Eco-friendly choices shine through for clean energy

As the world moves towards making more eco-friendly responsible choices, the demand for sustainable and renewable energy has driven consistent high growth in the solar inverter market. By Panasonic Industry.

A solar inverter (also called a photovoltaic or PV inverter) converts direct current (DC) into alternating current (AC), and is widely used in solar photovoltaic power generation systems.

Solar inverters available today are generally divided into three types: central inverters, string inverters and micro inverters.

Central inverters are mainly used in large-scale ground power stations, suitable for high voltage grid connection. The power range is normally between 100kW and 2500kW.

String inverters, also known as distributed inverters, are mainly used in industrial, commercial and residential areas. Power stations that use string inverters are not generally very large, and they are integrated into the national supply through full or surplus power grid connection. Power range is normally up to 200kW. String inverters are most commonly used and encountered in our daily lives.

Micro inverters are mainly used for direct integration on battery boards, that are suitable for small household power stations.

Standard film capacitors

Film capacitors can optimise the design of string inverters. Regardless of the type of solar inverter, the key requirements are high efficiency, high reliability and input voltage with a wide range of capacitance values. Metallised PP(polyproylene) film capacitors can play an essential role in a solar inverter's circuit design because they feature a large current handling ability, high reliability and proven safety performance. They can be used for I/O filtering, EMI suppression, snubber and DC link circuits.

On the input side of the primary DC filter circuit as well as for the DC-link circuit, DC-rated film capacitors provide DC filtering. For example, parts with voltage ratings of up to 1300V DC and a wide capacitance range of up to 110µF are available as one single component in Panasonic's EZPV series; both two-pin and four-pin terminal devices are available.

On the input side of the DC/DC converter circuit, as well as in snubber circuits, capacitors such as Panasonic's DC-rated ECWFD series (coating type), ECWFE and ECWFG (box type) film capacitors, are suitable for smoothing. Various rated voltage values are available from 450V DC up to 1100V DC with a capacitance range from 0.01µF to 12µF. The built-in fuse provides safety performance which, together with high frequency characteristics and high ripple current capacity help film capacitor devices to optimise the high voltage circuit of a solar inverter. Film capacitors with a higher rated voltage of 250 to 600V AC, for example Panasonic's AC-rated EZPQ industrial-grade AC capacitors, can be used as an output filter.

Reliability - especially in humid conditions - is critical for solar inverters which are used outdoors. To achieve high humidity resistance, for example, Panasonic has developed enclosure sealing technology and 100% aluminium vapour deposition processes (Figure 2).

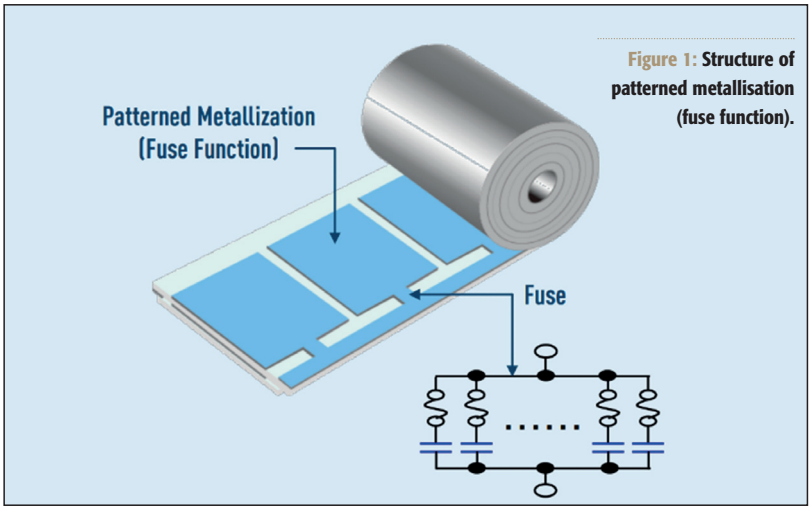

Figure 1: Structure of patterned metallisation (fuse function).

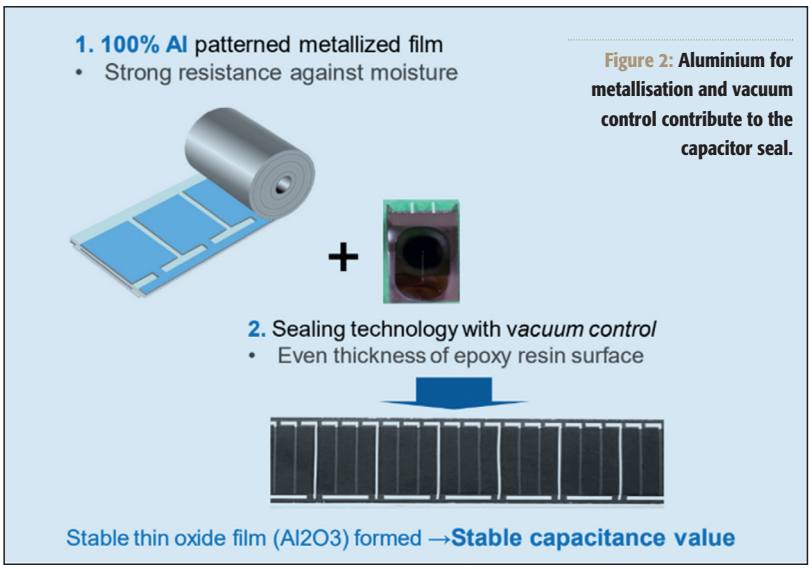

Figure 2: Aluminium for metallisation and vacuum control contribute to the capacitor seal.

Polymer aluminium capacitors

Conductive polymer solid aluminium capacitors play a major role in the optimisation of solar inverters. To efficiently generate energy from the sun, the solar panel must absorb energy from the sun

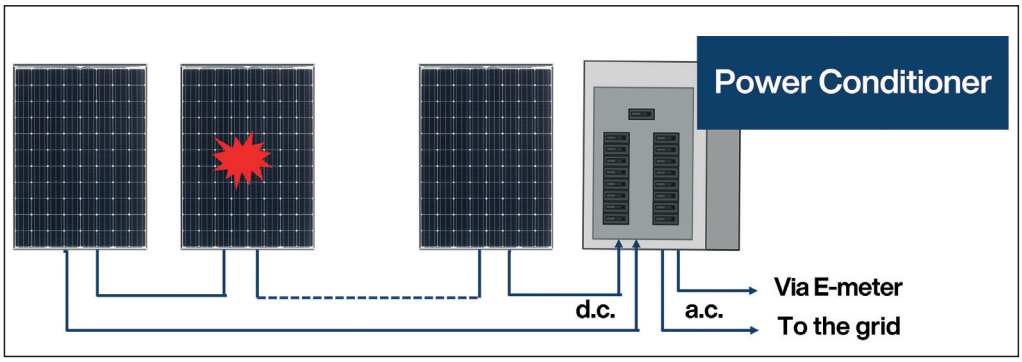

Figure 3: The role of a centralised power conditioner.

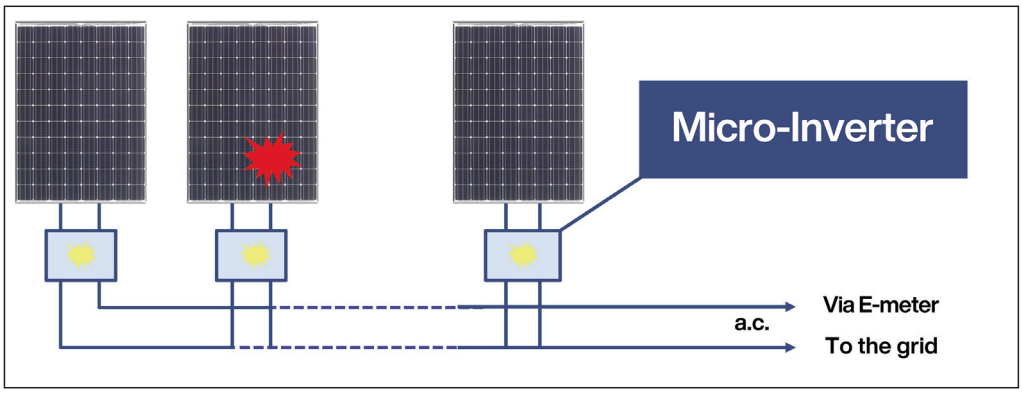

Figure 4: The position of a micro inverter.

continuously as the earth rotates. Detecting and tracking the live position of the sun and adjusting the angles of the panel to ensure that it always faces the sun, maximises the solar energy harvested.

Conventional solar inverters have a centralised power conditioner that controls the entire module but, ironically can cause the modules to become shaded, resulting in a decrease in energy output (Figure 3).

An example of conductive polymer solid aluminium capacitors is Panasonic's OS-CON series. Conductive polymer solid aluminum capacitors play a major role in the optimisation of solar inverters.

To resolve this, micro inverters are installed on each module to keep the panel facing the sun, while only one centralised power conditioner is necessary for several modules (Figure 4).

These micro inverters demand a long lifetime of five to 10 years and must save space as well as reduce costs. For example, a single OS-CON can replace seven MLCCs (multi-layer ceramic capacitors) in a micro inverter design, reducing PCB space by 31% without reducing capacitance, whereas using MLCCs reduces capacitance due to DC bias.

The 10 year life span is more than three times that of an electrolytic device, enabling OS-CON capacitors to replace aluminium electrolytic versions to increase the life of the micro inverter. Two OS-CON capacitors can replace three electrolytic ones to save space.

Resistors for solar inverters

Many resistors are used in a solar inverter circuit (Figure 6). Current requirements focus on high voltage, high efficiency for energy saving, and long life. For the resistor this means high reliability with long life, high voltage-withstand capability and high accuracy.

For the regulator and voltage-sense functions, resistors with a small case size (e.g., Panasonic's ERJP series) can be used. (Pansonic claims the resistive element trimming shape ensures anti-surge and anti-pulse-withstand performance.)

Gate driver resistors are normally required to have a high power capacity and to be able to survive the high temperatures caused by heat generated within the IGBT and inverter. Panasonic's ERJH series resistors use newly developed materials to achieve high heat resistance, says the

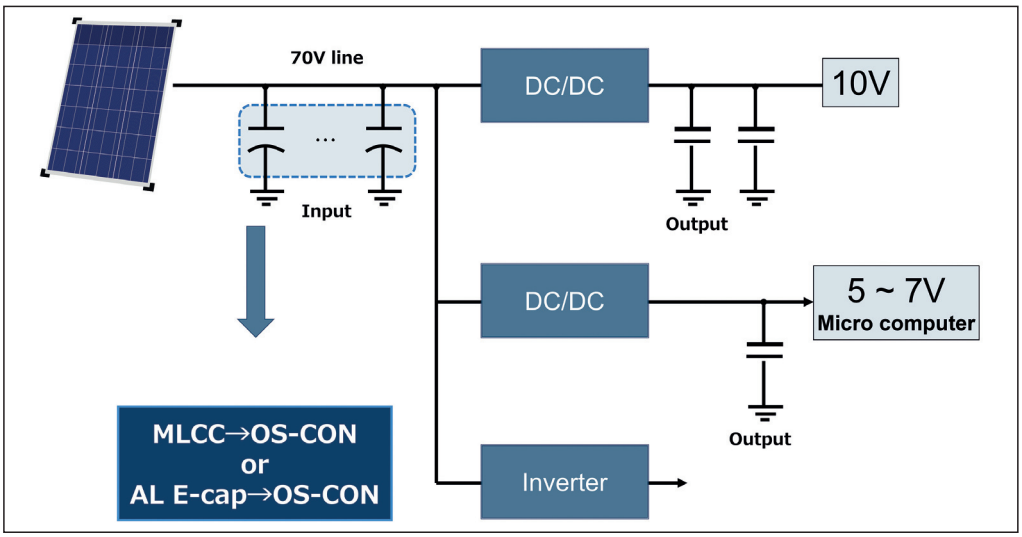

Figure 5: An example of a solar inverter circuit.

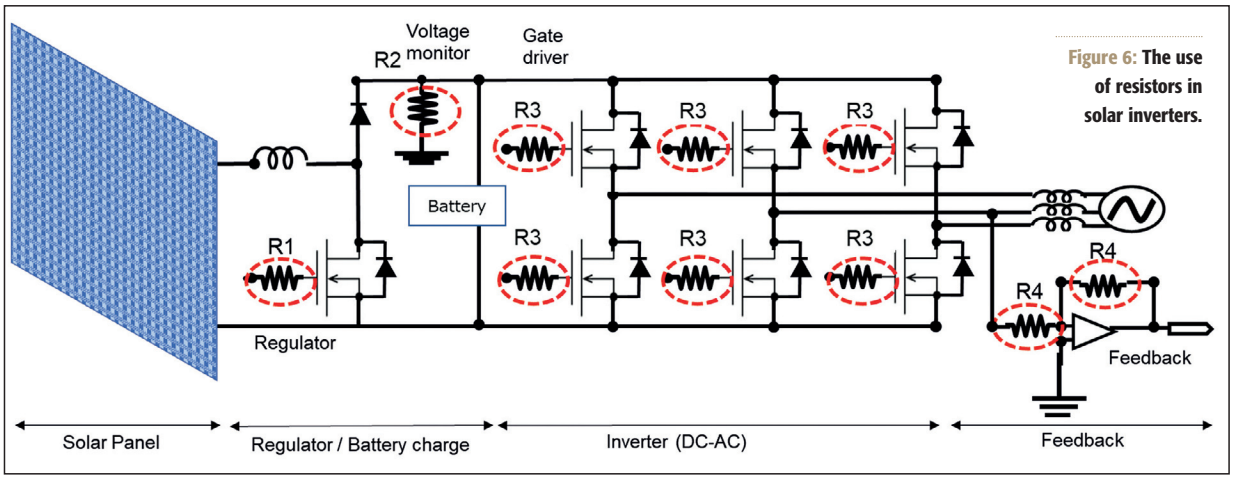

Figure 6: The use of resistors in solar inverters.

company. Maximum operating temperatures is now 175ºC) with rated operating range of 70ºC to 105ºC. The company also claims that solder crack resistance has been improved at high temperature.

In the motor drive control unit, resistors are required in the amplifier and feedback circuits. Key requirements are high reliability, long life and stable resistance. Resistors with an additonal resin layer on the underside can reduce solder joint cracking, while improvements to material and construction design can improve precision and extend life expectancy. Devices which meet anti-sulphuration specifications enable them to survive the harsh operating conditions that micro inverter applications routinely encounter.

Inductor design

Solar inverters need inductors that are capable of handling high voltages and large currents in the main circuit. These components are typically a custom design to meet both current handling and inductance requirements of the system. In addition to the inductor's role in the primary circuit, power inductors are also used in the auxiliary circuit for the controller and gate drivers, where digital logic provides critical controlling and monitoring functions for solar energy harvesting systems. The high switching speeds and harsh operating conditions can require high performance, metal composite power inductors to be specified.

One of the most important requirements of a power inductor for a DC/DC converter is high power efficiency. Inverter suppliers are facing tough demands for reduced inverter system size and higher efficiency, so the challenge for the inductor supplier is to provide an inductor at small size with high current capability and minimal heat dissipation.

A general trend in the electronic industry is the standardisation and modularisation of systems but this means that passive components suppliers need to provide products which scale over a broad range of requirements in regards to electrical power capability. A high current capability of an inductor series can support the standardisation of solar inverter systems, supporting a wider range of current flow, depending of the requirement of the individual system.

Exhibiting stability

Metal composite power choke coils exhibit stable inductance over current, but are also stable with temperature, in comparison to ferrite inductors, where the inductance value is influenced by the temperature of the inductor. This means design engineers need to qualify the component for different temperature ranges when used in solar inverters. With stable temperature behaviour, much less time is required for qualification, which reduces development cost and time.

Another area within a solar power inverter that requires a power inductor is the gate driver of the FET that transforms the DC current of the battery to the three-phase sine wave, which is fed in the power grid. While the inductance of a ferrite inductor will vary with age, the metal composite material is free from any effects of ageing, helping the inverter manufacturer to guarantee a system that functions over its entire specified lifetime.

As is the case with the DC/DC converter, the power inductor of the gate driver circuit benefits from a stable temperature behaviour of the inductance value. This attribute also helps to reduce development and qualification time of the gate driver circuit, as engineers do not need to consider a fluctuation of the inductance value of the inductor, which is not only influenced by the power loss of the inductor itself, but also by the heat dissipated by surrounding components.

Additionally, designers of inverter systems are under constant pressure to make systems smaller and more efficient. Compared to ferrite inductors, metal composite inductors have a much higher energy density, which leads to a size reduction of 30% to 50% for comparable current specifications. PCB space can be saved, or higher currents used, simply by replacing ferrite inductors with metal composite ones.

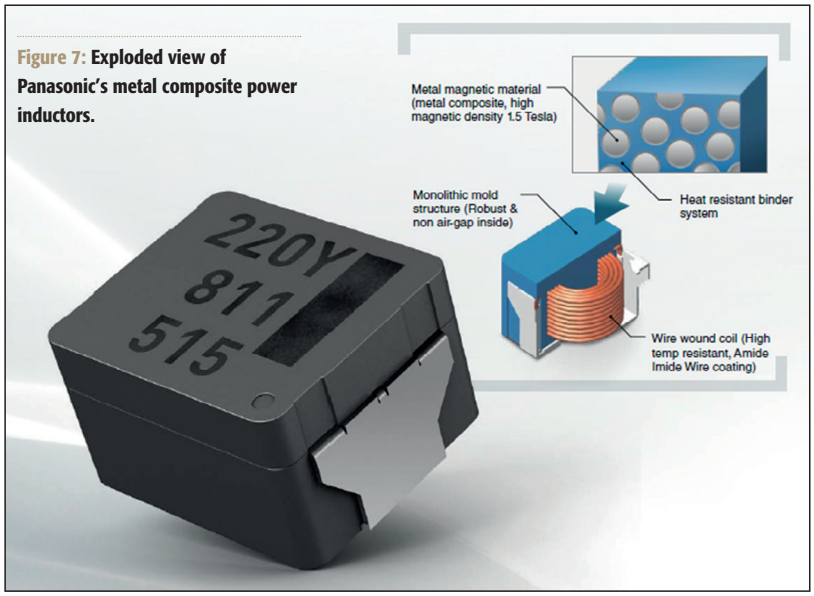

Figure 7: Exploded view of Panasonic's metal composite power inductors.