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7SG15 MicroTAPP

Automatic Voltage Control

Answers for energy

SIEMENS

Contents

Technical Manual Chapters

7SG15 MicroTAPP

Automatic Voltage Control

Document Release History

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Pre release

2012/05	Release of software revisions R9 and R18
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Software Revision History

Contents

1 Introduction

The MicroTAPP voltage control and monitor system is an advanced numeric system based on the widely used SuperTAPP relay. The operational requirements for efficient control of tap changing transformers and protection against abnormal voltage levels is provided in a compact and user friendly design contained within a standard Epsilon case of 4U (177mm) in height and E8 (208mm) or E12 (312mm) in width. The case size selected depends upon the input/output requirements of the scheme connections. Advanced features of metering, data storage and communications for remote control and data transfer are included as standard with the relay.

Full supervision and self-monitoring of the internal relay functions give a high operational reliability and the modular construction allows for on-site serviceability.

A standard, comprehensive menu-based interface gives user-friendly access to the relay settings, display options and fault data. A communications port is provided for local connection to a laptop PC and two fibre optic ports for remote connection. A Reydisp Evolution software package is used to set and commission the relay.

2 Power system requirements

An important aspect of supply quality is the correct application of voltage levels to all transmission and distribution networks. With a growing amount of embedded generation, both synchronous and asynchronous generator types are now becoming relatively common within distribution systems. The control of voltage levels require systems that can function under dynamic operating regimes. This need, coupled with growing customer expectation and use of sophisticated electrical equipment such as computers and thyristor controlled machinery puts an added responsibility upon the supplier of electrical energy to ensure that the delivered level and quality of supply is always within the parameters set down by regulatory bodies.

Automatic voltage control of the electrical network is implemented by use of voltage sensing relays which control motorised On Load Tap Changers (OLTC), for distribution system these devices are normally not economic below a transformer secondary voltage of 11kV or 6.6kV. The complexity of these systems and the mechanical nature of the OLTC contribute to the long term unreliability and danger of abnormal voltages being applied to the distribution system. The main problem areas with traditional schemes are: -

- Complex control circuitry associated with the parallel operation of transformers in a substation
- Operational limitations when networks are operated in parallel
- Inadequate performance under varying load conditions
- A high skill requirement for installation, operation and maintenance

The MicroTAPP system overcomes these historical problems associated with voltage control.

3 MicroTAPP Functionality

The overall functionality of the MicroTAPP can be understood by reference to Figure 1. Analogue quantities of voltage and current are connected to the measurement inputs. These quantities are filtered for noise, sampled at 32 times per cycle (for a 50Hz system) and digitised. The rate of sampling enables the stored waveform data to be used by the relay for measurement and supply quality analysis.

A separate input voltage is connected to the voltage monitor input and treated in the same way as for the measurement input but by discrete and separate algorithms. The connections to the relay allow for use with a 3 phase VT, one phase is used for measurement, one for level checking and the 3 phase connection for determination of voltage quality (NPS content). Where a single phase VT is used the measurement and monitor inputs are connected together.

3.1 Inputs

Plant inputs such as ‘tap in progress’ and remote ‘tap raise or lower’ are connected to status inputs and allocated for function in the input matrix, accessible from relay menu system. The tap change position is also connected to the relay for the purpose of ‘intelligent’ operation monitoring, the action of which is described in the protection section of this document. As a standard the following types of tap position sender are possible; Resistor chain, Binary Coded Decimal (BCD), True binary and Gray Code.

3.1.1 Voltage Measurement

The VT input to the relay is measured against the target settings applied via the menu system. The voltage is only used for measurement if the voltage quality is confirmed as satisfactory by the voltage monitor.

The relay will respond to a voltage which is outside the set-point deadband and initiate a timing interval prior to operation of the transformer tap changing mechanism.

3.1.2 Current Measurement

The transformer load current is measured from the output of a current transformer (CT) connected either at the transformer secondary terminals or at the transformer secondary side circuit breaker (CB). The settings menu enables the phase connection and polarity of the CT which is to be used for measurement in a particular installation to be entered into the relay.

The measurement of transformer current is used by the relay to: -

1 Calculate the group connected load and provide network Load Drop Compensation (LDC).

2 Calculate circulating reactive current and change the effective voltage measurement in proportion to the magnitude of the current and so encourage a tap change operation that will reduce the circulating current.

3 Provide on-line readings and historic data.

MicroTAPP relays use the MicroTAPP Peer to Peer Communication system (MPPC) for the transfer of load information to other relays allowing each relay to determine the summed site load and power factor.

3.1.3 Status

Plant signals connected to the relay status inputs are allocated to relay functions from the setting configuration menu and indicated by the input matrix in Figure 1.

3.2 Outputs

Dependent on the actions required, the output matrix, Figure 1, is allocated for function from the relay menu system. Internal relays can be operated to control the tap changer action, initiate alarms and drive indications.

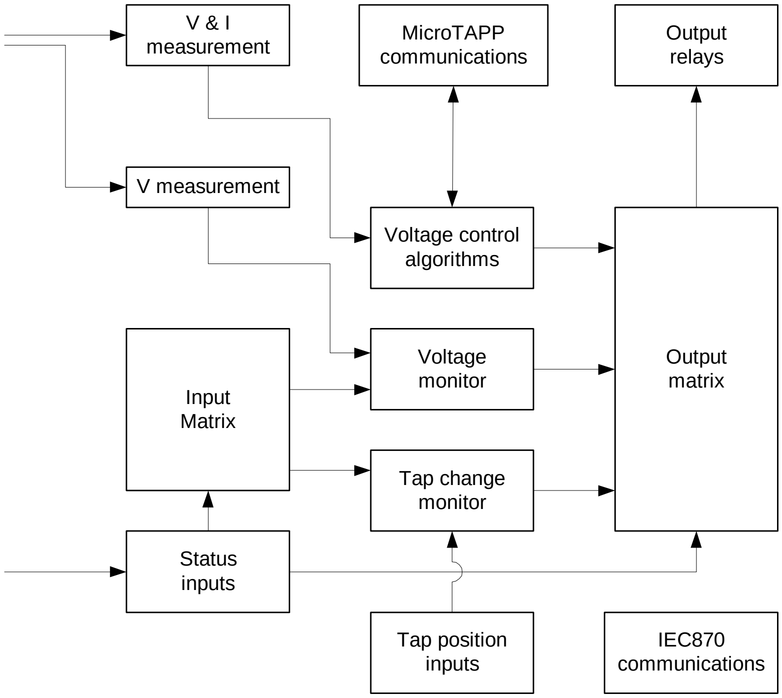


Figure 1

4 Description of operation

4.1 General

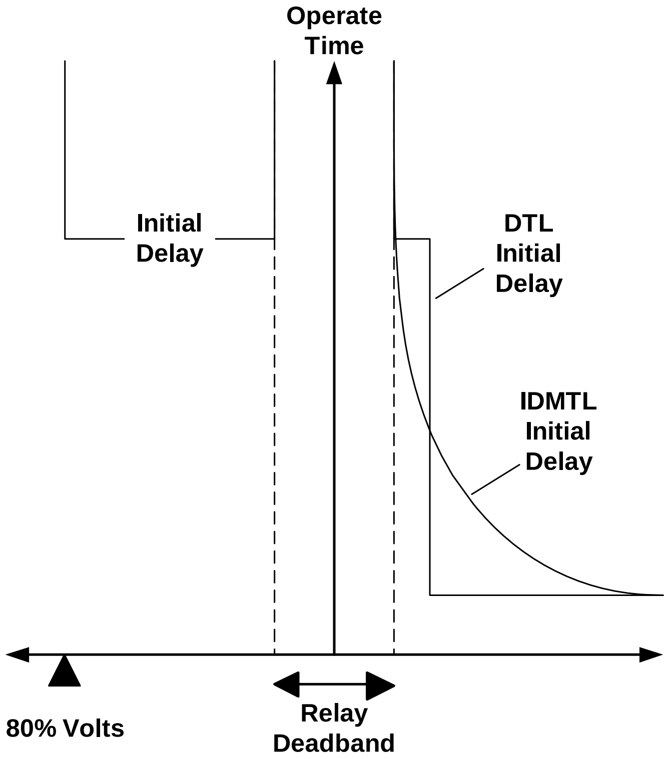


Figure 2

The MicroTAPP provides a system, at each point where voltage is regulated, that operates at all times with minimal human intervention and is capable of optimal operation under various power network arrangements.

A diagram showing the general layout of the relay fascia is shown at the end of this section in appendix A.

When selected to ‘automatic’ mode, the voltage regulating relay controls the transformer tap changer. Voltages which are outside set voltage limits (deadbands) automatically initiate the operation of the transformer tap changer in order to restore the secondary voltage to normal.

When selected to ‘manual’ mode, the voltage can be regulated via the relay manual raise/lower control integral switches. The application section of this document gives more information regarding other tap change controls that may be incorporated into the voltage control scheme.

The operating characteristics of the voltage regulating relay are such that a raise or lower command will only be issued after an initial time delay as set on the voltage regulating relay. A definite time characteristic or an inversely related initial time characteristic is selectable for voltage in excess of the Relay Deadband . Figure 2 shows the characteristics for both types of time delay setting.

The MicroTAPP provides two initial time delays, a definite and an inverse characteristic. The inverse time delay is dependant on the voltage deviation from the normal band and is defined by:-

$$t = \frac{\text{tsetting x Vband}}{\text{Vmeasured - Vtarget}}$$

The initial/inter-tap delay timers are designed to operate for optimum response to the ongoing voltage variation. Following a voltage deviation from the normal band the default display changes to indicate the timer status, consider Figure 3.

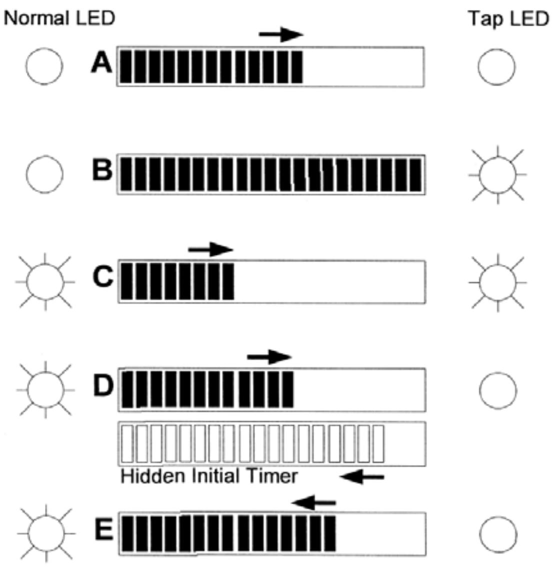


Figure 3

The initial delay timer increments (A) until the timer display is full, when a tap-change signal is issued (B). At this time the display resets and the inter-tap delay timer increments, shown by C, while the initial timer is held at the operative value. If the voltage is still abnormal after the first tap-change operation the inter-tap timer will continue to increment and initiate a further corrective tap-change operation.

If after completion of the tap-change the voltage is normal the initial delay timer will ‘run back’ while the displayed timer continues to increment (D). When the ‘hidden’ initial timer is equal to the displayed time the display will now ‘run back’ (E) to the reset position when the default display is restored.

Normally, voltage deviations take place slowly and are caused by changes in network loading. When a substantial change in voltage is seen it is most likely the result of a network abnormality. As an abnormally high voltage can cause damage to equipment if not corrected immediately the definite time delay of the MicroTAPP can be by-passed by a fast tapping feature in the event of substantial voltage excursions above the set band.

A fast tap occurs when the voltage rises to a level at least = Top of Dead Band + 2% of normal voltage for 2 seconds.

If the relay is allowed to make fast response to a substantial low voltage deviation, which is of a transient nature (such as for an auto-reclose sequence) and the tap change is operated to correct the deviation, an unwanted over-voltage will occur when the transient problem is corrected. For safety reasons, therefore, the IDMTL characteristic and the fast tap response for the DTL are only enabled for voltages above the relay dead-band.

Following an initial tap change operation (IDMTL or DTL) any subsequent corrective signals for the same voltage deviation will be delayed by a separate inter-tap time delay (definite time lag characteristic).

Monitoring of the voltage level is via separate connections and inputs to those used for voltage measurement. Under and over-voltage blocking functions inhibit operation of the regulating relay when the supplied voltage falls below, or rises above limits which are within the set alarm levels. Tap change operations that will correct the abnormal voltage are allowed.

Where a 3 phase VT is used, each phase is monitored as a check against fuse failure.

Raise and Lower commands operate normally open relay contacts. Output contacts can be mapped to internally generated alarms or lockout signals.

The following standard system conditions are catered for with minimal or no adjustment to the MicroTAPP: -

1. Where a transformer is in parallel with other transformers, either within a site or across a network, when set to TAPP mode, the relay operates in order to: -
    - maintain the system voltage at the correct level
    - operate at a tap position where minimal reactive circulating current flows from or into any system transformer which is a part of the network
2. In the event of a failure of communications either between grouped transformers or from a remote control centre, the relay operates in a stand-alone mode until the fault is rectified
3. If a transformer in a group is switched IN, no significant change in voltage will occur
4. If a transformer in a group is switched OUT by use of the ‘prepare to switch out’ function, no significant change in voltage will occur
5. The Load Drop Compensation (LDC) method maintains the voltage at the correct level regardless of the number of transformers connected to a common busbar
6. Settings applicable to different network or busbar running arrangements can be applied to each relay and implemented by a single instruction (either from a remote source or locally) or plant status change (operation of a bus-section CB for instance)
7. Each relay independently protects against incorrect operation which would allow abnormal voltages to be applied to the network

Up to 16 transformers operating in parallel can be controlled as a group.

4.2 Transformers in Parallel

With traditional schemes where 2 or more transformers are connected in parallel either within the same site or across a network, a reactive circulating current will flow between them unless the following conditions are met: -

- The transformers are identical
- The transformers have the same number of taps and tapping interval
- The transformers are always on the same tap position
- The transformers have the same impedance
- The transformers are fed from the same primary source or, more correctly, have the same voltage applied to the primary winding connections

These conditions put constraints on power system design, which are eliminated by the MicroTAPP voltage control system that is designed to detect reactive current and bias the relay target voltage in such a way that the circulating current is reduced to a minimum. Two methods of control are provided:

1. The TAPP system which uses an enhanced negative reactive circulating current principle.
2. Detection of circulating current between transformers connected to the same busbar but not through a network.

For the purpose of explanation the circulating current method is described first, the most widely used and preferred system, however, is the TAPP method which allows for transformers to be operated in parallel at any point in a network, i.e. operate groups of transformers at different substations in parallel.

4.2.1 Circulating Current Control

As described previously the MicroTAPP uses a communication system for the transfer of load information to other relays thus allowing each relay to determine the summed site load and power factor (**I load**) shown in Figure 4.

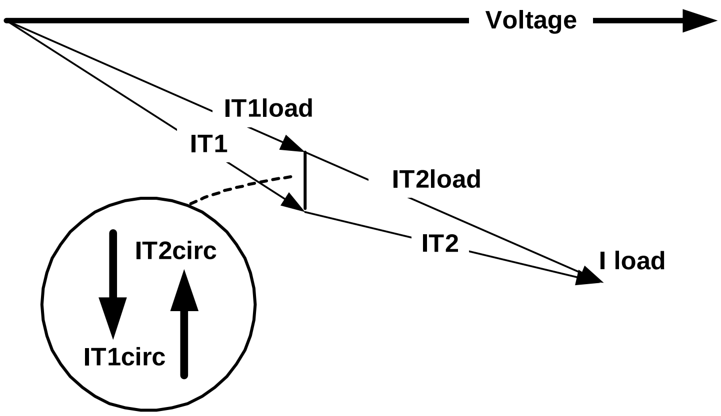


Figure 4

For explanation of the relay action consider a situation where 2 transformers are operating in parallel at a site.

Each MicroTAPP relay receives the same voltage by virtue of the common connection, represented in Figure 5 by 'A'. Over time the busbar voltage changes, in this example it rises until the upper band limit is reached, point B. As each relay is free to operate one will usually act first (T2 in this case) and initiate a tap change operation before T1. When this occurs, the busbar voltage will be reduced by ½ of a tapping interval to point C. This situation now results in a small circulating current which flows from T1 on the higher tap, **IT1circ** in Figure 3 and into T2 on the lower tap, **IT2circ**.

The MicroTAPP control algorithm calculates the magnitude of the circulating current which is the vector difference between load, IT1load, and the individual transformer current, IT1 in Figure 4 and determines the target voltage bias value according to the following rules: -

- If reactive current flows OUT a bias equivalent to the change in voltage is added to the measured voltage

- If reactive current flows IN a bias equivalent to the change in voltage is deducted from the measured voltage

Referring again to Figure 5, for T2, the effective measured voltage is now reduced to D and for T1, which did not operate, the measured voltage is returned to B.

The voltages measured by each relay are now different such that, if the voltage trend continues to rise T1 will tap down, and the transformers will be on the same tap positions, or if the voltage trend is down, T2 will tap up and the transformers will also be on the same tap positions.

Where the transformer are not identical, or the incoming voltage is different on each transformer, the MicroTAPP relays will always operate according to the above rules and ensure that minimal circulating current flows between transformers regardless of the actual tap positions.

This system of tap change control will operate at any system power factor but relies on the true measurement of **IT1load**. MicroTAPP uses the MPPC system for the transfer of load information between relays allowing each to determine the summed site load and power factor (**I load**) as shown in Figure 4. Unlike other relays that offer this option, MicroTAPP does not require use of circuit breaker auxiliary switches.

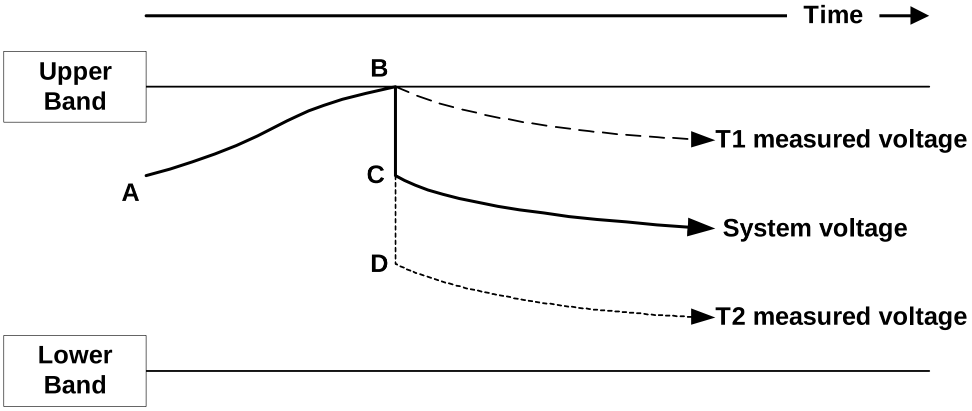


Figure 5

It is not possible for this method of circulating current control to be used when networks are operated in parallel as the summed load at that site can also contain reactive current flowing between remote transformers.

4.2.2 Negative Reactance circulating current control – TAPP

A modification of the circulating current principle is used to overcome the limitations of the circulating current system described in the previous section and allow operation of transformers in any configuration, in parallel at a site, or across a network.

A network Power Factor setting is used to calculate the magnitude of circulating current as the vector difference between IT1 (and IT2) and the transformer target load line at the target power factor. Figure 6 shows the situation where T1 is exporting reactive current, either to an adjacent transformer or into the network. The relay will operate to bring the voltage to the correct level (as described previously) in such a way as to reduce the magnitude of the reactive current. If, as for the previous example, two transformers are in parallel at the same site the circulating current will flow into T2 which will also act to correct the voltage while at the same time reduce the circulating current to a minimum.

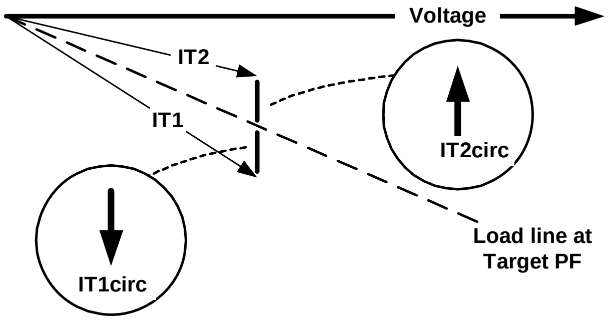


Figure 6

Unlike the previously described circulating current method, the TAPP system does not require load information from other transformers in order to minimise reactive current. As will be seen in the commissioning section of this manual, the instrument display gives a reading of the network power factor which can be used to set the optimum operating point of the relay.

Voltage control systems that use a conventional negative reactive circulating current method based on a 90° VT/CT connection, are not accurate at typical system power factors. As the load on a transformer increases the apparent measured voltage rises, causing the transformer to tap down, see Figure 7.

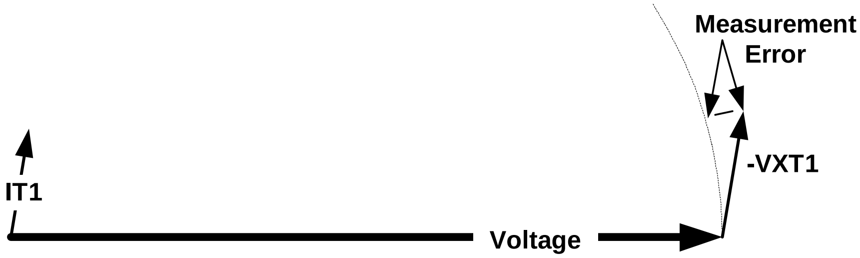


Figure 7

When conventional negative reactance control is used the transformer current, IT1, is used to produce a voltage –VXT1, which should have no effect on the relay for load current. When the load current power factor is less than unity, as shown, an error voltage is introduced into the circuitry which causes the relay to measure an incorrect higher voltage that results in a tendency to reduce the power system voltage below the required level.

MicroTAPP is set to operate at the true power factor. This gives reliable accuracy when set to the average system power factor and overcome the problems associated with other schemes.

4.2.3 Master/Follower control

The MicroTAPP can be configured for use with a Master/Follower tap change control scheme; however as described earlier, this arrangement is complex and imposes severe limitations on network operation. It is not recommended.

4.3 Load Drop Compensation

The MicroTAPP includes a ‘Load Drop Compensation’ facility which is be used to offset the effect of load related voltage drops. Unlike normal controls that respond to transformer load only, the MicroTAPP uses a communication system for the transfer of load information to other relays, thus allowing each relay to determine the summed site load **(I load)** as shown in Figure 4. Regardless of the number of transformers in service at any time the LDC effect will be accurate, unlike those systems where the transformer load and thus the LDC effect changes as the number of transformers in a group changes.

A single control determines the LDC setting and is based on the load at the chosen power factor (a Z setting). It is widely recognised that this arrangement gives the best overall predictable accuracy for load related voltage boosting. Maximum LDC will be applied when the measured load is equal to the System Group Capacity setting.

4.4 MT102 Advanced Features

4.4.1 Description of Operation

MicroTAPP voltage control relay (VCR) can be provided with functionality that will allow effective control to be exercised on either side of the transformer using a single fixed voltage transformer and includes load related voltage regulation.

Figure 8 shows a normal arrangement for a voltage regulation system that employs a MicroTAPP relay taking a voltage and current measurement input from the network side of the power transformer. Any adjustments to the target voltage level are initiated by the VCR to drive a tap-changing mechanism that may be connected to either the ‘primary’ or ‘secondary’ windings of the power transformer.

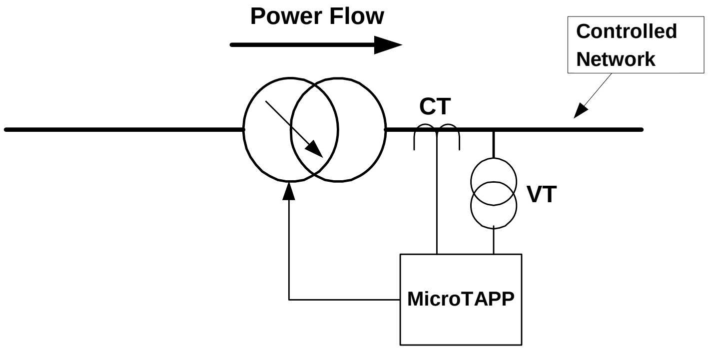


Figure 8

If a network configuration makes it necessary to change the controlled voltage point, a voltage and current transformer would be required on the other side of the power transformer together with a complex switching arrangement for the tap-changer control system. If the network running arrangement is such that the use of generation make it desirable for the controlled network to be changed from one side to the other, automatic voltage control may not be possible as shown by Figure 9.

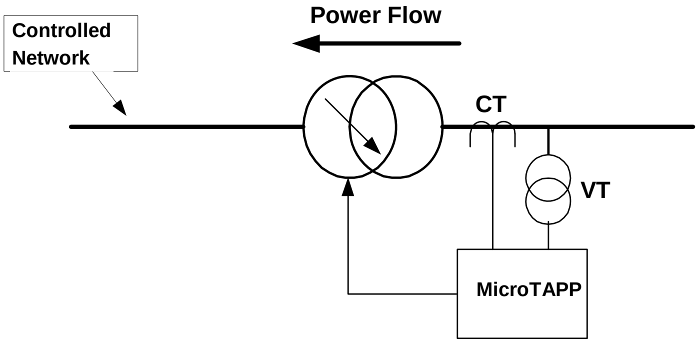


Figure 9

The advanced functionality of the MicroTAPP uses algorithms that enable the terminal voltage of the non-measured side of the power transformer to be calculated and effective control to be carried out without a requirement for any additional inputs. Information relating to the transformer is required as can be seen by reference to the relay setting section of this document and covers the following situations: -

4.4.2 Location of tap-changer, HV or LV side

Normally the controlled voltage winding is the un-tapped winding and the tapping interval is an equal percentage change for each tap position, based on a constant nominal output voltage on the fixed winding. If the controlled voltage point is on the tap-change side the effective voltage change for each tap position will not be constant across the tapping range.

The MicroTAPP relay uses the location of the tap-changer, with other information, to correctly determine the step by step voltage level.

4.4.3 Change in voltage per tap

The change in voltage per tap is required and as described above the actual effect is dependent on the location of the tap-changing mechanism. The value of tapping interval that is input into the relay is a single calculation as follows: -

The tap spacing is calculated regardless of the tap-changer location: -

Vhi*	= Highest voltage of the variable voltage winding (voltage as nameplate)
Vlo*	= Lowest voltage of the variable voltage winding (voltage as nameplate)
Vnom*	= Nominal voltage of the variable voltage winding (voltage as nameplate)
Tap	= Number of taps (not tap intervals)

* Irrespective of the actual tap changer location

$$\text{Tap spacing \%} = \frac{(Vhi - Vlo) \times 100}{Vnom \times (Tap-1)}$$

4.4.4 Single phase or 3 phase units

This setting determines load current for the transformer full load rating.

4.4.5 Direction of tap-changer for voltage increase

Some tap-change mechanisms operate to increase voltage by reducing the tap position. This setting allows for this situation.

4.4.6 Transformer impedance

Transformer impedance is used by all MicroTAPP relays for control of circulating current and, in this application, for the calculation of winding voltage drop.

4.4.7 Nominal voltage or winding load drop compensated target settings

In some applications where large transient loads are supplied it may be desirable to ignore the transformer voltage drop and control the voltage at an effective nominal level. This setting allows for this requirement.

4.4.8 Dead-Reckoning Block

Since the MT102 may be controlling the voltage on the opposite side of the Power Transformer from its measuring point, it is important that the Tap Position reported to the Relay by the TPI is correct. The Relay will therefore compare the Tap Position received from the TPI with its own "Dead-Reckoned" Tap Position. If a discrepancy is found the Relay will Alarm "Dead Reckoning Block" and block subsequent tap changes. This will only be reset once a correct Manual Raise/Lower operation has been carried out.

4.4 MicroTAPP–MicroTAPP communications

At a site each MicroTAPP can connect to other MicroTAPP relays through a screened twisted pair cable. The MicroTAPP Peer to Peer Communication system (MPPC) is used to transfer data between the relays relating to the overall operation of the MicroTAPP group at a site. If a MicroTAPP relay is de-energised, communications between other relays connected to the twisted pair cable is not affected.

4.5 Low Frequency Voltage Reduction

Where voltage reduction is used for load reduction purposes, usually to offset a shortfall in available generation, the relay can be configured to automatically initiate tap change operations. The power system frequency is continually monitored, if the frequency falls below a set level the target voltage setting is dropped by 5% to effect an immediate voltage reduction.

4.6 Transformer Switch out

When one transformer of a group is switched out of service a voltage drop will occur as additional load is ‘picked up’ by the remaining transformers, particularly if the transformers are heavily loaded and have a high impedance. The effect can be eliminated if the individual transformer tap changers are operated to offset the voltage drop prior to switch-out, e.g. raising the tap position of the transformer that will remain in and lowering the tap position of the transformer that is to be switched out.

On receipt of a signal (switch out command), MicroTAPP relays (allocated to a group) can be configured to communicate and operate each tap changer in such a way that minimal change in voltage will occur when the transformer is switched out. When the optimum tap positions are achieved a completion signal is returned.

When the load current is removed from the transformer to be switched out, the remaining relays return to normal tap change control. If the load current is not removed, after a period of time the relays reset to normal operation. The switch-out command can be initiated either by a SCADA signal, from a PC via a communications network or from a hard wired local control switch.

4.7 Transformer Switch in

Normally when a second transformer of a pair is switched into service the busbar voltage will increase. If the transformers have a high impedance and the load is high, the voltage increase can be significant. The MicroTAPP relay can avoid this increase by tapping the unloaded transformer prior to it being loaded.

The transformer should be energised by closing the HV CB and waiting for the unloaded transformer to complete any tap changes. The MicroTAPP relay will immediately operate the tap changer of the unloaded transformer to a position whereby the open circuit terminal voltage is equal to the busbar voltage. Once the NORMAL LED is illuminated the transformer can be energised by closing the LV CB.

The MicroTAPP controlling the loaded transformer sends load data to the unloaded transformer via the MPPC. This allows the unloaded transformer to be tapped to the desired voltage target prior to the LV CB closing. It also allows any LDC compensation to be included into the tap change control.

When the circuit breaker is closed, there will be no significant change in busbar voltage and the relays will then tap to minimise circulating current in the normal way. The advantage of this control switching sequence is the customer does not experience a large voltage fluctuation whilst switching transformers in and out of service.

4.8 Relay Settings

Settings applicable to a particular site can be applied to the relay either locally from the relay display, a PC via the relay fascia serial port, or remotely over a communications link via the rear mounted fibre optic connections.

8 groups of settings can be stored by the relay, at any time only one group is used by the relay for control. When the relay is energised, it will operate with the settings group that was last applied.

The MicroTAPP is designed to function as an integral control device within the Transformer/Site configuration, in this respect information relating to the installation is used by the relay as follows: -

Site data - number of transformers forming a group etc.

Transformer Data - rating, impedance, VT and CT details etc.

Tap change - number of steps, type etc.

Network data - Power Factor, system voltage, group capacity etc.

Voltage control - Basic, band, LDC etc.

4.8.1 Basic Set-point

The basic setting determines the operational target voltage for the relay with the transformer at no load. If LDC is not used the target voltage will be the basic setting.

4.8.2 Normal voltage deadband

A deadband setting with a range that will enable the voltage to be controlled within satisfactory limits for a practical number of tap changing operations is provided.

If the voltage fluctuates about the deadband, a corrective tap change operation will take place if the average voltage level deviates from the relay setting.

4.8.3 Load Drop Compensation (LDC)

The relay LDC corrective effect is based on system group capacity at the system power factor. Use of the LDC setting is discussed in the applications section of this manual.

4.8.4 Circulating Current Compensation

The relay will control group transformers in parallel without recourse to a complex Master/Follower scheme. Two methods can be used: -

1. Reactive current minimisation, an enhanced version of the TAPP patented system as used with the SuperTAPP range of Siemens Protection Devices Ltd equipment. Using this system, widely recognised for its operational advantages, transformers can operate in parallel either at a site or across a network thus giving greater network flexibility.
2. Circulating current control, this method enables transformers to operate in parallel when connected to a common busbar at a site at any power factor, but NOT across a network or between groups of busbars.

The relay response for each method, when selected, is determined by the transformer characteristics entered into the set-up menu.

4.8.5 Tap Stagger

The MicroTAPP can still be utilised for the export or import of reactive current (tap stagger). The voltage control menu is used to set the magnitude of the reactive current and a status input can be set to initiate the tap stagger process. The value of reactive current is set as a percentage of the transformer group full road rating, i.e. for a 9MVA group a setting of +10% would result in an exported reactive current of 0.9MVAr and a -10% setting would result in an import of 0.9MVAr.

4.8.6 Time Delays for Operation

When a busbar group voltage is outside upper or lower deadband, the initial corrective tap control output is delayed by a pre-set time. This time delay is the ‘initial tap time delay’ as described previously and shown in Figure 2.

Where the voltage is drifting in and out of the deadband, the initial delay time-out is determined by the difference between the accumulated times that the voltage is outside and inside the deadband. The relay counts up to the initial tap delay time for the period that the voltage is outside the deadband. If before the initial tap delay time is reached the voltage returns within the deadband, then the equipment will count down for the period that the voltage is within the deadband.

In the event of a voltage ‘swing through’ the relay accumulates voltage excursion times from both the lower and upper deadbands as described above. The first time delay to expire will initiate the appropriate corrective tap change operation.

If more than one tap change operation is required for correction of a voltage deviation, subsequent tap change operations are determined by an ‘inter-tap delay’ setting which has a definite time characteristic. The time is settable from the menu and should normally be slightly longer than the tap changer operating time.

5 Control

The relay provides for both Manual and Automatic control of the tap changing system.

The relay is configurable for either Local control, or Remote control through a communication system from a control centre. The communication medium may be serial communications or from hard wired contacts.

If manual control is exercised from a point where an indication of the power system voltage is not available the relay can be arranged to inhibit tap change operations that would drive the system voltage to an abnormal level, e.g. control at the tap changer mechanism.

5.1 Control Points

Electrical control of a tap change mechanism is normally exercised from three points: -

5.1.1 At the tap change mechanism

A Local/Remote selector switch at the Tap Changer is connected to the MicroTAPP enable input. When set to Local, this disables tap change operation from all other control points. When set to Remote, control is enabled from the MicroTAPP relay.

5.1.2 At the voltage control relay panel

A Local/Remote selector switch on the MicroTAPP, when set to Local, disables control from a remote control centre. If the tap change is set to Local at the tap change mechanism, Auto/Manual selection can still be altered and will take effect when the MicroTAPP is enabled.

5.1.3 At a remote site

When the MicroTAPP is set to Remote, controls can be selected and operated from a remote control centre providing the selector switch at the tap change mechanism is also set to Remote. If not, Auto/Manual selection can still be altered and will take effect when the MicroTAPP is enabled.

5.2 Control Switches

The MicroTAPP has integral control switches that can also be operated from a remote control centre, with the following functions: -

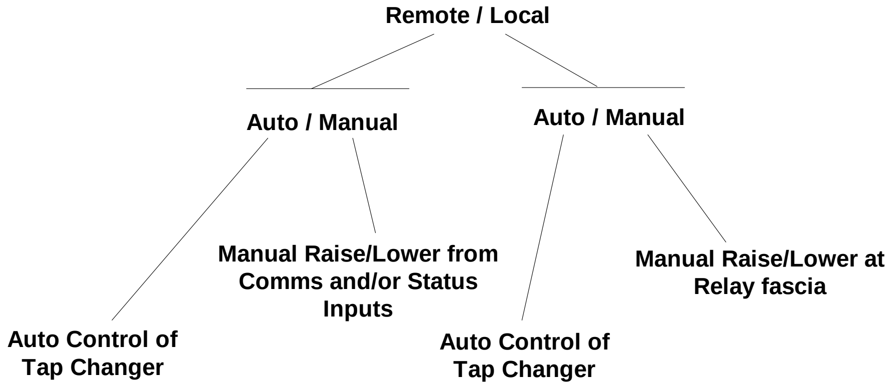


Figure 10

5.2.1 Local/Remote

A switch is provided to allow for the selection of control to be at the relay or from a remote location, normally a control centre. Remote control is via the communications or status inputs.

5.2.2 Auto/Manual

This switch sets the relay to Automatic or Manual voltage control.

When the MicroTAPP is set to ‘Manual’, the relay will not attempt to correct the voltage automatically. To aid Manual control, the relay status LEDs show the voltage level in respect of the relay deadband. A digital reading of the actual voltage level and the tap position is also given.

5.2.3 Raise/Lower

When the Auto/Manual switch is set to Manual this switch allows the tap changer to be operated either to increase the tap position or reduce the tap position.

The control is operative with the transformer energised or de-energised.

6 Protection

A comprehensive monitoring of the voltage control system is incorporated that will detect and prevent abnormal power system voltages either from incorrect operation of a tap changing mechanism or from incorrect control signals.

6.1 Voltage and Current

6.1.1 Measured voltage outside normal range

The voltage monitor is connected to separate inputs on the relay and not those used for voltage measurement, i.e. where a 3 phase VT is used A-B phase may be for measurement and B-C phase for measurement monitoring, see Figure 11.

If the measured system voltage is less than a pre-set under-voltage limit or greater than a pre-set over-voltage limit, the relay inhibits the appropriate tap control outputs to the relevant transformer but allows tap change operations that will correct the abnormal voltage. An under or over-voltage alarm is generated if the abnormal voltage reaches excessive levels for a time equal to the Alarm Time setting. The under-voltage and over-voltage alarm level is settable to accommodate the range of voltage allowable by the voltage control settings.

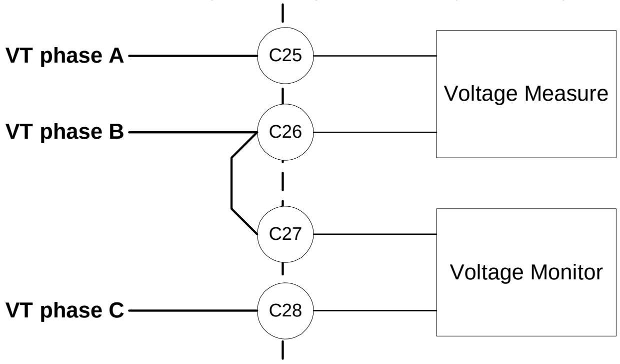


Figure 11

As a guideline, the maximum voltage that should normally be seen is = Target Level + Band + LDC. Note that the Target Level might be the "Target Voltage" setting or any relevant "Auxiliary Target" setting. So, for example, if the Target Voltage is 98%, the Band is +/- 1.5% and the LDC is 5%, the upper alarm setting should be at least 98% + 1.5% + 5% = 104.5%. In practice a further 1% should be added for tolerance. The actual Over-voltage Alarm level would therefore be 105.5%.

The minimum voltage that should normally be seen is = Target Level - Band. Note that the Target Level might be the "Target Voltage" setting or any relevant "Auxiliary Target" setting. So, for example, if the Target Voltage is 98%, the Band is +/- 1.5% and the minimum Auxiliary Target is 97%, the lower alarm setting should be no more than 97% - 1.5% = 95.5%. In practice a further 1% should be deducted for tolerance. The actual Under-voltage Alarm level would therefore be 94.5%.

The voltage monitor automatically blocks control signals that would drive the system voltage in the wrong direction. The overall action of the monitor is shown in Figure 12.

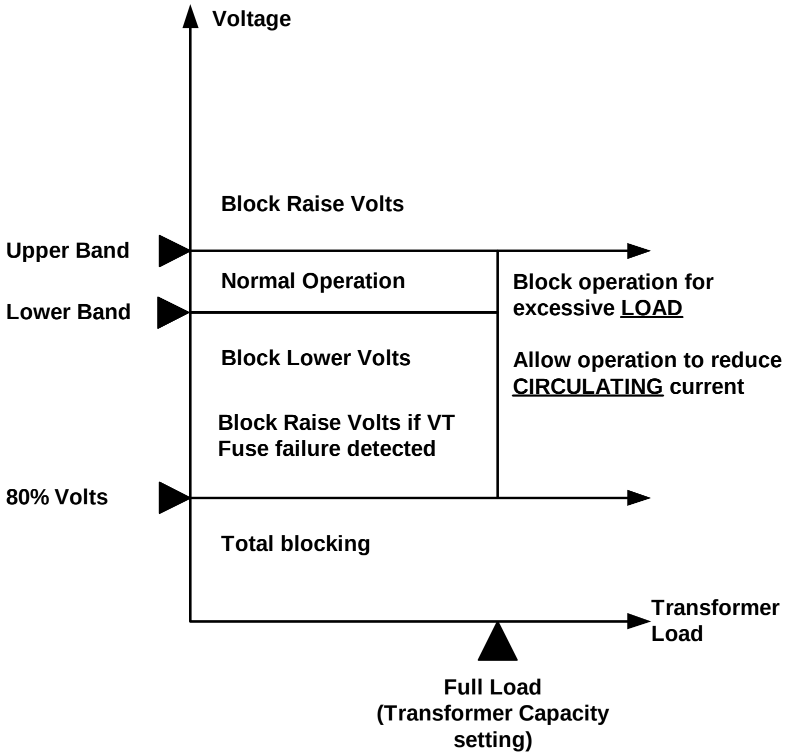


Figure 12

Assume that the voltage is approaching the high voltage setting level. If a tap change is issued it will be an instruction to lower the voltage, therefore for safety, the raise output logic can be blocked. The same argument can be applied to the low voltage setting level.

The voltage blocks will take effect at (upper voltage level - total dead-band) and (lower voltage level + total dead-band). Using typical settings as an example, if the monitor 'high' alarm setting is 105% and the 'low' alarm setting 94% and the relay band setting is ±1.5%, the 'raise' output will be blocked at 102% and the 'lower' output at 97%.

When the tap changer is operated manually from the tap change controls **at the tap changer**, the MicroTAPP can still be used to prevent incorrect control signals by routing the tap changer raise and lower signals through the MicroTAPP Block Raise and Block Lower output contacts respectively.

When the tap changer is operated manually from the relay, or from **a remote control centre**, all manual control signals will be allowed. Such operations should therefore only be carried out if there is an indication of the voltage level available at the point of control.

6.1.2 Voltage transformer faulty

Where a 3 phase VT is used the relay monitors all voltages in order to ensure the integrity of the VT secondary output. Any abnormalities detected (HV fuse blown for instance) will inhibit the voltage raise outputs from the relay and initiate an alarm. A VT failure is assumed when:-

$$\frac{\text{Vnps}}{\text{Vpps}} \text{ x } 100\% \geq 10\% \text{ when Vpps} \geq 5\text{V}$$

A VT / VT fuse failure will result in misleading phase information being placed on the MPPC by the MicroTAPP which has detected the failure. This will compromise the operation of all the MicroTAPP's sharing load information over the MPPC when they are set to operate in Circ. Current mode of control. For this reason, failure of a VT / VT Fuse will result in all the MicroTAPP's sharing the MPPC switching from Circ. Current to TAPP mode of control for the duration of the failure. Care should be taken, therefore, to set a valid System Power Factor setting even when using Circ. Current mode of control.

6.1.3 Load Current

If the true load current is greater than a pre-set limit, the relay system will inhibit tap control outputs to the and generate an over-current alarm, unless the situation is caused by circulating current flowing between transformers, in which case tap changing will be enabled that will reduce the circulating current, see Figure 12.

6.2 Tap Changer

The tap changer operation is monitored for a mechanism, wiring or relay fault. The following is provided: -

6.2.1 Tap Change Runaway

Following a tap change instruction the first incorrect tap change operation is detected immediately by the MicroTAPP and further operations are inhibited. An incorrect tap change operation is defined as ‘a tap change operation that is not initiated by a true control signal’. As an example, a slow to clear ‘raise’ contactor may allow a motor drive to continue driving the mechanism at the end of a tap change cycle such that the tap change maintaining switch recloses thus allowing the tap change to ‘run away’.

The MicroTAPP intelligently monitors the relationship between the initiating control signals, the tap change ‘in progress’ inputs and the tap position.

For a tap change to be correct, the following sequence must take place:-

1 A control signal must be issued to initiate the process

2 The tap position must change to a new position

3 The tap change mechanism must stop completely

A ‘Tap In Progress’ (TIP) auxiliary switch is closed while the tap is not at the rest position and used to indicate and monitor the operation of the mechanism. Figure 13 shows the MicroTAPP input status signals during a normal tap change operation.

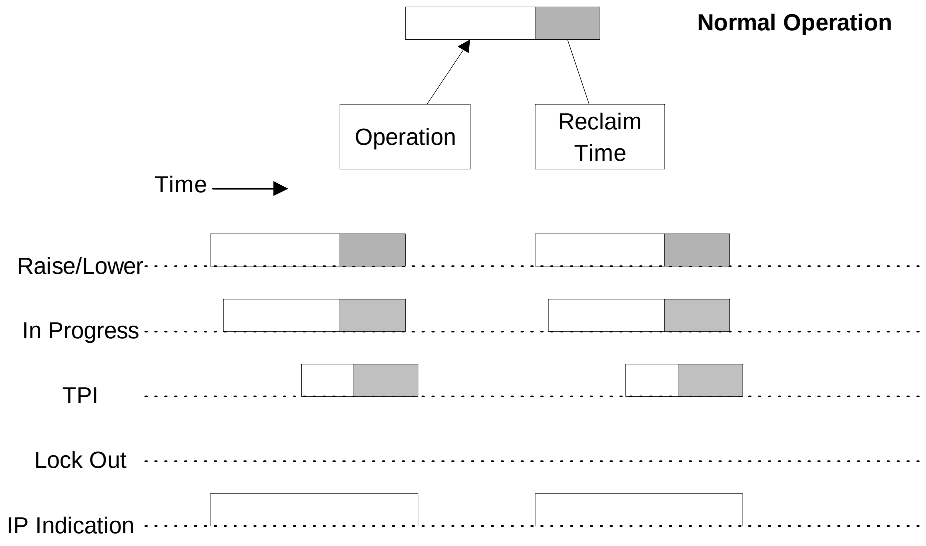


Figure 13

To confirm correct operation a definite break between successive tap change operations must be detected.

On detection of the completion of each signal the MicroTAPP checks that the mechanism has stopped by monitoring for no further signals, shown in the Figure as the ‘reclaim time’, set at 2 seconds for the MicroTAPP. If a further operation is detected in the reclaim time, a runaway condition is assumed and the relay will lockout

The TIP LED is maintained until all signals are removed, the tap position has changed and the reclaim time has expired.

For an incorrect tap change, Figure 14, where the mechanism over-runs, or continues to operate, a new control signal AND/OR 'in progress' is detected before the internally generated reclaim time has expired. The tap change has not satisfied rule 3 above, and a further tap position change will result in a lockout signal and the TIP LED will flash.

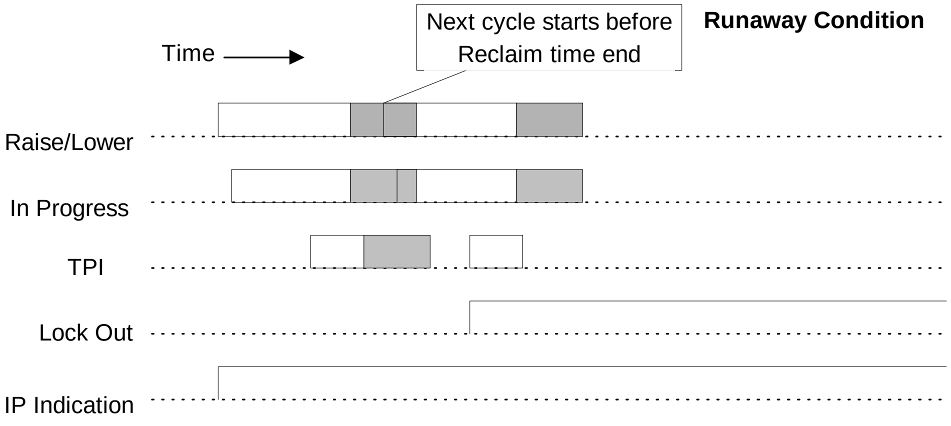


Figure 14

The runaway prevention unit also protects against a runaway situation during push button operation. Unwanted lockouts in manual control are prevented by avoiding further operations until the "In Progress" LED is extinguished.

If a lockout is required the relay can be configured to operate contacts both for lockout and alarms. Output contacts can be used for the tripping of a mechanically latched contactor or the permissive operation normally open contactor.

6.2.2 Tap Change Incomplete

If a 'raise' or 'lower' signal is sent to initiate a tap change operation and the operation is not completed, then the relay can be configured to issue an alarm and lockout the tap-change motor power supply. For a tap change operation to complete, a pulse must be seen at the 'In Progress' Status Input and the indicated tap position must change.

6.2.3 Limit of Tap Change Range

If the tap changer is on either the top or bottom tap position, an "End of Tap Range" alarm is issued. Further tap changes will be inhibited if they attempt to drive the tap changer beyond its extreme positions.

6.2.4 Tap Not Achievable

If the tap changer is on either the top or bottom tap position and the voltage goes out of the Dead-band in such a direction that a corrective tap change would be required beyond the tap changer extreme positions, a "Tap not achievable" alarm will be issued.

7 Other Features

7.1 Instrumentation and Metering

The MicroTAPP gives indications, shown by reference to the general layout in appendix A as follows: -

7.1.1 System ID

The relay has provision for input of a control system ID, e.g. "Transformer 1".

7.1.2 Control Switches

The relay status is indicated on the LCD display. The controls are integral within the voltage control relay, the display shows the control switch selection, see Figure 16.

7.1.3 Relay Healthy

An LED shows that the relay is operating correctly or has malfunctioned.

7.1.4 Voltmeter

Digital presentation of the power system voltage is shown on the LCD.

7.1.5 Voltage Trace

A voltage level trace is shown on the LCD.

This can be configured for a window of 15 minutes or 1 hour.

7.1.6 Tap Position Indicator (TPI)

Digital presentation of tap position is shown on the LCD.

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. The positions may also be indicated as the same position and labelled with suffix letters, i.e. 8A, 8B, 8C.

A system that allows for presentation of the tap position as indicated on the tap change mechanism is integrated into the TPI set-up menu, accessed by use of a ‘tap customisation sub-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 should also be marked as ‘T’ to indicate a 'Transfer' position, i.e. 7, 8T, 8, 8T, 9. This prevents a Runaway condition being detected.

The use of the sub-menu is best understood from the following examples.

A tap changer with top tap of 15 but with tap through positions labelled 8A, 8B and 8C.

1	2	3	4	5	6	7	8A	8B	8C	9	10	11	12	13	14	15

The total number of positions are 17 and entered in the in the settings/tap change/ no. of taps as 17. The tap customisation sub-menu is used to change the tap positions as follows:-

1	2	3	4	5	6	7	8T	8	8T	9	10	11	12	13	14	15

A tap changer with a tapping range from -5 through 0 to +11 the total number of positions is 17 and entered in the settings/tap change/no. of taps as 17.

The tap customisation sub-menu is used to change the tap positions as follows:-

-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11

7.1.7 Instruments

Extensive instrumentation is available from the LCD display or a remotely connected PC. Figure 15 shows the general format of the instrument display, the complete range of instrumentation is listed in section 9, Settings and Displays.

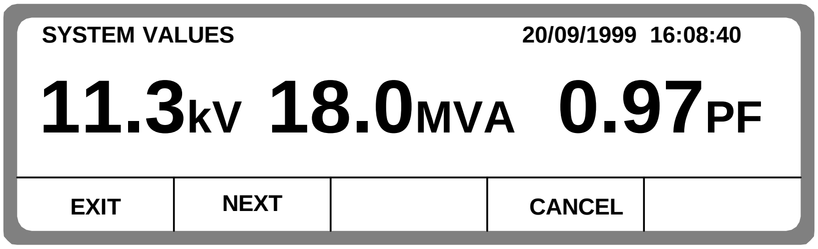


Figure 15

7.2 Data Storage with Date and Time

Data records are available in three forms, namely fault records, graphical records and event records.

7.2.1 Fault Records

This screen enables the 10 most recent tap-changer faults to be viewed. For each, the date and time of the fault and a short description of the events leading to the fault are provided.

Following maintenance all fault and any maintenance alarms can be cleared using the button labelled 'Reset' whereupon normal operation of the MicroTAPP will resume.

The reset button is available in place of the TEST LED function on the screen shown by Figure 16.

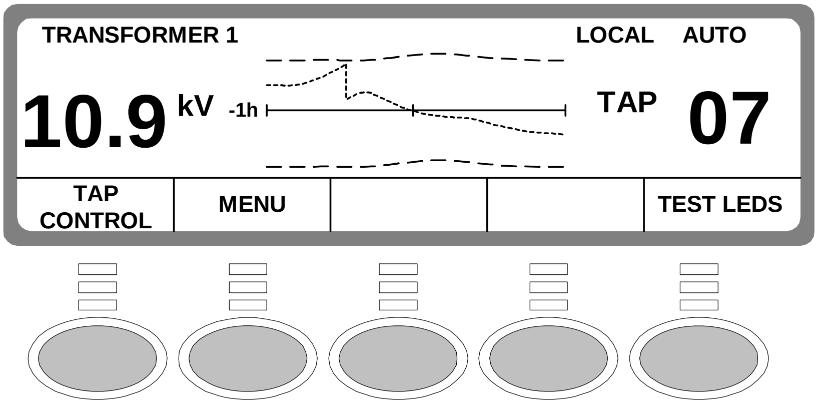


Figure 16

7.2.2 Graphical Records

Recordings of all operational data, voltage level, transformer load, summed load etc. are available for up to 24 hours from the relay.

7.2.3 Event Records

The event recorder feature of the relay allows the time tagging of any change of state of the relay. Each event is logged with the full date and time and actual event condition every 50ms. The following events are logged:-

- Change of setting (though not the actual setting changes). Also indication of which group of settings is active.
- Change of state of Output Relays
- Change of state of Status Inputs
- Operation of controls (Auto/Manual etc.)
- Issue of tap change operations
- Relay Reset

The event storage buffer holds 200 records. When the event buffer is full, then any new record over-writes the oldest.

Event records are stored in RAM with a capacitor providing back-up during breaks in auxiliary supply.

7.3 Communications

Two fibre optic communication ports are provided. Communication is compatible with the IEC60870-5-x FT 1.2 transmission and application standards.

A user friendly software package available on the Siemens Protection Devices Ltd website, Reydisp Evolution, is freely available to allow transfer of the following:

- Relay settings
- Graphical records
- Event records
- Instruments and meters
- Control Functions

Communications operation is described in detail in the Siemens Protection Devices Ltd technical report "Communications Interface Manual".

7.4 Self Monitoring

The MicroTAPP incorporates a number of self-monitoring features that initiate a reset sequence which can be used to generate an alarm output. In addition, the Relay Healthy LED gives visual indication.

A watchdog feature monitors the microprocessor. The relay program memory is continuously checked for data corruption. The power supply is continuously supervised. Any failure is detected with sufficient time warning so that the microprocessor can be shut down in a safe and controlled manner.

7.5 Password Feature

The programmable password feature enables the user to enter a 4 character alpha-numeric code. As soon as the user attempts to change a setting the password is requested before any setting alterations are allowed. Once the password has been validated, the user is said to be "logged on" and any further changes can be made without re-entering the password. If no more changes are made within 1 hour then the user will automatically be "logged out", re-enabling the password feature.

Note that the password validation screen also displays a numerical code. If the password is lost or forgotten, this code can be communicated to Siemens Protection Devices Ltd by authorised personnel, and the password can be retrieved.

The relay is supplied with the password set to "NONE" which means the feature is de-activated.

8 User Interface

The user interface either via the LCD or a PC is designed to provide a user-friendly method of entering settings and retrieving data from the relay.

8.1 General Arrangement

The MicroTAPP relay fascia includes a 40 character by 8 line, back-lit, liquid crystal display, 5 light emitting diodes and 5 push buttons. Appendix A shows the layout for the E8 case size.

Detailed drawings for both the E8 and E12 wiring connector blocks are available from the Siemens Protection Devices Ltd website.

8.1.1 Liquid Crystal Display

The liquid crystal display is used to present settings, instruments and fault data in a textual format.

The display contrast is factory set. It can be adjusted if required as follows:-

1. Press and hold the right most button.
2. Press either the left most or second left buttons to increase or decrease the contrast.

8.1.2 LED Indications

8.1.2.1 MicroTAPP Healthy

A green LED labelled ‘Relay Healthy’ is provided.

When the relay is powered up and running normally the LED will be on permanently. If a permanent fault is detected by the internal self-monitoring algorithms and watchdog the LED will flash continuously.

8.1.2.2 Voltage Normal

A green LED indicates that the measured voltage is normal.

8.1.2.3 Voltage High

A red LED indicates that the measured voltage is above the relay deadband setting. If the over-voltage monitor has detected a failure the LED will flash.

8.1.2.4 Voltage Low

A red LED indicates that the measured voltage is below the relay deadband setting. If the under-voltage monitor has detected a failure the LED will flash.

8.1.2.5 Tap in progress

An amber LED indicates that the tap change mechanism is in the operating state. If the tap change monitor has detected a failure the LED will flash.

8.2 Keypad and Display

Five push buttons are used to control and set-up all aspects of the voltage control system. The use of each button is indicated by a label above the button in the lower portion of the LCD.

When the voltage is ‘normal’ a graphical display showing the previous 15 minutes or one hour of voltage level is displayed together with the measured system voltage and the tap position.

Note that applying Auxiliary Target Voltages, Circulating Current compensation or Frequency compensation will not adjust the graphical display target voltage. In some cases, therefore, the voltage trace will be outside the band without Raise or Lower operations being initiated.

When the measured voltage makes an excursion from normal, the central area of the LCD changes to indicate the progress of the time-out period, see Figure 17. Two indications are given one for ‘high’ and one for ‘low’, normally only one bar is visible.

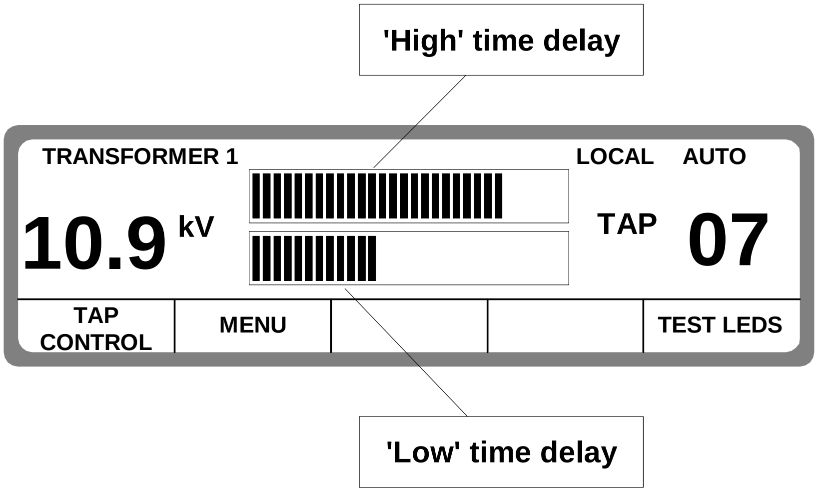


Figure 17

If the voltage level is such that it returns within the deadband before completion of the timeout period the timer will ‘run back’, for a DTL setting the runback rate is equal to the ‘run up’ rate.

Each out of band timer is independent, if a voltage ‘swing through’ occurs the display will show both time-outs, one increasing and one decreasing. The first timer that times-out will initiate a tap change in the appropriate direction.

When the buttons are operated the labels will change to indicate other functions. If a fault has occurred the ‘TEST LEDS’ button is automatically changed to ‘RESET’ and allows the fault to be cleared.

Operation of the ‘Tap Control’ button changes the LCD display to that shown in Figure 18 and gives a graphic display that allows selection of the tap change control to be changed by the ‘move’ button as required by site operating conditions, the Figure shows the auto/manual switch selected for operation. The function of the push buttons is also changed to enable the control switches to be operated.

Only three push buttons can be used when the relay cover is on, the two left most and the right hand button. These allow selection and operation of the tap change but give read only access to relay setting menus and stored fault data.

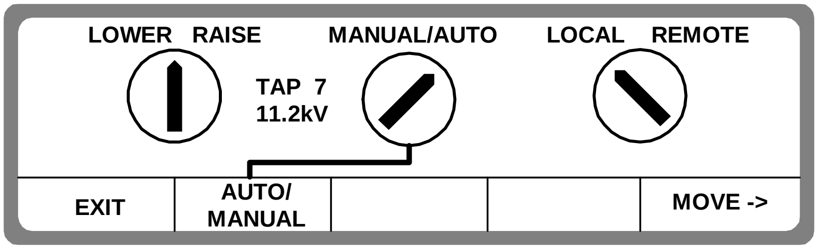


Figure 18

In addition, the following warnings can be displayed;

Locked Out	The Relay has Locked Out.
V out of band	The voltage is outside the Dead Band but the Relay is under Manual control and so cannot correct it automatically.
V very low	The voltage is below 80% of the nominal Primary Voltage.

No voltage	The voltage is below 20% of the nominal Primary Voltage. This will reset only once the voltage has returned to 70% of its nominal level.
TPI fault	Dead-reckoning Error detected or Tap Position is 0. [MicroTAPP 102 only]
Remote VT fuse blown	VT / VT Fuse failure reported over the MPPC
Switched to TAPP mode	Control mode switched from Circ. Current to TAPP due to MPPC or remote VT / VT Fuse failure

The complete range of controls and menu functions are detailed in the SETTINGS AND DISPLAY section of this document.

8.3 Serial communications port

A 25-pin isolated RS-232 is provided for access to the relay's stored data and settings. The PC or laptop computer used should be capable of driving the port with at least 7mA at 7V.

9 Settings and Displays

The basic settings/displays flow diagram is shown in Figure 19. This diagram shows the main modes of display, the Settings Mode, Instrument Display Mode and the Fault Data Display Mode. Intuitive operation of the push buttons allows each mode to be entered where further menu options enable settings to be entered. At each level a push button can be used to return to a higher menu level.

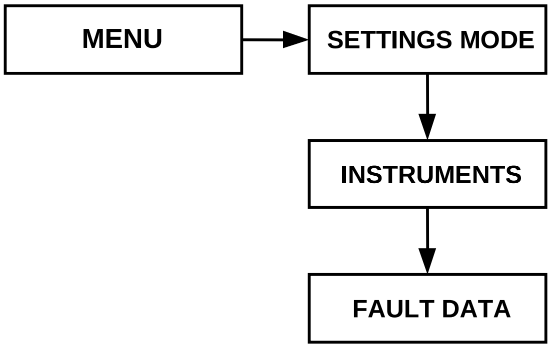


Figure 19

9.1 Settings Mode

For correct operation the MicroTAPP relay requires information regarding the network to which it is connected. Information relating to the transformer characteristics, the tap changer, other transformers operating in parallel, network parameters and voltage levels are entered as shown in Figure 20.

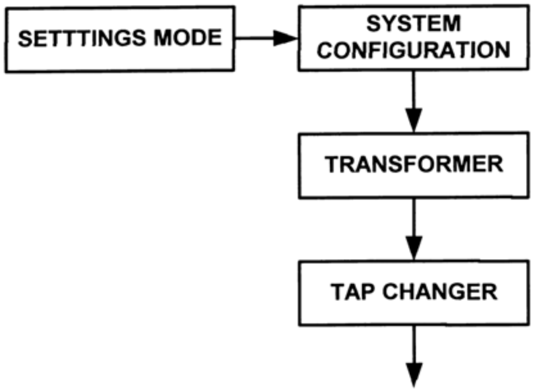


Figure 20

NOTE: [101] MicroTAPP 101 only
[102] MicroTAPP 102 only

System Configuration

Active Group	8 Settings Groups are provided. Selects the Group in use.
View/Edit Group	The Settings Group displayed on the LCD.
Status Select Group Mode	Configures the "Select Group" status inputs as either Level or Edge Triggered. If Level Triggered, MicroTAPP will change its active settings group when one of the "Select Group" inputs becomes active, and that change will remain in effect until the input has become inactive. If other "Select Group" inputs become active during this time they will be ignored. If Edge Triggered, MicroTAPP will change its active settings groups for every inactive-active transition at the appropriate "Select Group" input.
Relay Identifier	Characters and numbers can be used to identify the Relay. The identifier appears in the top left hand side of the display.
Set Date	Relay date.
Set Time	Relay Time.
Voltage display time	Length of the historical voltage trace.
MPPC Failure Detection	Enables inter-relay Communication Failure Detection. If enabled, the “MPPC Failure” output relay can be allocated to send an alarm.
Change Password	4 character code. Allows password protection of the Relay settings. By default this is set to NONE - no password.
Local / Remote Control	Defines method of Local / Remote control - at the Relay Keypad or through a Status Input.

Transformer

Transformer Number	Where the Relay is configured to communicate with other units using the MPPC it is important that each MicroTAPP is given a unique identifying number. For example, if two transformers, T1 and T2, are installed, it would be logical to use “1” as the identifier for the T1 Relay and “2” as the identifier for the T2 Relay.
Transformer Capacity	The Transformer Full Load continuous rating.
Transformer Impedance	The Transformer Nameplate Impedance at the nominal tap position.
[102] Transformer Nominal Primary Voltage	The Transformer Nameplate Primary Line Voltage at the nominal tap position.
Transformer Nominal Secondary Voltage	The Transformer Nameplate Secondary Line Voltage at the nominal tap position.
VT Phases	The VT phase connection.
VT Ratio	The VT Primary/Secondary ratio.
CT Phase	The CT phase connection.
CT Ratio	The CT Primary/Secondary ratio.
CT Direction	The CT polarity.

Tap-changer

Number of Taps	The number of Tap Positions. The Relay will not attempt to move beyond the maximum or minimum tap positions.
Input Type	The type of Tap Position Indicator (TPI) unit.
Additional resistor equiv. to	The size of the additional resistor in terms of tap steps.
Tap Customisation	When enabled a sub-menu allows Tap Positions to be re-named to match the tap change mounted indicator.
[101] Lowest Tap	Direction of Tapping. Where the lowest tap position corresponds to the lowest secondary voltage, a Raise operation will increase the voltage and a Lower operation will decrease the voltage. Where the lowest tap position corresponds to the highest secondary voltage, a Raise operation will decrease the voltage and a Lower operation will increase the voltage.

Tap Changer Runaway Detection	Enables Tap Changer Runaway Detection and Lockout.
Tap Pulse Length	Duration of Tap Change - Raise or Lower - signals.
Tap Changer Scheme	Step by Step control prevents repetitive operations in the event of a persistent Raise or Lower signal being applied to the Tap Changer. If this control is provided by the Tap Changer itself, the Relay should operate in Basic mode. If this control is to be provided by the Relay, it should operate in Step by Step mode.

Network Configuration

Transformer Group	Transformers which will operate in parallel should be configured to the same Transformer Group. Only those Transformers belonging to the same Group will share load information for LDC and Circulating Current compensation. If the Busbar arrangement changes in service, the Group selection must be re-arranged. This is can be done automatically by the Settings Group control.
System Group Capacity	The maximum capacity of a Transformer Group. This should allow for the outage of the largest Transformer. For example, if a group comprises three Transformers rated at 15, 15 and 20 MVA, the System Group Capacity setting should be 15 + 15 = 30 MVA.
Power System Rotation	Sequence of phase rotation. This can be checked using the Vpps and Vnps instruments. If correct, Vnps will be very low.
System Power Factor	Actual Load Power Factor. In TAPP mode this is used for control of circulating current. In Circulating Current mode it is used for various Relay calculations. If not known, the Power Factor can be taken from the Relay instruments when no circulating current is flowing between transformers.
Voltage Control Method	TAPP (the preferred option) or simple Circulating Current.
Frequency Voltage Reduction	Enables voltage reduction for drop in system frequency.
Frequency Voltage Reduction Level	The frequency at or below which the frequency voltage reduction applies.

Voltage Control

Target Voltage	Basic target voltage level.
Voltage Band	Voltage Control dead-band.
Load Drop Compensation	Allows the relay to increase the target voltage level in proportion to increasing load.
Initial Delay	The initial time delay before a Tap Change operation takes place. Normally this delay will be quite long, in the order of 60 seconds or more, so that unnecessary tap changes are not initiated for short-term fluctuations in voltage.
Inter-tap Delay	The time interval for successive Tap Change operations following an initial Tap Change. Normally this delay will be matched to the operating time of the Tap Changer, with an additional safety factor of 5 seconds to allow the Relay runaway logic to confirm correct operation of each tap change. A setting of CONTINUOUS will cause a continuous Raise/Lower command to be sent once the Initial Tap Delay has elapsed. This will be maintained until the voltage returns to normal.
High Voltage Characteristic	Definite time delay or a delay that is inversely proportional to the voltage deviation.
Fast Tap Down	Allows the relay to respond immediately to abnormally high voltages.
Tap Stagger Circulating Current	If required the relay can be set to export (+) or import (-) reactive current when the “Tap Stagger” status input is set high. The magnitude of the current is expressed as a percentage of the transformer rating.
Alarm Time	The time delay before certain alarm outputs are set (see Plant Output definitions).
Auxiliary Target 1	Temporary change to target voltage. This adjustment applies as long as the “Select Auxiliary Target 1” input is active.

Auxiliary Target 2	Temporary change to target voltage. This adjustment applies as long as the “Select Auxiliary Target 2” input is active.
Auxiliary Target 3	Temporary change to target voltage. This adjustment applies as long as the “Select Auxiliary Target 3” input is active.

[102] Advanced Features

VT / CT Location	On which side of Transformer VTs and CT are mounted.
Power Transformer Type	Transformer is 3-Phase or Single Phase.
Controlled Voltage Point	Which side of Transformer is to have its Voltage controlled.
Tap Spacing	Voltage change for each tap step – allows voltage to be calculated on “other” side of Transformer.
Nominal Tap Position	Tap Position at which nominal Power Transformer Ratio is in effect - allows voltage to be calculated on “other” side of Transformer.
Transformer Voltage Drop Compensation	Allow for Voltage drop across Transformer windings.
Lowest Tap	Direction of Tapping. Ratio specified as HV:LV.
Tap-Changer Location	On which side of Transformer the Tap-Changer is mounted.
Voltage Target Adjustment Step Size	Defines step % change in Target Voltage for each Voltage Target Adjustment operation.
Voltage Target Acknowledge Length	Length of Acknowledge pulse for completion of step change to Target Voltage.
Reactive Stability Factor	Allows Circulating Current compensation to be scaled down.

Voltage Monitoring

Overvoltage Alarm Level	Alarm Level for voltages outside top of Deadband.
Undervoltage Alarm Level	Alarm Level for voltages outside bottom of Deadband.
Overload Blocking Level	Prevents Tap Changer operating during Overload condition.

Functional Outputs (mapable to hardware Plant Outputs)

Relay Healthy	MicroTAPP is healthy. If an alarm is to be sent, a normally-closed contact should be used.	Instantaneous Alarm
Tap Raise	Raise Command to Tap Changer.	
Tap Lower	Lower Command to Tap Changer.	
Tap-changer Runaway	Uncontrolled Tap Changer operation has occurred. This output should be used to ‘trip’ the Tap Changer motor supply.	Instantaneous Alarm
Operation Permitted	When used, this output should close when a tap change is initiated by MicroTAPP and open at the end of the tap change cycle. If the tap changer operates incorrectly, for example a Runaway occurs, the contact will open.	
Voltage Control Alarm	Voltage has been out of Deadband for prolonged time.	Alarm after 15 minutes
U/V O/V Alarm	Voltage is outside Undervoltage or Overvoltage Alarm levels	Alarm after Alarm Time setting
Overload Alarm	Load is too high.	Instantaneous Alarm
Control in Auto	Automatic Voltage Control is in operation.	
Control in Local	Relay is in Local mode.	
Ready for Switch-Out	Relay is ready to be switched out of service. If the Transformer is not switched out in the next 5 minutes, the Relay(s) will revert to normal operation.	
Tap Incomplete	Last Tap Change operation was not completed.	Alarm after 5 minutes
Tap Count Alarm	Number of Tap Change operations has exceeded pre-set figure.	Instantaneous Alarm
Sum of I^2 Alarm	Accumulated value of I^2 has exceeded pre-set figure.	Instantaneous Alarm

Block Raise Command	The relay is blocking Raise operations. Can be used to block Raise commands initiated externally to Relay.	
Block Lower Command	The relay is blocking Lower operations. Can be used to block Lower commands initiated externally to Relay.	
VT Fuse Blown	A VT / VT Fuse failure has been detected.	Alarm after Alarm Time setting
Remote VT fuse blown	Indicates that a VT / VT Fuse failure has been reported by one of the other MicroTAPP's connected on the MPPC.	Instantaneous Alarm
Tap-change Reset	Lockout has been reset at relay.	
[102] Dead Reckoning Block	Dead Reckoned and Measured Tap Positions are out of alignment. Tapping is blocked.	
MPPC Failure	Failure Detected in Peer-to-Peer Communications.	Instantaneous Alarm
End of Tap Range	Indicates the Tap Position is at one of the extremes of its range.	Instantaneous Alarm
Tap not achievable	Indicates the Voltage is currently outside the Dead-band but the Relay can no longer compensate because it is already at the end of its Tap Range.	Instantaneous Alarm
[102] Voltage Target Acknowledge	Step change to Target Voltage completed.	
Group 1 Selected	Indicates Settings Group 1 is currently Active.	
Group 2 Selected	Indicates Settings Group 2 is currently Active.	
Group 3 Selected	Indicates Settings Group 3 is currently Active.	
Group 4 Selected	Indicates Settings Group 4 is currently Active.	
Group 5 Selected	Indicates Settings Group 5 is currently Active.	
Group 6 Selected	Indicates Settings Group 6 is currently Active.	
Group 7 Selected	Indicates Settings Group 7 is currently Active.	
Group 8 Selected	Indicates Settings Group 8 is currently Active.	

Any functional output can be allocated to any output relay. If more than one output is mapped to the same output relay, the status of the individual outputs are OR-ed together to obtain the overall status of the output relay.

With no outputs active, the number of output relays available for allocation is shown in the instruments as;

_ _ _ _ _

indicating that 5 output relays are available; RL1, 2, 3, 4 and 5.

If any output relays are active, these will be indicated in the instruments by a '1'. For example, if output relays 2 and 4 are active, the display will show;

RL2, 4 _ 1 _ 1 _

Functional Inputs (mapable to hardware Status Inputs)

Inverted Inputs	Specify which inputs are to be inverted.
MicroTAPP Enable	Input must be active for Relay to control voltage. Can be used to disable Relay if Tap Changer is to be controlled by alternative control systems - normally via a Local/Remote selector switch located at the Tap Changer mechanism.
Raise from Tap Changer	Raise Command from alternative control system - normally the Tap-Changer.
Lower from Tap Changer	Lower Command from alternative control system - normally the Tap-Changer.
Tap In Progress	TIP signal from Tap-Changer.
Tap Raise Block	Temporarily inhibit Tap Raise operations.
Tap Lower Block	Temporarily inhibit Tap Lower operations.
Prepare for Switch Out	Initiate Switch-out sequence. If the Transformer is not switched out within 5 minutes, the Relay(s) will revert to normal operation.
Tap Stagger	Biases the voltage control setting to allow the required reactive load to be imported or exported.

Remote Raise	Initiate manual Tap Raise operation - Relay must be in Manual and Remote modes.
Remote Lower	Initiate manual Tap Lower operation - Relay must be in Manual and Remote modes.
Remote Auto	Switch to Auto operation – Relay must be in Remote mode.
Remote Manual	Switch to Manual operation – Relay must be in Remote mode.
Select Auxiliary Target 1	Change Target Voltage. Available when the Relay is both in Local and Remote modes. Only one Auxiliary Target can be active at a time. If more than one input is raised, the highest numbered input (1, 2 or 3) takes priority.
Select Auxiliary Target 2	Change Target Voltage. Available when the Relay is both in Local and Remote modes. Only one Auxiliary Target can be active at a time. If more than one input is raised, the highest numbered input (1, 2 or 3) takes priority.
Select Auxiliary Target 3	Change Target Voltage. Available when the Relay is both in Local and Remote modes. Only one Auxiliary Target can be active at a time. If more than one input is raised, the highest numbered input (1, 2 or 3) takes priority.
Local / Remote	Select Local (input low) or Remote (input high) mode. This will only have an effect if setting "Local / Remote Control" is set to "Status Input".
[102] Voltage Target Increase	Step increase Target Voltage. To maximum of +20%.
[102] Voltage Target Decrease	Step decrease Target Voltage. To maximum of -20%.
[102] Voltage Target Reset	Reset Target Voltage level.
Select Group 1	Temporarily switch Active Settings Group to Group 1.
Select Group 2	Temporarily switch Active Settings Group to Group 2.
Select Group 3	Temporarily switch Active Settings Group to Group 3.
Select Group 4	Temporarily switch Active Settings Group to Group 4.
Select Group 5	Temporarily switch Active Settings Group to Group 5.
Select Group 6	Temporarily switch Active Settings Group to Group 6.
Select Group 7	Temporarily switch Active Settings Group to Group 7.
Select Group 8	Temporarily switch Active Settings Group to Group 8.

As for outputs, any functional input can be allocated to any status input.

Communication Interface

Station Address	Sets Relay address for communications.
IEC870 on Port	Selects the port to be used.
COM 1 Baud Rate	Selects transmission speed.
COM 1 Parity	Determines whether or not a parity check is transmitted with communication data.
COM 1 Line Idle	Sets the communication line idle sense.
COM 1 Data Echo	Enables connection of relays in a Ring.
COM 2 Baud Rate	Selects transmission speed.
COM 2 Parity	Determines whether or not a parity check is transmitted with communication data.
COM 2 Line Idle	Sets the communication line idle sense.
COM 2 Data Echo	Enables connection of relays in a Ring.
COM 2 Direction	Configures COM 2 to use Relay Front or Rear port, or to Auto-Detect which is active.
IEC60870 Class 2 Refresh Rate	Interval between creation of new IEC60870 class 2 measurand data frames.
IEC60870 Class 2 Window	Percentage of nominal figures which must be exceeded for new IEC60870 class 2 measurand data frame to be created.

Data Storage

Clear All Events	Clears all Event records
Clear All Faults	Clears all Fault records

Tap-Changer Maintenance

Delta Count Alarm	Number of Tap-Changer operations before an Alarm is given.
Sum I^2 Alarm	Accumulated I^2 level which must be exceeded before Alarm is given.

Clear Delta Tap-change count	Resets the maintenance count.
Clear Delta Sum of I^2 count	Resets the maintenance total.

9.2 Instruments

A comprehensive set of readings are available from the relay. These are accessed as shown in Figure 19 and display: -

System Values	Line Voltage, Load and Power Factor.
Voltages	Analogue Voltage levels – the values shown depend upon the connection method.
Loads	Transformer and Group Load.
Secondary Values	Analogue Voltage and Current levels – the values shown depend upon the connection method. Phase relationships shown relative to the Measured Voltage.
Frequency	Frequency of the Measured Voltage.
Phase Sequence	NPS and PPS values for secondary Voltage.
Tap-Changer Status	
Digital I/O Status	
Data Storage	Number of Events.
Tap Counter	Tap-Changer Maintenance values.
MPPC	Peer-to-Peer Communications status

9.3 Fault Data

The fault data mode is accessed as shown in Figure 19. When a fault occurs the MicroTAPP displays this screen automatically and when appropriate inhibits tap change operation.

This screen allows the 10 most recent tap-changer faults to be viewed. For each fault the date and time with a short description of the events leading to the fault is provided.

10 Relay Hardware

MicroTAPP relays are housed in either the Epsilon E8 or E12 case, depending on input/output configurations. The fascia PCB forms the human machine interface (HMI), with pushbuttons for entering settings, an LCD for displaying alphanumeric messages and LEDs for indication.

Peripheral devices such as output relays, status inputs and the communications interface are accommodated on the remaining PCBs.

Two options of Inputs and Outputs are available: -

	Inputs	**Outputs**
E8 case (MT101)	11	5
E12 case (MT102 or MT101 with extra I/O)	19	13

Appendix B at the end of this section shows a rear view of the relay with the connections shown for both the arrangements.

10.1 Internal Construction

The design for the internal arrangement of each case has been chosen to provide a high level of EMI screening, using multi-layer PCBs with ground planes, RFI suppression components and earthed metal screens.

The case is divided internally into noisy and quiet areas in order to improve noise immunity and reduce RFI emissions. The only direct connection from the quiet components to the external environment is via the optical serial communications interface, which is immune to radiated or conducted interference.

10.2 Front Cover

After the relay has been commissioned it is sealed by fixing a clear plastic cover over the front. This allows the user to see the entire front of the relay and enables normal operations of the control of the tap changer while preventing changes to operational settings. If required a security seal can be applied to the cover fixings.

10.3 Terminal Blocks

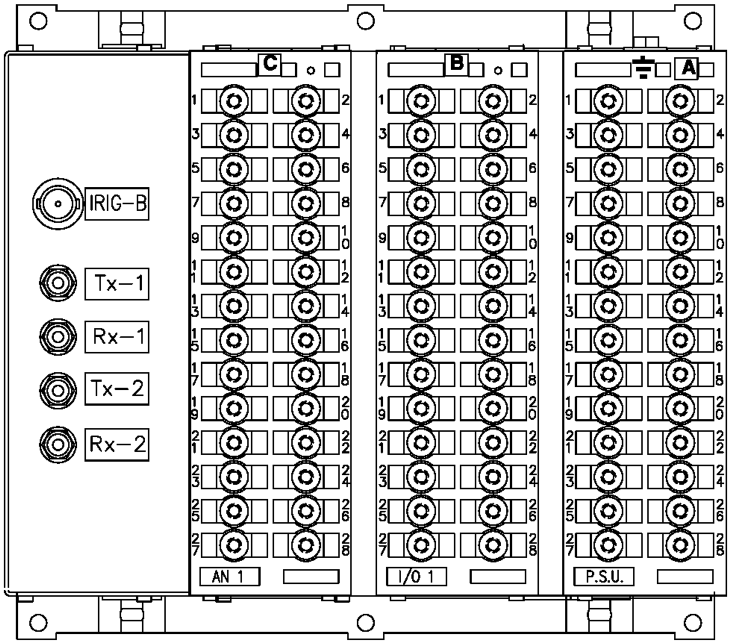
These are of the standard Epsilon design. All inputs and outputs (except for the serial communications interface) are made through these connectors. The terminal arrangement is shown in the appendix B at the end of this section

Appendix A

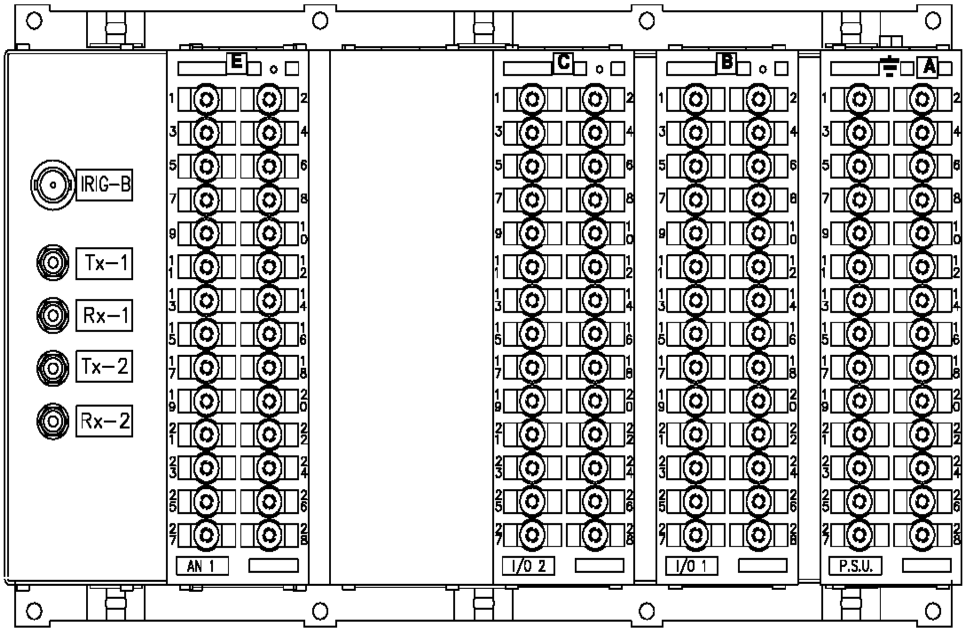

SIEMENS
RELAY HEALTHY
HIGH
NORMAL
LOW
MICROTAPP
CONTROL DISABLED
0·0 kV
No Voltage.
Transformer
switched out.
TAP
00
TAP CONTROL
MENU
TEST LEDS
TAP IN PROGRESS
7SG1510-1EJ30-0GA0
Microtapp
Article No. MT1-101-EJ
Configuration 2792H80001
Vn 63.5/110/220V
fn 50/60Hz
In 0.5/1/2/5A
Vx 48/110V
Status Input 110V
Wiring Diagram 2792W11002
Ser. No. 102411901/002

Appendix B

MicroTAPP Rear View (E8 case)

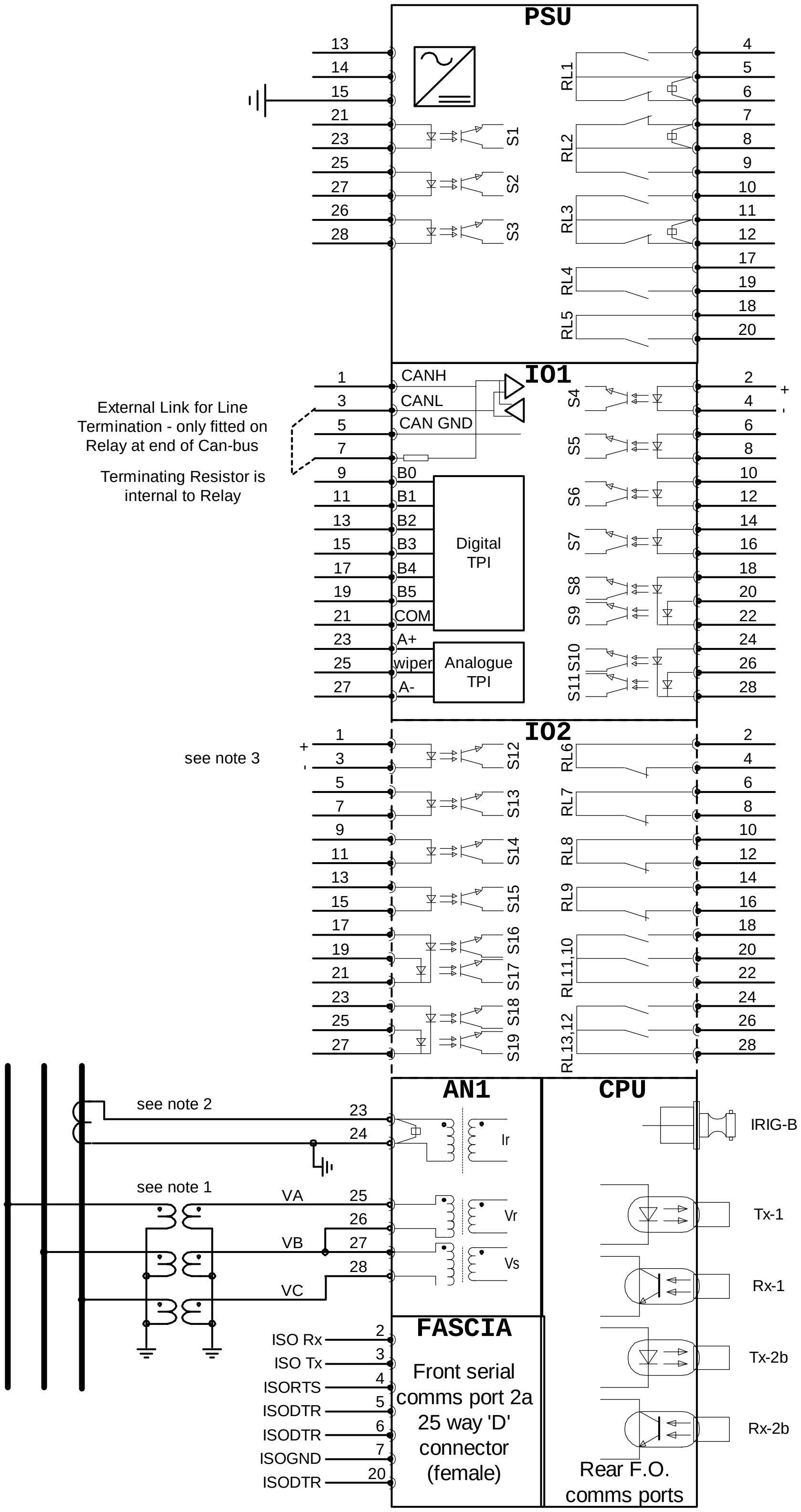


MicroTAPP Rear View (E12 case)



Note that the identification letter at the top of the card, A, B, C, D, E, refers to its position within a particular case. It does not refer to the card's functionality. This is instead specified by the functionality identifier at the bottom of the card, AN1, I/O2, I/O1, PSU.

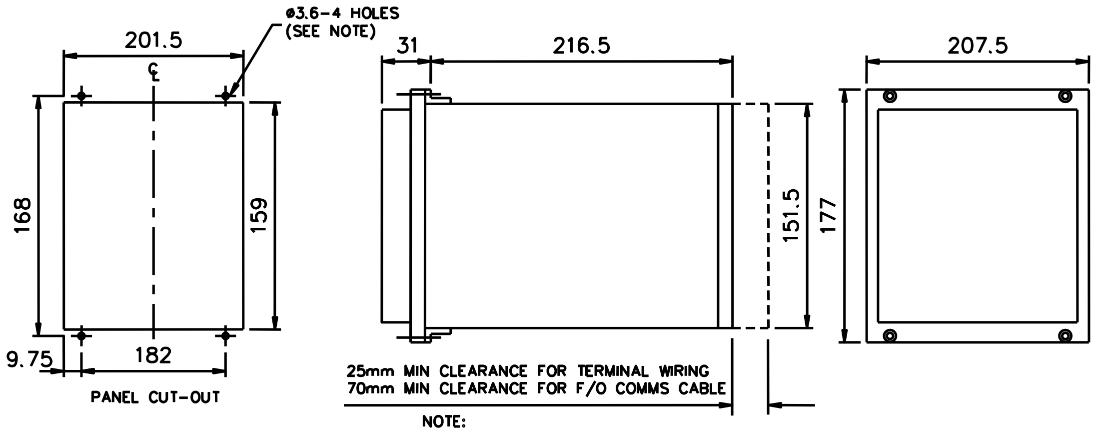
Appendix C



Notes

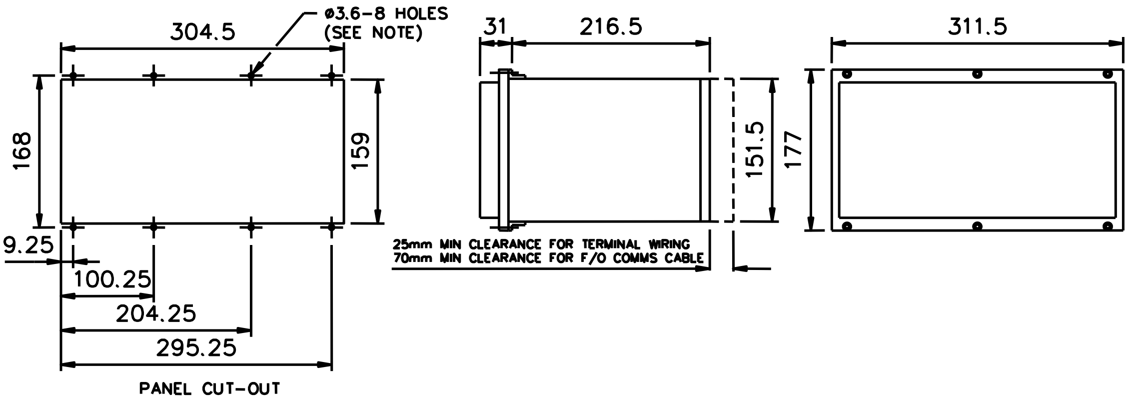
1. Analogue connections show use with a star-connected VT, other arangements can be used.
2. CT connection is shown on blue phase, any connection can used.
3. IO2 is provided on E12 case sizes only.
   IO2 arrangement is for MT-XXX-XJ ordering option.
   For MT-XXX-XK ordering option, all Output Contacts on IO2 are Normally-Open.

Appendix D



NOTE:
THE ø3.6 HOLES ARE FOR M4 THREAD FORMING (TRILOBULAR) SCREWS. THESE ARE SUPPLIED AS STANDARD AND ARE SUITABLE FOR USE IN FERROUS/ALUMINIUM PANELS 1.6mm THICK AND ABOVE. FOR OTHER PANELS, HOLES TO BE M4 CLEARANCE (TYPICALLY ø4.5) AND RELAYS MOUNTED USING M4 MACHINE SCREWS, NUTS AND LOCKWASHERS (SUPPLIED IN PANEL FIXING KIT).

Overall Dimensions and panel drilling
for Epsilon E8 case



Overall Dimensions and panel drillin
for Epsilon E12 case

7SG15 MicroTAPP

Automatic Voltage Control

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:
Pre release

2010/02	Document reformat due to rebrand

Software Revision History

Contents

1. General

These are preliminary performance specification.

2. Characteristics

2.1 Energising Quantities

Single-phase current (any phase) and 3-phase voltages will be measured at 50 or 60Hz.

	Measured Quantity	Nominal Values	Measured Range
V_n	AC Voltage	110V RMS	227% x V_n
I_n	AC Current	1A or 5A RMS	285% x I_n

From these quantities the following will be calculated with the specified accuracies.

Calculated Value	Accuracy
RMS Voltage	±0.25% @ 80% x Vn
RMS Current	±5% @ 20% x In
System Frequency	±0.125Hz between 47Hz and 63Hz
System Power Factor	±0.5°

2.2 Measuring Circuit Burden

1A current input	1VA	<0.5Ω
5A current input	1VA	<0.5Ω
110V voltage input	0.1VA	>1MΩ

2.3 Basic Voltage Control

V_t	**Target level**	85% to 115% step 0.1%
B_w	**Bandwidth**	0 to ±5% step 0.1%
t_i	**Initial Delay**	DTL: 2s to 180s step 1s IDMTL: time setting, target voltage and deadband to be defined

The relay will use phase A-B r.m.s. voltage for its basic bandwidth calculations.

2.4 Load Drop Compensation

The value is entered as a percent increase in busbar voltage required at the firm capacity of the substation (taking into account all transformers).

Bs	**Bias Level (at firm capacity)**	0 to 20% step 0.1%

Nt	**No. of transformers**	1 to 16 step 1
pf	**Initial Assumed System Power Factor**	0.85 to 1.0 step 0.01 leading and lagging

2.5 Coupling

The coupling level is entered as the nameplate impedance of the transformer. If the coupling is set other than zero then the transformers' taps will not drift apart. Over time the transformers will tend to drift together. At the correct setting the transformers will minimise circulating current quickly but will not result in hunting.

Coupling	5 to 50% step 0.1%

2.6 Frequency Load Control

The MicroTAPP will act to prevent frequency reduction by voltage reduction if appropriate by predicting the likely effect. The settings and accuracies are not yet defined.

2.7 Monitoring and Guard Levels

The MicroTAPP will prevent tap-changer runaway and out-of-limit tapping as follows:-

Overcurrent Level	100% to 200% step 1%
Overvoltage Level	95% to 120% step 1%
Undervoltage Level	80% to 105% step 1%
N.P.S. Level	10%

3. Auxiliary energising quantities

3.1 Auxiliary Power Supply

Four versions of power supply will be available.

Nominal	**Operating Range**
30 V DC	24 to 37.5 V DC
48, 110, V DC	37.5 to 137.5 V DC
220 V DC	175 to 290 V DC
110 V AC	82.5 to 137.5 V AC RMS[1]

3.2 Auxiliary Supply Burden

Quiescent	17W
Maximum	20W

4. Status Inputs

Nominal	Operating Range
30/34 V AC or DC	18 to 37.5 V
48/54 V AC or DC	37.5 to 60 V
110/125 V AC or DC	87.5 to 137.5 V
220/250 V AC or DC	175 to 280 V

4.1 Electricity Association ESI48-4

The 30/34V and 48/54V inputs meet the requirements of ESI48-4 ESI 1. However, the 110/125V and 220/250V inputs will operate with a DC current of less than 10mA. If 110/125V or 220/250V inputs compliant with ESI48-4 ESI 1 are required, a MicroTAPP with 48/54 V status can be supplied with external dropper resistors as follows:

Nominal Voltage	Resistor Value	Wattage
110, 125 V	2k7 ± 5%	2.5 W
220, 250 V	8k2 ± 5%	6.0 W

4.2 Status Input Performance

Minimum DC current to operate status input	10mA
Reset/Operate voltage ratio	≥90%
Recommended minimum pulse duration	500ms

5. Output Contacts

5.1 Carry continuously 5A a.c. or d.c.

5.2 Make and carry (limit L/R ≤ 40ms and V ≤ 300V)

For 0.5s	20A a.c. or d.c.
For 0.2s	30A a.c. or d.c.

5.3 Break (limit ≤ 5A and V ≤ 300V)

a.c. resistive	1250VA
a.c. resistive (p.f. ≤ 0.4)	250VA
d.c. resistive	75W
d.c. resistive L/R ≤ 40ms **L/R ≤ 10ms**	30W 50W

Minimum no. of operations (1250VA resistive a.c. load)	250,000
Minimum recommended load	0.5W, limits 10mA or 5V

6. Thermal withstand

6.1 CT Inputs

3.0 x I_n	continuous
3.5 x I_n	10 min
100A	1 sec
2500A	1 cycle

6.2 VT Inputs

250Vrms	continuous

7. Accuracy

7.1 Accuracy Reference Conditions

Settings	All settings
Auxiliary Supply	Nominal
Frequency	50/60Hz
Ambient temperature	20°C

7.2 Accuracy

Bandwidth accuracy	±1% of absolute level
Load measurement	±5% of total substation load (assuming balance load)
Circulating current measurement	±5% of non-load current
Repeatability	±1%
Delays	±1% or 0.5 sec

7.3 Accuracy Influencing Quantities

7.3.1 Temperature

Ambient range	-10°C to +55°C
Variation over range	≤ 5%

7.3.2 Frequency

Range	47Hz to 62Hz
Setting variation	≤ 5%

Operating time variation	≤ 5%

7.3.3 Harmonic Content

Harmonic Content	Frequencies to 350Hz
Setting Variation	≤ 5%
Operating time variation	≤ 5%

7.3.4 Auxiliary Supply (DC)

Allowable superimposed A.C. component	≤ 12% of D.C. level
Allowable breaks/dips in supply (collapse to zero from nominal voltage)	≤ 20ms

8. Environmental withstand

8.1 Temperature - IEC 60068-2-1/2

Operating range	-10°C to +55°C
Storage range	-25°C to +70°C

8.2 Humidity - IEC 60068-2-3

Operational test	56 days at 40°C and 95% r.h.

8.3 Transient Overvoltage - IEC 60255-5

Between all terminals and earth or any 2 terminals without damage or flashover	5kV 1.2/50µs 0.5J

8.4 Insulation – IEC 60255-5

Between any circuit and earth	2.0kV for 1min
Between independent circuits	2.0kV for 1min
Across normally-open contacts	1.0kV for 1min

8.5 High Frequency Disturbance - IEC 60255-22-1 Class III

2.5kV longitudinal mode	variation ≤ 3%
1kV transverse mode	variation ≤ 3%

8.6 Electrostatic Discharge - IEC 60255-22-2 Class III

8kV point discharge	variation ≤ 5%

8.7 Radio Frequency Interference - IEC 60255-2-3 Class III

20MHz to 1000MHz, 10V/m	variation ≤ 5%

8.8 Fast Transient - IEC 60255-22-4 Class IV

4kV 5/50ns, 2.5kHz repetitive	variation ≤ 3%

8.9 Vibration (Sinusoidal) - IEC 60255-21-1 Class I

Vibration response, 0.5gn	variation ≤ 5%
Vibration endurance, 1.0gn	variation ≤ 5%

8.10 Seismic - IEC 60255-21-3 Class I

Seismic response, 1gn	variation ≤ 5%

8.11 Shock and Bump - IEC 60255-21-2 Class I

Shock response, 5gn, 11ms	variation ≤ 5%
Shock withstand, 15gn, 11ms	variation ≤ 5%
Bump test, 10gn, 16ms	variation ≤ 5%

8.12 Mechanical Classification

Durability	≥ 10^6 operations

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

[101] MicroTAPP 101 only
[102] MicroTAPP 102 only
'C' indicates setting value is common across all Settings Groups.

1 System Config Menu

SETTING		RANGE	DEFAULT
Active Group	C	1 to 8	1
View / Edit Group	C	1 to 8	1
Status Select Grp. Mode	C	Edge Triggered or Level Triggered	Edge Triggered
Relay Identifier	C	Up to 16 alphanumeric characters	MICROTAPP
Set Date	C	DD/MM/YYYY	01/01/1980
Set Time	C	HH:MM:SS	00:00:00
Voltage Display Time	C	15 minutes or 1 hour	1 hour
MPPC Failure Detection	C	Enabled or Disabled	Disabled
Change Password	C	4 alphanumeric characters	NONE
Local / Remote Control	C	Keypad or Status Input	Keypad

2 Transformer Menu

SETTING		RANGE	DEFAULT
Transformer Number	C	1 to 16	1
Transformer Capacity (MVA)	C	1 to 10 @ steps of 0.1, 10.5 to 200 @ steps of 0.5, 201 to 2000 @ steps of 1	30.0 MVA
Transformer Impedance (%)	C	5 to 50 @ steps of 0.1	20.0 %
[102] Trfmr. Nominal Primary (kV)	C	0.4 to 40 @ steps 0.1, 41 to 200 @ steps of 1, 205 to 800 @ steps of 5	33.0 kV
Trfmr. Nominal Sec'y (kV)	C	0.4 to 40 @ steps 0.1, 41 to 200 @ steps of 1, 205 to 800 @ steps of 5	11.0 kV
VT Phases	C	3-Phase, AB, BC, CA, AE, BE, CE	3-Phase
VT Ratio (kV : V)	C	0.4 to 40 @ steps 0.1, 41 to 200 @ steps of 1, 205 to 800 @ steps of 5	11.0 kV : 110 V
		63.5, 100, 110, 120, 200, 210, 220, 230, 240, 250	
CT Phase	C	A, B or C	A
CT Ratio (A)	C	25 to 100 @ steps of 1 105 to 10,000 @ steps of 5	1500 : 1 A
		0.5, 1, 2, 5	
CT Direction	C	Forward or Reverse	Forward

3 TAP-Changer Menu

SETTING		RANGE	DEFAULT
Number of Taps	C	1 to 39	19
Input Type	C	Resistor Chain, Binary, BCD or Gray Code	Resistor Chain
Additional resistor equiv. to	C	0.5 to 2 @ step 0.01, 2.1 to 20 @ step 0.1	1.00 taps
Tap Customisation	C	Enabled or Disabled	Disabled
[101] Lowest Tap	C	Lowest Voltage or Highest Voltage	Lowest Voltage
T/C Runaway Detection		Enabled or Disabled	Enabled
Tap Pulse Length (milliseconds)	C	0 to 1000 @ step of 1, 1010 to 10,000 @ step of 10, 10,100 to 60,000 @ step of 100	1500 ms
Tap-changer Scheme	C	Basic or Step-by-Step	Basic

3.1 Tap Customisation Sub-Menu

SETTING		RANGE	DEFAULT
Physical Tap 0		-99 to 99 plus ‘ ‘ or ‘T’	0
Physical Tap 1		-99 to 99 plus ‘ ‘ or ‘T’	1
…		-99 to 99 plus ‘ ‘ or ‘T’	…
Physical Tap 39		-99 to 99 plus ‘ ‘ or ‘T’	39

NOTE: the available settings in this sub-menu will be dependant upon the “Number of Taps” setting in the Tap-changer Menu.

4 Network Config Menu

SETTING		RANGE	DEFAULT
Transformer Group		A to H	A
System Group Capacity (MVA)		1 to 10 @ steps of 0.1, 10.5 to 200 @ steps of 0.5, 201 to 2000 @ steps of 1	30.0 MVA
Power System Rotation		A-B-C or A-C-B	A-B-C
System Power Factor		0 to 0.95 @ steps of 0.01, 0.955 to 1.0 @ steps of 0.005	0.970 lagging
		Lagging or leading	
Voltage Control Method		TAPP or Circ. Current	TAPP
Frequency Voltage Reduction		Enabled or Disabled	Enabled
Freq. Voltage Redn. Level (Hz)		47 to 62 @ steps of 0.1	48.0 Hz

5 Voltage Control Menu

SETTING		RANGE	DEFAULT
Target Voltage (% of nominal voltage)		85 to 115 @ steps of 0.1	100.0 %
Voltage Band (% of nominal voltage)		0.5 to 10.0 @ steps of 0.1	+/- 1.5 %
Load Drop Comp. (% of nominal voltage)		0 to 20 @ step of 0.1	2.5 %
Initial Delay (seconds)		2 to 180 @ steps of 1	120 s
Inter-tap Delay (seconds)		Continuous, 1 to 120 @ steps of 1	10 s
High Volts Char.		DTL or IDMTL	DTL
Fast Tap Down		Enabled or Disabled	Enabled
Tap Stagger Circ. Current (% of System Group Capacity)		-10.0 to +10.0 @ steps of 0.1	0.0 %
Alarm Time (seconds)		0 to 900 @ steps of 10	900 s
Auxiliary Target 1 (% of nominal voltage)		85 to 115 @ step of 0.1	97 %
Auxiliary Target 2 (% of nominal voltage)		85 to 115 @ step of 0.1	94 %
Auxiliary Target 3 (% of nominal voltage)		85 to 115 @ step of 0.1	103 %

6 [102] Advanced Control Menu

SETTING		RANGE	DEFAULT
VT / CT Location		LV or HV	LV
Power Trfmr. Type		3-Phase, Single-Phase	3-Phase
Controlled Volt. Pt.		LV or HV	LV
Tap Spacing (% of nominal voltage)	C	0.1 to 5.0 @ steps of 0.01	1.25 %
Nominal Tap Position	C	-39 to +39 @ steps of 1	5
Tr. Volt. Drop Comp.		Enabled or Disabled	Enabled
Lowest Tap		Highest Ratio or Lowest Ratio	Highest Ratio
Tap-Changer Location		LV or HV	HV
V. Target Adjust. Step Size (% of nominal voltage)		0.50 to 2.50 @ steps of 0.05	1.25 %
Volt. Target Ackn. Length (milliseconds)		0 to 1000 @ step of 1, 1010 to 10,000 @ step of 10, 10,100 to 60,000 @ step of 100	1000 ms
Reactive Stability Factor (% of circulating current compensating voltage)		Disabled, 10 to 95 @ steps of 5	Disabled

7 Voltage Control Menu

SETTING		RANGE	DEFAULT
Overvoltage Alarm Level (% of nominal voltage)		85 to 135 @ steps of 1	105 %
Undervoltage Alarm Level (% of nominal voltage)		75 to 125 @ steps of 1	95 %
Overload Blocking Level (% of Transformer Capacity)		80 to 200 @ steps of 5	100 %

8 Output Config Menu

SETTING		RANGE	DEFAULT
Relay Healthy	C	RL 1 to RL 5 (to RL 13)	NONE
Tap Raise	C	RL 1 to RL 5 (to RL 13)	RL 5
Tap Lower	C	RL 1 to RL 5 (to RL 13)	RL 4
Tap-changer Runaway *	C	RL 1 to RL 5 (to RL 13)	RL 2
Operation Permitted	C	RL 1 to RL 5 (to RL 13)	NONE
Volt Control Alarm	C	RL 1 to RL 5 (to RL 13)	NONE
U/V O/V Alarm	C	RL 1 to RL 5 (to RL 13)	RL 3
Overload Alarm	C	RL 1 to RL 5 (to RL 13)	RL 3
Control in Auto	C	RL 1 to RL 5 (to RL 13)	NONE
Control in Local	C	RL 1 to RL 5 (to RL 13)	NONE
Ready for Switch-out	C	RL 1 to RL 5 (to RL 13)	RL 1
Tap Incomplete *	C	RL 1 to RL 5 (to RL 13)	RL 2
Tap Count Alarm	C	RL 1 to RL 5 (to RL 13)	NONE
Sum of I^2 Alarm	C	RL 1 to RL 5 (to RL 13)	NONE
Block Raise Command	C	RL 1 to RL 5 (to RL 13)	NONE
Block Lower Command	C	RL 1 to RL 5 (to RL 13)	NONE
VT Fuse Blown	C	RL 1 to RL 5 (to RL 13)	NONE
Remote VT fuse blown	C	RL 1 to RL 5 (to RL 13)	NONE
Tap-change Reset	C	RL 1 to RL 5 (to RL 13)	NONE
[102] Dead Reckoning Block	C	RL 1 to RL 5 (to RL 13)	NONE
MPPC Failure	C	RL 1 to RL 5 (to RL 13)	NONE
End of Tap Range	C	RL 1 to RL 5 (to RL 13)	NONE
Tap not achievable	C	RL 1 to RL 5 (to RL 13)	NONE
[102] Volt. Target Ackn.	C	RL 1 to RL 5 (to RL 13)	NONE
Group 1 Selected	C	RL 1 to RL 5 (to RL 13)	NONE
Group 2 Selected	C	RL 1 to RL 5 (to RL 13)	NONE
Group 3 Selected	C	RL 1 to RL 5 (to RL 13)	NONE
Group 4 Selected	C	RL 1 to RL 5 (to RL 13)	NONE
Group 5 Selected	C	RL 1 to RL 5 (to RL 13)	NONE
Group 6 Selected	C	RL 1 to RL 5 (to RL 13)	NONE
Group 7 Selected	C	RL 1 to RL 5 (to RL 13)	NONE
Group 8 Selected	C	RL 1 to RL 5 (to RL 13)	NONE

NOTE: the available settings in this Menu will be dependant upon the number of hardware output relays fitted.

* These operations also result in a Lockout.

9 Status Config Menu

SETTING		RANGE	DEFAULT
Inverted Inputs	C	S1 to S11 (to S19)	NONE
MicroTAPP Enable	C	S1 to S11 (to S19)	SI 1
Raise from T/C	C	S1 to S11 (to S19)	SI 2
Lower from T/C	C	S1 to S11 (to S19)	SI 3
Tap in Progress	C	S1 to S11 (to S19)	SI 7
Tap Raise Block	C	S1 to S11 (to S19)	NONE
Tap Lower Block	C	S1 to S11 (to S19)	NONE
Prepare Switch-out	C	S1 to S11 (to S19)	SI 6
Tap Stagger	C	S1 to S11 (to S19)	NONE
Remote Raise *	C	S1 to S11 (to S19)	SI 10
Remote Lower *	C	S1 to S11 (to S19)	SI 11
Remote Auto *	C	S1 to S11 (to S19)	SI 8
Remote Manual *	C	S1 to S11 (to S19)	SI 9
Select Aux Target 1	C	S1 to S11 (to S19)	SI 4
Select Aux Target 2	C	S1 to S11 (to S19)	SI 5
Select Aux Target 3	C	S1 to S11 (to S19)	NONE
Local / Remote	C	S1 to S11 (to S19)	NONE
[102] Volt. Target Incr. *	C	S1 to S11 (to S19)	NONE
[102] Volt. Target Decr. *	C	S1 to S11 (to S19)	NONE
[102] Volt. Target Reset *	C	S1 to S11 (to S19)	NONE
Select Group 1 **	C	S1 to S11 (to S19)	NONE
Select Group 2 **	C	S1 to S11 (to S19)	NONE
Select Group 3 **	C	S1 to S11 (to S19)	NONE
Select Group 4 **	C	S1 to S11 (to S19)	NONE
Select Group 5 **	C	S1 to S11 (to S19)	NONE
Select Group 6 **	C	S1 to S11 (to S19)	NONE
Select Group 7 **	C	S1 to S11 (to S19)	NONE
Select Group 8 **	C	S1 to S11 (to S19)	NONE

NOTE: the available settings in this Menu will be dependant upon the number of hardware status inputs fitted.

* These inputs are positive edge triggered. All other inputs are level dependant.
** These operations may be configured as edge or level triggered.

10 Communications Menu

SETTING		RANGE	DEFAULT
Station Address	C	0 to 254	0
IEC60870 on port	C	COM 1 or COM 2	COM 1
COM 1 Baud Rate	C	110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	19200
COM 1 Parity	C	NONE, ODD or EVEN	EVEN
COM 1 Line Idle	C	LIGHT OFF or LIGHT ON	LIGHT OFF
COM 1 Data Echo	C	OFF or ON	OFF
COM 2 Baud Rate	C	110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	19200
COM 2 Parity	C	NONE, ODD or EVEN	EVEN
COM 2 Line Idle	C	LIGHT OFF or LIGHT ON	LIGHT OFF
COM 2 Data Echo	C	OFF or ON	OFF
COM 2 Direction	C	AUTO-DETECT, FRONT PORT or REAR PORT	AUTO-DETECT
IEC60870 class 2 Refresh (seconds)	C	0 to 60 @ step of 1 70 to 600 @ step of 10	60 s
IEC60870 class 2 Window (% of nominal)	C	OFF, 1 to 20 @ step of 1	OFF

11 Data Storage Menu

SETTING		RANGE	DEFAULT
Clear all Events		NO or YES	NO
Clear all Faults		NO or YES	NO

12 TAP-Changer Maint. Menu

SETTING		RANGE	DEFAULT
Delta Count Alarm	C	OFF, 100 to 10,000 @ step of 10	500
Sum of I Squared Alarm (MA^2)	C	OFF, 10 to 1000 @ step of 10, 2000 to 99,000 @ step of 1000	9000 MA^2
Clear Delta Tap Change Count		NO or YES	NO
Clear Delta Sum of I^2 Count		NO or YES	NO

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Automatic Voltage Control

Document Release History

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Software Revision History

Contents

1 Introduction

The MicroTAPP relay has provision for communication either locally to a computer or remotely to an operations centre.

The Communication Interface, Figure 1, incorporates the following ports:

- A pair of fibre optic ST connectors for transmit and receive communications to a substation SCADA or integrated control system (Com 1).

- A pair of fibre optic ST connectors for access by protection engineers (Com 2). The same port can be accessed instead through an RS232 connector mounted on the relay fascia and provides facilities for access to the relay from a laptop computer or PC.

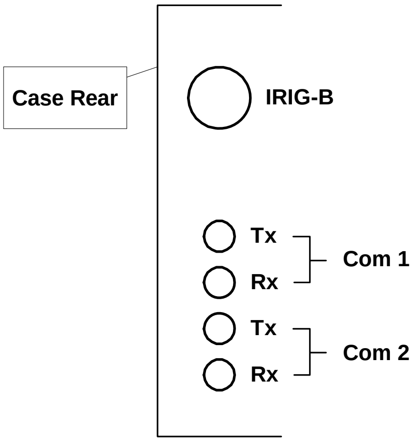

Figure 1

The IEC60870-5-103 standard protocol used by the relay for the transfer of data is fully described in the Reyrolle document 434TM05 “Informative Communication Interface”. An IRIG-B port is also provided for time synchronisation.

The Sigma range of products is available to connect to the fibre optic ports of the relays.

Sigma 1 is a fibre optic hub with one system port and up to 29 ports for connecting to the relays.

Sigma 3 is a fibre optic to dual RS232 interface. It has one fibre optic port for connection to the relay(s), and two electrical RS232 ports. The rear electrical port is intended for connection to a control system. The front port allows local access, for example, from a laptop PC. When a device is connected to the front port the rear is overridden, see Figure 2.

Sigma 4 is a portable fibre optic to RS232 conversion unit.

2 Connections

2.1 Physical Characteristics

The modular II relays are equipped with two fibre-optic, and one electrical serial communication ports. The fibre optic ports named Com1 and Com2 are located at the rear of the relay. Each consists of a pair of ST connectors, a transmitter (Tx) and a receiver (Rx). See Figure 1 left.

The RS232 electrical port is on the front of the relay. It uses a 25 pin D type socket. The relay is wired as a Data Communications Equipment (DCE) device, allowing standard serial cables to be used for connection to a computer. The electrical port is also named Com 2, allowing local access overriding the fibre-optic Com2.

2.2 Fibre Optic Cable

The modular II relay is optimised to use either a 50/125 µm or 62.5/125 µm glass fibre optic cable.

Fibre-optic transmission distances vary with transmitter, receiver and type of fibre. The tables at the end of this section show the achievable distances between Reyrolle devices.

2.3 Connection Methods

The fibre-optic ports of the relay are intended for connection to a master station or an adjacent relay either using a ‘star’ or ‘ring’ configuration. The “Transmit” output on the MicroTAPP must be connected to the “Receive” input of the next device, while the “Receive” input on the MicroTAPP must be connected to the “Transmit” output of the next device, see Figures 2, 3, 4 and 5 attached to the end of this section.

The fibre-optic ports may be used to build a ring network of relays, see Figures 2 & 3. If a ring is not considered to have sufficient security a Sigma 1 can be utilised to create a star network, see Figure 4.

Remote Dial-Up can be achieved with the use of telephone modems, see Figure 5. More information on connecting using telephone modems is given in the Reyrolle document 434/TIR/007.

Connection to the electrical port is via a standard modem cable.

3 Relay Settings

3.1 Transmission Method

Half duplex serial asynchronous transmission.

3.2 Communications Menu

The relay communications are set-up by accessing the ‘configuration/communications’ menu of the relay.
Relay settings should be matched to the settings on the master station. The settings for Com2 apply to both the fibre-optic and electrical ports.

3.2.1 Station Address

This is the relay's unique identifier for communications. The valid addresses are 1 to 254, allowing 254 devices on a network. Address 0 switches communications to the relay off.

3.2.2 IEC60870 on Port

Sets the port the IEC60870-5-103 protocol should operate on, either Com1 or Com2.

3.2.3 Com1 Baud Rate and Com2 Baud Rate

Sets the rate, the respective port will operate at in bits per second. Options are 75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600 and 115200.

3.2.4 Com1 Parity and Com2 Parity

Sets the parity used by the port. Options are None, Even and Odd.

3.2.5 Com1 Line Idle and Com2 Line Idle

Sets the line idle state used by the port, either **light off** or **light on**.

IEC60870-5-103 defines the line idle state as light on. However, some hardware may not be able to produce this so an option to switch to **light off** is provided.

The sigma units 1 & 3 contain switches to switch between Light off and Light on. On Sigma 4 this is achieved with a jumper connection, jumper OFF is **light off**. This setting has no effect on the electrical Com2 port.

3.2.6 Com1 Data Echo and Com2 Data Echo

When the relays are connected in a ring this setting should be **on**, enabling data to be echoed from one relay to the next. Otherwise it should be **off** to reduce the communications overhead.

3.2.7 Com2 Direction

This setting affects how the Com2 ports, fibre optic or electrical are used. Options are **Auto-Detect**, **Rear Port** and **Front Port**. Auto-Detect automatically switches to the front port when a device is plugged into it, reverting to the rear when the device is removed. The Rear Port and Front Port setting explicitly defines which port is active. If you try to communicate with a port when the other is active no communication will take place.

4 Fibre Optic Data

4.1 Launch Power (dBm)

The amount of light that can be focussed into the fibre.

CABLE TYPE	SOURCE								
	Argus (p)	**Argus**	**Modular I**	**Modular II**	**Sigma 1**	**Sigma 3 (p)**	**Sigma 3**	**Sigma 4 (p)**	**Sigma 4**
1 mm polymer	-10.5	-7	-10	-7	-7	14.8	-14.6	10.6	-14.6
200 µm PCS	-14.4	-6.2	-11.7	-6.2	-6.2	21.8	-13.4	21.7	-13.4
62.5 / 125 µm glass	-29	-16	-20	-16	-16		-22.7		-22.7
50 / 125 µm glass	-32.6	-19.8	-22.8	-19.8	-19.8		-26.2		-26.2

P = Polymer
G = Glass

4.2 Receiver Sensitivity (dBm)

The minimum amount of light required for operation.

	DESTINATION								
	Argus (p)	**Argus**	**Modular I**	**Modular II**	**Sigma 1**	**Sigma 3 (p)**	**Sigma 3**	**Sigma 4 (p)**	**Sigma 4**
Sensitivity (dBm)	-20	-24	-24	-24	-24	-20	-25.4	-25.4	-25.4

P = Polymer
G = Glass

4.3 Distance Calculation

Taking the launch power and receiver sensitivity from the above two tables, and allowing for a safety margin, losses due to joints in the cables and the loss per kilometre in the cables as specified by the cable manufacturer, the distance can be calculated as follows:

$$Distance(km) = \frac{LaunchPower - ReceiverSensitivity - SafetyMargin - JointLoss}{LossPerKiloMetre}$$

4.4 Distances

These figures are based on manufacturers' data and may be subject to change without notice. No account is taken of minimum distances. With certain fibres, it is possible to overload the receivers thus causing errors. All distances are in metres, and are maximum figures, allowing for LED degradation. All products are optimised for use with glass fibre cable, except where polymer (p) is stated.

1mm polymer

SOURCE	DESTINATION								
	Argus (p)	**Argus**	**Modular I**	**Modular II**	**Sigma 1**	**Sigma 3 (p)**	**Sigma 3 (ST)**	**Sigma 4 (p)**	**Sigma 4**
Argus (p)	40	70	0	70	70	40	80	80	80
Argus	4.5	6.5	0	6.5	6.5	4.5	6.0	7.0	6.0
Modular I	0	0	5.5	0	0	3.5	6.0	6.0	6.0
Modular II	4.5	6.5	0	6.5	6.5	4.5	6.0	7.0	6.0
Sigma 1	4.5	6.5	0	6.5	6.5	4.5	7.0	7.0	7.0
Sigma 3 (p)	10.0	35	35	35	35	10.0	45	45	45
Sigma 3 (ST)	2.5	4.5	4.5	4.5	4.5	2.5	5.0	5.0	5.0
Sigma 4 (p)	38	65	65	65	65	35	75	75	75
Sigma 4 (ST)	2.5	4.5	4.5	4.5	4.5	2.5	5.0	5.0	5.0

200µm PCS

SOURCE	DESTINATION								
	Argus (p)	**Argus**	**Modular I**	**Modular II**	**Sigma 1**	**Sigma 3 (p)**	**Sigma 3 (ST)**	**Sigma 4 (p)**	**Sigma 4**
Argus (p)	100	260	0	260	260	100	320	320	320
Argus	1540	2110	0	2110	2110	1540	2310	2310	2310
Modular I	0	0	1320	0	0	750	1520	1520	1520
Modular II	1540	2110	0	2110	2110	1540	2310	2310	2310
Sigma 1	1540	2110	0	2110	2110	1540	2310	2310	2310
Sigma 3 (p)	0	0	0	0	0	0	0	0	0
Sigma 3 (ST)	370	940	940	940	940	370	1140	1140	1140
Sigma 4 (p)	0	0	0	0	0	0	0	0	0
Sigma 4 (ST)	370	940	940	940	940	370	1140	1140	1140

62.5/125 µm glass

SOURCE	DESTINATION								
	Argus (p)	**Argus**	**Modular I**	**Modular II**	**Sigma 1**	**Sigma 3 (p)**	**Sigma 3 (ST)**	**Sigma 4 (p)**	**Sigma 4**
Argus (p)	0	0	0	0	0	0	0	0	0
Argus	350	1780	0	1780	1780	350	2280	2280	2280
Modular I	0	0	350	0	0	0	850	850	850
Modular II	350	1780	0	1780	1780	350	2280	2280	2280
Sigma 1	350	1780	0	1780	1780	350	2280	2280	2280
Sigma 3 (p)	0	0	0	0	0	0	0	0	0
Sigma 3 (ST)	20	20	20	20	20	20	20	20	20
Sigma 4 (p)	0	0	0	0	0	0	0	0	0
Sigma 4 (ST)	20	20	20	20	20	20	20	20	20

50/125 µm glass

SOURCE	DESTINATION								
	Argus (p)	**Argus**	**Modular I**	**Modular II**	**Sigma 1**	**Sigma 3 (p)**	**Sigma 3 (ST)**	**Sigma 4 (p)**	**Sigma 4**
Argus (p)	0	0	0	0	0	0	0	0	0
Argus	0	420	0	420	420	0	920	920	920
Modular I	0	0	0	0	0	0	0	0	0
Modular II	0	420	0	420	420	0	920	920	920
Sigma 1	0	420	0	420	420	0	920	920	920
Sigma 3 (p)	0	0	0	0	0	0	0	0	0
Sigma 3 (ST)	20	20	20	20	20	20	20	20	20
Sigma 4 (p)	0	0	0	0	0	0	0	0	0
Sigma 4 (ST)	20	20	20	20	20	20	20	20	20

Example:

A ring of relays with a Sigma 4p is required to communicate with a PC. The ring consists of an Argus relay and a MicroTAPP. From the Transmitter of the Sigma 4p to the Receiver of the Argus, using 1mm polymer fibre, the maximum distance is 38m. From the Transmitter of the Argus to the Receiver of the MicroTAPP (Modular II) using 1mm polymer fibre, the maximum distance is 70m. From the Transmitter of the MicroTAPP to the Receiver of the Sigma 4p, the maximum distance is only 7m with 1mm polymer fibre. However, using 200PCS, the maximum distance is extended to 2.3km! (There is a minimum distance associated with this configuration, however, of around 1.5km).

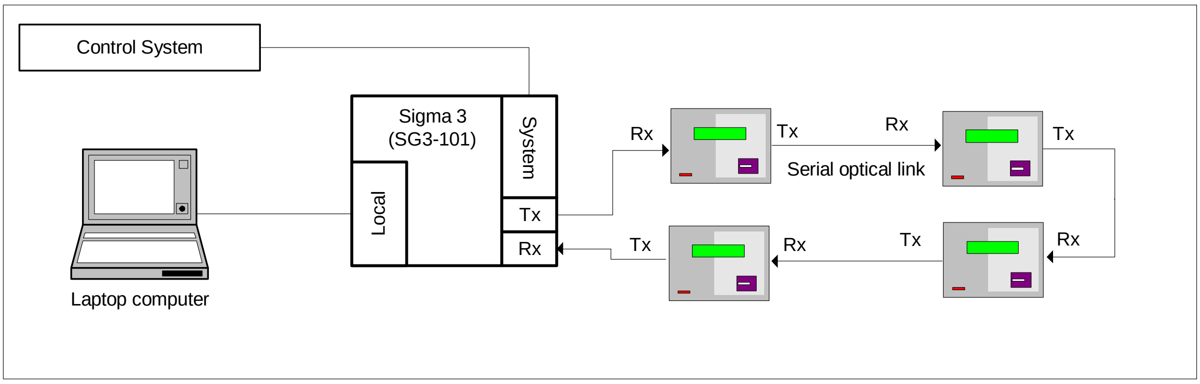

Figure 2 - Fibre Optic Ring Connection using Sigma 3

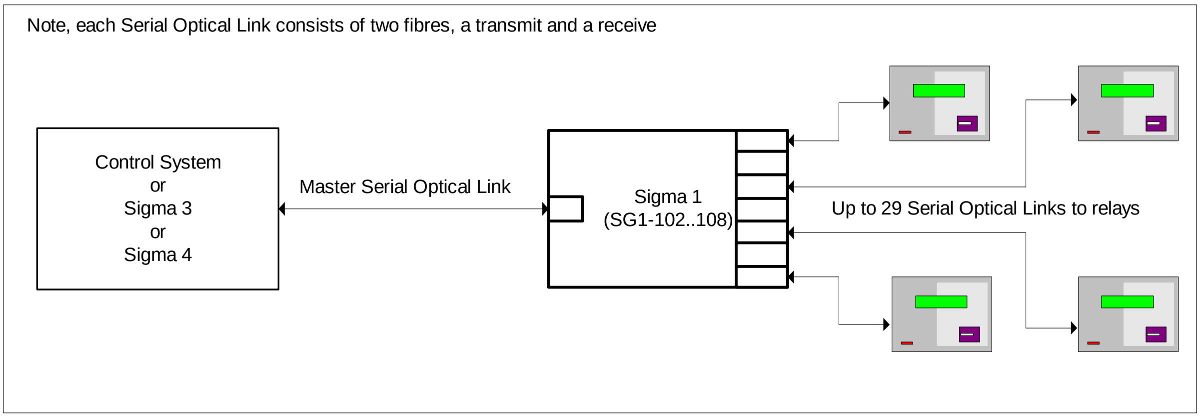

Figure 3 - Fibre Optic Star Connection Using Sigma 1

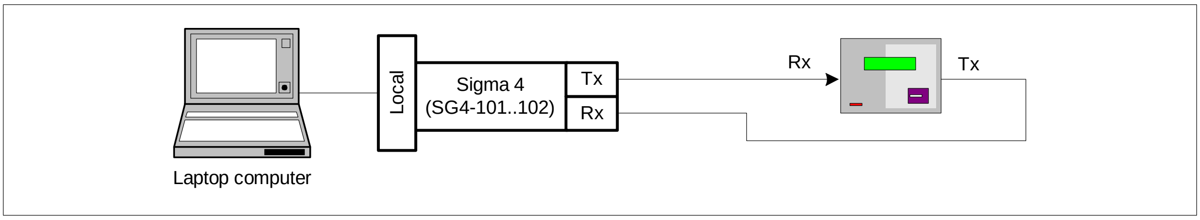

Figure 4 - Fibre Optic Connection to One Relay using Sigma 4

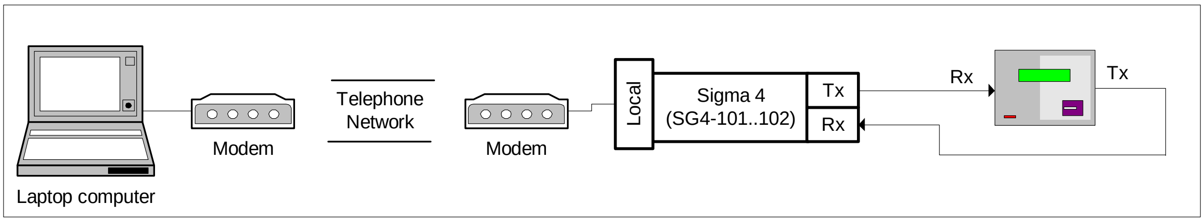

Figure 5 – Remote Dial-Up Connection using Sigma 4

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Contents

1 Introduction

The comprehensive design of the MicroTAPP relay simplifies the design of a tap change control system allowing a large reduction in the external wiring normally required. Application of the relay for voltage control of the most complex networks is easily accomplished.

2 Voltage Standards

The allowable range of permissible voltage at each supply point determines to a large extent, the operational voltages that can be applied at each voltage level on the network. Using typical voltage ranges it will be useful here to examine the maximum typical design voltage drops that can occur across a distribution system at extreme loading conditions.

For this example the network voltage levels are 33kV, 11kV and LV.

Table 1 lists voltage drops starting at the in-feed point, this example being only one of many, but used here for the purpose of explanation. The tables use figures for fixed tap distribution transformers based on a nominal output equivalent to the statutory voltage and off load adjustment in ±2.5% and ±5% steps. In practice the nominal voltage of fixed tap transformers is higher than the statutory voltage, giving a fixed boost over the levels used in this example.

% Voltage Difference (from nominal)	**At Source**		**Remote End**	
	No Load	**Full Load**	**No Load**	**Full Load**
33/11kV Transformer (Basic 100% used to offset higher voltage system drop)	0	0	0	0
MV System	0	0	0	-8
LV System	0	-1	0	-7
Total	0	-1	0	-15

No load/Full load variation	1	15

Table 1

Under the conditions shown in Table 1 where a basic control of voltage is used to give a constant voltage at the 11kV busbar, a customer connected close to the 33/11kV source can receive a supply that varies by only 1%, while a customer connected at a remote point on that network can receive a supply having a variation of some 15%.

Improved system utilisation can only be achieved and adequate voltage levels maintained if compensation for the full load drop can be successfully applied to the voltage control system such that the no-load/full-load variation is optimised.

2.1 Increasing the Network Capability

A method of Automatic Voltage Control (AVC) with Line Drop Compensation (LDC) has been used to offset the effects of line drops due to the load current effect upon the line R/X characteristic in order to achieve a constant voltage at the far end of a transmission line. This method is not practical for the distribution system where customers are connected along the length of multiple feeders radiating from a single substation with each feeder having a different load characteristic and length. The theoretical calculation of usable settings is, therefore, difficult for a distribution network.

If use of LDC is considered as **LOAD Drop Compensation** it can be employed in a practical way to increase the network utilisation. Using the data from Table 1 as an example, a modified **basic level** setting of -4% and an **LDC** setting of 8% is applied to the AVC. The effect on the voltage levels at the extremes of substation loading is seen by reference to Table 2.

% Voltage Difference (from nominal)	**At Source**		**Remote End**	
	No Load	**Full Load**	**No Load**	**Full Load**
33/11kV Transformer (Basic 96%)	-4	-4	-4	-4
33/11kV Transformer (LDC 8%)	0	+8	0	+8
MV System	0	0	0	-8
LV System	0	-1	0	-7
Total	-4	+3	-4	-11

No load/Full load variation	7	7

Table 2

The maximum variation across the network is now reduced from 15% to 7% through the change to the BASIC and LDC controls, resulting in an improved overall supply to the connected customers or, if the original deviation was acceptable, allowing the feeder lengths to be extended and the maximum variation indicated in Table 1 still achieved.

Theoretically the use of LDC will improve the situation to the ideal point where the absolute voltage variation is the same at both the source and remote ends of all feeders.

While abnormal network running and disparate feeder load profiles may cause the use of LDC to be reduced from the ideal, advantage can still be gained by the use of restricted settings, including those networks where voltage drops occur only on the LV system.

3 Wiring Diagrams

The MicroTAPP has been designed as a complete system. The external wiring requirement necessary for connection to other equipment is minimal. Examples of typical arrangements for control of a tap changing transformer are attached at the end of this section.

4 Application of TAP change control

Reference to the Description of Operation section of this document explains that the use of the MPPC communication between MicroTAPP relays for **summation of load current** purposes. The minimisation of circulating current is carried out by each relay using that transformer’s own current. When transformers are grouped consideration must be given to the Load Drop Compensation (LDC) requirements and effects of different running arrangements.

MicroTAPP is easily applied to double bus-bar substations allowing flexibility in the system running arrangements. The transformers do not have to be identical and can be supplied from different sources.

There are three main methods of application for MicroTAPP, as described in the description of operation section of this manual, each with particular advantages, giving the customer a wide choice depending on the particular application.

For maximum operational advantage the TAPP system is recommended.

4.1 TAPP Method – System Power Factor Setting

The TAPP method uses the “System Power Factor” setting applied to the relay with which to calculate the circulating current compensation. This setting is also used to normalise the line drop compensation applied, so that it is not affected by any circulating current and only relates to the load power factor.

Each MicroTAPP relay can monitor the state of the KANBUS link. The “Circulating current” and “line drop compensation” features both rely upon its operation to function correctly. An alarm can be given if a station in the group is lost when the MPPC Failure Detection set to “Enabled”.
In addition the MicroTAPP has a logic feature that will automatically switch all relays running as a group in circulating current mode to the TAPP method, if the loss of one of the relay stations on the MPPC KANBUS link between the relays is detected.

Therefore it is imperative that the setting applied to the relay accurately reflects the load power factor, irrespective of whether TAPP or circulating current is being used.

Ideally the power factor should be set identically on all transformers that normally supply a particular busbar load. The relay default power factor is 0.97 lagging and can be used initially, before the setting is refined to its’ operational value.

To find the setting to use, the relays should switched into AUTO voltage control mode and left to tap to the NORMAL steady state. Once the relay(s) have reached the deadband the power factors can be read from the relay Instruments display. The deadband is reached when the only the NORMAL green coloured LED is illuminated.

When using the TAPP method is important that the System Power Factor is set accurately to reflect the true load power factor. If there is a large error between these two parameters then the system voltage will also have an error.

Setting Example

Two transformers running in parallel at a single substation supply a common group load. The relays, tap changer and scheme are now fully commissioned and all relay Instruments are at expected values. The relays are switched to AUTO and the left to settle into their voltage deadbands. The Power Factor Instrument is now selected using the fascia keypad. The relay Power Factor and Group Load in MVA are recorded from both relays over a period of time. The results are examined to find where the peak load occurred. The “System Power Factor” setting applied should reflect the power factor when the load is near or at its steady peak level. The substation load will vary during the normal daily load cycle so these values may need to be recorded for some time before the point is reached where the load is at its maximum value.

In this example, one relay displays a power factor of 0.92 lagging and the other displays 0.94 lagging, at the point at which the load is near its recorded peak. The average of these two values is 0.93 lagging. Both relays should now be set with a System Power Factor of 0.93 lagging.

For loads normally supplied from two parallel substations the power factors from all transformers paralleled should be averaged when the peak load occurs. All relays should than be set to this average value. The system circulating current will then be minimised. Minimising the circulating current allows MVar demand to be minimised and hence power system losses reduced.

NOTE: It is important to set the System Power Factor setting when the substation load is high, as this is when the compensation for circulating current and Line Drop Compensation (LDC) have maximum effect. In TAPP mode, if a significant difference exists between the true load power factor and the MicroTAPP “System Power Factor” setting, a system voltage error will occur. Therefore it is important to find the true System Power Factor and set the relay accordingly when the system is heavily loaded.

4.2 Independent Single Transformers

At a single transformer site a MicroTAPP relay is arranged as shown in Figure 1. Connections are made to the VT for voltage measurement and to the CT for LDC and control of circulating current when the transformer is operated in parallel with other transformers at remote sites. The TAPP method should be selected if it is possible to parallel substations together, albeit as a temporary measure. If a single transformer substation is purely radial with no possibility of parallel operation with another substation then circulating current can be selected.

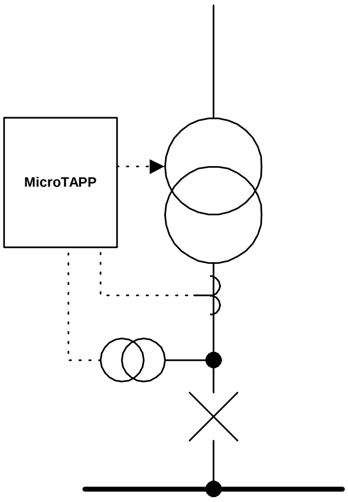


Figure 1

4.3 Parallel Transformers

When transformers are operated in parallel at a site use of the MPPC link between each voltage control relay enables accurate LDC at all times. Figure 2 shows the general MPPC arrangement for a multiple transformer site. If a MicroTAPP is de-energised, communication between other relays connected to the twisted pair cable is not affected.

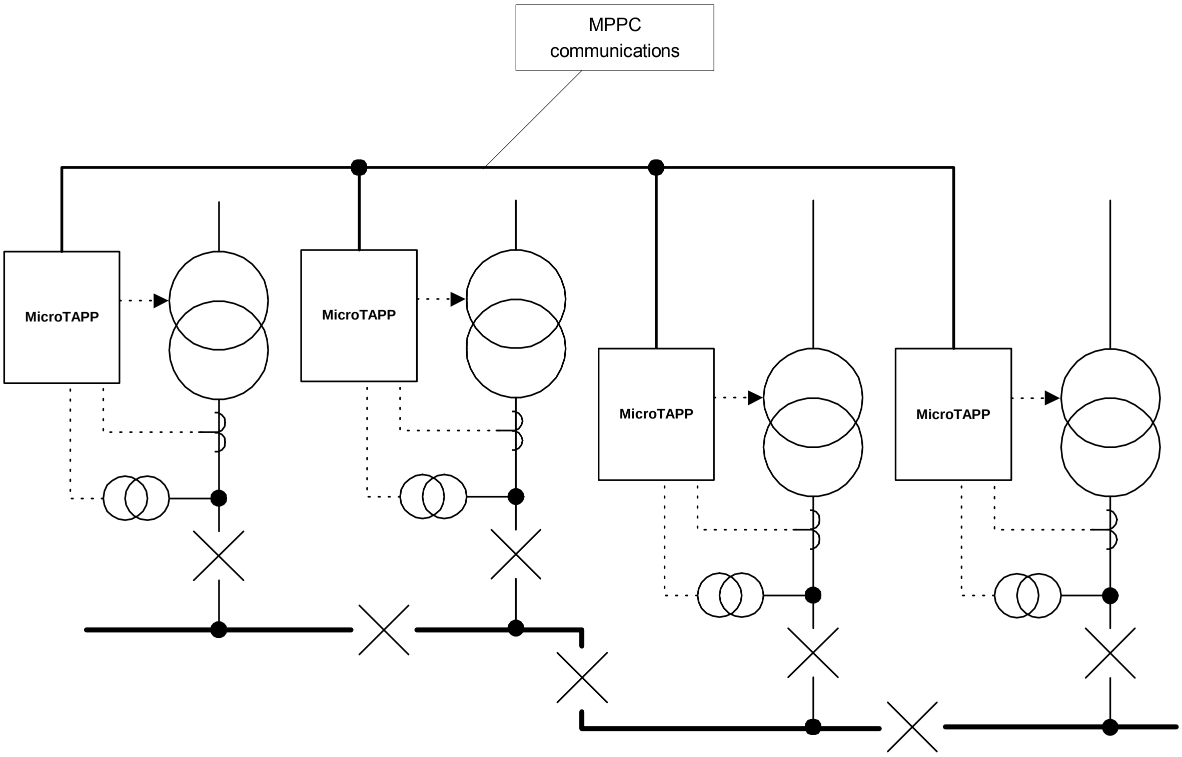


Figure 2

In more complex sites transformers may operate in groups with the busbar split, making two effective load groupings. Regardless of the transformer grouping the MPPC should always be connected to each relay. Where operational requirements necessitate changes to the busbar configuration and LDC is used, consideration must be given to the MicroTAPP relay settings.

Take an example of four transformers normally operating in two groups, i.e. two on each bus-bar as shown in Figure 2. The site can be operated as a single busbar with four transformers in parallel or as a two busbar site with each busbar supplied from two transformers.

The actual level of LDC for each of the two bus-bar groups will be proportional to the load on each of the respective bus-bars and these levels will be maintained (by virtue of the MPPC) at the correct level even if one transformer is taken out of service in either of the groups.

If the two groups are now interconnected either by closing the bus-coupler or operating the transformers in different system groups then the resulting levels of basic voltage and LDC will be a compromise based on the average settings and loading of each transformer in the new group.

If a single setting is not found to be satisfactory for all busbar configurations, alternate setting groups for different set-point levels and LDC etc. can be implemented from bus coupling CB auxiliary switch operation or from a SCADA signal.

4.4 Parallel networks

The MicroTAPP system uses a modified negative reactance design for the detection of circulating current. When selected for TAPP operation (modified negative reactance circulating current mode), the relay operates to minimise circulating current between transformers at the same site and also when transformers are operated in parallel across networks.

For optimum performance, an accurate normal network power factor must be entered as the “System Power Factor’ setting. Switching to alternative Setting Groups can be used to match step changes system power factor due to the reactive compensation switching in or out of service. There are eight setting groups so it is possible to adjust the “System Power Factor” to eight distinct values.

4.5 Embedded Generation

When generation is embedded in a network, where tap changing transformers are used, consideration must be given to the method of voltage control employed. The choice of voltage control is influenced by the type of generator, the generator rating and the relative capacity of the local network. Figure 3 shows a typical arrangement.

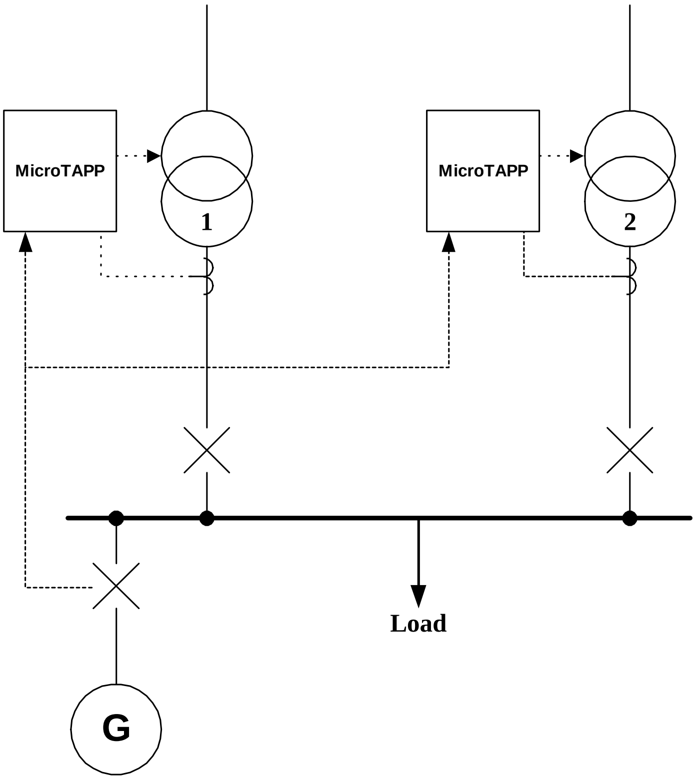


Figure 3

4.5.1 Generator Types

4.5.1.1 Synchronous

Synchronous generator control systems can control the generator terminal voltage and the power factor of load. The generator control can be set to run in power factor or voltage control mode. In either case the excitation is adjusted to hold either of these parameters within limits. Larger generators used for network control will run in power factor mode. This allows the MicroTAPP relay applied to GSU transformers to be set to TAPP method. In voltage control mode the power factor will tend to vary more and circulating current may be more suitable.

4.5.1.2 Asynchronous (Induction Generators)

Induction generators draw reactive magnetising current from the power system and export unity power factor load current. As the MicroTAPP relay is based on the negative reactance principle for tap change control, a significant variation in load power factor may affect relay performance. If the power factor range is large the MicroTAPP relay can be set to operate in ‘True Circulating Current’ mode. A disadvantage, as detailed in the ‘Description’ section of this manual is that networks cannot be operated in parallel.

4.6 Application of MicroTAPP

Generally, MicroTAPP can be applied as indicated in Tables 3 and 4. A ‘small generator’ will have an output which is significantly less than the load demand on the busbar, a ‘large generator’ will be capable of supplying significant proportion of the load. In practice the running arrangements for a particular site will determine the method of voltage control and the optimum settings that will be used, Tables 3 and 4 are included as a guide only.

Synchronous Generators		
Type of Generator	**Small Generator in parallel with Transformers**	**Large Generator in parallel with Transformers**
Power Factor control	Transformer voltage controlled by MicroTAPP. LDC may be used	Transformer voltage controlled by MicroTAPP. If a large LDC setting is used the effect will be reduced when the generator is running. A different setting group can be switched in to maintain the LDC at the correct level
Voltage control	Providing the generator and MicroTAPP voltage levels are similar, correct voltage will be maintained on the busbar. If a large LDC setting is used a circulating current will flow at higher load levels	

Table 3

Asynchronous Generators	
Small Generator	**Large Generator**
If operation of the generator does not cause a significant change in power factor the MicroTAPP can be used in TAPP mode. LDC settings will not change significantly	If operation of the generator causes a significant change in power factor the MicroTAPP can be used in circulating current mode. It will not be possible to run networks in parallel. A different setting group can be switched in to maintain the LDC at the correct level

Table 4

5 MT1-102 Advanced Relay - Application Guide

The advanced MicroTAPP relay (MT1-102) is available for applications where MW and MVar power flow is more dynamic, for instance when applied to Generator step up Transformers or at embedded generation sites. It has features that allow widely fluctuating loads to be accommodated on industrial supplies. Such loads are blast furnaces, rolling mills and smelter plants. The voltage control point can be switched between HV and LV depending upon the running arrangement of the plant. This is done by switching relay setting groups from the plant status fed to the relay via hardwired inputs or via the communication.

This relay can be fed from a AVC VT and CT on the HV or LV side of the transformer. It can also be used for single or three phase power transformers and allow reactive current compensation to be reduced to allow reactive current to flow through the system. It is therefore suitable for transmission applications and can be manually tapped to control MVar flow.

In all circumstances at a site where transformers are operated in parallel using the reactive circulating current control scheme, all relays must be set to operate from a voltage source on one side of the transformers only. With the MT1-102 relay this may be the directly measured voltage where the AVC VT is located, i.e. ‘normal’ or at the other side where the voltage is calculated, i.e. a ‘virtual’ VT. The relays can then have their control point switched, as demonstrated by the example below.

Application of the advanced settings is dependent upon particular operational situations. As an example consider a network where a local generation scheme supplies local load network which is also supplied by a long line from a remote source, Figures 4 and 5.

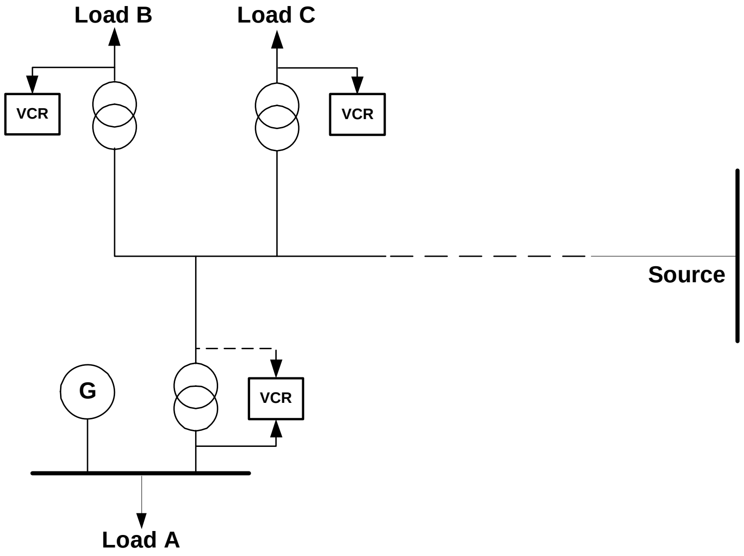


Figure 4

If the generation is active and the network is heavily loaded, voltage control is switched over to take control of the incoming voltage at load site A (see Figure 4) while the generation is configured to maintain the voltage on the local busbar. The incoming voltage at load sites B and C are supported by load site A and offset the line voltage drop from the source. Under light loading or during generation down time the VCR at load site A would be switched to take control of the voltage level at the local busbar.

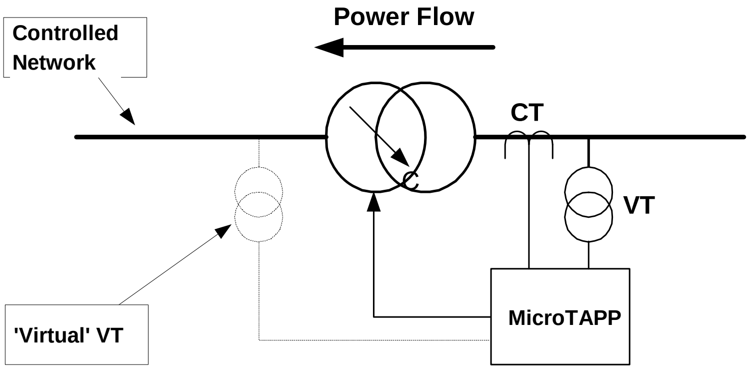


Figure 5

In a situation where a load fluctuates wildly, such a when running large motors or furnaces intermittently, automatic voltage control can result in an excessive number of tap change operations caused by the impedance drop through the transformer. In this instance the menu selection 'transformer voltage drop compensation' can be disabled. The disabling of this compensation allows a normal dead-band sensitivity to be applied while at the same time reducing the number of corrective tap-change operations to a practical number.

Figure 6 shows a situation where a heavy load causes a real voltage drop from A to B. After an initial time delay four tap-change operations will bring the voltage to the normal level at C. As the load is removed the busbar-voltage increases to a point D, where it may be excessive, and after a short delay if fast tap down is enabled, 5 tap-change operations are required to return the voltage to normal.

With the 'transformer voltage drop compensation' set to Disabled, the 'measured' voltage reduces to B when the load is applied and no corrective tap-change operations are required. As the load is removed the 'measured' voltage increases to E where, in this example, a single corrective tap change operation takes place after a normal time delay. This will reduce the number of tap changes and hence wear, but at the expense of some variation in the busbar voltage. To allow the transformer voltage drop to be ignored the VT must be located at the opposite side of the transformer from the load.

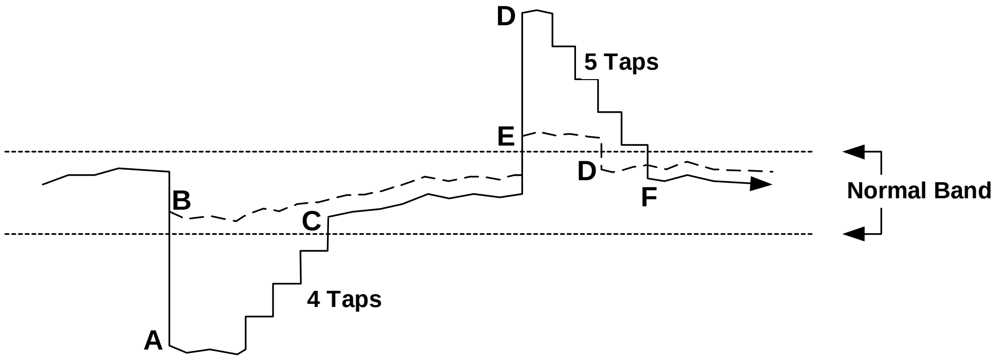


Figure 6

6 Network Control

6.1 Switching Out

When a transformer, as a member of a group, is switched out of service, an increase in load on the remaining units will cause a drop in the supplied power system voltage. If the transformers are high impedance this voltage drop can be very significant. Figure 7 shows the effect on the busbar voltage when a transformer is switched out. At switch-out the voltage falls from A to B and an initial time delay will take place before the first corrective tap-change operation at C which is then followed by further tap-change operations (determined by the inter-tap delay) until the voltage is returned to normal at D.

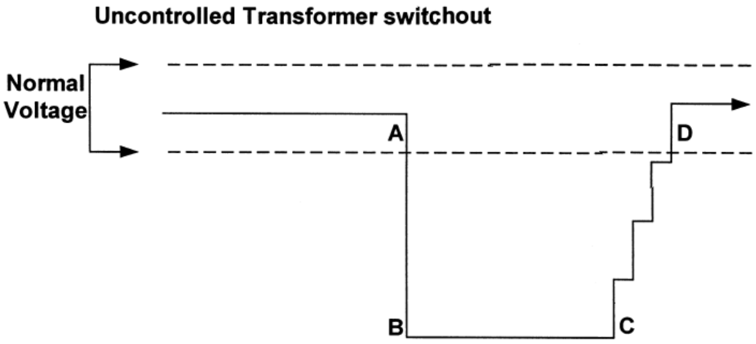


Figure 7

The MicroTAPP relay has functionality that enables automatic corrective tap changing to take place prior to switch-out. On receipt of a 'switch-out' signal the MicroTAPP relays operate the tap-changers such that, when the transformer is switched out, minimal change in voltage will be seen. The initiation instruction can be sent as serial data over a communication system or as a latched signal applied to a status input. On completion of the operation a signal (ready for switch-out) is returned either over the communication system or by operation of an output relay. The preparation sequence is shown in Figure 8. On receipt of a switch-out signal (A), the nominated MicroTAPP will immediately tap down until its measured power factor is unity and send a warning signal to other relays in the same group. The transformers that are to remain in service react to maintain the busbar voltage at the correct level as shown by the tap change operations A-B. On switch-out at C there may be relatively small resistive voltage drop that may or may not require a corrective tap-change (D).

6.2 Switching In

When a transformer, as a member of a group, is switched in, a reduction in load on the transformers already in service will result in a voltage increase. When energised but before being put on load, the relay will adjust its open circuit terminal voltage such that no change in voltage will occur when the transformer is closed onto the busbar. The energised but unloaded transformer should be allowed to complete tap changes until the dead band is reached. It can then be loaded by closing the LV CB. At this point some circulating current will flow and the relays will tap to minimise it, but will hold the system voltage at the normal level.

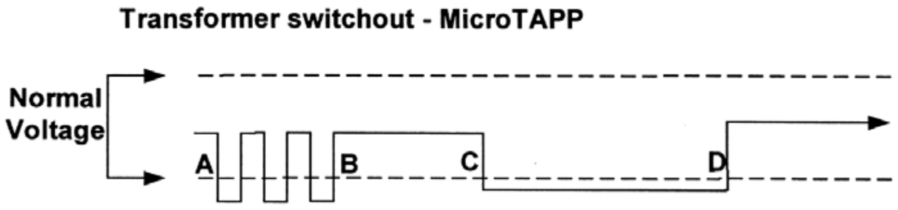


Figure 8

6.3 Falling Frequency

When available generation cannot meet demand the power system frequency will fall. When the frequency falls to a pre-defined value, circuit breakers are opened to shed load and thus return the frequency to normal.

Where loads are resistive a controlled voltage reduction can facilitate a load reduction before the operation of circuit breakers, a general standard for the reduction being two stages, each of 3%.

The MicroTAPP can be set to automatically effect a voltage reduction if the power system frequency falls below a set value, which would be higher than the trip out value, thereby reducing the possibility of loss of supply.

6.4 Tap Stagger

When in parallel with other transformers a MicroTAPP can be made to control voltage and at the same time import or export a fixed reactive current. The initiation instruction can be sent as serial data over a communication system or a signal applied to a status input.

6.5 Reactive Compensators

When power factor correction reactors are used to reduce power system losses the position of the reactive compensator can affect the operating point of the relay. Consider Figure 9 that shows a reactive compensator teed from the secondary connections from transformer 2 with the CT used for load current measurement located in the incoming side of the transformer circuit breaker.

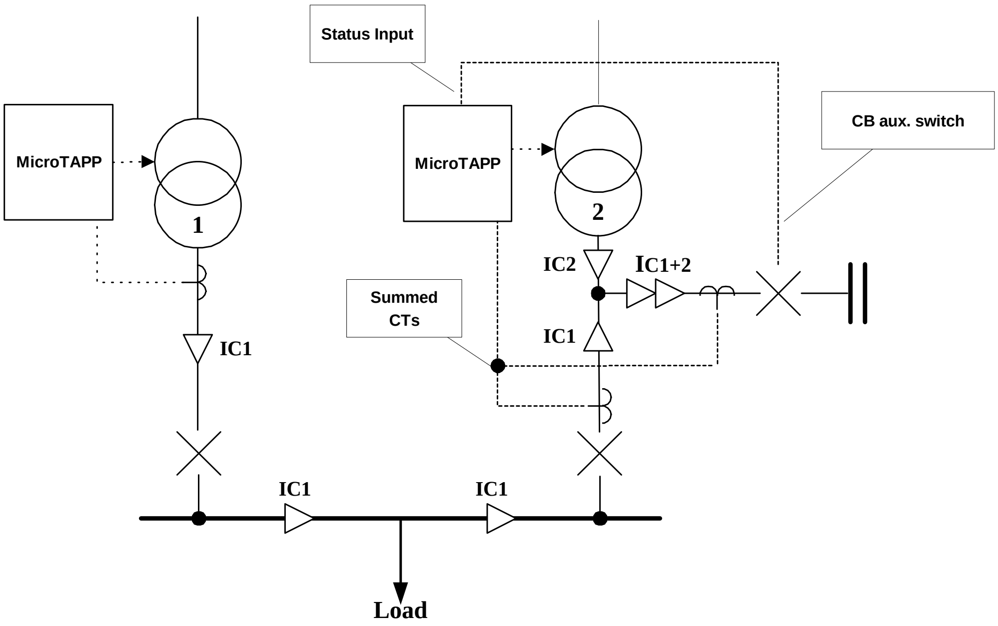


Figure 9

When the compensator is switched in, reactive current will flow through the LDC CT in the ‘wrong direction’ causing the apparent power factor to change. If reactive circulating current control is used for control of parallel transformers, the change in power factor will tend to make T2 operate at a higher voltage. A solution is to arrange for a group setting change with a new load power factor setting to be initiated automatically by closure of the compensator bank switch as shown in Figure 9. Obviously the original settings will be automatically re-applied when the switch is opened.

7 Voltage Transformers

7.1 Operational Considerations

The preferred location of the VT is at the transformer secondary connections.

In the case of a busbar connected VT it is important to disable MicroTAPP whenever the transformer secondary circuit breaker is open. If this precaution is not taken the regulating relay will be allowed to control a tap-changer without being able to measure its output voltage. Thus if the voltage is out of band (or drifts out of band) an unstable situation will arise caused by ineffective raise or lower instructions being issued by the relay to its tap-changer. The tap-changer will soon arrive at either its upper or lower limit producing an abnormal voltage.

Disabling is achieved by means of an auxiliary switch in the transformer’s lower voltage circuit breaker which is arranged to disconnect the MicroTAPP ‘enable’ input or by applying a signal to implement a ‘Tap change block’ command to the relay.

For more complex substations further auxiliary switches may be considered to be necessary in the bus-section and/or bus coupler circuit breakers in order to ensure that all possible operating conditions are catered for.

In common with most other voltage control schemes the MicroTAPP system can operate with either bus-bar or transformer connected VTs but the operational restrictions imposed by bus-bar VTs still apply and the ability of MicroTAPP to automatically match secondary voltages before putting transformers back on load (thus avoiding sudden step changes) cannot be utilised.

One significant advantage of the MicroTAPP system is that if an idle transformer is inadvertently restored to service on an unsuitable tap position then the inherent coupling features of MicroTAPP relays together with their “fast tap down” feature will quickly restore all transformers at the site to the optimum tap-positions. This applies to both types of VT connection but in particular to bus-bar VT schemes.

The VT used for measurement of voltage need not be related exactly to the transformer nominal output. The actual value is entered in the ‘system settings/transformer’ menu together with the transformer details, from which the control algorithms determine the actual voltage value.

Errors in the controlled voltage will be directly related to errors in the measured voltage and so these should be minimised by using the most accurate VTs available. As a guide the measuring accuracy of the VTs should be matched to the tap step resolution as a minimum requirement.

8 Current Transformers

As for a VT, the CT used for measurement of load current need not be related exactly to the transformer full load rating. The actual value is entered in the ‘system settings/transformer’ menu together with the power transformer details, from which the control algorithms determine the actual current value.

If the CT is mounted at the circuit breaker the CT current direction will be reversed, the setting menu allows the current direction to be reversed.

The accuracy of the measuring CTs is not as critical as it is with the measuring VTs. However, metering class CTs should be used if possible to minimise measuring errors.

9 Wiring Configurations

Diagrams located at the end of this section show typical arrangements for tap change control schemes. Inputs to the relay and outputs for indications and control are user programmable. Tables 5, 6 and 7 give examples of the I/O allocation for a complete control system as shown in the example scheme with the inclusion of other features not shown on the diagrams. 11 inputs are used with 5 outputs. Other combinations of I/O are available, see description of operation.

INPUTS	
Terminal	**Default Allocation**
Status 1	MicroTAPP enabled (to allow for control at tap changer)
Status 2	Lower signal to tap changer
Status 3	Raise signal to tap changer
Status 4	3% voltage reduction from SCADA **
Status 5	6% voltage reduction from SCADA **
Status 6	Prepare for Switch-Out from SCADA **
Status 7	Tap in Progress switch is closed
Status 8	Auto selection from SCADA **
Status 9	Manual selection from SCADA **
Status 10	Raise signal from SCADA **
Status 11	Lower signal from SCADA **

Table 5

Controls can also be carried out by use of the serial communication connections into the relay making use of the inputs marked ** unnecessary.

OUTPUTS	
Terminal	**Default Allocation**
Relay 1	Prepare for Switch-Out complete
Relay 2	Use N/C for Tap Changer motor supply contactor reset
Relay 2	Use N/O for Tap Changer motor supply latched contactor trip
Relay 3	Voltage control fault alarm
Relay 4	MicroTAPP initiated Lower signal
Relay 5	MicroTAPP initiated Raise signal

Table 6

OTHER INPUTS	
B9,11,13,15,17,19 (B23 is common)	Digital TPI
B23,25,27	Resistor TPI

Table 7

9.1 Voltage Transformers

Either a 3 phase or single phase voltage transformers can be used for voltage measurement. A 3 phase VT is preferable so that the level and voltage quality of all phases can be monitored. Figure 10 shows the relay connections for a 3 phase VT.

Where a single phase VT is used it can be connected between phases or from phase to earth, in either case the MicroTAPP set-up menu for the transformer allows the particular connection to be specified. Figure 11 shows the connections for a single phase VT.

9.2 Current Transformers

Figures 10 and 11 also show the relay connections for a current transformer. The input allows for any CT nominal secondary current up to 5 amps to be used. The MicroTAPP setup menu for the transformer allows the particular ratio to be specified.

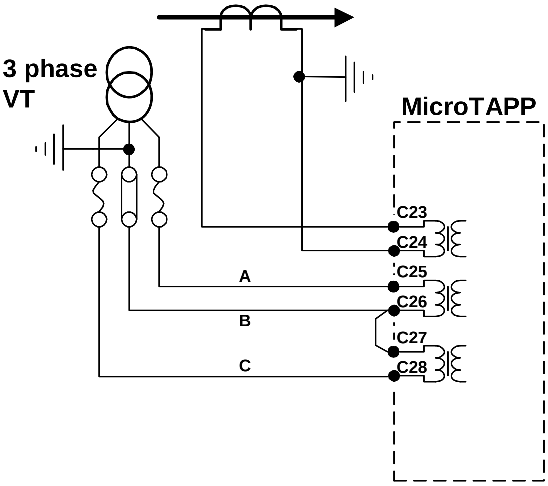


Figure 10

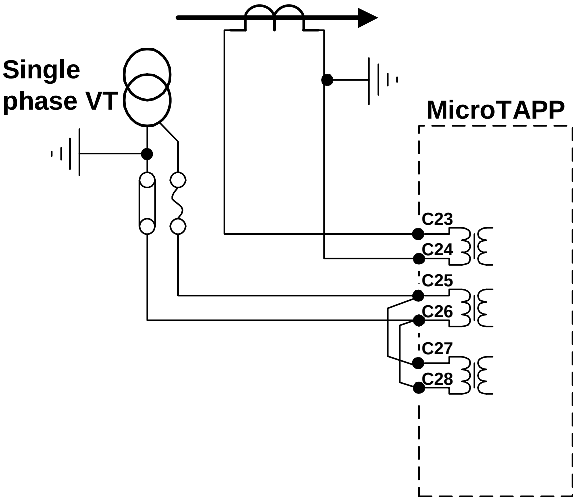


Figure 11

9.3 Inputs

The standard status inputs to the relay are rated for AC or DC voltages and have a range of 18V to 110V. When used at higher voltages up to 250V AC or DC, a series dropper resistor must be used as shown in the application diagrams at the end of this section. Alternately the relay can be specified with alternate voltage ratings, see performance specification section and order catalogue.

The inputs can be mapped to the required status configuration using the appropriate relay menu. A typical control scheme is shown at the end of this section.

9.4 Outputs

The standard outputs are relay contacts rated for 250V, AC or DC voltages, and have a current rating of 10A.

The outputs can be mapped to the required function using the relay system configuration menu, a typical control schemes are shown at the end of this section.

9.5 Tap Position

Connections are made to the MicroTAPP relay depending on the type of tap position sender unit provided with the tap changer as shown in Figures 12 and 13. Connections for all TPI sender unit types are provided.

The MicroTAPP monitors the integrity of the tap position. If a resistor type sender unit is used for the signalling of tap position an extra resistor having a value equal to 1 tap interval resistor must be inserted at the bottom of the resistor chain as shown in Figure 12. Where resistors are used for determination of tap position sender unit, a worn or poorly maintained moving contact may become open circuit and the indicator will read tap position ‘0’, indicating a faulty sender unit.

The total resistance of the resistor chain should be greater than 250Ω and less than 100kΩ. If the total resistance is less than 250Ω, the short-fall can be made good by increasing the size of the Additional resistor. The value of this resistor should then be entered in terms of tap steps in the setting "Additional resistor equiv. to". However, this setting added to the number of tap positions must be less than 40. Resistors should be rated to 1W and to 1% accuracy.

Resistor type Tap Position Sender Unit

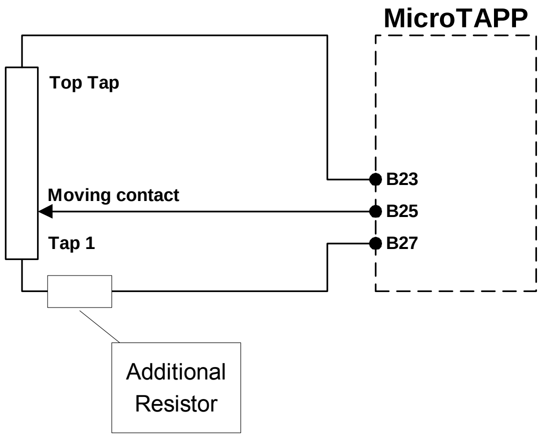


Figure 12

Where tap position is signalled from a switch, Figure 13 shows the connections, which are used for True binary, BCD and Gray code configurations. As with the Resistor type, a reading of tap position ‘0’ will indicate a faulty sender unit.

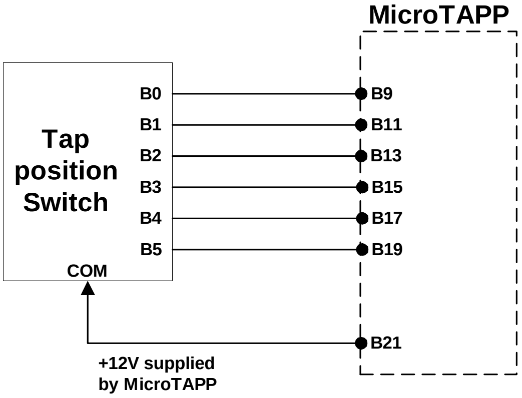


Figure 13

9.6 Transfer Tap Positions

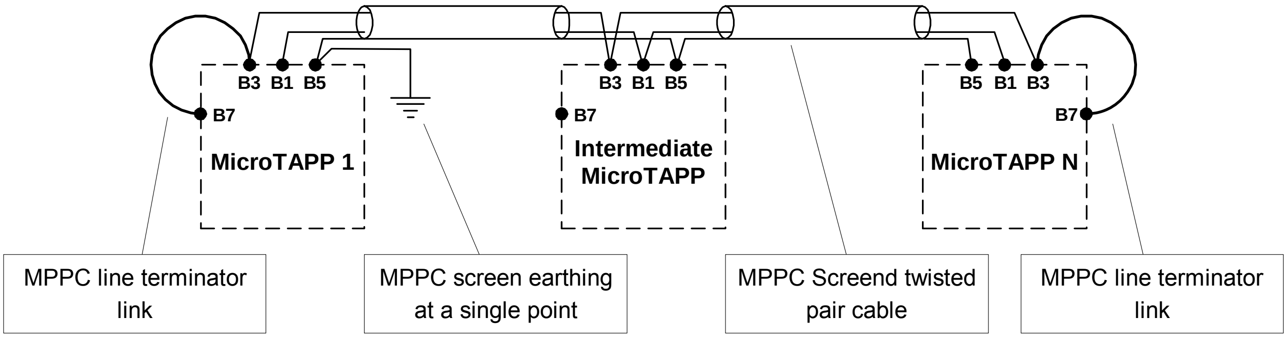
As described in the first section of this manual some tap changers have special positions which operate to re-arrange the winding configuration but do not alter the voltage. When at these positions a single tap change control will result in more than one tap change operation which must be recognised 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 a '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 be marked as 'T' to indicate a transfer position, in this case 7, 8T, 8, 8T, 9. It is important that the tap positions above the transfer point are also re-numbered.

The commissioning section of this manual gives details of the tap changer set-up procedure and correct determination of the number of 'physical' tap positions.

9.7 MicroTAPP Peer to Peer Communications (MPPC)

At a site, load and status information is passed between MicroTAPP relays by the MPPC system which is a screened twisted pair cable. The cable used should be a 22-swg shielded twisted pair cable with drain wire. The maximum cable length is of the order of several hundred meters



MPPC Inter-MicroTAPP connections

Figure 14

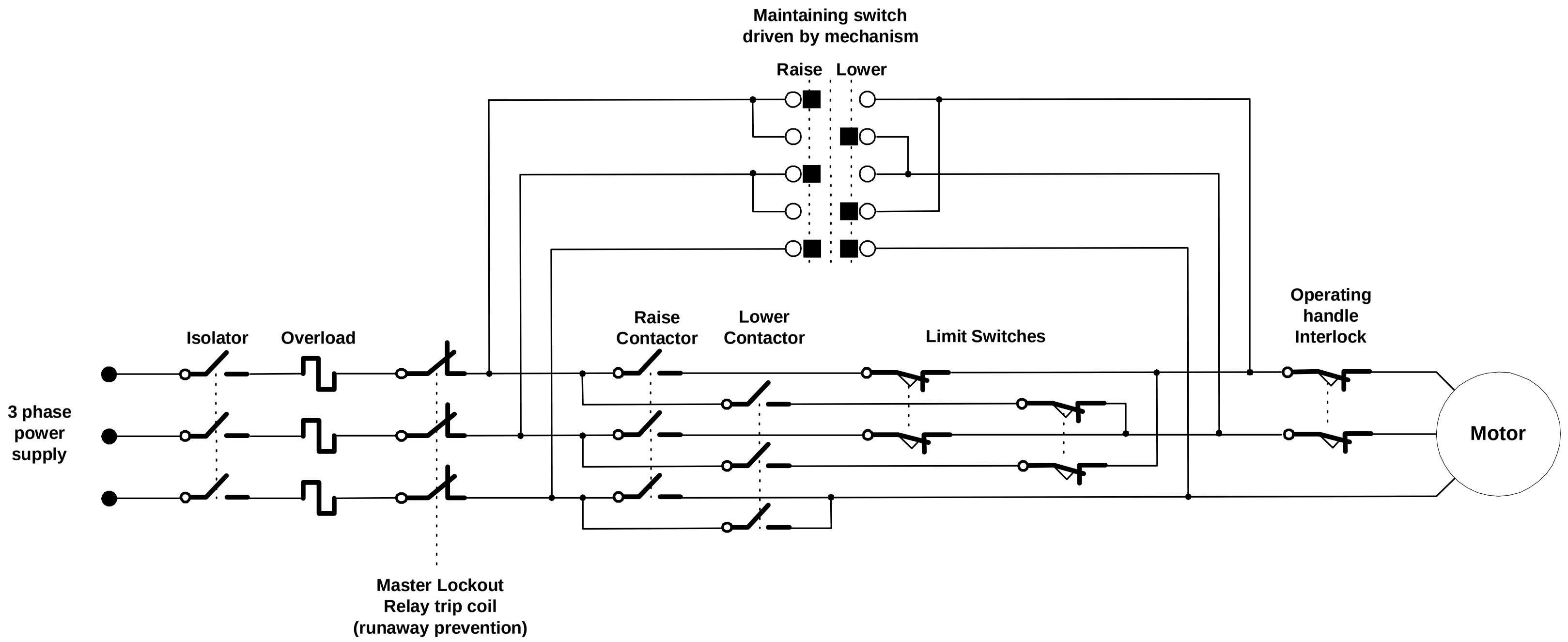
Each end of the MPPC cable must be connected to a line terminating resistor which is included within the MicroTAPP at terminal B7, the connections to which are made by linking from B3 to B7 on the first and last relay of the cable route as shown by Figure 14. The MPPC cable screen must be connected to earth at a SINGLE point only, again shown in Figure 14.

If an MPPC failure is detected when the relay is in circulating current mode (the "MPPC Failure Detection" setting in the "System Config" Menu must be set to "Enabled" for this to occur), the relay will automatically switch to TAPP mode.

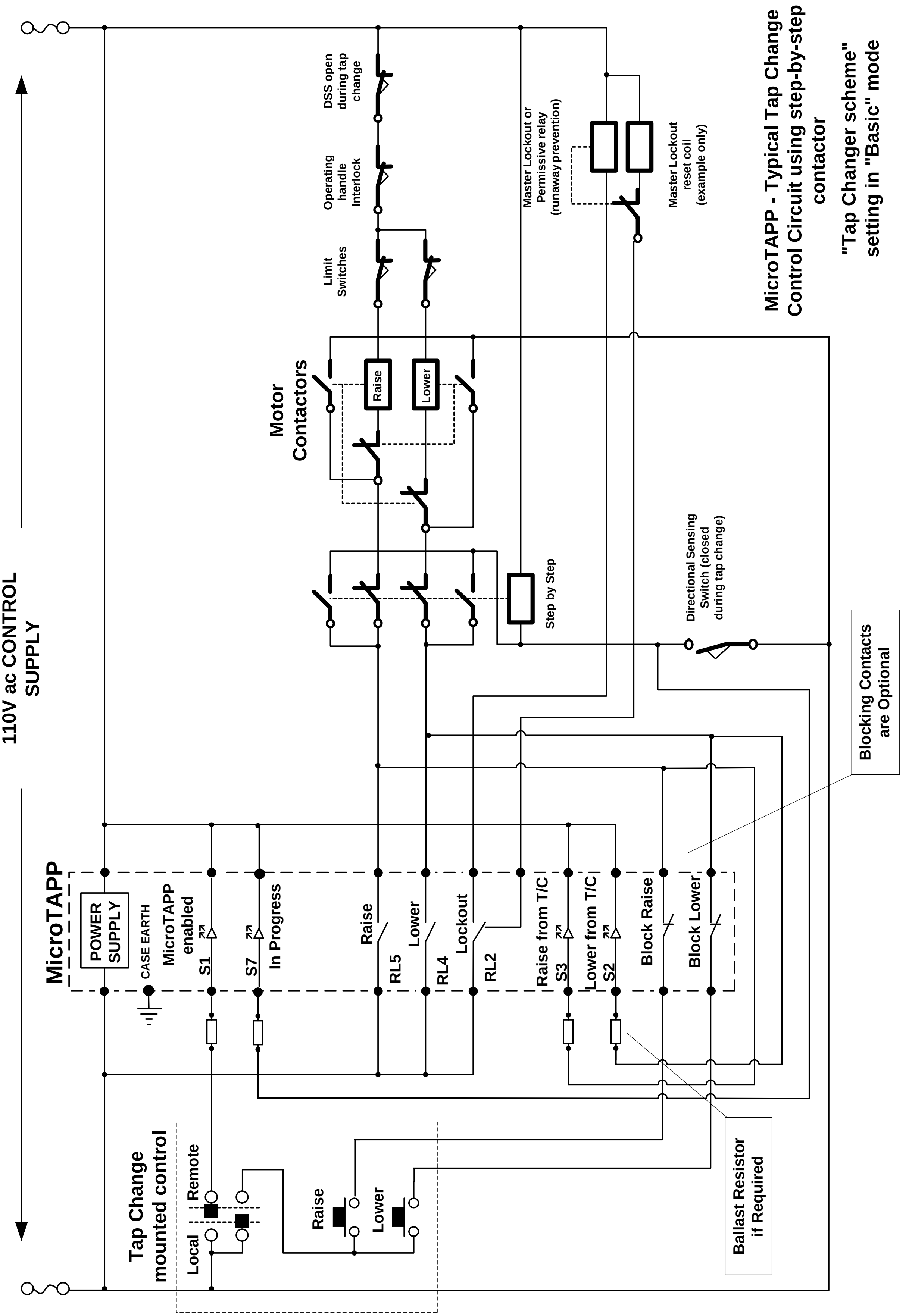
Only those relays set to the same Transformer Group will share load and circulating current information

9.8 Alarms

A wide range of abnormal states are detected by the MicroTAPP which are available from the Fault Data option in the relay menu and remotely via serial communication.

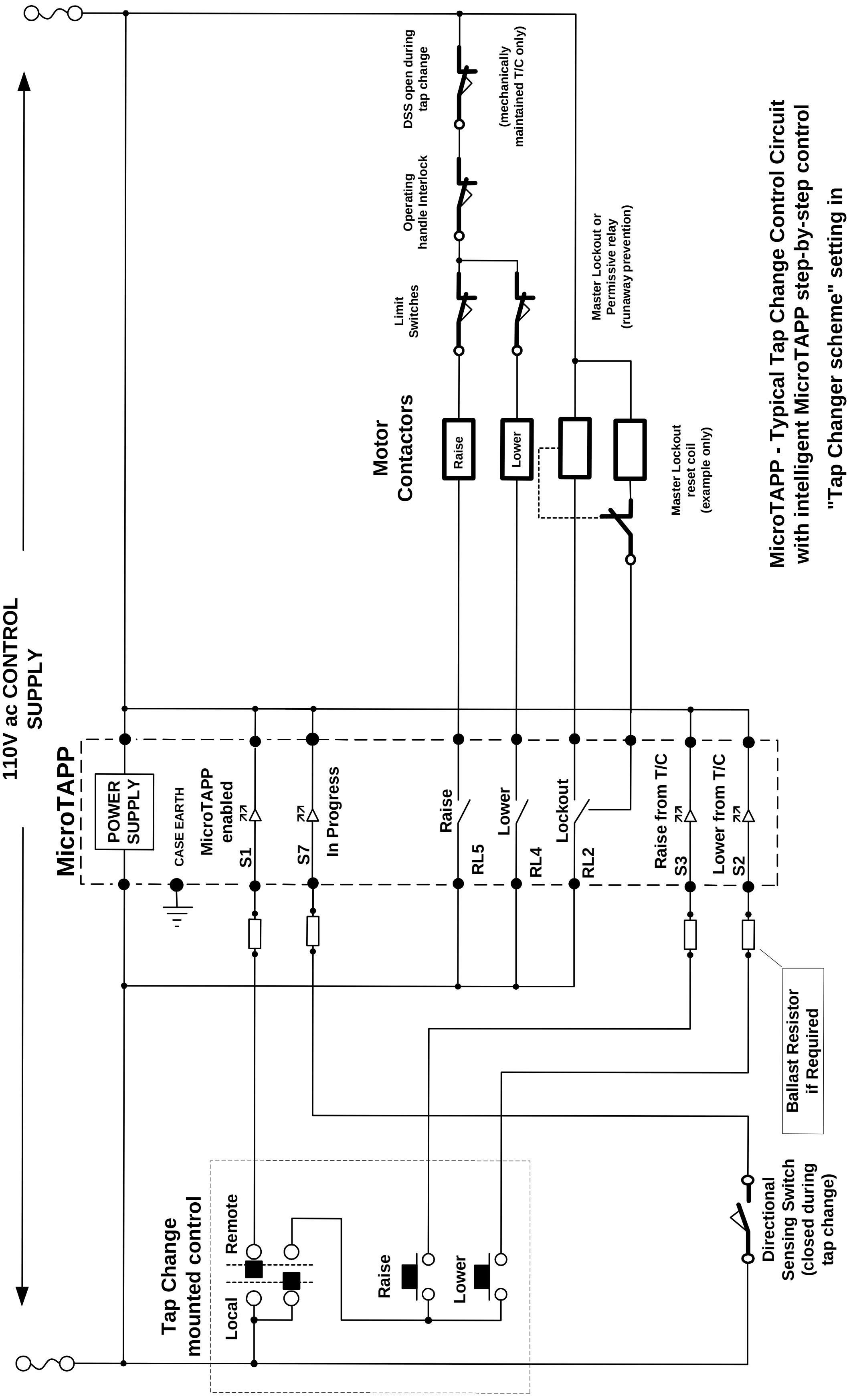


Typical Tap Changer Motor Circuit



MicroTAPP - Typical Tap Change Control Circuit using step-by-step contactor

"Tap Changer scheme" setting in "Basic" mode



MicroTAPP - Typical Tap Change Control Circuit with intelligent MicroTAPP step-by-step control

"Tap Changer scheme" setting in "Step-by-Step" mode

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

SIEMENS

Contents

1 Packaging

Relays are supplied in packaging designed to mechanically protect them while in both transit and storage.

This packaging should be recycled where systems exist, or disposed of in a manner which does not provide a threat to health or the environment. All laws and regulations specific to the country of disposal should be adhered to.

2 Unpacking, storage and handling

On receipt, remove the relay from the container in which it was received and inspect it for obvious damage. It is recommended that the relay modules are not removed from the case. To prevent the possible ingress of dirt, the sealed polythene bag should not be opened until the relay is to be used.

If damage has been sustained a claim should immediately be made against the carrier, also inform Reyrolle Protection and the nearest Reyrolle agent, using the Defect Report Form in the Maintenance section of this manual.

When not required for immediate use, the relay should be returned to its original carton and stored in a clean, dry place.

The relay contains static sensitive devices, these devices are susceptible to damage due to static discharge and for this reason it is essential that the correct handling procedure is followed.

The relay’s electronic circuits are protected from damage by static discharge when the relay is housed in its case. When individual modules are withdrawn from the case, static handling procedures should be observed.

- Before removing the module from its case the operator must first ensure that he is at the same potential as the relay by touching the case.
- The module must not be handled by any of the module terminals on the rear of the chassis.
- Modules must be packed for transport in an anti-static container.
- Ensure that anyone else handling the modules is at the same potential.

As there are no user serviceable parts in any module, there should be no requirement to remove any component parts.

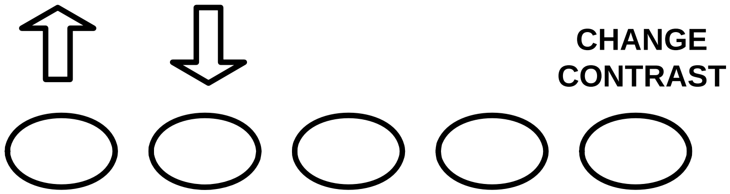
If any component parts have been removed or tampered with, then the guarantee will be invalidated. Reyrolle Protection reserve the right to charge for any subsequent repairs.

3 Recommended Mounting Position

The relay uses a liquid display (LCD) which is used in programming and or operation. The LCD has a viewing angle of ± 45º and is back lit. However, the best viewing position is at eye level, and this is particularly important when using the built-in instrumentation features.

If the LCD appears to be blank, but the Protection Healthy LED is correctly illuminated, the LCD contrast requires adjustment. To do this:

- Hold down the RIGHT-most key.
- Then hold either the LEFT-most key (contrast raise) or the SECOND LEFT-most key (contrast lower).



- Keep these keys pressed until the text “CHANGING CONTRAST” appears on the screen.
- This may take up to a minute. Keep watching the screen as the text will only flash up and it is easy to miss.
- You can then make small adjustments so the LCD reads correctly.

The relay should be mounted to allow the operator the best access to the relay functions.

4 Disposal

The Relay should be disposed of in a manner which does not provide a threat to health or the environment. All laws and regulations specific to the country of disposal should be adhered to.

The relays and protection systems manufactured under the Reyrolle brand currently do not come within the scope of either the European WEEE or RoHS directives as they are equipment making up a fixed installation.

5 External Connections

Application diagrams are provided elsewhere in this manual (refer to section 5).

External connections include the requirement for twisted pair cables connected between MicroTAPP control devices operating in a group. The control relay at each end of the loop of twisted pair cables require bus end resistors to be connected. These are provided inside every MicroTAPP relay but only need to be connected at both ends of the twisted pair interconnections (see section 1, Appendix C of this manual).

The twisted pair cable section must be earthed at one end only.

The twisted pair cable should be a single twisted pair overall shielded cable typically 22AWG (7 x 30) 0.35mm^2 conductors. Belden cable No 8761 or equivalent is recommended – available from RS Components.

6 Earthing

Terminal 15 of the PSU (Power Supply Unit) should be solidly earthed by a direct connection to the panel earth. The Relay case should be connected to terminal 15 of the PSU. It is normal practice to additionally 'daisy chain' together the case (safety) earths of all the Relays installed in a panel to prevent earth current loops posing a risk to personnel.

7 Relay Dimensions

The relay is supplied in an Epsilon case. Diagrams are provided elsewhere in this manual.

8 Fixings

8.1 Crimps

Amp Pidg or Plasti Grip Funnel entry ring tongue

Size	AMP Ref	Reyrolle Ref
0.25-1.6mm^2	342103	2109E11602
1.0-2.6mm^2	151758	2109E11264

8.2 Panel Fixing Screws

2-Kits – 2995G10046 each comprising:

- Screw M4 X10
  2106F14010 – 4 off

- Lock Washes
  2104F70040 – 4 off

- Nut M4
  2103F11040 – 4 off

8.3 Communications

Fibre optic connections – 4 per relay (Refer to section 4 – Communications Interface).

9 Ancillary Equipment

The relay can be interrogated locally or remotely by making connection to the fibre optic terminals on the rear of the relay or the RS232 port on the relay fascia.

For local interrogation a portable PC is required. The PC must be capable of running Microsoft Windows Version 3.1 or greater. Connection is made through a standard RS232 port on the PC. A standard straight-through (not cross-over) modem cable is required to connect from the PC to the 25 pin female D type connector on the front of the relay. If only a USB port is available on the PC, a suitable USB – RS232 converter must be used.

For remote communications more specialised equipment is required.

See the section on Communications for further information, and also see Report No. 690/0/01 on Relay Communications.

10 Precautions

When running fibre optic cable, the bending radius must not be more than 50mm.

If the fibre optic cables are anchored using cable ties, these ties must be hand tightened – under no circumstances should cable tie tension tools or cable tie pliers be used.

7SG15 MicroTAPP

Automatic Voltage Control

Document Release History

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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.

7SG15 MicroTAPP

Automatic Voltage Control

Document Release History

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Pre release

2010/02	Document reformat due to rebrand

Software Revision History

Contents

1 Introduction

Voltage control systems are continually operative when in service. Any deviations in accuracy and control will directly affect the customers connected to the controlled power system. The MicroTAPP relay is a maintenance free relay, with no user serviceable parts.

Minimal checks by skilled personnel trained in relay operation and capable of observing all the necessary safety precautions and regulations appropriate to this equipment can be carried out on the relay during normal operation. Ensure that all test equipment and leads have been correctly maintained and are in good condition.

No specialist test equipment is required.

2 Tests

As the tests can be best carried out with the transformers on load, care should be taken to ensure that no operation of the tap changers can take place when settings are changed. As settings will be changed for testing purposes, the operational levels should be noted prior to testing.

3 Basic Level Set-Point

Use a good quality RMS measuring voltmeter to measure the incoming voltage transformer level. Reduce the bandwidth control to ±1% and operate the BASIC control to confirm the upper and lower limits are correct.

4 Load Drop Compensation (LDC) Set-Point

Determine the site load, the LDC is calibrated for the full site loading (firm capacity), i.e. if a site is half loaded the LDC effect will be halved. Reduce the bandwidth control to ±1%, turn the LDC control to zero and adjust the basic setting until the relay UPPER deadband limit is reached. Increase the LDC control until the LOWER deadband limit is reached. The effective LDC at this point is 2% and can be related to the dial setting to confirm the correct effect.

5 Alarms

With the tap changer disabled alter the basic setting to allow the relay to read low. Check operation of alarm contacts.

6 Completion

On completion of tests all settings can be returned to normal.

7 DEFECT REPORT FORM

Form sheet for repairs and returned goods (fields marked with * are mandatory fields)

Sender:

*** Name, first name:**	Complete phone number (incl. country code):	Complete fax number (incl. country code):
Email address:	*** Org-ID and GBK reference:**	*** AWV:**

*** Order-/ reference-no (choosing at least 1 option):**

Order-no for repair:	order-/ delivery note-no for return of commission failure:	Beginning order-no for credit note demand:

Information concerning the product and its use:

*** Order Code (MLFB):**	Firmware version: V	*** Serial number:**	
* Customer:	Product was in use approximately since:	Station/project:	Hotline Input no.:
Customer original purchase order number:	Delivery note number with position number:	Manufacturer:	

*** Type of order (choosing at least 1 option):**

☐ Repair
☐ Upgrade / Modification to …
☐ Return of commission failure
☐ Warranty repair
☐ For collection
☐ Credit Note
☐ Quotation (not repair V4 and current products! See prices in PMD)

Type of failure:

☐ Device or module does not start up
☐ Sporadic failure
☐ Permanent failure
☐ Repeated breakdown
☐ Mechanical problem
☐ Knock sensitive
☐ Temperature caused failure
☐ Failure after firmware update
☐ Overload
☐ Transport damage
☐ Failure after ca ☐ hrs in use

Error description:

☐ Display message:
(use separated sheet for more info)

☐ Active LED messages:

☐ Faulty Interface(s), which?
☐ Wrong measured value(s), which?
☐ Faulty input(s)/output(s), which?

***Detailed error description** (please refer to other error reports or documentation if possible):

*** Shall a firmware update be made during repair or mechanical upgrade of protective relays? (choosing at least 1 option)**

☐ Yes, to most recent version
☐ No
☐ Yes, actual parameters must be reusable

repair report:

☐ Yes, standard report (free of charge)
☐ Yes, detailed report (charge: 400EUR)

Shipping address of the repaired/upgraded product:

Company, department

Name, first name

Street, number

Postcode, city, country

Date, Signature

E D EA MF TCC 6 release from 11/2009

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