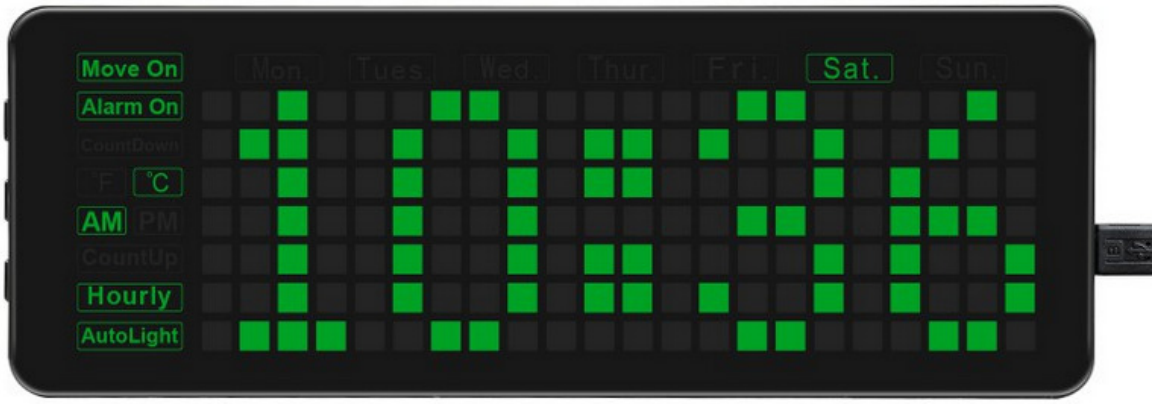
Pico Green Clock



Firmware Version 7.00
User Guide
Updated November 16th, 2022

IMPORTANT :
This User Guide is about Pico Green Clock firmware Version 7.00 from Andre St. Louys.
Versions 2.00 and up are based on the original Waveshare's Version 1.00 and add more features to the clock. If you're using the original firmware from Waveshare, many features described in this manual do not apply.

Join our Pico-Green-Clock discussion group on:
https://github.com/astlouys/Pico-Green-Clock/discussions

Pico Green Clock User Guide

Index

Pico Green Clock User Guide

Do you want to share your experience with the Pico Green Clock and help other users ?
Join our discussion group on:
https://github.com/astlouys/Pico-Green-Clock/discussions

Among the subjects of interest:
Which version of the firmware do you use?
Do you like it?
What are the features you appreciate the most?
Did you find some bugs (what are they)?
Did you improve the firmware (how)?
Did you add some more features (which)?
Let us know!

If you want to send me a personal email (as long as it is something constructive),
here is my email address:

Andre St. Louys
(Quebec, Canada)
astlouys@gmail.com

About Version 7.00

The two main features added in firmware Version 7.00 are:

1) Modify the Daylight Saving Time algorithm (also called in some countries: “Summer Time”, or “Spring-Forward”) to cover most (if not all) countries in the world.
2) Transfer the function supporting the DHT22 to Pico’s core 1 to prevent all the problems due to the callback functions and other interrupts.

The difference with UTC (“Coordinated Universal Time”) has also been added / integrated to the clock configuration now saved to flash. It is currently used for a few countries using UTC as a reference for time change, and it will be required if / when an NTP function is added to the clock (to read the time reference from Internet by WiFi)

As usual, you can refer to the revision history in the source code and / or at the end of this guide to get details about changes among different firmware versions.

Introduction

Waveshare Pico Green Clock

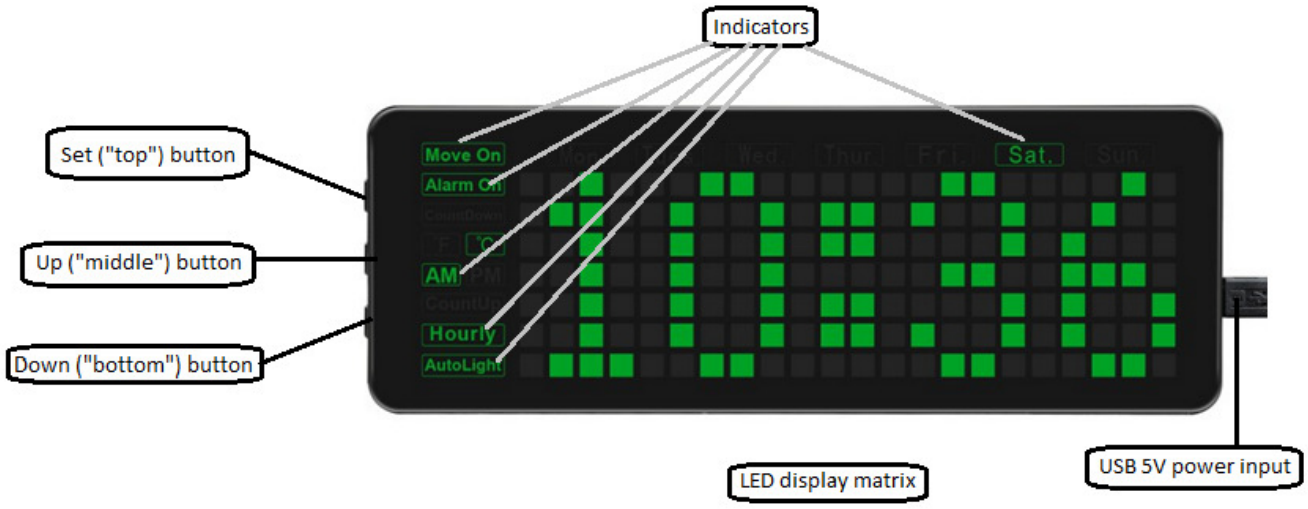
As mentioned on the cover page, this User Guide is about Firmware Version 7.00 from Andre St. Louys. Firmware Versions 2.00 and up are based on the original Waveshare's firmware Version 1.00 and add more features to the clock and tons of comments in the source code which is in C-Language.

The Waveshare's Green Clock uses a Raspberry Pi Pico microcontroller to control most of its functions / features (IMPORTANT: the microcontroller itself, Raspberry Pi Pico, is not included with the clock. However, it is not very expensive – more or less 15 US$ at the time of this writing). The clock display is made of a matrix of 22 X 7 green LEDs, along with many indicators (for DayOfWeek, AM / PM, Alarm On / Off, etc.). See figure below for more details.

There is also a real-time clock integrated circuit ("RTC IC") with a battery back-up, allowing the clock to keep the correct time and date in case of a power failure. Also beginning with version 6.00, most clock configuration parameters are saved to Pico's flash memory. In case of reboot and / or power failure, those parameters are read back from flash memory so that there is no need to go through the clock configuration again and again…

Some of the options / features / parameters of the clock are configurable at "run-time" (when the clock is powered on), while others are configurable only at "compile-time" (before compiling the source code to get the executable firmware), as indicated in the text that follows. Options that are configurable at compile-time mean that a change must be done in the source code and the firmware needs to be rebuilt and re-flashed ("re-programmed") in the Pico microcontroller's non-volatile memory for the option to take effect. On the other side, an option that is configurable at run-time means that the user can configure it once the clock is powered On and running.

Keep in mind the name given to the three clock buttons on the left of the clock. They will be used very often throughout this guide to show how to configure the clock.



The button at the top is called the “Set” button since it is usually used to scan through the many settings of the clock.

The button in the middle is called the “Up” button (not to be mixed up with the “top” or “Set” button) because it is usually used to increase the value of current setting.

The button at the bottom is called “Down” button because it is usually used to decrease the value of current setting.

Clock configuration saved to flash memory

Take note of this specific behavior the first time you run the firmware Version 7.00:

- If you already ran firmware Version 6.00 before, there is already a valid configuration saved to flash memory. Version 7.00 will add a few more parameters that will be initially saved with default values. You will have to set those parameters with specific values (refer to the section “clock setup” later in this guide). However, all the parameters that you’ve set before will still be valid with firmware Version 7.00 and read back from flash.
- If you never ran firmware Version 6.00 before, then there is no clock configuration saved to flash memory. Version 7.00 will detect that there is no valid configuration in flash and a default configuration will be generated and saved. You will have to set all clock parameters to your taste and they will then be saved to flash (refer to the section “clock setup” later in this guide).

Clock power-up sequence

The clock is powered by a USB (5 volts) charger / adaptor / power supply with a mini-USB connector.

When power is applied to the clock, many tests are performed. You may want to keep an eye on the different devices to make sure everything works fine.

Here is a summary of the clock power up sequence. [Square brackets] at the beginning of a line means that this step of the power-up sequence will execute only if the user has enabled the conditional compile for this device / option.

1) Turn On (for a few seconds) the two white LEDs ("night light") near the clock buttons on the left side of the clock.

2) Sound a few "beeps" with the integrated active buzzer to test it.

3) Performs a clock display pixel test. Each column of pixels is turned On in sequence.

4) Perform indicators test. Most indicators have two back-LEDs. Each one is turned On in sequence.

5) Blink the two white LEDs (night light) a few times.

6) Pixels twinkling animation for a few seconds (just for fun).

7) [Passive buzzer]: If a passive buzzer has been installed by user, it will make random sounds during pixel twinkling.

8) If display scrolling is configured "On", the "Move On" indicator is turned On accordingly on the clock display.

9) The appropriate temperature unit indicator is turned On (°C or °F), depending on the temperature unit that is configured.

10) If hourly chime is configured "On" or "Day", the "Hourly" indicator will be turned On accordingly.

11) Display Green Clock firmware version number.

12) [BME280]: If the conditional compile is set for an installed BME280 and its initialization returns an error code, an error message will scroll on the clock display. Other than this error message, BME280 algorithms have been tuned so that the clock will perform normally even if no BME280 has been installed.

13) [BME280]: If a BME280 has been installed by user, its "DeviceID" will be scrolled on clock display. The device ID for a "real" BME280 is 0x60.

14) [BME280]: If a BME280 has been installed by user, its "Unique ID" will be scrolled on clock display (consider the "Unique ID" as a "serial number"). The Unique ID is a hexadecimal number with a format of: XXXX XXXX.

15) [DHT22]: If the conditional compile is set for an installed DHT22 and an error occurs while trying to read the DHT22, an error message will scroll on the clock display. Other than this error message, DHT22 algorithms have been tuned so that the clock will perform normally even if no DHT22 has been installed.

16) [Passive buzzer]: If a passive buzzer has been installed by user, it will play a few jingles to test it while continuing to scroll information on the clock display.

17) Display Pico microcontroller's "Unique ID" in hexadecimal with a format of: XXXX XXXX XXXX XXXX (consider the "Unique ID" as a "serial number" for the Pico installed in the Green Clock). As you can guess by its name, this number is unique to the Pico that is installed in your clock. If you would replace it with another Pico, the Unique ID would be different.

18) Scroll current "Daylight Saving Time" mode / status, according to clock configuration and current time and date. Three different statuses are possible. "No support for daylight saving time" means that the clock completely ignores DST. It's like if DST does not exist for the clock. "Daylight saving time inactive" means that the clock takes care of the DST, but given the current date and time, daylight saving time is not active. Finally, "Daylight saving time is active" means that the clock takes care of DST, and given the current date and time, daylight saving time is active. Note: The clock manages automatically the change between active and inactive, based on current time and date and in compliance with the clock DST setting (refer to the clock setup later in this guide).

19) Display power supply voltage value (voltage supplied by USB power supply). It should be around 5.0 volts, but it may be a little higher or lower.

20) If sound has been cut off at compile time, a warning will scroll on clock display. There is an option in the source code to completely turn off all sounds generated by the clock. I used this feature during the development phase / cycles, when some coding sessions went on late during the night, while my wife was sleeping. If "sound cut-off" is scrolled on the clock display at power up, it means that this compile time option is active. No need to try finding a bug with alarm, chime, or anything else to explain how come no sound comes out of the clock! NOTE: ***ABSOLUTELY NO SOUND*** will be generated by the clock if this option is set at compile time.

21) Display Pico microcontroller internal temperature (is usually 1 or 2 degrees higher than ambient temperature).

22) Turn On the appropriate day-of-week indicator according to the real time clock setting.

23) Display time.

Clock features

Here is a brief description of clock features (in alphabetical order). More details are given later in the guide where each feature is described in its specific section.

Alarms (run-time)

Beginning with Version 6.00, there are now nine (9) alarms available on the clock. They can be independently set at a specific time (hour and minute) and with a selection of any number of days-of-week (new with Version 6.00), and they will sound an alarm when the programmed alarm parameters are reached. If a passive buzzer has been installed, the sound pitch will be slightly different for each alarm number and the number of "beeps" corresponds to the alarm number being heard. The alarm will sound during a one-hour period, or until the user presses the "Set" (top) button, whichever happens first.

Auto-brightness (run-time)

The auto-brightness feature allows the clock LED matrix display to be brighter when the ambient light is bright and to dim the clock display when the ambient light is darker (see section on auto-brightness setting later in this guide). Take note that a hysteresis has been added to this feature previously in the code, so that the brightness will change smoothly with changing light conditions (and not change back and forth immediately as was the case before).

The ambient light detection / sensor takes advantage of one of the analog-to-digital converter integrated in the Raspberry Pi Pico.

Beep types (compile-time)

The piezo (buzzer) provided in the clock is an "active" piezo. That is, it has its own integrated oscillator, so it is not possible to change the frequency of the sounds that are produced for the different usages (calendar events, keyclick, hourly chime, alarms, timers, etc…). However, a feature has been implemented in the clock firmware since Version 2.00 allowing the making of a different number of "beeps" of different duration. This allows distinguishing between a calendar event, hourly chime, button keyclick, etc…

Beginning with version 3.00 this feature has been improved even more to another level by adding the concept of a "sound pack" (a primary group of sounds) and a repeat count for this "sound pack". You will find more information about this later in this guide.

Version 6.00 brings the feature one step further by implementing an active buzzer queue (circular buffer) to optimize the code and make it much easier to handle the clock sound activity.

Firmware Version 4.00 and up also supports a "passive piezo" (that must be installed by user), allowing to change the sound frequency (the clock can then play jingles).

Calendar events (compile-time)

The user can define short strings of text (40 characters maximum) that will scroll on the clock display at specific dates. For example, "John's Birthday" would scroll on the display on April 14th, if this date (14-APR) has been defined in the source code as a "Calendar event" with the text associated (see file "CalendarEventsGeneric.cpp"). Up to 50 such calendar events may be programmed and more than one may be programmed for a specific day.

The calendar events will scroll on the screen during all day at the date defined in the clock configuration at compile time (the firmware must be rebuilt and re-flashed in Pico's memory). The text will scroll at xxh14 and xxh44 of each hour all day long (that is, every half hour), and a few beeps will also sound when the text begins scrolling. Those warning beeps are subjects to the same rules as the hourly chime. That is, if hourly chime is Off, the warning beeps will not sound (although the text will scroll, no matter the hourly chime setting). If hourly chime is On, warning beeps will sound during the whole day (that is, during the 24 hours period defined by the date of the calendar event). Finally, if hourly chime is intermittent ("OI" for On, Intermittent in the settings), the warning beeps will sound during daytime, as defined between "chime time On" and "chime time Off" in the clock configuration (set by default from 9h00 to 21h00). You will find more information about this, later in this guide.

If a passive buzzer has been installed by user, a specific jingle may be selected in the CalendarEventsGeneric.cpp file and the specify jingle will be played while the calendar event text is scrolled on the clock display.

A few of these calendar events have been programmed by default to show the user how to program others if desired. For example, "Happy New Year" and "Merry Christmas" are two such events that are programmed by default. Also, every first day of each month, an event called "Calendar event *Month* 1st" will scroll on clock display (where "*Month*" will be replaced by the actual month name). This is to easily provide a demonstration of the feature without having to remember a specific date.

Count-down timer (run-time)

A count-down timer can be programmed at run time and set to a specific start value. Once the count-down reaches zero, an alarm will sound (without respect to "chime time On" and "chime time Off").

Count-up timer (run-time)

A count-up timer may be started on the clock at run time. When started, the count-up timer will count from 00m00s and up, until stopped by user (no alarm sound is associated with this timer).

Date scrolling (run-time)

The user may configure the clock to scroll the date, the ambient temperature, external temperature, relative humidity and barometric pressure (if user installed a BME280), Pico's internal temperature and power supply voltage on the display at a predefined frequency (by default, every 5 minutes, which is a compile time parameter) (see section "Date scrolling" on clock setup later in the guide).

Beginning with firmware Version 3.00, the date, temperature and voltage are displayed as in "Friday July 6th 2022 21.25°C 4.96 Volts" (the temperature and power supply voltage are shown after the date). The letters are made of 5 X 7 character matrix (variable-width).

The support for outside temperature, relative humidity and barometric pressure reading is also an option available when user adds a BME280 sensor (not supplied with the Green Clock itself). See section on BME280 support later in the guide.

Daylight Saving Time (run-time)

NOTE: The concept of Daylight Saving Time (DST) is also called in some countries: Summer Time / Winter Time – Spring Forward / Fall back

The firmware automatically supports the Daylight Saving Time for most (if not all) countries of the world. This feature can be turned Off if the user so desires (refer to the "DST section" of clock setup later in this guide).

When the clock is powered up, the current status of the daylight saving time will be scrolled on the display (see section "Clock power-up sequence" above).

Daytime hourly chime (run-time)

This feature allows the "hourly chime" and "calendar events" to sound a "warning sound" only during the hours configured. This can prevent those sounds to be heard during the night, when people are sleeping.

There is also support for "nighttime workers" where the sounds are heard only during the night. See section on how to setup chime time On and chime time Off later in the guide.

Digits

The digits are built with the LED matrix of the clock. There are 4 X 7 characters and also 5 X 7 characters, making the digits more elegant ("better-shaped") than the usual 7-segments displays that we use to see with other clocks on the market.

Double dots blinking

There are two "dots" in the middle of the clock, between hour and minutes (see picture above in the Introduction). Note that since firmware Version 2.00 "slim" dots are used, as opposed to the "thick" dots that can be seen on the picture.

When the minute changes (say, for example, from 7h18m59s to 7h19m00s), the top dot begins to blink once a second, from 00 sec to 19 sec. Then, the bottom dot will blink from 20 sec to 39 sec. Finally, both dots will blink together from 40 sec to 59 sec. This allows someone to quickly evaluate (relatively) how "deep" we are in the current minute, and if the next minute change will occur soon.

Flash memory

Pico Green Clock User Guide

Beginning with firmware Version 6.00, the clock configuration is saved to flash (Pico's non-volatile memory). During the power-up sequence, the configuration is read from flash memory and restored to the clock. If this is the first time that the new Firmware is ran (Version 6.00 or a more recent version), the clock will detect a "wrong" flash configuration (in fact, wrong checksum since at this point, there is no configuration at all in flash memory) and will generate and save a default configuration.

Once this is done, every minute thereafter, the clock will compare the checksum of its active configuration with the one of the flash configuration. If user has made some change to the active clock configuration, it will be detected by the clock (checksums won't match) and the new active configuration will be saved to flash just before the next minute change (at xxhxxm59s). You may see a quick "glitch" on the display (blanking or "blinking", about a quarter of a second) when a new configuration is saved to flash. This is because interrupts must be disabled when writing to flash memory. Take note that no active wear-leveling algorithm has been implemented in flash writes. Most probably, writing a new configuration here and there during the life span of the clock will not be a problem for the many thousand cycles of writes available, but user must be aware that if flash writes are to occur many times a second, current algorithm is not appropriate. However, as a "passive wear leveling", the configuration is saved to flash only when the clock is in the normal "time display" mode. That means that if user remains in "setup mode" for a while and change many configuration parameters, chances are that only one flash write will occur, once user exit setup mode and go back to time display mode.

The following configuration parameters are saved to flash memory:

Software version number	Will eventually make updates easier if ever the configuration changes in the future.
Current year centile	First year two digits ("20"). Not very useful since it could have been hard-coded, but not a big problem to simply add it to the flash configuration.
Language	French and English are the two supported languages for now.
Daylight Saving Time	Select the appropriate algorithm for the User's country. `Not supported' may also be selected. Once properly setup, the clock will determine on power-up if Summer Time must be active or inactive, and will make automatic adjustment to clock time and UTC time at the specific moment of time change in spring and fall.
FlagSummerTime	Flag indicating current status of Daylight Saving Time (active or inactive).
UTC delta	Difference in time between "local time" and "UTC time" ("Coordinated Universal Time".
Temperature unit	Celcius or Fahrenheit
Time display mode	24-hours or 12-hours mode
Chime mode	On / Off / Day
Chime time On	9h00 by default
Chime time Off	21h00 by default
Night light mode	On / Off / Night / Auto
Night light time On	21h00 by default
Night light time Off	8h00 by default
Auto brightness	On / Off
Beep (keyclick)	Audible feedback when pressing clock buttons
Scroll enable	Scroll the date every 5 minutes.
Alarms 1 to 9	Alarms parameters: Status (On / Off) Alarm hour Alarm minute

	Alarm second (not available to user) Bitmask of active alarm days (any combination of days of week)
CRC16	Cyclic redundancy check of the configuration data.

Hour display mode (run-time)

The hour can be displayed in 24-hours format (00h00 to 23h59), or in 12-hours format (12h00 AM to 11h59 AM, then 12h00 PM to 11h59 PM). This can be set at run time (see section on clock setup later in the guide).

Hourly chime (run-time)

Every hour, at xxh00m00s, an hourly chime may sound to indicate that the hour just changed. This feature can be configured: On, Off, or Daytime. If configured for "Daytime" ("OI" for "On, Intermittent" in clock settings), the hourly chime will sound only during predefined hours in clock configuration (set between 9h00 and 21h00 by default) (see section on clock setup later in the guide).

NOTE: If the hourly chime is Off, the "Hourly" indicator on the display will be turned Off. If the hourly chime is On, the "Hourly" indicator on the display will be turned On with two LED backlights. If the hourly chime is set to "Day" ("OI"), only the left LED behind the "Hourly" indicator will be turned On. It is not easy to see the difference between full-2-LEDs On and only left-1-LED On and it may take some practice for the user to see the difference.

Idle monitor

It may be interesting to know what the current load is, on the microcontroller (Pico). Since firmware Version 6.00, a "System idle monitor" has been implemented. It gives an "average number of system loops performed by the firmware every second, based on the analysis / history of the last 60 seconds". That means the highest the number, the less busy is the system.

System idle monitor can be displayed on clock display with the remote control (remote must be installed by user). It can also be added to the clock scrolling data by a quick change in the source code.

For those interested in going deeper in this analysis, you may want to connect an external terminal emulator to the Pico's USB port and enable the DEBUG_IDLE_MONITOR option.

Keyclick sound (run-time)

A "keyclick" sound may be turned On or Off to give some feedback when the user pushes a clock button. If this option is turned On, a quick "click" will be heard each time a clock button is pressed to give the user a positive feedback that the button press has been processed by the clock (see section on clock setup later in this guide).

Language (run-time)

Two languages have been implemented so far in the clock firmware for date display: French and English. Provisions have been made for other languages, so that they could be easily implemented (as long as they use the usual English-like character set). English is the default language setting for firmware releases and it can be changed in clock configuration.

Night light (run-time)

Since the two white LEDs on the side of the clock (near the buttons) were not used, I thought it would be a good idea to use them as a "night light".

Obviously, do not expect the LEDs to provide enough light for reading or replacing your 800 lumens room light. But since they were not used anyway…

Moreover, be aware that given the way the electronic circuit is done, those two white LEDs will follow the green matrix LEDs brightness. So, if the clock brightness is low, the two white LEDs will be dimmed as well, in a way similar to the clock green matrix display.

Power supply voltage display (run-time)

If “Display scroll” is enabled (see section “Display scroll” on clock setup later in the guide), then the actual power supply voltage value will scroll on the display after the date and temperature. It should be around 5.00 volts.

The power supply voltage reading takes advantage of one of the analog-to-digital converter integrated in the Raspberry Pi Pico.

Temperature display (run-time)

The ambient temperature may be scrolled on the display, along with the date and the power supply voltage. The temperature may be shown in Celsius or Fahrenheit. This is a run time option (see section on clock setup – “Display scroll” - later in the guide).

If user installed a BME280, it can be used to read outside temperature, relative humidity and barometric pressure and those three values will be scrolled on clock display.

If a BME280 is not installed, it will have no impact on normal clock behavior, but the outside temperature, relative humidity and barometric pressure will not be scrolled.

If a DHT22 and / or a BME280 has been installed by user, total number of errors while reading the device(s) DHT22 and BME280 are reported while scrolling the date (for statistic purposes). For example, “(2/1758)” means that there has been 2 reading errors out of 1758 readings of the DHT22. Same applies for BME280, but it is indicated between square brackets instead of parenthesis. For example: “[2/12434]”. If no DHT22 and / or BME280 have been installed, it is normal to see that both numbers are the same “(for example: 534/534)”, since every reading trial will end up in an error.

UTC time (Coordinated Universal Time)

The support for the difference between local time and UTC time has been added to firmware Version 7.00. User must set this parameter once, when configuring the clock, but the clock will then maintain it automatically (since this time difference changes when hour changes from Summer Time to Winter Time and back).

Keeping track of UTC time allows correct algorithm behavior for those countries who use UTC time as a reference for changing from Summer Time to Winter Time (and back). This parameter will also be required whenever NTP (“Network Time Protocol”) is implemented on the clock to adjust the time from an Internet source in a future version.

Options

The following are options that are not provided with the clock but for which support has been added in the firmware. If you supply the device required, you can turn on the conditional compile in the code and get support for it.

DHT22

DHT22 is a temperature and humidity sensor. Support for it has been added in the code. I personally installed such a sensor outside to get rid of those remote temperature RF sensors which require battery change when temperature reaches -40 Celsius (yes… I live in Quebec!). However, when trying to install the device outdoors with a 3-meters cable (10 feet), I got about 80% reading errors. NOTE: New with firmware Version 7.00, I transfer the support code for DHT22 to Pico's second core (core 1) and I've seen a significant improvement in reliability (DHT22 communications are not corrupted with callbacks and / or other interrupts). Since I installed a BME280 some time ago, I will not use the DHT22 with a relatively long cable (I still use it for indoor temperature and humidity reading), but I'm greatly interested in hearing from those users who will install a DHT22 for outside temperature reading.

BME280

BME280 is a temperature, humidity and barometric pressure sensor. Support has also been added for it in the code. In fact, it shares the same I2C line protocol as the real time clock IC. So far, I never had a single reading error out of a many thousands readings.

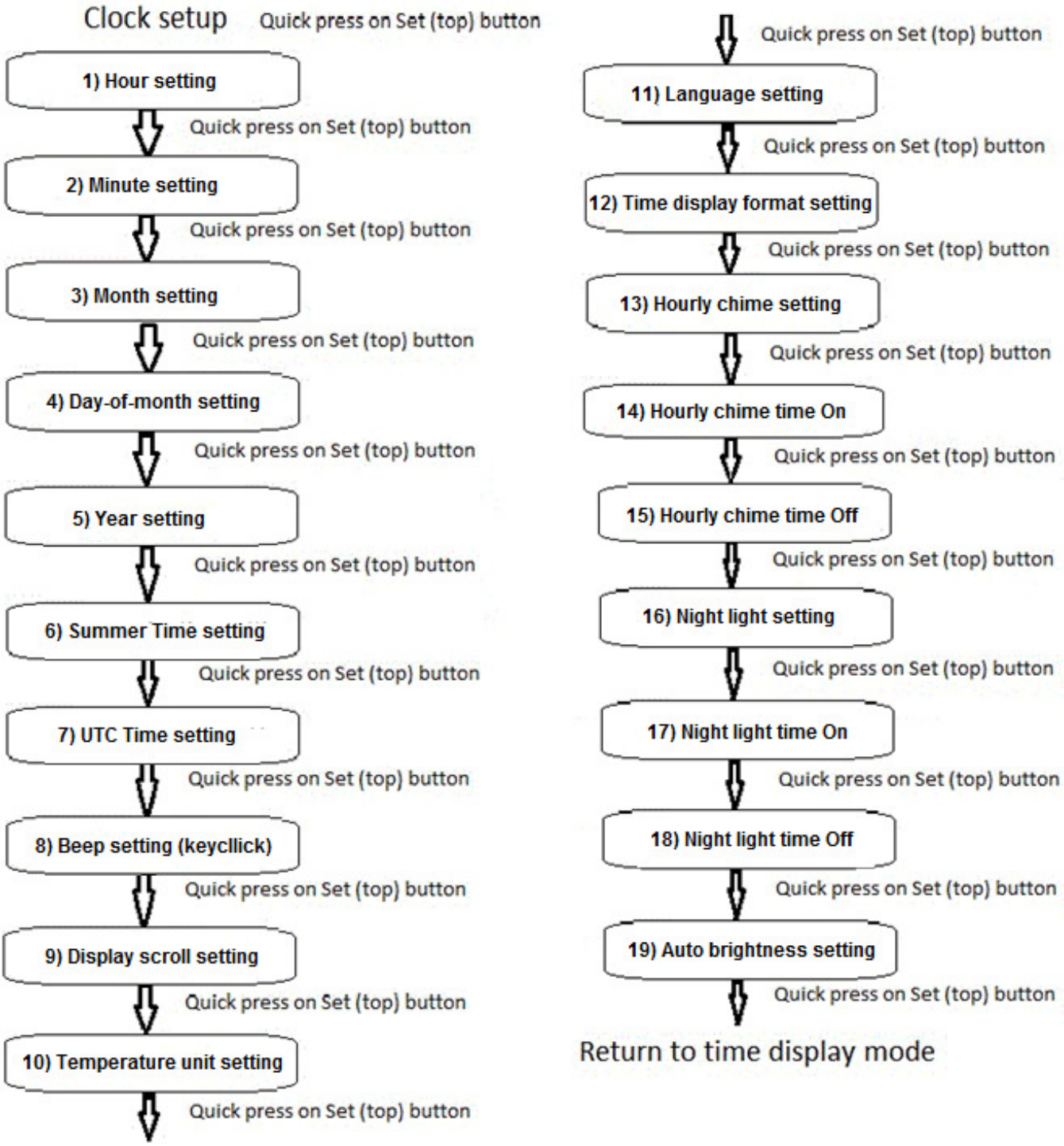
Infra-red sensor

Support for an infrared sensor to receive commands from a remote control has also been added in the code. Since one of my Green Clocks will be installed in a relatively high location on a wall, remote control becomes very handy since access to the clock's buttons will be difficult.

Passive buzzer / piezo

As opposed to the buzzer that comes with the clock, a passive buzzer does not have an integrated oscillator. It is then possible to drive the piezo with an external signal. By changing the frequency of this signal, the audio frequency generated will change and it becomes possible to play "tunes" / "jingles".

Clock setup



Refer to the paragraph – in the following section - with the number indicated in the box above to get more details about each step of the clock setup.

About clock buttons

Remember the name given to the three clock buttons:

- The Top button is called “Set” button since it is primarily used to scan through all settings.
- The Middle button is called “Up” button since it is primarily used to increase values (for example: increase hour value, increase minute value, etc).
- The Bottom button is called “Down” button since it is primarily used to decrease values (for example: decrease hour value, decrease minute value, etc).

When not otherwise mentioned, a “button press” means a “quick” button press, which is less than 300 milliseconds (shorter than one third of a second). Often, the clock will handle a “long press” (longer than one third of a second) by performing a different behavior than for a quick press. So, keep in mind the difference between a “quick press” and a “long press”.

Entering clock setup mode

To enter clock setup mode, make a quick press on the “Set” (top) button while the clock is in the usual “Time display” mode.

Each time you press on the “Set” (top) button, you navigate through the different clock settings, as illustrated on the diagram above.

To exit clock setup mode, you can:

- Wait for a timeout (20 seconds without pressing a button on the clock – see next section).
- Quick press the “Set” (top) button many times to scan all settings and then, press it once more when reaching the last setup step to return to the time display mode.
- Make a “long press” (longer that one third of a second) on the “Down” (bottom) button to exit clock setup mode at any time.

Clock setup timeout

If you leave the clock unattended for more than 20 seconds (changing the value of “20 seconds” is a compile-time option), it will return to the time display mode. Any change that has been made so far during this clock setup session will be saved in the clock settings (and also to the flash configuration if this is part of the flash configuration).

1) Hour setting

While referring to the Clock setup diagram above, press the “Set” (top) button until you reach the “Hour setting” step.

Current hour will blink on the clock display. Press the “Up” (middle) button to increase the hour value, or press the “Down” (bottom) button to decrease the hour value.

Depending on the current “Hour display format” (12-hour or 24-hour format), hour setting will go from 1 to 12 along with the AM / PM indicator, or from 00 to 23, without AM / PM indicator.

Take note that when you complete the clock setup, the integrated real-time clock integrated circuit (“RTC IC”) will be programmed with the new time and date. This IC is backed-up with a battery and will keep the accurate time in case of a power failure.

2) Minute setting

While referring to the Clock setup diagram above, press the “Set” (top) button until you reach the “Minute setting” step.

Current minute will blink on the clock display. Press the “Up” (middle) button to increase the minute value, or press the “Down” (bottom) button to decrease the minute value.

Take note that when you complete the clock setup, the integrated real-time clock integrated circuit (“RTC IC”) will be programmed with the new time and date. Also note that if you changed the setting of the minutes, the seconds will automatically start from zero.

3) Month setting

NOTE: Given the difference in the date format between French and English, the sequence for setting the month and the day-of-month is reversed when the clock language is set to French.

While referring to the Clock setup diagram above, press the “Set” (top) button until you reach the “Month setting” step.

Current month will blink on the clock display. Press the “Up” (middle) button to increase the month value, or press the “Down” (bottom) button to decrease the month value.

NOTE: The day-of-month may be automatically changed / updated in some occasion. For example, if day-of-month is currently set to 31, and you change the month from March to February, the day-of-month will automatically change from 31 to 28 (or 29 on a leap year) to comply with the upmost value for day-of-month in February.

4) Day-of-month setting

NOTE: Given the difference in the date format between French and English, the sequence for setting the month and the day-of-month is reversed when the clock language is set to French.

While referring to the Clock setup diagram above, press the “Set” (top) button until you reach the “Day-of-month” setting step.

Current day-of-month will blink on the clock display. Press the “Up” (middle) button to increase the day-of-month value, or press the “Down” (bottom) button to decrease the day-of-month value.

NOTE: The day-of-month will not allow you to go higher than the upmost value for any given month. So, you may have to adjust the month before adjusting the day-of-month. For example, if you want to change the date from February 14th to March 31st, day-of-month will not allow you to go higher than 28 (or 29) as long as the month is set to February.

5) Year setting

While referring to the Clock setup diagram above, press the “Set” (top) button until you reach the “Year setting” step.

Current year (last two digits) will blink on the clock display. Press the “Up” (middle) button to increase the year value, or press the “Down” (bottom) button to decrease the year value.

NOTE: Even if only the last two digits of the year are blinking, the year will go from 2000 down to 1999 and / or from 2099 up to 2100 as you would expect if you decrease or increase year value. Also, since firmware Version 6.00, those first two digits are saved to flash memory. So, in case of power outage, when the power goes back On, the high part of the year (first two digits) will keep the value assigned. This will help if you plan to

install a Pico Green Clock in the next Electric De Lorean, either to go back in 1845 or to go forward in 2187 - smile.

6) Daylight Saving Time (DST)

NOTE: Daylight Saving Time (DST) / Normal Time are also called, in some countries: Summer Time / Winter Time or Spring Forward / Fall Back.

While referring to the Clock setup diagram above, press the "Set" (top) button until you reach the "Daylight saving time" setting step.

"ST" (for "Summer Time") will be displayed on the clock, along with a number representing current setting. The value can be changed by pressing either on the "Up" (middle) or "Down" (bottom) button.

Value "0" means that the clock completely ignores DST (it's like if DST does not exist).

Refer to Appendix L at the end of this guide to find the setting corresponding to your country. (You may want to write this setting here for future reference: _____).

A value other than zero means that the clock supports DST, following the specifications of the target country (see Appendix L).

Once configured, the clock will automatically determine if DST must be active or inactive, depending on current setting (country) and current date and time. It will also change the time automatically as described in Appendix L.

Some countries require that UTC (Coordinated Universal Time) be properly set for DST to be correctly handled (this is the case for European Union, in particular). So, make sure to setup UTC correctly (see next section).

NOTE: Be aware that current DST status is kept in Pico's flash memory. So, the clock expects DST to change from "Summer Time" to "Winter Time" and later on, to "Summer Time" (and so on). If you try to make some tests with the clock by changing the time manually and observe the clock behavior, you must go through the correct sequence. That means that if you try to go twice in a row through the change from "Summer Time" to "Winter Time", hour change will not occur the second time since the clock "knows" that it is already in "Winter Time". For your tests to work as expected, you must go through a change from "Winter Time" to "Summer Time" between your two changes "Summer Time" to "Winter Time".

NOTE: I would like to hear from users from Chile and New-Zealand to know if my understanding of DST setting is correct and if the clock properly handles DST in those countries.

7) UTC setting

While referring to the Clock setup diagram above, press the "Set" (top) button until you reach the "UTC setting" step.

"UT" (for "Universal Time") will be displayed on the clock, along with a number representing current setting. The value can be changed by pressing either on the "Up" (middle) or "Down" (bottom) button. It goes from 0 to 12 and then -12 down to 0

UTC stands for "Coordinated Universal Time". Detailed explanation of UTC is beyond the scope of this guide but those interested may easily find information on Wikipedia.

Basically, you must enter the difference between UTC and your local time. Again, for those not familiar with this, it can easily be found on the Internet.

Be aware of something important: UTC Time reference "does not change". So, for example, if you adjust UTC to be "-5" while you are in "Normal Time" ("Winter Time"), it means, for example that when it is 18h00 UTC, it is 13h00 at your local time. Your local time is "-5" hours from UTC Time (18h00 – 5). However, during Summer Time, when your local time has changed to add one hour, UTC will become "-4" (-4 hours), since one hour has been added to your local time while UTC time reference has not changed.

Once the user has setup the clock, this change in time difference with UTC will automatically be taken care of by the clock. However, if ever there is a need to set the clock, this concept must be understood.

NOTE: As mentioned above, UTC is required by the clock DST algorithm to properly handle automatic DST support for some countries. UTC will also be required when NTP ("Network Time Protocol") is implemented in the clock. NTP will allow the clock to automatically "read" the time by WiFi (wireless) over the Internet and synchronize itself to prevent a drift in time over long period of time.

8) Keyclick setting

While referring to the Clock setup diagram above, press the "Set" (top) button until you reach the "Keyclick setting" step.

"BP" (for "beep") will be displayed on the clock, along with the value "ON" or "OF" (for OFF) blinking. The value can be changed by pressing either on the "Up" (middle) or "Down" (bottom) button.

This setting controls the "keyclick sound" (beep) produced when the user presses a clock button. "On" allows the keyclick to be heard each time the user presses a button (to give a positive feedback) whereas Off makes no sound when a button is pressed.

9) Display scroll setting

While referring to the Clock setup diagram above, press the "Set" (top) button until you reach the "Display scroll setting" step.

"DS" (for "Display scroll") will be displayed on the clock, along with the value "ON" or "OF" (for OFF) blinking. The value can be changed by pressing either on the "Up" (middle) or "Down" (bottom) button.

This setting controls if the clock will scroll the date, temperature and power supply voltage on the display every 5 minutes. (The setting can be "On" or "Off". Changing the 5 minutes period is a compile-time option).

NOTE: Beginning with Version 4.00, the display will no longer scroll every xxx seconds as was the case with previous versions. Instead, the display will scroll every "integer number of times the scroll period" as defined in the source code. For example, when set to 5 minutes period, scrolling will occur at xh00, xh05, xh10, xh15, etc… this allows the user to know in how long the next scroll will occur. In previous versions, scroll would have occurred every 300 seconds (5 minutes X 60 seconds each). Depending the exact time when the clock has been powered up, this 300 seconds count would have not necessarily be at xh00, xh05, etc… The scrolling time is now more deterministic.

NOTE: Current scrolling cycle will be skipped if the clock is not in "Time Display" mode (for example, if user is setting up the clock - or an alarm, or a counter – when scrolling time is reached).

NOTE: Beginning with Version 5.00, scrolling will begin 5 seconds after hour change. So, for example, scrolling will begin at 4h00m05s instead of 4h00m00s like in previous versions. This way, when the hourly chime sounds (at 4h00m00s in our example), it gives five seconds to look at the clock display to see what is the time, before beginning to scroll the date and other information. This is true only at hour change. So, when time changes from 4h04m59s to 4h05m00s, scrolling will begin without delay (and obviously, there is no "hourly chime" at 4h05m00s).

10) Temperature unit

While referring to the Clock setup diagram above, press the "Set" (top) button until you reach the "Temperature unit setting" step.

NOTE: Starting with firmware version 4.00, temperature unit setting has been added to the main clock setup list of parameters.

"TU" (for "Temperature unit") will be displayed on the clock, along with current setting (C for Celsius or F for Fahrenheit) blinking. The setting can be toggled from one to the other by pressing either on the "Up" (middle) or "Down" (bottom) button. The unit blinking will change on the clock display, but also the temperature indicator on the left of the display to follow the selected setting, Celsius or Fahrenheit.

11) Language

While referring to the Clock setup diagram above, press the "Set" (top) button until you reach the "Language setting" step.

"LG" (for "Language") will be displayed on the clock, along with current setting. The setting can be changed by pressing either on the "Up" (middle) or "Down" (bottom) button.

Languages supported for now are:
"E" – for English
"F" – for French

Language setting is mostly useful when scrolling the date on the display where day-of-week and month are displayed in the selected language. But there are also other messages that change depending on language setting.

12) Hour display format setting

While referring to the Clock setup diagram above, press the "Set" (top) button until you reach the "Time display format setting" step.

"HD" (for "Hour display") will be displayed on the clock, along with the value "12" (for 12-hour format) or "24" (for 24-hour format) blinking. The value can be changed by pressing either on the "Up" (middle) or "Down" (bottom) button.

If 12-hour format is selected, indicator AM or PM will show-up on the clock to complete the time information.

13) Hourly chime setting

While referring to the Clock setup diagram above, press the "Set" (top) button until you reach the "Hourly chime setting" step.

"HC" (for "Hourly chime") will be displayed on the clock, along with current setting "ON", "OF" (for OFF) or "OI" (for ON, Intermittent) blinking. The value can be changed by pressing one or more times on the "Up" (middle) or "Down" (bottom) button.

Hourly chime is a sound made of a few beeps that will be produced each time the hour changes from xxh59 to xxh00. The On and Off configuration settings are self-explanatory, but the OI ("On, Intermittent") means that the sound will be heard only during daytime (so that people in the house can sleep without being disturbed by these sounds every hour during the night). The settings (On, Off, OI) are run-time options, along with starting and ending time (see next two settings).

There is an indicator on the clock display that will light up when hourly chime is ON. Behind this indicator, there are two LEDs that will turn on. When the option is set to "OI" (daytime), then only the left LED will turn on. It is not easy to make the difference between one LED On or two LEDs On and it may take some time for the user to see the difference between both settings from the indicator.

Firmware versions 3.00 and up add support for "nighttime workers". We assume that it is possible, in some cases, that we want the hourly chime to sound during the night but be silent during the day. So, if the Chime time On is later than the Chime time Off (which is opposed to what we would intuitively expect), we assume that we want the sound to be heard *after* the Chime time On and *before* the Chime time Off.

NOTE: The Hourly chime setting (On, Off, OI) also applies to the sounds generated during calendar events.

NOTE: It user has installed a passive buzzer, a jingle will also be heard (close encounter of the 3rd kind or another configured by user) after the usual hourly chime.

NOTE: If, in some occasion, your life cycle is "out-of-usual-life", see the "Silent period" ("CD" button) on the remote control for a way to easily adapt to the situation.

14) Chime time On

NOTE: Even if you selected “Hourly chime On” or “Hourly chime Off” in the setup section 13 above, you still have to go through the “Chime time On” and “Chime time Off” settings (even if they are useless if Hourly chime setting is not “OI”). This makes the setup procedure always the same, no matter what are the selected clock parameters.

While referring to the Clock setup diagram above, press the “Set” (top) button until you reach the “Chime time On setting” step.

“ON” (for “Chime time On”) will be displayed on the clock along with the current setting blinking. The value can be changed by pressing the “Up” (middle) button to increase it, or the “Down” (bottom) button to decrease it. The default value for chime time On is 9h00 in the morning.

The chime time On is the time at which the hourly chime will begin to sound during the day. See also the chime time Off in next section. Note that the sounds for the Calendar Events also comply with the chime time settings.

NOTE: The hourly chime setting must be set to “Daytime” (that is: “OI” for “On, Intermittent” on the clock display while in setup mode) for the Chime time On setting to take effect.

NOTE: The discussion in this section applies for a “normal” daytime setting. The behavior described must be adapted “mutatis mutandis” if the Chime time On is later than Chime time Off, what has been called “nighttime worker” setting.

15) Chime time Off

NOTE: Even if you selected “Hourly chime On” or “Hourly chime Off” in setup section 13 above, you still have to go through the “Chime time On” and “Chime time Off” settings (even if they are useless if Hourly chime setting is not “OI”). This makes the setup procedure always the same, no matter what are the selected clock parameters.

While referring to the Clock setup diagram above, press the “Set” (top) button until you reach the “Chime time Off setting” step.

“OF” (for “Chime time Off”) will be displayed on the clock along with the current setting blinking. The value can be changed by pressing the “Up” (middle) button to increase it, or the “Down” (bottom) button to decrease it. The default value for chime time Off is 21h00 (9h00 PM).

The chime time Off is the last time at which the hourly chime will sound during the day. See also the chime time On in previous section. Note that the sound for the calendar events also complies with the chime time settings.

So, for example, if you set the chime time On at 8h00 in the morning and the chime time Off at 23h00 (11h00 PM), the hourly chime will sound every day (each time the hour changes from xxh59 to xxh00) from 8h00 in the morning up to (and including) 23h00 (11h00 PM). The warning sounds associated with the Calendar Events will also comply with the same On and Off times. By default, the On and Off times are set to 9h00 in the morning up to (and including) 21h00 (9h00 PM) in the evening. (Obviously, this assumes that "Hourly chime setting" is set to ("OI" – On, Intermittent).

NOTE: The hourly chime setting must be set to "Daytime" (that is: "OI" for "On, Intermittent" on the clock display while in setup mode) for the Chime time Off setting to take effect.

NOTE: The discussion in this paragraph applies for a "normal" daytime setting. The behavior described must be adapted "mutatis mutandis" if the Chime time On is later than Chime time Off, what has been called "nighttime worker" setting.

16) Night light setting

While referring to the Clock setup diagram above, press the "Set" (top) button until you reach the "Night light setting" step.

"NL" (for "Night light") will be displayed on the clock, along with current setting blinking: "ON", "OF" (for OFF), "OI" (for ON, Intermittent) or "AU" (for "Auto"). The setting can be changed by pressing one or more times on the "Up" (middle) or "Down" (bottom) button.

The night light uses the two white LEDs located inside the clock, near the push buttons. You can watch them during the power up sequence of the clock since they will be turned On for a few seconds and also blink a few times to indicate that the clock is starting. Since those LEDs were not used, I thought it would be a good idea to use them as a night light, even if the light level is, in fact, very low. For sure, they will not replace your 800 lumens room light!

In some ways, the setting of the night light is similar to the setting of the hourly chime. The On and Off configurations are self-explanatory, and the OI ("On, Intermittent") means that the night light will be On only during the nighttime period specified. As opposed to the hourly chime settings, however, the night light allows the LEDs to be turned On only during the night. There is no provision to turn On LEDs during the day for "daytime workers" since I thought it would have not been logical to do so.

There is also another setting available for the night light: "AU" for "Auto". If set to automatic, the LEDs will turn On when the ambient light falls under a certain level and becomes dark enough. They will automatically turn back Off when ambient light level is

bright enough. There is a “twilight zone” between bright and dark during which the night light status does not change. This is to prevent continuous night light blinking between On and Off when we are in the light brightness area close to the toggle area.

The night light setting (ON, OF, OI, AU) are run-time options, along with starting and ending time (see next two settings).

NOTE: When “Auto-brightness” setting is enabled, keep in mind that the white LEDs will follow the clock display brightness. That is, if the clock LEDs matrix display is dimmed, the white LEDs will also be dimmed. This is the way the clock electronics work.

NOTE: Every few seconds, the firmware checks the status of the night light settings. So, if you change the clock time and night light setting is set to “OI”, the white LEDs will eventually comply with the night light settings in the next few seconds…

17) Night light time On

NOTE: Even if you selected “Night light On”, “Night light Off” or “Night light Auto” in the setup section 16 above, you still have to go through the “Night light time On” and “Night light time Off” settings (even if they are useless if Night light setting is not “OI”). This makes the setup procedure always the same, no matter what are the selected clock parameters.

While referring to the Clock setup diagram above, press the “Set” (top) button until you reach the “Night light time On” setting step.

“ON” (for “Night light time On”) will be displayed on the clock along with the current setting blinking. The value can be changed by pressing the “Up” (middle) button to increase it, or the “Down” (bottom) button to decrease it. The default value for Night light time On is 21h00 in the evening.

The Night light time On is the time at which the Night light will turn On in the evening. See also the Night light time Off in next section.

NOTE: The Night light setting must be set to “Nighttime” (that is: “OI” for “On, Intermittent” on the clock display while in setup mode) for the Night light time On setting to take effect.

NOTE: The night lights may also be used as a discrete and silent warning in cases where an alarm is overkill. By setting the “Night light setting” to “OI” and adjusting the “Night light time On” to a specific time, you may then simply take a look at the night lights to see if you reached (or passed) the “target time”.

NOTE: The two white LEDs are subject to the "Auto brightness" setting and will follow the clock display brightness. That is, if the main clock display is dimmed, the two white LEDs will be dimmed too. This is the way the clock electronics work.

18) Night light time Off

NOTE: Even if you selected "Night light On", "Night light Off" or "Night light Auto" in the setup section 16 above, you still have to go through the "Night light time On" and "Night light time Off" settings (even if they are useless if Night light setting is not "OI"). This makes the setup procedure always the same, no matter what are the selected clock parameters.

While referring to the Clock setup diagram above, press the "Set" (top) button until you reach the "Night light time Off" setting step.

"OF" (for "Night light time Off") will be displayed on the clock along with the current setting blinking. The value can be changed by pressing the "Up" (middle) button to increase it, or the "Down" (bottom) button to decrease it. The default value for Night light time Off is 8h00 in the morning.

The Night light time Off is the time at which the white LEDs will turn Off in the morning. See also the Night light time On in the previous section above.

So, for example, if you set the Night light time On at 23h00 in the evening and the Night light time Off at 6h00 in the morning, the Night light will turn On every night at 23h00 and will turn Off every morning at 6h00.

By default, the On and Off times are set to 21h00 in the evening and 8h00 in the morning. (Obviously, this assumes that "Night light setting" is set to ("OI" – On, Intermittent).

NOTE: The Night light setting must be set to "Nighttime" (that is: "OI" for "On, Intermittent" on the clock display while in setup mode) for the Night light time Off setting to take effect.

NOTE: The two white LEDs are subject to the "Auto brightness" setting and will follow the clock display brightness. That is, if the main clock display is dimmed, the two white LEDs will be dimmed too. This is the way the clock electronics work.

19) Auto brightness setting

While referring to the Clock setup diagram above, press the “Set” (top) button until you reach the “Auto brightness setting” step.

“DIM” will be displayed on the clock. As opposed to most other settings that we went through so far, there is no “visible setting” blinking beside “DIM” on the clock display. Instead, user must take a look at the auto-light indicator at the bottom left of the clock.

The setting can be changed by pressing on the “Up” (middle) or “Down” (bottom) button. If the “Auto light” indicator is On, it means that the clock display brightness will change automatically. It will be bright if the ambient light level is high and it will be dimmed if the ambient light level is low.

In firmware version 5.00, the algorithm behind the auto brightness function has been changed to add an hysteresis. The clock LEDs matrix brightness will now change more slowly than what it used to do before. I didn’t like the display that was often changing intensity while some object was passing quickly in front of the clock or for a similar reason. Brightness change has now a greater latency, so don’t be surprised when you turn Off the room light in the night. It will take many seconds (up to one minute) for the clock display to slowly dim, down to its stabilized level (and the same applies if you turn On the light in a previously dark room).

NOTE: As explained, when set to “Auto brightness”, the clock display will be more or less bright depending of the ambient light intensity. It is interesting to know that when switching to “manual” (as opposed to auto-brightness), the clock display will remain in the current intensity. So, if you want the display to remain very bright in manual mode, either change the value from automatic to manual during the day, when the ambient light is very high (or alternatively, use a flashlight to beam the light sensor, just above the USB connector on the right side of the clock) and then change the setting from automatic to manual when the display has reached a bright status. In a similar way, if you want the display to remain very dim in manual mode, either change the value from automatic to manual during the night, when the ambient light is very low (or alternatively, use your hand to cover the light sensor, just above the USB connector on the right side of the clock) and then change the setting from automatic to manual when the display has reached a dim status.

NOTE: The two white LEDs (“night light”) follow the same rule as the clock display. So, if auto brightness is enabled, the two white LEDs will also be dimmed if ambient light level is low.

Alarm setup

About alarm setup

NOTE: The way alarms are handled with firmware version 6.00 is different than with previous firmware versions. User should read carefully this section to understand all changes that have been made.

New with firmware 6.00, there are now 9 independent alarms available in the Pico Green Clock. This has been made possible since the clock can now save all alarm parameters to Pico's flash memory. The alarms will not sound during a power failure, but they will be restored unchanged when the power goes back On (including their status "On" or "Off").

Also, alarms can now be configured for any number of days-of-week. For example, you can have one alarm for Monday to Friday, and a different one (different wake-up time) for the week-end, Saturday and Sunday, etc.

When the alarm time is reached, the alarm will sound during a one hour period, or until user presses the "Set" (top) button, whichever happens first. When pressing the "Set" button, the alarm will be silent, but will remain "On", until the next time alarm parameters are reached, in which case it will sound again. The alarm will sound "beeps" every five (5) seconds. The number of "beeps" corresponds to the alarm number which has been triggered. If more than one alarm has been triggered, two (or more) "trains of beeps" will be heard, one for each alarm number (and with a different number of beeps, corresponding to each alarm number).

Moreover, if user installed a passive buzzer, the pitch of every alarm will be different. That is, an alarm with an higher number will have a higher pitch (higher sound frequency).

Since there are now 9 alarms available, it is no more possible to turn On the left and / or right LED of the alarm indicator to show if a specific alarm is On or Off as was possible before, when only two (2) alarms were available. Instead, when at least one alarm is On, the alarm indicator is turned On. User must check alarm settings to determine which alarms are On and which alarms are Off.

Given the limited amount of buttons available on the clock and the limited width of the display (number of characters), some tricks have been done for alarm settings. User must follow the instructions below, some of them not being as intuitive as for other clock settings.

HINT: Since the number of "beep" corresponds to the alarm number, if it is usually difficult for you to wake up, it may be a good idea to use a "high" alarm number (alarm number 7 or 9, for example). When alarm time is reached, 7 or 9 beeps (depending on

alarm number) will ring instead of 1 (for alarm number 1, for example). On the other hand, if you wake up easily, you may prefer to use an alarm with a low number since it is less aggressive.

HINT: If you installed a passive buzzer in your Green Clock, you will realize that the alarm pitch (sound frequency) is lower for alarms with a small number and higher for alarms with a high number. This is something you may want to explore, along with the number of "beep" (see previous paragraph) to find the optimal alarm for your tastes (and needs).

HINT: Another hint for those who find it difficult to get out of the bed… You may want to program two or more alarms at the same time (with 9 alarms available, this is something now possible!). This way, more beeps will sound every second and this may be helpful. Also, since a press on the "Set" (top) button shut off all alarms simultaneously, it is not a problem. Another alternative is to program a second alarm one minute later than the first one and a third alarm two minutes later. If ever the first alarm didn't wake you up, chances are the second will (or the third). The downside of this hint is that if you wake up with the first alarm, you will have to come back one minute later to shut off the second alarm by pressing again the "Set" button when the second alarm begins beeping.

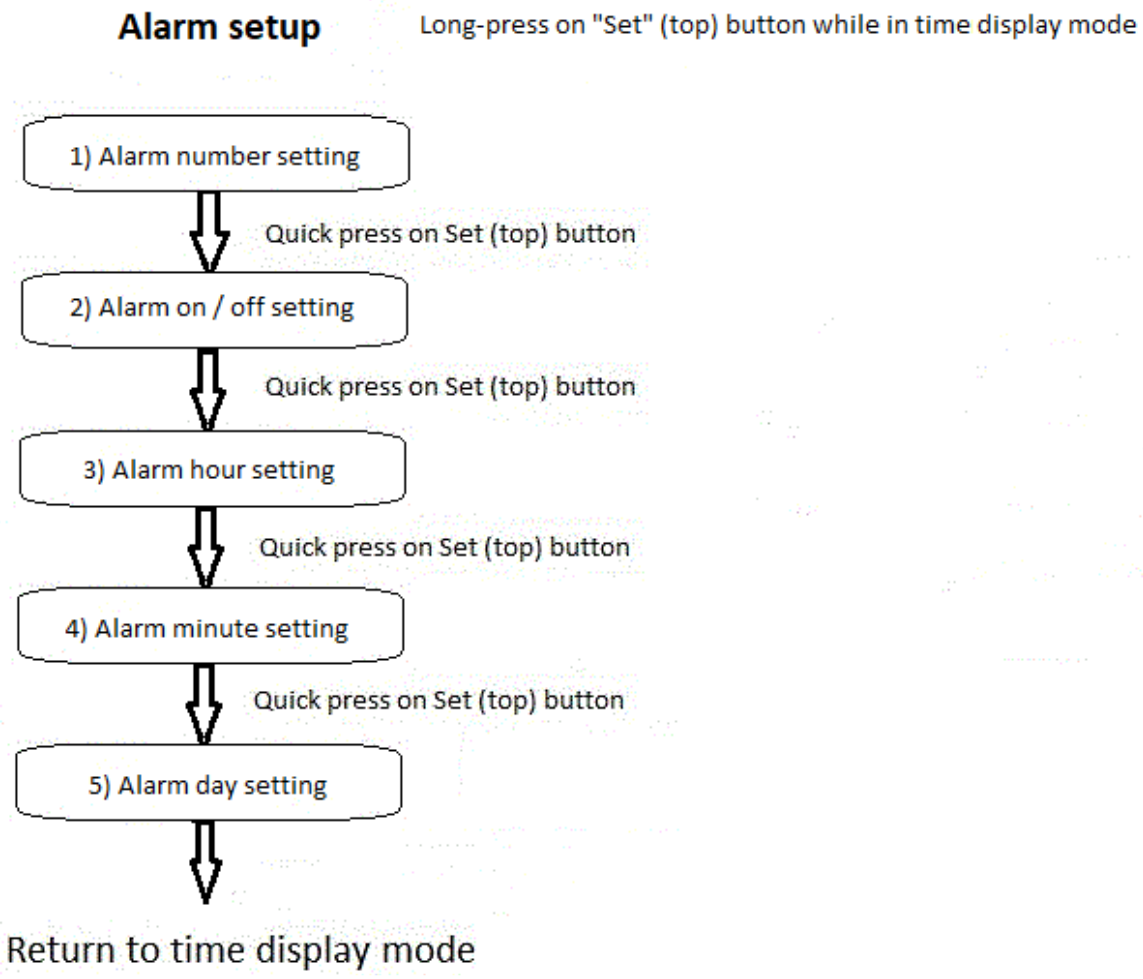
HINT: When an alarm is triggered, a text will scroll on clock display indicating "Alarm X" (where "X" represents the alarm number being triggered). You may personalize the text by changing it in the source code before re-building the firmware. Make a search for the string "(customize)" – without the quotes – to easily find the area in the code to make the change. This is a compile-time feature and can't be done at run time.

NOTE: Alarm beeps use a circular buffer ("sound queue") to keep track of the sounds to ring and let the clock performs its other duties. As mentioned, an alarm will repeat its "beeps" every five (5) seconds. However, if many alarms are triggered at the same time, it may happen that there are so many beeps to sound that it takes more than 5 seconds to beep them all. If ever the case, many beeps may be pending in the circular buffer and it may take some time for the alarm to stop beeping when user presses the "Set" (top) button (the buffer will have to empty first). Since this is a situation that is unlikely to happen in usual life, I didn't spend much time trying to find a solution (other than making the beeps shorter depending on how many alarms are simultaneously On). Keep that in mind if ever you want to test it.

NOTE: If more than one alarm is triggered, as indicated above, number of beeps will indicate which alarm is ringing, and there could be more than one. However, when user presses the Set ("top") button to make the alarm silent, all alarms currently active (beeping) will be silent simultaneously. There is no provision to shutoff only one of the alarms currently beeping.

NOTE: Alarm sound does not comply with Hourly chime settings. That is, alarm will sound no matter what is the setting for Hourly chime.

NOTE: If "NO_SOUND" is defined in the source code at compile time, ***absolutely no sound will be heard from the clock*** (no keyclick, no hourly chime, no alarm, no timer alarm, …). The message "WARNING: SOUND CUT OFF" will scroll on the clock display during the power up sequence. Make sure you didn't disable this message with an eventual change to the QUICK_START option.



Refer to the paragraph – in the following section - with the number indicated in the box above to get more details about each step of the alarm setup.

Entering alarm setup mode

To enter the alarm setup mode, make a long press (longer than one third of a second) on the "Set" (top) button while the clock is in the usual "Time display" mode.

Then, each time you press the "Set" (top) button, you go through the different alarm settings, as illustrated on the diagram above.

To exit alarm setup mode, you can:

- Wait for a timeout (20 seconds without pressing a button on the clock).
- Press the "Set" (top) button to go through all alarm settings and then one more time when reaching the last setup step to return to the time display mode.
- Make a "long press" (longer that one third of a second) on the "Down" (bottom) button to exit alarm setup mode at any time.

NOTE: The last method does not apply when alarm is in "day-of-week" setting step (see text below in paragraph 5).

When an alarm number is selected, current alarm values (On or Off, Hour and Minute) will be presented to user as starting parameters.

Alarm setup timeout

As indicated in the previous section, if you leave the clock unattended for more than 20 seconds (compile-time option), it will return to the normal time display mode.

1) Alarm number setting

While referring to the Alarm setup diagram above, press the "Set" (top) button until you reach the "Alarm number setting" step.

Press the "Up" (middle) button to increase alarm number or the "Down" (bottom) button to decrease alarm number. As previously indicated in the user guide, there are now nine (9) independent alarms available in the Waveshare's Green Clock).

The proposed choice will blink on the display until user presses the "Set" (top) button to select the choice displayed and to proceed with next step.

NOTE: For those who want to work on the source code, alarms are numbered 1 to 9 for the clock user, to be more "human-like". However, when working on the firmware source code, alarms are numbered 0 to 8.

2) Alarm On / Off setting

While referring to the Alarm setup diagram above, press the "Set" (top) button until you reach the "Alarm On / Off setting" step for the alarm number you want to configure.

Once the alarm number has been selected in the previous step, press the "Up" (middle) button or the "Down" (bottom) button to turn On or Off the selected alarm.

The proposed choice (On or Off) will blink on the display until user presses the "Set" (top) button to select the choice displayed and to proceed with next step.

NOTE: Since firmware Version 6.00, there are now 9 alarms available. So, it is no more possible to turn On the left and / or right LED of the alarm indicator on the clock to show which alarm is On or Off. Instead, when at least one alarm is On, the alarm indicator is turned On. User must check alarm settings to determine which alarms are On or Off.

3) Alarm hour setting

While referring to the Alarm setup diagram above, press the "Set" (top) button until you reach the "Alarm hour setting" step.

The current hour value for the selected alarm will be displayed and blinks. While current alarm hour blinks on the display, press the "Up" (middle) button to increase the proposed hour, or the "Down" (bottom) button to decrease it. The display will comply with current "Time format setting" to display the alarm in 12-hours or 24-hours display mode.

4) Alarm minute setting

While referring to the Alarm setup diagram above, press the "Set" (top) button until you reach the "Alarm minute setting" step.

The current minute value for the selected alarm will be displayed and blinks. While current alarm minute blinks on the display, press the "Up" (middle) button to increase the proposed minute, or the "Down" (bottom) button to decrease it.

NOTE: Even if it is not configurable by user, there is a "second" parameter in the source code. This value has been set to 29 seconds to be outside of the peak periods (00, 14, or 44 seconds). Even if the idle monitor seems to indicate that the load on the Pico is not that heavy, I decided to take a value relatively free of load. Trial and error will show if seconds can be initialized as "0". This also means that the clock display will change the minute and it will take 29 more seconds before the alarm begins to sound. Don't be surprised if minute changes on clock display and the alarm does not sound immediately.

5) Alarm days setting

This is the tricky part…

While referring to the Alarm setup diagram above, press the "Set" (top) button until you reach the "Alarm days setting" step.

The day-of-week indicators may be in any of three different statuses:

- Those day-of-week indicators that are turned "On" indicate that those days are selected ("active") for this alarm number.
- Those day-of-week indicators that are turned "Off" indicate that those days are not selected (they are "inactive") for this alarm number.
- The one day-of-week indicator that is blinking is the current "target day-of-week" for which we may decide if we want to turn it On (make it active and add it to the days selected) or turn it Off (make it inactive and remove it from the days selected).

IMPORTANT: *At this point in time, there is no way to know if the blinking day-of-week is selected or not for the current alarm.* We only know that it is a "proposed" (is a "target") day-of-week since it is blinking..

User has now the following choices:

1) Make a quick press on the "Up" (middle) button to move the target to the next day-of-week. While doing so, user can see if the day-of-week that was blinking before is selected for this alarm number (that is, if it is now On or Off). By pressing the "Up" button, the target day-of-week now blinking has changed for the next day-of-week in sequence. However, if user observed carefully, he knows if the new target day-of-week was previously On or Off (before pressing the "Up" button.

2) Make a quick press on the "Down" (bottom) button to move the target to the previous day-of week. While doing so, user can see if the day-of-week that was blinking before is selected for this alarm number (that is, if it is now On or Off). By pressing the "Down" button, the target day-of-week now blinking has changed

for the previous day-of-week in sequence. However, if user observed carefully, he knows if the new target day-of-week was previously On or Off (before pressing the “Down” button.

3) Make a long press on the “Up” (middle) button to add the target (currently blinking) day-of-week to the current alarm configuration (no matter if it is already active or not). The day-of-week will continue to blink until you change the target day-of-week. There is no way now to confirm if this day-of-week has been added or not. Make a quick press on the “Up” (middle) or the “Down” (bottom) button to change the “target” day number to confirm that the previously blinking day-of-week has been added as expected (it should now be turned On).

4) Make a long press on the “Down” (bottom) button to remove the target (currently blinking) day-of-week from the current alarm configuration (no matter if it is already inactive or not). The day-of-week will continue to blink until you change the target day-of-week. There is no way now to confirm if this day-of-week has been removed or not. Make a quick press on the “Up” (middle) or the “Down” (bottom) button to change the “target” day number to confirm that the previously blinking day-of-week has been removed as expected (it should now be turned Off).

The most straightforward way to proceed is to select option 3 or 4 above (depending if we want the blinking day-of-week to be included in the alarm setting or not), and then to select option 1 or 2 to confirm that everything is compliant to what we want.

As mentioned previously in this section (and as you can realize), a long press on the “Down” (bottom) button can’t be used to exit from alarm setup mode while setting up days-of-week. When your selection of days-of-week is done, make a quick press on the “Set” (top) button to exit from alarm setup mode and return to the time display mode. If one or more alarm status has been turned On, the alarm indicator on the clock display will be turned On.

Alarm configuration will be saved to flash at the next minute change after leaving the alarm setup mode.

Timer setup

About timer setup

The Pico Green Clock features a timer that can be set either as a “count-up” timer, or as a “count-down” timer. When used for count-down, user enters a start time (in minutes and seconds) and the timer begins the count-down, toward zero. When counter reaches zero, it beeps a ‘Timer alarm”.

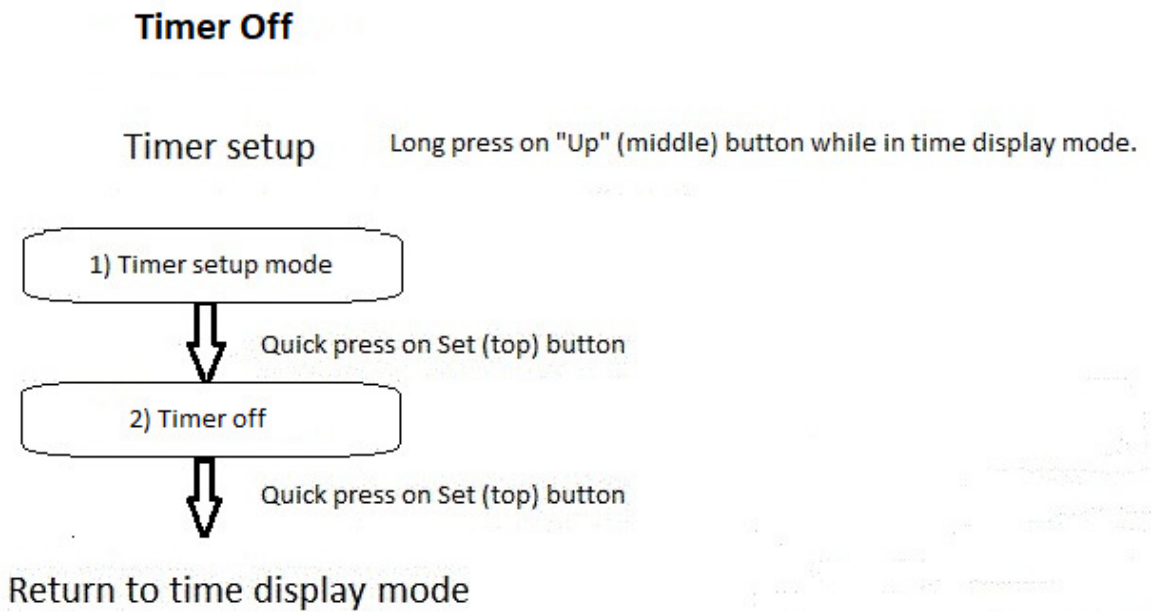
When used for “count-up”, it is different since we logically expect a count-up timer to start from zero. So, when started, the count-up timer begins counting up from zero until it is stopped by the user. There is no alarm sound associated with the count-up timer.

To enter the timer setup mode, make a “long press” on the “Up” (middle) button. A long press means to hold the button for more than one third of a second.

As you can do for Clock setup and Alarm setup, you can make a “long press” (longer that one third of a second) on the “Down” (bottom) button to exit timer setup mode at any time.

NOTE: When used as a “count-down timer”, it will not start if the “Minute” is set, then the “Second” but if the “Set” (Top) button is not pressed to start the timer before the time-out period.

Timer OFF



Refer to the paragraph – in the following section - with the number indicated in the box above to get more details about each step of the timer off setup.

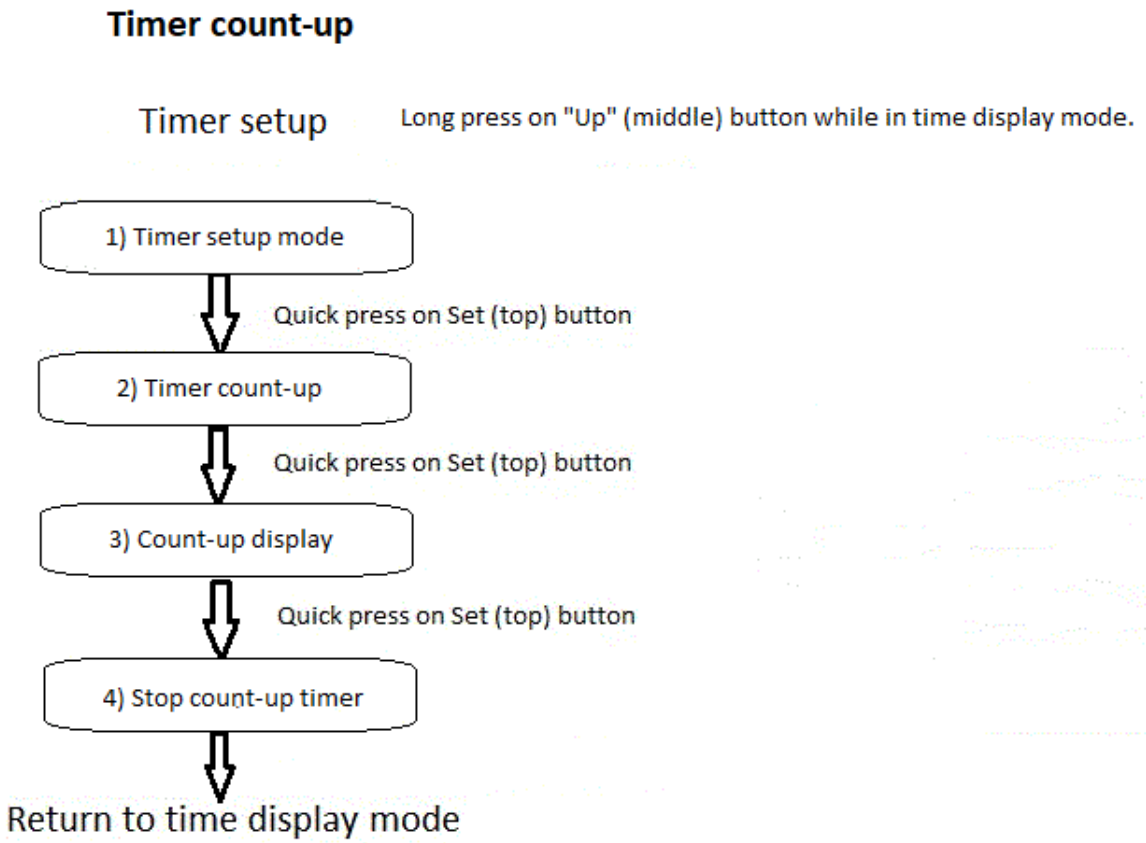
1) To turn off the timer, refer to the diagram above for “Timer off” and proceed as follow. First, make a long press on the “Up” (middle) button (longer than one third of a second) to enter the timer setup mode.

   Then, using the “Up” (middle) or “Down” (bottom) button, press until “OF” (for “Off”) blinks on the clock display and press on the Set (top) bottom to select this choice. Choices are “OF” (for Off), “DN” (for count-down timer), or “UP” (for count-up timer).

2) When pressing the “Set” (top) button, “OF” will stop blinking on the display to show that you made that selection.

   Press on the “Set” (top) button once again to return to time display mode when the timer has been turned Off (or wait for a time-out).

Timer Count-up



Refer to the paragraph – in the following section - with the number indicated in the box above to get more details about each step of the timer count-up setup.

1) To start the timer in “count-up” mode, refer to the diagram above for “Timer count-up” and proceed as follow. First, make a long press on the “Up” (middle) button (longer than one third of a second) to enter the timer setup mode.

   Then, using the “Up” (middle) or “Down” (bottom) button, press until “UP” (for count-up timer) blinks on the clock display and press on the “Set” (top) bottom to select this choice. Choices are “OF” (for Off), “DN” (for count-down timer), or “UP” (for count-up timer). The corresponding indicator on the clock display will follow the proposed choice (Off / Count-up / Count-down).

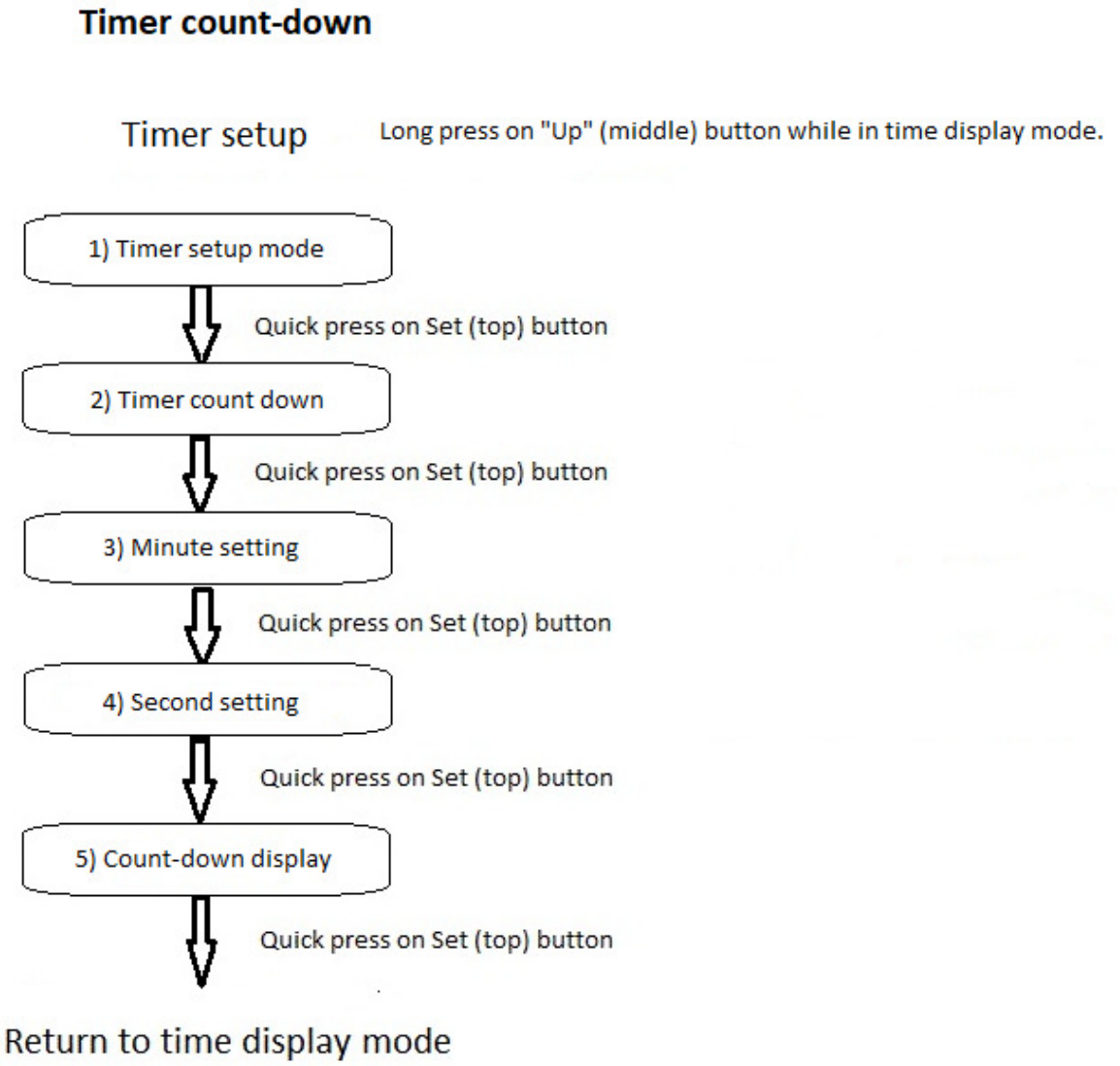
2) When pressing the “Set” (top) button, “UP” will stop blinking on the display to show that you made that selection.

3) Press on the “Set” (top) button once again to see the count-up timer starting to count the time from 00m00s.

4) The count-up timer will count until the user presses on the “Set” (top) button to stop it. Take note that the clock will remain in the Timer Up display mode until it is stopped by user.

5) When the count-up timer has been stopped, user may press on the “Set” (top) button again to return to the time display mode, or wait for a time-out to return to the time display mode.

Timer Count-down



Refer to the paragraph – in the following section - with the number indicated in the box above to get more details about each step of the timer count-down setup.

1) To start the timer in “count-down” mode, refer to the diagram above for “Timer count-down” and proceed as follow. First, make a long press on the “Up” (middle) button to enter the timer setup mode.

   Then, using the “Up” (middle) or “Down” (bottom) button, press until “DN” (for count-down timer) blinks on the clock display and press on the “Set” (top) bottom to select this choice. Choices are “OF” (for Off), “DN” (for count-down timer), or

"UP" (for count-up timer). The corresponding indicator on the clock display will follow the proposed choice (Off / Count-up / Count-down).

2) When pressing the "Set" (top) button, "DN" will stop blinking on the display to show that you made that selection.

   Press on the "Set" (top) button once again and the clock will display the count-down starting value with minutes blinking.

3) Press on the "Up" (middle) or "Down" (bottom) button to adjust the minutes of the count-down timer. Press the "Set" (top) button when done and the minutes will stop blinking as the seconds begin to blink.

4) Press on the "Up" (middle) or "Down" (bottom) button to adjust the seconds of the count-down timer. Press the "Set" (top) button when done and the count-down timer will start the count-down until it reaches zero minute and zero second.

5) At this point (that is, after adjusting the minutes and the seconds), you can leave the clock like this to see the count-down actual value at any time. When reaching zero, the "timer alarm" sound will be heard to warn you that the count-down value is over and the clock will automatically return to time display mode.

   Alternately, you can press the "Set" (top) button to return to the time-display mode while the count-down timer continues its work in the background. The count-down timer will proceed to count until zero (as can be seen by the indicator "count-down" light-up on the display). Even if you are in the "time display" mode, an alarm will be heard when the count reaches zero. The "count-down" indicator on the clock display will turn Off when the count-down is over. You can come back to the timer mode at any time to see the actual count of the count-down timer.

   It must be noted that the chime time On and the chime time Off have no impact on the count-down timer alarm. The alarm will sound even if we are currently outside of the hourly chime defined hours.

Other settings

Quick access to outside temperature

As mentioned in the clock setup procedure described previously, beginning with firmware version 4.00, the “Temperature unit” setting (toggling between Celsius and Fahrenheit) has been migrated from the “Up” (middle) button to the main list of clock setup parameters.

So, the “Up” (middle) button behavior has been used for other purposes. When pressing this button now, if an outside temperature sensor (BME280) has been installed, the outside temperature will scroll on clock display when pressing the “Up” (middle) button.

NOTE: The night light will also toggle (On or Off), for a few seconds, depending on its current setting.

Auto brightness

As mentioned in the clock setup procedure described previously, beginning with firmware version 4.00, the “Auto brightness” setting (toggling between steady brightness and auto brightness has been migrated from the “Down” (bottom) button to the main list of clock setup parameters. However, for a handy quick access, this function has been kept (replicated) on the “Down” (bottom) button. So, you can quickly toggle the setting this way too.

Appendix A – Access to BOOTSEL button

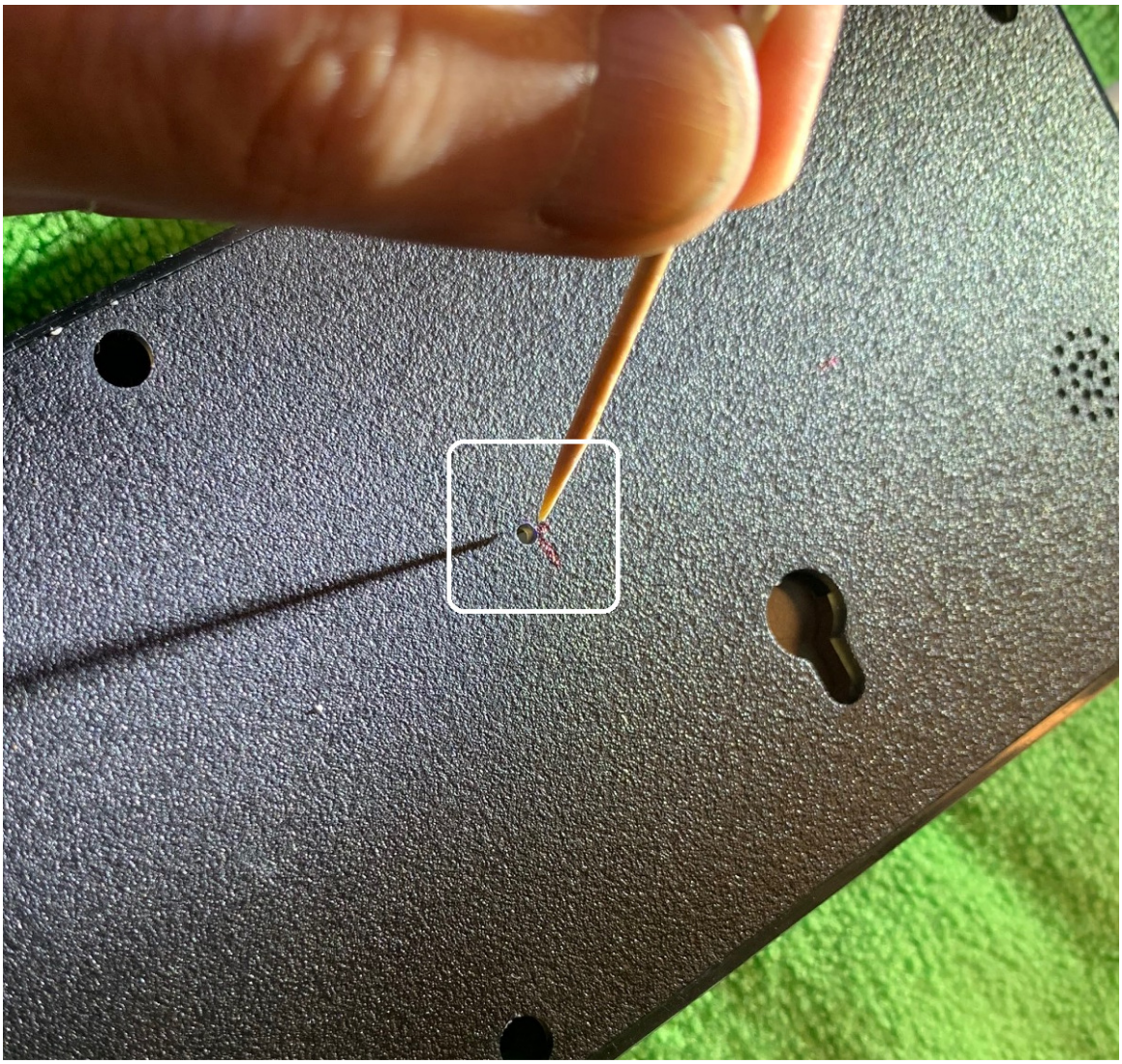
I followed David Ruck suggestion (David is also active on GitHub) and managed an access to the BOOTSEL button on the Pico. This allows re-flashing the Pico without having to open the clock case every time.

See pictures below as a guide. Take note that these pictures show the back cover on top of the clock case. If you take the back cover alone (without the clock case), you have to remove one mm from the values shown (you can see the case border – 1 mm – around the back cover)..

Access to BOOTSEL button – showing narrow side 35 mm from bottom (or 36 mm with case border).

Access to BOOSEL button – showing wide side 82.5 mm from left (or 83.5 mm with case border).

As illustrated on the pictures, I suggest that you use a wooden toothpick to press the BOOTSEL button to prevent possible damage to internal parts that could occur if you use a metal device.



Access to the BOOTSEL Pico button is possible through the hole.

Appendix B – Prepare cabling for external devices

As mentioned earlier in the guide, so far I installed / added four external devices to the Pico Green Clock:

1) An external temperature, humidity and barometric pressure sensor (BME280).
2) An ambient temperature and humidity sensor (DHT22).
3) An infra-red receiver to support commands sent from a remote control.
4) A passive buzzer / piezo allowing changing the sound frequency.

To install these external devices, we first need to make a hole on the side of the clock plastic case so that we can extend a cable outside of the case to connect the devices.

See the picture below. However, you may want to make the hole farther from the bolt stud so that it does not interfere.

Hole in the plastic case for external device cabling.

When the hole has been done, you can reinstall the clock pc board and prepare the cable. It is a good idea to choose a cable with a conductor size that can fit in the extra header connections, beside the Pico. You need to put some solder on the cable tips so that they can be easily inserted in the header slots.

I added a tie wrap on the cable (inside the clock case) to prevent it to be pulled outside of the case. Depending on the number of devices you want to add, the number of conductors may vary. I put an 8-wire cable since I already needed those eight, as shown in the table below.

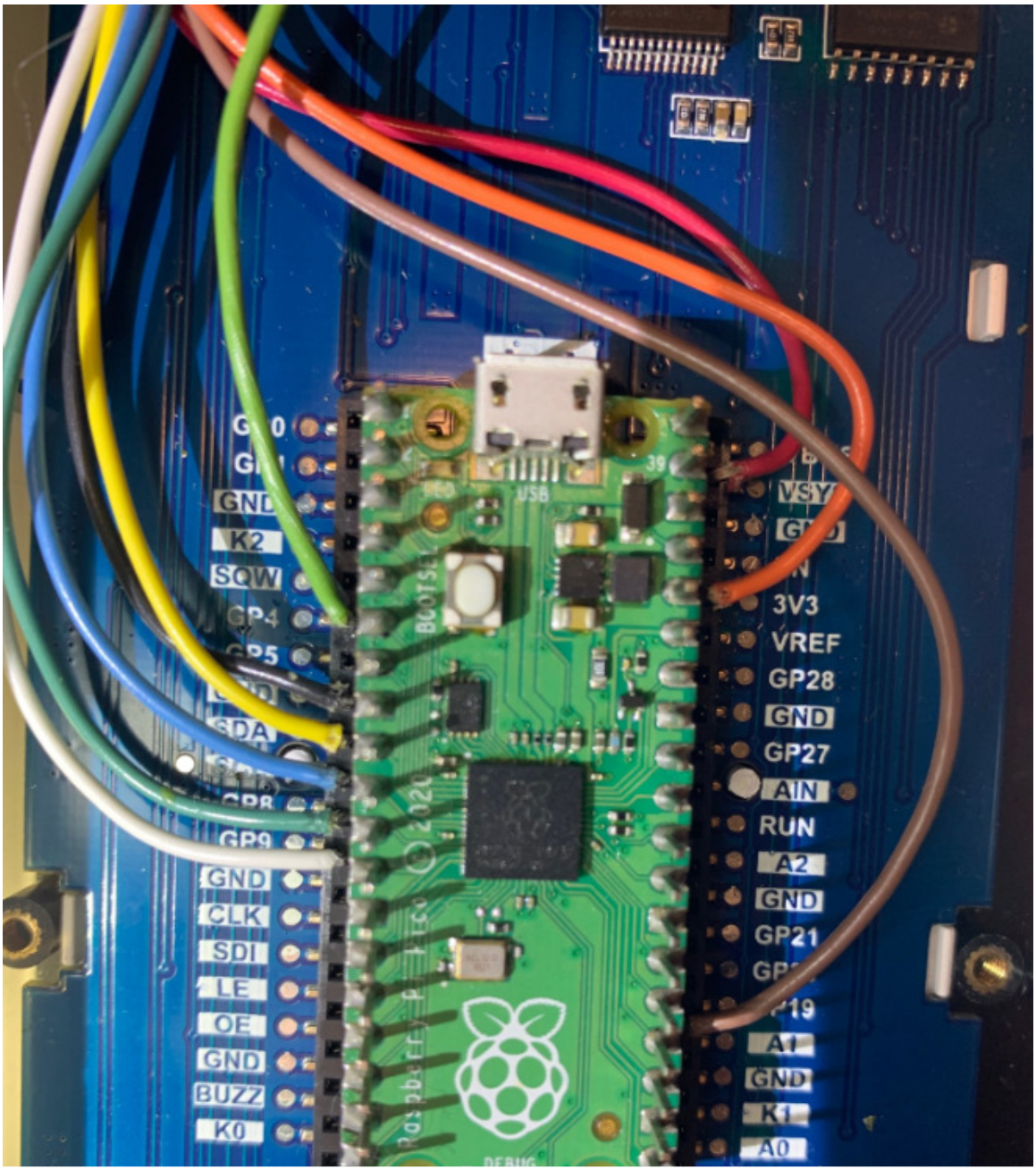
The cabling goes like this:

Pico Connection	Pico Pin number	Cable Color	Usage
Ground	8	Black	Ground for infrared receiver; passive buzzer, BME280, DHT22.
VSys + 5 volts	39	Red	Passive piezo through a 2N2222 transistor.
+3.3 volts	36	Orange	BME280, DHT22, Infrared receiver.
GPIO6	9	Yellow	I2C SDA (data line) to BME280.
GPIO7	10	Blue	I2C SCL (clock line) to BME280.
GPIO8	11	Green	DHT22
GPIO9	12	White	Infrared receiver signal (VS1838b).
GPIO19	25	Brown	Passive buzzer signal.

Note: As you can see, there are 8 cables shown in the table.

Note: GPIO4 (Pico's pin 6) was used in the previous firmware versions as a UART output to display debug information on an external monitor. A simpler connection is now used, USB-to-USB where the USB port of the Pico is directly connected to a PC's USB port (configured as a CDC USB serial). Refer to the specific section in this user guide for instructions on how to do it.

NOTE: Since the Pico power comes from the pins under the microcontroller in the Pico Green Clock (and not from the USB connector), VBus does not provide 5Vcc. VSys needs to be used for an external 5 Vcc source.



8-wire cable connected to the Pico double header
NOTE: The green cable connected to pin 6 of the Pico (GPIO4) is not used any more.

Appendix C – Adding a DHT22 sensor

Special note about DHT22

In the early firmware versions, a DHT22 device ("outside temperature and humidity sensor") was supported by the firmware and described in this user guide. When I developed the firmware, the DHT22 worked flawlessly when it was connected to the Green Clock with a 20cm cable. However, when this cable was replaced by another one, 3 meters long, I got from 75% to 80% errors in the communication between the Clock and the DHT22. Needless to say that such a rate is simply unusable. I tried to find related documentation on the Internet, but found nothing really useful, if not the fact that I was not the first to get similar problems. I tried the external pull-up resistor without success.

I then tried to improve the supporting code by changing the "polling" algorithm to an interrupt-driven routine… without success. I was not sure at this point if the DHT22 had a very poor timing, if the signal was degraded too much in the cable, or if the Pico was too busy with the callback functions to properly handle the DHT22…

While working on firmware Version 7.00, I moved the DHT22 support code from Pico's core 0 to Pico's core 1 and used the polling algorithm. There has been a significant improvement in the communication (less than 1% errors) although the cable used was relatively short (more or less 30 cm). I would believe that all callbacks and other interrupts on the microcontroller were causing problems with communication timings. I'm not sure at this point if a longer cable would have a significant impact and I'm particularly curious to hear from users that may try using a DHT22 for external temperature reading with a 3 to 5 meters cable…

(For info: I installed a BME280 as an outside temperature, relative humidity and barometric pressure sensor. This new device works flawlessly and after a few thousands reading cycles, I got 0 read errors.)

Pico Green Clock User Guide

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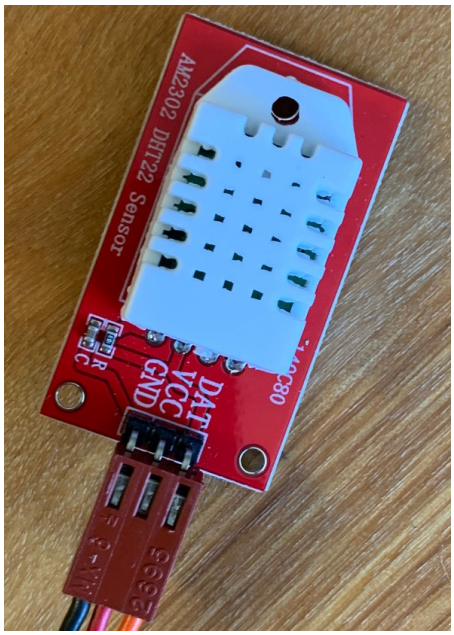
Text added in the Version 3.00 of the manual:

Starting with firmware version 3.00, support has been added for a DHT22 temperature and humidity sensor. Note that this sensor is not part of the Pico Green Clock and must be bought by user (more or less 10 US dollars).



The conditional compile option "DHT_SUPPORT" must be defined in the source code to be integrated into the firmware executable. In fact, if you plan to install a DHT22 in a near future, the conditional compile may already include the code. I built my own code to support the DHT22 and a few timeout's have been used, so that the Pico Clock will continue working without problem even if a DHT22 device is not actually connected. Since the delay of the timeout's represents more or less 20 milliseconds, and moreover, this delay occurs while the clock is scrolling the date, there is no impact for the user. (Just make sure that the cabling – if there is a cable already installed - is isolated from any outside static and / or electrical source).

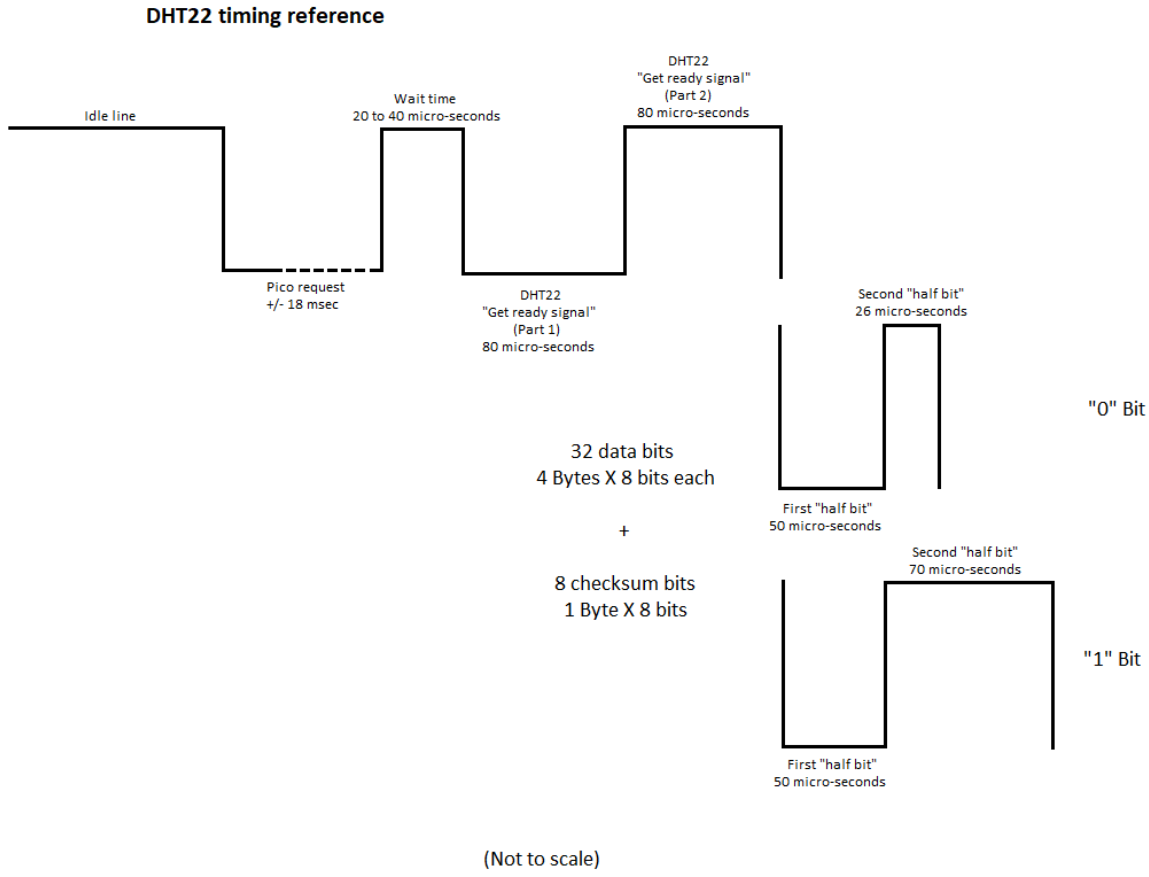
DHT22 specifications may be easily found on the Internet. (A timing reference is given below). The timing is similar to the DHT11. However, even if the DHT22 is slightly more expensive, its temperature range is wider and its precision is better.

A three conductor cable is required for 3.3 volts, Ground, and data (I configured the DHT22 on GPIO 8).

When the conditional compile option is turned On in the code, the temperature and humidity will be scrolled on clock display every five minutes (5 minutes is a compile-time parameter), along with the date and other information. Take note that if there is an error in the DHT22 communication, temperature will simply not be part of the data scrolled (a "bad temperature" will not be shown on the clock display).

You must turn On the conditional compile "DHT_SUPPORT" in the source code for the DHT22 to be recognized by the firmware. Also, if the device is enabled in the code and you don't have a DHT22 installed, the Green Clock will work normally without problem. The only impact will be errors reported in parenthesis during date scrolling. Read error from DHT22 are reported in parenthesis during date scrolling without any other indication (for example if you see (3/153) in the scrolled text, it means that there has been 3 errors on a total of 153 read cycles from the DHT22. Obviously, if no DHT22 is installed, the number of errors and the total number of read cycles will be the same. This

information may be useful if you have communication interference (from a close motor or something else), since you can get an idea of the relative impact of this interference.



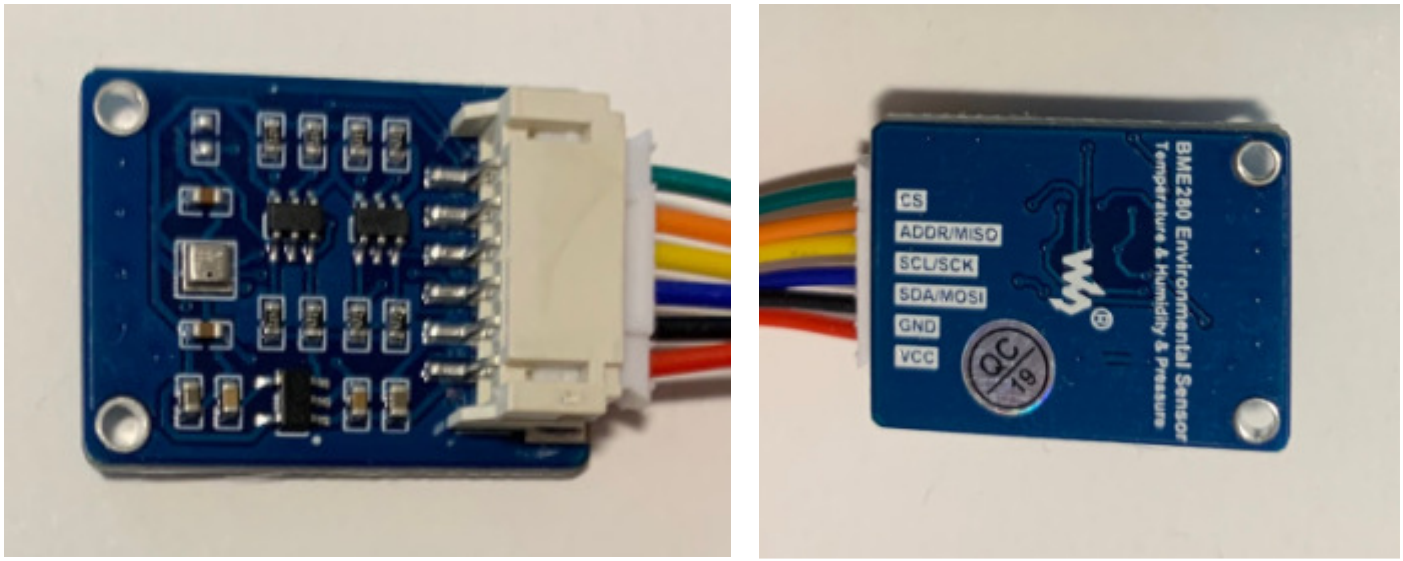
Appendix D – Adding a BME280 sensor

Introduction

A BME280 sensor can read the temperature, relative humidity and barometric pressure. I expected the BME280 to be a good candidate for temperature reading and in fact, after a few thousands read cycles, I got 0 errors while reading the BME280 with a 3-meters cable.

Be careful if you buy a BME280. It has been reported by a few Amazon customers that some sellers announce "BME280" devices, but what they received, in fact, was a BMP280 instead of a BME280 (BMP280 does not give relative humidity like the BME280. Humidity may be useful for future usage like Humidex factor, etc…). I paid my BME280 about 20US$ (for a single unit) from Waveshare since I wanted to make sure I would receive the right device.

In reference to the product on the picture below, be aware that not all cables are used since the module support either SPI or I2C communication. Cables have been provided for both protocols. For our purposes, only 4 cables are used for an I2C protocol connection: Vcc (3.3 volts), GND, SDA (data) and SCL (clock).



BME280 module from Waveshare. You can see the BME280 device itself which is the little square metallic case at the left of the module (left picture).

BME280 integration

The BME280 sensor supports SPI and I2C protocols. I used I2C for implementation in the Green Clock since this protocol is already used by the integrated real-time clock. Since I2C is kind of a "multi-drop" protocol, another device can be added on the same communication lines, as long as its device address is different. It means that we do not use an extra Pico's GPIO for this device.

So, 4 cables are required for the BME280 (see table in Appendix B):

- 3.3 Volts supply (Pico pin 36)
- Ground (Pico pin 8 – or other ground pin)
- SDA data line (GPIO6, Pico pin 9)
- SCL clock line (GPIO7, Pico pin 10)

Be careful not to feed the BME280 with 5 volts. Even if the device can work without problem at 5 volts, the Pico logic level is 3.3 volts.

You must turn On the conditional compile "BME280_SUPPORT" in the source code for the BME280 to be recognized by the firmware. Also, if the device is enabled in the code and you don't have a BME280 installed, the Green Clock will work normally without problem. The only impact will be an error message during the clock power-up sequence (indicating that there has been an error while trying to initialize the BME280) and the date and temperature scrolling will also report errors from BME280. Read errors from BME280 are reported in square brackets during date and temperature scrolling without any other indication (for example if you see [5/2833] in the scrolled text, it means that there has been 5 errors on a total of 2833 read cycles from the BME280. Obviously, if no BME280 is installed, the number of errors and the total number of read cycles will be the same. This information may be useful if you have communication interference (from a close motor or something else), since you can get an idea of the relative impact of this interference.

Appendix E – Adding a passive buzzer

Introduction

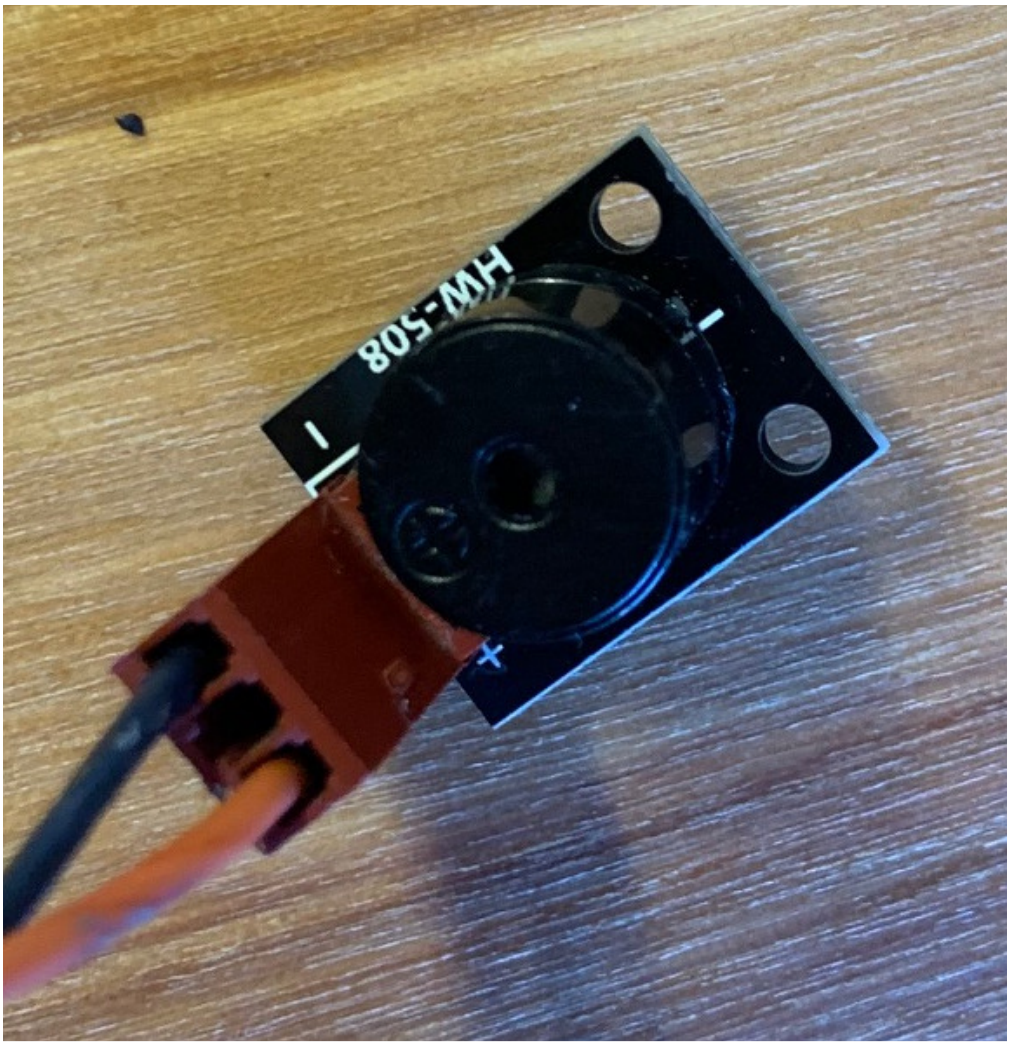
The Pico Green Clock provides an active buzzer. “Active” means that there is an oscillator integrated in the buzzer. This oscillator generates an audio frequency that is always the same, so it is not possible to play tunes or jingles. In version 2.00, I implemented algorithms that allow a specific duration and a “repeat count” for the basic “sound pack” and also another “repeat count” of the basic sound pack (see details in the source code). In Version 6.00 a sound queue has been added to optimize and simplify support for this active buzzer.

However, I thought it would be interesting to install a passive buzzer with firmware support to give more flexibility with sounds. Since there are still some GPIOs available on the Pico, I installed a passive buzzer on GPIO 19.

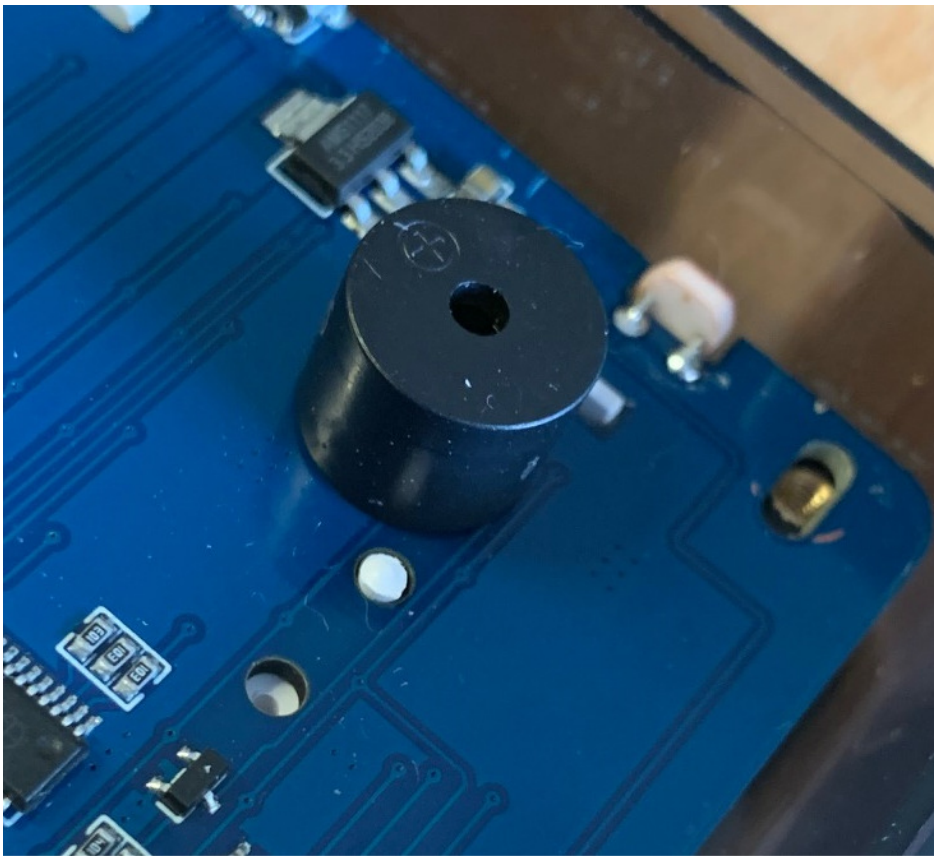
As you can see on the picture below, a passive buzzer looks very similar to an active buzzer. If you have a similar part and you want to identify if your buzzer is active or passive, there are two different ways:

1. Connect the buzzer directly to a 3.3 or 5 volts source. An active buzzer will make a sound whereas a passive buzzer will only make a “click”.

2. Check the buzzer with an ohmmeter. An active buzzer will typically have a resistance of several hundred ohms whereas a passive buzzer will have a low resistance value around 8 or 16 ohms.



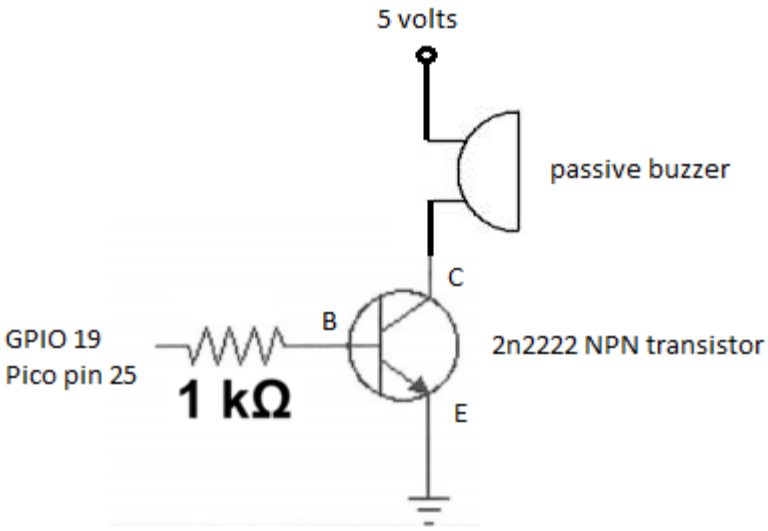
Passive buzzer to be added by user.



Active buzzer integrated in the Green Clock (on Pico Green Clock PC board).

As opposed to the other members of the Raspberry Pi family (Raspberry Pi 3, 4, etc…), the Pico is a microcontroller and does not run an operating system like Linux. That being said, the Pico nonetheless works with some form of multi-tasking. The callback functions, being based on timers or sound queues generate interrupts that must be serviced by the Pico. If we would decide to drive the passive buzzer simply by toggling the GPIO On and Off by software to generate the audio frequencies, we would most probably hear glitches here and there in the sound, when the Pico needs to service an interrupt in the middle of sound generation. For this reason, I used pulse width modulation ("PWM") to generate sounds on the passive buzzer. This offloads the frequency generation from the Pico software execution to a specific hardware section (in the Pico).

Since the Pico logic level is 3.3 volts, it is useful to add a NPN transistor (2N2222, 2N3904 or similar) as a buffer to drive the passive buzzer with 5 volts and getting a louder sound.



2N2222 NPN Transistor

Appendix F – Support of a remote control

Introduction

I'm planning to install one of my Green Clocks in a relatively high location on a wall, in my kitchen. I quickly realized that accessing the clock buttons would become a difficult task. So I thought it would be a good idea to add an infrared remote control to the clock…

The first step is to install an infrared receiver. The VS1838b IR receiver is not expensive and it takes care of filtering out the 38 kHz carrier of most remote controls.

VS1838b infrared receiver

Pico Green Clock User Guide

I built an infrared protocol analyzer (based on a Pico microcontroller, of course!) and I looked at the commands sent by a Memorex remote control that I use for an "under-the-counter" radio / CD player.

I implemented a decoding function in the Green Clock, so that I could act on each command received from the remote control.

The VS1838b infrared receiver must be installed outside the clock case (the colored plastic case would have significantly reduced the range of the remote if the receiver would have been installed inside the case). Like for the DHT22, a 3-wires cable is required for +3.3 volts, Ground, and GPIO 9 (data input).

All command decoding has been isolated in a separate include file called "memorex.cpp". This will allow implementation of other remote controls to be also isolated in separate modules without any impact on the main source code module.

When a valid command is received by the clock, a quick "beep" will sound (similar to a keyclick) and the command will be processed. If there is interference and / or if for any reason the command is not recognized by the clock, the infrared stream will simply be ignored and no "beep" will be heard.

Implementing another remote control

Chances are that you won't have a Memorex remote control similar to the one I use. However, if you take a look at the decoding module ("memorex.cpp"), you will see that most parts of the code required to analyze the protocol for another remote control are there. You may want to display the timing values on the clock display for each remote button. If you want to save long minutes (even hours) use an external terminal emulator to display the information and decode your own remote control. Make sure to isolate the protocol related code in an include file similar / compliant to memorex.cpp. See Appendix G on how to configure an external terminal emulator to display debug

information. I may create a repository for a remote control analyzer (based on a Pico) if I see an interest from users.

How to use the remote control

Once the protocol decoding function has been built and debugged for the Memorex remote control, next step has been to decide how to handle the commands sent from the remote (that is, how to assign a specific function to each remote button). Obviously, this remote control was originally designed to control a radio / CD player. So, the buttons on the remote often have no specific correspondence with the Green Clock.

Whenever possible, I tried to implement a "logical" match between the remote control and a specific clock functionality. When not possible, I simply make a correspondence that must be followed without trying to see a logical link between both. Also, a few more functions / features are now possible and have been implemented thanks to the remote control support.

Remote control buttons

For the text below, please refer to the remote control picture above. I tried to present and explain the functions associated with remote buttons in an order that will facilitate the comprehension and that will help the user to remember them. That's why they are not presented from top to bottom as seen on the remote control picture.

Power

The "Power" button on the remote control is not used at all with the clock. This way, as long as the original Memorex radio / CD player remains Off, I can play with all other buttons on the remote to interact with the Green Clock without the risk of the radio becoming crazy by also responding to all remote button presses. I suggest that you do the same if you implement another remote control.

If you press the "Power" button on the remote, the clock will beep (since it received a command that has been properly decoded), but will take no specific action.

CD door

The “CD door” button is located at the top left of the remote, beside the “Power” button and relatively apart from other buttons. I found this button located in a very good “stand alone” position and I decided to assign it to a function that I will use quite often: “Display outside temperature, relative humidity and barometric pressure” (this assumes that you have also installed a BME280 sensor for reading outside weather parameters).

So if you press the “CD door” button, the clock will sound a quick beep to indicate that a valid command has been received, and the outside temperature, relative humidity and barometric pressure will begin scrolling on the clock display.

NOTE: As mentioned in Appendix D about BME280, at the end of text scrolling, you will see numbers in square brackets (like: “[0/2844]”). I added to the scrolled data the number of errors in the communication sessions with the BME280 on the total number of exchanges. In the example above, there has been no error “0” and the clock requested 2844 times the weather parameters from BME280. This number “2844” depends on how long the clock has been up and running and the compile-time parameter who determines the period for the date and temperature scrolling. If you have a long cable or if there is a motor or other similar device near the cable, you may experience more errors on the long run. Take note that both values (number of errors and number of read cycles) will be reset to zero at each power-up.

Over

While looking at the remote control, I found that the “Over” and “Mute” buttons were located in symmetrical locations and I needed such an arrangement for two functions that were not available on the clock itself but have been added with the support of the remote control.

So, a new function as been allocated to the “Over” button: “Display Calendar Events for today”. If there is one or more Calendar Event programmed for the current day, they will scroll on the clock display.

Mute

Given the symmetric position of the “Mute” button with the “Over” button, the new function “Display Calendar Events for current week” has been implemented and allocated to the “Mute” button on the remote control.

If current day-of-the week is not Sunday, the clock will go backward until the nearest Sunday, and starting from that point, will display all Calendar Events programmed for the week (from Sunday, up to - and including - the next Saturday).

Set / memory / clock

Replicate the "Set" (top) clock button quick press.

There is a button identified "Set" (written on the button itself) which is also identified by "memory / clock" (written on the remote control body, this time).

It was easy to decide that this button would be used as an equivalent for the "Set" (top) button on the clock. In fact, this button simply replicates the "Set" button on the clock. It will allow the clock to enter clock setup mode if pressed while the clock is in the usual time display mode. It will then allow scanning all clock settings, the same way the "Set" (top) button does it on the clock.

Volume up / Volume down

Replicate the "Up" (middle) and "Down" (bottom) buttons quick press.

Just above the "Set / memory / clock" button, there is a "Volume up" / "Volume down" double button.

The same way it has been easy to decide on the function to assign to the "Set" button on the remote, the "Volume up" and "Volume down" buttons have been allocated to the same functions the "Up" (middle) and "Down" (bottom) buttons on the clock.

As we would expect, Volume Up and Volume Down will respectively increase and decrease values while we are in setup mode, in a way similar to what the "Up" and "Down" buttons do on the clock.

Stop

Replicate "Down" (bottom) button long press.

When you learned how to setup the clock, be it for clock settings, alarm settings or timer settings, you've seen that you can get out of setup mode by making a long press on the "Down" (bottom) button. So, I thought there should be a similar button on the remote control in order to get out of any setup mode… and I thought that the "Stop" button would be a good candidate for that purpose.

On top of being an "Exit from setup mode", the "Stop" button will display the average ambient light for the last 60 seconds if the clock is not currently in one of the setup modes. This function has no equivalent on the clock. Theoretically, ambient light values go from 0 to 4095 (12 bits AD converter). However, it is unlikely that you will ever see a

value in those extremes. With a flood light directly on the photocell, the value could be around 4040, whereas when very dark, the value could be around 140.

NOTE: I reversed the values originally given by the function to get ambient light. I thought it would be more intuitive to have a higher value when the light is at a higher level rather than the other way around.

Repeat / Up

Replicate "Set" (top) button long press.

As we've seen earlier, the "Set" button on the remote control has been configured to replicate the "Set" (top) button on the clock.

I thought it could be an easy way to remember the alarm setup button if it is located just beside the clock setup button.

So, pressing the "Repeat / Up" button on the remote control will enter the alarm setup mode. We then use the "Volume up" / "Volume down" buttons to change settings, the "Set" remote button to scan through the different alarm settings and / or the "Stop" remote button to get out of the alarm setting mode (in a way similar to the buttons used on the clock itself).

Random / Down

Replicate "Up" (middle) button long press.

I followed the same logic with the "Random / Down" remote button: The "Set" remote button enters the clock setup, the "Repeat / Up" enters alarm setup, so, the "Random / Down" (located just beside "Repeat / Up") enters the timer setup mode (all three setup buttons are placed on the same remote control row).

Once in the timer setup mode, we use the "Volume up" / "Volume down" to change current setting, the "Set" remote button to scan through the different settings, and the "Stop" button to exit timer setup.

Band / Tuner

A new function has been allocated to the "Band / Tuner" button. This button is located in the bottom left of the remote control and is easily reached with the thumb, even without looking at the remote. So, when pressing this button, the clock display will roll two dices

and display two random values between 1 and 6. No more need to roll dices with hands! The clock also makes some pixel twinkling animation and sound bubbling while randomizing the numbers.

CD

Another new function has been added, thanks to the remote control.

The "CD" button on the remote control could be interpreted as "Count Down" (of course, I know that originally, "CD" did not mean count-down on the remote… it's just a way to better remember). We've seen before that the "Random / Down" button has been already configured for the count-down timer. This time, however, we're not talking about the Count-down timer. The CD remote button will make the clock silent for 30 minutes each time the button is pressed.

If you have some visitors at home and there are seven Calendar Events programmed for this specific date, you may get tired of all sounds coming from the clock (Calendar Events, hourly chime, etc)… The "CD" remote control button will allow you to add 30 minutes of silence for each press. This silence period will have an effect on hourly chime and Calendar Events (not for other type of sounds, like alarms, timer count-down, etc…)

Also, if you pressed the button twice a while ago (for a one-hour silence period) and the "silence count-down" is down to 5 minutes, pressing the CD button once more will grow the silence period to 30 + 5 = 35 minutes (adding 30 minutes to the remaining 5 minutes).

If you want to cancel the silence period, use the "Play / Pause" button (see below).

Time

A new function has been allocated to the "Time" button. When pressing this button on the remote control, the clock display will show for a few seconds the current minute and current second (instead of current hour and current minute – the seconds will change a few times while the display remains in this mode before returning to normal time display mode). While the clock is in this mode, the two middle-dots will stop blinking to indicate that you are in "seconds display mode". Instead of the middle-dots blinking, you will see the seconds changing on the display.

After five seconds, the display will return to the usual time display mode.

Rewind / Down

The remote button with a “Rewind” symbol on it (also identified with “Dn” written on the remote body) is used to display the System idle monitor value. As mentioned in the Green Clock features previously in this guide, the System idle monitor gives the average number of system loops performed by the software during one second. This average is based on system activity during the last 60 seconds. So, the more processing the system must perform during the interrupt / callback routines and the more processing the system must perform during its endless system loop, the less system loops can be performed.

At the time of this writing (Firmware Version 6.00), the average System idle monitor is around 760,000 loops per second.

Fast forward / Up

The remote button with a “Fast forward” symbol on it (also identified with “Up” written on the remote body) is not used for now.

Numeral buttons (1 to 0)

So far, we’ve not discussed about the remote numeral buttons 1 to 0… Before going forward, let’s go back to the clock setup for a moment…

As we’ve seen previously, to proceed with the clock setup, be it directly with the clock buttons and / or with the remote control buttons that replicate the same clock functions, the procedure is straightforward: we press the “Set” button to enter setup mode, and we then press the “Set” button each time we want to proceed with the next setting in the list.

If you refer to the list of all clock settings in the corresponding section in this guide, you can see that there are a lot of settings in the list. If we want to modify a parameter that is at the end of the list, we have to go through all other parameters until we reach the one of interest. To make this process easier, the numeral buttons have been used when using the remote control.

NOTE: Since button 0 is physically located at the end of the numeral buttons on the remote control, it must be considered the last button (that is, 0 comes *after 9* and not *before 1* in the procedure logic).

When using the remote control, once we are in clock setup mode, we can use the “Set” button to scan through the many settings as we’ve already seen, but we can also use the numeral buttons on the remote control to jump directly to a specific setup section. Here is a quick reference of the sections associated with each numeral:

Remote control button	Setup section
1	Time / Date / Year
2	Daylight saving time
3	Keyclick
4	Display scroll
5	Temperature unit
6	Language
7	Time display format
8	Hourly chime
9	Night light
0	Auto brightness

For example, once you pressed the “Set” button, the hour will blink since you are in clock setup mode, hour setting. Instead of pressing the “Set” button many times to skip to the desired setting, you can press the button “7”, for example, if you want to jump directly to the “Time display format” setting (see the quick reference above).

Once in a specific setting section, you can still use the “Set” button to skip to the next setting in sequence. As another example, if you press the button “8”, you will be in the Hourly chime setting. You can use “Volume up” / “Volume down” buttons to change the setting. Now, if you want to change Hourly chime time On and Hourly chime time Off (which are the next settings in the regular sequence), you can press the “Set” button to go to the next steps in sequence.

You can go back and forth in the setup section of interest. For example, you’re allowed to return to Time setting (by pressing button “1”) after setting up Hourly chime.

Display

There is a reason why I presented the numeral buttons in the previous section, before the discussion about the “Display” button. In some way, the Display function is slightly similar to the Set function seen in the previous section.

The “Display” remote control button will enter a “generic display mode”. This can be observed by the clock display stopping the middle dots blinking.

Once in generic display mode, the selection of a specific numeral button will display information about the section selected (See the sections in the table for “Settings” in the previous section above. They also apply for Display).

For example, pressing “Display”, followed by button “4” (“Display scroll” as indicated in the quick reference in the previous section) will scroll on clock display a lot of

information about Display scroll (Status On / Off, Time period for scrolling, period of each dot-scroll, etc…)

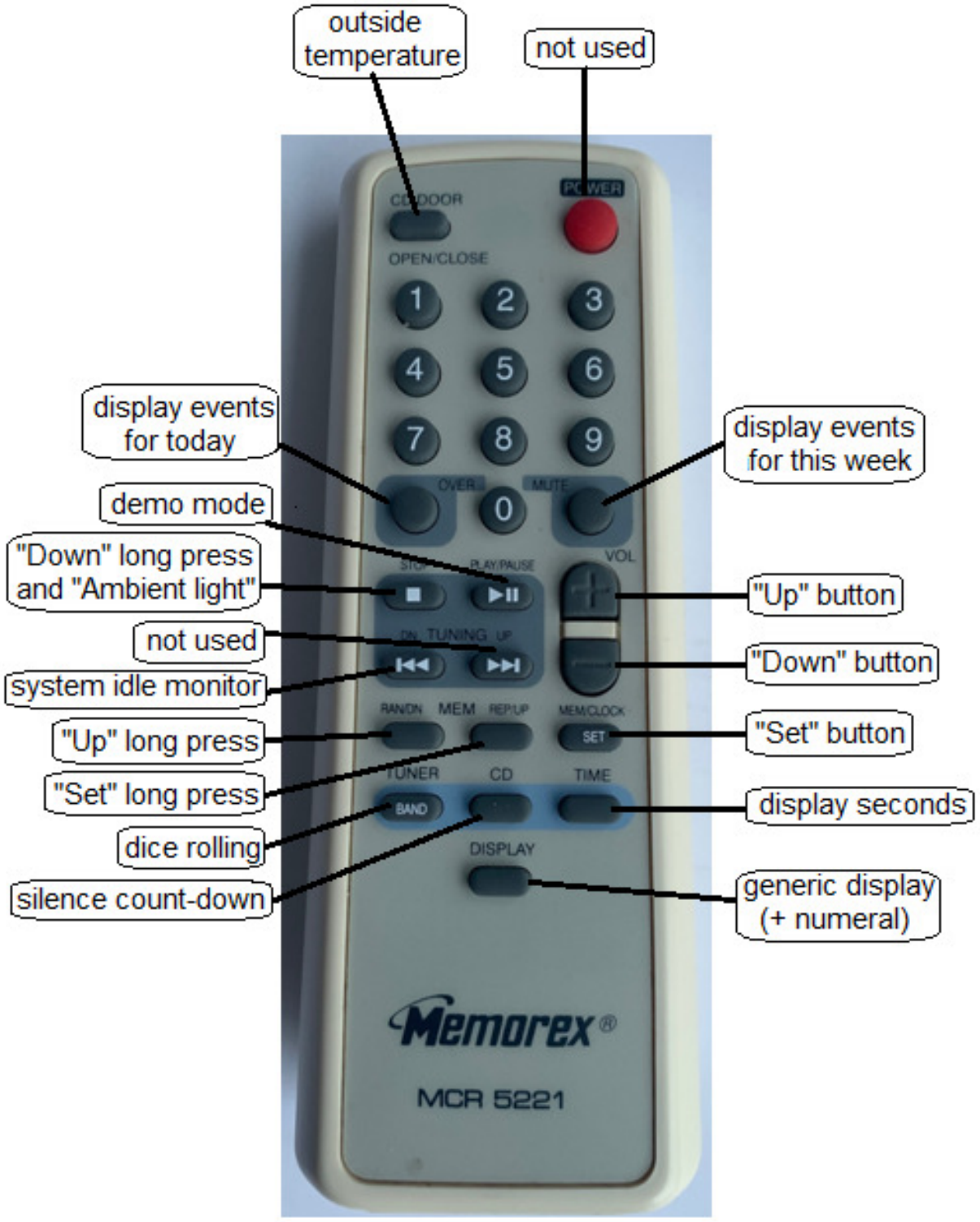
As opposed to the "Set" button, however, you can select only one display function at a time. If you want to display information about "Display scroll" and also about "Hourly chime", you have to press first "Display", then "4" ("Display scroll") and then "Display" again, followed by 8 ("Hourly chime").

Play / Pause

Finally, the last button that has not been discussed so far is the "Play / Pause" button. This is the button to remember when your friend hacker comes home. It performs many clock functions / demos, and also displays a lot of information (Matrix test, Indicators test, White LEDs test, Pixels twinkling, Active buzzer tests, Passive buzzer tests, Scroll Pico internal temperature, Scroll ambient temperature, Scroll outside temperature (given that you installed a BME280 sensor), Scroll power supply voltage, Scroll ambient light value, etc…

As a "side effect", pressing the "Play / Pause" will cancel any silence period currently on-going on the clock. If you still want a silence period after pressing "Play / Pause", simply press the button "CD" (to increment the silence period by 30 minutes each time) when the clock demo is over.

Pico Green Clock User Guide



Appendix G – Configuring an external monitor

Introduction

If you work on the source code of the Green Clock for significant changes, you will quickly realize that scrolling debug information on the clock display is a tedious task. Not much for the work required in the source code (many functions have been implemented to make the task easy), but for the time it takes to read the information scrolled on the display and making use of it.

This Appendix will show you how to make a connection with an external terminal emulator to display debug information. Not only such an external terminal emulator with a 80 X 24 screen (or more) is much easier to work with, but it is also much faster to read for debugging purposes than looking at a display scrolling only 4 or 5 characters at a time.

I recommend that you read the whole section before taking any action. The appendix goes from the most complicated setup to the easiest.

VT-101 terminal over RS232 line

If you're much younger than I am, you may have never heard about "VT-101". Back in the old days, when computers were costing hundreds of thousands of dollars, one big central computer was installed (called a "mainframe") and many users were connected to it using a "dumb terminal". Without going into details, such a terminal was used to receive plain data from the computer and send back plain data to the computer using a communication protocol called RS232. In fact, many different terminal models existed, but VT-101 originated from Digital Equipment Corporation (DEC) and was very popular. If you have such a monitor, you can use it to display debug information on its screen.

1) We can program the Raspberry Pi Pico so that two (2) specific GPIOs are configured as UART ("Universal Asynchronous Receiver Transmitter"), the IC used to implement the RS232 serial protocol. You can refer to the source code to see how to properly program the GPIOs (make a search for the string "uart"). You can also take a look at the function "uart_send()". The details about serial protocol are beyond the scope of this user guide.

2) Now that we know how to configure the Pico for serial communication, we're half done! In fact, even if the Pico is now able to receive and / or transmit data from / to a serial line, we still have to adjust the voltage levels. The Pico works with 3.3 volts, whereas RS232 works with higher voltage (there has been many

protocol revisions over the years, but the signal is usually swapping from -5 volts to + 5 volts. So, we need an RS232 adaptor to convert RS232 levels down to 3.3 volts compatible with the Pico.

I bought such an interface from Waveshare:

https://www.waveshare.com/rs232-board.htm

3) You can make things simple by using Vcc (3.3 volts), ground and TxIn (which transmits TO the external VT-101 monitor on the version of the interface that I received). You should not need to worry about CTS and RTS handshake, as long as the Pico's UART and the terminal are both programmed to ignored handshake. Also, as far as firmware Version 5.00 is concerned, there is no need to use the RxOut pin of the interface that could be used to receive characters sent from the VT-101 keyboard to the Pico (except if you implement new functions on the clock that could use it).

   Then, you simply connect the interface module to your VT-101 monitor using a cable with DB9 on both ends (or a DB9 and a DB25 if your terminal has a DB25 connector).

   Be aware that the protocol of the monitor must match the one of the Pico, namely for the speed and the handshake (in Version 5.00 firmware, speed is set at 38400 and no handshake is used: 38400 – N – 8 – 1). Refer to the terminal's user guide for how to set it up.

There is not much to say about sending information to the external monitor. Keep in mind that 38400 bauds ("baud" is the speed unit for RS232 serial communication) is relatively slow by today's computer standards. If you send too much information from callback or interrupt routines, you may have side effects on the timings that will trigger more problems than solutions!

Computer screen over RS232

If you don't have a VT-101 terminal (or another similar product), you can use an old PC to display debug information.

The PCs sold in the last few years don't have a serial port for RS232 communication. However, if you have an old PC, it may be a good opportunity to give it another life.

1) All you have to do is following the instructions in the section above ("VT-101 terminal over RS232 line"), but instead of connecting the Waveshare interface to a VT-101, connect it to the computer DB9 or DB25 that it should have if it was equipped with a serial port.

2) You also need to run a terminal emulator program on the computer. "Procomm" was a popular communication program that could run on DOS. There was also a version to run under Windows. HyperTerminal was also a terminal emulator program included in the first versions of Windows. TeraTerm is a "new generation" of terminal emulation software who works fine.

   Don't forget that you still have to configure the serial protocol on the communication program as you have to do on the VT-101 (38400 – N – 8 – 1 is a good starting point). Also remember that both ends (the Pico and the terminal emulator program on the PC) must have the same RS232 configuration.

3) Another advantage of using a PC is that most of the communication programs have an option to save all communications in a log file. So, you can save all information sent by the Pico to a file and then take the time to analyze it and modify your program accordingly.

Computer monitor over USB

If you don't have an old computer with a serial port, you still have another solution. It is to use a modern computer to receive information from the Pico via the USB port.

Pico Green Clock User Guide

1) It is important to understand that the Pico will still send the information from its internal UART and through an RS232 interface. So, you still have to perform the steps as described above in the section “VT-101 terminal over RS232 line”.

2) Since the Pico sends its data using an RS232 interface and you want to receive it using a USB port, you will need a RS232-to-USB adaptor. Make sure the adaptor you buy provides the device driver required by your OS (correct version of Mac, Windows, Linux, or other). Here are some examples of such an adaptor:

(Note: prices shown above are in Canadian $)

Some adaptors provide a DB9-to-DB25 adaptor. This may be useful if your Raspberry Pi RS232 adaptor has a DB25 connector instead of a DB9 connector. A DB9 is shown on the grey adapter below. The other, wider end is a DB25 (we actually don’t see it on the picture).

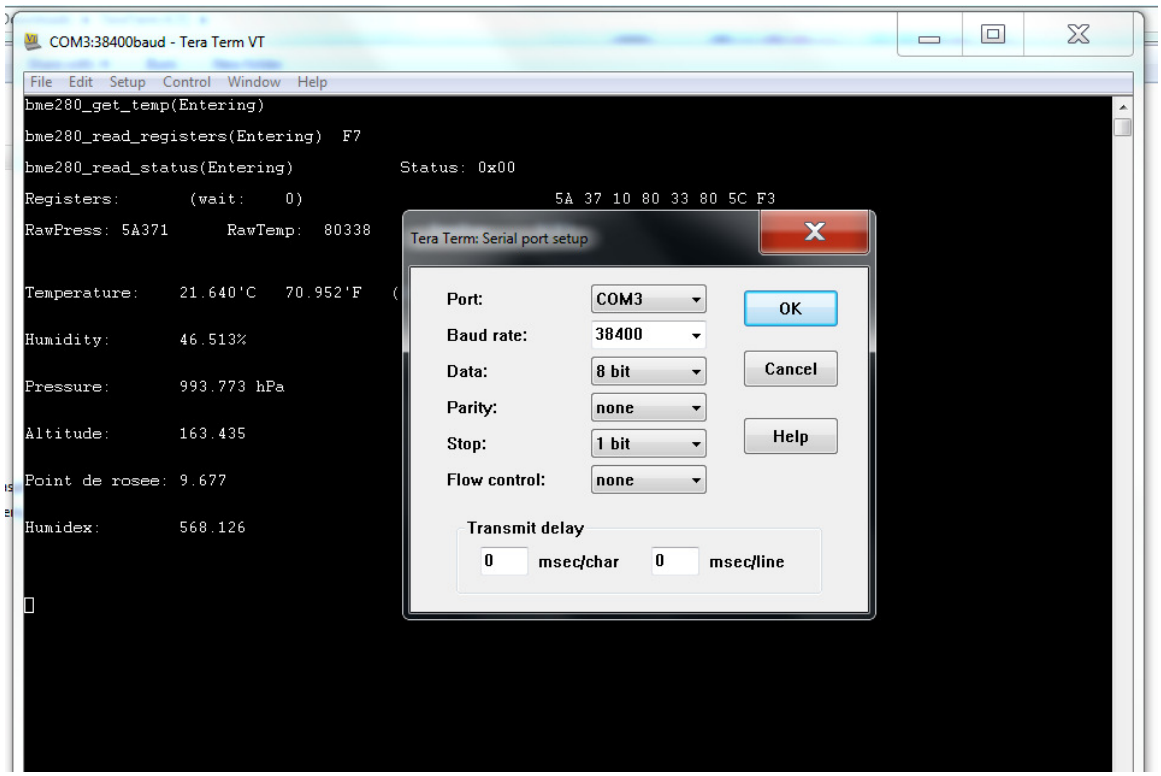
3) Follow the instructions that come with the adaptor to install the device driver. My understanding is that there is a chipset integrated inside one of the connectors (either USB or DB9). Consequently, you may need to plug the adapter before installing the driver. You may also need to reboot the system for the adaptor to work properly. (Note: the chipset is self-powered through the USB connection).

4) The final step is to find a terminal emulator program that will work on your computer. I use the popular TeraTerm, Freeware and Open source. As its author wrote, “it is not a full-fledge terminal emulator”, but I found it to be perfect to display debug information sent by a Raspberry Pi Pico.

https://download.cnet.com/Tera-Term/3000-2094_4-75766675.html

5) Start the terminal emulator and go to the “File / New connection” menu, you will see that there is a “Serial” option and a serial port number has been assigned to the serial-to-USB adaptor. Note: on some older Windows versions, you may need to install a special CDC driver for the adaptor to be recognized as a COMx (serial port) device.

6) Then, going to the menu “Setup / Serial port”, you can configure the protocol as you want (38400 – N – 8 – 1) is a good starting point, but as long as you set the Raspberry Pi the same way, it will work).



NOTE: Once in a while, it may happen that the terminal emulator stops display the data coming in. In this case, you may need to close the terminal application and restart it, which is a quick operation. Make sure you have previously saved the selected configuration "Setup / Save setup" so that you don't need to reconfigure every time. If a restart doesn't work, unplugged the RS232-to-USB adaptor (at the USB end) and plug it back, then stop and restart the terminal program.

Pico to computer, USB-to-USB

The easiest way to communicate between the Pico and your computer is probably with a USB-to-USB connection. In your Pico Green Clock make file (CmakeLists.txt), add the following lines:

Pico_enable_stdio_uart(Pico-Clock-Green 0)
Pico_enable_stdio_usb(Pico-Clock-Green 1)

The first line will stop sending the debug information to the Pico's UART and the second line will make it sent it through the USB port instead.

You can refer to the previous paragraphs to see how to setup a terminal emulator program on your PC and use it with a USB port. You can then increase the communication speed on both ends (I use 921600 bauds).

TeraTerm will give an error if you try to connect to the USB port when the Green Clock is not connected… and when the Green Clock is connected, it may be already too late to log the critical information that you want to analyze. For this reason, I added a loop at the beginning of the source code that beeps until user press the “Set” (top) button. While the system waits in the loop, user can start the terminal emulator program. Since the Green Clock is connected, the terminal program will recognize the USB connection and will be ready to receive data when user presses the “Set” button. Take a look at the source code for more information. When the firmware is built as a “Release” version, this loop is disabled so that the clock starts without any special user action.

You will see that being able to display debug information on a PC screen is really a plus when working on a microcontroller. However, remember that when working with real-time device, interrupt service routines or callback functions, or some other timing-sensitive stuff, we must be careful about where in the code we put the debug communication…

Appendix H - Firmware

This section gives general information about different subjects related to the source code and will be of interest to those who want to work on the code. It is not intended to explain the code in details, but rather to focus on some specific features of interest. The information is given below, in alphabetic order.

The author of this document is interested in receiving your comments and ideas about features that you have added to the Pico Green Clock (email address given after Index at the beginning of this document).

Alarm numbers

Beginning with Firmware Version 6.00, since it is now possible to save the clock configuration in flash memory, nine (9) independent alarms have been implemented. They are saved in flash, so that in case of a power failure, all alarms parameters will be restored to the active clock configuration on power-up.

As was the case when only two (2) alarms were available, alarm numbers have been numbered 1 to 9 to be more “natural” or “human-like” for the clock user. However, in the source code, these alarms are numbered 0 to 8.

Alpha characters

Even if a 5 X 7 character set has been implemented, 4 X 7 character set is still needed. Given the size of the clock display, 5 X 7 characters are too large to be used to display time on the display (which is relatively important for a clock!!). So, the 4 X 7 character set has been left in the code, and moreover, I tried to add the whole displayable ASCII characters. Result is not always good, but in some situation and / or for some characters, it proved to be useful.

Calendar events

Calendar Events are compile time options that may be configured before rebuilding the firmware. Basically, a "Calendar Event" is made of four elements:

1) A day-of-month (from 1 to 31).
2) A month (from 1 to 12).
3) An optional "jingle" identification.
4) A text (maximum of 40 characters).

When the specific date is reached (say, 15th of August), the text that has been defined in the source code will be scrolled on the clock display during 24 hours (the 15th of August in our example, from 00h00 up to 23h59), twice an hour, at xxh14 and xxh44. Time has been specifically chosen so that it will not interfere with the hourly chime (every xxh00) and / or date display which is by default every 5 minutes (xxh00, xxh05, xxh10, xxh15, etc…).

If an optional passive buzzer has been installed by user and if a specific jingle identification is given, it will be played when the Calendar Event is scrolled on clock display. As already mentioned, both passive and active buzzers will be heard in accordance with the hourly chime settings.

Up to 50 Calendar Events may be configured. It must be noted that no validation is done on the day-of-month and month configured in the source code. If invalid values are encoded, the corresponding string will simply never be scrolled.

A special case when the text is "Debug" will trigger a special handling in the "process_scroll()" function. This is very useful when we want to display run-time information, even while inside an ISR.

Character bitmap

Original software Version 1.00 from Waveshare proposed the 4 X 7 character set (a few characters were based on a 5 X 7 bitmap however). It may be observed that the 4 X 7 character bitmap itself is not implemented in the intuitive way we would expect. This is because the lowest bit is on the left side of the LED matrix, while the lowest bit is on the right side of the byte when we manipulate the bit positions.

In order to build on a more intuitive bitmap character set, the 5 X 7 character bitmap uses the function "reverse_bits()" allowing the character bitmap to be based the way we expect it to be. (I didn't change the way the 4 X 7 character set was handled, tough).

Clock "Option section"

Many options have been grouped at the beginning of the source code. These are the options most likely to be adjusted / changed to user's taste. The programmer may want to consult this section before modifying elsewhere in the code, and may also want to add any new feature that could be tuned to user's taste in this section.

Coding standard

Many function names have been changed from the original (Version 1.00) to better represent what they do. Also, even if most modern integrated development environment propose tools to easily navigate through the code, all functions have been sorted in alphabetical order (except "main()", which is first). There is no "one good standard", but the one I use has been deployed throughout the code: function name all in lowercase with an underscore to isolate tokens, variable names capitalized, etc…

Debug chunks of code

Many chunks of code that have been used for debugging purposes have been left in the code. I usually enclosed them between comments symbols /*** some code ***/ or "/// some code" to easily recognize them as "debug code" or "code that must be reviewed later". Also, before making an official release, I review all "***" and "///" to clean the code of extra and useless pieces of code. However, since the Pico Green Clock is something that programmers may want to work on, I left many such chunks of code in the sources.

Since they are commented out, they do not take extra space in the executable.

Function scroll_queue_value()

This function has been implemented to make debugging easier. It can be used even inside ISR to display markers and / or other useful information.

Look for examples in the code.

Function scroll_string()

The “scroll_string()” function is very helpful when implementing and / or debugging sections of the code. It allows displaying status, variables or other useful information on clock display at run-time for those without other debugging tool (serial monitor, USB display, etc…)

Options

As mentioned in the previous sections of this guide, I added four options to the clock so far:

1) A BME280 sensor (for outside temperature, relative humidity and barometric pressure).
2) A DHT22 sensor (for ambient temperature and relative humidity).
3) A passive buzzer (to play jingles).
4) An infrared receiver (to receive remote control commands).

Even if most sections of code related to these options have been made conditional compile, they could remain active all the time without problem.

The BME280 code will go through without significant impact on the timing if no BME280 has been installed. Number of errors and total read cycles [inside square brackets] will continue to be scrolled with date scrolling, tough.

The DHT22 code has time-outs that will make the code behaves without real change even if no DHT22 is installed. The only visual impact will be the error count (appearing in parenthesis) with the date scrolling.

The passive buzzer is feed with a sound queue working inside an interrupt service routine, so there will be no real impact if there is no passive buzzer connected on the target GPIO.

Finally, if there is no infrared receiver connected, the routine waiting to receive IR commands will simply stand there without receiving anything. Once more, there will be no real impact on clock behavior.

Remote control

A file called “memorex.cpp” contains all infrared commands related processing. If another brand of remote control is implemented, it would be a good idea to create another include file similar to “memorex.cpp”, so that only the include file name has to be changed in the main source file to support this other remote control

Test section

To keep the firmware as small as possible, a conditional compile option has been configured so that test code may or may not be included in the executable. (see "#ifdef TEST_MODE").

Many chunks of test code have been left in the source code to help any programmer adding new features to the clock or proceed with more tests.

Those chunks of test code must be considered as such: test code! It should help you with the implementation of new functions / features, but it must NOT be considered as "debugged" and "fool-proof" code! Use it at your own risk and effort!

Appendix I – GPIO used in Waveshare Green clock

List of GPIOs used in the Waveshare Green Clock:

GPIO number	Direction / Usage	Description
GPIO 0	(Out)	Pico's UART output to an external VT-101 type monitor.
GPIO 1	(In)	Pico's UART input from an external VT-101 type monitor.
GPIO 2	(In)	"Set" (Top) button
GPIO 3	(In)	SQW (DS3231 RTC IC)
GPIO 4		Not used.
GPIO 5		Not used.
GPIO 6	(I2C) SDA	Temperature reading from DS3231 / Data reading from BME280
GPIO 7	(I2C) SCL	Temperature reading from DS3231 / Data reading from BME280
GPIO 8	(In / Out)	DHT22 (must be added by user)
GPIO 9	(In)	Infrared receiver for remote control (must be added by user)
GPIO 10	(Out)	CLK (LED matrix controller)
GPIO 11	(Out)	SDI (LED matrix controller)
GPIO 12	(Out)	LE ("Latch Enable") for LED matrix controller
GPIO 13	(Out)	OE ("Output Enable") for LED matrix controller
GPIO 14	(Out)	Active buzzer / Piezo (integrated on Green clock pc board)
GPIO 15	(In)	"Down" (Bottom) button
GPIO 16	(Out)	A0 (address line for LED matrix controller)
GPIO 17	(In)	"Up" (Middle) button
GPIO 18	(Out)	A1 (address line for LED matrix controller)
GPIO 19	(Out)	Passive buzzer signal (must be added by user).
GPIO 20		Not used
GPIO 21		Not used
GPIO 22	(Out)	A2 (address line for LED matrix controller)
GPIO 23		Used internally for voltage regulation
GPIO 24		Used internally for voltage detection
GPIO 25	(Out)	On-board Pico`s LED
GPIO 26		ADC0 (Ambient light reading)
GPIO 27		Not used
GPIO 28		Not used
GPIO 29		ADC-Vref (Power supply voltage reading)

Appendix J – Framebuffer bitmap configuration

Framebuffer[] bitmap configuration

Framebuffer[0]:
Bit 0 = "Move On" indicator - left LED
Bit 1 = "Move On" indicator - right LED
Bit 2 = White LED - top
Bit 3 = "Monday" indicator - left LED
Bit 4 = "Monday" indicator - right LED
Bit 5 = White LED - bottom
Bit 6 = "Tuesday" indicator - left LED
Bit 7 = "Tuesday" indicator - right LED

Framebuffer[1]:
Bit 0 = "Alarm On" indicator - left LED
Bit 1 = "Alarm On" indicator - right LED
Bit 2 = Display matrix 1,1
Bit 3 = Display matrix 1,2
Bit 4 = Display matrix 1,3
Bit 5 = Display matrix 1,4
Bit 6 = Display matrix 1,5
Bit 7 = Display matrix 1,6

Framebuffer[2]:
Bit 0 = "Count Down" indicator - left LED
Bit 1 = "Count Down" indicator - right LED
Bit 2 = Display matrix 2,1
Bit 3 = Display matrix 2,2
Bit 4 = Display matrix 2,3
Bit 5 = Display matrix 2,4
Bit 6 = Display matrix 2,5
Bit 7 = Display matrix 2,6

Framebuffer[3]:
Bit 0 = "Fahrenheit" indicator
Bit 1 = "Celsius" indicator
Bit 2 = Display matrix 3,1
Bit 3 = Display matrix 3,2
Bit 4 = Display matrix 3,3
Bit 5 = Display matrix 3,4
Bit 6 = Display matrix 3,5
Bit 7 = Display matrix 3,6

Framebuffer[4]:
Bit 0 = "AM" indicator
Bit 1 = "PM" indicator
Bit 2 = Display matrix 4,1
Bit 3 = Display matrix 4,2
Bit 4 = Display matrix 4,3
Bit 5 = Display matrix 4,4
Bit 6 = Display matrix 4,5
Bit 7 = Display matrix 4,6

Framebuffer[5]:
Bit 0 = "Count Up" indicator - left LED
Bit 1 = "Count Up" indicator - right LED
Bit 2 = Display matrix 5,1
Bit 3 = Display matrix 5,2
Bit 4 = Display matrix 5,3
Bit 5 = Display matrix 5,4
Bit 6 = Display matrix 5,5
Bit 7 = Display matrix 5,6

Framebuffer[6]:
Bit 0 = "Hour chime" indicator - left LED
Bit 1 = "Hour chime" indicator - right LED
Bit 2 = Display matrix 6,1
Bit 3 = Display matrix 6,2
Bit 4 = Display matrix 6,3
Bit 5 = Display matrix 6,4
Bit 6 = Display matrix 6,5
Bit 7 = Display matrix 6,6

Framebuffer[7]:
Bit 0 = "Auto Light" indicator - left LED
Bit 1 = "Auto Light" indicator - right LED
Bit 2 = Display matrix 7,1
Bit 3 = Display matrix 7,2
Bit 4 = Display matrix 7,3
Bit 5 = Display matrix 7,4
Bit 6 = Display matrix 7,5
Bit 7 = Display matrix 7,6

Framebuffer[8]:
Bit 0 = Not used
Bit 1 = "Wednesday" indicator - left LED
Bit 2 = "Wednesday" indicator - right LED

Framebuffer[9]:
Bit 0 = Display matrix 1,7
Bit 1 = Display matrix 1,8
Bit 2 = Display matrix 1,9

Bit 3 = Not used
Bit 4 = "Thursday" indicator - left LED
Bit 5 = "Thursday" indicator - right LED
Bit 6 = Not used
Bit 7 = "Friday" indicator - left LED

Framebuffer[10]:
Bit 0 = Display matrix 2,7
Bit 1 = Display matrix 2,8
Bit 2 = Display matrix 2,9
Bit 3 = Display matrix 2,10
Bit 4 = Display matrix 2,11
Bit 5 = Display matrix 2,12
Bit 6 = Display matrix 2,13
Bit 7 = Display matrix 2,14

Framebuffer[11]:
Bit 0 = Display matrix 3,7
Bit 1 = Display matrix 3,8
Bit 2 = Display matrix 3,9
Bit 3 = Display matrix 3,10
Bit 4 = Display matrix 3,11
Bit 5 = Display matrix 3,12
Bit 6 = Display matrix 3,13
Bit 7 = Display matrix 3,14

Framebuffer[12]:
Bit 0 = Display matrix 4,7
Bit 1 = Display matrix 4,8
Bit 2 = Display matrix 4,9
Bit 3 = Display matrix 4,10
Bit 4 = Display matrix 4,11
Bit 5 = Display matrix 4,12
Bit 6 = Display matrix 4,13
Bit 7 = Display matrix 4,14

Framebuffer[13]:
Bit 0 = Display matrix 5,7
Bit 1 = Display matrix 5,8
Bit 2 = Display matrix 5,9
Bit 3 = Display matrix 5,10
Bit 4 = Display matrix 5,11
Bit 5 = Display matrix 5,12
Bit 6 = Display matrix 5,13
Bit 7 = Display matrix 5,14

Framebuffer[14]:
Bit 0 = Display matrix 6,7
Bit 1 = Display matrix 6,8
Bit 2 = Display matrix 6,9
Bit 3 = Display matrix 6,10
Bit 4 = Display matrix 6,11
Bit 5 = Display matrix 6,12
Bit 6 = Display matrix 6,13
Bit 7 = Display matrix 6,14

Framebuffer[15]:
Bit 0 = Display matrix 7,7
Bit 1 = Display matrix 7,8
Bit 2 = Display matrix 7,9
Bit 3 = Display matrix 7,10
Bit 4 = Display matrix 7,11
Bit 5 = Display matrix 7,12
Bit 6 = Display matrix 7,13
Bit 7 = Display matrix 7,14

Framebuffer[16]:
Bit 0 = "Friday" indicator - right LED
Bit 1 = Not used
Bit 2 = "Saturday" indicator - left LED
Bit 3 = "Saturday" indicator - right LED
Bit 4 = Not used
Bit 5 = "Sunday" indicator - left LED
Bit 6 = "Sunday" indicator - right LED
Bit 7 = Not used

Framebuffer[17]:
Bit 0 = Display matrix 1,15
Bit 1 = Display matrix 1,16
Bit 2 = Display matrix 1,17
Bit 3 = Display matrix 1,18
Bit 4 = Display matrix 1,19
Bit 5 = Display matrix 1,20
Bit 6 = Display matrix 1,21
Bit 7 = Display matrix 1,22

Framebuffer[18]:
Bit 0 = Display matrix 2,15
Bit 1 = Display matrix 2,16
Bit 2 = Display matrix 2,17
Bit 3 = Display matrix 2,18

Framebuffer[19]:
Bit 0 = Display matrix 3,15
Bit 1 = Display matrix 3,16
Bit 2 = Display matrix 3,17
Bit 3 = Display matrix 3,18

Bit 4 = Display matrix 2,19
Bit 5 = Display matrix 2,20
Bit 6 = Display matrix 2,21
Bit 7 = Display matrix 2,22

Bit 4 = Display matrix 3,19
Bit 5 = Display matrix 3,20
Bit 6 = Display matrix 3,21
Bit 7 = Display matrix 3,22

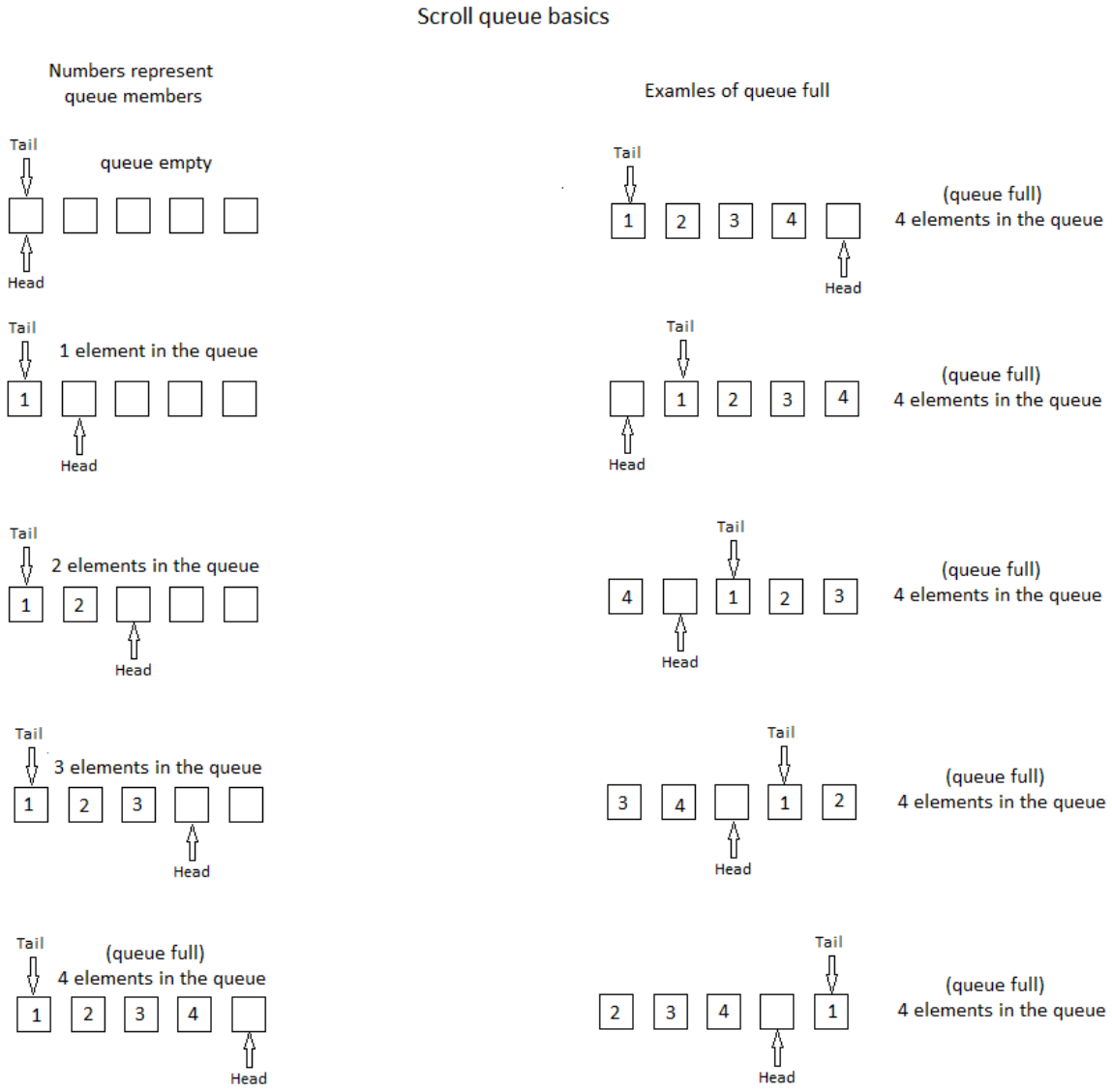
Framebuffer[20]:
Bit 0 = Display matrix 4,15
Bit 1 = Display matrix 4,16
Bit 2 = Display matrix 4,17
Bit 3 = Display matrix 4,18
Bit 4 = Display matrix 4,19
Bit 5 = Display matrix 4,20
Bit 6 = Display matrix 4,21
Bit 7 = Display matrix 4,22

Framebuffer[21]:
Bit 0 = Display matrix 5,15
Bit 1 = Display matrix 5,16
Bit 2 = Display matrix 5,17
Bit 3 = Display matrix 5,18
Bit 4 = Display matrix 5,19
Bit 5 = Display matrix 5,20
Bit 6 = Display matrix 5,21
Bit 7 = Display matrix 5,22

Framebuffer[22]:
Bit 0 = Display matrix 6,15
Bit 1 = Display matrix 6,16
Bit 2 = Display matrix 6,17
Bit 3 = Display matrix 6,18
Bit 4 = Display matrix 6,19
Bit 5 = Display matrix 6,20
Bit 6 = Display matrix 6,21
Bit 7 = Display matrix 6,22

Framebuffer[23]:
Bit 0 = Display matrix 7,15
Bit 1 = Display matrix 7,16
Bit 2 = Display matrix 7,17
Bit 3 = Display matrix 7,18
Bit 4 = Display matrix 7,19
Bit 5 = Display matrix 7,20
Bit 6 = Display matrix 7,21
Bit 7 = Display matrix 7,22

Appendix K – Scroll queue basics



Note: Also applies similarly to “Sound queue”.

Appendix L – Daylight Saving Time setting

While in "Clock setup" mode, when it is time to setup the Daylight Saving Time mode ("ST" for "Saving Time" showing up on clock display), refer to this table to determine what must be the setting to be used for your country.

NOTE: In all cases, the hour shift is 60 minutes (back or forward), except for Australia Lord Howe Islands which 30 minutes.

NOTE: I would appreciate receiving any feedback from users in different countries of the world to confirm if the Green Clock properly supports Daylight Saving Time / Summer Time for their country.

NOTE: For DST setting "5", it is important that UTC setting be properly setup on the clock for automatic DST support.

DST setting	Country / World area	DST start time	DST end time
1	Australia	1st Sunday October, 2h00	1st Sunday April, 3h00
2	Australia Lord Howe Island	1st Sunday October, 2h00	1st Sunday April, 2h00
3	Chile	2nd Saturday September, 0h00	1st Saturday April, 0h00
4	Cuba	2nd Sunday March, 0h00	1st Sunday November, 1h00
5	European Union Akrotin and Dhekelia Albania Andorra Bosnia and Herzegovina Faroe Islands	Last Sunday March, 1h00 UTC	Last Sunday October 1h00 UTC

	Gibraltar Greenland (except Danmarkshavn and Thule Air Base) Guernsey Isle of Man Jersey Kosovo		
6	Israel	Friday before last Sunday March, 2h00	Last Sunday October, 2h00
7	Lebanon	Last Sunday March, 0h00	Last Sunday October, 0h00
8	Moldova	Last Sunday March, 2h00	Last Sunday October, 3h00
9	New Zealand	Last Sunday September, 2h00	1st Sunday April, 2h00
10	Bahamas Bermuda Canada (except Yukon and Saskatchewan) Nunavut Ontario Quebec Greeland (Thule Air Base) Haiti	2nd Sunday March, 2h00	1st Sunday November, 2h00
11	Palestine	Saturday before last Sunday March, 2h00	Saturday before last Sunday October, 2h00
12	Paraguay	1st Sunday October, 0h00	Fourth Sunday March, 0h00

Appendix M – Revision history

Revision history.

Version 1.00	- Initial release from Waveshare
Version 2.00 10-FEB-2022	- Global code reformatting and rework. - Fix a bug allowing "DayOfMonth" to be set to 0. - Fix a bug allowing "DayOfMonth" to go higher than the maximum of 28, 29, 30 or 31 (depending of the month). - Fix a bug and make sure the "count-down" indicator is turned off when count-down timer reaches 00m00s. - Fix a bug when the clock is set for 12-hours time display and is displaying 00h00 AM instead of 12h00 AM. - Add a "test section" to put many chunks of code for testing and debugging purposes. - Add "FRENCH" option so that the date can be displayed in the corresponding format (compile-time option). (It will be easy to add other languages if the programmer makes a search for "ENGLISH" and / of "FRENCH" in the source code... ...and assuming the characters used are standard ASCII characters, similar to English). - Implement 5 X 7 character set with variable character width. - Implement a reverse_bits() function allowing the bitmap of the 5 X 7 characters to be more intuitively defined. - Add a generic "scroll_string()" function and a fill_display_buffer_5X7() function to easily handle 5 X 7 characters. - Change the name of many functions to make them more representative of what these functions do. - Make the scroll_string() function so that it can accept a string longer than what can be handled by the framebuffer. The function will wait until the framebuffer get some free space to transfer next chunk of the string. - Add a specific section at the top of the source code to select many default clock options at compile time. - Implement different tone types with different number of tones and duration for different events. (Note: Tone frequency can't be changed since the oscillator is integrated into the clock piezo). - Clock display will blink the two center dots according to the number of seconds passed since the last minute change. - Add automatic handling of "Daylight Saving Time" for most northern hemisphere countries. (Provision has been made to add different algorithms of daylight saving time for other areas of the world). - Add a new option for hourly chime. It may be On, Off, or "Day" (that is: OI for "On, Intermittent"). If set to "Day", chime will sound only during day hours, as defined between CHIME_TIME_ON and CHIME_TIME_OFF that can be set during clock setup. (They are set to 9h00 and 21h00 by default). - When Hourly chime is set to “Day”, only the left LED will be On in the “Hourly chime” indicator, so that user knows what is the setting. - Add an option in the clock setup to configure the Chime Time On and Chime Time Off. - Add handling of "Calendar events" that can be added by user at compile time. During the specified day of the year,

	the string defined by the user will scroll on the screen twice an hour, at xxh05 and xxh35. Moreover, a special sound will be heard when the message start scrolling during daytime as defined between CHIME_TIME_ON and CHIME_TIME_OFF.
Version 3.00 24-MAR-2022	- More code rework and optimization. - When powering up the clock, replace DST = 0xFF (hex value) by "DST = On" (and replace "DST = 0x00" by "DST = Off"). Will display “None” if daylight saving time has been set to Off (no support). - Add logic for 2 different "repeat counts" for sounds, to add versatility and more possibilities for different sound codes. - Day-of-month will change automatically if it becomes out-of-bound while setting up current month (for example, day-of-month will change automatically from 31 to 28 while we change month from 3 (March) to 2 (February). - Add suffix to day-of-month when scrolling the date in English (will now display "...March 31st..."). - Setting Chime time on and Chime time off now comply with 12 or 24-hours time format current setting. - Fix a bug allowing Hourly Chime to sound one hour later than Chime time off. - Fix a bug allowing Hourly Chime to sound sometimes while doing clock setup. - Setting alarms now comply with 12 or 24-hours time format current setting. - To help knowing which alarm is On (0 or 1), when Alarm 0 is On, Left Alarm LED is On in the alarm indicator and when Alarm 1 is On, Right Alarm LED is On in the indicator. NOTE: On power up, both alarms are set to OFF (this is also true in case of power failure), since there is no backed-up RAM available in the RTC IC to save such variables in case of power failure. - Change the logic so that each alarm (0 and 1) is now checked individually in the RTC IC. - Add the logic for each alarm (0 and 1) to have a distinct (different) alarm sound. - When setting up alarms, current alarm parameters saved in RTC IC are now proposed to user as default values. NOTE: As mentioned above, alarm status (On or Off) is lost on power failure (and will restart as Off), but other alarm parameters (Hour, Minute, Day-of-week) are kept in RTC IC with battery back-up. - Now blink the day-of-week while setting up day-of-week in alarm setup. - Language selection is now a run-time option. English and French are the available languages for now. - Hourly chime: add logic for "nighttime workers". If Chime time on is greater than Chime time off (as opposed to what we would normally expect), we assume that we want sounds to be heard during nighttime and not heard during daytime. Hourly chime will then sounds after Chime time on (in the evening) and before Chime time off (in the morning). - Add support for DHT22 (humidity and temperature sensor - compile time option). To implement this option, it must be "#define" in the code, and a 3-wire cable must be installed between GPIO 8 VSYS and GND, and a DHT22 can be installed outdoor. - Add Daylight saving time as run-time parameter. User can now select 0 (no support for DST) or 1 (North-America-like DST support). - Add changes already made by David Ruck to fine tune auto brightness. - When time display format is H12 (12-hours format), do not print a leading 0 to Hour, to comply with the standard.
Version 4.00 19-APR-2022	- Some code optimization. - Major cleanup in the "setup flags" to make it more straightforward to add options to the clock setup. - Transferred "Temperature unit" setup to the list of clock parameters setup.

	- Transferred "Auto-brightness" setup to the list of clock parameters setup. (NOTE: A copy of the "auto-brightness" function code has been left on the "bottom button quick press" for faster access if required). - Implement new "Night light" feature: use the two white LEDs inside the clock as a night light. It can be turned On, Off, OI ("On, Intermittent" - see Hourly chime for explanation about "OI" setting), or AU ("Auto"). - Since temperature unit setting is now transferred in the general clock setup, "Up" (middle) button quick press will now scroll on clock display the outside temperature and humidity if user has installed a DHT22. White LEDs will also blink on clock side. - To be more deterministic, instead of scrolling the date every xxx seconds, scrolling will now occurs when reaching an integer number of times the period specified. So, if we scroll the date every 5 minutes, scrolling will occur at xh00, xh05, xh10, xh15 and so on. This way, we know how long we have to wait until next scroll. - Add support for a remote control (see User guide for details). Infrared sensor must be bought by user to enable this option. - Time checking of calendar events has been changed from xxh05 and xxh35 to xxh14 and xxh44. Those values are unlikely to be a multiple integer value of the time period to display date and then, those two actions (date display and calendar events) will not interfere with one another. - Implement many functions that are accessible only with remote control (see User's guide for details): - Emulate the three clock buttons on the remote control so that we can achieve a similar behavior remotely. - Fix a problem in reading VSYS (power supply voltage). - Add some pixel twinkling when software starts (just for fun...) - Add column-by-column LED matrix test to make it easy to see if all LEDs work fine. Idem for all clock display indicators. - Add firmware support for an optional passive piezo so that sound frequency may be changed / modulated by software. PWM has been selected to drive the passive piezo. If we would use a completely "software" oscillator, we would hear hiccups in the sound when the other ISR / callback functions would run (this processing would interfere with the regularity of the sound). Similar to the scroll queue, a sound queue (circular buffer) has been implemented to handle the sounds of the passive piezo. - Add the structure member "Jingle" to the calendar Event structure. If it is not null, it identifies a jingle (quick music) that will play when the calendar event is scrolled on the display. (For example, we could ask to play "Jingle bell", along with the message "Merry Christmas" for December 25th. (NOTE: Passive piezo must have been installed by user to support this option). - Add Pico internal temperature display (compliant to the temperature unit - C or F - that has been selected for other temperatures). - Add programmable "silence period" to temporarily turn off hourly chime and calendar event sounds (available with remote control). - Add "dice rolling" to randomly display 2 dice values (from 1 to 6) on display (available with remote control). - Modify get_ads1015() function so that light value returned is intuitive: higher number means more light. Auto-brightness and automatic night-light functions have been modified accordingly.
Version 5.00 27-JUL-2022	- Uncomment matrix_test() and pixel_twinkling() in power-up sequence that were left mistakenly commented-out in release 4.00. - Add scrolling of firmware version number during power-up sequence and in display function. - Scroll Pico's "unique number" ("serial number") during power-up sequence and in display function. - When hour changes (from xh59 to xh00), date scrolling will now begin only 5 seconds later to let the time to look at the clock display to see current time

	when we hear the hourly chime. This is true only from xh59 to xh00 and not for other integer number of times the specified period (for example from xh04 to yh05 if date scrolling period is set to 5 minutes). - Command "Display auto-bright" (with remote control generic display): fix the logic for French message. - Modify the logic behind "automatic night light". There is now a "twilight" period during which the night light status does not change. This is to prevent a period of "On/Off" toggling when light level is just around the value to change night light status. - Modify the logic behind "clock auto-light" (or automatic brightness), so that clock display does not dim at all when ambient light intensity is high enough. - Also, slow down the frequency for reading ambient light (from one second to five seconds). Auto-brightness Will now take a few seconds to react when changed with remote control. - Adjust / change the ambient light levels for clock display dim intensities. - Since the auto-brightness of the clock display has been fine-tuned, the default configuration when the clock is powered on is now auto-brightness ON. - Add UART configuration to allow sending data to a VT101-type monitor connected to Pico's uart1. >>> NOTE: be careful to adjust voltage logic levels before connecting an external monitor. NOTE: see user guide on how to receive and display data from a Pico to a PC screen through USB port. - Improve / optimize the logic of the sound circular buffer and sound related functions for passive buzzer. - Add support for BME280 sensor (temperature, humidity and barometric pressure). The BME280 uses the same I2C channel as the DS3231 real-time clock. - Add calculation of approximate altitude based on barometric pressure. After a few tries, it has been commented out since it changes with pressure variations and it appears to be not very accurate. - If a BME280 has been installed, scroll "device ID" and device "unique ID" on clock power-up. - Rework algorithm of LED matrix automatic brightness and add more brightness levels.
Version 6.00 15-OCT-2022	- Add Pico's flash memory read, write and erase functions. - Add CRC16 function to calculate the cyclic redundancy checksum of an array of characters (using the 0x1021 polynom). - Add algorithms to save Green Clock configuration to flash memory and restore it when required. - Improve the "degree" symbol for Celsius and Fahrenheit. Thanks to Eric Escolano for proposing this improvement. - Fix a few "compile bugs" when some features are turned Off (remote control, DHT22, BME280, etc...). Thanks to "pjbroad" and "maxromanovsky" on GitHub for bringing this to my attention. - Add a "QUICK_START" compile option to easily allow skipping parts of the power-up sequence if so desired. - Change debug output from UART1 to UART0 for easier transfer to a PC through USB CDC interface. - Add a system idle monitor to get an idea of the load on the microcontroller. - Add a sound queue for the active buzzer (the one integrated with the Pico Green Clock). - Adapt the sound callback function to support both the passive buzzer and the active buzzer. - Implement 9 alarms since we can now save them in flash. Alarm algorithm has been completely reworked - Optimize sound algorithm throughout the code by using the sound active queue. - Tried to improve the DHT22 algorithm by replacing the “polling” algorithm by an interrupt-driven function… without success. I’m Still getting more or less 75% read errors. Maybe the Pico is too busy with the callback functions to be able to properly Handle the DHT22. When I have some extra time, I may take a look with a logic analyzer to see what happens. Whatever the case,

	I have 100% communication success (no error at all) with the BME280 device that I use (see User guide for more info).
Version 7.00 16-NOV-2022	- Given all timing problems while trying to read datastream from DHT22, offload that function to Pico's second core (core 1). - Implement two queues for inter-core communications since the SDK documentation recommends not using the fifos for this purpose if at all possible. - Implement a new generic Daylight Saving Time algorithm covering most countries of the world. - Add Universal Time Coordinate to the clock setup and to the flash configuration. It will be required when implementing time update / synchronization via NTP and it also allows to properly handle Daylight Saving Time / Summer Time for those countries who change the time based on UTC. - Add current DST status to flash memory to optimize DST algorithm. - Change algorithm to find DayOfWeek that was sometimes returning an out-of-sync value.