NCP5603GEVB

High Efficiency Charge Pump Converter/White LED Driver Evaluation Board User's Manual

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EVAL BOARD USER'S MANUAL

Abstract

This evaluation board describes a multi-functional system, capable of generating and controlling the power needed to utilized three features available in modern cellular phones. In addition to larger displays, with full color capability, flash and torch features have now been added to support the embedded camera and the night path finder. These features are made possible by using an ultra bright LED powered by standard battery cells.

Basic Circuit Description

Since the LED have a forward drop voltage ranging from 3 V to 4.5 V, depending upon the forward current, a straightforward connection to a standard battery is not feasible as depicted Figure 2. A boost structure must be used to make the power supply voltage compatible with the LED.

On the other hand, combining three functions in the same system creates a special case since the converter must be capable of driving the wide current load needed for the different functions. The typical currents used to drive the LED, summarized in Table 1, range from a low 1 mA to 350 mA when the flash is activated. Moreover, unlike the xenon photo flash, the LED system must have a relatively long pulse of light to properly illuminate the scene. Typically, a xenon pulse has a 1 ms flash duration, the LED system being in the 100 ms to 200 ms range. Consequently, the converter must be designed to support such a large demand.

High powered LED capable to sustaining up to 800 mA are under development and drivers for these devices should be available within a few months.

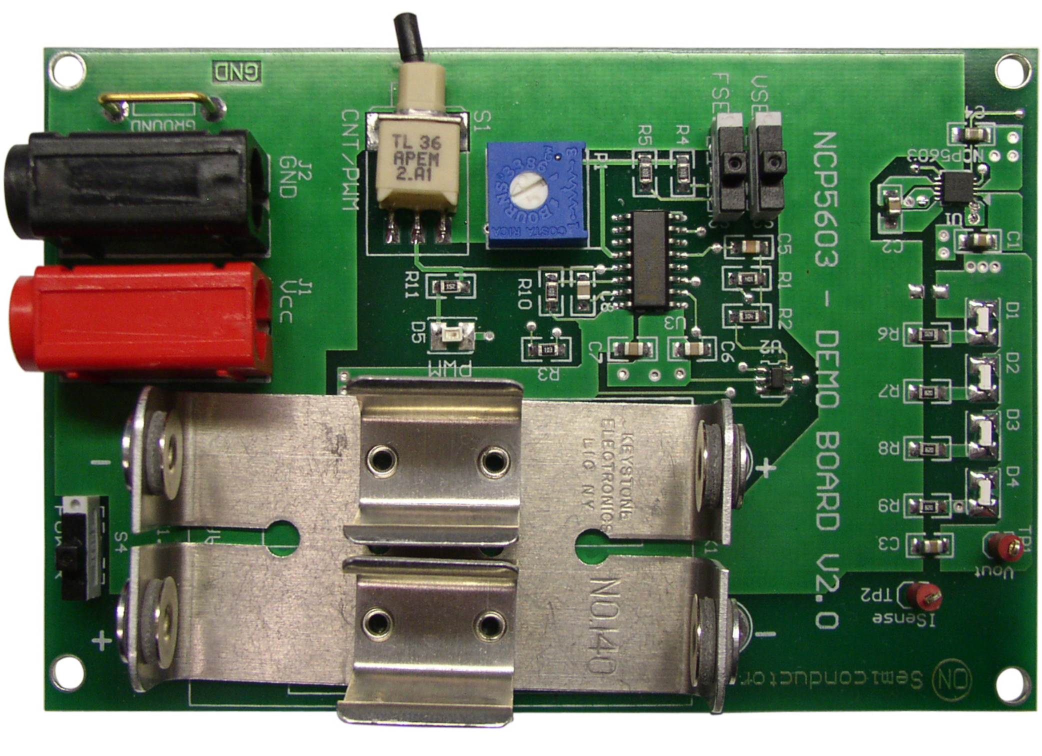

Figure 1. NCP5603GEVB

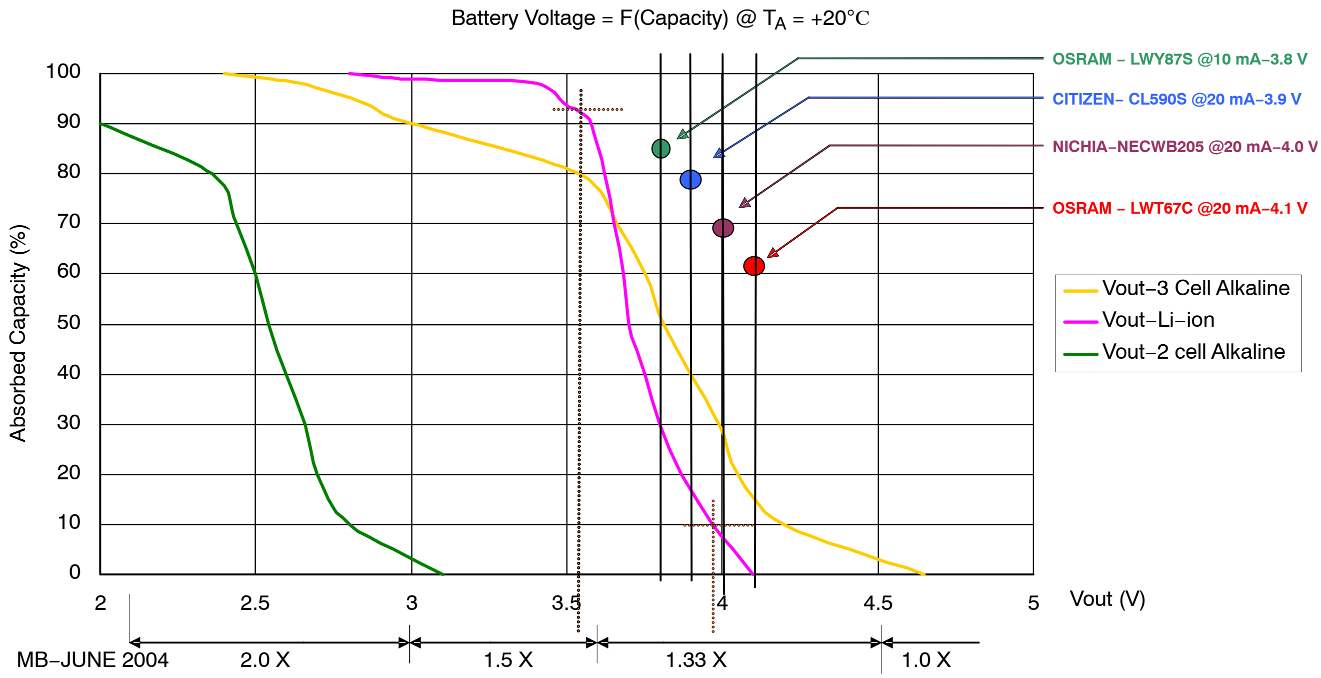

Figure 2. Typical Lithium-Ion Battery Voltage and White LED

Table 1. WHITE LED TYPICAL APPLICATIONS

LED	Backlight	Torch	Flash
OSRAM LWY85S	1 mA – 10 mA	–	–
OSRAM – LWT67C	1 mA – 20 mA	–	–
OSRAM	–	100 mA	–
OSRAM – LWW5SG	–	–	350 mA
CITIZEN – CL590S	1 mA – 20 mA	–	–
NICHIA–NECWB205	1 mA – 20 mA	–	–
LUMILED	–	–	800 mA

Along with the amount of current the converter provides, it is worthwhile to note the thermal behavior of both the silicon and the power LED.

According to the OSRAM's data sheet, the Dragon LED (LWW5SG) should have a maximum 4.5 V forward drop with 350 mA current. The power absorbed by the load will be 1.57 W and, assuming a 75% efficiency of the DC/DC converter, will translate to almost 2 W of input power. Consequently, some 400 mW will be dissipated as heat into the silicon and, according to the NCP5603 data sheet, the chip temperature will increase by $R_{\theta JA} \times Pin = 85 \times 0.4 = 34°\Delta C$. Such a temperature increase is acceptable since, even under the worst case +85°C ambient temperature, the junction will be below the maximum rating defined for this chip.

However, we must take into account the low battery situation: in this case, the efficiency of the converter can decrease and we end up with 60% efficiency, yielding almost 54°ΔC temperature increases. At this point, the silicon can rise above 125°C, under extreme high ambient temperature, and the global long-term reliability of the chip will be impaired. This can be avoided by either reducing the thermal resistance (using a heatsink by means of the PCB layer) or by ensuring the duty cycle is short enough to properly cool off the chip between pulses.

Generally speaking, the High Intensity LED are power limited and care must be observed to avoid any thermal run out during normal operation. This is particularly true for the flash mode in which, as depicted above, nearly 1.6 W are dissipated into the LED junctions. Because the junction to ambient thermal resistance is limited by the packaging of the LED, a good thermal contact to a dedicated layer on the printed board is essential. The LWW5SG specifications give a maximum 9°C/W junction-to-case thermal resistance, capable of limiting the temperature of the silicon to the 100°C maximum specified in the OSRAM data sheet. After dissipating 1.6 W, the maximum thermal to air resistance acceptable by the chip can be calculated as:

$$R_{\theta JA} = \frac{T_{jmax} - T_{amb}}{P_{chip}} =$$

$$= \frac{100 - 85}{1.6} = 9.37° C/W$$

Since the $R_{\theta JC}$ is 9°C/W, it is practically impossible to achieve a 0.38°C/W case to ambient thermal resistance and the only alternative is to limit the operating ambient temperature.

Assuming $T_{amb} = 60°C$, then $R_{\theta JA} = (100-60) / 1.6 = 25°C/W$.

In this case, the case-to-ambient thermal resistance is 25 − 9 = 16°C/W, a value more realistic, although not so easy to achieve with a room limited PCB.

NCP5603 operates without special treatment in terms of thermal sinking and a simple copper flag is built underneath the QFN package as depicted Figure 6.

The schematic of the multiple application, Figure 3, illustrates the three functions:

- Backlight → four LED in parallel, dimming capability
- Torch → one LED, no output adjustment
- Flash → one power LED, pulse width adjustable

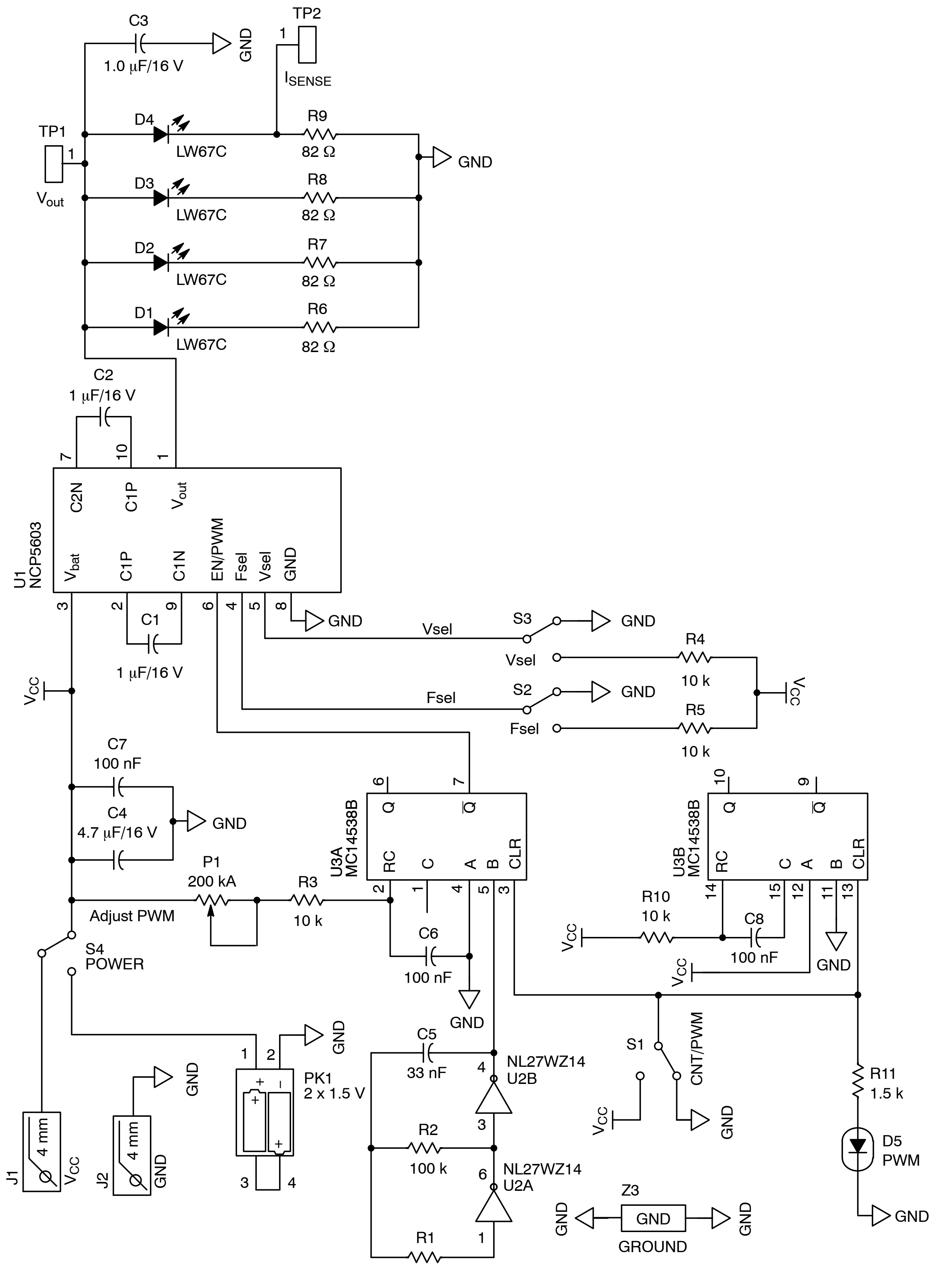

Figure 3. NCP5603G Evaluation Board Schematic

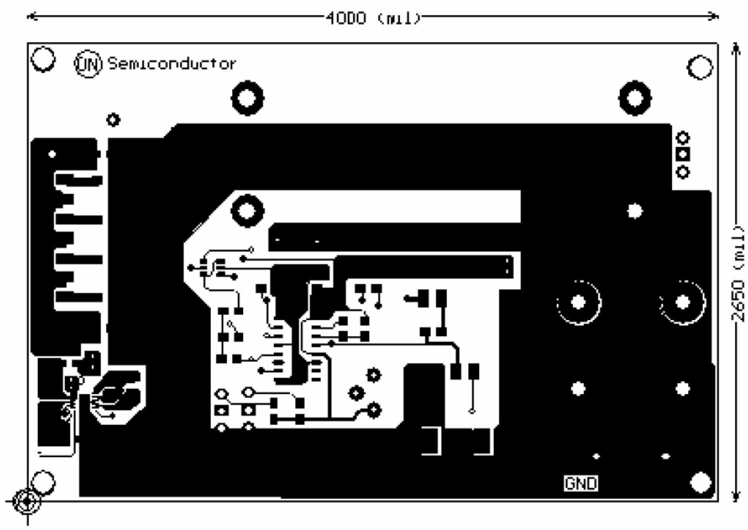

Figure 4. Top Layer

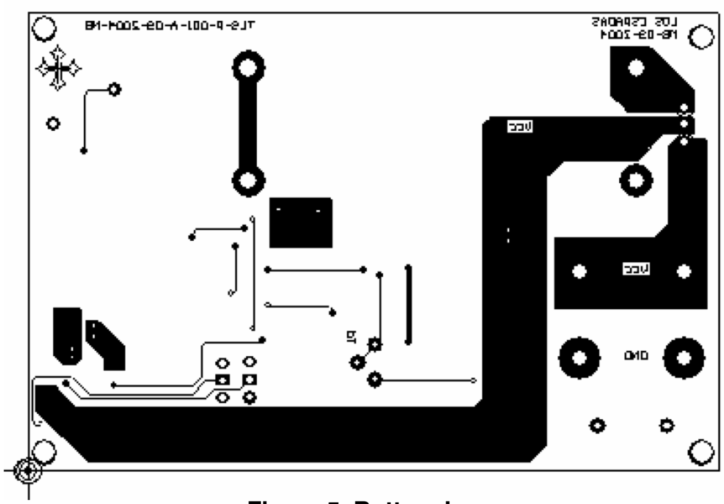

Figure 5. Bottom Layer

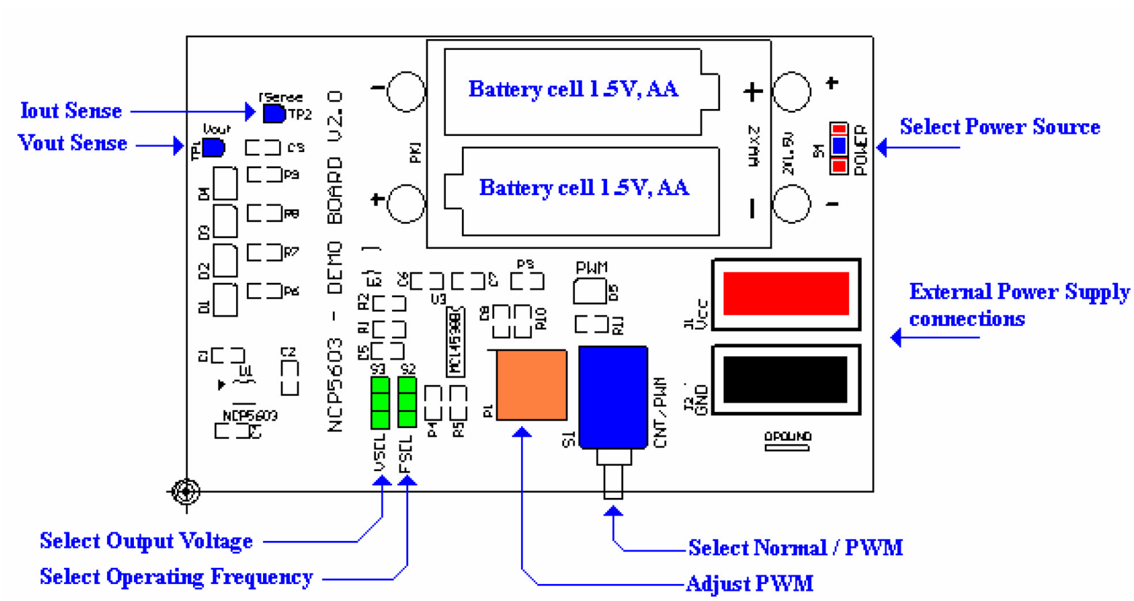

Figure 6. Silk Layer (Top View)

The system is powered by two AA cells in series, assembled in a standard battery holder, the operating mode being selected by the S1, S5 and S6 switches. Since the total current is limited by the DC/DC converter, the backlights LEDs are automatically deactivated when either the Torch or the Flash are selected. Moreover, the Flash is not available while the Torch is running.

An extra feature, backlight dimming, is provided by switch S1 is associated with potentiometer P1. When the switch is connected to ground, the NCP5603 enabling pin EN is high and the brightness is maximized. When the switch S1 is flipped to the Vcc position, the RESET of U5A is released and the EN pin is clocked High/Low by the clock generated by U2A/U2B. Simultaneously, diode LED D7 turns ON to identify the PWM mode of operation. The duty cycle of the U5A/$\overline{Q}$ output is manually adjusted by potentiometer P1 to set the brightness of the four associated LED.

The efficiency of the system has been evaluated at room temperature (see Table 2), the results being fully within the NCP5603 data sheet specifications.

Table 2. EVALUATION BOARD EFFICIENCY

V_{bat}	I_{bat}	V_{out}	I_{out}/LED	I_{out} Total	Yield	Comments
3.50 V	2.3 mA	0 V	0 mA	0 mA	–	No Load
3.50 V	132 mA	4.42 V	16.5 mA	66 mA	63.14%	
3.50 V	170 mA	4.92 V	21.4 mA	85.6 mA	70.78%	
3.10 V	131 mA	4.42 V	16.5 mA	66 mA	71.83%	
3.10 V	169 mA	4.92 V	21.4 mA	85.6 mA	80.38%	
3.10 V	300 mA	4.92 V	142 mA	142 mA	75.12%	Torch operation

The inrush current is internally limited by the chip, as depicted Figure 7, and no uncontrolled current takes place when the system starts up from scratch.

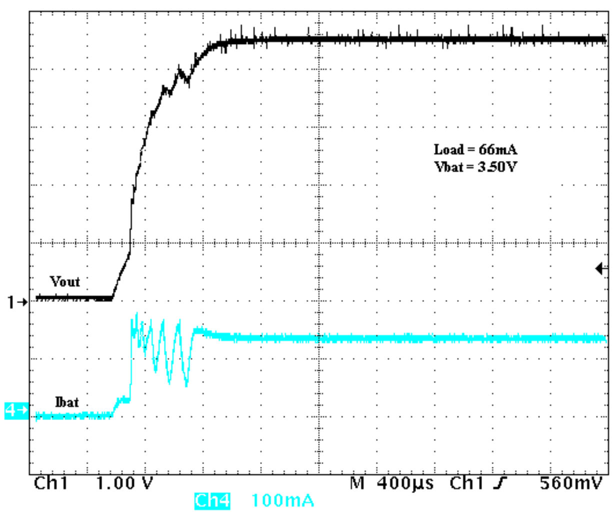

Figure 7. Typical Startup Timing

With a startup time well below 1 ms (from zero to full Vout, see Figure 7), the NCP5603 is fast enough to accommodate a flash application as shown in the demo board.

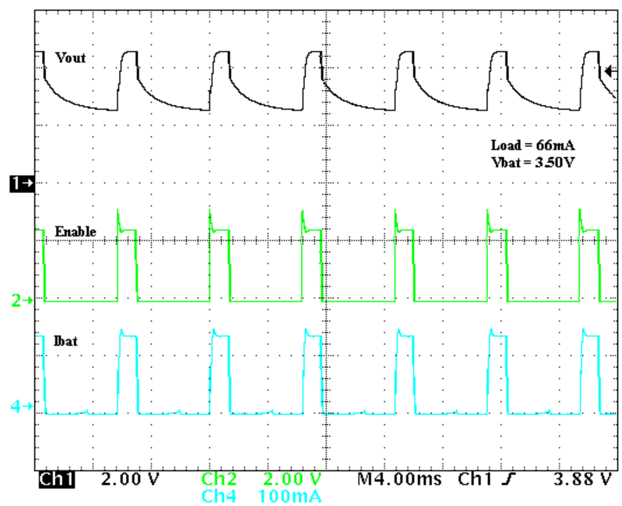

Figure 8. Typical Digital Dimming

Although there is no dedicated pin, the LED brightness can be dimmed by means of the EN digital control. The waveform captured in Figure 8 illustrate this behavior, the PWM being intentionally arranged out of the audio band for a portable system.

TEST PROCEDURE

Test Conditions

The evaluation board can operate with either an external power supply, or with two dry cell 1.5 V, AA type, and battery. The mechanical switch S4 is used to select one of the two power sources. The system is not designed to run the two power sources simultaneously and such connection must be avoided.

Using an External Power Supply:

1. Select a DC power supply with 500 mA output current capability (minimum), adjust the output voltage to 3.60 V
2. Connect the positive wire to the RED socket, connect the negative wire to the BLACK socket
3. Toggle switch S4 to turn on the system

Using Dry Cell Battery:

1. Make sure no external power supply is attached to the RED and BLACK sockets
2. Insert two 1.5 V, AA type cell in the holder. Make sure the polarity is properly respected
3. Toggle switch S4 to turn on the system

System Operation:

4. Select the Output Voltage (4.5 V or 5.0 V) by toggling the switch S3, B1
5. Select the operating frequency (260 kHz or 630 kHz) by toggling the switch S2, FSEL. Note: turn system off before switching frequency.
6. Select the Normal or PWM mode by toggling the switch S1. A RED LED turns On when the PWM mode is activated. The brightness of the LED (if necessary) can be adjusted (when the PWM mode is activated) by means of the potentiometer P1.

Table 3. BILL OF MATERIALS FOR THE NCP5603 EVALUATION BOARD

Designator	Qty.	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	RoHS Compliant
U1	1	NCP5603 Charge Pump	NA	NA	QFN10	ON Semiconductor	NCP5603MNR2G	No	Yes
U2	1	Dual Schmitt Trigger Inverter	NA	NA	TSOP−6	ON Semiconductor	NL27WZ14DTT1G	No	Yes
U3	1	Dual Retriggable One Shot	NA	NA	SOIC−16	ON Semiconductor	MC14538BDG	No	Yes
R1, R2	2	Resistor	100 kΩ	5%	0805	Vishay	CRCW08051040JNEA	Yes	Yes
R3, R4, R5, R10	6	Resistor	10 kΩ	5%	0805	Vishay	CRCW08051030JNEA	Yes	Yes
R6, R7, R8, R9	4	Resistor	82 Ω	5%	0805	Vishay	CRCW080582R0JNEA	Yes	Yes
R11	1	Resistor	1.5 kΩ	5%	0805	Vishay	CRCW08051530JNEA	Yes	Yes
C1, C2, C3	3	Ceramic Capacitor	1 μF, 10 V	10%	0805	Murata	GRM219R61A105KC01D	Yes	Yes
C4	1	Ceramic Capacitor	4.7 μF, 10 V	10%	0805	Murata	GRM219R61A475KE19D	Yes	Yes
C5	1	Ceramic Capacitor	33 nF, 50 V	10%	0805	Kemet	C0805C333K5RACTU	Yes	Yes
C6, C7, C8	3	Ceramic Capacitor	100 nF, 50 V	10%	0805	Kemet	C0805C104K5RACTU	Yes	Yes
J1	1	Banana Socket	NA	–	PLUG_4MM	Deltron Components	571−0500	Yes	Yes
J2	1	Banana Socket	NA	–	PLUG_4MM	Deltron Components	571−0100	Yes	Yes
D1, D2, D3, D4	4	LW Y87S White LED	NA	NA	OSRAM_LED	Osram	Q65110A1709	Yes	Yes
D5	1	HYPER MINI TOPLED	NA	NA	OSRAM_LED	Osram	Q65110A2364	Yes	Yes
TP1, TP2	2	Test Point	NA	NA	TEST_POINT	Keystone	5005	Yes	Yes
P1	1	ADJ. Potentiometer	200 kΩ	NA	VR−4	Bourns	3386F−1−204LF	Yes	Yes
PK2	1	AA Battery Pack	NA	NA	BPACK2	Keystone	2223	Yes	Yes
S1	1	Manual Switch	NA	NA	APEM_CMS	APEM	TL36WS84000	Yes	Yes
S2, S3, S4	3	Manual Switch	NA	NA	SIP3	EAO	09.03290.01	Yes	Yes
Z3	1	Ground	NA	NA	GND_TEST	Harwin	D3082−05	Yes	Yes

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