



# APPLICATION WIND TURBINES

SMART PITCH AND YAW SOLUTIONS

V - 1.0    EN

## SOLUTIONS FOR WIND TURBINES

Harvesting is as old as mankind and is the foundation for our survival. Mother earth is so kind donating us the WIND as a powerful energy and she allows us to use it. In respect for future generations, we are asked to save natural resources, and so it is noble to harvest energy out of this wind. Windmills have been used over centuries to mill flour or pump water. Today wind turbines are used to produce electrical energy. As wind is not blowing with a constant speed and direction, it is important to constantly adapt the angle of the blade and turn the rotor into the wind. This makes a maximum power tracking possible and produces as much energy as possible.

On the other hand, it is necessary to produce electricity with the lowest losses. Highly efficient solutions are necessary for fast amortization and best revenue. In addition it is also necessary to consider malfunctions and so to avoid damages or destruction of the turbine.

KEB, with its 30 years of experience in design and production of frequency inverters for most challenging applications, has designed robust drives, motors and brakes for the different movements inside the wind turbine. Proud of its 50,000 inverters installed in turbines around the world, KEB has launched the COMBIVERT P6, a flexible, reliable and easy to use 'all in one solution' for pitch control and the COMBIVERT H6 for yaw control. This solution is from users' perspective freely programmable and finds its application on-, near- and off-shore. Various bus communication protocols allow the drives to be connected to most turbine controllers.

### OPEN SOLUTION

- various fieldbus systems without gateway
- various encoder inputs on board
- PLC programming according to IEC 61131 standard
- for AC induction, synchronous and DC pitch motor
- for retrofit applications, the internal PLC can emulate older drives

### LOCAL ADDED VALUE

- core components supplied by KEB
- local cabinet manufacturing
- simple mechanical integration
- cost savings

## FREELY PROGRAMMABLE

- own pitch algorithms with own know-how
- maximization of energy yield
- reduction of fatigue loads
- increase of availability of the turbine by implementing suitable reactions for each condition
- basic condition monitoring of relevant pitch system components
- for well-fitting service support
- differentiation from competitors
- know-how copy protection available



## ALL IN ONE

- pitch inverter, backup charger, monitoring and PLC in one unit
- yaw inverter based on compact multi-axes system with integrated PLC
- reduced number of components
- compact cabinet
- clear cabinet layout, less wiring



## FUNCTIONAL SAFETY

- pitch drive with PL d according to EN ISO 13849
- yaw drive with STO and SBC
- certified by TÜV Rheinland
- Functional Safety is independent of the customer PLC program



# COMBIVERT P6 - PITCH SOFTWARE SOLUTIONS

## SOFTWARE PACKAGES AS REQUIRED

The P6 internal PLC can be programmed as needed. It comes with a Basic Library for all basic tasks, and the customer can program everything he needs on his own.

Or the P6 can be complemented with the Extended Pitch Library, which contains pre-defined function blocks for typical tasks of a pitch system. So the customer just needs to program the interface specific to the turbine.

Or the KEB experts can write a Customer-Specific Program for the pitch drive according to the customer's specification.

INVERTER + BASIC LIBRARY	EXTENDED PITCH LIBRARY	CUSTOMER-SPECIFIC PROGRAM
<ul style="list-style-type: none"><li>• Speed control / Position control</li><li>• Homing of motor encoder and blade encoder</li><li>• Charging circuit control (setpoint value and actual value)</li><li>• Temperature measurements</li><li>• Communication check</li><li>• Mains failure detection and phase loss detection</li><li>• Sample program</li><li>• Visualization samples</li><li>• Fan test program</li></ul>	<ul style="list-style-type: none"><li>• Smooth filtering of setpoints</li><li>• Plausibility check of encoders</li><li>• Monitoring of motor status and motor cable</li><li>• Monitoring of ultracapacitors and lead batteries</li><li>• Controlled discharge of ultracapacitors (for service)</li><li>• Secondary LVRT response</li><li>• Automatic adjustment of fieldbus and IP address</li><li>• Function test program (brake, inverter, motor)</li><li>• Data logger, event-triggered</li></ul>	<ul style="list-style-type: none"><li>• Customized pitch algorithm to<ul style="list-style-type: none"><li>- improve performance and maximize energy yield</li><li>- reduce fatigue loads on mechanical components</li></ul></li><li>• Pitch state machine<ul style="list-style-type: none"><li>- Selection of Manual/Automatic operation</li><li>- Selection of speed/positioning control</li></ul></li><li>• Processing of digital inputs / outputs</li><li>• Response to limit switches</li><li>• Plausibility check of limit switches</li><li>• Processing of field bus data</li><li>• Specific reactions on warnings and errors to increase the availability of the turbine</li><li>• Additional conditions that trigger a safety run</li><li>• Additional visualizations for service personnel</li><li>• Basic condition monitoring of relevant pitch system components</li><li>• Control of auxiliaries (grease pump, cabinet heater and fan)</li></ul>

No matter who does the programming: The know-how of the customer program can be protected against third-party access by using password protection, compiled libraries and encryption.



## HIGHLIGHTS

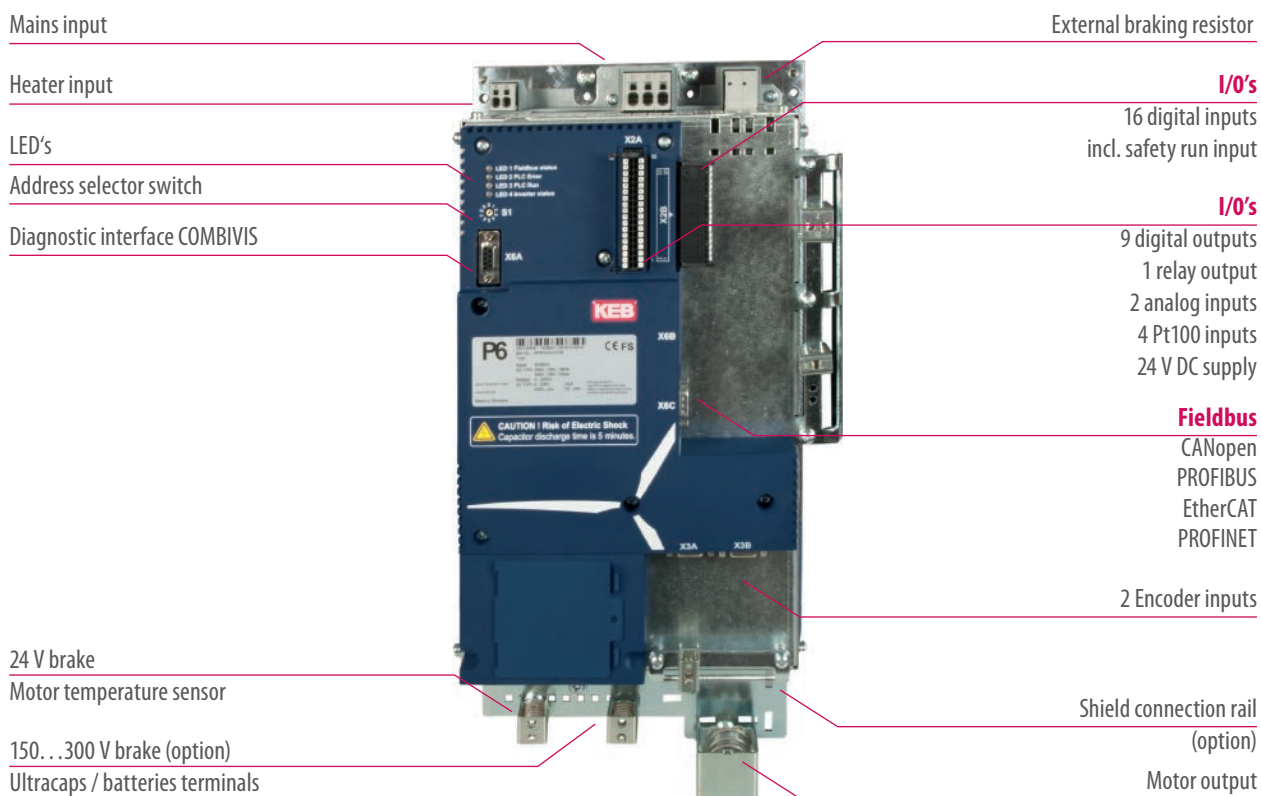
- specific software libraries available
- programming support
- flexible solution for customer add-ons



## VARIOUS SIZES

The P6 hardware is available in two electrical sizes for AC and for DC motors, suitable for pitch systems of 1 . . . 8 MW wind turbines.

INVERTER SIZE		18	19	19 DC
Rated input voltage			3 AC 400 V	
Output rated power	[kW]		18	
Output rated current AC	[A AC]	45	52	-
Maximum current AC at $\geq 6$ Hz for 3 s	[A AC]	90	120	-
Output rated current DC	[A DC]	-	-	52
Maximum current DC for 12 s	[A DC]	-	-	120
Rated current for shunt winding	[A DC]	-	-	5
Rated switching frequency	[kHz]	4	2	2
Max. switching frequency	[kHz]	4	4 (at $I < 45$ A)	4 (at $I < 45$ A)
Ultracaps charging current	[A]		5	
Dimensions	[mm]		240 x 400 x 310	
Weight	[kg]		16	





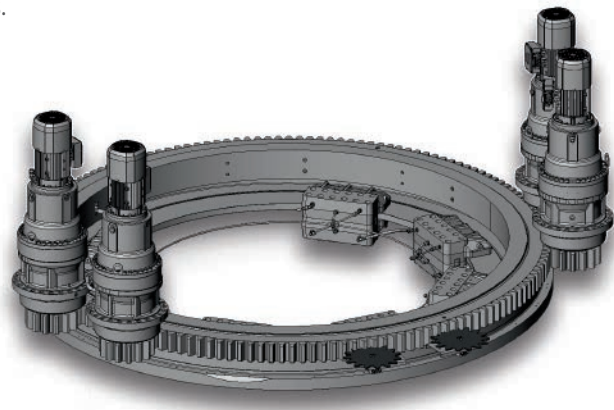
## NON-REDUNDANT SYSTEMS

For the yaw drive of wind turbines, KEB can provide different yaw solutions. They all contain

- smooth movement of the nacelle
- torque sharing
- reduction of mechanical load
- reduction of wear of the material.

Depending on the system configuration, the pitch drive controllers can also

- tense up the drives against each other
- use the electrical motor brakes instead of a hydraulic brake
- add STO for the safety of service personnel during service operations.



## REDUNDANT SYSTEMS

Used with a multiple inverter solution, the KEB Yaw Library PLC software ensures

- improved torque sharing
- monitoring and protection of motors, cables and gearboxes
- redundant operation, even if one drive is not operational
- increased availability, especially for offshore turbines.

This can be implemented by adding turbine-specific enhancements to the pre-programmed IEC 61131 function blocks.

KEB_YawMotionControl			
Enable	BOOL	BOOL LicenseValid	
TorqueSharingMethod	T_SHARING_METHOD	PositionCalibrationDone	BOOL
MotorCurrentMode	INT2 MOTOR_CTRL_MODE	NumberOfValidDrives	INT16
StartDrives	BOOL	FilteredMasterTorque	REAL
StartPos	REAL	AverageTorque	REAL
Reset	BOOL	ActMasterSpeed	REAL
CalibratePosition	BOOL	ActMasterPosition	REAL
ReferencePosition	REAL	TargetPositionReached	BOOL
TargetPosition	REAL		
TargetWindow	REAL		
PosRelative	BOOL		
GetSpeed	REAL		
GetLimit	REAL		
DriveSpeedOffset	REAL		
ClearRatio	REAL		
SpeedResolution	REAL		
TechnicalUnits	REAL		
NumberOfDrives	INT16		
MasterIndex	INT16		
DisableDrive	ARRAY[1..MAX_NR_OF_DRIVES] OF BOOL		
TorqueOffsetValues	WORD		
GetSpeedTrim	REAL		
GetSpeedTrim	REAL		
ResetIntegrator	BOOL		
ReferenceTorque	ARRAY[1..MAX_NR_OF_DRIVES] OF REAL		

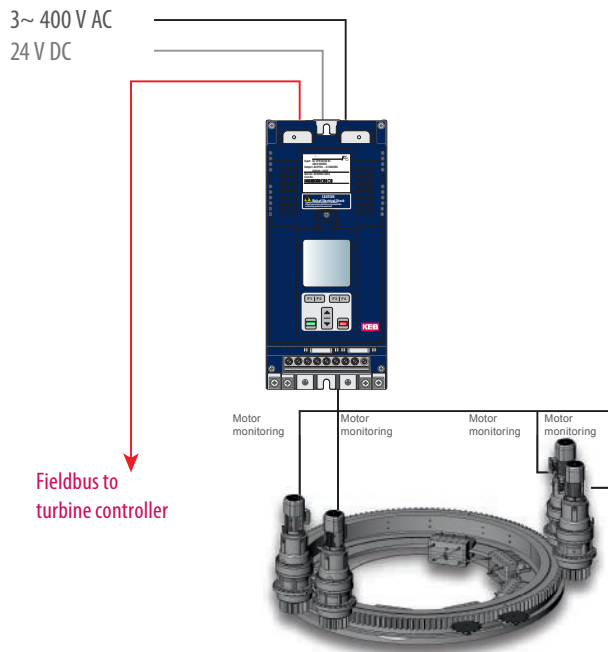


## HIGHLIGHTS

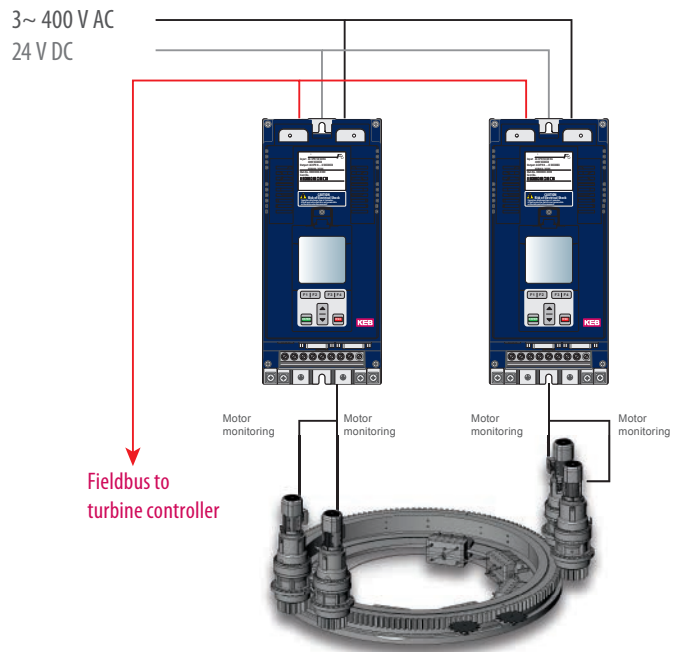
- smooth movement of the nacelle
- reduction of wear
- increased availability

# CONTROLLED YAW SOLUTIONS - HARDWARE

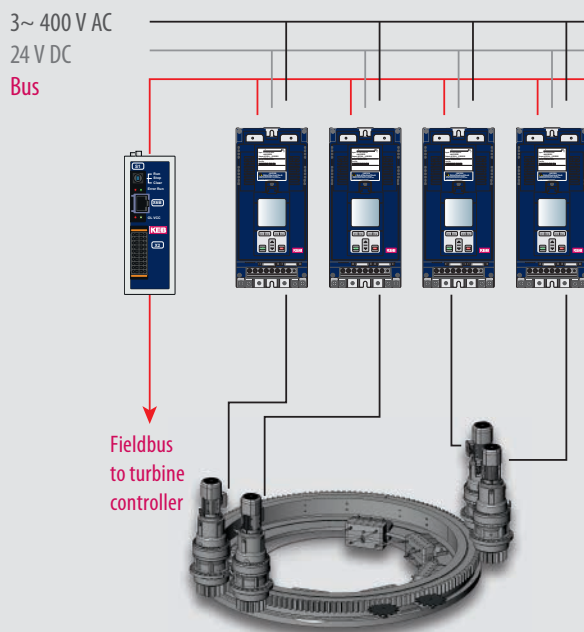
## SINGLE INVERTER



## DOUBLE INVERTER



## DISCRETE MULTIPLE INVERTER



## COMPACT MULTIPLE INVERTER





# COMPARISON OF HARDWARE SOLUTIONS

FEATURES	SINGLE INVERTER	DOUBLE INVERTER	DISCRETE MULTI INVERTER	COMPACT MULTI INVERTER
adapted industrial design	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
simple and user-friendly handling	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Feedback control				
Open loop operation	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
closed loop operation	—	—	<b>X</b>	<b>X</b>
Multiple encoder interface	—	—	<b>X</b>	<b>X</b>
Common DC bus	—	<b>O</b>	<b>O</b>	<b>X</b>
DC Fuses incl. monitoring function	—	—	—	<b>X</b>
24VDC 2A Brake supply	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Integrated 24V/25A supply	—	—	—	<b>X</b>
Integrated safety module STO and SBC <sup>1)</sup>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
IEC 61131 Programmable Control unit	—	—	External	<b>X</b>
Yaw Library	—	—	<b>X</b>	<b>X</b>
Webserver functionality	—	—	<b>O</b>	<b>O</b>
Bus Communication to turbine controller CAN, EtherCAT, PROFIBUS, PROFINET	<b>O</b>	<b>O</b>	<b>O</b>	<b>O</b>
Diagnostic and monitoring via PC software	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Motor control				
Induction	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
SMPM	—	—	<b>X</b>	<b>X</b>
IPM	—	—	<b>X</b>	<b>X</b>
I <sup>2</sup> -t motor protection	External	External	<b>X</b>	<b>X</b>
Redundancy				
Single	—	<b>X</b>	<b>X</b>	<b>X</b>
Multiple	—	—	<b>X</b>	<b>X</b>
Heatsink design				
Forced ventilated	<b>X</b>	<b>X</b>	<b>X</b>	<b>O</b>
Flat rear	<b>O</b>	<b>O</b>	<b>O</b>	<b>X</b>
Push through	<b>O</b>	<b>O</b>	<b>O</b>	<b>O</b>
Supply with AFE for regulated DC Voltage				
External	<b>O</b>	<b>O</b>	<b>O</b>	<b>O</b>
Internal	—	—	—	<b>O</b>
Size of drive components	Small	Medium	Large	Medium
Wiring complexity	Medium	Medium	Extensive	Simple

**X** Integrated

**O** Option

<sup>1)</sup> depending on inverter type

# DIAGNOSTIC TOOLS & PROGRAMS - PITCH AND YAW

## KEB PITCH AND YAW - DIAGNOSTIC TOOLS & PROGRAMS

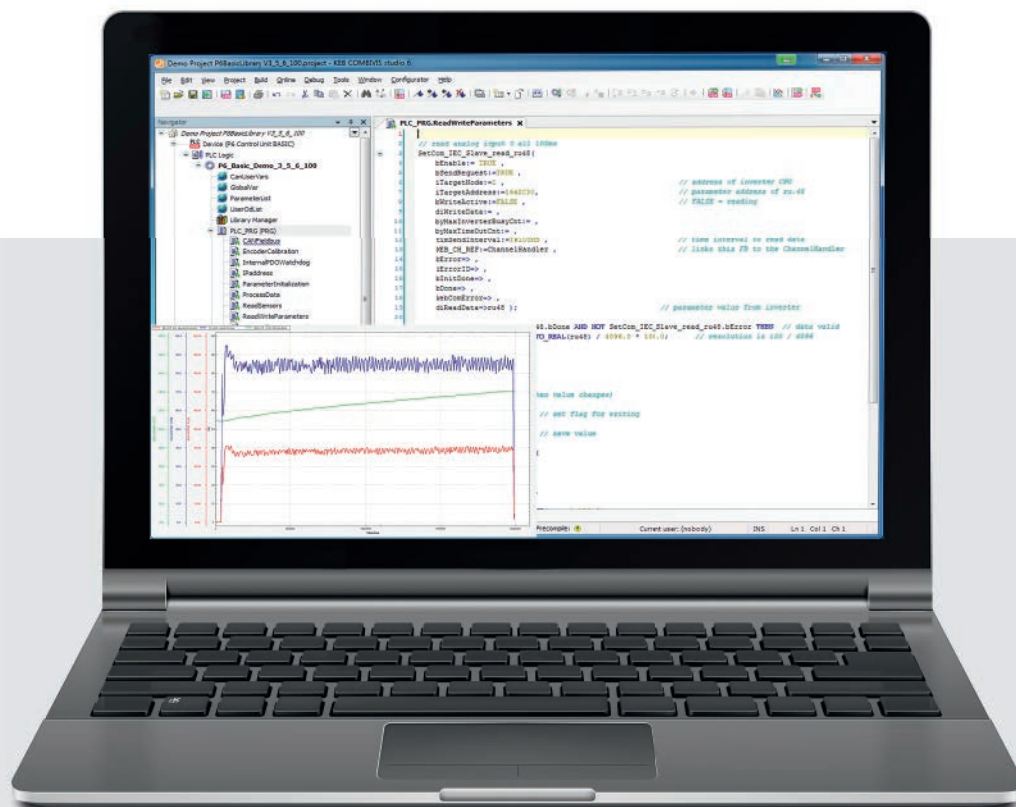
Programming and diagnostic tools optimized for this application reduce engineering efforts.

### COMBIVIS 6

- Diagnostic tool for the pitch inverter P6 and for yaw drives
- Display of operating conditions
- Oscilloscope function
- Download of customized adjustments
- Analysis of communication between drive and control

### PROGRAMMING WITH COMBIVIS studio 6

- CoDeSys based on IEC 61131-3
- Programming language: ST, IL, SFC, LD and FBD/CFD
- Integrated visualisation
- Simulation
- Debugging and file-management

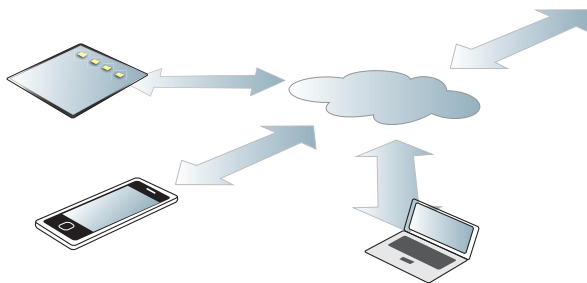


## WEBSERVER

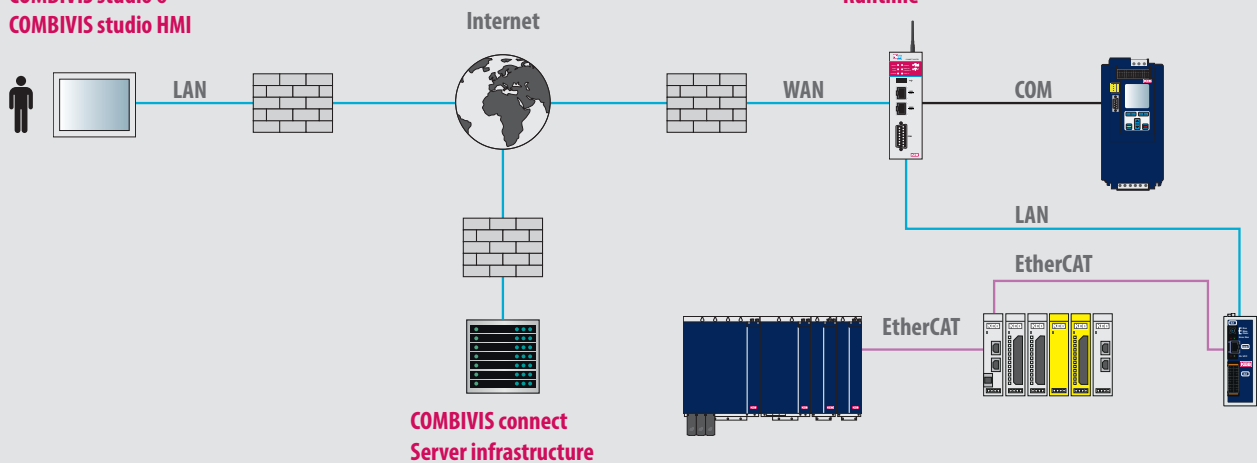
a functionality can be integrated in the pitch drive as well as in the control unit for the yaw control

### ADVANTAGES:

- No specific software is required
- A simple browser installed on a device can connect to the KEB products
- Password levels provides access to different information
- With KEB FTP tool, project documentations can be stored inside the memory and uploaded on site



COMBIVIS connect  
COMBIVIS studio 6  
COMBIVIS studio HMI



## HIGHLIGHTS

- Remote monitoring using Ethernet-based router
- Worldwide support from several server locations
- Also available as router with integrated 2G/3G/3G+ modem
- Access to remote devices via Ethernet or serial interface
- Proven COMBIVIS connect software connects the plant to be monitored to your workplace via VPN
- Additional HMI functionality for datalogging, long-term machine diagnostics and notification by e-mail and SMS

# PITCH MOTOR

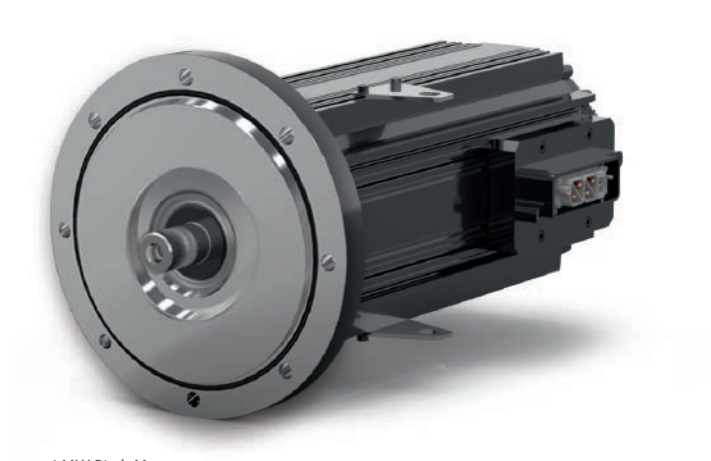
## POWERFUL, EFFICIENT AND EXCESSIVELY RELIABLE

The KEB Pitch Motors are available for various wind turbines in the power range up to 10 MW.  
The high dynamic, vibration resistant servo motors are equipped with a robust encoder system and with the KEB fail-safe brake.

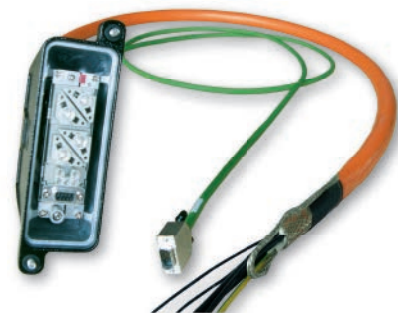
The high protection degree IP65 as well as the special corrosion painting allow using the KEB Pitch Motors in various climate conditions. If it is offshore or CCV / HCV – the KEB Pitch Motors guarantees safe and reliable operation. The dedicated housing design allows operation without additional forced ventilation.

## PLUG AND DRIVE

KEB offers pre-assembled motor and feedback cables with very robust and easy-to-handle connector systems.



*6 MW Pitch Motor*



*All-in-one motor cable*



## HIGHLIGHTS

- Vibration resistant
- HCV / CCV resistant
- Offshore operation, IP65
- Corrosion protection category C4M according to DIN EN ISO 12944-5
- Integrated holding brake, 24 V DC or 150 - 300 V DC with energy saving function
- Unique connector design with integrated power, encoder, brake and temperature sensor connectors

## TWO BRAKE DESIGNS, OPTIMIZED FOR APPLICATIONS WITH HIGH DEMANDS ON THE PROTECTION DEGREE



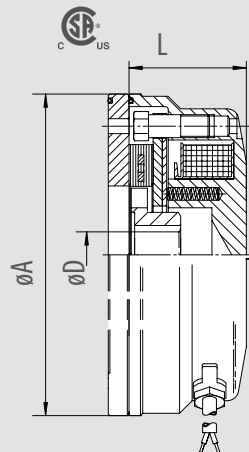
2 MW Spring applied pitch brake  
IP 65 Type 28 mounted between gearbox and motor



6 MW Spring applied pitch brake  
IP 00 type 38 mounted inside the motor

### COMBISTOP 28 IP65

Size	$M_{2N}^{1)}$ [Nm]	$P_{20}$ [W]	$\varnothing A$	$\varnothing D^{H7}$ max.	L
05	50	48	165	30	58.2
06	90	75	180	30	68.8
07	150	90	210	45	74.2
08	225	90	240	60	88
09	375	115	276	60	102



### COMBISTOP 38 WITH SPECIAL SEALING

Size	$M_{2N}^{1)}$ [Nm]	$P_{20}$ [W]	$\varnothing A$	$\varnothing D$ max.	L
05	36	48	147	30	57.7
06	70	62	164	35	68.8
07	100	65	190	45	75.5
08	150	75	218	60	87.4
09	250	80	253	60	101.7
10	500	130	307	75	110.8

1) rated torque after running-in



### HIGHLIGHTS

- More than 300,000 pitch and yaw brakes successful in operation
- HCV / CCV version available
- Rated voltage up to 300 VDC
- High vibration resistance (safety and lifetime)
- Coated and redundant springs with long lifetime for safe power-off stop
- Special friction lining for high emergency stop energy
- $\geq 200$  Nm special anti-condensation and anti-icing design
- Low energy and low coil temperature rise system



## OTHER DRIVES FOR WIND TURBINES

### INVERTER FOR SERVO PUMP OF HYDRAULIC PITCH SYSTEM



### AUXILIARY DRIVES FOR PUMPS, FANS AND AIR CONDITIONING



### LIFT AND HOIST DRIVES AND BRAKES

### C6 ROUTER FOR REMOTE MONITORING C6 HMI



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