CO2-Ampel

Quellen

Grundlagen und Projekthintergrund

- https://www.heise.de/select/make/2020/5/2022015381334973804 MAKE Artikel zum Thema CO2-Ampel und die Grundlage meines Bastelprojektes
- https://www.heise.de/select/make/2020/5/softlink/xyrg?wt_mc=pred.red.make.make052020.010.softlink.softlink Downloads und weitere Informationen zum MAKE Artikel
- https://www.umwelt-campus.de/forschung/projekte/iot-werkstatt Webseite der IoT-Werkstatt
- https://www.umwelt-campus.de/forschung/projekte/iot-werkstatt/ideen-zur-corona-krise-1 Hintergrundinformationen zum Projekt CO2-Ampel der IoT-Werkstatt

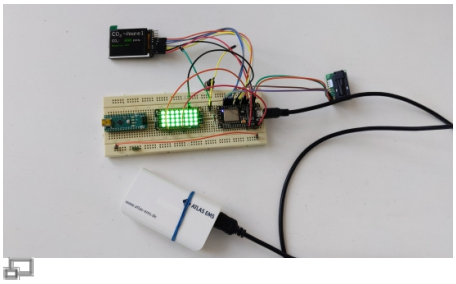
Informationen zur verwendeten Technik

- https://joy-it.net/de/products/SBC-NodeMCU Der verwendete Mikrocontroller
- https://joy-it.net/files/files/Produkte/SBC-NodeMCU/SBC-NodeMCU_pinout.png Pinbelegung des verwendeten Mikrocontrollers
- https://forbiddenbit.com/en/arduino-projects/esp8266/nodemcu-and-1-8-spi-st7735-display/ Verdrahtung und Ansteuerung meines Displays
- https://learn.adafruit.com/adafruit-neopixel-uberguide/arduino-library-use Dokumentation zur Verwendung der Adafruit NeoPixel Bibliothek
- https://learn.adafruit.com/adafruit-gfx-graphics-library/coordinate-system-and-units Dokumentation zur Verwendung der Adafruit TFT Grafikdisplay Bibliothek
- http://javl.github.io/image2cpp/http://javl.github.io/image2cpp/ Code-Generator für Byte Grafiken (für die Smiley Bilder im Dirsplay)
- https://github.com/realholgi/Encoder Dokumentation zur verwendeten Bibliothek für den Dreh-Encoder (Einstellung der LED Helligkeit)
- https://www.pjrc.com/teensy/td_libs_Encoder.html Homepage des Entwicklers der Encoder Bibliothek
- https://www.instructables.com/Select-Color-Display-for-ESP32/ Übersicht verschiedener TFT-Displays
- https://circuits4you.com/2019/01/08/esp8266-turn-off-wifi-save-power/ Konfiguration desWIFI am ESP8266
- https://makesmart.net/esp8266-d1-mini-mqtt Grundlagen zur Einbindung von MQTT im ESP8266

Arduino IDE

IDE herunterladen und installieren:

```
wget
https://downloads.arduino.cc/arduino-1.8.16-
linux64.tar.xz
tar xJz arduino-1.8.16-linux64.tar.xz
cd arduino-1.8.16
```



Prototyp auf Steckbrett

```
./install.sh
```

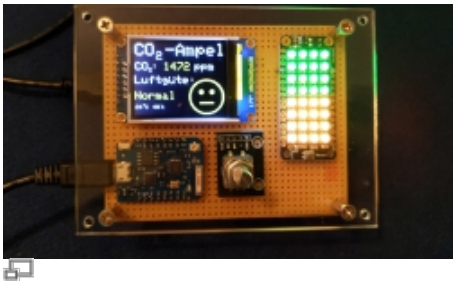
ESP8266 Unterstützung installieren:
`Arduino IDE –> Datei –> Voreinstellungen –> zusätzliche Boardverwalter URLs:`

```
https://arduino.esp8266.com/stable/package_esp8266com_index.json
https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_dev_index.json
```

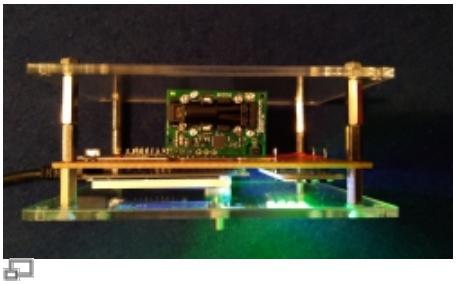
fertige Co2-Ampel an Powerbank

alles im grünen Bereich

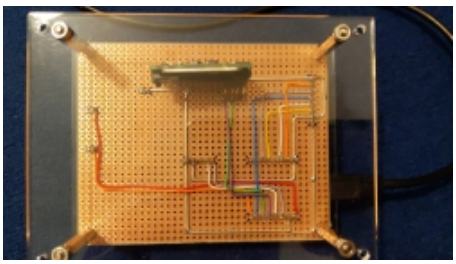
schlechte Luft



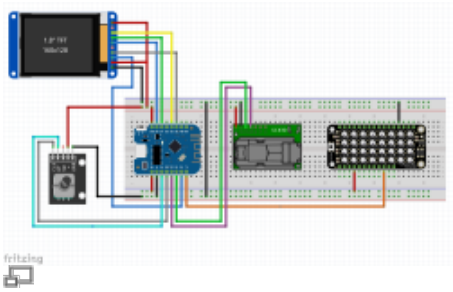
bals mal Lüften



Ansicht von oben



Verdrahtung von hinten



Verdrahtung via Fritzing

Einkaufsliste

Material:	Quelle:	ca. Preis	Link
D1 Mini Pro - ESP8266	Reichelt	7,30 €	https://www.reichelt.de/d1-mini-pro-esp8266-cp2104-d1-mini-pro-p266066.html
Sensirion SCD30	Mouser	43,46 €	https://www.mouser.de/ProductDetail/Sensirion/SCD30/?qs=rrS6PyfT74fdywu4FxpYjQ%3D%3D
NeoPixel FeatherWing - 4×8 RGB LED	Mouser	12,66 €	https://www.mouser.de/ProductDetail/Adafruit/2945/?qs=ivJcBTDythXnjfcjjhuHaQ%3D%3D
DEBO ROT SWITCH	Reichelt	2,65 €	https://www.reichelt.de/entwicklerboards-kodierter-drehschalter-debo-rot-switch-p239260.html
Display LED, 1,8„, 128×160, ST7735R	Reichelt	10,50 €	https://www.reichelt.de/entwicklerboards-display-led-1-8-128x160-st7735r-debo-tft-1-8-p192139.html
H25PR075 Lochrasterplatine, Hartpapier, 75x100mm	Reichelt	1,15 €	https://www.reichelt.de/lochrasterplatine-hartpapier-75x100mm-h25pr075-p8269.html

Quellcode

CO2-Ampel.ino

```
/*
Author:   Christoph von Thülen
Version:  1.0 10/23/2020

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Gewähr der MARKTFÄHIGKEIT oder EIGNUNG FÜR EINEN BESTIMMTEN ZWECK.
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diesem
Programm erhalten haben. Wenn nicht, siehe
<https://www.gnu.org/licenses/>.
-------------------------------------------------------------------------
-------------------------*/

// Libs to controll the 1.8" 120x160 px Display with ST7735 Controller:
#include <Adafruit_GFX.h>
#include <Adafruit_ST7735.h>
#include <SPI.h>

// Libs for the MCU itself
#include <ESP8266WiFi.h>  // Wifi part

// Lib for quadrature encoder like KY-040 or similar:
#include <Encoder.h>
#define ENCODER_OPTIMIZE_INTERRUPTS

// Libs to control the Sensirion CO2 sensor:
#include <SparkFun_SCD30_Arduino_Library.h>
#include <Wire.h>

// Adafruit NeoPixel FeatherWing
#include <Adafruit_NeoPixel.h>

// Include the Smiley grafics as byte array...
#include "graphics.c"

// Define some important things ...
// Used Pins to control the Display:
#define TFT_CS         15      // Use GPIO15 for Chip Select (CS)
#define TFT_RST         3      // Use GPIO0 for RESET
#define TFT_DC         16      // Use GPIO2 for DC

// Used pins to control the NeoPixel LEDs:
#define NEOPIXEL_DATA_PIN   1 // Use GPIO 1 for NeoPixel DIN (Data In)

// time intervall in seconds to read out the CO2 sensor
#define INTERVALL 5 // seconds
#define CO2_BAD_LOWER_LIMIT    2000
```

```
#define CO2_GOOD_UPPERLIMIT    1000

// Used rotary ecoder Pins:
#define ENC_DT  2        // use GPI/O 2 for DT
#define ENC_CLK 0        // use GPI/O 0 for CLK
#define ENC_BUTTON 12    // use GPI/O 12 for button click

// some color definitions:
#define BLACK    0x0000
#define BLUE     0x001F
#define RED      0xF800
#define GREEN    0x07E0
#define CYAN     0x07FF
#define MAGENTA  0xF81F
//#define ORANGE   0xFC20
#define ORANGE   0xFC00
#define YELLOW   0xFFE0
#define WHITE    0xFFFF

// some (font) size definitions
#define SMALL  1
#define MEDIUM 2
#define LARGE  3

// Internal state definitions
#define STATE_UNDEFINED 0
#define STATE_GOOD      1
#define STATE_NORMAL    2
#define STATE_BAD       3

// Lets call our 1.8" TFT Display (Controller Type: ST7735) simply:
"tft" ;-)
Adafruit_ST7735 tft = Adafruit_ST7735(TFT_CS, TFT_DC, TFT_RST); //Those
things are for the display

// Objekt SCD30 environment sensor
SCD30 airSensorSCD30;

// Declare some usefull variables ...
// ... for the CO2 Sensor:
int CO2 = 0 ;
char CO2_BUFFER[5] = {};
int Temperature = 0;
int Humidity = 0;

// ... for the LEDs:
#define MAX_BRIGHTNESS 38      // set maximum brightness value
#define MAX_LED_ROWS    8
#define LEDS_PER_ROW    4
#define NEOPIXEL_NO_OF_LEDS (MAX_LED_ROWS * LEDS_PER_ROW)
//NEOPIXEL_NO_OF_LEDS 32   // NeoPixel PCB has n LEDs
```

```
#define LED_OFF 0               // set corresponding color brightness to
zreo --> LED is switched of
int Brightness = 16;            // set default brightness to 16
int count = 0;                  // set counter to 0
int Row = 0;

// ... for the display graphics:
int graphics_width = 64;
int graphics_height = 64;
int Title_x_pos = 2;
int Title_y_pos = 1;
int CO2_Value_x_pos = 2;
int CO2_Value_y_pos = 34;
int InfoText_x_pos = 1;
int InfoText_y_pos = 58;
int State_y_Offset = 28;
int gfx_x_pos = 96;
int gfx_y_pos = 64;
int Temp_Humid_x_pos = 2;
int Temp_Humid_y_pos = 110;

extern const unsigned char smiley_good [];
extern const unsigned char smiley_normal [];
extern const unsigned char smiley_bad [];

// internal states
int last_state = STATE_UNDEFINED;       // set startup state to
undefined
int new_state = STATE_UNDEFINED;        // set startup state to
undefined

// Init Adafruit NeoPixel Matrix:
Adafruit_NeoPixel neoWing = Adafruit_NeoPixel(NEOPIXEL_NO_OF_LEDS,
NEOPIXEL_DATA_PIN, NEO_GRB + NEO_KHZ800);

// Init encoder lib with uses interrupt pins connected to encoder
Encoder encoder(ENC_CLK, ENC_DT);

void FillLEDMatrix(int, int, int);

// Some things to set up before the main loop starts:
void setup() {

// Display Setup
  //tft.initR(INITR_GREENTAB);   // use for displays with green tab
aka. Joy-IT
  tft.initR(INITR_BLACKTAB);   //  use for displays with red or black
tab
  tft.setRotation(1);          // Displayinhalt um 90° (1) gedreht
(Landscape Mode); (2) = 180°, (3) = 270°
```

```
// Configure serial interface (UART) for debug output:
  Serial.begin(115200);        // Note: if GPI/O Pin 1 is used other
than UART TxD
                               // then debug output prints via
"serial.print" will not work correctly in loop()
  Serial.println("Co2 Monitor is starting ...");

 //Turn off WiFi
  WiFi.mode(WIFI_OFF);    //This also works

// Initialize the I2C-Bus:
  Wire.setClock(100000L);            // 100 kHz SCD30
  Wire.setClockStretchLimit(200000L);// CO2-SCD30
  Wire.begin();
  if (Wire.status() != I2C_OK) Serial.println("Something wrong with
I2C");

// Initialize CO2 Sensor:
  if (airSensorSCD30.begin() == false) {
    Serial.println("The SCD30 did not respond. Please check wiring.");
    while(1) {
      yield();
      delay(1);
    }
  }

  airSensorSCD30.setAutoSelfCalibration(false); // Sensirion no auto
calibration
  airSensorSCD30.setMeasurementInterval(INTERVALL);     // CO2
measurement every 5 seconds

// Initialize NeoPixel LEDs:
  neoWing.begin();
  delay(1);

// Print static elemets on display screen:
// Title:
  tft.fillScreen(ST77XX_BLACK);
  tft.setTextWrap(false);
  tft.setCursor(Title_x_pos, Title_y_pos);    //Horiz (ma. 160
px)/Vertical (max. 128 px)
  tft.setTextSize(LARGE);
  tft.setTextColor(ST77XX_WHITE,ST77XX_BLACK);
  tft.print("CO -Ampel");
  tft.setCursor(Title_x_pos+37, Title_y_pos+14);    //Horiz (ma. 160
px)/Vertical (max. 128 px)
  tft.setTextSize(MEDIUM);
  tft.setTextColor(ST77XX_WHITE,ST77XX_BLACK);
  tft.print("2");

// Text for CO2 Value:
```

```
  tft.setCursor(CO2_Value_x_pos, CO2_Value_y_pos);
  tft.setTextSize(MEDIUM);
  tft.setTextColor(ST77XX_WHITE,ST77XX_BLACK);
  tft.print("CO");
  tft.setCursor(CO2_Value_x_pos+24, CO2_Value_y_pos+10);
  tft.setTextSize(SMALL);
  tft.print("2");
  tft.setCursor(CO2_Value_x_pos+29, CO2_Value_y_pos);
  tft.setTextSize(MEDIUM);
  tft.print(":");
  tft.setCursor(CO2_Value_x_pos+105, CO2_Value_y_pos);
  tft.setTextSize(MEDIUM);
  tft.print("ppm");

// Info Text
  tft.setCursor(InfoText_x_pos, InfoText_y_pos);
  tft.setTextSize(MEDIUM);
  tft.setTextColor(ST77XX_WHITE,ST77XX_BLACK);
  tft.print("Luftg""\201""te:");
}

// Begin main loop:
void loop() {

// Read new CO2 measurement from sensor:
  CO2 = airSensorSCD30.getCO2();                 // get new CO2 value
from sensor
  Temperature = airSensorSCD30.getTemperature();  // get new
temperature value from sensor
  Humidity = airSensorSCD30.getHumidity();        // get new humidity
value from sensor

// Debug output via serial interface:
//  Serial.println("CO2: "+String(String(CO2)));
//  Serial.println();

// display temperatur & humidity
  tft.setCursor(Temp_Humid_x_pos, Temp_Humid_y_pos);
  tft.setTextSize(SMALL);
  tft.setTextColor(ST77XX_WHITE,ST77XX_BLACK);
  tft.print(Temperature);
  tft.setCursor(Temp_Humid_x_pos+12, Temp_Humid_y_pos-4);
  tft.print((char)9);
  tft.setCursor(Temp_Humid_x_pos+17, Temp_Humid_y_pos);
  tft.print("C");
  tft.setCursor(Temp_Humid_x_pos+30, Temp_Humid_y_pos);
  tft.print(Humidity);
  tft.setCursor(Temp_Humid_x_pos+44, Temp_Humid_y_pos);
  tft.print("%");

  tft.setCursor(InfoText_x_pos, InfoText_y_pos+State_y_Offset);
```

```
  tft.setTextSize(MEDIUM);

// Compare CO2 value to three ranges:
  if(CO2 < CO2_GOOD_UPPERLIMIT) {                         // we are in
state GOOD
    new_state = STATE_GOOD;
    if ( last_state != new_state) {        // when the state has
changed, draw new text and simley
      tft.setTextColor(ST77XX_GREEN,ST77XX_BLACK);
      tft.print("Gut     ");
      tft.drawBitmap(gfx_x_pos, gfx_y_pos, smiley_bad, graphics_width,
graphics_height, BLACK);
      tft.drawBitmap(gfx_x_pos, gfx_y_pos, smiley_normal,
graphics_width, graphics_height, BLACK);
      tft.drawBitmap(gfx_x_pos, gfx_y_pos, smiley_good, graphics_width,
graphics_height, GREEN);
    }
    FillLEDMatrix(1, MAX_LED_ROWS, LED_OFF, Brightness, LED_OFF);
  }
  else if (CO2 >= CO2_BAD_LOWER_LIMIT) {                 // we are in
state BAD!
    new_state = STATE_BAD;
    if ( last_state != new_state) {       // when the state has
changed, draw new text and simley
      tft.setTextColor(ST77XX_RED,ST77XX_BLACK);
      tft.print("Schlecht");
      tft.drawBitmap(gfx_x_pos, gfx_y_pos, smiley_good, graphics_width,
graphics_height, BLACK);
      tft.drawBitmap(gfx_x_pos, gfx_y_pos, smiley_normal,
graphics_width, graphics_height, BLACK);
      tft.drawBitmap(gfx_x_pos, gfx_y_pos, smiley_bad, graphics_width,
graphics_height, RED);

    }
    FillLEDMatrix(1, MAX_LED_ROWS, Brightness, LED_OFF, LED_OFF);
  }
  else {                                  // we are in state NORMAL
    new_state = STATE_NORMAL;
    if ( last_state != new_state) {     // when the state has changed,
draw new text and simley
      tft.setTextColor(ST77XX_YELLOW,ST77XX_BLACK);
      tft.print("Normal  ");
      tft.drawBitmap(gfx_x_pos, gfx_y_pos, smiley_bad, graphics_width,
graphics_height, BLACK);
      tft.drawBitmap(gfx_x_pos, gfx_y_pos, smiley_good, graphics_width,
graphics_height, BLACK);
      tft.drawBitmap(gfx_x_pos, gfx_y_pos, smiley_normal,
graphics_width, graphics_height, YELLOW);
    }
    Row = (((CO2-1000)/125)+1);                 // calculate how many
LED rows we have to fill
```

```
    FillLEDMatrix(1, Row, (Brightness*2), Brightness, LED_OFF);

    // fill the rest with green color to get a rolling traffic light
effect
    if (Row < MAX_LED_ROWS){
      FillLEDMatrix((Row+1), MAX_LED_ROWS, LED_OFF, Brightness,
LED_OFF);
    }
  }
  last_state = new_state;  // set new state

  // set color to update CO2 value on display
  switch(last_state) {
  case 1: tft.setTextColor(ST77XX_GREEN,ST77XX_BLACK); break;
  case 2: tft.setTextColor(ST77XX_YELLOW,ST77XX_BLACK); break;
  case 3: tft.setTextColor(ST77XX_RED,ST77XX_BLACK); break;
  }

  // refresh CO2 Value on display:
  tft.setCursor(CO2_Value_x_pos+50, CO2_Value_y_pos);
  tft.setTextSize(MEDIUM);
  sprintf(CO2_BUFFER, "%4d", CO2);
  tft.print(String(CO2_BUFFER));

// read encoder:
  count = encoder.read();

// Debug output via serial terminal
  //Serial.print("Count: ");
  //Serial.print(count);
  //Serial.print(", Brightness: ");
  //Serial.print(Brightness);

// if encoder was turned left or right, set new brightness values:
// don't go higher than MAX_BRIGHTNESS linit
  if ((Brightness + count) > MAX_BRIGHTNESS ) {
    Brightness = MAX_BRIGHTNESS;
  }
// don't go negative!
  if ((Brightness + count) < 0 ) {
    Brightness = 0;
  }else {
    // increase or decrease brightness value according to positiv or
negative count value
    Brightness += count;
  }
  Serial.println(Brightness);

// Debug output via serial terminal
//    Serial.print(", Red: ");
//    Serial.print(Led_red);
```

```
//    Serial.print(", Green: ");
//    Serial.print(Led_green);
//    Serial.print(", Blue: ");
//    Serial.print(Led_blue);
//    Serial.println();

// reset encoder value for next read cycle:
    encoder.write(0);

 // delay(1000);  // for debug and test purpose only
}

// Function to fill LED matrix row by row
void FillLEDMatrix(int row_start, int row_end, int LED_red, int
LED_green, int LED_blue){

// use for filling the LED matrix from left to right
//  for (uint16_t j=row_start-1; j < row_end; j++) {
//    for(uint16_t i=0+j; i < NEOPIXEL_NO_OF_LEDS  ; i+= MAX_LED_ROWS)
{
//      neoWing.setPixelColor(i,LED_red,LED_green,LED_blue);
//    }
//  }

// use for filling the LED matrix from right to left
  for (uint16_t j=row_start-1; j < row_end; j++) {
    for(uint16_t i=0+j; i < NEOPIXEL_NO_OF_LEDS  ; i+= MAX_LED_ROWS) {
      neoWing.setPixelColor((NEOPIXEL_NO_OF_LEDS-1-
i),LED_red,LED_green,LED_blue);
    }
  }
  neoWing.show();
}
```

graphics.c

```
#include <avr/pgmspace.h>

// 'Simley_good_bw_64x64px', 64x64px
const unsigned char smiley_good [] PROGMEM = {
  0x00, 0x00, 0x00, 0x1f, 0xf8, 0x00, 0x00, 0x00, 0x00, 0x00, 0x01,
0xff, 0xff, 0x80, 0x00, 0x00,
  0x00, 0x00, 0x0f, 0xff, 0xff, 0xf8, 0x00, 0x00, 0x00, 0x00, 0x3f,
0xff, 0xff, 0xfe, 0x00, 0x00,
  0x00, 0x00, 0xff, 0xc0, 0x03, 0xff, 0x00, 0x00, 0x00, 0x03, 0xfe,
0x00, 0x00, 0x3f, 0xc0, 0x00,
  0x00, 0x07, 0xf0, 0x00, 0x00, 0x0f, 0xe0, 0x00, 0x00, 0x0f, 0xc0,
0x00, 0x00, 0x03, 0xf8, 0x00,
  0x00, 0x1f, 0x00, 0x00, 0x00, 0x00, 0xfc, 0x00, 0x00, 0x7e, 0x00,
0x00, 0x00, 0x00, 0x7e, 0x00,
```

```
  0x00, 0x7c, 0x00, 0x00, 0x00, 0x00, 0x3f, 0x00, 0x00, 0xf8, 0x00,
0x00, 0x00, 0x00, 0x1f, 0x80,
  0x01, 0xf0, 0x00, 0x00, 0x00, 0x00, 0x07, 0x80, 0x03, 0xe0, 0x00,
0x00, 0x00, 0x00, 0x07, 0xc0,
  0x07, 0xc0, 0x00, 0x00, 0x00, 0x00, 0x03, 0xe0, 0x07, 0x80, 0x00,
0x00, 0x00, 0x00, 0x01, 0xf0,
  0x0f, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0xf0, 0x0f, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x78,
  0x1e, 0x00, 0x02, 0x00, 0x00, 0x00, 0x00, 0x78, 0x1e, 0x00, 0x0f,
0x80, 0x01, 0xf8, 0x00, 0x3c,
  0x3c, 0x00, 0x1f, 0xc0, 0x03, 0xfc, 0x00, 0x3c, 0x3c, 0x00, 0x3f,
0xe0, 0x03, 0xfc, 0x00, 0x3c,
  0x3c, 0x00, 0x3f, 0xe0, 0x07, 0xfe, 0x00, 0x1e, 0x78, 0x00, 0x3f,
0xe0, 0x07, 0xfe, 0x00, 0x1e,
  0x78, 0x00, 0x3f, 0xe0, 0x07, 0xfc, 0x00, 0x1e, 0x78, 0x00, 0x1f,
0xc0, 0x03, 0xfc, 0x00, 0x0f,
  0x70, 0x00, 0x1f, 0xc0, 0x01, 0xf8, 0x00, 0x0f, 0xf0, 0x00, 0x07,
0x00, 0x00, 0xe0, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x07, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x07,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x07, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x07,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0x70, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0x78, 0x00, 0x60, 0x00, 0x00, 0x07, 0x00, 0x0f, 0x78, 0x00, 0xf0,
0x00, 0x00, 0x0f, 0x00, 0x1e,
  0x78, 0x00, 0xf8, 0x00, 0x00, 0x1f, 0x00, 0x1e, 0x38, 0x00, 0x7c,
0x00, 0x00, 0x3f, 0x00, 0x1e,
  0x3c, 0x00, 0x3f, 0x00, 0x00, 0xfe, 0x00, 0x3c, 0x3c, 0x00, 0x1f,
0xc0, 0x03, 0xfc, 0x00, 0x3c,
  0x1e, 0x00, 0x0f, 0xfc, 0x3f, 0xf0, 0x00, 0x3c, 0x1e, 0x00, 0x03,
0xff, 0xff, 0xe0, 0x00, 0x78,
  0x1f, 0x00, 0x01, 0xff, 0xff, 0x80, 0x00, 0x78, 0x0f, 0x00, 0x00,
0x3f, 0xfc, 0x00, 0x00, 0xf0,
  0x07, 0x80, 0x00, 0x00, 0x00, 0x00, 0x01, 0xf0, 0x07, 0xc0, 0x00,
0x00, 0x00, 0x00, 0x03, 0xe0,
  0x03, 0xe0, 0x00, 0x00, 0x00, 0x00, 0x03, 0xc0, 0x01, 0xf0, 0x00,
0x00, 0x00, 0x00, 0x07, 0xc0,
  0x01, 0xf8, 0x00, 0x00, 0x00, 0x00, 0x0f, 0x80, 0x00, 0xfc, 0x00,
0x00, 0x00, 0x00, 0x1f, 0x00,
  0x00, 0x7e, 0x00, 0x00, 0x00, 0x00, 0x7e, 0x00, 0x00, 0x3f, 0x00,
0x00, 0x00, 0x00, 0xfc, 0x00,
  0x00, 0x1f, 0xc0, 0x00, 0x00, 0x01, 0xf8, 0x00, 0x00, 0x07, 0xf0,
0x00, 0x00, 0x07, 0xf0, 0x00,
  0x00, 0x03, 0xfc, 0x00, 0x00, 0x3f, 0xc0, 0x00, 0x00, 0x00, 0xff,
0x80, 0x01, 0xff, 0x80, 0x00,
  0x00, 0x00, 0x7f, 0xff, 0xff, 0xfe, 0x00, 0x00, 0x00, 0x00, 0x1f,
```

```
0xff, 0xff, 0xf8, 0x00, 0x00,
  0x00, 0x00, 0x03, 0xff, 0xff, 0xc0, 0x00, 0x00, 0x00, 0x00, 0x00,
0x3f, 0xfe, 0x00, 0x00, 0x00
};

// 'Simley_normal_bw_64x64px', 64x64px
const unsigned char smiley_normal [] PROGMEM = {
    0x00, 0x00, 0x00, 0x1f, 0xf8, 0x00, 0x00, 0x00, 0x00, 0x00, 0x01,
0xff, 0xff, 0x80, 0x00, 0x00,
  0x00, 0x00, 0x0f, 0xff, 0xff, 0xf8, 0x00, 0x00, 0x00, 0x00, 0x3f,
0xff, 0xff, 0xfe, 0x00, 0x00,
  0x00, 0x00, 0xff, 0xc0, 0x03, 0xff, 0x00, 0x00, 0x00, 0x03, 0xfe,
0x00, 0x00, 0x3f, 0xc0, 0x00,
  0x00, 0x07, 0xf0, 0x00, 0x00, 0x0f, 0xe0, 0x00, 0x00, 0x0f, 0xc0,
0x00, 0x00, 0x03, 0xf8, 0x00,
  0x00, 0x3f, 0x00, 0x00, 0x00, 0x00, 0xfc, 0x00, 0x00, 0x7e, 0x00,
0x00, 0x00, 0x00, 0x7e, 0x00,
  0x00, 0xfc, 0x00, 0x00, 0x00, 0x00, 0x3f, 0x00, 0x00, 0xf8, 0x00,
0x00, 0x00, 0x00, 0x1f, 0x80,
  0x01, 0xf0, 0x00, 0x00, 0x00, 0x00, 0x0f, 0x80, 0x03, 0xe0, 0x00,
0x00, 0x00, 0x00, 0x07, 0xc0,
  0x07, 0xc0, 0x00, 0x00, 0x00, 0x00, 0x03, 0xe0, 0x07, 0x80, 0x00,
0x00, 0x00, 0x00, 0x01, 0xe0,
  0x0f, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0xf0, 0x1f, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0xf8,
  0x1e, 0x00, 0x02, 0x00, 0x00, 0x40, 0x00, 0x78, 0x1e, 0x00, 0x0f,
0x80, 0x01, 0xf8, 0x00, 0x7c,
  0x3c, 0x00, 0x1f, 0xc0, 0x03, 0xfc, 0x00, 0x3c, 0x3c, 0x00, 0x3f,
0xe0, 0x03, 0xfc, 0x00, 0x3c,
  0x3c, 0x00, 0x3f, 0xe0, 0x07, 0xfc, 0x00, 0x1e, 0x78, 0x00, 0x3f,
0xe0, 0x07, 0xfc, 0x00, 0x1e,
  0x78, 0x00, 0x3f, 0xe0, 0x07, 0xfc, 0x00, 0x1e, 0x78, 0x00, 0x1f,
0xc0, 0x03, 0xfc, 0x00, 0x0e,
  0x70, 0x00, 0x1f, 0xc0, 0x01, 0xf8, 0x00, 0x0f, 0xf0, 0x00, 0x07,
0x00, 0x00, 0xe0, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0x70, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0x70, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0x78, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x1e,
  0x78, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x1e, 0x38, 0x00, 0x0f,
0xff, 0xff, 0xf0, 0x00, 0x1e,
  0x3c, 0x00, 0x1f, 0xff, 0xff, 0xf8, 0x00, 0x3c, 0x3c, 0x00, 0x1f,
0xff, 0xff, 0xfc, 0x00, 0x3c,
```

```
  0x3e, 0x00, 0x1f, 0xff, 0xff, 0xf8, 0x00, 0x3c, 0x1e, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x78,
  0x1f, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x78, 0x0f, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0xf0,
  0x07, 0x80, 0x00, 0x00, 0x00, 0x00, 0x01, 0xf0, 0x07, 0xc0, 0x00,
0x00, 0x00, 0x00, 0x03, 0xe0,
  0x03, 0xe0, 0x00, 0x00, 0x00, 0x00, 0x03, 0xc0, 0x01, 0xf0, 0x00,
0x00, 0x00, 0x00, 0x07, 0xc0,
  0x01, 0xf8, 0x00, 0x00, 0x00, 0x00, 0x0f, 0x80, 0x00, 0xfc, 0x00,
0x00, 0x00, 0x00, 0x1f, 0x00,
  0x00, 0x7e, 0x00, 0x00, 0x00, 0x00, 0x7e, 0x00, 0x00, 0x3f, 0x00,
0x00, 0x00, 0x00, 0xfc, 0x00,
  0x00, 0x1f, 0xc0, 0x00, 0x00, 0x01, 0xf8, 0x00, 0x00, 0x07, 0xf0,
0x00, 0x00, 0x07, 0xf0, 0x00,
  0x00, 0x03, 0xfc, 0x00, 0x00, 0x3f, 0xc0, 0x00, 0x00, 0x00, 0xff,
0x80, 0x01, 0xff, 0x80, 0x00,
  0x00, 0x00, 0x7f, 0xff, 0xff, 0xfe, 0x00, 0x00, 0x00, 0x00, 0x1f,
0xff, 0xff, 0xf8, 0x00, 0x00,
  0x00, 0x00, 0x03, 0xff, 0xff, 0xc0, 0x00, 0x00, 0x00, 0x00, 0x00,
0x7f, 0xfe, 0x00, 0x00, 0x00
};

// 'Simley_bad_bw_64x64px', 64x64px
const unsigned char smiley_bad [] PROGMEM = {
  0x00, 0x00, 0x00, 0x1f, 0xf8, 0x00, 0x00, 0x00, 0x00, 0x00, 0x01,
0xff, 0xff, 0x80, 0x00, 0x00,
  0x00, 0x00, 0x0f, 0xff, 0xff, 0xf8, 0x00, 0x00, 0x00, 0x00, 0x7f,
0xff, 0xff, 0xfe, 0x00, 0x00,
  0x00, 0x00, 0xff, 0xc0, 0x03, 0xff, 0x00, 0x00, 0x00, 0x03, 0xfe,
0x00, 0x00, 0x3f, 0xc0, 0x00,
  0x00, 0x07, 0xf0, 0x00, 0x00, 0x0f, 0xe0, 0x00, 0x00, 0x0f, 0xc0,
0x00, 0x00, 0x03, 0xf8, 0x00,
  0x00, 0x3f, 0x00, 0x00, 0x00, 0x00, 0xfc, 0x00, 0x00, 0x7e, 0x00,
0x00, 0x00, 0x00, 0x7e, 0x00,
  0x00, 0xfc, 0x00, 0x00, 0x00, 0x00, 0x3f, 0x00, 0x00, 0xf8, 0x00,
0x00, 0x00, 0x00, 0x1f, 0x80,
  0x01, 0xf0, 0x00, 0x00, 0x00, 0x00, 0x0f, 0x80, 0x03, 0xe0, 0x00,
0x00, 0x00, 0x00, 0x07, 0xc0,
  0x07, 0xc0, 0x00, 0x00, 0x00, 0x00, 0x03, 0xe0, 0x07, 0x80, 0x00,
0x00, 0x00, 0x00, 0x01, 0xe0,
  0x0f, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0xf0, 0x1f, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0xf8,
  0x1e, 0x00, 0x02, 0x00, 0x00, 0x40, 0x00, 0x78, 0x3e, 0x00, 0x1f,
0x80, 0x01, 0xf8, 0x00, 0x7c,
  0x3c, 0x00, 0x3f, 0xc0, 0x03, 0xf8, 0x00, 0x3c, 0x3c, 0x00, 0x3f,
0xe0, 0x07, 0xfc, 0x00, 0x3c,
  0x38, 0x00, 0x3f, 0xe0, 0x07, 0xfc, 0x00, 0x1e, 0x78, 0x00, 0x3f,
0xe0, 0x07, 0xfc, 0x00, 0x1e,
  0x78, 0x00, 0x3f, 0xe0, 0x07, 0xfc, 0x00, 0x1e, 0x70, 0x00, 0x3f,
0xc0, 0x03, 0xfc, 0x00, 0x0e,
  0xf0, 0x00, 0x1f, 0xc0, 0x01, 0xf8, 0x00, 0x0f, 0xf0, 0x00, 0x07,
```

```
0x00, 0x00, 0xe0, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0xf0, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x0f, 0xf0, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00, 0x0f,
  0x70, 0x00, 0x00, 0x0f, 0xf0, 0x00, 0x00, 0x0e, 0x78, 0x00, 0x00,
0xff, 0xff, 0x00, 0x00, 0x1e,
  0x78, 0x00, 0x03, 0xff, 0xff, 0xc0, 0x00, 0x1e, 0x78, 0x00, 0x07,
0xff, 0xff, 0xf0, 0x00, 0x1e,
  0x3c, 0x00, 0x1f, 0xe0, 0x07, 0xf8, 0x00, 0x3c, 0x3c, 0x00, 0x3f,
0x80, 0x00, 0xfc, 0x00, 0x3c,
  0x1e, 0x00, 0x7e, 0x00, 0x00, 0x7e, 0x00, 0x7c, 0x1e, 0x00, 0xf8,
0x00, 0x00, 0x1f, 0x00, 0x78,
  0x1f, 0x00, 0xf0, 0x00, 0x00, 0x0f, 0x00, 0x78, 0x0f, 0x00, 0xe0,
0x00, 0x00, 0x07, 0x00, 0xf0,
  0x07, 0x80, 0x00, 0x00, 0x00, 0x00, 0x01, 0xf0, 0x07, 0xc0, 0x00,
0x00, 0x00, 0x00, 0x03, 0xe0,
  0x03, 0xe0, 0x00, 0x00, 0x00, 0x00, 0x03, 0xc0, 0x01, 0xe0, 0x00,
0x00, 0x00, 0x00, 0x07, 0xc0,
  0x01, 0xf0, 0x00, 0x00, 0x00, 0x00, 0x0f, 0x80, 0x00, 0xfc, 0x00,
0x00, 0x00, 0x00, 0x1f, 0x00,
  0x00, 0x7e, 0x00, 0x00, 0x00, 0x00, 0x7e, 0x00, 0x00, 0x3f, 0x00,
0x00, 0x00, 0x00, 0xfc, 0x00,
  0x00, 0x1f, 0x80, 0x00, 0x00, 0x01, 0xf8, 0x00, 0x00, 0x07, 0xf0,
0x00, 0x00, 0x07, 0xf0, 0x00,
  0x00, 0x03, 0xfc, 0x00, 0x00, 0x3f, 0xc0, 0x00, 0x00, 0x01, 0xff,
0x80, 0x01, 0xff, 0x80, 0x00,
  0x00, 0x00, 0x7f, 0xff, 0xff, 0xfe, 0x00, 0x00, 0x00, 0x00, 0x1f,
0xff, 0xff, 0xf8, 0x00, 0x00,
  0x00, 0x00, 0x03, 0xff, 0xff, 0xc0, 0x00, 0x00, 0x00, 0x00, 0x00,
0x7f, 0xfe, 0x00, 0x00, 0x00
};
```

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