7SG15 MicroTAPP

Automatic Voltage Control

Document Release History

This document is issue 2012/05. The list of revisions up to and including this issue is:

Pre release

2012/05	Release of software revisions R9 and R18
2010/02	Document reformat due to rebrand

Software Revision History

Contents

1 Introduction

Extensive accuracy, functional, and endurance testing is carried out at the factory prior to despatch. On-site confirmation of the setting ranges and accuracy levels are not necessary. However, in order to confirm correct operation of the overall voltage control scheme, it is suggested that the following minimum tests be carried out.

2 Test Equipment

It is assumed that CT injection testing has been carried out to confirm the VT and CT rating and ratio. Instruments required are: -

- A 500V Insulation resistance test set
- A variable voltage source
- A high quality RMS sensing digital voltmeter
- Timing stopwatch

For testing the communications channels: -

- Portable PC with fibre optic modem connections and 25-way serial cable

3 Inspection

Ensure that all connections are tight and in accordance with the relay wiring diagram and the scheme diagram. Check the relay is correctly programmed and the relay is fully inserted into the case. Refer to the Description of Operation for programming the relay.

4 Precautions

Before testing commences the equipment should be isolated from the current transformers and the CTs short circuited in line with the local site procedures. The inputs and alarm circuits should also be isolated where practical.

Ensure that the correct auxiliary voltage is applied to the circuit. See the relevant scheme diagrams for the relay connections.

5 LCD Contrast Adjustment

The LCD contrast will vary with temperature and the level may need to be adjusted. The contrast should be adjusted after the relay has been powered up for at least half an hour to let the temperature settle.

The procedure for adjusting the contrast is given in the installation section of this manual.

6 Tests

This document details the key testing that should be carried out. Other confirmation tests should be undertaken prior to service, depending on any additional functions incorporated into the design.

6.1 Insulation

For a new installation the wiring insulation should be tested: -

- Connect together all CT circuits and measure the insulation resistance between these circuits, all other circuits and earth.
- Connect together all VT circuits and measure the insulation resistance between these circuits, all other circuits and earth.
- Connect together the circuits of the status inputs and measure the insulation resistance between these circuits, all other circuits and earth.
- Connect together the circuits of the output relays and measure the insulation resistance between these circuits, all other circuits and earth.

For satisfactory results the insulation level should be above 1.5 MΩ.

6.2 Signal Inputs

An initial check of all wiring should be made to confirm the correct connections.

6.2.1 MicroTAPP enable and controls

All points of control should be checked, preferably prior to energising the transformer. If this is not possible care should be exercised when operating the tap change mechanism to prevent abnormal voltages. The checks shown in Table 1 should be carried out in sequence to confirm the correct operation of the various points of control (in the order 1A, 1B etc.). The table indicates a typical arrangement of three control points, particular installations may deviate from this configuration.

	Tap Change Mechanism	**MicroTAPP**	**Remote**
Sequence	**A**	**B**	**C**
1	Switch to LOCAL	Switch to LOCAL/MANUAL	
2	Check Tap change operation	Check control Inhibited	Confirm control blocked
3	Switch to REMOTE	Check tap change control and operation	Confirm control blocked
4		Switch to REMOTE	Confirm remote operation of tap change control
5		Switch to LOCAL	

Table 1

6.3 Automatic Voltage Control

Prior to despatch full accuracy, function and endurance testing is carried out to confirm correct operation of the relay, further on-site accuracy testing is unnecessary. Final checks for operation can be carried out when the transformer is energised.

6.4 Protection

6.4.1 Tap Position

As described earlier in this manual some tap changers have special positions which operate to re-arrange the winding configuration but do not alter the voltage.

When at these positions a single tap change control will result in more than one tap change operation which must be recognised for correct operation of the runaway prevention system. These positions may be indicated as the same position and labelled with suffix letters, i.e. 8A, 8B, 8C.

A system that allows for customisation of the tap position as indicated on the tap change mechanism is integrated into the TPI set-up menu, accessed by use of the 'tap customisation' sub-menu from the '/settings/tap-changer' menu. If a tap position is maintained as the same position through the 'transfer' cycle the positions can be re-numbered as the same position. For example, 7, 8, 8, 8, 9. To indicate that these tap positions are special, they must also marked as 'T' to indicate a transfer position, in this case 7, 8T, 8, 8T, 9. For correct indication it is important that the tap positions above the transfer point are also re-numbered.

6.4.2 Physical Tap Position

It is important that the number of tap positions is input correctly.

If, for example, a tap changer has 19 tap positions from 1 through 19, then 19 should be entered in the 'system/tap-changer/number of taps' and the tap customisation should be **disabled**.

If a tap changer has 19 tap positions from 1 through 19, but has **transfer positions** of 9, 10 and 11, then 19 should be entered in the 'system/tap-changer/number of taps' and the tap customisation should be **enabled**. In the tap customisation sub-menu the physical taps 9, 10 and 11 should be marked with a **'T'** in order to indicate the transfer tapping positions as shown below.

Physical Tap	8	9	10	11	12
Customised Tap	8	**9T**	**10**	**11T**	12

If, however, a tap changer has an indicated highest tap of 19 but has **transfer positions** of 10A, 10B and 10C, the actual number of **physical taps** will be 21.

21 should be entered in the 'system/tap-changer/number of taps' and the tap customisation should be **enabled**. In the tap customisation sub-menu the 21 physical taps must be changed as indicated in the tables shown below.

Physical Tap	9	10	11	12	13
Customised Tap	9	**10T**	**10**	**10T**	11

Physical tap 11 and 12 must be changed to tap 10 and the positions above altered to indicate the actual position as shown below.

Physical Tap	13	14	15	16	17	18	19	20	21
Customised Tap	11	12	13	14	15	16	17	18	19

6.4.3 TPI Operation

Operate the tap changer and confirm correct indications. If the transformer cannot be taken out of service the top tap position can conveniently be simulated by temporarily disconnecting the wire going to terminal B25 and then shorting B25 to B23 (for a resistor type sender unit).

After replacing any temporary connections, check the indication through the full range of the tap-changer (if possible).

In the unlikely event that satisfactory calibration cannot be obtained, the sender unit resistors should be replaced. Suitable resistors are 100 ohm, 1 Watt, 1% tolerance metal film resistors.

6.4.3.1 Checking for Normal Operation

Set the relay to Local/Manual. Operate the tap changer in the raise direction and observe the normal correct operation of tap changer. Immediately the "in Progress" LED goes off, operate the tap change once more in the same direction and again observe correct operation.

Repeat a) for the lower direction.

6.4.3.2 Checking for Lockout

Carry out a raise operation but this time simulate a potential runaway condition by permanently energising the ‘Raise’ or ‘Lower’ contactors or, alternatively, by repeated operation of the tap change control switch. The Runaway Prevention Unit should lock out soon after the first complete tap change operation, depending upon the tap change operating time.

Repeat for the lower direction.

For very fast tap change mechanisms more than one tap change operation may occur before the lockout operates. In this case great care should be exercised if the test is carried out with the transformer on load.

7 Operational Service

7.1 Off-Load Testing

Prior to being put on load but with the transformer energised, final operational checks can be carried out.

7.1.1 VT calibration

In some situations the VT output voltage may be found to be incorrect (measurement error or a non-standard ratio for instance). Any errors can be corrected by use of the settings/transformer/VT ratio option from the relay menu system.

For example, assume that a VT is used having a ratio of 10kV/110V but is known to actually produce 109V when the primary voltage is 10kV. The effective ratio is, therefore, 10.09kV/110V.

Using the relay menu system the VT ratio is changed to 10.1kV/110 effectively correcting the error.

7.1.2 Tap change operation

1 Set the MicroTAPP to Local/Auto

2 Set LDC to 0%, adjust the basic setting and balance the relay, note the voltage

3 Increase the basic setting for a higher voltage so that the relay indicates ‘low’. Confirm that the 'raise' contactor is operated

4 Decrease the basic setting for a lower voltage so that the relay indicates ‘high’. Confirm that the ‘lower’ contactor is operated

5 Return the setting to balance

7.1.3 Voltage Monitor

7.1.3.1 Checking for Correct Operation

Correct blocking action of the monitor can be checked as follows: -

1 Set the MicroTAPP to Local/Auto

2 Set LDC to 0%, adjust the basic setting and balance the relay, note the voltage

3 In the settings/voltage control menu, set the high alarm level 5 % above, and the low alarm level 5% below, the indicated voltage

4 Increase the basic setting for a higher voltage until the relay '**low**' LED flashes repeatedly. Confirm that the basic setting is 5% **above** the indicated voltage

5 Decrease the basic setting for a lower voltage until the relay '**high**' LED flashes repeatedly. Confirm that the basic setting is 5% **below** the indicated voltage

6 Return the basic setting to balance

7.1.3.2 Determination of High and Low Alarm Settings

The High setting is calculated using the formula:

(Max Basic Voltage %) + (Full Load LDC Boost %) + (+/- Deadband %) + (1% for margin)

Similarly the Low setting formula is;

(Min Basic Voltage %) - (+/- Deadband %) - (1% for margin)

Where the Max and Min Basic Voltages might be the "Target Voltage" setting, or any relevant "Auxiliary Target" setting.

For example, with a 100% target setting, 94% auxiliary target setting, 5% LDC setting and a ±1.5% band width setting, the "High" Alarm setting would be 100 + 5 + 1.5 + 1 = 107.5%,
and the "Low" Alarm setting would be 94 - 1.5 - 1 = 91.5%

The raise and lower "inhibit" relays are automatically set to operate at the band setting before the "Alarm" settings thus preventing the tap changer from operating in a direction which would cause the voltage to go outside the alarm limits.

Using the above example:
"High" inhibit = 107.5% - 1.5% = 105%
"Low" inhibit = 91.5% + 1.5% = 93%

Care must be taken when zero or very low LDC settings are used. This can result in these inhibits starting within the Deadband. If this is the case, the "High" and "Low" Alarm levels must be adjusted to bring the inhibits outside the Deadband.

7.1.3.3 3 phase VT monitor

The correct operation of the VT monitor can be confirmed by removal of the VT fuse connected to input terminal C26 on the relay. In this case the voltage monitor will block any raise control signals.

Set basic control to force MicroTAPP relay to raise voltage.

Confirm 'raise' control signals are blocked.

7.2 On-Load Tests

If a single transformer is commissioned and no load is connected, the relay should be set to 'manual' until such time that sufficient load is available for the 'on load' tests to be completed.

It is important that final tests are carried out using load current in order to confirm correct operation of the voltage control system as follows: -

1 Check VT/CT phase selection and polarity

2 Check LDC response for load boosting. This test is necessary even if LDC is not finally applied

3 Verify correct operation of tap change control for parallel transformers

For testing the control method should be selected to: -

TAPP in "menu/settings/setup/voltage control".

7.2.1 Settings

For the tests, settings should be applied as shown in table 2.

Menu	Setting	Value
Voltage Control	Band	±1.0%
	LDC	0%
	Initial Delay	DTL 180 sec
	Inter-tap Delay	60 sec
	Basic	Balance the relay to the system voltage

Table 2

7.2.2 Procedure

1 Switch all transformer tap change controls to Manual.

2 Adjust tap positions so that any circulating current is at a minimum and the system voltage level is satisfactory.

3 If the transformers are dissimilar or are connected across a network, different tap positions may be required in order to achieve minimum circulating current.

4 Measure the CT secondary current using a clip-on CT and note the reading.

5 Use the instrument display to establish the indicated load current and system power factor, confirm the readings are as expected. If the indicated power factor is suspect the CT phase selection is probably wrong. If the power factor is –ve the CT polarity is incorrect.

6 Set the system power factor in the settings/network menu.

7 Adjust the Basic level until the relay indicates LOW, note the reading.

8 Adjust the Basic level until the relay indicates HIGH, note the reading.

9 Set the basic level midway between the readings of 7 & 8 above, note the reading.

10 Confirm that basic balance point agrees with the power system voltage level.

Note: If the voltage set point does not appear to be correct the VT/CT phase angle selection may be incorrect.

11 Increase the LDC setting to 10%.

12 Depending on the site loading the relay should respond by calling for an increase in voltage (voltage indicating low). If the relay does not respond the CT may be reversed as the MicroTAPP will not allow a reverse LDC effect.

13 Adjust the Basic level until the relay indicates LOW, note the reading.

14 Adjust the Basic level until the relay indicates HIGH, note the reading.

15 Set the basic level midway between the readings of 7 & 8 above, note the reading.

16 Confirm that the LDC effect is correct, i.e. the change in the basic level set-point. If the LDC control has no effect the CT may be reversed.

Note: If the VT/CT connections and menu set-up are correct the change made to the basic setting will be 10% x (Load/Full Load). For example if the site is on full load the effective change will be 10%, if the site is on ½ load the effective change in the basic setting will be 5%.

7.2.3 Circulating Current

If the voltage control scheme in use is a Master/Follower arrangement the following tests will not be carried out.

Providing the above checks are carried out with satisfaction the operation of the relay for the minimisation of circulating current will be correct. However, further checks can be carried out, depending on the site configuration.

2 Transformer Substations

For this test the 2 transformers should be arranged such that the busbar voltage is normal and no circulating current is flowing.

The following procedure should now be carried out:

1 Switch to Manual.

2 Set the band to ±1.0%.

3 Set LDC to 0% on each relay.

4 Adjust basic setting midway between High and Low indications on each relay.

5 Tap down transformer 1 by 1 tap.

6 Tap up transformer 2 by 1 tap.

7 Transformer 1 relay should require a raise operation (Low LED on).

8 Transformer 2 relay should require a lower operation (High LED on).

9 Return transformers to correct tap positions.

Note: If the test does not give the expected result in 7 & 8, a small reduction of the band setting should initiate the correct indications, if not the VT/CT connections should be checked and the initial load tests repeated.

3 and 4 Transformer Substations

These tests can be carried out using the principle for a 2 transformer substation. The transformers should be arranged such that the busbar voltage is normal and no circulating current is flowing.

The following procedure should now be carried out:

1. Carry out procedure for a 2 transformer substation on T1 and T2

2. Carry out procedure for a 2 transformer substation on T2 and T3

3. Carry out procedure for a 2 transformer substation on T3 and T4

7.3 Operational Settings

Switch all tap change controls to auto and allow relays to achieve balance.

Make fine adjustments to Basic, Bandwidth and LDC settings. Correct adjustment of the deadband setting should be greater than the tapping interval of the transformer tap changer, i.e. for a tapping interval of 1.25% the band setting will be an absolute minimum of ±0.625% (plus a small margin for safety). Using this setting a tap change operation will always return the voltage to the centre of the target band. If after a period of operation an excessive number of tap change operations are made, the band setting can be widened.

Monitor voltage levels, transformer loads and operation counter over a period (at least 2 weeks) to confirm correct system operation under various load conditions.

7.4 System Power Factor Settings

Whether the relay is selected to operate in *TAPP* or *circulating current* Voltage Control Method, the target power factor must be set accurately. This is because the relay reverts to *TAPP* from *circulating current* if a fault on the MPPC KANBUS is selected. Also the Line Drop Compensation is also normalised to the target power factor. If the System Power Factor is not set closely to the true load power factor then a system voltage error will exist.

Therefore ideally the power factors of all relays should be checked when the voltage control scheme is fully operational and the power system normalised. The power factors used to derive the relay setting should be recorded when the group MVA loading is near to maximum. It is therefore necessary to record the displayed Power Factor and Group Load over a period of time to arrive at the best setting to apply to the relays. An average of all of the power factors from the transformers or substations running in parallel should be used as the System Power Factor Setting applied to all of the relays.

An example of this is covered in 4.1 of the Applications Guide.