Product Marketing Manager , Juan Venter, May 2013

Coordination Discrimination and Back-up protection (Cascading)

Discrimination

Definition of discrimination:

“coordination of the operating characteristic of two or more over current protective devices such that, on the incidence of over-currents within stated limits, the device intended to operate within these limits does so, while the others do not operate”

(IEC 60947-1)

Total discrimination: “Over-current discrimination such that, in the case of two over current devices in series, the protective device on the load side provides protection without tripping the other device

(IEC 60947-2)

Partial Discrimination “Over-current discrimination such that , in the case of two over-current protection devices in series, that the protection device on the load side provides the protection up to a given over current limit without tripping the other”

This limit is called the “selectivity limit current” (IEC 60947-2)

Discrimination

Main types of discrimination

Current discrimination - Uses current rating of circuit breaker to discriminate

Time discrimination – Uses tripping curves to discriminate

Each device must be fully rated, to be able to handle the short circuit fault level at the point of installation. Can be expensive but does not disrupt service to circuits unaffected by the fault.

Discrimination
Current Discrimination Example:

Consider the following two circuit breakers:

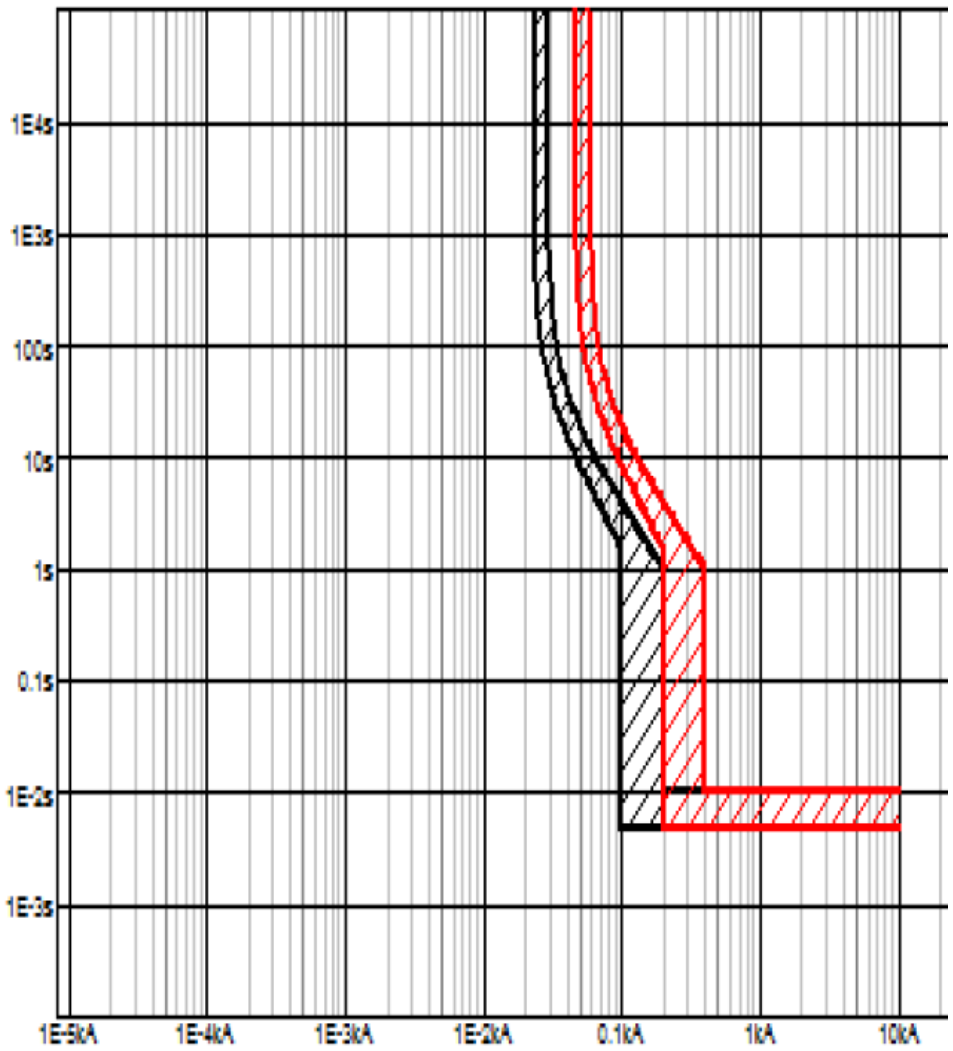
When a 40A (S203-C40) circuit breaker feeds 20A (S203-C20) circuit breaker. Both of these breakers are C-curve circuit breakers. (Time Delay curve are the same)

If an overload of 35A occur on the load side of the 20A the following happen:

- The 20A (Downstream) is in overload range and will trip between 25.6s and 83.2s (All tolerances included)
- The 40A (Upstream) Is still passing current under it`s rated current and will not trip at all

Discrimination

Current Discrimination Example:



- Tripping curve comparison between

  20A C-curve and 40A C-Curve

- It is important to note that this is only partial discrimination since under a short circuit both breakers may trip at a point of “selectivity limit current”

Discrimination

Time Discrimination Example:

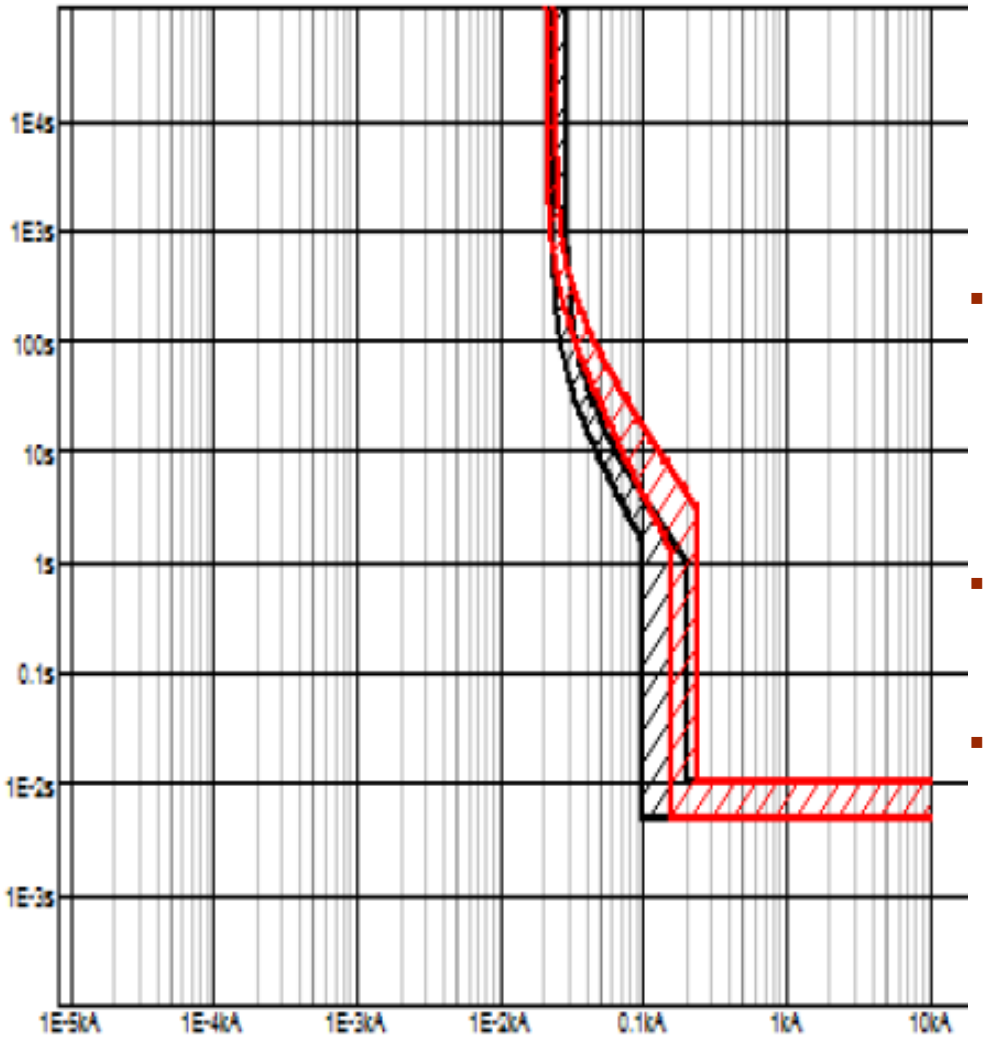
Consider the following two circuit breakers:

When a 20A (S203-K20) circuit breaker feeds 20A (S203-C20) circuit breaker. Both of these breakers are 20 A circuit breakers. The upstream breaker is a K-Curve and the load side is a C curve

If an overload of 35A occur on the load side of the 20A C-Curve the following happen:

- The 20A (Downstream) is in overload range and will trip between 25.6s and 83.2s (All tolerances included based on C-Curve characteristics)
- The 20A (Upstream) is also in overload but will trip in 84.5s to 225s

Discrimination
Current Discrimination Example:



- Tripping curve comparison between 20A K-curve and 20A C-Curve
- It is important to note that this is only partial discrimination.
- It is sometimes needed to have time and current discrimination to achieve the desired selectivity

Discrimination
Total Discrimination

					Supply S.	T2	T1 - T2						T1 - T2 - T3				
					Version	B, C, N, S, H, L											
	Char.	I_{cu} [kA]			Release	TM											
		10	15	25	I_n [A]	12.5	16	20	25	32	40	50	63	80	100	125	160
Load S.	C	S200	S200M	S200P	<2	T	T	T	T	T	T	T	T	T	T	T	T
		S200	S200M	S200P	3	T	T	T	T	T	T	T	T	T	T	T	T
		S200	S200M	S200P	4	T	T	T	T	T	T	T	T	T	T	T	T
		S200	S200M	S200P	6	5.5[1]	5.5	5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T
		S200	S200M	S200P	8			5.5	5.5	5.5	5.5	5.5	10.5	T	T	T	T
		S200	S200M	S200P	10			3[1]	3	3	3	4.5	7.5	8.5	17	T	T
		S200	S200M	S200P	13			3[1]		3	3	4.5	7.5	7.5	12	20	T
		S200	S200M	S200P	16					3[1]	3	4.5	5	7.5	12	20	T
		S200	S200M	S200P	20					3[1]		3	5	6	10	15	T
		S200	S200M	S200P	25							3[1]	5	6	10	15	T
		S200	S200M-S200P	-	32							3[1]		6	7.5	12	T
		S200	S200M-S200P	-	40									5.5[1]	7.5	12	T
		S200	S200M-S200P	-	50									3[1]	5[2]	7.5	10.5
		S200	S200M-S200P	-	63										5[2]	6[3]	10.5
		-	S290	-	80												4[3]
		-	S290	-	100												4[3]
		-	S290	-	125												

Back-up protection (Cascading)

Back-up protection

Back-up protection is an “over-current coordination of two protective devices in series where the protective device, generally but not necessarily on the supply side, effects the over-current protection with or without the assistance of the other protective device and prevents any excessive stress on the latter”

Advantages:

Cost Saving

Extremely rapid tripping

Smaller distribution board sizes

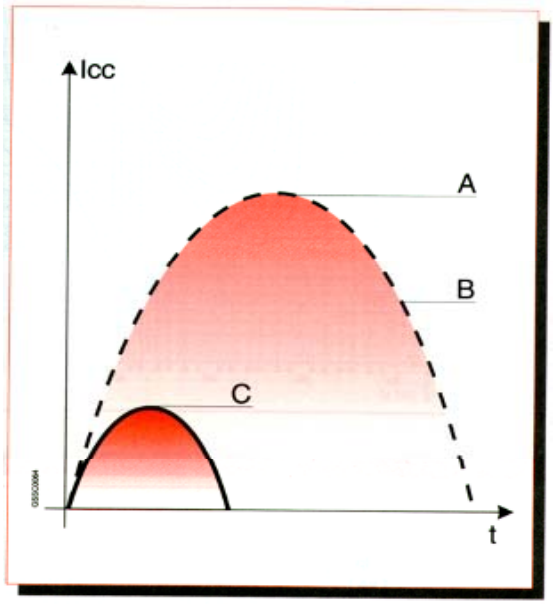
Disadvantages:

Low discrimination

Low service quality

Back-up protection (Cascading)
Short Circuit Protection technology

- Current limiting system
  The arising short circuit current is held as low as possible by means of high arc voltage and will interrupt the short circuit current in the first half of the half cycle. Clearing time is between 3 to 6ms.



A Prospective peak short circuit current

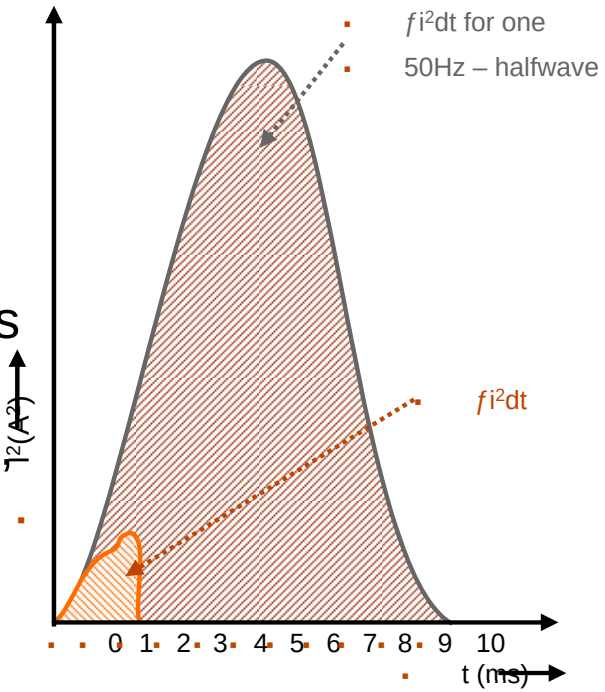
B Short circuit prospective current is the current that would flow if no protection device were present.

C Peak value limited by the Line CB

Back-up protection (Cascading)

Let Through Energy Integral – I^2t

- As the current intensity is not constant during its duration, it is necessary to utilize the integral in its limits of the beginning and breaking of the short circuit current. Therefore, the let-through energy is calculated as $\int i2dt$. This is also called the energy factor.
- It determines the loading and stressing of the external circuit as well as of the MCB itself. To limit the damage caused by a short circuit, the energy factor has to be as low as possible. The lower the energy of the short-circuit, the lower will be the possible damage. This led to the invention of the current limiting type MCB almost 50 years ago by ABB STOTZ-KONTAKT.
  A 10 kA MCB was shown at Hanover fair already in 1956, which, at that time, was really sensational.



Back-up protection (Cascading)

General rules

Cascading combinations are tested combinations and can't be calculated. (reference is made however to energy and let thru current curves)

Only combinations in table may be used.

The table is only true for 415V (Or whatever is specified by manufacturer)

When referred to S200 it includes 1P and 3P breakers.

When Cascading is used in a DB a "Cascaded system" warning label must be applied.

WARNING

This is a series-connected (cascaded) system. Except when recommended by the circuit-breaker manufacturer, do not replace any circuit-breaker in the system with a circuit-breaker that is not of identical type and rating.

Back-up protection (Cascading)

Back-up protection – MCB to MCB

MCB - MCB @ 415 V

			Supply S.	S200	S200M	S200P		S280	S290	S800N	S800S
	Char.			B-C	B-C	B-C		B-C	C	B-C-D	B-C-D-K
Load S.		I_{cu} [kA]		10	15	25	15	6	15	36	50
			I_n [A]	0.5..63	0.5..63	0.5..25	32..63	80, 100	80..125	25..125	25..125
S200	B,C,K,Z	6*	0.5..63		15	25	15		15	36	50
S200M	B,C	15	0.5..63			25				36	50
S200P	B,C, D,K,Z	25	0.5..25							36	50
		15	32..63							36	50
S280	B,C	6	80, 100								
S290	C,D	15	80..125								
S800N	B,C,D	36	10..125								
S800S	B,C,D,K	50	10..125								

Back-up protection (Cascading)

Back-up protection – MCCB to MCB

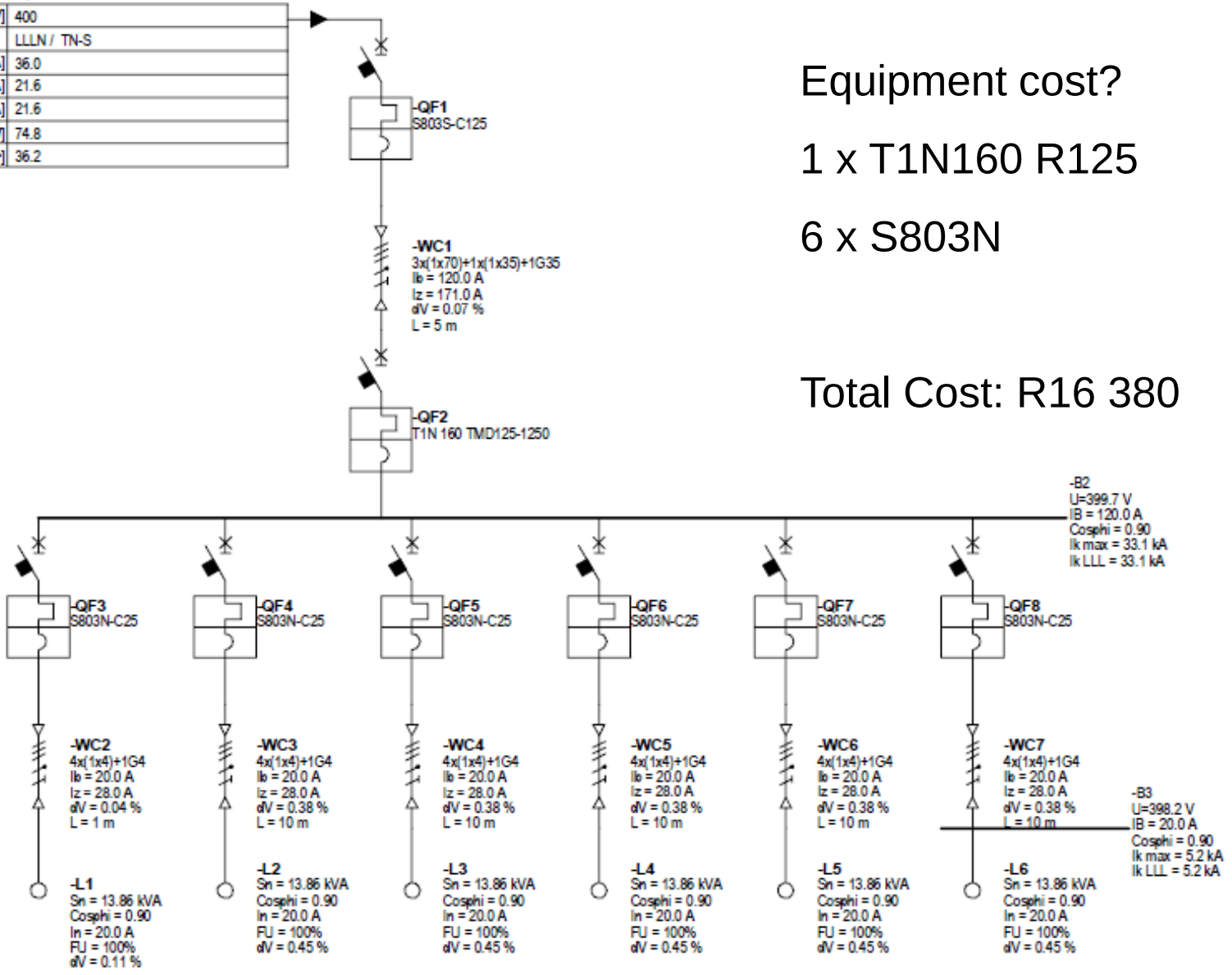
MCCB - MCB @ 415 V

			Supply S.	T1	T1	T1	T2	T3	T4	T2	T3	T4	T2	T4	T2	T4	T4
			Version	B	C	N				S			H		L	L	V
Load S.	Char.	I_n [A]	I_{cu} [kA]	16	25	36				50			70		85	120	200
S200	B,C,K,Z	0.5..10	6*	16	25	30	36	36	36	36	40	40	40	40	40	40	40
		13..63						16			16						
S200M	B,C	0.5..10	15	16	25	30	36	36	36	50	40	40	70	40	85	40	40
		13..63						25			25		60		60		
S200P	B,C, D,K,Z	0.5..10	25			30	36	36	36	50	40	40	70	40	85	40	40
		13..25				30	36	30	36	50	30	40	60	40	60	40	40
		32..63	15	16	25	30	36	25	36	50	25	40	60	40	60	40	40
S280	B,C	80, 100	6	16	16	16	36	16	30	36	16	30	36	30	36	30	30
S290	C,D	80..125	15	16	25	30	36	30	30	50	30	30	70	30	85	30	30
S800N	B,C,D	10..125	36										70	70	85	120	200
S800S	B,C,D,K	10..125	50										70	70	85	120	200

Back-up protection (Cascading)

Cost savings

Un	[V]	400
		LLLN / TN-S
Ik LLL	[kA]	36.0
Ik LN	[kA]	21.6
Ik LPE	[kA]	21.6
P	[kW]	74.8
Q	[kvar]	36.2



Equipment cost?

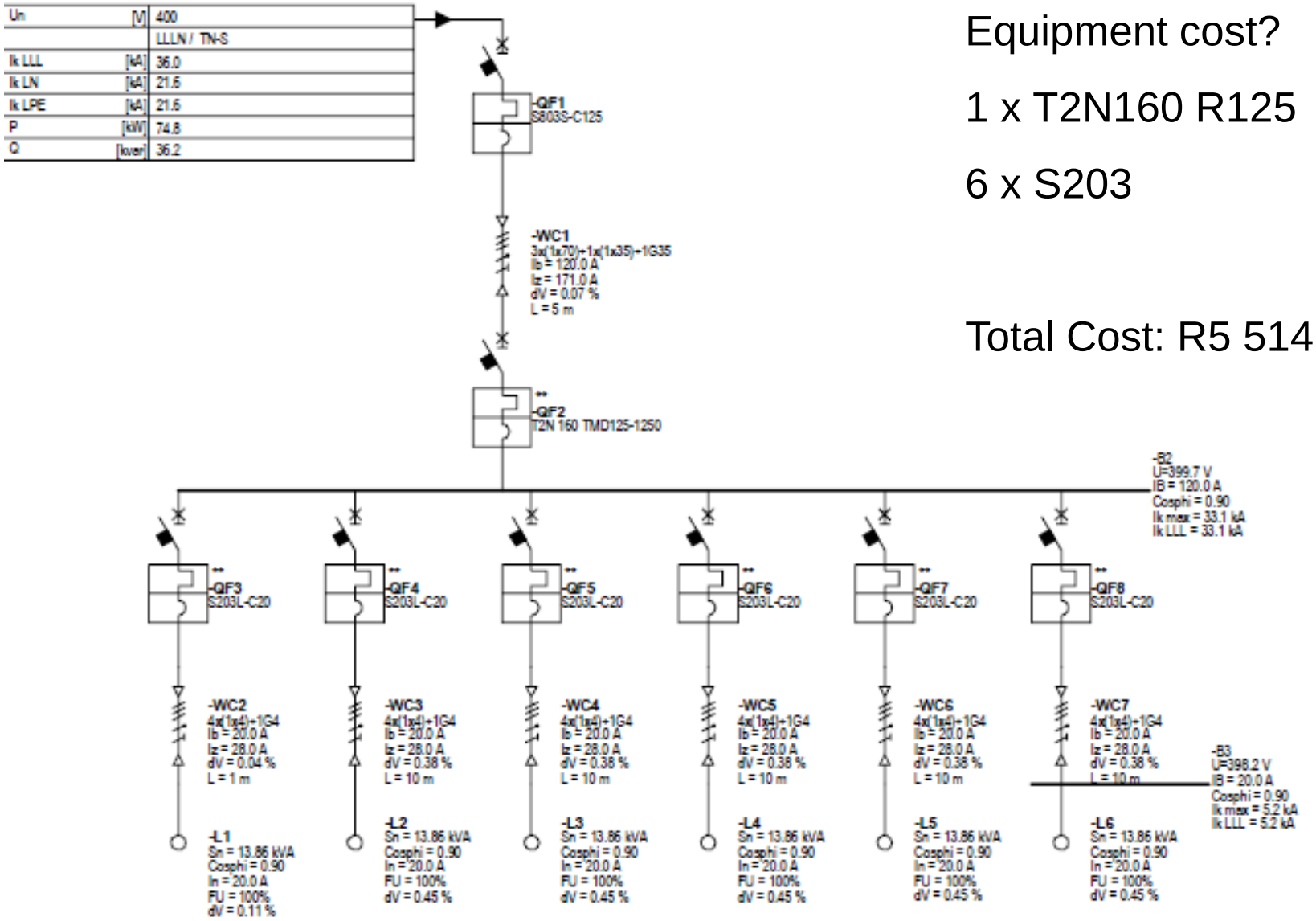
1 x T1N160 R125

6 x S803N

Total Cost: R16 380

Back-up protection (Cascading)

Cost savings



Equipment cost?

1 x T2N160 R125

6 x S203

Total Cost: R5 514

Back-up protection (Cascading)

Does cascading sacrifice discrimination

Does cascading sacrifice discrimination?

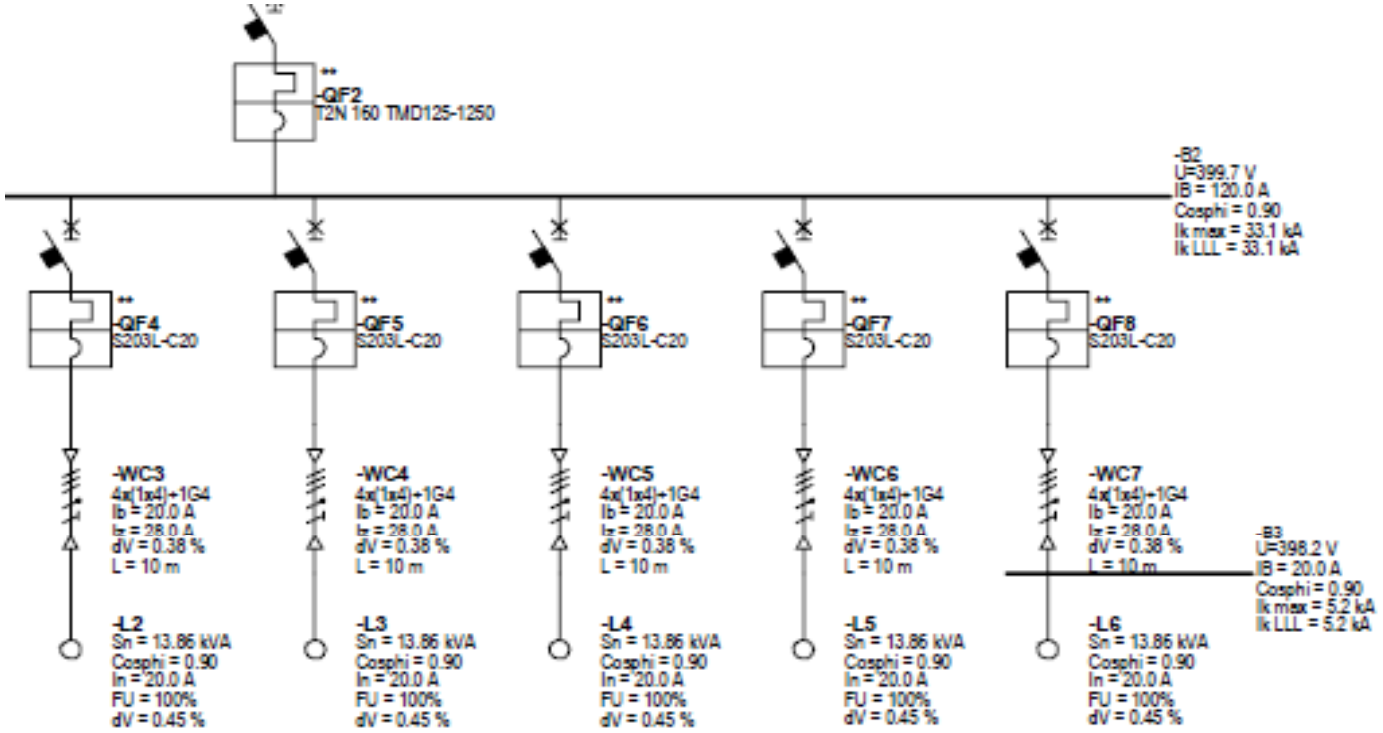
- To successfully cascade one have to limit current or time
- The most effective way of limiting the let-throught energy is to trip very quickly

Rapid tripping of the upstream breaker will sacrifice discrimination

Rapid tripping of the upstream breaker will increase the level of back-up protection

Back-up protection (Cascading)

Does cascading sacrifice discrimination



- When looking at discrimination, keep in mind where in the system the fault occurs
- If a short circuit occurs right at the DB, cascading will protect the system but discrimination will be sacrificed.
- If the fault occur far down the cable, discrimination will not be sacrificed

Back-up protection (Cascading)
The ABB advantage

- Cascading from 320A MCCB to MCB.

  This allows larger local mains (fewer local sections needed)

  This give you freedom to have sub distribution boards up to 320A without having to add special local section to facilitate cascaded 6kA sections

- Cascading from 30kA (320A feeder) to 6kA 80A & 100A (S280 series)

  Not all competitors can cascade to a 80A or 100A MCB downstream. This means these breakers must be fully rated for fault level which add costs

- Cascading from 40kA (320A) to 6kA (up to 63A). This is achieved by only changing the upstream breaker to a S-type (50kA). Downstream breakers remain 6kA.

  Competitors can only have a cascaded system by using downstream breakers with an higher fault level than 6kA

- Cascading from 50kA 125A to 6kA using a MCB (50kA) breaker upstream and 6kA MCB downstream. (DB size reduced due to current limiter being a MCB)

Back-up protection (Cascading)
The ABB advantage

- Cascading from 15kA to 6kA using MCB to MCB. (Local main S200 P and downstream breaker being S200). DB size reduced due to current limiter being a MCB
- Cascading from levels as high as 200kA 320A MCCB (T4V) to 36kA 125A MCB (S800)

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