

The ABB Guide to Circuit Breaker Selection for Generator protection

TABLE 1 - 400V

S _{rg} [kVA]	MCB	MCCB	ACB	
4	S20L/S260 B6	T2 160 In=10		
6	S20L/S260 B10			
7	S20L/S260 B13			
9	S20L/S260 B16	T2 160 In=25		
11	S20L/S260 B20			
14	S20L/S260 B25			
17	S20L/S260 B32	T2 160 In=63		
19	S20L/S260 B50			
21	S20L/S260 B63			
22	S280 B80			T2 160 In=100
28	S280 B100			
31				
35		T2 160 In=160		
38				
42				
44		T2 160		
48		T4 250		
55		T3 250		
69		T4 250		
80		T4 320		
87		T5 400		
100		T5 630		
111		S6 800		
138		S7 1250		
159		S7 1250		
173		S7 1600		
180		S8 3200		
190		S8 3200		
208				
218				
242				
277				
308				
311				
346				
381				
415				
436				
484				
554				
692				
727				
865				
1107				
1730				
2180				
2214				
2250				
2500				
2800				
3150				
3500				

N.B. It is always advisable to check that the settings of the releases are correct with respect to the effective decrement curve of the generator to be protected

TABLE 2 - 440V

S _{rg} [kVA]	MCB	MCCB	ACB	
4	S20L/S260 B6	T2 160 In=10		
6	S20L/S260 B8			
7	S20L/S260 B10			
9	S20L/S260 B13	T2 160 In=25		
11	S20L/S260 B16			
14	S20L/S260 B20			
17	S20L/S260 B25	T2 160 In=63		
19	S20L/S26 B32			
21	S20L/S260 B40			
22	S20L/S260 B50			T2 160 In=100
28	S280 B80			
31	S280 B100			
35		T2 160 In=160		
38				
42				
44		T2 160 In=160		
48		T4 250		
55		T3 250		
69		T4 250		
80		T4 320		
87		T5 400		
100		T5 630		
111		S6 800		
138		S7 1000		
159		S7 1000		
173		S7 1250		
180		S7 1600		
190		S8 3200		
208		S8 3200		
218				
242				
277				
308				
311				
346				
381				
415				
436				
484				
554				
692				
727				
865				
1107				
1730				
2180				
2214				
2250				
2500				
2800				
3150				
3500				

N.B. It is always advisable to check that the settings of the releases are correct with respect to the effective decrement curve of the generator to be protected

TABLE 3 - 500V

S _{rg} [kVA]	MCB	MCCB	ACB	
4		T2 160 In=10		
6				
7				
9		T2 160 In=25		
11				
14				
17		T2 160 In=63		
19				
21				
22				T2 160 In=100
28				
31				
35		T2 160 In=160		
38				
42				
44		T2 160 In=160		
48		T4 250		
55		T3 250		
69		T4 250		
80		T4 320		
87		T5 400		
100		T5 630		
111		S6 800		
138		S7 1250		
159		S7 1250		
173		S7 1600		
180		S8 2500		
190		S8 2500		
208				
218				
242				
277				
308				
311				
346				
381				
415				
436				
484				
554				
692				
727				
865				
1107				
1730				
2180				
2214				
2250				
2500				
2800				
3150				
3500				

N.B. It is always advisable to check that the settings of the releases are correct with respect to the effective decrement curve of the generator to be protected

TABLE 4 - 690V

S _{rg} [kVA]	MCB	MCCB	ACB	
4		T2 160 In=10		
6				
7				
9		T2 160 In=25		
11				
14				
17		T2 160 In=63		
19				
21				
22				T2 160 In=100
28				
31				
35		T2 160 In=160		
38				
42				
44		T2 160 In=160		
48		T4 250		
55		T3 250		
69		T4 250		
80		T4 320		
87		T5 400		
100		T5 630		
111		S6 800		
138		S7 1000		
159		S7 1000		
173		S7 1250		
180		S7 1600		
190		S8 2500		
208		S8 2500		
218				
242				
277				
308				
311				
346				
381				
415				
436				
484				
554				
692				
727				
865				
1107				
1730				
2180				
2214				
2250				
2500				
2800				
3150				
3500				

N.B. It is always advisable to check that the settings of the releases are correct with respect to the effective decrement curve of the generator to be protected

Protection and switching of generators

The need to guarantee an ever greater continuity of service has led to an increase in the use of emergency supply generators, either as an alternative to, or in parallel with, the public utility supply network.

Typical configurations include:

- 'island supply' (independent functioning) of the priority loads where the public supply fails
- parallel supply to the user installation alongside the public supply network

Unlike the public supply network, which has a constant contribution where a short-circuit occurs, the current supplied by the generator is a function of the parameters of the machine itself, and decreases with time. It is possible to identify the successive phases:

- 1 a subtransient phase; with a brief duration (10-50ms), characterized by the subtransient reactance X_d' (5-20% of the rated impedance value) and by the subtransient time constant T_d' (5-30ms)

- 2 a transient phase; may last up to some seconds (0.5-2.5s) and is characterized by the transient reactance X_d (15-40% of the rated impedance value) and by the transient time constant T_d (0.03-2.5s)

- 3 a synchronous phase; may persist until the tripping of external protection, and is characterized by the synchronous reactance X_d (80-300% of the rated impedance value)

As a first approximation, it can be estimated that the maximum value of the short-circuit current of a generator, with rated power S_{rg} at the rated voltage of the installation U_r, is equal to:

$$I_{kg} = \frac{I_{rg} \cdot 100}{X_d' \%}$$

Where I_{rg} is the rated current of the generator:

$$I_{rg} = \frac{S_{rg}}{\sqrt{3} \cdot U_r}$$

The circuit breaker for the protection of the generator shall be selected according to the following criteria:

- the set current higher than the rated current of the generator: I₀ ≥ I_{rg}
- breaking capacity I_{cu} or I_{cs} higher than the maximum value of short-circuit current at the installation point:
- - in the case of a single generator: I_{cu} (I_{cs}) ≥ higher than the maximum value of short-circuit current at the installation point:
 - in the case of a single generator: I_{cu} (I_{cs}) ≥ I_{kg}
 - in the case of n identical generators in parallel: I_{cu} (I_{cs}) ≥ I_{kg} (n-1)
 - in the case of operation in parallel with the network: I_{cu}(I_{cs}) ≥ I_{kgnet}

As the short-circuit contribution from the network is normally greater than the contribution from the generator.

- for circuit-breakers with thermo-magnetic releases, low magnetic trip threshold: I₀ = 2.5-3 · I_n

- for circuit breakers with electronic releases:

- trip threshold of the delayed short-circuit protection function (S), set between 1.5 and 4 times the rated current of the generator, in such a way as to intercept the decrement curve of the generator; I₂ = (1.5-4)I_{rg}; if the function S is not present, function I can be set at the indicated values I₂ = (1.5-4)I_{rg}
- trip threshold of the delayed short-circuit protection function (I₀) set at a value greater than the rated short-circuit current of the generator, so as to achieve discrimination with the devices installed downstream, and to allow fast tripping in the event of a short-circuit upstream of the device (working in parallel with other generators or with the network): I₀ ≥ I_{kg}

Example

Protection of a generator with S_{rg} = 100kVA, in a system with a rated voltage 440V

The generator parameters are: U_r = 440 V
 S_{rg} = 100kVA
 F = 50Hz
 I_{rg} = 131.2A
 X_d' = 6.5% (subtransient reactance)
 X_d = 17.6% (transient reactance)
 X_d = 230% (synchronous reactance)
 T_d' = 5.5 ms (subtransient time constant)
 T_d = 39.3ms (transient time constant)

From Table 2, an ABB SACE T2N160 circuit breaker is selected, with I_n = 160 A, with electronic release PR221-LS. For correct protection of the generator, the following settings are selected:
 Function L: 0.84 × I_n, corresponding to 134.4 A, value greater than I_{kg}
 Function I: 1.5 × I_n

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