Vehicle-to-vehicle communication using LEDs

LED technology can be used for much more than lighting. This article explains how cars' LED lights can also improve road safety, vehicle efficiency and traffic management

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Since the '60s LEDs have been used for signalling in machine-to-human interfaces, e.g. to indicate the status of printed circuit boards. In recent years they have also been used for data transmission, as an alternative light source to lasers at a significantly lower cost.

Over the last decade Light Emitting Diodes (LEDs) have become a familiar technology for a variety of lighting applications, including automotive. It's easy to verify their superior efficiency (measured by lumens/watt) and quality (measured by colour stability and lifetime) compared to the incandescent or halogen lamps commonly used in the past, and as the price of LED devices has fallen it's hardly a surprise that LEDs are emerging as the dominant lighting technology. (source : Technavio).

Car manufacturers have been adopting LED lights on their premium models for more than 10 years. As the technology has matured, LED lights mounted on mid-range models are now also commonplace. In parallel to this development, car manufacturers have been looking at ways to pass data about driving conditions and behaviours between cars – an application known as Vehicle to Vehicle Communications or V2V. The aims of V2V are to make driving safer and make road use more efficient (source : allledlighting.com). One approach is to use the LED lights of a car to transmit some of this V2V communications data (See Fig 1)

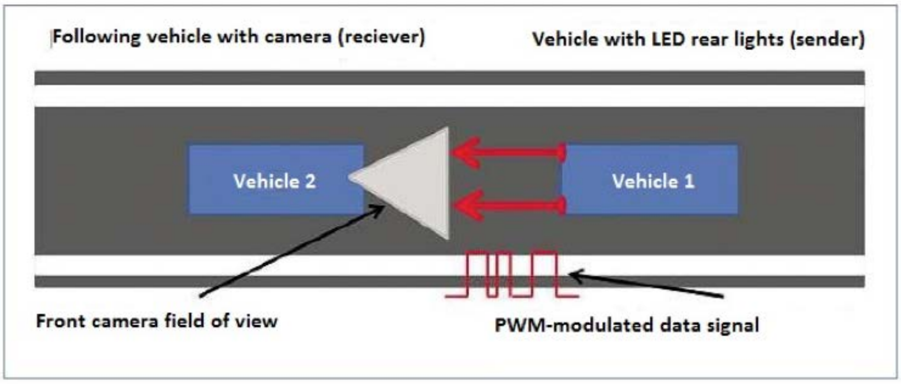

Figure 1: The main LED V2V communications system components shown as a block diagram

The advantage of using light signals over other approaches, that make use of internet and cloud technologies, is that light signals are immediate and local. In other words, they don't lose time sending signals to the internet and they don't have to wait to receive signals back. They also don't need the complex management and processing of signals from hundreds or thousands of cars in the area – V2V by LED only concerns the vehicles in the immediate vicinity, that is the vehicle in front and the vehicle behind. This makes the communication almost instant and therefore suitable for some types of real-time control functions of cars and other vehicles.

A number of organisations have been looking into communications techniques based on LEDs. For example, Intel has been researching the use of visible light communication (VLC) since 2008, and while their work on Li-Fi (light fidelity), as an alternative to Wi-Fi (wireless fidelity) communications, has largely stalled, Intel sees a significant opportunity for VLC to be applied to V2V communications (source : IEEE Spectrum). The opportunity is there for V2V VLC of vehicle size, speed and actions on the road to help with such features as adaptive cruise control, co-ordinated lane changing and collision avoidance. VLC could even be extended to co-ordinated start/stop of engines at traffic lights thus helping to reduce pollution and save fuel.

This does raise the question of how data transmission is accomplished. The answer is that LEDs are incredibly fast at switching on and off – so fast that it can't be detected by the human eye. So fast in fact that it is quite possible to transmit V2V messages via tail or headlights without interfering with their primary function in any way. And because LEDs can be phase shifted, it can also be done without interfering with CANBUS control signals, therefore using already existing vehicle electronic device management. LED technology in the future could therefore have a 'combo' application when mounted on cars: lighting + V2V communication.

This is all well and good in principle, but the technical implementation of signal transmission and detection will need specialist skills and tools during both development and production. With this in mind, Yokogawa has produced a specific model of Optical Spectrum Analyser. The AQ6373B is designed to precisely characterize and test the light emitted by LEDs. This instrument is used by LED manufacturers during the design of LED devices and also for quality checks during and after their mass production (see Fig 2).

For automotive electronics engineers, it is an invaluable tool that will help the analysis of power, control and data transmission signals to lighting units, and of data detection signals for cameras and other devices.

One of the issues facing researchers is how to make the system perform effectively in all lighting and weather conditions. During winter driving conditions it is easy for lights and cameras to become obscured by fog (source : ieee.org Xplore) or road debris thus fully or partially blocking signals, while during the summer there may be too much light 'noise' on bright days making it difficult for cameras to pick-up the light signals. As the LED is an opto-electronic device, other instruments also need to be deployed to

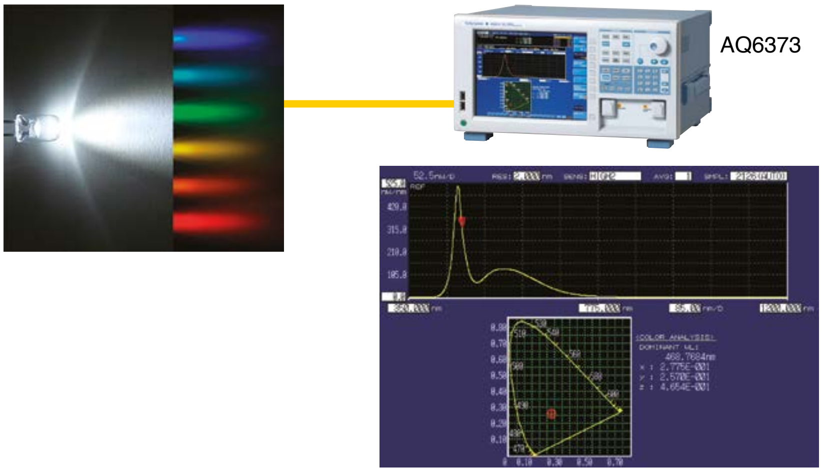

Figure 2 - Analysis of V2V LED communications with Yokogawa AQ6373B Optical Spectrum Analyser

measure and manage these effects. The Yokogawa portfolio also includes the DC current/voltage sources of the GS family and the oscilloscopes of the DLM series that can help designers and engineers to overcome these problems.
There has been much made of the prospects for connected vehicles, but while cloud technologies are great for human interaction and information applications, they are not ideal for V2V communication of vehicle behaviour in the immediate area. However, Visible Light Communications technologies may well be the right platform.

V2V will happen but will VLC V2V happen?

So it seems that there is no practical technology barrier for the adoption of V2V VLC communications. Cars already carry the necessary lighting transmission units and (increasingly) the cameras needed for receiving VLC signals (source : ieee.org Xplore). VLC isn't a suitable technology for all V2V communications or the features that would use such signals, but it is a simple way of implementing some of those functions, and exception processing (missing, partial or erroneous signals) could be managed in software used for the control functions being fed the signals. The same software approach could handle an unexpected event such as when a cyclist pushes in between cars queuing in city traffic.

Autonomous vehicles will almost certainly be introduced at some point, an example is the driverless taxi project in Singapore (source: BBC). The issue seems to be adopting the necessary standards and infrastructure. For example, the average age of cars in the UK in 2016 is approximately 7.7 years (source: Autocar), and given that investment needed for proposed short-range RF and Internet/ Cloud-based solutions is years away, VLC seems like a pragmatic and relatively straightforward technology to adopt across the automotive market, allowing some of the benefits to be introduced at an early stage as it is in fact complimentary to these approaches. Its use would allow short-range RF and cloud-based systems to be focused on applications that make better use of their capabilities since it is clear that no single technology provides a platform for all the possible uses of V2V communications.

It seems there is a great opportunity to improve road safety, vehicle efficiency and traffic management by simply extending the capabilities and features that already exist on many current vehicle designs, while other V2V enabled driver aids will come later as more complicated systems are developed. Yokogawa is working with several manufacturers and research organisation in this exciting field, and we look forward to progress in the near future.

If you would like to know more about how Yokogawa Optical Spectrum Analysers can help with LED applications such as V2V communications, click here for a free OSA demonstration at your lab.