CBC34803 EnerChip™ RTC

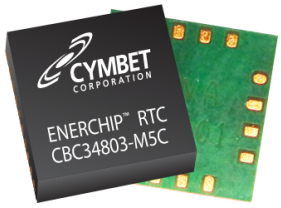
I²C Real-Time Clock/Calendar with Integrated Backup Power

Features

- Ultra low power Real Time Clock with Integrated rechargeable EnerChip™ solid state battery, power-fail detect and automatic switchover, **providing greater than 5 days (typical) of RTC backup**
- 5mm x 5mm x 1.4mm QFN package is the smallest commercially available RTC having integrated backup battery power
- Temperature-compensated charge control
- Integrated EnerChip™ recharged at VDD > 2.5V
- SMT assembly - lead-free reflow solder tolerant
- Counters for hundredths, seconds, minutes, hours, date, month, year, century, and weekday based on a 32.768 kHz oscillator
- Automatic leap year calculation
- Alarm capability on all counters
- 2 general purpose outputs
- 64 bytes of RAM
- Advanced crystal calibration to ± 2 ppm
- Advanced RC calibration to ± 16 ppm
- Automatic calibration of RC oscillator to crystal oscillator
- I²C-bus (up to 400kHz)
- Eco-friendly, RoHS compliant - tested

Applications

- **Power bridging** to provide uninterruptible RTC function during exchange of main batteries.
- **Consumer appliances** that have real-time clocks; provides switchover power from main supply to backup battery.
- **Ultra Low Power Timers** using only 35nA can be implemented with the CBC34803
- **Wireless sensors and RFID tags** and other powered, low duty cycle applications.
- **Business and industrial systems** such as: network routers, point-of-sale terminals, single-board computers, test equipment, multi-function printers, industrial controllers, and utility meters.
  - Time keeping application
  - Battery powered devices
  - Metering
  - High duration timers
  - Daily alarms
  - Low standby power applications



5mm x 5mm x 1.4mm 16-pin QFN Package

General Description

The EnerChip RTC CBC34803-M5C combines a Real-Time Clock (RTC) and calendar optimized for low power applications with an integrated rechargeable solid state backup battery and all power management functions. The EnerChip RTC ensures a seamless transition from main power to backup power in the event of power loss. The integrated power management circuit ensures thousands of charge-discharge cycles from the integrated EnerChip and manages battery charging, discharge cutoff, power switchover, and temperature compensation to maximize the service life of the device. The CBC34803 provides greater than 5 days of backup time in the event main power is interrupted. Longer backup time can be achieved by adding an extrnal EnerChip to the VCHG pin. The integrated EnerChip recharges quickly, has extremely low self-discharge, is non-flammable, and RoHS-compliant. The EnerChip is charged automatically anytime VDD is above 2.5V.

Data is transferred serially via an I²C-bus. Alarm and timer functions provide the option to generate a wake-up signal on an interrupt pin.

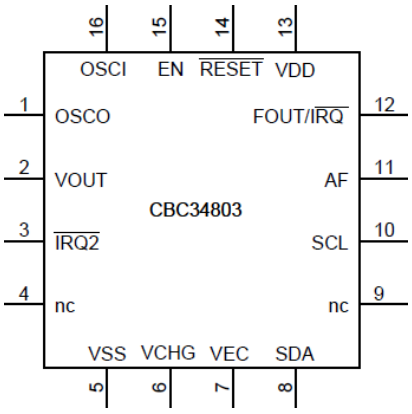


Figure 1: CBC34803 Pin-out Diagram

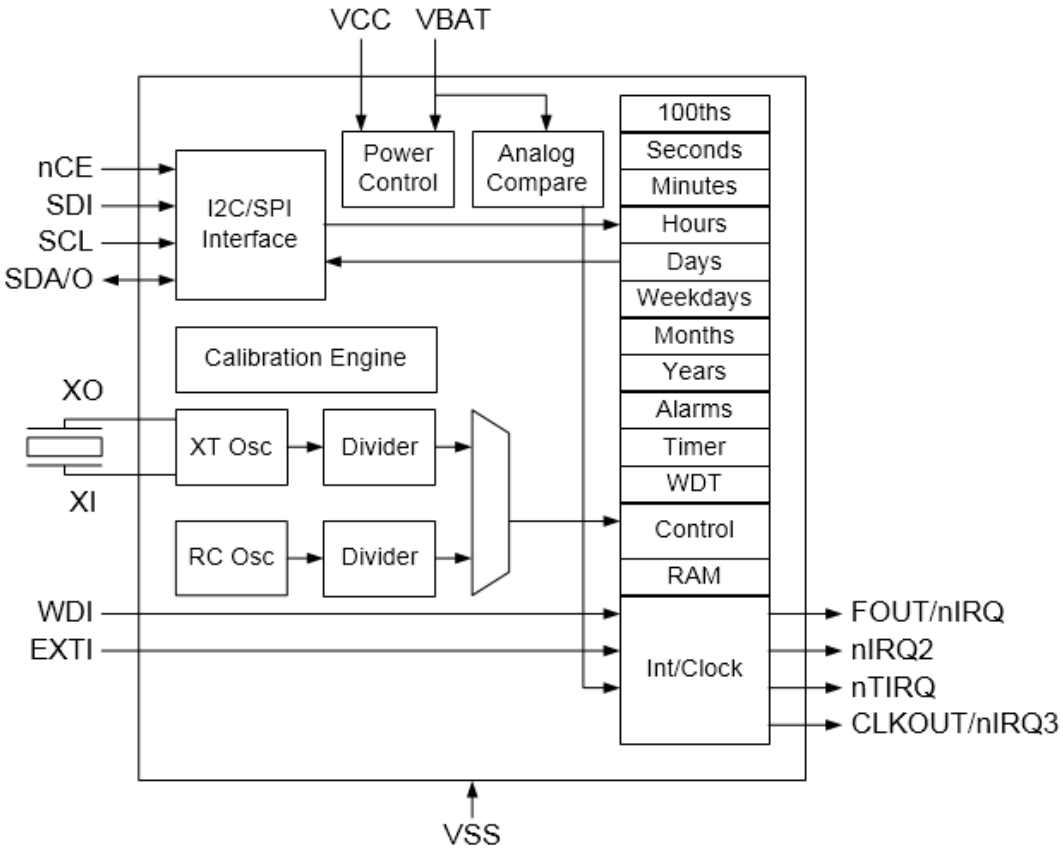


Figure 2: Functional Block Diagram of CBC34803 (AM0803) Real-Time Clock

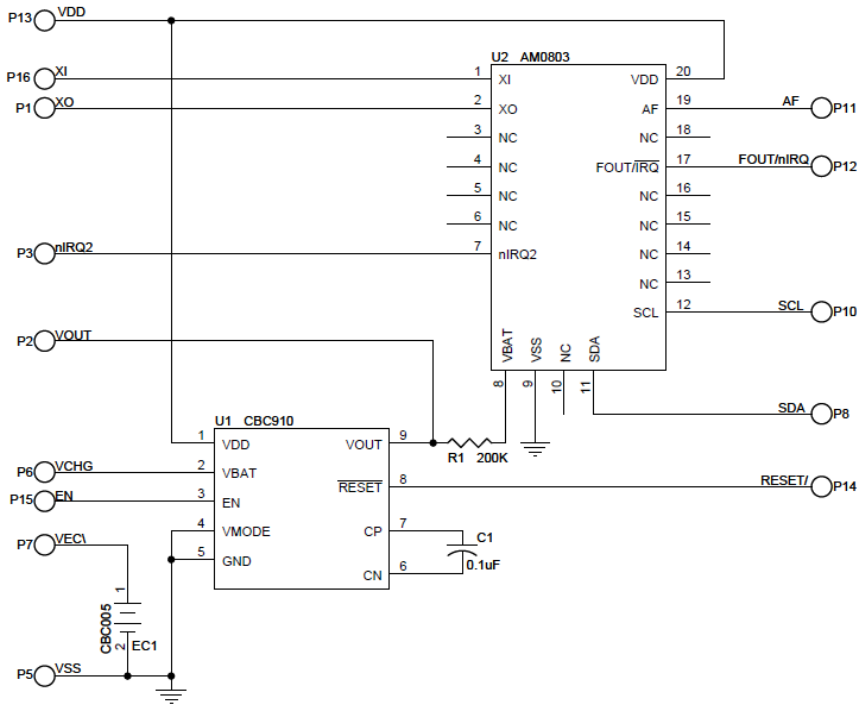


Figure 3: Internal Schematic of CBC34803 EnerChip RTC

CBC34803 Input/Output Descriptions

Pin Number	Label	Description
1	XO	Crystal output
2	VOUT	CBC910 VOUT and pin for external capacitor connection to supply switchover current at cold temperature (optional)
3	nIRQ2	Interrupt 2 / Output
4	NC	No connection
5	VSS	Ground
6	VCHG	4.1V (typical) charging source - connect to VEC and/or optional EnerChip(s) for extended backup time
7	VEC	Positive terminal of integrated thin film battery - connect only to VCHG via PCB trace
8	SDA	I²C data input / Output
9	NC	No connection
10	SCL	I²C clock input
11	AF	Autocalibration filter
12	FOUT/nIRQ	Interrupt 1 / Function output
13	VDD	Supply voltage; positive or negative steps in VDD can affect oscillator performance; recommend 100nF decoupling close to the device (see Fig. 30)
14	RESET/	Output signal indicating RTC is operating in backup power mode
15	EN	Charge pump enable; activates VCHG 4.1V (typ.) charging source
16	XI	Crystal input

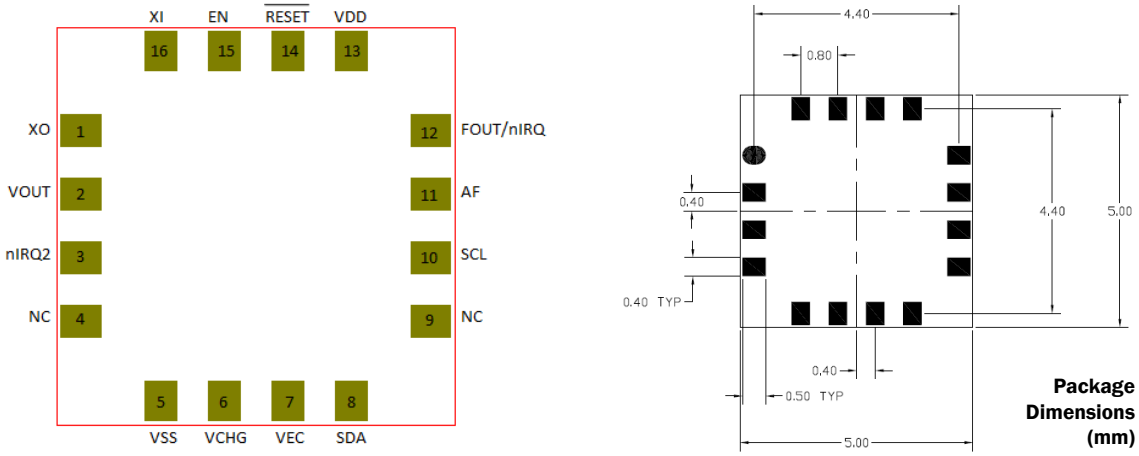


Figure 4: CBC34803 Package (left: top view, looking through package; right: pad dimensions)

EnerChip Properties

Energy capacity (typical):	5µAh
Recharge time to 80%:	<15 minutes
Charge/discharge cycles:	>5000 to 10% depth-of-discharge
Operating temperature:	-10°C to +70°C
Storage temperature:	-40°C to +125°C
Minimum VDD to charge EnerChip:	2.5V

Absolute Maximum Ratings

PARAMETER / PIN	CONDITION	MIN	TYPICAL	MAX	UNITS
V_{DD} with respect to GND	25°C	GND - 0.3	-	3.6	V
ENABLE Input Voltage	25°C	GND - 0.3	-	V_{DD}+0.3	V
V_{EC} (1)	25°C	3.0	-	4.15	V
V_{CHG} (1)	25°C	3.0	-	4.15	V
$\overline{\text{RESET}}$ Output Voltage	25°C	GND - 0.3	-	2.7	V
VOUT	25°C	GND - 0.3	-	3.6	V
XI, XO, SDA, SCL, AF, FOUT/nIRQ, nIRQ2	See Ambiq Micro AM0803 Data Sheet				

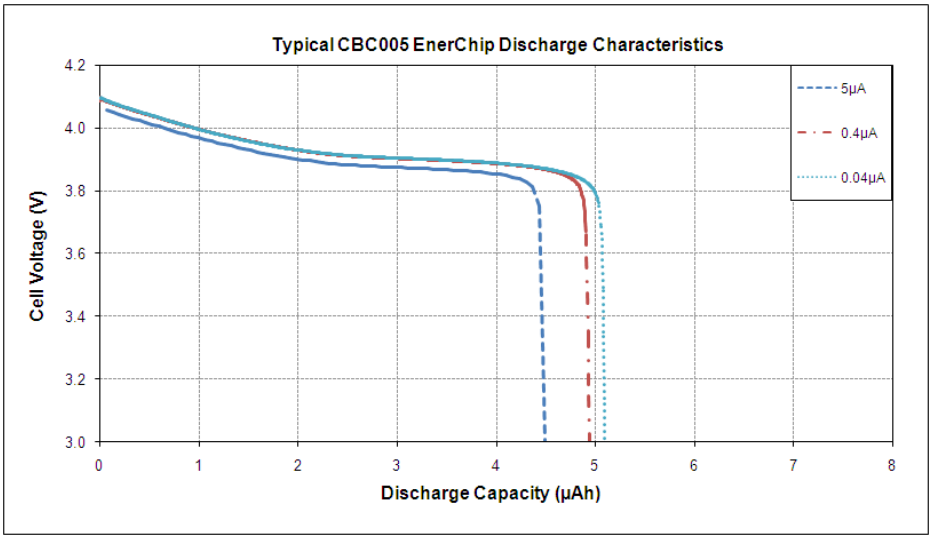
(1) *No external connections to these pins are allowed, except parallel EnerChips for extended backup time.*

Integrated EnerChip Thin Film Battery Operating Characteristics

PARAMETER		CONDITION	MIN	TYPICAL	MAX	UNITS
Self-Discharge (5 yr. average)		Non-recoverable	-	2.5	-	% per year
		Recoverable	-	1.5(1)	-	% per year
Operating Temperature		-	-10	25	+70	°C
Storage Temperature		-	-40	-	+125 (2)	°C
Recharge Cycles (to 80% of rated capacity)	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	-	11	22	minutes
		Charge cycle 1000	-	45	70	
Capacity		40nA discharge; 25°C	5	-	-	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.

Important Reference Documents for Design Information

- For complete specifications of the integrated Ambiq Micro AM0803 Real-Time Clock, see here: http://www.cymbet.com/products/enerchip-real-time-clocks.php
- For complete specifications of the Cymbet 5µAh EnerChip and integrated power management circuit, see here: http://www.cymbet.com/pdfs/DS-72-21.pdf .
- The EnerChip and power management functions within the CBC34803 are configured Mode 1 (VMODE = GND) as described in the CBC3105 data sheet.
- For an understanding of the tradeoffs in power consumption and timing accuracy when selecting a crystal oscillator, see Application Note AN-1058 at http://www.cymbet.com/pdfs/AN-1058.pdf .
- For guidelines regarding crystal selection and other important information pertaining to the AM0803, see here: http://ambiqmicro.com/resource-center/ .

Functional Description of Integrated AM0803 Real-Time Clock

The AM08xx serves as a full function RTC for host processors such as microcontrollers. The AM08xx includes 3 distinct feature groups: 1) baseline timekeeping features with 32.768 kHz oscillator and 2) advanced timekeeping features, and 3) basic power management features. Functions from each feature group may be controlled via memory mapped registers. These registers are accessed using either an I2C serial interface (e.g., in the AM0803) or a SPI serial interface (e.g., in the AM0813). For more information on the AM0803, see here: http://ambiqmicro.com/0800-series .

Low Power Operation

Minimum power operation will be achieved by turning off the charge pump in the power management circuit by driving ENABLE low once the internal EnerChip has been charged - typically one hour to full charge at room temperature.

the RTC has 3 low power modes, allowing the designer to make appropriate tradeoffs between power consumption and timing accuracy. Operating current drawn by the RTC is as follows:

~15 nA with RC oscillator (+/- 1% timing accuracy)
~22 nA with RC oscillator and autocalibration (3-35ppm timing accuracy depending on run time)
~58 nA with crystal oscillator (+/- 2ppm timing accuracy)

In addition to the RTC current, the integrated power management circuit typically draws 20-25nA from the EnerChip storage device at room temperature.

The following table provides typical run times of the CBC34803 in backup mode over temperature.

CBC34803 EnerChip RTC Operating Currents and Backup Time

RTC Mode	Typical (25°C)				Typical (70°C)			
	RTC Current (nA)	Cutoff Current (nA)	Total Battery Current (nA)	Backup Run Time (hours)	RTC Current (nA)	Cutoff Current (nA)	Total Battery Current (nA)	Backup Run Time (hours)
RC	15	21	36	139	40	32	72	69
Autocalibration	22	21	43	116	53	32	85	59
XT	58	21	79	63	90	32	122	41

Table 1: CBC34803 Backup Run Times at various RTC Modes and Temperatures

Crystal Oscillator Selection

The AMX8XX should work with any standard 32.768kHz tuning fork crystal with a load capacitance rating from 0 - 12pF and an ESR from 0 – 90kohms. Recommendations are as follows:

- Crystal load capacitance rating: 0 - 12pF
- Crystal ESR rating: 0 – 90kohms max
- No additional loading capacitors on the board
- Stray PCB capacitance on XO/XI: 2pF or less (less is better)

Typically, an oscillator allowance (OA) of 260-290kohms is generated. Increasing the loading capacitance on the XI/XO pins will decrease the OA and using crystals with a higher ESR will reduce the OA margin. The crystal will not affect the AMX8XX RTC current because a fixed bias current to the crystal is used. No external load capacitance is required because the frequency offset from the crystal is digitally calibrated out, to within +/- 2ppm. Mainstream crystals (3.2mm x 1.5mm) generally have a maximum ESR rating of 70kohms. The smaller 2.0mm x 1.2mm crystals generally have a maximum ESR of 90kohms. Some crystal vendors, such as Epson or Micro Crystal, might have some of the smaller crystals with lower ESR. Below is a list of crystals from several vendors that have been tested:

Abracon: ABS07-32.768KHZ-7-T, ABS06-32.768KHZ-9-T, ABS25.32.768KHZ-T
Epson: C-002RX, FC-135, FC-12D, FC-12M
Micro Crystal: CC7V-T1A, CM7V-T1A

CBC34803 (AM0803) Register Definitions (0x00 to 0x0F)

Offset	Register	7	6	5	4	3	2	1	0
0x00	Hundredths	Seconds - Tenths				Seconds - Hundredths			
0x01	Seconds	GP0	Seconds - Tens			Seconds - Ones			
0x02	Minutes	GP1	Minutes - Tens			Minutes - Ones			
0x03	Hours (24 hour)	GP3	GP2	Hours - Tens		Hours - Ones			
0x03	Hours (12 hour)	GP3	GP2	AM/PM	Hours - Tens	Hours - Ones			
0x04	Date	GP5	GP4	Date - Tens		Date - Ones			
0x05	Months	GP8	GP7	GP6	Months - Tens	Months - Ones			
0x06	Years	Years - Tens				Years - Ones			
0x07	Weekdays	GP13	GP12	GP11	GP10	GP9	Weekdays		
0x08	Hundredths Alarm	Hundredths Alarm - Tenths				Hundredths Alarm - Hundredths			
0x09	Seconds Alarm	GP14	Seconds Alarm - Tens			Seconds Alarm - Ones			
0x0A	Minutes Alarm	GP15	Minutes Alarm - Tens			Minutes Alarm - Ones			
0x0B	Hours Alarm (24 hour)	GP17	GP16	Hours Alarm - Tens		Hours Alarm - Ones			
0x0B	Hours Alarm (12 hour)	GP17	GP16	AM/PM	Hours Alarm - Tens	Hours Alarm - Ones			
0x0C	Date Alarm	GP19	GP18	Date Alarm - Tens		Date Alarm - Ones			
0x0D	Months Alarm	GP22	GP21	GP20	Months Alarm - Tens	Months Alarm - Ones			
0x0E	Weekdays Alarm	GP27	GP26	GP25	GP24	GP23	Weekdays Alarm		
0x0F	Status	CB	BAT	WDT	BL	TIM	ALM	EX2	EX1

CBC34803 (AM0803) Register Definitions (0x10 to 0xFF)

Offset	Register	7	6	5	4	3	2	1	0
0x10	Control1	STOP	12/24	OUTB	OUT	-	ARST	-	WRTC
0x11	Control2	-	-	-	OUT2S			OUT1S	
0x12	IntMask	CEB	IM		BLIE	TIE	AIE	EX2E	EX1E
0x13	SQW	SQWE	-		SQFS				
0x14	Cal_XT	CMDX	OFFSETX						
0x15	Cal_RC_Hi	CMDR	OFFSETR[13:8]						
0x16	Cal_RC_Low	OFFSETR[7:0]							
0x17	Int Polarity	-	-	EX2P	EX1P	-	-	-	-
0x18	Timer Control	TE	TM	TRPT	RPT			TFS	
0x19	Timer	Countdown Timer							
0x1A	Timer_Initial	Timer Initial Value							
0x1B	WDT	WDS	BMB					WRB	
0x1C	Osc. Control	OSEL	ACAL		AOS	FOS	-	OFIE	ACIE
0x1D	Osc. Status	XTCAL		LKO2	OMODE	-	-	OF	ACF
0x1E	RESERVED	RESERVED							
0x1F	Configuration Key	Configuration Key							
0x20	Trickle	TCS				DIODE		ROUT	
0x21	BREF Control	BREF				-			
0x22	RESERVED	RESERVED							
0x23	RESERVED	RESERVED							
0x24	RESERVED	RESERVED							
0x25	RESERVED	RESERVED							
0x26	AFCTRL	AFCTRL							
0x27	BATMODE I/O	IOBM	RESERVED						
0x28	ID0 (Read only)	Part Number –MS Byte = 00001000 (0x08)							
0x29	ID1 (Read only)	Part Number – LS Byte (e.g. 00000101 for AM0805)							
0x2A	ID2 (Read only)	Revision – Major = 00010					Revision – Minor = 011		
0x2B	ID3 (Read only)	Lot[7:0]							
0x2C	ID4 (Read only)	Lot[9]	Unique ID[14:8]						
0x2D	ID5 (Read only)	Unique ID[7:0]							
0x2E	ID6 (Read only)	Lot[8]	Wafer					–	–
0x2F	ASTAT	BBOD	BMIN	-	-	-	-	VINIT	-
0x30	OCTRL	WDBM	EXBM	-	-	-	-	-	-
0x3F	Extension Address	O4BM	BPOL	WDIN	EXIN	-	XADA	XADS	
0x40–7F	RAM	Normal RAM Data							
0x80–FF	RAM	Alternate RAM Data (I^2C Mode Only)							

THE FOLLOWING REGISTER BIT SETTINGS ARE IMPORTANT TO NOTE:

BREF [0x21, bits 7:4]: The default value out of reset is 1111. Do not change the contents of this register. This sets the VDD-to-backup battery switchover voltage threshold.

IOBM [0x27, bit 7]: The default value out of reset is 1. THIS MUST TO BE REPROGRAMMED TO 0. Setting this bit to 0 disables the bus interface in the backup power state to reduce currents through the bus I/Os.

POWER SUPPLY CURRENT CHARACTERISTICS OF INTEGRATED CBC910 POWER MANAGEMENT CIRCUIT ONLY

Ta = -20ºC to +70ºC

CHARACTERISTIC	SYMBOL	CONDITION		MIN	MAX	UNITS
Quiescent Current (CBC910 power management circuit only; $V_{DD} > V_{RESET}$; RTC current not included)	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_{QBATON} adds to RTC current when in backup mode)	$I_{QBATOFF}$	$V_{BAT} < V_{BATCO}$, V_{OUT}=0		-	0.5	nA
	I_{QBATON}	$V_{BAT} > V_{BATCO}$, ENABLE=V_{DD}, I_{OUT}=0		-	42	nA

INTERFACE LOGIC SIGNAL CHARACTERISTICS

V_{DD} = 2.5V to 5.5V, Ta = -20ºC to +70ºC

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) *$\overline{RESET}$ tracks V_{DD}; $\overline{RESET}$ = V_{DD} - (I_{OUT} x R_{OUT}).*

$\overline{\text{RESET}}$ SIGNAL AC/DC CHARACTERISTICS

V_{DD} = 2.5V to 5.5V, Ta = -20ºC to +70ºC

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
TRIP Voltage V_{DD} Rising	V_{RESET}	V_{MODE}=GND	2.85	3.15	V
$\overline{\text{RESET}}$ Hysteresis Voltage (V_{DD} to $\overline{\text{RESET}}$)	V_{HYST}	V_{MODE}=GND	45	75	mV

CHARGE PUMP CHARACTERISTICS (PERTAINS TO INTEGRATED CBC910 POWER MANAGEMENT CIRCUIT)

(NOTE: THIS TABLE PROVIDES IMPORTANT INFORMATION WHEN CONNECTING ADDITIONAL ENERCHIPS TO VCHG.)

V_{DD} = 2.5V to 5.5V, Ta = -20ºC to +70ºC

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 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=+25ºC	4.065	4.150	V
V_{CHG} Temp. Coefficient	T_{CCP}	I_{OUT}=1µA, Temp=+25ºC	-2.0	-2.4	mV/ºC
Charge Pump Current Drive	I_{CP}	I_{BAT}=1mA C_{FLY}=0.1µF, C_{BAT}=1.0µF	1.0	-	mA
Charge Pump on Voltage	V_{ENABLE}	ENABLE=V_{DD}	2.5	-	V

(1) $f_{CP} = 1/t_{CPPER}$

ADDITIONAL CHARACTERISTICS

Ta = -20ºC to +70ºC

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/ºC
V_{BAT} Cutoff Delay Time	t_{COOFF}	V_{BAT} from 40mV above to 20mV below V_{BATCO} I_{OUT}=1µA	18	-	ms

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

Extending CBC34803 Holdover Time Using an External EnerChip Battery

In some circumstances, the RTC power holdover time requirements may extend beyond number of hours specified in Table 1. Longer power backup time can be easily achieved by adding an external EnerChip to the VCHG pin 6. For example, an external CBC012 will add 500 hours in the RC mode for a total of 639 hours of backup time (26 days), Attaching an external CBC050 will add 1500 hours in RC mode for a total of 1639 hours which is over 68 days of power holdover per recharge.

Use the Backup run time values in Table 1 for each RTC mode and temperature to calculate the holdover time that would be experienced in various CBC34803 use modes.

Typical CBC34803 EnerChip RTC Connection to Microcontroller

Figure 5 illustrates how the CBC34803 is typically connected to a microcontroller (MCU) in a system. For simplicity, only the MCU lines routed to/from the CBC34803 are shown. The I/O line from the MCU to the EN pin of the CBC34803 is optional for reducing power consumption of the CBC34803. The EN pin can be forced low by the MCU when the integrated EnerChip does not need to be charged. If EN is not connected to the MCU or otherwise controlled externally, it must be tied to VDD to ensure the EnerChip is charged when VDD is valid. Capacitor C4 is optional for supplying switchover current during cold temperature operation.

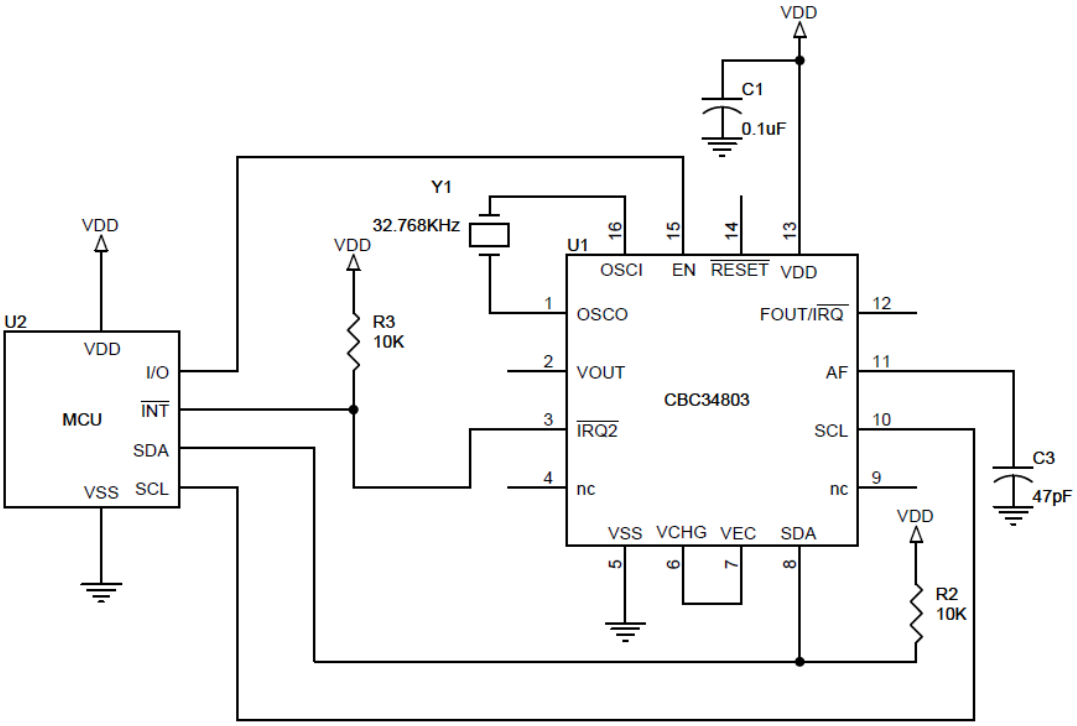


Figure 5: Typical Application Schematic Showing MCU Connections to CBC34803

Ordering Information

EnerChip RTC Part Number	Description	Notes
CBC34803-M5C	EnerChip RTC in 5mm x 5mm x 1.4mm 16-QFN Land Grid Array	Shipped in Tube
CBC34803-M5C-TR1 CBC34803-M5C-TR5	EnerChip RTC in 5mm x 5mm x 1.4mm 16-QFN Land Grid Array	Tape-and-Reel - 1000 pcs (TR1) or 5000 pcs (TR5) per reel
CBC-EVAL-12	EnerChip RTC Evaluation Kit	USB based Eval Kit with CBC34803 tab board

U.S. Patent No. 8,144,508. Additional U.S. and Foreign Patents Pending