WAGO: Designing for a Global Market

Interview with Jim Bachle – WAGO Industry Manager, Lighting Market

Residential LEDs Feature-Rich, Efficient, and Economic

Lighting Options for Shops and Garages
EEWeb | Lighting Electronics

EDITORIAL STAFF

Content Editor
Karissa Manske
kmanske@aspencore.com

Digital Content Manager
Heather Hamilton
hhamilton@aspencore.com

Global Creative Director
Nicolas Perner
nperner@aspencore.com

Graphic Designer
Carol Smiley
csmiley@aspencore.com

Audience Development
Claire Hellar
chellar@aspencore.com

Register at EEWeb
http://www.eeweb.com/register/

Published by
AspenCore
950 West Bannock
Suite 450
Boise, Idaho 83702
Tel | 208-639-6464

Victor Alejandro Gao
General Manager
Executive Publisher

Cody Miller
Global Media Director
Group Publisher

PRODUCT WATCH
4
Okaya's LED Light Bars
6
Okaya Surge Protective Device Protection

EEWEB FEATURE
10
Residential LEDs
Feature-Rich, Efficient, and Economic
16
Lighting Options for Shops and Garages

INDUSTRY INTERVIEW
20
WAGO: Designing for a Global Platform
Interview with Jim Bachle, WAGO Industry Manager, Lighting Market

Register at EEWeb
http://www.eeweb.com/register/
Okaya’s

LED Light Bars

Okaya’s LEDs are very different from cheaper LED strips found in many places on the internet. They are available in a wide variety, with LEDs in either twelve or twenty-four volts. Custom lengths between six inches up to seventy-nine units as one single unit are also available. These single units are in ruggedized housings that are also available in IP67 versions, meaning that they are completely protected from dust and also able to withstand water immersion up to one meter for thirty minutes, allowing the LEDs to be used outside without fear of weather caused problems. Adding the ability to wire these either in serial or parallel and with or without connectors, these light bars are incredibly flexible in their usage.

One problem that many people find with LEDs is that they are very direct and you can see every individual light in a strip or even in some of the LED bulbs. To fix this problem, Okaya uses high quality diffusers as well as LEDs with a wide, 120-degree viewing angle. This one-two combination provides consistent and even lighting.

Okaya LED strips have short lead times, between six to eight weeks after receipt of order, though contract blankets can shorten that even further. The flexibility provided by Okaya means that these light bars would work well in a variety of applications such as cabinets, channel lighting, sign backlighting, and even car decorations. To learn more about Okaya’s light bars, go to www.okaya.com or call them directly at 219-477-4488.

In this video, EEWeb engineer Josh Bishop features Okaya’s LED light bars, which were sent in a variety of color options: whites, warm or cool, red, green, blue, and an RGB strip. The RGB strip is particularly interesting as it is able to seamlessly transition between different colors and brightness. All options can be quickly cycled through with the use of a remote control.

Okaya uses high quality diffusers as well as LEDs with a wide, 120-degree viewing angle.
Okaya Electric is a world class developer and manufacturer of surge protection devices designed to protect all types of electronics from surges and spikes on power lines, primarily those caused by lightning. Lightning can affect equipment in a variety of ways through power lines, telephones and antennas. And without protection, these strikes induce voltages and currents that can damage or destroy equipment. To protect from lightning, surge protective devices (SPDs), can be incorporated into electronics to act as shunts, diverting harmful current away while also limiting transient overvoltages. SPDs function by creating a temporary path to ground when it detects voltages above permissible levels. During the normal operation of the SPDs, they act as opens between the device being protected and ground, having no effect on their typical performance.

Okaya's SPDs can be used for any device needing protection from surges. Okaya has developed the RGF10-152-Q4, with improvements and regulatory approvals particularly suited for outdoor LED luminaires. LED lighting is becoming more popular despite its higher cost due to high efficiencies and extremely long lifespan. However, if this lifespan is significantly reduced due to lightning strikes, any benefits are immediately lost. The RGF10 limits the incoming line voltage differential to 300 volts RMS and can withstand up to 1.5 kilovolts and 10,000 amps. Any surges or spikes above these levels may result in the destruction of the SPD, but the protected device will not be damaged, meaning that the inexpensive SPD will have to be replaced but the expensive electronics will be unharmed and fully functional.

Okaya's SPDs will give you the confidence you need by protecting your electronics from harm. To learn more information about Okaya's full line of surge protection devices and the RGF10-152-Q4, please visit Okaya.com or call them directly at 219-477-4488.

There are different types of surge protection devices — for protection on a component level, surge protective device components are available in the RA glass series, the RHCA ceramic SMD series, the GDT ceramic leaded series, and the RSSA semiconductor series — all designed to be integrated at the circuit level of a device. The system level SPDs are designed to be integrated at the point of entry for power lines or for telecommunication lines and are easy to use for those situations where changing the design of the device under protection is not feasible or reasonable.

There are different types of surge protection devices — for protection on a component level, surge protective device components are available in the RA glass series, the RHCA ceramic SMD series, the GDT ceramic leaded series, and the RSSA semiconductor series — all designed to be integrated at the circuit level of a device. The system level SPDs are designed to be integrated at the point of entry for power lines or for telecommunication lines and are easy to use for those situations where changing the design of the device under protection is not feasible or reasonable.

Okaya Electric is a world class developer and manufacturer of surge protection devices designed to protect all types of electronics from surges and spikes on power lines, primarily those caused by lightning. Lightning can affect equipment in a variety of ways through power lines, telephones and antennas. And without protection, these strikes induce voltages and currents that can damage or destroy equipment. To protect from lightning, surge protective devices (SPDs), can be incorporated into electronics to act as shunts, diverting harmful current away while also limiting transient overvoltages. SPDs function by creating a temporary path to ground when it detects voltages above permissible levels. During the normal operation of the SPDs, they act as opens between the device being protected and ground, having no effect on their typical performance.

Okaya Electric is a world class developer and manufacturer of surge protection devices designed to protect all types of electronics from surges and spikes on power lines, primarily those caused by lightning. Lightning can affect equipment in a variety of ways through power lines, telephones and antennas. And without protection, these strikes induce voltages and currents that can damage or destroy equipment. To protect from lightning, surge protective devices (SPDs), can be incorporated into electronics to act as shunts, diverting harmful current away while also limiting transient overvoltages. SPDs function by creating a temporary path to ground when it detects voltages above permissible levels. During the normal operation of the SPDs, they act as opens between the device being protected and ground, having no effect on their typical performance.

Okaya Electric is a world class developer and manufacturer of surge protection devices designed to protect all types of electronics from surges and spikes on power lines, primarily those caused by lightning. Lightning can affect equipment in a variety of ways through power lines, telephones and antennas. And without protection, these strikes induce voltages and currents that can damage or destroy equipment. To protect from lightning, surge protective devices (SPDs), can be incorporated into electronics to act as shunts, diverting harmful current away while also limiting transient overvoltages. SPDs function by creating a temporary path to ground when it detects voltages above permissible levels. During the normal operation of the SPDs, they act as opens between the device being protected and ground, having no effect on their typical performance.

Okaya Electric is a world class developer and manufacturer of surge protection devices designed to protect all types of electronics from surges and spikes on power lines, primarily those caused by lightning. Lightning can affect equipment in a variety of ways through power lines, telephones and antennas. And without protection, these strikes induce voltages and currents that can damage or destroy equipment. To protect from lightning, surge protective devices (SPDs), can be incorporated into electronics to act as shunts, diverting harmful current away while also limiting transient overvoltages. SPDs function by creating a temporary path to ground when it detects voltages above permissible levels. During the normal operation of the SPDs, they act as opens between the device being protected and ground, having no effect on their typical performance.

Okaya Electric is a world class developer and manufacturer of surge protection devices designed to protect all types of electronics from surges and spikes on power lines, primarily those caused by lightning. Lightning can affect equipment in a variety of ways through power lines, telephones and antennas. And without protection, these strikes induce voltages and currents that can damage or destroy equipment. To protect from lightning, surge protective devices (SPDs), can be incorporated into electronics to act as shunts, diverting harmful current away while also limiting transient overvoltages. SPDs function by creating a temporary path to ground when it detects voltages above permissible levels. During the normal operation of the SPDs, they act as opens between the device being protected and ground, having no effect on their typical performance.

Okaya Electric is a world class developer and manufacturer of surge protection devices designed to protect all types of electronics from surges and spikes on power lines, primarily those caused by lightning. Lightning can affect equipment in a variety of ways through power lines, telephones and antennas. And without protection, these strikes induce voltages and currents that can damage or destroy equipment. To protect from lightning, surge protective devices (SPDs), can be incorporated into electronics to act as shunts, diverting harmful current away while also limiting transient overvoltages. SPDs function by creating a temporary path to ground when it detects voltages above permissible levels. During the normal operation of the SPDs, they act as opens between the device being protected and ground, having no effect on their typical performance.

Okaya Electric is a world class developer and manufacturer of surge protection devices designed to protect all types of electronics from surges and spikes on power lines, primarily those caused by lightning. Lightning can affect equipment in a variety of ways through power lines, telephones and antennas. And without protection, these strikes induce voltages and currents that can damage or destroy equipment. To protect from lightning, surge protective devices (SPDs), can be incorporated into electronics to act as shunts, diverting harmful current away while also limiting transient overvoltages. SPDs function by creating a temporary path to ground when it detects voltages above permissible levels. During the normal operation of the SPDs, they act as opens between the device being protected and ground, having no effect on their typical performance.

Okaya Electric is a world class developer and manufacturer of surge protection devices designed to protect all types of electronics from surges and spikes on power lines, primarily those caused by lightning. Lightning can affect equipment in a variety of ways through power lines, telephones and antennas. And without protection, these strikes induce voltages and currents that can damage or destroy equipment. To protect from lightning, surge protective devices (SPDs), can be incorporated into electronics to act as shunts, diverting harmful current away while also limiting transient overvoltages. SPDs function by creating a temporary path to ground when it detects voltages above permissible levels. During the normal operation of the SPDs, they act as opens between the device being protected and ground, having no effect on their typical performance.
Residential LEDs

Feature-Rich, Efficient, and Economic

by Josh Bishop

Twenty years ago, the idea of lighting your house entirely with LEDs was laughable. Ten years ago, the idea of lighting your house entirely with LEDs was for those who couldn't figure out a better way to spend all their money. Now, residential LED lighting is not only affordable, it's the best option available in nearly every circumstance.
Lighting Electronics

Power supplies, changing the incoming electricity to a form that works for these technologies. While this may be beneficial in some ways, CFLs and their long, tubular counterparts suffer even more from flicker due to the ballasts they use. This has been significantly reduced in recent years as the magnetic ballasts have changed to electronic ballasts and electronic ballasts have also improved, however, when tube fluorescents are changed, their ballasts are rarely upgraded, meaning that new lights are frequently being powered by ancient ballasts.

LEDs, however, rarely flicker, except when being used in conjunction with a low quality or incompatible dimmer. As well as not flickering, there is no warm-up period before reaching full brightness like even the newest fluorescents. Being solid state, they also work at an extremely wide range of temperatures. Older magnetic ballasts frequently have minimum temperatures well above freezing and even the newest standard ballasts and lights have a significantly smaller temperature range than the standard LED bulbs. So, LEDs not only provide more consistent light, they produce full light immediately and without being affected by temperature.

Environmentally, LEDs are much more eco-friendly than their competitors, as they’re mercury free, have ridiculously long lifespans, meaning less waste, and are generally tougher than both incandescents and fluorescents, meaning less broken bulbs to throw out. While the life and quality of LEDs can vary dramatically depending on the manufacturer, even the least expensive LEDs have quadruple the lifespan of an incandescent, where the higher quality LEDs have over ten times the lifespan. Due to their lack of mercury, when the time eventually comes to dispose of these LEDs, they’ll leach fewer toxins into the environment.

As with all things in life, there are drawbacks. Some LED bulbs do not have very diffused light; the individual LEDs within the bulb are clearly visible. This issue is quickly being resolved with many bulbs already producing completely diffused light; however, there do remain some bulbs that still have this problem. LED strips are obviously even more prone to this issue as the strips separate each LED source into a bright pinpoint of light. For these, diffusers are available.

You can now find LEDs that act like a traditional incandescent while dimming as well, becoming even warmer as the light is dimmed, creating a great ambiance. You can now find LEDs that act like a traditional incandescent while dimming as well, becoming even warmer as the light is dimmed, creating a great ambiance. You can now find LEDs that act like a traditional incandescent while dimming as well, becoming even warmer as the light is dimmed, creating a great ambiance. You can now find LEDs that act like a traditional incandescent while dimming as well, becoming even warmer as the light is dimmed, creating a great ambiance.
though they can be expensive. In these scenarios, LED strips are ideal for indirect lighting or lighting where the effect can be seen but not the source itself.

Under cabinet lighting is becoming increasingly popular and there are many opportunities to do valance type lighting. In a bit of an ironic twist, heating can also be an issue with LEDs. Although they produce significantly less heat than incandescents, they’re also much more sensitive to extreme heat. If bulbs are placed facing down, the heat from the LED rises up into the electronics located in the base, potentially frying them. This is also a problem that the industry has been working feverishly to reduce and is, again, not a problem with many of the bulbs today but may be a problem with the larger bulbs. All other angles seem to have absolutely no problems with the heat given off by the LEDs.

With the way the prices have dropped over the last couple years, and the many benefits of LED bulbs, the situations in which LED lights would not be the ideal solution are very few and far between. There’s no need to rush out and replace every bulb and lighting fixture in the house immediately, but as older bulbs burn out, the best bet is to replace them with LED bulbs and then not worry about them for a couple more decades.
ARE YOU CONSIDERING ADDING LIGHTING TO a new shop or updating or replacing the existing lighting in your current garage? If so, then you have five competing lighting technologies to choose from. All five technologies are listed below but this article will focus on fluorescent tube lighting.

Lighting Options for Shops and Garages

by Nick Davis
Common Lighting Technologies (in alphabetical order):

- Fluorescent
- CFL (Compact Fluorescent Lamp)
- Tube lighting
- Halogen
- HID (High-Intensity Discharge)
- Incandescent
- LED (Light Emitting Diode)
  - Light bulb type
  - Tube type

The most common fluorescent lighting technology is the fluorescent tube. Fluorescent tubes are available in a variety of sizes with the most popular being T12, T8, and T5. In this nomenclature, "T" represents “tube” while the number represents the diameter of the tube as measured in eighths of an inch. For example, T5 means tube type with a diameter of 5/8 eighths of an inch.

During your research on lighting options, you should keep an eye out for the following three specs:

1. Lumens

This simply means the “brightness” of the light source. This may be a little confusing, but just remember that as pounds are to bananas and gallons are to milk, lumens are to light. For a comparison of Watts (W) vs. lumens, or to replace an incandescent bulb, see the examples below:

- 100W incandescent bulb, look for 1600 lumens
- 75W incandescent bulb, look for 1100 lumens
- 60W incandescent bulb, look for 800 lumens
- 40W incandescent bulb, look for 450 lumens

When most people hear the phrase “fluorescent lighting” they typically think of fluorescent tube lighting, and more specifically, T12 tube lighting. T12 fluorescent tubes, which are 1.5 inches in diameter, have been widely used in the past for lighting schoolrooms, office work areas, and garages and shops. These types of fluorescent lights are usually accompanied with two complaints: one being that they flicker and/or hum, and the other is that they don’t work in the cold.

Fact—the tubes themselves are not responsible for these flaws, but rather the ballast is the guilty component. A fluorescent ballast is required for any type of fluorescent light to work, including CFLs. In layman’s terms, the ballast increases the voltage across the fluorescent tube, which in turn allows the electrical current to flow thru the mercury vapor contained within the tube. Ballasts are available in two types: magnetic and electronic. Magnetic ballasts have been used for decades, and, due to their magnetic technology, are responsible for the humming and flickering of fluorescent tubes as well as their inability to work in cold conditions. Electronic ballasts have been used for decades, and, due to their magnetic technology, are responsible for the humming and flickering of fluorescent tubes as well as their inability to work in cold conditions. Electronic ballasts are able to provide excellent lighting (free of humming and flickering) with a typical starting temperature down to 0F (-18C); some higher-end electronic ballasts have a minimum starting temperature of -20F (-29C).

Using an electronic ballast along with T5HO (HO stands for High Output) fluorescent tubes is a great choice for garages and shops. This combination will provide you with years of high quality lighting, free of humming and flickering, capable of operating in low temperature conditions. T5HO tubes are available with a CRI rating of 85% (i.e., excellent color accuracy), come in a variety of lighting colors ranging from 3000K to 6500K, produce 450+ lumens (for the 4-foot length types), and can last up to 40,000 hours (4.5 years).

Although choosing an electronic ballast with T5HO tubes as your lighting solution may prove to be a bit more expensive than using incandescent, LED lighting, or CFL lighting, you won’t be disappointed in the brightness, quality, and longevity that this lighting solution will provide.
WAGO: Designing for a Global Market

Interview with Jim Bachle, WAGO Industry Manager – Lighting Market

As commerce within the lighting electronics world strives to design for a global economy, WAGO utilizes their long-standing reputation to meet demands while manufacturing in accordance with differing bodies of certification. EEWeb met up with Jim Bachle, WAGO’s Lighting Market Industry Manager, to discuss where the lighting industry has been, how it is changing, and how WAGO rises to the challenge of a growing marketplace with quality products.
Give us a bit of your background. How did you come to WAGO and what are you doing now?

I have been involved in the electrical industry since 1975. My background is in power distribution, automation and motor controls, with extensive experience with companies such as Westinghouse, Rockwell, and the like.

I joined WAGO twenty years ago as a Regional Sales Manager, moving through the ranks to become Western Zone Manager, then Product Manager for our line of interconnect products from 2000 to 2007. It was toward the end of my stint as Product Manager when WAGO developed a new series of components specifically for the lighting industry. When the opportunity came up to become Industry Manager, I was just crazy enough to raise my hand and go for it.

How do connectors or interconnects for lighting differ from the other market segments WAGO is involved with?

The lighting market really deals with a very specific set of products that have their home within the industry. We see some of our lighting-related products used on the contracting end, but that is from an installation standpoint. It’s an area we started getting involved with as an organization back in 1974, when we introduced our first lighting-related products.

As lighting has become more interesting and has moved from simple sockets, what are some of the challenges your customers face and how does that push them within the market?

It’s an exciting time to be in the industry and I think all companies and their customers share in the challenges that arise. As the technology changes and the race to the bottom from a pricing standpoint continues, we’re all challenged with trying to develop a product (in this case, specifically in solid-state lighting) that will provide the length of service anticipated by the market at an affordable price. This high level of quality comes in an ever-evolving, small package. In many instances, as our components shrink we’re altering the way we mount our products. We haven’t had to deal with surface mount technology prior to 2008 and now it’s very prevalent.

Lighting in North America versus markets in other countries varies. How do you see these variations affecting what WAGO does?

I just came back from the Light and Building Exposition in Frankfurt, Germany. Prior to the show, we had an internal meeting with all of WAGO’s global lighting managers. We compared notes as far as where we felt our individual markets were headed and how we could wrestle for the research and development money that is available.

I feel that in North America we’re more advanced in many ways. I look at our market and we’re doing things that are just beginning to hit other country’s companies. WAGO designs products for the global market. So really, our products get utilized everywhere in the world. That’s one thing we tout: what we incorporate into finished products in North America can be delivered and accepted in Europe or Asia—anywhere in the world. The differences are more from an installation practices standpoint than a fixture manufacturing standpoint.

You mentioned some things you’re doing here in North America are more advanced. What are the main differences you see between markets?

We’re hearing an awful lot of conversation about OLEDs and that’s an area in which we’re leading. Even Home Depot is selling OLED fixtures. That’s something that we haven’t seen an awful lot of anywhere else in the world. The OLED technology is becoming more and more embraced as the efficacy improves and they’re becoming much more than a glowing piece of artwork. At this point, it’s still a novelty in many other countries. We’re seeing some installations and research and development in Europe, but we’re not seeing the commercial use of OLED products.

When you mention acceptance, are there standards that differ from country to country or region to region? How do you address these differences?

We do design to a global standard and because of that, we look at the individual requirements of each country’s certification bodies, the NRTLs—the CSAs / ULs / IECs of the world. We look at things such as pull-out, temperature rise and voltage drop, and consider each one in the worst case. This is where we set our design platform. We certify each individual component to all of the existing major standards worldwide so when it’s implemented into a fixture it has the appropriate certification in place.

How are you able to stay cost competitive while handling all of the certifications versus another company who solely designs for one region?

It’s an area that is becoming increasingly difficult because we have a lot of competition designing only to a certain platform. And some of them are, quite frankly, very relaxed. The good news from our perspective is that the globe is shrinking.

We certify each individual component to all of the existing major standards worldwide so when it’s implemented into a fixture it has the appropriate certification in place.
The boundaries are coming down as we grow toward a one-world economy. Our customers are shipping within that single economy, so they’re looking for products that are accepted on the worldwide basis. We manufacture our products in Switzerland and Germany and apply a high level of automation to keep us very cost-effective while eliminating or minimizing direct labor costs. The result is a component that provides a very high level of quality while ensuring maximum efficiency in our manufacturing.

What is going on in the lighting industry right now that’s either exciting or challenging that WAGO is working on?

We have a tremendous amount of products in development constantly. The growth curve has been a geometric progression in the last seven or eight years, especially in North America. The acceptance of our products has been very widespread and we’re very pleased with the way our products have been accepted.

The biggest challenge, and this is true for all of us in the industry, is meeting the demands while trying to keep up with the changes in technology. This involves trying to stay ahead of the curve and anticipate what the market will want in the next six to eight months. It’s a moving target. There are no real hard and fast set standards and practices. I don’t want to call it the Wild West, but to a certain extent there are a lot of different opinions on how a specific application can be tackled. Our challenge is picking the winner, anticipating which direction the market will go, and knowing how to develop products that are going to fulfill the requirements of this ever-changing market. We’ve got end-product designs that are considered old when they’ve existed for a mere six months.

Prior to solid state lighting, there really weren’t an awful lot of changes or advances in fluorescent technology over the years. It’s something that had been manufactured since the 1940s. Things got exciting when we had ‘egg-crate’ diffusers or improved the efficiency of a ballast. I don’t want to over-simplify it, but the changes weren’t radical changes and they didn’t alter the manufacturing process or the appearance of the fixture per se. Now we’re seeing those advances coming at light-speed.

We really in the business of partnering with our manufacturing customers and developing products for them to fulfill their needs, making their products more accessible. We stand on our reputation. For years I’ve said we’re one of the best kept secrets in the market. Today, it’s in the lighting standpoint where we’ve become well recognized. This is because our products perform well, raising customer satisfaction. This knowledge base is of invaluable assistance when it comes to working with our customers. We’re not just supplying widgets and cutting our prices. We’re really in the business of partnering with our manufacturing customers and developing products for them to fulfill their needs, making their products more accessible. We stand on our reputation. For years I’ve said we’re one of the best kept secrets in the market. Today, it’s in the lighting standpoint where we’ve become well recognized. This is because our products perform well, raising customer satisfaction.

In closing, anything else you’d like to mention?

We’ve talked about the growth of the industry and we’re all comfortable with where it’s going. We’re looking at a 40% compounded annual growth rate on LED lighting over the next couple of years. There are new companies that are emerging and familiar customer companies that are continuing to reinvent themselves. Again, I think one of our biggest challenges is not only reaching those customer companies, but also helping them to better understand how we fit into their mold.

I’d like to close with a little piece of wisdom from Dr. Roland Haitz who said that, “...solid-state lighting is where the internet was in the 1980s. Just as we could not then have predicted what the internet is now, 30 years later, we cannot foresee all that light and lighting will become in the next decades. We know simply that it will be wondrous and beautiful.” There are so many things going on with connected lighting and the internet of things and controlling lighting and it is becoming a whole new industry that, quite frankly, was beyond what we could comprehend ten years ago. It’s a very exciting place to be. It has been said that Edison toiled late into the night by the light of a gas lamp, failing 10,000 times before perfecting the electric light. Today we are witnessing the dawn of the next revolution in our industry by the glow of Edison’s ingenuity. It is a source of great pride to have the industry embrace our products and recognize the value long associated with the WAGO brand as we progress through this transformation.
Sierra Circuits: A Complete PCB Resource

PLUS: The Ground Myth in Printed Circuits

MCU Wars: 32-bit MCU Comparison

Speed, Precision, Accuracy

How Keithley's test equipment is revolutionizing the industry

Cutting Edge SPICE Modeling

Let There Be LIGHT

New LED Filament Tower

MCU Wars: 32-bit MCU Comparison

Moving Towards a Clean Energy FUTURE

Hugo van Nispen, COO of DNV KEMA

Power Developer

Designing for Durability

Peter Kozakevicius, President and CEO of Astrodyn Corporation

How to GaN

MLCC VOLTAGE

Kohring

Printed Circuits

Sierra Circuits: A Complete PCB Resource

From Concept to Reality

Freescale and TI Embedded Modules

ARM Cortex Programming

Low-Power Design Techniques

View more EEWeb magazines—Click Here