External Battery Charging Solution

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APN Content Level	BASIC		INTERMEDIATE	✓	ADVANCED		Confidentiality	Public	✓	Private	

Hardware Compatibility	Product Line	AirPrime	Series	Q26xx	SL60xx	WMPxx

Software Compatibility	Series	ALL	

1 Version

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2 Introduction

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3 Overview

This application note describes how to interface an external battery charging chipset solution with an AirPrime 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

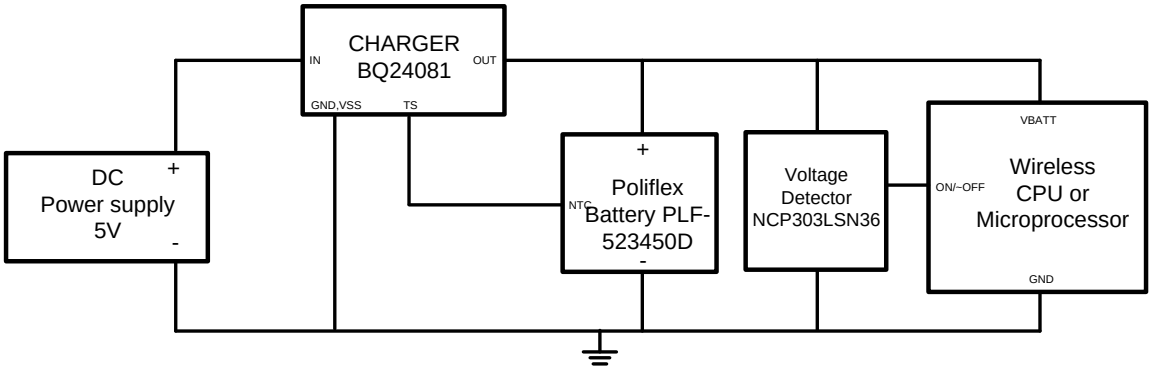


Figure 1. Synoptic of the charger interface

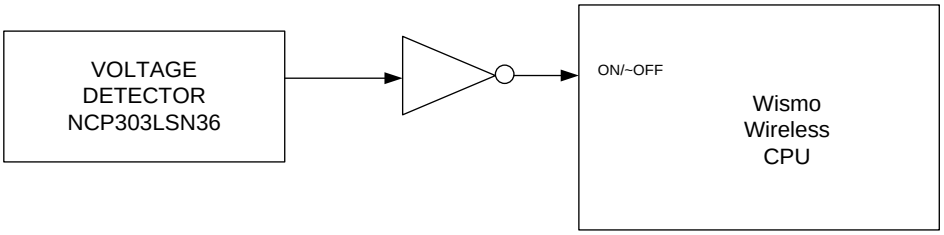


Figure 2. Invertor inserted when WISMO series is used

5.2 Description

As shown in Figures 1 and 2 above:

- The PLF-523450D battery is a Li-Polymer battery that can be charged with the same algorithm as Li-Ion ones.
- The battery charging current and voltage are monitored and controlled by the Charger BQ24081 which is powered by a +5V DC voltage source. A NTC included inside the battery allows the charger to monitor the battery temperature and to stop the charge if an over or under charging temperature is detected (see chapter 5.4.6 for further details). The charger integrates a dedicated algorithm for Li-ion batteries

Pre-charge, charge, and end of charge currents are set thanks to the resistor R100 (see the schematics in Figure 3). 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.

If the external battery charging solution is being designed for WISMO218, WISMO228 & WS6318 modules, the figure 2 shows an invertor inserted between the output of the voltage detector and the ON/~OFF input signal of the Wireless CPU (these modules are switched on by applying a low level to the ON/~OFF signal).

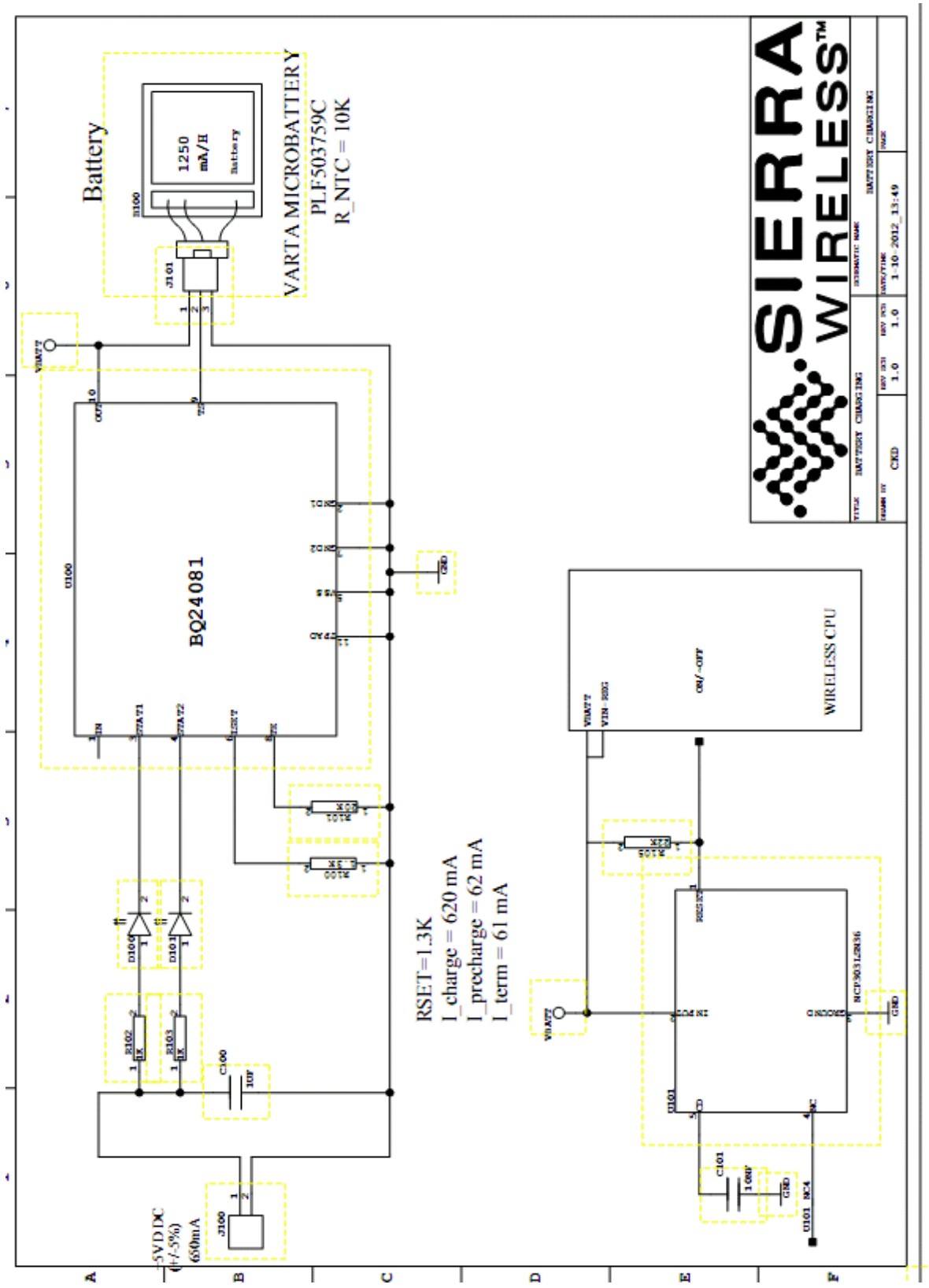


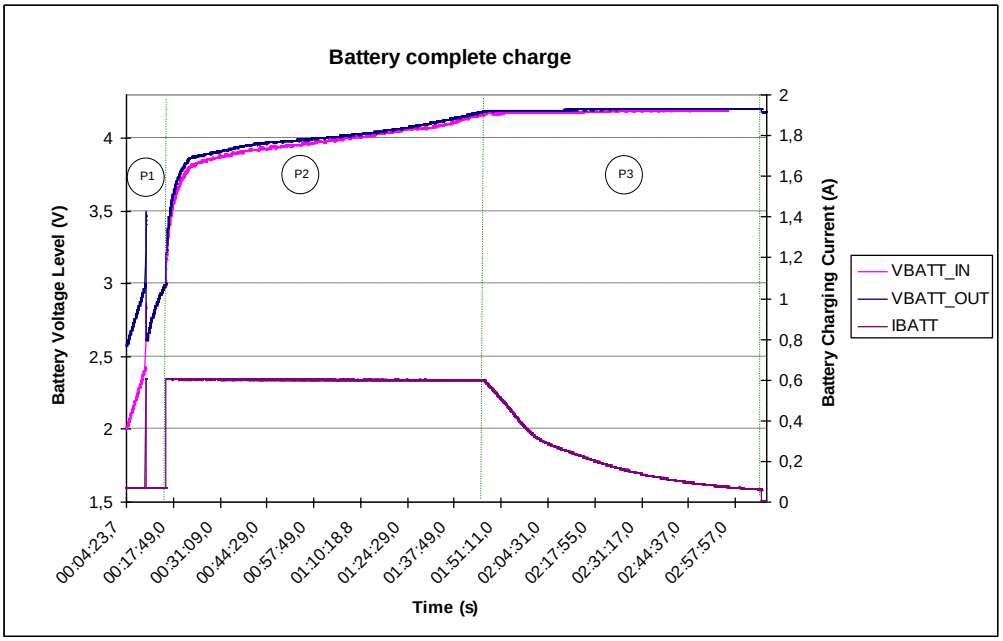
Figure 3. Schematic

5.3 Bill of Materials

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

5.4 Charge curves

Below 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.

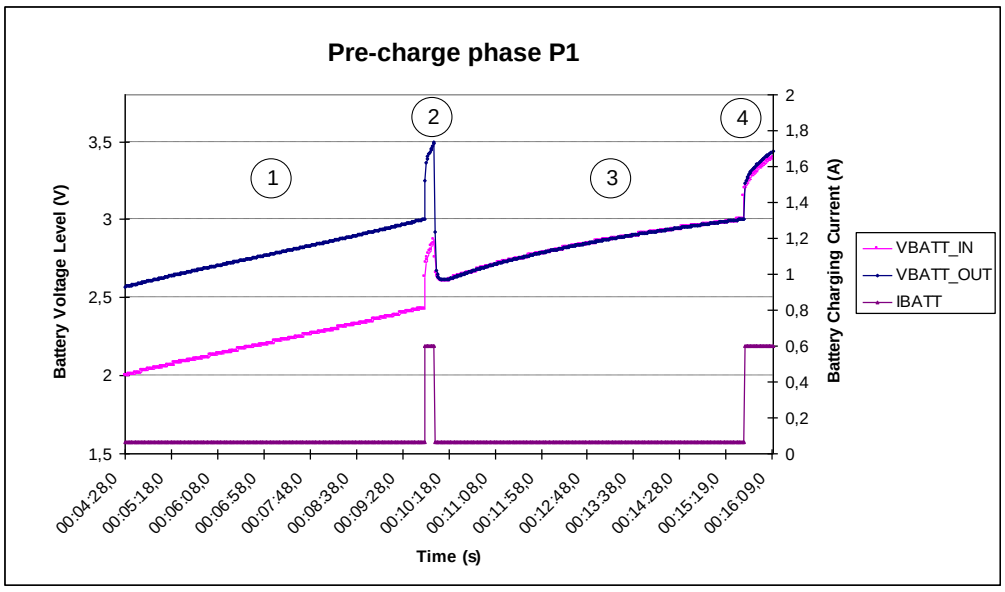
PCM under voltage protection activation mustn't happen in battery normal use.

5.4.1 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.



5.4.2 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 Q26). During this phase VBATT_OUT increase from 3V to 4.2V. When 4.2V threshold is reached, the end of charge phase starts.

5.4.3 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 Q26.

5.4.4 Recharge

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

5.4.5 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)

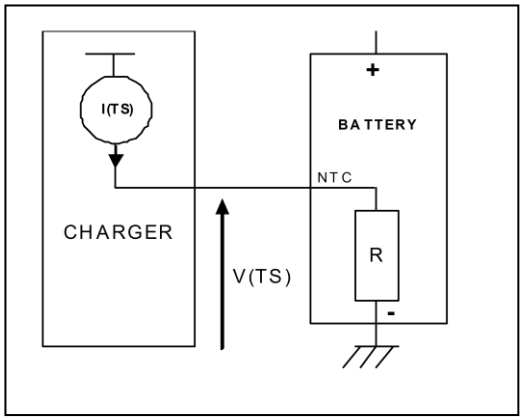
(1) 620mA when the module is OFF and its consumption needs to be deduced when it is ON.

(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 Q26 which is about C/26.

5.4.6 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.

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

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

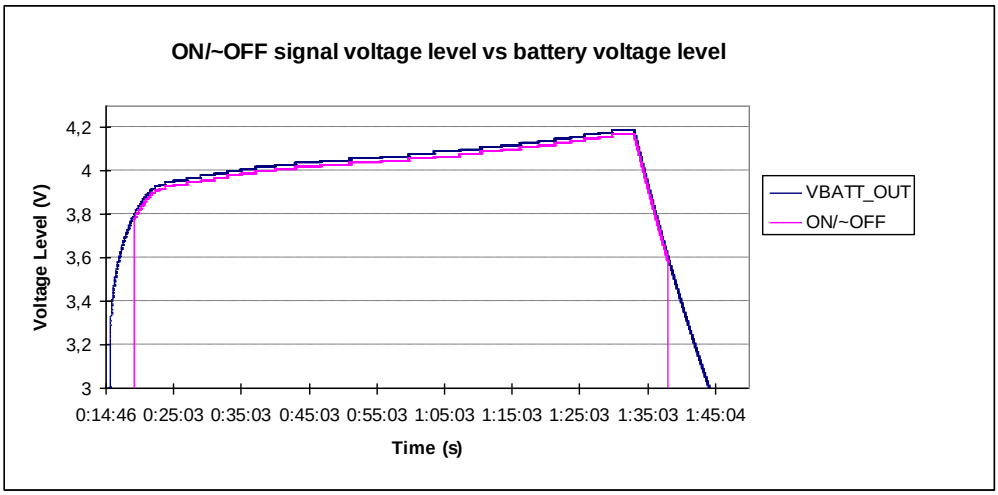
- « t_0» represents the ambient temperature (+25), in °C associated to R(to) (nominal resistor = 10K)
- « B » is the thermal sensibility (3430 K).
- « t » represents the temperature, in °C.
- « I(TS) » represents the temperature sensor current sourc
- « V(TS) » represents voltage level on NTC resistor

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].**

5.4.7 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.



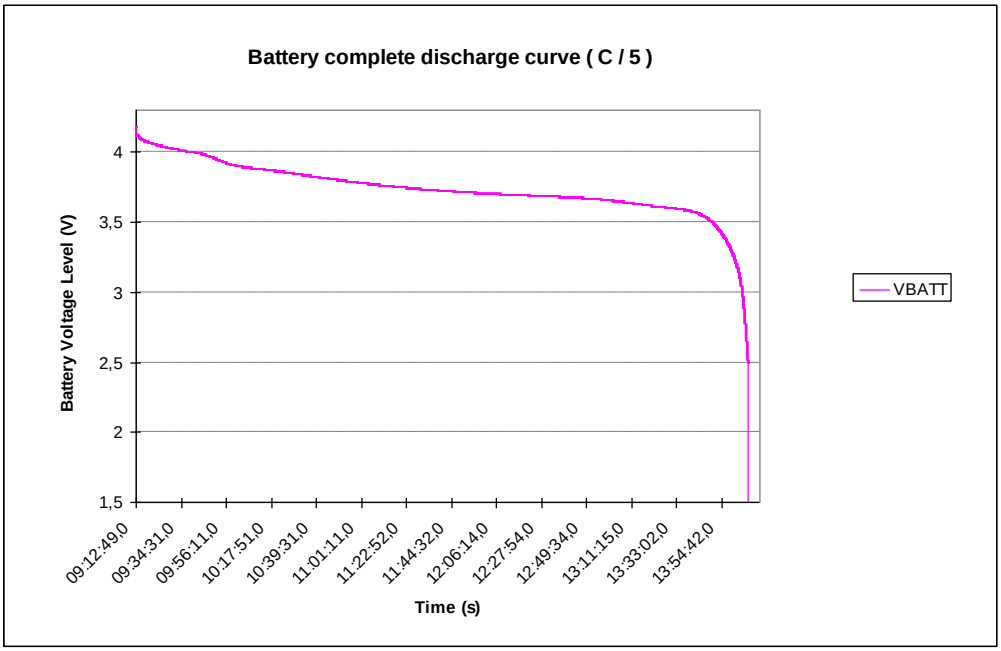
5.4.8 Charging capacity

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.



5.4.9 Charging time

Measured charging time is approximately 3 hours.

5.4.10 RF disturbance

Charger mus not be placed close to the RF part. No RF disturbance has been detected during charging phase.

5.4.11 Miscellaneous advice for a 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 Reference Documents

	Filename	Reference number
[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 & customer design guideline	4111963
[5]	Q2687 Product Technical Specifications & customer design guideline	4111964
[6]	WMP100 Product Technical Specification & Customer Design Guideline	4111967
[7]	Airprime WISMO2X8 Product Technical Specification & Customer Design Guideline	4111957
[8]	Airprime WS6318 Product Technical Specification & Customer Design Guideline	4110999

7 Support

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8 Document History

Version	Date	History
001	March 03, 2008	Creation
2.0	June 12, 2013	Updates

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