

MiCOM Agile P443

Distance Protection for Central European Applications (50 Hz)

The MiCOM Agile P443 is the ideal choice for solidly-earthed transmission systems and isolated or compensated systems at lower system voltages. The P443 protects overhead lines and underground cables, with an unparalleled ability to accommodate applications with any method of system earthing, and for the most onerous applications with up to eight distance zones. One device extends from distribution and sub-transmission up to the highest transmission voltage applications.

The MiCOMho provides fast, highly selective line protection. Advanced load blinding and disturbance detection techniques ensure stability when no tripping is required. Selectable mho and quadrilateral characteristics allow versatile deployment as the main protection for all transmission and distribution circuits.

Multiple main protection elements reside inside each relay: distance, delta directional comparison protection and directional earth/ground fault unit protection (DEF) for solidly earthed systems and a novel transient earth fault detection (TEFD) for isolated or compensated earthed systems. This permits simplified applications and reduced spares holdings.

Applications

The P443 is supplied with a comprehensive 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 can be disabled. Disabled functions are then completely removed from the menu, to simplify settings.

Key Benefits

- Subcycle fault clearance (0.7 to 1 cycle)
- Simple set mode: the relay determines its own settings from the protected line data
- Eight distance zones offer flexibility of application
- Optional phase preference tripping logic for isolated and compensated earthed systems
- An unrivaled transient earth fault detection (TEFD) with no need to add unreliable analogue hardware relays, nor analogue processing boards
- Integral teleprotection via MODEM, fibre, or MUX channel
- Compatibility with modern 2 Mbps communications equipment
- Cybersecurity aligned to industry standards and services (NERC® CIP, AAA, RADIUS, RBAC, Syslog)



Protection and Control

- Distance 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 for a wide range of applications and voltage levels
- Power swing alarm and block, plus out of step trip
- Phase preference loop tripping logic and TEFD for isolated and compensation-earthed networks
- Distance, DEF and delta directional comparison
- Multi-shot autoreclosure with check synchronism and adaptive breaker closing
- Improved system stability by CB failure fast reset element (< 0.75 cycle)

Advanced Communications

- InterMiCOM option for end-to-end protection communications; readily interfaces with end-to-end communications channels (56/64 kbps or E1 2 Mbps)
- Wide range of supported protocols Courier/K-Bus, IEC 60870-5-103, DNP 3.0 (EAI-485 or Ethernet) and IEC 61850
- Advanced IEC 61850 Edition 2 implementation with complete settings via SCL files
- Redundant communications with zero downtime using optional PRP/HSR technology



Functional Overview

ANSI	IEC 61850	Features	P443			
			A	B	C	D
	OptGGIO	Optocoupled logic inputs	16	24	16	24
	RlyGGIO	Relay output contacts	24	32	16	16
		High speed, high break contacts			4	8
	PTRC	Tripping mode - single or 3-pole		1 or 3 ph		
		Clockwise and anticlockwise phase rotation		x		
21P / 21G	PDIS	Distance zones		8		
		Characteristics Phase Ground		Mho and Quad Mho and Quad		
		CVT transient overreach elimination		x		
		Load blinder		x		
		Easy setting mode		x		
		Mutual compensation		x		
85	PSCH	Communication-aided schemes, PUTT, POTT, Blocking, Weak Infeed, DACH specials		x		
		Accelerated tripping - loss of load and zone 1 extension		x		
50/27	PSOF	Switch on to fault		x		
68	RPSB	Power swing blocking		x		
78		Out of step tripping		x		
		Delta directional comparison		x		
67N		Directional earth fault (DEF) unit protection		x		
TEFD	PTEF	Transient earth fault detection		1		
50 / 51 / 67	OcpPTOC/RDIR	Phase overcurrent stages		4		
50N / 51N / 67N	EfdPTOC/RDIR	Earth/ground overcurrent stages		4		
67N	PTEF	Transient Earth Fault		1		
64	SenRefPDIF	High impedance restricted earth fault		x		
67 / 46	NgcPTOC/RDIR	Negative sequence overcurrent		4		
46BC		Broken conductor		x		
49	PTTR	Thermal protection		x		
27	PTUV	Undervoltage protection stages		2		
59	PhsPTOV	Overvoltage protection stages		2		
59N	ResPTOV	Residual voltage protection stages		2		
50BF	RBRF	High speed breaker fail		x		
CTS / VTS		Current and voltage transformer supervision		x		
79	RREC	Autoreclose - shots supported		4		
25	RSYN	Check synchronism		x		
		No. of breakers controlled		1		
		Alternative setting groups		4		
FL	RFLO	Fault locator		x		
		Fault records		15		
		SOE event records		1024		
	RDRE	Disturbance recorder, samples per cycle		48		
		Number of channels in disturbance recorder analog / digital		8/16/64		
	XCBR	Circuit-breaker condition monitor		x		
		Graphical Programmable Scheme Logic (PSL)		x		
		IRIG-B time synchronism		(x)		
		InterMiCOM teleprotection		(x)		

Key (x) : denotes optional

Functional Overview

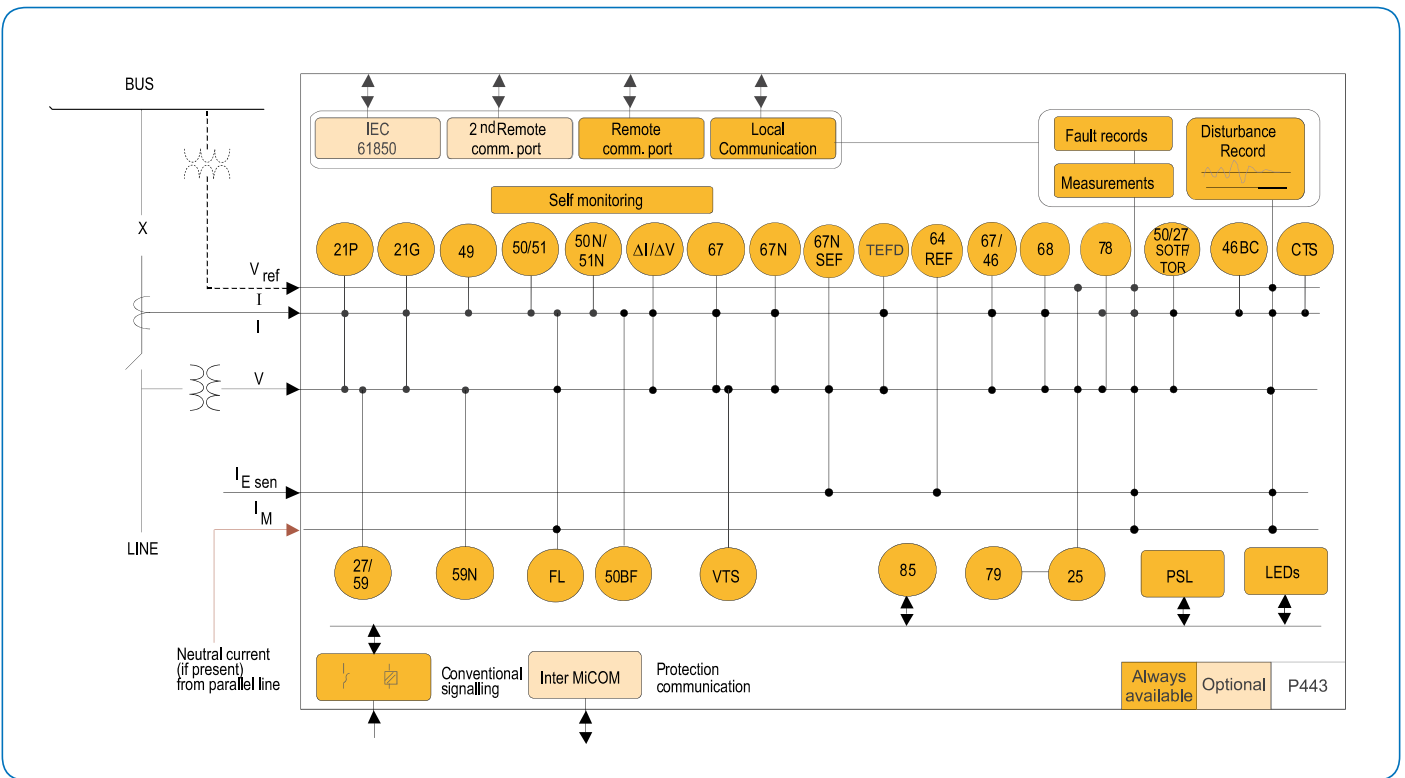


Figure 1: System overview of the P443 firmware 92

Applications

The protection functions overview table highlights the functions available.



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

Six zones of protection are shown for simplicity in Figures 2 and 3. Additional zones ZR and ZS are available too, to offer eight zones in total. The provision of eight zones allows bus-coupler application, with a full four zone application directionalised in one sense, plus another full four zone application in the opposite direction. Mho and quadrilateral (polygon) characteristics can 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 3) 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.

A settable alternative distance scheme initiates all the zone timers simultaneously and guarantees faster tripping times for evolving faults.

Blinder characteristics 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 zones 1 to 4, as depicted in Figure 4.

Tripping Time

The trip times shown in Figure 4 relate to a P443 with standard relay contacts and include the contact closure time. When fitted with High Speed-High Break (HSHB) contacts, all trip times are reduced by 3 to 4 ms. The trip time for P443 becomes 0.5 to 0.85 cycles. HSHB contacts can easily rupture repetitive shots of 10 A trip or close coil currents.

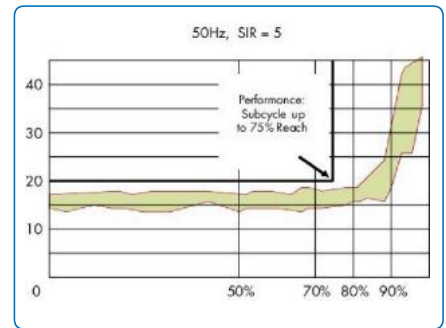


Figure 4: P443 sample min-max timing contour: 50 Hz, SIR=5

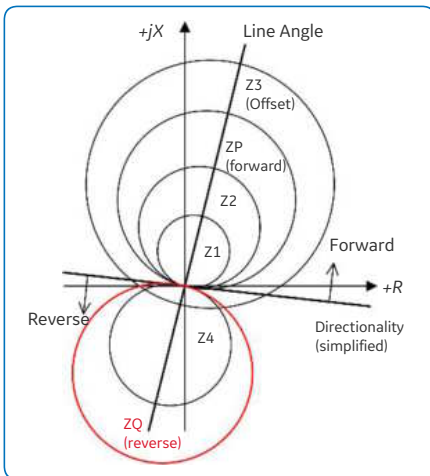


Figure 2: Mho characteristics (ZR, ZS omitted for simplicity)

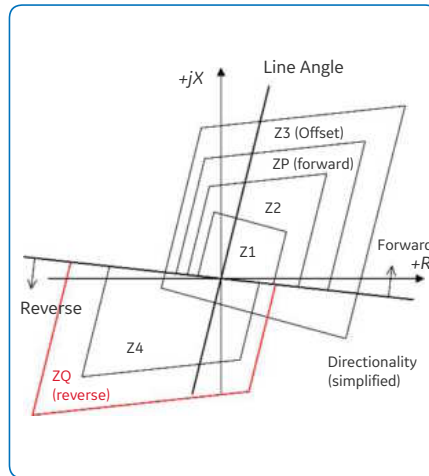


Figure 3: Quadrilateral characteristics (ZR, ZS omitted for simplicity)

Power Swing Blocking (PSB)

The MiCOMho recognises power swings quickly via the superimposed currents measured by the phase selector. A conventional PSB element based on the impedance band is provided to detect slow power swings. The distance trip time for faults occurring during a power swing remains subcycle.

Out of Step Tripping - OST

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

MiCOM Agile P443 version 92: The P40 platform model dedicated for Central European distance protection applications

Main Protection Schemes

Pre-configured distance schemes allow single and 3-phase tripping with or without a signaling channel:

- Basic scheme logic for standalone operation (without a signaling channel)
- Trip on close logic allows accelerated tripping to be selected following manual, or auto-reclose

Carrier Aided Scheme Includes:

- 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 communications channel. The distance, directional and DEF functions are thus flexible in configuration, operating either in shared channel logic or in discrete modes.

Delta Directional Comparison

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, as proven in the LFDC product. The advantage is that channels 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 Polarising (VCP) feature even ensures correct operation when the fault generates negligible zero or negative sequence voltage.

The "Virtual Current Polarising" feature can be switched-off when used in non-solidly earthed systems. Traditional relays would have required an extra CT input to cover this scenario - not the MiCOMho.

Phase Preference for Petersen Coil Earthed and Isolated Systems

MiCOM P443 is equipped with phase preference tripping logic for Petersen coil earthed and isolated systems. Tripping for a cross-country fault, can be set to follow either a so-called "cyclic" logic or an "acyclic" logic to select a phase preference for the impedance measurement. 1 out of 8 priority criteria can be selected.

Transient Earth Fault Detection

MiCOM P443 incorporates novel transient earth fault detection (TEFD) with no need to add unreliable analogue processing boards. This approach achieves the most cost-effective functional integration and protection scheme engineering. The TEFD technique works on a special frequency range centred at 220 Hz. Selecting this interharmonic spectrum avoids the 4th and 5th harmonics which are naturally prevalent in compensated networks.

InterMiCOM (Optional) Communications

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 cyclical redundancy checks (CRC) on the received data for maximum message security.

InterMiCOM provides 24 end-to-end signals, assignable to any function within a MiCOM relay's programmable logic. Default fail-safe states can also be set in case of channel outage.

Two physical formats for InterMiCOM are possible:

- EIA (RS) 232 for MODEM links
- InterMiCOM⁶⁴ at 56/64 kbit/s for direct fibre or multiplexed links

InterMiCOM⁶⁴ also includes support for 3-terminal applications, employing the same communications topology as in successful LFCB and P540 series products. 850 nm fibre communications are used to interface with multiplexers in IEEE C37.94 format (and to G.703 (64 kbps, E1 2 Mbps), V.35 and X.21 via P590 interfaces).

1300 nm channel options are used for direct fibre teleprotection.

In 3-terminal schemes, the communications are self-healing if one leg of the triangulation fails. The end-end transfer time of permissive or blocking scheme data is typically just 5 ms for InterMiCOM⁶⁴.

Backup Protection

- Four stages of both phase and earth (ground) fault protection
- Transient earth fault detection (TEFD)
- Negative sequence overcurrent and SEF (0.5% In sensitivity)
- Phase under/overvoltage protection
- Broken conductor protection
- Two stage high speed circuit-breaker failure protection

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.

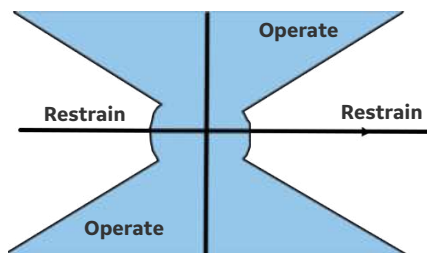


Figure 5: Load blinder

Control

Function Keys

Trip and close commands are facilitated from front panel hotkeys to allow direct CB control without the need to navigate a menu. Additional in/out, on/off and enable/disable controls are easily programmed (up to 10 F-keys).

Single Breaker Autoreclose

Autoreclose includes check synchronism, with adaptive closing of the breaker, compensating for the breaker's operating time. The user may select a single, two, three or four shot autoreclose cycle.

Programmable Scheme Logic

Powerful graphical logic allows the user to customise the protection and control functions (See Figure 6).

The gate logic includes 32 timers, 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 optimised to ensure that the protection outputs are not delayed by the PSL operation.

The programmable scheme logic is configured using graphical S1 Agile software, as shown in Figure 7. The relay outputs may be configured as latching ("Lockout") or self-reset.

All aspects of MiCOM P40 IED configuration are managed using the S1 Agile software (see Figure 8).

Measurement and Recording Facilities

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

Power System Measurements

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

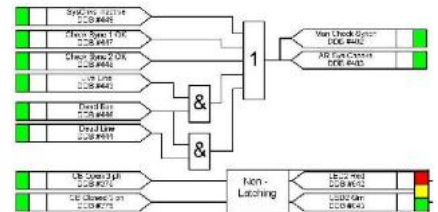


Figure 7: Programmable scheme logic



Figure 8: S1 Agile a powerful and intuitive PC tool suite

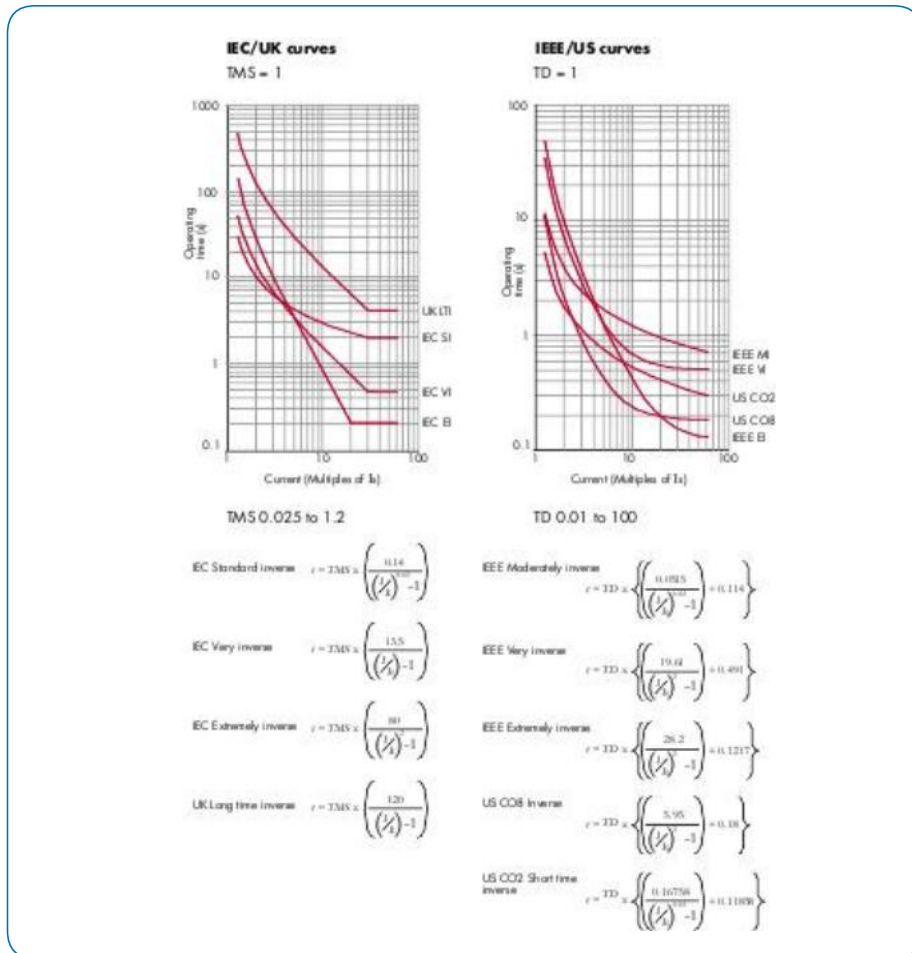


Figure 6: Inverse-time protection curves

Post Fault Analysis

Fault Location

A fault location algorithm provides the distance to fault in miles, kilometres, ohms or percentage of the line length. This proven algorithm tolerates pre-fault loading and fault arc resistance.

Event Records

Up to 1024 time-tagged event records can be stored.

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 8 analogue channels for P443, 64 digital and 1 time channel - all at a resolution of 48 samples/cycle. Disturbance records can be extracted from the relay via remote communications and saved in the COMTRADE format.

Plant Supervision

Circuit Breaker Condition Monitoring

- Monitors the number of breaker trip operations
- Records the sum of broken current quantities (interruption duty)
- Monitors the breaker operating times

Quality Built-in (QBi)

Grid Solutions' QBi initiative has deployed a number of initiatives to maximise field quality. Harsh environmental coating is applied to all circuit boards to shield them from moisture and atmospheric contamination. Transit packaging has been redesigned to ISTA standards and the fourth generation of CPU processing boosts not only performance, but also reliability.

GE-branded MiCOM P40 relays have no resident battery, to ease airfreight logistics.

Communications with Remote Operators and Substation Automation

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

The following protocols are available:

- Courier/K-Bus
- IEC 60870-5-103
- DNP 3.0 (EAI-485 or Ethernet)
- IEC 61850
- USB front-port communication

Px4x devices can be enhanced with an optional redundant Ethernet board. The redundancy is managed by the market's fastest recovery time protocols: IEC 62439-3 PRP and HSR allowing bumpless redundancy and RSTP, offering multi-vendor interoperability. The redundant Ethernet board supports either modulated or demodulated IRIG-B, IEEE1588 and the SNTP protocol for time synchronisation. The redundant Ethernet board also has a watchdog relay contact to alarm in case of a failure.

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

- P443 relays are housed in full 80TE cases, for 19" rack or flush mounting



Figure 9: P443 in Case Size 80TE (16")

Device Track Record - High Speed Distance Protection

Micromho subcycle distance protection deployed on EHV systems since 1983 - over 2,500 relays supplied. Very fast mho characteristics relay

Quadramho distance protection launched in 1984, adding quadrilateral characteristics to the range

Optimho universal mho and quadrilateral relays launched in 1989. Over 11,500 units delivered

Numerical implementation and phase selection proven in subcycle LFDC and LFZR relays

Approximately 50,000 P44x family distance relays delivered since launch in 1999

56/64 kbit/s teleprotection proven in over 50,000 LFCB and P540 series units delivered

MICOM P40 AGILE

GE's philosophy is one of continuous improvement in our products and solutions. Our emphasis on communication in MiCOM has become a focus which secures leadership in the digital substation. To mark this phase of evolution, the P40 Agile livery is applied to the range. P40 Agile is a mark of performance and quality, proudly available from GE, and only from GE.



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Imagination at work