SIEMENS

SIPROTEC 5 Application Note

Acquisition of transformer tap positions via an analog measurement transformer

SIP5-APN-038, Edition 2

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SIPROTEC 5 – Application Note
Acquisition of transformer tap positions via an analog measurement transformer
SIP5-APN-038, Edition 1

Content

1 Acquisition of transformer tap positions via an analog measurement transformer

1.1 Introduction

Usually binary signals such as BCD codes are used to indicate the position of a tap changer. However, an analog DC current can also represent this information. Thanks to SIPROTEC 5 devices from versions 7 onwards, recording the tap changer's position no longer requires any external devices. This is made possible through an analog transducer input, for example the plug-in module ANAI and the expansion module IO 212. With this technology, analog DC currents can be connected directly to the SIPROTEC 5 device. Each tap changer necessitates a separate channel. This application note assumes a DC input current range from 4 mA to 20 mA and a tap position range from 1 to 30 (i.e. 30 tap positions). Settings can be adapted so they correspond with other input currents and tap positions.

The application is divided into 3 parts:

1. Configuration of the tap changer function in DIGSI5

2. Configuration of the analog input module

3. Transformation of the transducer's output value transducer (measurement value) into tap position information.

1.2 Configuration of the tap changer

The tap changer function can basically be used in two different ways:
1. As a function group “tap changer”, to acquire the position of the primary tap changer to use this information, for example, for the transformer diff protection or to control the primary tap changer via remote access or CFC. Access the DIGSI5 library and the “switching devices” folder. This is found below the respective SIPROTEC 5 device folder. After opening the folder, drag and drop the function group (FG) symbol “tap changer” into the device configuration on the left side.

2. As a part of a voltage control function

In this case, the function “tap changer” is already part of one of the “voltage control function groups” which can be found in the folder “Automatic voltage control”. The function group can be added to the device configuration with the drag and drop function. (see fig.1)
The possible tap position range must be set in the information routing matrix under the tab “properties”, which is found in the inspector window on the bottom. Therefore, the signal “position” of the tap changer must be selected, which can be found in the FG “tap changer” in the FB (function block) “tap changer” (see fig. 2). The number of positions must now be entered, as well as an offset value (unless the position range begins with 1.. The smallest and biggest positions are automatically calculated and displayed. The tap coding type setting is irrelevant.

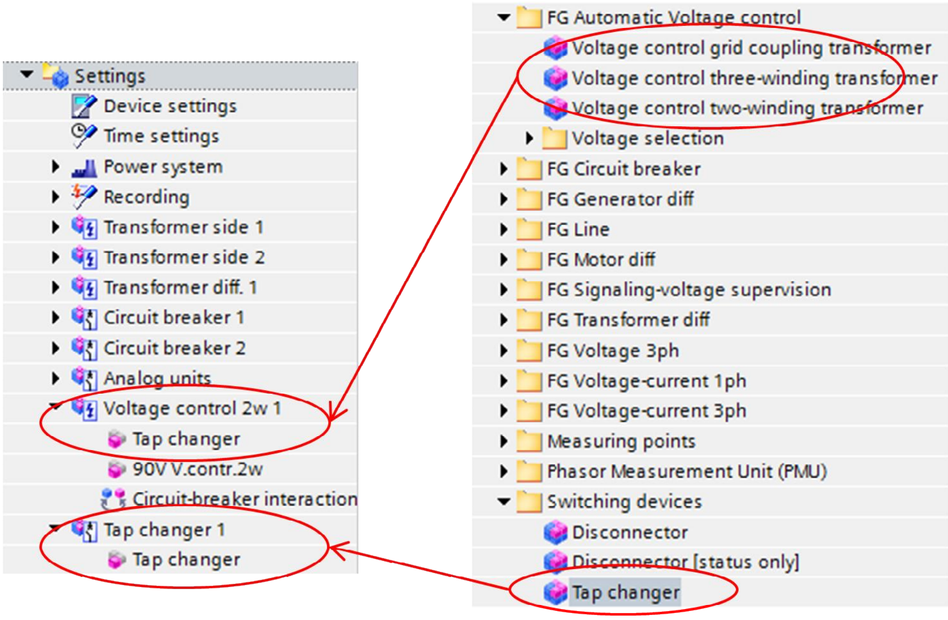

Fig.1: Creating a tap changer function

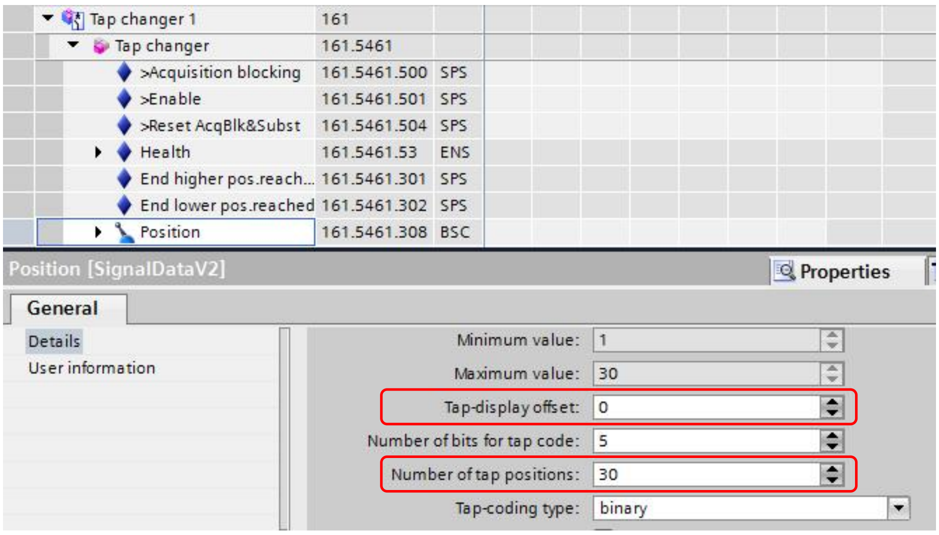

Fig.2: Setting the number of tap position and resulting minimum and maximum tap position

1.3 Configuration of the analog input module

1.3.1 Hardware configuration

Either the ANAI plug in module or the expansion module IO 212 can be used to acquire the analog DC input signals. Each primary tap changer necessitates one analog input channel.

The ANAI has 4 programmable current input channels; the IO 212 has 8 fast analog input channels. These can measure either DC currents or DC voltages. Since the acquisition of tap changer positions is a relatively slow procedure, the ANAI's 200mscycle time generally suffices.

The DIGSI5 will automatically add an "analog units" FG to the configuration after you add the HW in the "Hardware and protocols" editor. The respective settings can then be found in the project tree under "settings" and the FG "analog units".

1.3.2 Configuration of the analog measurement transducer (MT)

The MTs of the ANAI-CA-4EL have a signal range from -24mA to 24mA. They are programmable from -20mA to +20mA.A range from e.g. 2mA to 20mA is possible as well.

For our use, the “Range active” box must be checked in order to get 4 more parameters for the scaling of the current-measurement characteristic (see fig.3).

Generally “lower limit” and “upper limit” correspond with the minimum and maximum input current, (so 4 mA and 20 mA in this example”. “Lower limit - Sensor” and “Upper limit - Sensor” are the measurement values which the device creates when the input current is at its lower or upper limit (linear characteristic).

In our application, measurement value units have no significance and are therefore set to p.u. (per unit).This could be replaced by any other unit. The measurement value resolution is determined by the setting resolution. The measurement resolution is internally converted to an integer value. Thus, a value of 0,1 or smaller is fine.

Ideally, the lowest and highest tap position values are set as “lower limit sensor” and “upper limit sensor”. By doing this an additional scaling in the CFC can be avoided, for example on account of a division component (DIV_R). This would cost excess function points.
In our example we set a value of +1 for the “Lower limit – Sensor” and +30 for the “Upper limit – Sensor”. A DC current of 4 mA then produces a MV value of +1 (p.u.) and a current of 20 mA a MV produces a value of +30 (p.u.).

In fig. 2, the information routing displays these two measurements in one channel. “TD direct MV” is the direct measurement value representing the input current (4 mA to 20 mA). “TD scale MV” is the output value, ranging from 1 p.u. to 30 p.u. in our example.

Using a CFC, MV values will be transformed into transformer tap positions in the subsequent step.

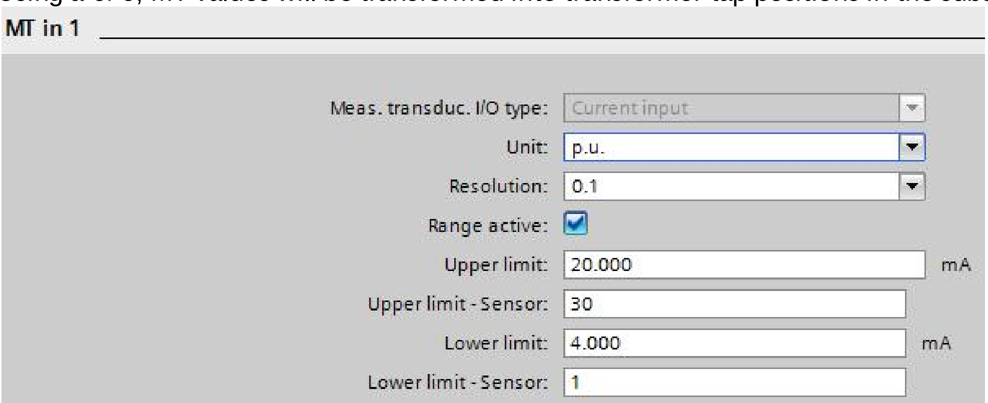

Fig.3: Configuration of input currents and measurement value range.

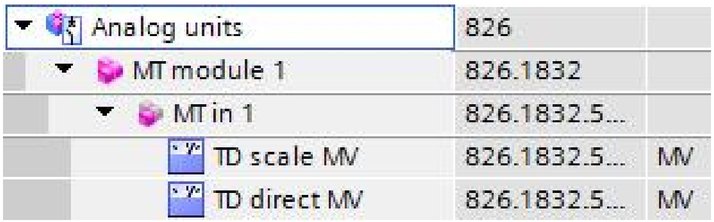

Fig.4: Signals of one measurement transducer (MT) channel.

1.4 Transformation of the output signal of the measurement transducer into a tap position

A new CFC plan can be created by double clicking on “add new chart” in the project tree.

Since the input signal of the CFC chart is a measurement value that changes spontaneously, the task level “measurement” is selected. It is possible to select all other CFC task levels as well.

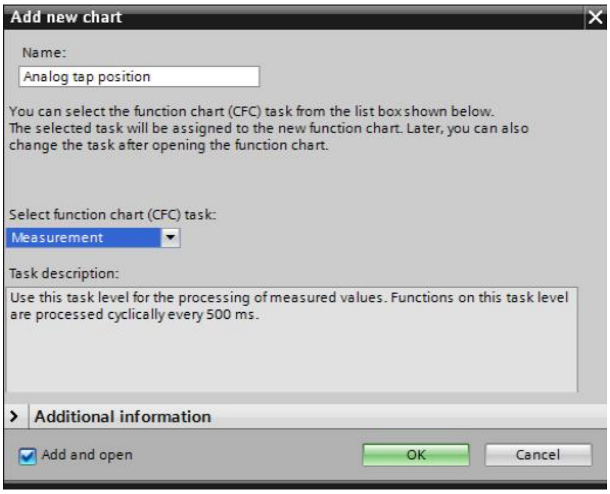

Fig.4: Selection of the CFC task level and creation of a new CFC chart.

1.4.1 Principle

The CFC chart contains the following basic component and signals:

Fig.5: Principle of transformation

A detailed description of the various CFC components addressed in the following section can be found in the DIGSI 5 help, which is also available as an online PDF on our protection homepage (www.siemens.com/siprotec).

BUILD_BSC (1) is a component available from DIGSI V7 onwards and transforms an integer value at its input (POS) into a tap position. This position can then be assigned to the respective tap changer.
To do so, the position signal (BSC) of the tap changer must be dragged from the signal catalog to the exit of BUILD_BSC (1).

Since many CFC components have a built in signal conversion feature, it is seldom necessary to convert the signal type. In our case the BUILD_BSC component transforms real values or measurement values into integer values for input For this reason we can connect the scaled MV directly to the input of the BUILD_BSC.

1.4.2 Handling limit and invalid values

If the input currents are slightly outside of the defined band, the BUILD_BSC (1) in fig. 5 component might output an invalid position instead of the corresponding lower or upper end tap position. As a consequence of the undefined current, the scaled value might fall out of the valid position range. This causes the output of

the invalid position. If it cannot be guaranteed that the input signal always lies within the preset range, the CFC plan must be extended. The invalid states are dealt with through two comparisons: LE_R (1) and GE_R (2), and the MUX_R (8) as follows (see fig.6).
If the analog input value (TD direct MV) falls within the valid band, both outputs OUT of LE_R (3) and GE_R (4) are logically zero. As a consequence, the output OUT of the NOR (3) and the input of IN2 of BOOL_INT (7) are both logically 1.). Therefore, the output OUT of BOOL_INT (7) has the integer value 2. The scaled MV at IN2 is routed to its output OUT by MUX_R (8).

If the analog input value (TD direct MV) is outside its valid band (4mA-20mA) then either IN1 or IN3 of the BOOL_INT (7) logically becomes 1. As a consequence, the inputs IN1 or IN3 of MUX_R (8) are routed to the output OUT. If the value of IN1is set to the real value corresponding to the smallest tap position (1.0) and the value of IN3 is set to the real value corresponding to the highest tap position (30.0), then these values are routed to the output of MUX_R. (8) With this, the end positions are stabilized (see green marking).

If the input current is clearly wrong, i.e. significantly outside of the allowed band, the tap position can systematically be set to an invalid value. The input current is verified using 2 stabilized components LIML_R (4) and LIMU_R (5). These components define the maximum tolerable deviation.

If the current is below the limit value of LIML_R (4) or above the limit value of LIMU_R (5), the respective output EXC of LIML_R (4) or LIMU_R (5) is 1 and therefore also the output Y of the OR gate (6) and the input IN4 of BOOL_INT (7).

In mode 2 of BOOL_INT (7), the integer value of the highest input number, which is logically 1, is put on the output. This means that IN 4 is prioritized over all other inputs. If this is logically 1, then the real value of IN4 of MUX_R (8) is routed to its output. With a well defined value outside the tap position range (e.g. -64), the tap position at the output of BUILD_BSC becomes invalid.

The LIML_R and LIMU_R elements are used instead of LE_R and GE_R , since these components provide a hysteresis setting, which prevents their output from jittering if the input current is just below or above the threshold. This would mean that the output jitters invalidly between one of the relative end positions.

If a binary signal that indicates an invalid position is required, the output Y on the OR gates could be used, for instance.

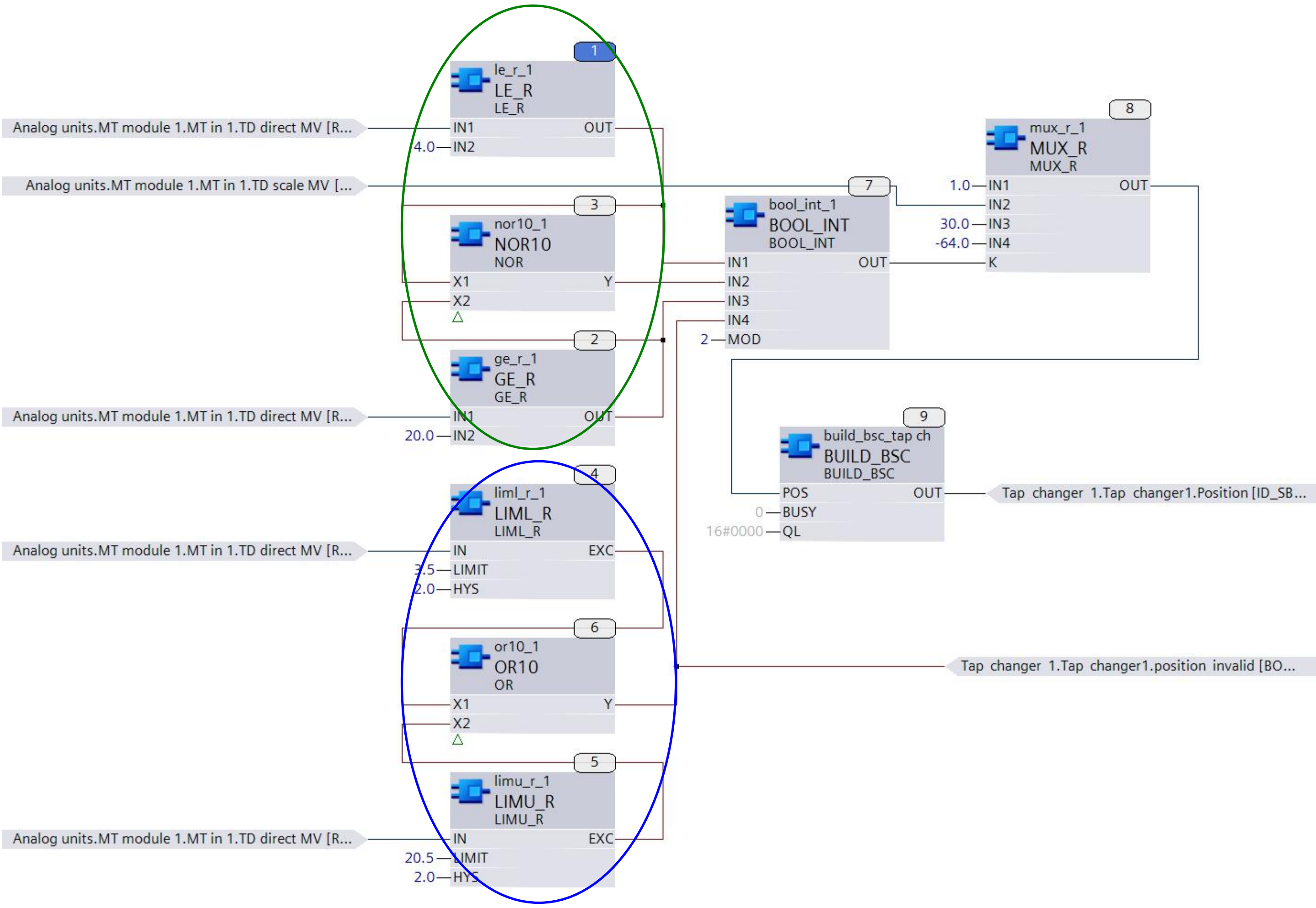

Fig.6: CFC logic for the transformation including the handling of invalid input signals.

1.5 Summary

Thanks to a relatively small CFC logic and an available SIPROTEC 5 device, the tap changer's position can be communicated in the form of an analog input signal without any additional external device. There is no longer a need for an extra device that translates the tap position into a bit pattern. The SIPROTEC 5 analog input transducers are programmable, so that any range between -20mA and 20mA can be used – not just the example demonstrated in this manual. With help of the IO 212, even DC voltages can be recognized as tap positions.

If you alter the module settings, the MV can be adapted to the tap changer positions. This does not require any scaling in the CFC, and extra function points for a multiplier or divider element in the CFC can be avoided.

This application saves costs for external devices, as well as additional wiring and testing.

- Modular system design in hardware, software, and communication
- Functional integration of various applications, such as protection, control, and fault recorder

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The information in this document contains general descriptions of the technical options available, which may not apply in all cases. The required technical options should therefore be specified in the contract.