

# VARIABLE SPEED DRIVES AND MOTORS

## Motor Shaft Voltages and Bearing Currents



ASSOCIATION FOR  
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ROTATING ELECTRICAL  
MACHINES ASSOCIATION

*Developed by the joint GAMBICA/REMA Working Group*

# MOTOR SHAFT VOLTAGES AND BEARING CURRENTS

## INTRODUCTION

This user guide provides information to enable the correct selection and installation of low voltage induction motors and Voltage Source PWM inverters with respect to minimising the effects of shaft voltages and potentially damaging bearing currents.

The guide has been produced by a working group of GAMBICA (Variable Speed Drives Group) and REMA. It is based on a review of published literature on the subject and the practical experience of the member companies.

Variable speed a.c. drives are used in ever increasing numbers because of their well known benefits for enhancing energy efficiency, and for flexible control of processes and machinery. While the connection of a motor to an inverter supply is relatively straightforward, some basic considerations are necessary to ensure trouble free and long term operation.

Bearing performance is one of the considerations required in engineering variable speed drive systems. Following these guidelines should provide user confidence in a sound solution.

For readers requiring more in-depth understanding, Technical Report No 2 will follow.

## CAUSE AND EFFECT

The vast majority of bearing failures in motors can be attributed to inadequate maintenance and mechanical and thermal causes eg: misalignment, vibration, incorrect lubrication and excessive radial or axial loading.

There are also potential electrical causes of bearing failure both in fixed and variable speed systems eg: supply imbalance, poor installation and grounding practices.

The introduction of rapid switching devices has significantly improved the performance of inverters, but has introduced new considerations. The inverter output voltage waveform interacts with the stray impedances of the motor and cables to induce voltages into the motor shaft. If these voltages are sufficient, damaging currents may flow in unintended circuits through the bearings, resulting in premature failure.

The form of this failure is a characteristic fluting of the bearing running surfaces (see picture). Of the few authenticated cases, the majority of the motors involved, were typically greater than 90 kW.

Different mechanisms are important, depending on the physical size of the motor and the supply voltage.



*Fluting on failed bearing*

## MOTOR SELECTION & INSTALLATION

Failure due to bearing currents is seldom encountered, but for security of operation the following should be observed.

### For motors with shaft height 280 mm and lower

- ◆ Adhere strictly to the motor and drive manufacturers' recommendations regarding the installation, cabling and grounding.

### For motors with shaft height over 280 mm

- ◆ Specify a motor with an insulated non-drive-end (NDE) bearing assembly.
- ◆ Potential grounding paths through connections to the shaft system must be taken into account, and the bearing insulation must not be by-passed. This includes, shaft mounted auxiliaries which may need an insulated coupling.
- ◆ Adhere strictly to the motor and drive manufacturers' recommendations regarding the installation, cabling and grounding.

### Supply Voltage

- ◆ For supply voltages over 500 V it may be necessary to incorporate filtering in the inverter output as well as taking into account the recommendations above.

## ALTERNATIVE APPROACH

It may not be possible to follow the above recommendations – for example because the drive is to be retrofitted to an existing motor or information is not available for the motor concerned.

Alternatively environmental conditions may preclude the use of insulated bearings (e.g. excessive moisture).

In these cases alternative strategies may be followed. Some examples are shown in the table below.

## EXAMPLES OF ALTERNATIVE PREVENTATIVE MEASURES

Motor Rating	Drive Related Cost	Alternative Preventative Measures (Relative Cost)			
		Preferred Preventative Measure	1	2	3
2.2 kW	280%	None Recommended			
90 kW or > 280 frame	150%	N.D.E.I.B (14%)	O.I (32%)	D.F. (34%)	S.F (82%)
250 kW	100%	N.D.E.I.B (7%) [C M F (3%) > 500 v]	S.F. (30%)		
500 kW	90%	N.D.E.I.B (3%) C.M.F. (2.6%)	S.F. (26%)		

### Key

- N.D.E.I.B. Non Drive End Insulated Bearing.
- S.F. Sinusoidal Filter.
- C.M.F. Common Mode Filter (Ferrite).
- D.F. du/dt Filter.
- O.I. Output Inductor.

### Notes

- ◆ Insulated bearings may be retro-fitted. Before proceeding consult motor manufacturer.
- ◆ Output inductors may be incorporated in the drive as standard equipment. Check with supplier.
- ◆ Filters may affect system performance. Check with supplier.
- ◆ The percentage values quoted in brackets are approximate comparison costs of the Variable Speed Drives and the Preventative Measures, with respect to the base motor price.

## APPLICATION SPECIFIC NOTES

### **Drives with high switching frequencies**

The magnitude of the problem is increased by high switching frequencies; therefore the switching frequency should be as low as acceptable for the application.

### **Frequent or continuous braking duty**

Where the drive spends a large part of its operating time in braking mode, the effect is similar to increasing the supply voltage by up to 20% – e.g. treat a 400 V application as if it were supplied with 480 V for Motor Selection and Installation.

### **Active front end rectifiers**

For drives with PWM active front ends (regenerative and/or unity power factor), the effective supply voltage is increased by up to 15%.

### **Hazardous Area Approval**

For the application of variable frequency drives with Ex. Motors, refer to the motor manufacturer for confirmation of their suitability and certification.



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GAMBICA is the Association for Instrumentation, Control, Automation and has a group profile for suppliers of Variable Speed Drives.

REMA is the Rotating Electrical Machines Association representing manufacturers of rotating electrical machines, other than turbine type machines, traction motors or machines for the use in aircraft.

The greatest care has been taken to ensure the accuracy of the information contained in this guide, but no liability can be accepted by GAMBICA, REMA or their members, for errors of any kind.

**Always refer to your Drive and Motor Suppliers if in doubt about correct matching.**



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