Safety Guidelines

This manual contains notices which you should observe to ensure your own personal safety, as well as to protect the product and connected equipment. These notices are highlighted in the manual by a warning triangle and are marked as follows according to the level of danger:

⚠️ Danger
indicates that death, severe personal injury or substantial property damage will result if proper precautions are not taken.

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indicates that death, severe personal injury or substantial property damage can result if proper precautions are not taken.

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indicates that minor personal injury or property damage can result if proper precautions are not taken.

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draws your attention to particularly important information on the product, handling the product, or to a particular part of the documentation.

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Only qualified personnel should be allowed to install and work on this equipment. Qualified persons are defined as persons who are authorized to commission, to ground, and to tag circuits, equipment, and systems in accordance with established safety practices and standards.

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Note the following:

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This product can only function correctly and safely if it is transported, stored, set up, and installed correctly, and operated and maintained as recommended.

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Disclaimer of Liability
We have checked the contents of this manual for agreement with the hardware and software described. Since deviations cannot be precluded entirely, we cannot guarantee full agreement. However, the data in this manual are reviewed regularly and any necessary corrections included in subsequent editions. Suggestions for improvement are welcomed.

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Preface

Purpose of the Manual

This manual supports you when you create sequential control systems and parameter controls. It provides you with an overview of the following:

- The basics of sequential control systems
- Working with the SFC Editor
- Sequential control systems on the programmable controller
- Putting sequential control systems into operation and monitoring and testing them
- Documenting SFC charts

You will find a detailed description of the software and procedures in the SFC online help.

This manual "SFC for S7" provides you with the information you require to use the SFC configuration tool in conjunction with CPUs in SIMATIC S7 programmable controllers (PLCs). If you use other target systems (for example, SIMADYN D), please read the additional documentation for this target system.

How Sections for Specific Systems are Indicated

If sections, paragraphs or even individual sentences in this S7 manual relate solely to S7 users, this is indicated by [S7]. This means that the information is relevant only to S7 or is different in other systems. In this case, if you use a different PLC, you will find the information you require in the manual for your specific system. If the [S7] label is in a title, the entire section applies only to S7; if the label is at the start of a paragraph, the paragraph is solely relevant to S7. In lists, the [S7] label applies only to the particular list.

Audience

This manual is intended for personnel involved in configuring, commissioning, and service.
Basic experience of working with PCs and Windows is assumed.
Validity of the Manual

This manual is valid for the SFC software version 5.2 or higher. You will find the latest information that could no longer be included in this manual along with instructions on installation in the README.TXT file accompanying the product.

Standard

The SFC software is based on the international standard DIN EN 61131-3 (IEC 1131-3) for programming languages for programmable logic controllers.

Further Support

If you have any questions about using the software described and cannot find an answer here, in the online help, or in the "readme" file, please contact the Siemens representative in your area.

If you have any questions or comments on this manual, please fill out the remarks form at the end of the manual and return it to the address shown on the form. We would be grateful if you could take the time to answer the questions giving your own personal opinion of the manual.

To help you to become familiar with working with SIMATIC S7 PLCs, we offer a range of courses. Please contact your regional training center or the central training center for more information.

SIMATIC Customer Support Online Services

The SIMATIC Customer Support team offers you substantial additional information about SIMATIC products via its online services:

- General current information can be obtained from:
  - the Internet under http://www.ad.siemens.de/simatic

- Current product information leaflets and downloads which you may find useful are available:
  - the Internet under http://www.ad.siemens.de/simatic-cs
  - via the Bulletin Board System (BBS) in Nuremberg (SIMATIC Customer Support Mailbox) under the number +49 (911) 895-7100.
    To access the mailbox, use a modem with up to V.34 (28.8 Kbps) with parameters set as follows: 8, N, 1, ANSI; or dial in via ISDN (x.75, 64 Kbps).

- You can find your local customer service representative for Automation & Drives in our customer service representative data bank:
  - in the Internet under http://www3.ad.siemens.de/partner/search.asp?lang=en
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The Basics of Sequential Control Systems

Introduction

This chapter explains the basics of sequential control systems.

Here, you will learn what a sequential control system is and what it is used for. You will get to know the terminology and elements of SFC and the rules governing the structure of the chart topology.

[S7] Following the description of the basics of SFC, you will find a brief introduction to the SFC_CTRL control block.
1.1 General Information on Sequential Control Systems

What is SFC?

An SFC chart (sequential function chart) is a sequential control system. The SFC editor is a tool for creating a sequential control system.

In these descriptions, the term “SFC” is used both as a sequential control system, an SFC chart or as the SFC editor depending on the context.

An SFC chart is assigned uniquely to a CPU and is also executed completely on this CPU.

What is a Sequential Control System?

A sequential control system is a controller partitioned to ensure step-by-step execution with control passing from one state to the next state dependent on conditions.

Sequential control systems can be used, for example, to describe the manufacture of products as event-controlled processes (recipes).

With a sequential control system, functions from basic automation (typically created with CFC) are controlled by operating and state changes and executed selectively.

Where are Sequential Control Systems Used?

The typical applications of sequential control systems involve processes and plants with discontinuous characteristics. Sequential control systems can, nevertheless, also be used for continuous processes and plant, for example for approach and withdrawal movements, operating point changes, and state changes due to faults etc.

[S7] Such systems can be used at various levels of a process or plant:

- **Device control level** (open valve, start motor ....)
- **Group control level** (proportioning, stirring, heating, filling ....)
- **Unit level** (tank, mixer, scales, reactor ....)
- **Plant level** (synchronization of units and common resources, for example routing)
1.2 SFC in the STEP 7 Environment

The **SIMATIC Manager** is used for all PLCs as the central database to coordinate the tools and objects. It manages the tools and data and is used to create and modify a project structure (CPU, CFC/SFC charts) and to start the SFC editor.

Figure 1-1 shows how SFC fits into the STEP 7 and PCS 7 environment:

![Diagram showing SFC in the STEP 7 / PCS 7 Environment]

Legend: **PH** (Plant Hierarchy) and **IEA** (Import/Export Assistant) belong to the Process Control System (PCS 7) and extend the SIMATIC Manager. **WinCC** is the operator control and monitoring system in PCS 7.
1.3 Steps in Configuration

Overview

To configure a chart, the following steps are necessary and should be performed in the order shown:

1. Create the project structure
2. Specify the chart properties
3. Specify the chart topology
4. Configure the steps and transitions
5. Adapt the operating parameters and run-time properties
6. Compile and download the chart
7. Test the sequential control system
8. Create the documentation

Creating the Project Structure

You first create or open an existing project. You can create a project in different ways:

In the SIMATIC Manager, select “File > New” and enter the new project name in the dialog box. You insert a program folder in the project.

In the component view of the SIMATIC Manager, you then create a chart folder below the program folder. In this chart folder, you insert the S7 software “SFC”.

[S7] As an alternative to the component view, you can also create the project in the plant view in PCS 7 (recommended view for PCS 7). Using the PCS 7 assistant, you create a project that contains a hierarchy folder in the plant view and a chart folder in the component view. An SFC chart is already included. For further information on creating a new project, refer to the online help “Help on PH and IEA”.

Specifying the Chart Properties

In the chart properties, you can modify the chart name and can enter a comment (for example describing the technological function). The plant properties also include the operating parameters with default values that you can modify (see Section 3.2).

Specifying the Chart Topology

Working with the SFC editor, you specify the chart topology by positioning the steps/translations and, where necessary, the structure elements (see Section 2.3.1).
Configuring Object Properties

You create steps and transitions in the chart topology and configure the actions and conditions for them (see Section 2.3.10 / 2.3.11).

[S7] You can access all the CFC objects (blocks), run-time groups, other SFC charts and all the shared resources of the CPU (bit memory, shared DBs, I/O signals).

Compiling and Downloading the Chart

When you compile your charts, the consistency of the data is checked and the chart is converted to machine code. Following error-free compilation, you download the SFC chart to the target system (see Section 2.5).

Starting Up and Testing the Sequential Control System

In the SFC editor, you then change from the Edit to the Test mode. The statuses of the chart elements are visualized by the use of different colors. You can monitor the properties of the individual chart elements and, if necessary, modify setpoints. For more detailed information, refer to Section 4.

Creating Documentation

With SFC, you can create the documentation for your chart. This includes the following options:

- Printing the chart in various views along with the parameter settings and the properties
- The chart reference data
- The logs (messages of the consistency check, the compiler, downloading etc.)

For more information on documentation, refer to Chapter 5.

1.4 The SFC Chart

The SFC chart has general attributes that you can modify. These include the entries for the chart name, the author, the chart comment, and the run-time properties.

Apart from these attributes, you can also create the chart topology in a graphic configuration. The topological structure of the sequential control system results from the sequence of chart elements (steps, transitions) you select.
1.5 Chart Elements

A chart consists of a sequence of chart elements. These elements include the following:

- Step
- Transition

and outside a sequence (can be freely positioned):

- Text

The remaining elements are structures made up of different elements:

- Sequence
- Simultaneous sequence
- Alternative sequence
- Loop
- Jump

Identifying “Steps” and “Transitions”

The basic elements, step and transition, have a name that is unique within the chart. When the editor creates one of these elements, it assigns a consecutive number that you can modify and change to a name with up to 16 characters. This name must not consist exclusively of numbers.

You can use the optional comment to add comments about the functionality of the element. A comment can take up several lines and consists of up to 80 characters although only 16 characters are displayed to the right of the chart element.

Screen Display

All the elements of a chart, including the links are displayed in white with black print in the unselected and unedited state.

Selected elements are displayed in blue.

Edited elements; in other words, steps or transitions whose object properties have been changed (apart from the name and comment) are displayed in gray with black labels.

Note: The colors explained here are the default settings, some of which can be modified (refer to the online help).
1.5.1 Steps

The step is a control instance for processing the actions associated with it on the PLC. You can configure up to three actions per step.

[S7] An action is a collection of statements and is formulated as follows:

- Assignments for assigning parameters to CFC blocks or shared resources, for example:
  
  \[ \text{Settemp} := 100 \]
  
  \[ \text{XYZ.pump.on} := \text{TRUE} \]

- Activating or deactivating a run-time group of an SFC chart, for example:
  
  \[ SFC-LaLi.EN := \text{off} \]

Note: Make sure that you keep to the specific rules for address assignments on other target systems.

In a chart, you can use an initial step, a variable number of normal steps (maximum 253) and a final step. When a chart is created, an initial step, a final step, and one transition are created automatically. These three elements form the initial state of a chart that you can edit by adding further chart elements.

![Figure 1-2 Icons of the Step Types](image)

The initial step is activated immediately without querying conditions as soon as the chart is started and the actions associated with it are executed according to the state of the successor transition. The final step does not have a successor transition; all actions are performed exactly once.

You can neither insert nor delete the initial or final steps. This makes sure that there is always one initial and one final step in a chart.

All other steps apart from the initial and final steps are normal steps.
1.5.2 Transitions

A transition contains the condition with which a sequential control system passes control from one step to the next. The condition can either be a process and/or time-related condition. Several conditions can be logically combined using Boolean operators. The result of the logic operation decides whether control is passed to the next step.

![Figure 1-3 Icon of a Transition](image)

[S7] The result of a transition condition is obtained from a Boolean expression formed by logic operations on shared addresses, CFC block I/Os, run-time group states, and the SFC chart state.

During compilation, an empty transition is given the default value TRUE. This default is necessary because while the formulation of a condition is optional, a defined value is required on the PLC to allow control to be passed on.

If several transitions become valid at the same time (in alternative sequences, in a loop or in jumps) the system automatically assigns priority from left to right in descending order.

1.5.3 Texts

With the “text” chart element, you can insert any static texts (free texts) in a chart as required.

The text object is a box with a character string with one or more lines. During the analysis phase, this allows you to insert descriptive texts into the chart that can later be replaced by automation functions.

These free texts are not embedded in the topological chart structure and are therefore not repositioned if you change the topology but remain where they are.
1.5.4 **Sequences**

A sequence is a path made up of steps and transitions that can be created with a selectable length and inserted in the chart. A defined sequence that starts and ends in a chart is known as a sequence path (for example from a sequence divergence to its convergence, see Figure 1-4). Sequence paths are found within simultaneous or alternative sequences (see Section 1.5.5 and 1.5.6).

![Sequence and Sequence Path Diagram](image)

Figure 1-4 Sequences and Sequence Paths
1.5.5 Simultaneous Sequence

If the control diverges along two or more sequence paths that should be executed at the same time, simultaneous sequences are used.

A simultaneous sequence consists of at least two sequence paths that are executed at the same time.

A simultaneous sequence is always preceded by a transition (or an alternative sequence). The simultaneous sequence paths end in a simultaneous convergence that is always followed by a transition (or alternative sequences).

The successor transition executes only when all actions of the steps at the end of every sequence path have been executed (apart from the "termination" action) and the condition for passing on control is satisfied (synchronization).

Figure 1-5 Example of a Simultaneous Sequence with Four Sequence Paths
1.5.6 Alternative Sequence

If control diverges into two or more sequence paths of which one and only one should be executed, alternative sequences are used.

An alternative sequence consists of at least two sequence paths, of which only one will be executed dependent on the state of the first transition in the individual sequence paths. This means that the path selected is the path whose transition is satisfied first. If more than one transition is true simultaneously, the sequence path furthest left with a true transition is executed.

Alternative sequences must be preceded and followed by a step (or simultaneous sequence).

Figure 1-6 Example of an Alternative Sequence with Four Sequence Paths
1.5.7 Loops

If you want a section of the chart to be repeated depending on a transition, you use a loop.

A loop consists of a sequence within a sequence path and a return path with a transition that encloses the sequence (see Figure 1-7). The start of the loop must be immediately following a step and the return path must converge again immediately before a step.

![Figure 1-7 Example of a Loop](image)

The transition of the return path is scanned after the successor transition. If the successor transition and the return path transition are true at the same time, the step (or simultaneous sequence) following the successor transition is executed.

**Note**

Return paths from within or into simultaneous or alternative sequences are not possible.
1.5.8 Jumps

Depending on a transition condition, jumps can be used to continue the execution of the SFC chart at any step within the same chart.

A jump always leads immediately out of the sequence following a step (origin of the jump). Several jumps are also possible.

A jump consists of an initiating transition and an arrow specifying the jump target. The name of the step to which control is passed if the transition is true is specified as the name of the step or ???, if the jump destination is as yet unknown.

The origin and target of a jump must always be a step.

Note

With jumps to a sequence path or from a sequence path of a simultaneous sequence, remember the possible consequences when running the chart on the PLC. For further information, refer to the online help.
1.6 Chart Topology

Chart Layout
When you select the chart topology, it is laid out according to strict rules. These determine the spacing between chart elements, the size of steps and transitions, the alignment of alternative sequences etc. You can change the display/layout rules at any time (Options > Customize > Display...).

You can center the entire plant topology on the display area. This achieves a uniform distribution of the elements in the chart. With the zoom functions, you can increase or reduce the size of the display (in steps of 25 to 200% depending on the zoom factor).

Syntax Rules
When you specify the plant topology of a sequential control system, the editor applies certain syntax rules.

Examples:
• If you insert a simultaneous sequence in a chart following a transition and before a step, a transition is created automatically before the step since the syntax rules require a transition before and after a simultaneous sequence.

• If you delete a step from a sequence path, a step (without parameters) is automatically inserted again.

Adding Chart Elements
To add further chart elements to the chart, select the icon of the required element in the element bar.

The mouse pointer changes its appearance from an arrow to the selected icon with a positioning crosshair. To insert the chart element, position the crosshair at the required position on a link and click the left mouse button. The inserted chart elements are selected and displayed in color.
1.7 [S7] The Control Block SFC_CTRL

Purpose

With the SFC control block SFC_CTRL, you can monitor and control an SFC chart. This allows you to influence the SFC chart from within CFC charts.

Using SFC_CTRL, you can query the status of an SFC chart and influence its execution. The control block is taken from the block catalog, inserted into the CFC chart and interconnected and assigned parameters.

Just like other blocks in CFC, you can use the control block in the object properties dialog of the steps and transitions of the SFC chart. This means that in one SFC chart, the control block can be used to control the same chart or a different SFC chart.

For information on the startup response of a sequential control system with and without SFC_CTRL, refer to Section 3.3.1.

Run-Time Properties

You install the control block and the SFC chart in one of the cyclic tasks (for example OB35). When using SFC_CTRL, make sure that it is installed in the run sequence directly before the SFC chart.

Interface

The control block represents the interface of the SFC chart reduced to all inputs that can have parameters assigned and be interconnected and all outputs that can be interconnected. The control block also has an input (CHART of the data type STRING) in which the assignment to the SFC chart can be stored. This assignment is the chart name. Specifying a chart name is optional, since the assignment can also be derived from the position in the run sequence.

The online help contains a detailed description of SFC_CTRL, including a block diagram, a description of all block inputs, block outputs and the status word as well as a table explaining how to deal with errors (causes and reactions).
Working with the SFC Editor

Introduction

With the SFC editor, you can create sequential control systems graphically and specify the actions and step control conditions. From beginning (creating the chart) to end (compiling and downloading to the PLC), the editor provides all the functions required.

How to use the editor is described in this chapter.

Requirements:

Before you can work with the SFC editor, the following requirements must be met:

1. You have created a project with an S7 program including a chart folder using the SIMATIC Manager or you have opened an existing project.

2. [S7] The function block FB300 (and SFB34 if you selected messages with ALARM_8) exists in the S7 program (this is copied to the block folder and entered in the symbol table automatically when the chart is created).

3. An SFC chart must exist.
2.1 Handling Charts

Note
All changes made in the SFC editor are saved immediately - there is therefore no extra save option in SFC. This means that you can no longer undo or cancel changes in the SFC editor by closing the editor without saving.

To back up your data, you should copy the entire program folder to a backup project. You can then revert to older versions at any time. This also allows you to archive complete projects.

Creating a Chart (SIMATIC Manager)
You create a chart with the SIMATIC Manager by opening the chart folder in the component view or opening the hierarchy folder of the project in the plant view and then inserting the chart. The chart is given a standard name by the system (SFC1 ...) that you can change. The name must be unique on the CPU. This is checked by the system.

Creating a Chart (SFC Editor)
Open the “New Chart” dialog box in SFC using the menu command “Chart > New”. Select the project and the chart folder in the component view.

[S7] In the plant view, open the hierarchy folder of the project in which you want to create the chart.

Enter a chart name in the “Object name” box. The name must be unique in the chart folder; this is checked by the system. When you click “OK”, a new window is opened with the SFC chart (initial status).

Opening a Chart (SIMATIC Manager)
You can open a chart using the SIMATIC Manager by double-clicking the chart icon in the chart folder of the S7 program in your project. The SFC editor is then started and the selected chart is opened.

Opening a Chart (SFC Editor)
In the “Chart” menu of the SFC editor, you will see the last charts to be edited shown as menu entries. If you select one of these chart names, the relevant chart is opened or, if it is already open, is displayed (brought to the foreground).
Copying Charts

With the SIMATIC Manager, you can copy charts; in other words, you can transfer tested substructures or even entire structures from one CPU to another CPU of the same type or copy them within the same CPU. Existing references are not lost if the relevant charts are copied together at one time.

Copying within the CPU

When you copy SFC charts within the CPU, this means the following:

- All copied SFC charts access the CFC charts and run-time groups copied at the same time.
- All SFC statements and SFC transition conditions react as follows depending on the objects they access:
  - If they access blocks of CFC charts that have not been copied, they continue to access the original blocks.
  - [S7] If they access shared resources (using symbolic addresses of the symbol table) they continue to access these resources.

Copying from CPU to CPU

Copying from CPU to CPU means the following:

- All copied SFC charts access the CFC charts and run-time groups copied at the same time.
- All SFC statements and SFC transition conditions react as follows depending on the objects they access:
  - If they access blocks of CFC charts that were not copied, these are changed to virtual access. These addresses are displayed in yellow in the SFC chart since they cannot be used to compile code (in the consistency check, they are listed in the error log).
  - [S7] If they access shared resources (using symbolic addresses from the symbol table), they access the same resources in the destination CPU. If these resources do not exist on the destination CPU, they are converted automatically to virtual access.

If an error occurs: An error log is displayed if block types required on the destination system no longer exist or are incompatible.

Deleting Charts

In the SIMATIC manager, you delete the SFC charts in the same way as other objects (select and press the DEL key). You cannot delete charts in the SFC editor.
2.2 Specifying the Chart Properties

You can modify the chart properties and the run sequence for the active chart on the CPU. With the menu command “Chart > Properties”, you open the properties dialog box. With “Options > Run Sequence”, you open the run-time editor in a separate window and with its own menu commands.

2.2.1 Chart Properties

In the properties dialog box, you can open three tabs:

- General
  This tab is used to enter or modify the chart name, the author and the comment.

- Operating Parameters PLC
  Here, you can set the operating parameters in a combo box (operating mode, step control mode) and activate or deactivate the chart execution options (command output, cyclic operation, time monitoring, autostart, use of default operating parameters when SFC starts, suppress messages).

- OS
  If the “Transfer chart to OS for visualization” option is set, the SFC chart is transferred to the OS automatically with the next PLC-OS transfer.

For a description of the operating parameters, refer to Section 3.2, Run-Time Behavior of SFC Charts, and in the online help.

2.2.2 Run-Time Properties

The run-time properties of an SFC chart determine how the SFC chart is included in the processing of the entire structure on the PLC. These properties are vital to the performance of the PLC in terms of reaction times, dead times, or the stability of time-dependent structures, for example control loops.

Run Sequence

Each SFC chart is installed in a run sequence

Each SFC chart must be installed in at least two tasks; in the

- task for the startup behavior ([S7] OB100)
- task for normal execution ([S7] e.g. OB35).
Note

[S7] If you want the chart to be controlled by a control block (SFC_CTRL), the chart must be installed immediately following the SFC_CTRL in the run sequence.

Run-Time Groups

SFC charts can be installed in run-time groups if you want them to have the attributes scan rate and/or phase offset. The attributes can be set only with the object properties of the run-time group; in other words, all charts of the run-time group have the same “scan rate” and “phase offset”.

By using SFC charts in run-time groups, technologically-oriented groups can be formed in conjunction with CFC charts. From a technological point of view, a better structuring of the project can be achieved that promises a considerable improvement in performance when configurations are changed (among other things due to shorter compilation times).

Changing the Run Sequence

To change the run sequence, select the chart icon, select “Cut”, then select the required task and then “Paste”. If you have selected a task, the SFC chart is installed at the beginning of the task. If you have selected a block, the SFC chart is installed following the block.

As an alternative to cut / paste, you can also drag a chart from an open task (right detailed window) to a task in the left window with the mouse.

Removing an SFC Chart from a Task

To remove a chart from a task, select the chart and delete it with the “Delete” function or with the DEL key. Before the chart is deleted, you are prompted to confirm your intention.
Installing an SFC Chart in a Run-Time Group

You create a run-time group in the Run Sequence window (opened with Edit > Run Sequence...) with the menu command “Insert Run-Time Group...” for the selected task (in the “Edit” menu or in the context-sensitive menu). In the dialog box, you enter the name and any comment you require and the run-time attributes for the scan rate and phase offset.

Install the SFC chart in the run-time group as usual (same procedure as installation in a task).

Run-Time Attributes of the SFC Chart and the Run-Time Group

A run-time group has the following three attributes:

- Enable
- Scan rate
- Phase offset

[S7] The Enable Attribute

The SFC chart or the run-time group is activated and deactivated with the enable attribute (on=1, off=0). As long as 0 is set, the SFC chart/run-time group will not be run regardless of any other conditions.

The enable attribute can be set dynamically. In this case, the value of a block output or the statement of a step decides whether or not the SFC chart is activated or deactivated.

[S7] The Attributes “Scan Rate” and “Phase Offset”

These attributes cannot be assigned directly to an SFC chart. Charts can only be given these attributes by installing them in a run-time group from which they inherit the selected attributes.

An SFC chart that is not installed in a run-time group has the default: “scan rate = 1” and “phase offset = 0”.

If you want different SFC charts on a CPU to run with different run-time attributes, they must be installed in different run-time groups.

Note: Since the SFC chart does not have its own (modifiable) run-time properties, the object properties of the selected SFC chart cannot be opened in the run sequence.
[S7] Changing the Scan Rate and Phase Offset

If you want to modify the run-time attributes, select the SFC chart in the Run Sequence window and select the “Object Properties” menu command (context-sensitive menu or “Edit” menu).

- **Scan rate:**
  The scan rate specifies whether the SFC chart is executed by the task each time the task is run or only in every nth run. Where “n” is an integer (n=2^t, where 0 <= t <= 15). The steps are a multiple of the basic cycle rate of the task. Default: 1 (execute every run)

**Example:**
Basic cycle of a cyclic interrupt (OB33): 500 ms
Possible cycle rates with scan rate: 1s, 2s, 4s, 8s, 16s etc.

- **Phase offset:**
  The phase offset can be used to achieve a better distribution of load on the CPU. It must be considered in conjunction with “n”, the scan rate. The SFC chart is processed as often as specified by “n”, offset in each case by “m” units of the cycle.
  Where “m” is an integer and 0 ≤ m ≤ (n-1)
  Default: 0 (no phase offset)

**Example:**
Basic cycle of a cyclic interrupt (OB33): 500 ms
Scan rate: 16. The SFC chart is executed every 8 seconds (0.5s x 16).
Phase offset: 3. The SFC chart is executed after 1.5s; 9.5s; 17.5s etc.

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**Caution**

Whenever possible, you should only use the scan rate and phase offset in the tasks that execute in defined cycles; in other words, with cyclic interrupts. In all other tasks you should be extremely careful, particularly with hardware interrupts and special tasks. Here, you should not change the default scan rate=1 and phase offset=0.
2.3 Configuring Sequential Control Systems

Requirements:
Before you can configure sequential control systems, you must first create the required basic automation functions with CFC and/or STEP 7 tools. At the same time, the PLC blocks to be used in the SFC charts are also inserted. Automation functions that do not yet exist can be added later and then used in an SFC chart.

Color Settings
The objects of a chart are displayed in different colors depending on their current state. The elements of an unselected sequential control system, for example, are displayed in “white” (parameters not set) or “gray” (parameters set) and in “blue” when they are selected.

With the “Customize Colors...” function in the “Options” menu, you can select your own color scheme for certain elements.

2.3.1 Creating the Chart Topology

When you create the chart topology, there are syntax rules that are automatically adhered to by the editor.

Loops, for example, leading into or out of alternative or simultaneous sequences are not permitted. Due to the block-oriented chart topography, only entire chart elements (including alternative and simultaneous sequences) can be enclosed by a loop. The return path of a loop can and must contain only one transition.

Adding Chart Elements
To add further chart elements to the chart, select the icon of the required element in the element bar.

The mouse pointer changes its appearance from an arrow to the selected icon with a positioning crosshair. To insert the chart element, position the crosshair at the required position on a link and click the left mouse button. The inserted chart elements are selected and displayed in color.
2.3.2 Creating a Sequence

When you create a sequence, then depending on the position, a Step Transition sequence (ST) or a Transition Step sequence (TS) is created (see Figure 2-1). You create a sequence by clicking a vertical link in the chart between a step and transition or between a transition and step.

![Diagram of ST and TS sequences]

Figure 2-1 Creating a TS or ST Sequence Depending on the Location

If you move the mouse pointer to a permitted insertion point in the existing sequence, you will see a horizontal green line.

By holding down the left mouse button and dragging the pointer vertically, you can select the length of the sequence you are inserting. The current length that will be inserted (number of ST/TS pairs) is displayed as a number at the insertion point.
2.3.3 Creating and Extending a Simultaneous Sequence

When you create a simultaneous sequence, two sequence paths are generated each consisting of one step. Depending on the point of insertion, a further transition is added automatically before or after the simultaneous sequence to ensure that the syntax is maintained.

If you open a lasso (in the Edit mode) around the elements of a sequence path, the enclosed elements become part of the left sequence path of the generated simultaneous sequence.

You can add further sequence paths to a simultaneous sequence or delete paths and also insert them in a different sequence. You can move a sequence path within a simultaneous sequence or to any other position in the chart (except in the return branch of a loop). If you delete the second last path, the remaining path is simply integrated in the surrounding structure and the simultaneous sequence is eliminated.

To add further sequence paths, simultaneous sequences, or alternative sequences to a simultaneous sequence, change to the required insert mode and click the mouse with the positioning cross located on the upper or lower double line.

If you move the mouse pointer to a permitted insertion point in the existing sequence, you will see a horizontal green line. Within the simultaneous sequence (in the vicinity of the upper simultaneous divergence or lower simultaneous convergence and beside a sequence path), the vertical green line indicates that you are inserting a further sequence path. If, for example, you insert an alternative sequence beside a sequence path, an extra step is created before and after the sequence to maintain the correct syntax.
2.3.4 Creating and Extending an Alternative Sequence

When you create an alternative sequence, two sequence paths are generated each containing one transition. Depending on the location, a further step is generated before or after the alternative sequence to maintain the syntax (see Section 1.6, Syntax Rules for the Chart Topology).

If you open a lasso (in the insert mode) around the elements of a sequence path, the enclosed elements become components of the left sequence path of the generated alternative sequence (refer to the description “Creating a Simultaneous Sequence”).

You can add further sequence paths to an alternative sequence or delete paths and also insert them in a different sequence. You can move sequence paths within the alternative sequence or to any other position in the chart. If you delete the second last path, the remaining path is simply integrated in the surrounding structure and the alternative sequence is eliminated.

To add further sequence paths, simultaneous sequences, or alternative sequences to an alternative sequence, change to the required insert mode and click the mouse with the positioning crosshair located on the divergence/convergence line.

If you move the mouse pointer to a permitted insertion point in the existing sequence, you will see a horizontal green line.

Within the alternative sequence (in the vicinity of the upper divergence or lower convergence beside the sequence path), the vertical green line indicates that you are inserting a further sequence path. If, for example, you insert a simultaneous sequence beside a sequence path, an extra transition is created before and after the sequence to maintain the correct syntax.
2.3.5 Creating a Loop

When you create a loop, a sequence path (that can consist of a single step) and a return path with a transition are generated.

You can create loops around existing sequences. You select the beginning and end of the loop by positioning the mouse pointer on the vertical link, holding down the left mouse button and dragging vertically to the required position and releasing the button. The syntax is maintained by adding whatever elements are necessary. If, for example, you create a loop around a transition, the enclosed sequence then consists of this transition and a step before and after it. Below the loop, a further transition is added.

The start and end point of the loop cannot be modified later. You can, however, move the elements you want including in the sequence of the loop into the loop and achieve the same result.
2.3.6 Creating a Jump

When you insert a jump, a transition is created with an arrow and information about the destination of the jump.

To insert a jump, click on the vertical link of the sequence immediately below a step. A simple click creates a jump with an undefined destination. The destination is displayed as question marks (???).

If you require more than one jump from a step, click on the horizontal line of the jump branch. The branch is then extended by a jump with each click.

When you insert the jump, you can also select the jump destination directly. Drag the mouse from the point of origin of the jump directly to the destination step and then release the mouse button. Instead of the question mark, the name of the step is now entered as the jump destination.

Note
With jumps to a sequence path or from a sequence path of a simultaneous sequence, remember the possible consequences when running the chart on the PLC.
For further information, refer to the online help.

Changing the Destination of a Jump

You specify the destination of the jump by changing the name (???) in the object properties of the destination. Double-click the destination to open a dialog box. All the existing steps of the chart are listed and can be sorted. From this list, you select the step name for the destination of the jump.

Note
If the jump destination is deleted, all the jumps to this step become undefined.
If the step name of a jump destination is changed later, all the jumps to the step are automatically adapted.
2.3.7 Creating and Editing a Text Element

You can insert, delete, copy, and move (to other charts not with Drag&Drop) a text object at any (free) position in the chart.

After inserting a text with the button of the toolbar or with the “Insert > Text” menu command, an opened text box is displayed in the chart. The text cursor is active and you can begin editing immediately. A line break is added automatically at the right edge of the box. If you enter more text than can be displayed in the box, the size of the box is not increased automatically and the text is moved out of the visible area. You can make the entire text visible by increasing the size of the box manually.

To change the size of a box, click on the box handles and drag with the mouse until the required size is reached. If you change the width of the box, the length of the text lines is automatically adapted. You can pick up the box using the handles of the frame and move it to any position in the chart.

When you open a text box, the cursor is positioned at the point in the text at which you clicked with the mouse. You can exit the editing mode and close the text box by clicking outside the text box with the mouse.

Note: If elements of the chart topology are covered by the text object, the text object is displayed as a frame with a transparent surface (no content). The chart elements below it remain visible.

Copying, Moving, Deleting

With the mouse pointer over the selected text box (displayed in a frame), open the context-sensitive menu with the right mouse button. This contains the menu commands: “Cut Text Object”, “Copy Text Object”, “Delete Text Object”.

To paste, click on a free position in the chart and then select the “Paste” menu command (context-sensitive menu or “Edit” menu). Click again at the required position to insert the text object (the mouse pointer is displayed as a symbol for “inserting” or “copying”).
2.3.8 Editing Chart Elements

In the “Edit” menu (and in the context-sensitive menu), you will find functions for editing the chart further.

Copy: you can copy the selected elements of a chart that form a syntactical unit (sequence of elements without gaps) and position them at a different, syntactically correct position within the chart or in a different chart on the same or another CPU. If necessary, new names may be assigned to the copied elements automatically. The copied elements contain the same actions or conditions as the originals.

Copying jumps: If you copy a sequence that contains a jump and the step of the jump destination, the jump destination is adapted appropriately in the copy. If you copy a sequence that contains a jump but the destination of the jump is not within the copied object, the jump destination is undefined (???).

Cut and Paste: You can move the selected elements of a chart that form a syntactical unit (no gaps) to another syntactically correct position within the chart or in another chart on the same or a different CPU (cut and paste).

Delete: The selected chart elements are removed from the chart topology after a prompt for confirmation (“Do you really want to delete the selected objects?”). If you delete only one element from a syntactical unit, the syntax is immediately restored by entering a new element to suit the syntax (this has no parameters assigned). This means that you have only deleted the parameter settings for the object.

The last step of a sequence path in a simultaneous sequence cannot be deleted. To delete a sequence path consisting of only one last step, you must select the sequence path by clicking on the vertical link.

The same principle applies to alternative sequences.

If you only select the transition in a jump, its content is deleted; if you select the jump destination (transition and jump destination are selected), the jump is deleted.

2.3.9 Editing in the Object Properties Dialog

The steps and transitions entered in the chart topology must now be linked to the “block world” or basic automation. You do this in the “Properties” dialog for the steps and transitions (Section 2.3.10 and 2.3.11).
2.3.10 **Editing Object Properties: Step**

You open the object properties by double-clicking the step you want to edit or using the menu command “Object Properties...” of the “Edit” menu or the context-sensitive menu if a step is already selected. A dialog box is displayed in which you specify the properties or formulate the actions.

When you edit the step, the properties dialog is divided into four tabs (see Figure 2-2).

**General** Tab

In the “General” tab, you can enter or modify the name, minimum and maximum run-time, chart comment and OS comment.

By clicking the “Confirmation” check box, you can assign a flag to the step. This flag determines the behavior of the step when the chart is run on the PLC in the “T / T and C” mode in other words, transitions following a step with this flag only become active and pass control to successor steps when they are satisfied and confirmed by the operator (as in the “T and C” mode). Without these flags, the successor transitions become active once their conditions are satisfied (as in the “T” mode).

In the **Minimum**: box, you can set the minimum time that a step should remain active regardless of whether the successor transition is already satisfied.

With the **Maximum**: setting, you can specify a time for the time monitoring limiting the maximum time that the step can be active.
In the Comment and OS comment boxes, you can enter comment text, for example, describing the actions to be executed by the step (maximum characters for chart: 80, for OS: 512). The OS comment is used in process control for visualizing the step.

Initialization, Processing, Termination Tabs

The tabs for the actions (processing phases) Initialization, Processing and Termination are structured identically (see Figure 2-3). Here, you configure the statements that control the process for initialization, normal processing and termination of the step (see Section 3.3.3).

Formulating Actions

You enter the statements for actions in a formatted dialog. For each step, you can formulate up to 50 statements per action. In the dialog box (Figure 2-3) 10 of these can be seen. You can scroll the list with the scroll bar.

If you position the mouse pointer on an input box, the complete entry is displayed as fast information including the data type and object type. Example in Figure 2-3:

3. \DP666\Reactor1\Motor3\CFC8.Ctrlr2.P_SEL [BOOL] CFC

A double backslash (\ \) is displayed between the path and the chart name.
In unselected lines, you can use the “Copy/Paste Action” functions in the context-sensitive menu to copy the statements of a complete action and paste them into another action. Using this function, you can, for example, copy the statements from the “Initialization” action to the “Termination” action and then change the settings “TRUE” to “FALSE”.

You will find the formulation options in the online help for SFC.

**Entering Addresses**

**Using the “Browse” dialog:**

When you browse (for example through CFC charts), all the available objects of the chart folder are found and displayed. Using a filter, you can list only the I/Os that are of interest in this particular phase of configuration. The filter is active only when the criteria are clearly defined; in other words, if an address is, for example, a constant, all I/Os are displayed unfiltered and can be selected for the second address.

You can insert the selected I/O in the address field with “Apply”, by double-clicking or by dragging.

**CFC chart:**

With the CFC chart open, you can select the block I/Os and can drag them to the address box of the Object Properties dialog.

If you insert a block I/O with a value identifier in the address box, the value identifier is also entered in the right (empty) address box. If there is more than one value identifier for this I/O, you can open the combo box with the value identifiers in the right address field by pressing the key combination ALT + DOWN. In the combo box, you can select the required value identifier for this address.

To allow the value identifiers to be displayed in SFC, the option “Parameter: Value identifier” must be selected in “Options > Customize > Layout...”.

**Edit:**

With text entries, make sure that the names are consistent. A symbol that does not exist in the symbol list (or a referenced symbol that is subsequently renamed) cannot be checked in the editor and is assumed to be correct. Such inconsistencies show up when you compile or run the consistency check.

Before you compile, these virtual accesses must be converted to real accesses (in other words, the relevant block must be placed in the CFC chart) otherwise compilation is stopped with an error.

**EN Attribute:**

[S7] The “<SFC chart>.EN := ON” statement starts an SFC chart. The statement “<SFC chart>.EN := OFF” deactivates an SFC chart (its final step is executed and then the chart is deactivated).

The same principle applies to activating and deactivating run-time groups. You can enable or disable the processing of CFC blocks and SFC charts in a run-time group with one statement.
Note
When you enter statements, they are checked so that correct syntactic and semantic formulation is guaranteed. The program, for example, also checks whether the data types of the logically combined addresses are compatible.

Unknown Addresses
If the address specified is recognized as an address type unknown, a dialog box is opened in which you can enter more detailed information. Here you can assign the type CFC access, [S7] SFC chart, run-time group or [S7] symbol and the corresponding data type. You can save your entry with “OK”, but it cannot be compiled until the address is defined (causes an error message).

Note
If you delete CFC blocks that are accessed by the SFC chart, these are retained as virtual blocks in the data management so that the statements of the SFC actions or the SFC transition conditions can remain displayed (as default, the addresses are displayed in yellow). In CFC, these deleted blocks are then located in the “Unplaced Blocks” catalog section. The virtual blocks are only deleted when there are no further references to them.

Modified Addresses
With SFC access to CFC blocks, please remember the following:
Being able to modify a type centrally means that it is possible to replace or modify blocks of which CFC block instances have already been generated. The type changes are also made to the CFC blocks. If there are SFC accesses to modified blocks, these modifications must also be made to the addresses in actions and transitions.

Documenting the Configuration
You can document the configured actions of the step. With the “Print” button in the Object Properties dialog, you obtain a log of the step with information about the properties and assignments for initialization, processing and termination.
2.3.11 **Edit Object Properties: Transition**

You open the object properties by double-clicking the transition you want to edit or using the menu command “Object Properties...” of the “Edit” menu or the context-sensitive menu if a transition is already selected. A dialog box with three tabs is opened in which you can specify the properties, the conditions and the OS comments.

**“General” Tab**

In the “General” tab, you can enter or change the name and comment.

**“Condition” Tab**

In the “Condition”, you specify the step control conditions for the selected transition.

![Logical Combination of Conditions with Three-Stage Transition Logic](image)

**Figure 2-4 Logical Combination of Conditions with Three-Stage Transition Logic**

**Formulating the Conditions of a Transition**

You formulate a transition as a Boolean expression, that can consist of 2 x 5 and 2 x 3 conditions. The conditions are combined using three-stage transition logic.

The Boolean operators are designed as buttons. With a simple mouse click on the operator, you can change it from “AND (\&)” to “OR (≥1)”. To make a “NAND” from an “AND” and a “NOR” from an “OR”, click the output of the operator. The negation is displayed by a period in bold print on the output line.
You will find the formulation options in the online help for SFC.

If you position the mouse pointer on an input box, the complete entry is displayed as fast information including the data type and object type.

You should whenever possible enter the addresses using the “Browse” selection dialog or from the open CFC chart since this means that the addresses are unique.

As when selecting addresses for the steps, you can also enter the value identifiers of the I/Os for the transitions.

[S7] EN attribute:
With the condition <SFC chart>.EN = on or <SFC chart>.EN = off, you can query whether or not an SFC chart is activated or deactivated.
With the condition <run-time group>.EN = ON <run-time group>.EN = OFF, you can query whether a run-time group is activated or deactivated.

**Note**
When you enter conditions, they are checked for consistency so that correct syntactic and semantic formulation of the subexpression is guaranteed. The program also checks whether the data types of the logically combined addresses are compatible.

The predefined three-stage logic is normally adequate. If you require more complex formulations, you can create them as a CFC chart and enter the results calculated in the chart as the address for transition conditions.

**“OS Comment” Tab**
Here, you can enter a comment text for each condition that is displayed on the OS during process control.
When you first open the “OS Comment” dialog, the formulated condition is entered as an OS comment and can then be changed as required.

- Unless you edit and modify the OS comment, the OS comment is adapted automatically whenever the compare condition is changed. This automatic updating also applies to renaming, copying, moving or deleting the referenced CFC blocks.

- If you change the condition belonging to a comment text that you have edited, this is not automatically adapted. In this case, a dialog box is opened telling you that you should check the comment text. You can cancel the change in this dialog box by clicking the “Cancel” button.

- You can initialize an individual OS comment in the SFC editor by deleting the OS comment. The text from the compare condition is then used again as the OS comment and from this time onwards is automatically adapted whenever the condition is changed providing you do not edit the OS comment. As an alternative: You can enter the original OS comment (text of the condition) again using the “Use Default” context-sensitive menu command.

- You can reinitialize the OS comments for all transitions of a chart folder at any time. With the “Options > Edit OS Comments...” menu command and the “Use all conditions for creating comments” option, the defaults are entered again.

You cannot change the Boolean operators in this dialog; the buttons are only for visualizing the existing logic operations.

**Modified and Unknown Addresses**

See Section 2.3.10, “Edit Object Properties: Step”.

**Documenting the Configuration**

You can document the configured conditions of the transition. With the “Print” button in the Object Properties dialog, you obtain a log of the transition with information about the properties and parameters of the conditions.
2.4 [S7] Messages and Message Configuration

2.4.1 [S7] Messages and SFC

SFC currently supports messages with ALARM_8.

2.4.2 [S7] Configuring Messages in SFC

You can start configuring messages in SFC with the menu command “Chart > Messages...”.

You can configure specific message texts for each SFC chart. You can modify the message texts integrated in the message structure of the FB300 run-time system (for example to distinguish messages of different charts).

Two message events have standard texts:

- Operator prompt
- Step timeout
2.5 Compiling and Downloading

[S7] Customizing the Compiler
With the “Customize > Compilation...” command in the “Options” menu, you open a dialog box in which you will see information about the resources used in conjunction with compiling charts. Here, you can decide which resources should remain unused during compilation of the charts of the current chart folder. The “Statistics” box shows you which resources are available on the CPU for compiling the charts and which are already being used.

[S7] Compiling
With the menu command “Chart > Compile...”, you open a dialog box in which you can decide between compiling the entire program or only the changes you have made.

You can also change settings for the SCL compiler before you compile. By clicking the “Customize Compiler (SCL)” button, you open a further dialog box in which you can activate or deactivate the options “Generate reference data”, “Optimize object code”, “Monitor array limits” and “Create debug information”.

In the dialog box, you can set or reset further SFC-relevant options:
If you set the “Delete empty run-time groups” option, empty run-time groups are deleted prior to compilation. Such empty run-time groups can arise from copying and Branch&Merge.

Consistency Check
During compilation, a consistency check is run automatically. The messages are written to a log file.

If errors and warnings occur, you can jump to the relevant chart by double-clicking the message.

You can also run the consistency check without a full compilation by selecting “Chart > Consistency Check...”.

Logs
Following the consistency check or compilation, you can display and print out the messages of both activities using the menu command “Options > Logs”.

[S7] PLC Comparison

If you want to compare the time stamp of the last modifications before downloading, you can start the “Compare” function in the “PLC” menu. A dialog box with the date and time of the following is displayed:

- The last download-relevant change
- The last offline program change
- The last online program change

If the time stamp of the last download-relevant change is older than the last offline program change, this has no further effects on the program execution on the CPU; you do not need to download the program again.

If the time stamp of the offline program modification is older than the download-relevant modification, you must compile the charts and download them to the CPU so that they match.

If the time stamp of the online program modification is older than the time stamp of the offline program modification, you must download the user program from the PC/PG to the CPU so that they match.

Note on H CPUs: If the H CPU is in the solo mode, for example after the failure of a CPU and there was a CPU failover, an online access results in a dialog being displayed. In this dialog, you can select the required CPU. In the redundant mode, this dialog does not appear.

[S7] Downloading

After you have compiled, you can download the user program to the PLC.

The following requirements must be met before you can download:

1. There must be a connection between the CPU and your PG/PC.
2. The Edit mode is set.

If these requirements are met, you can start the download with the menu command “PLC > Download...”. If you have made download-relevant changes in the configuration and have not compiled since you made the changes, you will be prompted to compile before you download. If the compilation is free of errors, the download will be started automatically when compilation is completed.

In the “Download” dialog box, you can choose between “Entire program” or “Changes only”.

Note

If you select “Entire program” for the download, the CPU is set to “STOP” following a prompt for confirmation and all the blocks are deleted.
**Note on H CPUs:** If the H CPU is in the solo mode, for example after the failure of a CPU and there was a CPU failover, an online access results in a dialog being displayed. In this dialog, you can select the required CPU. In the redundant mode, this dialog does not appear.

**Note on F systems:** You can only download programs with modified F components after entering an F password. Without this legitimization, downloading is aborted.

### Downloading Changes

If you select “Changes only” in the “RUN-P” CPU status, you can download the configuration changes to the PLC without needing to change the CPU to STOP. With this type of download, you only download changes that have been made since the last download.

### [S7] Notes on Downloading Changes

- If the chart topology of SFC charts has been changed (steps or transitions have been added, deleted, copied, moved, jump destination changed...), you must make sure that these charts are deactivated (command: Abort) before you start to download changes to the PLC.
- If SFC charts have been modified (chart properties, object properties are the steps/transitions) without changing their structure, you can download the charts after they have been compiled while the CPU is in RUN without needing to deactivate be modified SFC chart.
- If you have not changed the chart itself, but only the objects that are accessed (for example a symbol in the symbol table, run-time groups, block I/O), you do not need to deactivate the chart before it is downloaded.
- After downloading changes, the halted SFC chart is not started with the property “Autostart: on” but must be started again by the operator or via the control block.

---

**Caution**

Read the information about the causes of stoppages when downloading changes in the online help.

---

### Saving Settings without Compiling/Downloading

You can save the settings in the dialog box without starting compilation or a download (“Save Settings” button). This can, for example, be useful if you want use batch processing for compiling/downloading for several PLCs. See Section 2.5.1.
2.5.1 [S7] Compiling and Downloading to Several PLCs

Using batch processing, you can compile and/or download all the S7 programs of a project containing a chart folder.

This function is particularly useful when you need to compile and download programs for several PLCs. Examples:

- Distributed engineering. All the configured data are copied to the master project where they are compiled and downloaded.
- Central block type change. A block type used in several PLCs needs to be changed. After importing the block type into the CFC data management of the PLCs, all the charts must be compiled and downloaded.

To make sure that the job is executed correctly without a stoppage, you should check and adjust the settings in the dialog boxes for compilation and downloading. In these dialogs, you can save the settings (“Save Settings” button) without actually starting the compilation or download.

**Note on F systems:**

Downloading programs with modified F components is only possible after entering an F password. The job for this program is canceled; all following jobs continue to be executed. Downloading programs with unchanged F components does not require a password; in other words, the job is executed.

**Sequence**

In the SIMATIC Manager, select the “PLC > Compile/Download Programs...” menu command.

All the programs are listed in the dialog box in the form of a job table. You can decide whether each program will be compiled and/or downloaded. Status displays indicate whether or not the job was executed free of errors.

The “Compile” and “Download” jobs display their own dialog boxes when they are executed. Here, you can cancel the particular job with the “Cancel” button. A message is then displayed asking you whether you want to cancel the compilation/download of all remaining programs. If you answer “no” only the compilation or download of the current program is canceled and you go on to the next program in the job list. If you answer with “yes”, the entire operation is canceled; in other words, no further job is executed.

If you cancel all the jobs, the status display for “canceled by operator” is displayed in the line of the aborted program; the other jobs that have not been executed retain their selection identifiers.

If the job for a program was aborted due to an error, this does not affect the other jobs. Exception: If a compile job is aborted, the program cannot be downloaded.

Once the job list has been worked through, the dialog box remains open so that you can see the results based on the status displays.

If you require more detailed information about the actions and errors, you can view the logs of each individual program by selecting the status display box and clicking the “Logs” button.
2.6 [S7] Parameter-Controlled Operation

Below, you will find brief information about parameter-controlled operation and how it is configured. For a more detailed description with examples, refer to the online help of SFC.

What Does Parameter Control Mean?
Apart from fixed sequential control systems, parameter-controlled systems are used in batch processes. Parameter-controlled sequential control systems have variable parameters.

These variable parameters are located in a shared data block (recipe data block). You can give the recipe data block a symbolic name, for example “RecParDB”.

The variables of the recipe data block are values assigned to the parameters of the basic automation during configuration.

Configuring Parameter-Controlled Operation
You configure parameter-controlled operation with the SFC editor. The procedure is basically the same as when configuring the sequential control system. During configuration in the Object Properties dialog, you assign the values from the recipe data block to the parameters of the basic automation.

Modification on the OS
By changing the content of the recipe data block, parameter-controlled operation is possible with different parameter sets. The parameters are changed on the OS.
Introduction

This chapter describes the functions of sequential control systems on the PLC, when steps and transitions are processed, and the effects of a statement in the processing phase (action) of a step.
3.1 General

Requirements:

The chart created with the SFC editor is defined by the chart topology, the actions in the steps, the conditions in the transitions, and the run-time properties. The compilation following the creation of the chart results in executable code for the PLC system. The blocks created in this way are downloaded to the CPU.

State of the Sequential Control System

After downloading to the PLC, the sequential control system is in a defined state. This defined state is specified with the SFC editor (see 2.2 Specifying Chart Properties) and decides whether the sequential control system is started automatically or only following a start command.

You can modify how a chart is executed either by changing the operating parameters using the SFC editor during test and commissioning or on the OS, for example by changing the step control mode “step control with transition only (T)” to “step control confirmation by operator (C)” or changing the time monitoring from “Off” to “On”.

Interaction with the Basic Automation

On the PLC, the sequential control system has relationships to the basic automation via the action and transition functions. If the controller also requires parameters, there are also links to the parameter data.

Each SFC chart has a certain run behavior assigned to it. The basic automation with the blocks placed in the CFC charts can execute differently from the SFC chart itself. By placing a control block in a CFC chart, an assigned SFC chart can be controlled.

The structure of the run-time system allows the sequential control system and the blocks of the basic automation to run in different cycles to reduce the cycle load. In the same way, SFC charts can be installed in run-time groups and can then have different scan rates/phase offsets.
3.2 Run-Time Behavior of SFC Charts

How the Chart Executes

The PLC operating system evaluates certain events and executes the SFC chart according to these events. Such events include, for example, the following:

- Warm restart: The SFC chart is called automatically for initialization.
- Cyclic interrupts: The SFC chart is executed in the cycle specified by the OB in which the chart is installed.

The assignment of an SFC chart to the events must be made explicitly with the run-sequence editor; in other words, the chart must be installed in the appropriate task (called in SFC with “Edit > Run Sequence...”). Refer to Section 2.2, Specifying Chart Properties.

[S7] Mode

The operating mode decides how the chart executes; controlled by an operator (in the test mode or SFV) or automatically (controlled by a control block or another SFC chart).

The following modes are possible for an SFC chart:

- Auto (process mode)
  Control is automatic (for example using the control block SFC_CTRL within a CFC chart). The step control modes “T” (SCT input) and “T / T and C” (SGC input) can be set.
- Manual (operator mode)
  Execution of the chart is controlled manually by an operator (for example during commissioning or with SFV). All step control modes are permitted.

The “Operating Modes” topic in the online help contains a table with the possible combinations of mode changes.

[S7] Step Control Mode

The way in which control is passed from step to step within the chart can be specified with various step control modes. In the default mode “T”, the passing of control from one step to the next depends solely on whether the relevant transition is satisfied.

It is possible to change the step control modes in all operating modes. The individual step control modes are mutually exclusive.
Table 3-1 Step Control Modes

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Step control mode...</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Transition</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Confirmation by operator</td>
<td></td>
</tr>
<tr>
<td>T and C</td>
<td>Transition <strong>and</strong> confirmation by operator</td>
<td>refer to the online help.</td>
</tr>
<tr>
<td>T or C</td>
<td>Transition <strong>or</strong> confirmation by operator</td>
<td></td>
</tr>
<tr>
<td>T / T and C</td>
<td>Step-specific confirmation by the operator</td>
<td></td>
</tr>
</tbody>
</table>

**Minimum Run-Time of a Step**

In the step control modes “C” and “T or C”, the minimum run time of the step can be overridden by the operator.

**Chart Options**

With the chart execution options (for example cyclic operation, time monitoring etc.), you can specify how the sequential control system executes. The individual execution options can be combined: You can change the chart execution options in the “Chart > Properties: Operating Parameters PLC” dialog.

With the chart execution option “**Use default operating parameters when SFC starts: on**”, all the default settings / options set in the run-time properties become effective again when the SFC chart is started. The options may, for example, have been changed in the test mode.

For a description of the chart execution options, refer to the online help; the defaults for the chart execution options are listed in Section 3.3.

**Autostart**

An SFC chart with the “Autostart: on” property starts immediately after a warm restart on the CPU without any further operator input. After downloading changes (CPU does not change to STOP), there is not automatic start and the SFC chart must be started again by the operator or using the control block.

The setting for “Autostart” can only be changed in the “Chart > Properties” dialog in the “Operating Parameters PLC” tab.
3.3 [S7] How the Sequential Control System Behaves during Operation

What Determines How a Chart Behaves?

The behavior of a sequential control system depends on the operating parameters: operating state, mode, step control mode, and the chart execution options.

You can set the operating parameters when testing and during project startup or at the OS with SFV (except for the “Autostart” parameter that can only be set in the Chart Properties dialog in the “Operating Parameters PLC” tab).

The defaults of the operating parameters are as follows:

- **Mode**: Manual (operator mode)
- **Step control mode**: T (process-controllable)
- **Execution options**:
  - Command output: on
  - Cyclic operation: off
  - Time monitoring: off
- **Further options**:
  - Autostart: off
  - Use default operating parameters when SFC starts: off
  - Suppress messages: off

The following operating mode is set after the PLC has started up:

- **Operating Mode**:
  - OFF (if Autostart = off)
  - ON (if Autostart = on)

3.3.1 [S7] Start with and without Control Block SFC_CTRL

How the SFC chart starts depends on the mode.

**Auto mode**: when the chart starts in conjunction with an SFC_CTRL, the parameters of the SFC_CTRL are used, otherwise the default operating parameters of the SFC chart (see Table 3-2).

If the control block is not connected, the operating parameter values of the chart should be used; if it is connected, the parameters depend on the environment.

**Manual mode**: When the chart starts, the default or the currently set parameters of the SFC chart are used.

Depending on the setting of the operating parameters (Chart > Properties: Operating Parameters PLC) or in the test mode, option: “Use default operating parameters when SFC starts”, the current values are retained or these values are overwritten by the defaults.
Table 3-2  Parameters of the SFC Chart/SFC_CTRL

<table>
<thead>
<tr>
<th>Parameters of the SFC chart (manual)</th>
<th>Parameters of SFC_CTRL (Auto)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating mode:</td>
<td>CMODINI</td>
</tr>
<tr>
<td>Step control mode</td>
<td>SCT, SGC</td>
</tr>
<tr>
<td>Command output</td>
<td>INSTROUT</td>
</tr>
<tr>
<td>Cyclic operation</td>
<td>CYCLEEXEC</td>
</tr>
<tr>
<td>Time monitoring</td>
<td>TIME_MON</td>
</tr>
</tbody>
</table>

When the control block is used, illegal states at the inputs cause an error (LI_ERR). The causes and the consequent reactions are described in the online help.
3.3.2 [S7] The Operating States

The operating state of the sequential control system indicates the current state and, for example, whether operator intervention is necessary for continued operation or which commands are possible to change to a different operating state (see Figure LEERER MERKER).

![Mode Changes Diagram]

*) only with “SFC_CTRL”
(1) Final step done, cyclic operation off
(2) Final step done, cyclic operation on

Figure 3-1 Mode Changes

In the test mode, you can use the commands to change the operating states (see Figure 3-1).

- Start/resume
- Abort
- Halt
- Restart

For a detailed description of the commands and their meaning, refer to the online help of SFC.
3.3.3 Execution of a Sequential Control System

Phases of a Step

Each step is divided into three phases:

- Initialization is the action for first-time execution
- Execution is the action for cyclic execution
- Termination is the action for last execution

![Chart topology](image)

![Run-time phases](image)

Figure 3-2 Phases of a Step in Conjunction with a Successor Transition

Processing Steps and Transitions

The initial step is activated when the chart is started without querying conditions and its actions are executed.

A (normal) step can have the states “active” and “inactive”. A step becomes active after the preceding transition passes control to it. The actions are then triggered and executed. A step becomes inactive after the successor transition is satisfied.

If there is an abort, the termination processing of the previously active step is executed and the initialization of the final step is started (overlapping in the same cycle).

A transition has the states “FALSE” and “TRUE”. The state of the successor transition of the active step is queried. If the successor transition is true (the condition is true), the previous step is deactivated and the next step activated. If a minimum run time is configured, the transition is queried depending on the step control mode only after a this time has elapsed.
The actions of the **final step** are executed once only.

![Diagram of Sequential Control System](image)

When the chart progresses from one step to the next, the predecessor step is terminated in the same cycle as the first action (initialization or execution) of the next step. This allows the “non-latching behavior” specified in **IEC 1131 - 3** to be achieved.

**Example:** In step S4, the execution opens a valve and in the termination phase this is closed again. If the same valve is opened again in the first action of the next step (S5), the overlapping of the two actions (both in one cycle) means that the valve is not closed.

**Special Situations**

The example in Figure 3-3 shows the response when all three actions of a step are configured.

Other combinations are also possible:

- If no “initialization” is configured, the execution begins immediately when the step is activated.
- If no “termination” is configured, the step is deactivated immediately when the transition is true.
The minimum time in which a step is active depends on the number of configured actions (for normal steps 1 to 2 processing phases, with the final step up to 3). If a minimum run time is set for a step, the step remains active for at least this time even if the transition condition is satisfied earlier.

**Processing a Simultaneous Sequence**

The paths in simultaneous sequences are executed more or less simultaneously in one cycle (in other words, the entire simultaneous sequence). The simultaneous sequence paths are executed independent of each other.

The transition after the simultaneous sequence becomes true when all steps at the end of the sequence paths are active and the conditions are satisfied.

**Processing an Alternative Sequence**

The path of an alternative sequence that is executed is the sequence with the transition whose condition is true first.

If several conditions are true at the same time, the transition furthest left in the chart topology is activated.

---

**Note**

In an alternative sequence, there must not be no transition without parameters at the start of a sequence path. Reason: Transitions without parameters are always TRUE and are therefore automatically satisfied. This means that they are always true **before** a transition with parameters.
### Processing a Loop

Figure 3-4 illustrates the phases of a loop: To the left the elements in the chart topology, to the right the corresponding phases.

![Diagram of loop phases](image)

**Figure 3-4** Phases of a Loop

### Processing a Jump

The jump is executed when the transition of the jump is satisfied.

![Diagram of jumps](image)

**Figure 3-5** Example: Jumps from a Successor Transition and an Alternative Sequence

If there is more than one jump following the origin of a jump (S4), then (just as in alternative sequences), the jump whose transition is satisfied first is executed. If several transitions are true at the same time, the transition furthest left is activated. If the next element in the sequence is not a successor transition (such as T4 on the left in Figure 3-5) but an alternative sequence, all the transitions of the alternative paths (T5 and T7) are queried before the transitions of the jumps.
Test and Commissioning

Overview

To support you when you put a new program into operation, the SFC editor provides test functions that allow you to monitor the operation of the charts on the CPU, to control the running of the chart, and to change settings.

This chapter describes how to monitor and control the sequential control system when testing.
4.1 Activating the Test

Requirements for Testing

The sequential control system including the required basic automation functions must be loaded on the PLC.

[S7] The Modes for Testing

Before you switch over to testing, you can select between the process mode and the laboratory mode.

In the process mode, the communication for online dynamic display of the SFC charts is restricted and causes only limited extra load on the CP and bus.

The laboratory mode allows convenient and efficient testing and commissioning. In the laboratory mode, in contrast to the process mode, communication for online dynamic display of SFC charts is unrestricted.

You set the mode for testing with the menu commands “Options > Process Mode” or “Options > Laboratory Mode”.

Switching over to the Test Mode

You change from the Edit mode to the Test mode by clicking the button in the toolbar or using the menu command “Debug > Test Mode”. During the Test mode, you can change to the Edit mode at any time.

The mode change relates to the currently active SFC chart. This chart is displayed dynamically in its overview and is cyclically updated (you can set the watching cycle with the “Debug > Test Settings...” menu command.)

Note

If you change the test settings, you change the watching cycle for all charts of this CPU.

After you change to the Test mode, the current state of the chart is displayed. This means that a sequential control system that has already started cannot always be monitored or controlled from the start. This is, for example, the case with charts that are started immediately after they are downloaded to the CPU without any operator command being required (autostart).

[S7] Note on H CPUs If the H CPU is in the solo mode, for example after the failure of a CPU and there was a CPU failover, an online access (in this case, download) results in a dialog being displayed. In this dialog, you can select the required CPU. In the redundant mode, this dialog does not appear.
4.2 Display in the Test Mode

Compared with the Edit mode, the chart window has two more toolbars in the Test mode. These bars are normally arranged so that one is above and one below the working area (see Figure 4-1, here the element bar and the toolbar are not displayed).

The upper bar has the following buttons (from left to right):

- The combo box for selecting the mode
- The button for enabling the switchover to “Auto”
- A symbol for the status display (see Table 4-1)
- The combo box for selecting the step control modes
- The buttons for the commands (“Start / Continue”, “Abort”, “Hold” and “Restart”) to control the operating state
- The button for Confirm All
- Symbol to display illegal states at the SFC_CTRL inputs

The lower bar contains the following:

- The option buttons for activating and deactivating the chart execution options

![SFC Window in the Test Mode (without Element Bar and Toolbar)](image-url)
Operator prompt

The operator prompt (not with step control mode “T”) is displayed in a box beside the transition icon.

After clicking the box (or the button) and after execution has been resumed, the operator prompt is cleared again.

Displaying the States

The various states of the sequential control system, the steps, the transitions and the operator prompts are visualized by different colors and icons.

In addition to the color frame of the steps, a status display also appears. The icon of the status display is therefore an additional indicator of the current states in the chart in case the colors cannot be clearly distinguished.

Table 4-1 Appearance of the Status Display

<table>
<thead>
<tr>
<th>Status</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chart inactive</td>
<td>Check mark (black)</td>
</tr>
<tr>
<td>Step executed</td>
<td>Check mark (green)</td>
</tr>
<tr>
<td>Step active</td>
<td>Arrow</td>
</tr>
<tr>
<td>Step stopped</td>
<td>Arrow on line</td>
</tr>
<tr>
<td>Step error *)</td>
<td>Red lightning arrow</td>
</tr>
</tbody>
</table>

*) With error acknowledgment button “E” beside the lightning arrow

Colors

You cannot change the colors of the status indicator, these are the default colors of the step statuses. You will find the table with the defaults in the online help under “Default Colors”.

Display of the CPU mode

The operating mode of the CPU is displayed in the status bar (right information box) in color (green = RUN, red = STOP).
4.3 Operator Control and Monitoring of the Sequential Control System

Setting the Test Environment

With the "Debug > Test Settings..." menu command, you can open a dialog box in which you can change the watching cycle for the current program (default 2s). You can set cycles from 1 to 9 and in steps of ten from 10 to 90 seconds.

Setting the Test Mode

You can select the mode for the test in the Edit mode using the menu commands in the “Debug” menu. It is not possible to change over once you are in the Test mode.

Operator Control and Monitoring

You operate and monitor the chart in the overview display. Here, you can change the statuses, modes, step control modes, and the chart options as required.

If you double-click on a step or a transition, a dialog box appears resembling the object properties dialog in the Edit mode. You can also display the object properties for step and transition at the same time by selecting the required transition and opening both dialog boxes by double-clicking a step (or the other way round by selecting a step and double-clicking the transition). To be able to see both dialog boxes at the same time, the step and transition do not need to belong together.

A selected element in the chart is indicated by a blue background.

Confirming in the Chart and in the Object Properties Dialog

If a button is displayed for operator intervention or to confirm an error for the monitored step or transition, the dialog box with the object properties also has the corresponding button or buttons added to it. In Figure 4-3, the button is displayed with “C”.

Note: After a step run-time error has been acknowledged, the appearance of the step returns to the state before the error occurred (for example active = “green”).
4.3.1 The Object Properties of a Step during Testing

The Properties dialog is divided into four parts. These are the tabs: “General”, “Initialization”, “Processing” and “Termination”.

- **General**

  The “Name” box in the “General” tab is in a frame, the frame color corresponds to the operating state of the step or transition and is updated constantly (colors: see table in “Default Colors” in the online help).

  You can activate or deactivate the “Confirmation” option and which sets or resets a flag that is evaluated in the “T / T and C” step control mode (step-specific confirmation by user). The sequential control system operates as follows:

  - **process-controlled** for steps without the “Confirmation” option.
    Each satisfied successor transition of a step without the “Confirmation” option passes control without operator intervention (corresponds to “T”).

  - **operator-controlled** for steps with the “Confirmation” option.
    If the successor transition of an active step with the “Confirmation” option is satisfied, an operator prompt is set and control passes to the next step or steps after the prompt has been confirmed (corresponds to “T and C”).

[S7] By setting the “Target step” option, the current step is selected as the target step. This means that

  - the stopped SFC chart starts at the selected target step instead of at the start step with the next “Start” command.

  - the held SFC chart resumes at the target step after correct processing of the interrupted steps when the “Continue” command is set.

[S7] The target step marker is valid only for the next “Start” or “Continue” command. If the CPU is restarted and if there is a change from “Manual” to “Auto”, the target step marker is deleted.

[S7] **Note:** You can also select several steps as the target steps (for example in simultaneous sequences). The user is responsible for selecting the target steps so that the processing is feasible; in other word, that no blockages or endless loops result.

You can change the values of “Run Times Minimum” and “Run Times Maximum”. By clicking in the input box, you open a dialog in which you can change the current setting. Any changes you make are entered in the ES data management when you confirm with OK and take effect in the next processing cycle.

With the boxes “Run Times - Current”, “Time to minimum” and “Time to maximum” you can monitor the run time.

If no values were configured for the run times (time = 0), then “- - -” is displayed in the boxes.
• **Initialization, Processing, Termination Tabs**

The current value of the 1st address is shown in a box to its left. The box to the right beside the 2nd address contains the current value setting that you can modify. If you click the box, you open the “Change Value” dialog box, in which you can enter the new value.

After you close the dialog box, the changed value is written to the ES data management and becomes effective in the next processing cycle.

![Properties - S 1 (ACTIVE) -- Proj1\Pla1\Unit13\Funct2\SFC1](image)

Figure 4-2    Properties of the Step in the Test Mode

If the monitoring of the step detects a time error, the confirm button is added to the other buttons. This allows you to acknowledge the error from the dialog box.

Using the “Go To” button, you can jump from the current field of an operand to its point of use (block in the CFC chart, SFC chart, I/O address in HW Config.).
4.3.2 The Object Properties of a Transition during Testing

The Properties dialog of a transition is divided into four parts. These are as follows:

- **General**
  The “Name” box in the “General” tab is in a frame, the frame color corresponds to the operating state of the step or transition and is updated constantly (colors: refer to the table in “Default Colors” in the online help).

- **Current Cond.**
  shows the current state of the conditions.

- **Previous Cond.**
  shows the state of the condition of the previous processing cycle.

- **Cond. after Error**
  shows the state of the condition that led to an error.

**“Current Cond.” tab**

To the left of the first address and to the right of the second address there are fields with the current value of the address. You can modify the contents of both boxes. If you click one of the boxes, the “Change Value” dialog box is displayed in which you can enter a new value for the address.

After you close the dialog box, the changed value is written to the ES data management and becomes effective in the next processing cycle.

![Figure 4-3 Properties of the Transition in the Test Mode](image-url)
If an operator prompt is set for the transition being monitored in the chart and the button is displayed beside the transition, the button area in the dialog box of the object properties also has this button added. This allows you to acknowledge the operator prompt from the dialog box.

Using the “Go To” button, you can jump from the current field of an operand to its point of use (block in the CFC chart, SFC chart, I/O address in HW Config.).

**Status of the Logic Operation**

The results of the logic operations of the conditions using Boolean operators are visualized as colored links of varying thickness. A broad, green line means “satisfied”, a thin, red line means “not satisfied” and a thin, black line means “inactive”.

**Update**

The content is updated continuously in the “Current Cond.” tab. In the “Current Cond. -1” and “Cond. after Error” the “Update” button is also displayed. The state of the transition is entered here as it was at the time when the object properties were opened. Using the “Update” function, you can display the current state in a permanently open dialog box.
Documentation

Overview

This chapter describes how you create the documentation for your SFC chart. This includes printing the chart in various views and printing the parameter assignment, the properties, and chart reference data. You can also print the messages logs (for example of the consistency check).
5.1 Printing a Chart

Specifying the Page Layout

With the “Chart > Page Setup...” menu command, you can select the layout. In the list in the dialog box displayed, you can select the paper format (for example “A4”, “A4 with margin” etc.).

Footers

With the DOCPRO optional package, you can print the SFC chart along with footer data. In the footer data, a distinction is made between shared or global data and local data specific to a chart.

You can enter the global data for the project using DOCPRO or the SIMATIC Manager; the local chart-specific data must be entered with the SFC editor. Remember that the data specific to a chart overwrites the entries of the global data for the particular chart.

You can also enter data specific to a chart even when you have not installed the DOCPRO optional package. This data is saved and can be printed later when DOCPRO is available for print jobs.

The footer includes a fixed field with the continuous page number of the print job. With jobs up to 99 pages, both the consecutive number and the total number of pages is shown; for example, 2/14.

If the job covers more than 99 pages, the total number of pages is not shown however the page number is followed by a “+” to indicate that there are more pages to come; for example 1+ ... 7+ etc.

The number of the last page is followed by a “-”; for example 127-.

In the global footers, you can enter keywords that are replaced by the actual texts when you print out. The keywords that can be used and their meaning (origin) are explained in the online help of SFC.

With the menu command “Chart > Footers...”, you can open a dialog box (tabs “Part 1” to “Part 4” and “Free Fields”) in which you can enter the text you want to have printed out in the footer on each page.

You enter the text in the relevant input boxes below the title “For this Chart”.

Printing a Chart

You can print the active chart by clicking the button in the toolbar or with the “Chart > Print...” menu command. A dialog is opened in which you can select what you want to print and how you want it to appear:

- **Print What**
  - Chart properties
    The chart properties (name, project path, author, date created, date changed, comment and installation positions (tasks)) are printed.
  - Normal size
    With the normal setting, objects in the chart are printed with a fixed size. Depending on the topology and paper format, the chart may be spread over several pages.
  - Chart on one page
    The SFC chart is printed on one page regardless of its size. This provides an overview of the chart topology.
  - Section (window width):
    Only the content of the active window of the SFC chart is printed out.
  - Properties of steps/transitions:
    The parameter settings for the steps (properties, actions) and the transitions (properties, conditions) are printed.

- **Options:**
  - Alternative sequences aligned left
    With this option selected, the alternative sequences are printed on the left, otherwise they are printed centered in the plant topology.
  - With comment/text
    This option decides whether the comments for steps and transitions are printed in the plant topology. The comments are restricted to 16 characters just as on the screen. The texts inserted in the chart are also only printed when this option is set.

---

**Note**

The selected range is always printed for the entire chart. If you only require a printout of a step or a transition, use the print functions of the in the “Object Properties” dialog of the selected element.

---

**Print Preview**

With the “Chart > Print Preview...” menu command, you can display the pages to be printed on the screen before you send them to the printer.
5.2 Chart Reference Data

With the menu command “Options > Chart Reference Data” or with you start an application that generates comprehensive documentation in the form of lists, for example the run sequence, the cross-references of the addresses etc.

With a search function, you can search for specified addresses, symbols, I/Os etc. This helps you to check your configuration structure. With the “Cross-References of Addresses” list, you can, for example, check which addresses are used and how often and whether the write access is synchronized.

You do not need to close the window with the chart reference data if you want to continue working with the SFC editor. This means that you can view the lists while working with the SFC editor.

For a detailed description of the “Chart Reference Data”, refer to the online help.
5.3 Logs

The “Options > Logs...” menu command displays a dialog box with several tabs. The dialog displays only the tabs for the functions that were used already in the current chart folder. The tabs relevant to SFC charts are listed below:

- **Compilation**
  Lists the messages that occurred during compilation (including the compiler messages); for example, when only the S7 program exists in the project and there is not yet a station: “The program is not assigned to a concrete CPU”.

- **Consistency Check**
  This lists the messages that occurred during the consistency check, for example (with S7) “the immediate successor to the control block SFC_CTRL in the run sequence of OB31 is not the assigned SFC chart”.

- **Download**
  Lists the messages that occurred during downloading, for example, when no errors occurred in the download: “0 errors and 0 warnings found”.

- **Step Processing**
  After checking the SFC run-time behavior with the menu command “Options > Check Step Processing”, this tab lists the steps that use the same address in the terminating action of one step and in the initializing action or processing action of the next step. The log shows how many SFC charts were checked and how many accesses were found and the SFC charts with an unchanged run-time behavior.

- **Convert Format**
  After converting charts of older versions to $\geq$ V5.0, the charts that no longer have the same properties are listed here. These include, for example, the SFC charts that had the attributes “scan rate” and “phase offset” in the old version. The information includes the installation location (task) and the values for the scan rate and phase offset for every chart affected.

  Example: “SFC1: Task OB35  scan rate 4  phase offset 2”

The “Go To” button is activated when an object occurs in a selected message that can be displayed. If you click the button, the relevant chart is opened and the object selected and displayed centrally.
Technical Specifications

A.1 Technical Specifications

Hardware Requirements

- PG or PC with:
  - Pentium Processor
  - RAM 64 Mbytes (or more)
  - Hard disk 200 Mbytes (less RAM)
  - Graphics card VGA 640 x 480
    (recommended: SVGA 1024 x 768 or higher)
- SIMATIC S7-400

Software Requirements

- Microsoft Windows NT (SP 5)
- STEP 7
- SCL Compiler
- CFC

An authorization for STEP 7, SCL, CFC and SFC must be installed on drive C:.

General Numeric Data

<table>
<thead>
<tr>
<th>Object</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steps per chart</td>
<td>2 - 255</td>
</tr>
<tr>
<td>Transitions per chart</td>
<td>1 - 255</td>
</tr>
<tr>
<td>Statements per step and action</td>
<td>≤ 50</td>
</tr>
<tr>
<td>Conditions per transition</td>
<td>≤ 16</td>
</tr>
</tbody>
</table>
# Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Step control mode: confirmation by operator</td>
</tr>
<tr>
<td>C / C++</td>
<td>High-level language for programming computers</td>
</tr>
<tr>
<td>CFC</td>
<td>Continuous Function Chart</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>DB</td>
<td>Data Block</td>
</tr>
<tr>
<td>ES</td>
<td>Engineering System</td>
</tr>
<tr>
<td>FB</td>
<td>Function block (function block with memory)</td>
</tr>
<tr>
<td>FC</td>
<td>Function (function block without memory)</td>
</tr>
<tr>
<td>HID</td>
<td>Higher level designation</td>
</tr>
<tr>
<td>IEA</td>
<td>Import/Export Assistant</td>
</tr>
<tr>
<td>OB</td>
<td>Organization Block</td>
</tr>
<tr>
<td>OS</td>
<td>Operator Station</td>
</tr>
<tr>
<td>OCM</td>
<td>Operator Control and Monitoring (WinCC)</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>PCS 7</td>
<td>Process Control System (SIMATIC)</td>
</tr>
<tr>
<td>PG</td>
<td>Programming Device</td>
</tr>
<tr>
<td>PH</td>
<td>Plant Hierarchy</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable (Logic) Controller</td>
</tr>
<tr>
<td>SFB</td>
<td>System Function Block</td>
</tr>
<tr>
<td>SFC</td>
<td>Sequential Function Chart</td>
</tr>
<tr>
<td>SFV</td>
<td>SFC Visualization</td>
</tr>
<tr>
<td>STEP 7</td>
<td>Software development environment for SIMATIC S7 / M7</td>
</tr>
<tr>
<td>T</td>
<td>Step control mode: transition only</td>
</tr>
<tr>
<td>T or C</td>
<td>Step control mode: transition or confirmation by operator</td>
</tr>
<tr>
<td>T and C</td>
<td>Step control mode: transition and confirmation by operator</td>
</tr>
<tr>
<td>T / T and C</td>
<td>Step control mode: with confirmation of specified steps by operator</td>
</tr>
</tbody>
</table>
Glossary

A

Absolute addressing
If data is addressed in absolute form, the absolute address is used to access the value with which the operation will be performed. Example: The address Q4.0 identifies bit 0 in byte 4 of the process output image (PIQ).

Access
Chart elements or block I/Os can access addresses, charts, block I/Os, or run-time groups. A distinction is made between read and write access.

Action:
Actions allow the activation or deactivation of run-time group and SFC charts, as well as modifications to blocks and shared resources and their input parameters. The actions are formulated in SFC in the Properties dialog.

Address
An address is part of a STEP 7 instruction and tells the processor what it should perform an operation on. It identifies the location of data or an area containing data, examples: input I12.1; memory word MW25; data block DB3. It can be addressed in symbolic or absolute form.

In SFC, the address is part of a statement (step) or condition (transition).

Alternative sequence
Structure element of the SFC consisting of at least two sequence paths. Only the path whose transition becomes true first is executed by the PLC.

Programmable controller
A programmable controller a SIMATIC S7 PLC, a complete device (PLC with integrated operator panel) in SIMATIC C7 or an automation computer in SIMATIC M7. It is used for closed and open-loop control of processes in process engineering and manufacturing.
Basic automation

Basic automation is the configuration of the programmable controller (PLC). The configuration tools available are the CFC and SFC editors.

Block

Blocks are separate parts of a user program that are distinguished by their function, their structure or purpose.

CFC works with ready-made block types that are placed (inserted) in a CFC chart. When a block type is inserted in the chart, a block instance is created. These block instances and their graphic representation are blocks in the sense of CFC.

Block category

The block category identifies different forms of blocks. Block categories include, for example, data blocks (DBs), function blocks (FBs), and functions (FCs).

Block I/O

Block input or block output

Block input

Block I/O that can be interconnected with block outputs and addresses of the same data type or can have parameters assigned to it.

Block instance

A block instance is the implementation of a block type. A block type inserted in a CFC chart becomes a block instance. When it is inserted, the block instance is assigned run-time properties and is given a name that is unique within the chart.

Block output

Block I/O that can be interconnected with block inputs and addresses of the same data type.
C

CFC
Continuous Function Chart.

1. Function chart (CFC chart) with the graphic interconnection of technological functions (blocks).

2. An editor for plant/oriented, graphic configuration of automation tasks. Using CFC, entire software structures are created (CFC charts) from ready-made blocks.

Chart
Document in which continuous automation functions are created with the CFC configuration tool or in which sequential control systems are created with SFC.

Chart element
Chart elements of the SFC chart are the basic elements (step, transition, text) and structure elements (sequence, simultaneous sequence, alternative sequence, loop and jump).

Chart folder
Folder in the project structure containing charts of a user program.

Chart reference data
Chart reference data are data available to the user in addition to the graphic chart display in the form of lists, for example the list of accesses to shared addresses.

Chart topology
In the chart topology of the SFC chart, the chart elements are displayed according to fixed syntax rules (for example, order, spacing, extent and alignment of the elements). When the chart is created, the syntax rules are adhered to automatically by the editor.

Component view
Device-oriented view in the SIMATIC Manager. The project is displayed with its components (station, module, program ... ); alternative to the Plant View.
Condition

Conditions in a transition allow you to do the following:

- to read values of block I/Os or shared addresses
- To logically combine the read values with a constant or another read value using Boolean operators (=, >, <, ...)

The result of a condition is a Boolean variable that can be logically combined with the results of other conditions.

Consistency check

Checks the consistency of block types, shared addresses etc. of the chart folder.

Control block

With the SFC control block (SFC_CTRL), you can query the status of an SFC chart and influence its execution in CFC. The control block is inserted in the CFC chart, interconnected, and assigned parameters. It has its own run-time properties and can be modified (along with the SFC chart) in the run sequence. The control block must always be installed immediately before an SFC chart in the run sequence.

Cycle time

The cycle time is the time required by the CPU to execute the user program once.

D

Data block (DB)

Data blocks are data areas in the user program containing user data. There are shared data blocks that can be accessed by all logic blocks and instance data blocks that are assigned to a particular FB call. In contrast to all other blocks, they contain no instructions.

Data type

A data type specifies how the value of a variable or constant is used at a block I/O. "BOOL", for example, defines a binary variable; "INT" defines a 16-bit integer variable.

Dynamic display

In the dynamic display, input and output values of a block in a CFC chart or address values in an SFC chart are updated from the CPU in the Test mode.
Edit mode:
(Alternative to the Test mode)
In CFC, blocks can be inserted, copied, moved, deleted, assigned parameters, or interconnected.
In SFC the sequential control system is created in this mode. Chart elements can be inserted, copied, moved, deleted, renamed, and assigned parameters.

Enable attribute
The enable attribute is a run-time attribute. It activates or deactivates a run-time group or an SFC chart. As long as it is deactivated, the run-time group (or SFC chart) is not executed regardless of any other conditions.

The enable attribute can be set dynamically. In this case, the output value of a CFC block or the statement in an SFC action decides whether the run-time group (or SFC chart) is activated or deactivated.

Forced manual switchover
Switchover by the operator from the "AUTO" mode to the "MANUAL" mode without being enabled by the control block SFC_CTRL.

Hierarchy folder
The hierarchy folder is used to structure the plant in a hierarchy. It can contain further hierarchy folders and objects such as CFC / SFC charts, process pictures, reports, additional documents (Excel, Word, ...). The HID of an object is obtained from the name of the hierarchy folder (path) and the object name.

Higher level designation (HID)
The HID identifies parts of a plant according to functional aspects. This is made up of the hierarchical path of the plant hierarchy.

Installation and commissioning
The CFC/SFC editors provide test functions to allow you to monitor, modify, and change parameter settings on the PLC during installation and commissioning.
Installing

Procedure in which a CFC block/SFC chart is positioned in a run sequence and logged on with an organization block (OB in S7).

Interconnection

In CFC, the connection of an I/O to another element. The value of the interconnected input is fetched from the other end of the interconnection during run time. Read or write access from an SFC chart to a block I/O in a CFC chart is also known as an interconnection.

Jump

A jump is a structure element of SFC, with which the execution of an SFC chart can be continued at a different step in the same chart depending on a transition condition.

Laboratory mode

One of the two test modes. The laboratory mode allows convenient and efficient testing and commissioning. In the laboratory mode communication for online dynamic display of SFC charts is unrestricted.

As an alternative to the laboratory mode, you can also select the process mode (restricted test mode). It is not possible to switch over between the process and laboratory modes when testing is active (only in the edit mode).

Library

A folder for objects that can be used again and again. A library is not project-related. Blocks are made available in block libraries sorted according to certain criteria (block families, alphabetical order etc.). Different block libraries are used depending on the PLC or situation.

Loop

Structure element in SFC consisting of a sequence and a return path; the sequence encloses and contains exactly one transition.
Message configuration

Creating messages with their attributes and texts. Messages (for ALARM_8) can be configured from within SFC.

Online/Offline

In the SIMATIC Manager, objects of the programmable controller are displayed in the online view and the objects of the ES in the offline view. Online, there is a data connection between the PLC and the programming device/PG, offline there is no connection.

Operating mode

1. CPU:
Using the mode selector of the CPU, you can set the following operating modes:

   - RUN with access to the STEP 7 user program, for example, with programming device ("RUN-P"),
   - RUN with access protection ("RUN"),
   - STOP and
   - Memory Reset ("MRES").

2. SFC:
The mode decides how the execution of an SFC chart is controlled.

   - Auto (process mode): Control is automatic (for example using the control block).  
   - Manual (operator mode): Execution of the chart is controlled manually by an operator, for example during commissioning or with SFV (SFC Visualization in WinCC).

Operating state

1. The programmable controllers of SIMATIC S7 can adopt the following states: STOP, STARTUP, RUN and HOLD.

2. The sequential control system can operate in the following states IDLE, RUN, HELD, TERM, and ABORTED.

Operating system

General term for all the functions that control and monitor the execution of the user programs, the distribution of resources to the individual user programs, and the maintenance of the operating mode in conjunction with the hardware (for example standard operating system MS-WINDOWS).
Organization block (OB)

Organization blocks form the interface between the operating system of the CPU and the user program. The order of execution of the user program is specified in organization blocks.

An organization block corresponds to a task.

OS

Operator Station. A station for controlling and monitoring the process. In PCS 7, the WinCC software system is used for the OS with which all the process monitoring and control functions can be implemented.

P

Phase offset

The phase offset shifts the point of activation of the run-time group within a task by a defined time compared with the basic cycle. Phase offset allows a uniform distribution of load within the CPU. See also scan rate.

Plant hierarchy (PH)

A hierarchy structured according to technological aspects.

Plant view

View in the SIMATIC Manager based on technological aspects (plant, unit, function ...); alternative to component view.

PLC

PLC is used as a general term for the unit containing the CPUs on which the user program runs. In this case, it includes S7 programmable controllers and M7 automation computers.

Process

Sequence of chemical, physical, or biological processes for extraction, production or elimination of substances or products.

Process image

Reserved areas in the RAM of the CPU. Signal states of the input and output modules are entered here.
Process mode

One of the two test modes.
In the process mode, the communication for online dynamic display of the SFC charts is restricted and causes only limited extra load on the CP and bus.

As an alternative to the process mode, you can also select the laboratory mode (unrestricted test mode). It is not possible to switch over between the process and laboratory modes when testing is active (only in the edit mode).

Process variable

The process variable is a neutral object in terms of resources. It is used to connect the PLC configuration world (STEP 7, CFC ...) with the OS configuration world (WinCC). It contains information about its location during run time (for example the network address and the memory area on the PLC) as well as information on specific OS-relevant properties.

Processing phase

A step is divided into three processing phases: initialization, (cyclic) processing and termination. Each processing phase corresponds to an action with statements.

Program

General term for S7 and M7 programs.

Project

A folder for all the automation solutions regardless of the number of stations or modules and how they are networked.

Recipe

A recipe is a procedure for manufacturing a product according to a specific procedure.

Resources

Resources are pools of objects (FBs, FCs, DBs, OBs, bit memory, counters, timers etc.) that can be accessed when configuring and setting parameters for a CFC/SFC chart.
Run sequence
A program section with which the blocks and/or SFC charts can be installed with a specific execution sequence on the CPU. The run sequence is displayed as a separate window in CFC and contains the tasks (OBs) of the relevant PLC.

Run-time attribute
Run-time groups have run-time attributes that control their activation. All the blocks and/or SFC charts in a run-time group inherit these attributes from it.

Run-time group
Run-time groups are used to structure tasks. The blocks and/or SFC charts are installed in the run-time groups. Run-time groups have run-time attributes and can be activated and deactivated separately by interconnecting them with a block output or by a statement. If a run-time group is deactivated, none of the blocks it contains will be activated any longer.

Run-time properties
The run-time properties of block or SFC chart determine how the block/chart is included in the execution of the entire structure on the PLC. These properties are vital to the performance of the PLC in terms of reaction times, dead times, or the stability of time-dependent structures, for example control loops.

S

S7 program
A folder for the symbol table, the blocks, the source files, and the charts for the programmable S7 modules.

Scan rate
The scan rate is a run-time attribute. It specifies whether a run-time group is executed every time a task is executed or only every nth time. See also phase offset.

SCL
A high-level language similar to Pascal complying with IEC 1131-3 for programming complex solutions on a PLC, for example algorithms and data processing jobs.

Sequence
Structure element in SFC containing a sequence of steps and transitions.
Sequence path

In SFC, a sequence path is a series of chart elements (in the chart topology seen as a vertical path). A simultaneous sequence or an alternative sequence consists of at least two sequence paths arranged side-by-side and containing at least one element.

Sequential control system

A sequential control system switches from one to the next step dependent on conditions. In PCS 7, sequential control systems are implemented with SFC charts.

SFC

An SFC chart is a sequential control system that runs as a separate control system within the programmable controller.

Shared address

Shared addresses are I/O signals (input/output bits, bytes, words, double words; peripheral input/output bits, bytes, words, double words), memory bits, timers, counters, data block cells, functions, or function blocks. They can be accessed in absolute and symbolic form by SFC and CFC.

Symbolic access uses names (the symbol) of the shared address in the symbol table. For absolute access, the symbol table is not required. The absolute form of the shared address is entered. Symbolic addressing has the advantage that the connection is retained if the address is changed and the symbol stays the same.

When accessing addresses, make sure that the shared address has the same data type as the block I/O in the CFC chart or statement/condition in the SFC chart.

SIMATIC Manager

Graphic user interface for SIMATIC users under Windows 95/98/NT. The SIMATIC Manager is used, for example, to create projects and access libraries.
Statement

A statement in an action of a step can be used for the following:

- to write to CFC block I/Os
- to assign shared addresses
- to activate and deactivate SFC charts
- to activate and deactivate run-time groups

A statement always consists of a left (first) address, an operator and a right (second) address.

Step

The step is an element of a sequential control system and is the control instance for the execution of the associated actions. A step is divided into three processing phases: initialization, (cyclic) processing and termination.

Step control mode

An SFC chart can be executed in various step control modes. These affect the way in which the execution of the steps is enabled. You can select the following modes:

- C (Step control mode: confirmation by operator only)
  The sequential control system runs dependent on confirmation by the operator.

- T (Step control mode: transition only)
  The sequential control system runs controlled by the process (automatically).

- T or C (Step control mode: transition or confirmation by operator)
  The sequential control system runs controlled by the process or by the operator.

- T and C (Step control mode: transition and confirmation by operator)
  The sequential control system runs controlled by the process and by the operator.

- T / T and C (Control with operator confirmation of selected steps)
  The sequential control system runs process-controlled in steps without the "confirmation" flag (as in "T") and must be confirmed by the operator at steps with the flag (as in "T and C"). The "Confirmation" flag can be set or reset for specific steps in the Properties dialog of the step.

Step types

SFC uses different step types:

- Initial step
- Normal step
- Final step
Structure

A structure is a structured data type made up of various elements. An element can be an elementary or a structured data type.

Structure element

Structure elements in SFC consist of an arrangement of basic elements. These include: “sequence”, “simultaneous sequence”, “alternative sequence”, “loop” and “jump”.

Symbol

A symbol is a name defined by the user according to certain syntactical rules. After its purpose has been defined (for example to represent a variable, data type, jump label, block), it can be used in programming and in operator monitoring and control.

Example: address : I5.0, data type: BOOL, symbol: Emer stop.

Symbol table

Table for assigning symbols (= name) to addresses for shared data and blocks.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emer stop</td>
<td>I1.7</td>
</tr>
<tr>
<td>Control</td>
<td>FB24</td>
</tr>
</tbody>
</table>

Symbolic addressing

If data is addressed using symbols, the address to be processed is specified as a symbol (not as an absolute address). Symbols are assigned to addresses in the symbol table.

Target step

In the test mode (or in SFC visualization on the OS), a step can be selected as the target step. This means that the deactivated SFC chart begins again at the selected step instead of the initial step at the next "Start" command and a halted SFC chart resumes at the target step after completing execution of the interrupted step(s) when the "resume" command is received.

Task

Tasks form the interface between the operating system of the CPU and the user program. The order of execution of the user program is specified in tasks.

A task corresponds to an organization block (OB) in S7.
Test mode
(Alternative to the † Edit mode) Mode of CFC/SFC for testing and optimizing user program running online on the CPU. Values of block I/Os and the execution of SFC charts on the CPU can be monitored and modified. For testing, you can select either the † process mode or the † laboratory mode.

Top chart
A CFC chart that is not nested in another chart and can be displayed in the SIMATIC Manager († nested charts).

Transition
A transition is a basic element of SFC and contains the conditions according to which a sequential control system passes control from one step to the successor step.

Update cycle
In the Test mode, this specifies the intervals at which the watched block I/Os are updated.

User program
The user program contains all the instructions and declarations and the data for processing the signals allowing a plant or process to be controlled. It is assigned to a programmable module (for example CPU, FM) and can be structured in smaller units.
In S7, a user program on the ES consists of the † symbol table, the source files, the blocks, and the charts.

Value identifier
Symbolic substitute (text) for defined values of block I/Os of the data types BOOL, BYTE, INT, DINT, WORD and DWORD.
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