EXAR ...the analog plus™ company

BAN-001

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A Complete Interactive™ Battery Management System Using the XR-B1100

Preliminary

Introduction

Battery management is an important part of the design of any portable equipment. If system drain is extremely low, and the system will work properly on primary cells, then battery management is simplified. However, if system drain rates or usage requires a rechargeable technology, then there are many considerations in the charging and discharging of the batteries.

The EXAR InterActive Battery Management System monitors critical battery parameters to produce a highly accurate state-of-charge indication and to control slave charging systems. It is compatible with Ni-Cd, Ni-MHi, & Li-Ion technologies.

By providing charger control, fuel gauge display drivers, and both a digital and analog interface, the XR-B1100 battery management chip set can be used to develop a comprehensive battery management system.

This application note describes the circuit topology for one such circuit, which is available from EXAR as an evaluation board. It utilizes a 1-wire asynchronous master-slave hardware protocol, with the battery being the slave. Included are the software protocol and 1-to-2 line communications translation circuit descriptions.

This evaluation system comes with a Microsoft Windows compatible driver program for automated communications with the Interactive Battery Management System.

Principle of Operation

Figure 1 shows a block diagram of the system in an application that includes a simple charger circuit. Note that there is no intelligence in the charger.

The battery, when it senses no communications, and a short pulse of charge (required to revive a totally dead battery) will "take control" of the charger via the charge and discharge control pins.

For intelligent or interactive chargers, communications is established at the beginning of the charge cycle, allowing the battery and charger to make certain determinations together.

Figure 2 shows the block diagram of the evaluation board circuit. Note the single wire communications and the addition of the analog fuel gauge (AFG) which provides a 0-5VDC signal proportional to capacity. The configuration shown is for Li-Ion cells, which require intercell monitoring for safety and cell protection. The under-voltage protection disconnect removes all circuitry from the cells, including the on

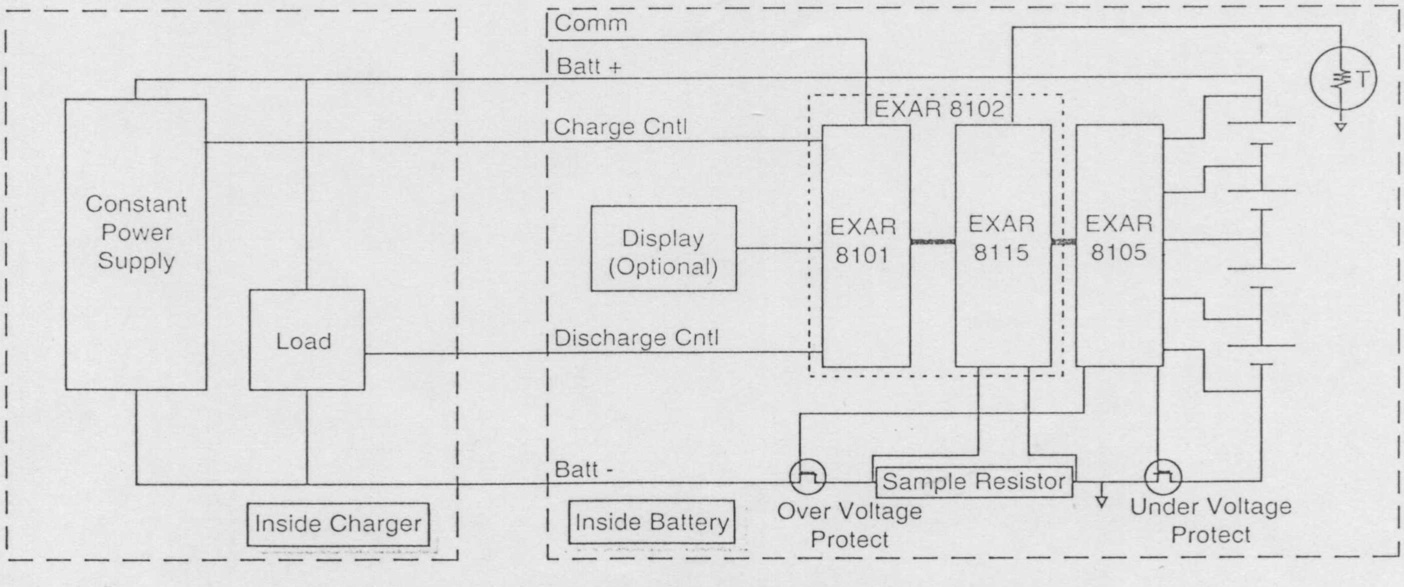

Figure 1. Block Diagram of a Simple System Including Charger

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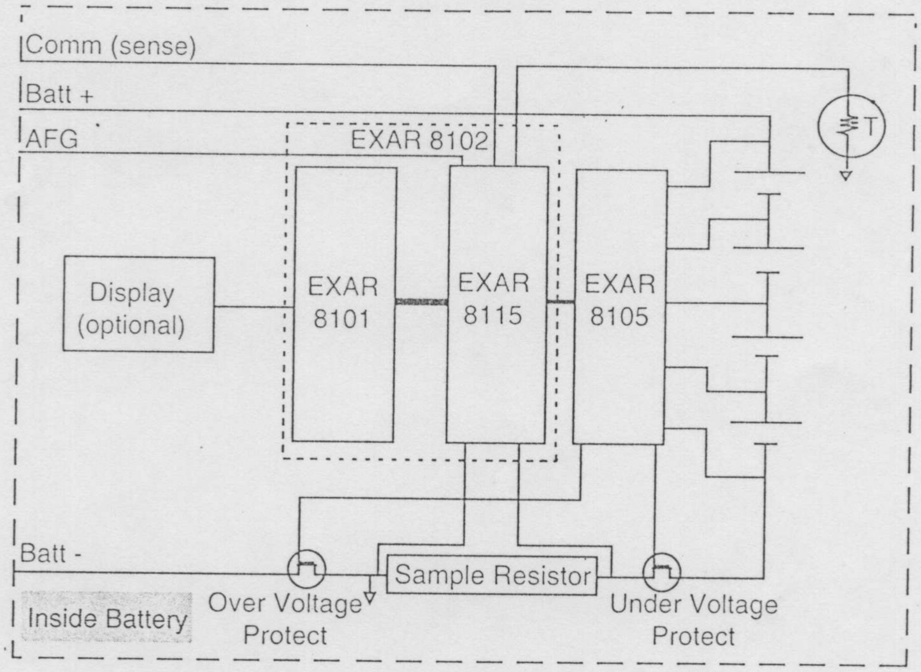

Figure 2. Evaluation Block Diagram

board electronics. A pulse of charge will momentarily turn the circuit back on, to enable a "dead" battery to be charged.

Circuit Operation

Battery charge and discharge current is monitored through the voltage drop across a sample resistor, which is in line with the low side of the cell pack. Current is measured via a high bandwidth coulomb counter, which accurately monitors load profile bandwidths of 150kHz.

Voltage measurements on the entire stack, and temperature measurements are made via a 10 bit A/D converter for high accuracy.

When batteries are in their non-active or "sleep" mode, they "awake" every 2 min. (adjustable) to make temperature measurements. Additionally, the system wakes up on any communications, or current drain.

Li-Ion protection is provided via on-chip buffers and comparators, which control off-chip pass FETs to remove the load or charge in problem situations.

The Li-Ion protection circuit requires a very small bias current, which virtually eliminates the cell pack imbalance impact.

The AFG is produced with a 4 bit DAC, to provide 16 steps from 0 to 5VDC, 0 being a dead battery.

The coulomb counter is a self reversing bidirectional integrator, followed by a 2 stage binary counter. This allows the system to keep up with a wide dynamic range of loads.

Temperature measurements can be made from linear and non-linear temperature sensors. An optional EEPROM can hold linearization tables for non-linear devices.

Tables for charge and discharge derating, and self discharge calculations can be mask options, or as is the case with the evaluation circuit, stored in the optional EEPROM.

Also in EEPROM or as mask options, the user can select charge cutoff methods, communications protocols, and other system parameters. If EEPROM is used, battery serial number, and date of manufacture can be stored during assembly test (pack charge & discharge).

Fuel Gauge capacity is "Learned" and optionally stored in EEPROM. This ensures that 100% = 100% of available charge, not nameplate. Also, a cycle counter is maintained to indicate battery life.

To alert users to system anomalies, service and calibration flags are carried in the system, and can be communicated via the communications port, or displayed on the optional on-board display.

Charge Cutoff Methods

The XR-B1100 supports all standard cutoff methods. The system will terminate charge on maximum voltage, maximum change in temperature, maximum temperature, a minus change in voltage, a minimum current, or a maximum time. The proper cutoff method is chosen based upon cell type.

In addition, the XR-B1100 supports a pack balancing algorithm, and a self discharge compensation "maintenance" algorithms, where appropriate. This ensures maximum battery capacity after removal from the charger.

Communications

The XR-B1100 evaluation system employs a proprietary communications protocol which is a great compromise between very robust and minimalist communications protocols. All standard protocols are available, as is a custom programming option.

The evaluation board protocol is an asynchronous, single wire, bidirectional master-slave interface, with the battery being the slave. The simple command-response pairs can be found in Table 2.

Figure 3 shows a circuit that will convert this hardware protocol to a standard RS-232c interface, for communicating with an IBM-PC. Provided with the evaluation board is a disk which contains a Microsoft Windows compatible software interface for monitoring battery functions. Custom software can be written to communicate with the system by sending the request byte information from Table 2 and decoding the answer byte per the information in the table.

Li-Ion Considerations

Li-Ion has special charging requirements in that each cell must be monitored during charge to ensure that no cell in the stack exceeds a maximum voltage. If so, the protection circuit automatically disconnects the charge current from the cells.

Additionally, to eliminate cell damage on discharge, if any cell drops below a minimum voltage, the load and all internal circuitry is disconnected.

A separate signal, the threshold of which is user settable, generates a logic high when the cell pack reaches an EOD condition.

On-Chip Display Drivers

The XR-B1100 provides 12 on-chip display drivers for fuel gauge, flag status, and charge state. These drivers are programmable to provide linear and non linear fuel gauges, and calibrate & service flags. Further, they are compatible with both LED and LCD displays.

Product Packaging and Connection

The XR-B1100 is a two chip set. The evaluation board has been developed with building blocks to allow user measurements within the circuit.

The evaluation board measures 18mm x 68mm, which allows for placement within the envelope of a 4/3 A-cell.

The board has 9 connections to off-board points including cell pack, load/charge, intercell voltages, analog and digital communications. Table 1 contains connection information.

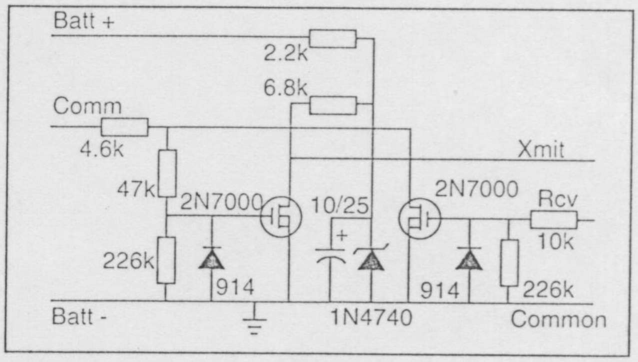

Figure 3. Communications Interface for Standard RS-232c

Connection	Name	Function
E2	Load +	Positive output of the smart battery pack
E3	C3+	Junction of Cell 3 and 4 in stack
E4	C2+	Junction of Cell 2 and 3 in stack
E5	C1+	Junction of Cell 1 and 2 in stack
E21	Load -	Negative output of the smart battery pack
E22	AFG	Analog fuel gauge output -- 0 to 5VDC
E23	Cell Pack +	Connects to the top of the cell stack
E24	Sense	Single Wire Communications Pin

Table 1. Evaluation Board Connections

Request Byte	Hex Value	Answer Byte
Abbreviated Temperature & Fuel Gauge Info	EC	T in upper nibble 12- 42∞C in 2∞C steps. FG in lower nibble.
Present Ah of Discharge	44	0 - 15.0 Ah max 0.1Ah steps
Last Stored Ah Value	54	0 - 15.0 Ah max 0.1Ah steps
Flags	5C	Calibration Required Bit 4 = High Battery at EOD Bit 0 = High Service Required Bit 1 = High
Software Version	84	Software Version Number: 0.0 - 25.5
Battery Voltage	94	0.0 - 25.5 VDC 0.1 VDC steps
Present Current Flow	9C	0.00 - 10.0 Amps
Temperature	A4	Temp = Degrees C + 40 Adjusted Range: -40 to 215 1∞C steps
Nameplate Ah	BC	0 - 25.5 Ahmax 0.1 Ah steps
Factory Calibrated Ah Capacity	C4	0 - 25.5 Ahmax 0.1 Ah steps
Present Ah Capacity	D4	0 - 25.5 Ahmax 0.1 Ah steps
Current Flow Resolution	8C	
Burst Request	AC	10 bytes in the Following Format
Burst Format		
Byte 1: Abbreviated Temp and Fuel Gauge info:		Upper nibble: T 12-44∞C in 2∞C steps Lower Nibble: Fuel Gauge. 00 - 0F hex
Byte 2: Experienced amp hour capacity		
Byte 3: Battery Name:		Upper Nibble= Ah rating. 0 - 15 Ah. Lower Nibble= Voltage Range. 0 - 15VDC
Bytes 4, 5, 6: Serial Number		
Byte 7: Date of Manufacture		
Byte 8: Number of Cycles High Byte		
Byte 9: Number of Cycles Low Byte		
Byte 10: Checksum of previous 9 Bytes.		

Table 2. Communications Software Protocol

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