SIERRA WIRELESS

External Battery Charging Solution
WM_DEV_MOD_APN_002-002

Author:	Sierra Wireless	Date:	February 18, 2010

APN Content Level	BASIC		INTERMEDIATE	✓	ADVANCED		Confidentiality	Public	✓	Private	

Software Compatibility*	FW:	N/A	Software Suite:	N/A	Plug-Ins:	TCP/IP	N/A	Security	N/A	Compiler Used:	N/A	Reference Hardware	Yes
						Internet	N/A	LUA	N/A			Reference Software	No
						C-GPS	N/A			RTE :	N/A		

** refer to software compatibility matrix section for more detail*

Hardware Compatibility									
	AirPrime Q Series :	Q2686	✓	Q2687	✓	Q26Extreme	✓	Q26Elite	
	AirPrime WMP Series :	WMP50	✓	WMP100	✓	WMP120	✓	WMP150	✓
	AirPrime WS Series :	WISMO218		WISMO228					
	AirPrime AR Series	AR3550		AR5550		AR8550			
	AirLink FXT Series :	Fastrack Xtend GPRS	✓	Fastrack Xtend EDGE	✓	Fastrack Xtend HSPA	✓	Fastrack Xtend CDMA	
	Legacy products (GSM):	Q24Classic	✓	Q24Plus	✓	Q24Extended	✓	Q24Auto	✓
		Fastrack Supreme	✓	Q64	✓	Q52 Omni			
	Legacy products (CDMA):	Q2438F		Q2438R					

1 Version

Application Notes may be updated over their lifetime. To ensure you design with the correct version, please check the application notes page in www.sierrawireless.com for latest versions.

2 Introduction

This APN (Application Note) is provided to Sierra Wireless distributors and clients to aid more rapid development of embedded applications using the Sierra Wireless portfolio of cellular solutions. To request a new application note, contact your regional Sierra Wireless Product Marketing Manager.

3 Application Note Description

This application note describes how to interface an external battery charging solution with an AirPrime Intelligent Embedded Module.

This application note is useful for customers who have the following requirements:

- Li-Polymer battery used
- Possible drops of the battery voltage below its over discharge threshold (~2.8V).
- Only a DC voltage source available to charge the battery (impossible to connect an external charger).

4 Abbreviations

Abbreviation	Definition
ADC	Analogue to Digital Converter
C	Nominal Battery Capacity
DC	Direct Current
N/A	Not Applicable
NTC	Negative Temperature Coefficient
Li-ion	Lithium-ion
PCM	Protection Circuit Module

5 Battery Charger Interface

5.1 Application synoptic

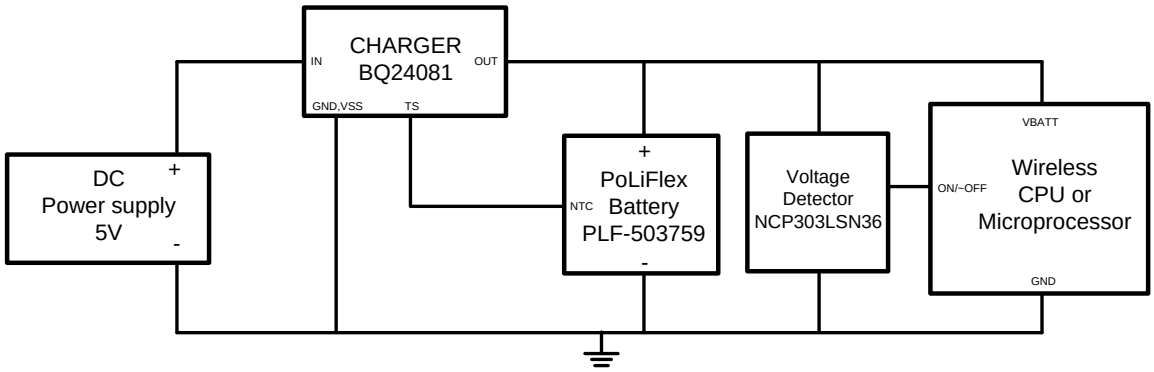


Figure 1. *Figure 1: Synoptic of the charger interface*

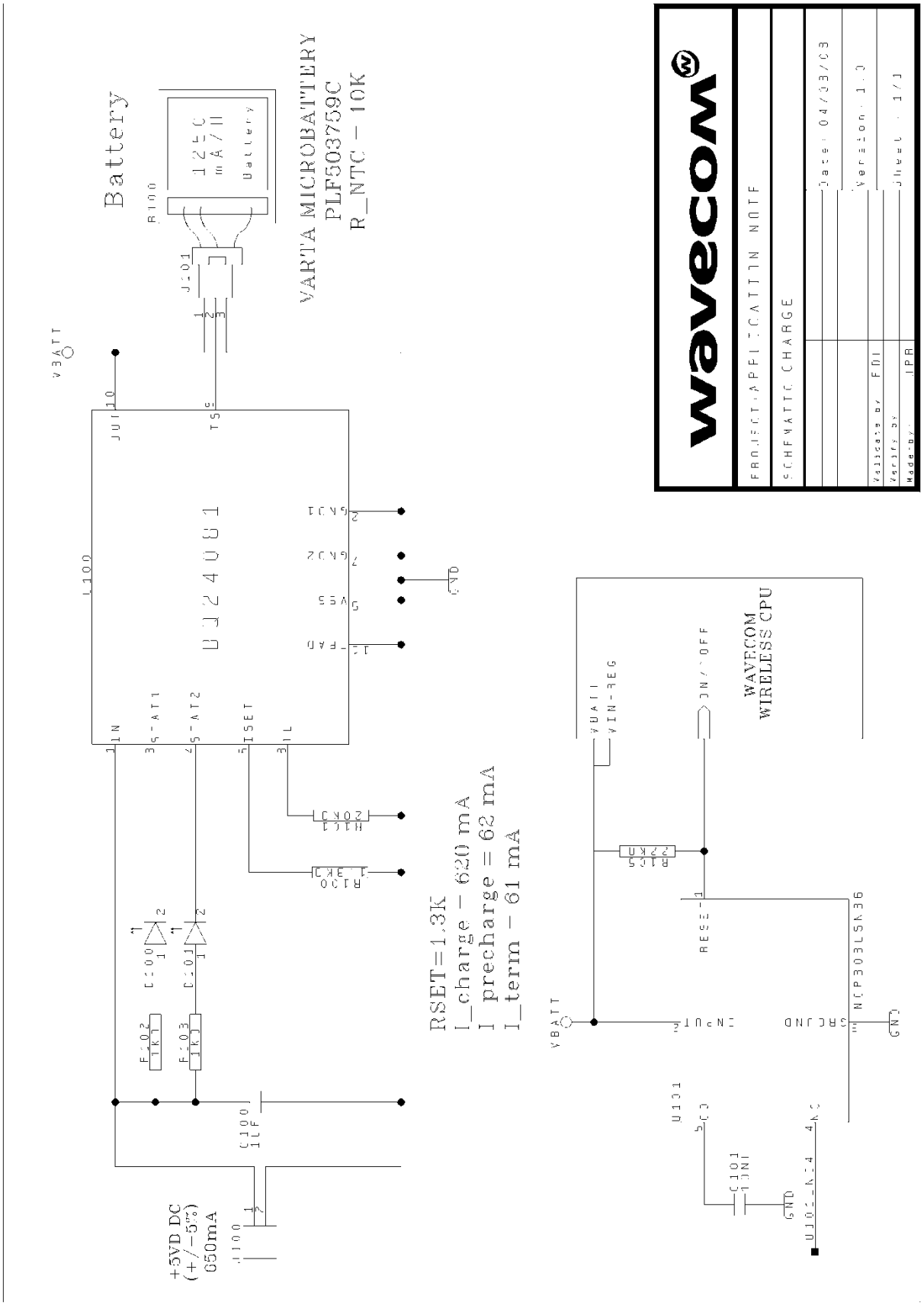
5.2 Description

The battery charger is power supplied by a +5V DC voltage source.

The battery charging current and voltage are monitored and controlled by the charger. A NTC included inside the battery allows the charger to monitor battery temperature and so to stop the charge if an over or under charging temperature is detected.

Pre-charge, charge, and end of charge currents are set thanks to the resistor R100. The charger integrates a dedicated algorithm for Li-ion batteries. The PLF-503759 battery is a Li-Polymer battery that can be charged with the same algorithm as Li-Ion ones. Two signals (STAT1 and STAT2) can be used to monitor the charging status. A voltage detector sets the ON/~OFF signal at high level once the battery voltage has reached a pre-defined value (3.8V) and so the module starts.

5.3 Schematics

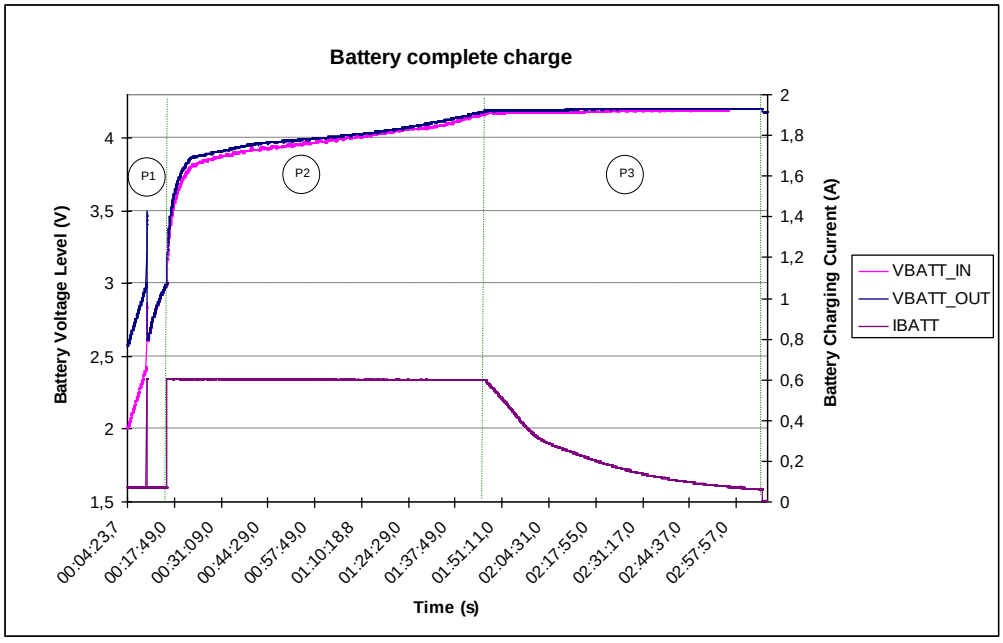


5.4 Bill of material

INDEX	FUNCTION	VALUE	TOL.	PACK	MANUFACTUER	DEVICE	QUANTITY
U101	VOLTAGE DETECTOR	-	-	NCP303LSN36T1	ON SEMI	NCP303LSN36	1
C101	CAPACITOR	10NF	+/-10%	C0603	-	C0603	1
C100	CAPACITOR	1UF	+80/-20%	C0603	-	C0603	1
R102, R103	RESISTOR	1KO	+/-5%	R0603	-	R0603	2
R101	RESISTOR	20KO	+/-1%	R0603	-	R0603	1
R105	RESISTOR	22KO	+/-5%	R0603	-	R0603	1
J100	CONNECTOR	-	-	WLD508-2CM	-	WLD508-2CM	1
D100, D101	GREEN LED	GREEN - HSMG		HSMX_C190	ROHM	HSMX_C190	2
J101	CONNECTOR	-	-	DF13-3P-1.25V	HIROSE	DF13-3P-1.25V	1
B100	BATTERY	3 PINS	-	-	VARTA MICROBATTERY		1
U100	CHARGER IC	-	-	DRC	TEXAS INSTRUMENT	BQ24081	1
R100	RESISTOR	1.3KO	+/-1%	R0402		R0402	1

5.5 Charge curves

Here is the curve of a complete battery charge.



VBATT_IN is the internal battery voltage level.Not accessible in normal use.

VBATT_OUT is the external battery voltage level (voltage on battery connector).

IBATT is the battery charging current. To be sure that the ammeter doesn't disturb the charge this current has been measured on the +5V DC source and so it includes

The charge process can be divided in three different phases:

- The pre-charging and PCM unlock* phase (P1)
- The charging phase (P2)

- The end of charge phase (P3)

(*) : Battery manufacturer recommends to not use the battery until PCM locking.

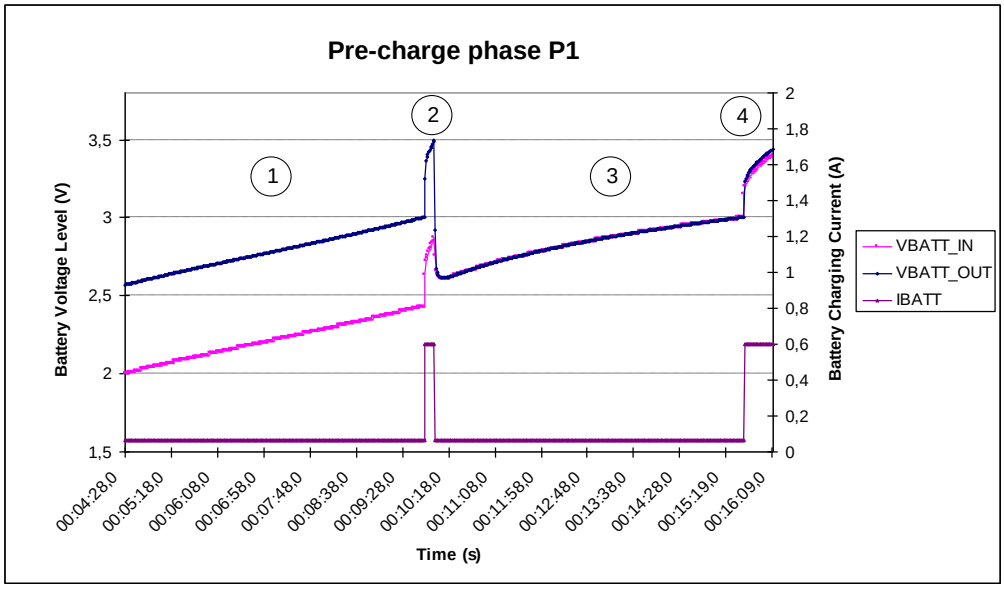
PCM under voltage protection activation mustn't happen in battery normal use.

5.5.1 Pre-charge and PCM protection de-activation

Pre-charge phase is a battery preconditioning phase before the charge.

The curve below shows the pre-charge phase P1 and can be decomposed in four different steps (1 to 4):

- Step N°1:
  - Battery voltage level is below 2.5V and so the PCM protection is activated.
  - The charger is plugged and the pre-charge phase starts with a pre-charge current of 62mA. VBATT_IN and VBATT_OUT increase until VBATT_OUT = 3V.
- Step N°2:
  - When VBATT_OUT=3V the charge starts for a short time (about 20s) with a charge current of 620mA. VBATT_IN and VBATT_OUT increase until VBATT_IN = 2.9V.
- Step N°3:
  - VBATT_IN = 2.9V and so the PCM protection is deactivated and now VBATT_IN = VBATT_OUT. Pre-charge starts again with a current of 62mA.
  - VBATT_IN and VBATT_OUT increase until VBATT_OUT = 3V
- Step N°4:
  - When VBATT_OUT = 3V the charge phase P2 starts.



5.5.2 Charge

Charge phase (P2) is a current regulation phase.

Once VBATT_OUT = 3V the charge phase P2 starts with a charging current of 620mA. This current is less important when the module is ON because it is needed to deduce its consumption (e.g. ~13mA for a Q24) .During this phase VBATT_OUT increase from 3V to 4.2V. When 4.2V threshold is reached, the end of charge phase starts.

5.5.3 End of charge

The end of charge phase (P3) is a voltage regulation and the charge termination phase.

With VBATT_OUT = 4.2V the current decreases from 620mA to 61mA. Once this threshold is reached the battery is considered as being charged and the charge ends.

It is important to notice that the end of charge current includes module consumption because this one has been switched ON by the voltage detector when VBATT_OUT = 3.8V. So for instance the end of charge current inside the battery is 48mA for a Q24.

5.5.4 Recharge

After charge termination if battery voltage level drops below 4.1V the charge restarts.

5.5.5 Charge currents

Charge phase	Theoretical current	Calculated Current
Pre-charge	C/20	62mA
Charge (constant current)	C/2	620mA(1)
End of charge (constant voltage)	~C/26	61mA(2)

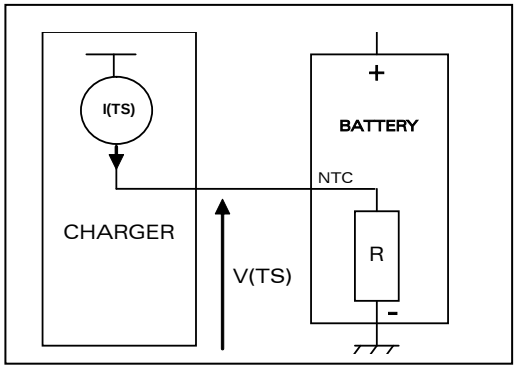
(1) 620mA when the module is OFF and its consumption needs to be deduced when it is ON.

(2) Charging circuit detects end of charge current at 61mA. The module is ON and its consumption is included it this figure. For example end of charge is detected at 48mA for a Q24 which is about C/26.

5.5.6 Temperature monitoring

The PLF-503759 battery includes a NTC resistor that allows the BQ24081 to monitor the battery temperature.

Schematic



Computing method

The resistor value depends on the temperature.

$$R(t) = R(t_0)\, e^{B\left(\frac{25-t}{298 * (+273}\right)}$$

$$V(TS) = R(t).I(TS)$$

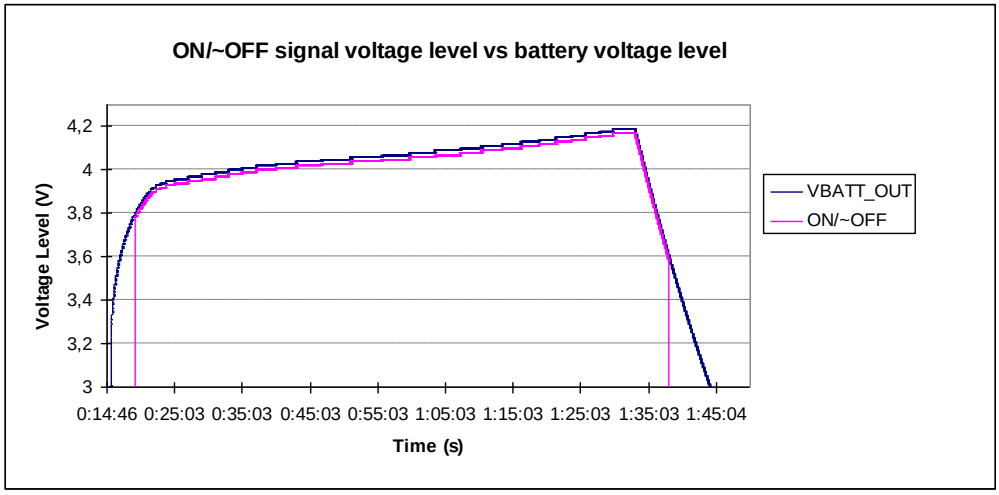
- « t_0» represents the ambient temperature (+25), in °C associated to R(to) (nominal resistor = 10K)
- « B » is the thermal sensibility (3430 K).
- « t » represents the temperature, in °C.
- « I(TS) » represents the temperature sensor current sourc
- « V(TS) » represents voltage level on NTC resistor

Battery charge works if **0 .5 V <V (TS) < 2.5V.**

By applying the previous formula we can see that the charger working temperature range is **[0 - 45°C].**

5.5.7 Voltage detector

The voltage detector is used to switch ON the module once the 3.8V threshold is reached. When the battery voltage drops below 3.6V the ON/~OFF signal is set to low by the voltage detector and so the module can proceed to an auto switch off when the 3.2V threshold is reached. It allows avoiding deep battery discharge.



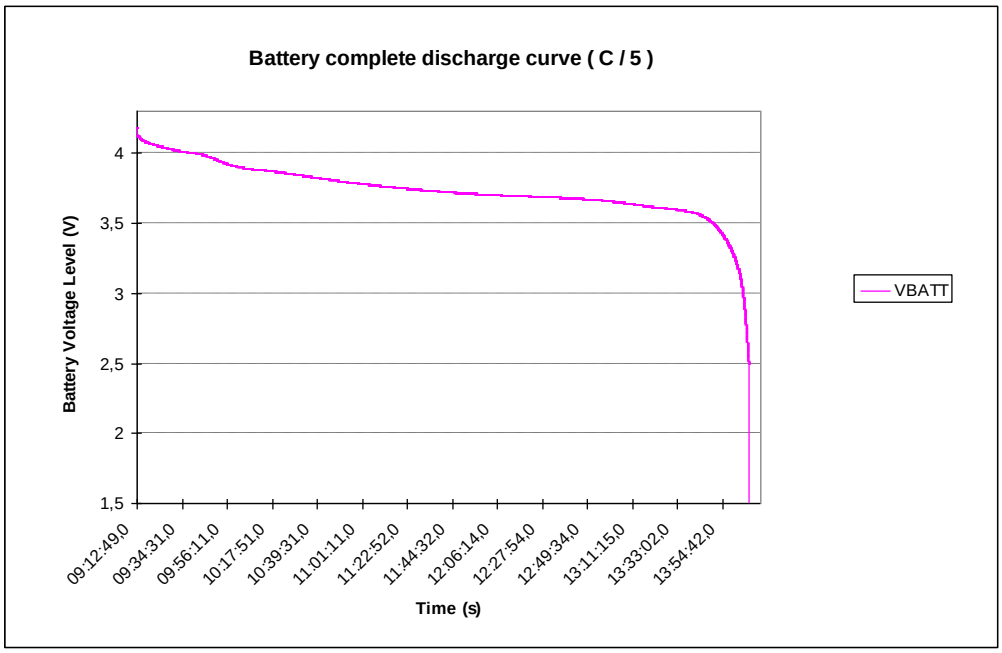
5.5.8 Charging capacity

The following curve is the discharge curve of a full charged battery.

The calculated capacity after a full charge is between 0.85C and 0.9C.

It is important to notice that VARTA advices to stop the charge when end of charge current drops below C/50.

The BQ24081 can't comply with this recommendation and stops charge at about C/26. That explain why the maximum charge capacity is 0.9C.



5.5.9 Charging time

Measured charging time is about 3 hours.

5.5.10 RF disturbance

Charger mustn't be placed close to the RF part. No RF disturbance has been detected during charging phase.

5.5.11 Miscellaneous advices for good charge

The charger is not a regulator and so we misadvise to perform long call with the charger activated. Application with batteries are normally done (except specific cases) to be charged and used without charger activated. The BQ24081 integrates timers to prevent this kind of problems.

6 Package Deliverables

This application note is delivered as a single compressed zip archive as follows:

Filename	Description
External_Battery_Charging_Solution-Rev002.zip	Application note

6.1 Documentation

List all of the files that will be included in the zip file.

This application note (plus, list any other PDF docs)

Filename	Description
External_Battery_Charging_Solution-Rev002.pdf	Application note

6.2 Software

List all of the files that will be included in the zip file.

Filename	Description
N/A	

6.3 Hardware

List all of the files that will be included in the zip file.

Filename	Description
N/A	

7 Reference Documents

	Filename	Reference
[1]	Charger IC BQ24081 datasheet (Texas Instruments)	SLUS698C
[2]	PLF-503759C battery datasheet (VARTA MICROBATTERY)	VKB N°66661.211.098
[3]	PLF-503759 battery technical drawing	N°691158
[4]	Q2686 Product Technical Specifications	WM_PRJ_Q2686_PTS_001
[5]	Q2687 Product Technical Specifications	WA_ENG_Q2687_PTS_001
[6]	WMP100 Product Technical Specification & Customer Design Guideline	WM_DEV_WUP_PTS_005-004
[7]	New Q24 Series Product Technical Specification	WM_PRJ_Q24NG_PTS_001

8 Support

For direct clients: contact your Sierra Wireless FAE
For distributor clients: contact your distributor FAE
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9 Document History

Version	Date	History
001	March 03, 2008	Creation
002	February 18, 2010	Update

10 Legal Notice

Important Notice

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6,191,741	6,199,168	6,339,405	6,359,591	6,400,336	6,516,204	6,561,851	6,643,501
6,653,979	6,697,030	6,785,830	6,845,249	6,847,830	6,876,697	6,879,585	6,886,049
6,968,171	6,985,757	7,023,878	7,053,843	7,106,569	7,145,267	7,200,512	7,295,171
7,287,162	D442,170	D459,303	D599,256	D560,911			

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