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Power supply for mobile devices

Mobile devices rely on an independent power source. Decisions that are made early on in device development – such as the choice of a suitable battery pack, charging concept, controls for power consumption and power supply dimensions – impact device usability, cost, operation and lifespan. Device function and application provide the guiding lines.

Building blocks of a mobile power supply
Simply put, a power supply system for mobile devices consists of four logic blocks: source, distribution, consumption and charging. Each block has its own intelligence and contains hardware and software. For the success of a device, it is important that the battery lasts a long time, provides sufficient power and is light and small. Next to operating time, weight and size the most important requirements of a mobile, battery-powered device include safety, durability and unhindered access to international markets. Each of the logic blocks offers the potential to find a perfect design compromise between often conflicting requirements. Therefore, the overall concept encompasses more than just the rechargeable battery.

1. Power source
If the power does not come out of the socket, then hopefully from a well-charged battery. A mobile device draws energy from the mains power supply or one or more battery packs. The rechargeable battery needs to be small and light but at the same time provide a lot of energy. Since these two requirements are contradictory, high energy density is at the top of the battery wish list.

Requirements for rechargeable batteries:
- High energy density, i.e. small and light
- Large capacity, i.e. long battery life
- Protection against deep discharge and overcharging
- Worldwide compatibility
- High load and charging currents
- Long lifetime

High energy density
But where does the energy come from? A battery consists of one or more cells. Different chemical processes are used to build these cells, but when it comes to energy density per cell, lithium-ion technology is far superior to all other chemical cell structures.

Large capacity
To turn a basic cell into a usable, reliable and rechargeable battery with the required performance, battery manufacturers connect several cells in parallel and/or series. The RRC2054, for example, connects four cells in series; this is called a 4S1P battery configuration.

Intelligent powerhouses
Integrated sensors and a microcontroller turn the configuration into a smart battery. An externally connected power management can retrieve status information and battery-specific data via the SMBus. A data logger records all critical events for evaluation in case of warranty issues or for analysis. The internal battery design determines not only the capacity and performance; it also impacts the subsequent reliability. Batteries from RRC, for example, support authentication, thereby ensuring that the application only uses battery types approved by the equipment manufacturer. Next to the electrical features, the manufacturing quality of the battery pack and the certifications passed are key factors for international marketing success. Device manufacturers have little influence on these factors bar choosing wisely when selecting a suitable battery pack.

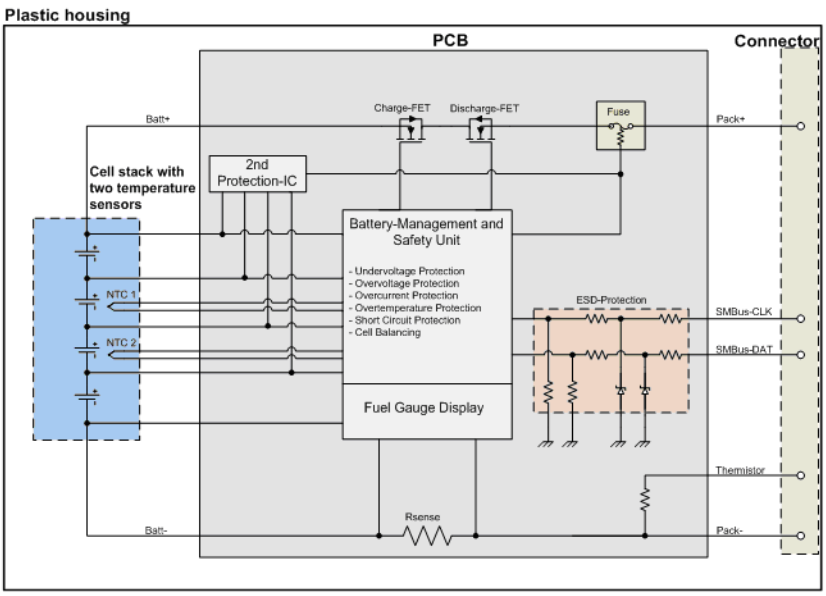

Fig 1: Block Diagramm of RRC2054 battery

Quality and safety at competitive prices
RRC develops and manufactures rechargeable, extremely high-energy lithium-ion battery packs with cells from Samsung and others. The packs are ideal for use in medical, industrial, instrumentation, logistics and military environments. In these markets, quality and safety are of the highest priority, while prices need to be competitive.

Danger of explosion
Lots of energy contained in a small space can be dangerous. Deep discharge leads to crystalline structures in the cell chemistry that can damage the insulation. In the worst case, the cell may explode. RRC prevents deep discharge by internal voltage monitoring in two stages. If the voltage falls below the first threshold, the internal electronics shuts the battery down, giving it time to recover. This deactivation is reversible. However, the battery pack is irreversibly switched off if the voltage falls below a second, lower threshold. This fail-safe mechanism protects the battery pack from self-destruction. Other internal protective mechanisms prevent the battery from damage due to high currents, overvoltage, short circuits, reverse polarity and overheating. The charge current can be limited depending on the temperature. Ideally, smart power management will prevent critical situations before the battery has to intervene as a last resort.

Always 100%
Batteries age, even if treated with the utmost care. Therefore, they are designed to calibrate themselves from time to time so as to retain a valid capacity reference for internal measurements. This way, the capacity gauge is also calibrated back to 100%.

Rules and regulations as far as the eye can see
EMC, UL, Safety, IEC62133, CE, RCM, EAC, KC, RoHS, REACH . . .

RRC is a German company with international manufacturing facilities and distribution channels around the globe. RRC has proactively used this international experience to have its standard packs certified in six different form factors for all relevant approvals. Each critical issue is tested and certified; the battery packs undergo the most stringent tests, including drop, vibration, impact and bend tests as well as tests for electromagnetic compatibility. As a minimum, each battery pack must pass the UN transport test if it is to be shipped without a dangerous goods declaration. But that is not enough to export to major markets. When it comes to safety, national regulations often differ from international standards. Therefore, RRC battery packs are certified to meet the special UL components standard for the USA and Canada, the PSE standard for Japan and the RCM stand for Australia and New Zealand. The batteries are currently undergoing the certification process for the KC approval necessary for Korea and the EAC approval for the Russian Federation. Needless to say, the battery packs comply with RoHS, REACH, recycling regulations and the electrical safety standard IEC62133. The CE declaration is mandatory.

The battery meets all relevant standards for use in the following markets:

Approved for the following regions/countries	RRC battery packs additionally comply with the following national standards
USA	UL component approval
Canada	UL component approval
Europe	CE
Australia	RCM approval
Japan	PSE approval, temperature-dependent adjustment of the charge voltage according to JEITA regulations
China	CCC approval, from 2015
Taiwan	BSMI approval, from 2015
Korea	KC approval, in process
New Zealand	RCM approval
Russian Federation	EAC approval, in process

Overview of major target markets

Good for small batches
Certifications are expensive and the RRC battery packs meet far more requirements and regulations than is common practice. Because the cost of certification tests for standard battery packs gets distributed over large quantities, it does not significantly impact the overall price. This is a clear advantage for developers of small-scale applications who can buy these internationally approved battery packs directly from stock. RRC paves the way for device manufacturers to a successful export business; registration of the final device is easier with the available certificates.

Application-specific builds
The small, flat battery packs don't always fit into the concept. For instance, when the batteries need to fit into the handle-like grips of a tablet computer. Provided that the incurred one-time costs for design and approval procedures are distributed over a large enough number of devices, RRC builds customized battery packs. Initially, a purely economic decision between potential value-add vs incurred costs.

2. Power distribution
The Smart Battery Manager (SBM) converts the voltage of the power supply or battery pack into different voltage levels for the application. If the device has more than one battery or if it is additionally supplied by the mains, the SBM distributes loads and currents dynamically as directed by the internal microcontroller. To enable device manufacturers to quickly develop a mobile device, congatec has created the SBM3 module as a reference design that supports up to two battery packs in the configurations 2S to 4S. congatec develops and manufactures standardized computer modules for OEMs. The SBM3 is part of a new Qseven Starter Kit for mobile embedded applications and provides a complete battery management subsystem. It was developed for congatec's low-power COM Express and Qseven modules.

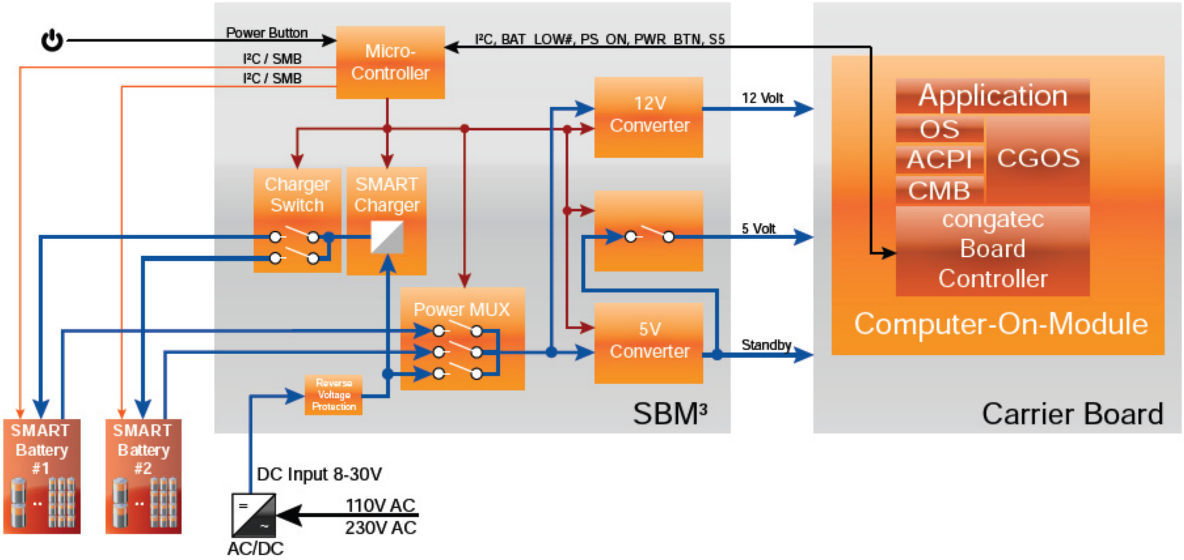

Fig 2: Block diagram illustrating how SBM3, carrier boards and computer module function

Voltages

The SBM3 is designed for input voltages from 8 V to 30 V and thus covers all common input ranges. For the application the SBM3 converts the input voltage to 12 V and two times 5 V. The reference design includes all possible options, and the conga-SBM3 Development Licence Kit provides all necessary information and documentation. This allows OEMs to design application-specific devices in a cost-effective way. For example, if a high input voltage of 30 V is not needed, hardware optimizations can reduce costs by up to a third.

Communication between SBM3 and carrier board

The SBM3 includes the STM32F100 32-bit ARM microcontroller. It communicates with both the battery and the COM's onboard controller and forms part of the logical interface between the power management of the operating system with ACPI support (e.g. Windows or Linux) and the physical hardware. The ACPI (Advanced Configuration and Power Interface) is the key element of the power management in the operating system. Before the introduction of ACPI, the power management functions and board-specific configurations were traditionally implemented in the BIOS. BIOS solutions were limited to static hardware configurations. The trend is now moving away from Advanced Power Management (APM) or BIOS implementations towards ACPI-compatible operating systems. By implementing ACPI, it becomes possible to equip any type of computer system at a reasonable cost with configuration and power management functions that previously were very close to the hardware in the BIOS. This gives the application itself access to these management functions via the operating system.

Signal	Description
BATLOW#	This signal is used by the battery system to generate interrupts upon special events such as AC power changes, attaching/detaching of batteries, battery low conditions, etc. A low pulse of at least one microsecond is necessary to be recognized by the system host.
SUS_S3#	A low level on PS_ON# or high level on SUS_S3# indicates that the Battery Management System should turn on system power. Otherwise the Battery Management System must turn off system power.
PWRBTN#	This signal is used to send a power-on request to the CPU module. The low pulse should be about 250 milliseconds long.
I2C_CLK	I²C-bus clock line used for communication between Battery Management System controller and system host
I2C_DAT	I²C-bus data line used for communication between Battery Management System controller and system host
SUS_S5#	This signal is active low when the system switches to the S5 (soft off) state.

Table1: Hardware Ssignals

Intelligent load and charge distribution
Some industrial units contain two batteries. The second one can be a small backup battery that powers the system while the main battery is being replaced. It can also be a redundant battery with similar high capacity that can be switched on as necessary. If a device has more than one battery, the question arises: Which of the two is to be charged or discharged? Or are they designed to both supply power at the same time? The conga-SBM3 supports dual charging and discharging and distributes the currents as directed by the software. The system reacts quickly when a battery is removed; it also configures itself dynamically, thereby guaranteeing continuous operation.

3. Consumption control
To make the available energy last as long as possible, smart power management is needed. The ACPI is a key element of clever power management. It is integrated into the operating system and communicates with the SBM3. The ACPI controls the total energy consumption via defined Power States. Individual components of the device, such as I/O or HD, can be switched off selectively via Device Power States, the S-States define various levels of sleep modes and the C-States regulate the CPU power. Here lies a wide field of opportunities to influence the power consumption.

Communication with the battery subsystem works the same as in commercial notebooks, i.e. via so-called control methods in the ACPI BIOS. For this reason, such a battery solution is referred to as CMB, Control Method Battery. As the name suggests, the software interface with the battery system consists of individual ACPI functions, the Control Methods. The two most important are _BIF (Battery Information) and _BST (Battery Status). _BIF sends static battery information, such as serial number, design voltage and model number to the ACPI OS. _BST, on the other hand, provides dynamically changing battery data such as, for example, charge status or remaining capacity. These methods are implemented in the congatec ACPI BIOS and provide the link between the operating system and the battery hardware. In addition, there is an event handler that needs to quickly respond to any changes in the battery condition. This handler is also implemented in the congatec ACPI BIOS and ensures that the operating system is notified of any change in the battery subsystem, for example when the network adapter is connected or disconnected. In this case, the power icon in the Windows status bar should be updated within seconds.

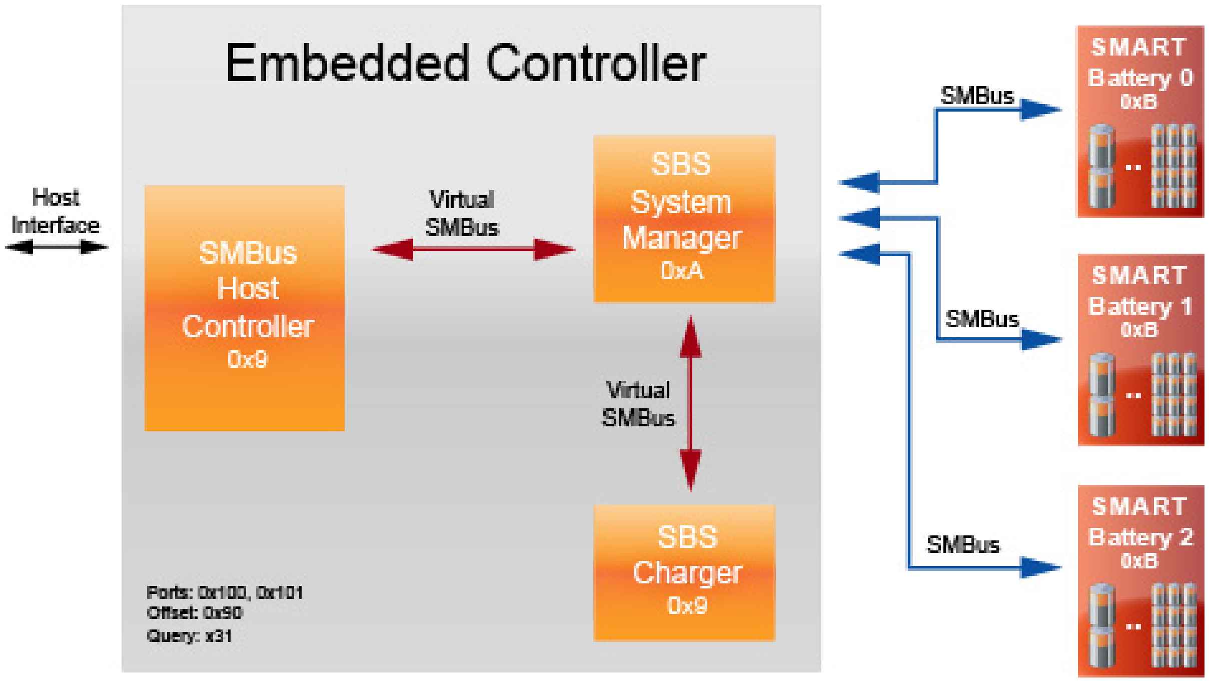

Fig 3: How the Smart Battery subsystem works

4. Recharging

Batteries need to be charged occasionally. The battery charging circuit is intelligent; one of its tasks is to deliver the appropriate charging currents for the selected battery type. Depending on temperature, battery condition and load volume, the charging circuit decides in collaboration with the SBM how high the currents have to be and how long they flow. The SBM relies on information it receives from the battery, such as the charge status and internal temperature. Similarly, the charging currents depend on the energy available via the power supply and the necessary division of power between application and battery. The decision whether multiple batteries must be loaded sequentially or in parallel, depends on the application. The requirements for the charging circuit are as contradictory as those for the battery pack – powerful, but at the same time small and light.

5. The overall concept

Operating time

A common requirement is for the battery to last as long as possible. Ideally, an entire working day, but at least for the duration of an application. The operating time of a mobile device depends on the capacity of the battery, the consumption of the device and the overall power management concept. The optimal solution is different for each application. Let us look at two examples.

Medical emergency versus industrial setting

Emergency doctor

In most cases, an emergency doctor will place the mobile device after use straight back into the charging unit in the ambulance or rescue helicopter. It can recharge quickly and is then ready for the next patient. The load current will likely be high and the charging cycle short. The focus is on standby; the battery life is secondary. The battery pack must be able to withstand high currents; the size of the charger is of minor importance. A conceivable solution is to have a second, backup battery that takes over in an emergency.

Service technician

The service technician, on the other hand, uses his mobile measuring instrument continuously throughout the working day. He has little opportunity and no time to recharge the battery in between jobs. A simple replacement battery is not an option either, as it would interrupt the series of measurements leading to a loss of data. A backup battery would be a better solution in this scenario. If the service technician places the measurement device into the charging unit after work, it can recharge slowly at low, battery-friendly currents. The main battery pack needs a high capacity, whereas a comparatively low capacity is sufficient for the backup battery. The mobile charger must be small and light.

How to find the right battery?

Simply designing large or oversized battery packs would be too expensive, too heavy and too bulky. It is therefore necessary to clarify some questions in advance. Which battery pack is suitable? What are the required dimensions? How many batteries should the device have? What Power Management concept is needed to achieve the targeted electricity savings? Which hardware parts can be switched off temporarily? How deeply can functions or parts of the system be put into sleep modes or D-States? Which charging concept suits the application? The answers to all these questions yield the overall concept for the power supply of the device. The power management and the entire power supply chain of a device used by an emergency doctor will differ greatly from one used by a service technician. There is no generally applicable solution because the requirements are simply too varied. RRC and congatec advise and assist OEMs in the choice of suitable battery packs and help with the design of the charging unit, the development of the application-specific computer with battery management and ACPI implementation.

Conclusion

From the device manufacturer’s perspective, batteries are just a sideshow. His focus, naturally, is on the application. But the success of a device depends to a large extent on an intelligent and optimized power supply. Battery cell technology is evolving. The trend goes towards more powerful battery packs that combine high voltage and large capacity, not unlike the power tool cells of a cordless screwdriver. The implementation of these new technologies, however, requires special know-how. A similar trend can be found in computer hardware where processors are becoming more complex, more powerful and more energy efficient. A powerful embedded PC is behind almost every application, but the complex design around the processor diverts development resources away from core business activities. Computer and battery are mandatory building blocks of the application, but they can be successfully delegated to the experts. New applications are conceivable only thanks to these new technologies. Therefore, it’s worth consulting the specialists from RRC and congatec. Their collaboration bundles their combined mobile embedded expertise, and together they are able to support the specific application of the customer. The Computer-on-Modules from congatec allow the device manufacturer to focus on the application-specific hardware and software, thereby greatly relieving in-house resources.

With the Mobility Starter Kit from congatec and RRC a laboratory set-up is quickly done. The more detailed Integration Kit further provides all schematics, source files of the microcontroller program along with complete development documentation.

Thanks to the tried, tested and certified components the user avoids many learning curves. Faster time-to-market and a more economical design with optimized hardware are a sound foundation for a customer's success. A classic win-win situation.

Fig 4: Mobility Starter Kit with all necessary hardware (SBM3, RCC battery pack, Computer-on-Module, carrier board, display and cable set) for fast evaluation

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About RRC power solutions GmbH

RRC power solutions, founded in 1989, is a leading company for high quality power supplies, battery charging technology, battery packs, integrated system solutions, energy storage systems and wireless power solutions for mobile and professional applications.

RRC develops, produces and delivers its electronic assemblies and products to leading original equipment manufacturers (OEMs) of notebooks, measuring instruments, medical devices, and military computer technology worldwide. OEMs integrate RRC's solutions into their own devices or sell them as accessories. RRC is a popular choice for the industry thanks to its trendsetting technology.

The company and its R&D center are based in Homburg/Saar. Branch offices are located in Los Angeles, Melbourne, Hong Kong, Shenzhen as well as representative offices worldwide.

RRC utilizes technology to drive new ideas, products and developments. Its research and development department creates the foundation for technological leadership.

In addition, RRC is certified according to DIN EN ISO 9001:2008 and DIN EN ISO 13485:2007 (manufacturer of medical devices).
www.rrc-ps.com

About congatec AG
congatec AG has its head office in Deggendorf, Germany and is a leading supplier of industrial computer modules using the standard form factors Qseven, COM Express, XTX and ETX. congatec's products can be used in a variety of industries and applications, such as industrial automation, medical technology, automotive supplies, aerospace and transportation. Core knowledge and technical know-how includes unique extended BIOS features as well as comprehensive driver and board support packages. Following the design-in phase, customers are given support via extensive product lifecycle management. The company's products are manufactured by specialist service providers in accordance with modern quality standards. Currently congatec has ~160 employees and entities in Taiwan, Japan, USA, Australia and the Czech Republic. More information is available on our website at www.congatec.com or via Facebook, Twitter and YouTube.