AND9177/D

How to Support Firmware Download Without Battery Using NCP1854

ON Semiconductor®

http://onsemi.com

APPLICATION NOTE

Introduction

The NCP1854 is a fully programmable single cell Lithium−ion switching battery charger optimized for charging from a USB compliant input supply and AC adaptor power source. The device integrates a synchronous PWM controller, power MOSFETs, and the entire charge cycle monitoring including safety features under software supervision. An optional battery FET can be placed between the system and the battery in order to isolate and supply the system.

During factory firmware download, the battery might not be connected and the system can be supplied by +5 V USB: the system is connected to an USB host (i.e. PC) only. In normal operation, NCP1854 state machine is designed to support this mode of operation if a BATFET is present and if the application processor can configure NCP1854 to factory mode within 32 seconds after Power Up Reset. In factory mode condition, the NCP1854 is locked in Weak Wait state (DCDC enable and no weak charge, refer to Charging Process figure in Datasheet). The factory mode is enabled through the FTRY pin or through I^2C (Register CTRL1 Bit FCTRY_MOD_REG) according to the following logic table.

FTRY pin	FCTRY_MOD_REG	FTRY_MODE (Factory mode)
0	0	Enable
0	1	Disable
1	0	Disable
1	1	Enable

Remark: The charge current loop (ICHG) and input current loop are disabled in factory mode so full power is available for the system.

Through I^2C the device is entirely programmable so the controller can configure appropriate current and voltage threshold for handle factory testing.

Support Firmware Download Without Battery

In some cases customer may don't want to use this BATFET for cost down reason, while still want to support this firmware download function without battery, which is not a standard application that NCP1854 is originally expected to cover. This part can still support this kind of degraded factory mode, also called 'pseudo factory mode' here.

This app note is just used to describe how to support this mode with NCP1854.

Below Figure 1 is a typical NCP1854 schematics without BATFET which need to support this 'pseudo factory mode'.

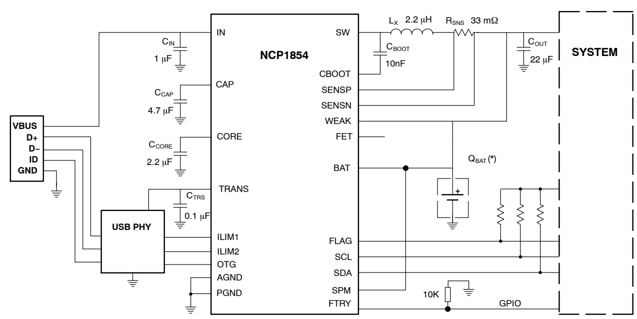

Figure 1. Application Circuit for Support Pseudo Factory Mode

Compare with the standard schematics with BATFET, there's some change for pin connection need to follow as listed below:

Pin connection configuration:

1. FET pin left floating
2. SPM pin connect to BAT directly
3. FTRY pin pull low through 10K to GND, also connect to AP GPIO
4. ILIM1 = 1, ILIM2 = 0 (floating) to set input current limit to 500 mA

FET pin Left Floating:

For NCP1854 state machine, FET pin left floating is similar than connecting it to a real BATFET gate terminal as both behave in high impedance. So, during BATFET detection (IC initialization), NCP1854 will be considering that a battery FET is present.

SPM pin connect to BAT:

If there's no battery present or VBAT = 0, NCP1854 state machine will switch from Wait sate to Weak Wait state, and if the application processor can configure NCP1854 to factory mode within 32 seconds, the IC will be able to keep

in the Weak Wait state stably. If there's battery connected on the application or SPM = VBAT = 1, NCP1854 state machine will switch from Wait state to Safe Charge state, so Full Charge Mode will be active.

FTRY pin pull low:

From above description, if the application processor can configure NCP1854 to factory mode within 32 seconds in no battery condition, or can configure FTRY pin to 1 within 32 seconds (I^2C communication is not available during firmware download period, and Register CTRL1 Bit FCTRY_MOD_REG is 1 in default), NCP1854 will keep in Weak Wait state, and this 'pseudo factory mode' now is active.

Drawback of this Method

If battery is in dead or weak state (fully discharged), which means SPM = VBAT = 0, NCP1854 can NOT distinguish the difference between weak battery or no battery from this signal.

In factory mode, the charge current loop (ICHG) and input current loop are disabled, so, for safety reason, it is important to make sure that FTRY pin is tied to 0 by default to disable the factory mode.

With no battery or weak battery and FTRY pin set to 0, NCP1854 would operate in Weak Safe state (with about 40 mA charging current) first.

Then, depending on the required operating mode, Application processor has to configure FTRY pin to high level within 32 seconds to switch to Weak Wait state if firmware download without battery has to be supported.

The main problem is when firmware download is not required and the battery is fully discharged. In this case, with FTRY tied to low level, the charger IC would wake up a fully discharged battery pack by charging with this Weak Safe charge current until voltage recovers to above the pack Under Voltage (UV) protection level (normally in the range of 2.8 V ~ 3 V, but in the worst case lowest battery pack UV level might be close to 2.5 V). Then NCP1854 would begin to operate in Weak Charge mode. In that mode, the **max charging current would be about 0.9 A at 2.5 V VBAT condition: assuming 90 % DC to DC efficiency and 500 mA input current limit active.** Though this big charging current period normally would be much shorter to raise the battery voltage from 2.5 V to 2.8 V, 0.9 A current might still be too high for some battery depending on their specification and technology. This point will need to be carefully checked with battery pack vendor. Another solution would be to set the battery pack UV protection level ≥ 2.8 V: when VBAT > 2.8 V, Weak Charge behavior is similar as full charge mode.

It will be also needed to avoid weak battery hot plug in at this 'pseudo factory mode' for the same reason.

Verification

With pin connection mentioned above, Figure 2 is a typical start up waveform with FTRY pin configured from 0 to 1 within 32s with no battery connected on the application. NCP1854 switched from Weak Safe state to Weak Wait state according to the high level of FTRY pin, and then locked in Weak Wait state just like operate in the normal factory mode.

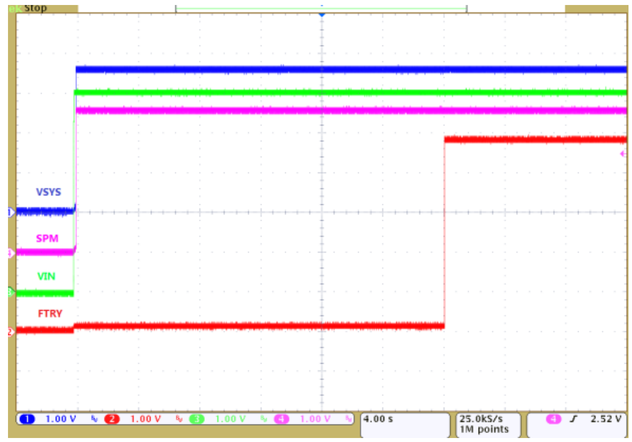

Figure 2. Typical Start Up Waveform with FTRY Pin Configuration without Battery

Improvement Solutions

To improve the drawback described above with fully discharged battery, a new solution is recommended as showed in Figure 3.

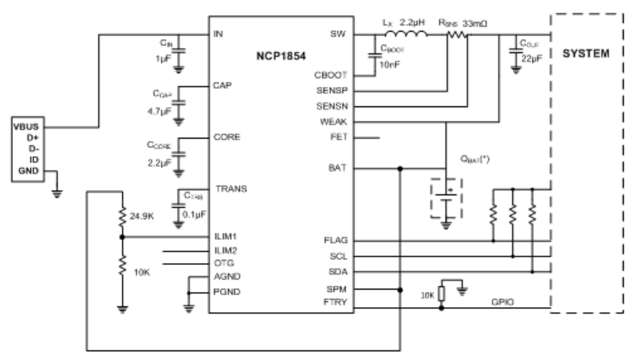

Figure 3. Application Circuit for Support Pseudo Factory Mode and Safely Charging for Weak Battery

Compare with Figure 1, the only difference is ILIM1 pin connection: ILIM1 connected to the center of a resistor divider between BAT and GND. Resistor between ILIM1 and BAT is 24.9 KΩ, between ILIM1 and GND is 10 KΩ.

As ILIMx pin high level threshold is about 0.88 V(within 10% tolerance in full temperature range), battery needs to be charged up to 3.1 V to configure the Input current limit to 500 mA (ILIM1 = 1, ILIM2 = 0) from original 100 mA (ILIM1 = 0, ILIM2 = 0) based on this pin connection. So for battery voltage below 2.1 V, the charging current is about 40 mA (Weak Safe); for battery voltage between 2.1 V to 3.1 V, the input current is limited to 100 mA; for battery voltage above 3.1 V, input current limit is 500 mA. This allows safer operation for the battery.

Figure 4 shows the start up waveform with a fully discharged battery pack at this configuration, max charging current is less than 180 mA for battery voltage below 3.1 V.

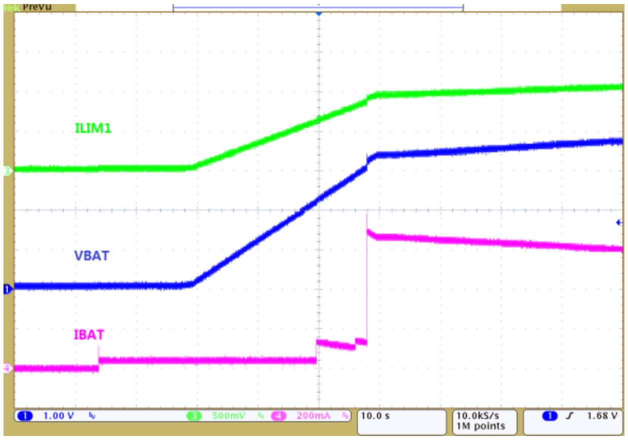

Figure 4. Start Up Waveform with a Fully Discharged Battery Pack

However the resistor divider is connected directly between BAT and GND. This configuration will reduce the battery life due to the 100 μA ~ 120 μA leakage current drawn by this resistor divider.

If this leakage can NOT be acceptable, the resistor divider connection can be changed to connect BAT and FLAG as showed in Figure 5.

FLAG is an open drain pin. The pin is at low level while charger is in active and wait states. When charge is completed or disabled or a fault occurs, the FLAG pin is high as the charge is halted. So charging process is nearly same as solution in Figure 3 but leakage current through bridge resistor network would only occur while power is present at IN pin.

Refer to Figure 6 for a charging profile. FLAG pin low level (25 ~ 35 Ω on impedance) tolerance would enlarge a little the battery voltage level that triggers the ILIMx threshold. This usually can be ignored since FLAG pin sink current is less than 1 mA.

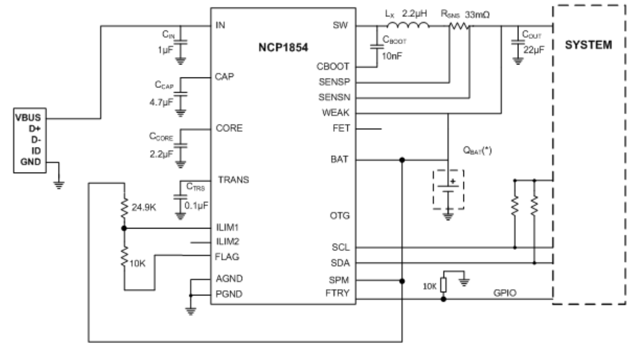

Figure 5. Application Circuit for Support both Pseudo Factory Mode and Weak Battery without Leakage Current

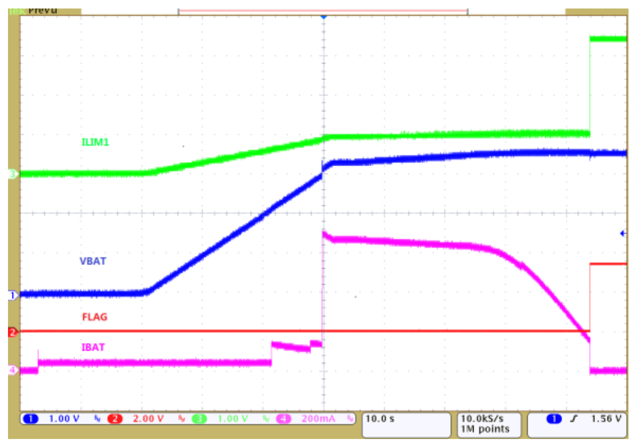

Figure 6. Charging Profile with Solution in Figure 5.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
Phone: 303−675−2175 or 800−344−3860 Toll Free USA/Canada
Fax: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800−282−9855 Toll Free USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910
Japan Customer Focus Center
Phone: 81−3−5817−1050

ON Semiconductor Website: **www.onsemi.com**

Order Literature: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative