ELCPD-07

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Electronic Trip Units

A practical guide to contemporary trip unit features

An ABB Specification Team Training Series Presentation

ABB

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Learning Objectives

- An understanding of the main types of trip units
- The range of available trip unit settings
- An assessment of contemporary embedded features.
- The use of miscellaneous features to aid coordination and selectivity

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Agenda

Trip Unit Technology
- Thermo / Magnetic Type
- Electronic Type

Trip Unit Settings
- Advanced Protection
- MV / LV Coordination
- Improving Selectivity Levels
- Curve Adjustment

Embedded Features
- On Board Analysis
  - Instantaneous Measurements
  - Counters
  - Network Analysis
  - Remote Monitoring

Miscellaneous Electronic Trip Unit Features
- Earth Fault Loop Impendence Values (Zs),
- Ambient Temp
- Power Losses

ABB

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Trip Unit Technology

Thermal/Magnetic & Electronic Trip Units

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Knowledge Check

How many generic types of trip unit are there on the main UK brand circuit breakers?

- ✗ A. 3
- ✗ B. 5
- ✓ C. 2
- ✗ D. 1

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Thermal/Magnetic Trip Units

Two Functions & Typical Setting Ranges

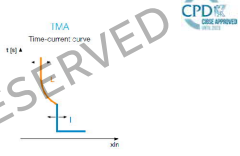
Two Functions

Overload Protection (Thermal)

Short Circuit Protection (Magnetic)

Typical Setting Ranges

Thermal (L)	0.7 to 1 x In
Magnetic (I)	5 to 10 x In or fixed



Rotary switch

Depending on the version it is possible to set the desired thresholds for protection by turning the front rotary switch.

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Thermal / Magnetic Trip Units

Advantages & Disadvantages

Advantages

Low Cost
Simple to set up
Can be used for AC and DC Protection

Disadvantages

Not very accurate
Basic Protection Only – No Advanced Settings
Limited Applications – Distribution (G Trips for Generators – MA for Motors)
Poor Discrimination (compared to Electronic Trips)
No Embedded Metering / Communications facilities

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Electronic Trip Units

Advantages

Extended Setting Range
More Accurate Settings – allowing precise protection to be set
Advanced Protection Settings
Better Discrimination (Including HV/LV Grading)
Multi Applications
Metering & Communication Functions
Trip Histories & Event Logging
Remote Setting
Load Profiles & Contact Wear Indication
Simple Connection to BMS/EMS Systems

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Trip Unit Settings

Advanced Protection

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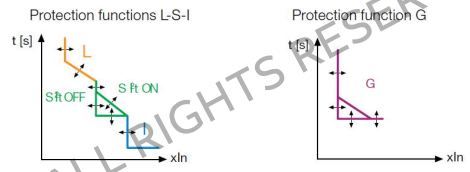
Advanced Protection Settings

Function I^2t ON/OFF



I^2t function is used to assist grading with different types of characteristic curves such as fuses or relays.

Used with Functions S & G

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Advanced Protection Settings

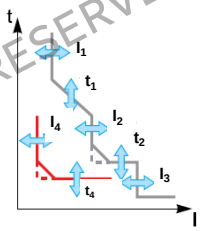
Functions & Extended Range

Functions

L – Long Time
S – Short Time (c/w time delay)
I – Instantaneous
G – Ground Fault

Extended Setting Range

L – I_1 – (0.4 to 1 x In) t_1 – (0.5 to 16s)@ 6x Ir
S – I_2 – (1.5 to 10 x In) t_2 – (0.1 to 0.4s) I^2t ON/OFF
I – I_3 – (1.5 to 15 x In)
G – I_4 – (0.2 to 0.8 x In) t_4 - (0.1 to 0.4s) I^2t ON/OFF



More incremental steps between setting values

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Knowledge Check

What is a benefit of backup protection?

- ✗ A. Full selectivity is achieved
- ✓ B. Cost reduction of installation, ie lower fault ratings of protection devices

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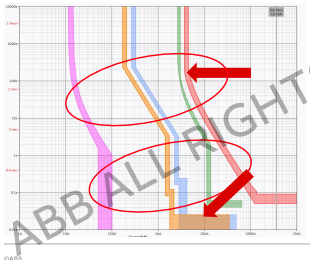
MV / LV Selectivity

Grading Example



Time/Current Selectivity Review

- Main ACB curve is set to EI (Extremely Inverse) to match the curve of the medium voltage relay providing close protection for the transformer and coordination of MV & LV
- Time/Current selectivity is achieved;
  - Overload Zone
  - Short Circuit Zone
- Curves still merge at points were high fault current is expected
  - This is energy selectivity zone
  - Overlapping is normal throughout all manufacturers
  - Selectivity tables must be referenced

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Improved Selectivity Levels

Examples

Upstream – 100A Thermal/Magnetic MCCB

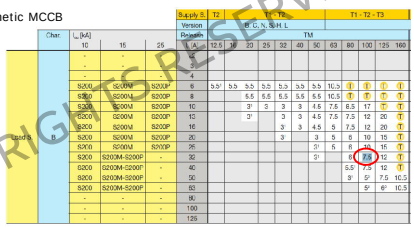
Downstream – 32A Type B MCB

Selectivity Limit = 7.5kA

$I_s > I_{PSCC}$

I_s = Ultimate Selectivity

I_{pscc} = Prospective Short Circuit Current



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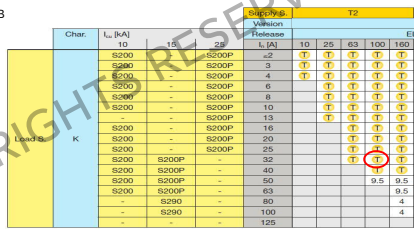
Improved Levels of Selectivity

Examples

Upstream – 100A Electronic MCCB

Downstream – 32A Type B MCB

Full energy selectivity achieved



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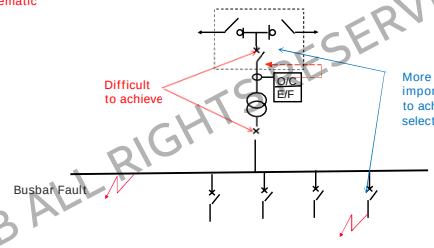
MV/LV Selectivity

Typical Schematic



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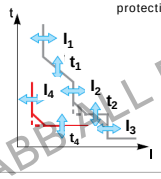
Curve Adjustments

Tips & Tricks

Motor:	Adjustment of t_1 – to avoid nuisance tripping during start up
Generator:	Adjustment of I_2 – Can be set low in order to provide closer s/c protection when supply is via a Generator
Transformer:	Adjustment of t_1 – to avoid nuisance tripping during start up
	Adjustment of I_2 – Can be set mid-high in order to provide best practice protection for any size Transformer



Can also be used for:

Capacitor Protection
Lighting Protection

Due to the flexibility in the setting ranges

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Embedded Features

Embedded Analysis

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Embedded Metering / On-Board Analysis

Ekip SmartVision & Electrical Distribution Control System

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Embedded Metering / On-Board Analysis – Instantaneous Measurements

Electronic trip units can be equipped with embedded meters - no external meters & CTs, fuses, etc.

Current	Phase sequence	Apparent power
Earth fault current	Frequency	Power factor
Phase-phase voltage	Active power	
Phase neutral voltage	Reactive power	

Instantaneous measurements		Parameters
Currents (RMS)	[A]	L1, L2, L3, Ne
Earth fault current (RMS)	[A]	g
Phase-phase voltage (RMS)	[V]	U12, U23, U31
Phase-neutral voltage (RMS)	[V]	U1, U2, U3
Phase sequence		
Frequency	[Hz]	f
Active power	[kW]	P1, P2, P3, Ptot
Reactive power	[kVAR]	Q1, Q2, Q3, Qtot
Apparent power	[kVA]	S1, S2, S3, Stot
Power factor		total
Peak factor		L1, L2, L3, Ne

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Embedded Metering / On-Board Analysis – Counters

Electronic trip units can be equipped with embedded meters - no external meters & CTs, fuses, etc.

Active energy	Reactive energy	Apparent energy

Counters recorded from installation or from the last reset		Parameters
Active energy	[kWh]	Ep total, Ep positive, Ep negative
Reactive energy	[kVARh]	Eq total, Eq positive, Eq negative
Apparent energy	[KVAh]	Es total

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Embedded Metering / On-Board Analysis – Network Analysis

Electronic trip units can be equipped with embedded meters - no external meters & CTs, fuses, etc.

Hourly average voltage values
Short voltage interruptions
Short voltage spikes
Slow voltage sags and swells
Voltage unbalance
Harmonic analysis

Network Analyzer		Parameters
Hourly average voltage value	[V] [Hz]	- Umin: 0.75 ... 0.95 x Un - Umax: 1.05 ... 1.25 x Un - Events counter (nr. of events day by day in the last year plus the total events in the breaker's lifetime)
Short voltage interruptions	[ms]	- Umin: 0.75 ... 0.95 x Un - Events counter (nr. of events day by day in the last year plus the total events in the breaker's lifetime)
Short voltage spikes	[ms]	- Umax: 1.05 ... 1.25 x Un - Events counter (nr. of events day by day in the last year plus the total events in the breaker's lifetime)
Slow voltage sags and swells	[ms]	- Umin1: 0.75 ... 0.90 x Un - Umin2: 0.75 ... 0.90 x Un - Umin3: 0.75 ... 0.90 x Un - Umax1: 1.05 ... 1.25 x Un - Umax2: 1.05 ... 1.25 x Un - Events counter (nr. of events day by day in the last year plus the total events in the breaker's lifetime)
Voltage unbalance	[V] [Hz]	- U neg. seq. = 0.02 ... 0.10 x Un - Events counter (nr. of events day by day in the last year plus the total events in the breaker's lifetime)
Harmonic analysis		Current and Voltage - up to 50° - Alarm THD: 5 ... 20% - Single harmonic alarm: 3 ... 10% plus a count of minutes the harmonic has been exceeded

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Remote Monitoring

Asset Management & Predictive Maintenance

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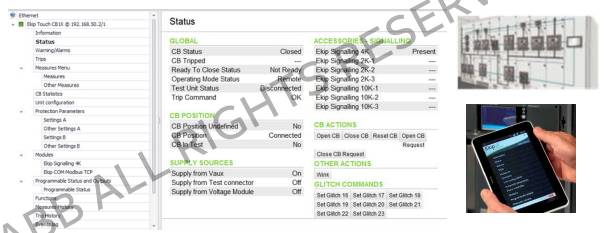
Communications

Metering & Asset Management Data can be communicated to BMS/EMS Systems



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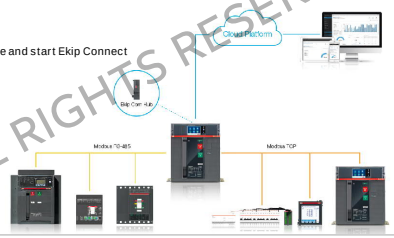
Supervision Platforms – ABB Ability [EDCS]

Example: EDCS (Electrical Distribution Control System)

Embedded solution

Plug-in the Ekip Com Hub module and start Ekip Connect wizard.

Plug & play:
- ACBs
- MCCBs
- MCBs
- Energy and Power meters



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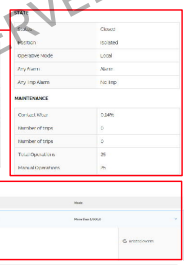
Asset Management

Predictive Maintenance (EDCS)

Remote supervision - single or multi-site Facility Manager or Service Provider access



- Ease of use: interactive images through tags & alarms
- Alarm management: reduce downtime
- Scheduled reports
- Power quality (THD)

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Asset Management

Predictive Maintenance (EDCS)

Essential Maintenance Data

Contact wear
Load profiles Trip/alarm/ maintenance histories
Information on last 30 trips/200 events

Operating times
Circuit breaker I.D.
Milestone dates.

Maintenance indicators		Parameters
Information on last 30 trips		Type of protection, fault values and time-stamping
Information on last 200 events		Type of event, time-stamping
Number of mechanical operations [1]	[no]	Can be associated to alarm
Total number of trips	[no]	
Total operating time	[h]	
Wear of contacts	[%]	Prealarm >80% Alarm = 100%
Date of maintenance operations performed		Last
Indication of maintenance operation needed		
Circuit-breaker I.D.		Type of circuit-breaker, assigned device name, serial number

Fault finding time is virtually zero

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Asset Management

Predictive Maintenance (EDCS)

Self-Diagnosis

Internal continuity checks
Abnormal breaker temperature

Operational failures

Self-diagnosis	Parameters
Check of continuity of internal connections	Alarm due to disconnection: rating plug, sensors, trip coil
Failure of circuit-breaker to open (ANSI 60FF)	Alarm following non-tripping of protection functions
Temperature (OT)	Prealarm and alarm for abnormal temperature

Fault finding time is virtually zero

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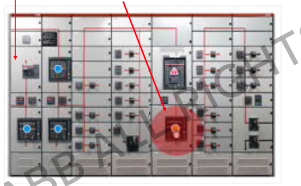
Organise your services and cut down on down time

Predictive Maintenance (EDCS)

Switchboard Layout

Choose breaker for monitoring



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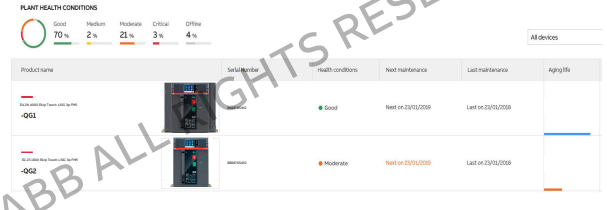
Predictive Maintenance: Organise your services and cut down on down time

Predictive Maintenance (EDCS)

Dashboard Layout



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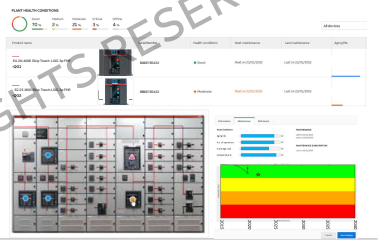
Organise your services and cut down on down time

Predictive Maintenance (EDCS)

Decision Making

- Overall plant health conditions
- Smart visualization (traffic light) to monitor the system at a glance, with proactive alerts
- Operation and Maintenance cost saving thanks to optimized maintenance schedule
- Spare parts management: you know exactly what you need, no waste of time
- Reduced downtime
- Based on an algorithm that considers:
  - Environmental conditions
  - Utilization conditions
  - Circuit breaker aging
  - Measures (Humidity / Vibration / Temperatures)



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Organise your services and cut down on down time

Predictive Maintenance (EDCS)

Component Health Check

Predictive maintenance monitors the health of connected devices by analysing the real time data provided through communication protocols.

Contact wear
Vibration
Faults currents
Tripping operations
Temperature.

EDCS also monitors the product itself and reports vital information that would be required in the event of an electrical fault or service.

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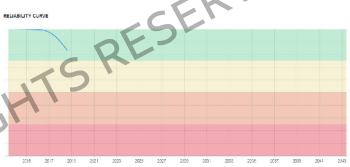
Organise your services and cut down on down time

Predictive Maintenance (EDCS)

Component Health Check



Serial number information and part description is vital in changing devices or performing maintenance.

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Selected General Electronic Trip Unit Features

Earth Fault Loop Impendence Values (Zs), Ambient Temp & Power Losses

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Zs Values

Using Earth Fault Loop Impendence Values (Zs) Comparisons

Earth Fault Loop Impendence Values (Zs) can be easily calculated based on the settings of the Electronic Trip Unit

5s – Check Characteristic Curve

0.4s – Use formulae below

$Zs = Vph / (Im * 1.2)$

Where Vph is the phase/neutral voltage
Im is the magnetic or instantaneous trip setting
1.2 = 20% tolerance of breaker trip characteristics

Example – 100A MCCB set to $I_1 = 1$, $I_2 = 5$ thus $I_2 = 500$
Zs = 230 / (500 x 1.2)
Zs = 230 / 600
Zs = 0.38 ohms

Addition of RCD on breaker if Zs is higher than megger reading

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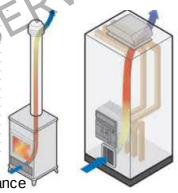
Temperature De-Rating

Electronic Trip Units are less sensitive to high ambient temperatures

XT1																					
T amb [°C]	10		20		30		40		45		50		60		70						
In [A]	MIN [A]	MAX [A]	MIN [A]	MAX [A]	MIN [A]	MAX [A]	MIN [A]	MAX [A]	MIN [A]	MAX [A]	MIN [A]	MAX [A]	MIN [A]	MAX [A]	MIN [A]	MAX [A]	MIN [A]	MAX [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	17	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	26	38	25	35	23	33					
50	40	58	39	55	37.1	53	35	50	33.9	48.5	33	47	31	44	29	41					
63	51	72	49	69	46.2	66	44.1	63	42.4	61	41	59	39	55	36	51					
80	64	92	62	88	58.8	84	56	80	54.3	77	53	76	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	125	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					



Electronic Trip Units do not undergo any variations in performance as the temperature varies.

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Power Losses

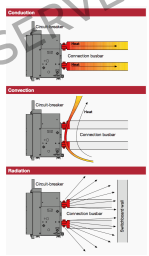
Power Losses are also reduced with Electronic Trip Units

	XT2	
	F	P/W
100	8.08	9.50

Thermal/Magnetic

	XT2	
	F	P/W
100	4.20	5.20

Electronic



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Power Losses

Higher Power Losses increase running costs

Ex. 1x Switchboard having 25 x 3P MCCBs

Th/Mag – 8w/Pole = 24 w / MCCB = 600w for Switchboard
Elect – 4w/Pole = 12w / MCCB = 300w for Switchboard

Based on 365, 24/7 Usage over a 20 year period.
Total Hours = 365x24 = 8760 Using a Kwh rating of £0.15 per unit (Est)

Th/Mag – 600 x 8760/1000 = 5256w/yr 0.15 x 5256 = £788.40/year
Elect – 300 x 8760/1000 = 2628w/yr 0.15 x 2628 = £394.20/year

Th/Mag – £788.40/year over 20yrs = £15,768
Elect – £394.20/year over 20yrs = £7,884

TOTAL SAVING OF £7,884 using Electronic Trips

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Knowledge Check

Summary

- An understanding of the main types of trip units.
- The range of available trip unit settings.
- An assessment of the main contemporary embedded trip unit features.
- The use of miscellaneous features to aid coordination and selectivity

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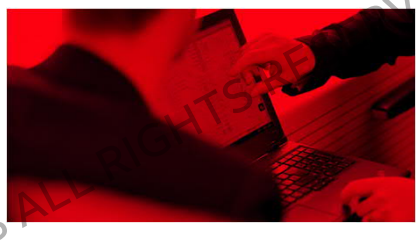
Questions



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