VACUUMSCHMELZE

Fachartikel

RENEWABLE ENERGY

Renewable Energy Using Solar Inverters

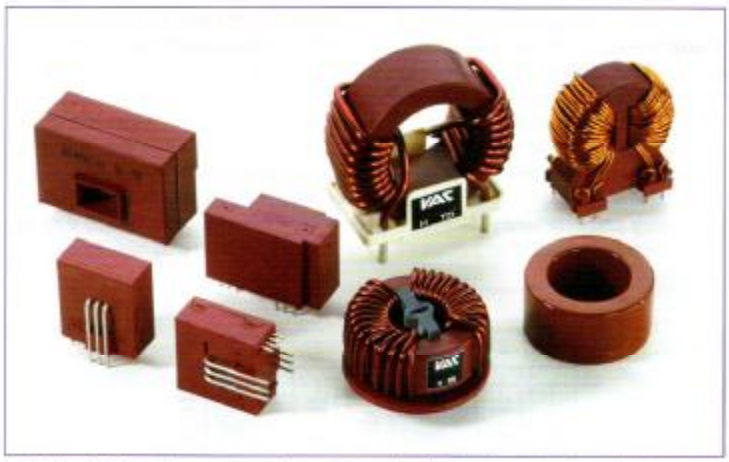
High efficiency and precise power detection

The advancement of photovoltaic technology is not only a vital step towards environmental protection, but also the pathway to almost inexhaustible sources of energy. Solar inverters must deliver maximum efficiency and precision through years of operation, while achieving high energy and cost efficiency.

By Dipl.-Ing. Roman Klinger, Product Marketing Manager, Vacuumschmelze GmbH&Co KG

Solar energy is an eco-friendly and almost inexhaustible source of power. In times of imminent climate change, attention and interest turn to sustainable forms of energy. The regenerative energy market has boomed in recent years, reaching record levels in 2006; according to figures supplied by the German Renewable Energy Federation (BEE), Germany's renewable-energy power generation rose by 11.1% to 71.5 billion kWh in 2006, equal to 11.6% of the country's gross power consumption. At a political level, the resolutions passed at the EU summit early this March have resulted in plans to increase the proportion of the energy mix supplied by renewable energies (such as water, wind and solar energy) from its current level of 6.5% to 20 % by 2020.

As market volume has risen, using solar power to generate electricity has become increasingly profitable. According to a survey by the International Business Forum for Regenerative Energies (IWR), prices for solar power plants of up to ten kilowatt output have fallen from around 14,000 euros to under 5,000 euros since 1991. While the boom in solar power has occasionally resulted in shortages, pushing up prices in the short term, we can assume that the long-term trend of lower unit prices will continue as production technologies continue to advance and solar cell factories expand.



Caption 1: Current sensors and common mode chokes, important in solar inverters.

From solar power system to power grid: current sensors measure grid input

In grid-connected solar power systems, the DC current produced by the solar modules is converted into the AC current (voltage 115V / 230V) by an inverter before feeding into the power grid. Small-scale inverters have a typical output range of between 1.5 and 6 kW, with peak levels of 2 to 4 kW. Larger inverter systems may have outputs of 30 – 100 kW and over.

Current sensors of VACUUMSCHMELZE (see Fig. 1) perform a range of functions in solar inverters, monitoring the AC output current that is fed into the grid and its DC part. For owners of solar power systems, high-precision current measurement is important since it forms the basis of the feed-in tariff. Unlike conventional Hall-effect sensors, VACUUMSCHMELZE current sensors use a patented magnetic field probe of Co-amorphous alloys as a zero-field detector, which offers an array of superior benefits such as minimal offset current and negligible long-term drift. Since the offset current is practically temperature-independent, the current sensors deliver ultra-precise readings under all conditions of use and operation.

The maximum direct current for grid feed-in varies from country to country;

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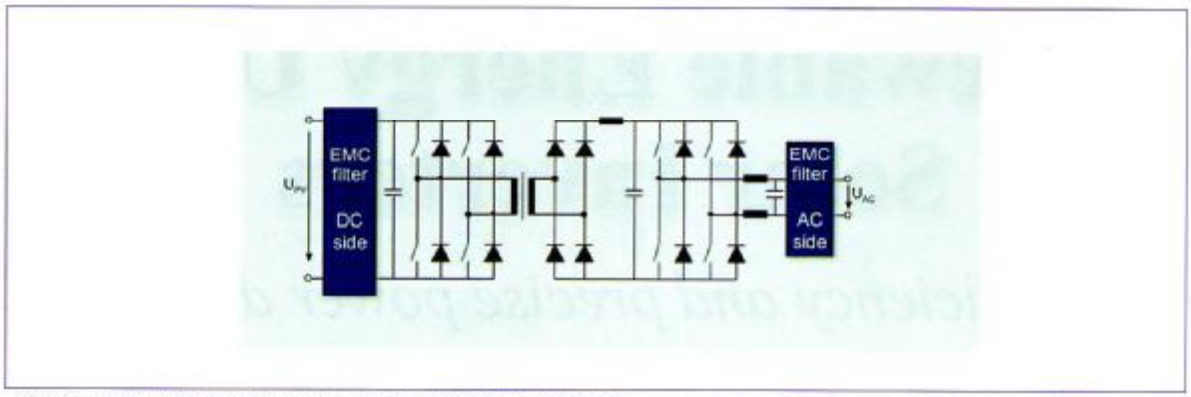
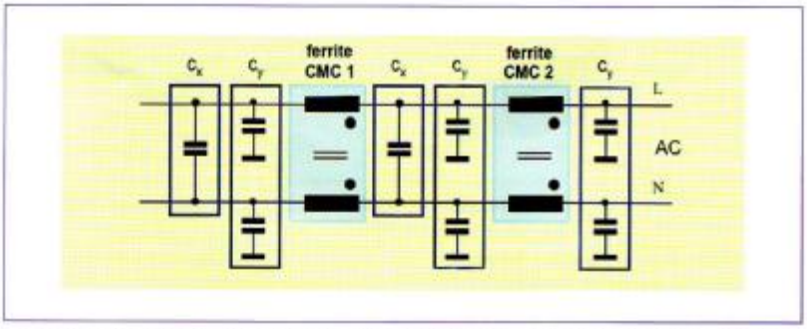


Caption 2: Inverter topology with middle frequency transformer.

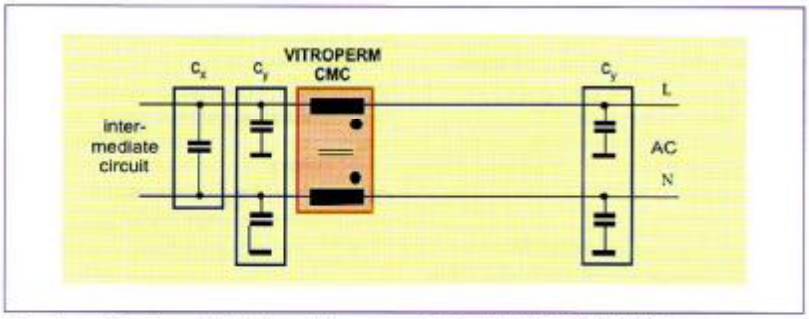
at a maximum of 1 ampere in Germany, it may be as little as a few milliamperes in other European countries. Because the DC component of grid current can saturate distribution transformers or transformers of other grid-connected devices, or trip an earth leakage circuit breaker, permitted maximum tolerances are laid down. Thanks to their design, VACUUMSCHMELZE current sensors are able to deliver readings of both DC and high-frequency AC to error levels typically lower than 0.3%.

Reliability and efficiency

VAC also supplies further innovative products such as Common Mode Chokes for use in the EMC filters of solar inverters. As Fig. 2 shows, they are installed at the input of the inverter (between solar panel and inverter) and at the output to the grid. They are designed to block or damp undesired interference voltage levels which could cause electromagnetic interference between electronic devices. Peak noise levels are specified by international regulations (e.g. EN 61000-6-3) and may not be exceeded by solar inverters. VAC supplies a broad range of common mode chokes for 250 V or 380 V mains operation plus high-insulation models for intermediate circuit voltages of up to 800 V to 1000 V. The chokes are designed to comply with the relevant safety standards EN 50178 or UL1741/UL840.



Caption 3: 2-stage EMC filter with common mode chokes with conventional ferrites.



Caption 4: 1-stage EMC filter with nanocrystalline VITROPERM CMC.

The main elements of common mode chokes are highly permeable tape-wound cores of VITROPERM®, a nanocrystalline alloy. Primarily composed of Fe, Si and B with additions of Nb and Cu, these materials are produced using Rapid Solidification Technology in the form of thin tapes. They serve as the basis of ultra-compact, high-performance EMC filters with good long-term properties and high temperature consistency, increasing the inverter's reliability and enhancing its efficiency. Recent surveys show that in some filter configurations, overall system efficiency can be improved by reducing the number of filter stages.

Two-stage EMC filters comprising two common mode chokes, multiple capacitors and other components are commonly in use (see Fig. 3). Due to the broadband damping of nanocrystalline common mode chokes a second filter stage is not necessary, reducing the total number of filter components (as shown in Fig. 4) and minimizing system losses to enhance the inverter's efficiency level of over 95 % still further. Since this is reflected in the attractive feed-in payments for solar power, each percentage point of added efficiency can thus be directly translated into return on capital. Manufacturers of solar systems thus strive to increase the efficiency of their designs by even the smallest amount in order to gain competitive edge and win market share.

With the specific property profile of low loss and high induction swing, nanocrystalline core materials are ideally suited for pulsed power converters, too.

In general, solar inverters are available both with power transformer and transformerless. In both types, the DC generated by the solar modules is converted to 50/60 Hz AC current which is fed into the power grid or used directly by consumers. Low-frequency transformers serve as galvanic isolation between the inverter and the grid and transfer the 50/60 Hz current generated by the inverter to the grid. Medium-frequency converters, on the other hand, are located between the solar panel and the intermediate circuit of the inverter (see Fig. 2), maintaining intermediate circuit stability despite voltage fluctuations in the solar panels and also functioning as galvanic isolation between the solar modules and power grid.

Switching frequencies of medium-frequency transformers typically range from approx. 30 kHz to 100 kHz. In comparison to conventional core materials, power transformers with VITROPERM® nanocrystalline tape-wound cores feature significantly higher induction and low core loss, delivering a high level of efficiency despite their extremely compact dimensions.

Safety and Personnel Protection

Transformerless inverter designs achieve even higher efficiency of up to 98% and over, and according to expert forecasts are facing major unit-based growth in the future. Statutory provisions stipulate that transformerless grid-feed solar inverters must feature personnel protection in the form of residual current monitoring units. These devices protect operating personnel from high voltage in the separate sub-network, while also protecting the solar plant itself from power surges and undesired frequencies.

In practice residual current monitors are used, which must be able to detect leakage current of only a few milliamperes (at operating current levels of several tens of amperes) and disconnect the system from the grid in the event of fault current. VAC offers very special high-precision current sensors and special tape-wound cores from rapidly solidified materials to perform this complex and critical function.

Solar power systems that meet these requirements will become increasingly important players in the energy mix of the future - and VACUUMSCHMELZE's innovative materials, high-precision current sensors, broadband common mode chokes and low-loss power transformers play a key role in this process

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