Implement Extra Functions with the NCP5608 LED Driver

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APPLICATION NOTE

Abstract: With more than 500 mA output current capability, the NCP5608 is capable to drive the high power LED used in the portable photo flash system. Although the embedded I2C makes programming the chip very easy, it turns out that the flash can be trigged by the camera with no access to the I2C protocol. In this case, an extra function is necessary to support this specific pulse mode. This Application Note depicts a simple way to implement such a need without sacrificing extra GPIO at MCU level.

SHORT NCP5608 DESCRIPTION

The chip provides two independent blocks with four LED per block:

- Block#1: dedicated to the Back Light, support 30 mA per LED
- Block#2: dedicated to the Flash, support 100 mA per LED

The current of each block can be set up independently by means of the I2C protocol, the maximum current being accurately preset by an external resistor. On the other hand, using such an external reference yields a very tight matching between the LED of a given block: typical 0.2% matching is achieved without the need for extra adjustment.

The Charge Pump converter is capable to supply the total current continuously, assuming the PCB is designed to evacuate the heat coming from the operation.

Generally speaking, the two blocks are used for their respective function, but one can connect all the LED pins to a single power full LED to generate a 500 mA flash pulse. It is possible also to combine the LED to get the most appropriate function in a given application: sharing the Flash and the Torch becomes very easy to implement.

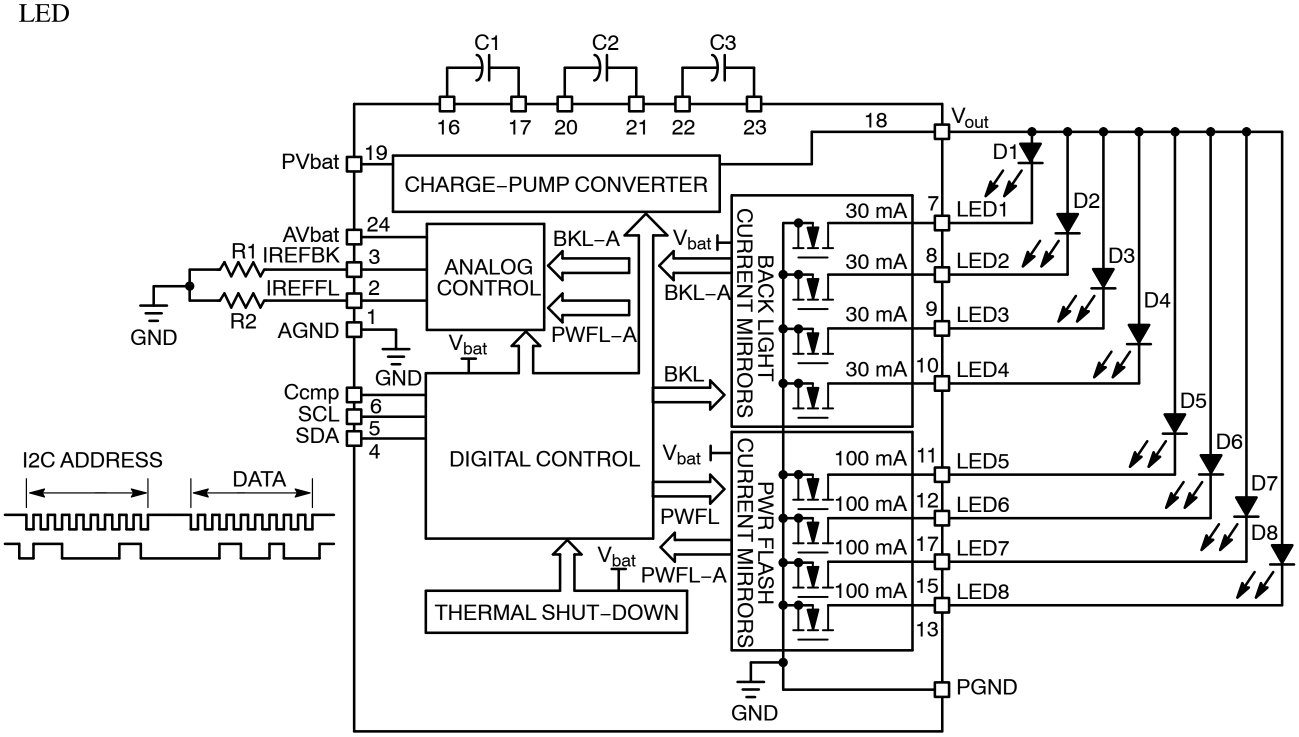

Figure 1. Basic NCP5608 Structure

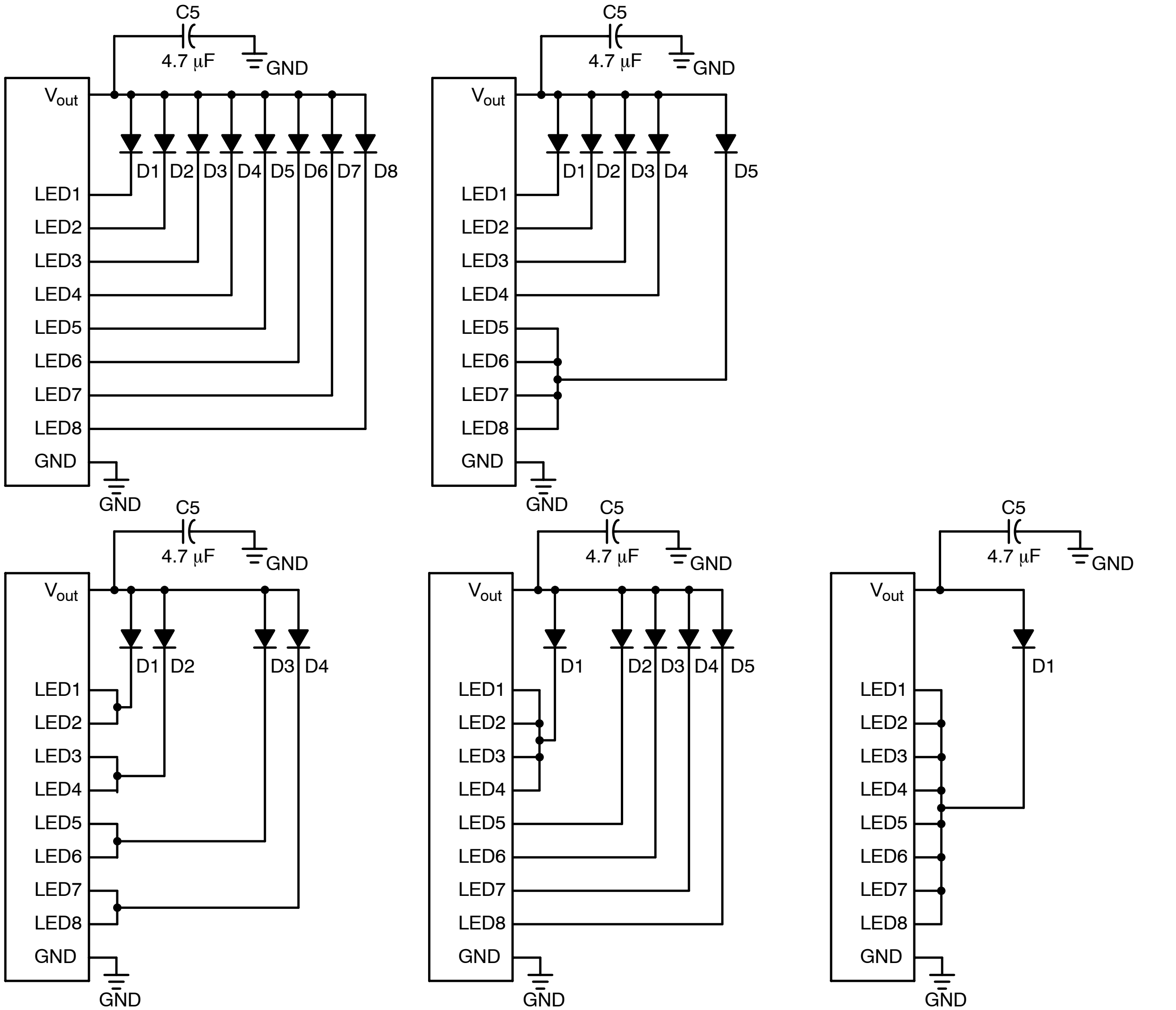

Figure 2. Basic LED Arrangement

Since they are independents, the blocks can run under different I−LED current, different lay−out and different timings. In both case, the I−LED current is regulated at the preset value. However, the internal registers do not make possible the set up of different current per LED. Similarly, there is no extra pin available to drive an Enable function since this is embedded into the I2C protocol.

EXTERNAL CONTROLS

Although no pins are available at NCP5608 package level, the current mirror technique used to set up the I−LED current brings flexibility to cope with special functions. As an example, one can implement a gradual dimming, a pulse flash, a flash/torch control, etc., with a few external components.

The simplified schematic diagram given Figure 3 depicts the current mirrors implemented into the chip. An integrated band gap reference gives an accurate and very stable 600 mV at the IREF pin, such a voltage being used to force a constant current through resistor R1, NMOS Q1 and PMOS Q2. The current is then mirrored and boosted by PMOS Q3 arranged with NMOS Q4. Finally, NMOS Q5 draws the same current, multiplied by the mirror ratio (see the NCP5608/D data sheet for the details) to bias the external LED. At this point, the current LED is then a function of resistor R14 and the content of the internal register: $I\text{−}LED = (V_{ref}/R1)*2^n$, with n = 0 to 5 for the back light and n = 0 to 7 for the power flash.

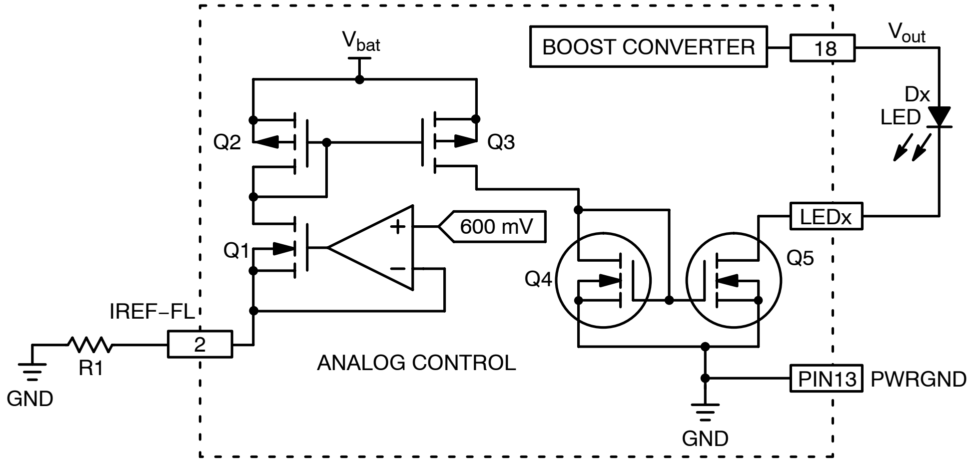

Figure 3. Typical NCP5608 Current Mirror

Consequently, it is possible to dynamically change the reference current during the operation of the chip, a mode we can implement into a pulsed flash structure.

PULSED FLASH

Although a single pulse is enough to illuminate a photo scene, one shall take care of the well known red eye mechanism. To solve this issue, a simple way is to generate one pre pulse before the final photo is taken: the first shot will force the pupils to close, reducing significantly the red eye effect, then send the main pulse to shot the photo. The proposed solution makes profit of the I2C protocol associated with the current mirror as depicted above.

The photo sequence will be controlled by the MCU and the camera, assuming the camera send the photo trig signal, the MCU being in charge of the pre−bias operation. To achieve such sequence, two resistors will be connected to the IREFFL pin:

– R2 = 30 kΩ → the maximum current will be 80 mA in the Power Flash block during pre bias cycle
– R6 = 5.6 kΩ → the maximum current will be 400 mA when the trigger pulse will be activated

The Back Light block is not affected by such operating conditions.

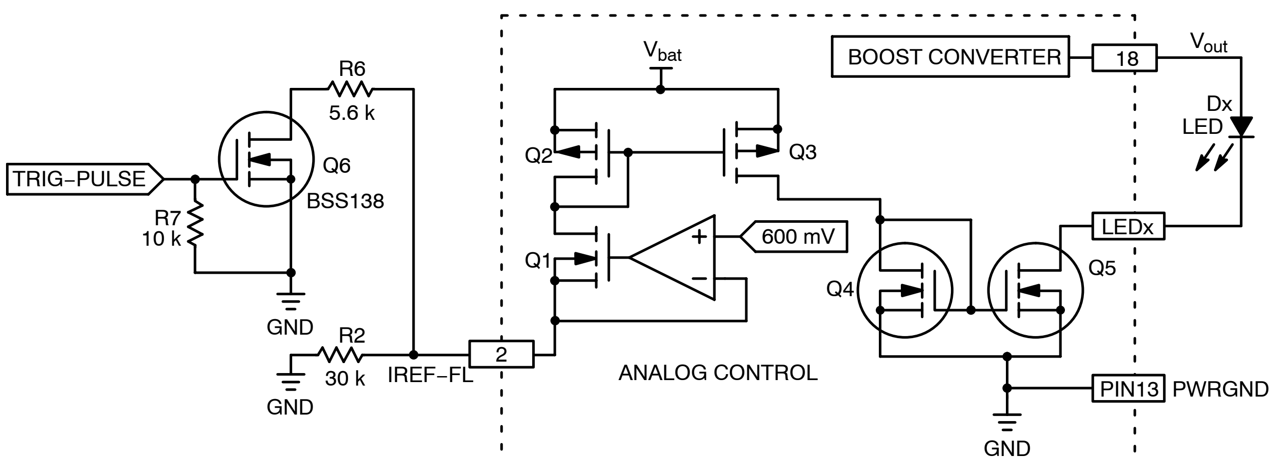

Figure 4. Dynamic IREF Structure

When the user pushes the photo trigger, the MCU first preset the I−LED current at the selected value: three bytes will be send over the I2C SDA line:

– $72 → select the NCP5608 I2C physical address, preset for a Write operation
– $02 → select the PWRFL register
– $64 → set I−LED = 100% of the reference current I−LED = 20 mA * 4

At this point, the PWRFL is in the pre condition mode and, beside the red eye effect, the MCU can run some measurements if the system is equipped with a photo sensor.

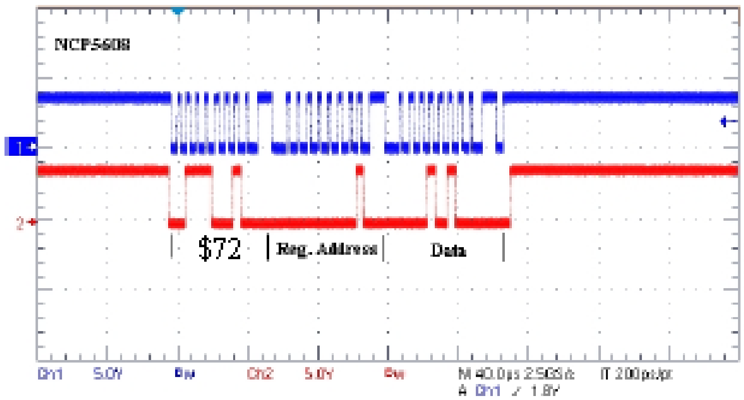

Figure 5. Power Flash Programming Sequence

When the camera is ready to take the picture, a trig pulse is send to the gate of Q1, thus connecting the second reference resistance to ground. As a consequence, the I−LED current increases to 100 mA per LED and the scene is properly illuminated.

The duration of the trig pulse depends upon the characteristics of the camera, the photo sensor (if any) and other environment conditions. Generally speaking, the pulse width ranges between 20 ms to 200 ms and the driver must be capable to maintain the full current during the sequence.

When the camera forces the trig signal to Low, the I−LED current returns to the pre bias conditions until the MCU switches OFF the flash function.

The function has been evaluated with the existing NCP5608 demo board modified as depicted in the schematic given Figure 6.

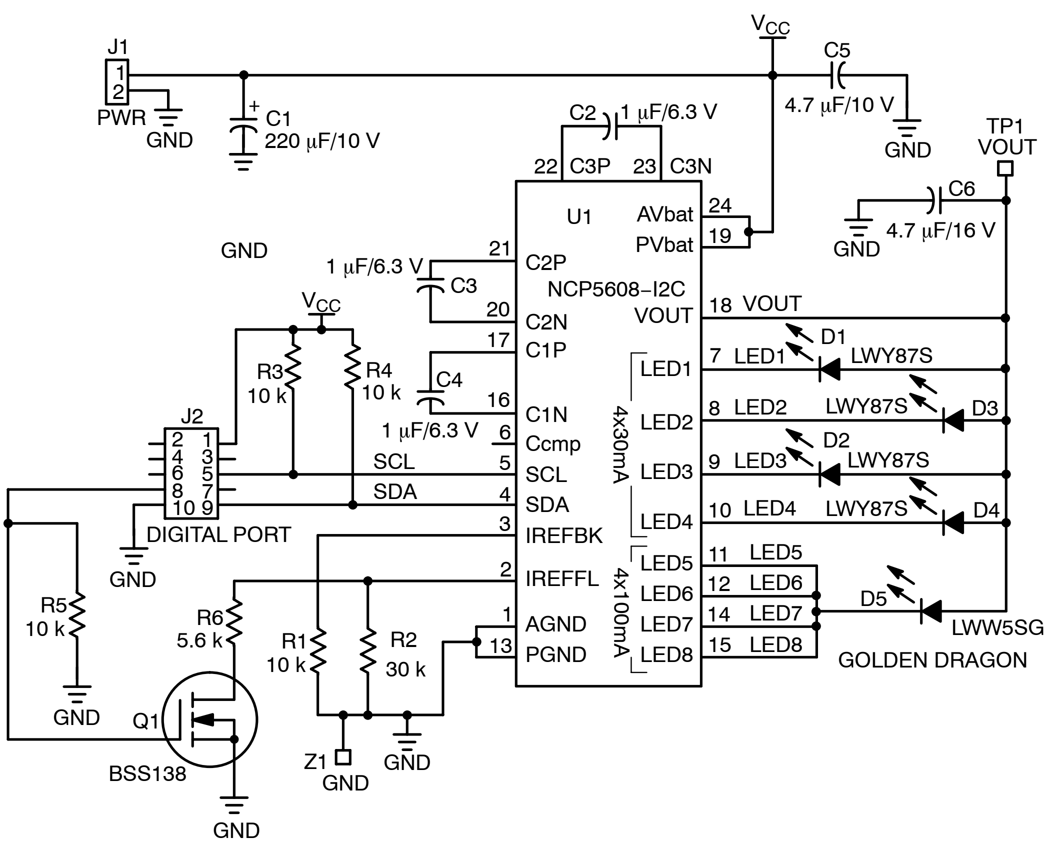

Figure 6. Modified NCP5608 Demo Board with Pulsed Flash Function

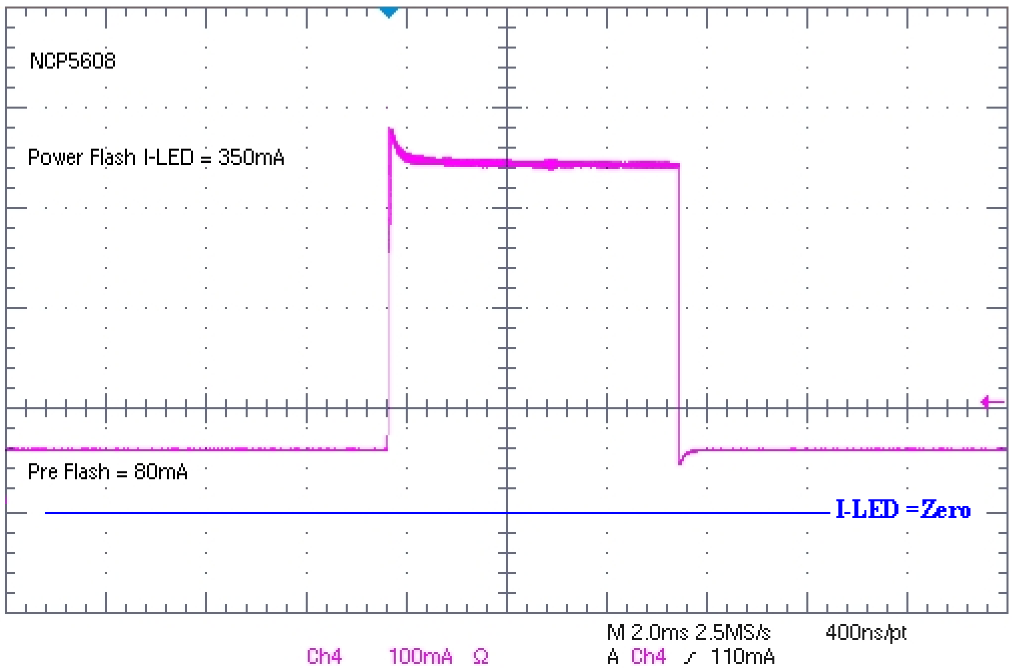

Figure 7. Typical Flash Pulsed Current

FLASH & TORCH

Although it is possible to use the same LED to support the Flash or the Torch function, some applications request one dedicated LED per function. In this case, sharing the Flash block cannot be achieved forwardly since the internal mirrors are driven by a common digital bus.

The discrete parts combining a NMOS and a PMOS in the same tiny package provide a simple way to solve the problem. As depicted in Figure 8, a digital multiplexed switch is built with the two external MOS devices associated to pull up resistors. The switches can be driven either by a single I/O and one inverter, or by means of two separates I/O at MCU level.

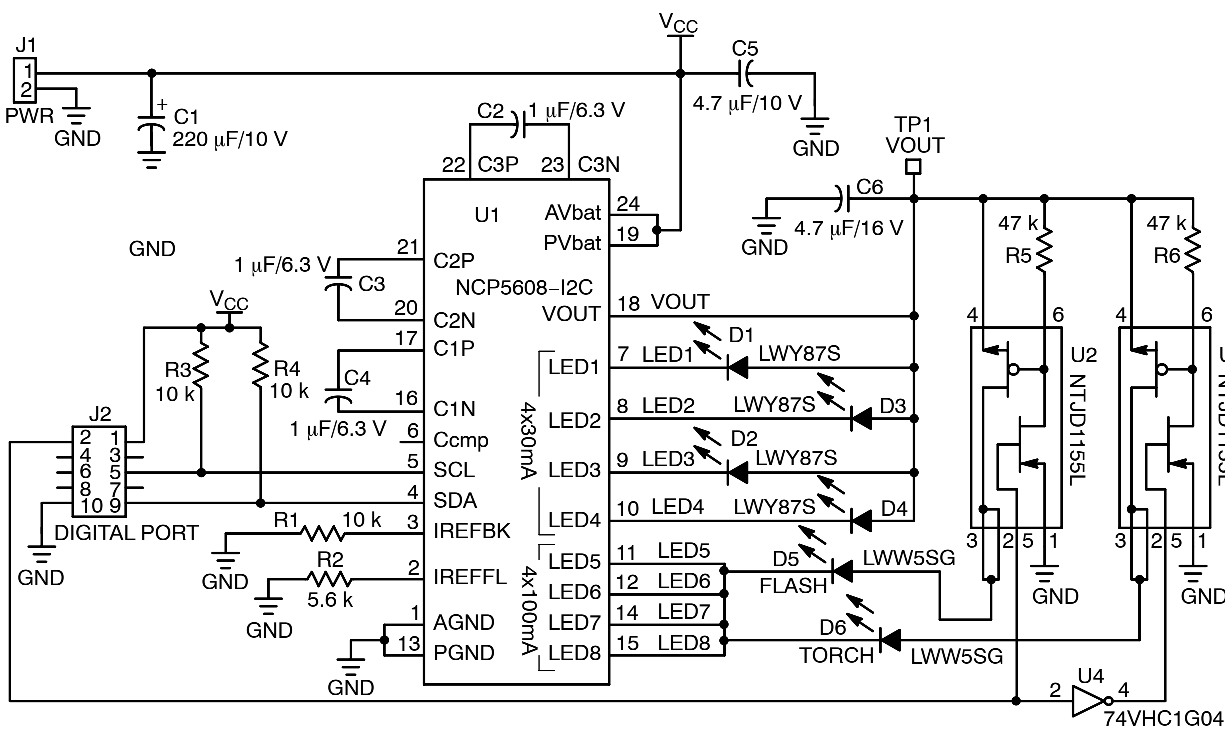

Figure 8. Multiplexed Flash & Torch System

GRADUAL DIMMING

The gradual dimming is a clever way to turn ON & OFF the display: there are no energy saving here, but a soft start illumination brings a more comfortable portable system. Such a function can easily be implemented at software level, the I2C protocol being the right tool to run such mode of operation. However, using the I2C implies using a relative large amount of software of the MCU just for a “fun” function: the Main micro−controller is largely occupied to monitor the system and might not be efficient to drive the gradual dimming.

Like the pulsed flash, we can make profit of the mirror current technique to implement the gradual dimming with just a few external components. Based on the schematic provided Figure 9, the MCU preset the I−LED current with the appropriate I2C message, then send the GDIM signal to activate the gradual dimming. The I−LED current increases gradually until the preset current value is reached. Similarly, the I−out current will decreases as the GDIM signal is Low.

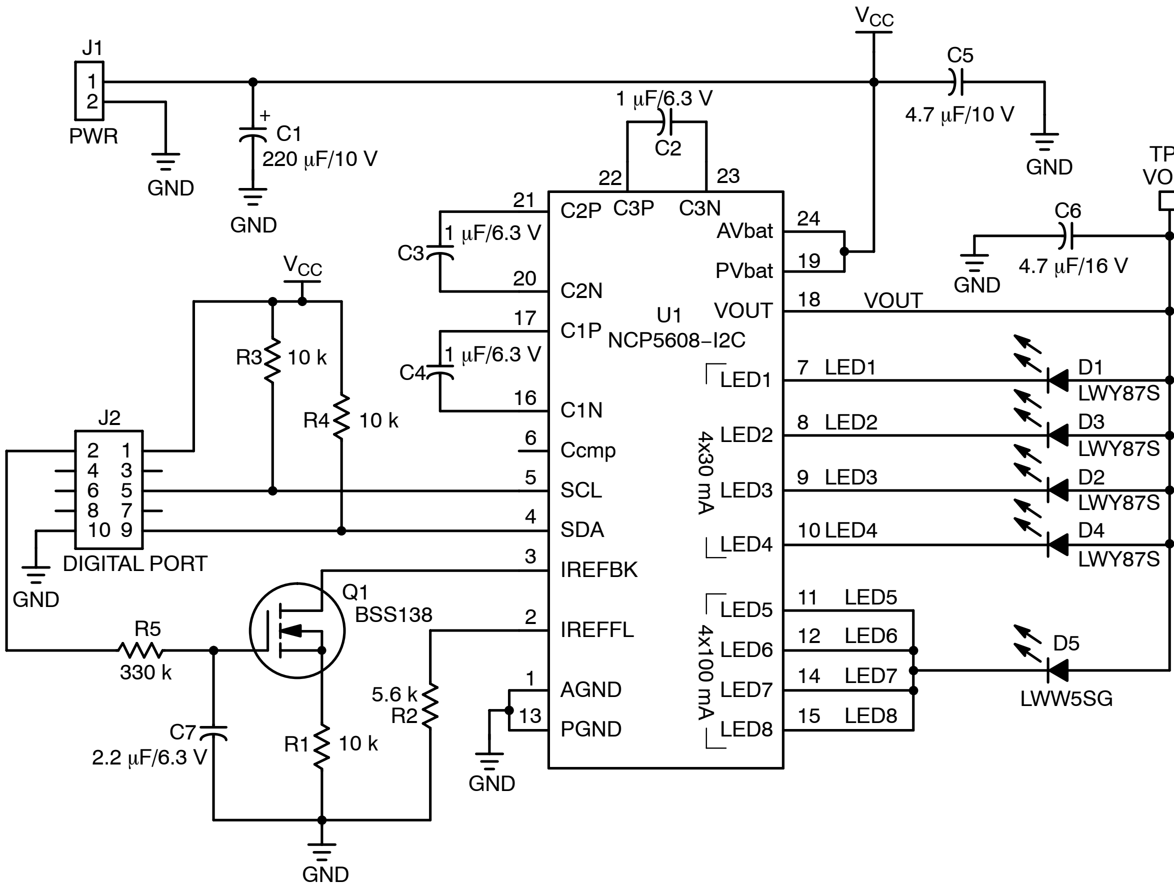

Figure 9. Back Light Gradual Dimming

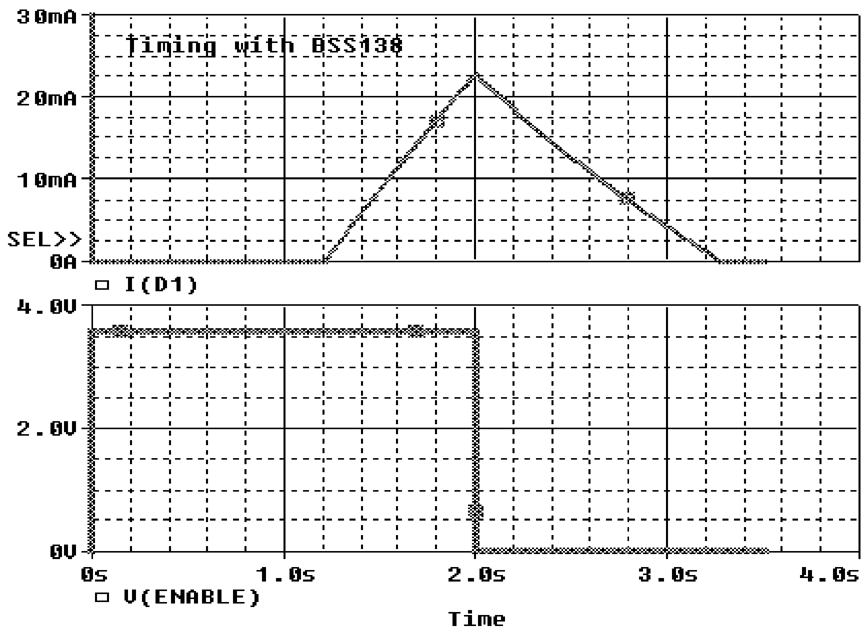

Figure 10. Typical PSPICE Gradual Dimming Simulation

SOFTWARE

The I2C protocol, widely used in the industry, is easy to implement into any MCU, even when the protocol is not included in the main chip. The evaluation boards, developed by the ON Semiconductor laboratory, are controlled by a simple but powerful 8 bits MCU from Freescale. All the software necessary to support the digital sequences are developed in assembler, but high level software can be used to create these routines.

Of course, programming the I2C protocol is easiest when such a feature is embedded into the MCU, but the development of similar function can be implemented in almost MCU, assuming the bit level instructions are available. The Application Note AND8267 (CONTROLLING THE NCP5602 WITH THE I2C SOFTWARE) provides a detailed example of such I2C control with a standard micro controller.

CONCLUSION

Although no extra pins are provided by the NCP5608 part beside the standard I2C protocol, some customer's specific functions can be implemented by using few external components. The pulsed power flash and the gradual back light dimming are easy to implement, bringing extra features for a very low cost.

The three examples depict in this Application Note can be combined in the same system, yielding more flexibility to support the customer's demands. From an I2C software stand point, none of the extra functions can be driven from the I2C, but dedicated pulses are necessary: these signals can be either GPIO pins or any standard logic output from a static controller.

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