RITHERM® – TEMPERATURE MONITORING AND LOAD OPTIMIZATION ON OVERHEAD TRANSMISSION LINES
The main targets of electricity supply companies when designing, planning and operating overhead lines are reliability and high supply availability at optimized cost. The larger power consumption, liberalization of energy markets and the resulting power transit lead to more frequent capacity bottlenecks, which can only be eliminated by building new overhead lines or optimizing the load distribution of the existing network.

More efficient utilization of existing high-voltage networks is, however, often prevented by inaccurate knowledge of the operational condition of the line. The conductor is also affected by incalculable external influences like ambient temperature, wind cooling and solar radiation. The conductor temperature and thus the amount of conductor sag increase with increasing load and overloading of the overhead power line.

RITHERM® now makes exact, continuous and low-cost monitoring of overhead power lines possible for the first time. RITHERM® does not measure the cable tension or ambient conditions like other systems, but makes a direct contactless measurement of the exact conductor temperature. The values recorded by RITHERM® can be used direct in the control center as a basis for increasing the transmission power and optimizing the lifetime of the overhead power lines.

Based on the annual mean temperature in Europe, the average transmission power of an overhead line can be increased by more than 20 % using RITHERM®.
RITHERM® – Your potential for more network safety

Electrical transmission networks are now used for tasks they were not designed for. At the time of construction, the close-meshed structure of the networks was planned to supply the load with power from nearby power stations with minimum power losses. The international transmission lines were originally intended only to act as a backbone to safeguard supplies in Europe.

With the opening up of energy markets, the networks are increasingly used for power trading and transporting large amounts of power to high load areas. The utilization of networks is also intensified by the larger share of power production provided by renewable energy. Especially the strongly growing wind power capacities in Europe and mainly in North Germany lead to heavily fluctuating power flows that cannot be adequately planned. The massive power surplus produced in the north due to the wind power stations in combination with additional power imports from NORDEL temporarily causes heavy power flows through the power networks of Germany and the neighboring countries like Belgium, the Netherlands, Austria, Poland and the Czech Republic. This distinctly reduces the line capacities available for international power trading. In addition, the heavy power flows decrease system stability and create heavily increased demands on effective monitoring of the line networks. This power can only be transported if optimum utilization of the available transit line capacities is possible.
Effective monitoring of overhead transmission lines

The growing demands on the European power networks lead to more frequent violation of the n-1 safety limit. A study by the European network operators assumes an overload of up to 180% on the remaining lines if an overhead line fails. Power peaks from wind power stations already cause overloads of national power lines in Germany, Poland, Belgium, the Netherlands, Austria and the Czech Republic.

Exact knowledge of the condition of the overhead line and the possible load potential is becoming increasingly important, especially when the overhead lines are operated close to their load limit. The decisive factor here is the thermal limit of the overhead line in critical spans. The temperature of the overhead line in the span is influenced by both the prevailing local temperature and wind conditions and the condition of the conductor and fittings. The RITHERM® system offers optimum monitoring via the exact conductor temperature. In contrast to other systems, the RITHERM® SAW sensor needs no additional power supply and is not influenced by ambient electromagnetic effects.

RITHERM® exactly records the absolute conductor temperature, which gives the control center the ideal basis for optimum use of the overhead line capacities. The easily used software and intuitive user interface show the current status of the line and the temperature at individually available intervals. RITHERM® therefore permits exact load forecasts and effective protection for the power network.
**RITHERM® – SAW technology optimized for use on overhead transmission lines**

The RITHERM® system comprises four elements:

- SAW (Surface Acoustic Wave) sensor with helical fixing rod
- Central unit
- SAW extension box with radar antennas
- Evaluation program for the control center

The SAW technology is already used for measuring temperature, pressure or tension in other applications. The sensors used in RITHERM® have been adapted to the specific conditions and requirements of overhead power lines.

The sensors are activated by a radar signal from the interrogation & control unit and do not need a separate power supply. This radar signal is converted to a SAW in the sensor. The SAW system measures the change in delay time along the sensor due to temperature-dependent changes in length and speed. The conductor temperature measured from this data takes the ambient temperature into account and has a tolerance of 3 K. This temperature is sent to the control unit and continuously retrieved over GPRS by the RITHERM® database server at the energy supply company.

**Principle of operation of the SAW sensor**

![Diagram of interdigital converter and reflectors](image)
These values can be used as the basis for increasing the transmission power and optimum matching of this power to the ambient conditions. This enables effective and low-cost prevention of overloading on the overhead power line.

The SAW sensor is activated by the radar signal.

The SAW sensor modifies the received signal and sends it back to the antenna.

The signal is sent to the database server by the central unit over GPRS.
RITHERM® – Technical data and scope of delivery

- Frequency: ISM band (2.4 GHz...2.4835 GHz)
- Ambient temperature: -35 °C...40 °C
- Maximum distance between sensor and antenna: 10 m
- Measuring accuracy: ± 1 K in the conductor temperature range -35 °C...150 °C
- Calculation accuracy: ± 3 K at nominal conductor temperature
  Temperature range: -35 °C...150 °C
- Sampling rate: 1 measurement of sensor temperature/minute
- Protection class: IP54

The RITHERM® system is available with two power supply variants. The system comprises the following components and options:

**RITHERM® system with solar power supply:**
- Solar power supply (2 panels) with battery backup, 12V, 330 Ah, buffer time (without sunlight): 40 days at 20 °C ambient temperature
- One SAW sensor with helical rod fixing
- SAW extension box
- Two transmit/receive antennas for RF signal transfer to and from sensor
- Central unit
- Transmission software for data transfer from tower to database server
- Database server software for calculating prospective conductor temperature in free span
- Client software for displaying measurements in control center
- All connecting cables and fixing material

**RITHERM® system with 230 V power supply:**
- One SAW sensor with helical rod fixing
- Two transmit/receive antennas for RF signal transfer to and from sensor
- Central unit with RF module and over-voltage protection
- Transmission software for data transfer from tower to database server
- Database server software for calculating prospective conductor temperature in free span
- Client software for displaying measurements in control center
- All connecting cables and fixing material

**RITHERM® extension options:**
- Additional sensor (for mounting on a tower with RITHERM® system already installed)
RITHERM® – Description of main components

SAW sensor

The SAW sensor consists of an aluminum profile on which the SAW chip is mounted. The SAW chip is connected to a transmit/receive antenna, which is protected against environmental influences by a cover. The sensor is installed on the overhead line using the helical rods molded into it.

RITHERM® central unit

The Central Unit (CU) is the base station of the system on the tower. It converts the data of the SAW extension box and the RF module and measures the ambient temperature required for the load forecast. The Central Control Unit (CCU) is responsible for process control of the microcontroller, which sends the data to the transformer station over GPRS. The CU also contains the power supply for the system.

Main components of CU:
- Batteries and charging controller (solar version)
- Overvoltage protection (230V version)
- Data converter (optical to digital)
- Central Control Unit
- Microcontroller
- GPS receiver (time synchronization)
- GPRS modem (data transfer to server)

RITHERM® SAW extension box

The SAW extension box contains the radar unit, which measures the sensor temperature using SAW technology in the frequency range of the ISM band. It also contains the RF unit consisting of generator, amplifier and overvoltage protection for the RF channels. The Digital Signal Processor (DSP) carries out signal control and transfers the data to the data converter.

Main components of the SAW extension box:
- Radar unit
- Digital Signal Processor (DSP)
- RF unit
- Data converter (digital to optical)
- Overvoltage protection

Server and client software

The server software is responsible for data transfer between the central unit on the tower and the server in the transformer station. It is also responsible for calculating the prospective conductor temperature. The client software shows the calculated conductor temperature on a graphical interface using a three-color code. The maximum permissible temperature must previously be stated by the customer. The client software can also be used to graphically display the temperature at individually defined intervals.

RED: Maximum permissible conductor temperature has almost been reached (difference 5K).
FLASHING RED: Maximum permissible conductor temperature has been exceeded.
YELLOW: The difference from the maximum permissible temperature is between 5K < \delta T < 10K.
GREEN: The difference from the maximum permissible temperature is greater than 10K.
RITHERM® – SAW technology in operation

The RITHERM® system was installed for the first time on various towers in the Czech Republic in 2006. The Czech network operator ČEPS had increasingly established the problem of growing differences between the planned loads on the power transit lines through the Czech network and the actual power loads. For this reason, RITHERM® has been used since 2006 to provide more effective monitoring of the load flow and line loads and to optimize the loads on these lines. RITHERM® enables the power connections to neighboring countries to be loaded and controlled more effectively and overloads leading to line failure can be prevented.

The installation took approx. two days per tower. The RITHERM® system has been operating reliably in the Czech network since 2006 and provides dependable figures for load optimization of the monitored network zones under a wide range of ambient conditions.

Systems installed for ČEPS

1. 245 in direction of Bujakow
2. 246 in direction of Kopanina
3. 441 + 442 in direction of Etzenricht
4. 443 in direction of Dobrezen
5. 444 in direction of Wielopole

Specified: -897 MW  Actual: -117 MW
Specified: -400 MW  Actual: -967 MW
Specified: -745 MW  Actual: -503 MW
Specified: 367 MW   Actual: 662 MW
Specified: -897 MW  Actual: -117 MW
Specified: -900 MW  Actual: -661 MW

Source: © ČEPS, 24.04.2007, 10.30 a.m.