

Visible Light Communication (VLC) and Its Future Prospective

Research Paper by Lee Chia Ching, Tan Ching Seong and Wong Hin Yong of Multimedia University and Mazlaini Yahya of TM Innovation Centre

Abstract—Visible light communication (VLC) technology has been gaining attention in both academia and industry recently. It is driven by the progress of light emitting diode (LED) technology for solid-state lighting (SSL). It has the potential of simultaneously using LEDs for illumination and wireless data transmission. The VLC technology is perceived as one of the alternatives for radio frequency (RF) wireless technology as it offers huge, unregulated, unlicensed bandwidth to cope with future demand of indoor wireless access to real-time bandwidth-intensive applications such as Voice over IP (VoIP), streaming video and music, and network attached storage (NAS) [1].

Introduction

The VLC system uses visible lights for data transmission, apart from its traditional role in indoor/outdoor lighting. The visible light is the form in which electromagnetic radiation with wavelength in a particular range is interpreted by the human brain which comprised visible spectrum covers wavelengths from 380 nm to 750 nm [2].

The VLC was pioneered in Japan, and there is now growing interest worldwide. Since 2003 the Visible Light Communication Consortium (VLCC) is established between major Japanese companies to develop, plan, research and standardise Japan's own visible light communication systems. Their targets are to develop, test, investigate, plan and standardise ubiquitous high-speed biologically-friendly VLC LED systems. The VLCC played a key role in specifying the two JEITA standards which are JEITA CP-1221 and JEITA CP-1222. In 2007, the VLCC proposed two standards which they called Visible Light Communication System Standard and Visible Light ID System Standard [3].

The incorporation of VLC components into everyday technology is being investigated by a number of universities, corporations and organisations worldwide which are Casio, Eurescom, France Telecom, NEC Corporation, Orange, Panasonic, Samsung, Sharp, Siemens AG, Telefonica, Toshiba, Università di Roma, Universität Dortmund, Universität Ilmenau, University of Athens, University of California, and the University of Oxford [3].

Casio releases its Picapi Camera iPhone application which claims to be the world's first application of augmented reality to use visible light communication technology [4]. Casio is using flashing dots (red, green, blue) from a display, or even flashing coloured lights to convey small amounts of data (8 bits) which are received via the camera and then translated into codes relating to specific information content. Next, Siemens announced VLC has reached a new record in wireless data transfer speeds, beating the previous speed by a factor of 2.5. Together with the Heinrich Hertz Institute, the company was able to achieve a speed of 500Mbps thanks to white Ostar LED light produced by Osram, a Siemens subsidiary. It can transfer data over a distance of 16.4 feet. VLC technology has been gaining attention lately as shown in Table 1 below.

Year	Organisation involved	VLC Event
2010	Siemens and Heinrich Hertz	Develop VLC system with data transmission of 500Mbps
2009	VLCC and IrDA	Issue specification standards for VLC
2008	EU-funded OMEGA project	Develop global standards of VLC for home network
2007	NEC	Develop a LED-backlit LCD television operated while transmit information to PDA

Table 1: VLC development timeline since 2007

Wireless Communication Technology

For future demand, wireless broadband transmission system is needed. Compare to radio frequency (RF) and Infrared (IR), these wireless communication technologies hardly achieve it. For VLC, it can achieve high data rates. Among the active researchers, Professor Harald Haas' current research focuses on optical wireless communications proposed parallelizing communication in VLC by using complex modulation, Orthogonal Frequency Modulation (OFDM) to increase data transmission. He published the first proof-of-concept results demonstrating that it is possible to exploit the high crest factor of OFDM to turn commercially available light emitting diode (LED) light bulbs into broadband wireless transmission systems [5].

Table 2 summarises the strengths and weaknesses of the VLC system compared to IR and RF system. The VLC offers the potential for the alternative besides high data rates. The main reasons are as follows [6]:

- LEDs are currently penetrating many areas of our everyday life. They are envisaged to replace high energy consuming light bulbs in private and business homes, and even in outdoor lighting. Moreover, they can be used in headlights of planes and trains, front and back lights in cars and trains, and for object illumination in museums, etc.
- Bandwidth is not limited.
- Existing local powerline infrastructure can potentially be utilised.
- Transmitters and receivers devices are cheap, and there is no need for expensive RF units.
- As light waves do not penetrate opaque objects, they cannot be eavesdropped. It is very difficult for an intruder to (covertly) pick up the signal from outside the room.
- Visible light radiations are undoubtedly free of any health concerns. Therefore, these systems will receive acceptance for use in hospitals, private homes, etc.
- No interference with RF based systems exists, so that the use in airplanes as well as in oil & gas venue are uncritical.

Wireless	Data rate	Strengths	Weaknesses
RF	150Mbps	1. Waves penetrate opaque object 2. Truly ubiquitous	1. Interference 2. Lack of security 3. Limited band-width 4. Health concerned
IR	1Gbps	1. Cheap	1. Visual safety lower data rate due to low emission
VLC	1Gbps	1. Lowest cost, using illumination devices 2. Free of health concern 3. High data rate and bandwidth	1. Providing uplink 2. Interfered by high intensity light

Table 2: Comparison between RF, IR and VLC



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Visible Light Technology

The VLC technology is driven by LEDs light because it is the strong candidate for future illumination devices. It has greater efficiency and longer lifetime. LEDs last for 100,000 hours, an efficiency rating of 30% and as an added benefit, LEDs do not contain mercury, a hazardous material that is hard to be recycled in the current illumination industries [7]. Researchers estimate that, because of their energy efficiency, a worldwide switch to LEDs would enable the closure of 560 power plants and result in annual CO₂ savings equivalent to the output of all the cars on the planet [7].

At present incandescent and fluorescent lamps are the predominant sources of artificial-lighting. The average incandescent lasts on average 1,000 hours. It loses much of their energy as heat, just 5% of the energy they consume is converted to light [7]. To reduce energy wastage, incandescent units are being phased out under a strong drive by many governments worldwide.

The immediate advantages of fluorescent bulbs over incandescent are operating life and energy efficiency. Fluorescent bulbs last for 10,000 hours, convert from 20% to 25% of their energy to light [7]. A disadvantage of fluorescents bulbs, however, is that they require mercury vapor to work efficiently. While this doesn't make them unsafe to operate, the bulbs cannot be disposed of with regular household garbage due to the toxicity of the mercury. Also, there is a potential health risk if a bulb breaks.

Furthermore, LED offers many advantages besides energy efficiency and operating lifetime as shown in Table 3.

	LED	Incandescent bulbs	Fluorescent lights
Electricity used	6-8Watts	60 Watts	13-15Watts
Contain mercury	No	No	Yes
RoHS Compliant	Yes	Yes	No
CO ₂ emissions	451pounds/year	4500pounds/year	1051pounds/year
Sensitive to humidity	None	Some	Yes
Turns on instantly	Yes	Yes	No
On/Off cycling effect	None	Some	Yes
Fragility	Durable	Not Durable	Not Durable
Heat emitted	3.4 btu's/hour	85 btu's/hour	30 btu's/hour
Failure Modes	Not typical	Some	Yes

Table 3: Comparison between LEDs, incandescent bulbs and fluorescent lights.

Characteristics of LED

For the illumination equipment, white lighting would be the general lighting used indoor. There are two primary ways of producing white light-emitting diodes, LEDs that generate high-intensity white light. One is to use individual LEDs that emit three primary colours - red, green, and blue - and then mix all the colours to form white light which is the RGB LED. The other is phosphor based LEDs which use a phosphor material to convert monochromatic light from a blue or UV LED to broad-spectrum white light, much in the same way a fluorescent light bulb works.

RGB LED needs electronic circuits to control the blending and diffusion of different colors, and because the individual colour LEDs typically have slightly different emission patterns (leading to variation of the colour depending on direction) even if they are made as a single unit, these are seldom used to produce white lighting [8].

Technology	Advantages	Disadvantages
Phosphor conversion	• Most mature technology • High-volume manufacturing processes • Relatively high luminous flux • Relatively high efficacy • Comparatively lower cost	• High Correlated Colour Temperature (cool/blue appearance) • Warmer Correlated Colour Temperature may be less available or more expensive • May have colour variability in beam
RGB	• Colour flexibility, both in multicolor displays and different shades of white	• Individual coloured LEDs respond differently to drive current, operating temperature, dimming, and operating time • Controls needed for colour consistency add expense • Often have low Colour Rendering Index score, in spite of good colour rendering

Table 4: Comparison between phosphor conversion LED and RGB LED.

Phosphor-based white LEDs involve coating LEDs of one colour with phosphor of different colours to form white light.

The phosphor conversion approach is most commonly based on a blue LED. When combined with a yellow phosphor (usually cerium-doped yttrium aluminum garnet or YAG:Ce), the light will appear white to the human eye [8].

CONCLUSION

VLC technology will be employed in the coming future, as the design of LED light technology become more mature. With different substrates of LED, it will be provided with better heat dissipation. Brightness of LED could improve accordingly and lesser amount of LED will need to employ in the room. Thus VLC technology costs lesser and consumes less energy. The future would be brighter and greener with LEDs.

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Energy Case Study

Objective

This energy saving case study is aimed at sharing an energy efficiency best practice with engineering practitioners.

Client

A car assembly plant in Shah Alam, Selangor. Its major processes include car body anti-rust, welding, painting, assembly and waste water treatment. Operate one shift per day and six days a week.

Challenges

The client incurs high electricity costs.

Solutions

An energy audit was performed by external energy manager. The client decided to reduce high capital expenditure and had set rigorous saving target. Therefore the energy audit focused mainly on low cost technical change and improvement in operating practices.

Processes leading to results:

Question 1: Why does the air compressor keep running over night?

Answer 1: The paint shop uses air driven motor to stir the paint for 24 hours. The electric motor is a fire hazard and therefore is not suitable for paint application.

Question 2: Why does the desiccant air dryer keep purging over night in the assembly area?

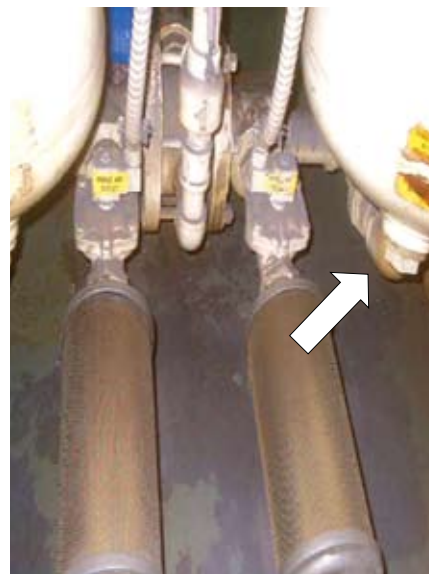
Answer 2: ahh..ahh..



Desiccant air dryer keeps purging over night

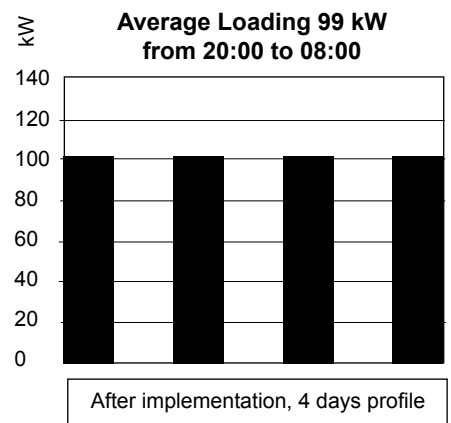
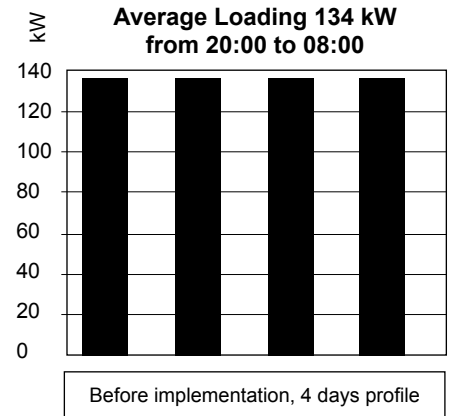


Car assembly plant.



Use part of the dry compressed air coming from the other vessel to dry the desiccant in the vessel then purge out.

Results



Investment

RM3,500 for zone control and time control.

Isolate the main air pipe to the assembly area by actuator valve & time control from 8pm to 8am.

This helps to reduce the air compressor loading from 134kW (paint shop + purging) to 99kW (paint shop only).

Direct savings achieved

RM18,000 per annum on electricity costs.

Payback period

3 months.

This case study is presented by
Ir Chin Kuan Hwa, P Eng, MIEM.
He is a Green Building Index facilitator and
is a Registered Energy Manager with Energy
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Earth Ground Resistance Measurement

Earth ground resistance testing is essential for not only safety reasons but also to achieve proper equipment performance. Safety issues include the risk of electrocution, fire, and lightning strike related hazards. Equipment performance issues due to poor earthing can be difficult to analyse, underlying the importance of testing new and existing installations carefully. Telecommunications equipment performance can be adversely affected and harmonic distortion issues may cause random effects such as RCD tripping and cable overheating.

Accurate earth testing instruments are essential, given that an apparently minor difference in the earth path resistance can be devastating when a large fault current is encountered, such as with a substantial power surge. A ten fold increase in the earth path resistance e.g. from 5 ohms to 50 ohms may not appear significant when measured with a basic instrument. However it could result in the metal frame of industrial equipment developing a lethal 100 volts potential instead of a nominal 10 volts. The earth current may also find an unintended lower resistance path that will result in extensive equipment damage.

Earth ground systems rely on a buried earth electrode or a grid system. The latter will often be found with telecommunications systems and utility or industrial installations where the expected fault current can be very high. Earth ground testers are required to test all types of earthing systems and these will use an AC voltage signal to avoid errors caused by DC electrolytic currents. The AC test frequency will often be 55Hz to avoid errors due to AC mains ground currents.

Over time, corrosive soils with high moisture content, high salt content, and high temperatures can degrade buried earth systems and their connections. Deterioration is inevitable and it is highly recommended that all grounds and ground connections are checked at least annually as a part of the normal predictive maintenance testing plan.

During these periodic checks if an increase in resistance of more than 20% is measured, the source of the problem should be investigated. Corrections should be made to lower the resistance by replacing or adding ground rods to the ground system.

There are four types of earth ground testing methods available with the stakeless technique being conveniently fast to quickly identify fault conditions before performing a detailed evaluation:

- Soil Resistivity (using stakes)
- Fall-of-Potential (using stakes)
- Selective (using 1 clamp and stakes)
- Stakeless (using 2 clamps only)

Typical Application sites

Radio communications towers

At most locations each tower leg will be individually grounded. These grounds are then interconnected. Any associated equipment building will usually have its own ground mat connected to the tower earths. Equipment connection to the utility earth may be avoided in order to minimise the problems associated with high frequency noise being induced in the supply earth conductor. RCD devices have made this approach more feasible as opposed to an MEN multiple earth system intended to protect against neutral line failure.

Electrical substations

A substation on a transmission and distribution system where voltage is normally transformed from a high value to low value. A typical substation will contain line termination structures, high-voltage switchgear, one or more power transformers, low-voltage switchgear, surge protection, controls, and metering. High earth fault currents dictate extensive earth systems.

Lightning protection at commercial/industrial sites

Most lightning fault current protection systems follow the design of having all four corners of the building grounded and these are usually

connected via a copper cable. Depending on the size of the building and the resistance value that it was designed to achieve, the number of ground rods will vary.

Recommended tests

End users are recommended to perform the same three tests at each application: stakeless measurement, 3-pole fall-of-potential measurement and selective measurement.

Stakeless measurement

First, perform a stakeless measurement on:

- The individual legs of the tower and the four corners of a building (telecommunications sites/towers)
- All grounding connections (electrical substations)
- The lines running to any remote site (remote switching)
- The ground stakes of the building (lightning protection)

For all applications, this is not a true ground resistance measurement because of the network ground. This is mainly a continuity safety test to verify that the site is grounded, that we have an electrical connection, and that the system can pass current.

3-pole fall-of-potential measurement

Second, measure the resistance of the entire system via the 3-pole fall-of-potential method. Keep in mind the rules for stake setting. This measurement should be recorded and measurements should take place at least twice per year. This measurement is the resistance value for the entire site.

Selective measurement

Lastly measure the individual grounds with the selective test. This will verify the integrity of the individual grounds, their connections, and determine whether the grounding potential is fairly uniform throughout. If any of the measurements shows a greater degree of variability than the others, the reason for this should be determined. The resistances should be measured on:

- Each leg of the tower and all four corners of the building (cell sites/towers)
- Individual ground rods and their connections (electrical substations)
- Both ends of the remote site (remotes witching)
- All four corners of the building (lightning protection)

The Fluke 1625 earth ground testers that can perform all four types of earth ground measurement:

- 3-and 4-pole fall-of-potential (using stakes)
- 4-pole soil resistivity testing (using stakes)
- Selective testing (using 1 clamp and stakes)
- Stakeless testing (using 2 clamps only)

The complete model kit comes with tester, a set of two leads, 4 earth ground stakes, 3 cable reels with wire, 2 clamps, batteries and manual .



Advanced features of the Fluke 1625 include:

- Automatic Frequency Control (AFC) - identifies existing interference and chooses a measurement frequency to minimize its effect, providing more accurate earth ground values
- R* Measurement - calculates earth ground impedance at 55 Hz to more accurately reflect the earth ground resistance of a fault-to-earth ground path.
- Adjustable limits - for quicker testing

Application note provided by Paul Brooker. Based on the Fluke Application Note: Earth Ground Resistance - Principles, testing methods and applications

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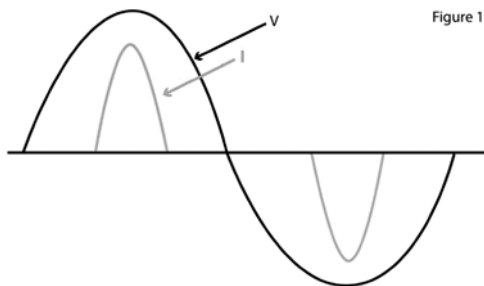
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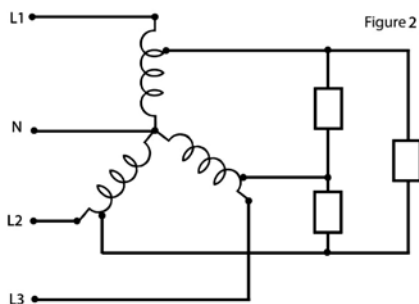
This article describes a simple but effective way to improve the power factor in a plant that has a range of electronic equipment incorporating simple low cost power supplies. These power supplies can result in an unexpectedly high RMS current that can lead to overloaded switchboards and wiring together with increased utility charges. The article also describes the measurements that should be made to ensure optimum operation.

Many devices incorporate low cost power supplies that draw narrow current pulses from the mains supply coincident with the voltage peaks. Figure 1 shows the effect.

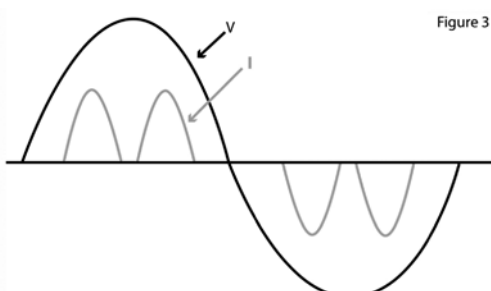


This sort of load characteristic has a poor power factor, typically around 0.5, and draws about twice the RMS current that it needs to for its power consumption. When a significant number of such devices are powered off a single circuit the total RMS current demand can become unexpectedly high and may exceed the rated current. In 4-wire, 3-phase circuits, there is the added problem of the high triplen (odd multiples of the 3rd harmonic, 3rd, 9th, 15th, 21st etc.) content in the phases adding together in the neutral. Overheating and fires can result if the neutral has not been oversized appropriately.

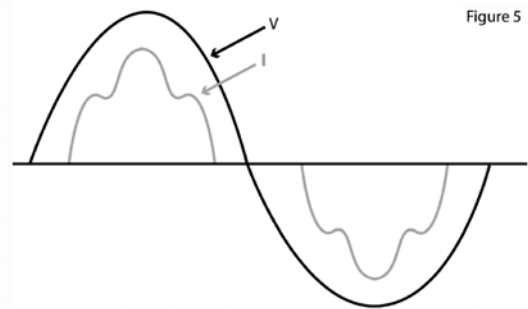
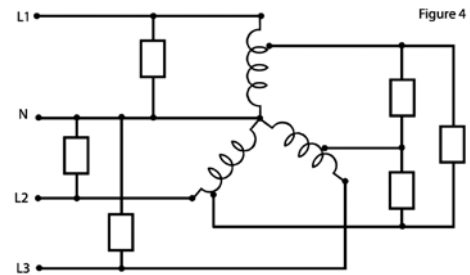
The first step of the solution is to explore what the current waveform in each phase looks like if a number of these devices are connected as a balanced phase-to-phase load on a 3-phase auto-transformer. Figure 2 shows the arrangement.



The taps on the transformer are chosen to produce 240V RMS on each device, rather than the usual 415V RMS phase-to-phase voltage of a 3-phase system. This phase-to-phase loading of the auto-transformer creates an interesting double current pulse in each of the 3 incoming phase lines, as shown in Figure 3.



Splitting the original single current pulse into two immediately improves the power factor. However, further improvement is possible. Adding a balanced phase-to-neutral load adds in the original single current pulses that are coincident with the voltage peaks. Figure 4 shows the extended arrangement, and Figure 5 shows the resultant composite current pulse shape.



The power factor of this composite current pulse can be 0.9 or higher. This nearly halves the RMS current in each phase compared to usual phase-to-neutral loading of the system. To ensure correct operation of the system it is advisable to use a power quality measurement instrument, such as a Hioki 3169, to perform some final checks and tune-ups:

- Adjust the load balance between the phase-to-neutral and phase-to-phase loads to achieve the best power factor.
- Monitor the RMS input current for an extended period while looking for low mains events. If the power supplies in the devices are switchmode units they will exhibit a constant power characteristic. Low input voltage causes higher input current. Ensure the rated current of the mains circuit is not exceeded with typical mains voltages at the site.
- Monitor for an extended period looking for high mains events. The maximum rated input voltage of the auto-transformer must not be exceeded.
- Adjust the load balance to the worst expected and check the neutral current. Harmonic analysis will reveal how much of the neutral current is due to additive triplens. Ensure the total measured RMS current is within the rated current of the neutral circuit.

This article is written by Mr Kevin Smith – Product Manager , TechRentals

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The following new members have been approved and accepted by the TEEAM Council (as at 14th August 2012). A warm welcome to all the new members and special appreciation is extended to those who introduced these new members. For those who are not yet members..... why wait? Join us and find out how our Association can offer our services to you.

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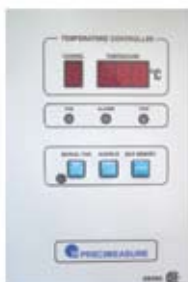
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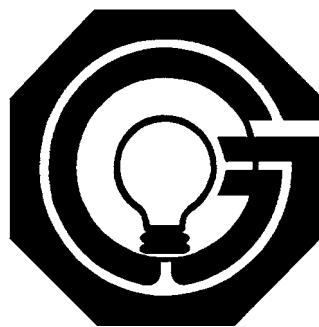
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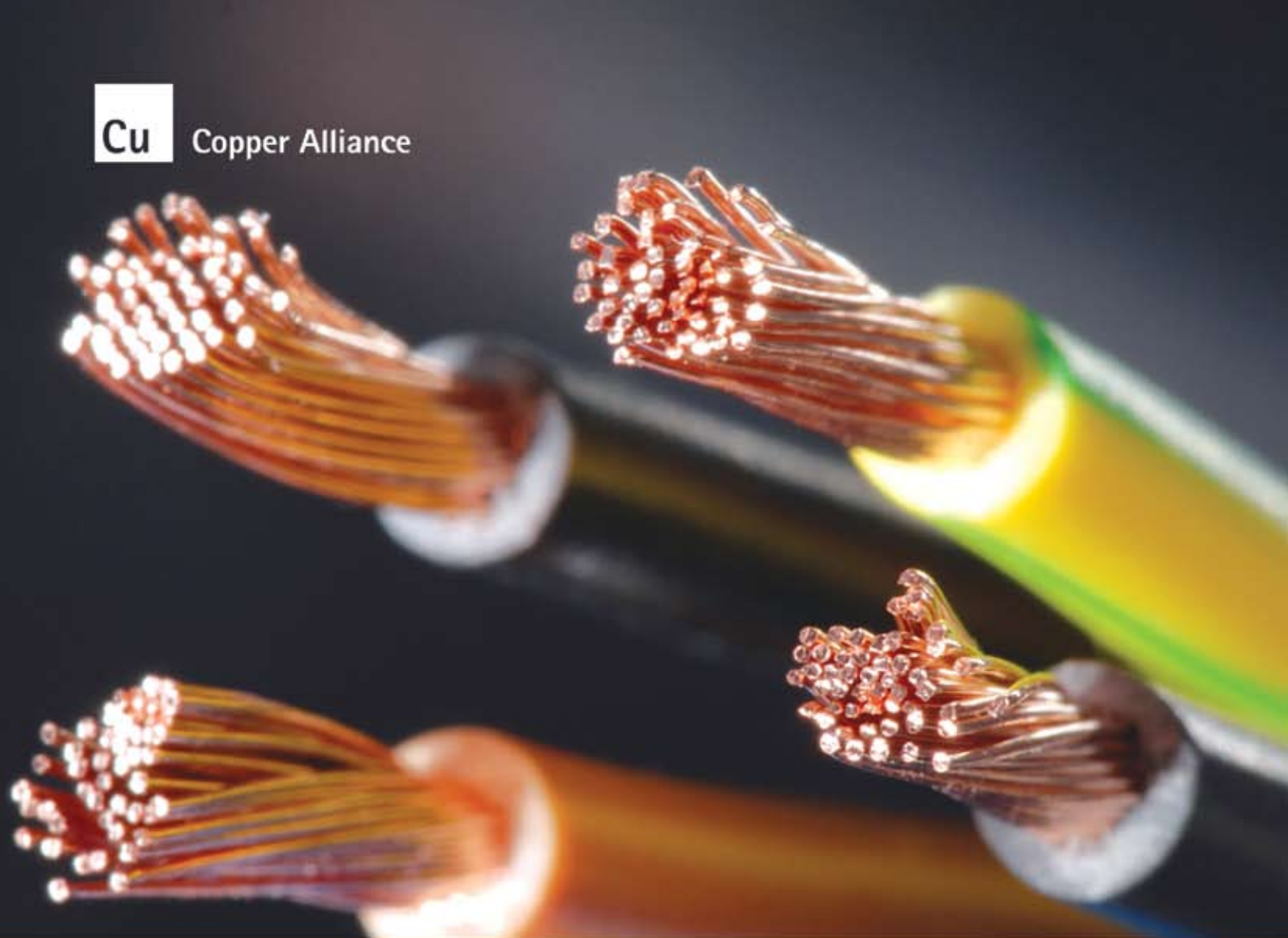
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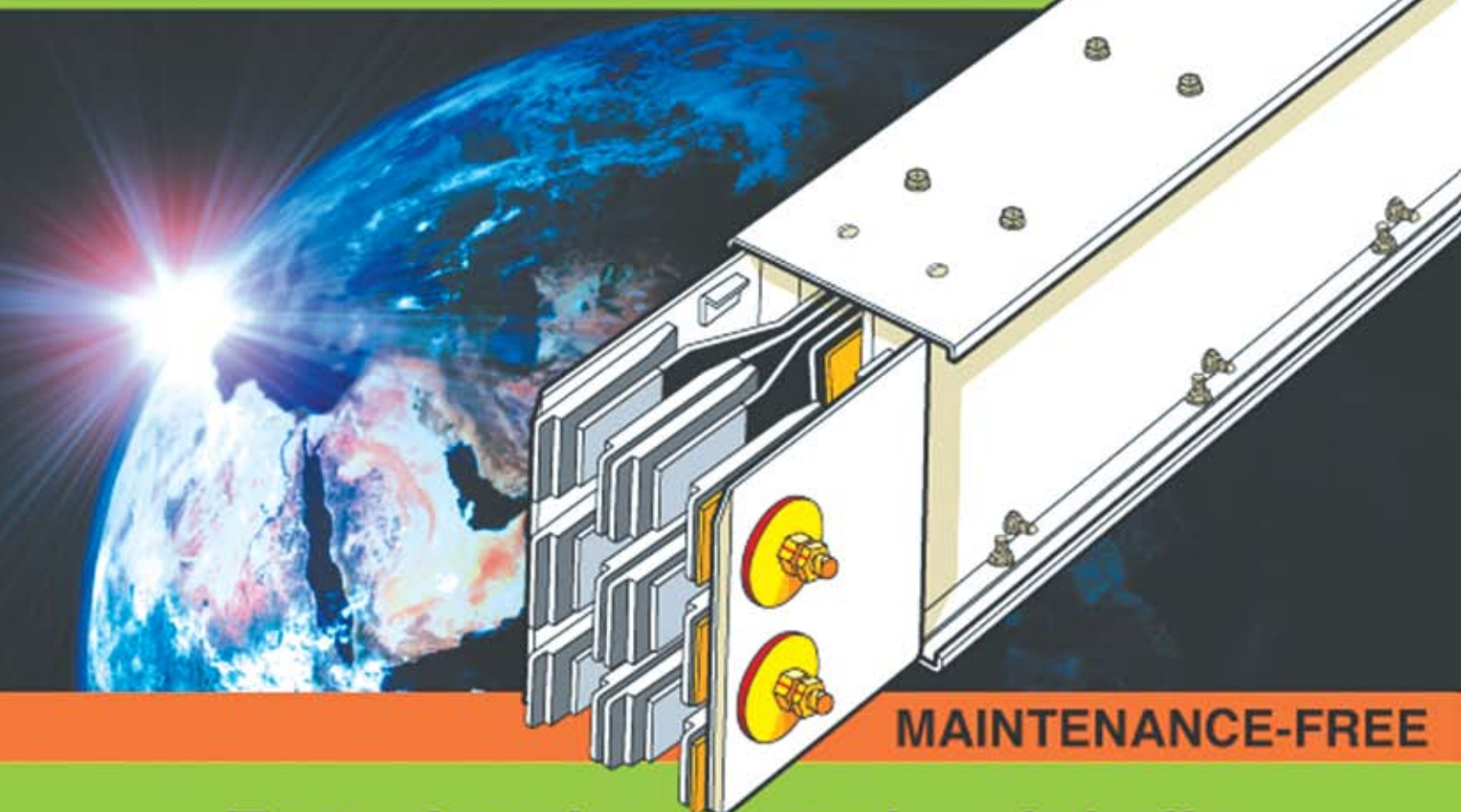


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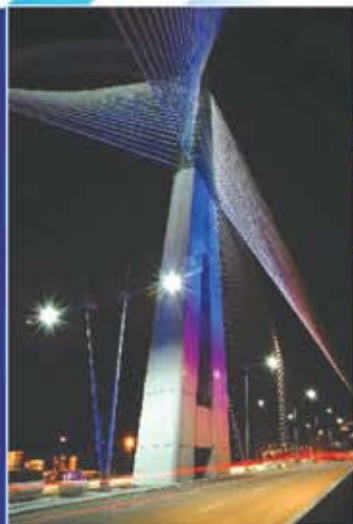


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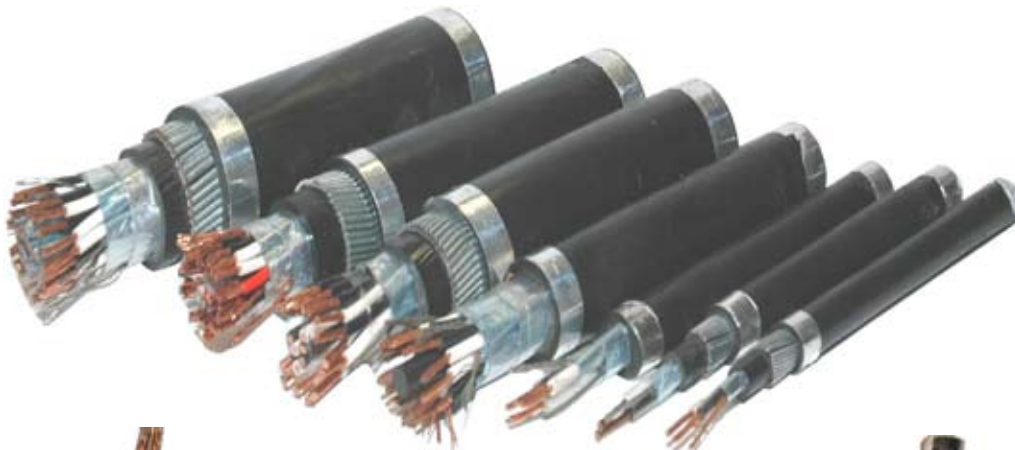
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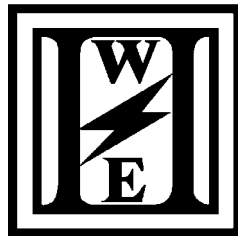
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Remarks : IFC-Inside Front Cover, IBC-Inside Back Cover,
OBC-Outside Back Cover, CF-Centre Fold.

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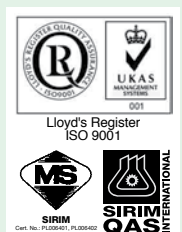


- Street Lighting Poles
- Decorative Lighting Poles
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- Antenna Poles
- CCTV Poles
- High Masts
- Stadium Floodlighting Masts
- Floodlighting Poles
- Mid-Hinged Columns
- Flag Masts / Flag Poles
- Advertising High Masts
- Traffic Signal Masts
- Traffic Light Poles
- Traffic Sign Gantry
- Power Transmission Poles
- Power Distribution Poles
- Telecommunication Poles

STANDARDS

LYCORPOLE® Hot Dip Galvanized columns, masts and poles are designed and manufactured in accordance with BS EN 40, BS 6399-2, BS EN 10025, BS EN 1011-1, 2, Institution of Lighting Engineers Technical Report No. 7, AS 4100, AS 1170.2, AS 1798, AS 2979, AWS D1.1 and AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

Hot Dip Galvanized to BS 729, BS EN ISO 1461, ASTM A123, ASTM A153 or AS/NZS 4680 is a standard feature. Where specified upon request, our Hot Dip Galvanized products can be enhanced with additional Powder Coating with oven baked PE-F polyester based powder to BS 6497 to withstand weather and UV resistance for anti-chalking and colour stability.



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