SIEMENS

SIPROTEC 5 Compact
CFC Chart Online Simulation

APN – C.006

SIPROTEC 5 Compact Application

CFC Chart Online Simulation

APN-C.006, Edition 1

Content

1 Introduction

Smaller CFC function charts often can be configured directly, and they work correctly right from the beginning. If the charts are more complex or logic is created that includes several charts it is rather likely that errors happen somewhere in the chart configuration. Often it is just a few simple things which are not correct but to find them without additional help can be quite time consuming and difficult.

To simplify the search of such errors DIGSI 5 provides 2 different features, an offline simulation of a CFC chart and an online simulation.

The *offline CFC simulation* uses the DIGSI5 built in state sequencer. With this sequencer it is possible to define several states with dedicated values for analog and binary inputs as well as all CFC source signals. It returns a record like a fault record for all beforehand marked logical signals in the CFC, which are shown with their states and values over the time axis. This kind of simulation is useful for example to verify fast changes of signals and their interaction.

As a difference the *online CFC simulation* shows in real time the state of signals in a CFC chart, which considers the input signals of the real physical device. For this, DIGSI must be connected to the physical device to acquire all the signals which are at this moment present on the device. With this method the states of signals in the CFC change in real time when changes to the device inputs take place. Alternatively, instead of a physical device, also a device simulation by the SIPROTEC 5 Digital Twin can be used and will provide identical functionality.

In this application note we use the standard interlocking scheme which comes with the application template for O/C protection of the 7SX800 or the 7SJ85 as an example.

2 CFC Online Simulation

2.1 The Interlocking in SIPROTEC 5 devices

The interlocking with SIPROTEC 5 devices is controlled with 2 signals for each switching element which can be found in the function block (FB) "Interlocking" in the function group (FG) for the switching device, such as "Circuit breaker" (CB) or "Disconnector" (DC). Switching of this device is possible if the "> Enable" signal for the corresponding switching direction is logically "1". If the signals are not used, then no interlocking condition is applied and the switching of this element is always allowed and possible, see figure 1.

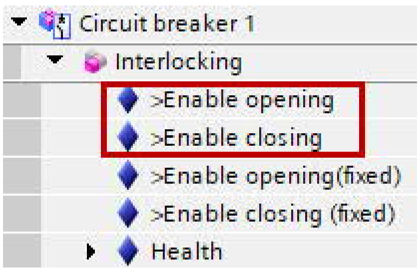

Figure 1 The ">Enable opening" and ">Enable closing" signals for the Circuit breaker 1.

If you disable the intelocking feature, e.g., by the lower key switch on the front panel or in the device menu then these two signals are considered permanently as logically "1" and so the interlocking with these signals is disabled.

Additionally, SIPROTEC 5 provides two more signals called ">Enable opening(fixed)" and ">Enable closing(fixed)". Fixed means, that the interlocking conditions defined for these signals never get overridden.

2.2 Interlocking configured in the CFC charts of 7SX800

For the feeder topology as in figure 2 with 2 busbar disconnectors (DC), 1 circuit breaker (CB)and 1 line disconnector we find the CFC interlocking chart according to figures 3a and 3b.

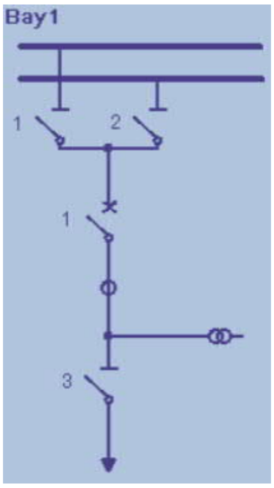

Figure 2

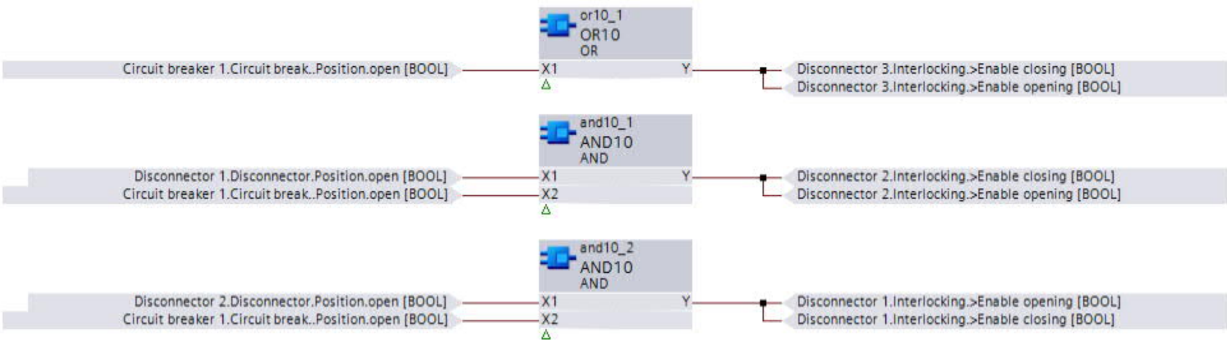

Figure 3a: Interlocking conditions for the disconnectors

The first interlocking condition is for DC 3 (the line disconnector, figure 3a). Closing and opening of this DC is allowed (">Enable closing" and ">Enable opening") if the CB is open ("Circuit breaker 1.Circuit break.Position.open") In this case no current can flow through this DC.

DC 2 can be closed and opened if DC 1 is open and the CB is open (2nd condition in figure 3a). In this situation there is no current flowing across DC 2 and it can be operated without danger. The interlocking condition for DC 1 is accordingly (3rd condition in figure 3a).

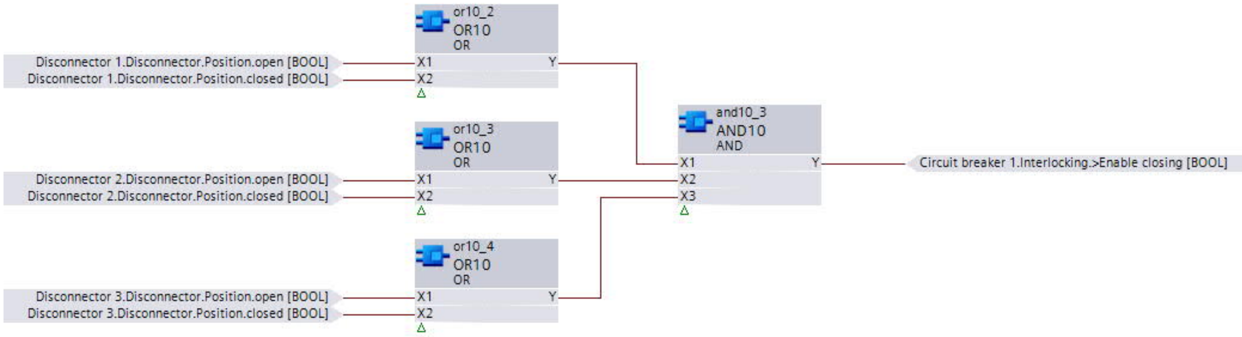

Figure 3b: Interlocking condition for the CB

In figure 3b we see that the circuit breaker can be opened any time, because ”>enable opening” is not used. However, it should be possible to close the CB only if all disconnectors have a valid position, either ”open” or ”closed”.

2.3 Testing the interlocking conditions with the CFC Online simulation function

We can trace the status of the incoming signals and the resulting interlocking conditions in the CFC online simulation. To do so, we follow the following general steps:

1. **Set up the CFC logic, compile it and verify that the compilation does not return any error.**
2. **Verify and ensure, that the device has no inconsistencies.**
3. **Download the configuration into the target device.**
4. **Open the CFC chart and start the online simulation, while DIGSI 5 remains connected to the device or alternatively, the Digital Twin.**
5. **If required, mark the signals for which the state should be shown permanently.**
6. **If required, modify input signals, trace, and verify the logic state of subsequent signals**

For this app note description, points 1., 2. and 3. are already fulfilled because the logic is supplied with the application template of the device.

To start the online simulation, click on the symbol with the orange triangle (figure 4) which you find in the icon bar on top of the CFC chart.

Figure 4: starting the online simulation clicking on the symbol with the orange triangle (the blue triangle button starts the offline simulation).

SIPROTEC 5 Compact Application

CFC Chart Online Simulation

If the CFC in DIGSI 5 corresponds with the CFC downloaded into the device, DIGSI 5 will switch into the CFC online simulation mode. This is indicated by an orange bar on top of the CFC chart, as you can see in figure 5.

If not, it will show an information and ask you to update the target device by downloading the latest offline configuration into the device. We can leave the online simulation by clicking on the same symbol, which has now a black square on it.

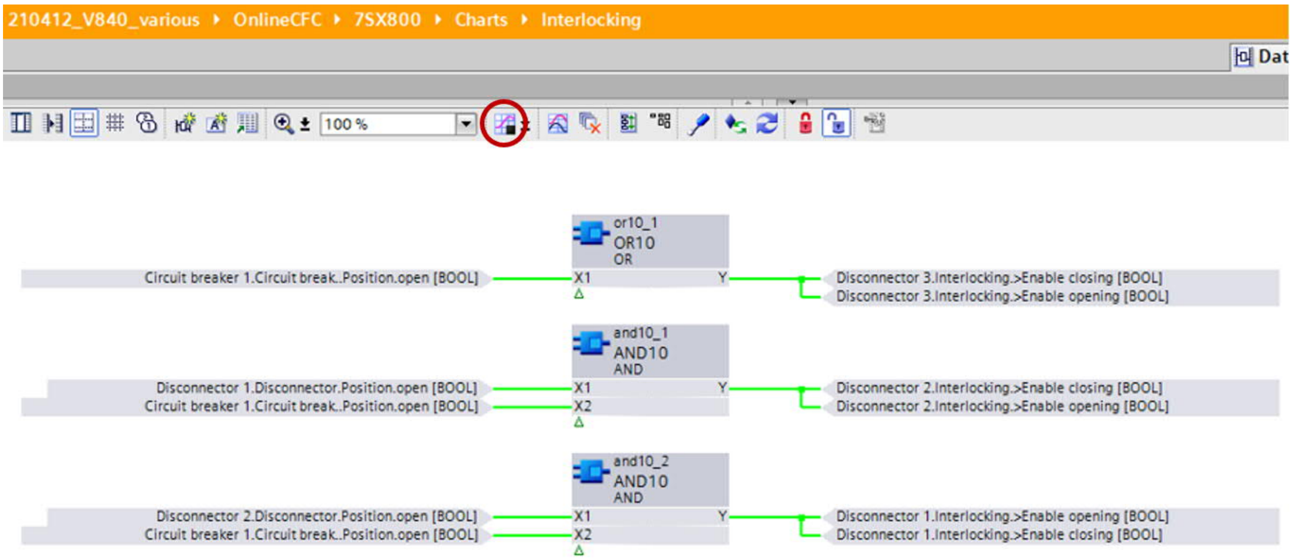

Figure 5: CFC online mode, first part of the CFC logic.

The green lines indicate that the corresponding signals are active (logically "1"). This is the case because the DCs and the CB are all open and so all the disconnectors are allowed to be switched in both directions. We can show the values of the various in- and outputs of the CFC elements, by placing the mouse on such an in- or output (figure 6, red circle). This works not only for Boolean values but for any in- or output value of any CFC block, e.g. integer values or real values (measurements).

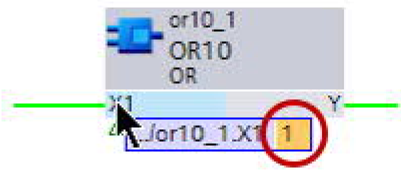

Figure 6: Pointing the mouse on a CFC interface provides the momentary value in the tooltip.

Additionally, according to step 5, we have the possibility to select up to 100 signal points (CFC element in- or outputs) for which we can show permanently their value. To do so we preferably switch from the "data flow" view to the "control flow" view (figure 7).

Figure 7: switching to the Control flow view

With the marked icon on the icon bar (circle in figure 8) we switch to the detailed view of the CFC elements. After this, the column “For test” opens and shows check boxes (red rectangle marking in figure 8). With each marked check box, DIGSI 5 provides the corresponding (real time) value, which we see in the column “Online val.” left to the check boxes.

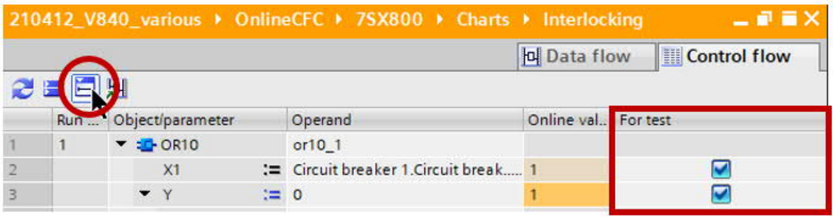

Figure 8: Marking signals in the Control view.

When we switch back to the “Data flow” view we find the same CFC element interfaces showing the current value (figure 9).

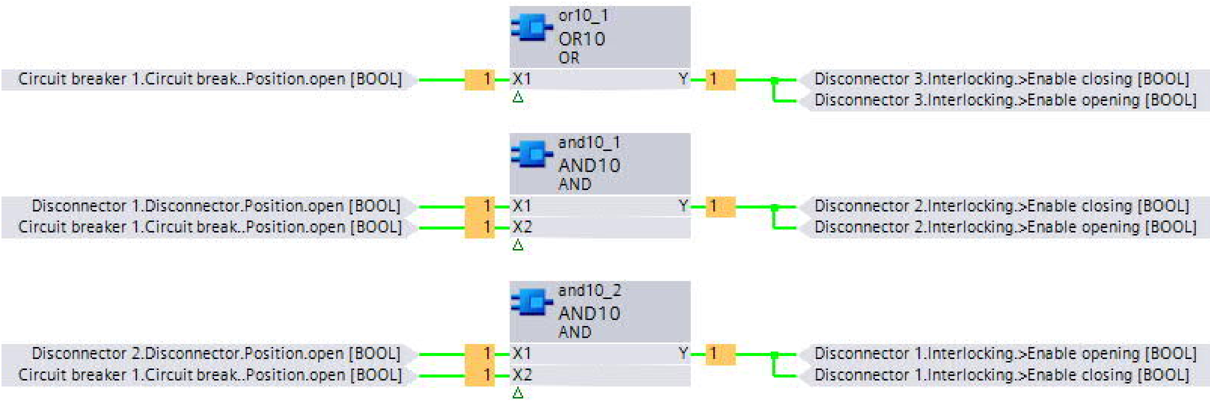

Figure 9: permanently shown real time values of CFC interfaces (1).

When we now close DC 2 the feeder topology looks as follows:

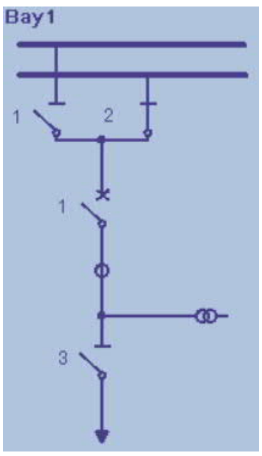

Figure 10: Disconnector 2 closed

The interlocking CFC chart for disconnectors now shows the following:

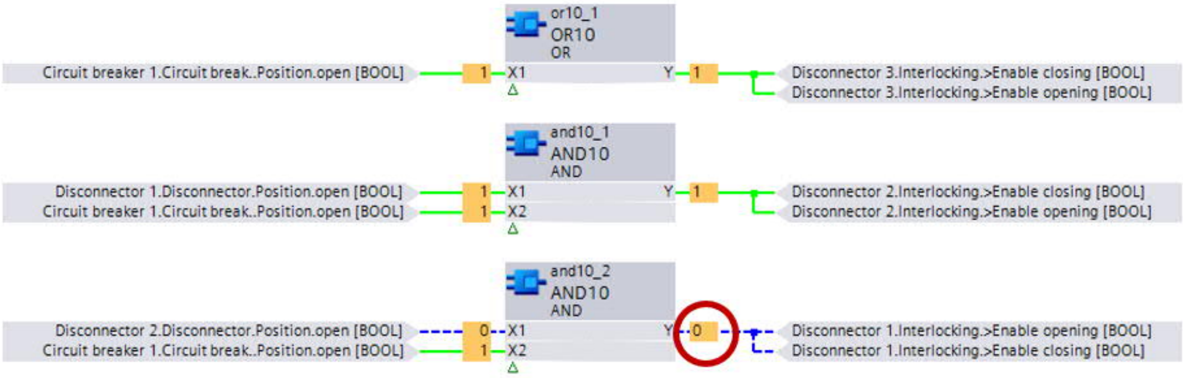

Figure 11: CFC online simulation with closed DC 2.

The “Disconnector 2.Disconnector.Position open” signal is “0” and as a result the switching action for DC 1 is not enabled in either direction. This is indicated by the blue dashed lines. The ”>enable” signals for disconnector 1 are both logically “0”. Hence SIPROTEC 5 does not permit, that this disconnector is being switched, because otherwise there could be a current flowing over this disconnector while being moved, which could damage the disconnector.

3 Summary

While the CFC offline simulation tests a CFC chart using a sequencer with given signals, the CFC online simulation enables testing a CFC chart in a physical device or in a Digital Twin device simulation, showing in real time values of the signals in this CFC chart.

This feature allows to test a CFC logic and trace all relevant signals under various input / operating conditions which facilitates bug search and bug fix of user designed CFC logics.

This on the one hand helps to increase the quality of such logic charts because the visualization of the signals helps to find hidden errors and to systematically investigate the logic, on the other hand it cuts down the time effort to find faults in the CFC, which have already been noticed.

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