Discrimination

In the context of power distribution schemes, the term 'discrimination' (sometimes referred to as 'selectivity') describes a hierarchy of circuit devices that are arranged such that a single upstream circuit breaker can fan out to several downstream devices to act in a co-ordinated fashion should a fault occur. Under fault conditions, only the upstream protective device closest to the fault should operate to clear the fault, leaving all other healthy circuits operable. This is especially important in installations where circuit failures could be life-threatening, such as in hospitals.

The concept of discrimination is similar to that of cascading, the prime difference being in the objectives of the application. Whereas discrimination is used to ensure continuity of supply to sub-circuits by limiting the disconnection to the faulted sub-circuit alone, cascading is used to buffer downstream protective devices against the effects of high prospective short circuit currents.

In both cases, the protective devices are specifically selected to meet the criteria for the type of co-ordination required.

When the selected devices are properly matched to fulfil the ideal discrimination principle described above, the co-ordinating devices are said to achieve 'total' discrimination. In many practical installations, however, a partial discrimination may be satisfactory for safe continuity of supply, with an added advantage of cost savings due to selecting a lower rated upstream circuit breaker.

Discrimination between two circuit breakers arranged in series may be based on either current or time. Where the magnitude of the fault current is to be used as the critical factor for selection, the co-ordination in this case is termed 'current discrimination'. Where the basis for selection is the duration over which the upstream device can withstand the fault current, the selection is to achieve 'time discrimination'. In some cases, time discrimination can be achieved by using an upstream device that has a built-in time delay.

Current Discrimination
In general, the basis for current discrimination is that the downstream protective device will have a lower current rating than the upstream device. It should also have a lower instantaneous tripping point. The discrimination tables that follow highlight the consequential increase in discrimination level as the differential in current ratings between the devices increases.

Time Discrimination
Discriminating by time between two devices in series relies on the operation of the upstream device being delayed at least until the downstream circuit breaker has tripped to clear the fault. The clearing time of the downstream device must be less than the time setting of the upstream device and the upstream device must also be capable of withstanding the fault current for the full duration of its time setting. There is generally no problem in achieving these conditions where the upstream device is a Category B circuit breaker specifically designed for this type of co-ordination duty.

Time/Current Characteristics
Comparison of the time/current characteristic graphs of the two devices proposed can give a quick check on their suitability for co-ordination in both current and time discrimination cases. Ideally, there should be no overlap of the respective curves to achieve total discrimination. If, however, the instantaneous portion of the curves do intersect, a partial discrimination will be achieved at the current level projected from the intersect point.

In the tables that follow, total discrimination is indicated by the letter 'T' in appropriate boxes. Total discrimination applies for all fault levels up to the lower breaking capacity of the two devices in co-ordination. Where a value is contained in any of the boxes, this indicates a partial discrimination of that value of current limit. If no discrimination is possible, this is shown by a dash symbol.

Note that 'partial discrimination' infers that, above the current limit value indicated, it is possible that both devices could trip, resulting in disconnection of other sub-circuits and loss of supply continuity to those areas of the distribution system.

Discrimination Tables

UPSTREAM ELECTRONIC ACB

			Z2 800A		Z2 1250A		Z2 1600A		Z2 2000A		Z3 2500A		Z3 3200A		Z3 4000A
Frame Rating															
	Model		STD Capacity	HIGH Capacity	STD Capacity	HIGH Capacity	STD Capacity	HIGH Capacity	STD Capacity	HIGH Capacity	STD Capacity	HIGH Capacity	STD Capacity	HIGH Capacity	STD Capacity
		Breaking Capacity	65kA	80kA	65kA	80kA	65kA	80kA	65kA	80kA	85kA	100kA	85kA	100kA	100kA
DOWNSTREAM MCCB 125A	YA2N Thermal/ Mag	25kA	T	T	T	T	T	T	T	T	T	T	T	T	T
	YA2S Thermal/ Mag	36kA	T	T	T	T	T	T	T	T	T	T	T	T	T
	YA2J Thermal/ Mag	65kA	T	T	T	T	T	T	T	T	T	T	T	T	T
250A	YA3N Thermal/ Mag	25kA	T	T	T	T	T	T	T	T	T	T	T	T	T
	YA3S Thermal/ Mag	36kA	T	T	T	T	T	T	T	T	T	T	T	T	T
	YA3J Thermal/ Mag	65kA	T	T	T	T	T	T	T	T	T	T	T	T	T
400A	YA5N Thermal/ Mag	25kA	T	T	T	T	T	T	T	T	T	T	T	T	T
	YA5H Thermal/ Mag	50kA	T	T	T	T	T	T	T	T	T	T	T	T	T
	YA5H Electronic	50kA	T	T	T	T	T	T	T	T	T	T	T	T	T
	YA5J Thermal/ Mag	65kA	T	T	T	T	T	T	T	T	T	T	T	T	T
	YA5K Electronic	70kA	T	T	T	T	T	T	T	T	T	T	T	T	T
800A	Y6H Thermal/ Mag	50kA	T	T	T	T	T	T	T	T	T	T	T	T	T
	Y6H Electronic	50kA	T	T	T	T	T	T	T	T	T	T	T	T	T
	Y6J Electronic	65kA	T	T	T	T	T	T	T	T	T	T	T	T	T
	Y6K Thermal/ Mag	85kA	T	T	T	T	T	T	T	T	T	T	T	T	T
1250A	Y7J Electronic	65kA	-	-	T	T	T	T	T	T	T	T	T	T	T
1600A	Y8K Electronic	85kA	-	-	-	-	T	T	T	T	T	T	T	T	T

T= Total Selectivity

Notes: All ACBs have instantaneous trip set to NON and the MCR set to ON.
Assumes all ACB time settings are greater than MCCB.
The above table is in accordance with IEC 60947-2, Annex A.

Discrimination Tables

UPSTREAM ELECTRONIC MCCB

DOWNSTREAM MCCB				400A		800A		1250A	1600A
		Model		YA5H-Electronic	YA5K-Electronic	Y6H-Electronic	Y6J-Electronic	Y7J-Electronic	Y8K-Electronic
			Breaking Capacity	50kA	70kA	50kA	65kA	65kA	85kA
	125A	YA2N Thermal/Mag	25kA	T	T	T	T	T	T
		YA2S Thermal/Mag	36kA	T	T	T	T	T	T
		YA2J Thermal/Mag	65kA	50	T	T	T	T	T
	250A	YA3N Thermal/Mag	25kA	T	T	T	T	T	T
		YA3S Thermal/Mag	36kA	T	T	T	T	T	T
		YA3J Thermal/Mag	65kA	50	T	T	50	T	T
	400A	YA5N Thermal/Mag	25kA	-	-	T	T	T	T
		YA5H Thermal/Mag	50kA	-	-	25	25	T	T
		YA5H Electronic	50kA	-	-	25	25	T	T
		YA5J Thermal/Mag	65kA	-	-	25	25	T	T
		YA5K Electronic	70kA	-	-	25	25	T	T

T= Total Selectivity

Notes: All pick-up current and time delay settings to be set at maximum on upstream MCCBs.
Partial discrimination level is in kA.
The above table is in accordance with IEC 60947-2, Annex A.

UPSTREAM THERMAL MAGNETIC MCCB

DOWNSTREAM K SERIES MCB	YA2N (25kA) or YA2S (36kA)						YA3N (25kA) or YA3S (36kA)									YA5H (50kA)	
In	20A	32A	50A	63A	100A	125A	20A	32A	50A	63A	100A	125A	160A	200A	250A	250A	400A
6A	260	T	T	T	T	T	260	T	T	T	T	T	T	T	T	T	T
10A	260	420	T	T	T	T	260	420	T	T	T	T	T	T	T	T	T
16A	260	420	650	T	T	T	260	420	650	T	T	T	T	T	T	T	T
20A	260	420	650	1000	T	T	260	420	650	1000	T	T	T	T	T	T	T
25A	260	420	650	1000	T	T	260	420	650	1000	T	T	T	T	T	T	T
32A	260	420	650	1000	1500	T	260	420	650	1000	1500	T	T	T	T	T	T
40A	260	420	650	1000	1500	2000	260	420	650	1000	1500	2000	T	T	T	T	T
50A	260	420	650	1000	1500	2000	260	420	650	1000	1500	2000	3000	T	T	T	T
63A	260	420	650	1000	1500	2000	260	420	650	1000	1500	2000	3000	2600	T	T	T

T= Total Selectivity

Notes: MCBs can be of any manufacture as long as they are Energy Class 3 as defined in EN 60898.
Table based on Type B & C characteristic MCBs.
MCBs can be 6kA or 10kA at 400V ac.
Partial discrimination level is in amps.
The above table is in accordance with IEC 60947-2, Annex A.

Discrimination Table

UPSTREAM THERMAL MAGNETIC MCCB

		YA2N (25kA) or YA2S (36kA)								YA3N (25kA) or YA3S (36kA)											YA5H (50kA)	
	In	16A	20A	32A	50A	63A	80A	100A	125A	16A	20A	32A	50A	63A	80A	100A	125A	160A	200A	250A	250A	400A
DOWNSTREAM K SERIES D TYPE MCB	6A	166	192	307	480	605	832	960	1200	166	192	307	480	605	832	960	1200	1664	2080	2000	2400	3840
	10A	-	-	307	480	605	832	960	1200	-	-	307	480	605	832	960	1200	1664	2080	2000	2400	3840
	16A	-	-	-	480	605	832	960	1200	-	-	-	480	605	832	960	1200	1664	2080	2000	2400	3840
	20A	-	-	-	480	605	832	960	1200	-	-	-	480	605	832	960	1200	1664	2080	2000	2400	3840
	25A	-	-	-	-	605	832	960	1200	-	-	-	-	605	832	960	1200	1664	2080	2000	2400	3840
	32A	-	-	-	-	-	832	960	1200	-	-	-	-	-	832	960	1200	1664	2080	2000	2400	3840
	40A	-	-	-	-	-	-	960	1200	-	-	-	-	-	-	960	1200	1664	2080	2000	2400	3840
	50A	-	-	-	-	-	-	-	1200	-	-	-	-	-	-	-	1200	1664	2080	2000	2400	3840
	63A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1664	2080	2000	2400	3840

T= Total Selectivity

Notes: Table based on Type D characteristic MCBs.
MCBs can be 6kA or 10kA at 400V ac.
Partial discrimination level is in amps.

Cascading

Cascading is sometimes referred to as 'back-up protection'. The technique of cascading is used to allow circuit breakers with a breaking capacity lower than the value of prospective short-circuit current at the connection point to be used when these are positioned downstream of a current-limiting circuit breaker of higher breaking capacity. The net result of this arrangement is that the downstream device acquires an enhanced 'installed' breaking capacity, therefore a less expensive, lower breaking capacity breaker can be used.

The upstream circuit breaker must have the normally required breaking capacity for its point of installation however, when combined with another circuit breaker downstream, the two devices in series will be able to clear a larger fault. For example: if a 10A, 6kA MCB is place downstream of a YA frame MCCB rated at 125A and 25kA, the MCB will have an installed breaking capacity of 14kA. Similarly, a 10A, 10kA MCB downstream of a YA frame MCCB rated at 250A and 25kA will have an installed breaking capacity of 25kA.

It should be noted that the cascading technique is not limited to only two devices in series. The important point is that it is the upstream device that is limiting the current to a value that can be interrupted by the following device, so that the pattern of paired devices can be repeated many times in an hierarchy of devices.

The following tables give 'installed breaking capacity' values of downstream circuit breakers for both the MCCB/MCB and MCCB/MCCB pairings of cascaded devices. Note that all values shown are at 400V ac. The values for the installed breaking capacities are given in kA.

Upstream YA frame MCCB with downstream S-series MCB –

MCB (6kA)	MCCB YA2N (25kA) 125A	MCCB YA2S (36kA) 125A	MCCB YA2J (65kA) 125A	MCCB YA3S (36kA) 160A	MCCB YA3J (65kA) 160A	MCCB YA3N (25kA) 250A	MCCB YA3S (36kA) 250A	MCCB YA3J (65kA) 250A
6	14	14	14	12	12	12	12	12
10	14	14	14	12	12	12	12	12
16	14	14	14	12	12	12	12	12
20	14	14	14	12	12	12	12	12
32	14	14	14	12	12	12	12	12
40	12	12	12	10	10	10	10	10
50	12	12	12	10	10	10	10	10
63	12	12	12	10	10	10	10	10

Upstream YA frame MCCB with downstream K-series MCB –

UPSTREAM MCCB

	Frame Rating	125A			250A		
	Model	YA2N T/Mag	YA2S T/Mag	YA2J T/Mag	YA3N T/Mag	YA3S T/Mag	YA3J T/Mag
Current Rating	Breaking Capacity	25kA	36kA	65kA	25kA	36kA	65kA
6A	10kA	25	30	30	25	25	25
10A	10kA	25	30	30	25	25	25
16A	10kA	25	30	30	25	25	25
20A	10kA	25	30	30	25	25	25
25A	10kA	25	30	30	25	25	25
32A	10kA	25	30	30	25	25	25
40A	10kA	25	30	30	23	23	23
50A	10kA	25	30	30	23	23	23
63A	10kA	25	30	30	23	23	23

DOWNSTREAM MCB

Cascading (continued)

UPSTREAM MCCB

	Frame Rating			125A			250A		
		Model		YA2N T/Mag	YA2S T/Mag	YA2J T/Mag	YA3N T/Mag	YA3S T/Mag	YA3J T/Mag
			Breaking Capacity	25kA	36kA	65kA	25kA	36kA	65kA
DOWNSTREAM MCCB	125A	YA2N T/Mag	25kA	-	36	50	-	36	50
		YA2S T/Mag	36kA	-	-	65	-	-	65
		YA2J T/Mag	65kA	-	-	-	-	-	-
	250A	YA3N T/Mag	25kA	-	-	-	-	36	50
		YA3S T/Mag	36kA	-	-	-	-	-	65
		YA3J T/Mag	65kA	-	-	-	-	-	-

UPSTREAM MCCB

	Frame Rating			125A					250A			
		Model		YA5H T/Mag	YA5H-Electric	YA5J T/Mag	YA5K-Electric	Y6H-Electric	Y6J T/Mag	Y6J-Electric	Y7J-Electric	Y8K-Electric
			Breaking Capacity	50kA		70kA		50kA	65kA	65kA	65kA	85kA
DOWNSTREAM MCCB	125A	YA2N T/Mag	25kA	36		50		-	36	36	-	-
		YA2S T/Mag	36kA	50		65		-	50	50	-	-
		YA2J T/Mag	65kA	-		70		-	-	-	-	-
		YA3N T/Mag	25kA	36		50		36	50	50	-	-
		YA3S T/Mag	36kA	50		65		50	65	65	-	-
		YA3J T/Mag	65kA	-		70		-	-	-	-	-
		YA5N T/Mag	25kA	36		50		36	50	50	36	36
		YA5H T/Mag	50kA	-		70		-	-	65	65	65
		YA5J T/Mag	70kA	-		-		-	-	-	-	85

Notes: Cascade fault level is expressed in kA.

Short-circuit Discrimination Levels

Where a high prospective fault level exists at the MCB distribution point, discrimination at short-circuit levels should be considered. This will require comparison of the device I^2t characteristics at the relevant prospective fault level.

Discrimination will be obtained at all fault levels for which the MCB total operating I^2t is lower than the pre-arcing I^2t of the device closer to the supply.

The data for typical cartridge fuses can be extracted from graphs and is presented in the following tables.

MCB, type B Current rating (A)	Fuse sizes								
	20	25	35	50	63	80	100	125	160
6	0.5	0.8	1.7	3.1	7.0	10.0	10.0	10.0	10.0
10	0.4	0.7	1.4	2.3	3.4	4.8	7.5	10.0	10.0
13		0.7	1.4	2.3	3.4	4.8	7.5	10.0	10.0
16			1.3	2.0	2.9	4.2	6.0	9.5	10.0
20				1.9	2.7	3.8	5.6	8.5	10.0
25				1.8	2.6	3.6	5.4	8.0	10.0
32					2.4	3.2	4.2	6.8	10.0
40						3.2	4.2	6.8	9.5
50							3.8	5.7	8.5
63							3.8	5.7	8.5

MCB, type C Current rating (A)									
6	0.5	0.8	1.7	3.1	7.0	10.0	10.0	10.0	10.0
10			1.4	2.3	3.4	4.8	7.5	10.0	10.0
13				2.3	3.4	4.8	7.5	10.0	10.0
16				2.0	2.9	4.2	6.0	9.5	10.0
20					2.7	3.8	5.6	8.5	10.0
25						3.6	5.4	8.0	10.0
32							4.2	6.8	10.0
40							4.2	6.8	9.5
50								5.7	8.5
63								5.7	8.5

MCB, type D Current rating (A)									
6	0.7	1.7	3.0	5.9	6.0	6.0	6.0	6.0	6.0
10			1.3	2.2	3.6	6.0	6.0	6.0	6.0
13				1.7	2.5	4.0	6.0	6.0	6.0
16				1.6	2.2	3.1	4.6	6.0	6.0
20					2.2	3.1	4.6	6.0	6.0
25						3.1	4.6	6.0	6.0
32						2.6	3.5	6.0	6.0
40							3.5	6.0	6.0
50								5.5	6.0
63									