# EnerChip™ CC 12µAh with Integrated Power Management

## Features

- Power Manager with Charge Control
- Integrated 12µAh Thin Film Energy Storage
- Built-in Energy Storage Protection
- Temperature Compensated Charge Control
- Adjustable Switchover Voltage
- Charges Integrated EnerChip Over a Wide Supply Range
- Low Standby Power
- SMT - Lead-Free Reflow Tolerant
- Thousands of Recharge Cycles
- Low Self-Discharge
- Eco-Friendly, RoHS Compliant

## Applications

- Standby supply
- Wireless sensors and RFID tags
- Localized power source
- Power Bridging
- Consumer appliances
- Business and industrial systems
- Energy Harvesting

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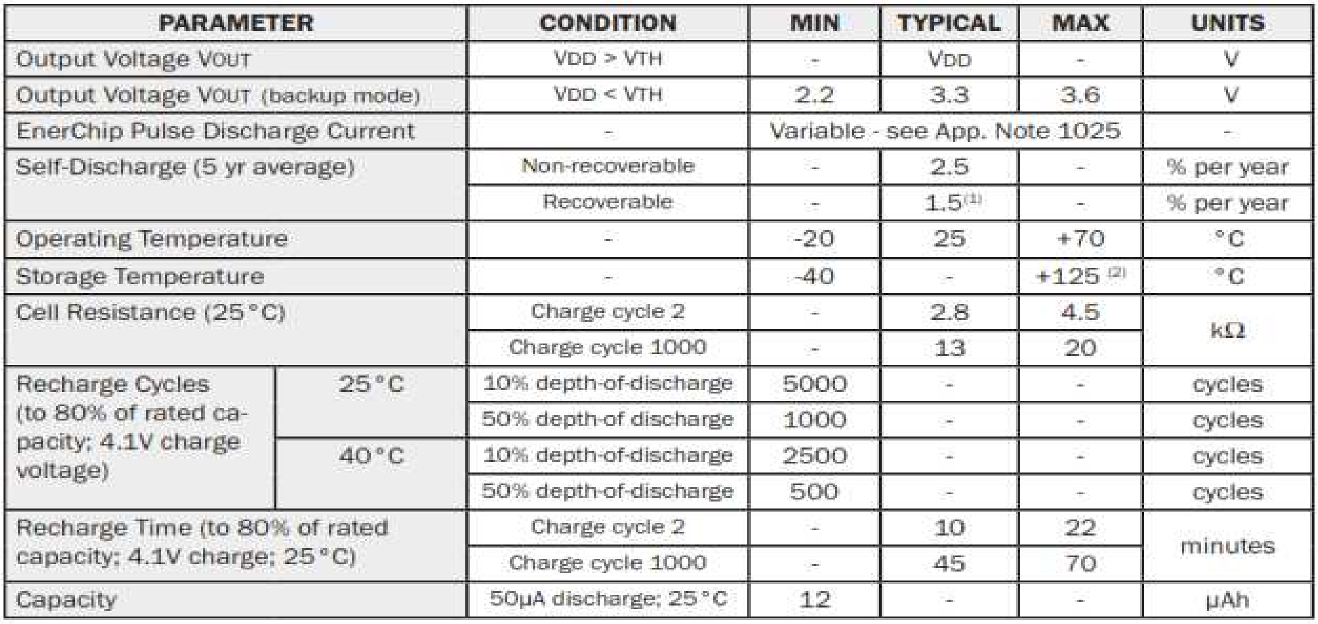
## Part Numbering Example: CCBC3112 T- A5

| | | | |
|---|---|---|---|
| **CCBC3112** | **T** | **D7C** | **A5** |
| **SERIES** | **SHIPPING PKG** | **PACKAGE STYLE** | **OPERATING TEMP.** |
| | T = Tube<br>Z1 = 1K<br>Z5 = 5K | D7C = 20-pin D7 DFN | -20°C to 70°C |

## Operating Characteristics



| PARAMETER | | CONDITION | MIN | TYPICAL | MAX | UNITS |
|---|---|---|---|---|---|---|
| Output Voltage $V_{OUT}$ | | $V_{DD} > V_{TH}$ | - | $V_{DD}$ | - | V |
| Output Voltage $V_{OUT}$ (backup mode) | | $V_{DD} < V_{TH}$ | 2.2 | 3.3 | 3.6 | V |
| EnerChip Pulse Discharge Current | | - | Variable - see App. Note 1025 | | | - |
| Self-Discharge (5 yr average) | | Non-recoverable | - | 2.5 | - | % per year |
| | | Recoverable | - | 1.5[1] | - | % per year |
| Operating Temperature | | - | -20 | 25 | +70 | °C |
| Storage Temperature | | - | -40 | - | +125 [2] | °C |
| Cell Resistance (25°C) | | Charge cycle 2 | - | 2.8 | 4.5 | kΩ |
| | | Charge cycle 1000 | - | 13 | 20 | |
| Recharge Cycles (to 80% of rated capacity; 4.1V charge voltage) | 25°C | 10% depth-of-discharge | 5000 | - | - | cycles |
| | | 50% depth-of discharge | 1000 | - | - | cycles |
| | 40°C | 10% depth-of-discharge | 2500 | - | - | cycles |
| | | 50% depth-of-discharge | 500 | - | - | cycles |
| Recharge Time (to 80% of rated capacity; 4.1V charge; 25°C) | | Charge cycle 2 | - | 10 | 22 | minutes |
| | | Charge cycle 1000 | - | 45 | 70 | |
| Capacity | | 50µA discharge; 25°C | 12 | - | - | µAh |

*1. First month recoverable self-discharge is 5% average.*

*2. Storage temperature is for uncharged EnerChip ™ CC device*

**Note: All specifications contained within this document are subject to change without notice**

### Electrical Properties

| | |
|---|---|
| EnerChip$^{TM}$ Backup Output Voltage: | 3.3V |
| Energy Capacity (typical): | 12µAh |
| Recharge time to 80%: | 10 minutes |
| Charge/ Discharge cycles: | >5000 to 10% discharge |

### Physical Properties

| | |
|---|---|
| Package size: | 7mm x 7mm |
| Operating temperature: | -20°C to +70°C |
| Storage temperature: | -40°C to +125°C |

7mm x 7mm DFN SMT Package

The EnerChip$^{TM}$ CC is the world's first Intelligent Thin Film Energy Storage Device. It is an integrated solution that provides backup energy storage and power management for systems requiring power bridging and/or secondary power. A single EnerChip$^{TM}$ CC can charge up to 10 additional EnerChips$^{TM}$ connected in parallel.

During normal operation, the EnerChip$^{TM}$ CC charges itself with a controlled voltage using an internal charge pump that operates from 2.5V to 5.5V. An ENABLE pin allows for activation and deactivation of the charge pump using an external control line in order to minimize current consumption and take advantage of the fast recharge time of the EnerChip$^{TM}$.

When the primary power supply dips below a user defined threshold voltage, the EnerChip$^{TM}$ CC will signal this event and route the EnerChip$^{TM}$ voltage to VOUT. The EnerChip$^{TM}$ CC also has energy storage protection circuitry to enable thousands of recharge cycles.

The CCBC3112-R4C is a 20-pin, 7mm x 7mm Dual Flat No-lead (DFN) package, available in tubes, trays, or tape-and-reel for use with automatic insertion equipment.

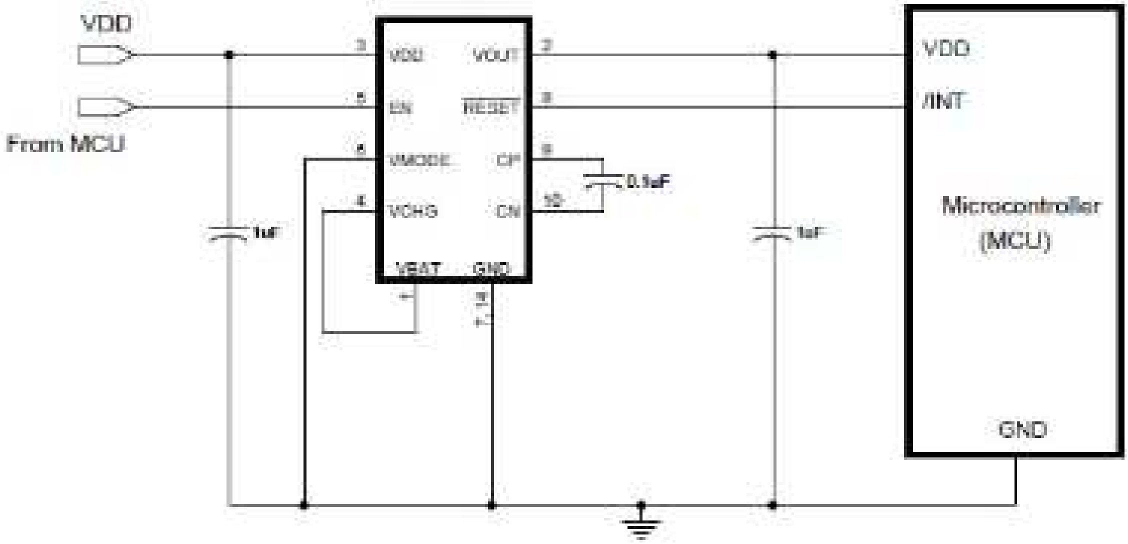


**Figure 1: Typical EnerChip$^{TM}$ CC Application Circuit**

### Functional Block Diagram

The EnerChip$^{TM}$ CC internal schematic is shown in Figure 2. The input voltage from the power supply (VDD) is applied to the charge pump, the control logic, and is compared to the user-set threshold as determined by the voltage on VMODE. VMODE is an analog input ranging from 0V to VDD. The ENABLE pin is a digital input that turns off the charge pump when low. VOUT is either supplied from VDD or the integrated EnerChip$^{TM}$. RESET is a digital output that, when low, indicates VOUT is being sourced by the integrated EnerChip$^{TM}$.

CFLY is the flying capacitor in the voltage doubler circuit. The value of CFLY can be changed if the output impedance of the EnerChip$^{TM}$ CC needs to be modified. The output impedance is dictated by 1/fC, where f is the frequency of oscillation (typically 100kHz) and C is the capacitor value (typically 0.1µF). GND is system ground.

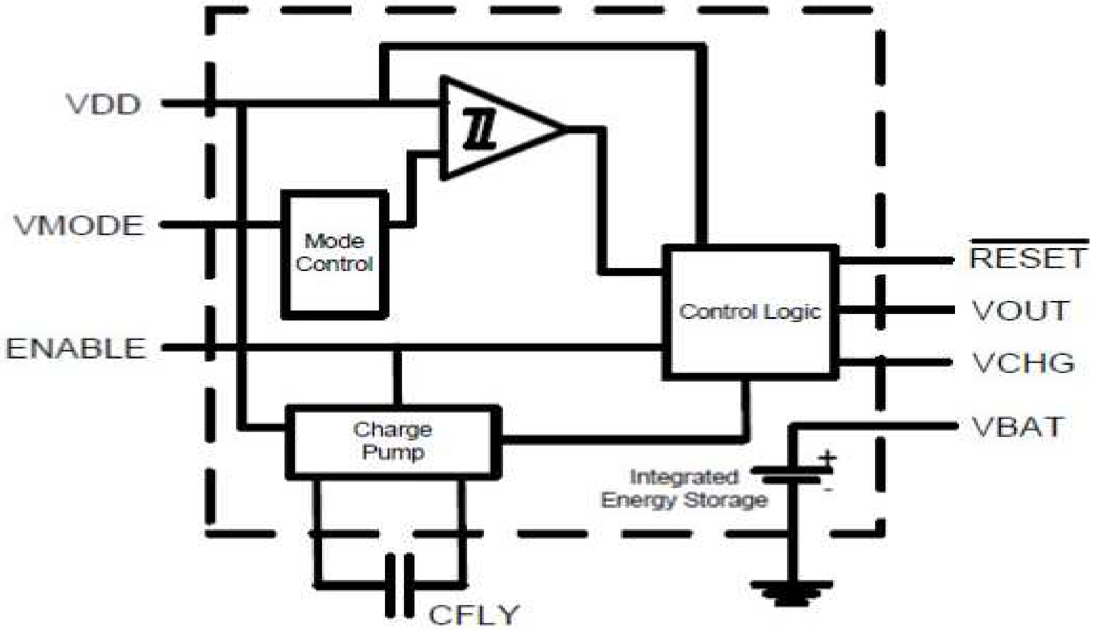


Figure 2: EnerChip$^{TM}$ CC CCBC3112 Internal Block Diagram

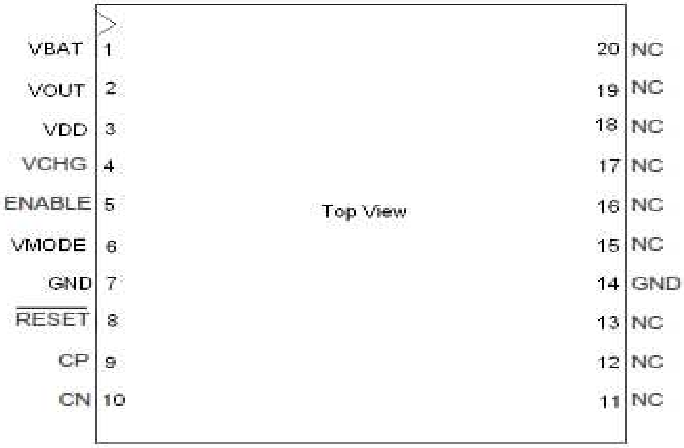
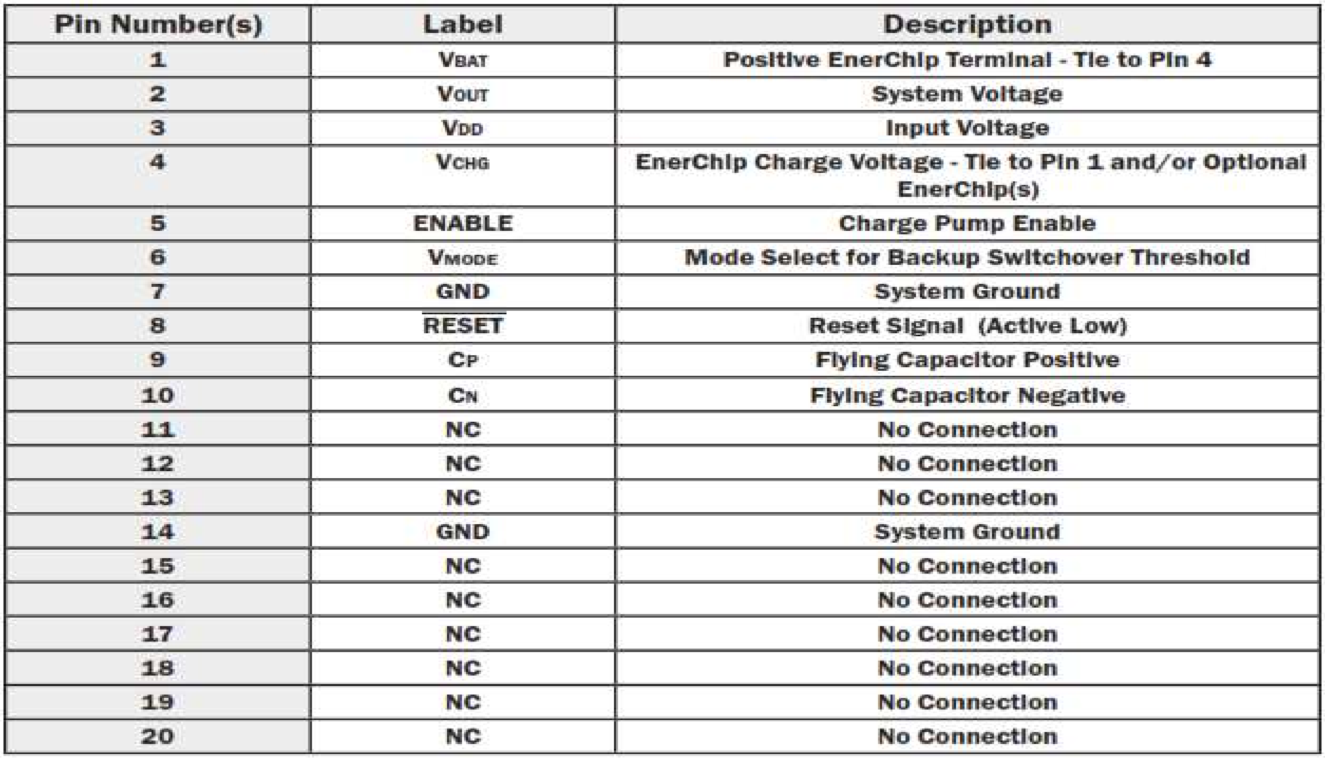


Figure 3: EnerChip$^{TM}$ CC CCBC3112 ackage Pin-Out

## CCBC3112-R4C Input/Ouput Descriptions



| Pin Number(s) | Label | Description |
|---|---|---|
| 1 | VBAT | Positive EnerChip Terminal - Tie to Pin 4 |
| 2 | VOUT | System Voltage |
| 3 | VDD | Input Voltage |
| 4 | VCHG | EnerChip Charge Voltage - Tie to Pin 1 and/or Optional EnerChip(s) |
| 5 | ENABLE | Charge Pump Enable |
| 6 | VMODE | Mode Select for Backup Switchover Threshold |
| 7 | GND | System Ground |
| 8 | $\overline{\text{RESET}}$ | Reset Signal (Active Low) |
| 9 | CP | Flying Capacitor Positive |
| 10 | CN | Flying Capacitor Negative |
| 11 | NC | No Connection |
| 12 | NC | No Connection |
| 13 | NC | No Connection |
| 14 | GND | System Ground |
| 15 | NC | No Connection |
| 16 | NC | No Connection |
| 17 | NC | No Connection |
| 18 | NC | No Connection |
| 19 | NC | No Connection |
| 20 | NC | No Connection |

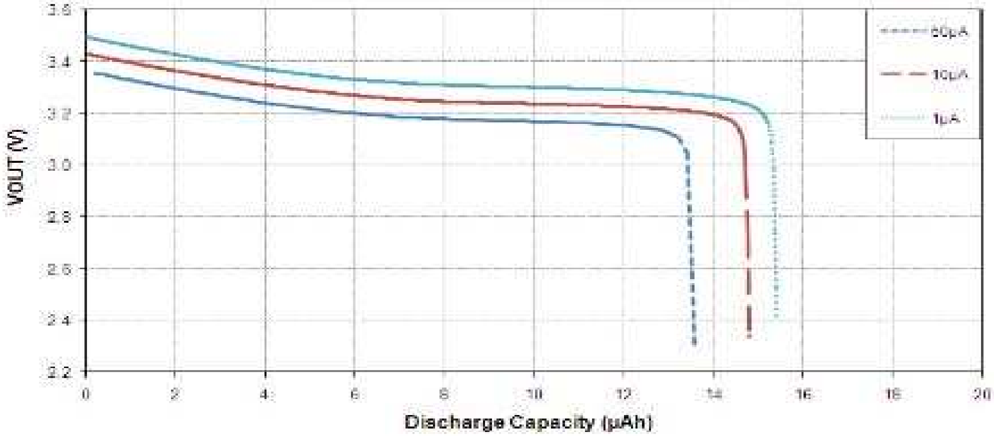
## Absolute Maximum Ratings

| PARAMETER | CONDITION | MIN | TYPICAL | MAX | UNITS |
|---|---|---|---|---|---|
| VDD with respect to GND | 25°C | GND - 0.3 | - | 6.0 | V |
| ENABLE and VMODE Input Voltage | 25°C | GND - 0.3 | - | VDD+0.3 | V |
| VBAT (1) | 25°C | 3.0 | - | 4.15 | V |
| VCHG (1) | 25°C | 3.0 | - | 4.15 | V |
| VOUT | 25°C | GND - 0.3 | - | 6.0 | V |
| $\overline{\text{RESET}}$ Output Voltage | 25°C | GND - 0.3 | - | VOUT+0.3 | V |
| CP, Flying Capacitor Voltage | 25°C | GND - 0.3 | - | 6.0 | V |
| CN | 25°C | GND - 0.3 | - | VDD+0.3 | V |

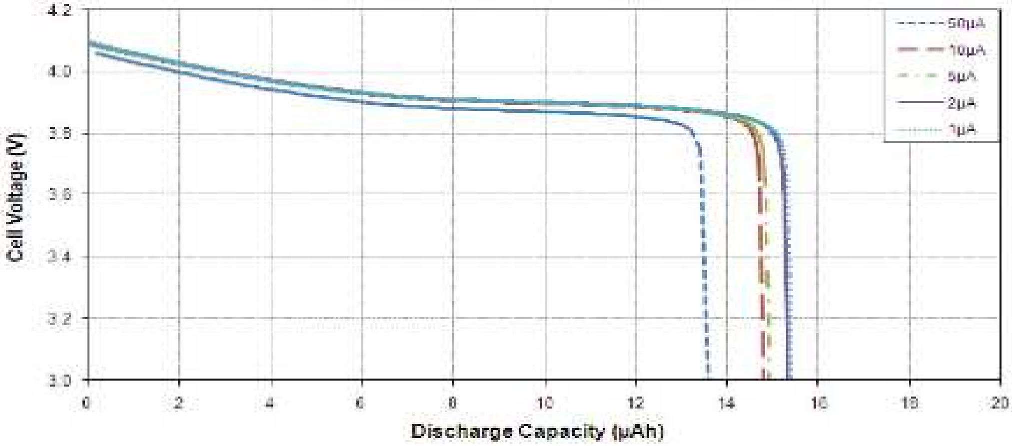
*(1) No external connections to these pins are allowed, except parallel EnerChips ™ .*

**Note: All specification contained within this document are subject to change without notice.**

**Typical VOUT of CCBC3112 in Backup Mode**



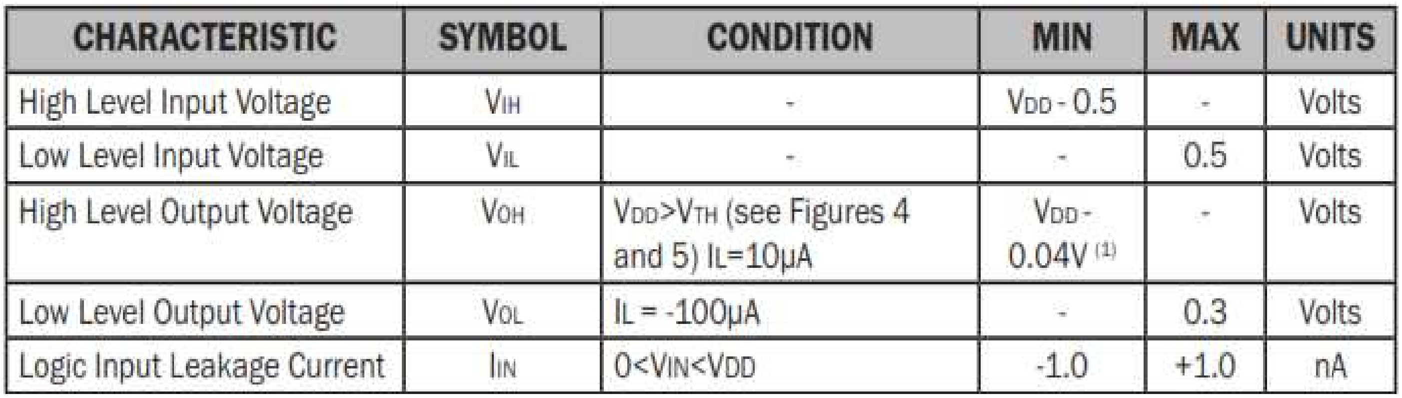
**Typical CCBC012 EnerChip™ Discharge Characteristics**



## Power Supply Current Characteristics
## Ta = -20°C to +70°C

| CHARACTERISTIC | SYMBOL | CONDITION | | MIN | MAX | UNITS |
|---|---|---|---|---|---|---|
| Quiescent Current | $I_Q$ | ENABLE=GND | $V_{DD}$=3.3V | - | 3.5 | µA |
| | | | $V_{DD}$=5.5V | - | 6.0 | µA |
| | | ENABLE=$V_{DD}$ | $V_{DD}$=3.3V | - | 35 | µA |
| | | | $V_{DD}$=5.5V | - | 38 | µA |
| EnerChip Cutoff Current | $I_{QBATOFF}$ | $V_{BAT} < V_{BATCO}$,<br>$V_{OUT}$=0 | | - | 0.5 | nA |
| | $I_{QBATON}$ | $V_{BAT} > V_{BATCO}$,<br>ENABLE=$V_{DD}$, $I_{OUT}$=0 | | - | 42 | nA |

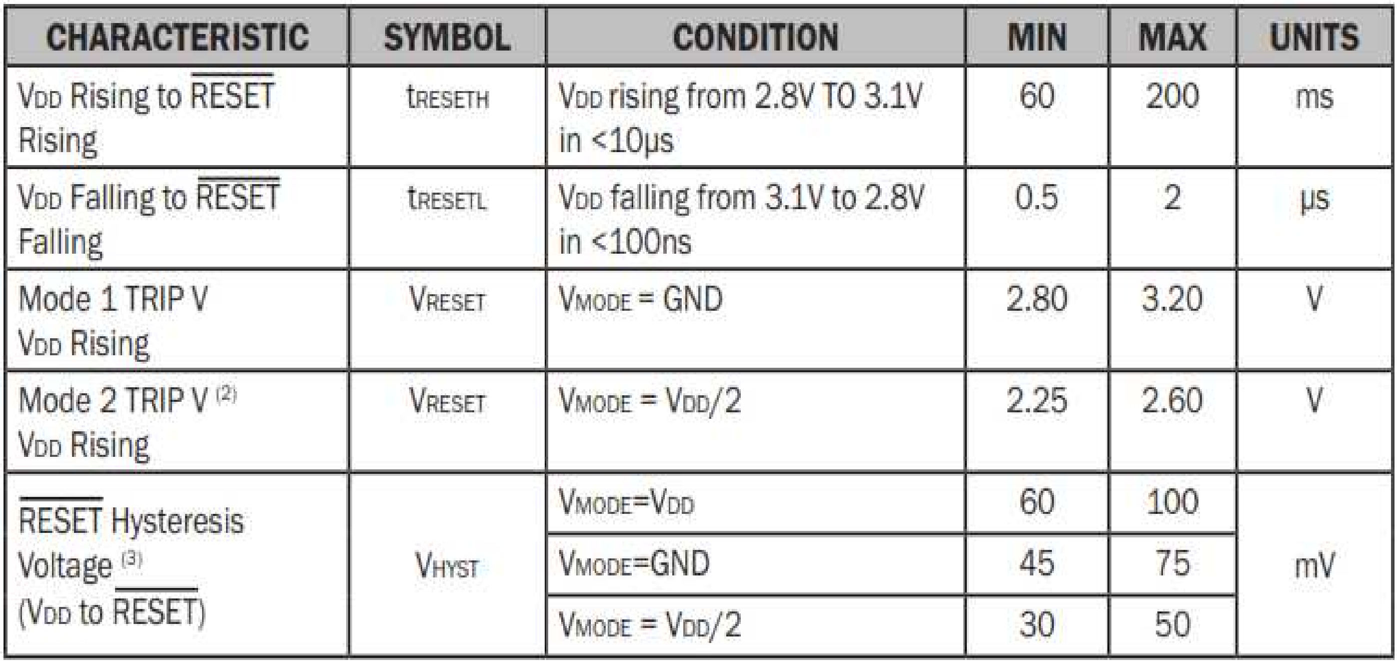
### Interface Logic Signal Characteristics
### $V_{DD}$ = 2.5V to 5.5V, Ta = -20°C to +70°C



| CHARACTERISTIC | SYMBOL | CONDITION | MIN | MAX | UNITS |
|---|---|---|---|---|---|
| High Level Input Voltage | $V_{IH}$ | - | $V_{DD}$ - 0.5 | - | Volts |
| Low Level Input Voltage | $V_{IL}$ | - | - | 0.5 | Volts |
| High Level Output Voltage | $V_{OH}$ | $V_{DD}$>$V_{TH}$ (see Figures 4 and 5) $I_L$=10µA | $V_{DD}$ - 0.04V (1) | - | Volts |
| Low Level Output Voltage | $V_{OL}$ | $I_L$ = -100µA | - | 0.3 | Volts |
| Logic Input Leakage Current | $I_{IN}$ | 0<$V_{IN}$<$V_{DD}$ | -1.0 | +1.0 | nA |

*(1) RESET tracks $V_{DD}$; RESET = $V_{DD}$ - (IOUT x ROUT).*

### RESET Signal AC/DC Characteristics
### $V_{DD}$ = 2.5V to 5.5V, Ta = -20°C to +70°C



| CHARACTERISTIC | SYMBOL | CONDITION | MIN | MAX | UNITS |
|---|---|---|---|---|---|
| $V_{DD}$ Rising to $\overline{\text{RESET}}$ Rising | $t_{RESETH}$ | $V_{DD}$ rising from 2.8V TO 3.1V in <10µs | 60 | 200 | ms |
| $V_{DD}$ Falling to $\overline{\text{RESET}}$ Falling | $t_{RESETL}$ | $V_{DD}$ falling from 3.1V to 2.8V in <100ns | 0.5 | 2 | µs |
| Mode 1 TRIP V $V_{DD}$ Rising | $V_{RESET}$ | $V_{MODE}$ = GND | 2.80 | 3.20 | V |
| Mode 2 TRIP V (2) $V_{DD}$ Rising | $V_{RESET}$ | $V_{MODE}$ = $V_{DD}$/2 | 2.25 | 2.60 | V |
| $\overline{\text{RESET}}$ Hysteresis Voltage (3) ($V_{DD}$ to $\overline{\text{RESET}}$) | $V_{HYST}$ | $V_{MODE}$=$V_{DD}$ | 60 | 100 | mV |
| | | $V_{MODE}$=GND | 45 | 75 | |
| | | $V_{MODE}$ = $V_{DD}$/2 | 30 | 50 | |

*(2) Users- selectable trip voltage can be set by placing a resistor divider from the VMODE pin to GND. Refer to Figure 8.*
*(3) The hysteresis is a function of trip level in Mode 2. Refer to Figure 9.*

## Charge Pump Characteristics
## $V_{DD}$ = 2.5V to 5.5V, Ta = -20°C to +70°C

| CHARACTERISTIC | SYMBOL | CONDITION | MIN | MAX | UNITS |
|---|---|---|---|---|---|
| ENABLE=$V_{DD}$ to Charge Pump Active | $t_{CPON}$ | ENABLE to 3rd charge pump pulse, $V_{DD}$=3.3V | 60 | 80 | µs |
| ENABLE Falling to Charge Pump Inactive | $t_{CPOFF}$ | - | 0 | 1 | µs |
| Charge Pump Frequency | $f_{CP}$ | | - | 120 | KHz (1) |
| Charge Pump Resistance | $R_{CP}$ | Delta $V_{BAT}$, for $I_{BAT}$ charging current of 1µA to 100µA<br>$C_{FLY}$=0.1µF, $C_{BAT}$=1.0µF | 150 | 300 | Ω |
| $V_{CHG}$ Output Voltage | $V_{CP}$ | $C_{FLY}$=0.1µF, $C_{BAT}$=1.0µF, $I_{OUT}$=1µA, Temp=+25°C | 4.075 | 4.125 | V |
| $V_{CHG}$ Temp. Coefficient | $T_{CCP}$ | $I_{OUT}$=1µA, Temp=+25°C | -2.0 | -2.4 | mV/°C |
| Charge Pump Current Drive | $I_{CP}$ | $I_{BAT}$=1mA<br>$C_{FLY}$=0.1µF, $C_{BAT}$=1.0µF | 1.0 | - | mA |
| Charge Pump on Voltage | $V_{ENABLE}$ | ENABLE=$V_{DD}$ | 2.5 | - | V |

*(1) fCP = 1/tCPPER*

## Additional Characteristics
## Ta = -20°C to +70°C

| CHARACTERISTIC | SYMBOL | CONDITION | LIMITS | | UNITS |
|---|---|---|---|---|---|
| | | | MIN | MAX | |
| $V_{BAT}$ Cutoff Threshold | $V_{BATCO}$ | $I_{OUT}$=1µA | 2.75 | 3.25 | V |
| Cutoff Temp. Coefficient | $T_{CCO}$ | - | +1 | +2 | mV/°C |
| $V_{BAT}$ Cutoff Delay Time | $t_{COOFF}$ | $V_{BAT}$ from 40mV above to 20mV below $V_{BATCO}$<br>$I_{OUT}$=1µA | 40 | - | ms |
| $V_{OUT}$ Dead Time, $V_{DD}$ Rising (2) | $t_{RSBR}$ | $I_{OUT}$=1mA<br>$V_{BAT}$=4.1V | 0.2 | 2.0 | µs |
| $V_{OUT}$ Dead Time, $V_{DD}$ Falling (2) | $t_{RSBF}$ | $V_{BAT}$=4.1V | 0.2 | 2.0 | µs |
| Bypass Resistance | $R_{OUT}$ | - | - | 2.5 | Ω |

(2) Dead time is the period when the VOUT pin is floating. Size the holding capacitor accordingly.

**Note: All specification contained within this document are subject to change without notice.**

Important timimg diagrams for the EnerChip™ CC relationship between EnerChip™ Switchover Timing and EnerChip™ Disconnect from Load Timing are shown in Figure 4.

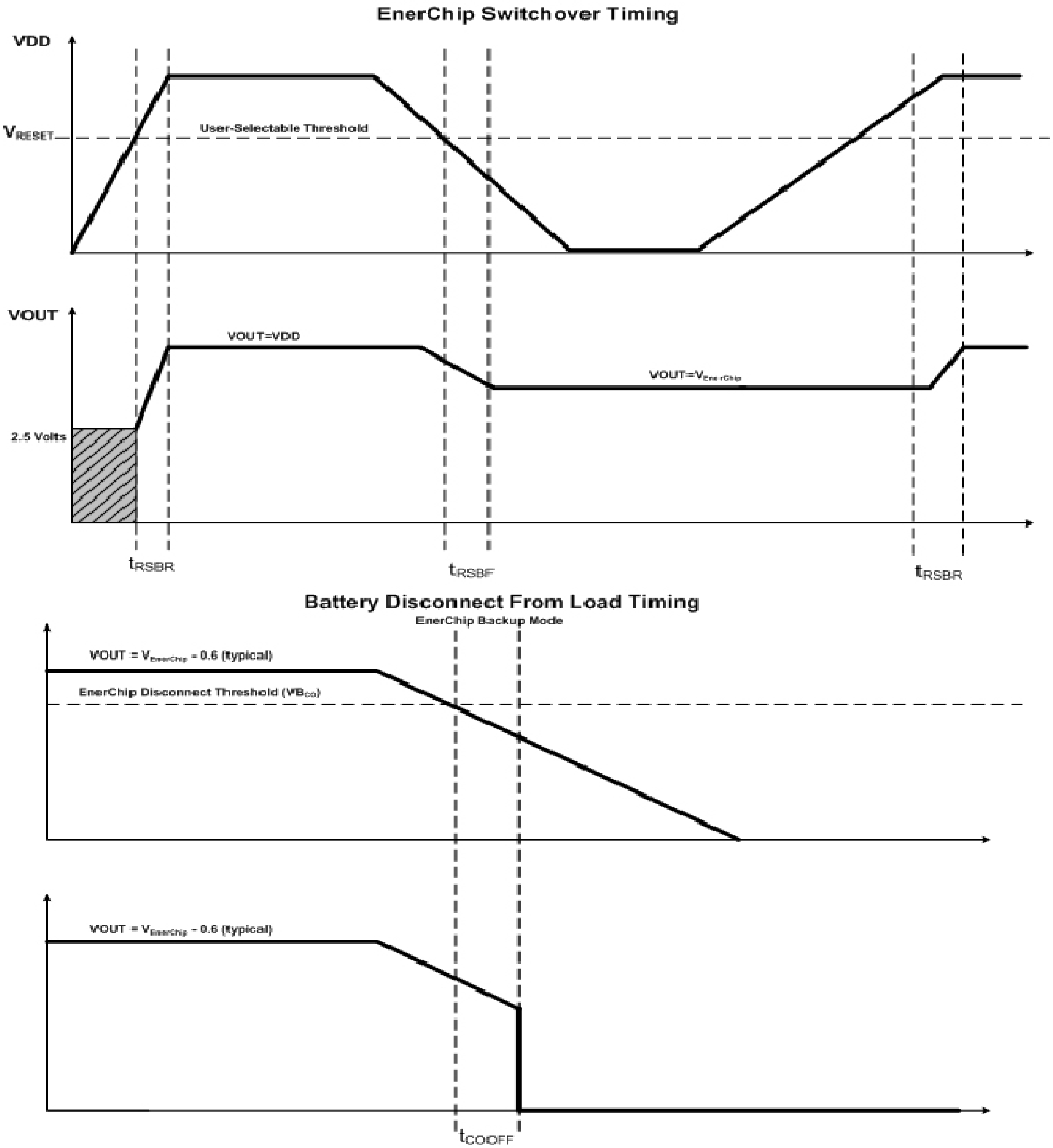


Figure 4. EnerChip™ CC Switchover and Disconnect Timing Diagrams

Timing diagrams for the EnerChip$^{TM}$ CC relationship between $V_{DD}$ to RESET and ENABLE high to charge pump becoming active are shown in Figure 5.

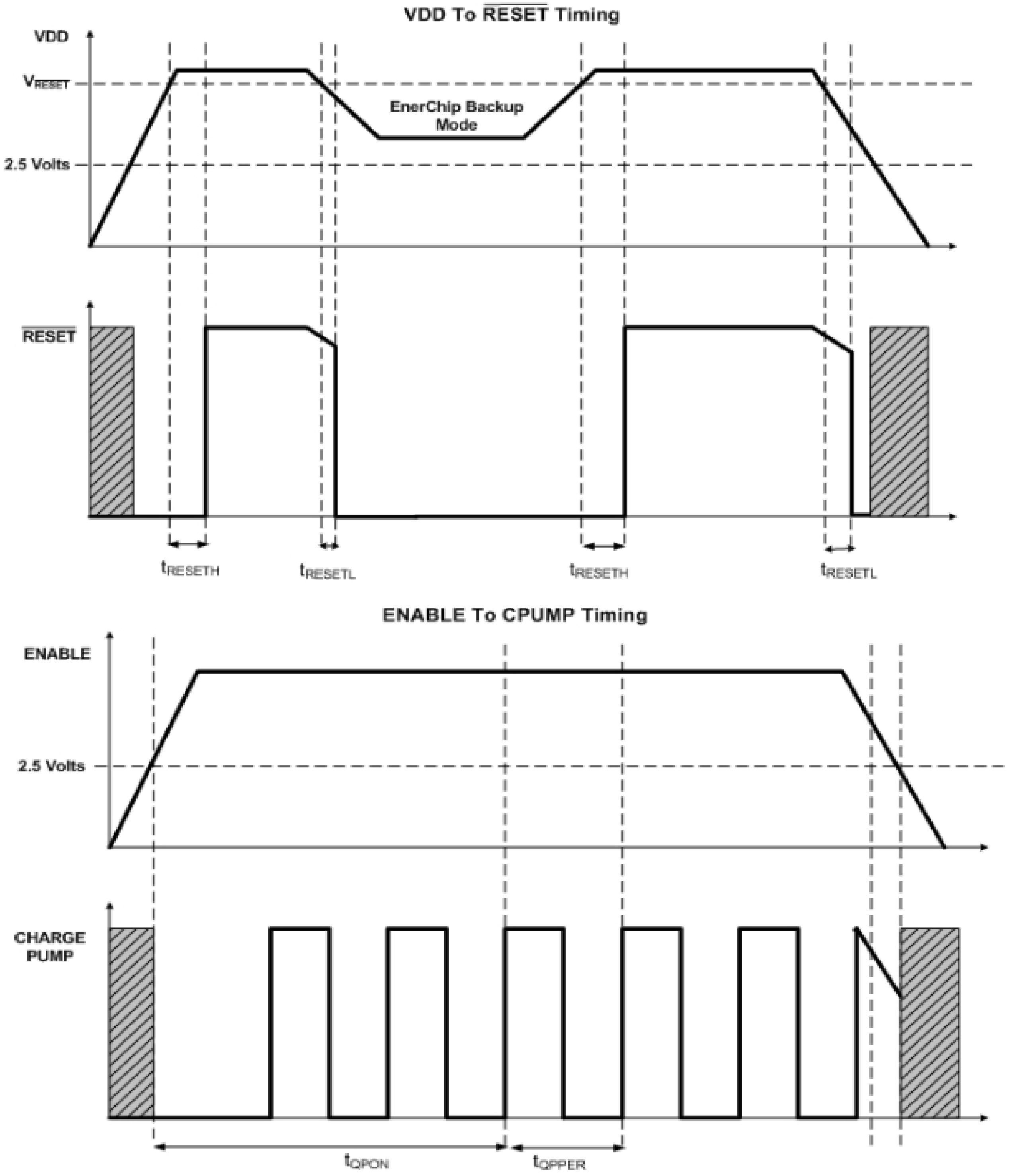


**Figure 5. Timing Diagram for VDD to RESET and Enable to Charge Pump Active.**

## EnerChip$^{TM}$ CC Detailed Description

The EnerChip$^{TM}$ CC uses a charge pump to generate the supply voltage for charging the integrated energy storage device. An internal FET switch with low RDSON is used to route VDD to VOUT during normal operation when main power is above the switchover threshold voltage. When VDD is below the switchover threshold voltage, the FET switch is shut off and VOUT is supplied by the EnerChip$^{TM}$. An interrupt signal is asserted low prior to the switchover.

## Operating Modes

The EnerChip$^{TM}$ CC can be operated from various power supplies such as a primary source or a non-rechargeable battery. With the ENABLE pin asserted high, the charge pump is active and charges the integrated EnerChip$^{TM}$. The EnerChip$^{TM}$ CC will be 80% charged within 10 minutes. Due to the rapid recharge it is recommended that, once the EnerChip$^{TM}$ CC is fully charged, the user de-assert the ENABLE pin (i.e., force low) to reduce power consumption. A Signal generated from the MCU could be used to enable and disable the EnerChip$^{TM}$ CC.

When controlling the ENABLE pin by way of an external controller - as opposed to fixing the ENABLE line to VDD - ensure that the ENABLE pin is forced low by the controller anytime the RESET line is low, which occurs when the switchover threshold voltage is reached and the device is placed in backup mode. Although the internal charge pump is designed to operate below the threshold switchover level when the ENABLE line is active, it is recommended that the ENABLE pin be forced low whenever RESET is low to ensure no parasitic loads are placed on the EnerChip$^{TM}$ while in this mode. If ENABLE is high or floating while VDD is in an indeterminate state, bias currents within the EnerChip$^{TM}$ CC could flow, placing a parasitic load on the EnerChip$^{TM}$ that could dramatically reduce the effective backup operating time.

The EnerChip$^{TM}$ CC supports 2 operational modes as shown in Figure 6 and 7.

### Mode 1 Operation

For use in 3.3 volt systems. The VMODE pin should be tied directly to GND, as shown in Figure 6. This will set the switchover threshold at approximately 3.0 volts.

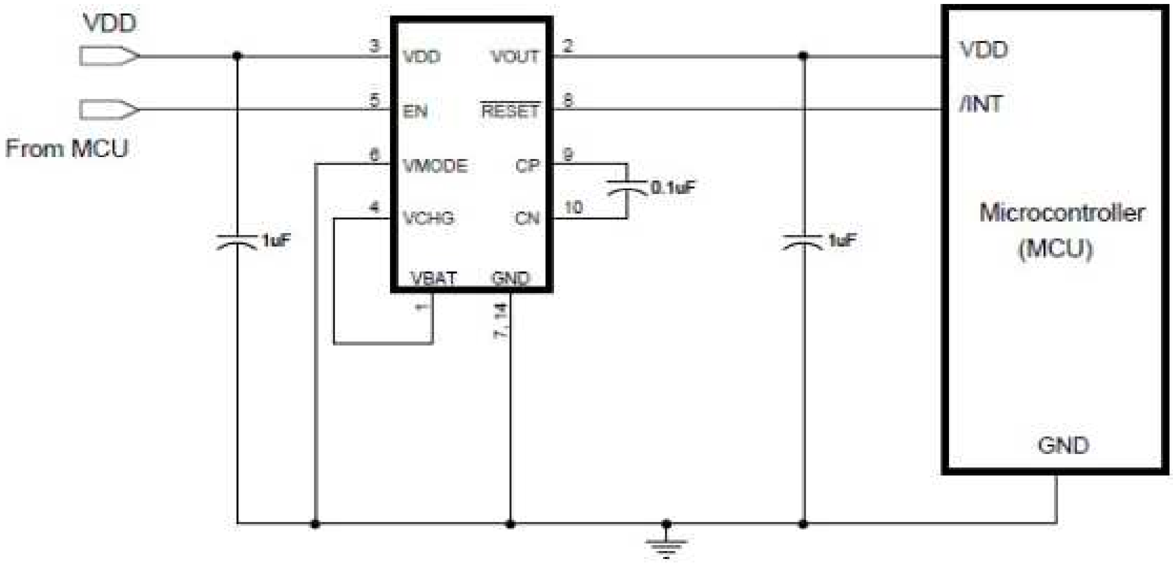


**Figure 6: CCBC3112 Typical Circuit for Mode 1 Operation**

## Mode 2 Operation

Figure 7 shows the circuitry for user-selectable switchover threshold to a value between 2.5 and 5.0 volts. Use Figure 8 to determine the value of R1. To determine the amount of hysteresis from the EnerChip$^{TM}$ switchover threshold, use Figure 9.

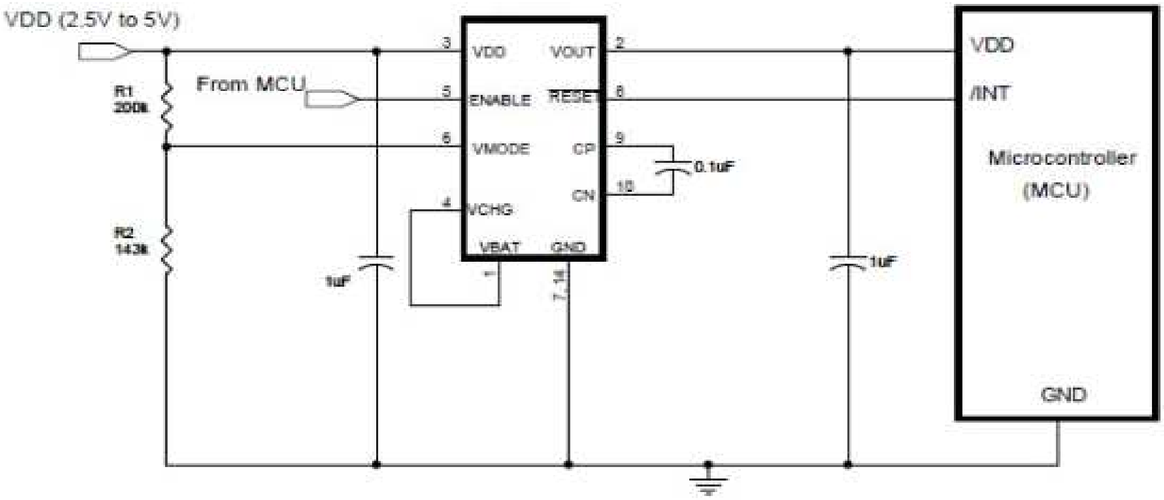


**Figure 7: CCBC3112 Typical Circuit for Mode 2 Operation**

EnerChip$^{TM}$ charging and backup power switchover threshold for 2.5 to 5.5 volt operation is selected by changing the value of R2 (see Figure 7). To determine the backup switchover point, set the value of R1 to 200kΩ and choose the value of R2 according to Figure 8. For example, to set a 3.0V trip point: If R1=200 kΩ then R2 = R1 x 0.72 = 144kΩ. Figure 7 shows a Mode 2 circuit with standard value resistors of 200kΩ and 143kΩ.

To determine the backup switchover hysteresis for Mode 2 operation, use Figure 9.

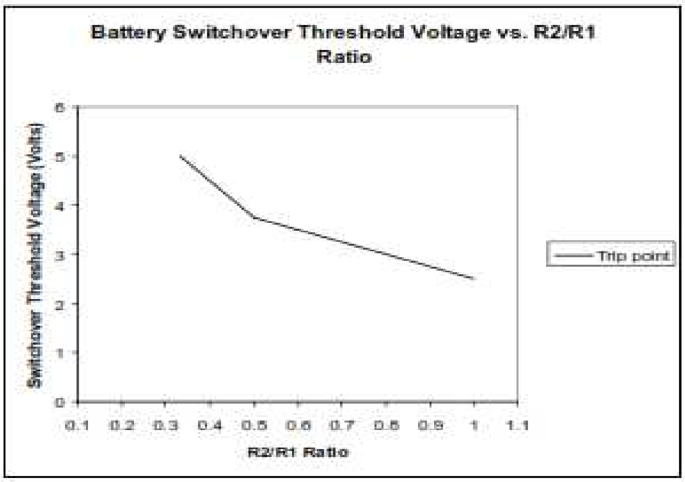


**Figure 8. Mode 2 Resistor Selection Graph**

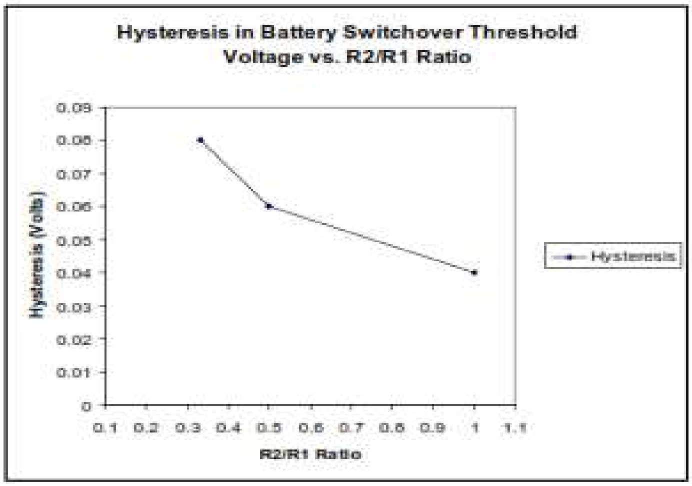
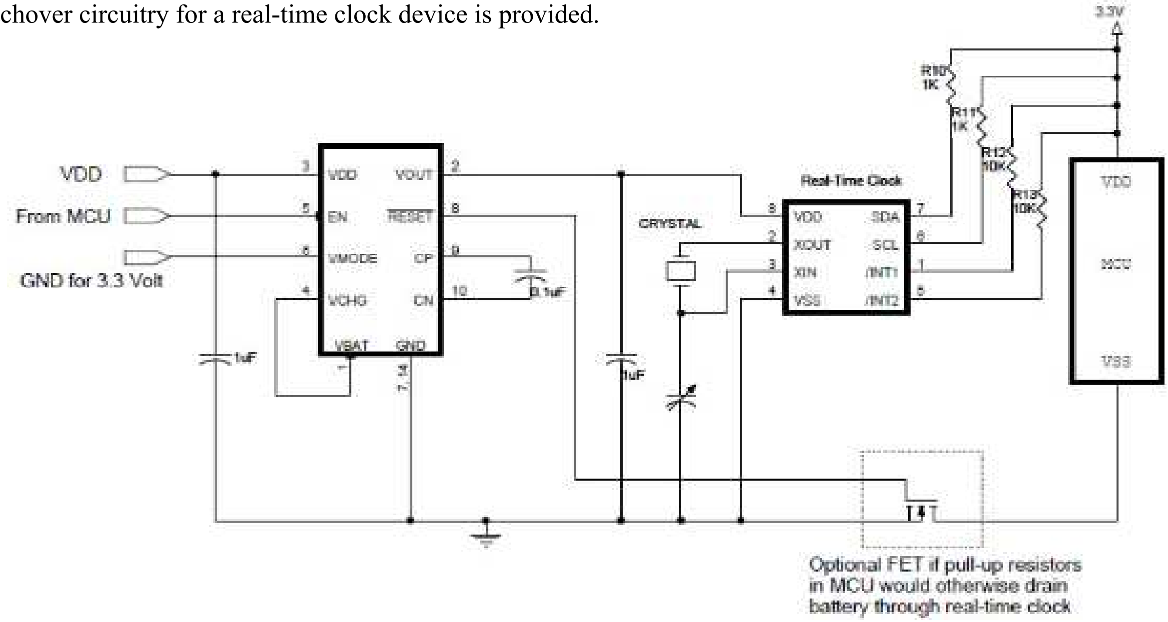


**Figure 9. Mode 2 Hysteresis as a Function of R2/R1**

## Real-Time Clock Application Circuit

The EnerChip™ CC as depicted in Figure 10 is a typical application circuit in a 3.3 volt system where backup and power switchover circuitry for a real-time clock device is provided.

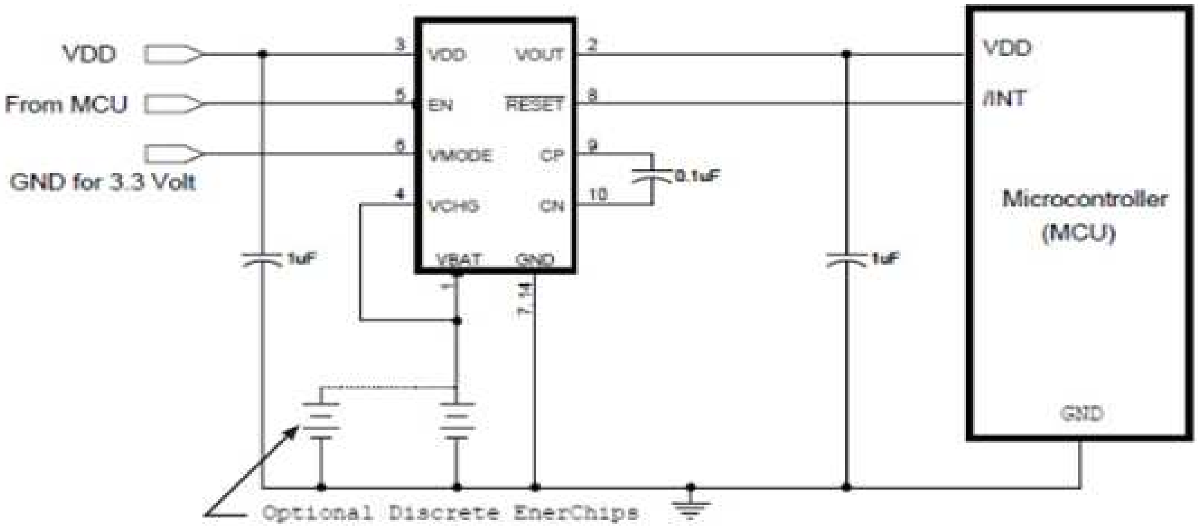


Optional FET if pull-up resistors in MCU would otherwise drain battery through real-time clock

**Figure 10: EnerChip™ CC Providing Backup Power for RTC with SPI Bus**

## Adding Power and Energy Capacity with Parallel EnerChips™

In some applications, additional EnerChip™ capacity might be needed. The schematic in Figure 11 shows how multiple EnerChips™ can be supported in parallel by a single EnerChip™ CC CCBC3112. Note that CFLY should be increased by 0.1µF for every additional EnerChip™.



Optional Discrete EnerChips

**Figure 11: EnerChip™ CC Providing Power Management for Multiple EnerChips™**

## EnerChip$^{TM}$ CC CBC3112 PCB Layout Guidelines - Important Notice!

There are several PCB layout considerations that must be taken into account when using the CCBC3112:

1. All capacitors should be placed as close as possible to the EnerChip$^{TM}$ CC. The flying capacitor connections must be as short as possible and routed on the same layer the EnerChip$^{TM}$ CC is placed.

2. Power connections should be routed on the layer the EnerChip$^{TM}$ CC is placed.

3. A ground (GND) plane in the PCB should be used for optimal performance of the EnerChip$^{TM}$ CC.

4. Very low parasitic leakage currents from the VBAT pin to power, signal, and ground connections, can result in unexpected drain of charge from the integrated power source. Maintain sufficient spacing of traces and vias from the VBAT pin and any traces connected to the VBAT pin in order to eliminate parasitic leakage currents that can arise from solder flux or contaminants on the PCB.

5. Pin 1 VBAT and Pin 4 VCHG must be tied together for proper operation.

6. There should be no traces, vias or connections under the CCBC3112 exposed die pad.

7. When placing a silk screen on the PCB around the perimeter of the package, place the silk screen outside of the package and all metal pads. Failure to observe this precaution can result in package cracking during solder reflow due to the silk screen material interfering with the solder solidification process during cooling.

8. The ENABLE pin must not be tied to $V_{DD}$ or pulled high until the final reflow of the device has been complete Failure to do so will result in damage to the battery.

9. See Figure 12 for location and dimensions of metal pad placement on the PCB.

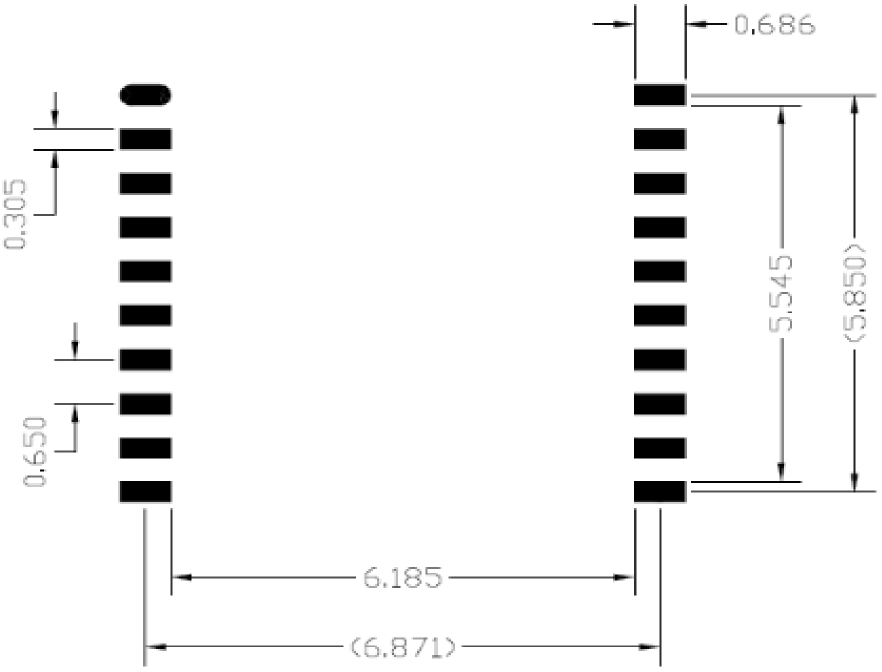
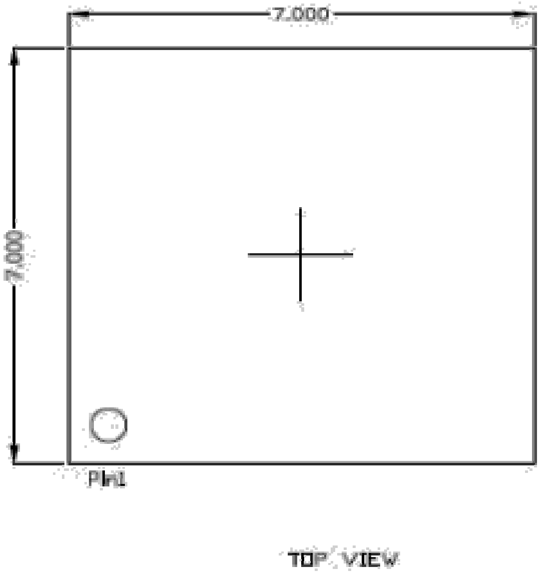
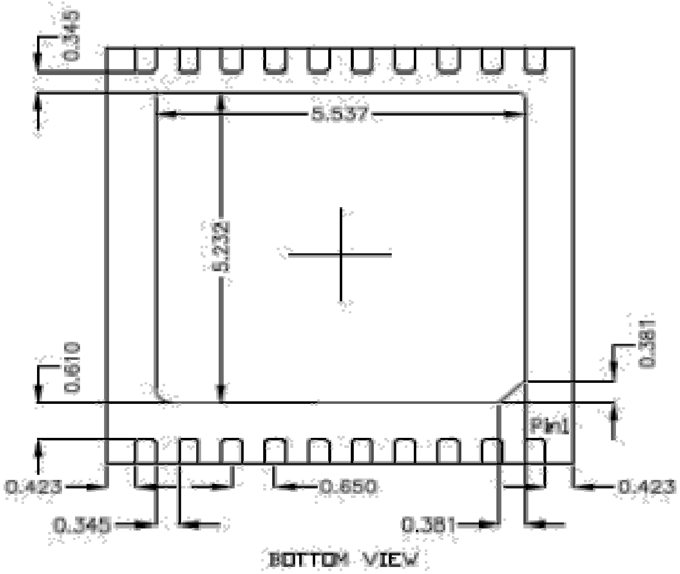
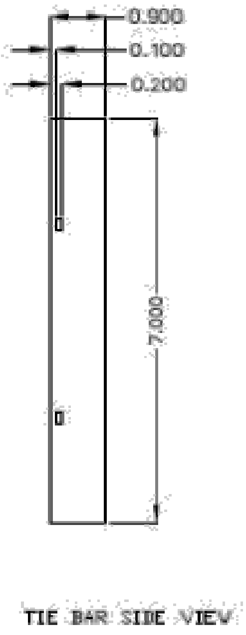


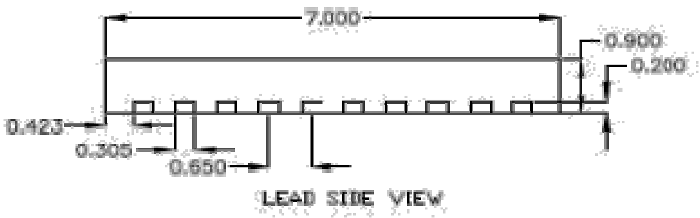
**Figure 12: Recommend PCB Layout for the CBC3112-D7C Package (Dimensions in mm)**

## CCBC3112 7mm x 7mm DFN Package Drawing and Dimensions









Notes:
1. Dimensions in millimeters.

2. Package dimensions do not include mold flash, protrusions, burrs or metal smearing.

3. Coplanarity applies to the exposed pad as well as the exposed terminals. Maximum coplanarity shall be 0.08. Warpage shall not exceed 0.10.

4. Exposed metallized feature connected to die paddle.

5. There are 10 contact pads on two opposite sides and no contact pads on the other two sides.

## Energy Harvesting with the EnerChip™ CC

The EnerChip™ CC can be configured to collect energy from transducers such as low power photovoltaic (PV) cells and use that harvested energy to charge the integrated EnerChip™ and deliver self-sustaining power to components such as microcontrollers, sensors, and radios in wireless systems. The schematic of Figure 13 illustrates the feedback connection made from RESET to EN to implement the energy harvesting function with the CCBC3150. In order to make most efficient use of the power available from the transducer (for example, a PV cell), it is necessary to know the electrical characteristics including voltage and peak power point of the transducer being used. For assistance in designing your system to effectively harvest energy from a power transducer in a specific environment, contact Cardinal Components, Inc.

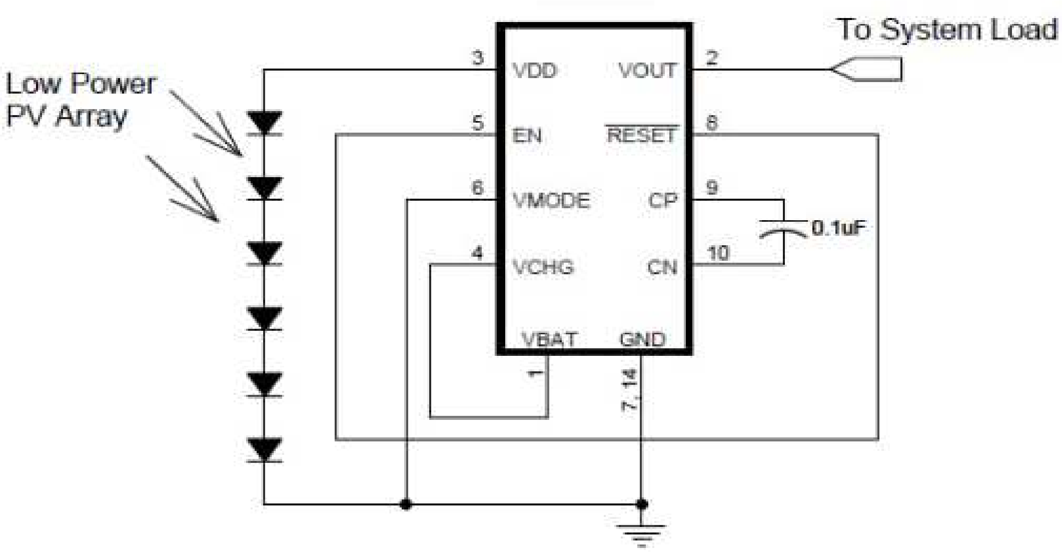


**Figure 13: Implementing Energy Harvesting with the EnerChip™ CC**