



ABB CONSULTANTS TALK-LOW VOLTAGE CIRCUIT BREAKERS- THURSDAY, 20 AUGUST, 2020

Circuit breakers trip units

Classification and selection overview

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Agenda

- Protection concept and application
- ABB CB's trip units overview (MCB/MCCB/ACB)
- Thermo-Magnetic Trip Units types
- Temperature derating
- Neutral Protection
- Electronic trip units
- Trip unit Interchangeability
- Voltage based measurements/protections functions
- Advanced trip units functions
- Trip unit Simulator/Trip units testing (Ekip Connect)

Protection concept and application

Overview

Conductors, Insulation and Overcurrent

Overcurrent conditions

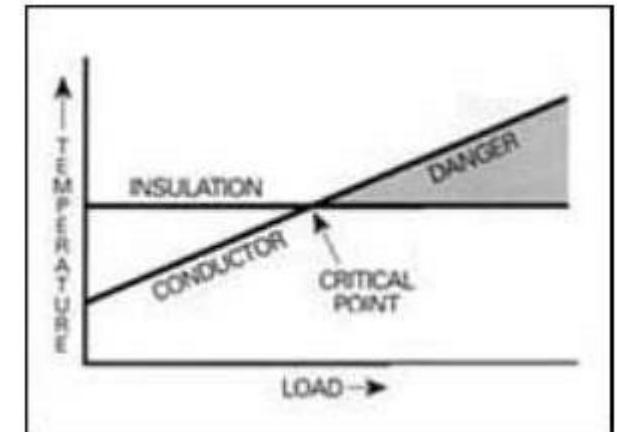
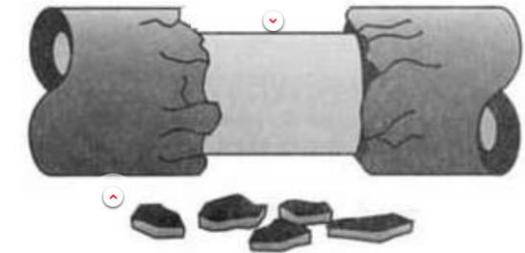
When a current flows in a conductor >> Heat is generated

so higher currents flowing will result in higher temperatures

Insulation of the conductor may break down, if the conductor temperature increases due to overcurrent condition (overload or short circuit)

The point at which the current in a conductor creates enough heat to exceed the temperature rating of its insulation is called the critical point.

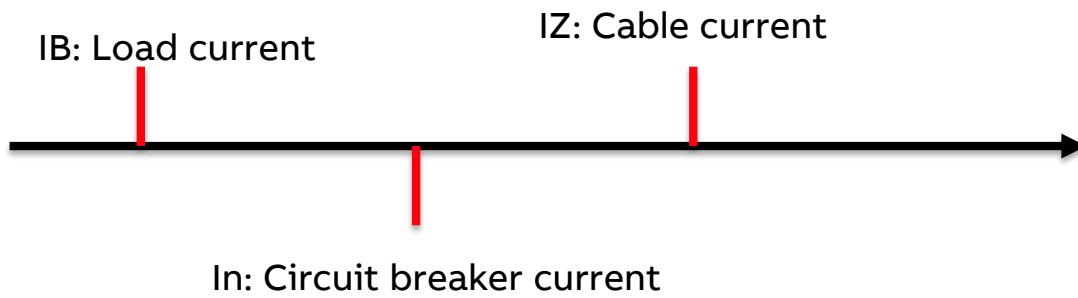
The current rating for a circuit is usually determined by the size and type of conductor and the type of insulation used.



IEC 60364-4-43

Overcurrent protection

Protection of Feeders



$$I_B \leq I_n \leq I_Z$$

Circuit breakers functionality

Complete Circuit breaker with Trip unit



MCB CB
Thermo-magnetic trip unit



MCCB CB
Thermo-magnetic trip unit



MCCB CB
Electronic trip unit



ACB CB
Electronic trip unit

Circuit breakers functionality

MV CB or LV Switch with external protection relay



HD4 MV CB



E2.2/MS Switch dis.



T7D Switch dis.



Ekip UP*



RELION Series relays
e.g. REF 615 relay*

Low Voltage Circuit Breakers

Classification and Typical Values

MCB's



Miniature circuit breaker

- Thermo-magnetic trip unit
 - Curves: B, C, K, D and Z

MCCB's



Moulded case circuit breaker

- Thermo-magnetic
 - TMF, TMD, TMA, TMG, MF, MA
- Electronic trip units
 - Ekip: LS/I, I, LSI, LSIG, E-LSIG, M-I, M-LIU, M-LRIU, G-LS/I, N-LS/I

ACB's



Air circuit breaker

- Electronic trip units only
 - Ekip: Dip, Touch, Hi-Touch, G Touch, G Hi-Touch
 - LI/ LSI/ LSIG

Thermo-magnetic trip units

Overview and range

Low Voltage Circuit breakers

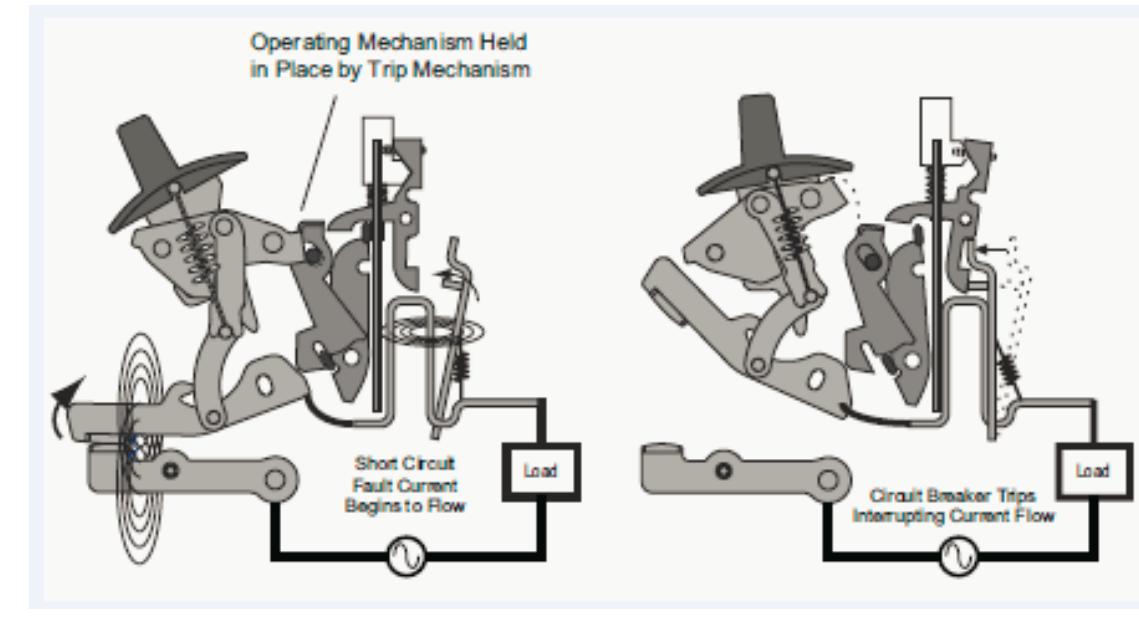
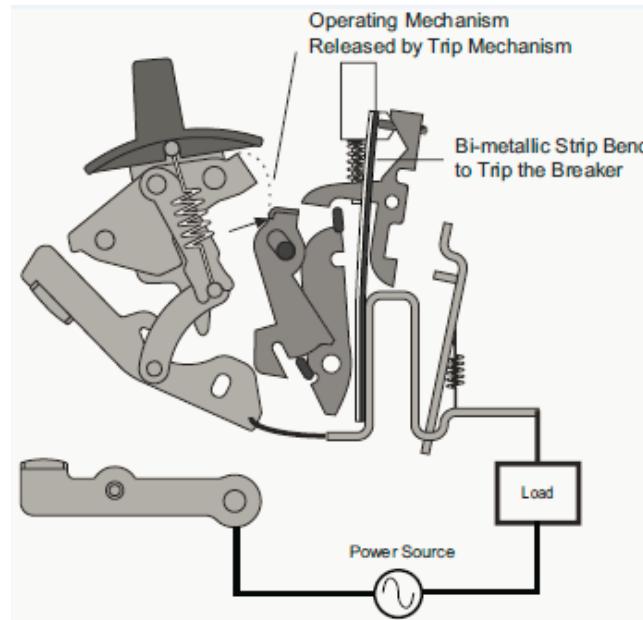
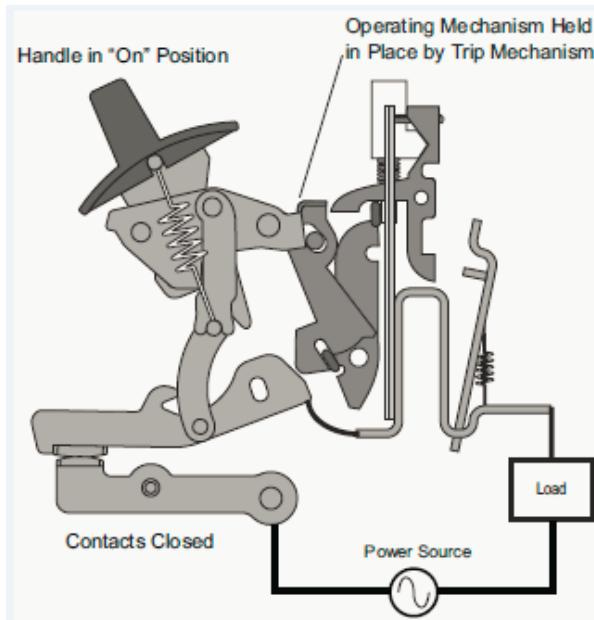
Screenshot from Specification requirements- MCBs Trip units

Operation: Under overload conditions, **thermal tripping** is to provide close protection of insulated conductors. Under short-circuit conditions, **magnetic trip** is to operate at 5 – 10 times normal rated current (Curve C). Magnetic operation is to be in the current limiting region and opening time is not to exceed 5 milliseconds.

Overcurrent protection

Protection of Feeders

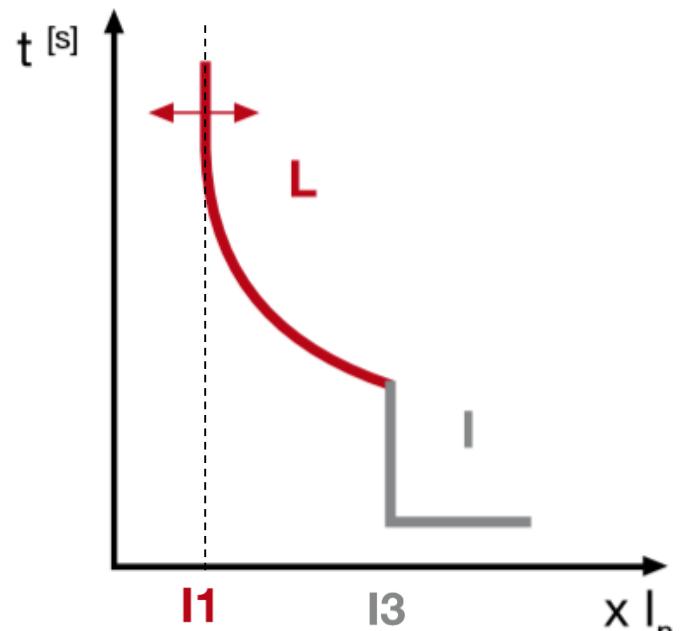
Circuit breakers functionality



Thermo-magnetic trip units

Tripping curve

Protection relay tripping curve



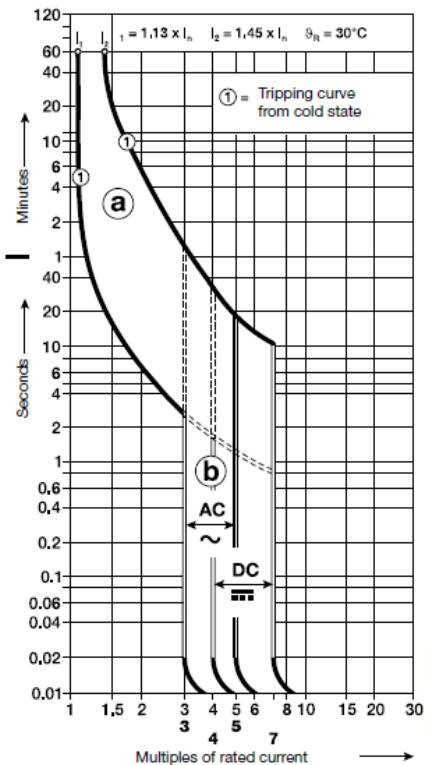
Thermo-magnetic trip unit

IEC 60947-2 vs IEC 60898-1

Miniature Circuit Breakers

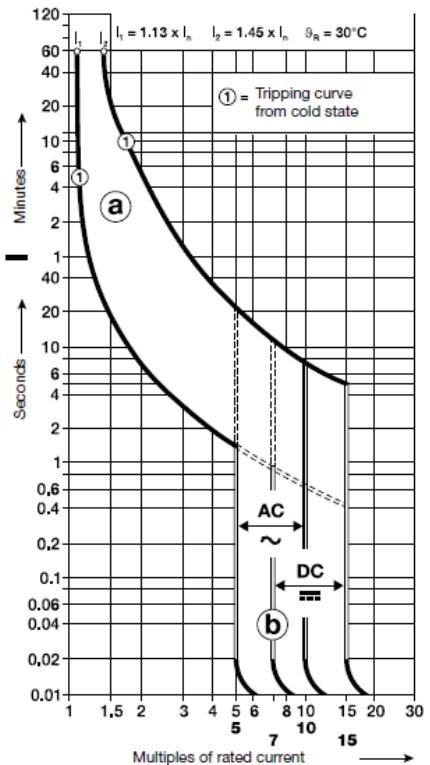
Characteristic B

IEC-EN60898



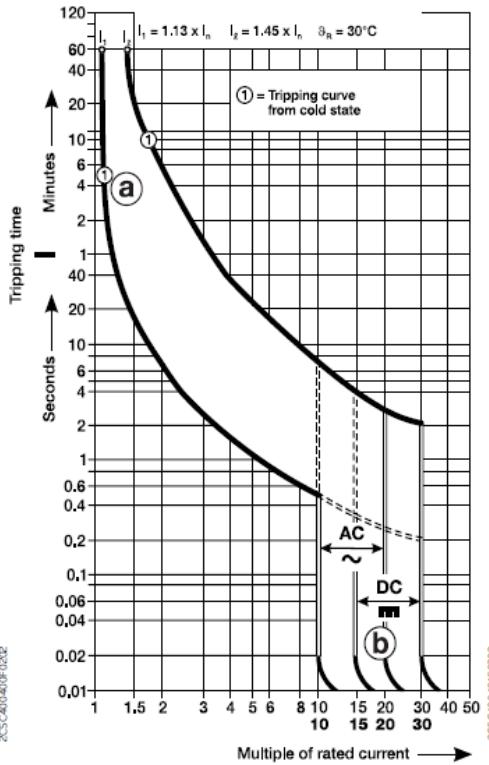
Characteristic C

IEC-EN60898



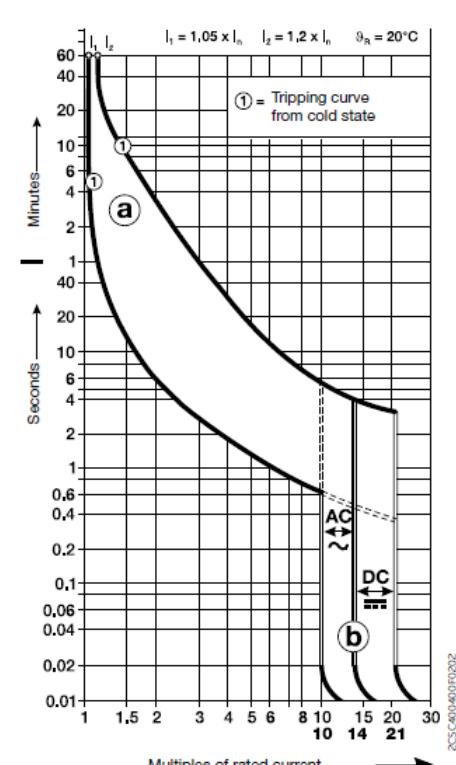
Characteristic D

IEC-EN60898



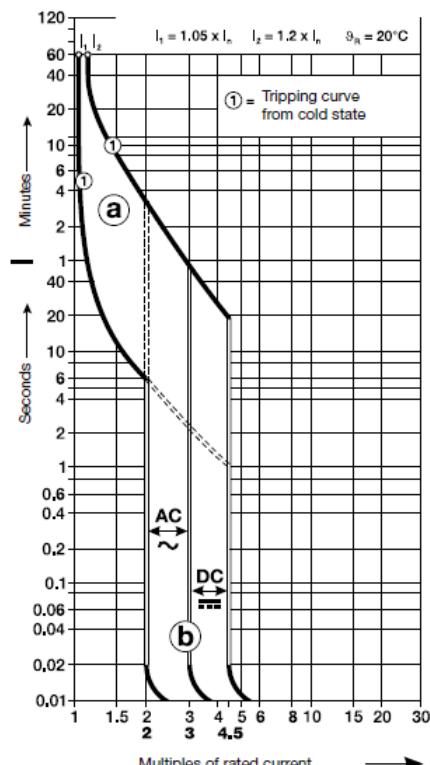
Characteristic K

IEC-EN60947-2



Characteristic Z

IEC-EN60947-2



IEC 60947-2 vs IEC 60898-1

Miniature Circuit Breakers

Type B&C:

Domestic sockets and light commercial applications where current surges are low

Type D and K

Electrical circuits which causes high inrush current, i.e. transformers, motors and X-ray machines

Type Z

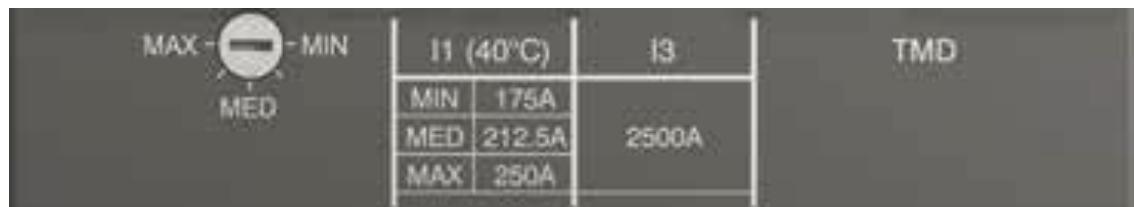
High impedance cables, devices and components that have low surge and short circuit tolerances such as semiconductor devices, or measuring circuits using current transformers

Thermo-magnetic trip units

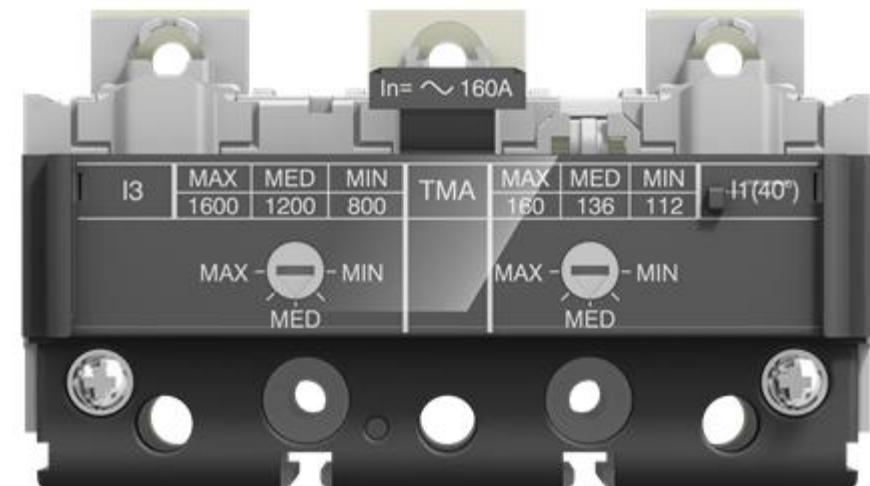
Protections and thresholds



TMF Trip unit



TMD Trip unit



TMA Trip unit

Thermo-magnetic trip units

Protections and thresholds

Application	Type	Thermal Protection	Threshold Setting	Magnetic Protection	Mag. Threshold
Distribution	TMF	✓	Fixed: I_n	✓	Fixed: $10 \times I_n$
	TMD	✓	$(0.7-1) \times I_n$	✓	Fixed: $10 \times I_n$
	TMA	✓	$(0.7-1) \times I_n$	✓	$(5-10) \times I_n$
Generator Protection	TMG (Tmax XT)	✓	$(0.7-1) \times I_n$	✓	Fixed: $3 \times I_n$
	TMG (Tmax T)	✓	$(0.7-1) \times I_n$	✓	$(2.5-5) \times I_n$
Motor Protection	MF	✗	-	✓	Fixed: $14 \times I_n$
	MA	✗	-	✓	$(6-14) \times I_n$

Temperature performance

Overview

Low Voltage Circuit breakers

Screenshot from Specification requirements- Trip units temperature derating

Deration: Thermal and Electronic over-current trips are to be ambient temperature derated at specified ambient conditions and corresponding temperature within the enclosures. MCCB shall not be derated if the space where the panels are installed is air-conditioned.

Trip units Temperature performances

Temperature Derating

Temperature performances

All circuit-breakers fitted with thermomagnetic trip unit have the thermal element set for a reference temperature of +40°C as per IEC 60947-2. With the same setting, for temperatures other than +40°C there is a variation in the thermal trip threshold.

De-ratings tables shall be followed for temperature derating up to 70 ° C

XT1		10		20		30		40		45		50		60		70	
T amb (°C)	In [A]	MIN [A]	MAX [A]														
	16	13	18	12	18	11.9	17	11.2	16	10.8	15.5	11	15	10	14	9	13
	20	16	23	15	22	14.7	21	14	20	13.6	19.4	13	19	12	18	11	16
	25	20	29	19	28	18.2	26	17.5	25	16.9	24.2	16	23	15	22	14	20
	32	26	37	25	35	23.8	34	22.4	32	21.7	31.0	21	30	20	28	18	26
	40	32	46	31	44	29.4	42	28	40	27.1	38.7	27	38	25	35	23	33
	50	40	58	39	55	37.1	53	35	50	33.9	48.4	33	47	31	44	28	41
	63	51	72	49	69	46.2	66	44.1	63	42.7	61	41	59	39	55	36	51
	80	64	92	62	88	58.8	84	56	80	54.2	77	53	75	49	70	46	65
	100	81	115	77	110	73.5	105	70	100	67.8	97	66	94	61	88	57	81
	125	101	144	96	138	91.7	131	87.5	125	84.7	121	82	117	77	109	71	102
	160	129	184	123	176	117.6	168	112	160	108.4	155	105	150	98	140	91	130

The electronic overcurrent trip units **do not undergo any variations** in performance as the temperature varies.

Neutral protection

Overview and range

Low Voltage Circuit breakers

Screenshot from Specification requirements- Neutral protection Trip units

All four (4) pole circuit breakers must have **neutral protection** accordingly their trip units should be able to sense the current on all four (4) poles. The trip unit should allow a separate setting for the neutral pole to select one of three settings (neutral unprotected), (neutral protected at 50% phase current) and (neutral protected at 100% of phase current).

Breakers of 1000A rating and above shall be provided with **ground fault protection** as per NEC requirements.

MCB's available versions

Phases Protection

1P/3P

Protection on live phases
Neutral protection/isolation is not provided



S201

S203

2P/4P

Protection and isolation on live phases and Neutral are provided



S202

S204

1P+N/3P+N (disconnecting neutral NA)

Protection and isolation on live phases and Neutral isolation only are provided



S201NA

S203NA

MCCB's available versions

Phases Protection

1P/3P

Protection on live phases

Neutral protection/isolation is not provided



A1 1P*



A1 3P

2P/4P

Protection and isolation on live phases and Neutral are provided



A1 2P*



A1 4P

Electronic Trip units

Overview and range

Low Voltage Circuit breakers

Screenshot from Specification requirements- TM or electronic Trip units

Circuit Breaker Trip Units: Unless otherwise specified, circuit breakers up to and including 400 a frame size are to be **thermal-magnetic type**, having bi-metallic inverse time delay over-current element for small overloads and instantaneous magnetic over-current trip element for operation under short-circuit conditions on each pole. Circuit breakers 250 A and larger are to have adjustable instantaneous trips.

Circuit breakers of rating 250 Ampere and above shall have **electronic trip unit**.

All MCCB's shall be equipped with **solid-state release** (adjustable for long time and short time and/or instantaneous protection depends on the selectivity achievements features).

Low Voltage Circuit breakers

Screenshot from Specification requirements- TM or electronic Trip units

Electronic trips units, applicable to circuit breakers 250 A frame size and larger, are to be solid state with long time delay settings between 0.5 and 1.0 times maximum trip rating, short time delay range of 3 to 10 times maximum trip rating with a maximum clearing time of 0.2 seconds, and instantaneous protection adjustable from 5 to 10 times continuous rating. Solid state trip units are to be insensitive to changes in ambient temperature between -20 and +55 deg C. Earth fault protection is to be built into trip unit where specified, and is to be suitable for connection to external current sensor. Push-to-trip button is to be provided on cover for testing the trip unit. Short time over current protection is only required for circuit breakers 630A and above.

Electronic trip units

Available versions

Electronic Trip unit Ekip

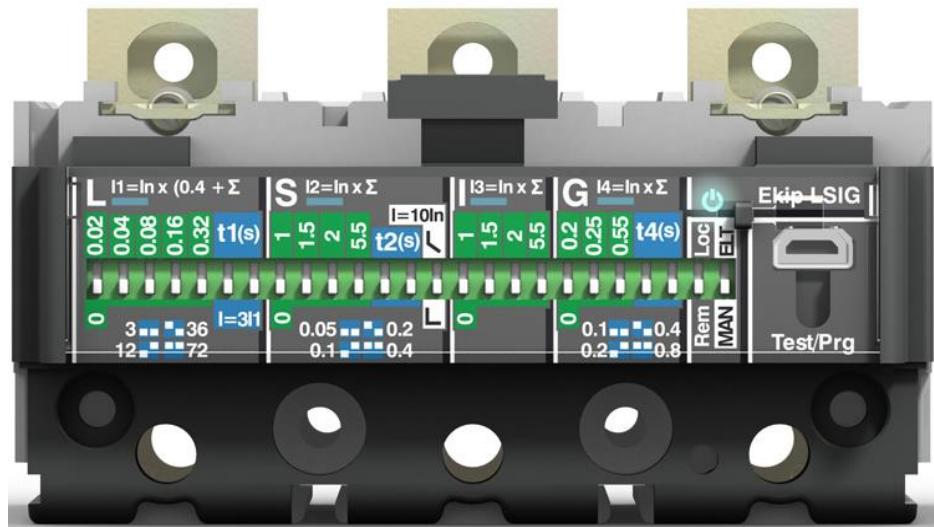
Electronic releases are connected with current transformers (3 or 4)

- Supplying the power necessary to the proper functioning of the release (self-supply)
- Detecting the value of the current flowing inside the live conductors
- Compatible with A.C. networks only
- Not affected by Temperature as in TM MCCB's

Electronic trip units

Available versions

Electronic Trip unit EKIP



Ekip Dip

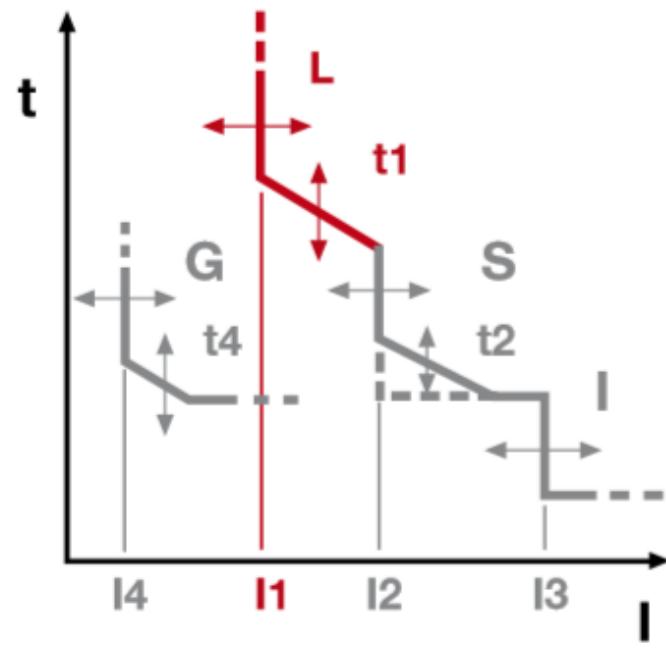


Ekip Touch/ Hi-Touch

Overcurrent protection

Protection of Feeders

Protection relay tripping curve

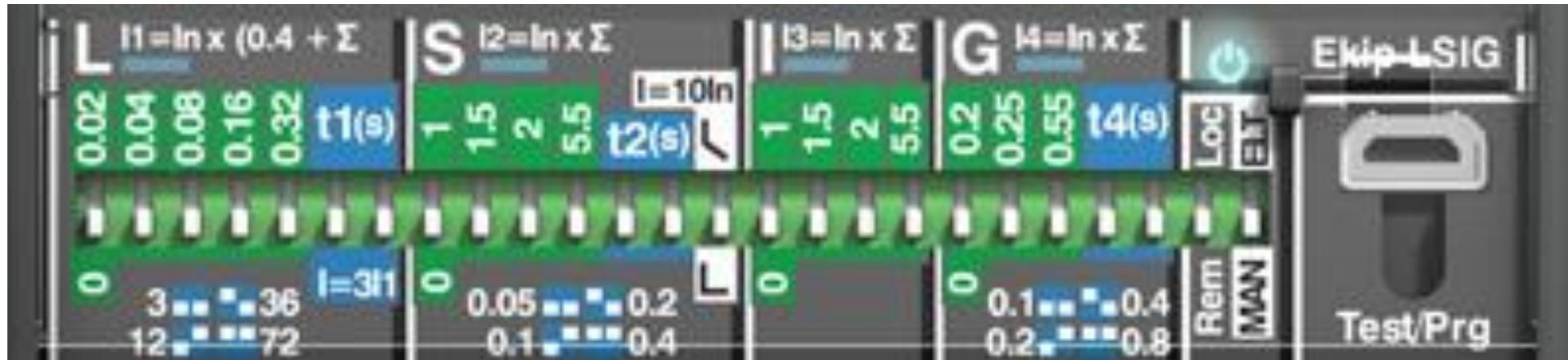


Electronic trip unit

MCCB Tmax Trip units

Trip units portfolio

Electronic Trip unit Ekip



Electronic trip units

Protections and thresholds

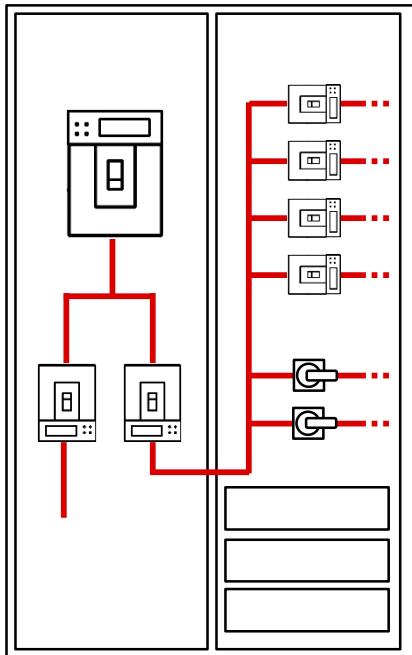
Example on Ekip LSIG Electronic Trip unit Ekip

Protection Function	Description	Trip Current Threshold	Trip time Threshold	Relation
L	Overloads with long inverse time delay trip	$I1 = (0.4-1) \times I_n$	$t1 = 3-12-36-60 \text{ at } 3I_1$	$t = k/I^2$ (inverse)
S	short-circuits with independent time delay	$I2 = (1-10) \times I_n$	$t2 = 0.05-0.4 \text{ s}$	$t = k/I^2$ (inverse) $t = k$ (definite)
I	short-circuits with adjustable threshold and instantaneous trip time	$I3 = (1-10) \times I_n$	Instantaneous (<40ms)	$t = k$ (definite)
G	earth fault with independent time delay trip	$I4 = (0.2-1) \times I_n$	$t4 = 0.1-0.8 \text{ s}$	$t = k$ (definite)

MCCB Tmax Trip units

Trip units portfolio

	Trip Unit	XT1	XT2	XT3	XT4	T4	T5	T6	T7
Power Distribution	TMD	•		•		•			
	TMA		•		•	•	•	•	•
	Ekip LS/I		•		•				
	Ekip I		•		•				
	Ekip LSI		•		•				
	Ekip LSIG		•		•				
	Ekip E-LSIG				•		•	•	
	PR221DS					•	•	•	
	PR222DS/P					•	•	•	
	PR222DS/PD					•	•	•	
	PR223DS					•	•	•	
	PR231/P								•
	PR232/P								•
	PR331/P								•
	PR332/P								•



MCCB Tmax Trip units

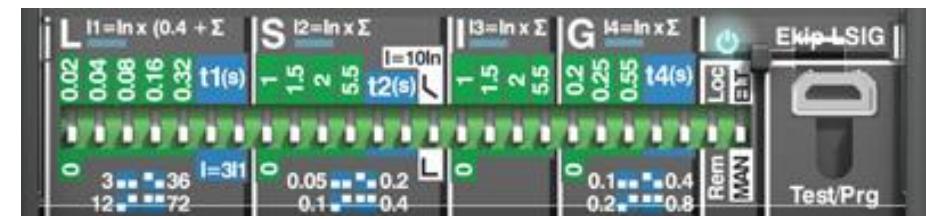
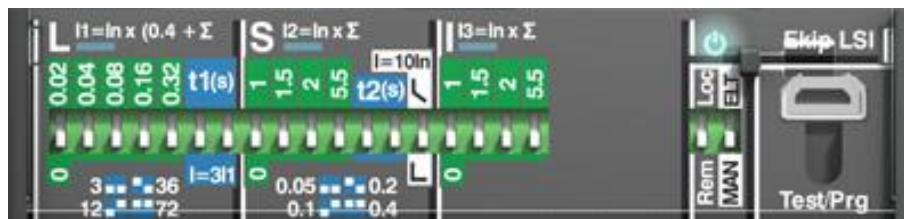
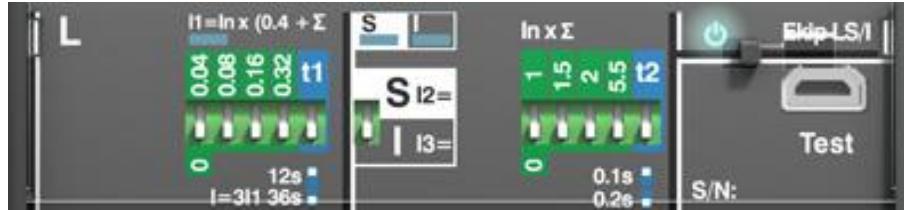
Trip units portfolio

	Trip Unit	XT1	XT2	XT3	XT4	T4	T5	T6	T7
Motor Protection	MF/MA	•		•	•	•			
	Ekip M-I	•							
	Ekip M-LIU	•			•				
	Ekip M-LRIU	•			•				
	PR221DS-I					•	•	•	•
	PR231DS-I								•
Generator Protection	TMG	•		•		•			
	Ekip G-LS/I	•			•				
EFDP	PR223EF				•	•	•	•	•
Oversized Neutral	160%	Ekip N-LS/I	•		•				

MCCB Tmax Trip units

Trip units portfolio

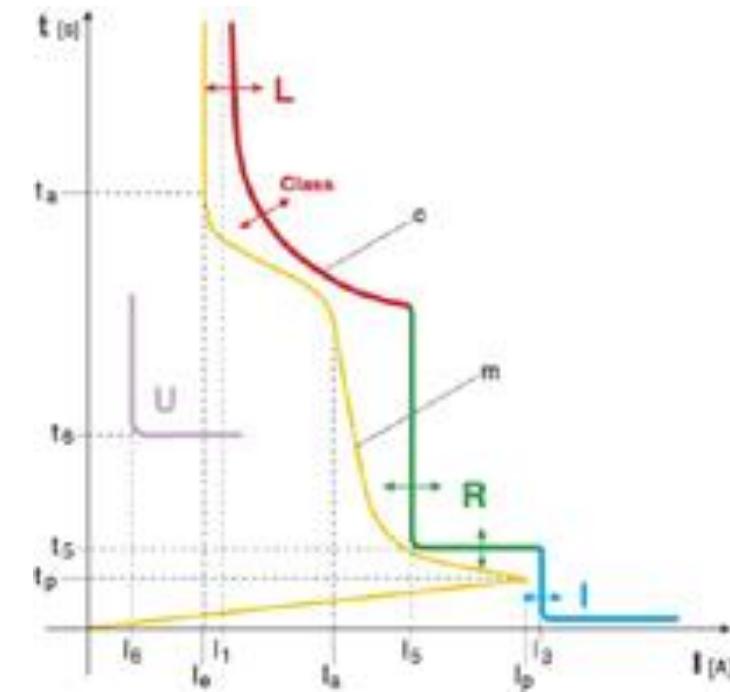
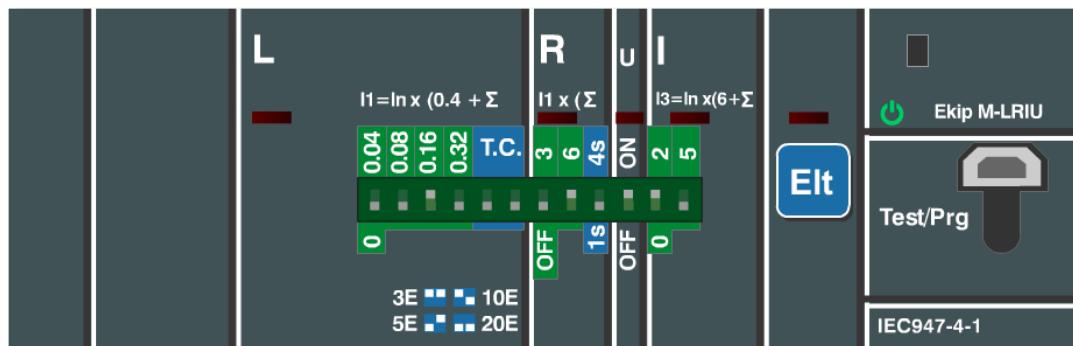
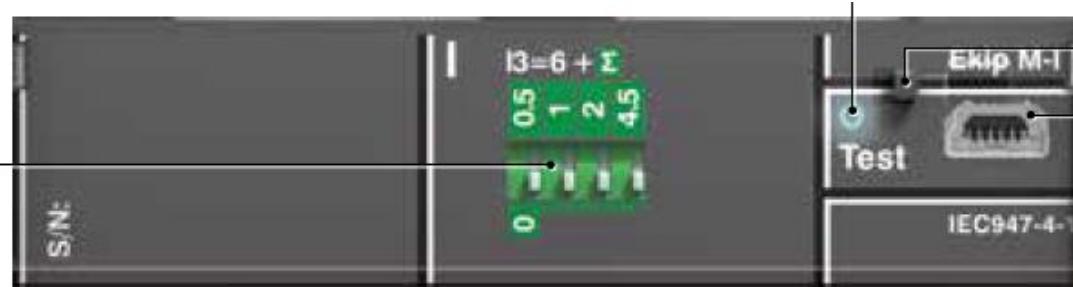
Electronic Trip unit EKIP - distribution



MCCB Tmax Trip units

Trip units portfolio

Electronic Trip unit EKIP – Motor Protection



Low Voltage Circuit breakers

Screenshot from Specification requirements- ACB Trip units

ACBs shall be fitted with the **protection devices** solid state type, instruments indicators and auxiliary control functions as specified in the schedules/drawings.

All circuit breakers with ratings above 1000A (one thousand) should have a built in **ammeter** on their trip units

Trip Unit Status Display: Shall indicate in words the status of normal breaker operation, long time over current pick up, instantaneous time over current trip, short time over current trip, ground fault trip. Unit shall have integral resettable counter to count long time, short time, instantaneous and ground fault trips.

SACE Emax 2

Control

Ekip Dip: The standard trip unit



- Current protection for basic distribution
- Thermal memory, separate settings for neutral
- LED signals trip cause; time and date of last trip available

Ekip Touch: The smart trip unit



More than Ekip Dip:

- Ready to be **upgraded and customized**
- Advanced protection set for more sophisticated systems (GFext + 2I)
- Ready for measuring
- Embedded Bluetooth

Ekip Hi-Touch: The ultimate trip unit



More than Ekip Touch:

- Advanced preloaded feature set
- **Class 1 accuracy**
- Exclusive directional protection for complex grids
- Dual setting for smart grids and arc-flash
- Self-power

Interchangeable Trip units

Overview

Low Voltage Circuit breakers

Screenshot from Specification requirements- Interchangeable Trip units

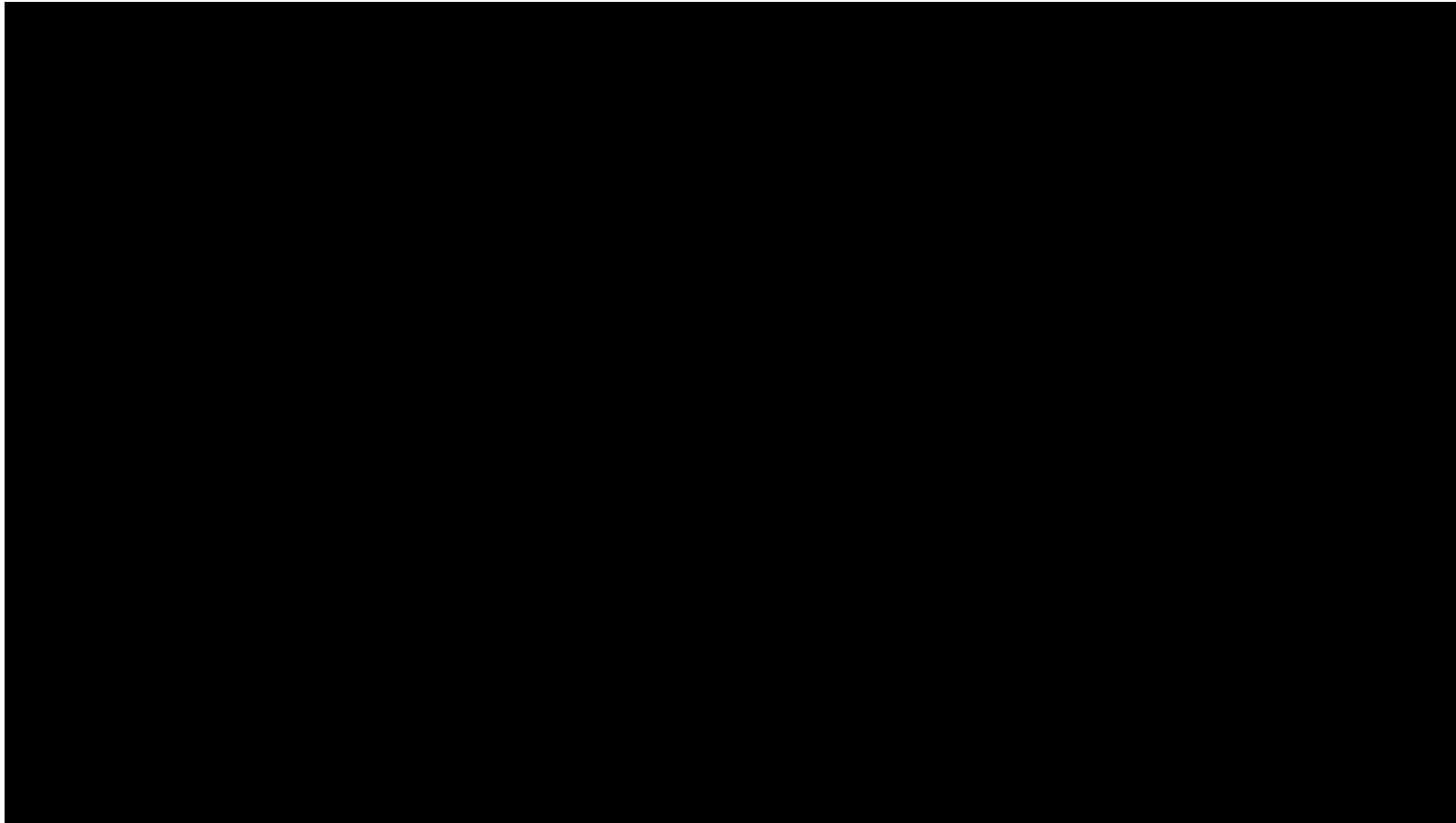
Trip units of ratings up to 160A shall be built in. Trip units above and including 160A shall be replaceable.

Interchangeable Trips: Thermal-magnetic trip circuit breakers of 150/160 A frame size are to have interchangeable trip units.

Non-interchangeable trip breakers shall have their covers sealed and breakers with interchangeable trips shall have the trip unit sealed to prevent tampering.

Interchangeable Trip units

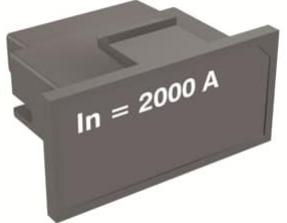
Tmax XT



<https://youtu.be/kztBPVla00o>

Interchangeable Trip units

Emax2



Rating
Plug



<https://youtu.be/1L6vpcbREW8>

Interchangeable Trip units

Rating Plug for MCCB/ACB

Rating Plug

The rating plugs are field interchangeable from the front on all trip units and enable the protection thresholds to be adjusted according to the actual rated current of the system.

This function is particularly advantageous in installations that may require future expansion or in cases in which the power supplied needs to be limited temporarily (e.g. mobile Gen Set).



Interchangeable Trip units

Rating Plug for MCCB/ACB

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This function is particularly advantageous in installations that may require future expansion or in cases in which the power supplied needs to be limited temporarily (e.g. mobile Gen Set).

Circuit-breaker	Rating plugs available
E1.2	400-630-800-1000-1250-1600
E1.2 250	100-200-250
E2.2	400-630-800-1000-1250-1600-2000-2500
E2.2 250	100-200-250
E4.2	400-630-800-1000-1250-1600-2000-2500-3200-4000
E6.2	400-630-800-1000-1250-1600-2000-2500-3200-4000-5000-6300



Advanced trip units

Overview

Low Voltage Circuit breakers

Screenshot from Specification requirements- ACB Trip units

Trip Unit shall have protective relays including:

- Over load and short circuit protection.
- Earth fault protection.
- Over-voltage
- Voltage unbalance.
- Current unbalance
- Reverse power.

Voltage Measurement/Protection function

External devices



CM-PVS.41S
U/O Voltage, Ph. Seq &
Failure Relay



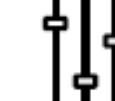
ABB M1M-10, M1M-12
Digital Power Meter



ABB M4M-20, M4M-30
Network Analyzers

Voltage Measurement/Protection function

Control - Default functionalities and upgradability of the trip units

											
	Standard Protection	Standard Measures	Measuring Package	Voltage Protections	Frequency Protections	Power Protections	Adaptive Protections	Data Logger	Network Analyzer	Advanced Voltage Protections	ROCOF Protections
Ekip Touch	●	●	↑	↑	↑	↑	↑	↑	↑	↑	↑
Ekip G Touch	●	●	●	↑	↑	↑	↑	●	↑	↑	↑
Ekip Hi-Touch	●	●	●	●	●	↑	●	●	●	↑	↑
Ekip G Hi-Touch	●	●	●	●	●	●	●	●	●	●	●

● Available by default

↑ Upgradable

↑ Some elements of the package are already provided by default. It is possible to upgrade the trip unit to achieve the complete package.

Communication in Trip units

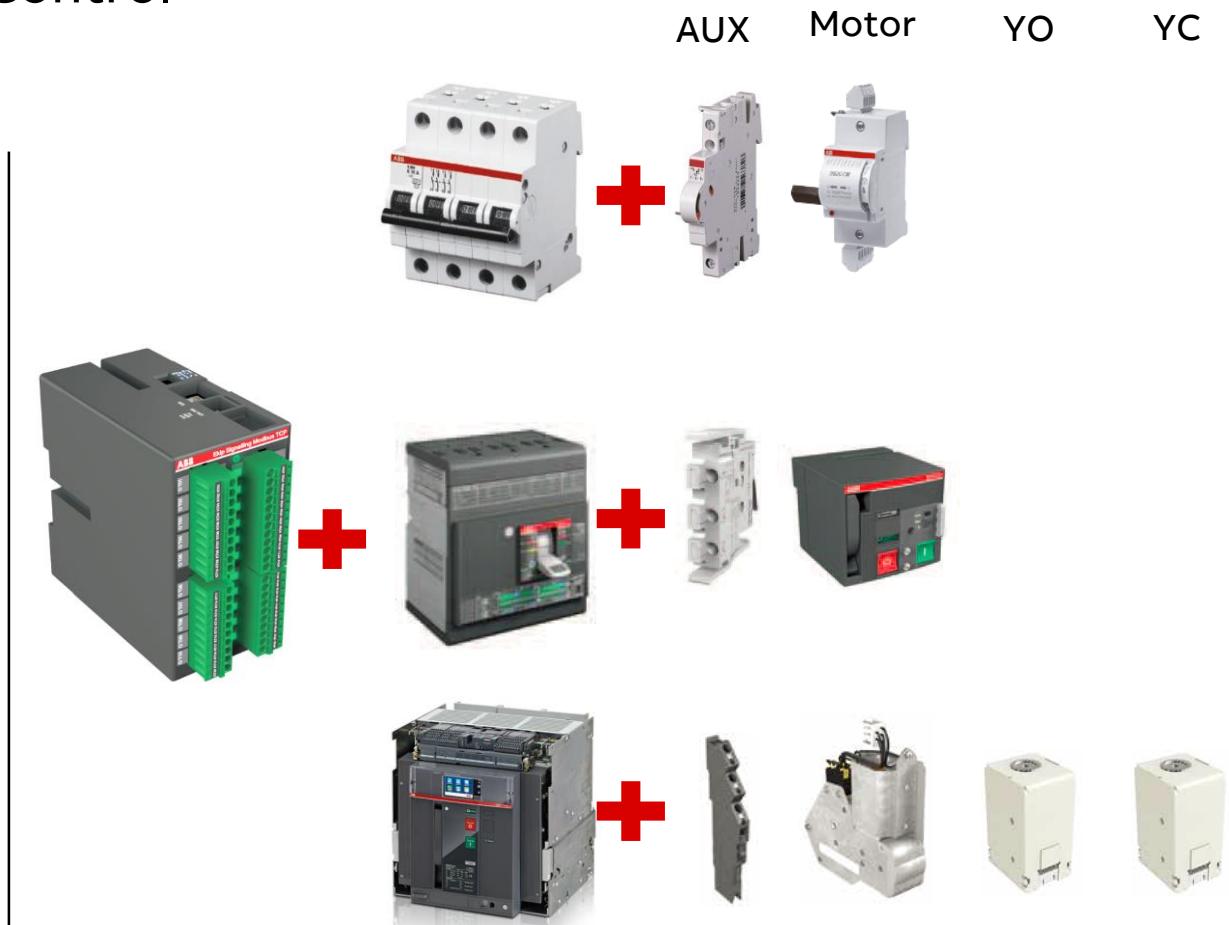
Overview

Trip units communication

Basic Level – Status Monitoring & Close/Open Control

Status Monitoring & Close/Open Control:

- In case it is requested to Monitor Circuit Breaker Positions (ON/OFF/Trip) & Control the operation (Open/Close) using Communication from the Centralized Management System (BMS, SCADA,..).
- We can use “**Ekip Signaling Modbus TCP**” which is used to convert the signals from hard wire into **Modbus TCP Communication** to communicate with the centralized management systems.
- Circuit Breakers have to be provided with auxiliary contact to indicate CB positions (ON/OFF/Trip) & to be provided with **Motor operator** to receive **opening** and **closing Commands***.

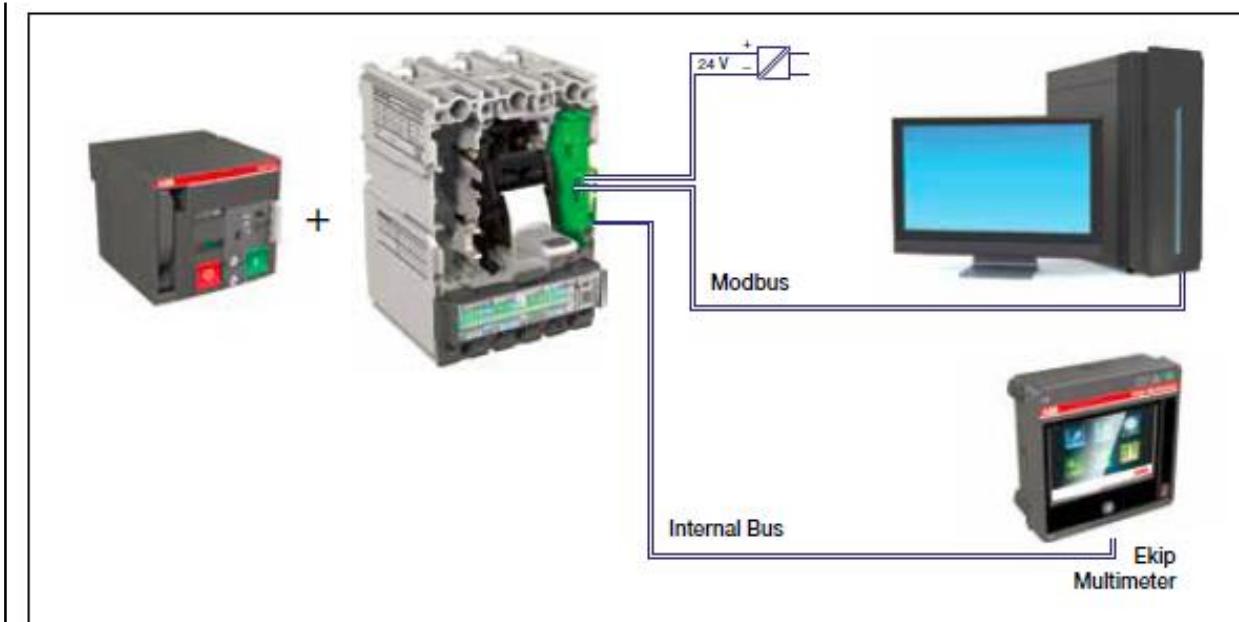


Circuit Breakers Monitoring Levels

Monitoring Level – Current & Energy Monitoring

Current & Energy Monitoring for MCCBs:

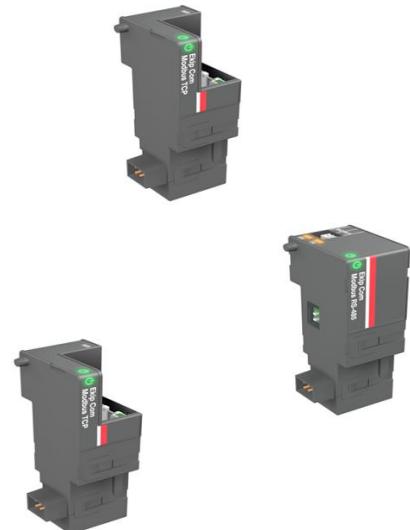
- For MCCB trip units have to be **Electronic type** that **Supports Communication & Current or Energy Measurements**.
- **Provided with additional communication modules** that communicate the data with **Modbus RTU Protocol**.
- It will be able to **transfer data (Current or Energy measuring, Status, trip history, events and protection thresholds)** to the centralized management system.
- It is also possible to receive opening & closing commands from the centralized management system.



Circuit breakers communication

Air Circuit breakers

Plug & Play modules



Plug&play communication cartridge modules enable direct communication with the seven most common industrial communication protocols and the cloud:

- Modbus RTU, Modbus TCP, Profibus DP, DeviceNet, ProfiNet, Ethernet/IP, IEC 61850, Com Hub

Multiple modules can be used simultaneously.

Additionally, Emax 2 offers a wide range of analog and digital I/O to acquire external measurement (i.e temperature) and signals.

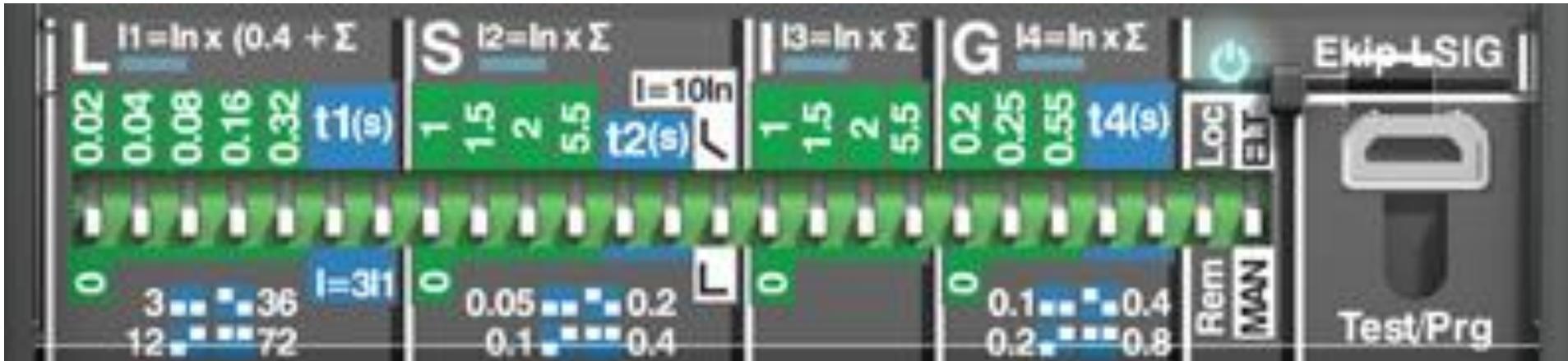
The most flexible and comprehensive connectivity offering

Trip unit demo simulator

Overview

Trip unit demo simulator

Example



<https://new.abb.com/low-voltage/products/circuit-breakers/tmax/trip-unit-simulator-xt>

ABB