Green Innovators of Innovation

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Susol
Super Solution

Low voltage circuit breakers

LS IS

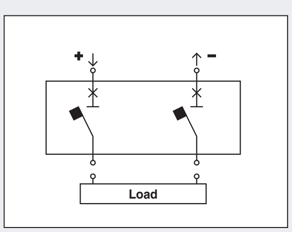
Susol MCCB for DC Application

Susol

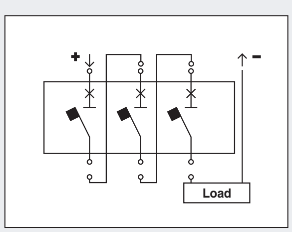
- Susol MCCB is sutable for DC application such as Photovoltaic Circuit Breaker, UPS and datacenter
- DC short circuit test tested by VDE
- Higher nominal voltage range up to 1000 VDC
- Rated Current : 16A~800A
- No of Pole: 2/3/4Pole
- Available for AC/DC application

		TD100			TD160			TS100			TS160			TS250			TS400			TS630			TS800		
Frame size (AF)		100			160			100			160			250			400			630			800		
Rated current, In (A)		16, 20, 25, 32, 40, 50, 63, 80, 100			100, 125, 160			40, 50, 63, 80, 100			100, 125, 160			125, 160 200, 250			300, 400			500, 630			700, 800		
No. of Poles (Pole)		2, 3, 4			2, 3, 4			2, 3, 4			2, 3, 4			2, 3, 4			2, 3, 4			2, 3, 4			2, 3, 4		
Rating (DC)	1000V	4P			4P			4P			4P			4P			4P			4P			4P		
	750V	3P			3P			3P			3P			3P			3P			3P			3P		
	500V	2P			2P			2P			2P			2P			2P			2P			2P		
Rated service breaking (DC)	Type	N	H	L	N	H	L	N	H	L	N	H	L	N	H	L	N	H	L	N	H	L	N	H	L
	1000V (4P)	42	65	100	42	65	100	50	85	100	50	85	100	50	85	100	50	85	100	50	85	100	50	85	100
	750V (3P)	42	65	100	42	65	100	50	85	100	50	85	100	50	85	100	50	85	100	50	85	100	50	85	100
	500V (2P)	42	65	100	42	65	100	50	85	100	50	85	100	50	85	100	50	85	100	50	85	100	50	85	100
Trip unit																									
	FTU (fixed-thermal, fixed-magnetic)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	FMU (adjustable-thermal, fixed-magnetic)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	ATU (adjustable-thermal, adjustable-magnetic)	-	-	-	-	-	-	-	-	-	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

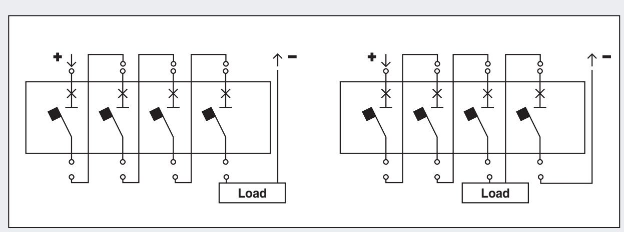
Exemplary circuit diagrams



DC500V (2P)



DC750V (3P)

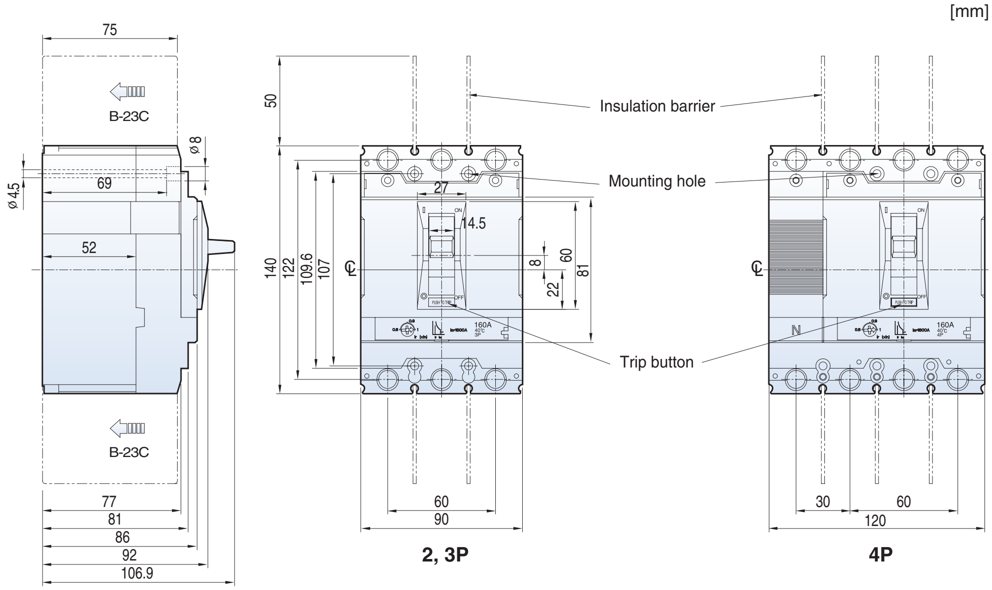


DC1000V (4P)

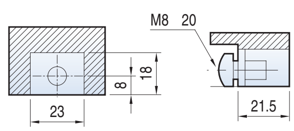
Overall dimensions

TD100/160

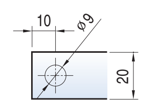
[mm]



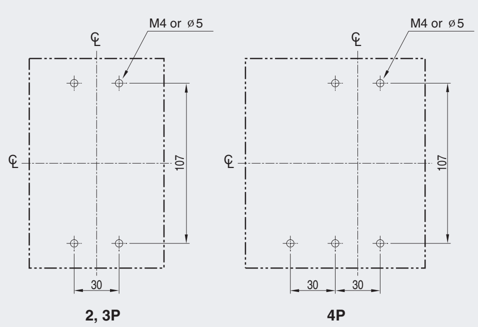
Terminal section



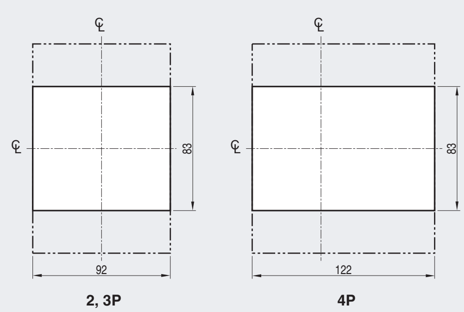
Conductor



Panel drilling



Front panel cutting

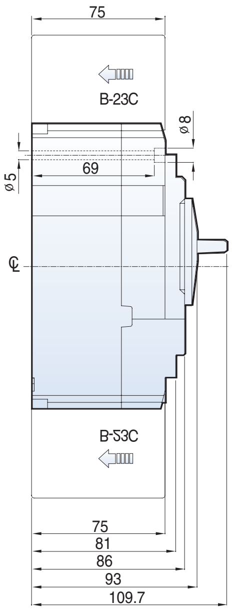


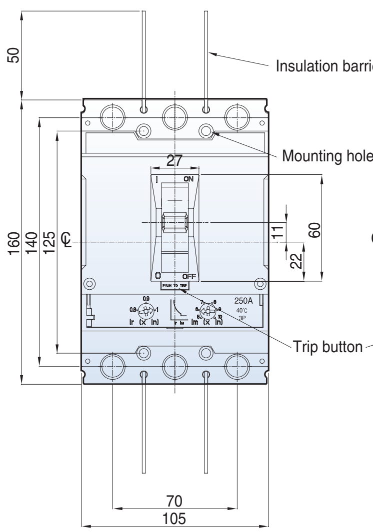
Overall dimensions

Susol

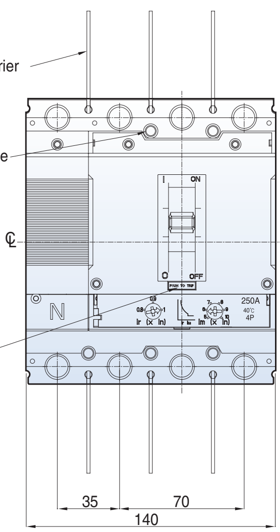
TS100/160/250

[mm]

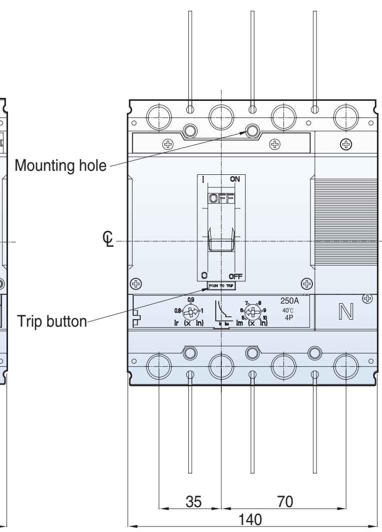




2, 3P

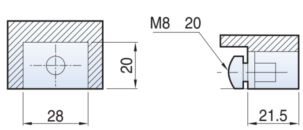


4P

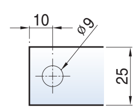


4P R

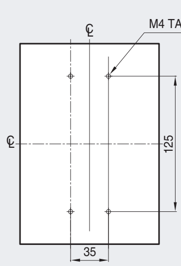
Terminal section



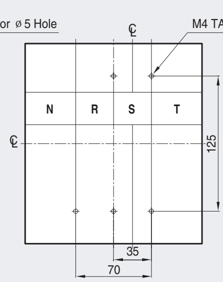
Conductor



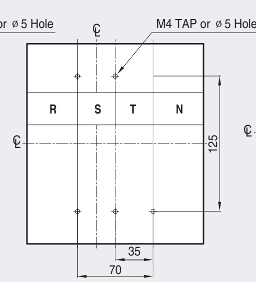
Panel drilling



2,3P

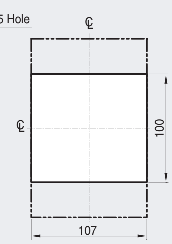


4P

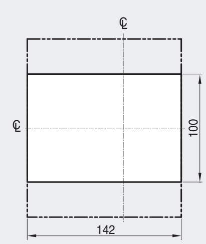


4P R

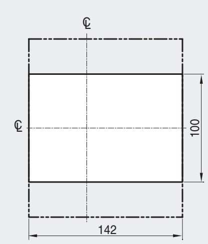
Front panel cutting



2,3P



4P



4P R

Overall dimensions

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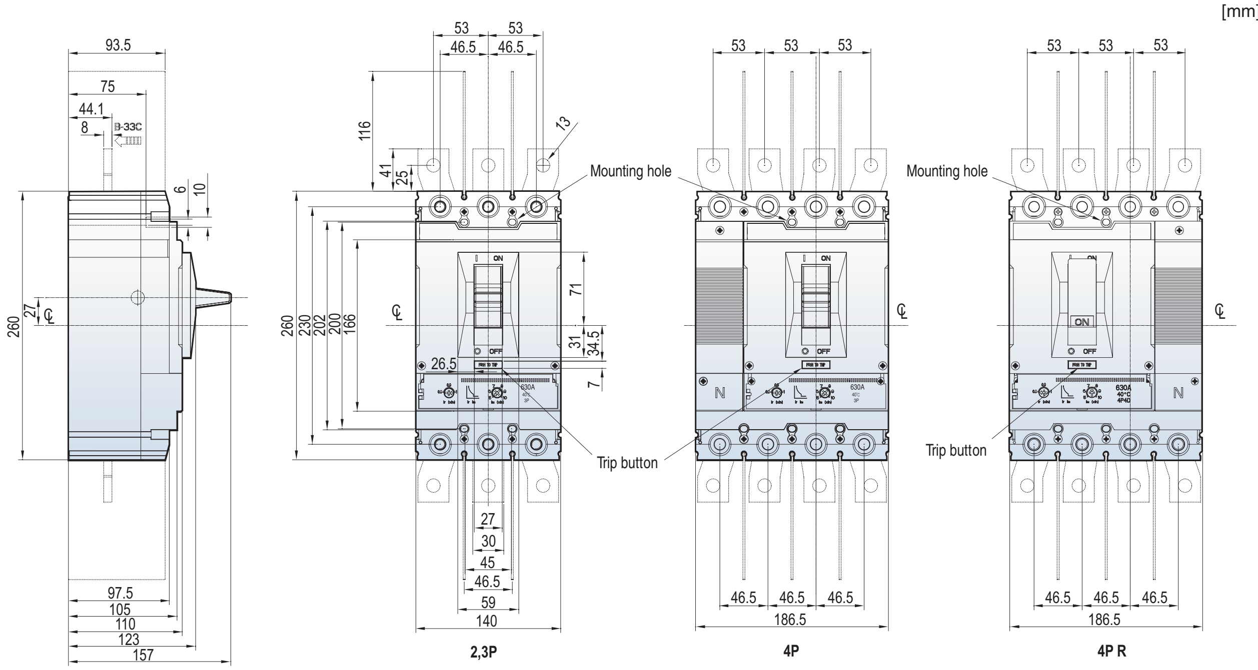
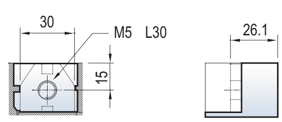
TS400/630

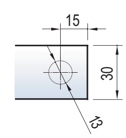
[mm]



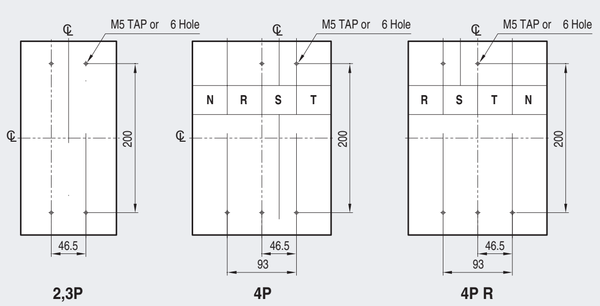
Terminal section



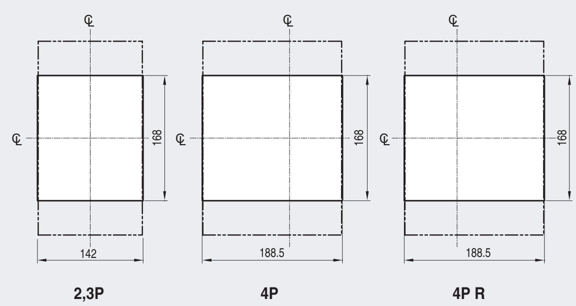
Conductor



Panel drilling



Front panel cutting



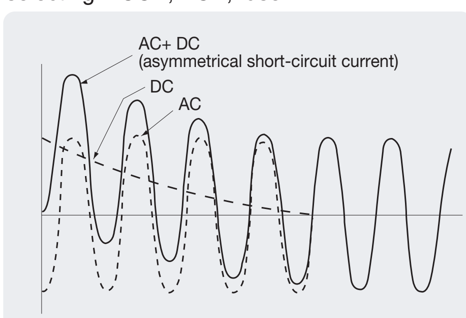
How to calculate short-circuit current value
Various short-circuit

The purpose of calculating short circuit values
- Selection of circuit breakers, fuse.
- Adjusting metering devices
- Consideration for mechanical resistance
- Consideration for thermal resistance

Various value of short-circuit current should be applied to the tests for upper factors.
Symmetrical current for AC and asymmetrical current for DC are used for classifying short circuit current.
Their differences should be essentially considered in the basic step of making network plan.

Symmetrical short-circuit current real value

Short-circuit current is composed of AC and DC as it shows on <Fig.1>. The short-circuit which indicates the real value of AC is called as symmetrical short-current real value, I (rms)sym. This current is the essential factor of selecting MCCB, ACB, fuse.



<Fig.1> Composition of short-circuit current

Maximum asymmetrical short-circuit current real value: I (rms)asym

The short-circuit which indicates the real value of DC is called as asymmetrical short-circuit current real value.
And this current value is changeable upon the short-circuit closing phase.
This current value is treated for checking the thermal resistant strength of wrings, CT and etc.
With symmetrical short-circuit current real value and short-circuit power factor, we can achieve the value, α from <Fig.5>.
and maximum asymmetrical short-circuit current real value is calculated with this formula.

$$I\,(rms)asym = \alpha I\,(rms)sym$$

3-phases average asymmetrical short-circuit current real value: I (rms)ave

Each phase is different in its input current value in 3 phases circuit. So that AC rate for 3 phases is different. This value is the average of asymmetrical short-circuit current of 3 phases.
And with symmetrical short-circuit current real value and short-circuit power factor, we can achieve the value, β, and 3-phases average asymmetrical short circuit current real value is calculated with this formula.

$$I\,(rms)ave = \beta I\,(rms)sym$$

Maximum asymmetrical short-circuit current instantaneous value: Imax

Each phase has different instantaneous current value. And when asymmetrical short-circuit current shows its maximum instantaneous value, the current value is called as maximum asymmetrical short-circuit current instantaneous value. This current is to test the mechanical strength of serial equipments.
And with symmetrical short-circuit current real value and short-circuit power factor, we can achieve the value, γ and maximum asymmetrical short-circuit current instantaneous value is calculated with this formula.

$$Imax = \gamma I\,(rms)sym$$

Network impedance for calculating short-circuit current value

Bellows should be considered for the calculation as the impedance components affecting circuit to trouble spot from short-circuit power.

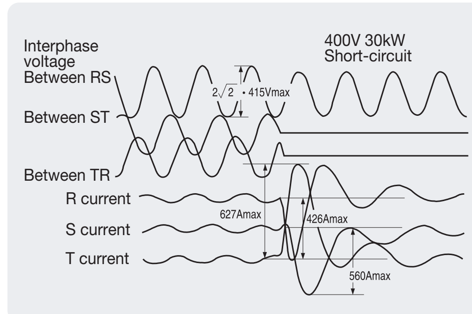
a. Primary part impedance of incoming transformer It's calculated from the short-circuit current data which is provided by power supplier. Calculated value can be regarded as reactance.

b. Impedance of incoming transformer Its amount is upon the capacity of transformer and primary voltage. Generally this impedance can be regarded as reactance and refer to <Table.4>, <Table.5>.

How to calculate short-circuit current value
Various short-circuit

c. Reactance of motor

Motor works as generator and supply short circuit current in the condition of an accident circuit such as <Fig.2>.
Generation factor of firm motor should be considered in a low voltage circuit where a circuit breaker operates quickly and in a high voltage circuit for the selection of fuse. Reactance of motor can be regarded in the range of 25% normally.



<Fig.2> Short-circuit of motor

d. Distribution impedance

Impedance of cable and busduct do control short-circuit remarkably in low voltage network. Refer to <Table.5>, <Table.6>.

e. Others

MCCB, ACB CT are equipments for the network of low voltage.
The impedance of these equipment which is calculated from short-circuit current value should be considered.
Generally, the impedance of those equipment is that of rated current (normal condition), if operators apply that impedance value, bigger reactance value may be applied to calculated short-circuit current value.

How to calculate short-circuit current value With percent impedance

Ohm formula (Ω), percent impedance formula (%), unit formula (per unit) can be applied to calculate short-circuit current value.

Ohm formula [Ω]

Short-circuit current value is calculated by converting into ohm value [Ω]

Percent impedance formula (%) Each impedance is converted into the impedance of base value and base voltage.

And the required amount for electric demand should be shown as percent unit.
And apply that value in ohm formula.

Unit formula

The base value equals 1.0. and all value of network shows in the way of decimal system. Applying any of upper calculation formulas to achieve short-circuit current value, it shows equal value. To select a certain formula for doing it, operator can select one of those formula which is proper to oneself. Below is percent impedance formula.

Finding base value

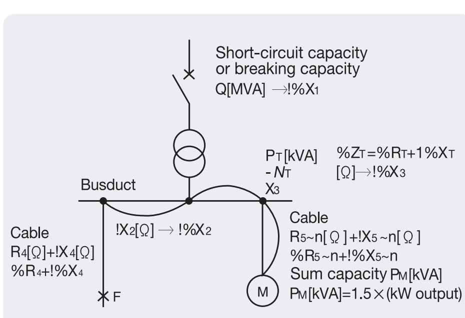
The rated current of transformer shall be the base value.

Base capacity $P_B = P_T$ [kVA]

Base voltage $V_B = V_T$ [V]

Base current $I_B = I_T = \frac{P_T}{\sqrt{3}V_T} \times 10^3$ [A]

Base impedance $Z_B = \frac{V_B^2}{P_B \times 10^3} = \frac{V_T^2}{P_T \times 10^3}$ [Ω]



<Fig.3> Base value

Converting impedance into base value

a. Primary part impedance of transformer: $\%X_1$

$$\%X_1 = \frac{P_B}{Q \times 10^3} \times 100 \ [\%]$$

Q: Primary part short-circuit capacity

b. Impedance of transformer: %ZT
It generally indicates as percent impedance. If base capacity is equal to transformer capacity, %ZT can be used as it is. When base capacity is not equal to transformer capacity, convert values by this formula.

$$\frac{P_T}{\%Z_T} = \frac{P_B}{\%Z_B}$$

%: value converted by base value

1phase transformer should converted into the value of 3 phase transformer, And the percent impedance is equal to $\frac{\sqrt{3}}{2} \times$ calculated urgent value.

c. Reactance of motor: %Xm
Transformer capacity shows the value in kW, so it is converted into unit, kVA.
(kVA value) ≒1.5×(Output of motor, kW)
%Xm= 25% Converting it from base capacity

$$\frac{P_M}{\%Xm} = \frac{P_B}{\%Xm}$$

(Converting formula for different capacity)

d. Impedance of busduct, cable
Cable: Area of cross-section & length
Busduct: Rated current

In <Fig.5>, <Fig.6>
Z_C = (Ω per each unit length)×(length) [Ω]
Convert this value into % value.

$$\%Z_C = \frac{Z_C}{Z_B}$$

(% converting formula)

2cables in same dimension, it's recommendable to divide the length by 2.

How to calculate short-circuit current value

Preparing a impedance map

Prepare impedance map according to the impedance value from (2). Various electricity suppliers like source, motor have same electric potential in impedance map.
As you find it on <Fig.4> (a), extend it from the unlimited bus to fault point, draw impedance map.

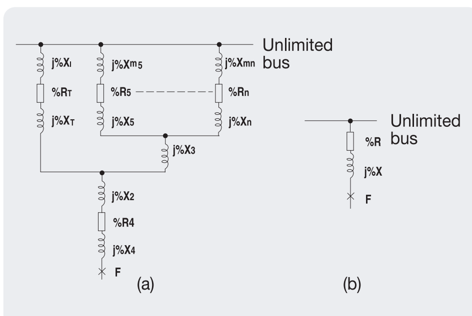
Calculating impedance

Calculate impedance as <Fig.4 (b)> in impedance map < Fig.4 (a)>

$\%Z = \%R + j\,\%X$

$\%Z = \sqrt{(\%R)^2 + (\%X)^2}$

Calculating symmetrical short-circuit current real value



<Fig.4> Base value

Calculating various short-circuit current value

IF (3ø) = IF (rms)sym (3ø)

$$= \frac{P_B \times 10^3}{\sqrt{3}V_B \cdot \%Z} \times 100$$

$$= \frac{I_B}{\%Z} \times 100[A]$$

Calculate various short-circuit current value with α, β, γ values from <Fig.5> like

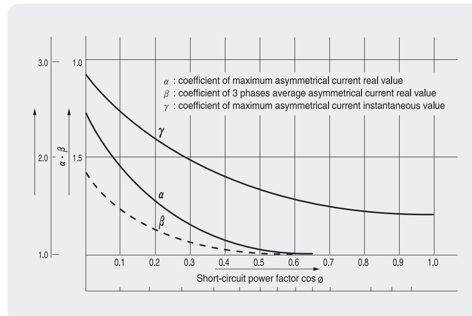
short-circuit power factor $\cos\,ø = \frac{\%R}{\%Z}$

3 phases average asymmetrical real value
I_F (rms)ave= βI_F (rms)sym
Maximum average asymmetrical real value
I_F (rms)asym= Ω I_F (rms)sym
Maximum asymmetrical instantaneous value
$I_F max = \gamma I_F$ (rms)sym

In case of 1 phase short-circuit

Current value from (5) multiplied by $\frac{\sqrt{3}}{2}$

Each short-circuit current value (1ø)= $\frac{\sqrt{3}}{2}$ (3phases short-circuit current) × α (or γ)



<Fig.5>

How to calculate short-circuit current value With a simple formula

For its special cases, calculating exact value should be needed, in the other hand, for the practical use, we recommend simple formula.

Finding a base value

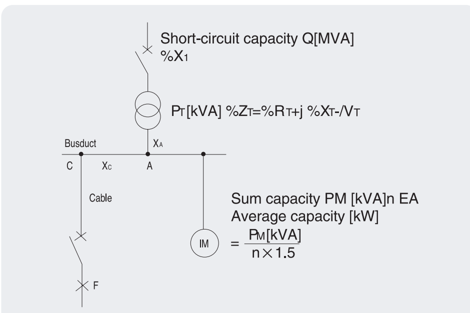
It shall be the rated current of transformer.

P_B= PT [kVA]

V_B= VT [V]

I_B= IT [A]

$$Z_B = \frac{VT_B\,[\Omega]}{PT \times 103}$$



<Fig.6> Base value

Short-circuit current from incoming circuit

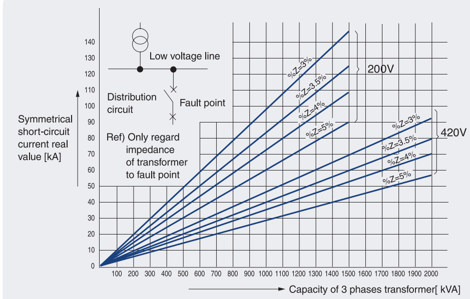
Disregard the impedance value of primary part of transformer. Calculate short-circuit current value according to <Fig.7>.
(If the impedance value of primary part of transformer is considered, calculate the current value as below formula)

$$I_A\,(R) = \frac{I_B}{\sqrt{(\%R_T)^2 + (\%X_1 + \%X_T)^2}} \times 100\,[A]$$

$$\%X_1 = \frac{P_B}{Q \times 10^3} \times 100\,[\%]$$

If the value of $\%R_T$ is not clear, $\%Z_T \fallingdotseq \%T_T$

$$I_A\,(R) = \frac{I_B}{\%X_1 + \%X_T} \times 100\,[A]$$



Ref 1) Calculation in the random voltage E Voltage line which is mostly close to E shall be selected to calculate it .
i.e. in case of 220V, (200V line value)÷200/220
Ref 2) Calculation for a certain impedance Zt (%) Impedance line which is mostly close to Zt (%) shall be selected to calculate it.
i.e. 420V, Zt= 4.5%
%Z=4% Line value (or 5% line) × 4 (or 5)/4.5
Ref 3) When the value is out of lines or over 200VA or below 100kA, multiply 10 times to the calculated values.

<Fig.7> Transformer capacity and short-circuit current

Short-circuit current to motor

$I_A\,(M) = 4 \times \Sigma$ (Rated current of motor)

Symmetrical short-circuit current at point A

$I_A = I_A\,(R) + I_A\,(M)$

Decreasing coefficient caused by busduct

Obtaining the value of $\frac{l \cdot I_A}{10VT}$

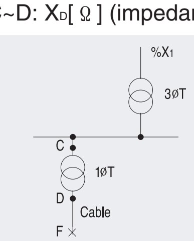
Calculate decreasing coefficient from <Fig.10>

Decreasing short-circuit current by reactance

When there's 1phase transformer in a certain circuit, calculate it in the base of reactance.
Regarding the reactance as pre-impedance at source part at point of <Fig.8>,

$$X_C = \frac{E_B}{\sqrt{3}\,I_C}$$

Reactance C~D: $X_D[\Omega]$ (impedance of 1 ø T)



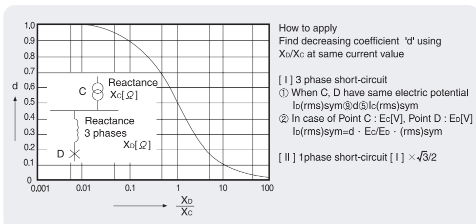
How to calculate short-circuit current value

Calculating the value of X_D/X_C and decreasing coefficient d from the reactance of <Fig.9>.
Current at point D $I_D=d \cdot I_C$

Impedance of 1 phase transformer $X_D= X(1\phi)\frac{1}{2}$

a. Short-circuit current at E_C voltage base
I_D (rms)sym · 3ø = d · I_C (rms)sym · 3ø

b. Short-circuit current at E_D voltage base
I_D (rms)sym · 3ø = d · I_C (rms)sym · 3ø × E_C/E_D



<Fig.9> Decreasing coefficient of short-circuit current by reactance: d

Coefficient d for cables

Calculating the value of $\frac{l\ I_D}{10V_T}$

Decreasing coefficient b value is calculated from <Fig.13>. For insulator drawn wrings, we can find the value directly from <Fig.13>.

Calculating symmetrical short-circuit current real value

I_F (rms)sym= b × I_D[D]

Various short-circuit current

In case of having short-circuit current power factor, find α, β, γ from <Fig.5>, If not find 3 values from <Table.1>

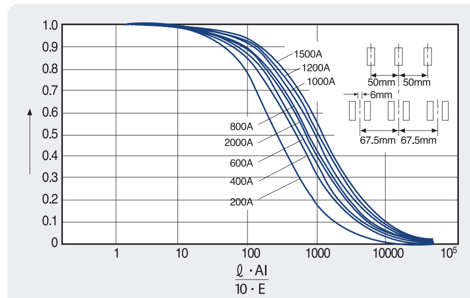
- 3 phases short-circuit asymmetrical current average value
  I_F (rms)ave= βI_F (rms)sym
- Maximum asymmetrical real value
  I_F (rms)ave= αI_F (rms)sym
- Maximum asymmetrical instantaneous value
  I_F (rms)ave= γI_F (rms)sym

<Table.2> α, β, γ values when short circuit power factor value is not definite.

Symmetrical short-circuit real value (A)	Variables		
	Maximum asymmetrical real value	3 phases short-circuit asymmetrical current average value	Maximum asymmetrical instantaneous value
2500	1.0	1.0	1.48
2501~5000	1.03	1.02	1.64
5001~1000	1.13	1.07	1.94
1001~15000	1.18	1.09	2.05
15001~25000	1.25	1.13	2.17
25000	1.33	1.17	2.29

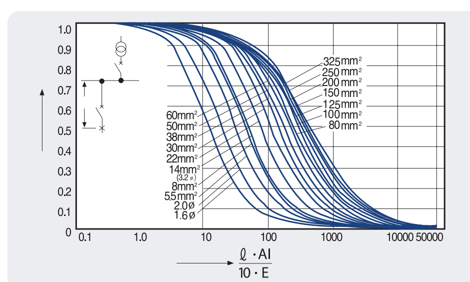
1 phase short-circuit

(Each current)= $\frac{\sqrt{3}}{2}$ × 3 phases short-circuit current × γ (or α)

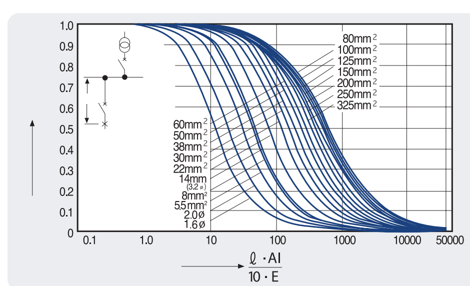


Busduct Ratings (A) Material		General busduct			
		Size [mm] [Ω/m]	Resistance R [Ω/m]	Reactance X [Ω/m]	Impedance Z [Ω/m]
Cu	200	3×25	2.41×10^{-4}	1.312×10^{-4}	2.74×10^{-4}
	400	6×40	0.751×10^{-4}	1.02×10^{-4}	1.267×10^{-4}
	600	6×50	0.607×10^{-4}	0.91×10^{-4}	1.094×10^{-4}
	800	6×75	0.412×10^{-4}	0.72×10^{-4}	0.830×10^{-4}
	1000	6×100	0.315×10^{-4}	0.60×10^{-4}	0.678×10^{-4}
	1200	6×125	0.261×10^{-4}	0.516×10^{-4}	0.578×10^{-4}
	1500	6×150	0.221×10^{-4}	0.449×10^{-4}	0.500×10^{-4}
	2000	6×125×2	0.129×10^{-4}	0.79×10^{-4}	0.800×10^{-4}

<Fig.10> Decreasing coefficient of general busduct (Cu)



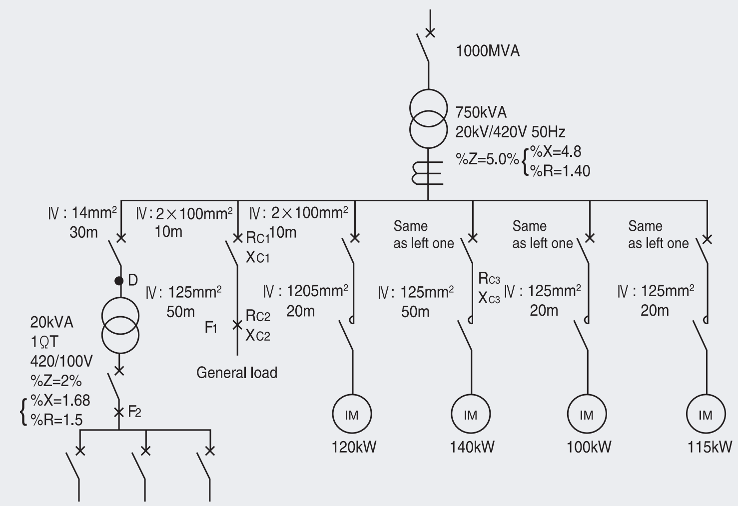
<Fig.11> Decreasing coefficient b in cable (600V IV)



<Fig.12> Decreasing coefficient b in cable (600V IV)

How to calculate short-circuit current value Calculation example

Calculation1) Short-circuit current value will be achieved by simple formula and percent impedance formula for <Fig.13>



<Fig.13>

Percent impedance formula

(1) Base value

$P_B = 750\text{kVA}$ $V_B = 420\text{V}$

$I_B = 1031\text{A}$ $Z_B = 0.237\ \Omega$

(2) Each impedance

a. Reactance at primary part of transformer

$$\%X_1 = \frac{750}{1000 \times 10^3} \times 100 = 0.075\ [\%]$$

b. Impedance of transformer

$\%R_T = 1.4\%$

$\%X_T = 4.8\%$

c. 1 ø Tr impedance

$$\%R_{T1} = \frac{1.15 \times 750}{20} \times \frac{1}{2} = 21.6\ [\%]$$

$$\%X_{T1} = \frac{1.68 \times 750}{20} \times \frac{1}{2} = 31.5\ [\%]$$

d. Reactance of transformer

$$\%X_{m1} = \frac{750}{120 \times 1.5} \times 25 = 104\ [\%]$$

$$\%X_{m2} = \frac{750}{140 \times 1.5} \times 25 = 89\ [\%]$$

$$\%X_{m3} = \frac{750}{100 \times 1.5} \times 25 = 125\ [\%]$$

$$\%X_{m4} = \frac{750}{115 \times 1.5} \times 25 = 108.7\ [\%]$$

e. Impedance of cable

Converting impedance of whole metal tube

[2×100mm² 10m]

$$\%R_{C1} = \frac{0.00018 \times 10}{0.237} \times \frac{1}{2} \times 100 = 0.38\ [\%]$$

$$\%X_{C1} = \frac{0.00013 \times 10}{0.237} \times \frac{1}{2} \times 100 = 0.27\ [\%]$$

[125mm² 20m]

$$\%R_{C2} = \frac{0.00014 \times 20}{0.237} \times 100 = 1.18\ [\%]$$

$$\%X_{C2} = \frac{0.00013 \times 20}{0.237} \times 100 = 1.09\ [\%]$$

[250mm² 50m]

$$\%R_{C3} = \frac{0.00007 \times 50}{0.237} \times 100 = 1.47\ [\%]$$

$$\%X_{C3} = \frac{0.00013 \times 50}{0.237} \times 100 = 2.74\ [\%]$$

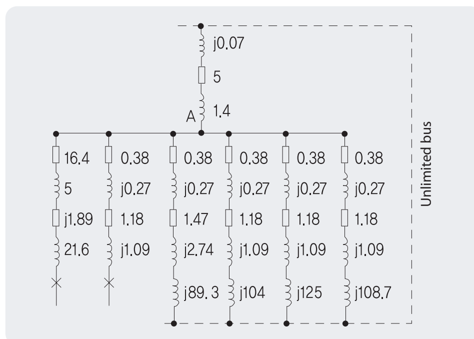
[14mm² 30m]

$$\%R_{C4} = \frac{0.00013 \times 30}{0.237} \times 100 = 16.45\ [\%]$$

$$\%X_{C4} = \frac{0.00015 \times 30}{0.237} \times 100 = 1.88\ [\%]$$

How to calculate short-circuit current value

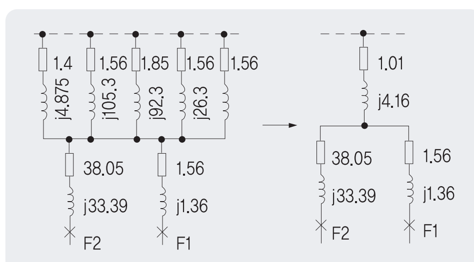
(3) Preparing a impedance map
Connect short-circuit supplier to the unlimited bus.



<Fig.14>

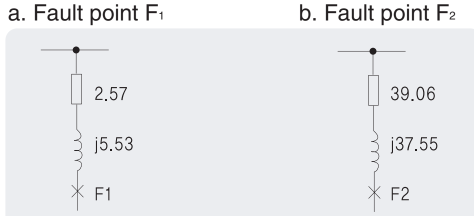
Calculating impedance

Calculate it in serial/parallel type formula



<Fig.15>

a. Fault point F_1 b. Fault point F_2



$\%Z_1 = \sqrt{(2.57)^2 + (5.53)^2} = 6.1[\%]$

$\%Z_2 = \sqrt{(39.06)^2 + (37.55)^2} = 54.2[\%]$

(5) Calculation of asymmetrical short-circuit current

a. Fault point F_1

$I_{F1}\text{ (rms)sym} = \frac{1031}{6.1} \times 100 = 16900[A]$

$\cos\varnothing_1 = \frac{2.57}{6.1} = 0.422$

b. Fault point F_2 (1 phase circuit)

$IF_2\text{ (rms)sym} = \frac{1031}{54.2} \times 100 = 1902[A] \cdots$ (at 100V)

$= \frac{1031}{54.2} \times 100 \times \frac{420}{100} = 7989[A] \cdots$ (at 420V)

IF_2 (rms)sym is short-circuit current. Therefore, convert it into 1 phase short-circuit current.

$IF_2\text{ (rms)}1\,\Omega\text{ sym} = 7989 \times \frac{\sqrt{3}}{2} = 6919[A]$

$\cos\varnothing_2 = \frac{39.06}{54.2} = 0.72$

(6) Various short-circuit current
Calculate α, β, γ from <Fig.5>.

a. Fault point F_1

$\cos\varnothing_1 = 0.422$

$\alpha = 1.05$ $\beta = 1.3$ $\gamma = 1.74$

$I_{F1}\text{ (rms)ave} = 1.03 \times 16900 = 17407$ [A]

$I_{F1}\text{ (rms)asym} = 1.05 \times 16900 = 17745$ [A]

$I_{F1}\text{max} = 1.74 \times 16900 = 29406$ [A]

b. Fault point F_2

$\cos\varnothing_2 = 0.72$

$\alpha = 1.0$ $\beta = 1.48$

$I_{F2}1\varnothing\text{ (rms)asym} = 1.0 \times 6919$ [A]

$I_{F2}1\varnothing\text{ max} = 1.48 \times 6919 = 10240$ [A]

Simple calculation formula

(1) Base value

$P_B = 750kVA$ $V_B = 420V$

$I_B = 1031A$ $Z_B = 0.237\,\Omega$

(2) Short-circuit current of incoming circuit
Disregard the impedance of primary part of transformer
In <Fig.7> $I_{A(R)} = 20500$ A

(3) Short-circuit current of motor
Sum of motor capacity=
$(120+140+100+115) \times 1.5 = 713$ [kVA]

$I_{A(M)} = \frac{713}{\sqrt{3} \times 420} \times 4 = 3920$ [A]

(4) Symmetrical short-circuit current at point A
$I_A = 20500+3920 = 24420$ [A]

How to calculate short-circuit current value
Calculation example

(5) Decreasing short-circuit current for cable

a. At point F_1

• 2 × 100mm² 10m

2 × 100mm² 10m= 100mm² 5m

$$\frac{l\ I_A}{10E} = \frac{20 \times 24420}{10 \times 420} = 29.1$$

Coefficient b= 0.935

Short-circuit current value at point C

Ic (rms)sym= 0.935 × 24420= 22850 [A]

• 125mm² 20m

$$\frac{l\ I_C}{10E} = \frac{20 \times 22850}{10 \times 420} = 108.9$$

I_{F1} (rms) sym= 0.785 × 244850= 17940 [A]

b. At point F_1

• 14mm² 30m

$$\frac{l\ I_C}{10E} = \frac{30 \times 24420}{10 \times 420} = 174.4$$

Coefficient b= 0.249

I_D (rms)3 ø sym= 0.24 × 24420= 6080 [A]

• Decreasing by the reactance (1 ø Tr)dp

Convert the value of '%X of 1 ø Tr' to base capacity

X_D= 750 × 2/20= 75%

Impedance of primary part at 1 ø Tr

$$XA = \frac{I_B}{I_D} \times 100 = \frac{1031}{6080} \times 100[\%]$$

Convert X_D to equivalent 3 phases, and

$$\frac{X_D/2}{X_A} = \frac{750 \times 2 \times 6080}{20 \times 2 \times 1031 \times 100} = 2.21$$

Coefficient d of <Fig.9> d= 0.32

I_{F2} (rms)3 ø sym= 0.32 × 6080=1945[A] (400V)

= 0.32 × 6080 × 420/100

= 817 [A] (100V)

$$\therefore I_{F2} \text{ (rms)1 ø sym} = 8171 \times \frac{\sqrt{3}}{2} = 7076 \text{ [A]}$$

(6) Various short-circuit current

Find α , β, γ from <Table.1>

a. At point F_1

α= 1.25 β = 1.13 γ = 2.17

IF1 (rms)ave= 1.13 × 17940= 20272 [A]

IF1 (rms)asym= 1.25 × 17940= 22425 [A]

IF1max= 2.17 × 17940= 38930 [A]

b. At point F_2

α= 1.13 γ= 1.94

IF21 ø (rms)asym= 1.13 × 7076= 7945 [A]

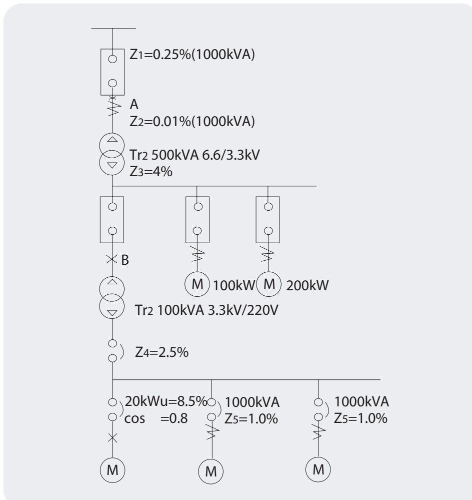
IF21 ø max= 1.94 × 7076= 13727 [A]

<Table.2> Comparison of short-circuit

Fault point		F_1	F_2
Symmetrical short-circuit current real value	Percent impedance calculation value	16900A	6919A
	Simple formula calculation value	17940A	7076A
		106%	102%
3 phases average asymmetrical current real value	Percent impedance calculation value	17407A	-
	Simple formula calculation value	20272A	-
		116%	-
Maximum asymmetrical current real value	Percent impedance calculation value	17745A	6919A
	Simple formula calculation value	22425A	7995A
		126%	115%

How to calculate short-circuit current value

Short-circuit current value will be achieved by simple formula for <Fig.16>



<Fig.16>

(1) Calculate rated current at each point

① Rated current I_{nA} at point A

$$I_{nA}=\frac{500[kVA]\times 1000}{\sqrt{3}\times 6.6[kV]\times 1000}=43.7[A]$$

② Rated current I_{nB} at point B

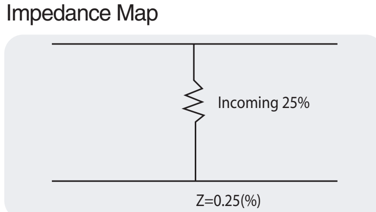
$$I_{nB}=\frac{100[kVA]\times 1000}{\sqrt{3}\times 3.3[kV]\times 1000}=17.5[A]$$

$$I_{nC}=\frac{20[kW]\times 1000}{\sqrt{3}\times 220[V]\times 0.85\times 0.8}=77.2[A]$$

(2) Put 1000k VA for base capacity and calculate short-circuit current at each point.

① Short-circuit current I_{SA} at point A

a) Impedance Map



b) Short-circuit I_{SA}

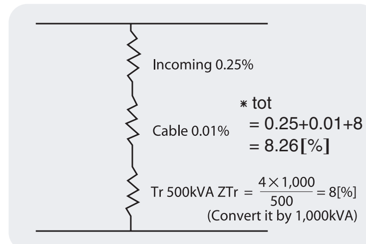
$$I_{SA}=\frac{1000[kVA]\times 1000\times 100}{\sqrt{3}\times 6.6[kV]\times 1000\times 0.25\%}=34990[A]$$

⁎ Breaking capacity of breaker [MVA]
MVA= 3 short-circuit current[kA] line to line voltage[kV]

② Short-circuit current at point B: I_{SB}

a) Impedance Map

⁎ Serial sum of impedance
Ztot= 0.25+0.01+8= 8.26[%]



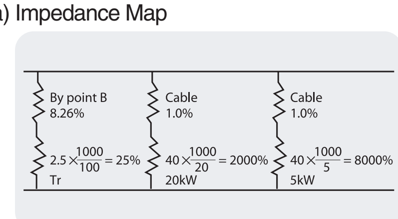
b) Short-circuit current I_{SC}

$$I_{SB}=\frac{1000[kVA]\times 1000\times 100}{\sqrt{3}\times 3.3[kV]\times 1000\times 8.26}=2118[A]$$

⁎ Breaking capacity of breaker [MVA]
MVA= $\sqrt{3}$ short-circuit current [kA] line to line voltage[kV]

③ Short-circuit current at point C: I_{SC}

a) Impedance Map



⁎ Parallel sum of impedance

$$Z=\frac{1}{\frac{1}{33.26}+\frac{1}{2001}+\frac{1}{8001}}=32.58\ [\%]$$

b) Short-circuit current I_{SC}

$$I_{SC}=\frac{1000[kVA]\times 1000\times 100}{\sqrt{3}\times 220[V]\times 32.58[\%]}=8055\ [A]$$

Calculation formula

$$\text{Rated current In}=\frac{\text{Transformer capacity}}{\sqrt{3}\times\text{Rated voltage}}$$

$$\text{Short-circuit current Is}=\frac{\text{Transformer capacity}\times 100}{\sqrt{3}\times\text{Rated voltage}\times\%Z}$$

How to calculate short-circuit current value Combination of transformer and impedance

<Table. 3> Combination of transformer and impedance

Transformer / Impedance / Transformer capacity (VA)	3 phases transformer											
	6.3kV/210V Oil Tr.			6.3kV/210V Mold Tr.			20kV/420V Mold Tr.			20kV/420V Oil Tr.		
	ZT[%]	RT[%]	XT[%]	ZT[%]	RT[%]	XT[%]	ZT[%]	RT[%]	XT[%]	ZT[%]	RT[%]	XT[%]
20	2.19	1.94	1.03									
30	2.45	1.92	1.53	4.7	2.27	4.12						
50	2.47	1.59	1.89	4.7	1.94	4.28						
75	2.35	1.67	1.66	4.4	1.56	4.11						
100	2.54	1.65	1.96	4.6	1.5	4.24						
150	2.64	1.64	2.07	4.2	1.29	4.0						
200	2.8	1.59	2.31	4.5	1.17	4.35						
300	3.26	1.46	2.92	4.5	1.2	4.33						
500	3.61	1.33	3.36	4.7	0.08	4.69	5.0	1.56	4.76	6.0	1.0	5.92
750	4.2	1.55	3.9	6.0	0.8	5.95	5.0	1.40	4.80	6.0	0.9	5.93
1000	5.0	1.35	4.82	7.0	0.7	6.96	5.0	1.26	4.84	6.0	0.8	5.95
1500	5.1	1.22	4.95	7.0	0.6	6.97	5.5	1.2	5.37	7.0	0.75	6.96
2000	5.0	1.2	4.85	7.5	0.65	7.47	5.5	1.1	5.39	7.0	0.7	6.96

<Table. 4> Example of transformer impedance

Transformer / Impedance / Transformer capacity (VA)	1 phase transformer					
	6.3kV/210V Oil Tr.			6.3kV/210V Mold Tr.		
	ZT[%]	RT[%]	XT[%]	ZT[%]	RT[%]	XT[%]
10				14.9	14.9	0.268
20				14.0	14.0	0.503
30				14.8	14.8	0.523
50				13.6	13.6	0.494
75				11.0	11.0	0.558
100				8.87	8.85	0.562
200				7.70	7.68	0.571
300				5.75	5.69	0.619
500				5.08	4.97	1.05
750				5.05	4.92	1.16
1000				4.03	3.93	0.904
2000				4.55	4.50	0.637
3000				4.29	4.22	0.768
5000				3.26	3.18	0.725
7500				2.72	2.81	0.775
10000	2.5	2.07	1.40	2.33	2.18	0.823
15000	2.37	1.84	1.49	2.04	1.82	0.937
20000	2.57	1.76	1.87	1.90	1.60	1.02
30000	2.18	1.58	1.50			
50000	2.05	1.47	1.42			
75000	2.27	1.46	1.74			
100000	2.48	1.49	1.98			
150000	3.39	1.31	3.13			
200000	3.15	1.31	2.87			
300000	2.23	1.28	2.96			
500000	4.19	1.09	4.03			

<Table. 5> Example of cable impedance (600 vinyl cable)

Cable dimension	Impedance of cable 1m (Ω)			
	Internal insulation wiring or cable of steel tube and duct	Internal vinyl tube wiring of steel tube and duct	Insulator wiring in building	Resistance (Ω) / cable 1meter
ø 1.6mm	0.00020	0.00012	0.00031	0.0089
ø 2mm				0.0056
ø 3.2mm				0.0022
5.5mm²				0.0033
8mm²				0.0023
14mm²	0.00015	0.00010	0.00026	0.0013
22mm²				0.00082
30mm²				0.00062
38mm²				0.00048
50mm²	0.00013	0.00009	0.00022	0.00037
60mm²				0.00030
80mm²				0.00023
100mm²				0.00018
125mm²				0.00014
150mm²				0.00012
200mm²				0.00009
250mm²				0.00007
325mm²				0.00005

<Remark1> At 60Hz, the reactance multiply 2 times itself, so 1/2 reactance of primary part can achieve IB.

<Remark2> When the cable is parallelly 2 or 3ea, reactance and resistance can be calculated in the condition of 1/3 and 1/3 length cable.

How to calculate short-circuit current value
Various short-circuit

<Table.6> Impedance sample of bus and busduct (50Hz)

[×10⁻⁴ Ω/m]

Ampere rating (A)	50Hz			60Hz		
	R	X	Z	R	X	Z
600	1.257	0.323	1.297	1.385	0.387	1.438
800	0.848	0.235	0.879	0.851	0.282	0.896
1000	0.641	0.185	0.667	0.645	0.222	0.682
1200	0.518	0.152	0.540	0.523	0.183	0.554
1350	0.436	0.129	0.454	0.443	0.155	0.469
1500	0.378	0.113	0.394	0.386	0.135	0.409
1600	0.360	0.107	0.375	0.367	0.128	0.389
2000	0.286	0.084	0.298	0.293	0.101	0.310
2500	0.218	0.065	0.228	0.221	0.078	0.235
3000	0.180	0.054	0.188	0.184	0.064	0.195
3500	0.143	0.042	0.149	0.146	0.051	0.155
4000	0.126	0.038	0.131	0.129	0.045	0.136
4500	0.120	0.036	0.125	0.122	0.043	0.130
5000	0.095	0.028	0.099	0.098	0.034	0.103

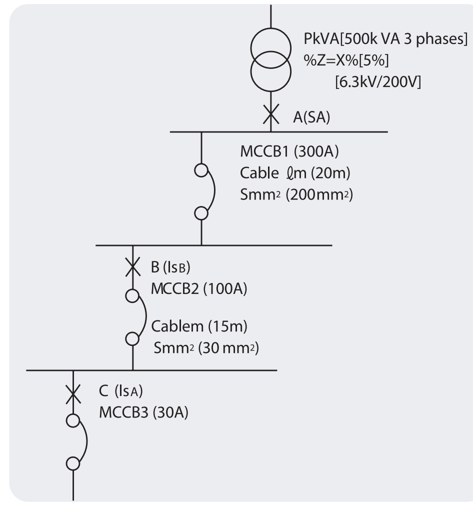
<Table.6> Impedance sample of Bus and busduct (50Hz)

[×10⁻⁴ Ω/m]

Ampere rating (A)	50Hz			60Hz		
	R	X	Z	R	X	Z
600	0.974	0.380	1.045	0.977	0.456	1.078
800	0.784	0.323	0.848	0.789	0.387	0.879
1000	0.530	0.235	0.580	0.536	0.282	0.606
1200	0.405	0.185	0.445	0.412	0.222	0.468
1350	0.331	0.152	0.364	0.338	0.183	0.384
1500	0.331	0.152	0.364	0.338	0.183	0.384
1600	0.282	0.129	0.311	0.289	0.155	0.328
2000	0.235	0.107	0.259	0.241	0.128	0.273
2500	0.166	0.076	0.182	0.169	0.091	0.192
3000	0.141	0.065	0.155	0.144	0.078	0.164
3500	0.122	0.056	0.135	0.127	0.068	0.143
4000	0.110	0.051	0.121	0.113	0.061	0.126
4500	0.094	0.043	0.104	0.096	0.052	0.109
5000	0.082	0.038	0.091	0.084	0.045	0.096
5500	0.078	0.035	0.086	0.080	0.043	0.091
6500	0.068	0.028	0.074	0.071	0.031	0.077

How to calculate short-circuit current value Calculation example

Using a certain graph, you can find and calculate the short-circuit current value which is at one position of network. No matter the condition of network is different, you can do the calculation through adjusting variables.



Graph note

P coordinates – Transformer capacity (kVA)
Is_1 coordinates – Short-circuit current value (kA)
Is_2 coordinates – Short-circuit current value affected cable condition (kA)
ⓐ Line - % impedance of transformer (%)
ⓑ Line - Length of cable (m)
ⓒ Line - Square mm of cable (mm^2)
ⓓ Line - Is_2 (kA)

Remark) ⓒ line shows the length of hard vinyl cable (600V IV)

How to calculate short-circuit current value

(1) 3 phases transformer

① Short-circuit current value at (A) where it is just below transformer. At P coordinates, find the coordinates value (g) of the cross point (f) which is from transformer capacity (e) and A line. Disregard primary part impedance of transformer.

② Find the short-circuit current value at Point B, C which are considered cable impedance.

- At short-circuit current g (kA) of Is_1 coordinates, find the value (h) of B line
- Move (h) to parallel direction of Is, and find the cross point (i) to C line.
- Move (i) to parallel direction of Is_2, and find the cross point value (j) to D line (g), finally find (k) of Is_2

(2) 1 phase transformer

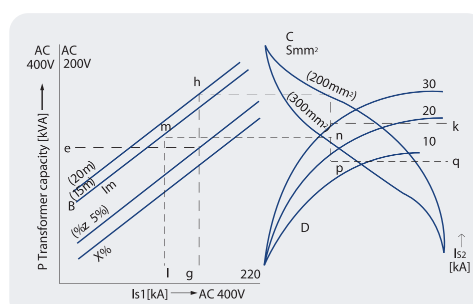
① Short-circuit current value where it is just below transformer. Find the value as same as that of 3 phase transformer and multiply it 3 times. (g'kA)

② Find the short-circuit current value where it is considered cable impedance.

- Multiply 2/3 times to g' of Is coordinates
- Find the Is_2 value as same as that of 3 phase transformer and multiply it 3/2 times.

Remark

1. It's not considered the transformer contribution. Multiply 4 times the rated current of transformer in cases.
2. The real short-circuit current value is littler lower that its calculated value by the way we suggest because we take the rated voltage as AC200V, 400V. So the current value should be calculated in the consideration of stability
3. The calculated value is symmetrical real value.



Memo

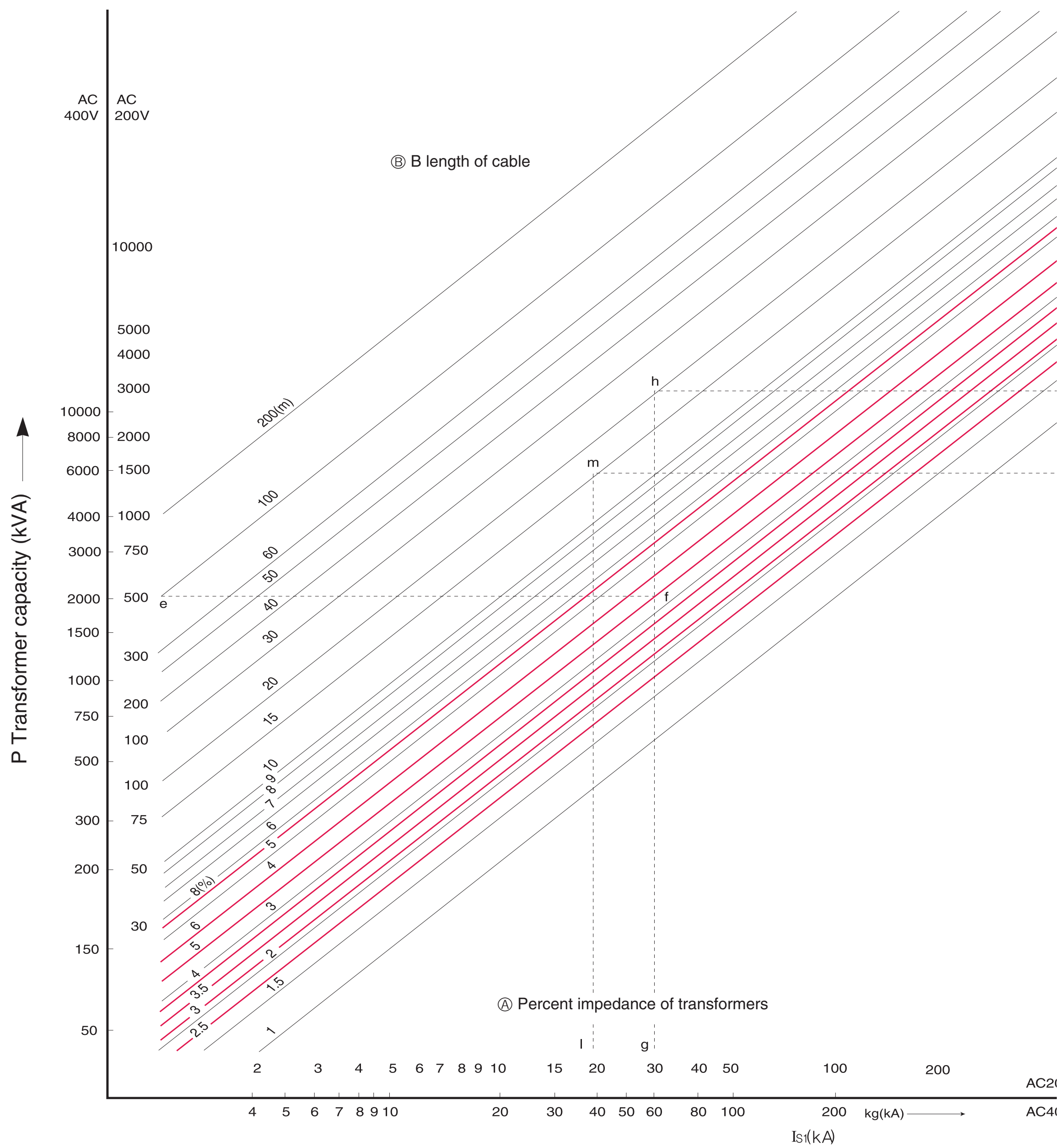
How to calculate short-circuit current value Calculation graph

(1) Short-circuit current value at point A (I_{SA})

- At P coordinates, find (f) which is the point which is to match transformer capacity 500kVA and A line. Then move (f) to I_{S1} direction and finally find (g).
- I_{SA}= 29kVA (g)

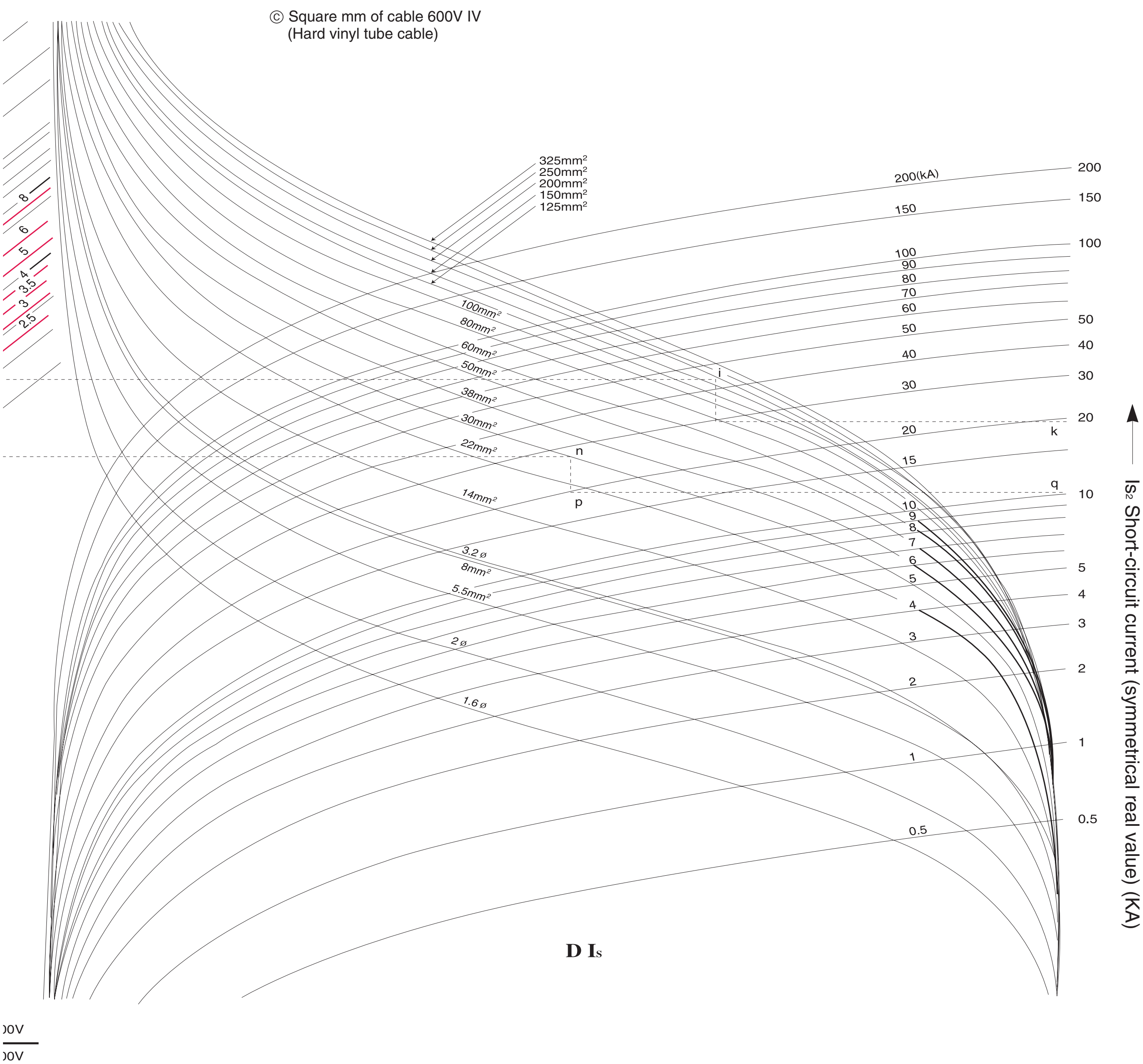
(2) Short-circuit current value at point B (I_{SB})

- Find value h of B line (20mm) at g (= 29kA) of I_{S1} coordinates
- Move h parallely to the direction of I_{S1}, and find value I at the cross point with C line (200mm)
- Move I parallely to the direction of I_{S2}, and find value j at the cross point with D line (g= 29kA)
- I_{SB}= 19kA (k)



(3) Short-circuit current value at point C (I_{sc})

- Find I_{s1} coordinates value (19kA) of short-circuit current value k (= 19kA) at Point B. and find cross point m between 19kA and B line.
- Move m parallely to the direction of I_{s1} coordinates, and find the cross point n at C line (30mm).
- Move n parallely to the direction of I_{s1} and find the cross point p of I_{s2} with D line.
- Isc= 10kA (g)



Green Innovators of Innovation

Safety Instructions

- For your safety, please read user's manual thoroughly before operating.
- Contact the nearest authorized service facility for examination, repair, or adjustment.
- Please contact a qualified service technician when you need maintenance.
  Do not disassemble or repair by yourself!
- Any maintenance and inspection shall be performed by the personnel having expertise concerned.

LSIS Co., Ltd.

www.lsis.biz

HEAD OFFICE
LS-ro 127 (Hogye-dong) dongan-gu Anyang-si
Gyeonggi-do Korea
Tel. (82-2)2034-4887, 4873, 4148
Fax. (82-2)2034-4648

CHEONG-JU PLANT
Cheong-Ju Plant #1, Song Jung Dong, Hung Duk Ku,
Cheong Ju, 361-720, Korea

Specifications in this catalog are subject to change without notice due to continuous product development and improvement.

Global Network

- **LSIS (Middle East) FZE ›› Dubai, U.A.E.**
  Address: LOB 19 JAFZA VIEW TOWER Room 205, Jebel Ali Freezone P.O. Box 114216, Dubai, United Arab Emirates
  Tel: 971-4-886 5360 Fax: 971-4-886-5361 e-mail: dhleef@lsis.biz
- **Dalian LSIS Co., Ltd. ›› Dalian, China**
  Address: No.15, Liaohexi 3-Road, Economic and Technical Development zone, Dalian 116600, China
  Tel: 86-411-8273-7777 Fax: 86-411-8730-7560 e-mail: tangyh@lsis.com.cn
- **LSIS (Wuxi) Co., Ltd. ›› Wuxi, China**
  Address: 102-A , National High & New Tech Industrial Development Area, Wuxi, Jiangsu, 214028, P.R.China
  Tel: 86-510-8534-6666 Fax: 86-510-522-4078 e-mail: luw@lsis.com.cn
- **LSIS-VINA Co., Ltd. ›› Hanoi, Vietnam**
  Address: Nguyen Khe - Dong Anh - Ha Noi - Viet Nam
  Tel: 84-4-882-0222 Fax: 84-4-882-0220 e-mail: sjbaik@lsis.biz
- **LSIS-VINA Co., Ltd. ›› Hochiminh , Vietnam**
  Address: 41 Nguyen Thi Minh Khai Str. Yoco Bldg 4th Floor, Hochiminh City, Vietnam
  Tel: 84-8-3822-7941 Fax: 84-8-3822-7942 e-mail: hjchoid@lsis.biz
- **LSIS Shanghai Office ›› Shanghai, China**
  Address: Room 32 floors of the Great Wall Building, No. 3000 North Zhongshan Road, Putuo District, Shanghai, China
  Tel: 86-21-5237-9977 Fax: 89-21-5237-7189 e-mail: baijh@lsis.com.cn
- **LSIS Beijing Office ›› Beijing, China**
  Address: B-Tower 17FL.Beijing Global Trade Center B/D. No.36, BeiSanHuanDong-Lu, DongCheng-District, Beijing 100013, P.R. China
  Tel: 86-10-5825-6025,7 Fax: 86-10-5825-6026 e-mail: sunmj@lsis.com.cn
- **LSIS Guangzhou Office ›› Guangzhou, China**
  Address: Room 1403, 14/F, New Poly Tower, No.2 Zhongshan Liu Road, Guangzhou 510180, P.R. China
  Tel: 020-8326-6754 Fax: 020-8326-6287 e-mail: chenxs@lsis.com.cn
- **LSIS Chengdu Office ›› Chengdu, China**
  Address: Room 1701 17Floor, huamin hanjun internationnal Building, No1 Fuxing Road Chengdu, 610016, P.R. China
  Tel: 86-28-8670-3201 Fax: 86-28-8670-3203 e-mail: yangcf@lsis.com.cn
- **LSIS Qingdao Office ›› Qingdao, China**
  Address: Room 2001,20/F,7B40, Galaxy Building, No.29 Shandong Road, Shinan District, Qingdao 266071, P.R. China
  Tel: 86-532-8501-6058 Fax: 86-532-8501-6057 e-mail: wangzy@lsis.com.cn
- **LSIS NETHERLANDS Co.Ltd ›› Schiphol-Rijk, Netherlands**
  Address: 1st. Floor, Tupolevlaan 48, 1119NZ,Schiphol-Rijk, The Netherlands
  Tel: 31-20-654-1420 Fax: 31-20-654-1429 e-mail: junshickp@lsis.biz
- **LSIS Gurgaon Office ›› Gurgaon, India**
  Address: 109 First Floor, Park Central, Sector-30, Gurgaon- 122 002, Haryana, India e-mail: hwyim@lsis.biz

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ABN250-DC光伏专用直流断路器

ABN250-D系列光伏专用直流塑壳断路器，适用于额定电流250A及以下，直流额定电压1000V的光伏发电配电线路中。本断路器具有过载长延时保护、短路瞬时保护功能，可用于分配光伏电能和保护线路及用电设备免受过载、短路等故障的危害。

ABN250-D型塑壳断路器的额定分断能力为20kA，使用类别为A，Ics=100%Icu，满足客户全部需求，可广泛应用于汇流箱、直流屏等设备当中。

AB N 250 250A DC 4P

6、极数
5、直流专用
4、额定电流
3、壳架电流
2、标准型
1、产品系列

技术资料

规格参数

额定电压(V)	1000V DC	额定绝缘电压	1000V
额定电流(A)	125A-160A-200A-250A	脱扣方式	热磁式
级数	2P、4P	电气寿命(次)	2000次
分断能力	20kA	额定冲击电压	8kV

标准认证

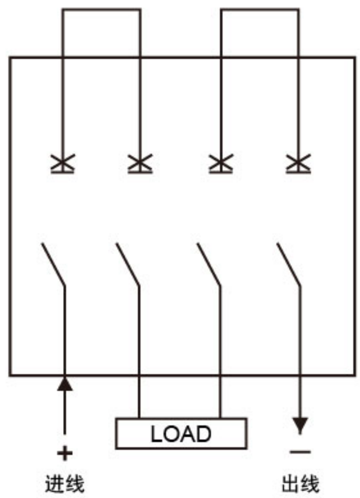
符合标准	IEC/EN60947-2
	GB14048.2
通过认证	CCC

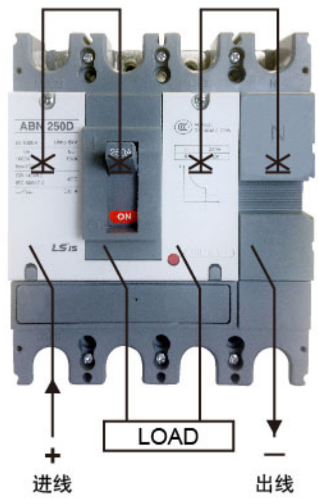
工作环境

降容	当环境温度超过40°C时，ABN产品的过载保护特性会随着温度发生很小的变化，需要对Ir进行整定，才能保证在高温环境下使用。 当海拔在2000米以上时，需考虑介电强度的改变和空气温度下降的因素，所以也需降容。
湿度	不超过50%
污染等级	3
环境温度(℃)	-25 ～+70
海拔(m)	2000

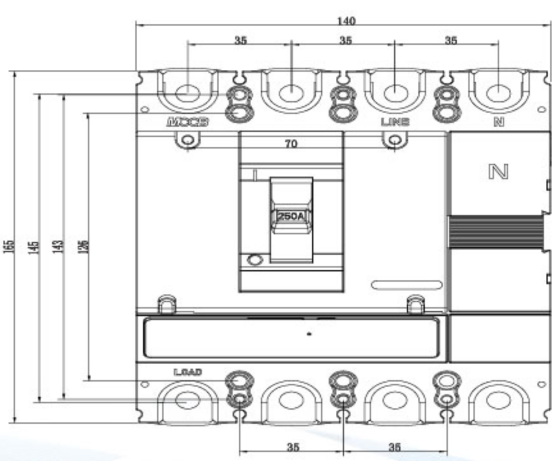
产品特点	
安装方式	四极串联接线
产品附件	辅助触点（AX）、报警触点（AL）、分励脱扣器（SHT）
安装方向	水平或垂直
断点类型	双断点
产品极性	无极性
使用类别	A

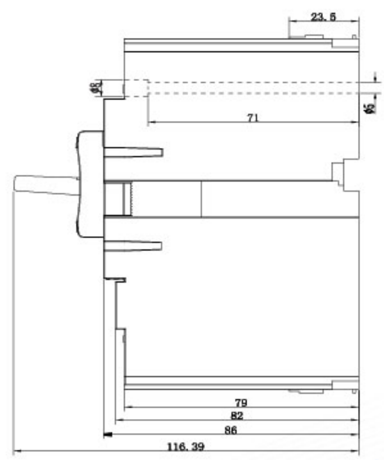
产品接线图





外形尺寸





■ **国内网络**

〉**乐星产电（无锡）有限公司**

上海总部
地址：上海市普陀区中山北路3000号长城大厦32层
电话：021-52379977　传真：021-52377189

南京分公司
地址：南京市白下区洪武路198号城开国际大厦1幢1702室
电话：025-84670005　传真：025-84670006

无锡工厂
地址：无锡市国家高新技术产业开发区102-A地块
电话：0510-85346666　传真：0510-85344099

青岛分公司
地址：青岛市市南区山东路29号银河大厦2001室
电话：0532-85016058　传真：0532-85016057

成都分公司
地址：成都市福兴街1号华敏翰尊国际大厦1710室
电话：028-86703201　传真：028-86703203

大连工厂
地址：大连经济技术开发区辽河西三路15号
电话：0411-87305872　传真：0411-87318227

北京分公司
地址：北京市朝阳区东三环中路24号乐城中心B座23层
电话：010-57613127　传真：010-57613128

广州分公司
地址：广州市天河区天河北路898号信源大厦1820室
电话：020-38182883　传真：020-38182884

宜昌工厂
地址：湖北省宜昌市谭家河路100号
电话：0717-6677572　传真：0717-6677007