Preliminary

CBC34813 EnerChip™ RTC

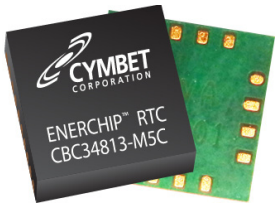
SPI Real-Time Clock/Calendar with Integrated Backup Power

Features

- Ultra low power Real Time Clock with Integrated rechargeable EnerChip™ solid state battery, power-fail detect and automatic switchover, **providing greater than 6 days of RTC backup**
- 5mm x 5mm x 1.4mm QFN package is the smallest commercially available RTC having integrated backup 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
- SPI-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 CBC34813
- **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 CBC34813-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 CBC34813 provides greater than 6 days of backup time in the event main power is interrupted. 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 SPI-bus. Alarm and timer functions provide the option to generate a wake-up signal on an interrupt pin.

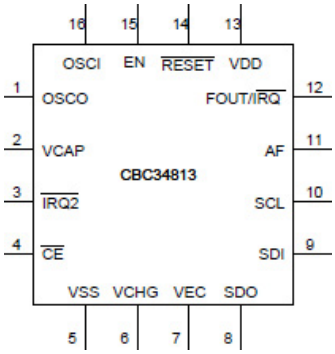


Figure 1: CBC34813 Pin-out Diagram

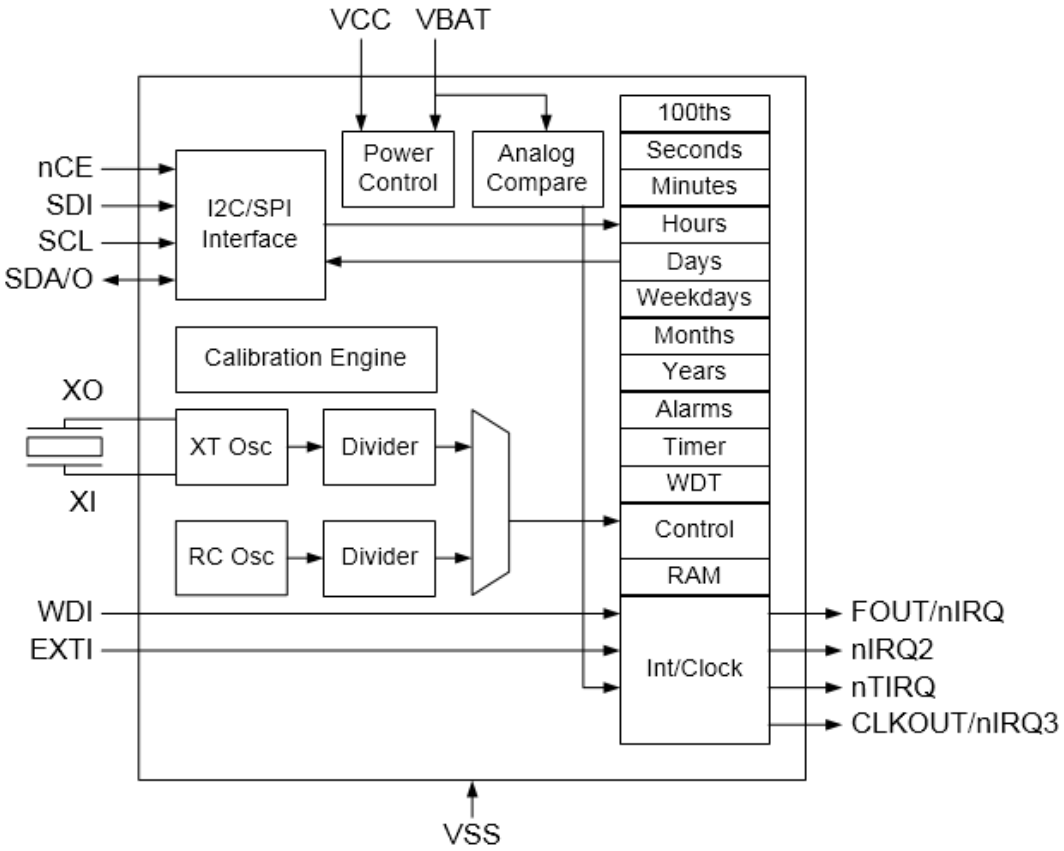


Figure 2: Functional Block Diagram of CBC34813 (AM0813) Real-Time Clock

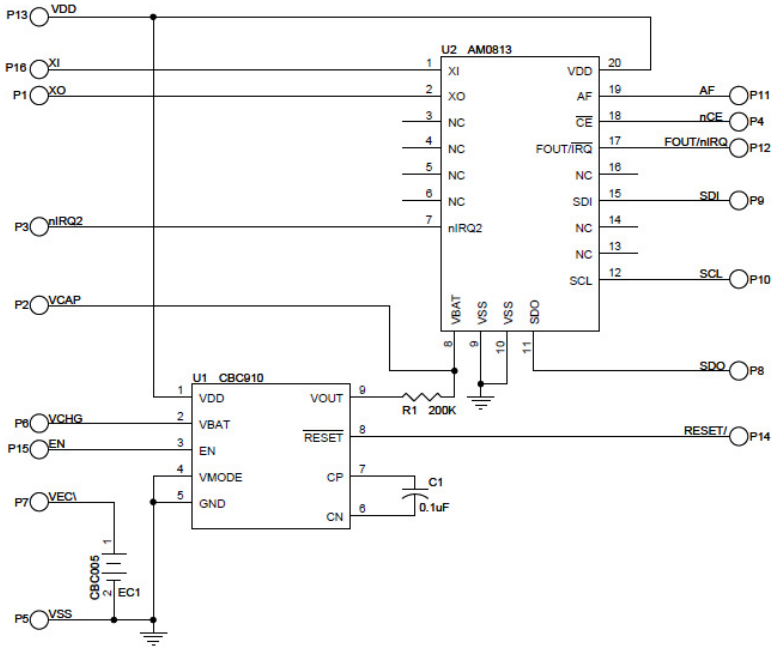


Figure 3: Internal Schematic of CBC34813 EnerChip RTC

CBC34813 Input/Output Descriptions

Pin Number	Label	Description
1	XO	Crystal output
2	VCAP	External capacitor connection to supply switchover current at cold temp. (optional)
3	nIRQ2	Interrupt 2 / Output
4	nCE	RTC SPI chip select
5	VSS	Ground
6	VCHG	4.1V (typical) charging source - connect to VBAT and/or optional EnerChip(s)
7	VEC	Positive terminal of integrated thin film battery - connect to only to VCHG via PCB trace
8	SDO	SPI-bus data output
9	SDI	SPI-bus data input
10	SCL	SPI-bus interface clock
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

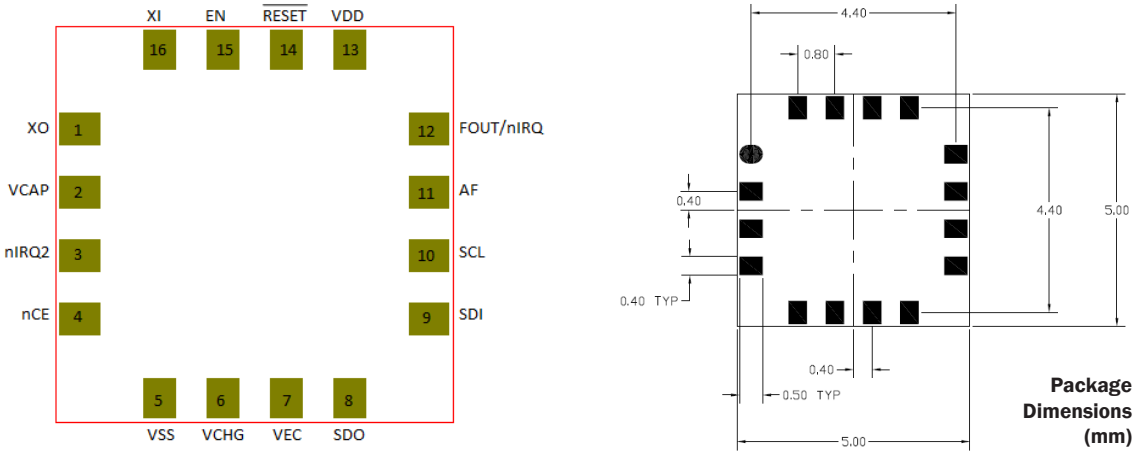


Figure 4: CBC34813 Package (left: top view, looking through package; right: pad dimensions)

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
VCAP	25°C	GND - 0.3	-	3.6	V
XI, XO, SDI, SDO, SCL, nCE, AF, FOUT/ nIRQ, nIRQ2	See Ambiq Micro AM0813 Data Sheet				

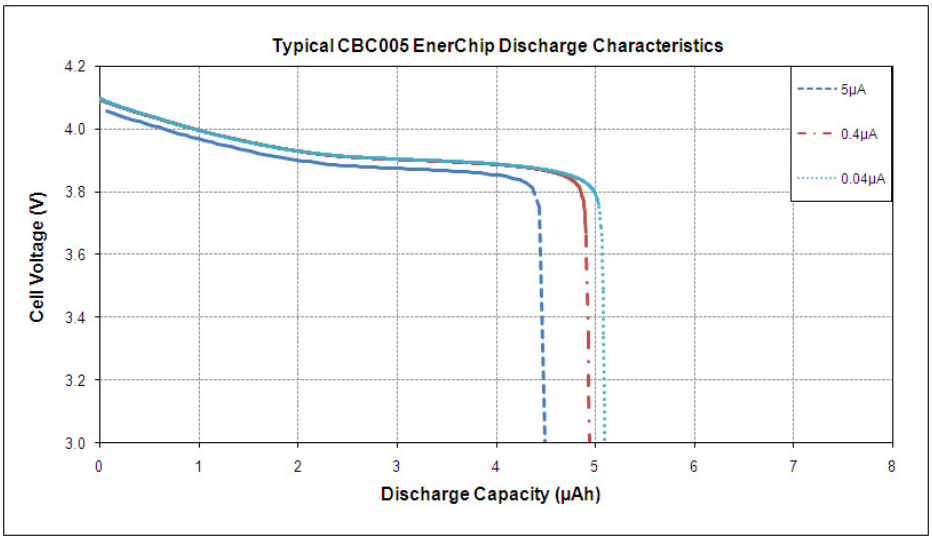
(1) *No external connections to these pins are allowed, except parallel EnerChips.*

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 complete specifications of the integrated AM0813 Real-Time Clock, see here: http://ambiqmicro.com

For complete specifications of the Cymbet 5µAh EnerChip and integrated power management circuit, reference the CBC3105 datasheet here: http://www.cymbet.com/pdfs/DS-72-21.pdf .

The EnerChip and power management functions within the CBC34813 are configured as in Mode 1 (VMODE = GND) as described in the CBC3105 DS-72-21 data sheet.

For guidelines regarding crystal selection and other important information pertaining to the AM0813, see here: http://ambiqmicro.com/resource-center/

Functional Description of Integrated AM0813 Real-Time Clock

The AM0813 serves as a full function RTC for host processors such as microcontrollers. The AM0813 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 AM0813, 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 trade-offs between power consumption and timing accuracy. Operating current drawn by the RTC is as follows:

<15 nA with RC oscillator
<20 nA with RC oscillator and autocalibration
<55 nA with crystal oscillator

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

Crystal Oscillator Selection

The AM0813 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 AM0813 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

CBC34813 (AM0813) Register Definitions (00 to 0F)

Offset	Register	7	6	5	4	3	2	1	0
00	Hundredths	Seconds - Tenths				Seconds - Hundredths			
01	Seconds	GP0	Seconds - Tens			Seconds - Ones			
02	Minutes	GP1	Minutes - Tens			Minutes - Ones			
03	Hours (24 hour)	GP3	GP2	Hours - Tens		Hours - Ones			
03	Hours (12 hour)	GP3	GP2	AM/ PM	Hours - Tens	Hours - Ones			
04	Date	GP5	GP4	Date - Tens		Date - Ones			
05	Months	GP8	GP7	GP6	Month - Tens	Month - Ones			
06	Years	Years - Tens				Years - Ones			
07	Weekdays	GP13	GP12	GP11	GP10	GP9	Weekdays		
08	Hundredths_Alarm	Hundredths_Alarm - Tenths				Hundredths_Alarm - Hundredths			
09	Second_Alarm	GP14	Second_Alarm - Tens			Second_Alarm - Ones			
0A	Minute_Alarm	GP15	Minute_Alarm - Tens			Minute_Alarm - Ones			
0B	Hour_Alarm (24 hour)	GP17	GP16	Hour_Alarm - Tens		Hour_Alarm - Ones			
0B	Hour Alarm (12 hour)	GP3	GP2	AM/ PM		Hours - Tens			
0C	Date_Alarm	GP19	GP18	Date_Alarm - Tens		Date_Alarm - Ones			
0D	Month_Alarm	GP22	GP21	GP20	Month_ Alarm - Tens	Month_Alarm - Ones			
0E	Weekday_Alarm	GP27	GP26	GP25	GP24	GP23	Weekday_Alarm		
0F	Status	CB	BAT	WDT	BL	TIM	ALM	EX2	EX1

The following register bits must be set prior to any switchover, even from VDD to the EnerChip.

BREF bits: The default value out of reset is 0000. This needs to be reprogrammed to 1111.
IOBM bit: The default value out of reset is 1. This needs to be reprogrammed to 0.

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	4.075	4.125	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	40	-	ms

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Ordering Information

EnerChip RTC Part Number	Description	Notes
CBC34813-M5C	EnerChip RTC in 5mm x 5mm x 1.4mm 16-QFN Land Grid Array	Shipped in Tube
CBC34813-M5C-TR1 CBC34813-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-12-34813	EnerChip RTC Evaluation Kit	USB based Eval Kit with CBC34813 tab board