APPLICATION NOTE

RV-1805-C3

Measuring Current Consumption and Frequency Accuracy

A COMPANY OF THE SWATCH GROUP

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1. OVERVIEW

The RV-1805-C3 should be used with a host microcontroller (e.g., a microcontroller development kit or an existing production system) to control memory reads and writes over the I^2C serial interface. All operations can be initiated over the serial interface including setting time, reading time, setting alarms and timers, clearing alarms and timers, and other functions described in the Datasheet RV-1805-C3.

A pico-ammeter can be inserted in series with the V_{DD} and V_{BACKUP} supply voltages to measure the ultra-low current consumption in each of the oscillation modes. Additionally, a high accuracy frequency counter can be used to measure frequency stability over extended periods under different calibration settings.

1.1. HARDWARE SETUP

It is assumed in the subsequent discussion that a microcontroller development kit is being used as a Host Controller (HC). It is also assumed that the HC has accessible pins for I^2C communication. For a proper pin connection of the RV-1805-C3 (resistors, capacitances) refer to the Datasheet RV-1805-C3.

1. Begin with the RV-1805-C3 and HC development board powered down.
2. Connect the I^2C_SDA (pin 5) and I^2C_SCL (pin 4) pins on the RV-1805-C3 to the SDA and SCL pins on the HC development board.
3. Connect any other digital inputs/outputs of interest on the RV-1805-C3 to the IO pins on the HC.
4. Connect the V_{DD}, V_{BACKUP} (if applicable), and V_{SS} pins on the RV-1805-C3 to appropriate supply voltages. The HC V_{DD} and RV-1805-C3 V_{DD} supplies should be the same voltage.
5. Power up the RV-1805-C3 and HC development board.

1.2. SOFTWARE SETUP

The RV-1805-C3 does require minimal driver development for the HC. All drivers are simple sequences of I^2C register writes. Detailed information on each register in the RV-1805-C3 can be found in the Datasheet RV-1805-C3.

The customer should develop the driver functions for their target MCU. Below are the function prototypes.

// I^2C Interface Functions described in the pseudo code:
void writereg(int8 RegisterAddress, int8 Value);
int8 readreg(int8 RegisterAddress);

2. MEASURING CURRENT CONSUMPTION

To measure current draw off the RV-1805-C3, an ammeter must be inserted in series with the RV-1805-C3 part, and the part must then be put into a desired oscillation state. Listed below are the steps required to measure current through the RV-1805-C3 V_{DD} pin in the most energy-efficient setting in crystal (XT) oscillation and RC oscillation modes.

1. Complete Steps 1-4 in Section 1.1.
2. Connect an ammeter in series with the V_{DD} pin of the RV-1805-C3. Power on the ammeter and set it to a range setting capable of measuring nA or tens of µA. To measure positive current, the ammeter polarity should be connected following the V_{DD} current.
3. Power up the RV-1805-C3 and the HC development board.
4. Issue a series of commands to place the RV-1805-C3 part in a typical low current oscillation state. The examples here use the I^2C access functions readreg and writereg described in the pseudo code.

    a. Set the CLKB bit (register 0x10 bit 4) to 1 and the CLKS field (register 0x11 bits [1:0]) to 0 to insure the $CLK/\overline{INT}$ pin is high and not drawing current through the pull-up resistor. Set the PSWB bit (register 0x10 bit 5) to 1 and the PSWS field (register 0x11 bits [4:2]) to 0 to insure the PSW pin is high and not drawing current through the pull-up resistor. Set the X bit (register 0x11 bit 5) to 0 to disable an internal input. This should force the $\overline{RST}$ pin to be high and not draw current through the pull-up resistor. Note that after first power up the CLKB bit and the CLKS field have these default values already.
    In order to change the PSWB bit to 1 the LKP bit (register 0x1D bit 5) must be set to 0 first.

    ```
    temp = readreg(0x1D)            // Read the Oscillator Status Register
    writereg(0x1D, temp & 0xDF)     // Set the LKP bit to 0
    temp = readreg(0x10)            // Read the Control1 Register
    writereg(0x10, temp | 0x30)     // Set the CLKB and PSWB bits to 1
    temp = readreg(0x11)            // Read the Control2 Register
    writereg(0x11, temp & 0xC0)     // Set the CLKS and PSWS fields and X bit to 0
    ```

    b. Set the IM field (register 0x12 bits [6:5]) to 0x3. This will minimize the current drawn by the alarm interrupt pulse generator (11: 1/4 seconds for both XT mode and RC mode). Note that after first power up the IM field has this default value already.

    ```
    temp = readreg(0x12)            // Read the Interrupt Mask Register
    writereg(0x12, temp | 0x60)     // Set the IM field to 0x3
    ```

    c. Set the TE bit low and the TFS field to 0x3 by writing the value 0x03 to register 0x18. This will minimize internal current drawn by the Countdown Timer. Note that after first power up the TE bit and the TFS field have these default values already.

    ```
    writereg(0x18, 0x03)            // Set the TE bit to 0 and the TFS field to 0x3
    ```

    d. Set the SQWE bit (register 0x13 bit 7) to 0 to disable the output square wave generator. When 0, the square wave generator is held at the value of CLKB (here CLKB = 1). Note that after first power up the SQWE bit has this default value already.

    ```
    temp = readreg(0x13)            // Read the Square Wave SQW Register
    writereg(0x13, temp & 0x7F)     // Set the SQWE bit to 0
    ```

    e. To observe the current with the Crystal oscillator running, set the OSEL bit (register 0x1C bit 7) to 0. Note that register 0x1F MUST be written with the value 0xA1 prior to any attempt to modify register 0x1C.

    ```
    temp = readreg(0x1C)            // Read the Oscillator Control Register
    writereg(0x1F, 0xA1)            // Load the Configuration Key Register with 0xA1
    ```

```
writereg(0x1C, temp & 0x7F)      // Set the OSEL bit to 0
```

f. To observe the current with the RC oscillator running, set the OSEL bit (register 0x1C bit 7) to 1. Note that register 0x1F MUST be written with the value 0xA1 prior to any attempt to modify register 0x1C.

```
temp = readreg(0x1C)             // Read the Oscillator Control Register
writereg(0x1F, 0xA1)             // Load the Configuration Key Register with 0xA1
writereg(0x1C, temp | 0x80)      // Set the OSEL bit to 1
```

g. The calendar counter registers (registers 0x00 through 0x07) may be read to verify that the internal timing system is operational. E.g. the Seconds Register (0x01).
The OMODE bit (register 0x1D bit 4) may be read to verify the selected Oscillator Mode. 0 = XT-Mode, 1 = RC-Mode

5. Change the ammeter range to a setting capable of measuring nA and observe the current draw. Averaging and filtering functions can help eliminate minor fluctuations in current caused by environmental radiation.

Note that nA current measurements can be influenced by both environmental conditions and equipment selection. Contact Micro Crystal AG at sales@microcrystal.com with any questions about measurement conditions.

3. MEASURING FREQUENCY ACCURACY

To measure frequency accuracy off the RV-1805-C3, a high-precision universal counter should be used to monitor the frequency output on the CLK/$\overline{\text{INT}}$ pin. Follow the steps below to achieve a high accuracy reading in crystal (XT) oscillation mode, RC oscillation mode, or autocalibration mode.

1. Complete Steps 1-4 in Section 1.1.
2. Connect a universal counter to Pin 3 of the RV-1805-C3. Choose a long integration time on the universal counter (e.g., 10 seconds) to ensure that a sufficient number of clock periods are captured.
3. Power up the RV-1805-C3 and the HC development board.
4. Place the RV-1805-C3 in a typical oscillation state by setting the SQWE bit (register 0x13 bit 7) to 1, and the SQFS field (register 0x13 bits [4:0]) to select a low frequency used to measure the internal oscillation modes. A frequency of 1 Hz (SQFS = 0xF) allows easy interpretation of the frequency error.

```
writereg(0x13, 0x8F)             // Set the SQWE bit to 1 and the SQFS field to 0xF (1 Hz)
```

5. Set the CLKS field (register 0x11 bits [1:0]) to 0x01 in order that the CLK/$\overline{\text{INT}}$ pin can drive the square wave output.

```
temp = readreg(0x11)             // Read the Control2 Register
writereg(0x11, temp | 0x01)      // Set the CLKS field to 0x01
```

6. Note that if the RV-1805-C3 is driving an external clock signal, the current drawn will be significantly higher than the current observed in low power mode.
7. Observe the frequency reported by the universal counter. For short integration times, the frequency may appear to fluctuate for the RC oscillator, in particular. This is a result of calibration and does not affect long term accuracy. Record frequency measurements over extended periods of hours or days to achieve the most accurate data.

a. To observe the Crystal oscillator, set the OSEL bit (register 0x1C bit 7) to 0. Note that register 0x1F MUST be written with the value 0xA1 prior to any attempt to modify register 0x1C.

```
temp = readreg(0x1C)             // Read the Oscillator Control Register
writereg(0x1F, 0xA1)             // Load the Configuration Key Register with 0xA1
writereg(0x1C, temp & 0x7F)      // Set the OSEL bit to 0
```

b. To observe the RC oscillator, set the OSEL bit (register 0x1C bit 7) to 1. Note that register 0x1F MUST be written with the value 0xA1 prior to any attempt to modify register 0x1C.

```
temp = readreg(0x1C)          // Read the Oscillator Control Register
writereg(0x1F, 0xA1)          // Load the Configuration Key Register with 0xA1
writereg(0x1C, temp | 0x80)   // Set the OSEL bit to 1
```

c. To observe the RC oscillator while autocalibration is active, set the OSEL bit (register 0x1C bit 7) to 1 and the ACAL field (register 0x1C bits [6:5]) to 0x3. Note that register 0x1F MUST be written with the value 0xA1 prior to any attempt to modify register 0x1C. This will enable autocalibration of the RC oscillator to occur every 512 seconds (roughly every 8.5 minutes). The first autocalibration cycle will begin as soon as ACAL is set to 0x3, and will be completed with a new RC calibration value in the Calibration RC registers (registers 0x15 and 0x16) within 50 seconds.

```
temp = readreg(0x1C)          // Read the Oscillator Control Register
writereg(0x1F, 0xA1)          // Load the Configuration Key Register with 0xA1
writereg(0x1C, temp | 0xE0)   // Set the OSEL bit to 1 and the ACAL field to 0x3
```

Note that frequency accuracy measurements are heavily influenced by test equipment. Contact Micro Crystal AG at sales@microcrystal.com with any questions about proper test setup.

4. DOCUMENT REVISION HISTORY

Date	Revision #	Revision Details
April 2014	1.0	Initial draft version
June 2014	1.1	- Added notes about default values. - Added locations of OMODE and OUT1S (new: CLKS).
July 2014	1.2	Released Version - Modified part number to RV-1805-C3
January 2015	1.3	- Changed 6 variable names