CBC-EVAL-11

EnerChip™ CC Inductive Charging Evaluation Kit

Overview

CBC-EVAL-11 is a demonstration kit combining an inductive transmitter board with a receiver board containing an EnerChip CC CBC3150 solid state storage device with integrated power management. The transmitter board operates at 13.56 MHz and derives its power from a USB port. In addition to the EnerChip CC, the receiver board has a planar antenna for receiving power from the transmitter board, an output capacitor for delivering pulse current for radio transmissions, and a header connector for mating to a target board containing, for example, a microcontroller and/or radio board. A block diagram of CBC-EVAL-11 is shown in Figure 1.

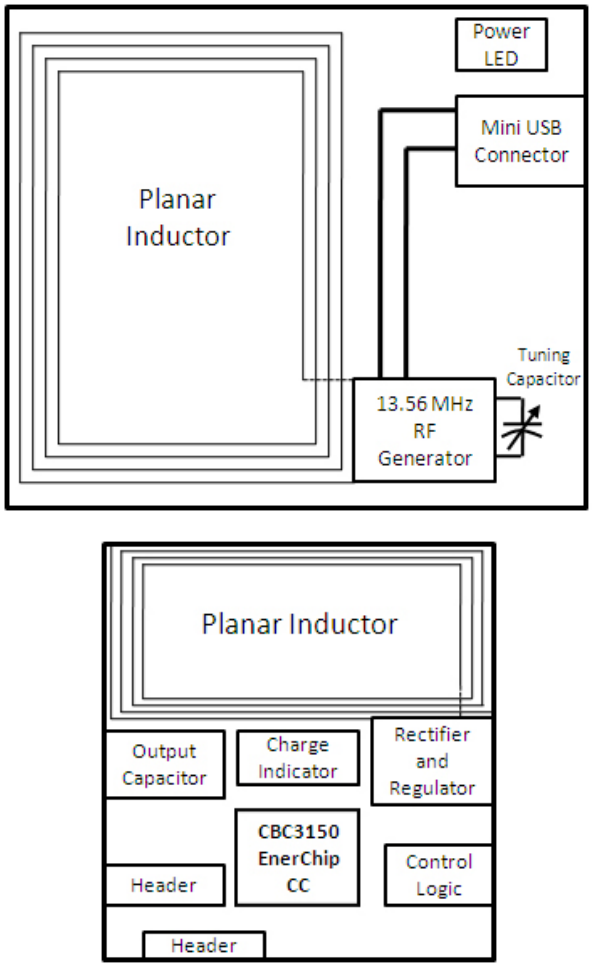


Figure 1: Block Diagram of CBC-EVAL-11 Evaluation Kit - transmitter board (top) and receiver board (bottom).



Figure 2: CBC-EVAL-11 Evaluation Kit.

Features

- Inductively-Coupled Charging Circuit
- Power Manager with Charge Control
- Microcontroller/Radio Interface Signals
- Integrated 50µAh Solid State Energy Storage
- Built-in Protection of Energy Storage Device
- Temperature Compensated Charge Control
- Adjustable Switchover Voltage
- Low Self-Discharge
- SMT - Lead-Free Reflow Tolerant
- Thousands of Recharge Cycles
- Eco-Friendly, RoHS Compliant

Applications

- **Rechargeable power source** eliminates cost of replacing conventional batteries.
- **Wireless sensors, data loggers, and RFID tags** and other powered, low duty cycle applications. Contactless recharging.
- **Localized power source** to keep microcontrollers and other devices alert in standby mode.
- **Medical devices** such as 'smart' bandages, external biological sensors, and patient monitoring. No direct connection needed to/from power supply; can be hermetically sealed.
- **Industrial systems** such as data logging in cold-chain time and temperature monitoring.
- **Inductive Coupling** allows convenient means of recharging integrated EnerChip for thousands of uses in RFID, sensor, and wireless transmitter applications.

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System Description

CBC-EVAL-11 (Figure 3) is an inductive RF charger for the CBC3150 with integrated energy storage management and energy harvesting emulation. The CBC-EVAL-11 system consists of an inductive wireless transmitter module tuned to a frequency of 13.56MHz and an inductive wireless charger (receiver) module. The transmitter module is designed to be powered by a computer USB port as shown in Figure 4.

The wireless inductive charger module consists of a planar inductor fabricated on the printed circuit board in parallel with a variable capacitor. This circuit forms a resonant tank circuit tuned to a frequency of 13.56 MHz, which in turn feeds the AC input of a full-wave bridge rectifier. The DC output of the rectifier is filtered by a capacitor and clamped by a Zener diode. The DC output is then regulated by a linear regulator to 3.3V and fed to the input of the Cymbet CBC3150. The CBC3150 has a power management circuit and a 50µAh thin film EnerChip rechargeable cell. When the CBC-EVAL-11 receiver antenna is placed near a magnetic field at a frequency of 13.56MHz, and if the voltage at the CBC3150 VDD pin is greater than 3.0V, the CBC3150 will route the harvested power directly to the energy harvesting connectors. In this mode of operation the CBC3150's RESET/ line will be high, the LED will be illuminated, and the CHARGE/ indicator on the energy harvesting connectors will be low. In this mode, the integrated EnerChip solid state energy storage device will charge from a completely depleted state to 80% of full charge within 30 minutes. When the CBC-EVAL-11 unit is removed from the magnetic field and the input voltage to the CBC3150 drops below 3.0V, the RESET/ line will go low, the LED will be off, and EnerChip power will be routed to the energy harvesting connector. The CHARGE/ indicator on the energy harvesting connectors will be forced high. For additional energy storage capacity, up to 9 additional CBC050 EnerChip storage devices may be connected to the VBAT pin of the CBC3150.

A second handshake line on the energy harvesting connector - BATOFF - is an input that can be used by the application controller to disable the CBC3150 energy storage charging circuitry. When the BATOFF line is driven high, the ENABLE input on the CBC3150 will be driven low, disabling the energy storage device charger circuits. This feature promotes a long service life of the EnerChip by removing the charging voltage from the EnerChip terminals when the EnerChip is fully charged. Due to the low self-discharge of the EnerChip, it is not necessary to constantly charge the cell when not in use. With the functions and connector pins available on the CBC-EVAL-11, an external load such as a radio and microcontroller (MCU) can be powered when in inductive charging mode, or directly from the CBC3150 EnerChip CC device on the CBC-EVAL-11 receiver board. For example, the radio/MCU board illustrated in Figure 3 is a target board available from Texas Instruments, as part of the eZ430-RF2500-SEH:MSP430 Solar Energy Harvesting Development Tool. Other low power radios and MCUs can also be connected to either the 6-pin right-angle connector, or the 5-pin straight header connector on the CBC-EVAL-11 receiver board.

Note: The shorting jumper provided with the wireless charger (receiver) board should be placed across pins 1 and 2 of the 3-pin header. This connects the CBC3150 charge pump output (VCHG) to the positive terminal of the EnerChip (VBAT) to allow the EnerChip to charge when input power is available to the CBC3150. Do not place the shorting jumper across pins 2 and 3 of the 3-pin header. Pin 1 is indicated by the square solder pad on the bottom of the receiver board. Also, the J5 silkscreen label on the top of the board is adjacent to pin 1.

The output of the CBC3150 is filtered by a 1000µF capacitor. This value of capacitor is only needed for applications that require high pulse currents such as a ZigBee radio. A short tutorial on specifying output capacitance for a given pulse current is given at the end of this section. A full Application Note on this topic - AN-1025: Using the EnerChip in Pulse Current Applications - is available from Cymbet.

The wireless inductive transmitter (Figure 5) consists of a DC-DC converter to boost the 5VDC input to 9V. A crystal oscillator is used to generate a 13.56MHz clock, which in turn is used to drive several buffers and a transistor driver that drives a planar inductor and series capacitor, forming a series resonate tank circuit tuned to a frequency of 13.56MHz.

Specifications for the EnerChip embedded in the EnerChip CC CBC3150 are given in the table below. Full specifications for the EnerChip CC CBC3150 are available at www.cymbet.com.

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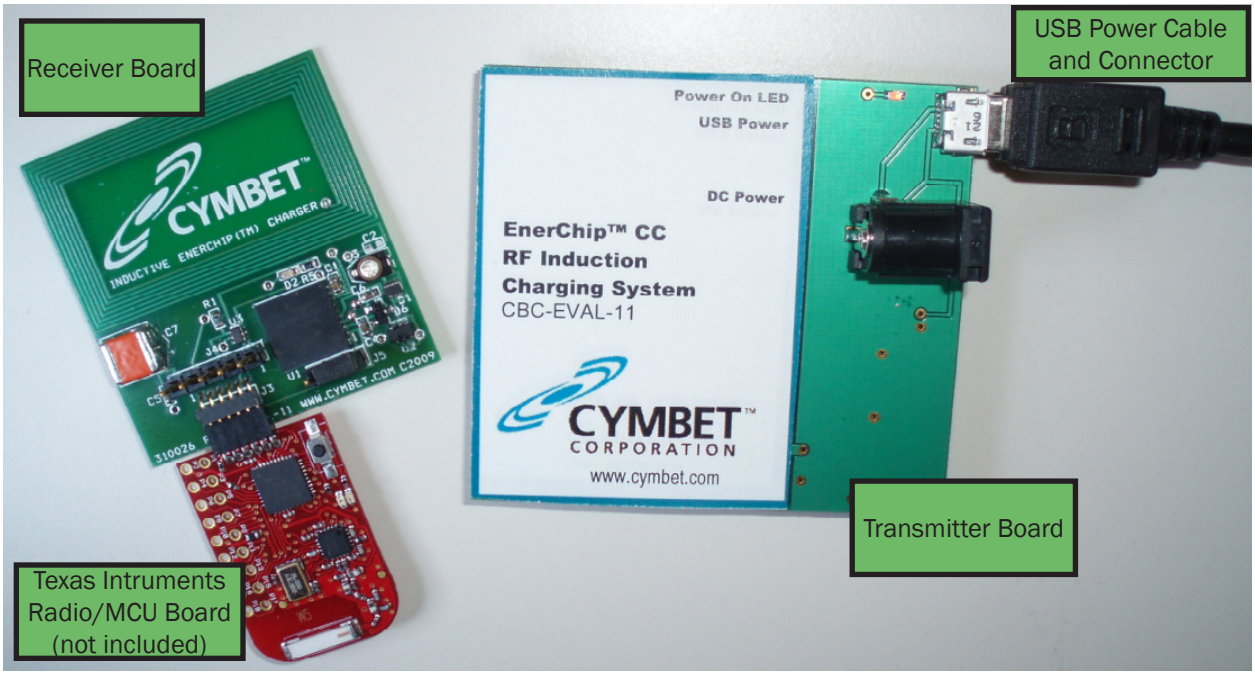


Figure 3: CBC-EVAL-11 Evaluation Kit.

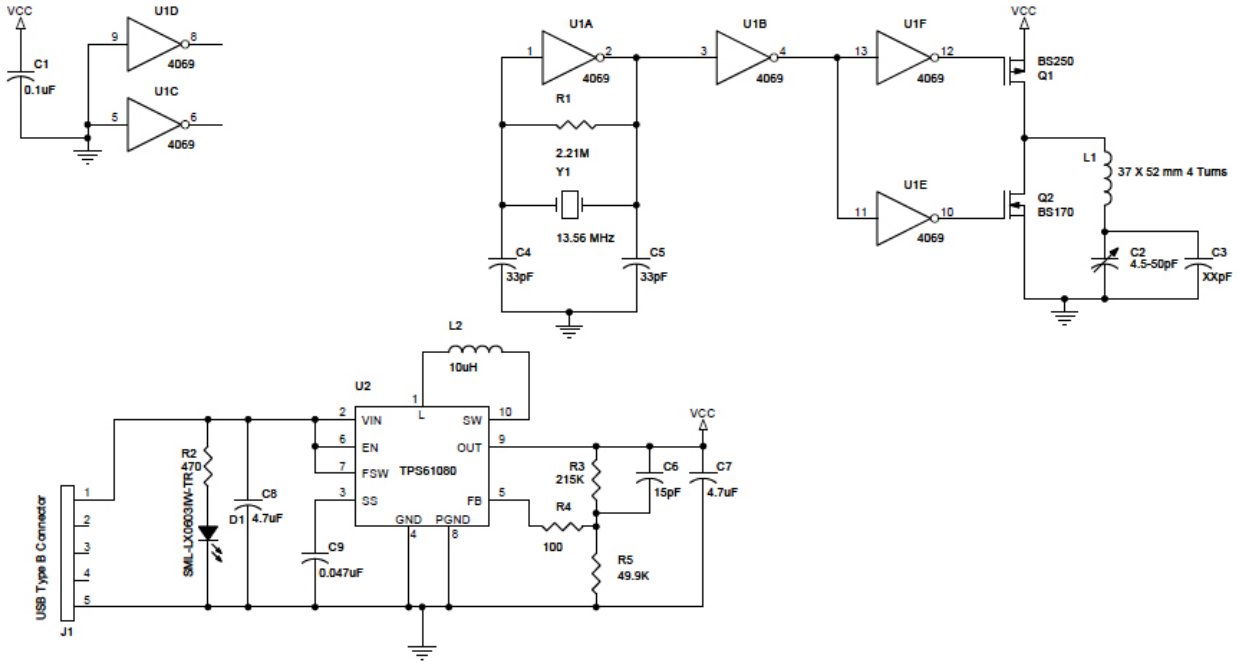


Figure 4: Schematic of CBC-EVAL-11 transmitter board.

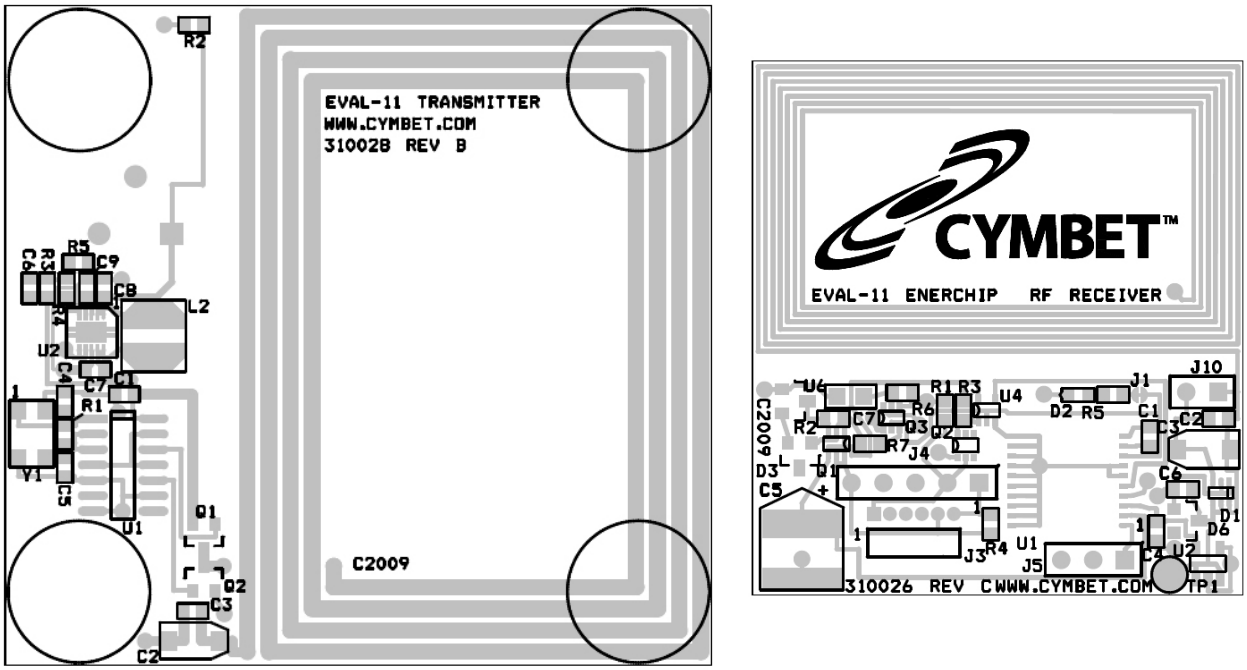


Figure 5: CBC-EVAL-11 circuit boards: transmitter (left [bottom view]) and receiver (right [top view]). The planar inductor on the receiver board may be physically and electrically isolated from the remaining circuitry and substituted with a different inductor for the purpose of evaluating other inductively coupled product concepts. See the section titled Circuit Board Alterations for proper techniques to separate the planar antenna from the receiver board.

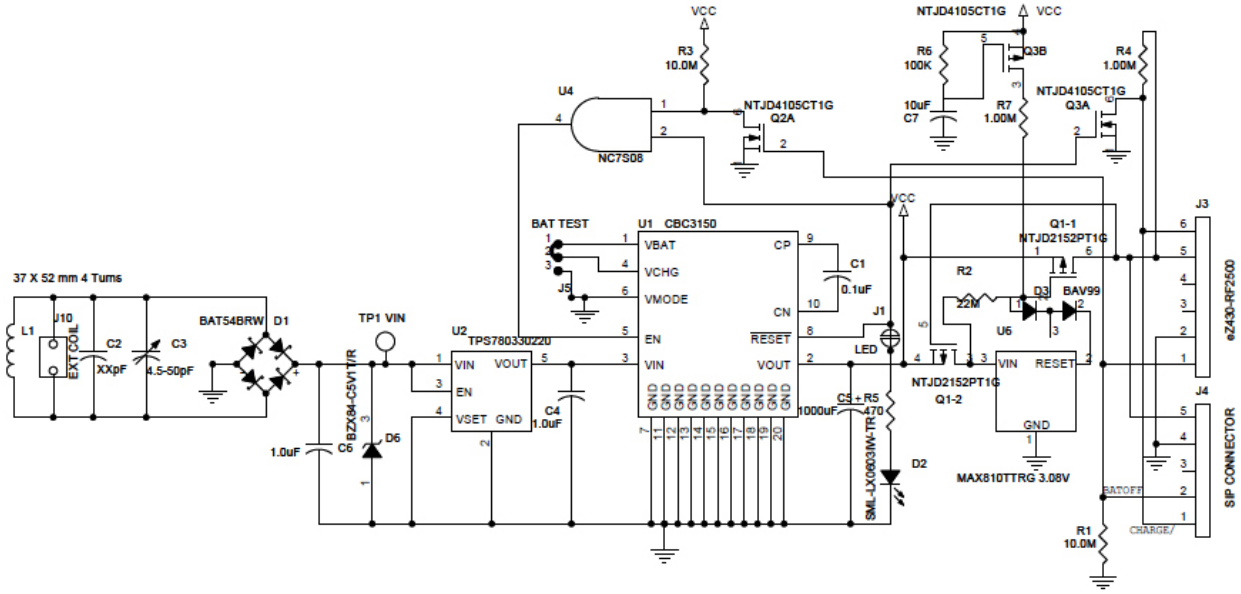


Figure 6: Schematic of CBC-EVAL-11 receiver board.

Absolute Maximum Ratings

Parameter	Condition	Min	Typical	Max	Units
V_{DD} with respect to GND	25°C	GND - 0.3	-	6.0	V
ENABLE and V_{MODE} Input Voltage	25°C	GND - 0.3	-	V_{DD}+0.3	V
V_{BAT} (1)	25°C	3.0	-	4.3	V
V_{CHG} (1)	25°C	3.0	-	4.3	V
V_{OUT}	25°C	GND-0.3	-	6.0	V
$\overline{RESET}$ Output Voltage	25°C	GND - 0.3	-	V_{OUT}+0.3	V
CP, Flying Capacitor Voltage	25°C	GND - 0.3	-	6.0	V
CN	25°C	GND - 0.3	-	V_{DD}+0.3	V

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

Operating Characteristics

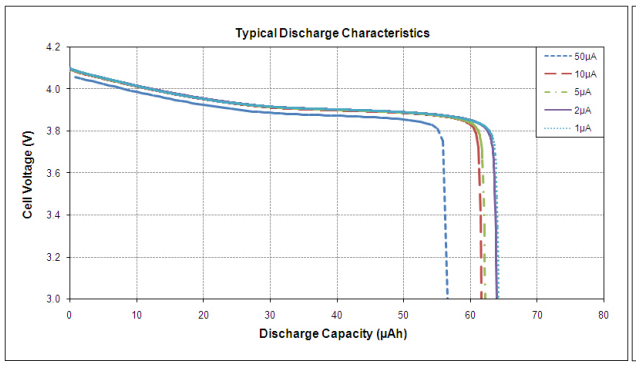
Parameter		Condition	Min	Typical	Max	Units
Output Voltage V_{OUT}		$V_{DD} > V_{TH}$	-	V_{DD}	-	V
Output Voltage V_{OUT} (Backup Mode)		$V_{DD} < V_{TH}$	2.2	3.3	3.6	V
EnerChip Pulse Discharge Current		-	variable - see App. Note 1025			-
Self-Discharge (5 yr average, 25°C)		non-recoverable	-	2.5	-	% per year
		recoverable	-	1.5(1)	-	% per year
Operating Temperature		-	-20	25	+70	°C
Storage Temperature		-	-40	-	+125 (2)	°C
Cell Resistance		25°C	-	1500	2500	Ω
Recharge Cycles (to 80% of rated capacity; 4.1 V charge voltage)	25°C	10% depth-of-discharge	5000	-	-	-
		50% depth-of discharge	1000	-	-	-
	40°C	10% depth-of-discharge	2500	-	-	-
		50% depth-of-discharge	500	-	-	-
Recharge Time (to 80% of rated capacity)		4.1 V constant voltage	-	30	-	minutes
Capacity		100 µA discharge; 25°C	50	-	-	µAh

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

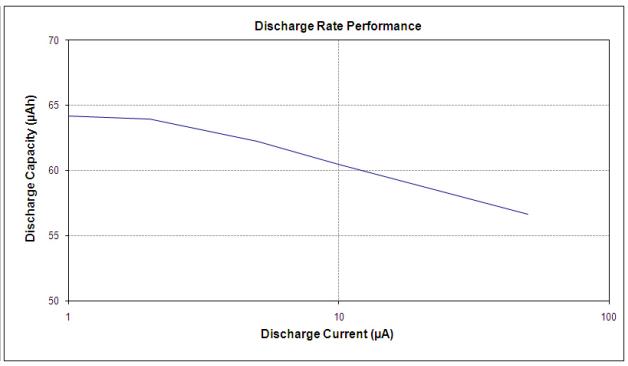
(2) *Storage temperature is for uncharged EnerChip CC device.*

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

Typical Discharge Capacity Characteristics



Typical Discharge Rate Performance



Pulse Discharge Current for a Wireless End Device

Pulse discharge currents place special demands on energy storage devices. Repeated delivery of pulse currents exceeding the recommended load current of a given chemistry will diminish the useful life of the cell. The effects can be severe, depending on the amplitude of the current and the particular cell chemistry and construction. Pulse currents of tens of milliamperes are common in wireless sensor systems during transmit and receive modes. Moreover, the internal impedance of the cell often results in an internal voltage drop that precludes the cell from delivering the pulse current at the voltage necessary to operate the external circuit. One method of mitigating such effects is to place a low Equivalent Series Resistance (ESR) capacitor across the EnerChip storage device. The EnerChip storage device charges the capacitor between discharge pulses and the capacitor delivers the pulse current to the load. Specifying the capacitance for a given EnerChip device in an application is a straightforward procedure, once a few key parameters are known. The key parameters are:

- EnerChip storage device impedance (at temperature and state-of-charge)
- EnerChip storage device voltage (as a function of state-of-charge)
- Operating temperature
- Pulse current amplitude
- Pulse current duration
- Allowable voltage droop during pulse discharge

Two equations will be used to calculate two unknown parameters:

1) the output capacitance needed to deliver the specified pulse current of a known duration;
2) the latency time that must be imposed between pulses to allow the capacitor to be recharged by the EnerChip storage device.

Both formulae will assume that the capacitor ESR is sufficiently low to result in negligible internal voltage drop while delivering the specified pulse current; consequently, only the EnerChip storage device resistance will be considered in the formula used to compute capacitor charging time and only the load resistance will be considered when computing the capacitance needed to deliver the discharge current.

The first step in creating an EnerChip storage device-capacitor couple for pulse current applications is to size the capacitance using the following formula:

Discharge formula: $C = t / [R * \ln (V_{max} / V_{min})]$

where:
C = output capacitance, in parallel with the EnerChip storage device;
t = pulse duration;
R = load resistance = Vout(average) / Ipulse

Vmin and Vmax are determined by the combination of the EnerChip storage device voltage at a given state-of-charge and the operating voltage requirement of the external circuit.

Once the capacitance has been determined, the capacitor charging time can be calculated using the following formula:

Charge formula: $t = - R * C * \ln [(V_{max} - V_{chg}) / (V_{min} - V_{chg})]$

where:
t = capacitor charging time, from Vmin to Vmax
R = EnerChip storage device resistance
C = output capacitance, in parallel with the EnerChip storage device

Vmax = final voltage to which the capacitor must be charged prior to delivering the next current pulse
Vmin = initial voltage on the capacitor when charging begins
Vchg = applied charging voltage on the capacitor

Electrical resistance of the energy storage device varies according to temperature and state-of-charge as described above. Worst-case conditions are often applied to the calculations to ensure proper system operation over temperature extremes, aging of the energy storage device, capacitance tolerance, etc.

Circuit Board Alterations

The CBC-EVAL-11 receiver board is designed to permit the user to separate the planar inductor from the remainder of the circuitry, allowing the user to attach another inductor, such as a coil. The planar inductor may be electrically isolated from the remainder of the circuit by cutting the trace connecting the inductor to the circuit. If physically separating the inductor from the circuit, be careful to saw cleanly between the inductor and the circuit and avoid damaging traces and components on the board. When sawing, be careful to not flex the circuit board; doing so can fracture the solder joints attaching the larger components to the board - specifically the 1000µF tantalum capacitor and the CBC3150 EnerChip in the surface mount DFN package. To minimize stress on the solder joints, it is recommended that the board be cut cleanly through rather than scoring and breaking the board apart.

The receiver board also has provision for connecting another coil and capacitor to facilitate the use of an LC tank circuit other than the one provided. Solder pads are provided for a 0606 size chip capacitor. Adjacent to those pads are plated vias in the board for inserting and soldering the ends of a user-supplied inductor.

Reference Documents

DS-72-03: EnerChip CC CBC3150 Data Sheet
AN-1025: Using the EnerChip in Pulse Current Applications

Important Notice

Cymbet provides the evaluaiton kit under the following conditions:
This evaluation board/kit is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY and is not considered by Cymbet to be a finished end-product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments might cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures might be required to correct this interference.

Persons handling the product(s) must have electronics training and observe good engineering practices. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such components or circuit boards. This evaluation kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore might not meet the technical requirements of these directives or other related directives.

Ordering Information

EnerChip CC Part Number	Description	Notes
CBC-EVAL-11	EnerChip CC Inductive Charging Evaluation Kit	Shipped in Box
CBC3150-D9C	EnerChip CC 50µAh Energy Storage in 20-pin D9 DFN Package	Shipped in Tube
CBC3150-D9C-TR1 CBC3150-D9C-TR5	EnerChip CC 50µAh Energy Storage in 20-pin D9 DFN Package	Tape-and-Reel - 1000 pcs (TR1) or 5000 pcs (TR5) per reel
CBC3150-D9C-WP	EnerChip CC 50µAh Energy Storage in 20-pin D9 DFN Package	Waffle Pack

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