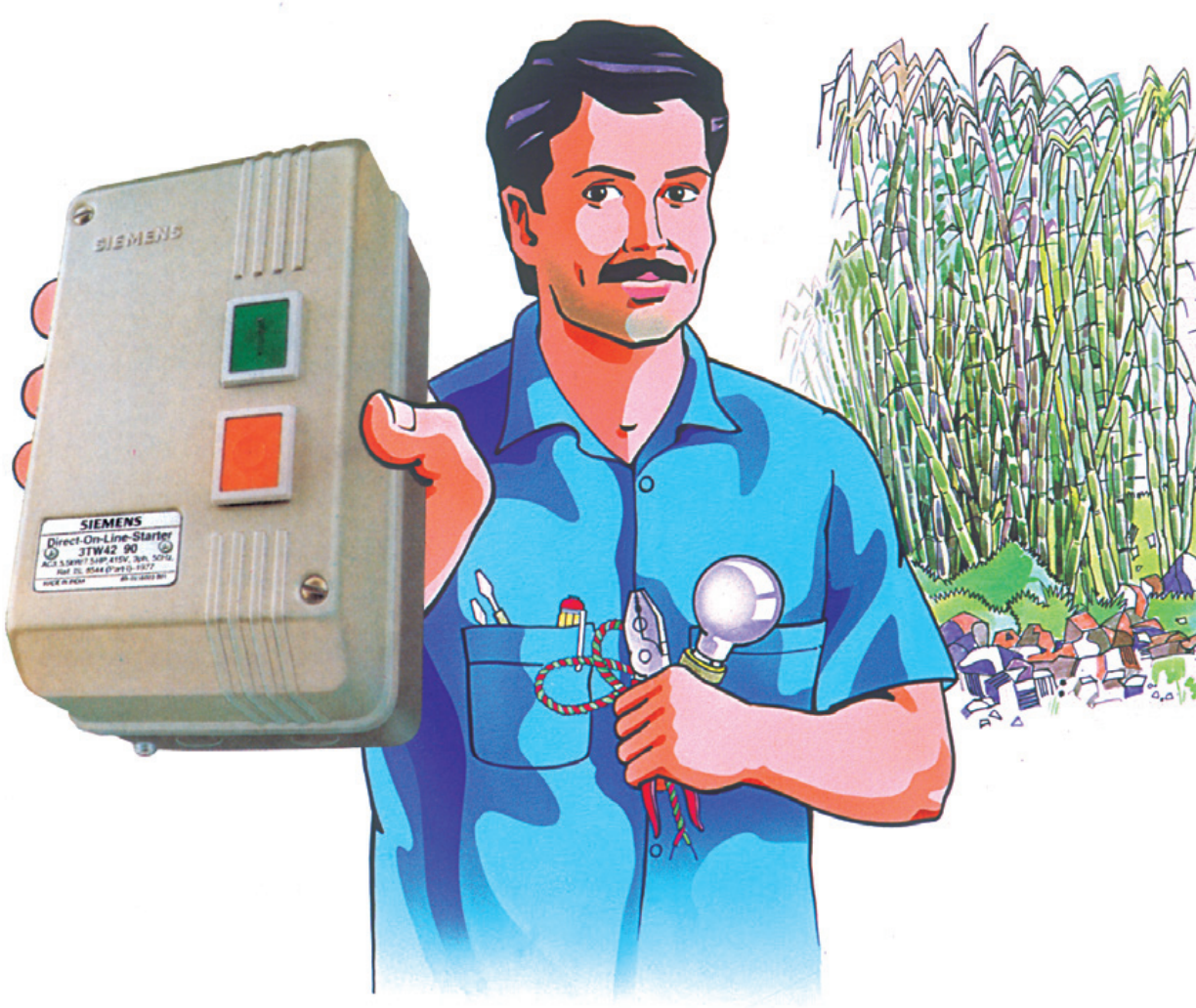
SIEMENS

A pocket guide to Motor Starter Selection & Maintenance



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1. Starter Details:

A motor Starter has two basic functions to perform;

1) Starting and stopping the motor.
2) Providing adequate protection to the motor and safeguarding it in the event of sustained overloads, single phasing, locked rotor conditions and undervoltage.

Siemens makes a wide variety and range of Starters suitable for various applications. However, for small general purpose motor feeders, we normally come across;

a) Direct-on-line starting and
b) Star Delta starting

1.a Direct-On-Line Starting

General:

The most economical and popular method of starting squirrel cage induction motors, is direct-on-line, where the starter is connected directly across the three phases of the supply. However, the starting current at the moment of switching direct-on-line can be as high

Fig. 1

as 6-8 times the rated current. Due to this reason, the Electricity Boards have laid down general regulations that direct-on-line starting of squirrel cage motors shall be allowed only for small motors-upto 5 or 7.5 H.P. This regulation is particularly enforced in rural areas.
The Siemens direct-on-line starter (Ref. Fig. 2) consists of three functional components:

1) The **contactor** which is responsible for the switching function and low voltage protection.
2) The **bimetal overload relay** which is the sensing device that switches off the contactor when the motor gets overloaded or under single phasing.
3) **Push buttons** used for switching 'ON' and 'OFF'

Contactor : The new DOL starter designed by Siemens for motors up to 10 HP is fitted with 3 TW02 type of contactor. This contactor is specially designed by Siemens considering the requirements of industry as well as agriculture.

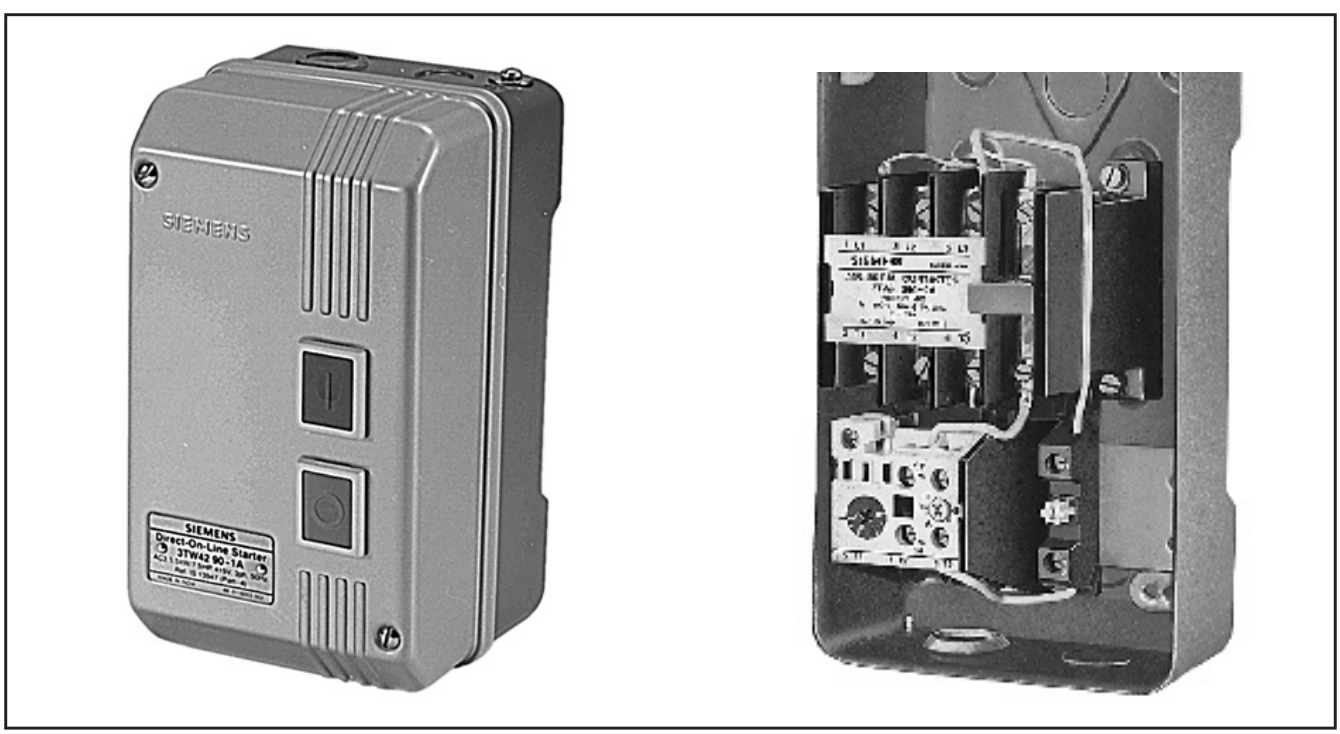


Fig. 2 Direct On Line Starter

Considering the specific need of the agricultural pumpset applications, Siemens has designed a special wide band coil (200-400V). This coil can operate reliably even when there is wide voltage fluctuation.

The contact rating of this contactor is 20 A. This high contact rating has made RAJA starter the most suitable starter even for the starting of 7.5 HP submersible pumps.

Bimetal Overload Relay: The RAJA direct-on-line starter is fitted with the new 3UW50 type of relay. These relays are computer calibrated and therefore, are very accurate.

The main benefit of this bimetal relay is the built-in single phasing protection in addition to the overload protection.

Operation of D.O.L. starter:
For starting, the 'ON' push button is pressed, which energizes the contactor coil, thus switching on the circuit.

When the 'OFF' push button is pressed, the contactor is de-energized, switching off the circuit.

The bimetal relay under normal functioning of motor, plays no active part in the starter. But under overload, single phasing or locked rotor conditions of motor, the bimetal relay cuts-off the supply to the contactor coil, tripping the circuit. The contactor itself provides the necessary 'no-voltage' protection in so far as it will drop out in the case of a supply failure, and for restarting on resumption of supply, the 'ON' push button will have to be pressed again.

1.b Star-Delta Starting:

General:

For squirrel cage motors which cannot be started direct-on-line due to starting current limitations, the simplest alternative is star-delta starting.

In star-delta starting the motor is started in 'star' connection,

the connections being changed over to 'delta' when the motor has reached nearly rated speed. By connecting the motor in 'star' during the starting period, the impressed phase voltage is reduced to 0.58 of the voltage in 'delta' connection. The corresponding line current in 'star' is thus only one-third that in delta. For most motors started direct-on-line, the current at the moment of staring is about six to eight times its rated current and therefore by starting in 'star' the current is reduced to only about 2 to 2.5 times the rated current.

As both, the phase voltage and current are reduced during the starting period in 'star' connection, the torque is also reduced and is only one-third of that in 'delta'. The starting torque produced by normal duty motors is about 150% of the rated torque and hence star-delta starting can be used only with drives where the load torque at the moment of starting is not more than 50% of the rated torque.

Fig. 3 gives a graphical representation of the star-delta phenomena. The motor

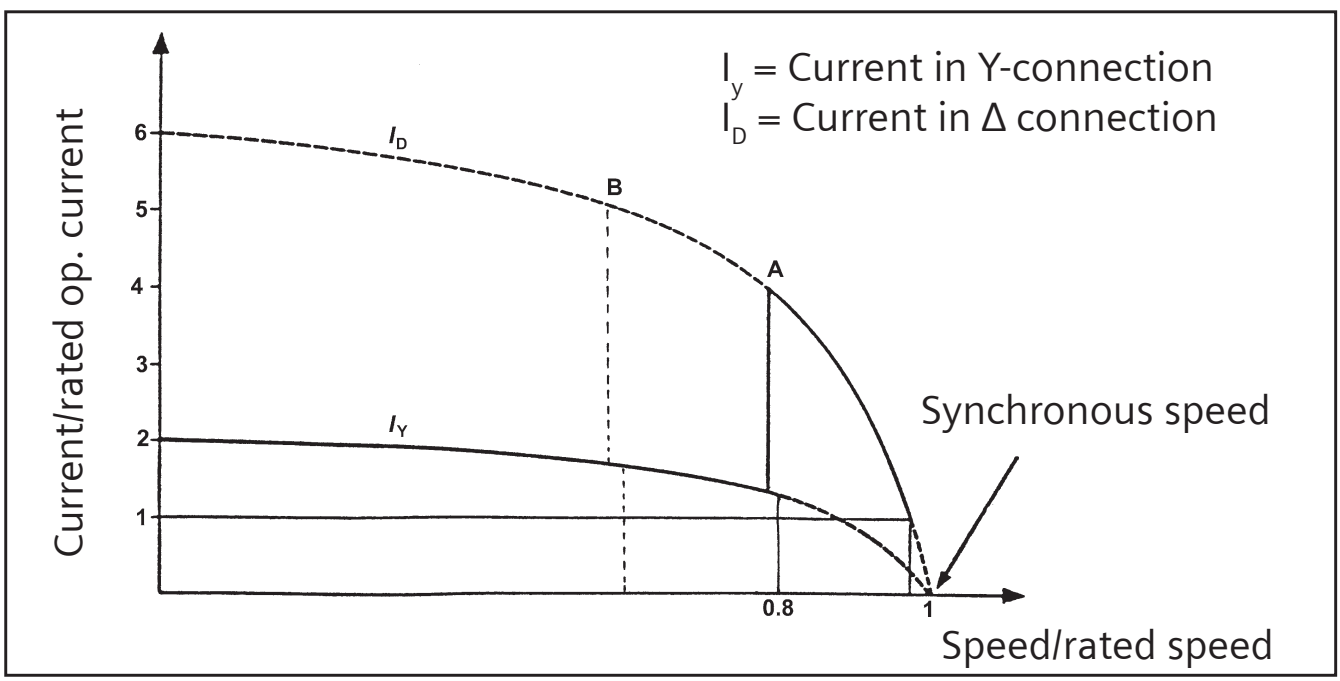


Fig. 3 - Star Delta Principle

is started in 'star' and once it has picked up speed, its connections are changed over to 'delta' However, the timing of the changeover is extremely important. To illustrate this, two changeover points 'A', 'B' have been shown to illustrate the effect of an early changeover. The shape of the delta curve is such that no appreciable limitation of the current is possible till the motor speed has reached at least 80% of its synchronous value.

Siemens manufactures two basic types of Star-delta starters:

1) **Handle Operated Star-Delta Starter** where the changeover of stator connections from 'star' to 'delta' is done manually through a switch.
2) **Automatic Star-Delta Starter** where the changeover of stator connections from 'star' to 'delta' is automatic after a preset time by the use of a timer.

For closer protection of the motor, particularly against single phasing, the overload relay in all Siemens Star-Delta Starters has been connected in the phase circuit, and hence should be set for 0.58 times the actual current drawn by the motor, as measured by an ammeter. In no case should be bimetal setting be more than 0.58 times the rated line current mentioned on the motor name plate.

Star-Delta Starter (Handle Operated):

Siemens RAJA Handle Operated Star-Delta starter type 3LW42 consists of a star-delta switch, a contactor, an overload relay, "Reset" push button and a safety 'ON' push button. (Fig. 4)

This RAJA starter, too, is fitted with the new 3TW02 contactor and the new 3UW50 bimetal overload relay which are discussed in section 1.a above.

The 3LAO is a motor control switch capable of making and

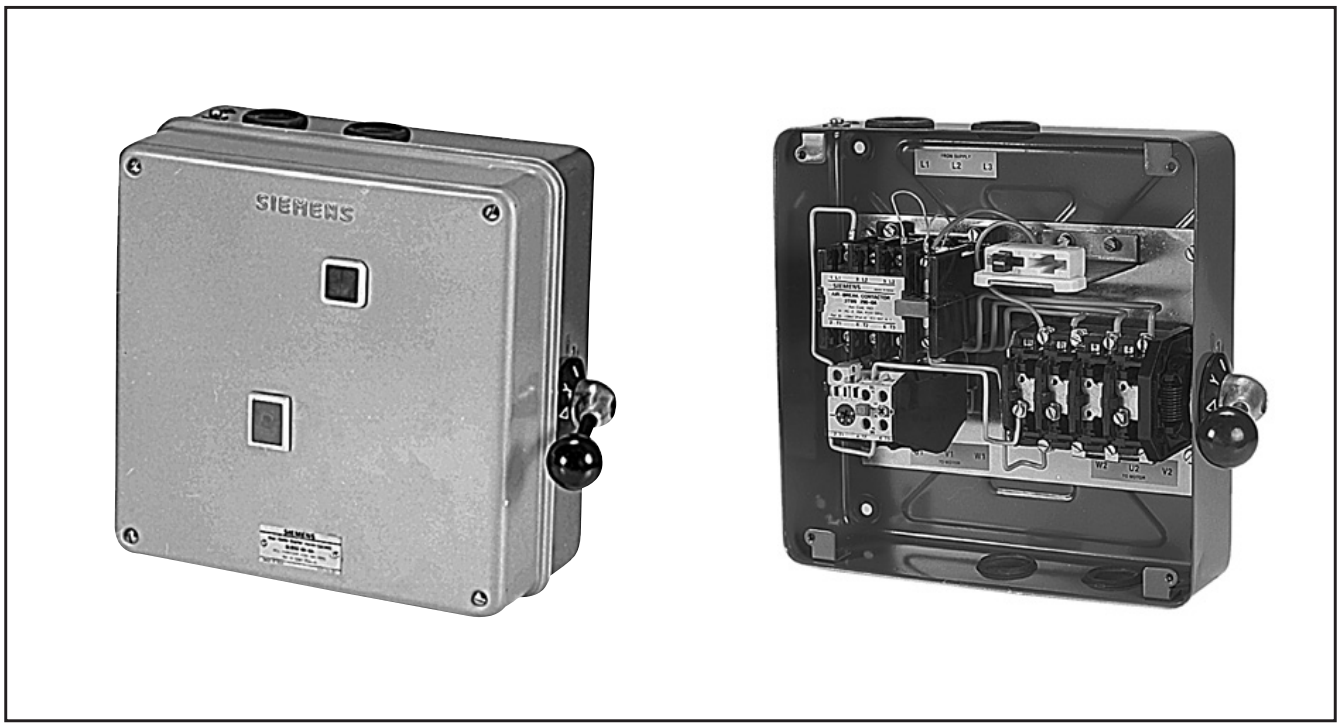


Fig. 4 Star-Delta Starter (Handle Operated)

breaking 6-8 times the rated current. A mechanical life of 50 lakh switching cycles is achieved by the use of a 'form-fit' design of parts. Special bearings are provided where parts of metal rub against plastic. These bearings show 200 times less wear than friction between metals.

The use of silver as contact material and short contact opening paths ensures a contact life of 10 lakh switching cycles.

This switch is used for the star-delta switching function.

Operation:

To start the motor, move the 3LAO switch handle from 'O' position to 'star' (Y) position with the right hand and press the 'start' - (I) push button with your left hand. The motor starts and when it has almost come to its rated speed (indicated when the motor hum reaches a steady pitch), turn the handle to 'delta' position, still taking care to keep the push button pressed.

Only now, the push button and the switch handle can be released.

The safety push button is provided to ensure that the motor cannot be left running in the 'Star' connection due to the negligence or ignorance of the operator, and thereby burn out. Also, the motor cannot be started in 'delta' position.

To stop the motor, bring the handle of the switch to 'O' position. Likewise if the starter trips automatically due to any fault, the switch handle is first to be brought to 'O' position and the bimetal relay has to be reset. Then the starting procedure described above can be adopted.

Automatic Star-Delta Starter:

Automatic Star-Delta Starter type 3TE consists of three contactors, one each for 'line', 'star' and 'delta', a bimetal overload relay, a timer for automatic changeover from 'star' to 'delta' and push buttons for control command. When the 'ON' push button is pressed, the line contactor and the star contactor pick up and the motor runs in 'star'. After the preset starting time, the timer automatically switches off the 'star' contactor and switches 'ON' the 'delta' contactor, thus after the starting period, the motor runs in 'delta'. The OFF push button has been provided to trip the entire circuit.

Siemens provide accurate timers to ensure changeover from 'star' to 'delta' at the correct set time.

Though more expensive, this starter has the added advantage over the Handle Operated star-delta starter in that it is fully automatic. Here the timer can be set initially and all future operations are automatic, thus avoiding the early changeover to 'delta' which could be possible by a hasty or ignorant operator.

2. Selection of Motor Starters

a. RAJA Motor Starters

a-1 RAJA Direct-on-Line Starters

Motor Rating at 415 V 3ph, 50Hz		**Starter Type**	Relay Range	Back-up Fuse Rating (Recommended)		Cu Cable (mm^2) Size
kW	HP			HRC	Rewirable	
0.25	0.33	3TW42 90-1A*64	0.63 - 1	4 A	36 SWG	1
0.55	0.75	3TW42 90-1A*66	1 - 1.6	6 A	34 SWG	1
0.75	1	3TW42 90-1A*68	1.6 - 2.5	6 A	27 SWG	1
1.1	1.5	3TW42 90-1A*69	2 - 3.2	10 A	26 SWG	1
1.5	2	3TW42 90-1A*71	3.2 - 5	16 A	25 SWG	1
2.2	3	3TW42 90-1A*72	4 - 6.3	16 A	24 SWG	1.5
3.7	5	3TW42 90-1A*74	6.3 - 10	25 A	21 SWG	1.5
-	-	3TW42 90-1A*75	8 - 12.5	25 A	19 SWG	1.5
5.5	7.5	3TW42 90-1A*77	10 - 16	32 A	18 SWG	2.5
7.5	10	3TW42 90-1A*78	12.5 - 20	32 A	18 SWG	4

a-2 RAJA Star-Delta Starters (Handle Operated)

Motor Rating at 415 V 3ph, 50Hz		**Starter Type**	Relay Range	Back-up Fuse HRC	Copper Cable (mm^2) Size	
kW	HP				Incoming from Supply	Outgoing to motor
3.7	5	3LW90-0A*72	4 - 6.3A	32 A	2.5	1.5
7.5	10	3LW42 90-0A*74	6.3 - 10	32 A	2.5	1.5
9.3	12.5	3LW42 90-0A*75	8 - 12.5	32 A	2.5	2.5
11	15	3LW42 90-0A*77	10 - 16	32 A	4.0	2.5

*Enter code for coil voltage. (“B” for 200-400V, “W” for 415V)

a-3 Raja Star-Delta Starters (Automatic)

Motor Rating at 415 V 3ph, 50Hz		**Starter Type**	Relay Range	Recommended Back-up Fuse HRC
kW	HP			
9.3	12.5	3TE02 90-0A*75	8 - 12.5	25
11	15	3TE02 90-0A*77	10 - 16	32
15	20	3TE02 90-0A*78	12.5 - 20	50
18.5	25	3TE02 90-0A*79	16 - 25	50

* Enter code for coil voltage, 50Hz. (“D” for 230-400V, “W” for 415V)

b. Other Starters

b-1 Direct-on-Line Starters - 20HP & above (without birelay)

Motor Rating at 415 V 3ph, 50Hz		**Starter Type**	Relay Range (Recommended)	Recommended Back-up Fuse HRC
kW	HP			
15	20	3TW04 94-2A##	3UA55 (20-32A)	50 A
18.5	25	3TW04 95-2A##	3UA55 (25-36A)	63 A
22	30	3TW04 96-2A##	3UA58Z1 (32-50A)	80 A
30	40	3TW04 97-2A##	3UA58Z1 (40-57A)	100 A
37	50	3TW04 98-2A##	3UA58Z2 (57-70A)	125 A
55	75	3TW05 90-2A##	3UA5830 (85-105A)	160 A

Enter code for coil voltage. (“RO” for 415V, “PO” for 230V)

b-2 Higher Rated Automatic Star-Delta Starters (without birelay)

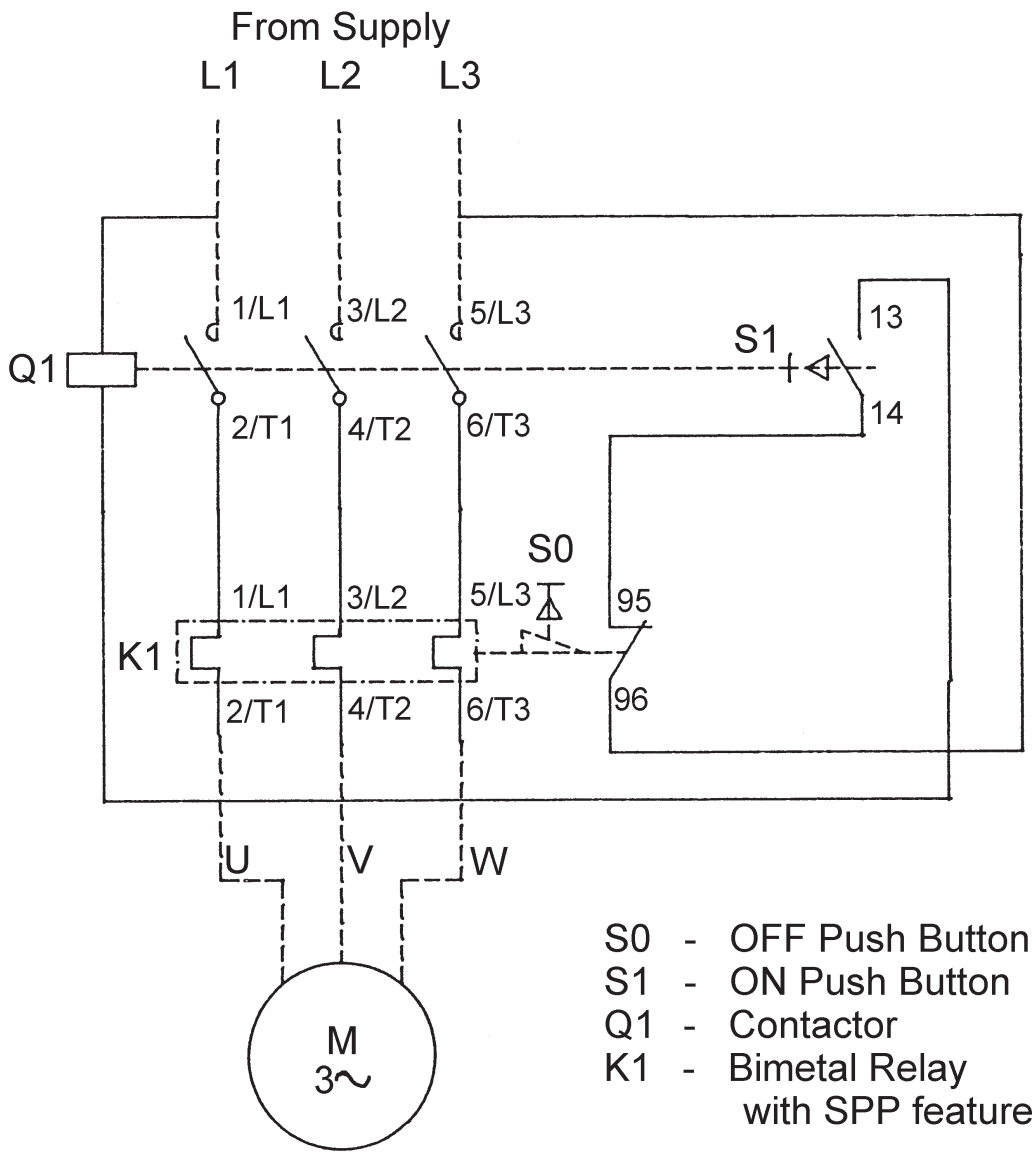
Motor Rating at 415 V 3ph, 50Hz		**Starter Type**	Relay Range (Recommended)	Recommended Back-up Fuse HRC
kW	HP			
22	30	3TE04 94-2A##	3UA55 (16-25A)	50 A
30	40	3TE04 94-2A##	3UA55 (20-32A)	63 A
37	50	3TE04 95-2A##	3UA55 (32-40A)	80 A
45	60	3TE04 96-2A##	3UA58Z1 (32-50A)	100 A
55	75	3TE04 97-2A##	3UA58Z1 (40-57A)	100 A

Enter code for coil voltage. (“RO” for 415V, “PO” for 230V)

3. Wiring Diagrams:

RAJA Direct-On-Line Starter

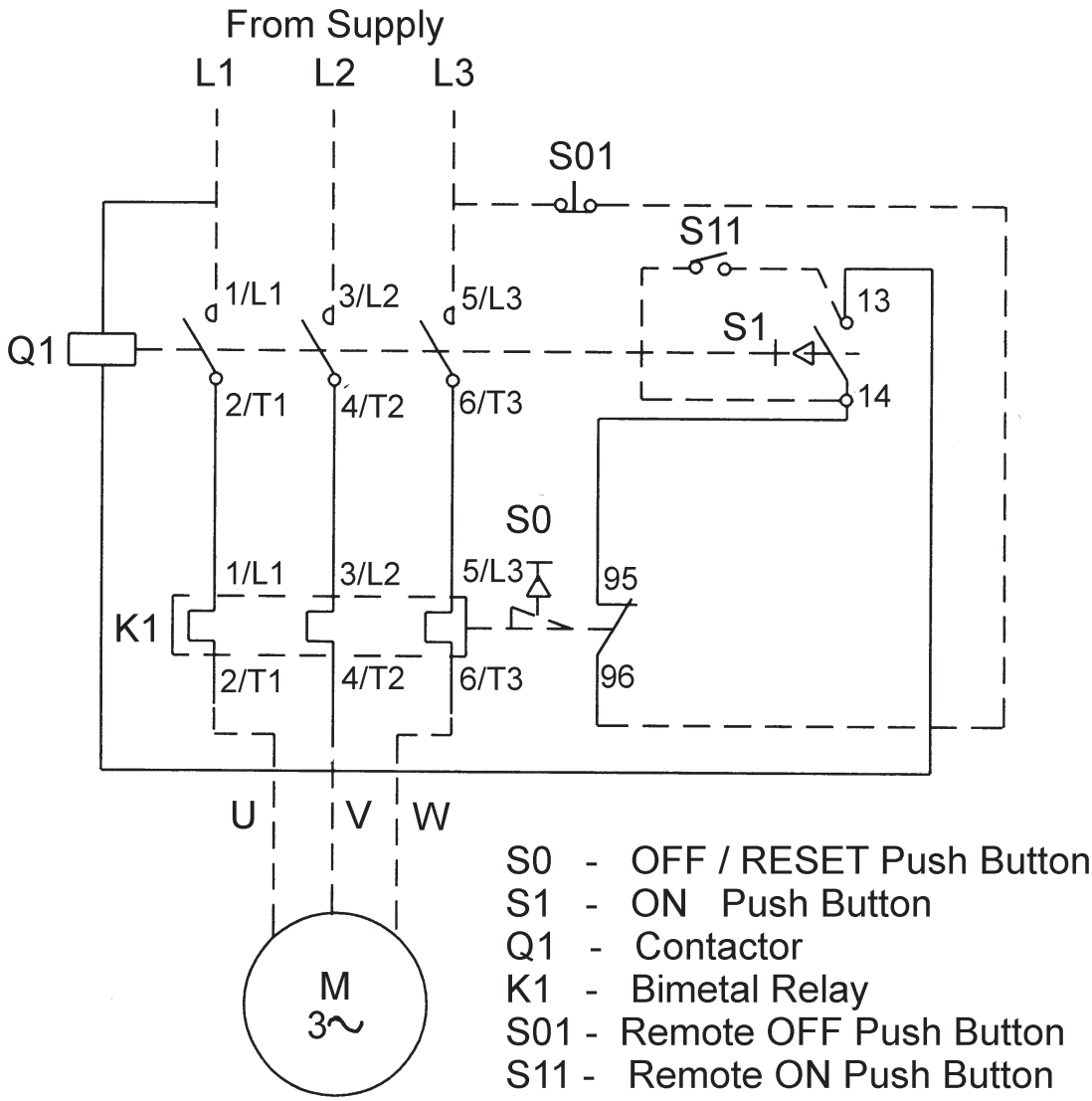
3TW42 90-1A



- Diagram shows connections made for contactor coils rated 200 - 400V (wide-band), 415V (320-455V), 50Hz.
- For coils rated between 220V and 250V 50Hz, disconnect the wire between L3-96 and connect the neutral of the supply system to the terminal 96 of the relay.

RAJA Direct-On-Line Starter (for Remote Operation)

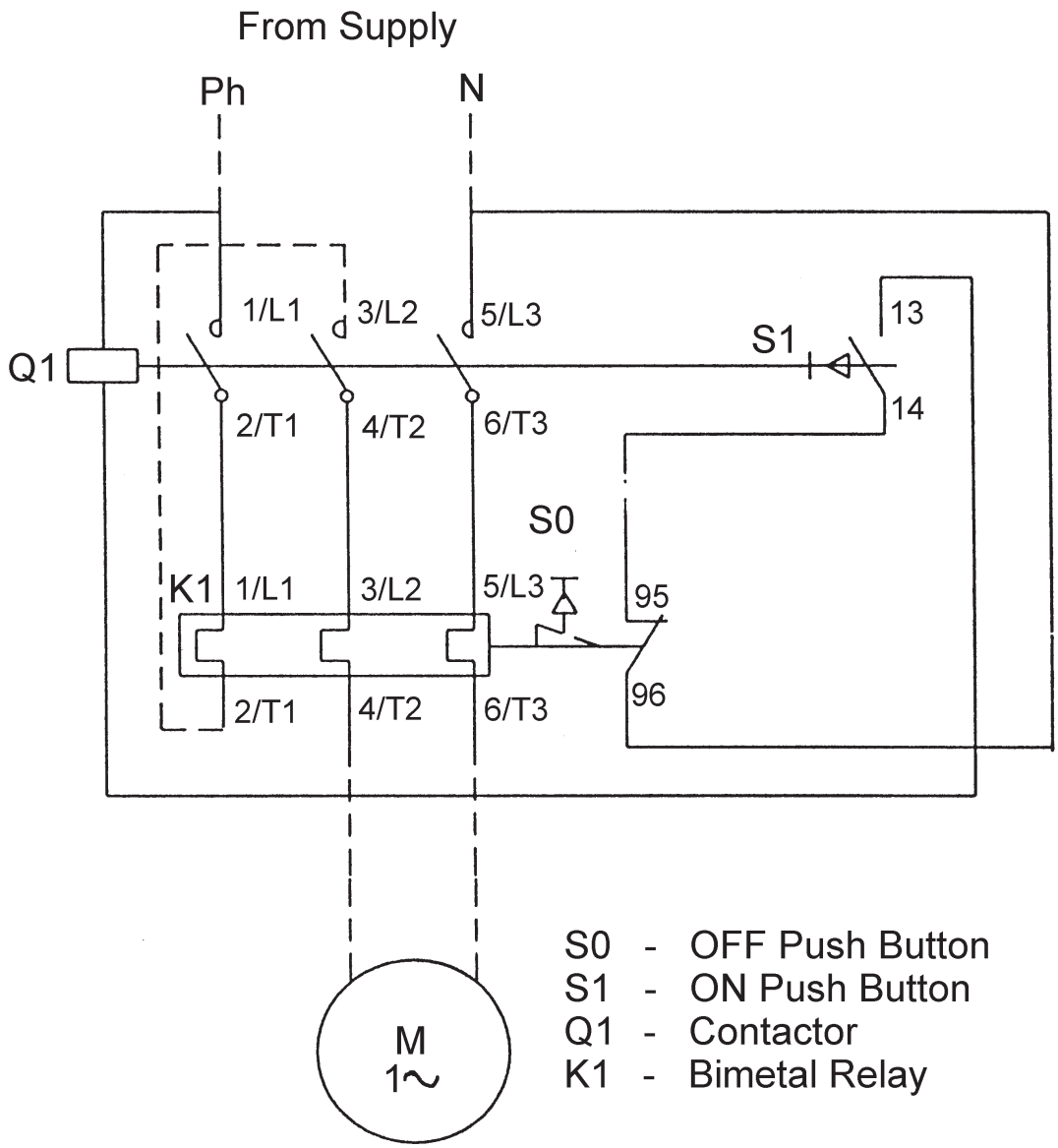
3TW42 90-1A



- Diagram shows connections made for contactor coils rated 200 - 400V (wide-band), 415V (320-455V), 50Hz.
- For remote operation disconnect the wire between terminal 5/L3 on contactor and terminal 96 on the relay. Connect the remote 'OFF' S01 push button as shown. Connect remote 'ON' S11 push button parallel to S1 as shown.

RAJA Direct-On-Line Starter (for Single Phase connection)

3TW42 90-1A

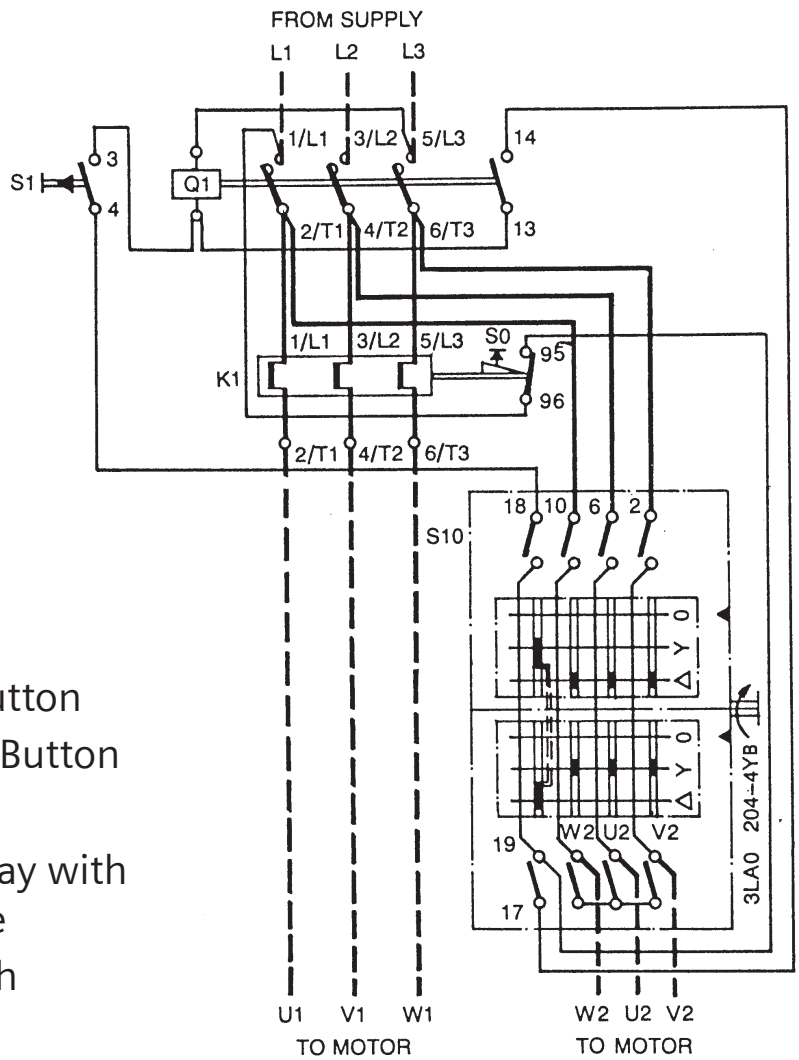


- Wiring Diagram for Single-Phase Motors

Note :
Connect 3/L2 to 2/T1 by cable of suitable size. (max 4 mm^2)

RAJA Star-Delta Starter (Handle Operated)

3LW42 90-0A

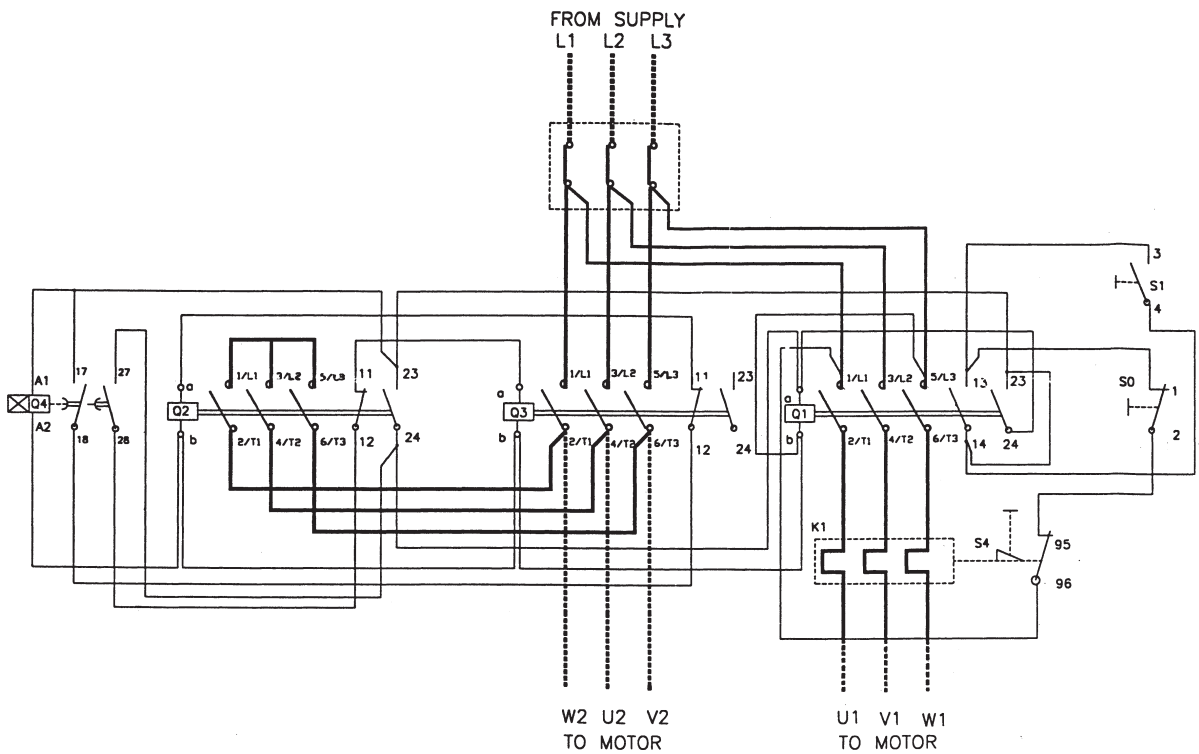


S1 = ON Push Button
S0 = Reset Push Button
Q1 = Contactor
K1 = Bimetal Relay with SPP Feature
S10 = 3LA0 switch

- Diagram shows connections made for contactor coils rated 200 - 400V (wide-band), 415V (320-455V), 50Hz.
- For coils rated between 220V and 250V 50Hz, disconnect the wire between 1/L1-96 and connect the neutral of the supply system to the terminal 96 of the relay.

Star-Delta Starter

3TE02 90-0A



Q1 = Line Contactor (2NO)

Q2 = Star Contactor (1NO + 1NC)

Q3 = Delta Contactor (1NO + 1NC)

S0 = OFF Push Button

S1 = ON Push Button

S4 = Reset Push Button

Q4 = Star Delta Timer with 1NO instantaneous and 1NO delayed Aux. Contact

K1 = Bimetal Relay

- Diagram shows connections made for contactor coils rated between 380V and 500V, 50Hz and for 230V-400V wide band coil.
- For coils rated between 220V and 250V, 50Hz. disconnect Q1.b-Q1.5/L3 and then connect the neutral of the supply system to the terminal Q1.b.

4. Installation & Maintenance guidelines

A. Installation:

a) Use the suitable starter as per your requirements. (Refer section 2 - Selection of Motor Starters)

b) Use the appropriate cable sizes and back-up fuse for smooth operation of the starter. Terminal screws = M4, stripped length = 10 mm, max. = 4 mm^2 copper

c) Mount the starter on vertical, rigid surface (maximum tilt permissible = ±15° with respect to the vertical plane)

d) Use of cable glands is recommended to avoid dust ingress.

e) Set the blue knob on the relay to 'manual' or 'auto' mode as appropriate.

f) Set the relay to actual motor current or as outlined in the operating instructions booklet.

g) Check the 'on'/'off' operation as outlined elsewhere in this brochure.

B. Maintenance

Caution !

Switch off the starter and disconnect the main supply by switching off the main switch before doing any maintenance.

Follow the various maintenance tips given in the operating instruction booklet

Routine Inspection:
Inspect terminals, contacts, arc chambers periodically - two months after installation and every six months thereafter. Routine inspections help to monitor the state of the contactor. These contribute to the reliability of the plant and minimize risk of breakdown during production hours.

Isolation for Maintenance:
Switch off the contactor & upstream devices before inspecting the contactor as a safety precaution.

Terminals:
Tighten terminals periodically
Connections have a tendency to loosen with time -

particularly those of aluminium which is a soft material. The terminals should be tightened with a torque specified in the table.

Screws	Tightening torque. N cm
M 3.0	40 - 55
M 3.5	80 - 100
M 4.0	80 - 100

Contact Condition:

Tarnished/Blackened Contact : Tarnishing is normal for any silver item, it is due to the formation of silver oxide which is a good conductor of heat and electricity, hence tarnished contacts need not be replaced. Blackened or sooty contacts which are otherwise in a good condition need not be replaced. These contacts can be cleaned with CRC 2-26.

Do not replace slightly pitted contact.

Whether a contact is good or not depends on the volume of contact material which remains in it. Replace contacts when the contact tip has become less than 40% of its original volume.

Do not employ carbon impression method to check healthiness of contacts.

Do not use abrasives e.g. do not file contacts, do not use emery paper on contacts. Abrasives remove silver from the contact tip & drastically reduce the contact life.

Do not grease the contacts.

The contact condition should be inspected after a fault i.e. short circuit. If the contacts are slightly welded, separate them with a screw driver. Slight but separable welding does not affect the performance of the contactor, its acceptability is recognized by IS13947/IEC 947 specifications.

If the contacts are not easily separable i.e. permanently welded, replace the contacts and use the contactor, provided its other parts are in proper condition. Replacing the complete contactor is not necessary in such a case.

Replace contacts in pairs i.e. fixed & moving contacts of one pole together. This ensures proper mating of the contact tips.

After replacing contacts, operate the contactor a few times before putting it back to normal service.

Do not replace the contacts after the mechanical life is over. Maximum number of replacements is about 4; after which the contactor requires replacement.

Magnets:
In case of rust/dust accumulation on the magnet faces, clean them with CRC 2-26/ Chamoi leather. Do not use degreasing agent as petrol. Dust/rust affect contactor performance and cause humming.
Do not clean magnets with sharp/pointed objects. Filing upsets the mating of the magnet faces. Clean lightly with fine size 00 emery paper if required.

Mechanical Life:
When the mechanical life of the contactor is over, replace the complete contactor.
Following are the indicators of the end of mechanical life.

- For E shaped magnet, air gap between the central limbs is reduced to zero. This is indicated when there is rubbing of paint on the central pole face of the upper magnet.
- Broken shading ring of the magnet.
- Flaring of magnet pole faces, hence difficulty in removing coil.
- Incurable humming.
- Sluggish operation.
- Contactor does not drop off.

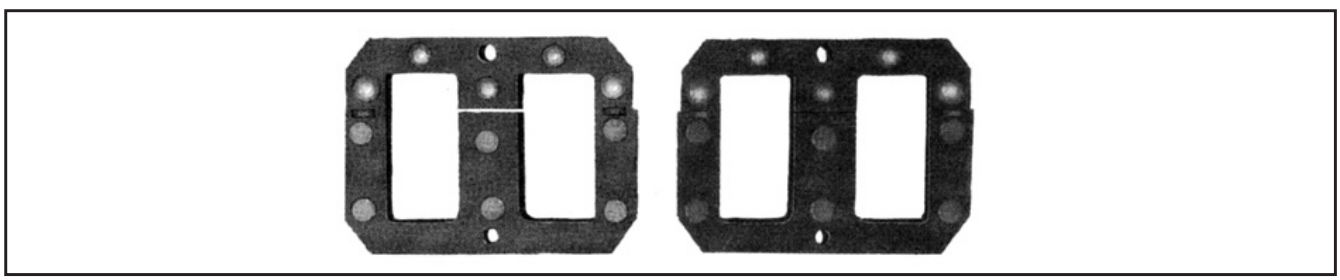
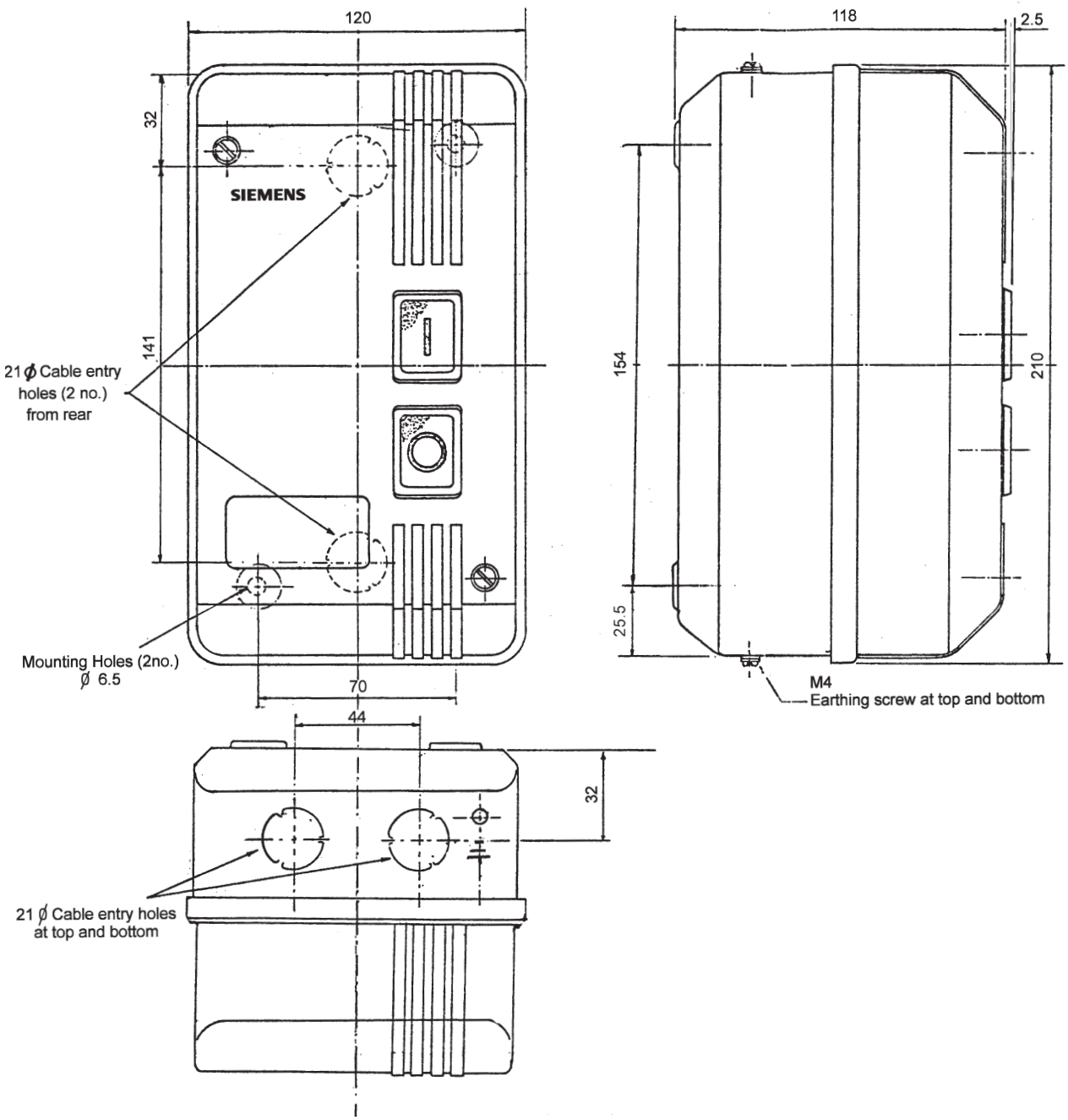


Fig. 5

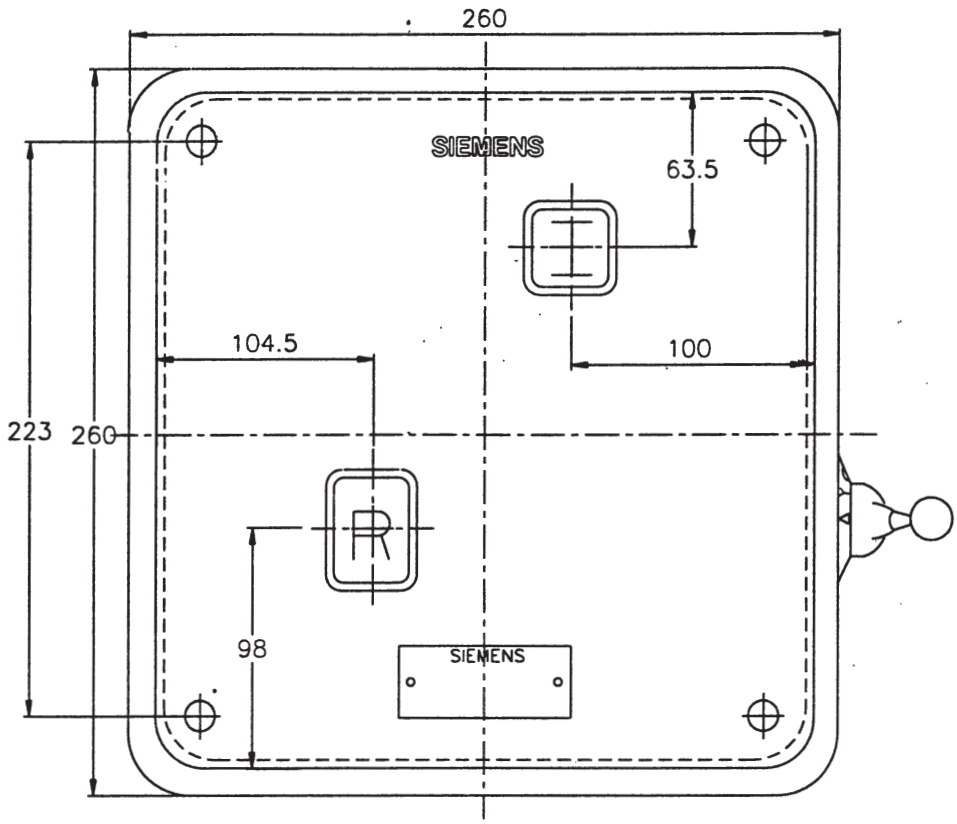
C. Dimensional Drawings:

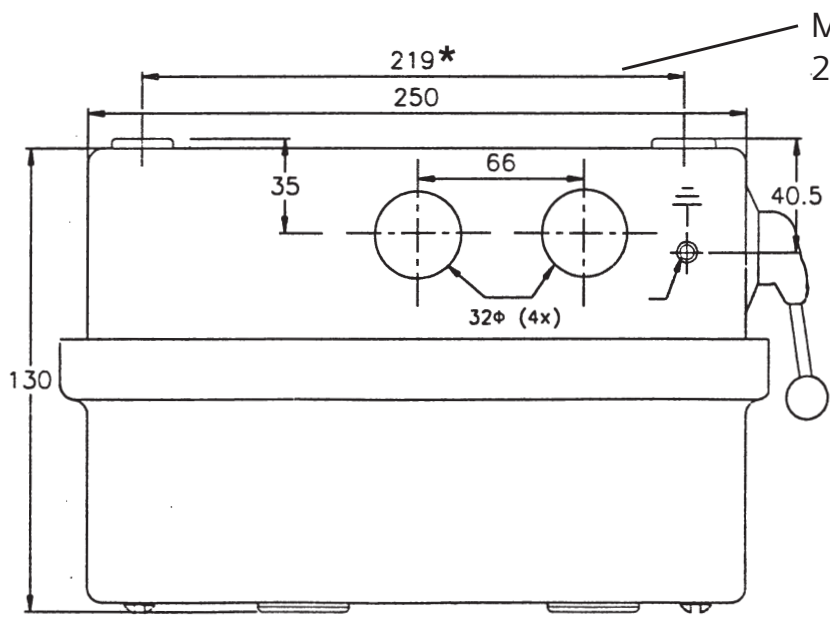
RAJA Direct-On-Line Starter



RAJA Star-Delta Starter Handle Operated

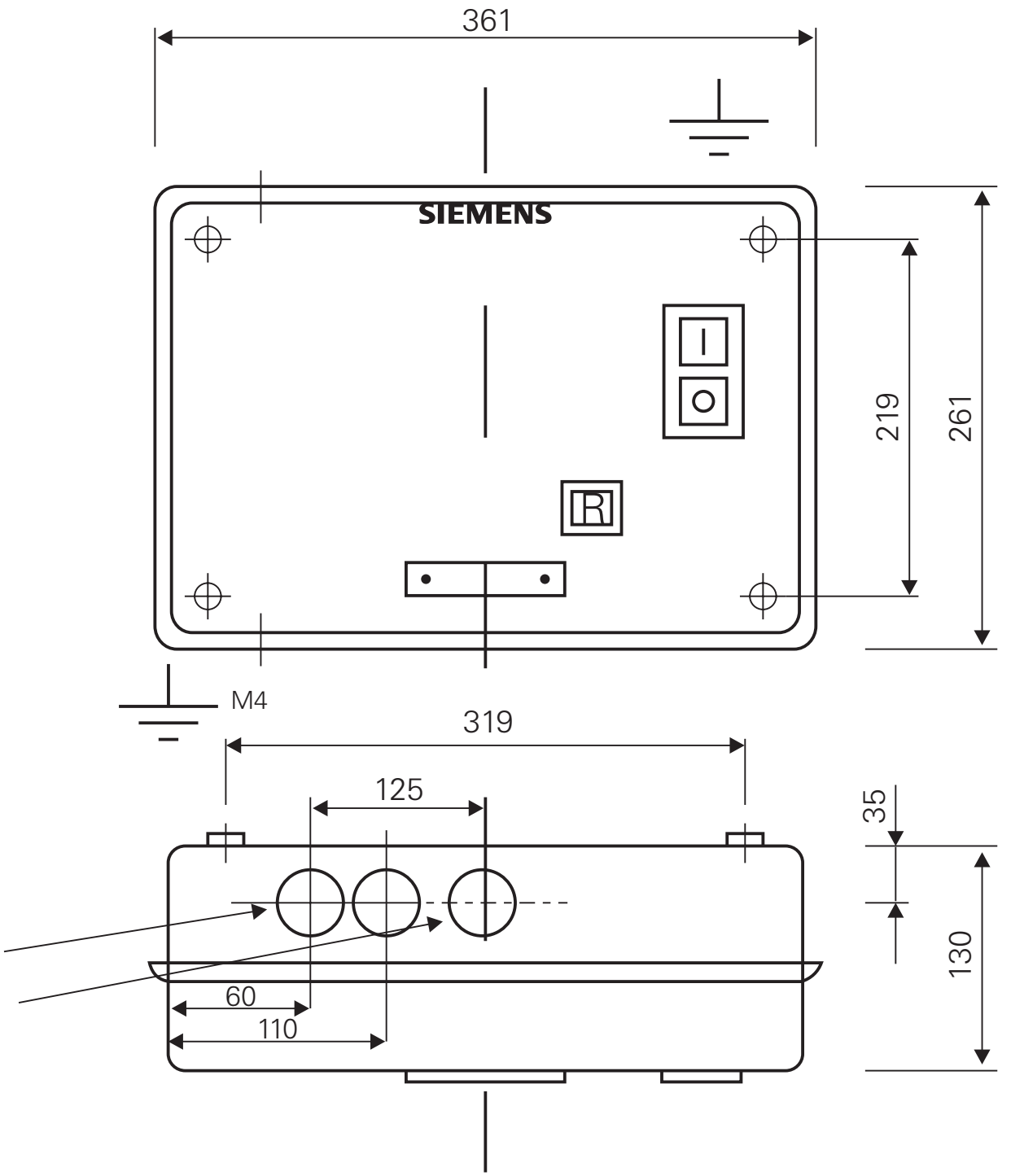
(Mounting Dimension) Use 1 x of M4 Screws.





Mounting Dimension
219 x 219 mm

Raja Star-Delta Starter (Automatic)



5. Trouble shooting

Trouble & Possible Cause	What to do
Contactors	
a) **Contacts chatter**	
1) Low voltage-coil not picking up properly	1) Correct voltage condition. In case there is persistent low-voltage, change to a lower voltage coil.
2) Broken Pole Shading ring.	2) Get contactor replaced.
3) Poor contact in control circuit	3) Clean contacts
4) Control circuit connections loose	4) Tighten the connections
b) **Welding or overheating**	
1) Low voltage preventing magnet from sealing	1) Correct voltage condition. In case of persistent low voltage, change to a lower voltage coil
2) Short circuit	2) Trace and correct fault, and check to be sure that fuse rating is correct.
3) Foreign matter preventing contact closing	3) Clean contacts with suitable solvent.

c) **Short life of contact tips**

1) Filling or Dressing	1) Do not file silver faced contacts. Rough spots or discoloration will not harm contacts. Silver oxide is a good conductor of electricity.
2) Weak contact pressure	2) Check for obstructions

d) **Noisy magnets**

1) Broken Shading ring	1) Mechanical life over. Replace contactor.
2) Dirt or rust on magnet faces	2) Clean with suitable solvent.

e) **Failure to pick-up and seal**

1) Low voltage	1) Check system voltage. In case of persistent low voltage, change to a lower voltage coil
2) Coil open or shorted	2) Replace the coil
3) Mechanical obstruction	3) Clean and check for free movement of contact assembly.

f) **Failure to drop out**

1) Voltage not removed	1) Check wiring of the coil circuit
2) Worn or rusted parts causing binding	2) Replace such parts

3) Residual magnetism due to lack of air gap in magnet path	3) Replace the contactor
4) Gummy substance on pole face causing binding	4) Clean with suitable solvent

g) **Overheating of coil**

1) Over-voltage	1) Check and correct terminal voltage/replace with a higher voltage coil
2) Under voltage-failure of magnet to seal in voltage	2) Correct terminal voltage/ replace with a lower coil
3) High ambient temperature	3) Replace starter in a more suitable area
4) Short circuit turns in coils caused by mechanical damage or corrosion	4) Replace coil
5) Dirt or rust on pole faces increasing air gap	5) Clean pole faces

Bimetal Overload Relay

a) **Tripping often**

1) Incorrect bimetal setting	1) Set relay properly
2) Sustained overload	2) Check for faults/excessive motor currents
3) Reduced supply voltage	3) Do not restart till voltage improves

b) **Failure to trip** (causing motor burn out)	
1) Wrong bimetal setting	1) Check rating and set the relay properly, to actual load current in case of DOL or 0.58 times load current in case of star-delta starter.
2) Mechanical binding due to dirt, corrosion etc.	2) Replace the relay
3) Incorrect control wiring	3) Check circuit
c) **Welding of contacts**	
1) Back up protection fuse rating too high	1) Replace relay and refer to Selection Table for proper back up fuse rating
Fuses (HRC type cartridge)	
a) **Constant blowing of fuses**	
1) Short circuit	1) Check the feeder circuit with a megger
2) Fuse rating too low.	2) Refer to Selection Table and select proper fuse
b) **Fuses not blowing under short circuit conditions**	
1) Fuse rating too high	1) Refer Selection Table and install suitable fuse

6. Spares for RAJA Motor Starters

1. Spares for RAJA DOL and HSD starters

Description	Type
Contactor	3TW0290-0A*51
Main Contact Kit-Three Pole	3TX0200-0YA0
Main Contact Kit-Single Pole	3TX0200-0YA1
Coil	3TX0203-0Y*6
Arc chamber	3TX0202-0YA0
Aux. Fixed Contacts	3TX0200-1YB0
Aux. Moving Contacts	3TX0200-1YC0
ON' Actuator	3TX0204-1YA0
OFF' Actuator	3TX0204-1YB0
Moving Contact Carrier	3TX0200-0YD0
Switch for HSD starter	3LA0204-4YB
Birelay	3UW5002-**

* Enter code for coil voltage, 50Hz (B for 200-400V, M for 220V, W for 415V)

** Refer code for Relay range

2. Spares for Raja ASD Starters

Description	Type
Contactor (1NO+1NC)	3TW0311-0A*51
Contactor (2NO)	3TW0320-0A*51
Main Contact Kit-Three Pole	3TX0300-0YA0
Main Contact Kit-Single Pole	3TX0300-0YA1
Coil	3TX0303-0Y*6
Aux. Fixed Contacts (NO)	3TX0300-1YB0
Aux. Fixed Contacts (NC)	3TX0300-1YD0
Aux. Moving Contacts	3TX0300-1YC0
Birelay	3UW5002-**
Star-delta Timer	7PU60203N#2

* Enter code for coil voltage, 50Hz (D for 230-400V, M for 220V, W for 415V)

Enter control voltage code (W for 230-400V, N for 220-240V, T for 380-440V)

** Refer code for relay range

** Code for 3UW50 relay range

Relay Range	0.63-1	1-1.6	1.6-2.5	2-3.2	3.2-5	4-6.3	6.3-10	8-12.5	10-16	12.5-20	16-25
Code	0J	1A	1C	1D	1F	1G	1J	1K	2A	2B	2C

Maximum Full Load Current for different types of motors (Reference IS 8789/9283/996)

Motor Rating		Max. Full Load Current (Amp)		
HP	kW	3 Ph, 415V, 4P Squirrel Cage IS 8789 : 1996 (Table 4)	3 Ph, 415V, 2P Submersible Motor IS 9283 : 1995 (Table 2)	1 Ph, 240V CSIR or Split-Phase IS 996 : 1979 (Table 9)
0.33	0.25	—	—	3.8
0.5	0.37	1.4	—	6
0.75	0.55	1.7	—	7
1	0.75	2.2	—	10
1.5	1.1	2.9	3.25	13
2	1.5	3.8	4.5	18
3	2.2	5.1	6.5	—
5	3.7	8.1	10	—
7.5	5.5	11.4	14.5	—
10	7.5	15.4	19.5	—
12.5	9.3	19.5	25	—
15	11	23	29	—
20	15	32	39	—
25	18.5	38.5	—	—

Note : The above table gives the max. full load current for various motors commonly used. It is recommended that the above table be referred to in conjuction with motor name plate data, before selecting the starter with appropriate relay range.

Notes :

Notes :

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