

# MiCOM ALSTOM P342/3/4/5/6

## Generator protection relays

MiCOM ALSTOM generator protection relays provide flexible and reliable integration of protection, control, monitoring and measurement functions.



Side view MiCOM ALSTOM P34x  
Generator protection relay

Extensive functionality is available to provide complete protection and control, with five models for a wide range of applications, covering most installations from small generators up to sophisticated systems including generator-transformer applications.

The variable number of opto inputs and output contacts available allow complex protection schemes to be created using the relay's powerful but easy to use "Programmable Scheme Logic" (PSL).

A choice of industry standard protocols are available on the relay, facilitating an easier integration into both new and existing network control systems.

The optional redundant ethernet board reduces the cost of ownership since the relay is natively embedded with the switch board. This reduces the amount of standalone switches needed, reducing the wiring, power supply and maintenance costs. Furthermore, increasing the availability rate decreases the risk of electrical outages.



Front view P34x

### Customer Benefits

- Extensive functionality to meet all generator and transformer protection applications
- Programmable Scheme Logic to allow easy customisation
- Flexible communications options including IEC 61850
- High break output contacts - no reliance on auxiliary devices
- Reduced cost of ownership via redundant ethernet ports

## Application

The MiCOM ALSTOM P342 is suitable for protection of generators which require cost effective high quality protection. Protection includes overcurrent, ground fault, neutral voltage displacement, sensitive or restricted ground fault, voltage dependent overcurrent or underimpedance, under and overvoltage, under and overfrequency, reverse, low forward or overpower, field failure, negative phase sequence thermal, negative phase sequence overcurrent and overvoltage, turbine abnormal frequency, generator thermal and overfluxing, rotor ground fault, rate of change of frequency, check synchronising, transformer thermal and loss of life as well as VT and CT supervision.

The P346 can be used if additional generator/ transformer differential protection is required. The P343 is suitable for protection of larger or more important generators, providing 100% stator ground fault via a 3rd harmonic measuring technique, pole slipping and unintentional energisation at standstill protection, in addition to the features of the P346. The P344 is similar to the P343 but includes a second neutral voltage input for ground fault / interturn protection. The P345 is similar to the P344 but includes 100% stator ground fault protection via a low frequency injection technique.

ANSI	IEC61850	FEATURES	P342	P343	P344	P345	P346
87GT	DifHzd/LzdPDIF/XfrPDIF	Generator/transformer differential	-	1	1	1	1
50DT	DifIntPDIF	Interturn (Split Phase)	-	1	1	1	1
50/51/67	OcpPTOC	Directional / non directional, instantaneous/ time delayed phase overcurrent	4	4	4	4	4
50N/51N	EfmPTOC	Non directional, instantaneous / time delayed phase ground fault	2	2	2	2	2
67N/67W	SenSelPTOC	Sensitive directional ground fault / wattmetric ground fault	1	1	1	1	1
64	SenRefPDIF	Restricted ground fault	1	1	1	1	1
51V	SbkOcpPVOC	Voltage dependent overcurrent	1	1	1	1	1
21	SbkUzpdDIS	Underimpedance	2	2	2	2	2
59N	VtpResPTOV	Neutral voltage displacement/residual overvoltage, interturn- measured (M), derived (D)	2M/2D	2M/2D	2M/2M/ 2D	2M/2M/2 D	2M/2M
27/59	VtpPhsPTUV/PTOV	Under/Over voltage	2/2	2/2	2/2	2/2	2/2
81U/81O/81R	FrqPTUF/PTOF/DfpPFRC	Under/Over frequency/df/dt	2/4/4	2/4/4	2/4/4	2/4/4	2/4/4
81AB	TafPTAF	Turbine abnormal frequency	6	6	6	6	6
32R/32L/32O	PwrPPWR	Reverse/Low Forward/Over power	2	2	2	2	2
40	ExcPDUP	Loss of field	2	2	2	2	2
46T	RtpTrpPTTR	Negative phase sequence thermal	2	2	2	2	2
46OC	NpsPTOC	Directional / non directional, negative phase sequence overcurrent	4	4	4	4	4
47	NpsPTOV	Negative phase sequence overvoltage	1	1	1	1	1
49G/T	ThmPTTR,Hot/TopPTTR	Stator/Transformer thermal overload	2/3/3	2/3/3	2/3/3	2/3/3	2/3/3
24	VhzPVPH	Overfluxing	5	5	5	5	5
LoL/Thru	LoLMMTR/MMXU	Loss of life/Thru fault monitor	1/1	1/1	1/1	1/1	1/1
78	PszPPAM	Pole slipping	-	1	1	1	1
27TN/59TN	StaHa3PTUV/PTOV	100% stator ground fault (3rd harmonic neutral under/over voltage)	-	1	1	1	1
64S	StaLfipeFI	100% stator ground fault (low frequency injection)	-	-	-	1	1
50/27	DmpPDMP	Unintentional energisation at standstill	-	1	1	1	1
50BF	CbfrCFB	CB Fail	2	2	2	2	2
	SvnRVCS	Current transformer supervision	1	2	2	2	2
	SvnRVCS	Voltage transformer supervision	1	1	1	1	1
25	AscRSYN	Check synchronising	2	2	2	1	1
64R	RtrLfipeFI	Rotor ground fault (available with CLIO option and P391)	Option	Option	Option	Option	Option
	RtfPTTR	RTDs x 10 PT100	Option	Option	Option	Option	Option
	CLiAlm/TrpPTUC	CLIO (4 analogue inputs+4 analogue outputs)	Option	Option	Option	Option	Option
		IRIG-B time synchronisation (modulated/demodulated)	Option	Option	Option	Option	Option
		Front communications port (EIA(RS) 232 9-pin)	1	1	1	1	1
		Rear communications port (EIA (RS)485 / K-Bus) (COMM1/RP1)	1	1	1	1	1
		Rear communications fibre optic/ethernet/ redundant ethernet port (COMM1/RP1)	Option	Option	Option	Option	Option
		2nd rear communications port (COMM2/RP2)	Option	Option	Option	Option	Option
	OptGGIO	Opto Inputs	8-24	16-32	24-32	24-32	16-32
	RlyGGIO	Output Contacts	7-24	14-32	24-32	24-32	14-32
	FnkGGIO	Function Keys	-	-	-	10	-
	LedGGIO	Programmable LEDs, Red/Green/Yellow (R/G/Y)	8R	18R/G/Y	18R/G/Y	18R/G/Y	18R/G/Y

**Global functions**

The following global functions are generally available in all devices:

- 4 setting groups
- Metering
- Event recording
- Disturbance recording
- Fault recording
- Trip circuit supervision via PSL
- Breaker state and condition monitoring
- 6 languages - English, French, German, Spanish, Russian, Chinese

**Main protection functions**

The main protection functions are autonomous and can be individually enabled or disabled to suit a particular application. Each protection function is available in 4 separate setting groups which can be individually enabled or disabled. 3-phase tripping with faulted phase indication is provided for all protection functions.

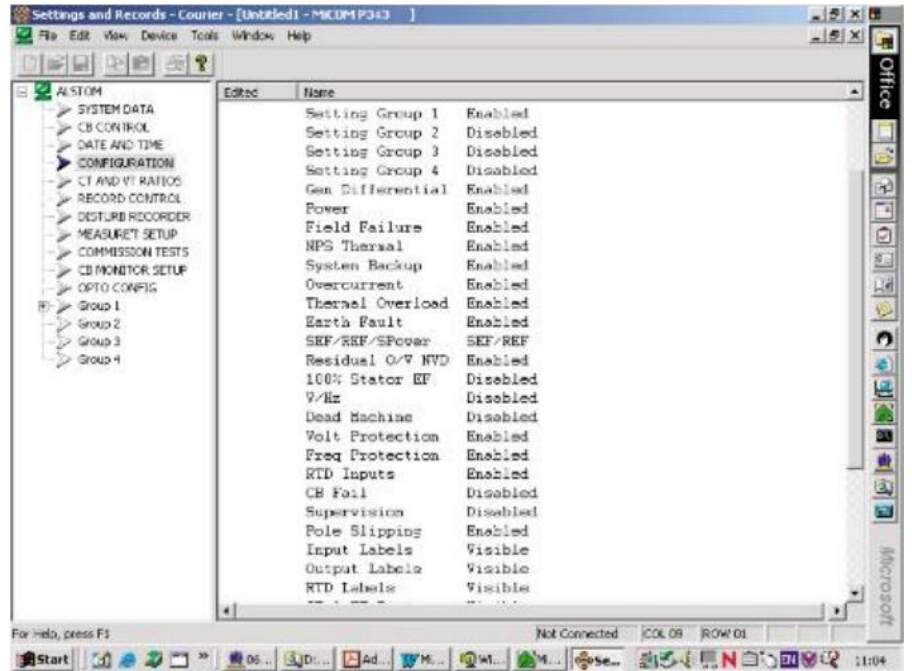
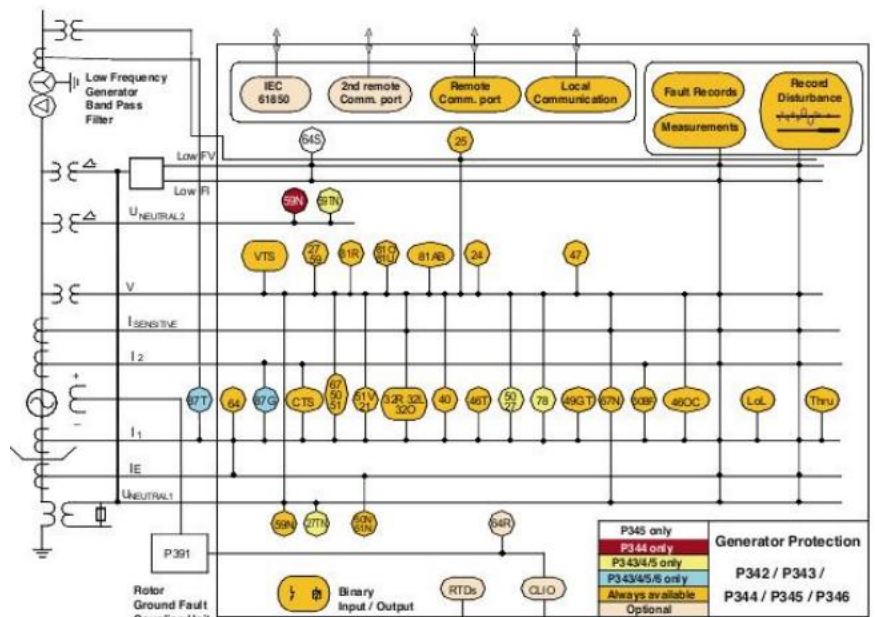


Figure 1 Simple function selection by mouseclick

**Functional Overview**



**MiCOM ALSTOM P342/3/4/5/6: Comprehensive protection for all your generator protection requirements**

### Generator/transformer differential(P343/4/5/6 only)

3-phase generator differential protection is provided to detect stator phase faults. This can be set as either a percentage bias scheme with a dual slope characteristic or as a high impedance scheme. When high impedance is used, additional stabilising resistance and a metrosil will be required. 3-phase biased generator-transformer differential protection is provided to detect phase faults. This includes ratio and vector compensation as well as 2nd and 5th harmonic restraint for transformer inrush currents and overfluxing. Two high set differential elements are provided to ensure rapid clearance of high fault currents.

### Interturn (split phase) differential(P343/4/5/6 only)

On generators with multi-turn coils and two or more windings per phase, such as hydrogenerators, interturn (split phase) differential may be used to detect turn to turn faults.

The element operates as a definite time overcurrent function with independent current setting per phase. It should be noted that when using this function the generator differential protection is not available.

### Interturn (residual overvoltage)

On generators with multi-turn or single turn coils interturn protection can be provided by measuring the residual voltage across the 3-phase windings. To prevent operation for external faults, a negative phase sequence apparent power and a directional negative phase sequence overcurrent element can be used to interlock the residual overvoltage element in PSL.

### 100% stator ground fault 3rd harmonic method (P343/4/5 only)

Third harmonic neutral undervoltage protection covers the final 15% of the stator winding and, in conjunction with the other ground fault elements, provides 100% ground fault protection for the stator. This is supervised by a 3-phase undervoltage element. Additional supervision using 3-phase active, reactive and apparent power can be enabled if required. A third harmonic neutral overvoltage protection is also provided for applications where the measurement is available at the terminal end of the generator. The blocking features of the undervoltage element are not required for this application.

### 100% stator ground fault low frequencyinjection method (P345 only)

Injecting a 20 Hz voltage to detect ground faults at the neutral point or terminals of generators is a reliable method for detecting ground faults in the entire generator and all electrically connected equipment. It has an advantage over the third harmonic method in that it is independent of the generator's characteristics and the mode of operation. Also, protection is possible at generator standstill. The protection relay measures the injected 20 Hz voltage and the flowing 20 Hz current. When the generator is operating normally, only a small amount of 20Hz current will flow as a result of the stator capacitance to ground. When a ground fault occurs on the generator stator windings the 20Hz current will increase. Two underresistance and one overcurrent stage of definite time protection are available. The measurement circuit is also monitored with a 20Hz undervoltage and undercurrent element which can be used to block the protection.

### Phase overcurrent

Four independent overcurrent stages are available. Each stage may be selected as non-directional or directional (forward/reverse). All stages have definite time (DT) delayed characteristics, two of the stages may also be independently set to one of nine inverse definite minimum time (IDMT) curves (IEC and IEEE). The IDMT stages have a programmable reset timer for grading with electromechanical relays and to reduce clearance times where intermittent faults occur. The phase fault directional elements are internally polarised by quadrature phase-phase voltages, and will make a correct directional decision down to 0.5 V ( $V_n = 110/120$  V) or 2.0 V ( $V_n = 380/440$  V). A synchronous polarising signal is maintained for 3.2s after voltage collapse to ensure that the instantaneous and time delayed overcurrent elements operate correctly for close-up 3-phase faults.

### Standard ground fault

The standard ground fault element operates from a ground fault input connection to measure the fault current in the ground path of the generator. Two independent stages are available. Both stages have definite time (DT) delayed characteristics, the first stage may also be independently set to one of nine inverse definite minimum time (IDMT) curves (IEC and IEEE).

### Sensitive ground fault

A core balance CT should be used to drive the sensitive ground fault function. The directionality is provided by the residual voltage.

## MiCOM ALSTOM P343/4/5: 100% stator ground fault and pole slipping protection for large machines

### Wattmetric

The sensitive ground fault protection is also suitable for Petersen Coil grounded systems by enabling a wattmetric element. This form of protection uses the sensitive ground fault protection directional characteristic, but with a directional residual power threshold providing an additional constraint on operation.

### Restricted ground fault

The restricted ground fault protection may be configured either as a high impedance or low impedance biased differential. When high impedance is used, additional stabilising resistance and a metrosil will be required.

### Voltage dependent overcurrent/underimpedance

In order to provide backup protection for phase faults, an element is included which can be set as either voltage controlled overcurrent, voltage restrained overcurrent or underimpedance. If selected as voltage controlled or voltage restrained overcurrent, the timing characteristic can be set as either definite time or IDMT. If selected as underimpedance, a 2 stage, 3-phase non-directional underimpedance element is provided.

### Neutral displacement/residual overvoltage

Residual overvoltage protection is available for detecting ground faults where there is an isolated or high impedance ground. The residual voltage can be measured from a broken delta VT, from the secondary winding of a distribution transformer ground at the generator neutral, or can be calculated from the 3-phase to neutral voltage measurements. Each stage can be set with a definite time delay or an inverse time delay characteristic. The P342/3/4/5/6 have 2 measured and 2 calculated stages of residual overvoltage protection. The P344/5 have an additional neutral voltage input and thus have an additional 2 stages of measured residual overvoltage protection.

### Under/overvoltage

Under/overvoltage protection may be configured to operate from either phase-phase or phase-neutral voltage elements. Two independent stages with definite time elements are available for under and overvoltage protection. The first stage can also be configured to an inverse time characteristic.

### Under/overfrequency

Two independent stages of overfrequency and four of underfrequency are provided. Each stage functions as a definite time element.

### Turbine abnormal frequency

Turbine abnormal frequency protection is included to protect the turbine blade from potential damage due to prolonged under/overfrequency operation of generators. Up to six frequency bands can be programmed, each having an integrating timer to record the time spent within the band. The time in each band is stored in battery backed memory so that loss of auxiliary supply to the relay does not lead to a loss of the recorded time. When the time within a band has reached the user set limit, an alarm can be raised to initiate investigation and maintenance.

### Rate of change of frequency

Four definite time delayed stages of  $df/dt$  protection are included which can be used for loss of grid or load shedding applications. The number of frequency averaging cycles, number of protection iterations, operating mode - fixed or rolling window - and direction of operation can be set to suit the application.

### Power protection

The power protection element provides two stages which may be independently configured to operate as reverse power (RP), over power (OP) or low forward power (LFP) protection. The direction of the power measured by the protection can be reversed by selecting the operating mode, generating/motoring. The power protection can be used to provide simple overload protection (OP), protection against motoring (RP, generating mode), CB interlocking to prevent overspeeding during machine shutdown (LFP, generating mode) and/or loss of load protection (LFP, motoring mode). In addition to the standard 3-phase power protection, a single-phase power protection element which uses the sensitive ground fault current input is available.

### Loss of field

To detect failure of the machine excitation, a two stage offset Mho impedance element is provided. This allows a small instantaneous characteristic to be used to provide fast tripping for loss of excitation at high power outputs, where system stability could be affected. The second stage can be set with a larger time delayed characteristic to provide stable, secure tripping under low power conditions. Integrating timers are provided to enable the impedance characteristic to provide time delayed pole slipping protection. A power factor alarm element is also available to offer more sensitive protection for unusual operating conditions, for example a lightly loaded unit operating as an induction generator.

### Negative phase sequence thermal

To protect against unbalanced stator currents caused by external faults or unbalanced loading, two stages of negative sequence protection are provided. These comprise a definite time alarm stage and a trip stage that operates with a thermal characteristic.

### Negative phase sequence overcurrent

Four definite time negative phase sequence overcurrent stages are included. Each stage may be selected as non-directional or directional (forward/reverse) and can operate for remote phase-phase and phase-ground faults even with delta-star transformers present.

### Negative phase sequence overvoltage

One definite time stage of negative phase sequence overvoltage protection is provided. Negative phase sequence overvoltage protection can be used for the detection of voltage unbalance which can quickly lead to overheating and damage of generators.

### Overfluxing

To protect the generator or connected transformer against overexcitation a five stage V/Hz element is provided. The first stage is a definite time alarm, the second stage can be used to provide an inverse/definite time trip characteristic and stages 3/4/5 are definite time.

### Unintentional energisation at standstill (P343/4/5 only)

If the machine circuit breaker is closed accidentally, when the machine is not running, very high current will result. A voltage supervised overcurrent scheme is available to protect against this condition. When the machine voltage is low, that is, the machine is not running, an instantaneous overcurrent element is enabled. Timers ensure that the element will be stable for normal voltage dips that could occur for system faults or machine reconnection.

### Pole slipping (P343/4/5 only)

The pole slipping protection uses the variation in "apparent" impedance as seen at the generator's terminals to detect pole slipping. If the measured impedance crosses the two halves of the lens characteristic and spends longer than a specified time in each half, a pole slip is counted. Two zones are created by a reactance line which is used to distinguish whether the impedance centre of the pole slip is located in the power system or in the generator. Separate counters are used to count pole slips in the 2 zones. A setting is also provided to determine whether the protection operates in a generating mode, motoring mode or both.

### Resistance temperature detectors (RTDs)

In order to monitor temperatures accurately, an option allowing measurement of temperatures using up to 10 platinum RTDs is available. This provides an instantaneous alarm and time delayed trip output for each RTD.

### Generator thermal overload

To monitor the thermal state of a generator, a thermal replica protection is provided. The thermal element has a trip and an alarm stage. Positive and negative sequence currents are taken into account so that any unbalance condition can be detected and any abnormal heating of the rotor can be avoided. There are separate time constants for heating and cooling and in the event of a loss of auxiliary supply the thermal state is stored in non-volatile memory.

Transformer thermal overload, Loss of Life (LoL)

The transformer thermal overload and LoL functions are based on the IEEE Standard C57.91-1995. Two three-stage definite time -delayed trip elements based on hot spot and top oil temperature are available for transformer overload protection. A pre-trip alarm is also provided.

Frequent excesses of transformer rated current or operation at elevated temperatures will shorten the life expectancy of the transformer. The relay provides a transformer LoL calculation, using a thermal model that estimates the hot spot temperature.

### Blocked overcurrent logic

Each stage of overcurrent and ground fault protection can be blocked by an optically isolated input. This enables the overcurrent and ground fault protection to be integrated into a blocked overcurrent busbar protection scheme.

### Analogue (Current Loop) Inputs and Outputs (CLIO)

Four analogue (or current loop) inputs are provided for transducers with ranges of 0-1mA, 0-10mA, 0-20mA or 4-20mA. The analogue inputs can be used for various transducers such as vibration monitors, tachometers and pressure transducers. Associated with each input there are two time delayed protection stages, one for alarm and one for trip.

Each stage can be set for 'over' or 'under' operation. Four analogue (or current loop) outputs are provided with ranges of 0-1mA, 0-10mA, 0-20mA or 4-20mA, which can alleviate the need for separate transducers. These may be used to feed standard moving coil ammeters for analogue indication of certain measured quantities or into a SCADA using an existing analogue RTU.

### Rotor ground fault

Rotor ground fault protection is used to detect ground faults in the excitation circuit of synchronous machines. The rotor ground resistance is measured using an external low frequency square wave injection, coupling and measurement unit and a P391 connected to the rotor circuit. The measurement of the rotor resistance is passed to the P34x via a current loop output (0-20mA) on the P391 connected to one of the four current loop inputs on the P34x. The rotor ground fault protection is only available if the relay includes the CLIO hardware option. Two underresistance stages of definite time protection are available for alarm and trip. The injection frequency is selectable at 0.25/0.5/1Hz via a jumper link in the P391.

### Phase rotation

A facility is provided to maintain correct operation of all the protection functions even when the generator is running in a reverse phase sequence. This is achieved through user configurable settings available in four setting groups. The phase rotation for all 3-phase currents and voltages can be reversed. Also, for pump storage applications where 2 phases are swapped for pumping operation, the swapping of the phases can be emulated in the relay via settings for the 3-phase currents and voltages.

## Supervisory Functions

### Circuit breaker failure protection

Two stage circuit breaker failure protection may be used for tripping upstream circuit breakers and/or the local secondary trip coil. The circuit breaker failure logic may also be initiated externally from other protection devices if required. The P343/4/5/6 CB fail logic can be set to use current measurement from any of the 2 sets of 3-phase current inputs. Typically CB failure protection uses the CTs on the busbar side of the generator.

### Voltage transformer supervision

Voltage transformer supervision (VTS) is provided to detect loss of one, two or three VT signals, providing indication and inhibition of voltage dependent protection elements. An optically isolated input may also be configured to initiate the voltage transformer supervision alarm and blocking when used with miniature circuit breakers (MCBs) or other external forms of voltage transformer supervision.

### Current transformer supervision

Current transformer supervision (CTS) is provided to detect loss of phase CT signals and inhibit the operation of current dependent protection elements. CTS is provided for both sets of 3-phase CTs in the P343/4/5/6 relays. A patented differential CTS is also provided to detect loss of phase CT inputs. Operation of the differential protection can be blocked during a CT failure, or alternatively temporarily desensitised to avoid an unwanted trip.

## Through fault monitoring

Through faults are a major cause of transformer damage and failure, stressing the insulation and mechanical integrity. An  $I^2t$  calculation based on the recorded duration and maximum current is stored for each phase. Cumulative stored calculations for each phase are monitored so that the user may schedule the transformer maintenance or identify a need for system reinforcement to reduce the fault level based on this data.

## Plant supervision

### Trip circuit monitoring

Monitoring of the trip circuit in both breaker open and closed states can be realised using the programmable scheme logic.

### Circuit breaker state monitoring

An alarm will be generated if there is a discrepancy between the open and closed contacts of the circuit breaker.

### Circuit breaker condition monitoring

The circuit breaker condition monitoring features include:

- monitoring the number of breaker trip operations
- recording the sum of the broken current quantity  $I_x$ ,  $1.0 \times 2.0$
- monitoring the breaker operating time
- monitoring the fault frequency counter

## Control

### Circuit breaker control and check synchronising

Circuit breaker control is available from the front panel user interface, optically isolated inputs and remotely via the substation communications. Check synchronising is included to verify that the generator frequency, voltage magnitude and phase angle match the system's before allowing the generator breaker to be closed. Transformer vector compensation is also included.

## Comprehensive post-fault analysis and communication options

### Programmable scheme logic

Programmable scheme logic allows the user to customise the protection and control functions. It is also used to program the functionality of the optically isolated inputs, relay outputs and LED indications.

The programmable scheme logic may be configured using the graphical S1 Studio PC based support software, as illustrated in figure 2.

### Independent protection settings groups

The settings are divided into two categories: protection settings and control and support settings. Four setting groups are provided for the protection settings to allow for different operating conditions and adaptive relaying.

### Control inputs

The ON/OFF status of 32 control inputs can be changed manually or remotely via the communications to provide user defined control functions.

### Function keys (P343/4/5/6 only)

Ten function keys are available for implementing scheme control functionality. The function keys operate in two modes, normal and toggled, and activate associated signals in PSL that can easily be used to customise the application. Each function key has an associated tri-colour LED (red, green, yellow) allowing for clear indication of the associated function's state.

### Indication

Eighteen tri-colour LEDs (P343/4/5/6) or 8 red LEDs (P342) are available for user programming. The P343/4/5/6 LED colours (red, green or yellow) are driven via digital databus signals in PSL and can be programmed to indicate up to four conditions/states for example.

- Off - Not in service
- Red - CB closed
- Green - CB open
- Yellow - CB not healthy

### Information interfaces

Information exchange is done via the local control panel, the front PC interface, the main rear communications interface (COMM1/RP1) or an optional second rear interface (COMM2/RP2).

### Local communication

The front EIA(RS)232 Courier communication port has been designed for use with the S1 Studio software and is primarily for configuring the relay settings and programmable scheme logic. It is also used to locally extract event, fault and disturbance record information and can be used as a commissioning tool by viewing all relay measurements simultaneously.

### Rear communication

The main rear communications interface supports the five protocols listed below (selected at time of order) and is intended for integration with substation control systems.

- Courier/K-Bus
- Modbus
- IEC 60870-5-103
- DNP 3.0
- IEC61850

IEC 61850 is available when the optional ethernet or redundant ethernet port is ordered. IEC 61850 offers high-speed data exchange, peer-to-peer communication, reporting, disturbance record extraction and time synchronisation. An optional fibre-optic interface is available for any of the above protocols. An optional 2nd rear communications port with the Courier protocol is available. This port is intended for central settings or remote access with S1 Studio. Clock synchronisation can be achieved using one of the protocols or using the IRIG-B input or using an opto input.

### Redundant ethernet ports (IEC61850)

Px4x devices can be enhanced with an optional redundant ethernet board. The redundancy is managed by the market's fastest recovery time protocols: self healing protocol and dual homing protocol allowing bumpless redundancy. Furthermore, the RSTP (Rapid Spanning Tree) protocol is also available. The redundant ethernet board supports either modulated or demodulated IRIG-B and the SNTP protocol for time synchronisation. The redundant ethernet board also has a watchdog relay contact to alarm in case of a failure.



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