

Electronic picture frame

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This document describes **eFrame2**, a Teensy application that provides a rotating display of images. The application is actually part of a much larger application,¹ but the **eFrame2** application can be used as a stand-alone, or as part of a much-different hosting application.

1 hardware

eFrame2's hardware consists of a Teensy 4.1, an Adafruit 3.5" TFT display,² and an XBee transceiver.³ These components are mounted on breakout boards for convenience, but they are otherwise unmodified. The display is mounted in landscape orientation. A prototype implementation is pictured at https://www.fenichel.net/pages/Indoor_Activities/electronics/datalogger/eFrame2/eframe2.jpg

2 libraries

eFrame2 makes use of the **ILI9341_t3**, **SD**, **SPI**, and **TouchScreen** libraries and, from the **ILI9341_t3** package, the fonts **font_Arial** and **font_ArialBold**. The lines

```
#define ILI9341_TFTWIDTH  240
#define ILI9341_TFTHEIGHT 320
```

in **ILI9341.h** had to be changed to

```
#define ILI9341_TFTWIDTH  320
#define ILI9341_TFTHEIGHT 480
```

and the libraries were otherwise unmodified.

3 files on the Teensy's μ SD card

Most of the files on the Teensy's μ SD card are uncompressed RGB **.bmp** files, 480 pixels wide by 320 pixels high. With one possible exception,⁴ each of these files is listed in the **catalog.txt** file, an ASCII file with four lines for each file, with the files in no special order. For each listed file, the four lines are the file name, two caption lines, and a blank line.

¹ See https://www.fenichel.net/pages/Indoor_Activities/electronics/datalogger/datalogger.pdf for a moderately obsolete description; **eFrame2** replaces the "annunciator" components of that application.

² See <https://www.adafruit.com/product/2050> (accessed 2025-06-19).

³ See <https://www.digi.com/xbee> (accessed 2021-05-25).

⁴ The Special Image; see Section 6.

4 autonomous operation

eFrame2 runs in a continuous loop, demonstrated at https://www.fenichel.net/pages/Indoor_Activities/electronics/datalogger/eFrame2/eframe2.mp4⁵

- It displays three⁶ images from those listed in **catalog.txt**, each for 10 seconds.⁶ The images can be chosen in the order in which they are listed in catalog.txt, or (as specified as a Parameter⁶) they can be chosen at random.
- It displays something else, chosen as follows:

Sometimes,⁶ it displays a Special Image;⁷ if no Special Image has been defined, then it displays the Heart Screen.⁸ Either is shown for 10 seconds.⁶

At other times, if a Text Screen⁹ has been defined, it displays that screen for 20 seconds.⁶ If no Text Screen is available, then it starts a new sequence of random images from those listed in **catalog.txt**.

When an image is displayed, the two caption lines from **catalog.txt** are displayed as an overlay. On the basis of a sample of the image's pixels, **eFrame2** chooses the caption lines' text color as white or black.

5 response to the touch screen

The application makes no use of the location information that is available from the ILL9341 touch screen. Instead, the entire screen is treated as a single big pushbutton.

If the screen is touched during display of an image, then the text color of the caption lines is toggled between white and black.

If the screen is touched during display of the Text Screen or the Heart Screen, then the application moves on to display the next random image.

6 Special Image

A Special Image is defined when the XBee receives a message whose characters are

F <file name>

naming a file on the μ SD card that may or may not be listed in **catalog.txt**. If the <file name> is empty (that is, if the received line is just an **F**), then the Special Image is undefined.

⁵ The video (**eFrame2.mp4**) is not handled well by some browsers. It works (with, *e.g.*, the [VLC media player](#)) if it is downloaded.

⁶ See Section 9.

⁷ See Section 6.

⁸ See Section 7.

⁹ See Section **Error! Reference source not found.**

7 Heart Screen

To display the Heart Screen, **eFrame2** uses the **ILI9341_t3** primitives to draw a big red heart on a white screen. Sometimes,⁶ up to three¹⁰ lines of text¹¹ are displayed in white over the middle of the heart.

8 Text Screen

The XBee recognizes a Text-Screen package when it receives

- a line consisting entirely of **A**
- one or more lines of the form

<size char><color char><text>

where the <size char> is **0**, **1**, **2**, **3**, or **4** to choose among font sizes 10, 14, 18, 24, and 32, respectively; and the <color char> is one of **0**, **1**, . . . **9** to choose among the **ILI9341_t3** colors black, red, orange, yellow, green, cyan, blue, magenta, purple, and white, respectively.

- A line consisting entirely of **Z**.

For example, a short Text-Screen package might be

```
A
26   2025-06-20 @ 1348
00
30   temperature 57 F (14 C)
30                   RH 98%
Z
```

When a Text Screen is defined, it is displayed in its turn (see Section 4) on a white background. A Text Screen is deleted when it has not been updated for 2 hours.⁶

9 parameters

Various parameters are set in the μ SD card's **eFrame2.ini** file. The contents of the file I now use are

```
BrightnessThreshold = 400 // caption black if brighter than this
CaptionOriginY      = 275
HoursBeforeTextTooOld = 2
NSampleColumns      = 100 // used with BrightnessThreshold
OddsAgainstHeartText = 3 // that is, a 25% chance
OddsAgainstSpecial   = 9 // that is, a 10% chance
RandomizeSlides     = 0 // 0 catalog order; 1 random order
SlideDisplaySeconds = 10
SlideSequenceLength = 3
SpecialDisplaySeconds = 10
UseXBee             = 1 // if 0, no Text Screen, no Special Image
TextDisplaySeconds  = 20
XP_XM_ohms          = 283 // measured resistance of the ILI9341 X+ to X-
```

¹⁰ Parameter set in **SlideMgr.inc**.

¹¹ If the ASCII file **heart.txt** is present on the μ SD card, the lines are copied from it.

10 software

The software is entirely contained in **eFrame2.ino** and the included modules **FileMgr.inc**, **Parameters.inc**, **SlideMgr.inc**, **TextScreen.inc**, **TouchMaster.inc**, and **XBee.inc**. The code is available at https://www.fenichel.net/pages/Indoor_Activities/electronics/datalogger/eFrame2/eFrame2.zip.