400 Series
Digital Protection Relays
Brochure

MPM 400-D
Motor Protection Relay

DPM 400-D
Directional Protection Relay

CPM 400-D
Overcurrent Protection Relay

VPM 400-D
Voltage & Frequency Protection Relay

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General Specifications and Advantages

DEMA 400 Series IEDs comprise of state-of-art digital relays for voltage (VPM 400-D), non-directional overcurrent (CPM 400-D), directional overcurrent (DPM 400-D) and motor (MPM 400-D) protection. All 400 Series relays are designed and optimized to provide facilities highest performance, robust operation and numerous assembly, commissioning, service advantages.

DEMA 400 Series Digital Protection Relays are type tested in internationally accredited laboratories to comply with IEC 60255, IEC 60529, IEC 60695, IEC 60068 and IEC 61850 standards, and have been introduced into service under the guarantee of ISO9001:2008.

Introduced into the market in 2017, DEMA 400 Series products have already been the relay of choice for many industrial facilities, renewable energy plants and medium voltage power distribution centres.

The table below summarizes the specifications for all 4 models of DEMA 400 Series relays.
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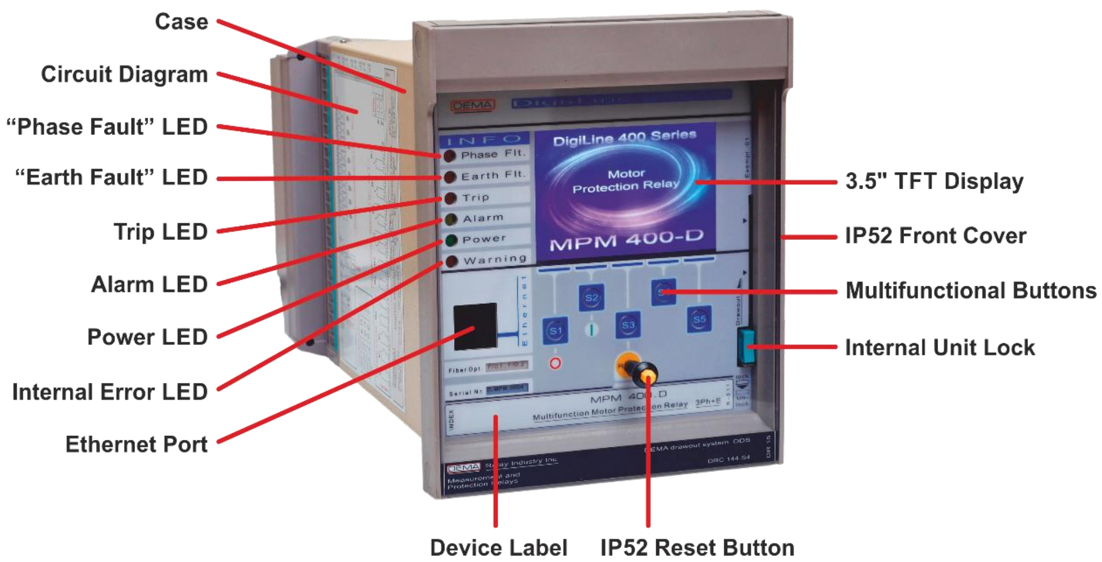
PROTECTION / CONTROL FUNCTION	ANSI CODE	VPM 400 Voltage Protection Relay	CPM 400 Overcurrent Protection Relay	DPM 400 Directional Overcurrent Protection Relay	MPM 400 Motor Protection Relay
Current Protection Functions					
Non-directional phase + earth + derived earth	50/51(P/N/N-D)		●	●	●
Directional phase + earth + derived earth	67(P/N/N-D)			●	●
Thermal over-load protection	49		●	●	●
Negative sequence over-current	46		●	●	●
3-phase under current	37P		●	●	●
Voltage Protection Functions					
3-phase over / under-voltage	59 / 27	●		●	●
Negative sequence over-voltage	47	●		●	●
Residual over-voltage	59N	●		●	●
Frequency Protection Functions					
Over-frequency / under-frequency	81O / 81U	●		●	●
Rate of change of frequency	81R	●		●	●
Power Protection Functions					
Directional active over-power / under-power	32OP / 32UP			●	●
Directional reactive over-power / under-power	32OQ / 32UQ			●	●
Watt-metric earth fault (Pe, Iecos)	32N			●	●
Motor Protection Functions					
RTD temperature protection	RTD				●
Automatic Control Functions					
Voltage controlled over-current	51V			●	●
Automatic recloser	79		●	●	●
Breaker failure supervision	50BF		●	●	●
Broken conductor	46BC		●	●	●
Cold load pickup	CLP		●	●	●
Pick-up current blocking	68		●	●	●
Switch-on-to-failure	SOTF		●	●	●
Voltage transformer supervision	74VT			●	●
Current transformer supervision	74CT			●	●
Logic selectivity scheme - Blocking		●	●	●	●
Logic selectivity scheme - Delaying			●	●	●
Other Functions & Specifications					
Voltage / current inputs		3 / 0	0 / 4	3 / 4	3 / 4
Programmable inputs		8	8	8	10
Programmable outputs		8	8	8	8
Time synchronization (IRIG-B + SNTP)		●	●	●	●
Communication ports (Ethernet / RS485 / F/O)		3 / 1 / (opt.) 2	3 / 1 / (opt.) 2	3 / 1 / (opt.) 2	3 / 1 / (opt.) 2
Analog Input (4-20) mA		●	●	●	●
Motor encoder					●
RTD inputs					8

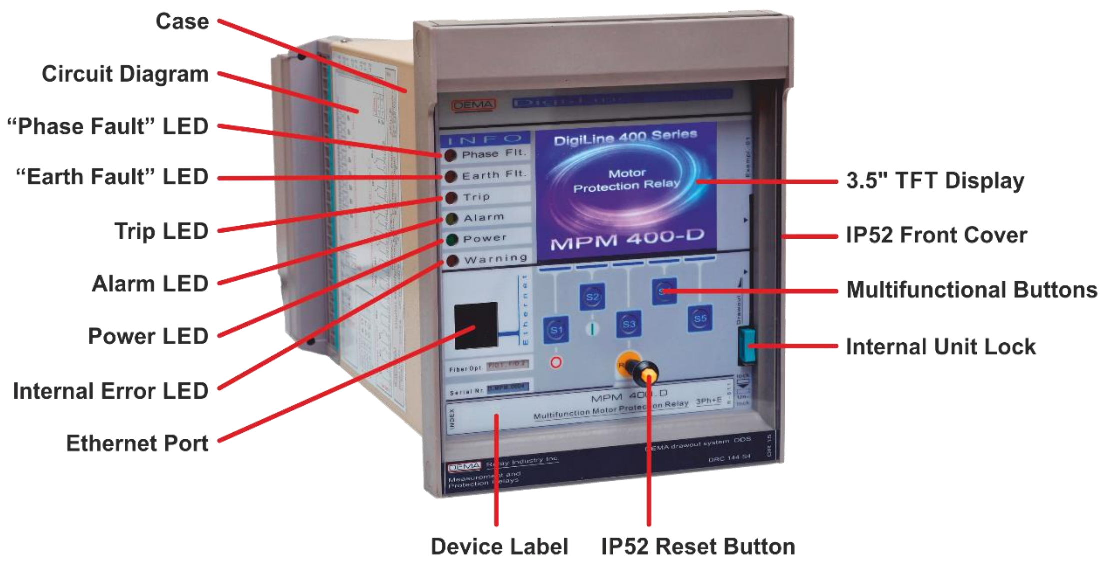
General Specifications and Advantages

- Auxiliary supply voltage compatibility with all voltages in the field: (24 – 240) V_{ac} / V_{dc}, operational range: (22 – 275) V_{ac} / V_{dc}.
- Operational ambient temperature range: (-25 … +85) ºC,
- Windows 32/64-bit based PC control software,
- Wide communication protocols support: IEC 61850 + GOOSE, IEC 60870-5-103, DNP 3.0, MODBUS RTU and TCP,
- Wide IEC, ANSI and custom delay curve support, enabling selectivity setup with all types of protection relays including electromechanical relays,
- 3-channel voltage inputs: (57 … 130) V_{AC} with continuous 260 V_{AC} and 10 s – 300 V_{AC} insulation withstand,
- 4-channel X/1 A and X/5 A current input with continuous 20 A and 1 s – 500 A thermal withstand,
- DMT and IDMT delay curve support for all current & voltage protection functions,
- Option for RMS or fundamental harmonics measurement method for various protection functions,
- Remote control and monitoring of the circuit breaker via dedicated menu with mimic diagram,
- Annunciating functions and 8/10 optically coupled programmable digital inputs that eliminate the need to use external annunciators (e.g. to evaluate Buchholz, temperature and pressure signals),
- 8 programmable 8 A – 250 V outputs (4 SPDT + 4 SPST),
- Full screen multimeter display, measurement functions that eliminate the need to use double core CTs and external meters,
- Built-in X/1 A and X/5 A current transformer compatibility,
- Super-capacitor fed real-time clock,
- 8 independent settings groups,
- 3-stage security password system,
- IP52 front side and IP20 backside environmental protection,
- Fast and low cost repairs thanks to the modular electronics,
- 3-year limited warranty,
- Matchless customer support, a variety of application schemas and technical documents. □

Physical Introduction



- **"Phase Fault" LED**
  "Phase Fault" indicates trip operations triggered by any of the active phase protection functions. The Trip LED runs continuously as long as the trip contact is in closed position, while flashing until reset if the CB is tripped by the relay and the disturbance is cleared.
- **"Earth Fault" LED**
  "Earth Fault" indicates trip operations triggered by any of the active earth protection functions. LED behaviour is the same with the "Phase Fault" LED.
- **Trip LED**
  Trip LED indicates trip operations triggered by any of the active protection functions. LED behaviour is the same with the "Phase Fault" LED.
- **Alarm LED**
  Alarm LED indicates abnormal states of the protected circuits, and is triggered by any of the active alarming functions. LED behaviour is configurable.
- **Power LED**
  Power LED indicates the presence of healthy auxiliary supply to the 400 Series relay.
- **Internal Error LED**
  Indicated with "Internal Error" label on the front panel of the relay, LED goes active in red colour if any internal errors are detected.
- **Ethernet Port**
  The ethernet port on the front panel is intended to provide PC connectivity via the dedicated PC program.
- **IP52 Front Cover**
  Internal unit is isolated from the environmental effects by the cover. The cover provides IP52 protection with its special sealing. The cover is mounted on the case via two integrated nuts. There is an external button on the transparent window of the cover that provides access to the reset button without having to remove the cover. ↺

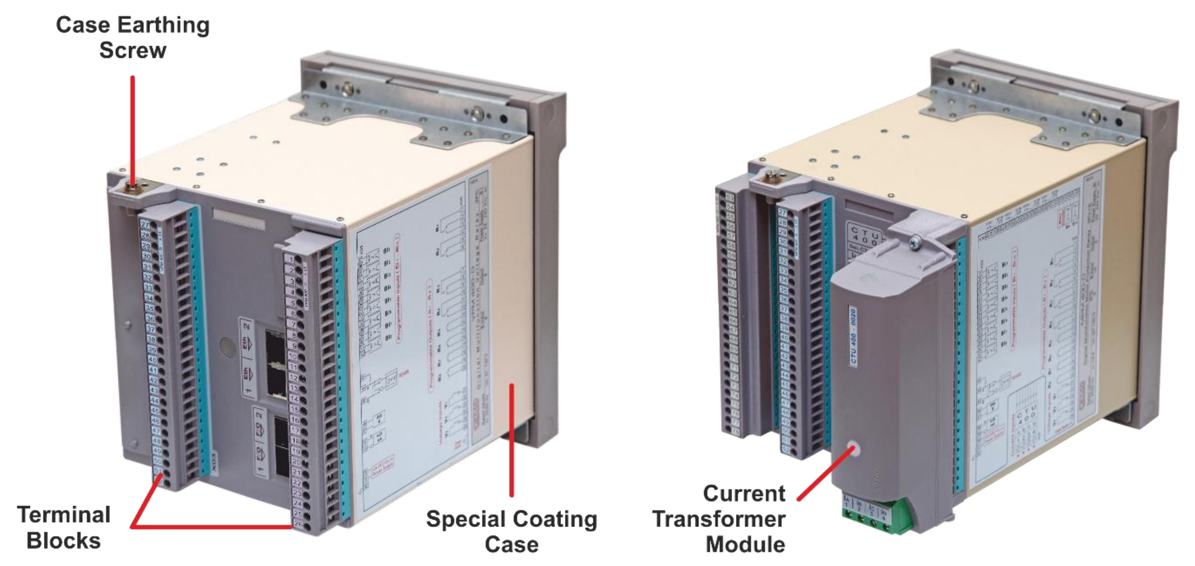


- **3.5" TFT Display**
  The backlit 320 px x 480 px 262 k 3.5" TFT display provides the local operator with enhanced control of the menus.

- **Multifunctional Buttons**
  Similar to cell phone menu control architecture, multifunctional buttons provide easy command and navigation control through the menus.

- **Internal Unit Lock**
  As a subsystem of the patented DDS (DEMA Draw out System) technology, internal unit lock provides locking and drawing out of the internal unit with ease. Locking ensures safe electrical contacts.

- **IP52 Reset Button**
  Provides access to the LED and Alarm menus. Reset button is used for viewing and resetting these menus, as well as resetting latched relays, if applicable. ↺



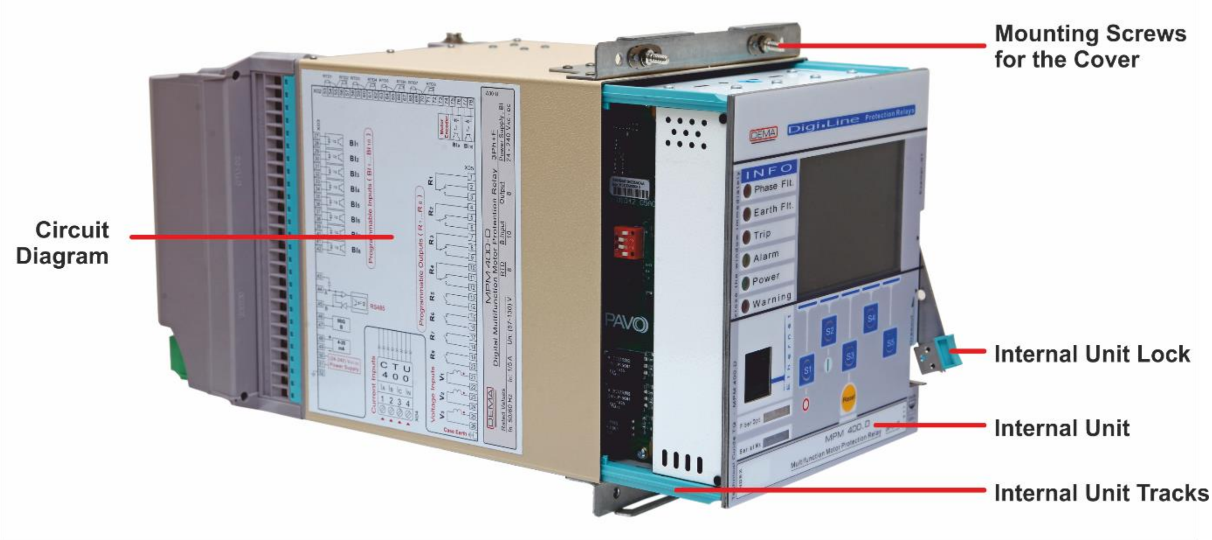
VPM 400

MPM 400 - DPM 400 - CPM 400

- **Case Earthing Screw**
  Maximum operation safety is achieved via grounding of this earthing screw, which is the terminal point for the conductance continuity of the case and the internal unit construction.

- **Terminal Blocks**
  Made of inflammable materials, terminal blocks are designed to ensure safe connection and cabling.

- **Special Coating Case**
  Using the state-of-art coating technology against corrosion and scratching, the relay case is immune against aging and environmental effects. ↺



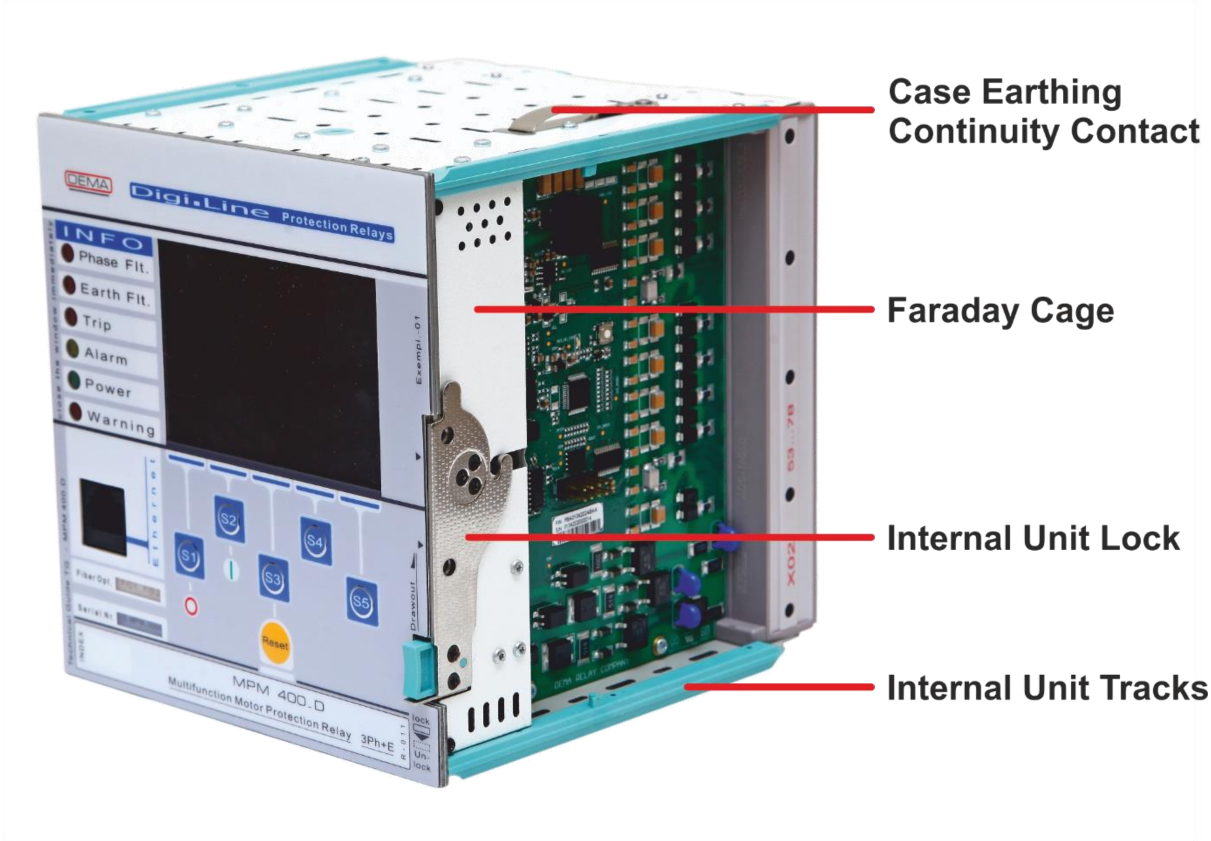
400 Series : Internal & External Units

- **Circuit Diagram**
  The circuit diagram of the device is fixed on the relay case. Users do not need to keep documents for basic cabling duties on the field thanks to this inerasable diagram.

- **Internal Unit**
  The internal unit houses the entire electronic systems, making it possible to replace the whole unit within seconds without having to black out the system. The modular design of electronic systems provides rapid and affordable maintenance & reparation in need. Critical electronic components are screened from noises in the Faraday cage inside of the unit.

- **Mounting Screws for the Cover**
  Mounting screws are fixed on the case and are employed to mount the cover on the case.

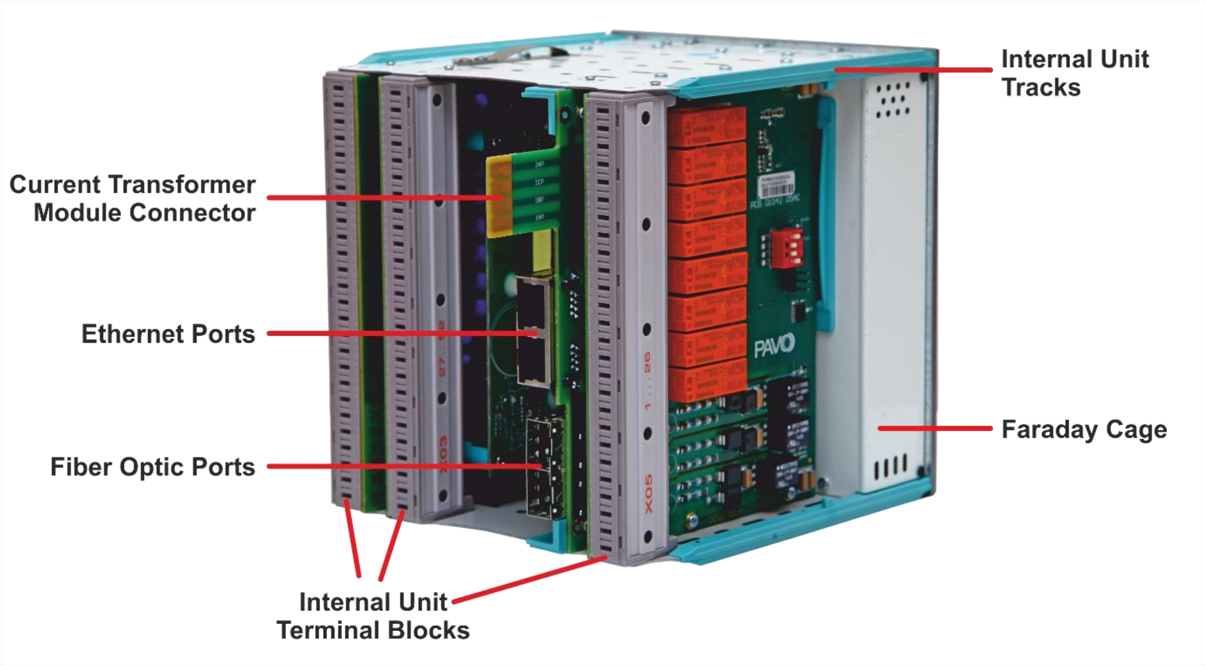
- **Internal Unit Tracks**
  High-endurance internal unit tracks provide robust draw-in and draw-out operation of the internal unit. ↺



400 Series : Internal Unit – Front View

- **Case Earthing Continuity Contact**
  Provides the earthing continuity of the internal unit to the casing. The low-resistance spring contact is rated for prospected earth fault current.

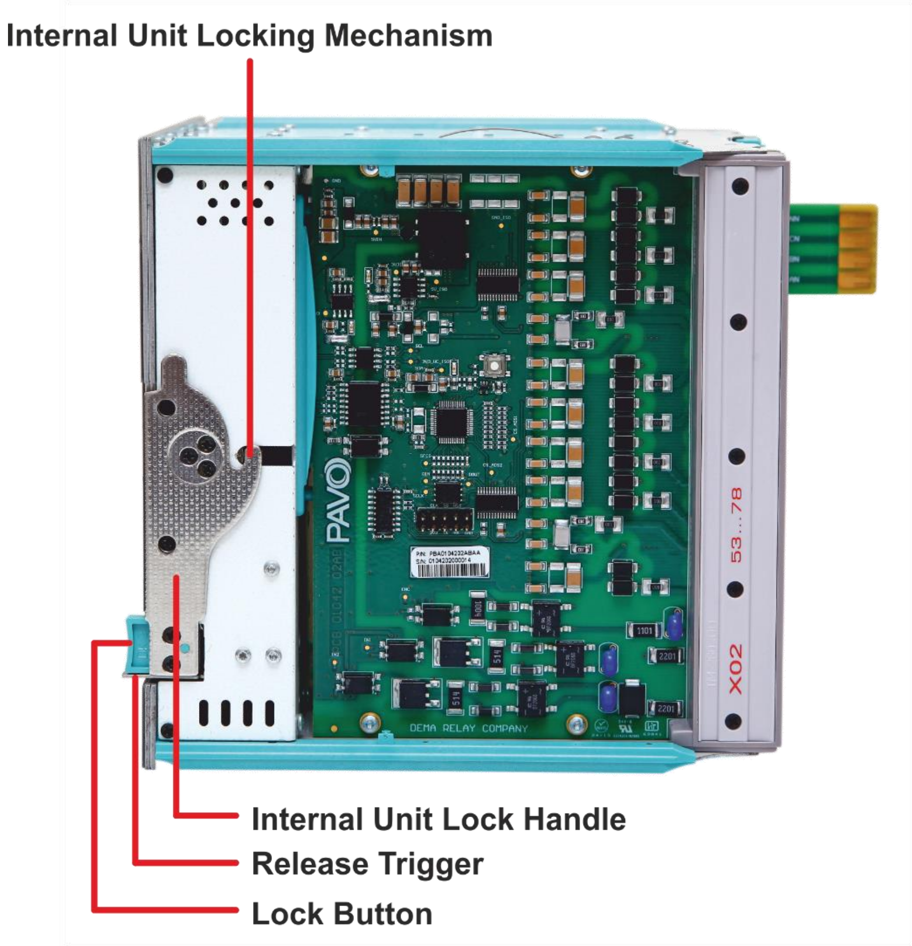
- **Faraday Cage**
  Digital signal processors, microprocessors and other critical components are safely embedded within the Faraday cage, clear of wave or field effects that may jeopardize the performance of the relay. ↺



400 Series : Internal Unit – Rear & Left Side View

- **Internal Unit Terminal Blocks**
  Sockets make the electrical connection by locking to the plugs when the internal unit is drawn into the case. All sockets are made of inflammable material.

- **Internal Unit Tracks**
  High-endurance internal unit tracks provide robust draw-in and draw-out operation of the internal unit.
  ↺

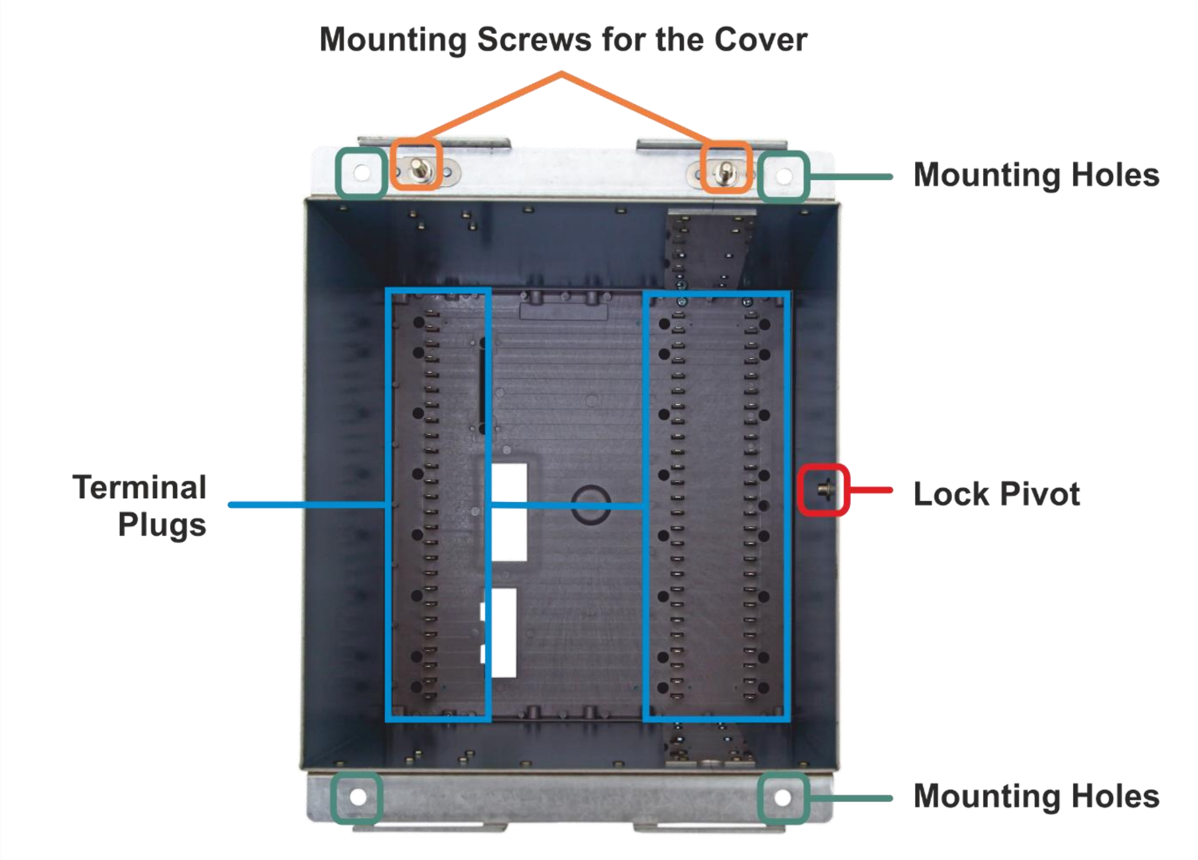


400 Series : Internal Unit – Right Side View

- **Internal Unit Locking Mechanism**
  As a subsystem of the patented DDS (DEMA Draw out System) technology, internal unit locking mechanism provides locking and drawing out of the internal unit with ease. Locking ensures safe electrical contacts.

- **Internal Unit Lock Handle and Release Trigger**
  The internal unit lock handle is released by the release trigger - that enables the drawing out of the internal unit by rotating the handle in upwards direction.

- **Lock Button**
  Lock button is used for locking the handle and the internal unit after the internal unit is drawn completely into the case. Before drawing the internal unit in, lock handle must be positioned parallel to the ground. ↺



400 Series : External Unit (Case) – Front View

- **Mounting Screws for the Cover**
  The cover is mounted onto the case via these screws. Screws are permanently fixed on the case.

- **Terminal Plugs**
  Plugs make the electrical connection by locking to the sockets when the internal unit is drawn into the case.

- **Lock Pivot**
  Internal unit locking mechanism locks to this pivot, providing mechanical and contacting stability.

- **Mounting Holes**
  The relay case is mounted on the panel or rack from these mounting holes. Connection elements necessary for mounting the case is supplied within the product box. □

400 Series Features & Functions

Phase & Earth Fault Instantaneous Protection (ANSI 50 / 50N)

There are 3 thresholds for instantaneous phase & earth fault protection. The setting zones are given below.

Phase fault protection ranges:
I› = (0.05 … 35) I_n
I›› = (0.05 … 35) I_n
I››› = (0.05 … 35) I_n

Earth fault protection ranges:
I_e› = (0.05 … 35) I_{en}
I_e›› = (0.05 … 35) I_{en}
I_e››› = (0.05 … 35) I_{en}

Phase & Earth Fault Delayed Protection (ANSI 51P / 51N)

DEMA 400 series relays provide a large variety of protection curves for delayed phase & earth fault protection. These curves consist of standard IEC/ANSI curves, definite time delay (DMT) as well as custom curves that are compatible with electromechanical relays. To help the users apply flexible and precise settings, these curves feature a large setting zone with relatively small steps. The resetting delay setting zones are likewise flexible and precise.

Calculated Non-directional Earth Protection (ANSI 50N-D/51N-D)

400 Series relays allow 2 stage non-directional earth overcurrent protection for calculated (vectoral) earth current over 3-phase signals.

Directional Phase and Earth Overcurrent Protection (ANSI 67P/67N)

400 Series IEDs feature directional protection functions with lowest voltage signal amplitude requirements in its class. The trip zone can be configured as "forward" or "reverse" (180°). The functions can be combined with non-directional functions. Thresholds for these functions are identical with the non-directional functions. Inverse or definite time delay options are available.

Calculated Directional Earth Protection (ANSI 67N-D)

400 Series relays allow 2 stage directional earth overcurrent protection for calculated (vectoral) earth current over 3-phase signals.

Thermal Overload Protection (ANSI 49)

Best protection for power transformers, overhead lines and underground cables at load around 1.0 – 1.5 I_n is provided by thermal overload protection schemes. Unlike the overcurrent curves, the thermal overload protection curve delivers relatively longer delays to provide maximum power availability, while preventing excessive thermal stresses on the protected equipment by utilizing thermal imaging technology. By applying appropriate combination of thermal overload and phase overcurrent functions, it is possible to achieve the optimal protection, selectivity and power availability solutions. In addition to the automatic protection function, the thermal stress on the equipment is monitored in real time for checking on demand. It should be noted that the thermal overload protection function fulfils the requirements of the IEC 60255-8 standard.

Negative Sequence Overcurrent Protection (ANSI 46):

Unbalanced phase current conditions without earth faults on the primary circuit of a distribution line or unbalanced current conditions with or without earth faults on the secondary circuit of a power transformer can be detected and intervened by this function. The delaying options are the same with phase overcurrent protection function.

Phase Undercurrent Protection (ANSI 37P)

This function is used in applications where undercurrent monitoring is required (e.g. tripping of a contactor controlling a water pump when the water source is exhausted). The function requires a 52a (normally open contact of the CB) signal for reliable operation. Setting zone is I‹ = (0.05 - 1.0) I_n with DMT delay.

Over / Under Voltage Protection (ANSI 59/27)

Over / under voltage protections are 2-staged functions that use definite time delays. RMS or fundamental harmonics measurement methods are available for both functions. The protections can be based on single phase or 3-phase measurements.
Protection ranges:
U< = (1 … 130) V, 0.1 V steps.
U> = (2 … 260) V, 0.1 V steps.
Over voltage delay (DMT)= (0.02 … 300) s, 0.01 s steps.
Under voltage delay (DMT)= (0.02 … 600) s, 0.01 s steps.
Hysteresis = %(1 … 20) in %1 steps.

Negative Sequence Over Voltage Protection (ANSI 47)

This single stage protection function is driven by the negative sequence component of the 3-phase voltage signal.
Protection range:
U2> = (1…130) V, 0.1 V steps.
Delay (DMT) = (0.02…120) s in 0.01 s steps.
Hysteresis = %(1…20) in %1 steps.

Neutral Overvoltage (ANSI 59N)

This single stage protection function is driven by the neutral voltage amplitude of a 3-phase open-delta circuit.
Protection range:
Ue1> = (1…260) V in 0.1 V steps.
Delay (DMT) = (0.02…600) s in 0.01 s steps.
Hysteresis = %(1…20) in %1 steps.

Over / Under Frequency Protection (ANSI 81O/81U)

400 Series IEDs feature over-frequency and under-frequency protections with 6 stages each.
Protection ranges:
f< and f> = (45.1…64.9) Hz in 0.1 Hz steps.
Delay (DMT) = (0.08 … 600) s in 0.01 s steps.
Hysteresis = %(1…20) in %1 steps.

Rate of Change of Frequency Protection (ANSI 81R)

400 Series IEDs feature rate of change of frequency protections with 6 stages.
Protection range:
df/dt = (-10…+10) Hz/s in 0.1 Hz/s steps.
Delay (DMT) = (0.08 … 200) s in 0.01 s steps.

Directional Active Over-power / Under-power Protection (ANSI 32OP/32UP)

These functions evaluate 3-phase current and voltage signals to perform 2-stage directional active over-power and under-power protection.
Protection range:
P>, P< = (1..10,000) (I_n/A)·W in 1 (I_n/A)·W steps.
Delay (DMT) = (0 … 150) s in 0.01 s steps.
Hysteresis = %(1…20) in %1 steps.

Directional Reactive Over-power / Under-power Protection (ANSI 32OQ/32UQ)

These functions evaluate 3-phase current and voltage signals to perform 2-stage directional reactive over-power and under-power protection.
Protection range:
Q>, Q< = (1..10,000) (I_n/A)·W in 1 (I_n/A)·W steps.
Delay (DMT) = (0.01 … 150) s in 0.01 s steps.
Hysteresis = %(1…20) in %1 steps.

Watt-metric Earth Fault (ANSI 32N)

The function evaluates 3-phase current and voltage signals to perform 2-strage watt-metric earth fault protection.
Protection range:
P_e>, P_e>> = (10…800) (I_{en}/A)·W, 1 (I_{en}/A)·W steps.
Delay: IDMT, or DMT = (0.02 … 150) s in 0.01 s steps.
Hysteresis = %(1…20), %1 steps.

Voltage Controlled Overcurrent Protection (ANSI 51V)

Voltage controlled overcurrent evaluate 3-phase current and voltage signals to perform up to 3 stages of protection.
The function is typically utilized to protect generators under overcurrent and short circuit conditions. U_2> setting range is (3 – 200) V, U> setting range is (1 – 130) V, each adjustable in 0.1 V steps.

Auto-reclosing (ANSI 79)

The auto-reclosing function that 400 series relays feature allows the users to auto-reclose the CB up to 4 shots. The auto-reclosing behaviour of a 400 series IED can be customized for all phase and earth protection functions and auxiliary timers, independently of each other. The inhibit time, the dead time and the delays between the auto-reclosing shots can be independently set. The advanced auto-reclosing algorithm of the IED ensures the safety of the system by blocking the auto-reclosing function in certain cases, such as the manual operation of the CB, detection of a fault current within the inhibit time, and detection a CB failure.

Circuit Breaker Failure Detection (ANSI 50BF)

This function checks to see if any poles of a circuit breaker fails to interrupt the primary circuit current when tripped. If such case is detected, the alarm menu notices the user about the fault and the logic signal to an upstream relay is removed, if applicable. The process starts with the opening of the CB; if the current measurements from one or more poles of the CB do not fall below the defined level of detection, then the fault is diagnosed. After a defined delay, the alarm is given and an output reacts, if programmed so. In applications where blocking or delaying logic selectivity schemes are utilized, the logic signal to the upstream relay is removed by means of this programmed output.

Broken Conductor Detection (ANSI 46BC)

The current faults in a distribution system are easily detected and cleared by protection relays. However, faults without overcurrent such as:

- breaking of an overhead line jumper,
- single phase fuse blow,
- closing failure of one of the poles of a CB,
- conducting problems of a primary power equipment,
- or open circuit on one of the current transformer secondary circuits introduce dangerous and intolerable conditions where different methods of protection should be utilized. The broken conductor detection function on CPM 310 G calculates the ratio between the negative sequence current and positive sequence current to sense and intervene these kinds of problems reliably, even at relatively low current signal levels from the healthy phases. The function behaviour can be modified by setting the critical ratio threshold and the delay.

Cold Load Pickup (CLPU)

The cold load pickup function provides the chance to shift the threshold values of the phase & earth & negative sequence overcurrent protection functions temporarily when the circuit breaker closes to drive cold loads such as high power motors, capacitor banks and power transformers. The shifting ratio can be set within the zone (20-800) % by 1 % steps, while the duration of this temporary state can be determined in the range (0.02 – 3,600) s by 0.1 s steps. The function resolves the pickup problems by shifting any independent thresholds desired and leaving others unchanged, while blocking none. The cold load pickup function is triggered by means of activation of a programmed input over one of the auxiliary contacts of the CB / contactor, or by a signal from an external device; thus, the risks of triggering by primary events which some other algorithms suffer are removed.

Inrush Blocking (ANSI 68)

Typical used to deactivate tripping conditions by detecting natural energizing characteristics of power transformers, this function compares the 2nd harmonics of current signal with the fundamental harmonic to block unwanted tripping. The blocking threshold is set within (10 – 35) range and function activity duration following the energizing moment is adjustable in (0.02 – 60) s range.

Switch onto Fault (ANSI SOTF)

The switch onto fault function provides an instantaneous trip or a time delayed trip when closing the breaker while a fault exists. The function contains a blocking functionality. It is possible to block $I_{>>}$ and $I_{>>>}$ function outputs and the reset timers, if desired.

VT Supervision (74VT)

This function supervises the signals from VTs and provides alarming & tripping options under abnormal conditions.

CT Supervision (74CT)

Monitoring the zero-sequence current and voltage values, this supervision function provides alarming & tripping options under abnormal CT conditions.

Output Latching (ANSI 86)

400 series IEDs allow operators to latch the all of the output relays on demand. The latching settings menu on the relay allows independent latching control for all of the outputs. Unlatching of the outputs is available via the reset button or an external signal to an appropriately programmed input.

Settings Groups

In open ring distribution systems, the setting values of a protection relay are closely related to the power flow direction at the point the relay is operated. Meanwhile, the time to change these settings when the power flow direction is to be altered under a force major is scarce. Taking these into account, the 400 Series IEDs features 8 settings groups that can handle 8 completely independent sets of values of protection and automatic control functions, that would save valuable time for the user while switching to the suitable settings in a new condition. Altering between the settings groups can be done manually on the control panel, via remote control over communication systems or by means of triggering of a programmed input.

Circuit Breaker Trip Circuit Supervision (ANSI 74TCM)

The trip circuit of a circuit breaker comprises the trip coil, the trip output of a relay and the cabling between them. An open circuit on one of these components would prevent the correct operation of the CB when needed. 400 series IEDs are capable of supervising the condition of the trip circuit continuously by one of the programmable inputs. In the case an open circuit is detected, the user is noticed about the situation by the alarm signal on the control panel, and if desired, remotely by means of a programmed output.

Circuit Breaker Supervision and Control

CPM series relays have built-in CB supervision and control functions that manage the essential values and statistics to keep track of the CB condition.

- The last opening and closing times of the CB,
- The total opening number of the CB,
- And the ΣA and ΣA² values (pole condition)

are continuously supervised by the function to notice the user in abnormal or critical conditions by means of local and / or remote alarming.

Blocking Logic Selectivity (ANSI 68)

400 Series IEDs support the blocking logic selectivity scheme. This scheme is to be applied on networks where power flow is unidirectional. When this scheme is applied, each of the relays on a series primary line blocks the next upstream relay by means of sending a blocking signal to their programmed input, blocking and preventing the latter to react. This circuit design leads to the blocking of all relays but the one closest to the fault point, enabling total selectivity without applying time stepping settings. Time delayed phase & earth & negative sequence overcurrent protection functions and the broken conductor detection function can be blocked this way.

Delaying Logic Selectivity

CPM 310 G supports the delaying logic selectivity scheme. This scheme is to be applied on networks where power flow is unidirectional. When this scheme is applied, each of the relays on a series primary line shifts the trip delays of the next upstream relay by means of sending a delaying signal to their programmed input, delaying the latter to react. This circuit design leads to the delaying of all relays but the one closest to the fault point, enabling total selectivity without applying time stepping settings. The tripping delays of the 2nd and 3rd thresholds of the phase & earth overcurrent protection functions can be prolonged this way.

Circuit Breaker Remote Control (ANSI 94)

400 series relays can remotely control circuit breakers by means of their trip relays and programmable outputs. The CB control can be done from the control panel of the relay and via the PC software.

Inputs and Outputs

400 series IEDs are equipped with 8/10 optically isolated & programmable inputs and 8 programmable output relays to fulfil demanding requirements of modern applications. The optically isolated inputs accept any signals within the range

(24 - 250) VAC / VDC. The outputs feature 4 SPDT and 4 SPST relays, each operating below 10 ms delays and rated 8 A / 250 VAC. Two of the outputs are predefined as trip and watchdog relays, and the rest are programmable. Input and output status are displayed on the relevant measurement menus.

Disturbance Waveform Recording

400 series IEDs can digitally save the disturbance waveforms in COMTRADE format, and the saved files can be downloaded and viewed over the PC software. All 400 series models can hold up to 18 seconds of waveforms, and duration for each prefault and fault recordings are programmable.
Being able to observe the disturbance waveforms allows users to analyse faults, confirm the convenience of the parameter settings, and understand the network behaviour better.

Event and Fault Recording (ANSI SER)

CPM series relays store up to 1,000 events and fault records. The event and fault records are time-stamped with the information from a super-capacitor fed real-time clock. The records comprise the precise timing, type and details of the events / faults. The records can be viewed on the device screen as well as on a PC utilizing the PC software.

Communication Functionality

400 Series IEDs are equipped with a total of three 100 Mbps ethernet ports (2 in rear, 1 in front) to provide fast and flexible communication solutions. In addition, the 115,200 bps RS485 port at the rear terminals enables conventional networking. 2 optical ports are optionally available.
400 Series IEDs support IEC 61850 + GOOSE, IEC 60870-5-103, MODBUS RTU / TCP and DNP 3.0 protocols.

All 400 Series IEDs embed a WEB server to enable remote configuration and control of the relay.

X/1 A & X/5 A CT Compatibility

400 series relays are suitable for use with conventional X/1 A and X/5 A current transformers. By making appropriate settings on the menus, the secondary nominal current can be selected as I_n = 1 A or I_n = 5 A within seconds.

Measurement Functions

400 series IEDs feature the following measurement functions:

- Frequency measurements: The primary circuit power frequency.
- Current measurements: Fundamental & r.m.s. amplitudes and phase angles for all phases and earth; positive, negative and zero-sequence values, %(I_2/I_1).
- Voltage measurements: Fundamental & r.m.s. amplitudes and phase angles for all phase-to-phase and phase-to-neutral voltages; positive, negative and zero-sequence values.
- Thermal Θ measurements: Thermal stress in percentage.
- Input & Output measurements: The states of programmable inputs and outputs as well as the trip and the watchdog relays.
- CB measurements: The last opening and closing times, total opening number, and ΣA & ΣA^2 (pole condition) for each of the circuit breaker poles.
- Auto-reclosing measurements: All statistics and measurements of the auto-reclosing activity, including number of successful auto-reclosing cycles, and auto-reclosing blockings.
- LED status: The momentary status of all 10 programmable (virtual) LEDs.

Watchdog Relay

400 series IEDs utilize a circuit to watch over the condition of the internal circuits and the power supply continuity to the device. At an instance of internal failure or power supply shortage, the watchdog relay reacts to close the normally closed contact, which is fixed at the open state in healthy operation conditions.
The positive operation characteristic of the watchdog relay therefor allows the users to monitor the healthiness of the protection system remotely, using appropriate circuitry evaluating the information from the N/O and N/C contacts of the watchdog relay.

Function Test

400 series relays feature a built-in functional test. The test is launched manually from the control panel. Once the test is initiated, the digital signal processor within the relay produces virtual overcurrent signals to run the protection functions activated by the user, leading to tripping of the circuit breaker and termination of the test. This test allows the users to check the basic condition and behaviour of the protection system elements (such as the trip circuit cabling, the circuit breaker and the auxiliary supply system) without having to use an external testing device. □

Protection and Reset Curves

DEMA 400 Series Digital Protection Relays can employ and run IEC and IEEE / ANSI protection and reset curves, as well as a wide range of special curves that are mostly used when 400 Series units are used in the same selectivity scheme with older models of protection relays such as electromechanical relays. The wide setting ranges make 400 Series compatible with most of the protection and selectivity schemes currently in use worldwide.

400 Series protection and reset curves, and formulas, parameters and setting ranges belonging to these are given in the below table. The Thermal Overload Protection Function is studied in detail in its dedicated section - for this, parameters and other information for thermal overcurrent protection is not given in the table. □

$$t = \left[\frac{A}{\left(\frac{I}{I_S}\right)^{\alpha} - 1} + B \right] \times TMS$$

Universal Formula for Protection Curves

$$t = \left[\frac{T_{res}}{1 - \left(\frac{I}{I_S}\right)^{\alpha}} + C \right] \times RTMS$$

Universal Formula for Reset Curves

Curve Type		Overcurrent Curve Parameters				Reset Curve Parameters					Applied Standard
Definition	Abbreviation	A	α (Trip Factor)	B	Setting Interval	Treshhold	α (Reset Factor)	C	Setting Zone	Reset Type	
Short Time Inverse	IEC STI	0.05s	0.04	0	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	IEC
Standard Inverse	IEC SI	0.14s	0.02	0	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	IEC
Very Inverse	IEC VI	13.5s	1	0	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	IEC
Extremely Inverse	IEC EI	80s	2	0	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	IEC
Long Time Inverse	IEC LTI	120s	1	0	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	IEC
Semiconductor Protection	SA Semic	35,500s	6	0	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	Special Curve SA
Definite Inverse (DI)	SB DI	2.96875s	2.3	1.96875s	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	Special Curve SB
Short Time Inverse (CO2)	SC CO2	0.0092s	0.02	0.008s	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	Special Curve SC
						6.9s	2	0	RTMS 0.025-3.2	IDMT	
Long Time Inverse (SD CO8)	SD CO8	21s	2	0.72s	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	Special Curve SD
						39.6s	2	0	RTMS 0.025-3.2	IDMT	
Standard Inverse (CO-C3H)	SE CO-C3H	1.81s	1.05	0.68s	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	Special Curve SE
						2.2s	2	0	RTMS 0.025-3.2	IDMT	
Moderately Inverse	IEEE MI	0.0515s	0.02	0.114s	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	IEEE / ANSI
						4.85s	2	0	RTMS 0.025-3.2	IDMT	
Very Inverse	IEEE VI	19.61s	2	0.491s	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	IEEE / ANSI
						21.6s	2	0	RTMS 0.025-3.2	IDMT	
Extremely Inverse	IEEE EI	28.2s	2	0.1217s	TMS 0.025-3.2	-	-	-	DMT 0.04-100s	DMT	IEEE / ANSI
						29.1s	2	0	RTMS 0.025-3.2	IDMT	
Definite Minimum Time	DMT	-	-	-	DMT 0.01-150s	-	-	-	DMT 0.04-100s	DMT	-
Thermal Overload	Parameters are studied in the *IEC Protection Curves* Section										IEC

Table of 400 Series Protection and Reset Curves Parameters

IEC Inverse Time Protection Curves

The "IEC (International Electrotechnical Commission) *60255-3, Electrical relays - Part 3: Single input energizing quantity measuring relays with dependent or independent time"* standard defines the following protection curves.

1. IEC Short Time Inverse: IEC STI.
2. IEC Standard Inverse: IEC SI.
3. IEC Very Inverse: IEC VI.
4. IEC Extremely Inverse: IEC EI.
5. IEC Long Time Inverse: IEC LTI.

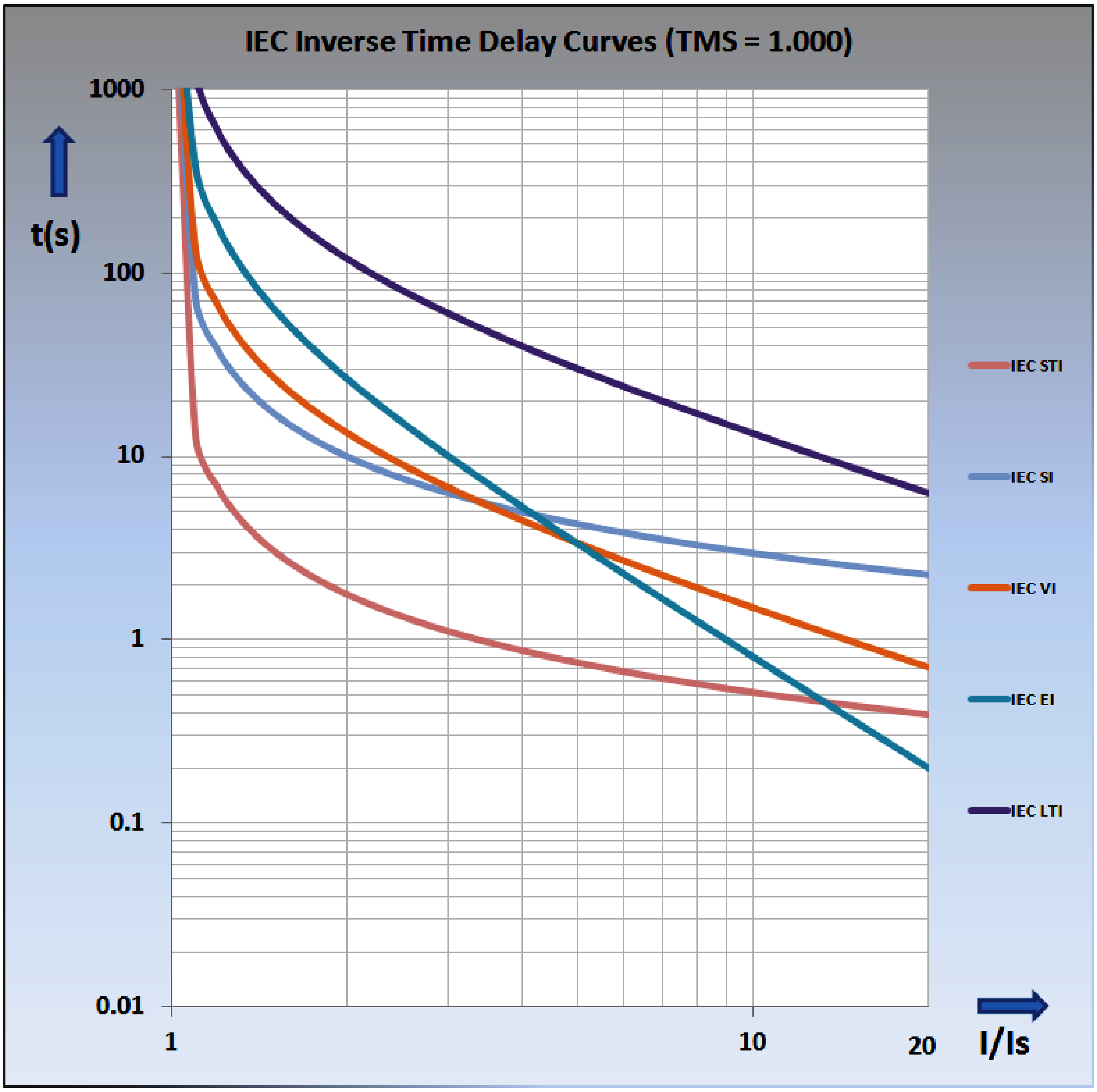
$$t = \left[\frac{A}{\left(\frac{I}{I_S}\right)^{\alpha} - 1} + B \right] \times TMS$$

Universal trip time delay formula is given above, while IEC constants for various curves are given on the below table.

t Trip delay (s).
A A constant for the characteristic (s).
I Momentary current (A).
Is Set current threshold (A).
α A constant for the characteristic (-).
B A constant for the characteristic (s).
TMS Time Multiplier Setting (-). ↺

Curve Type	Trip Delay Formula	Reset Delay Setting Zone
IEC STI **Short Time Inverse**	$t = \left[\frac{0.05\ s}{\left(\frac{I}{I_S}\right)^{0.04} - 1} \right] \times TMS,$	$tReset = DMT\ (0.04 - 100)\ s$
IEC SI **Standard Inverse**	$t = \left[\frac{0.14\ s}{\left(\frac{I}{I_S}\right)^{0.02} - 1} \right] \times TMS$	$tReset = DMT\ (0.04 - 100)\ s$
IEC VI **Very Inverse**	$t = \left[\frac{13.5\ s}{\left(\frac{I}{I_S}\right) - 1} \right] \times TMS$	$tReset = DMT\ (0.04 - 100)\ s$
IEC EI **Extremely Inverse**	$t = \left[\frac{80\ s}{\left(\frac{I}{I_S}\right)^{2} - 1} \right] \times TMS$	$tReset = DMT\ (0.04 - 100)\ s$
IEC LTI **Long Time Inverse**	$t = \left[\frac{120\ s}{\left(\frac{I}{I_S}\right) - 1} \right] \times TMS$	$tReset = DMT\ (0.04 - 100)\ s$

The image below shows the trip delay curves for all IEC characteristics with TMS = 1. TMS can be set within the range of (0.025 - 3.2) for any protection function.

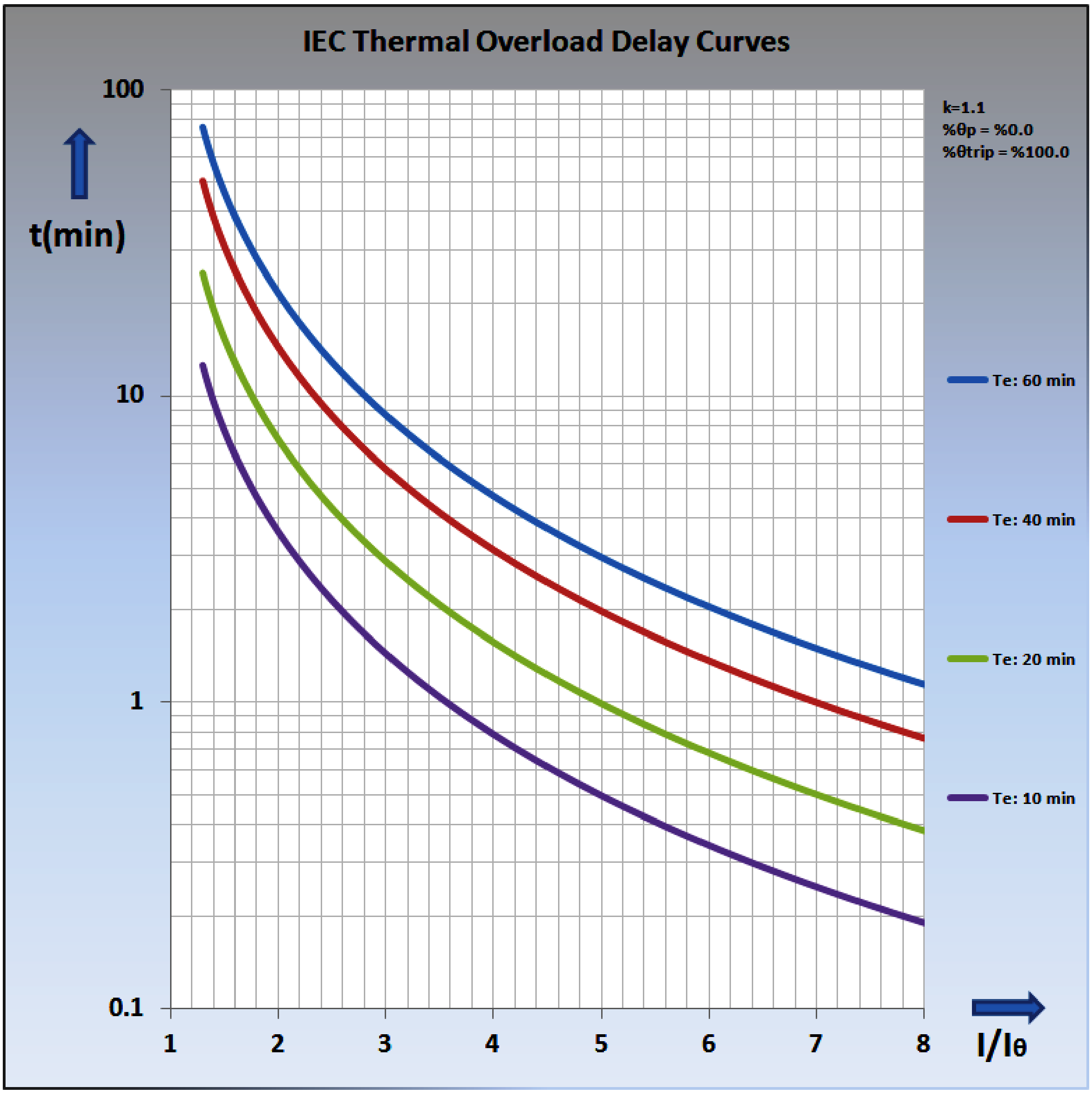


IEC Thermal Overload Protection Curves

IEC Thermal Overload Protection formula and sample curves according to this formula are given below. Formula characteristic is determined by the T_e, k, Iθ, $\%\theta_p$ and $\%\theta_{trip}$ parameters. When setting ranges for these parameters are considered, it is calculated that 400 Series relay can run 1,540,000 unique IEC Thermal Overload Protection curves; for its impossible to demonstrate all of the curves on a chart, sample curves are given on the below chart to express an overview of the characteristic. □

$$t = T_e \times \log_e \left[\frac{\left(\frac{I}{k \times I_\Theta}\right)^2 - \%\Theta_p}{\left(\frac{I}{k \times I_\Theta}\right)^2 - \%\Theta_{trip}} \right]$$

t	Trip time delay (minute).
T_e	Thermal Constant (minute); setting range: (1-200) min, in 1 min steps.
k	Trip Threshold Translation Constant (-); setting range: (1.00-1.50), in 0.01 steps.
I	RMS value of load current (A).
I_θ	Set current (A); setting range: (0.10-3.20) I_n, in 0.01 I_n steps.
$\%\theta_p$	Overload Pre-heating (%); setting range: (50-200) %, in 1% steps.
$\%\theta_{trip}$	Overload Trip Threshold (%); setting range: (50-200) %, in 1% steps. □



ANSI / IEEE Inverse Time Protection Curves

"IEEE (The Institute of Electrical and Electronics Engineers, Inc.) C37.112-2006: IEEE Standard Inverse-Time Characteristic Equations for Overcurrent Relays - Description" standard describes the protection curves named as below.

1. IEEE MI: IEEE Moderately Inverse Curve.
2. IEEE VI: IEEE Very Inverse Curve.
3. IEEE EI: IEEE Extremely Inverse Curve.

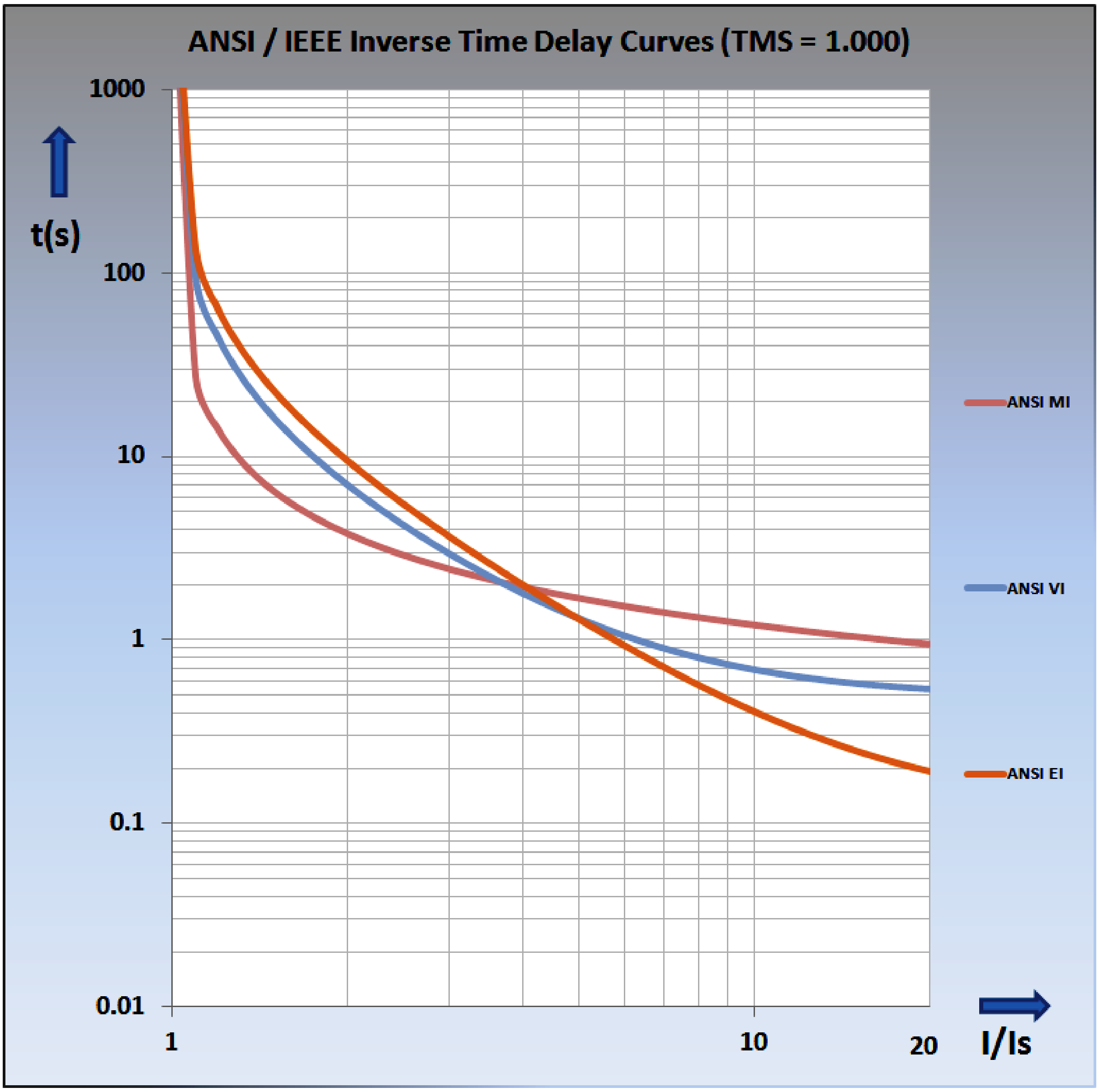
$$t = \left[\frac{A}{\left(\frac{I}{I_S}\right)^{\alpha} - 1} + B \right] \times TMS$$

Universal trip time delay formula is given above, while ANSI / IEEE constants for various curves are given on the below table.

t Trip delay (s).
A A constant for the characteristic (s).
I Momentary current (A).
Is Set current threshold (A).
α A constant for the characteristic (-).
B A constant for the characteristic (s).
TMS Time Multiplier Setting (-). ↺

Curve Type	Trip Delay Formula	Reset Delay Setting Zone
ANSI / IEEE MI Moderately Inverse	$t = \left[\frac{0.0515\ s}{\left(\frac{I}{I_S}\right)^{0.02} - 1} + 0.114\ s \right] \times TMS$	$DMT\ (0.04 - 100)\ s$ *or* $RTMS\ (0.025 - 3.2)$
ANSI / IEEE VI Very Inverse	$t = \left[\frac{19.61\ s}{\left(\frac{I}{I_S}\right)^{2} - 1} + 0.491\ s \right] \times TMS$	$DMT\ (0.04 - 100)\ s$ *or* $RTMS\ (0.025 - 3.2)$
ANSI / IEEE EI Extremely Inverse	$t = \left[\frac{28.2\ s}{\left(\frac{I}{I_S}\right)^{2} - 1} + 0.1217\ s \right] \times TMS$	$DMT\ (0.04 - 100)\ s$ *or* $RTMS\ (0.025 - 3.2)$

The image below shows the trip delay curves for all ANSI / IEEE characteristics with TMS = 1.00. TMS can be set in the range (0.025 - 3.2) for any protection function. □



Custom Protection Curves

400 Series Special Curves include inverse protection curves for electromechanical relays, constant time characteristic and reset curves. These curves are listed below.

1. SA Semic: Semiconductor Protection Curve.
2. SB DI: Definite Inverse Curve.
3. SC CO2: Short time Inverse Curve.
4. SD CO8: Long Time Inverse Curve.
5. SE CO-C3H: Standard Inverse Curve.

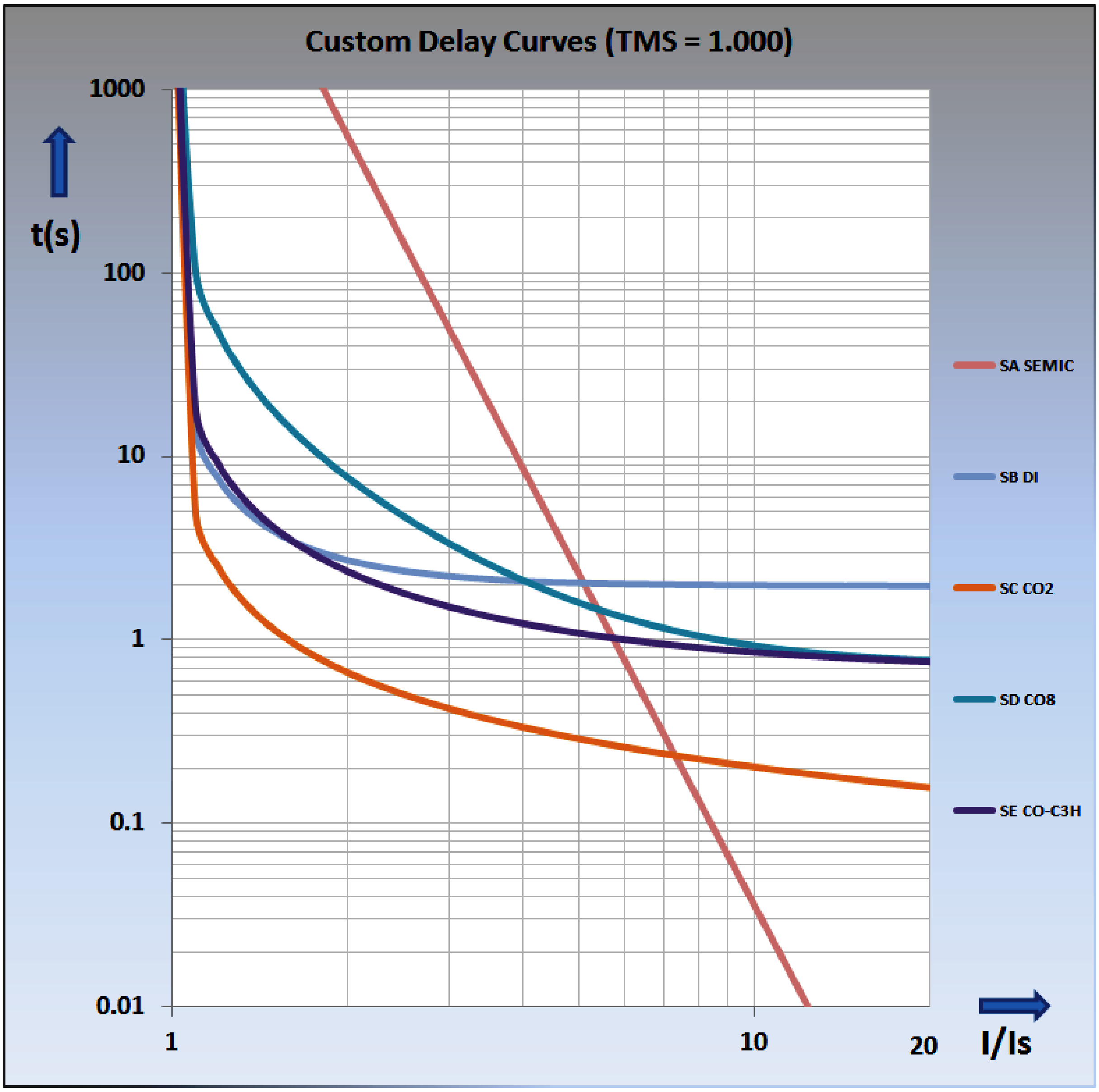
$$t = \left[\frac{A}{\left(\frac{I}{I_S}\right)^{\alpha} - 1} + B \right] \times TMS$$

Universal trip time delay formula is given above, while special curve parameters are given on the below table.

t Trip delay (s).
A A constant for the characteristic (s).
I Momentary current (A).
Is Set current threshold (A).
α A constant for the characteristic (-).
B A constant for the characteristic (s).
TMS Time Multiplier Setting (-). ↺

Curve Type	Trip Delay Formula	Reset Delay Setting Zone
SA Semic **Semiconductor Protection**	$t = \left[\frac{35500\ s}{\left(\frac{I}{I_S}\right)^{6} - 1} \right] \times TMS$	$DMT\ (0.04 - 100)\ s$
SB DI **Definite Inverse**	$t = \left[\frac{2.96875\ s}{\left(\frac{I}{I_S}\right)^{2.3} - 1} + 1.96875\ s \right] \times TMS$	$DMT\ (0.04 - 100)\ s$
SC CO2 **Short Time Inverse**	$t = \left[\frac{0.0092\ s}{\left(\frac{I}{I_S}\right)^{0.02} - 1} + 0.008\ s \right] \times TMS$	$DMT\ (0.04 - 100)\ s$ *or* $RTMS\ (0.025 - 3.2)$
SD CO8 **Long Time Inverse**	$t = \left[\frac{21\ s}{\left(\frac{I}{I_S}\right)^{2} - 1} + 0.720\ s \right] \times TMS$	$DMT\ (0.04 - 100)\ s$ *or* $RTMS\ (0.025 - 3.2)$
SE CO-C3H **Standard Inverse**	$t = \left[\frac{1.81\ s}{\left(\frac{I}{I_S}\right)^{1.05} - 1} + 0.680\ s \right] \times TMS$	$DMT\ (0.04 - 100)\ s$ *or* $RTMS\ (0.025 - 3.2)$

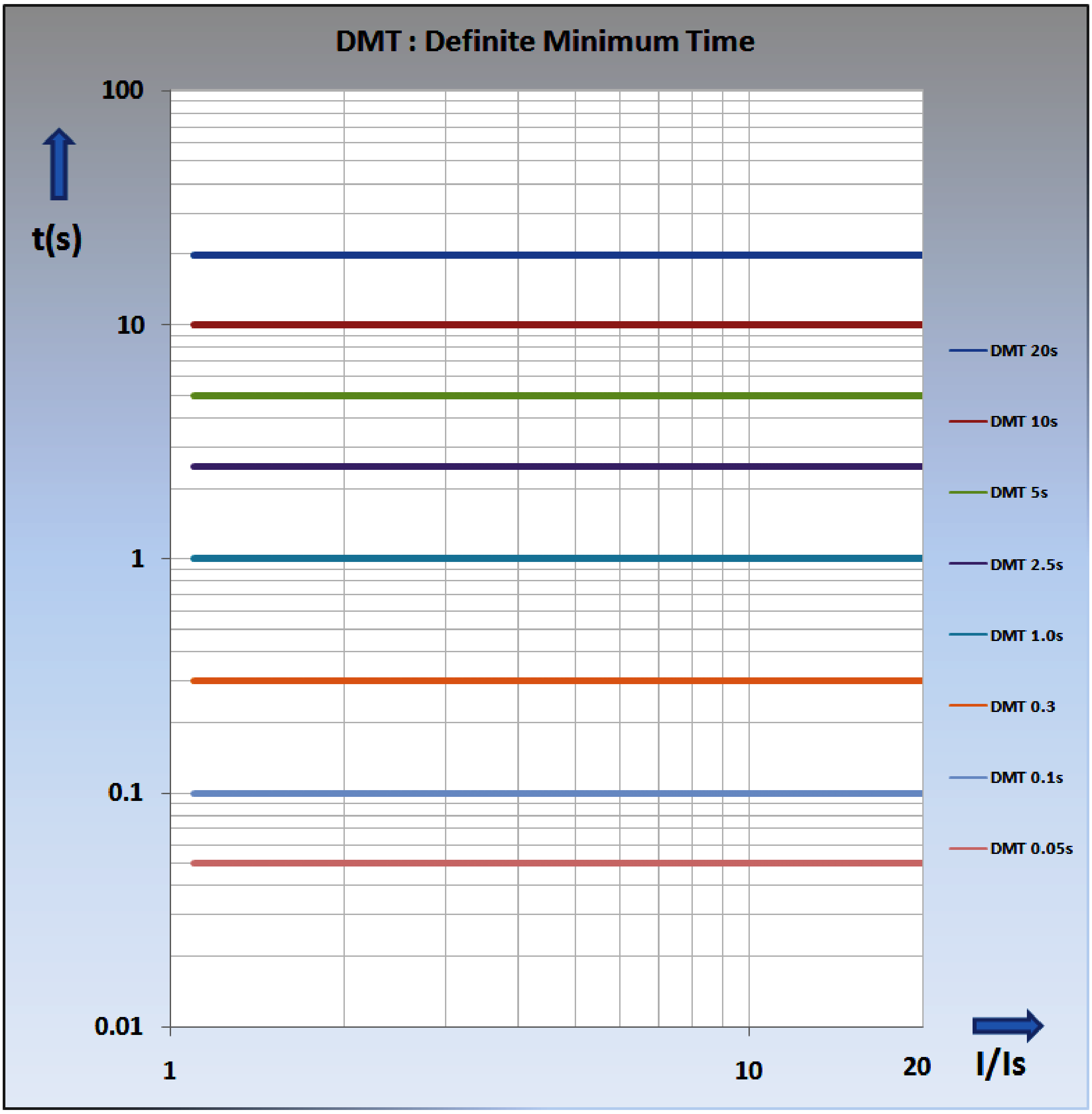
The image below shows the custom trip delay curves with TMS = 1.00. TMS can be set in the range (0.025 - 3.2) for any protection function. □



DMT: Definite Time Protection and Reset Delays

DMT characteristic is used for obtaining constant trip and reset delays. There are no parameters for the DMT characteristic other than the constant trip or reset delay. Characteristic notation is as follows: e.g., t = DMT 0.25 s.

The image below shows the DMT characteristics for given current values. □

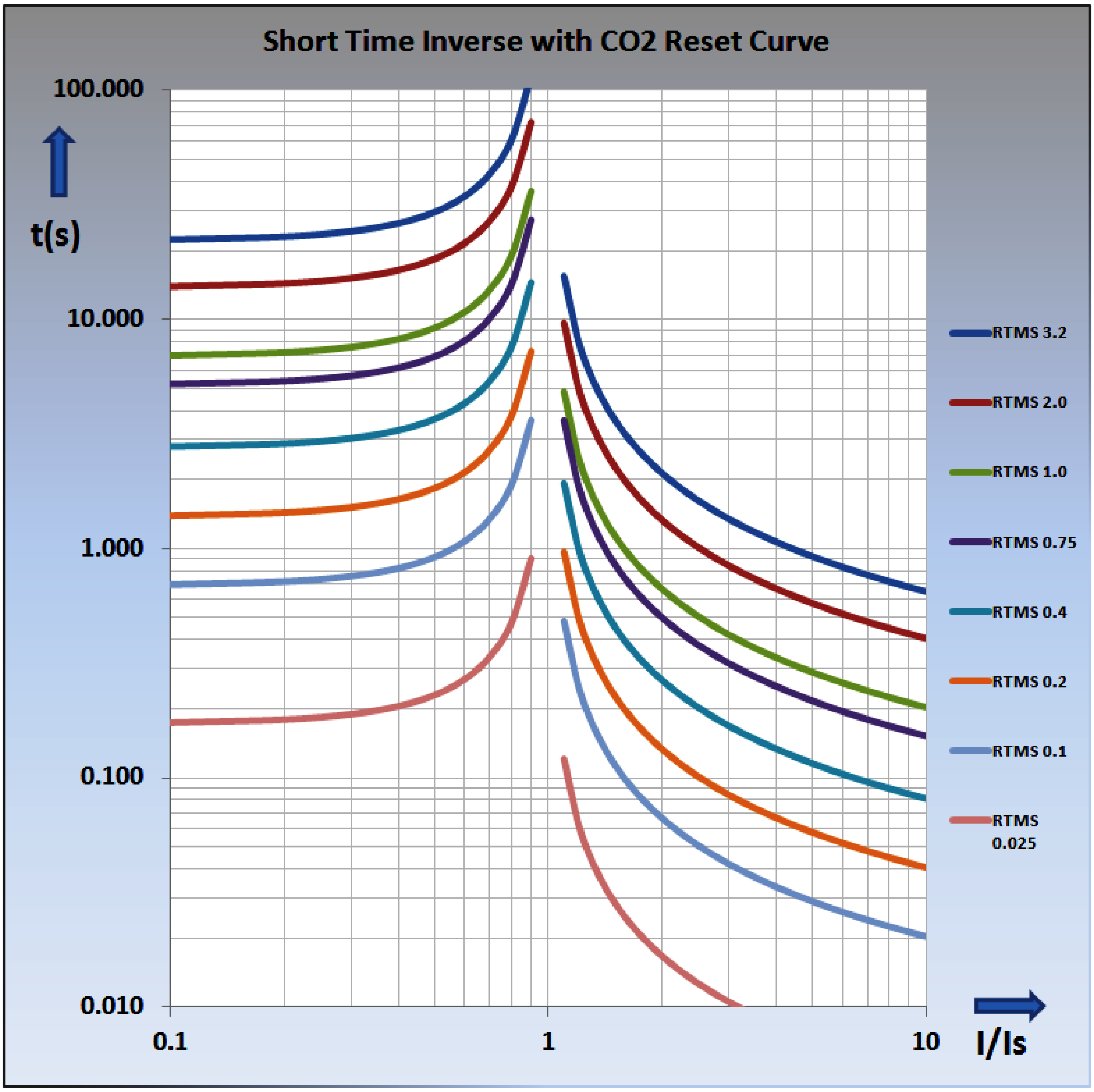


RIDMT: Inverse Definite Time Reset Curves

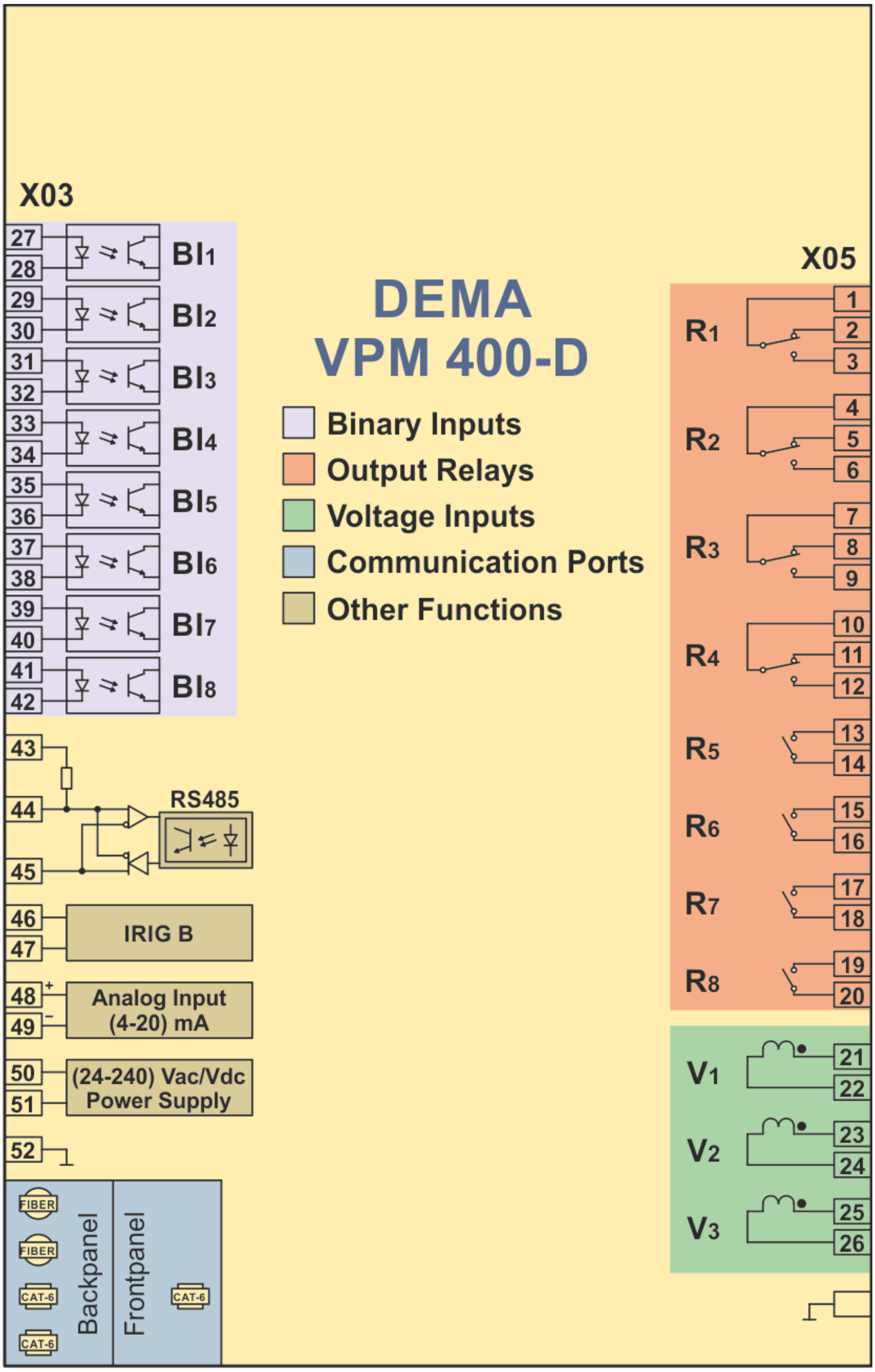
RIDMT curves are used to obtain the inverse D.M.T. resetting characteristics for IEEE/ANSI and custom curves that are needed to provide selectivity schemes when electromechanical relays are protecting a primary line in series with the one 400 Series protects. The RIDMT parameters differ with the tripping curve they are based on. The table *400 Series Protection and Reset Curves Parameters* on page 16 shows these parameters. The sample image below shows the CO2 short time inverse trip characteristic and its RIDMT curve. The formula given below explains the calculation method of the reset delay for CO2 RIDMT curve. □

$$t = \left[\frac{6.9\,s}{1 - \left(\frac{I}{I_S}\right)^2} \right] \times RTMS$$

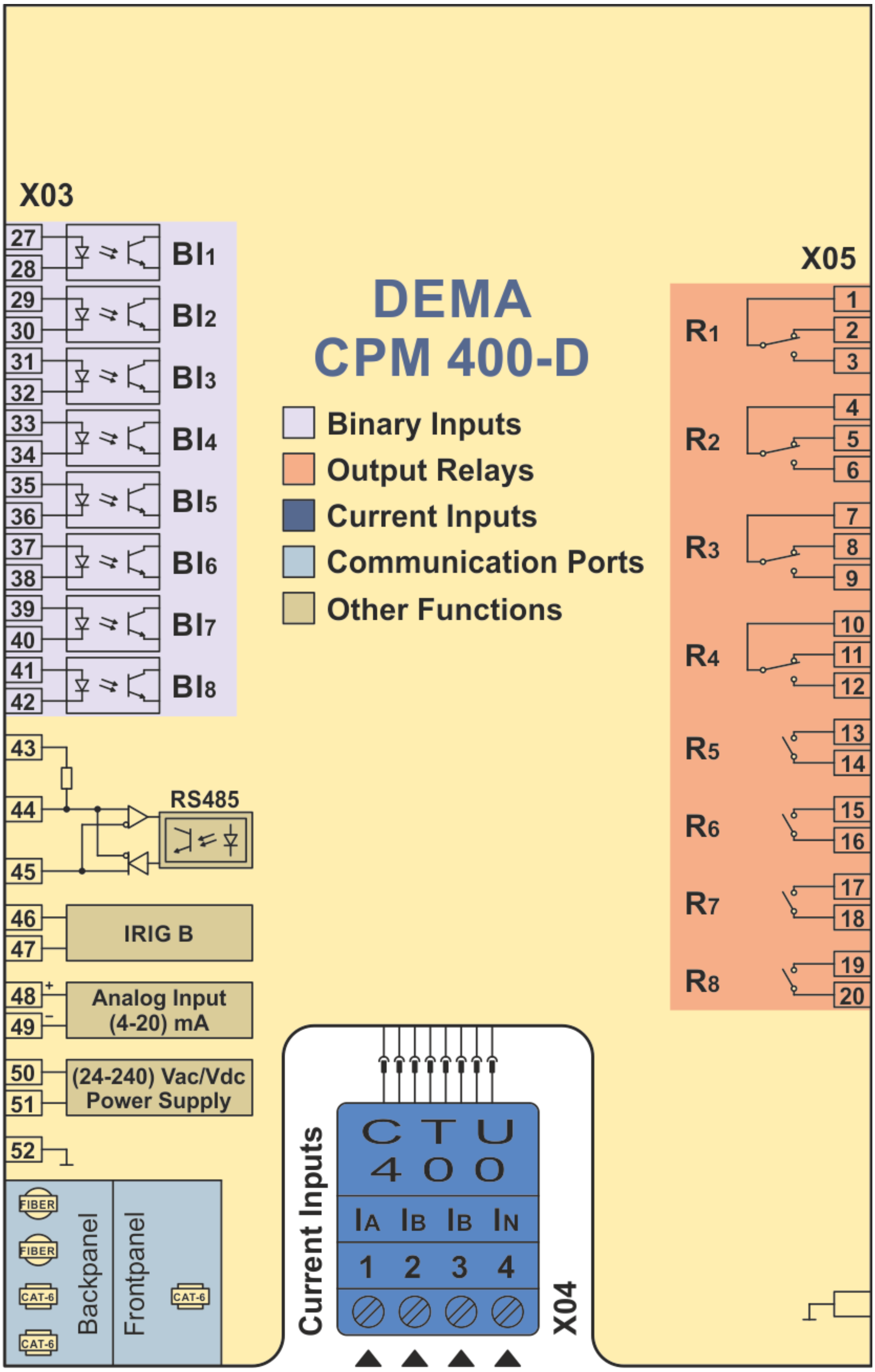
Sample IDMT formula: CO2 IDMT Reset Curve Formula
Please check the table on page 16 for other IDMT formulas.



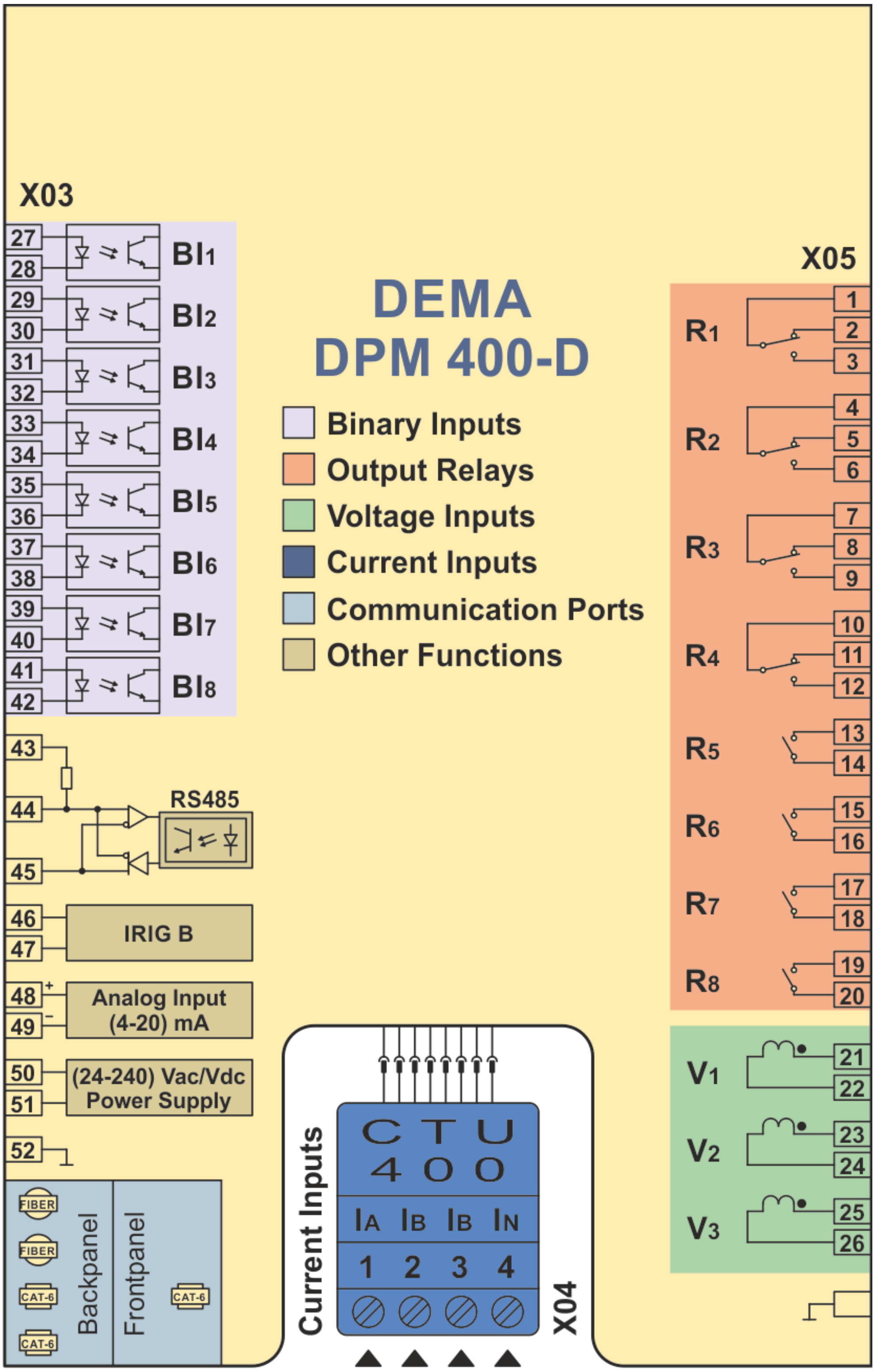
Circuit Diagrams



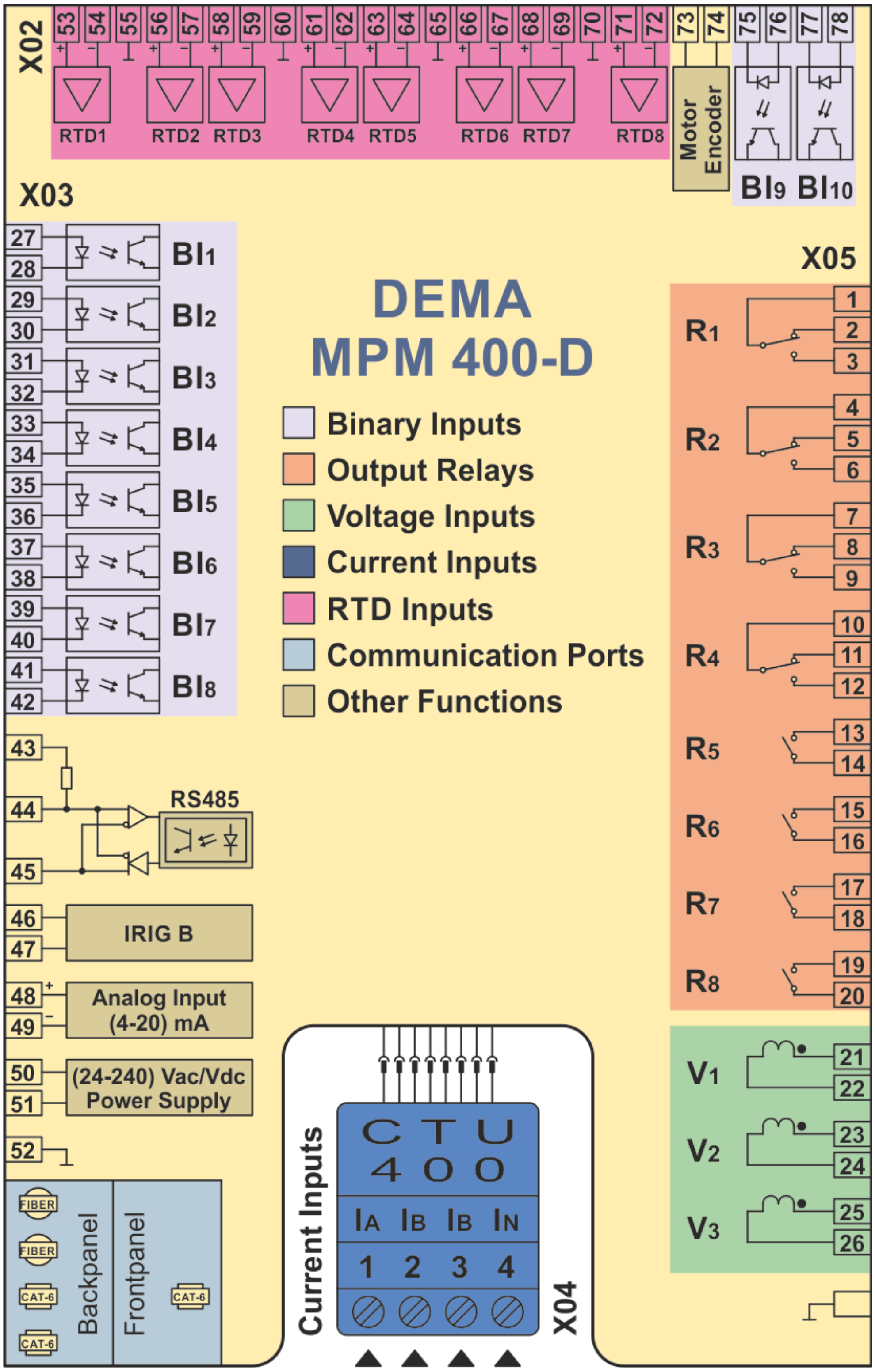
DEMA VPM 400-D Voltage Protection Relay Circuit Diagram



DEMA CPM 400-D Non-directional Overcurrent Protection Relay Circuit Diagram



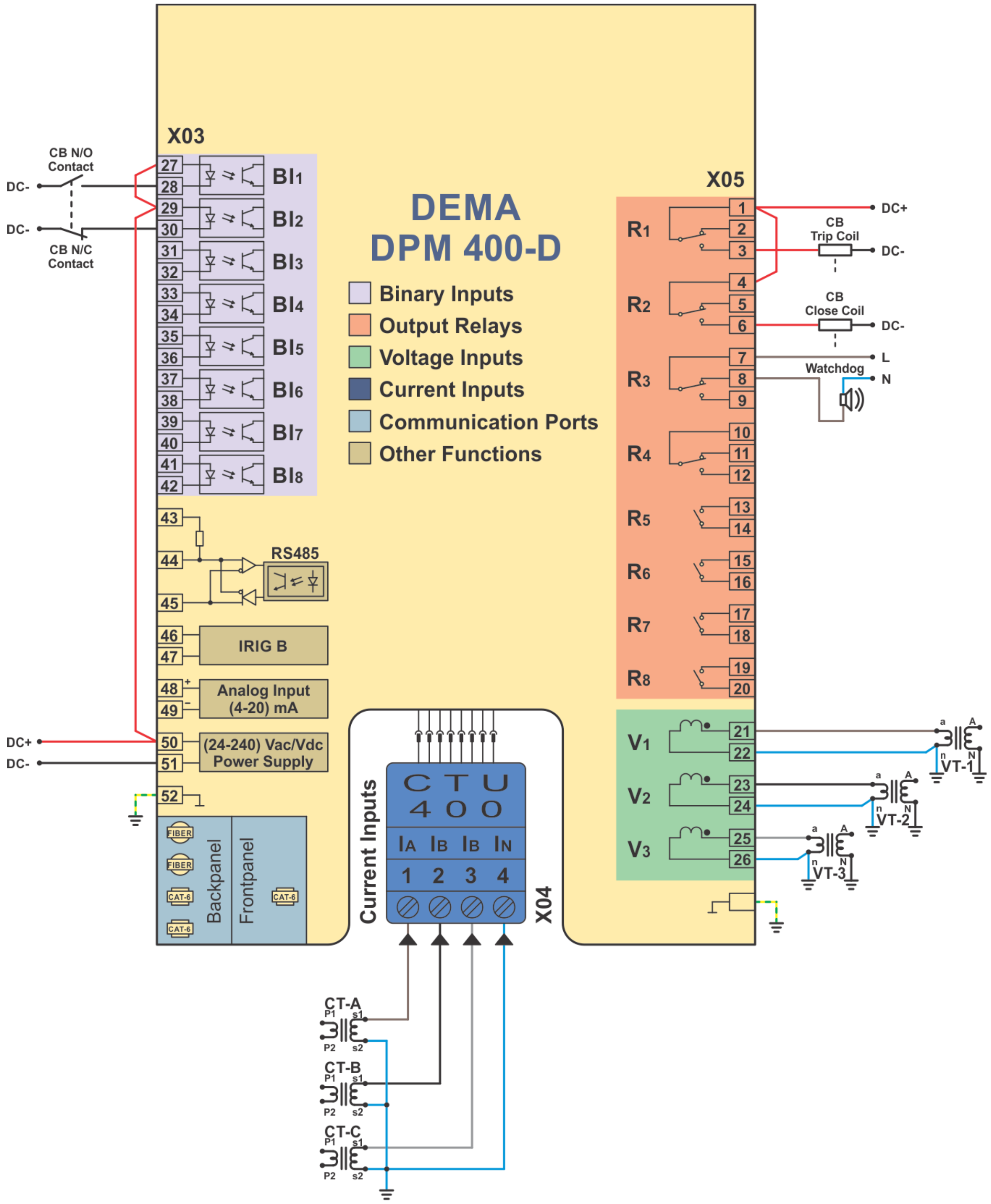
DEMA DPM 400-D Directional Protection Relay Circuit Diagram



DEMA MPM 400-D Motor Protection Relay Circuit Diagram

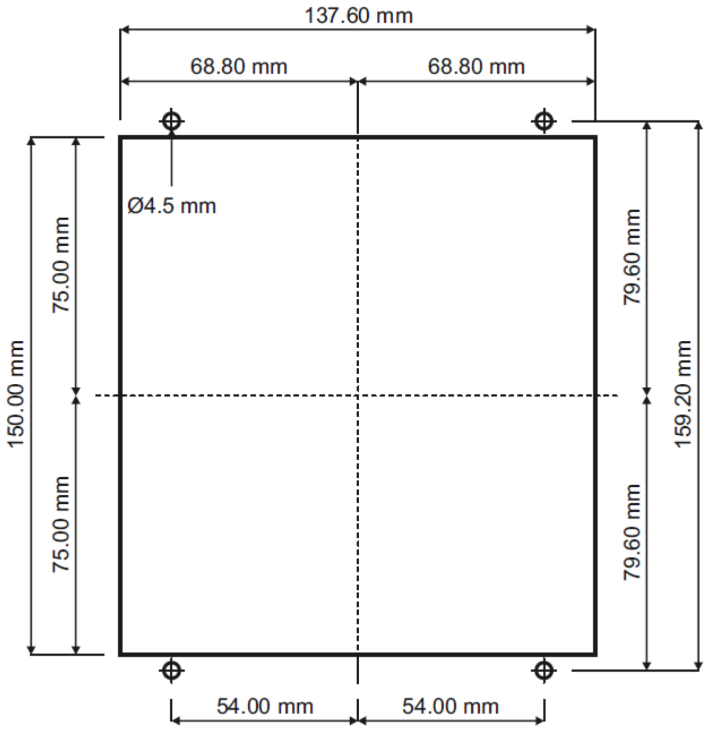
Sample Application Diagram

A sample basic application diagram for 400 Series model DPM 400-D is given below. Note that every project has its own circuitry requirements and must me studied independently. ▱

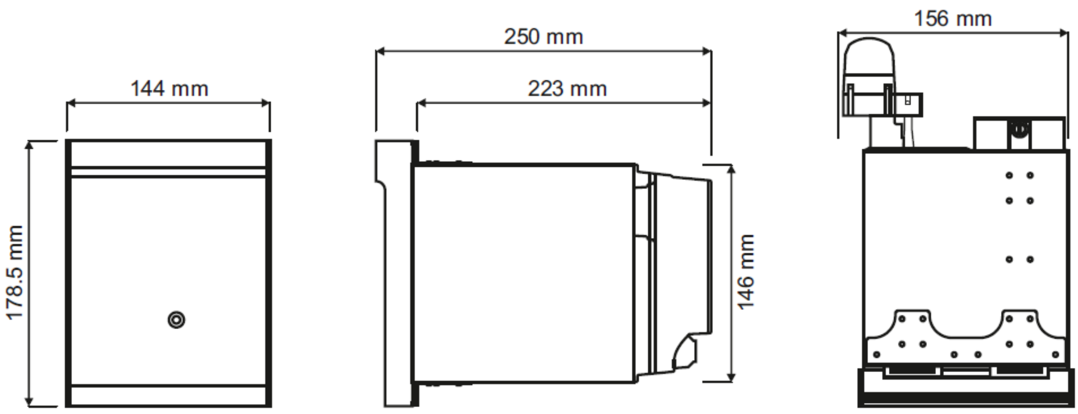


Technical Drawings

The general dimensional and cut out drawings valid for all DEMA 400 Series Digital Protection Relay models are given below. □



Cutout Drawings



General Dimensions

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