5.6 Winch control
with variable frequency drive

ABB's winch control program enables the ABB variable frequency drive (VFD) range to be used in different winching control configurations on board ships, offshore platforms and in harbors.

Dedicated drives for marine and offshore applications
ABB variable frequency drives are certified for marine applications, enabling continuous speed and torque control of:

- Anchor winches
- Mooring winches
- Ro-Ro (roll on, roll off) quarter ramp winches
- Towing winches

Built-in brake choppers connect the DC bus voltage to an external resistor which converts braking energy into heat. Low harmonic drives meet the strictest harmonic standards; no additional filtering equipment is needed to ensure power supply quality. Regenerative drives can recover energy from a process and feed it back into the network, thus saving energy.

A key feature of the ABB variable frequency drive is its direct torque control (DTC) motor control platform.

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Passenger ship

DTC enables the drive to deliver full torque at zero speed, with or without the need for a feedback encoder. This is an advantage because the harsh environment on a vessel's open deck can often damage an encoder or interfere with the feedback signal to the motors.

Avoiding hydraulic system inefficiencies
ABB variable frequency drive with special inbuilt winch control program is a profitable solution compared to the traditional and costly hydraulic winch controller. The VFD solution for winch control has significantly lower maintenance costs and performance inefficiency together with better overall system reliability.

Compared to hydraulic control of winch systems, an AC drive provides substantial power and energy savings when continuous running of a hydraulic pump is not required. Additionally, hydraulic systems use oils which pose a pollution risk to the environment. An AC drive based electrical winch control system can eliminate this risk.

Winch interface for control stands
The winch can be controlled from control stands located on port, starboard and upper deck of the vessel. The electrical interface supports either traditional inputs and outputs (I/O) or fieldbus gateways commanded by a programmable logic controller (PLC). Four control stands can be supported: three via digital I/O and a fourth via a fieldbus gateway.

Anchor control
Ready-made control logic provides speed control of the anchor, whether it is being raised or lowered. Slip detection and anchor-in protection are also provided as safeguards for anchor movements.

Mooring control
When mooring a vessel to a harbour or pier, the tension within the mooring ropes can be controlled either manually or automatically.

Hand-mooring: The control logic can be configured to allow the operator to control the winch manually from the harbour using continuous speed control. The logic also allows for high speed slack rope when letting out the ropes, thereby speeding up operating time in the hand-mooring control mode.

- Peak torque protection prevents damage to the rope. It detects severe tightening of the rope and immediately sends a signal to adjust the speed, thereby protecting the rope and the winch system from overload.

Auto-mooring: Following the hand-mooring procedure, and with the rope already pre-tensioned, auto-mooring can be enabled. This is a speed control application with torque limitation which provides smooth continuous mooring. Pre-defined auto-mooring modes are available as follows:

- Time control – auto-mooring rope tension control is based on a programmable re-mooring time interval.
- Load cell sensor – auto-mooring rope tension control is based on real measured status.
- Constant on – auto-mooring rope tension control is always on, without closing the mechanical brake and stopping the winch motor.

The rope tension set-point can be a fixed internal parameter value or it can be sent via external digital- and analog input signals. The actual rope tension can also be defined without any sensor with the help of unique torque measuring logic.

Power control
The power control function limits the speed of the winch depending on the load. With a very light load, for example, the winch can run at high speed whereas, if there is a heavy load then the speed can be limited. The speed is adjusted according to a series of cross points located on the forward and reverse power curves. These cross points, each of which has a speed and torque connection, can be identified by the user, by way of power control parameters within the winch control program.

Ro-Ro control
Ro-Ro quarter ramp control logic is used for raising or lowering the ship's vehicle access ramp. Special protection is provided to slow down the speed and torque before parking the access ramp in the upper end position.

With the Ro-Ro access ramp in the loading position, the special holding and tension control mode can be used.

Mechanical brake control logic and torque memory
The winch control program features integrated brake control logic to control the winch motor's external disk or drum brake. The brake control logic utilizes torque memory and pre-magnetizing to open and close the mechanical brake safely and reliably.

The brake control logic, together with the DTC-controlled winch motor, enables the drive to hold the winch machinery stationary until the mechanical brake takes over.

Adaptive programming
Function block programming within the drive enables the user to change or modify the ready-made winch control program application to their customized platform.

Master-follower for winch motors working together
When several winch motors are connected to the same machinery, the ready-made master-follower arrangement supports the speed and torque control mode with load sharing mode.

Motor heating
The drive's DC injection function can be enabled by the winch operator to provide controlled winch motor heating. This function keeps winch motors dry when they are in standby mode and is beneficial for open-deck motors.

Major benefits from installing a variable frequency drive
- The ideal solution for retrofits – the existing winch motor, motor cable and operator control can be reused.
- Space saving on the deck – simplified winch arrangement.
- Lower noise level.
- Reduced maintenance costs – Soft starting reduces startup current peaks. Smooth continuous speed and torque control reduce stress on the whole mooring system.
- DTC (Direct Torque Control) eliminates the need for a pulse encoder, increasing the reliability of the winch system.
- Safe and accurate anchor and mooring winch control throughout the whole speed range.
- Cost reduction compared to closed loop systems.
- Environmentally friendly solution – Oil-free operation with fully electronic equipment.
- Reduction of mechanical wear.
- External programmable logic controller (PLC) not needed because the winch control program includes winch operation and protection functions.
- Multi I/O functionality allowing three different control stands to be connected directly to the drive.
- Anchor-in or anchor-slowdown protection reduces the speed as the anchor approaches its end position. Slip protection operates between the winch drum and winch motor.
- The peak torque protection in hand-mooring function detects severe tightening of the rope enabling immediate speed adjustment to protect the rope and the winch system from overload.
- Mechanical brake control with torque memory.
- Easy start-up and maintenance of drive system.
- Adjustable auto-mooring provides accurate rope tension control and eliminates the need for load cells on the ropes.

Case m/s Mariella,
Viking Line

Cost efficient winch retrofit using variable frequency drive
"The old system is breaking the motors, when we are in the harbour, when we have torque control; it's going on and off all the time. It's full ahead or nothing." says Jonas Rautelius, the ship's electrician describing the existing three-speed mooring control system.

When the ship arrives in port, the ship's winches keep it secure to the dock so that the passengers can safely board and depart the ship. The ship's six winches, in operation since 1985, use a three-speed control system with three winding, direct-on-line (DOL) motors and an external mooring controller and load sensor in the gearbox.

Existing control
Using this system to moor the ship, winch operators watch the rope until it is taut, adjusting the speed of the winch accordingly. Each speed change made to the winch (low, middle, or high speed) results in a direct-on-line start of one of the motor's windings. DOL starting and the high torque demands of the mooring operation place substantial stress on the winch system. As a result, rotors on the winch motors would periodically break. In addition, the age of the winches makes finding spare parts more difficult. Typically, some spare parts have long delivery times, especially motor parts.

The contactors used to start the motors direct-on-line are also prone to failures, adding to the maintenance of the ship. If the winch is hauling in the rope and a contactor fails, it is possible for the rope to continue to spin around the winch's drum, uncontrolled, until the main power is disconnected.

Cost efficient modernization with ABB drives
After contacting ABB, Viking Line decided to evaluate and test ABB's proposed solution on one winch. Using the ship's drawings from 1985, ABB specified the ACS800-01 marine certified industrial drive with the built-in winch control program. This allowed the m/s Mariella to keep the existing three-winding motor, motor cable, and operator control stands. "It was quite cheap to do it like this" says Jonas. "This is a big factor in deciding to do the rest." The drive's IP55 enclosure permitted it to be mounted directly to the wall of the ship.

"The best thing is that we don't have to touch it anymore." says Jonas Rautelius, the electrician from m/s Mariella. "It's easier; winch operators can just put the auto-mooring control on and leave the winch. With the old system, they had to constantly see if the rope was tight."

Measuring torque allows auto-mooring without load cell sensors
Because the drive uses ABB's direct torque control (DTC), it does not rely on external sensors such as a load cell sensor in the gearbox or encoder on the motor. DTC allows open-loop control of the winch motor and this permitted the m/s Mariella to reuse the existing winch motor without having to install an encoder. The winch control program in the drive uses DTC and patented winch application torque measuring logic to measure the rope's tension and to calculate the required torque at every start without a load cell sensor.

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Electrical winches offer significant savings over the conventional hydraulic winch configuration, as well as significant benefits in environmental issues. The vessel's crew also benefits from considerably reduced noise levels on deck.

Easier operation
With the ABB solution, as the ship arrives in harbour, the winch operation starts with the drive in hand-mooring control to quickly and smoothly let out the rope at a high speed. When the rope is connected to the harbour, the winch hauls in the slack rope quickly. The winch control program's peak torque protection function automatically stops the hand-mooring operation when the torque limits are reached. Winch operators then switch to auto-mooring mode. In auto-mooring mode, time control sequences are used to continually monitor the rope's tension, automatically making adjustments as needed to keep the ship secure.

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Integrated mechanical brake control
Brake control is integrated into the winch's brake circuit through a relay output on the drive. The drive ensures the disc brake is closed before stopping the drive's torque control. When opening the brake, the sequence is reversed, the drive determines and brings the motor to the needed torque to hold the rope's tension, and then releases the brake.

Cost efficient retrofit
- Improves reliability
- Reduces maintenance
- Reuses existing winch motor
- Reuses existing motor cable
- Reuses existing operator control stand
- Replaces contactor control
- Eliminates external load cell sensor
- Eliminates auto-mooring unit
- Integrated brake control
- Soft starting eliminates start-up peaks
- Smooth continuous speed and torque control
- Improves operator experience
- Marine certified hardware (ACS800-01)
- Wall mounted drive
- Adaptive programming in the drive is used to match existing signals to drive controls

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Viking Line, MS Mariella

m/s Mariella

- Built 1985
- Length 176.9m
- Width 28.4m

With room for 2,500 passengers and 450 cars, a disco, a casino, restaurants and shopping, Viking Line's cruise ship the m/s Mariella is a floating family entertainment experience providing service between Helsinki and Stockholm.

Viking Line

Today Viking Line has seven vessels which sail between the Finnish mainland, Åland Islands and Sweden as well as between Finland and the Baltic states. Operations include passenger services, recreation and cargo carrier services

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Figure 1: The existing winch motor, motor cable, mechanical disc brake and operator control stand were reused.

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Figure 2: Rope tension is maintained automatically using time control sequences without a load cell sensor

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Figure 3: Built-in auto-mooring with mechanical brake control keep the ship securely docked

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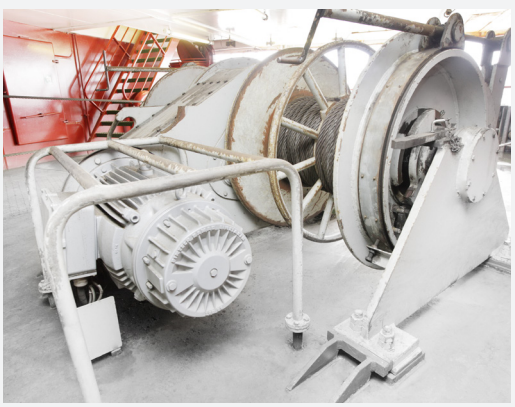
Figure 4: The wall mounted ACS800 industrial drive with built-in winch control program replaced contactors for smooth, trouble free starting.



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