HamClock

Keep track of much more than the time with this Wi-Fi enabled device.

Elwood Downey, WBØOEW

I thought it would be useful to build a desk clock that could show accurate time, geography, time zone, solar activity, sunrise and sunset times, Maidenhead locators, beam heading, Northern California DX Foundation (NCDXF) beacons, news headlines, and other timely information in one small device. Here's how I assembled a 7-inch diagonal thin-film transistor (TFT) touchscreen color display, with a few embedded components to access all that data via Wi-Fi.

HamClock Functions

A cylindrical projection of a color world map dominates the screen in a feature-rich presentation. In Figure 1, you can see the day and night terminator, the projections of the overhead Sun and Moon, the locations of the home (DE) and remote (DX) operators, the antipode of DE, and optionally, the locations and current transmission frequency of the NCDXF propagation beacons. Tap on the touchscreen map to set a new DX location, and hold for a second to set a new DE location.

Screen Details

Two boxes to the left of the map show local time and date, latitude, longitude, Maidenhead grid square, sunrise, and sunset information for the DE (orange) and DX (green) locations. The short-path distance and beam heading from the DE location is shown for the DX location. These color-coded locations are shown on the map. The small orange map symbol drawn as the inverse of the DE symbol is the DE antipode. Whenever a new DX location is tapped on the map, the great circle connecting through DE and DX, the DE antipode is displayed as a white
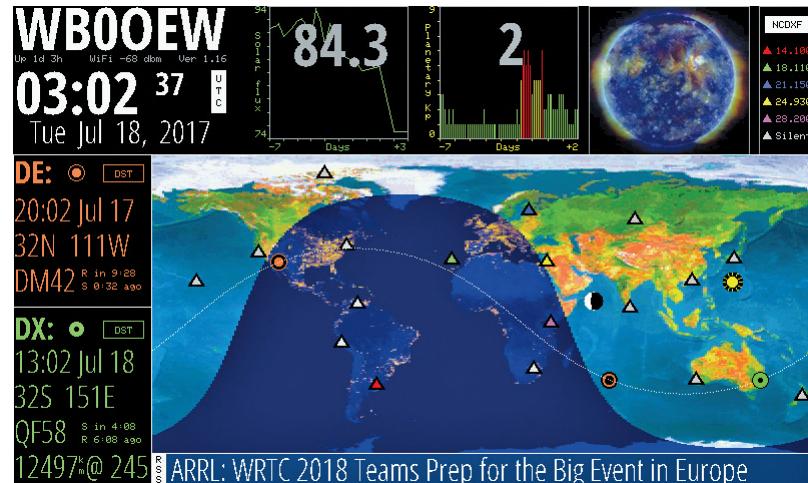

Figure 1 — The screen display of the HamClock.

dotted line. This line automatically disappears after a few moments, to reduce screen clutter.

Fine tune the latitude and longitude of the DX by tapping directly on these numbers. Tap on the upper or lower half of the latitude digits to move the location one degree north or south, and tap on the left or right half of the digits to move the location west or east. Toggle between miles and kilometers by tapping on the DX bearing digits.

Time

The software includes a table of time zones based on a grid spacing of approximately 11 miles. Time zones are determined by government policy, so they may change over time. Always double-check this information. You can manually add 1 hour to the displayed time for DE and DX during daylight saving time. [Daylight saving time start and end times and dates do not necessarily occur on the same date and time around the globe, and the offset might be a fraction of an hour. — *Ed*.]

To save display space, I compressed Sun time information. The first row always suggests a future, and the second row the past. For a station in daylight in late afternoon, the display might read "S in 0:40, R 10:22 ago" where S means "Sets" and R means "Rose." For a station in nighttime approaching dawn, the display might read "R in 0:47, S 10:00 ago." This eliminates dependencies on time zones.

Data Rows

A row of news headlines (collected from your selected website RSS feeds) overlays the bottom of the map. There are five areas at the top section of the display. On the left is your call sign and UTC time. The time remains accurate by using a Network Time Protocol (NTP) connection over Wi-Fi. The software automatically cycles through a list of several stratum-one NTP servers. If the software cannot contact any of the NTP servers, a large question mark will appear to the right of the seconds digits to indicate the time might not be correct.

The main clock need not stay on UTC. You can tap on the upper or lower half of any word or digit to advance or slow the time by that one unit. If the time has been changed in this manner, the UTC button on the right will show all white characters to indicate the time is not UTC. Tap that button to instantly return to UTC. Changing time in this manner causes the map to be redrawn to synchronize all information to that moment. Thus, you can examine the location of the terminator in the past or future, but only between January 1, 1970 and January 19, 2038.

The second area across the top displays plots of recent solar activity. Either solar flux or sunspot number can be toggled by tapping on the plot. The solar flux prediction is plotted 3 days into the future. The sunspot numbers are published starting from the beginning of the current month. For this reason, the sunspot numbers will go back less than 7 days for the first week of each month.

The third area toggles between plots for planetary Kp geomagnetic index and X-ray solar flux. The data is plotted for the previous 7 days and may be toggled by tapping on the plot. The Kp index prediction is plotted 2 days into the future.

The fourth area shows images from the Solar Dynamics Observatory (SDO) and, if the optional sensor is installed, plots of temperature, pressure, and humidity for the past hour. The sensor for these data points can be located in the shack or extended outdoors if desired. Tap on the graph to cycle through the images and plots. If the sensor is not connected, the software displays only the SDO images.

Solar flux is accessed from the Canadian Space Weather Center, of Natural Resources Canada. X-ray and geomagnetic information are from the NOAA/NWS (National Oceanic and Atmospheric Administration/National Weather Service) Space Weather Pre-
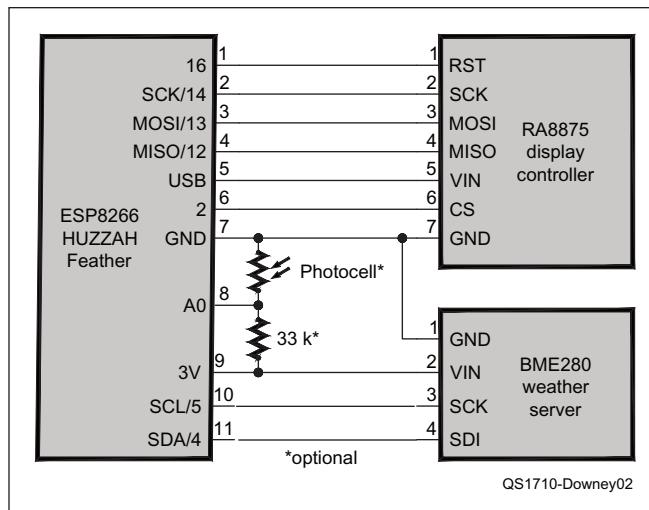

Figure 2 — Wiring diagram of the main HamClock components.

diction Center. Sunspot numbers are accessed from Solar Influences Data Center in Belgium. Solar images are from the SDO. I chose RSS feeds from a wide variety available online.

The area to the far upper right is for the NCDXF HF propagation beacons. The symbols for these beacons may be toggled on or off by tapping on the button labeled NCDXF. When the beacons are on, they are color coded to indicate which frequency they are currently broadcasting, if any. The beacons change frequencies, or go silent, every 10 seconds in a pattern that moves around the globe. These beacon symbols may be removed from the map if they are of no interest.

Construction

I purchased all my hardware for this project from **www.adafruit.com**. Other components may be substituted, but take note of any differences. Table 1

shows a list of my components and the prices I paid. The sensor and stand are optional. Figure 2 shows the simple wiring diagram. If the sensor connection is longer than a few feet, connect the SDA and SCL lines to 3 V with 5.6 kΩ resistors to help deal with the cable capacitance.

Display Controller

The RA8875 display controller relieves the processor from performing display refresh, and adds hardware-assisted drawing primitives. Unfortunately, it is pretty slow to address individual pixels, so drawing the world map and updating overlaid information still takes noticeable time. The backlight for the display can be brightened by closing one or both of the solder bridges on the back of the RA8875 display controller. I found that shorting the 25 mA bridge was sufficient. Shorting the 100 mA bridge draws too much current. The

Table 1
List of HamClock Parts (www.adafruit.com)

Description	Product Number	Approximate Price
Adafruit HUZZAH ESP8266 Wi-Fi system-on-chip	2821	$16
RA8875 display controller	1590	$5
7" TFT display with resistive touch	2354	$48
FPC extension cable and board	2098	$5
Pimoroni Raspberry Pi 7" TFT stand, optional	2033	$15
Photo cell, optional	161	$1
BME280 weather sensor, optional	2652	$20

Figure 3 — The rear of the HamClock shows how the main components are adhered to the back of the bezel and shows the wiring using female-female jumper wires.

HUZZAH USB bridge does not negotiate for higher current, so you must supply about 1 A from a separate 5 V source. The display is very sensitive to small changes in supply voltage, so if the display flickers, check that you have good power connections everywhere.

A Larger Display

A 9-inch diagonal display has about twice the total viewing area of the 7-inch model, but has the same number of pixels. I got one (part number ER-TFTM090-2) from EastRising via **www.buydisplay.com**. I also tried an alternative, smaller Adafruit HUZZAH breakout board, product ID 2471. There are a few minor differences, so please contact me if you are interested in trying these alternatives.

Main Controller

The main controller of the HamClock is the Adafruit HUZZAH ESP8266 Wi-Fi system-on-chip. It includes an 80 MHz 32-bit RISC processor with 1 MB flash memory and 80 KB RAM available for applications after the required Wi-Fi firmware. I developed and loaded firmware for this device using the Arduino IDE. Adafruit has instructions on their HUZZAH support page for adding the ESP toolchain to

this IDE. If you use the optional sensor, install the sensor library.

Powering Up

Upon powering up for the first time, you are asked to calibrate the touchscreen, enter Wi-Fi credentials, and your call sign. These can also be changed later if desired. Next, a splash screen displays your call sign in a rainbow of colors and the Wi-Fi attempts to connect with the designated access point. After these preliminaries are over, the screen renders the main display.

The HamClock attempts to connect to Wi-Fi when first powered up. If it fails to connect, the map will continue to function, but the time sync and data plots will not be available. In this case, you could manually set UTC time. The HamClock automatically retries websites and Wi-Fi as required.

Add automatic brightness control by connecting an optional photocell to the analog input of the ESP8266 (see Figure 2). To calibrate the brightness, tap the upper or lower portion of the NCDXF frequency list to set the desired display brightness in a darkened room. Then turn on the room lights and repeat for the desired brightness in a well-lit room. You can also

manually control brightness without the photocell.

Software

My software for this project is available on the *QST* in Depth web page, at **www.arrl.org/qst-in-depth**. Also, be sure to check for any last-minute updates or changes on my web page for this project, **www.clearsky institute.com/ham/HamClock**.

You might wish to edit the list of RSS feeds in my software in the "rss feeds [ ]" array near the top of the "Wi-Fi.cpp" file, or make the array empty to disable RSS feeds. You can now proceed to compile and load the firmware.

Packaging

I packaged my 7-inch HamClock in the Adafruit Raspberry Pi bezel, product number 2033, and used double-sided tape to attach the circuit boards to the back (see Figure 3). I mounted my 9-inch LCD version in a document display panel. My 7-inch unit draws about 300 mA, so for portable expeditions I use a pocket-size 2,200 mAh lithium-ion polymer (LiPo) battery USB power stick that runs the display for about 5 hours. My HamClock project met all my expectations, and I hope you find it useful as well.

Elwood Downey has been licensed continuously since 1974 as WBØOEW. He graduated with honors with a Bachelor's in electrical engineering from Purdue University in 1977. He passed all the FCC written tests (including Amateur Extra) on his first try, but waited for the no-code rules to achieve his Amateur Extra class license in 2008. Elwood is enjoying a career as both an electronics and software engineer, specializing in telescope control systems and other related astronomical instrumentation. He can be reached at **wb0oew@arrl.net** and maintains a small ham web presence at **www.clearskyinstitute.com/ham**.

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