PM Synchronous Motors

Technical Data

S..09

Bauer® Gear Motor

An Altra Industrial Motion Company

Bauer Gear Motor

We are all familiar with the figures: around 70 per cent of industrial energy demand comes from electric motors. This represents CO2 emissions on the order of some 427 million tons. The European Commission is convinced that savings equal to the electrical power consumption of Sweden could be achieved with suitable measures.

Bauer Gear Motor welcomes the EU Directive

EU Directive ErP 2009/125/EC (Eco-design Requirements for Energy-using Products) defines the conditions for these savings. The EU member states gave their support to the new rules for reducing the energy demand of industrial motors at a meeting of the ecodesign regulatory committee on 11 March 2009.

The ordinance sets out three stages:

from 16 June 2011 onward, motors must comply as a minimum with MEPS (Minimum Efficiency Performance Standards) energy efficiency class IE2 (High Efficiency; formerly EFF1). From January 2015 onward, energy efficiency class IE3 (Premium Efficiency) will be the standard for motors with rated power of 7.5 to 375 kW, and from January 2017 onward for motors with rated power of 0.75 to 375 kW. Motors controlled by frequency converters are exempt from this regulation. For such motors, IE2 is sufficient.

Company policy

We see ecodesign as an affirmation of our efforts. Bauer Gear Motor strives to reach its goals with minimum consumption of raw materials and energy, the least possible impact on the environment, and efficient use of resources. Bauer Gear Motor fully supports the Directive, especially because most of our developments are committed to energy savings.

What does the EU directive mean?

IEC 60034-30 is an international standard for energy-efficient motors and will in future years be used worldwide in this area. Electric motors account for approximately 1.07 billion kWh of the total energy demand of the EU. Using energy efficient motors would achieve energy savings of 20 to 30 per cent, thereby reducing the total cost of ownership (TCO) and reducing global warming.

Bauer Gear Motor PMSM-Drives already fulfill the future requirements of IE4 laid down in the draft IEC 60034-30 Edition 2 which will be approved shortly.

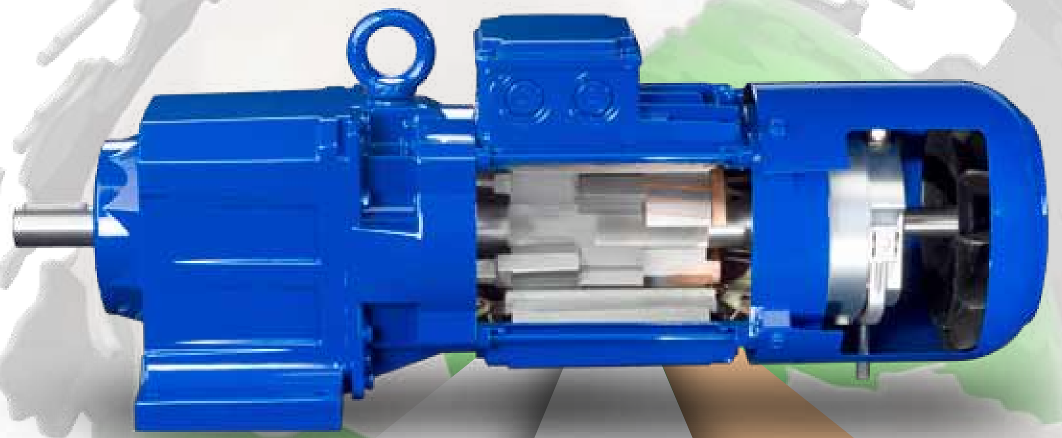
As things stand today

New IE (International Energy Efficiency) efficiency classes were introduced at the beginning of 2009:

- IE1 = Standard Efficiency (~EFF2)
- IE2 = High Efficiency (~EFF1)
- IE3 = Premium Efficiency (10 - 15% higher efficiency as IE2)
- IE4 = Super Premium Efficiency




Comparison of the Motor Tecnologies



Aluminium

Losses 100%

Permanent Magnet

No voltage induction in the rotor

- no heat losses in the rotor
- Rotor losses reduced by 100%
- Total losses reduced by approximately 25%
- Total efficiency increased ≥ 10%

Copper

higher electrical conductability of copper

- Rotor resistance reduces by 40%
- Heat losses in rotor reduced by 40%
- Total losses reduced by 10..15%
- Total efficiency increasded by 1…2%




Permanent Magnet Synchronous Motors (PMSM)

The stator of a permanent magnet synchronous motor has the same structure as the stator of a three-phase asynchronous induction motor (ASM), with three separate phase windings. However, a PMSM has a rotor with embedded permanent magnets made from the rare-earth material, instead of the squirrel-cage rotor found in induction motors.

These permanent magnets and the resulting constant magnetic field eliminate the need for inducing a magnetic field in the rotor in order to produce torque, and they eliminate the need for a speed difference (slip) between the rotating fields of the stator and the rotor, which is required in an induction motor. The rotor rotates synchronously with the rotating field of the stator.

A synchronous motor cannot start up by itself when connected to the mains, due to the inertia of the rotor and the high speed of the rotating stator field. Magnetic coupling between the two components is not possible under these conditions. Consequently, the rotor must be brought up to the speed of the rotating field. A frequency converter allows this to be done by increasing the speed of the rotating field in a controlled manner while maintaining magnetic coupling between the stator and the rotor.

Synchronous motors run at constant speed independent of the load. The torque of a synchronous motor is proportional to the current. The input current necessary for the required torque is determined from the rotor position and the motor data on the following page. This requires a field-oriented frequency converter with a suitable algorithm for controlling synchronous motors.

PM synchronous motors have considerably higher power density and much better efficiency than induction motors. For geared motors, this yields higher system efficiency with minimal installation volume. PMSM drives can produce higher torques with the same installation volume, which may allow a smaller motor size to be used in some applications.

Advantages:

- Small installation volume and minimal weight
- Extremely high efficiency under rated operating conditions
- Considerably better efficiency than induction motors, even under partial load conditions
- High torque density and power density
- High overload capacity
- Lower life-cycle costs
- Clear operating cost saving potential (resulting in a smaller CO_2 footprint)
- Short payback time
- Futureproof Investment

Technical data

All motors: converter supply voltage 380 to 500 V

Motor data sheet: S09SA4 (example)		
Rated power P_N	1.5	kW
Rated torque M_n	9.55	Nm
Rated current I_n	2.9	A
Motor poles 2p	4	
Rated speed n_n	1500	rpm
Rated frequency	50	Hz
Motor efficiency η	IE4 – 89.2	%
Motor connection	Y	
Phase-to-phase resistance U–V R_{20}	9.9	ohm
Winding resistance Rs_{20}	4.95	ohm
D-axis inductance L_d	79	mH
Q-axis inductance L_q	113	mH
Reverse EMF constant k_e	200	V / 1000 rpm
Torque constant k_t	3.2	Nm/A
Peak torque $M_{max\ (60s)}$	25	Nm
Peak current $I_{max\ (60s)}$	8.0	A
Moment of inertia	0.00245	kgm²

Reverse EMF constant ke

The reverse EMF is the voltage induced in the rotor by the magnetic field of the stator. It depends on the rotational speed of the rotor.

Torque constant kt

Ratio of motor torque to motor current in amperes.

D-axis inductance Ld

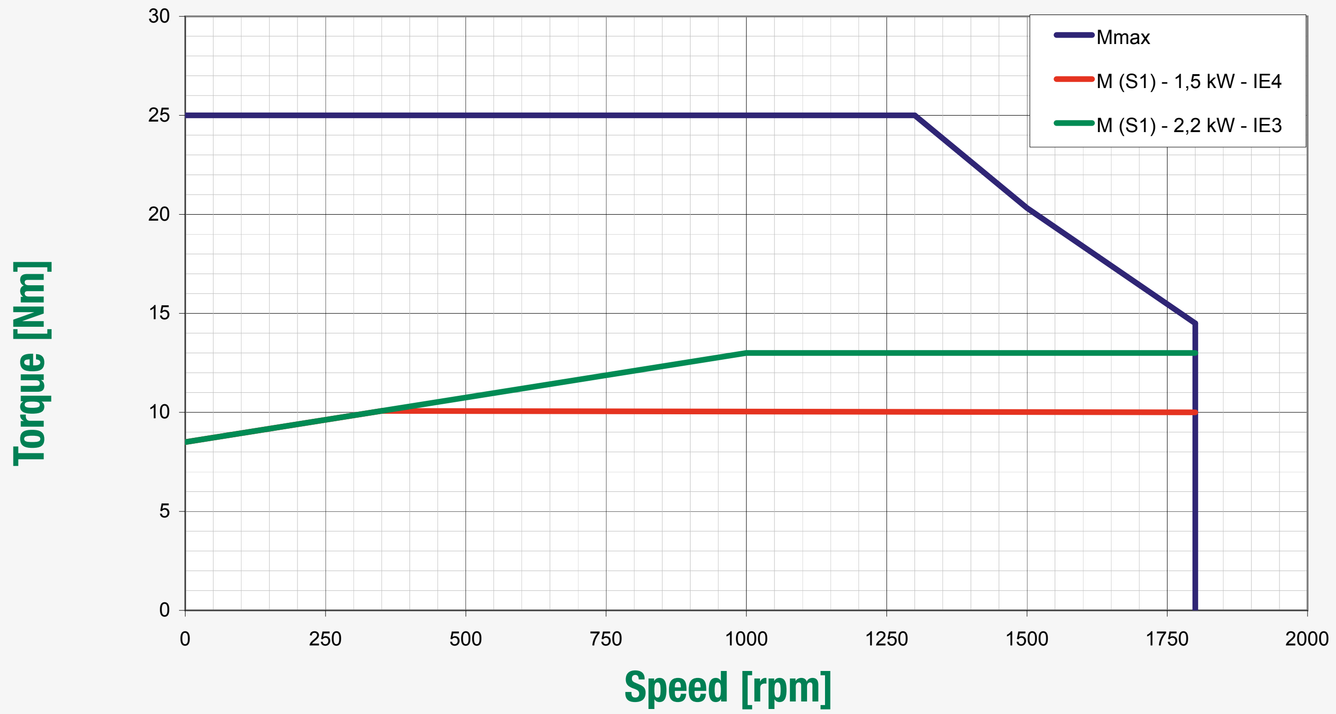
The inductance in the direction of current component id, which generates the magnetic flux.

Q-axis inductance Lq

The inductance in the direction of current component iq, which generates the torque.

Inductance

A measure of the ability of an electrical conductor to produce a magnetic field.






Technical Data

Motor Data (ventilated)						S09SA4
Rated power P_N	kW	1,5	2,2	2,2	3	4
Rated torque M_n	Nm	10	14	10	12,75	12,75
Rated current I_n	A	3,1	4,3	5	6,8	7,9
Motor poles 2p		4	4	4	4	4
Rated speed n_n	1/min	1500	1500	2250	2250	3000
Rated frequency	Hz	50	50	75	75	100
Motor efficiency η	%	IE4 - 89,2	IE3 - 86,7	IE4 - 91,1	IE3 - 89,2	IE4 - 91,5
Motor connection		Y	Y	D	D	Y
Phase-to-phase resistance U–V R_{20}	Ohm	9,9	9,9	3,3	3,3	2,46
Winding resistance Rs_{20}	Ohm	4,95	4,95	4,95	4,95	1,23
D-axis inductance L_d	mH	79	79	26,3	26,3	19,3
Q-axis inductance L_q	mH	113	113	37,5	37,5	27,4
Reverse EMF constant k_e	V/1000 1/min	200	200	115	115	100
Torque constant k_t	Nm/A	3,2	3,2	1,8	1,8	1,6
Peak torque $M_{max (60s)}$	Nm	25	25	25	25	25
Peak current $I_{max (60s)}$	A	8	8	14	14	17
Moment of inertia	kgm²	0,00245				
Data Inverter Duty						
n1 (from - to)	1/min	100 bis 350	100 bis 1000	100 bis 350	100 bis 1000	100 bis 1000
M1	Nm	8,5 + 0,0045*n1				
n1 (from - to)	1/min	350 bis 1800	1000 bis 1800	350 bis 3000	1000 bis 3000	100 bis 3600
M1	Nm	10	13	10	13	13

Motor Data (ventilated)						S09XA4
Rated power P_N	kW	2,2	3	4	5,5	7,5
Rated torque M_n	Nm	14	19	17,5	17,5	24
Rated current I_n	A	4,35	5,9	9,2	10,7	14,8
Motor poles 2p		4	4	4	4	4
Rated speed n_n	1/min	1500	1500	2250	3000	3000
Rated frequency	Hz	50	50	75	100	100
Motor efficiency η	%	IE4 - 89,8	IE3 - 87,7	IE4 - 90,8	IE4 – 93,0	IE3 - 91,5
Motor connection		Y	Y	D	Y	Y
Phase-to-phase resistance U–V R_{20}	Ohm	5,3	5,3	1,76	1,31	1,31
Winding resistance Rs_{20}	Ohm	2,65	2,65	2,65	0,655	0,655
D-axis inductance L_d	mH	50,8	50,8	16,9	12,7	12,7
Q-axis inductance L_q	mH	71,3	71,3	23,8	17,9	17,9
Reverse EMF constant k_e	V/1000 1/min	204	204	118	102	102
Torque constant k_t	Nm/A	3,2	3,2	1,8	1,6	1,6
Peak torque $M_{max (60s)}$	Nm	35	35	35	40	40
Peak current $I_{max (60s)}$	A	11	11	19	27	27
Moment of inertia	kgm²	0,0038				
Data Inverter Duty						
n1 (from - to)	1/min	100 bis 375	100 bis 1000	100 bis 1000	100 bis 1000	100 bis 1500
M1	Nm	11,5 + 0,0075*n1				
n1 (from - to)	1/min	375 bis 1800	1000 bis 1800	1000 bis 3000	750 bis 3600	1500 bis 3600
M1	Nm	14	19	19	19	23




Motor Data (non-ventilated)				SU09SA4 / SA09SA4
Rated power P_N	kW	1,1	1,65	2,2
Rated torque M_n	Nm	7	7	7
Rated current I_n	A	2,2	3,9	4,6
Motor poles 2p		4	4	4
Rated speed n_n	1/min	1500	2250	3000
Rated frequency	Hz	50	75	100
Motor efficiency η	%	IE4 - 88,5	IE4 - 90,3	IE4 - 91,0
Motor connection		Y	D	Y
Phase-to-phase resistance U–V R_{20}	Ohm	9,9	3,3	2,46
Winding resistance Rs_{20}	Ohm	4,95	4,95	1,23
D-axis inductance L_d	mH	79	26,3	19,3
Q-axis inductance L_q	mH	113	37,5	27,4
Reverse EMF constant k_e	V/1000 1/min	200	115	100
Torque constant k_t	Nm/A	3,2	1,8	1,6
Peak torque $M_{max\ (60s)}$	Nm	20	20	20
Peak current $I_{max\ (60s)}$	A	6,5	11	13
Moment of inertia	kgm²	0,00245		
Data Inverter Duty				
n1 (from - to)	1/min	100 bis 2000	100 bis 3000	100 bis 3600
M1	Nm	7,5 - 0,0003*n1		

Motor Data (non-ventilated)				SU09XA4 / SA09XA4
Rated power P_N	kW	1,5	2,2	3
Rated torque M_n	Nm	10	10	10
Rated current I_n	A	3,1	5,7	6,5
Motor poles 2p		4	4	4
Rated speed n_n	1/min	1500	2250	3000
Rated frequency	Hz	50	75	100
Motor efficiency η	%	IE4 - 90,0	IE4 - 91,2	IE4 - 92,7
Motor connection		Y	D	Y
Phase-to-phase resistance U–V R_{20}	Ohm	5,3	1,76	1,31
Winding resistance Rs_{20}	Ohm	2,65	2,65	0,655
D-axis inductance L_d	mH	50,8	16,9	12,7
Q-axis inductance L_q	mH	71,3	23,8	17,9
Reverse EMF constant k_e	V/1000 1/min	204	118	102
Torque constant k_t	Nm/A	3,2	1,8	1,6
Peak torque $M_{max\ (60s)}$	Nm	25	25	25
Peak current $I_{max\ (60s)}$	A	8	14	15
Moment of inertia	kgm²	0,0038		
Data Inverter Duty				
n1 (from - to)	1/min	100 bis 2000	100 bis 3000	100 bis 3600
M1	Nm	10,6 - 0,0005*n1		

Altra Industrial Motion

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TB Wood's
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1-888-829-6637– Press #5
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TB Wood's
Belted Drives
Chambersburg, PA - USA
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For application assistance: 1-888-829-6637 – Press #7

Engineered Bearing Assemblies

Kilian Manufacturing
Engineered Bearing Assemblies
Syracuse, NY - USA
1-315-432-0700

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