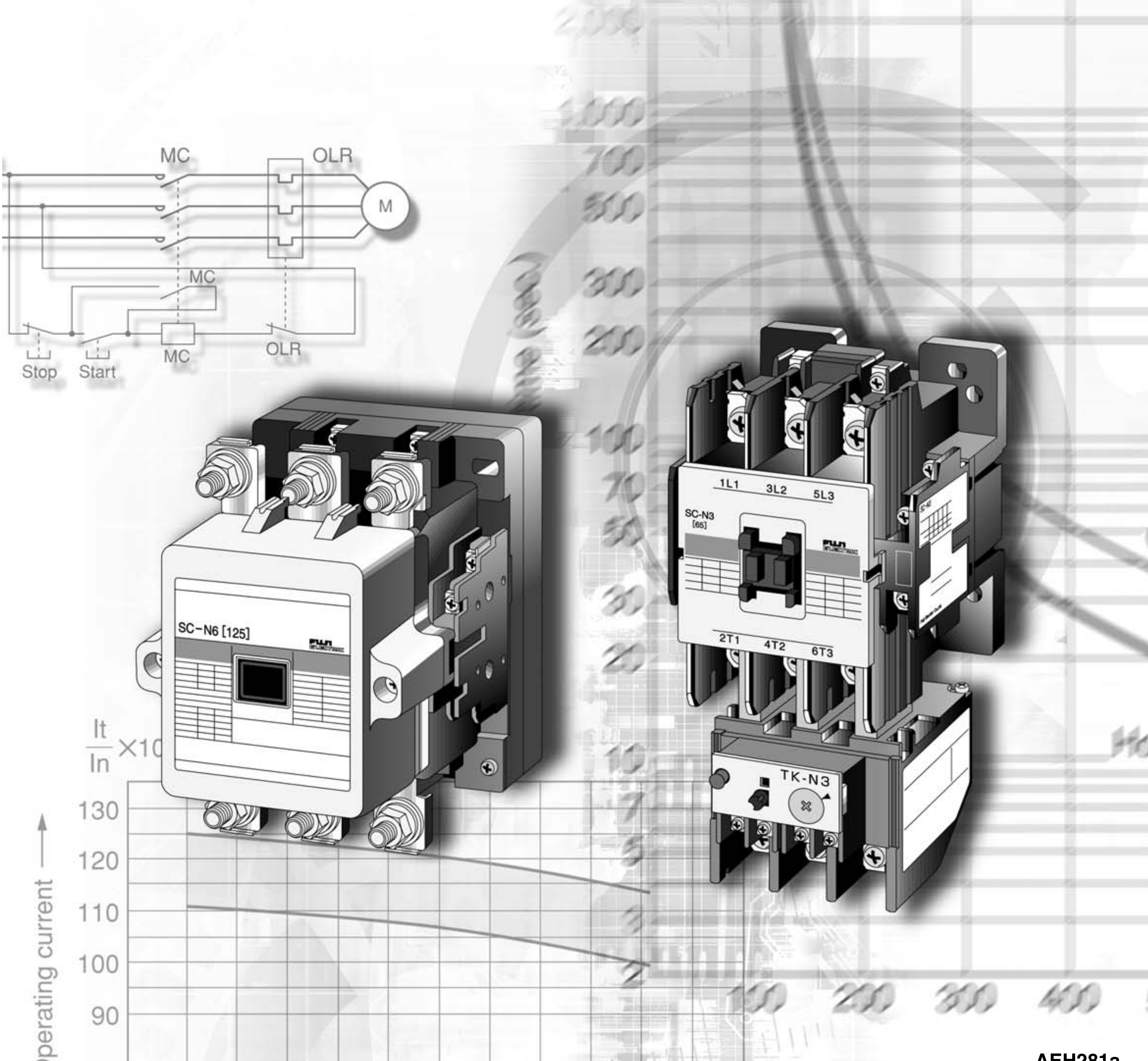
FUJI Magnetic Contactors and Motor Starters

Technical Information



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Chapter 1

Contactors and Starters

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1-1-1 Making and breaking capacities

Utilization category	Typical application		IEC 60947-4-1, EN 60947-4-1, VDE 0660, JIS C 8201-4-1					
			Making and breaking			Making		
			Ic/Ie	Ur/Ue	cosø or L/R	I/Ie	U/Ue	cosø or L/R
AC-1	Non-inductive or slightly inductive loads, resistance furnaces		1.5	1.05	0.8	1.5	1.05	0.8
AC-2	Slip-ring motors: Starting, switching off		4.0	1.05	0.65	4.0	1.05	0.65
AC-3	Squirrel-cage motors: Starting, switching off during running	Ie ≤ 100A	8.0	1.05	0.45	10	1.05	0.45
		Ie > 100A	8.0	1.05	0.35	10	1.05	0.35
AC-4	Squirrel-cage motors: Starting, plugging, inching	Ie ≤ 100A	10	1.05	0.45	12	1.05	0.45
		Ie > 100A	10	1.05	0.35	12	1.05	0.35
AC-5a	Switching of electric discharge lamp controls		3.0	1.05	0.45	3.0	1.05	0.45
AC-5b	Switching of incandescent lamps		1.5	1.05	*	1.5	1.05	*
DC-1	Non-inductive, slightly inductive loads, resistance furnaces		1.5	1.0ms	–	1.5	1.05	1.0ms
DC-3	Shunt-motors: Starting, plugging, inching Dynamic braking of DC motors		4.0	2.5ms	–	4.0	1.05	2.5ms
DC-5	Series-motors: Starting, plugging, inching Dynamic braking of DC motors		4.0	15ms	–	4.0	1.05	15ms
DC-6	Switching of incandescent lamps		1.5	*	–	1.5 *	1.05	*

Note: * Test to be carried out with an incandescent lamp load.

Ie: Rated operational current
Ue: Rated operational voltage
I: Current made
U: Voltage before make
Ur: Recovery voltage
Ic: Current broken

1-1-2 Intermittent duty

IEC 60947-4-1, EN 60947-4-1, VDE 0660		JIS C 8201-4-1					
				Test duty: On-load factor *			
Classification	Operations per hour	Classification	Operations per hour	AC-1, 2, 3	AC-4	DC-1	DC-3, 5
Not specified	1,200	0	1,800	15%	Specified by manufacturer	25%	Specified by manufacturer
	300	1	1,200	25%		40%	
	120	2	600	40%		40%	
	30	3	300	40%		40%	
	12	4	150	60%		60%	
	3	5	30	60%		60%	
	1	6	6	60%		60%	

Note: * Not specified in IEC, EN and VDE

1-1-3 Mechanical and electrical durability
(1) Make/break operations

IEC 60947-4-1, EN60947-4-1, VDE 0660			JIS C 8201-4-1		
Classification	Mechanical (×10³)	Electrical (×10³)	Classification	Mechanical (×10³)	Electrical (×10³)
Not specified	10,000	Not specified	0	10,000	1,000
	3,000		1	5,000	500
	1,000		2	2,500	250
	300		3	1,000	100
	100		4	250	50
	10		5	50	10
	3		6	5	1
	1				

(2) Test duty

Category		IEC 60947-4-1, EN 60947-4-1, VDE 0660, JIS C 8201-4-1					
		Making			Breaking		
		I/Ie	U/Ue	cosø or L/R	Ic/Ie	Ur/Ue	cosø or L/R
AC-1		1	1	0.95	1	1	0.95
AC-2		2.5	1	0.65	2.5	1	0.65
AC-3	Ie ≤ 17A	6	1	0.65	1	0.17	0.65
	Ie > 17A	6	1	0.35	1	0.17	0.35
AC-4	Ie ≤ 17A	6	1	0.65	6	1	0.65
	Ie > 17A	6	1	0.35	6	1	0.35
DC-1		1	1	1ms	1	1	1ms
DC-3		2.5	1	2ms	2.5	1	2ms
DC-5		2.5	1	7.5ms	2.5	1	7.5ms

1-1-4 Conformity of contactors and starters to international standards

(1) Frame size 03 to 5-1

Version		No. of TOR heat elements	Type	IEC	VDE	EN	JIS	JEM	TÜV	CE mark	UL	CSA	Srandard for marine use LR	BV	KR	NK
Contactor Open	Non-reversing	–	SC-□	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	❍	❍	❍	❍
	Reversing	–	SC-□RM	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
	DC operated	–	SC-□/G	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	❍	–	❍
Starter Open	Non-reversing	2	SW-□	–	–	–	–	❍	–	–	–	–	–	–	–	–
		3	SW-□/3H	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
		3	SW-□/2E	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
	Reversing	2	SW-□RM	–	–	❍	–	❍	–	–	–	–	–	–	–	–
		3	SW-□RM/3H	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
		3	SW-□RM/2E	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
	DC operated	2	SW-□/G	–	–	❍	–	❍	–	–	–	–	–	–	–	–
		3	SW-□/G3H	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
Starter Enclosed	Non-reversing	2	SW-□C	–	–	–	–	❍	–	–	–	–	–	–	–	–
		3	SW-□C/3H	❍	❍	❍	❍	❍	–	–	–	–	–	–	–	–
Thermal overload relay	Standard	2	TR-□	–	–	–	–	❍	–	–	–	–	❍	❍	–	–
		3	TR-□/3	❍	❍	❍	❍	❍	❍	❍	❍ R	❍	❍	❍	–	–
	2E type	3	TK-□	❍	❍	❍	❍	❍	❍	❍	❍ R	❍	❍	❍	–	–
Industrial relay	Standard	2	SH-□	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	❍	❍	–	–
	DC operated	3	SH-□/G	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	❍	–	–

Note: ❍ Available, ❍ L: UL Listed, ❍ R: UL Recognized

(2) Frame size N1 to N16

Version		No. of TOR heat elements	Type	IEC	VDE	EN	JIS	JEM	TÜV	CE mark	UL	CSA	Standard for marine use LR	BV	KR	NK
Contactor Open	Non-reversing	–	SC-☐	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	❍	❍	–	❍
	Reversing	–	SC-☐RM	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
	DC operated	–	SC-☐/G	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	❍	❍	–	❍
	With SUPER MAGNET	–	SC-☐/SE	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	❍	❍	–	❍
Starter Open	Non-reversing	2	SW-☐	–	–	–	–	❍	–	–	–	–	–	–	–	–
		3	SW-☐/3H	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
		3	SW-☐/2E	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
	Reversing	2	SW-☐RM	–	–	–	–	❍	–	–	–	–	–	–	–	–
		3	SW-☐RM/3H	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
		3	SW-☐RM/2E	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
	DC operated	2	SW-☐/G	–	–	–	–	❍	–	–	–	–	–	–	–	–
		3	SW-☐/G3H	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
	With SUPER MAGNET	2	SW-☐/SE	–	–	–	–	❍	–	–	–	–	–	–	–	–
		3	SW-☐/SE3H	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	–	–	–	–
Starter Enclosed	Non-reversing	2	SW-☐C	–	–	–	–	❍	–	–	–	–	–	–	–	–
		3	SW-☐C/3H	❍	❍	❍	❍	❍	–	–	–	–	–	–	–	–
Thermal overload relay	Standard	2	TR-☐	–	–	–	–	❍	–	–	–	–	–	–	–	–
		3	TR-☐/3	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	❍	❍	–	–
	2E type	3	TK-☐	❍	❍	❍	❍	❍	❍	❍	❍ L	❍	❍	❍	–	–

Note: ❍ Available, ❍ L: UL Listed, ❍ R: UL Recognized

(3) Optional unit

Version	Type	IEC	VDE	EN	JIS	JEM	TÜV	CE mark	UL	CSA	Standard for marine use LR	BV	KR	NK
Auxiliary contact block	SZ-A☐	❍	❍	❍	❍	❍	❍	❍	❍ R	❍	❍	❍	–	–
Operation counter unit	SZ-J☐	❍	❍	❍	❍	❍	–	–	❍ R *	❍ *	–	–	–	–
Main circuit surge suppression unit	SZ-ZM☐	❍	❍	❍	❍	❍	–	–	❍ R	❍	–	–	–	–
Interlock block	SZ-RM	❍	❍	❍	❍	❍	–	–	❍ R	❍	–	–	–	–
Coil surge suppression unit	SZ-Z☐	❍	❍	❍	❍	❍	❍	❍	❍ R	❍	–	–	–	–
Base unit for thermal overload relay	SZ-H☐	❍	❍	❍	❍	❍	❍	❍	❍ R	❍	–	–	–	–
Reset release button	SZ-R☐	❍	❍	❍	❍	❍	–	–	❍ R	❍	–	–	–	–
Dial cover	SZ-DA	❍	❍	❍	❍	❍	–	–	❍ R	❍	–	–	–	–
Terminal cover	SZ-T☐	❍	❍	❍	❍	❍	❍	–	❍ R	❍	–	–	–	–

Note: ❍ Available, ❍ L: UL Listed, ❍ R: UL Recognized
* Approval for use in combination with the contactor or starter.

1-2 Ratings and specifications

1-2-1 Versions and ratings

Frame size				03	0	05	4-0	4-1	5-1	N1
Type	Contactor, non-reversing		Open	SC-03	SC-0	SC-05	SC-4-0	SC-4-1	SC-5-1	SC-N1
			Enclosed	SC-03C	SC-0C	SC-05C	SC-4-0C	SC-4-1C	SC-5-1C	SC-N1C
	Starter, non-reversing *3		Open	SW-03	SW-0	SW-05	SW-4-0	SW-4-1	SW-5-1	SW-N1
			Enclosed	SW-03C	SW-0C	SW-05C	SW-4-0C	SW-4-1C	SW-5-1C	SW-N1C
	Contactor, reversing		Open	SC-03RM	SC-0RM	SC-05RM	SC-4-0RM	SC-4-1RM	SC-5-1RM	SC-N1RM
	Starter, reversing *3		Open	SW-03RM	SW-0RM	SW-05RM	SW-4-0RM	SW-4-1RM	SW-5-1RM	SW-N1RM
			Enclosed	SW-03RMC	SW-0RMC	SW-05RMC	SW-4-0RMC	SW-4-1RMC	SW-5-1RMC	SW-N1RMC
Rating										
Standard duty AC-3	Max. motor capacity (kW)		200–240V	2.5	3.5	3.5	4.5	5.5	5.5	7.5
			380–440V	4	5.5	5.5	7.5	11	11	15
			500–550V	4	5.5	5.5	7.5	11	11	15
			600–690V	4	5.5	5.5	7.5	7.5	7.5	11
	Operational current (A)		200–240V	11	13	13	18	22	22	32
			380–440V	9	12	12	16	22	22	32
			500–550V	7	9	9	13	17	17	24
			600–690V	5	7	7	9	9	9	15
Heavy duty AC-4, AC-2	Max. motor capacity (kW)		200–240V	2	2.5	2.5	4.5	5	5	5.5
			380–440V	2.2	4	4	4	5.5	5.5	7.5
			500–550V	3.5	5.5	5.5	5.5	7.5	7.5	7.5
	Operational current (A)		200–240V	8	11	11	18	19	19	22
			380–440V	6	9	9	9	12	12	16
			500–550V	6	9	9	9	13	13	13
Resistive load AC-1	Operational current (A)		200–240V	20	20	20	25	32	32	50
			380–440V	20	20	20	25	32	32	50
Rated thermal current (A)				20	20	20	25	32	32	50
Performance										
Operating cycles per hour	AC-3, AC-1			1,800	1,800	1,800	1,800	1,800	1,800	1,200
	AC-4, AC-2			600	600	600	600	600	600	300
Durability ON/OFF operations (×10³)	Mechanical			10,000	10,000	10,000	10,000	10,000	10,000	10,000
	Electrical	AC-3		*1	*1	*1	*1	*1	*1	*1
		AC-4, AC-2		30	30	30	30	30	30	30
		AC-1		500	500	500	500	500	500	500
Auxiliary contact arrangement (non-reversing)										
Standard				1NO 1NC	1NO 1NC	1NO+1NC 2NO 2NC	1NO 1NC	1NO 1NC	1NO+1NC 2NO, 2NC 2NO+2NC	2NO+2NC
On request				–	–	–	–	–	–	4NO+4NC
Combined thermal overload relay										
Standard type		2-element *2		TR-0N	TR-0N	TR-0N	TR-5-1N	TR-5-1N	TR-5-1N	TR-N2
		3-element		TR-0N/3	TR-0N/3	TR-0N/3	TR-5-1N/3	TR-5-1N/3	TR-5-1N/3	TR-N2/3
Phase-loss protection type				TK-0N	TK-0N	TK-0N	TK-5-1N	TK-5-1N	TK-5-1N	TK-N2
Reset				Manual/auto	Manual/auto	Manual/auto	Manual/auto	Manual/auto	Manual/auto	Manual/auto

Notes: *1 Refer to page 62.
*2 Does not conform to IEC, UL/CSA and JIS standards.
*3 2-element type: SW-□, 3-element type: SW-□**/3H**, SW-□**/2E**

Frame size			N2	N2S	N3	N4	N5	N6	N7
Type	Contactor, non-reversing	Open	SC-N2	SC-N2S	SC-N3	SC-N4	SC-N5	SC-N6	SC-N7
		Enclosed	SC-N2C	SC-N2SC	SC-N3C	SC-N4C	SC-N5C	SC-N6C	SC-N7C
	Starter, non-reversing *3	Open	SW-N2	SW-N2S	SW-N3	SW-N4	SW-N5	SW-N6	SW-N7
		Enclosed	SW-N2C	SW-N2SC	SW-N3C	SW-N4C	SW-N5C	SW-N6C	SW-N7C
	Contactor, reversing	Open	SC-N2RM	SC-N2SRM	SC-N3RM	SC-N4RM	SC-N5RM	SC-N6RM	SC-N7RM
	Starter, reversing *3	Open	SW-N2RM	SW-N2SRM	SW-N3RM	SW-N4RM	SW-N5RM	SW-N6RM	SW-N7RM
		Enclosed	SW-N2RMC	SW-N2SRMC	SW-N3RMC	SW-N4RMC	SW-N5RMC	SW-N6RMC	SW-N7RMC
Rating									
Standard duty AC-3	Max. motor capacity (kW)	200–240V	11	15	18.5	22	30	37	45
		380–440V	18.5	22	30	40	55	60	75
		500–550V	18.5	25	37	37	55	60	75
		600–690V	15	22	30	37	55	60	90
	Operational current (A)	200–240V	40	50	65	80	105	125	150
		380–440V	40	50	65	80	105	125	150
		500–550V	29	38	60	60	85	90	120
		600–690V	19	26	38	44	64	72	103
Heavy duty AC-4, AC-2	Max. motor capacity (kW)	200–240V	9	9	15	18.5	22	25	37
		380–440V	15	15	22	30	40	45	55
		500–550V	12.5	15	25	30	45	45	60
	Operational current (A)	200–240V	35	35	50	65	80	93	125
		380–440V	32	32	50	65	80	90	105
		500–550V	20	24	38	48	72	72	90
Resistive load AC-1	Operational current (A)	200–240V	60	80	100	135	150	150	200
		380–440V	60	80	100	135	150	150	200
Rated thermal current (A)			60	80	100	135	150	150	200
Performance									
Operating cycles per hour	AC-3, AC-1		1,200	1,200	1,200	1,200	1,200	1,200	1,200
	AC-4, AC-2		300	300	300	300	300	300	300
Durability ON/OFF operations (×10³)	Mechanical		10,000	5,000	5,000	5,000	5,000	5,000	5,000
	Electrical	AC-3	*1	*1	*1	*1	*1	*1	*1
		AC-4, AC-2	30	30	30	30	30	30	30
		AC-1	500	500	500	500	500	500	500
Auxiliary contact arrangement (non-reversing)									
Standard			2NO+2NC	2NO+2NC	2NO+2NC	2NO+2NC	2NO+2NC	2NO+2NC	2NO+2NC
On request			4NO+4NC	4NO+4NC	4NO+4NC	4NO+4NC	4NO+4NC	4NO+4NC	4NO+4NC
Combined thermal overload relay									
Standard type		2-element *2	TR-N2	TR-N3	TR-N3	TR-N5	TR-N5	TR-N6	TR-N7
		3-element	TR-N2/3	TR-N3/3	TR-N3/3	TR-N5/3	TR-N5/3	TR-N6/3	TR-N7/3
Phase-loss protection type			TK-N2	TK-N3	TK-N3	TK-N5	TK-N5	TK-N6	TK-N7
Reset			Manual/auto	Manual/auto	Manual/auto	Manual/auto	Manual/auto	Manual/auto	Manual/auto

Notes: *1 Refer to page 62 or 63.
*2 Does not conform to IEC, UL/CSA and JIS standards.
*3 2-element type: SW-□, 3-element type: SW-□**/3H**, SW-□**/2E**

1-2 Ratings and specifications

Frame size				N8	N10	N11	N12	N14	N16
Type	Contactor, non-reversing		Open	SC-N8	SC-N10	SC-N11	SC-N12	SC-N14	SC-N16
			Enclosed	SC-N8C	SC-N10C	SC-N11C	SC-N12C	SC-N14C	–
	Starter, non-reversing *3		Open	SW-N8	SW-N10	SW-N11	SW-N12	SW-N14	–
			Enclosed	SW-N8C	SW-N10C	SW-N11C	SW-N12C	SW-N14C	–
	Contactor, reversing		Open	SC-N8RM	SC-N10RM	SC-N11RM	SC-N12RM	SC-N14RM	–
	Starter, reversing *3		Open	SW-N8RM	SW-N10RM	SW-N11RM	SW-N12RM	SW-N14RM	–
			Enclosed	SW-N8RMC	SW-N10RMC	–	–	–	–
Rating									
Standard duty AC-3	Max. motor capacity (kW)		200–240V	55	65	90	120	180	220
			380–440V	90	110	160	220	315	440
			500–550V	130	132	160	250	400	500
			600–690V	132	132	200	300	480	500
	Operational current (A)		200–240V	180	220	300	400	600	800
			380–440V	180	220	300	400	600	800
			500–550V	180	200	230	360	600	720
			600–690V	150	150	230	360	600	630
Heavy duty AC-4, AC-2	Max. motor capacity (kW)		200–240V	45	55	65	90	120	180
			380–440V	75	90	110	160	220	315
			500–550V	90	90	130	160	250	–
	Operational current (A)		200–240V	150	180	220	300	400	600
			380–440V	150	180	220	300	400	600
			500–550V	145	145	180	230	360	–
Resistive load AC-1	Operational current (A)		200–240V	260	260	350	450	660	800
			380–440V	260	260	350	450	660	800
Rated thermal current (A)				260	260	350	450	660	800
Performance									
Operating cycles per hour	AC-3, AC-1			1,200	1,200	1,200	1,200	1,200	1,200
	AC-4, AC-2			300	300	300	300	300	300
Durability ON/OFF operations (×10³)	Mechanical			5,000	5,000	5,000	5,000	5,000	2,500
	Electrical	AC-3		*1	*1	*1	*1	*1	*1
		AC-4, AC-2		30	30	30	30	30	15
		AC-1		500	500	500	500	500	250
Auxiliary contact arrangement (non-reversing)									
Standard				2NO+2NC	2NO+2NC	2NO+2NC	2NO+2NC	2NO+2NC	2NO+2NC
On request				4NO+4NC	4NO+4NC	4NO+4NC	4NO+4NC	4NO+4NC	4NO+4NC
Combined thermal overload relay									
Standard type			2-element *2	TR-N8	TR-N10	TR-N12	TR-N12	TR-N14	–
			3-element	TR-N8/3	TR-N10/3	TR-N12/3	TR-N12/3	TR-N14/3	
Phase-loss protection type				TK-N8	TK-N10	TK-N12	TK-N12	TK-N14	
Reset				Manual/auto	Manual/auto	Manual/auto	Manual/auto	Manual/auto	–

Notes: *1 Refer to page 63.
*2 Does not conform to IEC, UL/CSA and JIS standards.
*3 2-element type: SW-☐, 3-element type: SW-☐**/3H**, SW-☐**/2E**

1-2-2 Main circuit ratings

(1) IEC 60947-4-1, EN 60947-4-1, VDE 0660

Type	Max. motor capacity (kW) Three-phase motor Standard duty AC-3				Rated operational current (A) Three-phase motor Standard duty AC-3				Rated thermal current (A)
	200–240V	380–440V	500–550V	600–690V	200–240V	380–440V	500–550V	600–690V	
SC-03	2.5	4	4	4	11	9	7	5	20
SC-0	3.5	5.5	5.5	5.5	13	12	9	7	20
SC-05	3.5	5.5	5.5	5.5	13	12	9	7	20
SC-4-0	4.5	7.5	7.5	7.5	18	16	13	9	25
SC-4-1	5.5	11	11	7.5	22	22	17	9	32
SC-5-1	5.5	11	11	7.5	22	22	17	9	32
SC-N1	7.5	15	15	11	32	32	24	15	50
SC-N2	11	18.5	18.5	15	40	40	29	19	60
SC-N2S	15	22	25	22	50	50	38	26	80
SC-N3	18.5	30	37	30	65	65	60	38	100
SC-N4	22	40	37	37	80	80	60	44	135
SC-N5	30	55	55	55	105	105	85	64	150
SC-N6	37	60	60	60	125	125	90	72	150
SC-N7	45	75	75	90	150	150	120	103	200
SC-N8	55	90	130	132	180	180	180	150	260
SC-N10	65	110	132	132	220	220	200	150	260
SC-N11	90	160	160	200	300	300	230	230	350
SC-N12	120	220	250	300	400	400	360	360	450
SC-N14	180	315	400	480	600	600	600	600	660
SC-N16	220	440	500	500	800	800	720	630	800

(2) UL 508, CSA C22.2

Type	Max. motor capacity (HP)						Rated operational current (A)						Continuous current (A)	File No. Approval mark
	Three-phase motor				Single-phase motor		Three-phase motor				Single-phase motor			
	200V	220–240V	440–480V	550–600V	100–120V	220–240V	200V	220–240V	440–480V	550–600V	100–120V	220–240V		UL CSA
SC-03	2	2	5	5	1/3	1	7.8	6.8	7.6	6.1	7.2	8	11	E42419
SC-0	3	3	5	5	1/3	1	11	9.6	7.6	6.1	7.2	8	13	
SC-05	3	3	5	5	1/3	1	11	9.6	7.6	6.1	7.2	8	13	
SC-4-0	5	5	7 1/2	7 1/2	1	2	17.5	15.2	11	9	16	12	20	
SC-4-1	5	5	10	10	1	2	17.5	15.2	14	11	16	12	20	
SC-5-1	5	5	10	10	1	2	17.5	15.2	14	11	16	12	20	
SC-N1	7 1/2	10	25	25	2	5	25.3	28	34	27	24	28	50	
SC-N2	10	15	30	30	3	7 1/2	32.2	42	40	32	34	40	60	
SC-N2S	15	20	40	40	3	10	48.3	54	52	41	34	50	80	
SC-N3	20	25	50	50	5	15	62.1	68	65	52	56	68	100	
SC-N4	25	30	60	60	7 1/2	15	78.2	80	77	62	80	68	135	
SC-N5	30	30	60	75	7 1/2	15	92	80	77	77	80	68	150	
SC-N6	40	40	75	100	10	20	119.6	104	96	99	100	88	150	
SC-N7	50	50	100	125	15	25	149.5	130	124	125	135	110	200	
SC-N8	60	60	150	150	–	–	177.1	154	180	144	–	–	260	
SC-N10	75	75	150	200	–	–	220.8	192	180	192	–	–	260	
SC-N11	100	100	200	250	–	–	285.2	248	240	242	–	–	350	
SC-N12	125	150	300	350	–	–	358.8	360	361	336	–	–	450	
SC-N14	200	200	500	600	–	–	552	480	590	578	–	–	660	
SC-N16	250	300	600	700	–	–	692.3	720	722	672	–	–	800	

1-2-3 Auxiliary contact ratings

(1) IEC, JIS

Type	Continuous current (A)	Make and break capacity at AC (A)	Rated operational current (A)						Minimum voltage and current
			AC			DC			
			Voltage (V)	AC-15 Ind. load	AC-12 Res. load	Voltage (V)	DC-13 Ind. load	DC-12 Res. load	
SC-03 to N12	10	60	100–120	6	10	24	3	5	5V DC, 3mA
		30	200–240	3	8	48	1.5	3	
		15	380–440	1.5	5	110	0.55	2.5	
		12	500–600	1.2	5	220	0.27	1	
SC-N14, N16	10	60	100–120	6	10	24	10	10	24V DC, 10mA
		60	200–240	6	10	48	3	5	
		40	380–440	4	10	110	1.5	2.5	
		25	500–600	2.5	10	220	0.5	1	

Note: In normal atmosphere (with no dust or corrosive gases), the failure rate is approximately 10^{-7}.

(2) UL, CSA

Type	Continuous current (A)	Rated operational current (A)					
		AC (Rating code: A600)			DC (Rating code: Q300)		
		Voltage (V)	Making	Breaking	Voltage (V)	Making	Breaking
SC-03 to N16	10	120	60	6	125	0.55	0.55
		240	30	3			
		480	15	1.5	250	0.27	0.27
		600	12	1.2			

Note: Rating codes are specified by UL508 and CSA C22.2 No. 14.

1-2-4 Operating coil voltage

(1) SC-03 to 5-1, SC-N1 to N4 (AC operated)

Type	Coil voltage and frequency
	AC
SC-03	24V 50Hz/24–26V 60Hz
SC-0	48V 50Hz/48–52V 60Hz
SC-05	100V 50Hz/100–110V 60Hz
SC-4-0	100–110V 50Hz/110–120V 60Hz
SC-4-1	110–120V 50Hz/120–130V 60Hz
SC-5-1	200V 50Hz/200–220V 60Hz
SC-N1	200–220V 50Hz/220–240V 60Hz
SC-N2	220–240V 50Hz/240–260V 60Hz
SC-N2S	346–380V 50Hz/380–420V 60Hz
SC-N3	380–400V 50Hz/400–440V 60Hz
SC-N4	415–440V 50Hz/440–480V 60Hz
	480–500V 50Hz/500–550V 60Hz

(2) SC-N5 to N16, SC-N1/SE to N4/SE (AC/DC operated)

Type	Coil voltage and frequency	
	AC	DC
SC-N5, N6, N7, N8	24–25V 50/60Hz	24V
SC-N10, N11, N12	48–50V 50/60Hz	48V
SC-N14, N16, N1/SE	100–127V 50/60Hz	100–120V
SC-N2/SE, N2S/SE	200–250V 50/60Hz	200–240V
SC-N3/SE, N4/SE	265–347V 50/60Hz	–
	380–450V 50/60Hz	–
	460–575V 50/60Hz	–

Note: Other voltages are available on request.
N5 to N12: 24 to 575V (24 to 240V DC)
N14 and N16: 100 to 575V (100 to 240V DC)
N1/SE to N3/SE: 24 to 250V (24 to 240V DC)
N4/SE: 24 to 575V (24 to 240V DC)

(3) SC-03/G to 5-1/G, SC-N1G to N3/G (DC operated)

Type	Coil voltage
	DC
SC-03/G	12V, 24V, 48V, 60V, 100V
SC-0/G	110V, 120V, 200V, 210V, 220V
SC-05/G	
SC-4-0/G	
SC-4-1/G	
SC-5-1/G	
SC-N1/G	
SC-N2/G	
SC-N2S/G	
SC-N3/G	

Note: Other voltages are available in the range of 12 to 250V on request.

1-3-1 Making and breaking current capacity

Type	Test condition														Test result *
	Voltage (V)	Frequency (Hz)	Current (A)	Power factor (cosø)	Breaking operations 0.85Us	Breaking operations 1.1Us	Arcing time (ms)	Voltage (V)	Frequency (Hz)	Current (A)	Power factor (cosø)	Breaking operations 0.85Us	Breaking operations 1.1Us	Arcing time (ms)	
SC-03	3ø, 231	50	110	0.44	25	25	4–7	3ø, 462	50	90	0.44	25	25	5–7.5	Good
SC-0	3ø, 231	50	130	0.44	25	25	4.5–6	3ø, 462	50	120	0.44	25	25	4.5–7.5	
SC-05	3ø, 231	50	130	0.44	25	25	4–5.5	3ø, 462	50	120	0.44	25	25	4.5–7.5	
SC-4-0	3ø, 231	50	180	0.44	25	25	4–7	3ø, 426	50	160	0.44	25	25	4.5–7.5	
SC-4-1	3ø, 231	50	220	0.44	25	25	4–7.5	3ø, 462	50	220	0.44	25	25	4.5–8	
SC-5-1	3ø, 231	50	220	0.44	25	25	4–7.5	3ø, 462	50	220	0.44	25	25	4.5–8	
SC-N1	3ø, 231	50	320	0.45	25	25	4–6	3ø, 462	50	320	0.45	25	25	5–7	
SC-N2	3ø, 231	50	400	0.45	25	25	4–6	3ø, 462	50	400	0.45	25	25	5–7	
SC-N2S	3ø, 231	50	500	0.45	25	25	4–8	3ø, 462	50	500	0.45	25	25	5–8	
SC-N3	3ø, 231	50	650	0.45	25	25	4–8	3ø, 462	50	650	0.45	25	25	5–8	
SC-N4	3ø, 231	50	800	0.44	25	25	5–9	3ø, 462	50	800	0.44	25	25	5–10	
SC-N5	3ø, 231	50	1,050	0.34	25	25	4–9	3ø, 462	50	1,050	0.34	25	25	4–10	
SC-N6	3ø, 231	50	1,250	0.36	25	25	4–12	3ø, 462	50	1,250	0.36	25	25	4–13	
SC-N7	3ø, 231	50	1,520	0.35	25	25	3–12	3ø, 462	50	1,500	0.35	25	25	3–13	
SC-N8	3ø, 231	50	1,800	0.37	25	25	4–12	3ø, 462	50	1,800	0.37	25	25	5–13	
SC-N10	3ø, 231	50	2,200	0.37	25	25	4–13	3ø, 462	50	2,200	0.37	25	25	6–14	
SC-N11	3ø, 231	50	3,000	0.32	25	25	5–13	3ø, 462	50	3,000	0.32	25	25	6–15	
SC-N12	3ø, 231	50	4,000	0.32	25	25	5–13	3ø, 462	50	4,000	0.32	25	25	6–15	
SC-N14	3ø, 231	50	6,000	0.32	25	25	5–10	3ø, 462	50	6,000	0.32	25	25	6–16	
SC-N16	3ø, 231	50	8,000	0.33	25	25	5–13	3ø, 462	50	8,000	0.33	25	25	6–19	

1-3-2 Making current capacity

Type	Test condition								Duty	Test result *
	Voltage (V)	Frequency (Hz)	Current (A)	Power factor (cosø)	Voltage (V)	Frequency (Hz)	Current (A)	Power factor (cosø)	Making operations	
SC-03	3ø, 242	50	132	0.44	3ø, 484	50	108	0.44	50	Good
SC-0	3ø, 242	50	156	0.44	3ø, 484	50	144	0.44	50	
SC-05	3ø, 242	50	156	0.44	3ø, 484	50	144	0.44	50	
SC-4-0	3ø, 242	50	216	0.44	3ø, 484	50	192	0.44	50	
SC-4-1	3ø, 242	50	264	0.44	3ø, 484	50	264	0.44	50	
SC-5-1	3ø, 242	50	264	0.44	3ø, 484	50	264	0.44	50	
SC-N1	3ø, 242	50	384	0.45	3ø, 484	50	384	0.45	50	
SC-N2	3ø, 242	50	480	0.45	3ø, 484	50	480	0.45	50	
SC-N2S	3ø, 242	50	600	0.45	3ø, 484	50	600	0.45	50	
SC-N3	3ø, 242	50	780	0.45	3ø, 484	50	780	0.45	50	
SC-N4	3ø, 242	50	960	0.44	3ø, 484	50	960	0.44	50	
SC-N5	3ø, 242	50	1,260	0.34	3ø, 484	50	1,260	0.34	50	
SC-N6	3ø, 242	50	1,500	0.36	3ø, 484	50	1,500	0.36	50	
SC-N7	3ø, 242	50	1,824	0.35	3ø, 484	50	1,800	0.35	50	
SC-N8	3ø, 242	50	2,160	0.37	3ø, 484	50	2,160	0.37	50	
SC-N10	3ø, 242	50	2,640	0.37	3ø, 484	50	2,640	0.37	50	
SC-N11	3ø, 242	50	3,600	0.32	3ø, 484	50	3,600	0.32	50	
SC-N12	3ø, 242	50	4,800	0.32	3ø, 484	50	4,800	0.32	50	
SC-N14	3ø, 242	50	7,200	0.32	3ø, 484	50	7,200	0.32	50	
SC-N16	3ø, 242	50	9,600	0.33	3ø, 484	50	9,600	0.33	50	

Us: Coil rated voltage

* Tested to confirm that there are no permanent arcing, no flash-over between poles, no blowing of the fusible element in the earth circuit and no welding of the contacts.

1-3-3 Mechanical durability

IEC Standards testing procedures require that the mechanical durability test be carried out without current flowing in the main circuit, with the rated voltage applied to the coil and for at least as many on-off operation cycles as specified for the corresponding intermittent duty class as shown in the table on page 5.

The mechanical life of the contactor is inversely proportional to the third or fourth power of the operating voltage.

Therefore, if the control circuit voltage is 10% higher than the coil's rated voltage, the mechanical durability will be reduced by half.

An increase in control circuit voltage will harm the operating mechanism, core and shading coil.

The results of the mechanical durability test for SC series contactors are given in the table below.

(1) Criteria

(a) The contactors shall operate normally after completion of the mechanical durability test.

(b) There shall be no loosening of conductor connection parts.

(2) Test results

Type	Test condition		Test result							
	Control circuit voltage (at 50Hz) (V)	Operating cycles per hour	Minimum pick-up voltage (V)				Maximum drop-out voltage (V)			
			Before test	After 1,000 × 10^3 operations	After 5,000 × 10^3 operations	After 10,000 × 10^3 operations	Before test	After 1,000 × 10^3 operations	After 5,000 × 10^3 operations	After 10,000 × 10^3 operations
SC-03	210	12,000	118	116	119	120	82	82	80	83
SC-0	210	12,000	116	115	117	116	84	87	85	84
SC-05	210	12,000	122	122	120	121	79	81	82	78
SC-4-0	210	12,000	126	128	127	125	90	90	86	88
SC-4-1	210	12,000	124	126	126	124	88	90	91	88
SC-5-1	210	12,000	126	128	125	124	92	94	92	90
SC-N1	210	6,000	111	113	112	120	82	83	86	88
SC-N2	210	6,000	112	112	115	122	78	78	80	84
SC-N2S	210	6,000	130	129	127	–	109	98	100	–
SC-N3	210	6,000	130	129	127	–	109	98	100	–
SC-N4	210	6,000	126	128	128	–	86	90	88	–
SC-N5	230	1,800	144	144	144	–	86	86	86	–
SC-N6	230	1,800	148	148	148	–	87	87	87	–
SC-N7	230	1,800	148	148	148	–	87	87	87	–
SC-N8	230	1,800	145	145	145	–	86	86	86	–
SC-N10	230	1,800	145	145	145	–	86	86	86	–
SC-N11	230	1,800	147	147	147	–	88	88	88	–
SC-N12	230	1,800	147	147	147	–	88	88	88	–
SC-N14	230	1,800	148	148	148	–	88	88	88	–
SC-N16	230	1,800	148	148	148 *	–	88	88	88 *	–

Note: Coil rating: For frame size N4 or less 200V 50Hz/200–220V 60Hz
For frame size N5 and above 200V–250V 50/60Hz, 200–240V AC

* After 2,500 × 10^3 operations

1-3-4 Electrical durability

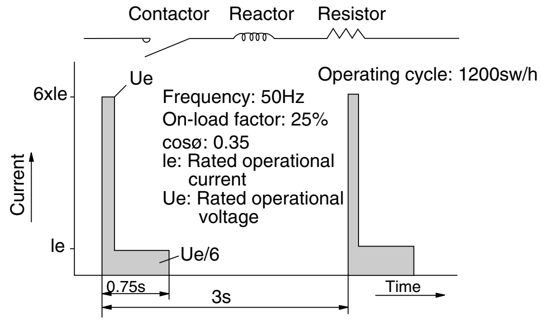
The electrical durability test must be carried out for the number of operation cycles specified for the corresponding intermittent duty class shown in the table on page 5, and under the circuit conditions of the corresponding utilization category as defined in the table on page 4.

Contact wear is caused by arcing that occurs between contacts when the current is interrupted. The amount of contact wear is directly proportional to approximately the second power of the interrupted current value.

Therefore, when a contactor is used for inching or plugging operations, the expected service life of the contacts will be much less than if used for normal operations.

(1) Test condition - Category AC-3

The method of determining the durability and performance is prescribed by IEC as below.



Contactor makes a current equal to six times that of its rated operational current, immediately reduces the current to the rated operational current, and then breaks.

(2) Criteria

The value of the overtravel shall exceed the permissible minimum overtravel value. The insulation resistance after testing shall be over 5MΩ. (500V DC megger)

(3) Test results

Type	Test condition				Test result						
	Voltage (at 50Hz) Ee (V)	Current Ie (A)	Power factor cosø	Operations per hour	Overtravel (mm) Before test	After 500 × 10³ operations	After 1,000 × 10³ operations	After 1,500 × 10³ operations	After 2,000 × 10³ operations	Permissible minimum overtravel	Insulation resistance (MΩ)
SC-03	220	11	0.34	1,800	1.5	1.4	1.2	0.9	0.6	0.3	100
	440	9	0.32	1,800	1.5	1.2	0.9	0.6	–	0.3	
SC-0	220	13	0.32	1,800	1.5	1.4	1.2	0.9	0.7	0.3	100
	440	12	0.33	1,800	1.5	1.2	0.9	0.6	–	0.3	
SC-05	220	13	0.32	1,800	1.5	1.3	1.1	0.9	0.6	0.3	100
	440	12	0.33	1,800	1.5	1.2	0.9	0.6	–	0.3	
SC-4-0	220	18	0.35	1,800	1.7	1.4	1.1	0.7	–	0.3	100
	440	16	0.31	1,800	1.7	1.3	0.9	–	–	0.3	
SC-4-1	220	22	0.34	1,800	1.7	1.3	0.8	–	–	0.3	100
	440	22	0.32	1,800	1.7	1.2	0.7	–	–	0.3	
SC-5-1	220	22	0.34	1,800	1.7	1.3	0.8	–	–	0.3	100
	440	22	0.32	1,800	1.7	1.2	0.7	–	–	0.3	
SC-N1	220	32	0.35	1,200	1.8	1.5	1.3	1.1	–	1.0	100
	440	32	0.36	1,200	1.8	1.5	1.2	–	–	1.0	
SC-N2	220	40	0.35	1,200	1.8	1.6	1.3	1.2	–	1.0	100
	440	40	0.34	1,200	1.8	1.6	1.3	–	–	1.0	
SC-N2S	220	50	0.35	1,200	2.0	1.7	1.4	–	–	1.0	100
	440	50	0.34	1,200	2.0	1.7	1.4	–	–	1.0	
SC-N3	220	65	0.35	1,200	2.0	1.7	1.4	–	–	1.0	100
	440	65	0.35	1,200	2.0	1.7	1.4	–	–	1.0	
SC-N4	220	80	0.37	1,200	2.1	2.0	1.9	–	–	1.0	100
	440	80	0.35	1,200	2.1	1.9	1.7	–	–	1.0	
SC-N5	220	105	0.35	1,200	2.7	1.9	–	–	–	1.0	100
	440	105	0.35	1,200	2.7	1.6	–	–	–	1.0	
SC-N6	220	125	0.35	1,200	3.0	2.7	2.4	–	–	1.0	100
	440	125	0.34	1,200	3.0	2.1	–	–	–	1.0	
SC-N7	220	150	0.35	1,200	3.0	2.7	2.4	–	–	1.0	100
	440	150	0.36	1,200	3.0	2.5	2.0	–	–	1.0	
SC-N8	220	180	0.33	1,200	4.1	3.6	3.1	–	–	1.5	100
	440	180	0.35	1,200	4.1	3.5	2.8	–	–	1.5	
SC-N10	220	220	0.35	1,200	4.1	3.6	3.1	–	–	1.5	100
	440	220	0.35	1,200	4.1	3.4	2.7	–	–	1.5	
SC-N11	220	300	0.34	1,200	5.3	4.7	4.0	–	–	2.0	100
	440	300	0.35	1,200	5.3	4.5	3.8	–	–	2.0	
SC-N12	220	400	0.36	1,200	5.3	4.7	–	–	–	2.0	100
	440	400	0.35	1,200	5.3	4.5	–	–	–	2.0	
SC-N14	220	600	0.36	1,200	4.5	3.8	–	–	–	2.0	100
	440	600	0.34	1,200	4.5	3.7	–	–	–	2.0	
SC-N16	220	800	0.36	1,200	4.5	3.2 *	–	–	–	2.0	100
	440	800	0.35	1,200	4.5	3.0 *	–	–	–	2.0	

* After 250 × 10³ operations

1-3-5 Overcurrent withstand value

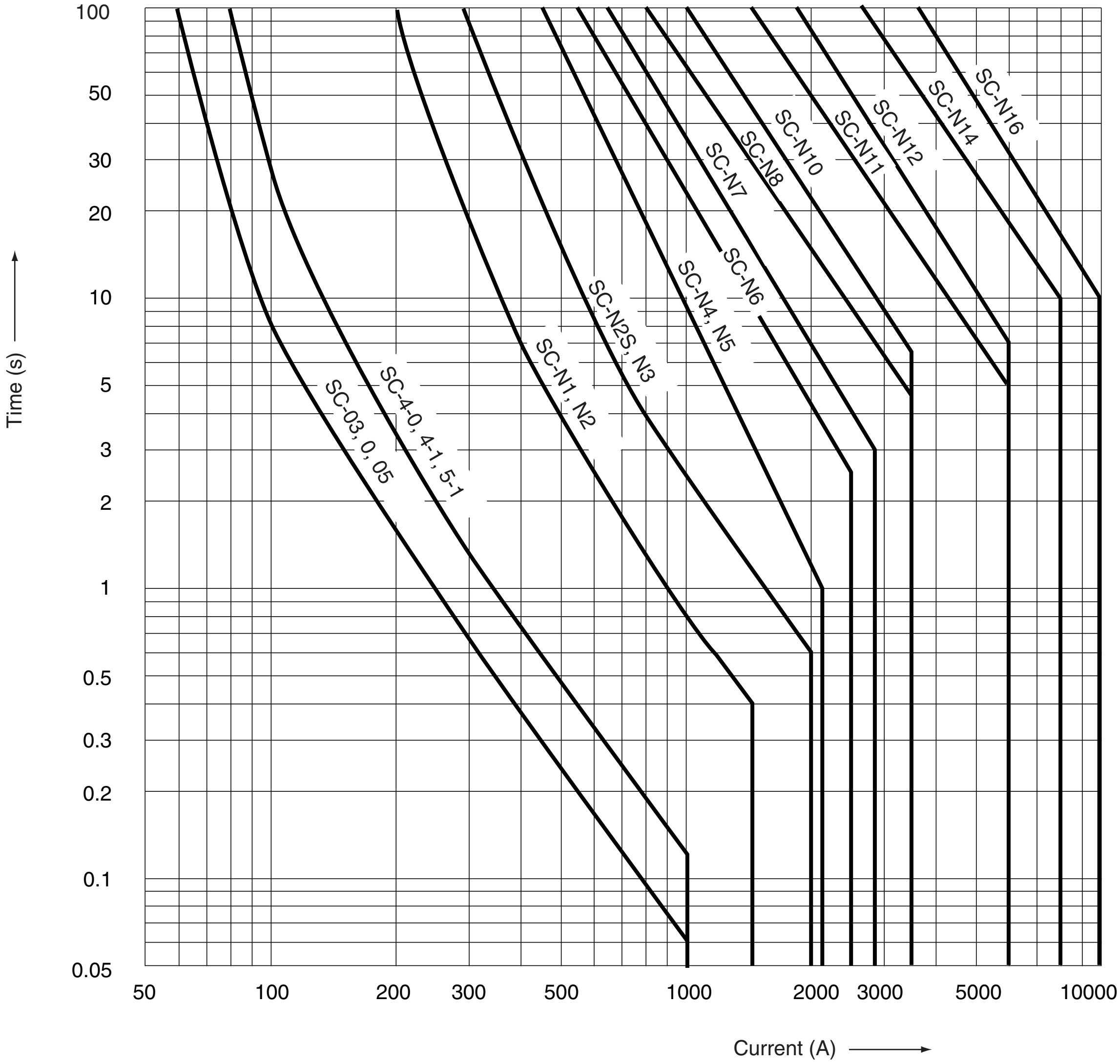
The overcurrent withstand value is maximum value of current which can be allowed to flow in contactors for a specified period of time which is expressed by "time-current (root-mean-square) value".

The starting current of squirrel-cage motor is 5 to 6 times the full load current. The starting time of special purpose motors for blower, winder, fan and centrifugal separator having a large rotational inertia is 7 to 8 seconds, which is a longer period than that of standard motor with driven machine.

Thus larger current than the rated operational current will be allowed to flow through the contactors for a longer time than usual under these conditions.

The graph below indicates the overcurrent withstand values for SC series contactors.

Fig. 1 Contactor overcurrent withstand value



1-3-6 Short-circuit current withstand value

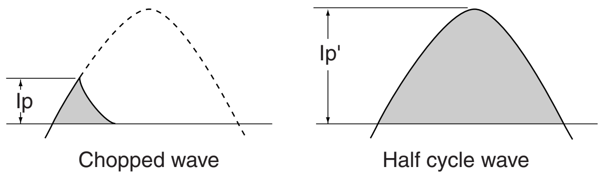
When a short-circuit fault occurs on the load side of the contactor, the short-circuit current is interrupted by an MCCB or a fuse.

However, the contact is influenced by a repulsion force generated by the large current that flows before the interruption occurs. This causes the contact pressure to decrease and the temperature of the contacting portion to rise with the possibility of the contact welding.

If the magnetic repulsion force is greater than the contact pressure, the contact will open and the arc energy generated between the contacts may also cause them to be welded. The magnitude of this repulsion force is directly proportional to the second power of the peak value of the current passing through the unit.

The maximum withstand values of SC series contactors against the chopped wave or half cycle wave are as shown below.

Fig. 2 Wave form of current interrupted



Type	Chopped wave		Half cycle wave	
	Ip (A)	Ip/Ie	Ip' (A)	Ip'/Ie
SC-03	6,700	609	1,400	127
SC-0	6,700	515	1,400	107
SC-05	6,700	515	1,400	107
SC-4-0	7,500	416	1,600	88
SC-4-1	7,500	394	1,600	84
SC-5-1	7,500	394	1,600	84
SC-N1	10,000	384	2,400	92
SC-N2	10,000	285	2,400	68
SC-N2S	13,000	260	2,800	56
SC-N3	13,000	200	2,800	43
SC-N4	16,000	200	3,500	44
SC-N5	16,000	172	3,500	38
SC-N6	17,000	136	3,700	29
SC-N7	19,000	126	4,400	29
SC-N8	25,000	138	5,600	31
SC-N10	25,000	113	5,600	25
SC-N11	38,000	126	8,000	27
SC-N12	40,000	100	8,500	21
SC-N14	62,000	103	13,000	21
SC-N16	69,000	86	14,600	18

Notes: Ie: Rated operational current (A)
Ip, Ip': Peak current (A)
Ip/Ie, Ip'/Ie: Multiple of rated operational current (at 220V AC)

1-3-7 Operating characteristics

(1) Pick-up and drop-out voltage

The contactor shall operate correctly at 85% of the coil's rated voltage when the temperature has reached a constant value following the temperature rise test.

- **Test condition**

Ambient temperature: 20°C
On-Off operation: 20 operations

Coil ratings

- SC-03 to 5-1, SC-N1 to N4
  200V AC (200V, 50Hz/200–220V 60Hz)
- SC-03/G to N3/G
  200V DC
- SC-N5 to N16
  200V (200–250V AC, 50/60Hz, 200–240V DC)

Type	Frequency (Hz)	Pick-up voltage (V)	Drop-out voltage (V)	Exciting current (mA)	Watt loss (W)	Remarks
SC-03	50 60	105–125 116–136	70–98 80–110	40–52 35–47	2.3–3.3 2.3–3.3	50Hz/60Hz common use
SC-0	50 60	105–125 116–136	70–98 80–110	40–52 35–47	2.3–3.3 2.3–3.3	
SC-05	50 60	105–125 116–136	7–98 80–110	40–52 35–47	2.3–3.3 2.3–3.3	
SC-4-0	50 60	118–136 130–146	75–106 88–120	42–53 37–48	2.3–3.3 2.3–3.3	
SC-4-1	50 60	118–136 130–146	75–106 88–120	42–53 37–48	2.3–3.3 2.3–3.3	
SC-5-1	50 60	118–136 130–146	75–106 88–120	42–53 37–48	2.3–3.3 2.3–3.3	
SC-03/G	DC	88–124	24–52	35	7	DC coil
SC-0/G	DC	88–124	24–52	35	7	
SC-05/G	DC	86–122	28–56	35	7	
SC-4-0/G	DC	92–128	28–56	35	7	
SC-4-1/G	DC	92–128	28–56	35	7	
SC-5-1/G	DC	92–130	30–60	35	7	
SC-N1/G	DC	80–120	30–70	45	9	
SC-N2/G	DC	80–120	30–70	45	9	
SC-N2S/G	DC	80–120	24–60	60	12	
SC-N3/G	DC	80–120	24–60	60	12	
SC-N1	50 60	110–130 120–140	75–105 85–115	56–69 49–61	2.7–4.5 2.7–4.5	50Hz/60Hz common use
SC-N2	50 60	110–130 120–140	75–105 85–115	56–69 49–61	2.7–4.5 2.7–4.5	
SC-N2S	50 60	115–135 130–150	85–110 100–125	60–75 61–76	3.6–6 3.6–6	
SC-N3	50 60	115–135 130–150	85–110 100–125	60–75 61–76	3.6–6 3.6–6	
SC-N4	50 60	120–140 135–155	70–95 95–120	65–80 66–81	3.8–6.3 3.8–6.3	

Note: The exciting current and watt loss are those when sealed with applied voltage of 200V AC (for 50Hz), 220V AC (for 60Hz).

Type	Frequency (Hz)	Pick-up voltage (V)	Drop-out voltage (V)	Exciting current (mA)	Watt loss (W)	Remarks
SC-N5	50·60 DC	140–150 140–160	60–100 40–100	18–23 12–15	2.6–4.3 2.5–3.5	With SUPER MAGNET (AC/DC common use)
SC-N6	50·60 DC	140–150 140–160	60–100 40–100	22–28 14–18	2.7–4.4 2.8–4.2	
SC-N7	50·60 DC	140– 150 140–160	60–100 40–100	22–28 14–18	2.7–4.4 2.8–4.2	
SC-N8	50·60 DC	140–150 140–160	60–100 40–100	25–33 19–23	3.8–6.0 3.7–5.5	
SC-N10	50·60 DC	140–150 140–160	60–100 40–100	25–33 19–23	3.8–6.0 3.7–5.5	
SC-N11	50·60 DC	140–150 140–160	60–100 40–100	27–34 20–24	4.5–6.9 3.9–5.8	
SC-N12	50·60 DC	140–150 140–160	60–100 40–100	27–34 21–24	4.5–6.9 3.9–5.8	
SC-N14	50·60 DC	140–160 140–160	60–100 40–100	41–52 35–43	6.2–9.5 6.8–9.5	
SC-N16	50·60 DC	140–160 140–160	60–100 40–100	41–52 35–43	6.2–9.5 6.8–9.5	
SC-N1/SE	50·60 DC	140–150 140–160	60–100 40–100	18–19 12.5	2.8–3.2 1	
SC-N2/SE	50·60 DC	140–150 140–160	60–100 40–100	18–19 12.5	2.8–3.2 1	
SC-N2S/SE	50·60 DC	140–150 140–160	60–100 40–100	18–19 12.5	2.9–3.3 1	
SC-N3/SE	50·60 DC	140–150 140–160	60–100 40–100	18–19 12.5	2.9–3.3 1	
SC-N4/SE	50·60 DC	140–150 140–160	60–100 40–100	20–21 14	3.2–3.6 1	

Notes:
- The exciting current and watt loss are those when sealed with applied voltage of 200V AC (for 50Hz), 220V AC (for 60Hz), or 220V DC (models N5 to N16).
- A three-phase full-wave rectified DC power supply is used for models N5 to N16.

(2) Abrupt voltage drop characteristics

Standard type contactors are designed to operate correctly at 85% of their coil's rated voltage.

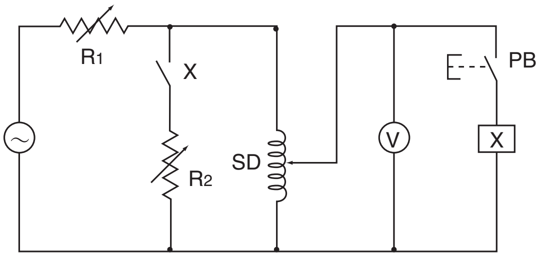
If there is no margin in power source capacity, the operating voltage will abruptly drop due to inrush current at the moment the contacts close.

If the operating voltage drops below the sealed voltage of the contactor, the contacts will not close completely. Since the contactor makes and breaks the inrush current in an extremely short period of time, contact welding is likely under these conditions.

(a) Test Condition

Confirm that the contactor operates normally with no contact weld when the rated voltage is applied to the tested contactor (X) and the applied voltage suddenly drops to 75% (65% for N5 models or higher) of the coil's rated voltage when the main contacts close.

Fig. 3 Test circuit (for AC)



R_1, R_2: Variable resistor
SD: Auto transformer
V: Voltmeter
X: Tested contactor
PB: Pushbutton switch

(b) Test result

Type		Test condition		Test result
		Coil applied voltage before contactor close (V) (60Hz)	Coil applied voltage immediately after contactor close (V) (60Hz)	
AC operated	**SC-03**	200	150	No contact weld
	SC-0	200	150	
	SC-05	200	150	
	SC-4-0	200	150	
	SC-4-1	200	150	
	SC-5-1	200	150	
DC operated	**SC-03/G**	200 (DC)	150 (DC)	No contact weld
	SC-0/G	200 (DC)	150 (DC)	
	SC-05/G	200 (DC)	150 (DC)	
	SC-4-0/G	200 (DC)	150 (DC)	
	SC-4-1/G	200 (DC)	150 (DC)	
	SC-5-1/G	200 (DC)	150 (DC)	
AC operated	**SC-N1**	200	150	No contact weld
	SC-N2	200	150	
	SC-N2S	200	150	
	SC-N3	200	150	
	SC-N4	200	150	
AC/DC operated	**SC-N5**	200	130	No contact weld
	SC-N6	200	130	
	SC-N7	200	130	
	SC-N8	200	130	
	SC-N10	200	130	
	SC-N11	200	130	
	SC-N12	200	130	
	SC-N14	200	130	
	SC-N16	200	130	
DC operated	**SC-N1/G**	200 (DC)	150 (DC)	No contact weld
	SC-N2/G	200 (DC)	150 (DC)	
	SC-N2S/G	200 (DC)	150 (DC)	
	SC-N3/G	200 (DC)	150 (DC)	
AC/DC operated	**SC-N1/SE**	200	130	No contact weld
	SC-N2/SE	200	130	
	SC-N2S/SE	200	130	
	SC-N3/SE	200	130	
	SC-N4/SE	200	130	

Note: Coil ratings:

- SC-03 to 5-1, SC-N1 to N4
  200V AC (200V 50Hz/200–220V 60Hz)
- SC-N5 to N16
  200V (200–250V AC 50/60Hz, 200–240V DC)
- SC-03/G to 5-1/G, SC-N1/G to N3/G
  200V DC
- SC-N1/SE to N4/SE
  200V (200–250V AC 50/60Hz, 200–240V DC)

(3) Operating time

(a) Coil ratings: 100V

Type	Voltage (V)	Frequency (Hz)	Pick-up time (ms)			Drop-out time (ms)			Auxiliary contact arrangement
			Main contact	Auxiliary NO contact *	Auxiliary NC contact *	Main contact	Auxiliary NO contact *	Auxiliary NC contact *	
SC-03	100 110	50 60	9–20 8–18	9–20 8–18	5–14 5–14	5–16 5–16	5–16 5–16	8–19 8–19	1NO, 1NC
SC-0	100 110	50 60	9–20 8–18	9–20 8–18	5–14 5–14	5–16 5–16	5–16 5–16	8–19 8–19	1NO, 1NC
SC-05	100 110	50 60	9–20 8–18	9–20 8–18	5–14 5–14	5–16 5–16	5–16 5–16	8–19 8–19	1NO+1NC
SC-4-0	100 110	50 60	9–20 8–18	9–20 8–18	5–14 5–14	5–16 5–16	5–16 5–16	8–19 8–19	1NO, 1NC
SC-4-1	100 110	50 60	9–20 8–18	9–20 8–18	5–14 5–14	5–16 5–16	5–16 5–16	8–19 8 –19	1NO, 1NC
SC-5-1	100 110	50 60	9–20 8–18	9–20 8–18	5–14 5–14	5–16 5–16	5–16 5–16	8–19 8–19	1NO+1NC
SC-N1	100 110	50 60	10–17 11–18	10–17 11–18	6–14 7–17	6–16 7–17	4–15 4–16	9–17 9–19	2NO+2NC
SC-N2	100 110	50 60	10–17 11–18	10–17 11–18	6–14 7–17	6–16 7–17	4–15 4–16	9–17 9 –19	2NO+2NC
SC-N2S	100 110	50 60	10–18 12–21	11–19 13–22	8–15 9–15	8–18 5–14	5–13 5–13	8–20 8–20	2NO+2NC
SC-N3	100 110	50 60	10–18 12–21	11–19 13–22	8–15 9–15	8–18 5–14	5–13 5–13	8–20 8–20	2NO+2NC
SC-N4	100 110	50 60	16–23 18–27	14– 23 16–25	11–19 13–22	7–17 6–16	7–17 7–17	9–20 9–20	2NO+2NC
SC-N5	100	AC·DC	39–45	40–46	37–43	27–33	27–33	30–36	2NO+2NC
SC-N6	100	AC·DC	31–37	30–36	28–34	30–36	31–37	34–41	2NO+2NC
SC-N7	100	AC·DC	31–37	30–36	28–34	30–36	31–37	34–41	2NO+2NC
SC-N8	100	AC·DC	38–44	35–41	32–38	31–37	33–39	34–44	2NO+2NC
SC-N10	100	AC·DC	38–44	35–41	32–38	31–37	33–39	34–44	2NO+2NC
SC-N11	100	AC·DC	43–49	40–46	37–43	41–47	42–49	44–54	2NO+2NC
SC-N12	100	AC·DC	43–49	40–46	37–43	41–47	42–49	44–54	2NO+2NC
SC-N14	100	AC·DC	69–75	68–75	55–70	56–62	56–63	61– 68	2NO+2NC
SC-N16	100	AC·DC	69–75	68–75	55–70	56–62	56–63	61–68	2NO+2NC
SC-N1/SE	100	AC·DC	21–27	22– 27	18–27	18–24	17–24	21–26	2NO+2NC
SC-N2/SE	100	AC·DC	21– 27	22–27	18–27	18–24	17–24	21–26	2NO+2NC
SC-N2S/SE	100	AC·DC	24–30	25–32	20–28	24–32	24–31	27–34	2NO+2NC
SC-N3/SE	100	AC·DC	24–30	25–32	20–28	24–32	24–31	27–34	2NO+2NC
SC-N4/SE	100	AC·DC	39–45	40–46	37–43	27–33	27–33	30–36	2NO+2NC
SC-03/G	100	DC	43–47	43–47	35–39	10–24	21–23	28–30	1NO, 1NC
SC-0/G	100	DC	43–47	43–47	35–39	10–24	21–23	28–30	1NO, 1NC
SC-05/G	100	DC	43–47	43–48	35–40	10–24	21–23	28–30	2NO, 2NC 1NO+1NC
SC-4-0/G	100	DC	44–48	45–50	37–43	10–25	21–23	25–29	1NO, 1NC
SC-4-1/G	100	DC	44–48	45–50	37–43	10–25	21–23	25–29	1NO, 1NC
SC-5-1/G	100	DC	45–49	46–51	38–43	10–26	21–24	25–30	2NO, 2NC 1NO+1NC 2NO+2NC
SC-N1/G	100	DC	40–50	42–52	35–45	8–17	6–15	12–21	2NO+2NC
SC-N2/G	100	DC	40–50	42–52	35–45	8–17	6–15	12–21	2NO+2NC
SC-N2S/G	100	DC	60–70	61–71	52–62	14–21	12–20	17–24	2NO+2NC
SC-N3/G	100	DC	60–70	61–71	52–62	14–21	12–20	17–24	2NO+2NC

Notes:
- Coil ratings:
  SC-03 to 5-1, SC-N1 to N4 100V AC (100V AC 50Hz/100–110V 60Hz)
  SC-N5 to N16 100V (100–127V AC 50/60Hz, 100–120V DC)
- A three-phase full-wave rectified DC power supply is used for models N5 to N16.

* NO: Normally open
NC: Normally closed

1-3 Performance and characteristics

(b) Coil ratings: 200V

Type	Voltage (V)	Frequency (Hz)	Pick-up time (ms)			Drop-out time (ms)			Auxiliary contact arrangement
			Main contact	Auxiliary NO contact *	Auxiliary NC contact *	Main contact	Auxiliary NO contact *	Auxiliary NC contact *	
SC-03	200 220	50 60	9–20 8–18	9–20 8–18	5–14 5–14	5–16 5–16	5–16 5–16	8–19 8–19	1NO, 1NC
SC-0	200 220	50 60	9–20 8–18	9–20 8–18	5–14 5–14	5–16 5–16	5–16 5–16	8–19 8–19	1NO, 1NC
SC-05	200 220	50 60	9–20 8–18	9–20 8–18	5–14 5–14	5–16 5–16	5–16 5–16	8–19 8–19	1NO+1NC
SC-4-0	200 220	50 60	9–20 8–18	9–20 8–18	5–14 5–14	5–16 5–16	5–16 5–16	8 –19 8–19	1NO, 1NC
SC-4-1	200 220	50 60	9–20 8–18	9–20 8 –18	5–14 5–14	5–16 5–16	5–16 5–16	8–19 8–19	1NO,1NC
SC-5-1	200 220	50 60	9–20 8–18	9–20 8–18	5–14 5–14	5–16 5–16	5–16 5 –16	8–19 8–19	1NO+1NC
SC-N1	200 220	50 60	10–17 11–18	10–17 11–18	6–14 7–17	6–13 7–17	4–12 4–12	9–17 9–19	2NO+2NC
SC-N2	200 220	50 60	10–17 11–18	10–17 11–18	6–14 7–17	6–13 7–17	4–12 4–12	9–17 9–19	2NO+2NC
SC-N2S	200 220	50 60	10–18 12–21	11–19 13–22	8–15 9–15	8–18 5–14	5–13 5–13	8–20 8–20	2NO+2NC
SC-N3	200 220	50 60	10–18 12– 21	11–19 13–22	8–15 9–15	8–18 5–14	5–13 5–13	8–20 8–20	2NO+2NC
SC-N4	200 220	50 60	16–23 18–27	14–23 16–25	11–19 13–22	7–17 6–16	7–17 7–17	9–20 9–20	2NO+2NC
SC-N5	200	AC·DC	39–45	40–46	37–43	27–33	27– 33	30–36	2NO+2NC
SC-N6	200	AC·DC	31–37	30–36	28–34	30–36	31–37	34–41	2NO+2NC
SC-N7	200	AC·DC	31–37	30–36	28–34	30–36	31–37	34–41	2NO+2NC
SC-N8	200	AC·DC	38–44	35–41	32–38	31– 37	33–39	34–44	2NO+2NC
SC-N10	200	AC·DC	38–44	35–41	32–38	31–37	33–39	34–44	2NO+2NC
SC-N11	200	AC·DC	43–49	40–46	37–43	41–47	42–49	44–54	2NO+2NC
SC-N12	200	AC·DC	43–49	40–46	37– 43	41–47	42–49	44–54	2NO+2NC
SC-N14	200	AC·DC	69–75	68–75	55–70	56–62	56–63	61–68	2NO+2NC
SC-N16	200	AC·DC	69–75	68–75	55–70	56–62	56–63	61–68	2NO+2NC
SC-N1/SE	200	AC·DC	21–27	22–27	18–27	18–24	17–24	21–26	2NO+2NC
SC-N2/SE	200	AC·DC	21– 27	22–27	18–27	18–24	17–24	21–26	2NO+2NC
SC-N2S/SE	200	AC·DC	24–30	25–32	20–28	24–32	24–31	27–34	2NO+2NC
SC-N3/SE	200	AC·DC	24–30	25–32	20–28	24–32	24–31	27–34	2NO+2NC
SC-N4/SE	200	AC·DC	39–45	40–46	37–43	27– 33	27–33	30–36	2NO+2NC
SC-03/G	200	DC	43–47	43–47	35–39	10–24	21–23	28–30	1NO, 1NC
SC-0/G	200	DC	43–47	43–47	35–39	10–24	21–23	28–30	1NO, 1NC
SC-05/G	200	DC	43–47	43–48	35–40	10–24	21–23	28–30	2NO, 2NC 1NO+1NC
SC-4-0/G	200	DC	44–48	45–50	37–43	10–25	21–23	25–29	1NO, 1NC
SC-4-1/G	200	DC	44–48	45–50	37–43	10–25	21–23	25–29	1NO, 1NC
SC-5-1/G	200	DC	45–49	46–51	38–43	10–26	21–24	25–30	2NO, 2NC 1NO+1NC 2NC+2NC
SC-N1/G	200	DC	40–50	42–52	35–45	8–17	6–15	12–21	2NO+2NC
SC-N2/G	200	DC	40–50	42–52	35–45	8–17	6–15	12–21	2NO+2NC
SC-N2S/G	200	DC	60–70	61–71	52–62	14–21	12–20	17–24	2NO+2NC
SC-N3/G	200	DC	60–70	61–71	52–62	14–21	12–20	17–24	2NO+2NC

Notes:
- Coil ratings:
  SC-03 to 5-1, SC-N1 to N4 200V AC (200V AC 50Hz/200–220V 60Hz)
  SC-N5 to N16 200V (200–250V AC 50/60Hz, 200–240V DC)
- A three-phase full-wave rectified DC power supply is used for models N5 to N16.

* NO: Normally open
NC: Normally closed

1-3-8 Coil characteristics

(1) AC operated

(a) Coil ratings: 100V

Type	Voltage (V)	Frequency (Hz)	Power consumption (VA)		Exciting current (mA)	Watt loss (W)	Power factor (cosø)
			Inrush	Sealed	Sealed	Sealed	Sealed
SC-03	100 110	50 60	90 95	9 9	90 80	2.7 2.8	0.32
SC-0	100 110	50 60	90 95	9 9	90 80	2.7 2.8	0.32
SC-05	100 110	50 60	90 95	9 9	90 80	2.7 2.8	0.32
SC-4-0	100 110	50 60	90 95	9 9	90 80	2.7 2.8	0.32
SC-4-1	100 110	50 60	90 95	9 9	90 80	2.7 2.8	0.32
SC-5-1	100 110	50 60	90 95	9 9	90 80	2.7 2.8	0.32
SC-N1	100 110	50 60	120 135	12.7 12.4	127 113	3.6 3.8	0.29
SC-N2	100 110	50 60	120 135	12.7 12.4	127 113	3.6 3.8	0.29
SC-N2S	100 110	50 60	180 190	13.3 13.4	133 122	4.5 5	0.34
SC-N3	100 110	50 60	180 190	13.3 13.4	133 122	4.5 5	0.34
SC-N4	100 110	50 60	200 210	14.3 14.4	143 131	4.8 5.3	0.34
SC-N5	100 110	50 60	85 100	2.8 3.2	28 29	2.2 2.3	0.8
SC-N6	100 110	50 60	175 220	3.1 3.6	31 33	2.6 2.8	0.84
SC-N7	100 110	50 60	175 220	3.1 3.6	31 33	2.6 2.8	0.84
SC-N8	100 110	50 60	205 260	3.9 4.4	39 41	3.3 3.6	0.84
SC-N10	100 110	50 60	205 260	3.9 4.4	39 41	3.3 3.6	0.84
SC-N11	100 110	50 60	200 255	3.6 4.2	36 38	3.1 3.4	0.88
SC-N12	100 110	50 60	200 255	3.6 4.2	36 38	3.1 3.4	0.88
SC-N14	100 110	50 60	410 470	5.2 5.3	52 53	4.7 5	0.9
SC-N16	100 110	50 60	410 470	5.2 5.3	52 53	4.7 5	0.9
SC-N1/SE	100 110	50 60	120 145	2.8 3.2	28 29	2.1 2.3	0.75
SC-N2/SE	100 110	50 60	120 145	2.8 3.2	28 29	2.1 2.3	0.75
SC-N2S/SE	100 110	50 60	145 180	2.7 3.1	27 28.5	2 2.3	0.74
SC-N3/SE	100 110	50 60	145 180	2.7 3.1	27 28.5	2 2.3	0.74
SC-N4/SE	100 110	50 60	85 100	2.8 3.2	28 29	2.2 2.3	0.8

Note: Coil ratings:

- SC-03 to 5-1, SC-N1 to N4 100V AC (100V 50Hz/100–110V 60Hz)
- SC-N5 to N16, SC-N1/SE to N4/SE 100V (100–127V AC 50/60Hz, 100–120V DC)

(b) Coil ratings: 200V

Type	Voltage (V)	Frequency (Hz)	Power consumption (VA)		Exciting current (mA)	Watt loss (W)	Power factor (cosø)
			Inrush	Sealed	Sealed	Sealed	Sealed
SC-03	200 220	50 60	90 95	9 9	45 40	2.7 2.8	0.32
SC-0	200 220	50 60	90 95	9 9	45 40	2.7 2.8	0.32
SC-05	200 220	50 60	90 95	9 9	45 40	2.7 2.8	0.32
SC-4-0	200 220	50 60	90 95	9 9	45 40	2.7 2.8	0.32
SC-4-1	200 220	50 60	90 95	9 9	45 40	2.7 2.8	0.32
SC-5-1	200 220	50 60	90 95	9 9	45 40	2.7 2.8	0.32
SC-N1	200 220	50 60	120 135	12.7 12.4	63.5 56.3	3.6 3.8	0.29
SC-N2	200 220	50 60	120 135	12.7 12.4	63.5 56.3	3.6 3.8	0.29
SC-N2S	200 220	50 60	180 190	13.3 13.4	66.5 67	4.5 5	0.34
SC-N3	200 220	50 60	180 190	13.3 13.4	66.5 67	4.5 5	0.34
SC-N4	200 220	50 60	200 210	14.3 14.4	71.5 72	4.8 5.3	0.34
SC-N5	200 220	50 60	85 95	4 4.6	20 21	3.2 3.6	0.8
SC-N6	200 220	50 60	190 230	4.9 5.8	25 26	3.4 3.7	0.7
SC-N7	200 220	50 60	190 230	4.9 5.8	25 26	3.4 3.7	0.7
SC-N8	200 220	50 60	200 255	5.4 6.2	28 30	4.7 5.2	0.84
SC-N10	200 220	50 60	200 255	5.4 6.2	28 30	4.7 5.2	0.84
SC-N11	200 220	50 60	240 320	5.7 6.5	30 31	5.6 6	0.93
SC-N12	200 220	50 60	240 320	5.7 6.5	30 31	5.6 6	0.93
SC-N14	200 220	50 60	400 460	9.3 11	46 47	7.8 8.6	0.85
SC-N16	200 220	50 60	400 460	9.3 11	46 47	7.8 8.6	0.85
SC-N1/SE	200 220	50 60	105 130	3.5 4.2	18 19	2.8 3.2	0.77
SC-N2/SE	200 220	50 60	105 130	3.5 4.2	18 19	2.8 3.2	0.77
SC-N2S/SE	200 220	50 60	130 160	3.6 4.3	18 19	2.9 3.3	0.75
SC-N3/SE	200 220	50 60	130 160	3.6 4.3	18 19	2.9 3.3	0.75
SC-N4/SE	200 220	50 60	80 95	4 4.6	20 21	3.2 3.6	0.8

Note: Coil ratings:

- SC-03 to 5-1, SC-N1 to N4 200V AC (200V 50Hz/200–220V 60Hz)
- SC-N5 to N16, SC-N1/SE to N4/SE 200V (200–250V AC 50/60Hz, 200–240V DC)

(2) DC operated

(a) Coil ratings: 100V

Type	Voltage (V)	Power consumption (W)		Exciting current (mA)	Time constant (ms)
		Inrush	Sealed	Sealed	Sealed
SC-03/G	100	7	7	70	50
SC-0/G	100	7	7	70	50
SC-05/G	100	7	7	70	50
SC-4-0/G	100	7	7	70	50
SC-4-1/G	100	7	7	70	50
SC-5-1/G	100	7	7	70	50
SC-N1/G	100	9	9	90	60
SC-N2/G	100	9	9	90	60
SC-N2S/G	100	12	12	120	70
SC-N3/G	100	12	12	120	70
SC-N5	100 110	95 115	2.0 2.1	20 21	1
SC-N6	100 110	210 260	2.4 2.5	24 25	1
SC-N7	100 110	210 260	2.4 2.5	24 25	1
SC-N8	100 110	245 300	3.2 3.4	32 34	1
SC-N10	100 110	245 300	3.2 3.4	32 34	1
SC-N11	100 110	264 340	2.9 3.1	29 31	1
SC-N12	100 110	264 340	2.9 3.1	29 31	1
SC-N14	100 110	425 490	4.7 5.2	47 52	1
SC-N16	100 110	425 490	4.7 5.2	47 52	1
SC-N1/SE	100 110	135 160	2.0 2.1	20 21	1
SC-N2/SE	100 110	135 160	2.0 2.1	20 21	1
SC-N2S/SE	100 110	165 205	1.9 2.1	19 21	1
SC-N3/SE	100 110	165 205	1.9 2.1	19 21	1
SC-N4/SE	100 110	95 115	2.0 2.1	20 21	1

Note: Coil ratings:

- SC-03/G to N3/G 100V DC
- SC-N5 to N16 100V (100–120V DC, 100–127V AC 50/60Hz)
- SC-N1/SE to N4/SE 100V (100–120V DC, 100–127V AC 50/60Hz)

(3) Coil resistance at 20°C (Average)

(a) AC coil

Type	Resistance (Ω)		
	100V AC (100V 50Hz 100–110V 60Hz)	200V AC (200V 50Hz 200–220V 60Hz)	400V AC (380–400V 50Hz 400–440V 60Hz)
SC-03	81	321	1,228
SC-0	81	321	1,228
SC-05	81	321	1,228
SC-4-0	81	321	1,228
SC-4-1	81	321	1,228
SC-5-1	81	321	1,228
SC-N1	56	223	913
SC-N2	56	223	913
SC-N2S	25	105	422
SC-N3	25	105	422
SC-N4	24	101	449
SC-N5	95	417	1,489
SC-N6	41	162	614
SC-N7	41	162	614
SC-N8	35	149	610
SC-N10	35	149	610
SC-N11	28	105	405
SC-N12	28	105	405
SC-N14	12	55	222
SC-N16	12	55	222

Note: Resistance value of electronic circuit is not included.

(b) AC/DC coil

Type	Resistance (Ω)	
	100V (100–127V AC 50/60Hz 100–120V DC)	200V (200–250V AC 50/60Hz 200–240V DC)
SC-N1/SE	70	306
SC-N2/SE	70	306
SC-N2S/SE	54	241
SC-N3/SE	54	241
SC-N4/SE	95	417

Note: Resistance value of electronic circuit is not included.

(c) DC coil

Type	Resistance (Ω)		
	24V DC	100V DC	200V DC
SC-03/G	90	1,526	5,585
SC-0/G	90	1,526	5,585
SC-05/G	90	1,526	5,585
SC-4-0/G	90	1,526	5,585
SC-4-1/G	90	1,526	5,585
SC-5-1/G	90	1,526	5,585
SC-N1/G	64	1,108	4,451
SC-N2/G	64	1,108	4,451
SC-N2S/G	50	873	3,426
SC-N3/G	50	873	3,426

1-3-9 Temperature rise test

The temperature rise test is carried out with the rated voltage applied to the coil, and rated current (shown in table below) flowing through the main circuit.

Under these conditions, temperature rise of contacts, terminals and coil shall not exceed the value specified by the standard after the temperature reaches a constant value.

(1) Test results – Contactors

Type	Test conditions			Test result (K)			
	Current (A)	Coil voltage (V/Hz)	Wire size (mm^2)	Contact	Terminal		Coil (Resistance method)
					Line	Load	
SC-03	20	220/60	2.5	55	42	40	46
SC-0	20	220/60	2.5	53	40	38	46
SC-05	20	220/60	2.5	50	39	38	45
SC-4-0	25	220/60	4.0	58	43	41	48
SC-4-1	32	220/60	6.0	70	48	47	50
SC-5-1	32	220/60	6.0	72	48	48	50
SC-N1	50	220/60	10	63	46	43	60
SC-N2	60	220/60	16	59	44	43	61
SC-N2S	80	220/60	25	62	41	40	63
SC-N3	100	220/60	35	77	48	47	62
SC-N4	135	220/60	50	87	49	46	72
SC-N5	150	250/60	50	68	47	40	36
SC-N6	150	250/60	50	56	41	37	31
SC-N7	200	250/60	95	72	46	43	32
SC-N8	260	250/60	150	59	33	34	42
SC-N10	260	250/60	150	58	33	34	42
SC-N11	350	250/60	185	69	42	41	35
SC-N12	450	250/60	150x2	83	45	46	42
SC-N14	660	250/60	240x2	72	36	34	16
SC-N16	800	250/60	240x2	55	36	33	17
Temp. rise limit	Ambient temperature: 55°C			*	50	50	85 (E class)

Note: * Temperature rise is limited without damage to adjacent parts.

(2) Test results – Starters

Type	Test conditions			Test result (K)			
	Current (A)	Coil voltage (V/Hz)	Wire size (mm^2)	Contact	Terminal		Coil (Resistance method)
					Line	Load	
SW-03	11	220/60	1.5	56	29	40	53
SW-0	13	220/60	2.5	68	31	48	57
SW-05	13	220/60	2.5	65	29	48	56
SW-4-0	18	220/60	2.5	55	36	49	55
SW-4-1	22	220/60	4.0	46	30	46	55
SW-5-1	22	220/60	4.0	49	31	47	56
SW-N1	32	220/60	6.0	51	37	44	62
SW-N2	40	220/60	10	47	35	34	61
SW-N2S	50	220/60	10	55	42	44	65
SW-N3	65	220/60	16	67	48	49	64
SW-N4	80	220/60	25	68	47	49	63
SW-N5	105	250/60	35	64	45	44	40
SW-N6	125	250/60	50	72	48	48	37
SW-N7	150	250/60	50	76	48	48	43
SW-N8	180	250/60	95	66	40	39	41
SW-N10	220	250/60	95	71	42	44	42
SW-N11	300	250/60	185	46	42	42	29
SW-N12	400	250/60	240	78	44	34	39
SW-N14	600	250/60	185x2	73	38	36	20
Temp. rise limit	Ambient temperature: 55°C			*	50	50	85 (E class)

Note: * Temperature rise is limited without damage to adjacent insulated parts.

1-3-10 Rated impulse withstand voltage

Frame size	Contactor		Starter	
	Main circuit	Auxiliary and control circuit	Main circuit	Auxiliary and control circuit
03, 0, 05, 4-0, 4-1, 5-1	6kV	6kV	6kV	6kV
N1, N2, N2S, N3, N4, N5, N6, N7, N8	8kV	6kV	6kV	6kV
N10, N11, N12, N14, (N16)	8kV	6kV	8kV	6kV

( ): Contactor only

1-3-11 Insulation resistance and dielectric property

Frame size	Contactor	Starter
03, 0, 05, 4-0, 4-1, 5-1	Table a	Table a
N1, N2, N2S, N3, N4, N5, N6, N7, N8	Table b	Table a
N10, N11, N12, N14, (N16)	Table b	Table b

( ): Contactor only

(1) Table a

Measuring point		Between live parts and earth (Contact: Open/ closed)	Between control circuit and earth (Contact: Open/ closed)	Between main circuits and control circuits (Contact: Open/ closed)	Between main poles (Contact: Open)	Between line and load sides (Contact: Open)
Insulation resistance	Standard requirement	5MΩ or over	5MΩ or over	5MΩ or over	5MΩ or over	5MΩ or over
	Test result	100MΩ or over	100MΩ or over	100MΩ or over	100MΩ or over	100MΩ or over
Dielectric property	Standard requirement	2,500V 50Hz 1 min.	2,500V 50Hz 1 min.	2,500V 50Hz 1 min.	2,500V 50Hz 1 min.	2,500V 50Hz 1 min.
	Test result	2,500V 50Hz 1 min.	2,500V 50Hz 1 min.	2,500V 50Hz 1 min.	2,500V 50Hz 1 min.	2,500V 50Hz 1 min.

(2) Table b

Measuring point		Between live parts and earth (Contact: Open/ closed)	Between control circuit and earth (Contact: Open/ closed)	Between main circuits and control circuits (Contact: Open/ closed)	Between main poles (Contact: Open)	Between line and load sides (Contact: Open)
Insulation resistance	Standard requirement	5MΩ or over	5MΩ or over	5MΩ or over	5MΩ or over	5MΩ or over
	Test result	100MΩ or over	100MΩ or over	100MΩ or over	100MΩ or over	100MΩ or over
Dielectric property	Standard requirement	3,500V 50Hz 1 min.	2,500V 50Hz 1 min.	3,500V 50Hz 1 min.	3,500V 50Hz 1 min.	3,500V 50Hz 1 min.
	Test result	3,500V 50Hz 1 min.	2,500V 50Hz 1 min.	3,500V 50Hz 1 min.	3,500V 50Hz 1 min.	3,500V 50Hz 1 min.

1-3-12 Noise characteristics

The noise generated by the contactors operating and while they are in the closed position is minimal due to the specially designed "free floating magnetic mechanism" and "shading coils."

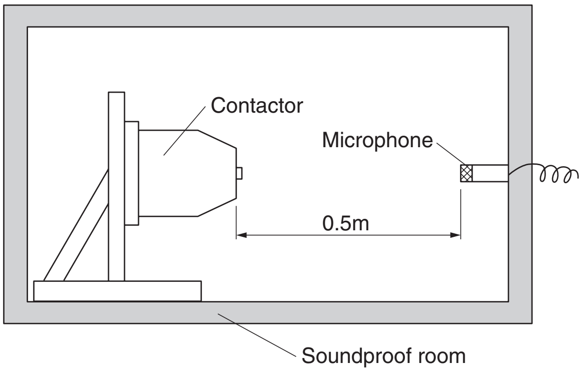
(1) Test condition

Type	SC-03 to SC-N4	SC-N5 to SC-N14
Coil rated voltage	200V 50Hz/ 200–220V 60Hz	200–250V 50/60Hz 200–220V DC
Coil applied voltage	200V AC 50Hz	
Soundproof room background noise	30dB (A-weighted sound pressure level)	
Measuring device	Precision noise meter CRT oscillograph	

(2) Test results

Type	Maximum noise level (dB)		
	Pick-up	Drop-out	Sealed
SC-03	100	100	30
SC-0	100	100	30
SC-05	101	101	30
SC-4-0	102	100	30
SC-4-1	102	100	30
SC-5-1	102	101	30
SC-N1	90	87	30
SC-N2	90	87	30
SC-N2S	87	87	30
SC-N3	87	87	30
SC-N4	84	84	30
SC-N5	87	84	30
SC-N6	85	85	30
SC-N7	86	85	30
SC-N8	86	80	30
SC-N10	86	80	30
SC-N11	88	84	30
SC-N12	88	84	30
SC-N14	117	112	30
SC-N16	117	112	30

Fig. 7 Noise level testing equipment



1-3-13 Reversing change-over time

When automatic reversing is triggered by a change-over switch with a short time snap action as shown in Fig. 8, the contactor will quickly change from MC_F to MC_R or MC_R to MC_F.

Fig. 9 illustrates the timing of such an abrupt reversing operation. Because small-sized contactors have a rapid action, their change-over time (t) is even shorter. If the change-over time (t) is shorter than the arcing time of the main circuit, an arc short will occur between the main contacts and cause abnormal wear or welding.

Change-over times are given in the table on the right.

When using the SC-03RM to SC-N3RM types, installation of a control relay (see Fig. 10) is recommended. Doing so will extend the change-over time and so reduce the possibility of arcing.

Fig. 8 Reversing by change-over switch

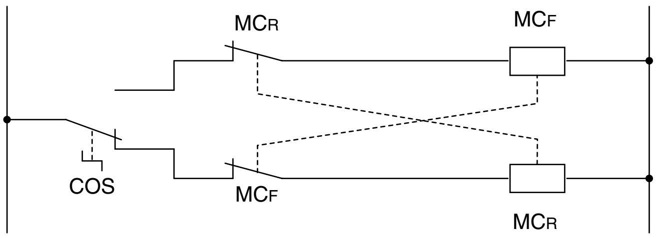


Fig. 9 Timing diagram

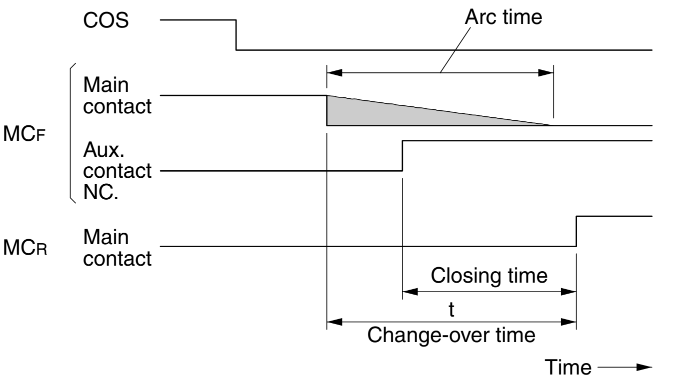
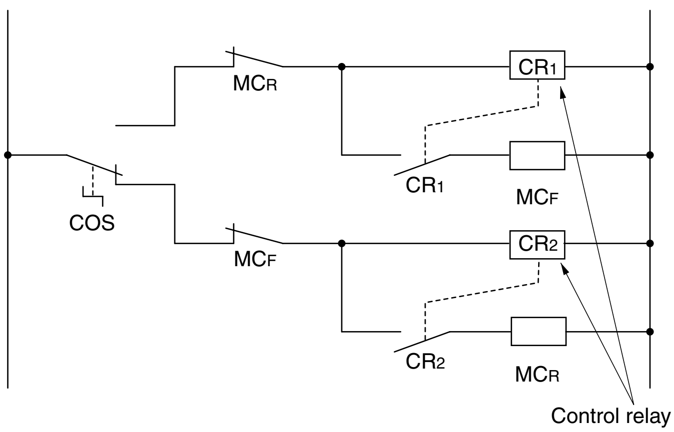


Fig. 10 Reversing of using control relay (CR)



Type	Arc time (ms) at 10×Ie (A) breaking		Change-over time (ms) With mechanical interlock device
	220V	440V	
SC-03RM	4–7	5–7.5	15–21
SC-0RM	4.5–6	4.5–7.5	15–21
SC-05RM	4–5.5	4.5–7.5	15–21
SC-4-0RM	4–7	4.5–7.5	14–19
SC-4-1RM	4–7.5	4.5–8	14–19
SC-5-1RM	4–7.5	4.5–8	14–19
SC-N1RM	4–6	5–7	11–28
SC-N2RM	4–6	5–7	11–28
SC-N2SRM	4–8	5–8	14–32
SC-N3RM	4–8	5–8	14–32
SC-N4RM	5–9	5–10	19–30
SC-N5RM	4–9	4–10	32–77
SC-N6RM	4–12	4–13	27–63
SC-N7RM	3–12	3–13	27–63
SC-N8RM	4–12	5–13	35–44
SC-N10RM	4–13	6–14	35–44
SC-N11RM	5–13	6–15	50–60
SC-N12RM	5–13	6–15	50–60
SC-N14RM	5–10	6–16	70–110

1-3-14 Off-delay release contactors

This is a combination of DC-operated magnetic contactor and off-delay release unit. It prevents circuit opening due to instantaneous voltage drops.

**Fig. 11 SC-03/G to 5-1/G+SZ-DE☐
SC-N1/G to N3/G+SZ-DE☐**

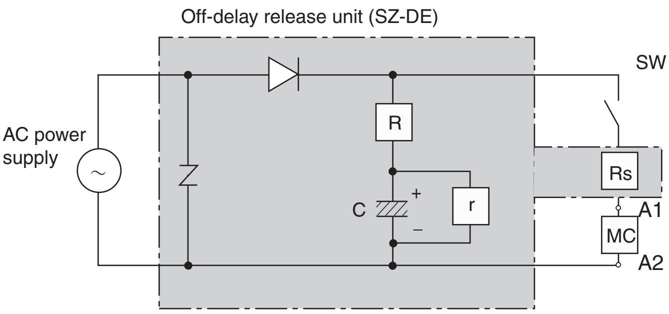
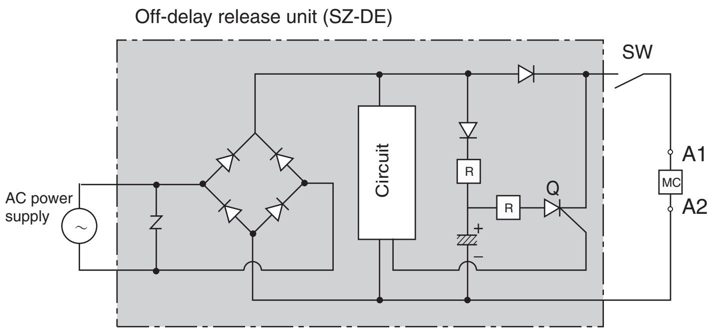


Fig. 12 SC-N4/SE to N14+SZ-DE☐



(1) Delay time measurement data

If a problem occurs in power lines due, for example, to lightning, there will be a short power interruption and a reduction in the voltage that will remain until the problem is removed. Instantaneous power interruptions and voltage drops are, to a certain extent, unavoidable and they may continue for up to 0.3s. An interval of 1s must be allowed to ensure safety.

With contactors, if a voltage drop of 50% or more continues for between 0.005 and 0.02s, the contactors are released. In order to avoid stoppages in installations when instantaneous power interruptions and voltage drops occur, an Off-delay release contactor (a combination of a DC-operated magnetic contactor and off-delay release unit) that delays the release of the contactors for between 1 and 5s is used. The delay time for SC-03 to SC-N3 models is 1 to 5s, and the delay time for SC-N4 to SC-N14 models is 1 to 4s.

Disparities in the delay time may be caused by allowable error in the capacitances of the units and differences in the holding force of the contactors.

For more details on the disparities in the delay times for different models and different operational voltages, refer to the table below.

(a) Test condition

Control circuit voltage: Decreased from 100%V to 0V
Coil: Cold state
Ambient temperature: Normal temperature

(b) Off-delay time (Example)

Contactor			Off-delay time (s)			
Type	Aux. contact	Additional aux. contact block	SZ-DE100 (100V AC)	SZ-DE110 (110V AC)	SZ-DE200 (200V AC)	SZ-DE220 (220V AC)
SC-03/G, 0/G	1NO	–	2.0–2.7	1.9–2.6	2.0–2.7	1.8–2.5
SC-05/G	2NO	–	1.9–2.6	1.8–2.5	1.9–2.7	1.7–2.3
SC-05/G	2NO	SZ-A40 (4NO)	1.6–2.2	1.5–2.2	1.6–2.3	1.4–2.2
SC-4-0/G, 4-1/G	1NO	–	2.0–2.6	1.8–2.5	2.0–2.7	1.8–2.4
SC-5-1/G	2NO	–	1.8–2.5	1.7–2.4	1.7–2.5	1.6–2.3
SC-5-1/G	2NO	SZ-A40 (4NO)	1.6–2.3	1.4–2.2	1.6–2.3	1.4–2.3
SC-N1/G, N2/G	–	–	1.7–2.5	2.0–3.0	1.8–2.7	2.2–3.3
		SZ-A40 (4NO)	1.5–2.3	1.8–2.8	1.6–2.4	2.0–3.0
SC-N2S/G, N3/G	–	–	1.6–2.5	2.0–3.0	1.6–2.4	2.0–3.1
		SZ-A40 (4NO)	1.5–2.3	1.8–2.8	1.5–2.3	1.9–2.8
SC-N4/SE, N5	–	–	1.6–2.4	1.9–2.9	1.7–2.5	2.1– 3.2
SC-N6, N7	–	–	1.5–2.2	1.7–2.7	1.6–2.4	2.0–3.0
SC-N8, N10	–	–	1.6–2.4	1.9–2.9	1.5–2.2	1.8–2.8
SC-N11, N12	–	–	1.4–2.1	1.6–2.6	2.0–3.0	2.5–3.8
SC-N14	–	–	1.3–2.5	1.5–2.8	1.5–2.7	1.7–2.9

Note: The values given in the above table are representative samples.

(2) Durability of capacitors

The capacitors in Off-delay release units must have a large capacity and be compact. For this reason, aluminum catalytic capacitors are used. It is well known that this type of capacitor is a wear-out failure type. Basically, degradation and consumption of the electrolyte leads to deterioration in the characteristics and eventually the capacity is reduced, signalling the end of the service life. Although the time taken to reach the end of the service life is influenced to some extent by ripple current and the number of charges and discharges, it is significantly influenced by temperature, with the service life halved for every increase of 10°C.

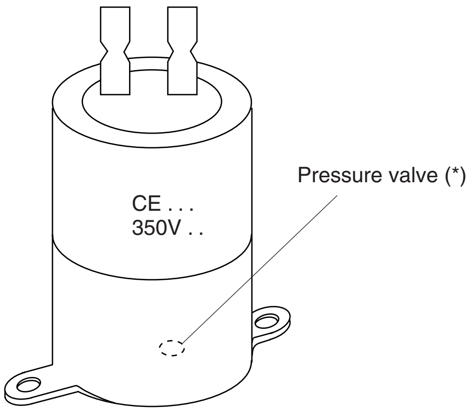
The life expectancies for the capacitors used in Off-delay release units are as follows.

Life expectancies of capacitors

- Cumulative charged life:
  The cumulative time for which the Off-delay release unit is used with the rated voltage applied
  Cumulative charged life of capacitor at 55°C: 100,000 hours
- Discharge time life:
  The number of Off-delay release operations due, for example, to power interruptions
  Discharge time life of capacitor at 55°C: 100,000 operations

As described above, capacitors have a finite service life and so inspection is required if they are used for several years. There is a pressure valve (*) attached to the bottom of the capacitor and when the capacitor reaches the end of its service life, the valve opens and electrolyte starts to leak out. This can be used as a rough guide to determine when the service life has expired.

Fig. 13 Schematic diagram of pressure valve



(3) Precautions regarding the operation command contact and connection position

Ensure that the operation command contact (switch) is connected to the DC side. If it is connected to the AC input side, the following problems will occur.

- Off-delay release operation will occur even if the operation command contact is turned OFF.
- Chattering will occur in the contactor.

(In combinations of models SC-03/G to N3/G and model SZ-□DE, this is because when the switch closes, initially only single-phase half-wave current is supplied.)

1-3-15 Mechanical latch contactors

Mechanical latch contactors are used where operating sequence continuity must be maintained regardless of any outside interruptions, such as voltage failure or instantaneous voltage drop. Typical applications are for electric furnaces, machine tool circuits, standby power supply and normal power changeover circuits in hospitals, schools and office buildings.

These contactors are provided with two coils. One is CC (Closing Coil) and the other is TC (Tripping Coil).

An interlocking circuit is provided between the CC coil and the TC coil. Since a coil voltage is not applied during operation it is extremely quiet. Power consumption can also be saved.

(1) Ratings Same as standard types.

(2) Performance

Type				Making and breaking current (A)		Operating cycles per hour	Durability operation (×10³)		Utilization category
Non reversing contactor		Reversing contactor							
AC-operated	DC-operated	AC-operated	DC-operated	Making	Breaking		Mechanical	Electrical	
SC-03/V	**SC-03/VG**	**SC-03RM/V**	**SC-03RM/VG**	10×Ie	8×Ie	1,200	1,000	500	AC-3
SC-0/V	**SC-0/VG**	**SC-0RM/V**	**SC-0RM/VG**	10×Ie	8×Ie	1,200	1,000	500	AC-3
SC-05/V	**SC-05/VG**	**SC-05RM/V**	**SC-05RM/VG**	10×Ie	8×Ie	1,200	1,000	500	AC-3
SC-4-0/V	**SC-4-0/VG**	**SC-4-0RM/V**	**SC-4-0RM/VG**	10×Ie	8×Ie	1,200	1,000	500	AC-3
SC-4-1/V	**SC-4-1/VG**	**SC-4-1RM/V**	**SC-4-1RM/VG**	10×Ie	8×Ie	1,200	1,000	500	AC-3
SC-5-1/V	**SC-5-1/VG**	**SC-5-1RM/V**	**SC-5-1RM/VG**	10×Ie	8×Ie	1,200	1,000	500	AC-3
SC-N1/VS, N2/VS SC-N2S/VS, N3/VS		**SC-N1RM/VS, N2RM/VS SC-N2SRM/VS, N3RM/VS**		10×Ie	8×Ie	600	500	500	AC-3
SC-N4/VS, N5/VS, N6/VS SC-N7/VS, N8/VS, N10/VS SC-N11/VS, N12/VS		**SC-N4RM/VS, N5RM/VS SC-N6RM/VS, N7RM/VS SC-N8RM/VS, N10RM/VS SC-N11RM/VS, N12RM/VS**		10×Ie	8×Ie	600	250	250	AC-3
SC-N14/VS		**SC-N14RM/VS**		10×Ie	8×Ie	600	100	100	AC-3

Ie: Rated operational current.

(3) Coil characteristics

(a) AC operated

Type	Power consumption (VA)		Coil voltage *	Min. closing and tripping signal time (s)
	Closing	Tripping		
SC-03/V	95	150	100V AC	0.3
SC-0/V	95	150	(100V 50Hz	
SC-05/V	95	150	100–110V 60Hz)	
SC-4-0/V	95	150	200V AC	
SC-4-1/V	95	150	(200V 50Hz	
SC-5-1/V	95	150	200–220V 60Hz)	
SC-N1/VS	100	140	100V	0.3
SC-N2/VS	100	140	(100–110V	
SC-N2S/VS	115	140	50/60Hz	
SC-N3/VS	115	140	100–110V DC)	
SC-N4/VS	161	266	200V (200–220V	
SC-N5/VS	161	266	50/60Hz	
SC-N6/VS	229	266	200–220V DC)	
SC-N7/VS	229	266		
SC-N8/VS	273	385		
SC-N10/VS	273	385		
SC-N11/VS	490	385		
SC-N12/VS	490	385		
SC-N14/VS	500	660		

Notes: • The above figures are given as examples. They are subject to the following conditions.
Coil temperature: 20°C
Coil ratings: 200–220V, 50/60Hz
Applied voltage: 200V AC, 60Hz

* Following voltage ranges are also available.
SC-03/V to 5-1/V: 24 to 220V AC 50/60Hz
SC-N1/VS to N12/VS: 24 to 220V AC 50/60Hz
SC-N14/VS: 100 to 220V AC 50/60Hz

(b) DC operated

Type	Power consumption (W)		Coil voltage *	Min. closing and tripping signal time (s)
	Closing	Tripping		
SC-03/VG	7	150	100, 110V DC	0.3
SC-0/VG	7	150	200, 220V DC	
SC-05/VG	7	150		
SC-4-0/VG	7	150		
SC-4-1/VG	7	150		
SC-5-1/VG	7	150		
SC-N1/VS	95	150	100V	0.3
SC-N2/VS	95	150	(100–110V DC	
SC-N2S/VS	110	150	100–110V AC	
SC-N3/VS	110	150	50/60Hz)	
SC-N4/VS	153	198	200V (200–220V DC	
SC-N5/VS	153	198	200–220V AC	
SC-N6/VS	216	198	50/60Hz)	
SC-N7/VS	216	198		
SC-N8/VS	260	294		
SC-N10/VS	260	294		
SC-N11/VS	515	294		
SC-N12/VS	515	294		
SC-N14/VS	500	660		

Notes: • The above figures are given as examples. They are subject to the following conditions.
Coil temperature: 20°C
Coil ratings: 200–220V, 50/60Hz
Applied voltage: 200V DC

* Other voltage with a voltage range of 24 to 220V DC (100 to 220V DC for N14/VS type) are also available.

(4) Operating characteristics and operating time

(a) AC operated

Type	Pick-up voltage (V)				Operating time (ms)					
	Closing coil		Tripping coil		Pick-up			Drop-out		
	50Hz	60Hz	50Hz	60Hz	Main contact	Aux. NO contact	Aux. NC contact	Main contact	Aux. NO contact	Aux. NC contact
SC-03/V	109–129	120–141	46–66	50–72	9–20	–	–	4–11	–	–
SC-0/V	109–129	120–141	46–66	50–72	9– 20	–	–	4–11	–	–
SC-05/V	112–132	123–144	46–68	50–72	10–22	10–22	6–17	4–11	4–11	10–18
SC-4-0/V	113–136	123–144	46–68	50–72	9–21	–	–	5–13	–	–
SC-4-1/V	113–136	123–144	46–68	50–72	9–21	–	–	5–13	–	–
SC-5-1/V	115–139	125–146	46–68	50–72	9–21	9–21	6–19	5–13	5–13	9–20
SC-N1/VS	120–132	130–135	90–110	100–122	14–18	14–19	8–16	8–15	6–14	10–19
SC-N2/VS	120–132	130–135	90–110	100–122	14–18	14–19	8–16	8–15	6–14	10–19
SC-N2S/VS	120–132	130–135	90–110	100–122	18–22	18–23	10–18	8–15	5–13	8–20
SC-N3/VS	120–132	130–135	90–110	100–122	18– 22	18–23	10–18	8–15	5–13	8– 20
SC-N4/VS	140–150	140–150	90–120	100–130	39–45	40–46	37–43	11–17	11–17	14–21
SC-N5/VS	140–150	140–150	90–120	100–130	39–45	40–46	37–43	11–17	11–17	14–21
SC-N6/VS	140–150	140–150	90–120	100–130	38–43	37–42	35–40	11–17	10–17	15– 22
SC-N7/VS	140–150	140–150	90–120	100–130	38–43	37–42	35–40	11–17	10–17	15– 22
SC-N8/VS	140–150	140–150	90–120	100–130	43–47	40–44	37–41	13–20	15–22	16– 27
SC-N10/VS	140–150	140–150	90–120	100–130	43–47	40–44	37–41	13–20	15– 22	16–27
SC-N11/VS	140–150	140– 150	90–120	100–130	42–45	39–42	36–40	13–20	14–22	16–27
SC-N12/VS	140–150	140–150	90–120	100–130	42–45	39–42	36–40	13–20	14–22	16– 27
SC-N14/VS	140–160	140–160	90–140	90–140	69–75	68– 75	55–70	16–30	16–30	16– 30

Notes: • Coil ratings: 03/V to 5-1/V: 200V AC (200V, 50Hz/200 to 220V 60Hz)
N1/VS to N14/VS: 200V (200 to 220V AC, 50/60Hz, 200 to 220V DC)
• Operating time: 03/V to 5-1/V: For 200V AC, 50Hz.
N1/VS to N14/VS: For 200V AC, 50Hz.

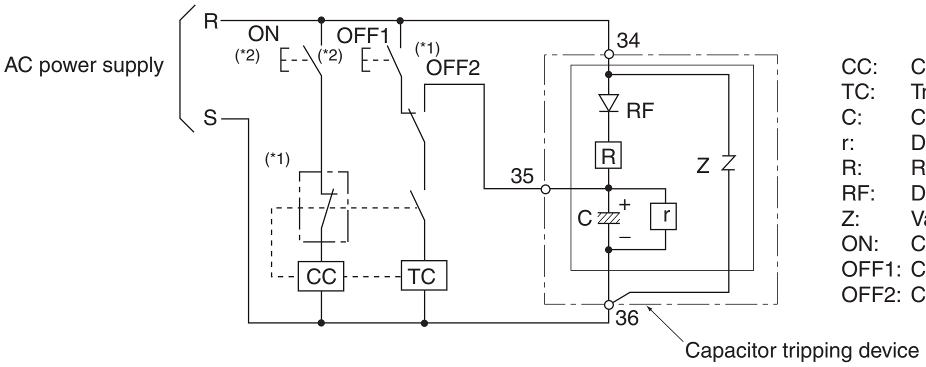
(b) DC operated

Type	Pick-up voltage (V)		Operating time (ms)					
	Closing coil	Tripping coil	Pick-up			Drop-out		
			Main contact	Aux. NO contact	Aux. NC contact	Main contact	Aux. NO contact	Aux. NC contact
SC-03/VG	46–63	23–42	42–51	–	–	23–28	–	–
SC-0/VG	42–63	23–42	42–51	–	–	23–28	–	–
SC-05/VG	45–62	24–43	43–52	43– 52	36–42	23–28	20–25	27–32
SC-4-0/VG	48–65	24–43	43–52	–	–	23–28	–	–
SC-4-1/VG	48–65	24–43	43–52	–	–	23–28	–	–
SC-5-1/VG	48–65	24–43	45–54	45–54	39–44	23–28	20–25	26–31
SC-N1/VS	115–125	100–125	14–16	14–18	8–16	13–15	11–15	15–19
SC-N2/VS	115–125	100–125	14–16	14–18	8–16	13–15	11–15	15–19
SC-N2S/VS	115–125	100–125	18–20	18–22	10–18	9–11	6–10	9–20
SC-N3/VS	115–125	100–125	18–20	18–22	10–18	9–11	6–10	9–20
SC-N4/VS	140–160	100–125	35–41	34–41	31–39	18–26	18–26	21–30
SC-N5/VS	140–160	85–105	35–41	34–41	31– 39	18–26	18–26	21–30
SC-N6/VS	140–160	85–105	35–41	34–42	33–39	18–26	17–26	21–31
SC-N7/VS	140–160	85–105	35–41	34–42	33–39	18–26	17–26	21–31
SC-N8/VS	140–160	85–105	38–44	35–42	32–39	20–28	22–30	23–35
SC-N10/VS	140–160	85–105	38–44	35–42	32–39	20–28	22–30	23–35
SC-N11/VS	140–160	85–105	38–44	35–42	32–38	20–28	21–30	23–35
SC-N12/VS	140–160	85–105	38–44	35–42	32–38	20–28	21–30	23–35
SC-N14/VS	140–160	80–120	64–70	63–70	50–65	33–41	33–41	33–46

Notes: • Coil ratings: 03/VG to 5-1/VG: 200V DC
N1/VS to N14/VS: 200V (200 to 220V DC, 200 to 220V AC, 50/60Hz)
• Operating time: For 200V DC.

1-3 Performance and characteristics

Fig. 14 Capacitor tripping circuit example



CC: Closing coil
TC: Tripping coil
C: Capacitor
r: Discharge resistor
R: Resistor
RF: Diode
Z: Varistor
ON: Contact for ON
OFF1: Contact for OFF
OFF2: Contact for capacitor trip

Notes: NC contact for ON:

*1 With SC-N4/VS to N14/VS models, because they have an electronic NC contact function (i.e., an electronic circuit for controlling the closing coil), the contactor's own auxiliary NC contact is not connected. With SC-03/V to 5-1/V models and SC-N1/VS to N3/VS models, the latch unit's built-in NC contact (terminals 55–56) is connected in series.

*2 Use a non-overlapping circuit configuration for the ON command (ON) and trip commands (OFF1 and OFF2). Overlapping may result in contact chattering or burning of the coil.

(5) Resistance to vibration and shock

(a) Resistance to vibration

The test checks that the self-hold contact of the SH-4 industrial relay connected in series with the tested contact does not open, and the bounce time is between 0.1 and 1ms. No vibration is applied to the SH-4.

(b) Resistance to shock

The test investigates contact malfunctions and contact durability when drop impact is applied in the normally mounted state using a pneumatic drop tester. Malfunctions are detected in the same way as for the vibration resistance test.

(c) Test result

The contactor operates normally and the parts are not damaged within the figures shown in table below.

Type	Resistance to vibration (double amplitude 2mm) Acceleration (m/s^2)	Resistance to shock (m/s^2)		
		Malfunction durability	Mechanical durability Screw mounted	Rail mounted
SC-03/VG	30	100	500	400
SC-0/VG	30	100	500	400
SC-05/VG	30	100	500	400
SC-4-0/VG	30	100	500	400
SC-4-1/VG	30	100	500	400
SC-5-1/VG	30	100	500	400
SC-N1/VS	30	100	500	350
SC-N2/VS	30	100	500	350
SC-N2S/VS	30	100	500	350
SC-N3/VS	30	100	500	350
SC-N4/VS	30	100	500	–
SC-N5/VS	30	100	500	–
SC-N6/VS	30	100	500	–
SC-N7/VS	30	100	500	–
SC-N8/VS	30	100	500	–
SC-N10/VS	30	100	500	–
SC-N11/VS	30	100	500	–
SC-N12/VS	30	100	500	–
SC-N14/VS	30	100	500	–

Chapter 2

Thermal Overload Relays

CONTENTS

2-1 Ratings and specifications

2-1-1 Standard type

On-contactor mounting	3-element	**TR-0N/3**		**TR-5-1N/3**		**TR-N2/3**		**TR-N3/3**	
	2-element *2	**TR-0N**		**TR-5-1N**		**TR-N2**		**TR-N3**	
Separate mounting	3-element	**TR-0NH/3**		**TR-5-1NH/3**		**TR-N2H/3**		**TR-N3H/3**	
	2-element *2	**TR-0NH**		**TR-5-1NH**		**TR-N2H**		**TR-N3H**	
Contactor to be combined		SC-03	SC-0 SC-05	SC-4-0	SC-4-1 SC-5-1	SC-N1	SC-N2	SC-N2S	SC-N3
Ampere setting range (A)		0.1–0.15	0.1–0.15	0.1–0.15	0.1–0.15				
		0.13–0.2	0.13–0.2	0.13–0.2	0.13–0.2				
		0.15–0.24	0.15–0.24	0.15–0.24	0.15–0.24				
		0.2–0.3	0.2–0.3	0.2–0.3	0.2–0.3				
		0.24–0.36	0.24–0.36	0.24–0.36	0.24–0.36				
		0.3–0.45	0.3–0.45	0.3–0.45	0.3–0.45				
		0.36–0.54	0.36–0.54	0.36–0.54	0.36–0.54				
		0.48–0.72	0.48–0.72	0.48–0.72	0.48–0.72				
		0.64–0.96	0.64–0.96	0.64–0.96	0.64–0.96				
		0.8–1.2	0.8–1.2	0.8–1.2	0.8–1.2				
		0.95–1.45	0.95–1.45	0.95–1.45	0.95–1.45				
		1.4–2.2	1.4–2.2	1.4–2.2	1.4–2.2				
		1.7–2.6	1.7–2.6	1.7–2.6	1.7–2.6				
		2.2–3.4	2.2–3.4	2.2–3.4	2.2–3.4				
		2.8–4.2	2.8–4.2	2.8–4.2	2.8–4.2				
		4–6	4–6	4–6	4–6	4–6	4–6		
		5–8	5–8	5–8	5–8	5–8	5–8		
		6–9	6–9	6–9	6–9	6–9	6–9		
		7–11	7–11	7–11	7–11	7–11	7–11	7–11	7–11
			9–13	9–13	9–13	9–13	9–13	9–13	9–13
				12–18	12–18	12–18	12–18	12–18	12–18
					16–22				
						18–26	18–26	18–26	18–26
						24–36	24–36	24–36	24–36
								28–40	28–40
							32–42		
								34–50	34–50
								45–65	45–65
									48–68
									53–80 *1
									63–95 *1
									85–105 *1

On-contactor mounting	3-element	**TR-N5/3**		**TR-N6/3**	**TR-N7/3**	**TR-N8/3**	**TR-N10/3**	**TR-N12/3**		**TR-N14/3**
	2-element *2	**TR-N5**		**TR-N6**	**TR-N7**	**TR-N8**	**TR-N10**	**TR-N12**		**TR-N14**
Separate mounting	3-element	–		**TR-N6H/3**	–	–	**TR-N10H/3**	**TR-N12H/3**		**TR-N14H/3**
	2-element *2	–		**TR-N6H**	–	–	**TR-N10H**	**TR-N12H**		**TR-N14H**
Contactor to be combined		SC-N4	SC-N5	SC-N6	SC-N7	SC-N8	SC-N10	SC-N11	SC-N12	SC-N14
Ampere setting range (A)		18–26	18–26							
		24–36	24–36							
		28–40	28–40							
		34–50	34–50							
		45–65	45–65	45–65	45–65					
		53–80	53–80	53–80	53–80					
			65–95	65–95	65–95	65–95				
			85–105							
				85–125	85–125	85–125	85–125			
				110–160 *1	110–160	110–160	110–160	110–160	110–160	
						125–185	125–185	125–185	125–185	
							160–240	160–240	160–240	
								200–300	200–300	
									240–360	240–360
									300–450	300–450
										400–600

Notes:
- TR-N10/3 and TR-N10 to N14/3 and TR-N14 types are provided with CTs.
- Setting range of SW-03 and 03/H for 380–440V AC: Max. 6–9A
- When ordering the thermal overload relays for starter use, select the appropriate setting range.

*1 Separate mounting only
*2 Does not conform to IEC, UL/CSA and JIS standards.

2-1-2 Long-time operating type

On-contactor mounting	3-element 2-element *2	– –		– –		**TR-N2L/3** **TR-N2L**		**TR-N3L/3** **TR-N3L**	
Separate mounting	3-element 2-element *2	**TR-0NLH/3** **TR-0NLH**		**TR-5-1NLH/3** **TR-5-1NLH**		**TR-N2LH/3** **TR-N2LH**		**TR-N3LH/3** **TR-N3LH**	
Contactor to be combined		SC-03	SC-0 SC-05	SC-4-0	SC-4-1 SC-5-1	SC-N1	SC-N2	SC-N2S	SC-N3
Ampere setting range (A)		0.95–1.45	0.95–1.45	0.95–1.45	0.95–1.45				
		1.4–2.2	1.4–2.2	1.4–2.2	1.4–2.2				
		1.7–2.6	1.7–2.6	1.7–2.6	1.7–2.6				
		2.2–3.4	2.2–3.4	2.2–3.4	2.2–3.4				
		2.8–4.2	2.8–4.2	2.8–4.2	2.8–4.2				
		4–6	4–6	4–6	4–6	4–6	4–6		
		5–8	5–8	5–8	5–8	5–8	5–8		
		6–9	6–9	6–9	6–9	6–9	6–9		
		7–11	7–11	7–11	7–11	7–11	7–11	7–11	7–11
			9–13	9–13	9–13	9–13	9–13	9–13	9–13
				12–18	12–18	12–18	12–18	12–18	12–18
						18–26	18–26	18–26	18–26
							24–36	24–36	24–36
								28–40	28–40
								34–50	34–50
									45–65
									53–80 *
									65–95 *

On-contactor mounting	3-element 2-element *2	**TR-N5L/3** **TR-N5L**		**TR-N6L/3** **TR-N6L**	**TR-N7L/3** **TR-N7L**	**TR-N10L/3** **TR-N10L**		**TR-N12L/3** **TR-N12L**		**TR-N14L/3** **TR-N14L**
Separate mounting	3-element 2-element *2	– –		**TR-N6LH/3** **TR-N6LH**	– –	**TR-N10LH/3** **TR-N10LH**		**TR-N12LH/3** **TR-N12LH**		**TR-N14LH/3** **TR-N14LH**
Contactor to be combined		SC-N4	SC-N5	SC-N6	SC-N7	SC-N8	SC-N10	SC-N11	SC-N12	SC-N14
Ampere setting range (A)		18–26	18–26							
		24–36	24–36							
		28–40	28–40							
		34–50	34–50							
		45–65	45–65	45–65	45–65					
		53–80	53–80	53–80	53–80					
			65–95	65–95	65–95					
				85–125	85–125	85–125	85–125			
				110–160 *	110–160	110–160	110–160	110–160		
						125–185	125–185	125–185		
							160–240	160–240	160–240	
								200–300	200–300	
									240–360	240–360
									300–450	300–450
										400–600

Notes: Setting range of SW-03/2L and 3L for 380–440V AC: Max. 6–9A
Select the appropriate setting range when ordering the thermal overload relays for starter use.
*1 Separate mounting only
*2 Does not conform to IEC, UL/CSA and JIS standards.

2-1 Ratings and specifications

2-1-3 Quick operating type

On-contactor mounting	3-element	**TR-0NQ**		**TR-5-1NQ**		**TR-N2Q** *1	
Separate mounting	3-element	**TR-0NQH**		**TR-5-1NQH**		**TR-N2QH** *1	
Contactor to be combined		SC-03	SC-0 SC-05	SC-4-0	SC-4-1 SC-5-1	SC-N1	SC-N2
Rated operational current (A)	200–240V 380–440V	11 9	13 12	18 16	22 22	27 30	39 37
Ampere setting range (A)		1.4–2.2	1.4–2.2	1.4–2.2	1.4–2.2		
		1.7–2.6	1.7–2.6	1.7–2.6	1.7–2.6		
		2.2–3.4	2.2–3.4	2.2–3.4	2.2–3.4		
		2.8–4.2	2.8–4.2	2.8–4.2	2.8–4.2		
		4–6	4–6	4–6	4–6		
		5–8	5–8	5–8	5–8		
		6–9	6–9	6–9	6–9		
		7–11 *1	7–11 *1	7–11 *1	7–11 *1		
			9–13 *1	9–13 *1	9–13 *1		
				12–18 *1	12–18 *1	12–18	12–18
						18–26	18–26
							24–36

On-contactor mounting	3-element	**TR-N3Q** *1		**TR-N5Q** *1	
Separate mounting	3-element	**TR-N3Q** *1		–	
Contactor to be combined		SC-N2S	SC-N3	SC-N4	SC-N5
Rated operational current (A)	200–240V 380–440V	52 48	65 65	80 80	105 105
Ampere setting range (A)		18–26	18–26	18–26	18–26
		24–36	24–36	24–36	24–36
		28–40	28–40	28–40	28–40
		34–50	34–50	34–50	34–50
			45–65	45–65	45–65
			53–80 *2	53–80	53–80
			65–95 *2		65–95

Notes: • Setting range of SW-3/3Q for 380–440V AC: Max. 6–9A

*1 Thermal overload relay with phase-loss protection is available with setting ranges of TR-0NQ, TR-5-1NQ and all setting ranges of TR-N2Q to N5Q.
Type numbers are TK-0NQ, TK-5-1NQ, TK-N2Q to N5Q. The setting ranges of these TK-☐Q type relays are as same as those of the above setting ranges.

*2 Separate mounting only.

2-1-4 2E type (with phase-loss protection)

On-contactor mounting	3-element	**TK-0N**		**TK-5-1N**		**TK-N2**		**TK-N3**	
Separate mounting	3-element	**TK-0NH**		**TK-5-1NH**		**TK-N2H**		**TK-N3H**	
Contactor to be combined		SC-03	SC-0 SC-05	SC-4-0	SC-4-1 SC-5-1	SC-N1	SC-N2	SC-N2S	SC-N3
Ampere setting range (A)		0.1–0.15	0.1–0.15	0.1–0.15	0.1–0.15				
		0.13–0.2	0.13–0.2	0.13–0.2	0.13–0.2				
		0.15–0.24	0.15–0.24	0.15–0.24	0.15–0.24				
		0.2–0.3	0.2–0.3	0.2–0.3	0.2–0.3				
		0.24–0.36	0.24–0.36	0.24–0.36	0.24–0.36				
		0.3–0.45	0.3–0.45	0.3–0.45	0.3–0.45				
		0.36–0.54	0.36–0.54	0.36–0.54	0.36–0.54				
		0.48–0.72	0.48–0.72	0.48–0.72	0.48–0.72				
		0.64–0.96	0.64–0.96	0.64–0.96	0.64–0.96				
		0.8–1.2	0.8–1.2	0.8–1.2	0.8–1.2				
		0.95–1.45	0.95–1.45	0.95–1.45	0.95–1.45				
		1.4–2.2	1.4–2.2	1.4–2.2	1.4–2.2				
		1.7–2.6	1.7–2.6	1.7–2.6	1.7–2.6				
		2.2–3.4	2.2–3.4	2.2–3.4	2.2–3.4				
		2.8–4.2	2.8–4.2	2.8–4.2	2.8–4.2				
		4–6	4–6	4–6	4–6	4–6	4–6		
		5–8	5–8	5–8	5–8	5–8	5–8		
		6–9	6–9	6–9	6–9	6–9	6–9		
		7–11	7–11	7–11	7–11	7–11	7–11	7–11	7–11
			9–13	9–13	9–13	9–13	9–13	9–13	9–13
				12–18	12–18	12–18	12–18	12–18	12–18
					16–22				
						18–26	18–26	18–26	18–26
						24–36	24–36	24–36	24–36
								28–40	28–40
							32–42		
								34–50	34–50
								45–65	45–65
									48–68
									53–80 *
									63–95 *
									85–105 *

On-contactor mounting	3-element	**TK-N5**		**TK-N6**	**TK-N7**	**TK-N8**	**TK-N10**	**TK-N12**		**TK-N14**
Separate mounting	3-element	–		**TK-N6H**	–	–	**TK-N10H**	**TK-N12H**		**TK-N14H**
Contactor to be combined		SC-N4	SC-N5	SC-N6	SC-N7	SC-N8	SC-N10	SC-N11	SC-N12	SC-N14
Ampere setting range (A)		18–26	18–26							
		24–36	24–36							
		28–40	28–40							
		34–50	34–50							
		45–65	45–65	45–65	45–65					
		53–80	53–80	53–80	53–80					
			65–95	65–95	65–95	65–95				
			85–105							
				85–125	85–125	85–125	85–125			
				110–160 *	110–160	110–160	110–160	110–160	110–160	
						125–185	125–185	125–185	125–185	
							160–240	160–240	160–240	
								200–300	200–300	
									240–360	240–360
									300–450	300–450
										400–600

Notes:
- Setting range of SW-03/2E for 380–440V AC: Max. 6–9A
- When ordering the thermal overload relays for starter use, select the appropriate setting range.

* Separate mounting only

2-2-1 Operating characteristics

The operating characteristics of a thermal overload relays represents its tripping time and response current starting from cold or hot state.

Cold starting characteristics

In cold starting, tripping time is measured from the time when the temperature of the thermal overload relay is equal to the ambient temperature.

Hot starting characteristics

In hot starting, tripping time is measured from the time when the thermal overload relay reaches the steady state after non-tripping current flows two hours.

Standard	When all poles are equally energized				When all poles are not equally energized			Ambient temp.
	Operating limit		Overload (hot start)	Locked rotor (cold start)	Phase-loss protection	Operating limit Non-tripping	Tripping Hot start	
	Non-tripping	Tripping						
IEC 60947-4-1	105% Ie	120% Ie (2h max.)	class 10A 150% Ie 2min max.	class 10A 720% Ie 2 to 10s max.	Not provided	3-phase: 105% Ie	2-phase: 132% Ie	20°C
			class 10 150% Ie 4min max.	class 10 720% Ie 4 to 10s max.			1-phase: 0 (2h max.)	
			class 20 150% Ie 8min max.	class 20 720% Ie 6 to 20s max.	Provided	2-phase: 100% Ie	2-phase: 115% Ie	
			class 30 150% Ie 12min max.	class 30 720% Ie 9 to 30s max. *		1-phase: 90% Ie	1-phase: 0 (2h max.)	
JIS C 8201-4-1	105% Ie	120% Ie (2h max.)	class 5 150% Ie 2min max.	class 5 720% Ie 5s max.	Not provided	3-phase: 105% Ie	2-phase: 132% Ie	20°C
			class 10A 150% Ie 2min max.	class 10A 720% Ie 2 to 10s max.			1-phase: 0 (2h max.)	
			class 10 150% Ie 4min max.	class 10 720% Ie 4 to 10s max.				
			class 20 150% Ie 8min max.	class 20 720% Ie 6 to 20s max.	Provided	2-phase: 100% Ie	2-phase: 115% Ie	
			class 30 150% Ie 12min max.	class 30 720% Ie 9 to 30s max. *		1-phase: 90% Ie	1-phase: 0 (2h max.)	

Notes: • Ie: Set current
• The standard values given are for thermal overload relays with an ambient temperature compensator.
* The maximum operating time is used for items exceeding 30s.

2-2-2 Auxiliary contact ratings

(1) Conforming to IEC and JIS

Type	Conventional free air thermal current (A)	Rated operational current (A)		
		Rated voltage (V)	AC-15	DC-13
TR-0N/3, 0NQ **TR-5-1N/3, 5-1NQ** **TK-0N, 5-1N** **TR-0NLH/3, TR-5-1NLH/3**	5	24 100–120 200–240 380–440 500–600	3 (0.3)* 2.5 (0.3)* 2 (0.3)* 1 (0.3)* 0.6 (0.3)*	1.1 (0.3)* 0.28 0.14 – _
TR-N2/3 to N14/3 **TR-N2L/3 to N14L/3** **TR-N2Q to N5Q** **TK-N2 to N14**	5	24 100–120 200–240 380–440 500–600	3 (0.5)* 2.5 (0.5)* 2 (0.5)* 1 (0.5)* 0.6 (0.5)*	1.1 (0.5)* 0.28 0.14 – _

Notes: Conforming to IEC 60947-4-1.
( )* NO contact of auto reset type.

(2) Conforming to UL and CSA

Type	Continuous current (A)	Rated operational current (A)						Rating code
		AC			DC			
		Rated voltage	Make	Break	Rated voltage	Make	Break	
TR-0N/3, 5-1N/3 TK-0N, 5-1N	2.5	120V	15	1.5	125V	0.22	0.22	C600
		240V	7.5	0.75				R300
		480V	3.75	0.375	250V	0.11	0.11	
		600V	3	0.3				
TR-N2/3 to N14/3 TK-N2 to N14	5	120V	30	3	125V	0.22	0.22	B600
		240V	15	1.5				R300
		480V	7.5	0.75	250V	0.11	0.11	
		600V	6	0.6				

2-2-3 Making and breaking capacity

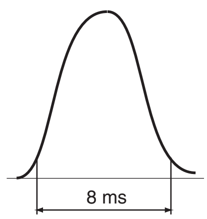
Type	Operational current (A)	Test current (A)			No. of operations	Power factor cosø	Operating duty	Test result
		Test voltage	Make	Break				
TR-0N/3, 5-1N/3 TK-0N, 5-1N	2	264V AC	20	2	50	0.3	at 10-second interval	No contact weld
		240V AC	20	2	6,000			
TR-N2/3 to N14/3 TK-N2 to N14	2	264V AC	20	2	50	0.3	at 10-second interval	No contact weld
		240V AC	20	2	6,000			

2-2-4 Resistance to vibration and shock

The relays are tested to confirm that the items specified by JEM 1356 are satisfied.

Test item		Test condition and method	Judgement conditions	Test result
Resistance to vibration	Mechanical endurance test	• Frequency: 10 to 25Hz • Double amplitude: 2mm • Direction: All 3 axes • Time: 2 hours in each direction • Main circuit: No current	• The relay can be used without damage to any part. • (There is no significant difference during the 200% Ie operating time before and after vibration is applied.)	• No loose screws and no damage to any part. • (The rate of change during the 200% In operating time was within ±5%, indicating no problems in practice.)
	Malfunction endurance test	• Setting current value: Minimum of current value in adjustment setting range • Main circuit current: Set current • Frequency: 10 to 55Hz (changed continuous and uniformly over one minute) • Double amplitude: 0.3mm • Direction: All 3 axes • Time: 10 minutes in each direction	• The NC contact's drop-out time is less than 1ms.	• No NC contact malfunction.
Resistance to shock	Mechanical endurance test	• Shock value: 500m/s² (drop test) • Direction: All 3 axes • Number of times: 3 times in each direction • Main circuit current: No current	• The relay can be used without damage to any part. • (There is no significant difference during the 200% Ie operating time before and after shock is applied.)	• No loose screws and no damage to any part. • (The rate of change during the 200% Ie operating time was within ±5%, indicating no problems in practice.)
	Malfunction endurance test	• Setting current value: Minimum of current value in adjustment setting range • Main circuit current: Set current • Shock acceleration: 50m/s² • Direction: All 3 axes • Number of times: 3 times in each direction	• The NC contact's drop-out time is less than 1ms.	• No NC contact malfunction.

Notes:
- The judgement conditions indicated in parentheses are items not specified by JEM 1356. (FUJI's own judgement conditions)
- Shock waves of width 8ms were used in the test for shock resistance. Refer to the diagram.
- The test for malfunctions was performed after temperature saturation.



Width of shock waveform

2-2 Performance and characteristics

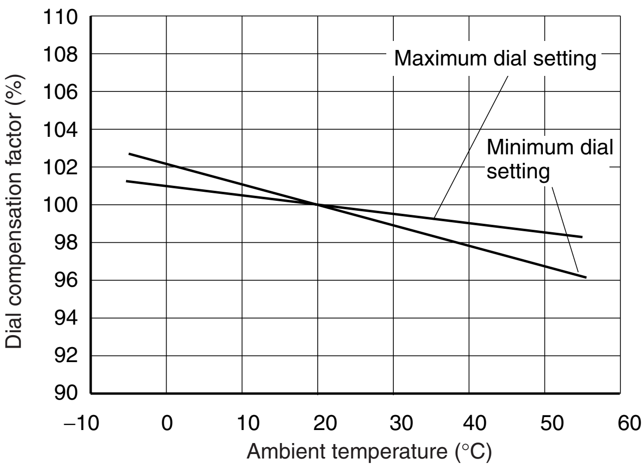
2-2-5 Operating temperature compensation

The current for the thermal overload relay is adjusted using an ambient temperature of 20°C as a standard. An ambient temperature compensator is provided to minimize the affect of fluctuations in the ambient temperature on the operating characteristics.

If the ambient temperature of the thermal overload relay is greatly lower than 20°C, the relay may fail to operate. If the temperature is greatly higher than 20°C, the relay may mistrip. In either case, the set current value must be used as a compensation as shown in the figure at the right.

Example: Calculating the set current value at an ambient temperature of 55°C

$$\frac{\text{Dial setting at 20°C}}{\text{Compensation factor at 55°C}} = \text{Dial setting for 55°C}$$



2-2-6 Thermal time constants

With thermal relays used to protect motors that perform fluctuating load operation or intermittent operation based on separate programs, in order to prevent a mistrip, it is necessary to obtain the equivalent continuous current for each of the fluctuating currents and set the current to the maximum of these values. If, however, the motor's thermal capacity is small relative to the set values, or if the operation is completely irregular, a FUJI motor guard that directly measures the winding temperature must be used.

Type	Current setting range	Thermal time constant Tc (sec)
TR-0N, TK-0N	6 to 9A or less	120
TR-5-1N, TK-5-1N	7 to 11A or over	90
TR-N2, TK-N2 TR-N3, TK-N3 TR-N5, TK-N5	–	160
TR-N6, TK-N6 TR-N7, TK-N7 TR-N8, TK-N8	–	200
TR-N10 to N14 TK-N10 to N14	–	350

2-3-1 Standard type/220V

Motor rating * 220V 50Hz 3-phase		Heater element setting range (A)							
		TR-0N/3 TK-0N		**TR-5-1N/3 TK-5-1N**		**TR-N2/3 TK-N2**		**TR-N3/3 TK-N3**	
		Contactor to be combined							
(kW)	(A)	**SC-03**	**SC-0 SC-05**	**SC-4-0**	**SC-4-1 SC-5-1**	**SC-N1**	**SC-N2**	**SC-N2S**	**SC-N3**
0.06	0.39	0.36–0.54	0.36–0.54	0.36–0.54	0.36–0.54				
0.09	0.58	0.48–0.72	0.48–0.72	0.48–0.72	0.48–0.72				
0.12	0.68	0.48–0.72	0.48–0.72	0.48–0.72	0.48–0.72				
0.18	1.1	0.8–1.2	0.8–1.2	0.8–1.2	0.8–1.2				
0.25	1.3	0.95–1.45	0.95–1.45	0.95–1.45	0.95–1.45				
0.37	1.9	1.4–2.2	1.4–2.2	1.4–2.2	1.4–2.2				
0.55	2.3	1.7–2.6	1.7–2.6	1.7–2.6	1.7–2.6				
0.75	3.3	2.8–4.2	2.8–4.2	2.8–4.2	2.8–4.2				
1.1	4.2	4–6	4–6	4–6	4–6	4–6	4–6		
1.5	5.5	4–6	4–6	4–6	4–6	4–6	4–6		
2.2	8.4	6–9	6–9	6–9	6–9	6–9	6–9	7–11	7–11
3	11	7–11	9–13	9–13	9–13	9–13	9–13	9–13	9–13
3.7	13.5			12–18	12–18	12–18	12–18	12–18	12–18
4	14.5			12–18	12–18	12–18	12–18	12–18	12–18
5.5	20				16–22	18–26	18–26	18–26	18–26
7.5	26.5					24–36	24–36	24–36	24–36
11	39						32–42	28–40	28–40
15	50							34–50	34–50
18.5	61								45–65

Motor rating * 220V 50Hz 3-phase		Heater element setting range (A)								
		TR-N5/3 TK-N5		**TR-N6/3 TK-N6**	**TR-N7/3 TK-N7**	**TR-N8/3 TK-N8**	**TR-N10/3 TK-N10**	**TR-N12/3 TK-N12**		**TR-N14/3 TK-N14**
		Contactor to be combined								
(kW)	(A)	**SC-N4**	**SC-N5**	**SC-N6**	**SC-N7**	**SC-N8**	**SC-N10**	**SC-N11**	**SC-N12**	**SC-N14**
5.5	20	18–26	18–26							
7.5	26.5	24–36	24–36							
11	39	34–50	34–50							
15	50	45–65	45–65	45–65	45–65					
18.5	61	53–80	53–80	53–80	53–80					
22	72	65–95	65–95	65–95	65–95	65–95				
30	98		85–105	85–125	85–125	85–125	85–125			
37	118			85–125	85–125	85–125	85–125			
45	143				110–160	110–160	110–160	110–160		
55	177					125–185	125–185	125–185		
75	240							200–300	200–300	
90	285							200–300	200–300	
110	340								240–360	240–360
132	405									300–450
160	495									400–600

Note: * The motor full load currents are typical examples.
TR: Standard type
TK: With phase-loss protection device

For 2-element type (TR-☐): Same heater element setting range

2-3-2 Standard type/380V

Motor rating * 380V 50Hz 3-phase		Heater element setting range (A)							
		TR-0N/3 TK-0N		TR-5-1N/3 TK-5-1N		TR-N2/3 TK-N2		TR-N3/3 TK-N3	
		Contactor to be combined							
(kW)	(A)	**SC-03**	**SC-0 SC-05**	**SC-4-0**	**SC-4-1 SC-5-1**	**SC-N1**	**SC-N2**	**SC-N2S**	**SC-N3**
0.06	0.23	0.15–0.24	0.15–0.24	0.15–0.24	0.15–0.24				
0.09	0.34	0.24–0.36	0.24–0.36	0.24–0.36	0.24–0.36				
0.12	0.39	0.36–0.54	0.36–0.54	0.36–0.54	0.36–0.54				
0.18	0.63	0.48–0.72	0.48–0.72	0.48–0.72	0.48–0.72				
0.25	0.74	0.64–0.96	0.64–0.96	0.64–0.96	0.64–0.96				
0.37	1.1	0.8–1.2	0.8–1.2	0.8–1.2	0.8–1.2				
0.55	1.3	0.95–1.45	0.95–1.45	0.95–1.45	0.95–1.45				
0.75	1.8	1.4–2.2	1.4–2.2	1.4–2.2	1.4–2.2				
1.1	2.4	1.7–2.6	1.7–2.6	1.7–2.6	1.7–2.6				
1.5	3.2	2.2–3.4	2.2–3.4	2.2–3.4	2.2–3.4				
2.2	4.7	4–6	4–6	4–6	4–6	4–6	4–6		
3	6.4	5–8	5–8	5–8	5–8	5–8	5–8		
3.7	7.7	5–8	5–8	5–8	5–8	5–8	5–8		
4	8.4	6–9	6–9	6–9	6–9	6–9	6–9		
5.5	11.5		9–13	9–13	9–13	9–13	9–13	9–13	9–13
7.5	15			12–18	12–18	12–18	12–18	12–18	12–18
11	21.5				16–22	18–26	18–26	18–26	18–26
15	28.5					24–36	24–36	24–36	24–36
18.5	35						24–36	28–40	28–40
22	41							34–50	34–50
30	56								45–65

Motor rating * 380V 50Hz 3-phase		Heater element setting range (A)								
		TR-N5/3 TK-N5		TR-N6/3 TK-N6	TR-N7/3 TK-N7	TR-N8/3 TK-N8	TR-N10/3 TK-N10	TR-N12/3 TK-N12		TR-N14/3 TK-N14
		Contactor to be combined								
(kW)	(A)	**SC-N4**	**SC-N5**	**SC-N6**	**SC-N7**	**SC-N8**	**SC-N10**	**SC-N11**	**SC-N12**	**SC-N14**
11	21.5	18–26	18–26							
15	28.5	24–36	24–36							
18.5	35	28–40	28–40							
22	41	34–50	34–50							
30	56	45–65	45–65	45–65	45–65					
37	68	53–80	53–80	53–80	53–80					
45	83		65–95	65–95	65–95	65–95				
55	103		85–125	85–125	85–125	85–125	85–125			
75	139				110–160	110–160	110–160	110–160	110–160	
90	165					125–185	125–185	125–185	125–185	
110	197						160–240	160–240	160–240	
132	235							200–300	200–300	
160	290							200–300	200–300	
200	355								240–360	240–360
250	440									300–450
315	570									400–600

Note: * The motor full load currents are typical examples.
TR: Standard type
TK: With phase-loss protection device

For 2-element type (TR-☐): Same heater element setting range

2-3-3 Long-time operating type/220V

Motor rating * 220V 50Hz 3-phase		Heater element setting range (A)							
		TR-0NLH/3 TK-0NLH		TR-5-1NLH/3 TK-5-1NLH		TR-N2L/3 TK-N2L		TR-N3L/3 TK-N3L	
		Contactor to be combined							
(kW)	(A)	SC-03	SC-0 SC-05	SC-4-0	SC-4-1 SC-5-1	SC-N1	SC-N2	SC-N2S	SC-N3
0.18	1.1	0.8–1.2	0.8–1.2	0.8–1.2	0.8–1.2				
0.25	1.3	0.95–1.45	0.95–1.45	0.95–1.45	0.95–1.45				
0.37	1.9	1.4–2.2	1.4–2.2	1.4–2.2	1.4–2.2				
0.55	2.3	1.7–2.6	1.7–2.6	1.7–2.6	1.7–2.6				
0.75	3.3	2.8–4.2	2.8–4.2	2.8–4.2	2.8–4.2				
1.1	4.2	4–6	4–6	4–6	4–6	4–6	4–6		
1.5	5.5	4–6	4–6	4–6	4–6	4–6	4–6		
2.2	8.4	6–9	6–9	6–9	6–9	6–9	6–9	7–11	7–11
3	11	7–11	9–13	9–13	9–13	9–13	9–13	9–13	9–13
3.7	13.5			12–18	12–18	12–18	12–18	12–18	12–18
4	14.5			12–18	12–18	12–18	12–18	12–18	12–18
5.5	20				16–22	18–26	18–26	18–26	18–26
7.5	26.5					24–36	24–36	24–36	24–36
11	39						32–42	28–40	28–40
15	50							34–50	34–50
18.5	61								45–65

Motor rating * 220V 50Hz 3-phase		Heater element setting range (A)								
		TR-N5L/3 TK-N5L		TR-N6L/3 TK-N6L	TR-N7L/3 TK-N7L	TR-N10L/3 TK-N10L		TR-N12L/3 TK-N12L		TR-N14L/3 TK-N14L
		Contactor to be combined								
(kW)	(A)	SC-N4	SC-N5	SC-N6	SC-N7	SC-N8	SC-N10	SC-N11	SC-N12	SC-N14
5.5	20	18–26	18–26							
7.5	26.5	24–36	24–36							
11	39	34–50	34–50							
15	50	45–65	45–65	45–65	45–65					
18.5	61	53–80	53–80	53–80	53–80					
22	72	65–95	65–95	65–95	65–95	65–95				
30	98		85–105	85–125	85–125	85–125	85–125			
37	118			85–125	85–125	85–125	85–125			
45	143				110–160	110–160	110–160	110–160		
55	177					125–185	125–185	125–185		
75	240							200–300	200–300	
90	285							200–300	200–300	
110	340								240–360	240–360
132	405									300–450
160	495									400–600

Note: * The motor full load currents are typical examples.
TR: Standard type
TK: With phase-loss protection device

For 2-element type (TR-☐): Same heater element setting range

2-3-4 Long-time operating type/380V

Motor rating * 380V 50Hz 3-phase		Heater element setting range (A)							
		TR-0NLH/3 TK-0NLH		TR-5-1NLH/3 TK-5-1NLH		TR-N2L/3 TK-N2L		TR-N3L/3 TK-N3L	
		Contactor to be combined							
(kW)	(A)	**SC-03**	**SC-0 SC-05**	**SC-4-0**	**SC-4-1 SC-5-1**	**SC-N1**	**SC-N2**	**SC-N2S**	**SC-N3**
0.18	0.63	0.48–0.72	0.48–0.72	0.48–0.72	0.48–0.72				
0.25	0.74	0.46–0.96	0.46–0.96	0.46–0.96	0.46–0.96				
0.37	1.1	0.8–1.2	0.8–1.2	0.8–1.2	0.8–1.2				
0.55	1.3	0.95–1.45	0.95–1.45	0.95–1.45	0.95–1.45				
0.75	1.8	1.4–2.2	1.4–2.2	1.4–2.2	1.4–2.2				
1.1	2.4	1.7–2.6	1.7–2.6	1.7–2.6	1.7–2.6				
1.5	3.2	2.2–3.4	2.2–3.4	2.2–3.4	2.2–3.4				
2.2	4.7	4–6	4–6	4–6	4–6	4–6	4–6		
3	6.4	5–8	5–8	5–8	5–8	5–8	5–8		
3.7	7.7	5–8	5–8	5–8	5–8	5–8	5–8		
4	8.4	6–9	6–9	6–9	6–9	6–9	6–9		
5.5	11.5		9–13	9–13	9–13	9–13	9–13	9–13	9–13
7.5	15			12–18	12–18	12–18	12–18	12–18	12–18
11	21.5				16–22	18–26	18–26	18–26	18–26
15	28.5					24–36	24–36	24–36	24–36
18.5	35						24–36	28–40	28–40
22	41							34–50	34–50
30	56								45–65

Motor rating * 380V 50Hz 3-phase		Heater element setting range (A)								
		TR-N5L/3 TK-N5L		TR-N6L/3 TK-N6L	TR-N7L/3 TK-N7L	TR-N10L/3 TK-N10L		TR-N12L/3 TK-N12L		TR-N14L/3 TK-N14L
		Contactor to be combined								
(kW)	(A)	**SC-N4**	**SC-N5**	**SC-N6**	**SC-N7**	**SC-N8**	**SC-N10**	**SC-N11**	**SC-N12**	**SC-N14**
11	21.5	18–26	18–26							
15	28.5	24–36	24–36							
18.5	35	28–40	28–40							
22	41	34–50	34–50							
30	56	45–65	45–65	45–65	45–65					
37	68	53–80	53–80	53–80	53–80					
45	83		65–95	65–95	65–95	65–95				
55	103		85–125	85–125	85–125	85–125	85–125			
75	139				110–160	110–160	110–160	110–160	110–160	
90	165					125–185	125–185	125–185	125–185	
110	197						160–240	160–240	160–240	
132	235							200–300	200–300	
160	290							200–300	200–300	
200	355								240–360	240–360
250	440									300–450
315	570									400–600

Note: * The motor full load currents are typical examples.
TR: Standard type
TK: With phase-loss protection device

For 2-element type (TR-□): Same heater element setting range

Chapter 3

Operating Conditions

CONTENTS

3 Operating Conditions
3-1 Standard operating conditions

Performance characteristics for contactors and starters are assured by testing under the following conditions.

- Ambient temperature range: –5 to +40°C
  (The temperature must not exceed 40°C at any time; the average temperature over a 24-hour period must not exceed 35°C; and the average temperature over a year must not exceed 20°C.)
- Temperature range inside panel box: –5 to +55°C
- Relative humidity: 45 to 85%
- Altitude: 2,000m max.
- Atmosphere: No excessive dust, smoke, flammable gases, corrosive gases, steam, or salt.
  No sudden temperature changes resulting in condensation or icing.

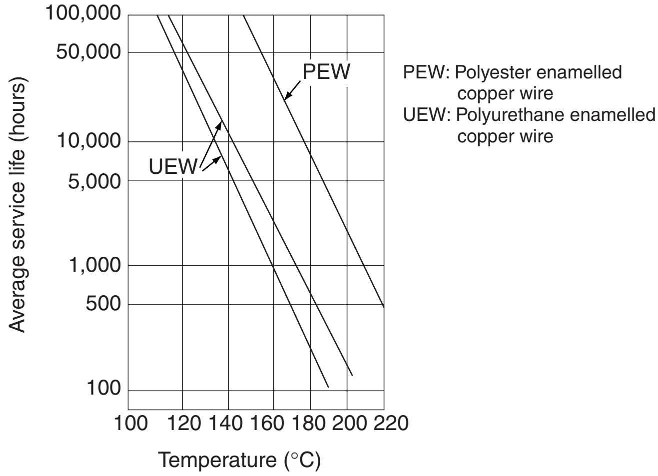
3-2-1 Durability at high temperatures

The durability of a contactor at high temperatures is mainly determined by the aging of molded parts and the coil's winding insulation material. The latter is a particularly significant factor.

SC series contactors are designed to operate for long periods even if the temperature inside the control panel is 55°C.

The coil's continuous service life can be estimated the sum of the ambient operating temperature and the coil's temperature rise (refer to page 27). As shown by the graph, the durability can be improved by lowering the ambient temperature.

Fig. 1 Temperature vs service life characteristics of magnet wire



3-2-2 Tropical, humid, or extremely cold locations

Contactors and starters are sometimes exported to or used in tropical, humid, or extremely cold locations, either as standalone products or built into panels or other structures. In such cases, standard products can be used as long as they satisfy the conditions detailed in the following table. In applications that go beyond the scope of these conditions, however, models can be produced that satisfy special specifications.

Ambient conditions			Standard products	Special products for tropical, humid, or extremely cold locations
Temperature	Operating condition	Without enclosure *3	−5 to +55°C	−50 to +55°C *1 (−25 to +55°C)
		With enclosure	−5 to +40°C	−50 to +40°C *1 (−25 to +40°C)
	Transport Storage		−40 to +65°C	−60 to +65°C *2 (−40 to +65°C)
Relative humidity			85% max.	95% max.

Notes:
- These conditions are based on the assumption that there is no icing or condensation due to sudden changes in temperature.
- The figures in parentheses apply to models SC-N1/SE to SC-N4/SE and model SC-N5 and over.

*1: The lower limit is −10°C for thermal overload relays.
*2: The lower limit is −40°C for thermal overload relays.
*3: The temperature inside the panel is given.

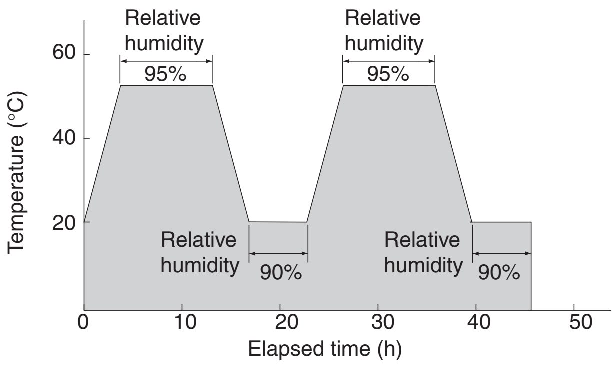
3-2-3 High temperature and humidity test

Although it is desirable for contactors and starters to be used under normal operating conditions, in practice there are situations where it is difficult to maintain these conditions. For this reason, tests are performed under the following conditions.

(1) Temperature and humidity test

Testing is performed under the conditions shown in the following graph. It is confirmed that there are no problems caused by rust, deterioration in insulation, or deformation of molded items, and that there is no adverse effect on performance.

Fig. 2 Temperature and humidity test conditions



(2) Salt spray test

The salt spray test is often used as a method of evaluating the environment-resistance of a contactor. Testing is performed under the conditions given in the following table. It is confirmed that there are no changes in operation before and after the salt spray test.

Salt spray test conditions (JIS Z 2371)

Water	Distilled water
Salt	Sodium chloride
Temperature	35°C
pH value at 35°C	6.5 to 7.2
Volume of salt water sprayed over 1h across an area of $80cm^2$	1 to 2ml
Spraying time	48h
Cleaning method for tested item	Washing (at room temperature)

3-2-4 Protective structure for special environments

(1) Dust

When using contactors and starters at locations subject to particularly large amounts of dust, such as cement factories, spinning factories, or construction sites, either use a control panel of a dust-proof construction or use a contactor or starter with an enclosure that has dust-proof specifications (SC-☐LG or SW-☐LG models). If dust adheres to the contacts, the contact resistance will increase, and there will be an abnormal temperature rise in contactor parts, resulting in the deterioration of insulation and a reduction in electrical durability. In addition, dust may accumulate at insulated parts, resulting in decreased insulation and possibly leading to a short-circuit. Also, if dust builds up between the contacting surfaces of an AC-operated magnetic armature, it may result in incomplete magnetic attraction and lead to problems in operation.

(2) Corrosive gases

When using contactors or starters at locations subject to particularly large amounts of corrosive gas, such as chemical factories, refineries, or sewage plants, it is generally desirable to consider protection together with a protective structure for the panel. Protection against mild corrosive gases can be provided by using plating with a high resistance to corrosive gases at weak points. There is no effective method, however, for protecting the silver contact material and there is a limit to the degree of protection possible when the product is used by itself. Furthermore, contactors and starters that can be used in environments subject to mild corrosive gases can be made on request. Select a product suitable for the application environment. The lower the humidity and temperature are, the slower the rate of metal corrosion will be, even in environments subject to corrosive gases, and so raising the pressure inside the panel and feeding in clean air (i.e., air purging) is effective in preventing corrosion.

The relationship between humidity/temperature and the rate of metal corrosion is shown in the following graphs.

Fig. 3 Relationship between humidity and the occurrence of rust

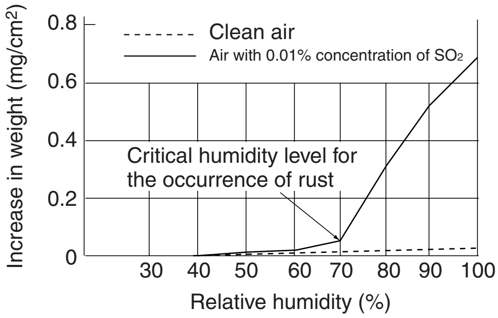
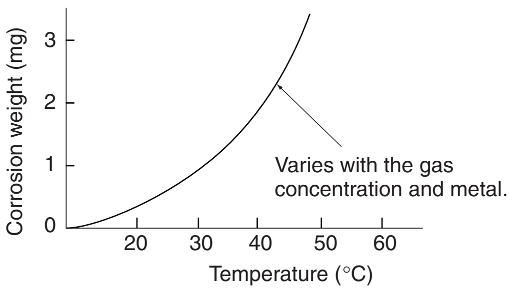


Fig. 4 Relationship between temperature and the occurrence of rust



Examples of environments with corrosive gases

Gas type	Concentration (ppm)		Environment example	Type of metal affected and nature of effect
	Normal	Abnormal		
Hydrogen sulfide gas (H_2S)	0.02 max.	0.07 min.	Thermal regions Near iron/copper blast furnaces Sewage plants Paper, pulp, and rayon factories	Ag: Blackening Cu: Blackening, corrosion
Sulfurous acid gas (SO_2)	0.04 max.	0.07 min.	Near iron/copper blast furnaces Chemical factories	Ni: Blackening Fe: Red rust, corrosion Zn: White rust, corrosion Cu: Blackening Corrosion is unlikely to occur, however, if the relative humidity is less than 65%.
Chlorine gas (Cl_2)	0.02 max.	0.05 min.	Water purification plants Swimming-pool sterilization rooms Chemical factories	Sn: Blackening, corrosion Cr: Blackening, corrosion
Nitrous acid gas (NO_2)	0.04 max.	0.5 min.	Urban areas Chemical factories	Fe: Red rust, corrosion Zn: White rust, corrosion Corrosion is unlikely to occur, however, if the relative humidity is less than 65%.
Ammonia gas (NH_3)	0.01 max.	5 min.	Chemical factories	Brass: Stress corrosion cracking

Resistance of metals to corrosive gases

Material	H_2S	SO_2	Cl_2	NO_2	NH_3
Silver	Poor	Average	Average	Average	Good
Copper	Poor	Average	Poor	Average	Good
Nickel	Average	Poor	Poor	Average	Good
Chrome	Average	Average	Average	Average	Good
Tin	Good	Good	Good	Good	Good
SUS304	Excellent	Good	Poor	Excellent	Excellent
Brass	Poor	Average	Poor	Average	Poor
White metal	Average	Good	Poor	Poor	Good

(3) Products for other types of special environment

Products for the following types of special environment can be made on request.

(a) Products using zinc-plated cores

These products are suitable for locations with humidity levels approaching 100% (plastic greenhouses, kitchens, and outdoor panels) and locations where chlorine gas is present, such as electrical installations at water purification plants.

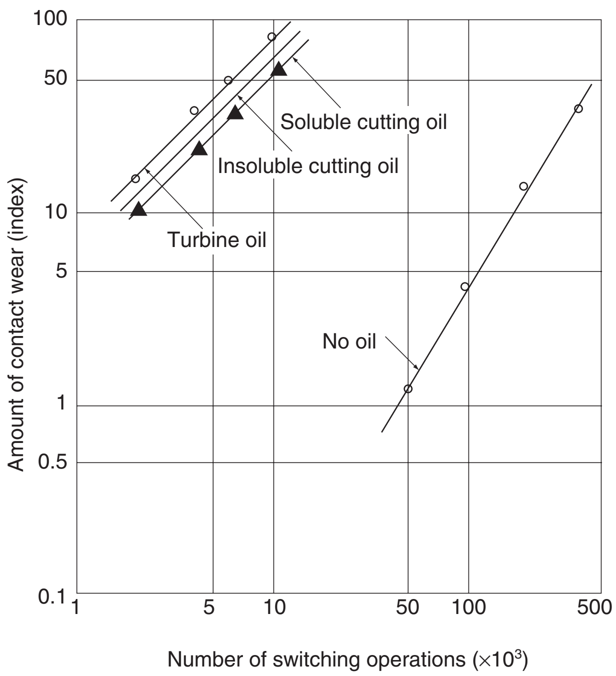
(b) Ammonia-free products

These products are suitable for environments with a high-degree of sealing and a relatively high temperature and humidity level (e.g., control panels for car-washing equipment and explosion-proof boards for coal mines).

3-2-5 Oil mist

When using machine tools, for example, there are occasions when cutting oil forms an oil mist and adheres to the contacting surfaces in contactors and starters in the control panel. Although contact failure is unlikely in environments subject to oil mist, oil decomposition due to switching arcs can lead to the release of large amounts of hydrogen gas, which will accelerate wear and tear in the contacts. The amount of wear in contacts with oil present is approximately 10 to 100 times that of contacts without oil present. Therefore, it is desirable to provide a protective structure to prevent oil mist entering the panel interior.

Fig. 5 Comparison of the amount of wear in contacts with and without oil present



- Tested product: SC-5-1
  Product without oil
  Product with oil: Before the test and with 1,000 switching operations, 1.5μl of oil is applied to all contacts.
- Test conditions: 3ø, 200V, 3.7kW
  AC-3 load
  1,200 operations per hour
- Amount of contact wear: Total amount of wear for 3 phases

3-2-6 High altitudes

When using contactors and starters at high altitudes, the dielectric strength and cooling coefficient are reduced because of the lower air density and so it is necessary to correct the ratings in the way shown below.

(1) Criteria for using at high altitudes

The values for the rated insulation voltage and the rated continuous current of contactors and starters used at high altitudes are reduced by the correction coefficients (shown below) specified by ANSI, IEC, BS, and EN standards.

Rating correction coefficients for altitudes exceeding 1,000m

Altitude (m)	ANSI C37.30-1971			IEC 60282-1, BS, EN60282-1			
	Rated insulation voltage	Rated continuous current	Ambient temperature	Voltage of dielectric strength test	Rated insulation voltage	Rated continuous current	Temperature rise
1000	1.00	1.00	1.00	1.0	1.0	1.0	1.0
1200	0.98	0.995	0.992	1.0 to 1.05 proportional	1.0 to 0.95 proportional	1.0 to 0.99 proportional	1.0 to 0.98 proportional
1500	0.95	0.99	0.980	1.05	0.95	0.99	0.98
1800	0.92	0.985	0.968	1.05 to 1.25 proportional	0.95 to 0.8, proportional	0.99 to 0.96 proportional	0.98 to 0.92 proportional
2100	0.89	0.98	0.956				
2400	0.86	0.97	0.944				
2700	0.83	0.965	0.932				
3000	0.80	0.96	0.920	1.25	0.8	0.96	0.92
3600	0.75	0.95	0.896	–	–	–	–
4200	0.70	0.935	0.872	–	–	–	–
4800	0.65	0.925	0.848	–	–	–	–
5400	0.61	0.91	0.824	–	–	–	–
6000	0.56	0.90	0.800	–	–	–	–

Notes:
- Because the normal operating conditions for starters apply at 2,000m, use the above correction coefficients to correct the ratings for starters used above 2,000m.
- It is sufficient to reduce either the rated continuous current or the ambient temperature (i.e., not both).
- ANSI C37.30: American National Standard Definitions and Requirements for High-voltage Air Switches, Insulators, and Bus Supports
  BS, EN 60282-1: High voltage fuses Part 1. Current-limiting fuses
  IEC 60282-1: High voltage fuses Part 1. Current-limiting fuses

(2) Countermeasures for decreased ambient temperature

In general, temperatures are lower at higher altitude, so use products with specifications for extremely cold locations as appropriate.

Chapter 4

Application and Selection

CONTENTS

4-1 Applications to motors

4-2 Load applications

4-3 Protection of motors

4-1 Applications to motors

Magnetic motor starters and contactors are basically designed for use in making and breaking motor loads. It is necessary to understand the performance characteristics of contactors, power supplies and loads in order to select the most suitable contactor for the load. Selection considerations are described in the following.

4-1-1 Starting of squirrel-cage motors

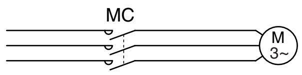
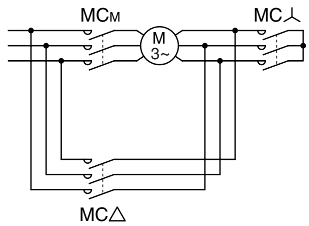
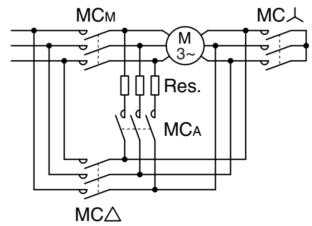
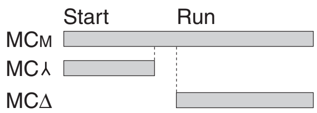
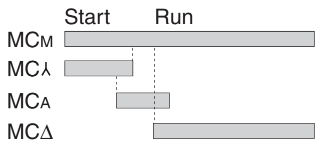
The typical starting method for squirrel-cage motors is full voltage starting, i.e., direct-on-line starting.
However, a starting current having a magnitude 5 to 6 times the motor full load current may flow in the circuit at the time of starting.
If the power supply has insufficient capacity, or if the power cable is installed over a long distance and/or has a small cross-sectional area, there will be a large voltage drop due to the starting current, which may cause contactors or other equipment on the same power system to erroneously operate.
As a rule, it is recommended to employ the star-delta or reduced voltage starting method for motors having a rating of 5.5kW and above, in order to avoid a large starting current.
Typical starting methods for 3-phase squirrel-cage motors are as follows:

1. Full voltage starting............... Direct-on-line starting
2. Reduced voltage starting ...... Star-delta starting
   Reactor starting
   Autotransformer starting

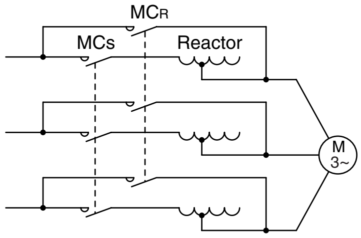
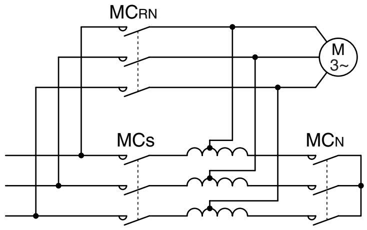
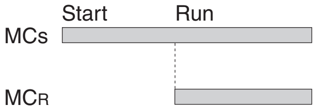
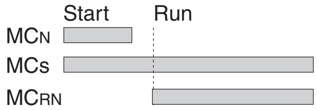
(1) Comparison of different starting methods

Two systems are available for the starting of low voltage squirrel-cage motors: full voltage starting and reduced voltage starting.
Reduced voltage starting is further divided into star-delta starting, reactor starting and autotransformer starting. Each method of starting has both advantages and disadvantages.

When selecting a starting method, care must be given to establishing a suitable relation between the power supply capacity, permissible starting current, load torque and starting torque, accelerating torque and starting time. The major differences between these starting methods are shown in the table below.

Type of starting	Full voltage starting	Reduced voltage starting	
		Star-delta starting	Star-delta starting (Closed transitional system)
Circuit			
Operational timing diagram			
Arrangement	The full voltage is applied to the motor at the time of starting. This is the most popular starting method.	The motor is started in star connection, then switched over to delta connection for running. The starting current and starting torque are reduced to 1/3 (33.3%) those of full voltage starting.	The motor remains connected to the power supply even at the time of change-over from star to delta connection.
Advantage	• Since starting torque is large, can be carried out under full load conditions. • Accelerating torque is large. • Starting time duration is short. • The most economical among all starting methods.	• The voltage drop at the time of starting is reduced. • The most economical method of reduced voltage starting.	• Starting current can be lowered. • As transient inrush current can be restricted to a minimum at the time of change-over from star to delta connection, both mistrip of MCCB's and related troubles such as contact welding can be prevented.
Disadvantage	• Since the starting current is large, high voltage drop is to be expected. • As the starting current and starting torque are large at the time of starting, the power supply or load will be subject to shocks.	• The starting torque and accelerating torque are small. • Since the motor is open-circuited when changing over from star connection to delta connection, a large shock can be expected to be given to the power supply or load. • Both the starting current and the starting torque cannot be adjusted.	• Price is higher than those of standard type star-delta starters. • The starting torque is small.
Starting performance as a percent of full voltage			
Voltage at motor terminal	100%	57.7%	57.7%
Starting current	100%	33.3%	33.3%
Starting torque	100%	33.3%	33.3%
Application	When the capacity of the power supply is large enough to permit full load starting, this is the most economical method of starting.	• Motors with a rating of over 5.5kW which start under no-load or light load conditions. • Machinery and loading-unloading equipment with a clutch.	• Motors having a rating of over 5.5kW which start under no-load or light load conditions. • Where it is desired to restrict inrush current to a minimum at the time of change-over from star to delta connection.

4-1 Applications to motors

Type of starting	Reduced voltage starting	
	Reactor starting	Autotransformer starting
Circuit		
Operational timing diagram		
Arrangement	The motor starts with the voltage reduced by the insertion of reactors on the primary side.	The full voltage is applied to the motor after acceleration following starting under autotransformer-reduced voltage.
Advantage	• The starting current and the starting torque can be adjusted by selecting a suitable tap. • The accelerating torque increases rapidly, providing smooth acceleration. • Since this is a closed circuit transition starting method, the change-over from starting to running occurs smoothly.	• Starting current is the least among all reduced voltage starting methods. • Inrush current at the time of change-over is small. • The accelerating torque increase slightly together with the speed. The maximum torque is less than that with the reactor starting method.
Disadvantage	• More expensive than star-delta starting. • Increase in torque is comparatively small. • The starting torque is small.	• Ratio of the reduction of starting current is larger than that of the reduction of starting torque.
Starting performance as a percent of full voltage		
Voltage at motor terminal	50–65–80% (taps 50–65–80%)	50–65–80% (taps 50–65–80%)
Starting current	50–65–80% (taps 50–65–80%)	25–42.2–64% (taps 50–65–80%)
Starting torque	25–42.2–64% (taps 50–65–80%)	25–42.2–64% (taps 50–65–80%)
Application	Loads requiring a large starting torque.	• Where starting current must be reduced. • Where high starting efficiency is required.

(2) Basic criteria for selection

(a) Starting contactor selection points

In order to select the most cost-efficient contactors for your purposes, the following points should be taken into consideration:

• Making and breaking current capacity

The relationship between the motor full load current and the starting current will vary with the starting method chosen. Starting current when using a reduced voltage starting method is less than that with a full voltage method. For example, star-delta starting results in only one-third the starting current generated by full voltage starting. Thus it is possible to use contactors of the AC-3 category that provide a higher motor rating.

• Operation cycles and temperature rise

General purpose contactors are designed to operate up to 1200 to 1800 times per hour.
In practice, such a high frequency of on-off operation is unlikely to be carried out. Moreover, in the case of reduced voltage starting, current flows through the starting contactors for only a short period of time, provided the motor starts normally. Therefore, if it is to be used infrequently, a contactor having a lower rating than one for continuous use may be selected.

• Mechanical and electrical durability

Where contactors operate under normal conditions, and are not used for inching or plugging operations, it is unlikely that they will exceed a million operations during their service lifetime.
Inching and plugging are not often performed when the application warrants reduced voltage starting.

On the other hand, hoist and crane motors are often involved in inching and plugging, so contactors used for these kinds of applications require a durability greater than a million operations.
Therefore, operating conditions and expected frequency of operation must be taken into consideration when selecting contactors.

(b) Precautions to be taken when selecting contactors for motor running

Torque is proportional to the second power of the voltage. In the case of reduced voltage starting, the starting torque is less than that of full voltage starting.
The full voltage is applied to the motor only after it has accelerated to close to its final running speed; at starting time the motor must be under little or no load.
If starting torque is inadequate–for example if a voltage drop reduces the voltage too low, or if the motor is erroneously started under full load–the motor will not start, or will start but fail to reach normal running speed during the acceleration phase. If the motor does not begin to move (locked-rotor condition) a current of the same magnitude as the starting current will continue to flow through it. If it starts but does not accelerate to full speed, a current of almost the same magnitude as the starting current will continue to flow through it.

Even if the motor has failed to start or to reach full speed, it will still be changed over to full load mode after the pre-set time elapses, allowing full voltage to be applied.
Therefore, even when a reduced voltage starting method is used, the motor running contactor may make a current having the same magnitude as the starting current under full voltage starting.
If the motor is under locked-rotor condition, after the full voltage has been applied, the overload relay will operate, causing the contactor to break the locked-rotor current. For these reasons, contactors for motor running circuits should have AC-3 category making and breaking capacities.

(c) Making and breaking capacities of contactors for motor starting

Category AC-3 contactors have a making capacity of 10 times and breaking capacity of 8 times the rated operational current. Since the starting current of a squirrel-cage motor is, as a rule, 5 to 6 times the full load current, such a contactor will have a safety factor of 1.67 times ($10 \div 6 = 1.67$) the starting current in its making capacity. Therefore, even in the case of reduced voltage starting, it is necessary for motor starting contactors to have a making capacity of 1.67 times the starting current under reduced voltage starting conditions.

(d) Breaking capacity of motor starting contactors in normal running

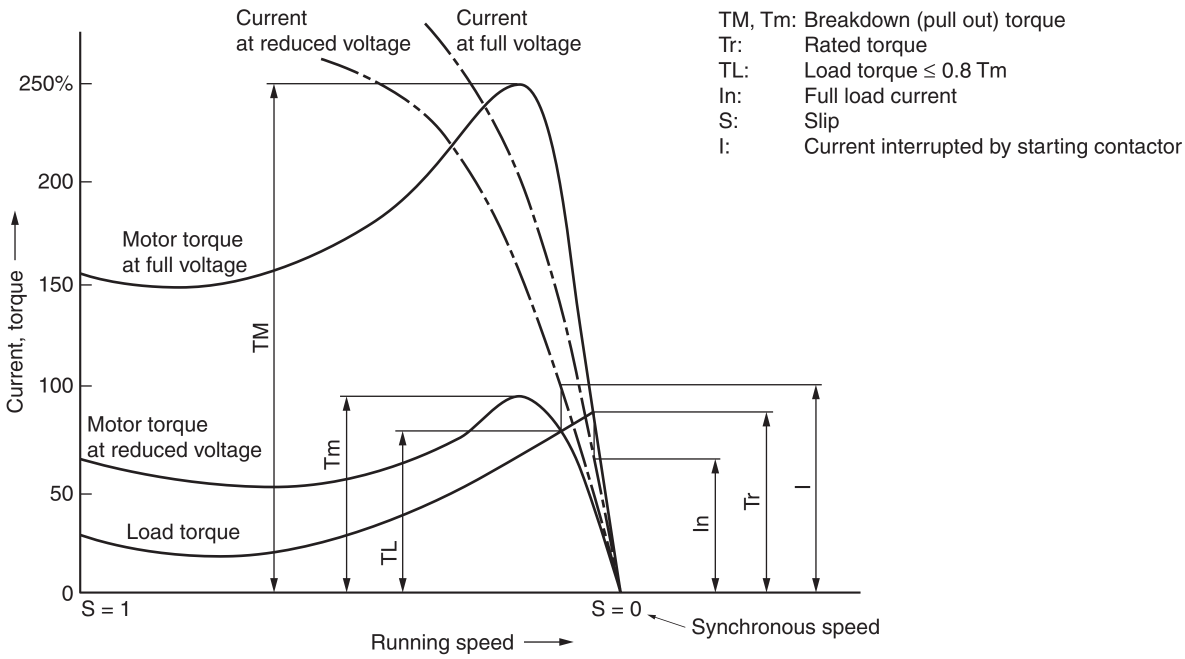
When a reduced voltage starting method is applied, the current interrupted by the contactors when changing over from starting to full voltage is assumed to be as follows:

1) A current corresponding to a load torque equal to 80% of the maximum motor torque at reduced voltage, or
2) If load torque is greater than motor rated torque, a current corresponding to the motor rated torque at reduced voltage. (Refer to “Motor current and torque characteristics” on page 60.)

Contactors can be selected with reference to the following table (page 60) of making and breaking current values.

4-1 Applications to motors

Fig. 1 Motor current and torque characteristics



Starting method and contactor		Taps (a%)	Contactor rated operational current (Multiple of motor full load current)	Contactor making current (Multiple of motor full load current)	Contactor breaking current (Multiple of motor full load current)	Contactor continuous current	
						Multiple of motor full load current	Time
Direct-on-line starting	MC	–	1In	6In	1In	1In	Continuous
Star-delta starting	MCλ	–	0.35In	2In	0.7In	2In	Short time
	MCΔ	–	0.6In	1.2In	0.6In	0.6In	Continuous
	MCA	–	*	*	*	*	Short time
	MCM	–	0.6In	1.2In	0.6In	0.6In	Continuous
Autotransformer starting	MCs	a=50	0.6In	1.5In	–	1.5In	Short time
	MCs	a=65	0.6In	2.6In	–	2.6In	Short time
	MCs	a=80	0.6In	3.9In	–	3.9In	Short time
	MCN	a=50	0.25In	–	0.5In	1.5In	Short time
	MCN	a=65	0.25In	–	0.46In	1.4In	Short time
	MCN	a=80	0.25In	–	0.25In	0.95In	Short time
	MCRN	a=50	1In	2.4In	1In	1In	Continuous
	MCRN	a=65	1In	2.4In	1In	1In	Continuous
	MCRN	a=80	1In	1.6In	1In	1In	Continuous
Reactor starting	MCs	a=50	0.8In	3In	–	3In	Short time
	MCs	a=65	0.8In	3.9In	–	3.9In	Short time
	MCs	a=80	0.8In	4.8In	–	4.8In	Short time
	MCRN	a=50	1In	1In	1In	1In	Continuous
	MCRN	a=65	1In	1.4In	1In	1In	Continuous
	MCRN	a=80	1In	1.25In	1In	1In	Continuous

Note: * Contactor ratings depend on resistor capacity and current carrying time.

(3) Selecting a starting system by taking voltage variation into consideration

In order to reduce adverse load influence on the power system, a starting system should be selected that restricts voltage variation within the allowable limits. Fig. 3 below, illustrating the voltage variation curves of various starting methods, can be used to help select an appropriate system.
When using these curves, please note the following assumptions.

a) The main circuit should be as shown in Fig. 2, i.e., the motor is loaded on a transformer.
b) For percent impedance, only reactance is taken into consideration.
c) Starting power factor is 0 ($\cos\phi_s = 0$).
d) The motor starting current is 6 times the full load current. As for the power factor ($\cos\phi_s$) and efficiency (η) at rated operation, $\cos\phi_s \times \eta = 0.7$.
e) Main circuit cable impedance is ignored.

Example of use

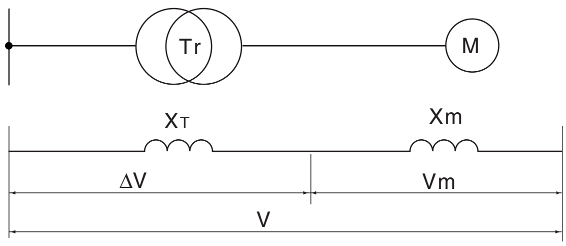
Suppose the following conditions hold for the main circuit:
a) Motor output capacity (Pm) = 45kW
b) Transformer capacity (Pt) = 150kVA
c) Transformer percent impedance ($\%X_T$) = 4%
d) Allowable voltage variation factor (ΔV) ≤ 5%

Method

a) The ratio (Kt) of Pt to Pm is Kt = Pt/Pm = 3.3
b) Select the point on the x axis corresponding to the allowable voltage variation factor (5% in this case). Since the percent impedance is 4%, select the point on the y axis corresponding to Kt (3.3) on the 4% impedance scale. Draw lines through the selected points, perpendicular to the axes, so that they intersect at point A.
c) When a vertical line is dropped from point A to the x axis, it passes through the curves of all the applicable starting methods. In this example, star-delta starting, reactor starting (50 tap) and autotransformer starting (50, 65% taps) can be used.
d) The required interrupting capacity of the circuit breaker can be obtained as follows.

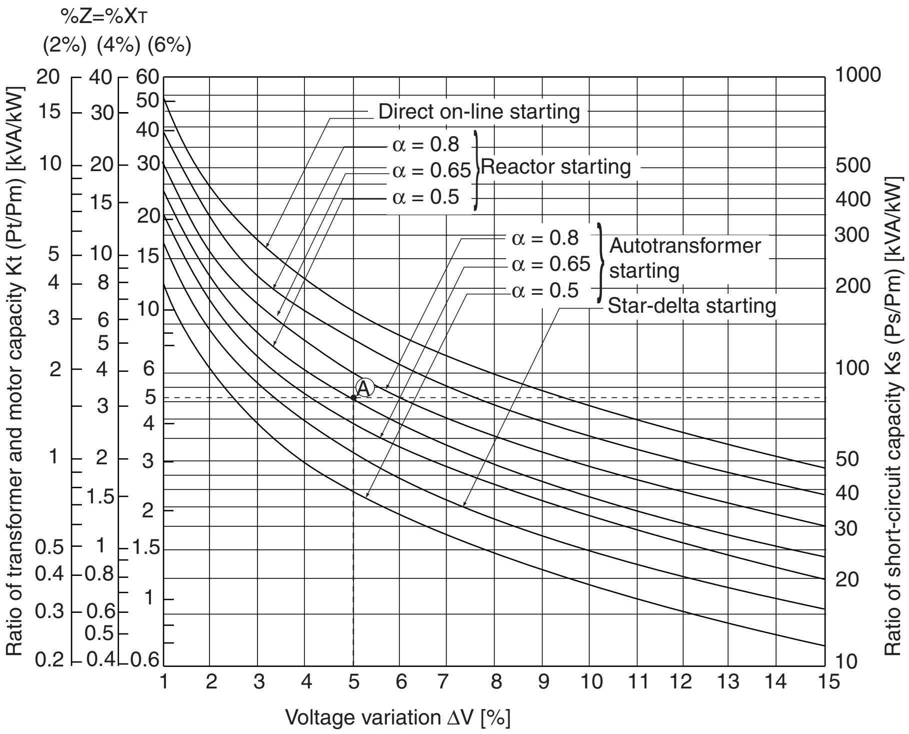
Interrupting capacity = Ks (point of intersection with the scale at right) x Pm
= 83 x Pm (kW)

Fig. 2 Main circuit and its equivalent circuit



Pt: Transformer capacity
Vm: Transformer secondary voltage
$\%Z = \%X_T$ (Percent impedance)
Ps: Short-circuit capacity at secondary side
Pm: Motor output capacity
V: Rated voltage
In: Full load current
n•In = Starting current
Starting impedance = Starting reactance = Xm
Starting power factor $\cos\phi_s = 0$

Fig. 3 Voltage variation and short-circuit capacity of various starting methods



4-1-2 Breaking current and electrical durability

(1) Breaking current and electrical durability curves/AC-3 duty

Fig. 4 SC-03 to 5-1

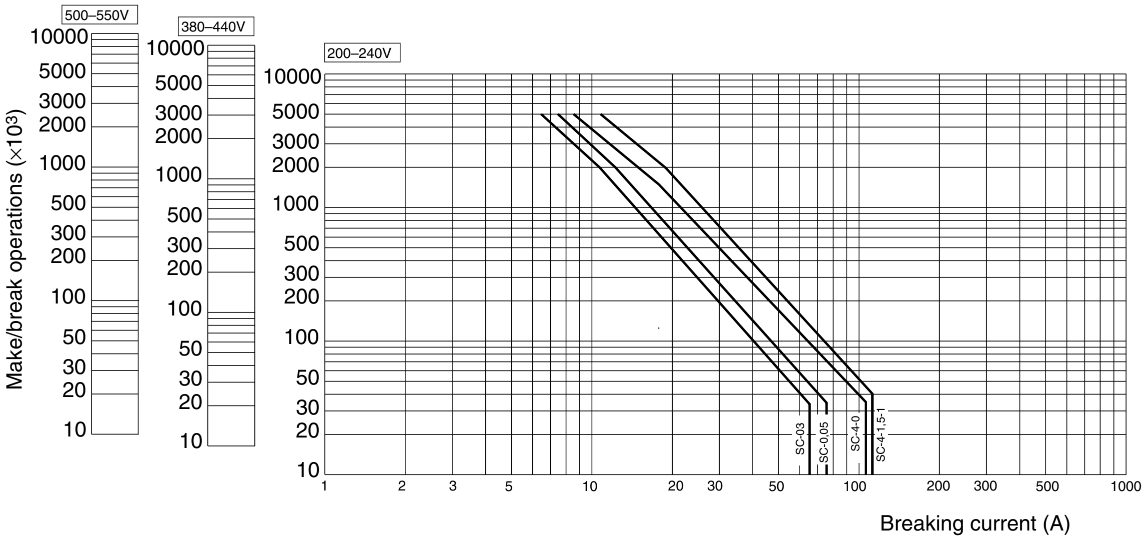
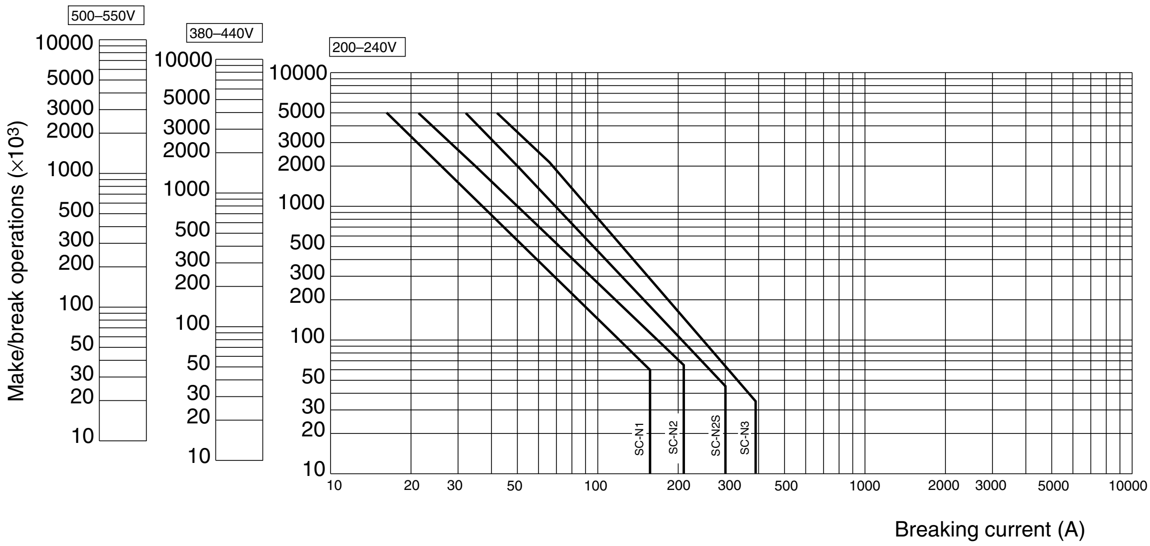
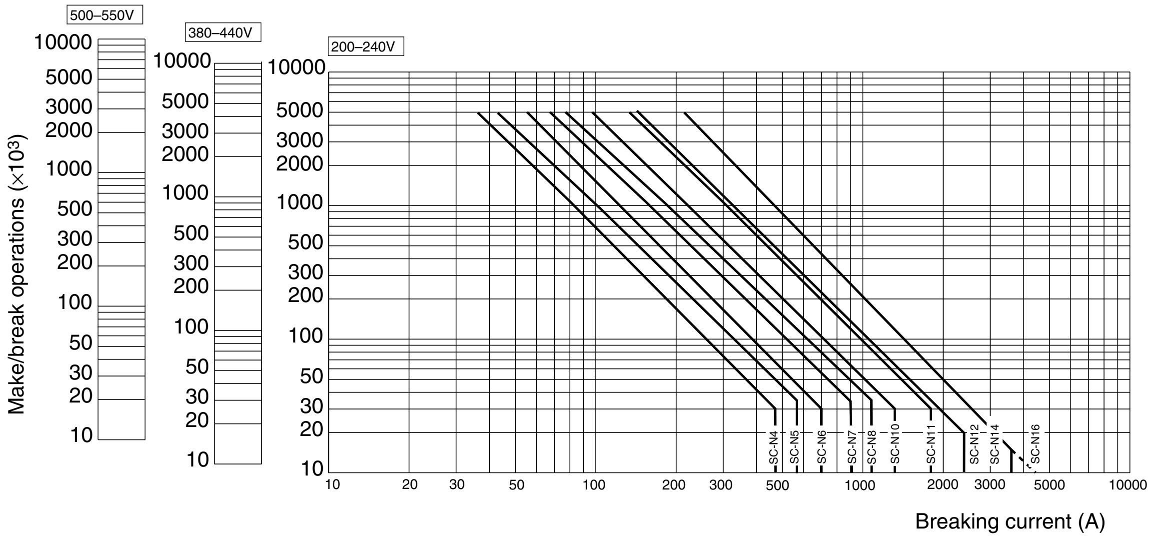


Fig. 5 SC-N1 to N3



Note: Currents above the rated operating current are for inching and plugging applications.

Fig. 6 SC-N4 to N16



Note: Currents above the rated operating current are for inching and plugging applications.

(2) Inching operations and electrical durability

Contact life is approximately inversely proportional to the magnitude of breaking current.
Therefore, where inching operations are carried out, contact life will be greatly reduced.
When normal and inching operations are combined, contact life, X can be calculated by the following formula.

$$X = \frac{A}{1+\frac{C}{100}\left(\frac{A}{B}-1\right)}$$

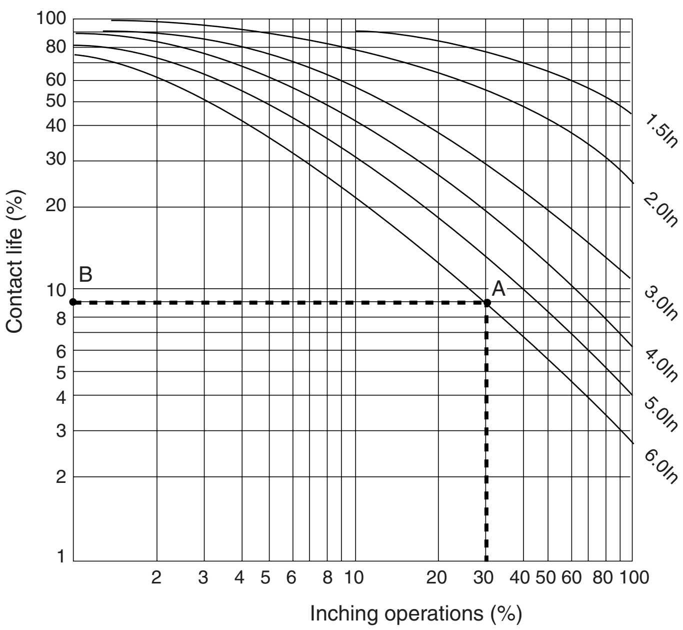
Where,

A: Contact life when normal operations are carried out
B: Contact life when only inching operations are carried out
C: Inching ratio (%)

$$= \frac{\text{No. of inching operations}}{\text{Total No. of switching operations}} \times 100\%$$

Fig. 7 shows contact life curves calculated by this formula. Contact life can easily be determined by referring to the graph below. For example, when an SC-0 contactor is used for a motor whose full load current is 10A, the starting current is six times the full load current, and 30% of all on/off operations are inching operations, then contact life is calculated as follows:
From Fig. 4 the electrical durability of an SC-0 contactor is approximately 3 million operations (3×10^6) when breaking the full load current of 10A at 220VAC.
In Fig. 7 draw a vertical line from the point on the x axis corresponding to the 30% inching ratio so that it intersects the 6.0In curve at point A. Then draw a line through A, parallel to the x axis, intersecting the y axis at point B. The y axis scale has been established assuming contact life is 100% when the inching ratio is 0%. Therefore, in this example, an inching operation ratio of 30% reduces contact life to 9% of what it would be under normal operational use. The electrical durability of the SC-0 contactor would be only $(3\times10^6)\times0.09 = 0.27\times10^6$ on/off operations.

Fig. 7



4-1-3 Direct-on-line starting

(1) Description

In the direct-on-line starting method, the full voltage is applied directly to the motor as soon as the switch is engaged. Since this type of starter is inexpensive to install and easy to operate, this starting method is frequently used for squirrel-cage motors with small ratings.
Category AC-3 contactors are suitable for this purpose. However, since a high current flows on starting, it is necessary that special attention be paid to prevent abrupt voltage drop due to insufficient power supply capacity and excessively long main circuit wiring.
In addition, during inching and plugging operations, the contactor opens and closes with currents Ip and Is as shown in Fig. 9, which will reduce the electrical durability.

Fig. 8 Wiring diagram of direct-on-line starting

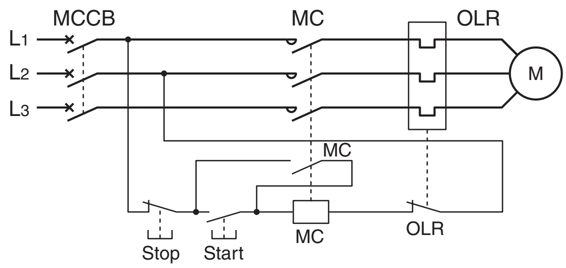
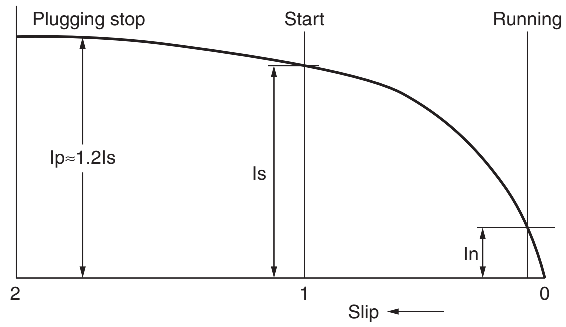


Fig. 9 A current when inching and plugging operations are carried out



(2) Contactors for direct-on-line starting (AC-3)

(a) Applications where the electrical durability is taken into consideration

Main circuit voltage	Motor rating		Electrical durability				
	Output (kW)	Max. full load current (A)	$1,000 \times 10^3$ operations	$2,000 \times 10^3$ operations	$3,000 \times 10^3$ operations	$4,000 \times 10^3$ operations	$5,000 \times 10^3$ operations
200–240V	1.5	6.6	SC-03	SC-03	SC-03	SC-03	SC-03
	2.5	11	SC-03	SC-03	SC-4-0	SC-4-1, 5-1	SC-4-1, 5-1
	3.5	13	SC-03	SC-0, 05	SC-4-1, 5-1	SC-4-1, 5-1	SC-N1
	4.5	18	SC-4-0	SC-4-1, 5-1	SC-N1	SC-N1	SC-N2
	5.5	22	SC-4-0	SC-N1	SC-N2	SC-N2	SC-N2
	7.5	32	SC-N1	SC-N2	SC-N2S	SC-N2S	SC-N2S
	11	40	SC-N2	SC-N2S	SC-N2S	SC-N3	SC-N5
	15	50	SC-N2	SC-N2S	SC-N5	SC-N6	SC-N6
	18.5	65	SC-N2S	SC-N3	SC-N6	SC-N7	SC-N7
	22	80	SC-N4	SC-N6	SC-N7	SC-N8	SC-N10
	30	105	SC-N6	SC-N7	SC-N8	SC-N10	SC-N11
	37	125	SC-N6	SC-N8	SC-N10	SC-N11	SC-N11
	45	150	SC-N7	SC-N10	SC-N11	SC-N11	SC-N14
	55	180	SC-N8	SC-N11	SC-N12	SC-N14	SC-N14
	65	220	SC-N10	SC-N11	SC-N14	SC-N14	SC-N14
	90	300	SC-N11	SC-N14	–	–	–
	120	400	SC-N14	–	–	–	–
380–440V	4	9	SC-03	SC-0, 05	SC-4-1, 5-1	SC-4-1, 5-1	SC-N1
	5.5	12	SC-03	SC-4-0	SC-4-1, 5-1	SC-N1	SC-N1
	7.5	16	SC-4-0	SC-N1	SC-N1	SC-N1	SC-N1
	11	22	SC-4-1, 5-1	SC-N1	SC-N2	SC-N2	SC-N2S
	15	32	SC-N1	SC-N2	SC-N2S	SC-N2S	SC-N3
	18.5	40	SC-N2	SC-N2S	SC-N4	SC-N5	SC-N5
	22	50	SC-N2S	SC-N3	SC-N5	SC-N6	SC-N6
	30	65	SC-N3	SC-N6	SC-N6	SC-N7	SC-N7
	40	80	SC-N4	SC-N6	SC-N7	SC-N8	SC-N10
	55	105	SC-N6	SC-N7	SC-N10	SC-N10	SC-N11
	60	125	SC-N6	SC-N8	SC-N10	SC-N11	SC-N11
	75	150	SC-N7	SC-N10	SC-N11	SC-N12	SC-N14
	90	180	SC-N8	SC-N11	SC-N12	SC-N14	SC-N14
	110	220	SC-N10	SC-N14	SC-N14	SC-N14	SC-N14
	160	300	SC-N11	SC-N14	–	–	–
	220	400	SC-N14	–	–	–	–

4-1 Applications to motors

(b) Applications where inching and plugging operations are carried out

Main circuit voltage	Motor rating: Output (kW)	Motor rating: Max. full load current (A)	Inching and plugging for 10% operation: Electrical durability 100×10^3 operations	Inching and plugging for 10% operation: Electrical durability 500×10^3 operations	Inching and plugging for 50% operation: Electrical durability 100×10^3 operations	Inching and plugging for 50% operation: Electrical durability 500×10^3 operations	Inching and plugging for 100% operation: Electrical durability 100×10^3 operations	Inching and plugging for 100% operation: Electrical durability 500×10^3 operations
200–240V	0.4	1.8	SC-03	SC-03	SC-03	SC-03	SC-03	SC-03
	0.75	3.3	SC-03	SC-03	SC-03	SC-03	SC-03	SC-03
	1.5	6.6	SC-03	SC-03	SC-03	SC-4-0	SC-03	SC-N1
	2.5	11	SC-03	SC-4-0	SC-4-0	SC-N1	SC-4-1, 5-1	SC-N2
	3.5	13	SC-4-0	SC-4-0	SC-4-0	SC-N2	SC-N1	SC-N2S
	4.5	18	SC-4-0	SC-N1	SC-N1	SC-N2S	SC-N1	SC-N3
	5.5	22	SC-4-1, 5-1	SC-N1	SC-N1	SC-N2S	SC-N1	SC-N5
	7.5	32	SC-N1	SC-N2	SC-N2	SC-N5	SC-N2S	SC-N7
	11	40	SC-N2	SC-N2S	SC-N2S	SC-N7	SC-N4	SC-N7
	15	50	SC-N2S	SC-N3	SC-N3	SC-N7	SC-N5	SC-N10
	18.5	65	SC-N3	SC-N5	SC-N6	SC-N8	SC-N6	SC-N11
	22	80	SC-N4	SC-N6	SC-N6	SC-N11	SC-N7	SC-N14
	30	105	SC-N5	SC-N7	SC-N7	SC-N12	SC-N8	SC-N14
	37	125	SC-N6	SC-N8	SC-N8	SC-N14	SC-N10	–
	45	150	SC-N7	SC-N10	SC-N10	–	SC-N11	–
	55	180	SC-N8	SC-N11	SC-N11	–	SC-N12	–
	65	220	SC-N10	SC-N12	SC-N11	–	SC-N14	–
	90	300	SC-N11	–	SC-N14	–	–	–
	120	400	SC-N12	–	–	–	–	–
380–440V	0.75	1.7	SC-03	SC-03	SC-03	SC-03	SC-03	SC-03
	1.5	3.4	SC-03	SC-03	SC-03	SC-03	SC-03	SC-4-0
	2.5	5.6	SC-03	SC-03	SC-03	SC-4-1, 5-1	SC-0, 05	SC-4-1, 5-1
	3.5	7.8	SC-03	SC-0, 05	SC-0, 05	SC-4-1, 5-1	SC-4-0	SC-N1
	4	9	SC-03	SC-4-0	SC-4-0	SC-N1	SC-4-1, 5-1	SC-N2
	5.5	12	SC-03	SC-4-1, 5-1	SC-4-1, 5-1	SC-N2	SC-4-1, 5-1	SC-N2S
	7.5	16	SC-4-0	SC-4-1, 5-1	SC-4-1, 5-1	SC-N2S	SC-N1	SC-N3
	11	22	SC-N1	SC-N1	SC-N1	SC-N2S	SC-N2	SC-N6
	15	32	SC-N1	SC-N2S	SC-N2	SC-N6	SC-N3	SC-N7
	18.5	40	SC-N2	SC-N4	SC-N2S	SC-N6	SC-N4	SC-N8
	22	50	SC-N2S	SC-N5	SC-N4	SC-N8	SC-N6	SC-N11
	30	65	SC-N3	SC-N6	SC-N6	SC-N10	SC-N7	SC-N11
	40	80	SC-N4	SC-N7	SC-N6	SC-N11	SC-N7	SC-N14
	55	105	SC-N5	SC-N8	SC-N7	SC-N14	SC-N10	SC-N14
	60	125	SC-N6	SC-N10	SC-N8	SC-N14	SC-N11	–
	75	150	SC-N7	SC-N11	SC-N10	–	SC-N11	–
	90	180	SC-N8	SC-N11	SC-N11	–	SC-N14	–
	110	220	SC-N10	SC-N12	SC-N11	–	SC-N14	–
	160	300	SC-N11	–	SC-N14	–	–	–
	220	400	SC-N12	–	–	–	–	–
	315	600	SC-N14	–	–	–	–	–

Note: • The inching ratio (%) = $\frac{\text{Number of inching operations}}{\text{Total number of switching operations}} \times 100$

4-1-4 Star-delta starting

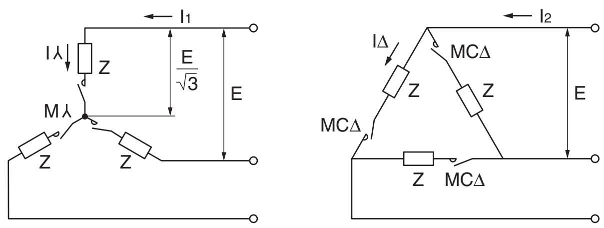
(1) Description

The star-delta starting method is a typical reduced voltage starting method.
A star-delta motor has six leads so that the winding can be switched to either the star or delta connection. The motor is star connected at the time of starting, and when the motor has reached normal speed, the winding is changed over to delta connection.

- At the time of starting with the motor winding connected in star mode, a voltage of $1/\sqrt{3}$ of the line voltage is applied to the motor winding.
  When motor winding impedance = Z, line voltage = E, phase current = $I_\curlywedge$ and line current = I_1,

$$I_\curlywedge = \frac{\frac{1}{\sqrt{3}}E}{Z} = \frac{E}{\sqrt{3}\,Z}\ I_1$$

Fig. 10



- Changing over from star to delta mode after the motor is running. The full voltage E is applied to the motor. Since the impedance of the motor winding is Z,

$$I_\Delta = \frac{E}{Z}$$

  However, the line current I_2 is

$$I_2 = \sqrt{3}\ I_\Delta = \frac{\sqrt{3}\,E}{Z}$$

- Therefore, the ratio of I_1 (the line current in the case of star connection) to I_2 (the line current in the case of delta connection) is

$$\frac{I_2}{I_1} = \frac{\frac{E}{\sqrt{3}\,Z}}{\frac{\sqrt{3}\,E}{Z}} = \frac{1}{3}$$

  Namely the motor draws only one-third of the starting current in star connection that it does in full voltage delta starting.

- When the starting current of a motor is $6 \times In$ (In = full load current of the motor), the starting current in the case of star connection is

$$\frac{1}{3} \times 6 \times In = 2In.$$

  In this case, more than 200% of full load current is not exceeded.

Since the torque is directly proportional to the square of the voltage,

$$\frac{T_\curlywedge}{T_\Delta} = \frac{(E\sqrt{3}\,)^2}{(E)^2} = \frac{1}{3}$$

Accordingly the starting torque and starting current will be 1/3 those of full voltage starting.

(2) Wiring diagrams for automatic star-delta starting

Automatic star-delta starting methods using contactors can be classified as open transition systems and closed transition systems.

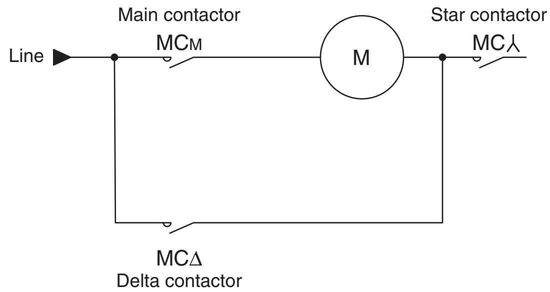
(a) Open transition system

This is a popular connecting method since the circuit is simple and economical.
However, the motor is temporarily disconnected from the power supply when connection is changed over from star to delta, so that a residual voltage is generated within the motor stator winding.
This voltage overlaps the power supply voltage which can be expected to produce a transient inrush current larger than the starting current.

This kind of large inrush current is likely to cause trouble, such as an abnormal voltage drop in an emergency power supply unit, or erroneous tripping of MCCBs protecting against short circuits.

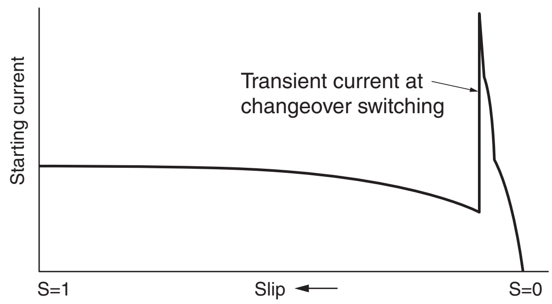
Fig. 11 Open transition system

- 3-contactor type



Contactor	Start	Transition	Run
MCM			
MC ⅄			
MCΔ			

- Speed-current characteristic

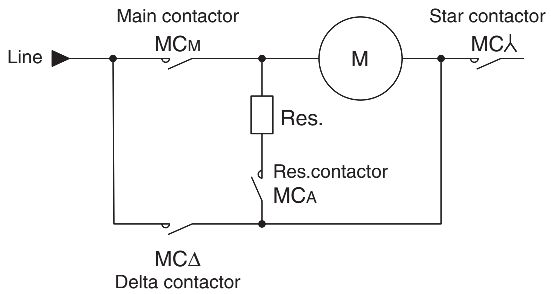


(b) Closed transition system

In this system, resistors and a resistor circuit closing contactor are added to the star-delta starter used in the open transition system.
At the time of change-over, the motor will not be disconnected from the power supply, so restricting any large transient inrush current.
Thus this system prevents erroneous tripping of MCCBs due to transient inrush current.
Moreover since the necessary generator capacity of emergency generating equipment is determined according to the motor's starting kVA, the size and the price of such equipment can obviously be reduced.

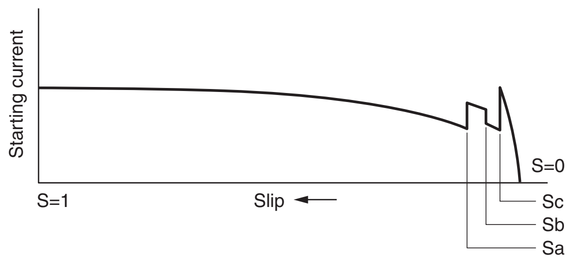
Fig. 12 Closed transition system

- One-line diagram



Contactors	Start	Transition			Run
		Sa	Sb	Sc	
MCM					
MC ⅄					
MCA					
MCΔ					

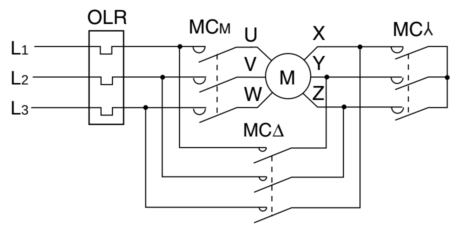
- Speed-current characteristic



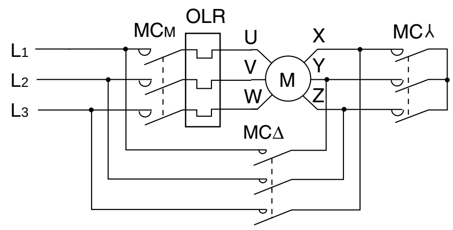
(3) Thermal overload relay

When installing the thermal overload relays, there are two alternative methods, which differ by the location where relays are installed. The choice is between line current detection and phase current detection systems as shown in the diagram below.
In the line current detection system, the heater element of the thermal overload relay is selected to agree with motor full load current, and in the phase current detection system the element is selected to conform with a current having a magnitude of $1/\sqrt{3}$ of the full load current.
The phase current detection system allows use of smaller thermal overload relays than those required by the line current detection system. However, since the wire sizes of the motor circuit are the same in both cases, it is necessary to check if the wires can be connected or not before smaller frame size relays are used.

Fig. 13 Installation of thermal overload relay



(a) Line current detection



(b) Phase current detection

(4) Selection of contactors

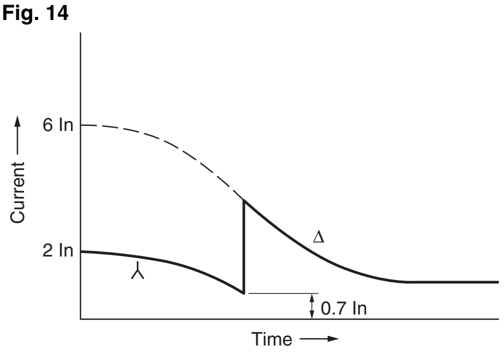
(a) Contactors for star starting use

- The starting current of the motor is twice its full load current.
- A contactor is satisfactory if it can make and break the starting current. The making and breaking capacity of a contactor is

$$10In \times \frac{1}{3} = 3.5In, \text{ where } In = \text{motor full load current.}$$

- An AC-3 class contactor is suitable for star starting use. Since the making capacity of this contactor is 10 times the rated operational current, the rated operational current (Ie) of the contactor for star connection use is
  $Ie = 3.5In/10 = 0.35In.$
- Moreover, when a contactor is used for star starting a short time rating will suffice since it is only required when the motor is started.
  The starting time (ts) of the motor is given by the following formula.
  $$ts = 4+2\sqrt{p} \text{ (sec), where } p = \text{motor (kW)}$$
  However, if the contactor is used repeatedly during the starting time of the motor, it must have an overcurrent capacity of $3\times ts$ (sec) when $p \leq 37kW$, or $2\times ts$ (sec) when $p > 37kW$.
- When changeover from star connection to delta connection occurs, the contactor for star starting breaks the following current.
  $$0.7\times In = 0.7\times\frac{1}{0.3} Ie = 2.5Ie$$
  (In = motor full load current, Ie = contactor rated operational current.)
  Namely, it breaks a current of 2.5 times the rated operational current.
  The electrical durability of the contactor is calculated using this as the breaking current.

Fig. 14



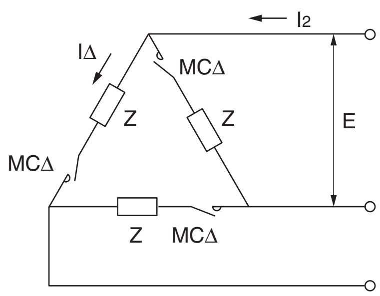
(b) Contactor for delta running use

The contactor connects each phase of the delta connection. The phase current is

$$I\Delta = \frac{1}{\sqrt{3}} In = 0.6In.$$

The contactor for delta running use should be of AC-3 class and its rated operational current should be 0.6 times the full load current of the motor.

Fig. 15

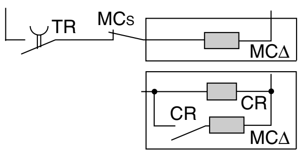


(5) Contactors for star-delta starting

(a) Open transition system

Main circuit voltage	Motor rating		Contactor			Permissible starting time for starting contactor (sec)	Permissible number of repeat starting operations
	Output (kW)	Max. full load current (A)	For star (MC⅄) connection		For main (MCM) and delta (MCΔ) connection		
			Electrical durability				
			500×10³ operations	100×10³ operations			
200–240V	5.5	22	SC-03, 0, 05	SC-03, 0, 05	SC-4-0, 4-1, 5-1	8.7	3
	7.5	32	SC-0, 05	SC-0, 05	SC-4-0, 4-1, 5-1	9.5	3
	11	40	SC-4-0, 4-1, 5-1	SC-4-0, 4-1, 5-1	SC-N1	10.6	3
	15	50	SC-N1	SC-N1	SC-N1	11.7	3
	18.5	65	SC-N1	SC-N1	SC-N2	12.6	3
	22	80	SC-N1	SC-N1	SC-N2S	13.4	3
	30	105	SC-N2S	SC-N2	SC-N3	15.0	3
	37	130	SC-N2S	SC-N2S	SC-N4	16.2	3
	40	135	SC-N2S	SC-N2S	SC-N4	16.6	3
	45	152	SC-N3	SC-N3	SC-N5	17.4	2
	55	180	SC-N3	SC-N3	SC-N6	18.8	2
	60	196	SC-N5	SC-N4	SC-N6	19.5	2
	65	212	SC-N6	SC-N4	SC-N7	20.1	2
	75	254	SC-N7	SC-N5	SC-N8	21.3	2
	90	300	SC-N7	SC-N6	SC-N8	23.0	2
	110	367	SC-N7	SC-N7	SC-N10	25.0	2
	120	400	SC-N10	SC-N8	SC-N11	25.9	2
	160	533	SC-N11	SC-N10	SC-N12	29.3	2
	180	600	SC-N11	SC-N10	SC-N12	30.8	2
	220	800	SC-N14	SC-N11	SC-N14	33.7	2
380–440V	5.5	12	SC-03, 0, 05	SC-03, 0, 05	SC-03, 0, 05	8.7	3
	7.5	16	SC-03, 0, 05	SC-03, 0, 05	SC-4-0, 4-1, 5-1	9.5	3
	11	22	SC-03, 0, 05	SC-03, 0, 05	SC-4-0, 4-1, 5-1	10.6	3
	15	32	SC-4-0, 4-1, 5-1	SC-4-0, 4-1, 5-1	SC-4-1, 5-1	11.7	3
	18.5	40	SC-4-0, 4-1, 5-1	SC-4-0, 4-1, 5-1	SC-N1	12.6	3
	22	50	SC-N1	SC-N1	SC-N1	13.4	3
	30	65	SC-N1	SC-N1	SC-N2	15.0	3
	40	80	SC-N2	SC-N1	SC-N2S	16.6	3
	55	105	SC-N2S	SC-N2	SC-N3	18.8	2
	60	125	SC-N2S	SC-N2S	SC-N4	19.5	2
	75	150	SC-N3	SC-N3	SC-N5	21.3	2
	90	180	SC-N5	SC-N4	SC-N6	23.0	2
	110	220	SC-N6	SC-N4	SC-N7	25.0	2
	160	300	SC-N7	SC-N7	SC-N8	29.3	2
	220	400	SC-N10	SC-N8	SC-N11	33.7	2
	315	600	SC-N12	SC-N11	SC-N12	39.5	2
	440	800	SC-N14	SC-N11	SC-N14	46.0	2

Note: • When applying models SC-03, 0, 05, 4-0, 4-1, 5-1, N1, N2, N2S, and N3 to an MCΔ, use a circuit equipped with a time delay relay.



With time delay relay

(b) Closed transition system

Main circuit voltage	Motor rating		Contactor			Permissible starting time for starting contactor (sec)	Permissible number of repeat starting operations	Starting resistor (per phase)
	Output (kW)	Max. full load current (A)	For star (MC⅄) connection	For main (MCM) and delta (MCΔ) connection	For resistor closing (MCA)			
200–240V	5.5	26	SC-03, 0, 05	SC-4-0, 4-1, 5-1	SC-03, 0, 05	8.7	3	120W 3.6Ω
	7.5	34	SC-03, 0, 05	SC-4-0, 4-1, 5-1	SC-03, 0, 05	9.5	3	120W 2.7Ω
	11	48	SC-4-0, 4-1, 5-1	SC-N1	SC-03, 0, 05	11	3	120W 2.0Ω
	15	65	SC-N1	SC-N2	SC-03, 0, 05	12	3	180W 1.5Ω
	18.5	79	SC-N1	SC-N2S	SC-4-0, 4-1, 5-1	13	3	225W 1.2Ω
	22	93	SC-N1	SC-N3	SC-4-0, 4-1, 5-1	13	3	225W 1.0Ω
	30	124	SC-N2S	SC-N4	SC-4-0, 4-1, 5-1	15	3	300W 0.75Ω
	37	152	SC-N2S	SC-N5	SC-N1	16	3	450W 0.6Ω
	45	180	SC-N4	SC-N6	SC-N2	17	2	450W 0.5Ω
	55	220	SC-N5	SC-N7	SC-N2	19	2	600W 0.4Ω
	75	300	SC-N6	SC-N8	SC-N2S	21	2	2×600W 0.6Ω (2 connected in parallel)
	90	360	SC-N7	SC-N10	SC-N3	23	2	0.26Ω 250A 4s rating
	110	440	SC-N8	SC-N11	SC-N3	25	2	0.21Ω 310A 5s rating
	132	528	SC-N8	SC-N12	SC-N4	27	2	0.18Ω 360A 4s rating
	160	640	SC-N10	SC-N12	SC-N5	29	2	0.16Ω 430A 5s rating
380–440V	5.5	13	SC-03, 0, 05	SC-03, 0, 05	SC-03, 0, 05	8.7	3	80W 15Ω
	7.5	17	SC-03, 0, 05	SC-4-0, 4-1, 5-1	SC-03, 0, 05	9.5	3	80W 10Ω
	11	24	SC-03, 0, 05	SC-4-0, 4-1, 5-1	SC-03, 0, 05	11	3	80W 8Ω
	15	32.5	SC-4-0, 4-1, 5-1	SC-4-1, 5-1	SC-03, 0, 05	12	3	180W 6Ω
	18.5	39.5	SC-4-0, 4-1, 5-1	SC-N1	SC-03, 0, 05	13	3	225W 4.7Ω
	22	46.5	SC-4-0, 4-1, 5-1	SC-N1	SC-4-0, 4-1, 5-1	13	3	225W 4Ω
	30	62	SC-N1	SC-N2S	SC-4-0, 4-1, 5-1	15	3	300W 3Ω
	37	76	SC-N1	SC-N2S	SC-4-0, 4-1, 5-1	16	3	450W 2.4Ω
	45	90	SC-N1	SC-N3	SC-N1	17	2	450W 2Ω
	55	110	SC-N2	SC-N3	SC-N1	19	2	600W 1.6Ω
	75	150	SC-N2S	SC-N5	SC-N1	21	2	2×600W 2.4Ω (2 connected in parallel)
	90	180	SC-N4	SC-N6	SC-N1	23	2	2×600W 2.0Ω (2 connected in parallel)
	110	220	SC-N5	SC-N7	SC-N2	25	2	0.84Ω 150A 5s rating
	132	264	SC-N5	SC-N8	SC-N2S	27	2	0.72Ω 180A 4s rating
	160	320	SC-N7	SC-N10	SC-N2S	29	2	0.6Ω 210A 5s rating

Notes: • When applying models SC-03, 0, 05, 4-0, 4-1, 5-1, N1, N2, N2S, and N3 to an MCΔ, use a circuit equipped with a time delay relay.
• The values for the motor output are based on the values specified in JIS C8201-4-1 and JEM 1038-1990.

- **Selection conditions**

(1) Motor load: For light load starting (e.g., fans and pumps)

(2) Electrical durability: 100,000 operations min.

(3) If the number of repeat starting operations exceeds the figure given in the above table, provide an OFF time of at least 15 minutes.

(4) Selection of the switching current for each starting process was based on a symmetric AC base and 120% max. of the motor star starting current. The following conditions, however, apply to the motor: The motor is a FUJI general-purpose motor or equivalent product and the motor must accelerate to more than 2 times the rated slip after completion of star starting.

4-1-5 Reactor starting

(1) Description

In this method of starting, a reactor is connected in each motor line to produce a voltage drop in the motor starting current. A time delay relay shorts out these reactors after the motor has gained normal speed. Thus the motor starts on a reduced voltage and operates at full voltage.

(2) Selection of contactors

Starting reactors normally have taps of 50–65–80% standard voltage. The voltage applied to motor starting, starting current and starting torque for each tap are as shown in the table on the right. Contactors are selected on the basis of the 80% tap, which results in the largest current, so that they can be applied irrespective of which tap they are connected to. Assuming that the full motor load current is In and the starting current at the time of full voltage starting is 6In, then the starting current will be 4.8In (0.8 × 6In) when 80% tap is used.
Since the making and breaking capacity required for MCs starting contactors is

$$\frac{10}{6} \times 4.8In = 8In,$$

those MCs starting contactors having a rated operational current of 0.8In within the AC-3 category will be suitable.
It is unnecessary to take the electrical durability of these MCs contactors into consideration, since hardly any current flows through the MCs contactor when the MCRN contactor is closed.
The making and breaking capacity required for MCRN running contactors must be within the AC-3 category when starting failure is taken into consideration, and the continuous current capacity must be equal to or exceed the motor full load current.
The overcurrent withstand values for MCs contactors must permit the passing of a current of 4.8In during starting.

Starting characteristics

	Taps 50%	65%	80%
Voltage at motor	50%	65%	80%
Starting current	50%	65%	80%
Starting torque	25%	42.2%	64%

Fig. 16 Circuit diagram (for explanation)

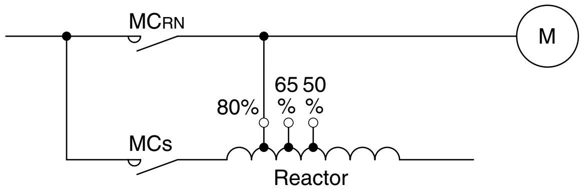
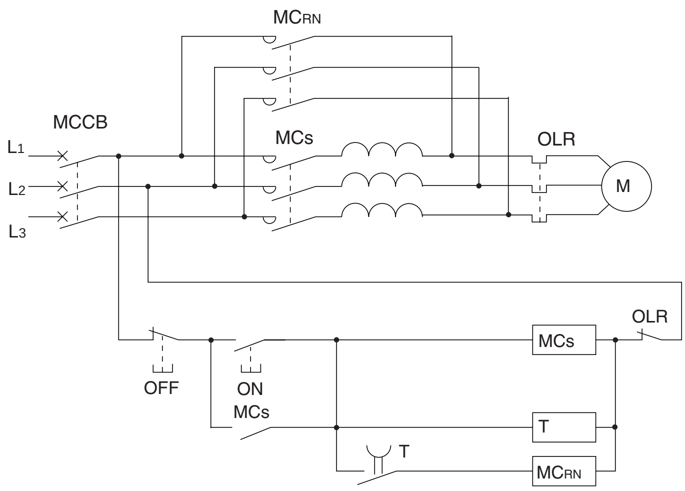


Fig. 17 Wiring diagram



(3) Contactors for reactor starting

Main circuit voltage	Motor rating		Contactor		Permissible starting time for starting contactor ts (s)	Permissible number of repeat starting operations
	Output (kW)	Max. full load current (A)	For running (MCRN)	For starting (MCs)		
200–240V	2.5	11	SC-0, 05	SC-03	7.2	3
	3.5	13	SC-0, 05	SC-03	7.7	3
	4.5	18	SC-4-0	SC-4-0	8.2	3
	5.5	22	SC-4-1, 5-1	SC-4-1, 5-1	8.7	3
	7.5	32	SC-N1	SC-N1	9.5	3
	11	40	SC-N2	SC-N1	10.6	3
	15	50	SC-N2S	SC-N2	11.7	3
	18.5	65	SC-N3	SC-N3	12.6	3
	22	80	SC-N4	SC-N4	13.4	3
	30	105	SC-N5	SC-N5	15.0	3
	37	125	SC-N6	SC-N6	16.2	3
	45	150	SC-N7	SC-N6	17.4	2
	55	180	SC-N8	SC-N7	18.8	2
	65	220	SC-N10	SC-N8	20.1	2
	90	300	SC-N11	SC-N11	23.0	2
	120	400	SC-N12	SC-N12	25.9	2
	180	600	SC-N14	SC-N14	30.8	2
	220	800	SC-N16	SC-N16	33.7	2
380–440V	2.5	5.6	SC-03	SC-03	7.2	3
	3.5	7.8	SC-03	SC-03	7.7	3
	4	9	SC-03	SC-03	8.0	3
	5.5	12	SC-0, 05	SC-0, 05	8.7	3
	7.5	16	SC-4-0	SC-4-0	9.5	3
	11	22	SC-4-1, 5-1	SC-N1	10.6	3
	15	32	SC-N1	SC-N1	11.7	3
	18.5	40	SC-N2	SC-N1	12.6	3
	22	50	SC-N2S	SC-N2	13.4	3
	30	65	SC-N3	SC-N3	15.0	3
	40	80	SC-N4	SC-N4	16.6	3
	55	105	SC-N6	SC-N5	18.8	2
	60	125	SC-N6	SC-N6	19.5	2
	75	150	SC-N7	SC-N6	21.3	2
	90	180	SC-N8	SC-N7	23.0	2
	110	220	SC-N10	SC-N8	25.0	2
	160	300	SC-N11	SC-N11	29.3	2
	220	400	SC-N12	SC-N12	33.7	2
	315	600	SC-N14	SC-N14	39.5	2
	440	800	SC-N16	SC-N16	46.0	2

4-1-6 Autotransformer starting

(1) Description

An autotransformer starter provides reduced voltage at the motor terminals for starting through the use of a tapped, 3-phase autotransformer. The motor is started with MC_N and MC_S contactors closed. After it accelerates, a time delay relay causes transfer from reduced voltage start to full voltage operation connection without disconnecting the motor from the power supply.

(2) Selection of contactors

Assuming that the transformer tap is a (%) and the motor full load current is In, the transformer primary current (I) can be expressed as follows:

$$I = a^2In$$

When the transformer tap values are 50–65–80% the motor terminal voltage, starting current and starting torque are as shown in the table below.
Therefore, the primary current of the transformer at the time of motor starting is maximal with the 80% tap and approximately 3.8In if the motor starting current is 6In.
The making and breaking capacity required for MC_S contactor is

$$\frac{10}{6} \times 3.8In = 6.3In$$

Therefore AC-3 category contactors with a rated operational current of 0.63In are appropriate for selection. The maximal current of 1.5In flows through the MC_N contactor when the 50% tap is used.
Consequently the making and breaking capacity is

$$\frac{10}{6} \times 1.5In = 2.5In$$

Accordingly, MC_N contactors are selected from among those having a rated operational current of 0.25In within the AC-3 category.
It is unnecessary to take the electrical durability of MC_S contactors into consideration because they do not interrupt current.
However, it is necessary in the case of the MC_N contactor if it interrupts current in excess of 0.5In.
For overcurrent withstand values, it is assumed that MC_N and MC_S contactors allow current of 1.5In and 3.8In respectively to flow during starting.

Starting characteristics

	Taps		
	50%	65%	80%
Voltage at motor	50%	65%	80%
Starting current	25%	42.2%	64%
Starting torque	25%	42.2%	64%

Fig. 18 Voltage and current for autotransformer starting (single-phase equivalent circuit)

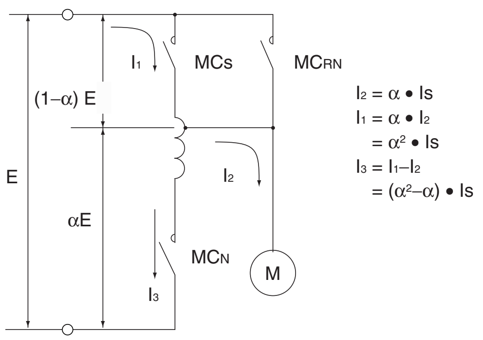
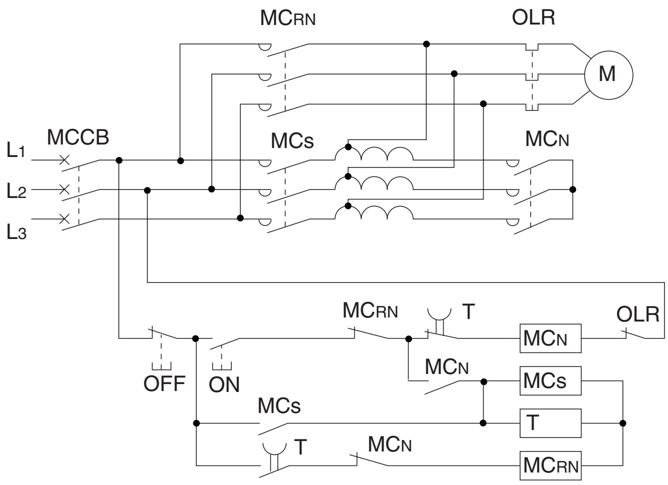


Fig. 19 Wiring diagram

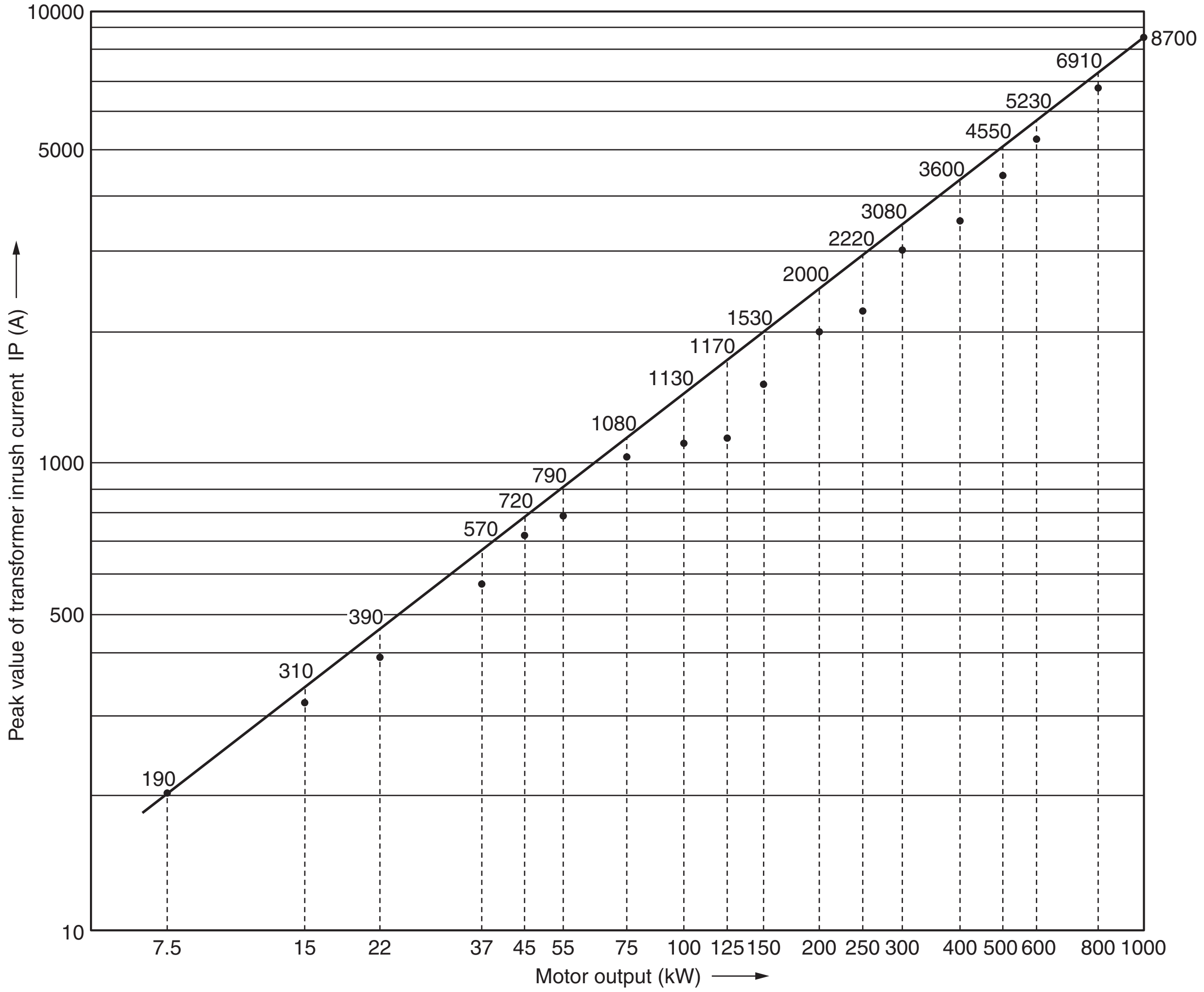


(3) Contactors for autotransformer starting

Main circuit voltage	Motor rating		Contactor			Permissible starting time for starting contactor ts (s)	Permissible number of repeat starting operations
	Output (kW)	Max. full load current (A)	For running (MCRN)	For starting (MCs)	For neutral circuit (MCN)		
200–240V	11	40	SC-N2	SC-N2	SC-0, 05	10.6	3
	15	50	SC-N2S	SC-N2S	SC-4-0	11.7	3
	18.5	65	SC-N3	SC-N2S	SC-4-1, 5-1	12.6	3
	22	80	SC-N4	SC-N3	SC-N1	13.4	3
	30	105	SC-N5	SC-N4	SC-N1	15.0	3
	37	125	SC-N6	SC-N5	SC-N2	16.2	3
	45	150	SC-N7	SC-N5	SC-N2S	17.4	2
	55	180	SC-N8	SC-N6	SC-N3	18.8	2
	65	220	SC-N10	SC-N8	SC-N4	20.1	2
	90	300	SC-N11	SC-N10	SC-N5	23.0	2
	120	400	SC-N12	SC-N11	SC-N6	25.9	2
	180	600	SC-N14	SC-N14	SC-N8	30.8	2
	220	800	SC-N16	SC-N14	SC-N11	33.7	2
380–440V	11	22	SC-4-1, 5-1	SC-4-1, 5-1	SC-03	10.6	3
	15	32	SC-N1	SC-N1	SC-0, 05	11.7	3
	18.5	40	SC-N2	SC-N1	SC-0, 05	12.6	3
	22	50	SC-N2S	SC-N2	SC-4-0	13.4	3
	30	65	SC-N3	SC-N2S	SC-4-1, 5-1	15.0	3
	40	80	SC-N4	SC-N3	SC-N1	16.6	3
	55	105	SC-N5	SC-N4	SC-N2	18.8	2
	60	125	SC-N6	SC-N5	SC-N2	19.5	2
	75	150	SC-N7	SC-N5	SC-N2S	21.3	2
	90	180	SC-N8	SC-N7	SC-N3	23.0	2
	110	220	SC-N10	SC-N8	SC-N4	25.0	2
	160	300	SC-N11	SC-N10	SC-N6	29.3	2
	220	400	SC-N12	SC-N11	SC-N6	33.7	2
	315	600	SC-N14	SC-N14	SC-N8	39.5	2
	440	800	SC-N16	SC-N16	SC-N11	46.0	2

4-1 Applications to motors

Fig. 20 Reference example: Inrush current for commercially available autotransformer (for autotransformer starting)
Rating: 440V, time: 1min



Notes:
- Ip for 220V circuits will be approximately twice the value shown in the above graph.
- The Ip values shown in the graph are calculated based on the worst conditions and represent the peak values for the first half-wave.

4-2-1 Transformer load applications

(1) Transformer primary switching

When a transformer is connected to its power supply, transient inrush current exceeding 10 times its rated full load current can be expected. This transient inrush current results from the iron core being momentarily saturated by the flux of the DC component transiently generated at the moment the transformer is energized. Thus the contactor selected for switching the transformer circuit must have the capability of handling the expected transient inrush current, otherwise contact welding will occur.
The ratings given in the table below are suitable for contactors being used to switch transformers having inrush current not exceeding 20 times their rated current, irrespective of the nature of their secondary loads.

Contactor type	Single-phase transformer				Three-phase transformer			
	220V Capacity (kVA)	Rated current (A)	440V Capacity (kVA)	Rated current (A)	220V Capacity (kVA)	Rated current (A)	440V Capacity (kVA)	Rated current (A)
SC-03	1	5	1.5	3	2	5	2.5	3
SC-0	1.5	7.5	2	5	3	7.5	4	5
SC-05	1.5	7.5	2	5	3	7.5	4	5
SC-4-0	2	9	3	7	3.5	9	5	7
SC-4-1	2.5	10	4	9.5	4	10	7.5	9.5
SC-5-1	2.5	10	4	9.5	4	10	7.5	9.5
SC-N1	3	13	5	12	5	13	10	12
SC-N2	4	17	7.5	16	6.5	17	12	16
SC-N2S	5	25	10	24	10	25	18	24
SC-N3	7	32	15	32	12	32	25	32
SC-N4	9	40	18	40	15	40	30	40
SC-N5	10	46	20	45	18	46	35	45
SC-N6	15	62	25	55	25	62	42	55
SC-N7	17	75	33	75	30	75	60	75
SC-N8	20	90	40	90	35	90	70	90
SC-N10	25	110	50	110	42	110	85	110
SC-N11	33	150	57	130	57	150	100	130
SC-N12	44	200	90	200	75	200	150	200
SC-N14	65	300	130	300	110	300	250	300
SC-N16	90	400	175	400	150	400	300	400

4-2-2 Resistive load applications

(1) Resistive load switching

Contactors conforming to IEC standards for use in switching resistive loads are listed in the table below. The table gives the ratings of SC series contactors when used to switch resistive loads. Current carrying capacity can be increased by connecting contacts in parallel.

Contactor type	Single-phase				Three-phase			
	110V		220V		220V		440V	
	Resistive load				Resistive load			
	Capacity (kW)	Rated current (A)	Capacity (kW)	Rated current (A)	Capacity (kW)	Rated current (A)	Capacity (kW)	Rated current (A)
SC-03	2.2	20	4.4	20	7.6	20	15	20
SC-0, 05	2.2	20	4.4	20	7.6	20	15	20
SC-4-0	2.7	25	5.5	25	9.5	25	19	25
SC-4-1, 5-1	3.5	32	7	32	12	32	24	32
SC-N1	5.5	50	11	50	19	50	38	50
SC-N2	6.6	60	13	60	23	60	46	60
SC-N2S	8.8	80	17	80	30	80	61	80
SC-N3	11	100	22	100	38	100	76	100
SC-N4	14	135	29	135	51	135	102	135
SC-N5	16	150	33	150	57	150	114	150
SC-N6	16	150	33	150	57	150	114	150
SC-N7	22	200	44	200	76	200	152	200
SC-N8	28	260	57	260	99	260	198	260
SC-N10	28	260	57	260	99	260	198	260
SC-N11	38	350	77	350	133	350	266	350
SC-N12	50	450	99	450	171	450	343	450
SC-N14	72	660	145	660	251	660	503	660
SC-N16	88	800	176	800	304	800	609	800

(2) Parallel connection switching

AC magnetic contactors are designed primarily for the switching of three-phase motors. When these contactors are used for switching single phase resistive loads, it is possible to increase their current carrying capacity by connecting the main contacts of the 3 poles in parallel. When used in this manner it is necessary to take the following matters into consideration.

(a) Current carrying capacity

Assuming the number of contacts connected in parallel to be "n", the current carrying capacity can be expressed by the following formula:

$2\sqrt{n-1} \times Ith$ (Ith: Rated thermal current of contactor).

Hence, if n = 2 or 3
the current carrying capacities are

$2\sqrt{2-1} \times Ith = 2Ith$ and

$2\sqrt{3-1} \times Ith = 2.8Ith$ respectively.

(b) Making and breaking capacity

The opening times for three main contacts vary slightly with each other. Therefore, when switching single phase loads only the last opening contact interrupts the current and only the first closing contact makes the current. Therefore, the switching capacity is similar to when handling three phase loads.

(c) Intermittent duty (the No. of switching cycles per hour)

The reduction ratio of switching frequency is normally directly proportional to the square of the interrupting current. If the interrupting current is twice as much as the rated operating current, the switching frequency is reduced to a quarter of the maximum switching frequency when interrupting the rated operating current.
So supposing that the switching frequency is 1200 cycles per hour when the rated operating current is Ie, the switching frequency can be expressed by the following formula when switching a 2×Ie current:

$$1200\left(\frac{Ie}{2Ie}\right)^2 = 1200 \times \frac{1}{4} = 300 \text{ switches per hour.}$$

(d) Electrical durability

When 2 or 3 poles connected in parallel are applied to single phase circuits, only the contact which opens last interrupts the current in the early stages of operation and this contact alone takes the wear.
Thus in course of time this contact can be expected to fail at which time a second contact will take its place; it will fail and the third contact will take over.
Therefore, supposing the number of contacts connected in parallel to be "n", the electrical durability is "n" times longer than when a single contact is used for interrupting the current, since "n" contacts connected in parallel relieve one another.

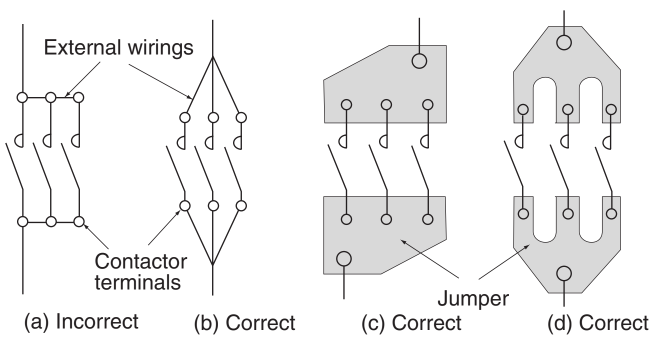
However, since the current carrying capacity is $2\sqrt{n-1}$ times the rated operating current the electrical life is

$$\frac{n}{(2\sqrt{n-1})^2} = n/4\,(n-1) \text{ times}$$

(e) Parallel connection of poles

When connecting poles in parallel the resistance value of the connectors used on each pole must be similar.

Fig. 21 Parallel connecting poles



4-2-3 Capacitor load applications

(1) Capacitor switching

When using a magnetic contactor for a capacitor circuit, the inrush current when the circuit is made and the recovery voltage when the circuit is broken require particular consideration. The inrush current when the circuit is made is determined by the impedance of the circuit. If the impedance is extremely small, a large inrush current with higher harmonic current will flow. This current may, particularly if capacitors are connected in parallel, combine with the discharge current from capacitors already closed, resulting in a larger inrush current, and significantly increasing the risk of contact welding. For this reason, in handling capacitor loads, it is desirable to have a series reactor to suppress the inrush current when the circuit is made and also to suppress distortion in the voltage or current due to harmonics. (In general, a reactor of approx. 6% the capacity of the capacitor is recommended.) With low-voltage circuits, however, a reactor is often not used, e.g., for cost reasons, or there is a transformer at upstream in the circuit that suppress the inrush current. Also, because a large recovery voltage will occur between contacts when the circuit is broken, sufficient insulation recovery characteristics are required in the contactor.

The following table of SC-series contactors allows logical and economical selection based on considering the transient phenomena in capacitor circuit switching and contactor operation.

(a) Contactors for capacitor circuits

Contactor type	Single-phase capacitor				Three-phase capacitor					
	200–220V		400–440V		200–220V		400–440V		500–550V	
	Capacity (kvar)	Rated current (A)	Capacity (kvar)	Rated current (A)	Capacity (kvar)	Rated current (A)	Capacity (kvar)	Rated current (A)	Capacity (kvar)	Rated current (A)
SC-03	1.2	6	1.7	4.3	2	6	3	4.3	3	3.5
SC-0	1.8	9	3.2	8	3	9	5	8	5	6
SC-05	1.8	9	3.2	8	3	9	5	8	5	6
SC-4-0	3	15	6	15	5	15	10	15	10	12
SC-4-1	4	20	8	20	7	20	14	20	14	16
SC-5-1	4	20	8	20	7	20	14	20	14	16
SC-N1	6	30	12	30	10	30	20	30	20	25
SC-N2	7.5	38	15	38	13	38	26	38	25	30
SC-N2S	11	53	21	53	18	53	36	53	35	41
SC-N3	13	65	26	65	22	65	45	65	40	50
SC-N4	15	75	30	75	26	75	52	75	50	55
SC-N5	16	80	32	80	28	80	55	80	60	70
SC-N6	20	100	40	100	35	100	69	100	75	87
SC-N7	26	130	52	130	45	130	90	130	90	105
SC-N8	35	175	70	175	60	175	120	175	150	170
SC-N10	35	175	70	175	60	175	120	175	150	170
SC-N11	47	235	94	235	80	235	160	235	200	230
SC-N12	60	300	120	300	104	300	208	300	250	290
SC-N14	88	440	176	440	152	440	300	440	375	435
SC-N16	107	535	214	535	185	535	370	535	430	497

Notes:
- The inrush current peak value must be less than 20 times the capacitor's rated current.
- Selection is based on a contactor current carrying capacity that allows for 1.3×1.15 times the capacitor's overcurrent.
- The above table is applicable when a series reactor that is 0.5% or more of the capacitor's capacity is inserted.
- Electrical durability: 100,000 operations min.
- Use the following formula to convert kvar to μF:

$$C = \frac{kvar}{2\pi f E^2} \times 10^9\ (\mu F)$$

E: Rated voltage
f: Frequency

(b) Contactors for parallel capacitor banks (three-phase capacitor circuits)

Circuit voltage	Capacitor (C_2) Capacity (kvar)	Capacitor (C_2) Rated current (A)	Contactor type with serial reactor * K = 0.06	Contactor type with serial reactor * K ≥ 0.005	Contactor type without serial reactor
200–220V	5	14.5	SC-4-0	SC-4-0	SC-N2
	7.5	21.6	SC-4-1, 5-1	SC-4-1, 5-1	SC-N3
	10	28.9	SC-N1	SC-N1	SC-N4
	15	43.4	SC-N2S	SC-N2S	SC-N6
	20	57.8	SC-N3	SC-N3	SC-N8
	25	72.3	SC-N4	SC-N4	SC-N8
	30	86.7	SC-N4	SC-N5	SC-N10
	40	115.6	SC-N7	SC-N7	SC-N11
	50	144.5	SC-N8	SC-N8	SC-N12
	60	173.4	SC-N8	SC-N8	SC-N14
	75	216.8	SC-N11	SC-N11	SC-N14
	100	289	SC-N12	SC-N12	–
	125	361	SC-N14	SC-N14	–
	150	434	SC-N14	SC-N14	–
	185	535	SC-N16	SC-N16	–
400–440V	5	7.3	SC-03	SC-0, 05	SC-N1
	7.5	10.8	SC-03	SC-4-0	SC-N2
	10	14.5	SC-4-0	SC-4-0	SC-N2
	15	21.6	SC-4-1, 5-1	SC-N1	SC-N3
	20	28.9	SC-N1	SC-N1	SC-N5
	25	36.1	SC-N2	SC-N2	SC-N6
	30	43.4	SC-N2S	SC-N2S	SC-N7
	40	57.8	SC-N3	SC-N3	SC-N8
	50	72.3	SC-N4	SC-N4	SC-N10
	60	86.7	SC-N4	SC-N5	SC-N11
	75	108.4	SC-N7	SC-N7	SC-N11
	100	145	SC-N8	SC-N8	SC-N12
	125	181	SC-N8	SC-N10	SC-N14
	150	217	SC-N11	SC-N11	–
	200	289	SC-N12	SC-N12	–
	250	361	SC-N14	SC-N14	–
	300	434	SC-N14	SC-N14	–
	370	535	SC-N16	SC-N16	–

Notes:
- The above table applies for an electrical durability of approx. 100,000 operations.
- Selection is based on a contactor current carrying capacity that allows for 1.3×1.15 times the capacitor's overcurrent.
- Use the following formula to convert kvar to μF:

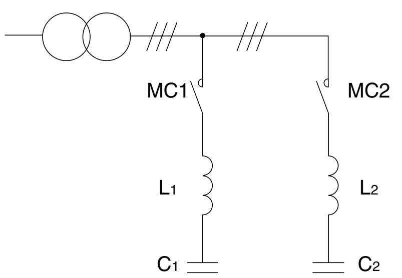
$$C = \frac{kvar}{2\pi f E^2} \times 10^9 \ (\mu F)$$

E: Rated voltage
f: Frequency

$$^* K = \omega L_2 / \frac{1}{\omega C_2} = \omega L_1 / \frac{1}{\omega C_1}$$

C_1: Capacity of capacitor already made
C_2: Capacity of capacitor to be made

Fig. 22

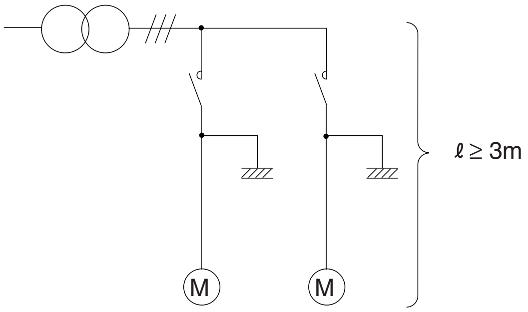


(c) Contactors for motors connected to condensive capacitors

The following table shows contactors to be used when two or more motors with power-factor regulating capacitors are operated in parallel using the same power supply.

Motor Voltage	Output (kW)	Capacity of power-factor regulating capacitor (μF)	Contactor type 250×10³ operations	1,000×10³ operations
220V 50Hz	0.4	20	SC-03	SC-03
	0.75	30	SC-03	SC-0, 05
	1.5	40	SC-03	SC-4-0
	2.2	50	SC-0, 05	SC-4-1, 5-1
	3.7	75	SC-4-0	SC-N1
	5.5	100	SC-N1	SC-N2
	7.5	150	SC-N2	SC-N2
	11	200	SC-N2S	SC-N2S
	15	250	SC-N3	SC-N3
	18.5	300	SC-N4	SC-N4
	22	400	SC-N5	SC-N6
	30	500	SC-N6	SC-N7
	37	600	SC-N7	SC-N7
	45	700	SC-N8	SC-N8
440V 50Hz	0.75	7.5	SC-03	SC-03
	1.5	10	SC-03	SC-0, 05
	2.2	15	SC-0, 05	SC-4-0
	3.7	20	SC-0, 05	SC-4-0
	5.5	25	SC-4-0	SC-4-1, 5-1
	7.5	40	SC-4-1, 5-1	SC-N1
	11	50	SC-N1	SC-N2
	15	75	SC-N2	SC-N2S
	18.5	75	SC-N2S	SC-N2S
	22	100	SC-N2S	SC-N3
	30	125	SC-N3	SC-N4
	37	150	SC-N4	SC-N6
	45	200	SC-N5	SC-N6

Fig. 23



4-2-4 Lamp load applications

(1) Incandescent lamp loads

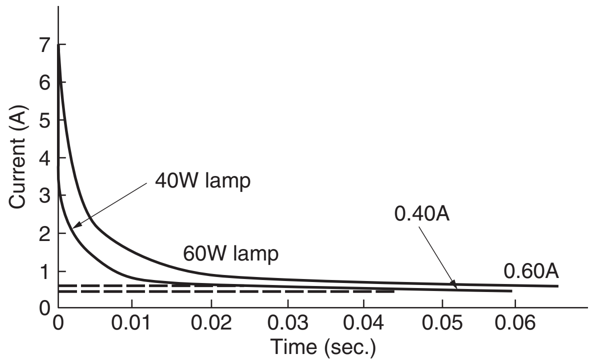
The resistance (ohm) offered by tungsten filaments is very small just before they begin to glow. Therefore, according to theory, an inrush current 13 to 16 times the continuous current can be expected the moment voltage is applied.

However, in actual practice the inrush current is suppressed to a value 7 to 10 times the continuous current. This is due to the increase in resistance from circuit self-heating impedance.

The diagram gives an example of current-time characteristics after voltage has been applied.
When selecting a contactor, it is necessary that the continuous current values of the incandescent lamps be less than the rated operational current of the contactor (category AC-3)

Fig. 24 Current-time characteristic after voltage is applied

In the case of 100V AC circuit



Number of incandescent lamps that can be switched per contactor

Contactor type	100V AC								200V AC							
	For each lamp capacity								For each lamp capacity							
	100W	150W	200W	250W	300W	500W	1,000W	1,500W	100W	150W	200W	250W	300W	500W	1,000W	1,500W
SC-03	11	7	5	4	3	2	1	–	22	14	11	8	7	4	2	1
SC-0, 05	13	8	6	5	4	2	1	–	26	17	13	10	8	5	2	1
SC-4-0	18	12	9	7	6	3	1	1	36	24	18	14	12	7	3	2
SC-4-1, 5-1	19	12	9	7	6	3	1	1	38	25	19	15	12	7	3	2
SC-N1	26	17	13	10	8	5	2	1	52	34	26	20	17	10	5	3
SC-N2	35	23	17	14	11	7	3	2	70	46	35	28	23	14	7	4
SC-N2S	50	33	25	20	16	10	5	3	100	66	50	40	33	20	10	6
SC-N3	65	43	32	26	21	13	6	4	130	86	65	52	43	26	13	8

4-2 Load applications

(2) Fluorescent lamp loads

The inrush current at the time of starting a fluorescent lamp is approx. 10 times its normal running current and it takes 1 to 2 seconds to settle down. Therefore, it is necessary to select contactors in the AC-3 category which have a rated operational current exceeding that of the continuous current drawn by the fluorescent lamp circuits.

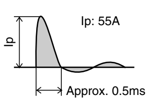
Number of rapid-start fluorescent lamps (high power factor type) that can be switched per contactor

Contactor type	100V AC								200V AC							
	For each lamp capacity								For each lamp capacity							
	40W								40W				110W			
	Lamp type FLR-40S		FLR-40S/36		FLR-110H		FLR-110H/100		Lamp type FLR-40S		FLR-40S/36		Lamp type FLR-110H		FLR-110H/100	
	One or two lamps								One or two lamps							
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
	Input current								Input current							
	0.53A	0.94A	0.45A	0.8A	1.3A	2.5A	1.18A	2.2A	0.27A	0.47A	0.23A	0.4A	0.65A	1.25A	0.59A	1.10A
SC-03	20	11	24	13	8	4	9	5	40	23	47	27	16	8	18	10
SC-0, 05	24	13	28	16	10	5	11	5	48	27	56	32	20	10	22	11
SC-4-0	33	19	40	22	13	7	15	8	66	38	78	45	27	14	30	16
SC-4-1, 5-1	35	20	42	23	14	7	16	8	70	40	82	47	29	15	32	17
SC-N1	49	27	57	32	20	10	22	11	96	55	113	65	40	20	44	23
SC-N2	66	37	77	43	26	14	29	15	129	74	152	87	53	28	59	31
SC-N2S	94	53	111	62	38	20	42	22	182	106	217	125	76	40	84	45
SC-N3	122	69	144	81	50	26	55	29	240	138	282	162	100	52	110	59

(3) Inverter-type fluorescent lamp loads

Even if the parameters determining the wattage and voltage of the inrush current prevention circuit and smoothing capacitor for starting inrush current are the same, the capacity will differ significantly depending on the model. The following tables give examples of specifications for commercially available Hf inverter-type stabilizers.

Examples of specifications for Hf inverter-type stabilizers

Watts	Input power supply	Power factor	Combined lamp power	Smoothing capacitor capacity	Starting inrush current *
200V AC 32W for 2 lamps	Rated output: 0.36A 72W High output: 0.50A 98W	High power factor	32/45W	47μF	

Note: * Measured values for power supply phase of 90°, giving the largest starting inrush current.

Number of Hf inverter-type fluorescent lamp loads per contactor that can be switched

Contactor	Number of switchable lamp loads
SC-4-0	6
SC-4-1, 5-1	9
SC-N1	12
SC-N2	18
SC-N2S	25
SC-N3	30

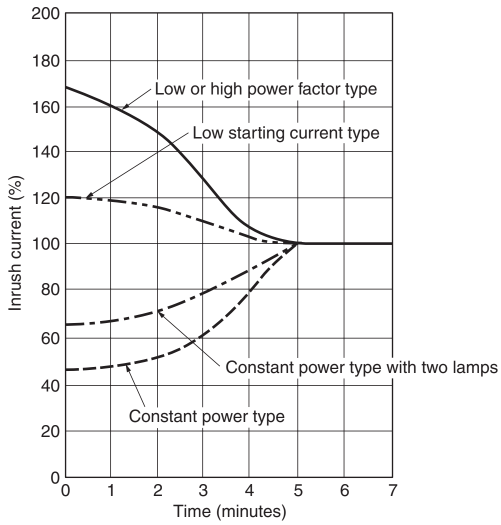
(4) Mercury-arc lamp loads

Mercury-arc lamps are equipped with a starting stabilizer to limit the current to non-destructive levels. The starting characteristics of a mercury-arc lamp depend on the characteristics of this stabilizer. Stabilizers are available in low power factor, high power factor, constant power and low starting current types.
The diagram indicates the starting characteristics of these different stabilizers.

Low power factor, high power factor and constant power types develop inrush current between 1.2 to 1.8 times the continuous running current, and their starting time is between 4 to 6 minutes.

When selecting contactors it is necessary to consider the duration of starting time and the contactor withstand values. The contactors in the SC series have an ample tolerance to withstand current having a magnitude of 1.2 to 1.8 times the rated operational current for a period of 4 to 6 minutes.
The normal operating current must always remain within the rated operational current of the contactor.

Fig. 25 Starting characteristics of mercury-arc lamp loads



Number of mercury-arc lamps that can be switched per contactor

Contactor type	100V AC							
	For each lamp capacity							
	40W	100W	200W	250W	300W	400W	700W	1,000W
	Input current for low-/high-power factor type							
	0.6/1.2A	1.3/2.4A	2.6/4.3A	3.0/4.8A	3.6/5.5A	4.9/7.5A	8.5/14A	12.0/20A
SC-03	18/9	8/4	4/2	3/2	3/2	2/1	1/–	–/–
SC-0, 05	21/10	10/5	5/3	4/2	3/2	2/1	1/–	1/–
SC-4-0	30/15	13/7	6/4	6/3	5/3	3/2	2/1	1/–
SC-4-1, 5-1	31/15	14/7	7/4	6/3	5/3	3/2	2/1	1/–
SC-N1	43/21	20/10	10/6	8/5	7/4	5/3	3/1	2/1
SC-N2	58/29	26/14	13/8	11/7	9/6	7/4	4/2	2/1
SC-N2S	83/41	38/20	19/11	16/10	13/9	10/6	5/3	4/2
SC-N3	108/54	50/27	25/15	21/13	18/11	13/8	7/4	5/3

Contactor type	200V AC							
	For each lamp capacity							
	40W	100W	200W	250W	300W	400W	700W	1,000W
	Input current for low-/high-power factor type							
	0.27/0.53A	0.64/1.0A	1.2/1.9A	1.5/2.1A	1.75/2.5A	2.3/3.3A	4.1/5.9A	5.8/8.3A
SC-03	40/20	17/11	9/5	7/5	6/4	4/3	2/1	1/1
SC-0, 05	48/24	20/13	10/6	8/6	7/5	5/3	3/2	2/1
SC-4-0	66/33	28/18	15/9	12/8	10/7	7/5	4/3	3/2
SC-4-1, 5-1	70/35	29/19	15/10	12/9	10/7	8/5	4/3	3/2
SC-N1	96/49	40/26	21/13	17/12	14/10	11/7	6/4	4/3
SC-N2	129/66	54/35	29/18	23/16	20/14	15/10	8/5	5/4
SC-N2S	185/94	78/50	41/26	33/23	28/20	21/15	12/8	8/6
SC-N3	240/122	101/65	54/34	43/30	37/26	28/19	15/11	11/7

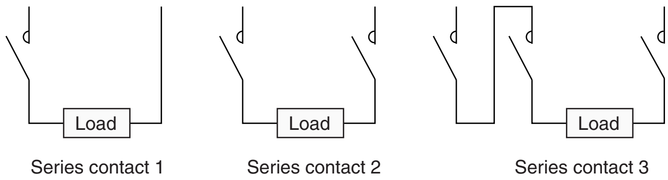
4-2-5 DC load applications

FUJI magnetic contactors in the SC series are normally used in AC circuit applications. However, they may also be used in DC circuits, and in this case their contacts must be connected in series as shown in the diagram.
When used in this manner they will be found to be more economical than using contactors exclusively designed for DC applications. Coils are available for both AC and DC.
If the following ratings are observed the equipment will have an electrical durability of approx. 500,000 operations.

Wiring connection

Contacts must be connected in series when the contactors are used in DC applications.

Fig. 26



Type	No. of contacts connected in series	Rated operational current (A)							
		Class DC-1 (Resistive, L/R ≤ 1ms.)				Class DC-3, 6 (DC motor, L/R ≤ 15ms.)			
		24V	48V	110V	220V	24V	48V	110V	220V
SC-03	1	13	13	10	1.2	6	3	2	0.35
	2	13	13	10	6	12	6	4	1.2
	3	15	15	15	15	15	10	8	4
SC-0	1	13	13	10	1.2	6	3	2	0.35
	2	13	13	10	6	12	6	4	1.2
	3	15	15	15	15	15	10	8	4
SC-05	1	13	13	10	1.2	6	3	2	0.35
	2	13	13	10	6	12	6	4	1.2
	3	15	15	15	15	15	10	8	4
SC-4-0	1	16	13	10	1.5	8	6	2	0.35
	2	16	16	12	8	16	12	6	1.5
	3	18	18	18	15	18	18	12	6
SC-4-1	1	20	15	12	2	10	8	3	0.35
	2	20	20	15	10	20	15	8	2
	3	22	22	20	15	22	22	15	8
SC-5-1	1	20	15	12	2	10	8	3	0.35
	2	20	20	15	10	20	15	8	2
	3	22	22	20	15	22	22	15	8
SC-N1	1	25	25	15	2	15	8	3	0.35
	2	25	25	25	20	25	15	8	2
	3	35	35	30	25	35	25	20	8
SC-N2	1	30	30	20	2	20	15	4	0.35
	2	30	30	30	20	30	20	15	3
	3	45	45	40	35	35	30	30	8
SC-N2S	2	60	60	40	20	60	30	20	3.5
	3	60	60	60	40	60	60	60	13
SC-N3	2	80	80	50	20	80	40	20	4
	3	80	80	80	60	80	80	80	20
SC-N4	2	80	80	50	20	80	40	20	4
	3	80	80	80	60	80	80	80	20
SC-N5	2	120	120	80	40	120	80	40	15
	3	120	120	120	120	120	120	120	80
SC-N6	2	120	120	80	40	120	80	40	15
	3	120	120	120	120	120	120	120	80
SC-N7	2	160	160	100	80	160	120	80	40
	3	160	160	160	160	160	160	160	160
SC-N8	2	200	200	160	160	200	160	120	60
	3	200	200	200	200	200	200	200	200
SC-N10	2	200	200	160	160	200	160	120	60
	3	200	200	200	200	200	200	200	200
SC-N11	2	300	300	200	200	300	200	160	80
	3	300	300	300	300	300	300	300	300
SC-N12	2	400	400	330	300	400	300	200	100
	3	400	400	400	400	400	400	400	400
SC-N14	2	600	500	420	300	–	–	–	–
	3	600	600	600	420	–	–	–	–

4-2-6 Selection of control transformers

(1) Selection of control transformers

When selecting control transformers, both continuous capacity and short-time capacity must be considered.

Continuous capacity refers to the holding capacity of all of the magnetic contactors. Short-time capacity refers to the capacity required when switching the circuit, and is several times the size of the normal continuous capacity. In particular, the short-time capacity is determined by the voltage drop allowed in the secondary output voltage when the contactor is closed. In this case, taking voltage fluctuations in the main power supply into consideration, 5% can be used as a rough estimate. The following table shows the coil characteristics for FUJI magnetic contactors.

Magnetic contactor coil characteristics

Type	Inrush				Sealed			
	Power consumption Ps (VA)	Active power Pw (W)	Reactive power Pv (var)	Power factor (cosø)	Power consumption Ps (VA)	Active power Pw (W)	Reactive power Pv (var)	Power factor (cosø)
SC-03	95	70	65	0.73	9	2.9	8.5	0.32
SC-0	95	70	65	0.73	9	2.9	8.5	0.32
SC-05	95	70	65	0.73	9	2.9	8.5	0.32
SC-4-0	95	70	65	0.73	9	2.9	8.5	0.32
SC-4-1	95	70	65	0.73	9	2.9	8.5	0.32
SC-5-1	95	70	65	0.73	9	2.9	8.5	0.32
SC-N1	120	88	82	0.73	12.7	3.7	12	0.29
SC-N2	120	88	82	0.73	12.7	3.7	12	0.29
SC-N2S	180	97	151	0.54	13.3	4.5	12.5	0.34
SC-N3	180	97	151	0.54	13.3	4.5	12.5	0.34
SC-N4	200	118	161	0.59	14.3	4.8	13.4	0.34
SC-N5	80	80	8	0.99	4	3.2	2.4	0.8
SC-N6	190	188	27	0.99	4.9	3.4	3.5	0.7
SC-N7	190	188	27	0.99	4.9	3.4	3.5	0.7
SC-N8	200	200	20	0.99	5.4	4.5	2.9	0.84
SC-N10	200	200	20	0.99	5.4	4.5	2.9	0.84
SC-N11	240	239	24	0.99	5.7	5.3	2.1	0.93
SC-N12	240	239	24	0.99	5.7	5.3	2.1	0.93
SC-N14	400	400	0	1	9.3	7.9	4.9	0.85
SC-N16	400	400	0	1	9.3	7.9	4.9	0.85

(a) Calculation example

The control transformer capacity can be calculated using the following formula:

$$Ps = \sqrt{Pw^2+Pv^2}$$

Ps: Apparent power (kVA)
Pw: Active power (kW)
Pv: Reactive power (kvar)

$$\text{Total power factor, } \cos ø = \frac{Pw}{Pv}$$

For example, the following calculations are for the case where three SC-N6 contactors start operation in a configuration where one SC-N2 contactor is already operating.

(b) Short-time capacity

In this case, using the values in the above table, the calculation will be as follows:

Total active power, Pw=3.7+188×3=567.7 (W)

Total reactive power, Pv=12+27×3=93 (var)

$$\text{Total apparent power, } Ps = \sqrt{Pw^2+Pv^2} = \sqrt{567.7^2+93^2} = 575\text{VA}$$

$$\text{Total power factor, } \cos ø = \frac{Pw}{Ps} = \frac{567.7}{575} = 0.99$$

Therefore, the short-time capacity required in this case is approx. 580VA with cosø=0.99.

(c) Continuous capacity

After the three SC-N6 contactors start operation, using the values in the above table, the calculation will be as follows:

Total active power, Pw=3.7+3.4×3=13.9 (W)

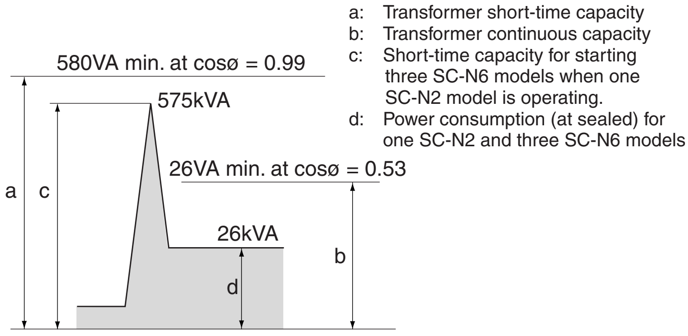
Total reactive power, Pv=12+3.5×3=22.5 (var)

Total apparent power, $Ps = \sqrt{Pw^2+Pv^2} = \sqrt{13.9^2+22.5^2} = 26VA$

Total power factor, $\cos ø = \frac{Pw}{Ps} = \frac{13.9}{26} = 0.53$

Therefore, in this case, the required short-time capacity is 580VA (cosø=0.99) and the required continuous capacity is 26VA (cosø=0.53). Select a control transformer that satisfies these criteria.

Fig. 27 Relationship between transformer capacity and load



The following table only gives examples of control transformers, but applying this table to the above example would indicate that a transformer with a rated capacity of 750VA is suitable.

Examples of overload capacity for transformers at different power factors (with voltage fluctuation at 5%)

Rating capacity (VA)	Power factor (cosø)							
	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
10	11	8.1	6.5	5.5	4.7	4.1	3.7	3.4
20	21	17	13	11	10	8.7	7.8	7.1
30	30	23	19	16	14	12	11	10
50	55	42	35	29	25	22	20	18
75	98	77	63	53	46	41	37	34
100	160	120	100	87	76	67	61	57
200	350	280	230	200	170	150	140	130
300	650	530	440	380	340	310	280	260
500	1,000	850	740	660	590	550	510	510
750	1,500	1,200	1,100	970	880	810	760	770
1,000	2,500	2,100	1,800	1,600	1,500	1,400	1,300	1,300
2,000	5,100	4,200	3,600	3,100	2,800	2,500	2,300	2,200
3,000	7,500	6,300	5,400	4,800	4,300	3,900	3,600	3,500
5,000	15,000	13,000	11,000	10,000	9,100	8,400	7,900	7,900
7,500	25,000	21,000	19,000	17,000	16,000	15,000	14,000	14,000
10,000	35,000	31,000	28,000	25,000	24,000	22,000	22,000	23,000
15,000	52,000	47,000	44,000	41,000	39,000	37,000	37,000	41,000
20,000	69,000	63,000	59,000	56,000	54,000	53,000	53,000	63,000

Note: The above table gives values for standard FUJI control transformers as examples.

The following table shows the capacity of transformers required when one magnetic contactor is used.

Transformer capacity required for 1 contactor
(ε =Voltage fluctuation rate)

Type	Transformer capacity (VA)		
	2% < ε ≤ 5%	5% < ε ≤ 10%	10% < ε ≤ 15%
SC-03	200	100	75
SC-0	200	100	75
SC-05	200	100	75
SC-4-0	200	100	75
SC-4-1	200	100	75
SC-5-1	200	100	75
SC-N1	200 (200)	100 (100)	75(75)
SC-N2	200 (200)	100 (100)	75(75)
SC-N2S	200 (200)	100 (100)	75(100)
SC-N3	200 (200)	100 (100)	75(100)
SC-N4	200 (200)	100 (100)	100(75)
SC-N5	200	100	75
SC-N6	300	200	200
SC-N7	300	200	200
SC-N8	300	200	200
SC-N10	300	200	200
SC-N11	300	500	300
SC-N12	300	500	300
SC-N14	500	300	200
SC-N16	500	300	200

Notes:
- The above table gives values for standard FUJI control transformers as examples.
- The values in parentheses are for SC-N1/SE to SC-N4/SE models (with SUPER MAGNET).
- If devices other than contactors are connected to the secondary side of the same transformer, consideration of the permissible voltage drop of these devices is required when making a selection.

4-3-1 Overview of motor protection

Induction motors are the most basic source of motive power in production installations. At present, with the adoption of the dimensions specified in IEC and E-, B-, and F-class insulation, the development of products that are smaller, lighter, and capable of better performance is advancing, and these products are used in a wide range of applications. Also, along with recent developments in automation and power saving technology, applications where motors are used not only in continuous operation, but also in intermittent operation or forward/reverse operation are increasing. The potential effects of motor failure have also expanded. In addition to motor stoppages, total failure of the installation or system incorporating the motor is also possible. Preventing such failures requires a thorough consideration of the motor's heating characteristics and operation method, and a protection method that is appropriate for the application conditions is required.

Devices for protecting motors can be classified according to detection type and include current-detection devices (e.g., thermal overload relays and MCCBs for motor protection) and temperature-detection devices. The application conditions for these protective devices with respect to the motor's operation method, starting time, and protected items are shown in the following table. Also, the application conditions for quick operating type, standard type, and long-time operating type thermal overload relays and magnetic motor starters based on the starting time are given on pages 90 and 91.

Select the protective device that is best suited to the application by considering the protected items using the following tables together with consideration of economic viability, maintainability, and size. Also, for added safety, selection of a thermal overload relay with 3 elements or with phase-loss protective device (2E type) is recommended.

(1) Application conditions for protective devices for low-voltage motors

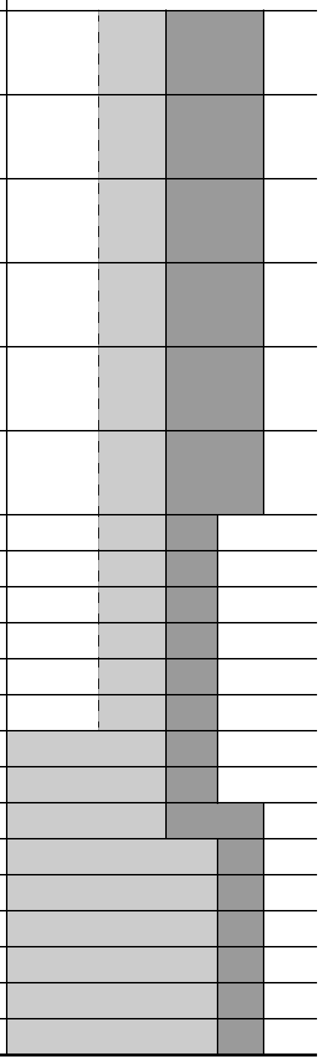
Type of protection	Motor operation method		Constant load, continuous load						Fluctuating load, intermittent load		Reverse rotation protection (Phase sequence protection)	Short-circuit protection	Leakage protection
	Motor starting time		Short		Standard		Long		–				
	Motor classification (example)		Submersible motor, increased safety motor		Motors for pumps, fans, and other basic applications		Motors for ventilators, blowers, and centrifugal separation		Motors for elevators, cranes, and machine tools				
	Protected item		Overload, locked rotor	Phase-loss	Overload, locked rotor	Phase-loss	Overload, locked rotor	Phase-loss	Overload *1	Phase-loss *1	–	–	–
Protective device	Quick operating OL relay 3-element	TR-☐Q	○	Δ									
	Standard type OL relay 2-element *3	TR-☐	Δ		○				Δ				
	3-element	TR-☐/3	Δ		○	Δ *2			Δ	Δ			
	With phase-loss protection		Δ	Δ	○	○			Δ	Δ			
	With phase-loss and phase sequence protection		Δ	Δ	○	○			Δ	Δ	○		
	Long time operating OL relay 2-element *3	TR-☐L					○		Δ				
	3-element	TR-☐L/3					○	Δ	Δ				
	Motor protection MCCB	EA☐M SA☐M	Δ		○	Δ *2			Δ	Δ		○	
	Motor protection ELCB	EG☐M SG☐M	Δ		○	Δ *2			Δ	Δ		○	○

Notes: ○ Applicable
Δ Not applicable in some cases

*1 Applicable in some cases if the operating frequency is regular.
*2 Phase-loss protection is possible for motors with output of 2.2kW or less.
*3 Does not conform to IEC, UL/CSA and JIS standards.

(2) Application conditions for starters based on motor starting time

Motor capacity (200 to 200V) (kW)	Quick operating type			Standard type			Long-time operating type			Application based on starting time (cold start: ——— 6In, – – – 5In) Starting time (s) 0.5 1 2 3 4 5 10 20 30
	Starter	Thermal overload relay	Heater range (A)	Starter *1	Thermal overload relay *1	Heater range (A)	Starter	Thermal overload relay	Heater range (A)	
0.2	–	–	–	SW-03/3H SW-0/3H SW-05/3H	TR-0N/3	0.95–1.45	SW-03/3L SW-0/3L SW-05/3L	–	0.95–1.45	
0.4	SW-03/3Q SW-0/3Q SW-05/3Q	TR-0NQ	2.2–3.4	SW-03/3H SW-0/3H SW-05/3H	TR-0N/3	1.7–2.6	SW-03/3L SW-0/3L SW-05/3L	–	1.7–2.6	
0.75	SW-03/3Q SW-0/3Q SW-05/3Q	TR-0NQ	4–6	SW-03/3H SW-0/3H SW-05/3H	TR-0N/3	2.8–4.2	SW-03/3L SW-0/3L SW-05/3L	–	2.8–4.2	
1.5	SW-03/3Q SW-0/3Q SW-05/3Q	TR-0NQ	5–8	SW-03/3H SW-0/3H SW-05/3H	TR-0N/3	5–8	SW-03/3L SW-0/3L SW-05/3L	–	5–8	
2.2	SW-03/3Q SW-0/3Q SW-05/3Q	TR-0NQ	9–13	SW-03/3H SW-0/3H SW-05/3H	TR-0N/3	7–11	SW-03/3L SW-0/3L SW-05/3L	–	7–11	
3.7	SW-4-0/3Q SW-4-1/3Q SW-5-1/3Q	TR-5-1NQ	12–18	SW-4-0/3H SW-4-1/3H SW-5-1/3H	TR-5-1N/3	12–18	SW-4-0/3L SW-4-1/3L SW-5-1/3L	–	12–18	
5.5	SW-N1/3Q	TR-N2Q	18–26	SW-N1/3H	TR-N2/3	18–26	SW-N1/3L	TR-N2L/3	18–26	
7.5	SW-N2/3Q	TR-N2Q	24–36	SW-N2/3H	TR-N2/3	24–36	SW-N2/3L	TR-N2L/3	24–36	
11	SW-N2S/3Q	TR-N3Q	34–50	SW-N2S/3H	TR-N3/3	34–50	SW-N2S/3L	TR-N3L/3	34–50	
15	SW-N3/3Q	TR-N3Q	45–65	SW-N3/3H	TR-N3/3	45–65	SW-N3/3L	TR-N3L/3	45–65	
18.5	SW-N4/3Q	TR-N5Q	53–80	SW-N4/3H	TR-N5/3	53–80	SW-N4/3L	TR-N5L/3	53–80	
22	SW-N5/3Q	TR-N5Q	65–95	SW-N5/3H	TR-N5/3	65–95	SW-N5/3L	TR-N5L/3	65–95	
30	–	–	–	SW-N6/3H	TR-N6/3	85–125	SW-N6/3L	TR-N6L/3	85–125	
37	–	–	–	SW-N7/3H	TR-N7/3	110–160	SW-N7/3L	TR-N7L/3	110–160	
45	–	–	–	SW-N8/3H	TR-N8/3	125–185	SW-N8/3L	TR-N10L/3	125–185	
55	–	–	–	SW-N10/3H	TR-N10/3	160–240	SW-N10/3L	TR-N10L/3	160–240	
75	–	–	–	SW-N11/3H	TR-N12/3	200–300	SW-N11/3L	TR-N12L/3	200–300	
90	–	–	–	SW-N12/3H	TR-N12/3	240–360	SW-N12/3L	TR-N12L/3	240–360	
110	–	–	–	SW-N12/3H	TR-N12/3	300–450	SW-N12/3L	TR-N12L/3	300–450	
132	–	–	–	SW-N14/3H	TR-N14/3	400–600	SW-N14/3L	TR-N14L/3	400–600	
160	–	–	–	SW-N14/3H	TR-N14/3	400–600	SW-N14/3L	TR-N14L/3	400–600	



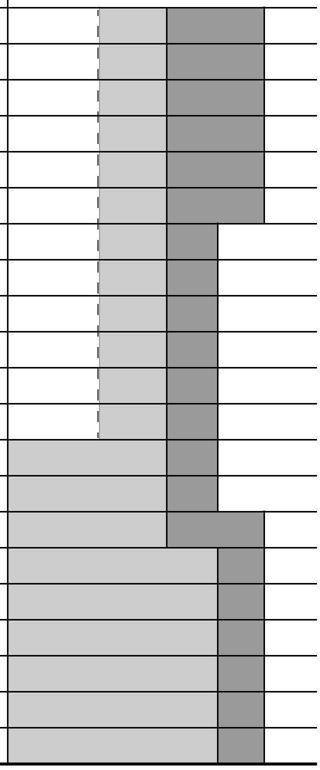
Notes:
- The selection of heater ranges in the above table is based on the full load current for standard motors. Check the value of the full load current before actual use.
- Apply the starting time at 5In to submersible pump motors.

Quick operating types, Standard types, Long-time operating types

*1 Types with phase-loss protective device are also available.

(3) Application conditions for separate mounting type thermal overload relays based on motor starting time

Motor capacity (200 to 220V) (kW)	Quick operating type		Standard type		Long-time operating type (for large inertia load starting)		Application based on starting time (cold start: ——— 6In, – – – 5In) Starting time (s)
	Thermal overload relay	Heater range (A)	Thermal overload relay *	Heater range (A)	Thermal overload relay	Heater range (A)	0.5 1 2 3 4 5 10 20 30
0.2	–	–	TR-0NH/3	0.95–1.45	TR-0NLH/3	0.95–1.45	
0.4	TR-0NQH	2.2–3.4	TR-0NH/3	1.7–2.6	TR-0NLH/3	1.7–2.6	
0.75	TR-0NQH	4–6	TR-0NH/3	2.8–4.2	TR-0NLH/3	2.8–4.2	
1.5	TR-0NQH	5–8	TR-0NH/3	5–8	TR-0NLH/3	5–8	
2.2	TR-0NQH	9–13	TR-0NH/3	7–11	TR-0NLH/3	7–11	
3.7	TR-5-1NQH	12–18	TR-5-1NH/3	12–18	TR-5-1NLH/3	12–18	
5.5	TR-N2QH	18–26	TR-N2H/3	18–26	TR-N2LH/3	18–26	
7.5	TR-N2QH	24–36	TR-N2H/3	24–36	TR-N2LH/3	24–36	
11	TR-N3QH	34–50	TR-N3H/3	34–50	TR-N3LH/3	34–50	
15	TR-N3QH	45–65	TR-N3H/3	45–65	TR-N3LH/3	45–65	
18.5	TR-N3QH	53–80	TR-N3H/3	53–80	TR-N3LH/3	53–80	
22	TR-N3QH	65–95	TR-N3H/3	65–95	TR-N3LH/3	65–95	
30	–	–	TR-N6H/3	85–125	TR-N6LH/3	85–125	
37	–	–	TR-N6H/3	110–160	TR-N6LH/3	110–160	
45	–	–	TR-N10H/3	125–185	TR-N10LH/3	125–185	
55	–	–	TR-N10H/3	160–240	TR-N10LH/3	160–240	
75	–	–	TR-N12H/3	200–300	TR-N12LH/3	200–300	
90	–	–	TR-N12H/3	240–360	TR-N12LH/3	240–360	
110	–	–	TR-N12H/3	300–450	TR-N12LH/3	300–450	
132	–	–	TR-N14H/3	400–600	TR-N14LH/3	400–600	
160	–	–	TR-N14H/3	400–600	TR-N14LH/3	400–600	



Notes:
- The selection of heater ranges in the above table is based on the full load current for standard motors. Check the value of the full load current before actual use.
- Apply the starting time at 5In to submersible pump motors.

☐ Quick operating types, ☐ Standard types, ☐ Long-time operating types

* Types with phase-loss protective device are also available.

4-3-2 Overload and locked rotor protection

As long as the motor is operated within the rated specification range, the temperature of the winding insulation stays below the rated temperature, allowing the motor a normal operating life. If overloaded or if the rotor locks, current exceeding the rated current flows through the winding resulting in a rise of temperature. High temperature can cause deterioration of the winding insulation and motor burnout. To prevent damage, it is important to shut down the motor before the winding insulation reaches the critical temperature.
With current-responsive protection, an appropriate protector is selected based on the motor heating characteristic curve which shows the time taken from the beginning of overcurrent until the winding insulation reaches the critical temperature. There are two types of heating characteristic curves: the cold starting curve describing temperature rise of the winding insulation from the ambient temperature and the hot starting curve for which it rises from the rated operating temperature. Examples of cold and hot starting characteristics for a FUJI motor are shown in Fig. 28.
The operating curve of the current-responsive protector must lie below the heating characteristic curve in Fig. 28. The heating characteristics depend on the winding insulation type, degree of protection, and the number of poles. For a typical thermal overload relay (OLR) used as a current-responsive protector, the standard operating characteristics are defined for use with a standard motor (see page 42).
A standard thermal overload relay satisfies the standard operating characteristics as well as the operating characteristics of FUJI motors. When the specifications listed in the magnetic motor starter catalog are complied with, it is possible to protect a motor operating continuously with a constant load from both overload and locked-rotor over-heating. The proper relationship between motor heating characteristics and thermal overload relay operating characteristics is shown in Fig. 29.

Fig. 28 Motor heating characteristics

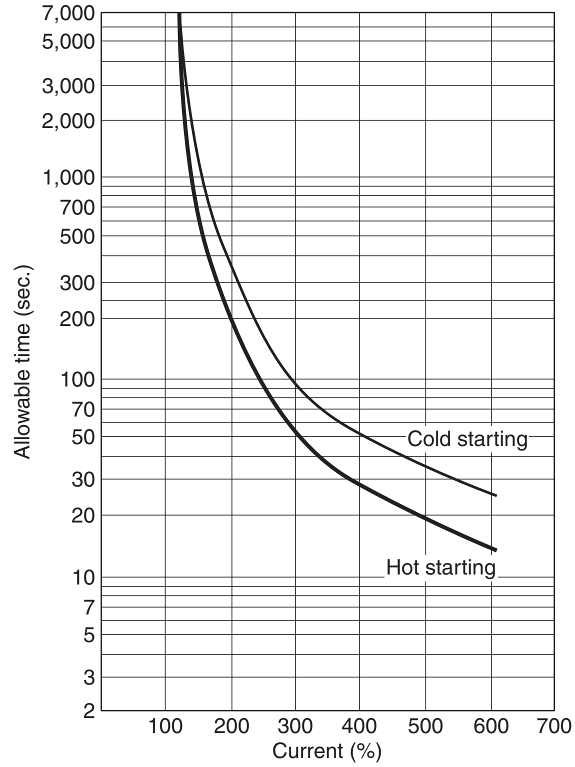
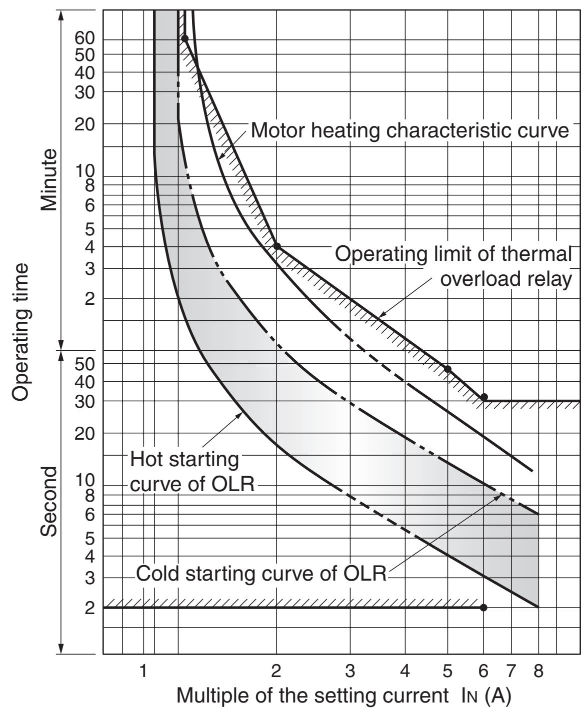


Fig. 29 Coordination between motor heating and thermal overload relay operating characteristics



4-3-3 Motor protection for large inertia load starting

For motors driving loads with a large moment of inertia (such as blowers, winders, separators and so on), the standard thermal overload relay cannot be used since it may trip during the long start-up sequence of the motor. For such applications, FUJI supplies long-time operating thermal overload relays and standardized magnetic motor starters for starting heavy loads. The magnetic motor starter consists of a long-time operating thermal overload relay and a magnetic contactor.
When using the thermal overload relay, make sure that the motor heating characteristic curve is above the operating characteristic curve of the thermal overload relay.

4-3-4 Protection for compressor and submersible pump motors

The temperature of a motor through which refrigerant flows (such as a cooler compressor motor) or through which water flows (such as a submersible pump motor) does not rise abnormally even if current exceeding the rated current flows. Because of this property, compressor and submersible pump motors can be overloaded to some extent. However, if the temperature rises too abruptly in the event of a locked rotor, the motor receives little benefit from the refrigerant. In such a case, the motor must be shut down as quickly as possible.
Submersible pump motors not cooled by water have been produced and put on the market. With regard to motor burnout protectors for submersible drain pump motors, JIS B 8325, the standard for submersible pump motors for waste water draining, states:

(1) For water sealed motors

Protectors which trip within five seconds in response to a current five times the rated motor current (such as the relays with phase-loss protective device/2E, or phase-loss and phase sequence protective device/3E) must be used.

(2) For hydraulic sealed and dry sealed motors

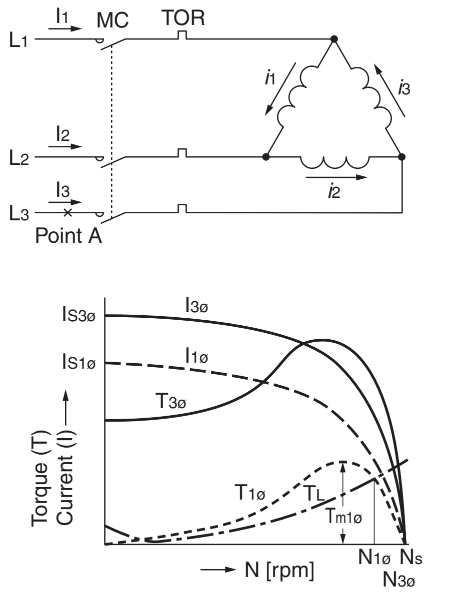
FUJI standard thermal overload relays are applicable. FUJI supplies quick operating type thermal overload relays for compressor motors and water sealed submersible pump motors, and standardized magnetic motor starters consisting of a quick operating type thermal overload relay and a magnetic contactor.
In submersible pump motor applications, phase-sequence protection is often required. In such cases, an magnetic motor starter with a 3E relay is recommended.

4-3-5 Phase-loss protection

With a three-phase motor circuit, a blown fuse of any phase can cause phase-loss operation. Fig. 30 shows the current and torque characteristics of a motor with a delta-connected stator, which is operating without the L_3 phase.
If the motor is started without the L_3 phase, the motor generates no starting torque and will not start. Phase-loss starting current $I_{S1\phi}$, that is about 80% of three-phase starting current $I_{S3\phi}$, flows through the L_1 and L_2 phases, and the thermal overload relay trips. ($I_{S1\phi}$ is also 4.8 times the rated current I_N.)
If any phase is lost during operation, the result depends on the relationship between phase-loss operation torque $T_{1\phi}$ and load torque T_L as follows:

1) If the phase-loss starting torque $T_{m1\phi}$ is smaller than load torque T_L, the load torque brakes the motor to a stop and the thermal overload relay trips, resulting in the same conditions as in phase-loss starting.
2) If the phase-loss starting torque $T_{m1\phi}$ is greater than the load torque T_L, the motor continues to operate at a constant running speed of $N_{1\phi}$—the speed at which $T_{1\phi}$ and T_L balance.

Fig. 30 The three- and phase-loss current and the torque-speed curve of a motor

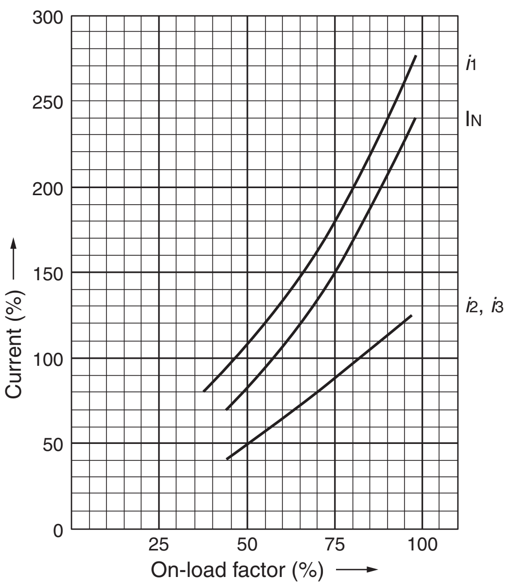


$I_{3\phi}$: Three-phase current
$I_{1\phi}$: Phase-loss current
$I_{S3\phi}$: Three-phase starting current
$I_{S1\phi}$: Phase-loss starting current
$T_{3\phi}$: Three-phase torque
$T_{1\phi}$: Phase-loss torque
$T_{m1\phi}$: Phase-loss starting torque
T_L: Load torque
$N_{3\phi}$: Rotational speed during three-phase operation
$N_{1\phi}$: Rotational speed during phase-loss operation
N_s: Synchronous speed

4-3 Protection of motors

Fig. 31 shows ratios of line and phase currents to their corresponding rated currents. When the on-load factor is $1/\sqrt{3}$ or 58%, the line current (I_1 and I_2) becomes equal to the rated current and a phase current i_1 that is 115% of the rated current flows through the phase winding to which full voltage is applied, resulting in a localized temperature rise within the motor.

Fig. 31 Current variations during the phase-loss operation



For the Y axis, the rated line and phase currents correspond to 100%.

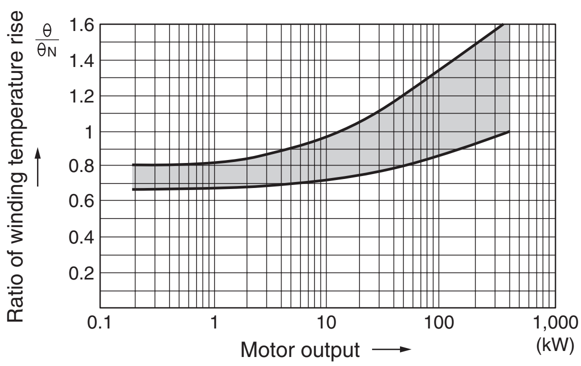
Current	All 3 phases alive (at 100% load) a	Phase loss at point A (Refer to Fig. 30) (at 58% load) b	$\frac{b}{a}$
I_1	I_N	I_N	1
I_2	I_N	I_N	1
I_3	I_N	0	0
i_1	$\frac{I_N}{\sqrt{3}}$	$\frac{2}{3} I_N$	1.15
i_2	$\frac{I_N}{\sqrt{3}}$	$\frac{2}{3} I_N$	0.58
i_3	$\frac{I_N}{\sqrt{3}}$	$\frac{1}{3} I_N$	0.58

Note: I_1, I_2, I_3: Line current
i_1, i_2, i_3: Phase current
I_N: Rated line current (all three phases alive)

Fig. 32 shows measured values for winding temperature rises of various motor types and outputs during phase-loss and three-phase operation. During measurement the line current during phase-loss operation was made equal to the three-phase rated current. Fig. 32 shows that the ratio of temperature rise during phase-loss operation to that during three-phase operation increases with motor output.

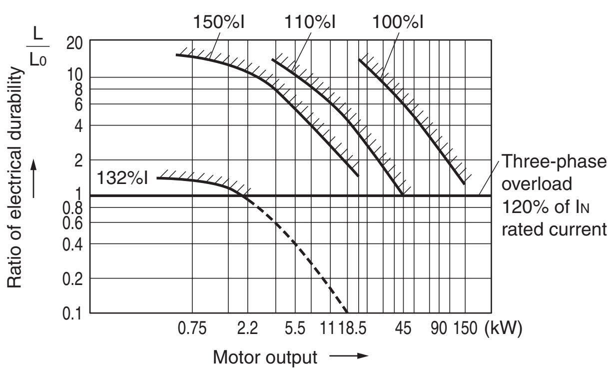
Fig. 33 shows ratios of the winding insulator electrical durability for phase-loss operation to that for three-phase operation, assuming that the unit ratio corresponds to the electrical durability when a current that is 120% of the rated current flows during three-phase operation. Fig. 33 uses the limit operating current in the phase-loss condition as a parameter.
For motors with output of 2.2kW or lower, phase-loss protection is possible using a standard thermal overload relay (with three heater elements); for motors with output exceeding 2.2kW, phase-loss protection is possible by reducing the operating current during phase-loss operation. The IEC standard defines that the operating current must be 115% or lower of the rated limit operating current.
The TK series thermal overload relay (2E thermal relay) meets the requirement. If overloaded during three-phase operation, the TK series thermal overload relay operates as the standard thermal overload relay. During phase-loss operation, the differential amplifier (the ADL mechanism) of the relay operates on a current that is 115% or lower of the rated operating current, thus providing phase-loss protection.

Fig. 32 Temperature rise during the phase-loss operation



θ_N: Temperature rise of winding during three-phase operation
θ: Temperature rise of winding during phase-loss operation

Fig. 33 Variations of the electrical durability of the windings with respect to the limit operating current in the phase-loss condition



L_0: Electrical durability of winding during three-phase overload operation
L: Electrical durability of winding during phase-loss operation

4-3-6 Phase-sequence protection

The purpose of phase-sequence protection is prevention of hazards due to reverse rotation of the driven machine rather than motor protection, and whether it is necessary depends on the characteristics of the driven machine. Since the cause of improper phase-sequence is mis-wiring during installation or modification of the electrical system, phase-sequence protection may be omitted if electrical tests have been conducted carefully and strictly. However, it is recommended that a phase-sequence relay be installed to protect the motor from any possible mistake made during electrical installation. FUJI supplies the QE-20N type phase-sequence relays for use as phase-sequence protectors. By using the QE-20N type phase-sequence relay together with the 2E thermal overload relay, multi-factor protection including overload is possible.

4-3-7 Protective coordination with short-circuit protective devices

Starters are designed to protect motors from burnout due to overloads, locked rotor, or phase-loss, and for regular switching. They do not have the capacity to make or break a circuit when a current greater than the overload current (i.e., more than 10 times the full load current) flows due to a short-circuit. Therefore, a short-circuit protective device that has the capacity to break short-circuits, such as an MCCB or current-limiting fuse, is required to protect against excessive current caused by short-circuits. In this case, it is necessary to provide protective coordination, with a starter (thermal overload relay) protecting against overloads, locked rotor, and phase-loss, and a short-circuit protective device protecting against short-circuits. The basic principles of this kind of protective coordination are as follows:

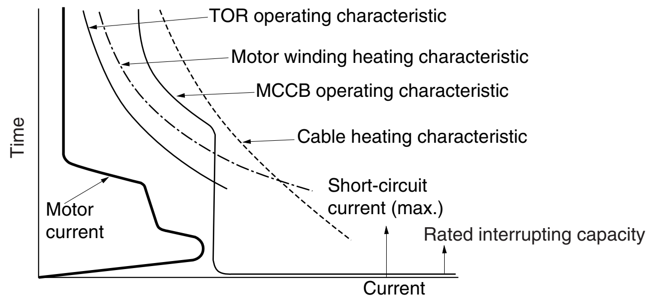
1) The combined protective characteristic curve for the starter and the short-circuit protective device must be under the heating characteristic curve for the motor and cables.
2) The protective devices must not operate at the normal running and starting currents for operation with the rated load.
3) The short-circuit protective device must have sufficient breaking capacity.
4) In the overload region, the starter must operate before the short-circuit protective device.
5) At currents greater than the breaking capacity of the starter, the short-circuit protective device must operate and protect the starter.

(1) Classification and selection of protective coordination

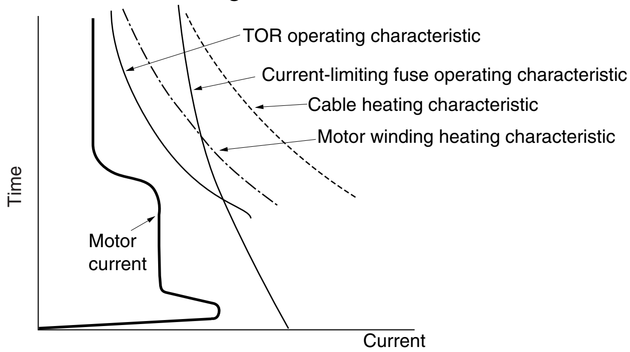
When a short-circuit current flows, although it is interrupted by the short-circuit protective device (SCPD), if the selected combination of starter and SCPD is not appropriate, burning may occur in the starter contacts or the thermal overload relay heater elements due to the electromagnetic energy of the short-circuit current.

Fig. 34 Protective coordination characteristic curves for motor circuits

• When MCCB is used



• When current-limiting fuse is used



(a) Conformance to IEC and JIS standards

The conditions for protective coordination in IEC 60947 and JIS C 8201 are divided into the following two types, and the selection of a combination of starter and short-circuit protective device that will provide protection for each is hypothesized.
The prospective short-circuit current, **r** and rated conditional short-circuit current, **Iq** (which is determined by the manufacturer) are also assumed for the short-circuit current.
The selection tables on pages 96 to 101 give combinations for various short-circuit currents.
The type of protective coordination is classified according to the degree of burning that occurs in the starter due to short-circuits in the following way.

Type 1:
Burning may occur in the starter or thermal overload relay. At inspection, either partial or total replacement may be performed if necessary.

Type 2:
There is no burning. A mild degree of contact welding may occur. The thermal overload relay characteristics satisfy the values specified in the standards. Continuous use without replacement is possible.

(b) Conformance to UL and CSA standards

With UL 508 and CSA C22-2 No. 14, the prospective short-circuit current is specified, contact welding is allowed, and the degree of burning related to the current-limiting fuse and molded case circuit breaker is specified in ratings.
The selection tables on pages 102 to 105 give combinations for various short-circuit currents.

(2) Coordination with short-circuit protective devices (conformance to IEC and JIS)

(a) Prospective short-circuit current, r (240V, 440V)

Starter				Protective coordination						
Starter type	Contactor type	Combined thermal overload relay type	Ampere setting range (A)	Type 1			Type 2			
				Short-circuit current r (kA)	FUJI MCCB *		Short-circuit current r (kA)	Fuse rating IEC 60269-1 gG, gM (A)	FUJI current-limiting fuse	
					Type	Rating (A)			Type	Rating (A)
SW-03/3H SW-03/2E	SC-03	TR-0N/3 TK-0N	0.36–0.54	1	SA33C/3	3	1	2	BLA003	3
			0.48–0.72	1	SA33C/3	3	1	4	BLA005	5
			0.64–0.96	1	SA33C/5	5	1	4	BLA005	5
			0.8–1.2	1	SA33C/5	5	1	4	BLA005	5
			0.95–1.45	1	SA33C/10	10	1	4	BLA005	5
			1.4–2.2	1	SA33C/20	20	1	4	BLA005	5
			1.7–2.6	1	SA33C/20	20	1	6	BLA007	7
			2.2–3.4	1	SA33C/20	20	1	6	BLA007	7
			2.8–4.2	1	SA33C/20	20	1	10	BLA015	15
			4–6	1	SA33C/20	20	1	10	BLA015	15
			5–8	1	SA33C/20	20	1	20	BLA030	30
			6–9	1	SA33C/20	20	1	20	BLA030	30
			7–11	1	SA33C/20	20	1	20	BLA030	30
SW-0/3H SW-0/2E SW-05/3H SW-05/2E	SC-0 SC-05	TR-0N/3 TK-0N	0.36–0.54	1	SA33C/3	3	1	2	BLA003	3
			0.48–0.72	1	SA33C/3	3	1	4	BLA005	5
			0.64–0.96	1	SA33C/5	5	1	4	BLA005	5
			0.8–1.2	1	SA33C/5	5	1	4	BLA005	5
			0.95–1.45	1	SA33C/10	10	1	4	BLA005	5
			1.4–2.2	1	SA33C/20	20	1	4	BLA005	5
			1.7–2.6	1	SA33C/20	20	1	6	BLA007	7
			2.2–3.4	1	SA33C/20	20	1	6	BLA007	7
			2.8–4.2	1	SA33C/20	20	1	10	BLA015	15
			4–6	1	SA33C/20	20	1	10	BLA015	15
			5–8	1	SA33C/20	20	1	20	BLA030	30
			6–9	1	SA33C/20	20	1	20	BLA030	30
			7–11	1	SA33C/20	20	1	20	BLA030	30
			9–13	1	SA33C/30	30	1	25	BLA030	30

Note: * Combination is also possible with an SA33B/☐.

Starter				Protective coordination						
Starter type	Contactor type	Combined thermal overload relay type	Ampere setting range (A)	Type 1			Type 2			
				Short-circuit current r (kA)	FUJI MCCB *		Short-circuit current r (kA)	Fuse rating IEC 60269-1 gG, gM (A)	FUJI current-limiting fuse	
					Type	Rating (A)			Type	Rating (A)
SW-4-0/3H SW-4-0/2E	SC-4-0	TR-5-1N/3 TK-5-1N	0.36–0.54	3	SA33C/3	3	3	2	BLA003	3
			0.48–0.72	3	SA33C/3	3	3	4	BLA005	5
			0.64–0.96	3	SA33C/5	5	3	4	BLA005	5
			0.8–1.2	3	SA33C/5	5	3	4	BLA005	5
			0.95–1.45	3	SA33C/10	10	3	4	BLA005	5
			1.4–2.2	3	SA33C/20	20	3	4	BLA005	5
			1.7–2.6	3	SA33C/20	20	3	6	BLA007	7
			2.2–3.4	3	SA33C/20	20	3	6	BLA007	7
			2.8–4.2	3	SA33C/20	20	3	10	BLA015	15
			4–6	3	SA33C/20	20	3	10	BLA015	15
			5–8	3	SA33C/20	20	3	20	BLA030	30
			6–9	3	SA33C/20	20	3	20	BLA030	30
			7–11	3	SA33C/20	20	3	20	BLA030	30
			9–13	3	SA33C/30	30	3	25	BLA040	40
			12–18	3	SA53C/30	30	3	32	BLA040	40
SW-4-1/3H SW-4-1/2E SW-5-1/3H SW-5-1/2E	SC-4-1 SC-5-1	TR-5-1N/3 TK-5-1N	0.36–0.54	3	SA53C/3	3	3	2	BLA003	3
			0.48–0.72	3	SA53C/3	3	3	4	BLA005	5
			0.64–0.96	3	SA53C/5	5	3	4	BLA005	5
			0.8–1.2	3	SA53C/5	5	3	4	BLA005	5
			0.95–1.45	3	SA53C/10	10	3	4	BLA005	5
			1.4–2.2	3	SA53C/20	20	3	4	BLA005	5
			1.7–2.6	3	SA53C/20	20	3	6	BLA007	7
			2.2–3.4	3	SA53C/20	20	3	6	BLA007	7
			2.8–4.2	3	SA53C/20	20	3	10	BLA015	15
			4–6	3	SA53C/20	20	3	10	BLA015	15
			5–8	3	SA53C/20	20	3	20	BLA030	30
			6–9	3	SA53C/20	20	3	20	BLA030	30
			7–11	3	SA53C/20	20	3	25	BLA040	40
			9–13	3	SA53C/30	30	3	32	BLA040	40
			12–18	3	SA53C/30	30	3	40	BLA060	60
			16–22	3	SA53C/50	50	3	50	BLA075	75

Note: * Combination is also possible with an SA33B/☐ or SA53B/☐.

4-3 Protection of motors

Starter				Protective coordination						
				Type 1			Type 2			
Starter type	Contactor type	Combined thermal overload relay type	Ampere setting range (A)	Short-circuit current r (kA)	FUJI MCCB Type	FUJI MCCB Rating (A)	Short-circuit current r (kA)	Fuse rating IEC 60269-1 gG, gM (A)	FUJI current-limiting fuse Rating (A)	FUJI current-limiting fuse Ampere setting range (A)
SW-N1/3H SW-N1/2E	SC-N1	TR-N2/3 TK-N2	4–6	3	SA63C/60	60	3	25	BLA040	40
			5–8	3	SA63C/60	60	3	25	BLA040	40
			6–9	3	SA63C/60	60	3	25	BLA040	40
			7–11	3	SA63C/60	60	3	32	BLA060	60
			9–13	3	SA63C/60	60	3	32	BLA060	60
			12–18	3	SA63C/60	60	3	32	BLA060	60
			18–26	3	SA63C/60	60	3	50	BLA075	75
			24–36	3	SA63C/60	60	3	50	BLA075	75
SW-N2/3H SW-N2/2E	SC-N2	TR-N2/3 TK-N2	4–6	3	EA103C/75	75	3	25	BLA040	40
			5–8	3	EA103C/75	75	3	25	BLA040	40
			6–9	3	EA103C/75	75	3	25	BLA040	40
			7–11	3	EA103C/75	75	3	32	BLA060	60
			9–13	3	EA103C/75	75	3	32	BLA060	60
			12–18	3	EA103C/75	75	3	32	BLA060	60
			18–26	3	EA103C/75	75	3	50	BLA075	75
			24–36	3	EA103C/75	75	3	50	BLA075	75
			32–42	3	EA103C/75	75	3	50	BLA075	75
SW-N2S/3H SW-N2S/2E	SC-N2S	TR-N3/3 TK-N3	7–11	3	EA103C/100	100	3	32	BLA060	60
			9–13	3	EA103C/100	100	3	32	BLA060	60
			12–18	3	EA103C/100	100	3	32	BLA060	60
			18–26	3	EA103C/100	100	3	50	BLA075	75
			24–36	3	EA103C/100	100	3	50	BLA075	75
			28–40	3	EA103C/100	100	3	50	BLA075	75
			34–50	3	EA103C/100	100	3	50	BLA075	75
SW-N3/3H SW-N3/2E	SC-N3	TR-N3/3 TK-N3	7–11	5	EA203B/125	125	5	32	BLA060	60
			9–13	5	EA203B/125	125	5	32	BLA060	60
			12–18	5	EA203B/125	125	5	32	BLA060	60
			18–26	5	EA203B/125	125	5	50	BLA075	75
			24–36	5	EA203B/125	125	5	50	BLA075	75
			28–40	5	EA203B/125	125	5	50	BLA075	75
			34–50	5	EA203B/125	125	5	50	BLA075	75
			45–65	5	EA203B/125	125	5	80	BLA100	100
SW-N4/3H SW-N4/2E	SC-N4	TR-N5/3 TK-N5	18–26	5	EA203B/150	150	5	50	BLA075	75
			24–36	5	EA203B/150	150	5	50	BLA075	75
			28–40	5	EA203B/150	150	5	50	BLA075	75
			34–50	5	EA203B/160	160	5	50	BLA075	75
			45–65	5	EA203B/150	150	5	80	BLA100	100
			53–80	5	EA203B/150	150	5	100	BLA125	125

Starter				Protective coordination						
Starter type	Contactor type	Combined thermal overload relay type	Ampere setting range (A)	Type 1			Type 2			
				Short-circuit current r (kA)	FUJI MCCB Type	Rating (A)	Short-circuit current r (kA)	Fuse rating IEC 60269-1 gG, gM (A)	FUJI current-limiting Type	Rating (A)
SW-N5/3H SW-N5/2E	SC-N5	TR-N5/3 TK-N5	18–26	5	EA203B/175	175	5	50	BLA075	75
			24–36	5	EA203B/175	175	5	50	BLA075	75
			28–40	5	EA203B/175	175	5	50	BLA075	75
			34–50	5	EA203B/175	175	5	50	BLA075	75
			45–65	5	EA203B/175	175	5	80	BLA100	100
			53–80	5	EA203B/175	175	5	100	BLA125	125
			65–95	5	EA203B/175	175	5	100	BLA125	125
			85–105	5	EA203B/175	175	5	125	BLA150	150
SW-N6/3H SW-N6/2E	SC-N6	TR-N6/3 TK-N6	45–65	10	EA203B/225	225	10	160	BLA200	200
			53–80	10	EA203B/225	225	10	160	BLA200	200
			65–95	10	EA203B/225	225	10	160	BLA200	200
			85–125	10	EA203B/225	225	10	160	BLA200	200
SW-N7/3H SW-N7/2E	SC-N7	TR-N7/3 TK-N7	45–65	10	SA403B/350	350	10	160	BLA200	200
			53–80	10	SA403B/350	350	10	160	BLA200	200
			65–95	10	SA403B/350	350	10	160	BLA200	200
			85–125	10	SA403B/350	350	10	160	BLA200	200
			110–160	10	SA403B/350	350	10	160	BLA200	200
SW-N8/3H SW-N8/2E	SC-N8	TR-N8/3 TK-N8	65–95	10	SA403B/350	350	10	200	FCK2-250	250
			85–125	10	SA403B/350	350	10	200	FCK2-250	250
			110–160	10	SA403B/350	350	10	200	FCK2-250	250
			125–185	10	SA403B/350	350	10	200	FCK2-250	250
SW-N10/3H SW-N10/2E	SC-N10	TR-N10/3 TK-N10	85–125	10	EA403B/400	400	10	200	FCK2-250	250
			110–160	10	EA403B/400	400	10	200	FCK2-250	250
			125–185	10	EA403B/400	400	10	250	FCK2-300	300
			160–240	10	EA403B/400	400	10	250	FCK2-300	300
SW-N11/3H SW-N11/2E	SC-N11	TR-N12/3 TK-N12	110–160	10	SA403B/400	400	10	315	–	–
			125–185	10	SA403B/400	400	10	315	–	–
			160– 240	10	SA403B/400	400	10	315	–	–
			200–300	10	SA403B/400	400	10	315	–	–
SW-N12/3H SW-N12/2E	SC-N12	TR-N12/3 TK-N12	110–160	18	SA603R *	600	18	450	–	–
			125–185	18	SA603R *	600	18	450	–	–
			160–240	18	SA603R *	600	18	450	–	–
			200–300	18	SA603R *	600	18	450	–	–
			240–360	18	SA603R *	600	18	450	–	–
			300–450	18	SA603R *	600	18	450	–	–
SW-N14/3H SW-N14/2E	SC-N14	TR-N14/3 TK-N14	240–360	18	SA803R/800	800	–	–	–	–
			300–450	18	SA803R/800	800	–	–	–	–
			400–600	18	SA803R/800	800	–	–	–	–
–	SC-N16	–	–	30	S1203/1200	1,200	–	–	–	–

Note: * Not based on IEC 60947 Type 1.

(b) Rated conditional short-circuit current, Iq (240V, 440V)

Starter				Protective coordination						
Starter type	Contactor type	Combined thermal overload relay type	Ampere setting range (A)	Type 1			Type 2			
				Short-circuit current Iq (kA)	FUJI MCCB Type	FUJI MCCB Rating (A)	Short-circuit current Iq (kA)	Fuse rating IEC 60269-1 gG, gM (A)	FUJI current-limiting Type	FUJI current-limiting Rating (A)
SW-N1/3H SW-N1/2E	SC-N1	TR-N2/3 TK-N2	4–6	18	SA103RA/50	50	50	20	BLA030	30
			5–8	18	SA103RA/50	50	50	20	BLA030	30
			6–9	18	SA103RA/50	50	50	20	BLA030	30
			7–11	18	SA103RA/50	50	50	25	BLA040	40
			9–13	18	SA103RA/50	50	50	25	BLA040	40
			12–18	18	SA103RA/50	50	50	25	BLA040	40
			18–26	18	SA103RA/60	60	50	50	BLA075	75
			24–36	18	SA103RA/60	60	50	50	BLA075	75
SW-N2/3H SW-N2/2E	SC-N2	TR-N2/3 TK-N2	4–6	18	SA103RA/50	50	50	20	BLA030	30
			5–8	18	SA103RA/50	50	50	20	BLA030	30
			6–9	18	SA103RA/50	50	50	20	BLA030	30
			7–11	18	SA103RA/50	50	50	25	BLA040	40
			9–13	18	SA103RA/50	50	50	25	BLA040	40
			12–18	18	SA103RA/50	50	50	25	BLA040	40
			18–26	18	SA103RA/60	60	50	50	BLA075	75
			24–36	18	SA103RA/60	60	50	50	BLA075	75
			32–42	18	SA103RA/60	60	50	50	BLA075	75
SW-N2S/3H SW-N2S/2E	SC-N2S	TR-N3/3 TK-N3	7–11	18	SA103RA/100	100	50	25	BLA040	40
			9–13	18	SA103RA/100	100	50	25	BLA040	40
			12–18	18	SA103RA/100	100	50	25	BLA040	40
			18–26	18	SA103RA/100	100	50	50	BLA075	75
			24–36	18	SA103RA/100	100	50	50	BLA075	75
			28–40	18	SA103RA/100	100	50	50	BLA075	75
			34–50	18	SA103RA/100	100	50	50	BLA075	75
SW-N3/3H SW-N3/2E	SC-N3	TR-N3/3 TK-N3	7–11	18	SA103RA/100	100	50	25	BLA040	40
			9–13	18	SA103RA/100	100	50	25	BLA040	40
			12–18	18	SA103RA/100	100	50	25	BLA040	40
			18–26	18	SA103RA/100	100	50	50	BLA075	75
			24–36	18	SA103RA/100	100	50	50	BLA075	75
			28–40	18	SA103RA/100	100	50	50	BLA075	75
			34–50	18	SA103RA/100	100	50	50	BLA075	75
			45–65	18	SA103RA/100	100	50	80	BLA100	100
SW-N4/3H SW-N4/2E	SC-N4	TR-N5/3 TK-N5	18–26	18	SA103RA/100	100	50	50	BLA075	75
			24–36	18	SA103RA/100	100	50	50	BLA075	75
			28–40	18	SA103RA/100	100	50	50	BLA075	75
			34–50	18	SA103RA/100	100	50	50	BLA075	75
			45–65	18	SA103RA/100	100	50	80	BLA100	100
			53–80	18	SA103RA/100	100	50	100	BLA125	125

Starter				Protective coordination						
Starter type	Contactor type	Combined thermal overload relay type	Ampere setting range (A)	Type 1			Type 2			
				Short-circuit current Iq (kA)	FUJI MCCB Type	FUJI MCCB Rating	Short-circuit current Iq (kA)	Fuse rating IEC 60269-1 gG, gM (A)	FUJI current-limiting Type	FUJI current-limiting Rating
SW-N5/3H SW-N5/2E	SC-N5	TR-N5/3 TK-N5	18–26	18	H203B/150	150	50	50	BLA075	75
			24–36	18	H203B/150	150	50	50	BLA075	75
			28–40	18	H203B/150	150	50	50	BLA075	75
			34–50	18	H203B/150	150	50	50	BLA075	75
			45–65	18	H203B/150	150	50	80	BLA100	100
			53–80	18	H203B/150	150	50	100	BLA125	125
			65–95	18	H203B/150	150	50	100	BLA125	125
			85–105	18	H203B/150	150	50	125	BLA150	150
SW-N6/3H SW-N6/2E	SC-N6	TR-N6/3 TK-N6	45–65	25	H203B/225	225	50	100	BLA125	125
			53–80	25	H203B/225	225	50	100	BLA125	125
			65–95	25	H203B/225	225	50	100	BLA125	125
			85–125	25	H203B/225	225	50	125	BLA150	150
SW-N7/3H SW-N7/2E	SC-N7	TR-N7/3 TK-N7	45–65	25	H203B/225	225	50	100	BLA125	125
			53–80	25	H203B/225	225	50	100	BLA125	125
			65–95	25	H203B/225	225	50	100	BLA125	125
			85–125	25	H203B/225	225	50	125	BLA150	150
			110–160	25	H203B/225	225	50	160	BLA200	200
SW-N8/3H SW-N8/2E	SC-N8	TR-N8/3 TK-N8	65–95	35	H203B/225	225	50	200	–	–
			85–125	35	H203B/225	225	50	200	–	–
			110–160	35	H203B/225	225	50	200	–	–
			125–185	35	H203B/225	225	50	200	–	–
SW-N10/3H SW-N10/2E	SC-N10	TR-N10/3 TK-N10	85–125	35	SA403R/300	300	50	200	–	–
			110–160	35	SA403R/300	300	50	200	–	–
			125–185	35	SA403R/300	300	50	250	–	–
			160–240	35	SA403R/300	300	50	250	–	–
SW-N11/3H SW-N11/2E	SC-N11	TR-N12/3 TK-N12	110–160	35	SA403R/400	400	50	315	–	–
			125–185	35	SA403R/400	400	50	315	–	–
			160–240	35	SA403R/400	400	50	315	–	–
			200–300	35	SA403R/400	400	50	315	–	–
SW-N12/3H SW-N12/2E	SC-N12	TR-N12/3 TK-N12	110–160	35	SA603R *	600	50	450	–	–
			125–185	35	SA603R *	600	50	450	–	–
			160–240	35	SA603R *	600	50	450	–	–
			200–300	35	SA603R *	600	50	450	–	–
			240–360	35	SA603R *	600	50	450	–	–
			300–450	35	SA603R *	600	50	450	–	–
SW-N14/3H SW-N14/2E	SC-N14	TR-N14/3 TK-N14	240–360	50	SA803R/800	800	–	–	–	–
			300–450	50	SA803R/800	800	–	–	–	–
			400–600	50	SA803R/800	800	–	–	–	–
–	SC-N16	–	–	50	SA803R/800	800	–	–	–	–

Note: * Not based on IEC 60947 Type 1.

(3) Coordination with short-circuit protective devices (conformance to UL and CSA)

Starter				Protective coordination		
Starter type	Contactor type	Combined thermal overload relay type	Ampere setting range (A)	Short-circuit current (kA)	Rated current for 600V AC current-limiting fuse	Rated current for 600V AC molded case circuit breaker
SW-03/3H SW-03/2E	SC-03	TR-0N/3 TK-0N	0.1 to 0.15	5	1	15
			0.15 to 0.24	5	1	15
			0.24 to 0.36	5	2	15
			0.36 to 0.54	5	3	15
			0.48 to 0.72	5	3	15
			0.64 to 0.96	5	3	15
			0.8 to 1.2	5	5	15
			0.95 to 1.45	5	5	15
			1.4 to 2.2	5	10	15
			1.7 to 2.6	5	10	15
			2.2 to 3.4	5	15	15
			2.8 to 4.2	5	15	15
			4 to 6	5	15	15
			5 to 8	5	20	15
SW-0/3H SW-0/2E SW-05/3H SW-05/2E	SC-0 SC-05	TR-0N/3 TK-0N	0.1 to 0.15	5	1	15
			0.15 to 0.24	5	1	15
			0.24 to 0.36	5	2	15
			0.36 to 0.54	5	3	15
			0.48 to 0.72	5	3	15
			0.64 to 0.96	5	3	15
			0.8 to 1.2	5	5	15
			0.95 to 1.45	5	5	15
			1.4 to 2.2	5	10	15
			1.7 to 2.6	5	10	15
			2.2 to 3.4	5	15	15
			2.8 to 4.2	5	15	15
			4 to 6	5	15	15
			5 to 8	5	20	15
			6 to 9	5	30	15
			7 to 11	5	30	15
SW-4-0/3H SW-4-0/2E	SC-4-0	TR-5-1N/3 TK-5-1N	0.1 to 0.15	5	1	15
			0.15 to 0.24	5	1	15
			0.24 to 0.36	5	2	15
			0.36 to 0.54	5	3	15
			0.48 to 0.72	5	3	15
			0.64 to 0.96	5	3	15
			0.8 to 1.2	5	5	15
			0.95 to 1.45	5	5	15
			1.4 to 2.2	5	10	15
			1.7 to 2.6	5	10	15
			2.2 to 3.4	5	15	15
			2.8 to 4.2	5	15	15
			4 to 6	5	15	15
			5 to 8	5	20	15
			6 to 9	5	30	15
			7 to 11	5	30	15
			9 to 13	5	30	20
			12 to 18	5	50	40

Note: Use a current-limiting fuse or molded case circuit breaker that is listed by UL, CSA.
Select a breaker that is suitable for the rated operating voltage and the application.

Starter				Protective coordination		
Starter type	Contactor type	Combined thermal overload relay type	Ampere setting range (A)	Short-circuit current (kA)	Rated current for 600V AC current-limiting fuse	Rated current for 600V AC molded case circuit breaker
SW-4-1/3H SW-4-1/2E SW-5-1/3H SW-5-1/2E	SC-4-1 SC-5-1	TR-5-1N/3 TK-5-1N	0.1 to 0.15	5	1	15
			0.15 to 0.24	5	1	15
			0.24 to 0.36	5	2	15
			0.36 to 0.54	5	3	15
			0.48 to 0.72	5	3	15
			0.64 to 0.96	5	3	15
			0.8 to 1.2	5	5	15
			0.95 to 1.45	5	5	15
			1.4 to 2.2	5	10	15
			1.7 to 2.6	5	10	15
			2.2 to 3.4	5	15	15
			2.8 to 4.2	5	15	15
			4 to 6	5	15	15
			5 to 8	5	20	15
			6 to 9	5	30	15
			7 to 11	5	30	15
			9 to 13	5	30	20
			12 to 18	5	50	40
SW-N1/3H SW-N1/2E	SC-N1	TR-N2/3 TK-N2	4 to 6	5	20	60
			5 to 8	5	20	60
			6 to 9	5	20	60
			7 to 11	5	20	60
			9 to 13	5	20	60
			12 to 18	5	50	60
			18 to 26	5	50	60
			24 to 36	5	50	60
SW-N2/3H SW-N2/2E	SC-N2	TR-N2/3 TK-N2	4 to 6	5	20	60
			5 to 8	5	20	60
			6 to 9	5	20	60
			7 to 11	5	20	60
			9 to 13	5	20	60
			12 to 18	5	50	60
			18 to 26	5	50	60
			24 to 36	5	50	60
			32 to 42	5	70	70

Starter				Protective coordination		
Starter type	Contactor type	Combined thermal overload relay type	Ampere setting range (A)	Short-circuit current (kA)	Rated current for 600V AC current-limiting fuse	Rated current for 600V AC molded case circuit breaker
SW-N2S/3H SW-N2S/2E	SC-N2S	TR-N3/3 TK-N3	7 to 11	5	20	60
			9 to 13	5	20	60
			12 to 18	5	50	60
			18 to 26	5	50	60
			24 to 36	5	50	60
			28 to 40	5	70	70
			34 to 50	5	70	70
			45 to 65	5	125	125
SW-N3/3H SW-N3/2E	SC-N3	TR-N3/3 TK-N3	7 to 11	5	20	60
			9 to 13	5	20	60
			12 to 18	5	50	60
			18 to 26	5	50	60
			24 to 36	5	50	60
			28 to 40	5	70	70
			34 to 50	5	70	70
			45 to 65	5	125	125
			48 to 68	5	125	125
SW-N4/3H SW-N4/2E	SC-N4	TR-N5/3 TK-N5	18 to 26	5	50	60
			24 to 36	5	50	60
			28 to 40	5	70	70
			34 to 50	5	70	70
			45 to 65	5	125	125
			53 to 80	10	150	125
SW-N5/3H SW-N5/2E	SC-N5	TR-N5/3 TK-N5N	18 to 26	5	50	60
			24 to 36	5	50	60
			28 to 40	5	70	70
			34 to 50	5	70	70
			45 to 65	5	125	125
			53 to 80	10	150	125
			65 to 95	10	150	125
			85 to 105	10	150	125
SW-N6/3H SW-N6/2E	SC-N6	TR-N6/3 TK-N6	45 to 65	10	150	175
			53 to 80	10	150	175
			65 to 95	10	150	175
			85 to 125	10	150	175
SW-N7/3H SW-N7/2E	SC-N7	TR-N7/3 TK-N7	45 to 65	10	150	175
			53 to 80	10	150	175
			65 to 95	10	150	175
			85 to 125	10	150	175
			110 to 160	10	200	225

Note: Use a current-limiting fuse or molded case circuit breaker that is listed by UL, CSA.
Select a breaker that is suitable for the rated operating voltage and the application.

Starter				Protective coordination		
Starter type	Contactor type	Combined thermal overload relay type	Ampere setting range (A)	Short-circuit current (kA)	Rated current for 600V AC current-limiting fuse	Rated current for 600V AC molded case circuit breaker
SW-N8/3H SW-N8/2E	SC-N8	TR-N8/3 TK-N8	65 to 95	10	225	400
			85 to 125	10	225	400
			110 to 160	10	225	400
			125 to 185	10	225	400
SW-N10/3H SW-N10/2E	SC-N10	TR-N10/3 TK-N10	85 to 125	10	300	400
			110 to 160	10	300	400
			125 to 185	10	300	400
			160 to 240	10	300	400
SW-N11/3H SW-N11/2E	SC-N11	TR-N11/3 TK-N11	110 to 160	18	300	400
			125 to 185	18	300	400
			160 to 240	18	300	400
			200 to 300	18	300	400
SW-N12/3H SW-N12/2E	SC-N12	TR-N12/3 TK-N12	110 to 160	18	300	400
			125 to 185	18	300	400
			160 to 240	18	300	400
			200 to 300	18	450	600
			240 to 360	18	450	600
			300 to 450	18	450	600
SW-N14/3H SW-N14/2E	SC-N14	TR-N14/3 TK-N14	240 to 360	30	800	800
			300 to 450	30	800	800
			400 to 600	30	800	800
–	SC-N16	–	–	42	1,000	800

⚠ Safety Considerations

- For safe operation, before using the product read the instruction manual or user manual that comes with the product carefully or consult the Fuji sales representative from which you purchased the product.
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