

MiCOM P521

Fast Feeder Differential Protection



The MiCOM P521 relay provides high-speed two-ended current differential unit protection of overhead lines and underground cables in applications such as ring mains and parallel feeders. The integration of many protection functions allows application to a wide range of power systems, providing both local and remote backup protection.

Optimum phase selection is assured, as the scheme measures the currents entering and leaving the protected plant zone. Fast tripping results for an internal fault, with stability for any out-of-zone fault

The signalling interface options support metallic, direct fibre optic and multiplexed digital links. As digital communication is used, long distances between scheme ends can be achieved, and the signalling channel is monitored continuously.

Tripping uses a proven characteristic comparing differential current with through current. Phase differential elements of this type offer consistent detection of solid and resistive faults, with optimum faulted phase selection, tripping, and indication.

A full range of back-up protection is integrated. This enhances the dependability of the protection, as hot-standby elements such as overcurrent can be brought into service whenever a signalling channel outage may occur.



CUSTOMER BENEFITS

- Highly selective unit protection.
- Variety of end-to-end communications interface options
- Integrated back-up elements can run as hot standby in the event of comms channel outage
- 8 boolean logic equations
- 4 programmable inter-trip commands

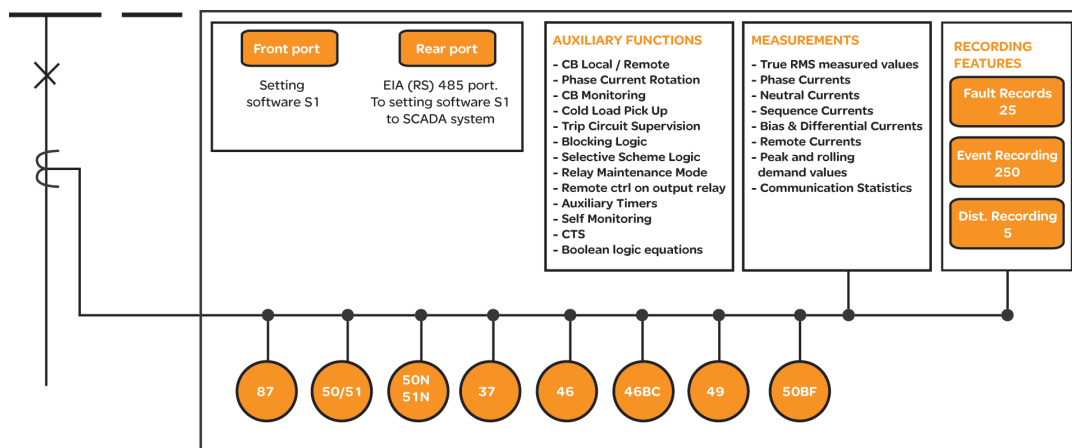
Protection Functions Overview		P521
87P	Phase segregated current differential protection	•
	Intertripping (Direct, Permissive and Current differential)	•
	Propagation delay compensation	•
	3 Pole tripping only	•
	Fibre optic or metallic signalling channels	•
	Supervision of protection signalling channel	•
	Interchangeable protection signalling interface	•
	Vector Compensation (all vector groups)	•
	Ratio Correction	•
	Inrush restraint (menu selectable)	•
50/51	Non-directional phase overcurrent protection	•
50/51N	Non-directional earth fault protection	•
49	Thermal overload	•
46	Negative sequence overcurrent protection	•
46BC	Broken conductor detection	•
37	Undercurrent detection	•
CBF	Circuit breaker fail protection	•
CTS	Current transformer supervision	•
	Circuit breaker control	•
	Circuit breaker monitoring	•
TCS	Trip circuit supervision	•
	Cold load pick-up protection for phase and E/F protection	•
	Blocking logic	•
	Selective logic	•
	5 optically isolated inputs	•
	8 output relays + watchdog output relay	•
	4 fixed function LEDs and 4 programmable LEDs	•
	2 setting groups	•
	Front EIA(RS)232 communication port (Modbus)	•
	Rear EIA(RS)485 communication port (choice of protocol)	•
	8 Boolean logic equations	•



MiCOM P521:
A full suite of protection and control standard functions

Functional Overview

(Description of ANSI code nos., see Protection Function Overview)



APPLICATION

The MiCOM P521 current differential scheme provides a comprehensive protection package, primarily designed for unit protection of overhead and underground feeders up to and including distribution voltage levels.

The P521 is limited to three pole tripping only and is suitable for cable applications where no auto-reclosing is required.

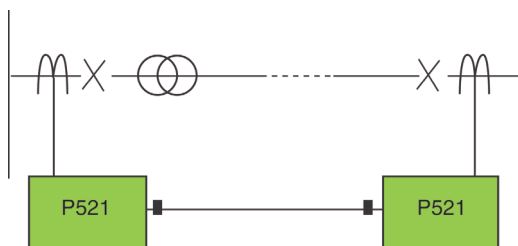
The MiCOM P521 is supplied with a full suite of protection and control functions as standard. Current differential protection by its nature requires few protection settings, and for most applications the factory default settings can be used - the P521 relay as supplied is ready to protect!

Transformer Applications

Figure 1 shows a protected line and transformer “unit”. The P521 compensates for the vector group shift and zero sequence filtering effects of the in-zone transformer. Second harmonic restraint is used to stabilize the protection against magnetizing inrush currents.

Where transformer loads are tapped off the protected line, it is not essential to install CTs at the tap. There exists the facility to time grade the differential protection with downstream relays or fuses.

Fig.1: P521 in-zone transformer application

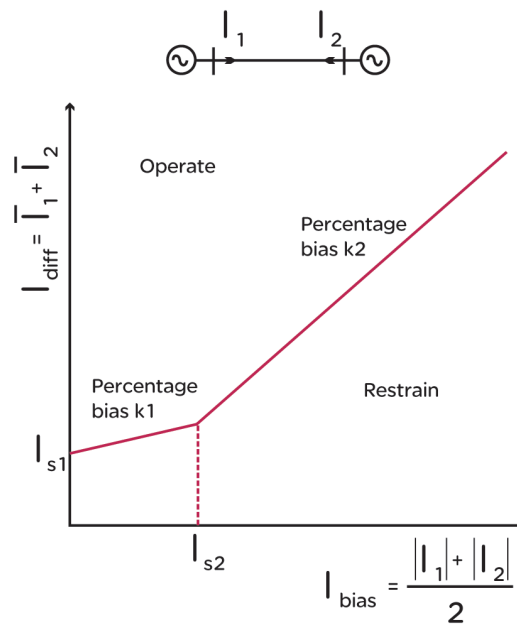


MAIN FUNCTIONS

Differential Protection

The primary protection element in the P521 relay is true, phase-segregated current differential protection. The measurement algorithm is extremely reliable, offering fast detection of internal faults, and stability for external faults. The differential algorithm has a dual slope percentage bias restraint, as shown in Figure 2. An internal fault will generate differential current.

Fig.2: Biased Current Differential Protection



The bias current is that which merely flows through the protected unit, as a load or through-fered external fault. The initial slope (k_1) ensures sensitivity to low current faults, whereas the k_2 slope is raised to counter the effects of current transformer saturation mismatch.

When a trip is issued by the differential element, in addition to tripping the local breakers, the P521 sends a current differential intertrip signal to the remote end. This will ensure tripping of both ends of the protected line.

CT Ratio and Vector Correction

Where line CT ratios at either end of the protected feeder are different, the P521 contains a settable correction factor to compensate for the mismatch.

In applications with in-zone transformers, the P521 compensates for the vector group shift and zero sequence filtering effects of the in-zone transformer, so no external interposing CTs are required.



MiCOM P521:
A comprehensive protection package

Inrush Restraint / Blocking

Second harmonic restraint is used to stabilize the protection against magnetizing inrush currents during transformer energisation. Alternatively, user can select the blocking mode which will block differential from tripping when the second harmonic component exceeds the setting.

Overcurrent and Earth Fault Protection

The overcurrent and earth fault protection is provided as a form of back-up protection. The P521 has four stages of overcurrent and four stages of earth fault protection. The first two stages have an IDMT or definite time (DT) characteristic.

The third and fourth stages are DT only. The overcurrent and earth fault protection can be either permanently enabled or disabled, or alternatively enabled upon failure of the differential protection communication channel. A wide range of IEC and IEEE/ANSI curves are available.

Negative Sequence Overcurrent Protection

Negative sequence overcurrent protection can be used to provide greater sensitivity to resistive phase to phase or phase to earth faults even with delta transformers present. The negative sequence element can also be used to provide efficient back-up protection for dedicated motor protection relays.

Broken Conductor Detection

The broken conductor protection element detects unbalanced conditions caused by broken conductors, maloperation of single phase switchgear or single phasing conditions.

Undercurrent Protection

The P521 provides undercurrent detection that can be used to provide loss of mains protection.

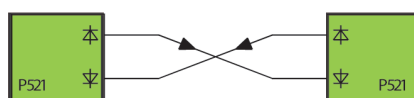
Thermal Overload

Transformers and cables must be protected to account for their particular thermal characteristics. The MiCOM P521 relay includes a thermal overload element based upon the true RMS value of the current. Alarm and overload thresholds are fully programmable to match each device requirement.

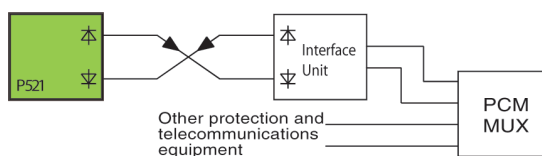
Cold Load Pickup

When a feeder is energised after a long outage most connected devices will draw a significant inrush current. The inrush current may be greater than the overcurrent or earth fault settings thus causing mal-operation. To prevent unwanted tripping the P521 has a cold load pickup function that automatically increases the overcurrent settings for a selectable time. Following a successful close the settings revert back to their normal values.

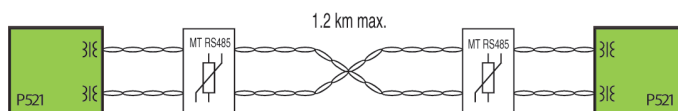
Fig.3: Protection Signalling options



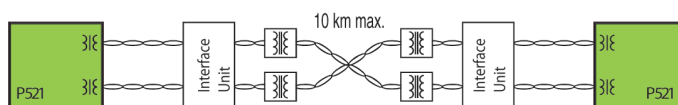
a) Direct link using optical fibres



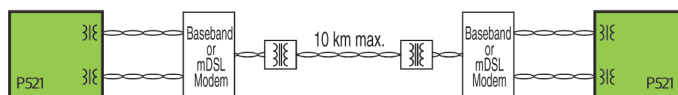
b) Multiplexed link - relay connected to a remote PCM multiplexer using optical fibres and via Interface Units



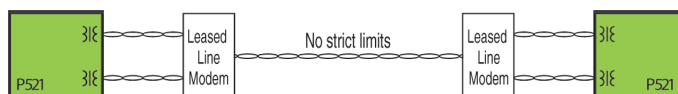
c) Direct EIA485 connection with MT RS485 surge protection device (Scheme A)



d) EIA485 connection via Interface Units (with optional PCM-FLU isolating transformers) - (Schemes F,G)



e) pilot wire communications via leased line or mDSL modem (with optional PCM-FLU isolating transformers) - (Schemes D,E)



f) Conditioned telephone line communications via suitable modems - (Schemes B,C)

PROTECTION SIGNALLING

Interfacing Options

The MiCOM P521 relay is designed to ensure compatibility with a wide range of communication equipment and media. It is supplied fitted with one of the following protection signalling interfaces (order option):

- 850nm multi-mode fibre
- 1300nm multi-mode fibre
- 1300nm single-mode fibre
- EIA(RS)232 electrical
- EIA(RS)485 electrical

These interfaces allow a variety of signalling links to be used, as shown in Figure 3 and summarised below. Signalling bandwidths of 9.6 / 19.2 / 56 / 64 kbps are available, subject to the type of link used.

Where 4 wire unconditioned twisted-pair metallic pilots are available, distances up to 25km can be achieved using Interface Units. For distances less than 1.2km, direct 4 wire EIA(RS)485 connection can be used.

For 2 or 4 wire unconditioned twisted-pair metallic pilots, options for other modems exist, allowing distances up to 18km to be achieved.

For 2 wire conditioned pilots (provided by a telecommunications company), a suitable type of modem must be used, and there is no strict limit to the distance.

For connection to multiplexer equipment, electrical interfaces conforming to the G.703, V.35, and X.21 recommendations are available, by using the 850nm fibre interface in the P521.

In direct fibre optic applications, the distance achievable depends on the type of fibre interface chosen, as detailed in the table below.

Fibre Interface Option	Typical fibre run
850nm multi-mode (to P59x)	1 km
1300nm multi-mode	50 km
1300nm single-mode	100 km

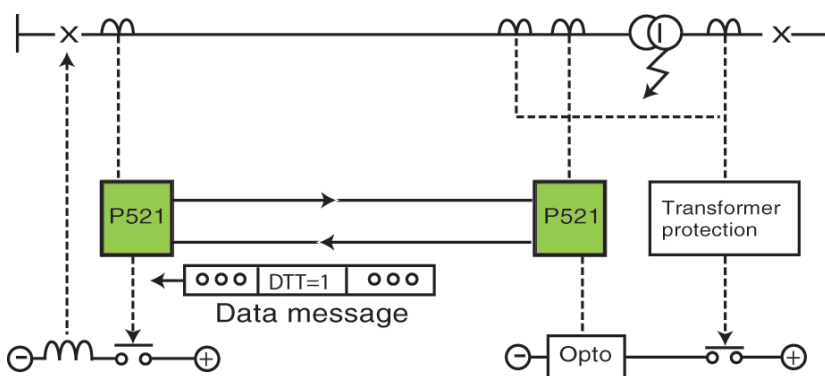
The P521 protection signalling interface is interchangeable, which allows simple upgrade without the need for any software changes.

Direct Intertripping

A typical application of the user defined direct intertripping facility is shown in Figure 4.

Using the selective Intertrip settings, either a user-configurable input or an internal status signal can be assigned for this purpose. Upon receipt of this message the remote relay will operate user specified outputs for direct transfer tripping or blocking, and provide indication of the remote intertrip. The indication can be disabled then it acts as signal transfer function.

Fig.4: Example Application of Direct Intertripping



Permissive Intertripping

There is an auxiliary signalling facility whereby a permissive intertrip command is sent over the protection communication channel.

A user configurable input can be assigned for this purpose. When energised, the communication message to the remote relay is modified. Upon receipt of this message, and providing one or more currents are above the differential setting (I_{s1}), the remote relays will initiate a trip, operate the user defined outputs and provide an indication of the remote intertrip. If required the current checking can be disabled thus enabling the permissive intertrip feature to operate as a second direct intertrip function. The indication can be disabled then it acts as signal transfer function.

Programmable Intertripping

There are 4 independent programmable intertripping signals which can be assigned with any logic inputs, protection signals and logic equation outputs and transfer these signals to the remote end relay.

CONTROL

Circuit Breaker Control

Circuit breaker control is available from the front panel user interface, optically isolated inputs and remotely via the substation communications.

Programmable Inputs and Outputs

The MiCOM P521 relay includes 5 logic inputs and 9 logic outputs including a watch-dog. All inputs and outputs are freely configurable, with the exception of RLY1 which is a dedicated trip relay. RLY1 and RLY2 outputs are changeover contacts, typically used for tripping.

All programmed thresholds (time delayed or instantaneous) can be easily routed to any of the outputs.

Blocking Logic

When the MiCOM P521 relay is used on critical networks, management of protection relays must take surrounding devices into consideration.

Blocking inputs can be configured independently from each other to block any combination of the user selected elements (e.g. current differential, thermal overload, overcurrent etc.).

Selective Relay Scheme Logic

A dedicated input can temporarily alter the overcurrent and earth fault time-delay settings in response to a downstream phase/earth fault start condition. This function allows the MiCOM relay to discriminate correctly when used in a cascade scheme. The selective relay scheme logic function can be enabled or disabled by the user as required.

Output Relay Latching

Any of the outputs, including trip, can be latched. Reset of the outputs is possible from a logic input, the front panel user interface or through the remote communications.

Boolean Logic Equations

A total of 8 logic equations are available, each with 16 variables. The variables can be logic input, protection signals, output of other equations, etc.

MEASUREMENTS & POST FAULT ANALYSIS

Event Recording

Up to 250 events are stored in the MiCOM P521 relay's Flash memory. Events include the change in state of inputs/outputs and presence of any alarms. All events are time-tagged to 1ms.

Fault Records

Records of the last 25 faults are stored in Flash memory. The information provided in the fault record includes:

- Indication of faulted phase
- Protection flags
- Active setting group
- Local phase and neutral currents
- Differential currents
- Maximum bias current
- Communications channel status
- Fault time and date

Disturbance Recording (Oscillography)

A total of 5 disturbance records can be stored with 15 seconds in total duration. The disturbance recorder function is triggered by any of the programmable thresholds, by an external input, or via the remote communications. The data is stored in memory and can be transferred to a data analyser using the front communication port or the rear EIA(RS)485 port.

Instantaneous Records

Five instantaneous (start) records can be stored in the MiCOM P521 relay. Each instantaneous record includes:

- Start time (date & duration)
- Origin (phase & earth threshold)

These records are intended to aid preventative maintenance.

25

Last faults stored

5

Disturbance files stored with 15 seconds in total duration

up to 250

Events can be stored in the MiCOM P521 relay's Flash memory

MEASUREMENTS

General Measurements

- Local and remote phase currents
- Local neutral current
- Phase differential currents
- Phase bias currents
- Sequence currents
- Thermal state
- Peak and rolling demand values

Protection Signalling Supervision

Dependable communications are essential for high-performance differential protection. The MiCOM P521 monitors the protection signalling channel, and reports the following error statistics in line with the guidance from ITU-T G.821.

- Channel propagation delay
- Channel status
- Number of valid messages
- Number of errored messages
- Number of errored seconds
- Number of severely errored seconds

PLANT SUPERVISION

Circuit Breaker Failure Protection

If the fault current has not been interrupted following a set time delay from circuit breaker trip initiation, the P521 can be configured to initiate a circuit breaker failure (CBF) condition. CBF operation can be used to backtrip upstream breakers or remove blocking signals from upstream relays.

Circuit Breaker Supervision and Monitoring

The MiCOM P521 relay provides advanced circuit breaker monitoring features. The relay monitors the operating and closing times of the CB to ensure that they do not exceed adjustable thresholds. The state of the circuit breaker is also monitored by use of the CB auxiliary contacts. If the relay detects the circuit breaker contacts in the same state for more than 5 seconds the relay will initiate an alarm. During faults, I and I2 values are summed and memorised for each phase. The MiCOM P521 relay also provides Trip Circuit Supervision via a user definable input. Any break in the trip circuit will be accompanied by an alarm.

Current Transformer Supervision

This innovative CTS function can detect a CT failure by comparing the load currents and unbalanced currents of local and remote end. Upon the detection of a CT failure, the negative sequence overcurrent, undercurrent and broken conductor protection will be inhibited. The differential protection can be restrained upon the setting.



P521 makes current differential protection available over pilot wires.

INFORMATION INTERFACES

Information exchange is performed via the LCD, the local PC interface and via the rear communications interface.

Local Communication

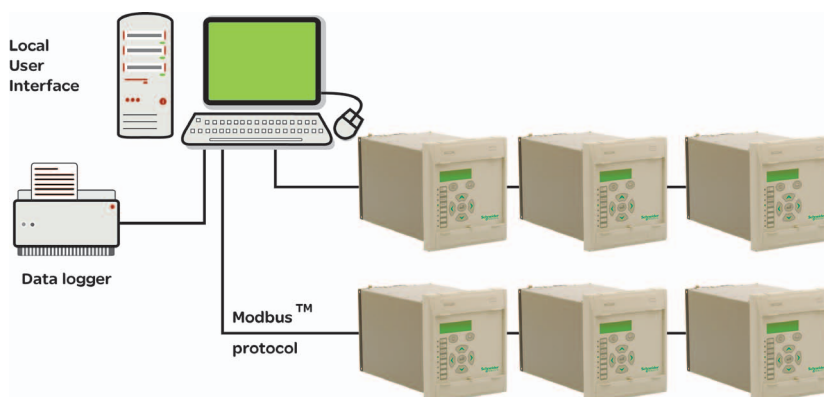
The front EIA(RS)232 port has been designed for use with MiCOM S1, providing the ability to programme the settings (on or off-line), configure the relay, extract and view records, view the measurement information dynamically and perform control functions.

Remote Communication

The rear communication port is based upon EIA(RS)485 voltage levels and is designed for permanent connection to network control and data acquisition systems (see Figure 5). One of the three protocols listed below should be selected at the time of order:

- Modbus
- IEC 60870-5-103
- DNP3

Fig. 5 : Connect to Control System





TRACK RECORD - HIGH SPEED DIFFERENTIAL PROTECTION

- **P54x MiCOM series** introduced in 1999. Worldwide application, with over 13,200 units delivered.
- **PQ741** numerical current differential protection launched in 1996. Over 3,000 units delivered.
- **P521 MiCOM series** introduced in 2003. Worldwide application, with over 2,200 units delivered.

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Publishing: Sonovision
Design: Schneider Electric
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