AN-1009
Application Note

Charging EnerChips™ in Low Voltage Systems

Introduction

Evaluation board EVAL-02 is a development board that includes a charge pump and two thin film rechargeable batteries – the CBC050 and CBC012 EnerChips™ from Cymbet Corporation. EnerChips provide backup and bridging power for real-time clocks (RTCs), static random access memories (SRAMs), and microcontrollers (MCUs). The purpose of this evaluation platform is to allow designers to characterize EnerChip rechargeable thin film batteries in low power designs operating in systems using supply voltages ranging from 2.7V to 5.5V. A block diagram of the evaluation board is shown in *Figure 1*.

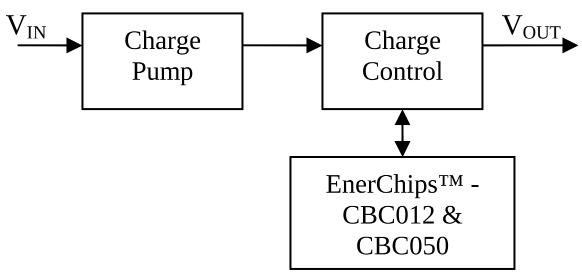

Figure 1. EVAL-02 Block Diagram.

Circuit Description

The charge control circuit uses the Microchip MCP1253 charge pump to charge the EnerChip at a constant 4.1V with a supply voltage as low as 2.7V. A small number of external components set the battery charging voltage and prevent the battery from draining back into the MCP1253 when system power is lost. On this demonstration board, the main system power is a CR2032 coin cell. When main power is lost, the circuit allows the EnerChip backup battery to deliver power to the load.

Conversely, when main system power recovers to at least the specified minimum value of V_{IN}, power is delivered to the load directly from the output of the charge pump. Whenever sufficient voltage and power are available to the MCP1253, the EnerChip will be charging. This ensures that the EnerChip is always in a charged state when needed to supply backup power.

As the battery is charged, the battery charging current decays until the battery is fully charged. *Figure 2* shows a typical charging profile of current versus time for the EnerChip. To calculate the maximum current draw during charging, multiply the rated battery capacity by the peak value shown on the graph. For example, the typical peak current drawn by the Cymbet CBC050-Q8C is 3.8 µA x 50 = 190 µA. *Figure 3* shows the typical state-of-charge versus charging time when using a constant 4.1V to charge the EnerChip.

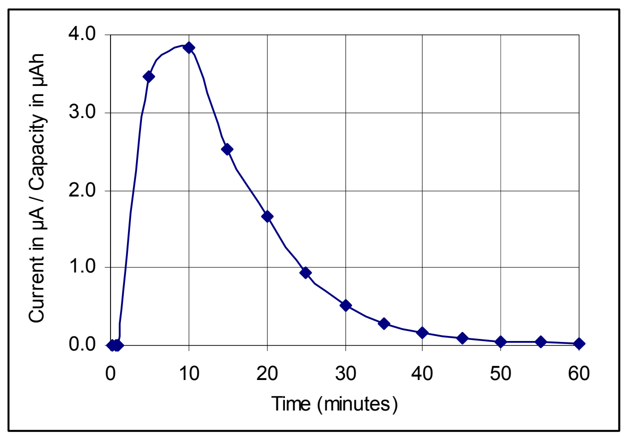

Figure 2. Charging Current Profile; Vc = 4.1V.

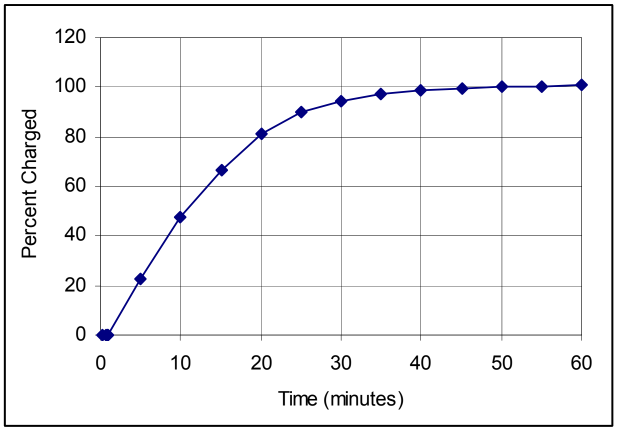

Figure 3. Typical Charge vs. Charging Time.

In order to provide the longest possible backup time and also maximize the service life of the EnerChip, it is essential to eliminate all parasitic leakage paths that would otherwise deplete the battery capacity regardless of the system operating mode. This design uses a simple but effective technique to isolate itself from the power supply during power outages. Isolation prevents any discharging of the battery through the charging circuit or the power supply input.

The output voltage from the board – whether operating from the backup battery or main system power – is available from either of two connectors, allowing the user to choose from any of three voltage ranges. Output can be taken directly from the EnerChip or from either one or two diode drops below the EnerChip output voltage. This allows designers to deliver power to the load without exceeding the supply voltage rating of common integrated circuits while not wasting charge capacity from the EnerChip, as would occur with the use of a linear or shunt regulator.

Data sheets showing discharge profiles and other important characteristics of the EnerChip products can be found at http://www.cymbet.com/content/products.asp.

Operational Description

The EVAL-02 schematic is given in *Figure 4*. Basic operation is as follows.

When jumper J3 is applied, coin cell BT1 provides main power to the charge pump and the external load under normal operation. V_{OUT} of charge pump MCP1253 also delivers 4.1V to charge either backup battery CBC012 or CBC050 (or neither), depending on the position of jumper JP1. Should there be insufficient voltage to drive the charge pump – as when the coin cell voltage falls below approximately 2.7V – output PGOOD will be driven low, turning off FETs Q1A and Q1B. In this state, charging of the EnerChip backup battery is discontinued and the EnerChip is isolated from the charge pump circuitry. Backup battery voltage, less one or two diode drops (depending on the position of shorting jumper JP2), will be present across J1. When V_{BAT}, as measured across J2, drops below approximately 3.3 volts, FETs Q2A and Q2B are turned off, disconnecting the backup battery from the load. This feature prevents the EnerChip from becoming discharged too deeply, a condition that could destroy the battery.

Applying a shorting jumper across the JP3 pins allows the user to disable the MCP1253 charge pump, putting the circuit into a low power mode.

The high level electrical specifications of EVAL-02 are given in *Table 1* and the Bill of Materials is listed in *Table 2*.

Table 3 serves as a reference guide for understanding the modes of operation resulting from each of the header connection (e.g., jumper) settings.

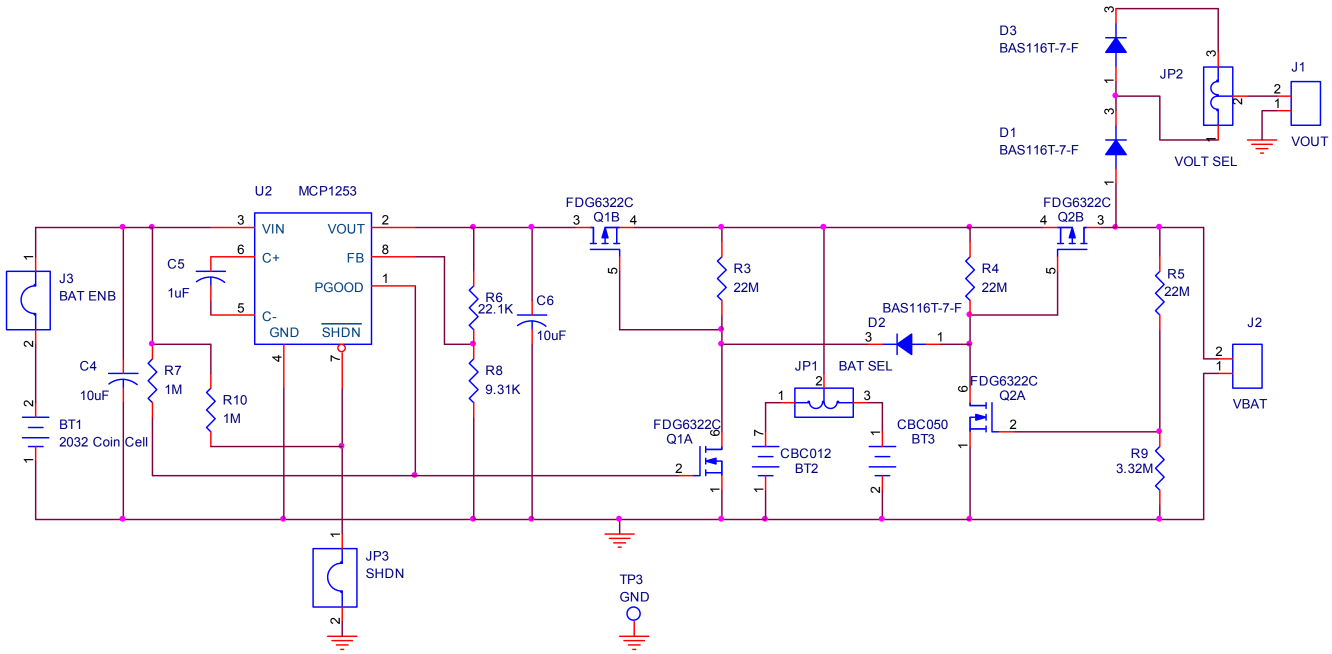

Figure 4. EVAL-02 Schematic.

Parameter	Symbol	Min.	Typical	Max.	Units
Input Voltage	V_{IN}	2.7	---	5.5	Volts
Input Current (battery charging)	I_{IN}	---	2.5	---	mA
Charger Quiescent Current (battery charged)	I_Q	---	190	250	μA @ 3.3 Volts
V_{OUT} (pin 2 of J1), 2μA load	V_{OUT}	2.3	3.1	3.3	V
Charging Voltage (pin 2 of JP1)	V_C	4.05	4.1	4.15	V
Battery Cutoff Voltage (pin 2 of J2)	V_{BC}	3.0	3.3	3.6	V
Operating Temperature	T	0	---	70	°C

Table 1. Electrical Specifications of EVAL-02.

Quantity	Reference	Manufacturer	Manufacture Part #	Description	Digi Key Part #
1	U2	Microchip	MCP1253-ADJI/MS	DC/DC Converter	MCP1253-ADJI/MS-ND
2	Q1,Q2	Fairchild Semiconductor	FDG6322C	IC FET DGTL N/P-CHAN DUAL SC70-6	FDG6322CCT-ND
3	D1,D2,D3	Diodes Inc	BAS116T-7-F	DIODE SWITCH 85V 150MW SOT523	BAS116T-FDICT-ND
3	C2	Panasonic	ECJ-1VB0J105K	1uF Cap Ceramic 6.3 volt	PCC1915TR-ND
2	C1,C3	Panasonic	ECJ-1VB0J106M	10uF Cap Ceramic 6.3 volt	PCC2395CT-ND
1	R3	VISHAY/DALE	CRCW060322K1FKEA	RES 22.1K OHM 1/10W 1% 0603 SMD	541-22.1KHCT-ND
1	R4	VISHAY/DALE	CRCW06039K31FKEA	RES 9.31K OHM 1/10W 1% 0603 SMD	541-9.31KHCT-ND
2	R1,R2	VISHAY/DALE	CRCW06031M00FKEA	RES 1.0M OHM 1/10W 5% 0603 SMD	541-1.00MHTR-ND
1	R8	VISHAY/DALE	CRCW06033M32FKEA	RES 3.32M OHM 1/10W 1% 0603 SMD	541-3.32MHCT-ND
3	R5,R6,R7	STACKPOLE ELECTRONICS INC	RMCF 1/16 22M 5% R	RES 22M OHM 1/10W 5% 0603 SMD	RMCF1/1622M5%R-ND
1	BT1	MPD (Memory Protection Devices)	BA2032SM	HOLDER COIN CELL 2032 EJECT SMD	BA2032SM-ND
1	BT2	Cymbet Corporation	CBC012	Lithium Cell 12µAH 5X5mm 8 pin LLP	N/A
1	BT3	Cymbet Corporation	CBC050	Lithium Cell 50µAH 8X8mm 56 pin QFN	N/A
0.12	J1,J2,J3	Samtec	TSW-150-07-G-S	CONN HEADER 50POS .100" SGL GOLD	SAM1029-50-ND
0.16	JP1,JP2,JP3	Samtec	TSW-150-07-G-S	CONN HEADER 50POS .100" SGL GOLD	SAM1029-50-ND
1	Bare Board	Cymbet Corporation	750003	3V Evaluation Board, EVAL-04	N/A

Table 2. EVAL-02 Bill of Materials (BoM).

Header Identifier	Description	Important Notes on Operation
J1: V_{OUT}	**Output pins** to connect to external load.	Output pins. Do not short pins together. Pin 2 is V+, pin 1 is GND.
J2: V_{BAT}	**V_{BAT} output pins.**	Output pins. Do not short pins together. Pin 2 is V+, pin 1 is GND.
J3: BAT ENB	**Connects coin cell to circuit**, which operates charge pump, charges backup battery, and delivers power to the load (V_{OUT} and V_{BAT}) during normal operation.	Short pin 1 to pin 2 to connect coin cell.
JP1: BAT SEL	**Connects** one of the two **CBC backup batteries** to the circuit.	Short pin 1 to 2 to select CBC012. Short pin 2 to 3 to select CBC050.
JP2: VOLT SEL	**Selects one of two output voltage ranges** - either one or two diode drops lower than V_{BAT}.	Short pin 1 to 2 to select V_{OUT} to be one diode drop below V_{BAT}. Nominal voltage range is 2.3V to 3.3V (with 2µA load). Short pin 2 to 3 to select V_{OUT} to be two diode drops below V_{BAT}. Nominal voltage range is 1.6V to 2.8V (with 2µA load).
JP3: SHDN	**Disables** the MCP1253 **charge pump**.	Short pin 1 to pin 2 to disable the charge pump. Backup battery will no longer be connected to the charging source in this mode. Power to the load (if any) will be provided by the backup battery connected via JP1.

Table 3. Reference Table for Header Pins.