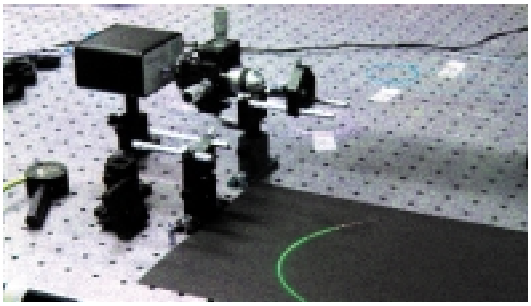
R&D

> **"ABB's R&D vision is to develop technological leadership positions which will ensure our growth and profitability – now and in the future."**

A lasing optical fiber as sensor basis

For decades, the heart of some of the world's best temperature and pressure sensors has been a vibrating quartz crystal. This very sensitive element allows measurements to be made with astonishing accuracy. However, quartz pressure sensors also have some drawbacks: they are bulky, fragile and cannot be used at temperature above 150°C due to the thermal limits of the electronics. Scientists at ABB Corporate Research have invented a new sensor concept based on a fiber laser which avoids all of the above-mentioned drawbacks. In this concept, the vibrating element is just light.

A simple configuration encloses a piece of rare-earth-doped fiber between two matched Bragg gratings. The fiber laser is end pumped by a remote laser. By proper combination of the doped fiber and the elliptical core sensing fiber a beat frequency can be generated which is proportional to



the parameter to be measured. Such a laser cavity can be used to measure temperature, pressure, displacements, vibrations, etc.

The beauty of the technique is that the fiber alone replaces the sensing element, amplifier, computing unit, power supply and data bus.

Thus, any application currently using a quartz oscillator could now use this special 'fiber laser based' arrangement.

Furthermore, the stimulating light can be 'fed' to the fiber laser from a remote (up to 30-40 km distant) source via a standard optical fiber, and also collected remotely. This avoids having active electronics in the, possibly harsh, sensor environment. As the whole system is optical, there is no need for data or power cables, and there is no risk presented by electromagnetic interference.

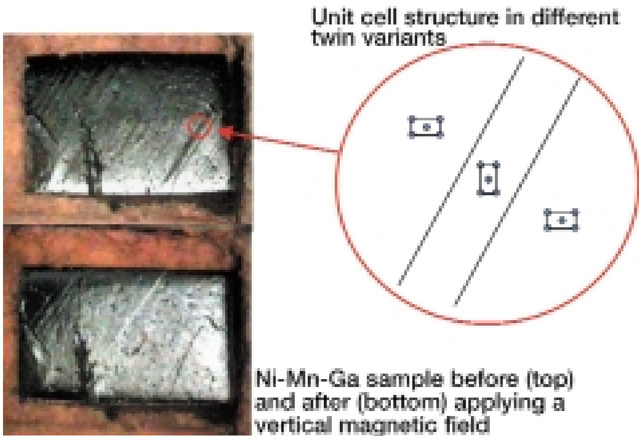
To further simplify future implementation of sensors based on this principle, it is possible, by using multiplexing techniques, to string many sensing points out along a single fiber length.

Laboratory tests have shown the idea works very well and Corporate Research scientists are now busy using the technique to realize advanced hardware for major ABB industrial applications which would otherwise not be possible.

Breakthrough in new materials: Magnetic Shape Memory alloys

During the 1990s an exciting new class of 'smart' materials was discovered – Magnetic Shape Memory, or Magnetic Strain Materials (MSM). These new metallic alloys provide us with a remarkable engineering effect which can be used in various actuator and sensor structures.

Smart materials that can provide large and precise movement with fast control are of great interest, as actuators based on such materials could replace traditional technologies, like electromagnetic, hydraulic and pneumatic drives, and open up entirely new applications. Piezoelectric and magnetostrictive materials, which are nearing their technological maturity, are suitable for applications requiring small strains at high speed. Thermally actuated shape memory alloys, like Nitinol, featuring large strains and high forces but their response is slow due to thermomechanical control.



The basic MSM effect mode is extensional strain where the sample shortens in the direction of an applied magnetic field and extends in one of the perpendicular directions. The third dimension remains the same and the total volume of the sample does not change. Reversion of the shape change can be achieved by using a perpendicular magnetic field.

The MSM effect occurs at the unit cell scale when the external magnetic field is strong enough to rotate a lattice axis. This 'rotation' is accomplished by a slight shifting of the lattice atoms and is not smooth, being more like a toggle. The atom shifting is metastable, but once the atoms are shifted over halfway, they snap into the other orientation. This snapping can even be heard in large samples! Once the atoms are shifted to the other orientation, they will remain there without the external magnetic field. The atoms can be re-oriented by an external magnetic field or by mechanical stress.

Dr. Kari Ullakko at Helsinki University of Technology first suggested this new strain mechanism of magnetic reorientation and demonstrated it in Ni-Mn-Ga alloys at MIT in 1996. Since then, research institutions around the world have raced to discover other such materials, and several alloys have been found. ABB Corporate Research Finland has been collaborating with Dr. Ullakko and his team since 1997 and, as a result, the reorientation mechanism was verified.

During 1999 development was extremely rapid and, so far, the best results have been obtained with the Heusler alloy Ni-Mn-Ga, where the extensional strain is 5.6%. Terfenol-D, the most widely used magnetostrictive material, has a maximum strain of only 0.2 %.

More experiments on fatigue and dynamic properties need to be done to produce better MSM materials at lower cost. ABB Corporate Research Finland has been a major industrial partner in Dr. Ullakko's research team and collaboration will continue. Our goal is to find unique value adding applications that only MSM technology can enable.

Power line modem for subsea applications

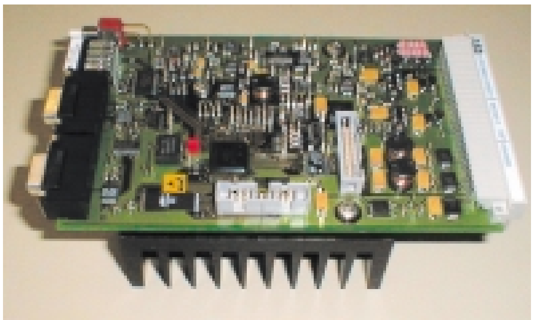
World's first power line modem capable of transmitting PROFIBUS over a 50 km subsea cable

ABB Corporate Research has co-operated with Business Unit Offshore Systems to develop a high speed subsea modem which can communicate data, in real time and using a PROFIBUS protocol, over a 50-km subsea power cable.

Future oil production plant will be increasingly installed subsea, resulting in dramatically increased communication and automation requirements. However, the cost of installing additional data cabling is very high, so using existing power lines can provide a cost-effective alternative.

An equally important aspect is that fieldbus systems in subsea installations are now state-of-the-art.

ABB has capitalized on these two aspects and developed a power line modem for subsea power cables which covers the real time aspects of a 9.6-kbit PROFIBUS fieldbus protocol. Additionally, the modem is transparent to all character-based protocols, and interfaces to RS 485 and RS 232 connectors. This modem provides great flexibility by displaying very high performance when communicating data in real time over a 50-km link – which can suffer attenuation of up to 80 dB. It is built as a plug-and-play unit so that the user can merely connect any devices which supports any character-based protocol.



Also, the modem already has a complete communication channel analysis tool that gives the user the opportunity to analyze the suitability of his power system for communication purposes. In future, the modem will achieve a higher degree of automation so that adaptive carrier selection will be possible.

The functional demonstrator was delivered to the Business Unit after only four months of development time, and it was possible to demonstrate PROFIBUS capability over a 50-km power line to customers.

With the new modem, ABB Offshore Systems has attained a leading position in power line communication systems for subsea applications. Rising communication demands are opening new markets and this product gives ABB a strong position in the subsea automation area.