



THE LEADING MANUFACTURER OF ULTRACAPACITORS AND LITHIUM-ION CAPACITORS

## LICAP Technologies Application Note

### Wind Turbine Emergency Blade Pitch Ultracapacitor Energy Storage System

Wind turbines utilize grid power for operational functions including electric pitch control of the blades to optimize shaft RPM as wind speeds change. Should grid power fail, the blades must be feathered to stop shaft rotation to avoid damage to or catastrophic destruction of the wind turbine. A backup power source, or uninterruptable power supply (UPS) provides power for the emergency blade pitch when grid power fails. Historically, standby power came from lead acid battery UPS systems. Lead acid batteries are the greatest barrier to reliable stand by wind turbine emergency blade pitch systems. LICAP ultracapacitors have significant performance advantages over lead acid batteries at the critical moment of zero tolerance for UPS failure.



Ultracapacitors, like batteries, are energy storage devices that can meet the energy requirements for successful emergency blade feathering. Batteries store and release energy by way of an electrochemical reaction between anode and cathode whereas ultracapacitors store energy electrostatically, a physical process where charge is stored on the polarized electrode plates. Table 1 compares ultracapacitors to lead acid batteries.

Parameter	Lead Acid Batteries	Ultracapacitors
Power Density	40 W/kg	5900 W/kg
Energy Density	50 Wh/kg	6 Wh/kg
Lifespan - Float Charging	2 – 4 years	10 - 15+ years*
Recharge Time	8-16 hours	3-6 minutes (Module)
Usable Energy	50%	75%
Temp Sensitivity	Upper limit 76°F (25°C) Lower limit -4°F (-20°C)* * significant capacity reduction at -20C	Upper limit 149°F (65°C) Lower limit -40°F (-40°C)
Low Temperature	50% Ah Capacity @ -22°F (-30°C)	97% Capacitance @ -58°F (-50°C)
Voltage Per Cell	2V	2.7V
Hazmat	Lead, toxic fluids, and gas	Lead Free, Non-toxic

**Table 1 - Comparison of ultracapacitors and lead acid batteries**



**LICAP 3000F, 2.7V Ultracapacitor cell**

Ultracapacitors have an internal DC resistive path referred to as equivalent series resistance, or ESR. ESR determines the discharge rate capability of the module as it limits the maximum peak and continuous current flowing through the ultracapacitor cells. The lower the ESR, the more current can flow. LICAP ultracapacitors are among the lowest ESR specifications in the industry and can handle pitch motor peak inrush currents with ease.

Lifetime of LICAP ultracapacitor energy storage systems for UPS applications is measured as DC calendar life. DC life is the expected module lifetime that is primarily a function of per cell voltage and operating temperature. The DC life specification for our 2.7V, 3000F ultracapacitor cell is 10 years at rated voltage (2.7V) and 77°F. Operating the cell at less than rated voltage results in extended DC lifetime, 15+ years depending on temperature. LICAP defines ultracapacitor lifetime as a 20% capacitance fade or a 100% increase in Equivalent Series Resistance (ESR) over the design lifetime, typically 10 - 15 years or longer.

LICAP Ultracapacitors have improved reliability and lifespan over other ultracapacitor manufacturers due to our Activated Dry Electrode process. Other ultracapacitor

manufacturers use a wet/slurry process for creating the electrode which is susceptible to premature end of life due to residual solvent contamination.

LICAP ultracapacitors also have a superior life (cycle and calendar) as compared to batteries, as well as greater charge and discharge efficiency.

Compared to lead acid batteries, ultracapacitors are safer, non-toxic, require zero routine maintenance, offer a 10 - 15+ year life cycle\* and operate over a wider temperature range with no performance degradation.

### **Battery box retrofit solution: Change batteries to ultracapacitors**

Today, a majority of new wind turbines with electric pitch control already use ultracapacitors for the pitch control UPS system. However, some manufacturers still use lead acid batteries, which can become a maintenance problem after only a few years. To address this problem, LICAP Technologies has partnered with Windurance LLC to develop an ultracapacitor retrofit solution to replace the existing battery-based energy storage and charger system in GE 30Nm & 20Nm wind turbines. It is designed as a “drop in” replacement not requiring any modification to the pitch control system box or operating system. The ultracapacitor modules and capacitor charger unit (CCU) are common across the different pitch box iterations, and use the existing battery mounting locations and power cables. The retrofit kit includes brackets for mounting the CCU and an additional wire harness for monitoring and communications features.

For this retrofit solution, each LICAP module contains 6 x 2.7V, 3000F ultracapacitor cells connected in series. A 30Nm wind turbine will use 6 modules in series per blade (36 cells), and a 20Nm wind turbine will use 4 modules in series per blade (24 cells). These systems operate at 87V and 58V respectively, which enables the cells to operate at only 2.42V each. Operating at 2.42V per cell results in optimal lifetime performance for the ultracapacitor cells. Please contact LICAP Technologies for additional information.

### **LICAP Module SM0500-016-GER:**



Module internal busbars are laser welded to the cell terminals as shown in the inset above to minimize resistance and ensure reliable connection.

### Module Specifications:

Parameter	Specification
Capacitance	500F, -0/+20%
Voltage	16Vdc rated, 17V surge
ESR (DC)	1.8mΩ, max initial, laser welded busbars
Current	1900A peak, 160A continuous ( $\Delta T = 40^{\circ}\text{C}$ )
Usable Energy	13.3Wh (75%) from $V_{\text{max}}$ to $0.5 V_{\text{max}}$
Power Density	4162W/kg
Temperature Range	-40°C to +65°C
DC Life	10+ years @rated voltage, 25°C

### Windurance Capacitor Charging Unit (CCU) 700-70004, 700-70005, 700-70006 specifications:



Parameter	Specification
Input Voltage	230VAC +/-10%, 299VAC max @ 1A
Frequency	47Hz to 63Hz
Output Current	3A maximum
Power	180W maximum
Output Voltage	20Nm w/4 modules 58V, 30Nm w/6 modules 87V
Communication	Physical layer, isolated RS485 9600 baud 2 wire
Module Voltage Sensing	Individual and total stack sensing

## **Our Story**

LICAP Technologies, established in 2016, is a manufacturer of innovative ultracapacitor electrode material, high quality ultracapacitor cells and ultracapacitor modules. Our patented LICAP Activated Dry Electrode manufacturing process was developed in our California R&D laboratories. Dr. Linda Zhong, the leader in modern ultracapacitor electrode design with over forty patents in the US and abroad, is our company President. LICAP Technologies leads the way in ultracapacitor performance.

\*Actual ultracapacitor life cycle is a function of ultracapacitor cell voltage and temperature. Please contact LICAP Technologies for a life estimation if required.

## **Please Contact Us for Further Information**

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