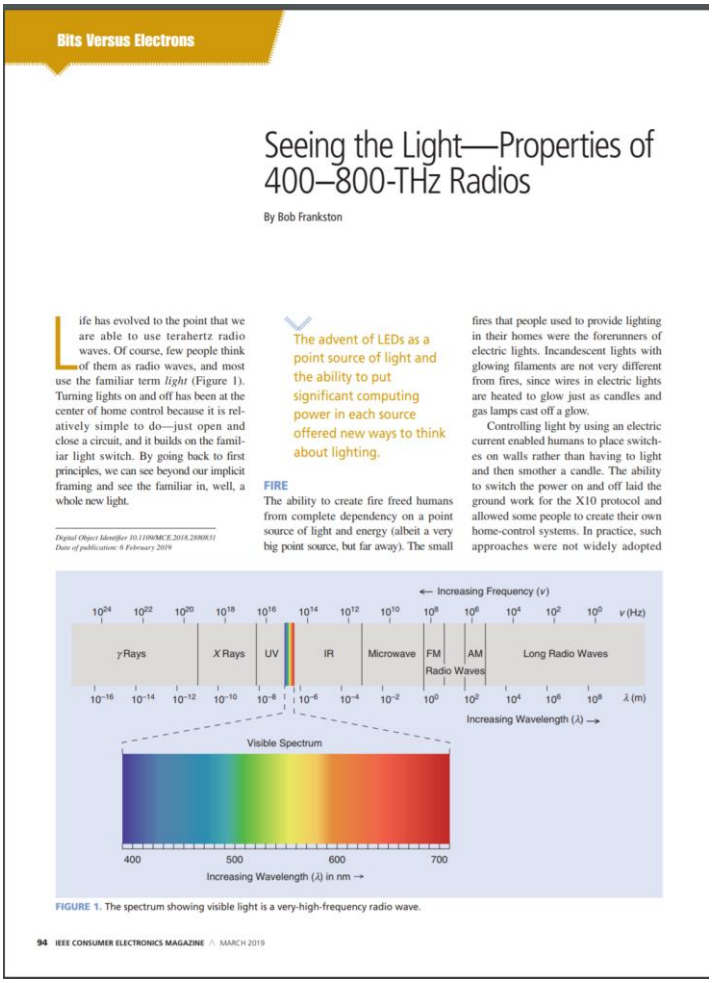
Seeing the Light - Properties of 400-800 Terahertz Radios

Let There Be 400 THz Waves



Bits Versus Electrons

Seeing the Light—Properties of 400–800-THz Radios

By Bob Frankston

Life has evolved to the point that we are able to use terahertz radio waves. Of course, few people think of them as radio waves, and most use the familiar term *light* (Figure 1). Turning lights on and off has been at the center of home control because it is relatively simple to do—just open and close a circuit, and it builds on the familiar light switch. By going back to first principles, we can see beyond our implicit framing and see the familiar in, well, a whole new light.

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The advent of LEDs as a point source of light and the ability to put significant computing power in each source offered new ways to think about lighting.

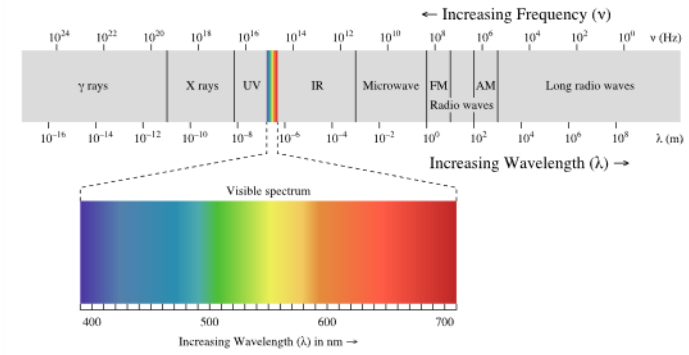
FIRE

The ability to create fire freed humans from complete dependency on a point source of light and energy (albeit a very big point source, but far away). The small fires that people used to provide lighting in their homes were the forerunners of electric lights. Incandescent lights with glowing filaments are not very different from fires, since wires in electric lights are heated to glow just as candles and gas lamps cast off a glow.

Controlling light by using an electric current enabled humans to place switches on walls rather than having to light and then smother a candle. The ability to switch the power on and off laid the ground work for the X10 protocol and allowed some people to create their own home-control systems. In practice, such approaches were not widely adopted

FIGURE 1. The spectrum showing visible light is a very-high-frequency radio wave.

You can read this article online on the IEEE Website.



Life has evolved to take advantage of the properties of terahertz radio waves. Of course, few people think of them as radio waves and use the familiar term *light*. Turning lights on and off has been at the center of home control because it's relatively simple to do – just open and close a circuit and it builds on the familiar light switch.

By going back to first principles, we can see beyond our implicit framing and see the familiar in, well, a whole new light.

Update February 2019

A completely different aspect – the psychological benefits of light: The Hidden Power of Light.

Fire

The ability to create fire freed humans from complete dependency on a point source of light and energy. (Albeit a very big point source but far away). The small fires we used to provide lighting in our homes were the forerunners of electric lights. Incandescent lights with glowing filaments aren't all that different from fires given that wires are heated to glow just as candles and gas lamps cast off a glow.

Controlling the light by using an electric current enabled us to place switches on walls rather having to smother a candle. The ability to switch the power on and off laid the ground work for the X10 protocol and allowed some of us to create their own home control systems. In practice, such approaches were not widely adopted because replacing a light switch didn't, in itself, seem to provide much value.

I soon discovered that there were few cases where scripting (automating) the behavior of lights delivered much value. While I did program my porch lights to come on at dusk the task itself could also be done simply by putting a simple photocell in the bulb.

Light (Bulbs)

The advent of LEDs as a point source of light and the ability to put significant computing power in each source gives us new ways to think about lighting. As with any new technology we tend to see it through the lens (AKA an analog computing device for light) of the past.

Even at this early stage, these new bulbs are something very different from the bulbs of the past. The early LED bulbs were very limited, and I had to search for bulbs that looked right. With new bulbs I could change the settings and discovered the importance of light temperature. I found that 3500ºK is a soft light that is good for the kitchen while I use a high temperature for my office.

If I want to I can turn the kitchen red but, in practice, it's the subtle changes that are the more powerful. As it becomes easier to take advantage of the new capabilities the focus shifts form automation to day to day convenience.

These smart bulbs turned out to be a good match for Alexa and its kin. Users could take advantage of the capabilities without mastering complex control programs, though it's still a work-in-progress. We don't need to automate our homes. We want to be in control and while telling Alexa to dim the lights involves a lot of technology, it puts us in control.

Beyond Bulbs

Today light "bulbs" no longer look like Tulip bulbs –a shape dictated, at least in part, by the need to maintain a near vacuum so the heated filament would immediately vaporize. (which makes the classic bulb an impressive feat of engineering).

I can now buy light sources in various shapes such as panels and tiles which I can mount using 3M command strips and use Velcro to easily remove and rearrange the lighting. I can also light them up in various colors and patterns.

As the prices come down and the capabilities improve we will start to think of surfaces rather than point sources of light. We need to think beyond just aiming light. We can now paint surfaces with light as well as projecting ambience. We can also think of matching the colors we use in printing (subtractive colors) with the additive sources.

As we evolved to take advantage of light, we also evolved to compensate. Thus, we can see a tree as green on a bright sunny day but also on an overcast day because our brain knows it is supposed to be green. This doesn't mean that the subtleties are not important. Color temperature does make a significant difference in the feel of a room even if we can't articulate why.

Professionals are used to treating light as a medium. The rest of us are learning how to think outside the bulb.

In Control?

The new degrees of freedom require rethinking the protocols we use to control lights. Early protocols like X-10 were relatively simple – sending an on/off messages and, perhaps, setting brightness. There were only a small number of endpoints (light sockets).

We're just at the beginning of discovering what is possible. This means we need protocols that make it easy to focus on the relationships between endpoints – the source of control information and the endpoints. The endpoint might be a traditional bulb, or it can be a surface or a tile, or it can be a group of light sources or "meta lights".

Traditional protocols like Bluetooth and Zigbee build in many assumptions. Fortunately, I see a trend towards using standard Internet protocols which separate the relationships from the path between them. Rather than rigid standards, we need open protocols and interfaces. In 1997 I wrote[i] about using XML, today this is being implemented using JSON. But the particular formatting of the message is less important than simply being open.

As the protocols evolve, we also need to better understand how to define trust relationships between endpoints rather than relying on perimeter security (firewalls). One problem with perimeter security is that a single compromised device can take over the entire network. Perimeter security isn't sufficient to address important uses such as controlling a shared driveway light or rules like time of day access or conditional access for Airbnb visitors.

How do we program the behavior we want either directly in software or by explaining it to Alexa (just another kind of programming)?

Millions of Points of Light

At CES in 2018, I was walking past the Ford booth in the North Hall and was confused for a moment because it looked like I was outside in a city street with a dark canopy.

My brain quickly figured out I was looking at a screen inside a room.

Clearly light isn't just for illumination. It is used for signaling as cephalopods have been doing for millions of years. Humans signal with light when they blush or look someone in the eye.

The meaning isn't in any individual pixel but is in the whole. If you get too close to the pixels that meaning (context) disappears, and you just see a spot of color. The ability to paint with light by controlling each point source

individually is not new. In fact, in the 1930's we figured out how to control millions of such points – dots or pixels – and used it present images at a distance. You may know it as tele-vision.

Soon the distinction between such screens and other "paintable" surfaces will disappear. We may be able to paint a house using addressable particles rather than using today's materials (and, please, dispose of those particles responsibly – we've already got too much plastic in our ecosystem).

Seeing the Light

Conversely, our devices are increasingly able to see the signal in the light be it detecting gesture or faces. Using vision (which needn't be limited to visible light), we can do far better than with traditional motion sensors. We can also use other senses like touch, smell (volatile gases) and more. With such capability come new opportunities for abuse. Is that camera really only sensing motion and not spying on us? What are the policies for the data? The potential for benefit is so great that we can't simply ban the use of imaging and other sensing though we can regulate how it's used.

Very High-Frequency Radios

By rethinking light from first principles, new possibilities can be discovered. Conversely, we can take our knowledge of how we can communicate using light and apply this understanding to traditional radio waves. We are going to look back at today's spectrum policy as being akin to reserving colors (such as Royal Purple) for the exclusive use of royalty.

Fortunately, with software, we can learn by doing as long as we are cautious and recognize that we are indeed learning and making mistakes.

This approach is especially appropriate for consumer electronics because we learn by using the technology rather than just building industrial solutions for others.

[i] https://rmf.vc/IEEE1997