Variable speed control of compressors
ABB drives control the compressors of the world‘s longest gas export pipeline

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ABB drives power Ormen Lange

Since 2007, gas from the Ormen Lange offshore gas field flows through the world's longest subsea pipeline from Norway to the United Kingdom. The huge compressors for the gas transport are driven by three 48 MW MEGADRIVE-LCI variable speed drives from ABB. The complete drive systems, which include transformers and motors, were put through rigorous tests under full-load conditions. The drives satisfied the test requirements in every respect.

Ormen Lange - Norway's second largest gas field

Ormen Lange, which translated means "Long Snake", is located 120 km off the northwest coast of Norway at a water depth of 800 to 1100 m. It is Norway's second largest gas field and has estimated gas reserves of 395 billion cubic meters. The annual production is forecasted to 20 billion cubic meters, which is equivalent to the total annual energy demand of Norway. When it reaches full production the field may meet 20 percent of the UK's demand for gas.

Nyhamna onshore processing plant

The untreated wellstream gas from the Ormen Lange gas field is transported to the onshore processing plant in two 120 km long pipelines. From the processing plant, which brings the gas up to sales quality, it is exported to the UK.

ABB supplied three MEGADRIVE-LCI systems for the gas export compressors, as well as two ACS 6000 variable speed drives for the Nyhamna gas processing plant. The ACS 6000 drives control the speed of compressors, which recompress flash gas before feeding it back into the main gas line. By using variable speed drives, the compressors run at their optimum operating points, resulting in significant energy savings.

The world's longest export pipeline

After being processed, the gas is compressed before being exported in a 1200 km long pipeline to Easington, UK. The gas export system is the world's longest subsea pipeline.

The pipeline has a diameter of 42 – 44 inches (1.1 meter). The construction of the pipeline required approximately one million tons of steel.

Start-up of commercial production was in 2007.

Variable speed drives - the most efficient way to control compressors

Usually, the places in which users of natural gas are concentrated lie far from the gas fields and the processing plants. In the past, compressors driven by gas turbines were used in the larger production facilities to transport the gas through the pipelines to the users. In recent years, however, an increasing number of gas turbine drives have been replaced with electric variable speed drives as in comparison they offer significant advantages.

Besides the lower investment costs, electric variable speed drives are more efficient than gas turbines and require only a fraction of the maintenance. Apart from the obvious maintenance cost reduction, this results in a higher uptime. Other factors that influence the decision in favor of electric drives, are the desire to benefit from the high reliability and excellent control properties of the electronically adjustable AC drives as well as the need to avoid CO_2 and NO_x emissions. In the light of global warming and the Kyoto protocol, the reduction of CO_2 emissions will gain even more importance in the future.

The world's longest gas export pipeline: The gas will be transported 1200 km from Nyhamna (NO) to Easington (UK).

Benefits

- High reliability and availability
- Low maintenance costs
- High uptime and increased production hours
- Operation of the compressor at the optimal speed / power range
- High efficiency
- No CO_2 and NO_x emission

MEGADRIVE-LCI variable speed drive system

ABB‘s MEGADRIVE-LCI is the optimal solution for high-voltage and high-power applications.

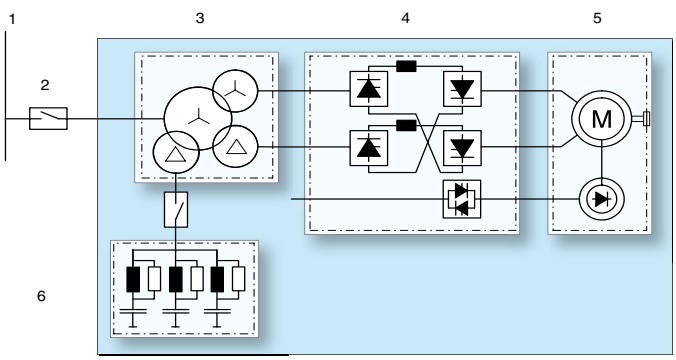
Standard MEGADRIVE-LCI converter designs are available for powers up to 72 MW, engineered designs to 100 MW and beyond. This type of converter has been in operation for more than 30 years and has achieved an excellent reputation for reliable operation in the harshest environments.

The MEGADRIVE-LCI track record for compressor applications is as impressive as its reliability history.

Variable speed drive systems for Ormen Lange

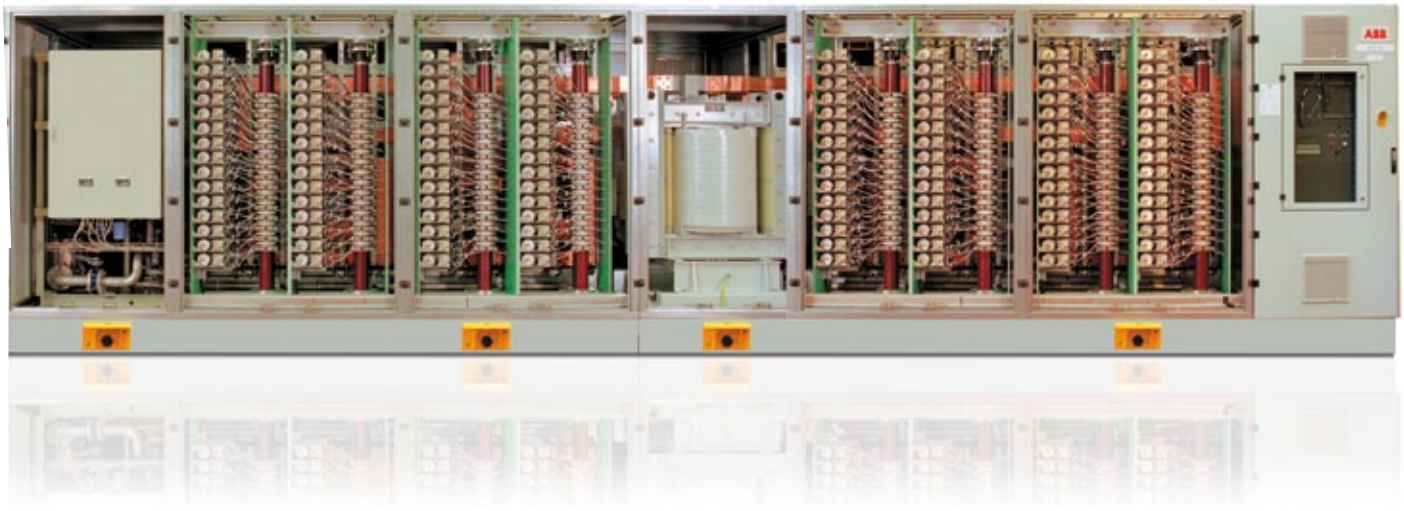
ABB supplied three MEGADRIVE-LCI variable speed drive (VSD) systems for the Ormen Lange project.

One Ormen Lange VSD system consists of:
– Four-winding transformer
– Filter system of a total of 24.6 MVAr
– 12/12-pulse MEGADRIVE-LCI converter
– 48 MW synchronous motor



Basic circuit diagram of the 48 MW drive system for the Ormen Lange project:

1 132 kV power supply
2 Main circuit breaker
3 Four-winding transformer
4 Converter (rectifier, DC reactor, inverter, excitation, controller)
5 Synchronous motor with brushless excitation
6 Filter system



MEGADRIVE-LCI - all integrated 48 MW current source inverter, including DC reactors and water-cooling unit

Transformer

The four-winding transformer has a 132 kV primary winding, two electrically 30° phase shifted 7.65 kV secondary windings (for the 12-pulse rectifier) and an 11 kV tertiary winding (for the filter system).

MEGADRIVE-LCI converter

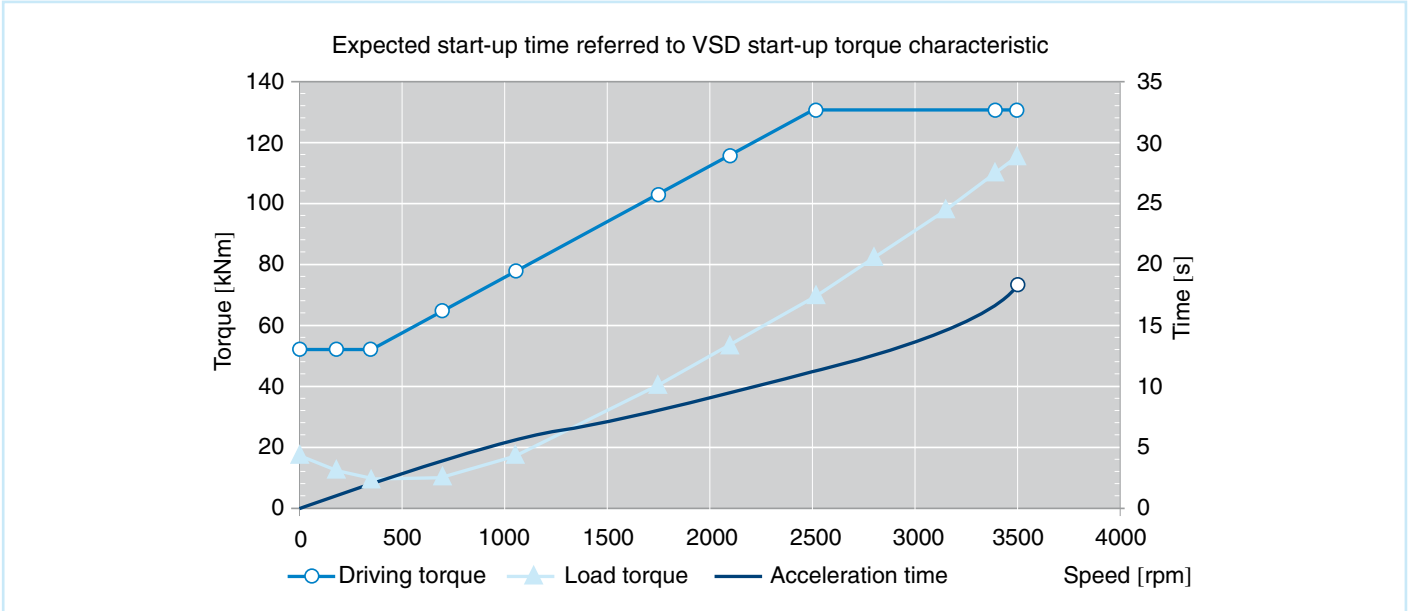
The converter consists of a 12-pulse line-commutated thyristor rectifier, two DC reactors and a 12-pulse load-commutated thyristor inverter. A three-phase AC controller energizes the exciter machine.

Motor

The 2-pole synchronous motor has two electrically 30° phase shifted 6.7 kV stator windings (for the 12-pulse inverter). Its exciter winding is fed via the exciter machine and the rotating diodes.

The total efficiency of the VSD system, which consists of transformer, converter, motor and filters, at nominal power/speed is better than 96.5%.

Main technical data of the MEGADRIVE-LCI system	
MEGADRIVE-LCI	
Number of units	3
Power system voltage	132 kV / 50 Hz
Four-winding transformer	132 / 7.65 / 7.65 / 11 kV
Nominal data of motor	
Shaft power	48 MW
Shaft speed (nominal / max)	3500 / 3780 rpm (58.33 / 63 Hz)
Voltage per winding	6700 V
Current	2325 A
Motor protection	EEx P II T3
Cooling	Air-to-water / TEWAC
Control rage	Speed: 2520 - 3780 rpm Shaft power: 16 - 48 MW
Converter	
Number of thyristors	120
Cooling	Water-to-water



Load torque, run-up torque and run-up time as a function of speed

Testing

To ensure that the equipment meets the specifications defined by the customer, the complete drive system was put through rigorous tests before being shipped. The tests had to be performed under full-load conditions and over the entire speed control range, requiring a complex, large-scale set-up.

Test program

The following tests were performed:

– Routine tests of the various drive components (transformer, converter, motor and filters)
– Full-load performance test of one complete VSD system
– Full-load string test of one complete VSD system together with the compressor

Routine tests

Routine tests and functional tests form an integral part of the scope of supply of the individual drive components. They are performed in accordance with international standards and quality assurance procedures.

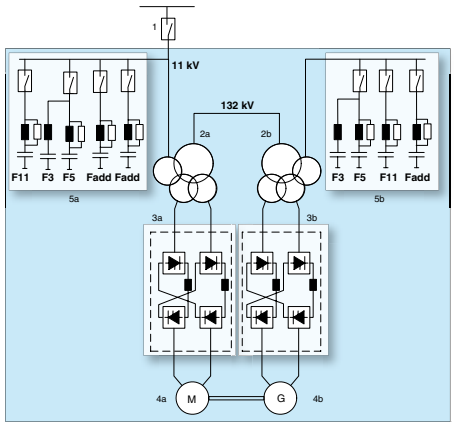
Full-load performance test

The performance tests were conducted at ABB's test facility. They had to be carried out under full-load conditions and over the whole speed control range. To conduct such tests with one drive only would require a supply power of approximately 50 MW of active power on a 132 kV level. However, both a 132 kV supply system and 50 MW of active power are usually not available.

Test set-up

Therefore, a so-called back-to-back test configuration was chosen, in which two identical drive systems are operated with one working in motor operation (the VSD system to be tested) and the other in generator operation (which is used as load and power recovery). With this configuration only the losses of the two drive systems and the excess reactive power, which is not compensated by the two filter systems, need to be provided by the supply system of the test field.

Since there is no 132 kV supply system available in the test field, the test arrangement was supplied using the 11 kV filter winding of the transformer. As a consequence the rating of the 11 kV filter windings of the converter transformers had to be increased to cover those special requirements. Additonal filter circuits (see Fadd in the back-to-back test configuration diagram) and switching devices were needed to compensate the reactive power flow to a minimum at any operating condition.



1 Breaker
2 Four-winding transformer
3 MEGADRIVE-LCI converter
4 Motor
5 Filter
a MEGADRIVE- LCI in motor operation (drive to be tested)
b MEGARIVE-LCI in generator operation (as load)

Back-to-back test configuration

Back-to-back test set-up
Background: Two MEGADRIVE-LCI drives
Foreground: Synchronous motor and generator coupled

This complex test configuration required extensive calculations and simulations to determine the reactive power demand in various operating conditions and to ensure not only the system stability during start-ups and filter switching but also safe shut downs under all system conditions. The preparation, installation and commissioning of the large-scale test set-up took several months.

Tests

The tests included heat and load runs in three operating points: at nominal load point, at maximum load and speed and at minimum speed of the control range. The purpose of the tests was to verify the computed losses, the temperature rise, the motor vibrations and the current harmonics, thereby proving that the guaranteed values would not be exceeded.

The tests confirmed that the measured values were better than those calculated for all three operating points. The drive system fulfilled the test requirements in every respect and to the customer's full satisfaction.

Thanks to the extensive testing in ABB's test facilities, the drive systems can be installed and commissioned without any need for additional acceptance and performance tests on site.

Full-load string test

The full-load string test of the complete VSD system together with the compressor was performed at the compressor manufacturer's test facility. The equipment satisfied the test requirements in every respect.

View of a converter transformer

View of the test filter installation

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