Create Accurate LED Lighting Using Closed Loop Precision Control

As lighting moves into its role hosting sensing and awareness for the IoT, entirely new paradigms are erupting. One of them will be the criticality of time to market for luminaire design. The good news is that the world's #1 MCU provider, Renesas, is stepping up to meet the challenge by combining an ultra-low power MCU with precise sensing and a highly optimized set of peripherals to address a broad range of lighting control applications.

While LED lighting has made great advances in terms of delivery of initial quality of light, very little has been done to “close the loop” to increase precision without increasing the BOM cost. One reason for this has been the steady increase in the quality of LEDs. As manufacturers have produced better quality LEDs, color and lumen stability over lifetime has been of less. The increasing quality has also been accompanied by decreasing costs. Where the LEDs may have represented 60% or 80% of a commercial luminaire’s bill of materials only a few years ago, we’re now seeing this reduced to something more in the magnitude of 20%. This reduction is enabling the industry to begin delivering features, such as white/color tunability, that were previously too costly to be marketable.

As white/color tunability has become affordable, users will begin to demand it as a more mainstream feature for a number of reasons, including comfort/health, task efficiency, personalization and eventually, simply because it is fun. While certain health effects of light have been known for decades, the move to more controllable digital light has opened up new areas of study, and enabled at the building level. The result is that we’ll begin to see more and more studies describing the palliative (“feel” better), well-being and health effects, including circadian rhythm, that stem from our correct use of light. We’ll also begin to see more modeling of the effects of different types of lighting on task efficiency, both due to increased comfort and well-being, as well as direct physiological effects such as visual acuity and eye strain.

All this suggests that tunable light will rapidly become a mainstream offering, and that will come with challenges of its own. The big one will be in maintaining color accuracy and consistency over lifetime. By combining good power systems, thermal management and quality optics with quality LEDs, luminaire manufacturers have a straight-forward path to delivering quality of light (QoL) over lifetime with a single correlated color temperature (CCT). However, things get a lot less straight forward when you introduce color tunability, even in a simple “warm-string/cool-string” two-channel tuning model. While a look-up table in a smart light can tell you that a 40/60 mix of warm/cool will deliver a CCT of 3500K at 100% output at 25°C ambient, as the LEDs make subtle shifts in CCT based upon current and ambient heat fluctuations what’s the correct mix at 75% or 50% or 23.65% where the user happened to slide the dimmer? And while the ambient temperature shifts as a result of the PCB warming up? The human eye is very sensitive to color shifts, with as little as a 2/10ths of a percent difference being noticeable from light to light. Maintaining light to light consistency

under any table-driven real-world color-mixing scenario demands deep characterization knowledge of the selected LEDs, as well as highly precise (read “expensive”) componentry.

The ultimate solution is to “close the loop” by way of adding color sensing. Instead of accounting for the complex variables, factoring them for environmental changes, and projecting them against lifetime behavior predictions, why not simply read the current CCT from a sensor and then move “more this way” or “less this way” until you arrive at the target. With a high-accuracy, calibrated sensing solution, the luminaire or replacement lamp manufacturer can replace ultra-precise components, including LEDs, with ones that are simply stable and granular “enough”.

But designing a closed-loop tuning system out of discrete components will be a challenging task for many luminaire manufacturers who are still suffering the shock of transition from a cosmetic design focus to LED lighting’s electronics engineering emphasis. Tackling the closed loop tuning task isn’t impossible, but it is time and resource intensive, so the likely result will be the difficult tradeoff between time to market and the quality of the design that results. In a new reference design, Renesas' RL78/I1A MCU device family has been combined with precision sensing in the form of ams' AS7225 smart lighting director to eliminate that trade-off.

Using 16-bit PWM timers and a rich analog portfolio of ADC, comparators and PGAs, the Renesas RL78/I1A microcontroller is capable of driving up to six independent LED strings. Operating at 32MHz, the ultra-low-power 16-bit microcontroller is designed from the ground up for LED lighting control. Incorporating up to 64 KB flash and 4 KB on-chip memory, its ADC supports up to 11 channels, a comparator with up to 6 channels, an internal DAC, and a 6-input PGA.

The ams AS7225 Smart Lighting Director combines embedded intelligence with a digital tri-stimulus chromatic ‘calibrated for life’ nano-optic sensor to deliver closed loop white tuning directives to the RL78/I1A. The direct XYZ filter design uses CIE1931 XYZ and CIE 1976 u’ v’ coordinate mapping as the basis for high-precision white/color tuning. Tuning directives are delivered via an industry standard I2C slave interface, while a built-in I2C master interface offers native expansion support for both daylighting and spectral presence functionality.

Architected around the Renesas RL78/G1D microcontroller, the Bluetooth Smart Module allows the user to create an IoT lighting solution and set the desired lighting parameters using a Bluetooth® Smart-based smartphone control application. The IEEE 802.15.1, Bluetooth Smart v4.2 compliant module is capable of 2.4 GHz RF operating frequency with ceramic antenna and AES128 encryption.

Overall, the Renesas/ams reference design delivers capable, yet efficient, processing power, and high resolution PWM timers combined with precision XYZ filter-directed daylight and color tuning to enable excellent control performance in a broad range of lighting systems. Provided reference code serves as a building block for rapid prototyping and integration for color tunable luminaires and replacement lamp designs including support for DALI/DMX512 communication.

Renesas RL78/I1A Microcontroller

- Ultra-low-power 16-bit microcontroller operating at 32 MHz and optimized for LED lighting control
- Up to 64 KB flash and 4 KB on-chip memory
- 6 channels of 16-bit timers with PWM capability
- Smooth start function, dithering function, forced output stop function (unsynchronized with comparator or external interrupt), and interleave PFC function
- Analog: ADC supports up to 11 channels, 8/10-bit resolution, 2.125µs conversion time; Comparator with up to 6 channels; Internal DAC: 3 channel 8-bit resolution, window comparator mode; PGA (x4 to x32): 6 input; On-chip temperature sensor
- DALI support
- SSOP: 20, 30, 38 Standard: −40 °C to +105 °C Extended: −40 °C to +125 °C

Ordering Information

Part Number Prefix:

R5F1076, R5F107A, R5F107D

Website

www.arrow.com

ams AS7225 Smart Light Director

- Sensor-integrated chromatic-white tunable director
- Accurate measurements for Correlated Color Temperature (CCT) and color point deviation from the black body curve for white light color in the delta u' v' coordinate system
- Nano-optic deposited interference filter technology to provide XYZ color coordinates sensing consistent with the CIE 1931 color coordinates standard
- Maps the XYZ coordinates to the x, y of the 2-dimensional color gamut and scales the coordinates to the CIE 1976 u'v' coordinate system
- 20-pin LGA package 4.5 x 4.7 x 2.5 mm; 0°C to +85°C

Ordering Information

Part Number:

AS7225

Website:

http://www.arrow.com

Ultra-Low-Power Bluetooth® Smart Module

- Low-power Bluetooth Smart module (IEEE 802.15.1, Bluetooth Smart v4.2), based on Renesas RL78/G1D MCU
- 2.4 GHz RF operating frequency with ceramic antenna and AES128 encryption
- GATT Server and Client with up to 8 connections in server mode
- BT SIG qualified stack: GAP, GATT, Security Manager, L2CAP, HCI, LL
- Bluetooth Smart profiles and custom profiles
- Over-the-air firmware upgrade; Bluetooth Developer Studio Plug-in

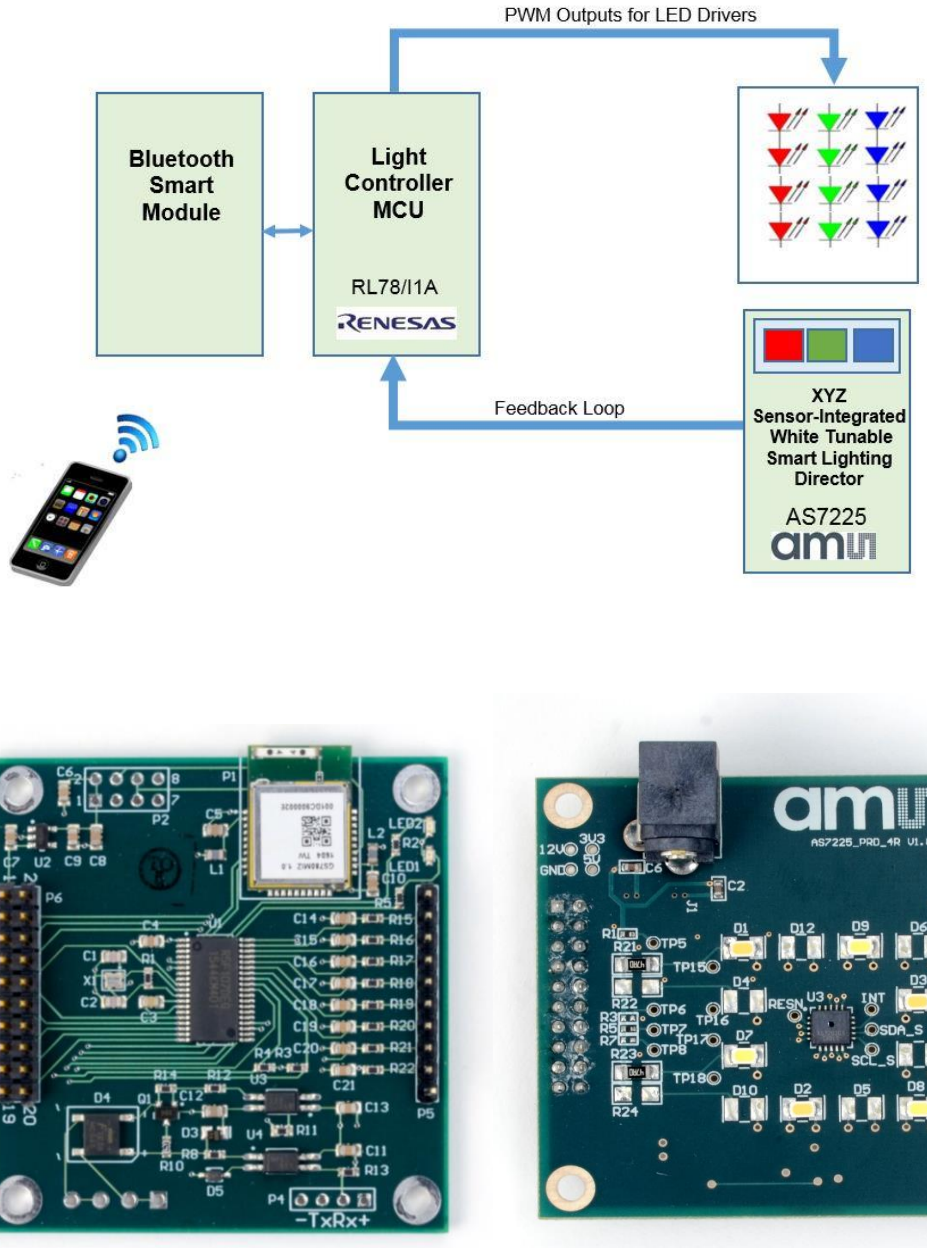

Figure 1: Renesas and ams reference design for lighting control

For more information on this reference design, please contact exactcolor@renesas.com

Contact Us Today!

Call **1-800-833-3557** to speak with your local Arrow M2M business development manager, or email us at m2m@arrow.com for more information.

Arrow Electronics, Inc.
Intelligent Systems
9201 E Dry Creek Rd.
Englewood, CO 80112