

Graphic LCD Hookup Guide a learn.sparkfun.com [tutorial](#)

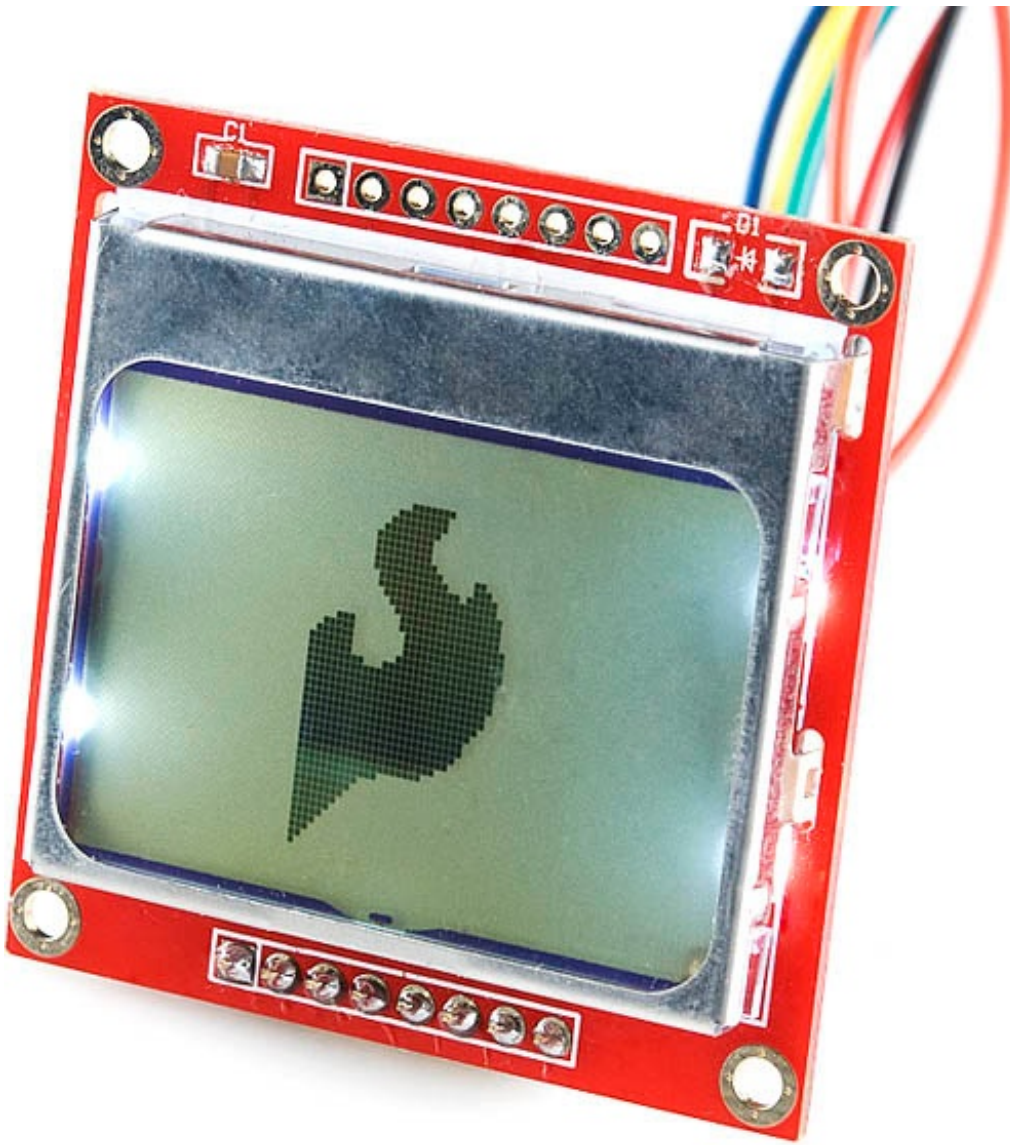
Available online at: <http://sfe.io/t140>

Contents

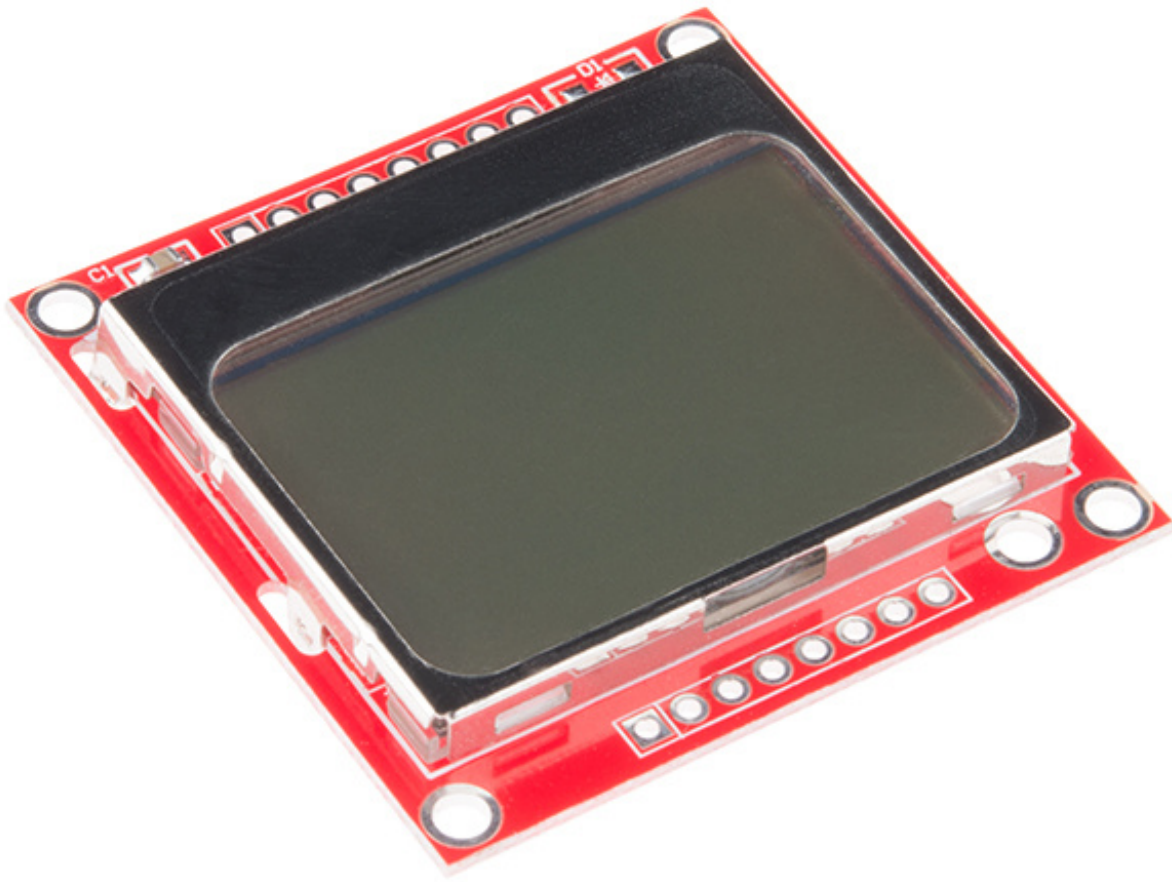
- [Introduction](#)
- [Display Overview](#)
- [Hardware Assembly & Hookup](#)
- [Example Code 1: LCD Demo](#)
- [Example Code 2: Drawing Bitmaps](#)
- [Resources and Going Further](#)

Introduction

Remember the days when cell phones were still "dumb," and they had physical keypads and just a tiny monochrome LCD for a display? Now that iPhones, Galaxies, and the like have revolutionized that market, those little LCDs have to find a new purpose in life: adding customized graphical displays to projects!



These [84x48 pixel black and white LCDs](#) are what you might have found in an old [Nokia 3310](#). They're not flashy, and they don't have a lot of display real-estate. But, they are *easy* to control. If you're looking to step up your project's user interface (UI) game from simple displays or LEDs, this graphic LCD is a good place to start.



[Graphic LCD 84x48 - Nokia 5110](#)

LCD-10168

Retired

In this tutorial we'll show how to control these graphic LCDs with just an Arduino and a few wires in between. We'll cover everything from hardware assembly to example code, and beyond.

Required Materials

- [Arduino](#), [RedBoard](#) or any [Arduino-compatible](#) board.
- [Male headers](#) (included with [Retail Kit](#)) to solder to the display and make it breadboard compatible.
- [Jumper wires](#) to connect from breadboard to Arduino.
- [Breadboard](#) to tie everything together.

Suggested Reading

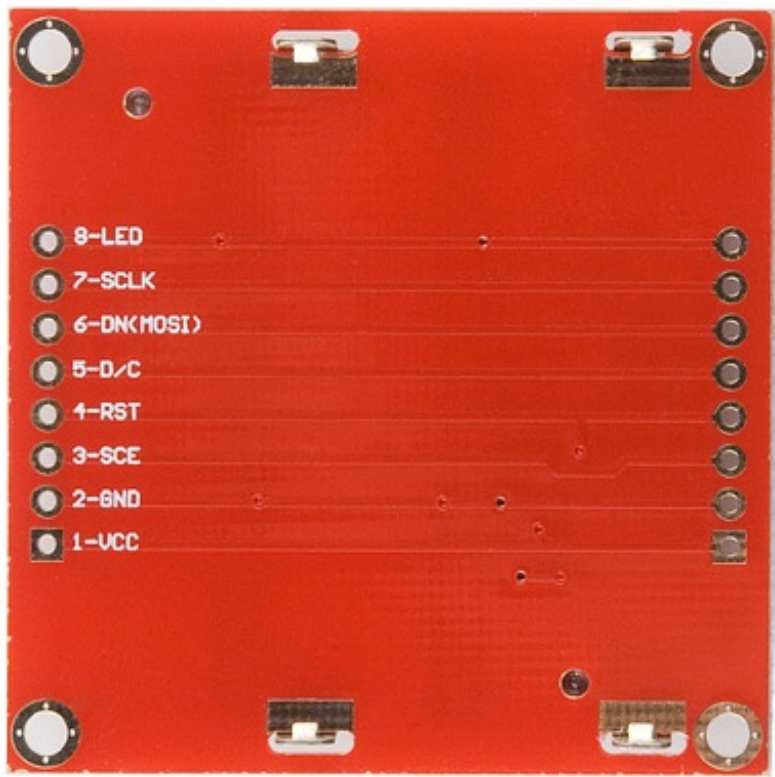
- [What is an Arduino?](#) -- We'll use an Arduino to send commands and display data to the LCD.
- [Serial Peripheral Interface \(SPI\)](#) -- An SPI-like interface is used to control the LCD.
- [How to Use a Breadboard](#) -- The breadboard ties the Arduino to the LCD.

Display Overview

Before diving into hookup and example code, let's first take a look at the LCD and its breakout board. On this page we'll cover everything from the pinout of the board to the interface used to control the display.

The Pinout

To interface with and power the graphic LCD, there are two, parallel 8-pin headers above and below it. Flipping the board over, you'll find the labels for each of the pins.



As you may be able to tell by the faint traces connecting them, each pin on one header is connected to the parallel pin on the other side. Here are the eight unique pins along with an overview of their purpose:

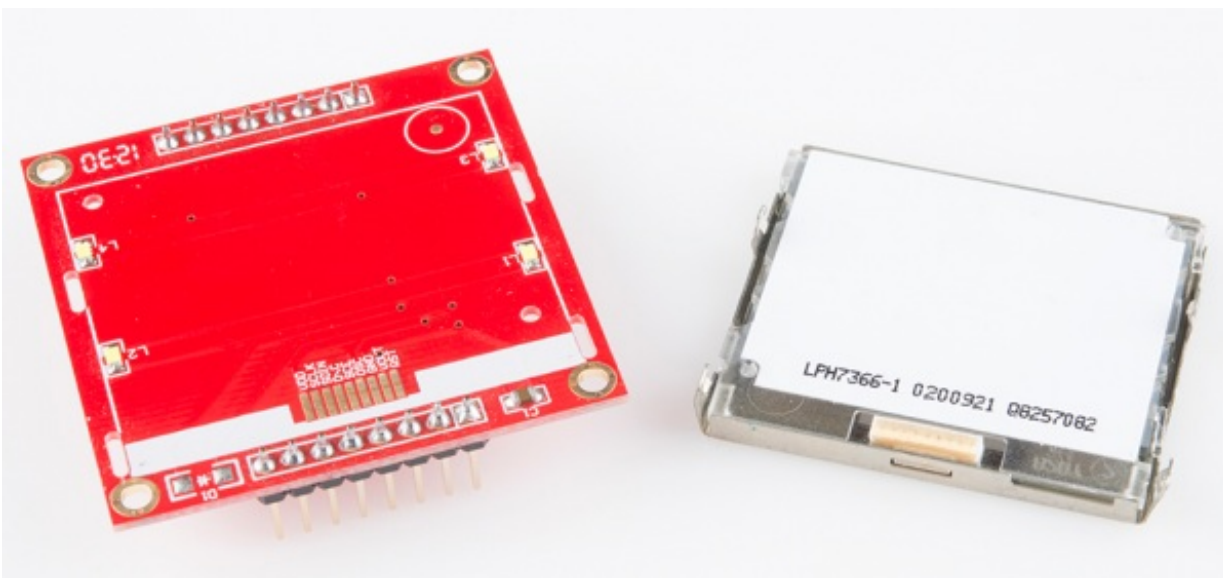
Pin Number	Pin Label	Pin Function	Input/Output?	Notes

1	VCC	Positive power supply	Input	Supply range is between 2.7V and 3.3V
2	GND	Ground	Input	
3	SCE	Chip select	Input	Active low
4	RST	Reset	Input	Active low
5	D/C	Mode select	Input	Select between command mode (low) and data mode (high).
6	DN(MOSI)	Serial data in	Input	
7	SCLK	Serial clock	Input	
8	LED	LED backlight supply	Input	Maximum voltage supply is 3.3V.

Power Supplies

There are two different supply voltages on the LCD. The most important supply voltage --**VCC**-- supplies the logic circuits inside the LCD. The [datasheet](#) states this should be **between 2.7 and 3.3V**. In a normal state, the LCD will consume about 6 or 7mA.

The second voltage supply is required for the LED backlights on the board. If you were to remove the LCD from the PCB (not that you should, or need to), you'd see that these are backlights in their simplest form -- four white LEDs spaced around the edges of the board. You may also notice that there aren't any current limiting resistors.



This means you have to be *careful* with this voltage supply. Either stick a current limiting resistor in

series with the 'LED' pin, or limit the supply to **3.3V max**. The LEDs can pull a lot of current! With nothing to limit them, they'll pull about 100mA at 3.3V.

The Control Interface

Built into this LCD is a [Philips PCD8544 display controller](#), which converts the massive parallel interface of the raw LCD to a more convenient serial one. The PCD8544 is controlled through a synchronous serial interface similar to [SPI](#). There are clock (**SCLK**) and data (**DN**) input lines, and an active-low chip select (**SCE**) input as well.

On top of those three serial lines, there is another input -**D/C** -- which tells the display whether the data it's receiving is a command or displayable data.

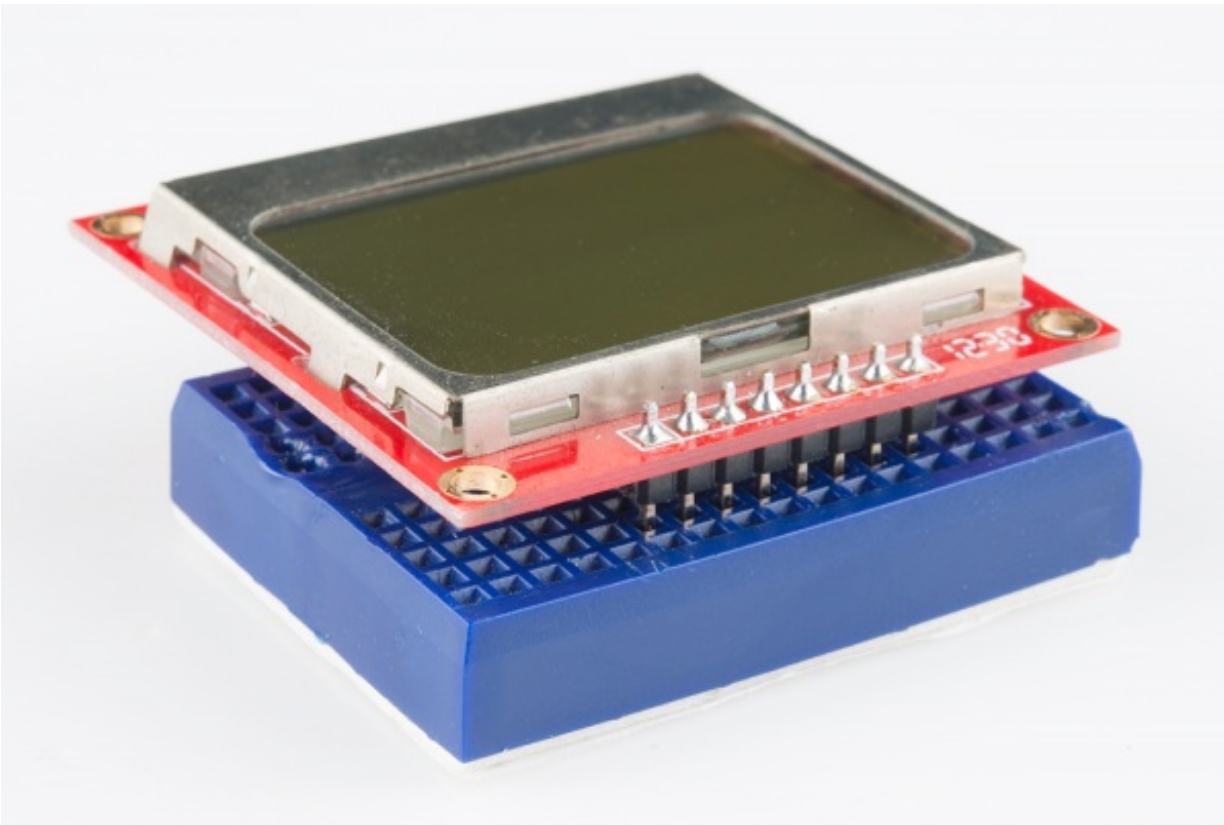
For a list of commands, check out the "Instructions" section of the PCD8544 datasheet (page 11). There are instructions to enable clearing of the display, inverting the pixels, powering it down, and more.

Hardware Assembly & Hookup

Before we get to uploading code and sending data to the display, let's take care of the hardware stuff first. That includes assembling the display, and hooking it up to the Arduino.

Assembly

To "assemble" the LCD, you'll need to [solder](#) something to one (or both) of the 8-pin headers. There are plenty of options available here. To make the LCD breadboard-compatible, [straight](#) or [right-angle male headers](#) can be soldered in.



LCD with strait male headers soldered in, plugged into a [mini blue breadboard](#).

Otherwise, [wires](#) or other [connectors](#) can be soldered to the display pins.

Hookup

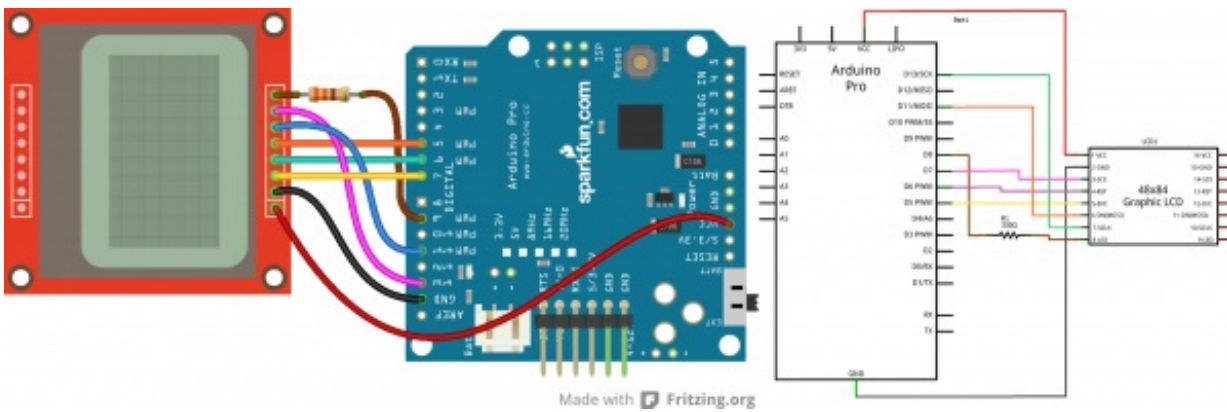
In this example we'll be connecting the LCD up to an Arduino, but this hookup should be easily adaptable to other development platforms. For the data transmission pins -- SCLK and DN(MOSI) -- we'll use the Arduino's **hardware SPI pins**, which will help to achieve a faster data transfer. The chip select (SCE), reset (RST), and a data/command (D/C) pins can be connected to **any digital I/O pin**. Finally, the LED pin should be connected to a PWM-capable Arduino pin, so we can dim the backlight as we please.

Unfortunately, the LCD has a **maximum input voltage of 3.6V**, so we can't hook up a standard 5V Arduino straight to it. We need to shift levels. This leads us to a few options for hookup:

Direct Connect

The easiest hookup is to connect the Arduino pins directly to the LCD. To allow for this easy hookup, you'll need a 3.3V-operating Arduino like the [3.3V/8MHz Pro](#) or [3.3V Pro Mini](#).

This setup *can* work for 5V Arduino's, ignoring the 3.6V limit on the V_{CC} and data lines. We've done this. It works. But it may decrease your LCD's life.



The data pins are connected as follows:

LCD Pin	Arduino Pin	Notes
1 - VCC	3.3V (VCC)	3.3V only (not 5V!)
2 - GND	GND	
3 - SCE	7	Can be any digital pin.
4 - RST	6	Can be any digital pin.
5 - D/C	5	Can be any digital pin.
6 - DN(MOSI)	11	Can't be moved.
SCLK	13	Can't be moved.
LED	9	Can be any PWM pin. 330Ω resistor in between the pins.

Limiting Resistors

Sticking resistors in-line with the data signals is a cheap, and easy way to add some protection to the 3.3V lines. If you have an Arduino Uno (or similar 5V 'duino) and some 10kΩ and 1kΩ resistors lying around, try this:

resistors), and run the other signals through the shifter. You lose remote reset capability, but the rest of the control remains.

Check out the hook up guides for those boards for more help in shifting the signal between Arduino and LCD.

Example Code 1: LCD Demo

With the hardware all hooked up, we're ready to upload a sketch and start drawing on the LCD!

The Sketch

Note: This example assumes you are using the latest version of the Arduino IDE on your desktop. If this is your first time using Arduino, please review our tutorial on [installing the Arduino IDE](#).

Download, unzip, open the sketch from the [GitHub repository](#).

[Nokia 5100 LCD Example Example Sketch \(ZIP\)](#)

Below is a snippet of the example LCD control code. This small novella of a sketch shows off an array of graphics driver functions, character drawing tools, and other useful functions to help you get started using the LCD. You will need to include the *LCD_Functions.h* header in the same directory as the sketch folder from the download. Otherwise, your code will not compile when uploading to Arduino.

```
language:c
/* Nokia 5100 LCD Example Code
   Graphics driver and PCD8544 interface code for SparkFun's
   84x48 Graphic LCD.
   https://www.sparkfun.com/products/10168

by: Jim Lindblom
   adapted from code by Nathan Seidle and mish-mashed with
   code from the ColorLCDShield.
date: October 10, 2013
license: Officially, the MIT License. Review the included License.md file
Unofficially, Beerware. Feel free to use, reuse, and modify this
code as you see fit. If you find it useful, and we meet someday,
you can buy me a beer.
```

This all-inclusive sketch will show off a series of graphics functions, like drawing lines, circles, squares, and text. Then it'll go into serial monitor echo mode, where you can type text into the serial monitor, and it'll be displayed on the LCD.

This stuff could all be put into a library, but we wanted to leave it all in one sketch to keep it as transparent as possible.

Hardware: (Note most of these pins can be swapped)
Graphic LCD Pin ----- Arduino Pin

```

1-VCC ----- 5V
2-GND ----- GND
3-SCE ----- 7
4-RST ----- 6
5-D/C ----- 5
6-DN(MOSI) ----- 11
7-SCLK ----- 13
8-LED - 330 Ohm res -- 9

```

The SCLK, DN(MOSI), must remain where they are, but the other pins can be swapped. The LED pin should remain a PWM-capable pin. Don't forget to stick a current-limiting resistor in line between the LCD's LED pin and Arduino pin 9!

```

*/
#include <SPI.h>
#include "LCD_Functions.h"

/* This array is the same size as the displayMap. We'll use it
as an example of how to draw a bitmap. xkcd comic transposing
makes for an excellent display application.
For reference, see: http://xkcd.com/149/ */
static const char xkcdSandwich[504] PROGMEM = {
0xFF, 0x8D, 0x9F, 0x13, 0x13, 0xF3, 0x01, 0x01, 0xF9, 0xF9, 0x01, 0x81, 0xF9, 0xF9, 0x01, 0xF1,
0xF9, 0x09, 0x09, 0xFF, 0xFF, 0xF1, 0xF9, 0x09, 0x09, 0xF9, 0xF1, 0x01, 0x01, 0x01, 0x01, 0x01,
0xF9, 0xF9, 0x09, 0xF9, 0x09, 0xF9, 0xF1, 0x01, 0xC1, 0xE9, 0x29, 0x29, 0xF9, 0xF1, 0x01, 0xFF,
0xFF, 0x71, 0xD9, 0x01, 0x01, 0xF1, 0xF9, 0x29, 0x29, 0xB9, 0xB1, 0x01, 0x01, 0x01, 0xF1, 0xF1,
0x11, 0xF1, 0xF1, 0xF1, 0xE1, 0x01, 0xE1, 0xF1, 0x51, 0x51, 0x71, 0x61, 0x01, 0x01, 0xC1, 0xF1,
0x31, 0x31, 0xF1, 0xFF, 0xFF, 0x00, 0x01, 0x01, 0x01, 0x01, 0x60, 0xE0, 0xA0, 0x01, 0x01, 0x81,
0xE1, 0x61, 0x60, 0xC0, 0x01, 0xE1, 0xE1, 0x21, 0x21, 0xE0, 0xC1, 0x01, 0xC1, 0xE1, 0x20, 0x20,
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0xFF, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x33,
0x5F, 0x8F, 0x84, 0x05, 0x07, 0x06, 0x0C, 0x0E, 0x0E, 0x0C, 0x14, 0x34, 0x68, 0x88, 0xD8, 0x70,
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0x0E, 0x01, 0xC0, 0x3F, 0xE0, 0x00, 0x00, 0x03, 0x0E, 0x08, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
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0xEF, 0xBB, 0x83, 0x86, 0x88, 0xB0, 0x80, 0x80, 0x80, 0x8F, 0x90, 0x90, 0x90, 0x9F, 0x8F, 0x80,
0x9F, 0x9F, 0x87, 0x8D, 0x98, 0x80, 0x8C, 0x9E, 0x92, 0x92, 0x9F, 0xC0, 0xC7, 0xFF, 0xB8, 0x8F,
0x80, 0x90, 0x90, 0xC0, 0xF0, 0x8E, 0x81, 0x80, 0x81, 0x8F, 0xB8, 0xE0, 0x80, 0x80, 0x80, 0x80,
0x80, 0x80, 0x80, 0x80, 0x80, 0x80, 0x80, 0xFF,
};

void setup()

```

```

{
  Serial.begin(9600);

  lcdBegin(); // This will setup our pins, and initialize the LCD
  updateDisplay(); // with displayMap untouched, SFE logo
  setContrast(40); // Good values range from 40-60
  delay(2000);

  lcdFunTime(); // Runs a 30-second demo of graphics functions

  // Wait for serial to come in, then clear display and go to echo
  while (!Serial.available())
  ;
  clearDisplay(WHITE);
  updateDisplay();
}

// Loop turns the display into a local serial monitor echo.
// Type to the Arduino from the serial monitor, and it'll echo
// what you type on the display. Type ~ to clear the display.
void loop()
{
  static int cursorX = 0;
  static int cursorY = 0;

  if (Serial.available())
  {
    char c = Serial.read();

    switch (c)
    {
      case '\n': // New line
        cursorY += 8;
        break;
      case '\r': // Return feed
        cursorX = 0;
        break;
      case '~': // Use ~ to clear the screen.
        clearDisplay(WHITE);
        updateDisplay();
        cursorX = 0; // reset the cursor
        cursorY = 0;
        break;
      default:
        setChar(c, cursorX, cursorY, BLACK);
        updateDisplay();
        cursorX += 6; // Increment cursor
        break;
    }
    // Manage cursor
    if (cursorX >= (LCD_WIDTH - 4))
    { // If the next char will be off screen...
      cursorX = 0; // ... reset x to 0...
      cursorY += 8; // ...and increment to next line.
      if (cursorY >= (LCD_HEIGHT - 7))
      { // If the next line takes us off screen...

```

```

        cursorY = 0; // ...go back to the top.
    }
}
}
}

/* This function serves as a fun demo of the graphics driver
functions below. */
void lcdFunTime()
{
    clearDisplay(WHITE); // Begin by clearing the display
    randomSeed(analogRead(A0));

    /* setPixel Example */
    const int pixelCount = 100;
    for (int i=0; i<pixelCount; i++)
    {
        // setPixel takes 2 to 3 parameters. The first two params
        // are x and y variables. The third optional variable is
        // a "color" boolean. 1 for black, 0 for white.
        // setPixel() with two variables will set the pixel with
        // the color set to black.
        // clearPixel() will call setPixel with with color set to
        // white.
        setPixel(random(0, LCD_WIDTH), random(0, LCD_HEIGHT));
        // After drawing something, we must call updateDisplay()
        // to actually make the display draw something new.
        updateDisplay();
        delay(10);
    }
    setStr("full of stars", 0, LCD_HEIGHT-8, BLACK);
    updateDisplay();
    delay(1000);
    // Seizure time!!! Err...demoing invertDisplay()
    for (int i=0; i<5; i++)
    {
        invertDisplay(); // This will swap all bits in our display
        delay(200);
        invertDisplay(); // This will get us back to where we started
        delay(200);
    }
    delay(2000);

    /* setLine Example */
    clearDisplay(WHITE); // Start fresh
    int x0 = LCD_WIDTH/2;
    int y0 = LCD_HEIGHT/2;
    for (float i=0; i<2*PI; i+=PI/8)
    {
        // Time to whip out some maths:
        const int lineLength = 24;
        int x1 = x0 + lineLength * sin(i);
        int y1 = y0 + lineLength * cos(i);

        // setLine(x0, y0, x1, y1, bw) takes five variables. The
        // first four are coordinates for the start and end of the

```

```

// line. The last variable is the color (1=black, 0=white).
setLine(x0, y0, x1, y1, BLACK);
updateDisplay();
delay(100);
}
// Demo some backlight tuning
for (int j=0; j<2; j++)
{
  for (int i=255; i>=0; i-=5)
  {
    analogWrite(blPin, i); // blPin is ocnected to BL LED
    delay(20);
  }
  for (int i=0; i<256; i+=5)
  {
    analogWrite(blPin, i);
    delay(20);
  }
}

/* setRect Example */
clearDisplay(WHITE); // Start fresh

// setRect takes six parameters (x0, y0, x1, y0, fill, bw)
// x0, y0, x1, and y0 are the two diagonal corner coordinates
// fill is a boolean, which determines if the rectangle is
// filled in. bw determines the color 0=white, 1=black.
for (int x=0; x<LCD_WIDTH; x+=8)
{ // Swipe right black
  setRect(0, 0, x, LCD_HEIGHT, 1, BLACK);
  updateDisplay();
  delay(10);
}
for (int x=0; x<LCD_WIDTH; x+=8)
{ // Swipe right white
  setRect(0, 0, x, LCD_HEIGHT, 1, WHITE);
  updateDisplay();
  delay(10);
}
for (int x=0; x<12; x++)
{ // Shutter swipe
  setRect(0, 0, x, LCD_HEIGHT, 1, 1);
  setRect(11, 0, x+12, LCD_HEIGHT, 1, BLACK);
  setRect(23, 0, x+24, LCD_HEIGHT, 1, BLACK);
  setRect(35, 0, x+36, LCD_HEIGHT, 1, BLACK);
  setRect(47, 0, x+48, LCD_HEIGHT, 1, BLACK);
  setRect(59, 0, x+60, LCD_HEIGHT, 1, BLACK);
  setRect(71, 0, x+72, LCD_HEIGHT, 1, BLACK);
  updateDisplay();
  delay(10);
}
// 3 Dee!
setRect(25, 10, 45, 30, 0, WHITE);
setRect(35, 20, 55, 40, 0, WHITE);
setLine(25, 10, 35, 20, WHITE);
setLine(45, 30, 55, 40, WHITE);

```



```

setLine(25, 30, 35, 40, WHITE);
setLine(45, 10, 55, 20, WHITE);
updateDisplay();
delay(2000);

/* setCircle Example */
clearDisplay(WHITE);
// setCircle takes 5 parameters -- x0, y0, radius, bw, and
// lineThickness. x0 and y0 are the center coords of the circ.
// radius is the...radius. bw is the color (0=white, 1=black)
// lineThickness is the line width of the circle, 1 = smallest
// thickness moves in towards center.
for (int i=0; i<20; i++)
{
  int x = random(0, LCD_WIDTH);
  int y = random(0, LCD_HEIGHT);

  setCircle(x, y, i, BLACK, 1);
  updateDisplay();
  delay(100);
}
delay(2000);

/* setChar & setStr Example */
// setStr takes 4 parameters: an array of characters to print,
// x and y coordinates for the top-left corner. And a color
setStr("Modern Art", 0, 10, WHITE);
updateDisplay();
delay(2000);

/* setBitmap Example */
// setBitmap takes one parameter, an array of the same size
// as our screen.
setBitmap(xkcdSandwich);
updateDisplay();
}

```

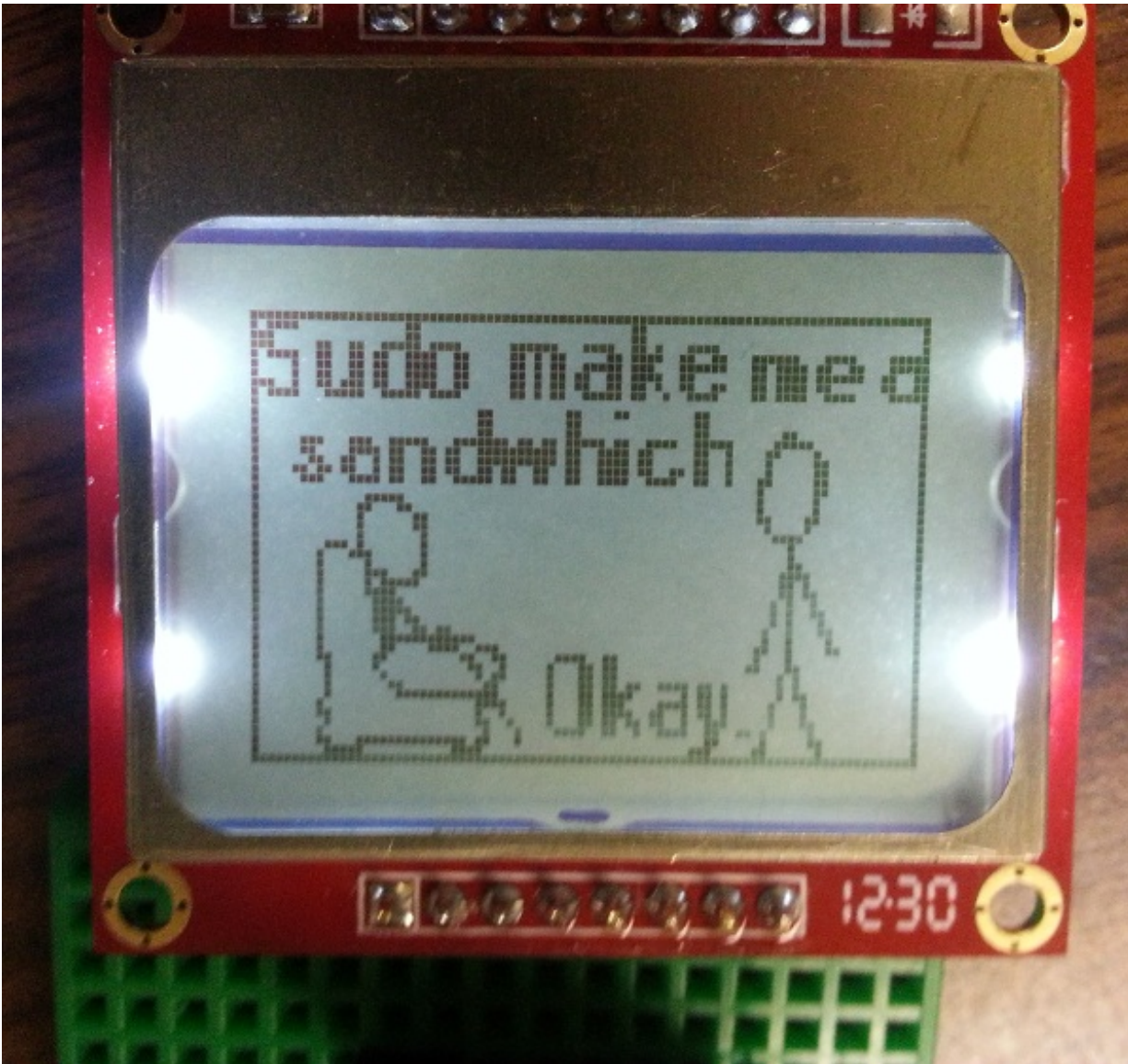
For help understanding the sketch, check the comments in the code. Most of the action takes place in the `lcdFunTime()` function.

Heads up! If the display is not showing pixels even with the correct logic levels and example code, it may just have slight variances in the way that they were manufactured. You can see the pixels faintly on the screen at an angle or pushing down on the LCD. You will need to try and set the contrast where it says `setContrast(40)` on line 87 to a value of 60. There is probably some variances in the LCD's contrast which might explain why certain LCDs have issues displaying defined pixels on the screen.

The Sketch in Action

Once uploaded to your Arduino, the sketch will begin by running the demo -- a set of basic animations and graphics functions. To begin, we'll draw some random **pixels** on the screen ("It's full of stars..."). Then we'll move on to examples of drawing **lines**, **rectangles**, and **circles**. Throughout there are examples of drawing **characters** and **strings**. Finally the demo closes out with an

homage to a [monochrome comic](#) which seems a perfect fit for this little monochrome LCD.



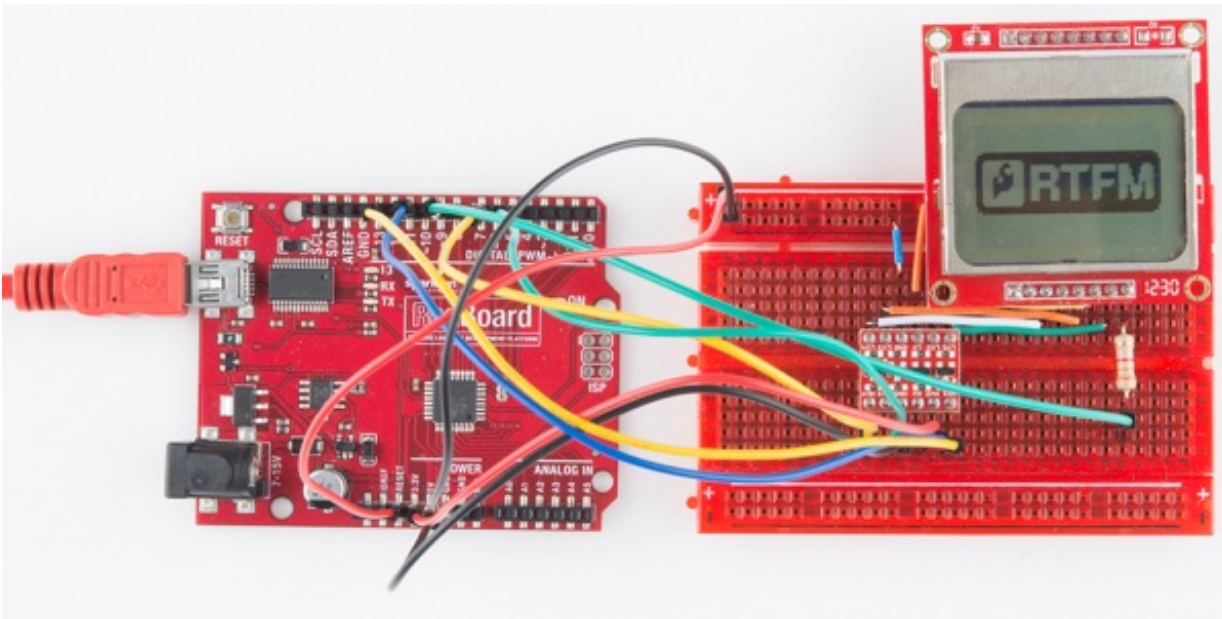
This is a demo of drawing bitmaps on the screen, which is one of the more rewarding tasks we can accomplish with the 'duino/LCD combo.

After the demo runs its course, the sketch will enter into a serial echo mode. Open the serial monitor (set the baud rate to 9600 bps), and type stuff over to the Arduino. It should start printing everything you send it onto the LCD.

If you're intrigued by the possibilities of drawing bitmaps on the screen, check out the next page! We'll show you how to import your own 84x48 bitmap and draw it on the screen.

Example Code 2: Drawing Bitmaps

If the last demo has you chomping at the bit to design your own 84x48 bitmaps and display them, continue reading through this example. We'll show you how to scale and import a bitmap, then compile it into your Arduino code and send it to the LCD, so you can have your own, silly graphic.



Find/Make/Modify a Bitmap

To begin, find a bitmap image that you'd like to print to the LCD. 84x48 monochrome pixels doesn't give you a *lot* of room, but you can still get some fun stuff on there. Here are a few examples:

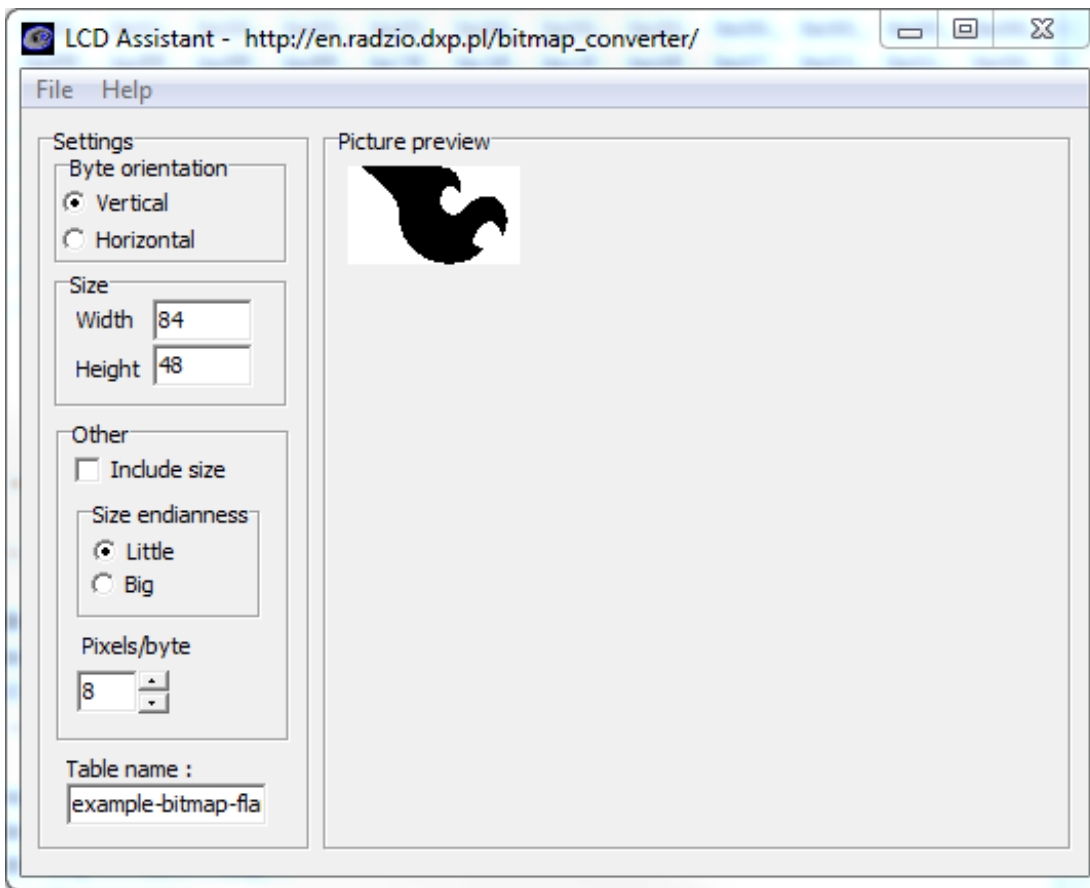


After you've picked an image, you'll need to massage it to make it both **monochrome** (2-bit color) and **84 x 48 pixels**. Most standard image editors can help with this. For Windows users, [Paint](#) is all you need to scale the image. Then save it as a monochrome bitmap.

Convert Bitmap to Array

The next step is converting that regular image file to a 504-byte array of char's. There are a number of programs that can help with this around the web. We recommend [LCD Assistant](#).

To load up an image in LCD Assistant, go to *File > Load Image*. A preview of the image should open up, make sure it's the right size -- 84 pixels wide, 48 pixels tall. Also make sure the *Byte orientation* is set to **Vertical** and the *Size endianness* is set to **Little**. The rest of the default settings (8 pixels/byte, etc.) should already be set correctly:



Then go to *File > Save output* to generate a temporary text file. Open that text file to have a look at your shiny new array. You'll need to modify the **type** of the array to be just `uchar` (no `unsigned` or `const`). Also make sure the array has the proper naming conventions (no dashes, don't start with a number, etc.).

Import into the Sketch and Draw!

With that array created, copy the entire table over to your Arduino sketch. Use the same sketch from [Example 1](#). Paste the array wherever you'd like. Now, to test out your drawing, replace the `setup()` and `loop()` in the last sketch with the below (making sure the rest of the functions and variables remain in the sketch):

```
language:c

// ...LCD definitions, variables, and bitmap array defined above.

void setup()
{
  lcdBegin(); // This will setup our pins, and initialize the LCD
  setContrast(60); // Good values range from 40-60
  setBitmap(flameBitmap); // flameBitmap should be replaced with the name of your BMP array
  updateDisplay(); // Update the display to make the array show up.
}

void loop()
{
}
```

// LCD control and graphics functions defined below...

Fun stuff! Now you can overlay text, or draw on on your bitmap. You can even try importing multiple graphics to create animations!

Resources and Going Further

Thanks for checking out our Monochrome 84 x 48 Graphic LCD Hookup Guide! Should you require any further resources to get your LCD up and running, here are some handy places to look:

- **LCD and Driver Resources**
 - [PCD8544 LCD Controller Datasheet](#)
 - [LCD Datasheet](#) -- Not exactly SparkFun's LCD, but a pretty close match.
 - [GitHub Repository](#) - Example code used in this tutorial for the Nokia graphic LCD.
- **Arduino Libraries and Code**
 - [PCD8544 Arduino Library](#) -- A dependable Arduino library for the PCD8544 LCD driver.
 - [AdaFruit LCD Library](#) -- Adafruit has an *amazing* Arduino library to help interface with this LCD. Also requires their graphics library.
- **Bitmap Tools**
 - [LCD Assitant](#)
 - [Bitmap2LCD](#)
 - [TheDotFactory](#) -- Nifty tool to create array definitions for custom fonts.

Going Further

Now that you've got control of your graphic LCD, you can embed it into all sorts of cool projects. If you need some inspiration, here are some related tutorials to help you out:

- [OLED Display Hookup Guide](#) -- While not exactly an LCD, this OLED provides a nice, crisp text display to your project.
- [MP3 Player Shield Music Box](#) -- This MP3 Player Music Box could be well served by a sweet graphic display. Hmm...
- [ITG-3200 Hookup Guide](#) -- The ITG-3200 is a fully-featured 3-axis gyroscope sensor. This display could be used to create a visual angular velocity meter.

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