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Acquisition of transformer tap positions via an analog measurement transducer

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SIPROTEC 5 Application

Acquisition of transformer tap positions via an analog measurement transducer

SIP5-APN-038, Edition 3

Content

1 Acquisition of transformer tap positions via an analog measurement transducer

1.1 Introduction

This application note is an update of the first release and can be used for all configuration versions ≥ V7. The replaced application note can be used only for SIP5 devices up to V7.5x. From versions V7.8x upwards this application note must be used.
Typically, the position of a tap changer is indicated via binary signals (e.g. a BCD code), however it can also be represented by an analog DC current. From SIPROTEC 5 version 7 on it is possible to connect these analog DC currents directly, i.e. without an external device, to a SIPROTEC 5 device, using an analog transducer input (e.g. in the plug-in module ANAI or in the expansion module IO 212) in order to receive the correct position of the tap changer.

This application note 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 output value of the transducer (measurement value) into a tap position information.

This application note uses as an example 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). Other value ranges of input currents or different tap positions can be handled by adapting the settings accordingly.

1.2 Configuration of the tap changer

The tap changer function can be used basically in 2 different ways:

1. As a function group “tap changer”, to acquire the position of the primary tap changer, for example to use this information for the transformer diff protection. To do so, in the DIGSI5 library the folder „switching devices „below the respective SIPROTEC 5 device folder must be opened and the function group (FG) symbol “tap changer” dragged and dropped into the device configuration on the left hand side.

2. As a part of a voltage control function

In this case, the function “tap changer” is already part of one of the function groups “voltage control” which can be found in the library in the folder “Automatic voltage control”.

The function group can be added to the device configuration in the same way. (see fig.1)

The possible tap position range must be set in the information routing matrix in the tab “properties” in the inspector window on the bottom. Therefore, the signal “position” of the tap changer which can be found in the FG “tap changer” in the FB (function block) “tap changer” must be selected (see fig. 2). To be entered are the number of positions and – if the position range should not begin with 1 – additionally an offset value. The smallest and biggest position is then calculated by DIGSI5 and shown in this dialog. The setting tap coding type has no relevance for this application.

Acquisition of transformer tap position via an analog measurement transducer

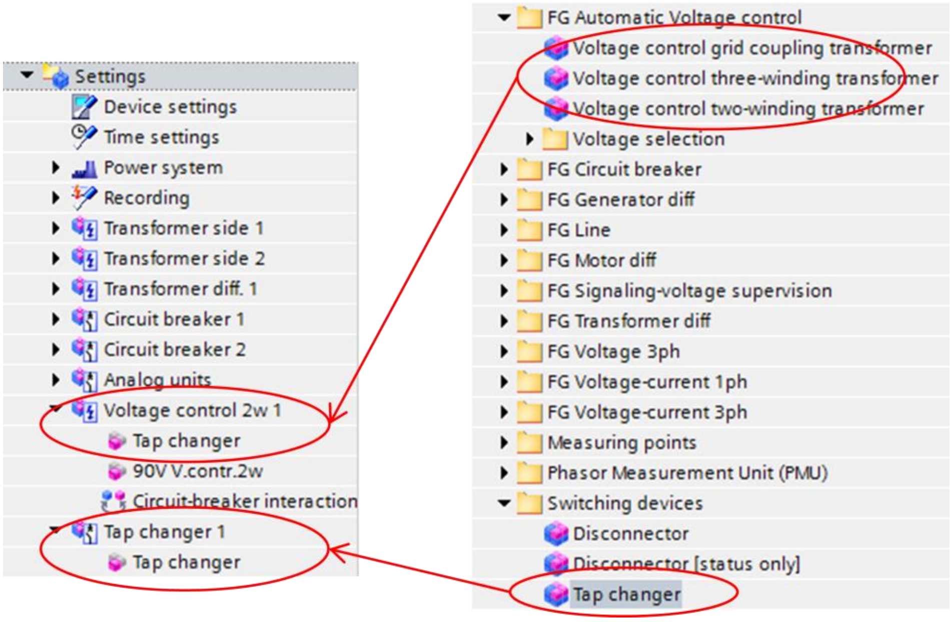

Fig.1: Creating a tap changer function

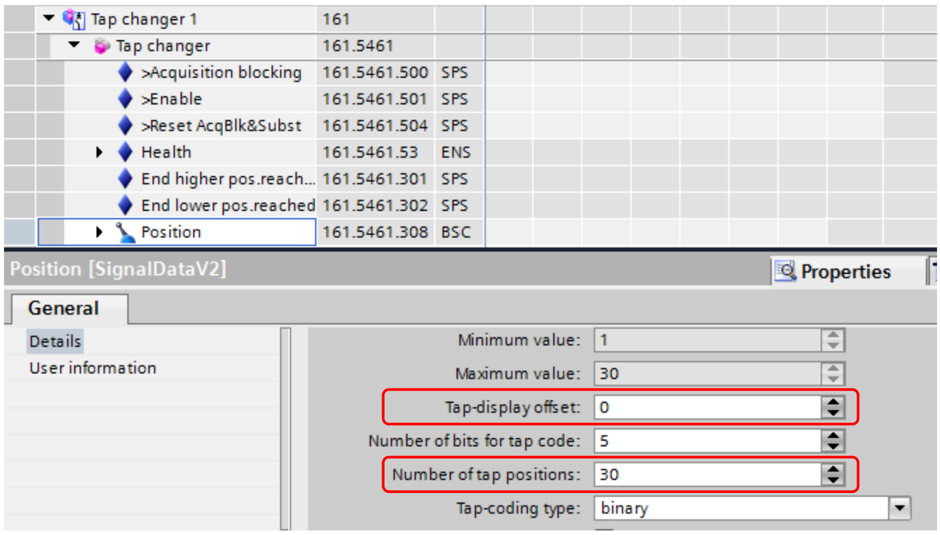

Fig.2: Setting the number of tap position and resulting minimum and maximum tap position

1.3 Configuration of the analog input module

1.3.1 Hardware Configuration

To acquire the analog DC input signals the ANAI plug in module or the expansion module IO 212 can be used. For each primary tap changer one analog input channel is required.

The ANAI has 4 programmable current input channels; the IO 212 has 8 fast analog input channels, which can either measure DC currents or DC voltages. Since the acquisition of tap changer positions is a relatively slow procedure, the cycle time of 200ms of the ANAI is usually sufficient.

After having added the HW in the “Hardware and protocols” editor the DIGSI5 automatically adds a FG “analog units” to the configuration. The respective settings can be found then under the FG “analog units” under “settings” in the project tree.

1.3.2 Configuration of the analog measurement transducer (MT)

The MTs of the ANAI have a signal range from -24mA to 24mA. They are programmable from -20mA to +20mA, so any other range can be set, e.g. 4mA to 20mA.

For our application the setting box “Range active” must be checked 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, 4 mA and 20 mA in our example. “Lower limit - Sensor” and “Upper limit - Sensor” are the measurement values which are created in the device when the input current is at its lower or upper limit (linear characteristic). In our application these values must be set to 0 and 100 and will be rescaled later in a CFC chart to the minimum and maximum tap position.

The unit of the measurement values has no significance and therefore is set to p.u. (per unit). However, also every other unit could be used here. The setting resolution is responsible for the resolution of the measurement value, which is converted internally into an integer value. So, a resolution value of 0.1 or smaller is ok.

In fig.4 we see these two measurement values of one channel in the information routing. “TD direct MV” is the direct measurement value representing the input current (4 mA to 20 mA, shown as 20% to 100% in the CFC). “TD scale MV” is the output value, in our example ranging from 0 p.u. to 100 p.u.

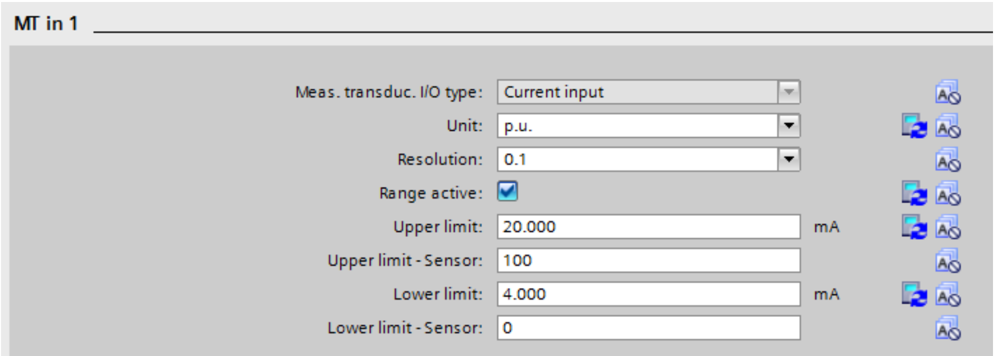

Fig.3: Configuration of input currents and measurement value range.

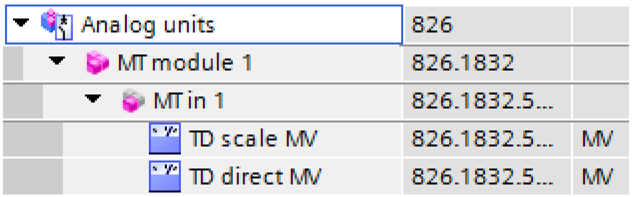

Fig.4: Signals of one measurement transducer (MT) channel.

In the next step these MV values will be transformed into transformer tap positions via a CFC logic.

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

A new CFC plan is created double clicking on “add new chart” in the project tree under the sub tree “charts”.

Since the input signal of the CFC chart is a measurement value which changes spontaneously, the task level “measurement” is selected. However, also all other task levels of the CFC are possible.

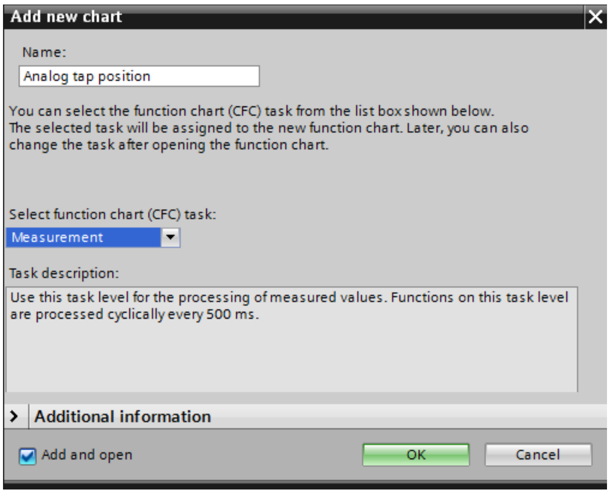

Fig.4: Selection of the CFC task level and creation of a new CFC chart.

3.1 Principle:

The component to create a tap changer position is the BUILD_BSC:

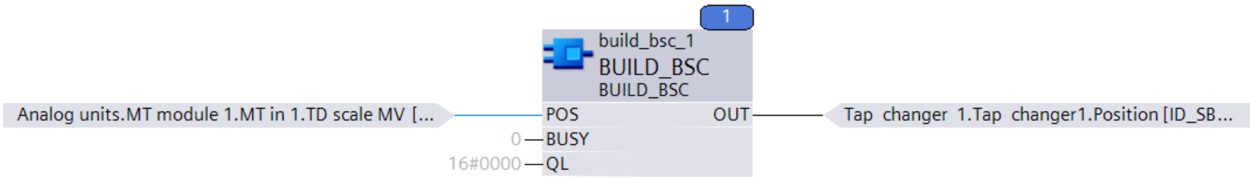

Fig.5: Principle of the transformation

A detailed description of the various CFC components used in the following part can be found in the DIGSI 5 help, which is also available as a pdf document in the internet on our protection homepage (www.siemens.com/siprotec).

BUILD_BSC (1) is a component which can be found in the DIGSI 5 library, CFC components, under the group “conversion”.

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

Since many CFC components have a built-in signal conversion feature, often it is not necessary to transform the signal type explicitly. In our case the BUILD_BSC component also accepts real values or measurement values and transforms them into an integer value for the input. For this reason, we can directly connect the signal type MV (a real value) to the input of the BUILD_BSC.

The basis for the POS input is the TD scale value of the analog input transducer which we set in chapter 2.2 to a range from 0 to 100. To obtain the right range for the POS input we need to rescale this range corresponding to the lowest and highest tap position, 1 to 30 in our case. To do this rescaling we could use a MULT component, which however costs 40 FP. A component without FP is the NL_MV (group: non-linear) where a characteristic can be defined consisting of up to 4 straights with different slopes. In our case we use only one straight, defined by 2 points (x1,y1) and (x2,y2). The first point has the coordinates (0; smallest tap pos), the second point (100; highest tap pos). The NL_MV component also allows negative values for y therefore also negative tap positions can be handled (e.g. -10 to +10).

Since the in- and output of the NL_MV component is not a real value but a structure value (consisting of several single values) the SPLIT_XMV component needs to follow the NL_MV which then provides the correctly scaled real value (output VAL_R).

In our example the components have the following settings:

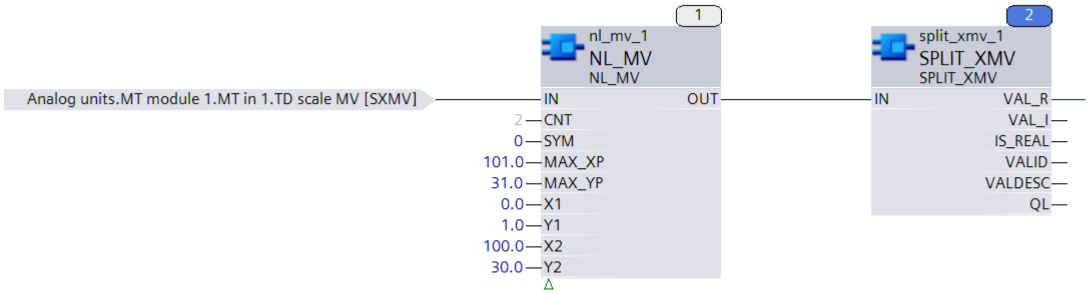

Fig.5.1: scaling the values for the correct tap positions.

The corresponding points for tap pos 1 and 30: (x1;y1) = (0;1) and (x2;y2) = (100;30). SYM=0, we do not need to handle negative x-values. CNT=2 for a 2-point characteristic. MAX_XP and MAX_YP is set to a slightly higher than the max. expected values because otherwise the output could be invalid for the max. values. We don't want this here because we do the limit handling separately.

1.5 Handling limit and invalid values

If the input currents are slightly outside 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, since the scaled measurement value might consequently fall out of the valid position range (1 to 30). If we cannot guarantee that our input signal lies always in the strict band we must extend our CFC plan to overcome this problem. The invalid states are handled with 2 comparisons, LE_R (3) and GE_R (4) (group "compare"), and the MUX_R (10) (group "selection") as follows (see fig.7).

If the analog input value (TD direct MV) is inside the defined valid band, both outputs OUT of LE_R (3) and GE_R (4) are logically zero and therefore the output OUT of the NOR (5) is logically 1, as well as the input IN2 of BOOL_INT (9). Consequently, the output OUT of BOOL_INT (9) has the integer value 2 which brings the MUX_R (10) to route the scaled position value (VAL_R of SPLIT_XMV) at IN2 to its output OUT.

If the analog input value (TD direct MV) is outside its valid band (20% to 100%) then either IN1 or IN3 of the BOOL_INT (9) becomes logically 1 and therefore the inputs IN1 or IN3 of MUX_R (10) are routed to its output OUT. Setting the value of IN1 to the real value corresponding to the smallest tap position (1.0) and the value of IN3 to the real value corresponding to the highest tap position (30.0) these values are routed to the output of MUX_R (10) to keep the end positions in this situation (see green marking).

The comparison values for the TD direct MV (block 3 and 4) comes from the fact that the primary values 4mA and 20mA are rescaled in percent values in the CFC, in the way, that the max. absolute value corresponds to 100 (%). So 20mA = 100 and 4mA is 4/20*100 = 20 (%).

In order too systematically set the tap position to an invalid value if the input current is obviously wrong, being significantly outside the allowed band, this input current is verified using 2 stabilized components LIML_R (6) and LIMU_R (7) with which the maximum tolerable deviation is defined.

If the current is below the limit value of LIML_R (6) or above the limit value of LIMU_R (7) the respective output EXC of LIML_R (6) or LIMU_R (7) is logically 1 and therefore also the output Y of the OR gate (8) and the input IN4 of BOOL_INT (9) (see blue marking).

In the mode 2 of BOOL_INT (9) the integer value of the highest input number which is logically 1 is put on the output. This means, IN 4 gets the highest priority of all inputs. If it is logically 1 then the real value of IN4 of MUX_R (10) 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 the LE_R and GE_R because these components provide a hysteresis setting, which prevents their output from jittering if the input current is just below and above the threshold and so the position information from jittering between invalid and the relative end position.

The LIMIT value of LIML_R should be set so low that the drop off value including the hysteresis is still below the lowest regular TD direct value (drop off value is LIMIT value *(1+HYS), HYS is a percent value, so 1.02 in our example of fig.7). Otherwise the tap changer position can be invalid for a too late reset of LIML_R.

In the same way the LIMIT value of LIMU_R should be set (drop off at LIMIT value*(1-HYS)).

If a binary signal is required that indicates the invalid state of the position the output Y of the OR gate (8) can be used e.g.

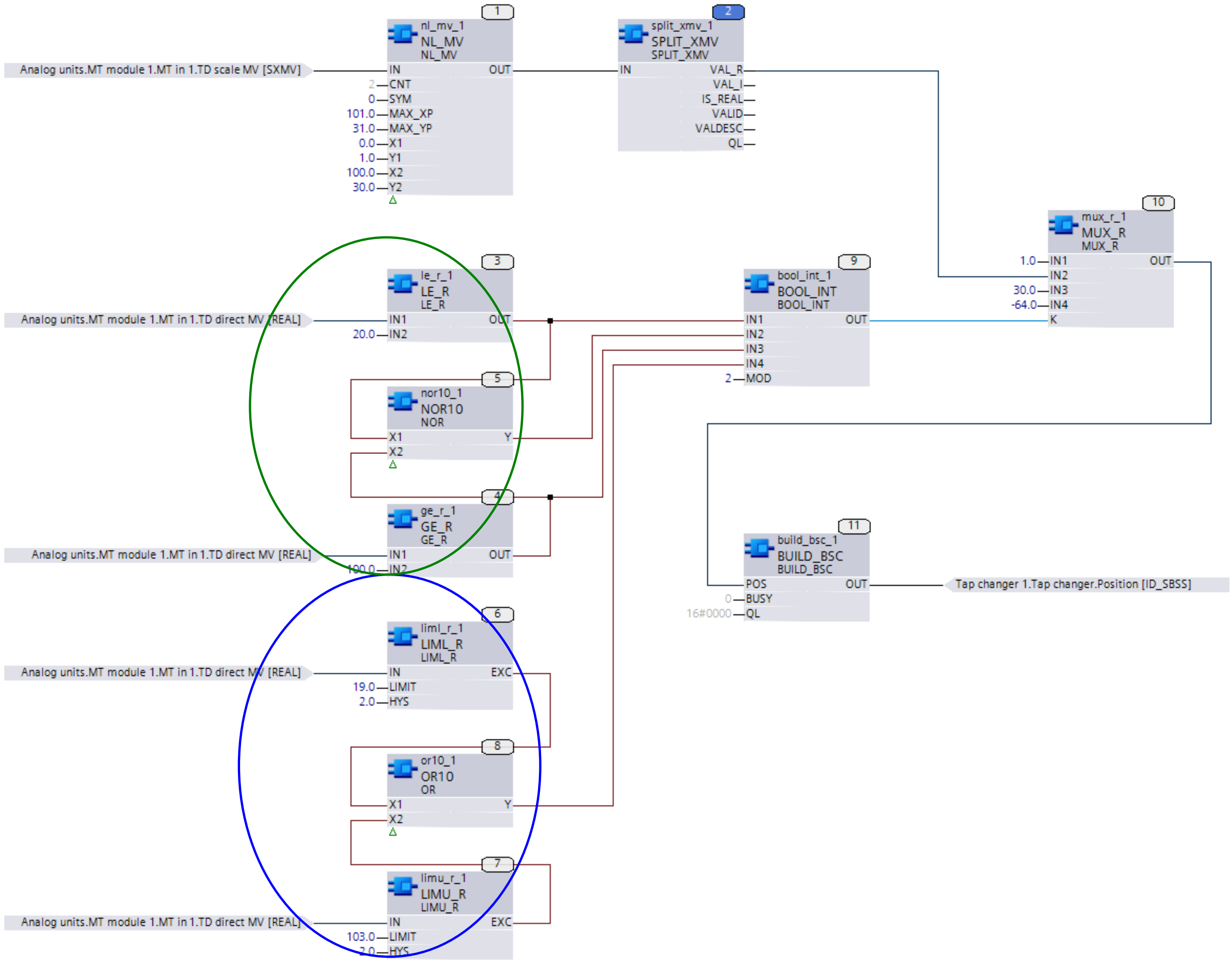

Fig.7: Complete CFC logic for the transformation including the handling of invalid input signals.

1.6 Summary

With a relatively small CFC logic and one of the available analog input modules the SIP5 devices can register the position of an online tap changer via analog input signals directly, without the need for an extra device providing the tap position as a bit pattern to the SIPROTEC5 devices.

The analog input transducers of SIPROTEC5 are programmable, so that not only the common 4-20mA input range can be used but any other range within -20mA to 20mA, the limits of the module. With the IO 212 even DC voltages could represent the tap position.

Using the settings of the NL_MV component the number and range of tap positions can be adapted to the requirements. Extra function points like for a multiplier or divider element are not charged for this NL_MV.

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

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