MiCOM P341
Interconnection Protection Relay

The MiCOM Interconnection Protection Relay offers the protection requirements necessary for operating machines in parallel with the main power supply network. It provides flexible and reliable integration of protection, control, monitoring and measurements. Extensive functionality is available to satisfy complete protection and control for a wide range of system applications, including protection for both connection and generator in simple applications or the more sophisticated interconnection protection necessary for larger units or those connected at higher voltages.

The P341 also provides Dynamic Line Rating (DLR) protection to optimize transmission line capacity enabling a larger penetration of distributed generation (DG) such as windfarms.

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 logic.

A customer 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 stand alone switches needed, reducing the wiring, power supply and maintenance costs. Furthermore, increasing the availability rate decreases the risk of electric outages.

APPLICATION
With embedded generators running in parallel with the normal public supply there is a risk that, due to fault clearances on the external system, the embedded generator may become disconnected (islanded) also from the main supply network. The machines may continue to supply external load and there is a significant risk the islanding may cause loss of system earth where the system earth is on the star winding of a network transformer, poor quality of supply to local loads and unsynchronised reconnection due to auto-reclosure of the remote circuit breaker.

Rate of change of frequency and voltage vector shift protection functions are provided to detect this loss of mains/grid (or islanded) condition.

The P341 also provides overcurrent and ground fault, under and overvoltage, under and overfrequency, thermal overload, negative phase sequence overcurrent and overvoltage and power protection for the point of connection of the embedded generator and supply network.

Check synchronising is also included to supervise the closing of the circuit breaker.

The P341 also provides Dynamic Line Rating protection to optimize transmission line capacity enabling a larger penetration of distributed generation such as windfarms.
## FUNCTIONS OVERVIEW

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### Functional Overview

(Description of ANSI code nos., see Protection Function Overview)
GLOBAL FUNCTIONS
The following global functions are generally available:
- 4 setting groups
- Metering
- Event recording
- Disturbance recording
- Fault recording
- 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.

Three phase tripping with faulted phase indication is provided for all protection functions.

Rate of Change of Frequency
The four df/dt stages can be used to detect the fluctuation in frequency that will occur as the machine adjusts to the new load conditions following loss of the grid or can be used for 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.

To improve stability for external system events an adjustable definite time delay can be used.

Voltage Vector Shift
This protection measures the instantaneous change in the three phase voltage angle that occurs when the connection to the main supply network is lost. To provide stability this element must be less sensitive than the rate of change of frequency element. However, it operates without any intentional time delay, providing fast tripping.

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, to reduce autoreclose dead times 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 0.5V (Vn = 110/120V) or 2.0V (Vn = 380/440V). 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 three phase faults.

Standard Ground Fault
The standard ground fault element operates from a residual current that is derived internally from the summation of the three phase currents.

The directionality of the ground fault elements is provided by either residual voltage or negative sequence voltage. Voltage transformer supervision (VTS) can be used to block the directional element or to revert it to non-directional.

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

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 sensitive ground fault element may be configured as a high impedance differential restricted ground fault element. When high impedance restricted ground fault protection is used an additional stabilising resistance and a metrosil will be required.

Blocked Overcurrent Logic
Each stage of overcurrent, ground fault and sensitive 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.

Neutral Displacement/Residual Overvoltage
Two stages of measured and calculated residual overvoltage (or neutral voltage displacement) protection are provided in the P341. Depending on the VT configuration, the protection will operate from either an internally calculated value from the 3 phase to neutral voltage measurements or a directly measured value of residual voltage from a broken delta VT or from the secondary winding of a distribution transformer ground at the generator neutral.

The P341 first stage can be configured for either inverse time or definite time operation, with all subsequent stages definite time only.

This function provides protection against ground faults irrespective of the system grounding connection used.

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/Over Frequency
The P341 provides two independent stages of overfrequency and four of under frequency. Each stage functions as a definite time element.

Power Protection
The selectable power element can be used to provide loss of mains protection whether the normal power flow is into or out of the utility system, tripping when import power reverses, or export power exceeds normal limits. In addition to the standard 3 phase power protection (minimum setting 2% Pn) a sensitive single phase power protection element can be used (minimum setting 0.5% Pn) which uses the sensitive ground fault current input.

Thermal Overload
To monitor the thermal state of a generator or a feeder, 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 loss of auxiliary supply the thermal state is stored in non volatile memory.

Negative Phase Sequence Overcurrent
Four definite time negative phase sequence overcurrent stages are available within the P341.

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 within the P341. Negative phase sequence overvoltage protection can be used for the detection of voltage unbalance which will quickly lead to overheating and damage of generators.

Analog (Current Loop) Inputs and Outputs (CLIO)
Four analog (or current loop) inputs are provided for transducers with ranges of 0-1mA, 0-10mA, 0-20mA or 4-20mA. The analog 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 analog (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 analog indication of certain measured quantities or into a SCADA using an existing analog RTU.
Dynamic Line Rating (DLR) (P341 V7x Software)
The P341 provides Dynamic Line Rating (DLR) protection to optimize transmission line capacity. Gains of 20 to 50% can be achieved, depending on the environmental conditions, enabling more Distributed Generation (DG) such as windfarms to be connected to the grid by taking into account the real-time weather conditions to calculate the line rating compared to using the fixed summer/winter line ratings.

DLR is a cost-effective alternative to reinforcing overhead lines to increase capacity and there are also benefits to the wind farm owner in that higher revenues can be made with a higher line rating.

DLR calculates the real-time rating (ampacity) of the line from some or all of the local weather measurements - wind speed, wind direction, ambient temperature and solar radiation via the transducer (current loop) inputs and compares this rating to the line current. The relay has 6 definite time DLR stages which can be set as a percentage of the line ampacity. These stages can be used for load management by sending commands to the DG to hold or reduce their output when the line current is close to the line rating and also as a back-up, in case the wind farm power output is not reduced, the relay can initiate tripping of the DG.

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 to 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.

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.

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
In the P341 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 $\sum I_x$, $1.0 \leq x \leq 2.0$
- monitoring the breaker operating time
- monitoring the fault frequency counter

Figure 1: Simple function selection by mouseclick
**CONTROL**

**Circuit Breaker Control and Check Synchronizing**

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 ones before allowing the generator breaker to be closed. Transformer vector compensation is also included.

**Programmable Scheme Logic**

Programmable scheme logic in the P341 allows the user to customise the protection and control functions. It is also used to programme the functionality of the digital inputs, output contacts and LED indications. The programmable scheme logic comprises gate logic and general purpose timers. The gate logic includes OR, AND and majority gate functions, with the ability to invert the inputs and outputs, and provide feedback.

The system is optimised to evaluate changes to the scheme logic signals and thus minimise any delays in logic execution. The programmable scheme logic may be configured using the graphical MiCOM S1 Studio PC based support software.

The required logic is drawn as shown and is then downloaded directly into the relay. The logic may also be uploaded from the relay and then modified using MiCOM S1 Studio support software.

**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 within the P341 PSL.

**Latched Output Contacts**

Each P341 relay output contact can be individually programmed to be latched. Once in the latched state, the contact can be reset either locally or remotely, or via the PSL. In addition to the ability to latch output contacts, each of the contacts can be individually conditioned by a timer to give pulse, dwell, delay on pick-up or delay on drop-off operation.

**MEASUREMENTS & POST FAULT ANALYSIS**

The P341 is capable of measuring and storing a number of quantities. All events, faults and disturbance records are time tagged to a resolution of 1ms using an internal real time clock. A pulsed opto input or an optional IRIG-B port is also available to maintain the accuracy of the real time clock. A supervised and easily accessed lithium battery ensures that the real time clock and records are maintained during auxiliary supply interruptions.

**Power System Measurements**

The measurements provided will depend upon the application and model of the relay. Where appropriate the measurements may be viewed in primary or secondary terms and can be viewed locally or remotely.

Measurements include:
- Phase / line voltages
- Sequence voltages
- Phase angles
- System frequency
- Phase / line currents
- Sequence currents
- W/Var/VA

**Event Recording**

The P341 relay can store up to 512 event records for viewing locally on the LCD, or extraction via the communication ports.

**Fault Recording**

The relays store the last 5 faults records, typically containing:
- Date and time
- Protection operation
- Active setting group
- Fault voltages, frequency, etc.

**Disturbance Recording**

The relays have an internal waveform capture facility with a user programmable trigger point. The P341 can record 10 disturbances, each with a duration of 7.5 seconds (75s maximum) at a sampling rate of 24 samples per cycle. All disturbance records capture both analog and digital information and when extracted via the communication ports, are stored in Comtrade format. These records can be examined using MiCOM S1 Studio or any other suitable software programme.
INFORMATION INTERFACES
Information exchange is done via the local control panel, the front PC interface, the main rear communications interface (COMM1) or an optional second rear interface (COMM2).

Local Communication
The front EIA(RS)232 communication port has been designed for use with the MiCOM 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 P341 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 synchronization.

An optional fiber optic interface is available for any of the above protocols with the P341.

An optional 2nd rear communications port with the Courier protocol is available. This port is intended for central settings or remote access with MiCOM S1 Studio.

Clock synchronization can be achieved using one of the protocols or using the IRIG-B input or using an opto input.

Redundant Ethernet Ports (IEC61850) (P341)
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 synchronization. The redundant Ethernet board also has a watchdog relay contact to alarm in case of a failure.

Password Protection
To prevent unauthorised setting changes, the P341 provides two password levels.

Comprehensive post-fault analysis and communication options
**MiCOM P341**

**DEVICE TRACK RECORD - INTERCONNECTION PROTECTION RELAYS**

- **MiCOM P94x**: Designed for all frequency based load applications. Over 600 units installed since 1999.
- **MiCOM P342/3**: Designed for all generator protection applications. Over 2,000 units installed since 1999.
- **MiCOM P341**: Designed for all interconnection protection applications. Over 600 units installed since 1999.

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**EMC Compliance**

- Compliance with the European Commission Directive on EMC

**Product safety**

- Compliance with the European Commission Low voltage directive

**P34X third party compliances**

- File Number: E205519
- Original Issue Date: 05-10-2002
- (Complies with Canadian and US requirements)
- Certificate Number: 104 Issue 2
- Assessment Date: 16-04-2004

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As standards, specifications and designs change from time to time, please ask for confirmation of the information given in this publication.

Design: Schneider Electric Industries SAS - Sonovision
Photos: Schneider Electric Industries SAS
Printed: Altavia Connexion - Made in France