HB-LED Alert Device with Intense Light Output

Jerry Vereen, Principal Engineer of Egret Technologies shows how LED technology opens fields for new applications and can make life easier. He gives insights in challenges and future perspectives.

The deaf community is using standard Videophones and sign-language to communicate. Video Relay Services are also available to enable a deaf person to communicate with a hearing person by way of a sign-language interpreter at a call center. This article discusses how Egret Technologies used LED technology in the design of a product to provide an intense light output to alert the deaf person of an incoming Videophone call.

Problem

Standard off-the-shelf Videophones operate assuming the person can hear the ring signal and answer the call. However, calls are often missed for the deaf or hard of hearing person. An attempt to solve this problem without modifying the Videophone hardware was made by simply flashing the LCD screen of the Videophone on and off. Needless to say that the amount of light from the screen was just not sufficient to call attention to a person in an adjacent room or with their back turned. Egret Technologies was given the task to provide a cost effective and innovative solution.

Solution

The Alert Device (Flasher) provides a high output light "pulse" similar to a camera flash to call attention to the deaf person that a call is coming in. The Flasher is a separate device that sits near the Videophone and is attached to the Videophone. In addition to providing an intense light output, the cadence of the "flash" can be controlled by the Videophone to allow different on and off times and patterns based on received caller ID. Similar to a caller ID on a phone, the pattern of light pulses can be used to identify the caller at a distance from the Videophone. The Videophone and Flasher solution is shown in Figure 1.

Figure 1: Videophone and Flasher

Ring Strobe Signal

When a call is received at the Videophone it identifies the caller and drives a strobe signal to the Flasher. The Flasher receives this signal and generates an intense flash of light to alert the deaf person of an incoming call. The duty cycle of the Ring Strobe Signal determines the on time duration and the off time duration according to the caller ID pattern.

Product Requirements

The required size of the product needed to be about the size of a small PC speaker. The customer required front, back, and side visibility of light. The design also needed to have a firm and sturdy feel and be heavy enough so that attached cables would not pull the unit off a countertop or desktop. The required unit cost also had to be very low (less than $20 (€14 EUR) to the end user).

The light intensity requirement was not directly specified, however, the customer required the need for a

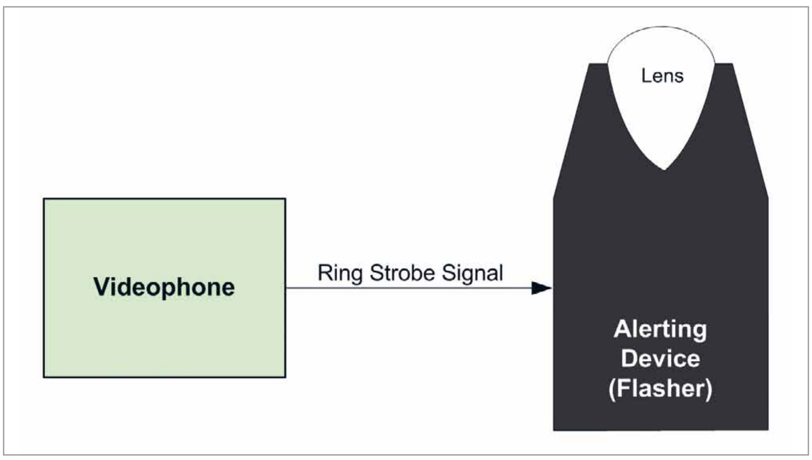

Figure 2: Videophone Sends Ring Strobe to Flasher

strong flash similar to a camera flash, but with the option to use longer on time durations. Customer approval was obtained before committing to hardware, by Egret Technologies performing a live demonstration using an LED Driver Evaluation Kit, LED Module, and sample lens at the customer facility.

The Light Source - Competing Technology

Various lighting technologies were examined prior to the onset of the project. The primary contenders were the Xenon Flash Tubes and High Brightness White LEDs.

Xenon Flash Tubes:

- Flash “on” time limited to short bursts
- Circuitry more complex
- Very high voltages required to drive the Xenon bulb complicating the UL approval process
- Higher part cost than LEDs
- Higher manufacturing assembly costs due to package type
- Shorter bulb life

High Brightness LEDs:

- Supports longer “on” times
- Operates from “safe” low voltages
- Surface mount package can be placed by machine reducing manufacturing assembly and labor cost
- Lower part cost
- Longer life
- Off-the-shelf LED driver chips available

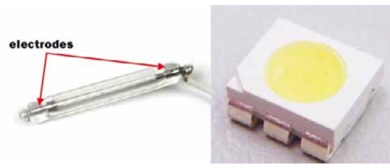

Figure 3: Typical Xenon Flash Tube (left) and CREE CLP6B-WKW-CD0E0453 LED Package (right)

Although the xenon flash tube does provide an intense and pure white light output, the LED solution was better especially in terms of lower design complexity and lower cost. Finally, the ability to have longer on times was a plus.

The initial demonstration at the customer’s facility was done with a single LED module. At that point the customer requested that a second LED module be added.

Core Design Attributes

The heart of the design consists of a Camera Flash Boost Converter IC and two High Brightness LED modules. The Boost Converter is configured to operate in strobe mode for this application. In this mode, the Boost Converter switches continuously to supply maximum current for the LEDs, but for a limited time. The current through the LEDs is regulated by the Boost Converter and set by an external resistor. The time duration of the strobe signal (Strobe~) controls the LED on time. The Boost Converter consists of a gated oscillator, a 24V boost circuit, and an LED current-regulation circuit. The Boost Converter operates from a 2.6 V to 5.5 V input range. For this application, the input supply was sourced from a wall-mounted AC/DC power supply that outputs +5 VDC at 1A.

With two LED modules there is enough light output to alert the person, even if they are not close to the Flasher. Each LED module has three LEDs which are connected in parallel in the design. The Modules are then connected in series. Read further to understand this design decision.

Design Considerations

LED: Selection of the LED required obtaining samples and running some tests in the lab. Based on these tests a 3-LED High Brightness LED Module was selected that has a wide dispersion angle of 120°. This provides the desired distribution of light across the room. To approach 360 degrees of light from the Flasher, two LED modules were used (one on each side of the PCB). This approach allows the device to be placed almost anywhere in the room, even against a wall. To that end the PCB and Lens were “arched” to extend the height of the LEDs above the black plastic housing and provide side light. See Figure 4.

LED Configuration: The boost converter’s 24 V output voltage is high enough to drive a string of LEDs in series. For this design a combination of series and parallel is used.

Note that parallel LEDs may exhibit slight variation in forward current from LED to LED resulting in differences in brightness. This affect is minimal if the LEDs are on the same substrate as is the case for this application.

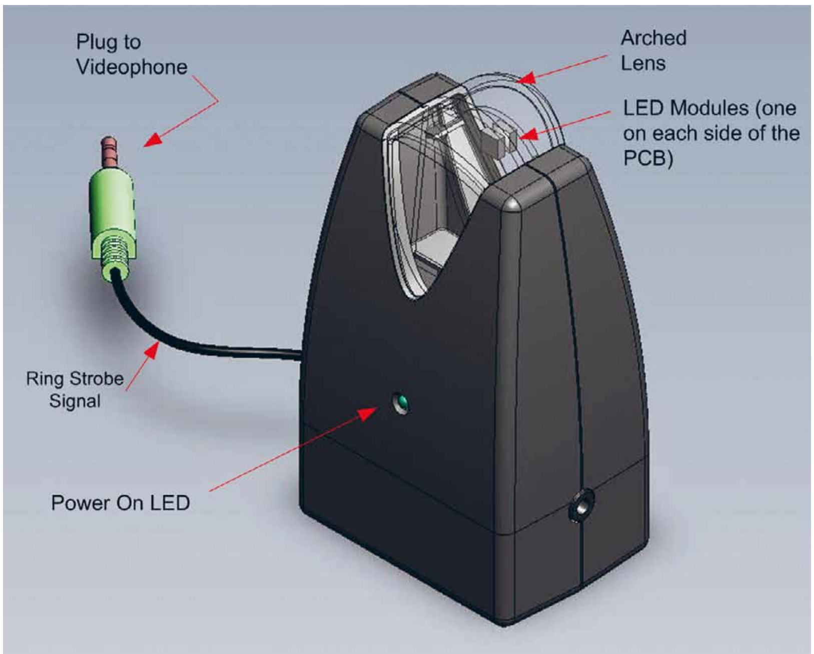

Figure 4: LED Module Location

Given the 24 V output of the Boost Converter and the worst case V_F = 4.4 V of an individual LED, the following scenarios fall out:

6 LEDs in series:
6 × 4.4 V = 26.4 V (voltage drop too high for Boost Converter)

2 LEDs in series, 3 in parallel:
2 × 4.4 V = 8.8 V

The 2nd scenario is a reasonable compromise between a series and parallel configuration and was the one Egret Technologies chose for this design. The LED Modules are then placed in series to ensure that both Modules are driven at the same current level, while the individual LEDs within each Module are in parallel. See Figure 5.

LED Brightness: LED Brightness is determined by forward current. The LED Module is specified for a continuous forward current of each LED in the Module at 50 mA. This was the current level that was chosen and configured to be driven by the Boost Converter. Maximum peak forward LED current is 100 mA for each LED, allowing for an additional 50 mA of current margin. Maintaining LED current control was critical to the design and this was handled by the Boost Converter as follows.

The typical forward drop of an individual LED is 3.8 V at 50 mA. The strobe current is then set by the resistor R_{STB}. From the Boost Converter's data sheet,
$R_{STB} = 600 / I_{LED}$. Since there are 3 LEDs in parallel the current is evenly divided for this estimate.

I_{LED} = 3 × 50 mA = 150 mA,
therefore desired I_{LED} = 150 mA

Now calculating R_{STB}:
R_{STB} = 600 / 150 mA = 4 kΩ

Boost Converter: The Boost Converter is actually a switching regulator designed to drive LEDs, therefore careful attention to the selection of inductor, input capacitor, and output capacitor is prudent, as well as in providing a clean feedback signal with little noise, as is true with any switching regulator design. The Boost Converter controls LED brightness by regulating the current through the LEDs to a selectable level controlled by an external resistor. The current into the LEDs is regulated to 1000 times the current set by the STB pin resistor, R_{STB}. When the EN pin is low the converter is in precharge mode and the converter switches continuously until the output capacitor is charged to 24 V. Once the OUT feedback pin reaches 24 V, the converter does not switch again until OUT falls below 23.5 V. This results in 500 mV ripple on the output. The LED pin is high impedance in the precharge state and the external LEDs are off. Conversely, when the enable pin is high the LED driver turns on and the LEDs illuminate. Figure 6 depicts the 24 V precharge state (LEDs off) and the LED on state where ~7.6 V is dropped across the output (due to 2 series LED's).

Schmitt Trigger Buffer: The Strobe signal from the Videophone was treated with additional care as the signal is being driven over a cable several feet. Being a TTL level signal and the fact that capacitance in the cable would slow the edges, an input buffer was added to the design to clean up the signal, rather than connecting directly to the Boost Converter's enable pin. The buffer

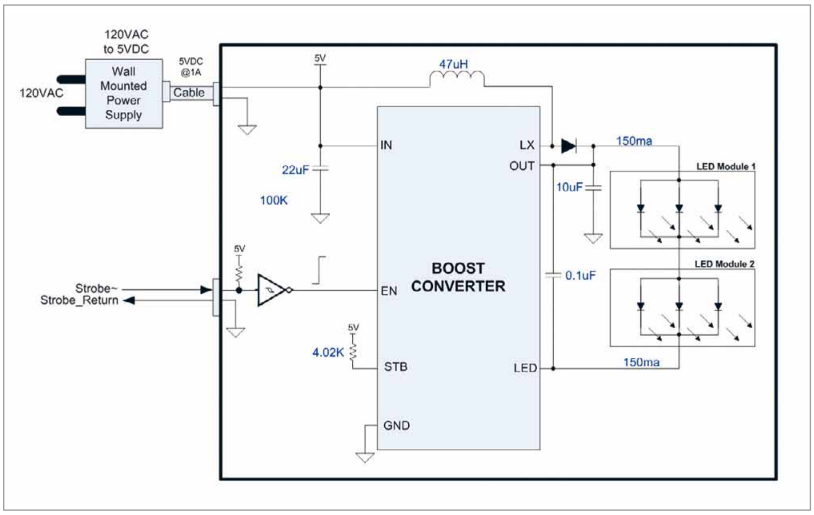

Figure 5: **Flasher Circuit Block Diagram**

Figure 6: **Scope Plot of Boost Converter's LED Drive**

Figure 7: **Mechanical Design**

selected has a schmitt trigger input stage which adds hysteresis to the switching region. The buffer also protects the boost regulator from external voltage transients that might otherwise damage the boost regulator. Finally, a pull-up resistor was added to the input of the buffer to ensure that the enable signal is deactivated when there is no cable connected from the answering device to the Flasher, while power is applied to the Flasher.

Mechanics: The enclosure is a molded plastic housing (ABS UL94-V0) customized for appearance and application. The Lens is polycarbonate UL94-V0 and tinted white with 50% translucency. A weight is placed inside the bottom of the unit to provide stability.

Application Hints

LED On Time: There was no limitation built into the Flasher hardware design to prevent excessively long LED on times. At the same time, however, the brightness of the LEDs was critical to user satisfaction. Since current is pulsed to the LED, the highest brightness is obtained by providing a short duration flash. If the LED is left on for a “long” time, the power consumption is high and the parts can build up heat. Although no damage can occur due to this scenario, it was recommended to use LED On times shorter than 200 ms.

LED On Time Specification (High Brightness Flash).
Condition:
Strobe control line from the Videophone in the low state,
LED On Time Spec:
30 ms (typical), 200 ms (maximum)

- “On” times shorter than 30 ms can be used to convey caller ID info
- “On” times in the 30 ms to 100ms range provide a high brightness output

Cadence Ideas for Caller ID
Caller ID can be used to provide unique per caller (or per caller group) flash sequences, controlled by the pulse width and timing of the strobe control signal.

The following methods illustrate the concept:

- Combine a number of successive high brightness flashes with different off times between groups of flashes
  - ON, Long OFF, ON, Long OFF, etc
  - ON, short OFF, ON, Long OFF, etc
  - ON, short OFF, ON, short OFF, ON, Long OFF, etc
- Combine “low” level LED flashes with high level LED flashes, e.g. A 400 microsecond LED On pulse is still visible and these low light “blips” could be interspersed with high brightness flashes to convey ID information. The Long Off time could contain a number of these low light pulses.

Conclusions

Applications for High Brightness LEDs are evolving into many areas and uses. To ensure that the LEDs truly provide years of operation in an application, the electronics that drive the LEDs must be designed carefully and with plenty of margin built in. The approach that Egret Technologies took was to design from a systems perspective. After all, it does not matter what fails, the life of the LED is dependent on the life of the supporting electronics as well.

Imprint

LED professional Review (LpR)
ISSN 1993-890X

Publisher

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Front-page picture
Image: Arno Grabher-Meyer, LED professional, Philips 12 W EnduraLED bulb
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