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 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.

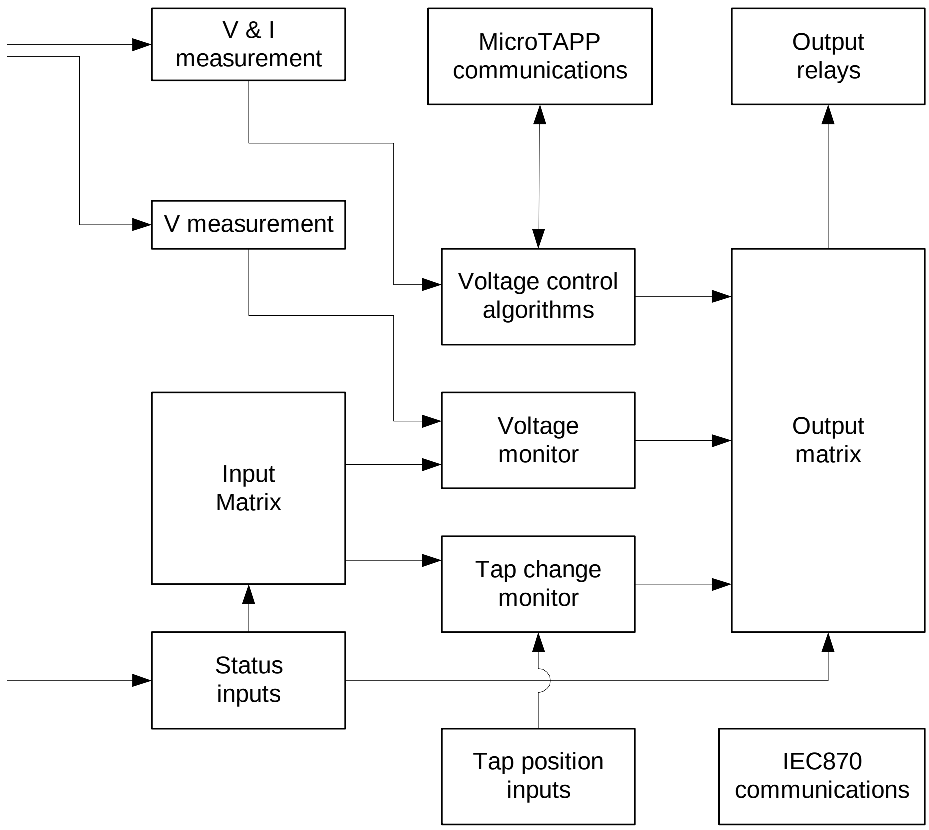


Figure 1

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.

4 Description of operation

4.1 General

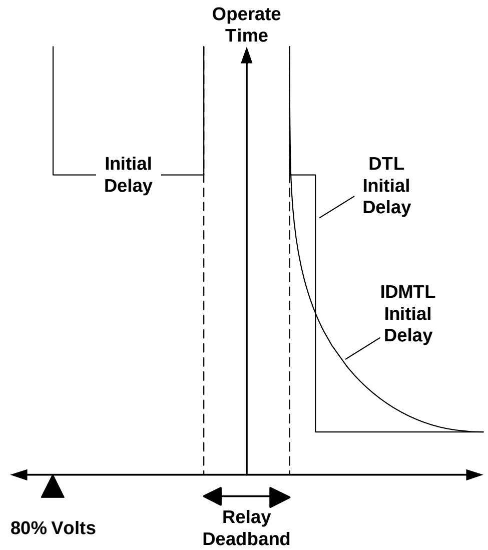


Figure 2

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.

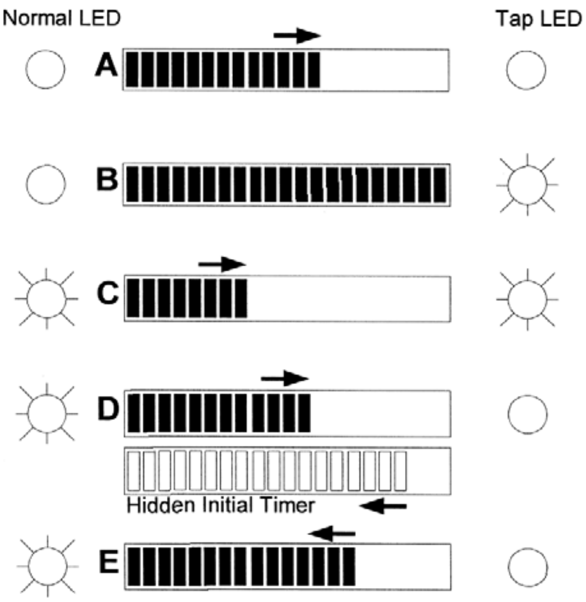


Figure 3

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.

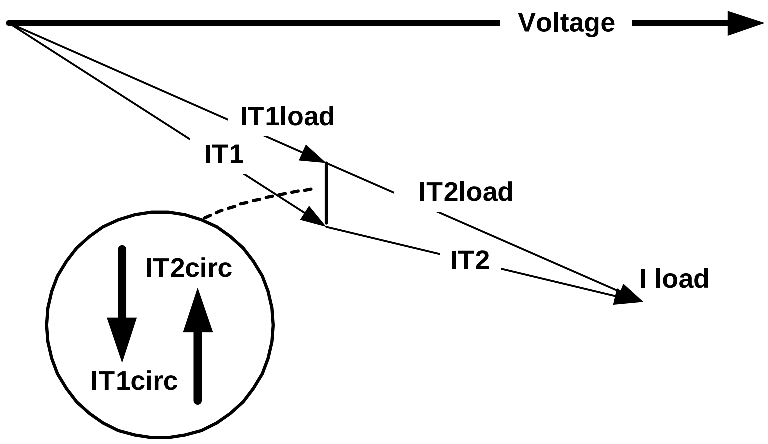


Figure 4

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.

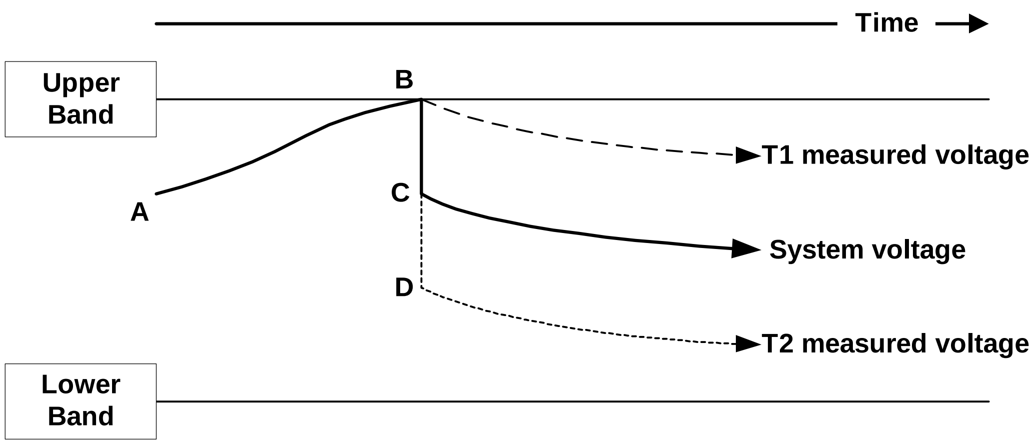


Figure 5

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.

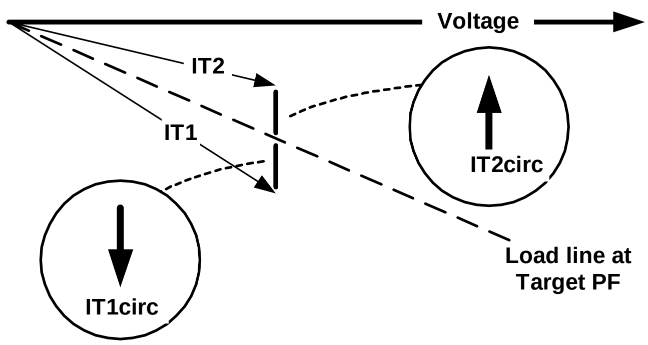


Figure 6

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.

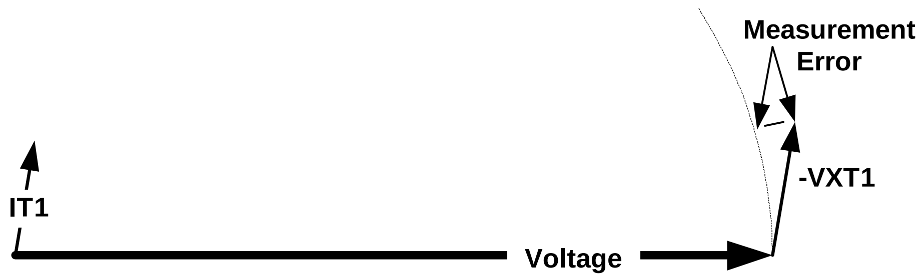


Figure 7

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.

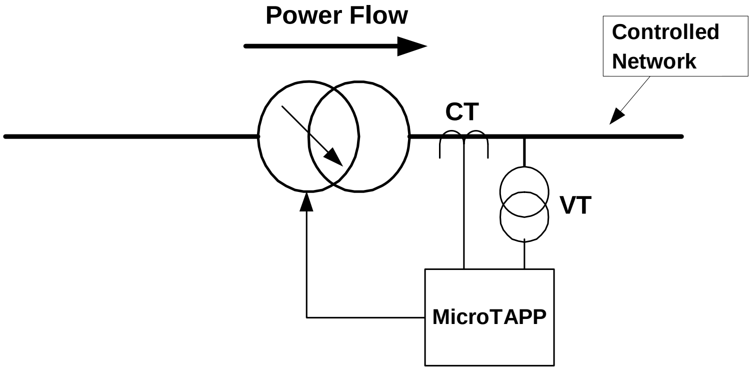


Figure 8

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.

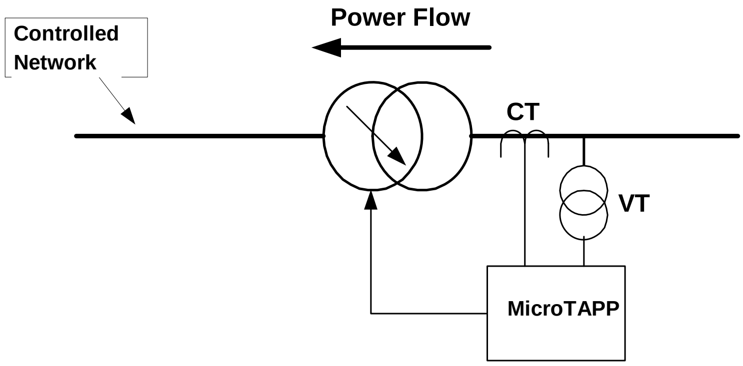


Figure 9

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: -

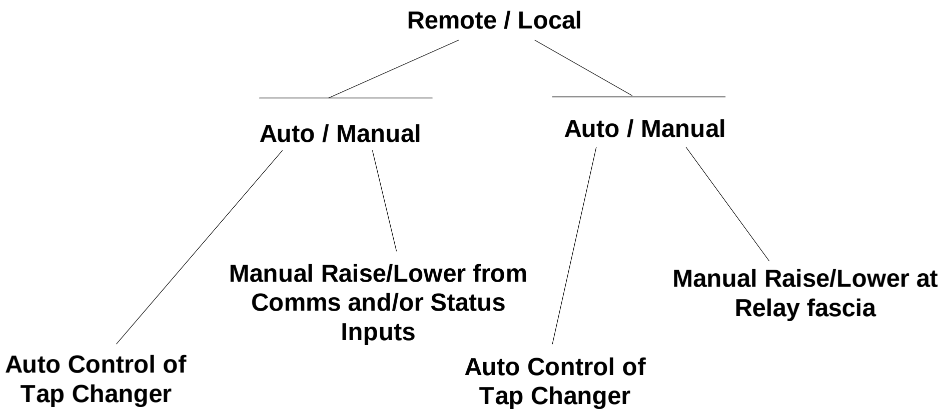


Figure 10

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.

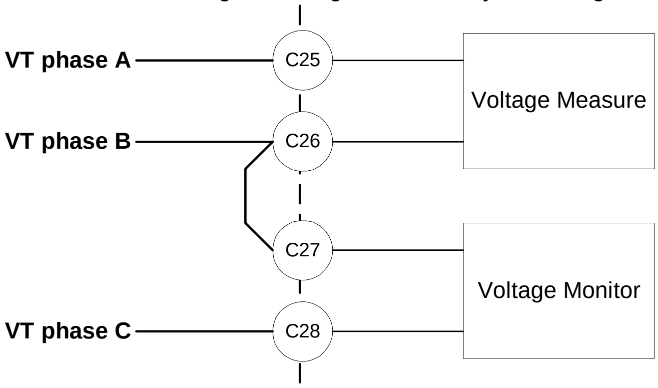


Figure 11

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.

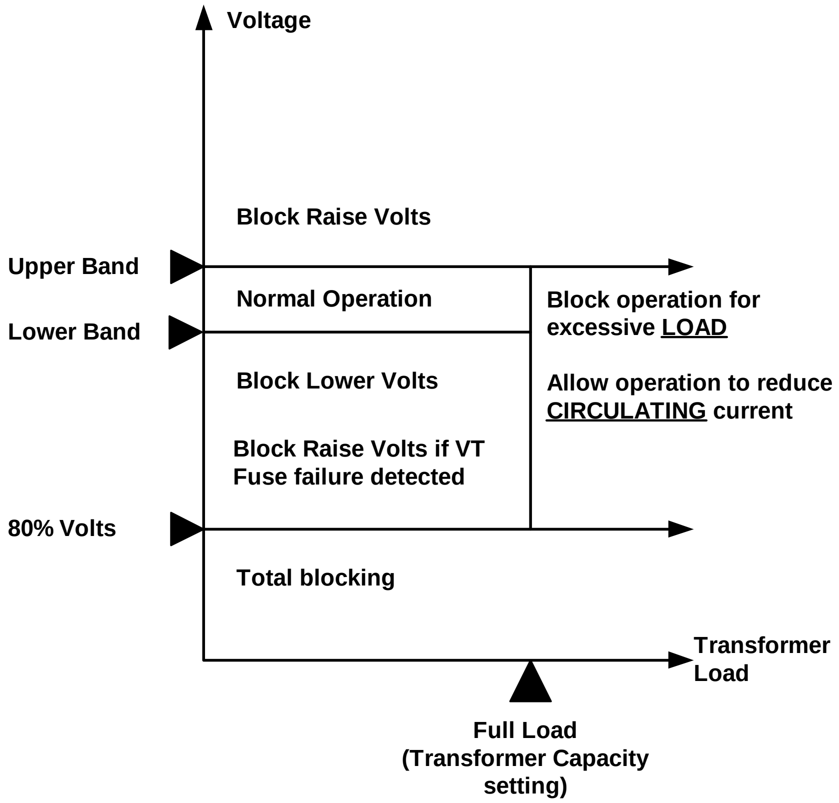


Figure 12

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:-

Error! Bookmark not defined. $$\frac{Vnps}{Vpps} \times 100\% \geq 10\% \text{ when } Vpps \geq 5V$$

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.

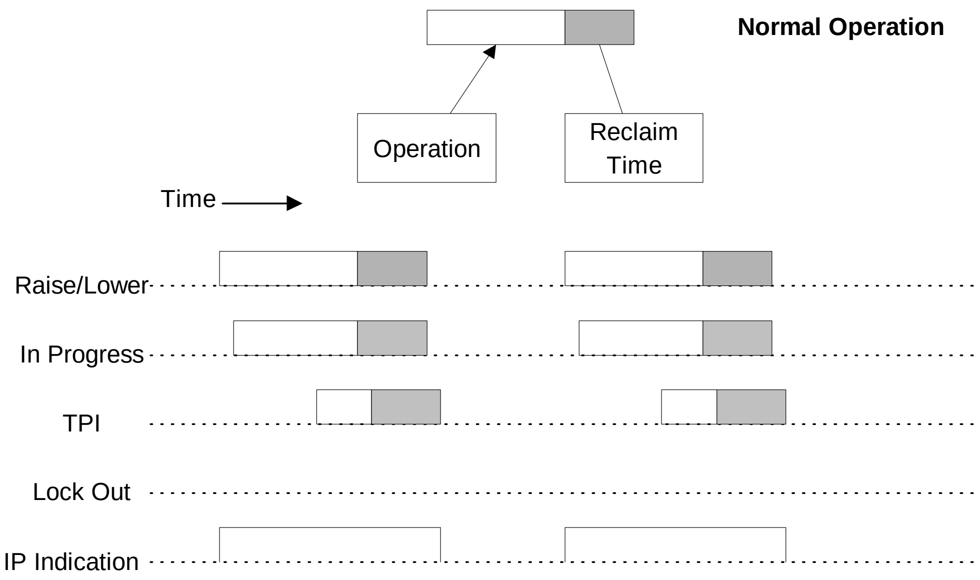


Figure 13

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.

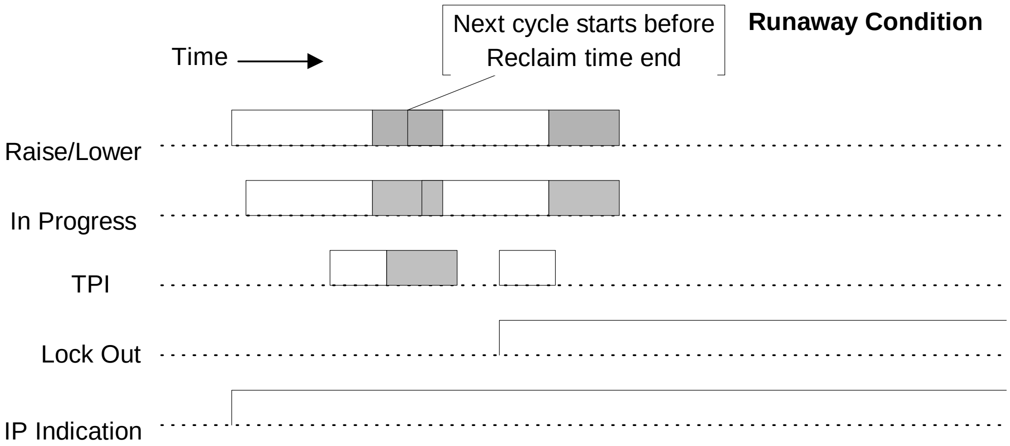


Figure 14

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.

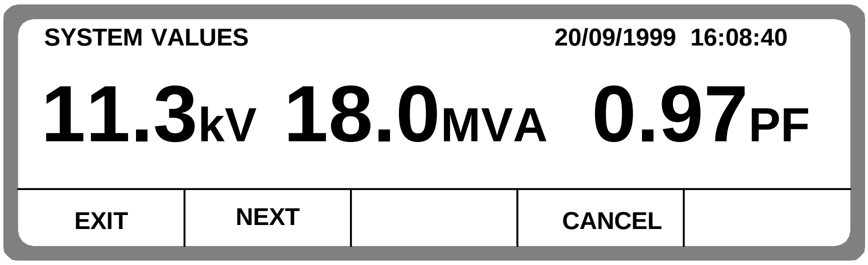


Figure 15

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.

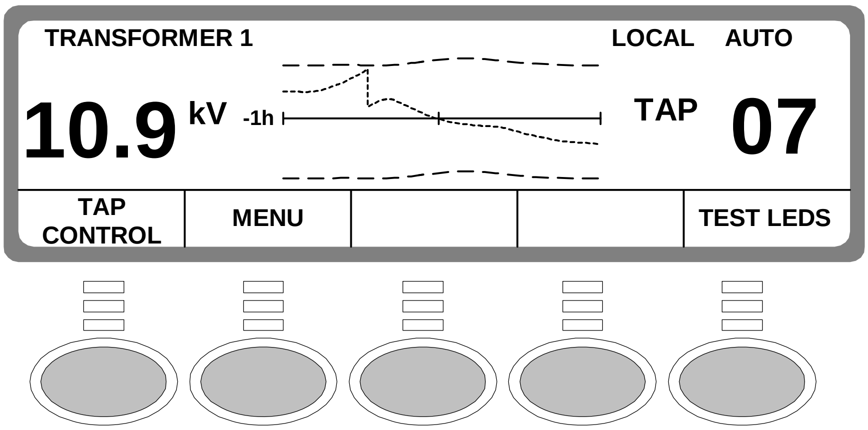


Figure 16

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.

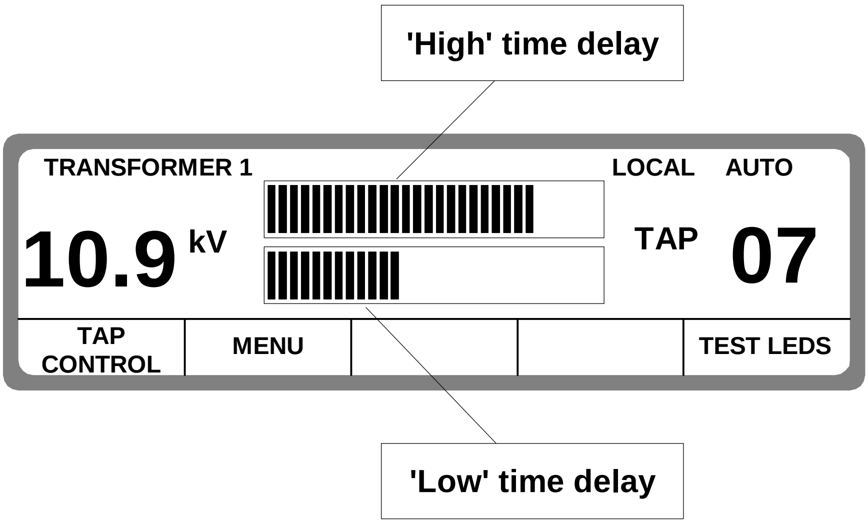


Figure 17

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.

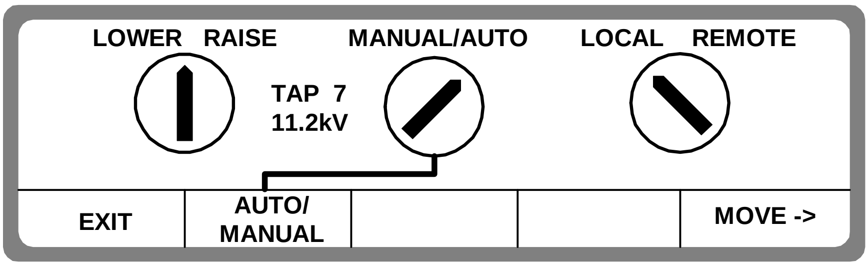


Figure 18

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]

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.

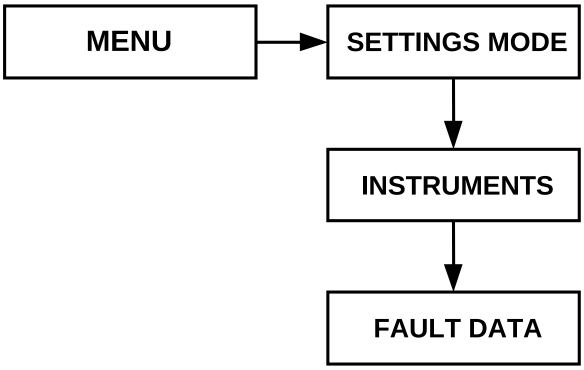


Figure 19

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.

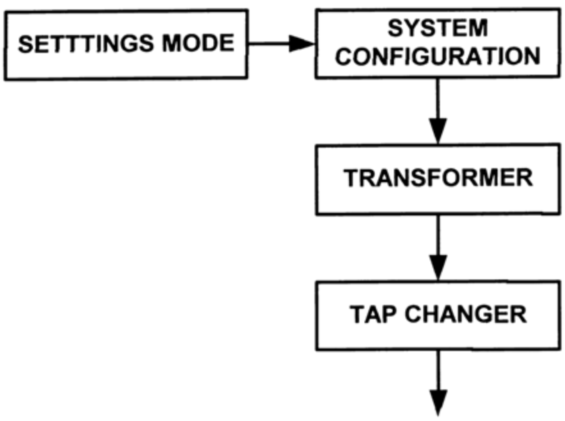


Figure 20

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	The VT voltages are not balanced. Applies only to 3-phase VT supply.	Alarm after Alarm Time setting
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.

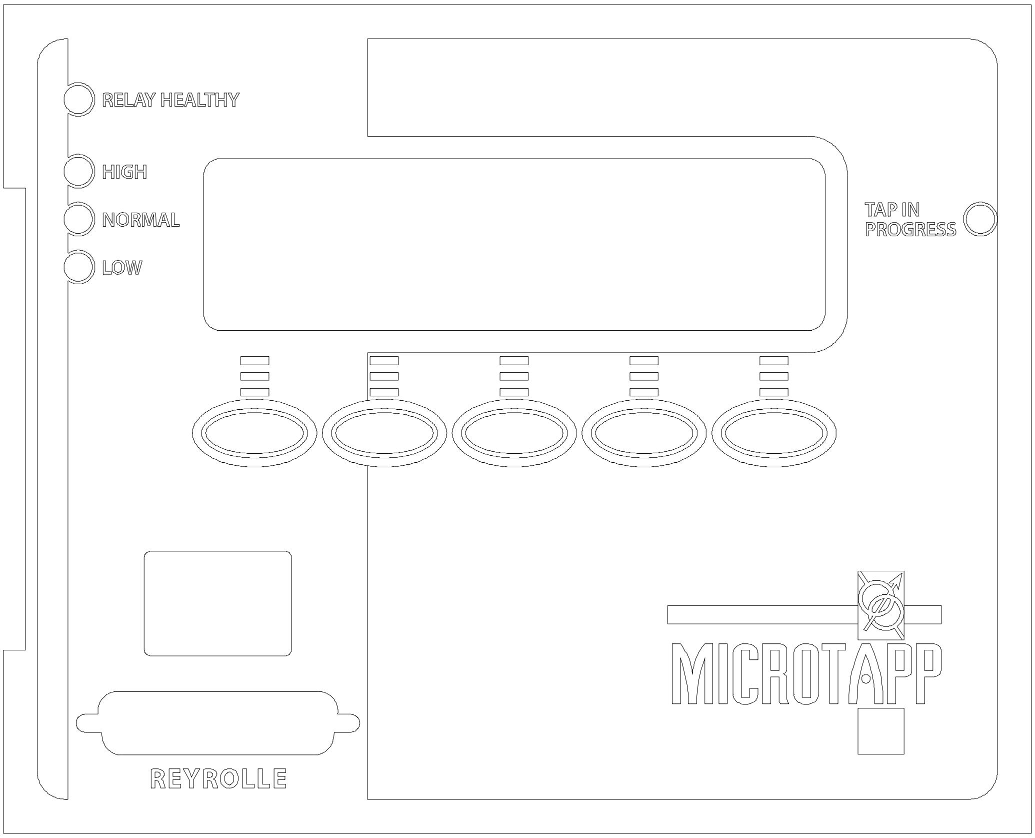
10.2 Front Cover

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

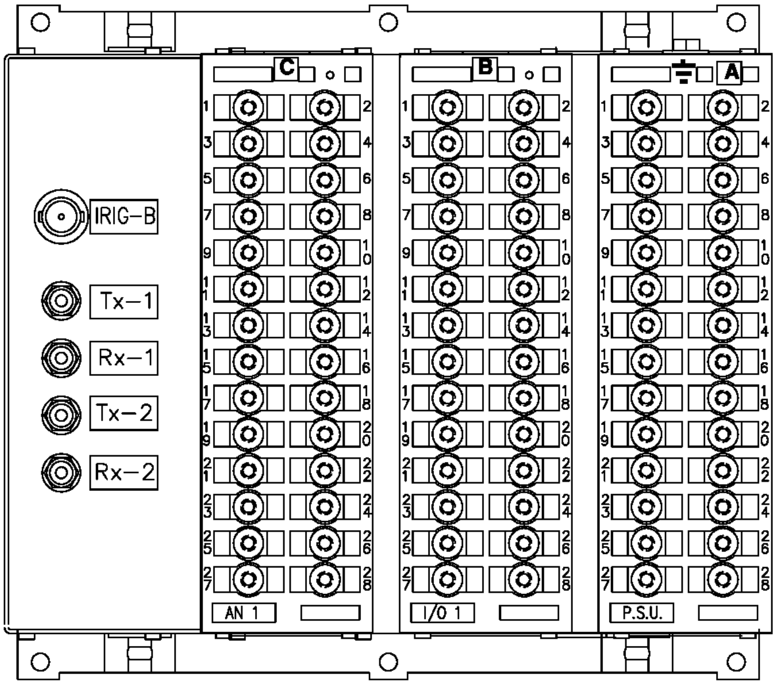
These are of the standard Epsilon design. All inputs and outputs (except for the serial communications interface) are made through these connectors. The terminal arrangement is shown in the appendix B at the end of this section

Appendix A

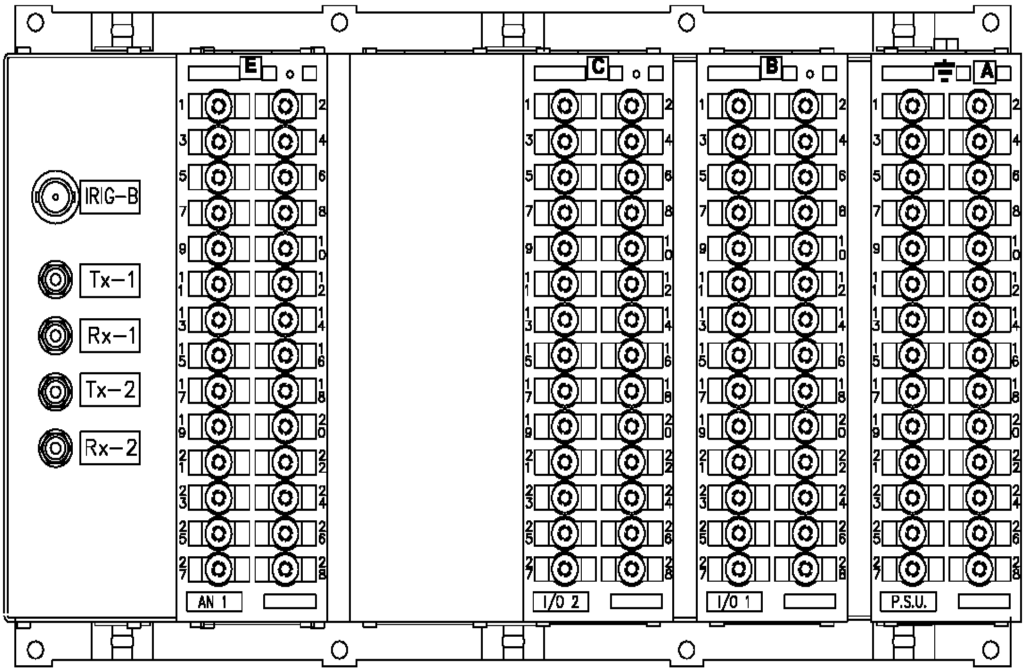

RELAY HEALTHY
HIGH
NORMAL
LOW
TAP IN PROGRESS
MICROTAPP
REYROLLE

Appendix B

MicroTAPP Rear View (E8 case)

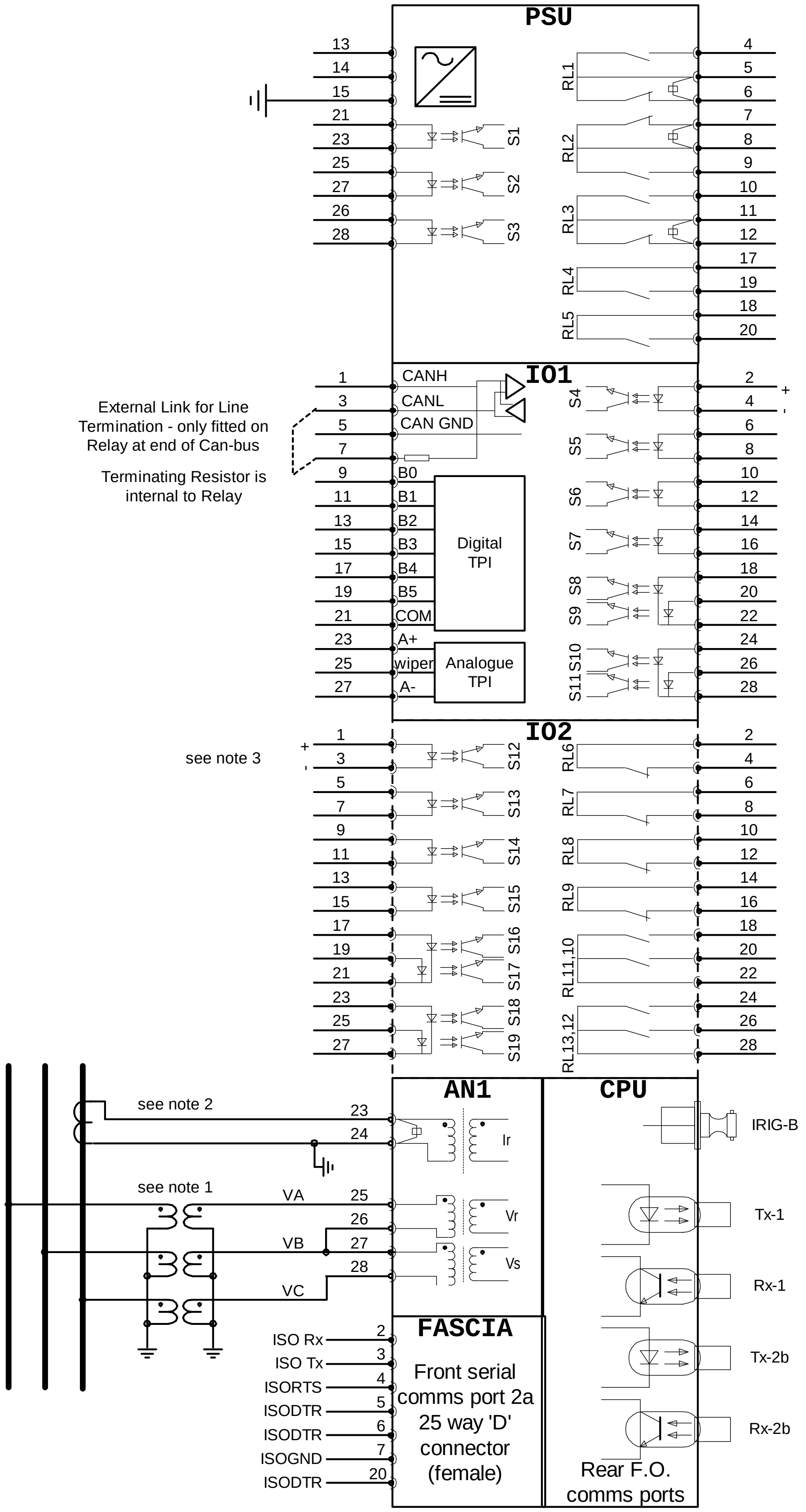


MicroTAPP Rear View (E12 case)



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.

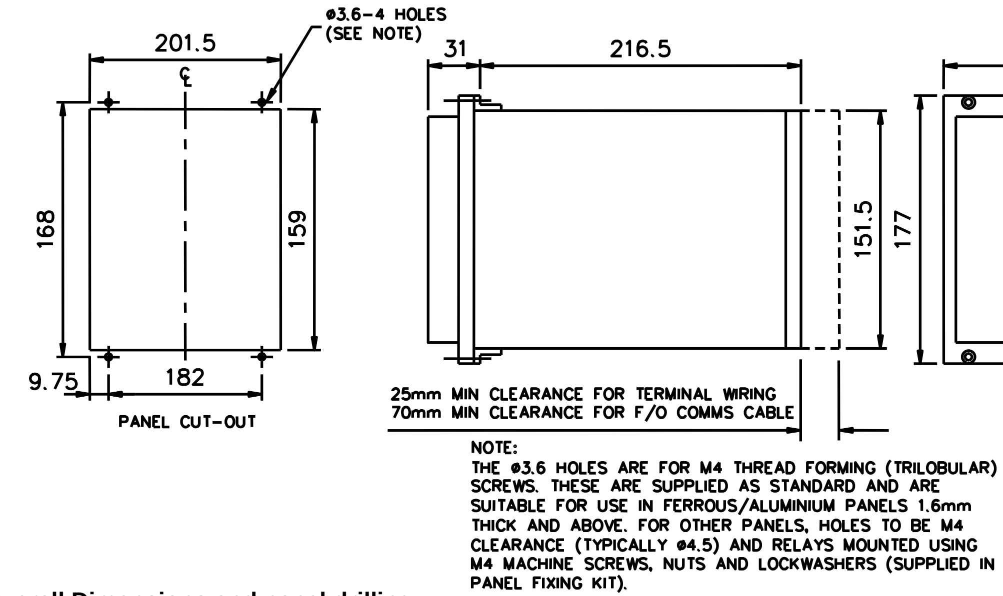
Appendix C



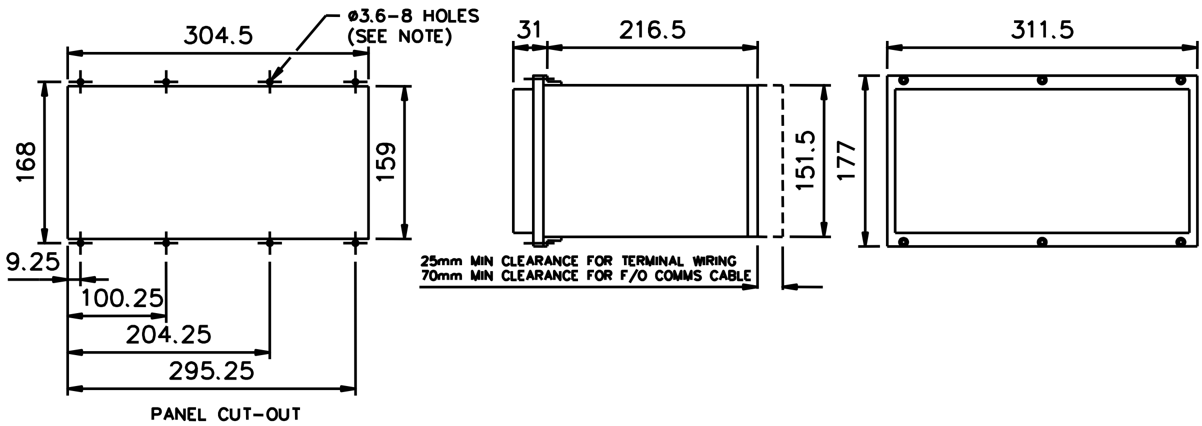
Notes

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



Overall Dimensions and panel drilling for Epsilon E8 case



Overall Dimensions and panel drillin for Epsilon E12 case