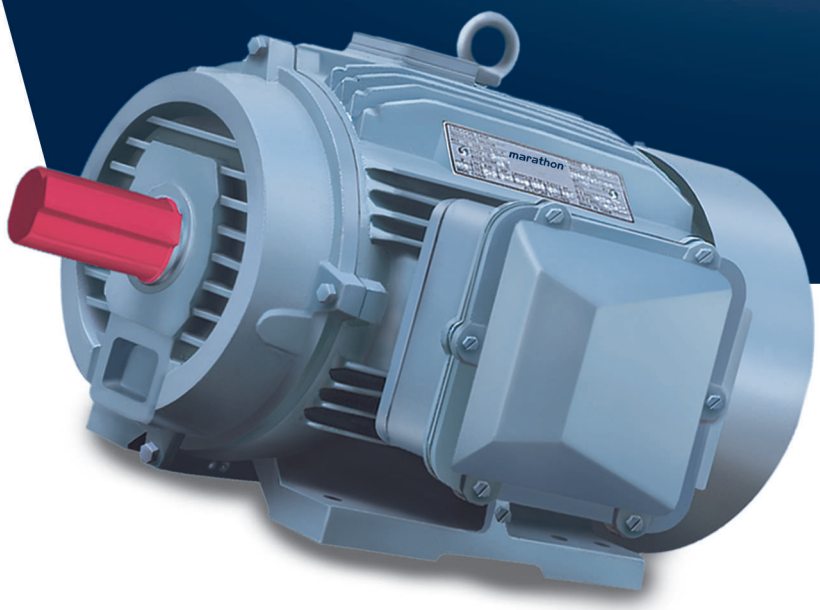
marathon™ Motors



VD

Totally Enclosed Fan Cooled Low Voltage Ac Cage Induction Motors

A Regal Brand

REGAL

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MARATHON Electric introduces VD series motors tailor made for inverter drives having enhanced dielectric strength and adequate thermal margin suitable for variable speed application.

PWM technology involving high switching frequency IGBT drive has enabled AC induction motors to be operated as variable speed drives. However, there had been a documented increase of premature winding failure for standard general purpose motors when operated with inverter drives.

High and steep front voltage spikes (dV/dt) produced by latest generation IGBT drives associated with the phenomenon of voltage wave reflection due to longer cable length imposes stress on the motor winding resulting rapid ageing and deterioration of insulation system.

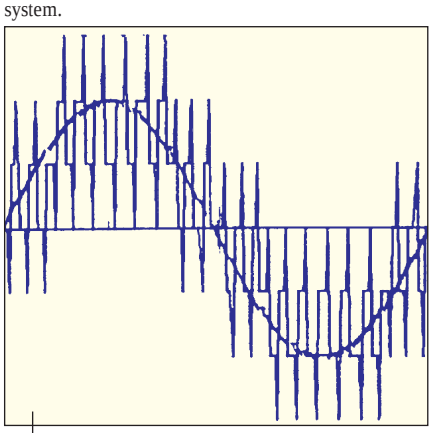

Fig. 1
Typical sine wave generated by inverter pulse

The rating for Variable speed motors need to be selected based on following aspects-

- Heating due to harmonic content of inverter waveform.
- Reduced ventilation due to low speed operation.
- Constant torque/Constant Power/ Variable torque requirement of load.
- Other limiting factors eg. maximum permissible motor speed, ambient temp. altitude etc.

While variable speed drives provide highest energy saving for variable torque (Centrifugal pump, fan) applications, for constant torque and constant power application, Variable speed drives offer significant process control improvements. Basic inverters permit operation over a typical 20:1 speed range. With closed loop vector control the effective range may be increased to 1000:1.

Principle of Operation

So far DC motor had been the only choice where precise torque and speed control was required. AC induction motor has no direct control over the currents of the rotor, so a rapid transient response from one steady state to another had been a problem. Through highly sophisticated motor modeling algorithms and internal circuitry, the vector control drive has solved this problem. With quick instantaneous changes in the stator current, quick instantaneous changes occur in the rotor current. Vector drive manipulates the motor torque by indirectly controlling the current of the rotor through the stator windings. Calculating and quantifying the corresponding changes in the rotor current is the

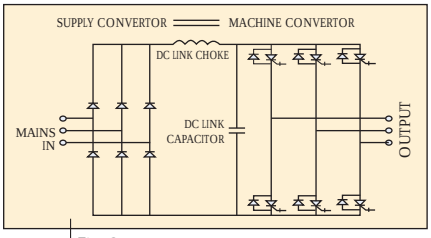

Fig. 2
Typical Voltage Source PWM inverter

genius of the vector drive.

Some vector control drives also require position feedback from a shaft mounted encoder. Vector Control associated with space vector modulation techniques for voltage source inverters have enabled to achieve high quality current and torque response using induction motor drives.

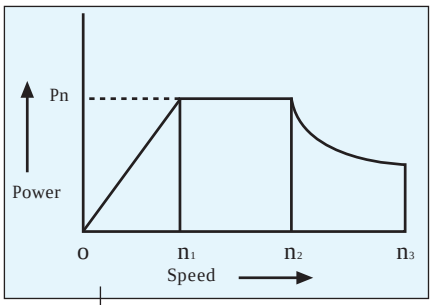

Fig. 3

Mostly voltage source inverters employing PWM control is employed for variable speed drives. PWM voltage source inverters employ a converter section comprising of a rectifier bridge supplying power to DC link filter which operates at a nominal constant voltage. The DC link supply is fed to the inverter section converting DC to AC through a 3 Phase bridge comprising high speed switching devices (IGBT) producing a variable voltage variable frequency sinusoidal supply for the motor.

Inverters would deliver a proportional voltage and frequency up to base voltage (V1) and base frequency f1 (Corresponding base speed n1) set by the user. Beyond base frequency, voltage (V1) remains fixed as per available supply voltage up to maximum permissible frequency f2 (Corresponding speed n2) and f3 (Corresponding speed n3). Motor output rating becomes proportional to frequency up to f1 and motor output remains constant beyond f1 up to f2 and motor

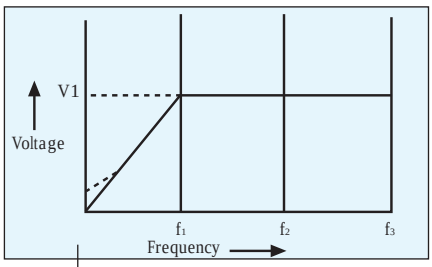

Fig. 4

operates with reduced output upto maximum permissible frequency f3. f2 is normally decided by limiting motor temp. rise owing to higher iron loss at higher frequency and high windage loss (Self cooled motors) and minimum P.O.T requirement. f3 is decided mainly based on max. speed limitation imposed by bearing and rotor assembly. Operating flux of the motor remains constant up to base frequency (f1) by keeping V/f as constant. However, at low frequencies (<10Hz.) it is necessary to provide voltage boost to maintain required torque.

Speed (n)	Torque (T)	Power (P)	Voltage (V)
$o - n_1$	Constant	$p\alpha n$	V/f
$n_1 - n_2$	$T\alpha \frac{1}{n}$	Constant	V_1
$n_2 - n_3$	$T\alpha \frac{1}{n^2}$	$P\alpha \frac{1}{n}$	V_1

Table 1

Note :

n_1 = Speed at base frequency (f1)
n_2 = Maximum speed at max. motor torque
n_3 = Maximum Speed at reduced output

Rating

Construction	Frame Size	Output Range
Aluminum Body	VDA63 –VDA 180L	4 Pole : 0.12KW-18.5KW 6 Pole : 0.37KW-15KW
Cast Iron Body	VD80 – VD 355L	4 Pole : 0.55KW- 280KW 6 Pole : 0.37KW-250KW
	VK355S – VK400L	4Pole :180KW-315KW 6 Pole :160KW-280KW
	VDC315F-VDC355F	4 Pole : 350KW-560KW

Table 2

Standards

VD series motors are manufactured to the following national and International standards.

Standards	India	International	
		IEC	NEMA
Dimension	IS 1231	IEC60072-1	MG1-PT.4
Protection	IS4691	IEC60034-5	MG1-1.26B
Mounting	IS2253	IEC60034-7	MG1-PT.4
Performance	—	IEC/TS-60034-17/ IEC/TS-60034- 25	MG1-Pt30 & 31
Cooling	IS6362	IEC 60034-6	

Table 3

VD series motors meet in general MG1-Pt.31 requirement for “Definite Purpose Inverter Fed Motors”. VD series motors up to 460V base voltage are designed for —

- Peak voltage -1600V Max
- Carrier Switching Frequency : 3-5Khzs
- Voltage rise time>0.1 microsec.
- Total harmonic distortion<2.5%

Motors with still higher base voltage up to 690V are designed suitable for still higher peak voltage.

Supply Voltage and frequency

Standard motors are suitable for operation for a mains supply of 3 Phase, 415V+/-10%, 50Hz.+/-5% . However, motors can be offered for any base voltage from 200Volt to 690Volts.

Protection

VD series motors are provided with IP55 degree of protection as standard. IP56 degree of protection can be provided on request.

Duty

Standard VD series motors are designed for S1 duty. VD series crane duty motors suitable for S4/S5 duty ratings are available as a seperate range. Motor to suit other duty conditions may be offered on request.

Insulation and Temp. rise

The motors are designed suitable for 45°C ambient temperature and provided with class F insulation with temp. rise limiting to class B limit. Research have shown that thermal margin enhances dielectric performance of inverter fed motors significantly. Class H insulation may be offered on request. Motor re-rating factor due to ambient temperature and altitude is indicated in the motor selection chart. Apart from many other specific design considerations, VD series motors are provided with special insulation system to withstand voltage stresses imposed by IGBT based drives comprising of the following.

- Special grade of wire insulation depending on motor rating
- Vacuum impregnation /Multi dip treatment
- Tropicalisation treatment
- Phase separator/Overhang tape

Cooling

Standard motors are suitable for operation with shaft mounted fan with standard IC411 cooling configuration.

Various forms of cooling is given below.

Code	Arrangement
IC411	Totally Enclosed Fan Cooled. Motor cooled by its own shaft driven externally mounted fan. Cooling effect reduces with reduction of speed. Overspeeding increases Windage loss and noise level
IC410	Totally Enclosed Non ventilated (TENV). Free convection (self cooling), no external mounted fan,
IC418	Totally enclosed Air Over Motor cooled by airstream. Cooling effect reduces with reduced airstream velocity.
IC 416	Totally enclosed Force cooled. Motor cooled by independent fan.Constant cooling throughout speed range.

Table 4

Consideration for Variable speed operation

Variable speed drives are used for operation both at low and high speed. Cooling for variable speed motors gets affected while operating at lower speed whereas during high speed operation windage losses, bearing lubrication, increase in noise level, increased temp. due to shaft seals if any require special attention. Max. permissible speed for standard VD series motor is indicated in Table 5. At low speed (Below 10Hz.) loss distribution changes substantially which may lead to higher surface temp. Temp. rise near bearing location should be periodically checked to ascertain that they are within limit. For sustained operation at low speed separate Force ventilation (FV) unit is recommended. FV unit is also used to restrict windage loss and motor noise when the motor runs frequently near to highest permissible operating speed of the bearing system. For applications necessitating higher speed than 80Hz. refer to us.

Frame Size	Maximum permissible R.P.M.
80-160	6000
180	4800
200	4500
225-280	3600
315 - 2 Pole	3600
315-4,6 Pole	3000
355-2 pole	3600
355-4, 6 Pole	2500

Table 5

Force Ventilation Unit

Force ventilation unit replaces integral shaft mounted fan with an independently mounted separately excited motor driven fan. The unit provides constant airflow to the drive motor throughout speed range. Totally Enclosed Air over motor /TEFC motor, depending on the design of FV unit, is provided to drive the independent fan. Fan motor rating depends on the rating and size of drive motor. Specially designed axial flow fan with optimized air delivery, low noise level and minimum power input is provided.

Following table provides brief specification of standard FV unit. However, FV unit specification is normally reviewed with drive requirement and is subject to change as required.

Bearing

Metric size Ball and Roller bearings are used. Double sealed bearings are provided with high temp. grease suitable for operation upto 110°C. Grease relief arrangement is provided for motors having re-greasing facility.

Frame Size	Drive End Bearing	Non Drive End Bearing
80	6204ZZ	6204ZZ
90	6205ZZ	6204ZZ
100	6206ZZ	6205ZZ
112	6206ZZ	6205ZZ
132	6208ZZ	6207ZZ
160	6309ZZ	6209ZZ
180	6310ZZ	6210ZZ
200	6312	6310ZZ
225	6313	6313
250	6314	6313
280	6317	6314
315 S/M-2 pole	6317	6316
315S/M- >4 Pole	6319	6316
315M/L- 2 Pole	6317	6317
315M/L- >4 Pole	6319	6319

(For bigger sizes refer to MARATHON Electric)

Table 7

Bearing Current

Depending on motor size and supply voltage rating, bearing current may be generated owing to shaft voltage caused by high dV/dT common mode voltage (CMV) and motor parasitic capacitance. Normally bearing fluting caused by such bearing currents are noted from motor rating 110KW upwards. For frame sizes 280 and above insulated bearing housing is provided as standards. Good installation practice can reduce the risk of bearing current. Some recommendations are as follows.

- Effective grounding of drive system components (Drive, Motor, Driven equipment) Ensure good HF bonding for potential equalization between drive components.
- Use of symmetrical motor cables with armour shield
- Proper installation of motor cables and connectors.

Electromagnetic Compatibilty

By following inverter manufacturer's recommendation on earthing, screening, filters and cable layout, emission requirements of EN50081 and immunity level of EN50082 Part1 for domestic and part2 for industrial environments can be achieved.

Frame	Supply	Current Amps	Input Watts	Increase in Overall Length Without Encoder mm	Air Delivery CMH
VFD132	3PH,415V,50HZ	0.2	80	165	300
VFD160				170	400
VFD180		0.3	132	190	500
VFD200				190	600
VFD225				190	800
VFD250				180	1000
VFD280		0.82	372	180	2000
VFD315				215	3000
VFD355		1.0	500	355	4000

Table 6

Motor Protection

VD series S1 duty motors in frame sizes 200 and above are recommended with thermistor protection as standard. 3 Nos. PTC140 (Class B Rise) provided in winding overhang are connected in series and thermistor terminals are brought out to terminal box. For operation with Class F rise PTC160 thermistor may be provided.

Accessories

Encoders/tachogenerators are required to provide close loop control between inverter and motor for accurate position control and monitoring. These units are fitted at NDE side on request.

Incremental encoders provide feedback on rotor movement by converting rotational movement into electrical signals used for numerical processing for precise speed control. Incremental encoders operating on photo electric measuring principle provides very high degree of measurement accuracy. AC Tacho-generators using permanent magnet rotor are used for simple speed monitoring and control. They convert the input speed to a three phase voltage whose magnitude and frequency is proportional to speed.

Drive Selection

Drive rating should be selected based on Rated Current of motor. For loads requiring higher acceleration torque a larger drive may be necessary since standard drives provide 150% FLT during acceleration. It should also be noted that motor performance is dependent on drive parameters eg. Modulation process, carrier frequency, voltage rise time, cable length etc. Accordingly drive parameters as specified in motor selection table should be considered during motor selection.

Motor Selection

Selection of motor rating should be based on following–

- Check the type of load and speed range – Constant Torque, Constant Power or Variable torque. For Constant torque application calculate Torque requirement throughout the speed range. Refer to 'Motor selection chart (4 pole and 6 Pole)' for selecting recommended motor frame size with Class B temp. rise. For sustained operation at lower frequencies (<10 Hz.) under constant torque condition and for sustained operation beyond base speed (Constant Power operation), force ventilated motor is recommended. For constant torque operation below 5 Hz., refer to MARATHON Electric for voltage boost details.
- Check and consider ambient temp., altitude, Supply voltage, Frequency and variation to check motor rating. Apply Re-rating factor as required.
- Calculate acceleration time based on 150% motor torque superimposed on load characteristics and check whether this is acceptable. This is particularly important for high inertia drives. (Most drives are rated for a short time current of 150% rated current for 60Sec.)
- Check and ensure that maximum permissible motor speed (Table -5) is not exceeded.
- For constant power operation beyond 80Hz. Refer to MARATHON Electric.

Data Required for Motor Selection

Following details are required for selecting motor rating/Frame Size for Variable speed drives.

- Supply Voltage
- Base speed at Mains Frequency
- Motor Polarity Speed Range
- Type of Load – Variable Torque, Constant Torque, Constant Power
- Load characteristics and load GD^2 – Calculate Required accelerating torque.
- Duty details
- Motor Enclosure

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Motors

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