WIND TURBINE OBSTRUCTION LIGHTING

When International Tower Lighting, LLC considered the particular needs of wind turbine lighting systems, they started from the ground-up and surpassed FAA requirements to tackle this unique need.

By Andy Rudolph, P.E.

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WHEN THE ENGINEERING TEAM at International Tower Lighting, LLC considered the unique demands and requirements of obstruction lighting systems for wind turbines, they were venturing into uncharted territory. Among the multitude of challenges, the first key question was whether to modify an existing telecommunications lighting system or to design a lighting system specifically for wind turbines. Extensive industry research and consultation with experts in the field yielded the definitive answer, the designers at ITL responded with the IFH-1710 and built it entirely from the ground up to serve the requirements of the wind turbine industry.

The project began with a careful investigation of the regulatory and environmental factors governing the wind turbine industry. In addition to strict FAA requirements, the wind industry and the wind turbine environment have their own standards and concerns, especially with regard to compliance with environmental stewardship and advanced energy technologies. It was clear that, as with their original telecommunication designs and equipment, success with the IFH-1710 would require strict adherence to the industry's most demanding specifications.

With clear guidelines for designing and manufacturing a light build to surpass the industry's own

standards, the engineering design team set the bar high. They concluded that the ultimate design of the new IFH-1710 must:

- Be highly *energy efficient*;
- Use *sustainable materials and advanced technology*;
- Be *rugged* enough to endure harsh environmental conditions;
- Be *compact* enough for the limited space available on a wind turbine nacelle; and
- Be *flexible* enough to meet the needs and individual requirements of different customers.

What follows is an overview of the criteria that figured heavily in every stage of the design process and how ITL's design team addressed each engineering challenge.

FAA REQUIREMENTS

In tackling regulatory compliance, the team began with the requirements specific to wind turbine farms that may be found in chapter 13 of FAA Advisory Circular AC 70/7460-1K available at www.faa.gov. The FAA defines a wind turbine farm as "*wind turbine development that contains more than three (3) turbines of heights over 200 feet above ground level.*" Not every wind turbine within a farm is required to be lit. The FAA requires unlit gaps of no more than ½ statue mile. FAA Type L-864 red flashing lights are preferred for night-time marking and all lights are required to flash synchronously.

Detailed technical specifications for the L-864 lighting system can found in the FAA Advisory Circulars and Engineering in table 1.

The FAA clearly states that the type L-864 red flashing lighting system is preferred for wind turbine farms, so this made the decision clearly in favor of designing the IFH-1710 as an L-864 that would flash synchronously. To avoid costly cabling between lights, the team elected to use the timing signals derived from the Global Positioning System for flash synchronization. However, further investigation revealed that not all GPS receivers are created equal. Thorough testing of several models resulted in significant differences in the speed and ability to receive the required timing signals under varying environmental conditions. Based on test results, ITL's design team favored use of a one-piece GPS receiver manufactured by Garmin that was found to be extremely fast and reliable at achieving a satellite fix. It was also compact enough to fit inside the cover of the IFH-1710 lighting system.

LED TECHNOLOGY AND OPTICS

Due to their ability to efficiently produce light, LEDs are finding their way into everything from flashlights to street lights. Choosing high power LED technology was one of the design team's easiest choices. However, the companies that manufacture LEDs generally design them to disperse light over a wide area. The light beam of a high power LED can be as wide as 120 degrees. FAA requirement for obstruction lighting systems require a vertical beam of only 3 degrees and heavily restrict the amount of light allowed past 10 degrees below horizontal.

Early on, ITL recognized that an efficient secondary optic would be required to tame the wide LED light beam into the tight "disc of light" re-

quired for a wind turbine obstruction lighting system. So, the IFH-1710 includes custom-designed and molded optical grade PMMA (Acrylic) precision optics coupled with high power LEDs to meet these challenging requirements.

THERMAL DESIGN

The power dissipated by an LED, usually only about 1 watt, may sound quite low. However, this power is packed into a very small space. The light emitting area of an LED, called the die, can be as small as 1mm square. 1mm is about the diameter of the wire used to make a large paperclip. Even a small amount of power in such a small space leads to high power density. If great care is not taken to remove heat from the LED die the temperature will rise. High temperature adversely affects LED life and efficiency, so an effective thermal design is critical to the success of an LED lighting system.

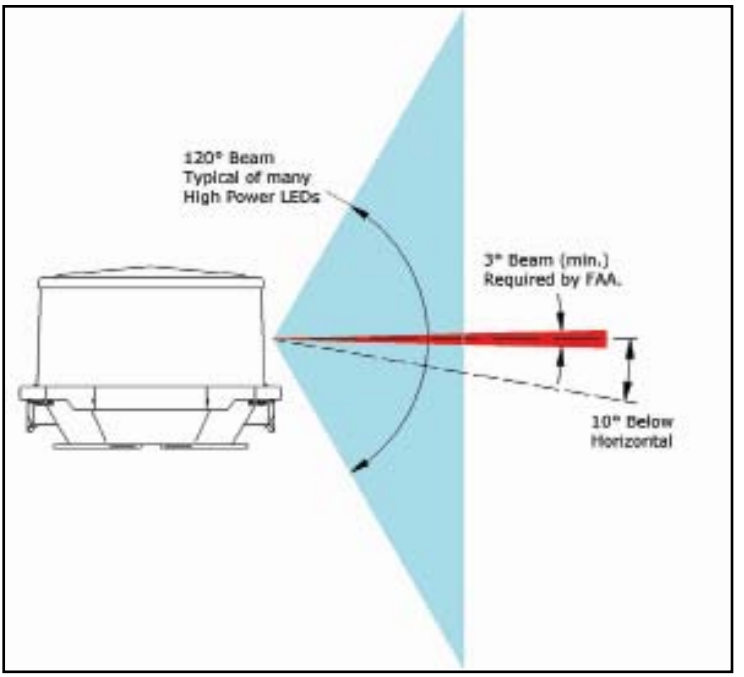

Figure 1: LED beam detail

Traditionally, electronic components like LEDs have been mounted to printed circuit boards, which have a copper layer and fiberglass substrate. Fiberglass is a thermal insulator and therefore, is

FAA Advisory Circulars & Engineering Briefs	
AC 70/7460-1K	Obstruction Marking and Lighting
AC 150/5345-43F	Specification for Obstruction Lighting Equipment
AC 150/5345-53C	Airport Lighting Equipment Certification Program
EB 67D	Light Sources other than Incandescent and Xenon for Airport and Obstruction Lighting Fixtures

Table 1

not well suited for most high power LED designs. Metal clad printed circuit boards (MCPCBs) replace the fiberglass substrate with an aluminum plate. The copper layer is separated from the aluminum by a thermally conductive yet electrically insulating dielectric layer. The resulting metal clad printed circuit board is highly effective at removing heat from the LED.

For their IFH-1710 design, ITL chose metal clad printed circuit boards and mounted them to an aluminum heat sink to efficiently conduct heat away from the LEDs. A rugged cast aluminum base then conducts the heat out of the lighting system.

POWER SUPPLY

The light output of an LED is primarily determined by the DC current flowing through it. So to achieve constant light output, conversion from AC power into a DC current would be necessary.

The two main types of power supplies are the linear power supply and the switching power supply. The linear power supply is simple and rugged but dissipates excess power as heat. This is both inefficient and detrimental to the life of LEDs. Switching power supplies were specifically developed to minimize the production of unnecessary heat and can also be designed to accept a wide range of AC voltage and frequency. This flexibility makes them usable worldwide without modification. These characteristics make the switching power supply an ideal solution for driving LEDs. In the IFH-1710, the switching power supply accepts 120 to 240Vac, 50

or 60Hz to power the LEDs while minimizing the production of excess heat.

SUSTAINABILITY

Aluminum accounts for over 60% of the weight of the IFH-1710. ITL's engineers chose aluminum because of its ability to conduct heat and its sustainable nature as one of the most highly recycled metals in the United States. However, sustainability does not just mean using highly recycled materials and an energy efficient design. Sustainability also encompasses "the capacity to endure." The IFH-1710 wind turbine obstruction light would need to endure.

Wind turbine obstruction lights are subject to extremes in weather, including heat, cold, wind, rain, and snow as well as other factors such as vibration and lightning. While ITL's design makes every effort to prevent failure, it would also need to be repairable. A dispose-of-upon-failure design would not be a sustainable one. To be truly sustainable, the IFH-1710 obstruction light would need to be field repairable. Thus, the design must include accessibility and modularity.

The resulting highly accessible features of the field-repairable design of the IFH-1710 include a hinged cover that uses rugged stainless steel draw latches to secure it when closed. The interior may then be accessed in seconds, while also remaining highly secure and protected from the elements when latched closed.

Further, modularity is achieved as all of the electronics including the controller, power supply, GPS and LED boards are included in a single replaceable assembly called the LED Light Engine. The LED Light Engine is assembled around a custom designed aluminum extrusion. LED circuit boards and optics are installed on the outside surfaces to direct light 360 degrees around. In the center of the light engine

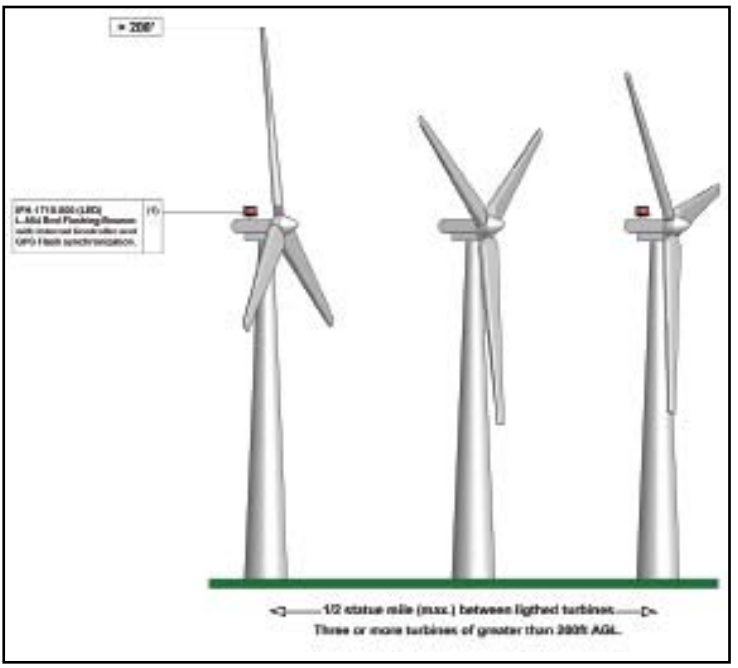

Figure 2: WindTurbine farm with IFH-1710

are two card slots that house the controller circuit board and power supply circuit board. A GPS and photocell for determining day/night operating mode are mounted on top of the light engine. The entire light engine assembly can be removed from the cast aluminum base for servicing by loosening only four fasteners. All of the light engine's components are replaceable.

INSTALLATION

The wind turbine obstruction lighting customer's objective is to produce clean and sustainable electricity from wind, not to provide a home for an obstruction light. With that in mind, ITL endeavored to minimize the size of its wind turbine obstruction light. The resulting design of the IFH-1710 is a complete obstruction lighting system contained within a compact flash head. What this means to the customer is that it requires virtually no space inside the nacelle.

To simplify installation, the IFH-1710 comes with a prewired cable for connecting power and Form-C alarm contacts. For a new wind farm, mounting the flash head and connecting the cable is all that is necessary. For existing wind farms, the IFH-1710 is designed to be flexible enough to match the flash rate of other manufacturer's lighting systems with only the flip of switch.

UNIQUE CIRCUMSTANCE; FRESH APPROACH

Obstruction lighting design is not a one system-fits-all-industries proposition. When venturing from telecommunications lighting systems to those for the wind turbine industry, International Tower Lighting, LLC recognized that the unique circumstances of the industry demanded a fresh design from the ground-up.

Using extensive engineering design expertise in the obstruction lighting field honed over the last twenty years, the company has now introduced its new wind turbine obstruction lighting system in the form of the IFH-1710, addressing exacting standards for energy efficiency, sustainability and ease of installation.