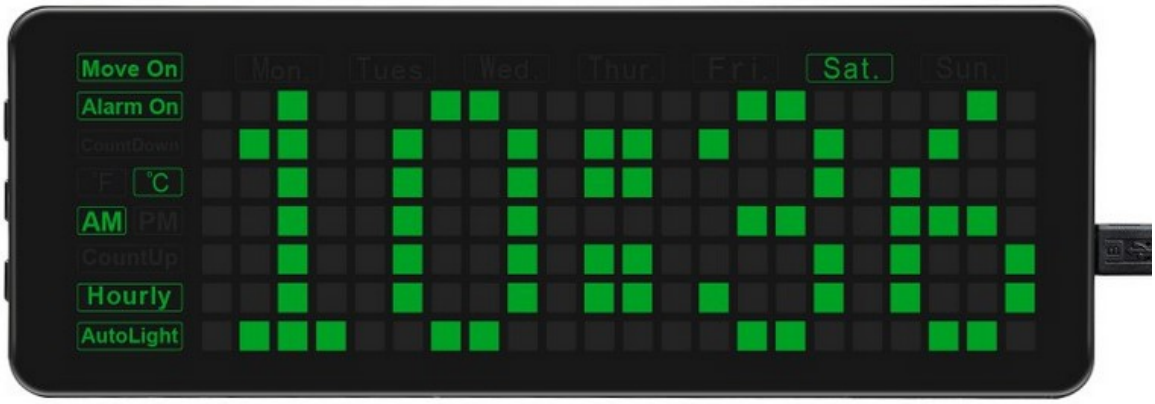
Pico Green Clock



Firmware Version 3.00

User's Guide

Updated April 1st, 2022

IMPORTANT :
This user's guide is about firmware Version 3.00 from Andre St. Louys. Version 3.00 is based on the original Waveshare's Version 1.00 and adds more features to the clock. If you're using the original software from Waveshare, many of the features described in this manual will not apply.

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Introduction

Waveshare Pico Green Clock

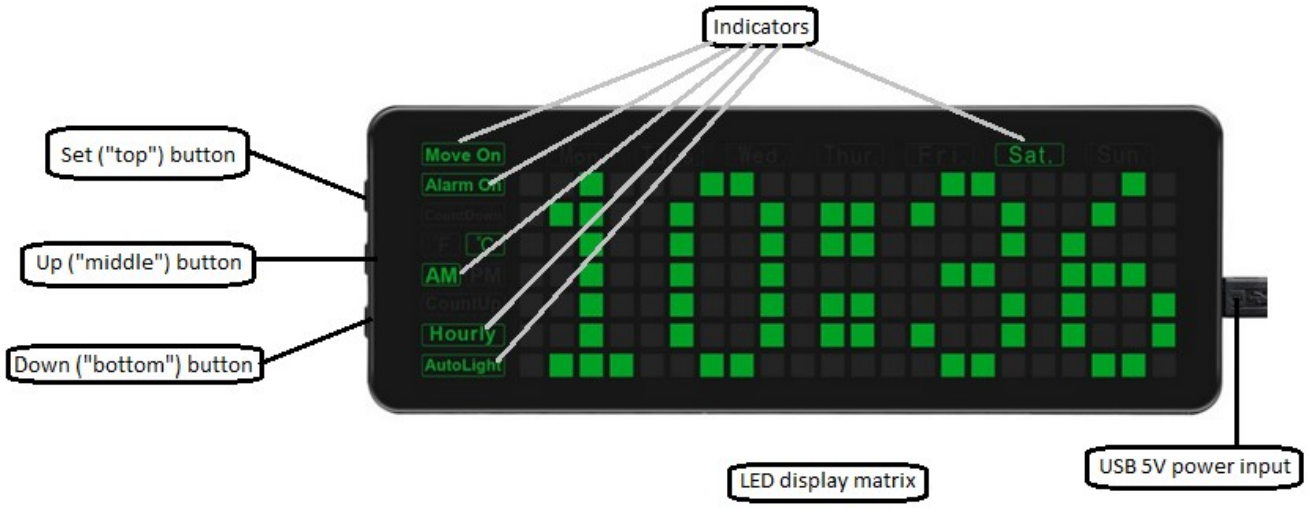
As mentioned on the cover page, this user's guide is about Firmware Version 3.00 from Andre St. Louys. Firmware Version 3.00 is based on original Waveshare's firmware Version 1.00 and adds more features to the clock and tons of comments to the source code which is in C-Language.

The Green Clock uses a Raspberry Pi Pico microcontroller to control most of its functions / features (IMPORTANT: the microcontroller, Raspberry Pi Pico itself is not included with the clock. However, it is relatively cheap – more or less 10 US$). The clock display is made of a matrix of 22 X 7 green LEDs, along with many indicators (for Day-of-week, 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 alarm settings in case of a power failure.

Some of the options / features 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 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") on the Pico microcontroller for the option to be active. 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 to 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 power-on

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

As soon as the power is applied to the clock, it performs its functions.

It will first scroll the Daylight saving time status / mode, power supply voltage and optionally sound cutoff:

- Daylight Saving Time: The clock will display the current daylight saving time (“DST”) status / mode. Three different values are possible for now: “DST = None” means that the clock completely ignores DST. It’s like if DST simply does not exist for the clock. “DST = Off” means that the clock supports DST, but given the current date and time, daylight saving time is not active. Finally, “DST = On” means that the clock supports DST, and given current date and time, daylight saving time is active.
- Power supply voltage: Displays current voltage supplied by the USB power supply. (Strangely, I’ve seen this value changed with the time to reach more than 7 volts at some point. I’m convinced that this is a problem with the “reading” of the voltage - not the power supply itself. Disconnecting and reconnecting the power supply cord fix the problem. Not sure if this a problem with the Pico used during my tests).
- Sound cut-off: There is an option in the code to completely turn off all sounds generated by the clock. I used this feature during the development phase, when some coding sessions continue late during the night, while my wife was sleeping. If “sound cut-off” is scrolled on the clock display at power on, it means that this compile time option is active. No need to try finding a bug with alarms, chime, or anything else !

Clock features

Alarms (run-time)

There are two alarms available on the clock. They can be independently set at a specific time and day of week, and they will sound an alarm when the programmed alarm time is reached.

Auto-brightness (run-time)

The auto-brightness feature allows the clock 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 the guide).

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

Beep types (compile-time)

The piezo integrated in the clock 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, alarm, timer, etc…). However, a feature has been implemented in Version 2.00 of the firmware allowing the making of a different number of "beeps" of different duration. This allows distinguishing between a calendar event, hourly chime, button keyclick, etc…

In version 3.00 this feature has been improved to another level by adding the concept of a "sound pack" (a primary group of sounds) and a repeat count for this "sound pack". More on this later.

Calendar events (compile-time)

The user can define short strings of text (40 characters maximum) to 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 with the text associated. Up to 50 such calendar events may be programmed and more than one may be programmed for a specific day. However, it must be understood that it takes some time to scroll the strings

on the clock display. If there are too many events defined for the same day, there is a risk that the audience will miss part of them.

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 the Pico). The text will scroll at xxh05 and xxh35 of each hour all day long (that is, every half hour), and a few warning beeps will also sound during daytime, as defined between "chime on time" and "chime off time" (set by default from 9h00 to 21h00).

A few of these calendar events have been programmed by default to show the user how to program others is 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). 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 (with no respect to "chime on time" and "chime off time").

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 the 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 and power supply voltage on the display at a predefined frequency (currently every 3 minutes, which is a compile time parameter) (see section "Date scrolling" on clock setup later in the guide).

With firmware Version 2.00, the date, temperature and voltage are displayed as in "Friday July 6 2022 21.25'c 4.82 Volts" (the temperature and power supply voltage are shown after the date). The letters are made of 5 X 7 character matrix (variable-width).

Version 3.00 adds the suffix to the day (in the previous example: "…July 6th…". The support for external reading of temperature an humidity is also an option when adding a DHT22 sensor (not supplied with the Green Clock itself). See section on DHT22 support later in the guide.

Daylight saving time (run-time)

The firmware automatically supports the Daylight Saving Time for most northern hemisphere countries. This feature can be turned off, or other type of time change (for other countries) can be easily implemented as run-time options.

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

"North America" is the DST algorithm currently supported. It also corresponds to most northern hemisphere countries DST scheme. The second Sunday of March at 2h00 in the morning, the time will automatically go forward by one hour. In a similar way, the time will go back by one hour at 2h00 in the morning on the first Sunday of November.

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 alarms to sound during the night, when people are sleeping.

There is also the support for "nighttime workers" where the sounds are heard 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 in other clocks.

Double dots blinking

There are two “dots” in the middle of the clock, between the hours and the minutes (see picture above in the Introduction). Note that firmware since Version 2.00 uses “slim” dots, as opposed to what can be seen on the picture.

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

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 xxh00, an hourly chime will sound to indicate that the hour just changed. This feature can be configured: On, Off, or Daytime. If configured for “Daytime”, the hourly chime will sound only during predefined hours (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”, only the left LED behind the “Hourly” indicator will be turned On. It is not easy to see the difference between full-on and only left-on and it will take some practice for the user to make the difference.

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 pressed has been processed by the clock (see section on clock setup later in the 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 has been made the default in Version 2.00.

Power supply voltage display (run-time)

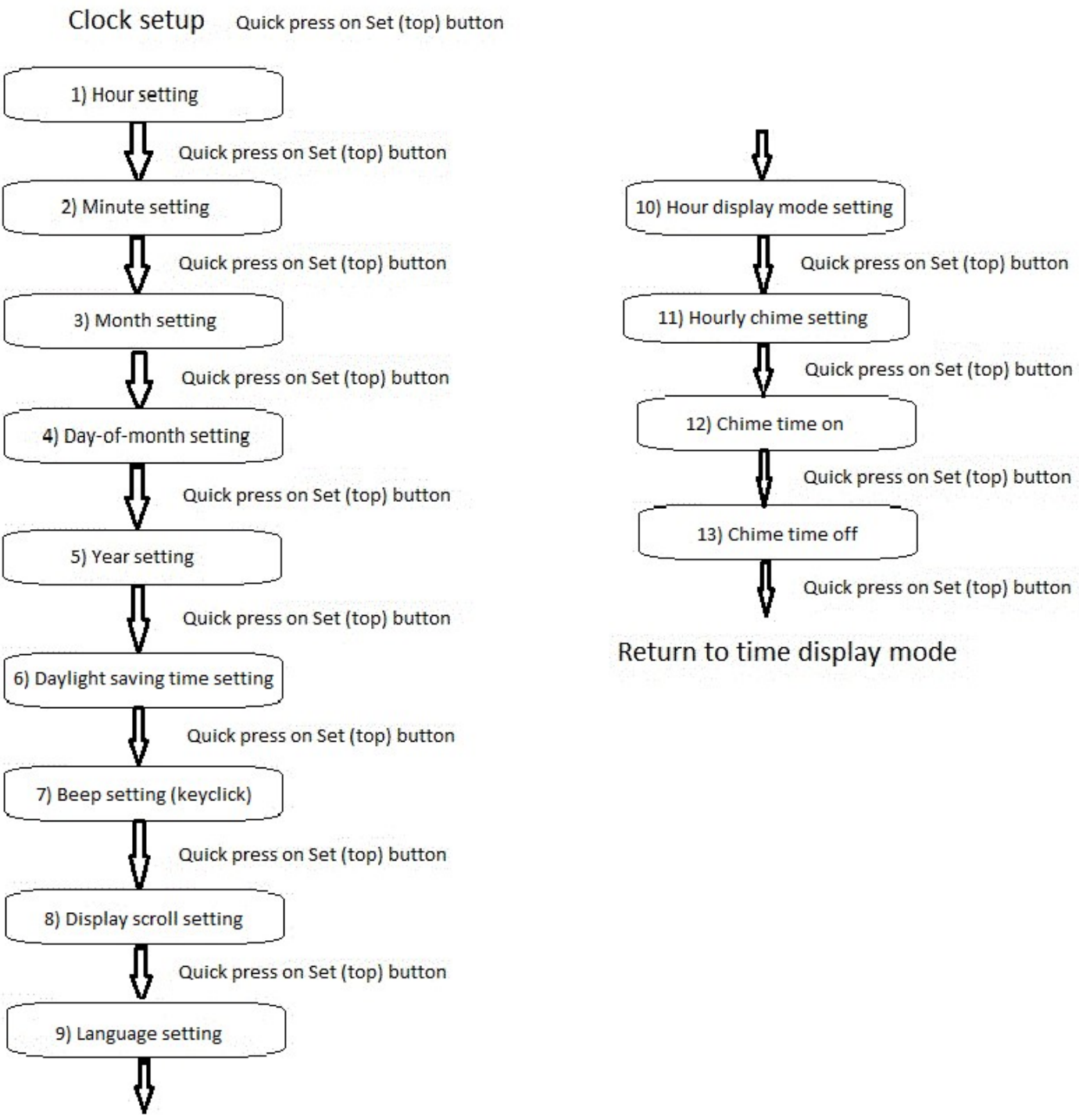
If the display scroll is enabled (see section “Display scroll” on clock setup later in the guide), then the actual power supply voltage value will scroll on the display after the date and temperature.

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).

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 proceed with settings.
- The Middle button is called “Up” button since it is primarily used to increase values (like hour setting, minute setting, etc).
- The Bottom button is called “Down” button since it is primarily used to decrease values (like hour setting, minute setting, 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). In some cases, 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 the 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 go 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 paragraph), or you can press the “Set” (top) button one more time when reaching the last setup step to return to the time display mode. You can also 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 (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.

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 mode” (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 and the seconds will start from zero. 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 and the seconds will start from zero.

3) Month setting

NOTE: Given the difference in the date format between French and English, note that the sequence for setting the month and the day-of-month are 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.

The day-of-month may be automatically changed 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, note that the sequence for setting the month and the day-of-month are 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.

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.

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 we would expect. However, if there is a power outage, when the power goes back on, the high part of the year (first two digits) will revert to “20”. (Which shouldn’t a problem, except if you plan to install the Pico Green Clock in the next Electric De Lorean to go back in 1845 or forward in 2187 !!).

6) Daylight Saving Time (DST)

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

“ST” (for “saving 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).

Value “1” means that the clock support DST, following the North America standard (which is also compliant to most northern hemisphere countries). The second Sunday of March at 2h00 in the morning, the time will automatically go forward by one hour. In a similar way, the time will go back by one hour at 2h00 in the morning on the first Sunday of November. If ever there is a power failure between 2h00 and 3h00 in the morning the night the DST changes, the clock may be wrong in guessing DST setting. Re-starting the clock a few hours later will fix the problem.

7) Beep setting (keyclick)

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

8) 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 3 minutes. (The setting can be “ON” or “OFF”. Changing the 3 minutes frequency is a compile-time option).

9) 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

More languages should be easily added in the code. If ever we reach a point where the firmware grows to big to fit in Pico’s memory, this is an option that could be transferred to compile-time instead of run-time.

Language setting is mostly useful when scrolling the date on the display where day-of-week and month are displayed in the selected language. In some other occasions, language is also useful to comply with user language.

10) Hour display mode setting

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

11) Hourly chime setting

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

“HC” (for “hourly chime”) will be displayed on the clock, along with the value “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 configurations 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 version 3.00 adds support for “nighttime workers”. We assume that it is possible, in some cases, that we want the 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 normally expect), we assume that we want the sound to be heard *after* the Chime time on and *before* the Chime time off.

NOTE: In case of power outage, Hourly chime setting will revert to compile-time setting.

12) Chime time on

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 on time”) 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 the next paragraph. Note that the sound for the calendar events also complies 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) for the Chime time on setting to take effect. Also, in case of a power failure, Chime time on and Chime time off will revert to their default values (respectively 9h00 and 21h00 – 10h00 PM).

NOTE: In case of power outage, Chime time on setting will revert to compile-time setting.

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.

13) Chime time off

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 off time is 21h00 (10h00 PM).

The chime time off is the last time at which the hourly chime will sound during the day. See also the chime on time in the previous paragraph. Note that the sound for the calendar events also complies 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) for the Chime time off setting to take effect. Also, in case of a power failure, Chime time on and Chime time off will revert to their default values (respectively 9h00 and 21h00 – 10h00 PM).

So, for example, if you set the chime time on at 8h00 in the morning and the chime time off to 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 sound 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: In case of power outage, Chime time off setting will revert to compile-time setting.

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.

Alarm setup

About alarm setup

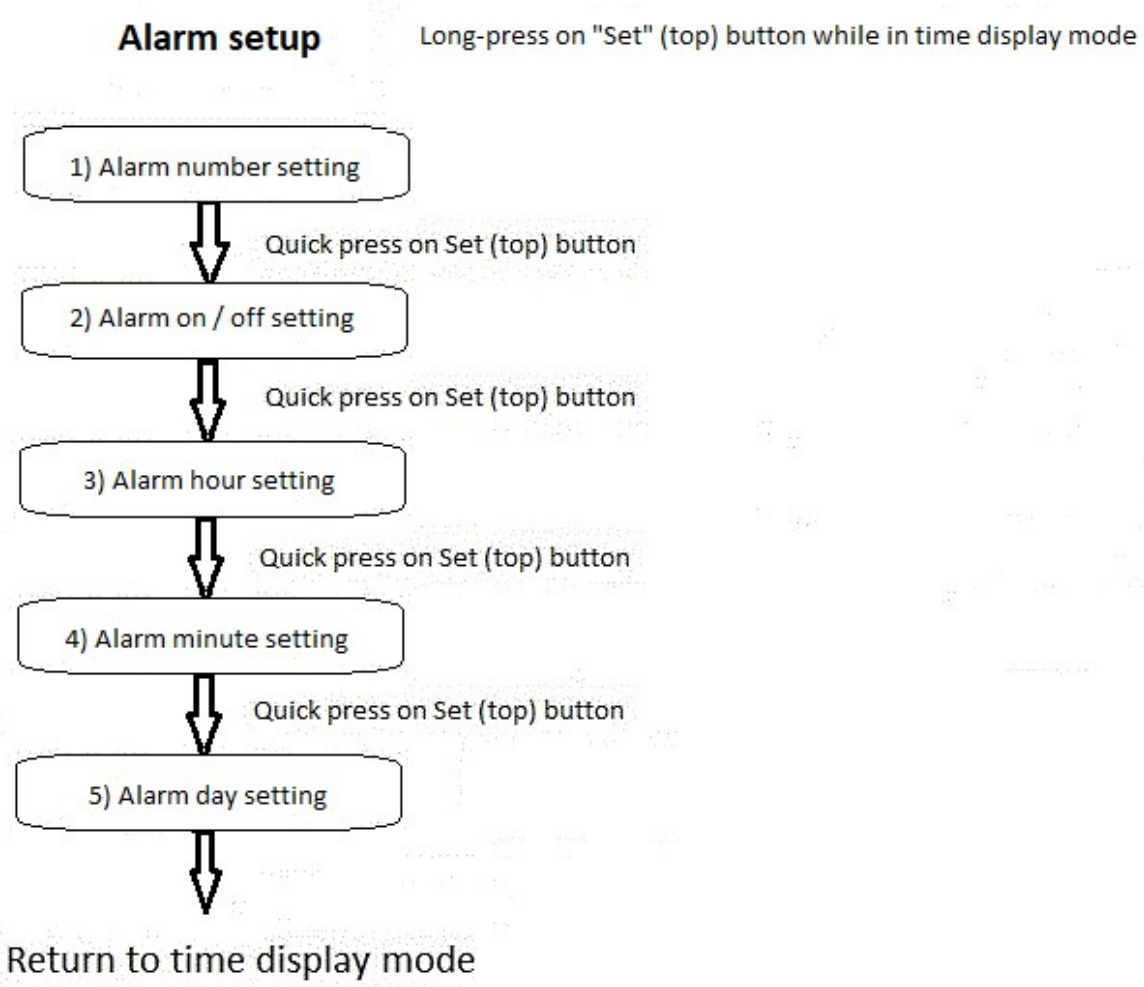
There are two independent alarms that can be set on the Waveshare Green Clock (Alarm 1 and Alarm 2).

Alarm parameters (Hour, Minute, Day-of-week) are kept in the Real-time-clock integrated circuit ("RTC IC"). So, they will still be remembered by the system in case of restart and / or power failure. However, alarm status ("On" or "Off") is not battery backed-up. In case of restart / power failure, alarm status for both alarms will be reset to "Off".

If some alarm parameters are set (that is: hour, minute and day-of-week), but the On / Off setting remains to Off, the parameters will not be saved in the RTC IC. In other words, an alarm is saved in the RTC IC only when it is set to "On".

When an alarm (1 or 2) is On and the configured hour, minute and day-of-week is reached, an alarm sound will be heard. Alarm sound is independently defined in the code (compile-time parameter) and may be different for alarm 1 and alarm 2. Also, alarm sound does not comply with Hourly chime setup. 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 display when the clock is powered on.



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 on 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), or you can press the “Set” (top) button one more time when reaching the last setup step to return to the time display mode. You can also make a “long press” (longer that one third of a second) on the “Down” (bottom) button to exit alarm setup mode at any time.

Alarm setup timeout

If you leave the clock unattended for more than 20 seconds (compile-time option), it will return to the 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 or the “Down” (bottom) button to alternate between alarm number 1 and alarm number 2 (as mentioned earlier in the manual, there are two independent alarms available in the Waveshare Green Clock).

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

NOTE: Alarm numbers are 1 and 2 for the clock user, to be more “human-like”. However, when working on the source code, alarm numbers are 0 and 1 respectively.

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.

Once the alarm number (1 or 2) 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 will blink on the display until the user presses the “Set” (top) button to select the choice displayed and to proceed with next step.

In a way similar to the Hourly chime “Daytime” setting, when alarm number 1 is on, the left LED in the alarm indicator will turn on. When alarm number 2 is on, the right LED in the alarm indicator will turn on. It may take some practice to be able to see the difference between left LED on, right LED on, or both LEDs on.

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.

While the current alarm hour blinks on the display, press the “Up” (middle) button to increase the proposed hour, or the “Down” (bottom) button to decrease the proposed hour. The display will comply with current “Display mode 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.

While the current alarm minute blinks on the display, press the “Up” (middle) button to increase the proposed minute, or the “Down” (bottom) button to decrease the proposed minute.

5) Alarm day setting

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

At this point, you can select the day-of week for the selected alarm. The proposed day-of-week indicator will blink on the clock display. Press the “Up” (middle) button to go to the next day-of-week, or the “Down” (bottom) button to go to the previous day-of-week.

Then make a quick press on the “Set” (top) button to return to the time display mode. If the selected alarm status has been turned On, the alarm indicator on the clock display (left LED and / or right LED) will have been turned on and the alarm parameters will have been saved in the RTC IC.

Timer setup

About timer setup

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

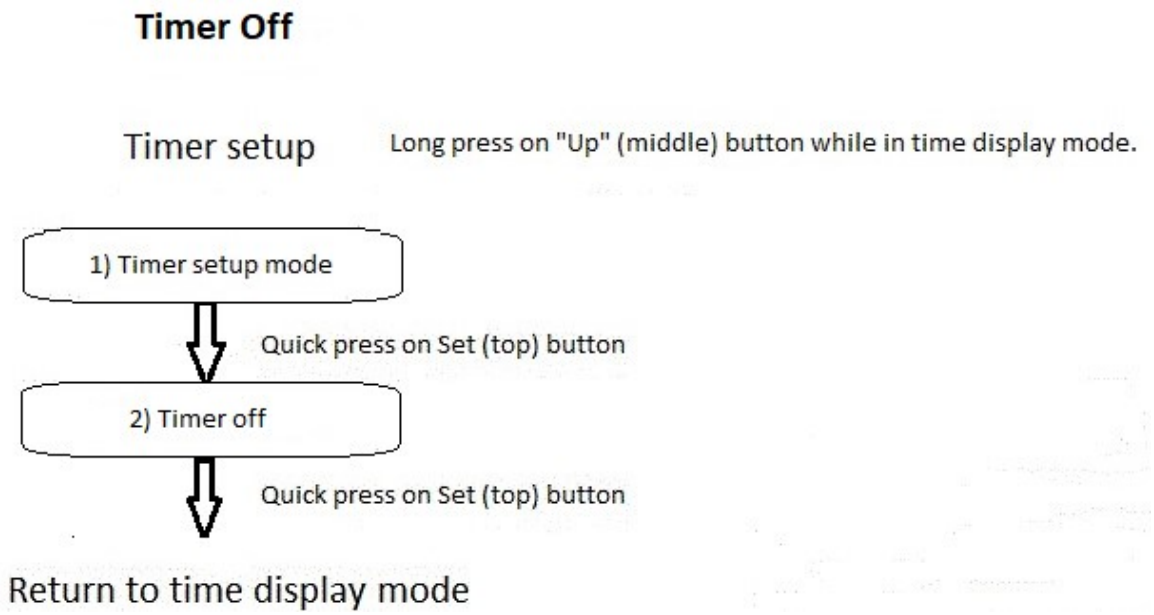
When used for “count-up”, it is different since we logically expect a count-up timer to start from zero. So, when started, the count-up timer begins counting up from zero until it is stopped by the user. There is no alarm associated with the count-up timer.

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.

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 “Hour” is set, then the “Minute” but the Set (“Top”) button is not pressed to start it 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.

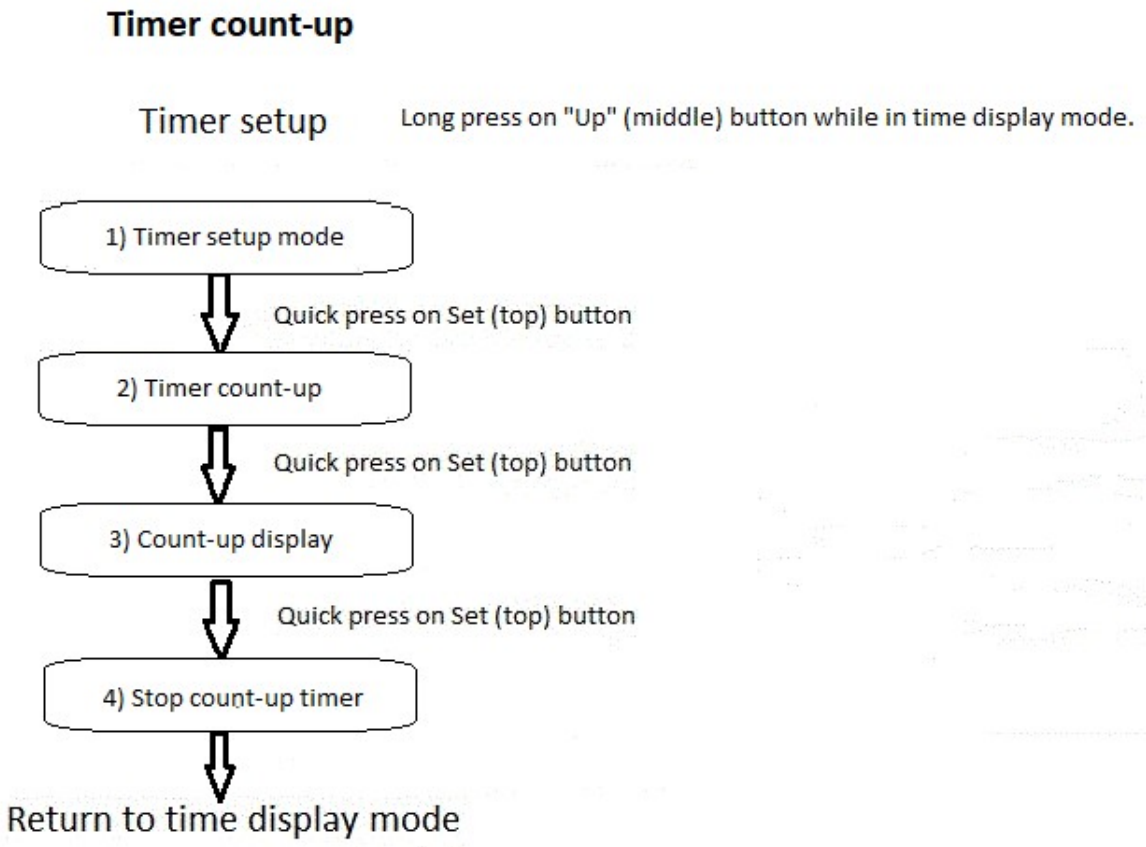
1) To turn off the timer, refer to the diagram above for “Timer off” and proceed as follow. First, make a long press on the “Up” (middle) button to enter the timer setup mode.

   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 while the timer has been turned off.

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 to enter the timer setup mode.

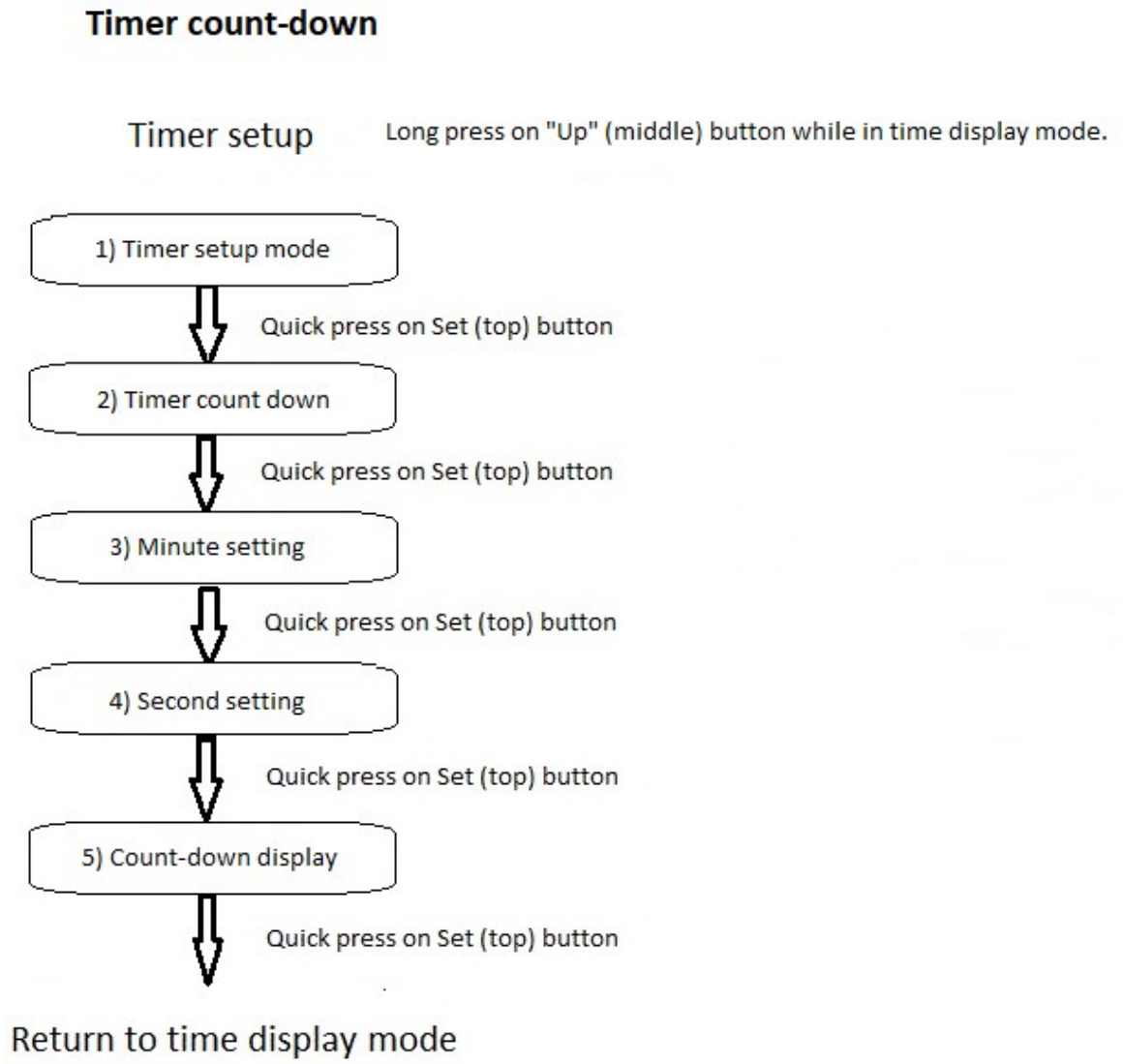
   Then, using the “Up” (middle) or “Down” (bottom) button, press until “UP” (for count-up timer) blinks on the clock display and press on the “Set” (top) bottom to select this choice. Choices are “OF” (for off), “DN” (for count-down timer), or “UP” (for count-up timer). The corresponding indicator on the 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. At this point, 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 reaching zero minute and zero seconds.

5) At this point, you can leave the clock like this to see the count-down actual value at any time. When reaching zero, an 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. 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 reach zero. The “count-down” indicator on the clock display will turn off when the count-down is over.

   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 chime defined hours.

Timer setup

Other setup

1) Temperature unit

To change the temperature display from Celsius to Fahrenheit (or vice-versa), press the "Up" (middle) button on the clock, while in time display mode. The indicator will toggle between Celsius and Fahrenheit.

2) Clock display brightness

There are two different settings available for the clock display brightness: Full brightness and Automatic brightness.

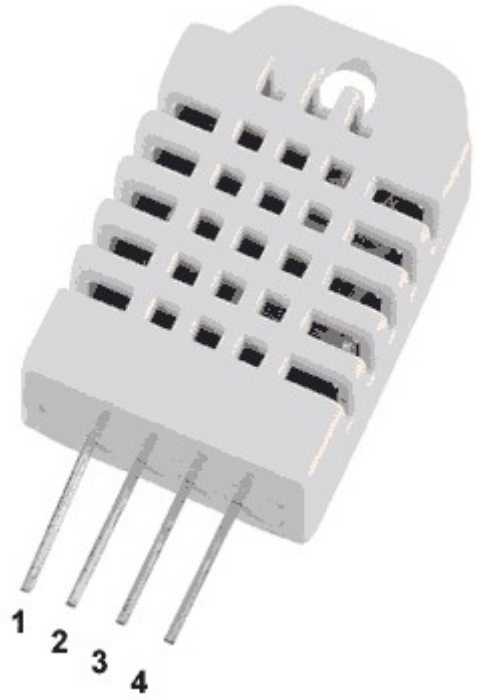
When the setting is set to "automatic brightness", the display will be in full brightness mode when the ambient light is bright and the clock display will become dim when the ambient light becomes darker.

To toggle the setting, make a quick press on the "Down" (bottom) button while in time display mode. When in "Automatic brightness", the corresponding indicator ("Auto light") will turn on, on the clock display.

Thanks to David Ruck for his modification to auto-brightness. I replicated David's change in the code which allows more "fine tune" in clock brightness and allows the display to become "very dim" when the ambient light is dark. (I also used his modification to improve the digit "7" in the 4 X 7 format).

DHT22 support

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



The conditional compile option "DHT_SUPPORT" must be defined in 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 include the code. A few time-out's have been integrated in the code, so that the clock will continue working without problem. Since the delay of the time-out'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. (NOTE: DHT22 timing reference is given in Appendix B).

I did install the DHT22 on Pico's gpio #8. A three conductor cable is required for VCC, Ground, and data.

A hole must be drilled in the clock plastic case to get the cable out of the circuit. On each side of the Pico, there is an extra header in which the cable conductors may be easily inserted (if the cable size is selected accordingly).

Firmware

This section gives general information about different subjects related to the source code and will be of interest for 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 the Index of this document).

Alarm numbers

It has been seen in the user guide that two different alarm numbers are available. They have been numbered 1 and 2 to be more "natural" or "human-like" for the clock user. However, in the code, these alarms are numbered 0 and 1.

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. So, the 4 X 7 character 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 three elements:

1) A day-of-month (from 1 to 31).
2) A month (from 1 to 12).
3) 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), twice an hour, at xxh05 and xxh35. Time has been specifically chosen so that it will not interfere with the hourly chime (every xxh00).

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 entered, 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 base 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).

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 to better represent what they do. Also, even if most modern integrated development environment proposed tools to easily navigate through the code, all functions have been sorted in alphabetical order. There is no “one standard”, but the one I use has been spreaded through the code: function name all in lowercase with an underscore to isolate token, variable name capitalized, etc…

Variable names have also been sorted in alphabetical order.

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". Also, before making an official release, I always scan all "***" and "///" to clean the code of extra and useless pieces of code. However, since the Pico Green Clock is something that more 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 the clock display at run-time for those without other debugging tool (serial monitor, USB display, etc…)

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 add new features to the clock or proceed with more tests.

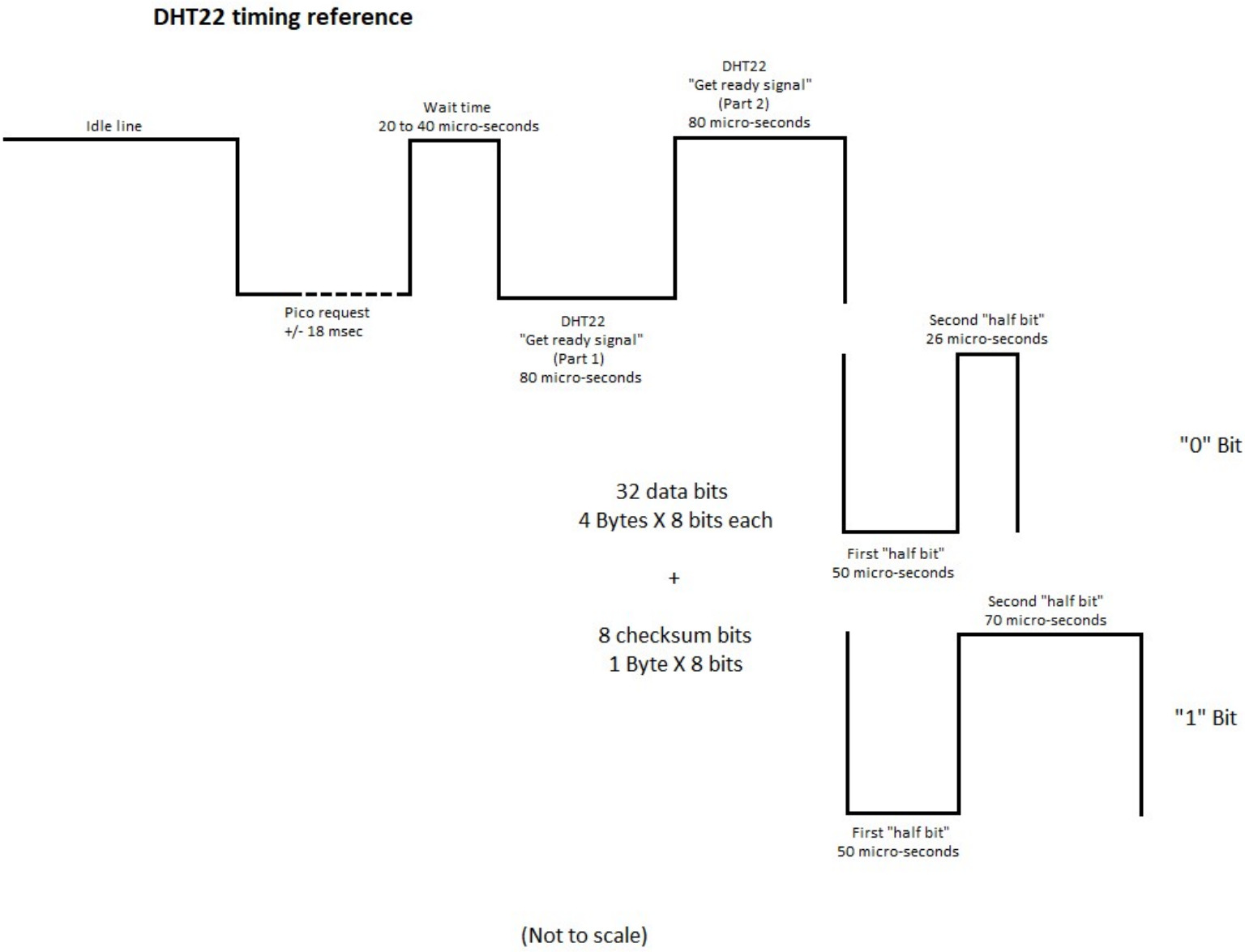
Those chunks of test code must be considered as such: test code ! It should help you with the implementation of new functions / features, but it must NOT be considered as "debugged" and "fool-proof" code ! Use it at your own risk and effort !

Appendix A – GPIO used in the Waveshare Green Clock

List of GPIOs used in the Waveshare Green Clock:

GPIO number	Direction / Usage	Description
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)
GPIO 7	(I2C) SCL	(Temperature reading)
GPIO 8	Custom protocol	DHT22 (added... not on the original Green Clock)
GPIO 9		Not used
GPIO 10	(Out)	CLK (LED matrix controler)
GPIO 11	(Out)	SDI (LED matrix controler)
GPIO 12	(Out)	LE
GPIO 13	(Out)	OE
GPIO 14	(Out)	Piezo
GPIO 15	(In)	"Down" (Bottom) button
GPIO 16	(Out)	A0 (LED matrix brightness control)
GPIO 17	(In)	"Up" (Middle) button
GPIO 18	(Out)	A1 (LED matrix brightness control)
GPIO 19		Not used (Reserved)
GPIO 20		Not used
GPIO 21		Not used
GPIO 22	(Out)	A2 (LED matrix brightness control)
GPIO 23		Used internally for voltage regulation
GPIO 24		Used internally for voltage detection
GPIO 25	(Out)	On-board Pico LED
GPIO 26		ADC0 (Ambient light reading)
GPIO 27		Not used
GPIO 28		Not used
GPIO 29		ADC-Vref (Power supply reading)

Appendix B – DHT22 timing reference



Appendix C – Framebuffer bitmap configuration

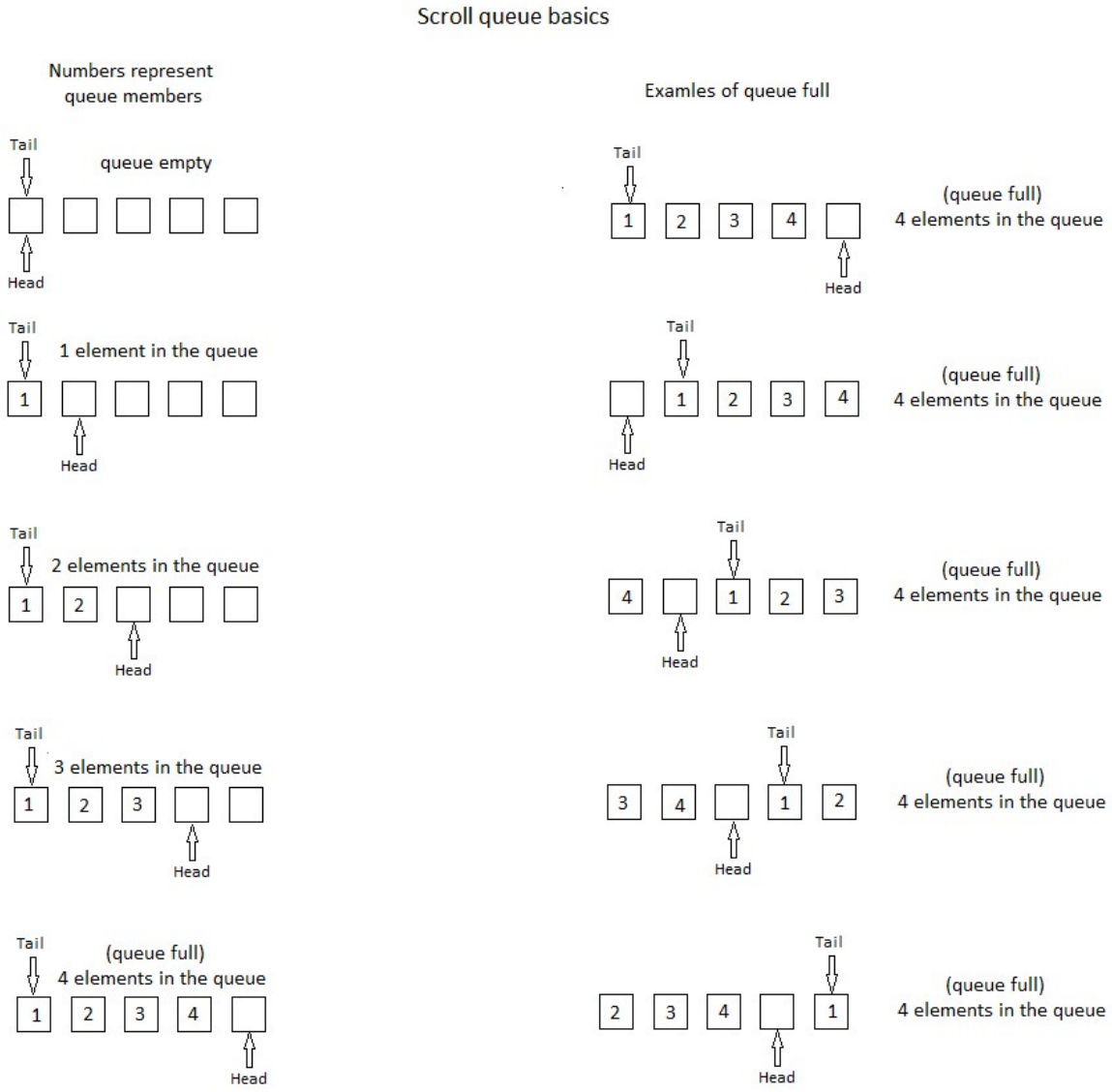
Framebuffer[] bitmap configuration

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 Bit 3 = Not used	Framebuffer[9]: Bit 0 = Display matrix 1,7 Bit 1 = Display matrix 1,8 Bit 2 = Display matrix 1,9 Bit 3 = Display matrix 1,10

Bit 4 = "Thursday" indicator - left LED Bit 5 = "Thursday" indicator - right LED Bit 6 = Not used Bit 7 = "Friday" indicator - left LED	Bit 4 = Display matrix 1,11 Bit 5 = Display matrix 1,12 Bit 6 = Display matrix 1,13 Bit 7 = Display matrix 1,14
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 D – Scroll queue basics



Appendix E – Revision history

Revision history.

	- Initial release from Waveshare
10-FEB-2022 2.00	- 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”, on ly 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.

Appendix E – Revision history

24-MAR-2022 3.00	- 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.