



# Key components for wind power systems

*The function of large resistors and capacitors used in wind turbines and grid power is explored*

BY BERTRAM SCHOTT  
Vishay, Malvern, PA  
[www.vishay.com](http://www.vishay.com)

The use of wind power systems is increasing across the world. In 2009, the installed capacity of wind power in Europe was 75 GW, up 10 GW from 2008. In the U.S. the capacity was 35 GW and in China it was 25 GW, up 10 GW and 14 GW, respectively. Worldwide, the installed capacity of wind power grew by 38 GW in 2009. All told, there are about 100,000 wind turbines installed across the world, accounting for 2% of the total energy demand. By the end of 2010, another 29 GW of wind power capacity will be installed worldwide, along with an additional 12,000 wind turbines.

As the demand for wind energy continues to grow, so too does the demand for components that meet the requirements of the wind turbines being manufactured. Modern power electronics in wind turbines not only push the limits of components, but also require a long life of about 20 years in harsh environments, where circuits are often exposed to high ambient temperatures and vibration.

In this article, we explore the function of "large" resistors and capacitors used in wind turbines and grid power, along with the required device specifications for these applications. Capacitor applications include dc linking, IGBT snubbers, and ac filtering. Resistor applications include current limitation during capacitor pre-charge and dc-chopper or crowbar triggering, and current measurement. "small" capacitors and resistors, which are typically used in the control circuits of wind turbines, are beyond the scope of this article.

## Resistors

Resistors in wind turbines (see Fig. 1) include the pre-charge, chopper, crowbar, and ac-filter resistors. The pre-charge resistor limits the inrush current into the dc-link capacitor at initial switch-on. To accomplish this, the device requires high single-pulse energy and a high voltage rating. The inductance of the resistor helps in limiting the inrush current as well; therefore, wirewound resistors

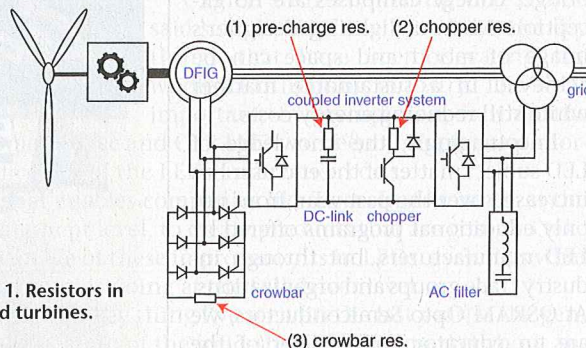


Fig. 1. Resistors in wind turbines.

are a perfect choice. The pulse energy for the pre-charge resistor is typically about 5 J for capacitance of 10  $\mu$ F and dc voltage of 690 V.

The chopper resistor limits the current when the chopper switch is on. The chopper is usually switched at high frequency to control the dc voltage. Therefore, the resistor must have high-voltage capability and high repetitive pulse energy ratings, which is equivalent to a high continuous power rating. Low parasitic inductance is mandatory in the chopper resistor, because of the high switching frequency in the kilohertz range, and can be achieved by employing thick-film technology. The need for high power ratings in a small size, and hence high power density, can be met with heatsink-mountable resistors. The resistor can be mounted on the same heatsink as the chopper switch.

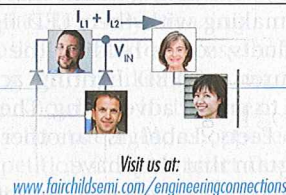
The crowbar resistor limits current and voltage, such as in the case of low- or high-voltage ride-through. Typical specifications for this device in wind turbines include a high energy pulse capability of up to 4 MJ, resistance of 10 to 100 m $\Omega$ , a power rating from 1 to 20 MW, and maximum current rating in the range of 10 to 20 kA for the typical fault ride through periods of 200 ms.

The ac filter resistor is used together with the ac filter capacitor to form RC filters. Together, with the inductance of the output transformer, they can also form RL filters. A high continuous power rating for the ac filter

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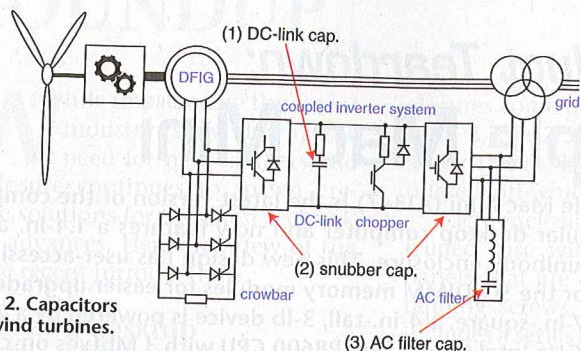


Fig. 2. Capacitors in wind turbines.

resistor is a must. Corrugated ribbon construction aids rapid cooling and the inductance of the wirewound resistor can positively contribute to the filtering effect.

The current shunt resistor provides current measurement for testing purposes. Typical requirements include current ratings from 800 A to 900 A, resistance of 0.1 to 0.6 mΩ, a power rating of 500 W, and temperature coefficient of 100 ppm/K.

### Capacitors

Capacitors in wind turbines (see Fig. 2) include the dc-link, snubber, and ac filter capacitors. The dc-link capacitor is used to stabilize the dc-link voltage. Whether metalized film or aluminum electrolytic, the dc-link capacitor in a wind turbine requires capacitance from 3,300 to 4,700 μF and a high rated voltage from 690 to 1,000 V. Film capacitors have two big advantages in wind turbines: the intrinsic self-healing ef-

fect after an electrical breakdown of the dielectric; and the lack of any liquid electrolyte that is slowly lost and therefore limits the lifetime of the component.

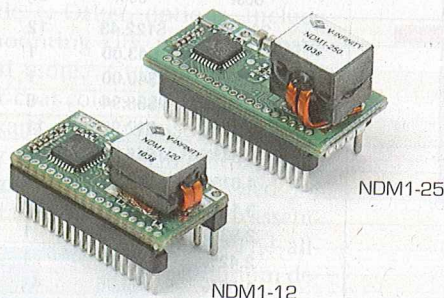
Aluminum electrolytic capacitors can also be used as dc-link capacitors. Their advantage is that they have a much higher capacitance per volume [C/V] and capacitance per price ratio than film capacitors. But voltage rating in aluminum capacitors is limited to 450 V, and so the devices have to be arranged as voltage dividers, which decreases the effective C/V-value and increases cost. The lack of any self-healing mechanism in case of breakdown of the dielectric and the limited lifetime due to the loss of electrolyte are also drawbacks. However, aluminum electrolytic capacitors are often a good choice for small wind power systems in the kW range.

The snubber capacitors reduce voltage and current spikes in power semiconductor switching applications (for example, IGBTs) in order to protect semiconductors, and to reduce total losses and EMI. Wind turbines require devices with a capacitance less than 1 μF due to their high switching frequency, and a high rated voltage from 1,000 V to 1,200 V.

The ac filter capacitor reduces harmonics in the line frequency. Typical requirements include a voltage range from 760 V to 24 kV and power from 50 to 800 kVar.

When selecting key components for these turbines—from dc-link, snubber, or ac filter capacitors, to pre-charge, chopper, or crowbar resistors—designers should not only look for devices featuring the required specifications, but also for a robust design in order to ensure reliable operation over a long period of about 20 years.

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### HIGHLIGHTS

#### Current-sense resistor is industry's first in 0603 size

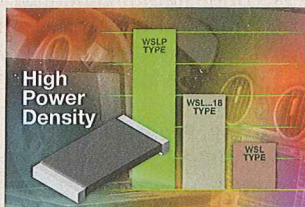
The surface-mount WSLP0603 power metal strip resistor is the industry's first 0.4-W current-sensing resistor in the 0603 package size. Suiting current-sensing applications in dc/dc converters for computers, VRMs for laptops, Li-ion battery safety and management, and electronic automotive systems, the 1.6 x 0.8-mm resistor can replace larger current-sensing resistors, saving circuit board space and resulting in smaller and lighter consumer products.

The device features a resistance range of 10 to 100-m $\Omega$  and high-temperature performance to 170°C. The resistor also offers inductance values from 0.5 to 5 nH, an excellent frequency response to 50 MHz, and low thermal EMF of less than 3  $\mu$ V/°C. (\$0.175 ea/qty greater than 100,000 — 4 to 6 weeks ARO.)

**Vishay Intertechnology, Malvern, PA**

Steve Hendricks 402-563-6320 [steve.hendricks@vishay.com](mailto:steve.hendricks@vishay.com)

[www.vishay.com](http://www.vishay.com)



#### 50-V tantalum polymer capacitors are industry's first

The TCJ series now includes the industry's first 1- $\mu$ F/50-V and 10- $\mu$ F/35-V SMD polymer tantalum capacitors. With the voltage range extension, the series now meets the demands of dc/dc converter applications that supply circuits in devices such as LCD TVs, base stations, rectifiers, and LED power drivers in PC monitors and new LED-technology TVs.

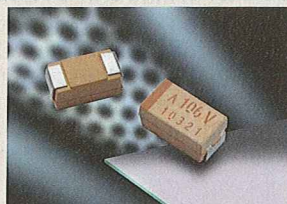
The RoHS-compliant series is made with conductive polymer to reduce ignition failure. The capacitors maintain stability in ambient temperature (25°C) and applied voltages, and are 3x reflow compatible up to 260°C. The devices also exhibit low ESR, and suit continuous operation with only a  $\pm$ 20% voltage derating.

Available in 13 case sizes, the capacitors operate in temperatures from -55° to 125°C. (1- $\mu$ F B case, \$0.620 ea/10,000 — 8 weeks ARO.)

**AVX, Myrtle Beach, SC**

Dan Lane 843-946-0483 [dan.lane@avx.com](mailto:dan.lane@avx.com)

[www.avx.com](http://www.avx.com)



#### Tiny slide switch offers momentary action, long life



Measuring just 2.6 x 7.6 mm, the JSM0001 subminiature slide switch provides SPDT momentary action

and is designed specifically for applications where height or surface area is restricted. It is extremely sensitive to actuation despite its small size, suiting it for on/off touchscreens, handheld games, remote controls, and instrumentation applications.

The switch has a contact rating of 10 mA at 5 Vdc, with a lifespan to 100,000 cycles. It is RoHS-compliant and meets all requirements of RoHS

directive 2002/95EC. (Contact company for pricing — available now.)

**C&K Components, Newton, MA**

Allison Turner 617-969-3700

[allison.turner@coactive-tech.com](mailto:allison.turner@coactive-tech.com)

<http://www.ck-components.com>

#### Crystal resonator surpasses quartz crystals

Suited for wired Ethernet, HDMI, SATA, USB 3.0, and PCI-e applications, the XRCGB-M hybrid crystal resonator series incorporates a quartz crystal element and offers an accuracy of less than  $\pm$ 100 ppm. At low frequency (24 to 30 MHz), initial tolerance of the series is  $\pm$ 30 ppm, plus temperature characteristic of  $\pm$ 40 ppm over the -30° to 85°C range.

At high frequency (30.1 to 48

MHz), initial tolerance is  $\pm$ 45 ppm, plus temperature characteristic  $\pm$ 40 ppm over the range -30° to 85°C. Measuring just 2.0 x 1.6 x 0.7 mm, comparing favorably to its quartz crystal equivalents. The series is available in frequencies of 24, 25, 27, 27.12, 30, 33.86, 40, and 48 MHz, with additional frequencies under development. (\$0.35 each — stock to 11 weeks ARO.)



**Murata Electronics**

**North America, Smyrna, GA**

Information 770-436-1300

<http://www.murata-northamerica.com>

#### VCO in S-band offers low phase noise

The CRO3150A-LF voltage-controlled oscillator operates at 3,125 to 3,175 MHz with a tuning-voltage range of 0.5 to 4.5 Vdc. This VCO features a typical phase noise of -108 dBc/Hz at 10-kHz offset and a typical tuning sensitivity of 21 MHz/V.

In addition, the device delivers a typical output power of 4.5 dBm at 5-Vdc supply while drawing 25 mA typ over the -40° to 85°C temperature range. This VCO features typical second-harmonic suppression of -19 dBc and comes in a standard 0.5 x 0.5 x 0.22-in. Mini-16-SM package. (Contact company for pricing and availability.)

**Z-Communications**

**Poway, CA**

Sales 858-621-2700

[sales@zcomm.com](mailto:sales@zcomm.com)

<http://www.zcomm.com>

#### Filter capacitors have values to 75 $\mu$ F

The B3279\* series MKP AC capacitors are output filter capacitors featuring a value range of 2 to 75  $\mu$ F. The series offers capacitor types for voltages up to 400 Vac, and can be used in a range of output filter modules for three-phase power converters or drives.

The devices have radial terminals for PCB mounting and operate in temperatures to 105°C. The B3279\*



ous shooting, and real-time image capture with no lag between resolutions. A 4-lane MIPI interface supports fast data transfer.

Designed to be used with a baseband or an application processor for integrated image signal processing, the low power imager has an on-chip VCM driver and fast mode switching between different resolutions. Other integrated features include temperature sensing, 256 bytes of one-time programmable memory, lens shading correction, and pixel defect correction. The chip fits a standard module size of 8.5 x 8.5 mm. (Contact Scott Foster for pricing — samples available now; prod qty, March 2011.)

**Omnivision Technologies**

**Santa Clara, CA**

Scott Foster 408-567-3077

sfoster@ovt.com

<http://www.ovt.com>

## Backlights suit touch-enabled displays

Suited for backlighting touch-enabled display graphics in a wide variety of applications, the Ultra-thin

light guides employ side-firing, high efficiency LEDs strategically spaced along the guide edge and focuses the light into a guide 0.6 mm or less in thickness.

The guides' light extraction technologies place light precisely where needed for bright light without hot spots or dark areas. Said to offer better color and uniformity control, lower parts count, and reduced power consumption, the guides are compatible with a variety of overlays, including glass, polycarbonate, polyester, acrylic, and practically any nonconductive material. (About \$1 ea / 50,000 — available now.)

**Global Lighting Technologies**  
**Brecksville, OH**

David DeAgazio 440-922-4584

sales@glthome.com

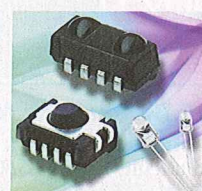
<http://www.glthome.com>

## IR receivers target 3D LCD-shutter glasses

Developed specifically for the LCD-shutter glasses used with 3D-ready TV sets, the surface-mount TSOP75D25 and TSOP35D25 IR re-

ceivers are designed to operate on 25-kHz carrier frequency, which is lower than that used by standard TV remote controls and thus helps avoid interference. And the receivers are designed to receive signals from an 830- or 850-nm emitter because TV remotes operate at 940 nm,

The 2.3 x 3.0 x 6.8-mm TSOP75D25 has dual lenses, while the 4.0 x 5.3 x 7.5-mm TSOP35D25



has a single lens. The receivers feature optical-noise suppression for use with compact fluorescent lights, LCD

backlights, and plasma panels. The IR devices can be mounted in a side or top view and have a viewing angle of  $\pm 50^\circ$ . (\$1 ea / small qty — samples available now; prod qty, 6 to 8 weeks ARO.)

**Vishay Intertechnology**  
**Malvern, PA**

Information 619-336-0860

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