Electric Motors

Preamble

The data on electric motors reproduced here was taken from the latest Western Electric catalogue available at the time of this publication.

There are many different types of electric motors available but I have included only the two most common types used in engineering namely the three phase squirrel cage motor (pages 6-12) and the single phase squirrel cage motor (pages 13-16). It would be expected that most engineering designs would require a three phase motor but data on single phase motors has been included as these are required for domestic or commercial applications when three phase supply is not readily available.

Three phase motors

The Western Electric range of three phase motors include:

- totally enclosed fan cooled
- dust ignition proof
- non sparking
- flameproof
- two-speed
- brake motors
- geared motors
- slip ring motors.

For electric motors there are several types of protection available, some of which are detailed on page 10. However, Western Electric do not produce three phase motors other than the totally enclosed fan cooled type with protection designation IP55 or higher. IP55 is their standard (off-the-shelf) protection rating but higher ratings can be made to order.

Hence in this manual, I have included data on the totally enclosed fan cooled type only in sizes 0.18-110 kW (frames 63-280).

Note : The frame size of a motor is actually the distance in mm between the base of the motor feet to the centreline of the rotor. This is a common designation used by all electric motor manufacturers. As the frame size increases, the motor power increases.

There are 18 mounting arrangements as shown on page 10 that include various foot, flange and face mounted configurations.

Four synchronous speeds are available depending on the number of poles, namely:

- 2 pole, 3000 rpm
- 4 pole, 1500 rpm
- 6 pole, 1000 rpm
- 8 pole, 750 rpm

Under no load conditions, the actual motor speed is the synchronous speed (close enough). The full load speed is less than synchronous speed and is given in the performance data tables. Between no load and full load, the speed can be taken to be directly proportional to theload (with little error). That is, the speed-load relationship is very close to a linear one so that linear interpolation can be used for intermediate loads and speeds.

Notes :

- Precise motor performance varies with each motor and can only be ascertained by performance testing of the motor.

- A squirrel cage electric motor self-adjusts to the power and torque required by the load. The motor does this by varying the current draw and as load increases, the current draw increases. It is not good practice to overload the motor because the extra current draw can cause overheating and eventula failure. However, it is also not good practice to use a motor with capacity much greater than the load even though the motor will have a long life. The motor will cost more, take up more space and operate at a lower efficiency. As is common with most prime movers used in engineering, electric motors have maximum efficiency at full load output and a lower efficiency at part load output.

In addition to performance data and motor dimensions for three phase motors, I have included radial and axial (thrust) load capacities. These capacities are given in Table 1, page 11 and are based on bearing operating life of 30,000 hours. Thrust loads are based on the assumption that the thrust is acting toward the motor, no data was available for thrust in the opposite direction (away from the motor).
If combined radial and axial load occurs, then it is necessary to reduce the maximum axial load capacity. Western Electric provided me with a large number of graphs but I have simplified these to a general graph as given on page 12. The method of using this graph is described in the selection method.

Single phase motors
Western Electric single phase motors come in three different styles depending upon the method of starting namely :
- permanent capacitor - type 4APC
- capacitor start/induction run - type 4APJC
- capacitor start/capacitor run - type 4APCC.

In addition, there are three mounting arrangements available with these motors namely :
- standard arrangement with feet for floor mounting - type B3
- flange mounted - type B5
- "C" type face - type B14.

The various styles and mounting arrangements are described on page 13.

Only two synchronous speeds are available in the single phase motors namely :
- 2 pole - 3000 rpm
- 4 pole - 1500 rpm.

Selection method - three phase motors
1. Determine the mechanical data such as torque, power and speed.
2. From the data tables page 6-7, for the appropriate synchronous speed, choose a motor that has a torque/power output at least equal to that required.
   Note: The Western Electric catalogue refers to full load which is actually the maximum load for continuous operation of the motor. The full load requirement of the driven machine will often be less than the maximum motor load. To avoid confusion, I have called the full load requirement of the driven machine the 'design load' (design power).
3. Determine the motor speed at design load (if this is less than full load). Use the data tables page 6-7 to find the speed at full load. At no load, the speed is the synchronous speed. Hence by linear interpolation the speed at design load can be determined.

4. If there is a gear, pulley, chain-wheel, flywheel or other mechanism directly attached to the motor shaft that produces a radial or overhung load, this load should be calculated to ensure that it does not exceed the allowable value for the motor. The allowable overhung load is given in Table 1, page 11. If the allowable overhung load is exceeded, the bearing life will be reduced. To avoid this use a larger pulley or gear, or if this is not possible, choose a bigger motor.
   Notes :
   - When the overhung load is excessive, another option is to use an intermediate shaft (layshaft) with its own bearings coupled to the motor with a flexible coupling. This prevents transmission of the overhung load to the motor and the need to increase pulley or motor sizes.
   - The most accurate method of determining the overhung load on the motor shaft is by calculation of the chain or belt tensions or gear tooth forces. However, an *approximate* value may be calculated using the following formulas (derived in Chapter 6 page 31):

$$F = \frac{2fT}{d} = \frac{60fP}{\pi dN}$$

   Where : F = overhung load in N
   T = motor torque in Nm (design not maximum or full load torque)
   P = motor power in W (design not maximum or full load power)
   d = PCD of the pulley or gear attached to the motor shaft in m
   N = speed at design load in rpm
   f = drive application factor
   = 1.0 for a chain drive or tooth belt
   = 1.25 for a gear drive
   = 1.5 for a vee belt
   = 2.0 for a flat friction belt

5. If there is a mechanism directly attached to the motor shaft that causes a thrust (axial) load only, this load should be calculated to ensure that it does not exceed the allowable value for the motor. The allowable thrust load on the motor is also given in Table 1, page 11. If the allowable thrust load is exceeded, the bearing life will be reduced. To avoid this, choose a larger motor.
   Note: Another option is to use an intermediate shaft (layshaft) with its own bearings coupled to the motor to take the axial load.
6. If there is a helical gear or other mechanism directly attached to the motor shaft that causes *both* radial and thrust loads simultaneously, the allowable thrust load must be reduced to less than the value given in Table 1. Use Figure 1, page 12. For example, if a frame 71 motor has a radial load acting on it equal to the maximum value allowed, then the allowable thrust load is the value given in Table 1 multiplied by 0.68. If the radial load is 50% of the maximum allowed, then the allowable thrust load is the table value multiplied by 0.84.
7. Obtain the required performance data from the relevant table page 6-7 and the required dimensions from the dimension tables page 8-9.

Example

A three phase electric motor is to provide a design power of 12 kW @ approx. 1450 rpm. The motor shaft will have a wedge belt pulley of pitch diameter 100 mm directly attached to it. The maximum bore of the pulley is 42 mm.

Select a suitable foot mounted motor and complete the following table:

Motor type	
Number of poles	
Maximum power output	
Speed at design power	
Torque at design power	
Efficiency at design power	
Current draw at maximum load	
Nominal output shaft diameter	
Mounting bolt hole centre distance (side)	
Mounting bolt hole centre distance (end)	

Solution

Following the steps in the selection method:

1. Design power = 12 kW at approx. 1450 rpm.
2. Synchronous speed = 1500 rpm, therefore a 4 pole motor is needed.
   From the performance data table page 6, choose a F160LO4 (frame size 160, 4 pole) that has a maximum power output (full load) of 15 kW.
3. Calculating the speed at design load :
   No load speed = 1500 rpm
   Full load (15 kW) speed = 1455 rpm
   Therefore by linear interpolation, the speed at design load (12 kW)
   $= 1500 - \frac{12}{15} \times (1500 - 1455) = 1464$ rpm
4. Checking the overhung load:

$$F = \frac{60 f P}{\pi d N}$$

$f = 1.5$ (wedge belt pulley)
$P = 12$ kW $= 12000$ W
$d = 0.1$ m (100 mm)
$N = 1464$ rpm

Substituting :

$$F = \frac{60 \times 1.5 \times 12000}{\pi \times 0.1 \times 1464} = 2348 \text{ N}$$

From Table 1, page 11, the maximum radial load is 2800 N, therefore the overhung load is OK.

5. There is no axial load.
6. The torque at design power may be calculated from :

$$P = T\,\omega$$

$$\therefore\ 12000 = T \times \frac{\pi \times 1464}{30} \quad \therefore\ T = 78.3 \text{ Nm}$$

Note : Approximate answer may be calculated as : 12/15 x 98 = 78.4 Nm

The design load is 80% (12/15) of the full load power. The efficiency at full load is 88% and at 75% load is 87%. Therefore at design load, the efficiency will be 87.2%.

Using the performance data table page 6 and the dimension table page 9, the table may be completed as below:

Motor type	F160LO4
Number of poles	4
Maximum power output	15 kW
Speed at design power	1464 rpm
Torque at design power	78.3 Nm
Efficiency at design power	87.2%
Current draw at maximum load	28.6 A
Nominal output shaft diameter	42 mm (OK for pulley)
Mounting bolt hole centre distance (side)	254 mm
Mounting bolt hole centre distance (end)	254 mm

Electrical and General Performance

2 Pole — 3000 RPM Synchronous Speed 415 volt 50Hz

MOTOR TYPE	OUTPUT (kW)	FULL LOAD SPEED (RPM)	I_{NL} (A)	I_{FL} (A)	$\frac{I_{ST}}{I_{FL}}$	EFFICIENCY AT: 100 FL	0.75 FL	0.5 FL	POWER FACTOR AT: 100 FL	0.75 FL	0.5 FL	FULL LOAD TORQUE (Nm)	$\frac{T_{ST}}{T_{FL}}$	$\frac{T_{PU}}{T_{FL}}$	$\frac{T_M}{T_{FL}}$	M of I J kgm 2	NET WEIGHT kg
4AP63-2S	0.18	2810	0.41	0.47	4.27	68	66	60	0.75	0.63	0.49	0.621	2.63	2.55	2.92	0.000162	4.0
4AP71-2S	0.37	2880	0.58	0.84	4.63	72	71	68	0.85	0.75	0.62	1.275	2.16	2.02	2.18	0.000413	5.5
4AP71-2	0.55	2800	0.74	1.13	4.74	75	75	72	0.85	0.76	0.63	1.92	2.60	2.19	2.37	0.000473	8.5
4AP80-2S	0.75	2840	1.0	1.63	5.32	76	76	73	0.85	0.76	0.62	2.53	2.15	1.86	2.31	0.00107	9.0
4AP80-2	1.1	2840	1.35	2.35	5.64	77	79	79	0.87	0.79	0.64	3.7	2.06	1.90	2.10	0.00144	10.0
4AP90S-2	1.5	2870	1.68	3.0	5.72	79	76	72	0.87	0.80	0.69	5.04	2.18	1.96	2.55	0.00252	13.0
4AP90L-2	2.2	2850	2.18	4.2	6.05	81	79	73	0.88	0.82	0.74	7.35	2.53	2.08	2.68	0.003	15.5
4AP100L-2	3.0	2850	2.45	5.6	6.46	81	79	76	0.90	0.86	0.76	10.2	2.98	2.60	3.10	0.014	23/30
4AP112M-2SB	4.0	2900	2.64	7.9	6.60	81	79	76	0.89	0.86	0.81	13.2	2.05	1.53	2.51	0.027	40.8
4AP112M-2B	5.5	2910	3.48	10.1	7.23	85	84	81	0.88	0.86	0.77	18.1	2.17	1.55	2.72	0.05	47.2
4AP132S-2B1	5.5	2930	3.83	10.3	9.34	84	84	83	0.88	0.85	0.77	18.0	2.92	1.95	4.3	0.057	67.7
4AP132S-2B1	7.5	2910	4.86	14.0	6.94	84	84	83	0.91	0.85	0.77	24.8	2.41	2.03	3.08	0.057	67.7
4AP132M-2	11.0	2930	8.0	20.2	6.93	87	86	84	0.86	0.81	0.71	35.9	2.01	1.82	2.75	0.063	84.0
F160MK02	11.0	2910	6.9	20.7	6.03	84	83	80	0.88	0.86	0.82	36.0	2.11	1.91	2.83	0.04	115.0
F160M02	15.0	2905	7.4	27.0	5.89	89	86	83	0.87	0.86	0.82	49.0	2.10	2.05	2.89	0.045	120.0
F160L02	18.5	2920	9.8	33.3	6.91	89	87	86	0.87	0.86	0.80	61.0	2.38	2.12	2.75	0.067	135.0
F180M02	22.0	2935	10.3	38.7	6.98	90	88	85	0.88	0.86	0.82	72.0	2.21	2.05	2.65	0.1	190.0
F200LK02	30.0	2955	16.2	52.8	6.96	90	89	86	0.88	0.84	0.79	97.0	2.22	1.82	2.53	0.175	270.0
F200L02	37.0	2955	18.0	65.9	6.30	91	90	87	0.86	0.83	0.78	120.0	2.46	1.92	2.57	0.222	300.0
F225M02	45.0	2970	23.0	81.0	6.75	91	89	86	0.85	0.84	0.80	145.0	2.41	1.77	2.44	0.33	385.0
F250M02	55.0	2970	24.0	93.6	7.00	93	91	90	0.88	0.85	0.80	177.0	2.56	2.23	2.74	0.42	455.0
F280S02	75.0	2970	29.0	127.6	7.20	92	90	86	0.89	0.87	0.83	241.0	2.51	1.75	2.55	0.782	663.0
F280MK02	90.0	2970	31.0	151.4	7.00	92	91	89	0.90	0.89	0.85	289.0	2.82	2.20	2.64	0.935	685.0
F280M02	110.0	2970	33.0	185.0	7.05	92	91	89	0.90	0.88	0.84	354.0	2.60	1.80	2.60	1.115	690.0

4 Pole — 1500 RPM Synchronous Speed 415 volt 50Hz

MOTOR TYPE	OUTPUT (kW)	FULL LOAD SPEED (RPM)	I_{NL} (A)	I_{FL} (A)	$\frac{I_{ST}}{I_{FL}}$	EFFICIENCY AT: 100 FL	0.75 FL	0.5 FL	POWER FACTOR AT: 100 FL	0.75 FL	0.5 FL	FULL LOAD TORQUE (Nm)	$\frac{T_{ST}}{T_{FL}}$	$\frac{T_{PU}}{T_{FL}}$	$\frac{T_M}{T_{FL}}$	M of I J kgm 2	NET WEIGHT kg
4AP63-4	0.18	1350	0.5	0.54	2.84	60	59	53	0.75	0.62	0.50	1.29	1.84	1.75	1.83	0.0014	4.5
4AP71-4	0.37	1370	0.76	1.0	3.15	68	69	65	0.77	0.64	0.50	2.62	1.70	1.60	1.85	0.0029	6.5
4AP80-4S	0.55	1380	1.0	1.4	3.89	74	74	71	0.76	0.65	0.51	3.82	1.85	1.72	2.08	0.006	9.0
4AP80-4	0.75	1380	1.16	1.8	3.76	72	75	75	0.79	0.69	0.54	5.2	1.79	1.70	1.91	0.0072	10.0
4AP90S-4	1.1	1410	1.84	2.5	4.52	74	74	73	0.80	0.74	0.59	7.54	2.21	1.98	2.45	0.012	13.0
4AP90L-4	1.5	1410	2.53	3.3	5.35	77	77	73	0.82	0.75	0.61	10.1	2.26	2.09	2.55	0.014	15.5
4AP100L-4S	2.2	1440	2.8	4.6	5.93	80	81	78	0.82	0.76	0.65	14.72	2.47	1.95	2.60	0.024	23/29
4AP100L-4	3.0	1430	3.68	6.1	5.75	81	81	74	0.84	0.74	0.61	20.1	2.19	2.05	2.42	0.03	26/33
4AP112M-4	4.0	1440	4.62	7.9	6.80	84	83	80	0.83	0.76	0.63	27.1	3.44	3.20	3.72	0.049	46.4
4AP132S-4	5.5	1450	5.54	10.3	6.81	86	85	82	0.85	0.77	0.65	36.4	2.12	1.64	2.97	0.093	65.2
4AP132M-4	7.5	1450	6.32	13.8	7.38	87	78	72	0.86	0.87	0.72	49.2	2.22	1.98	2.89	0.11	77.8
4AP132M-4	10.0	1450	8.79	19.7	7.25	84	83	80	0.83	0.78	0.71	66.0	2.11	1.78	2.42	0.12	78.3
F160M04	11.0	1455	9.5	21.2	5.80	87	86	83	0.83	0.78	0.67	72.0	2.57	2.25	2.56	0.13	115.0
F160L04	15.0	1455	14.2	28.6	6.19	88	87	84	0.83	0.78	0.67	98.0	2.71	2.31	2.74	0.14	140.0
F180M04	18.5	1460	12.7	32.9	6.69	90	89	88	0.87	0.83	0.73	121.0	2.40	2.13	2.87	0.167	185.0
F180L04	22.0	1460	13.0	38.7	7.29	91	89	88	0.87	0.82	0.74	144.0	2.42	2.22	2.89	0.2	210.0
F200LK04	30.0	1465	19.0	52.2	6.94	91	90	89	0.88	0.82	0.74	196.0	2.70	2.43	2.81	0.35	280.0
F225S04	37.0	1475	20.0	63.7	7.08	92	91	89	0.88	0.85	0.78	240.0	2.42	2.19	2.99	0.65	355.0
F225M04	45.0	1475	23.0	75.7	7.40	93	92	90	0.89	0.85	0.78	291.0	2.61	2.27	3.11	0.775	400.0
F250M04	55.0	1475	29.0	94.7	7.13	93	92	91	0.87	0.85	0.78	356.0	2.70	2.29	3.31	0.958	460.0
F280S04	75.0	1480	37.0	124.8	6.77	93	92	91	0.90	0.87	0.83	484.0	2.18	1.83	2.78	1.81	580.0
F280MK04	90.0	1480	47.0	153.2	7.18	93	92	91	0.88	0.82	0.74	580.0	2.40	1.96	3.20	2.15	650.0
F280M04	110.0	1480	63.0	183.0	6.96	94	93	91	0.89	0.83	0.75	711.0	2.10	2.02	2.95	2.39	690.0

Electrical and General Performance

6 Pole — 1000 RPM Synchronous Speed 415 volt 50Hz

MOTOR TYPE	OUTPUT (kW)	FULL LOAD SPEED (RPM)	I_{NL} (A)	I_{FL} (A)	$\frac{I_{ST}}{I_{FL}}$	EFFICIENCY AT: 100 FL	0.75 FL	0.5 FL	POWER FACTOR AT: 100 FL	0.75 FL	0.5 FL	FULL LOAD TORQUE (Nm)	$\frac{T_{ST}}{T_{FL}}$	$\frac{T_{PU}}{T_{FL}}$	$\frac{T_M}{T_{FL}}$	M of I J kgm 2	NET WEIGHT kg
4AP80-6S	0.37	910	0.94	1.0	3.32	67	66	60	0.73	0.60	0.46	3.9	2.05	1.79	2.0	0.00204	9.0
4AP80-6	0.55	910	1.17	1.4	3.19	70	70	65	0.76	0.65	0.60	5.8	1.91	1.82	2.03	0.00263	10.0
4AP90S-6	0.75	940	1.57	2.0	3.84	72	69	63	0.73	0.64	0.50	7.74	1.87	1.79	2.56	0.00498	13.0
4AP90L-6	1.1	930	2.59	2.8	3.95	74	70	66	0.75	0.64	0.50	11.3	2.00	1.90	2.29	0.00634	15.5
4AP100L-6	1.5	940	2.53	3.6	4.75	76	77	74	0.75	0.67	0.54	15.3	2.05	2.03	2.42	0.033	22/29
4AP112M-6S	2.2	950	2.93	4.9	4.86	80	78	74	0.77	0.72	0.59	22.9	2.49	2.17	2.57	0.049	38.5
4AP112M-6	3.0	940	3.38	6.3	5.02	82	83	82	0.80	0.74	0.64	30.8	2.46	2.20	2.73	0.066	45.1
4AP132S-6	4.0	960	4.69	8.3	5.72	84	85	84	0.79	0.72	0.59	39.8	2.59	2.31	3.08	0.15	64.3
4AP132M-6	5.5	950	5.24	12.3	5.75	85	85	86	0.80	0.75	0.64	54.9	2.55	2.43	3.34	0.19	77.2
F160M06	7.5	960	7.0	15.6	5.53	85	84	82	0.79	0.72	0.60	75.0	2.48	2.22	2.64	0.115	120.0
F160L06	11.0	960	10.0	22.3	5.83	87	87	86	0.79	0.75	0.65	109.0	2.52	2.17	2.49	0.163	140.0
F180L06	15.0	965	10.0	27.9	5.01	89	89	88	0.84	0.81	0.74	148.0	2.07	1.66	2.25	0.275	195.0
F200LK06	18.5	970	13.0	34.5	5.22	90	90	89	0.83	0.80	0.72	182.0	1.95	1.76	2.30	0.375	250.0
F200L06	22.0	970	14.0	40.1	5.11	91	90	89	0.84	0.81	0.75	217.0	1.98	1.65	2.67	0.55	270.0
F225M06	30.0	975	20.0	56.7	5.82	91	90	89	0.81	0.76	0.66	294.0	2.40	1.87	2.43	0.85	360.0
F250MK06	37.0	975	26.0	68.3	5.42	92	92	91	0.82	0.80	0.73	362.0	2.60	2.00	2.23	1.15	440.0
F280SK06	45.0	985	30.0	79.3	5.80	93	92	91	0.85	0.81	0.73	436.0	2.70	2.03	2.30	1.84	570.0
F280MK06	55.0	980	40.0	96.9	6.50	93	93	92	0.85	0.83	0.77	536.0	2.85	2.00	2.60	2.20	630.0
F280M06	75.0	985	46.0	132.0	6.03	94	93	92	0.87	0.82	0.76	727.0	2.70	2.20	2.46	2.89	700.0

8 Pole — 750 RPM Synchronous Speed 415 volt 50Hz

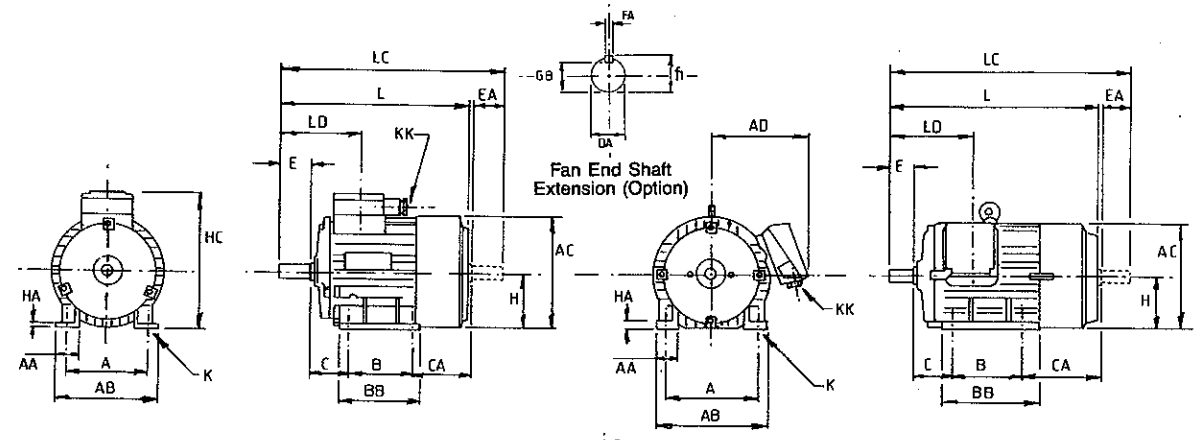
MOTOR TYPE	OUTPUT (kW)	FULL LOAD SPEED (RPM)	I_{NL} (A)	I_{FL} (A)	$\frac{I_{ST}}{I_{FL}}$	EFFICIENCY AT: 100 FL	0.75 FL	0.5 FL	POWER FACTOR AT: 100 FL	0.75 FL	0.5 FL	FULL LOAD TORQUE (Nm)	$\frac{T_{ST}}{T_{FL}}$	$\frac{T_{PU}}{T_{FL}}$	$\frac{T_M}{T_{FL}}$	M of I J kgm 2	NET WEIGHT kg
4AP90L-8	0.55	705	1.58	1.85	3.26	66	64	56	0.63	0.53	0.42	7.4	1.93	1.93	2.36	0.0053	15.5
4AP100L-8	0.75	700	1.42	2.0	3.09	69	64	56	0.65	0.53	0.42	10.3	1.65	1.60	1.87	0.025	22/29
4AP100L-8	1.1	690	2.33	2.9	3.65	73	72	64	0.71	0.72	0.69	15.5	1.78	1.70	2.04	0.033	22/29
4AP112M-8S	1.5	710	2.8	3.6	3.84	78	77	72	0.72	0.63	0.50	20.4	1.67	1.65	2.12	0.049	38.3
4AP112M-8	2.2	700	3.28	5.0	3.82	80	78	75	0.75	0.65	0.51	30.8	1.88	1.85	2.33	0.065	44.6
4AP132S-8	3.0	715	4.82	7.0	4.53	81	83	80	0.73	0.72	0.62	40.3	2.08	1.97	2.94	0.15	63.7
4AP132M-8	4.0	715	5.49	8.9	4.69	82	83	80	0.75	0.67	0.54	54.0	2.26	2.13	2.83	0.15	76.4
F160MK08	4.0	725	4.5	9.0	5.18	83	83	81	0.79	0.71	0.59	53.0	1.70	1.58	2.17	0.082	105.0
F160M08	5.5	720	5.2	11.4	5.61	84	83	82	0.80	0.74	0.61	73.0	1.70	1.67	1.37	0.115	115.0
F160L08	7.5	725	9.0	16.0	5.53	85	85	84	0.79	0.71	0.59	99.0	1.97	1.40	2.59	0.163	140.0
F180L08	11.0	720	9.5	21.2	4.62	87	87	86	0.83	0.78	0.69	146.0	1.88	1.67	2.02	0.275	190.0
F200LK08	15.0	725	10.0	29.0	4.66	89	87	86	0.81	0.79	0.71	198.0	1.89	1.74	1.97	0.45	245.0
F225S08	18.5	730	16.0	35.3	5.49	89	88	87	0.82	0.76	0.66	242.0	2.31	2.13	2.39	0.95	340.0
F22M08 5	22.0	735	18.0	41.5	5.78	90	88	87	0.82	0.75	0.63	286.0	2.20	2.04	2.37	1.11	355.0
F250M08	30.0	730	26.0	58.1	5.40	91	90	89	0.79	0.72	0.61	393.0	2.20	1.98	2.33	1.51	460.0
F280SK08	37.0	735	29.0	66.7	6.67	92	92	91	0.84	0.77	0.68	481.0	2.40	1.94	2.44	2.6	550.0
F280MK08	45.0	735	40.0	83.2	6.50	93	92	90	0.81	0.74	0.62	585.0	2.70	2.33	2.85	3.15	670.0
F280M08	55.0	735	44.0	103.0	6.99	93	93	92	0.80	0.75	0.64	712.0	2.80	2.34	2.61	3.70	730.0

I_{NL} = No Load Current
I_{FL} = Full Load Current
I_{ST} = Locked Rotor Current

T_{ST} = Locked Rotor Torque
T_{PU} = Pull Up Torque
T_M = Maximum Torque
T_{FL} = Full Load Torque

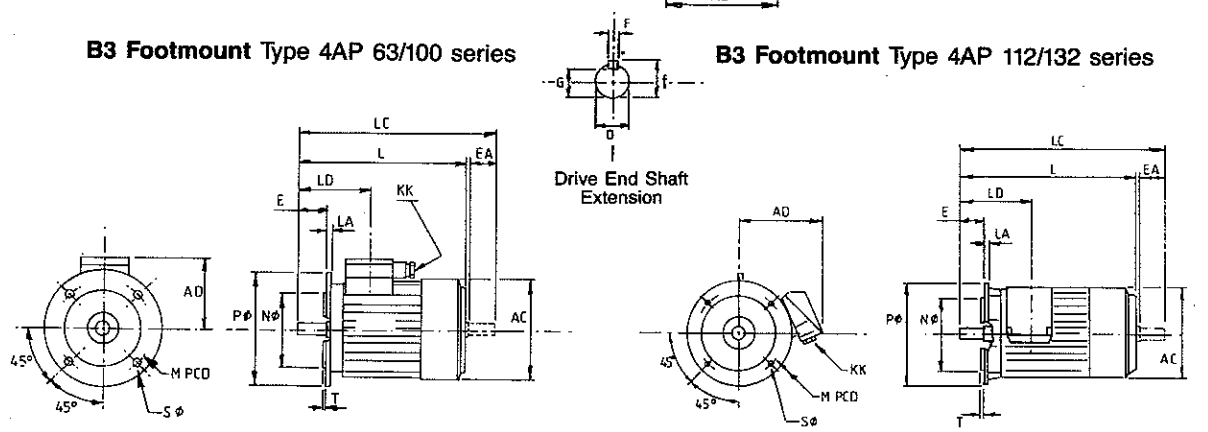
Dimensions

Western Electric Three Phase Squirrel Cage Motors



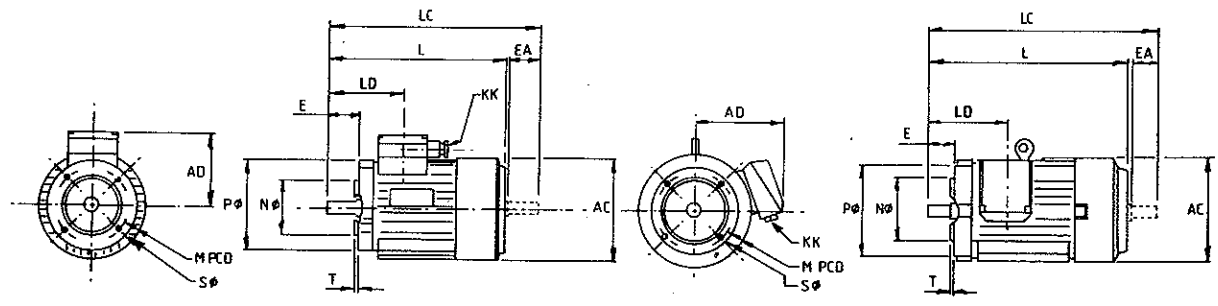
B3 Footmount Type 4AP 63/100 series

B3 Footmount Type 4AP 112/132 series



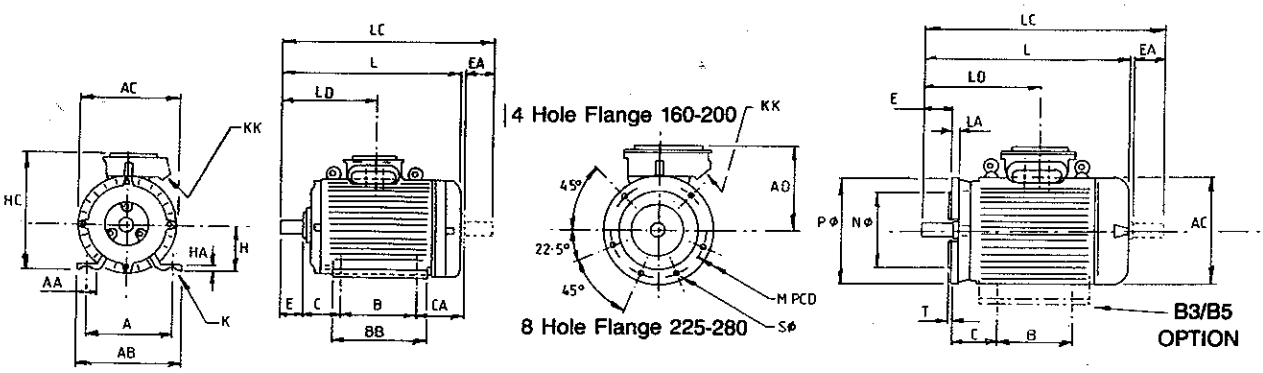
B5 Flangemount Type 4AP 63/100 series

B5 Flangemount Type 4AP 112/132 series



B14A/B14B Facemount Type 4AP 63/100 series

B14A/B14B Facemount Type 4AP 112 series
B14A Facemount Type 4AP 132 series



B3 Footmount Type F 160/280 series

B5 Flangemount Type VF 160/280 series

Dimensions

B3 Footmount

FRAME	A	AA	AB	AC	AD	B	BB	C	CA	Ø D	Ø DA	E	EA	F	HC	G	GB	H	HA	FA	Ø K	Pg KK	L	LA	LC	f	LD
63	100	26	116	118	105	80	96	40	66	11	11	23	23	4	158	8.50	8.50	63	7	4	7	13.50	205	8	232	12.50	90
71	112	32	132	132	122	90	106	45	71	14	14	30	30	5	173	11	11	71	8	5	7	13.50	231	8	266	16	102
80	125	36	150	154	130	100	126	50	83	19	19	40	40	6	198	15.50	15.50	80	9	6	10	16	268	10	313	21.50	120
90S	140	39	167	172	136	100	127	56	91	24	24	50	50	8	214	20	20	90	10	8	10	16	292	10	347	27	125
90L	140	39	167	172	136	125	145	56	86	24	24	50	50	8	214	20	20	90	10	8	10	16	312	10	367	27	125
100L	160	42	188	198	141	140	167	63	138	28	28	60	60	8	241	24	24	100	12	8	12	16	391	12	461	31	159
112M	190	45	225	240	202	140	195	70	163	28	28	60	60	8	N/A	24	24	112	15	8	12	21	426	12	493	31	165
132S	216	47	255	280	218	140	202	89	161	38	38	80	80	10	N/A	33	33	132	17	10	12	21	483	15	570	41	213
132M	216	47	255	280	218	178	240	89	181	38	38	80	80	10	N/A	33	33	132	17	10	12	21	521	15	608	41	213
160M	254	60	314	320	240	210	250	108	171	42	38	110	80	12	403	37.10	33	160	20	10	15	2x29	594	13	679	45	241
160L	254	60	314	320	240	254	294	108	177	42	38	110	80	12	403	37.10	33	160	20	10	15	2x29	644	13	729	45	241
180M	279	65	346	358	290	241	300	121	211	48	42	110	110	14	467	42.50	37.10	180	25	12	15	2x29	690	13	793	51.50	393
180L	279	65	346	358	290	279	338	121	193	48	42	110	110	14	467	42.50	37.10	180	25	12	15	2x29	690	13	813	51.50	393
200LK	318	80	398	416	320	305	385	133	206.50	55	48	110	110	16	516	48.80	42.50	200	30	14	19	2x36	744	15	864.50	58.80	396
200L	318	80	398	416	320	305	385	133	266.50	55	48	110	110	16	516	48.80	42.50	200	30	14	19	2x36	804	15	924.50	58.80	396
225S	356	85	441	485	350	286	370	149	268	60	55	140	110	18	577	53.20	48.80	225	32	16	19	2x36	835	16	953	64.20	441
225M2	356	85	441	485	350	311	370	149	243	55	48	110	110	16	577	48.80	42.50	225	32	14	19	2x36	805	16	923	64.20	411
225M	356	85	441	485	350	311	370	149	243	60	55	140	110	18	577	53.20	48.80	225	32	16	19	2x36	835	16	953	64.20	441
250M2	406	90	496	485	350	349	439	168	237.50	60	55	140	110	18	601	53.20	48.80	250	35	16	24	2x42	882	18	1004.50	64.20	432
250M	406	90	496	485	350	349	439	168	237.50	65	60	140	140	18	601	58.20	53.20	250	35	18	24	2x42	882	18	1034.50	69.20	432
280S2	457	100	557	570	410	368	454	190	219.50	65	60	140	140	18	689	58.20	53.20	280	40	18	24	2x42	900	18	1057.50	69.20	474
280S	457	100	557	570	410	368	454	190	219.50	75	65	140	140	20	689	67.60	58.20	280	40	18	24	2x42	900	18	1057.50	79.60	474
280M2	457	100	557	570	410	419	520	190	253.50	65	60	140	140	18	689	58.20	53.20	280	40	18	24	2x42	985	18	1142.50	69.20	474
280M	457	100	557	570	410	419	520	190	253.50	75	65	140	140	20	689	67.60	58.20	280	40	18	24	2x42	985	18	1142.50	79.60	474

Dimensions mm (not binding)

B5 Flangemount

FRAME	Ø M	Ø N	Ø P	Ø S	T	t 1
63	115	95	140	10	3.50	12.50
71	130	110	160	10	3.50	16
80	165	130	200	12	3.50	21.50
90S	165	130	200	12	3.50	27
90L	165	130	200	12	3.50	27
100L	215	180	250	15	4	31
112M	215	180	250	15	4	31
132S	265	230	300	15	4	41
132M	265	230	300	15	4	41
160M	300	250	350	19	5	41
160L	300	250	350	19	5	41
180M	300	250	350	19	5	45
180L	300	250	350	19	5	45
200LK	350	300	400	19	5	51.50
200L	350	300	400	19	5	51.50
225S	400	350	450	19	5	58.80
225M2	400	350	450	19	5	51.80
225M	400	350	450	19	5	58.80
250M2	500	450	550	19	5	58.80
250M	500	450	550	19	5	64.20
280S2	500	450	550	19	5	64.20
280S	500	450	550	19	5	69.20
280M2	500	450	550	19	5	64.20
280M	500	450	550	19	5	69.20

B14A Flange

Frame	MØ	NØ	PØ	SØ	T
63	75	60	90	M5	2.50
71	85	70	105	M6	2.50
80	100	80	120	M6	3
90	115	95	140	M8	3
100	130	110	160	M8	3.50
112	130	110	160	M8	3.50
132	165	130	200	M10	3.50

B14B Flange

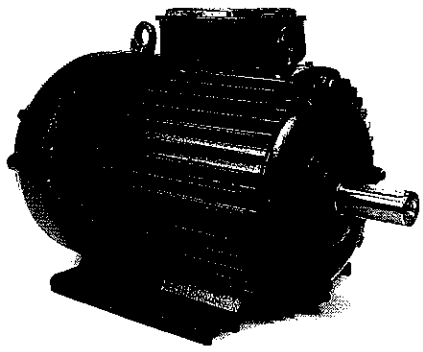
Frame	MØ	NØ	PØ	SØ	T
63	100	80	120	M6	3
71	115	95	140	M8	3
80	130	110	160	M8	3.50
90	130	110	160	M8	3.50
100	165	130	200	M10	3.50
112	165	130	200	M10	3.50

Bearing Sizes

NDE	Frame	6201	Frame	6202	Frame	6204	Frame	6205
DE	63	6201	71	6202	80	6204	90	6205
NDE	Frame	6206	Frame	6306	Frame	6308	Frame	6309
DE	F100	6206	112	6306	132	6308	F160	6309
NDE	Frame	6310	Frame	6312	Frame	6313	Frame	6313
DE	F180	6310	F200	6312	F225	6315	F250	6315

Frame	6315
F280	6316

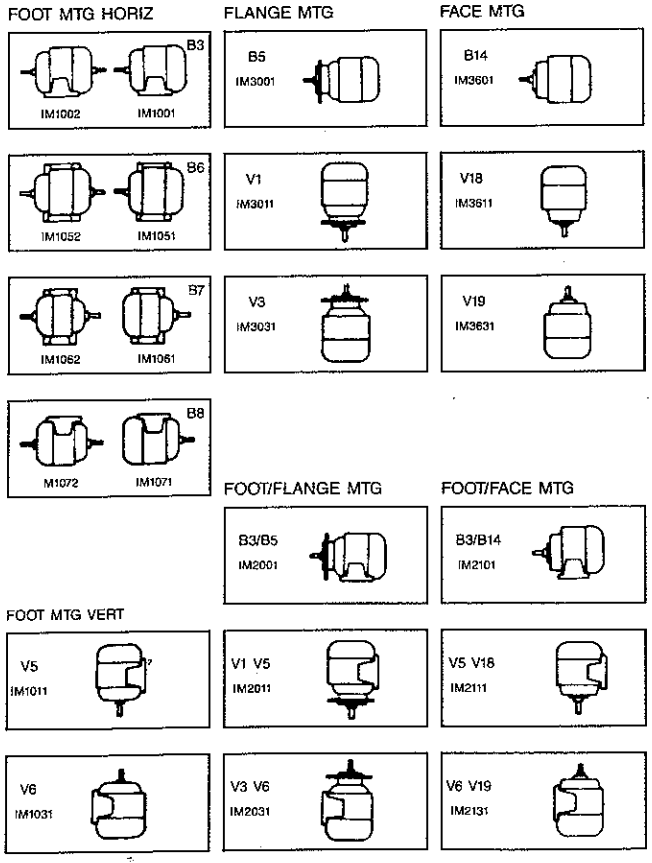
Totally Enclosed Fan Cooled
Protection IP55
Insulation Class 'F'
Ratings 0.18 kW to 315 kW
Frames 63 to 355



Degrees of Protection

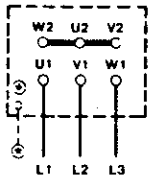
Designation	First Numeral Protection against contact and against ingress of foreign bodies	Second Numeral Protection against water
IP44	Protection against contact with live or moving parts inside the enclosure by tools, wires, or such objects of thickness greater than 1mm. Protection against ingress of small solid foreign bodies (diameter greater than 1mm) excluding the ventilation openings (intake and discharge of external fans) and the drain hole of enclosed machine, which may have degree 2 protection.	Water splashed against the enclosure from any direction shall have no harmful effect.
IP54	Complete protection against contact with live or moving parts inside the enclosure.	Water splashed against the machine from any direction shall have no harmful effect.
IP55	Protection against harmful deposits of dust. The ingress of dust is not totally prevented, but dust	Water projected by a nozzle against the enclosure from any direction shall have no harmful effect.
IP56	cannot enter in an amount sufficient to interfere with satisfactory operation of the machine.	Water from heavy seas or water projected from powerful jets shall not enter the machine in a harmful quantity.
IP65	Complete protection against contact with live or moving parts inside the enclosure. Complete protection against ingress of dust.	Water ptojected by a nozzle against the machine from any direction shall have no harmful effect.
IP6X	Dust-excluding ignition proof.	

Mounting Arrangement

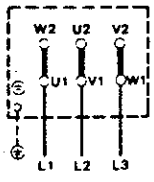


Connection Diagrams

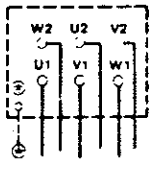
Three-phase motors with cage rotor



Star connection

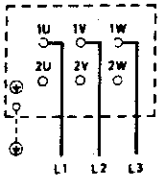


Delta connection

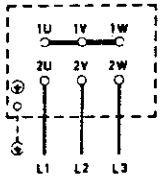


Connection to star-delta switch

Multi-speed motors in Dahlander connection (tapped winding)

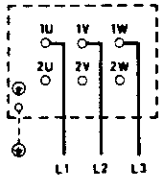


low speed

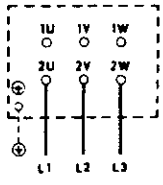


high speed

Multi-speed motors with 2 separate windings



low speed



high speed

Table 1 Maximum shaft loads

Motor frame - number of poles	Max. radial load (N)	Max. axial load (N)	Motor frame - number of poles	Max. radial load (N)	Max. axial load (N)
63-2	185	120	160-2	2250	1570
63-4	235	155	160-4	2800	2070
71-2	220	130	160-6	3220	2500
71-4	280	180	160-8	3500	2800
71-6	320	225	180-2	3040	2130
80-2	330	200	180-4	3800	2850
80-4	420	270	180-6	4370	3400
80-6	480	340	180-8	4750	3800
90-2	420	250	200-2	4200	3000
90-4	520	340	200-4	4600	3400
90-6	600	420	200-6	5400	4200
90-8	650	490	200-8	5900	4800
100-2	650	390	225-2	5200	3650
100-4	820	530	225-4	6500	4900
100-6	940	660	225-6	7500	5900
100-8	1020	760	225-8	8100	6500
112-2	960	570	250-2	6600	4600
112-4	1200	780	250-4	8200	6400
112-6	1380	960	250-6	9500	7600
112-8	1500	1120	250-8	10300	8250
132-2	1350	800	280-2	8400	5900
132-4	1700	1100	280-4	10500	8300
132-6	1950	1370	280-6	12000	9600
132-8	2100	1580	280-8	13100	10500

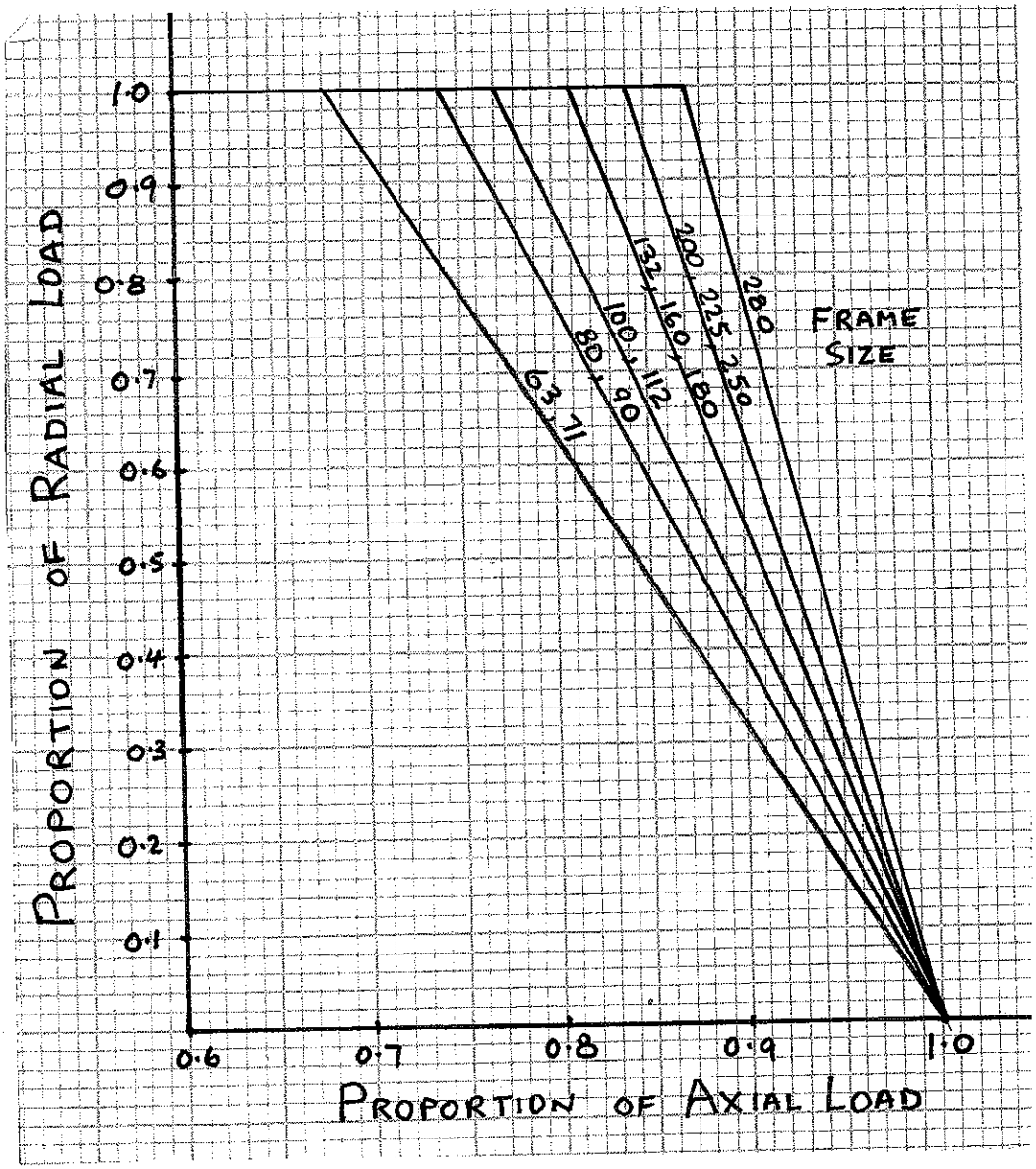


Fig. 1 Combined radial and axial load capacity

Single Phase Motors

SINGLE PHASE DESIGNS

Western Electric single phase motors are manufactured to comply with IEC recommendations IEC72-1.

The standard enclosure is designed to give IP54 protection against the harmful ingress of dust and water.

Dependent on the application we are able to offer three styles of single phase motor. These can be described as follows:-

(1) Permanent Capacitor 4APC

This design is suitable for fans, blowers and centrifugal pump applications requiring starting torque between 30% and 50% of full load torque, depending on frame size. 4APC motors are started by means of a permanently connected capacitor.

(2) Capacitor Start / Induction Run 4APJC

Suitable for industrial and agricultural applications of a more demanding nature requiring starting torque between 160% and 230% of full load torque, depending on frame size. This additional torque is obtained by the use of a start capacitor in combination with an auxiliary winding. In the course of the motor starting operation the auxiliary winding is disconnected by means of an integral centrifugal switch.

(3) Capacitor Start / Capacitor Run 4APCC

This design features high starting performance, efficiencies, power factors and low currents. The use of both start and permanently connected capacitors allows higher output within a given frame.

Construction

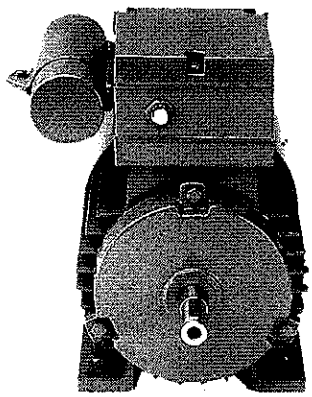
All stator frames are of die-cast aluminium with cast iron endshields and flanges. Ball bearings type ZZ are fitted as standard and grease packed for life.

Mounting Arrangements

The standard arrangement is with feet for floor mounting (B3). All motors may have a flange (B5) or a "C" type face (B14) at the driving end, either with or without feet. (See mounting dimensions, pages 4-7)

Insulation / Temperature Rise

All motors have Class F insulation as standard with Class B temperature rise (80°c) and will operate satisfactorily in an ambient temperature range of -30°C to +45°C and at altitudes of up to 1000 metres above sea level.

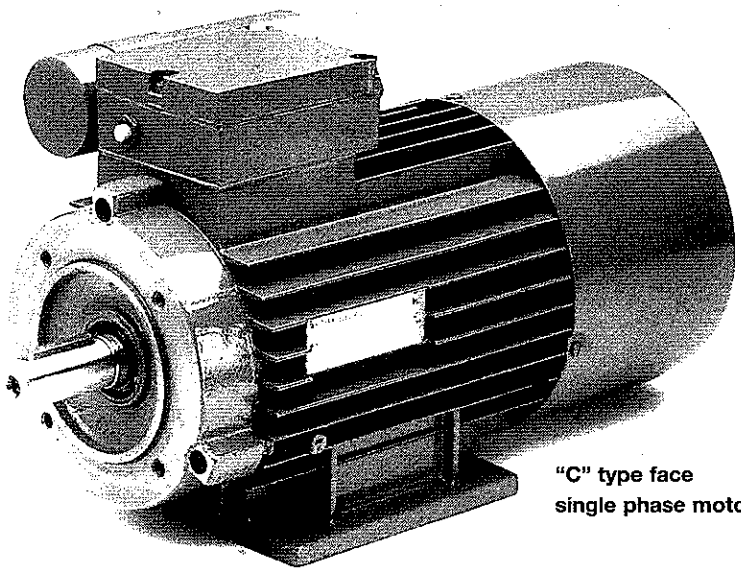


Type 4APJC

Protection

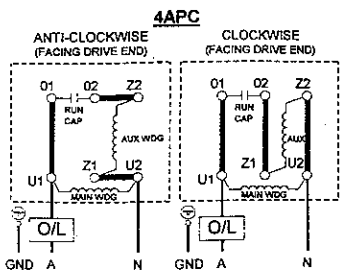
Manual reset thermal overloads are fitted as standard and are conveniently located in the top mounted terminal box.

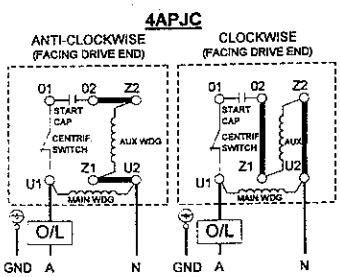
4APC and 4APCC motors must not be run under no-load conditions.

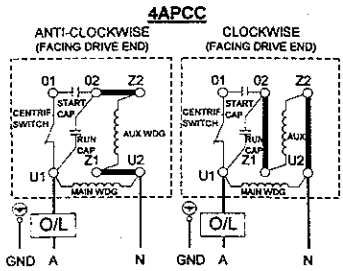


"C" type face single phase motor

CONNECTION DIAGRAMS

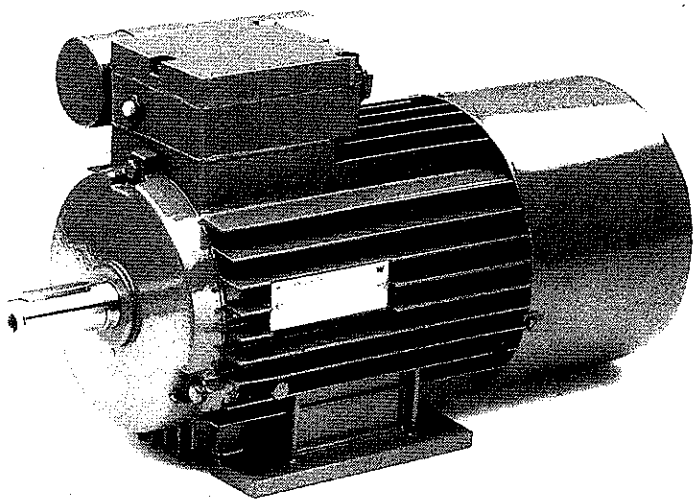






Single Phase Motors

Electrical and General Performance Data



TYPE 4APC
Permanently connected capacitor
Suitable For Fan Duty Only

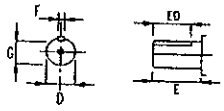
Size	Output (kW)	Full Load Speed (RPM)	Full Load Current (A)	St. Current / F.L. Current	Full Load Torque (Nm)	St. Torque / F.L. Torque	Power Factor at Full Load	Efficiency (%) at Full Load	Start Capacitor (µF/V)	Run Capacitor (µF/V)	Net Weight (kg)
Two Pole Motors – 3000 RPM Synchronous Speed			**240 Volts 50 Hz**								
4APC90S-2	1.5	2760	8.8	4.1	5.2	0.45	0.99	72%	-	35µF/400V	14.5
4APC90L-2	2.2	2760	12.5	3.6	7.6	0.34	0.98	75%	-	45µF/400V	18
4APC100L-2	3	2840	16	4.5	10.1	0.37	1.00	78%	-	60µF/450V	25.5
Four Pole Motors – 1500 RPM Synchronous Speed			**240 Volts 50 Hz**								
4APC63-4	0.18	1410	1.4	2.8	1.2	0.37	0.86	62%	-	60µF/400V	5.5
4APC71-4	0.37	1410	2.8	2.7	2.5	0.39	0.87	63%	-	10µF/450V	7.5
4APC80-4S	0.55	1430	4	3.2	3.7	0.36	0.86	67%	-	14µF/400V	9.7
4APC80-4	0.75	1425	4.8	3.1	5.0	0.32	0.93	70%	-	16µF/400V	11
4APC90S-4	1.1	1350	6.8	2.9	7.8	0.47	0.96	70%	-	25µF/400V	14.5
4APC90L-4	1.5	1370	9.35	3.1	10.5	0.36	0.95	70%	-	35µF/500V	18.5
4APC100L-4S	2.2	1410	12.5	3.6	14.9	0.47	0.98	75%	-	50µF/450V	25.5

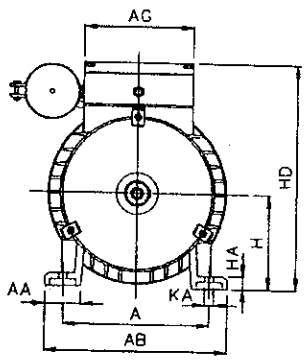
TYPE 4APJC AND 4APCC
4APJC – Capacitor Start/Induction Run
4APCC – Capacitor Start/Capacitor Run

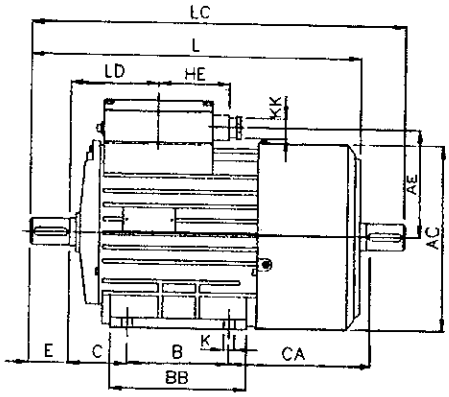
Size	Output (kW)	Full Load Speed (RPM)	Full Load Current (A)	St. Current / F.L. Current	Full Load Torque (Nm)	St. Torque / F.L. Torque	Power Factor at Full Load	Efficiency (%) at Full Load	Start Capacitor (µF/V)	Run Capacitor (µF/V)	Net Weight (kg)
Two Pole Motors – 3000 RPM Synchronous Speed			**240 Volts 50 Hz**								
4APJC71-2	0.37	2810	3.1	3.8	1.3	1.7	0.80	62%	40µF/320V	-	7.25
4APJC80-2S	0.55	2890	4.3	4.6	1.8	1.8	0.83	64%	80µF/320V	-	10
4APJC80-2	0.75	2900	5.6	5.2	2.5	1.75	0.80	70%	80µF/320V	-	11.6
4APJC90S-2	1.1	2880	8.87	4.4	3.6	2.3	0.77	67%	100µF/320V	-	15
4APJC90L-2	1.5	2880	11	5.1	5.0	2	0.80	71%	140µF/320V	-	18.7
4APCC90L-2	2.2	2780	12.8	3.8	7.6	1.9	0.94	76%	120µF/320V	45µF/450V	19.3
4APCC100L-2	3	2840	16	4.3	10.1	1.8	1.00	78%	160µF/320V	60µF/450V	25.5
Four Pole Motors – 1500 RPM Synchronous Speed			**240 Volts 50 Hz**								
4APJC71-4S	0.18	1400	2.2	3.1	1.2	2.3	0.68	50%	40µF/320V	-	6.7
4APJC80-4S	0.37	1430	4.2	3.5	2.5	2.2	0.66	56%	60µF/320V	-	11
4APJC80-4	0.55	1410	5.3	4	3.7	1.6	0.70	62%	60uµF/20V	-	12.2
4APJC90S-4	0.75	1400	6.3	3.5	5.1	2	0.83	60%	80µF/320V	-	15
4APJC90L-4	1.1	1400	8.9	4.1	7.5	2.1	0.79	65%	100µF/320V	-	18.5
4APCC90L-4	1.5	1370	9.4	3.5	1.7	0.72	0.92	72%	80µF/320V	35µF/450V	19
4APCC100L-4S	2.2	1370	12.5	3.6	15.3	1.8	0.98	75%	120µF/320V	50µF/450V	25.5

Single Phase Motors

DIMENSIONS

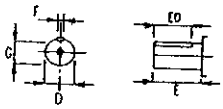


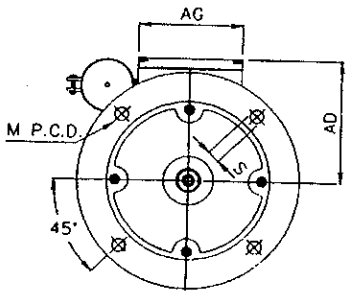


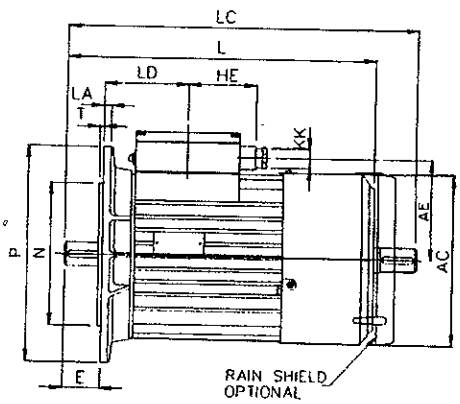


4APC B3

Size	A	AA	AB	AC	AG	B	BB	C	CA	H	HA	HD	AE	K	KA	L	LC	LD	HE	KK	D	E	F	G	GD
63-.s	100	26	116	118	86	80	96	40	66	63	7	192	101	7	9	205	232	76	71	Ø22 x 18 T.P.I.	11	23	4	8.5	4
63-.									92							231	258								
71-.s	112	32	132	132	86	90	106	45	71	71	8	206	105	7	10	231	266	79	71		14	30	5	11	5
71-.									96							256	291								
80-.s	125	36	150	154	86	100	126	50	83	80	9	210	102	10	12	268	313	86	71		19	40	6	15.5	6
80-.									114							299	344								
90S-.	140	39	167	172	86	100	127	56	111	90	10	221	102	10	12	312	367	81	71		24	50	8	20	7
90L-.						125	145		128							354	409								
100L-.	160	41	188	198	117	140	167	63	156	100	12	242	116	12	16	408	479	102	86		28	60	8	24	7





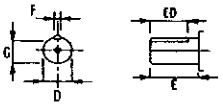


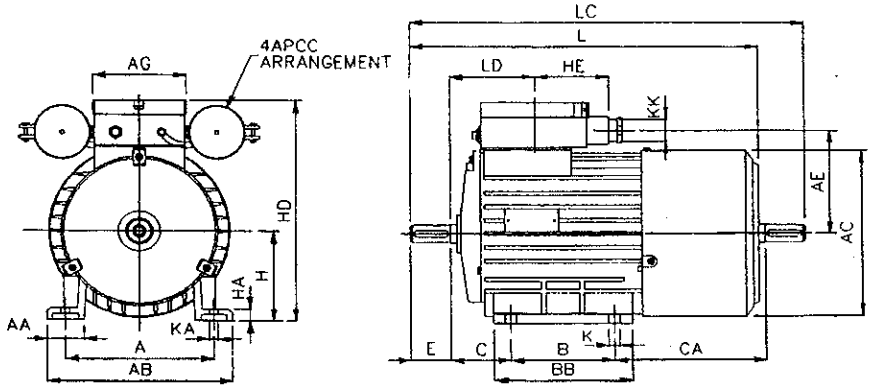
4APC B5

Size	AC	AG	AD	AE	L	LC	LD	HE	KK	M	N	P	S	T	LA	D	E	F	G	GD
63-.s	118	86	129	101	205	232	76	71	Ø22 x 18 T.P.I.	115	95	140	10	3	8	11	23	4	8.5	4
63-.					231	258														
71-.s	132	86	135	105	231	266	79	71		130	110	160	10	3.5	8	14	30	5	11	5
71-.					256	291														
80-.s	154	86	130	102	268	313	86	71		165	130	200	12	3.5	10	19	40	6	15.5	6
80-.					299	344														
90S-.	172	86	131	102	312	367	81	71		165	130	200	12	3.5	10	24	50	8	20	7
90L-.					354	409														
100L-.	198	117	142	116	408	479	102	86		215	180	250	15	4	12	28	60	8	24	7

Single Phase Motors

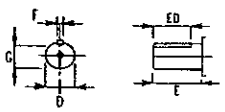
DIMENSIONS

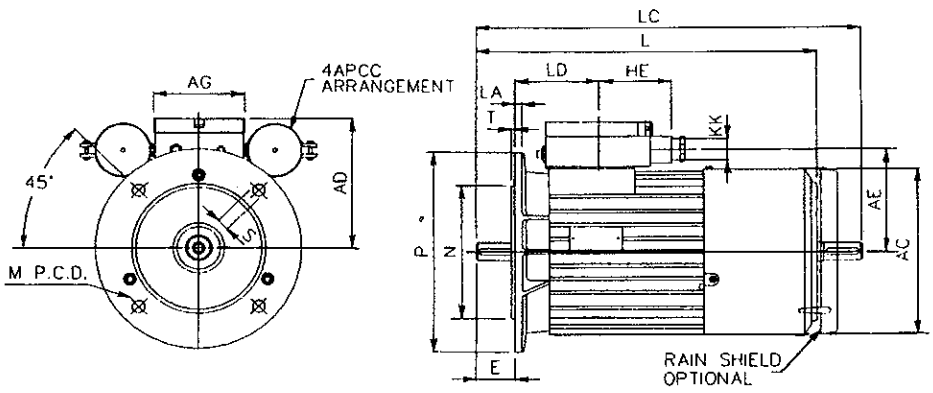




4APJC / 4APCC B3

Size	A	AA	AB	AC	AG	B	BB	C	CA	H	HA	HD	AE	K	KA	L	LC	LD	HE	KK	D	E	F	G	GD
63-.s	100	26	116	118	86	80	96	40	110.5	63	7	192	101	7	9	250	277	76	71	Ø22 x 18 T.P.I.	11	23	4	8.5	4
63-.									136.5							276	303								
71-.s	112	32	132	132	86	90	106	45	117.5	71	8	206	105	7	10	278	313	79	71		14	30	5	11	5
71-.									142.5							303	338								
80-.s	125	36	150	154	86	100	126	50	130.5	80	9	210	102	10	12	316	361	86	71		19	40	6	15.5	6
80-.									161.5							347	392								
90S-.	140	39	167	172	86	100	127	56	161	90	10	221	102	10	12	362	417	81	71		24	50	8	20	7
90L-.						125	145		178							404	459								
100L-.	160	42	188	198	117	140	167	63	199	100	12	241	116	12	12	457	512	102	79		28	60	8	24	7





4APJC / 4APCC B5

Size	AC	AG	AD	AE	L	LC	LD	HE	KK	M	N	P	S	T	LA	D	E	F	G	GD
63-.s	118	86	129	101	250	277	76	71	Ø22 x 18 T.P.I.	115	95	140	10	3	8	11	23	4	8.5	4
63-.					276	303														
71-.s	132	86	135	105	278	313	78	71		130	110	160	10	3.5	8	14	30	5	11	5
71-.					303	338														
80-.s	154	86	130	102	316	361	86	712		165	130	200	12	3.5	10	19	40	6	15.5	6
80-.					347	392														
90S-.	172	86	131	102	362	417	81	71		165	130	200	12	3.5	10	24	50	8	20	7
90L-.					404	459														
100L-.	198	117	141	116	457	512	102	79		215	180	250	15	4	12	28	60	8	24	7