12-Channel RGB LED Drivers with I²C Control

Brief Description

Use the KTD2052 Evaluation (EVAL) Kit to demonstrate and evaluate the KTD2052A functionality, performance, and PCB layout. The EVAL Kit is a convenient tool for software development of RGB LED lighting patterns and animations. The kit includes a fully assembled and tested PCB with the KTD2052A integrated circuit chip installed, a wiring harness, and an Adafruit QT Py RP2040 microcontroller board configured for CircuitPython with pre-loaded KTD2052A demo software. The demo software shows many lighting patterns, most of which run autonomously using the KTD2052A's pattern generator. Four RGB modules (12 LEDs total) are mounted on the PCB and shine at moderate brightness setting in the demo software to reduce human-eye fatigue.

This EVAL Kit may optionally be used to evaluate the KTD2052B/C/D 12-channel RGB LED drivers by replacing the IC and making minor modifications to the demo software.

Ordering Information

Part Number	Description	IC Package
KTD2052AEVAA-MMEV01	KTD2052 EVAL Kit	UDFN22-8

EVAL Kit Photo
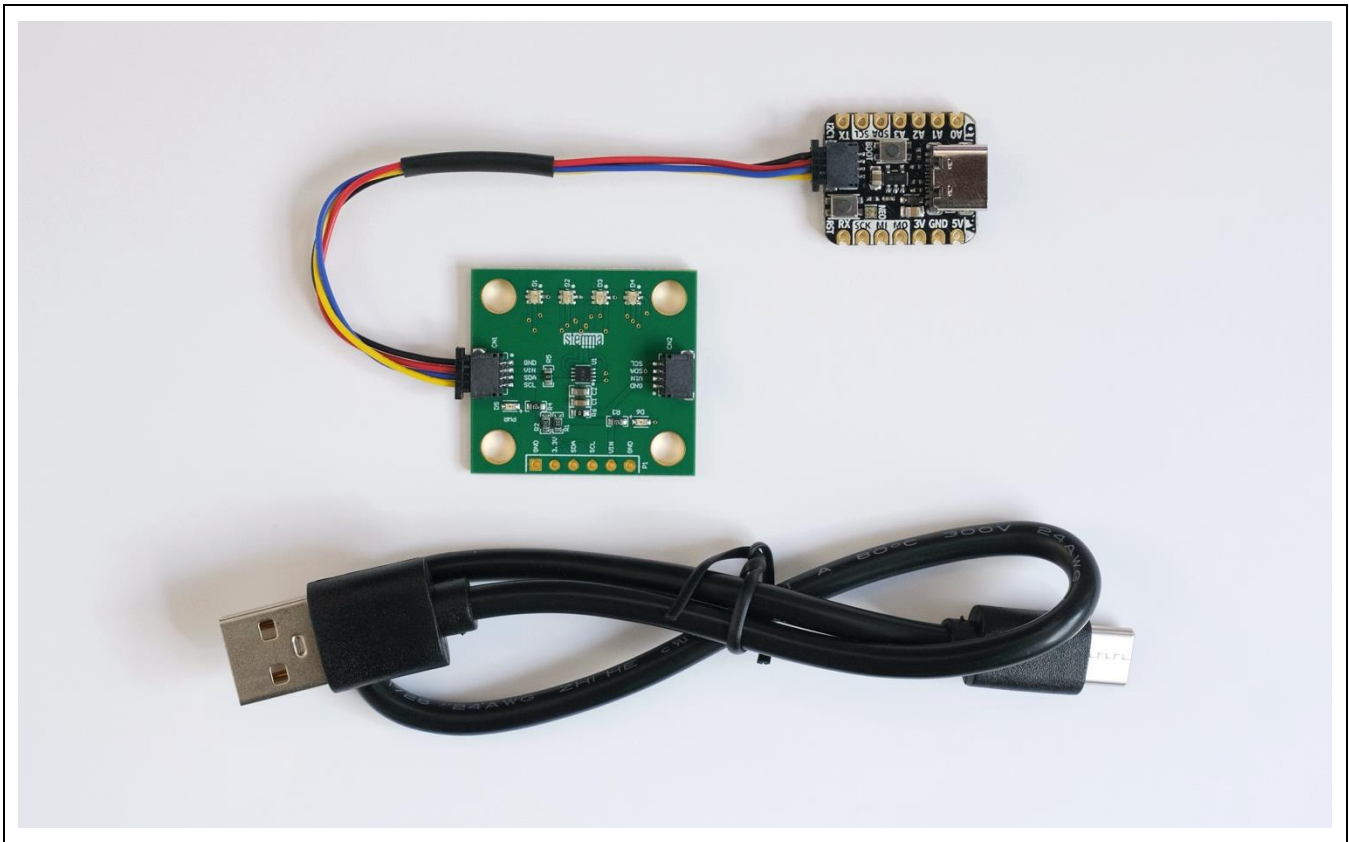
Table of Contents

EVAL Kit Physical Contents

Item #	Description	Quantity		
		Included	Downloadable	User-Supplied
1	KTD2052 EVB Rev1.0 fully assembled printed circuit board	1		
2	StemmaQT/Qwiic I^{2}C wire harness	1		
3	Adafruit QT Py RP2040 µC fully assembled printed circuit board	1		
4	USB type-A to type-C cable	1		
5	Anti-Static Bag	1		
6	Quick-Start Guide printout	1		
7	EVAL Kit box	1		
5	Demo software (pre-loaded on QT Py)	1	by request	
6	EVAL Kit Manual (either pre-loaded on QT Py or downloadable)	1	1	
7	USB 5V/0.5A power source			1

User-Supplied Equipment

Required Equipment

1. 5V/0.5A USB VBUS Power Source – either an AC wall adapter, battery power bank, or an available USB port from a computer. Any USB power sources with 0.5A rating or more is adequate.

Optional Equipment

1. Computer with USB port – for software development using a software text editor, and to copy/paste/save the software (filename = *code.py*) from the editor to the QT Py RP2040 board.
2. 5V/0.5A Adjustable Power Supply – for testing with variable input voltage.
3. Digital Multimeter – to measure input voltage, input current, or LED current.
4. Oscilloscope – to observe the multiplexed output waveforms.

Recommended Operating Conditions

| Symbol	Description	Value	Units
VBUS	USB VBUS Voltage	4.5 to 5.5	V
V$_{IN}$	Input Voltage	3 to 5.5	V
I$_{IN}$	Input Current	0 to 0.5	A

Quick Start Procedures

Follow the below quick start steps in sequence to ensure a safe and successful power-up of the EVAL Kit.

1. Using the StemmaQT/Qwiic I^{2}C wiring harness, connect the EVAL Kit PCB to the QT Py PCB. To avoid damage within the connectors, do not insert the StemmaQT/Qwiic connectors upside down.
2. Connect the USB cable to the QT Py RP2040 PCB.
3. Connect the other end of the USB cable to a USB 5V power source (user-supplied). You may use an AC wall adapter, battery power bank, or an available USB port from a computer.
4. When power is applied, the demo software executes. Observe the first three patterns to ensure full functionality:
    a. All 4 RGB modules turn dim white for 3 seconds.
    b. Red flashes 3 times quickly on RGB1, then white chases 1 time quickly across RGB1/2/3/4.
    c. Blue breathes 4 times slowly on RGB1/2/3/4.
5. After the test patterns, the demo continues with many other patterns.
6. When complete, the entire demo repeats and loops endlessly.
7. When desired, remove power by pulling the AC wall adapter from the AC outlet, or by disconnecting the USB cable from the USB power source.
8. Optionally, to read or modify the demo software, connect the USB cable to a computer.
    a. The QT Py RP2040 connects as an 8MB USB flash drive. The software and collateral documents are stored within.
    b. Open the CircuitPython text file *code.py* with a software editor. Adafruit recommends the freeware *Mu* editor, which is optimized for CircuitPython.
    c. When editing *code.py*, save changes to the QT Py RP2040. After saving, the code will recompile and execute automatically.
    d. For backup, the *code.py* file is already replicated as *KTD2052_demo_code.txt* on the QT Py RP2040.
9. For additional resources:
    a. KTD2052 Product https://www.kinet-ic.com/ktd2052/
    b. KTD2052 EVAL Kit https://www.kinet-ic.com/ktd2052aevaa-mmev01/
    c. Adafruit QT Py RP2040 https://learn.adafruit.com/adafruit-qt-py-2040/overview
    d. Adafruit CircuitPython https://learn.adafruit.com/welcome-to-circuitpython/overview
    e. Mu Editor Installation https://codewith.mu

QR Codes

| KTD2052 Product	KTD2052 EVAL Kit	
Adafruit QT Py RP2040	**Adafruit CircuitPython**	**Mu Editor Installation**

Electrical Schematic
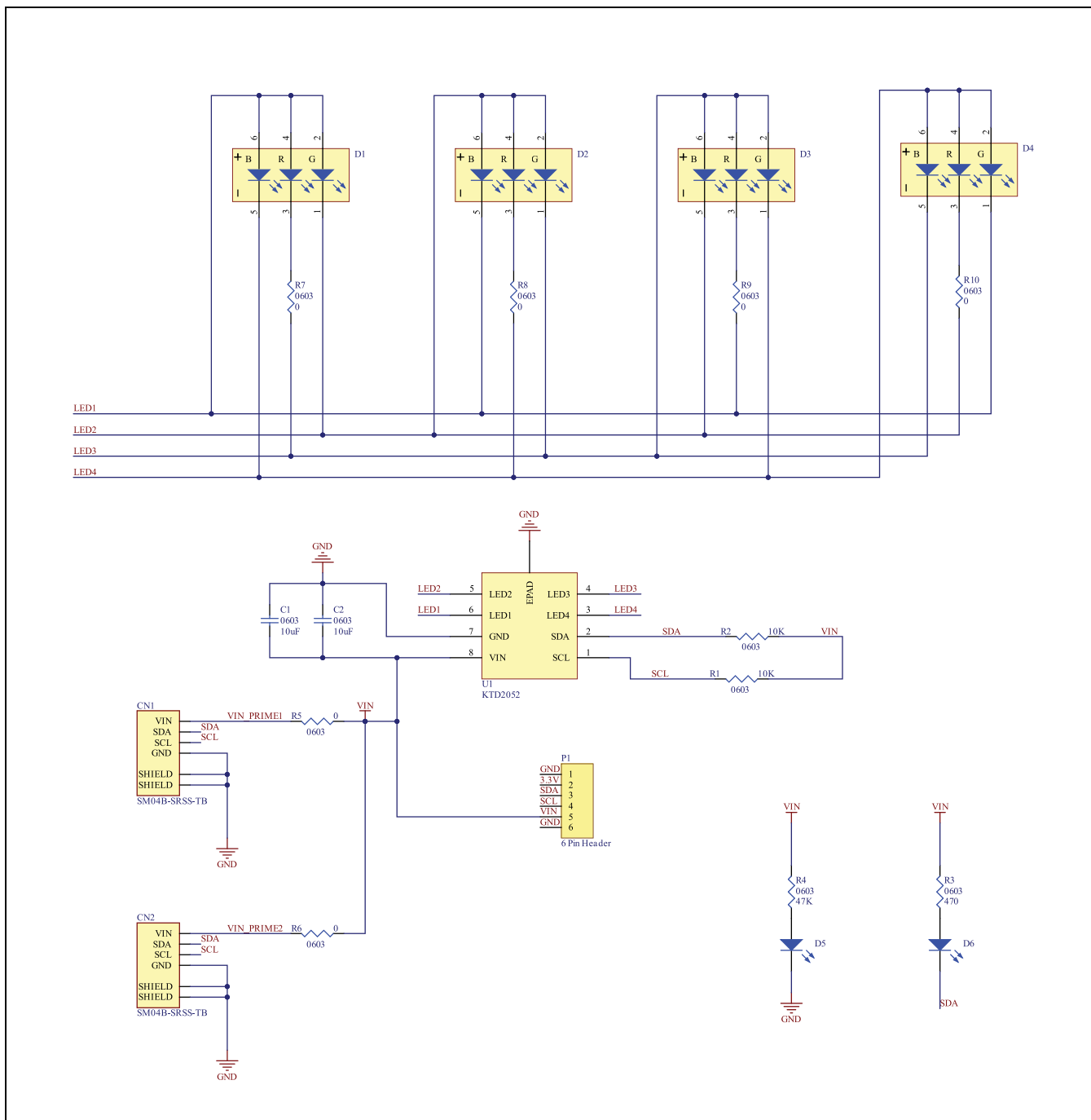
Bill of Materials (BOM)

Item #	Quantity	Designator	Description	Value	Package	Manufacturer	Manufacturer Part Number
1	2	C1, C2	CAP CER 10µF 16V X5R 0603	10µF	0603	Murata	GRT188R61C106KE13D
2	2	CN1, CN2	CONN HEADER SMD R/A 4POS 1MM		SMD	JST Sales America Inc.	SM04B-SRSS-TB(LF)(SN)
3	4	D1, D2, D3, D4	LED Tri-Color Blue/Green/Red 468nm/518nm/632nm 6-Pin SMD-B T/R		SMD-6L	Everlight	19-337C/RSBHGHC-A88/4T
4	2	D5, D6	LED RED CLEAR 0603 SMD		0603	Würth Elektronik	150060RS75000
5	1	P1	CONN HEADER VERT 6POS 2.54MM		TH	Sullins Connector Solutions	PREC006SAAN-RC
6	2	R1, R2	RES SMD 10KΩ 1% 1/10W 0603	10K	0603	Yageo	AC0603FR-0710KL
7	1	R3	RES SMD 470Ω 1% 1/10W 0603	470	0603	Yageo	AF0603FR-07470RL
8	1	R4	RES SMD 47KΩ 1% 1/10W 0603	47K	0603	Panasonic Electronic Components	ERJ-3EKF4702V
9	6	R5, R6, R7, R8, R9, R10	RES SMD 0Ω JUMPER 1/10W 0603	0	0603	Yageo	AC0603JR-070RL
10	1	U1	12-Channel RGB LED Drivers with I^{2}C Control		UDFN	Kinetic Technologies	KTD2052AEVAA-TR

Printed Circuit Board (PCB) 3D CAD
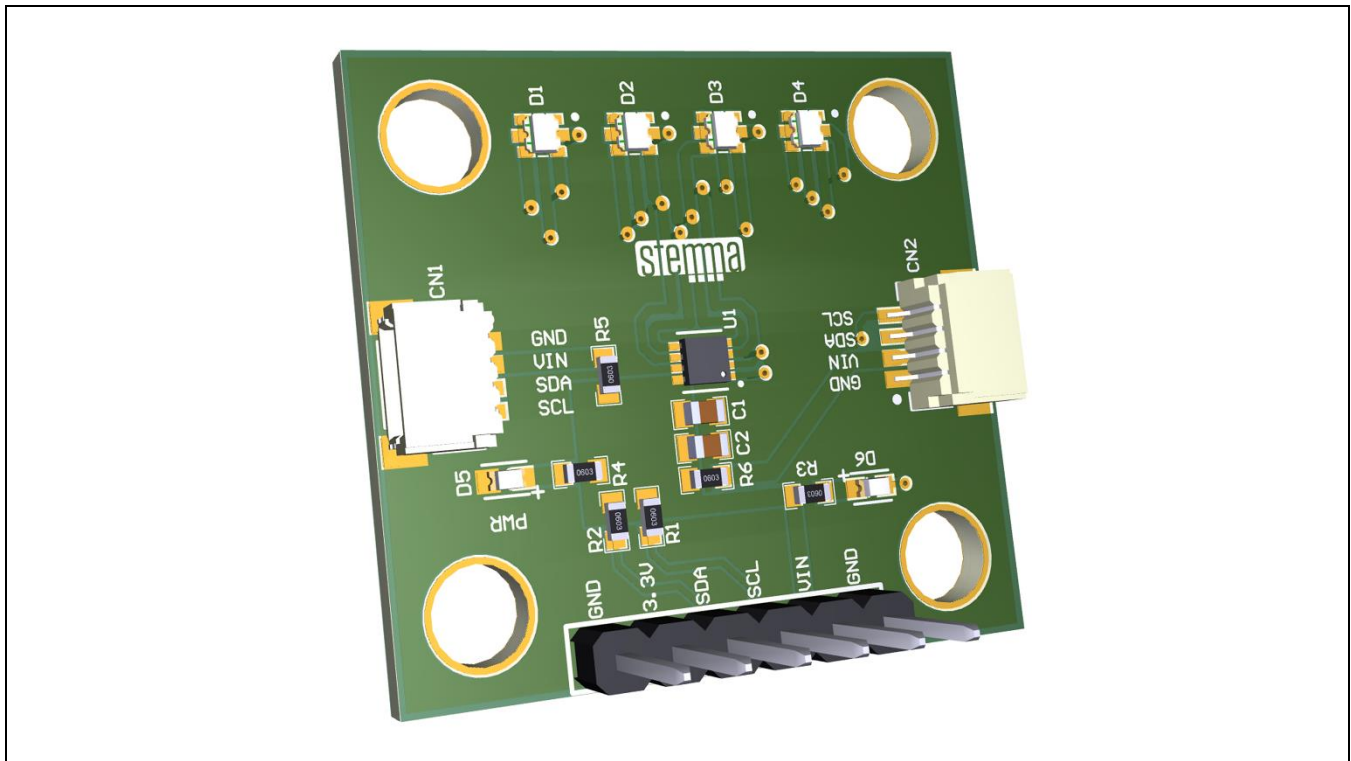
Printed Circuit Board (PCB) Layout
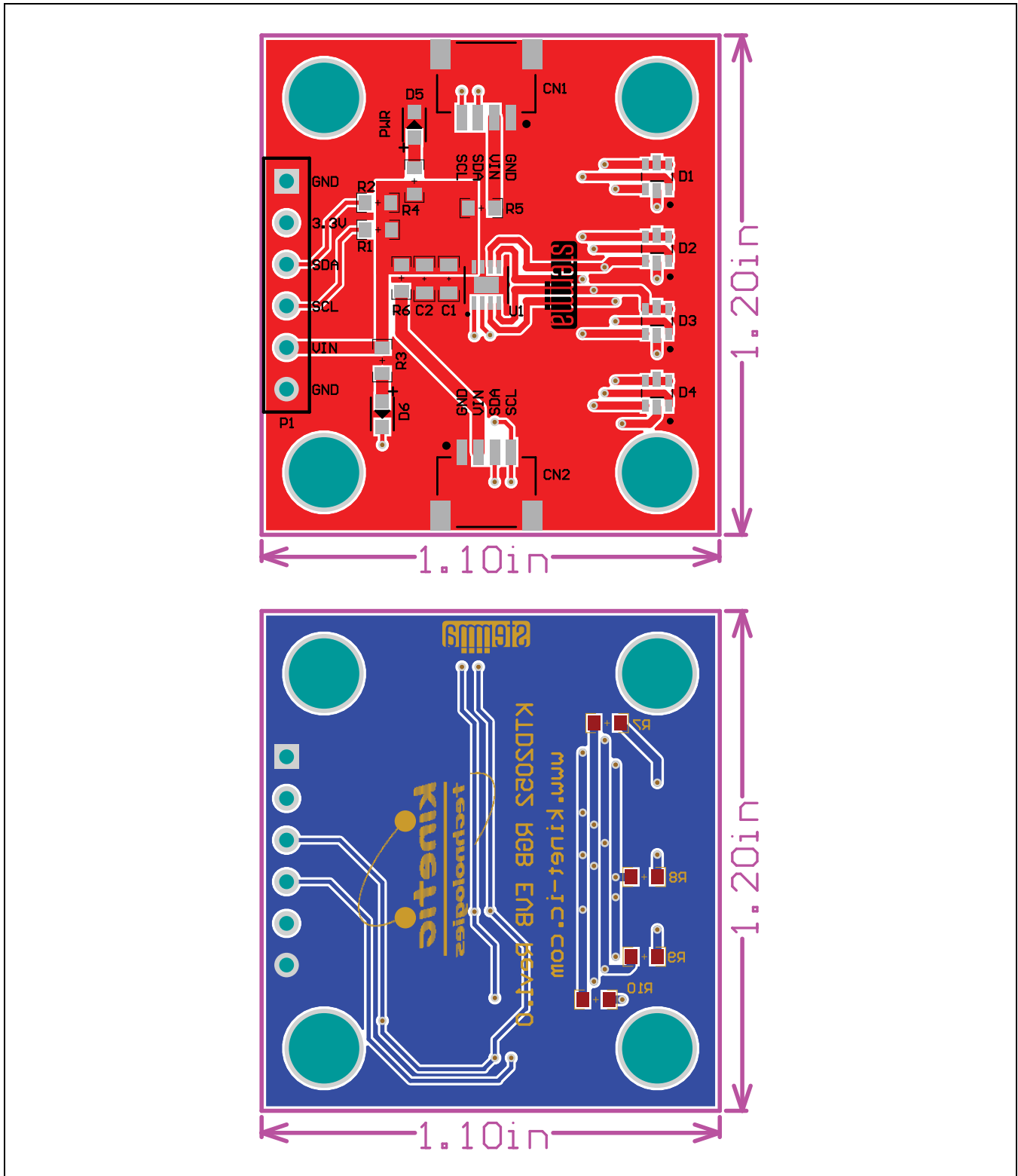
Adafruit QT Py RP2040

Per the description at https://learn.adafruit.com/adafruit-qt-py-2040/overview:

What a cutie pie! Or is it... a QT Py? This diminutive dev board comes with one of our new favorite chips, the RP2040. It's been made famous in the new Raspberry Pi Pico and our Feather RP2040 and ItsyBitsy RP2040, but what if we wanted something really smol?

A new chip means a new QT Py, and the Raspberry Pi RP2040 is no exception. When we saw this chip, we thought, "This chip is going to be awesome when we give it the cuuutie QT Py Treatment," and so we did! This QT Py features the RP2040 and all niceties you know and love about the original QT Py.

At the time of launch, there is no Arduino core support for the chip on this board. There is great C/C++ support, an official MicroPython port, and a CircuitPython port! We of course recommend CircuitPython because we think it's the easiest way to get started. And it has support with most of our drivers, displays, sensors, and more, supported out of the box so you can follow along with our CircuitPython projects and tutorials.

StemmaQT / Qwiic Wire Harness

Per the description at https://learn.adafruit.com/adafruit-qt-py-2040/overview:

The star of the QT Py is our favorite connector - the STEMMA QT, a chainable I^2C port that can be used with any of our STEMMA QT sensors and accessories. Having this connector means you don't need to do any soldering to get started.

What can you pop into the QT port? How about OLEDs! Inertial Measurement Units! Sensors a-plenty. All plug-and-play thanks to the innovative chainable design: SparkFun Qwiic-compatible STEMMA QT connectors for the I^2C bus so you don't even need to solder. Just plug in a compatible cable and attach it to your MCU of choice, and you're ready to load up some software and measure some light.

Use any SparkFun Qwiic boards! Seeed Grove I^2C boards will also work with an adapter cable.

Evaluation and Bench Testing

Visual Inspection and Test Patterns

The demo software starts by running a utility test pattern.

1. *chip_status_check():* all 4 RGB modules turn on with dim white in order to detect short or open-LED via the BE_STAT bit.
   a. Dim white is shown for 3 seconds. It is very dim and may show some color shift due to the RGB performance at very low currents and the green color of the PCB.
   b. During this time, the software reads back and prints (to the console in a software editor) the ID register and Monitor register contents. A legend is also printed to help decode the bits.
   c. These registers provide readback of the Kinetic vendor ID, the KTD2052 die ID, the output short-circuit status, the BrightExtend™ dropout status (which is used to indicate an open-LED fault when the LED currents are set very dim), the CoolExtend™ status (which can indicate a hot die temperature, settable as 90, 105, 120, or 135°C), and input under-voltage lock out (UVLO) status or die over-temperature protection (OTP) thermal shutdown status.
2. After the status check, the software demo loops indefinitely, starting with the below:
   a. *PowerUp_Boot_Sequence():* Red flashes 3 times quickly on RGB1, then white chases 1 time quickly across RGB1/2/3/4.
   b. *Breathe_All_Blue(4):* Blue breathes 4 times slowly on RGB1/2/3/4.
   c. The rest of the demo loop continues with multiple colors, patterns, and animations.

Input Voltage and Current

The input voltage may be measured at the VIN and GND pins on the P1 header (not populated). By default, VIN = 3.3V is provided via the StemmaQT / Qwiic wire harness from the QT Py RP2040 board, which has a 3.3Vout LDO regulator.

To vary the input voltage, first remove R5 (0Ω) and R6 (0Ω) and then connect a bench supply (3V to 5.5V, 0.5A) at the VIN and GND pins on the P1 header (not populated). To measure the input current, place a current meter in series with the bench supply.

Output Voltage and Current

Monitor the multiplexed output voltage waveforms by using an oscilloscope and carefully probing any of the vias on the four LED output traces near the RGBs. However, due to the Charlieplexing scheme, these waveforms are difficult to interpret. Nevertheless, it is easy to observe the current-sink headroom by measuring the lowest voltage levels and how much margin they have above ground.

To measure LED output current, please note that the red LEDs within the RGB modules have the lowest Vf. Therefore, they are the best place to insert a series-connected current meter and measure the current without causing current-sink dropout. Keep in mind, if BrightExtend™ is enabled and low VIN is causing a blue or green LED to dropout, then the red LED current will automatically reduce. Therefore, turn off BrightExtend™ if measuring the current accuracy vs. setting.

Measure the output current for a red LED by removing one of the corresponding R7 – R10 (0Ω) resistors. (In the future, R7 – R10 may be replaced by a PCB short trace. In this case, it is necessary to cut the trace with a knife to remove the 0Ω resistance.) Next, solder some small wires to the removed resistor's landing pattern and connect a DC current meter (with floating chassis ground and low capacitance) to measure the average current. A handheld digital multimeter (DMM) usually works well. Alternatively, solder a small wire loop to the landing pattern and connect an oscilloscope current probe to the loop to see the multiplexed current waveform. When running the demo software, the current will change continuously. So, for a DC measurement, it may be necessary to modify the software to hold a static current setting for an extended period.

Small Red LEDs D5 and D6

The D5 red LED indicates the presence of input voltage at VIN. The D6 red LED indicates I²C traffic on the SDA pin. It flickers whenever SDA is pulled low. Because the KTD2052 has an internal pattern generator, D6 often flickers only momentarily when a new animation pattern is loading. D6 provides a visual highlight for how little I²C traffic is needed.

Evaluating Other ICs

The KTD2052 EVAL Kit may optionally be used to evaluate other ICs in the same family:

Part #	Description	AutoBreathe™	7-bit I^{2}C Address	Package
KTD2052A	**12 Ch RGB LED Driver with I^{2}C Control**	**No**	**0x74 default**	UDFN22-8
KTD2052B	12 Ch RGB LED Driver with I^{2}C Control	Yes	0x74 alternate	
KTD2052C	12 Ch RGB LED Driver with I^{2}C Control	No	0x75 alternate	
KTD2052D	12 Ch RGB LED Driver with I^{2}C Control	Yes	0x75 alternate	

To evaluate other devices, order samples separately, remove (de-solder) the KTD2052A, clean the PCB, and carefully solder the new sample to the PCB. For the KTD2052C, modify the *Configuration* section of the demo software with the correct I^{2}C slave address. For the KTD2052B/D, consult an authorized Kinetic representative to request fully configured and tested AutoBreathe™ demo software. The software adds a long *time.sleep(20)* command near the beginning of the code to allow the AutoBreathe™ default pattern to execute automatically for 20 seconds at power up without any microprocessor involvement.

Troubleshooting

Symptom	Root Cause	Solution
RGBs do not light at all.	Software may be corrupted.	Resave a known good copy of the software to the QT Py RP2040. Reset or cycle the power if needed.
RGBs do not light at all, or software gets stuck.	Software may have a syntax error, usually after editing.	Fix the syntax error and resave the software to the QT Py RP2040.
RGBs do not light at all, or software gets stuck.	StemmaQT / Qwiic wire harness or connectors may be damaged.	Remove power and check the wire harness and connector contact pins for damage. Replace the cable and/or connectors as necessary.
RGBs do not light.	The KTD2052 may have detected a short circuit or failed LED.	Inspect the KTD2052 and RGB solder connections and the RGB LEDs themselves; repair or replace as necessary.
Some or all RGBs show the wrong colors.	Software may have a syntax error, usually after editing.	Fix the syntax error and resave the software to the QT Py RP2040.
Some or all RGBs show the wrong colors.	One or more RGB modules are soldered to the PCB with 180-degree rotation.	Find the rotated RGB or RGBs by using a microscope and inspecting carefully. Replace the RGB(s) in the correct orientation.
There is audible noise. The KTD2052 should not create audible noise.	The AC adapter may have large output ripple in the audio range due to skip/burst/PFM operation at light-loads. This ripple can cause squealing from the ceramic input capacitors on the KTD2052 PCB due to piezoelectric effect.	Try a different model of AC adapter.

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