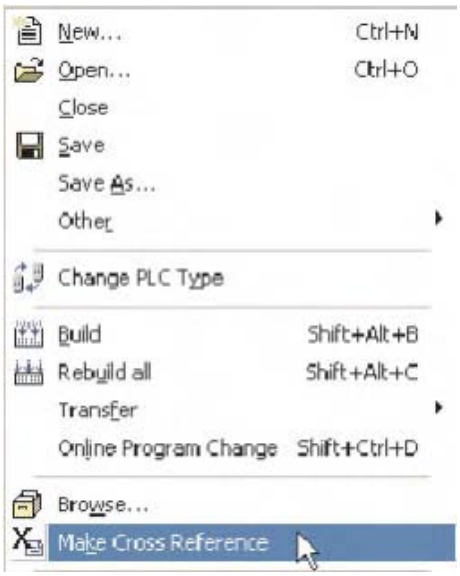
4.5 Cross Reference List

To generate a Cross Reference List:

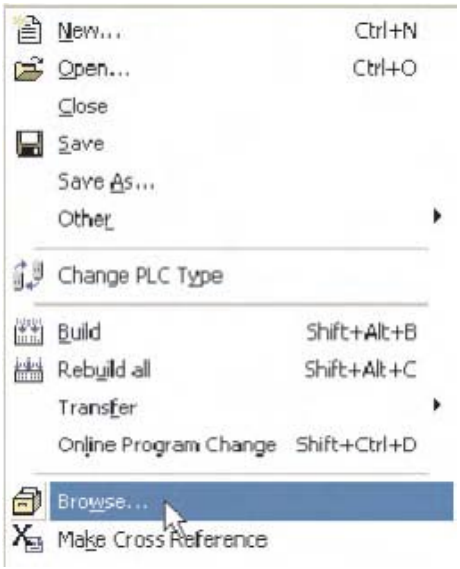
① Open the ***Extras/Options*** Menu and select ***Cross Reference***

② Check both options shown and re-compile the project.



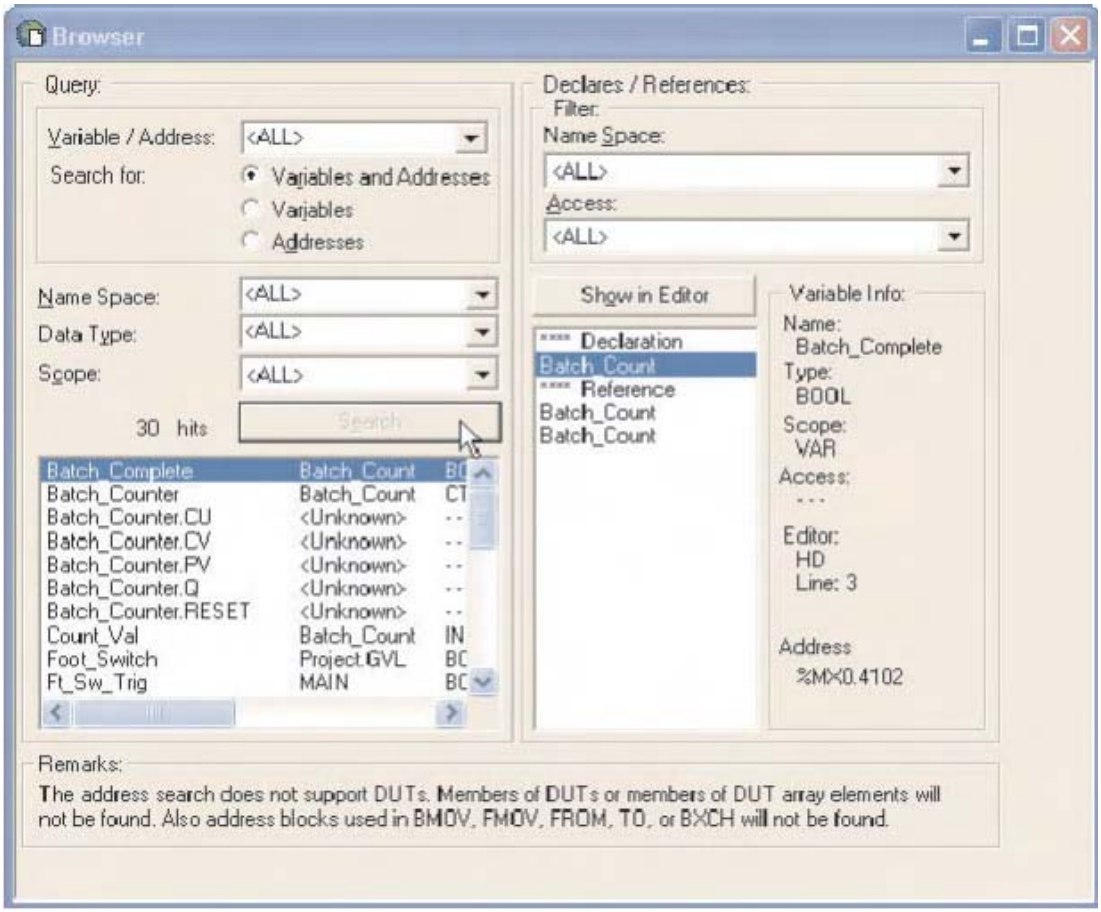


③ Then select ***Make Cross Reference*** from the ***Project*** Menu and the list is generated.



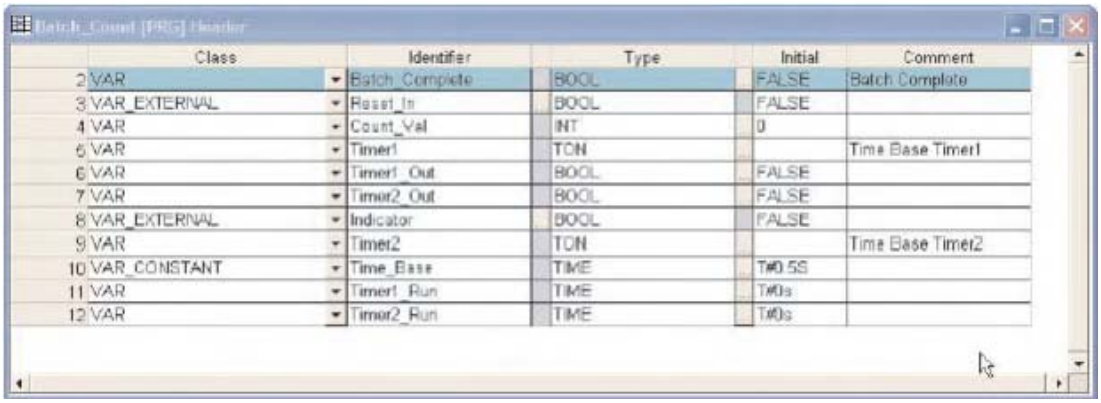
④ Open the Browser, either from the ***Project*** menu, or via the toolbar icon .

⑤ Click on the ***Search*** button and the full list will be displayed.

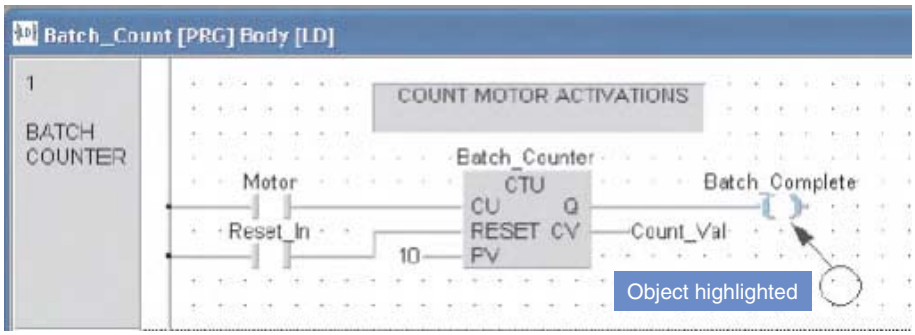


Specific variables etc. can be searched by using the query selection boxes. Individual details of the highlighted entry are then shown on the right hand side of the window.

The ***Show in Editor*** button opens the header of the highlighted right hand list element, for example:



Or

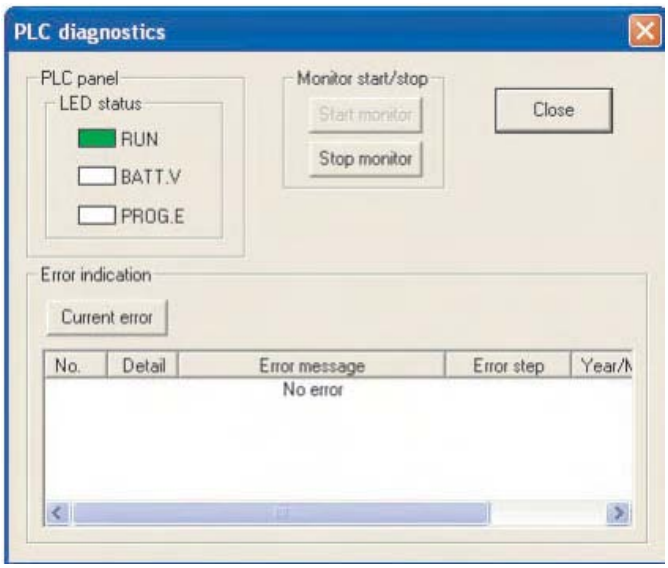


The Cross Reference List may be printed out, using the print facility within GX IEC Developer.

4.6 PLC Diagnostics

In GX IEC Developer various diagnostic functions are available.The functions in the ***Debug*** menu allow to perform precise troubleshooting and error analysis of your application.

Click on ***PLC Diagnostics*** to open the window shown below.



Clear Text Error Message

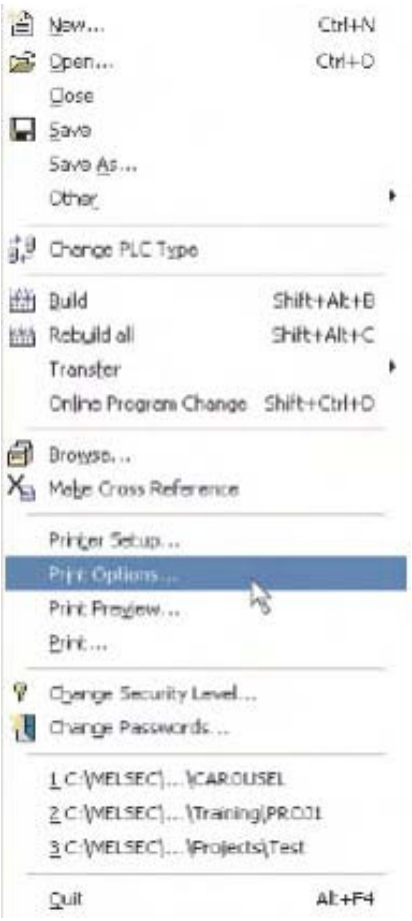
The error data registers of the PLC are evaluated with clear text and respective help texts.

The most important hardware errors such as “Fuse blown” are displayed in a window and evaluated.

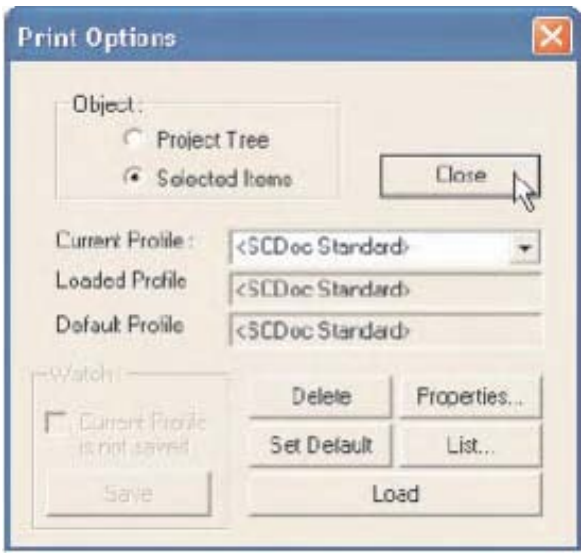
User errors can be determined. These user errors are stored with a self-created text file (USER_ERR.TXT) and allow a quick error correction. The last eight user errors are stored into a FIFO register and only be removed when they no longer occur.

4.7 Project Documentation

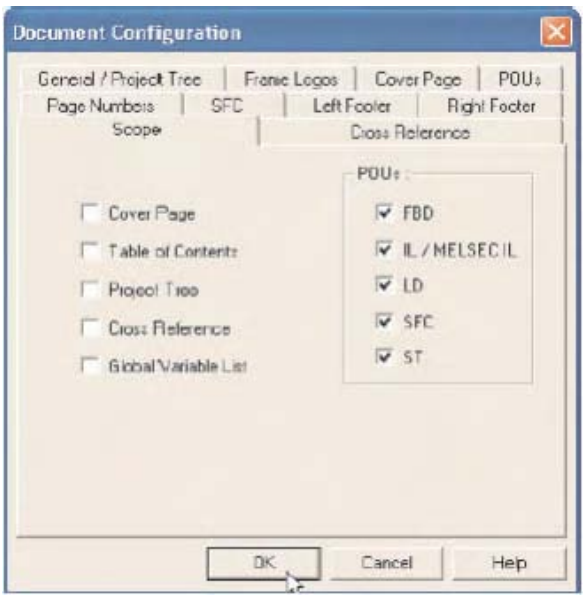
Project documentation can be set up using the ***Print Option*** facility from the ***Project*** Menu:



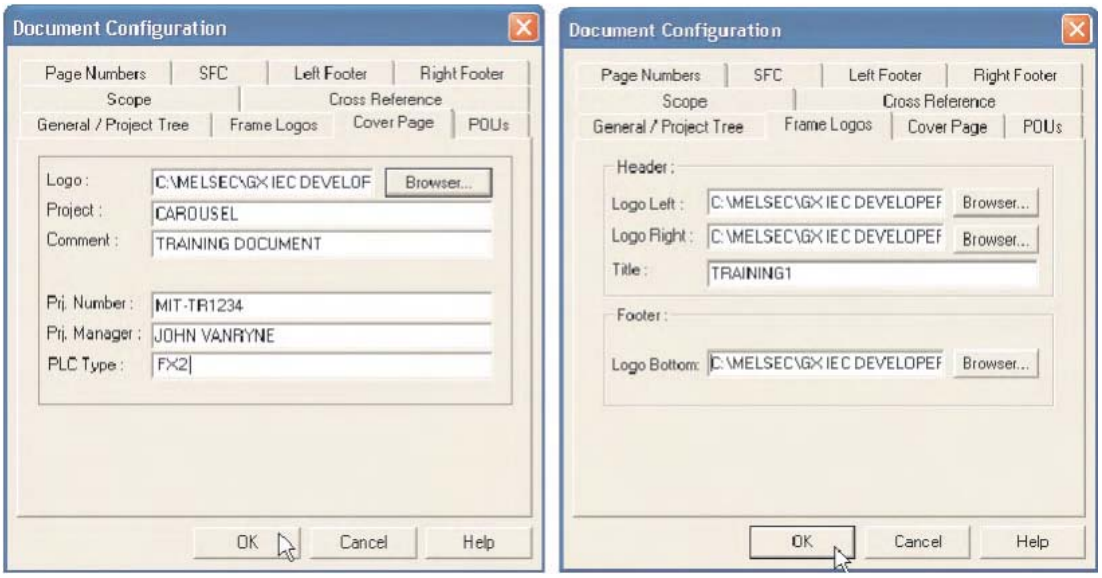
The “Change Configuration” dialogue box can then be seen. Previous project profiles can be retrieved here, or work with the default profile. Either select the ***Project Tree*** for all elements, or ***Selected Items*** for specific highlighted items, open ***Properties***:



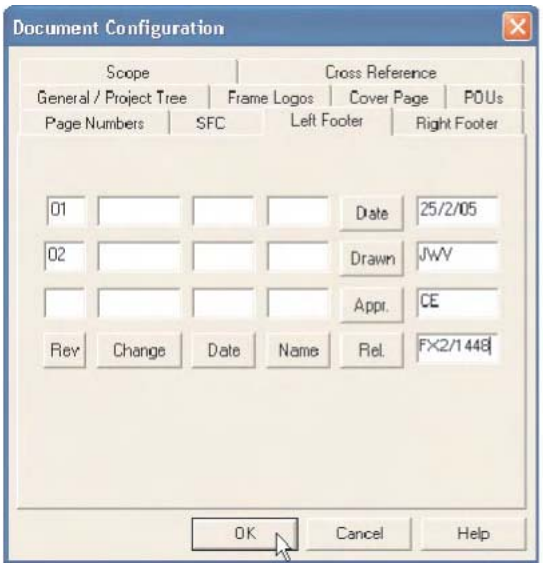
The ***Document Configuration*** folder is shown below. Select the tabs to configure the document as required. In this example, only the COUNTER_FB_CE will be printed, as the ***Selected Items*** option was chosen:

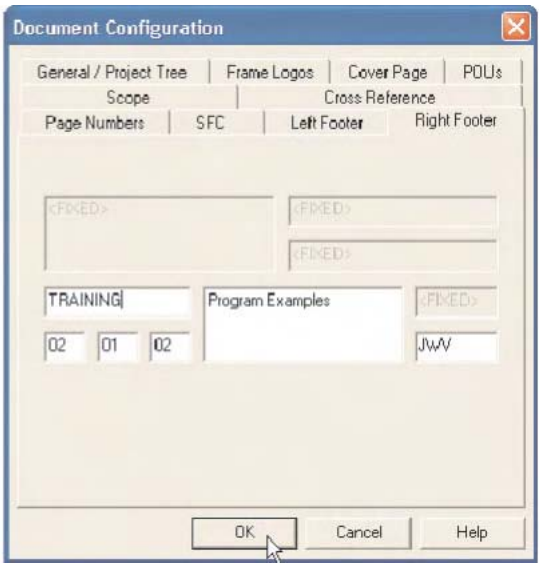


User defined logos and information can be assigned, in the ***Cover Page*** tab, for the front sheet and for the frame from the ***Frame Logos*** tab:

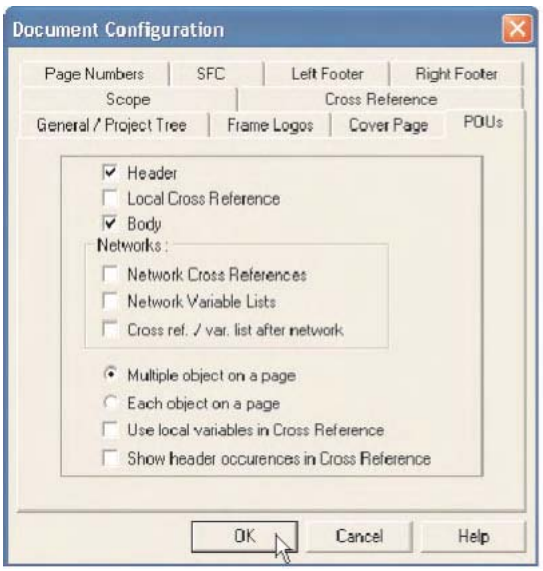


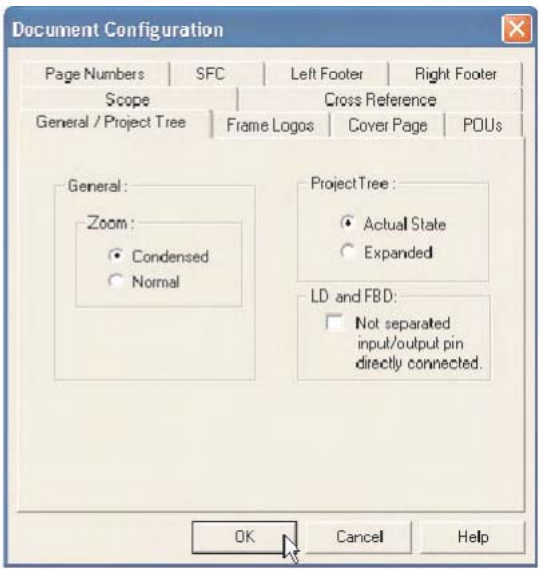
Detailed information can be assigned, to the left and right footers. The field labels in the ***Left Footer*** dialogue can be renamed, by clicking on the name buttons, as required:



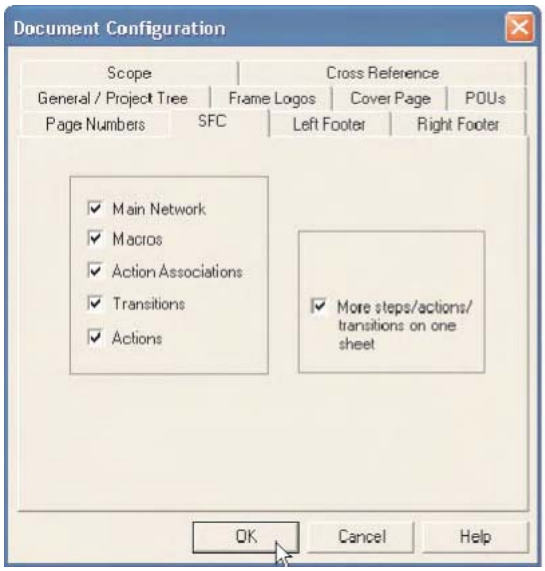


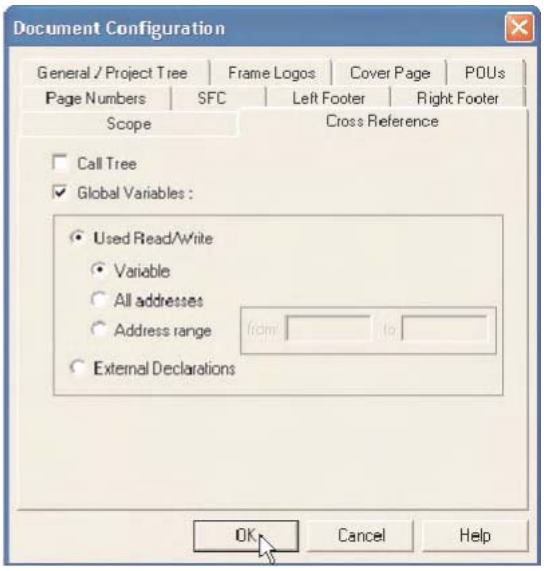
Specification for POU appearance and general project specifications are available from the ***POUs*** and ***General/Project Tree*** tabs.



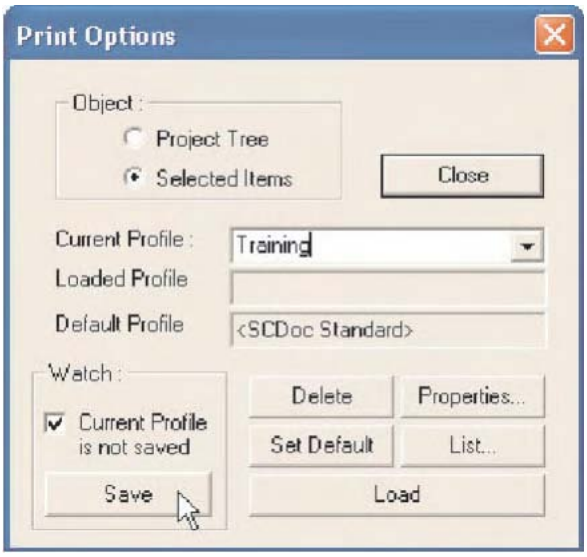


Specification for SFC appearance and cross reference specifications, are available from the ***SFC*** and ***Cross Reference*** tabs:





The configured profile can be saved, by simply naming the ***Current Profile*** field and then clicking the ***Save*** button. It can then be recalled at any time using the selection box:



5 Program Example

5.1 QUIZMASTER

Subjects covered:

- Timing
- Counting
- Logical Operations: Latching – Interlocks – Use of internal M device.
- Functional Instructions: Reset Function – Pulse Function

Description

A comprehensive automatic quiz game controller; Captures and latches the first player to activate respective 'Answer Response Button'. Only one contestant response lamp will be activated; all subsequent responses from other contestants are locked out.

Task

- Produce a PLC Ladder Diagram, which ensures that only one of the Contestant Indicator Lamps illuminates.
- When the chairman presses the Start Button, the contestants have a 10 second window to offer a response via their response push buttons.
- During the answer response period, the elapsed time (0 -10 Sec) is displayed on the analogue gauge of the training rig.
- The Chairman may reset the system at any time by using a separate button.

I/O List

– Inputs

X0	-	Player1 Response Button
X1	-	Player2 Response Button
X2	-	Player3 Response Button
X3	-	Player4 Response Button
X4	-	Chairman Start Timing
X5	-	Reset Game

– Outputs

Y0	-	Player1 Answer Lamp
Y1	-	Player2 Answer Lamp
Y2	-	Player3 Answer Lamp
Y3	-	Player4 Answer Lamp
Y4	-	Time-up Indication
Y5	-	Question Timing

5.1.1 Method

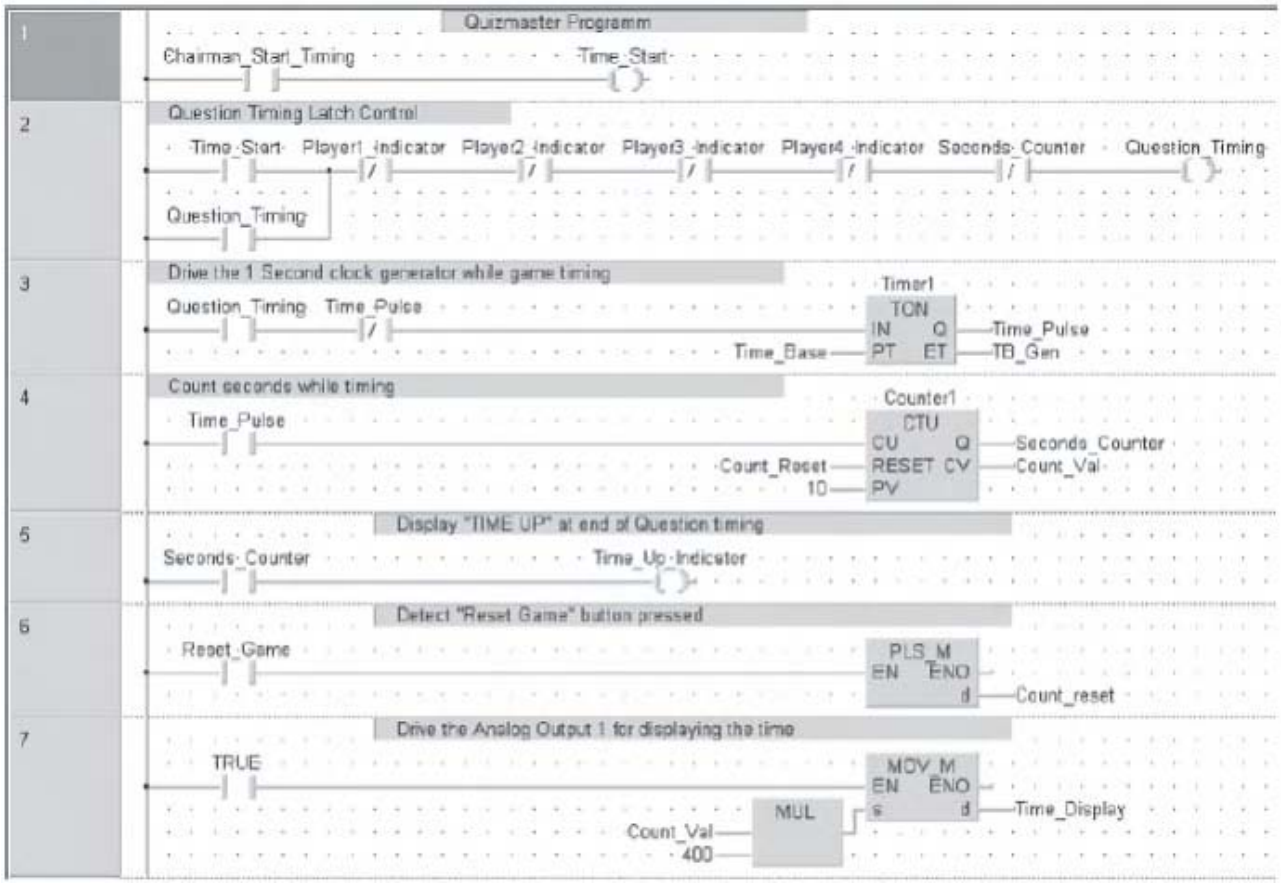
① Create a new project and name it “Quizmaster”.

② Enter the following data into the ***Global Variables List***:

	Class	Identifier	MIT-Addr	IEC-Addr	Type	Initial
0	VAR_GLOBAL	Player1_Response	%I0	%I0	BOOL	FALSE
1	VAR_GLOBAL	Player2_Response	%I1	%I1	BOOL	FALSE
2	VAR_GLOBAL	Player3_Response	%I2	%I2	BOOL	FALSE
3	VAR_GLOBAL	Player4_Response	%I3	%I3	BOOL	FALSE
4	VAR_GLOBAL	Chairman_Start_Timing	%I4	%I4	BOOL	FALSE
5	VAR_GLOBAL	Reset_Game	%I5	%I5	BOOL	FALSE
6	VAR_GLOBAL	Player1_Indicator	%Q0	%Q0	BOOL	FALSE
7	VAR_GLOBAL	Player2_Indicator	%Q1	%Q1	BOOL	FALSE
8	VAR_GLOBAL	Player3_Indicator	%Q2	%Q2	BOOL	FALSE
9	VAR_GLOBAL	Player4_Indicator	%Q3	%Q3	BOOL	FALSE
10	VAR_GLOBAL	Question_Timing	%Q4	%Q4	BOOL	FALSE
11	VAR_GLOBAL	Time_Display	%IW1	%MW14.4.1	INT	0
12	VAR_GLOBAL	Time_Up_Indicator			BOOL	FALSE

③ Create a new POU of Class ***PRG*** (Program Type) and Language ***Ladder Diagram*** and name it “Game_Control”.

④ Enter the following code into the POU.

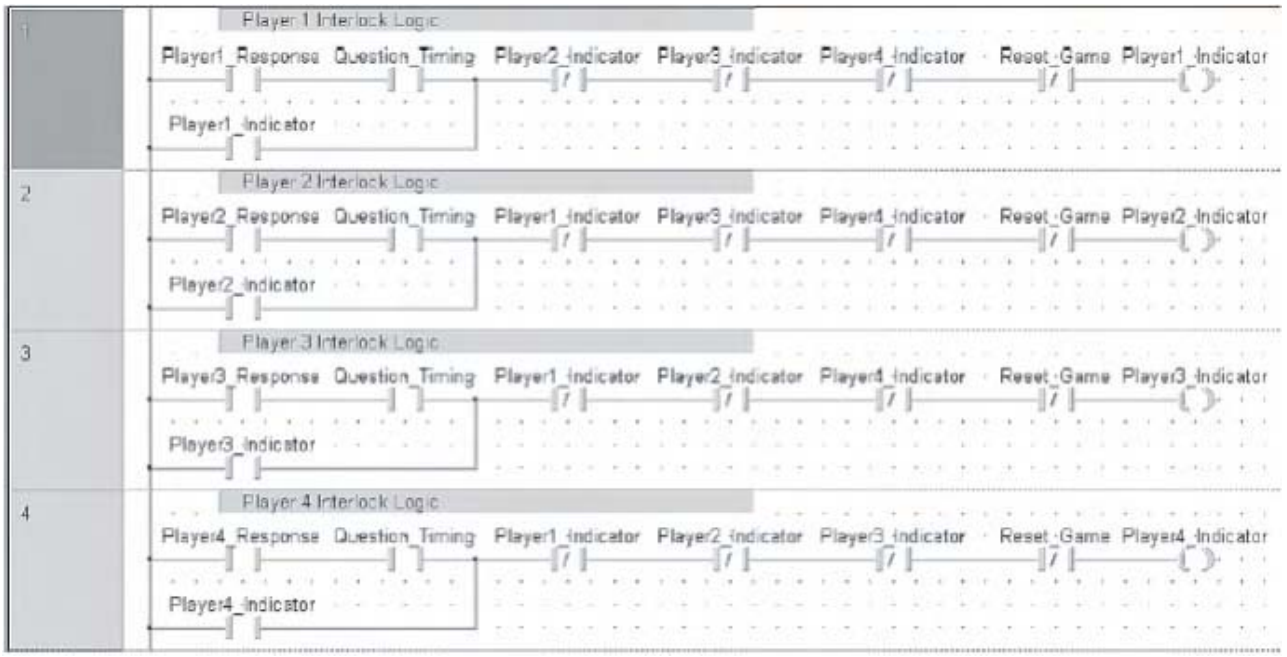


The finalised Header of the “Game_Control” POU should read as follows

	Class	Identifier	Type		Initial	Comment
0	VAR	Time_Start	BOOL		FALSE	
1	VAR	Time_Pulse	BOOL		FALSE	
2	VAR	TB_Gen	TIME		T#0s	
3	VAR_CONSTANT	Time_Base	TIME		T#1s	
4	VAR	Count_Reset	BOOL		FALSE	
5	VAR	Seconds_Counter	BOOL		FALSE	
6	VAR	Count_Val	INT		0	
7	VAR	Timer1	TON			
8	VAR	Counter1	CTU			
9	VAR	Config_Analog	BOOL		FALSE	

⑤ Create a new POU of Class ***PRG*** and of Type ***Ladder*** and name it “Player_Logic”

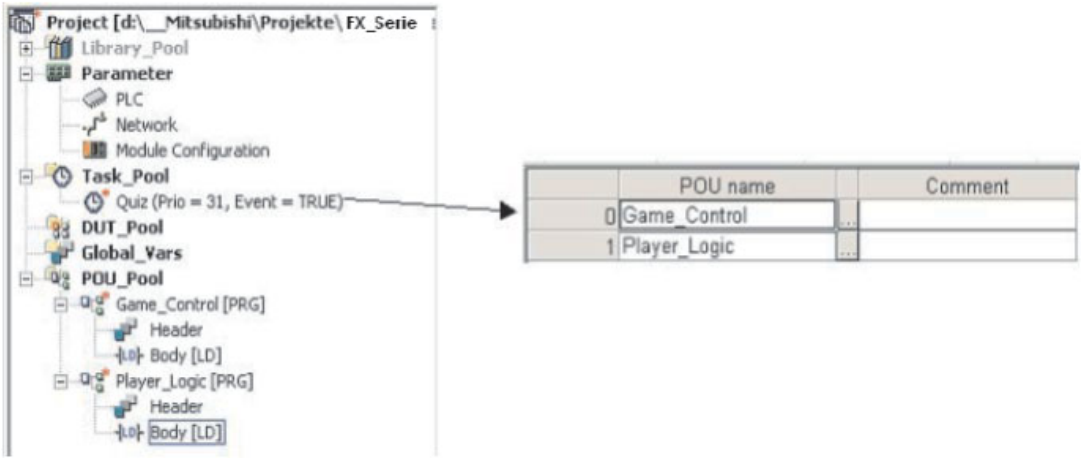
⑥ Enter the following Ladder code into the new POU:



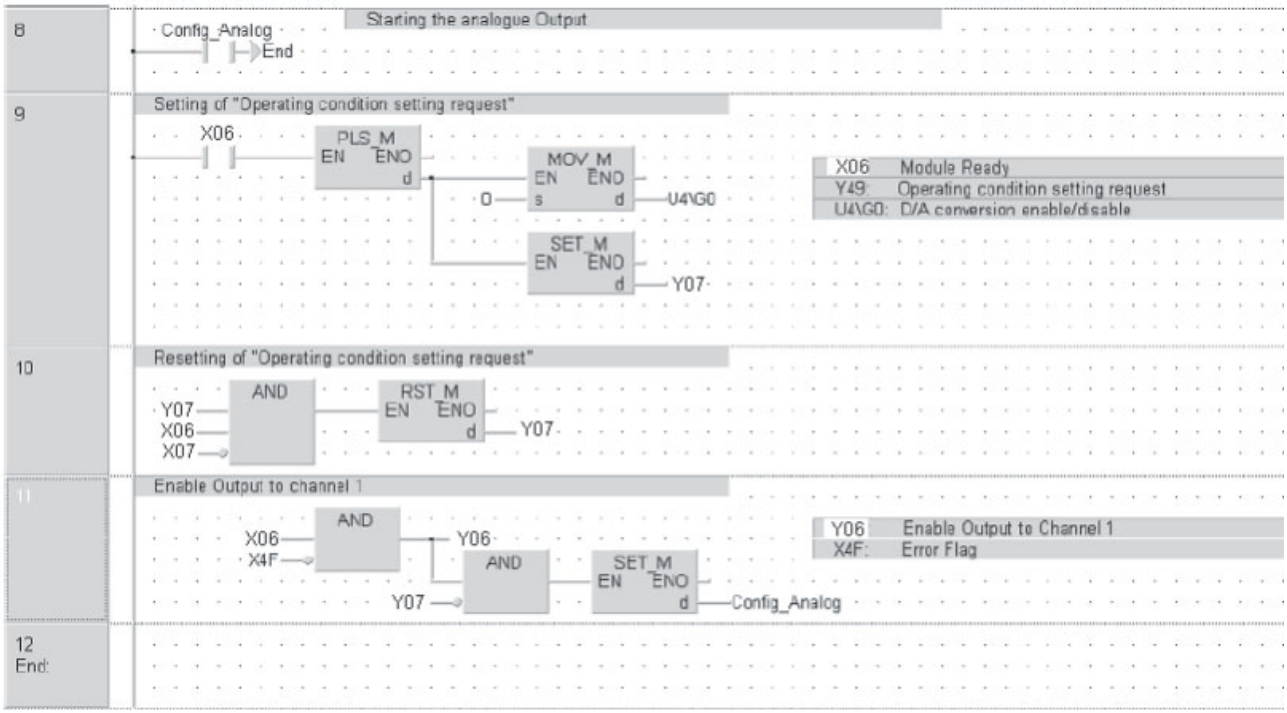
The finalised Header of the “Player_Logic” POU should read as follows:

	Class	Identifier	Type		Initial	Comment
0	VAR					

⑦ Create a new Task in the Task Pool “QUIZ”. Bind the POU’s, “Player_Logic” and “Game_Control” respectively into the new task as shown below:



⑧ Add the following networks to the POU “Game_Control” to start the analogue output to channel 1, which is connected to the gauge.



5.1.2 Quizmaster - Principle of Operation

① Enter, test and save the project “Quizmaster” including annotation.

② Download the project to the FX-SERIES PLC.

③ Ensure the project is working correctly by monitoring the operation while operating the inputs.

④ Momentarily switch input X4 to begin contestant answer response timing.

⑤ Wait for initial contestant response from X0, X1, X2 or X3 and latch appropriate contestant indicator. Lock out further operation of all inputs.

⑥ While waiting for response, run response timer for a period of 10 seconds and present running time on display.

⑦ At end of time period, lock any further action from all contestant response inputs, stop the time display and illuminate ‘Time Up’ indicator.

⑧ Wait for chairman to activate ‘Reset’ input X5, in order to clear all game status flags and outputs, so as to begin a new round.

⑨ Go back to step 1 or end game.

5.1.3 Quizmaster Program Description

POU “Game_Control”

- Network 1

  When the Chairman Start Timing button is pressed, Local Variable “Time_Start is pulsed via the PLS_M instruction.

- Network 2

  Question_Timing is latched providing that no player indicators are on and the seconds counter is not counting.

- Network 3

  The Question_Timing contact enables the 1 second time base cut throat timer to run. 1 second pulses are generated on the “Time_Pulse” output.

- Network 4

  The pulses from the Time_Pulse flag are counted using a CTU “Count UP” counter, which counts for 10 second period.

- Network 5

  When the Seconds_Counter flag operates, the Time_Up_Indicator activates and is illuminates the lamp.

- Network 6

  When the “Reset_Game” input is activated, a pulse is generated to provide a pulse to reset the seconds counter in network 7 below.

- Network 7

  The TRUE input is “always on”, therefore the Count_Val multiplied with the offset of 400 digits/Volt is sent permanently as “Time_Display” to the analogue output module.

POU “Player_Logic”

- Networks 1- 4

  These routines control the player interlocks. For example if player 1 is the first to operate his of her response button, then that lamp illuminates and locks out all subsequent responses from other players.

  Each player control logic routine lock out other subsequent player responses.

  Players can only offer a response when the "Question_Timing" flag is active.

6 Functions and Function Blocks

Below is a table illustrating the comparison between ‘Functions’ and ‘Function Blocks’:

Item	Function Block	Function
Internal variable storage	Storage	No storage
Instancing	Required	Not required
Outputs	No output One output Multiple Outputs	One output
Repeated execution with same input values	Does not always deliver the same output value	Always delivers the same output value

- Functions are part of the instruction set.
- Functions are included in the standard and manufacturers libraries. i.e. TIMER_M is a function, as is MOV_M, PLUS_M etc. from the Mitsubishi Instruction Set in the Manufacturers Library.
- User defined functions can easily be created out of tested program parts.

  This means that functions can be created i.e. for system/process calculations, and can be stored in libraries and reused many times, with different variable declarations. This would be in the same way that i.e. a MOV instruction would be used but with the advantage of being user specific.

6.1 Functions

Most control programs have some form of maths within them, i.e. for analogue signal conditioning, displaying engineering units etc. These are frequently reused within the program structure.

By using user defined functions, program design time can be dramatically reduced.

6.1.1 Example: Creating a Function

Objective:

Build a Function to change Fahrenheit to Centigrade.

Formula is:

$$Centigrade = \frac{(Fahrenheit - 32) \times 5}{9}$$

The Function will be named “Centigrade” and the input variable will be named “Fahrenheit”.

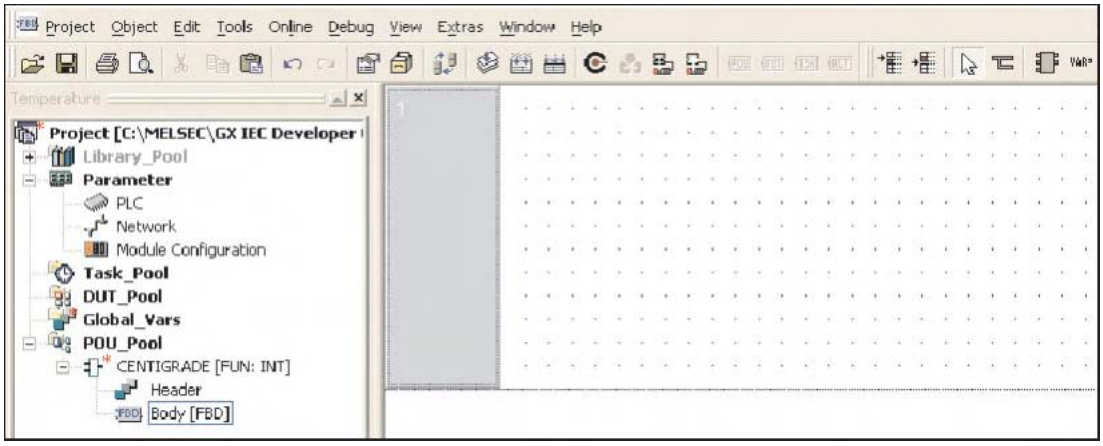
Procedure

① Select a new POU and name it Centigrade.

This time click the “FUN” option, instead of “PRG.” Select ***Function Block Diagram*** as the editor. The Result Type of FUN should be left as INT (Integer type).

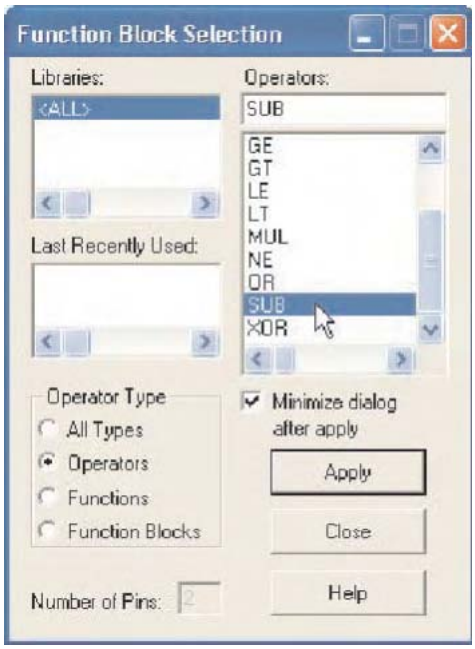
Centigrade will now have appeared on the POU tree:

② Double click on the FBD body icon, to open the body network:

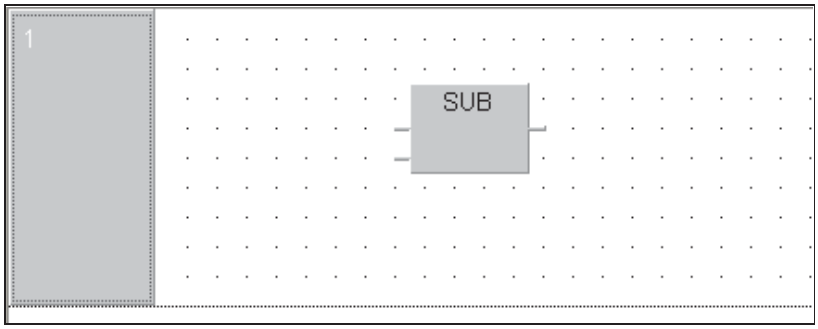


Selecting the Function:

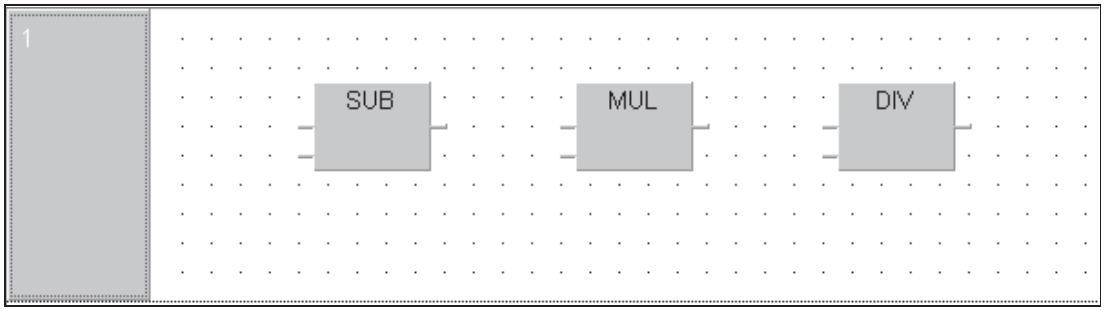
① Select the **function block** icon from the toolbar and select ***SUB*** from the operators list:



② Using ***Appl***y or double clicking on the selection object, place it on the screen:



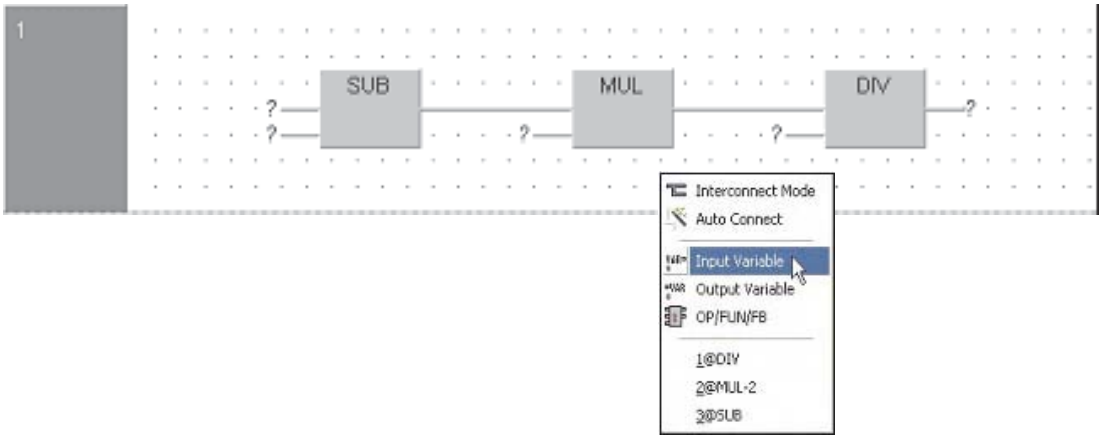
③ Repeat the above process so that the following is visible:



Declaring the Variables

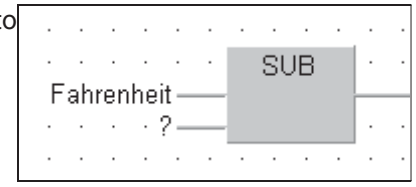
There are a variety of methods available to declare variables. The following procedure illustrates how to declare variables from the body of the FBD:

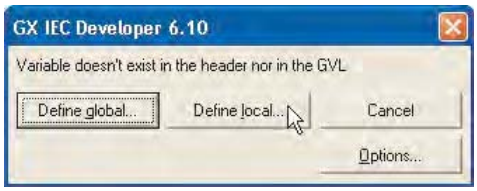
① Place input and output variables by right clicking the mouse in the work area. From the following popup menu, select and place input and output variable tags onto the FBD as shown below:



Alternatively, click on the toolbar button  .

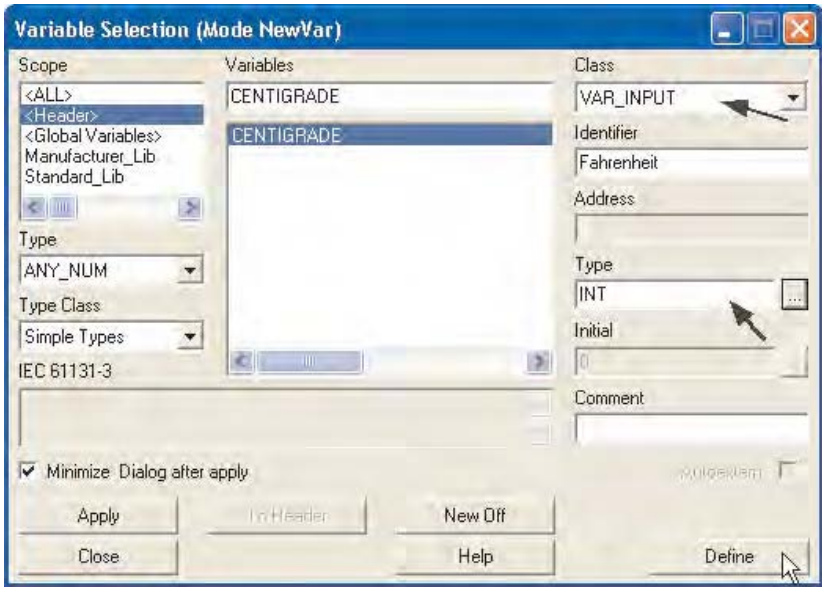
② Declare the variable “Fahrenheit” by simply typing it into the variable area:





Because this variable name has not yet been defined in the header (LVL), a prompt dialogue will be presented to choose Global or Local variable, click ***Define Local***.

③ Fill out the properties of the variable thus: Class: VAR_INPUT, Type: INT, as shown below:



NOTES

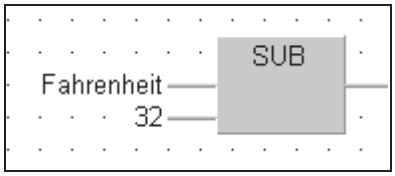
The Class VAR_INPUT is required as this variable enables values to be input into the function when it is connected as part of a program. It will produce a left hand pointing input connection point on the function symbol.

Notice also that the variable CENTIGRADE is automatically listed. This is because the “output variable name” must be the same as the “Function name”.

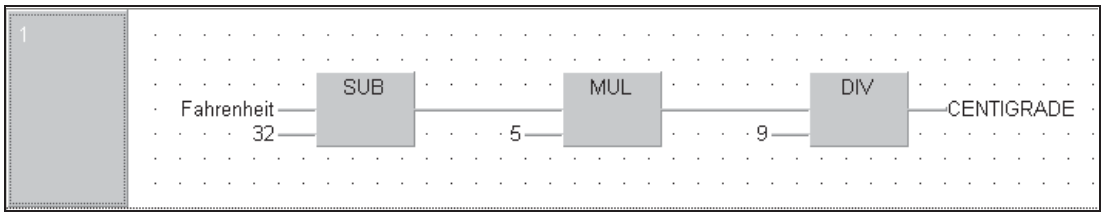
④ Click ‘Define’ and the variable will be written to the header of the Function ‘CENTIGRADE’. You can check it by opening the header.

Declaring Constants

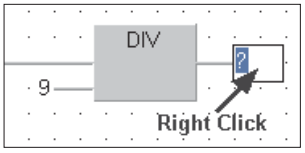
① Declare constant “32” by simply typing the number into the variable box:



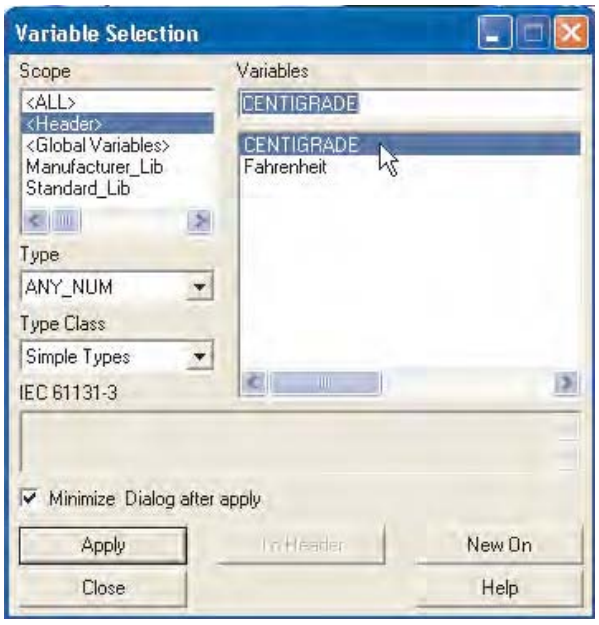
② Complete the circuit of the Function CENTIGRADE as follows:



Hint: When entering the CENTIGRADE variable, it is not necessary to type it, simply right click on the variable box (or press F2).



③ In the ***Variable Selection*** window, ‘Double click’ on CENTIGRADE or click to select and press ***Apply***.



CENTIGRADE is automatically placed in the header variable list as it is the name of the function, it must therefore also be specified as the output argument.

If desired, to clarify correct check the Header of the Function ‘CENTIGRADE’; it should appear as follows:

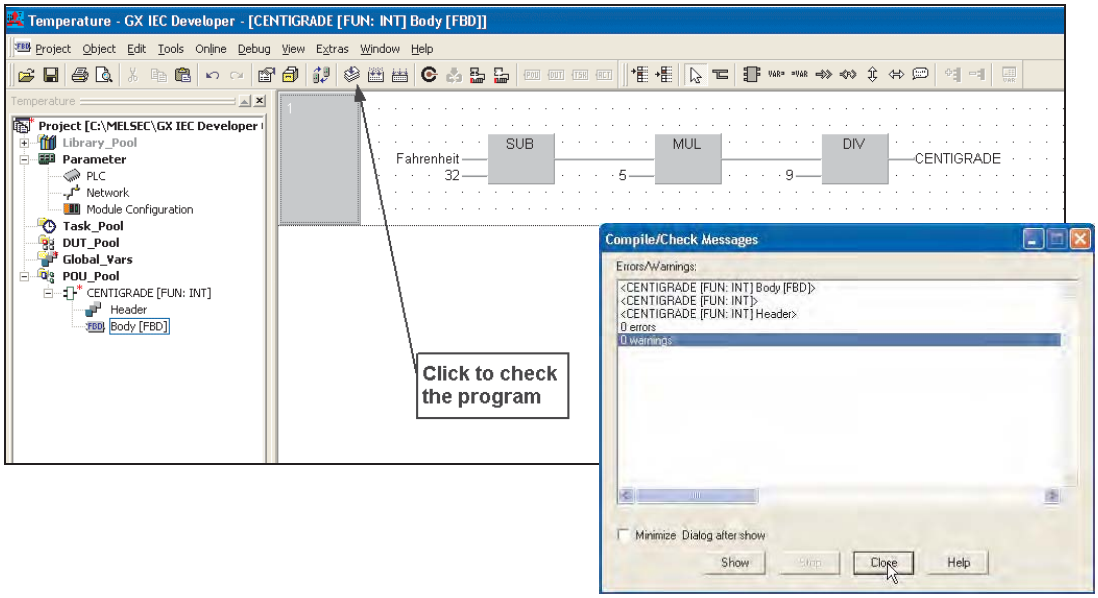
	Class	Identifier		Type		Initial	Comment
0	VAR_INPUT	Fahrenheit		INT	...	0	

NOTE

Alternatively, the Variable “Fahrenheit” may be entered directly into the Header (as above) and selected (F2 or right click on variable box) at point of entry in the body.

Checking Network Integrity

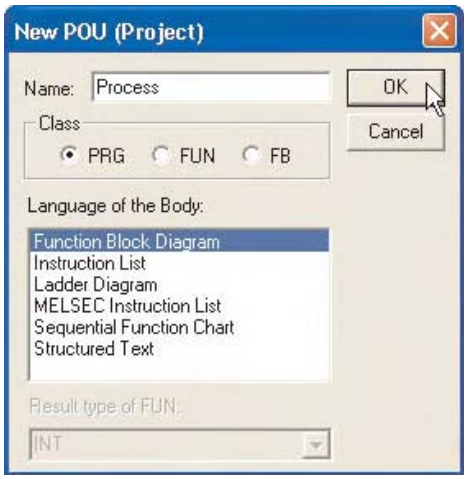
① Check the Network; you should have no errors and no warnings!



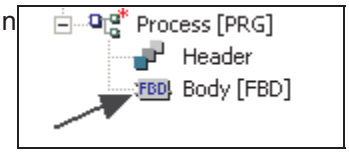
② Close down all work windows and any dialogues that may be open.

Creating a New Program POU

① Create a new POU called “Process” of Class “PRG” with a language of ***Function Block Diagram*** “FBD”:

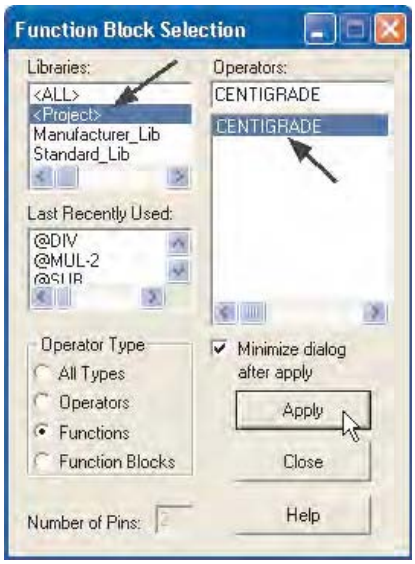


② Open up (Double Click) the body of Ladder POU “Process” in the project POU pool.



Placing a user Function

① Click on the Function Block icon again, but this time select ***Functions*** and select the ***Project Library***. Notice the newly created function “Centigrade” is now filtered down into the operators list:

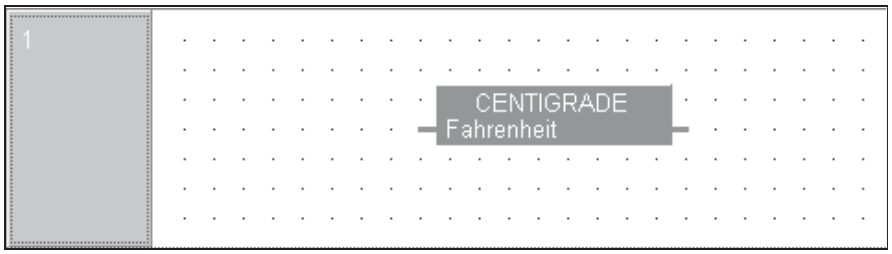


② Select CENTIGRADE and click ‘Apply’.

NOTE

Depending on preference, it is possible to minimise the ***Function Block selection*** window following ***Apply*** by ticking the selection box as above.

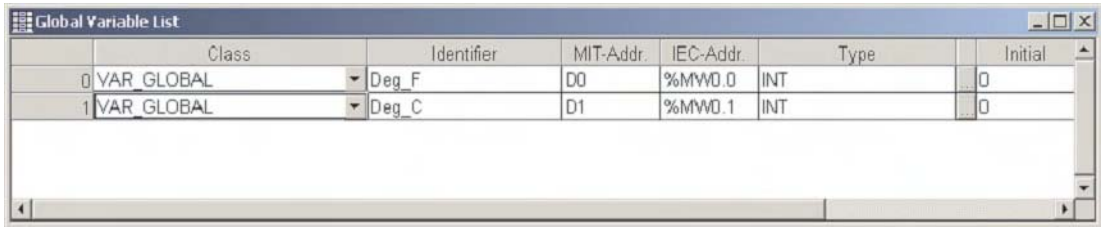
The following will be displayed:



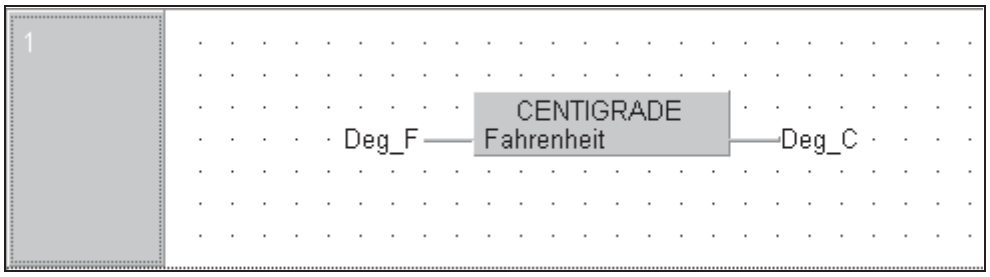
Assigning the Global Variables

Once the function is placed on the new network assign variables to it.

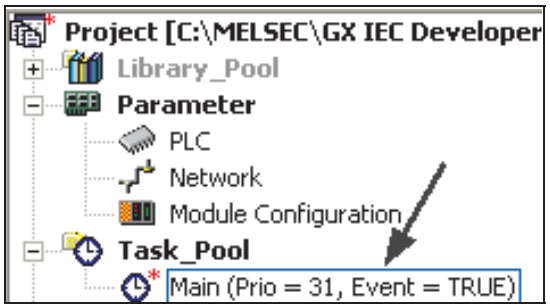
① Assign Variable names in the Global Variable List as shown:



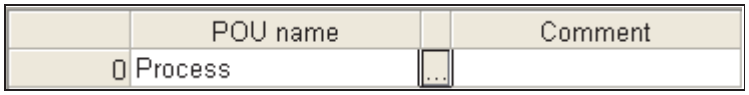
The Body of the POU “Process" should read:



② Create a new task in the ***Task Pool*** named “Main”.

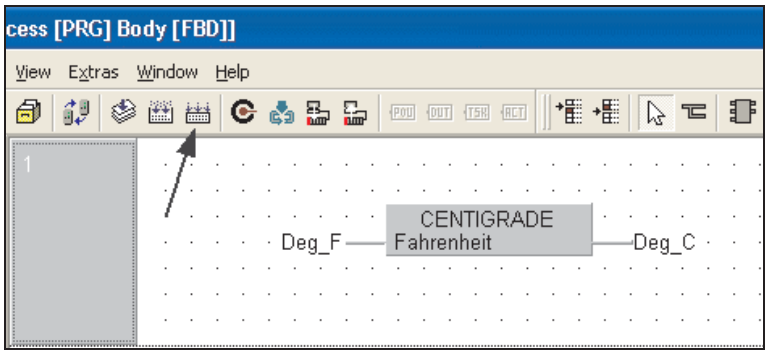


③ Bind the POU “Process” to the Task “Main”:

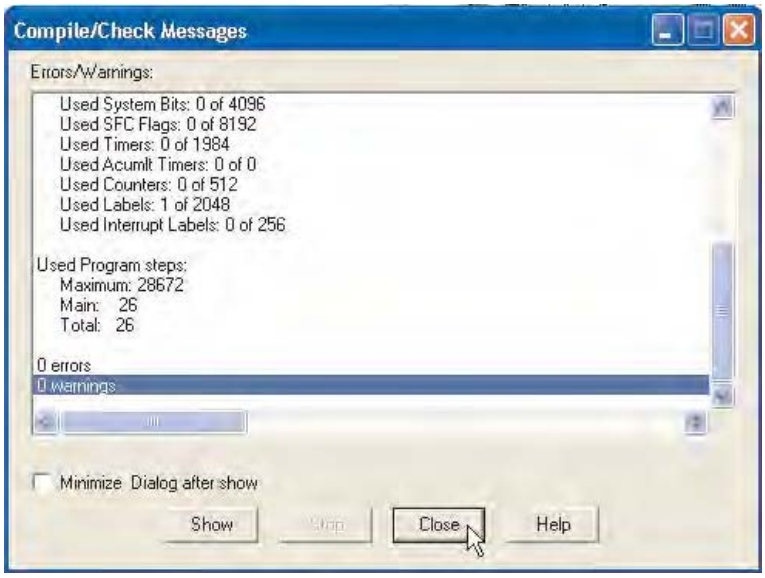


Compiling the Program

Compile the project using the ***Rebuild All*** operation from the tool bar:



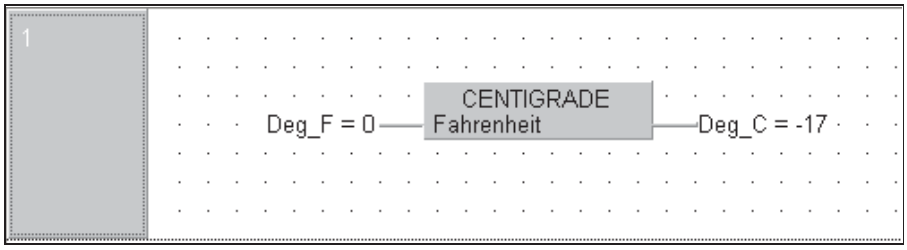
Following compilation the following should be displayed:



If there are errors, click on the error detail and resolve the problem(s).

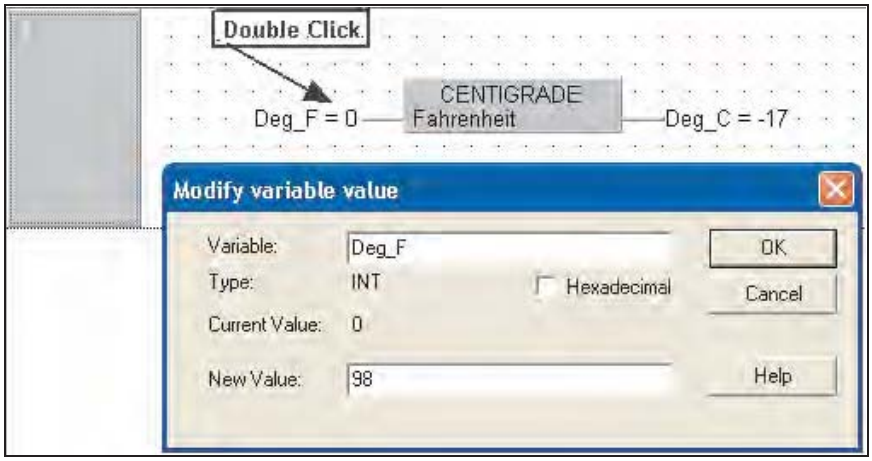
Monitoring the program

① Transfer the project to the PLC and monitor this network using the Monitor button on the toolbar:



② Using the on screen variable forcing feature, input numbers into the 'Deg_F' variable as follows:

'Double Click' on the input variable and enter a value into the ***Modify variable value*** dialogue as shown:



For reference, 100 deg F = 37 deg C (actual 37.7 deg C)

6.1.2 Processing Real (Floating Point) Numbers

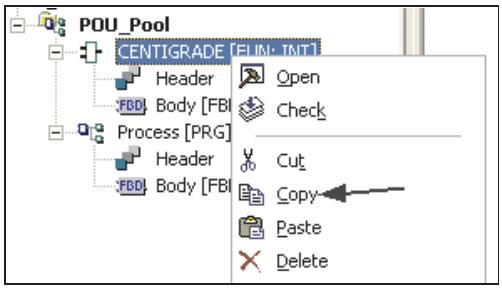
The existing CENTIGRADE function currently can only process 16 Bit Integer Whole Number (+32767 to -32768) values which is the numeric system default when creating Functions. The following example will utilise the Function 'CENTIGRADE', modifying it to process "REAL" floating point values*.

* Only valid on processors supporting this feature.

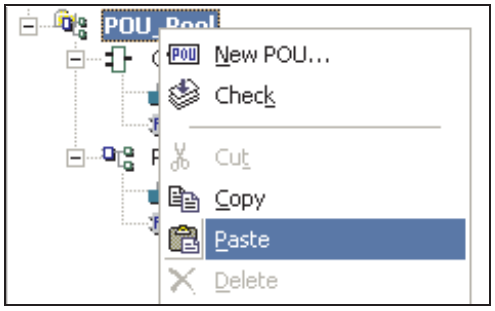
Duplicating a Function

Make a duplicate copy of the function 'CENTIGRADE' and rename it 'CENTIGRADE1' as follows:

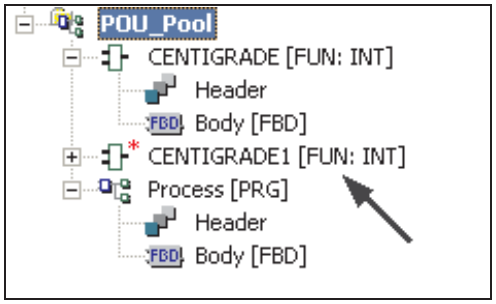
① Right Click on the CENTIGRADE Icon in the POU Pool of the project and select ***Copy***.



② Right Click on the POU pool icon of the project and select ***Paste***.

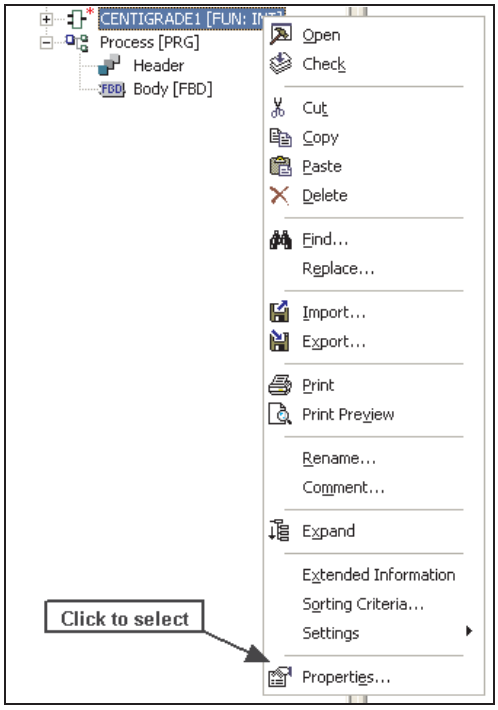


The system will automatically paste a duplicate copy of 'CENTIGRADE' and rename it to 'CENTIGRADE1':

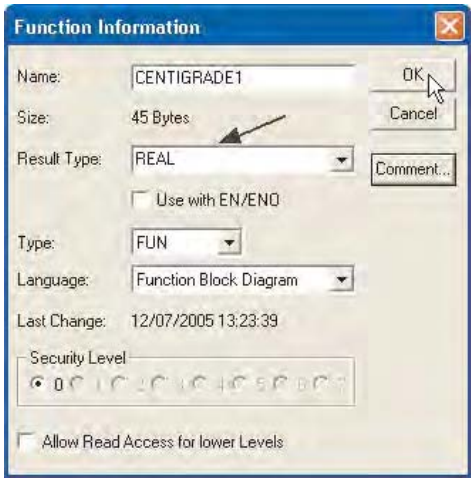


Changing the Result type of a Function

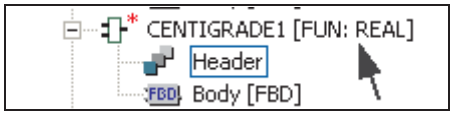
① Right click on the newly created Function ‘CENTIGRADE1’ and click on ***Properties***.



② On displaying the ***Function Information*** window, set the result type to REAL.



The type should now displayed as ***Real*** in the Project Navigation Window:

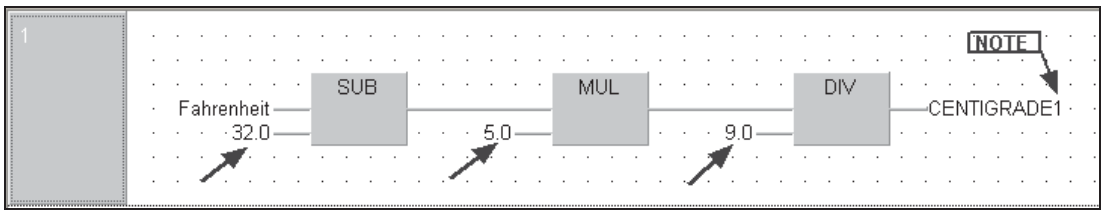


③ Modify the Header of CENTIGRADE1 so that the Fahrenheit variable is of type ‘REAL’:

	Class	Identifier	Type	Initial	Comment
0	VAR_INPUT	Fahrenheit	REAL	0.0	

Modifying Constants to type 'REAL'

① Open the Body of CENTIGRADE1 and modify the constants to 'Floating Point' types (i.e. 32.0) and the output variable name to read as follows:

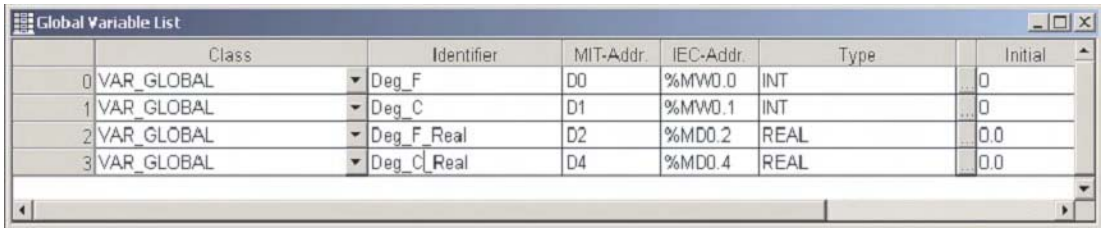


NB: Remember to alter CENTIGRADE to CENTIGRADE1.

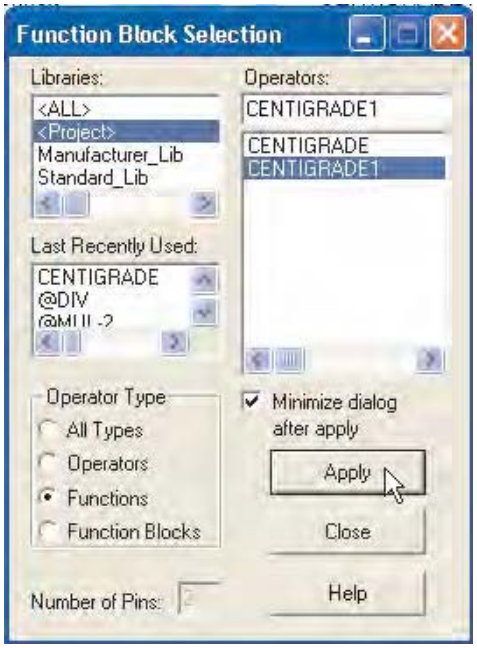
② Close editors and save all changes.

Placing the "REAL" number Function 'CENTIGRADE1' onto the working POU "Process"

① In the GVL editor, create two new variables thus:

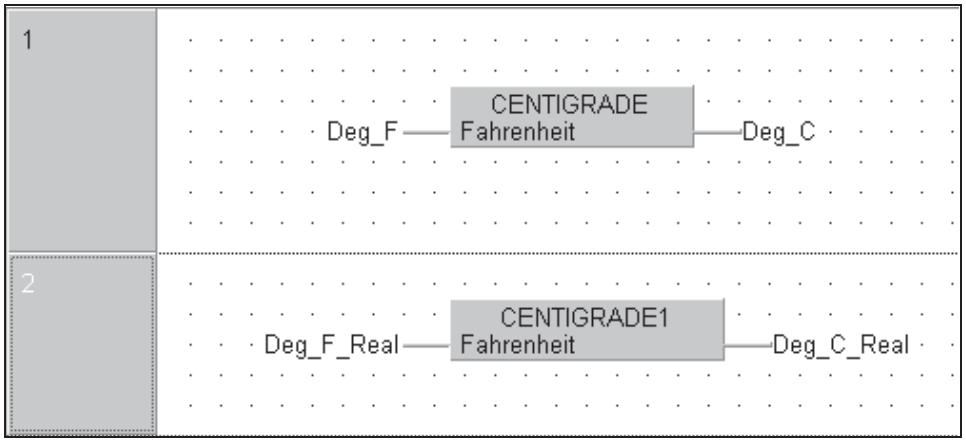


② Open the Body of POU "Process" and place the Function CENTIGRADE1 into it as shown below:



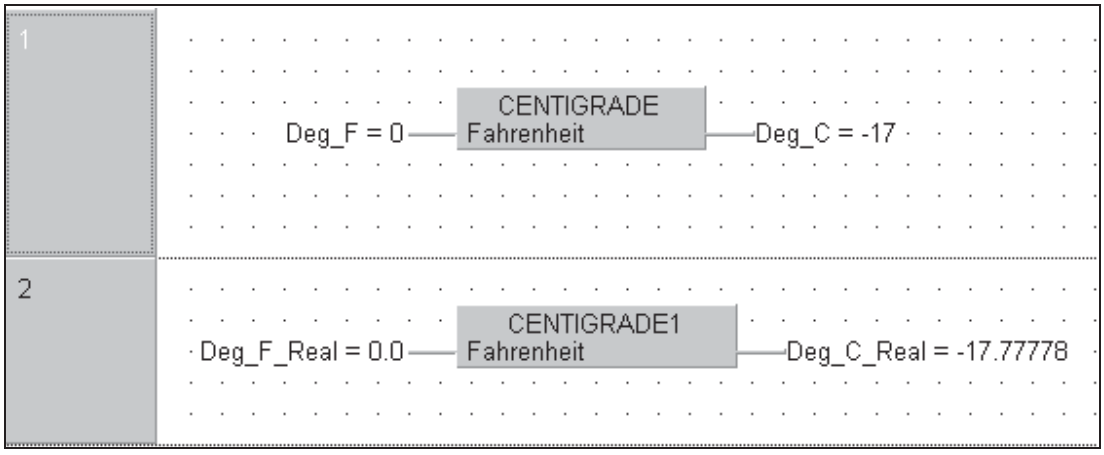
NOTE REAL numbers use 2 consecutive Registers (32 Bits) and are stored in a special portable IEE format, hence the allocation in the above GVL example.

③ Complete the POU “Process” to read as follows:



Save the Project, Close all open dialogues and rebuild the project.

Transfer the project to the PLC and monitor this network using the Monitor button on the toolbar:



Modify the value of the input variable “Deg_F_Real” and observe the output result on the display. Note the 7 Digit floating point accuracy.

6.2 Creating a Function Block

Objective:

Build a Function Block to act as a Star/Delta Starter. Declare the following variables:

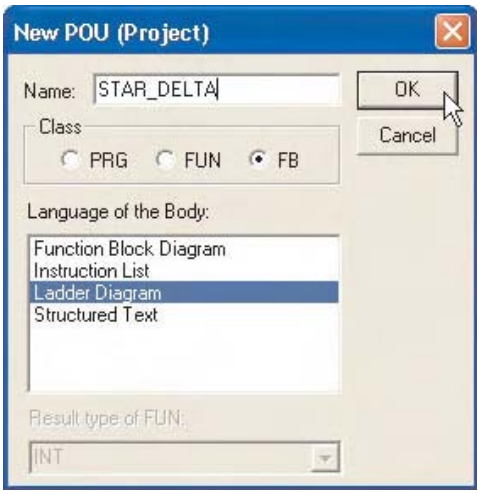
- Start Pushbutton: **START**
- Stop Pushbutton: **STOP**
- Overload Contact: **OVERLOAD**
- Switchover Time: **TIMEBASE**
- Time Register: **TIME_COIL**
- Star Contactor Output: **STAR_COIL**
- Delta Contactor Output: **DELTA_COIL**

Name the Function Block **STAR_DELTA.**

Procedure:

① Start a new "Empty" project in GX-IEC Developer called "**Motor Control**" with no POU's.

② Create a new POU named "STAR_DELTA" of Class "Function Block" (***FB***) with a language Body type ***Ladder Diagram***.



STAR_DELTA will now have appeared on the POU tree.

③ Click once to open the Header and Body branches.

④ Double click, to open the Header.

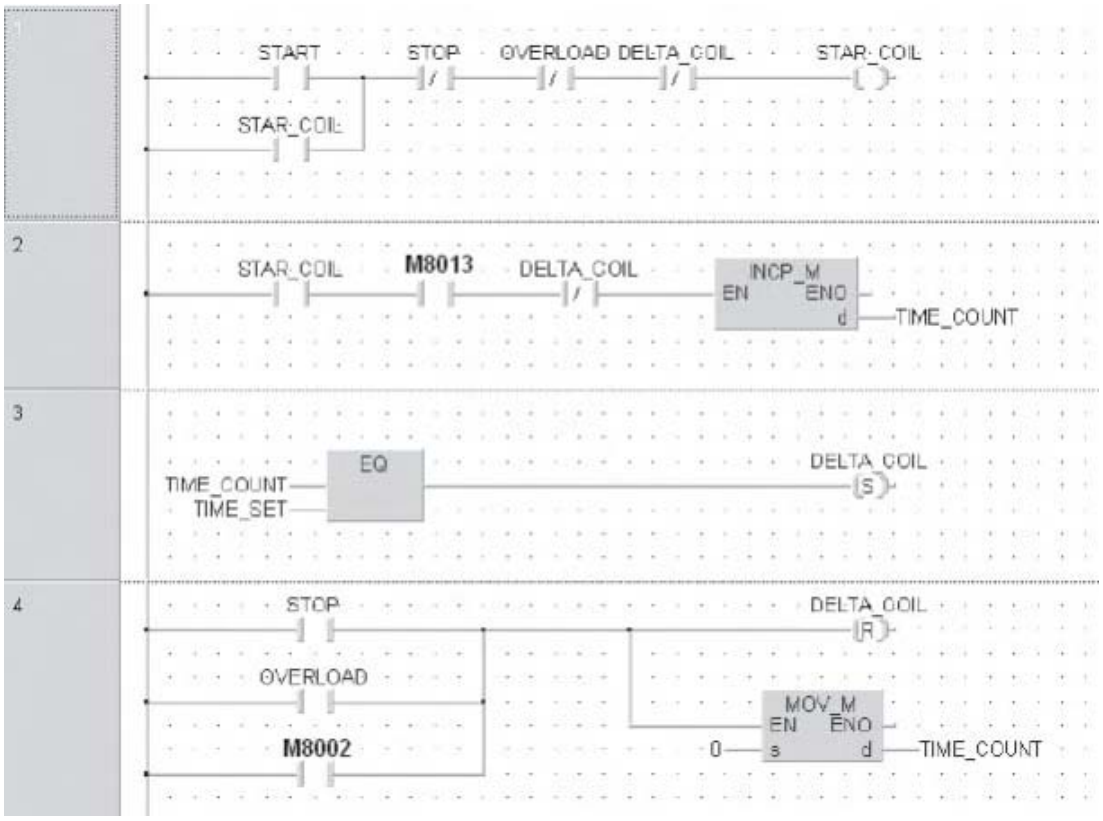
Declaring Local Variables

① Declare variables as shown below.

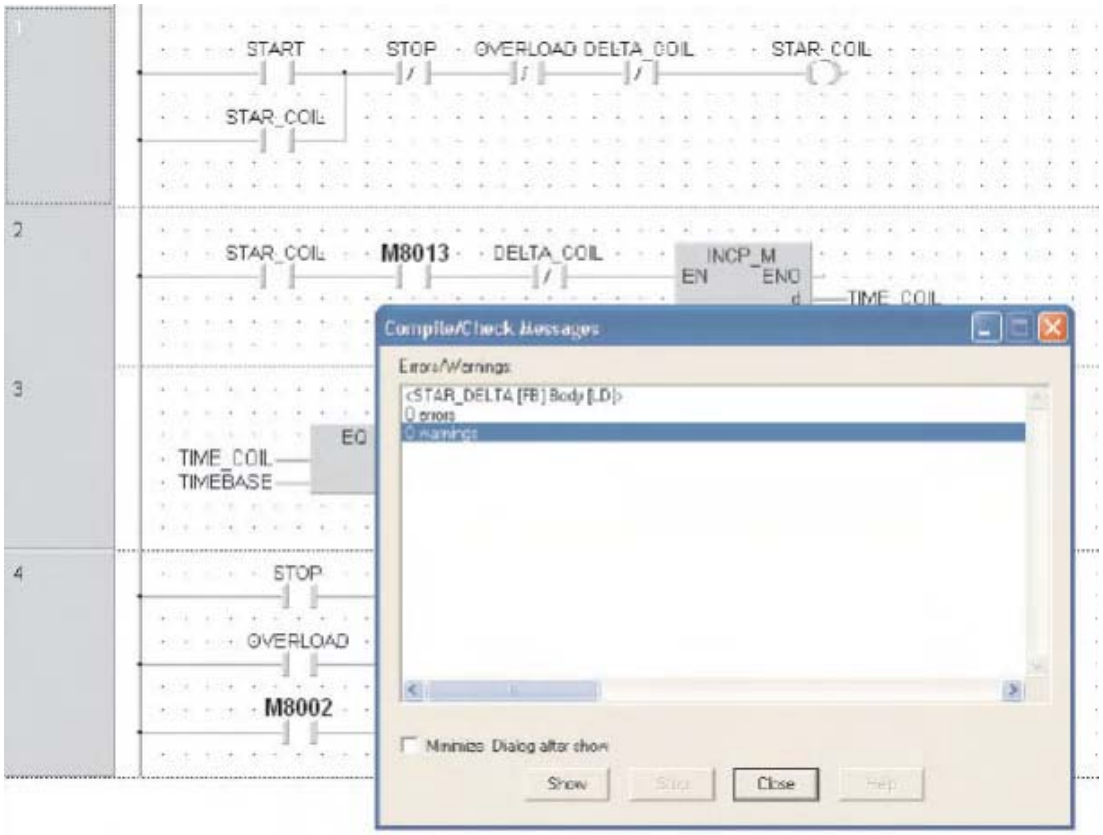
	Class	Identifier	Type	Initial	Comment
0	VAR_INPUT	START	BOOL	FALSE	
1	VAR_INPUT	STOP	BOOL	FALSE	
2	VAR_INPUT	OVERLOAD	BOOL	FALSE	
3	VAR_INPUT	TIME_SET	INT	0	
4	VAR_OUTPUT	DELTA_COIL	BOOL	FALSE	
5	VAR_OUTPUT	STAR_COIL	BOOL	FALSE	
6	VAR_OUTPUT	TIME_COUNT	INT	0	

② Check, save and then close the Header window.

③ Open the body and build the ladder networks as shown below:



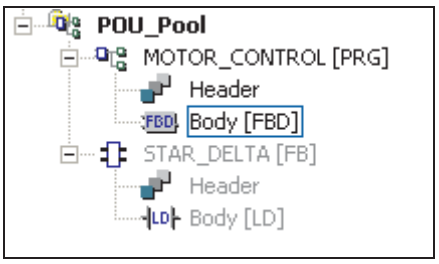
④ Check the Body, there should be no errors and no warnings!



Creating New Program POU "Motor Control"

① Close down all work windows and any dialogues that may be open.

② Create a new POU "MOTOR_CONTROL" of Class ***PRG*** and FBD (***Function Block Diagram***) as the language of the body.



Creating new Global Variables List

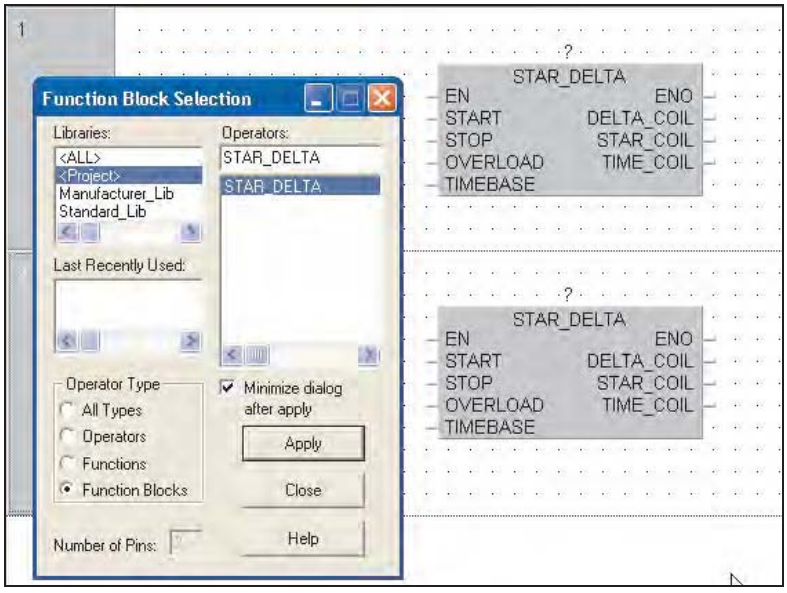
Open the GVL and enter the following I/O details:

Global Variable List

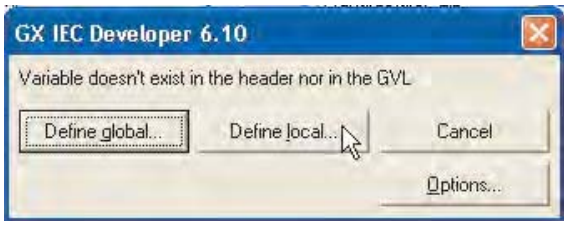
	Class	Identifier	MIT-Addr	IEC-Addr	Type	Initial
0	VAR_GLOBAL	START1	X0	%IX0	BOOL	FALSE
1	VAR_GLOBAL	STOP1	X1	%IX1	BOOL	FALSE
2	VAR_GLOBAL	OVERLOAD1	X2	%IX2	BOOL	FALSE
3	VAR_GLOBAL	STAR_COIL1	Y00	%QX0	BOOL	FALSE
4	VAR_GLOBAL	DELTA_COIL1	Y01	%QX1	BOOL	FALSE
5	VAR_GLOBAL	TIME_COIL1	D0	%MW0.0	INT	0
6	VAR_GLOBAL	START2	X3	%IX3	BOOL	FALSE
7	VAR_GLOBAL	STOP2	X4	%IX4	BOOL	FALSE
8	VAR_GLOBAL	OVERLOAD2	X5	%IX5	BOOL	FALSE
9	VAR_GLOBAL	STAR_COIL2	Y02	%QX2	BOOL	FALSE
10	VAR_GLOBAL	DELTA_COIL2	Y03	%QX3	BOOL	FALSE
11	VAR_GLOBAL	TIME_COIL2	D1	%MW0.1	INT	0

Assigning Instance Names

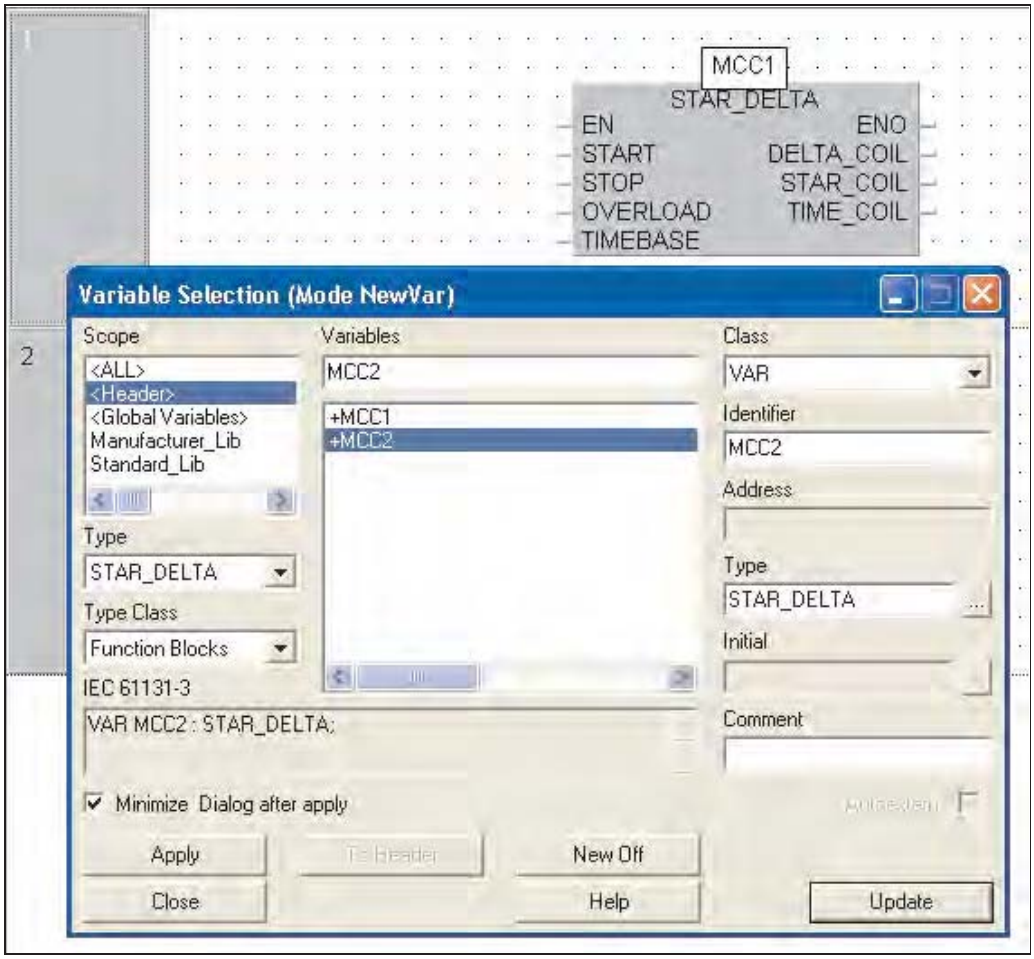
① Open the Body of MOTOR_CONTROL and enter create two networks. Place a Instance of the Function Block STAR_DELTA into each network as shown in the following figure:



② Assign ‘instance names’ to both instances of the Function Block, STAR_DELTA by typing MCC1 and MCC2 into the Instance names above each Instance of the FB. At the system prompt, click ***Define Local***.



③ Create entries for the instance names in the header for MCC1 and MCC2 as follows:

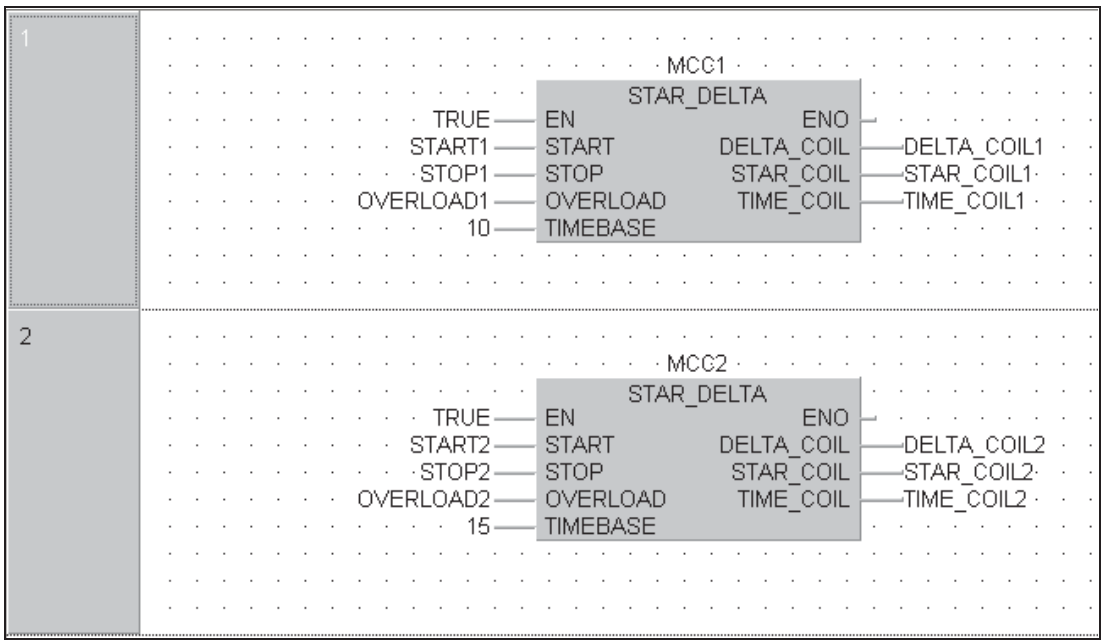


An Instance is the copy of the function block for this POU. For this example simply type MCC1 and MCC2. Notice that once entered, the instances are listed in the variable selection window as +MCC1 and +MCC2 as Type: STAR_DELTA.

The Instances must be declared in the POU Header. As can be seen from the previous figures, Instance names are added in the same way as adding any other new variable from the POU body.

Assigning Variables to a Function Block

Now complete the POU by assigning variables to your Function Blocks as shown below:



NOTES

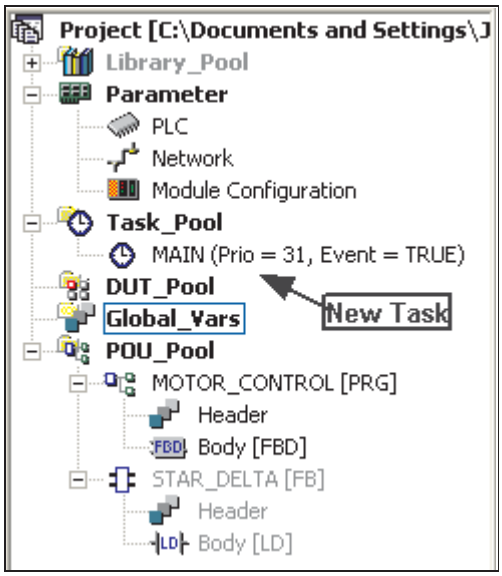
Mitsubishi addresses or symbolic declarations may be used. However, if Mitsubishi 'MELSEC' direct addresses are used then the program will no longer adhere to the IEC conventions.

Designating the variable "TRUE" as above, automatically assigns a 'normally on' contact (Q-Series SM400) which is neater and conforms to IEC conventions.

The STAR_DELTA FB can be used many times in the project and must use different Instance names.

Creating a New Task:

① Create a new Task "MAIN" in the task pool:

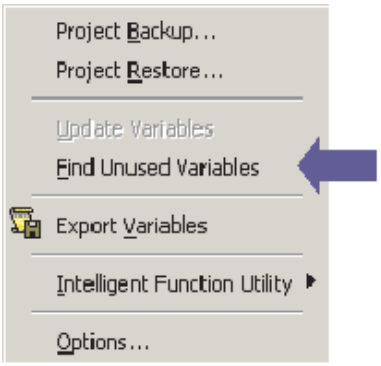


② Double click on the task and bind the POU “MOTOR_CONTROL” to the task “MAIN”:

	POU name		Comment
0	MOTOR_CONTROL	...	

③ Save the Program, close all windows and dialogues.

Find unused Variables



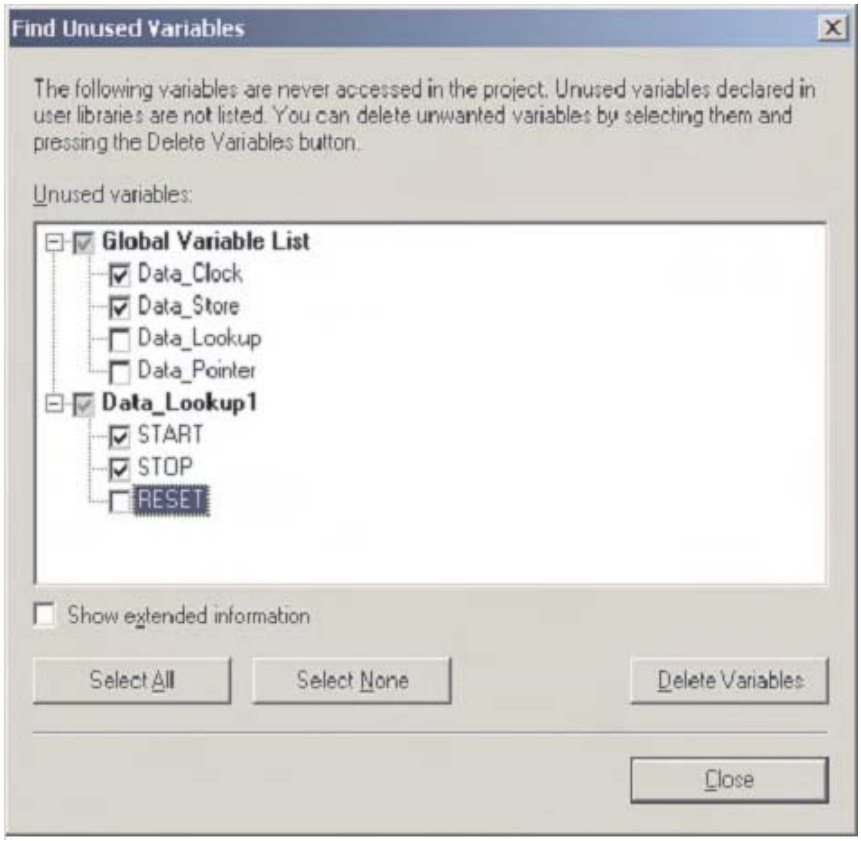
By using the function ***Extras*** → ***Find unused Variables*** you can find and delete all unused global and local variables that are declared but not used in a project.

Unused global and local variables will be detected in the whole project, excluding the user libraries.

NOTE

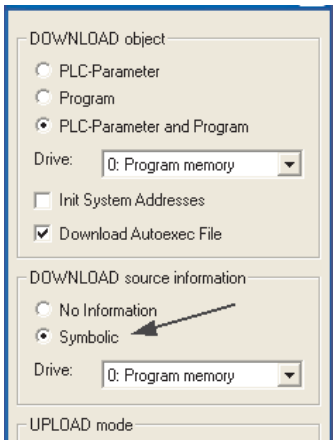
Finding unused variables can only be performed if the project has been build and was not changed since them. Otherwise a warning message will be displayed.

Each unused variable is listed under the container of its declaration: the Global Variable List for global variables, or the corresponding POU for local variables. Only those containers are listed where unused variables exist. For example, if there is no global variable, the Global Variable List location will not be enlisted. Containers are written in bold text and appear at a higher level than their contained items.

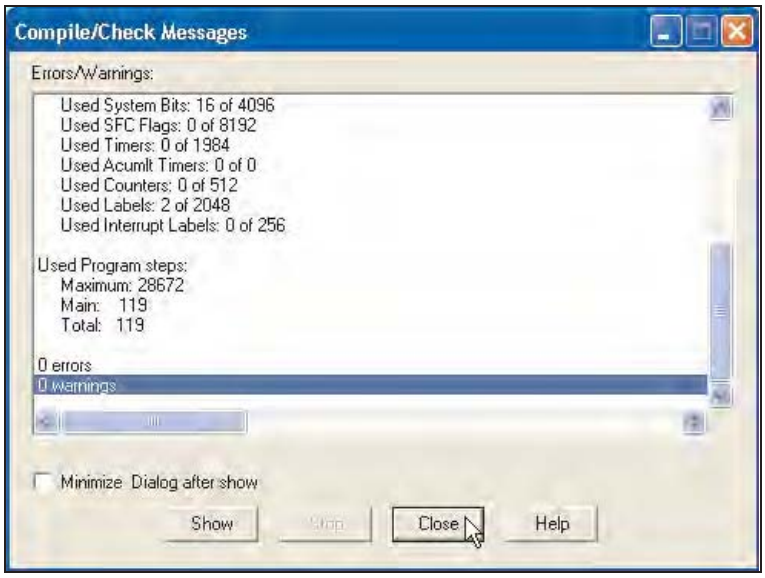


NOTE

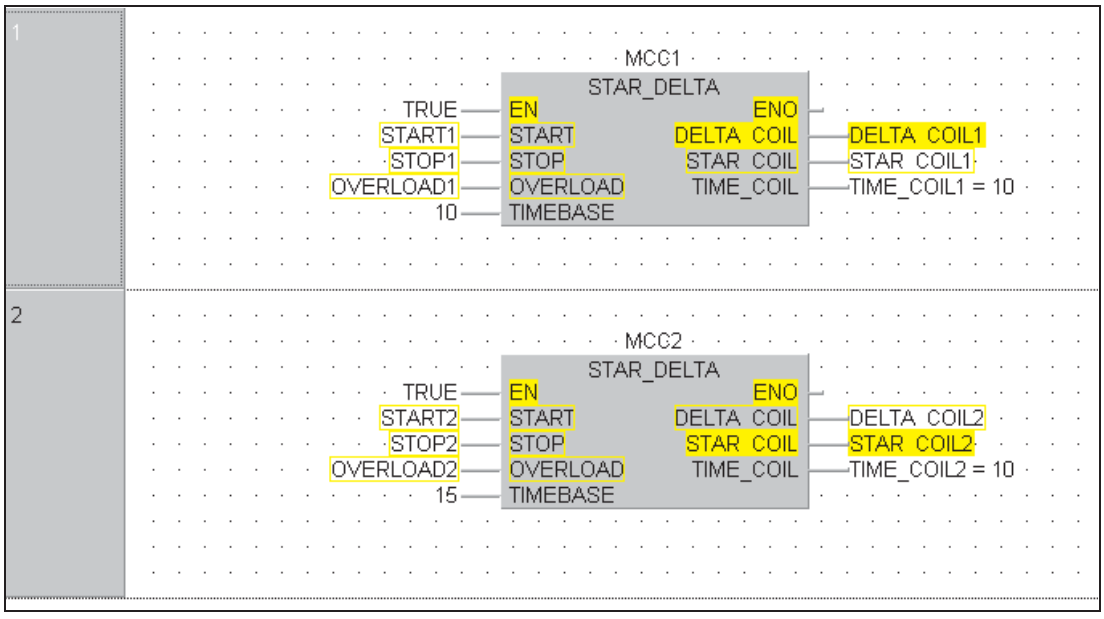
This can produce large reductions in the size of the source code. This is important particularly if the option to send all ***Symbolic*** (Source) Code to the PLC has been selected for download:



Compile the program in the normal manner, using the “Rebuild All” button on the toolbar:



Open the MOTOR_CONTROL POU and monitor the program for correct operation.

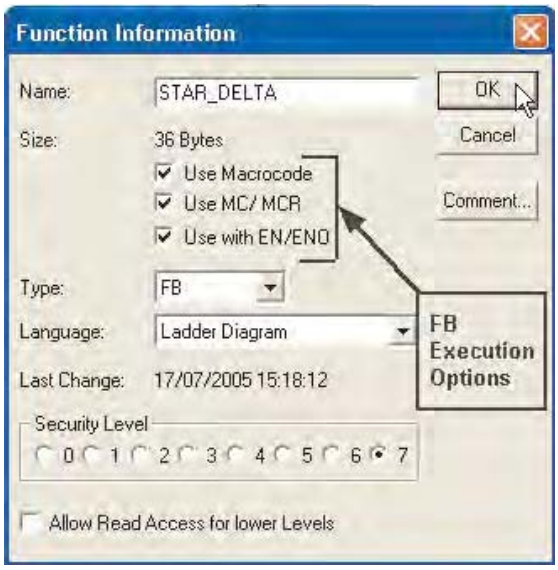


6.3 Execution options of Function Blocks

Function blocks can be executed in different ways:

- Macrocode execution
- MC – MCR execution
- Use with EN/ENO

The execution mode is selected in the ***Function Information*** dialogue box:



How to set the execution option:

① Select the function block in the Project Navigator window.

② Display the Function Information dialogue box by right clicking and select ***Properties***.

③ Activate the check box. The use of MC-MCR option can only be activated when the other two options have already been activated.

This does not make any changes to instantiation and the programming of instances in the various programming languages.

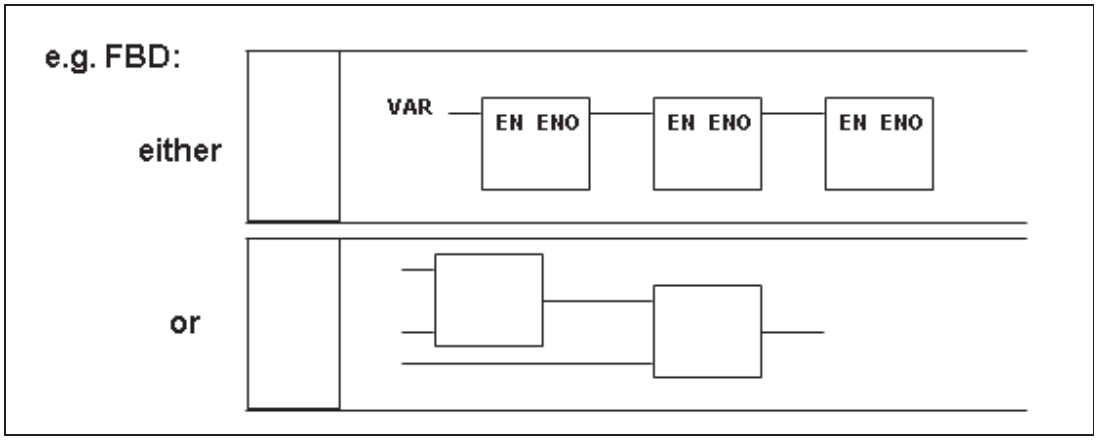
6.3.1 Macrocode execution

- Standard execution: The function block is called via a system label.
- Macrocode execution: The function block is expanded internally.

With Macro Code	Without Macro Code (standard execution)
No internal system labels are needed to execute a function block instance.	Each instance uses internal system labels (pointers).
Consequence: The number of function blocks you can use is only limited by the size of the PLC memory as function blocks are independent of system labels.	Consequence: Since the number of available system labels is limited (FX: 128, A: 256, Q: 1024) you cannot use more than a theoretical limited number of function blocks. In practice this number is even smaller as system labels are also required for other internal processes.
User-oriented execution of the function block	Implementation of the function block construct in conformity with the IEC 61131-3 standard
No restrictions on the handling of timers and coils within the function block.	Restrictions on the handling of timers and coils within the function block (subroutines).

6.3.2 Enable / EnableOutput (EN/ENO)

- The EN input makes the function (or FB, see later), conditional (Switch On/Off)
- The ENO reflects the status of the EN line.
- Only instructions with or without EN should be used in a network, do not mix both types.
- The EN/ENO chain should have all its pre-conditions at the beginning:

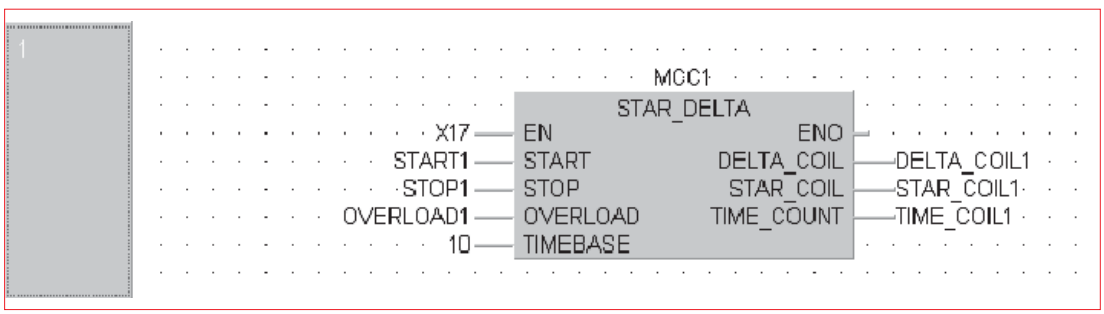


Function Definitions

- All devices suffixed "_E" have EN / ENO lines, otherwise they do not.
- All devices suffixed "_M" are manufacturers instructions, i.e. in this case from the relevant Mitsubishi instruction set.
- Care should be taken, especially when using the FBD editor, not to disobey the Mitsubishi programming rules. When building circuits like the previous example, it is tempting to chain lots of instructions together to achieve, i.e. the calculation required. However, if the chosen Mitsubishi instruction, would normally sit at the end position on the rung, why should it suddenly become a series element, simply because you are using FBD?
- Choose the correct instruction for the job i.e. that may well be one from the IEC set.
- Also remember that a 16 bit Mitsubishi multiplication produces a 32 bit answer. If variables are used, then the result "type" should reflect this, i.e. the operands may be of type INT, the result of type DINT.

Exercise (Gated Operation)

Edit the Function Block STAR_DELTA to have an EN/ENO input/output feature. Drive the EN (enable) input with external MELSEC X17 contact:

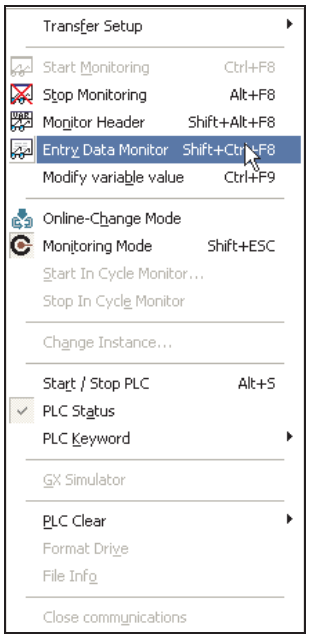


7 Advanced Monitoring Functions

The following diagrams are used for illustration purposes only; use the STAR_DELTA project and its relevant devices with the following procedures.

7.1 Entry Data Monitoring

① Whilst in Monitor Mode, select ***Entry Data Monitor*** from the ***Online*** Menu:



The following table will be displayed:

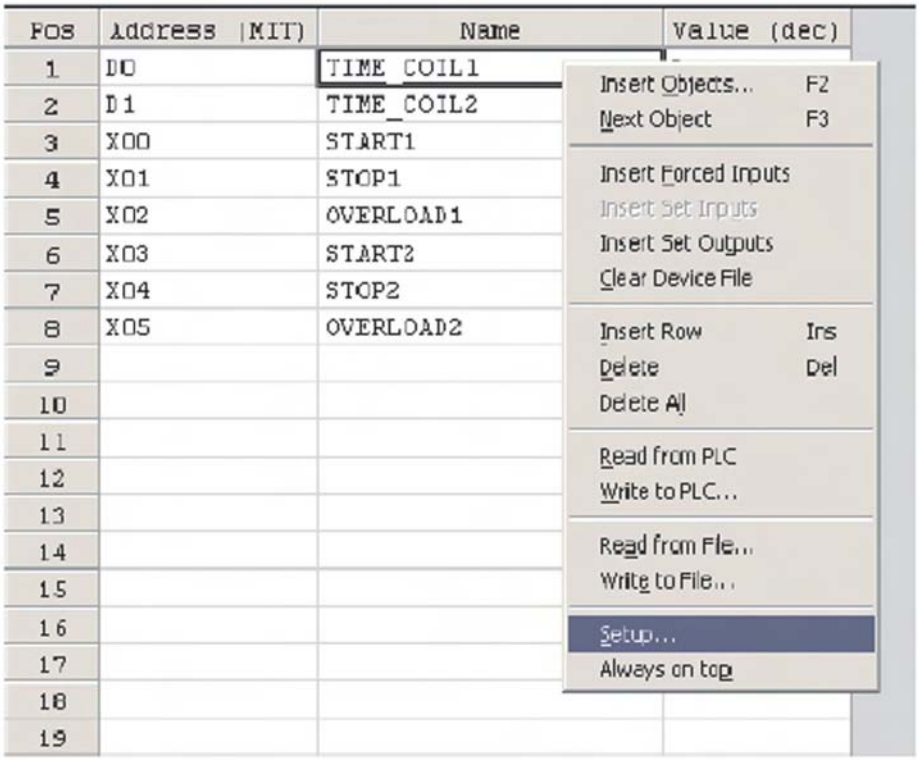
Pos	Address (MIT)	Name	Value (dec)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			

② Click in the Mitsubishi Address left hand column and type in the required device, any identifier name will be automatically shown together with the current value. Column widths can be altered. In the head of the table, move the cursor over the left border of the column you want to alter. Then press the left mouse button and move the border to the left or right. Release the left mouse button at the desired position.

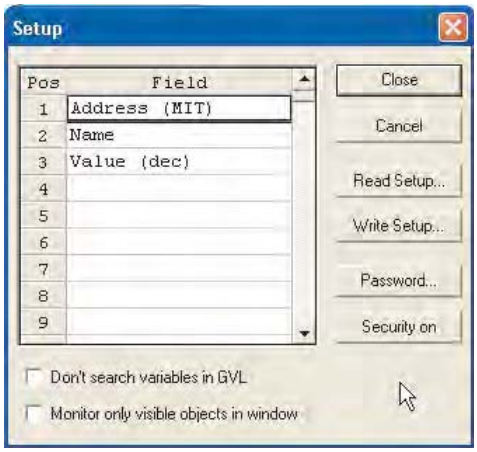
Pos	Address (MIT)	Name	Value (dec)
1	D0	TIME_COIL1	0
2	D1	TIME_COIL2	0
3	X00	START1	0
4	X01	STOP1	0
5	X02	OVERLOAD1	0
6	X03	START2	0
7	X04	STOP2	0
8	X05	OVERLOAD2	0

7.1.1 Customising the EDM

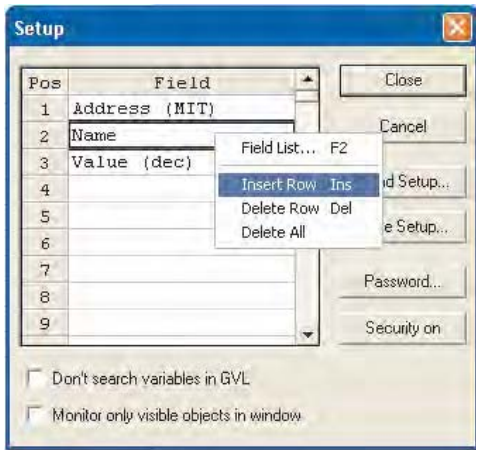
① Right Clicking the mouse button, displays the following window. Select ***Setup***.



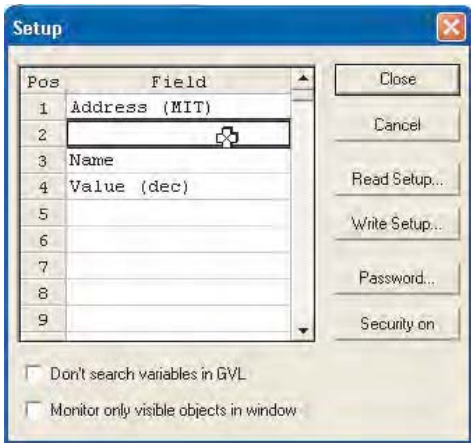
The ***Setup*** window allows the EDM to be user configurable; clicking the right mouse button, displays the configurator window. In this procedure Columns will be added to the EDM table for IEC Address and Hex Value Monitor.



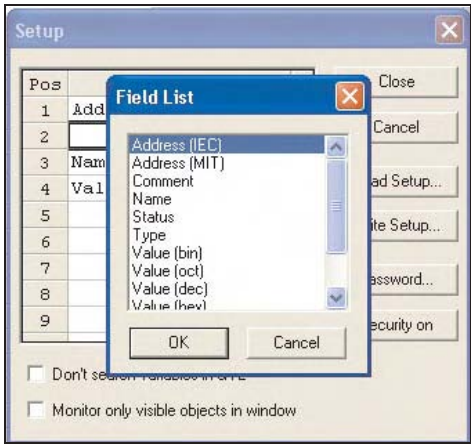
② Highlight or right click on the ***Name*** field and select ***Insert Row*** as shown.



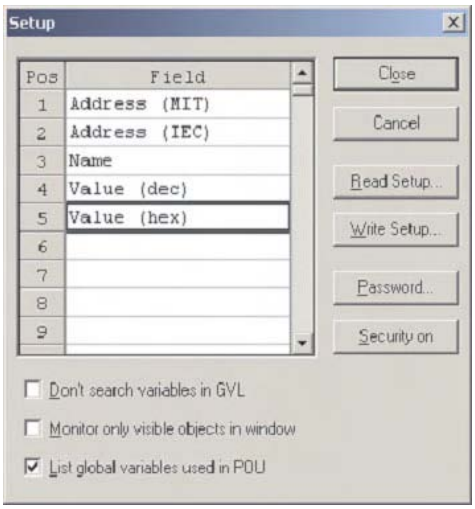
A second window appears, showing options for this row, select ***Value (hex)***, ***Value (bin)***. Repeat for ***Address (IEC)*** and ***Type***.



③ Double click on the empty field or press F2 and select ***Address (IEC)*** from the list as shown.



④ Click ***OK*** and the item will be added to the EDM layout. Add ***Value (hex)*** to the Pos 5 field in the table.



⑤ Click to close the setup box and observe altered EDM layout:

Pos	Address (MIT)	Address (IEC)	Name	Value (dec)	Value (hex)
1	D0	%MW0.0	TIME_COIL1	0	0
2	D1	%MW0.1	TIME_COIL2	0	0
3	X00	%IX0	START1	0	0
4	X01	%IX1	STOP1	0	0
5	X02	%IX2	OVERLOAD1	0	0
6	X03	%IX3	START2	0	0
7	X04	%IX4	STOP2	0	0
8	X05	%IX5	OVERLOAD2	0	0

In this way, the EDM table can be used to display multiple data on one table.

Try adjusting the column widths and the zoom facility from the ***View*** menu, to display complete picture. The display size is much dependent on the screen resolution set on the computer being used.

From here values can be entered to any object displayed, i.e. the value of D100 may be altered by entering a number into the respective field.

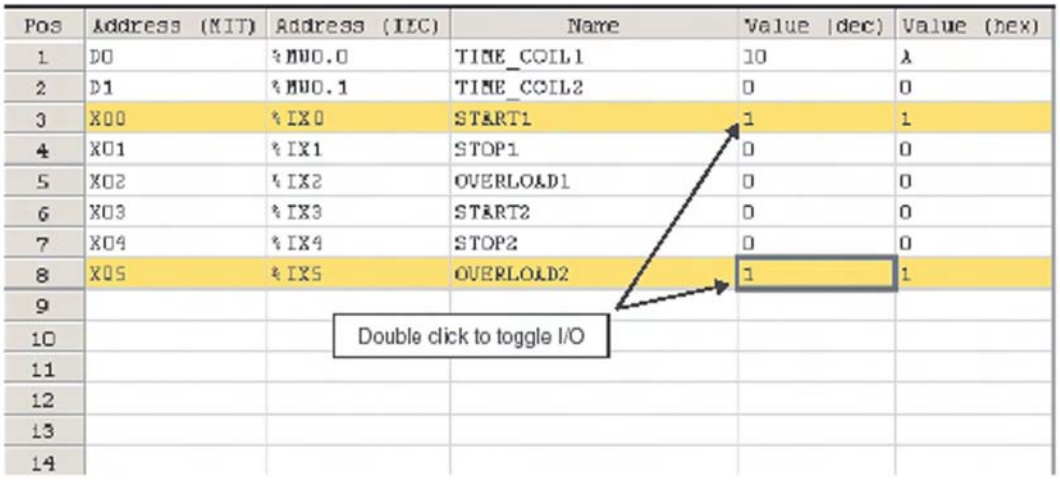
7.1.2 Monitor Limitations

NOTE

Remember, the behaviour of the monitor facility is dependant on the code being run in the PLC; if the PLC code is writing a constant to this address, the value entered will be overwritten by the program. This situation is prevalent here as the values of D0 and D1 are being continuously written to by the PLC code.

7.1.3 Toggling Boolean Variables

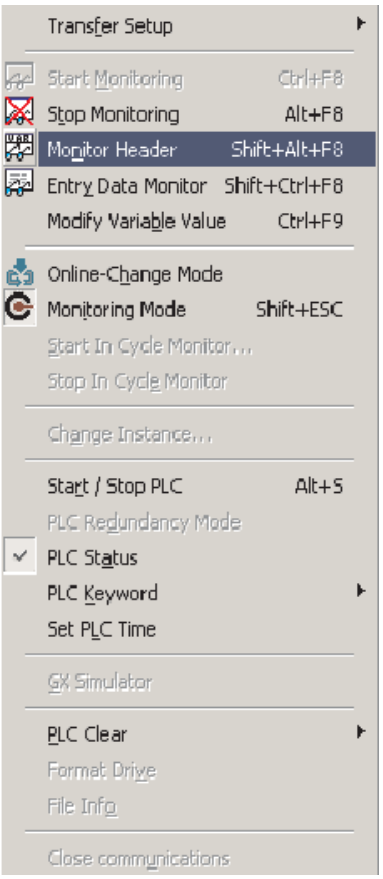
Providing the physical input to the PLC is not active, it is possible to toggle the input image in the CPU on and off by double clicking on the value field for that Boolean addresses as shown:



Pos	Address (MIT)	Address (IEC)	Name	Value (dec)	Value (hex)
1	D0	%MW0.0	TIME_COIL1	10	A
2	D1	%MW0.1	TIME_COIL2	0	0
3	X00	%IX0	START1	1	1
4	X01	%IX1	STOP1	0	0
5	X02	%IX2	OVERLOAD1	0	0
6	X03	%IX3	START2	0	0
7	X04	%IX4	STOP2	0	0
8	X05	%IX5	OVERLOAD2	1	1
9					
10					
11					
12					
13					
14					

7.2 Monitoring Headers

Another facility available, whilst in ***Monitor Mode*** and with the POU body highlighted, is the ***Monitor Header*** function in the ***Online*** menu. It is also available from the Online Toolbar



All elements of the Header identifiers of the highlighted POU are now displayed and monitored:

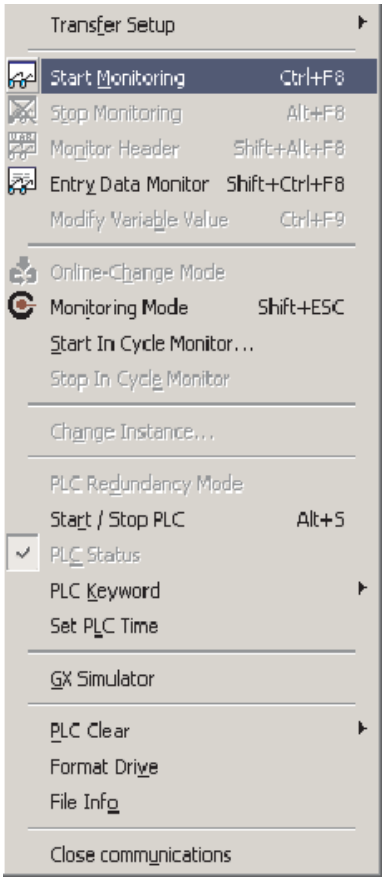
Pos	Address (MIT)	Address (IEC)	Name	Value (dec)	Value (hex)
1			-MOTOR_CONTROL		
2	X00	%IX0	START1	1	1
3	X01	%IX1	STOP1	0	0
4	X02	%IX2	OVERLOAD1	0	0
5	Y01	%QX1	DELTA_COIL1	1	1
6	Y00	%QX0	STAR_COIL1	0	0
7	D0	%MW0.0	TIME_COIL1	10	A
8	X03	%IX3	START2	0	0
9	X04	%IX4	STOP2	0	0
10	X05	%IX5	OVERLOAD2	1	1
11	Y03	%QX3	DELTA_COIL2	0	0
12	D1	%MW0.1	TIME_COIL2	0	0
13	Y02	%QX2	STAR_COIL2	0	0
14			+MCC1		
15			+MCC2		
16					

Note that the Boolean variables in the EDM are shown highlighted, when monitoring.

7.3 Monitor Mode Essentials

Multiple Windows may be monitored simultaneously by first opening them separately and using 'Tile Windows' feature in the Window Menu. It is important to realise when first entering Monitor mode,  only the target window in view will be monitored.

Further windows may be monitored by first bringing them into the target view and clicking individually on the ***Start Monitoring*** (Ctrl+F8) selection from the ***Online*** menu:

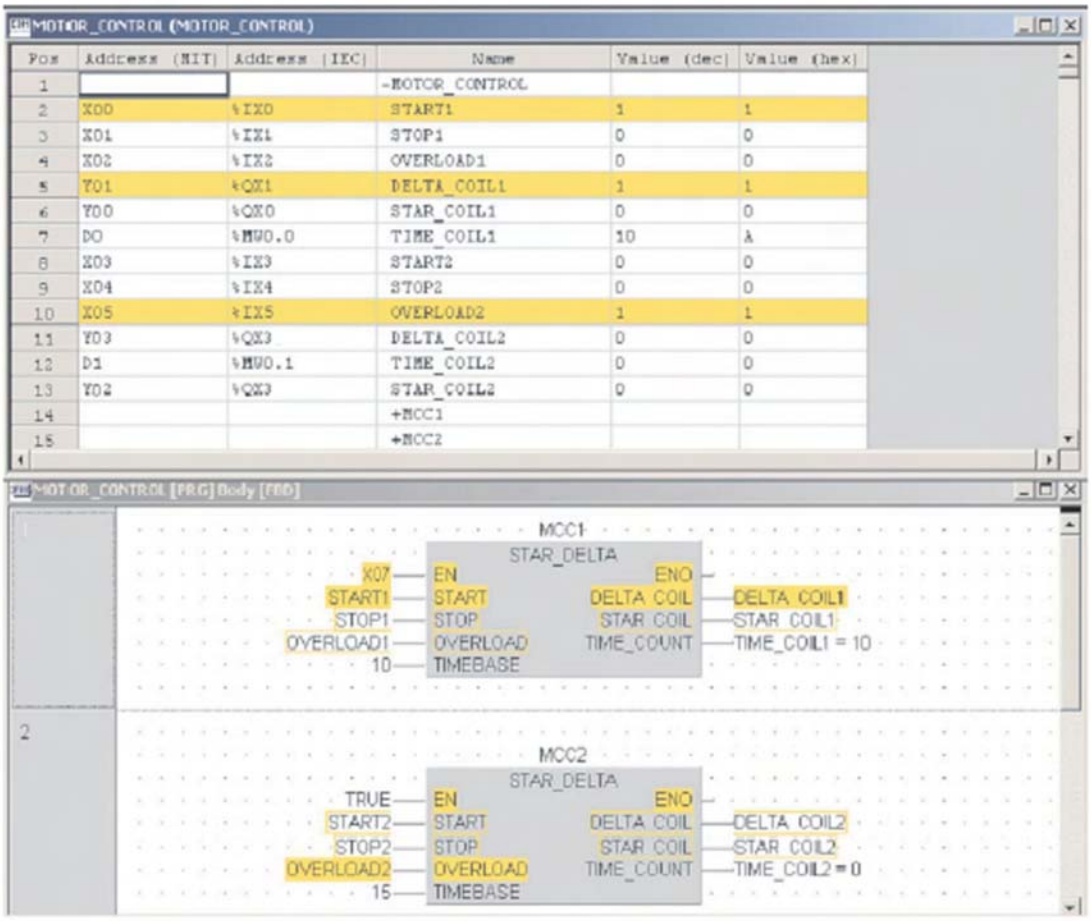


NOTE

This monitor initialisation method is to prevent all open windows from being monitored simultaneously even if they are open but not in view. This would have the effect of potentially significantly increasing the communications traffic between the PLC and the Computer. This would ultimately result in very slow monitor response times on the GX IEC Developer displays, particularly on FX PLC's.

Simultaneous Monitoring of Header and Body

Here is an example of Monitoring a POU and its header simultaneously:



7.4 Monitoring Mitsubishi “Transfer Form” Objects

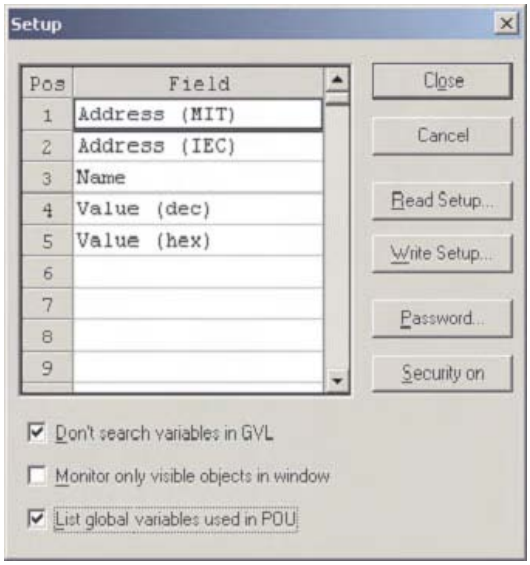
It is also possible to monitor using the Mitsubishi Kn (Official – ‘Transfer Form’) notation for Boolean objects. For example K1X0 monitors X0 - X3 as shown in the following example:

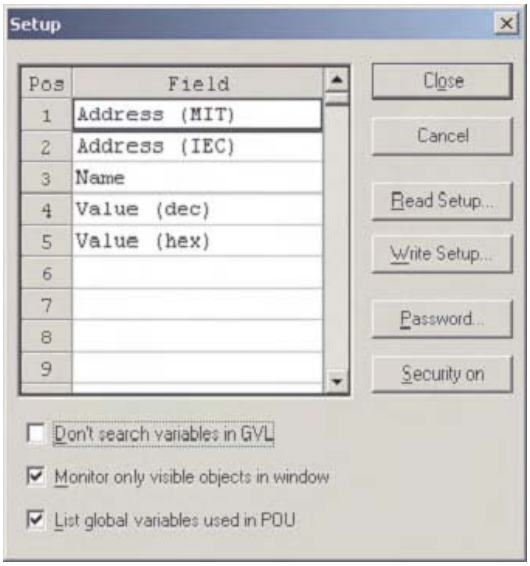
Pos	Address (MIT)	Address (IEC)	Name	Value (dec)	Value (hex)
1	D0	%MW0.0	TIME_COIL1	10	A
2	D1	%MW0.1	TIME_COIL2	0	0
3	X00 0	%IX0	START1	1	1
4	X01	%IX1	STOP1	0	0
5	X02	%IX2	OVERLOAD1	0	0
6	X03	%IX3	START2	0	0
7	X04	%IX4	STOP2	0	0
8	X05	%IX5	OVERLOAD2	1	1
9					
10	K1X6	%IW19.1.6	K1X6	1	1
11					
12					

Setup Options

Don’t Search Variables in GVL - if a direct Mitsubishi address is entered into the ***Entry Data Monitor*** (EDM), for example M0 the system automatically searches the GVL for the identifier. This can take a long time in large projects. By checking the box as shown, this automatic search is disabled.

Monitor only Visible Objects in Window - generally all elements in the EDM are monitored, even if they are not visible. By checking the box as shown, only objects in the active window are monitored. This speeds up response for large headers.

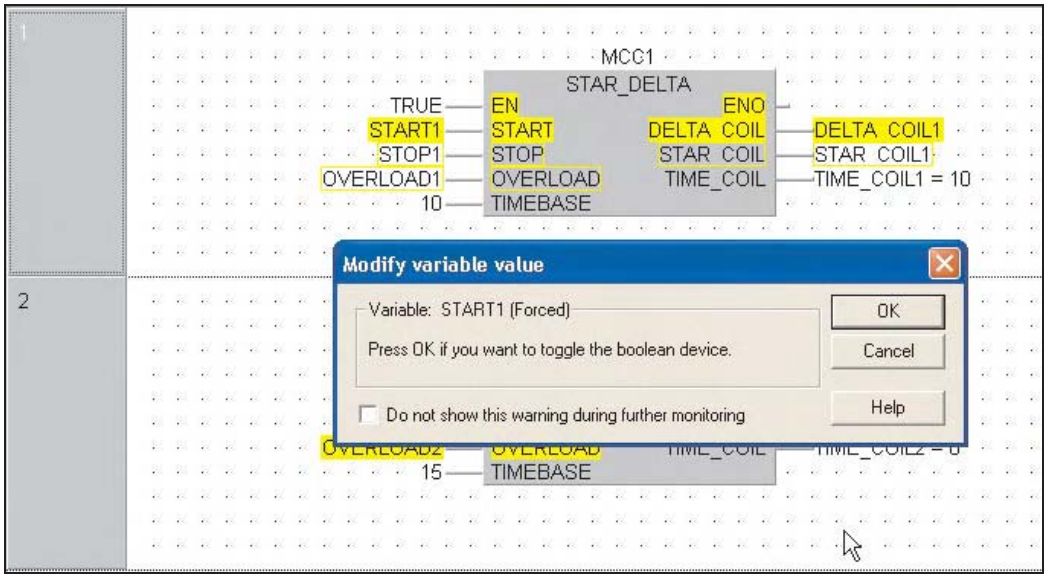




7.5 Modifying Variable Values from the POU Body

It is possible to change the value of a variable from the POU body, in Monitor Mode. This can be a toggle of a Boolean or writing a value to an Integer/Real value etc. To invoke this, double click on the variable label, i.e. ENABLE. This dialogue will appear, click OK to toggle on, click OK again to toggle off. If there is PLC code writing to this variable, then this will overwrite this action.

The dialogue box can be disabled, so that operation is simply by the mouse.



For Integer/Real variables, use the same procedure, i.e. double click on the variable name, whilst in monitor mode. The new value can be entered either as decimal or as a hexadecimal value.

Again, if there is PLC code writing to this variable, then this will overwrite this action.

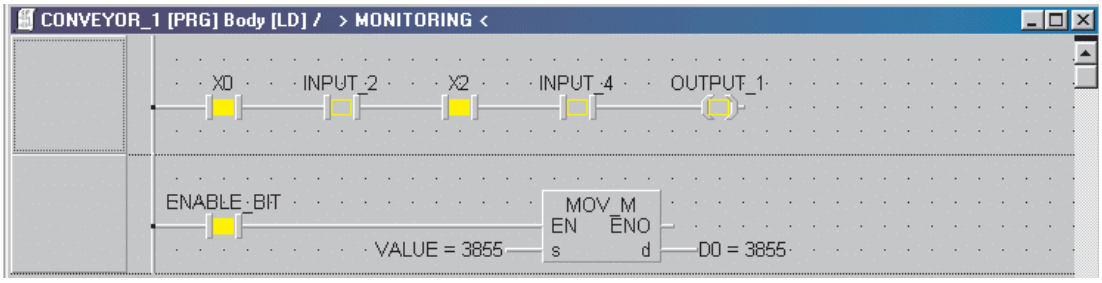
NOTE

Both operations also operate on direct MELSEC addresses (For further illustrations, see previous section: “Functions”).

IMPORTANT TIP

When using the Ladder editor, hold down the CTRL key and double click on the variable name. The actual address of the selected GV will then be displayed, as shown below. Repeating the operation will toggle back to the identifier.

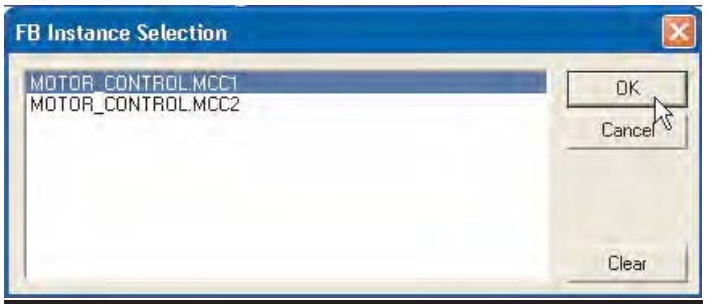
If Monitor Mode is stopped, then started again, identifiers are displayed.



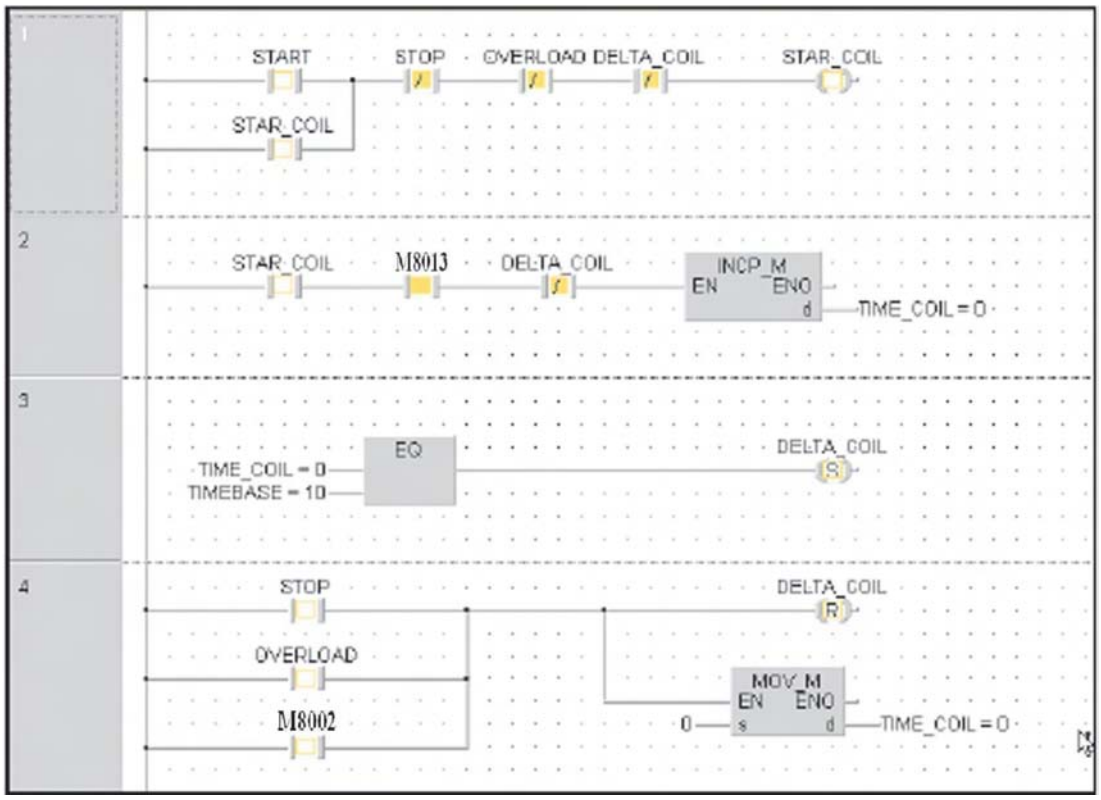
7.6 Monitoring “Instances” of Function Blocks

Individual “Instances” of Function Blocks may be monitored independently.

① To monitor an instance of the POU FB STAR_DELTA in the current project, open the POU Body and click on the Monitor mode button. The following dialogue choice window will be displayed:



② Select the instance of the Function Block MOTOR_CONTROL.MCC1 and observe the monitored page:



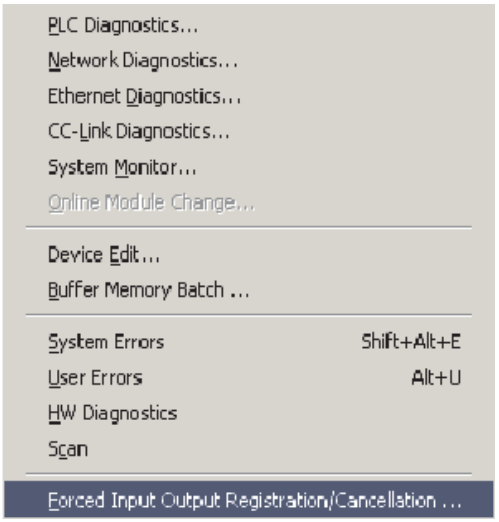
In this manner every instance of any Function Block may be monitored autonomously.

8 Forcing Inputs and Outputs

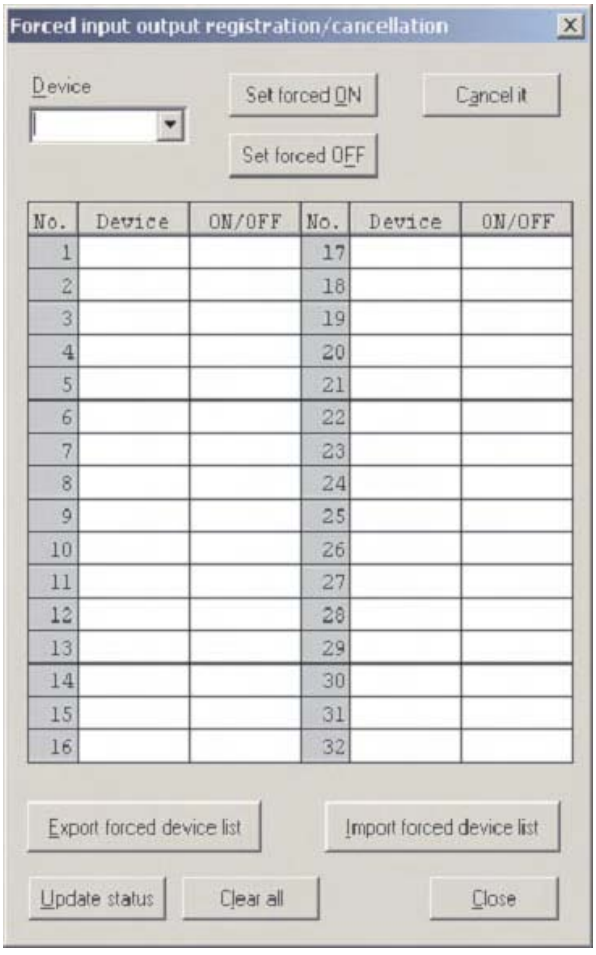
This GX IEC Developer feature enables both the Physical Hardware Input and Output registers to be forced independently from the program scan.

Although great care must be exercised when operating this feature in live situations, it is particularly useful, as it enables the states of all physical input and output devices to be overridden.

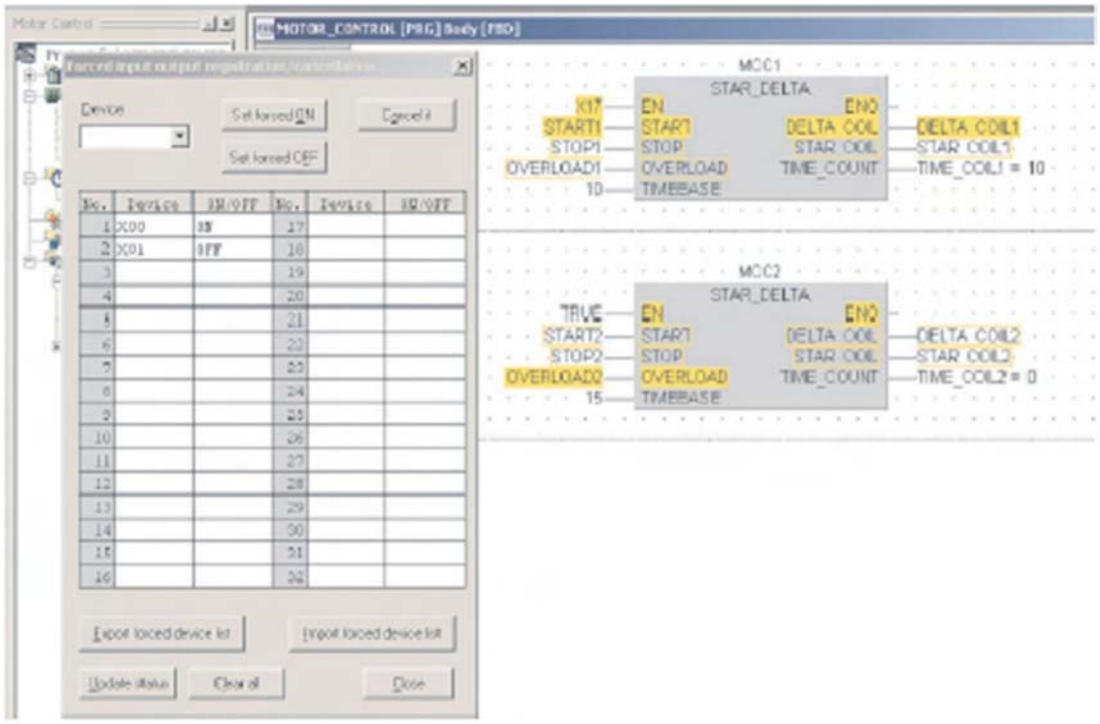
① To activate this function, and select the ***Forced input output registration/cancellation*** select it from the ***Debug*** menu thus:



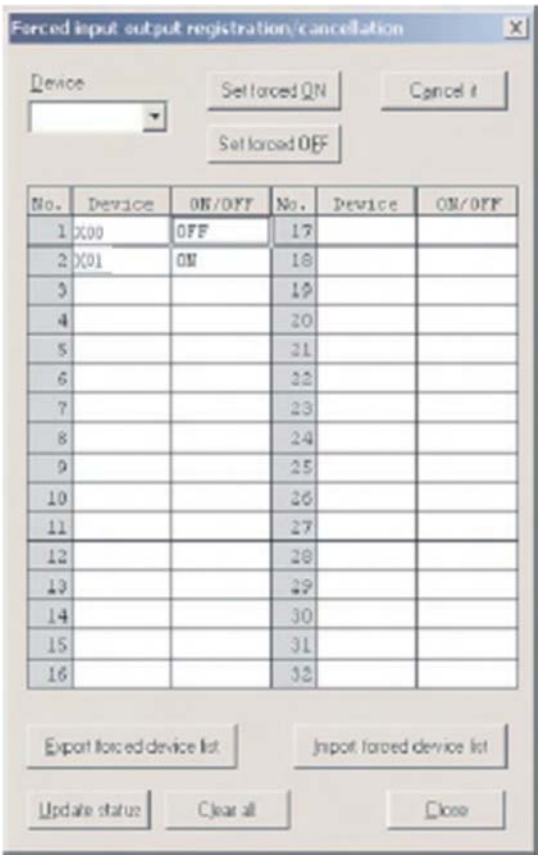
- The following window will be displayed:



② Enter X10 and X11 into the ***Device*** dialogue box and click on the ***Set Forced ON*** button for both variables:

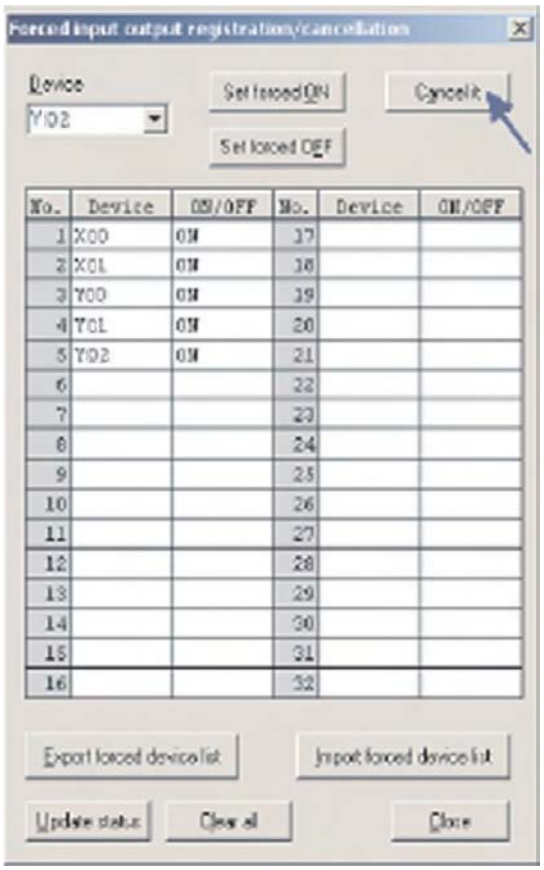


③ To toggle the status of X10 or X11, double click the left mouse button over the ***ON/OFF*** status cell.

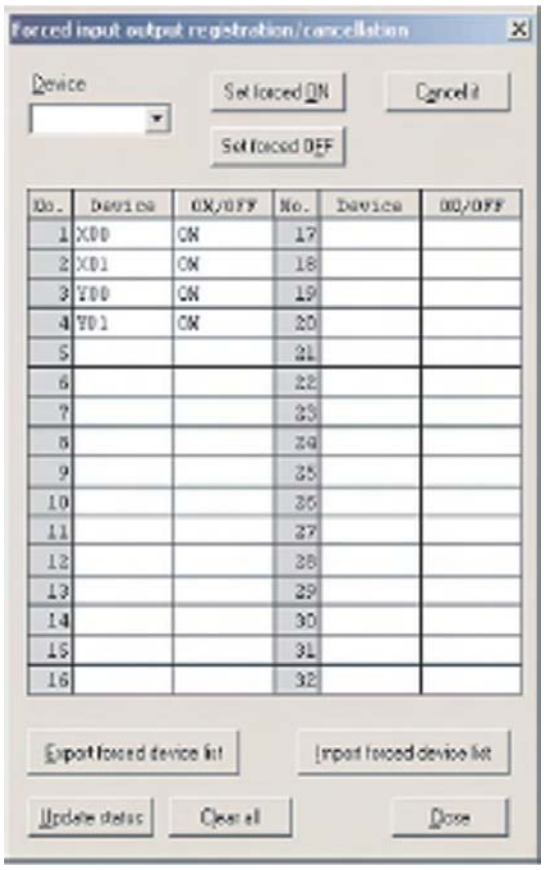


④ Carry out this method of forcing on Y20, Y21 and Y22, noting the effect on the devices.

⑤ To clear a force on an individual device, enter the device then click on the ***Cancel it*** button thus.

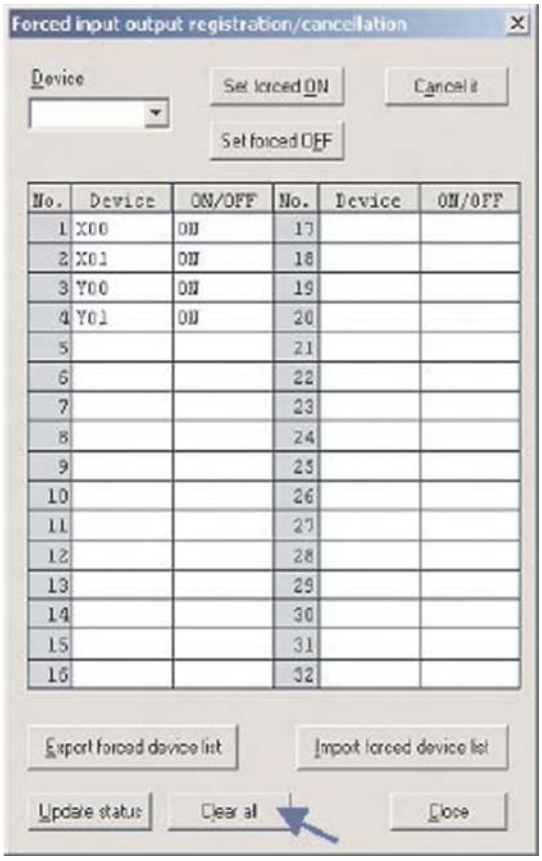


⑥ The following display will result:

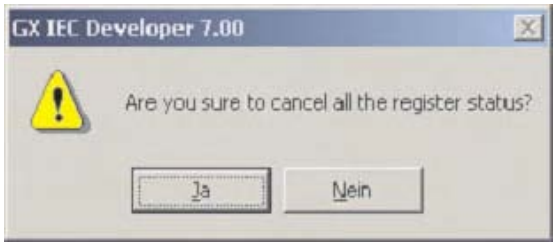


NOTE When any forces are registered within the PLC, the 'Mode' light on the CPU flashes at 2Hz.

⑧ To clear all forces registered in the CPU, click the ***Clear All*** button



⑨ Confirm the cancellation request using the following response:

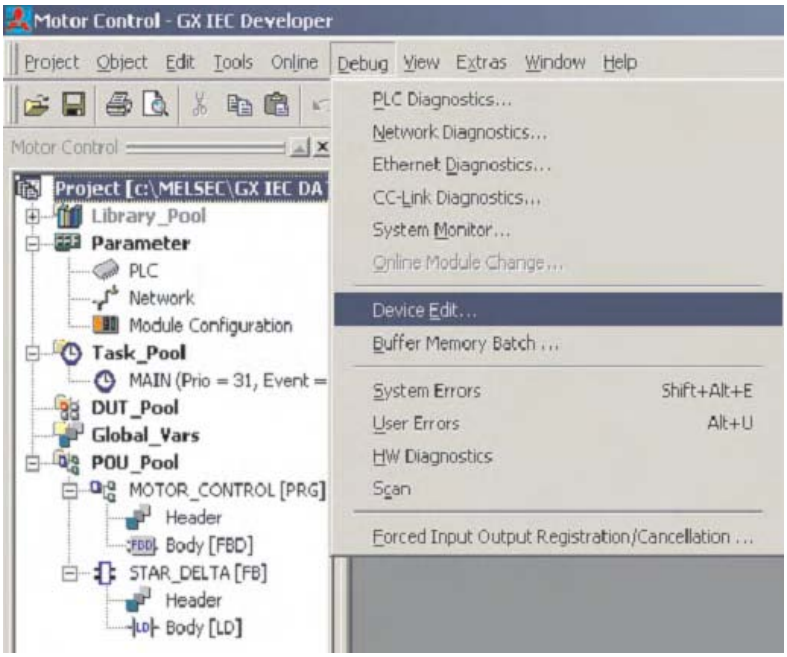


NOTE Individual forces may be removed from the active force table by clicking the ***Cancel it*** button for the appropriate entry.

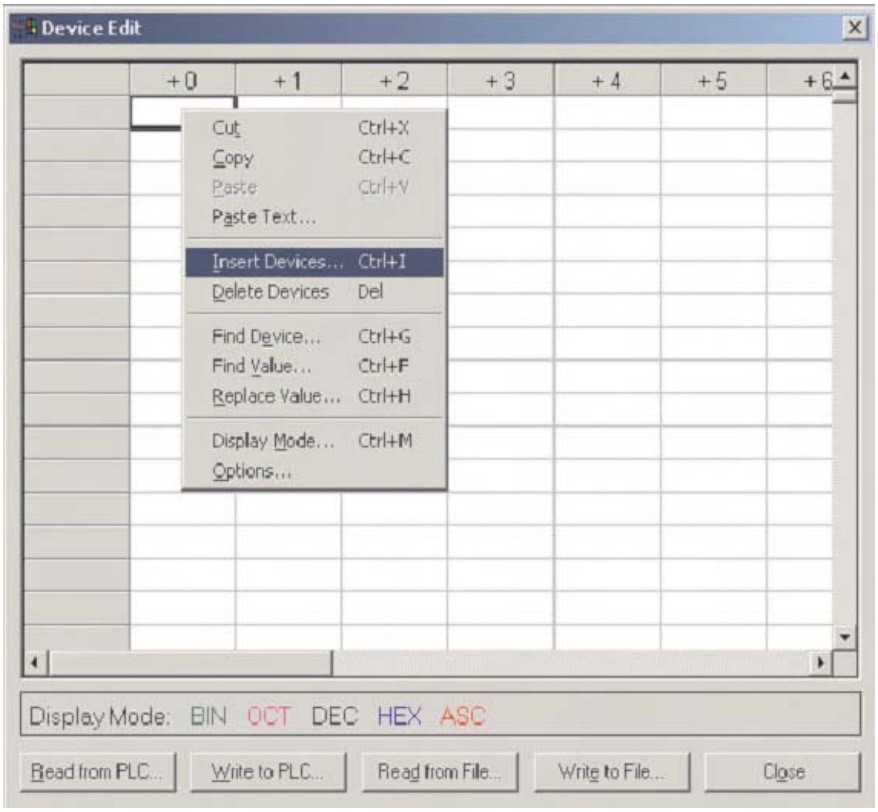
9 Device Edit

The ***Device Edit*** function is akin to the ***D,W,R set*** in MELSEC MEDOC and ***Device Memory*** feature in GX Developer.

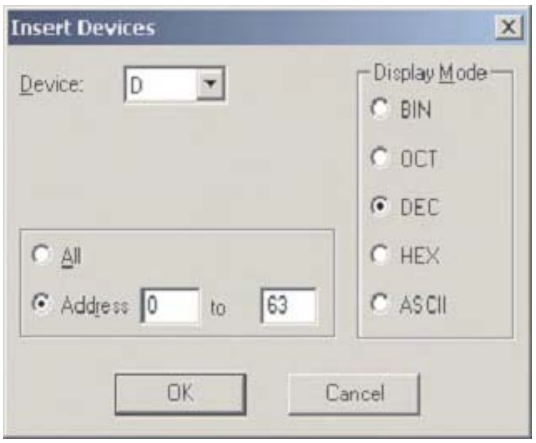
① Select ***Device Edit*** from the ***Debug*** menu.



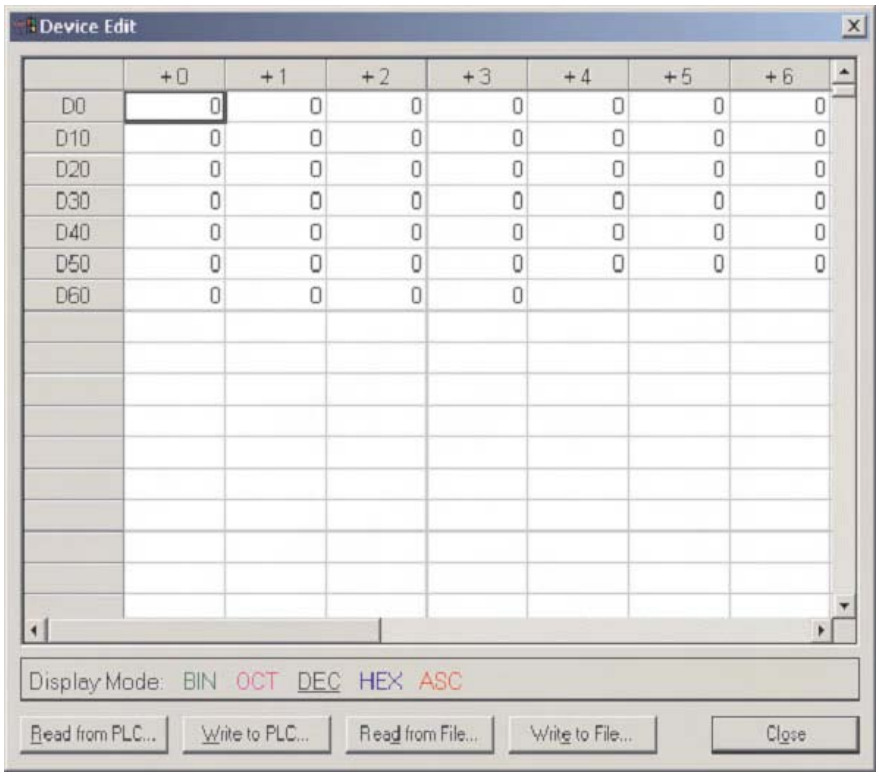
② Highlight the cell in the top left hand corner. Click the right mouse button and then select ***Insert Devices***:



③ Select a device type, from the ***Device*** selection box. If you want all devices of this type, then just click ***OK***. It's more likely though; you will want to enter a range by clicking on the address field and entering your range, then click ***OK***.

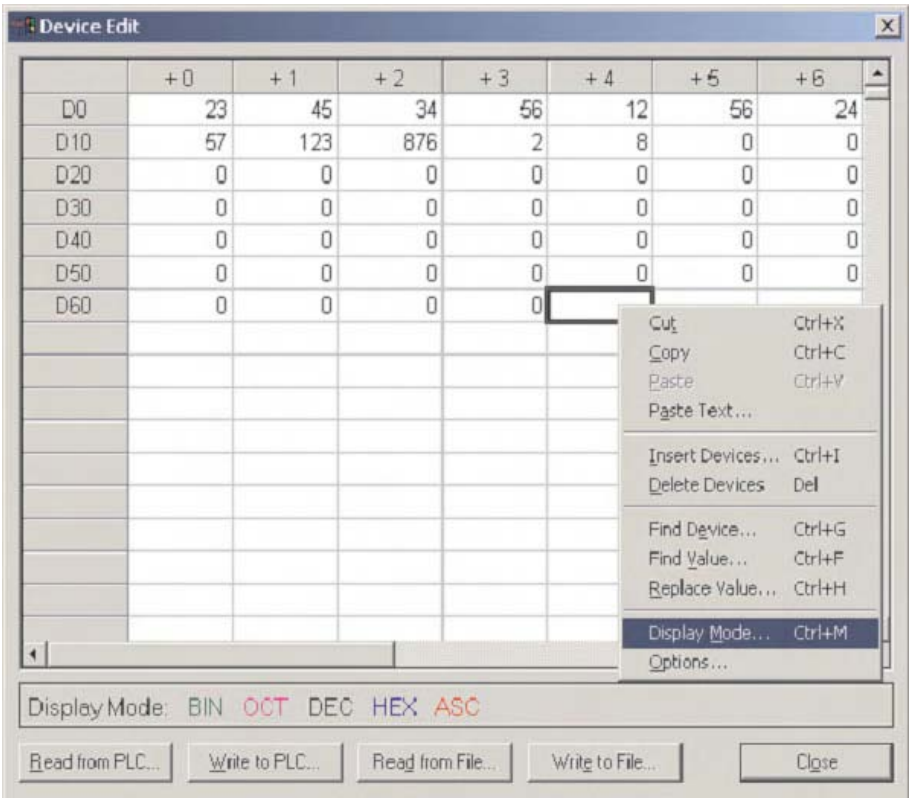


The device table can be configured as you wish and can be stored, as a file or written to the PLC. Information can also be uploaded from the PLC and displayed as below.

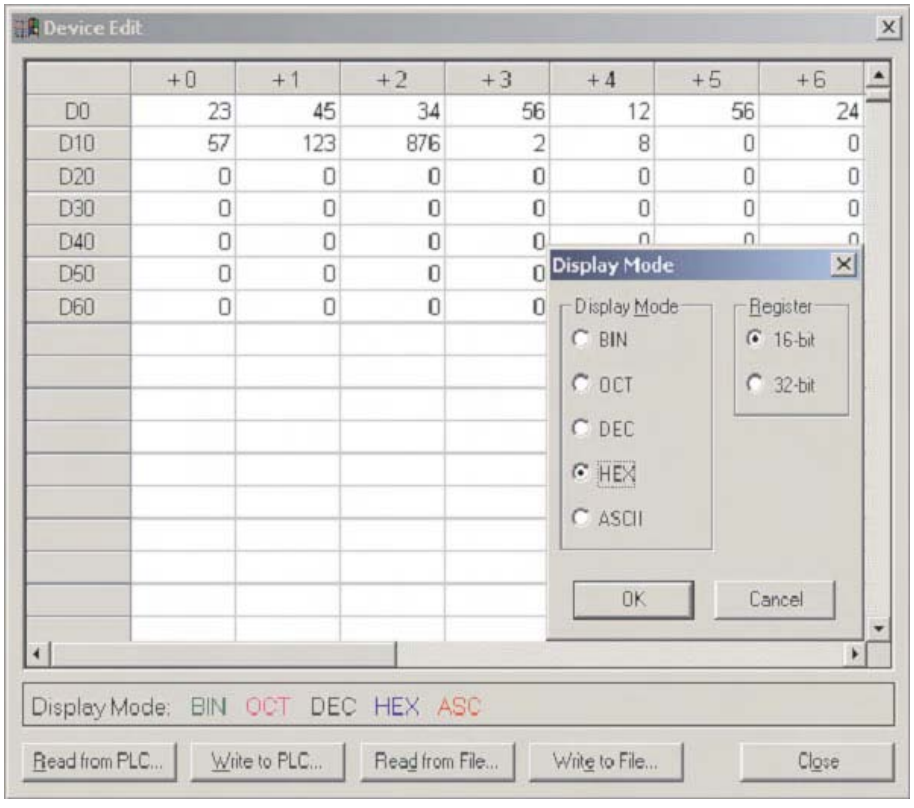


The right mouse button supports many editing functions, find and replace, copy / paste, etc.

④ Highlight a row by clicking on the left hand box, i.e. “D0” Select ***Display Mode***:



This window allows the display format to be changed - try ***HEX***.



It should be noticed that the selected row now displays values in hexadecimal, the other values remain unchanged. In fact, individual cells can have different display formats, making this feature extremely flexible.

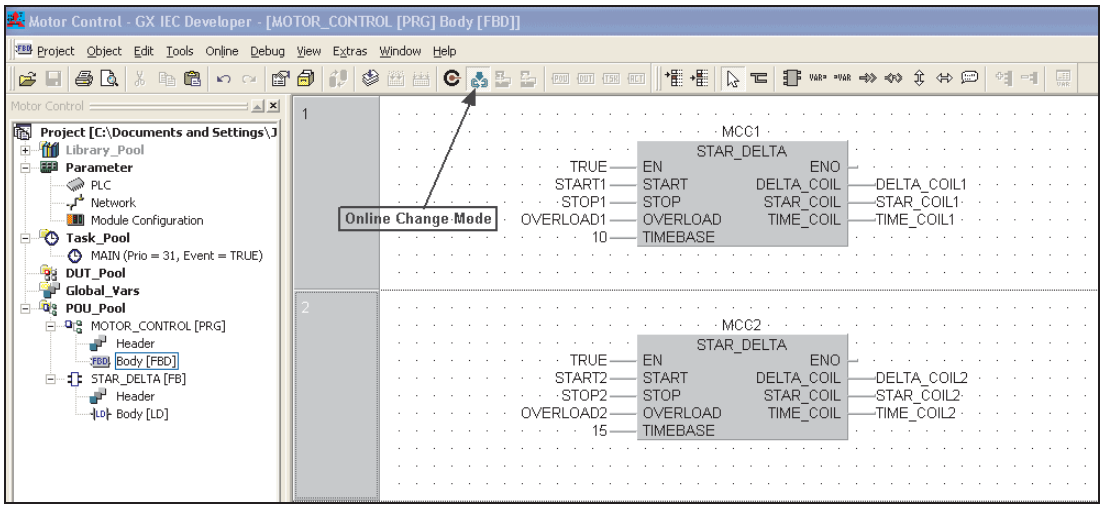
10 Online Mode

There are two methods for evoking online editing; via the online menu or the toolbar icon. Use ***Save as*** in the ***Project*** menu to create a copy of the current project. Rename the Copy to “Motor_Control_Mod”. The following operations will apply to this modified program.

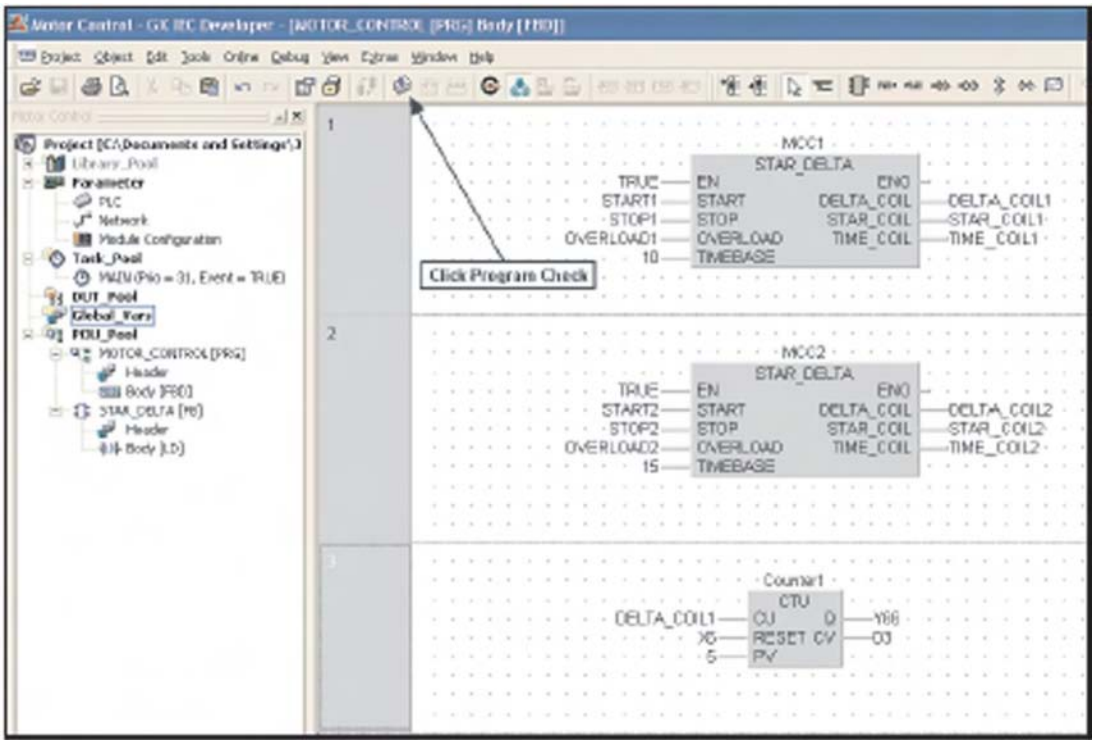
Rebuild the project and download it to the PLC.

10.1 Online Change Mode

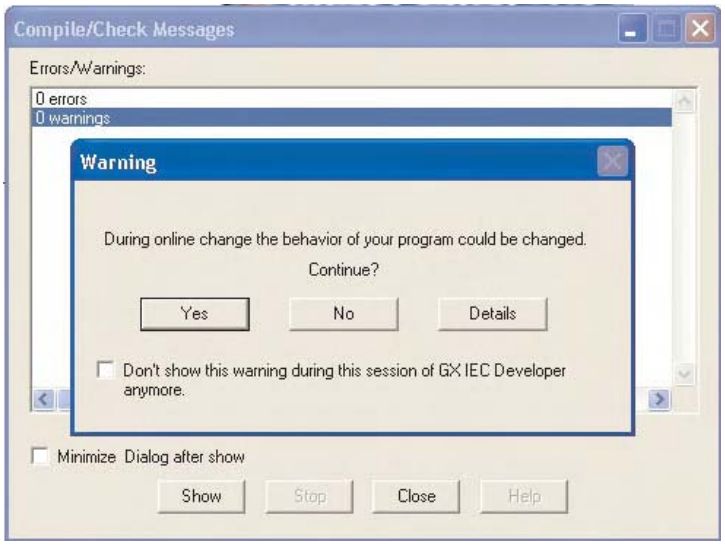
① Open the body of the ‘MOTOR_CONTROL’ POU and select ***Online change mode***:



② Add an additional network as shown below:

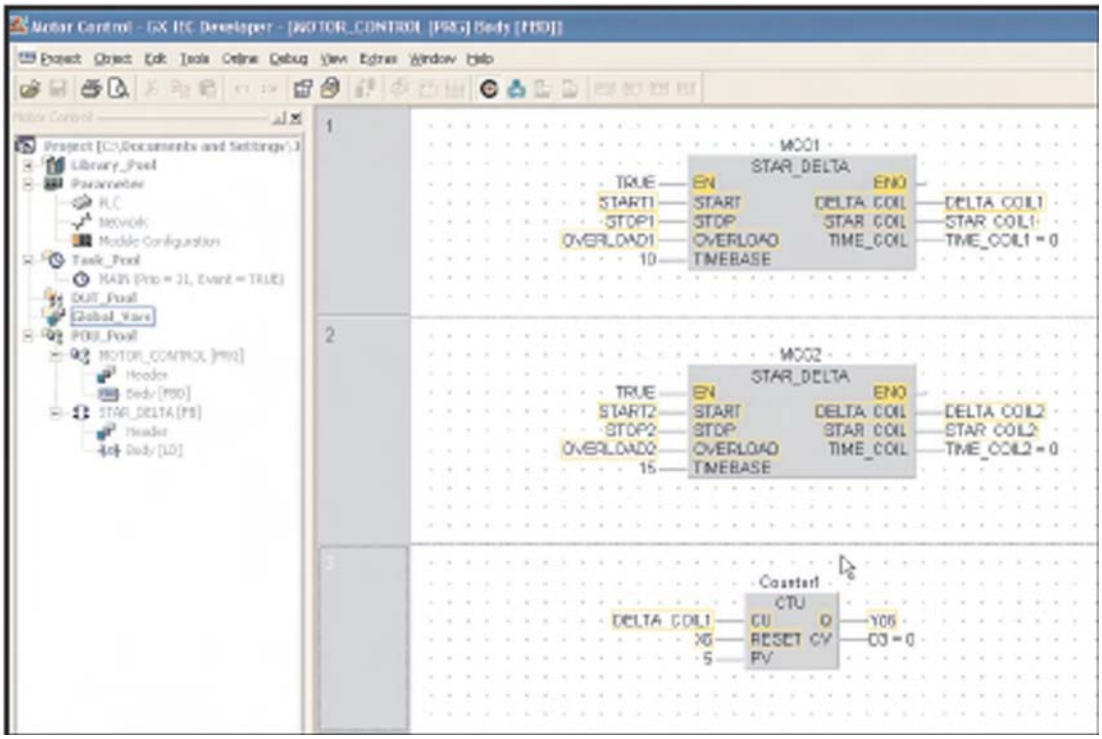


③ Then with the mouse, click away from this network or click on the check button and the changes are compiled and sent to the PLC automatically following a prompt to carry out or abort the action:



NOTE | Online editing is only allowed if the code is identical in the resident project and PLC.

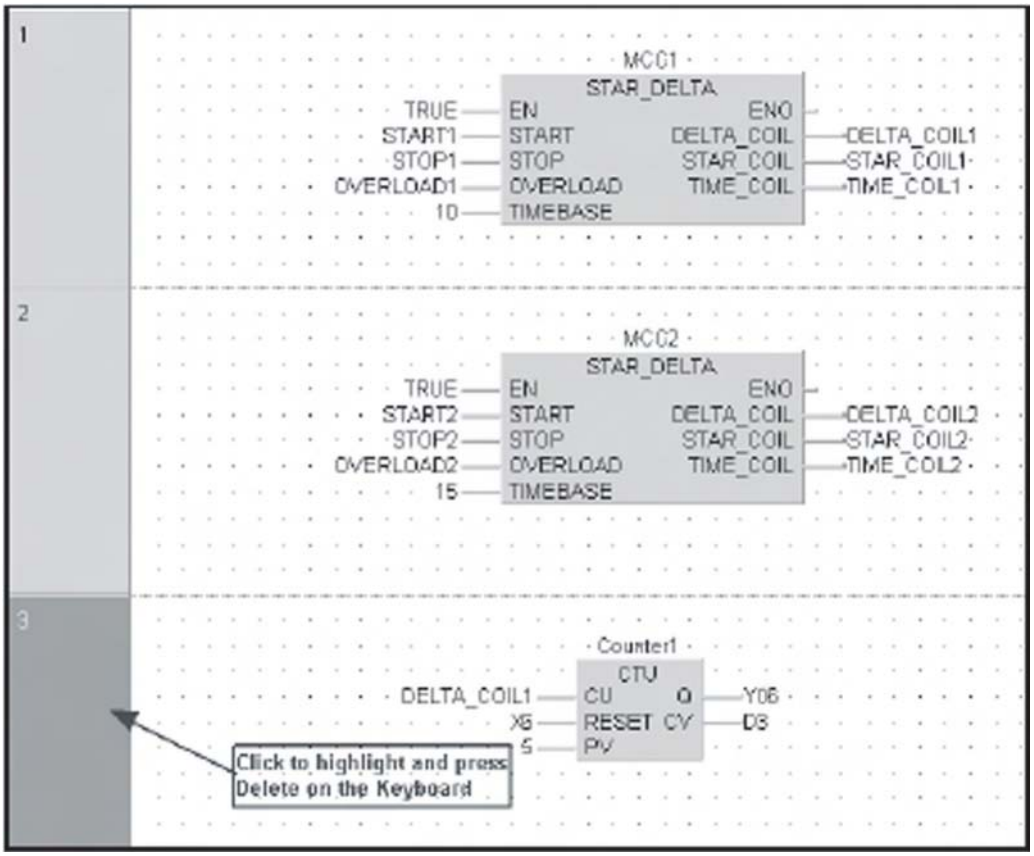
④ Enter Monitor mode and observe the operation of the modified block:



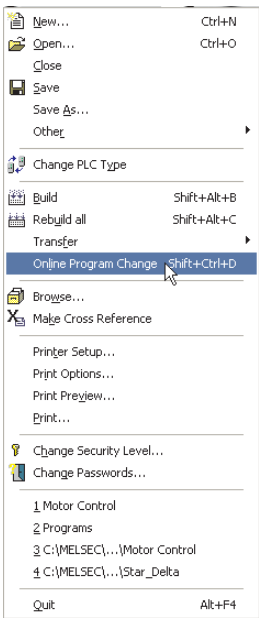
10.2 Online Program Change

Where complete networks are to be added or removed, the “Online Program Change” operation must be used. This method is the preferred method of making changes to the program whilst on-line. For example: If the recently added counter network is to be removed from the program, carry out the following procedure (Remember the PLC and GX-Developer programs must be identical before proceeding).

① Highlight network 3 on the POU body “MOTOR_CONTROL” and press "Delete" on the keyboard.

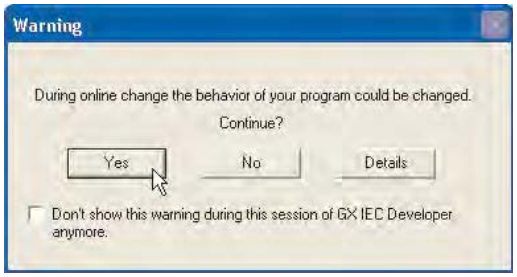


② Invoke the ***Online Program Change*** feature from the ***Project*** Menu. GX IEC Developer will compile and write the online change automatically.

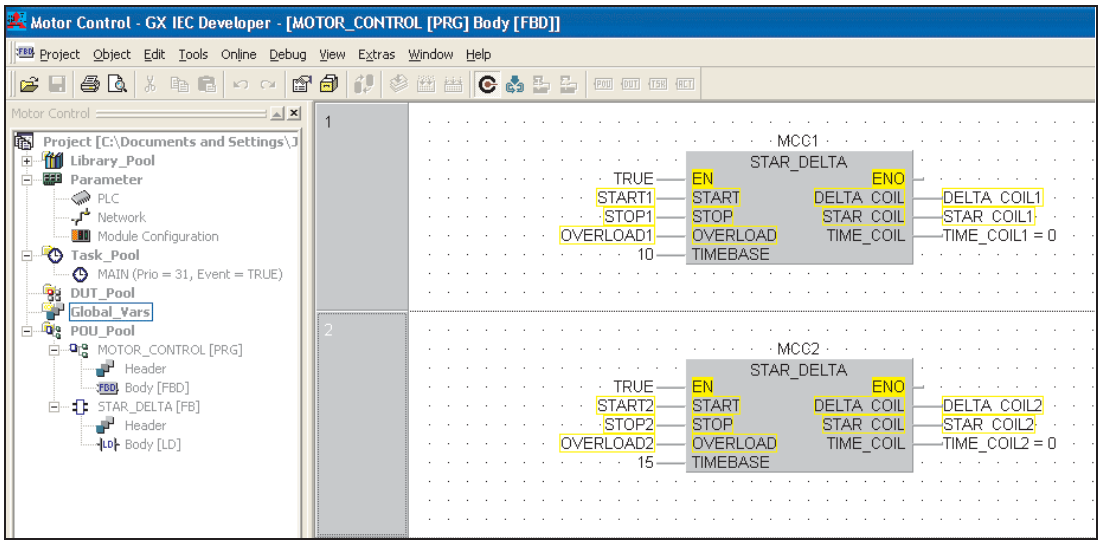


The system will prompt to continue or abort the process at this point.

③ Click ***Yes*** and wait for the download synchronisation process to complete:



④ Confirm correct operation by entering ***Monitor mode*** in the active POU.



11 Data Unit Types (DUT)

The following example illustrates the operation of DUT (**D**ata **U**nit **T**ypes).

The previous “Motor Control” example will be used to illustrate the procedures for creating and using DUT’s.

User defined Data Unit Types (DUT), can be created. This can be useful for programs which contain common parts, for example; the control of a number of identical ‘Star Delta’ motor starters. Therefore a Data Unit Type, called ‘SD’ can be created, composing patterns of different elements, i.e. INT, BOOL etc.

When completing a global variable list, identifiers of type SD can be used. This means that the predefined group called ‘SD’ can be used with the elements defined as required for each Motor Control, thus reducing design time and allowing re-use of the DUT together with Function Blocks.

If an element called START exists in type “SD,” then it can be reused for each ‘Star Delta’ Motor Control instance when declared in the GVL; STAR_DELTA1.START, STAR_DELTA2.START etc.

This means for one declaration, many derivatives can be used. One particular use for this procedure is in the interface to Tag Groups in SCADA systems. This can keep communication cycles fast and efficient by utilising shorter and sequential data transactions, instead of multiple fragmented data requests to and from the PLC.

11.1 Example use of a DUT

The following example illustrates the use of a DUT.

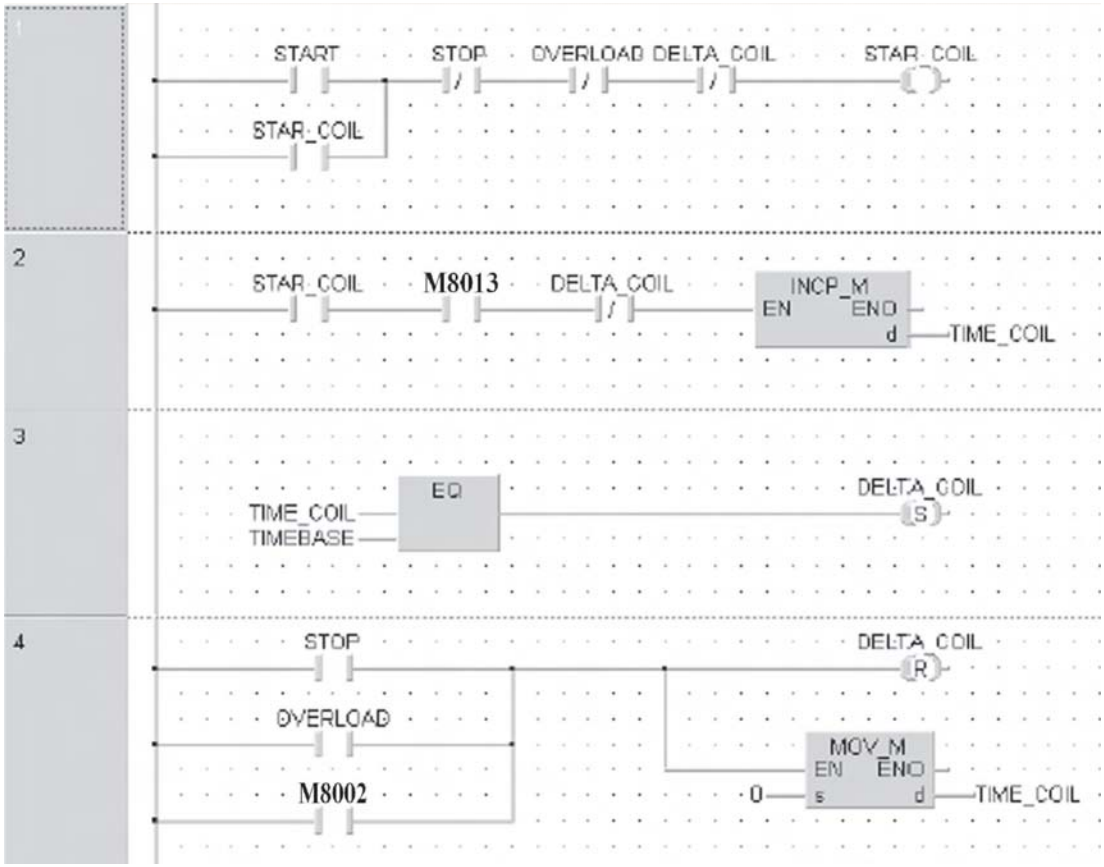
① Create a new project called “Motor Control DUT”:

② Ceate a new Program POU called MOTOR_CONTROL

③ Create a new Task in the task pool called MAIN and bind the Program MOTOR_CONTROL to it.

④ Create a new Function Block “STAR_DELTA” and re-enter the following program code. Alternatively, ‘Copy-Paste’ the original function block, ‘Body and Header’, from the project “Motor Control” as follows:

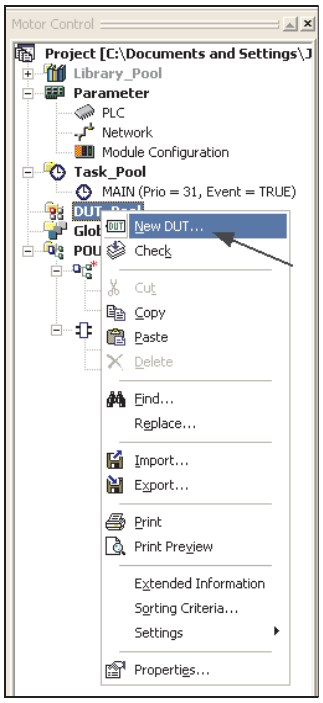
Body: STAR_DELTA



Header: STAR_DELTA

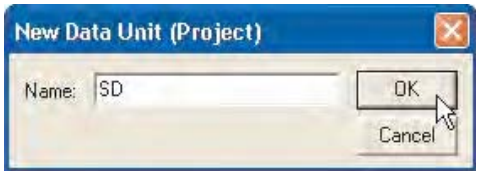
	Class	Identifier	Type	Initial	Comment
0	VAR_INPUT	START	BOOL	FALSE	
1	VAR_INPUT	STOP	BOOL	FALSE	
2	VAR_INPUT	OVERLOAD	BOOL	FALSE	
3	VAR_INPUT	TIMEBASE	INT	0	
4	VAR_OUTPUT	DELTA_COIL	BOOL	FALSE	
5	VAR_OUTPUT	STAR_COIL	BOOL	FALSE	
6	VAR_OUTPUT	TIME_COIL	INT	0	

The Header contains the definitions (Mask) of the data types that will be used when creating the DUT “SD”.

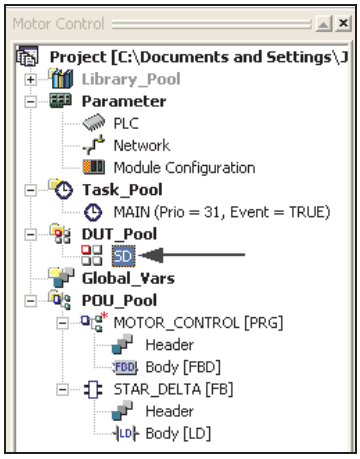


⑤ Create a new DUT by right clicking on the ***DUT Pool*** icon in the Program navigation window

or from the DUT icon  on the toolbar.



⑥ Enter the new DUT name as SD at the prompt.



The new DUT will now be displayed under the ***DUT Pool*** in the project.

⑦ Open the DUT by clicking on the Icon and the following will be displayed:

	Identifier	Type		Initial	Comment
0			...		

⑧ Enter the following data into the DUT “SD”.

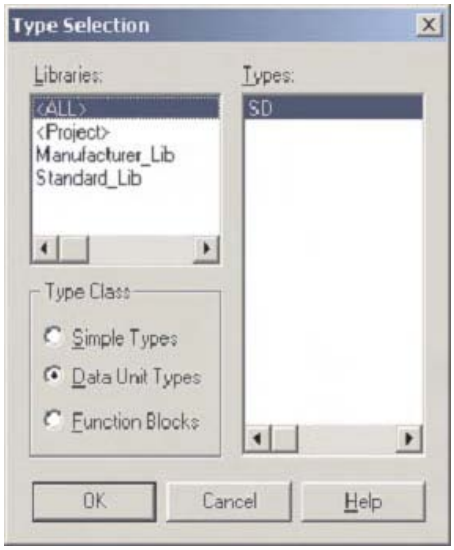
	Identifier	Type		Initial	Comment
0	DELTA	BOOL	...	FALSE	
1	O_L	BOOL	...	FALSE	
2	STAR	BOOL	...	FALSE	
3	START	BOOL	...	FALSE	
4	STOP	BOOL	...	FALSE	
5	TB	INT	...	0	
6	TV	INT	...	0	

⑨ Close the DUT and save the program.

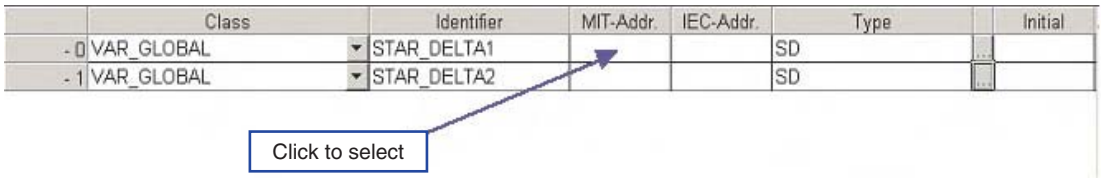
⑩ Open the GVL and create 2 new entries STAR_DELTA1 and STAR_DELTA2.

⑪ Click the 'ellipsis' [...] to specify the ***Type*** as "Data Unit Types" SD for both entries:

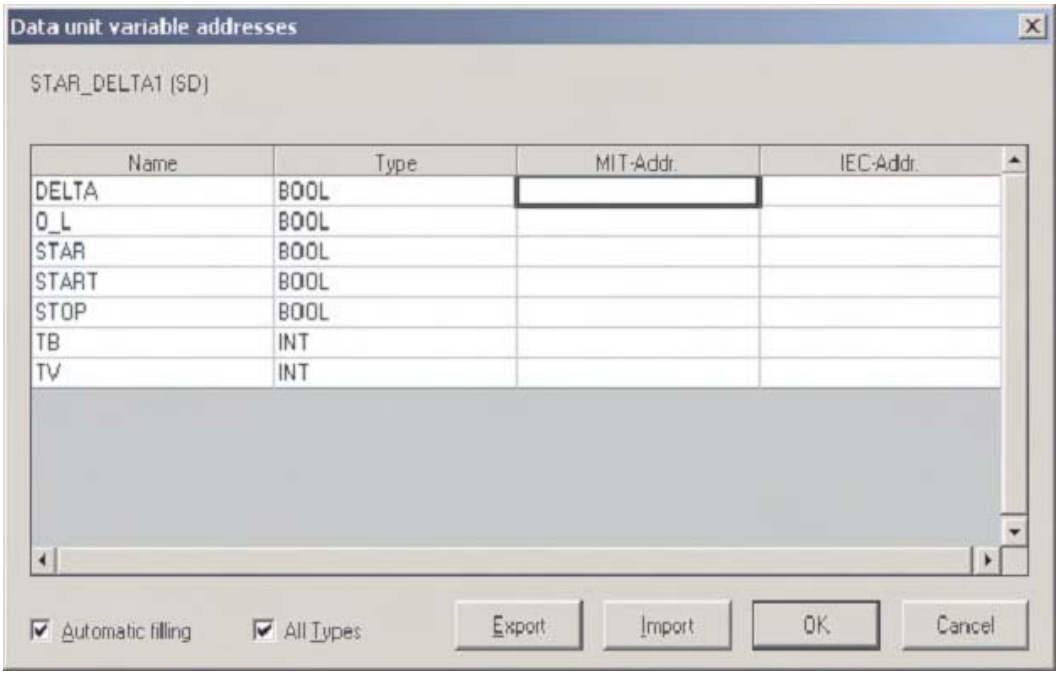
	Class	Identifier	MIT-Addr.	IEC-Addr.	Type		Initial
- 0	VAR_GLOBAL	STAR_DELTA1			SD	...	
- 1	VAR_GLOBAL	STAR_DELTA2			SD	...	



⑫ Next, click on the ***MIT-Addr.*** cell for STAR_DELTA1 to enter the variable data for the selected DUT entry:



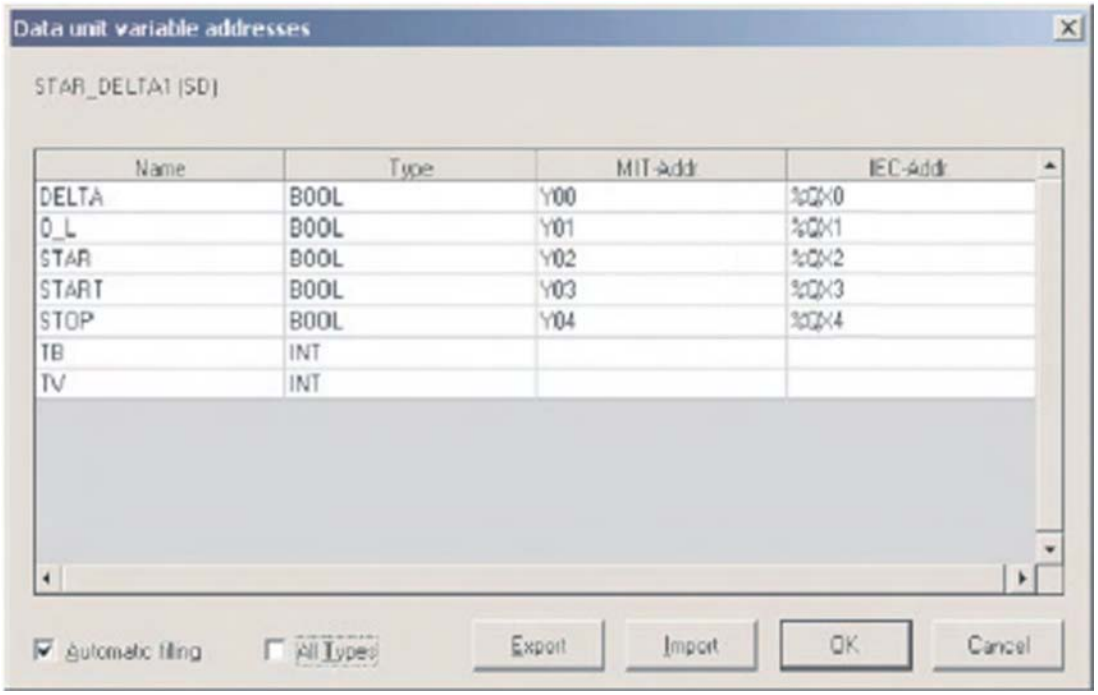
Resulting window:



11.2 Automatic Filling, Variables

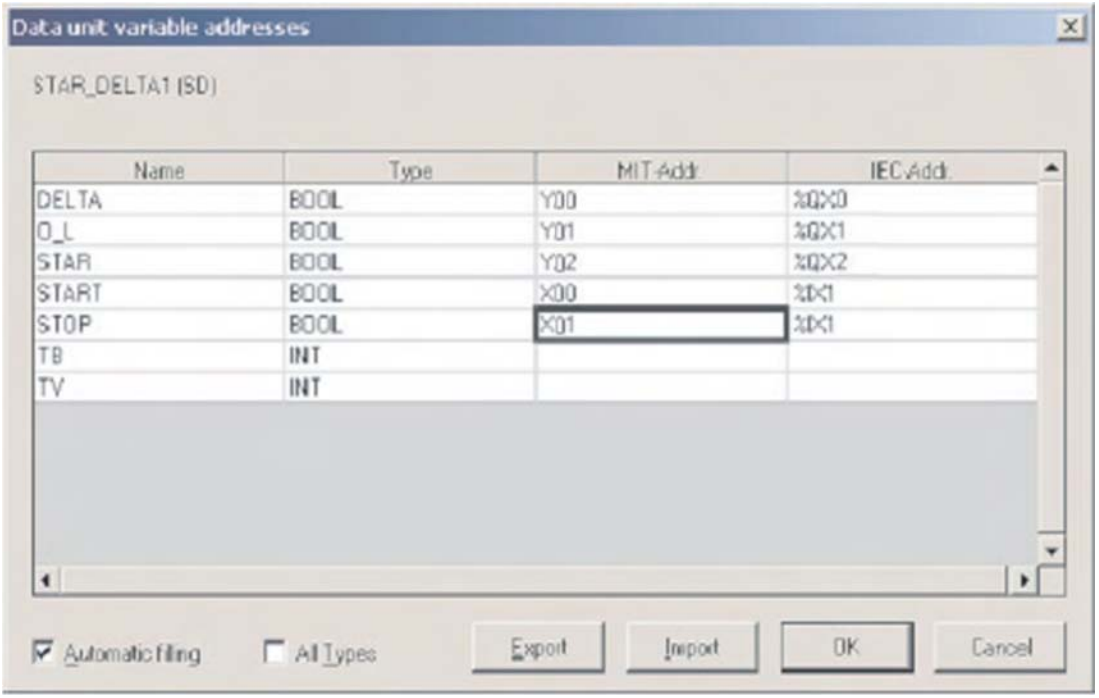
① Deselect ***All types*** as this operation is illegal when using mixed variable types.

② Enter Y00 in the ***MIT-Addr.*** position for the variable: 'DELTA':

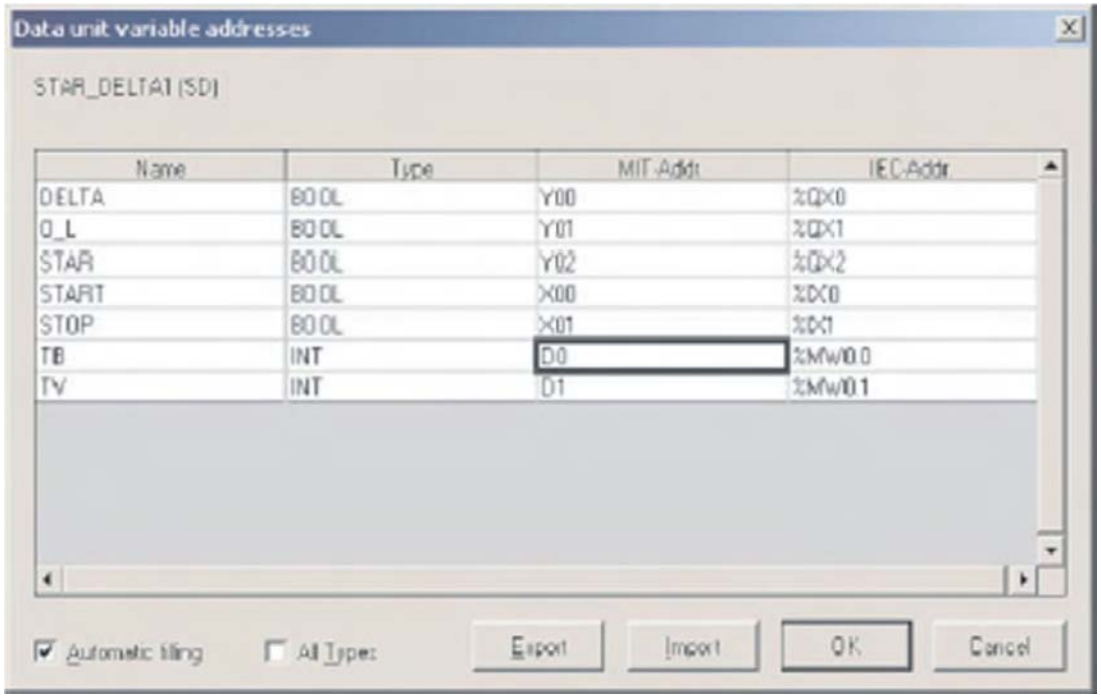


The system will try to sequentially 'Auto Fill' the variables of type BOOL. Although in many situations this is recommended, in this case it is only partially successful.

③ Therefore overtype "START and STOP" variables with X00 and X01 thus:

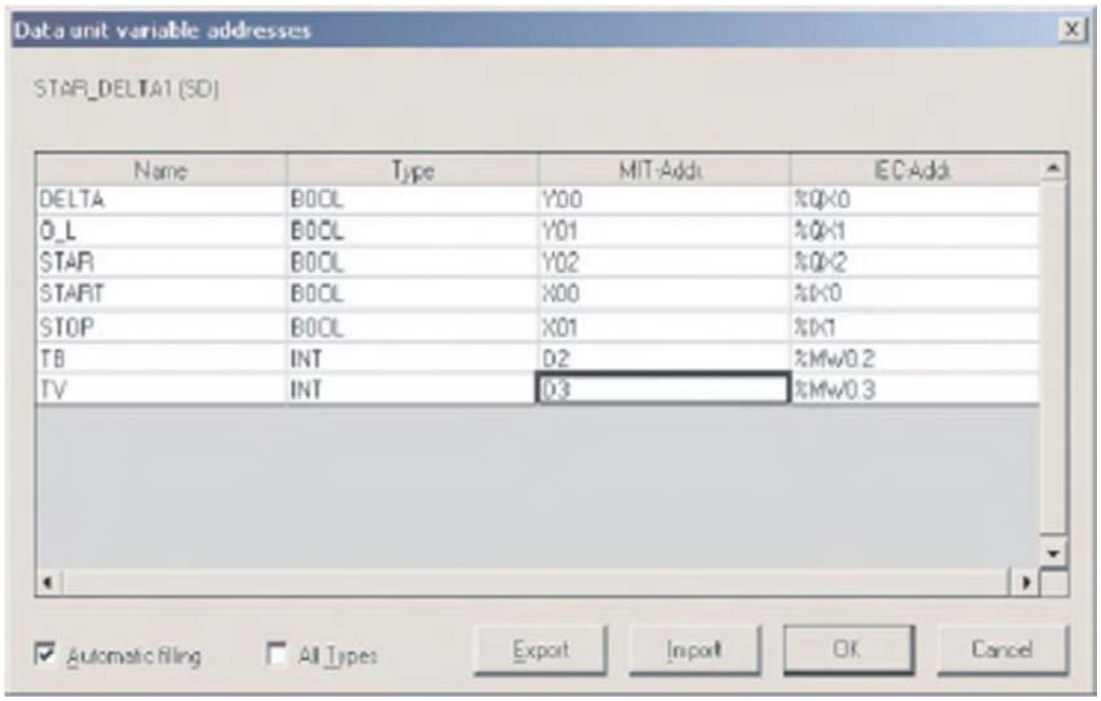


④ Finally, enter the two remaining Integer Variables TB and TV using MELSEC addresses D0 and D1 using the “Auto Fill” feature:



⑤ Click OK to save the current configuration.

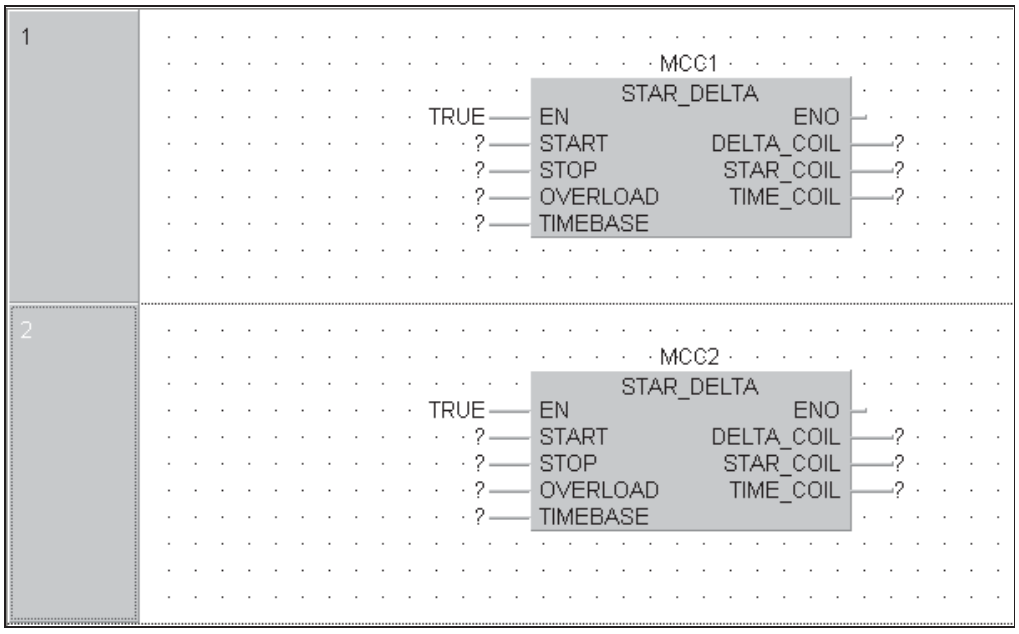
⑥ Repeat this series of operations for “STAR_DELTA2” entering the next sequential head address for each variable “TYPE”:



⑦ Examine the GVL, it should read as follows:

	Class	Identifier	MIT-Addr.	IEC-Addr.	Type		Initial
+0	VAR_GLOBAL	STAR_DELTA1	DELTA:	DELTA:	SD	...	
+1	VAR_GLOBAL	STAR_DELTA2	DELTA:	DELTA:	SD	...	

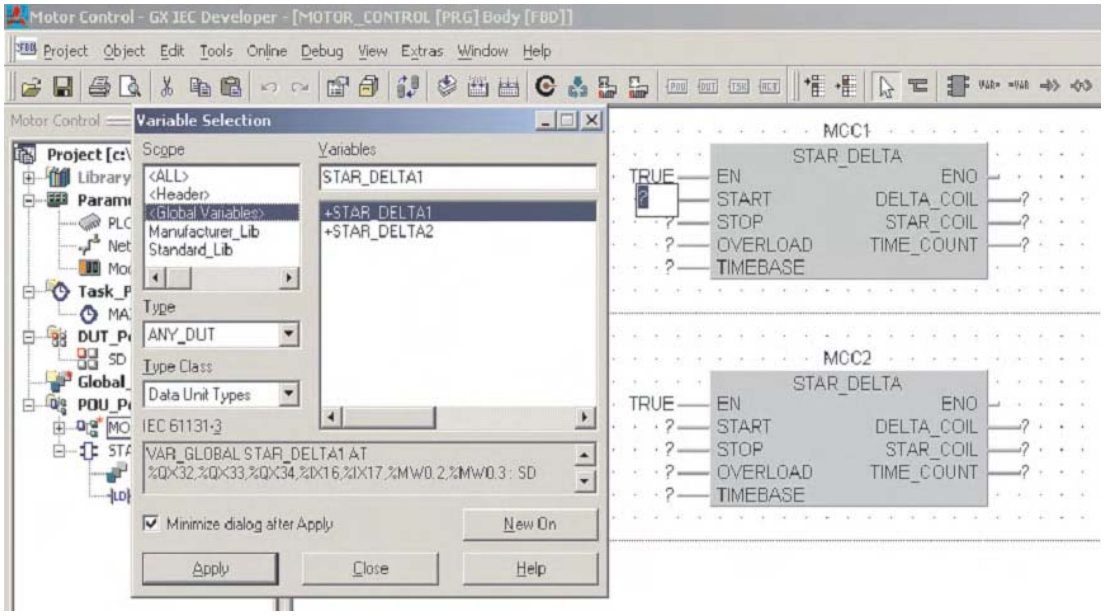
Open the MOTOR_CONTROL program POU and place 2 instances of the user created Function Block STAR_DELTA as shown:



11.3 Assigning DUT Variables to Function Blocks

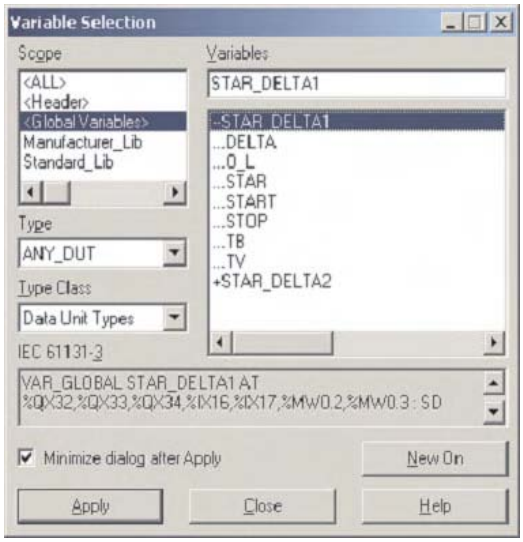
To assign variables to the Function blocks...

① ...right Click on a variable (or F2). The following variable selection window appears:

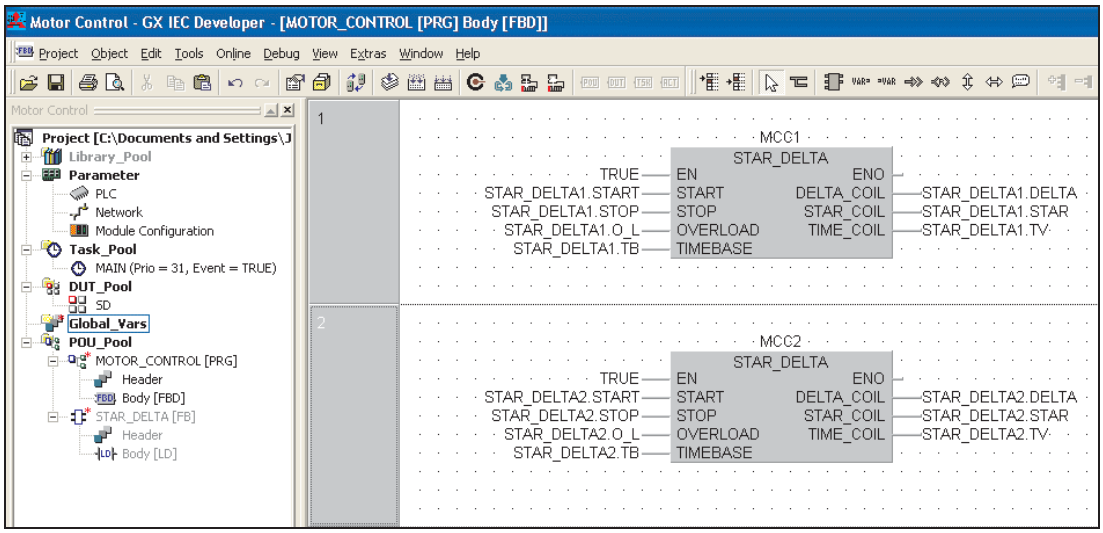


② Set the ***Scope*** to ***Header***, ***Type Class*** to ***Data Unit Types*** and ***Type*** to ***ANY_DUT***.

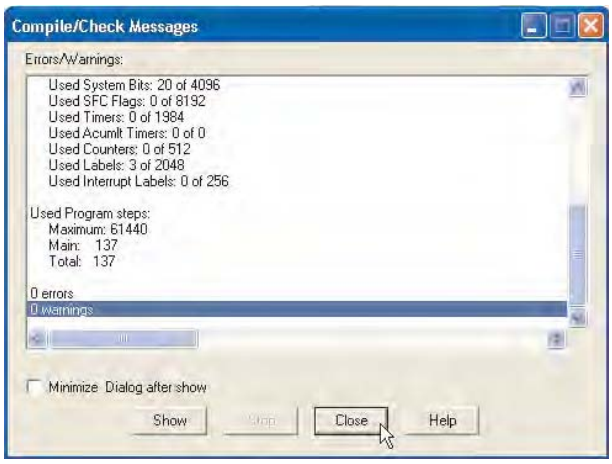
③ Double Click on +STAR_DELTA1 and the following expanded DUT variable list appears:



④ Pick and assign the variables to the two STAR_DELTA Function Blocks on the MOTOR_CONTROL Program POU as shown:

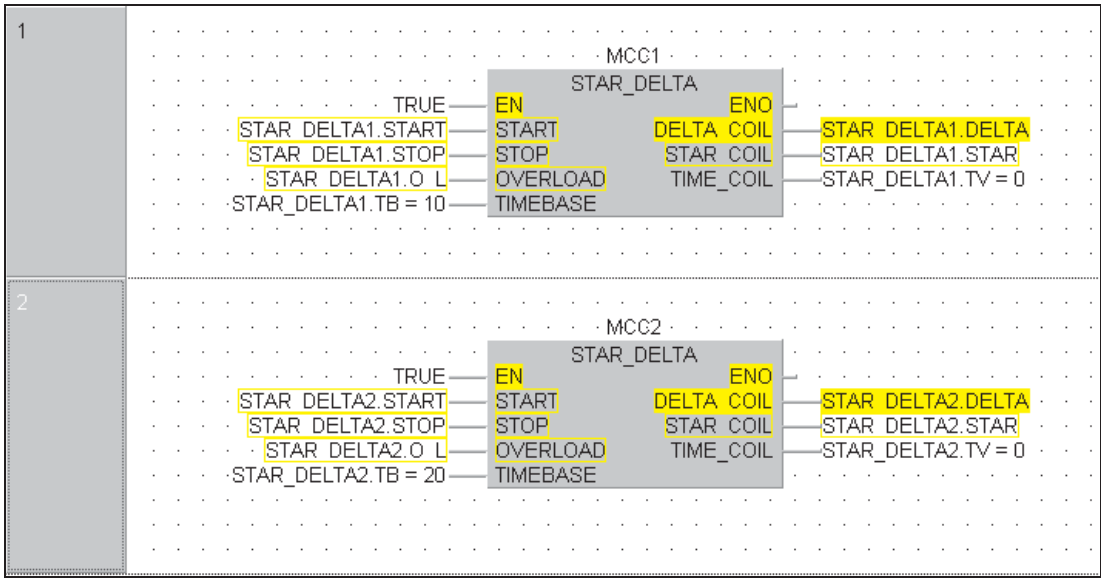


Save the project and ***Rebuild All*** to compile the code:



Download and monitor the project. Before the Function Blocks can operate, it is necessary to write values into the TIMEBASE inputs: STAR_DELTA1.TB and STAR_DELTA2.TB. This is carried out by using the online variable modification technique described in an earlier section.

Simulate the operation of both Function Blocks as shown on the next page in order to confirm that everything functions as expected:


1
MCC1
STAR_DELTA
TRUE
EN
ENO
STAR_DELTA1.START
START
DELTA_COIL
STAR_DELTA1.DELTA
STAR_DELTA1.STOP
STOP
STAR_COIL
STAR_DELTA1.STAR
STAR_DELTA1.O_L
OVERLOAD
TIME_COIL
STAR_DELTA1.TV = 0
STAR_DELTA1.TB = 10
TIMEBASE
2
MCC2
STAR_DELTA
TRUE
EN
ENO
STAR_DELTA2.START
START
DELTA_COIL
STAR_DELTA2.DELTA
STAR_DELTA2.STOP
STOP
STAR_COIL
STAR_DELTA2.STAR
STAR_DELTA2.O_L
OVERLOAD
TIME_COIL
STAR_DELTA2.TV = 0
STAR_DELTA2.TB = 20
TIMEBASE

12 Arrays

12.1 Overview

An array is a field or matrix of variables, of a particular type.

For example, an **ARRAY [0..2] OF INT**, is a one dimensional array of three integer elements (0,1,2). If the start address of the array is D0, then the array consists of D0, D1 and D2.

Identifier	Address	Type	Length
Motor_Volts	D0	ARRAY	[0...2] OF INT

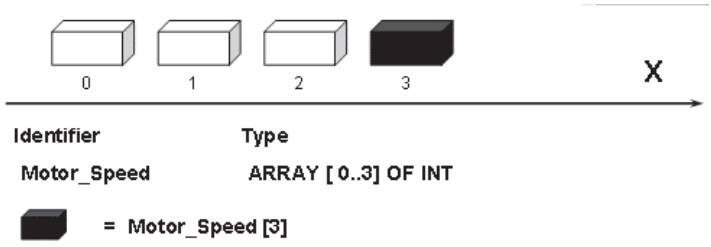
In software, program elements can use: Motor_Volts[1] and Motor_Volts[2], as declarations, which in this example mean that D1 and D2 are addressed.

Arrays can have up to three dimensions, for example: ARRAY [0...2, 0...4] has three elements in the first dimension and five in the second.

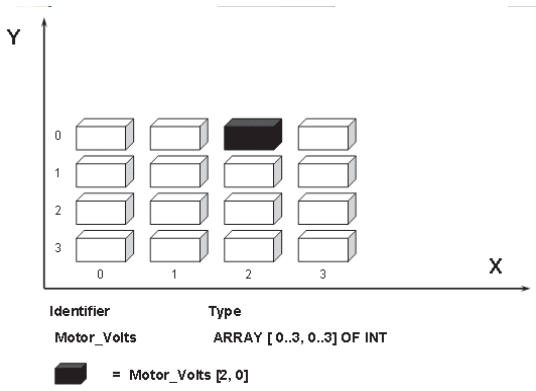
Arrays can provide a convenient way of 'indexing' tag names, i.e. one declaration in the Local or Global Variable Table can access many elements.

The following diagrams illustrate graphical representation of the three Array types.

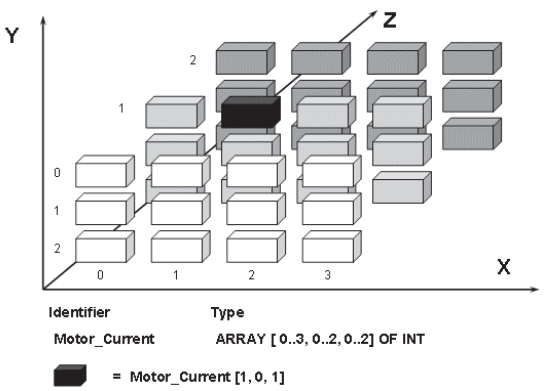
Single Dimensional Array



Two Dimensional Array



Three Dimensional Array

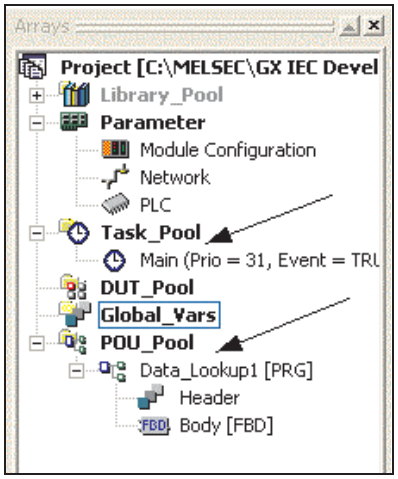


12.2 Array Example: Single Dimension Array

The following example is used to illustrate a single dimension array. The array is 10 words long and uses Global MELSEC addresses D100-D109. This example uses only “Standard IEC” Operators, Functions and Function Blocks.

① Create a new project and define one new POU of Class “Program” using a body of language ***FBD*** and named “Data_Lookup1”

② Create a new Task in the task pool named “Main” and bind the program POU “Data_Lookup1” to it:

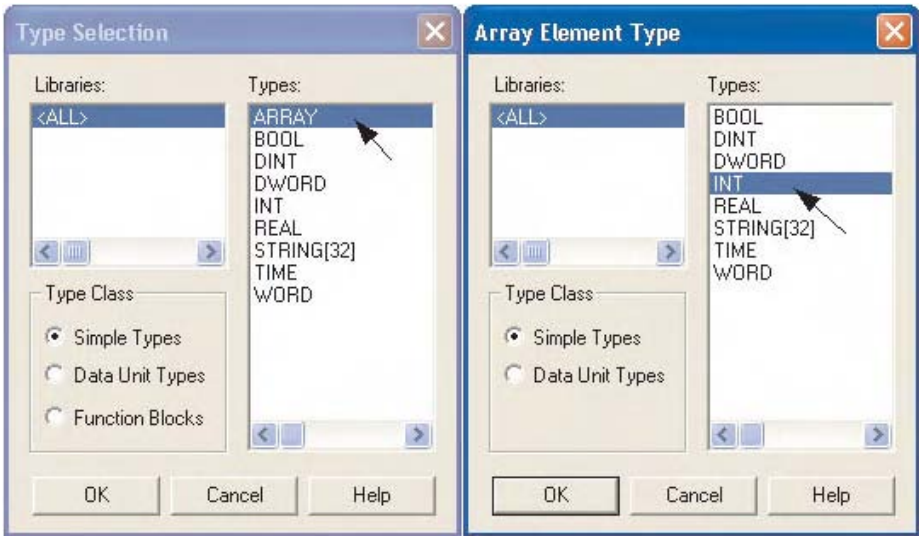


③ Open the Global Variables list and create the following entries:

	Class	Identifier	MIT-Addr.	IEC-Addr.	Type		Initial
0	VAR_GLOBAL	Data_Clock	X0	%IX0	BOOL	...	FALSE
1	VAR_GLOBAL	Data_Store	D100	%MW0.100	ARRAY [0..9] OF INT	...	[10(0)]
2	VAR_GLOBAL	Data_Lookup	D10	%MW0.10	INT	...	0
3	VAR_GLOBAL	Data_Pointer	D11	%MW0.11	INT	...	0

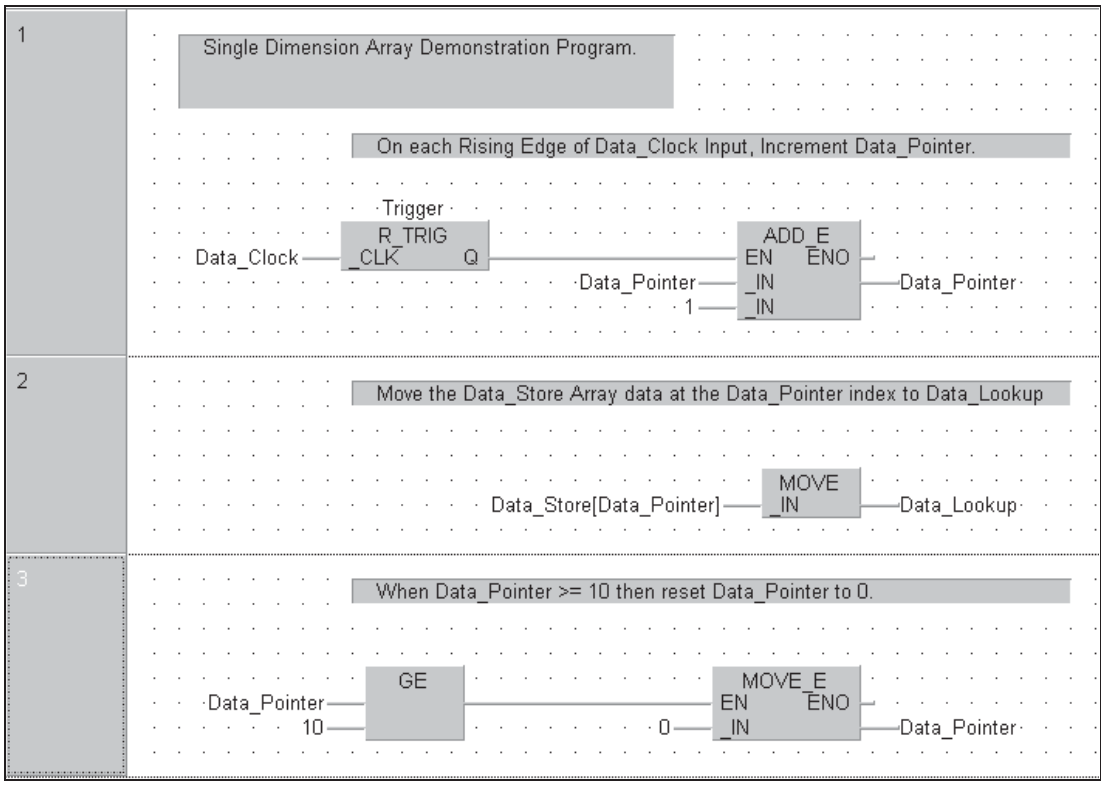
NOTE

The variable type “Array” in entered as follows:



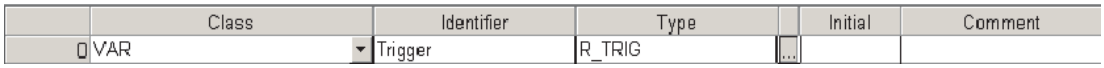
Note that when the array entry first appears, it will be dimensioned to the default value of ARRAY [0..3] OF INT. It is necessary to re dimension it to [0..9] of INT for this example, as shown below:

④ Open the Program POU “Data_Lookup1” and enter the following Function Block Diagram:



Note: Define the ‘R_Trig’ Function block with instance name “Trigger”.

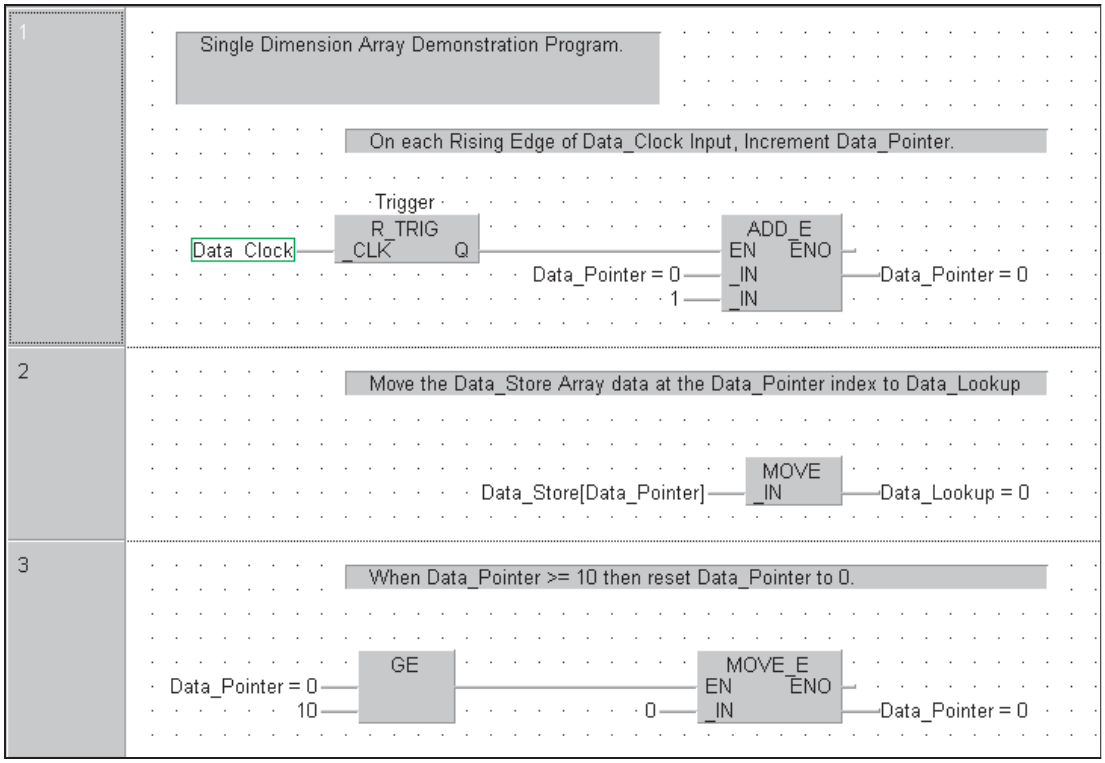
⑤ Check the Header reads as shown below:



⑥ Save the program and use ***Rebuild All*** to compile the program.

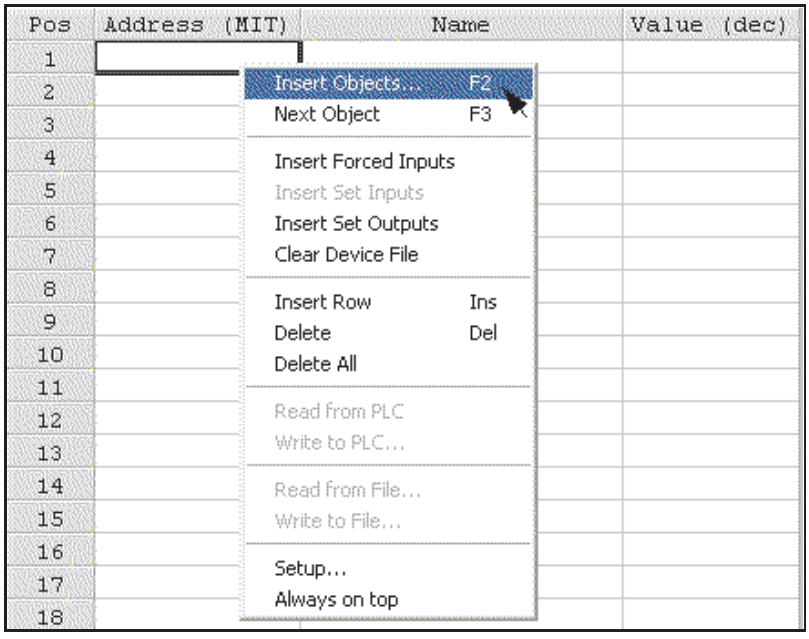
⑦ Transfer the program to the PLC.

⑧ Monitor the POU body (see next page)



Before the program is able to function as intended it is necessary to input data into the physical MELSEC addresses occupied by the array variables. There are two ways in which this may be achieved:

- Use the ***Device Edit*** feature from the ***Debug*** menu as previously described, using ***Insert Devices*** in the range D100 to D109, and enter any 10 random integer values between -32768 to +32767 and write them to the PLC.
- Open the ***Entry Data Monitor*** feature from the ***Online*** menu.
  - Right Click on the ***Address*** or ***Name*** column headers and select ***Insert Objects*** from the menu list as shown:



– From the resulting window select the ***Data_Store*** variable name and click ***Add***:

– Because the variable name “Data_Store” is an array, the system presents the entry with a “+“ prefix. Clicking on the variable name expands the array details into the table as shown:

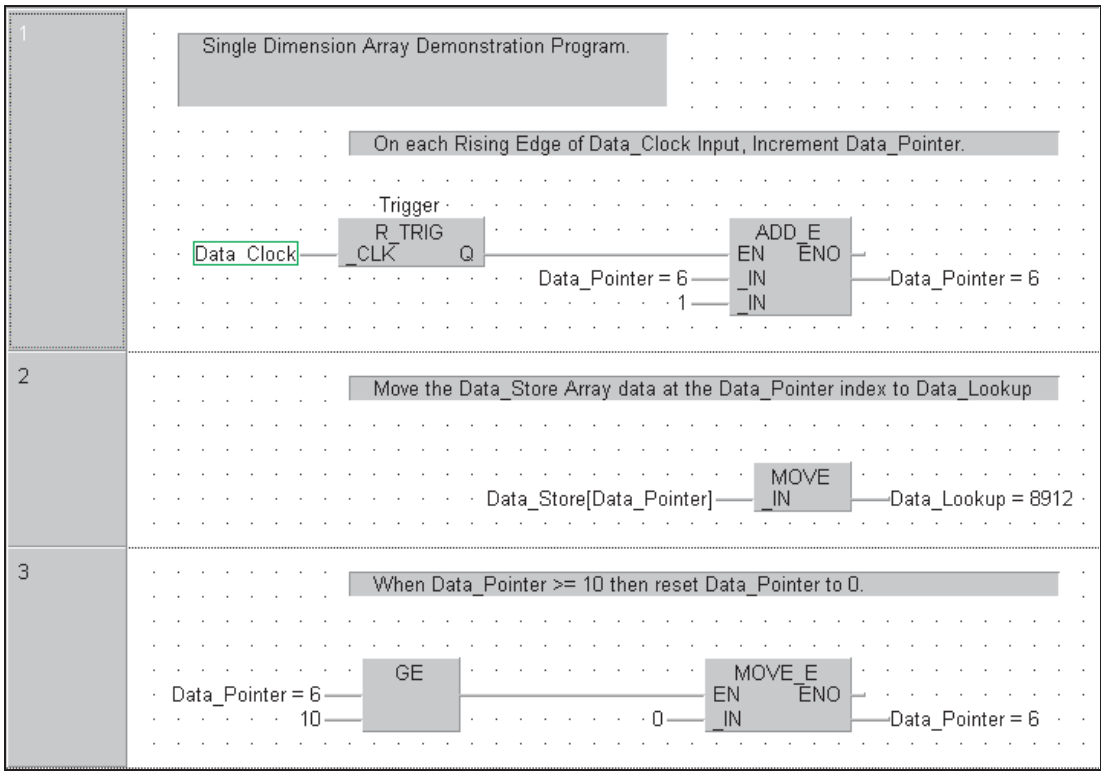
Pos	Address (MIT)	Name	Value (dec)
1		-Data_Store	
2	D100	[0]	0
3	D101	[1]	0
4	D102	[2]	0
5	D103	[3]	0
6	D104	[4]	0
7	D105	[5]	0
8	D106	[6]	0
9	D107	[7]	0
10	D108	[8]	0
11	D109	[9]	0

– Clicking on the “-“ Prefix collapses the array details.

– While monitoring the variable values, enter any 10 random integer values between -32768 to +32767 as shown below:

Pos	Address (MIT)	Name	Value (dec)
1		-Data_Store	
2	D100	[0]	1234
3	D101	[1]	4321
4	D102	[2]	7654
5	D103	[3]	4236
6	D104	[4]	17
7	D105	[5]	32766
8	D106	[6]	8912
9	D107	[7]	43
10	D108	[8]	186
11	D109	[9]	9999

– Switch back to monitor the body of the POU “Data_Lookup1” and observe the operation of the program, noting how the value alters on the output variable “Data_Lookup” as the data pointer increases:



- The program is designed to reset the pointer to zero on the 10th element and thus will repeat scan the table with an upward increment (Index 0-9).

13 Working with Libraries

13.1 User Defined Libraries

All Functions and Function Blocks, created so far, have been resident in the current project and only available to that project.

User defined libraries, allow the creation of libraries containing user created POU's, Functions, Function Blocks etc. These libraries are available globally, i.e. can be accessed by other projects.

Therefore, engineers working with separate projects can have access to common libraries of standard circuit parts.

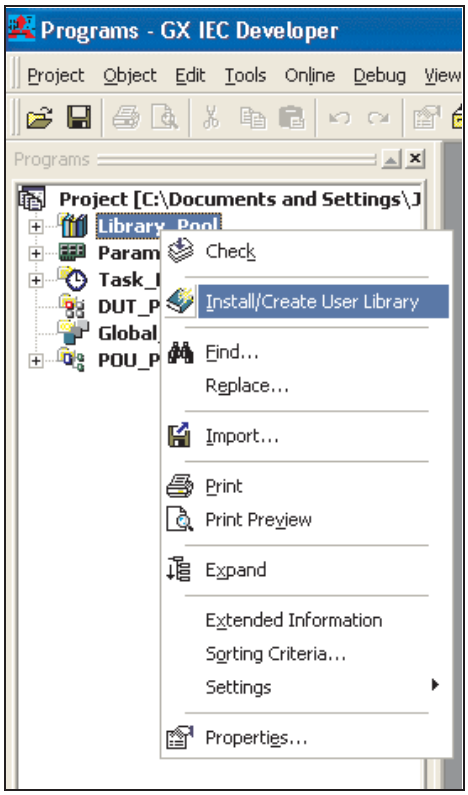
As already seen, when called program functions, the ***Standard Library*** contains IEC functions. The ***Manufacturer Library*** contains Mitsubishi functions (denoted by *_M) – M meaning manufacturer, not Mitsubishi!

Any user defined libraries will also appear on this list.

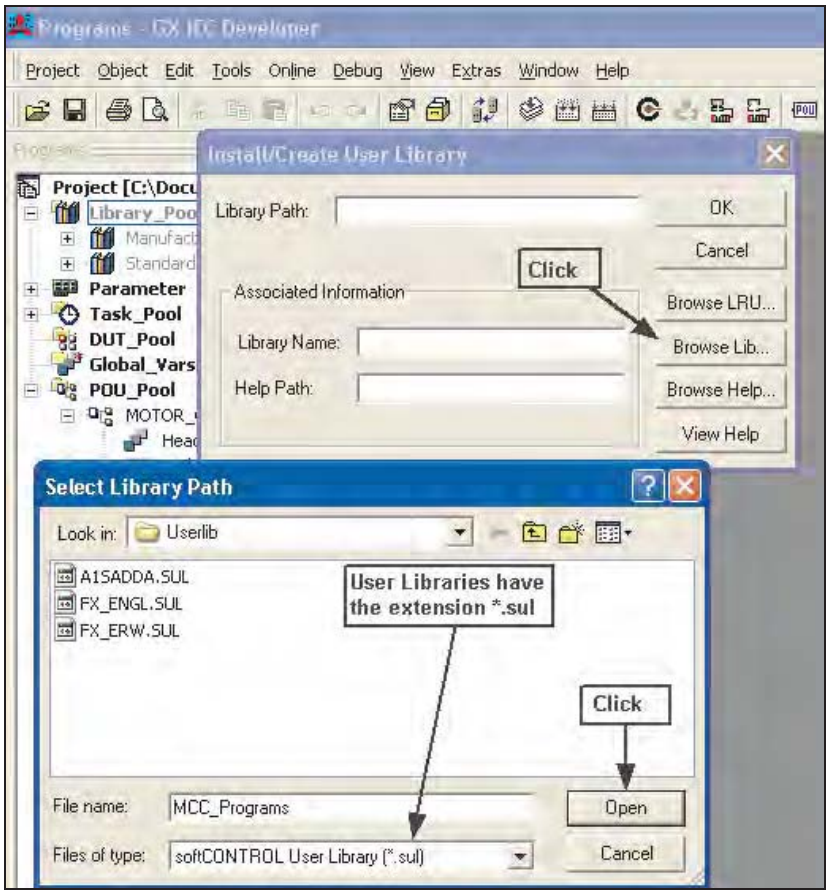
13.1.1 Example – Creating a new Library

① Assign the function block STAR_DELTA to a new library.

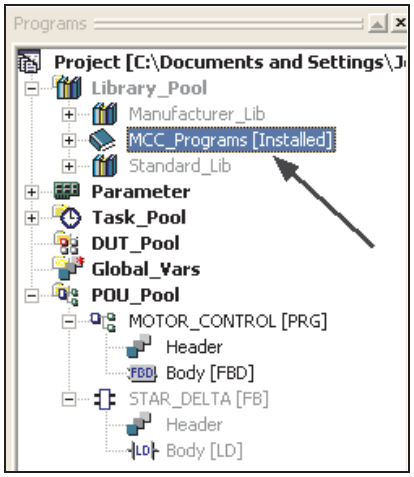
② Right Click the Library Pool, in the Project Navigator window and from the displayed menu select ***User Library*** and ***Install/Create Library***.



③ Click on ***Browse Lib*** and enter a file name “MCC_Programs” into the window below. The directory path can be changed if desired. In this case it is suggested that the default path is used. This being: “C:\MELSEC\GX IEC DEVELOPER 7.00\Userlib”.



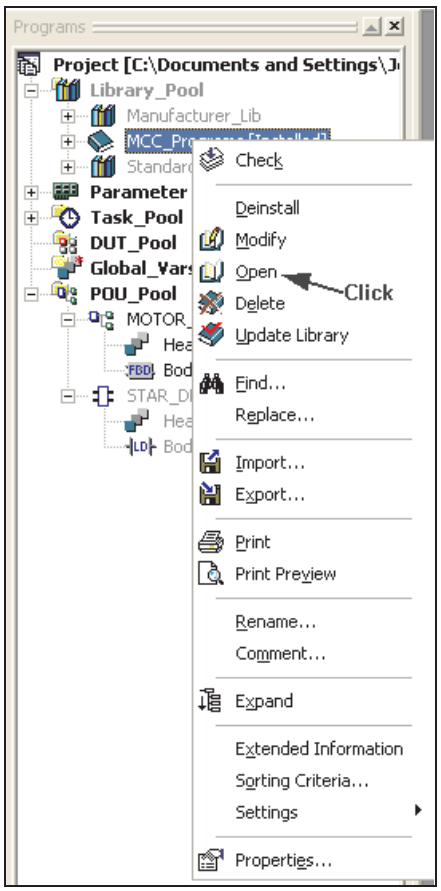
④ Click ***Open*** when done:



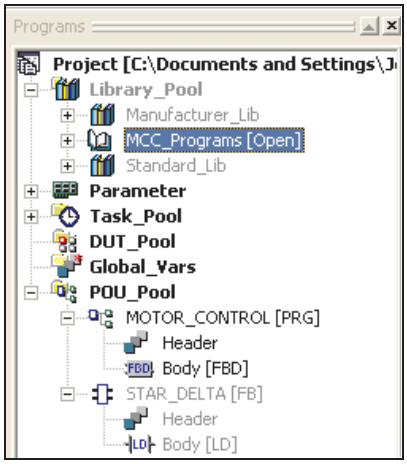
Notice the new Library “MCC_Programs” that is now present in the project Library Pool.

13.1.2 Opening the Library

① Open the Library by right clicking on the icon 'MCC_Programs' and click on ***Open*** from the menu:



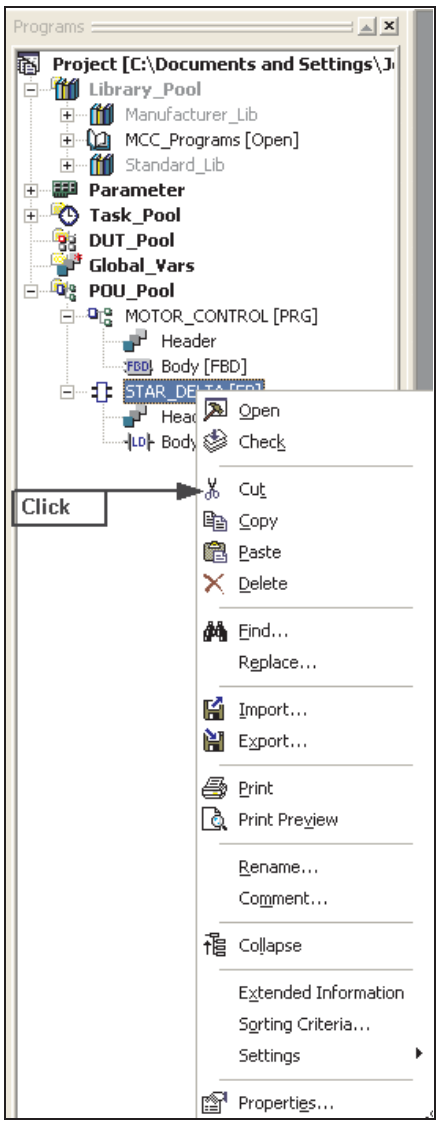
The Library is now open and may be accessed and edited:



13.1.3 Moving a POU “Function Block” to an open Library

The Function Block STAR_DELTA will now be moved into the Library ‘MCC_Programs’.

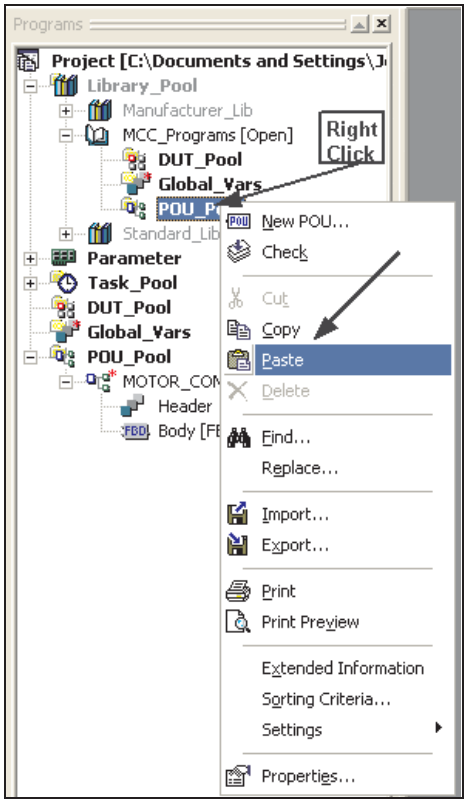
① Right click on the STAR_DELTA icon in the Project navigation window and click on ***Cut***:



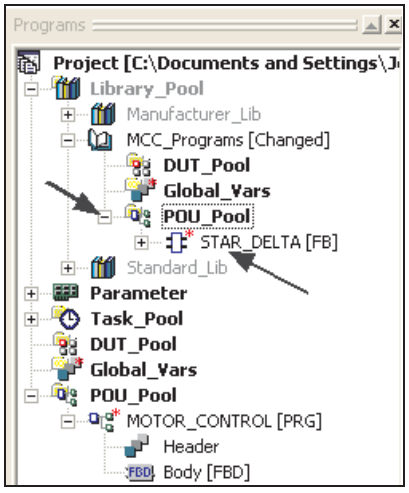
The following dialogue will be displayed:

② Select ***Yes***

③ Right Click on the User Library icon and select ***Paste*** from the menu:



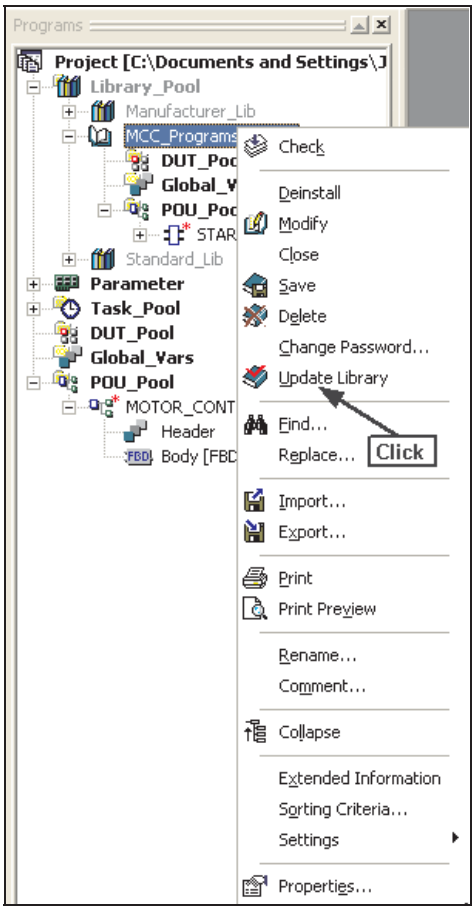
④ Click on the '+' on the new entry in the Library POU Pool to expand the 'STAR_DELTA' Function Block:



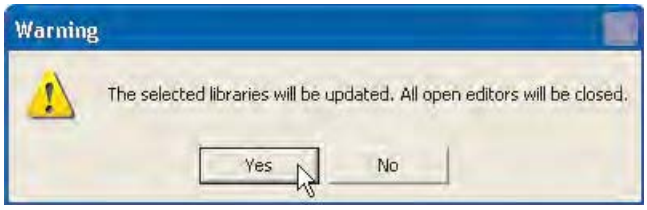
The Function Block POU, "STAR_DELTA" is now present in the Library "MCC_Programs" and no longer in the Project POU Pool.

Any POU, Function, Function Block, PRG or DUT can be added to the library in this way.

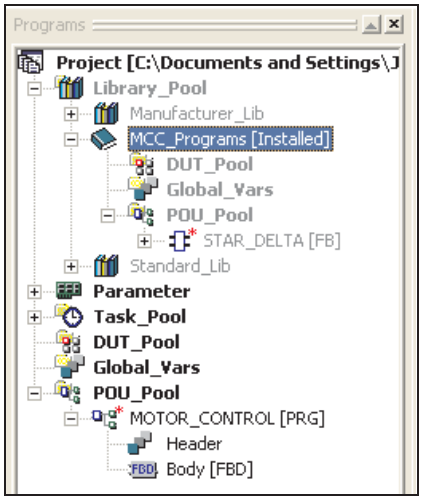
⑤ When editing of the library is complete, click ***Update Library***. This will update and close the library.



The following message will be displayed:

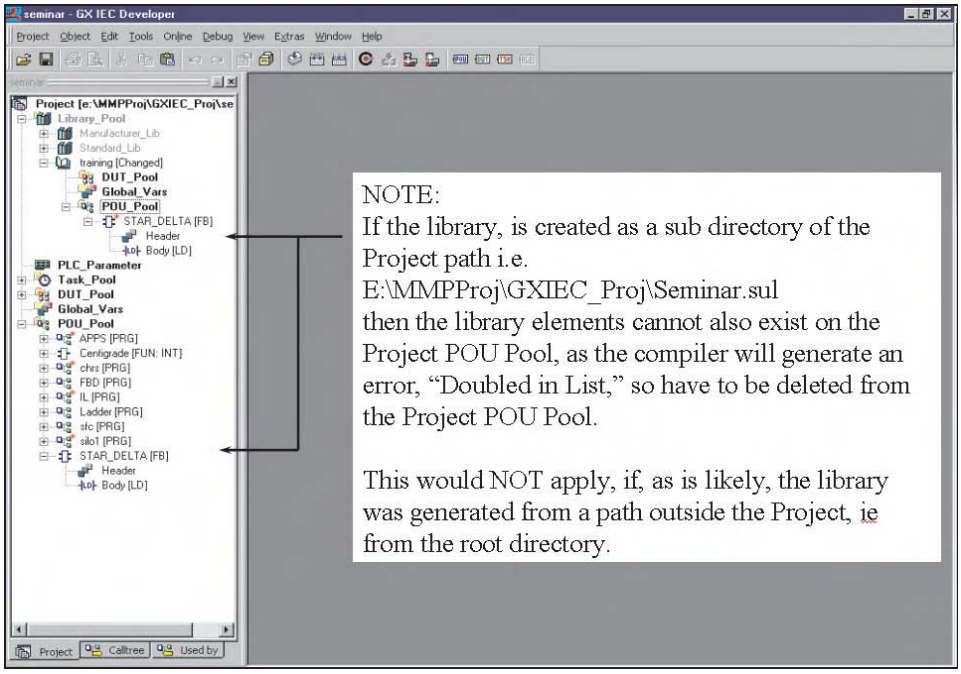


⑥ Click ***Yes*** and the library will be updated, saved and closed.



The library is now stored in the default location of “C:\MELSEC\GX IEC DEVELOPER 7.00\Userlib” as set when creating the library.

13.2 Special Note about Libraries



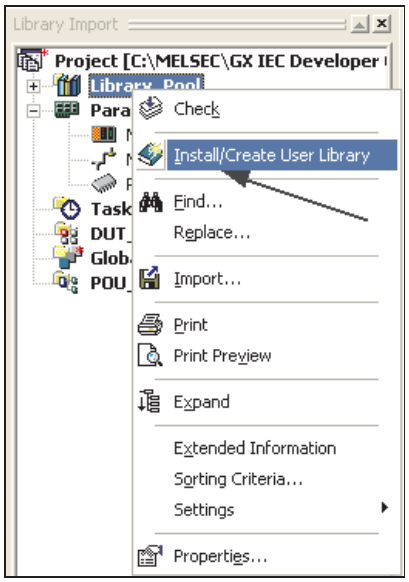
13.3 Importing Libraries into Projects

Once 'User Libraries' have been created, it is possible to re-use routines by importing them into other applications. Mitsubishi Electric has produced many Libraries of commonly used routines. For example, 'Intelligent Module' interfaces such as A/D and D/A Function Blocks containing all the code to facilitate a working interface for these and many more modules. These Function Blocks are available free on many of the Mitsubishi web sites and some are provided on the GX IEC Developer Master Disk.

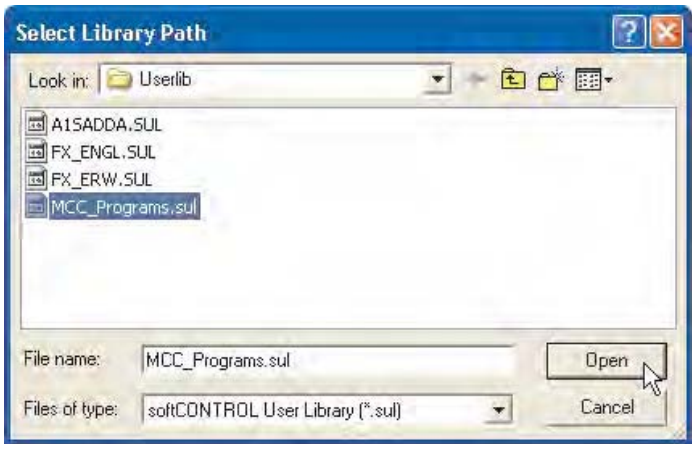
The following two examples describe the methods used to import libraries into working applications:

The previously saved library "MCC_Programs" will be imported into the current project and the Function Block contained therein will be re-used.

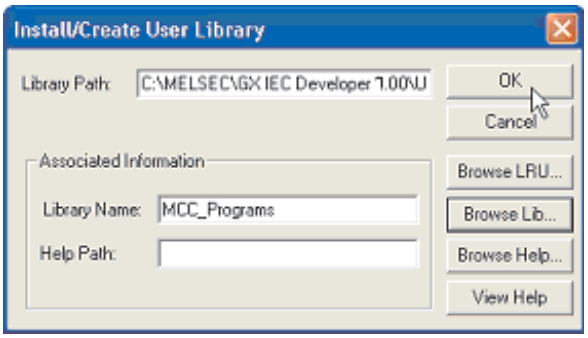
① Create a new empty project with no POU's called "Library Import".



② Enter the following details into the prompt:



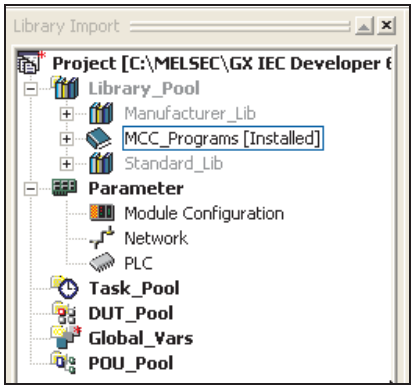
③ Next click ***OK*** to accept the entries.



NOTE

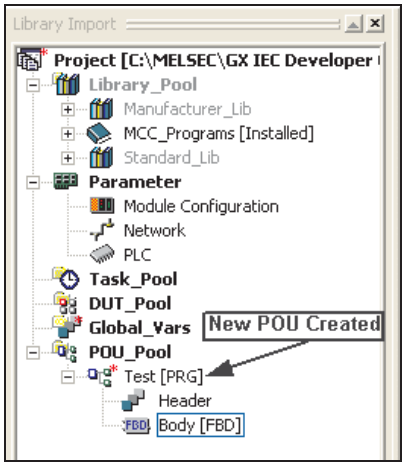
The help path is used for user help files that can be created in order to describe the operation of routines held in the library. These files can be created in MS-Word, for example in HTML format and manually saved with the reserved extension *.CHM. These files can be bound to the library by clicking ***Browse Help*** in the same manner as the ***Library Name*** selection illustrated above.

The new imported library is now installed into the application and can now be used within the project as shown:

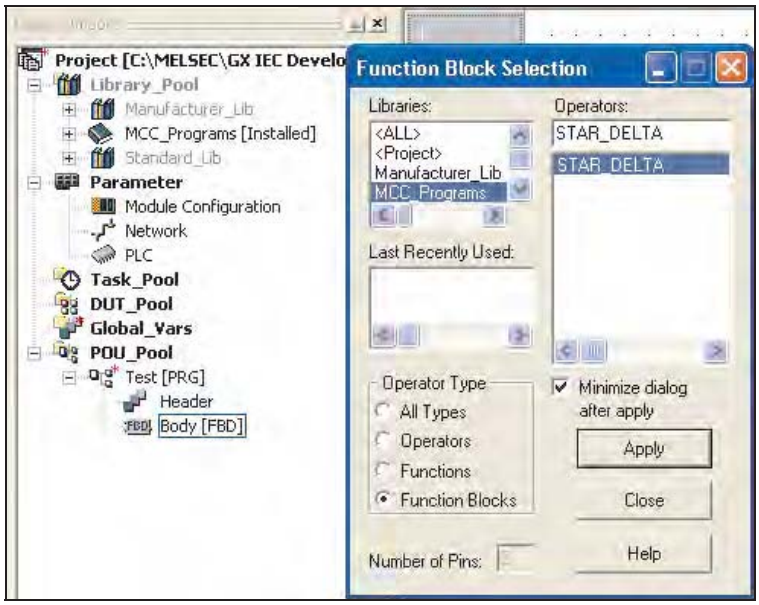


Items stored in libraries can be easily recalled and selected into a project, as shown in the following illustrations:

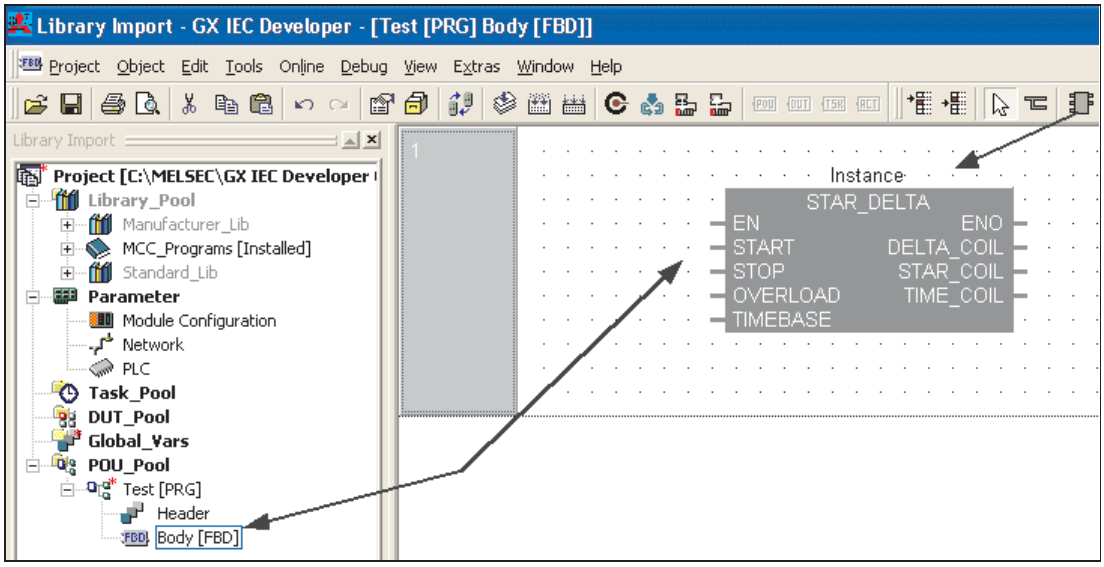
① Create a new POU, type: ***FBD*** and named “Test”:



② Open the new POU and select the Function Block as shown:



As can be seen the new library appears in the domain and may be selected as shown:



13.3.1 Example: Importing a Mitsubishi Library Function Block

The following illustrations demonstrate the procedures required to import a Mitsubishi Function Block for analogue input using a Q-Series Module Q64AD.

NOTE This example works for a PLC of the MELSEC System Q only.

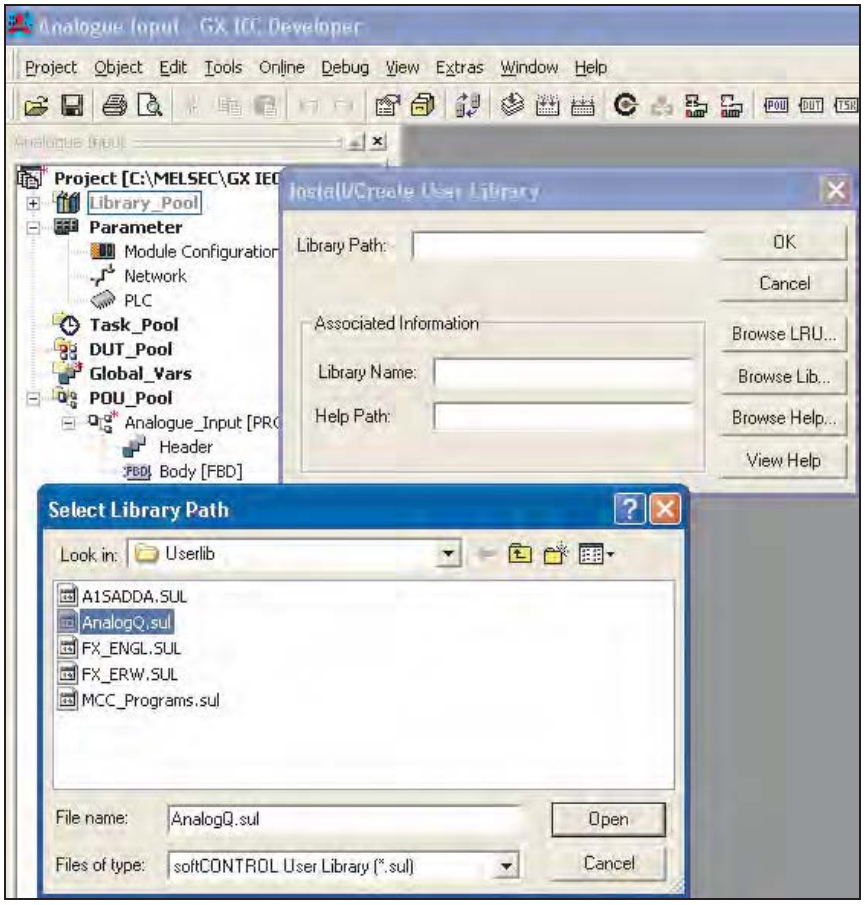
In order for the following example to function correctly, it is necessary to install the Mitsubishi Q-Series Analogue Library into the project.

The Analogue Function Block library “AnalogQ” is to be found on the Mitsubishi Website or can be installed directly from the GX IEC Developer disk from the Function Block selection on the installer program. The library can now be accessed from the “Userlib” directory.

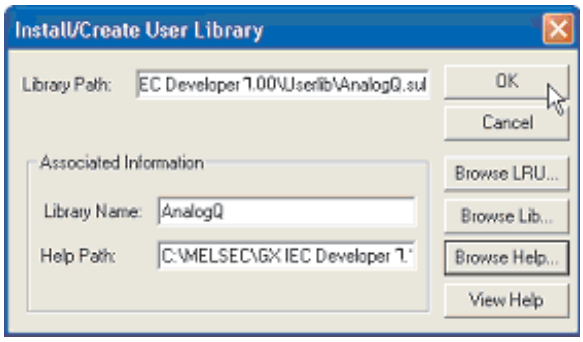
① Create a new empty project with no POU’s called “Analogue_Demo”.

② Create a new POU (Type: ***FBD***, Class: ***PRG***) and name it “Analogue_Input”

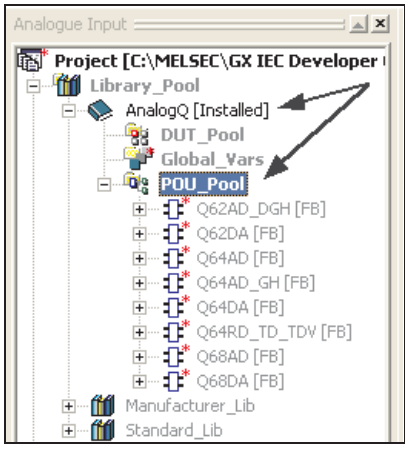
③ Right Click on the Library_Pool Icon and select ***Browse Lib***. Select the AnalogQ.sul library file and click ***Open***.



④ Click ***OK*** on the ***Install/Create User Library*** prompt:

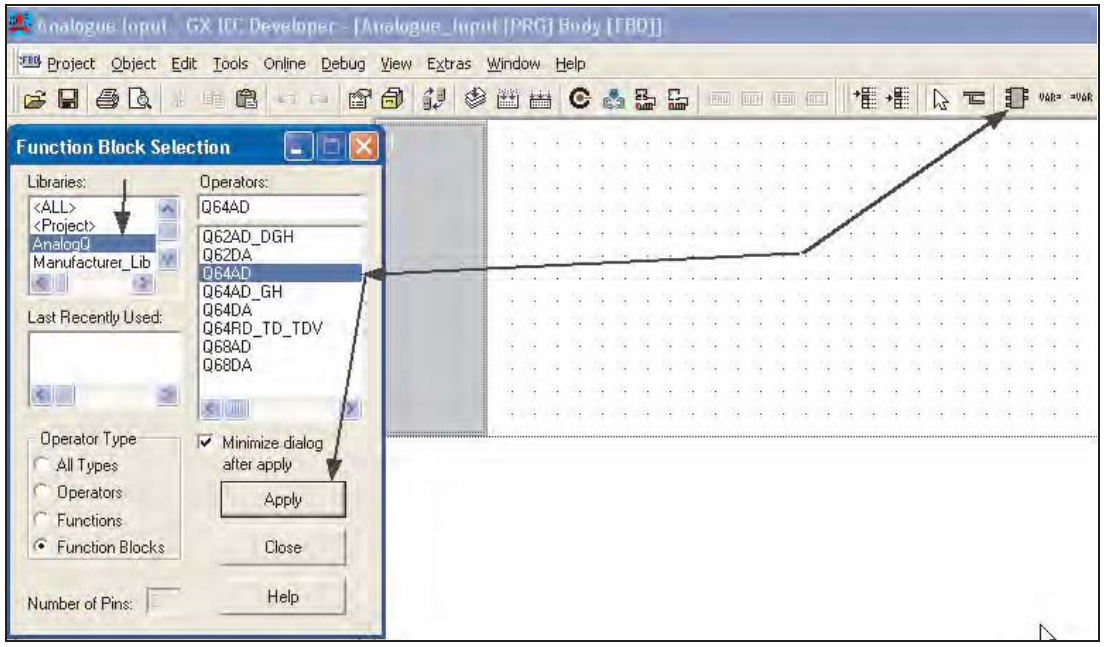


Note the new “AnalogQ” library in the Project Navigation Window.

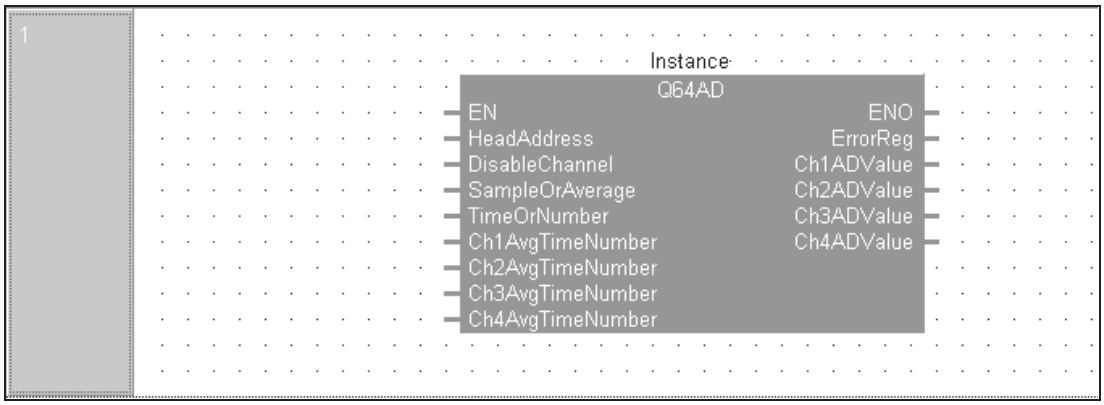


⑤ Create a new task in the task pool: “MAIN” and bind the POU “Analogue_Input” to it.

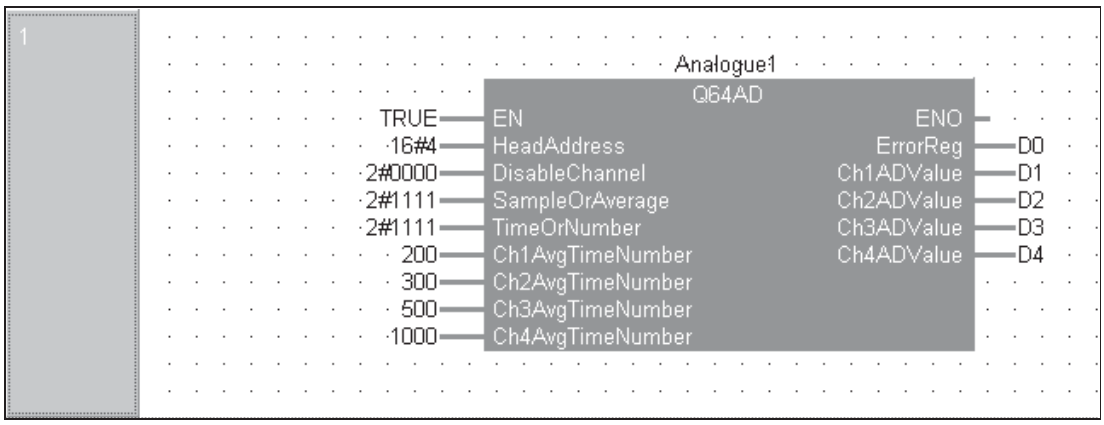
⑥ Place the Q64AD Function Block into the POU as shown below:



The Function Block will appear thus:



⑦ Define all variables as below:



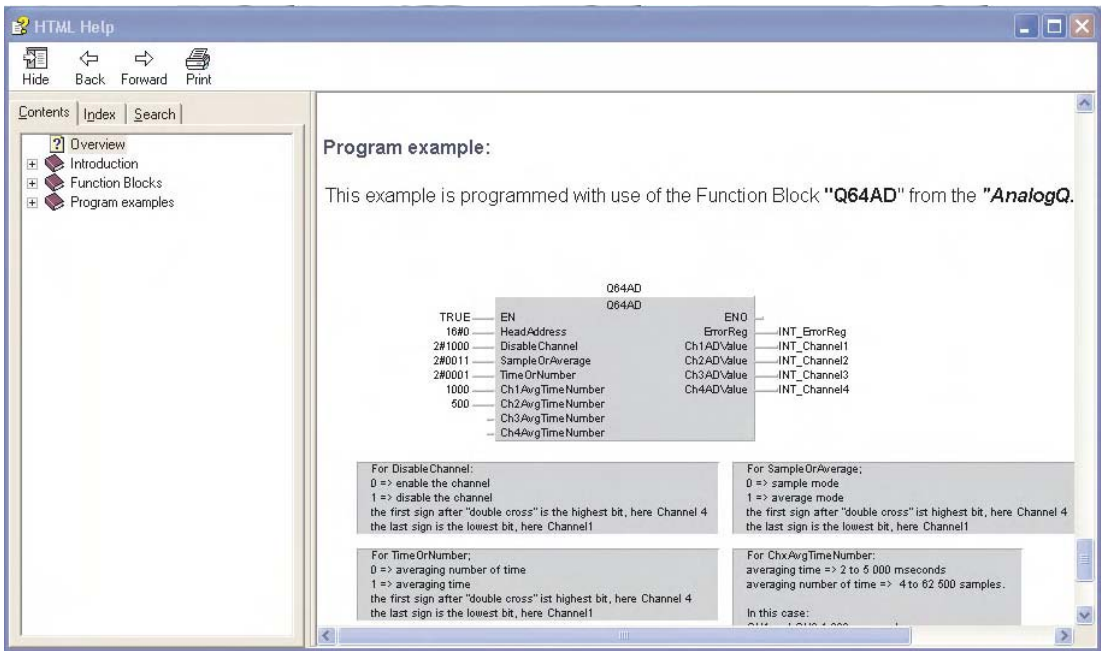
⑧ Compile and download the program to the PLC.

⑨ Monitor and test for correct operation. Observe the behaviour of the analogue outputs due to the “sampling settings”

13.3.2 Library Function Block Help:

Providing the accompanying Library Help file has been imported, for a full explanation with examples of all Analogue Q Library Function Blocks, click to highlight the Function Block and press the “F1” Key.

The following HTML Help Screen will be displayed:



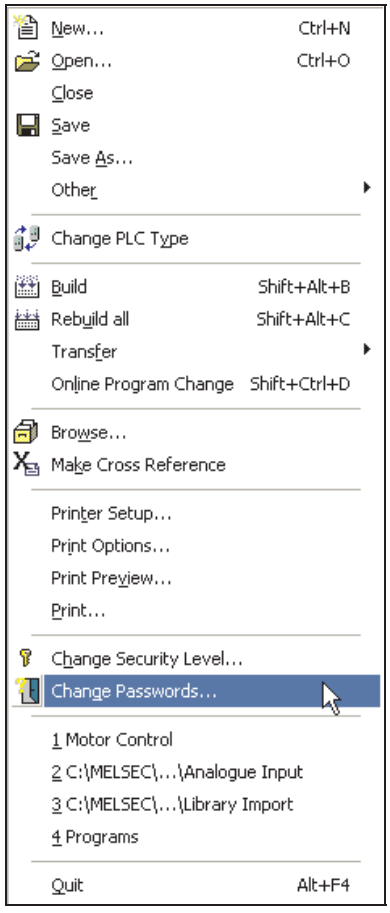
The Help files cover every aspect from the setup of the Q-Series analogue hardware modules to use of the library function Blocks.

14 Security

14.1 Password

You can protect all or parts of the program with a password. You can protect against editing of program parts and also protect circuits from being viewed by others. This is particularly relevant for user defined function blocks. In addition, the PLC password (Keyword) is also available.

14.1.1 Setting the Password

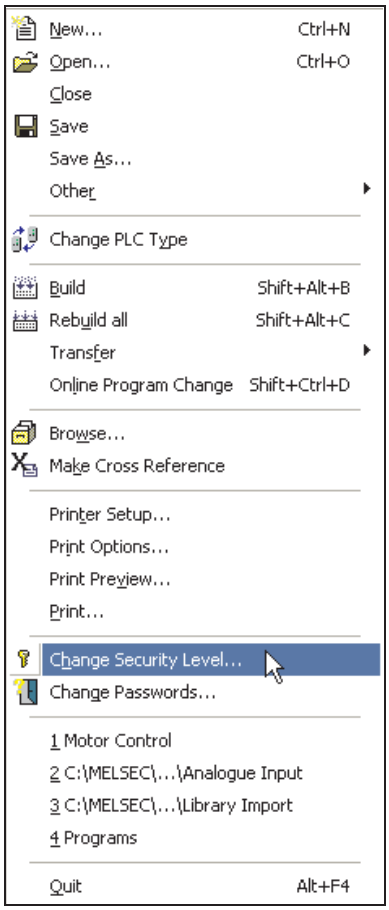


Passwords can be entered and security levels can be changed, using these windows, via the ***Project*** menu.

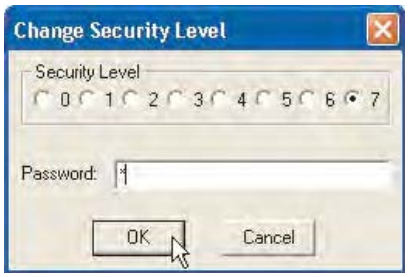
To illustrate the operation of passwords, select ***Security Level*** 7 and enter a new password for this level (For simplicity here, press 7). Re-enter the password and click ***Change***.

14.1.2 Changing the Security Level

① Select ***Change Security Level*** from the ***Project*** menu:



② Enter the password for 'Level 7' and if accepted, the user will be logged on at this level.



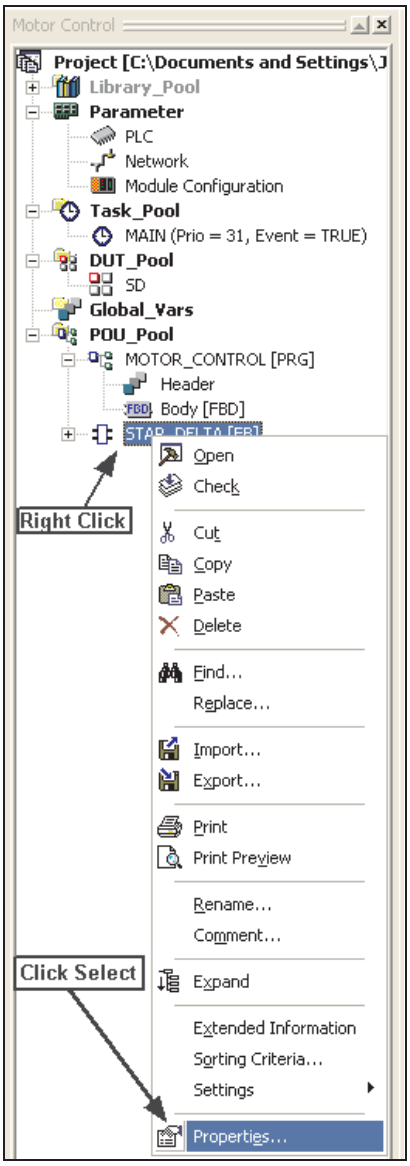
Once logged on, the security attributes for many items may be altered. For example one of the most common security options is to change access to POU's, i.e. User Functions and Function Blocks.

14.1.3 Modifying POU Password Access

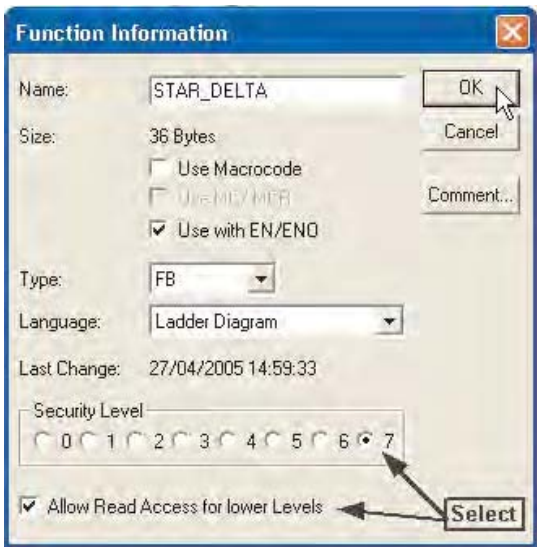
In order to protect the content or control access to User POU's the security attributes may be adjusted, whilst being logged into the security current level, as follows:

Setting Security Level

① Open the project "Motor Control" and open the header of the Function Block "STAR_DELTA":



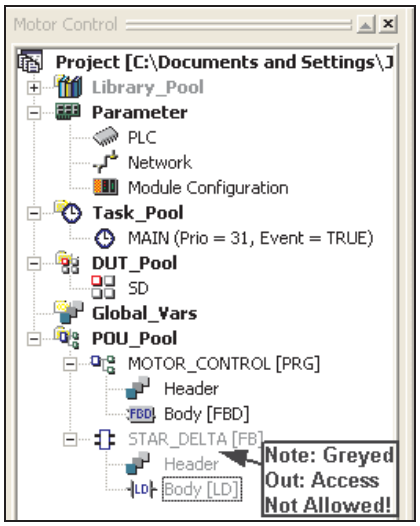
② Adjust the Security to Level '7' and click ***Allow Read Access for lower Levels***. This will allow subordinate users "Read access" only to the Header and body of the function Block:



③ Change the security level to Level '0' and access the header and body of the Function Block "STAR_DELTA". Read access will be allowed for monitoring purposes but any alteration to the code is **not** possible.

④ Log in again to Level 7 and alter the security attributes of the Function Block "STAR_DELTA" so that read access is **NOT** allowed for lower levels.

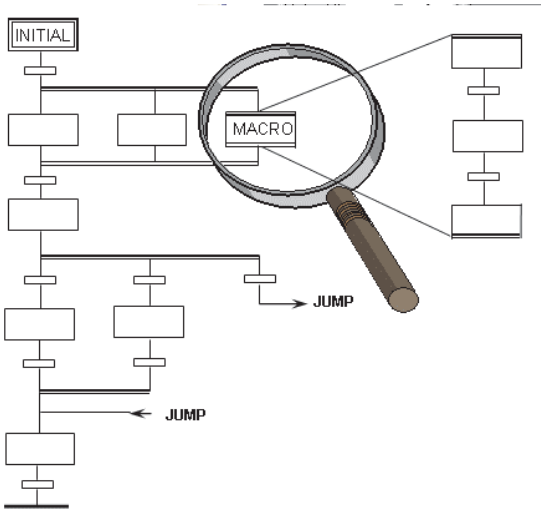
⑤ Change the security level to '0' and try to access the body of the Function Block "STAR_DELTA". The Header and Body of the POU will be greyed out with access to the POU completely blocked:



Access attributes for any individual object or complete folder in the 'Project Navigation Window' above can be individually set, allowing higher degrees of flexibility in the program security settings.

15 Sequential Function Chart - SFC

15.1 What is SFC?

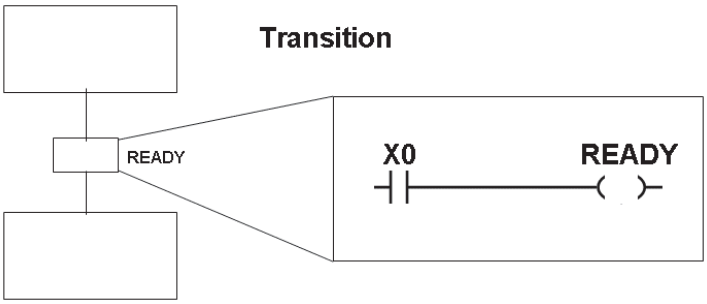


- The “Sequential Function Chart” editor is a guided editor.
- Graphical Flowchart representation.
- Based on the French Grafcet (IEC 848)
- SFC is a structural language which divides the process into steps and transitions.
- The steps “hide” actions (no POUs) and / or directly switched bit operands.
- Transitions always contain one link/network which activates the progression instruction (name of the transition).

  (It is also possible to use a discrete address instead of a name.)
- Actions can be created in every editor, except SFC.
- Transitions can be created in every editor, except SFC.
- The SFC code resides in the Micro-computer area of the plc, so allocate memory space in PLC Parameters (A series only).

15.2 SFC Elements

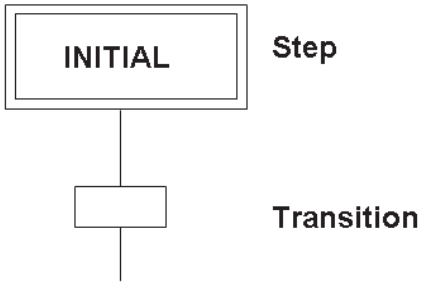
15.2.1 SFC Transitions



- Transitions represent a link which starts progression.
- They can be created in every IEC editor.
- Except in SFC.
- It is also possible to use a bit directly instead of the name READY.

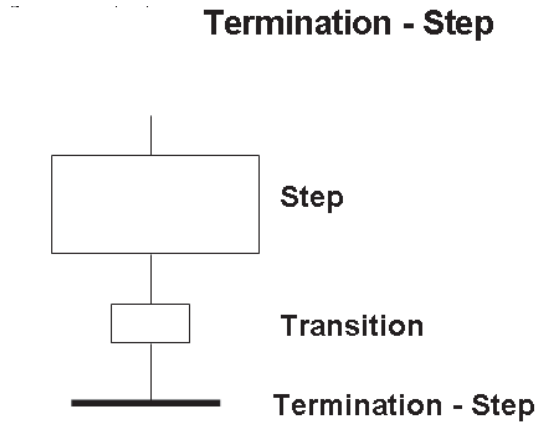
15.2.2 Initial Step

SFC programs begin with an Initial Step function which indicates the start of a sequence:

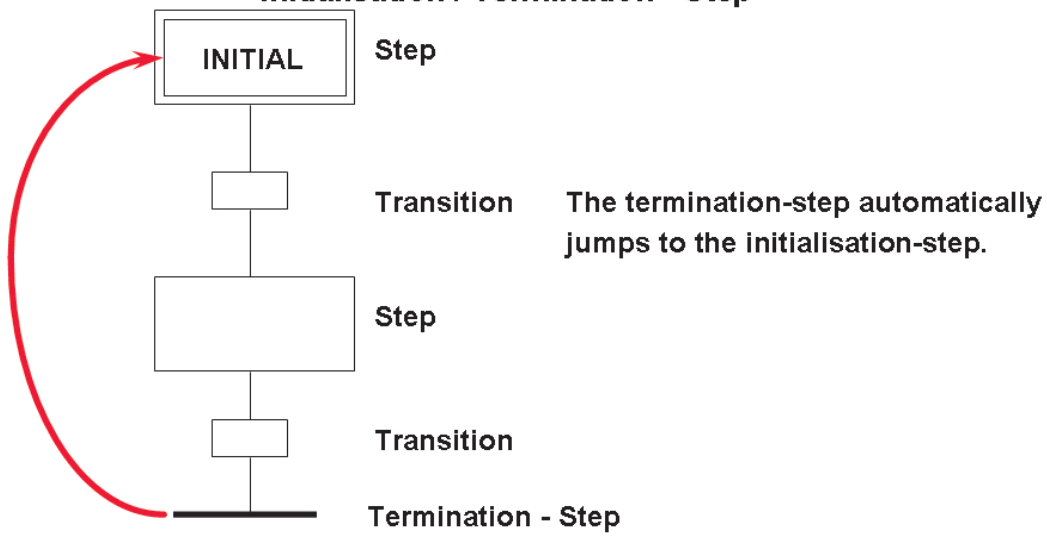


15.2.3 Termination Step

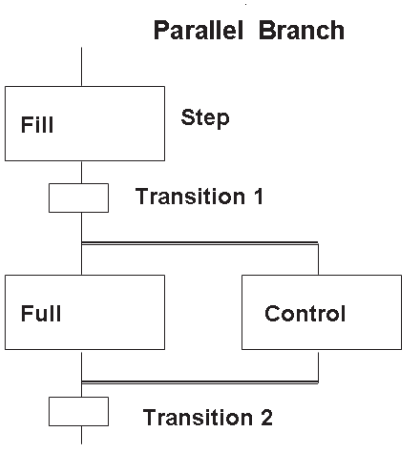
All Sequences finish with a Termination Step:

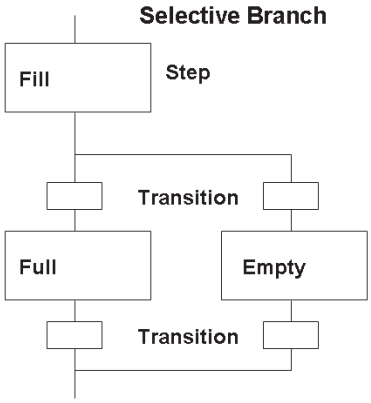


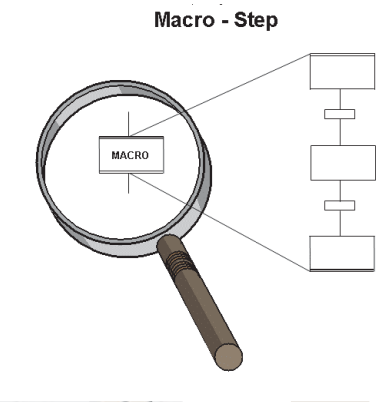
Initialisation / Termination - Step

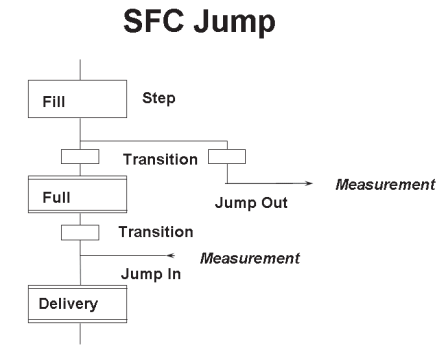


15.3 SFC configuration examples



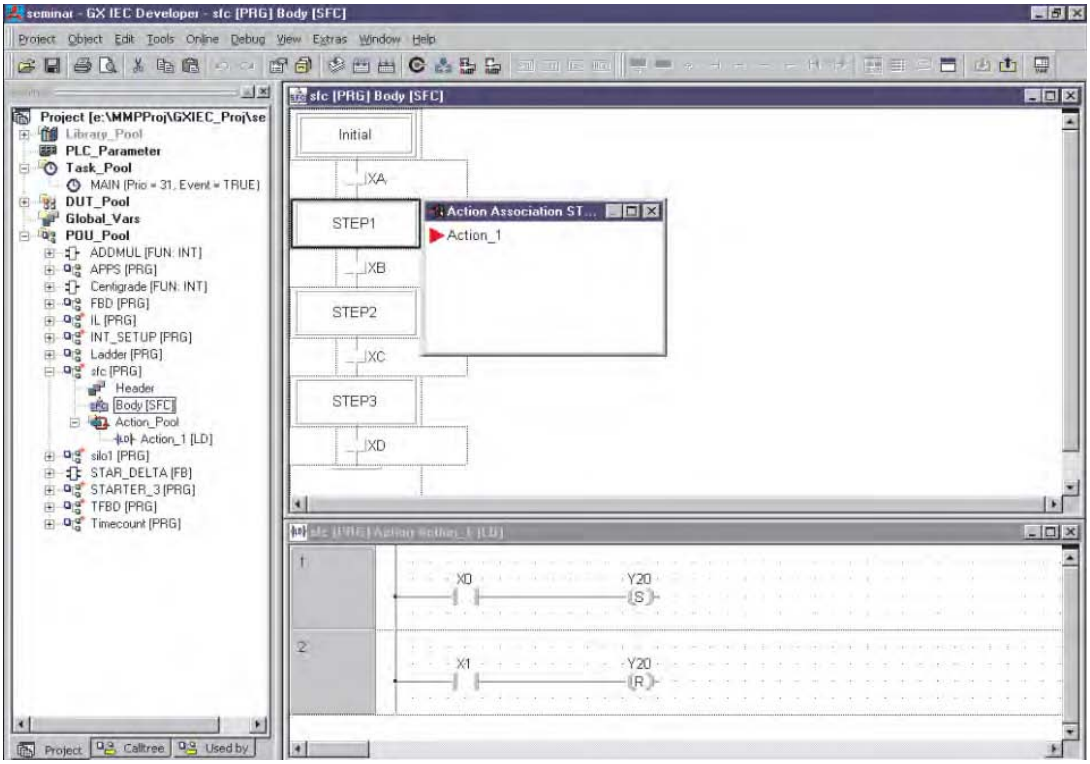




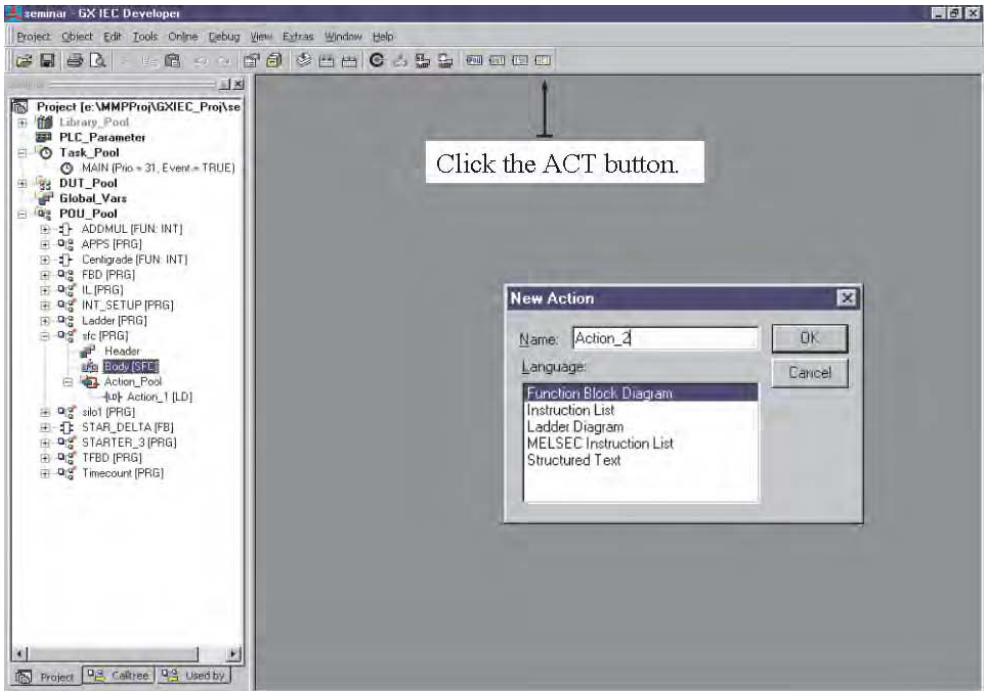


15.4 SFC Actions

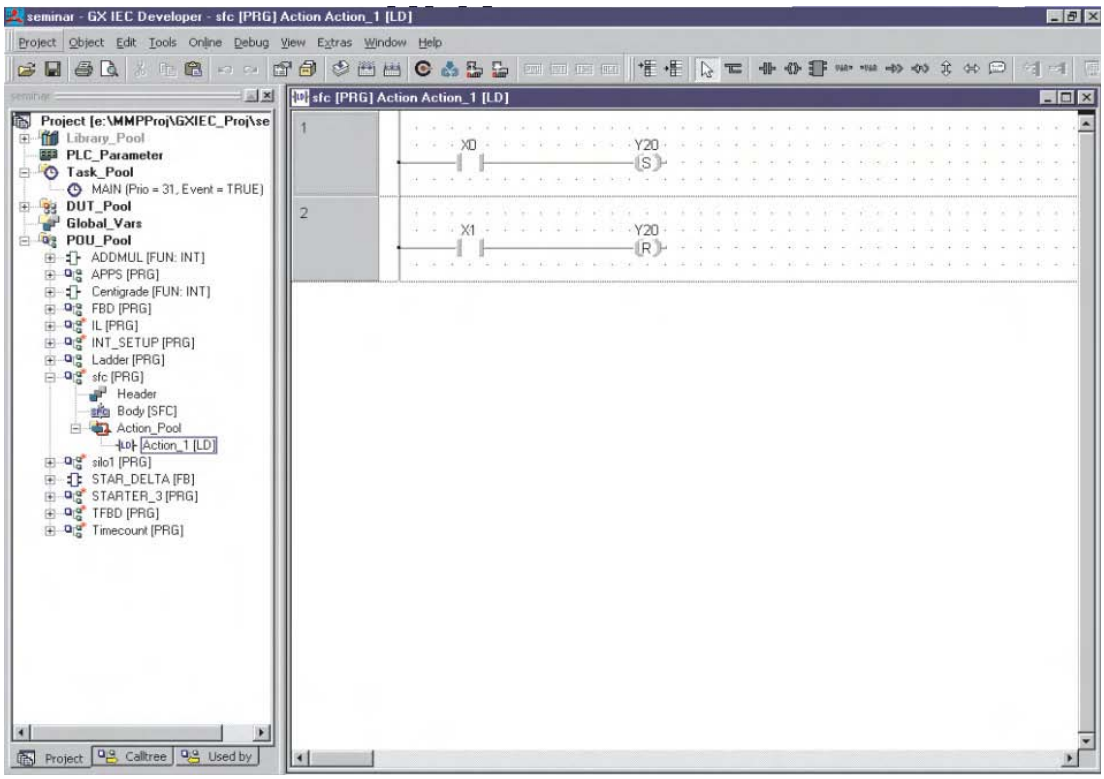
Each step has associated actions. An action is simply a program, as for a POU. Each action has associated logic written in either, IEC LD, IL, FBD or ST:



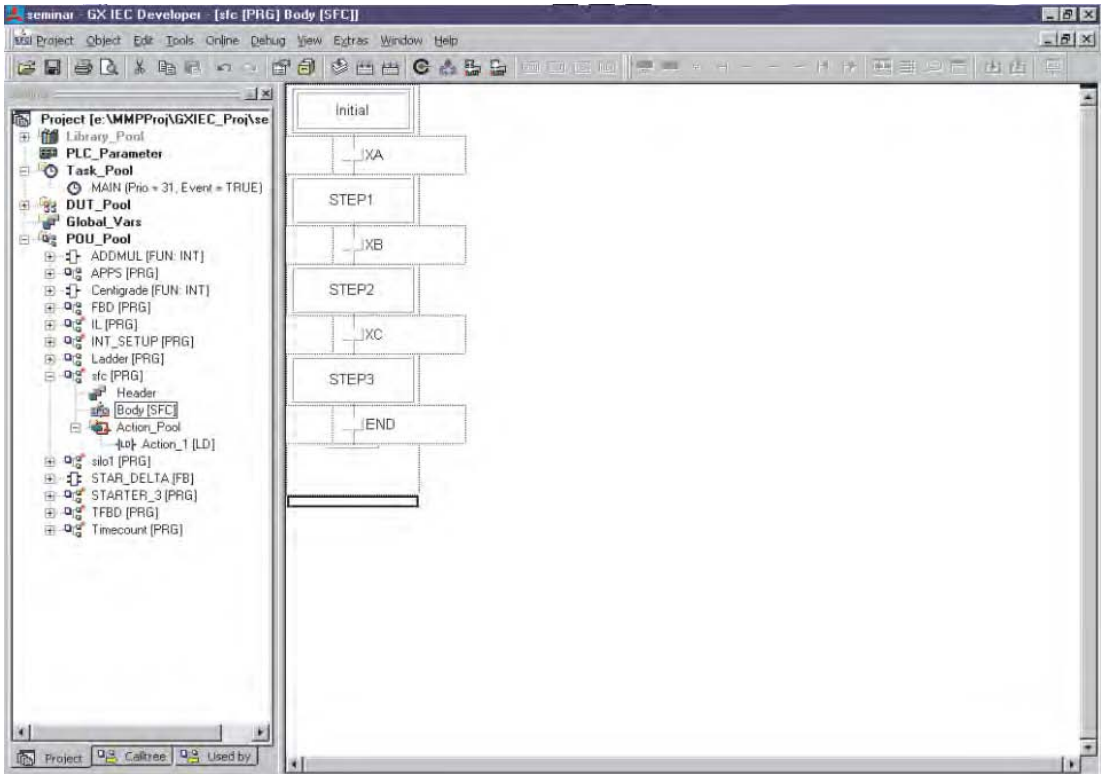
New Actions are created by clicking on the ***ACT*** button on the toolbar. Select the required editor, as for POUs:



Actions can be programs within their own right. Action_1 may be a complete ladder interlocking routine, consisting of many networks

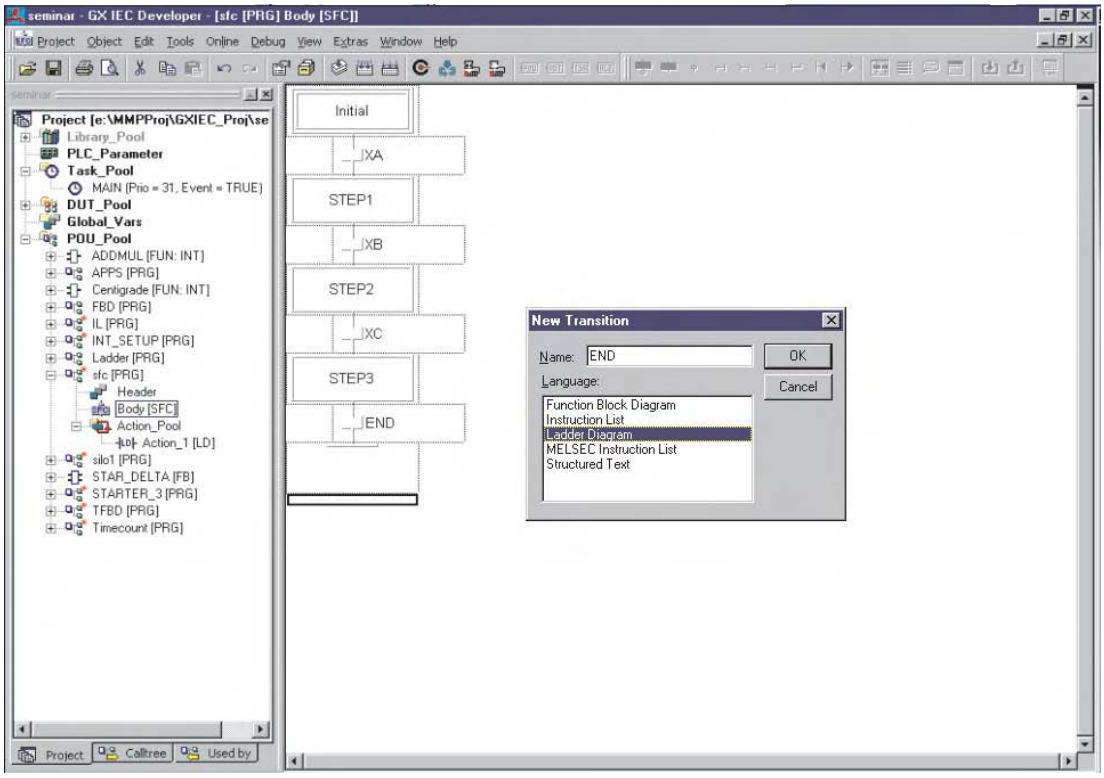


Each Transition can be a simple device i.e. Mitsubishi address XA, or an identifier name, or more complex, as a single network program written in either IEC, IL, LD or FBD:

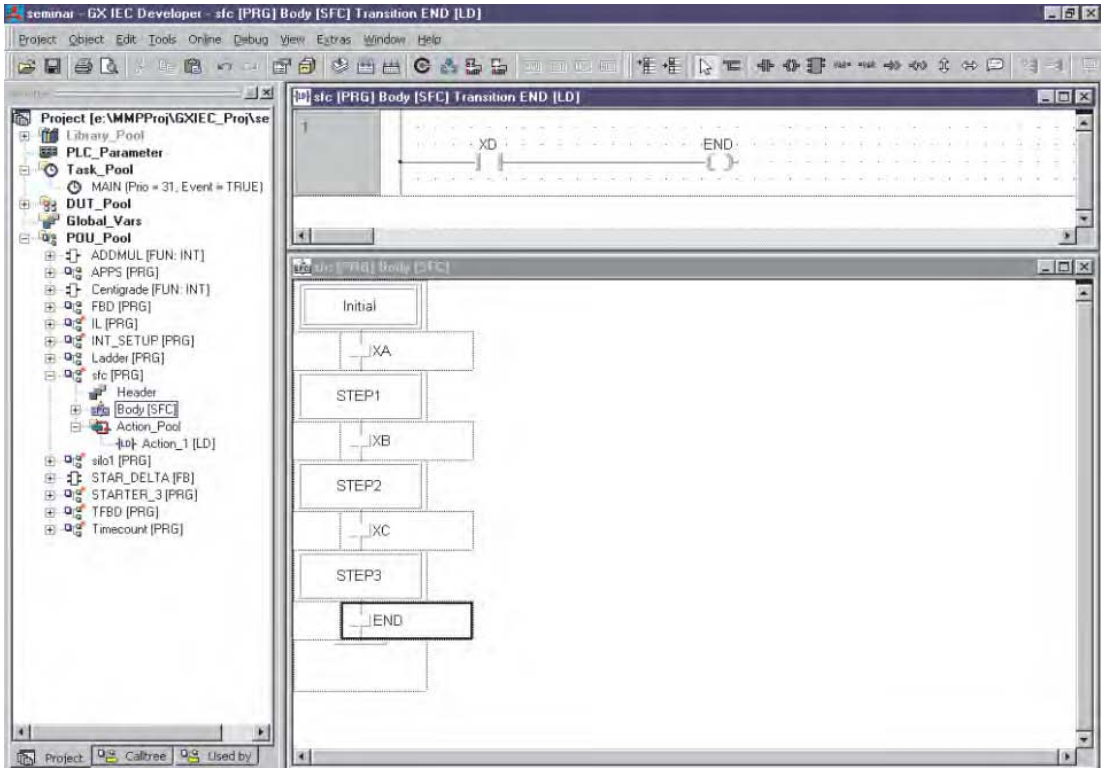


15.5 Complex Transitions

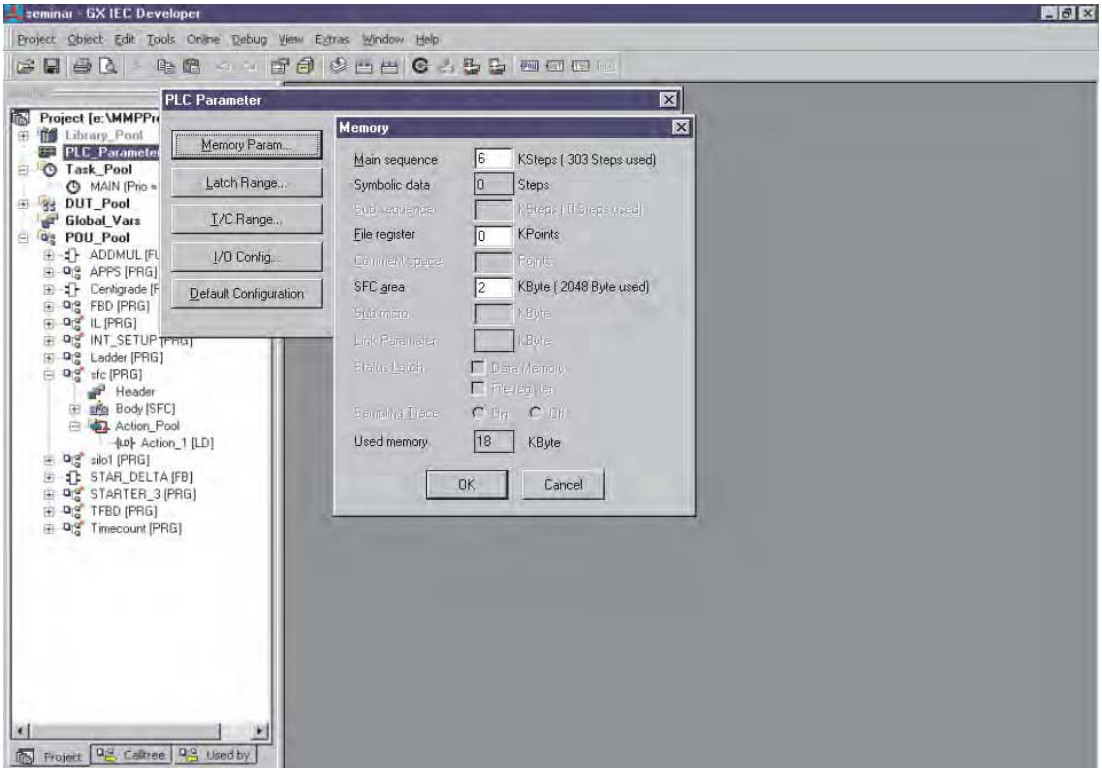
To program a complex transition, input a Transition name and hit the enter key. Choose the required editor, as for Actions:



The transition could be a complex expression but it only consists of one network:

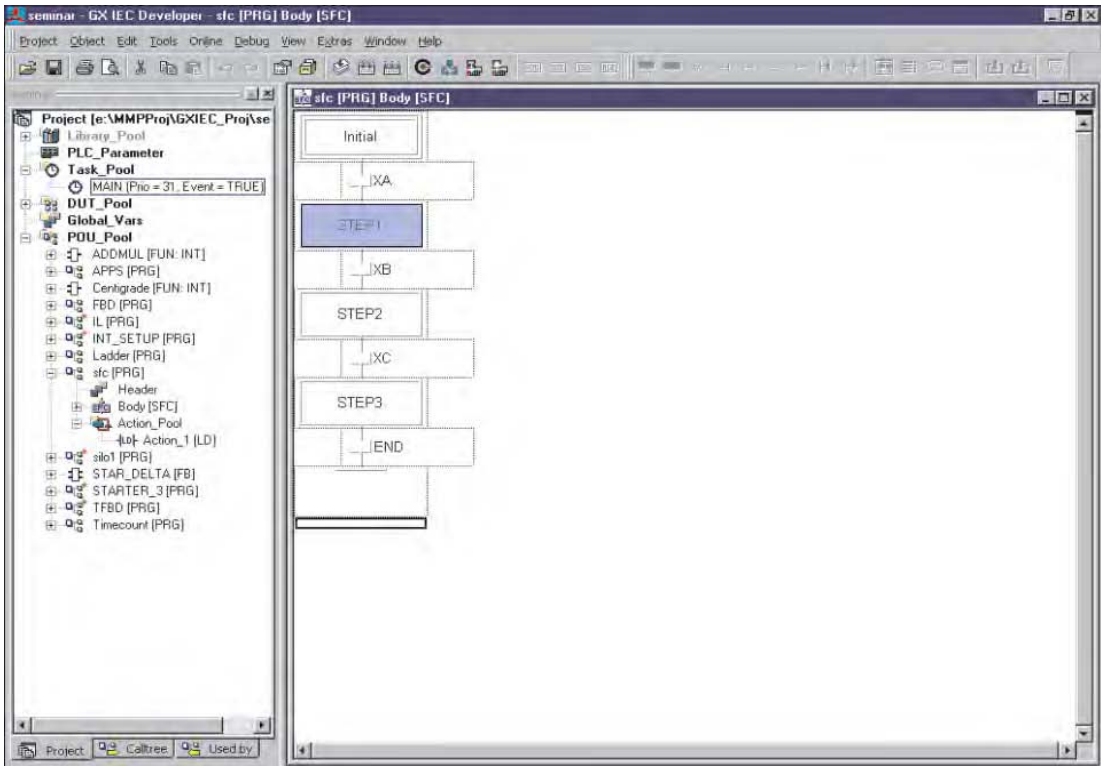


For A(ns) Series PLC's, SFC's reside in the micro computer area of the memory cassette. This area must be allocated from PLC Parameters / Memory, as shown below:



This is not the case for Q series, as the MELSEC System Q supports SFC's in the program area. Also for FX range, SFC's actually compile to STL code in the program area.

One popular feature of SFC's, is that in monitor mode, the current step is highlighted. This means for fault finding purposes, engineers can see exactly how far the sequence has progressed and can investigate accordingly:



16 IEC Instruction List

- The “Instruction List” editor is a free text editor.
- No line addresses are released.
- Functions and function blocks can be called.
- In addition to the IEC networks MELSEC networks can be included.
- Comments can be included within (* *)
- By means of the Windows functionality a program can be written for example in WinWord and then be copied via the clip board into GX IEC Developer.

16.1 Example of IEC Instruction List (IL)

```
 LD      X4          (* Interrogation X4 *)
ANDN     M5          (* ANDN M5 *)
ST       Y20         (* Assignment OUT to Y20 *)

LD       TEST        (* Load TEST into accu *)
BCD_TO_INT           (* Convert accu *)
ST       RESULT      (* Write accu to RESULT *)
```

16.1.1 Some useful tips

To Perform : “ + D0 D1 D2 ” in IEC IL, becomes:

```
LD      D0
ADD     D1
ST      D2
```

To Perform : “ + D0 D1 D2 ” and then “ + D2 K50 D3 ” becomes:

```
LD      D0
ADD     D1,D2,50
ST      D3
```

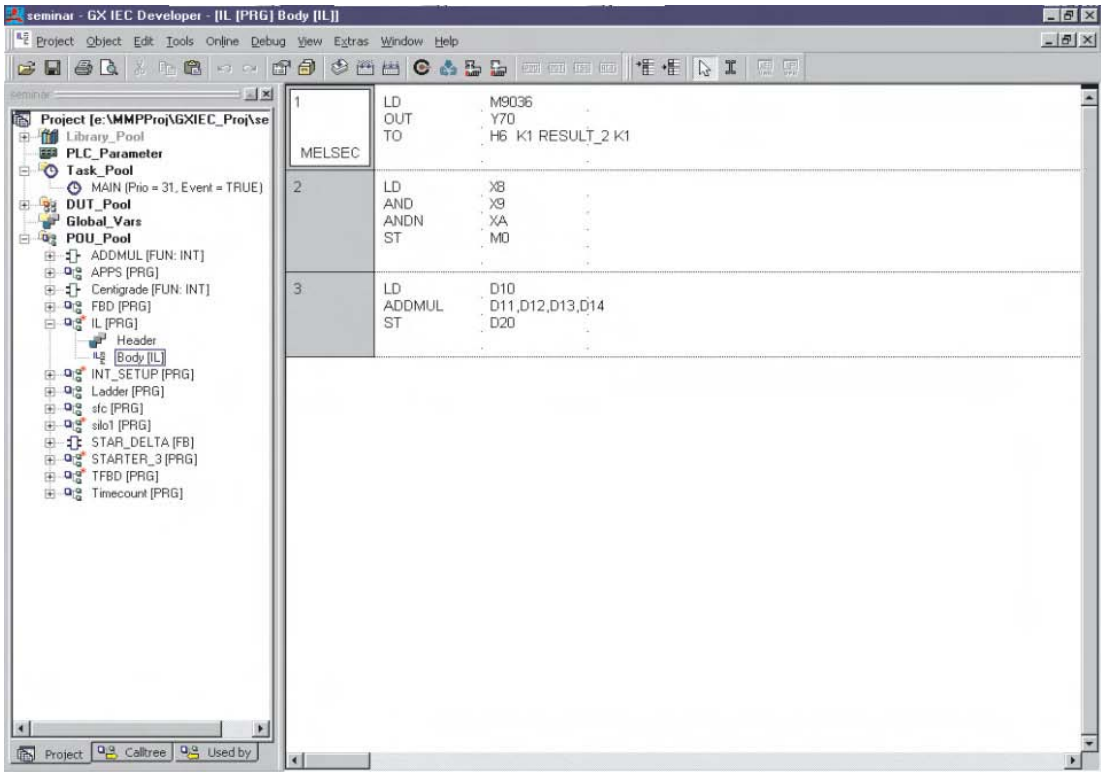
Use of an “_E” function can simplify still further. To Perform : “ + D0 D1 D2 ” and then “ + D2 K50 D3 ” from a conditional input X0 becomes:

```
LD      X0
ADD_E   D0,D1,D2,50,D3
```

This is because the ADD_E function has an Enable Output (ENO) feature.

16.2 Mixing IEC IL and Melsec IL in POUs

Both IEC IL and Melsec IL networks can be incorporated into the same POU. This is achieved, by highlighting the current network, selecting from the Edit Menu, ***New Network*** then ***Melsec Before*** from the ***Options*** list:



17 IEC Structured Text

ST is a high level textual editor, which has the appearance of PASCAL but is a dedicated language for industrial control applications.

POUs, Functions and Function Blocks can be created using ST.

IEC Structured Text example:

IF …..THEN ….. ELSE conditions
CASE ...ELSE .... END_CASE structures
REPEAT
RETURN
Expression Evaluation
Variable Declaration etc

Complex mathematical expressions can be realised using these operators, in a few lines of text.

17.1 Structured Text Operators

Operator	Description	Precedence
(….)	Parenthesised expression	Highest
Function(….)	Parameter list of a function, function evaluation	
**	Exponentiation, ie raising to a power	
-	Negation	
NOT	Boolean compliment	
*	Multiplication	
/	Division	
MOD	Modulus operation	
+	Addition	
-	Subtraction	
<,>,<=,>=	Comparison operators	
=	Equality	
<>	Non equality	
AND, &	Boolean AND	
XOR	Boolean exclusive OR	
OR	Boolean OR	Lowest

17.2 Structured Text Program Example

A new Function Block will be constructed to perform a simple “Centigrade to Fahrenheit” conversion similar to that used in a previous example, in order to illustrate the use of the ‘Structured Text’ language editor.

The formula used is as follows:

$$Fahrenheit = \frac{Celsius \times 9}{5} + 32$$

The input and result variables will be in Floating Point (REAL) format.

NOTE

For the FX range of PLCs, floating point calculation is only possible with the main units of the FX2N, FX2NC, and FX3U series.

① Create a new project called "Structured_Text".

② Create a new POU named "Fahrenheit", of Class: ***FUN***, Result Type: ***REAL***, with a language of “ST” (***Structured Text***):

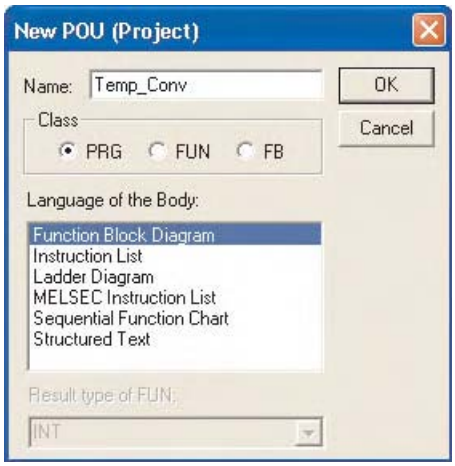
③ Create an entry in the header (LVL) of the Function “Fahrenheit”:

	Class	Identifier		Type		Initial	Comment
0	VAR_INPUT	Centigrade		REAL	...	0.0	

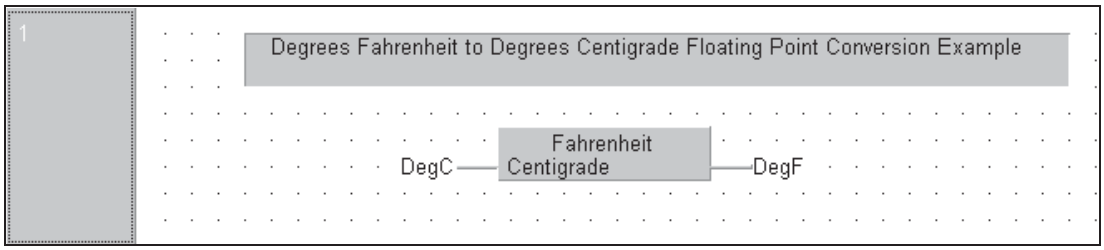
④ Open the Body of the Function “Fahrenheit” and enter the following simple ST program:

Fahrenheit := (Centigrade*9.0/5.0+32.0);

⑤ Create a new POU with a name “Temp_Conv”, Class: ***PRG***, Language: ***Function Block Diagram***



⑥ Open the body of the program POU “Temp_Conv” and enter the following program example:



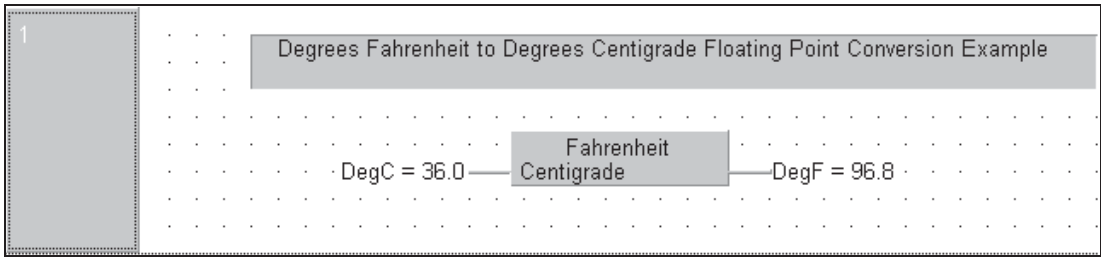
⑦ Edit the LVL (Header) of the POU “Temp_Conv” to include 2 local variables as shown below:

	Class	Identifier	Type	Initial	Comment
0	VAR	DegC	REAL	0.0	
1	VAR	DegF	REAL	0.0	

⑧ Close all open editors, compile the project using “Rebuild All”. Save and download to the PLC.

⑨ Monitor the program body of “Temp_Conv” and observe the values on screen.

⑩ Force new values into the input variable “DegC” of the equation by double clicking on the variable Tag Name.



NOTE

In this example, Local Variables are used to directly enter values via the GX-IEC Developer programming / monitoring interface; normally values are entered via Global Variables.

18 PROFIBUS/DP Communication

The open PROFIBUS/DP network enables extremely fast data exchange with a very wide variety of slave devices, including remote digital I/Os, remote analog I/Os, frequency inverters and a range of other devices from third-party manufacturers. Of course, PROFIBUS/DP slaves from MITSUBISHI ELECTRIC can also be connected to master devices from other manufacturers.

The installation of remote digital or analog I/Os helps to reduce costs for wiring.

Structure

The maximum coverage of a bus segment is 1200 m (at a maximum of 93.75 kbit/s). Up to 3 repeaters are allowed. Thus the maximum distance between 2 stations is calculated with 4800 m.

Cable types

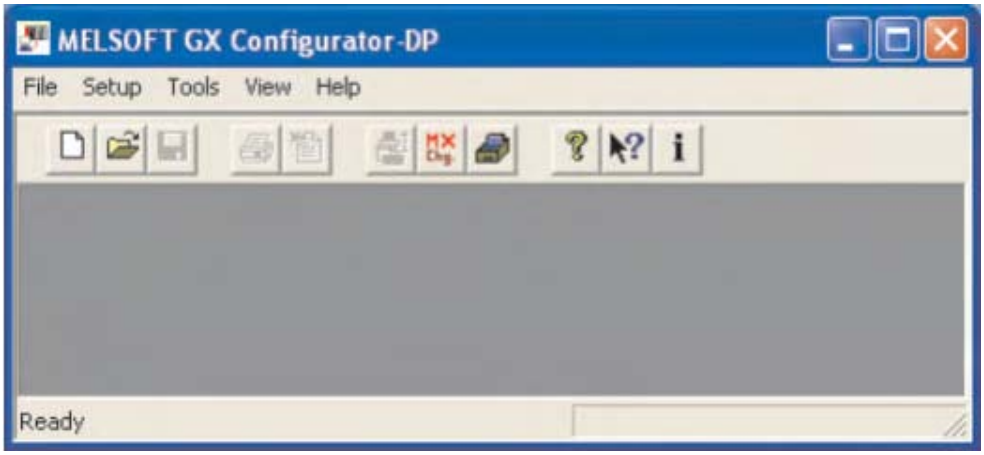
To help reduce costs PROFIBUS/DP uses RS 485 technology with shielded 2-wire cabling.

18.1 Configuring the PROFIBUS/DP Network

In combination with the software GX Configurator DP the FX3U-64DP-M master unit as well as master modules from the A series or the MELSEC System Q give you user-friendly plug-and-play technology. The configuration software is self-explanatory, using a graphical model for setting up the network. You simply select the slave unit, assign the station numbers and specify where the information is stored in the master station.

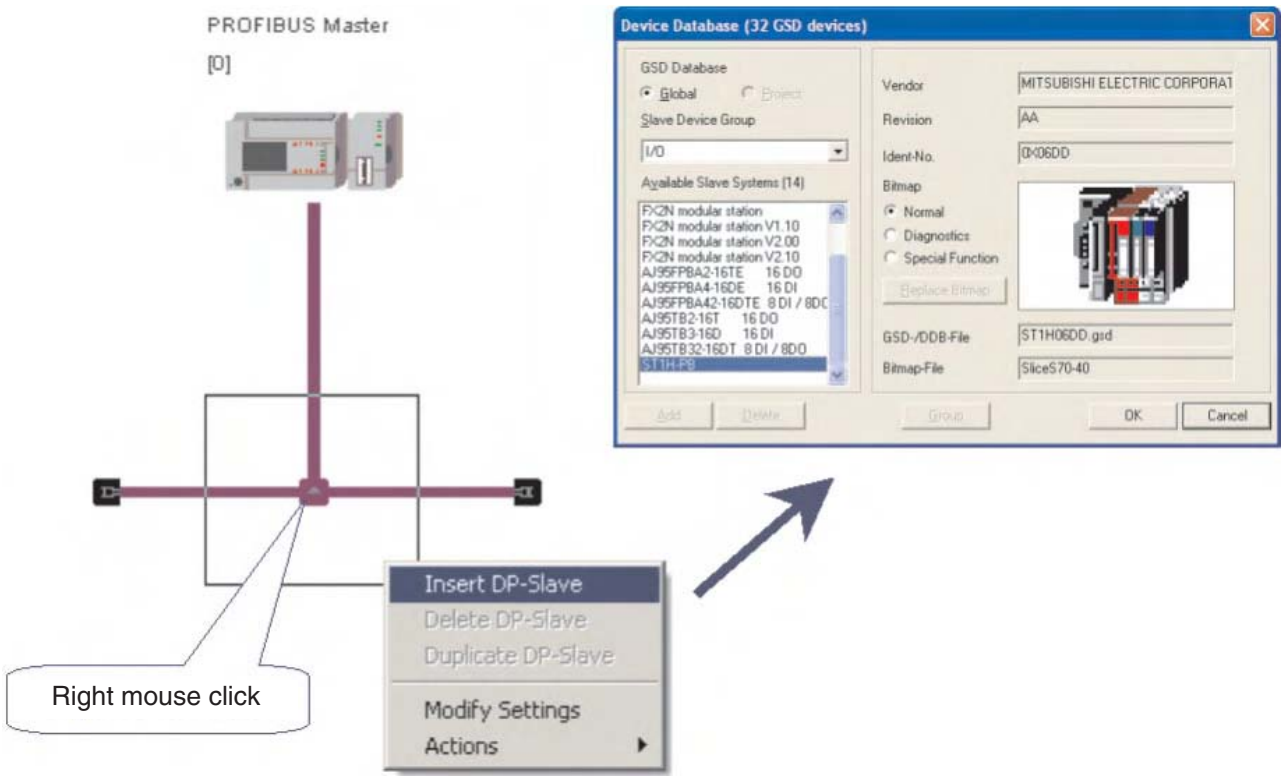
In this chapter the configuration of a PROFIBUS/ DP master module FX3U-64DP-M installed in a FX3U base unit is shown. Connected to the master module is a slave station consisting of digital and analog modules of the MELSEC ST series. For more information of the ST series please refer to the Technical Catalogue Networks, art.-no. 136730.

① Start GX Configurator DP and open a new project.

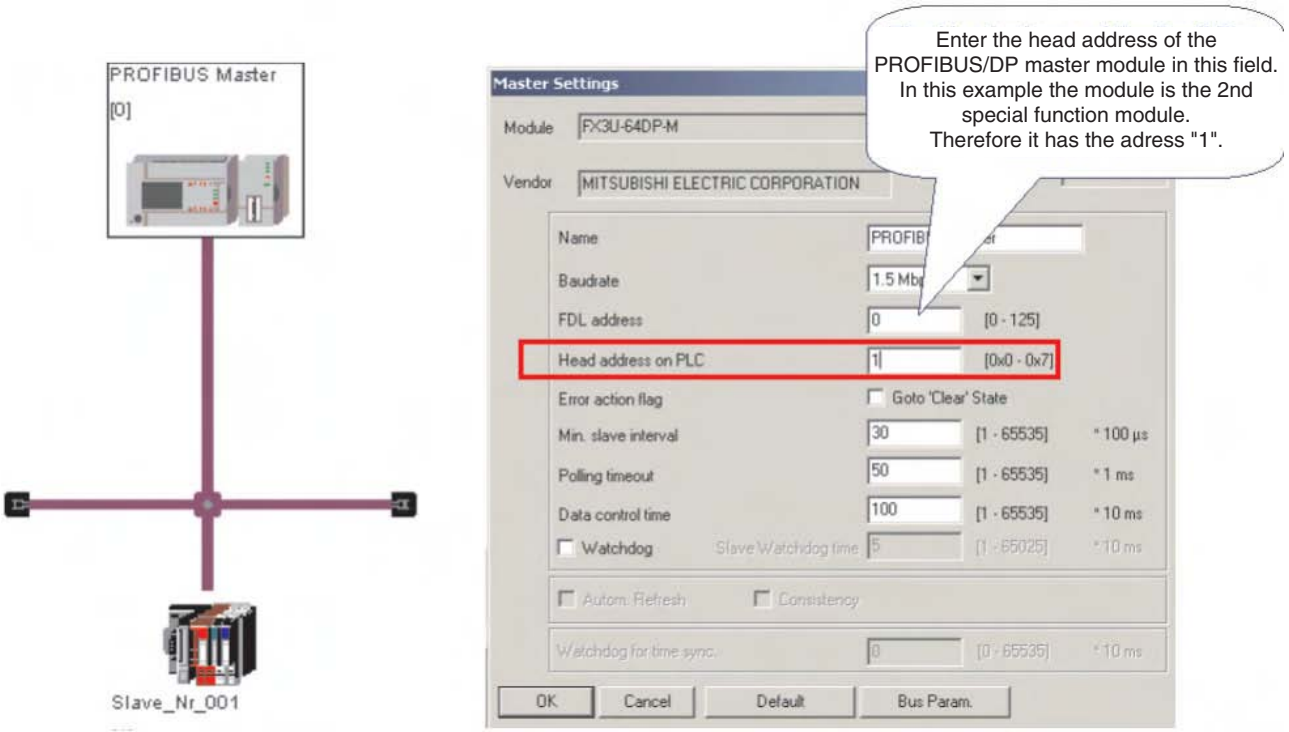


② In the dialog ***Network Setup*** *select* ***FX***. As ***MELSEC Device*** FX3U-64DP-M is automatically entered.

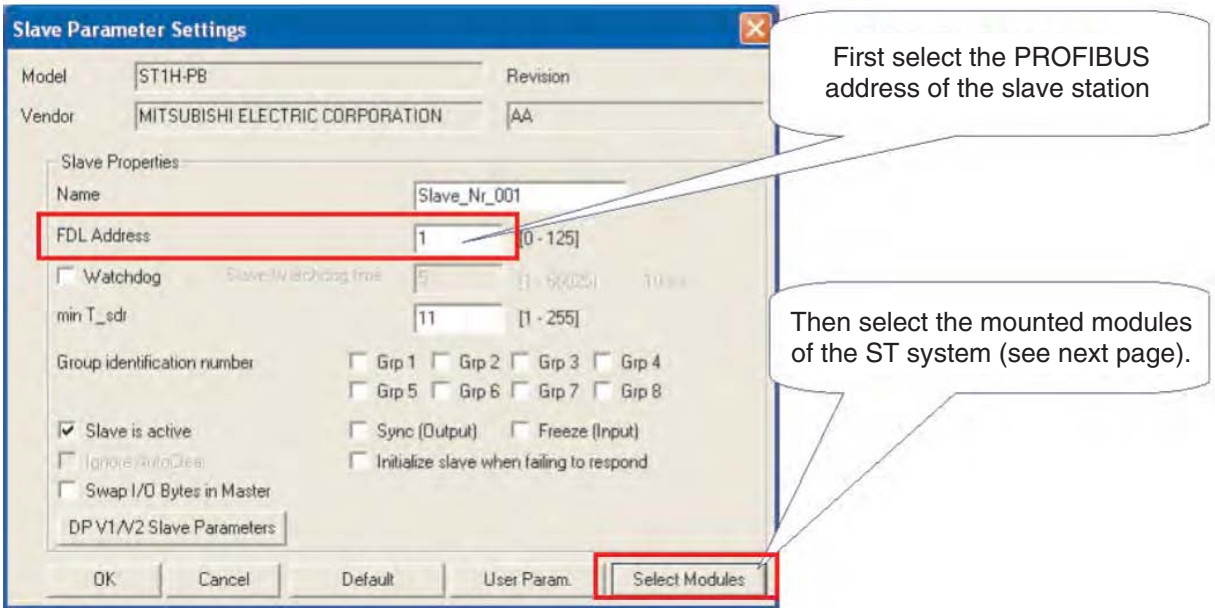
③ Insert DP-Slave in empty project.



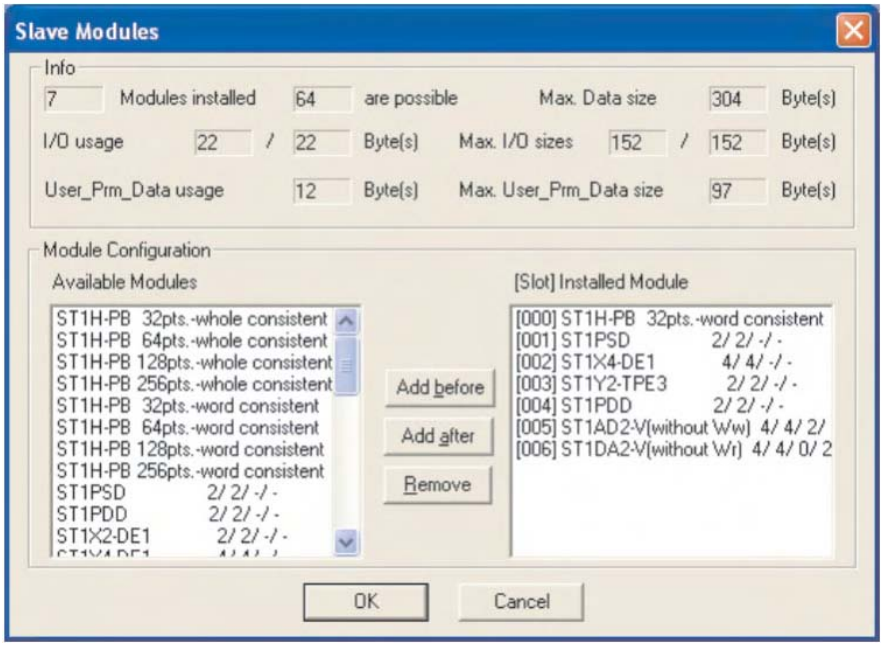
④ Define the head address of the master module.



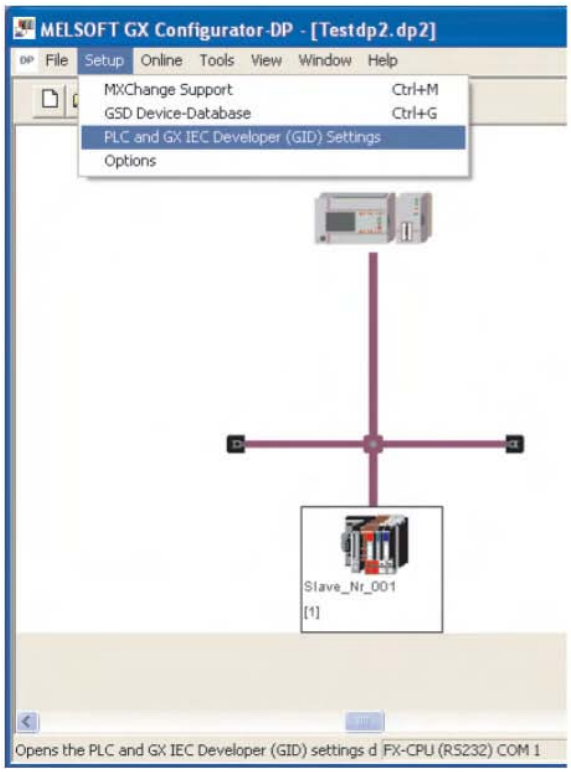
⑤ Configure the slave station. In this example it is a head module of the MELSEC ST series (ST1H-PB).

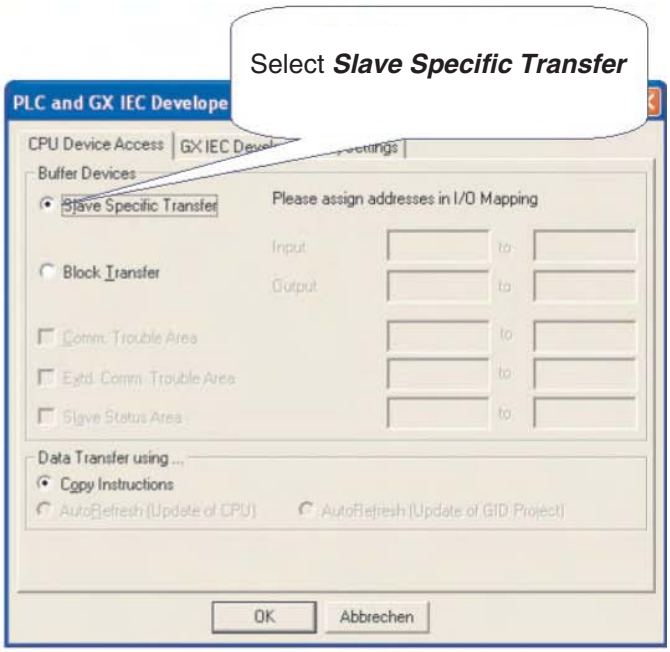


⑥ Select modules

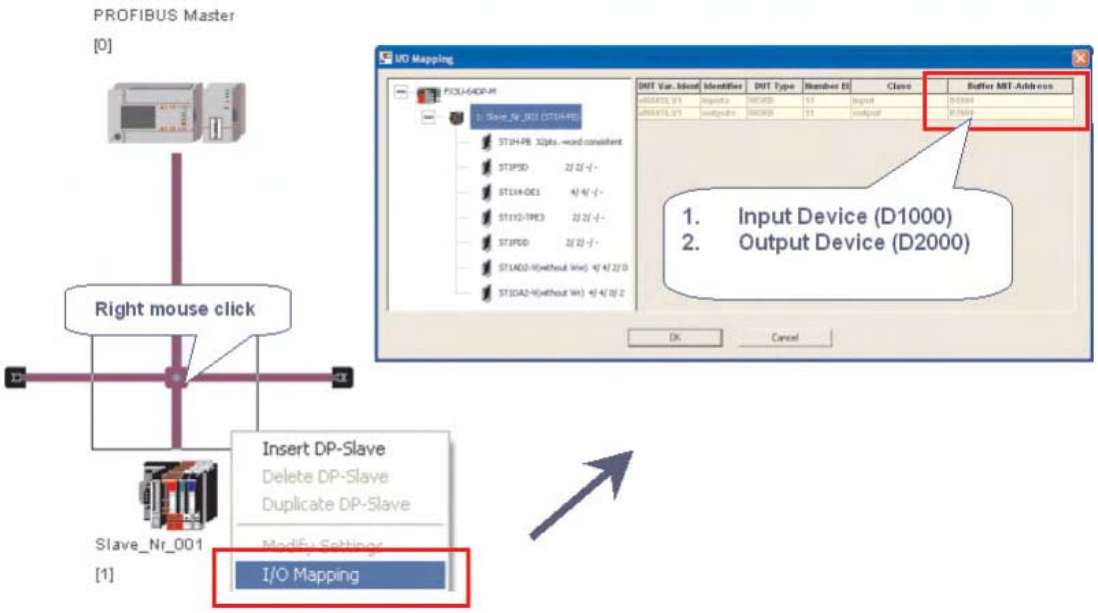


⑦ Make PLC settings for input and output devices.

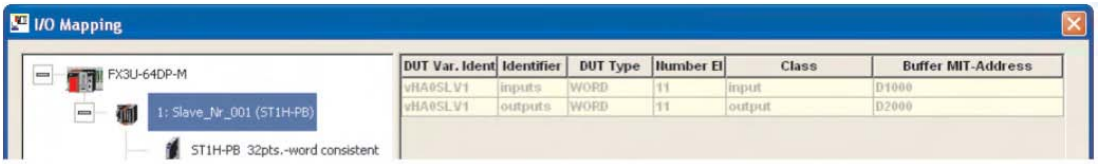


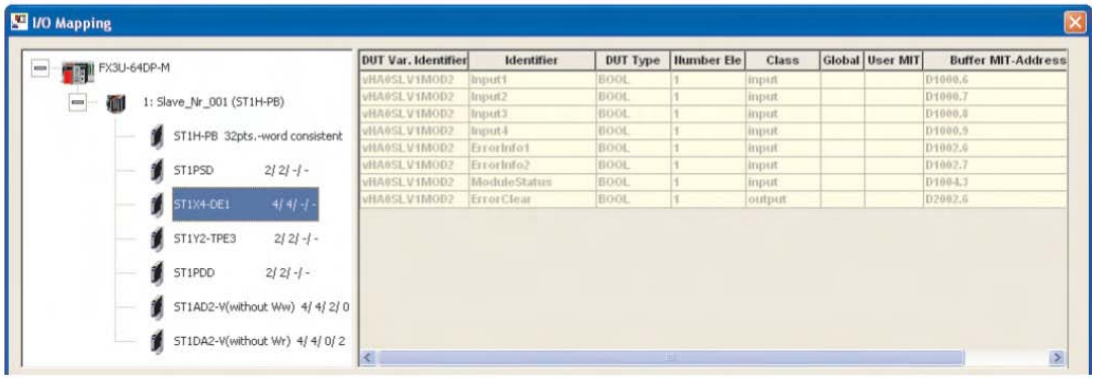


⑧ Slave Specific Transfer

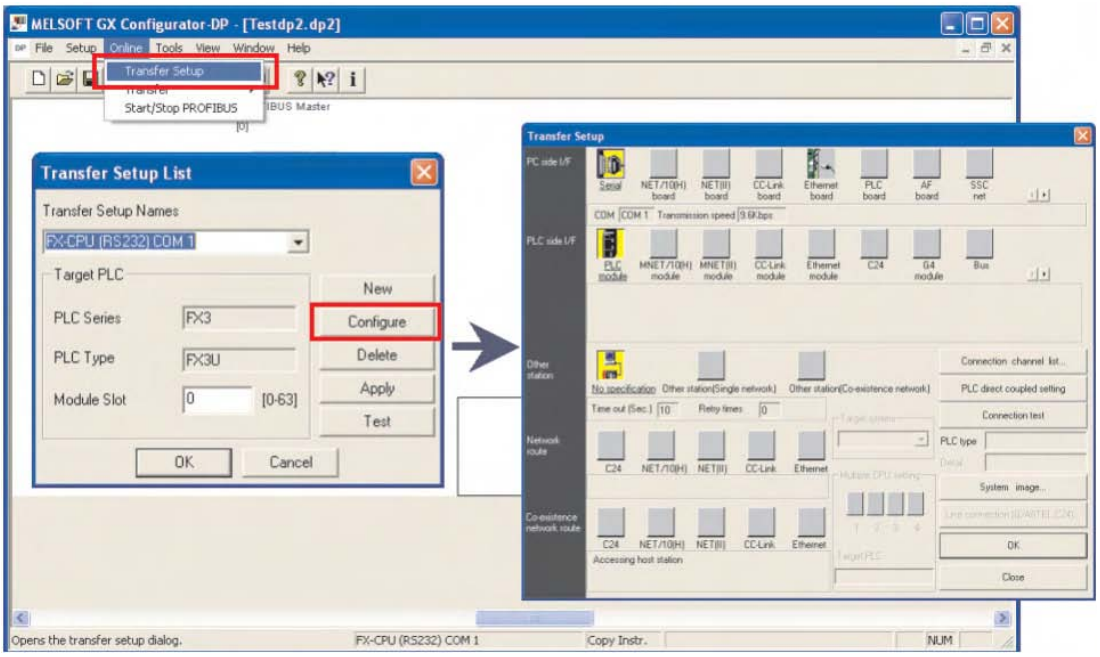


⑨ I/O mapping

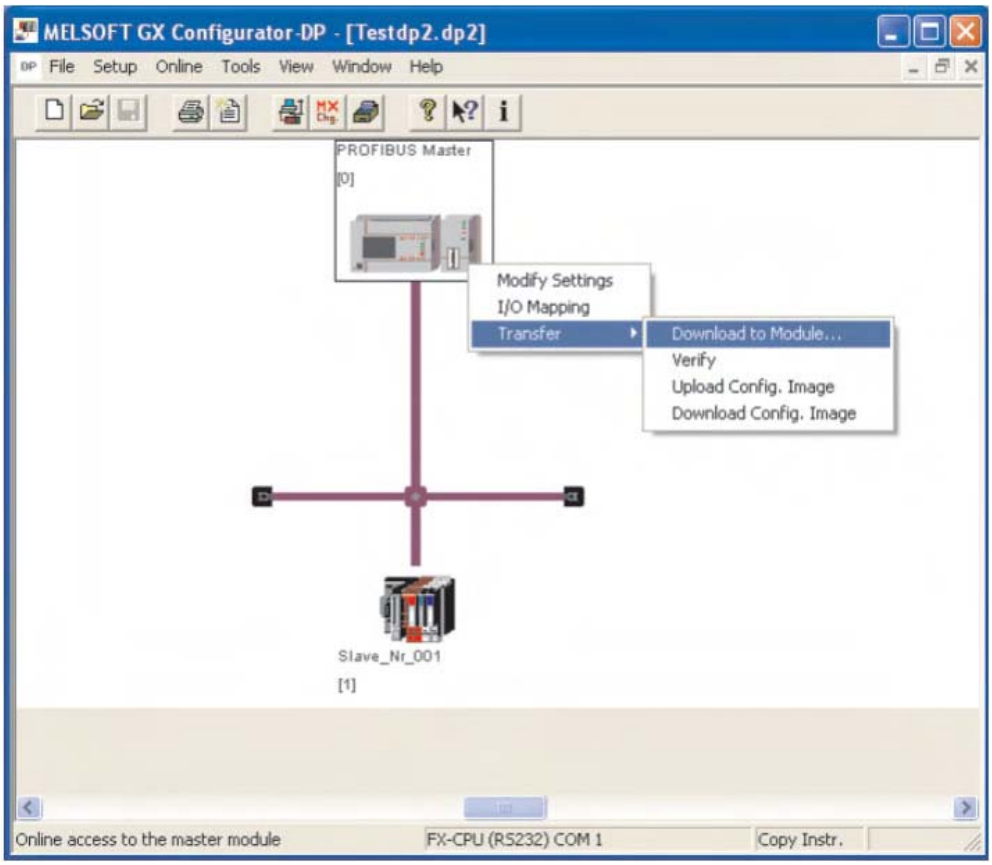




⑩ Before download please select ***Transfer Setup***

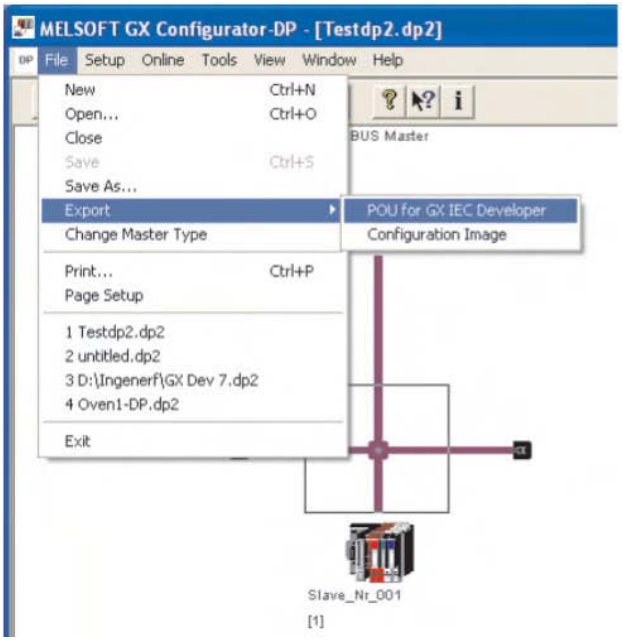


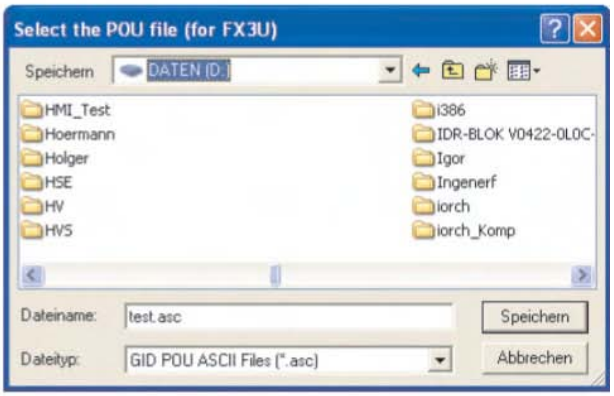
⑪ Transfer configuration to PROFIBUS/DP master module.



⑫ POU for GX IEC Developer

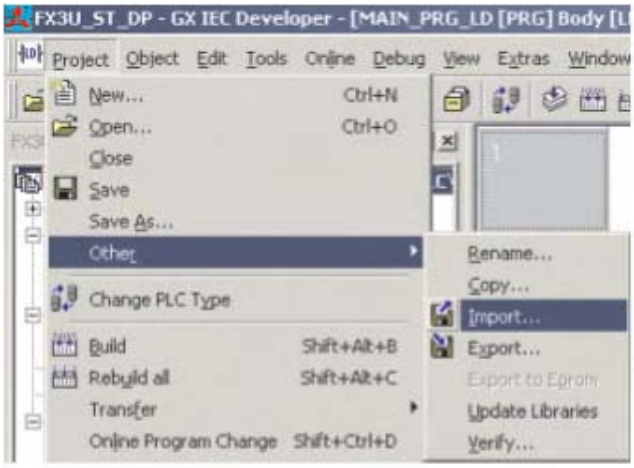
The created POU can be exported to the GX IEC Developer project. This POU will initialize the PROFIBUS/DP master module in the PLC program.

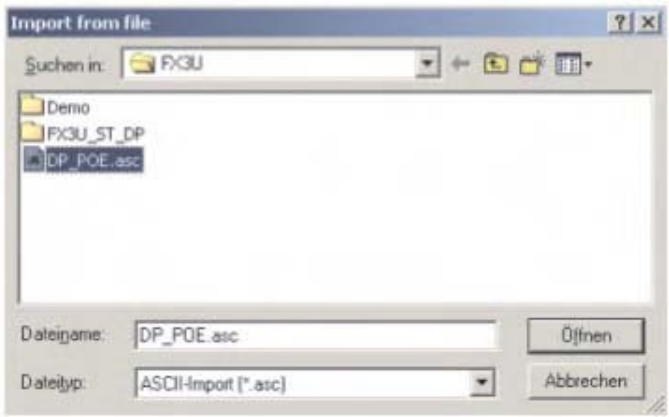


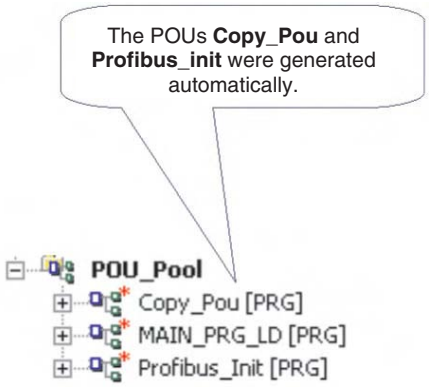


⑬ Import of the POU in the GX IEC Developer project.

(A new project with the correct CPU has already been created and saved.)








```
(* Exchange PLC data with Profibus DP *)
(* Module Type FX3U-64DP-M: Mode 3 *)
LD M8000
FROM_M K1,K5,K1,TEMP_WORD (* read profibus start ready flag *)
WORD_TO_BOOL_E TEMP_WORD,DATA_EXCHANGE_FLAG

LD DATA_EXCHANGE_FLAG
FROM_M K1,K84,K4,DP_ARRAY_INPUT_CONSISTENCY_WORD[0] (* read input consistency flag *)
FROM_M K1,K92,K4,DP_ARRAY_OUTPUT_CONSISTENCY_WORD[0] (* read output consistency flag *)

WORD_TO_INT_E DP_ARRAY_OUTPUT_CONSISTENCY_WORD[0], DP_ARRAY_TEMP_INT[0]
WORD_TO_INT_E DP_ARRAY_OUTPUT_CONSISTENCY_WORD[1], DP_ARRAY_TEMP_INT[1]
WORD_TO_INT_E DP_ARRAY_OUTPUT_CONSISTENCY_WORD[2], DP_ARRAY_TEMP_INT[2]
WORD_TO_INT_E DP_ARRAY_OUTPUT_CONSISTENCY_WORD[3], DP_ARRAY_TEMP_INT[3]

INT_TO_BITARR_E DP_ARRAY_TEMP_INT[0],K16,DP_ARRAY_OUTPUT_CONSISTENCY[0]
INT_TO_BITARR_E DP_ARRAY_TEMP_INT[1],K16,DP_ARRAY_OUTPUT_CONSISTENCY[16]
INT_TO_BITARR_E DP_ARRAY_TEMP_INT[2],K16,DP_ARRAY_OUTPUT_CONSISTENCY[32]
INT_TO_BITARR_E DP_ARRAY_TEMP_INT[3],K16,DP_ARRAY_OUTPUT_CONSISTENCY[48]

WORD_TO_INT_E DP_ARRAY_INPUT_CONSISTENCY_WORD[0], DP_ARRAY_TEMP_INT[0]
WORD_TO_INT_E DP_ARRAY_INPUT_CONSISTENCY_WORD[1], DP_ARRAY_TEMP_INT[1]
WORD_TO_INT_E DP_ARRAY_INPUT_CONSISTENCY_WORD[2], DP_ARRAY_TEMP_INT[2]
WORD_TO_INT_E DP_ARRAY_INPUT_CONSISTENCY_WORD[3], DP_ARRAY_TEMP_INT[3]

INT_TO_BITARR_E DP_ARRAY_TEMP_INT[0],K16,DP_ARRAY_INPUT_CONSISTENCY[0]
INT_TO_BITARR_E DP_ARRAY_TEMP_INT[1],K16,DP_ARRAY_INPUT_CONSISTENCY[16]
INT_TO_BITARR_E DP_ARRAY_TEMP_INT[2],K16,DP_ARRAY_INPUT_CONSISTENCY[32]
INT_TO_BITARR_E DP_ARRAY_TEMP_INT[3],K16,DP_ARRAY_INPUT_CONSISTENCY[48]

(* write output data after profibus start is possible *)
(* Output data *)
```

2

```
LD DATA_EXCHANGE_FLAG
AND DP_ARRAY_OUTPUT_CONSISTENCY[0] (* check if no data consistency *)
```

⑭ Rebuild the GX IEC Developer project and transfer it to the FX3U. After restarting the PLC the PROFIBUS communication will start.

19 Ethernet Communications

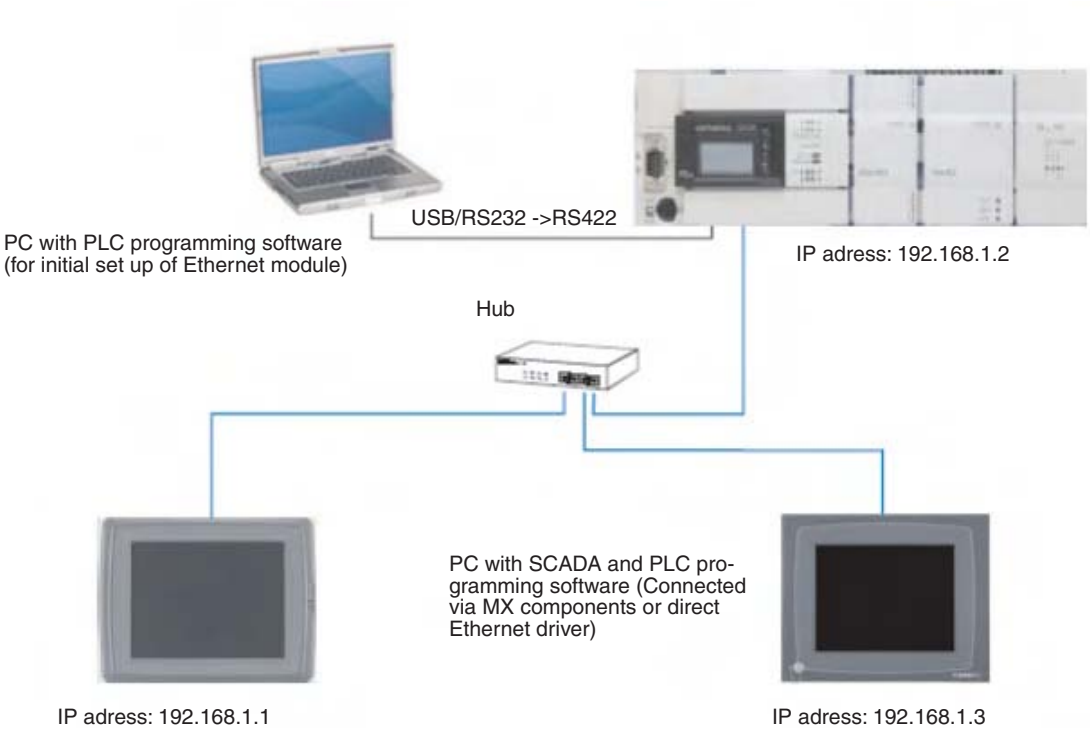
19.1 Configuring a FX3U Eternet Module by Parameter

This section provides a step-by-step guide to setting up a Ethernet module FX3U-ENET (to be referred to as 'module' from now on) by parameter setting, GX Developer 8.00 or later.

As an example, this section will show how to set up a module for allowing TCP/IP communications between a FX3U, a SCADA PC and an E1071 HMI. Also shown is how the programming software can be configured to communicate with the FX3U via Ethernet once the settings have been made.

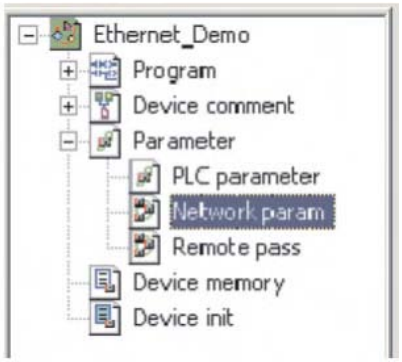
The diagram below shows the layout of the example Ethernet network. Proposed IP addresses are shown next to the Ethernet nodes.

Please note that more attention is given to the set up of the PLC than the PC or HMI, as the user may require more specific settings than this section covers.

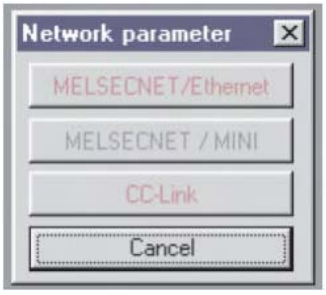


19.1.1 Configuring the PLC (using initial set up PC)

① Using the programming software, call up the ***Network*** Parameter selection box by double clicking on the option highlighted by the arrow.

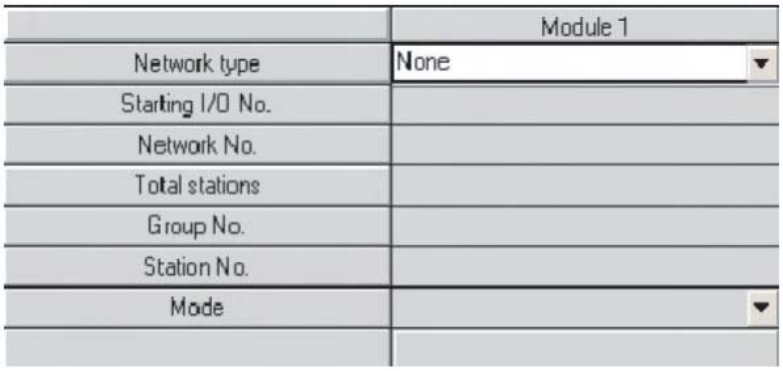


② When the box has been opened, select ***MELSECNET/Ethernet*** as shown below.

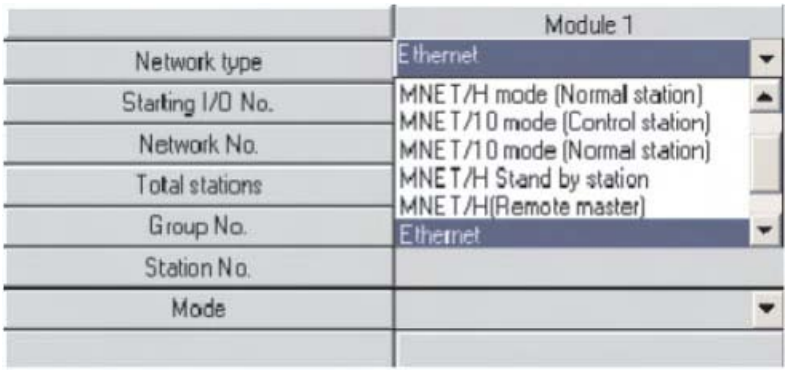


This opens up the dialogue box to allow the Ethernet module to be configured which can be seen below.

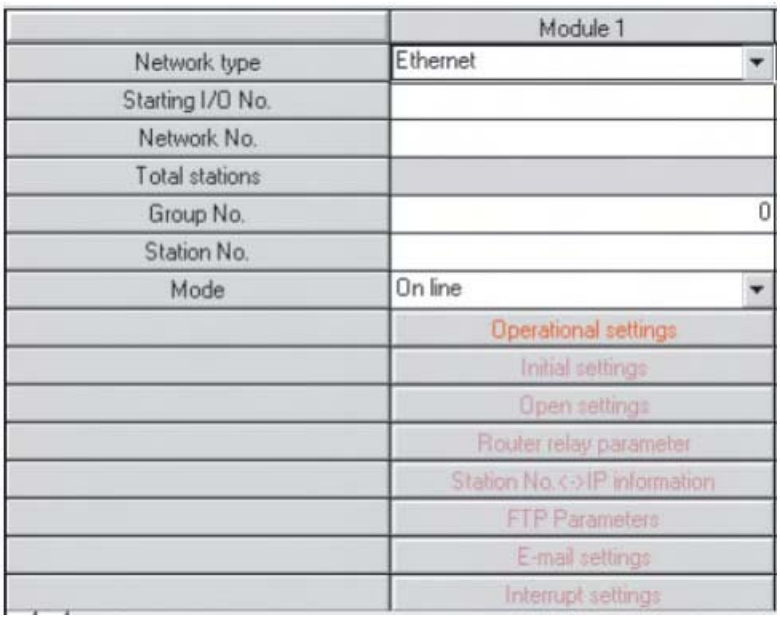
③ In the Network type window, click on the down arrow, to show the available selections:



④ Ethernet is the final option in the list. Select it as shown below:



⑤ The dialogue box now shows the specific setting options for the module. The buttons in the bottom half of the table that are in red are for setting the mandatory parts of the module, those in magenta are optional, and are set as required.



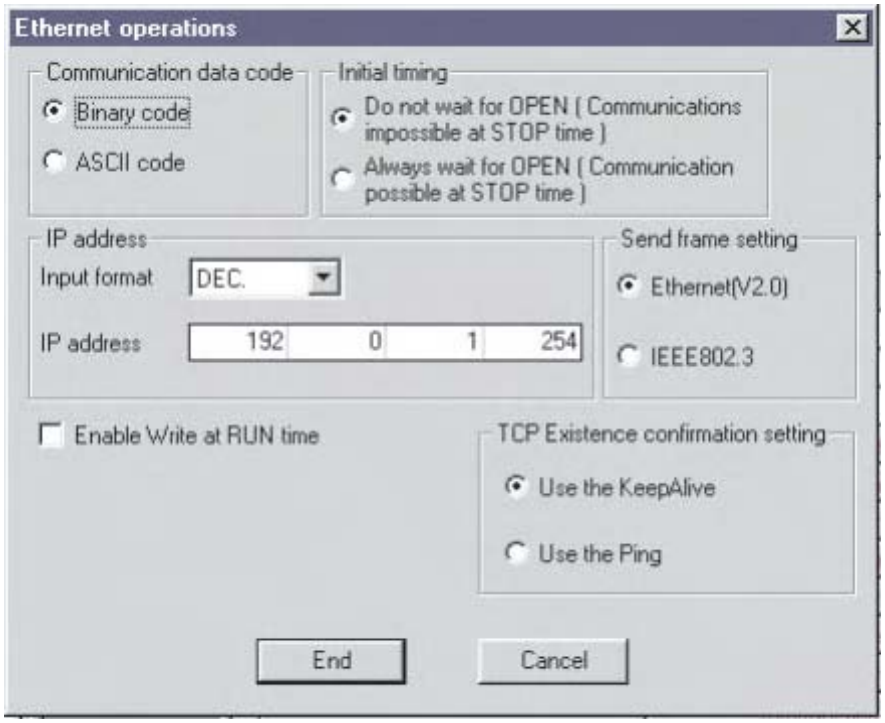
⑥ Click in the boxes in the top half of the table and enter the values as required. The table below shows the settings for the FX3U in the example system described earlier.

	Module 1	
Network type	Ethernet	
Starting I/O No.	0000	
Network No.	1	<— see Note below
Total stations		
Group No.	0	
Station No.	2	<— see Note below
Mode	On line	
	Operational settings	
	Initial settings	
	Open settings	
	Router relay parameter	
	Station No.<->IP information	
	FTP Parameters	
	E-mail settings	
	Interrupt settings	

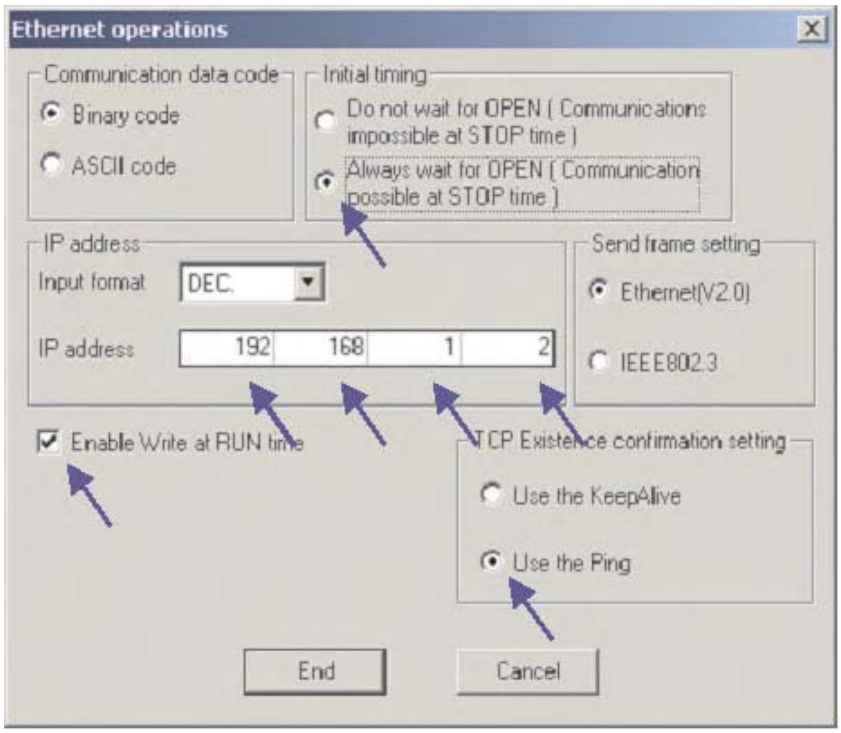
NOTE

The “network number” and “station number” settings are used to identify the module when FX3U PLC’s use the Ethernet for Peer-to-Peer communications (not covered in this document). These settings are also used when the programming software is to communicate to the FX3U PLC across the Ethernet network. This subject is covered later in the document.

⑦ Next, click on the ***Operational settings*** to bring up the dialogue shown below. The settings already there are the defaults that the programming software applies.



⑧ The dialogue below shows the settings required for the example system described earlier. The arrows highlight the differences for clarity.



⑨ After the settings here are made, click ***End*** to return to the main network parameter setting window. Note that the ***Operational settings*** button has now changed to blue, indicating that changes have been made.

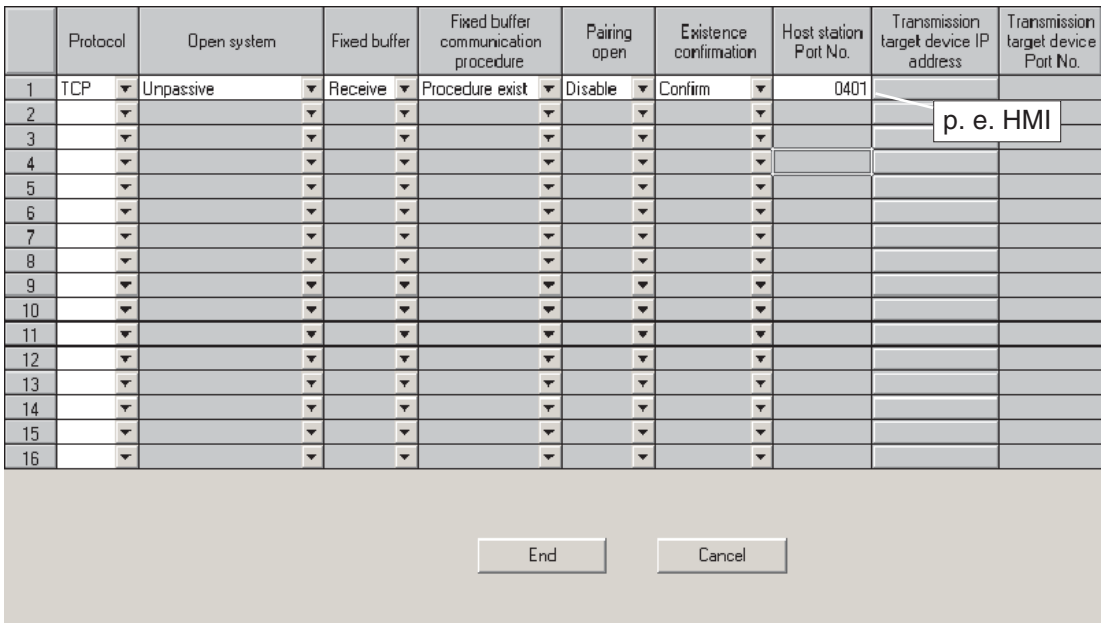
	Module 1
Network type	Ethernet
Starting I/O No.	0000
Network No.	1
Total stations	
Group No.	0
Station No.	2
Mode	On line
	Operational settings
	Initial settings
	Open settings
	Router relay parameter
	Station No.<->IP information
	FTP Parameters
	E-mail settings
	Interrupt settings

Next, click on ***Open settings*** to bring up the following dialogue. This is where the settings for the Scada and HMI will be made.

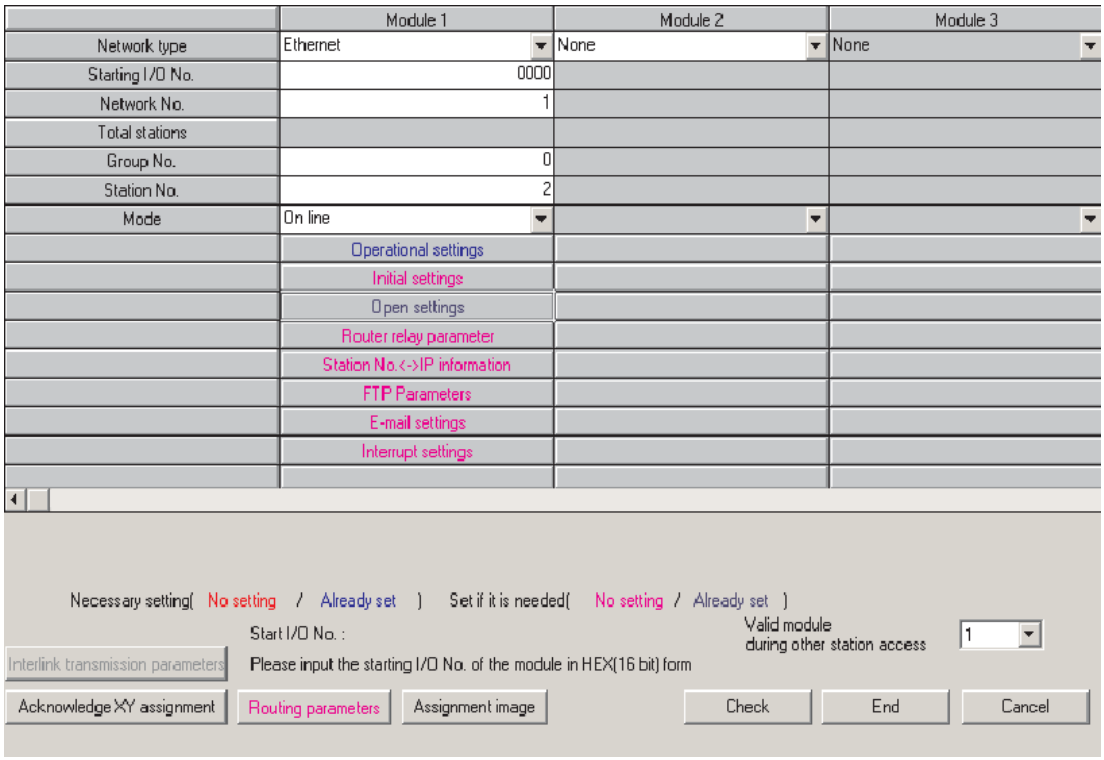
NOTE

There is no need to set anything here, if the Ethernet card is **only** to be used for program monitor/edit using the programming software (as described later).

The dialogue below shows the settings required for communication with both the Scada and the HMI, for the example system described earlier. The settings are made by selecting the required options from the drop-down lists in each window, or typing as required.



⑪ When the settings have been made, click ***End*** to return to the main network parameter setting window.

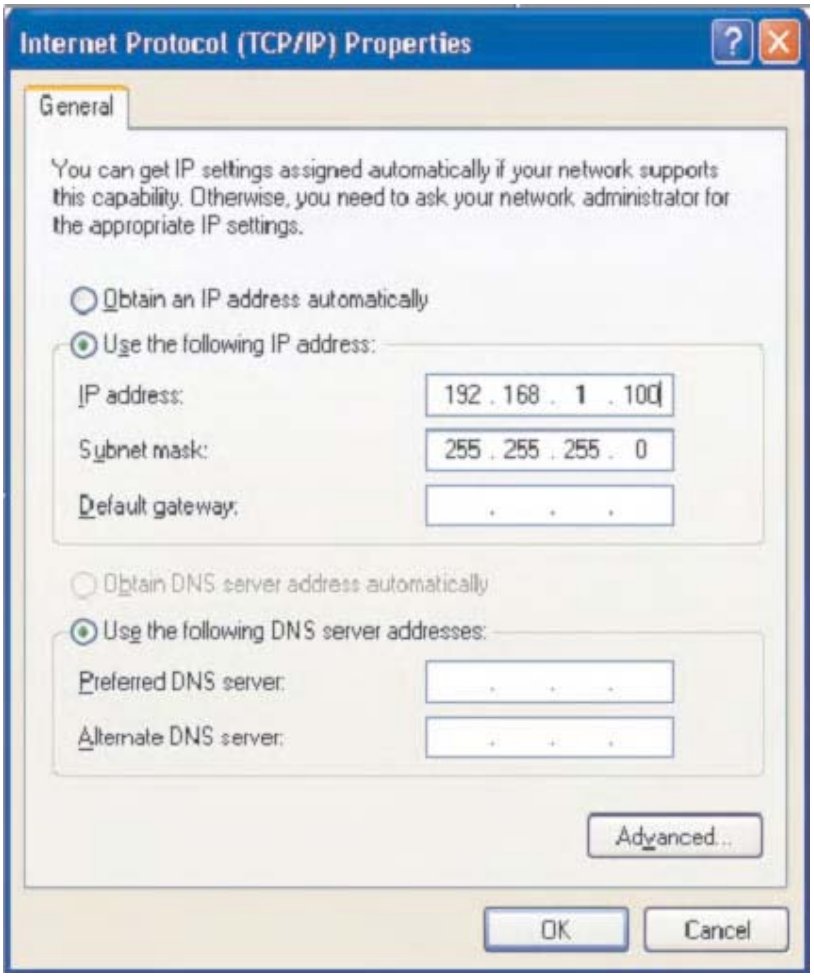


No more setting is required here for communications with the Scada or the HMI.

⑫ Click ***End*** to check and close the main network parameter setting dialogue. These settings will be sent to the PLC next time the parameters are downloaded.

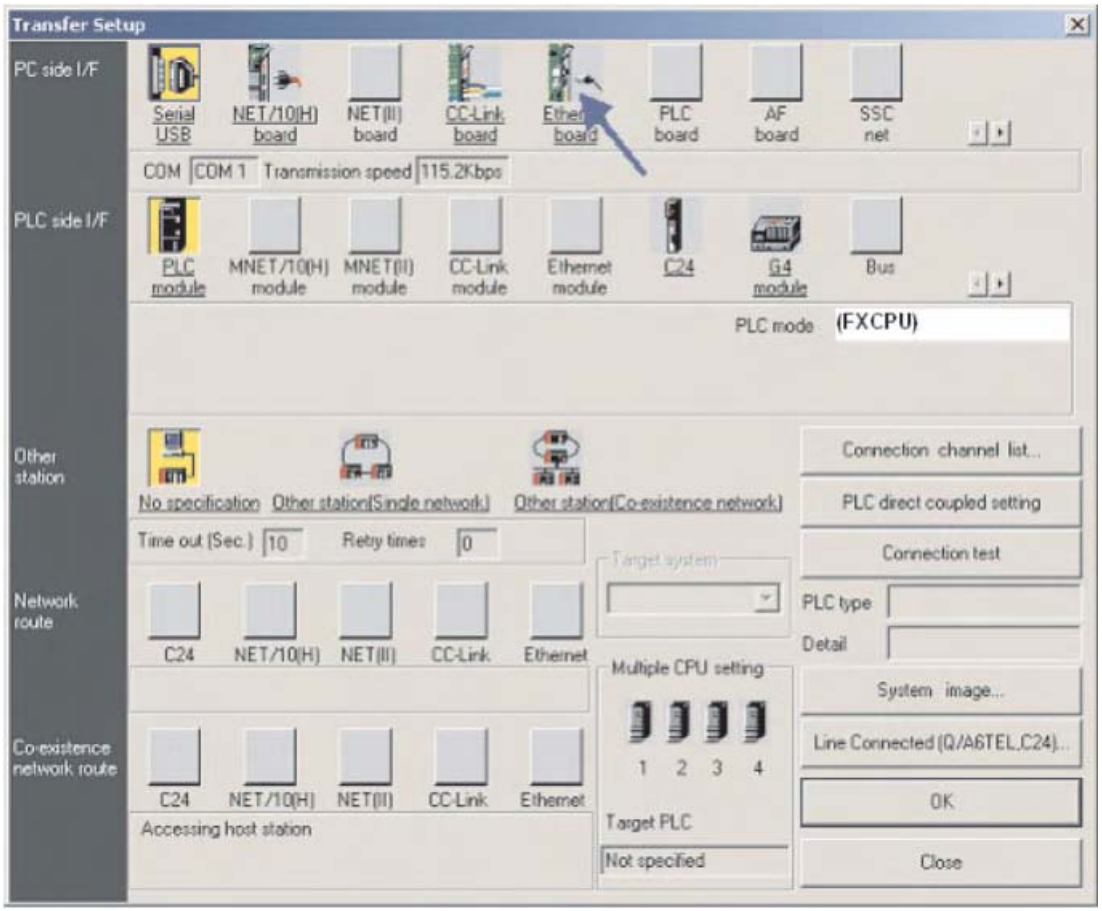
19.2 Configuring the PC on the Ethernet

① Open the Network properties of Windows, and assign an IP address and subnet mask in the TCP/IP properties dialogue for the Ethernet network adapter to be used. Please note that after changing IP address, the PC may require a restart.



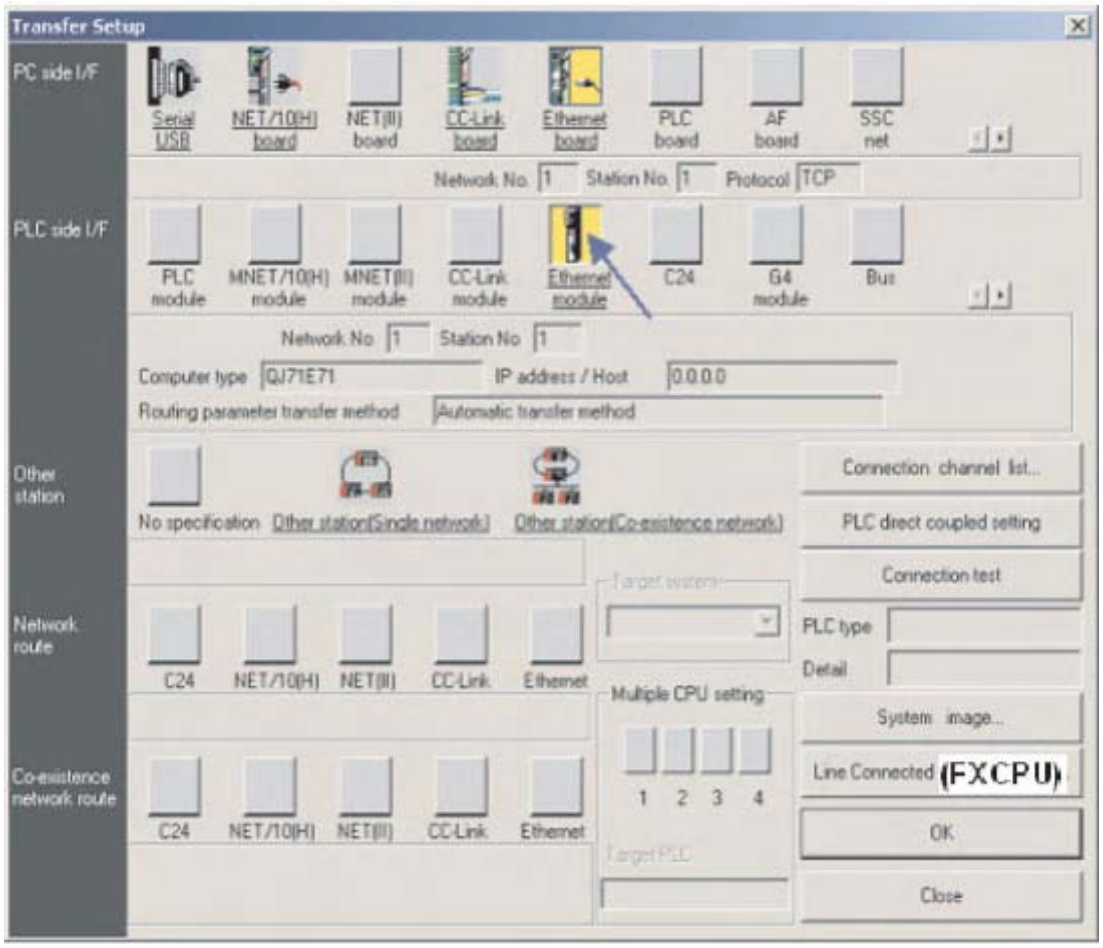
19.3 Configuring GX Developer to access the PLC on Ethernet

① Open the connection settings dialogue as shown.



② The default connection is for the ***PC Side I/F*** to use serial connection to the PLC CPU module. Change the ***PC Side I/F*** to ***Ethernet board*** by clicking on it as shown above, and saying ***Yes*** to the question about present setting will be lost (i.e. the setting of serial to CPU).

③ The ***PC Side I/F*** should default to Network No. = 1, Station No = 1 and Protocol = TCP as shown above. If it does NOT show this, then double click on ***Ethernet board*** and make these settings in the appropriate places

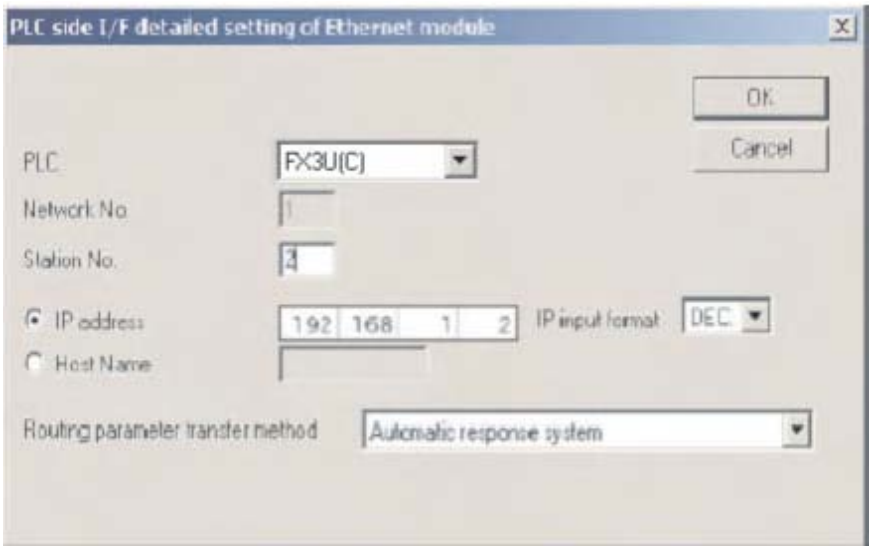


④ Next, double click on ***Ethernet module*** under ***PLC side I/F*** as shown above. This will open up the dialogue to allow the selection of the PLC to be communicated with over the Ethernet. Enter the settings shown, as these were the settings put into the PLC earlier. (refer back to parts 6 and 7 in section 19.1.1)

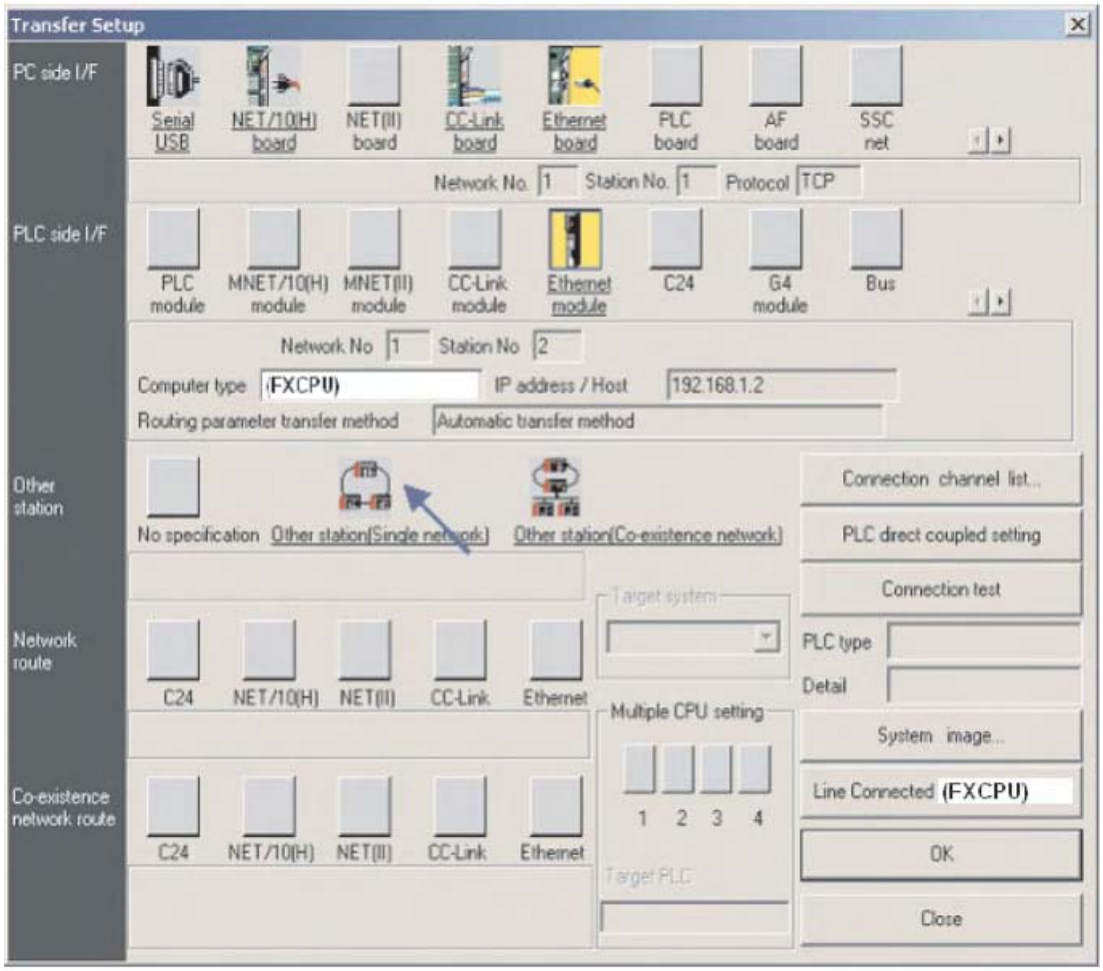
⑤ Click ***OK*** when done.

NOTE

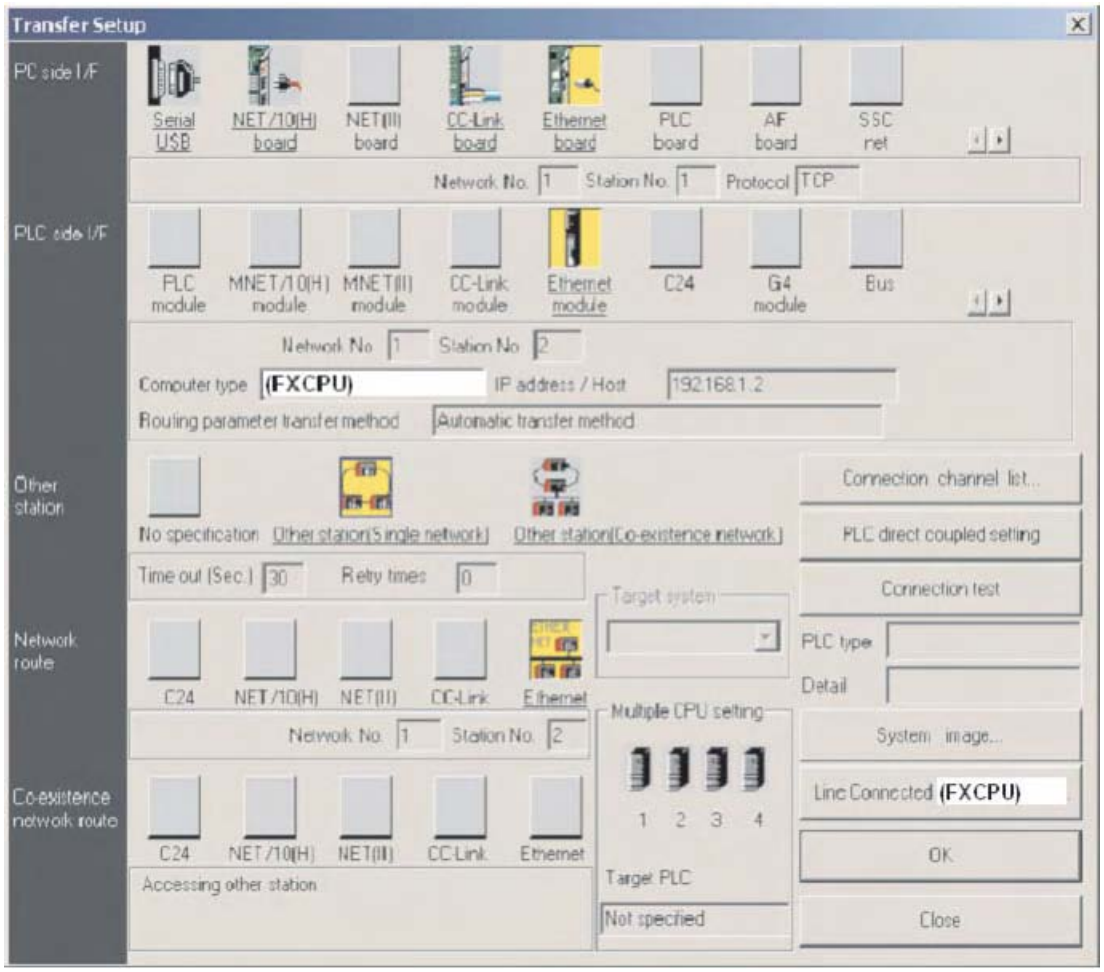
There is no need to specify a port number, as the programming software will use a MELSOFT Protocol dedicated port by default.



⑥ Next, single click on ***Other station (Single network)*** as shown below.

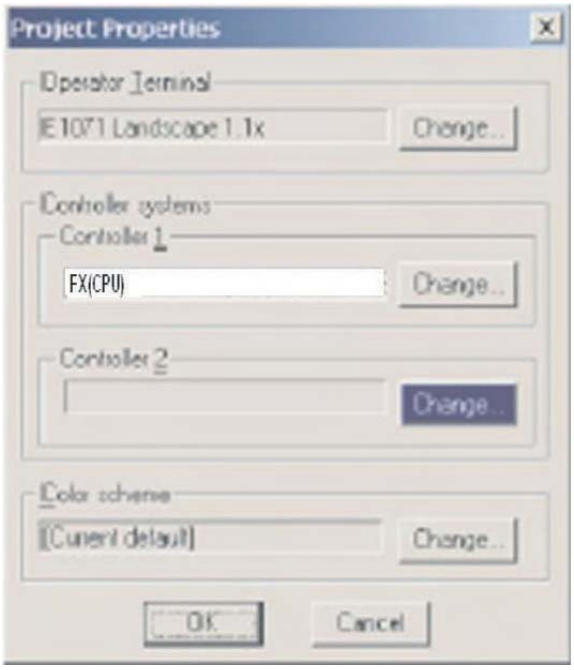


⑦ This will complete the setting, making the dialogue look as shown below. Click ***Connection test*** to confirm the settings are correct. Then click ***OK*** when finished.

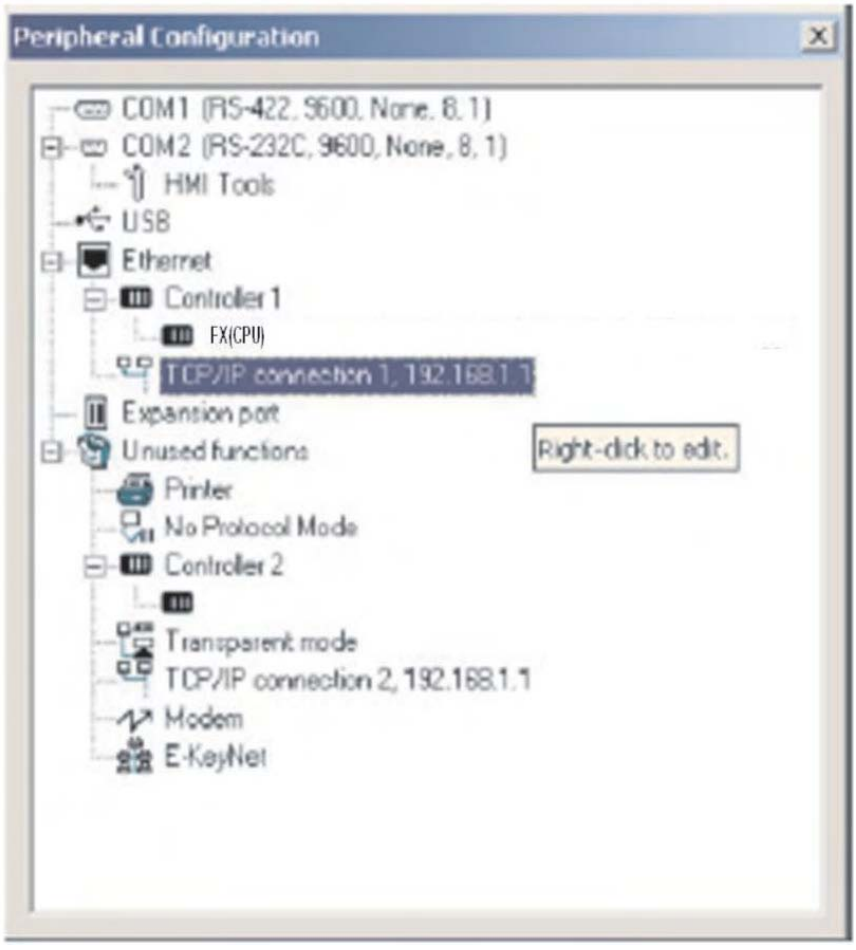


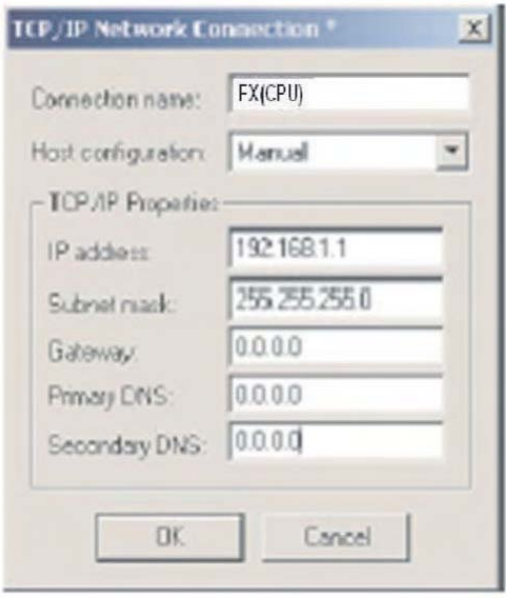
19.4 Setting up the HMI

① The E-Designer project for the example system needs to have the following settings.

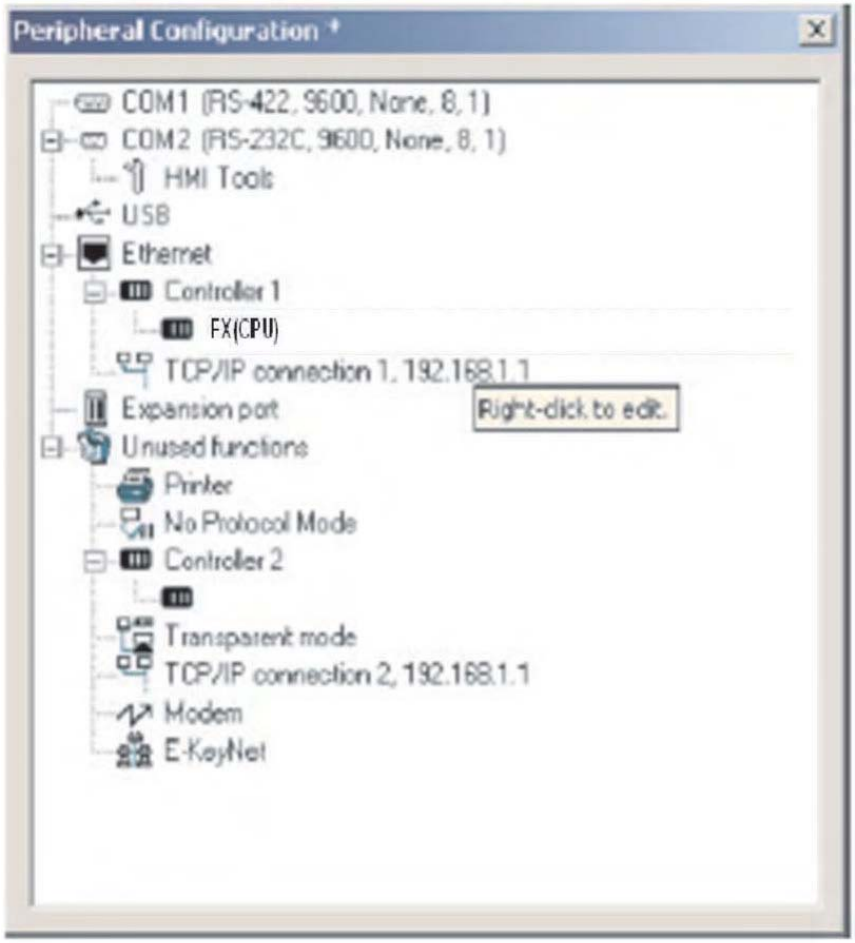


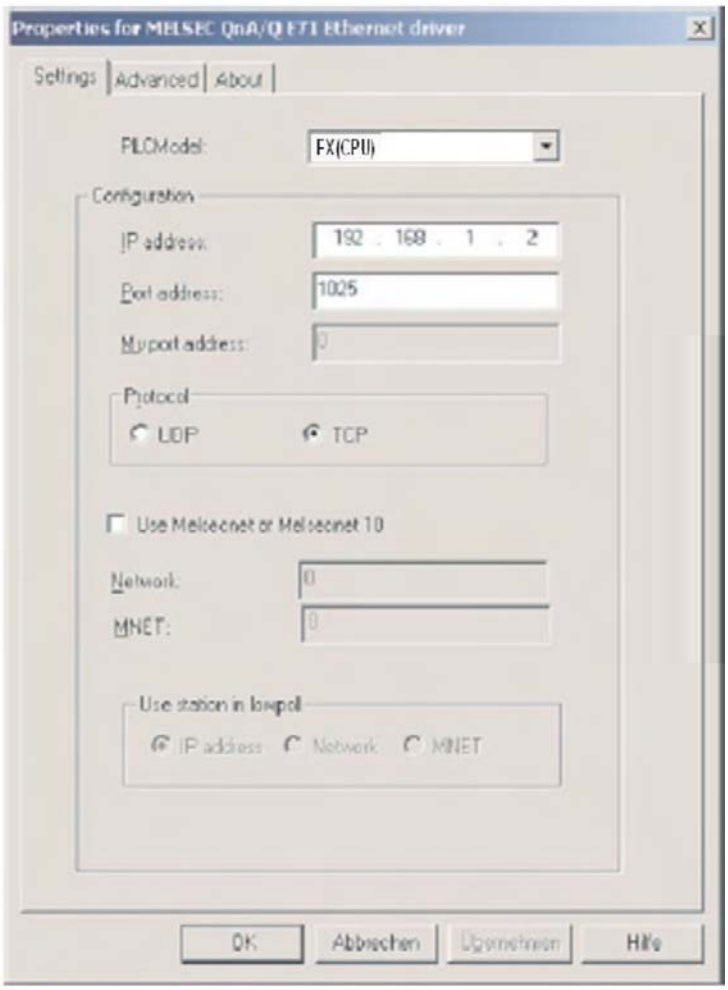
② Next, open up the ***Peripherals*** options under the System menu, and configure the HMI's TCP/IP connection as shown:





③ Then make the following settings for Controller 1 (i.e. the target PLC), according to the settings made in the PLC earlier.





As with the MQE settings earlier, note that E71 port number 1025, decimal 1025 is equal to hex 401 (set in the PLC Local station port number – refer back to part 10 of section 19.1.1).

④ Click ***OK***, exit the Peripheral settings and download these settings with the project.

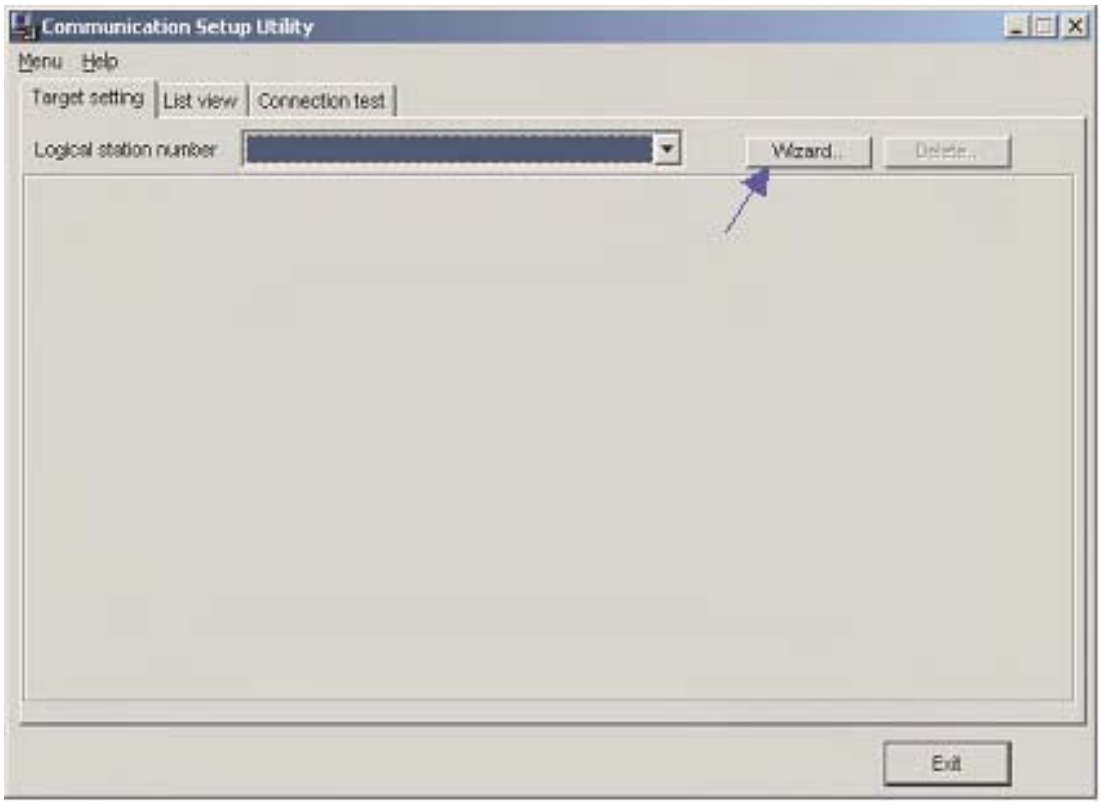
19.5 Communication via MX Component

MX Component is a tool designed to implement communication from PC to the PLC without any knowledge of communication protocols and modules.

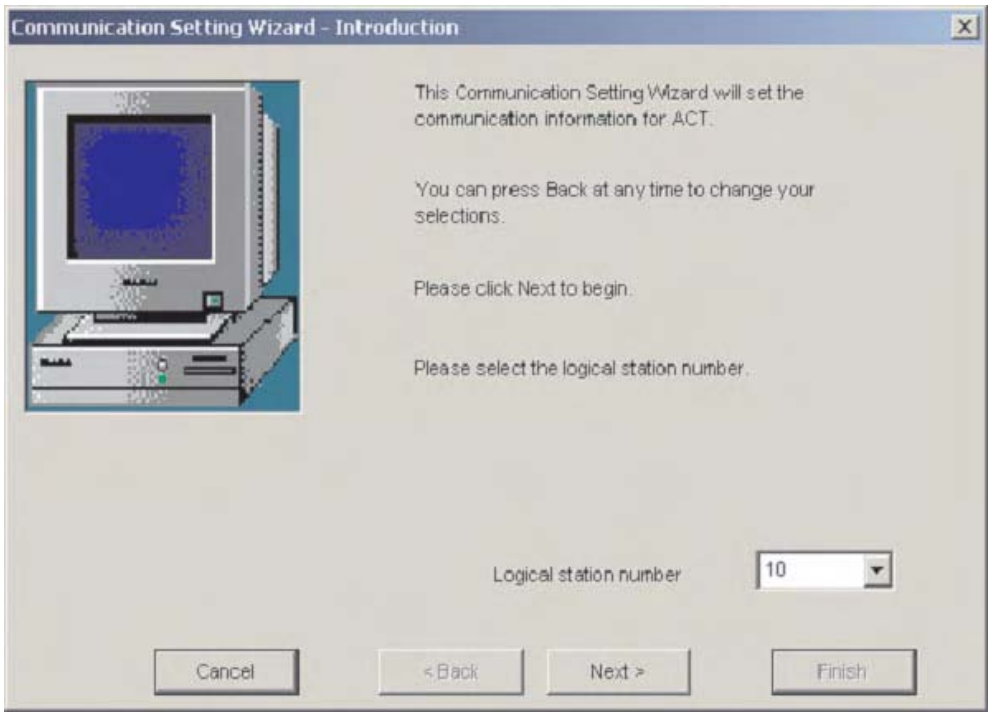
It supports serial CPU port connection, serial computer links (RS232C, RS422), Ethernet, CC-Link and MELSEC networks.

The figure below shows the easy way for creating of communication between a PC and a PLC via MX Component.

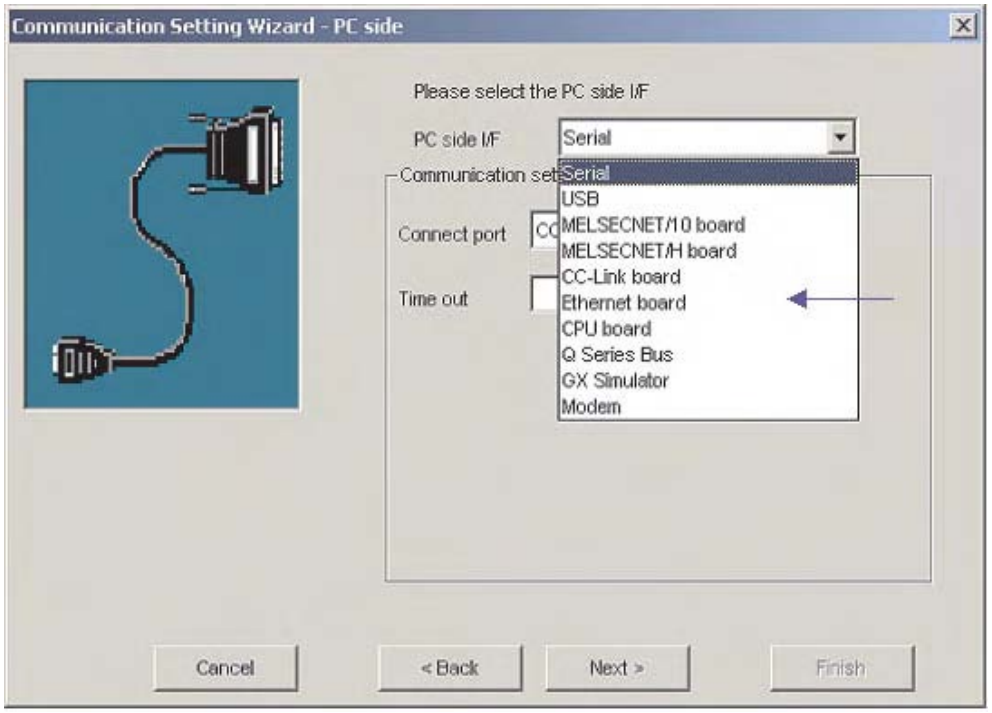
① Start the ***Communication Setting Utility*** and select the ***Wizard***



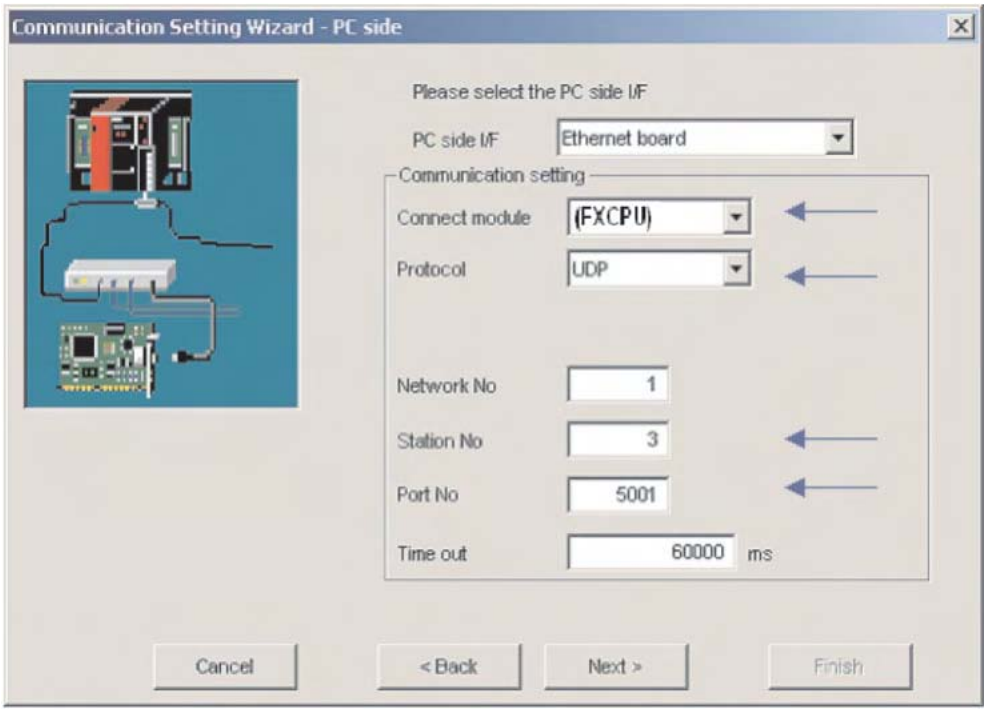
② First you must define the ***Logical station number***



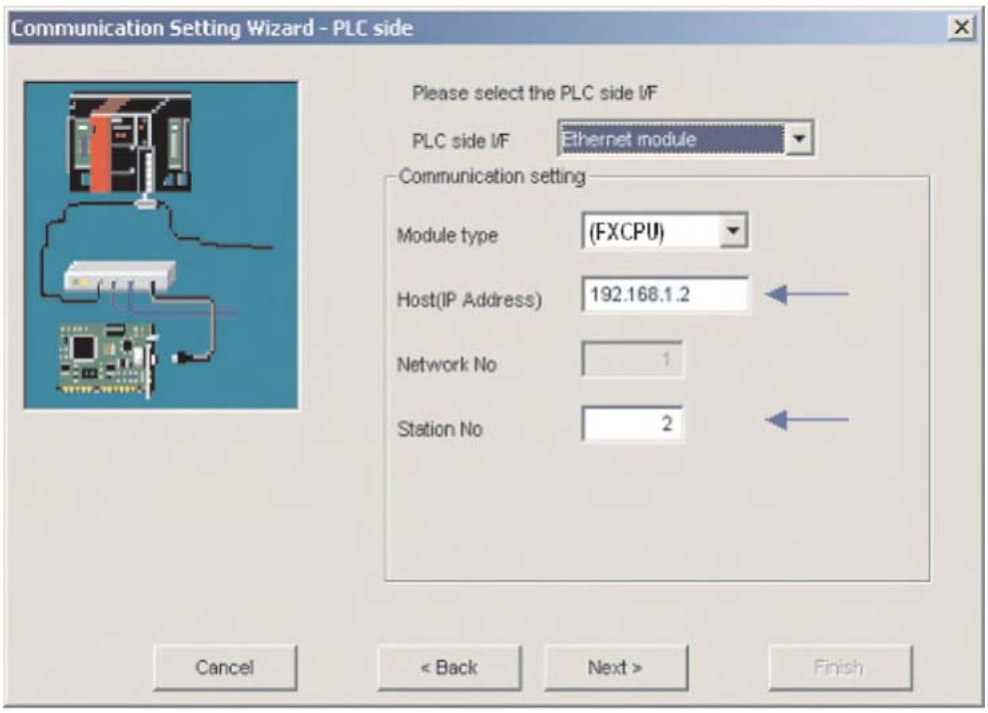
③ Next, configure the ***Communication Settings*** on the PC side



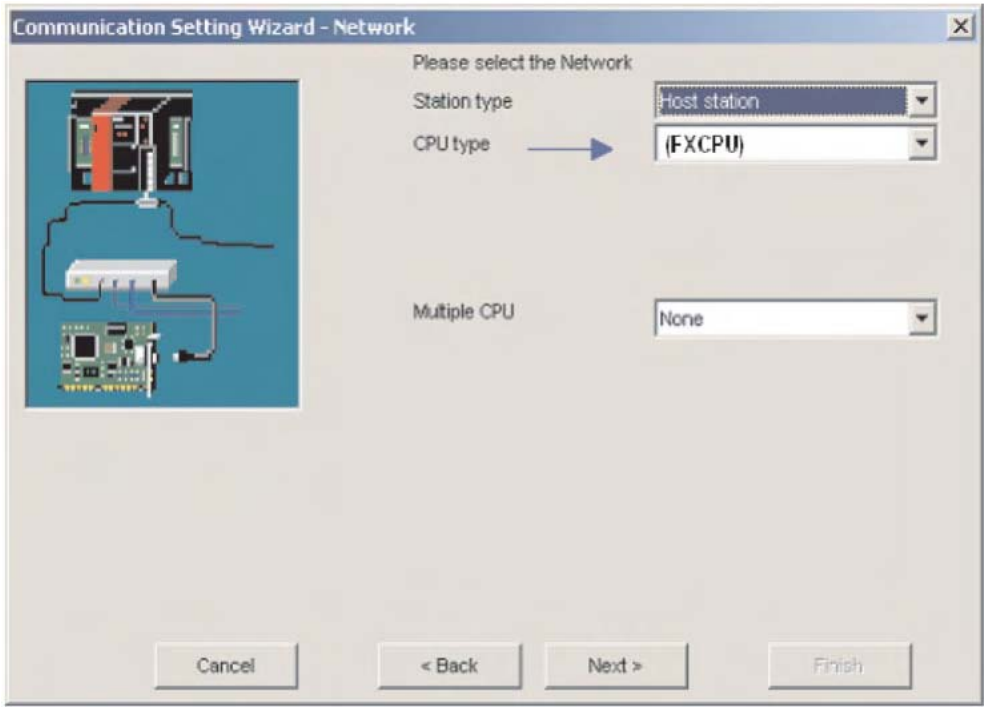
④ Select the UDP protocol and the default Port 5001



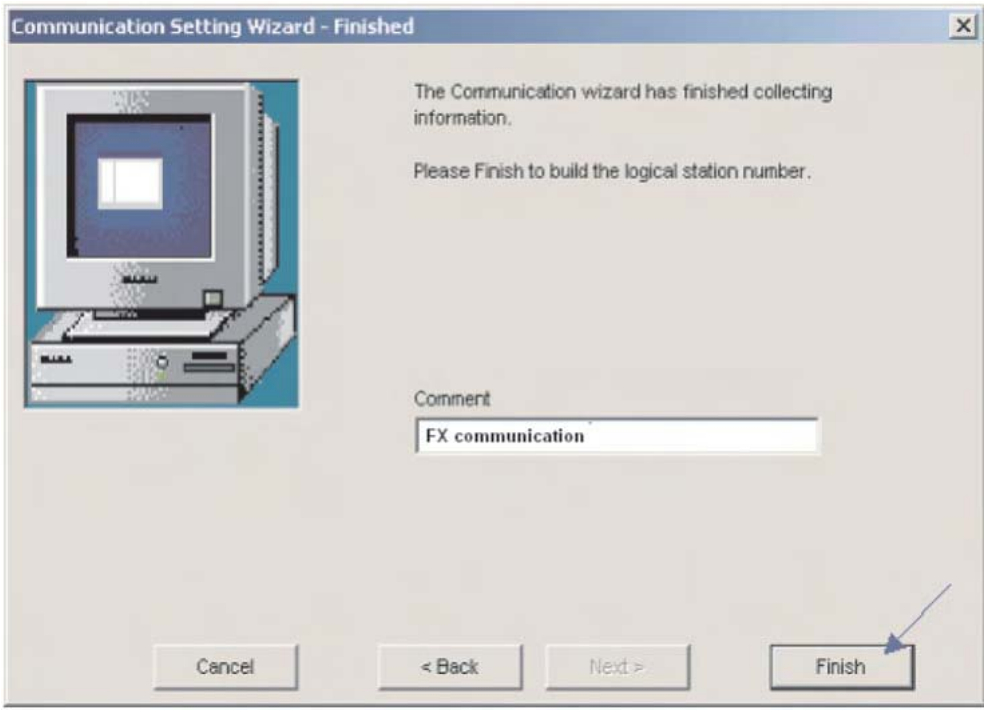
⑤ Configure the communication settings of the PLC side required for the example system described earlier.



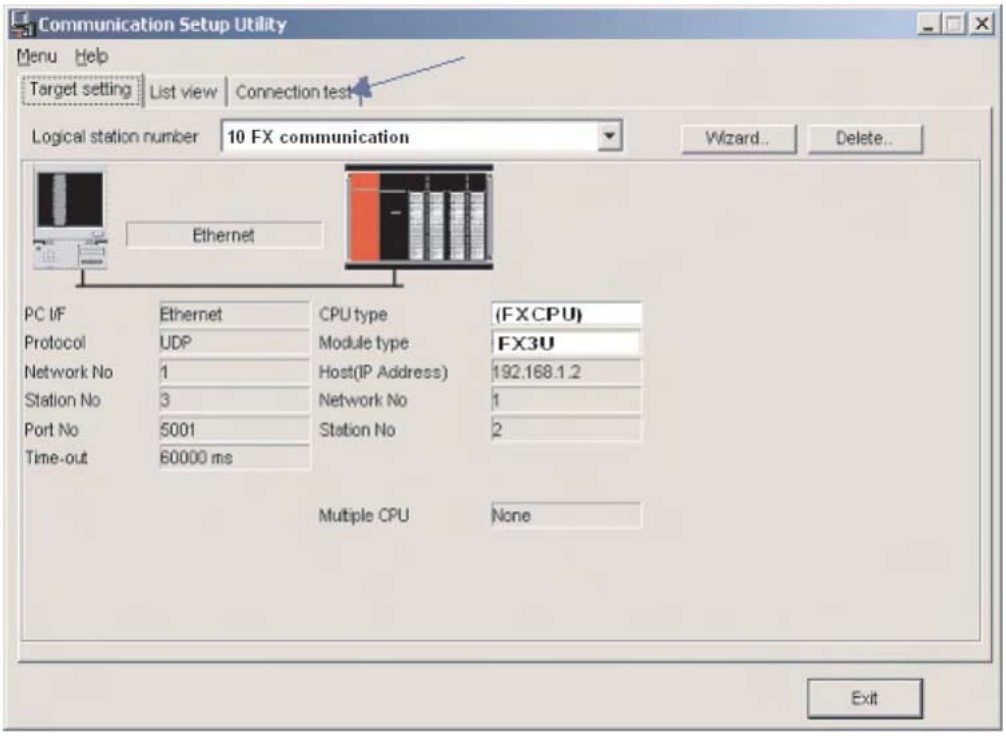
⑥ Select the correct CPU type.



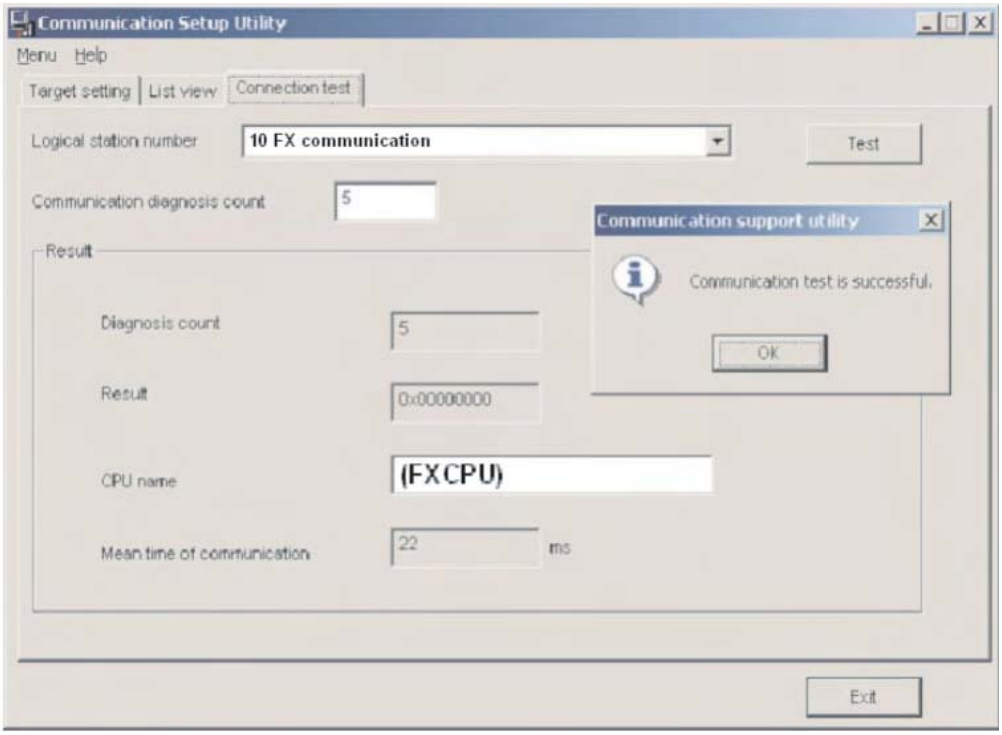
⑦ For the conclusion of the configuration define a name and press the ***Finish*** button



Now the definition of communication is finished. Under the folder ***Connection test*** the connection can be examined.



Select the ***Logical station number*** for which you want to accomplish the test. The ***Diagnosis count*** shows how many successful connection came. ***Result*** shows the test results. In case of an error an error number is indicated.



After configuring the communication paths you can access all controller devices (read/write) with Microsoft programming languages like MS Visual Basic, MS C++ etc.

The Mitsubishi MX components described below are powerful, user-friendly tools that make it very easy to connect your Mitsubishi PLC with the PC world.

A Appendix

A.1 Special Relays

In addition to the relays that you can switch on and off with the PLC program there is also another class of relays known as special or diagnostic relays. These relays use the address range starting with M8000. Some contain information on system status and others can be used to influence program execution. Special relays cannot be used like other internal relays in a sequence program. However, some of them can be set ON or OFF in order to control the CPU. Represented here are some of the most commonly used devices.

Special relays can be divided in two groups:

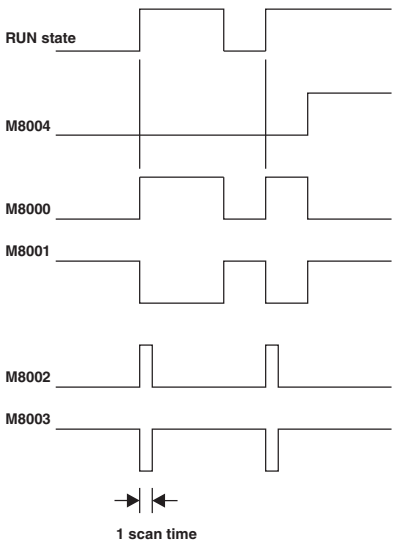
– Special relays whose signal state can only be read by the program (for instance using a LD or LDI instruction).

– Special relays whose signal state can be read and written (set or reset) by the program.

The following tables feature a "Read" and a "Write" column. If the symbol "●" is shown in one of these columns, the corresponding action is possible. The symbol "—" means that the corresponding action is not allowed.

There are also special registers for word information in a FX CPU. They are descriped in the next section.

A.1.1 PLC Status Diagnostic Information (M8000 to M8009)

Special Relay	Read	Write	CPU	Function	
M8000	●	—	FX1S FX1N FX2N FX2NC FX3U	RUN monitor (NO contact)	
M8001	●	—		RUN monitor (NC contact)	
M8002	●	—		Initial pulse (NO contact)	
M8003	●	—		Initial pulse (NC contact)	
M8004	●	—		Error occurrence	
M8005	●	—	FX2N FX2NC FX3U	Battery voltage low (ON when battery voltage is below the value set in D8006)	
M8006	●	—		Battery error latch (M8006 is set when battery voltage low is detected)	
M8007	●	—		Momentary power failure	
M8008	●	—		Power failure detected	
M8009	●	—		24V DC down (service power supply)	

A.1.2 Clock Devices and Real Time Clock (M8011 to M8019)

Special Relay	Read	Write	CPU	Function
M8010	—	—	—	Not used
M8011	●	—	FX1S FX1N FX2N FX2NC FX3U	10 ms clock pulse ON and OFF in 10 ms cycle (ON: 5 ms, OFF: 5 ms)
M8012	●	—		100 ms clock pulse ON and OFF in 100 ms cycle (ON: 50 ms, OFF: 50 ms)
M8013	●	—		1 s clock pulse ON and OFF in 1 s cycle (ON: 500 ms, OFF: 500 ms)
M8014	●	—		1 min clock pulse ON and OFF in 1 min cycle (ON: 30 s, OFF: 30 s)
M8015	●	●		Clock stop and preset (For real time clock)
M8016	●	—		Time read display is stopped (For real time clock) The contents of D8013 to D8019 is frozen, but the clock is still running.
M8017	●	●		±30 seconds correction (For real time clock)
M8018	●	—		Real time clock installation detection (Always ON) For an FX2NC a memory card with integrated RTC must be installed.
M8019	●	—		Real time clock (RTC) setting error

A.1.3 PLC Operation Mode (M8030 to M8039)

Special relay	Read	Write	CPU	Function	
M8030	●	—	FX2N/ FX2NC/FX3U	Battery LED OFF When M8030 set to ON, LED on PLC is not lit even if battery voltage low is detected.	
M8031	●	●	FX1S/ FX1N FX2N FX2NC FX3U	Non-latch memory all clear	If this special auxiliary relays are activated, the ON/OFF image memory of Y, M, S, T, and C, and present values of T, C, D, special data registers and R are cleared to zero. However, file registers (D) in program memory, and extension file registers (ER) in the memory cassette are not cleared.
M8032	●	●		Latch memory all clear	
M8033	●	●		Memory hold STOP When PLC is switched from RUN to STOP, image memory and data memory are retained.	
M8034	●	●		All outputs disable All external output contacts of PLC are turned OFF. The program however is still executed.	
M8035	●	●		Forced RUN mode	
M8036	●	●		Forced RUN signal	
M8037	●	●		Forced STOP signal	
M8038	—	●		Communication parameter setting flag (for N:N network setting)	
M8039	●	●		Constant scan mode When M8039 is ON, PLC waits until scan time specified in D8039 and then executes cyclic operation.	

A.1.4 Error Detection (M8060 to M8069)

Special relay	Read	Write	CPU	Function
M8060	●	—	FX2N/ FX2NC FX3U	I/O configuration error
M8061	●	—	FX1S FX1N FX2N FX2NC FX3U	PLC hardware error
M8062	●	—	FX2N FX2NC	PLC/Programming device communication error
M8063 ①	●	—	FX1S FX1N FX2N FX2NC FX3U	Serial communication error 1 [ch1]
M8064	●	—		Parameter error
M8065	●	—		Syntax error
M8066	●	—		Ladder error
M8067 ②	●	—		Operation error
M8068	—	●		Operation error latch
M8069	—	●	FX2N FX2NC FX3U	I/O bus check ③

① The operation varies according to a PLC: Cleared in an FX1S, FX1N, FX2N, FX1NC, or FX2NC when PLC switches from STOP to RUN. Not cleared in an FX3U PLC.
Serial communication error 2 [ch2] in FX3U PLCs is detected by M8438.

② Cleared when PLC switches from STOP to RUN.

③ When M8069 is ON, I/O bus check is executed.If an error is detected, the error code 6130 is written to special register D8069 and the special relay M8061 is set.

A.1.5 Extension Boards (Dedicated to FX1S and FX1N)

Special relay	Read	Write	CPU	Function
M8112	●	●	FX1S FX1N	Extension board FX1N-4EX-BD: Input BX0
				Extension board FX1N-2AD-BD: ch1 input mode change
				Extension board FX1N-1DA-BD: output mode change
M8113	●	●		Extension board FX1N-4EX-BD: Input BX1
				Extension board FX1N-2AD-BD: ch2 input mode change
M8114	●	●		Extension board FX1N-4EX-BD: Input BX2
M8115	●	●		Extension board FX1N-4EX-BD: Input BX3
M8116	●	●		Extension board FX1N-2EYT-BD: Output BY0
M8117	●	●		Extension board FX1N-2EYT-BD: Output BY1

A.1.6 Analog Special Adapter for FX3U (M8260 to M8299)

Special Register	Read	Write	CPU	Function
M8260 to M8269	●	●	FX3U	1st* special adapter
M8270 bis M8279	●	●		2nd* special adapter
M8280 bis M8289	●	●		3rd* special adapter
M8290 bis M8299	●	●		4th* special adapter

* The unit number of the analog special adapter is counted from the main units side.

A.2 Special Registers

Just like the special relays (section A.1) starting at address M8000 the FX controllers also have special or diagnostic registers, whose addresses start at D8000. Often there is also a direct connection between the special relays and special registers. For example, special relay M8005 shows that the voltage of the PLC's battery is too low, and the corresponding voltage value is stored in special register D8005. The following tables shows a small selection of the available special registers as examples.

Special registers can be divided in two groups:

– Special registers whose value can only be read by the program

– Special relays whose value can be read and written by the program.

The following tables feature a "Read" and a "Write" column. If the symbol "●" is shown in a one of these columns, the corresponding action is possible. The symbol "—" means that the corresponding action is not allowed.

A.2.1 PLC Status Diagnostic Information (D8000 to D8009)

Special Register	Read	Write	CPU	Function
D8000	●	●	FX1S FX1N FX2N FX2NC FX3U	Watchdog timer setting (in 1ms steps). (Writes from system ROM at power ON) Value overwritten by program is valid after END or WDT instruction execution. The setting must be larger than the maximum scan time (stored in D8012). Default value is 200 ms.
D8001	●	—		PLC type and system version FX1S: 22V_{VV} FX1N: 26V_{VV} FX2N/FX2NC/FX3U: 24V_{VV} (e. g. FX1N Version 1.00 → 26100)
D8002	●	—		Memory capacity 0002 → 2k steps (FX1S only) 0004 → 4k steps (FX2N/FX2NC only) 0008 → 8k steps or more (not for FX1S) If 16K steps or more "K8" is written to D8002 and "16" or "64" is written to D8102.
D8003	●	—		Memory typ: 00_H→ RAM (Memory cassette) 01_H→ EPROM (Memory cassette) 02_H→ EEPROM (Memory cassette or flash memory) $0A_H$→ EEPROM (Memory cassette or flash memory, write-protected) 10_H→ Built-in memory in PLC
D8004	●	—		Error number (M) If D8004 contains e.g. the value 8060, special relay M8060 is set.
D8005	—	—	FX2N FX2NC FX3U	Battery voltage (Example: "36" -> 3.6 V)
D8006	—	—		Low battery voltage detection level. Default settings: FX2N/FX2NC: 3.0 V ("30") FX3U: 2.7 V ("27")
D8007	—	—		Momentary power failure count Operation frequency of M8007 is stored. Cleared at power-off.
D8008	—	—	FX2N FX2NC FX3U	Power failure detection Default settings: FX2N/FX3U: 10 ms (AC power supply) FX2NC: 5 ms (DC power supply)
D8009	—	—	FX2N FX2NC FX3U	24V DC failed device Minimum input device number of extension units and extension power units in which 24V DC has failed.

A.2.2 Scan Information and Real Time Clock (D8010 to D8019)

Special Register	Read	Write	CPU	Function
D8010	●	—	FX1S FX1N FX2N FX2NC FX3U	Present scan time (in units of 0.1 ms)
D8011	●	—		Minimum value of scan time (in units of 0.1 ms)
D8012	●	—		Maximum value of scan time (in units of 0.1 ms)
D8013	●	●	FX1S FX1N FX2N FX2NC FX3U	Real time clock: Seconds (0 to 59)
D8014	●	●		Real time clock: Minutes (0 to 59)
D8015	●	●		Real time clock: Hours (0 to 23)
D8016	●	●		Real time clock: Date (Day, 1 to 31)
D8017	●	●		Real time clock: Date (Month, 1 to 12)
D8018	●	●		Real time clock: Date (Year, 0 to 99)
D8019	●	●		Real time clock: Day of the week (0 (Sunday) to 6 (Saturday))

A.2.3 PLC Operation Mode (D8030 to D8039)

Special Register	Read	Write	CPU	Function
D8030	●	—	FX1S FX1N	Value of analog volume VR1 (Integer from 0 to 255)
D8031	●	—		Value of analog volume VR2 (Integer from 0 to 255)
D8032 – D8038	—	—	—	Not used
D8039	—	●	FX1S FX1N FX2N FX2NC FX3U	Constant scan duration Default: 0 ms (in 1 ms steps) (Writes from system ROM at power ON) Can be overwritten by program

A.2.4 Error Codes (D8060 to D8069)

Special Register	Read	Write	CPU	Function
D8060	●	—	FX2N FX2NC FX3U	If the unit or block corresponding to a programmed I/O number is not actually loaded, M8060 is set to ON and the first device number of the erroneous block is written to D8060 Meaning of the four digit code: 1st digit: 0 = Output, 1 = Input 2nd to 4th digit: First device number of the erroneous block
D8061	●	—	FX1S/FX1N FX2N FX2NC FX3U	Error code for PLC hardware error
D8062	●	—	FX2N /FX2NC FX3U	Error code for PLC/PP communication error
D8063	●	—	FX1S FX1N FX2N FX2NC FX3U	Error code for serial communication error 1 [ch1]
D8064	●	—		Error code for parameter error
D8065	●	—		Error code for syntax error
D8066	●	—		Error code for ladder error
D8067	●	—		Error code for operation error
D8068*	—	●		Operation error step number latched In case of 32K steps or more, step number is stored in [D8313, D8312].
D8069*	●	—		Error step number of M8065 to M8067 In case of 32K steps or more, step number is stored in [D8315, D8314].

* Cleared when PLC switches from STOP to RUN.

A.2.5 Extension Boards (Dedicated to FX1S and FX1N)

Special Register	Read	Write	CPU	Function
D8112	●	—	FX1S FX1N	Adapter FX1N-2AD-BD: Digital input value ch.1
D8113	●	—		Adapter FX1N-2AD-BD: Digital input value ch.2
D8114	●	●		Adapter FX1N-1DA-BD: Digital output value ch.1

A.2.6 Analog Special Adapter for FX3U (D8260 to D8299)

Special Register	Read	Write	CPU	Function
D8260 to D8269	●	●	FX3U	1st* special adapter
D8270 bis D8279	●	●		2nd* special adapter
D8280 bis D8289	●	●		3rd* special adapter
D8290 bis D8299	●	●		4th* special adapter

* The unit number of the analog special adapter is counted from the main units side.

A.3 Error Code List

When an error has been detected in the PLC, the error code is stored in special registers D8060 to D8067 and D8438. The following actions should be followed for diagnostic errors.

Represented here are some of the most common error codes.

A.3.1 Error codes 6101 to 6409

Error	Special Register	Error Code	Description	Corrective Action
PLC hardware error	D8061	0000	No error	—
		6101	RAM error	
		6102	Operation circuit error	
		6103	I/O bus error (M8069 = ON)	Check for the correct connection of extension cables.
		6104	Powered extension unit 24 V failure (M8069 = ON)	
		6105	Watchdog timer error	Check user program. The scan time exceeds the value stored in D8000.
		6106	I/O table creation error (CPU error) When turning the power ON to the main unit, a 24V power failure occurs in a powered extension unit. (The error occurs if the 24V power is not supplied for 10 seconds or more after main power turn ON.)	Check the power supply for the powered extension units.
		6107	System configuration error	Check the number of the connected special function units/blocks. A few special function units/blocks are limited the number to connect.
Communication error between PLC and programming device (FX_{2N} and FX_{2NC} only)	D8062	0000	No error	—
		6201	Parity, overrun or framing error	Check the cable connection between the programming device and the PLC. This error may occur when a cable is disconnected and reconnected during PLC monitoring.
		6202	Communication character error	
		6203	Communication data sum check error	
		6204	Data format error	
		6205	Command error	
Serial communication error	D8063	0000	No error	—
		6301	Parity, overrun or framing error	● Inverter communication, computer link and programming: Ensure the communication parameters are correctly set according to their applications. ● N:N network, parallel link, etc.: Check programs according to applications. ● Remote maintenance: Ensure modem power is ON and check the settings of the AT commands. ● Wiring: Check the communication cables for correct wiring.
		6302	Communication character error	
		6303	Communication data sum check error	
		6304	Communication data format error	
		6305	Command error	
		6306	Communication time-out detected	
		6307	Modem initialization error	
		6308	N:N network parameter error	
		6312	Parallel link character error	
		6313	Parallel link sum error	
		6314	Parallel link format error	
		6320	Inverter communication error	

Error	Special Register	Error Code	Description	Corrective Action
Parameter error	D8064	0000	No error	—
		6401	Program sum check error	STOP the PLC, and correctly set the parameters.
		6402	Memory capacity setting error	
		6403	Latched device area setting error	
		6404	Comment area setting error	
		6405	File register area setting error	
		6406	Special unit (BFM) initial value setting, positioning instruction setting sum check error	
		6407	Special unit (BFM) initial value setting, positioning instruction setting error	
		6409	Other setting error	

A.3.2 Error codes 6501 to 6510

Error	Special Register	Error Code	Description	Corrective Action
Syntax error	D8065	0000	Kein Fehler	During programming, each instruction is checked. If a syntax error is detected, modify the instruction correctly.
		6501	Incorrect combination of instruction, device symbol and device number	
		6502	No OUT T or OUT C before setting value	
		6503	– No OUT T or OUT C before setting value – Insufficient number of operands for an applied instruction	
		6504	– Same label number is used more than once. – Same interrupt input or high speed counter input is used more than once.	
		6505	Device number is out of allowable range.	
		6506	Invalid instruction	
		6507	Invalid label number [P]	
		6508	Invalid interrupt input [I]	
		6509	Other error	
		6510	MC nesting number error	

A.3.3 Error codes 6610 to 6632

Error	Special Register	Error Code	Description	Corrective Action
Circuit error	D8066	0000	No error	—
		6610	LD, LDI is continuously used 9 times or more.	This error occurs when a combination of instructions is incorrect in the entire circuit block or when the relationship between a pair of instructions is incorrect. Modify the instructions in the program mode so that their mutual relationship becomes correct.
		6611	More ANB/ORB instructions than LD/LDI instructions	
		6612	Less ANB/ORB instructions than LD/LDI instructions	
		6613	MPS is continuously used 12 times or more.	
		6614	No MPS instruction	
		6615	No MPP instruction	
		6616	No coil between MPS, MRD and MPP, or incorrect combination	
		6617	Instruction below is not connected to bus line: STL, RET, MCR, P, I, DI, EI, FOR, NEXT, SRET, IRET, FEND or END	
		6618	STL, MC or MCR can be used only in main program, but it is used elsewhere (e.g. in interrupt routine or subroutine).	
		6619	Invalid instruction is used in FOR-NEXT loop: STL, RET, MC, MCR, I (interrupt pointer) or IRET.	
		6620	FOR-NEXT instruction nesting level exceeded	
		6621	Numbers of FOR and NEXT instructions do not match.	
		6622	No NEXT instruction	
		6623	No MC instruction	
		6624	No MCR instruction	
		6625	STL instruction is continuously used 9 times or more.	
		6626	Invalid instruction is programmed within STL-RET loop: MC, MCR, I (interrupt pointer), SRET or IRET.	
		6627	No RET instruction	
		6628	Invalid instruction is used in main program: I (interrupt pointer), SRET or IRET	
		6629	No P or I (interrupt pointer)	
		6630	No SRET or IRET instruction	
		6631	SRET programmed in invalid location	
		6632	FEND programmed in invalid location	

A.3.4 Error codes 6701 to 6710

Error	Special Register	Error Code	Description	Corrective Action
Operation error	D8067	0000	No error	—
		6701	– No jump destination (pointer) for CJ or CALL instruction – Label is undefined or out of P0 to P4095 due to indexing – Label P63 is executed in CALL instruction; cannot be used in CALL instruction as P63 is for jumping to END instruction.	This error occurs in the execution of operation. Review the program, or check the contents of the operands used in the applied instructions.*
		6702	CALL instruction nesting level is 6 or more	
		6703	Interrupt nesting level is 3 or more	
		6704	FOR-NEXT instruction nesting level is 6 or more.	
		6705	Operand of applied instruction is inapplicable device.	
		6706	Device number range or data value for operand of applied instruction exceeds limit.	
		6707	File register is accessed without parameter setting of file register.	
		6708	FROM/TO instruction error	This error occurs in the execution of operation. Review the program, or check the contents of the operands used in the applied instructions. Check whether the specified buffer memories exist in the equipment. Check whether the extension cables are correctly connected.
		6709	Other (e.g. improper branching)	This error occurs in the execution of operation. Review the program, or check the contents of the operands used in the applied instructions.*
		6710	Mismatch among parameters	This error occurs when the same device is used within the source and destination in a shift instruction, etc.

* Even if the syntax or circuit design is correct, an operation error may still occur.For example: "T200Z" itself is not an error. But if Z had a value of 400, the timer T600 would be attempted to be accessed. This would cause an operation error since there is no T600 device available.

A.4 Number of Occupied Input/Output Points and Current Consumption

The following tables show how many input/output points are occupied in a base unit by a certain unit, along with the power supply type and current consumption values needed for selecting a product.

The current consumption is determined differently in the following cases.

5V DC and internal 24V DC are supplied to the products through an extension cable, and the current consumption must be calculated

Subtract the current consumption at the internal 24V DC as follows.

– For the AC power type main unit, subtract the current consumption at the internal 24V DC from the 24V DC service power supply.

– For the DC power type main unit, subtract the current consumption at the internal 24V DC from the power supply for the internal 24V DC.

– Some special function modules need "external 24 V DC". Include this current in the calculation of current consumption when the current is supplied by the 24V DC service power supply. When the current is supplied by an external power supply, the current is not included in the calculation of current consumption.

A.4.1 Interface Adapter Boards and Communication Adapter Boards

Type	Number of occupied I/O points	Current consumption [mA]		
		5 V DC	24 V DC (internal)	24 V DC (external)
FX1N-232-BD	—	20	—	—
FX2N-232-BD	—			
FX3U-232-BD	—			
FX1N-422-BD	—	60*	—	—
FX2N-422-BD	—			
FX3U-422-BD	—	20*	—	—
FX1N-485-BD	—	60	—	—
FX2N-485-BD	—			
FX3U-485-BD	—	40	—	—
FX3U-USB-BD	—	15	—	—
FX1N-CNV-BD	—	—	—	—
FX2N-CNV-BD				
FX3U-CNV-BD				

* When a programming tool or GOT is connected, add the current consumed by this unit (see next page)

Programming Tool, Interface Converter, Display Module and GOT

Type	Number of occupied I/O points	Current consumption [mA]		
		5 V DC	24 V DC (internal)	24 V DC (external)
FX-20P(-E)	—	150	—	—
FX-232AWC-H	—	120	—	—
FX-USB-AW	—	15	—	—
FX3U-7DM		20		
FX10DM-E	—	220	—	—
F920GOT-BBD5-K-E	—	220	—	—

A.4.2 Special Adapters

Type	Number of occupied I/O points	Current consumption [mA]			
		5 V DC	24 V DC (internal)	24 V DC (external)	At start up
FX3U-4HSX-ADP	—	30	30	0	30*
FX3U-2HSY-ADP	—	30	60	0	120*
FX3U-4AD-ADP	—	15	0	40	—
FX3U-4DA-ADP	—	15	0	150	—
FX3U-4AD-PT-ADP	—	15	0	50	—
FX3U-4AD-TC-ADP	—	15	0	45	—
FX2NC-232ADP	—	100	0	0	—
FX3U-232ADP	—	30	0	0	—
FX3U-485ADP	—	20	0	0	—

* The current consumption at start up must be considered when connected to a DC powered base unit.

A.4.3 Extension Blocks

Type	Number of occupied I/O points	Current consumption [mA]		
		5 V DC	24 V DC (internal)	24 V DC (external)
FX2N-8ER-ES/UL	16	–	125	0
FX2N-8EX-ES/UL	8	—	50	0
FX2N-16EX-ES/UL	16	—	100	0
FX2N-8EYR-ES/UL	8	—	75	0
FX2N-8EYT-ESS/UL	8	—	75	0
FX2N-16EYR-ES/UL	16	—	150	0
FX2N-16EYT-ESS/UL	16	—	150	0

A.4.4 Special Function Modules

Type	Number of occupied I/O points	Current consumption [mA]			
		5 V DC	24 V DC (internal)	24 V DC (external)	At start up
FX3U-4AD	8	110	0	90	—
FX3U-4DA	8	120	0	160	—
FX3U-20SSC-H	8	100	0	220	—
FX2N-2AD	8	20	50 ①	0	170
FX2N-2DA	8	30	85 ①	0	190
FX2N-4AD	8	30	0	55	—
FX2N-4DA	8	30	0	200	—
FX2N-4AD-TC	8	30	0	50	—
FX2N-4AD-PT	8	30	0	50	—
FX2N-8AD	8	50	0	80	—
FX2N-5A	8	70	0	90	—
FX2N-2LC	8	70	0	55	—
FX2N-1HC	8	90	0	0	—
FX2N-1PG-E	8	55	0	40	—
FX2N-10PG	8	120	0	70 ②	—
FX2N-232IF	8	40	0	80	—
FX2N-16CCL-M	8 ③	0	0	150	—
FX2N-32CCL-M	8	130	0	50	—
FX2N-32ASI-M	8 ④	150	0	70	—
FX0N-3A	8	30	90 ①	0	165
FX2N-10GM	8	—	—	5	—
FX2N-20GM	8	—	—	10	—

① When analog special function blocks (FX0N-3A, FX2N-2AD and FX2N-2DA) are connected to an input/ output powered extension unit (FX2N-32E□ or FX2N-48E□), the following limitation must be taken into consideration. (When the blocks are connected to the main unit, this limitation is not applied.)

The total current consumption of the analog special function blocks (FX0N-3A, FX2N-2AD and FX2N-2DA) should be less than the following current values.
- When connected to FX2N-32E□: 190 mA or less
- When connected to FX2N-48E□: 300 mA or less.

② When the voltage of the external DC power supply is 5 V DC, the current is 100 mA.

③ A FX2N-16CCL-M cannot be used together with a FX2N-32ASI-M. The following number of points is added according to the products connected to the network: (Number of remote I/O stations) x 32 points.

④ A FX2N-32ASI-M cannot be used together with a FX2N-16CCL-M. Only one unit can be added to the whole system. The following number of points is added according to the products connected to the network: (Number of active slaves) x 8 points.

A.5 PLC Components Glossary

The following table describes the meaning and functionality of the single components und parts of a Mitsubishi PLC.

Component	Description
Connection for expansion adapter boards	Optional expansion adapter boards can be connected to this interface. A variety of different adapters are available for all FX lines (except the FX2NC). These adapters extend the capabilities of the controllers with additional functions or communications interfaces. The adapter boards are plugged directly into the slot.
Connection for programming units	This connection can be used for connecting the FX-20P-E hand-held programming unit or an external PC or notebook with a programming software package (e.g. GX Developer).
EEPROM	Read/write memory in which the PLC program can be stored and read with the programming software. This solid-state memory retains its contents without power, even in the event of a power failure, and does not need a battery.
Memory cassette slot	Slot for optional memory cassettes. Inserting a memory cassette disables the controller's internal memory – the controller will then only execute the program stored in the cassette.
Extension bus	Both additional I/O expansion modules and special function modules that add additional capabilities to the PLC system can be connected here. See Chapter 6 for an overview of the available modules.
Analog potentiometers	The analog potentiometers are used for setting analog setpoint values. The setting can be polled by the PLC program and used for timers, pulse outputs and other functions.
Service power supply	The service power supply (not for FX2NC) provides a regulated 24V DC power supply source for the input signals and the sensors. The capacity of this power supply depends on the controller model (e.g. FX1S and FX1N: 400mA; FX2N-16M□-□□ through FX2N-32M□-□□: 250 mA, FX2N-48M□-□□ through FX2N-64M□-□□: 460 mA)
Digital inputs	The digital inputs are used for inputting control signals from the connected switches, buttons or sensors. These inputs can read the values ON (power signal on) and OFF (no power signal).
Digital outputs	You can connect a variety of different actuators and other devices to these outputs, depending on the nature of your application and the output type.
LEDs for indicating the input status	These LEDs show which inputs are currently connected to a power signal, i.e. a defined voltage. When a signal is applied to an input the corresponding LED lights up, indicating that the state of the input is ON.
LEDs for indicating the output status	These LEDs show the current ON/OFF states of the digital outputs. These outputs can switch a variety of different voltages and currents depending on the model and output type.
LEDs for indicating the operating status	The LEDs RUN, POWER and ERROR show the current status of the controller. POWER shows that the power is switched on, RUN lights up when the PLC program is being executed and ERROR lights up when an error or malfunction is registered.
Memory battery	The battery protects the contents of the MELSELC PLC's volatile RAM memory in the event of a power failure (FX2N, FX2NC and FX3U only). It protects the latched ranges for timers, counters and relays. In addition to this it also provides power for the integrated real-time clock when the PLC's power supply is switched off.
RUN/STOP switch	MELSEC PLCs have two operating modes, RUN and STOP. The RUN/STOP switch allows you to switch between these two modes manually. In RUN mode the PLC executes the program stored in its memory. In STOP mode program execution is stopped and it is possible to program the controller.

Index

A

Adapter boards . . . . . 2 - 17
Analog modules . . . . . 2 - 18
Arrays
  Overview . . . . . 3 - 16
  programming . . . . . 12 - 1
AS interface . . . . . 2 - 27
  Network module . . . . . 2 - 27
Auto connect . . . . . 4 - 20

B

Base unit
  FX1N . . . . . 2 - 9
  FX1S . . . . . 2 - 8
  FX2N . . . . . 2 - 9
  FX2NC . . . . . 2 - 10
  FX3U . . . . . 2 - 10
  Overview . . . . . 2 - 6
  Power supply . . . . . 2 - 11
  S/S terminal . . . . . 2 - 12

C

CANopen
  Network module . . . . . 2 - 26
CC-Link
  Network modules . . . . . 2 - 25
Comment
  copying . . . . . 4 - 34
  deleting . . . . . 4 - 34
  for program networks . . . . . 4 - 33
Communication adapters . . . . . 2 - 29
Connection setup . . . . . 19 - 9
Connection Setup . . . . . 4 - 37
Connection Test . . . . . 4 - 39
Counter
  Device addresses . . . . . 3 - 20
  programming . . . . . 4 - 25
Counter modules . . . . . 2 - 20
Cross Reference . . . . . 4 - 47

D

Data types . . . . . 3 - 15
Data Unit Types . . . . . 3 - 17, 11 - 1
Debug Menu
  Device Edit . . . . . 9 - 1
  Forcing In- and Outputs . . . . . 8 - 1
Device Edit (function in Debug menu) . . . . . 9 - 1
DeviceNet
  Network modules . . . . . 2 - 26
Display Mode . . . . . 9 - 3
Documentation
  Network Comments . . . . . 4 - 33
  Network Header . . . . . 4 - 33
  Print options . . . . . 4 - 51
Download of programs . . . . . 4 - 41
DUT . . . . . 3 - 17
  see Data Unit Types

E

EEPROM . . . . . A - 14
EN-Input . . . . . 6 - 22
ENO-Output . . . . . 6 - 22
Entry Data Monitor
  customising . . . . . 7 - 2
  selection . . . . . 7 - 1
Error codes . . . . . A - 7
ETHERNET
  Configuration . . . . . 19 - 1
  Network modules . . . . . 2 - 22
Extension
  blocks . . . . . 2 - 16
  boards . . . . . 2 - 15
  units . . . . . 2 - 15

F

Floating point values
  see REAL Numbers
Function
  comparison with Function Blocks . . . . . 6 - 1
  creation . . . . . 6 - 2
  duplicating . . . . . 6 - 10
  Result type . . . . . 6 - 11

Function Block
assigning instance names · · · · · · · · · 6 - 16
assigning of DUT variables · · · · · · · · 11 - 8
assigning variables · · · · · · · · · · · · 6 - 18
comparison with Funktion · · · · · · · · · 6 - 1
creation · · · · · · · · · · · · · · · · · · 6 - 14
entering into Ladder program · · · · · · · 4 - 18
execution options · · · · · · · · · · · · · 6 - 21
Instances · · · · · · · · · · · · · · · · · 4 - 25
monitoring instances · · · · · · · · · · · 7 - 11
Function Block Diagram · · · · · · · · · · · 3 - 13
FX family
Current consumption · · · · · · · · · · · A - 11
occupied I/O points · · · · · · · · · · · · A - 11
Overview · · · · · · · · · · · · · · · · · · 2 - 6
Power supply · · · · · · · · · · · · · · · 2 - 11
FX0N-32NT-DP· · · · · · · · · · · · · · · · 2 - 23
FX1N-8AV-BD · · · · · · · · · · · · · · · · 2 - 30
FX1N-CNV-BD · · · · · · · · · · · · · · · · 2 - 29
FX2N-10PG· · · · · · · · · · · · · · · · · · 2 - 21
FX2N-16CCL-M · · · · · · · · · · · · · · · 2 - 25
FX2N-1HC · · · · · · · · · · · · · · · · · · 2 - 20
FX2N-1PG-E · · · · · · · · · · · · · · · · · 2 - 21
FX2N-232IF· · · · · · · · · · · · · · · · · · 2 - 28
FX2N-32ASI-M · · · · · · · · · · · · · · · · 2 - 27
FX2N-32CAN · · · · · · · · · · · · · · · · · 2 - 26
FX2N-32CCL · · · · · · · · · · · · · · · · · 2 - 25
FX2N-32DP-IF · · · · · · · · · · · · · · · · 2 - 24
FX2N-64DNET · · · · · · · · · · · · · · · · 2 - 26
FX2N-8AV-BD · · · · · · · · · · · · · · · · 2 - 30
FX2NC-ENET-ADP· · · · · · · · · · · · · · · 2 - 22
FX2N-CNV-BD · · · · · · · · · · · · · · · · 2 - 29
FX3U-20SSC-H · · · · · · · · · · · · · · · · 2 - 21
FX3U-2HSY-ADP· · · · · · · · · · · · · · · · 2 - 20
FX3U-4HSX-ADP· · · · · · · · · · · · · · · · 2 - 20
FX3U-64DP-M · · · · · · · · · · · · · · · · 2 - 23
FX3U-CNV-BD · · · · · · · · · · · · · · · · 2 - 29
FX3U-ENET · · · · · · · · · · · · · · · · · 2 - 22

G

Global Variables
assigning · · · · · · · · · · · · · · · · · 4 - 9
Definition · · · · · · · · · · · · · · · · · 3 - 6
List · 3 - 6
Global Variables List
adding entries · · · · · · · · · · · · · · · 4 - 26
assigning of variables · · · · · · · · · · · 4 - 9
checking· · · · · · · · · · · · · · · · · · 4 - 12
Glossary · · · · · · · · · · · · · · · · · · A - 14
Grounding · · · · · · · · · · · · · · · · · 2 - 11
Guided Ladder Entry Mode· · · · · · · · · · 4 - 36
GVL
see Global Variable List
GX Configurator DP · · · · · · · · · · · · · 18 - 1

H

HMI· 2 - 2

I

IEC61131-3 · · · · · · · · · · · · · · · · · 3 - 1
Inputs
Assignment · · · · · · · · · · · · · · · · 2 - 37
wiring · · · · · · · · · · · · · · · · · · · 2 - 12
Instance
for function blocks· · · · · · · · · · · · · 6 - 16
Instruction List · · · · · · · · · · · · · · · 3 - 11
Interconnect Mode · · · · · · · · · · · · · · 4 - 20
Interface
adapters· · · · · · · · · · · · · · · · · · 2 - 28
modules · · · · · · · · · · · · · · · · · · 2 - 28

L

Labels· 3 - 10
Ladder Diagram
entering a Function Block · · · · · · · · · 4 - 18
Guided Ladder Entry Mode · · · · · · · · 4 - 36
Overview · · · · · · · · · · · · · · · · · · 3 - 12
Precautions · · · · · · · · · · · · · · · · 4 - 21
programming · · · · · · · · · · · · · · · · 4 - 14
Local Variables
define new · · · · · · · · · · · · · · · · · 4 - 19
Definition · · · · · · · · · · · · · · · · · · 3 - 6
List · 3 - 6
LVL
see Local Variable List

M

Macrocode execution· · · · · · · · · · · · · 6 - 21
MELSEC · · · · · · · · · · · · · · · · · · · 2 - 6
Memory battery· · · · · · · · · · · · · · · · A - 14
Monitor headers (function in Monitor Mode) · · 7 - 6

N

Network Comments . . . . . 4 - 33
Network Header . . . . . 4 - 33
Network modules
  AS interface . . . . . 2 - 27
  CANopen . . . . . 2 - 26
  CC-Link . . . . . 2 - 25
  DeviceNet . . . . . 2 - 26
  ETHERNET . . . . . 2 - 22
  PROFIBUS . . . . . 2 - 23
Network number (Ethernet parameter) . . . . 19 - 4
Network Parameter . . . . . 19 - 2

O

Online menu
  Transfer Setup . . . . . 4 - 37
Online Menu
  Entry Data Monitor . . . . . 7 - 1
  Monitor Header . . . . . 7 - 6
  Start Monitoring . . . . . 7 - 7
Online Program Change (function in Project Menu) . . . . . 10 - 3
Open settings (Ethernet) . . . . . 19 - 6
Operational settings (Ethernet) . . . . . 19 - 4
Optical couplers . . . . . 2 - 8
Outputs
  Assignment . . . . . 2 - 37
  wiring . . . . . 2 - 13

P

PLC
  comparison with relay systems . . . . . 2 - 1
  Diagnostics . . . . . 4 - 50
  History . . . . . 2 - 1
PLCopen . . . . . 3 - 1
Positioning modules . . . . . 2 - 21
POU
  assigning to Task . . . . . 4 - 30
  creation of new . . . . . 4 - 8
  Definition . . . . . 3 - 2
  Header . . . . . 4 - 13
  programming . . . . . 4 - 14
POU Pool
  Definition . . . . . 3 - 4
Process image processing . . . . . 2 - 4
PROFIBUS/DP
  configuration . . . . . 18 - 1
  Network module . . . . . 2 - 23
Program
  check . . . . . 4 - 23
  cross reference . . . . . 4 - 47
  download to PLC . . . . . 4 - 37
  monitoring . . . . . 4 - 44
Programmable Logic Controller
  see PLC
Project
  I/O Assignment . . . . . 2 - 37
Project Menu
  Change Passwords . . . . . 14 - 1
  Change Security Level . . . . . 14 - 2
  Online Programm Change . . . . . 10 - 3
Properties (of a Task) . . . . . 4 - 31

R

Real variables
  modifying in monitor mode . . . . . 7 - 10
Relay
  comparison with PLC systems . . . . . 2 - 1
Result type
  for function . . . . . 6 - 11
RUN/STOP switch . . . . . A - 14

S

SCADA . . . . . 2 - 2
Sequential Function Chart
  Overview . . . . . 3 - 14
Service power supply . . . . . A - 14
SFC
  Initial step . . . . . 15 - 2
  Overview . . . . . 3 - 14
  Termination step . . . . . 15 - 2
  Transitions . . . . . 15 - 2
Sink
  inputs . . . . . 2 - 12
  outputs . . . . . 2 - 14
Source
  inputs . . . . . 2 - 12
  outputs . . . . . 2 - 14
Special adapter
  connection . . . . . 2 - 32
  descriped . . . . . 2 - 17
Special function modules
  address . . . . . 2 - 38
  descriped . . . . . 2 - 17

Special Register
described . . . . . A - 4
Diagnostic information . . . . . A - 5
Error codes . . . . . A - 6
PLC operation mode . . . . . A - 5
Real time clock . . . . . A - 5
Special Relays
described . . . . . A - 1
Diagnostic information . . . . . A - 1
Error detection . . . . . A - 3
PLC operation mode . . . . . A - 2
Real time clock . . . . . A - 2
Start Monitoring (function in Online menu) . . . 7 - 7
Station number (Ethernet parameter) . . . . 19 - 4
Structured Text . . . . . 3 - 12
System Image . . . . . 4 - 40

T

Task
assigning a POU . . . . . 4 - 30
Attributes . . . . . 4 - 31
create new . . . . . 4 - 29
Definition . . . . . 3 - 3
Pool . . . . . 3 - 7
Properties . . . . . 4 - 31
Task Pool
Definition . . . . . 3 - 7
Temperature control module . . . . . 2 - 18, 2 - 19
Timer
Device addresses . . . . . 3 - 20
programming . . . . . 4 - 27
Trouble shooting
Error codes . . . . . A - 7
Special registers . . . . . A - 6
Special relays . . . . . A - 3

V

Variables
assigning to a instruction . . . . . 4 - 19
Global (Definition) . . . . . 3 - 6
see also Global Variables
Local (Definition) . . . . . 3 - 6
see also Local Variables
selection from POU Header . . . . . 4 - 16

Global Partner. Local Friend.

EUROPE
MITSUBISHI ELECTRIC
EUROPE B.V.
German Branch
Gothaer Straße 8
D-40880 Ratingen
Phone: +49 (0) 2102 / 486-0
Fax: +49 (0) 2102 / 486-1120
e mail: megfamail@meg.mee.com

FRANCE
MITSUBISHI ELECTRIC EUROPE B.V.
French Branch
25, Boulevard des Bouvets
F-92741 Nanterre Cedex
Phone: +33 1 55 68 55 68
Fax: +33 1 55 68 56 85
e mail: factory.automation@fra.mee.com

IRELAND
MITSUBISHI ELECTRIC EUROPE B.V.
Irish Branch
Westgate Business Park, Ballymount
IRL-Dublin 24
Phone: +353 (0) 1 / 419 88 00
Fax: +353 (0) 1 / 419 88 90
e mail: sales.info@meir.mee.com

ITALY
MITSUBISHI ELECTRIC EUROPE B.V.
Italian Branch
Via Paracelso 12
I-20041 Agrate Brianza (MI)
Phone: +39 039 6053 1
Fax: +39 039 6053 312
e mail: factory.automation@it.mee.com

SPAIN
MITSUBISHI ELECTRIC EUROPE B.V.
Spanish Branch
Carretera de Rubí 76-80
E-08190 Sant Cugat del Vallés
Phone: +34 9 3 / 565 3160
Fax: +34 9 3 / 589 1579
e mail: industrial@sp.mee.com

UK
MITSUBISHI ELECTRIC EUROPE B.V.
UK Branch
Travellers Lane
GB-Hatfield Herts. AL10 8 XB
Phone: +44 (0) 1707 / 27 61 00
Fax: +44 (0) 1707 / 27 86 95
e mail: automation@meuk.mee.com

JAPAN
MITSUBISHI ELECTRIC CORPORATION
Office Tower "Z" 14 F
8-12,1 chome, Harumi Chuo-Ku
Tokyo 104-6212
Phone: +81 3 6221 6060
Fax: +81 3 6221 6075

USA
MITSUBISHI ELECTRIC AUTOMATION
500 Corporate Woods Parkway
Vernon Hills, IL 60061
Phone: +1 847 / 478 21 00
Fax: +1 847 / 478 22 83

AUSTRIA
GEVA
Wiener Straße 89
AT-2500 Baden
Phone: +43 (0) 2252 / 85 55 20
Fax: +43 (0) 2252 / 488 60
e mail: office@geva.at

BELARUS
TEHNIKON
Oktjabrskaya 16/5, Ap 704
BY-220030 Minsk
Phone: +375 (0)17 / 210 4626
Fax: +375 (0)17 / 210 4626
e mail: tehnikon@belsonet.net

BELGIUM
Koning & Hartman B.V.
Researchpark Zellik, Pontbeeklaan 43
BE-1731 Brussels
Phone: +32 (0)2 / 467 17 51
Fax: +32 (0)2 / 467 17 45
e mail: info@koningenhartman.com

BULGARIA
AKHNATON
Andrej Ljapchev Lbvd. Pb 21 4
BG-1756 Sofia
Phone: +359 (0) 2 / 97 44 05 8
Fax: +359 (0) 2 / 97 44 06 1
e mail: —

CZECH REPUBLIC
AutoCont
Control Systems s.r.o.
Nemocnicni 12
CZ-702 00 Ostrava 2
Phone: +420 59 / 6152 111
Fax: +420 59 / 6152 562
e mail: consys@autocont.cz

DENMARK
louis poulsen
industri & automation
Geminivej 32
DK-2670 Greve
Phone: +45 (0) 70 / 10 15 35
Fax: +45 (0) 43 / 95 95 91
e mail: lpia@lpmail.com

ESTONIA
UTU Elektrotehnika AS
Pärnu mnt.160i
EE-11317 Tallinn
Phone: +372 (0) 6 / 51 72 80
Fax: +372 (0) 6 / 51 72 88
e mail: utu@utu.ee

FINLAND
Beijer Electronics OY
Ansatie 6a
FIN-01740 Vantaa
Phone: +358 (0) 9 / 886 77 500
Fax: +358 (0) 9 / 886 77 555
e mail: info@beijer.fi

GREECE
UTECO A.B.E.E.
5, Mavrogenous Str.
GR-18542 Piraeus
Phone: +302 (0) 10 / 42 10 050
Fax: +302 (0) 10 / 42 12 033
e mail: sales@uteco.gr

HUNGARY
Meltrade Ltd.

Fertõ Utca 14.
HU-1107 Budapest
Phone: +36 (0)1 / 431-9726
Fax: +36 (0)1 / 431-9727
e mail: office@meltrade.hu

ISRAEL
TEXEL Electronics Ltd.
Box 6272
IL-42160 Netanya
Phone: +972 (0) 9 / 863 08 91
Fax: +972 (0) 9 / 885 24 30
e mail: texel_me@netvision.net.il

KAZAKHSTAN
Kazpromautomatics Ltd.
2, Scladskaya Str.
KAZ-470046 Karaganda
Phone: +7 3212 50 11 50
Fax: +7 3212 50 11 50
e mail: info@kpakz.com

LATVIA
SIA POWEL
Lienes iela 28
LV-1009 Riga
Phone: +371 784 / 22 80
Fax: +371 784 / 22 81
e mail: utu@utu.lv

LITHUANIA
UAB UTU POWEL
Savanoriu pr. 187
LT-2053 Vilnius
Phone: +370 (0) 52323-101
Fax: +370 (0) 52322-980
e mail: powel@utu.lt

MOLDOVA
INTEHSIS SRL
Cuza-Voda 36/1-81
MD-2061 Chisinau
Phone: +373 (0)2 / 562 263
Fax: +373 (0)2 / 562 263
e mail: intehsis@mdl.net

NETHERLANDS
Koning & Hartman B.V.
Donauweg 2 B
NL-1000 AK Amsterdam
Phone: +31 (0)20 / 587 76 00
Fax: +31 (0)20 / 587 76 05
e mail: info@koningenhartman.com

NORWAY
Beijer Electronics A/S
Teglverksveien 1
N-3002 Drammen
Phone: +47 (0) 32 / 24 30 00
Fax: +47 (0) 32 / 84 85 77
e mail: info@beijer.no

POLAND
MPL Technology Sp. z o.o.
ul. Sliczna 36
PL-31-444 Kraków
Phone: +48 (0) 12 / 632 28 85
Fax: +48 (0) 12 / 632 47 82
e mail: krakow@mpl.pl

ROMANIA
Sirius Trading & Services srl
Str. Biharia No. 67-77
RO-013981 Bucuresti 1
Phone: +40 (0) 21 / 201 1146
Fax: +40 (0) 21 / 201 1148
e mail: sirius@siriustrading.ro

RUSSIA
Avtomatika Sever Ltd.
Lva Tolstogo Str. 7, Off. 311
RU-197376 St Petersburg
Phone: +7 812 1183 238
Fax: +7 812 1183 239
e mail: as@avtsev.spb.ru

RUSSIA
Consys
Promyshlennaya St. 42
RU-198099 St Petersburg
Phone: +7 812 325 3653
Fax: +7 812 147 2055
e mail: consys@consys.spb.ru

RUSSIA
Electrotechnical Systems Siberia
Shetinkina St. 33, Office 116
RU-630088 Novosibirsk
Phone: +7 3832 / 119598
Fax: +7 3832 / 119598
e mail: info@eltechsystems.ru

RUSSIA
Elektrostyle
Poslannikov Per., 9, Str. 1
RU-107005 Moscow
Phone: +7 095 542 4323
Fax: +7 095 956 7526
e mail: info@estl.ru

RUSSIA
Elektrostyle
Krasnij Prospekt 220-1, Office No. 312
RU-630049 Novosibirsk
Phone: +7 3832 / 106618
Fax: +7 3832 / 106626
e mail: info@estl.ru

RUSSIA
ICOS
Industrial Computer Systems Zao
Ryazanskij Prospekt, 8A, Off. 100
RU-109428 Moscow
Phone: +7 095 232 0207
Fax: +7 095 232 0327
e mail: mail@icos.ru

RUSSIA
NPP Uralelektra
Sverdlova 11A
RU-620027 Ekaterinburg
Phone: +7 34 32 / 532745
Fax: +7 34 32 / 532745
e mail: elektra@etel.ru

RUSSIA
STC Drive Technique
Poslannikov Per., 9, Str. 1
RU-107005 Moscow
Phone: +7 095 790 7210
Fax: +7 095 790 7212
e mail: info@privod.ru

SERBIA AND MONTENEGRO
INEA SR d.o.o.
Karadjordjeva 12/260
SCG-113000 Smederevo
Phone: +381 (0)26/ 617 - 163
Fax: +381 (0)26/ 617 - 163
e mail: inea_sr@verat.net

SLOVAKIA
AutoCont Control s.r.o.
Radlinského 47
SK-02601 Dolný Kubín
Phone: +421 435868 210
Fax: +421 435868 210
e mail: info@autocontcontrol.sk

SLOVENIA
INEA d.o.o.
Stegne 11
SI-1000 Ljubljana
Phone: +386 (0) 1-513 8100
Fax: +386 (0) 1-513 8170
e mail: inea@inea.si

SWEDEN
Beijer Electronics AB
Box 426
S-20124 Malmö
Phone: +46 (0) 40 / 35 86 00
Fax: +46 (0) 40 / 35 86 02
e mail: info@beijer.se

SWITZERLAND
ECONOTEC AG
Postfach 282
CH-8309 Nürensdorf
Phone: +41 (0) 1 / 838 48 11
Fax: +41 (0) 1 / 838 48 12
e mail: info@econotec.ch

SOUTH AFRICA
CBI Ltd.
Private Bag 2016
ZA-1600 Isando
Phone: +27 (0) 11/ 928 2000
Fax: +27 (0) 11/ 392 2354
e mail: cbi@cbi.co.za

TURKEY
GTS
Darülaceze Cad. No. 43 Kat. 2
TR-80270 Okmeydani-Istanbul
Phone: +90 (0) 212 / 320 1640
Fax: +90 (0) 212 / 320 1649
e mail: gts@turk.net

UKRAINE
CSC Automation Ltd.
15, M. Raskova St., Fl. 10, Office 1010
UA-02002 Kiev
Phone: +380 (0) 44 / 494 3355
Fax: +380 (0) 44 / 494 3366
e mail: csc-a@csc-a.kiev.ua

MITSUBISHI ELECTRIC
FACTORY AUTOMATION

Mitsubishi Electric Europe B.V. /// FA - European Business Group /// Gothaer Straße 8 /// D-40880 Ratingen /// Germany
Tel.: +49(0)2102-4860 /// Fax: +49(0)2102-486112 /// info@mitsubishi-automation.com /// www.mitsubishi-automation.de

Specifications subject to change /// Art. no. 208661 /// 08.2007