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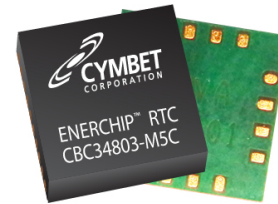
CBC34803 EnerChip™ RTC

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 external 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.
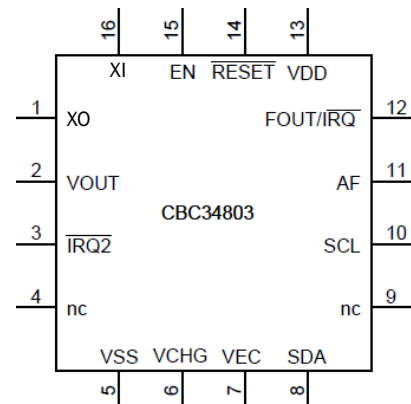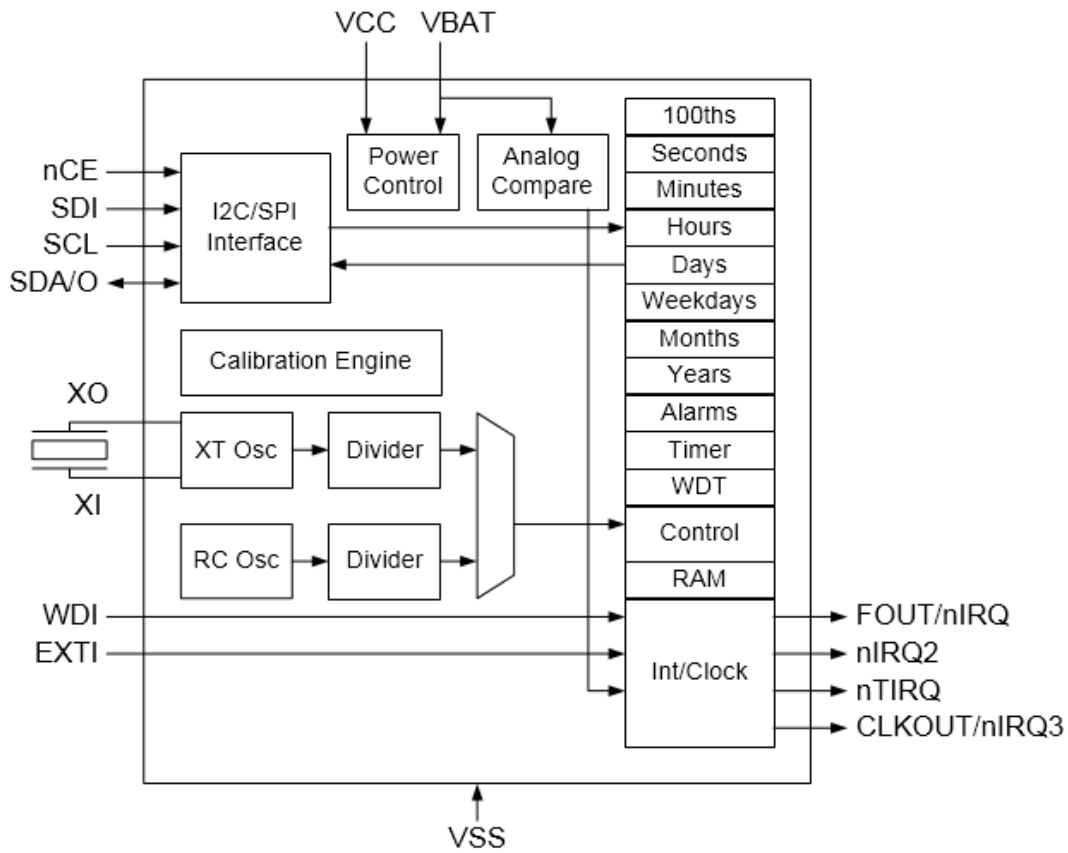

Figure 1: CBC34803 Pin-out Diagram

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

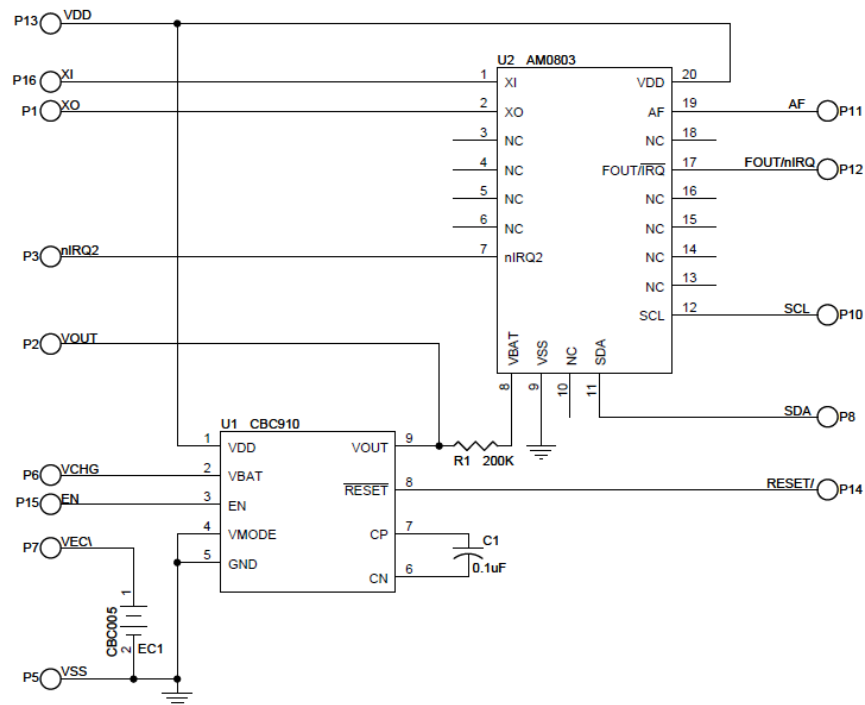*Figure 3: Internal Schematic of CBC34803 EnerChip RTC*

CBC34803 Input/Output Descriptions

Pin Number	Label	Description
1	XO	Crystal output
2	VOUT	CBC910 VOUT
3	nIRQ2	Interrupt 2 / Output
4	NC	No connection
5	VSS	Ground
6	VCHG	4.1V (typical) charging source - connect to VEC (and to optional EnerChip bare die battery for extended backup time if used)
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 - (note this is an open drain output)
13	VDD	Supply voltage; positive or negative steps in VDD can affect oscillator performance; recommend 100nF decoupling close to the device
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

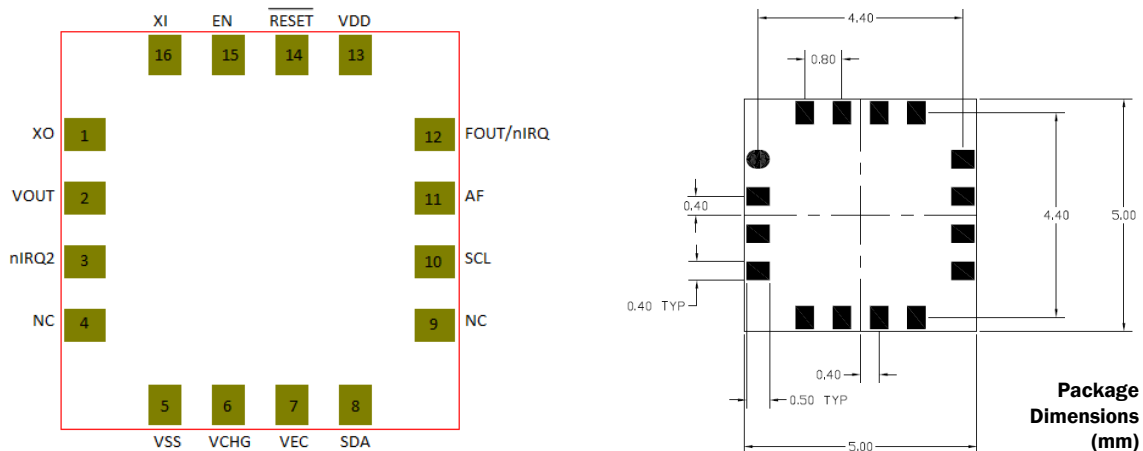*Figure 4: CBC34803 Package (left: top view, looking through package; right: pad dimensions)*

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
$\overline{RESET}$ 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.*
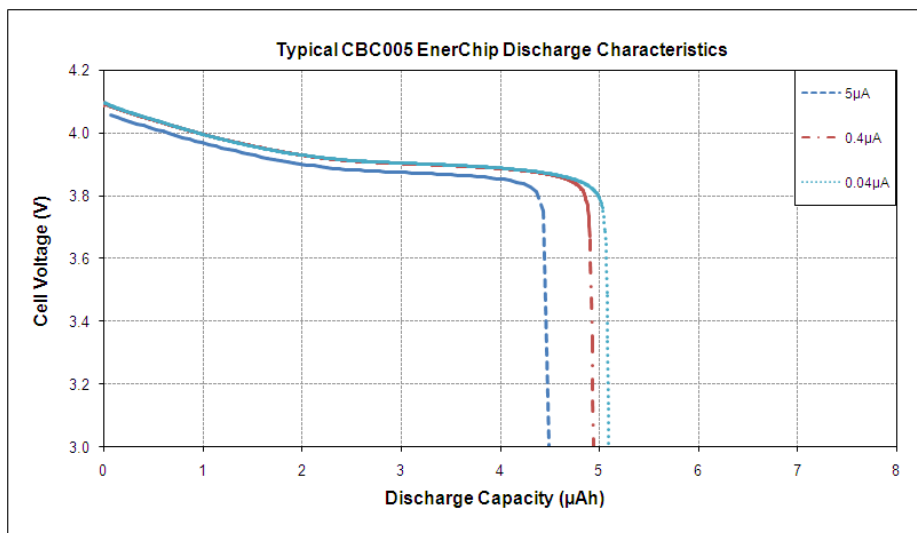
Note: All specifications contained within this document are subject to change without notice.

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}	$V_{BAT} > V_{BATCO}$, 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}	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}).*

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 $\overline{RESET}$ Rising	t_{RESETH}	V_{DD} rising from 2.8V TO 3.1V in <10µs	60	200	ms
V_{DD} Falling to $\overline{RESET}$ Falling	t_{RESETL}	V_{DD} falling from 3.1V to 2.8V in <100ns	0.2	60	µs
TRIP Voltage V_{DD} Rising	V_{RESET}	V_{MODE}=GND	2.85	3.15	V
$\overline{RESET}$ Hysteresis Voltage (V_{DD} to $\overline{RESET}$)	V_{HYST}	V_{MODE}=GND	45	75	mV

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

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 this datasheet: http://www.cymbet.com/pdfs/DS-72-41.pdf .

- 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 .

Functional Description of Integrated AM0803 Real-Time Clock

The AM0803 serves as a full function RTC for host processors such as microcontrollers. The AM0803 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://www.cymbet.com/pdfs/AM08XX_Data_Sheet_DS0002V1p0.pdf.

Low Power Operation

Minimum power operation will be achieved by turning off the CBC34803 charge pump in the power management circuit by driving ENABLE (pin 15) 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 internal 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 after calibration at 25 °C)

In addition to the RTC current, the internal 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

CBC34803 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 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^{2}C Mode Only)							

Registers With Special Programming Considerations

The following registers have special operations that require programmer attention when using the CBC34803 parts. Listed below are these registers by category of issue:

Key Register Access Values

The following registers require a write to the Configuration Key register of a specific value to allow a one-time access. The Configuration Key register is automatically reset after the register is written:

Oscillator Control [0x1C] -> Write Configuration Key register to A1 hex (0xA1) prior to access
Trickle [0x20]   -> Write Configuration Key register to 9D hex (0x9D) prior to access
BREF Control [0x21]   -> Write Configuration Key register to 9D hex (0x9D) prior to access
AFCTRL [0x26]   -> Write Configuration Key register to 9D hex (0x9D) prior to access
BATMODE I/O [0x27]   -> Write Configuration Key register to 9D hex (0x9D) prior to access
OCTRL [0x30]   -> Write Configuration Key register to 9D hex (0x9D) prior to access

Timing Register Holdoff During Read or Write

Reading any of the following registers in an autoincrement address or burst mode must finish the burst in 10 milliseconds to avoid losing time. This is because the timing chain freezes until the burst is done to avoid nonsensical time reads and can only assure correct time if you finish the entire register burst in 10 milliseconds. Reading the timing registers (Hundredths ->Years) takes about 100 clocks so a 10KHz bus clock should be able to read the registers in the required 10mS if you don't delay between reads.
These registers are Hundredths, Seconds, Minutes, Hours (24 Hour), Hours (12 Hour), Date, Months and Years.

Status Register

The Status register [0x0F] was listed as read-only in earlier documentation but all bits can be read or written unless the ARST bit of the Control 1 [0x10] register is set which will cause a reset of interrupt bits (TIM, BL, ALM, WDT, XT1, XT2) on any Status read.

Relationships Between Control1 Register and Oscillator Control Register

The Stop bit in the Control1 [0x10] register invalidates the OMODE bit in the Oscillator Status [0x1D] register. The LKO2 bit in the Oscillator Status register locks out the R/W functionality of the OUTB bit of the Control1 register.

⚠ **THE FOLLOWING REGISTER BIT SETTINGS ARE IMPORTANT FOR PROPER OPERATION**

OSC.Control [0x1C, bit 4]: The default value of **AOS** out of reset is 0. THIS MUST TO BE REPROGRAMMED TO 1. To enable low power RC Oscillator to RUN while in the backup power state to increase run time.

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

BATMODE I/O [0x27, bit 7]: The default value of **IOBM** 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.

Cal_XT [0x14], Cal_RC_Hi [0x15], and Cal_RC_Low [0x16]: must be programed with values that provide the desired clock accuracy. A description of the calibration process follows in this datasheet. Also refer to Applications Note AN-1058 for register value administration details.

Crystal Oscillator Selection

The CBC34803 should work with any standard 32.768kHz tuning fork crystal with a load capacitance rating from 0 - 12.5pF and an ESR from 0 – 90kohms. Recommendations are as follows:

- Crystal load capacitance rating: 0 - 12.5pF
- 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 internal 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: FC-135, FC-12D, FC-12M
Micro Crystal: CC7V-T1A, CM7V-T1A

Required Calibration of Crystal Oscillator Frequency for Proper System Operation

The CBC34803 uses an ultra-low power Real Time Clock chip that differs slightly in operation from legacy higher power real time clocks. The following instructions must be implemented for proper operation.

In order to reduce power to the lowest level possible, the input load capacitance on the XO and XI pins on the CBC34803 device has been purposely designed to be as low as possible and still retain good stability and startup characteristics. **Consequently the crystal oscillator frequency on CBC34803 parts will tend to run 100-300ppm higher in frequency than the nominal value of 32.768KHz when used with a 5 to 12pF crystal.**

In order to compensate for this higher frequency, the CBC348o3 device has a set of calibration registers into which the frequency offset in ppm is written. The clock divider chain then adds or subtracts pulses based on the value in the calibration registers to insure that the nominal divided clock frequencies are now at submultiples of 32.768Khz.

When calibrating the CBC34803, the fundamental crystal frequency is not changed, only the frequencies that are below the fundamental frequency are modified by writing the ppm offset coefficients into the calibration registers. This can be verified by setting the FOUT function to be a square wave and then measuring the various undivided clock output vs. the divided clock after calibration. Please refer to the Ambiq Micro datasheet for the calibration procedure.

Depending on the desired frequency tolerance for the application, one of two approaches can be used for calibration:
1. For those applications where it is cost prohibitive to calibrate each unit, a generic calibration offset can be used. The resulting frequency deviation will then match the crystal tolerance. Typically during system qualification testing, several units will be tested and an average of all the fundamental oscillator frequencies will be used to calculate the ppm offset coefficient to be written into the calibration registers.
2. For those applications requiring high precision, each unit can be measured and calibrated before shipping. This approach will yield a system with a minimum of 2ppm frequency tolerance.

Initial Timing Calibration Algorithm

To initially calibrate out any crystal frequency inaccuracies and any parasitic load inaccuracies, the following procedure should be run using a timing measurement device that can resolve better than one ppm in less than a half-second. This device could be a frequency counter with a good calibration, a custom circuit built on the device-under-test (DUT) board of the system tester that includes an accurate oscillator of 10MHz or better and a counter that can count how many tenths of microseconds between the edges of the clock output from the CBC34803, or possibly the system tester itself if it can be calibrated to resolve tenths of microseconds between edges of the output clock. The procedure is as follows:

1. Set the OFFSETX, CMDX, and XTCAL register fields to 0 to make sure the oscillator is running without any calibration taking place. The CMDX and OFFSETX fields are both in the CAL_XT register. The XTCAL bits are in the Osc Control register.
2. Select the XT oscillator by setting the OSEL bit of the Osc register to 0.
3. Configure a square wave output on one of the output pins of frequency Fnom (for example 16Hz). See register SQW in the datasheet for information on how to do this.
4. Measure the pulse width of several cycles of the square wave with a resolution of better than 0.25ppm (resolve edges to 15ns or better using averaging if needed) and convert to a frequency Fmeas by taking the reciprocal of the pulse width.
5. Compute the pulse adjustment value (PADJ) required in ppm as:
   $((32,768 - Fmeas)*1000000) / 32,768 = PADJ$.
6. Compute the adjustment value in steps as $PADJ / (1000000 / 2^{19}) = Padj / (1.90735) = ADJ$.
7. If ADJ < -320 the XT frequency is too high to be calibrated. Contact Cymbet for design assistance.
8. Compensate by starting at the top of this table and proceeding down until the pertinent condition is met and set the fields XTCAL, CMDX, and OFFSETX as indicated:

If ADJ is as below	set XTCAL =	set CMDX =	set OFFSETX =
ADJ < -256	3	1	(ADJ + 192)/2
-256 < ADJ < -192	3	0	(ADJ + 192)
-192 < ADJ < -128	2	0	(ADJ + 128)
-128 < ADJ < -64	1	0	(ADJ + 64)
-64 < ADJ < 64	0	0	(ADJ)
64 < ADJ < 128	0	1	(ADJ)/2

Otherwise, XT is too low to calibrate. Contact Cymbet.

The calibration register values can be saved in nonvolatile memory in the final system's microprocessor for reloading when system power is recovered.

Timing Calibration Settings Calculator

Cymbet has created a Timing Calibration Settings Calculator for the CBC34803. This Excel spreadsheet can be found here: http://www.cymbet.com/pdfs/Spreadsheet-to-set-EnerChip-RTC-348x3-values.xls.

To measure the timing error that might need correction, test your system with the CBC34803 over a period of time and measure any clock drift. Once testing is complete, enter the Measured Error to Correct (seconds) and the time duration of the test (seconds, hours, days, weeks) in the yellow indicated fields. If the ADJ range is valid (green), the Calculator will then compute the values for the following registers: OFFSETX, CMDX, XTCAL and OSEL.

Additional information on crystal oscillator use can be found in this Application Note:
AN- 1058 Using CBC348xx EnerChip RTC in High Accuracy Applications

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.

Figure 5: Typical Application Schematic Showing MCU Connections to CBC34803

GUIDELINES FOR HANDLING ENERCHIP RTC DEVICES

The EnerChip™ RTC with an integrated thin film, solid state battery features all solid state construction, are packaged in standard integrated circuit packages, and can be reflow soldered for high volume PCB assembly.

The CBC34803 EnerChip RTC is considered an MSL-3 rated device for storage and handling purposes.

Device Handling & Storage
- EnerChip RTCs are packaged and shipped in tubes or reels in moisture barrier bags, and are sensitive to moisture absorption. They must be kept in the sealed bag until ready for board mounting and reflow soldering.
- If the EnerChip RTCs are removed from the sealed bag more than 168 hours prior to board mounting, they must be baked at 125°C for a minimum of 24 hours prior to board mounting and reflow soldering.
- Store the EnerChip RTCs in an environment where the temperature and humidity do not undergo large fluctuations. Store at 10°C to 30°C and at less than 60% relative humidity.

Electrostatic Discharge (ESD)
- The EnerChip RTCs are sensitive to ESD damage prior to receiving a battery charge cycle. Therefore, adherence to ESD prevention guidelines is required.
- Remove RTC devices from protective shipping and storage containers at approved ESD workstations only.
- All equipment used to process the devices must be configured to minimize the generation of static charges. This includes soldering and de-soldering equipment and tools, pick-and-place equipment, test equipment, and all other tools and equipment used to handle or process the devices.
- Failure to observe these precautions can lead to premature failure and shall void product warranty.

Other Use Guidelines
- Do not connect the EnerChip RTC to other types of batteries.
- To increase battery life, avoid placing the EnerChip RTC near devices that would generate heat exceeding the 70°C operating limit.

DO NOT HAND SOLDER ENERCHIP RTC DEVICES

When soldering an individual uncharged EnerChip RTC, a QFN capable soldering station with temperature control should be used. It is very important to be able to control the solder temperature and time when soldering an EnerChip RTC.

## ENERCHIP ASSEMBLY REPAIR TECHNIQUES

For the EnerChip RTC QFN package, use a hot air rework station to remove a defective or misplaced EnerChip package. If there are other EnerChips in the vicinity of the EnerChip being replaced, use proper heat shielding to protect the adjacent EnerChip package from the heat source and turn off any heat source that would otherwise be used to heat the bottom of the board during removal of the EnerChip. This will prevent the adjacent EnerChip(s) from being damaged during the rework procedure.

SMT PROCESS

The EnerChip RTCs are packaged in standard surface mount packages. Refer to the solder paste material data sheets for attachment of the package to a PCB using solder reflow processes. Ensure that the solder reflow oven is programmed to the correct temperature profile prior to assembling the EnerChip RTC on the PCB.

REFLOW SOLDERING

- The maximum number of times an uncharged EnerChip RTC may be reflow soldered is three times.
- **The surface temperature of the EnerChip RTC package must not exceed 240°C.**
- The recommended solder reflow profile is shown in Figure 6 below; refer to the table for time and temperature requirements. Whenever possible, use lower temperature solder reflow profiles.
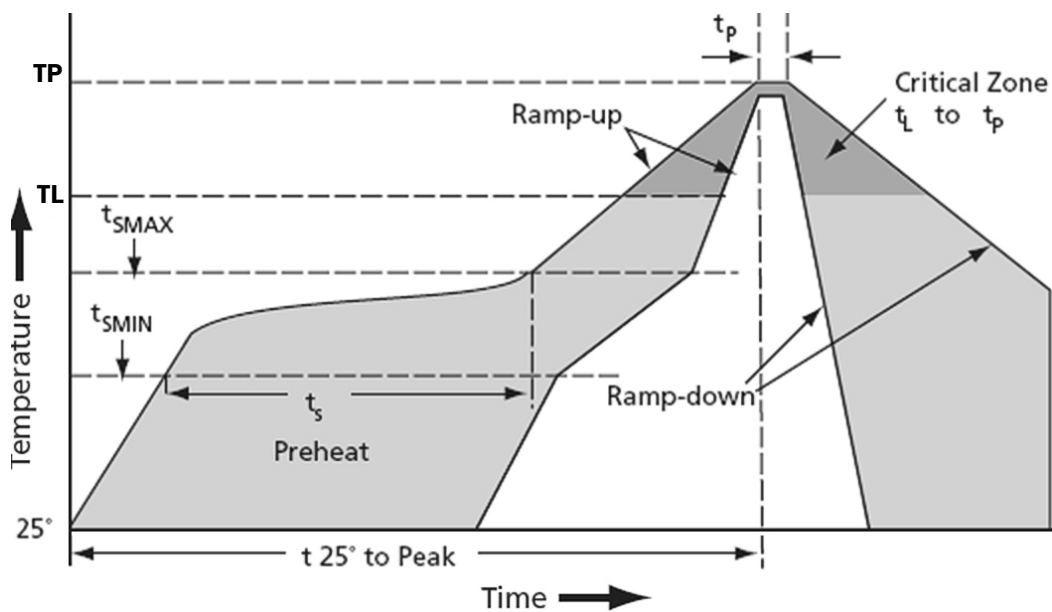
Parameter	Sn/Pb	Pb-free
Soak temperature, min, TSMIN	100°C	150°C
Soak temperature, max, TSMAX	150°C	200°C
Soak time, max, tS	2 min	2 min
Max ramp-up rate (TL to TP)	3°C/sec	3°C/sec
Liquidous temperature, TL	183°C	217°C
Time tL maintained above TL	60-150 sec	60-150 sec
Max peak temperature, TP	220°C	240°C
Max time tP at peak temperature TP	20 sec	30 sec
Max ramp-down rate (TP to TL)	6°C/sec	6°C/sec
Time 25°C to peak temperature	6 min max	8 min max

Figure 6: EnerChip RTC Solder Reflow Profile and Specification Table

GUIDELINES FOR IN-CIRCUIT TESTING OF THE INTERNAL ENERCHIP BATTERY

It is very important to verify EnerChip device connectivity after reflow solder process. It is important to read and understand the proper test flow for the EnerChip devices. Following the proper test method will ensure reworkability of boards.

Precautions and Important Processes
After assembly on a printed circuit board, the CBC34803 integrated solid state battery is in an uncharged state. It is important that the CBC34803 battery remain untested and uncharged until the last step of an in-circuit system test so that if other components fail test and need to be replaced, the CBC34803 will still be in a reflow-solderable state. The crystal and RTC in the CBC34803 can be tested independently from the battery at the same time the other system elements are being tested.

There are two considerations when doing post-assembly testing of the user's circuit board:

1. When performing circuit testing, short the internal EnerChip battery to GND by forcing the VCHG/VEC pins to ground potential during testing of the EnerChip RTC and other circuit functions. This will prevent the integrated EnerChip from accumulating charge while the CBC34803 VDD and EN pins are active.
2. When the overall circuit testing is complete, it is permissible to verify connection to the EnerChip battery and 4.1V output of the charge pump at the VCHG pin by forcing the CBC34803 VDD and EN pins high for **NO MORE THAN 3 SECONDS.** Activating the charge pump for longer than 3 seconds will put sufficient charge into the EnerChip that board level rework is no longer permitted without destroying the EnerChip.

Factory In-Circuit EnerChip Post Assembly Test Steps

CBC34803 In-Circuit Test Procedure
1. In order to keep the CBC34803 battery from charging during testing, apply GND using an in-circuit test bed pin or other shorting method to the VCHG and VEC pins (6 and 7, respectively) that are normally tied to-gether on the PCB. Alternatively, the EN pin on the CBC34803 can be forced to a logic low before performing board level testing as this will also prevent charge from accumulating in the battery. *WARNING: If the enable pin is asserted for more than 3 seconds with VDD ≥ 2.5 volts, the CBC34803 may not be reflowed again.*
2. Enable power domains under test, with VCHG/VEC net shorted to GND or EN forced to a logic low level.
3. Run all vectors to ensure proper functionality of all semiconductor devices.
4. After all other circuits are functional and boards have been reworked if needed.
5. Apply voltage to VIN that is in the range of 2.5V to 5.5V. (Note: VIN = VDD.)
6. Verify that the VCHG/VEC net is 4.1 volts +/- 0.025 volts.
7. Allow the battery to charge a very small amount by leaving the device in the above-noted configuration for one second.
8. The chart in Figure 7 should be referenced to determine the voltage on the VCHG/VEC pin to be expected after driving the ENABLE pin high for one second. The decay curves in the chart represent specific load impedances as might be encountered with Automated Test Equipment (ATE). Additionally, the decay curves represent the span of EnerChip cell impedances as specified in the respective data sheets. Note: If not using ATE with the ability to add a load impedance, it will be necessary to add resistance in parallel with the voltage measurement device so the readings will match the graph of Figure 7. Any measurement equipment and associated impedance circuits must only be temporally tied to the VCHG/VEC node for the time needed to make the measurement (seconds) and no longer as the measurement impedance will cause the battery to become discharged below 2.5V at which time the cell will become permanently damaged.
9. The graph in Figure 7 depicts the time-dependent and temperature-dependent voltage of the EnerChip RTC after applying a 4.1VDC charging voltage for approximately one second, followed by a brief discharge at a specific load resistance. Using this graph as a guide, the test engineer can develop a simple test that is feasible with the available test equipment and fixtures and meets the production throughput needs.

10. The test engineer has the freedom to choose a point on the discharge curve that falls within the parameters of test throughput and equipment measurement capability. In order for the EnerChip to be considered as meeting the gross functional test specification, the voltage on the VCHG/VEC pin must be above the value indicated by whichever line is chosen as the reference line.
11. Data at two temperatures is shown in order to encompass the range of anticipated factory test floors. Note the influence of temperature on the EnerChip test discharge voltage when setting the test specification pass/fail limits.

EnerChip Charge-Discharge Profiles for Setting Post-Assembly Test Limits
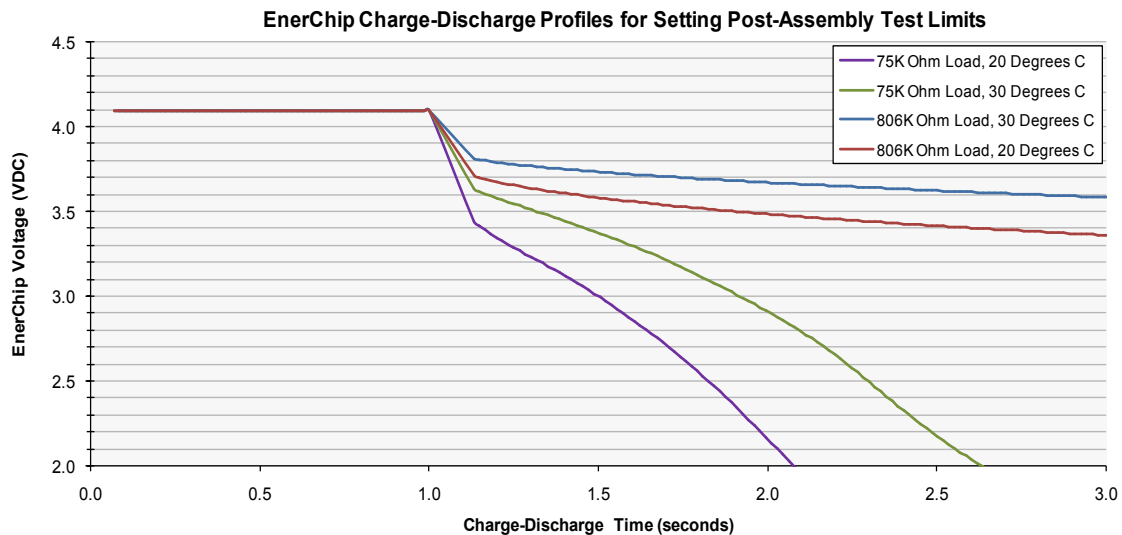
Figure 7: Voltage Determination on the VCHG/VEC Pin

CBC34803 Internal Battery Backup Verification: Optional Board/System Level Test. [1]

Warning: Board level reflow/rework is not permitted if the following procedure is used.

The following test is normally used in the prototype testing phase as this test may take 10-15 minutes to perform which is typically unsuitable for high speed in-circuit testing.

1. Power up board or system.
2. Ensure that CBC34803 EN pin 15 is asserted and VDD is > 2.5 volts.
3. Allow battery to charge for several minutes.
4. Program device to be battery-backed.
5. Remove power for at least several seconds to one minute.
6. Power up board or system.
7. Read device formerly under battery-backed operation.
8. Verify device contents.

Notes:
[1] This test does not verify the actual capacity of the integrated battery. In order to verify actual capacity, the device must be charged for at least one hour and then provide RTC power holdover until battery cut-off occurs.

CBC34803 Packaging

EnerChip CBC34803 devices are packaging in tubes or reels. The following specifications are for the 1000 and 5000 part reel packaging configurations.
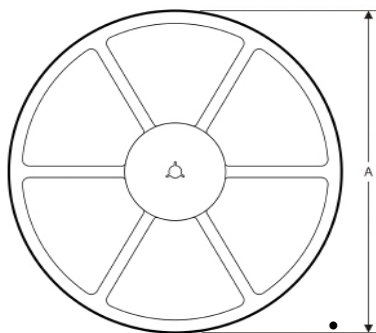
CBC34803-Q5C-TR1 is a 7 inch reel with 1000 parts. Cymbet uses the Advantek LOKREEL Mini RJ7xx packaging reel that has an outside diameter of 7 inches (180mm) and 1/2 inch (13mm) diameter arbor hole. Reel hubs measure 2.36 inches (60mm). The 7 inch reel is compliant with EIAJ standards for dimension and surface resistivity.

CBC34803-Q5C-TR5 is a 13 inch reel with 5000 parts. Cymbet uses the Advantek 13" LOKREEL packaging reel that has an outside diameter of 13 inches (330mm) and 1/2 inch (13mm) diameter arbor hole. Reel hubs measure 4 inches (102mm). The 13 inch reel is compliant with EIAJ standards for dimension and surface resistivity.

Cymbet Part	Package Type, # of Devices	Reel Size Outside Diameter - A	Tape Width W, W1 Cavity Pitch P1	Meters per Reel	Pockets/ Reel	Width A0	Length B0	Depth K0
CBC34803-M5C-TR1	QFN, 1000	180mm	16mm, 8 mm	108	7000	5.45	5.45	1.8
CBC34803-M5C-TR5	QFN, 5000	330mm	16mm, 8mm	540	13000	5.45	5.45	1.8

TAPE AND REEL INFORMATION
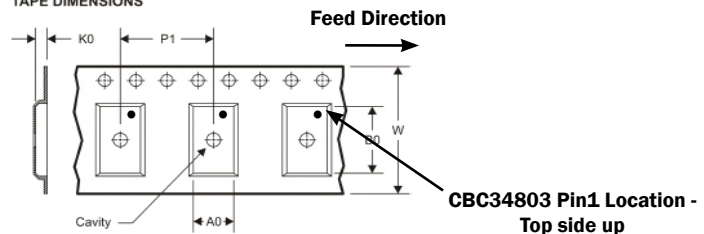
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

CBC34803 Pin1 Location - Top side up

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-12-34803	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