However, the technology only took on major significance with the later deregulation of the energy sector in many countries and the resultant drive to improve asset utilization, reduce service requirements and increase equipment lifetime.

To meet these new demands, ABB Corporate Research in Sweden carried out a prestudy in 2002 to assess OLTCs based on vacuum interrupter technology. This led, in the following year, to a project group being formed and the first sketches for the VUCG design. The VUCG integrates vacuum interrupters as well as auxiliary contacts operated with a unidi-

LARS JONSSON, MAGNUS BACKMAN, PETTER NILSSON – ABB has developed a new product range of on-load tap changers (OLTCs) based on vacuum interrupter technology. The new OLTCs confine arcs to a vacuum interrupter, thus avoiding the transformer oil degradation and contact wear that traditional OLTCs experience.

Advantages of vacuum interrupter technology
ABB’s new OLTCs confine the arcs within a specially developed vacuum interrupter. This eliminates oil degradation and increases contact lifetime (to 1,000,000 operations). Further, OLTCs that utilize vacuum interrupters have a much higher current interruption capability than the equivalent traditional type.

History of vacuum interrupter OLTC development
OLTCs and vacuum switches existed in parallel from the early 1900s before they were combined into a single product. In the 1970s, ASEA patented various aspects of vacuum interrupter technology, including OLTC applications. At first, the combination of OLTC and vacuum switches was made on the reactance-type tap changers that was, and predominantly still is, used in the United States, operating on the low-voltage side of the transformer at high currents.

ABB’s new OLTCs confine the arcs within a specially developed vacuum interrupter. This eliminates oil degradation and increases contact lifetime.

Traditionally, when winding ratios are changed on an energized power transformer using an OLTC, arcing occurs in the transformer oil. Over time, these arcs will degrade both the OLTC contacts and the insulating properties of the oil, necessitating regular services and oil changes.
The VUCG that was introduced to the market in 2008 provides an easy field upgrade from traditional to vacuum technology. The same year, development started on the optimization of the contact material for the vacuum interrupter. In 2009, the VUCG model reached 600,000 operations in an electrical endurance test. The following year, the first synthetic test circuit for vacuum tap changers was designed and built. This enabled long test series at high power.

In 2012, the VUCL and the VUBB were introduced to the market and in 2016, ABB introduced the world's most capable vacuum tap changer, VUCG 1800. The vacuum product range also includes the VRLTC, a reactor-type tap changer, developed by ABB for the United States market.

**Functional description**

The two key functions of the OLTC are to select the tap in a tapped winding and to commutate the load between taps in a directional mechanism, which is the main differentiator from competitor solutions.

In 2004, the first VUCG diverter switch prototype was designed and built. 2005 saw the introduction of a new spring mechanism using compression springs, after previous solutions, which used clock springs, were shown to be insufficiently reliable. Also, a new mechanical rectifier to provide unidirectional rotation was designed. The VUCG was presented at CIGRE 2006.

In 2006, the first prototype of the new VUCL was designed and built. The design was similar to the VUCG but contained a switch to bypass the vacuum interrupters in normal operation – thereby allowing higher currents. The following year saw the initial design of the VUBB. Also, a selector switch type with compensation for the position of the cam slot was invented.

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Using vacuum interrupters in parallel for single-phase applications significantly reduces contact wear.

Introducing the world’s strongest vacuum tap changer

ABB is continuing its 100-year history of pioneering tap changers with the introduction of the world’s strongest tap changer, the VUCG 1800. The VUCG 1800 enables tap changing in high-end transformer applications without the need for enforced current splitting. The introduction of parallel breaking with vacuum interrupters is a leap forward in the application of vacuum technology. Using vacuum interrupters in parallel for single-phase applications significantly reduces contact wear on tap changers, even with high current levels and step voltages. The breaking current passes through three vacuum interrupters instead of just one, which distributes wear more evenly over the contacts. The new tap changer uses the same proven vacuum interrupters as before, ensuring the same high quality and long service life as for all ABB vacuum tap changers.

Other switching techniques, eg, those based on semiconductors, will make another shift in technology possible. Semiconductor-based switching has already been applied in a pilot installation and, as in the case of vacuum technology, the time will come when it finds mainstream use in OLTCs.

In a diverter switch type OLTC, only the diverter switch, where the switching power is handled, uses vacuum interrupters. The tap selector part is identical to that of a traditional tap changer.

The diverter switch has two sets of vacuum contacts (MV, RV) and two sets of rotating auxiliary contacts. The spring drive unit (SDU) converts the slow motion of the motor drive to the fast motion required for switching the contacts and also provides the synchronization required. The fact that energy is stored in springs ensures the switching cycle will be completed even if the power supply fails. Independent of whether the motor drive starts a raising or lowering maneuver, the SDU will always be aligned in the same direction, ie, it is unidirectional. The unidirectional motion ensures that the contact switching sequence will be the same for all operations, giving a minimum switching stress on the electrical contacts.

The key component, the vacuum interrupter, is based on over 40 years of experience and millions of successfully delivered units, and is thus an extremely reliable product. However, in the unlikely event of vacuum interrupter failure, the auxiliary contact system is designed to carry out a certain number of tap operations by itself and trigger a protective relay alarm.

**2 Diverter switch overview**

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