SIEMENS

SIMATIC
CFC for S7

Getting Started Release 01/2005

First Steps

The Getting Started for This product is not a stand-alone description.
It is a part of the manual and can be called via "First Steps".

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

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

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Siemens AG
Bereich Automation and Drives
Geschaeftsgebiet Industrial Automation Systems
Postfach 4848, D- 90327 Nuernberg

First Steps

Introduction

This chapter “First Steps" is intended as a primer for newcomers to CFC who want to get to know the package quickly. The example is divided into various tasks and guides you step-by-step from the simplest configuration jobs to the creation of a chart with chart I/Os and blocks in CFC.

Note:

You will find a ready-made example in the SIMATIC Manager as follows:
File > Open... > “Sample projects" tab > **ZDt04_01_CFC** (German).
(English: **ZEn**..., French: **ZFr**..., Spanish: **ZEs**..., Italian: **ZIt**...)

In this example, it is assumed that CFC will be used in the STEP 7 environment. This means that the STEP 7 standard package, SCL, and CFC are installed. The PLC used is either S7-300 or S7-400.

You can create the sample project “CFCEXA_2" described below with the SIMATIC Manager.

Creating a Closed-Loop Control with a Simulated Process

Creating the Project

This section describes the steps involved in creating a project with the menu commands of the SIMATIC Manager. You configure the hardware with HW Config (this can be done later but must be done before you download to the CPU). This example is restricted to the S7 program:

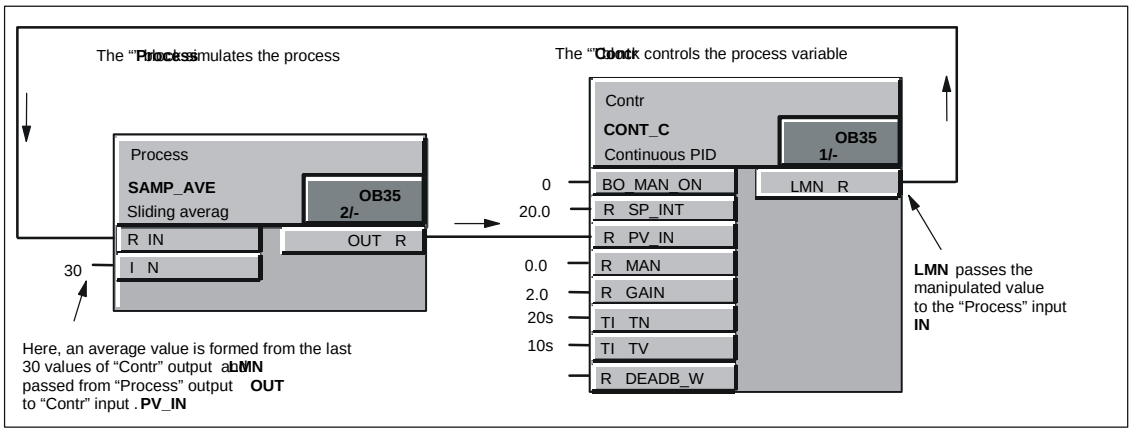
1. In the toolbar, select  or **File > New...**.
   In the “New Project" dialog box, enter the project name “CFCEXA_2" and enter it with “OK".
2. With the project folder selected, click the menu command **Insert > Program > S7 Program**.
   The S7 program is created in the "Component View" with a source files folder, block folder, and symbol table.
3. With the S7 Program folder selected, click the menu command **Insert > S7 Software > Chart Folder**.
   The chart folder is created.
4. With the chart folder selected, click the menu command **Insert > S7 Software > CFC**.
   A chart "CFC(1)" is created; Give this the name "Control".
5. Double-click the CFC chart to open it.

All the requirements for working with the CFC editor have now been satisfied.

Creating a Chart

Aim

You will now create a controller with process simulation in which the process is simulated by a sliding average value. You will use two blocks for this, SAMP_AVE and CONT_C. The SAMP_AVE block forms the average value from a number of input values and the CONT_C is a PID controller that controls this variable average value.



Inserting the Blocks

1. Open the catalog  if it is not already open (default).
2. In the catalog, click the button  of the libraries. Here you can open the **CFC Library**. This is a collection of block libraries.
3. Now open the folder **ELEM_300**. This is a library with blocks suitable for the S7-3xx CPU. If you are using the S7-4xx CPU, open the folder **ELEM_400**. You can drag blocks from the list that appears to the chart.
   In the folder, the blocks are stored sorted in block families  or are all together in alphabetical order in "All Blocks"  .
4. Click on the + character in front of the "All Blocks", folder to expand it.
5. Click **CONT_C**, hold down the mouse button and drag the block to the chart. Position it to the top right on sheet 1.
6. Then take the block **SAMP_AVE** and position it on the left beside the CONT_C block.

7. Double-click on a free position close to the two blocks to change to the sheet view (or, in the toolbar click ).

   In the sheet view, you can see the blocks as graphic objects with a header and several I/Os on the body. The I/Os (inputs left, outputs right) are displayed as fields with the I/O name and in the "wide" display the data type. With **Options > Customize > Block/Sheet Bar Width.....**, you can set the block width "Narrow" or "Wide". If "Narrow" is set (default), the blocks are displayed narrower and without the data type being shown.

   Tip: You can display the full information of the I/O as a tooltip by positioning the mouse pointer on the I/O.

Interconnecting the Blocks

Now interconnect the blocks as follows:

1. On the SAMP_AVE block, click the output **OUT** and then click the input **PV_IN** on the CONT_C block.
2. On the CONT_C block, click the output **LMN** and then click the input **IN** on the SAMP_AVE block.

   You can also interconnect in the opposite order: First click on the input and then the output. As an alternative, you can also drag a block I/O to the I/O you want to interconnect using the mouse.

The two blocks are now interconnected.

Changing the Appearance of the Blocks.

The blocks are displayed in the chart with all their I/Os (inputs and outputs) as dictated by the block type. In our example, however, we do not require all the I/Os and to make the display simpler and clearer we want to make the unnecessary I/Os invisible in the chart. In the same dialog, we will also change the block names.

1. Double-click the block header of the CONT_C block: The "Properties" dialog box is opened for this block. The name ("1") is already selected and you can type in the new name "Contr" immediately.
2. Now select the "Inputs/Outputs" tab. Using the horizontal scroll bar, go right until the "Not displayed" column appears.
3. Click the first selection cell, hold down the mouse button, and drag the mouse pointer vertically to the end of the column: The entire column is selected. With the mouse pointer in the selected area, click the right mouse button and select the "Set" command in the menu.

4. Some I/Os that are currently invisible will, however, be needed later in the test mode to input values. We will make these visible again.

   MAN_ON
   SP_INT
   PV_IN
   MAN
   GAIN
   TN
   TV
   DEADB_W
   LMN.

Setting Parameters for the I/Os and Selecting Them for Testing

1. In the "Inputs/Outputs" tab, go to the column "Watched" and set all the visible I/Os.
2. In the "Value" column, enter "20" for **SP_INT**
   (this is the default setpoint for the controller).
   Close the Object Properties by clicking "OK".

You can also set parameters directly for an individual I/O:

1. Double-click the block input **MAN_ON** of the controller.
2. In the "Value" box, change the "1" to "0".
   This disables the "Manual Mode" that would interrupt the control loop.
3. Close the dialog box by clicking "OK".

Follow the same procedure with the SAMP_AVE block (using the Properties dialog of the individual I/Os or in the Properties dialog of the block as described below).

1. Double-click the SAMP_AVE block header. Name this block “Process".
2. In the "Inputs/Outputs" tab, set the input **N** in the "Watched" column (if it is nor already set).
3. In the "Value" column, enter the value "30" for **N**.
   (This is the number of input values to be used for the average value.)
4. Close the dialog box by clicking "OK".

The blocks are now interconnected and have the parameters required for our process simulation.

Compiling and Downloading the Chart

The next step is to compile the chart as a program.

1. Select the following button in the CFC toolbar  or
   Chart > Compile > Charts as Program....
   In the dialog box that appears, set "Compile: Entire program". Complete the dialog with "OK".
   Compilation is now started and the progress is displayed in a dialog box. Confirm the final message with the S7 logs with "Close" (you can ignore the displayed warning).

   Note:
   The next step is only possible if you have configured and connected a CPU of the type S7-3xx or S7-4xx to your PC (or on a simulated automation system with S7-PLCSIM) The setting of the key switch on the CPU must be: RUN-P.

2. To download the program to the CPU, select the button 
   or **PLC > Download...**.
   In the dialog box, select the type of download (this is already set: "Entire program").

Before you download the program, the CPU is set to STOP (after a prompt that you answer with "Yes") and any blocks already on the CPU are deleted. The download is displayed in a further dialog box. After downloading the programs successfully (with no errors), a message is displayed to show that downloading is complete and asking you whether you want to restart the CPU. If you answer "Yes", you can return the CPU to the "RUN" mode.

The CPU changes to the **RUN** mode. The program is loaded and can now be tested.

Testing the Program

In the test mode, you can monitor the values of the block I/Os and change the values of the block inputs. The values registered for testing are shown on a yellow background.

If you change some of the parameters, you can monitor the controller response, for example how the manipulated value approaches the setpoint and settles.

Changing to the Test Mode

Before you change to the test mode, change the mode from "Process Mode" to "Laboratory Mode" ("Test > Laboratory Mode"). This means that all block I/Os are automatically activated for "Watching".

Note: In the "Process Mode", the default setting is **no** I/O registered for watching. In this test mode, you would have to select the relevant blocks and register them explicitly for watching (by clicking ).

Activating the Test Mode:

- Click  or select **Debug > Test Mode**.

Changing Values Online

You can set a different setpoint for the example, as follows:

1. On the controller, double-click the **SP_INT** input and set a different value (< 100) as the internal setpoint in the dialog box that follows.
2. Click "Apply" so that the value is adopted and the dialog box remains open for further changes.

After you have made a few changes and observed the control response, close the dialog box with "OK".

You can, for example, influence the speed of the settling at the block inputs:

GAIN (Proportional gain, determines the control gain)

TN (Reset time, determines the I-action)

TV (Derivative time, determines the D-action)

If you change “GAIN" to a lower value and “TN" to a longer time, the dynamic response of the controller is changed and the control response of the example is more “sluggish".

With the **MAN_ON** block input, you can interrupt the control loop and switch over to "Manual Mode" (=1). The manipulated value (in other words the value at the output **LMN**) is then set by the value of the **MAN** input.

The Result

In this part of the example, you have got to know the elementary aspects of configuring in CFC. You have created a project with the SIMATIC Manager, created a CFC chart, and inserted blocks from a library. You have interconnected the blocks and set parameters. You have created an executable program and downloaded it to the CPU. In the test mode, you were able to monitor and modify the dynamic response of the control loop.

Making Changes to the Chart

We will now leave the test mode.

- You change to the edit mode by clicking the  button.

Changing the Run-Time Properties

Introduction

The blocks of a chart have certain run-time properties. These run-time properties determine when and in which order the blocks are executed on the CPU. To structure their execution, the blocks are installed in OBs.
In this example, the default installation of the blocks is in OB35 (cyclic interrupt 100 ms) and because they are also involved in a restart, they are installed in OB100 (warm restart).

So that you do not need to worry about the run sequence for every block, CFC installs the blocks one after the other after a particular block. This block is also the "Predecessor for Installation" for a block installed later. This attribute is automatically passed on to the last block to be installed. In the CFC status bar (to the bottom right in the window) and due to the light-green color of the runtime properties box of the block, you can see which block is currently the "Predecessor for Installation".

When you create a CFC chart, a run-time group is created automatically and has the same name as the chart.

You can assign attributes to the run-time group that decide the scan rate of the OB cycle and the phase offset with which the blocks are executed.

Changing the Run-Time Properties

You want the blocks to be executed in a different sequence. The test mode is deactivated, you now call the run-time editor with the run sequence.

1. Click the button in the toolbar  or select **Edit > Run Sequence...**.

   A new window is opened displaying all the OBs. Objects have already been installed in OB 100 and OB 35 as can be seen by the + in a box in front of the OB icon.

2. Select OB 35 and the run-time group "Ctrl" it contains. The blocks are displayed in the right-hand detailed window.

   Note: The run-time group was created automatically when you created the chart.

3. Keep the mouse pointer on the run-time group and select the **Object Properties...** menu command with the right mouse button. A dialog box is displayed.

4. Make the following entries in the input boxes:

Name:	Ctrl	(default retained)
Comment	U8_PV0	
Scan rate	8	
Phase offset	0	(default retained)
Optimizing the Run Sequence	√	(default retained)
Active	√	(default retained)

5. Enter your settings with "OK".

With the setting you have made for the scan rate, the blocks are now executed every eighth run; In other words with the basic cycle for OB35 of 100 ms they will be executed every 800 ms.
The phase offset can be used to achieve a better distribution of load on the CPU when you have blocks in several run-time groups. Since this is not relevant in this example, the default "0" remains, in other words, no phase offset..

The "Optimize Run Sequence" option determines whether or not the run-time group is included in an optimization run that must be started explicitly (see Section **Fehler! Verweisquelle konnte nicht gefunden werden.**). With the "active" option, the run-time group is activated or deactivated for processing in the CPU.

Copying Blocks within the Chart

As a practical exercise, you will now copy the content of sheet 1 to sheet 2 and continue editing there. When you copy interconnected blocks the interconnections are retained.

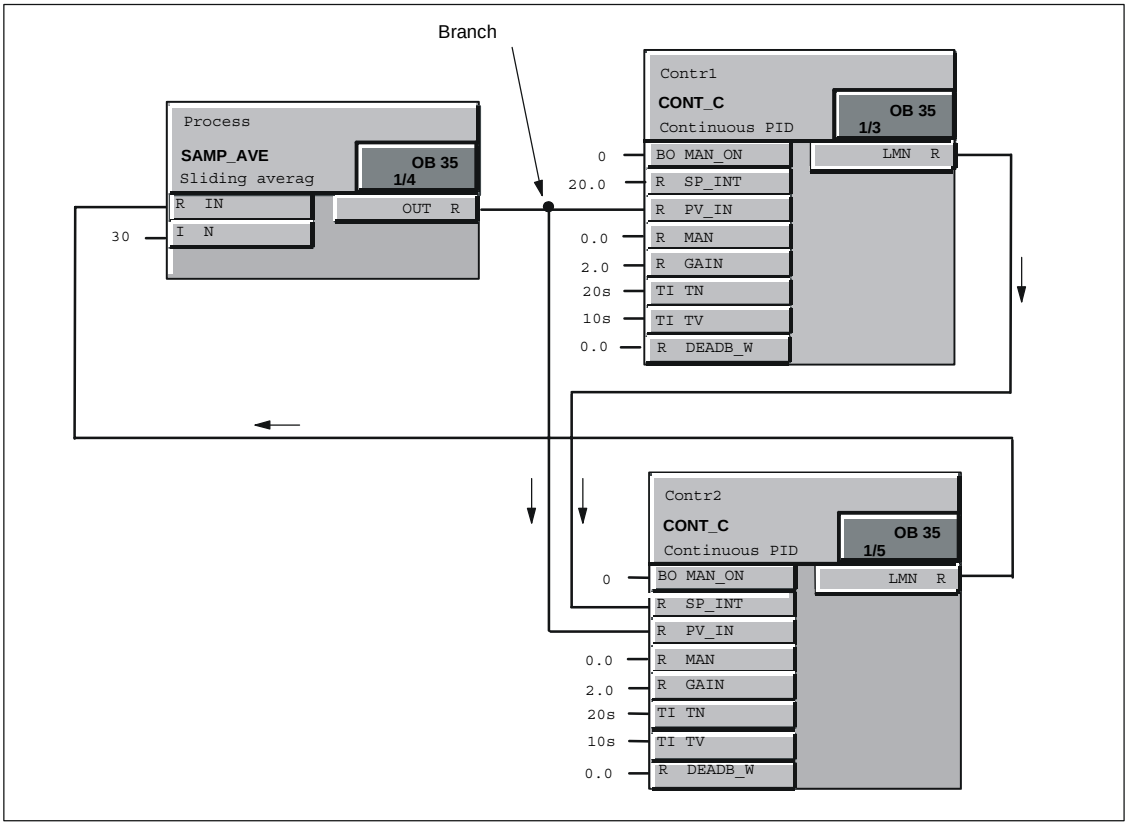
1. Change back from the run sequence to chart editing.
   To do this, click any point in the chart window (CFCEXA_2\S7 Program(1)\...\\Control) or click  again and change to the overview by clicking  .
2. In sheet 1, hold down the left mouse button and draw a lasso around the interconnected blocks. The blocks are now selected (blue).
3. Remain on the selection with the mouse pointer, hold down the Ctrl key and drag the blocks to sheet 2 (below sheet 1).
4. Select the "Contr1" block, copy it and insert it in the same sheet again. The block is called "Contr2".

Changing the Interconnection

1. Click the connecting line or the output **LMN** of "Contr1" and press the "Del" key. The connection to input **IN** of "Process1" is deleted.
2. Click **LMN** of "Contr1" and then **SP_INT** of "Contr2".

   (Later, you will learn a more elegant method of "rewiring" without deleting and interconnecting again).
3. Click **LMN** of "Contr2" and then **IN** of "Process1".
4. Click **OUT** of "Process1" and then **PV_IN** of "Contr2".

With the blocks positioned as shown, the interconnection appears as follows:



Compiling, Downloading and Testing Changes

The chart must be compiled again and then downloaded to the CPU.

1. Select the  button in the toolbar.
   In the dialog box, set the option "Compile: Changes only" and click "OK".
   Compilation is started, confirm the logs message with "Close".

2. To download the program, select the  button.
   In the dialog box, set "Download: Changes only" and confirm with "OK".

   When you download changes (as opposed to the entire program) the CPU does not need to be set to STOP.
   Caution! If you are working with a real project, make sure that you are familiar with the information in "Reasons for STOP when Downloading Changes Online" in the online help.

   (**Help > Contents**, "Index" Tab: Type in "Reasons for" and click the "Display" button.)

After downloading, you can return to the test mode and test your modified program.

The Result

In this part, you have learnt that the blocks of the CFC chart have certain run-time properties on the CPU and that you can modify them. You have also seen that substructures known as run-time groups are used in the run sequence and which attributes you can assign to them.

You have copied blocks within a chart and seen that the interconnections between the blocks are retained. You have modified interconnections and once again created an executable program. You have seen the difference between downloading the entire program and downloading changes only.

Creating Chart I/Os and a Chart-in-Chart

In the following section you will create chart I/Os for a CFC chart and insert this chart in a different CFC chart.

Creating a Chart with Chart I/Os

The chart I/Os of a chart can be used to "encapsulate" CFC charts for further use. When you create the chart I/Os, you can specify which block I/Os are relevant for interconnection with other charts or blocks and must be applied to chart I/Os.

Preparations

1. Create a new chart by clicking  in the toolbar. In the dialog box, enter the object name : "Sim_reg" and confirm with "OK". The new chart is displayed.
2. By clicking on  in the toolbar, the chart "Sim_reg" and the chart "Control" are displayed one beside the other.
3. Set the overview display for both charts by clicking  .
4. Copy the blocks of sheet 1 of the "Control" chart to sheet 1 of the "Sim_reg" chart in the same way as you did when copying blocks within a chart.
5. Close the "Control" chart and change to the sheet view (sheet 1) of the "Sim_reg" chart.
6. Open the block catalog in the catalog by clicking on the  button and then on the block family **MULTIPLX**.
7. Drag the block **SEL_R** to sheet 1 and give it the name "Switch" (in the Properties dialog).

To include the "Switch" block in our example, you must now "rewire" an existing interconnection; In other words you modify an interconnection without deleting the existing one.

8. On the "Contr" block, select the **PV_IN** input, hold down the mouse button and drag the I/O to "Switch" **IN1**. The output **OUT** of "Process" is now connected to **IN1** of "Switch".

As an alternative, you could also delete the existing connection and create new interconnections.

The output of "Switch" must now be connected to the input for the process variable of "Contr".

9. Connect "Switch" **OUT** with "Contr" **PV_IN**.

The "Switch" now switches depending on the value of the input **K**, the value of the input **IN0** (K=1) or **IN1** (K=0) to output OUT.

In a real project, this would allow you to switch over between a process simulation (IN1) and a real process (process value from the process connected to IN0).

Creating Chart I/Os for the Chart

You now create the chart I/Os for the chart. These are then connected to the selected block I/Os.

1. Click the  button in the toolbar or select **View > Chart I/Os**.
   The dialog for editing chart I/Os is opened and "docked" to the upper part of the chart window.
2. In the left-hand window, click the Block Icon of the inputs **IN**. The block inputs are displayed in the right-hand window (currently empty).
3. In the working field of the chart, select the **MAN_ON** block I/O on "Contr" and drag the I/O to the right window of the chart I/Os to the "Name" box. The I/O is then entered with all its properties.
4. Follow the same procedure with all further non-interconnected inputs (see table).
5. Change the name of I/O **K** of the "Switch" block in the chart I/Os by double-clicking in the "Name" box. Enter **SIM** here. Instead of **IN0**, enter **PV** (Process value).
6. In the left window of the chart I/Os, click on the block icon of the outputs **OUT**. Select the **LMN** output on the "Contr", hold down the Ctrl key and drag the I/O to the right window of the chart I/Os to the "Name" field.

The chart I/Os then appear as follows:

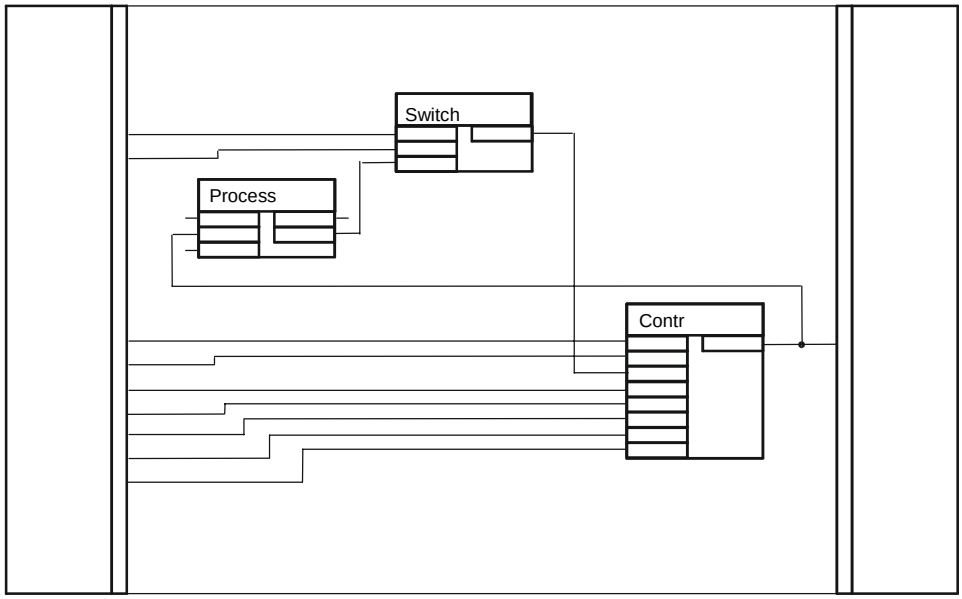
Block	Block input	Data type	Block output	Data type
Contr	MAN_ON	BOOL	LMN	REAL
	SP_INT	REAL		
	MAN	REAL		
	GAIN	REAL		
	TN	TIME		
	TV	TIME		
	DEADB_W	REAL		
Switch	SIM (previously: K)	BOOL		
	PV (previously: IN0)	REAL		

The sheet bar displays the I/O names and comments, I/O type, and data type applied to the chart I/Os.

You have now created all the chart I/Os for the chart.

7. You can now close the window of the chart I/Os by clicking  again and can "tidy up" the chart to make it clearer to read.

8. Move the blocks in the chart so that as few connection lines as possible cross over other lines. One possible arrangement is shown below.



Inserting a Chart in Another Chart

The chart "Sim_reg" created in the previous configuration step with chart I/Os will be inserted in another chart. Create the new chart as follows:

1. Click the  button in the toolbar. In the dialog box, enter "Top Chart" in **Object name:** and confirm with "OK". The new chart is displayed.

2. Open the "Charts" catalog by clicking the  button.
   In a tree hierarchy you will see the charts "Top Chart", "Control" and "Sim_reg".
   Note: If the catalog only contains the message "! "! (no hierarchy folder exists)" then you have set the option "Display catalog with plant hierarchy" in the **Options > Customize > Display...** dialog box. Since the project was created without the plant hierarchy, this option must be disabled (click the check box: The check mark is removed).

3. Select the "Sim_reg" chart and drag it to the working area of "Top Chart". The original chart is copied.

4. Change to the sheet view.

The chart with chart I/Os appears like a block and can be recognized as a chart by its icon:

5. So that you can see that this is a copy of the previously created chart, open it by selecting it and then selecting the **Open** command using the right mouse button.

In the title bar, you will recognize that this is a "nested chart" by the path: **...\\Top Chart\Sim_reg**.

In the catalog of the charts, a + box is displayed in front of "Top Chart". By clicking the box (or double-clicking the chart icon), you can open up the tree and the hierarchy of the chart becomes visible: The "Sim_reg" chart is displayed in this branch as an active chart (icon of the open folder).

To return to the top chart, you can select "Open Parent Chart" with the right mouse button or select the path for the "Top Chart" in the "Window" menu.

The Result

In this part, you have learnt how to edit a chart so that it has chart I/Os that allow it to be interconnected to other block I/Os and to be used as often as required. You have seen how a chart can be inserted like a block with the chart-in-chart technique. You have seen that, in contrast to the block, the inserted chart can be opened and modified.

With the chart-in-chart technique, you can create nested charts and therefore create a structure according to technological aspects with greater clarity.

Creating a Block Type

Normally, the entire chart folder containing the open chart is compiled. This produces a program that can be downloaded to a CPU. You can, however, also compile a single chart and create a block type from it. This is then placed in the block library or in the S7 program so that it can be used again.

Compiling a Chart as a Block Type

You will now compile the original chart "Sim_reg" as a block type.

1. Close all the charts (**Window > Close All**).

Make sure that you open the **Original chart** "Sim_reg" that is located at the same hierarchical level as the charts "Top Chart" and "Control".

2. Select the "Sim_reg" chart in the "Charts" catalog and open it with "Open" using the right mouse button.
3. Select Chart > Compile > Chart as Block.

A dialog appears in which you can enter further information.

4. In the "Properties Block Type" box, enter the following:

FB number:	110
Symbolic name:	REG_1
Name (header):	REG_1
Family:	CONTROL
Author:	TEST
Version (Header):	0.1

5. Confirm the dialog box with "OK".

The compilation is started and progress is indicated in a dialog. After successful compilation, the "FB110" block is in the block folder and the symbol name "REG_1 is entered in the symbol table.

Testing the Block

The next step is to create a new chart and to insert the block **REG_1** in it.

1. Create a new chart "Test".
2. Press the "F5" key (or **View > Update**) so that CFC reads the changes in the symbol table and the block folder.
3. Open the S7 program in the catalog of the blocks. Here, you will see the new block type **REG_1**.
4. Insert **REG_1** into the "Test" chart by dragging it with the mouse and change to the sheet view. You will see the block I/Os as you created them as chart I/Os. The **EN** and **ENO** I/Os are added by the system (so that the block can be activated and deactivated). These I/Os are invisible (default). If you want to display these I/Os as well, you must make them visible in the Object Properties, "Inputs/Outputs" tab.
5. Compile the charts as program all together and download the program to the CPU. Click  .

   You receive a message that the program has been changed and must first be compiled.
6. Answer the question "Do you want to compile now and then download?" with "Yes".

   You see a dialog box with the tabs "Compile Charts as Program" and "Download S7".
7. Select "Scope: Changes" in both tabs and start with "OK".
8. Then change to the test mode  to watch and change the I/Os of the block.

   With the **SIM** input, you can change over between internal simulation (= 0) and external process value (of the **PV** input) (= 1).

Final Comments

In this brief example, you have got to know a few of the possibilities available with CFC. The exercises have illustrated how simply and conveniently you can create a program for an automation task that can then be run on the CPU.

Once you have worked through this example, you will know CFC well enough to start tackling more complex tasks.

The following chapters and the comprehensive online help of CFC will provide you with more information.