



MiCOMho Agile P443/P445/P446

High Performance Distance Protection

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

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. Series compensated line applications are also 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 applications and reduced spares holdings, as the MiCOMho can be adopted as the standard protection platform.

Applications

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

The protection functions overview table highlights the functions available.

The 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 can be disabled. Disabled functions are then completely removed from the menu, to simplify settings.

Main Benefits

- P443/P446: subcycle fault clearance (0.7 to 1 cycle)
- Simple set mode: the relay determines its own settings from protected line data
- Integral teleprotection via MODEM, fibre, or MUX channel
- Compatibility with modern 2 Mbps communications equipment
- IEC 61850-9-2LE process bus ready
- Cybersecurity aligned to industry standards and services (eg. 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 in all applications and at all voltage levels
- Power swing alarm and block, plus out of step trip
- 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
- IEEE 1588 precision-time synchronising



Functional Overview

ANSI	IEC 61850	FEATURES	P446			P443				P445			
			A	B	C	A	B	C	D	A	B	C	D
	OptGGIO	Optocoupled logic inputs	24	24	24	16	24	16	24	8	12	16	16
	RlyGGIO	Relay output contacts	32	8	16	24	32	16	16	8	12	16	8
		High speed, high break contacts		12	8			4	8				4
	PTRC	Tripping mode - single or 3-pole	1 or 3 ph						3 ph				
		Clockwise and anticlockwise phase rotation	x										
		IEC 61850-9-2 process bus option	x			-				-			
21P / 21G	PDIS	Distance zones	5			6 *				5			
		Characteristics Phase Ground	Mho and Quad Mho and Quad						Mho 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	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 (incremental quantities)	x										
67N		Directional earth fault (DEF) unit protection	x										
50 / 51 / 67	OcpPTOC/RDIR	Phase overcurrent stages	4										
50N / 51N / 67N	EfdPTOC/RDIR	Earth/ground overcurrent stages	4										
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 or 2			1				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)**										

Note *: P443 global model has 6 zones, a special 8 zone 50Hz DACH variant (SW 92) is available for Central Europe, not covered in this brochure

Note **: Key (x) : denotes optional

Functional Block Diagram

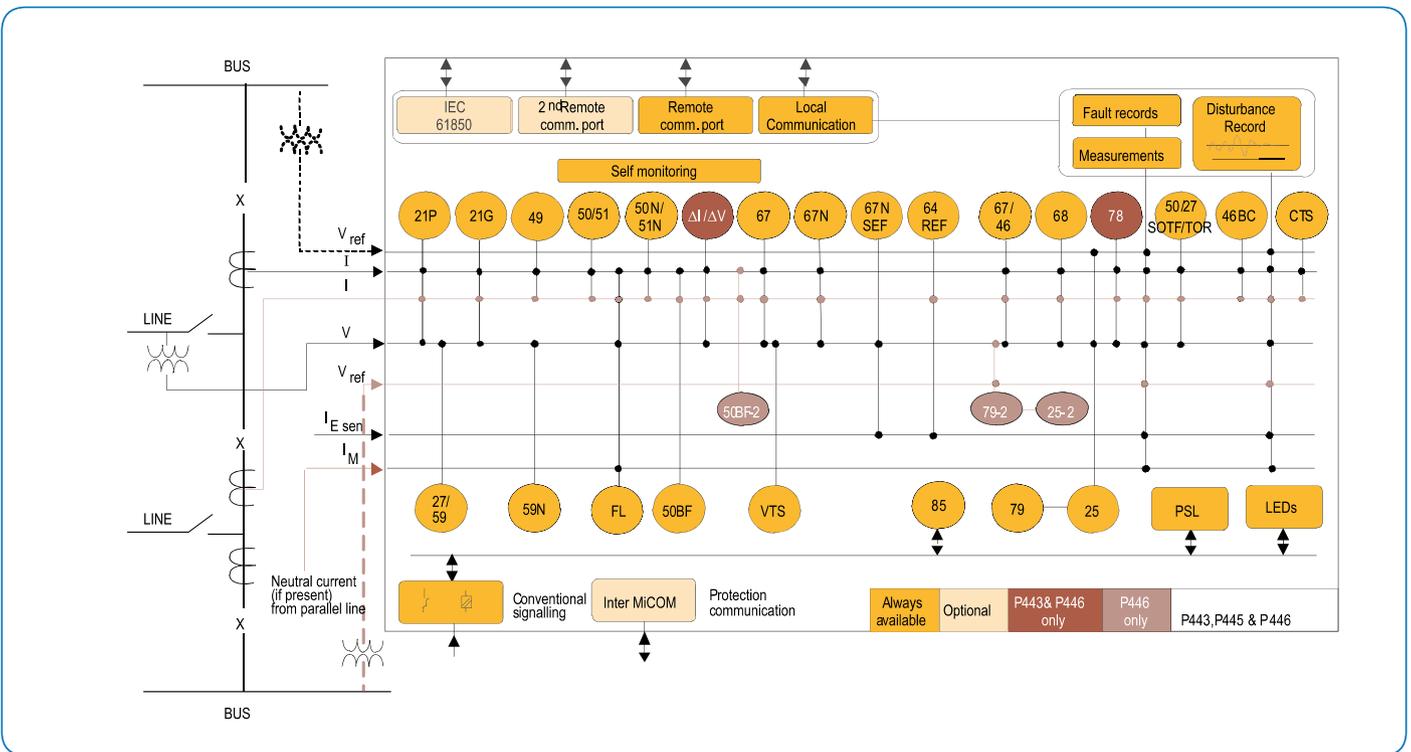


Figure 1: System overview of the P44y series



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 or six zones of protection are provided as shown in Figures 2 and 5. Depending on 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).

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

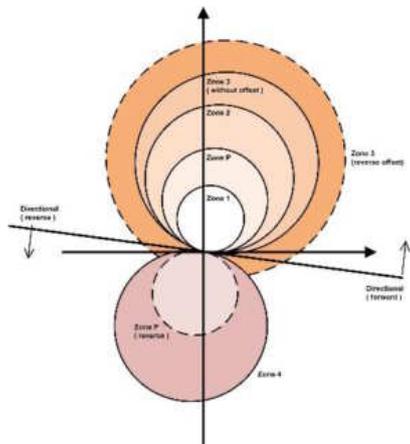


Figure 2: Mho characteristics in P445/P446 (Note - P443 offers additional ZQ)

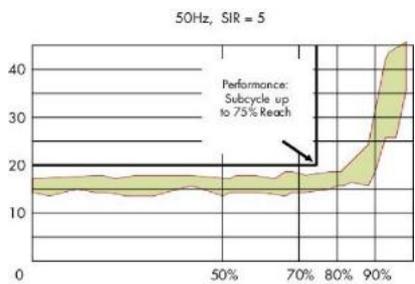


Figure 3: P443/446 sample min-max timing contour: 50 Hz, SIR=5

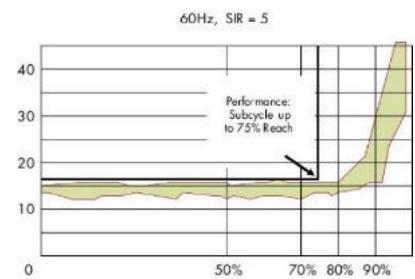


Figure 4: P443/446 sample min-max timing contour: 60 Hz, SIR=5

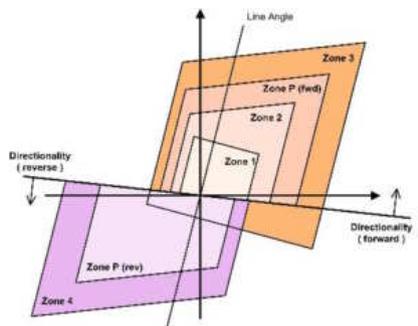


Figure 5: Quadrilateral characteristics in P445/P446 (Note - P443 offers additional ZQ)

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 cycles 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 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 P443/446 becomes 0.5 to 0.85 cycles. HSHB contacts easily rupture repetitive shots of 10 A trip or close coil currents.

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 (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.

MiCOMho Agile P446: A full-scheme distance relay with subcycle technology, suitable for dual breaker 1/3 phase reclosing applications - dual check synchronism included

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 - Incremental Quantities (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, 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.

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

InterMiCOM provides 8 to 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.

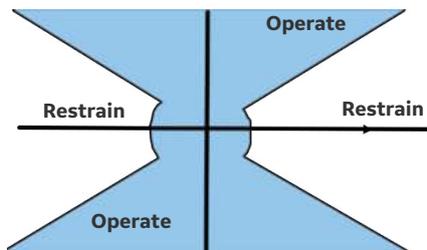


Figure 6: Load blinder

Backup Protection

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

IEC 61850-9-2LE Process Bus Interface

An optional process bus interface is available, allowing the relay to receive current and voltage sampled data from non-conventional instrument transformers such as optical and Rogowski devices. In other digital substation architectures, the -9-2LE data is generated by merging units in the yard, which digitise conventional 1 A/5 A and 100/120 V secondaries for safer and more economical cross-site communication to IEDs via fibre optics.

Grid Solutions' -9-2LE implementation has been designed to be especially resilient and reliable in the presence of "noise", such as latency, jitter or missing/suspect data.

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

Function Keys

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

Single Breaker Autoreclose

P443 & P445 with check synchronism include adaptive closing of the breaker taking into account breaker operating time. The user may select a single, two, three or four shot autoreclose cycle.

Dual Breaker Autoreclose

P446 with check synchronism include adaptive closing of breakers taking into account breakers' operating time. The following additional features are offered in the P446 to permit two breaker reclosing in a leader-follower scheme:

- Two CB controls - CB1 and CB2 are assigned. The user selects which is the leader and which is the follower breaker
- Individual selection of recloser on or off
- Follower action - follows successful closing 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 customise the protection and control functions (See Figure 8).

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 8. 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 9).

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.

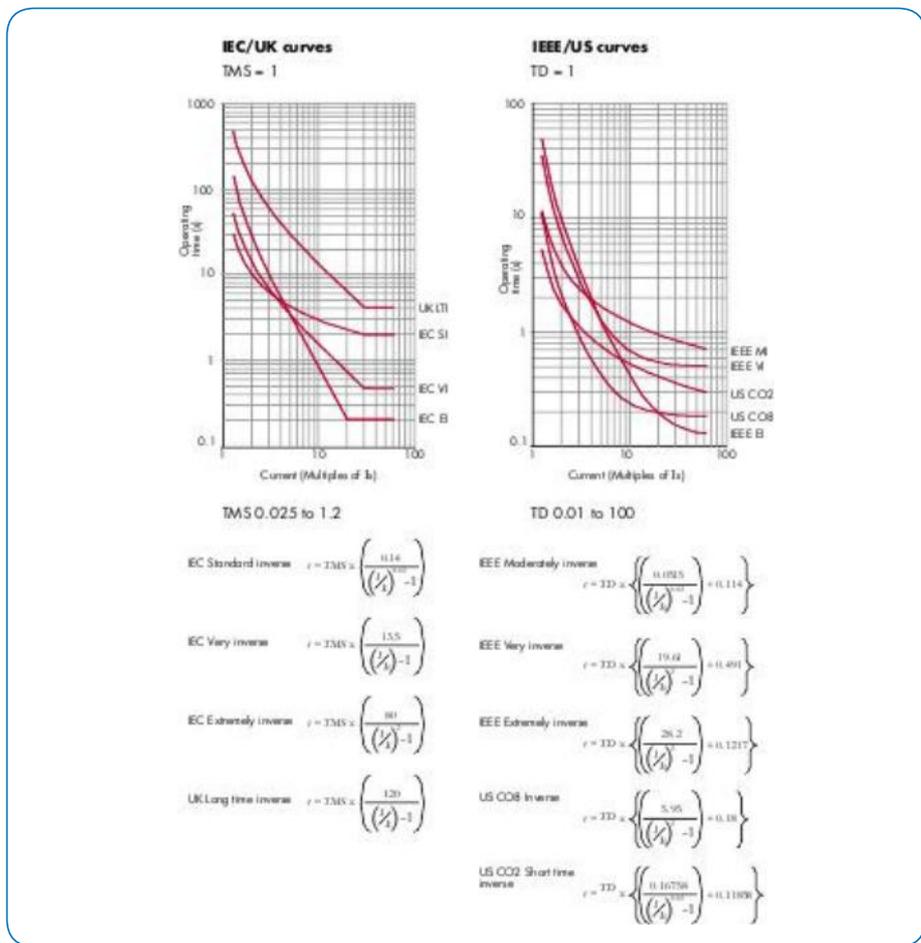


Figure 7: Inverse-time protection curves

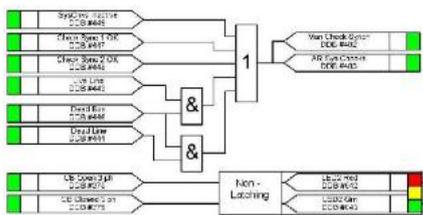


Figure 8: Programmable scheme logic



Figure 9: S1 Agile a powerful and intuitive PC tool suite

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, 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 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

- 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 footprint. P445 hardware B, C and D are supplied in 60TE (12") case widths



Figure 10 P445 in Case Size 40TE (8")

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

Grid Solutions' 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 Grid Solutions, and only from Grid Solutions.



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Imagination at work