



The Byte Attic's

# Agon light™

## Hardware Manual

© 2022 by Bernardo Kastrup. All rights reserved.

Last updated on: 10/14/22 1:46:37 AM

Provided as-is, expressly without warranties and/or representations of any kind.

The author disclaims all responsibility for damages incurred as a direct and/or indirect result of the use of this manual and/or the system it describes.



# What is Agon light™?

- A modern 8-bit microcomputer and microcontroller in one small, low-cost board
- Requires no host PC: Agon light puts out its own video (VGA, various modes, 64 colors), audio (2 identical mono channels), accepts a PS/2 keyboard and has µSD-card storage
- Features a control port with SPI, I<sup>2</sup>C, 20 distinct GPIOs, a system clock output, as well as power (3.3V and 5V) and ground rails
- Features a separate ACCESS.bus header for e.g. an optional status display
- Aims at the best possible trade-off across performance, cost and flexibility with cutting-edge technology
- There are no FPGAs and no emulation in Agon™: the 'bare wires' are exposed directly to the firmware programmer
- Agon light is powered by USB and runs internally at 3.3V

# What is so unique and attractive about it?

- Instant-on, stand-alone, BASIC-programmed\* microcontroller: no host PC or sketch compilation required
- Control your whole house from the immediacy of a BASIC prompt! \*
- Say goodbye to assembly:
  - C-programmable audio/video coprocessor firmware with freely available tooling
  - C-programmable CPU firmware with freely available tooling
- A hardware canvas for you to make of it your own dream, firmware-customized microcomputer
- A laboratory for computer science experimentation
- The most advanced 8-bit microcomputer to date
- The best balance of cost, performance and programmability
- Agon light is an open-hardware and open-source project, so you get *all* the information about the system

\* Requires installation of Quark™ firmware by Dean Belfield



The Byte Attic's

# Agon light™

Technical  
overview and  
specifications



# Architecture and specifications

- Two subsystems:
  - The *processor subsystem*
  - The *terminal subsystem*
- The *processor subsystem* comprises:
  - CPU (eZ80F92 running at 18.432MHz)
  - System memory (512KB, 10ns, parallel SRAM)
  - µSD-card port (as main storage)
  - ZDI port (for programming the firmware of the CPU)
  - Control port (including 20 GPIOs) to control your projects from BASIC\*
- The *terminal subsystem* comprises:
  - Audio/video coprocessor (ESP32-PICO-D4 running at 240MHz)
  - Terminal memory (8MB, 133MHz, serial pSRAM)
  - Keyboard port (PS/2)
  - VGA port (various modes, 64 colors)
  - Audio jack (2x mono)
  - USB 2.0 port (for power and programming the ESP32's firmware)
- The two subsystems communicate with each other via full-duplex high-speed serial link (384 kilobits per second), featuring flow control

\* Requires installation of Quark™ firmware by Dean Belfield

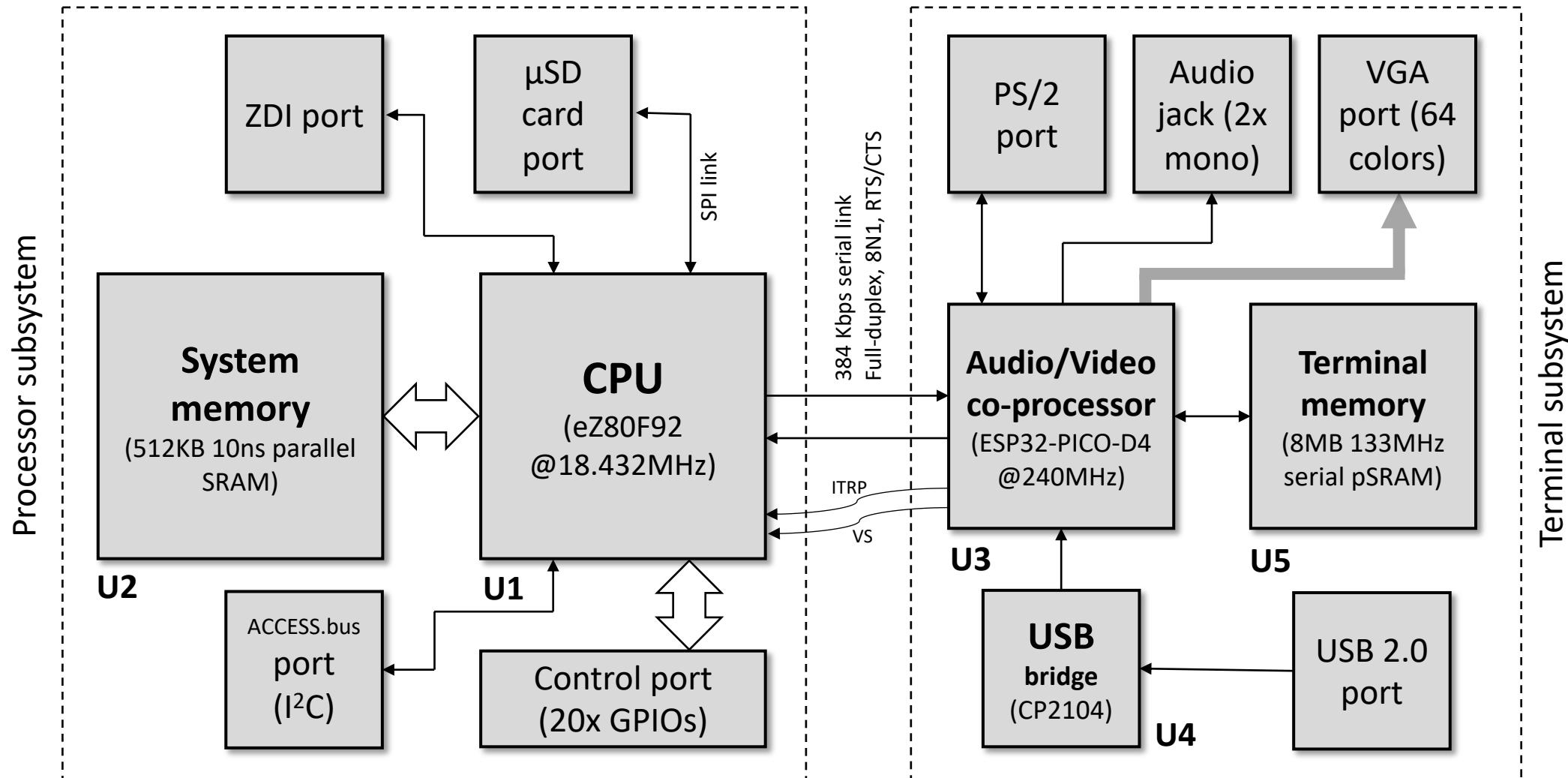
# Theory of operation

- The *terminal subsystem*:
  - Reads out the (PS/2) keyboard and sends the corresponding keypress tokens to the CPU via a high-speed serial link
  - Generates the screen based on display-list commands issued by the CPU and sent to the ESP32 via a high-speed serial link
  - Produces the VGA & audio signals
  - Supports the FabGL™ library
  - Sends the vertical synch signal (**VS**, from pin 21/IO15) both to the VGA port *and the CPU*
  - Sends a general-purpose, firmware-programmable signal (**ITRP**, from pin 28/SD2) to the CPU
- The *processor subsystem*:
  - Runs the BIOS and BASIC interpreter\*
  - Executes application code
  - Drives the GPIOs based on the application code
  - Drives the *terminal subsystem* by issuing display-list and audio-related commands to the ESP32 via a high-speed serial link
  - Manages storage ( $\mu$ SD-card)
  - The eZ80F92 CPU receives the vertical synch (**VS**, in pin 89/PB1/T1\_IN) and a general-purpose firmware-programmable signal (**ITRP**, in pin 88/PB0/T0\_IN) from the ESP32, both of which can be used by the eZ80F92 as interrupts

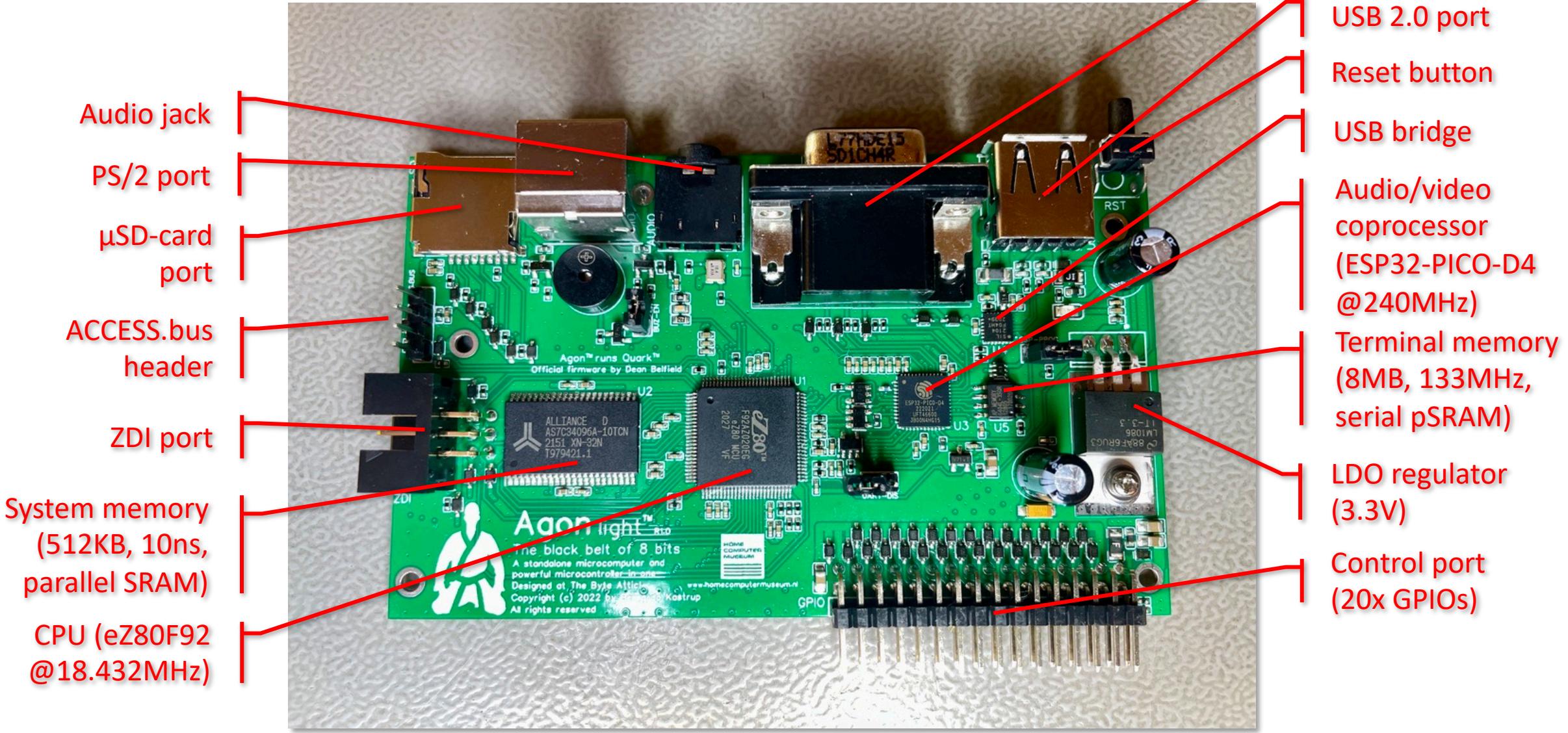
\* Requires installation of Quark™ firmware  
by Dean Belfield

# System diagram

↔ Serial link  
↔ Parallel link



# Circuit board

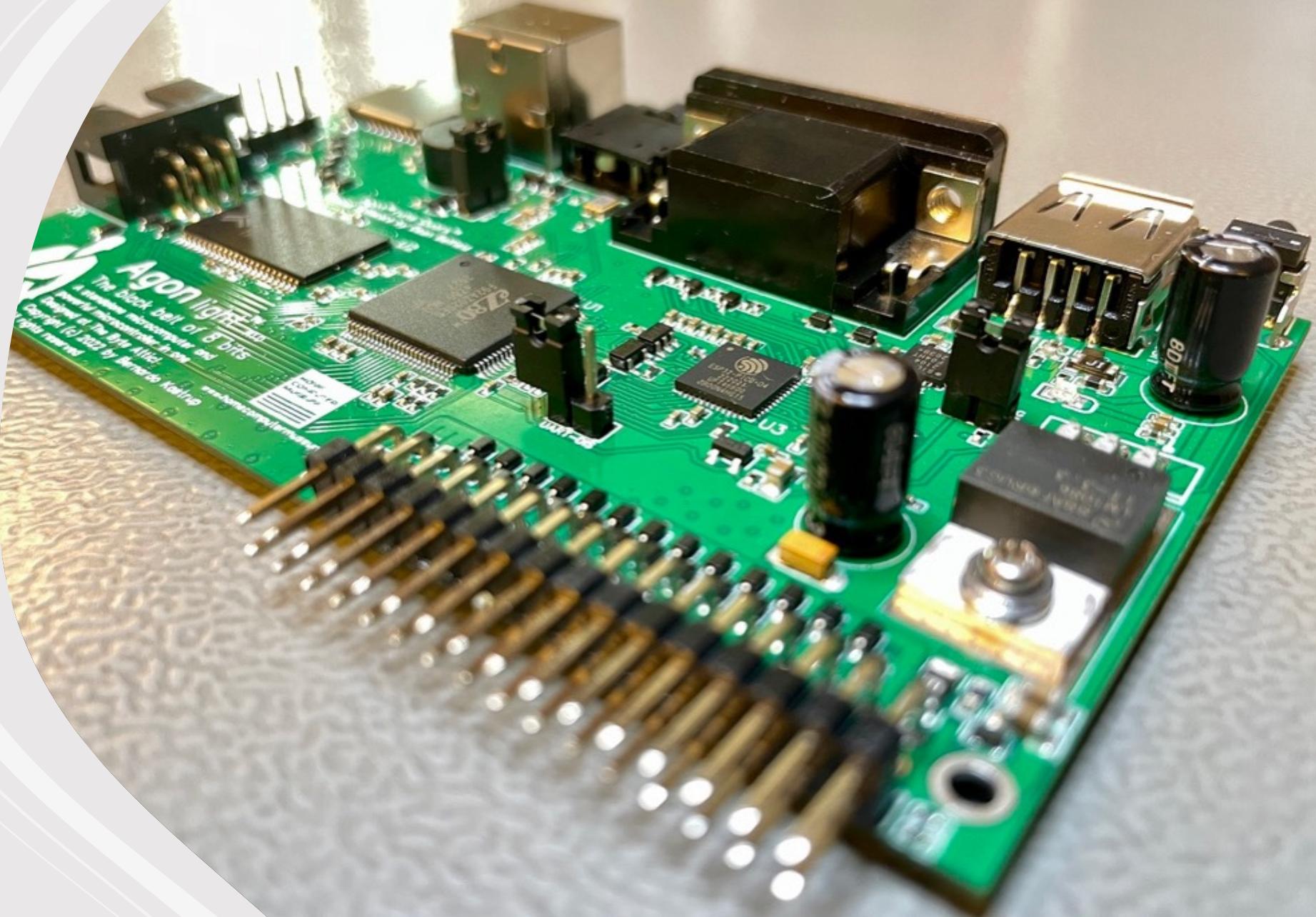




The Byte Attic's

# Agon light™

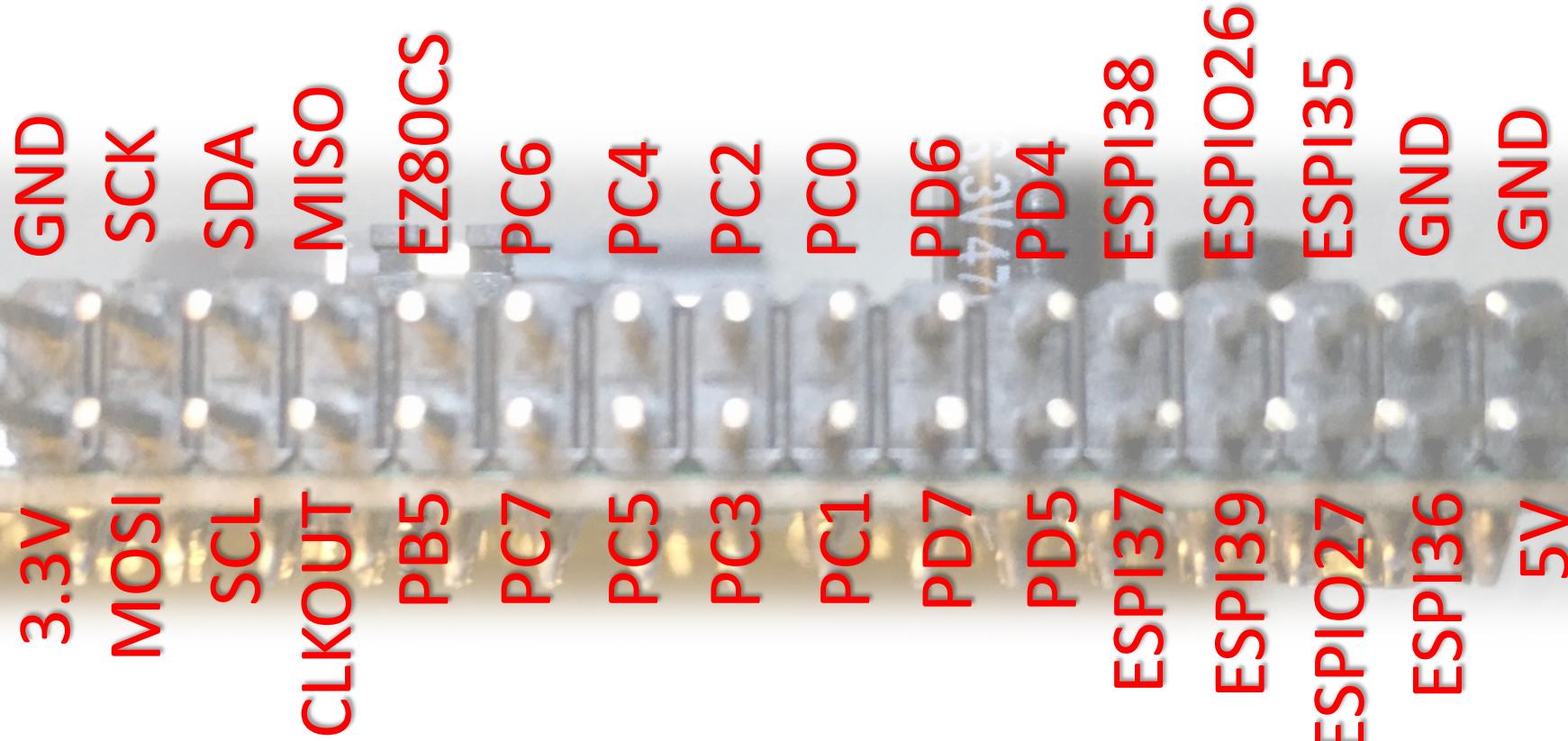
User's  
guide



# Control port signal descriptions

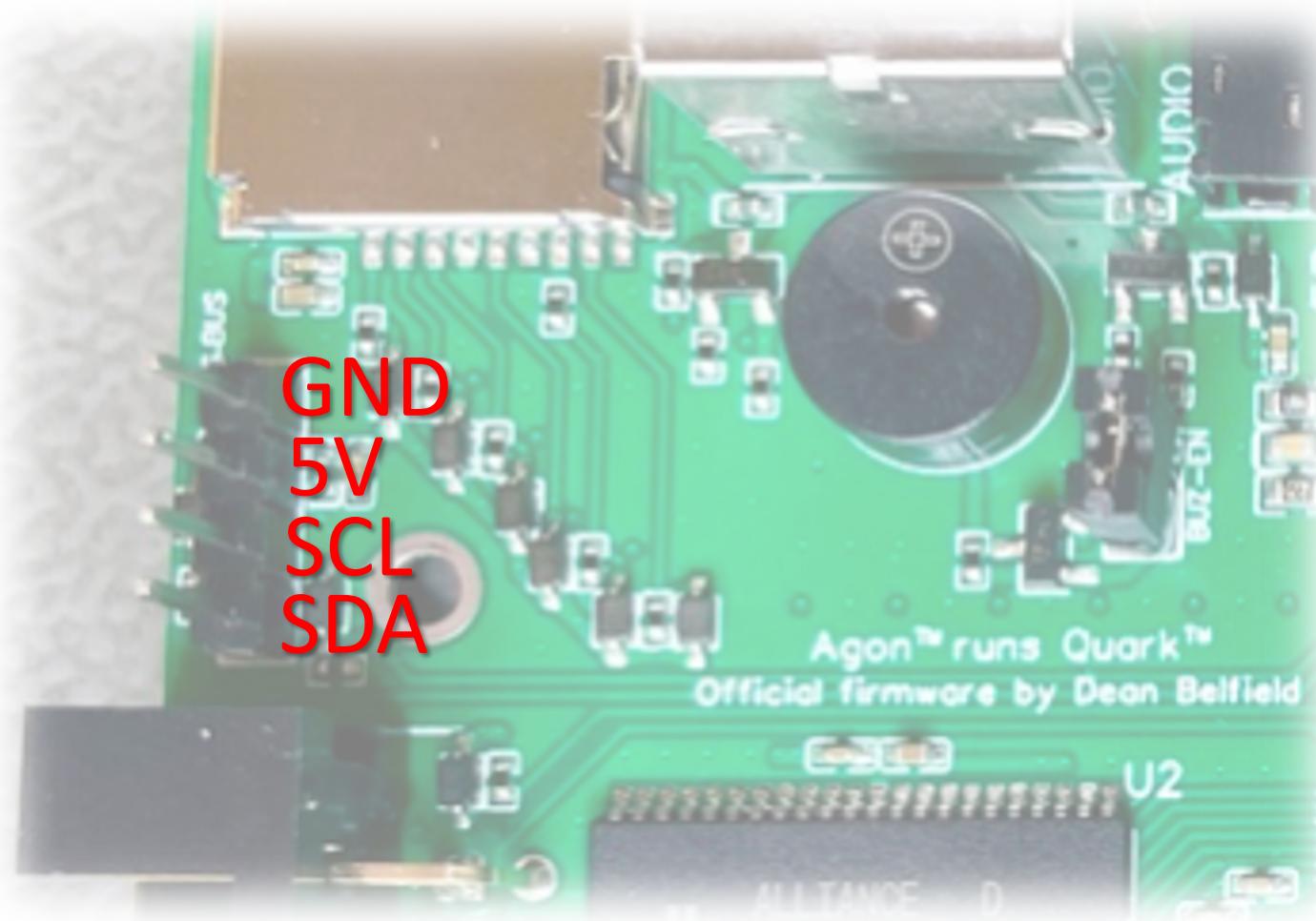
- **CLKOUT**: System clock (18.432MHz) buffered by the eZ80F92 CPU (PHI)
- ESP32-PICO-D4 *bidirectional* GPIOs:  
(see datasheet for clarifications)
  - **ESPIO26** (pin 15, IO26) and **ESPIO27** (pin 16, IO27), both pulled up by 22KΩ resistors
- ESP32-PICO-D4 GP *inputs*:  
(see datasheet for clarifications)
  - **ESPI39** (SENSOR\_VP), **ESPI38** (SENSOR\_CAPP), **ESPI37** (SENSOR\_CAPN), **ESPI36** (SENSOR\_VN), **ESPI35** (IO35)
- **MOSI** (pin 95, PB7), **SCK** (pin 91, PB3), **MISO** (pin 94, PB6), **EZ80CS** (pin 90, PB2/!SS): SPI signals of the eZ80F92
- **SDL**, **SCA**: I<sup>2</sup>C signals of the eZ80F92
- eZ80F92 *multi-functional, bidirectional* GPIOs:  
(see datasheet for clarifications)
  - **PB5/T5\_OUT**
  - **PC0/TxD1**, **PC1/RxD1**, **PC2/!RTS1**, **PC3/!CTS1**, **PC4/!DTR1**, **PC5/!DSR1**, **PC6/!DCD1**, **PC7/!RI1**
  - **PD4/!DTR0**, **PD5/!DSR0**, **PD6/!DCD0**, **PD7/!RI0**

# Control port pinout



See schematics and eZ80F92 and ESP32-PICO-D4  
datasheets for more comprehensive signal descriptions

# ACCESS.bus header pinout



# Pinout of serial link between CPU and ESP32

- On the *eZ80F92*'s side:
  - Pin 68 (**PD0/TXD0/IR\_TXD**) is the transmitter
  - Pin 69 (**PD1/RXD0/IR\_RXD**) is the receiver
  - Pin 70 (**PD2/!RTS0**) is RTS (signal '*eZ80RTS*' in the schematics)
  - Pin 71 (**PD3/!CTS0**) is CTS (signal '*eZ80CTS*' in the schematics)
- On the *ESP32-PICO-D4*'s side:
  - Pin 10 (**IO34**) is the receiver (connected to signal '*eZ80TxD*' in the schematics)
  - Pin 22 (**IO2**) is the transmitter (connected to signal '*eZ80RxD*' in the schematics)
  - Pin 17 (**IO14**) is CTS (connected to signal '*eZ80RTS*' in the schematics)
  - Pin 20 (**IO13**) is RTS (connected to signal '*eZ80CTS*' in the schematics)

# Recommended configuration of serial link between CPU and ESP32

---

*Channel:* full duplex, asynchronous

---

*Baud rate:* 384,000 bits per second

---

*Signal structure:* 1 start bit, 8 data bits, 1 stop bit,  
no parity bit (8N1)

---

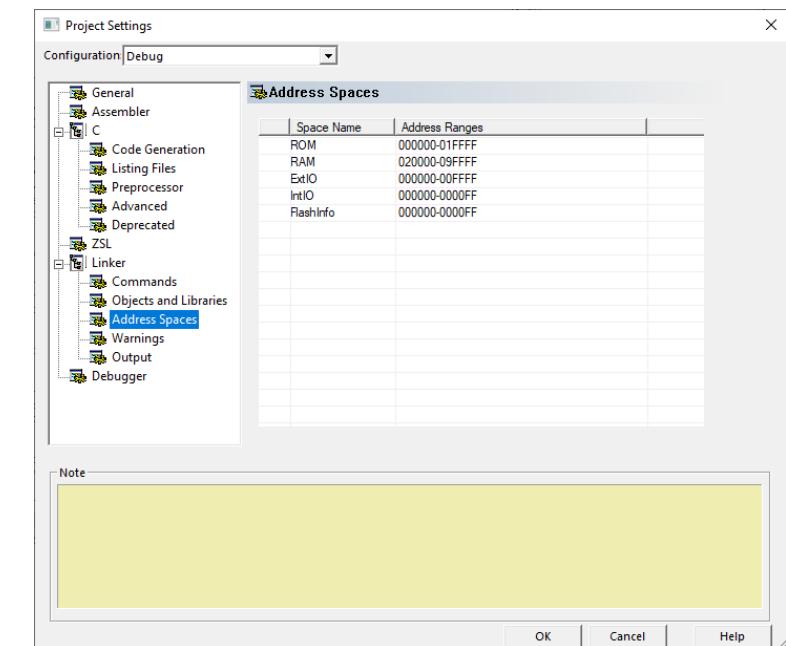
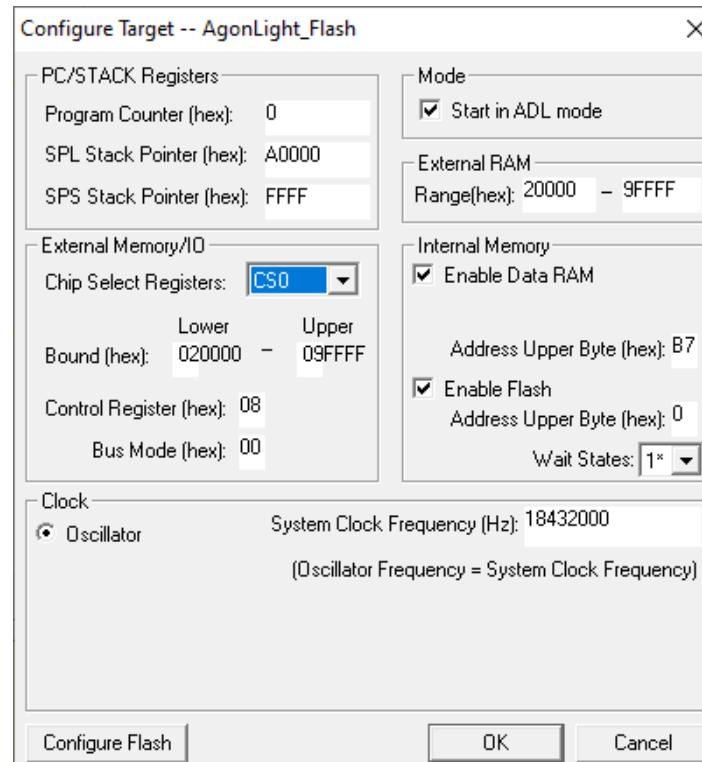
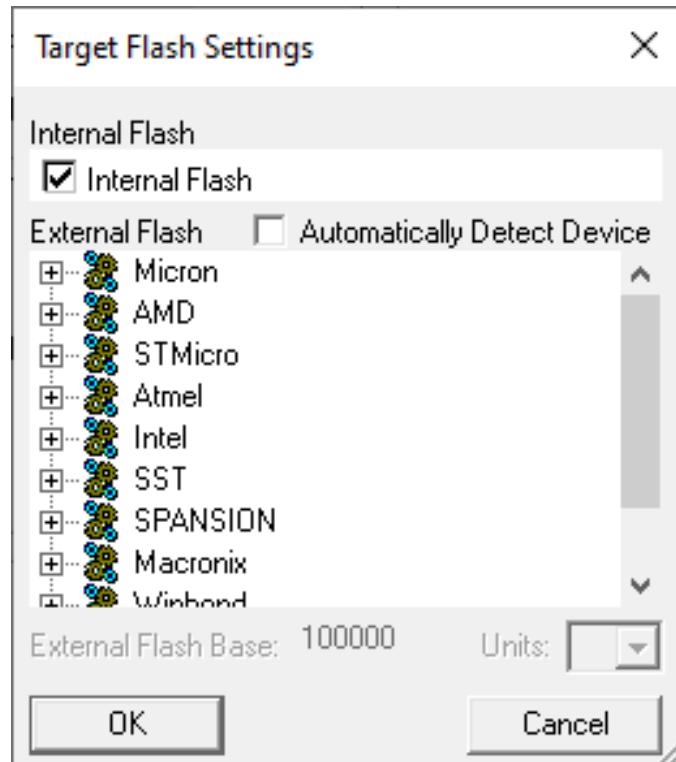
*Flow control:* CTS/RTS

---

Other possible baud rates are: 115200, 128000, 144000, 192000, 230400 and 288000 bps

# Developing firmware for the eZ80F92

- Use the freely-available Zilog ZDS-II™ IDE, downloadable from:  
[https://www.zilog.com/index.php?option=com\\_zcm&task=view&soft\\_id=38&Itemid=74](https://www.zilog.com/index.php?option=com_zcm&task=view&soft_id=38&Itemid=74)
- Documentation is provided in the Agon light Github repository, in the directory /Third party documentation
- Configure your project as per the figures below (CS1, CS2 and CS3 are *not* used in Agon light, so their settings don't matter)



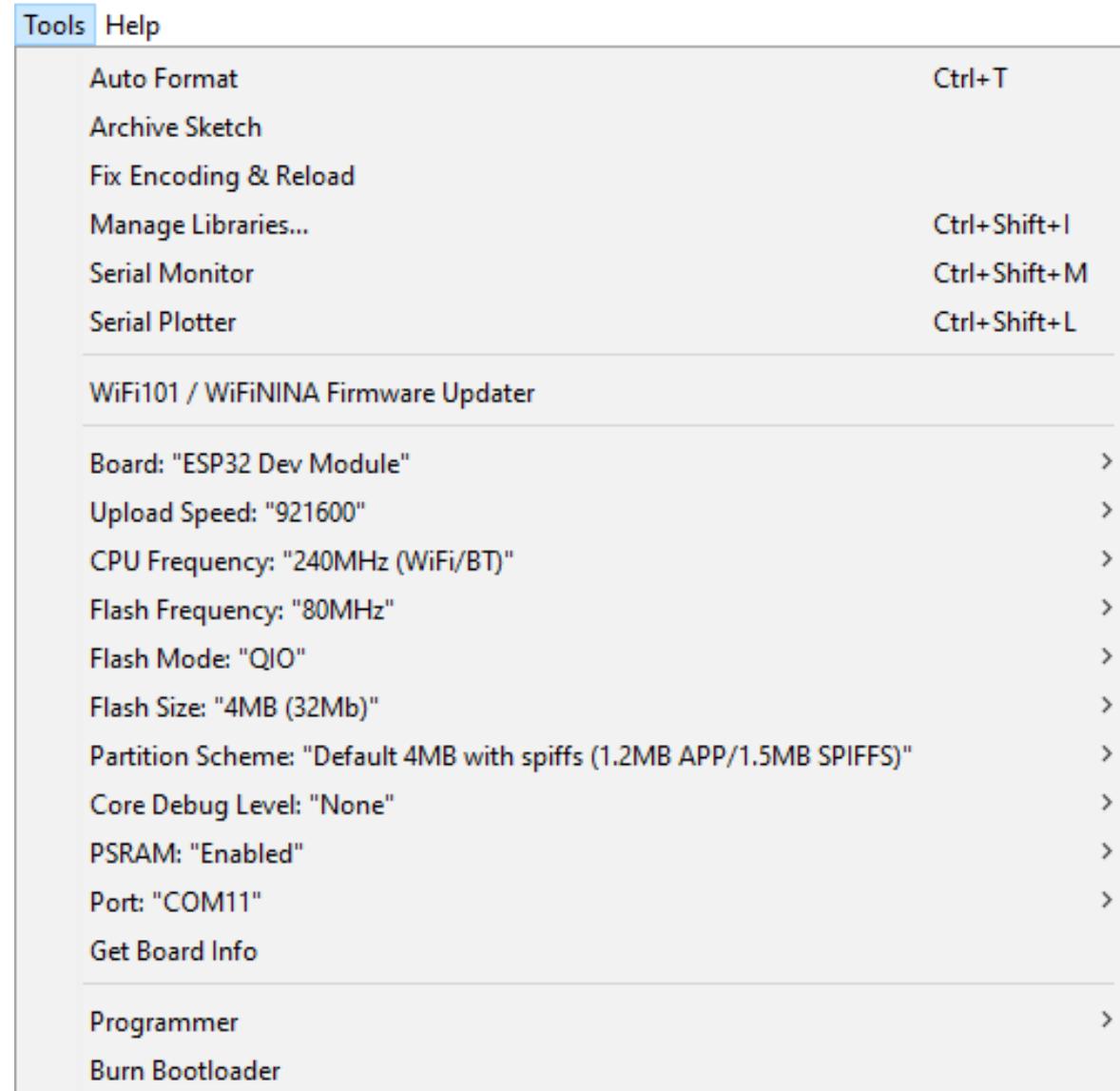
# Required programming/debugging USB smart capable

- To upload firmware into the eZ80F92 CPU, from within the ZDS-II IDE, you will need a Zilog opto-isolated *USB Smart Cable*, shown in the photos
- Zilog product number:  
ZUSBSC00100ZACG (little stock), or  
ZUSBESC0200ZACG (more stock)
- There seems to be homebrew alternatives to this cable with plans available online, but I have not tested any of them



# Developing firmware for the ESP32-PICO-D4

- Use the freely-available Arduino™ IDE
- Install the FabGL™ library as per instructions available online
  - Link to the FabGL library: <http://www.fabgl.org/index.html>
  - Link to installation tutorial: <https://youtu.be/8OTaPQISTas>
- The figure to the right illustrates a suitable configuration for loading an Arduino sketch into the ESP32
  - Change the port number to the one active in your case



# Power supply and signal level considerations

- Agon light can be powered (5V) *either* from its USB port *or* from the 5V pin in its control port
- If Agon light is powered from the USB port, then the 5V pin in the control port can be used to power an external circuit connected to Agon light
- Similarly, the 3.3V pin in the control port can be used to power an external circuit, *but it cannot be used to power Agon light*
- The on-board LDO regulator can provide up to 1.5A of current at 3.3V
  - This is the maximum *total* current for Agon light's internal use *and* devices powered from the 3.3V pin in the control port
  - It assumes that the USB device powering Agon light can deliver 1.5A; otherwise, that device becomes the bottleneck
- All GPIO/I<sup>2</sup>C/SPI logic signals on the control and ACCESS.bus ports are referenced to 3.3V and, therefore, are *not* TTL-level
  - You must use (two-way) level-shifters if you plan to integrate those signals with external circuitry running at 5V-level
- The GPIO/I<sup>2</sup>C/SPI logic signals on the control and ACCESS.bus ports are NOT buffered
  - Those signals have the current and fanout limitations described in the eZ80F92 and ESP32-PICO-D4 datasheets
  - It is recommended that you buffer those signals before driving external circuits with them, particularly for larger fanouts
  - If you use an unbuffered signal to drive an external LED, a 1KΩ current-limiting resistor, in series with the LED, is (highly) recommended

# Power through USB

- For powering Agon light™ alone, a USB 2.0 cable with *USB A connectors on both ends* will suffice (it will deliver up to 500mA at 5V)
- For powering Agon light™ *and* another circuit attached to Agon light's control port, a USB 3.0 cable with *USB A connectors on both ends* is recommended (it will deliver close to 1A at 5V)

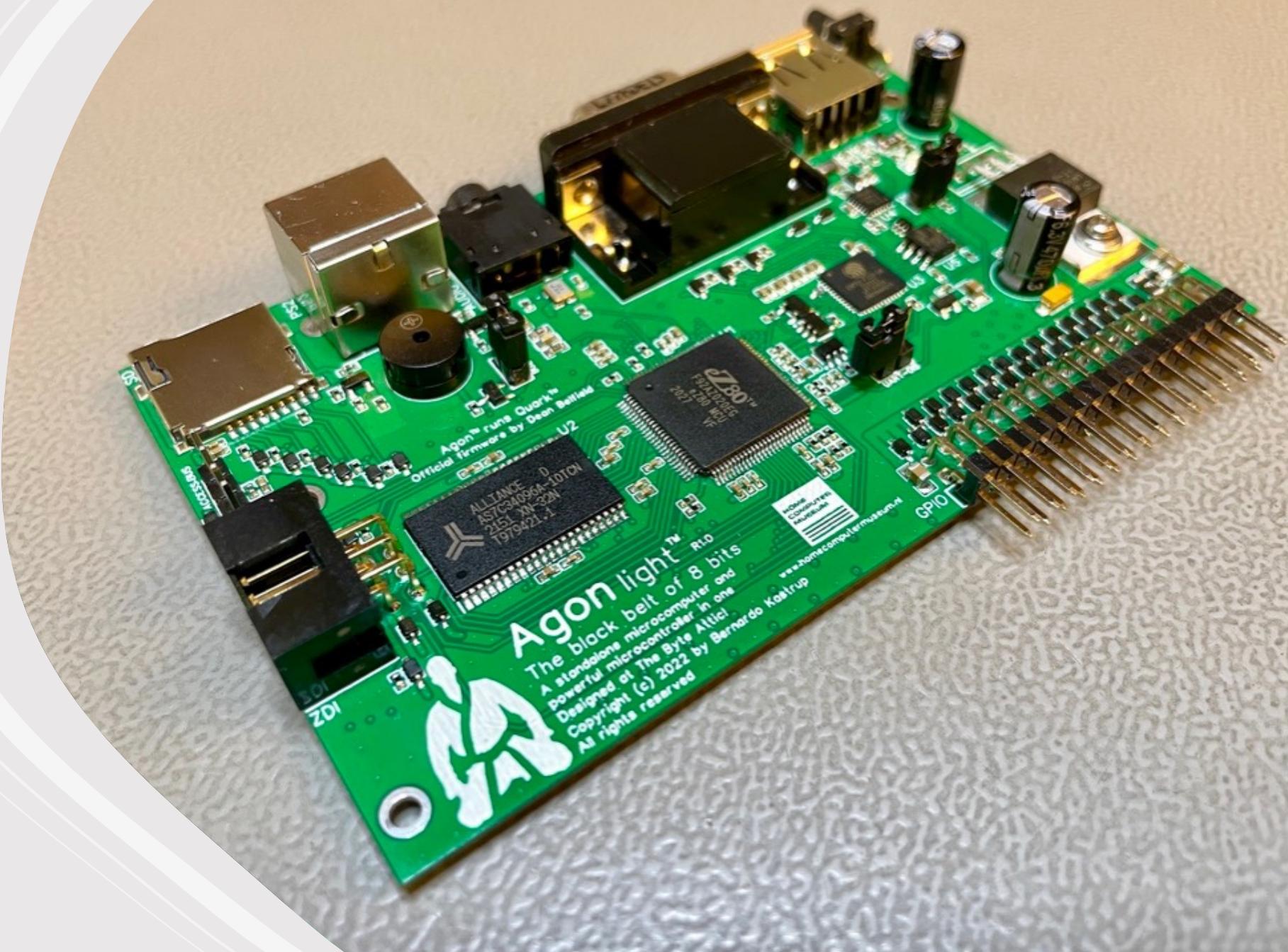




The Byte Attic's

# Agon light™

Assembly  
guide

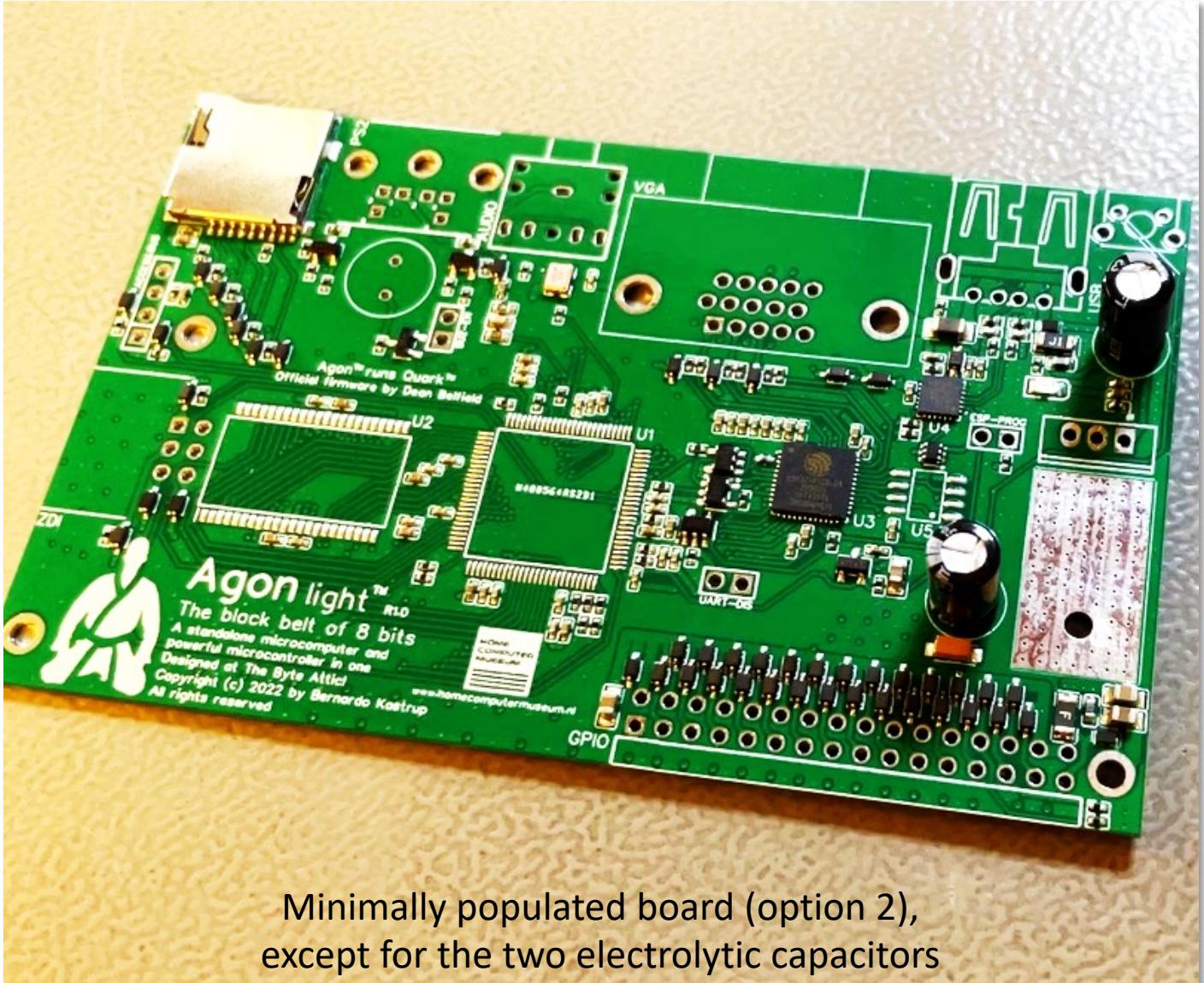


# Assembly options

- There are four options:
  1. You buy the bare PCB and fully populate it yourself (requires a stencil and reflow oven)
  2. You buy a PCB minimally populated with the small parts and the two QFN ICs (U3 and U4), which are hard to solder by hand
  3. You buy a PCB with all SMD parts already populated from factory, only the through-hole parts still needing to be soldered
  4. You buy a fully-populated board, so you need not do any soldering yourself
- Options (1), (3) and (4) will not be discussed further: if you choose option (1) you know what you are doing, option (3) is easy enough, and option (4) requires nothing of you
- Option (2) requires though-hole and fine-pitch QFP drag-soldering. Here are the instructions for doing it properly:  
<https://youtu.be/k9TF2ZCngoE>
- Reasons for choosing option (2): PCB makers charge a premium (usually 50% of the parts' costs) for procuring parts for you, and there are multiple import fees involved. It's cheaper (and better, if you know how to do it) to buy and populate the most expensive parts (U1, U2 and U5) yourself, especially if you are building Agon light to sell it commercially

# Manufacturing files

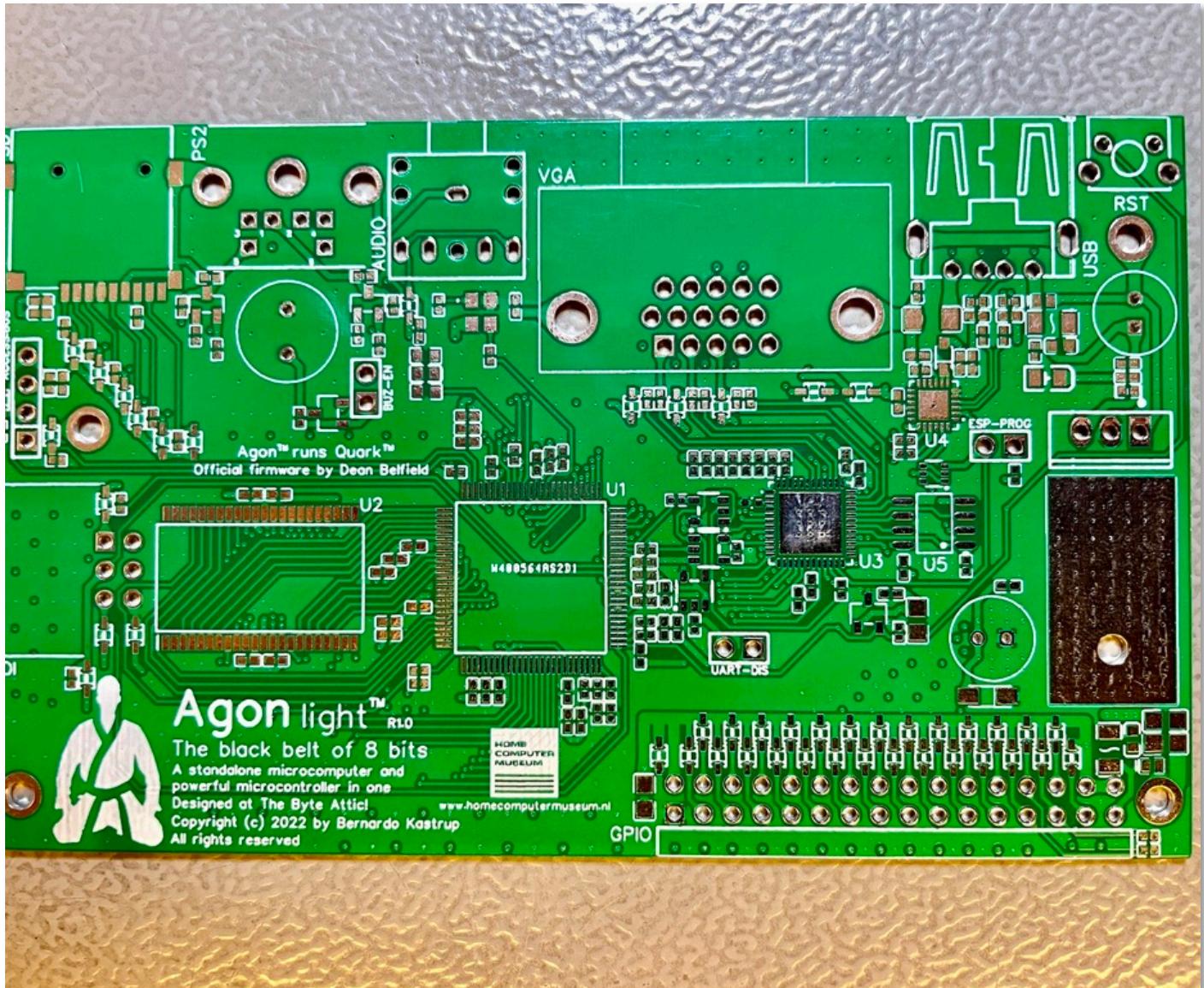
- All files are available in the /Manufacturing directory of Agon light's Github repository at:  
<https://github.com/TheByteAttic/AgonLight>
- For option (4), send the following files to your PCB manufacturer, next to the Gerber file (`Gerber_PCB_AgonLight_R1.0.zip`):
  - `PickAndPlace_PCB_AgonLight_R1.0.csv`
  - `BOM_PCB_AgonLight_R1.0.csv`
- For option (3), send these files:
  - `PickAndPlace_PCB_AgonLight_R1.0_NoTHT.csv`
  - `BOM_PCB_AgonLight_R1.0_NoTHT.csv`
- For option (2), send these:
  - `PickAndPlace_PCB_AgonLight_R1.0_MINIMAL.csv`
  - `BOM_PCB_AgonLight_R1.0_MINIMAL.csv`



Minimally populated board (option 2), except for the two electrolytic capacitors

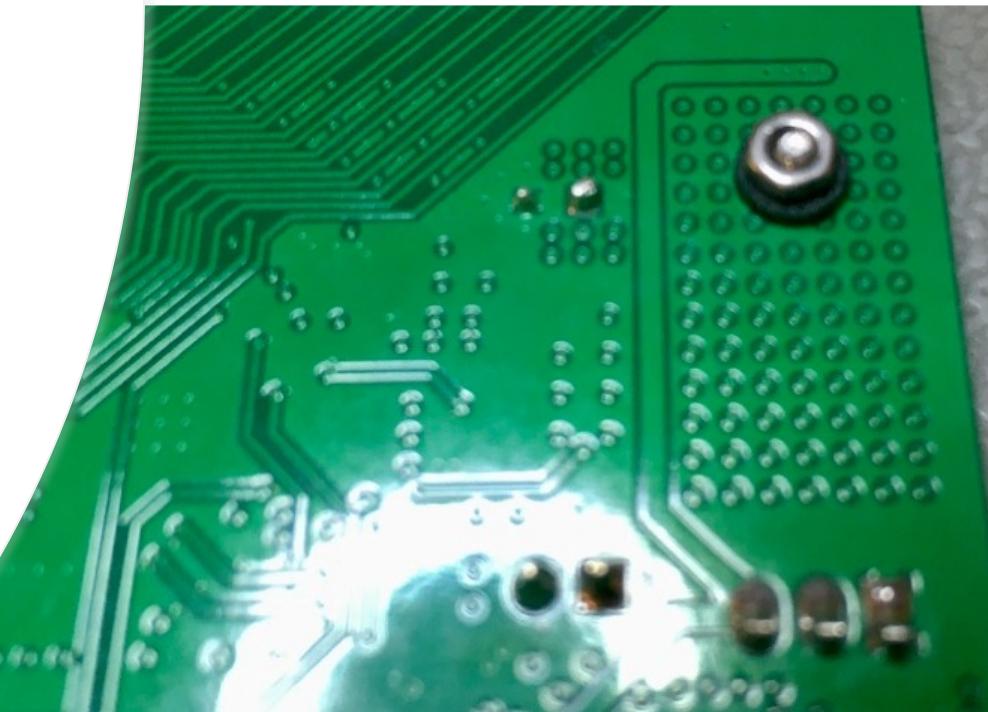
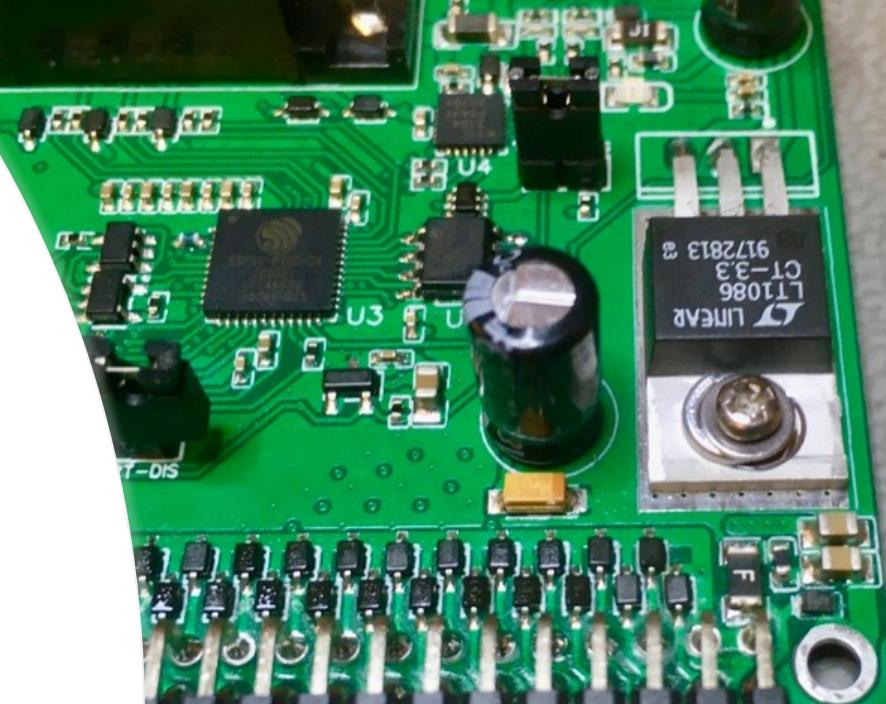
# PCB layer stack

- Agon light's PCB has four layers:
  - Two signal layers (top and bottom)
  - Two inner planes (GND and 3.3V)
- The stack is as follows:
  - *TopLayer* (signals + 3.3V copper fill)
  - *Inner1* (GND plane)
  - *Inner2* (3.3V plane)
  - *BottomLayer* (signals + GND copper fill)
- Agon light has tiny VIAs: **0.4mm** diameter with **0.205mm** drill holes, so choose a compatible process with your manufacturer
- Total PCB thickness of **0.8mm** is recommended, so to improve signal integrity

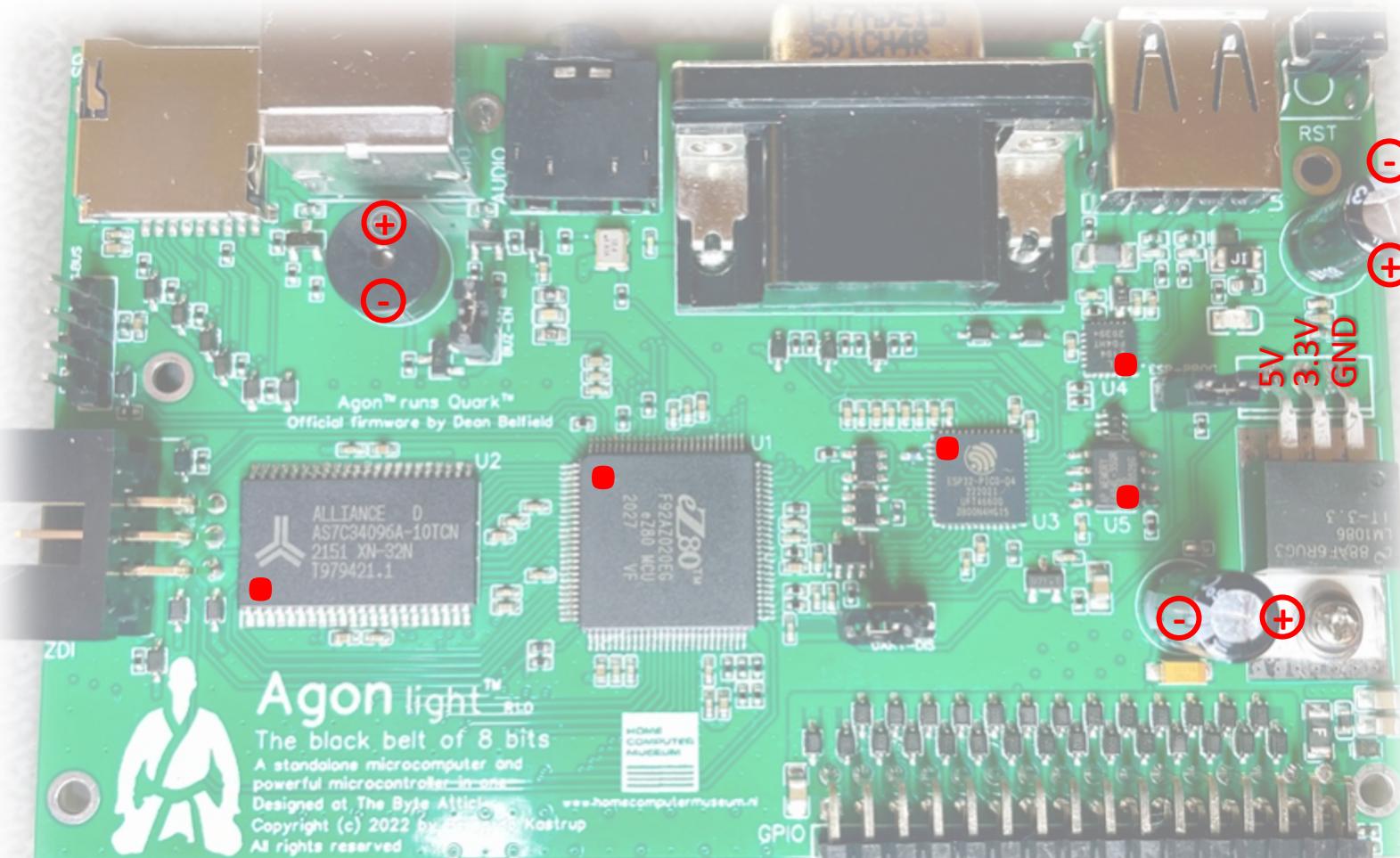


# Mounting the LDO regulator

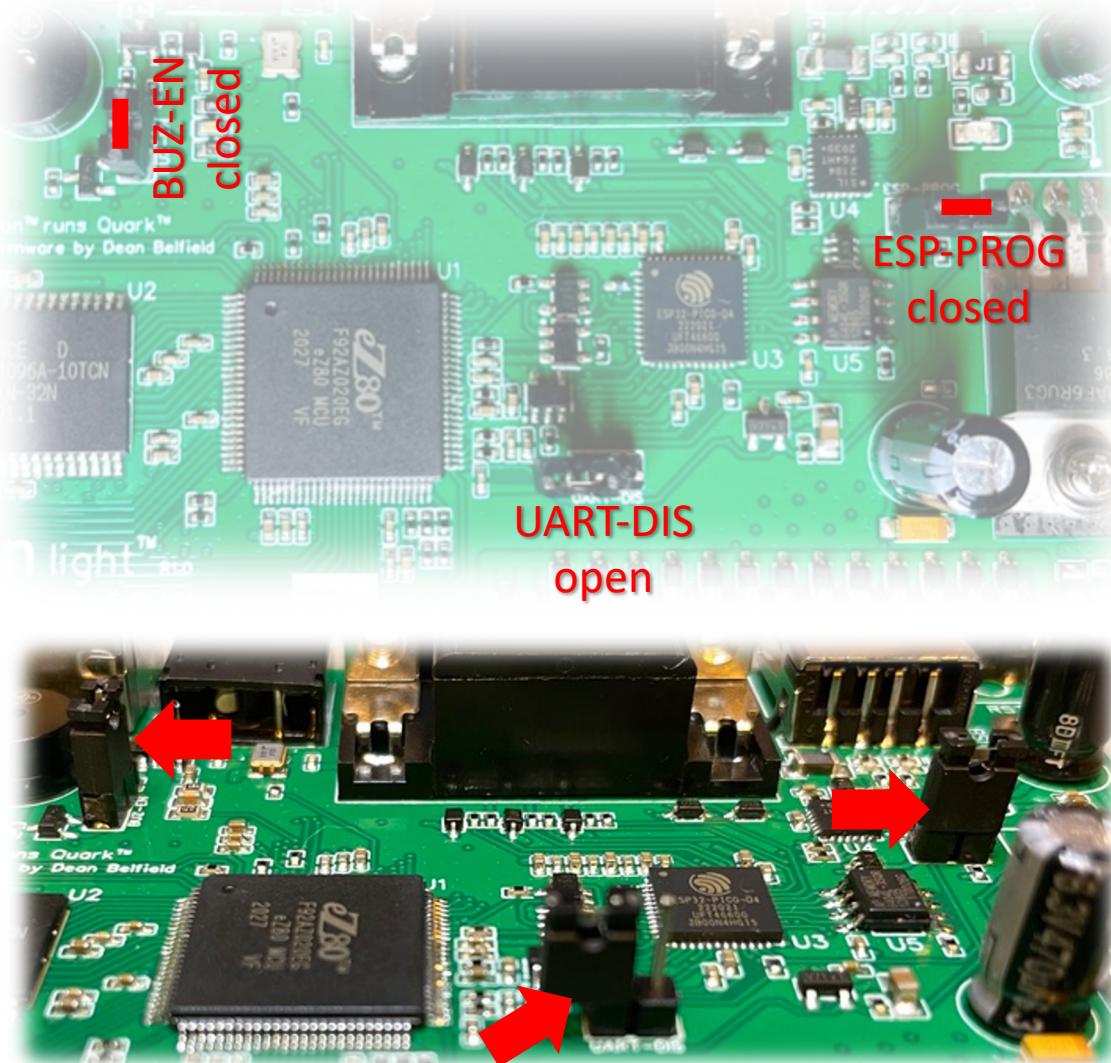
- Agon light's 3.3V  $V_{cc}$  rail is provided by a Low-DropOut (LDO) linear regulator
- The regulator must be mounted flush against the corresponding exposed metal area on the top of the PCB (see top-right photo)
- The regulator's tab (chassis) is at 3.3V, as is the exposed copper area on which it is to be mounted
- Use *no thermal paste or insulating spacers*; simply clean the tab and the exposed metal area with IPA before mounting
- Affix the regulator with a 2mm-diameter bolt, a regular and a lock washer on the top, and a nylon (or other dielectric material) washer and nut at the back (see bottom-right photo)
- The nylon washer is important to insulate the back of the board (which is copper-filled with GND) from the bolt-nut combination, which will be at 3.3V
  - Using a metal washer on the back side increases the risk of a short-circuit if the solder mask fails



# Part orientations



# Default settings for the jumpers

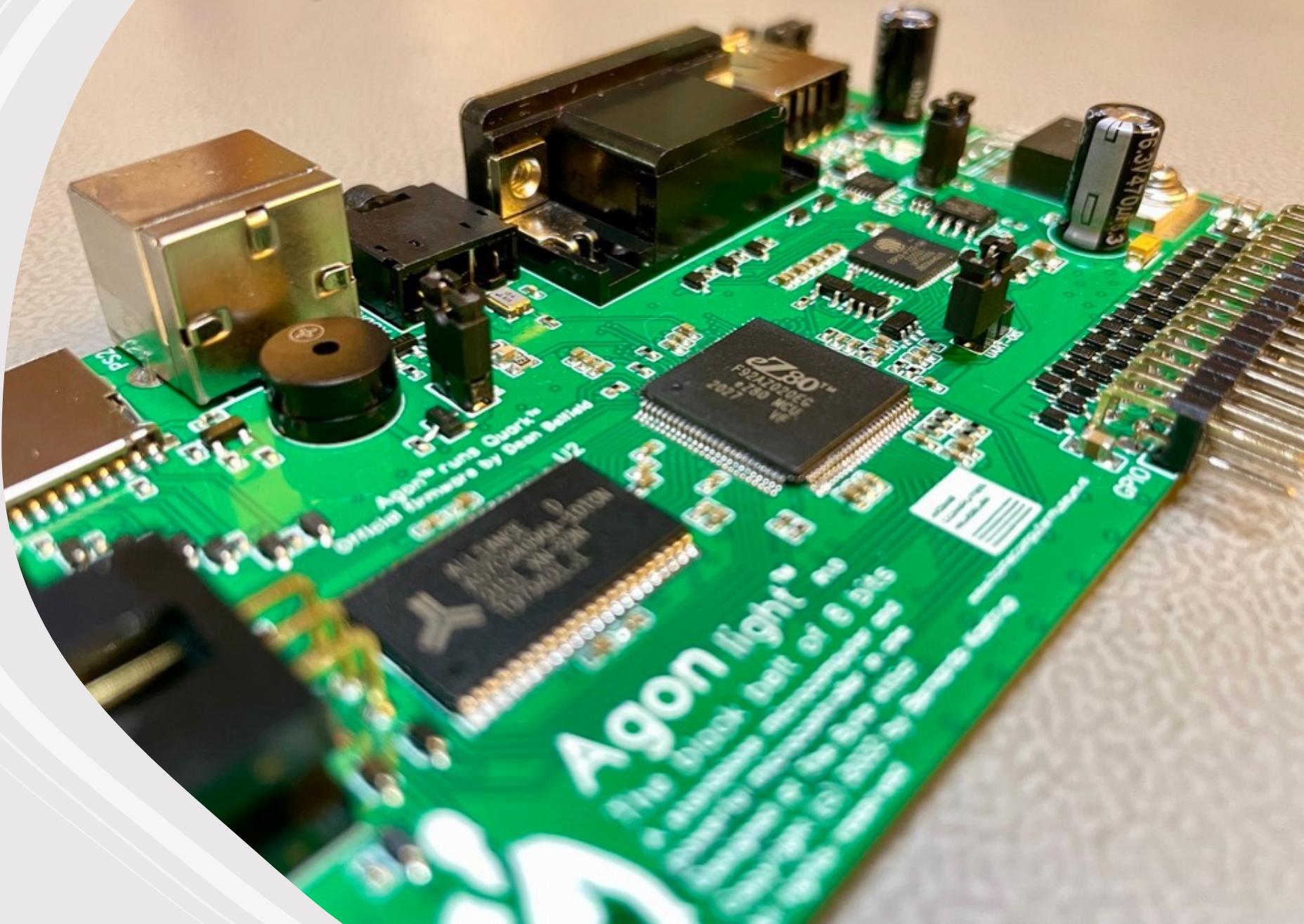


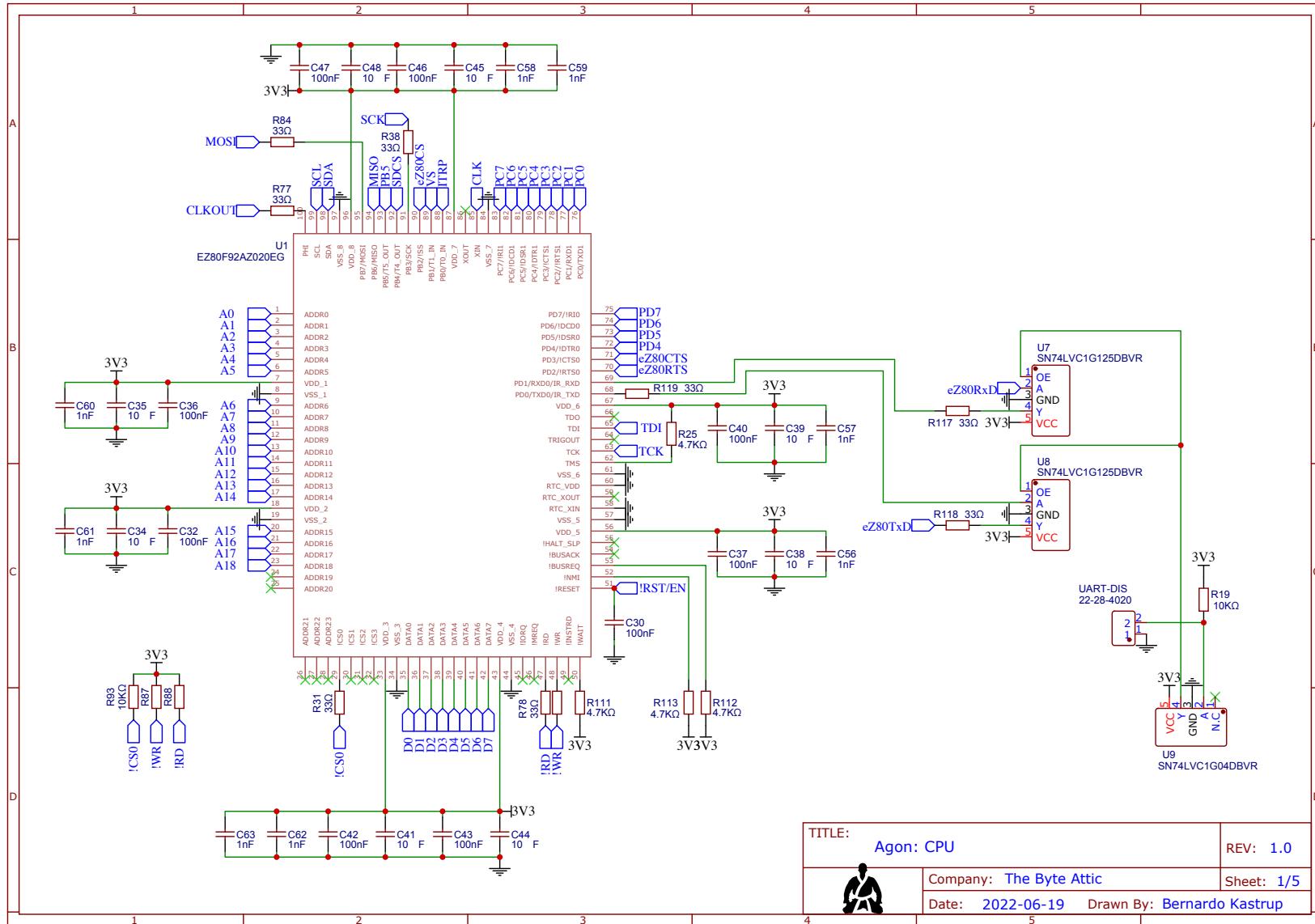
# When to change jumper settings

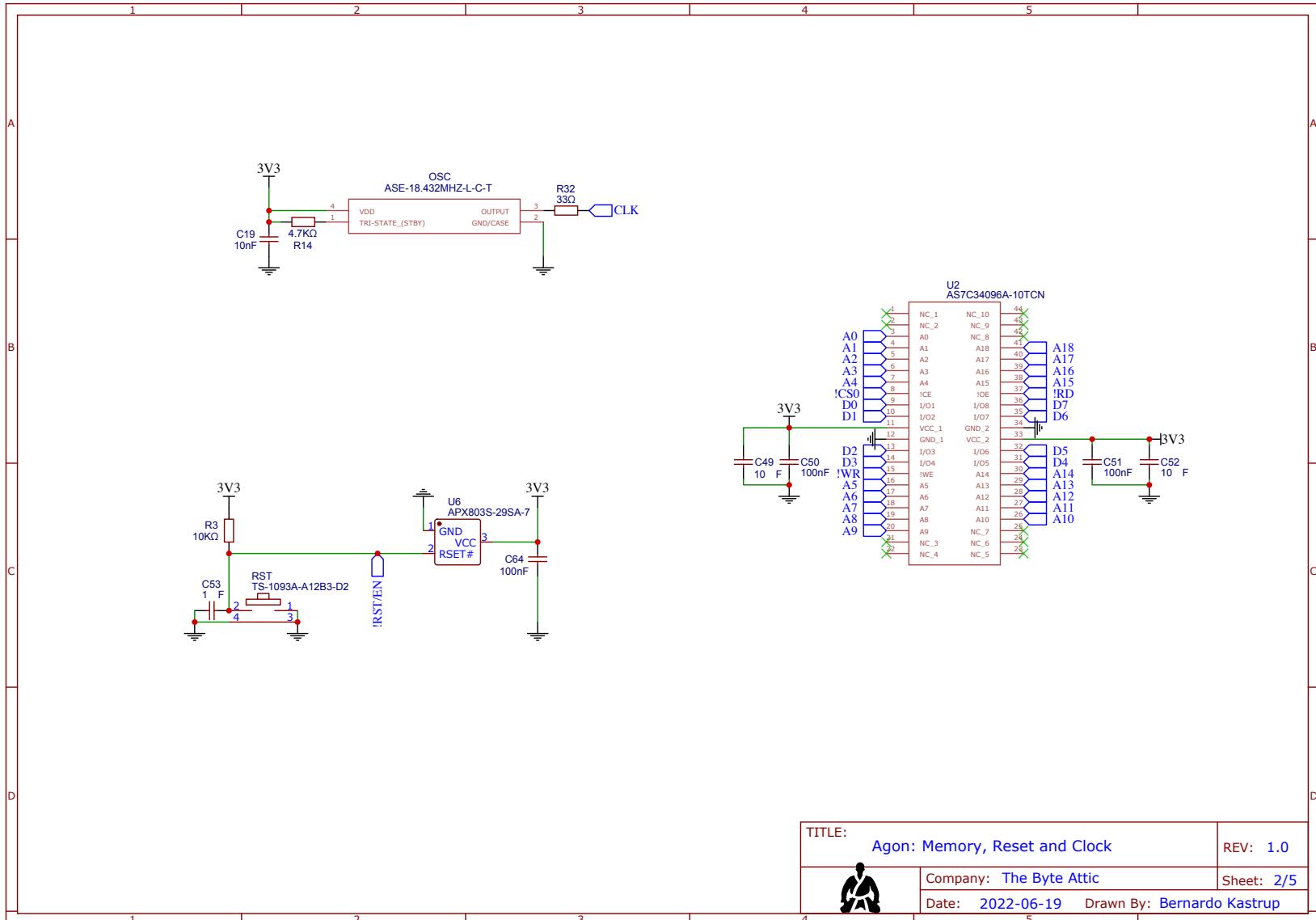
- Agon light should operate normally during both firmware programming and application execution with the default jumper settings (see previous page), but the ESP32 is known to be a sensitive device
  - Therefore, Agon light has built-in resources to deal with that sensitivity
- If the ESP32 goes into programming mode during execution, remove the jumper ‘ESP-PROG’ after programming (remember to place it back before reprogramming the ESP32)
- If you fail to program the ESP32, place the jumper ‘UART-DIS’ during programming (remember to remove it after programming, or Agon light will not operate properly)
- The buzzer produces sounds if speakers are not connected. If those sounds bother you, you can disable the buzzer by removing the jumper ‘BUZ-EN’

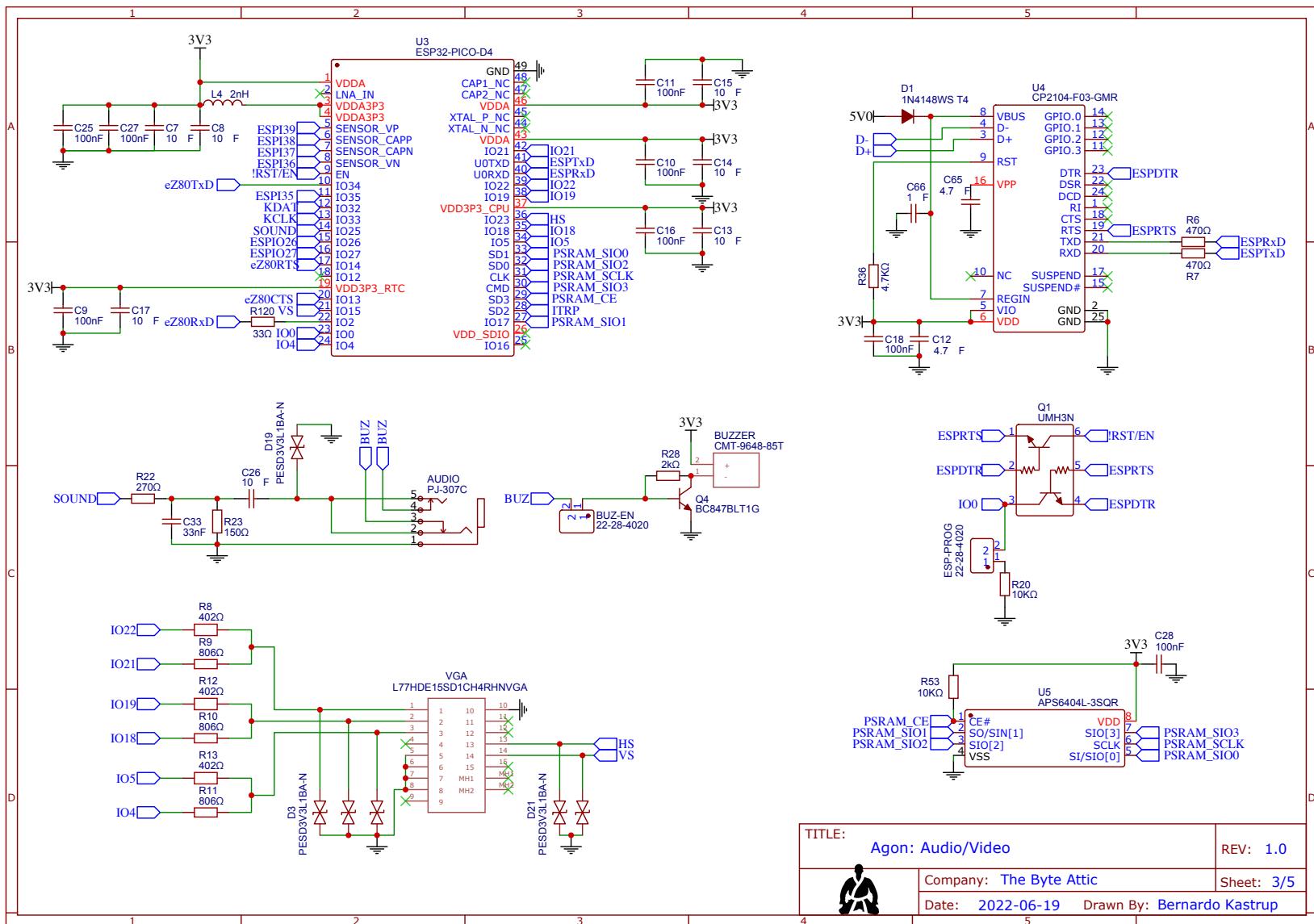


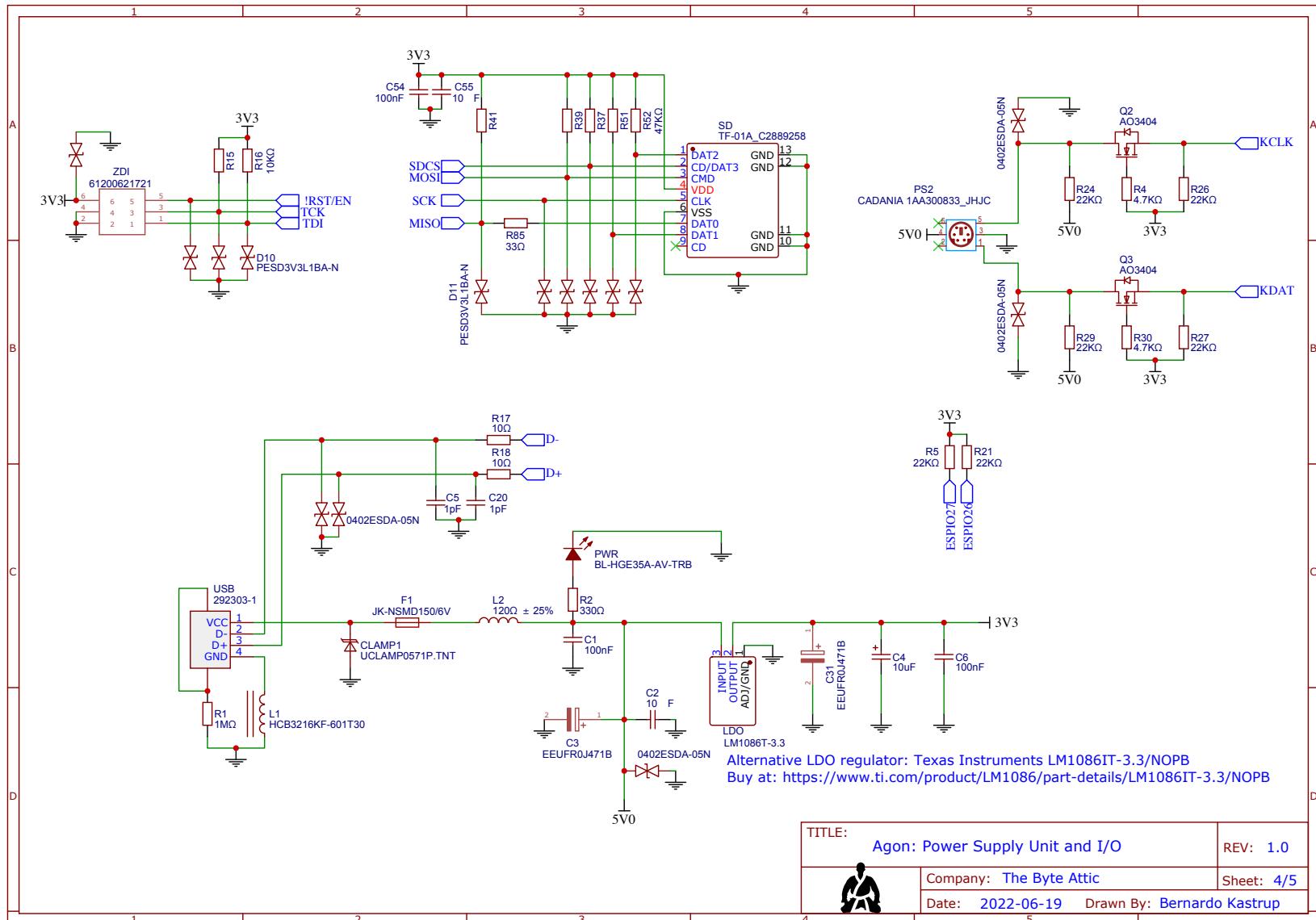
The Byte Attic's  
**Agon**  
light™  
Schematics

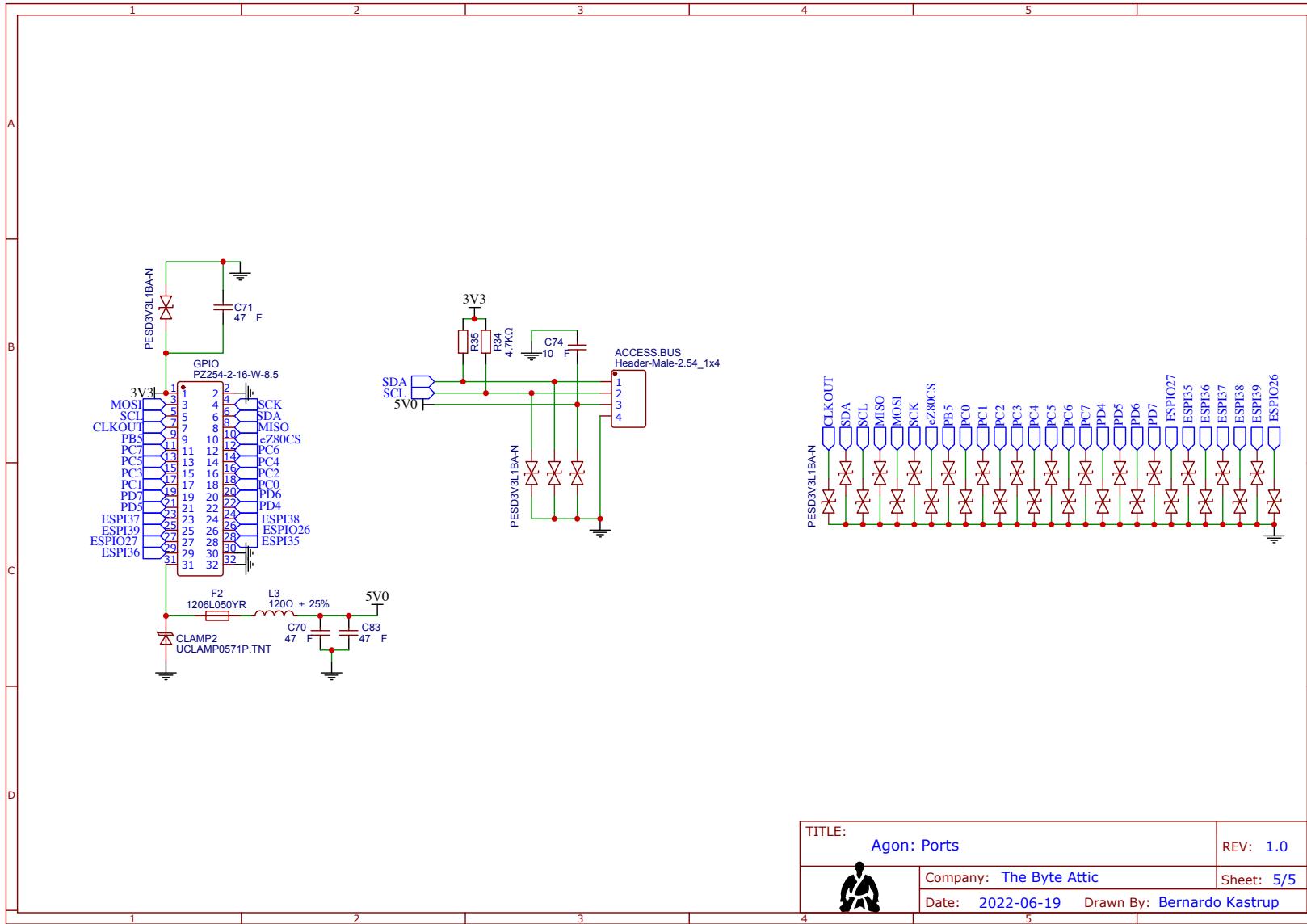










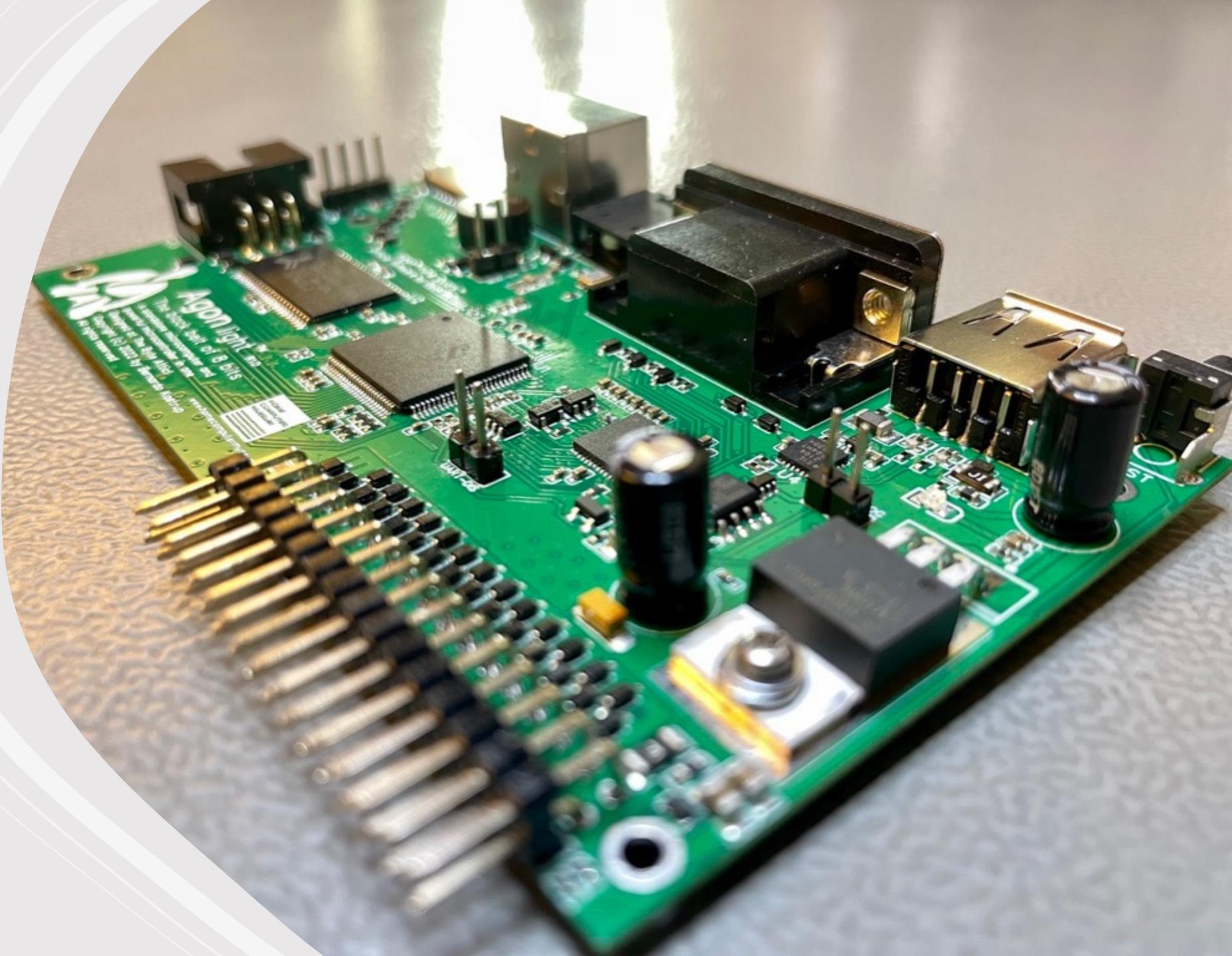




The Byte Attic's

# Agon light™

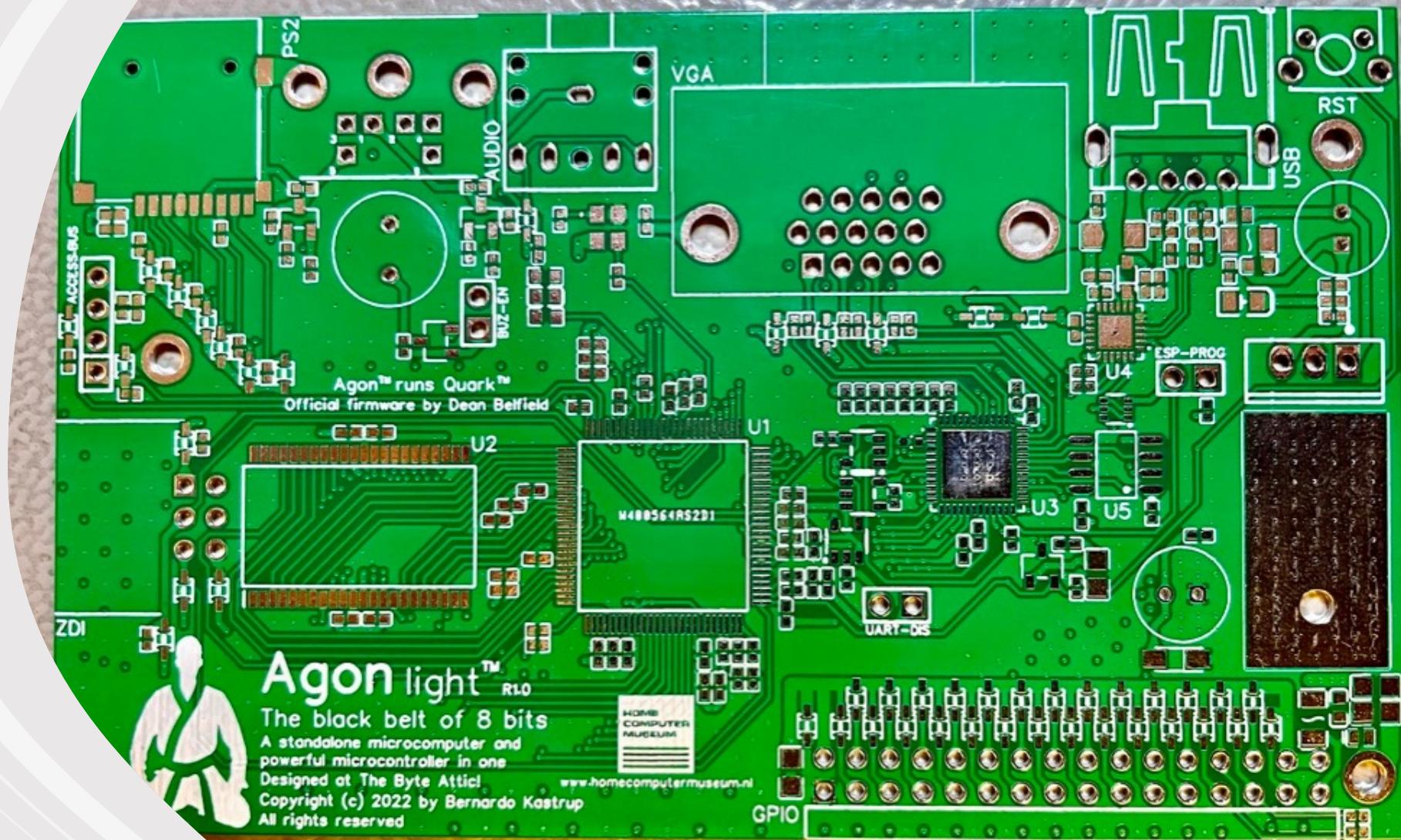
Bill of  
Materials



ID	Name	Designator	Descriptor	Footprint	Quantity	Manufacturer Part	Manufacturer	Supplier	Supplier Part	Price
1	BCK4911L1G	R49		SOT-23-3	1	BUCK4911L1G	ON	On Semiconductor	C4933	0.035
2	2.4Q	R28		R0402	1	0402WIGB201TCE	Unifim	LSCC	C4109	0.001
3	ASE-18.432MMR2-LC-T	OSC		ASE1843MMR2-LC-T	1	ASE-18.432MMR2-LC-T	ABRACON	Mouser	815-ASE18.432MMR2-LC-T	0.384
4	P224-2.16-W.8.5	U2		SOP-20	1	AS73409BA-10TCN	Alliance Memory	913-AS73409BA-10TCN		
5	Henderson-15A_1.5A	GPIO		HDR-TH-3D-P2.54-H-MA-12-C15-S2.5-54	1	P224-2.16-W.5.5	HELI(华利天福)	LCSC	C289496	0.049
6	Henderson-15A_1.5A	ACCESS BUS		HDR-TH-4P-2.54-V2.5-5V	1	4P-1.5A-MOD-chip	Gentix	C24378		
7	P-30TC	AUDIO		AUDIO-TH-PA30TC	1	P-30TC	BOOMLE	LCSC	C16584	0.049
8	22.28-4020	BUZ-EN-ESP-FRIG-QART-DIS		HDR-TH-2P-4024-54-V-M-1	3	22.28-4020	MOLEX	LCSC	C234182	0.076
9	CMT-9648-85T			CMT964885ST	1					
10	100MF				23	CDSB10405NNNC	SAMSUNG	LCSC	C1525	0.001
11	10uF			C3.65-C9-C10-C11-C16-C19-C25-C27	20	CDSB10405NNUNC	SAMSUNG	LCSC	C1525	0.005
12	1uF			C8.20-C30-C56-C37-C40-C42-C43-C	2	CDSB10405NNUC	SAMSUNG	LCSC	C1520	0.001
13	4.7uF			C4.70-C50-C51-C54-C64	2	CDSB10405NNC	SAMSUNG	LCSC	C1373	0.006
14	10uF			C5.6-C57-C58-C59-C60-C61-C62-C63	1	CDSB10405NNNC	SAMSUNG	LCSC	C15195	0.001
15	1uF			C0402	8	C0402B10250NC	FH	LCSC	C1523	0.001
16	1uF			C0402	1	C05A05020NNNC	SAMSUNG	LCSC	C29566	0.003
17	EU-PRO471B			CAP-TH-0250W-5065H-01270	2	EU-PRO471B	Panasonic	LCSC	667-EU-PRO471B	
18	10uF			CAP-TH-0250W-5065H-01270	1	TAAJ060G05BN	AVX	LCSC	C1711	0.098
19	33nF			C0402	1	C10B33BPNNNNC	SAMSUNG	LCSC	C1117	0.006
20	3uF			C0405	1	C10B34BPNNNNC	SAMSUNG	LCSC	C82323	0.009
21	47uF			C0805	3	C11A47BPNNNNC	SAMSUNG	LCSC	C16780	0.143
22	UCLAMP057P-TNT	CLAMP1		SGP16IN01-2_L1-W1-P1-B1-RD	2	UCLAMP057P-TNT	SEMTECH	LCSC	C51287	0.403
23	11A48WN5 T4	D1		SOD-323_L18-W13-L5.5-RD	1	11A48WN5 T4	SEMTECH	LCSC	C2128	0.013
24	PEDSV3181A-N			D2.0-D-045.05.06.07.09.05.01.01.01	2	PEDSV3181A-N	Burme Semicon (Shenzhen)	LCSC	C316020	0.051
25	ES03	D8		D2.0-D-045.05.06.07.09.05.01.01.01	2	PEDSV3181A-N	Burme Semicon (Shenzhen)	LCSC	C316020	0.051
26	0402ESDA-05N	D88-ESDA-ED-PROT1-ED-PROT2-ED-PROT3		D0402-BI	5	0402ESDA-05N	Burme Semicon (Shenzhen)	LCSC	C316049	0.019
27	JK-NSMD150/UV	F1		F1206	1	JK-NSMD150/UV	JK(金科)	LCSC	C2830249	0.036
28	1.206LS05YR	F2		F1206	1	1.206LS05YR	Littelfuse	LCSC	C16512	0.028
29	HCB2126F-601T30	L1		L1206	1	HCB2126F-601T30	TAITIC	LCSC	C57023	0.028
30	3A1200-22%	L1.3		L1206	2	BLUM18KG121TNT1D	Murata	LCSC	C85831	0.017
31	31-2H	L4		L1206	1	ASUS-0002-2001-T	Abracon LLC	LCSC	C186815	0.224
32	LM1086T-3.3	U0		TO-220-3_L10-WA5-P2.54L	1	LM1086T-3.3	HGSemi	LCSC	C44481	0.241
33	CADANIA-1A-308383-1HC	P52		TO-220-3_L10-WA5-P2.54L	1	LM1086T-3.3	C. Distrolec, I	LCSC	C25744	0.001
34	BL-HG153A-AV/TRB	PWR		LED0803-8-R	1	BL-HG153A-AV/TRB	Bright LED Elec	LCSC	C165984	0.047
35	U03404	Q1		SC-70-6.12-1.25-1.35-10.05-12.5-1-BR	1	U03404	CJ	LCSC	C192925	0.049
36	A10M	R1		SOT-23-3_L2.9-W1.35-P1.50-L1.52-4-BR	1	SOT-23-3_L2.9-W1.35-P1.50-L1.52-4-BR	Guangdong Hotteck	LCSC	C26583	0.001
37	3.90u	R2		R0402	1	0402WIG104TCE	Unifim	LCSC	C1504	0.001
38	3.90u	R2		R0402	1	0402WIG3300TCE	Unifim	LCSC	C1504	0.001
39	10uF	R93		R0402	9	0402WIG1002TCE	Unifim	LCSC	C25744	0.001
40	4.7uF	R4.814-025-S8034-835-R3.6-1111		R0402	10	0402WIG491TCE	Unifim	LCSC	C25900	0.001
41	22kO	R5.42JL24R565427,R29		R0402	6	0402WIG2202TCE	Unifim	LCSC	C25188	0.001
42	47uF	R8.12,R13		R0402	2	0402WIG4702TCE	Unifim	LCSC	C25107	0.001
43	4020	R8.12,R11		R0402	3	PFR0402S4028IN9	RESi(瑞步睿思)	LCSC	C26927	0.079
44	8060	R17,R18		R0402	2	TO-225B8060TCE	Unifim	LCSC	C50111	0.079
45	100	R17,R18		R0402	2	TO40WIG100TCE	Unifim	LCSC	C25077	0.001
46	330	R31.132,R38,R77,R78,R79,R84,R85		R0402	12	0402WIG330TCE	Unifim	LCSC	C25105	0.001
47	47uF	R37,R39,R41,R51,R52		R0402	5	0402WIG4702TCE	Unifim	LCSC	C25792	0.001
48	2700	R22		R0402	1	0603WAF2700TCE	Unifim	LCSC	C22966	0.001
49	1500	R23		R0402	1	0603WAF2700TCE	Unifim	LCSC	C22966	0.002
50	TF-314-C289315B	SD		TF-SM0-TE-02	1	TF-03A	Yundi (含清元渝)	LCSC	C289258	0.086
51	E280F242020EG	U1		QFI50-040X016X016X016N	1	E280F242020EG	Zilog	Mouser	692-E280F242020EG	
52	E28P24-01CQ-D4	U3		QFI-48-17.0-047-0-003-003-003-004	1	E28P24-01CQ-D4	Espresso Systems	LCSC	C193707	3.82
53	C2P104-03-GMR	U4		QFI-24-17.0-047-0-003-003-004	1	C2P104-03-GMR	SILICON LABS	LCSC	C47070	2.361
54	AP56404-550R	U5		SOP-8-4.9-W3.9-P2.7-L1.56-0.1-L	1	AP56404-550R-SN	AP Memory	Mouser	878-AP56404-550R-SN	
55	AR9355-256M-7	U6		SOT-223-12-L9-W4.6-H1.9-L2.5-S8.9-R	1	AR9355-256M-7	Diodes Incorporated	LCSC	C14931	
56	SM74LVC1250BVR	U7, U8		SOT-223-5-L0-W17-P0.95-L5.8-BR	2	SM74LVC1250BVR	Yundi	LCSC	C3594	0.087
57	SN74LVC1250BVR	U9		SOT-223-5-L3-W17-P0.95-L5.8-BR	1	SN74LVC1250BVR	Ti	LCSC	C7877	0.112
58	U77H-1E15D01CHARRINGA	U10		US-B-A-TH-2923-1	1	292393-1	TE Connectivity	LCSC	C86461	0.407
59	U77H-1E15D01CHARRINGA	VGA		US-B-A-TH-2923-1	1	292393-1	Yundi	LCSC	C499319	0.062
60	612006217221	ZIN		SHD9006217221	1	TS-1093A-AT283-02	Yundi	LCSC		
61	TS-1093A-AT283-02	RST				TS-1093A-AT283-02	Yundi	LCSC		



The Byte Attic's  
**Agon**  
light™  
PCB

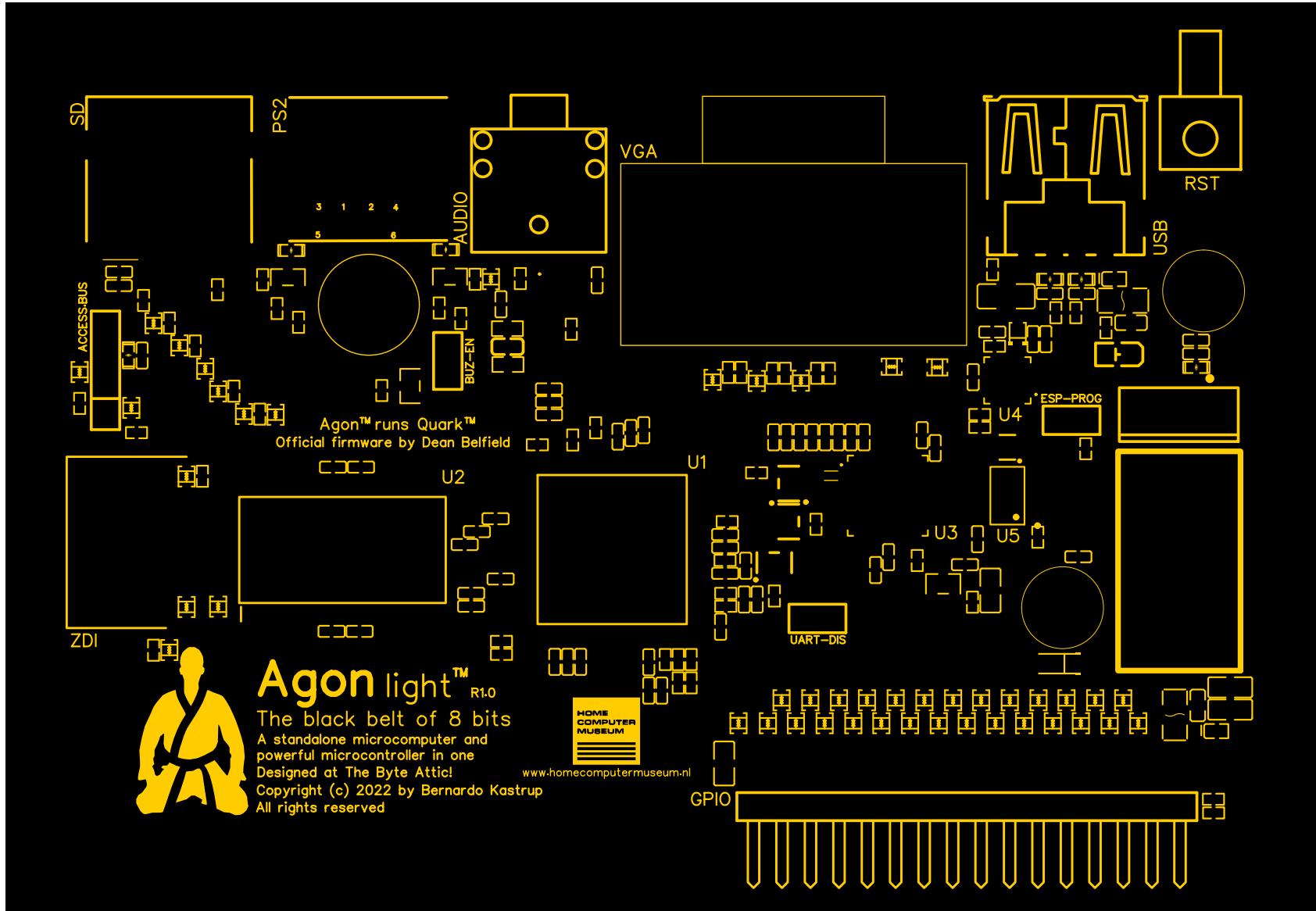


# PCB dimensions (diagram *not* to scale)

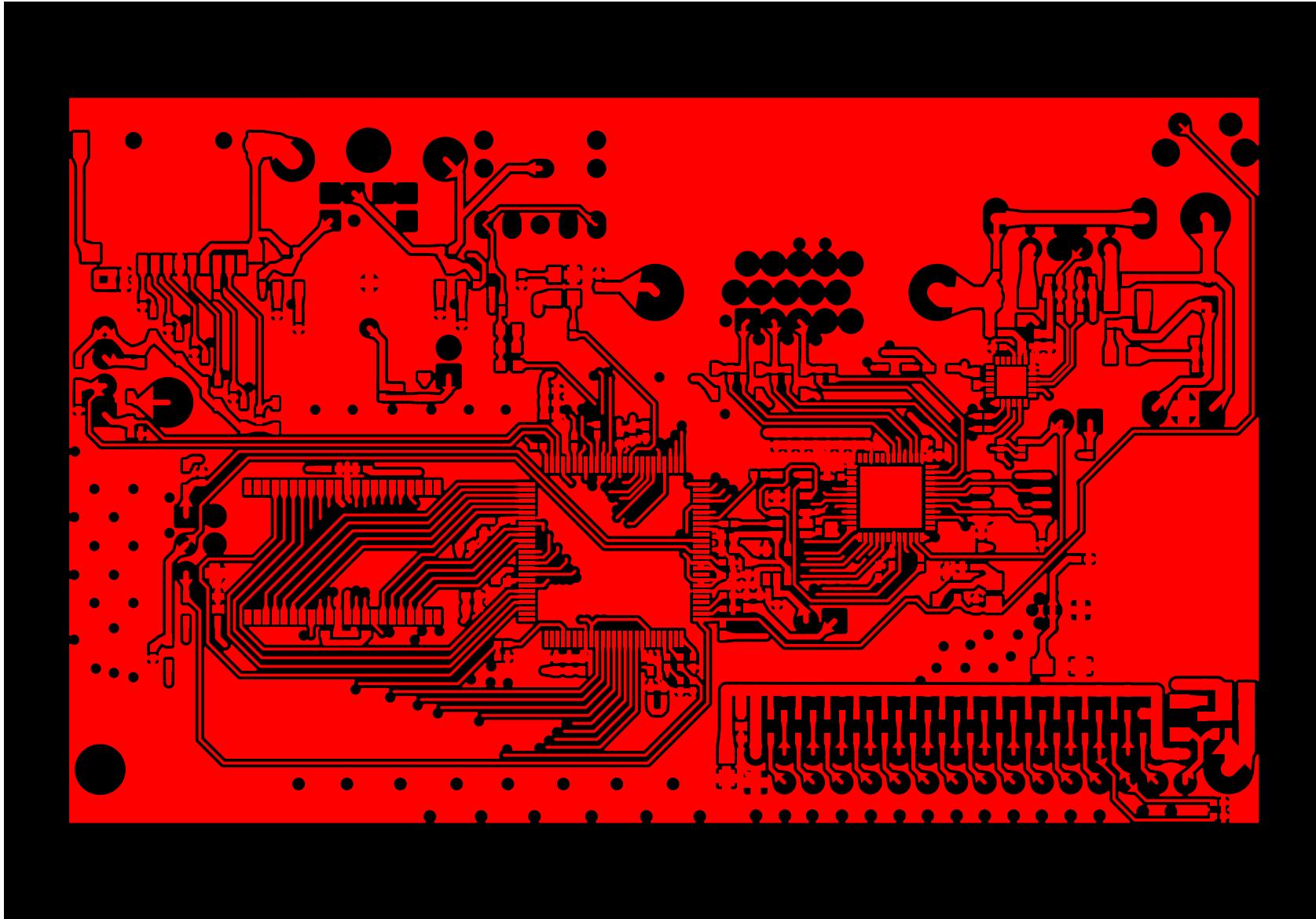


All holes  
are  
2.505mm  
in  
diameter

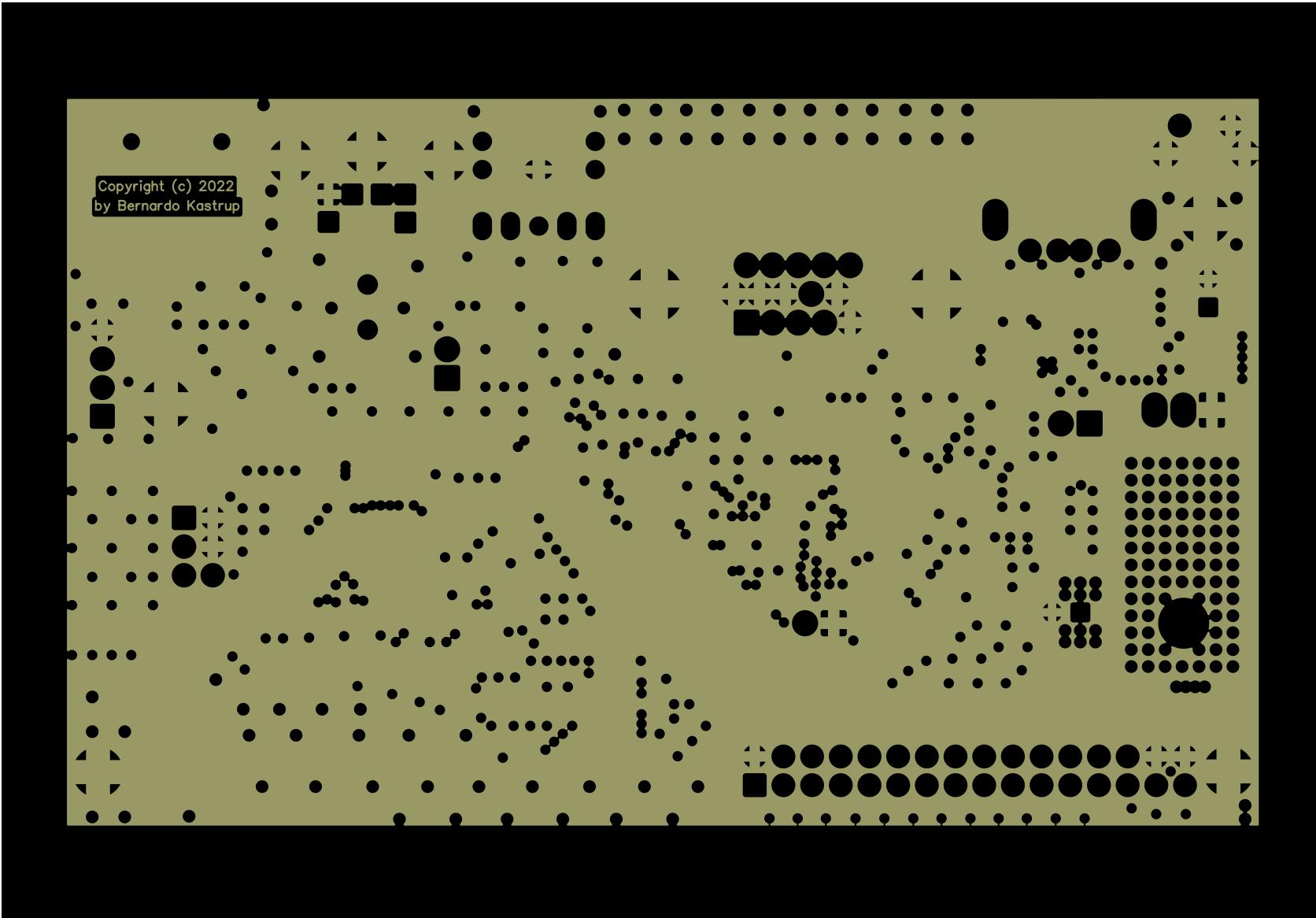
# Top silkscreen



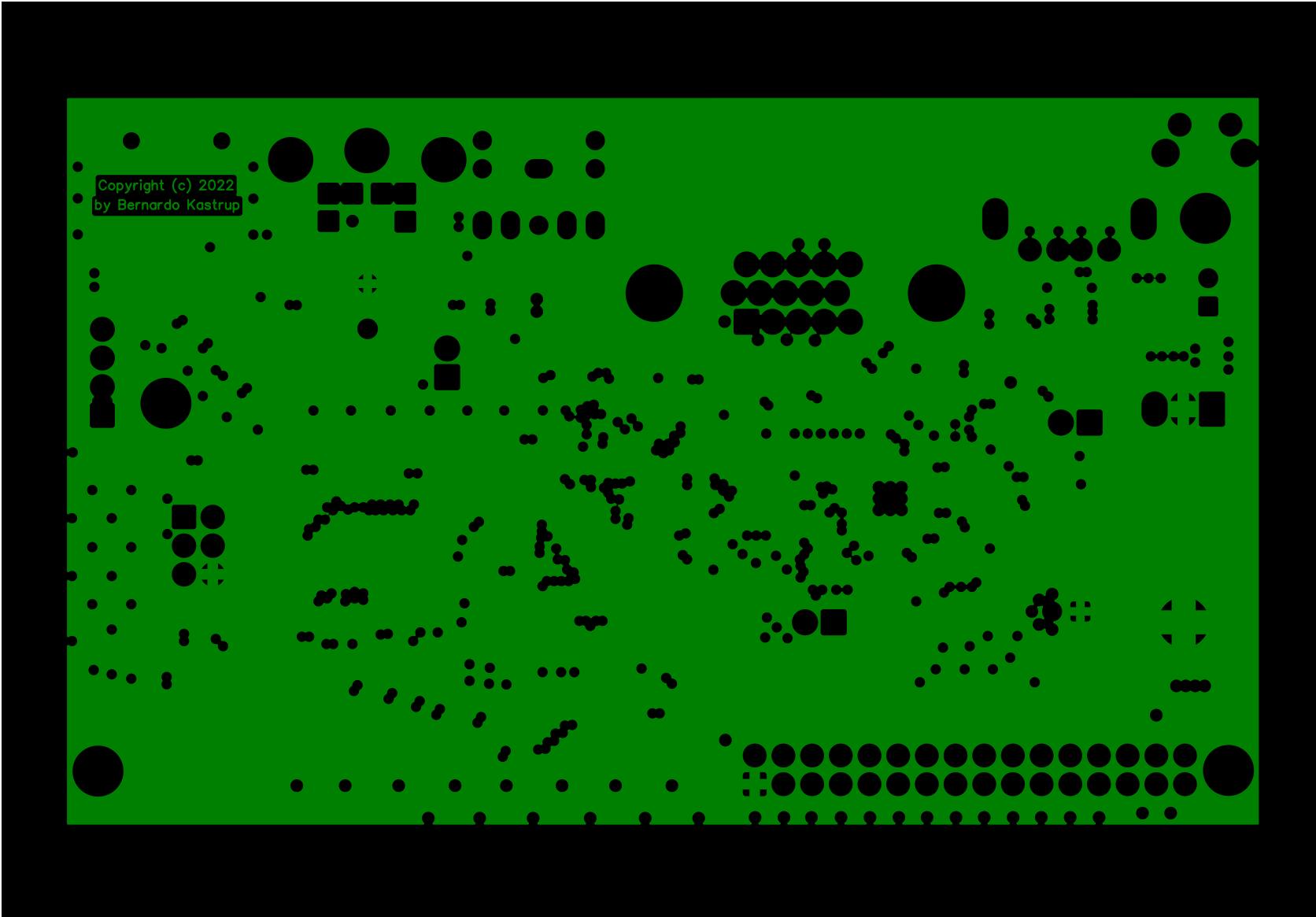
Top metal layer (3.3V filled)



## First inner plane (GND)



## Second inner plane (3.3V)



Bottom metal layer (GND filled)

