

VARIABLE SPEED DRIVES AND MOTORS

Motor Insulation and PWM Inverter Drives



AUTOMATION
INSTRUMENTATION & CONTROL
LABORATORY TECHNOLOGY



ROTATING ELECTRICAL
MACHINES ASSOCIATION

Developed by the joint GAMBICA/REMA Working Group

VARIABLE SPEED DRIVES AND MOTORS

Motor Insulation and PWM Inverter Drives

INTRODUCTION

This user guide provides information to enable the correct matching of low voltage induction motors up to 690V and PWM inverters with respect to motor insulation.

The guide was produced by a working group of GAMBICA (Variable Speed Drives Group) and REMA, which are the associations for variable speed drive and electric motor manufacturers respectively. It is based on a review of published literature on the subject and a variety of test results and practical experience of member companies.

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

Insulation performance is one of the considerations required in engineering variable speed drive solutions. Following these guidelines gives the user confidence in the final selection.

For readers requiring a more in-depth understanding, Technical Report No1 'Motor Insulation Performance Under PWM Inverter Operation' is available from GAMBICA or REMA.

SUMMARY

- ◆ Motor winding insulation experiences higher voltage stresses when used with an inverter than when connected directly to the a.c. mains supply.
- ◆ The higher stresses are dependent on the motor cable length and are caused by the fast rising voltage pulses of the drive and transmission line effects in the cable.
- ◆ For supply voltages less than 500V a.c. most standard motors are immune to these higher stresses.
- ◆ For supply voltages over 500V a.c. a motor with an enhanced winding insulation system is required. Alternatively, additional components can be added to limit the voltage stresses to acceptable levels.

APPLICATION SPECIFIC NOTES

Applications with 'long' cable lengths

The definition of 'long' depends on the drive rating and type, and may vary between 50m for lower power drives and 500m for higher powers - refer to manufacturers technical documentation. For these applications, new factors are introduced and the drive supplier should be consulted.

Drive switching strategies

Some drive types use control strategies which could allow bipolar switching. These systems could theoretically double the motor peak voltage stress. GAMBICA inverter manufacturers implement control mechanisms to inhibit bipolar switching. If in doubt the drive or motor supplier should be consulted.

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% and this should be taken into consideration - e.g. treat a 400V application as if it was supplied with 480V.

Active front end

For drives with PWM active front ends (regenerative and/or unity power factor), the effective supply voltage is increased by around 15% and this should be taken into consideration e.g. treat a 480V application as if it was supplied with 550V.

Hazardous area approval

The application of inverters to 'Ex' motors may invalidate the hazardous area certification - refer to the motor manufacturer.

Motor Insulation and PWM Inverter Drives

MOTOR SELECTION

For supply voltages less than 500V a.c.

- ◆ Select a standard motor from REMA manufacturers (see back page). No further insulation considerations are necessary for PWM inverters.
- ◆ For motors from other suppliers, where the motor cable length exceeds 10m, the pulse withstand capability should be established by reference to the supplier. The permitted voltage/rise-time characteristic should equal or exceed curve A shown in the graph.

For supply voltages in the range 500V - 690V a.c.

- ◆ Select a motor with an enhanced insulation system available from REMA manufacturers. The additional cost of the enhanced insulation is typically 10 - 20% of the standard motor cost. No further insulation considerations are necessary for PWM inverters.
- ◆ For motors from other suppliers, the pulse withstand capability should be established by reference to the supplier. The permitted voltage/rise time characteristic should equal or exceed curve B shown in the graph.

Notes:

- i) Motor frame size selection must be appropriate for the application and duty.
- ii) Insulation requirements may be affected by the application specific notes overleaf.

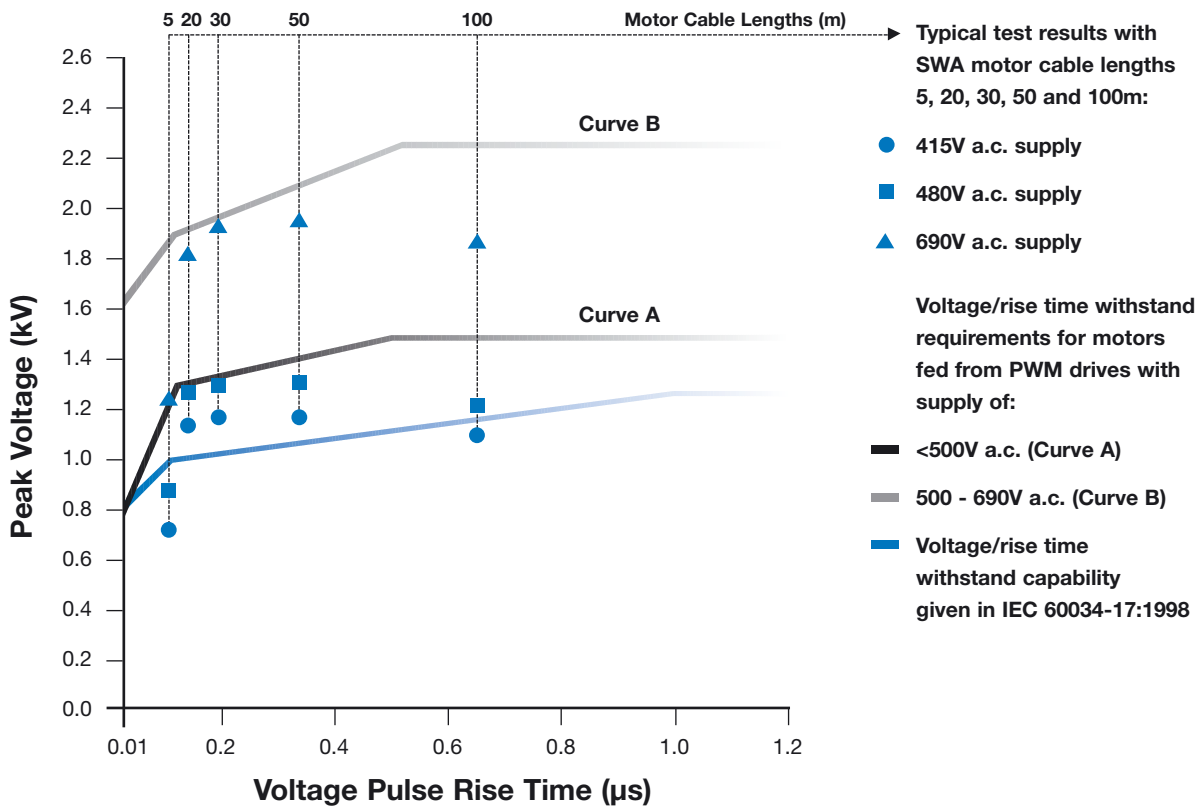
ALTERNATIVE APPROACH

Use Additional Preventative Methods

It may not be possible to follow the above recommendations - for example because the drive is to be retro-fitted to an existing motor, or data is not available for the motor concerned. In these cases an additional preventative measure is recommended - options are shown in the table on the right and the relative merits should be discussed with the drive supplier.

If special measures such as drive output reactors or filters are to be used for other reasons e.g. to limit the capacitance charging currents associated with motor cables or to reduce ripple currents, then no further special precautions are usually required.

MOTOR PULSE WITHSTAND CHARACTERISTIC CURVES PEAK VOLTAGE/RISE TIME



- Notes: i) Motor pulse withstand requirements on 415V supply generally exceed the minimum capability specified in IEC 60034-17.
 ii) Pulse risetime is in accordance with the IEC 60034-17 definition.
 iii) These curves are based on the practical experience of GAMBICA and REMA members.

TYPICAL RELATIVE COSTS - DRIVES AND PREVENTATIVE MEASURES (MOTOR = 100%)

RATING	DRIVE	PREVENTATIVE MEASURE			
		OUTPUT INDUCTOR	OUTPUT dv/dt FILTER	SINUSOIDAL FILTER	MOTOR TERMINATION UNIT
2.2kW, 415V	350%	75%	440%	330%	170%
75kW, 415V	220%	15%	100%	150%	10%
250kW, 415V	120%	5%	65%	110%	3%
160kW, 690V	150%	15%	40%	N/A	4%
250kW, 690V	140%	15%	40%	N/A	2%
500kW, 690V	140%	15%	35%	N/A	1%
POWER CIRCUIT OUTLINE					



The GAMBICA Association Limited
 St George's House,
 195-203 Waterloo Road,
 London SE1 8WB
 Tel: +44(0)20 7793 3050
 Fax: +44(0)20 7793 7635
 Email: assoc@gambica.org.uk
 Web: www.gambica.org.uk



Rotating Electrical Machines Association
 Westminster Tower,
 3 Albert Embankment,
 London SE1 7SL
 Tel: +44(0)20 7793 3041
 Fax: +44(0)20 7582 8020
 Email: rema@beama.org.uk
 Web: www.rema.uk.com

GAMBICA is the Association for Instrumentation, Control, Automation & Laboratory Technology 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

GAMBICA MEMBERS
 - Variable Speed Drives

ABB Automation Ltd

9 The Towers, Wilmslow Road
 Didsbury, Manchester M20 2AB
 Tel: +44 (0)161 445 5555
 Fax: +44 (0)161 448 1089
 Email: drives.sales@gb.abb.com
 Web: www.abb.co.uk

ALSTOM Power Conversion Ltd

Boughton Road, Rugby
 Warwickshire CV21 1BU
 Tel: +44 (0)1788 563625
 Fax: +44 (0)1788 563780
 Email: general.drives@powerconv.alstom.com
 Web: www.alstom.com

Baldor UK Ltd

Mint Motion Centre, 6 Bristol Distribution
 Park, Hawley Drive, Bristol BS32 0BF
 Tel: +44 (0)1454 850000
 Fax: +44 (0)1454 859001
 Email: sales@baldor.co.uk
 Web: www.baldor.co.uk

Claude Lyons Ltd

Brook Road, Waltham Cross
 Hertfordshire EN8 7LR
 Tel: +44 (0)1992 768888
 Fax: +44 (0)1992 788000
 Email: info@claudelyons.co.uk
 Web: www.claudelyons.co.uk

Control Techniques UK

Stafford Park 4, Telford TF3 3BA
 Tel: +44 (0)1952 213700
 Fax: +44 (0)1952 213701
 Email: ctdirect@compuserve.com
 Web: www.controltechniques.com

Danfoss Ltd

Perivale Industrial Park
 Horsenden Lane South
 Greenford, Middlesex UB6 7QE
 Tel: +44 (0)870 241 7200
 Fax: +44 (0)870 241 7150
 Email: uk.drives.sales@danfoss.com
 Web: www.danfoss.co.uk

Eaton Ltd, Cutler-Hammer

Carina, Sunrise Parkway, Linford Wood
 Milton Keynes, Bucks MK14 6NR
 Tel: +44 (0)1908 541600
 Fax: +44 (0)1908 660527
 Email: Ch-help-uk@eaton.com
 Web: www.ch.cutler-hammer.com/global/uk

GE Power Controls Limited

East Lancashire Road
 Liverpool L10 5HB
 Tel: +44 (0)151 524 1122
 Fax: +44 (0)151 524 6282
 Email: sales@gepc.ge.com
 Web: www.gepowercontrols.com

HID Ltd / Hitachi

Shuttleworth Close
 Gaptown Ind Estate
 Great Yarmouth
 Norfolk NR31 0NQ
 Tel: +44 (0)1493 442525
 Fax: +44 (0)1493 442323
 Email: sales@hid.co.uk
 Web: www.hid.co.uk

Hill Graham Controls Ltd

Lincoln Road, Cressex
 High Wycombe
 Bucks HP12 3RB
 Tel: +44 (0)1494 440121
 Fax: +44 (0)1494 438810
 Email: hillgraham@compuserve.com
 Web: www.hillgraham.com

IMO Precision Controls Ltd

100 North Circular Road
 Staples Corner, London NW2 7JP
 Tel: +44 (0)208 452 6444
 Fax: +44 (0)208 450 2274
 Email: imo@imopc.com
 Web: www.imopc.com

Lenze Ltd

Caxton Road, Bedford MK41 0HT
 Tel: +44 (0)1234 321200
 Fax: +44 (0)1234 261815
 Email: sales@lenze.co.uk
 Web: www.lenze.co.uk

Mitsubishi Electric Europe B.V.

Automation Systems Division
 Travellers Lane, Hatfield
 Herts AL10 8XB
 Tel: +44 (0)1707 276100
 Fax: +44 (0)1707 278695
 Web: www.industrial.meuk.co.uk

Moeller Electric Ltd

PO Box 35, Gatehouse Close
 Aylesbury, Bucks HP19 8DH
 Tel: +44 (0)1296 393322
 Fax: +44 (0)1296 421854
 Email: support@moeller.co.uk
 Web: www.moeller.co.uk

Omron Electronics UK Ltd

1 Apsley Way, Staples Corner, London NW2 7HF
 Tel: +44 (0)20 8450 4646
 Fax: +44 (0)20 8450 8087
 Email: oeuuk_sales@eu.omron.com
 Web: www.omron.co.uk

Rockwell Automation Ltd

Pitfield, Kiln Farm, Milton Keynes MK11 3DR
 Tel: +44 (0)1908 838800
 Fax: +44 (0)1908 839699
 Email: emccourt@ra.rockwell.com
 Web: www.automation.rockwell.com

Schneider Electric Ltd

University of Warwick Business Park
 Sir William Lyons Road, Coventry CV4 7EZ
 Tel: +44 (0)2476 416255
 Fax: +44 (0)2476 417517
 Web: www.schneider.co.uk

Siemens plc

Automation & Drives, Sir William Siemens House
 Princess Road, Manchester M20 2UR
 Tel: +44 (0)161 446 6400
 Fax: +44 (0)161 446 5471
 Email: info@plcman.siemens.co.uk
 Web: www.siemens-industry.co.uk

Yaskawa Electric Europe GmbH

Units 2/3 Centurion Court
 Brick Close, Kiln Farm
 Milton Keynes, Bucks MK11 3JA
 Tel: +44 (0)1908 565874
 Fax: +44 (0)1908 565891
 Web: www.yaskawa.co.uk

REMA MEMBERS

- Motors

ALSTOM Electrical Machines Ltd

Leicester Road, Rugby, Warks CV21 1BD
 Tel: +44 (0)1788 542121
 Fax: +44 (0)1788 541280
 Web: www.powerconv.alstom.com

ALSTOM Power Ltd

Lichfield Road, Stafford ST17 4LN
 Tel: +44 (0)1785 223221
 Fax: +44 (0)1785 274176

Baldor UK (Ltd)

Mint Motion Centre, 6 Bristol Distribution
 Park, Hawley Drive, Bristol BS32 0BF
 Tel: +44 (0)1454 859000
 Fax: +44 (0)1454 859001
 Email: sales@baldor.co.uk
 Web: www.baldor.co.uk

EFACEC (UK) Ltd

Unit 12, Riverside Industrial Park
 Ipswich, Suffolk IP2 8JX
 Tel: +44 (0)1473 602352
 Fax: +44 (0)1473 602194

Essex International Ltd

Ellis Ashton Street
 Huyton Business Park
 Liverpool L36 6BW
 Tel: +44 (0)151 443 6000
 Fax: +44 (0)151 443 6025
 Web: www.superioressex.com

Invensys Brook Crompton

St Thomas Road, Huddersfield
 West Yorkshire HD1 3LJ
 Tel: +44 (0)1484 422150
 Fax: +44 (0)1484 557201
 Web: www.brookcrompton.com

Morley Electric Motors Co Ltd

Bradford Road, Leeds
 West Yorkshire LS28 6QA
 Tel: +44 (0)113 257 1734
 Fax: +44 (0)113 257 0751
 Email: sales@morleymotors.com
 Web: www.morleymotors.com

Peebles Electrical Machines Ltd

Wood Road, Rosyth
 Dunfermline, Fife, KY11 2EA
 Tel: +44 (0)1383 422001
 Fax: +44 (0)1383 422285

SEM Ltd

Faraday Way, Orpington
 Kent BR5 3QT
 Tel: +44 (0)1689 884700
 Fax: +44 (0)1689 884884
 Web: www.sem.co.uk

Siemens plc

Automation and Drives
 Sir William Siemens House
 Princess Road
 Manchester M20 2UR
 Tel: +44 (0)161 446 5330
 Fax: +44 (0)161 446 5395
 Email: info@plcman.siemens.co.uk
 Web: www.siemens-industry.co.uk

Teco Electric Europe Limited

Marshall Stevens Way
 Trafford Park
 Manchester M17 1PP
 Tel: +44(0)161 877 8025
 Fax: +44(0)161 877 8030