

# MiCOM P446, P443 and P445

## High Performance Distance Protection



P443 in Case Size 80 TE (16")



P445 in Case Size 40TE (8")

Transmission and distribution systems are essential to route power from generation to consumers. The mode of transport is generally via overhead lines, which must have maximum in-service availability. The exposed nature of lines make them fault-prone, and protection devices must trip to initiate isolation of any faulted circuit.

The MiCOM provides fast, highly selective protection, to trip for genuine line faults. Advanced load blinding and disturbance detection techniques - such as power swing blocking - ensure stability when no tripping is required.

Selectable mho and quadrilateral (polygon) characteristics allow versatile deployment as main protection for all effectively-grounded transmission and distribution circuits, whether lines, cables or hybrid. Series compensated line application is supported.

Multiple main protection elements reside inside each relay: distance, delta directional comparison protection, and directional earth/ground fault unit protection (DEF). This permits simplified application and spares holding, as the MiCOM can be adopted as the standard protection platform.

### KEY FEATURES

#### Distance Protection :

- High speed operation in less than one cycle
- Load blinder prevents spurious trips cascading through the network, in extreme conditions such as on the verge of a blackout
- Simple to deploy in all applications, and at all voltage levels

#### Power swing alarm and block, plus out of step trip

- Unrivalled detection principle
- OST to split into asynchronous islands

#### Comprehensive range of teleprotection schemes

- Distance, DEF and delta directional comparison

#### InterMiCOM option for end-end protection communications

- Reliable and secure, saving the investment in external teleprotection equipment

#### Extensive back-up protection facilities

#### Multi-shot autoreclosure with check synchronism

- Single circuit breaker applications (P443 & P445)
- Dual circuit breaker applications (P446)

#### Programmable Scheme Logic

#### Feeder measurements, fault/event records and high resolution oscillography

#### Readily interfaces to SCADA using standard communication protocols



### CUSTOMER BENEFITS

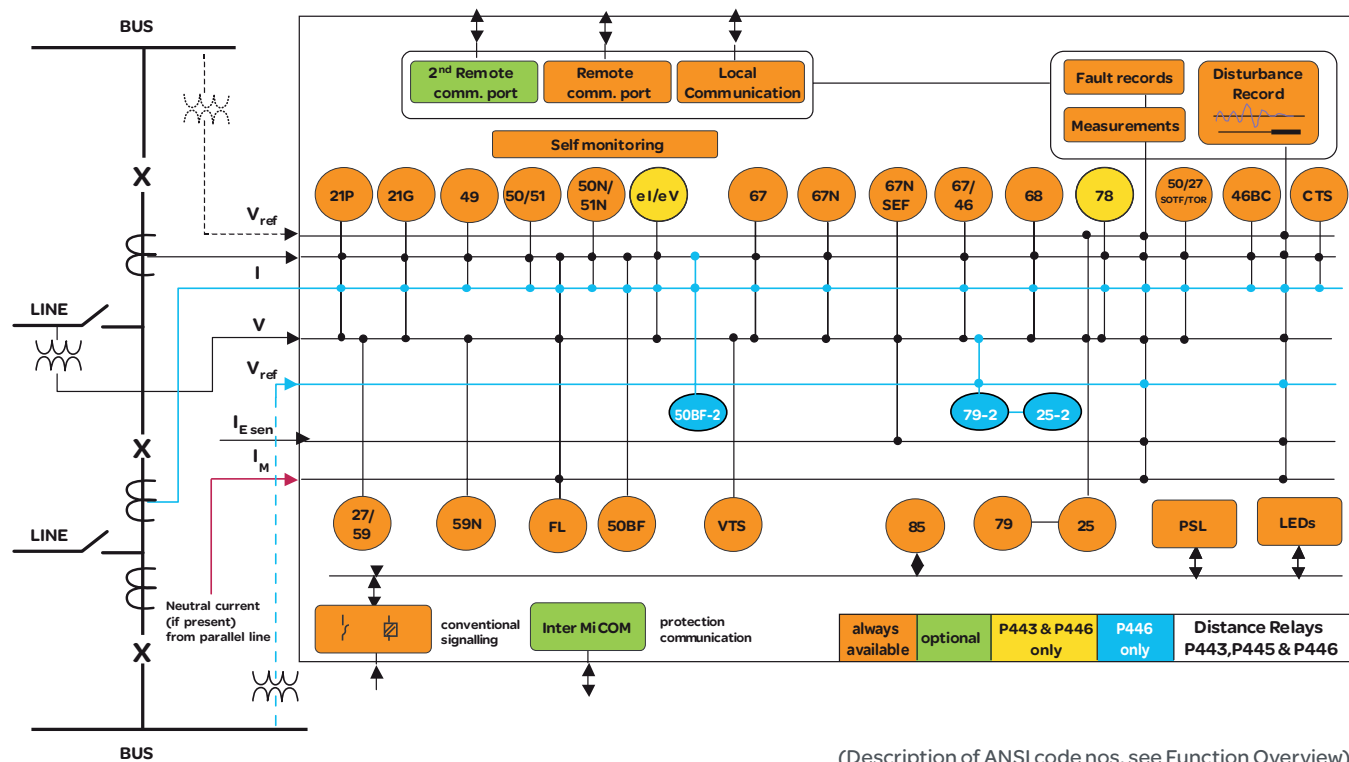
- P443/P446: Sub-cycle fault clearance (0.7 to 1 cycle)
- Simple set mode - the relay determines its own settings from protected line data
- Power swing blocking without the need for settings
- Integral teleprotection via MODEM, fiber, or MUX channel.

## PROTECTION FUNCTIONS OVERVIEW

| ANSI         | FEATURE                                                        |        | P446         |    |    | P443 |    |    |    | P445         |    |    |    |
|--------------|----------------------------------------------------------------|--------|--------------|----|----|------|----|----|----|--------------|----|----|----|
|              |                                                                |        | A            | B  | C  | A    | B  | C  | D  | A            | B  | C  | D  |
|              | Optocoupled logic inputs                                       |        | 24           | 24 | 24 | 16   | 24 | 16 | 24 | 8            | 1  | 16 | 16 |
|              | Relay output contacts                                          |        | 32           | 8  | 16 | 24   | 32 | 16 | 16 | 8            | 12 | 16 | 8  |
|              | High Speed, high break contacts                                |        | -            | 12 | 8  | -    |    | 4  | 8  | -            |    |    | 4  |
|              | Tripping Mode - single or three pole                           |        | 1 or 3ph     |    |    |      |    |    |    | 3ph          |    |    |    |
|              | Clockwise and Anticlockwise phase rotation                     |        | ●            |    |    |      |    |    |    |              |    |    |    |
| 21P /21G     | Distance Zones                                                 |        | 5            |    |    |      |    |    |    |              |    |    |    |
|              | Characteristics                                                | Phase  | Mho and Quad |    |    |      |    |    |    | Mho          |    |    |    |
|              |                                                                | Ground | Mho and Quad |    |    |      |    |    |    | Mho and Quad |    |    |    |
|              | CVT Transient overreach elimination                            |        | ●            |    |    |      |    |    |    |              |    |    |    |
|              | Load Blinder                                                   |        | ●            |    |    |      |    |    |    |              |    |    |    |
|              | Easy Setting mode                                              |        | ●            |    |    |      |    |    |    |              |    |    |    |
|              | Mutual compensation                                            |        | ●            |    |    |      |    |    |    |              |    |    |    |
| 85           | Communication-aided schemes, PUTT, POTT, Blocking, Weak Infeed |        | ●            |    |    |      |    |    |    |              |    |    |    |
|              | Accelerated tripping - Loss of Load, and Zone 1 extension      |        | ●            |    |    |      |    |    |    |              |    |    |    |
| 50 /27       | Switch on to Fault                                             |        | ●            |    |    |      |    |    |    |              |    |    |    |
| 68           | Power Swing Blocking                                           |        | ●            |    |    |      |    |    |    |              |    |    |    |
| 78           | Out of Step Tripping                                           |        | ●            |    |    |      |    |    |    | -            |    |    |    |
| eI/eV        | Delta Directional Comparison                                   |        | ●            |    |    |      |    |    |    | -            |    |    |    |
| 67N          | Directional Earth Fault (DEF) unit protection                  |        | ●            |    |    |      |    |    |    |              |    |    |    |
| 50 /51 /67   | Phase overcurrent stages                                       |        | 4            |    |    |      |    |    |    |              |    |    |    |
| 50N/51N/ 67N | Earth/ground overcurrent stages                                |        | 4            |    |    |      |    |    |    |              |    |    |    |
| 67/46        | Negative sequence overcurrent                                  |        | ●            |    |    |      |    |    |    |              |    |    |    |
| 46BC         | Broken conductor                                               |        | ●            |    |    |      |    |    |    |              |    |    |    |
| 49           | Thermal protection                                             |        | ●            |    |    |      |    |    |    |              |    |    |    |
| 27           | Undervoltage protection stages                                 |        | 2            |    |    |      |    |    |    |              |    |    |    |
| 59           | Overvoltage protection stages                                  |        | 2            |    |    |      |    |    |    |              |    |    |    |
| 59N          | Residual voltage protection stages                             |        | 2            |    |    |      |    |    |    |              |    |    |    |
| 50BF         | High speed breaker fail                                        |        | ●            |    |    |      |    |    |    |              |    |    |    |
| CTS/VTs      | Current and Voltage Transformer supervision                    |        | ●            |    |    |      |    |    |    |              |    |    |    |
| 79           | Autoreclose - shots supported                                  |        | 4            |    |    |      |    |    |    |              |    |    |    |
| 25           | Check synchronism                                              |        | ●            |    |    |      |    |    |    |              |    |    |    |
|              | No. of Breakers controlled                                     |        | 1 or 2       |    |    | 1    |    |    |    | 1            |    |    |    |
|              | Alternative setting groups                                     |        | 4            |    |    |      |    |    |    |              |    |    |    |
| FL           | Fault Locator                                                  |        | ●            |    |    |      |    |    |    |              |    |    |    |
|              | Fault Records                                                  |        | 15           |    |    |      |    |    |    |              |    |    |    |
|              | SOE Event Records                                              |        | 512          |    |    |      |    |    |    |              |    |    |    |
|              | Disturbance recorder, samples per cycle                        |        | 48           |    |    |      |    |    |    |              |    |    |    |
|              | Circuit Breaker condition monitor                              |        | ●            |    |    |      |    |    |    |              |    |    |    |
|              | Graphical Programmable Scheme Logic (PSL)                      |        | ●            |    |    |      |    |    |    |              |    |    |    |
|              | IRIG-B time synchronism                                        |        | (●)          |    |    |      |    |    |    |              |    |    |    |
|              | InterMiCOM teleprotection                                      |        | (●)          |    |    |      |    |    |    |              |    |    |    |

Key (•) : denotes optional

## Functional Overview



## APPLICATION

### Distance Protection

Three models are available, the P443 and P446 subcycle relays for transmission systems, and the P445 for simpler application in distribution systems (with smaller cases for easy retrofitting).

The Protection Functions Overview table highlights the functions available.

The MiCOM P443, P445 and P446 are supplied with a full suite of protection and control functions as standard.

The configuration column of the menu is used to control which functions the user requires in the intended application and which may be disabled.

Disabled functions are completely removed from the menu, to simplify setting.



Figure 1: P443 / P446 User interface



Versatile protection for universal application.

The “simple set” mode invokes an inbuilt wizard, to simplify the job of the protection engineer

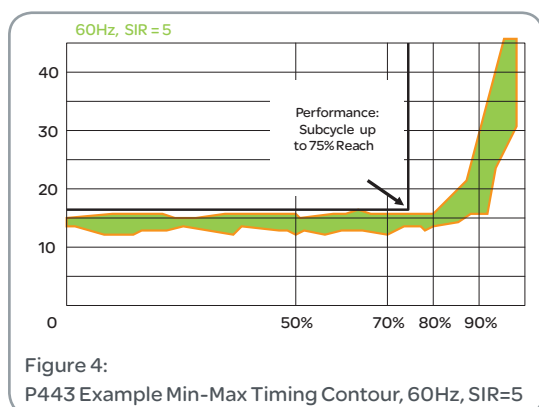
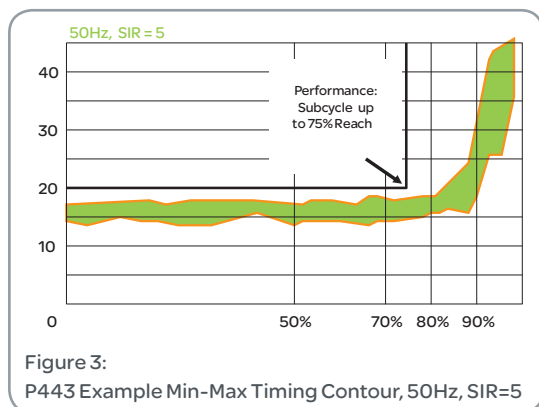
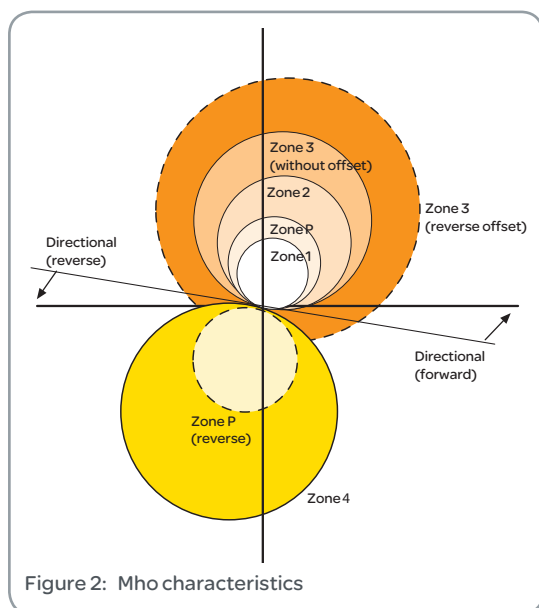
## MAIN PROTECTION FUNCTIONS

### Distance Protection

Five zones of protection are provided as shown in Figure 2.

Depending upon the models, the relay allows mho and quadrilateral (polygon) characteristics to be independently selected for the phase and ground distance elements.

The mho is shown in Figure 2, and uses well-proven principles to provide dynamic expansion for faults off the characteristic angle.



The quadrilateral characteristics (Figure 5) provide enhanced fault arc resistance coverage. An adaptive technique is used to tilt the reactance reach line of each zone and eliminate under/overreaching effects due to prefault load flow (Note that the P445 offers quad characteristics for ground elements only).

Blinder characteristics (Figure 6) prevent false tripping due to encroachment of heavy loads.

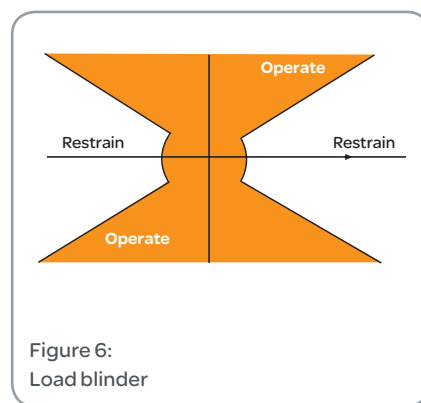
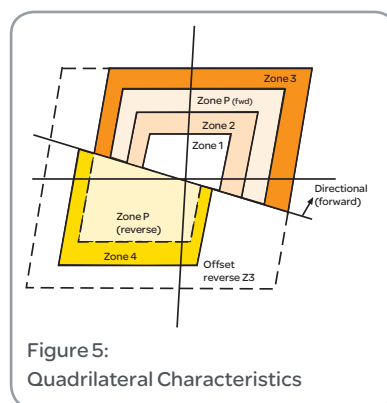
A superimposed current phase selector detects the faulted phase(s) and, controls which of the distance elements will initiate a trip. Combined with the directional decision from a proven delta principle, secure operation of distance zones is assured.

The trip time is typically 0.7 to 1 cycle for the P443 & P446, and 1 to 1.3 cycle for the P445.

### High Speed - High Break Contacts

The trip times shown in Figures 3 and 4 relate to a P443 with standard relay contacts, and fully include the contact closure time.

When fitted with High Speed-High Break (HSHB) contacts, all trip times are reduced by 3 to 4ms. The trip time for P443 becomes 0.5 to 0.85 cycle. HSHB contacts easily rupture repetitive shots of 10A trip or close coil currents.



### Power Swing Blocking (PSB)

The MiCOM recognizes power swings quickly, by means of the superimposed currents measured by the phase selector. The PSB does not require any impedance band or timers to be set. The technique is essentially "Settings-Free", and without any load encroachment issues.

### Out of Step Tripping - OST (P443 & P446 only)

If severe disturbances risk asynchronism in transmission networks, it may be required to separate into islands, using P443/P446 OST. Predictive mode OST initiates separation before damage occurs.

## MiCOM P446 :

A full-scheme distance relay with subcycle technology, suitable for dual breaker 1/3 ph reclosing applications, 2 x c/s included

## MAIN PROTECTION SCHEMES

Pre-configured distance schemes allow single and three phase tripping with or without a signalling channel.

- Basic scheme logic for stand alone operation (without a signalling channel).
- Trip on Close logic allows accelerated tripping to be selected following manual, or auto-reclose.

## CARRIER AIDED SCHEME INCLUDE:

- Direct transfer tripping
- Permissive underreach scheme (PUR)
- Permissive overreach (POR) with open breaker, weak infeed echo logic and weak infeed trip feature
- Blocking scheme
- User-defined custom schemes

The relay provides two independent teleprotection schemes each using a separate communication channel. The distance, directional and DEF functions are thus flexible in configuration, to operate in shared channel logic or in discrete modes.

## Delta Directional Comparison

### (P443 & P446 only)

Superimposed voltage and current signals are used to make highly-secure fault directional decisions.

The respective forward/reverse decisions at each line end can be used in a teleprotection scheme, for full line unit protection.

The advantage is a channel send even faster than for distance aided schemes.

## Directional Earth Fault (DEF)

The DEF element can be used within the aided schemes to detect high resistance ground faults.

The innovative “Virtual Current Polarizing” feature even ensures correct operation when the fault generates negligible zero or negative sequence voltage. Traditional relays would have required an extra CT input to cover this scenario - not required for the MiCOM protection.

## InterMiCOM (Optional)

InterMiCOM allows high performance permissive and blocking type unit protection to be configured, plus transfer of any digital status information between line ends. Intertripping is supported too, with channel health monitoring and cyclic redundancy checks (CRC) on the received data for maximum message security.

InterMiCOM provides eight end-end signals, assignable to any function within a MiCOM relay's programmable logic. Default failsafe states can be set in case of channel outage.

Two physical formats for InterMiCOM are possible:

- EIA (RS) 232 for MODEM links
- InterMiCOM<sup>64</sup> at 56/64kbit/s for direct fiber or multiplexed links.

InterMiCOM<sup>64</sup> additionally includes support for 3-terminal applications, employing the same communications topology as in successful LFCB and P540 series products. 850nm fiber communication is used to interface to multiplexers in IEEE C37.94 format (and to G.703, V.35 and X.21 via P590 interfaces).

1300nm channel options are used for direct fiber teleprotection. In 3-terminal schemes, the communications are self-healing if one leg of the triangulation fails.

End-end transfer time of permissive or blocking scheme data is typically just 5ms for InterMiCOM<sup>64</sup>.

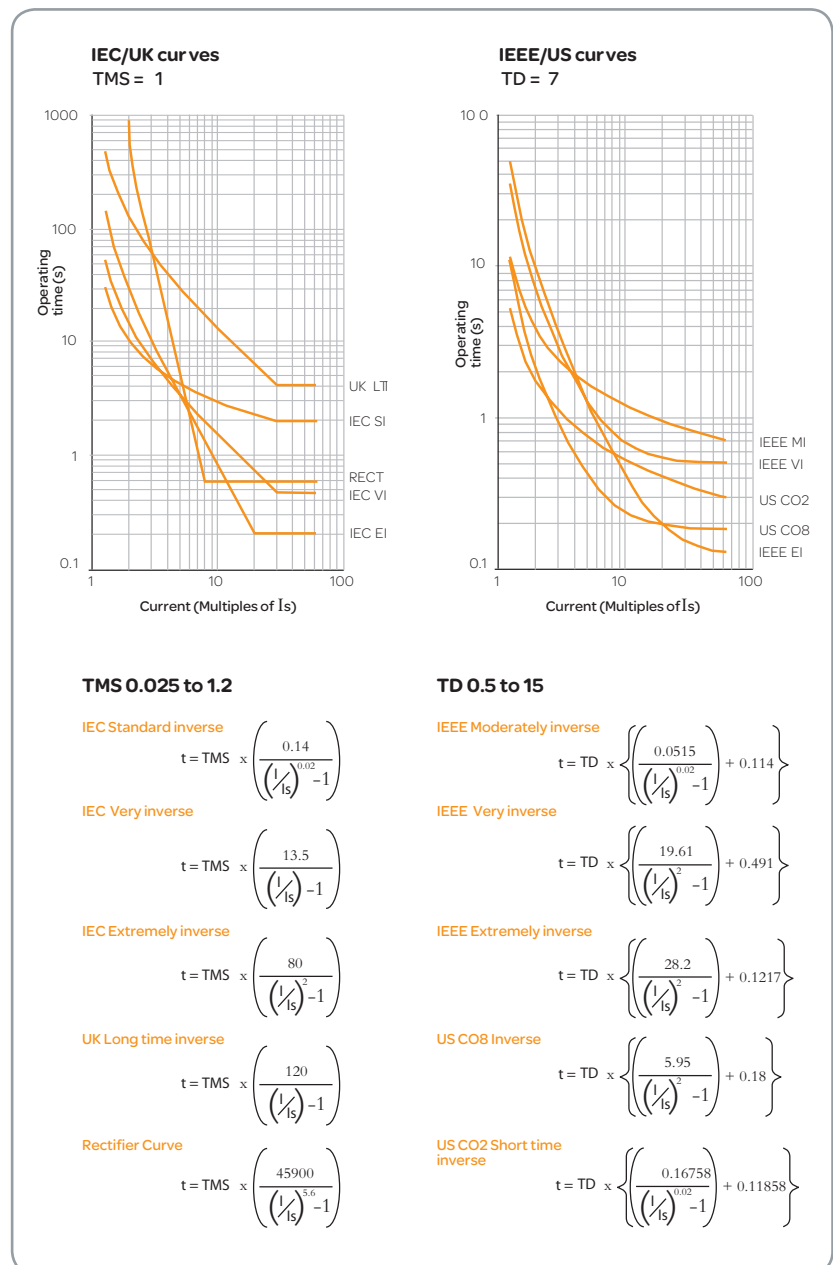


Figure 7: IEC and IEEE/ANSI IDMT

## BACKUP PROTECTION

### Overcurrent Protection

Four stages of both phase and earth (ground) fault protection are provided with a choice of standard IDMT curves (Figure 7). Negative sequence overcurrent is also available.

### Voltage Protection

Phase under and overvoltage protection functions are available in addition to residual overvoltage and compensated overvoltage.

### Broken Conductor

This protection detects the percentage phase unbalance due to an open phase condition.

### Thermal Overload

A thermal replica provides alarm and trip stages, to warn and protect in the event of prolonged circuit overloading.

### High Speed Breaker Failure

Two stage circuit breaker failure protection for backtripping upstream circuit breakers, and re-tripping of the local circuit breaker if required.

## SUPERVISORY FUNCTIONS

### VT Supervision (Fuse Fail)

Voltage transformer supervision is provided to detect loss of one, two or three VT signals for line VTs.

### CT Supervision

Current transformer supervision is provided to detect loss of phase CT input signals.

## CONTROL

### Hotkey Menu

Trip and close commands are facilitated from front panel "hotkeys", to allow direct CB control without the need to navigate a menu. Other in/out, on/off and enable/disable controls are easily programmed.

### Single Breaker Autoreclose

with check synchronism (P443 & P445) The user may select a single, two, three or four shot autoreclose cycle.

### Dual Breaker Autoreclose with Check Synchronism (P446 only)

The following additional features are offered in P446, to permit two breaker reclosing in a leader-follower scheme:

- Two CB Control - CB1 and CB2 are assigned. The user selects which is the leader, and which the follower breaker.
- Individual selection of recloser on or off
- Follower action - Follows successful close of the leader, reclosing after a settable delay. Alternatively the follower may wait to be closed manually.
- Independent lockout and reset per breaker.

### Programmable Scheme Logic

Powerful graphical logic allows the user to customize the protection and control functions. The gate logic includes OR, AND, MAJORITY and Set/reset Latch Logic gate functions, with the ability to invert the inputs and outputs, and provide feedback. The system is optimized to ensure that the protection outputs are not delayed by the PSL operation.

The programmable scheme logic is configured using the graphical MiCOM S1 Studio PC software, as shown in Figure 8.

The relay outputs may be configured as latching (eg "Lockout") or self-reset.

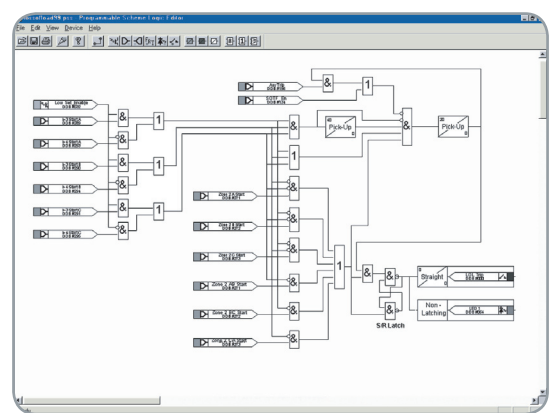


Figure 8: PSL Editor (MiCOM S1 Studio)

### User Interface

The user interface and menu text are available in English, French, German and Spanish as standard.

The ability to customize the menu text and alarm descriptions is also supported.

### Password Protection

Password protection may be independently applied to the front user interface, front communications port and rear communications port. Two levels of password protection are available providing access to the controls and settings respectively.

### Measurement and Recording Facilities

All event, fault and disturbance records are time tagged to a resolution of 1ms. An optional IIRIG-B port is available for accurate time synchronization.

### Power System Measurements

Instantaneous and time integrated voltage, current and power measurements are provided. These may be viewed in primary, or secondary values.



## POST FAULT ANALYSIS

### Fault Location

A fault location algorithm provides distance to fault in miles, kilometres, ohms or percentage of the line length.

The proven algorithm used tolerates pre-fault loading and fault arc resistance.

### Event Records

Up to 512 time-tagged event records are stored in battery backed memory.

### Fault Records

The last 15 faults are stored :

- Indication of the faulted phase
- Protection operation
- Active setting group
- Fault location (distance to fault)
- Relay and CB operating time
- Pre-fault and fault currents, voltages and frequency

### Disturbance Records

The oscillography has 12 analog channels, 32 digital and 1 time channel, all at a resolution of 48 samples/cycle.

Disturbance records can be extracted from the relay via the remote communications and saved in the COMTRADE format.

## PLANT SUPERVISION

### Trip Circuit Supervision

Supervision of the trip circuit can be implemented using optocoupled inputs and the programmable scheme logic.

### CB State Monitoring

An alarm will be generated if there is a discrepancy between the open and closed CB auxiliary contacts.

### Circuit Breaker Condition Monitoring

- Monitoring the number of breaker trip operations
- Recording the sum of broken current quantity (interruption duty)  
 $\Sigma I^2: 1.0 \leq x \leq 2.0$
- Monitoring the breaker operating time

## REMOTE AUXILIARY COMMUNICATIONS

The wide range of communication options, including IEC 61850, provides interfacing to almost any type of Substation Automation System or SCADA system.

Two auxiliary communication ports are available; a rear port providing remote communications and a front port providing local communications. An additional, second rear port can be ordered as an option.

Any of the following listed rear port protocols can be chosen at the time of ordering.

- Courier/K-Bus
- IEC 60870-5-103
- DNP 3.0 (EAI-485 or Ethernet)
- IEC 61850 (P443 and P446 only)

### IEC 61850

IEC 61850 is available with all models when the optional Ethernet port is ordered. IEC 61850 offers high-speed data exchange, peer-to-peer communication, reporting, disturbance record extraction and time synchronization.

### Second Rear Courier Port

The optional second port is designed typically for dialup modem access by protection engineers/operators, when the main port is reserved for SCADA traffic.

## CASE SIZE

- P446 relays are housed in full 80TE cases, for 19" rack or flush mounting.
- P443 relays are housed in full 80TE cases, for 19" rack or flush mounting.
- P445 hardware A is housed in a narrow 40TE (8") case to retrofit in any compact or vertical case footprints.
- P445 hardware B, C and D are supplied in 60TE (12") case width

**MiCOM P443:**

A full-scheme distance relay with subcycle technology

**MiCOM P445:**

Designed for easy retrofitting





### DEVICE TRACK RECORD - HIGH SPEED DISTANCE PROTECTION

- Approximately 15,000 **MiCOM P44x** family distance relays delivered since launching in 1999.

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