L.V. CIRCUIT BREAKERS

Circuit Breakers (Thermal-Magnetic Type)

F01 / F02
16A ... 225A

F10 / F11 / F11R
16A ... 125A

F12 / F12R / F12M
16A ... 160A

F21 / F22
16A ... 160A

F31 / F32 / F33
16A ... 250A

F51 / F52 / F53
200A ... 300A

F61 / F62
300A ... 400A

F71
300A ... 800A

F82 / F83
400A ... 800A

Circuit Breakers (Electronic Type)

F82E / F83E
300A ... 800A

F91E / F92E
1000A ... 1250A

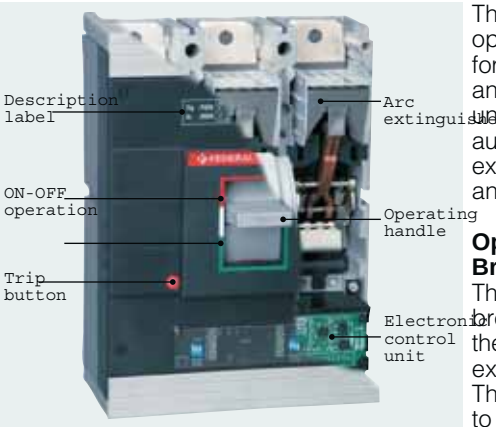
F101E / F102E
1000A ... 1600A

F111E / F112E
1600A ... 2500A

CONTENTS

TS EN 60947-2
EN 60947-2
IEC 60947-2
CE

Assembly Position	**: Free**
Altitude	**: 2000 m (max)**
Relative Humidity	**: %50 (40°C) , %90 (20°C)**
Ambient Temperature	**: between -20°C and +60°C**
Pollution Degree	**: III**
Protection Class	**: IP40 (at assembly lever area)**



Pic-1

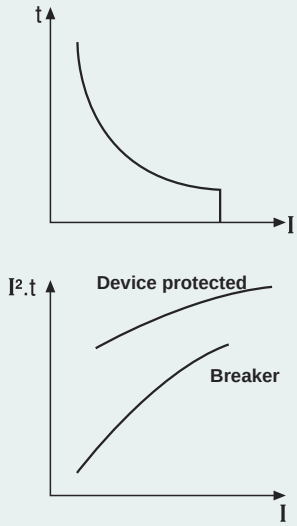


Fig-1

I= Current passing through
t= Current passing duration

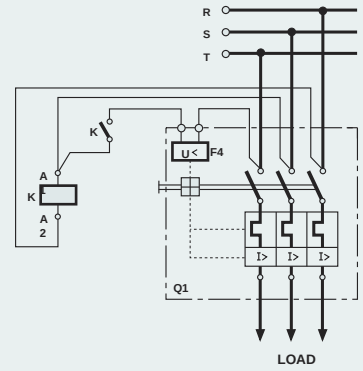


Fig-2

K : Contactor (Coil AC 380 V)
F4: Low voltage release (UVR)
Q1: LV circuit breaker

The circuit breaker is a mechanical opening-closing device, which is used for closing, breaking, separating circuit and transporting current of that circuit under ordinary conditions and for automatically breaking the circuit under extraordinary conditions like short circuit and over current.

Operating Principle of the Circuit Breaker:
The most important function of the circuit breaker, in addition to opening-closing the circuit, is to protect the circuit under extraordinary conditions.
There are some units inside the device to let the breaker fulfill its protection functions. Opening units of LV circuit breakers are described as release mechanism in TS EN 60947-2 standard.

Releases :
- Over current releases (Over current opening unit)
- Under voltage releases (Low voltage opening unit)
- Shunt Trip releases (Remote release unit)

All the circuit breakers are equipped with over current releases. However, under voltage and shunt trip-release coil is not a standard accessory and added to the circuit breaker as per requirement.

Over Current Releases:
All the values exceeding rated current value are called over current.

Formation of Over Current:
Over currents in electrical circuits result from increase of power expended the or a short circuit. Both over currents are very dangerous for electrical circuits. Over currents lead to thermal and dynamic forcing in electrical circuit.
- Although over currents, which are a result of increase in power expended, are not usually too high, they can go up to (2-3) time more than the rated current.
- Currents resulting from short circuit depend on characteristic of the electrical circuit. For example, they can go up to 3,2 kA in a transformer of 100 kVA; or 60kA in a transformer of 2500 kVA. Electrical devices such as transformer, generator, motor, cable etc. have a thermal forcing value I2 to resist without damage due to the heat caused by over current. As it can be seen in the formula, both current value and current delay time is very important. In order to keep $I^2.t$ value under a particular value, flow duration of the current should decrease as the current increases. LV circuit breakers open the circuit below $I^2.t$ value of the protected device to provide safe protection (Figure-1).

Over Current Release are divided into two:
1. Releases opened under over load conditions,
2. Releases opened under short circuit conditions.

Releases opened under over load conditions: These are the releases that operate when the current expended in the circuit exceeds the rated current value of the breaker. They operate on reverse time delay basis. As current value increases, opening duration decreases.

Releases opened under short circuit conditions:
These are the releases that open the circuit in a very short time when the short circuit current exceeds the adjustment value of the release.

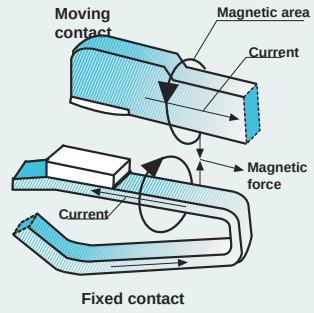
Undervoltage Releases:
Voltage going below a particular value in electrical circuits or failure of any phase in tri-phase circuits may result in failure of devices. For example, failure of any phase in tri-phase motor shall overload other phases and result in failure of the motor. When required, low voltage coil can be assembled to the breaker to prevent occurrence of such failures. As under voltage coil is usually supplied by two phases, control of other phase is performed by a contactor (Figure-2).

Shunt Trip Releases
They are used for remote-release of the circuit breaker. When a voltage is applied to a shunt trip release, opening should be made up to 70% and %110 of the supply voltage.

TYPES OF CIRCUIT BREAKERS:
LV circuit breakers are manufactured in two different types depending on the release type. These are thermal-magnetic and electronic circuit breakers.

Thermal - Magnetic Circuit Breakers:
Thermal protection function, (1,1-3) x In:
(For protection under over load conditions)

Bimetal, which provides thermal protection, consists of combination of two metals with different extension coefficients under heat. When bimetal is heated, it bends towards the metal with less extension. In this way, a notch that assists opening of the breaker mechanism is released to disable the breaker. Bending speed of bimetal is in direct proportion with size of the current passing through the breaker. Because, increase of current means increase of heat. In this way, over current protection function of the breaker is fulfilled by bimetal at load



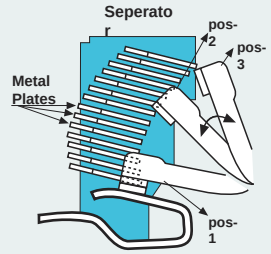


Fig - 3

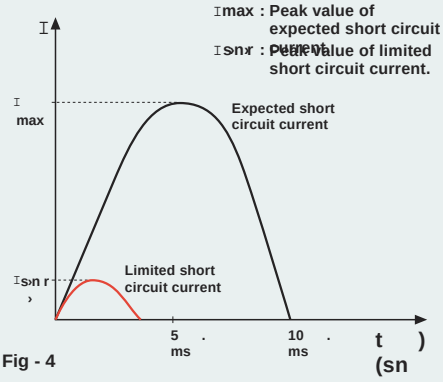
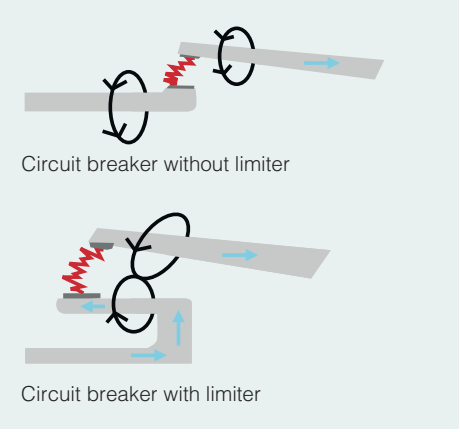


Fig - 4



The only difference between circuit breakers with and without limiters is in the construction of fixed contacts. Fixed contacts of circuit breakers with limiters are in the structure to reverse the direction of current and form reverse magnetic force to push the moving contact.

currents higher than the rated current.

Magnetic protection function, >3 x In: (For protection under short circuit conditions)

Another function of the breaker is to protect the connected circuit against short circuits. Short circuit may occur as a result of contact of phases with each other or contact of phase-ground. Since a very high current shall pass through the cables in case of short circuit, system energy should be broken in a shorter time due to thermal protection. Breaker should perform instant opening to protect load it is connected to. The part fulfilling this function is a mechanical opening mechanism that operates with magnetization caused by the magnetic area formed by the short circuit current.

Circuit Breakers with Electronic Over Current Release:
The feature discriminating electronic circuit breakers from thermal-magnetic breakers is to control the over current releases with electronic circuit. Electronic control is performed via microprocessor. During design of the electronic circuit, worst possibilities to encounter in operation have been taken into consideration. In high circuit currents, direct opening has been ensured without operating electronic circuit. In this way, possibility of failure in the electronic circuit has been eliminated. Federal electronic circuit breakers can be connected to computer through RS-232 protocol upon request. In this way;
-Computer memory can be used instead of current recording devices.
-Maximum, minimum, average etc. values of the drawn current at various time intervals (day-night) can be taken.
-Statistical information can be accessed any time.
-Opening period of the breaker can be adjusted in case of over current formation.
-Rated current and instant opening current of the breaker can be changed on computer.
-External opening control can be provided.
Rated and instant opening current adjustment areas of electronic circuit breakers are quite wide. This feature allows wide use opportunity to the breaker. Furthermore, electronic circuit breakers are not affected from ambient temperatures.

Operating principle of limiter circuit breaker:
While breaker is opened and closed with lever, moving contact should be in ON position in pos-1, in OFF position in pos-3 (Figure - 3). The short circuit current that comes into existence when there is a short circuit in a breaking current without limiter opens the breaker by enabling the breaking mechanism via releases and takes breaking lever to trip position. Opening duration varies between 10-20 ms. In Federal limiter breakers, reverse magnetic area where short circuit occurs takes moving contact from pos-1 to pos-2 and contact remains in this position. That is, contact does not come to ON position again. Opening of the moving contact starts with the first millisecond of the short circuit. The contact arrives pos-2 in the first two milliseconds and complete cut-off of the arc lasts in 3-5 milliseconds maximum. Magnetic releases, which get into operation with start of the short circuit, take the breaking mechanism to OFF position; the mechanism takes the moving contact in pos-2 to pos-3 and the breaking lever remains in trip position. The current, which takes the moving contact from pos-1 to pos-2, is a lower current than the expected short circuit current. Limited current is at one-eighth and even one-tenth of the expected current (Figure- 4), The expected short circuit current would flow in a shorter time than the current if there was no limiter circuit breaker.

Advantages of Federal limiter circuit breaker:
-They protect transformers, cables and other devices in circuit by limiting the current up to 90% depending on the breaker type.
-As explosions and arcs remain at a very low level, critical safety is guaranteed in order not to give damage to other devices in the panel.

PARTS OF CIRCUIT BREAKERS

Body and Cover: Fiber-glass polyester resin has been used as the body and cover material in accordance with EN 60512-20-2 standard. This material, which is called BMC (Bulk Molding Compound) in the literature, is preferred due to high electrical and mechanical values and can resist to a temperature of 160°C continuously. BMC material does not burn when in contact with wire at a temperature of 960°C in accordance with IEC 695-2-1.

Bimetal: Bimetal is a material consisting of combination of two plate metals with different extension coefficients against heat. The current passing through the breaker heats up bimetal. Due to effect of this heat, bimetal bends towards the less-extending plate. Since heat increases as the current passing through the breaker increases, bimetal is heated more and bends more. In this way, it controls the opening mechanism to open the breaker.

Contacts: Contact alloy is determined for breakers by considering broken and carried current values and construction. Usually silver, graphite, nickel, wolfram alloy contacts are used in breakers.

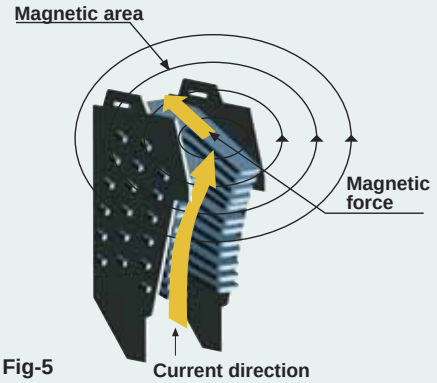


Fig-5

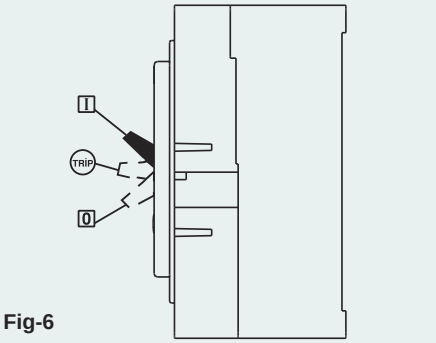
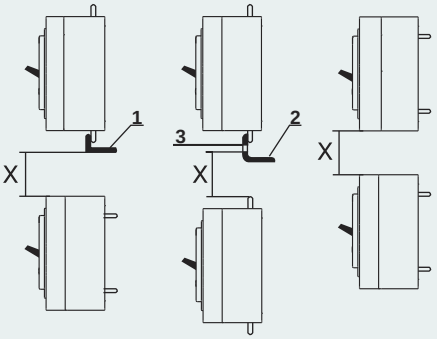


Fig-6

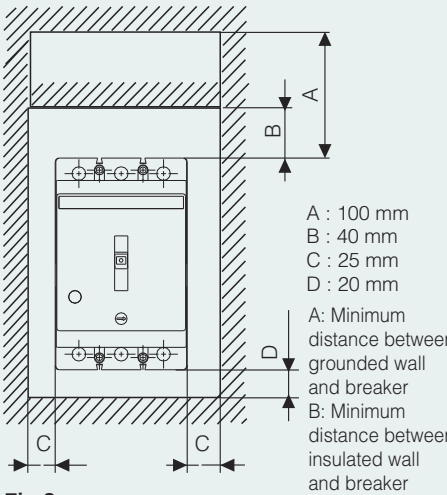


1) Busbar
2) Cable
3) Cable Terminal

Type	x
F10-F11/F12 F21-F22 F31-F32-F33 F51-F52-F53	(mm) 140
F61-F62/F71 F82-F83/F82E-F83E	180
F92E F101E-F102E F1 1E-F112E	

1

Fig-7



A : 100 mm
B : 40 mm
C : 25 mm
D : 20 mm

A: Minimum distance between grounded wall and breaker
B: Minimum distance between insulated wall and breaker

Fig-8

Contacts, which are made of silver-graphite alloys with a smoothers structure, are used in fixed (bottom) contacts, silver - wolfram contacts, which are harder, are used in moving (top) contacts. A swaged structure has been ensured in moving contacts. In this way, swaged and hard alloy contacts have a place on soft fixed contacts in each opening-closing. In this way, the lowest resistance is ensured. Moving contact should touch the fixed contact very well in order to have low contact resistance. However, excessive contact pressure force results in damage of contacts in a shorter period than normal. Contact alloys are very important for a healthy opening-closing.

Arc Extinguisher Cell (Separator): Separators are used to extinct the arc which is formed during operation of the breaker operating under energy. While moving contact is separated from fixed contact, current continues to flow between contacts for a while and this is called arc. This arc should be extinct in a very short time.

Extinction of Arc: Arc is pushed towards separators due to magnetic field formed around the arc. In this way, arc is extended and becomes slim and broken off between separator plates (Figure-5). Due to characteristic of the material used on side walls of the separators, a gas comes out due to high temperature caused by the arc. This gas has an important effect on extinction of the arc.

Utilization Type of the Circuit Breaker: There are 3 positions indicating position of the breaker. These positions are shown in Figure-6.

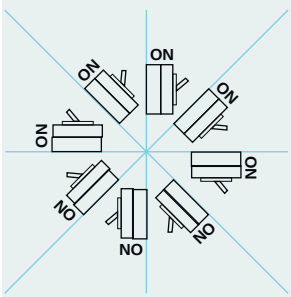
ON/I Position: It indicates that contacts of the breaker are closed. In this position, the breaker lever is in the top position.

TRIP Position: It indicates that the breaker is opened due to any failure (over load or short circuit). In this case, breaker lever is in the middle position between ON and OFF positions. In order to take the breaker, which is in trip position, to ON position; push the breaker lever downwards as shown by the OFF sign. Breaker shall be set with “click” sound. After that, pull the lever as shown by ON sign to close the breaker.

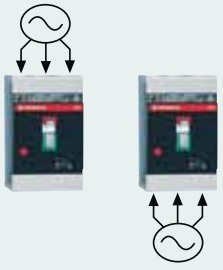
OFF/0 Position: It indicates that contacts of the breaker are open. In this way, the breaker lever is in the bottom position.

Assembly: Important considerations during assembly are listed below.
- The place to assemble the breaker should be free of dust and moisture.
-Breaker should be assembled in a way not to be subject to gas and vapor. - If the environment is dusty and moist, the breaker must be assembled in a housing with appropriate protection degree.
- While the breaker is in operation, it should not be exposed to vibration and sudden impacts.
- Minimum distances between two breakers assembled one on another should be as shown in Figure-7.
- Minimum distances between grounded or insulated wall and the breaker should be as shown in Figure-8.
- Assembly method of the connectors (for F31 and F51 type switches) vary according to connection at the front or at the back. Connector may be demounted, reversed and mounted again if required.
- Cable connections of measurement devices should be made through busbars, no connection should be made through terminals of the breaker (Please request extension busbars from factor for connections to be made with cable shoes.)
- End insert should be used in connections of multi-wire cables to breaker connector and no brazing should be made at cable ends.
- In connection is made to the breaker via copper busbars, busbars should be painted and feather edges should be rounded to minimize the risk of jumping.
- Phase curtains must be placed in the conduit between two busbars in the breaker body.
- Grounding should be made in accordance with the regulations.

Protection System Against Earth Residual Currents with Circuit



Assembly can be made in any angle.


Power connection can be made at top or bottom connectors.

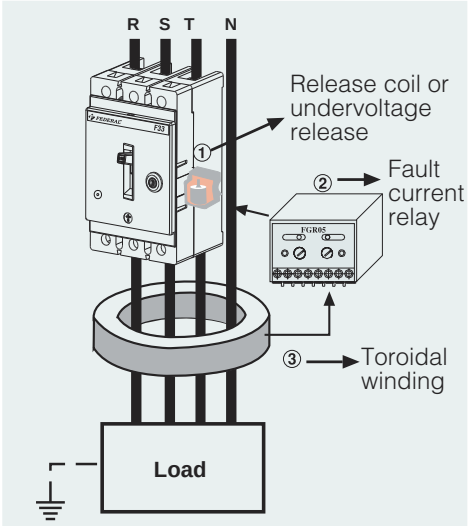


Fig - 9 Protection system in circuit breakers against fault currents

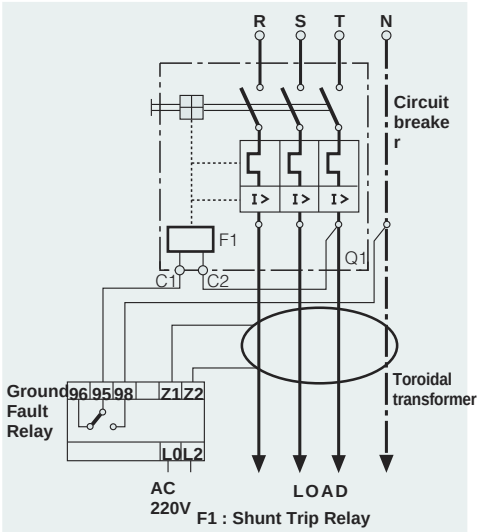


Fig-10 Use of ground fault current detection system with shunt release coil in circuit breaker

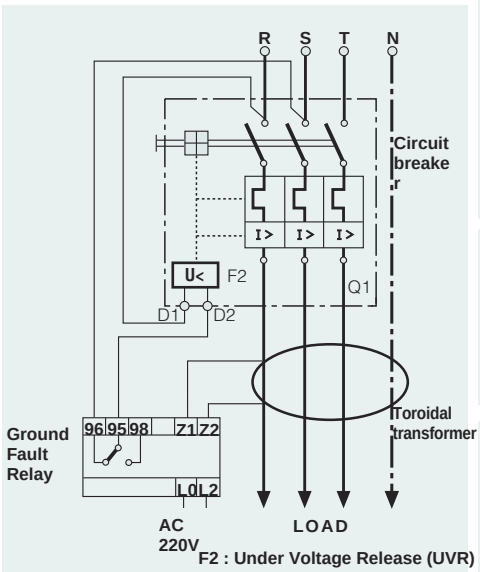


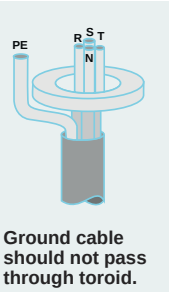
Fig- 11 Use of ground fault relay with undervoltage release in circuit breaker

Breakers:
Even small values (>30mA) of ground fault currents to occur in electrical circuits are quite dangerous in terms of safety of life and fire. As normal breakers cannot detect such small ground fault currents, no additional protection is provided against ground leakages. Ground fault protection system can be added to electronic breakers without an additional mechanism. With this system, protection at (0,1-1)xIn sensitivity can be provided. Protection against ground faults in non-electronic breakers and electronic breakers needing protection against leakage currents lower than the value mentioned above is provided with combination of toroidal transformer and leakage current detection relays. However, in this system, in order to let the circuit breaker open in ground leakage currents, remote-release coil or low voltage coil should have already been mounted to the breaker (Figure-9). Fault current of the fault current detection relay should be adjusted according to protection type and appropriate values to ensure selectivity among other detection relays. According to the standards, this values has been determined as 30mA for life protection and (300-500)mA for fire protection.

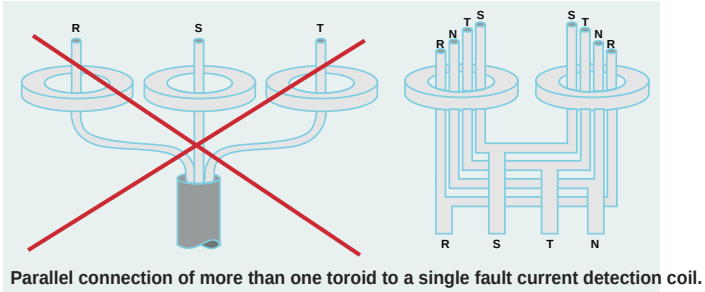
Assembly:
All the phases and neutral cable, if any, shall pass through the toroidal transformer. Ground cable should not pass through the toroidal. Secondary cables of toroidal shall be connected to ground leakage detection relay (Z1-Z2) terminals and appropriate voltage written on the relay is supplied to energy input terminals of the relay. Remote-release coil or low voltage coil must have been connected to the breaker in order to open the circuit breaker due to ground fault. If remote-release coil has been connected to the circuit breaker, energy supplied to opening coil should be supplied through open contact of the ground leakage detection coil normally (Figure-10). If low voltage coil has been connected to the circuit breaker, energy supplied to the low voltage coil should be supplied through upper part of the energy breaker and normally closed contact of the ground leakage detection relay (Figure-11).

Important considerations in assembly:
- Cables should pass through center of the toroidal transformer to the extent possible.
- Toroids with appropriate diameters should be utilized. Utilization of toroids with higher diameters shall reduce sensitivity.

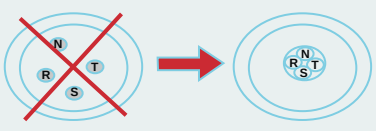
Different Connections:
o If cables cannot pass through a toroid with high diameter, several toroids can be connected parallel to the same ground detection relay. However, this transaction reduces sensitivity of the device and increases opening threshold.
o If it is not possible to place the toroid around primary busbars, it can be placed on neutral-ground connection of the transformer for balanced loads.



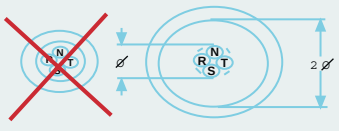
Ground cable should not pass through toroid.



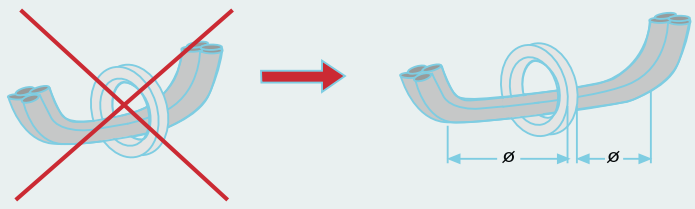
Parallel connection of more than one toroid to a single fault current detection coil.



Cables should be located at center of toroid.



Diameter of toroid should be twice of total cable diameter.



Cables should not be entwisted near toroid.





Type		F01	F02	F10	F11	F11R	F12M	F12	F12R	F21	F22	F31	F32	F33
Rated current - In (40, 50 or 55°C)	A	16,20,25,32,40, 50,63,80,100,125, 160,200,225		16,20,25,32, 40,50,63,80, 100,125			16,20,25,32,40, 50,63,80,100, 125,160			16,20,25,32,40, 50,63,80,100, 125,160		16,20,25,32,40, 50,63,80,100,125, 160,200,225,250		
Number of poles	Quantity	1		3			1, 3, 4			3		3		
Rated operating voltage - Ue (a.c.) 50-60 Hz	V	240		415			415			415		415		
Rated insulation voltage - Ui (a.c.) 50-60 Hz	V	750		750			750			750		750		
Rated impulse withstand voltage - Uimp	kV	8		8			8			8		8		
Test voltage (1 min) (a.c.) 50-60 Hz	V	3.000		3.000			3.000			3.000		3.000		
Rated current adjustment area - I_1	A	Fixed		(0,8-1)In ⑭			(0,8-1)In			(0,7-1)In		(0,7-1)In		
Instant opening current adjustment area - I_2	① A	8xIn		10xIn ⑨			10xIn ⑨			8xIn ⑪		8xIn		
Highest nominal short circuit breaking capacity - Icu	②													
(a.c.) 50-60 Hz 220/240 V	(kA rms)	35	65	25	35	50	35	50	50	50	100	65	85	100
(a.c.) 50-60 Hz 380/415 V	(kA rms)	12	14	20	25	35	25	35	35	25	50	35	50	70
(a.c.) 50-60 Hz 440 V	(kA rms)	-	-	12	16	20	16	20	20	20	42	25	32	40
(a.c.) 50-60 Hz 500 V	(kA rms)	-	-	8	10	12	10	12	12	12	30	18	22	25
(a.c.) 50-60 Hz 690 V	(kA rms)	-	-	-	-	-	-	8	-	8	20	12	13	14
(d.c.) 250 V ③	(kA rms)	10	10	15	20	25	20	25	25	15	15	22	22	22
Nominal operating short circuit breaking capacity - Ics $_{415V\sim}$	④ (kA rms)	%100 (240V~)		%75	%75	%75	%75	%50	%75	%100	%50	%100	%100	%100
Rated short circuit making capacity-Icm 415 V~	kA peak	74	143⑬	32	52	74	52	74	74	53	105	74	105	154
Breaking duration (in short circuit)	ms	<7		<10			<10			<10		<7		
Category (EN 60947-2 / IEC 60947-2)		A		A			A			A		A		
Thermal fixed - magnetic fixed		❐		❒			❒			❒		❒		
Thermal adjusted - magnetic fixed		❒		❐			❐			❐		❐		
Thermal fixed - magnetic adjusted		—		—			—			—		—		
Thermal fixed - magnetic fixed		—		—			—			—		—		
Microprocessor unit (Electronic)		—		—			—			—		—		
Residual current threshold (only for F11R-F12R)	mA	—		30-100-300			30-100-300			—		—		
Time delay (only for F11R-F12R)	ms	—		50-500-800			50-500-800			—		—		
Current limiting		❐		❐			❐			❐		❐		
Mechanical life	Operation	>15.000		>15.000			>15.000			>15.000		>15.000		
Electrical life	Operation	3000		3000			3000			3000		3000		
Weight	kg	0,85		0,9			1			1,3		2,2		
Minimum connection sections ⑤	mm^2	2.5,2.5,4,6,10, 10,16,25,35,50, 70,95,95		2.5,2.5,4,6,10,10 16,25,35,50			2.5,2.5,4,6,10,10 16,25,35,50,70			2.5,2.5,4,6,10,10, 16,25,35,50,70		2.5,2.5,4,6,10,10,16, 25,35,50,70,95,95,120		
Maximum - minimum tightening torque	Nm	10		6			6			6		10		
Undervoltage release ⑧		—		❐			❐			❐		❐		
Shunt trip release ⑧		—		❐			❐			❐		❐		
Auxiliary contact block ⑧		—		❐			❐			❐		❐		
Motor control mechanism		—		—			—			—		❐		
Extended rotary handle		—		—			—			—		❐		
Lock Mechanism with key		—		❐			❐			❐		❐		
Extension bar		❐		❐			❐			❐		❐		
Terminal cover		—		❒			❒			❒		❒		
Inverser (mechanical) lock		—		—			—			—		❐		
Phase seperator		—		❐			❐			❒		❒		
Extension handle		—		—			—			—		—		

- ❒ marked sections are standard, ❐ sections are manufactured upon order.
- ① see technical characteristic tables for products with value.
- ② Icu: O-t-CO test (O : Breaking maneuver, CO : Closing maneuver, t : Waiting duration)
- ③ For serial connected two poles of the breaker.
- ④ Ics : O - t - CO - t - CO test (O : Breaking maneuver, CO : Closing maneuver, t : Waiting duration)
- ⑤ Connection sections are given in accordance with TS EN 60947-1 standard.
- ⑥ F61,F62,F91E,F92E,F101E,F102E,F111E and F112E type circuit breakers are manufactured with long busbar as the standard.








F51	F52	F53	F61	F62	F71	F82	F83	F82E	F83E	F91E	F92E	F101E	F102E	F1 1E	F112E
125,160,200, 225,250,300			300,400		300,400,500, 630,800	400,500,630,800		300,400,500, 630,800		1000,1250		1000,1250,1600		1600,2000,2500	
3 / 4			3		3	3/4		3/4		3/4		3		3	
415			415		415	415		415		415		415		415	
750			750		750	750		750		750		750		750	
8			8		8	8		8		8		8		8	
3.000			3.000		3.000	3.000		3.000		3.000		3.000		3.000	
(0,7-1)In			(0,7-1)In		(0,7-1)In	(0,7-1)In ⑩		(0,4-1)In		(0,4-1)In		(0,4-1)In		(0,4-1)In	
(4-10)In ⑫			(5-10)xIn		(5-8)xIn	(5-8)In		(2-10)I1		(2-10)I1		(2-10)I1		(2-10)I1	
65	85	100	50	75	42	75	100	75	100	80	100	80	100	85	125
35	50	65	35	50	35	50	70	50	70	50	65	50	65	50	65
25	35	50	28	35	30	30	50	35	50	35	45	40	45	35	50
20	25	40	21	25	25	20	42	30	42	25	35	25	35	30	42
14	16	18	14	16	20	20	25	20	25	18	25	20	25	20	25
22	22	22	20	25	20	—	—	—	—	—	—	—	—	—	—
%100	%100	%75	%75	%100	%75	%100	%75	%100	%75	%50	%50	%50	%50	%100	%50
74	105	154	52	74	74	105	154	105	154	74	143	74	143	105	143
<7			<10		<10	<10		<10		<20		<20		<20	
A			A		A	A		A		A		A		A	
❒			❒		❒	❒		❒		❒		❒		❒	
❒			❒		❒	❒		❒		❒		❒		❒	
❒			❒		❒	❒		❒		❒		❒		❒	
❒			❒		❒	❒		❒		❒		❒		❒	
—			—		—	❒		❒		❒		❒		❒	
—			—		—	—		—		—		—		—	
—			—		—	—		—		—		—		—	
❒			❒		—	❒		❒ ⑦		— ⑦		❒ ⑦		❒ ⑦	
>15.000			> 15.000		> 15.000	> 15.000		> 15.000		>15.000		>15.000		> 15.000	
3000			3000		3000	3000		3000		3000		3000		3000	
4,2 / 5,6			5,8		8	9,5 / 13,5		9,5 / 13,5		21 / 28		27		55	
50,70,95,95,120, 185			185,240		185,240,2(30x5), 2(40x5),40x12	240,2(30x5), 2(40x5),40x12		185,240,2(30x5), 2(40x5),40x12		40x15 , 2(40x12)		2(40x10),2(40x15)		80x15 , 2(80x10), 2(80x15)	
25			25		40	40		40		50		50		50	
❒			❒		❒	❒		❒		❒		❒		❒	
❒			❒		❒	❒		❒		❒		❒		❒	
❒			❒		❒	❒		❒		❒		❒		❒	
—			—		❒	❒		❒		❒		❒		❒	
❒			—		❒	❒		❒		❒		—		—	
❒			—		❒	❒		❒		❒		❒		❒	
❒			❒ ⑥		❒	❒		❒		❒ ⑥		❒ ⑥		❒ ⑥	
❒			❒		❒	❒		❒		❒		❒		❒	
—			—		❒	❒		❒		❒		—		❒	
❒			❒		❒	❒		❒		❒		❒		—	
—			❒		❒	❒		❒		❒		❒		❒	

- ⑦ As an additional protection against short circuit currents in federal electronic circuit breakers, mechanical opening mechanism operating with magnetic field of the short circuit current has been planed on each phase. In this way, mechanical opening unit is open in over currents such as short circuit and risk of not opening in case of electronic card failure has been eliminated. This is a great advantage of Federal circuit breakers.
- ⑧ In new type breakers, accessories can be easily mounted by the user by opening the front cover. (Plug-In)
- ⑨ In 16,20,25,32 A, 500A magnetic opening limit is standard.
- ⑩ 800A'de 500-800A thermal adjustment area is standard
- ⑪ Adjustment area for 160A is (0,8-1) In
- ⑫ Adjustment area for 125,160A is (5-10) In
- ⑬ Value at 240V~ for F01 - F02 type breakers
- ⑭ F11R compact type circuit breakers with residual current protection are fixed without thermal adjustment

Network Protection Breakers: Big powerful motor, load with starting resistance don at exist in main networks and lines are quite long. LV circuit breaker should open in short circuit currents to occur by the end of these lines. Therefore, magnetic adjustments of the circuit breakers utilized in main lines should be between (4 - 8)xIn.

Three-phase thermal-magnetic circuit breakers / For protection of main

Nominal current In (A)	Rated current adjustment area I1 (A)	Short circuit opening current I2 (A)	Standard breaking capacity		Medium breaking capacity		High breaking capacity	
			Type	Order code	Type	Order code	Type	Order code
16	(0,8-1)In	500A		9AM-TDS43-0016		9AM-TSS43-0016		-
20	(0,8-1)In	500A		9AM-TDS43-0020		9AM-TSS43-0020		-
25	(0,8-1)In	500A		9AM-TDS43-0025		9AM-TSS43-0025		-
32	(0,8-1)In	500A		9AM-TDS43-0032		9AM-TSS43-0032		-
40	(0,8-1)In	500A	F10	9AM-TDS43-0040	F11	9AM-TSS43-0040	-	-
50	(0,8-1)In	10 In	20kA	9AM-TDS43-0050	25kA	9AM-TSS43-0050		-
63	(0,8-1)In	10 In		9AM-TDS43-0063		9AM-TSS43-0063		-
80	(0,8-1)In	10 In		9AM-TDS43-0080		9AM-TSS43-0080		-
100	(0,8-1)In	10 In		9AM-TDS43-0100		9AM-TSS43-0100		-
125	(0,8-1)In	10 In		9AM-TDS43-0125		9AM-TSS43-0125		-
16	(0,8-1)In	500A		9AR-TSS43-0016		-		-
20	(0,8-1)In	500A		9AR-TSS43-0020		-		-
25	(0,8-1)In	500A		9AR-TSS43-0025		-		-
32	(0,8-1)In	500A		9AR-TSS43-0032		-		-
40	(0,8-1)In	500A		9AR-TSS43-0040		-		-
50	(0,8-1)In	10 In	F12	9AR-TSS43-0050	-	-	-	-
63	(0,8-1)In	10 In	35kA	9AR-TSS43-0063		-		-
80	(0,8-1)In	10 In		9AR-TSS43-0080		-		-
100	(0,8-1)In	10 In		9AR-TSS43-0100		-		-
125	(0,8-1)In	10 In		9AR-TSS43-0125		-		-
160	(0,8-1)In	10 In		9AR-TSS43-0160		-		-
16	(0,7-1)In	200A		9AA-TSS43-0016		-		9AA-THS43-0016
20	(0,7-1)In	200A		9AA-TSS43-0020		-		9AA-THS43-0020
25	(0,7-1)In	200A		9AA-TSS43-0025		-		9AA-THS43-0025
32	(0,7-1)In	8 In		9AA-TSS43-0032		-		9AA-THS43-0032
40	(0,7-1)In	8 In		9AA-TSS43-0040	-	-	F22	9AA-THS43-0040
50	(0,7-1)In	8 In	F21	9AA-TSS43-0050		-	50kA	9AA-THS43-0050
63	(0,7-1)In	8 In	25kA	9AA-TSS43-0063		-		9AA-THS43-0063
80	(0,7-1)In	8 In		9AA-TSS43-0080		-		9AA-THS43-0080
100	(0,7-1)In	8 In		9AA-TSS43-0100		-		9AA-THS43-0100
125	(0,7-1)In	8 In		9AA-TSS43-0125				9AA-THS43-0125
160	(0,8-1)In	8 In		9AA-TSS43-0160		-		9AA-THS43-0160
16	(0,7-1)In	200A		9AB-TSS43-0016		9AB-TMS43-0016		9AB-THS43-0016
20	(0,7-1)In	200A		9AB-TSS43-0020		9AB-TMS43-0020		9AB-THS43-0020
25	(0,7-1)In	200A		9AB-TSS43-0025		9AB-TMS43-0025		9AB-THS43-0025
32	(0,7-1)In	8 In		9AB-TSS43-0032		9AB-TMS43-0032		9AB-THS43-0032
40	(0,7-1)In	8 In		9AB-TSS43-0040		9AB-TMS43-0040		9AB-THS43-0040
50	(0,7-1)In	8 In		9AB-TSS43-0050		9AB-TMS43-0050		9AB-THS43-0050
63	(0,7-1)In	8 In		9AB-TSS43-0063	F32	9AB-TMS43-0063	F33	9AB-THS43-0063
80	(0,7-1)In	8 In	F31	9AB-TSS43-0080	50kA	9AB-TMS43-0080	70kA	9AB-THS43-0080
100	(0,7-1)In	8 In	35kA	9AB-TSS43-0100		9AB-TMS43-0100		9AB-THS43-0100
125	(0,7-1)In	8 In		9AB-TSS43-0125		9AB-TMS43-0125		9AB-THS43-0125
160	(0,7-1)In	8 In		9AB-TSS43-0160		9AB-TMS43-0160		9AB-THS43-0160
200	(0,7-1)In	8 In		9AB-TSS43-0200		9AB-TMS43-0200		9AB-THS43-0200
225	(0,7-1)In	8 In		9AB-TSS43-0225		9AB-TMS43-0225		9AB-THS43-0225
250	(0,7-1)In	8 In		9AB-TSS43-0250		9AB-TMS43-0250		9AB-THS43-0250
125	(0,7-1)In	(5-10) In				9AD-TMS43-0200		9AD-THS43-0200
160	(0,7-1)In	(5-10) In				9AD-TMS43-0225		9AD-THS43-0225
200	(0,7-1)In	(5-10) In	F51	9AD-TSS43-0200	F52	9AD-TMS43-0250	F53	9AD-THS43-0250
225	(0,7-1)In	(4-10) In	35kA	9AD-TSS43-0225	50kA	9AD-TMS43-0300	70kA	9AD-THS43-0300
250	(0,7-1)In	(4-10) In		9AD-TSS43-0250				
300	(0,7-1)In	(4-10) In		9AD-TSS43-0300				
300	(0,7-1)In	(5-10) In	F61	9AP-TSS43-0300	F62	9AP-TMS43-0300	-	-
400	(0,7-1)In		35kA	9AP-TSS43-0400	50kA	9AP-TMS43-0400		-
300	(0,7-1)In			9AF-TSS43-0300		-		-
400	(0,7-1)In			9AF-TSS43-0400		-		-
500	(0,7-1)In	(5-8) In	F71	9AF-TSS43-0500	-	-	-	-
630	(0,7-1)In		35kA	9AF-TSS43-0630		-		-
800	(0,7-1)In			9AF-TSS43-0800		-		-
400	(0,7-1)In			-		9AG-TMS43-0400		9AG-THS43-0400
500	(0,7-1)In	(5-8) In		-	F82	9AG-TMS43-0500	F83	9AG-THS43-0500
630	(0,7-1)In			-	50kA	9AG-TMS43-0630	70kA	9AG-THS43-0630
800	(0,6-1)In			-		9AG-TMS43-0800		9AG-THS43-0800

Generator Circuit Protection Breakers: As the short circuit current to occur in the generators is at very low values, magnetic adjustments of the circuit breaker to be used for protection of generators should be (3 - 5)xIn

Three-phase thermal-magnetic circuit breakers / For protection of generator circuits :

Nominal current In (A)	Rated current adjustment area I1 (A)	Short circuit opening current I2 (A)	Standard breaking capacity		Medium breaking capacity		High breaking capacity	
			Type	Order code	Type	Order code	Type	Order code
16	(0,7-1)In	160A		9AA-TSJ43-0016		-		9AA-THJ43-0016
20	(0,7-1)In	160A		9AA-TSJ43-0020		-		9AA-THJ43-0020
25	(0,7-1)In	160A		9AA-TSJ43-0025		-		9AA-THJ43-0025
32	(0,7-1)In	160A		9AA-TSJ43-0032		-		9AA-THJ43-0032
40	(0,7-1)In	5 In	**F21** 25kA	9AA-TSJ43-0040	-	-	**F22** 50kA	9AA-THJ43-0040
50	(0,7-1)In	5 In		9AA-TSJ43-0050		-		9AA-THJ43-0050
63	(0,7-1)In	5In		9AA-TSJ43-0063		-		9AA-THJ43-0063
80	(0,7-1)In	4 In		9AA-TSJ43-0080		-		9AA-THJ43-0080
100	(0,7-1)In	4 In		9AA-TSJ43-0100		-		9AA-THJ43-0100
125	(0,7-1)In	4 In		9AA-TSJ43-0125		-		9AA-THJ43-0125
160	(0,8-1)In	4 In		9AA-TSJ43-0160				9AA-THJ43-0160
16	10-16	160A		9AB-TSJ43-0016		9AB-TMJ43-0016		9AB-THJ43-0016
20	16-20	160A		9AB-TSJ43-0020		9AB-TMJ43-0020		9AB-THJ43-0020
25	20-25	160A		9AB-TSJ43-0025		9AB-TMJ43-0025		9AB-THJ43-0025
32	25-32	160A		9AB-TSJ43-0032		9AB-TMJ43-0032		9AB-THJ43-0032
40	32-40	5 In		9AB-TSJ43-0040		9AB-TMJ43-0040		9AB-THJ43-0040
50	40-50	5 In		9AB-TSJ43-0050		9AB-TMJ43-0050		9AB-THJ43-0050
63	50-63	5In	**F31** 35kA	9AB-TSJ43-0063	**F32** 50kA	9AB-TMJ43-0063	**F33** 70kA	9AB-THJ43-0063
80	63-80	4 In		9AB-TSJ43-0080		9AB-TMJ43-0080		9AB-THJ43-0080
100	80-100	4 In		9AB-TSJ43-0100		9AB-TMJ43-0100		9AB-THJ43-0100
125	100-125	4 In		9AB-TSJ43-0125		9AB-TMJ43-0125		9AB-THJ43-0125
160	125-160	4 In		9AB-TSJ43-0160		9AB-TMJ43-0160		9AB-THJ43-0160
200	160-200	4 In		9AB-TSJ43-0200		9AB-TMJ43-0200		9AB-THJ43-0200
225	180-225	4 In		9AB-TSJ43-0225		9AB-TMJ43-0225		9AB-THJ43-0225
250	200-250	4 In		9AB-TSJ43-0250		9AB-TMJ43-0250		9AB-THJ43-0250

Short circuit current of a generator

Srg rated power (kVA)
Ur rated voltage (V)
Ikg short circuit current (A)
Irg rated current (A)
Xd% temporary reactance (%)
(Reactance observed around 5-20% of the impedance value for 5-30 ms)

Is calculated with the following formula.

$$I_{kg} = \frac{I_{rg} \cdot 100}{X''_d\,\%} \qquad I_{rg} = \frac{S_{rg}}{\sqrt{3} \cdot U_r}$$

Circuit breakers should be selected according to the following formula in order to protect the generator circuits.

For single generator Icu ⩾ Ikg
For n pieces of identical generator connected parallel, Icu ⩾ Ikg x (n-1)
For generator connected to network parallel, Icu ⩾ Iknet.

Generator			Breaker
kVa	kW	A	A
9.4	7.5	13.6	16
12.5	10	18.2	20
18.7	15	27.3	32
25	20	36.4	40
31.3	25	45.5	50
37.5	30	54.6	63
50	40	73	80
62.5	50	91	100
75	60	109	125
100	80	146	160
125	100	182	200
156	125	228	250
187	150	273	300
250	200	364	400
312	250	455	500
375	300	546	630
500	400	730	800
625	500	910	1000
750	600	1090	1250
1000	800	1460	1600
1250	1000	1820	2000
1563	1250	2280	2500

Motor Circuit Protection Breakers: Motors draw very high current for a short time during first start-up. In order to ensure operating continuity and to protect the system, magnetic adjustment area of the breaker to be selected should be (8 - 12)xIn.

Three-phase thermal-magnetic circuit breakers For protection of motor circuits:

Nominal current In (A)	Rated current adjustment area I1 (A)	Short circuit opening current I2 (A)	Standard breaking capacity		Medium breaking capacity		High breaking capacity	
			Type	Order code	Type	Order code	Type	Order code
16	0-16	200	F21 25kA	9AA-TSM43-0016	-	-	F22 35kA	9AA-THM43-0016
20	16-20	200		9AA-TSM43-0020		-		9AA-THM43-0020
25	20-25	250		9AA-TSM43-0025		-		9AA-THM43-0025
32	25-32	320		9AA-TSM43-0032		-		9AA-THM43-0032
40	32-40	400		9AA-TSM43-0040		-		9AA-THM43-0040
50	40-50	500		9AA-TSM43-0050		-		9AA-THM43-0050
63	50-63	630		9AA-TSM43-0063		-		9AA-THM43-0063
80	63-80	800		9AA-TSM43-0080		-		9AA-THM43-0080
100	80-100	1000		9AA-TSM43-0100		-		9AA-THM43-0100
125	100-125	1250		9AA-TSM43-0125		-		9AA-THM43-0125
160	125-160	1600		9AA-TSM43-0160				9AA-THM43-0160
16	110-16	200	F31 35kA	9AB-TSM43-0016	F32 50kA	9AB-TMM43-0016	F33 70kA	9AB-THM43-0016
20	16-20	200		9AB-TSM43-0020		9AB-TMM43-0020		9AB-THM43-0020
25	20-25	250		9AB-TSM43-0025		9AB-TMM43-0025		9AB-THM43-0025
32	25-32	320		9AB-TSM43-0032		9AB-TMM43-0032		9AB-THM43-0032
40	32-40	400		9AB-TSM43-0040		9AB-TMM43-0040		9AB-THM43-0040
50	40-50	500		9AB-TSM43-0050		9AB-TMM43-0050		9AB-THM43-0050
63	50-63	630		9AB-TSM43-0063		9AB-TMM43-0063		9AB-THM43-0063
80	63-80	800		9AB-TSM43-0080		9AB-TMM43-0080		9AB-THM43-0080
100	80-100	1000		9AB-TSM43-0100		9AB-TMM43-0100		9AB-THM43-0100
125	100-125	1250		9AB-TSM43-0125		9AB-TMM43-0125		9AB-THM43-0125
160	125-160	1600		9AB-TSM43-0160		9AB-TMM43-0160		9AB-THM43-0160
200	160-200	2000		9AB-TSM43-0200		9AB-TMM43-0200		9AB-THM43-0200
225	180-225	2250		9AB-TSM43-0225		9AB-TMM43-0225		9AB-THM43-0225
250	200-250	2500		9AB-TSM43-0250		9AB-TMM43-0250		9AB-THM43-0250

Motor Power		Motor Rated Current	Breaker Rated Current
(kW)	(Hp)	(A)	(A)
5,5	7,5	11,5	16
9	12	18,5	20
11	15	22,5	25
15	20	30	32
18,5	25	36	40
22	30	43	50
30	40	58	63
37	50	72	80
40	54	79	100
51	70	98	100
59	80	112	125
80	110	147	160
100	136	188	200
132	175	243	250
140	190	260	300
160	220	292	300
200	270	368	400
250	340	465	500
315	430	580	630

Note: These circuit breakers provide short circuit protection. Overload protection should be provided via thermal relays connected to the contactors

Three-phase electronic circuit breakers :

Nominal current In (A)	Rated current adjustment area I1 (A)	Short circuit opening current I2 (A)	Medium breaking capacity		High breaking capacity	
			Type	Order code	Type	Order code
300	120-300	(2-10)xI1	F82E 50kA	9AG-EMS43-0300	F83E 70kA	9AG-EHS43-0300
400	160-400			9AG-EMS43-0400		9AG-EHS43-0400
500	200-500			9AG-EMS43-0500		9AG-EHS43-0500
630	250-630			9AG-EMS43-0630		9AG-EHS43-0630
800	320-800			9AG-EMS43-0800		9AG-EHS43-0800
1000	400-1000	(2-10)xI1	F91E 50kA	9AG-EMS43-1000	F92E 65kA	9AG-EHS43-1000
1250	500-1250			9AG-EMS43-1250		9AG-EHS43-1250
1000	400-1000	(2-10)xI1	F101E 50kA	9AI-EMS43-1000	F102E 65kA	9AI-EHS43-1000
1250	500-1250			9AI-EMS43-1250		9AI-EHS43-1250
1600	640-1600			9AI-EMS43-1600		9AI-EHS43-1600
1600	640-1600	(2-10)xI1	F111E 50kA	9AG-EMS43-1600	F112E 65kA	9AG-EHS43-1600
2000	800-2000			9AG-EMS43-2000		9AG-EHS43-2000
2500	1000-2500			9AG-EMS43-2500		9AG-EHS43-2500

Delay time of the short circuit opening current (when required) can be adjusted as t2 : 100-150-200-250-300-350-400 ms..

Mono-phase thermal-magnetic circuit breakers:

Nominal current In (A)	Rated current adjustment area I1 (A)	Short circuit opening current I2 (A)	Standard breaking capacity		High breaking capacity	
			Type	Order code	Type	Order code
16	10-16	160	F01 12kA	9AB-TSS41-0016	F02 14kA	9AB-THS43-0016
20	16-20	160		9AB-TSS41-0020		9AB-THS43-0020
25	20-25	200		9AB-TSS41-0025		9AB-THS43-0025
32	25-32	250		9AB-TSS41-0032		9AB-THS43-0032
40	32-40	320		9AB-TSS41-0040		9AB-THS43-0040
50	40-50	400		9AB-TSS41-0050		9AB-THS43-0050
63	50-63	500		9AB-TSS41-0063		9AB-THS43-0063
80	63-80	800		9AB-TSS41-0080		9AB-THS43-0080
100	80-100	800		9AB-TSS41-0100		9AB-THS43-0100
125	100-125	1000		9AB-TSS41-0125		9AB-THS43-0125

Impact of ambient temperature on rated operating current of the circuit breaker:
Values in the chart show the highest operating currents to be applied as a function of the ambient temperature. Increase in ambient temperature of the breaker shall result in decrease in allowed operating current of the breaker. Therefore, by considering the ambient temperature of the breaker, the rated current should be calibrated according to ambient temperature or the circuit breaker should be selected according to operating currents suitable for the value in the table. If the breaker is operated in an environment with a temperature higher than the calibrated ambient temperature, it opens earlier than the nominal values. If it is operated in a colder environment, it opens later than the nominal values.

In(A)	20°C	30°C	40°C	50°C	60°C
Thermal-Magnetic Circuit Breakers					
16	17,1	16,6	16,0	15,2	14,6
20	21,4	20,8	20,0	19,0	18,2
25	26,7	26,0	25,0	23,8	22,8
32	34,2	33,3	32,0	30,4	29,1
40	42,8	41,6	40,0	38,0	36,4
50	53,5	52,0	50,0	47,5	45,5
63	67,4	65,5	63,0	59,9	57,3
80	85,6	83,2	80,0	76,0	72,8
100	107,0	104,0	100,0	95,0	91,0
125	133,8	130,0	125,0	118,8	113,8
160	171,2	166,4	160,0	152,0	145,6
200	214,0	208,0	200,0	190,0	182,0
200	240.8	234,0	225,0	213,8	204,8
250	267.5	260,0	250,0	237,5	227,5
300	321.0	312,0	300,0	285,0	273,0
400	428.0	416,0	400,0	380,0	364,0
500	535.0	520,0	500,0	475,0	455,0
630	674.1	655,2	630,0	598,5	573,3
800	856.0	832,0	800,0	760,0	728,0

Example: Highest operating current of an F31 type circuit breaker with 100 A rated current calibrated to 40°C would be 95 A in an environment of 50°C.

Utilization of Circuit Breakers in Direct Current Circuits:
Non-electronic thermal-magnetic circuit breakers can be safely used in switching of DC currents.
As it is seen in Figure-12, 2 or 3 poles are connected serially for voltages higher than 250V and voltage per pole is reduced.

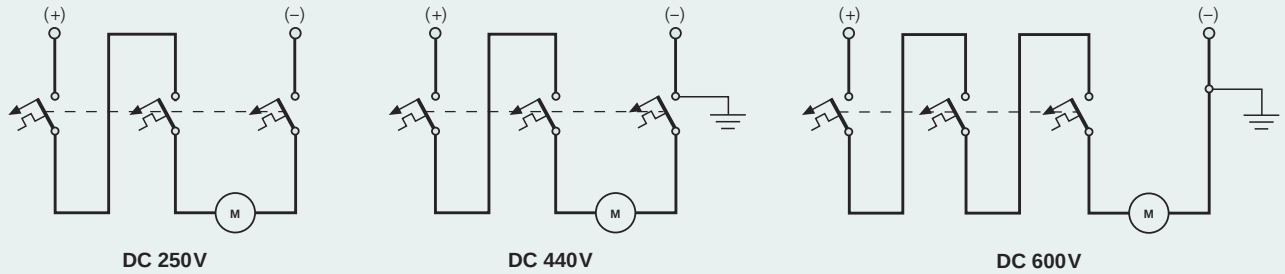


Fig-12

Breaker Selection Table Used for Protection of 3-Phase Capacitor Circuits:
(400 V, for Ambient Temperature 40°C)

Capacitor		Breaker
Power (kVAr)	Rated Current (A)	Rated Current In (A)
5	7.6	**16**
10	15.2	**25**
15	22	**40**
20	29	**63**
25	36	**80**
30	43	**100**
40	58	**100**
50	72	**125**
60	87	**125**
80	115	**160**
100	144	**200**
150	216	**300**
200	288	**400**
250	361	**500**
300	433	**630**
350	505	**800**
400	577	**800**
500	722	**1000**
550	793	**1250**
600	866	**1250**

Circuit breakers protecting capacitor circuits :
They should resist temporary currents during enablement and disablement of the capacitors.
They should resist currents at 15% more than capacity value and periodical and permanent over currents arising due to voltage harmonics.
They should have high mechanical and electrical life.
They should be selected to protect contactors after them.
They should break short circuit currents to occur in capacitor connectors.

According to IEC 60831-1 standard

Capacitors can operate continuously at currents 1.3 times more than rated currents and capacity value can be 15% more.

Accordingly, the highest current to pass through the circuit can reach 1,5 x Irc.

Icmax = 1.3 x 1.15 x Irc

Icmax : Maximum current to pass through the capacitor
Irc : Capacitor rated current

Therefore

Rated current of the circuit breaker to be selected should be higher than 1.5 x Irc.
Thermal adjustment should be at 1.5 x Irc value.
Magnetic adjustment should not be lower than 15 x Irc.

Breakers Used in LV Main Distribution Panels of Distribution Transformers:
(up to 36kV voltage)

Transformer power Sn (kVA)	Nominal current In (A)	Breaker rated current In (A)	Short circuit current Usc (%)	3-phase short circuit current Isc (rms) (A)
40	58	63	4,5	1283
50	72	80	4,5	1603
63	91	100	4,5	2020
80	115	125	4,5	2566
100	144	160	4,5	3207
125	180	200	4,5	4009
160	231	250	4,5	5132
200	289	300	4,5	6415
250	361	400	4,5	8019
315	455	500	4,5	10103
400	578	630	4,5	12830
500	723	800	4,5	16038
630	910	1000	4,5	20207
800	1156	1250	6	19245
1000	1445	1600	6	24057
1250	1805	2000	6	30071
1600	2312	2500	6	38491
2000	2900	3000	6	48113
2500	3600	4000	6	60142

Example: Rated current of the primary circuit breaker to be connected to the main distribution panel of a 1600 kVA transformer should be 2500A; short circuit breaking capacitor should be at least 50 kA. Short circuit breaking capacities of breakers at secondary outputs should be selected to be at least 50 kA.

Highest short circuit current of a distribution transformer on load side:
Tri-phase short circuit current of a transformer, with 36kV medium voltage side and 0.4kV output side, between low voltage ends is found with the following formula.

Sn : Nominal power of the transformer (kVA)
In : Rated current of the transformer (A)
Un : Output voltage between phases when transformer is unloaded (V)
Usc : Short circuit voltage of the transformer (%)
Isc : 3-phase maximum short circuit current at secondary side of the transformer (rms) (A)

$$Isc(rms) = \frac{S \times 100}{1{,}73 \times Un \times Usc}$$

Example:
What would be the continuous short circuit current when (Un: 400 V, Usc: %4,5) secondary of 630 kVA transformer is subject to short circuit?

$$Isc\ (rms) = \frac{630 \times 100}{1{,}73 \times 400 \times 4{,}5}$$

$$= 20207\ A$$

Calculation of short circuit at any point of the line:

$$I_{sc} = \frac{Un}{\sqrt{3}.\sqrt{Rt^2 + Xt^2}} \text{ (kA)}$$

Rt: Total resistance (mΩ)
Xt: Total reactance (mΩ)

Note: Rms value is an expression used in alternative voltage and current measurement and this value is the AC (alternative current) value equivalent to effective or DC (direct current) value. For example, AC voltage giving light amount of a lamp, on which 12V DC voltage is applied, is called 12V ACrms voltage. AC rms value = AC peak value / 1.41

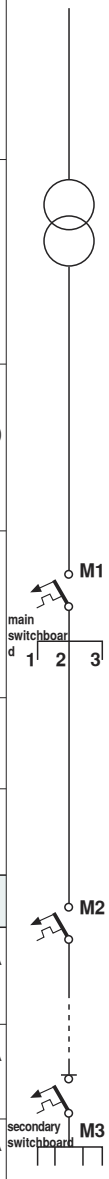
Detailed calculation of short circuit at any point of the facility :

Facility zone	Resistance (mΩ)	Reactance (mΩ)
At network side	$R_1=Z_1 \times \cos\varphi \times 10^{-3}$ $\cos\varphi = 0.15$ $Z_1=\frac{U^2}{P_1}$ (Network impedance of the interconnected system)	$X_1=Z_1 \times \sin\varphi \times 10^{-3}$ $\sin\varphi = 0.98$
Transformer	$R_2=\frac{Pc \times U^2}{S^2} \times 10^{-3}$ Pc=cupper loss (W) S=apparent power of transformer (kVA)	$X_2=\sqrt{Z_2^2-R_2^2}$ $Z_2=\frac{Usc}{100} \times \frac{U^2}{S}$ Z_2= impedance of transformer
Cables (1)	$R_3=\frac{L}{k.S} \times 10^3$ k=56 (Cu) or 36 (Al) k=self-conductivity $\left(\frac{m}{\Omega mm^2}\right)$	X_3=0.07L (tri-phase cables) X3=0.15L (mono-phase cables) L : cable length (m) S : cable section (mm^2)
Busbars	$R_3=\frac{L}{k.S} \times 10^3$ k=56 (Cu) veya 36 (Al) k=self-conductivity $\left(\frac{m}{\Omega mm^2}\right)$	X_3=0.15 L L : busbar lenght (m) S : busbar section (mm^2)
Circuit breaker	R_4 negligible	X_4 negligible

Calculation of short circuit currents (kA)

	Resistance (mΩ)	Reactance (mΩ)	Short circuit current (kA)
M1	$Rt_1=R_1+R_2+R_3$ $Rt_1=2.61$	$Xt_1=X_1+X_2+X_3$ $Xt_1=12.2$	$\frac{400}{\sqrt{3}\sqrt{(2.61^2+12.2^2)}}$ =18.52kA
M2	$Rt_2=Rt_1+R_4+R_5$ $Rt_2=2.71$	$Xt_2=Xt_1+X_4+X_5$ $Xt_2=12.65$	$\frac{400}{\sqrt{3}\sqrt{(2.71^2+12.65^2)}}$ =17.86kA
M3	$Rt_3=Rt_2+R_6+R_7$ $Rt_3=9.46$	Xt3=Xt2+X6+X7 $Xt_3=17.55$	$\frac{400}{\sqrt{3}\sqrt{(9.46^2+17.55^2)}}$ =11.58kA

(1) If there are more than one parallel cable per phase, divide resistance and reactance of one cable into number of cables.



Facility zone	Resistance (mΩ)	Reactance (mΩ)
network side P1=500 MVA	$R_1=\frac{400^2}{500} \times 0.15 \times 10^{-3}$ R_1=0.05 mΩ	$X_1=\frac{400^2}{500} \times 0.98 \times 10^{-3}$ X_1=0.31 mΩ
Transformer S=800 kVA Usc=%6 U=400 V Pc=9700 W	$R_2=\frac{9700 \times 400^2 \times 10^{-3}}{800^2}$ R_2=2.42 mΩ	$X_2=\sqrt{\left(\frac{6}{100} \times \frac{400^2}{800}\right)^2-(2.42)^2}$ X_2=11.75 mΩ
Connection cables From transformer to Circuit breaker 2 (3x240) mm2 Copper per phase L=4 m	$R_3=\frac{4 \times 10^3}{56 \times 240 \times 2}$ R_3=0.14 mΩ	$X_3=0.07 \times \frac{4}{2}$ X_3=0.14 mΩ
circuit breaker	R_4=0	X_4=0
output busbar no2 (Al) 10x80 mm2 Per phase L=3 m	$R_5=\frac{3 \times 10^3}{36 \times 800}$ R_5=0.10 mΩ	X_5=0.15 x 3 X_5=0.45 mΩ
circuit breaker	R_6=0	X_6=0
Connection between secondary panel and primary low voltage panel (cables)(3x185 mm copper per phase L= 70 m	$R_7=\frac{70 \times 10^3}{56 \times 185}$ R_7=6.75 mΩ	X_7=0.07 x 70 X_7=4.9 mΩ

Calculation of short circuit at any point of the network:
The following tables allow fast calculation of the short circuit current at any point in the network, if short circuit current at network side, cable section, type and length are known.

Reading of diagram:
Cable section and short circuit current on network side is marked in the table. Cable length is found on the cable section row. Cable length and short circuit current at network side are intersected and marked. This value gives the short circuit current to occur at the end of the cable.

380 V										
Cable (mm^2) Cu	Al	Cable length (m)								
1,5	2,5	—	—	—	1	—	—	2	—	3
2,5	4	—	—	1	—	—	2	3	4	5
4	6	—	1	—	—	2	3	4	6	8
6	10	1	—	—	2	3	4	6	9	12
10	16	1	2	—	3	5	7	10	15	20
16	25	2	—	3	5	8	11	16	24	32
25	35	3	4	5	8	13	18	25	38	50
35	50	4	5	7	11	18	25	35	53	70
50	70	5	8	10	15	25	35	50	75	100
70	120	7	11	14	21	35	49	70	105	140
95	150	10	14	19	29	48	67	95	143	190
120	185	12	18	24	36	60	84	120	180	240
150	240	13	20	26	39	65	91	130	195	260
185	300	15	23	30	46	77	108	154	231	308
240		19	28	38	57	96	136	192	283	284
300		24	36	48	72	120	168	240	360	480
Isc network (kA)		Isc Short circuit current at Isc load side (kA)								
100		65	51	42	30	19	14	10	7	5
90		62	49	41	29	19	14	10	7	5
80		58	47	39	29	18	13	10	7	5
70		52	44	37	28	18	13	10	6	5
60		47	40	35	27	18	13	9	6	5
50		41	36	32	25	17	13	9	6	5
45		38	34	30	24	17	13	9	6	5
40		35	32	28	23	16	13	9	6	5
35		31	28	26	21	16	12	9	6	5
30		27	25	23	20	15	12	9	6	5
25		23	22	20	18	14	11	9	6	5
22		21	20	19	18	13	11	9	6	5
15		14	14	13	12	11	9	7	6	4
10		10	10	9	9	8	7	6	5	4
7		7	7	7	6	6	5	5	4	3
5		5	5	5	5	5	4	4	3	3
4		4	4	4	4	4	3	3	3	2

415 V										
Cable (mm^2) Cu	Al	Cable length (m)								
1,5	2,5	—	—	—	—	1	—	2	3	5
2,5	4	—	—	—	1	2	3	4	5	8
4	6	—	—	1	2	3	4	6	8	12
6	10	—	1	2	3	4	6	9	13	19
10	16	—	2	3	5	7	10	15	20	30
16	25	2	3	5	8	11	16	24	32	48
25	35	4	5	8	13	17	25	38	50	75
35	50	5	7	11	18	24	35	53	70	105
50	70	9	12	18	30	42	60	89	120	179
70	120	11	15	23	38	53	75	113	151	226
95	150	14	19	29	48	66	95	143	190	285
120	185	18	24	36	60	84	120	180	240	360
150	240	19	26	39	65	91	130	195	260	391
185	300	23	30	46	77	107	154	231	308	462
240		28	38	57	96	134	192	288	384	576
300		36	48	72	120	168	240	360	480	720
Isc network (kA)		Isc Short circuit current at Isc load side (kA)								
100		45	40	25	20	12	8	5	4	3
90		45	35	25	20	12	8	5	4	3
80		45	35	25	15	12	8	5	4	3
70		40	35	25	15	12	8	5	4	3
60		40	35	25	15	12	8	5	4	3
50		35	30	25	15	12	8	5	4	3
45		35	30	25	15	12	8	5	4	3
40		30	30	25	15	12	8	5	4	3
35		30	25	20	15	10	8	5	4	3
30		25	25	20	15	10	7	5	4	3
25		25	20	20	12	10	7	5	4	3
22		22	20	17	12	10	7	5	4	3
15		15	15	12	10	8	6	5	4	3
10		10	10	10	8	7	6	4	3	2
7		7	6	6	6	5	4	4	3	2
5		5	5	4	4	4	3	3	2	2
4		4	4	4	3	3	3	2	2	2

Example:
A value (67m) lower than 70 m cable length is selected on the row corresponding to 95 mm^2 cable (Cu) section in 380V panel. Short circuit current to occur is found as 11 kA by intersection this column with the row giving a higher value (Isc: 22 kA) of the 20 kA short circuit current at network direction. Short circuit breaking capacity of the circuit breaker to be used at this point should be higher than (Icu) 11 kA.

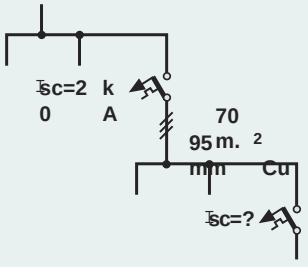


Fig-13

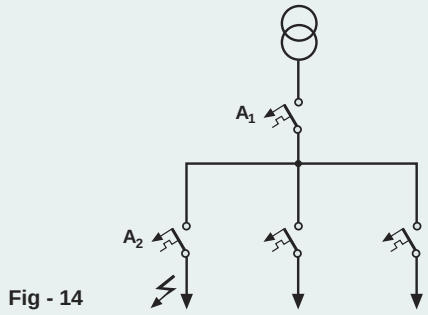


Fig - 14

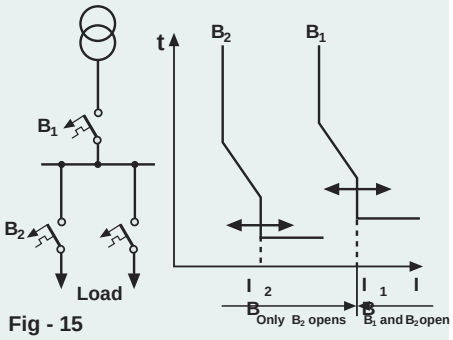


Fig - 15

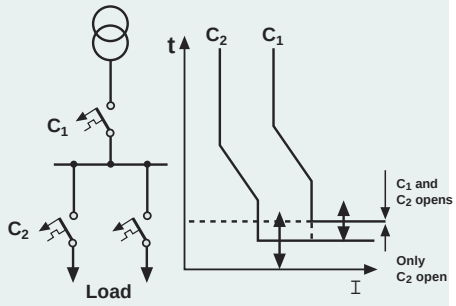
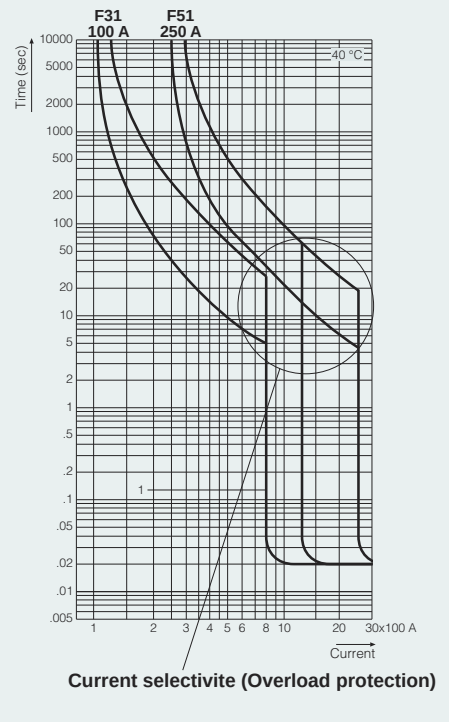


Fig - 16



Current selectivite (Overload protection)

Selectivity:
When there is a fault at any point within the network, coordination of the automatic protection elements, which eliminates the fault only via the protection device located on the top or near the fault, is called selectivity. For example, when there is a fault in the load side controlled by A2 circuit breaker due to any reason such as over load or short circuit, if A2 is opened first and A1 remains closed, there is full selectivity for this system (Figure-14). If the above-mentioned condition cannot be met to the nominal short circuit current, there is partial selectivity. Selectivity ensures operating continuity, which is mandatory at many industrial, commercial or similar facilities. Selectivity is ensured with opening current (I1) and opening time (t) parameters of the circuit breaker. These are;

Current Selectivity:
Let suppose that IB1 rated current of B1 circuit breaker is higher than IB2 rated current of B2 circuit breaker in Figure-15. B2 circuit breaker opens the circuit in fault currents lower than IB1 current to provide current selectivity. This selectivity may be upgraded to full selectivity by using a circuit breaker with current limiter in B2. Because, limiter breakers limit the short circuit current and open the circuit in a very short time (less than 10 ms). That is, selectivity should be provided both in over loads and in short circuits.

Time Selectivity:
Thanks to short-time delay adjustment of the circuit breaker, selectivity is provided by comparing opening times with other breakers in the system. As it is seen in Figure-16, operating curves of C1 and C2 breakers are intersected and delay time adjustment of C1 breaker is increased according to C2 breaker to provide selectivity. Here, C1 circuit breaker should have an electrodynamic resistance in compliance with the resistance current during short-time delay. It should be like delay (at transformer side) > delay (load side).

Selectivity Chart:
Selectivity chart shows the current values at which the circuit breaker closest to the load shall open. Combinations providing selectivity are shown in dark areas. Within these areas, thermal and magnetic opening curves of the circuit breakers at transformer and load sides have been designed to avoid intersections. That is, selectivity tables have been arranged to have the maximum instant opening current of the breaker at the network side at 1.5 times or more than the instant opening current of the breaker at the load side.

I_2 = Short circuit tripping current of circuit breaker (A)

$$\frac{I_2 \text{ (On transformer side)}}{I_2 \text{ (On load side)}} \geq 1,5$$

Selectivity Limit:
This is the current value at which both protection elements shall open at the same time when selectivity limit is exceeded. Selectivity limit currents in the tables have been given as the top limit of the short circuit opening current of the circuit breaker at the network side.

Current Time Curve of 400A NH Fuse with 400A Circuit Breaker:
A circuit breaker, in accordance with EN 60947-2 standard:
Should operate without opening for 2 hours at 1,05xIn,
Should open within 2 hours at 1,3xIn.
In practice, this time is adjusted as, 5-10 minutes.
However a NH fuse, in accordance with EN 60269-1 standard:
Should operate without opening for 3 hours at 1,25xIn.
Should open within 3 hours at 1,6xIn.
Accordingly, a circuit breaker opens earlier than NH Fuses in over currents and provides better protection especially in over currents. (Figure - 17)
NH fuses are protection devices which mainly provide protection against short circuit.

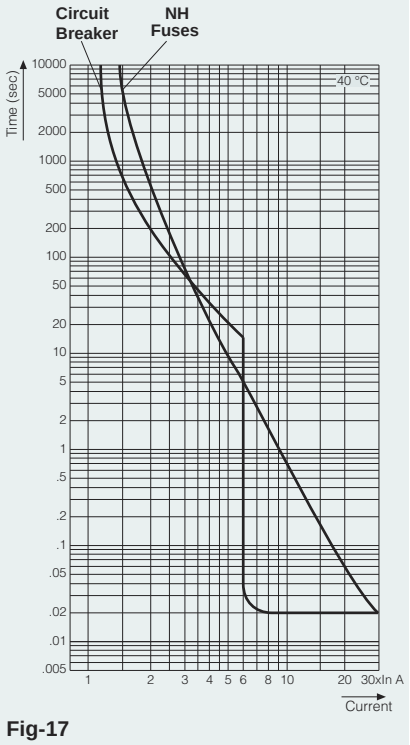
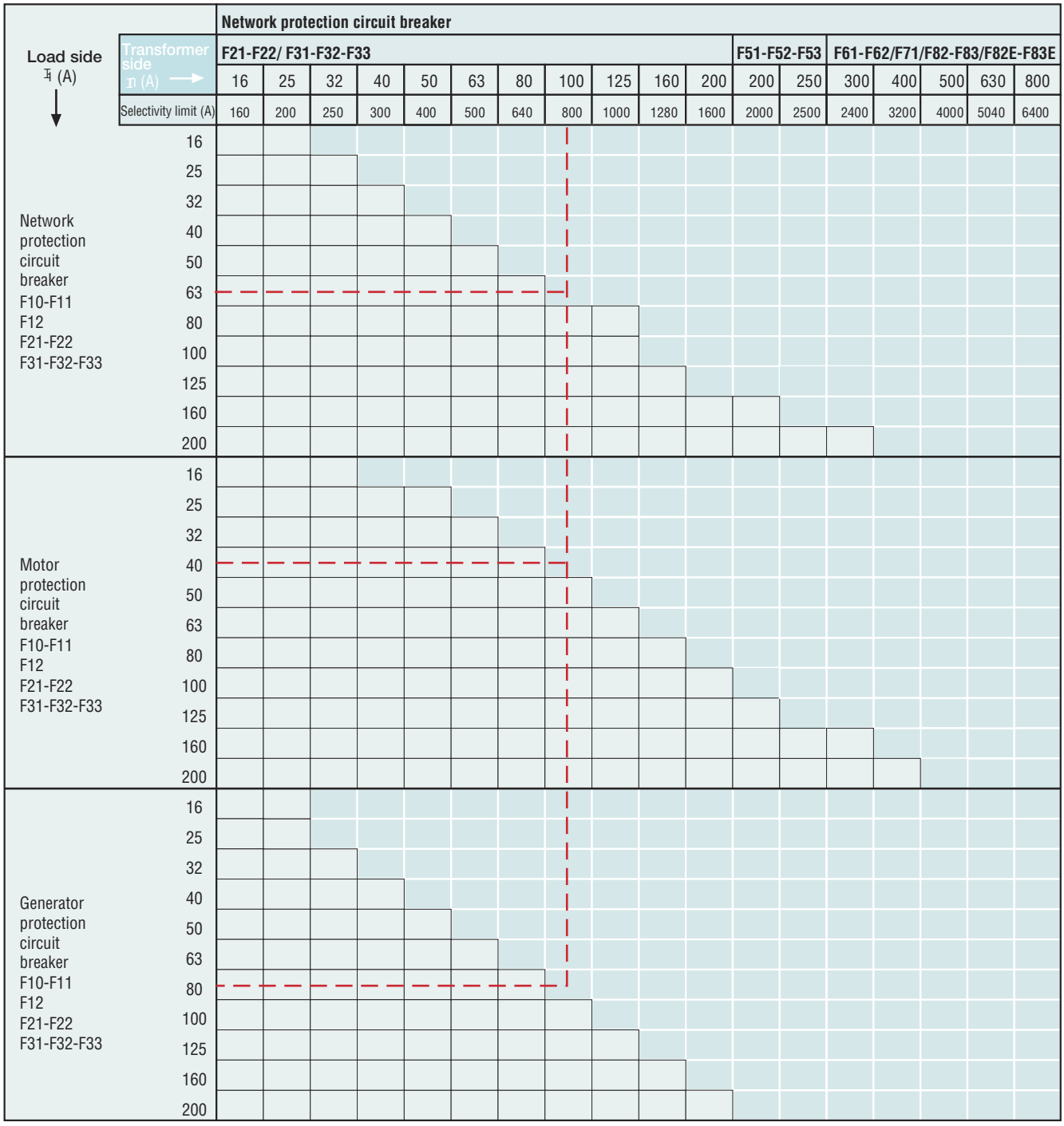


Fig-17
Current Time Curve of 400A NH Fuse with 400A Circuit Breaker



Example :
If there is a network protection circuit breaker with 100 A nominal current at the transformer side, the following circuit breakers should be utilized at the secondary outputs (load side) right below the breaker to provide full selectivity;

Network protection : maximum 63 A
Motor protection : maximum 40 A
Generator protection: maximum 80 A

Load side I_1 (A) ↓	Transformer side I_n (A) →	Network protection circuit breaker											
		F51-F52-F53		F61-F62/F71/F82-F83/F82E-F83E					F91E-F92E F101E-F102E		F111E-F112E		
		200	250	300	400	500	630	800	1000	1250	1600	2000	2500
	Selectivity limit (A)	2000	2500	2400	3200	4000	5040	6400	10000	12500	16000	20000	25000
Network protection circuit breaker F51-F52-F53 F61-F62 F71 F82-F83	200												
	250												
	300												
	400												
	500												
	630												
	800												
Motor protection circuit breaker F51-F52-F53 F61-F62 F71 F82-F83	200												
	250												
	300												
	400												
	500												
	630												
	800												
Generator protection circuit breaker F51-F52-F53 F61-F62 F71 F82-F83	200												
	250												
	300												
	400												
	500												
	630												
	800												

Load side I_1 (A) ↓	Transformer side I_n (A) →	Motor protection circuit breaker											
		F51		F61-F62/F71/F82-F83					F91E-F92E F101E-F102E		F112E		
		200	250	300	400	500	630	800	1000	1250	1600	2000	2500
	Selectivity limit (A)	2400	3000	3600	4800	6000	7560	9600	10000	12500	16000	20000	25000
Network protection circuit breaker F51-F52-F53 F61-F62 F71 F82-F83 F82E-F83E	200												
	250												
	300												
	400												
	500												
	630												
	800												
Motor protection circuit breaker F51-F52-F53 F61-F62 F71 F82-F83 F82E-F83E	200												
	250												
	300												
	400												
	500												
	630												
	800												
Generator protection circuit breaker F51-F52-F53 F61-F62 F71 F82-F83 F82E-F83E	200												
	250												
	300												
	400												
	500												
	630												
	800												

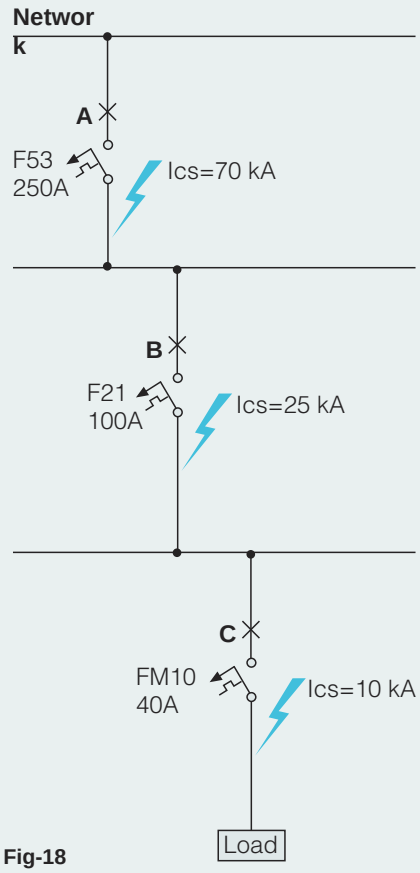


Fig-18

Sequential Connection:
Sequential connection is a utilization type which allows use of lower-cost circuit breakers at the load side by using the current limiting feature of circuit breakers.
Compact circuit breakers at the network side provide protection against over load and short circuit currents. These elements allow circuit breakers with a breaking capability lower than the short circuit current to operate within rated breaking capability limit. As the current is kept under control of the limiter circuit breaker in the whole circuit, sequential connection is useful for all the switching devices at load side of the circuit breaker.

Utilization of Sequential Connection:
In sequential connections, circuit breaker elements can be placed in different panels. In this way, sequential connection makes it possible to use circuit breakers with lower capacity than the possible Ics operating short circuit current to occur in the area of the device. Important point is that a circuit breaker at the capacity to break this short circuit current should be connected at the network side.

Coordination Among Circuit Breakers:
Utilization of a circuit breaker, which has a breaking capacity lower than the short circuit current, is allowed only when another circuit breaker with the required breaking capacity is placed at the network side. In this case, characteristics of both elements should be coordinated with each other in a way not to give any damage to the element at the load side and cables protected by these elements.

3-Step Sequential Connection:
Criteria about sequential connection of serially connected A, B and C circuit breakers are fulfilled in two conditions. A breaker placed at the network side is used for both B and C breakers for sequential connection. Here, it should be checked whether (A+B and A+C) and (A+B and B+C) combinations have the required breaking capacity or not. (Figure - 18)

Sequential Connection Table

			Network Side																					
			F10	F11	F21	F61	F12	F22	F31	F51	F62	F71	F32	F52	F82	F91	F101	F111	F92	F102	F112	F33	F53	F83
		kA	16		25		30			35					50				65			70		
Load Side	F10	16	-	25	25	20	30	35	35	25	20	-	45	25	20	-	-	-	-	-	-	45	25	20
	F11		-	-	-	25	30	35	35	35	35	35	50	50	50	-	-	-	-	-	-	70	70	70
	F21	25	-	-	-	25	30	35	35	35	35	35	50	50	50	-	-	-	-	-	-	70	70	70
	F61		-	-	-	-	30	35	35	35	35	35	50	50	50	-	-	-	-	-	-	-	-	70
	F12	30	-	-	-	-	-	35	35	35	35	35	50	50	50	-	-	-	-	-	-	70	70	70
	F22		-	-	-	-	-	-	-	35	35	35	50	50	50	-	-	-	-	-	-	70	70	70
	F31		-	-	-	-	-	-	-	-	35	35	50	50	50	-	-	-	-	-	-	70	70	70
	F51	35	-	-	-	-	-	-	-	-	-	35	50	50	50	-	-	-	-	-	-	70	70	70
	F62		-	-	-	-	-	-	-	-	-	-	50	50	50	-	-	-	-	-	-	-	-	70
	F71		-	-	-	-	-	-	-	-	-	-	50	50	50	-	-	-	-	-	-	-	-	70
	F32		-	-	-	-	-	-	-	-	-	-	-	-	50	50	50	50	65	65	65	70	70	70
	F52	50	-	-	-	-	-	-	-	-	-	-	-	-	-	50	50	50	65	65	65	70	70	70
	F82		-	-	-	-	-	-	-	-	-	-	-	-	-	50	50	50	65	65	65	-	-	70
	F33		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	70
	F53	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	F83		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Ground Fault Relay (FGR)

Ground Fault Relay:

When a fault current is detected in the system according to the sign coming from toroidal transformer, the circuit breaker controls the shunt trip or the undervoltage release to open the circuit breaker. Fault current value and time to operate the relay can be adjusted on the relay.

Type	FGR-05R	FGR-10R	FGR-20R
Fault current adjustment	30-500 mA	100-1000 mA	200-2500 mA
Order code	8AT-N0000-0500	8AT-N0000-1000	8AT-N0000-2500
Opening time adjustment	0,1 - 2,0 sn		
Supply	110 / 220 V AC 50/60 Hz		
Output relay	3 A, 250 V AC		
Reset	Manual / Electrical (Remote)		

Toroidal Transformer

Toroidal Transformer:

Ground fault relay and toroidal transformer are used with circuit breakers to detect even small ground leakages and open the circuit breaker.

Toroidal Transformer Diameter (mm) Ø	Order Code
60 mm	8AT-R0000-0060
110 mm	8AT-R0000-0110
160 mm	8AT-R0000-0160
210 mm	8AT-R0000-0220

Undervoltage Release :

It is used for opening the circuit breaker when energy is cut off or voltage goes below 70% of the operating voltage. In order to close the breaker, the voltage should be equal to or higher than 85% of the operating voltage. When no energy is supplied to the low voltage coil, the circuit breaker does not open.

F71 Undervoltage Release

Type	Operation Voltage	Working Voltage	Tri Voltage	Order Code
F21-F22	220 V~	> 187 V~	< 154 V ≈	9AA-CA000-0220
	380 V~	> 323 V~	< 266 V ≈	9AA-CA000-0380
F31-F32-F33	220 V~	> 187 V~	< 154 V ≈	9AB-CA000-0220
	380 V~	> 323 V~	< 266 V ≈	9AB-CA000-0380
F51-F52-F53	220 V~	> 187 V~	< 154 V ≈	9AD-CA000-0220
	380 V~	> 323 V~	< 266 V ≈	9AD-CA000-0380
F61-F62	220 V~	> 187 V~	< 154 V ≈	9AE-CA000-0220
	380 V~	> 323 V~	< 275 V ≈	9AE-CA000-0380
F71	220 V~	> 187 V~	< 154 V ≈	9AF-CA000-0220
	380 V~	> 323 V~	< 275 V ≈	9AF-CA000-0380
F91E-F92E	220 V~	> 187 V~	< 154 V ≈	9AH-CA000-0220
	380 V~	> 323 V~	< 275 V ≈	9AH-CA000-0380
F101E-F102E	220 V~	> 187 V~	< 154 V ≈	9AI-CA000-0220
	380 V~	> 323 V~	< 275 V ≈	9AI-CA000-0380
F111E-F112E	220 V~	> 187 V~	< 154 V ≈	9AK-CA000-0220
	380 V~	> 323 V~	< 275 V ≈	9AK-CA000-0380

Note : Circuit breaker does not open when no energy is supplied to undervoltage release.

"–" DC, "~" AC, "≂" DC-AC

F31-F32-F33
Extended Rotary Handle

Extended Rotary Handle:

It is used for opening - closing the circuit breaker. It is used for rotating the circuit breaker, not pushing-pulling it upwards-downwards.

Type	Order Code
F31-F32-F33	8AB-G000-0000
F51-F52-F53	8AD-G000-0000
F71	8AF-G000-0000
F82-F83/F82E-F83E	8AG-G000-0000
F91E-F92E	8AH-G000-0000

Operating Handle Extention

Operating Handle Extention:

F82E - F83E - F91E - F92E - F101E - F102E	8AG-UK100-0000
F111E - F112E	8AG-UK000-0000

Lock Mechanism with key

Lock Mechanism with key:
Lock mechanism mechanically locks the circuit breaker, which is on (trip) position due to service, and avoids ON and OFF positions.

Type	Order Code
F10-F11-F12	8AL-E0000-0000
F21-F22	8AA-E0000-0000
F31-F32-F33	8AB-E0000-0000
F51-F52-F53	8AD-E0000-0000

Type	Order Code
F71	8AF-E0000-0000
F82-F83/F82E-F83E	8AG-E0000-0000
F91E-F92E	8AH-E0000-0000

Shunt Trip Release

Shunt Trip Release :
It is used for opening the circuit breaker remotely. When the breaker is in closed (ON) position, when voltage is supplied to the opening relay the breaker is opened and gets Trip position. Opening relay may be manufactured at different voltages set out in the table in order to operate in AC and DC voltages. Operation of opening coil is guaranteed between 70% and 110% of the nominal voltage according to standards.

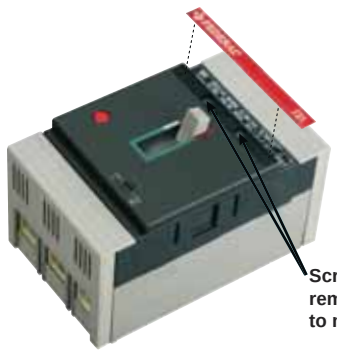
Operating voltages	F12	F21-F22	F31-F32-F33	F51-F52-F53	F61-F62	F71	F82-F83 F82E-F83E	F91E-F92E	F101E F102E	F111E-F112E
110 V ~	8AM-BA000-0110	8AA-BA000-0110	8AB-BA000-0110	8AD-BA000-0110	8AP-BA000-0110	8AF-BA000-0110	8AG-BA000-0110	8AH-BA000-0110	8AI-BA000-0110	8AK-BA000-0110
220 V ~	8AM-BA000-0220	8AA-BA000-0220	8AB-BA000-0220	8AD-BA000-0220	8AP-BA000-0220	8AF-BA000-0220	8AG-BA000-0220	8AH-BA000-0220	8AI-BA000-0220	8AK-BA000-0220
380 V ~	8AM-BA000-0380	8AA-BA000-0380	8AB-BA000-0380	8AD-BA000-0380	8AP-BA000-0380	8AF-BA000-0380	8AG-BA000-0380	8AH-BA000-0380	8AI-BA000-0380	8AK-BA000-0380
24 V –	8AM-BD000-0024	8AA-BD000-0024	8AB-BD000-0024	8AD-BD000-0024	8AP-BD000-0024	8AF-BD000-0024	8AG-BD000-0024	8AH-BD000-0024	8AI-BD000-0024	8AK-BD000-0024
48 V –	8AM-BD000-0048	8AA-BD000-0048	8AB-BD000-0048	8AD-BD000-0048	8AP-BD000-0048	8AF-BD000-0048	8AG-BD000-0048	8AH-BD000-0048	8AI-BD000-0048	8AK-BD000-0048
110 V –	8AM-BD000-0110	8AA-BD000-0110	8AB-BD000-0110	8AD-BD000-0110	8AP-BD000-0110	8AF-BD000-0110	8AG-BD000-0110	8AH-BD000-0110	8AI-BD000-0110	8AK-BD000-0110
220 V –	8AM-BD000-0220	8AA-BD000-0220	8AB-BD000-0220	8AD-BD000-0220	8AP-BD000-0220	8AF-BD000-0220	8AG-BD000-0220	8AH-BD000-0220	8AI-BD000-0220	8AK-BD000-0220

Auxiliary Contact Block

Auxiliary Contact Block:
It is used for supplying electrical signaling of the circuit breaker according to the operating position. Auxiliary contacts are opened and closed with primary contacts to fulfill warning and locking functions.

NO : Normally open contact
NC : Normally closed contact

Type	Contact equipment NO	NC	Operating voltage	Rated current	Order Code
F10-F11-F12	1	1	250 V~	2 A	8AL-A0011-0000
F21-F22	1	1	250 V~	2 A	8AA-A0011-0000
F31-F32-F33	1	1	250 V~	2 A	8AB-A0011-0000
	2	2	250 V~	2 A	8AB-A0022-0000
F51-F52-F53	1	1	250 V~	2 A	8AD-A0011-0000
	2	2	250 V~	2 A	8AD-A0022-0000
F61-F62	1	1	400 V~	4 A	8AE-A0011-0000
F71	1	1	400 V~	4 A	8AF-A0011-0000
	2	2	400 V~	4 A	8AF-A0022-0000
F82-F83/F82E-F83E	1	1	400 V~	4 A	8AG-A0011-0000
	2	2	400 V~	4 A	8AG-A0022-0000
	4	4	400 V~	4 A	8AG-A0044-0000
F92E	1	1	400 V~	4 A	8AH-A0011-0000
	2	2	400 V~	4 A	8AH-A0022-0000
F101E-F102E	1	1	400 V~	4 A	8AJ-A0011-0000
	2	2	400 V~	4 A	8AJ-A0022-0000
	4	4	400 V~	4 A	8AJ-A0044-0000
F111E-F112E	1	1	400 V~	4 A	8AK-A0011-0000
	2	2	400 V~	4 A	8AK-A0022-0000



Screws should be removed to mount accessories

F10...F112E

Terminal protective cover:

Terminal cover:
It provides a safe insulation by preventing contact of the terminal (busbar or cable) sections of the circuit breaker. Furthermore, terminal protective cover also insulates terminals from each other by passing through channels between poles. It is available in all our circuit breakers as a standard.

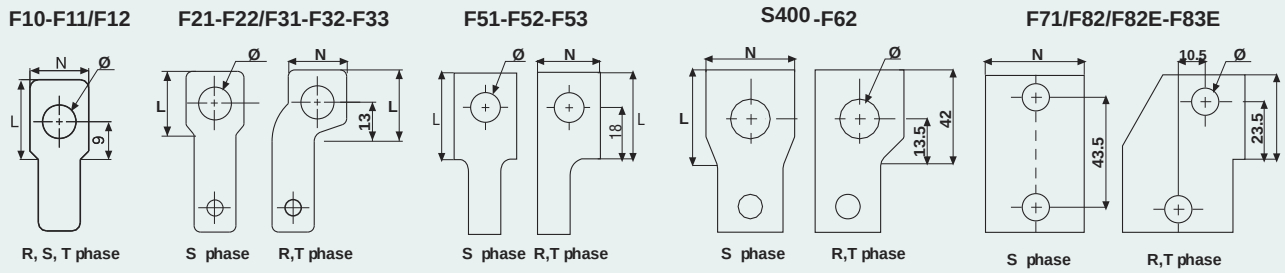
Type	Order code
F10-F11	8AM-F0000-0000
F12	8AR-F0000-0000
F21-F22	8AA-F0000-0000
F31-F32-F33	8AB-F0000-0000
F51-F52-F53	8AD-F0000-0000
F61-F62	8AP-F0000-0000

Type	Order code
F71	8AF-F0000-0000
F82-F83/F82E-F83E	8AG-F0000-0000
F91E-F92E	8AH-F0000-0000
F101E-F102E	8AI-F0000-0000
F111E-F112E	8AK-F0000-0000

Extension Bars :
Extension busbars allow easy and healthy cable or busbar connections to the terminals of the breaker. Busbars are manufactured of electrolytic copper material with silver coating.

Type	Lenght L (mm)	Width N (mm)	Thickness P (mm)	Hole Diameter Ø	Tightening Torque (Nm)	Nominal Current (A)	Quantity (Pieces)	Order Code
F10-F11/F12	36	14	3	M8	10	16 A - 125 A	6	8AM-H3000-0125
F21-F22	16	18	3	M8	10	16 A - 125 A	6	8AB-H3000-0100
F31-F32-F33	35	18	5	M8	10	125 - 160 A	6	8AB-H5000-0125
F51-F52-F53	35	25	5	M12	25	200 A - 250 A	6	8AD-H5001-0250
F61-F62	42	38	8	M10	25	250 A - 400 A	6	8AE-H5000-0300
F71 F82-F83 F82E-F83E	31	40	5	M10	40	300 A	6	8AF-HΔΔΔ00-0□□□
	31	40	6	M10	40	400 A - 500 A	6	
	31	40	8	M10	40	630 A	6	8AG-HΔΔΔ00-0□□□
	31	40	12	M10	40	800 A	6	

□□□: Write ampere value.
ΔΔΔ : Write busbar thickness. (Enter 5 for 300A , 6 for 400A - 500A, 8 for 630A and 12 for 800A .)



Extension Bars

Connection Terminals: They are dispatched with screwdriver or allen screw head.

Type	Cable Number	Cable Section (mm^2)	Cable Diameter Ø (mm)	Tightening Torque (Nm)	Bolt Type	Quantity (pieces)
F10-F11/F12	1	2.5...50	6	6	Screwdriver	3
F21-F22/F31-F32-F33	1	2,5...120	12	10	Alien	3
F21-F22/F31-F32-F33	1	2,5...95	12	6	Screwdriver	3
F31-F32-F33	1	10...120	13	12	Alien	3
F51-F52-F53	1	95...120	13	25	Alien	3

Not: Connection terminal of F31-F32-F33 type circuit breaker can be manufactured as allian or screw head upon request.

Connection Terminals

F31-F32-F33/F51 Motor Control Mechanisms

Motor Control Mechanisms:
They are used for opening - closing the circuit breaker remotely. Moreover, thanks to the notch on it, manual opening-closing can be made. Motor control mechanism is assembled on top cover of the circuit breaker. It has mechanical locking feature.

F31-F32-F33 Motor Control Mechanisms:

Technical Specification:

Order Code	8AB-DA000-0220
Operating voltage	220 V AC *
Power	100 W
Opening time	1 s
Closing time	1 s

F71/F82-F83/F82E-F83E/F92E/F101E-F102E
Motor Control Mechanisms

F71/F82-F83/F82E-F83E/F91E-F92E/F101E-F102E Motor Control Mechanisms:

Technical Specification:

Order Code	
F71	8AF-DA000-0220
F82-F83 / F82E-F83E	8AG-DA000-0220
F91E-F92E	8AH-DA000-0220
F101E-F102E	8AN-DA000-0220
Operating voltage	220 V AC *
Power	100 W
Opening time	4 s
Closing time	3.5 s

F111E-F112E Motor Control Mechanisms

F111E-F112E Motor Control Mechanisms:

Technical Specification:

Order Code	
F111E-F112E	8AK-DA000-0220
Operating voltage	220 V AC *
Power	500 W
Opening time	1.5 s
Closing time	1.5 s

* Different operating voltages (AC/DC) can be made if required.

Circuit diagram of motor control mechanism of F31-F32-F33 type circuit breakers :

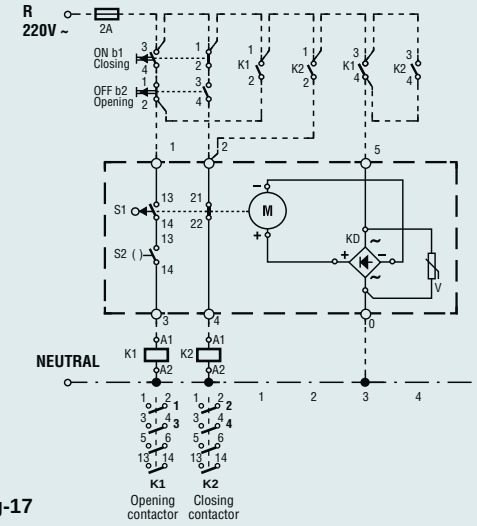
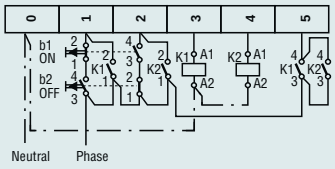


Fig-17

○ : Terminals
b1 : Opening button (Used by the authorizhed person)
b2 : Closed button
S1 : Motor mechanism switching limit
S2 : Electrical and mechanical locking switch against the breaker closed
K1 : Opening contactor
K2 : Closed contactor
KD : Bridge diot
V : Varistor (250 V AC)
— — : Motor mechanism limit
----- : Users connections



Terminal connection diagram

Circuit diagram of motor control mechanism of F71/F82-F83/F82E-F83E/F91E-F92E type circuit breakers :

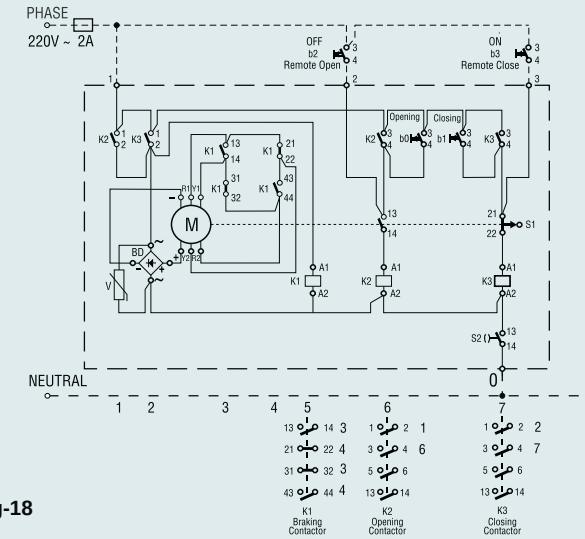
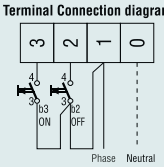


Fig-18

0 : Terminals
b0 : Opening button
b1 : Closing button
b2 : Remote Open OFF button
(mounted by user.)
b3 : Remote Close ON button
(mounted by user.)
S1 : Limiting switch
S2 : Electrical and mechanical locking switch
K1 : Braking contactor of motor mechanism
K2 : Opening contactor
K3 : Closing contactor
BD : Bridge Diot
V : Varistor (250V AC)
R1 : Closing motor coal end
Y1 : Closing motor first beasing winding end
R2 : Closing motor coal end
Y2 : Closing motor second beasing winding end
..... : Limits of Motor Mechanism
——— : Users Connections

Terminal Connection diagram



Circuit diagram of motor control mechanism of F111E-F112E type circuit breakers :

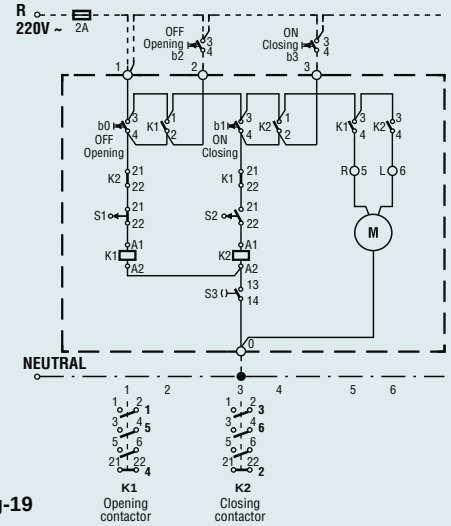
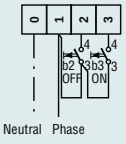


Fig-19

○ : Terminals
b0 : Opening button
b1 : Closing button
b2 : Shunt trip OFF button (Used by the authorizhed person)
b3 : Shunt trip ON button (Used by the authorizhed person)
S1 : Under limiting switch
S2 : Upper limiting switch
S3 : Electrical and Mechanical locking switch
K1 : Opening contactor (FC-09D01)
K2 : Closing contactor (FC-09D01)
R : Motor end which will move the circuit breaker's operating handle forward.
L : Motor end which will move the circuit breaker's operating handle backward.
— — : Motor mechanism limit
------ : Users connections



Terminal connection diagram

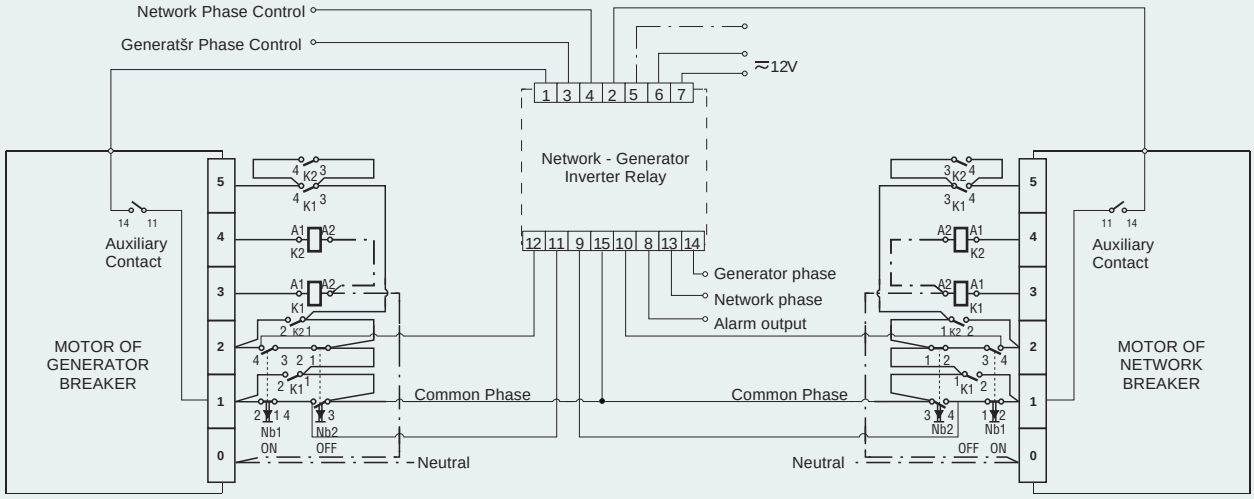
Output contacts	**:** 250V AC, 10A
Supply voltage	**:** 12V AC
Input voltage	**:** 220 V AC
Dimensions	**:** 96x96 mm
Order Code	**:** 9HK-DF000-0000

Generators are very important for facilities, where electrical failures are quite frequent and likely to cause significant damages. Although generator is used, manual enablement of the generator by authorized personnel may last for minutes. Manually enabled generator should be disabled after energy failure ends and network switch is enabled to supply the system from the network. This fact results in both time and labor loss. Elimination of this issue is possible with network-generator automation.

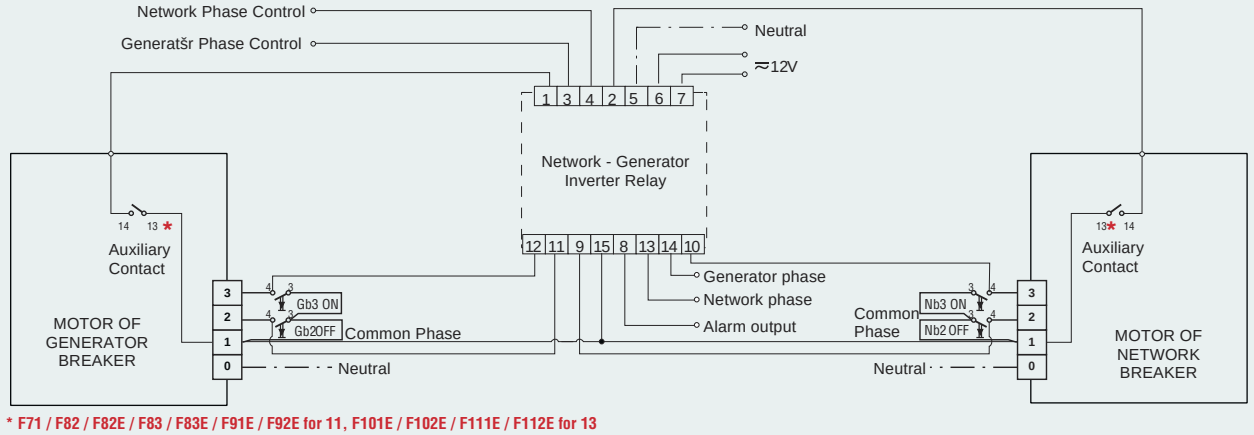
Network - Generator Inverser Relay:
It is used to ensure automatic transition between network and generator at places where the circuit breaker is used for inverter purposes. Line, supply, switch statuses can be monitored on the relay. Fault contact and alarm and opening coil connection can be made. Establishment of network-generator automation, in other words automatic inverter system is both easy and important. Because a fault shall cause enablement of network and generator at the same time, therefore phase intersection and a short circuit.
In order to eliminate this possibility of fault and to provide operating safety, mechanical lock is utilized.
As locking is made mechanically, not electrically; possibility of ON or OFF position of both circuit breakers due to faults in the control system is totally prevented.

Mechanical Lock Order Codes:

F31	8AB-V0000-0000
F71	8AF-V0000-0000
F82-F83-F82E-F83E	8AG-V0000-0000
F91E-F92E	8AH-V0000-0000
F101E-F102E	8AI-V0000-0000
F111E-F112E	8AK-V0000-0000



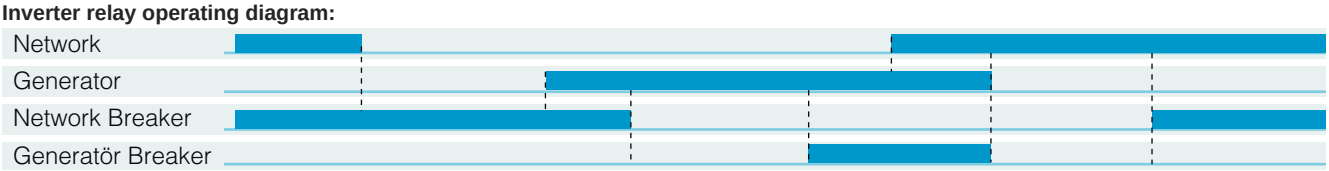
Connection diagram of F31-F32-F33 type circuit breaker with motor mechanism for inverter automation system.



* F71 / F82 / F82E / F83 / F83E / F91E / F92E for 11, F101E / F102E / F111E / F112E for 13

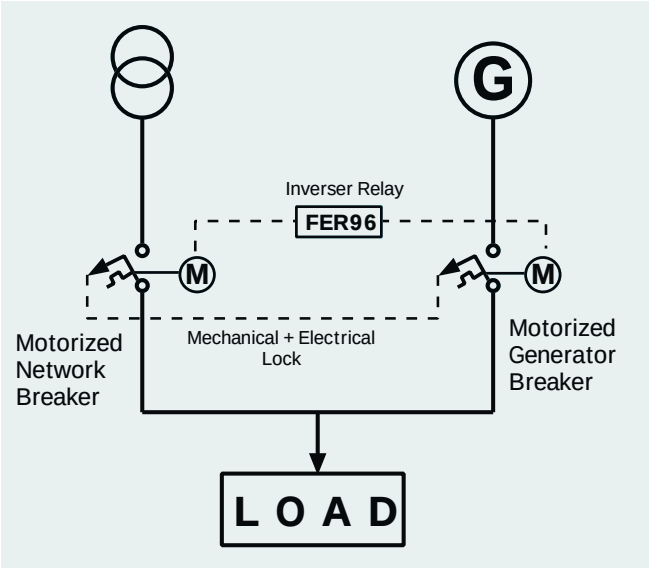
Connection diagram of F71/F82-F83/F82E-F83E/F91E-F92E/F101E-F102E/F111E-F112E type circuit breaker with motor mechanism for inverter automation system.

Inverter relay operating diagram:



Inverser system with motorized MCCB + mechanical lock

F31	8AB-V2000-0000
F71	8AF-V2000-0000
F82-F83-F82E-F83E	8AG-V2000-0000
F91E-F92E	8AH-V2000-0000
F101E-F102E	8AI-V2000-0000
F111E-F112E	8AK-V2000-0000



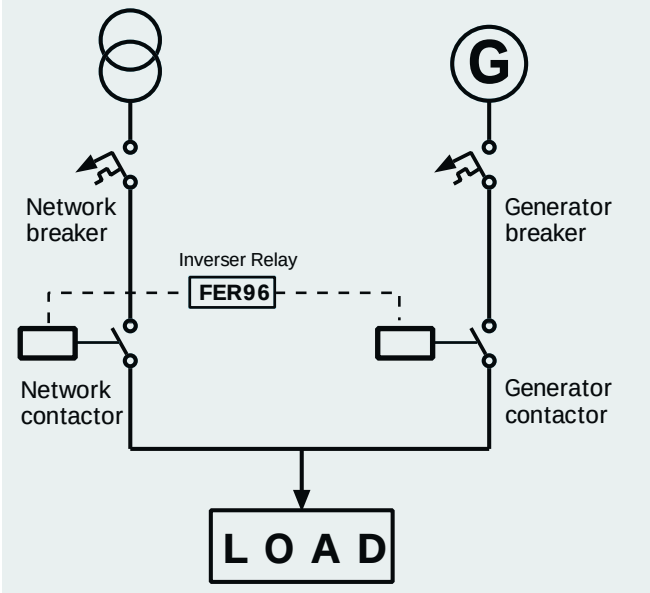
Alternative Inverser

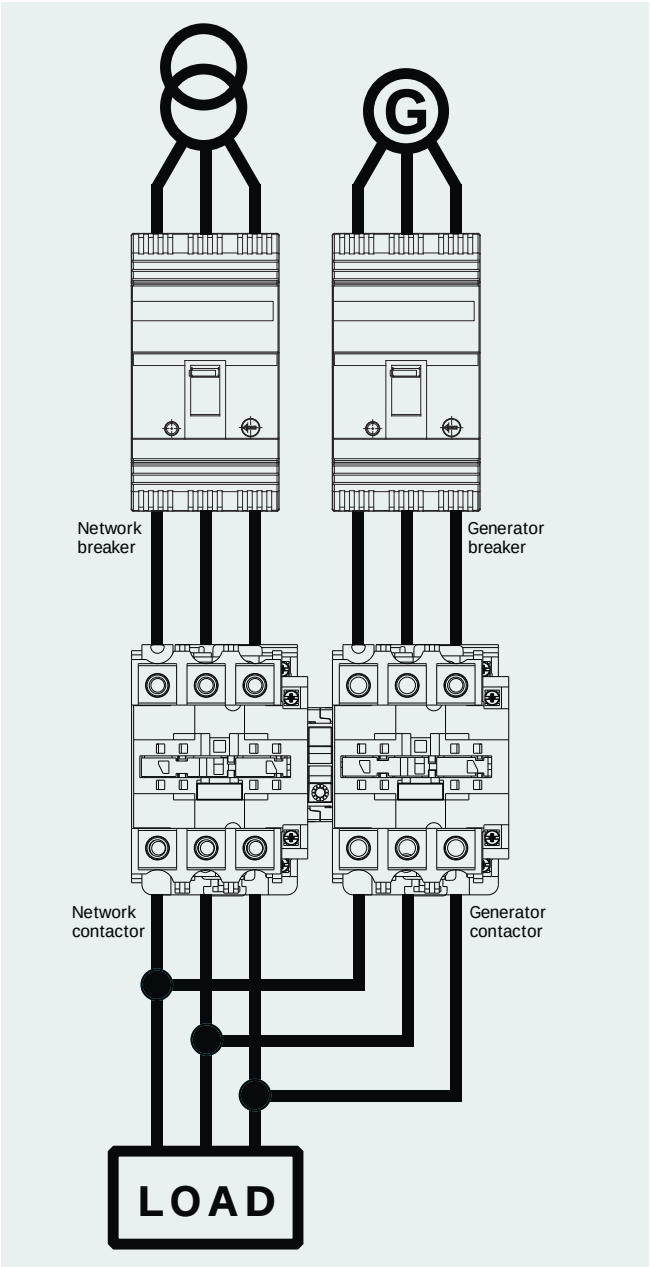
Network - generator systems can be made with compact type circuit breakers with motor mechanism or combination of compact type circuit breaker and contactor either.

As seen on right diagram, compact type circuit breakers are used for overload and short circuit protection while contactors are used for switching.

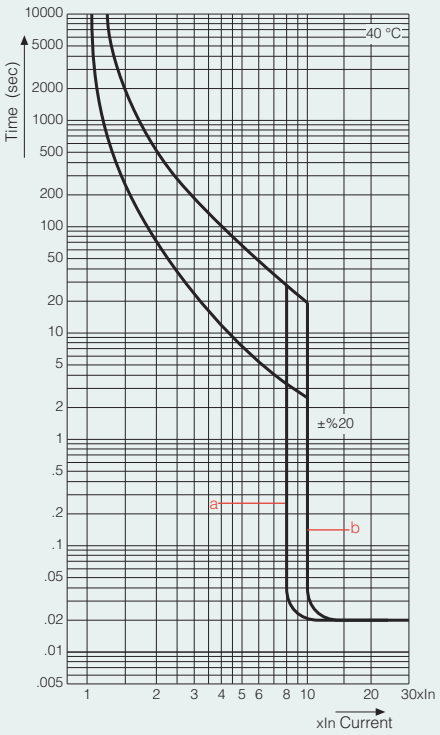
Inverser system can be made with mechanical and also electrical locking for contactors up to FC95D and with electrical locking only for contactors FC115D to FC750D

Inverser system 300A to 2500A can be made with mechanical and also electrical locking by using high current contactors.



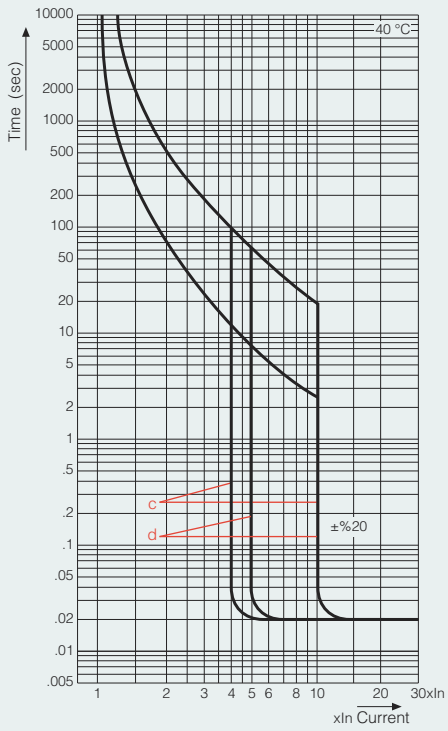


F01-F02/F10-F11/F21-F22/F31-F32-33
Thermal magnetic type circuit breaker



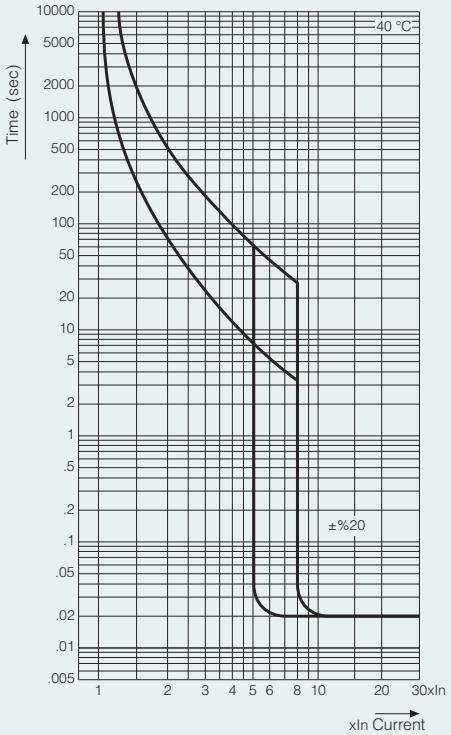
a: F01-F02 / F21-F22 / F31-F32-F33
b: F10-F11 / F12

F51-F52-F53/F61-F62
Thermal magnetic type circuit breaker

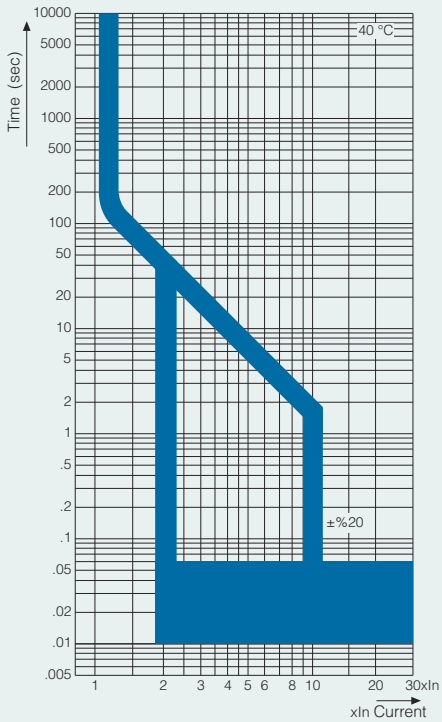


c: F51-F52-F53
d: F61-F62

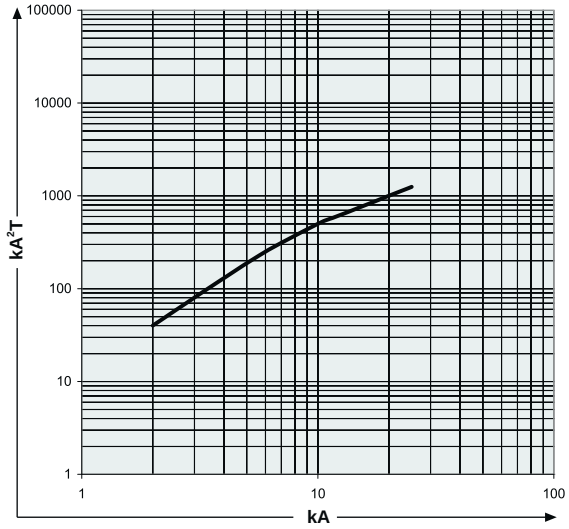
F71/F82-F83
Thermal magnetic type circuit breaker



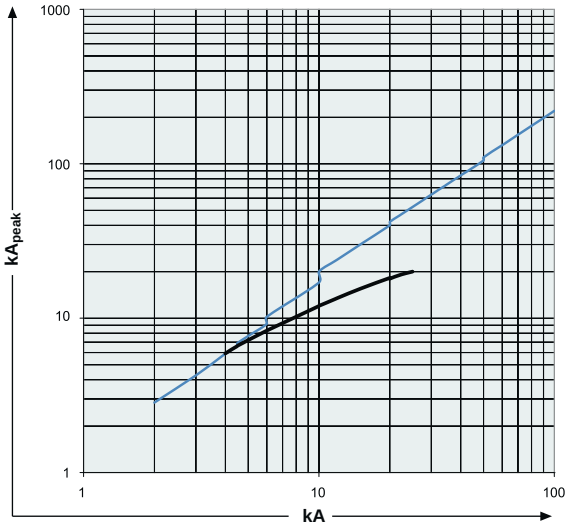
F82E-F83E/F91E-F92E/F101E-F102E/F111E-F112E
Thermal magnetic type circuit breaker



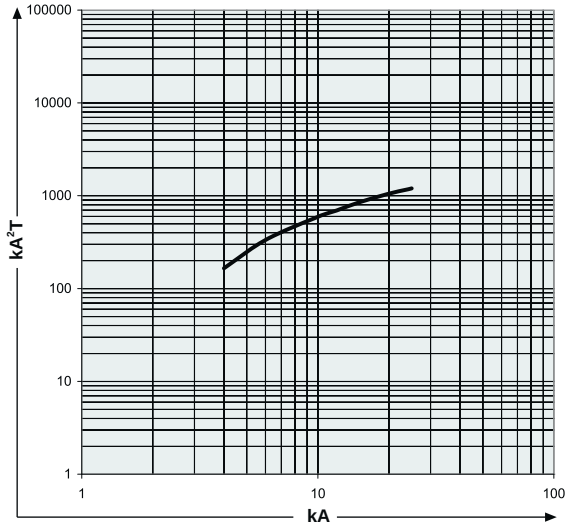
F11 I^2T Curve



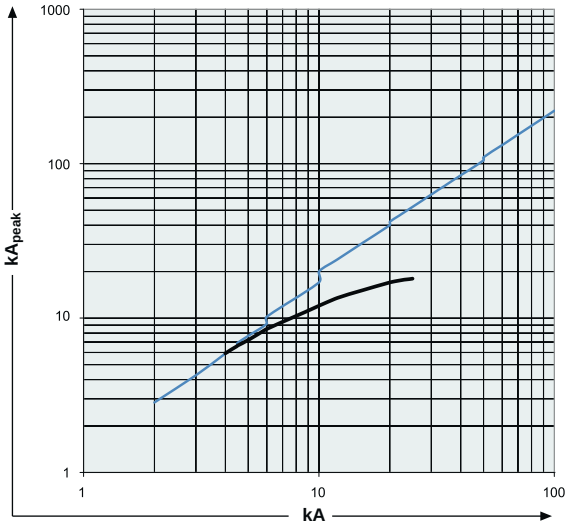
F11 I_{peak} Curve



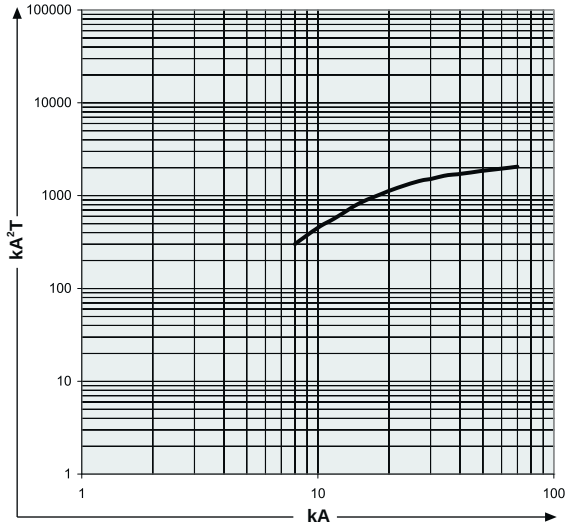
F21 I^2T Curve



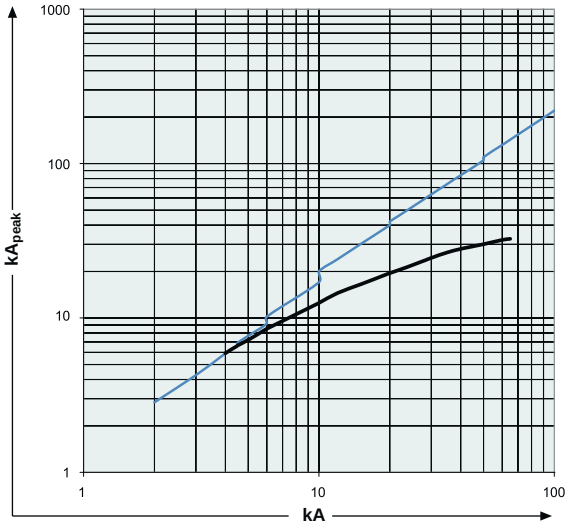
F21 I_{peak} Curve



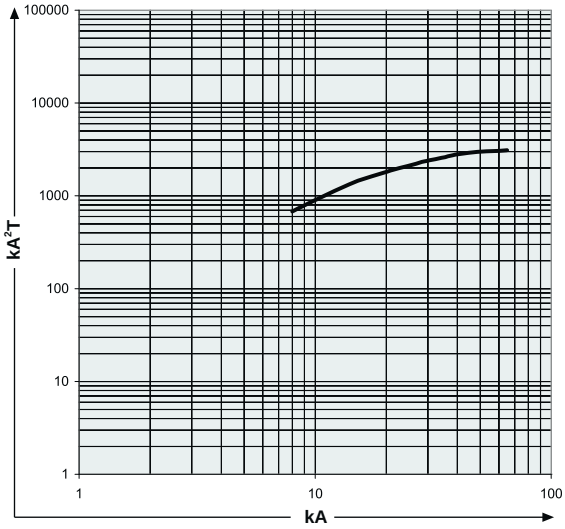
F31 I^2T Curve



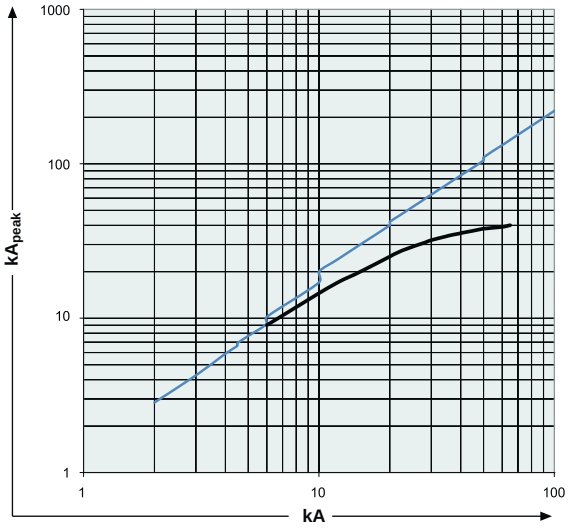
F31 I_{peak} Curve



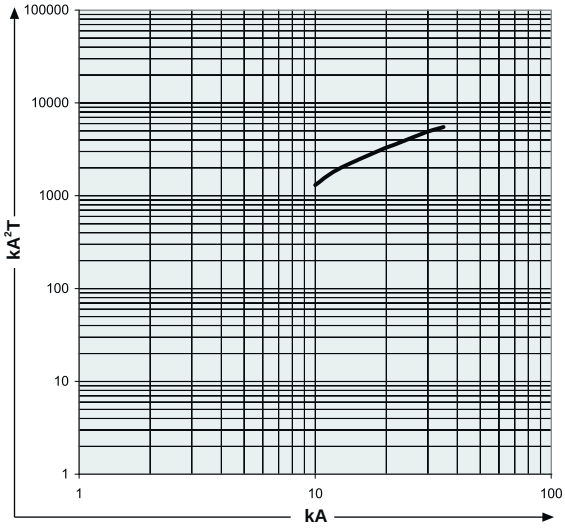
F51 I^2T Curve



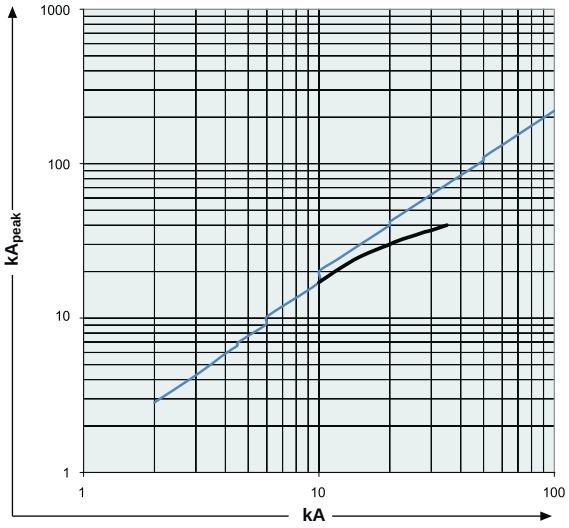
F51 I_{peak} Curve



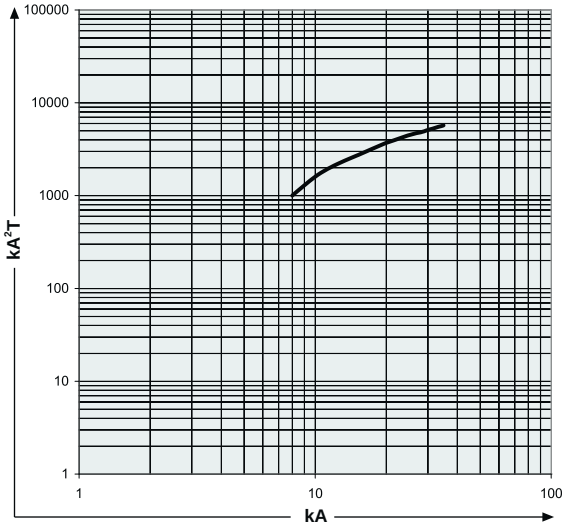
F61 I^2T Curve



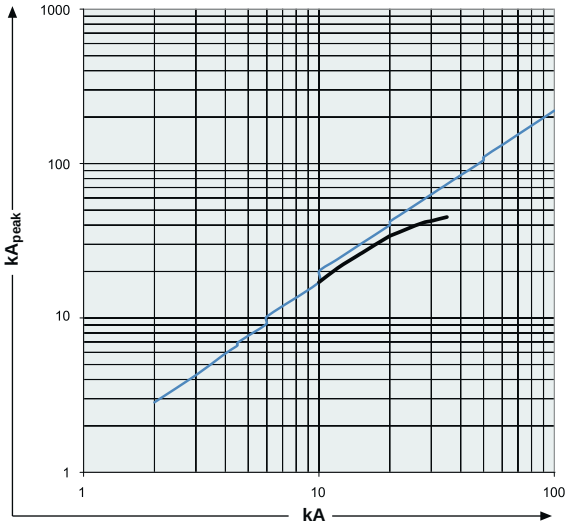
F61 I_{peak} Curve



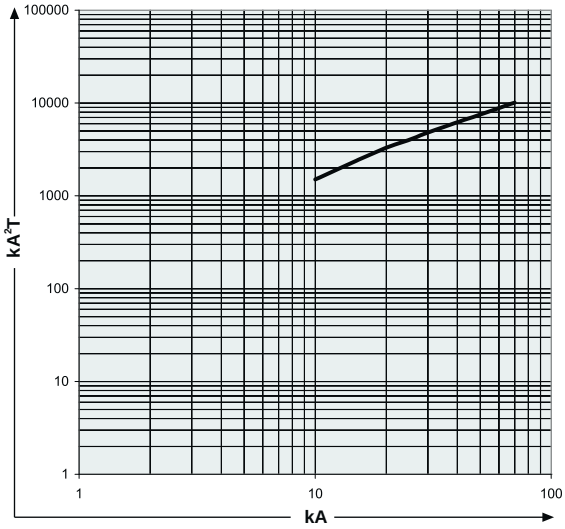
F71 I^2T Curve



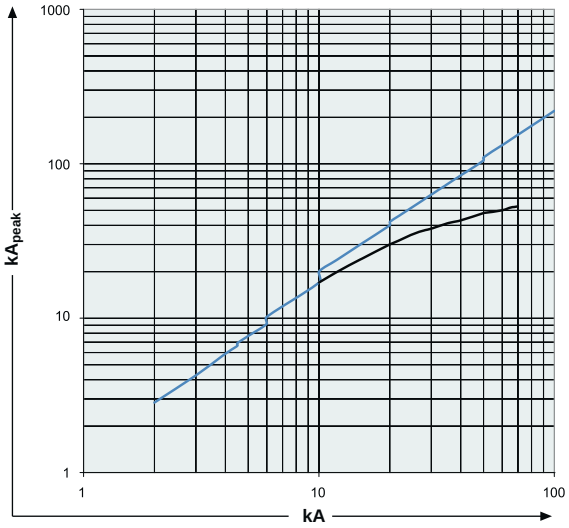
F71 I_{peak} Curve



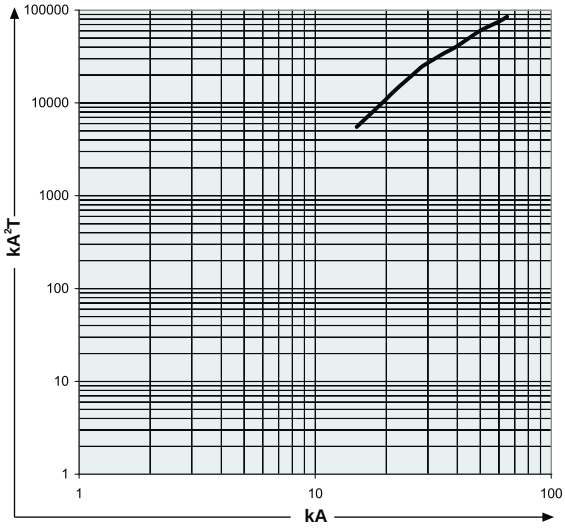
F82 I^2T Curve



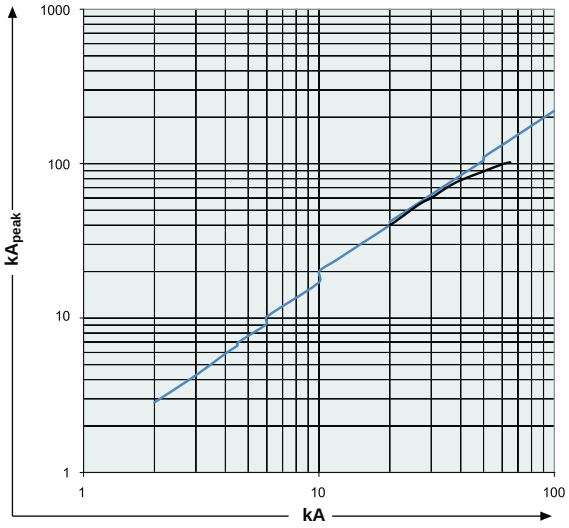
F82 I_{peak} Curve



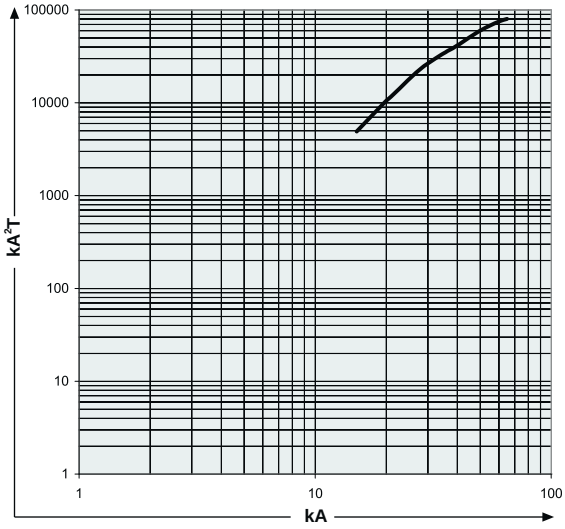
F91 I^2T Curve



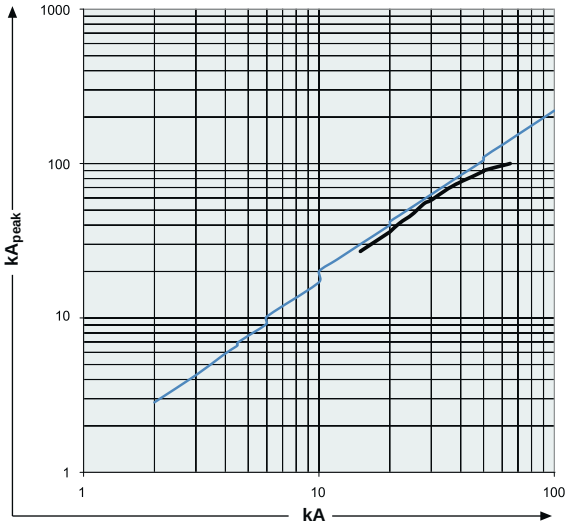
F91 I_{peak} Curve



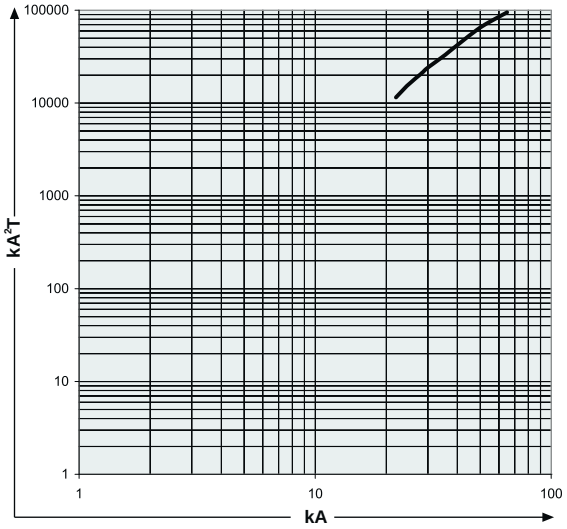
F101 I^2T Curve



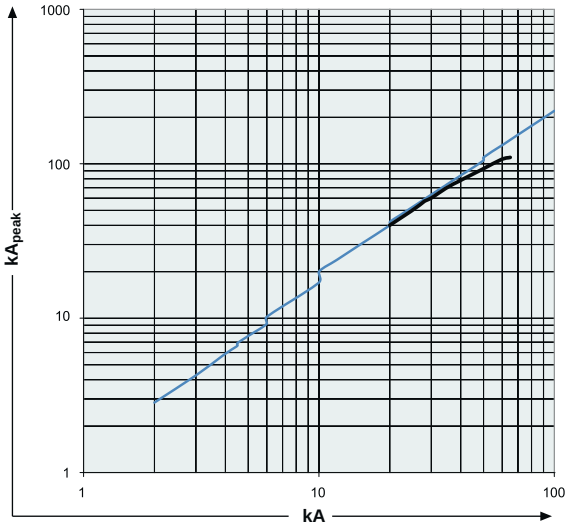
F101 I_{peak} Curve



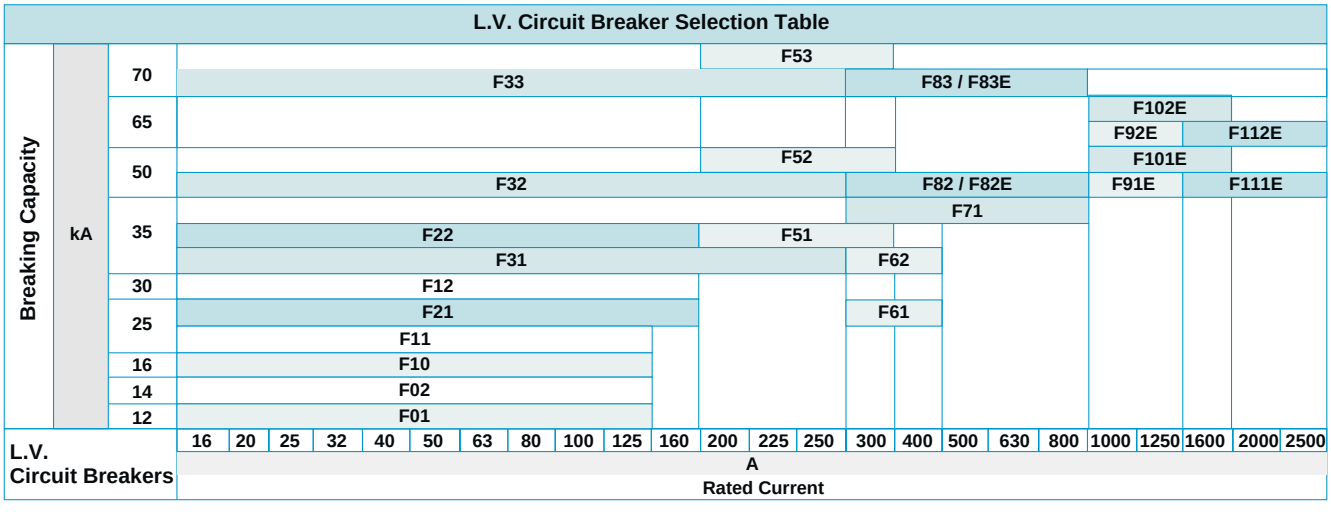
F112 I^2T Curve



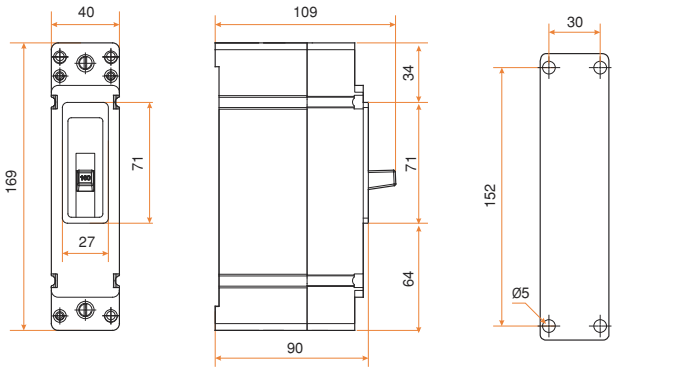
F112 I_{peak} Curve



Power losses for per pole (W)																									
Rated Current (A)																									
	16	20	25	32	40	50	63	80	100	125	160	200	225	250	300	400	500	630	800	1000	1250	1600	2000	2500
F10	5.5	5	5.8	4.3	4.3	5.5	8.2	14	10.4	10.8														
F11	5.5	5	5.8	4.3	4.3	5.5	8.2	14	10.4	10.8														
F12	5.5	5	5.8	4.3	4.3	5.5	8.2	14	10.4	10.8	16.2													
F21	2.8	3.8	4.2	4.3	4.5	5.5	7.8	9.6	10.4	10.8	16.2													
F22	2.8	3.8	4.2	4.3	4.5	5.5	7.8	9.6	10.4	10.8	16.2													
F31	3	2.5	3.3	3.8	4.6	5.9	7.8	6.4	8.6	10	12	17	20	25										
F32	3	2.5	3.3	3.8	4.6	5.9	7.8	6.4	8.6	10	12	17	20	25										
F33	3	2.5	3.3	3.8	4.6	5.9	7.8	6.4	8.6	10	12	17	20	25										
F51												24	18	21	28									
F52												24	18	21	28									
F53												24	18	21	28									
F61															18	32								
F62															18	32								
F71															26	24	32	44	45					
F82																32	32	44	45					
F83																32	32	44	45					
F82E															8	14	22	35	45					
F83E															8	14	22	35	45					
F91E																				44	68			
F92E																				44	68			
F101E																				40	63	104		
F102E																				40	63	104		
F111E																						44	69	108
F112E																						44	69	108

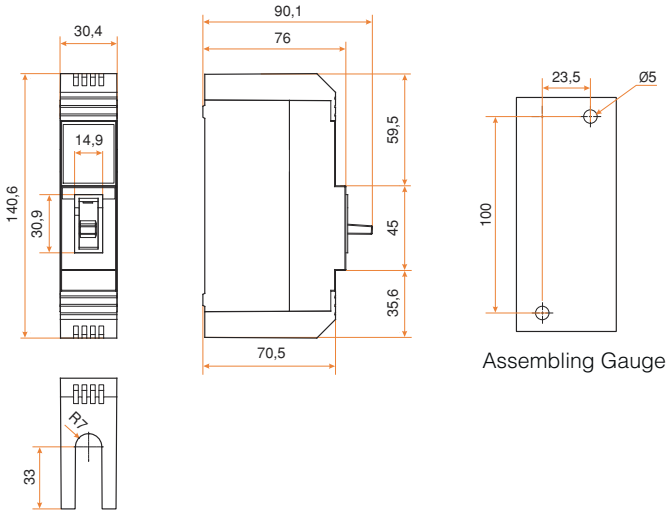


F01



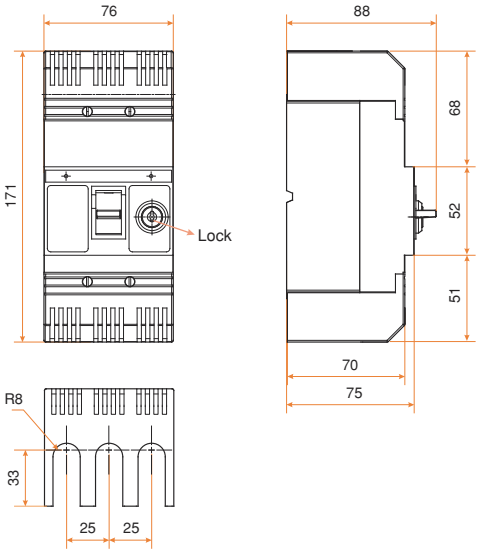
Assembling Gauge

F12M

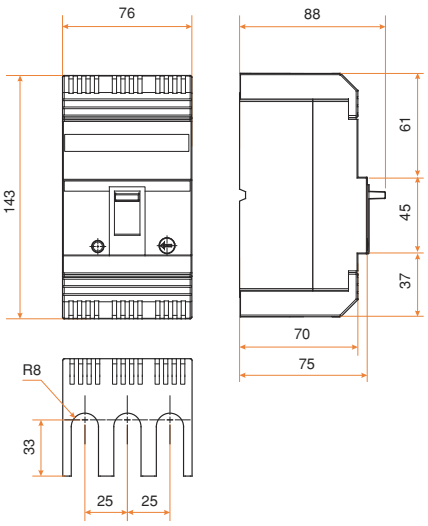


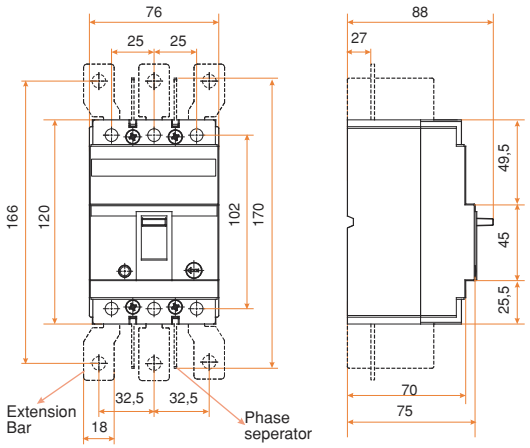
Assembling Gauge

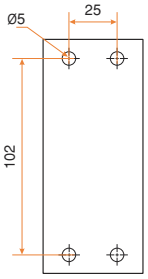
F11 WITH LOCK COVER



F11 THERMAL ADJUSTABLE



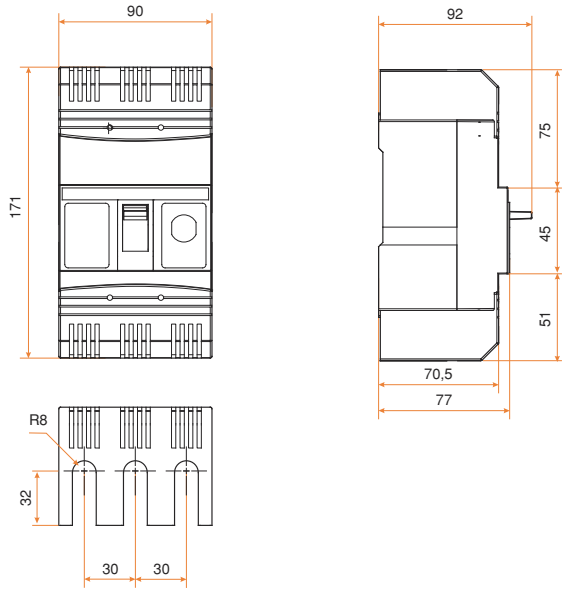




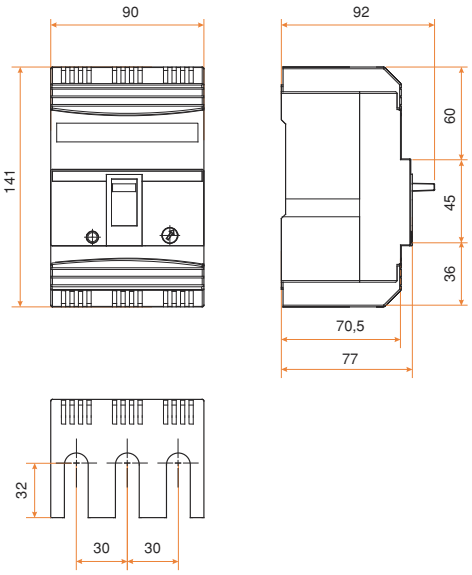
Assembling Gauge

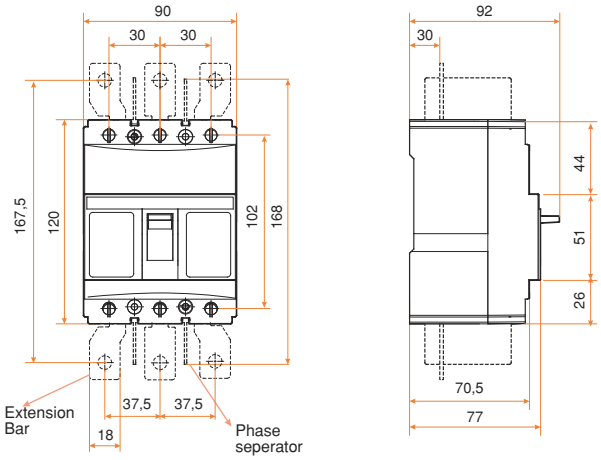
- - - - Shown parts with discrete lines are manufactured as per customer request.

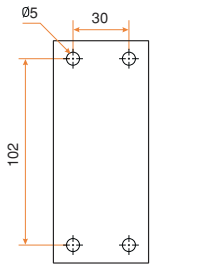
F12 WITH LOCK MECHANISM



F12 THERMAL ADJUSTABLE



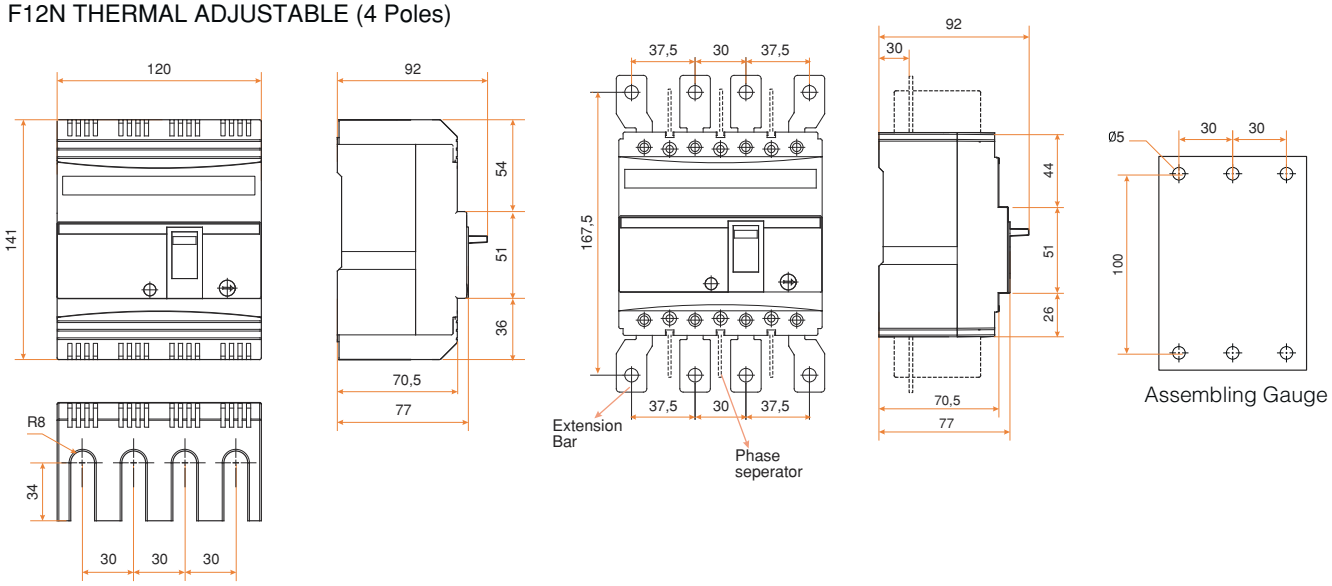




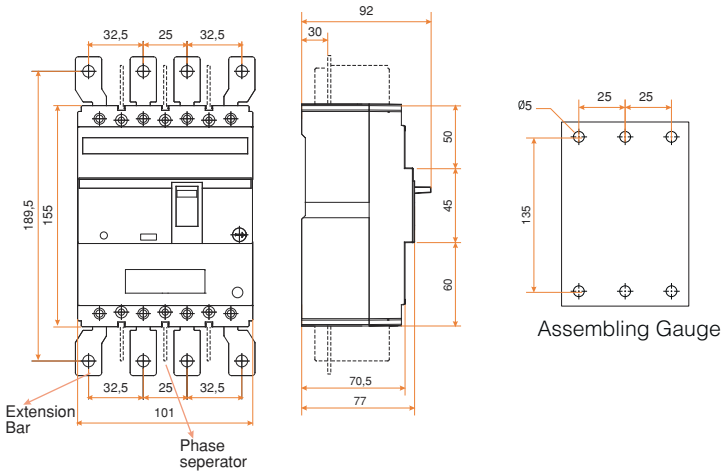
Assembling Gauge

- - - - Shown parts with discrete lines are manufactured as per customer request.

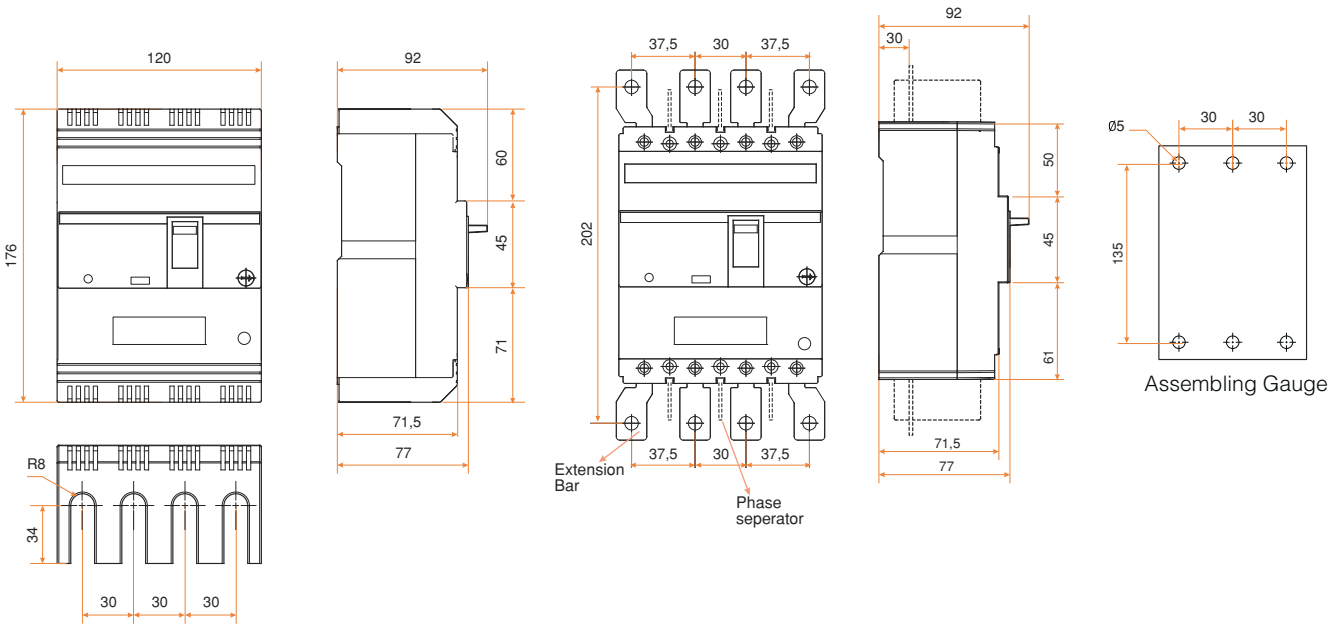
F12N THERMAL ADJUSTABLE (4 Poles)



F11R COMPACT TYPE CIRCUIT BREAKER WITH RESIDUAL CURRENT PROTECTION TYPE

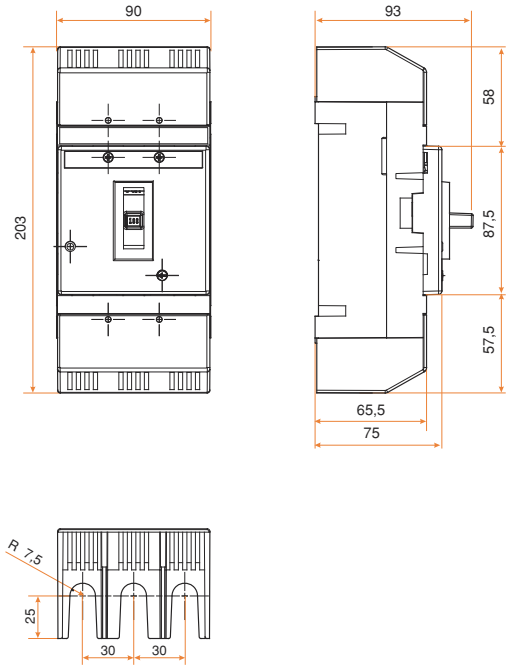


F12R COMPACT TYPE CIRCUIT BREAKER WITH RESIDUAL CURRENT PROTECTION TYPE

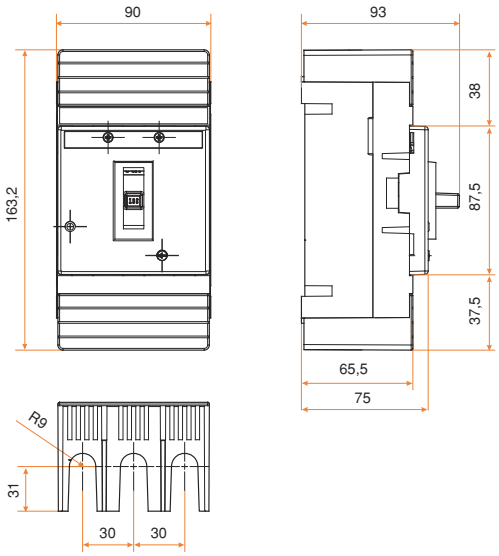


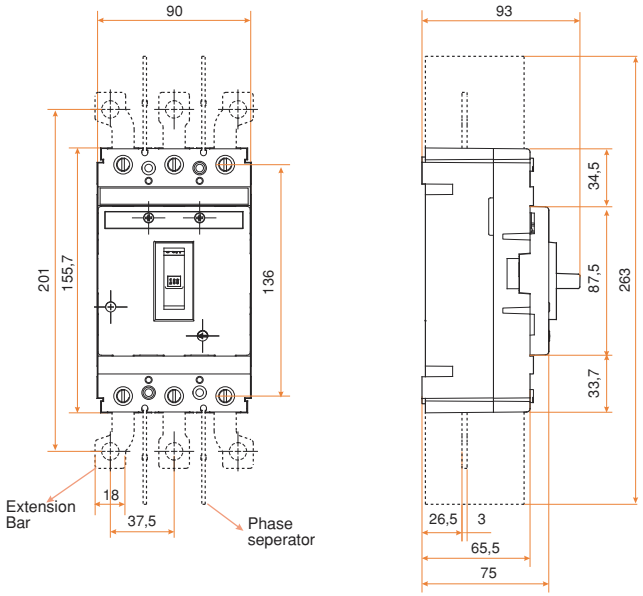
- - - - Shown parts with discrete lines are manufactured as per customer request.

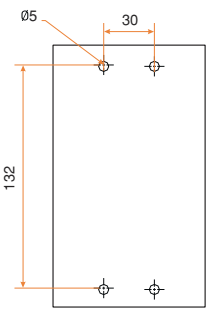
F21 WITH LONG TERMINAL COVER



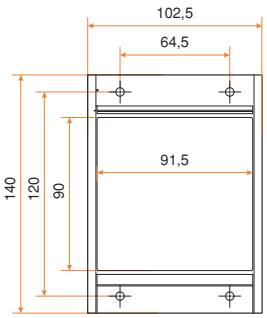
F21 WITH SHORT TERMINAL COVER







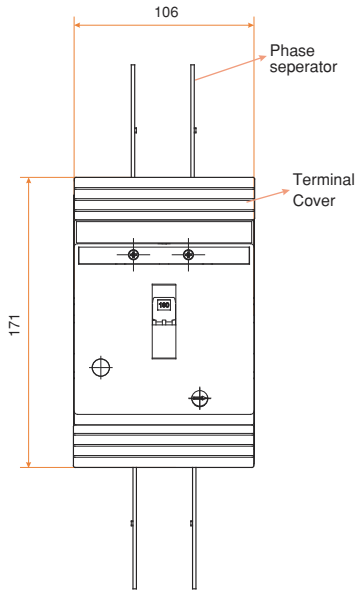
Assembling Gauge

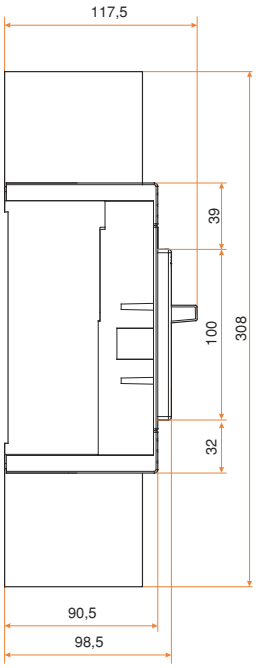


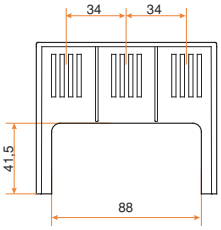
Panel Frame

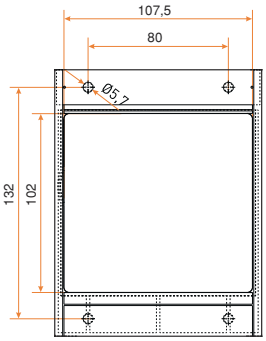
- - - - Shown parts with discrete lines are manufactured as per customer request.

F31

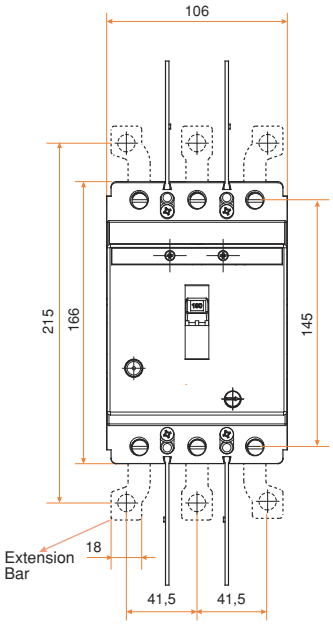


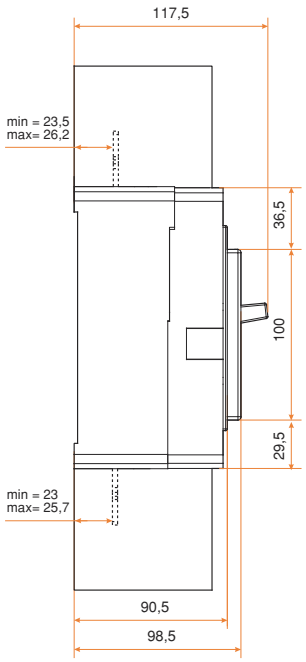


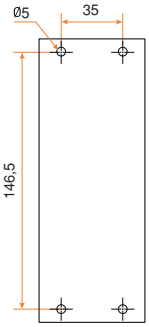




Panel Frame



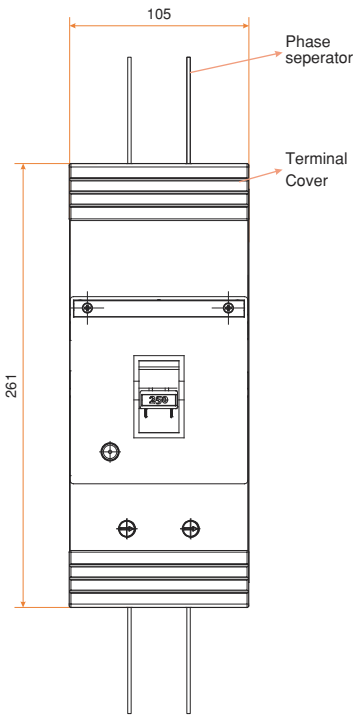


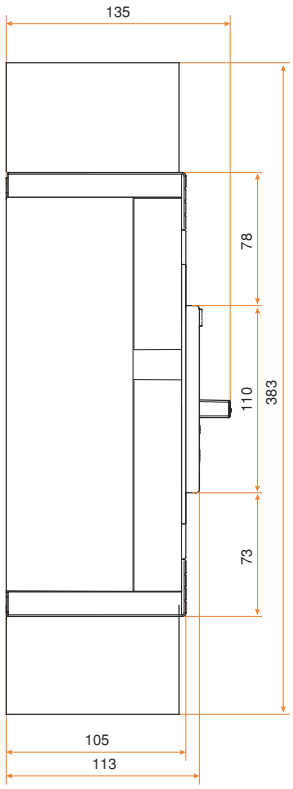


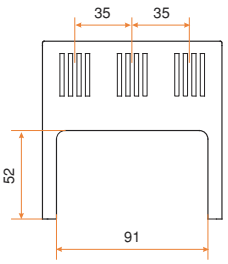
Assembling Gauge

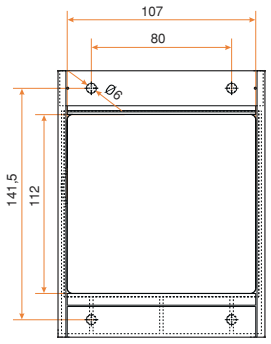
- - - - Shown parts with discrete lines are manufactured as per customer request.

F51

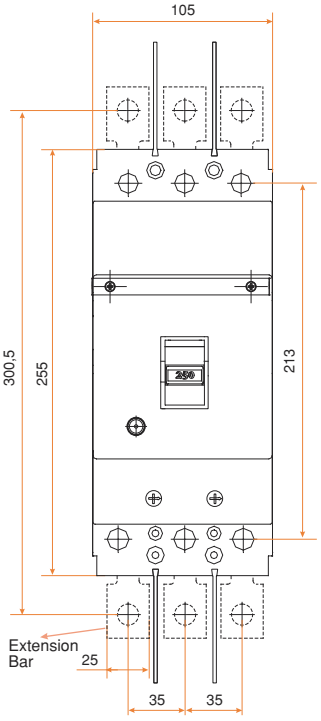


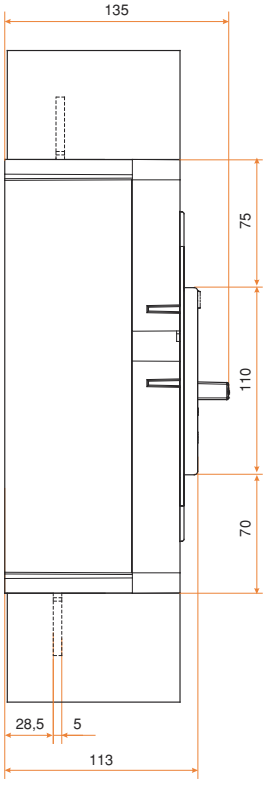


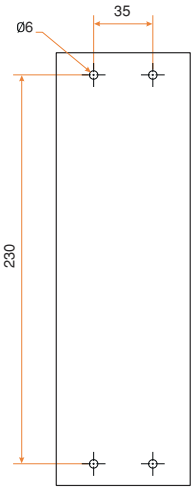




Panel Frame



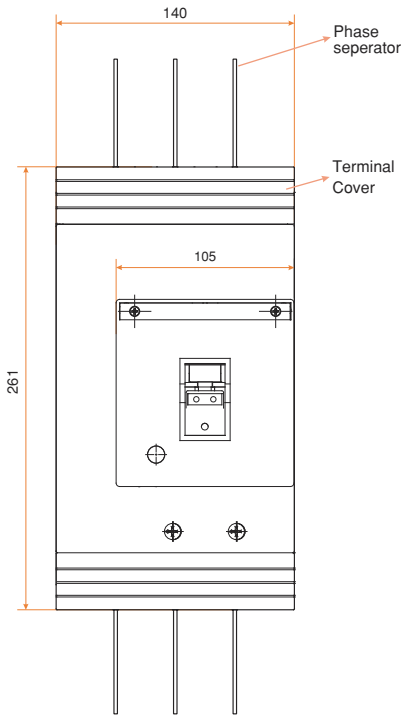


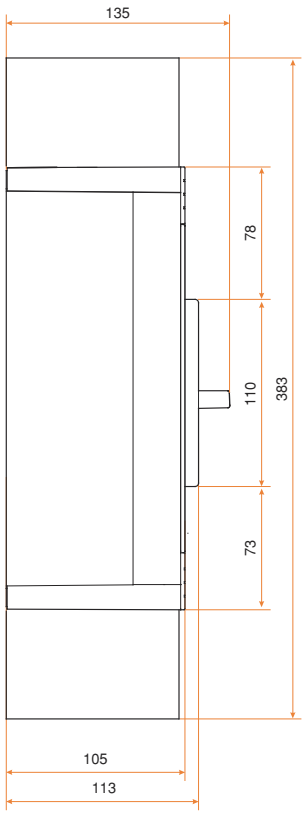


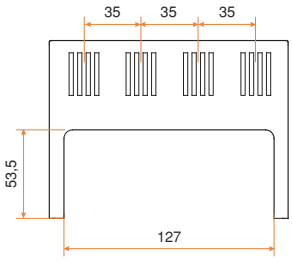
Assembling Gauge

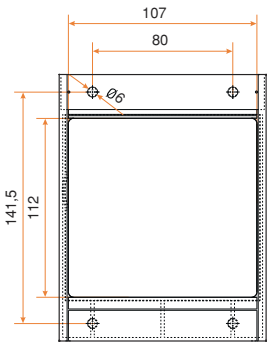
- - - - Shown parts with discrete lines are manufactured as per customer request, (only 300 A are produced with extension bar as a standard)

F51N (4 Poles)

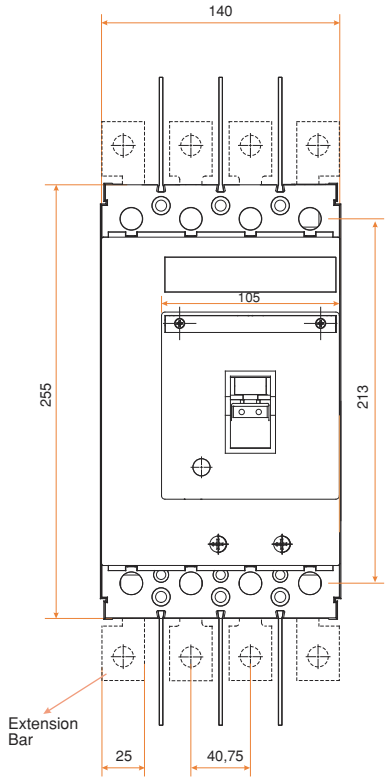


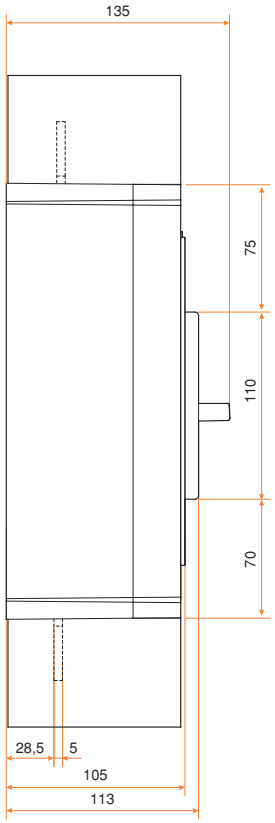


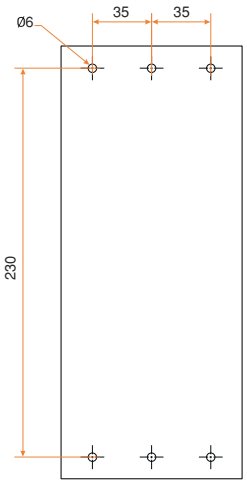




Panel Frame



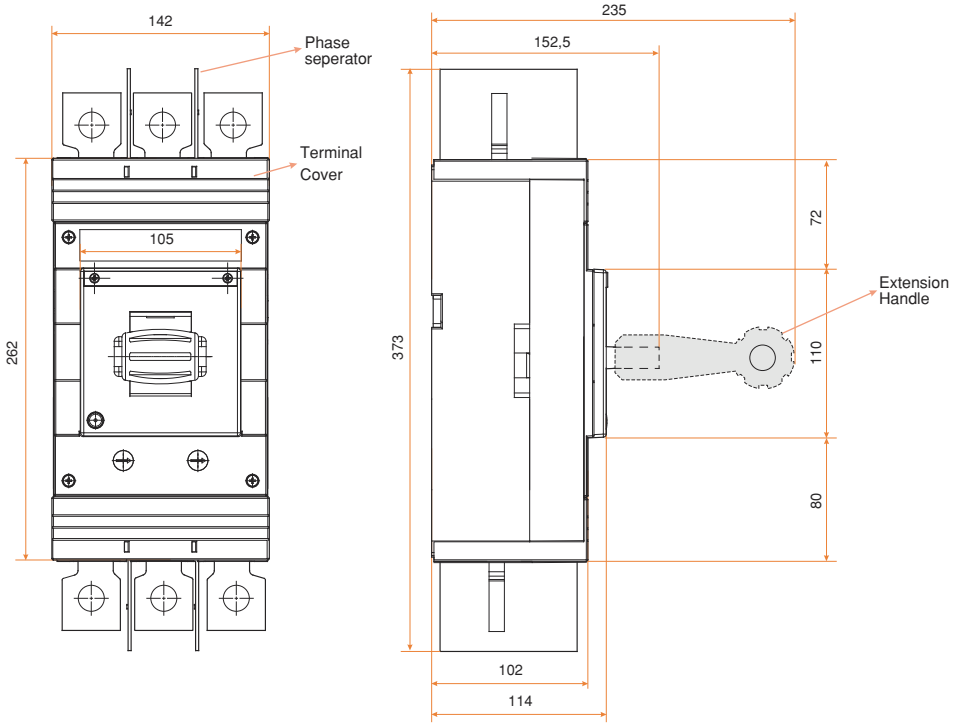


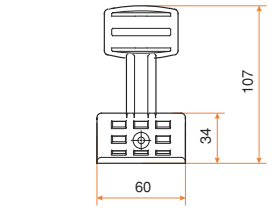


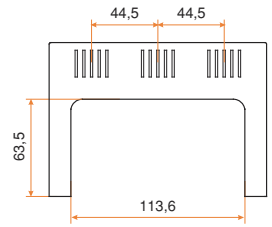
Assembling Gauge

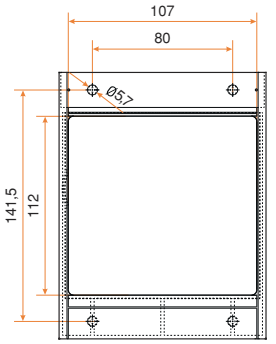
- - - - Shown parts with discrete lines are manufactured as per customer request, (only 300 A are produced with extension bar as a standard)

F61

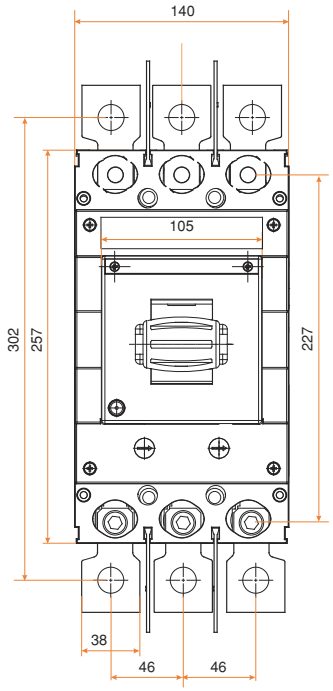


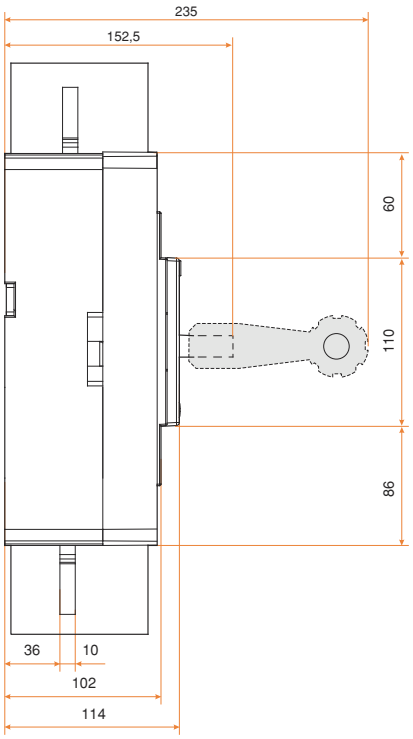


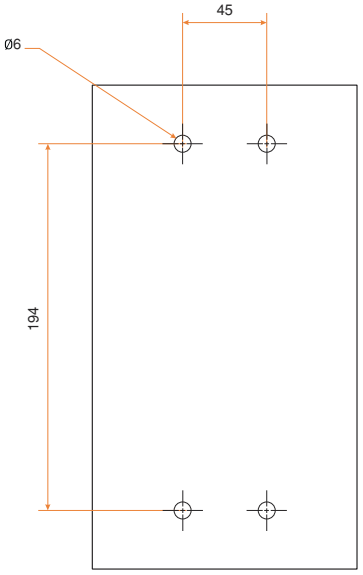




Panel Frame



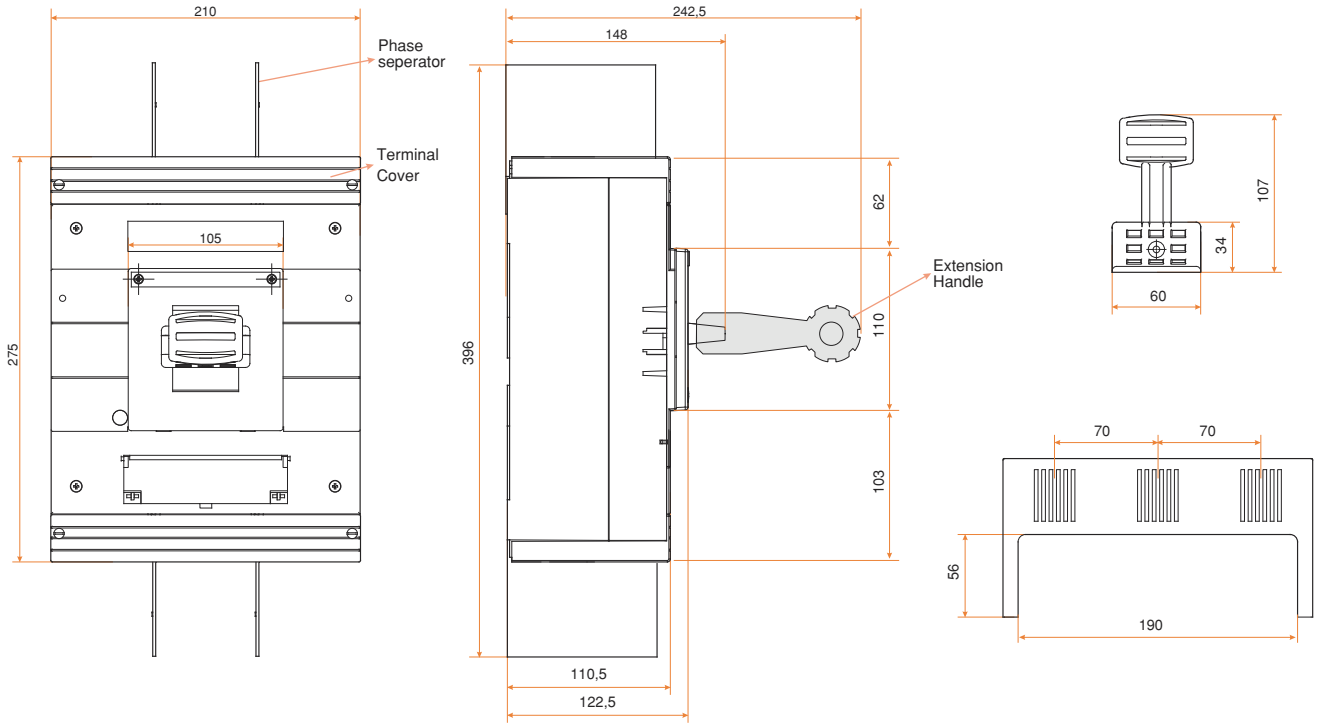


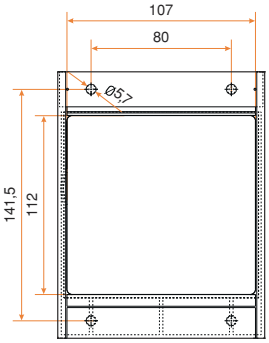


Assembling Gauge

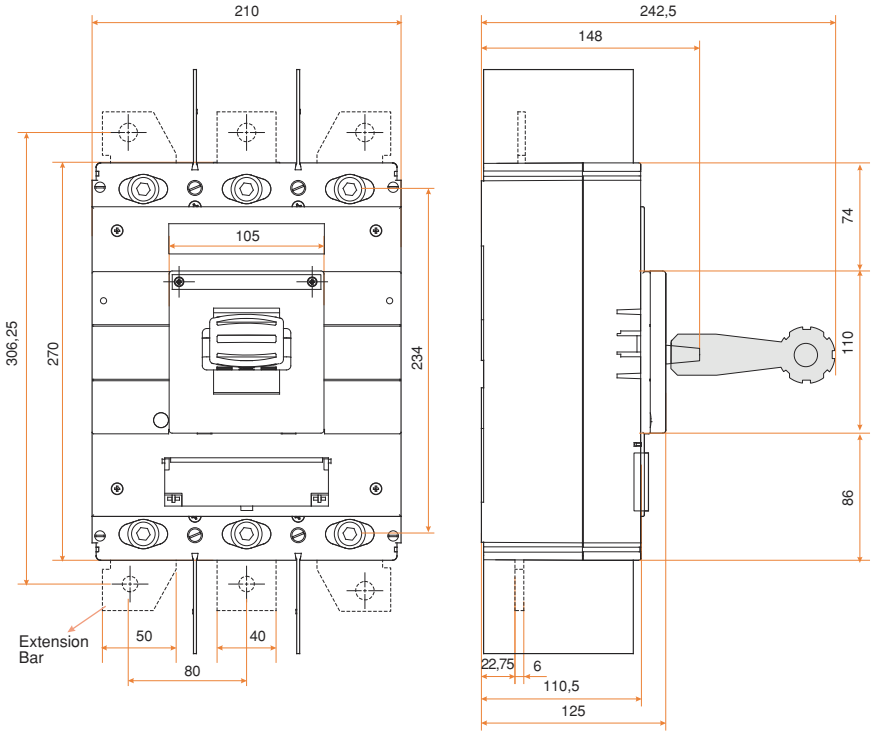
- - - - Shown parts with discrete lines are manufactured as per customer request.

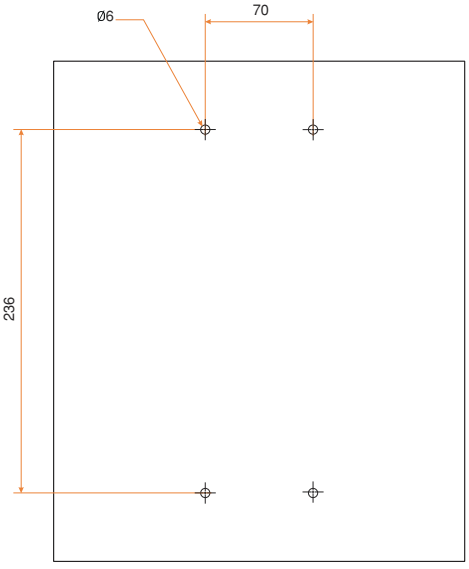
F71





Panel Frame

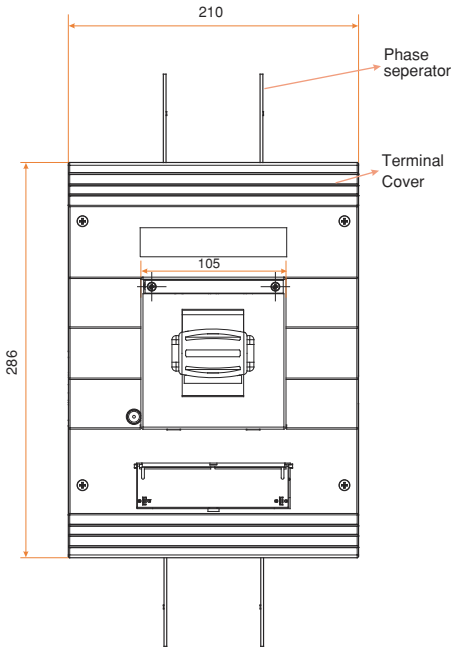


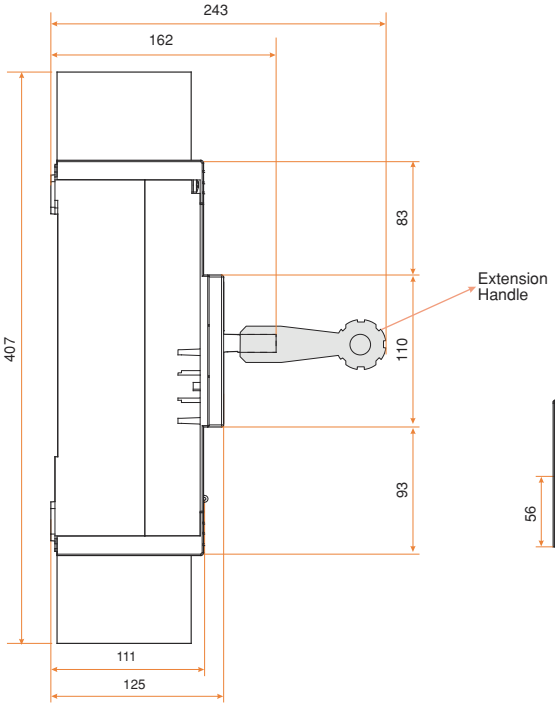


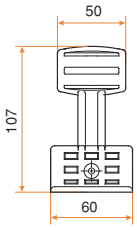
Assembling Gauge

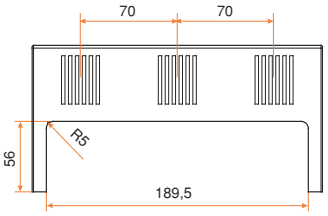
- - - - Shown parts with discrete lines are manufactured as per customer request.

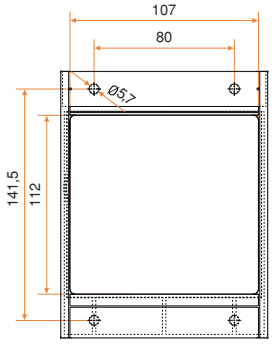
F82



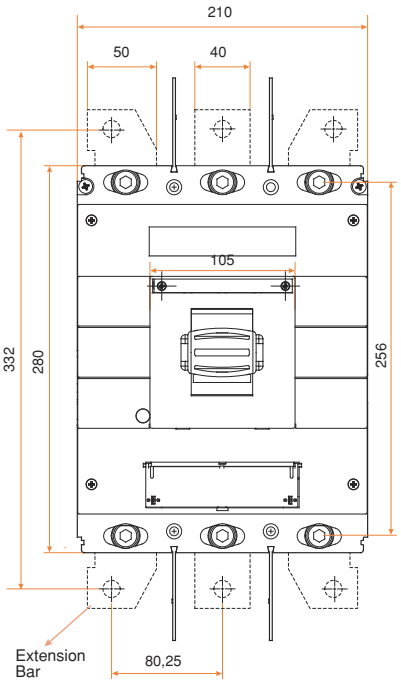


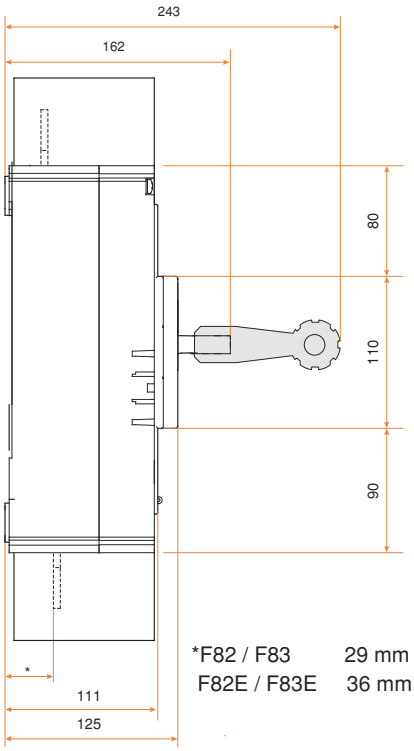




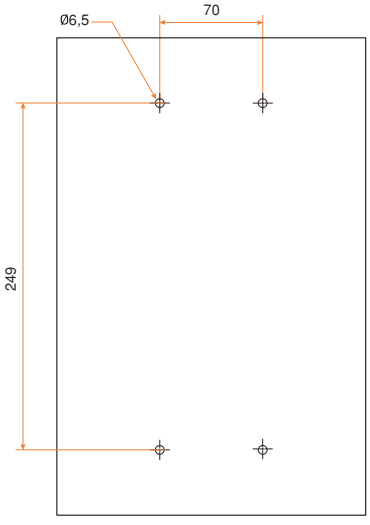


Panel Frame





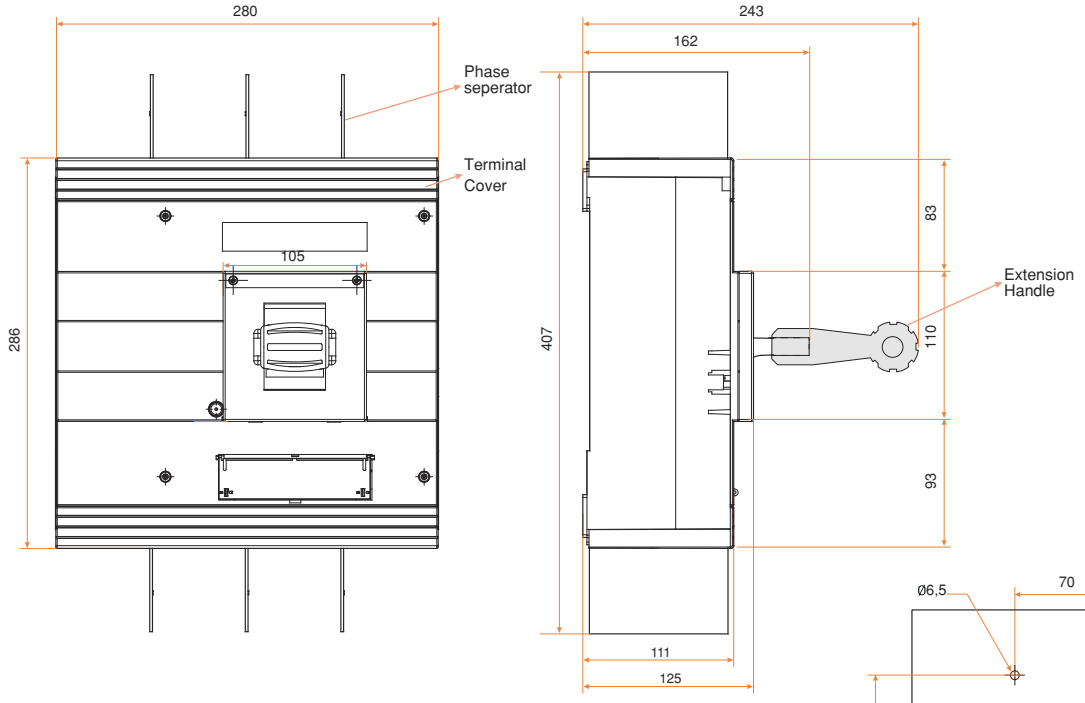
*F82 / F83 29 mm
F82E / F83E 36 mm

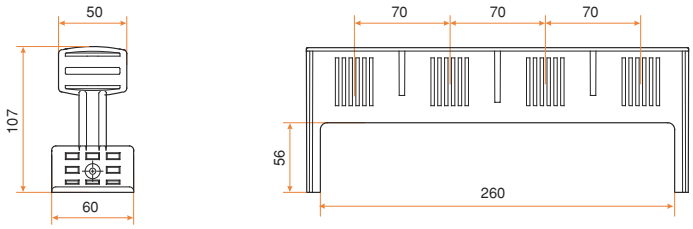


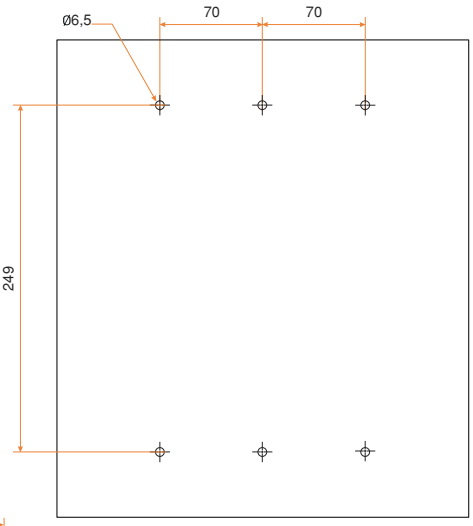
Assembling Gauge

- - - - Shown parts with discrete lines are manufactured as per customer request.

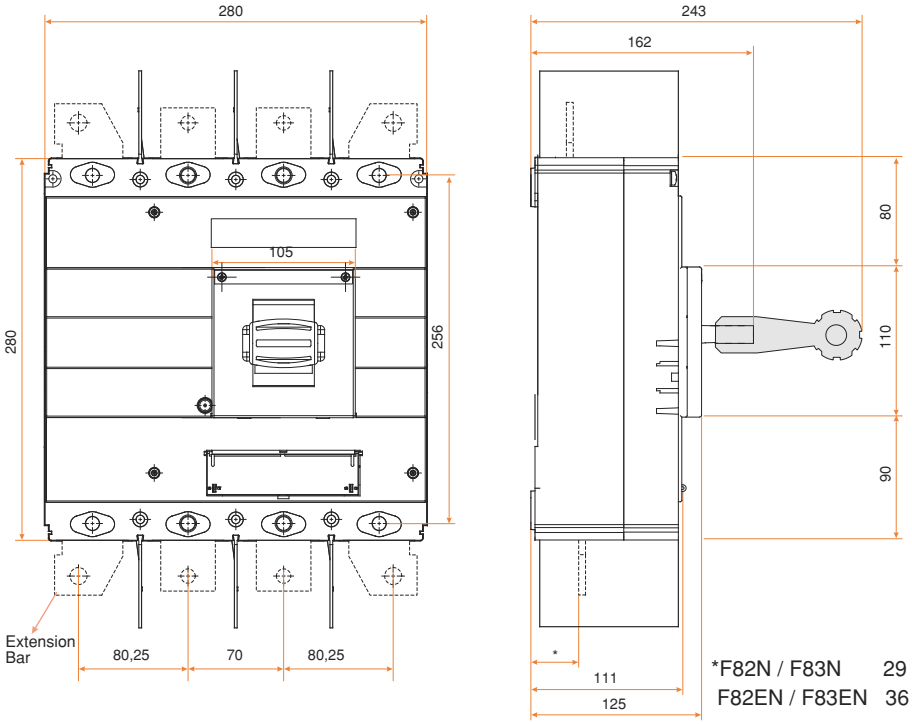
F82N



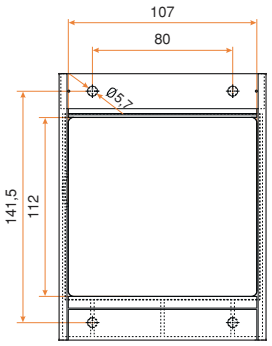




Assembling Gauge



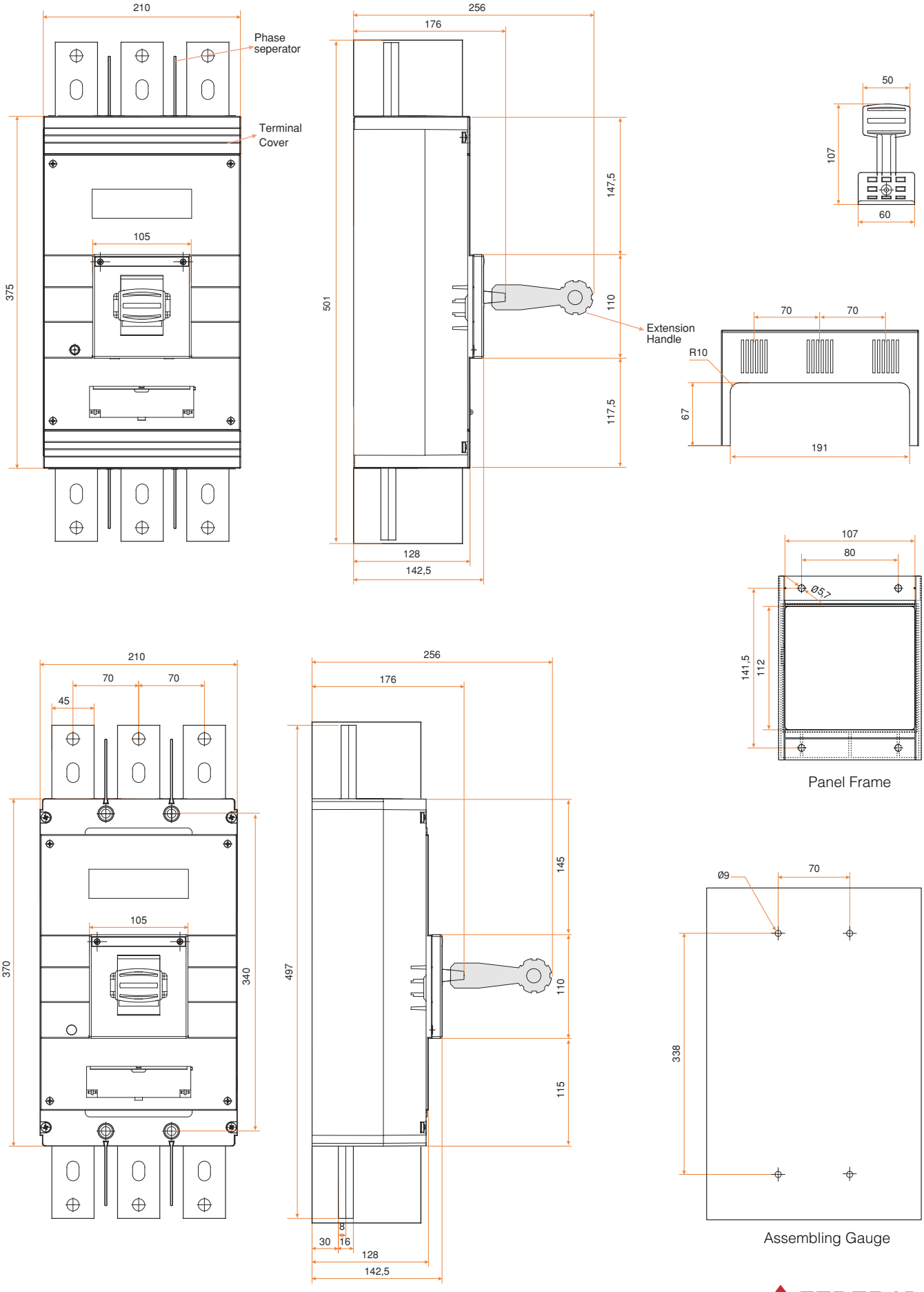
*F82N / F83N 29 mm
F82EN / F83EN 36 mm



Panel Frame

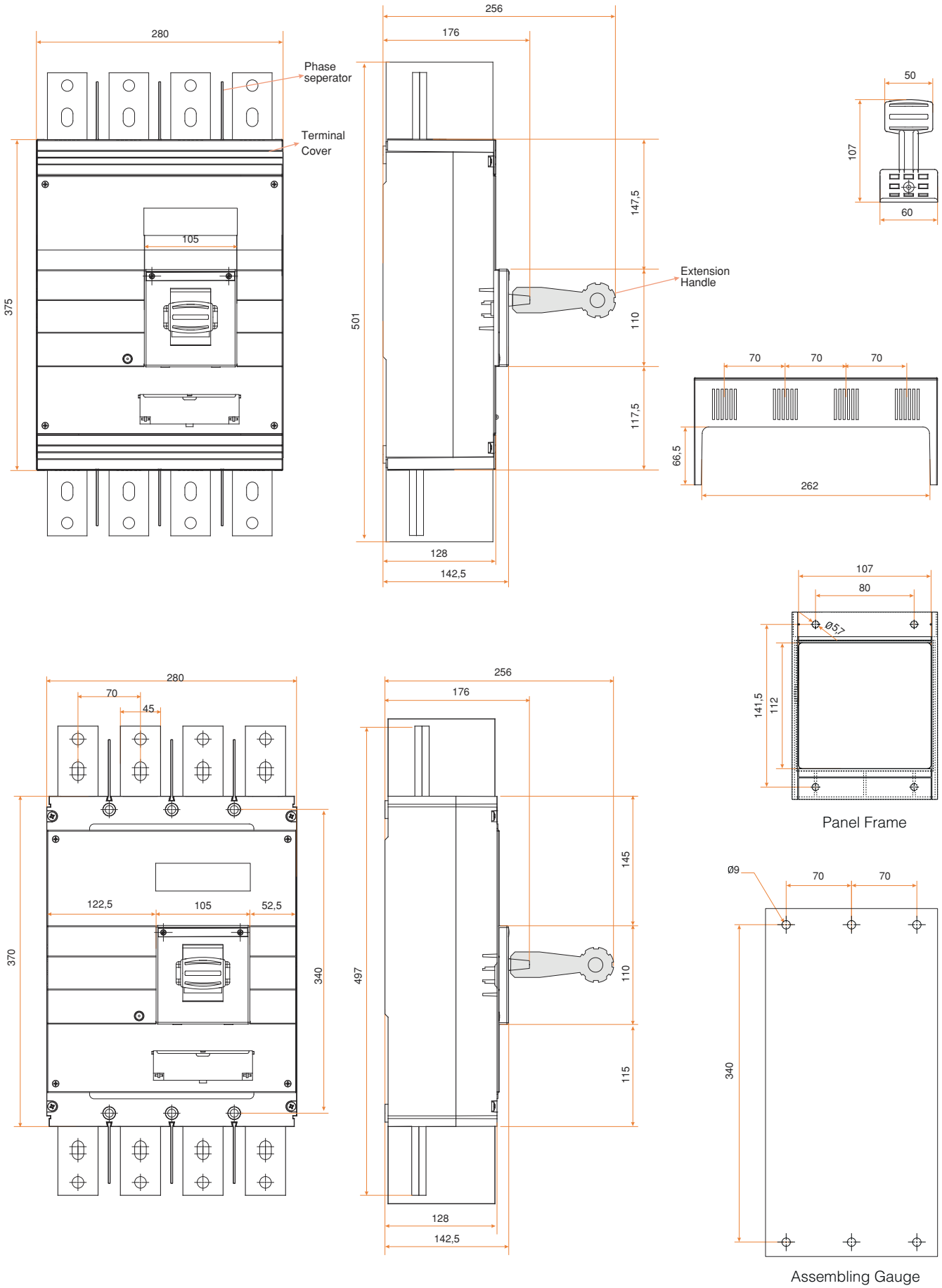
- - - - Shown parts with discrete lines are manufactured as per customer request.

F91

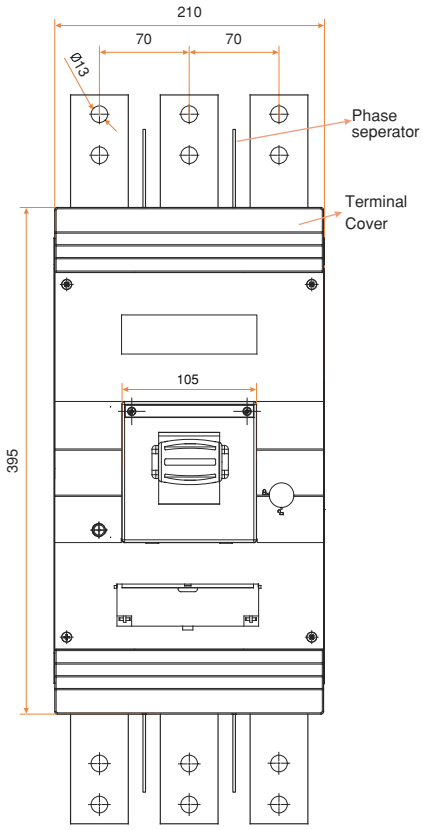

210
Phase
seperator
Terminal
Cover
105
375
256
176
147,5
501
110
117,5
128
142,5
Extension
Handle
50
107
60
70
70
R10
67
191
107
80
Ø5,7
141,5
112
Panel Frame
210
70
70
45
105
370
340
256
176
145
497
110
115
8
30
16
128
142,5
Ø9
70
338
Assembling Gauge

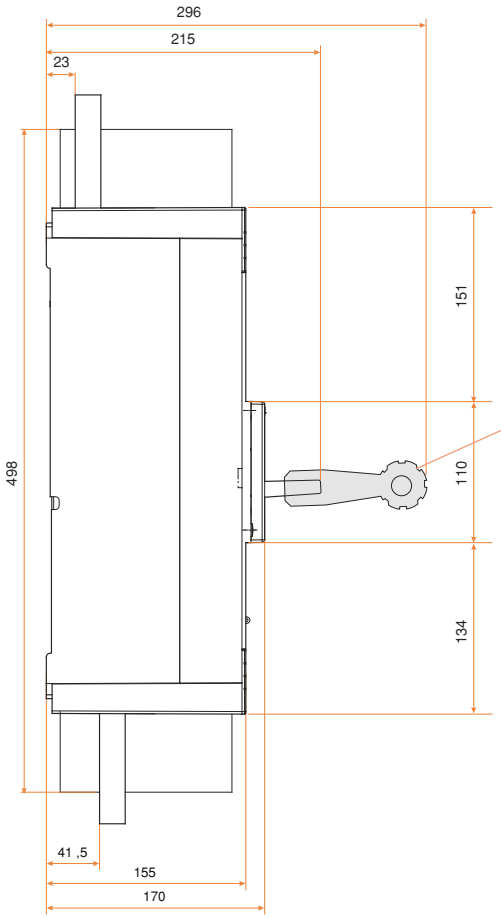
FEDERAL

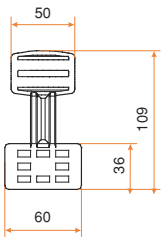
F91N (4 Poles)

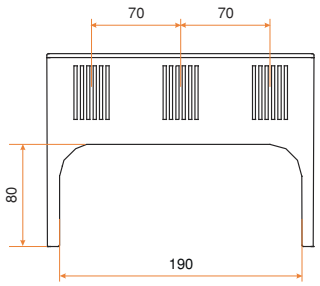

280
Phase seperator
Terminal Cover
105
375
256
176
147,5
501
Extension Handle
110
117,5
128
142,5
50
107
60
70
70
70
66,5
262
107
80
Ø5,7
141,5
112
Panel Frame
280
70
45
122,5
105
52,5
370
340
256
176
145
497
110
115
128
142,5
Ø9
70
70
340
Assembling Gauge

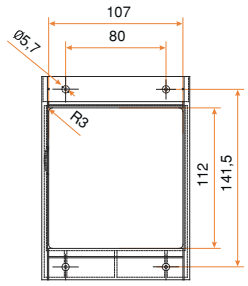
F101E



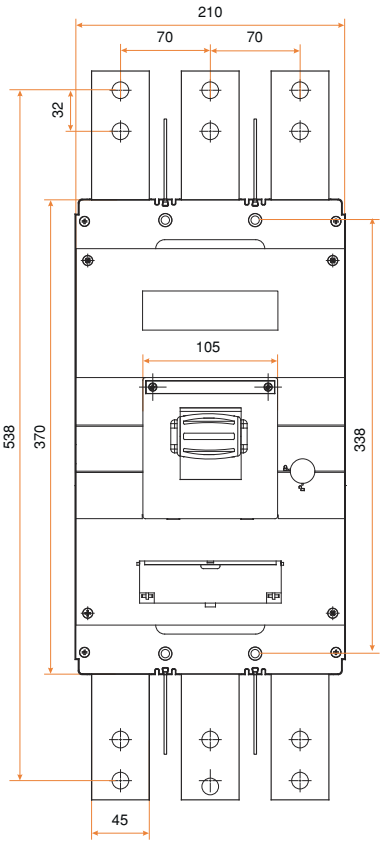


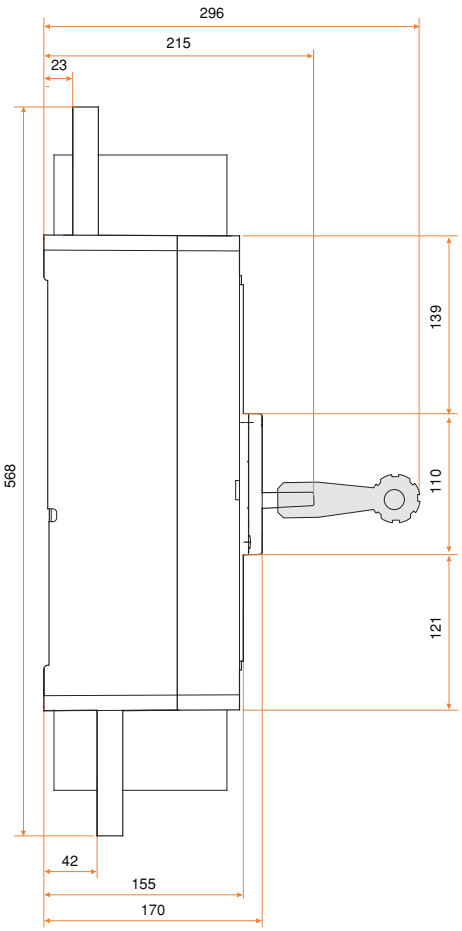


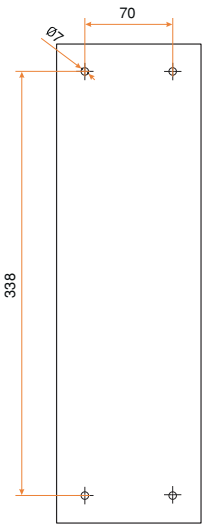




Panel Frame

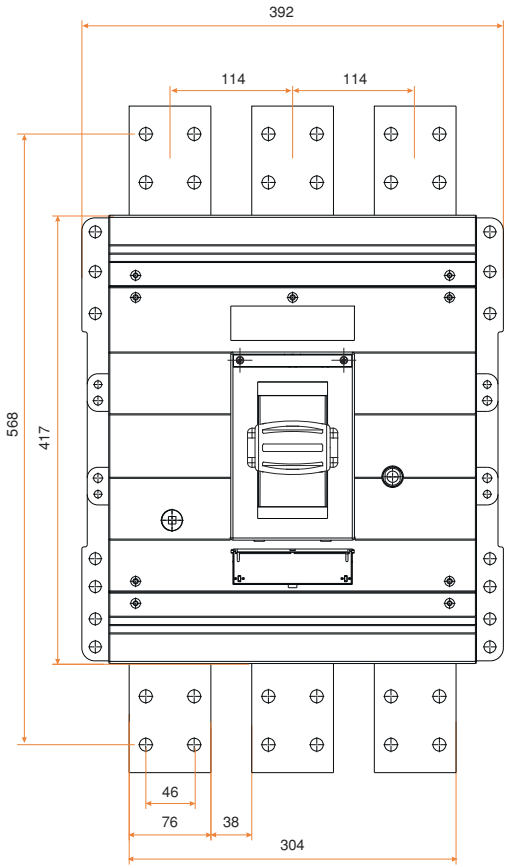


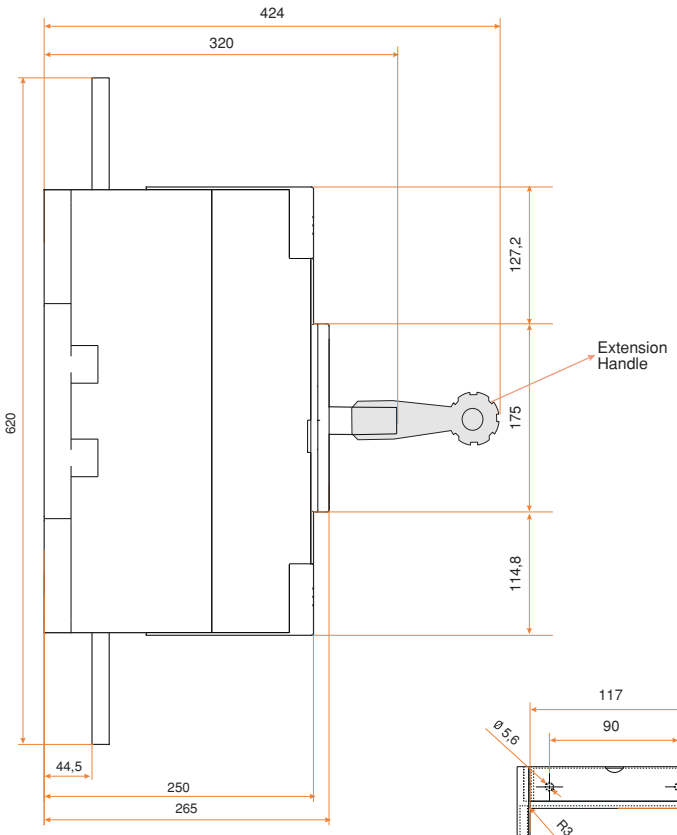


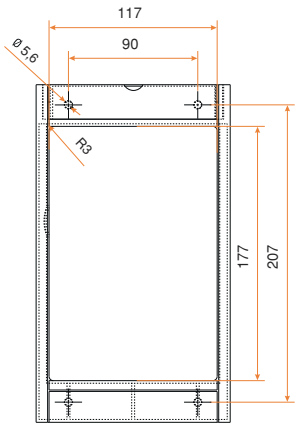


Assembling Gauge

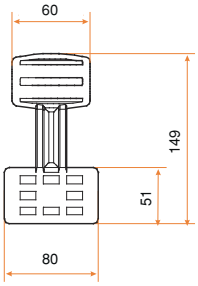
F111

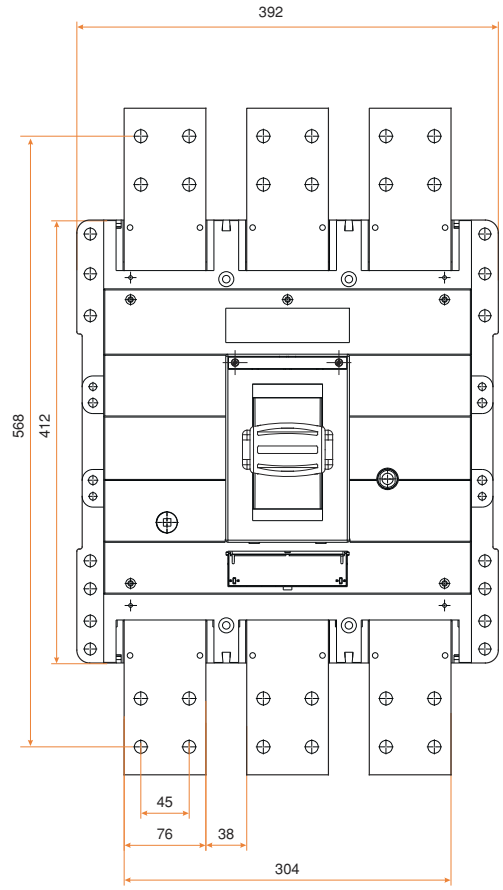


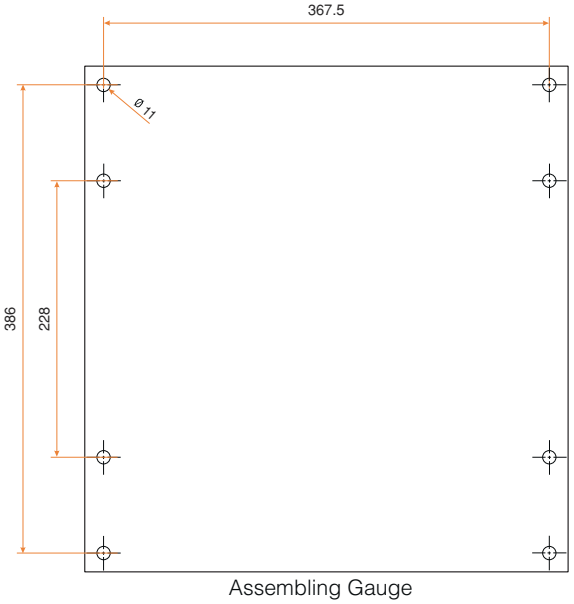




Panel Frame

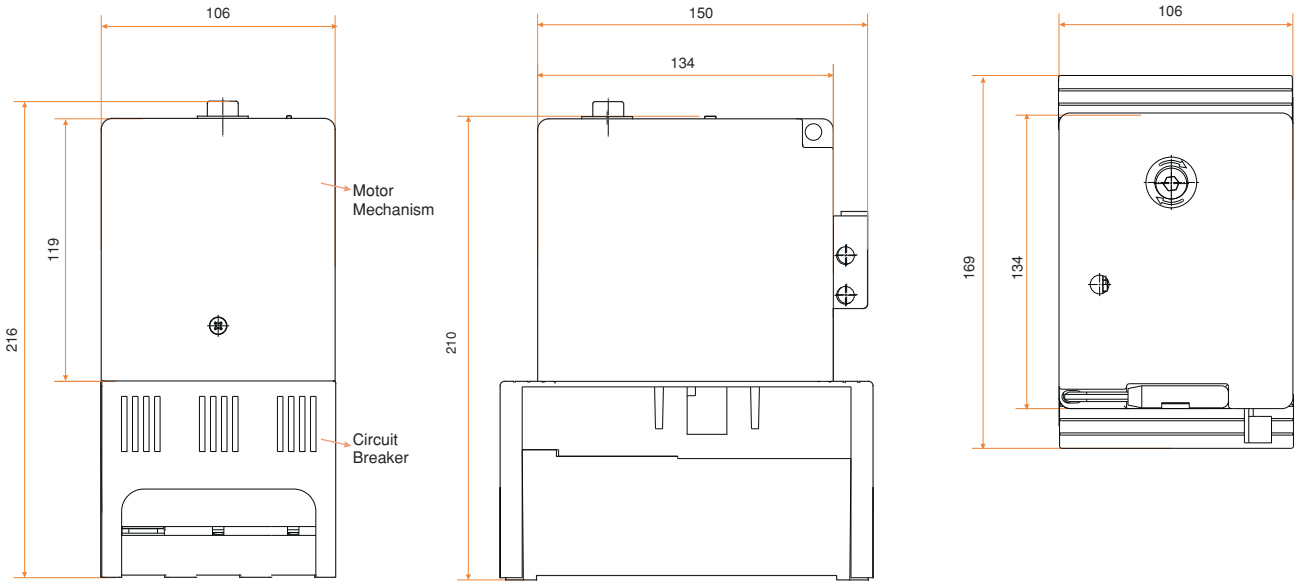




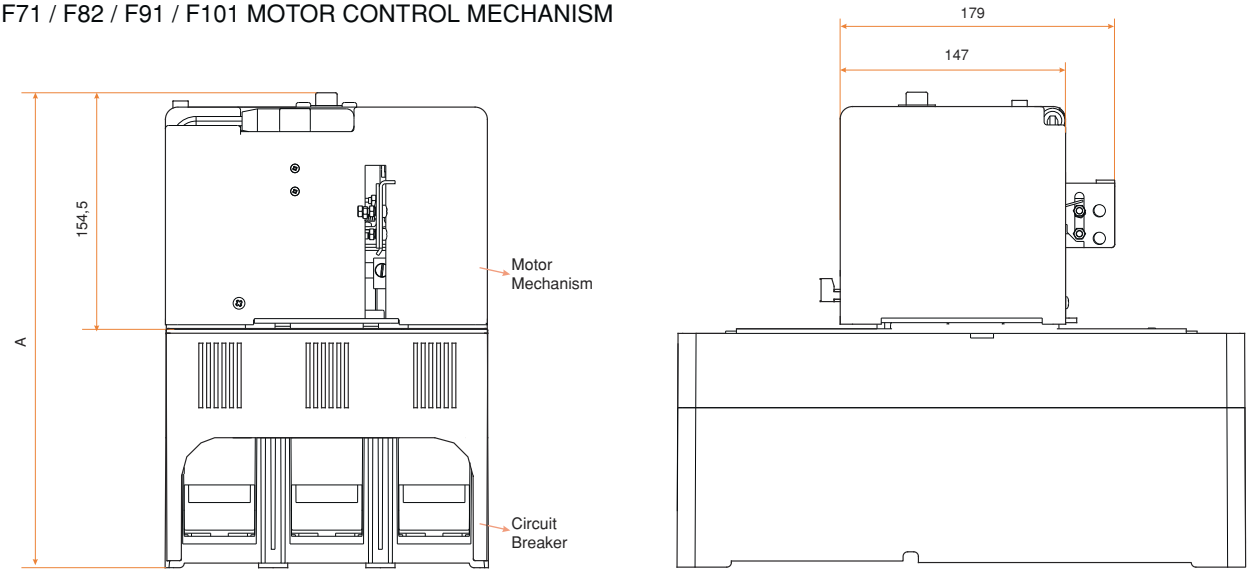


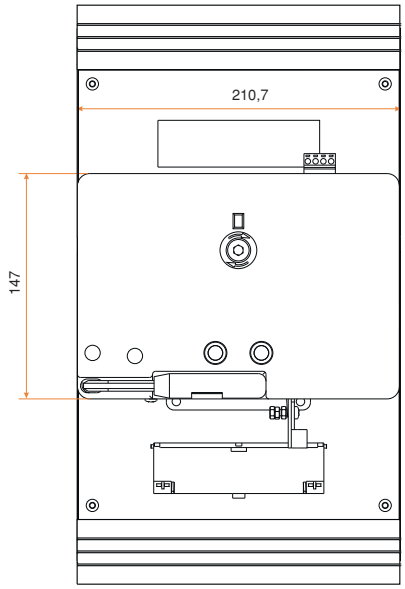
Assembling Gauge

F31 MOTOR CONTROL MECHANISM



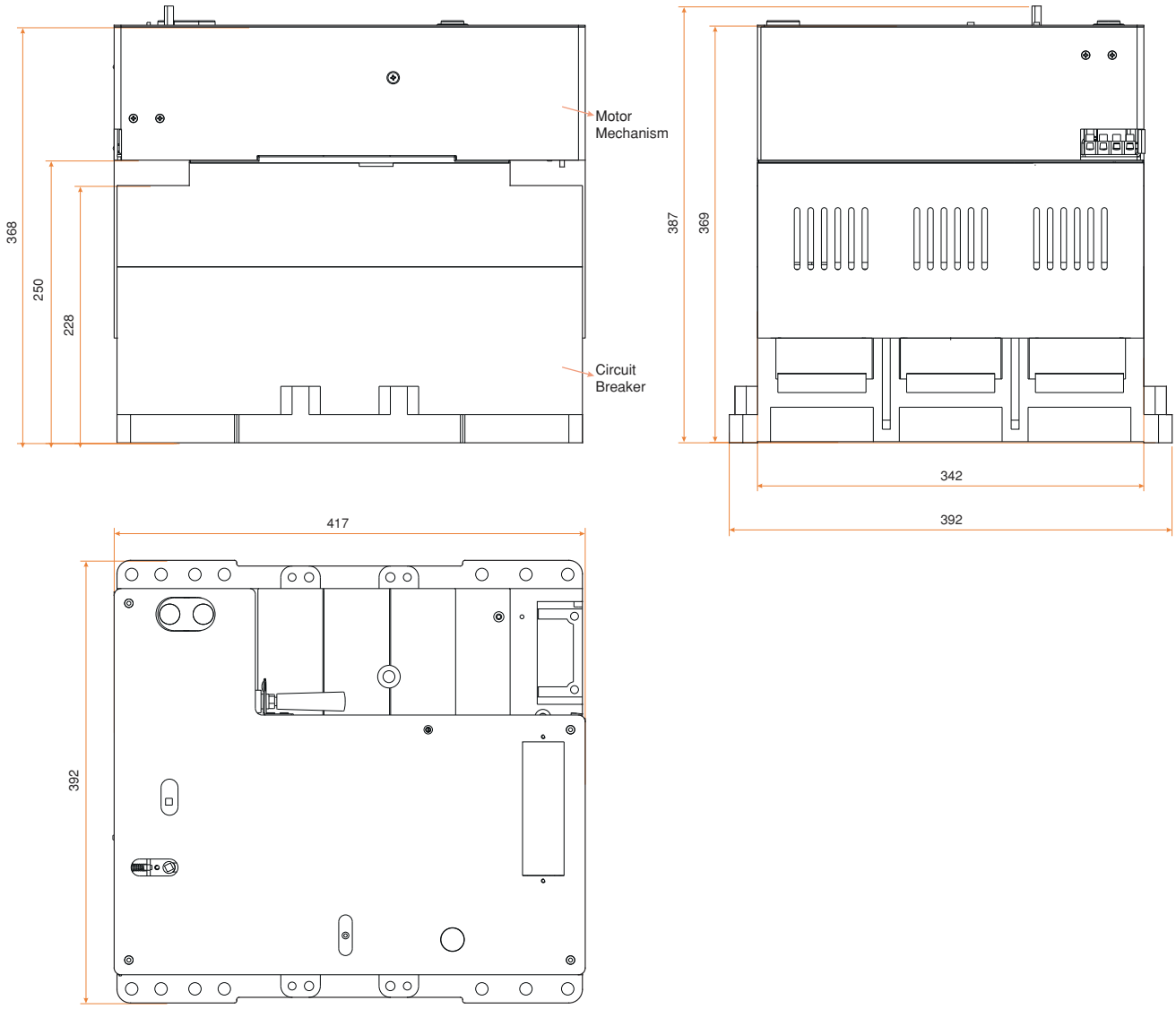
F71 / F82 / F91 / F101 MOTOR CONTROL MECHANISM



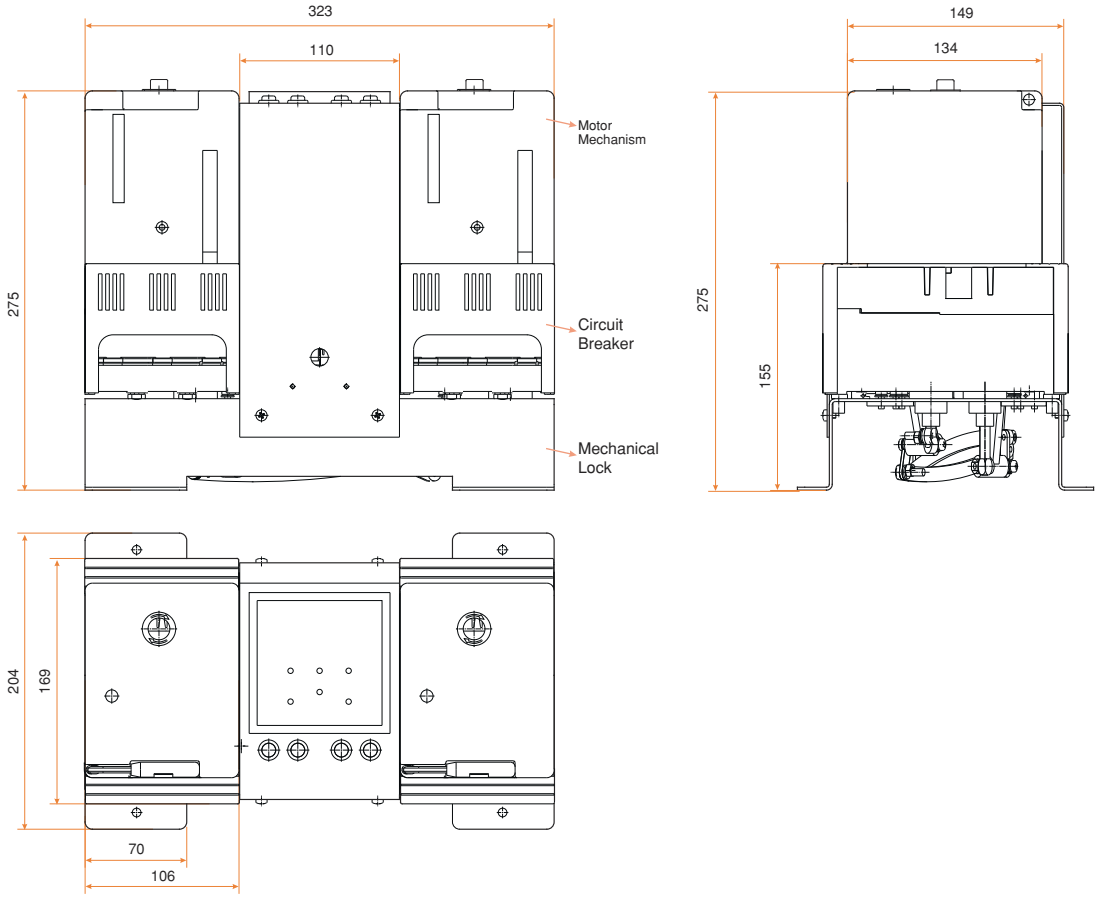


Type	Dimensions
	A
F71	265
F82E	265
F92E	282
F101E	309

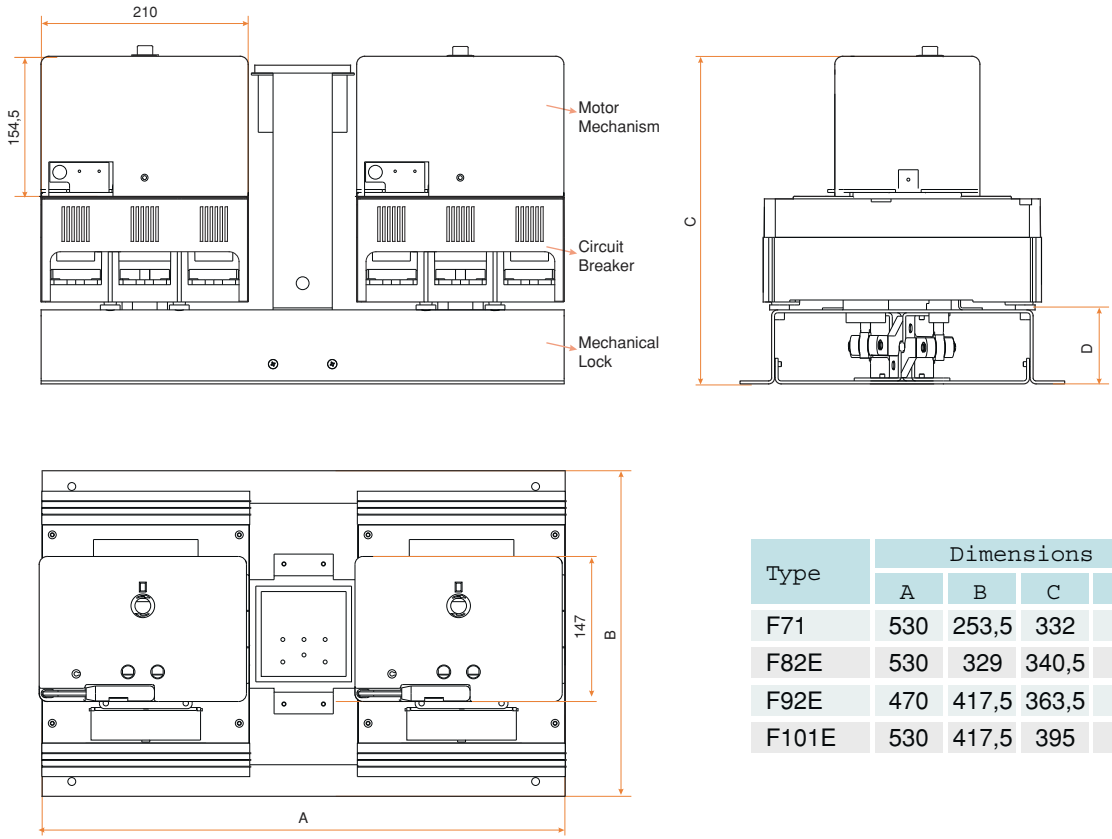
F111 MOTOR CONTROL MECHANISM



F31 INVERSER SET

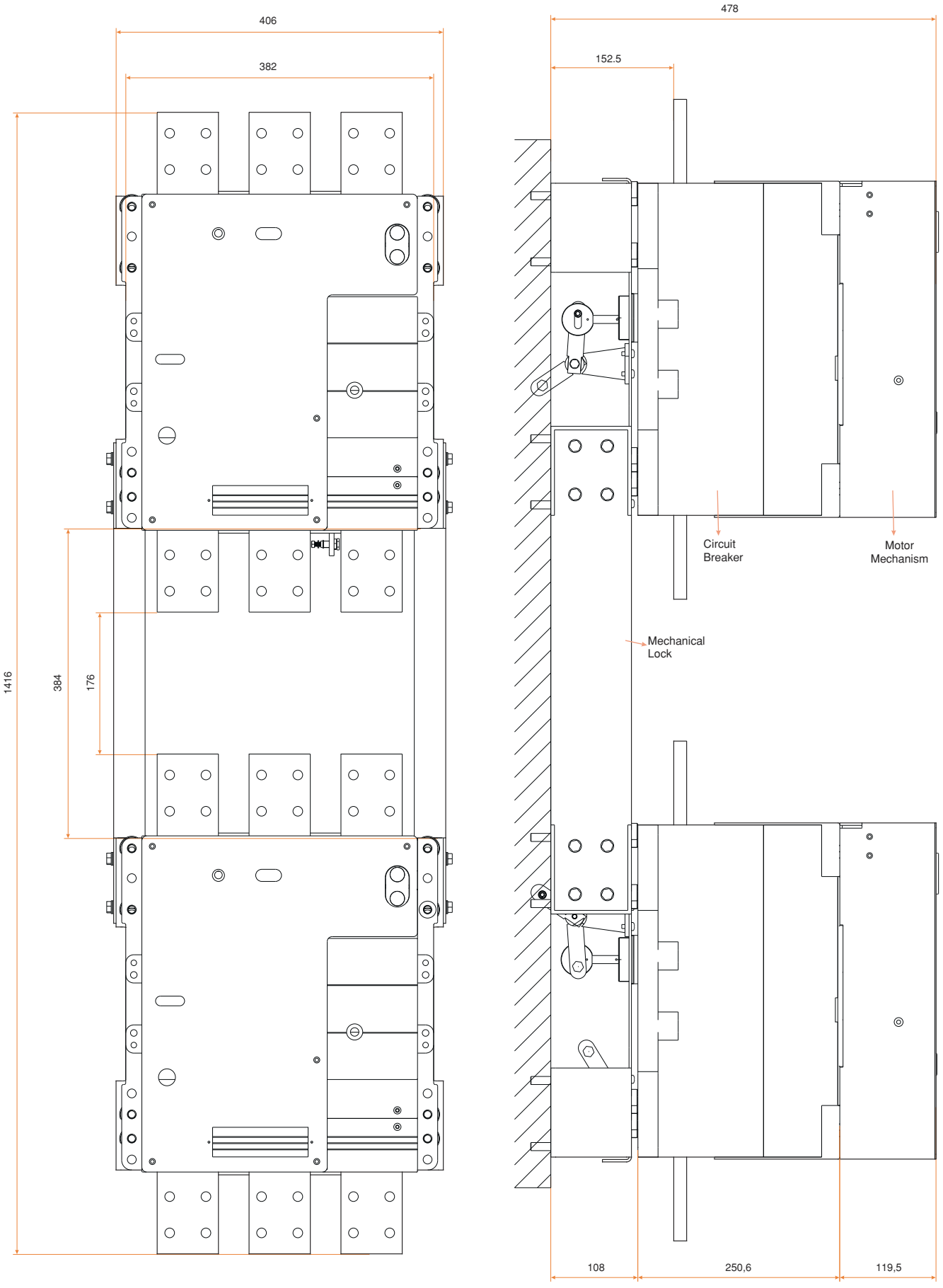


F71/F82E/F92E/F101E INVERSER SET

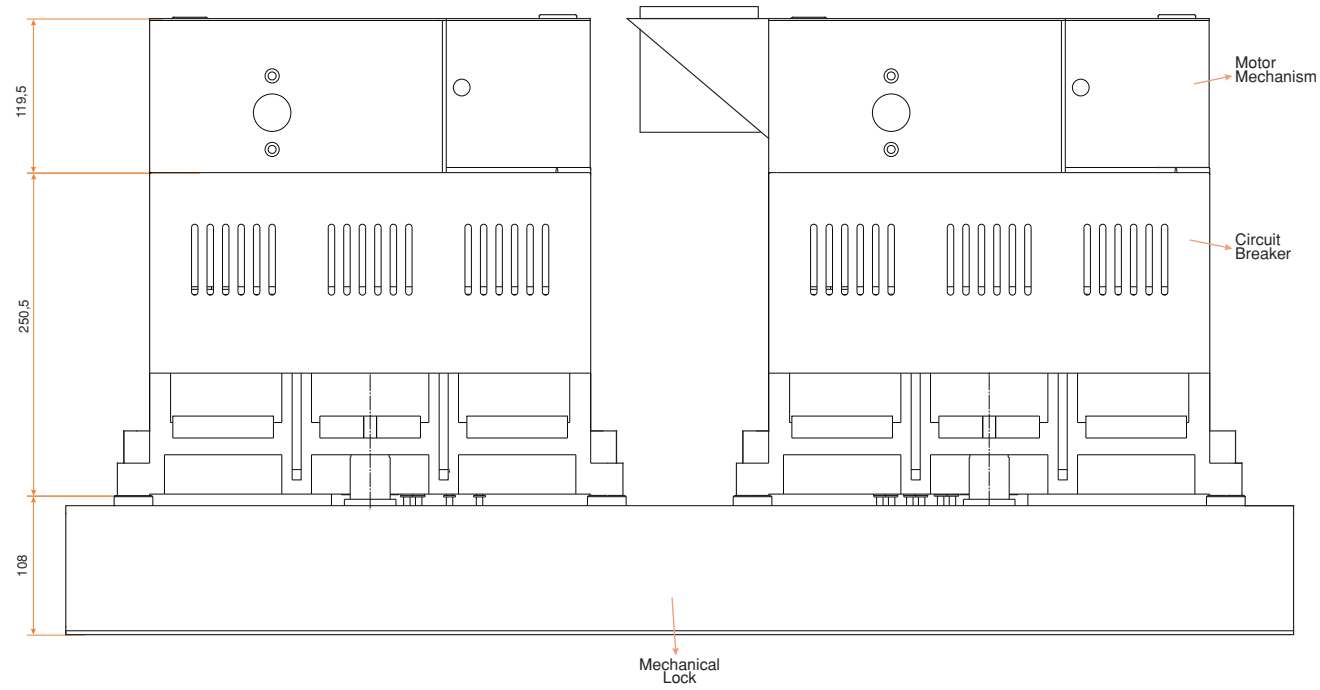


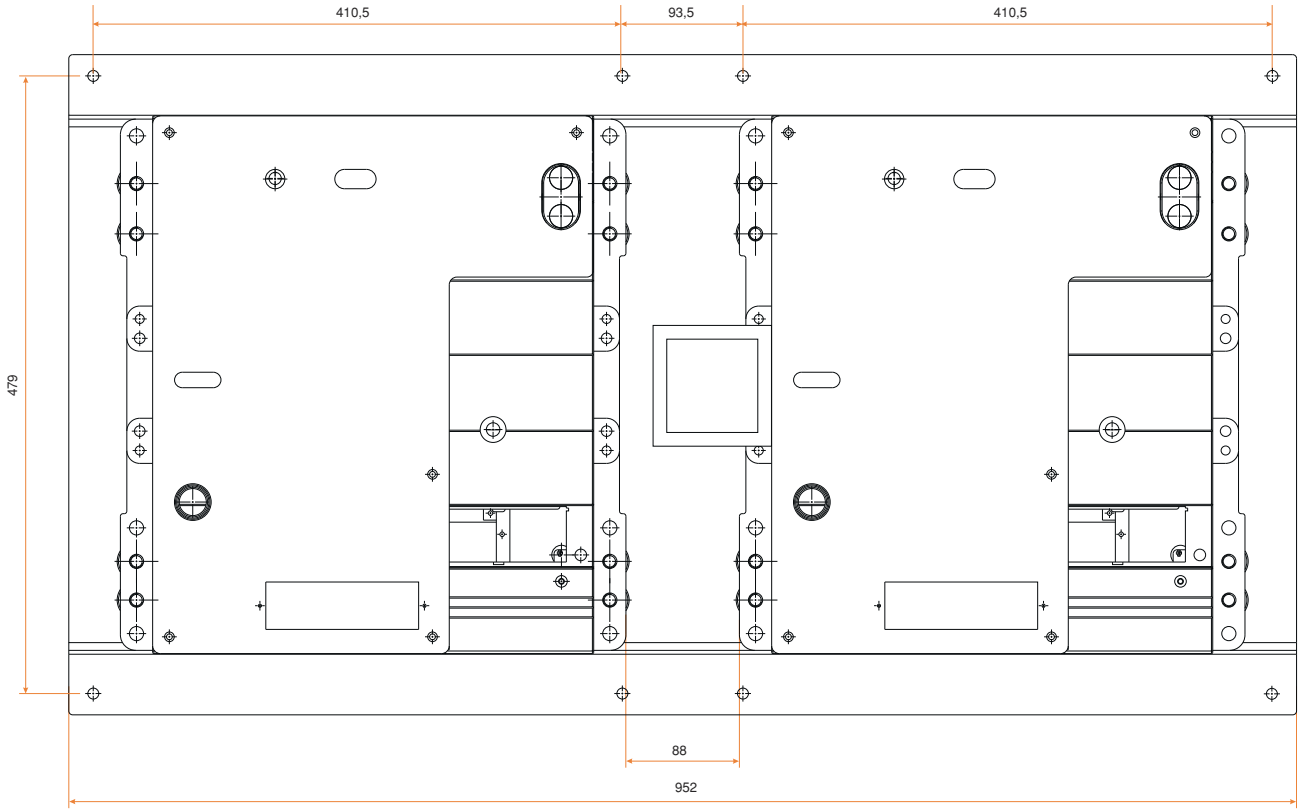
Type	Dimensions			
	A	B	C	D
F71	530	253,5	332	75
F82E	530	329	340,5	75
F92E	470	417,5	363,5	75
F101E	530	417,5	395	75

F111 INVERSER SET (VERTICAL)

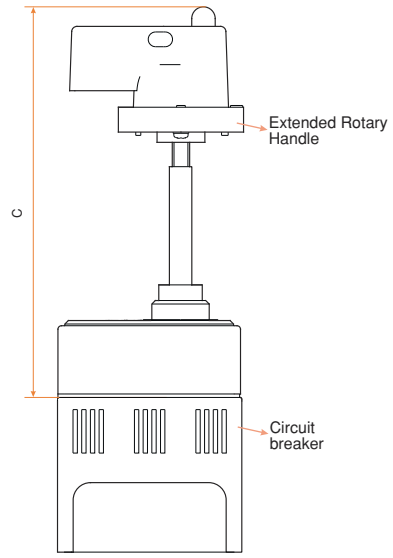


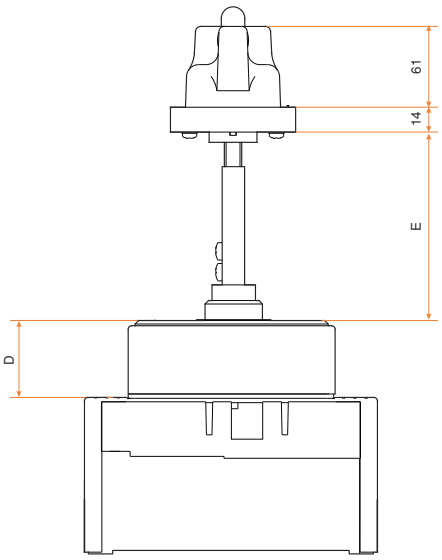
F111 INVERSER SET (HORIZANTAL)

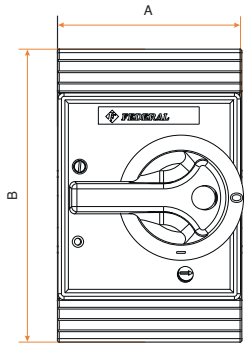




EXTENDED ROTARY HANDLE







Type	Dimensions					
	A	B	C	D	E	
					min	max
F31 / F51	105	119,5	225	45	100	172
F71 / F82E / F92E	210	135	310	63,5	100	180

Please ask special design dimensions CD for panel builder.