BL-Motor System
A brushless synchronous motor with variable speed control for powers from 500kW to 50MW
The BL motor system is a brushless drive system. Its strengths are economy of operation, low maintenance and a wide application.

The BL motor System is a drive System using a brushless 3-phase synchronous motor whose speed is regulated by a thyristor converter. For this reason this System is also known as the "converter motor" system.

Numerous plants for the generation of energy in power plants and the processing of chemicals, plastics and rubber as well as in the distribution of natural gas both at home and abroad have been equipped with BL motor systems from AEG. Synchronous motors have also proven successful under the tough conditions encountered in everyday Operation of test systems and in the most varied applications in industry.

BL motor systems can be designed and manufactured for the many and varied customer specifications and standards applicable today. Through this level of flexibility BL motor systems can be ideally integrated in national and international plant projects.

The main advantages of the BL motor system from AEG

Economic operation
The normal payback period of a BL motor System is just a few years: Through its high level of efficiency, optimum process control, speed and torque regulation and the low repair requirements.

Low maintenance
The BL motor system requires the lowest level of maintenance in comparison with other electrically controlled drives. And it is even better in comparison to mechanical, hydraulic or thermodynamic control systems.

Universal applications
The BL motor system can be designed for virtually any power and speed. This System therefore covers many applications in many branches of industry, above all it can be used under difficult environmental conditions which involve dust, corrosive or explosive gas, salty air or radioactivity.

The title page photograph shows two natural gas reciprocating compressors with BL motor System drives, 2,000 kW, 420 rpm, 14-pole, flameproof class EEx-e, 12-pulse converter.

That is the digital form of AEG prospect A52 V2.7.36/0689. AEG Industrial Engineering GmbH Berlin 2006
1) Converters for BL motor systems are installed in AEG intermas cubicles with steel panels and are system-tested ex works.

In the left-hand cubicle are the two air-cooled thyristor bridges of a 6-pulse converter for 1,900 kW. The right-hand cubicle contains the drive control, regulation, and excitation as well as in this case a comprehensive set of optional equipment meeting the customers' specification. The DC choke is installed separately.

2) Basic circuit diagram of a 6-pulse BL motor drive system.

1 Mains converter (LCC)  
2 DC-Smoothing reactor  
3 Motor converter (MCC)  
4 Voltage detection  
5 Synchronous motor  
6 Driven machine  
7 Speed controller  
8 Current controller  
9 Pulse generator  
10 Ignition angle control  
11 Control loop exciter  
12 Brushless excitation
The operation of the BL motor drive system from AEG

In principle, Operation of a BL motor System is similar to that of a converter-fed DC motor drive. In the BL motor System however the mechanical DC motor commutator which is subject to wear has been replaced by an electronic commutator. This means: The robustness and freedom from maintenance of the brushless excited synchronous motor have been combined with the optimum control provided by the converterfed DC motor to form a new drive System - the BL motor system.

The electrical characteristics of the System

A mains converter adjusts the speed and torque. As in a DC drive the speed at a constant magnetic flux level is proportional to the DC voltage and the torque is proportional to the DC current. The speed control and the subordinate current control act upon the mains converter through a firing circuit, as in a DC drive.

A motor converter serves as an electronic commutator. This applies the DC current to the three motor conductors in cycles of blocks with an electrical length of 120 degrees. In order to avoid the high cost of self-commutated motor converter thyristors the principle of load commutation is used. This results in an overexcited synchronous motor which then provides the commutation and control reactive power for the motor converter. The firing pulses for the motor converter are generated by the "electronic distributor", in the analogy of a combustion engine. This is a firing circuit for a variable input voltage and input frequency. The firing angle of the motor converter in motor operation is almost constant at $\alpha = 150$ degrees, independent of the speed.

The motor voltage and speed are normally proportional (constant torque). In field weakening operation however a constant motor voltage and a rising speed are used (constant power). The exciter circuit of the drive controls the required motor voltage characteristic.

3) The power ranges of electrically controlled drives

1. BL motor system
2. Asynchronous motor with Monoverter I converter
3. Sub-synchronous converter cascade (USK)
4. Synchronous motor with direct converter
5. DC drive.

The BL motor system is the only brushless and therefore substantially maintenance free control drive for medium and high power and speeds. The asynchronous squirrel cage motor with the Monovertor also operates with low maintenance but is limited to low and medium ratings and speeds.

The synchronous motor has a 3-phase winding in a star circuit in the stator. When fed from a 12-pulse motor converter the stator is provided with two winding systems which are offset through 30 degrees electrical. The rotor is fitted with a DC exciter winding and an attenuation cage. The DC exciter current is supplied by an asynchronous exciter motor with a rotating diode rectifier (AEG Rotaduct system). This replaces the brushes in the drive motor.

Braking (by reversal of the DC voltage) and

Reversing (by reversing the motor converter pulses) are possible with BL motor systems without further major cost.
4) Test runs under rated load conditions at high capacities are possible with two drives in so-called back to back operation. The measurement of the bosses in these two 10 MWBL motor systems showed a level of efficiency of 95.0% at 4,500 rpm, including all components for example transformers, converters and the motor.

5) Depending upon the power of the drive, 12-puls frequency converters can be installed on the mains and motor sides (see figure above), or on the mains side only (see figure below)
The concept of the complete BL motor system

The performance characteristics

The BL motor system is a speed controlled single drive without commutator and brushes. It is similar to the DC drive. The rated capacities start at 500 kW up to more than 50,000 kW. The rated speeds - without gears - are from 100 to 6,000 rpm. The standard speed range is 1: 10. Speed stability is better than 1%. BL motor systems can be operated in the lower speed range with constant torque and in the upper speed range with constant power (field weakening range). Reversal of the direction of rotation is electronic.

A tachogenerator is not required since the speed actual value is formed from the motor frequency. Braking is possible without additional equipment for the power stack.

The BL motor system provides a high level of efficiency even under partial bad conditions and at intermediate speeds. Its availability level is also very high since the motor bearings and the cubicle ventilation fans are the only parts subject to wear. It also cannot “fall out of step” through overloads and it can be designed for any bad cycles, like the DC drive. The “breakaway” torque for the motor can be set to more than twice the rated torque level. The system is monitored and protected by electronics.

BL motor systems are a well tested and largely standardised drive system. International standards have been taken into consideration. The systems are suitable for integration into modern automation systems (bus connection).

6) The control electronics of the BL-drive is part of LOGIDYN D system and consist of plug-in cards in the single and double Europa format. They are fitted in a hinged magazine. The control, fault annunciation and safety Systems as well as customer-specific links are provided in programmable microprocessor memories. If a superimposed group control level is provided then communication with this is via the bus. For further information ask for more detailed description of LOGIDYN D2 control system.
Characteristics at the mains network

In motors with shaft heights of 560 mm and above (corresponding to approx. 2,000 kW, 1,500 rpm) a 12-pulse circuit is preferred on both the mains and motor sides. The loads imposed upon the mains network and the motor through harmonics are therefore very slight. Below this shaft height either 6-pulse or 12-pulse circuits are possible.

The starting current is normally lower than or equal to the rated current. There are therefore no noticeable voltage dips in the supply network. Within the voltage and frequency tolerances stated by the customer for the mains network the drive will maintain its rated speed and constant power. The motor “levels out” smoothly after a mains under voltage or a mains failure. Furthermore BL motor systems do not react to mains short circuits by “reversing the supply”. They therefore do not increase the short circuit rating of the busbar.

BL motor systems provide the lowest possible operating costs since they only take the power actually required for the process out of the network. For example, under off-load conditions less than 5 % of the rated current - (including exciter) - is used. By comparison asynchronous motors require 20 to 35 % when dung.

Our supply and performance features

To complete the entire BL motor system AEG can also supply converter transformers and circuit breakers. Comprehensive works testing of drive components - in special cases also an in-house test of the complete drive system - give customers the security they require. AEG does not just supply the BL motor system itself. Experienced project engineers also handle the detail work of project planning and co-ordination, construction and the space requirements, questions of ventilation, calculations of vibration, reactive power compensation, assembly and cabling as well as smooth commissioning, personnel training and service. For this drive system AEG has more than 25 years operational experience and a reference list covering over 400 plants supplied to date. One more reason for you to contact us.

7) BL motor systems like these 1,700 kW mixer drives in the plastics and rubber processing industry must operate at constant torque over the speed range. In such cases the optimum solution has proven to be BL motors in the protection class IP 54 with a top-mounted air/water cooler.

8) Fully digital control loops are state of the art with LOGIDYN D with high-speed microprocessor systems. AEG and its customers alike benefit from this new form of technology of BL-MOTOR SYSTEM because design, commissioning, documentation, diagnosis, and service procedure have become much easier. The example of a speed controller in the figure illustrates how freely designed software modules are represented on the screen of a PC.

9) LogiCAD for control and sequence process control and simulation with real-time analysis and with included...
...and the specific characteristics of the converter

The control electronics and the power circuit of the converter are installed in separate cubicie sections. This well proven standard method of construction has many advantages: it simplifies fast and flexible project work according to customer specification. Furthermore it leads to the lowest possible production and testing costs in the manufacturer's works and guarantees reliable Operation and fast service at the point of installation.

Common characteristics of the control electronics and the power circuit

The thyristor and control electronics section are of modular construction. This compact construction takes up very little space. Easy access and therefore fast replacement of components is guaranteed. High flexibility means that the electrical and mechanical parts can more easily be designed to meet customers specifications and works standards.

Protection classes from IP 00 to IP 54 are possible, for installation in industrial environments, in sea air or in other severe environmental conditions.

Design of the power circuit

The thyristor power circuit consists of simple standard modules. The mains and motor converters use the same semiconductor cells. All thyristors are of AEG manufacture (today Eupec) because of their robust construction and availability. Commutation equipment like capacitors, diodes, fast thyristors or chokes are not required. If possible parallel thyristor circuits are not used. Instead, series circuits are used when AC voltages of over 1,300 V are required.

The system can be designed for voltages between 380 V and 10 kV. Systems over 4 MW require a circuit which does not use fuses. Ventilation at these power ratings is either by forced air, through air/water heat exchangers or with direct water cooling, redundant fan assemblies, can be fitted.

10) BL motor converters are fitted with disc thyristors. Depending upon the drive capacity cells with diameters of 74 mm, 120 mm or 150 mm are used without paralleling. When used for medium voltage the high blocking voltage of up to 6500 V per thyristor allow a small number of cells to be connected in series. AEG production, today Eupec Germany.

The control electronics of the converter

The control, monitoring, protection and fault signal processing, using microprocessor technology. The control program can be modified quickly and easily.

Speed and torque control is effected from here just as the time-dependent torque monitor and the blocking protection in drives with constant bad torque or the processing of the measurement results from transformer and motor monitors. Adjustable ramps are provided for acceleration and deceleration. Coupling to the bus System of a superimposed control station is possible. Initial fault value annunciation and follow-up signals are standard or optional as are safety devices to prevent overload, over current, under voltage, over voltage, short-circuit, earth fault or over speed. The operating Status, warning and fault signals are shown by LED displays.

The system includes a diagnostic plug for analog and digital signals in order to quickly locate any sporadic faults in the control electronics with the aid of the digital fault recorder AEG Logitron. On request the Logitron unit can be permanently installed in the converter in a 19 inch rack magazine. All the measurements are then stored permanently (last in first out) and can be printed out at any time.
This 12-pulse converter with 24 disc thyristors has an air/water cooler with two air circuits in the centre of the cubicle. The cooling air is drawn through the thyristor module by two cross-flow fans (to the left and right under the hood) and is forced into the cooler. This advantageous design requires no cooling air supply from the outside. This avoids heat dissipation to the control room. Operation is at a low noise level and the unit is in addition sealed against dust and water to protection class P54.
The features of powerful synchronous motors

Modern designed synchronous high power motors have always formed a part of the AEG scope of supply. The synchronous motor of the BL motor system is almost identical to the synchronous generator used for electricity generation. From the construction of generators we have long been familiar with the special features of brushless excitation and have our own product - the AEG Rotaduct - on the market. Our economical drive systems have today been produced on the basis of these years of experience. Constant further development in our works at Bremen and Essen guarantee the acknowledged high technical standing and reputation of this equipment.

Every drive system requires a specific technical solution - and AEG can supply it

Through a constant exchange of information and experience with our customers and their planning and engineering offices it is possible for us to match the motors ideally to the practical requirements. In addition to the general operating characteristics this includes, such characteristics as:

- High levels of efficiency
- Low noise emission levels
- Long operation life
- Low erection and commissioning costs
- Easy servicing.

Further requirements are created by many different customer specifications. And we can also provide the optimum solution in each case:

The choice of voltage - whether low or high voltage - is determined by the thyristor configuration. Depending upon the required maximum speed we can offer 2-pole to 16-pole motors and even higher pole numbers in special cases.

Our standard program includes all important design aspects required for 1 EC 34-7 as well as other international standards VDE, NEMA, BS for example. Protection classes from IP 23 to IP 65 as well as the explosion protection, flameproof classes Ex(e), Ex(p) and Ex(n) with PIB or BASEEFA certificate are available also conventional types of cooling using air and air/water. The windings are generally constructed with insulation class F.

All standard motors are provided with two bearing design, even the high speed turbo rotor motors. The bearir on the non-driven side always being insulated. Larger drives have sliding bearings which are also available in the lower power ranges at customer request. The smooth-running characteristics according to VDI 2056 are “Good".

Depending upon the application, the motors can be fitted with cage type rotors or with salient pole type rotors. A strong damper cage reduces the losses resulting from current harmonics in the rotor and at the same time reduces the commutation time.

Torsional and bending vibration safely under control

Drives with four poles and more run below the critical speed. The first ‘critical bending’ speed therefore lies above rated speed. Two pole high speed drives are designed to allow continuous running at the first critical bending speed.

BL motors produce only little alternating torque levels. In some cases however it is recommended that the shaft should be assessed for the “critical torsion” speeds whilst including the motor, coupling and machine. Our specialists solve this problem by using our own computer factories programmes.

12) High speed BL motors for boiler feed pumps and turbine compressors have 2-pole turbo rotors of forged steel, like power plant generators. The high speeds of up to 6,000 rpm and the supply through converters do however require additional special knowledge for calculation and design. AEG has the specialists and experience required for this.

13) BL motors can be fitted with all conventional types of bearings, whether block or plate bearings, sliding or self-aligning roller bearings. The protection classes reach from IP 23 to IP 65. Also explosion protection in the flame proof classes “e” (increased safety), “p” (overpressures encapsulation) and “n” (nonsparking) form part of the standard supply programme.
AEG is your competent partner for the construction of BL motor systems

The technical and economic advantages of this system have led to it being used in a wide range of applications for medium and high power ratings. BL motor systems are already in operation in almost 50% of the recognized applications stated below. Others are already at the project or planning stage. A large number of deliveries worldwide form our best references.

Branches of industry for which BL motor systems are of particular importance:

**Electricity generation**
- Boilerfeed pumps
- Hot water circulation pumps
- Condensate pumps
- Fresh air fans
- Suction fans
- Cooling water pumps
- REA pressure raising fans
- Mill fans
- Coal mills
- Hot water pumps for remote heating
- Wind power generators.

**Chemicals**
- Turbo-compressors
- Screw compressors
- Ammonia reciprocating pumps
- Refiners
- Rotary pumps
- Diesel engine test beds
- Wind tunnels.

**Plastics and rubber processing**
- Extruders
- Mixers
- Calenders.

**Natural gas supply**
- Turbo-compressors
- Reciprocating compressors.

**Test systems**
- Balance and centrifugal test beds
- Pump and compressor test beds

**Marine and offshore technology**
- Propulsion drives
- Shaftmounted generators
- Drives on drilling rigs.

**Iron and steel works, coal and ore mining**
- Furnace fans
- Sintering fans
- Dust extraction systems
- Rotary kilns
- Grinding systems
- Conveyor belts.

**Further applications**
- Drinking water pumps
- Fans of all types.

The operating data: 10,000 kW each, 4,500 rpm in continuous operation or 13,650 kW, 5,000 rpm for 15 minutes (at the so called TÜV point). Faultless operation since 1984 has far exceeded the availability levels expected by the operator. Since then, a 100 % feed pump drive of 15,000 kW, 4,700 rpm (18,200 kW, 5,100 rpm for 15 minutes) has also been put into operation for a lot of other power supply company.

In coal fired power stations, boiler feed pumps are amongst the largest auxiliary drives. If pumps are frequently operated under partial bad conditions there can be considerable energy saving through the use of the BL motor system as a speed controlled gearless electric drive. The photograph shows two 75 % boiler feed pump drives of a 650 MW power plant during erection (Figure 13).
Some practical examples of high ratings

With a rating of 3,200 kW at 875 rpm this speed controlled mixer drive (Figure 15) is one of the largest in the world. The converter used was constructed as a 12-pulse converter on both the mains and motor sides. The results are low current harmonics in the supply network and uniform torque on the drive shaft.

In nuclear stations with water cooled reactors a total of 40 BL motor systems have been installed for cooling water circulation pumps. The motor was designed with a type B3 mounting (Figure 16). Further special features of the motors included the air/water cooler, brake and reversing lock which are located axially below the active section.
Examples for the application of BL motor System inverter

In high power drives the components of the BL motor System are designed for medium voltage. The thyristor power circuit is therefore mounted either in an open frame (Figure 16) or in enclosed Intermas cubicles. The 6 kV converter illustrated here contains water cooled thyristors. The transfer of signals between the control cubicle and the thyristor circuit for the control of the firing pulses and for status feedback is by light, through optical fibres. This standardised Megasemi module technology from AEG has also been in use for lot of years in other medium and high voltage applications. For example in dynamic reactive power compensators, HVDC systems and petrochemical electric arc reactors.

The converters of the BL motor system are also often used for starting of large synchronous machines. The rating of these starting converters frequently need only represent a few percent of the motor capacity. The illustration (Figure 18) shows a 3,000 kW converter for starting up one or more large generators in gas turbine power stations. The package with a width of only 3 metres which was completely pre-wired and operationally tested ex works contains the DC smoothing chokes, thyristor modules, the control electronics and the complete static exciter system of the Semipol type.

We have been manufacturing BL motor Systems and starting converters for almost three decades. 360 plants have been supplied to lot of countries. They are operating there every day faultlessly, under severe conditions. You can trust our references from all over the world. Please ask for our detailed reference list for the "BL Motor Systems".

Also we used BL motor system to controlled speed of large generators / motors in hydro power storage power plants with 25 MW and more to install continues speed / load control of pump / turbine. Our sales engineers would be pleased to assist you with any further details, information or advice you may wish for. Please contact us

AEG Industrial Engineering GmbH · D–14199 Berlin · Tel +49 30 820 99 490 · Fax +49 30 820 99 499 · www.aeg-ie.com
AEG Berlin
factory for current rectifier products

AEG have been developing, projecting, manufacturing and selling power electronics plants and components for more than 60 years. The new production facility in Berlin with more than 46000 square metres of production and office premises, around 1000 employees and modern production equipment has been in service since 1984 to provide the facilities required to consolidate and expand upon the technological lead held by the company. During the last 8 years AEG’s propriety factory together with its highly experienced engineers and personell was rented and operated by several different companies. Today it is Converteam GmbH a daughter of Barclays Bank

Characteristics of the systems, plant and components include innovative technology, high safety and reliability levels and quality assurance with extremely accurate quality control and operational testing facilities. The extensive service provided meets the high quality standards of the products.

The reference list of different power electronics applications are long and not limited.

Products and Services

The division program includes:

- Converter for drive technology
- Motion control systems
- Converter for power plant technology
- Rectifier for high voltage and high current applications.
- Construction of controls and workshop Services
- Wind generation applications
- Converters: 50/60/16 2/3 Hz

These products are being marketed by the specialized departments for plant construction as part of the total plants

Your Partner

AEG
Industrial Engineering GmbH
International Berlin Office
Hohenzollerndamm 152
14199 Berlin, Germany

Tel.: +49(30)82099490
Fax: +49(30)82099499
E-Mail: aeg@aeg-ie.com
Web: www.aeg-ie.com

AEG Industries at Hohenzollerndamm area is the communication centre for current and former AEG factories world wide and is responsible for plant engineering

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