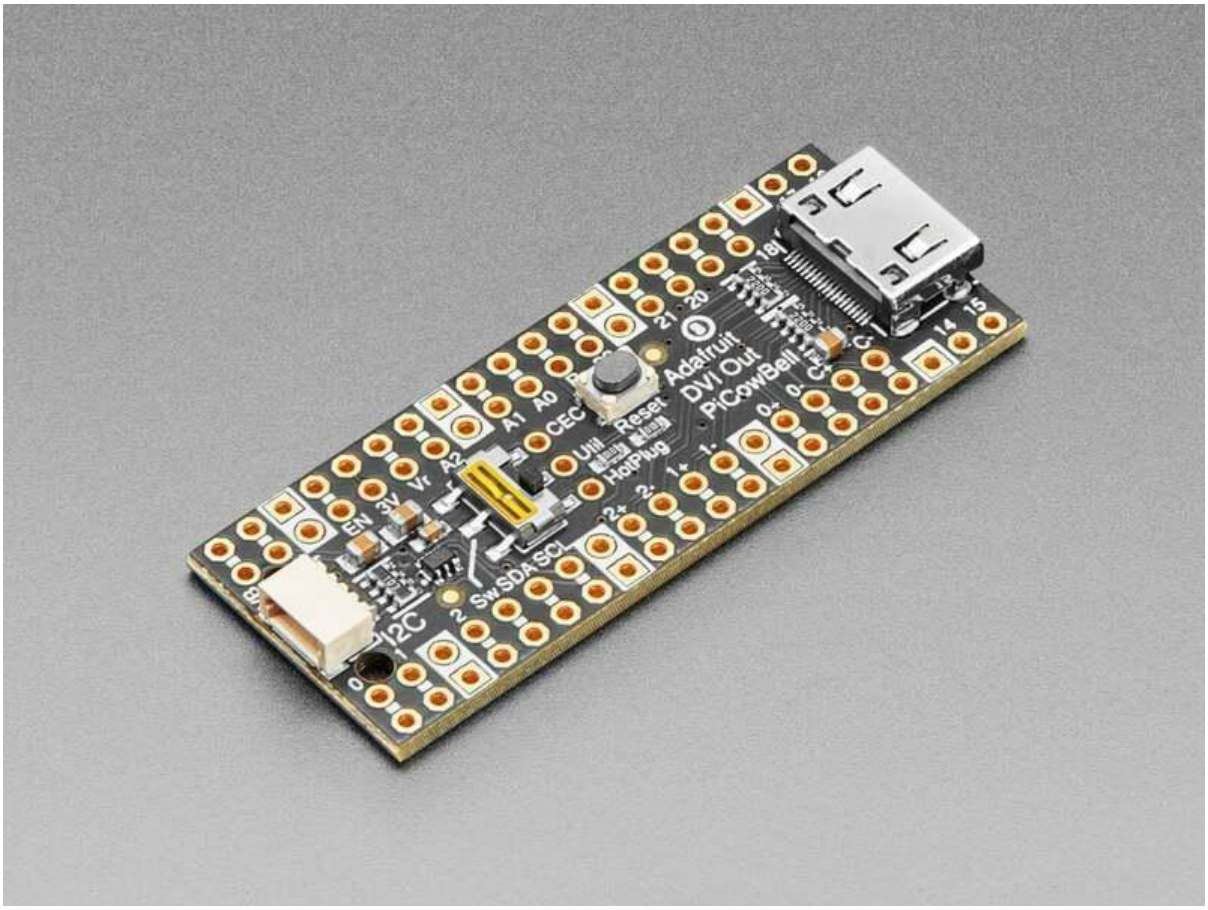
# Adafruit PiCowbell DVI Output

Created by Liz Clark



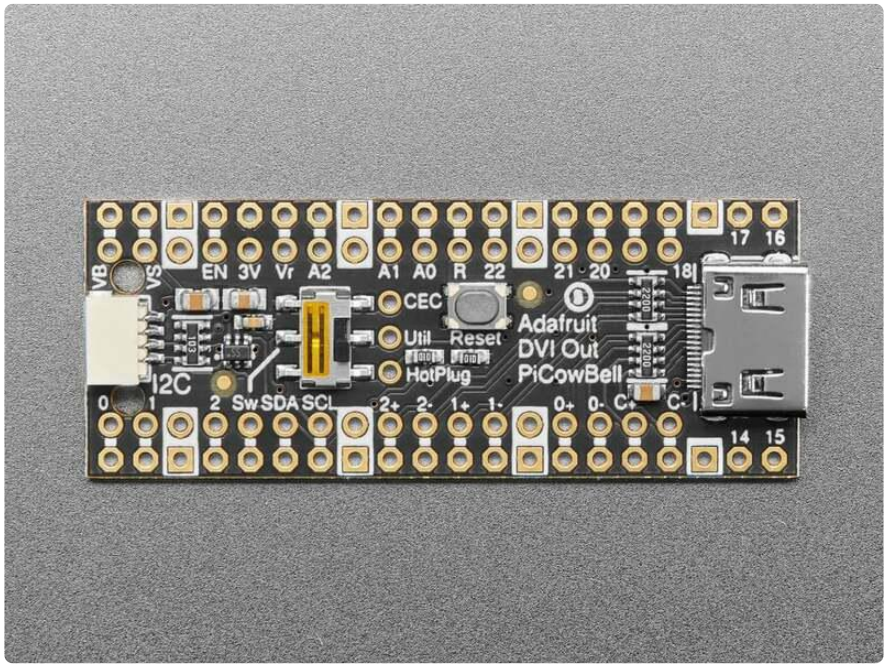

https://learn.adafruit.com/adafruit-picowbell-dvi-output

Last updated on 2023-08-29 04:52:21 PM EDT

# Table of Contents

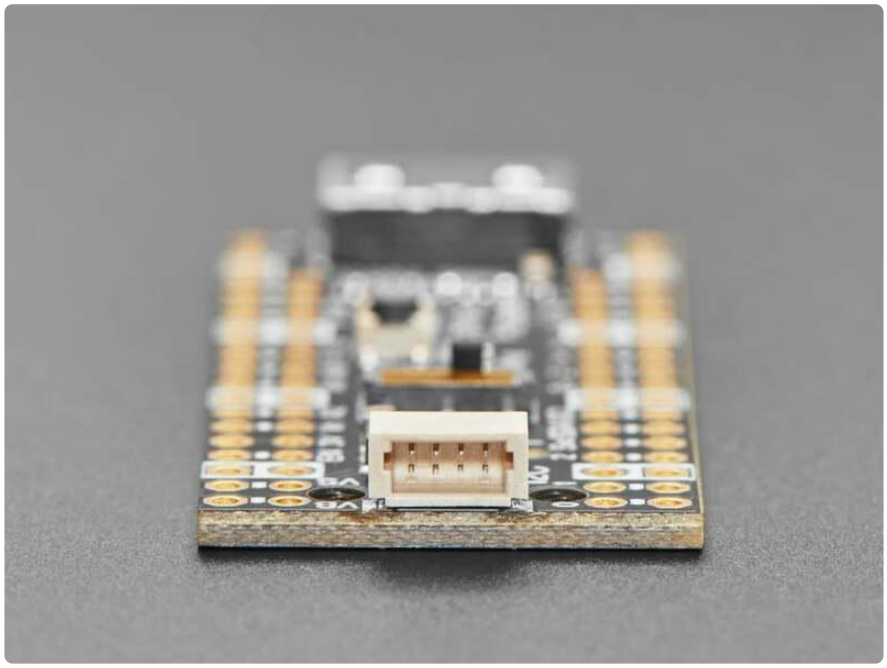
# Overview

Ding dong! Hear that? It's the PiCowbell ringing, letting you know that the new Adafrui t PiCowbell DVI Output for Pico is in stock and ready to display images and graphics from a microcontroller directly to an HDMI monitor or television! Note it doesn't do audio, just graphics.



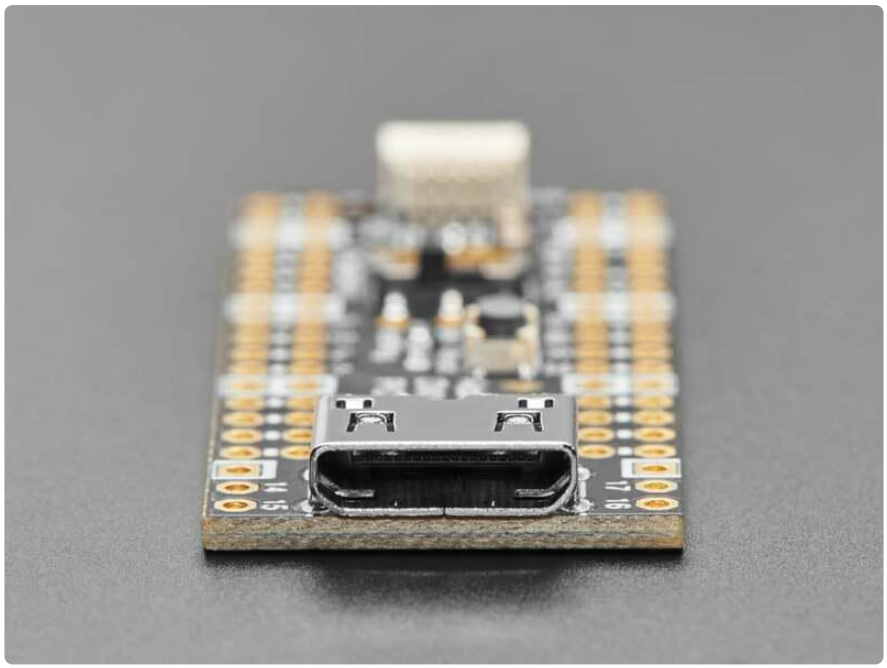

The PiCowbell DVI is the same size and shape as a Raspberry Pi Pico and is intended to socket underneath this board to make your next video output project super easy. Mini HDMI connector for use with standard HDMI cables? Yes! STEMMA QT / Qwiic

connector for fast I2C? Indeed. Reset button and extra switch for restarting code or changing configuration? Bien sur.

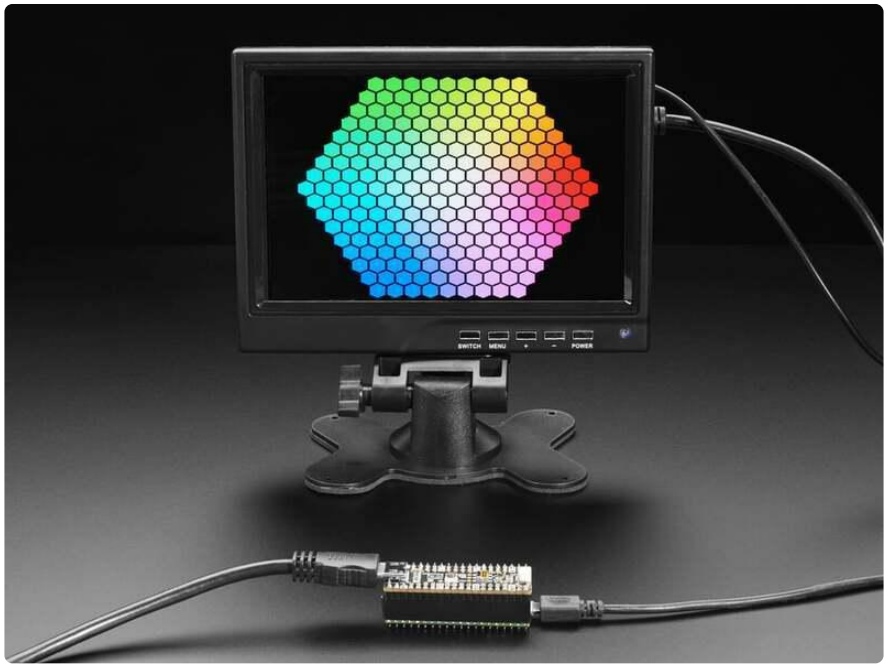


The PiCowbell DVI provides you with:

- Right angle JST SH connector for I2C / Stemma QT / Qwiic connection. Provides 3V, GND, IO4 (SDA), and IO5 (SCL). Also connected through to the HDMI sink (monitor) with level shifting, so the EDID can be read.
- Mini HDMI connector for DVI output to any HDMI display or monitor.
    - GPIO6: D2+
    - GPIO7: D2-
    - GPIO8: D1+
    - GPIO9: D1-
    - GPIO10: D0+
    - GPIO11: D0-
    - GPIO12: Clock +
    - GPIO13: Clock -
- Pin breakout for HDMI extras: Utility, CEC, and HotPlug pins.
- Reset button - Press to restart your program.
- Slide switch - On GPIO #3 for whatever purpose you wish.
- Many pads on the 'Bell has a duplicate hole pad next to it for solder-jumpering.
- The ground pads have white silkscreen rectangles to easily identify them.
- Gold-plated pads for easy soldering.

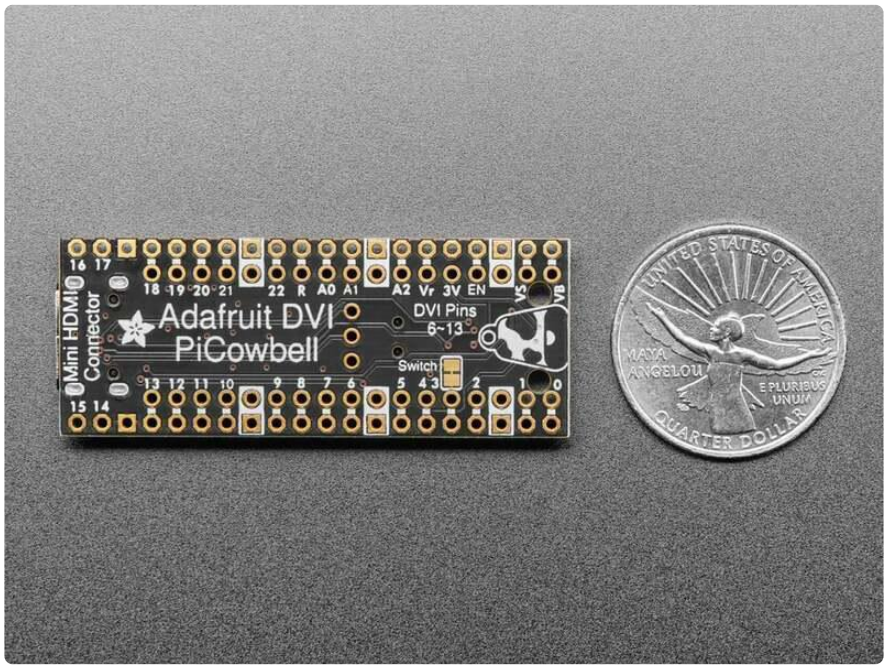


In Arduino, which is what we recommend, we use our fork of PicoDVI () to create an internal framebuffer of 320x240 or 400x240 16-bit pixels that is then continuously blitted out as pixel-doubled 640x480 or 800x480 digital video. Whatever you 'draw' to the internal memory framebuffer appears instantly on the digital display in crisp color. Since the library is a subclass of AdafruitGFX, it'll be familiar to folks who have used our TFT or OLED displays before.



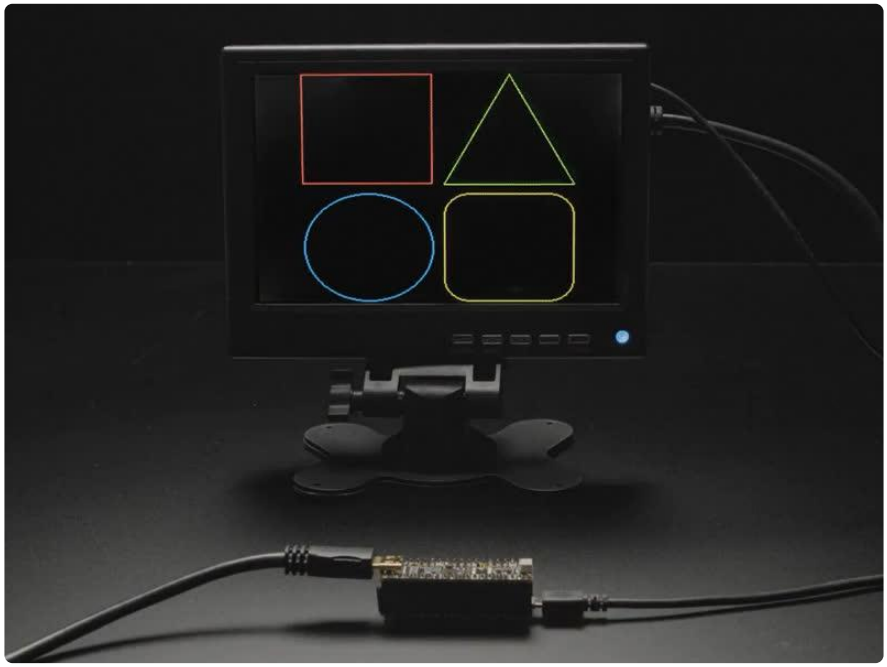
There's also DVI output support in CircuitPython as of 8.1.0b2 () - but note that it uses a lot of memory so in particular if you want to use PicoW with WiFi support, you'll likely only be able to get away with monochrome display. The older Pico (no W) has more memory since some isn't dedicated to WiFi.

Note that the DVI video generation uses one full core, both PIOs and 150K (320x240) or 190K (400x240) of SRAM. It's kinda maxed out, so be aware of the remaining resource limitations.




We also connected the HDMI-connectors I2C pins to the SDA/SCL of the Pico (through a safe level shifter) so you can read the EDID EEPROM of displays, and have broken out the CEC and Utility pads. The Hot Plug Detect pin is also available. Read this pin to know when a display has been connected!

Each order comes with an assembled PCB and header. You will need to solder in the header yourself, but it's a quick task.

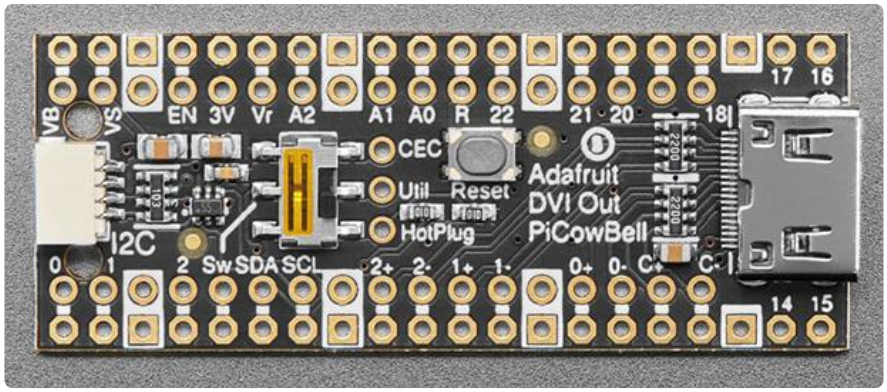


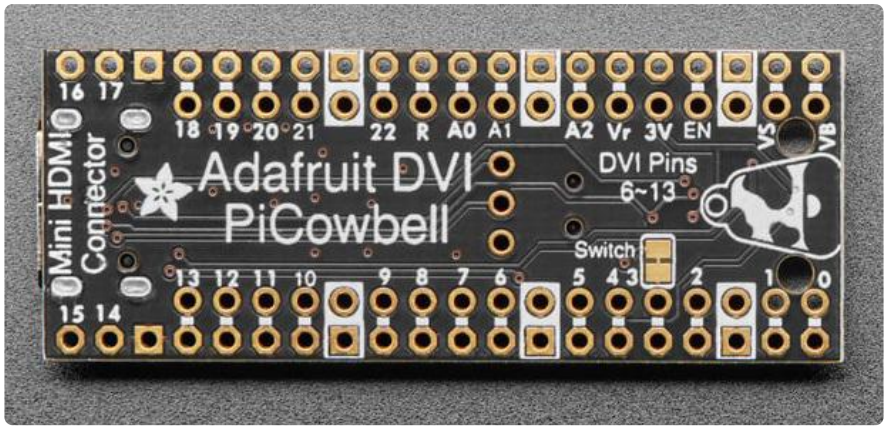
Please Note! There are a lot of possible configurations, and we stock various headers depending on how you want to solder and attach. Especially if you want the Pico on top so that the BOOTSEL button and LED are accessible.

1. Use the Pico Stacking Headers () if you want to be able to plug into a breadboard or other accessory with sockets.
2. Use the Pico Socket Headers () if you want to plug directly in and have a nice solid connection that doesn't have any poking-out-bits.
3. Use the Short Socket Headers () for a very slim but pluggable design; note that you'll want to trim down the Pico's headers or use the short plug headers on the Pico () to have a skinny sandwich.

---

# Pinouts




## Power

- VB (VBUS) - This is the micro-USB input voltage, connected to the micro-USB port on the Raspberry Pi Pico. It is nominally 5V.
- VS (VSYS) - This is the main system input voltage. It can range from 1.8V to 5.5V and is used to generate the 3.3V needed for the RP2040 and the GPIO pins.
- EN (3V3_EN) - This connects to the enable pin on the Raspberry Pi Pico, and is pulled high (to VSYS) via a 100kΩ resistor.

- 3V - This is the 3.3V output from the Raspberry Pi Pico.
- VR (ADC_VREF) - This is the ADC power supply and reference voltage. It is generated on the Raspberry Pi Pico by filtering the 3.3V supply. It can be used with an external reference when ADC performance is required.
- All ground pins are highlighted in white on the silk. This is the common ground for power and logic.

## I2C Logic

- SCL - I2C clock pin on the PiCowbell. It is connected to your microcontroller I2C clock line, which is GPIO5 on the Pico. This connection is shared with the STEMMA QT port on the end of the board.
- SDA - I2C data pin on the PiCowbell. It is connected to your microcontroller I2C data line, which is GPIO4 on the Pico. This connection is shared with the STEMMA QT port on the end of the board.
- STEMMA QT () - These connectors allow you to connect to dev boards with STEMMA QT connectors or to other things with various associated accessories (). The port is located on the end of the PiCowbell.

## Duplicate GPIO Hole Pads

The following pads on the PiCowbell DVI have a duplicate hole pad next to it for solder-jumpering:

- GP0-GP13, GP18-GP22, Reset, A0-A2, VR, 3V, EN, VS and VB. Ground pins that have a duplicate hole pad are highlighted in white on the board silkscreen.
    - Note that GP3 is connected by default to the switch (Sw) on the front of the PiCowbell. It can be disconnected by cutting the Switch jumper on the back of the PiCowbell, described below.

## Mini HDMI Connector

- Mini HDMI connector - On the end of the board is the mini HDMI connector. It provides DVI output to any HDMI display or monitor. The following GPIO pins are routed to the connector:
    - GPIO6: D2+
    - GPIO7: D2-
    - GPIO8: D1+
    - GPIO9: D1-

    - GPIO10: D0+
    - GPIO11: D0-
    - GPIO12: Clock +
    - GPIO13: Clock -

## Additional HDMI Pins

Three additional pins for the HDMI connector are broken out in the center of the board, between the slide switch and the reset button.

- Utility pin - labeled Util on the board silk. This pin is reserved for future HDMI specification updates. It is connected to pin 17 on the mini HDMI port.
- CEC pin - labeled CEC on the board silk. Consumer Electronic Control () is a one-wire bidirectional serial bus that is standardized for remote control functions. It is connected to pin 14 on the mini HDMI port.
- Hot Plug Detection pin - labeled HotPlug on the board silk. It is connected to pin 19 on the mini HDMI port. Hot plug detection is used to detect if a device is connected or disconnected to the HDMI connector by monitoring power, plug and unplug events.

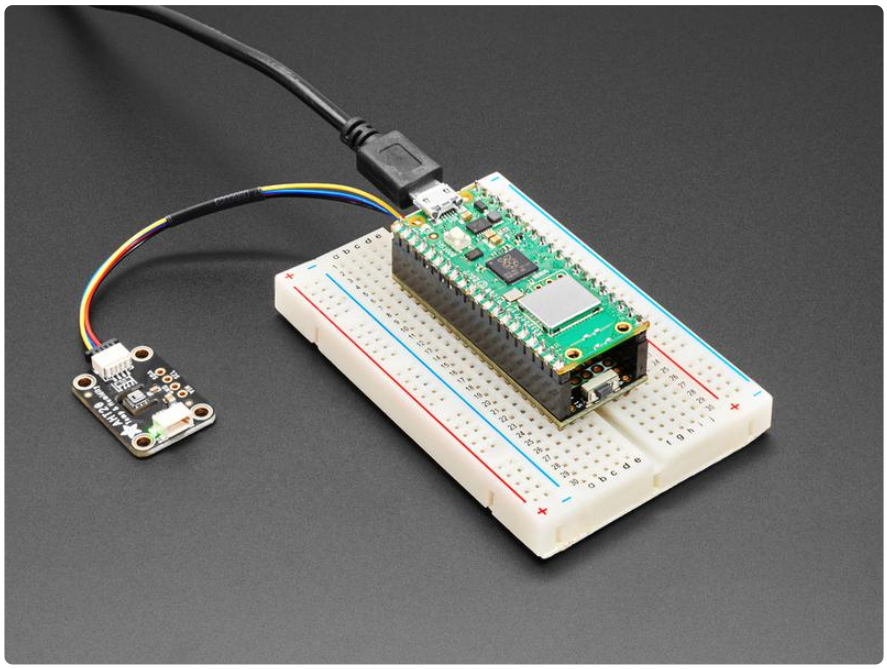
## Reset Button

In the center of the board, to the right of the sliding switch, is the reset button. It is routed to the reset pin on the PiCowbell and is labeled R on the board silk. You can press it to restart your program.

## Slide Switch and Switch Jumper

- Slide switch - on the front of the board, to the right of the STEMMA QT port, is a slide switch that can be used for whatever purpose you like. By default it is connected to GP3, labeled Sw on the board silk.
    - It is tied to ground, reading as `False` in CircuitPython or `LOW` in Arduino, when it is switched up towards pin A2 on the silk.
    - It is open, reading as `True` in CircuitPython or `HIGH` in Arduino, when it is switched down towards pin SCL on the silk.
- Switch jumper - on the back of the board, directly next to GP3, is the Switch jumper. It is outlined in white on the silk and is labeled Switch. If you cut the jumper, it will disconnect the slide switch from GP3.

# Assembly



Although these pages show the PiCowbell Proto, the soldering instructions are applicable for all PiCowbell boards.

There are four ways to get your PiCowbell board working with your Pico. To keep things flexible, PiCowbells do not come with headers: there's a lot of possible configurations and we stock various headers depending on how you want to solder and attach. Especially since you want the Pico on top, so that the BOOTSEL button and LED are accessible.

The options are as follows.

1. Use the Pico Stacking Headers () if you want to be able to plug into a breadboard or other accessory with sockets.
2. Use the Pico Socket Headers () if you want to plug directly into the Pico and have a nice solid connection that doesn't have any poking-out-bits.
3. For some PiCowbells: Use the Short Socket Headers () for a very slim but pluggable design, note that you'll want to trim down the Pico's headers or use the short plug headers on the Pico () to have a skinny sandwich.
4. For some PiCowbells: Solder the PiCowbell directly to the standard headers already soldered to your Pico. Of course this is very compact and inexpensive but you won't be able to remove the PiCowbell. However, this method is not possible for some PiCowbell variants depending on the clearance of the components on the PiCowbell (i.e. the PiCowbell Adalogger and its coin cell battery holder).

The next page shows how to solder standard headers onto a Pico board. The following four pages walk you through each type of PiCowbell assembly so you can choose the one that will work best for you!

You MUST solder all of the pins for the PiCowbell to work! Soldering only a few pins, or not soldering at all are not sufficient!

If you're unsure about soldering up the Pico and PiCowbell, check out our FAQ on soldering ().

---

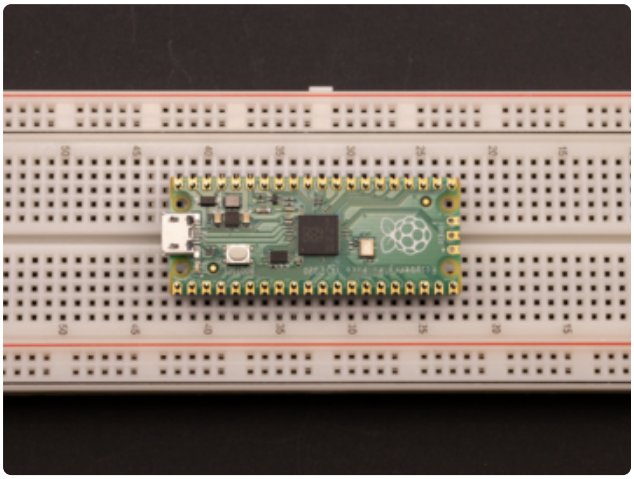
# Pico

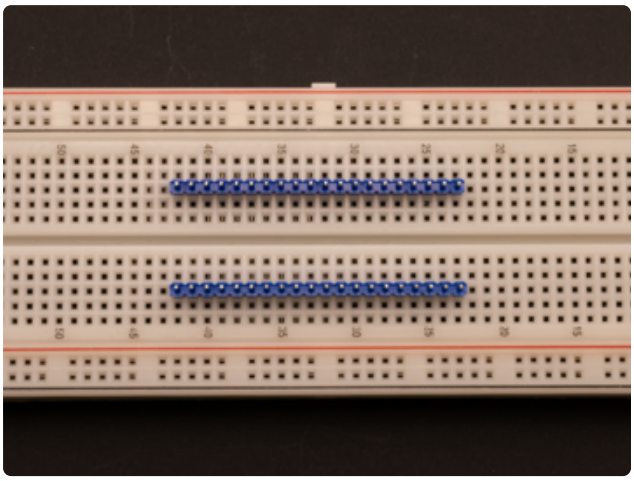
Three out of four of the assembly methods included in this guide assume you have a Raspberry Pi Pico soldered up with standard male headers in preparation for using it with the PiCowbell Proto. This page will show you how to solder a set of standard headers to a Pico.

(The shorty header assembly method uses short male headers on the Pico. The soldering concept is exactly the same, but use the shorty male headers on the Pico instead of standard ones. You can follow these instructions with the shorty headers and you'll be set for that.)

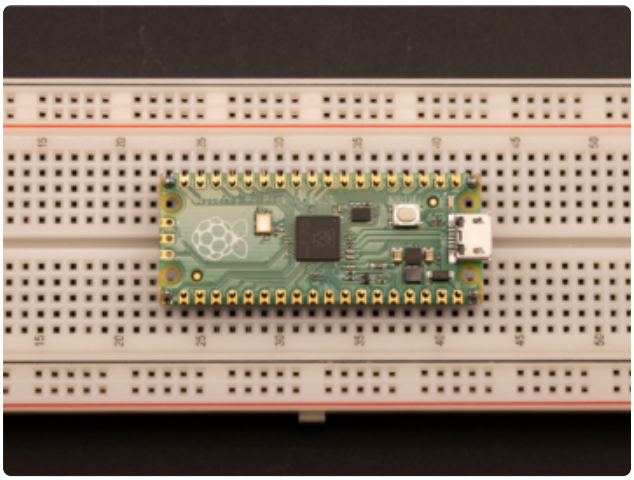
Follow the steps below to solder the standard male headers to a Pico. The process is the same for all flavors of Pico, such as Pico W.

## Assembly Steps

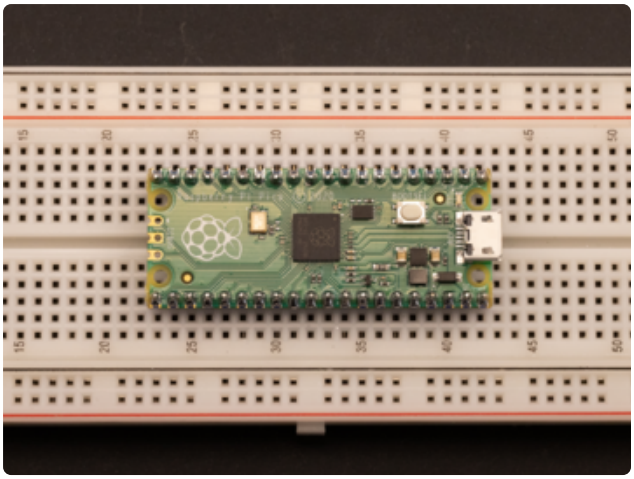




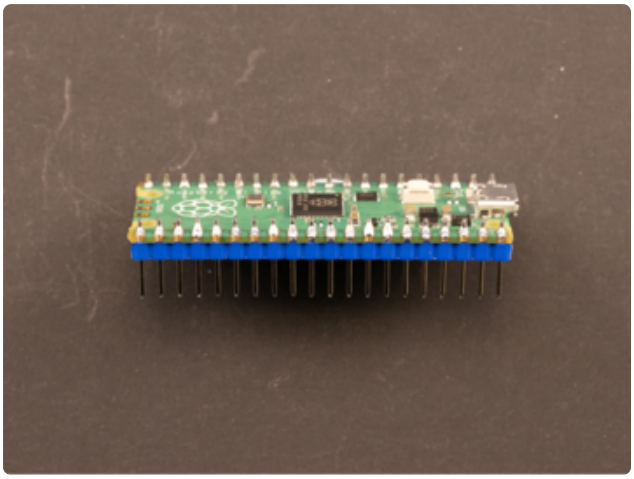
Use the Pico to line up the headers on a breadboard. This is the easiest way to ensure the headers are soldered on straight.



Solder the pins on each end of the two header strips, so the four corners of the Pico are soldered. This ensures the Pico and headers are attached properly while you continue to solder the rest of the pins.



Solder the rest of the pins.



Remove it from the breadboard. You're done!

For a bit more detail on the process of soldering standard male headers to a board, check out the How to Solder Headers' Male Headers page ().

---

# Stacking Headers

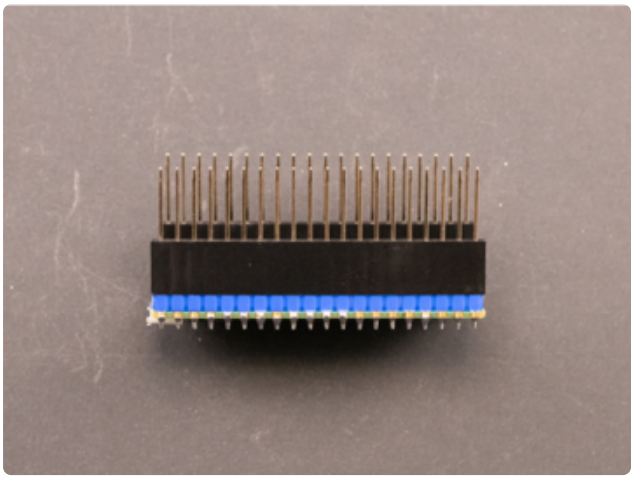
The first PiCowbell assembly method uses stacking headers, which allows you to use a breadboard with your PiCowbell-Pico sandwich. This is super helpful when you're still prototyping other parts of your project, or simply want jumper-wire access to the Pico pins in addition to the PiCowbell.

This page assumes you have already soldered standard male headers to your Pico. If you have not, please return to the Pico assembly page () and follow the steps there.

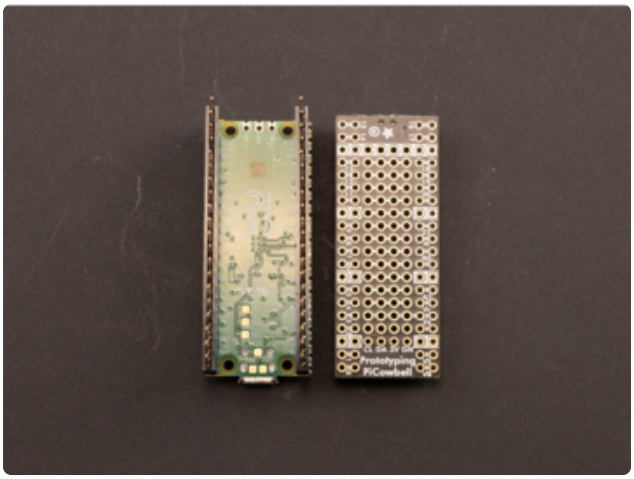
Follow the steps below to solder stacking headers to your PiCowbell.

Although these pages show the PiCowbell Proto, the soldering instructions are applicable for all PiCowbell boards.

## Assembly Steps



Place a standard-header-soldered Pico upside down on the table, so the long side of the header pins are facing up. Press the female sockets of each stacking header onto one of the rows of standard headers attached to the Pico, until they are fully attached.

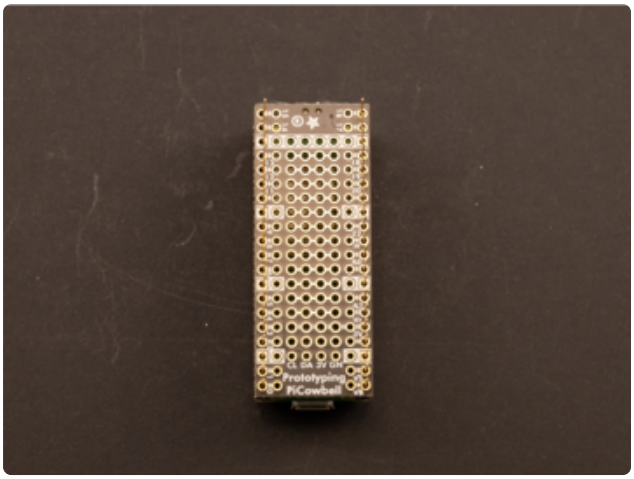


Ensure the PiCowbell is oriented correctly before beginning assembly. The PiCowbell should be top-down, so that you are looking at the bottom of the PiCowbell. The STEMMA QT connector should be on the same end as the Pico USB connector, and the reset button should be on the opposite end with the Pico debug pins.

The PiCowbell pins must match the pinout on the Pico.

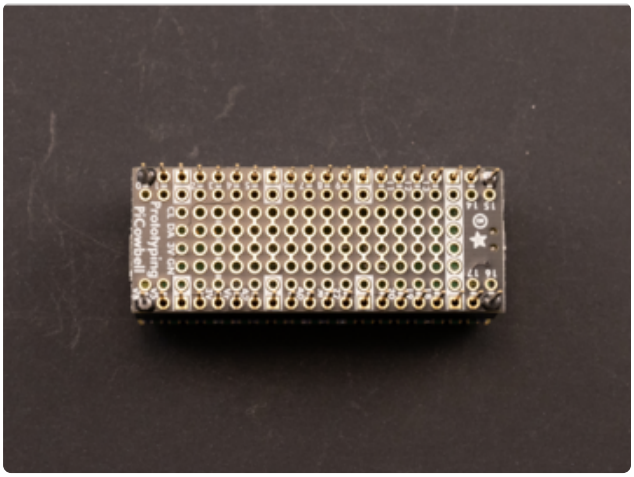
Remember, the pins are labeled on the bottom of the Pico. In this case, that works well because they are labeled on both sides of the PiCowbell, allowing for direct comparison before attaching the PiCowbell to the stacking header assembly.

Ensure the PiCowbell is oriented properly before beginning soldering! If you solder it on upside down or backwards, it will not function properly!

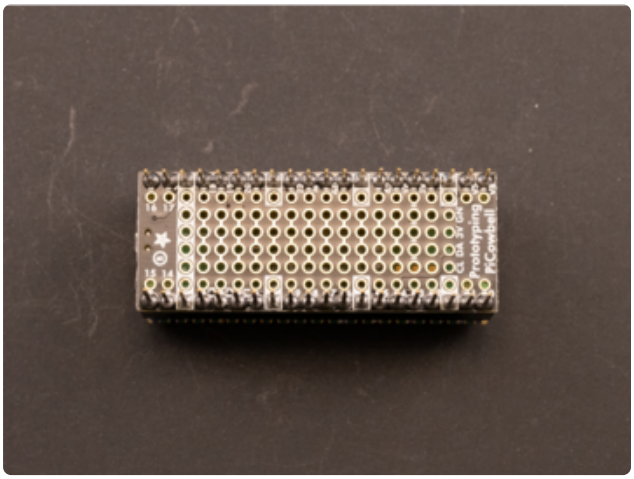


Press the PiCowbell onto the male pins sticking up from the stacking headers. You may need to push the stacking header pins in or out a bit to get the PiCowbell attached.

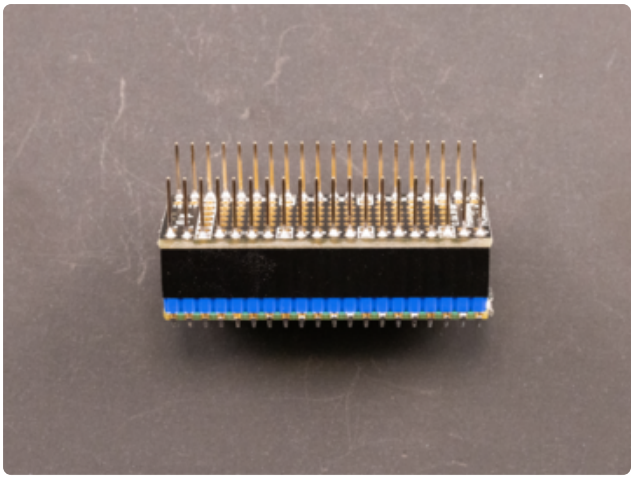
With the stacking header male pins sticking up, the bottom of the PiCowbell should be facing up as well.

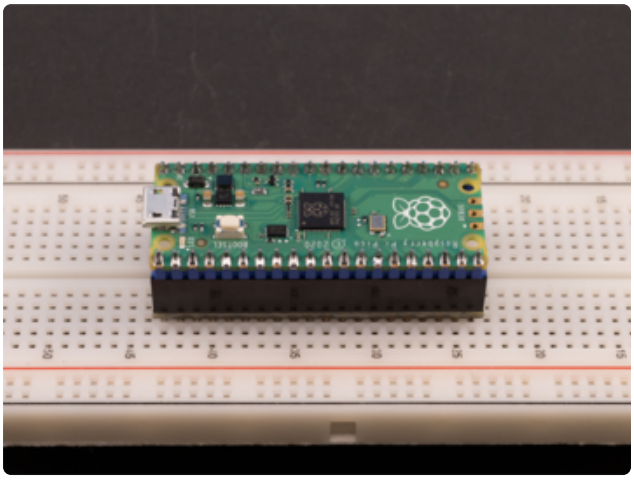


Solder the pins on each end of each stacking header, so that the opposite four corners of the PiCowbell are soldered on.



Solder the rest of the pins onto the PiCowbell.





You're done! Now you can attach the whole sandwich to a breadboard, have access to the pins via the breadboard, and still be able to use the PiCowbell as well.

---

# Socket Headers

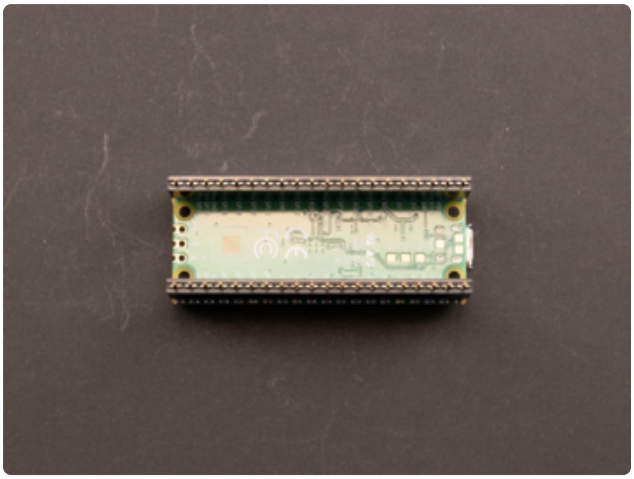
This PiCowbell assembly method uses female socket headers on the PiCowbell to create a standalone sandwich when attached to a Pico with standard male headers.

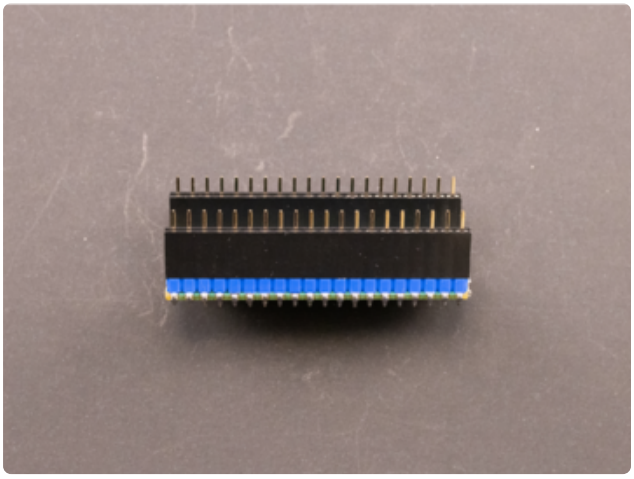
This page assumes you have already soldered standard male headers to your Pico. If you have not, please return to the Pico assembly page () and follow the steps there.

Follow the steps below to solder socket headers to your PiCowbell.

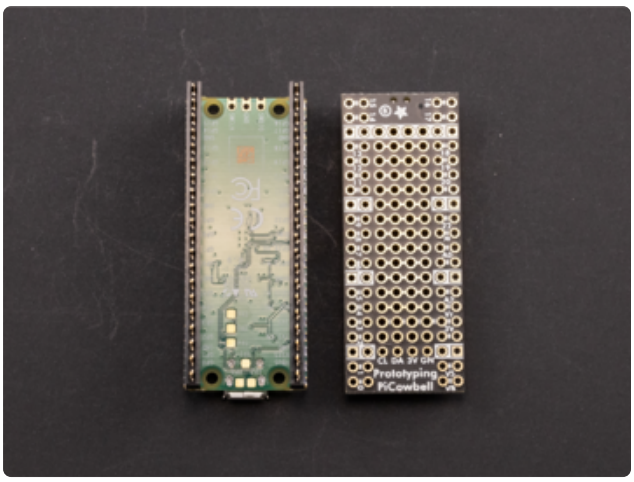
Although these pages show the PiCowbell Proto, the soldering instructions are applicable for all PiCowbell boards.

## Assembly Steps





Place a standard-header-soldered Pico upside down on the table, so the long side of the header pins are facing up. Press the female sockets onto one of the rows of standard headers attached to the Pico, until both are fully attached.

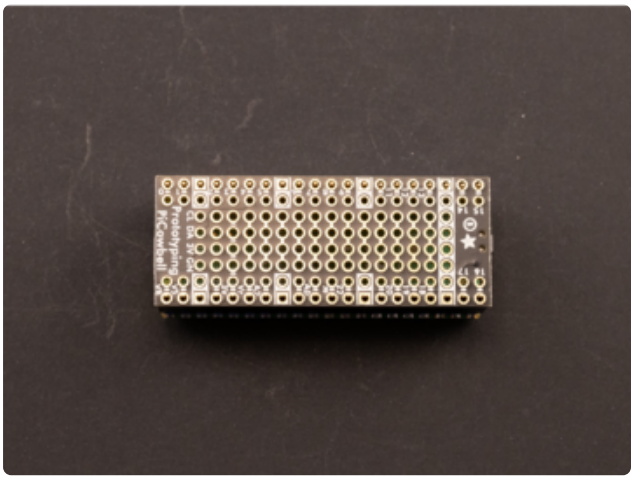


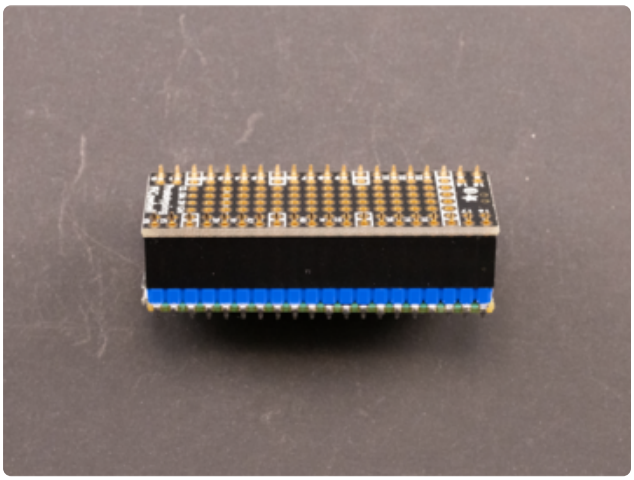

Ensure the PiCowbell is oriented correctly before beginning assembly. The PiCowbell should be top-down, so that you are looking at the bottom of the Cowbell. The STEMMA QT connector should be on the same end as the Pico USB connector, and the reset button should be on the opposite end with the Pico debug pins.

The PiCowbell pins must match the pinout on the Pico.

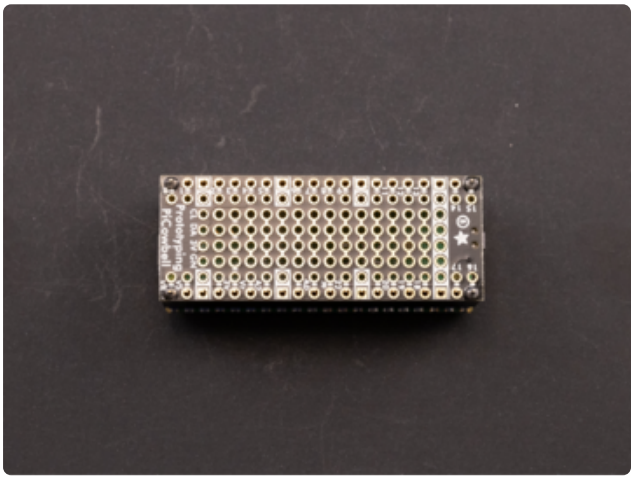
Remember, the pins are labeled on the bottom of the Pico. In this case, that works well because they are labeled on both sides of the PiCowbell, allowing for direct comparison before attaching the PiCowbell to the stacking header assembly.

Ensure the PiCowbell is oriented properly before beginning soldering! If you solder it on upside down or backwards, it will not function properly!

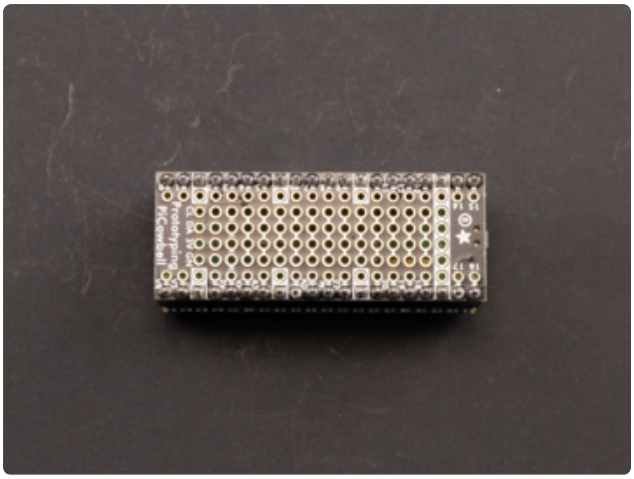




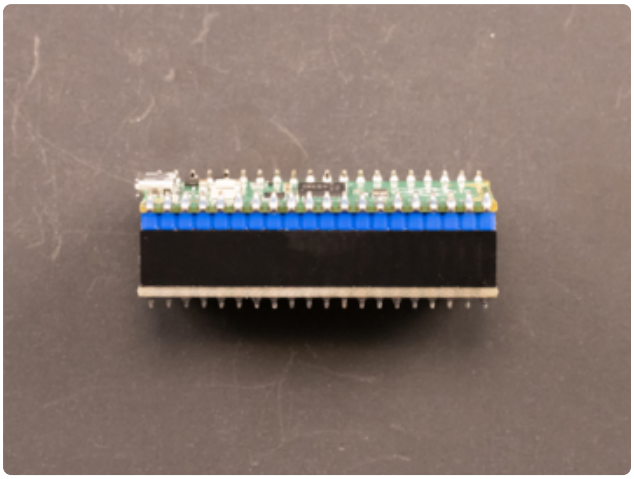
Press the PiCowbell onto the pins sticking up from the socket headers. You may need to push the stacking header pins in or out a bit to get the PiCowbell attached.



Solder the pins on each end of each socket header, so that the opposite four corners of the PiCowbell are soldered on.



Solder the rest of the pins onto the PiCowbell.



That's it, you're done!

---

# Shorty Socket Headers

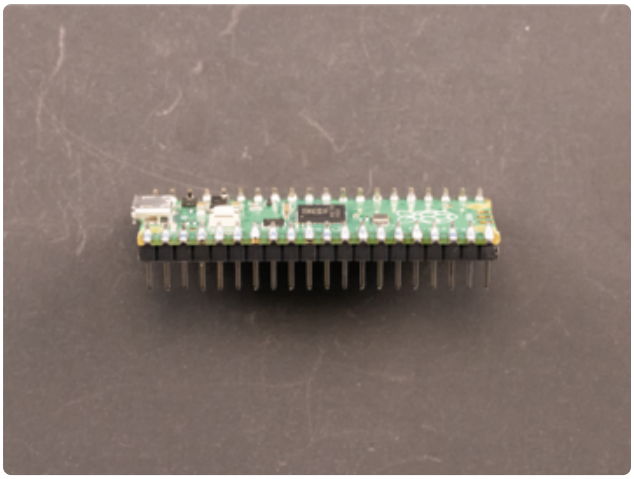
This PiCowbell assembly method uses shorty female socket headers on the PiCowbell to create a standalone sandwich when attached to a Pico with shorty male headers.

This page assumes you have already soldered shorty male headers to your Pico. If you have not, please return to the Pico assembly page () and follow the steps there. The page shows how to solder standard male headers to the Pico, but the concept is identical with the shorty headers.

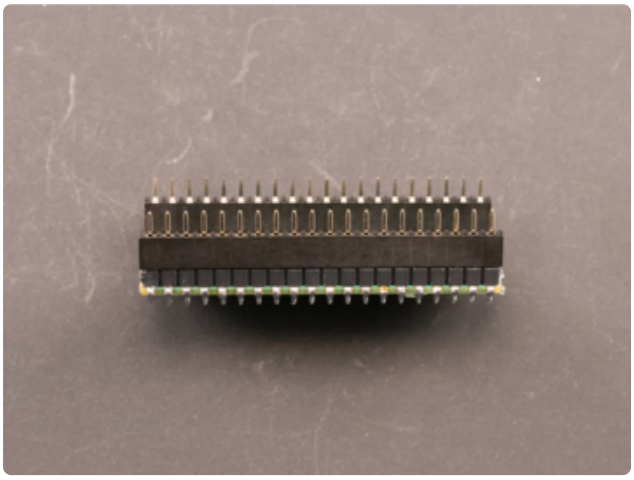
Follow the steps below to solder shorty socket headers to your PiCowbell.

Although these pages show the PiCowbell Proto, the soldering instructions are applicable for all PiCowbell boards.

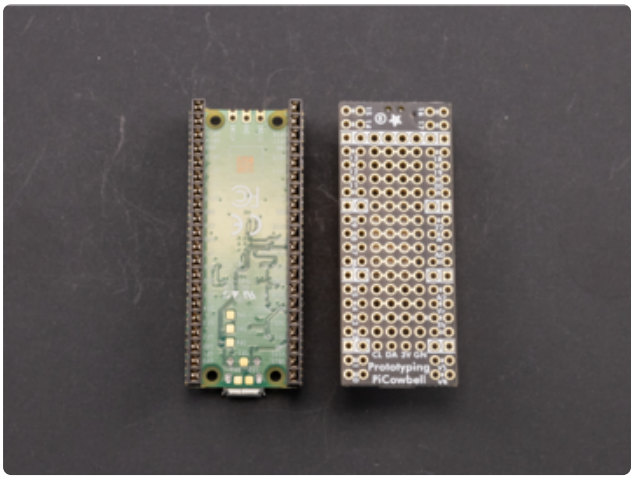
## Assembly Steps



Solder the short male headers () to the Pico. See the Pico assembly page () for instructions on soldering headers to the Pico.



Place a shorty-header-soldered Pico upside down (headers up) on the table. Press the each of the short female sockets onto one of the rows of short headers attached to the Pico, until both are fully attached.

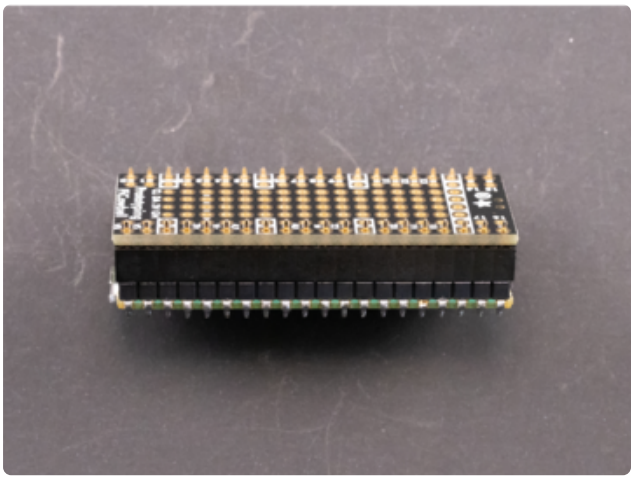


Ensure the PiCowbell is oriented correctly before beginning assembly. The PiCowbell should be top-down, so that you are looking at the bottom of the Cowbell. The STEMMA QT connector should be on the same end as the Pico USB connector, and the reset button should be on the opposite end with the Pico debug pins.

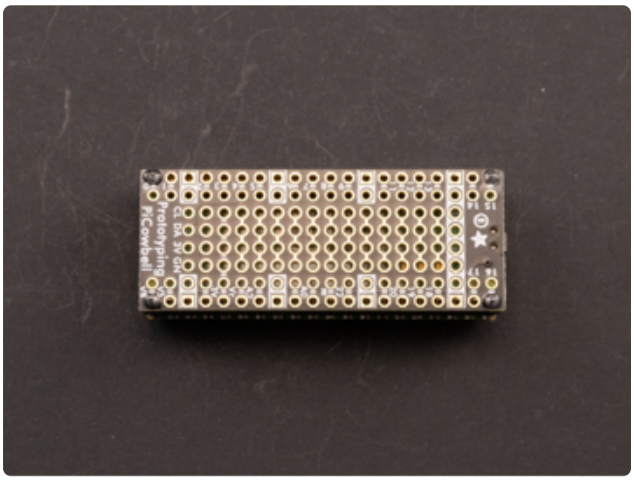
The PiCowbell pins must match the pinout on the Pico.

Remember, the pins are labeled on the bottom of the Pico. In this case, that works well because they are labeled on both sides of the PiCowbell, allowing for direct comparison before attaching the Cowbell to the stacking header assembly.

Ensure the PiCowbell is oriented properly before beginning soldering! If you solder it on upside down or backwards, it will not function properly!



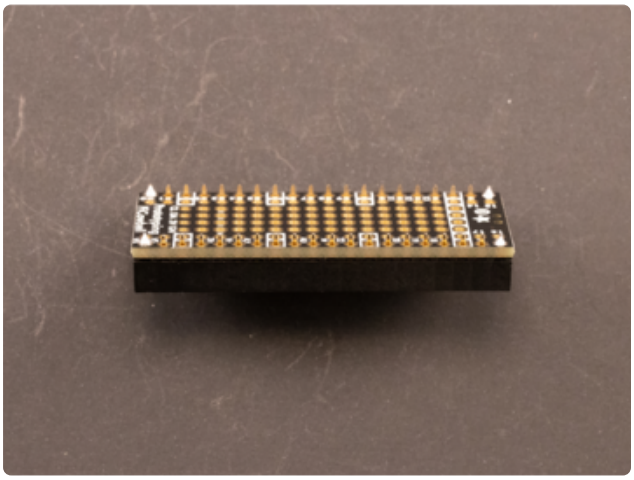
Press the PiCowbell onto the pins sticking up from the shorty female headers. You may need to push the shorty header pins in or out a bit to get the PiCowbell attached.



Solder the pins on each end of each female header, so that the opposite four corners of the PiCowbell are soldered on.

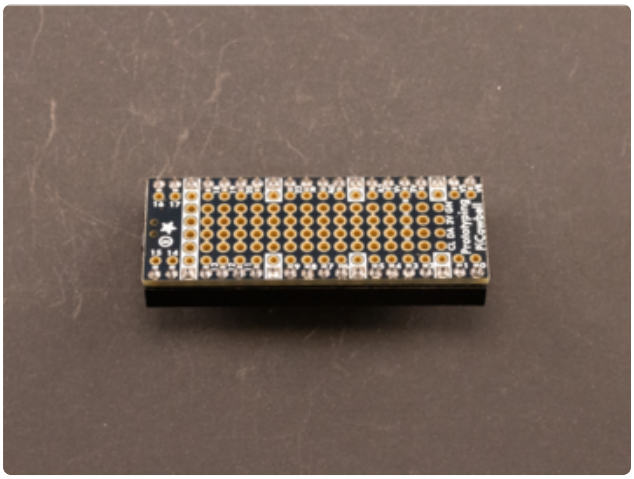
Try not to use too much solder on these four pins! The solder can wick into the associated female header socket, onto the inserted male pin, and permanently attach the two boards.

Do not use too much solder when tacking the four corners! It can wick into the female header and permanently attach the two boards!

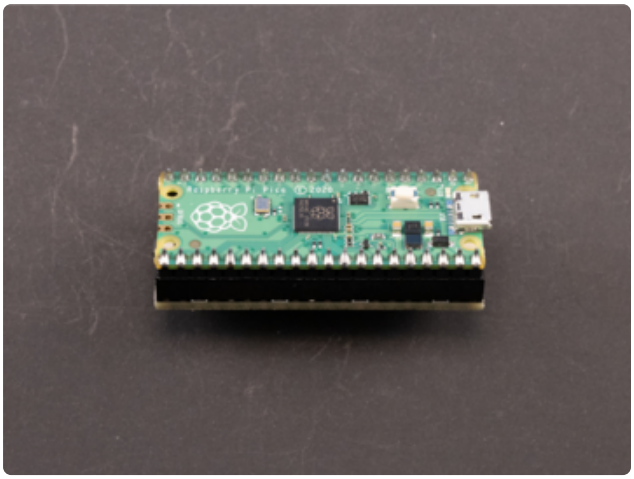


CAREFULLY remove the partially soldered PiCowbell from the Pico, before continuing to solder the rest of the PiCowbell pins.

As stated above, too much solder on the shorty female header pins can wick into the associated header socket, onto the inserted male pin, and permanently attach the two boards.



Solder the rest of the pins onto the PiCowbell. Be sure to keep the shorty female headers square while you solder the rest of the pins.



Press the PiCowbell onto the Pico to attach the two boards. Make sure you've oriented it correctly!

The STEMMA QT connector should be on the same end as the Pico USB connector, and the reset button should be on the opposite end with the Pico debug pins.

That's it! You're done!

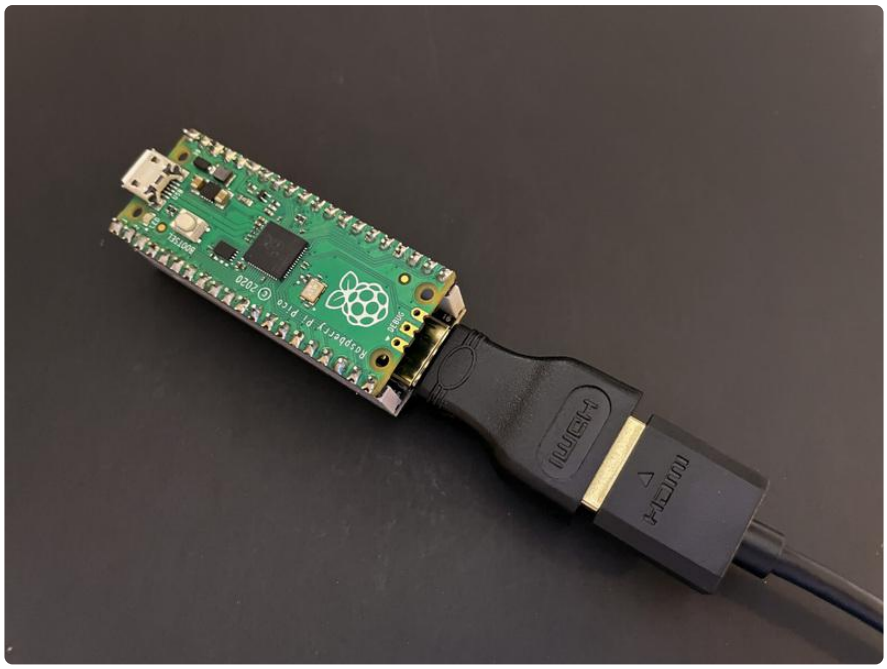
---

# CircuitPython

It's easy to use the PiCowbell DVI with CircuitPython and the PicoDVI () core module. This module has been added to CircuitPython as of 8.1.0b2 () - but note that it uses a l ot of memory so in particular if you want to use Pico W with WiFi support, you'll likely only be able to get away with monochrome display.

## Wiring

Plug the PiCowbell into a Pico board using headers according to the instructions on the Assembly pages (). Then, plug a mini HDMI to HDMI adapter with an HDMI cable into the PiCowbell mini HDMI port.



Mini HDMI Plug to Standard HDMI Jack Adapter

What an adorable little pug! Sorry - plug! What an adorable mini HDMI to HDMI plug. We find this plug adapter really helpful....

https://www.adafruit.com/product/2819

## CircuitPython Usage

To use with CircuitPython, you need to first install the PicoDVI dependencies into the l ib folder onto your CIRCUITPY drive. Then you need to update code.py with the example script.

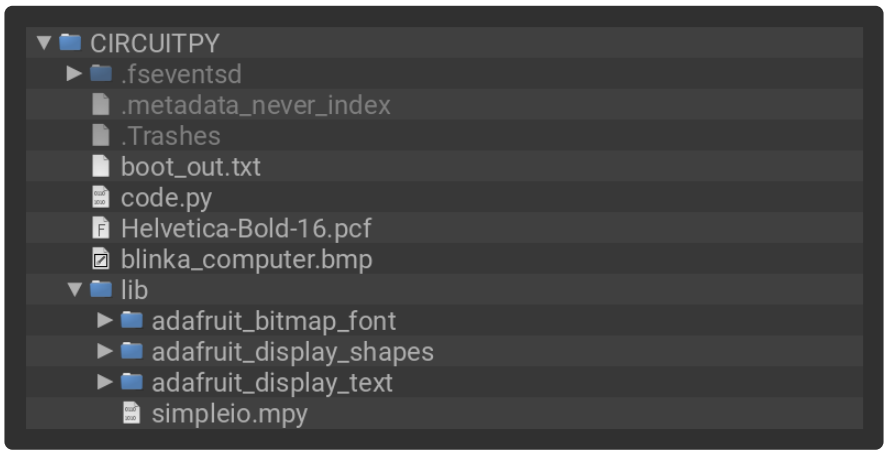
Thankfully, we can do this in one go. In the example below, click the Download Project Bundle button below to download the necessary libraries and the code.py file in a zip file.

Connect your Pico board to your computer via a known good data+power USB cable. The board should show up in your File Explorer/Finder (depending on your operating system) as a flash drive named CIRCUITPY.

Extract the contents of the zip file, and copy the entire lib folder, the Helvetica-Bold-16.pcf font file, blinka_computer.bmp bitmap file and code.py file to your CIRCUI TPY drive.

Your CIRCUITPY/lib folder should contain the following folders and file:

- adafruit_bitmap_font/
- adafruit_display_shapes/
- adafruit_display_text/
- simpleio.mpy




## Hello World DVI Output Example

Once everything is saved to the CIRCUITPY drive, you can connect the PiCowbell to an HDMI monitor and connect your Pico to USB power. You'll see the Hello World example display on the screen.

```
# SPDX-FileCopyrightText: 2023 Liz Clark for Adafruit Industries
# SPDX-FileCopyrightText: Adapted from Phil B.'s 16bit_hello Arduino Code
#
# SPDX-License-Identifier: MIT

import gc
import math
from random import randint
import time
import displayio
import picodvi
import board
import framebufferio
import vectorio
import terminalio
import simpleio
from adafruit_bitmap_font import bitmap_font
from adafruit_display_text import label, wrap_text_to_lines
from adafruit_display_shapes.rect import Rect
from adafruit_display_shapes.circle import Circle
from adafruit_display_shapes.roundrect import RoundRect
from adafruit_display_shapes.triangle import Triangle
```

```
from adafruit_display_shapes.line import Line

displayio.release_displays()

# check for DVI Feather
if 'CKP' in dir(board):
    fb = picodvi.Framebuffer(320, 240,
        clk_dp=board.CKP, clk_dn=board.CKN,
        red_dp=board.D0P, red_dn=board.D0N,
        green_dp=board.D1P, green_dn=board.D1N,
        blue_dp=board.D2P, blue_dn=board.D2N,
        color_depth=8)
# otherwise assume Pico
else:
    fb = picodvi.Framebuffer(320, 240,
        clk_dp=board.GP12, clk_dn=board.GP13,
        red_dp=board.GP10, red_dn=board.GP11,
        green_dp=board.GP8, green_dn=board.GP9,
        blue_dp=board.GP6, blue_dn=board.GP7,
        color_depth=8)
display = framebufferio.FramebufferDisplay(fb)

bitmap = displayio.Bitmap(display.width, display.height, 3)

red = 0xff0000
yellow = 0xcccc00
orange = 0xff5500
blue = 0x0000ff
pink = 0xff00ff
purple = 0x5500ff
white = 0xffffff
green =  0x00ff00
aqua = 0x125690

palette = displayio.Palette(3)
palette[0] = 0x000000 # black
palette[1] = white
palette[2] = yellow

palette.make_transparent(0)

tile_grid = displayio.TileGrid(bitmap, pixel_shader=palette)

group = displayio.Group()

def clean_up(group_name):
    for _ in range(len(group_name)):
        group_name.pop()
    gc.collect()

def show_shapes():
    gc.collect()
    cx = int(display.width / 2)
    cy = int(display.height / 2)
    minor = min(cx, cy)
    pad = 5
    size = minor - pad
    half = int(size / 2)
    rect = Rect(cx - minor, cy - minor, size, size, stroke = 1, fill=red, outline =
red)
    tri = Triangle(cx + pad, cy - pad, cx + pad + half, cy - minor,
                   cx + minor - 1, cy - pad, fill=green, outline = green)
    circ = Circle(cx - pad - half, cy + pad + half, half, fill=blue, stroke = 1,
outline = blue)
    rnd = RoundRect(cx + pad, cy + pad, size, size, int(size / 5), stroke = 1,
                    fill=yellow, outline = yellow)

    group.append(rect)
    group.append(tri)
```

```
    group.append(circ)
    group.append(rnd)
    rect.fill = None
    tri.fill = None
    circ.fill = None
    rnd.fill = None

    time.sleep(2)

    rect.fill = red
    tri.fill = green
    circ.fill = blue
    rnd.fill = yellow
    time.sleep(2)
    clean_up(group)
    del rect
    del tri
    del circ
    del rnd
    gc.collect()

def sine_chart():
    gc.collect()
    cx = int(display.width / 2)
    cy = int(display.height / 2)
    minor = min(cx, cy)
    major = max(cx, cy)

    group.append(Line(cx, 0, cx, display.height, blue)) # v
    group.append(Line(0, cy, display.width, cy, blue)) # h

    for i in range(10):
        _n = simpleio.map_range(i, 0, 10, 0, major - 1)
        n = int(_n)
        group.append(Line(cx - n, cy - 5, cx - n, (cy - 5) + 11, blue)) # v
        group.append(Line(cx + n, cy - 5, cx + n, (cy - 5) + 11, blue)) # v
        group.append(Line(cx - 5, cy - n, (cx - 5) + 11, cy - n, blue)) # h
        group.append(Line(cx - 5, cy + n, (cx - 5) + 11, cy + n, blue)) # h

    for x in range(display.width):
        y = cy - int(math.sin((x - cx) * 0.05) * float(minor * 0.5))
        bitmap[x, y] = 1
    group.append(tile_grid)
    time.sleep(2)
    clean_up(group)

def widget0():
    gc.collect()
    data = [31, 42, 36, 58, 67, 88]
    num_points = len(data)

    text_area = label.Label(terminalio.FONT, text="Widget Sales", color=white)
    text_area.anchor_point = (0.5, 0.0)
    text_area.anchored_position = (display.width / 2, 3)
    group.append(text_area)
    for i in range(11):
        _x = simpleio.map_range(i, 0, 10, 0, display.width - 1)
        x = int(_x)
        group.append(Line(x, 20, x, display.height, blue))
        _y = simpleio.map_range(i, 0, 10, 20, display.height - 1)
        y = int(_y)
        group.append(Line(0, y, display.width, y, blue))
    prev_x = 0
    _prev_y = simpleio.map_range(data[0], 0, 100, display.height - 1, 20)
    prev_y = int(_prev_y)
    for i in range(1, num_points):
        _new_x = simpleio.map_range(i, 0, num_points - 1, 0, display.width - 1)
        new_x = int(_new_x)
        _new_y = simpleio.map_range(data[i], 0, 100, display.height - 1, 20)
```

```
        new_y = int(_new_y)
        group.append(Line(prev_x, prev_y, new_x, new_y, aqua))
        prev_x = new_x
        prev_y = new_y

    for i in range(num_points):
        _x = simpleio.map_range(i, 0, num_points - 1, 0, display.width - 1)
        x = int(_x)
        _y = simpleio.map_range(data[i], 0, 100, display.height - 1, 20)
        y = int(_y)
        group.append(Circle(x, y, 5, fill=None, stroke = 2, outline = white))

    time.sleep(2)
    clean_up(group)

def widget1():
    gc.collect()
    data = [31, 42, 36, 58, 67, 88]
    num_points = len(data)
    bar_width = int(display.width / num_points) - 4
    x_mapped_w = display.width + 2
    h_mapped_h = display.height + 20

    text_area = label.Label(terminalio.FONT, text="Widget Sales", color=white)
    text_area.anchor_point = (0.5, 0.0)
    text_area.anchored_position = (display.width / 2, 3)
    group.append(text_area)
    for i in range(11):
        _y = simpleio.map_range(i, 0, 10, 20, display.height - 1)
        y = int(_y)
        group.append(Line(0, y, display.width, y, blue))
    for i in range(num_points):
        _x = simpleio.map_range(i, 0, num_points, 0, x_mapped_w)
        x = int(_x)
        _height = simpleio.map_range(data[i], 0, 100, h_mapped_h, 0)
        height = int(_height)
        group.append(vectorio.Rectangle(pixel_shader=palette, width=bar_width,
                     height=display.height + 1, x=x, y=height, color_index = 2))

    time.sleep(2)
    clean_up(group)

def text_align():
    gc.collect()
    TEXT = "hello world"

    text_area_top_left = label.Label(terminalio.FONT, text=TEXT, color=red)
    text_area_top_left.anchor_point = (0.0, 0.0)
    text_area_top_left.anchored_position = (0, 0)

    text_area_top_middle = label.Label(terminalio.FONT, text=TEXT, color=orange)
    text_area_top_middle.anchor_point = (0.5, 0.0)
    text_area_top_middle.anchored_position = (display.width / 2, 0)

    text_area_top_right = label.Label(terminalio.FONT, text=TEXT, color=yellow)
    text_area_top_right.anchor_point = (1.0, 0.0)
    text_area_top_right.anchored_position = (display.width, 0)

    text_area_middle_left = label.Label(terminalio.FONT, text=TEXT, color=green)
    text_area_middle_left.anchor_point = (0.0, 0.5)
    text_area_middle_left.anchored_position = (0, display.height / 2)

    text_area_middle_middle = label.Label(terminalio.FONT, text=TEXT, color=aqua)
    text_area_middle_middle.anchor_point = (0.5, 0.5)
    text_area_middle_middle.anchored_position = (display.width / 2, display.height /
2)

    text_area_middle_right = label.Label(terminalio.FONT, text=TEXT, color=blue)
    text_area_middle_right.anchor_point = (1.0, 0.5)
```

```
    text_area_middle_right.anchored_position = (display.width, display.height / 2)

    text_area_bottom_left = label.Label(terminalio.FONT, text=TEXT, color=purple)
    text_area_bottom_left.anchor_point = (0.0, 1.0)
    text_area_bottom_left.anchored_position = (0, display.height)

    text_area_bottom_middle = label.Label(terminalio.FONT, text=TEXT, color=pink)
    text_area_bottom_middle.anchor_point = (0.5, 1.0)
    text_area_bottom_middle.anchored_position = (display.width / 2, display.height)

    text_area_bottom_right = label.Label(terminalio.FONT, text=TEXT, color=white)
    text_area_bottom_right.anchor_point = (1.0, 1.0)
    text_area_bottom_right.anchored_position = (display.width, display.height)

    group.append(text_area_top_middle)
    group.append(text_area_top_left)
    group.append(text_area_top_right)
    group.append(text_area_middle_middle)
    group.append(text_area_middle_left)
    group.append(text_area_middle_right)
    group.append(text_area_bottom_middle)
    group.append(text_area_bottom_left)
    group.append(text_area_bottom_right)

    time.sleep(2)
    clean_up(group)

def custom_font():
    gc.collect()
    my_font = bitmap_font.load_font("/Helvetica-Bold-16.pcf")
    text_sample = "The quick brown fox jumps over the lazy dog."
    text_sample = "\n".join(wrap_text_to_lines(text_sample, 28))
    text_area = label.Label(my_font, text="Custom Font", color=white)
    text_area.anchor_point = (0.0, 0.0)
    text_area.anchored_position = (0, 0)

    sample_text = label.Label(my_font, text=text_sample)
    sample_text.anchor_point = (0.5, 0.5)
    sample_text.anchored_position = (display.width / 2, display.height / 2)

    group.append(text_area)
    group.append(sample_text)

    time.sleep(2)
    clean_up(group)

    del my_font
    gc.collect()

def bitmap_example():
    gc.collect()
    blinka_bitmap = displayio.OnDiskBitmap("/blinka_computer.bmp")
    blinka_grid = displayio.TileGrid(blinka_bitmap,
pixel_shader=blinka_bitmap.pixel_shader)
    gc.collect()
    group.append(blinka_grid)

    time.sleep(2)
    clean_up(group)

    del blinka_grid
    del blinka_bitmap
    gc.collect()

def sensor_values():
    gc.collect()
    text_x = "X: %d" % randint(-25, 25)
    text_y = "Y: %d" % randint(-25, 25)
    text_z = "Z: %d" % randint(-25, 25)
```

```
    x_text = label.Label(terminalio.FONT, text=text_x, color=red)
    x_text.anchor_point = (0.0, 0.0)
    x_text.anchored_position = (2, 0)
    y_text = label.Label(terminalio.FONT, text=text_y, color=green)
    y_text.anchor_point = (0.0, 0.0)
    y_text.anchored_position = (2, 10)
    z_text = label.Label(terminalio.FONT, text=text_z, color=blue)
    z_text.anchor_point = (0.0, 0.0)
    z_text.anchored_position = (2, 20)
    group.append(x_text)
    group.append(y_text)
    group.append(z_text)

    for i in range(40):
        if i == 10:
            group.scale = 2
        elif i == 20:
            group.scale = 3
        elif i == 30:
            group.scale = 4
        x_text.text = "X: %d" % randint(-50, 50)
        y_text.text = "Y: %d" % randint(-50, 50)
        z_text.text = "Z: %d" % randint(-50, 50)
        time.sleep(0.1)
    time.sleep(0.1)
    clean_up(group)
    group.scale = 1

display.show(group)

while True:
    show_shapes()
    sine_chart()
    widget0()
    widget1()
    text_align()
    custom_font()
    bitmap_example()
    sensor_values()
```

This example is a port of the Arduino 16bit_hello code written by Phil B (). with some slight variation to show off some of the unique abilities of displayio.

The example begins by showing a rectangle, circle, triangle and rounded rectangle and changing the fill attribute from `None` to a color.

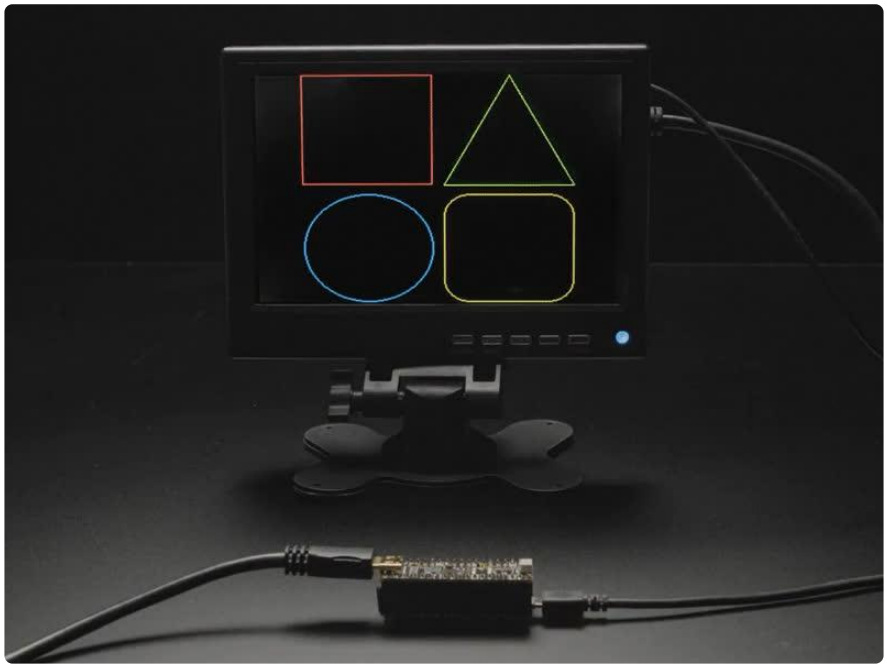
Then, a few chart variations are shown, including a sine wave pattern, line graph and bar graph.

Next is a text alignment example, showing how to use the `anchor_point` and `anchor_position` functions in the adafruit_display_text library.

Following that is a custom text example, loading a bitmap font instead of the built-in terminalio font.

Then there is a quick break from fonts to show off a bitmap image, specifically Blinka happily using her computer.

Finally, an example shows how to update the text in a `Label` object for projects where you want to display text information that updates over time.



It's important to note that the example code is optimized to be able to run all of the examples in a loop, which you more than likely won't want to do for your projects. As a result, the `clean_up(group)` function is run after each example to use `pop()` to remove all of the graphical elements of the displayio `group`. Garbage collection () (`gc.collect()`) is also run to conserve memory. Additionally, each graphical element is created and deleted each time in each of the functions.

If you were to run, for example, the `sensor_values()` function on its own for a project, you would instantiate the graphical elements once, before the loop, and then update the text with the "values" in the loop:

```
...

text_x = "X: %d" % randint(-25, 25)
text_y = "Y: %d" % randint(-25, 25)
text_z = "Z: %d" % randint(-25, 25)
x_text = label.Label(terminalio.FONT, text=text_x, color=red)
x_text.anchor_point = (0.0, 0.0)
x_text.anchored_position = (2, 0)
y_text = label.Label(terminalio.FONT, text=text_y, color=green)
y_text.anchor_point = (0.0, 0.0)
y_text.anchored_position = (2, 10)
z_text = label.Label(terminalio.FONT, text=text_z, color=blue)
z_text.anchor_point = (0.0, 0.0)
z_text.anchored_position = (2, 20)
group.append(x_text)
group.append(y_text)
group.append(z_text)

while True:
    for i in range(40):
        if i == 10:
```

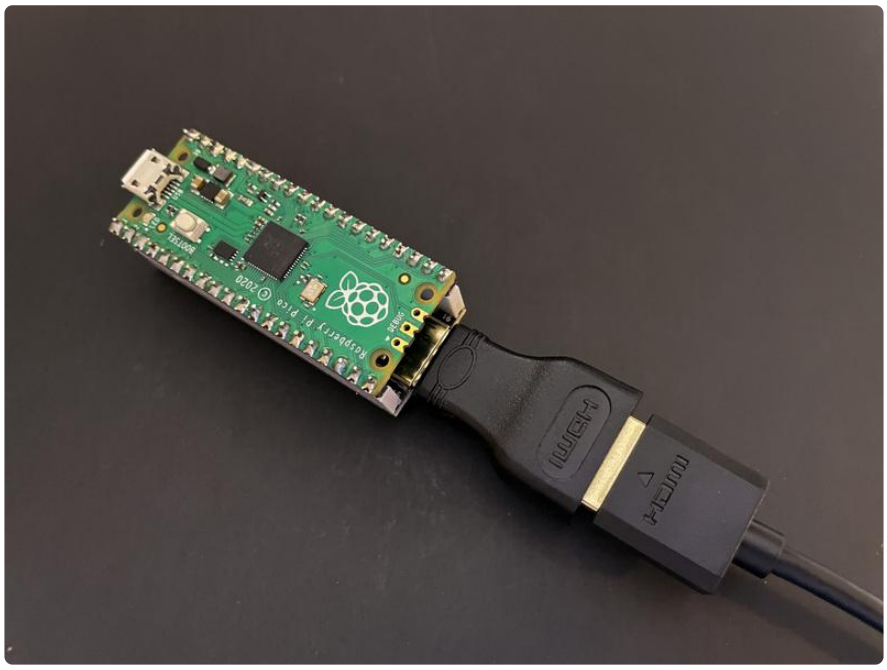
```
        group.scale = 2
    elif i == 20:
        group.scale = 3
    elif i == 30:
        group.scale = 4
    x_text.text = "X: %d" % randint(-50, 50)
    y_text.text = "Y: %d" % randint(-50, 50)
    z_text.text = "Z: %d" % randint(-50, 50)
    time.sleep(0.1)
```

# Arduino

Using the PiCowbell DVI with Arduino involves connecting the PiCowbell to a Pico board, connecting the boards to an HDMI monitor and USB power, installing the Adafruit fork of the PicoDVI library and running the provided example code.

## Wiring

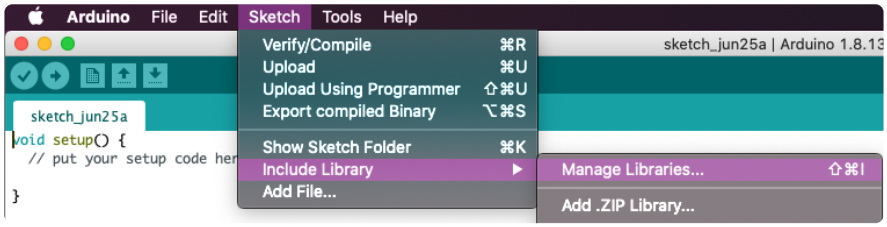
Plug the PiCowbell into a Pico board using headers according to the instructions on the Assembly pages (). Then, plug a mini HDMI to HDMI adapter with an HDMI cable into the PiCowbell mini HDMI port.



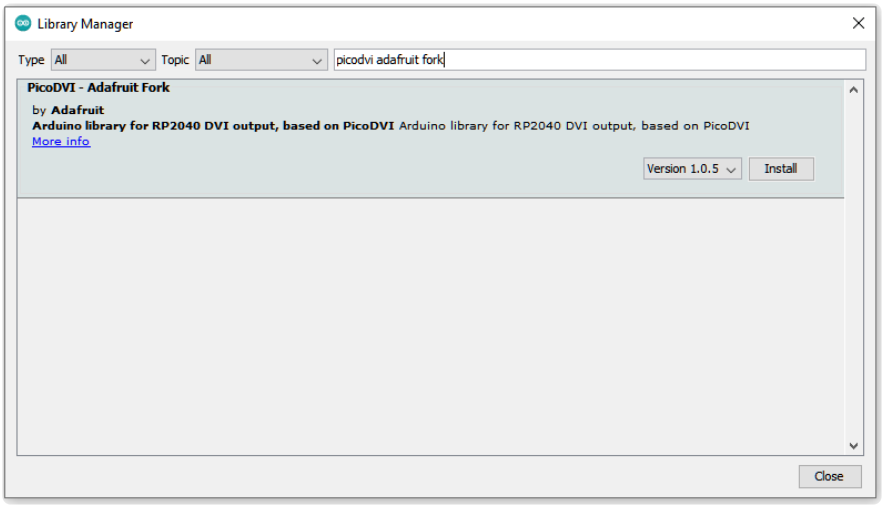
[Mini HDMI Plug to Standard HDMI Jack Adapter]
What an adorable little pug! Sorry - plug! What an adorable mini HDMI to HDMI plug.  We find this plug adapter really helpful....
https://www.adafruit.com/product/2819

## Library Installation

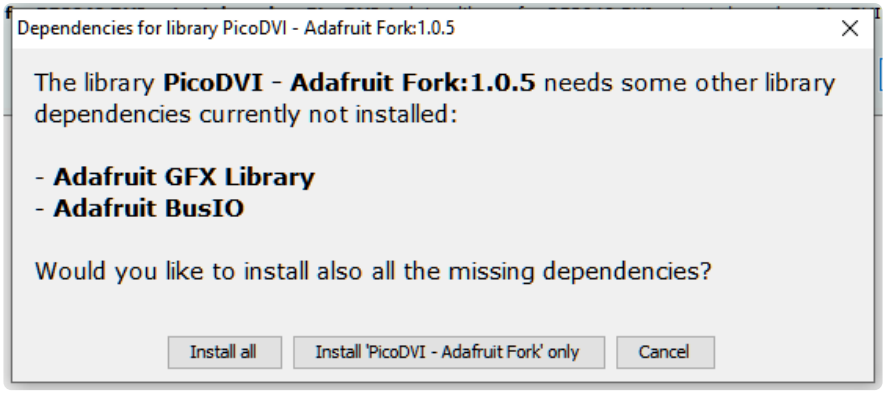
You can install the Adafruit fork of the PicoDVI library for Arduino using the Library Manager in the Arduino IDE.




Click the Manage Libraries ... menu item, search for PicoDVI - Adafruit Fork and select the PicoDVI - Adafruit Fork library:




If asked about dependencies for any of the libraries, click "Install all".




If the "Dependencies" window does not come up, then you already have the dependencies installed.

If the dependencies are already installed, you must make sure you update them through the Arduino Library Manager before loading the example!

## Example Code

```
// SPDX-FileCopyrightText: 2023 Phil B. for Adafruit Industries
// SPDX-License-Identifier: MIT

// Basic full-color PicoDVI test. Provides a 16-bit color video framebuffer to
// which Adafruit_GFX calls can be made. It's based on the EYESPI_Test.ino sketch.

#include <PicoDVI.h>                  // Core display & graphics library
#include <Fonts/FreeSansBold18pt7b.h> // A custom font

// Here's how a 320x240 16-bit color framebuffer is declared. Double-buffering
// is not an option in 16-bit color mode, just not enough RAM; all drawing
// operations are shown as they occur. Second argument is a hardware
// configuration -- examples are written for Adafruit Feather RP2040 DVI, but
// that's easily switched out for boards like the Pimoroni Pico DV (use
// 'pimoroni_demo_hdmi_cfg') or Pico DVI Sock ('pico_sock_cfg').
DVIGFX16 display(DVI_RES_320x240p60, adafruit_dvibell_cfg);

// A 400x240 mode is possible but pushes overclocking even higher than
// 320x240 mode. SOME BOARDS MIGHT SIMPLY NOT BE COMPATIBLE WITH THIS.
// May require selecting QSPI div4 clock (Tools menu) to slow down flash
// accesses, may require further over-volting the CPU to 1.25 or 1.3 V.
//DVIGFX16 display(DVI_RES_400x240p60, adafruit_feather_dvi_cfg);

void setup() { // Runs once on startup
  if (!display.begin()) { // Blink LED if insufficient RAM
    pinMode(LED_BUILTIN, OUTPUT);
    for (;;) digitalWrite(LED_BUILTIN, (millis() / 500) & 1);
  }
}

#define PAUSE 2000  // Delay (milliseconds) between examples
uint8_t rotate = 0; // Current screen orientation (0-3)
#define CORNER_RADIUS 0

void loop() {
  // Each of these functions demonstrates a different Adafruit_GFX concept:
  show_shapes();
  show_charts();
```

```
  show_basic_text();
  show_char_map();
  show_custom_text();
  show_bitmap();
  show_canvas();

  if (++rotate > 3) rotate = 0; // Cycle through screen rotations 0-3
  display.setRotation(rotate);  // Takes effect on next drawing command
}

// BASIC SHAPES EXAMPLE ----------------------------------------------------

void show_shapes() {
  // Draw outlined and filled shapes. This demonstrates:
  // - Enclosed shapes supported by GFX (points & lines are shown later).
  // - Adapting to different-sized displays, and to rounded corners.

  const int16_t cx = display.width() / 2;  // Center of screen =
  const int16_t cy = display.height() / 2; // half of width, height
  int16_t minor = min(cx, cy);             // Lesser of half width or height
  // Shapes will be drawn in a square region centered on the screen. But one
  // particular screen -- rounded 240x280 ST7789 -- has VERY rounded corners
  // that would clip a couple of shapes if drawn full size. If using that
  // screen type, reduce area by a few pixels to avoid drawing in corners.
  if (CORNER_RADIUS > 40) minor -= 4;
  const uint8_t pad = 5;                   // Space between shapes is 2X this
  const int16_t size = minor - pad;        // Shapes are this width & height
  const int16_t half = size / 2;           // 1/2 of shape size

  display.fillScreen(0); // Start by clearing the screen; color 0 = black

  // Draw outline version of basic shapes: rectangle, triangle, circle and
  // rounded rectangle in different colors. Rather than hardcoded numbers
  // for position and size, some arithmetic helps adapt to screen dimensions.
  display.drawRect(cx - minor, cy - minor, size, size, 0xF800);
  display.drawTriangle(cx + pad, cy - pad, cx + pad + half, cy - minor,
                       cx + minor - 1, cy - pad, 0x07E0);
  display.drawCircle(cx - pad - half, cy + pad + half, half, 0x001F);
  display.drawRoundRect(cx + pad, cy + pad, size, size, size / 5, 0xFFE0);
  delay(PAUSE);

  // Draw same shapes, same positions, but filled this time.
  display.fillRect(cx - minor, cy - minor, size, size, 0xF800);
  display.fillTriangle(cx + pad, cy - pad, cx + pad + half, cy - minor,
                       cx + minor - 1, cy - pad, 0x07E0);
  display.fillCircle(cx - pad - half, cy + pad + half, half, 0x001F);
  display.fillRoundRect(cx + pad, cy + pad, size, size, size / 5, 0xFFE0);
  delay(PAUSE);
} // END SHAPE EXAMPLE

// CHART EXAMPLES ----------------------------------------------------------

void show_charts() {
  // Draw some graphs and charts. GFX library doesn't handle these as native
  // object types, but it only takes a little code to build them from simple
  // shapes. This demonstrates:
  // - Drawing points and horizontal, vertical and arbitrary lines.
  // - Adapting to different-sized displays.
  // - Graphics being clipped off edge.
  // - Use of negative values to draw shapes "backward" from an anchor point.
  // - C technique for finding array size at runtime (vs hardcoding).

  display.fillScreen(0);  // Clear screen

  const int16_t cx = display.width() / 2;  // Center of screen =
  const int16_t cy = display.height() / 2; // half of width, height
  const int16_t minor = min(cx, cy);       // Lesser of half width or height
  const int16_t major = max(cx, cy);       // Greater of half width or height
```

```
// Let's start with a relatively simple sine wave graph with axes.
// Draw graph axes centered on screen. drawFastHLine() and drawFastVLine()
// need fewer arguments than normal 2-point line drawing shown later.
display.drawFastHLine(0, cy, display.width(), 0x0210);  // Dark blue
display.drawFastVLine(cx, 0, display.height(), 0x0210);

// Then draw some tick marks along the axes. To keep this code simple,
// these aren't to any particular scale, but a real program may want that.
// The loop here draws them from the center outward and pays no mind
// whether the screen is rectangular; any ticks that go off-screen will
// be clipped by the library.
for (uint8_t i=1; i<=10; i++) {
  // The Arduino map() function scales an input value (e.g. "i") from an
  // input range (0-10 here) to an output range (0 to major-1 here).
  // Very handy for making graphics adjust to different screens!
  int16_t n = map(i, 0, 10, 0, major - 1); // Tick offset relative to center point
  display.drawFastVLine(cx - n, cy - 5, 11, 0x210);
  display.drawFastVLine(cx + n, cy - 5, 11, 0x210);
  display.drawFastHLine(cx - 5, cy - n, 11, 0x210);
  display.drawFastHLine(cx - 5, cy + n, 11, 0x210);
}

// Then draw sine wave over this using GFX drawPixel() function.
for (int16_t x=0; x<display.width(); x++) { // Each column of screen...
  // Note the inverted Y axis here (cy-value rather than cy+value)
  // because GFX, like most graphics libraries, has +Y heading down,
  // vs. classic Cartesian coords which have +Y heading up.
  int16_t y = cy - (int16_t)(sin((x - cx) * 0.05) * (float)minor * 0.5);
  display.drawPixel(x, y, 0xFFFF);
}

delay(PAUSE);

// Next, let's draw some charts...
// NOTE: some other examples in this code take extra steps to avoid placing
// anything off in the rounded corners of certain displays. The charts do
// not. It's *possible* but would introduce a lot of complexity into code
// that's trying to show the basics. We'll leave the clipped charts here as
// a teachable moment: not all content suits all displays.

// A list of data to plot. These are Y values only; X assumed equidistant.
const uint8_t data[] = { 31, 42, 36, 58, 67, 88 };       // Percentages, 0-100
const uint8_t num_points = sizeof data / sizeof data[0]; // Length of data[] list

display.fillScreen(0);  // Clear screen
display.setFont();      // Use default (built-in) font
display.setTextSize(2); // and 2X size for chart label

// Chart label is centered manually; 144 is the width in pixels of
// "Widget Sales" at 2X scale (12 chars * 6 px * 2 = 144). A later example
// shows automated centering based on string.
display.setCursor((display.width() - 144) / 2, 0);
display.print(F("Widget Sales")); // F("string") is in program memory, not RAM
// The chart-drawing code is then written to skip the top 20 rows where
// this label is located.

// First, a line chart, connecting the values point-to-point:

// Draw a grid of lines to provide scale & an interesting background.
for (uint8_t i=0; i<11; i++) {
  int16_t x = map(i, 0, 10, 0, display.width() - 1);   // Scale grid X to screen
  display.drawFastVLine(x, 20, display.height(), 0x001F);
  int16_t y = map(i, 0, 10, 20, display.height() - 1); // Scale grid Y to screen
  display.drawFastHLine(0, y, display.width(), 0x001F);
}
// And then draw lines connecting data points. Load up the first point...
int16_t prev_x = 0;
int16_t prev_y = map(data[0], 0, 100, display.height() - 1, 20);
// Then connect lines to each subsequent point...
```

```
  for (uint8_t i=1; i<num_points; i++) {
    int16_t new_x = map(i, 0, num_points - 1, 0, display.width() - 1);
    int16_t new_y = map(data[i], 0, 100, display.height() - 1, 20);
    display.drawLine(prev_x, prev_y, new_x, new_y, 0x07FF);
    prev_x = new_x;
    prev_y = new_y;
  }
  // For visual interest, let's add a circle around each data point. This is
  // done in a second pass so the circles are always drawn "on top" of lines.
  for (uint8_t i=0; i<num_points; i++) {
    int16_t x = map(i, 0, num_points - 1, 0, display.width() - 1);
    int16_t y = map(data[i], 0, 100, display.height() - 1, 20);
    display.drawCircle(x, y, 5, 0xFFFF);
  }

  delay(PAUSE);

  // Then a bar chart of the same data...

  // Erase the old chart but keep the label at top.
  display.fillRect(0, 20, display.width(), display.height() - 20, 0);

  // Just draw the Y axis lines; bar chart doesn't really need X lines.
  for (uint8_t i=0; i<11; i++) {
    int16_t y = map(i, 0, 10, 20, display.height() - 1);
    display.drawFastHLine(0, y, display.width(), 0x001F);
  }

  int bar_width = display.width() / num_points - 4; // 2px pad to either side
  for (uint8_t i=0; i<num_points; i++) {
    int16_t x = map(i, 0, num_points, 0, display.width()) + 2; // Left edge of bar
    int16_t height = map(data[i], 0, 100, 0, display.height() - 20);
    // Some GFX functions (rects, H/V lines and similar) can accept negative
    // width/height values. What this does is anchor the shape at the right or
    // bottom coordinate (rather than the usual left/top) and draw back from
    // there, hence the -height here (bar is anchored at bottom of screen):
    display.fillRect(x, display.height() - 1, bar_width, -height, 0xFFE0);
  }

  delay(PAUSE);

} // END CHART EXAMPLES

// TEXT ALIGN FUNCTIONS ------------------------------------------------

// Adafruit_GFX only handles left-aligned text. This is normal and by design;
// it's a rare need that would further strain AVR by incurring a ton of extra
// code to properly handle, and some details would confuse. If needed, these
// functions give a fair approximation, with the "gotchas" that multi-line
// input won't work, and this operates only as a println(), not print()
// (though, unlike println(), cursor X does not reset to column 0, instead
// returning to initial column and downward by font's line spacing). If you
// can work with those constraints, it's a modest amount of code to copy
// into a project. Or, if your project only needs one or two aligned strings,
// simply use getTextBounds() for a bounding box and work from there.
// DO NOT ATTEMPT TO MAKE THIS A GFX-NATIVE FEATURE, EVERYTHING WILL BREAK.

typedef enum { // Alignment options passed to functions below
  GFX_ALIGN_LEFT,
  GFX_ALIGN_CENTER,
  GFX_ALIGN_RIGHT
} GFXalign;

// Draw text aligned relative to current cursor position. Arguments:
// gfx   : An Adafruit_GFX-derived type (e.g. display or canvas object).
// str   : String to print (as a char *).
// align : One of the GFXalign values declared above.
//         GFX_ALIGN_LEFT is normal left-aligned println() behavior.
//         GFX_ALIGN_CENTER prints centered on cursor pos.
```

```
//         GFX_ALIGN_RIGHT prints right-aligned to cursor pos.
// Cursor advances down one line a la println(). Column is unchanged.
void print_aligned(Adafruit_GFX &gfx, const char *str,
                   GFXalign align = GFX_ALIGN_LEFT) {
  uint16_t w, h;
  int16_t  x, y, cursor_x, cursor_x_save;
  cursor_x = cursor_x_save = gfx.getCursorX();
  gfx.getTextBounds(str, 0, gfx.getCursorY(), &x, &y, &w, &h);
  if (align == GFX_ALIGN_RIGHT)       cursor_x -= w;
  else if (align == GFX_ALIGN_CENTER) cursor_x -= w / 2;
  //gfx.drawRect(cursor_x, y, w, h, 0xF800);      // Debug rect
  gfx.setCursor(cursor_x - x, gfx.getCursorY());  // Center/right align
  gfx.println(str);
  gfx.setCursor(cursor_x_save, gfx.getCursorY()); // Restore cursor X
}

// Equivalent function for strings in flash memory (e.g. F("Foo")). Body
// appears identical to above function, but with C++ overloading it it works
// from flash instead of RAM. Any changes should be made in both places.
void print_aligned(Adafruit_GFX &gfx, const __FlashStringHelper *str,
                   GFXalign align = GFX_ALIGN_LEFT) {
  uint16_t w, h;
  int16_t  x, y, cursor_x, cursor_x_save;
  cursor_x = cursor_x_save = gfx.getCursorX();
  gfx.getTextBounds(str, 0, gfx.getCursorY(), &x, &y, &w, &h);
  if (align == GFX_ALIGN_RIGHT)       cursor_x -= w;
  else if (align == GFX_ALIGN_CENTER) cursor_x -= w / 2;
  //gfx.drawRect(cursor_x, y, w, h, 0xF800);      // Debug rect
  gfx.setCursor(cursor_x - x, gfx.getCursorY());  // Center/right align
  gfx.println(str);
  gfx.setCursor(cursor_x_save, gfx.getCursorY()); // Restore cursor X
}

// Equivalent function for Arduino Strings; converts to C string (char *)
// and calls corresponding print_aligned() implementation.
void print_aligned(Adafruit_GFX &gfx, const String &str,
                   GFXalign align = GFX_ALIGN_LEFT) {
  print_aligned(gfx, const_cast<char *>(str.c_str()));
}

// TEXT EXAMPLES -----------------------------------------------------------

// This section demonstrates:
// - Using the default 5x7 built-in font, including scaling in each axis.
// - How to access all characters of this font, including symbols.
// - Using a custom font, including alignment techniques that aren't a normal
//   part of the GFX library (uses functions above).

void show_basic_text() {
  // Show text scaling with built-in font.
  display.fillScreen(0);
  display.setFont();                    // Use default font
  display.setCursor(0, CORNER_RADIUS); // Initial cursor position
  display.setTextSize(1);               // Default size
  display.println(F("Standard built-in font"));
  display.setTextSize(2);
  display.println(F("BIG TEXT"));
  display.setTextSize(3);
  // "BIGGER TEXT" won't fit on narrow screens, so abbreviate there.
  display.println((display.width() >= 200) ? F("BIGGER TEXT") : F("BIGGER"));
  display.setTextSize(2, 4);
  display.println(F("TALL and"));
  display.setTextSize(4, 2);
  display.println(F("WIDE"));

  delay(PAUSE);
} // END BASIC TEXT EXAMPLE

void show_char_map() {
```

```
  // "Code Page 437" is a name given to the original IBM PC character set.
  // Despite age and limited language support, still seen in small embedded
  // settings as it has some useful symbols and accented characters. The
  // default 5x7 pixel font of Adafruit_GFX is modeled after CP437. This
  // function draws a table of all the characters & explains some issues.

  // There are 256 characters in all. Draw table as 16 rows of 16 columns,
  // plus hexadecimal row & column labels. How big can each cell be drawn?
  const int cell_size = min(display.width(), display.height()) / 17;
  if (cell_size < 8) return; // Screen is too small for table, skip example.
  const int total_size = cell_size * 17; // 16 cells + 1 row or column label

  // Set up for default 5x7 font at 1:1 scale. Custom fonts are NOT used
  // here as most are only 128 characters to save space (the "7b" at the
  // end of many GFX font names means "7 bits," i.e. 128 characters).
  display.setFont();
  display.setTextSize(1);

  // Early Adafruit_GFX was missing one symbol, throwing off some indices!
  // But fixing the library would break MANY existing sketches that relied
  // on the degrees symbol and others. The default behavior is thus "broken"
  // to keep older code working. New code can access the CORRECT full CP437
  // table by calling this function like so:
  display.cp437(true);

  display.fillScreen(0);

  const int16_t x = (display.width() - total_size) / 2;  // Upper left corner of
  int16_t       y = (display.height() - total_size) / 2; // table centered on screen
  if (y >= 4) { // If there's a little extra space above & below, scoot table
    y += 4;     // down a few pixels and show a message centered at top.
    display.setCursor((display.width() - 114) / 2, 0); // 114 = pixel width
    display.print(F("CP437 Character Map"));           //   of this message
  }

  const int16_t inset_x = (cell_size - 5) / 2; // To center each character within
cell,
  const int16_t inset_y = (cell_size - 8) / 2; // compute X & Y offset from corner.

  for (uint8_t row=0; row<16; row++) { // 16 down...
    // Draw row and columm headings as hexadecimal single digits. To get the
    // hex value for a specific character, combine the left & top labels,
    // e.g. Pi symbol is row E, column 3, thus: display.print((char)0xE3);
    display.setCursor(x + (row + 1) * cell_size + inset_x, y + inset_y);
    display.print(row, HEX); // This actually draws column labels
    display.setCursor(x + inset_x, y + (row + 1) * cell_size + inset_y);
    display.print(row, HEX); // and THIS is the row labels
    for (uint8_t col=0; col<16; col++) { // 16 across...
      if ((row + col) & 1) { // Fill alternating cells w/gray
        display.fillRect(x + (col + 1) * cell_size, y + (row + 1) * cell_size,
                         cell_size, cell_size, 0x630C);
      }
      // drawChar() bypasses usual cursor positioning to go direct to an X/Y
      // location. If foreground & background match, it's drawn transparent.
      display.drawChar(x + (col + 1) * cell_size + inset_x,
                       y + (row + 1) * cell_size + inset_y, row * 16 + col,
                       0xFFFF, 0xFFFF, 1);
    }
  }

  delay(PAUSE * 2);
} // END CHAR MAP EXAMPLE

void show_custom_text() {
  // Show use of custom fonts, plus how to do center or right alignment
  // using some additional functions provided earlier.

  display.fillScreen(0);
  display.setFont(&FreeSansBold18pt7b);
```

```
  display.setTextSize(1);
  display.setTextWrap(false); // Allow text off edges

  // Get "M height" of custom font and move initial base line there:
  uint16_t w, h;
  int16_t  x, y;
  display.getTextBounds("M", 0, 0, &x, &y, &w, &h);
  // On rounded 240x280 display in tall orientation, "Custom Font" gets
  // clipped by top corners. Scoot text down a few pixels in that one case.
  if (CORNER_RADIUS && (display.height() == 280)) h += 20;
  display.setCursor(display.width() / 2, h);

  if (display.width() >= 200) {
    print_aligned(display, F("Custom Font"), GFX_ALIGN_CENTER);
    display.setCursor(0, display.getCursorY() + 10);
    print_aligned(display, F("Align Left"), GFX_ALIGN_LEFT);
    display.setCursor(display.width() / 2, display.getCursorY());
    print_aligned(display, F("Centered"), GFX_ALIGN_CENTER);
    // Small rounded screen, when oriented the wide way, "Right" gets
    // clipped by bottom right corner. Scoot left to compensate.
    int16_t x_offset = (CORNER_RADIUS && (display.height() < 200)) ? 15 : 0;
    display.setCursor(display.width() - x_offset, display.getCursorY());
    print_aligned(display, F("Align Right"), GFX_ALIGN_RIGHT);
  } else {
    // On narrow screens, use abbreviated messages
    print_aligned(display, F("Font &"), GFX_ALIGN_CENTER);
    print_aligned(display, F("Align"), GFX_ALIGN_CENTER);
    display.setCursor(0, display.getCursorY() + 10);
    print_aligned(display, F("Left"), GFX_ALIGN_LEFT);
    display.setCursor(display.width() / 2, display.getCursorY());
    print_aligned(display, F("Center"), GFX_ALIGN_CENTER);
    display.setCursor(display.width(), display.getCursorY());
    print_aligned(display, F("Right"), GFX_ALIGN_RIGHT);
  }

  delay(PAUSE);
} // END CUSTOM FONT EXAMPLE

// BITMAP EXAMPLE ------------------------------------------------------------

// This section demonstrates:
// - Embedding a small bitmap in the code (flash memory).
// - Drawing that bitmap in various colors, and transparently (only '1' bits
//   are drawn; '0' bits are skipped, leaving screen contents in place).
// - Use of the color565() function to decimate 24-bit RGB to 16 bits.

#define HEX_WIDTH  16 // Bitmap width in pixels
#define HEX_HEIGHT 16 // Bitmap height in pixels
// Bitmap data. PROGMEM ensures it's in flash memory (not RAM). And while
// it would be valid to leave the brackets empty here (i.e. hex_bitmap[]),
// having dimensions with a little math makes the compiler verify the
// correct number of bytes are present in the list.
PROGMEM const uint8_t hex_bitmap[(HEX_WIDTH + 7) / 8 * HEX_HEIGHT] = {
  0b00000001, 0b10000000,
  0b00000111, 0b11100000,
  0b00011111, 0b11111000,
  0b01111111, 0b11111110,
  0b01111111, 0b11111110,
  0b01111111, 0b11111110,
  0b01111111, 0b11111110,
  0b01111111, 0b11111110,
  0b01111111, 0b11111110,
  0b01111111, 0b11111110,
  0b01111111, 0b11111110,
  0b01111111, 0b11111110,
  0b01111111, 0b11111110,
  0b00011111, 0b11111000,
  0b00000111, 0b11100000,
  0b00000001, 0b10000000,
```

```
};
#define Y_SPACING (HEX_HEIGHT - 2) // Used by code below for positioning

void show_bitmap() {
  display.fillScreen(0);

  // Not screen center, but UL coordinates of center hexagon bitmap
  const int16_t center_x = (display.width() - HEX_WIDTH) / 2;
  const int16_t center_y = (display.height() - HEX_HEIGHT) / 2;
  const uint8_t steps = min((display.height() - HEX_HEIGHT) / Y_SPACING,
                            display.width() / HEX_WIDTH - 1) / 2;

  display.drawBitmap(center_x, center_y, hex_bitmap, HEX_WIDTH, HEX_HEIGHT,
                     0xFFFF); // Draw center hexagon in white

  // Tile the hexagon bitmap repeatedly in a range of hues. Don't mind the
  // bit of repetition in the math, the optimizer easily picks this up.
  // Also, if math looks odd, keep in mind "PEMDAS" operator precedence;
  // multiplication and division occur before addition and subtraction.
  for (uint8_t a=0; a<=steps; a++) {
    for (uint8_t b=1; b<=steps; b++) {
      display.drawBitmap( // Right section centered red: a = green, b = blue
        center_x + (a + b) * HEX_WIDTH / 2,
        center_y + (a - b) * Y_SPACING,
        hex_bitmap, HEX_WIDTH, HEX_HEIGHT,
        display.color565(255, 255 - 255 * a / steps, 255 - 255 * b / steps));
      display.drawBitmap( // UL section centered green: a = blue, b = red
        center_x - b * HEX_WIDTH + a * HEX_WIDTH / 2,
        center_y - a * Y_SPACING,
        hex_bitmap, HEX_WIDTH, HEX_HEIGHT,
        display.color565(255 - 255 * b / steps, 255, 255 - 255 * a / steps));
      display.drawBitmap( // LL section centered blue: a = red, b = green
        center_x - a * HEX_WIDTH + b * HEX_WIDTH / 2,
        center_y + b * Y_SPACING,
        hex_bitmap, HEX_WIDTH, HEX_HEIGHT,
        display.color565(255 - 255 * a / steps, 255 - 255 * b / steps, 255));
    }
  }

  delay(PAUSE);
} // END BITMAP EXAMPLE

// CANVAS EXAMPLE ------------------------------------------------------------

// This section demonstrates:
// - How to refresh changing values onscreen without erase/redraw flicker.
// - Using an offscreen canvas. It's similar to a bitmap above, but rather
//   than a fixed pattern in flash memory, it's drawable like the screen.
// - More tips on text alignment, and adapting to different screen sizes.

#define PADDING 6 // Pixels between axis label and value

void show_canvas() {
  // For this example, let's suppose we want to display live readings from a
  // sensor such as a three-axis accelerometer, something like:
  //   X: (number)
  //   Y: (number)
  //   Z: (number)
  // To look extra classy, we want a custom font, and the labels for each
  // axis are right-aligned so the ':' characters line up...

  display.setFont(&FreeSansBold18pt7b); // Use a custom font
  display.setTextSize(1);               // and reset to 1:1 scale

  char          *label[] = { "X:", "Y:", "Z:" };       // Labels for each axis
  const uint16_t color[] = { 0xF800, 0x07E0, 0x001F }; // Colors for each value

  // To get the labels right-aligned, one option would be simple trial and
  // error to find a column that looks good and doesn't clip anything off.
```

```
// Let's do this dynamically though, so it adapts to any font or labels!
// Start by finding the widest of the label strings:
uint16_t w, h, max_w = 0;
int16_t  x, y;
for (uint8_t i=0; i<3; i++) { // For each label...
  display.getTextBounds(label[i], 0, 0, &x, &y, &w, &h);
  if (w > max_w) max_w = w; // Keep track of widest label
}

// Rounded corners throwing us a curve again. If needed, scoot everything
// to the right a bit on wide displays, down a bit on tall ones.
int16_t y_offset = 0;
if (display.width() > display.height()) max_w += CORNER_RADIUS;
else                                    y_offset = CORNER_RADIUS;

// Now we have max_w for right-aligning the labels. Before we draw them
// though...in order to perform flicker-free updates, the numbers we show
// will be rendered in either a GFXcanvas1 or GFXcanvas16 object; a 1-bit
// or 16-bit offscreen bitmap, RAM permitting. The correct size for this
// canvas could also be trial-and-errored, but again let's make this adapt
// automatically. The width of the canvas will span from max_w (plus a few
// pixels for padding) to the right edge. But the height? Looking at an
// uppercase 'M' can work in many situations, but some fonts have ascenders
// and descenders on digits, and in some locales a comma (extending below
// the baseline) is the decimal separator. Feed ALL the numeric chars into
// getTextBounds() for a cumulative height:
display.setTextWrap(false); // Keep on one line
display.getTextBounds(F("0123456789.,-"), 0, 0, &x, &y, &w, &h);

// Now declare a GFXcanvas16 object based on the computed width & height:
GFXcanvas16 canvas16(display.width() - max_w - PADDING, h);

// Small devices (e.g. ATmega328p) will almost certainly lack enough RAM
// for the canvas. Check if canvas buffer exists. If not, fall back on
// using a 1-bit (rather than 16-bit) canvas. Much more RAM friendly, but
// not as fast to draw. If a project doesn't require super interactive
// updates, consider just going straight for the more compact Canvas1.
if (canvas16.getBuffer()) {
  // If here, 16-bit canvas allocated successfully! Point of interest,
  // only one canvas is needed for this example, we can reuse it for all
  // three numbers because the regions are the same size.

  // display and canvas are independent drawable objects; must explicitly
  // set the same custom font to use on the canvas now:
  canvas16.setFont(&FreeSansBold18pt7b);

  // Clear display and print labels. Once drawn, these remain untouched.
  display.fillScreen(0);
  display.setCursor(max_w, -y + y_offset); // Set baseline for first row
  for (uint8_t i=0; i<3; i++) print_aligned(display, label[i], GFX_ALIGN_RIGHT);

  // Last part now is to print numbers on the canvas and copy the canvas to
  // the display, repeating for several seconds...
  uint32_t elapsed, startTime = millis();
  while ((elapsed = (millis() - startTime)) <= PAUSE * 2) {
    for (uint8_t i=0; i<3; i++) {  // For each label...
      canvas16.fillScreen(0);    // fillScreen() in this case clears canvas
      canvas16.setCursor(0, -y); // Reset baseline for custom font
      canvas16.setTextColor(color[i]);
      // These aren't real accelerometer readings, just cool-looking numbers.
      // Notice we print to the canvas, NOT the display:
      canvas16.print(sin(elapsed / 200.0 + (float)i * M_PI * 2.0 / 3.0), 5);
      // And HERE is the secret sauce to flicker-free updates. Canvas details
      // can be passed to the drawRGBBitmap() function, which fully overwrites
      // prior screen contents in that area. yAdvance is font line spacing.
      display.drawRGBBitmap(max_w + PADDING, i * FreeSansBold18pt7b.yAdvance +
                            y_offset, canvas16.getBuffer(), canvas16.width(),
                            canvas16.height());
    }
```

```
    }
  } else {
    // Insufficient RAM for Canvas16. Try declaring a 1-bit canvas instead...
    GFXcanvas1 canvas1(display.width() - max_w - PADDING, h);
    // If even this smaller object fails, can't proceed, cancel this example.
    if (!canvas1.getBuffer()) return;

    // Remainder here is nearly identical to the code above, simply using a
    // different canvas type. It's stripped of most comments for brevity.
    canvas1.setFont(&FreeSansBold18pt7b);
    display.fillScreen(0);
    display.setCursor(max_w, -y + y_offset);
    for (uint8_t i=0; i<3; i++) print_aligned(display, label[i], GFX_ALIGN_RIGHT);
    uint32_t elapsed, startTime = millis();
    while ((elapsed = (millis() - startTime)) <= PAUSE * 2) {
      for (uint8_t i=0; i<3; i++) {
        canvas1.fillScreen(0);
        canvas1.setCursor(0, -y);
        canvas1.print(sin(elapsed / 200.0 + (float)i * M_PI * 2.0 / 3.0), 5);
        // Here's the secret sauce to flicker-free updates with GFXcanvas1.
        // Canvas details can be passed to the drawBitmap() function, and by
        // specifying both a foreground AND BACKGROUND color (0), this will fully
        // overwrite/erase prior screen contents in that area (vs transparent).
        display.drawBitmap(max_w + PADDING, i * FreeSansBold18pt7b.yAdvance +
                           y_offset, canvas1.getBuffer(), canvas1.width(),
                           canvas1.height(), color[i], 0);
      }
    }
  }

  // Because canvas object was declared locally to this function, it's freed
  // automatically when the function returns; no explicit delete needed.
} // END CANVAS EXAMPLE
```


Upload the Example Code to the Pico. Then, you can connect the PiCowbell to an HDMI monitor and USB power to the Pico. You'll see the 16bit_hello example display on the screen.

There is an excellent explainer page () for the example code in the PicoDVI Arduino Library Learn Guide.

PicoDVI Arduino Library Learn Guide

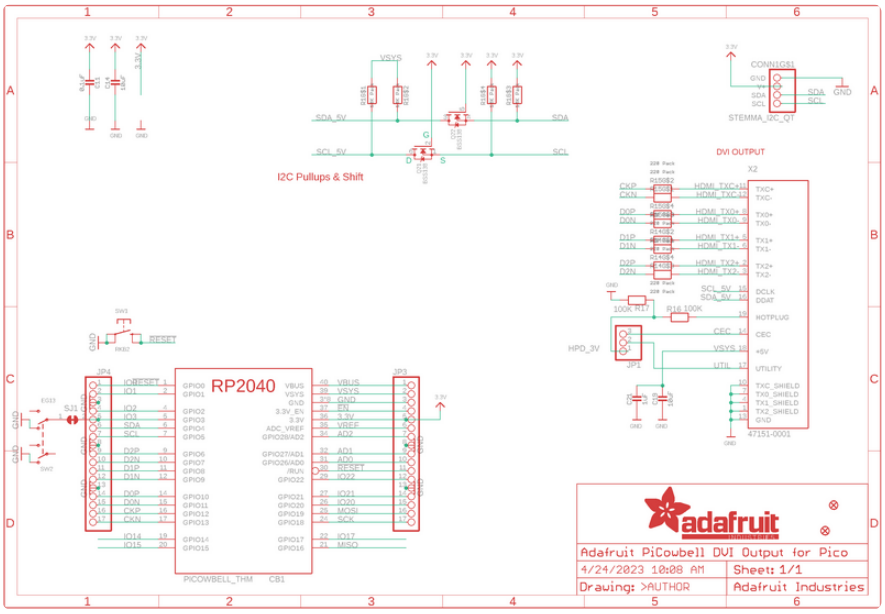
# Downloads

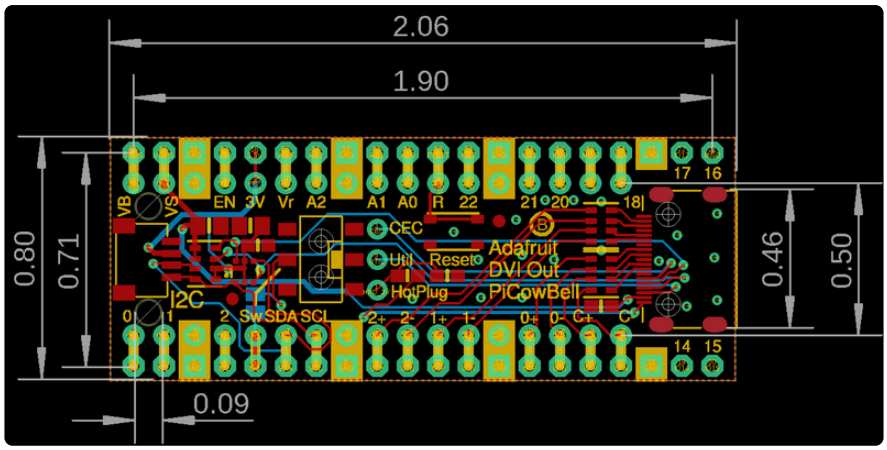
## Files

- HDMI Wikipedia page with connector pinouts ()
- EagleCAD PCB files on GitHub ()
- Fritzing object in the Adafruit Fritzing Library ()

## Schematic and Fab Print

Dimensions are in inches.




2.06
1.90
0.80
0.71
0.46
0.50
0.09
VB
VS
EN
3V
Vr
A2
A1
A0
R
22
21
20
18
17
16
15
14
CEC
Util
HotPlug
Reset
Adafruit
DVI Out
PiCowBell
I2C
0
1
2
SW
SDA
SCL
2+
2-
1+
1-
0+
0-
C+
C-

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

Adafruit:
5745