LUMISSIL Microsystems

A Division of ISSI

Matrix LED Drivers for Appliance Interfaces

A well-designed user interface is an appliance selling feature; aesthetic use of LEDs creates a high-end look with approachable appliance control

Today's home appliances have more value-added features than ever before. Appliance designers must consider and select the best control interface to support this rich functionality, while continuing to make a product that is aesthetically pleasing and easy for consumers to use.

Household appliances have multiple selection options for enabling different features. LEDs can be used for indicating which feature is enabled, at what power level, for how long, when a function begins and when it is complete. Multi-color LEDs provide the best user feedback since color can be used as another dimensional indicator along with it's ON/OFF or brightness level.

USER INTERFACE

The appliance user interface has traditionally been mechanically based; requiring users to select the desired function by physically turning a knob or pushing buttons. With the introduction of the microcontroller (MCU), the range of function selections and operating options have increased to a complex level. A simple mechanical interface cannot keep up with the demands of increasingly automated functions such as sensing, process control and cycle times.

The mechanical knobs and switches are being replaced with MCU based capacitive sensing inputs which have no movable or raised parts, resulting in an easy to clean interface with no mechanical wear and tear. In addition, a greater number of LEDs are being incorporated in the user interface to provide visual feedback for the appliance operating status.

A well-designed user interface, sometimes called a human-machine interface (HMI), simplifies the management of this massive amount of control information found in today's appliances. A typical LED-based interface consists of low power LEDs configured to drive seven segment displays, individual color or icon backlighting. An HMI not only allows the user to configure the appliance operation; it also displays the operating status.

There are many types of LED displays to fit the target price of the appliance; 7-segment LED, dot matrix LED or strategically placed individual LEDs. Typically, the design engineer would use the onboard MCU to drive these LEDs. However, MCU-based LED driving consumes valuable CPU cycles and the display refresh can be uneven or unreliable, depending on the firmware and bandwidth of the MCU. For this reason, designers of complex control panels turn to programmable LED drivers to offload the MCU resulting in simplified firmware and a stable LED output.

MICROCONTROLLER DRIVE

An MCU's GPIO outputs can be programmed to drive LEDs in a simple state of either ON or OFF. For high currents, external FETs are necessary since the MCU's GPIO has limited current handling capability. This is a cost-effective approach if there are few LEDs and the MCU has sufficient bandwidth to support the ON/OFF control of the LEDs, see Figure 1.

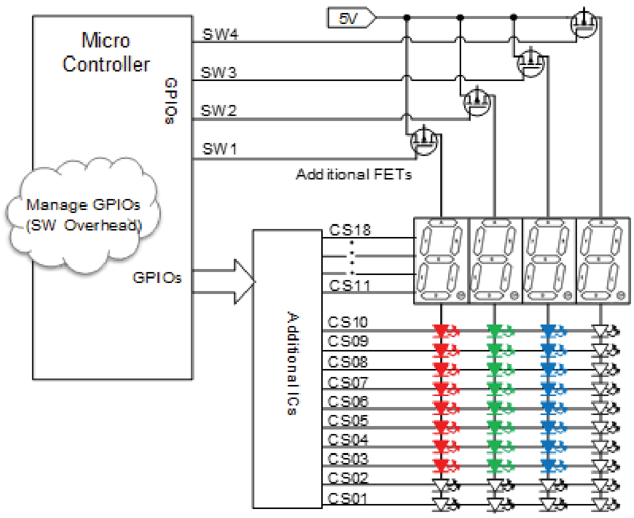

Figure 1 Traditional Driving

However, if LED animation effects are desired, then a high bandwidth and more expensive MCU and its associated software overhead is necessary since it must constantly refresh the GPIOs to achieve both dimming and animation.

In addition, the external FET switches need to be configured as current sources which gets complicated if there is a mix of Red, Green, Blue or White LEDs requiring different current levels. Due to variations in LED and resistor tolerances, the current through the different LEDs will vary, resulting in a perceived variation in brightness levels at the user interface.

DEDICATED LED DRIVERS FOR USER INTERFACES

An alternative approach is to use a dedicated matrix LED driver to offload much of the MCU bandwidth. Matrix LED drivers have programmable registers which facilitate the animation, color changing, brightness adjustment and de-ghosting of an LED array. The MCU only needs to program these registers over a standard serial bus such as I2C or SPI resulting in lower bandwidth requirements. This register-based serial communication lowers MCU bandwidth since there are no GPIOs which require a constant update.

Figure 2 shows how the IS31FL3746 can be used to simplify the same arrangement of LEDs and seven segment display as in Figure 1. The IS31FL3746 has the key features necessary to assure a consistent LED output. It also has other features such as EMI reduction, ghost elimination, and LED open/short detection not possible in a discrete implementation. The IS31FL3746 is available with either I2C (IS31FL3746A) or SPI (IS31FL3746B) bus options for added flexibility.

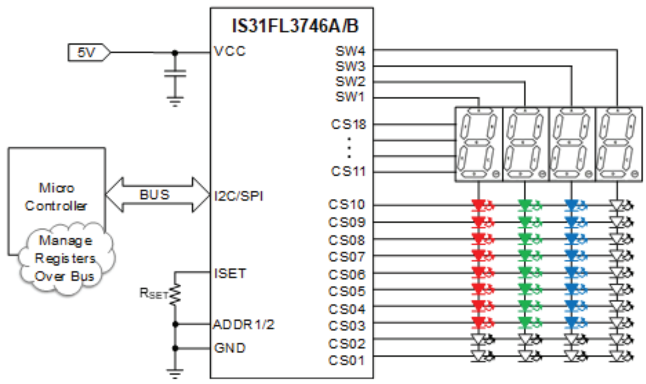

Figure 2 Matrix LED Driver

CONTROLLING MANY LEDS

In a matrix array configuration, LEDs are arranged in rows and columns resulting in a scanning architecture which is the most efficient when driving more than 36 LEDs. The basic concept is that each LED and its associated register can be addressed by its row/column location in the array.

The columns are controlled by FET switches (SWy) which provide power for the row current sinks (CSx). In the case of the IS31FL3746 there are four FET switches (columns) and 18 current sinks (rows) resulting in an array size of 4x18 or 72 individually addressable LEDs. As shown in Figure 3, each LED location has its own associated programmable register for setting the LEDs PWM, current and open/short detection.

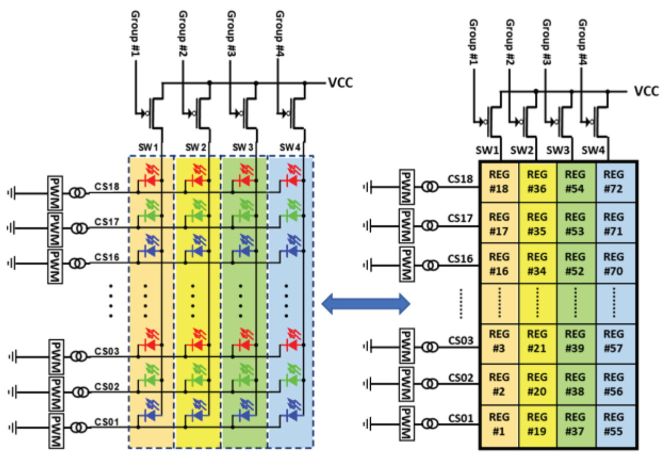

Figure 3. LED and Register Arrangement in Array

An internal state machine sequentially cycles through each of the four FET switches and enables all 18 current sinks for a short duration. Only those LEDs associated with the switch (column) and the current sinks (rows) will turn ON for a specific duration before the sequence continues to the next switch (column).

Each LED in the array has an associated programmable register for adjusting its operating PWM value and current level. As the state machine cycles from SW1 to SW4 the register values are applied to the current sink rows. For example, when SW1 is active then the values of registers 1~18 (group 1) are applied to the LEDs in group 1. Between switch activations there is a short period called 'de-ghost' time used for discharging any parasitic capacitors which if not discharged might cause a false turn ON of an LED. After this de-ghost time the state machine enables the next switch and its group of LED registers. This scanning continues indefinitely in a loop going from SW1 to SW4 then back to SW1, etc.

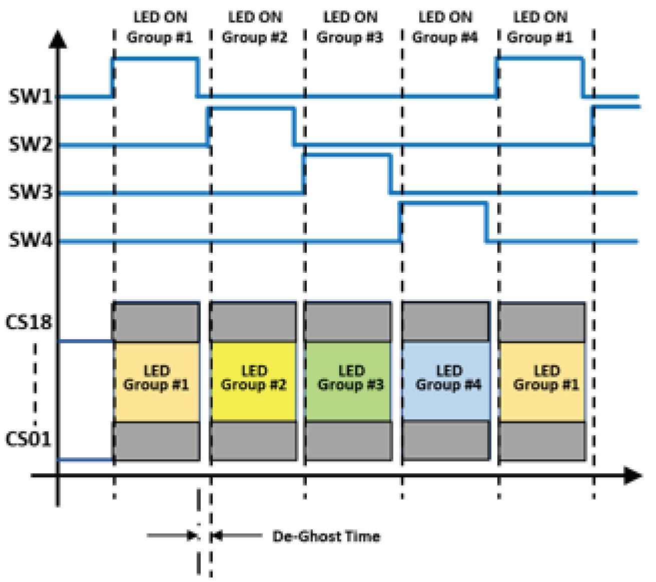

Figure 4. Scanning of a Matrix LED Driver

COMPLETE USER INTERFACE IN A CHIP

A matrix LED driver addresses the need to control the many LEDs found in an appliance user interface. In addition, there are mechanical knobs and buttons which should be replaced by capacitive touch interfaces.

There are several advantages to touch-sensing inputs over mechanical inputs. The major advantage is hygiene; since mechanical inputs introduce open spaces under the knob or button which can accumulate grime and bacteria. A capacitive sense input has no movable or raised parts with no open spaces making it easier to maintain a hygienically clean surface.

Lumissil has introduced the IS31FL3800 to provide a complete HMI solution. It combines an MCU, a matrix LED driver with capacitive key inputs to provide a complete front panel solution. The IS31FL3800 has an I2C bus interface so it can be programmed and controlled by an external microcontroller.

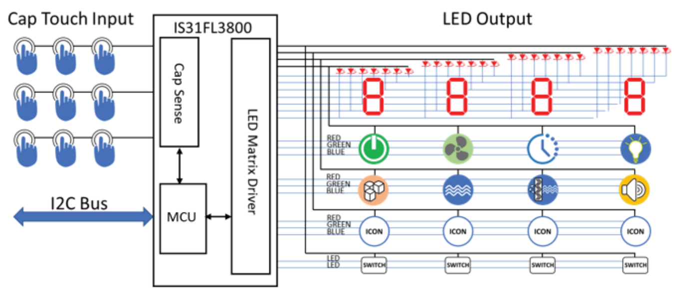

Figure 5. IS31FL3800 Cap Sense and LED driver

Today's home appliances need a smart and elegant user interface not only as a selling feature but also to facilitate the use and programming of the many selectable functions. The IS31FL3800 provides a single chip solution to handle most of the requirements for HMIs requiring LED visual outputs and capacitive sensing inputs.

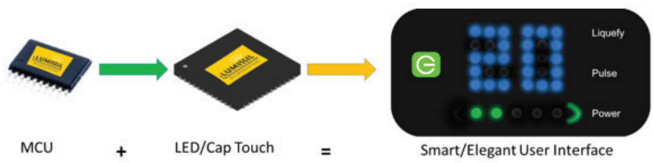

Figure 6 IS31FL3800 Single Chip Solution for HMI

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SUMMARY

Appliances with intuitive interfaces are a must have feature to compete in today's market. Creating an eye-catching interface requires LED lighting with color animation and an easy to clean touch interface.

Lumissil Microsystems offers a family of innovative LED drivers and capacitive touch IC solutions to help HMI designers create appliance interfaces with reliable control, informative feedback, and hygienically clean surfaces. Evaluation boards and associated software code are available for each LED driver. Figure 7 is an example eval board for the IS31FL3733 matrix driver.

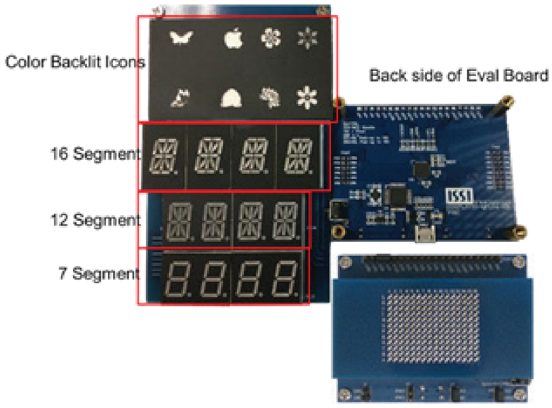

Figure 6 IS31FL3800 Single Chip Solution for HMI

Visit our website, www.lumissil.com to view the wide selection of LED drivers, download datasheets, application notes, example code and reference designs. Download a previous IS31FL3800 newsletter (https://tinyurl.com/Lumissil-Matrix-LED-Drivers1) article which has a more detail discussion on the available GUI and evaluation board.

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