

CT Requirements of Distance Relays

Example MiCOM P43x range

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Agenda

Impact of CT saturation on distance measurement

Determination of relays CT requirements

CT sizing based on application data

Impact of CT saturation on distance measurement

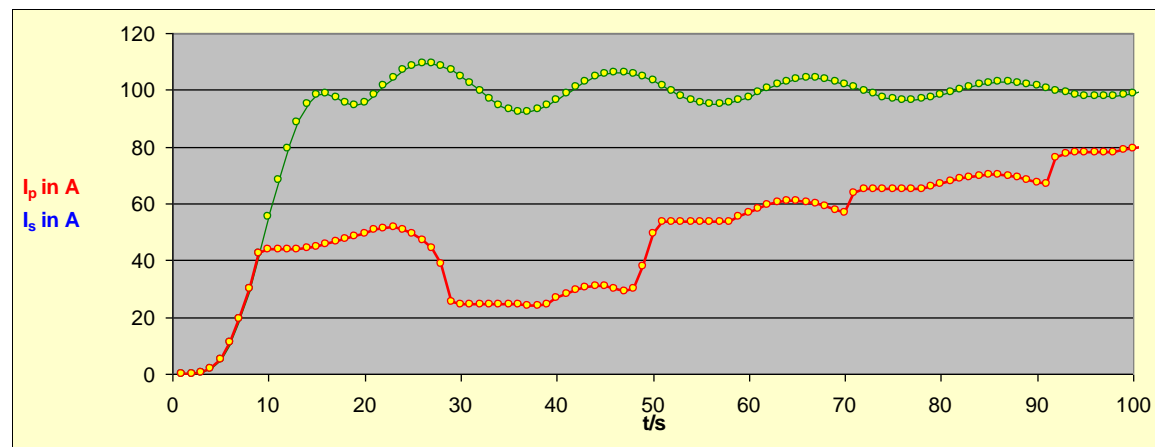
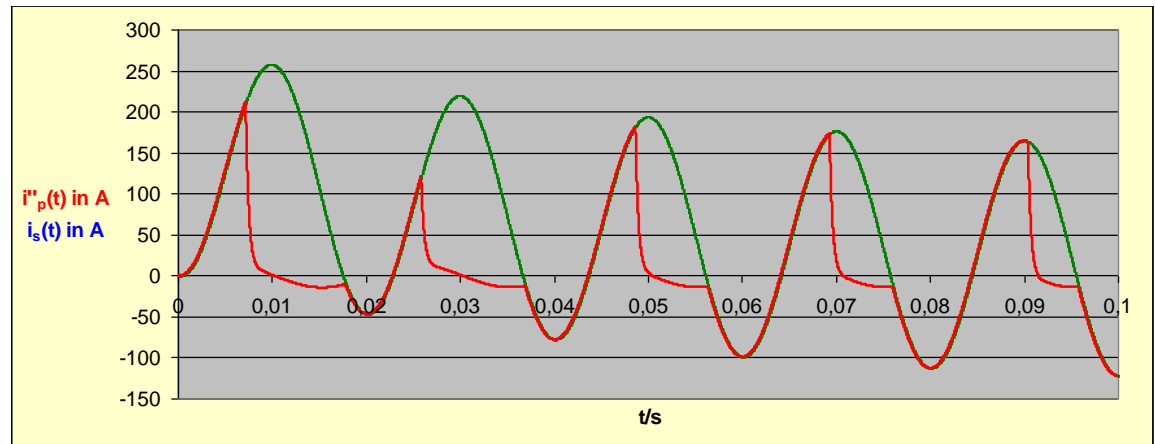
CT saturation causes measurement errors

Example based on Fourier Filtering:

Fundamental current magnitude measurement value is too small

- ⇒ impedance gets bigger
- ⇒ Starting $I >> / Z <$
 - may pick up delayed or
 - falsely reset temporarily

Fourier



Impact depends on methods !

Impact of CT saturation on distance measurement

- CT saturation causes measurement errors

Using Fourier Filtering:

- Fundamental current magnitude measurement value is too small
 - ⇒ impedance gets bigger
 - ⇒ Starting $I > Z <$ may pick up delayed or falsely reset temporarily
 - Fundamental current is phase-shifted, further lagging to voltage
 - ⇒ impedance gets turned anti-clockwise
 - ⇒ reactance becomes bigger
 - (in extreme situations, directional decision would be endangered ?)
- ⇒ Impedance may get out of (instantaneous) tripping zone
- ⇒ Distance protection tends to underreach (= lack of dependability).
- Effect depends on zone characteristic and impedance calculation method(s).
 - Transient CT saturation causes transient measurement errors, effective for about $2 \times T_p$ only.

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CT dimensioning factor

CT dimensioning formulae:

⇒ Secondary accuracy limiting voltage
(≠ Kneepoint voltage)

$$V_{sal} \geq K_d \cdot K_{ssc} \cdot I_{sn} \cdot (R_{ct} + R_b)$$

⇒ Rated accuracy limit factor
of the CT

$$n_n \geq K_d \cdot K_{ssc} \cdot \frac{(R_{ct} + R_b)}{(R_{ct} + R_{bn})} = K_d \cdot K_{ssc} \cdot \frac{(P_{ct} + P_b)}{(P_{ct} + P_{bn})}$$

To avoid saturation,
dimensioning factor has to be

$$K_d = K_{max} \approx 1 + \frac{X_p}{R_p} = 1 + \omega T_p$$

But saturation is acceptable ...

$$K_d = K_{emp} \ll K_{max}$$

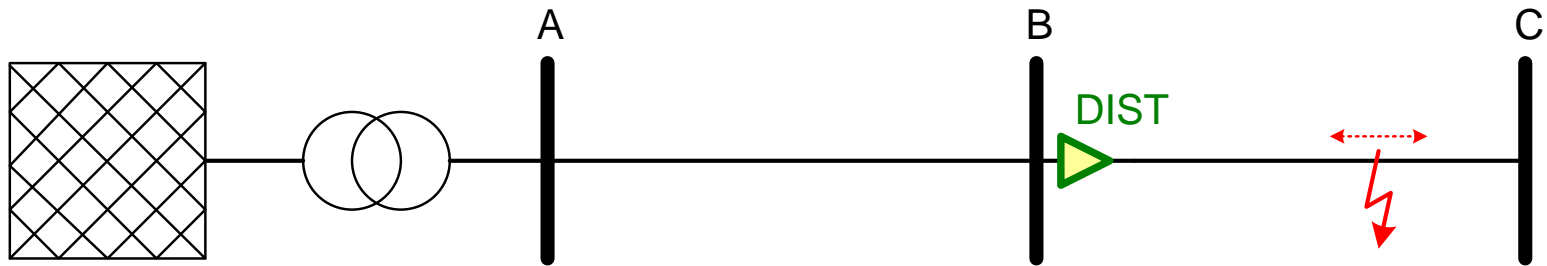


**CT dimensioning factor depends on application and device.
Determination by manufacturer!**

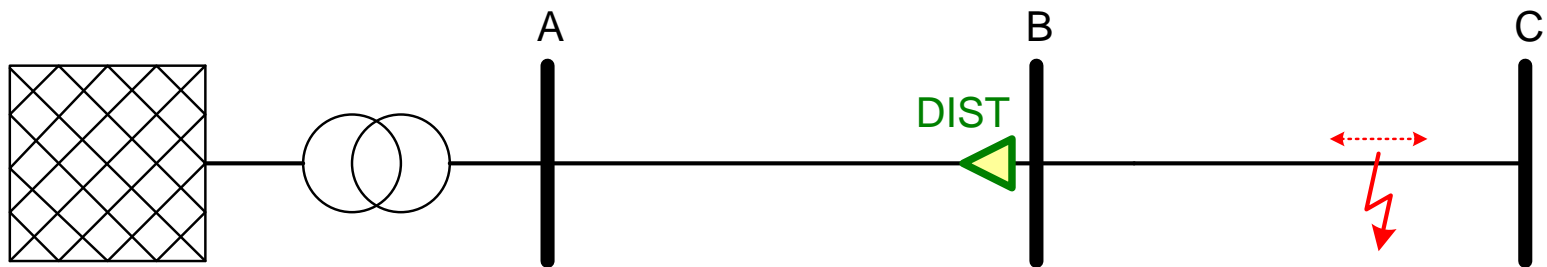
Determination of relays CT requirements

Test system model

Forward Faults

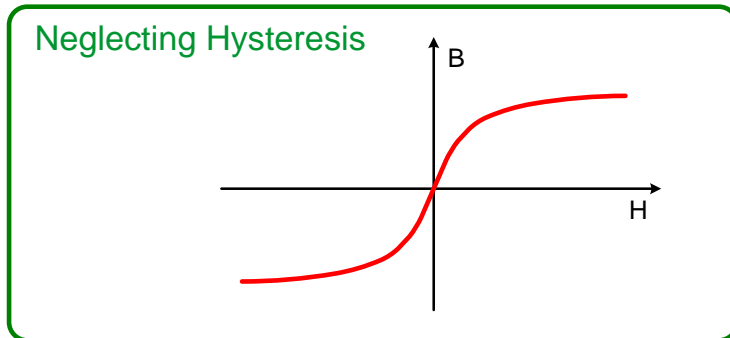
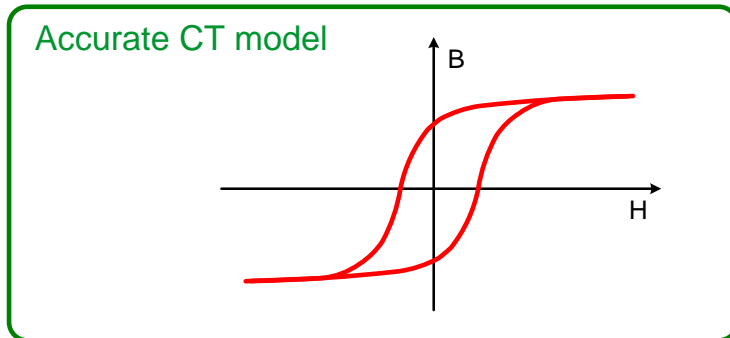


Backward Faults



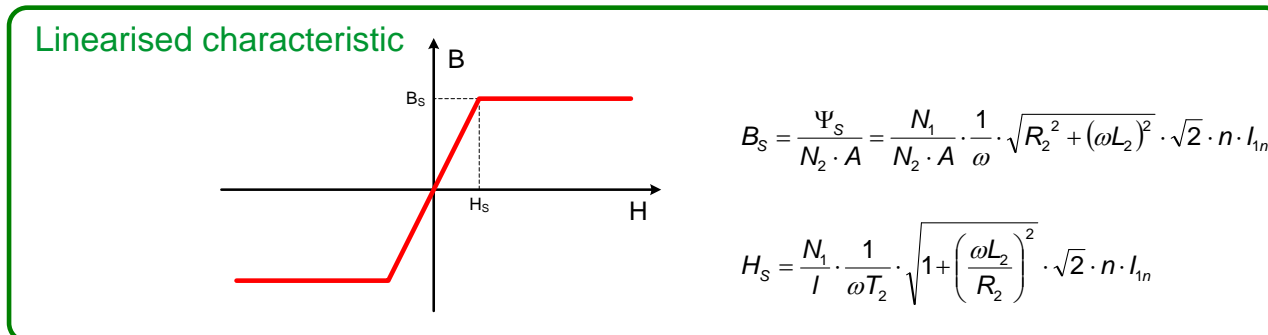
Determination of relays CT requirements

Impact of CT model



+ CT model simplification requires less calculation bandwidth.

- But model inaccuracy results in determination of higher CT requirements



Determination of relays CT requirements

Testsequence

Test series

= Variation of all parameters

Test cycle

= Determination of CT dimensioning
for a given set of parameters

Test process

= Reduction of dimensioning factor, until
incorrect protection operation occurs in at least
1 out of 10 repetitions

Individual test

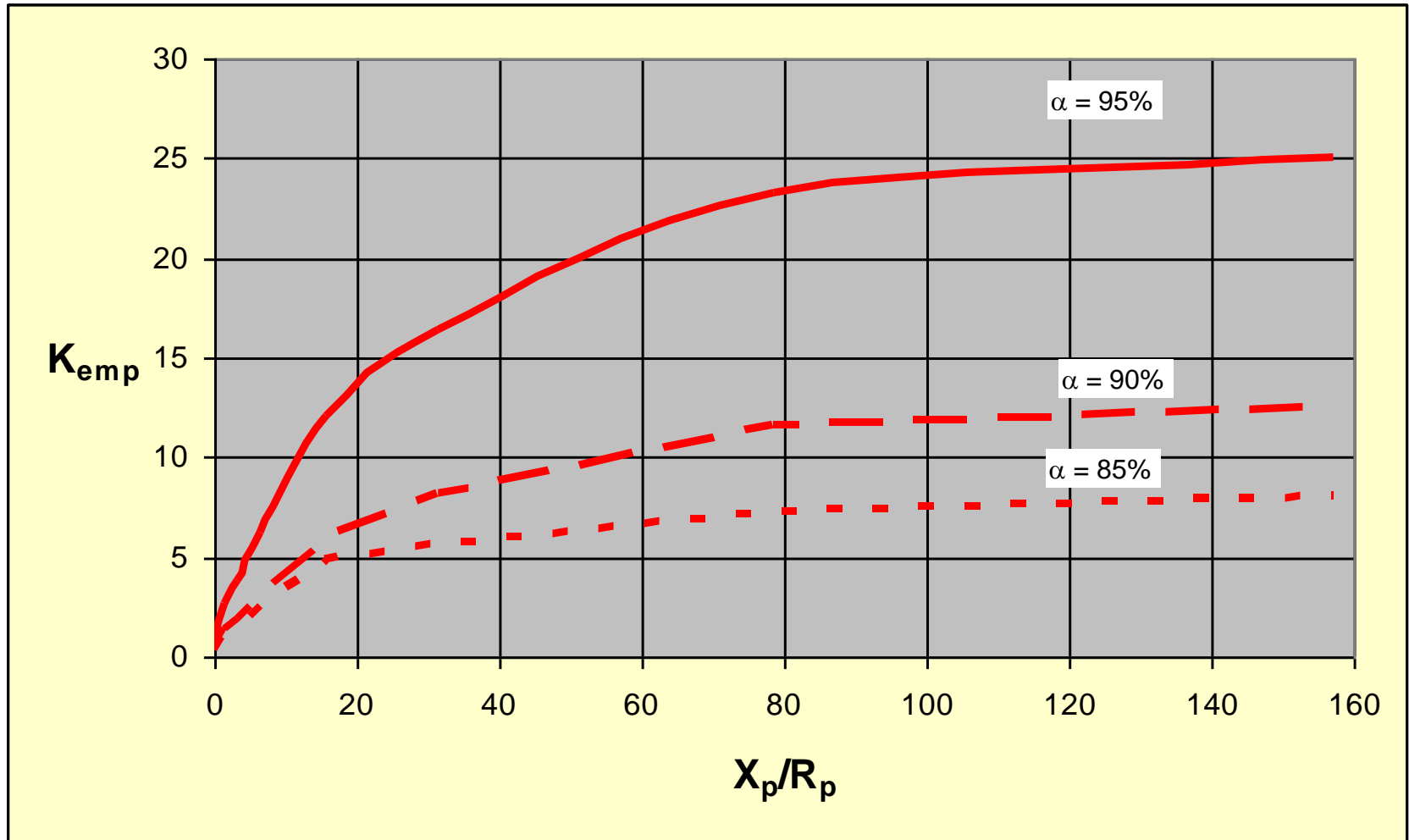
= shot test and comparison of
actual with ideal operation

Parameters:

- U_n Nominal voltage (ref.)
- I_{sc} Short-circuit current (ref.)
- α Fault location
- SIR Source impedance ratio
- F Type of fault
- φ Point on wave
- T_p Primary system time constant
- $r_{L0}, r_{S0}, X_{L0}, X_{S0}$
Ratio of zero- to positive-sequence
line (source) resistance (reactance)
- T_S CT secondary side time const.
- X_S/R_S Burden quality

Determination of relays CT requirements

Result



Agenda

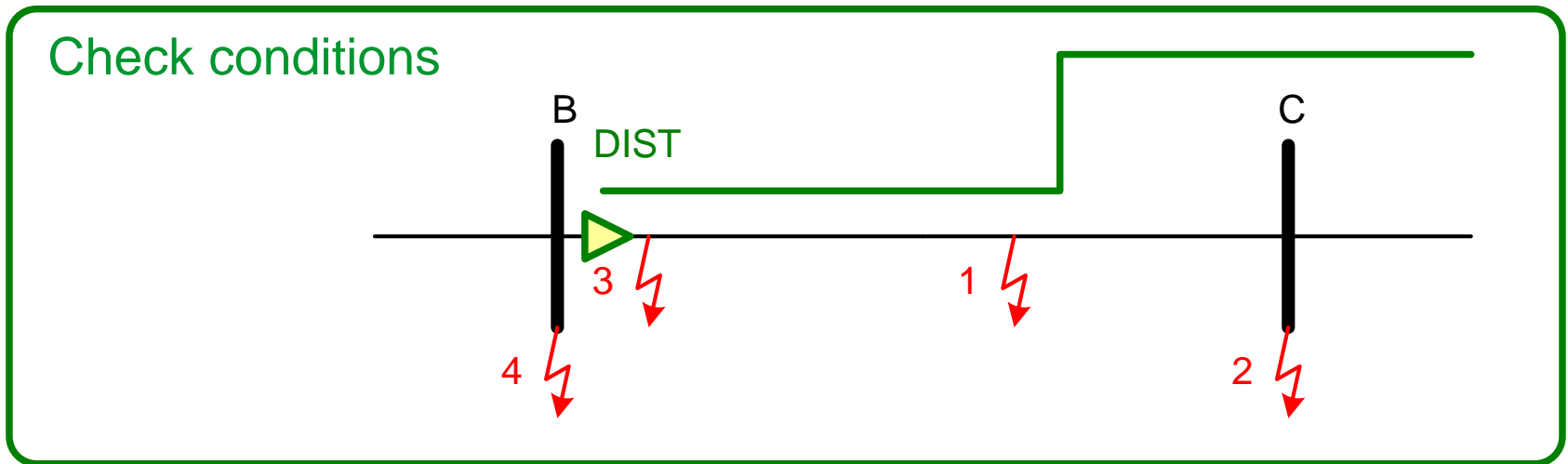
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Determination of relays CT requirements

CT sizing based on application data

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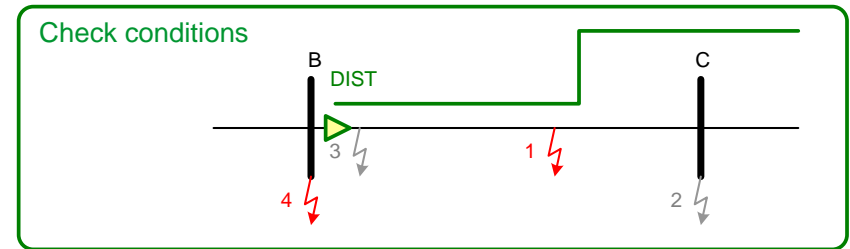
General check points



- 1: Check at Zone 1 reach limit
- 2: Check Zone 2 operation at line end
- 3: Check correct forward decision
- 4: Check correct backward decision

CT sizing based on application data Recommendation

- 1 ⚡ Usually, it is sufficient to determine the required dimensioning based on the maximum short-circuit current for faults at the zone 1 end reach. The instantaneous zone 1 operation then is ensured acc. to the permitted tolerances mentioned on previous slide.



- 4 ⚡ For close up faults in backward direction it is essential to take the correct directional decision. This is secured even with minimum CT dimensioning factor (per curve (3) above), if the short-circuit current is less than twice the maximum short-circuit current at zone 1 reach end.

Otherwise, with bigger short-circuit currents for faults in backward direction, a second calculation of the required dimensioning factor needs to be done, using that fault current and the (possibly different) primary system time constant for that fault scenario.



It is recommended to use CTs of accuracy class 5P (or equivalent).

CT sizing based on application data

Consideration of Auto-Reclosing

Example 1-shot unsuccessful AR

⇒ Additional dimensioning factor to cover magnetization of CT core due to current flow during initial fault (duration = t'):

$$K_d = K_{emp} + \left[1 + \omega \cdot T_p \cdot \left(1 - e^{-\frac{t'}{T_p}} \right) \right] \cdot e^{-\frac{t_{dead}}{T_s}}$$

CT sizing based on application data

Your experience ...

???

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your energy™



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