



The Byte Attic's

# Agon light™

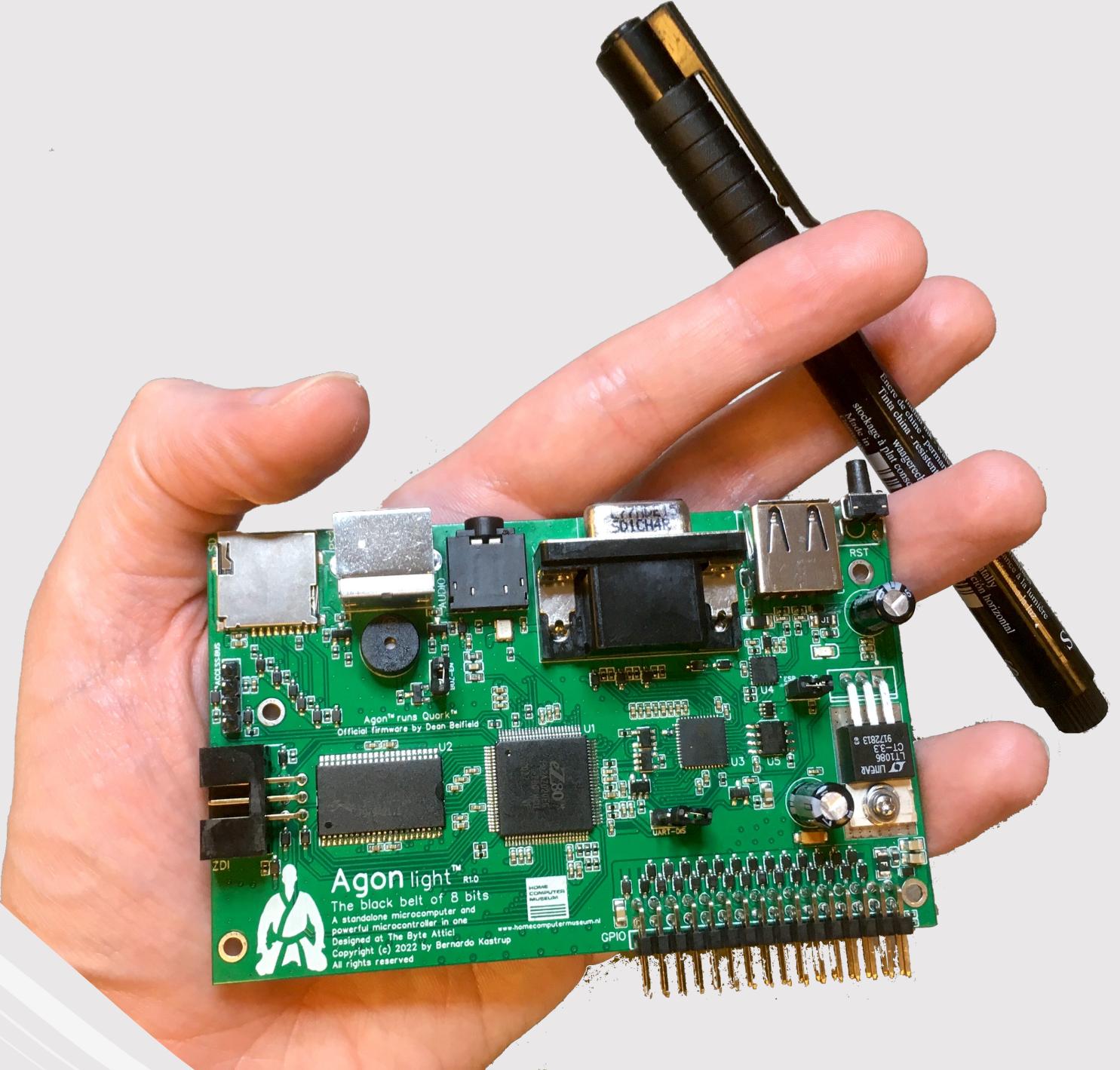
## Manual

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# 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



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# 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

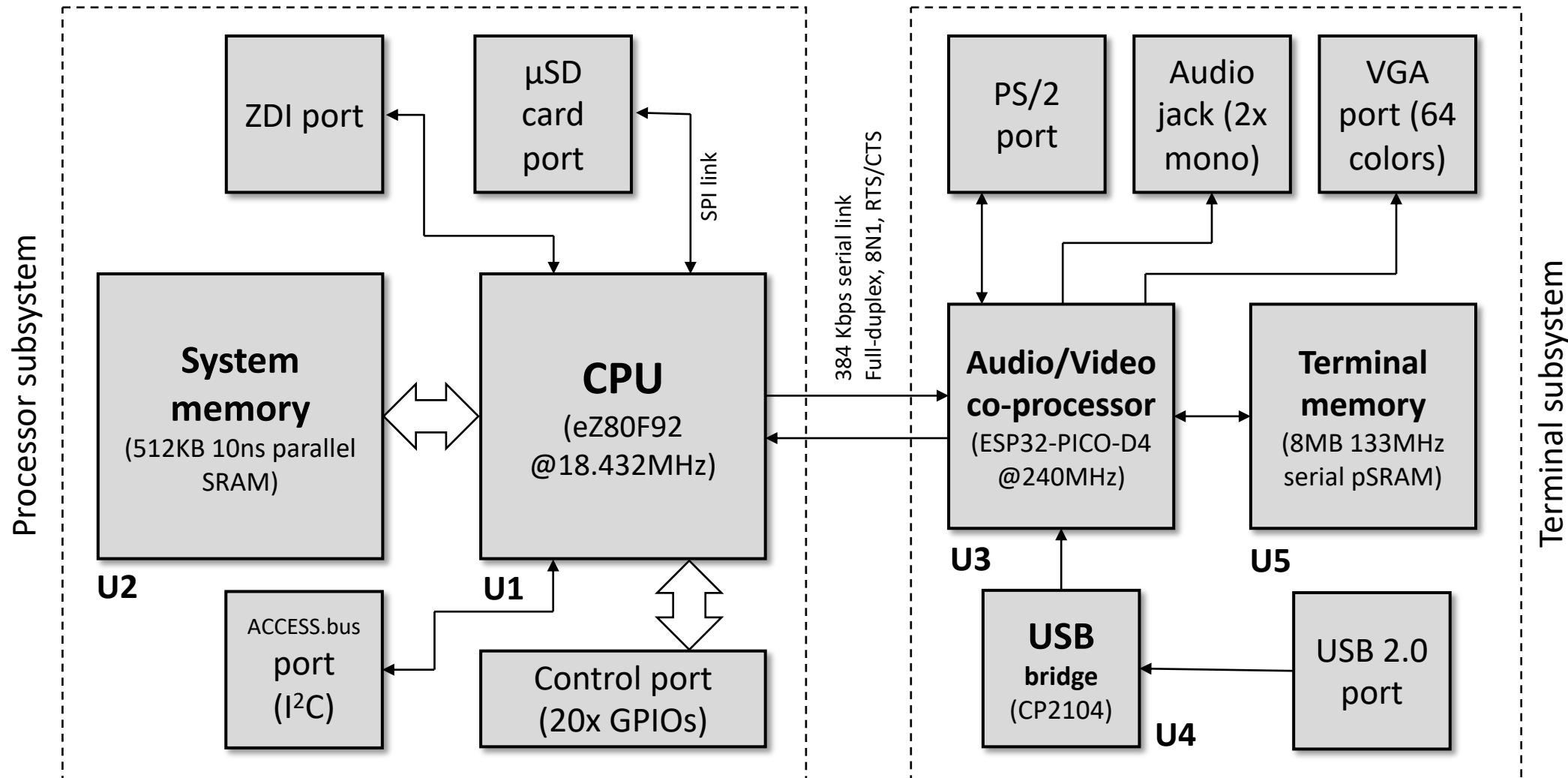
# Theory of operation

- 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
- 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)

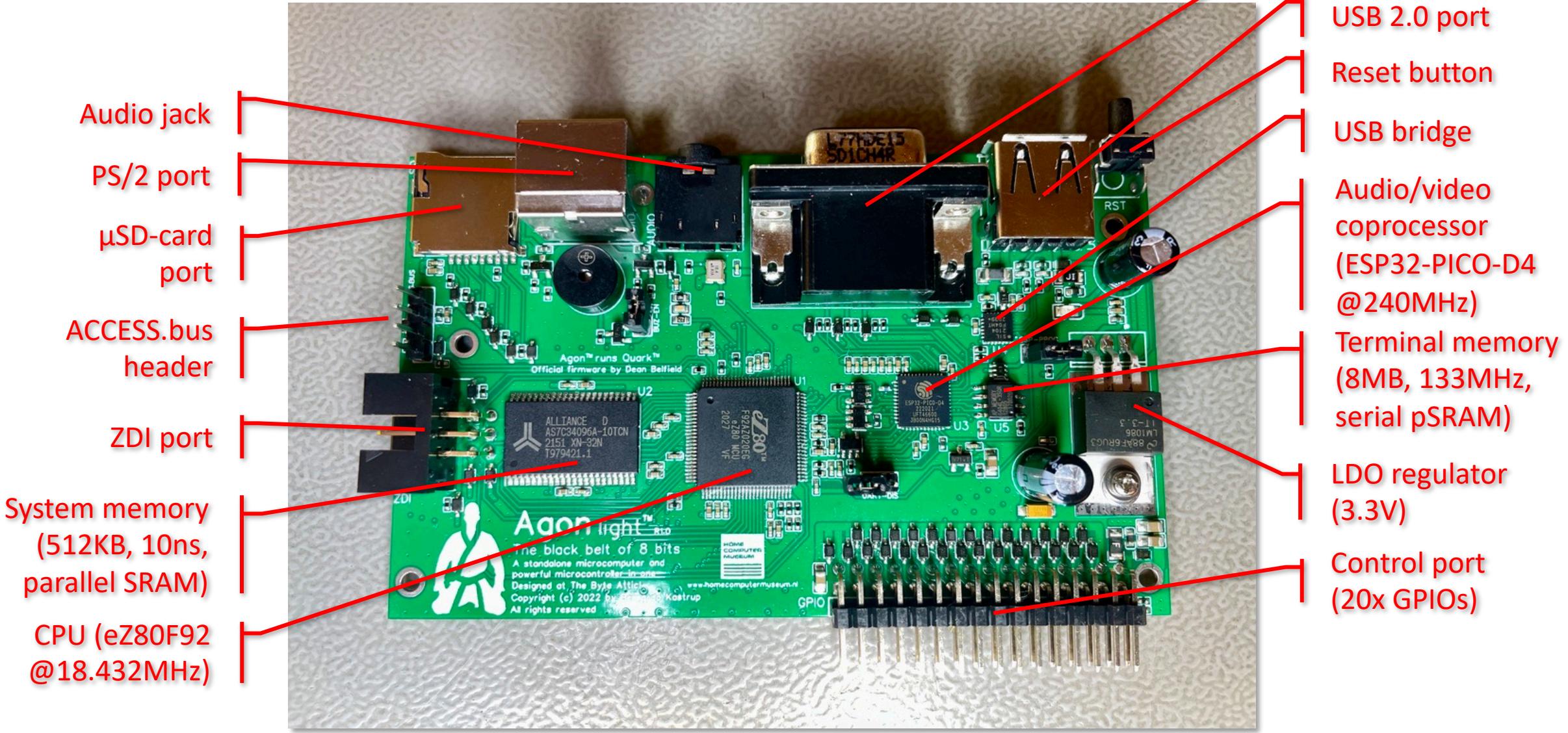
\* Requires installation of Quark™ firmware by Dean Belfield

# System diagram

↔ Serial link  
↔ Parallel link



# Circuit board

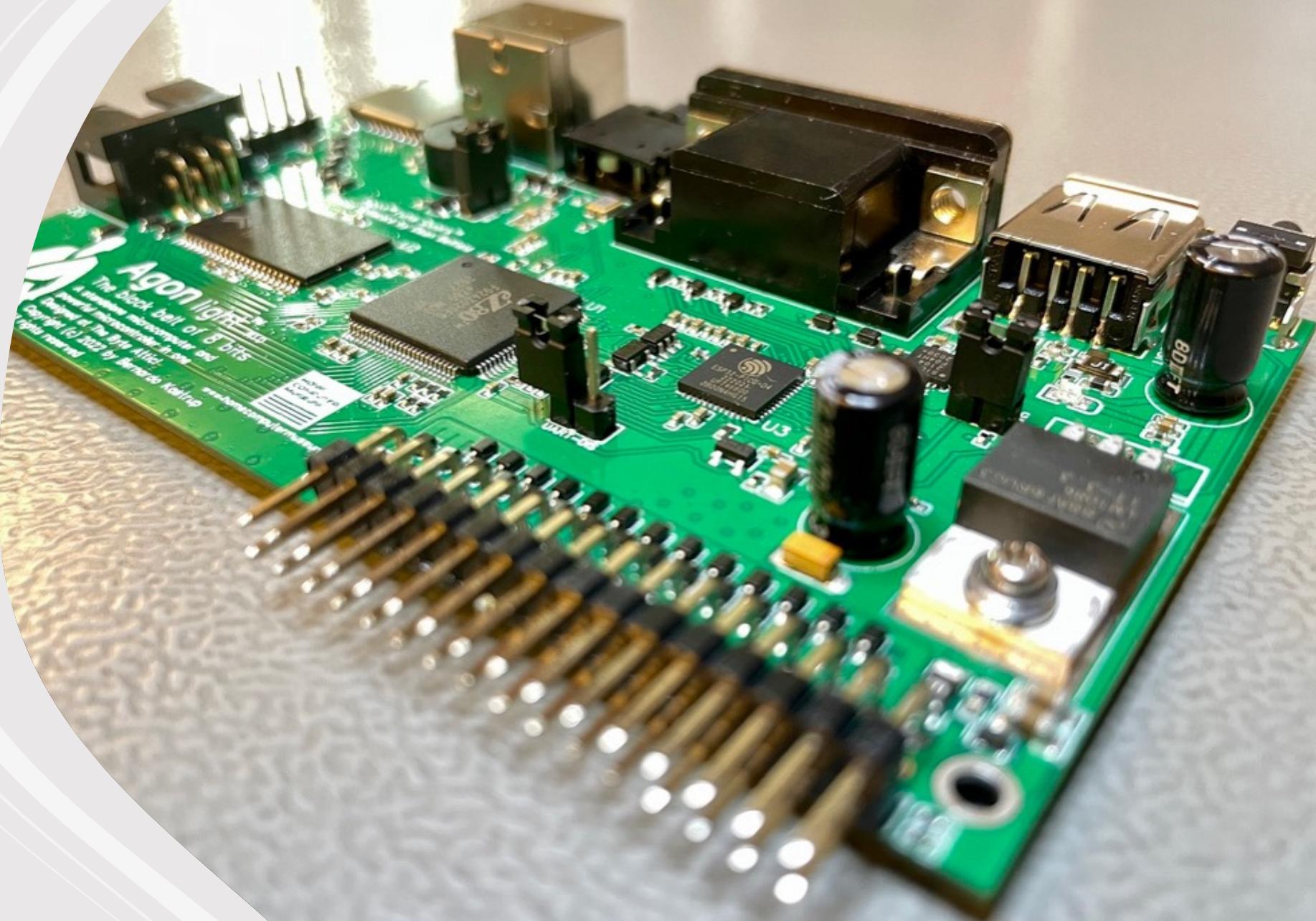




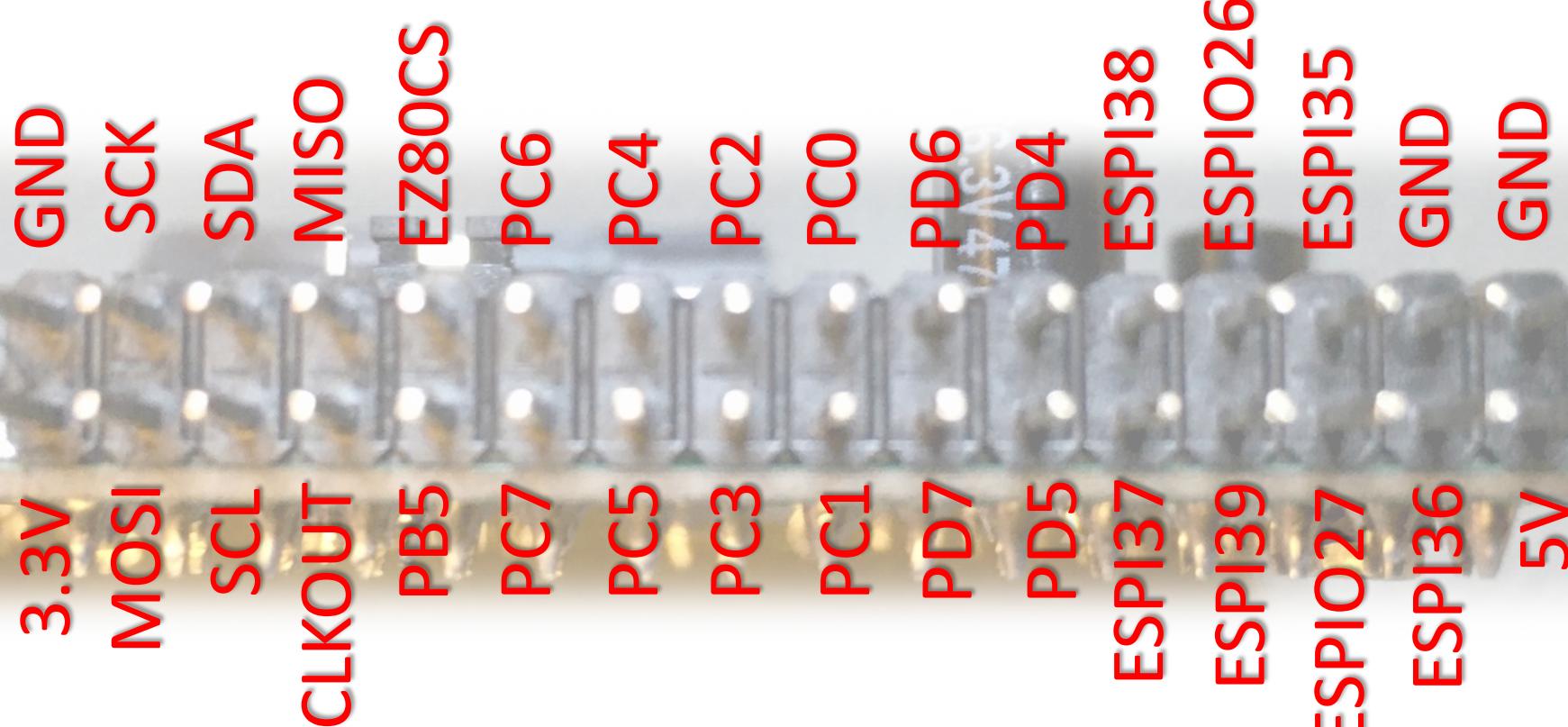
The Byte Attic's

# Agon light™

User's  
guide

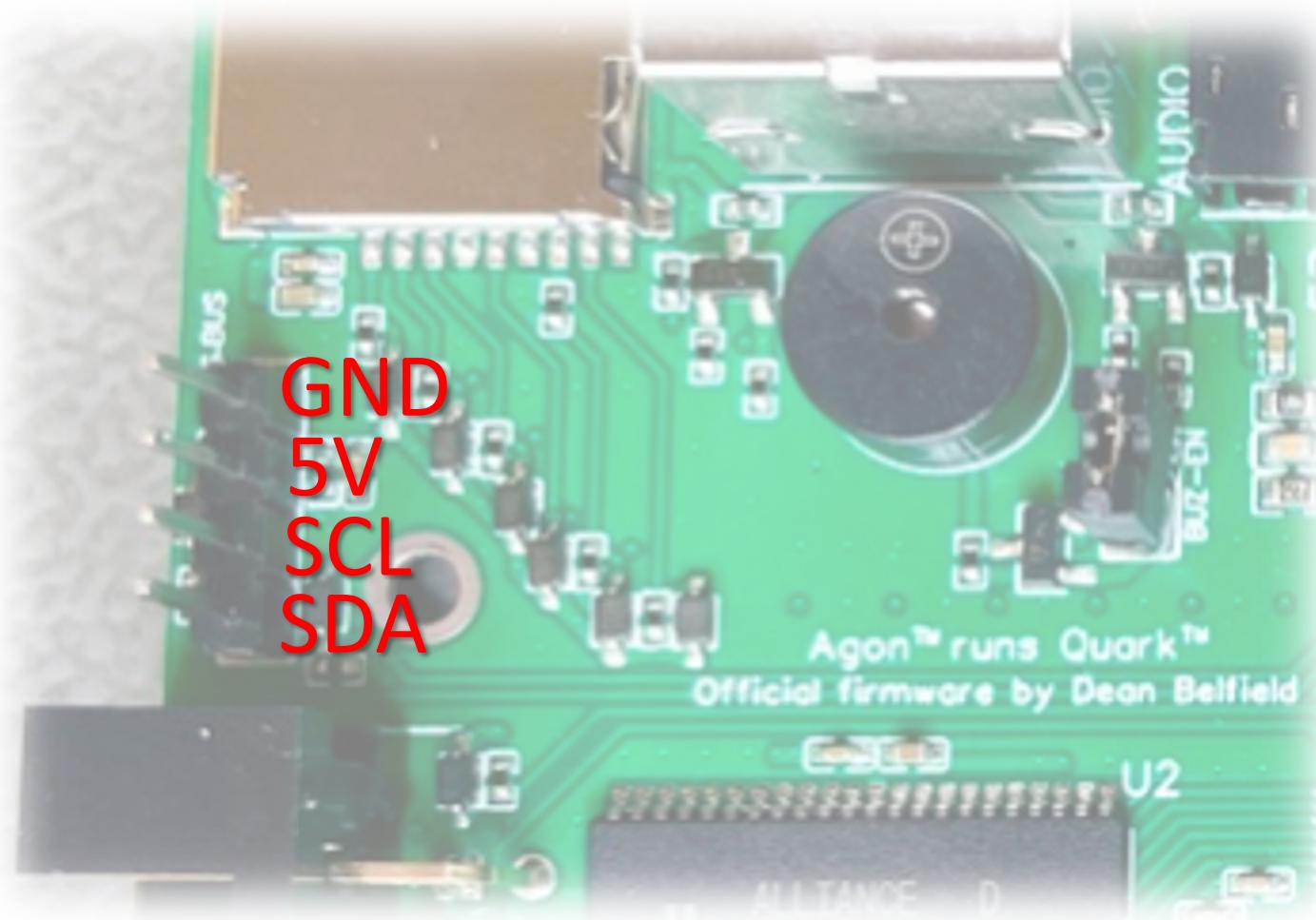


# Control port pinout



See schematics for signal references

# 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

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*Channel:* full duplex, asynchronous

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*Baud rate:* 384,000 bits per second

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

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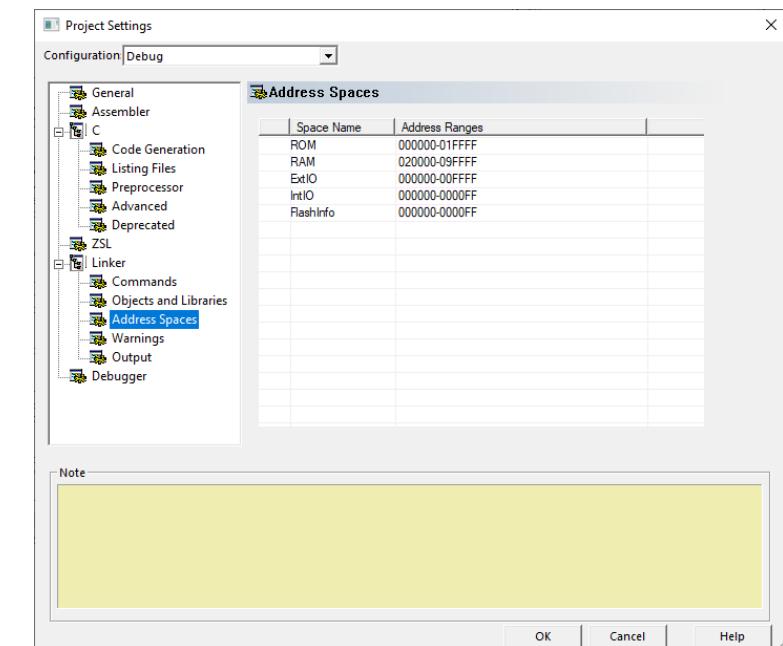
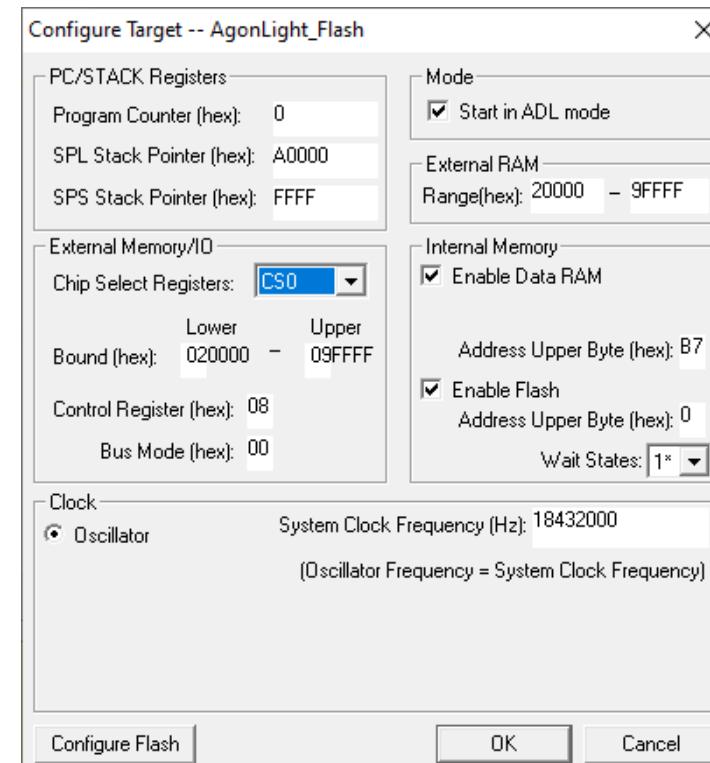
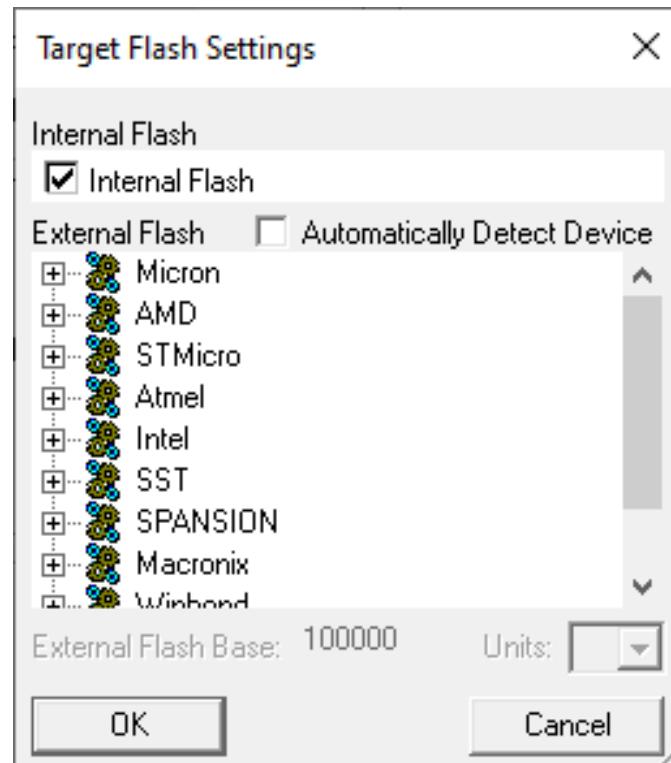
*Flow control:* CTS/RTS

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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)



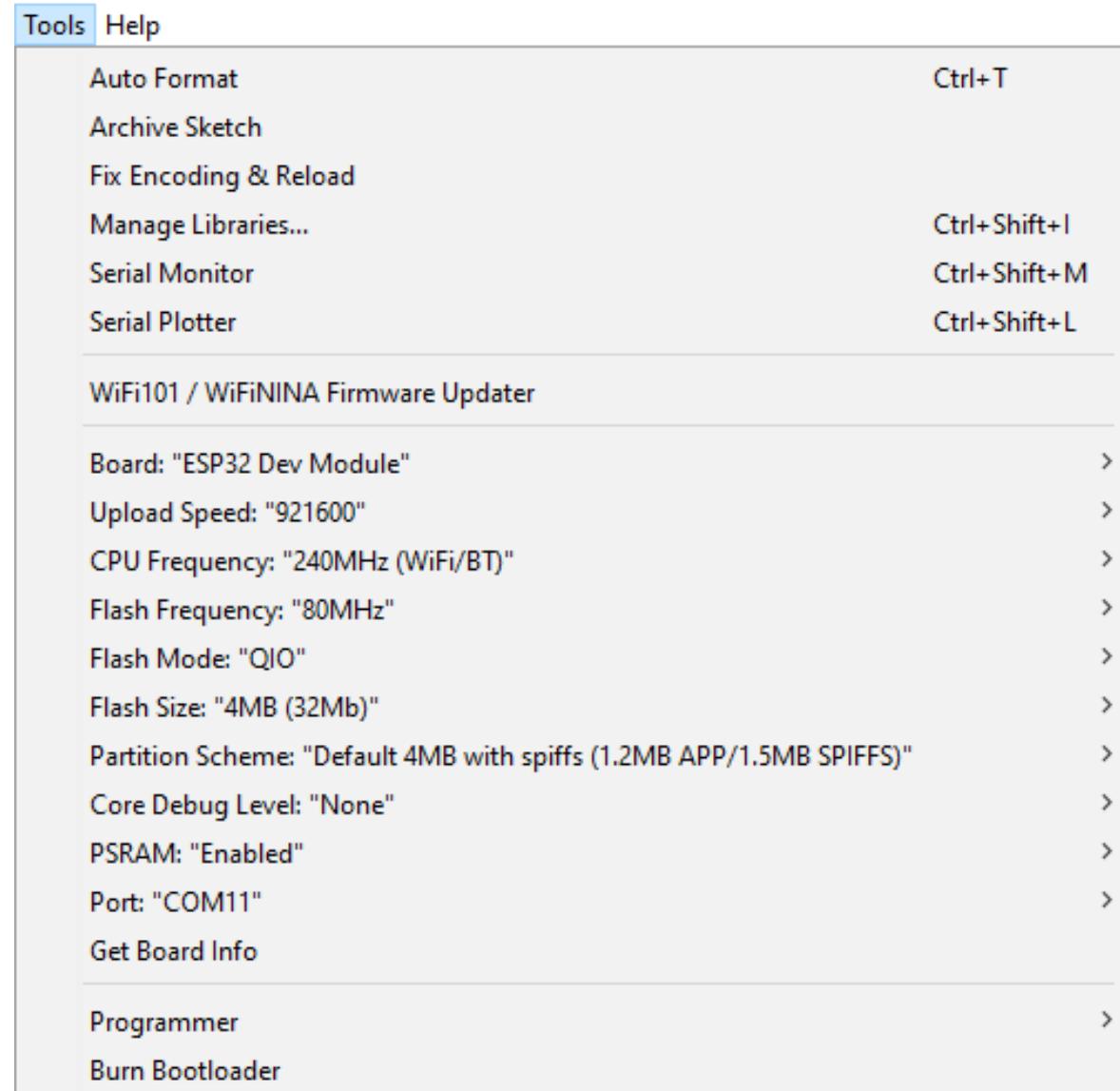
# Required programming/debugging USB smart capable

- 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
- 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)

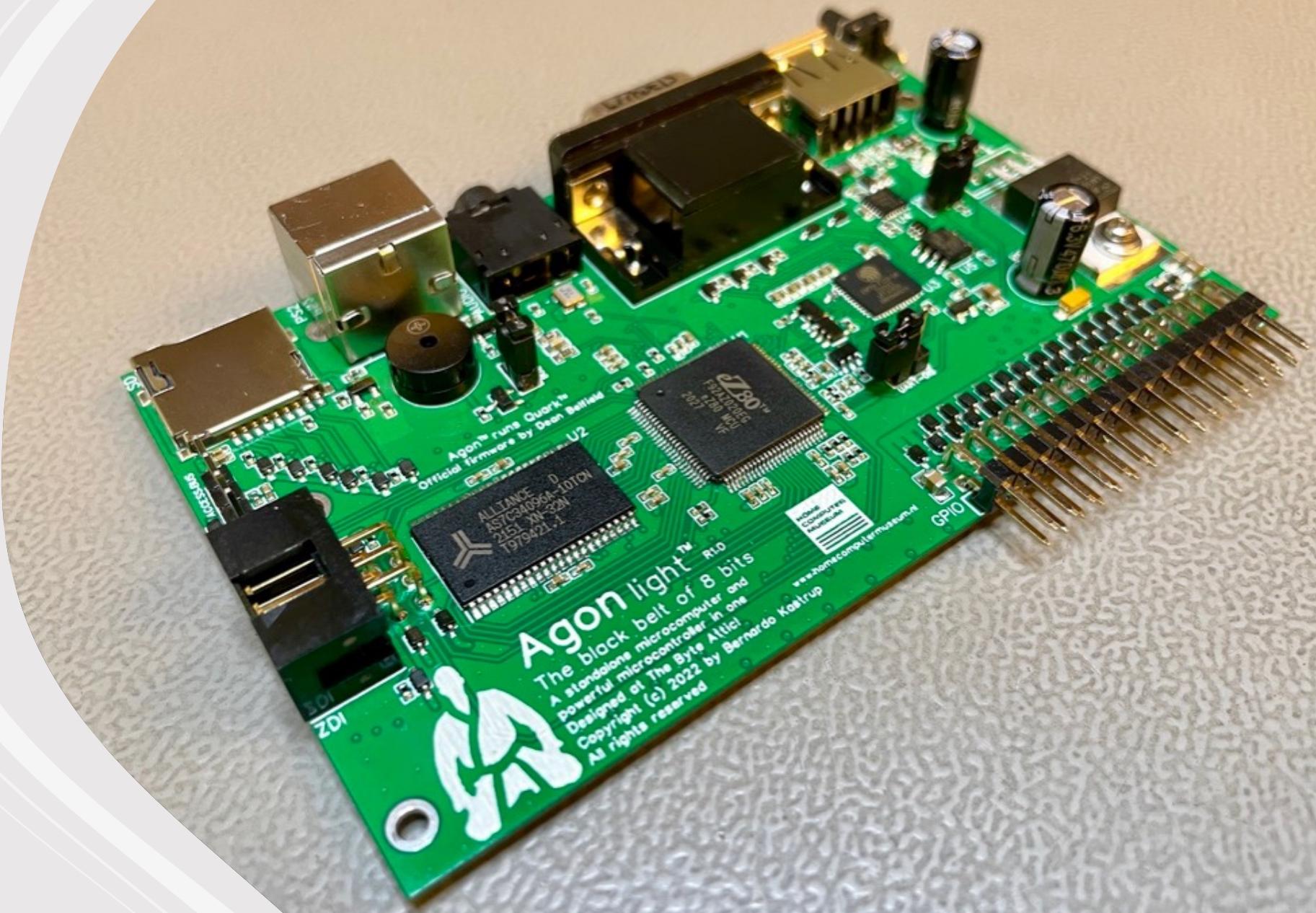




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# Agon light™

Assembly  
guide

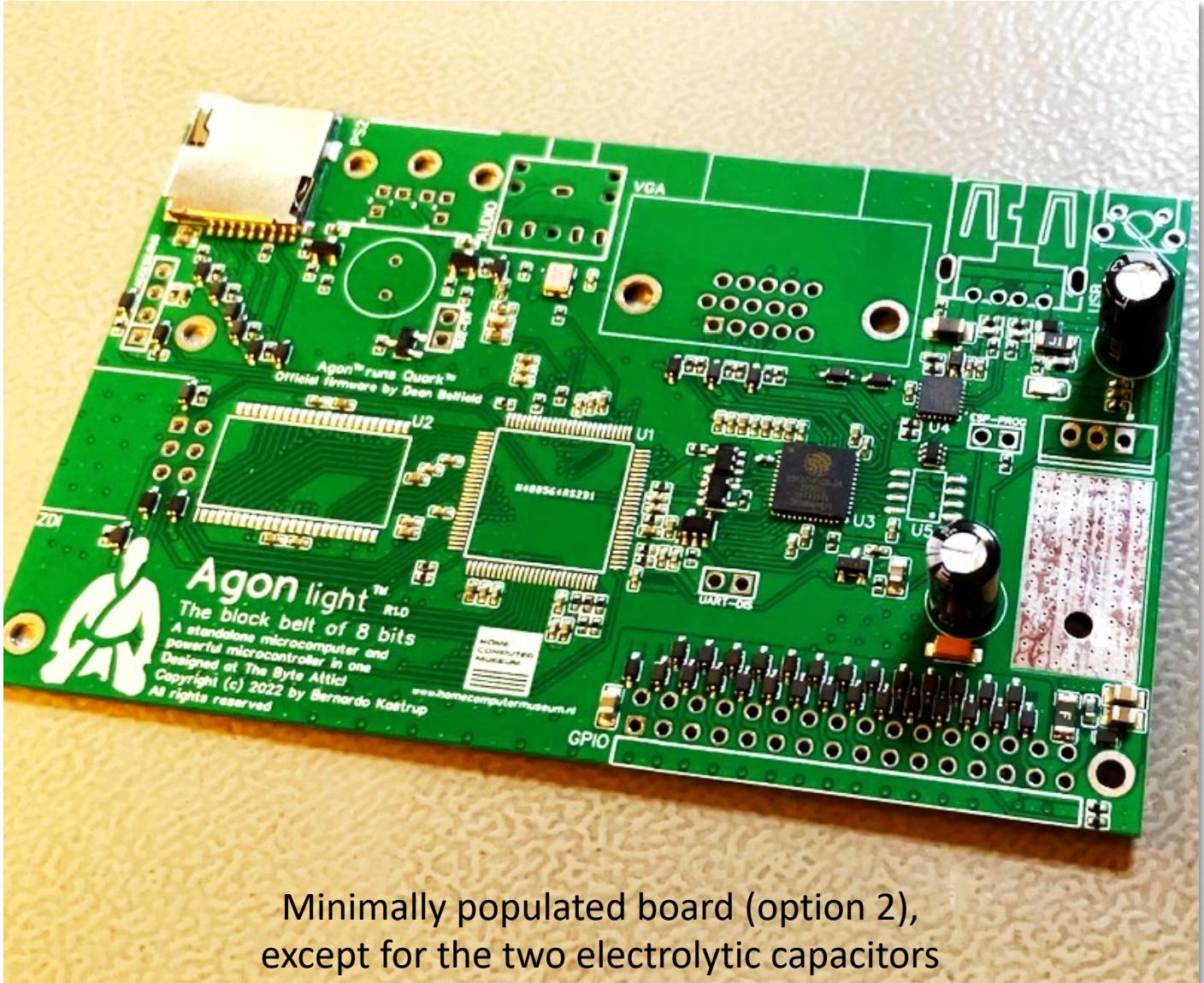


# Assembly options

- 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

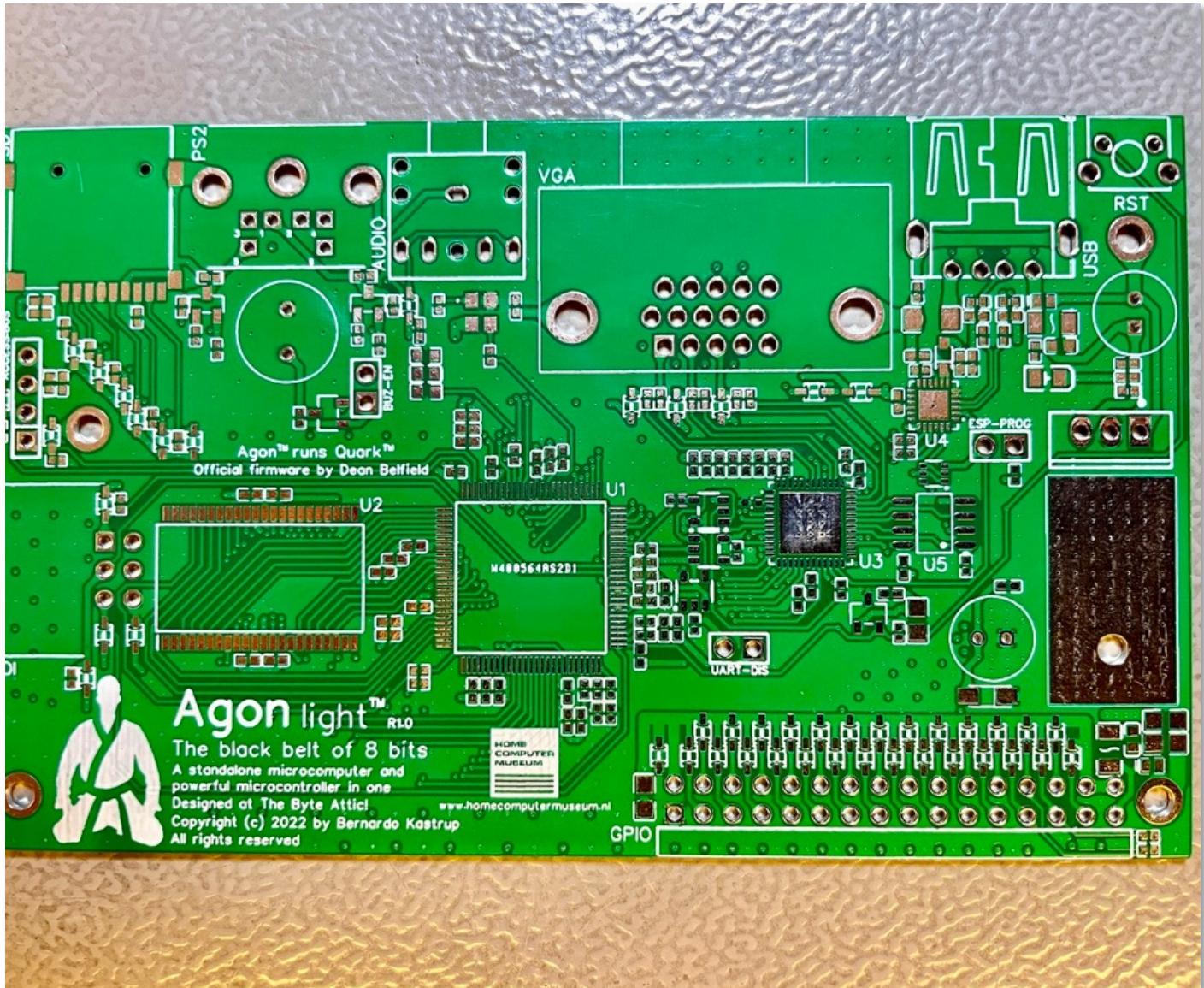
- All files are available in the `/Manufacturing` directory of Agon light's Github repository at:  
<https://github.com/TheByteAttic/AgonLight>
- For option (4), send the following files to your PCB manufacturer, next to the Gerber file (`Gerber_PCB_AgonLight_R1.0.zip`):
  - `PickAndPlace_PCB_AgonLight_R1.0.csv`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

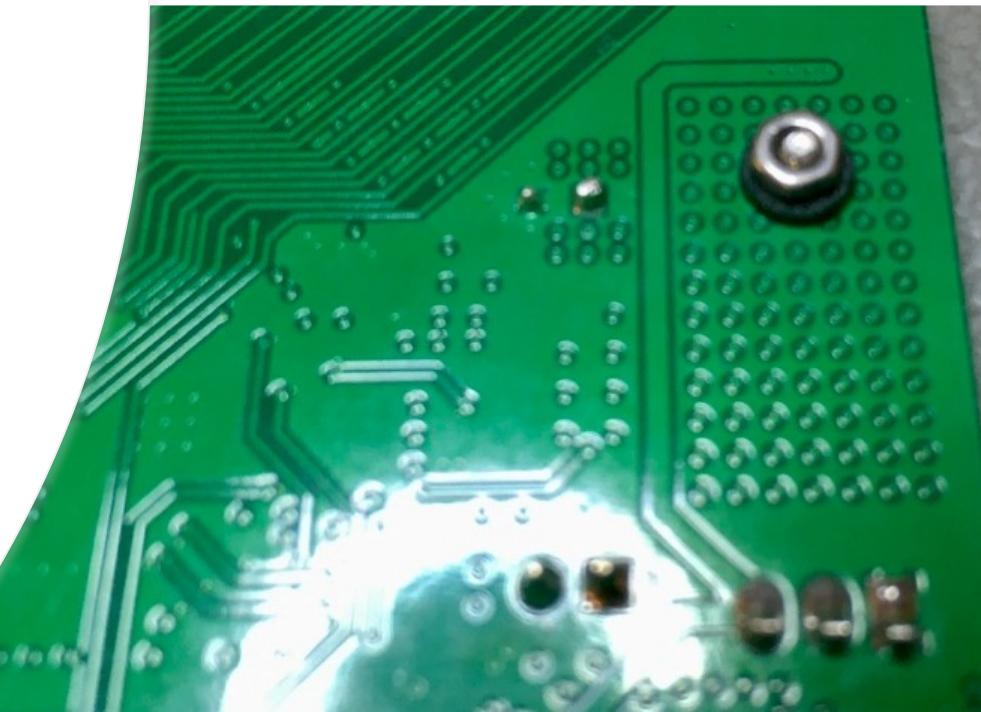
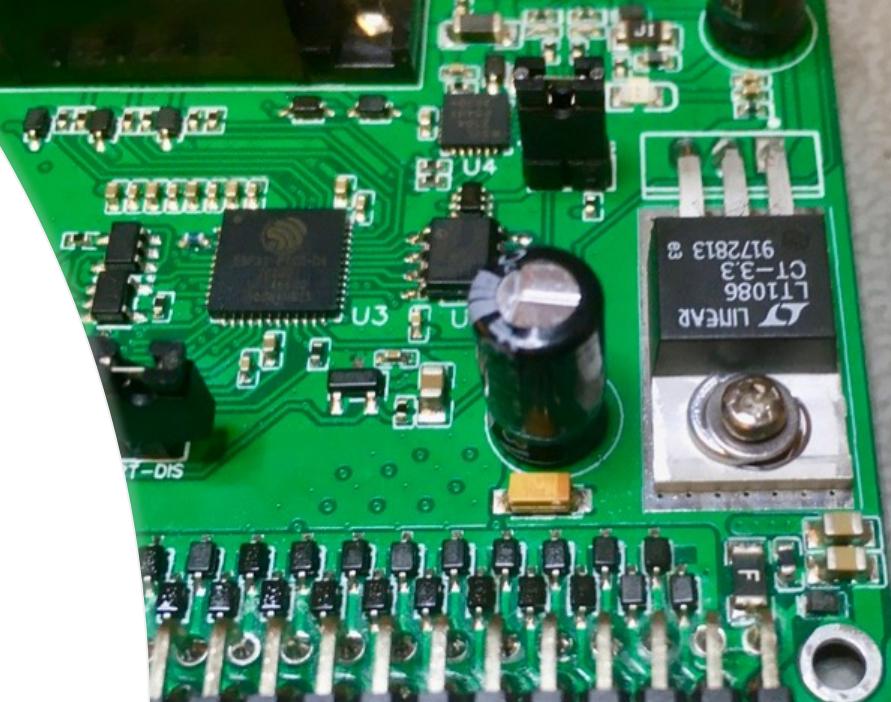
# PCB layer stack

- 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

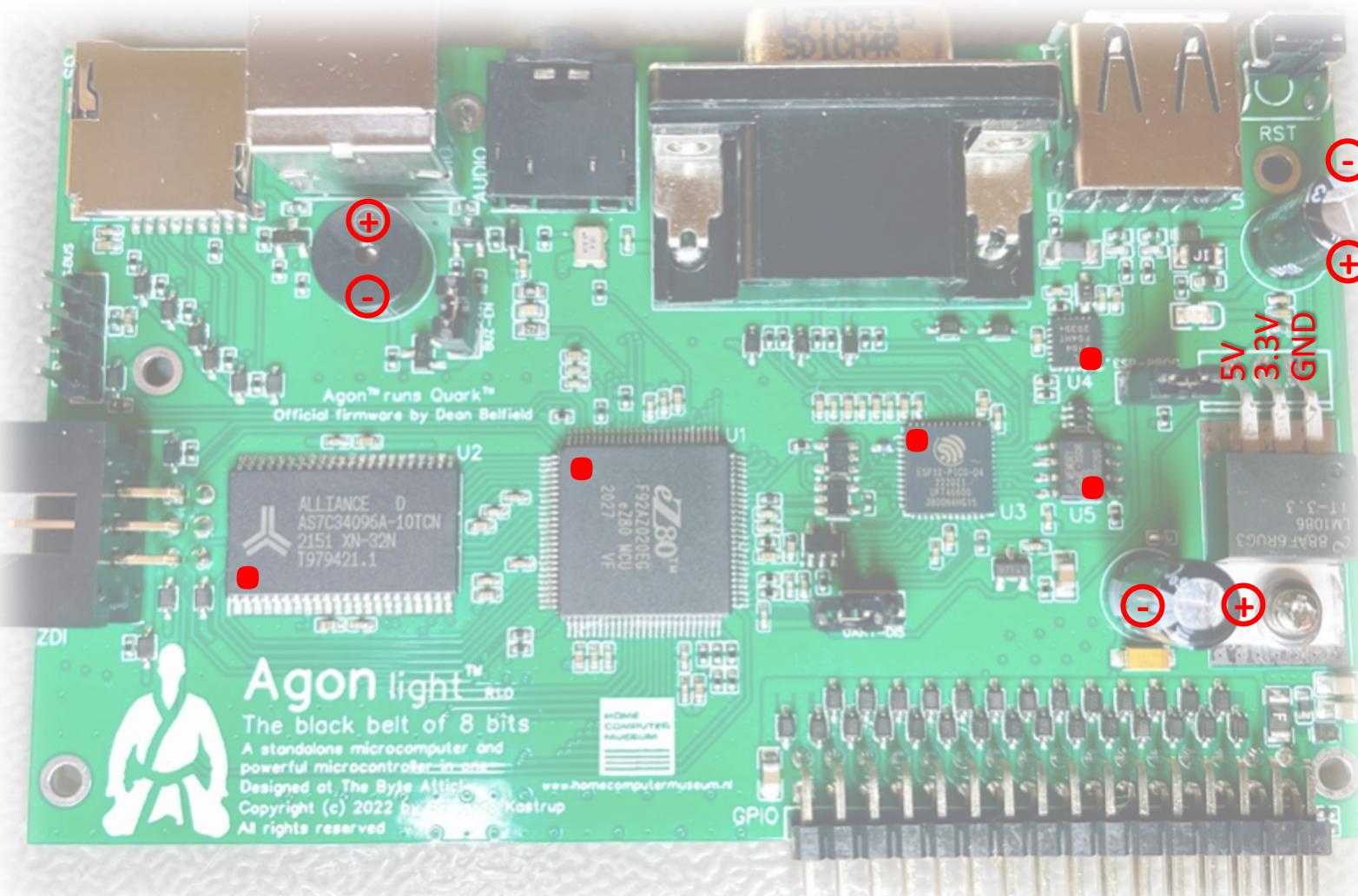


# Mounting the LDO regulator

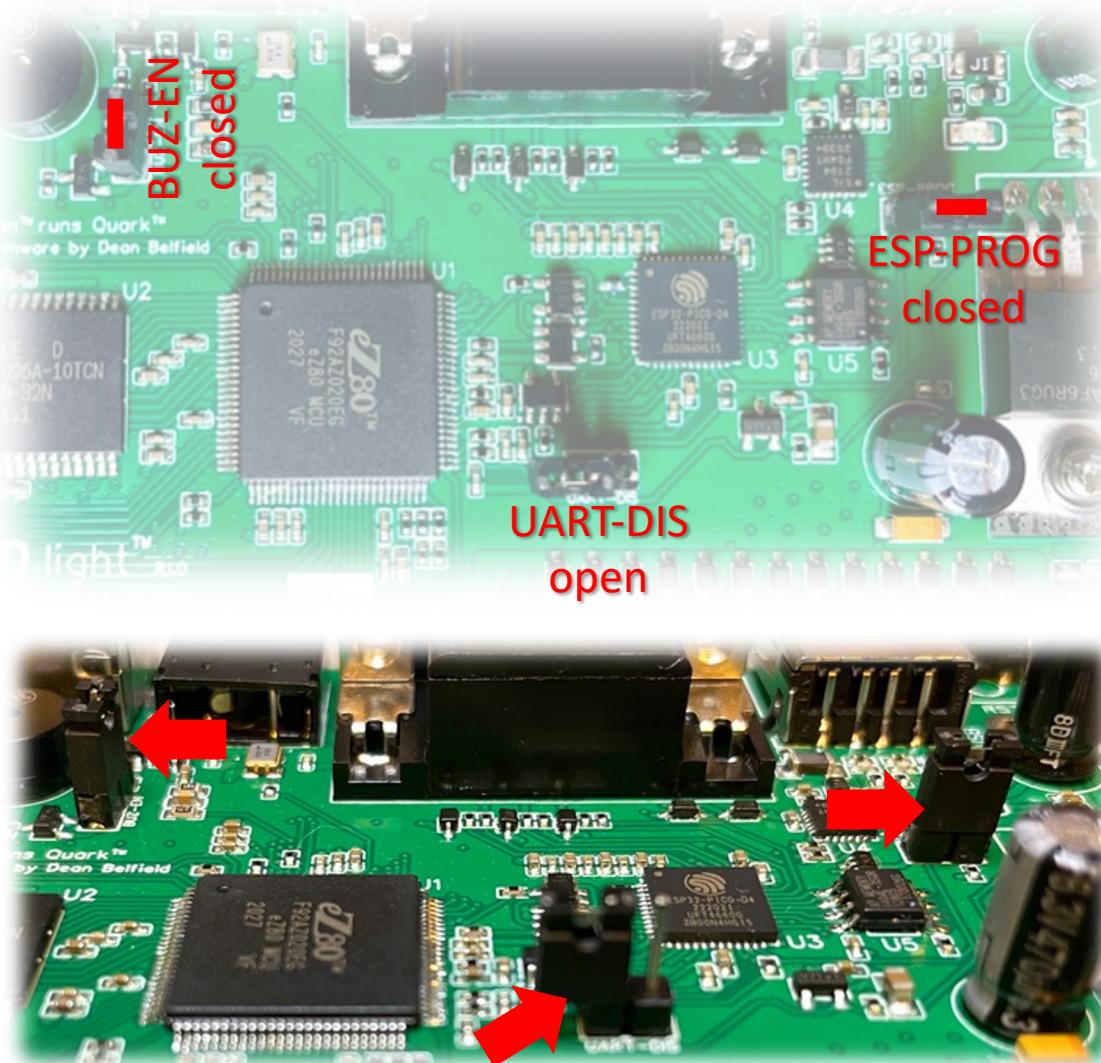
- Agon light's 3.3V  $V_{cc}$  rail is provided by a Low-DropOut (LDO) linear regulator
- The regulator must be mounted flush against the corresponding exposed metal area on the top of the PCB (see top-right photo)
- The regulator's tab (chassis) is at 3.3V, as is the exposed copper area on which it 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

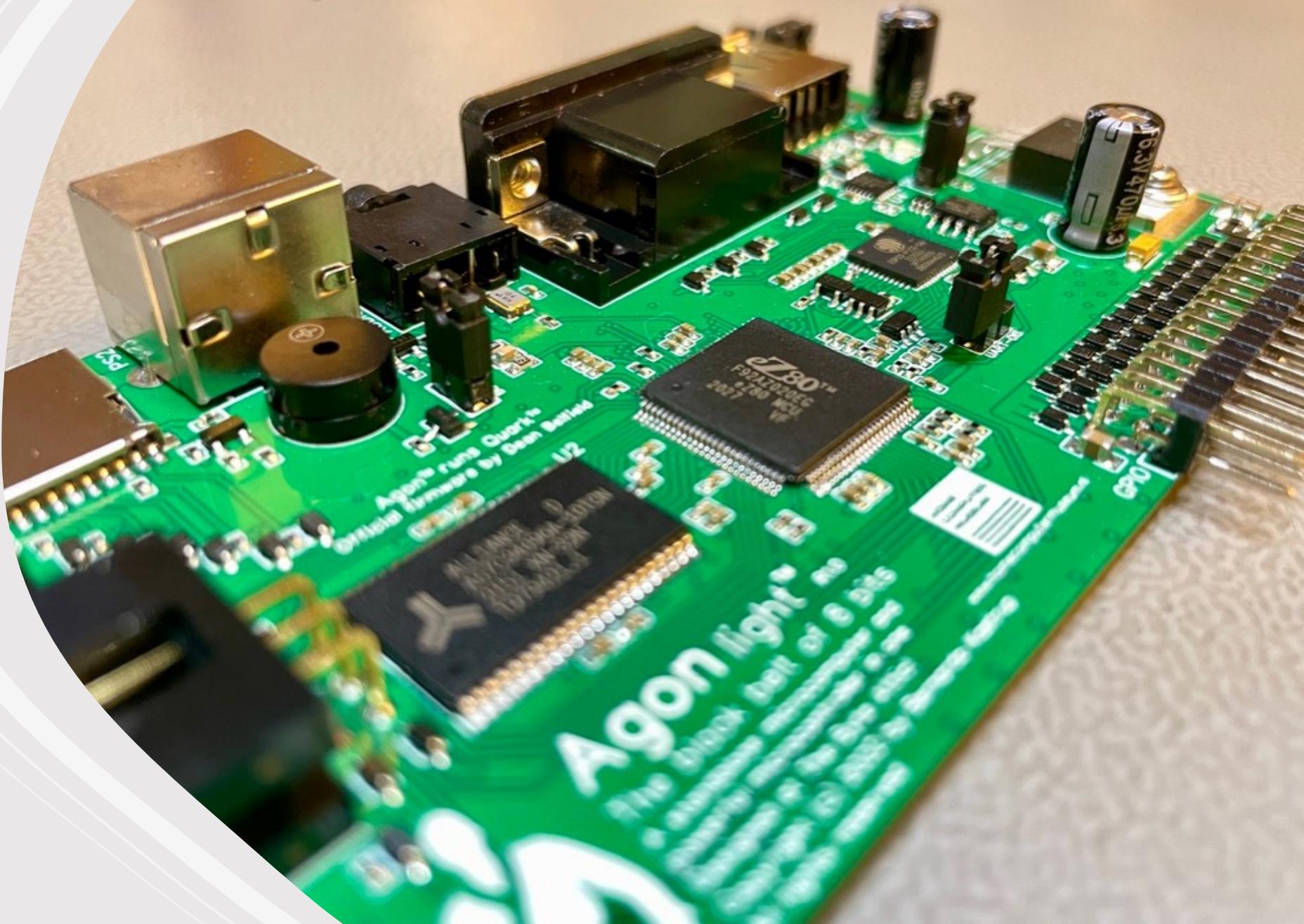


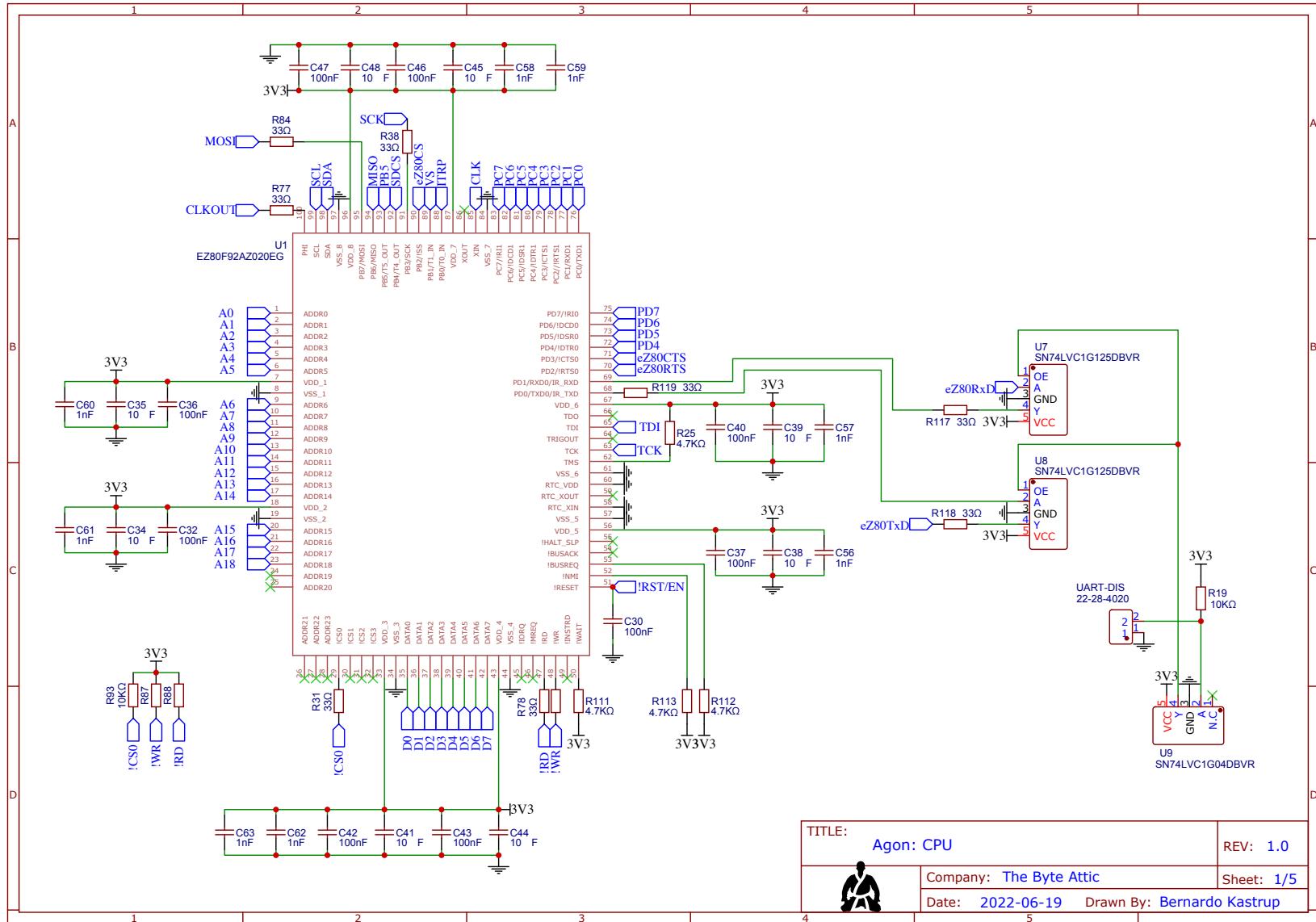
# When to change jumper settings

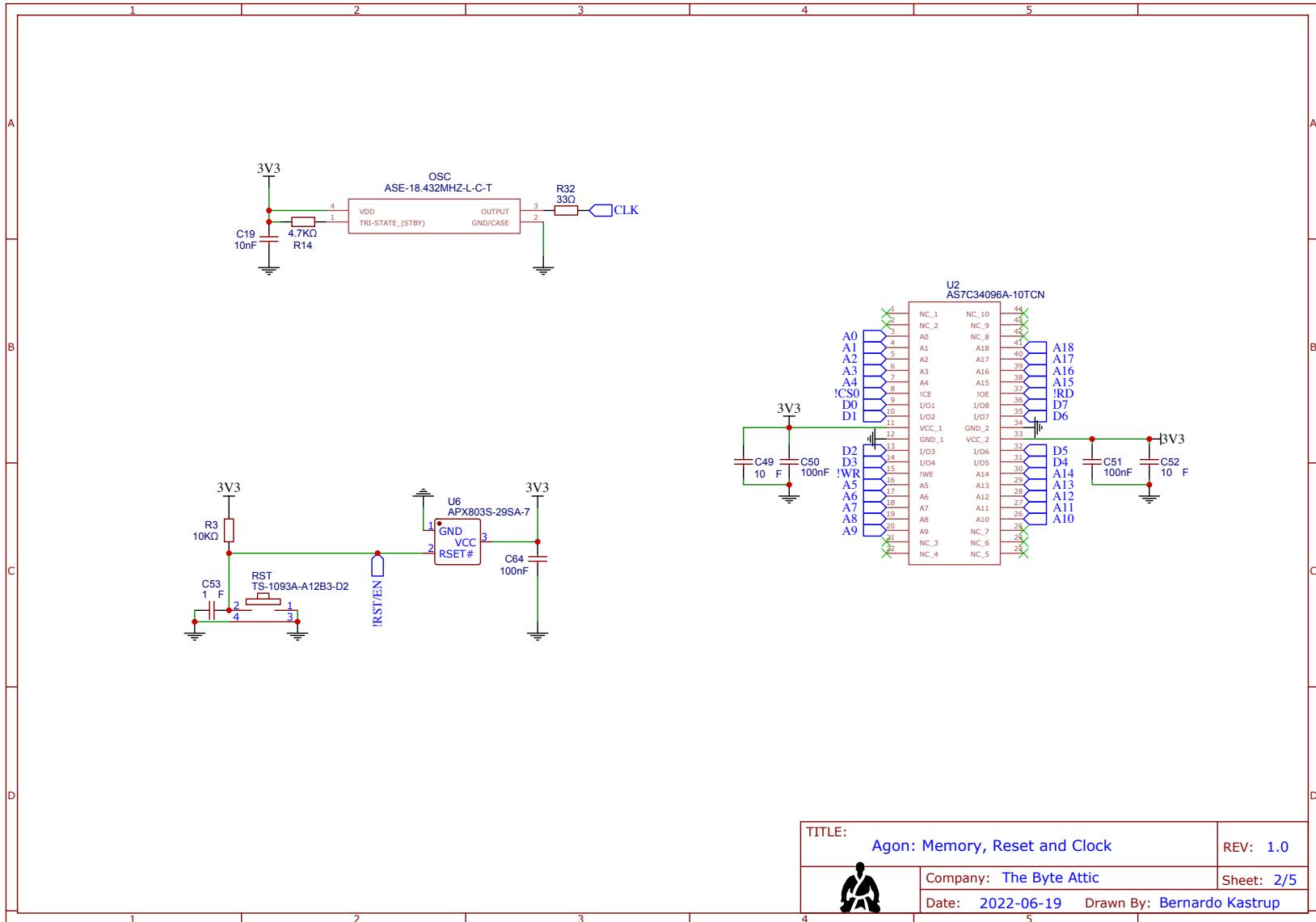
- Agon light should operate normally during both firmware programming and application execution with the default jumper settings (see previous page), but the ESP32 is known to be a sensitive device
  - Therefore, Agon light has built-in resources to deal with that sensitivity
- If the ESP32 goes into 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’

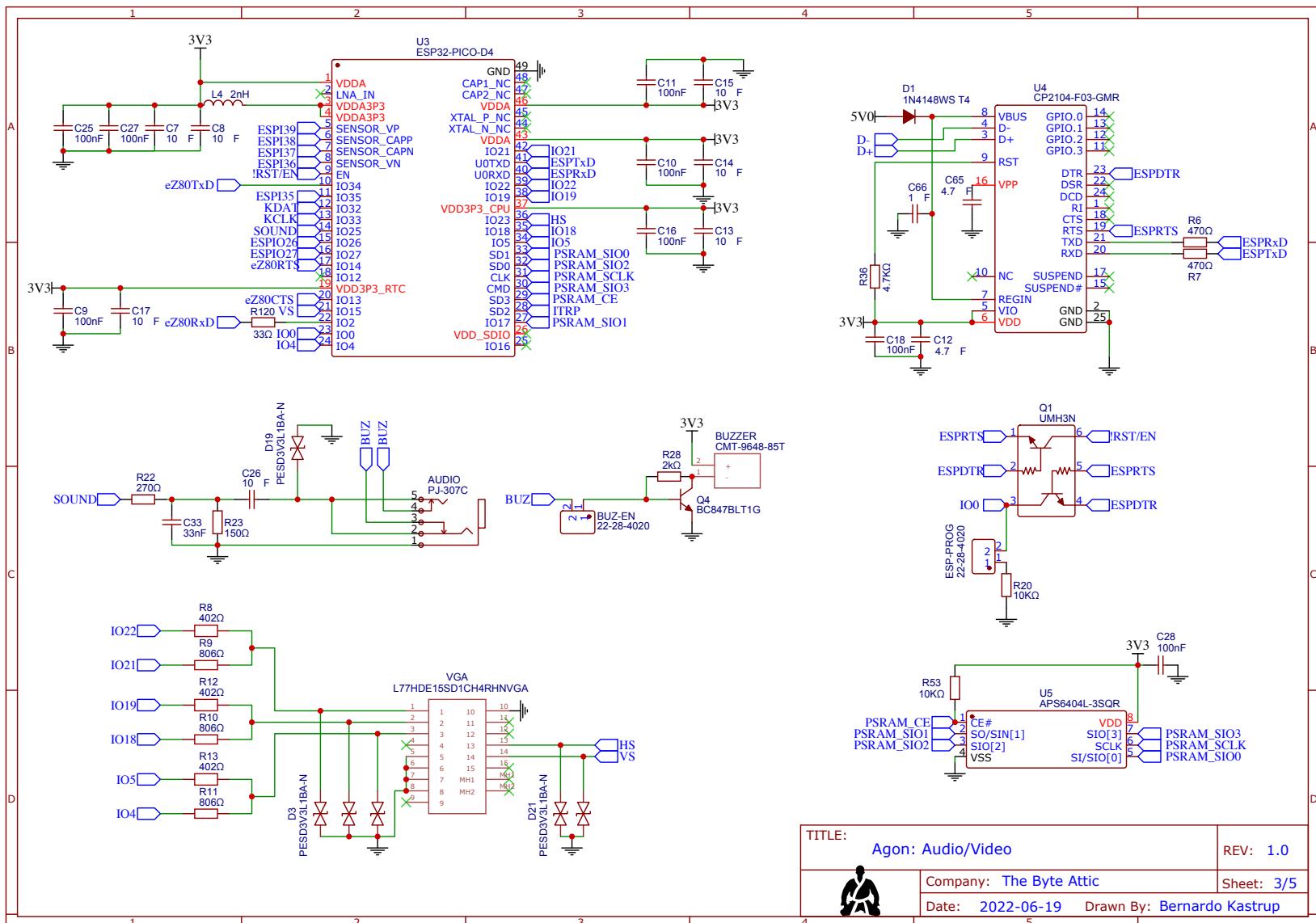


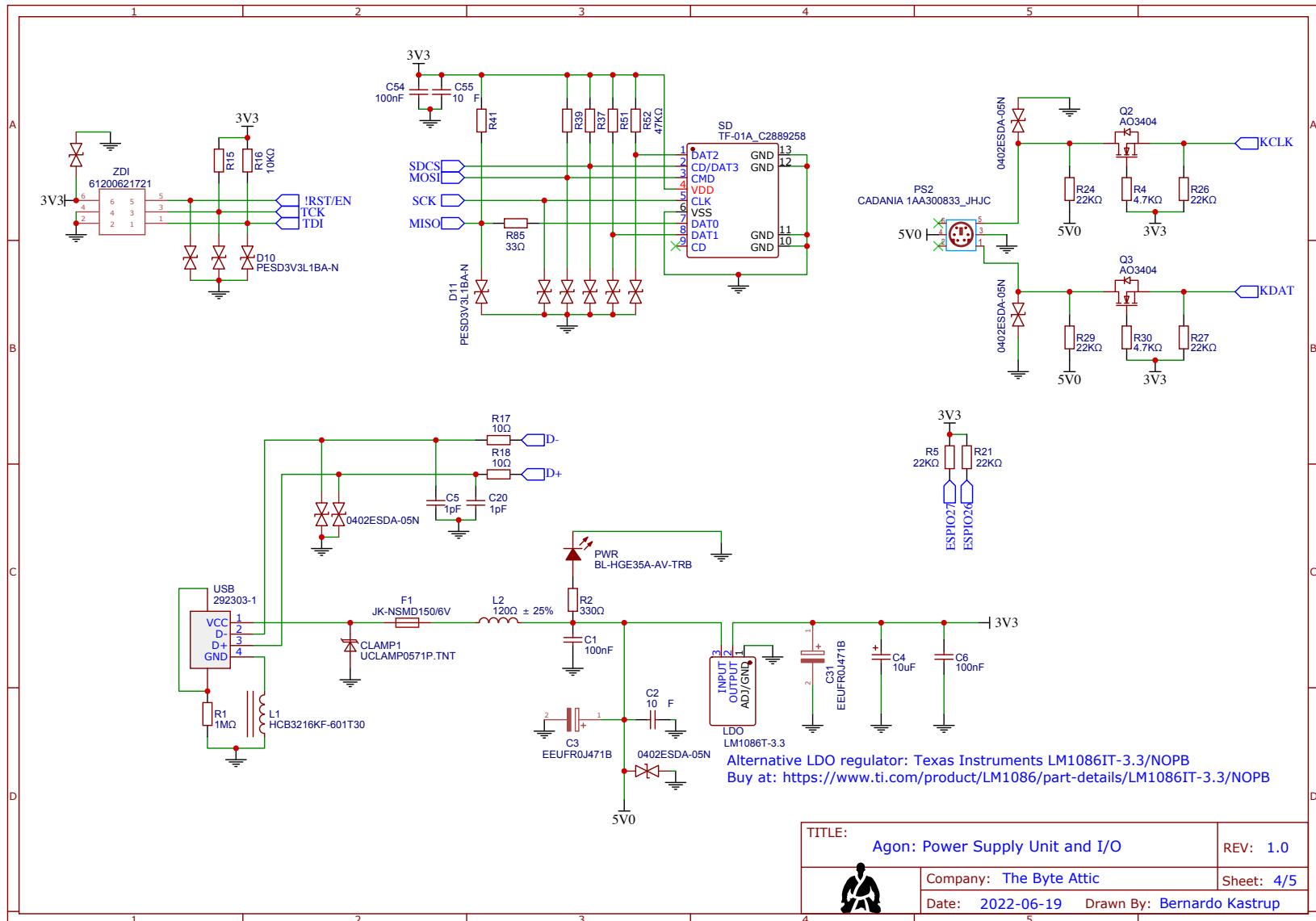
The Byte Attic's  
**Agon**  
light™  
Schematics

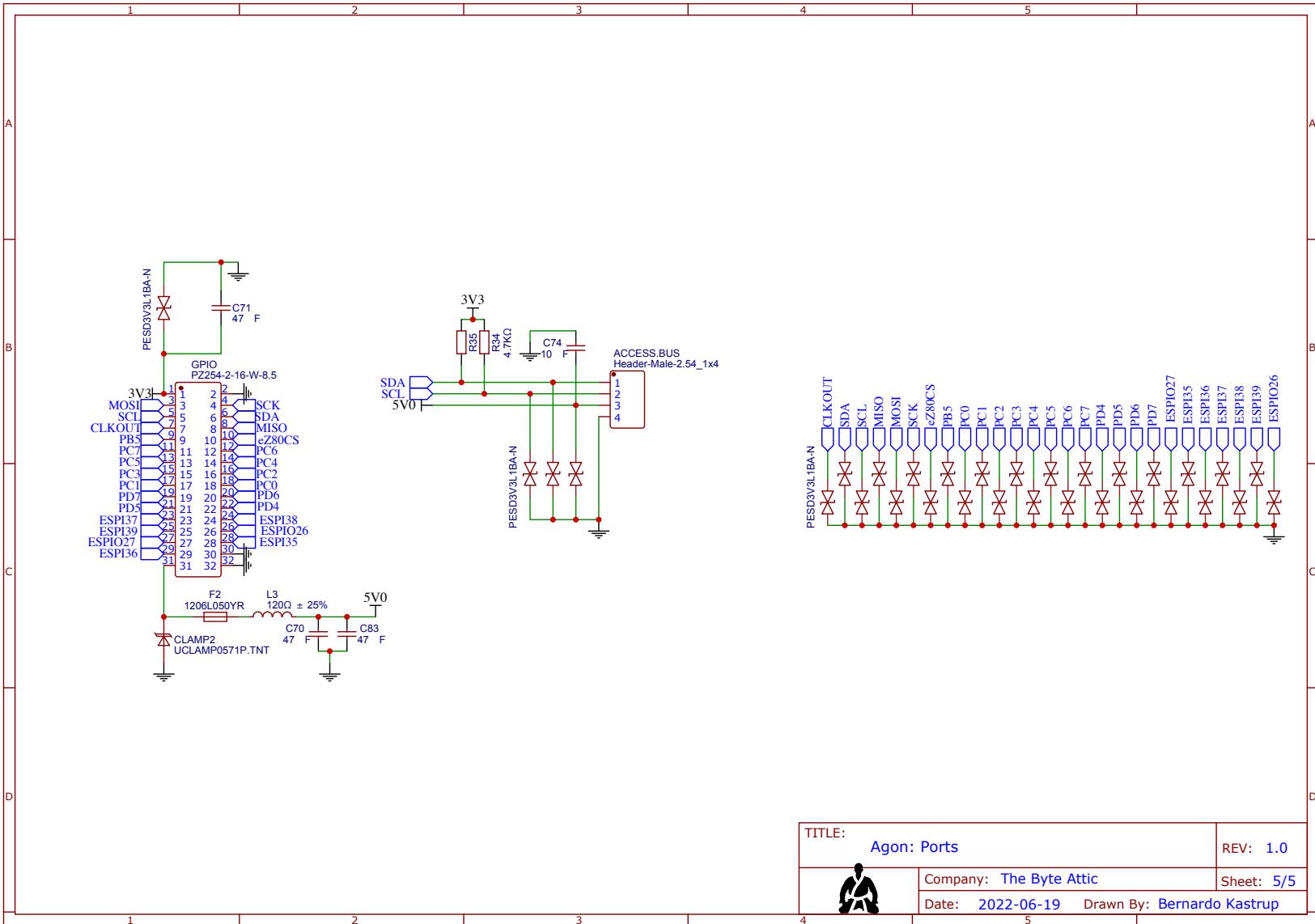










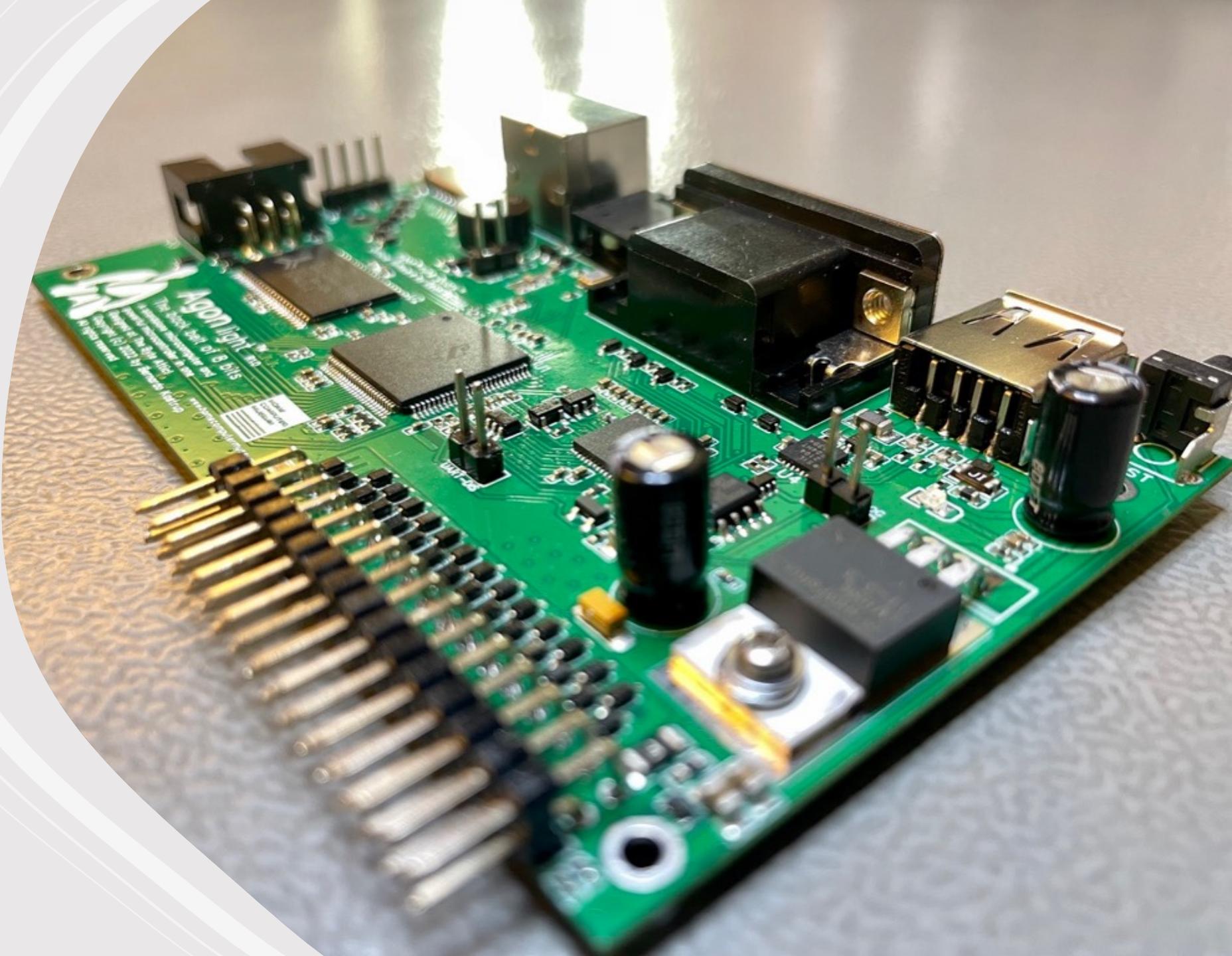




The Byte Attic's

# Agon light™

Bill of  
Materials



ID	Name	Designator	Footprint	Quantity	Manufacturer Part	Manufacturer	Supplier	Supplier Part	Price
1	B08478UTIG	Q4	SOT-23-3_L2-W1.6-P1.90-L52-8-BR	1	BC8478L1T1G	ON	LSC	C4393	0.035
2	R28	R28	R0402	1	0402WGF2001CE	Unidom	LSC	C4109	0.001
3	A5E-18.432MHz-LC-T	OSC	AS18432MHzLC-T	1	A5E-18.433MHz-LC-T	ABRACON	Mouser	815-A5E18.432MHzLC-T	0.384
4	A57C34096A-10TCN	U2	SO28PBP118X12044N	1	A57C34096A-10TCN	Alliance Memory	Mouser	913-A57C34096A-10TCN	0.043
5	PZ256-2-16-W-8.5	GPIO	HOB-TH-32P-2.54-1H-44-R2_CTS-52-54	1	AP1=1.0MMGchip	NETL(华虹美泰)	LSC	C284956	0.049
6	Header-Male-2.54_1x4	ACCESS_BUS	HOB-TH-32P-2.54-1H-44-R2_CTS-52-54	1	AP1=1.0MMGchip	Centow	LSC	C14378	0.049
7	PJ-307C	PI	HOB-TH-4P-1H-44-R2_CTS-52-54	1	AP1=1.0MMGchip	BOOMIC	LSC	C16684	0.043
8	22-28-4020	BIZ-EN-ESP-PROGUART-DIS	HOB-TH-3P-2.54-V.M-1	3	22-28-4020	MOLEX	LSC	C234182	0.076
9	CMT-9648-85T	BUZZER	CMT964885T	1					
10	10nf	C8/C9/C10/C11/C16/C18/C25/C27/C8/C9/C10/C11/C16/C18/C25/C27/C8/C9/C10/C11/C16/C18/C25/C27/C8/C9/C10/C11/C16/C18/C25/C27	C0402_NEW	23	CLO5B10405NNINC	SAMSUNG	LSC	C1525	0.001
11	10pF	C5/C8/C9/C10/C11/C16/C17/C25/C34/C35/C38/C39/C41/C44/C45/C48/C49/C52/C55/C74	C0402	20	CLO5A105M05NUINC	SAMSUNG	LSC	C1525	0.005
12	1pF	C5/C8/C9/C10/C11/C16/C17/C25/C34	C0402	2	0402CG3100C50NT	FH	LSC	C1550	0.001
13	4.7μF	C12/055	C0402	2	CLO5A475UMPNINC	SAMSUNG	LSC	C2773	0.006
14	10nf	C13	C0402	1	CLO5B13U3B5NNINC	SAMSUNG	LSC	C1595	0.001
15	1nF	C56/C57/C58/C59/C60/C61/C62/C63	C0402	8	CLO5A105C05NUINC	FH	LSC	C1523	0.001
16	1uf	C66	C0402	1	CLO5A105C05NUINC	SAMSUNG	LSC	C29266	0.003
17	ELUF/F0471B	C3/31	CAP-SDM-13.2-W1.6-R-RD	2	0402CG3100C50NT	Panasonic	LSC	657-EU-F0471B	0.098
18	10uf	C4	CAP-SDM-13.2-W1.6-R-RD	1	TAJA06061BNJ	AVX	LSC	C7171	0.006
19	33nF	C33	C0003	1	CL10033KBRBNNINC	SAMSUNG	LSC	C23117	0.006
20	1uf	C53	C0005	1	CL218105GBPNINC	SAMSUNG	LSC	C28333	0.009
21	47μF	C70/C71/C73	C0805	3	CL2142750MNINN	SAMSUNG	LSC	C16780	0.026
22	UC1AM9857512-TNT	CLAMP-DIODE	SGP1650N12A	2	UGLMARPS72P1NT	SEATECH	LSC	C51287	0.043
23	IN4148W5/14	D1	SOD-323_L1.8-W1.3-L5.2-RD	1	IN4148W5/14	C	LSC	C2128	0.013
24	PESD3V31BA-N		02-033-04-05-06-07-08-09-011-01 2-013-014-015-016-017-019-020-021-022-023-024-025-026-027-028-029-030-031-032-033-034-035-036-037-038-039-040-041-042-043-044-045-046-047-048-049-050-051-052-053-054-055-056-057-058-059-060-061-062-063-064-065-066-067-068-069-070-071-072	SD-323_L1.8-W1.3-L5.2-BI	PESD3V31BA-N	Bourne Semicon (Shenzhen)	LSC	C346020	0.051
25	E5D3	DB8-ESD-LED-PROT-LED-DB8	DB402-BI	1	0402LS04-05N	Bourne Semicon (Shenzhen)	LSC	C316049	0.019
26	0402ESD-PROT-LED-DB8	PROT2/SDP/PROT3	DB402-BI	5	0402LS04-05N	Bourne Semicon (Shenzhen)	LSC	C316049	0.019
27	JK-15MAD150/6V	F1	F1306	1	JK-15MAD150/6V	JK(金利)	LSC	C280249	0.036
28	1206LS050R	F2	F1206	1	1206LS050R	Uitec	LSC	C163512	0.065
29	IC03216MF-601730	L1	L1206	1	HE3216MF-601730	TAITEC	LSC	C37023	0.028
30	120nf ±25%	L2/L3	L0603	2	BLUM18KG121TN1D	Multata	LSC	C88811	0.017
31	3.1H	L4	IND-SMD-12.2-W0.6	1	ASIC-00402-2801-T	Abracon	LSC	C188816	0.224
32	UM10867-3.3	LDO	TO-220-3_L10-W4.5-P2.54-L	1	UM10867-3.3	HSSEM	C. Directec, I	C444381	0.241
33	CADANIA_JAK30833_JHJC	PS2	PS2-PORT	1	BL-HGE55A-AV-TRB	Bright LED Elec.	LSC	C165984	0.047
34	BL-HGE33A-AV-TRB	PWR	LEDR0805-0-RD	1	UM3B3	LSC	C65882	0.049	
35	UM3B3	Q1	SC70-6_12.2-W1.3-P1.90-L5.2-1-BR	2	AQ3404	GumGum HomeTech	LSC	C192925	0.001
36	A03404	Q2_0.03	SOT-23-3_L2.9-W1.6-P1.90-L5.2-4-BR	1	0402WGF10MTC	Unidom	LSC	C26983	0.001
37	1mA	R1	R0402	1	0402WGF10MTC	Unidom	LSC	C21024	0.001
38	3mA2	R2	R0402	1	0402WGF100TC	Unidom	LSC	C2744	0.001
39	10kΩ	R3_R15/16/19_R30/34/35_R36/1111	R0402	9	0402WGF100TC	Unidom	LSC	C25077	0.001
40	4.7kΩ	R4_R14/R25_3.30_R34/35_R36/1111	R0402	10	0402WGF4701CE	Unidom	LSC	C25900	0.001
41	2kΩ	R5_R12/14_R15/16_R17/18	R0402	6	0402WGF5220TC	Unidom	LSC	C27948	0.001
42	47kΩ	R6/7	R0402	2	0402WGF4701CE	Unidom	LSC	C25117	0.001
43	40kΩ	R8/12/R13	R0402	3	PTFF04024024BKN9	RES(研华)香港	LSC	C262962	0.079
44	80kΩ	R9/10/R11	R0402	3	TC0228B8600TC	Uniroyal Elec.	LSC	C150511	0.061
45	100	R12/R18	R0402	2	0402WGF100TC	Unidom	LSC	C25077	0.001
46	330	R31_R32/R34/35_R36/1111_R37/1718_R38/1719_R39/1720	R0402	12	0402WGF330TC	Unidom	LSC	C25105	0.001
47	47kΩ	R37/1718_R38/1719_R39/1720	R0402	5	0402WGF4701CE	Unidom	LSC	C27942	0.001
49	1500	R23	R0603	1	0603WAF15005E	Unidom	LSC	C22966	0.002
50	TF-01A_CZB891258	SD	TF-01A	1	TF-01A	Vland(台湾元通)	LSC	C28208	0.002
51	EZ80F924202DEG	U1	QFP55PQFP55QFN160X160X160N	1	EZ80F924202DEG	Zilog	LSC	C2889328	0.088
52	ESP32-F02-GMR	U3	QFN-44_L7D-W7-P0-0030-BLEP2.6	1	ESP32-F02-GMR	Espresso Systems	LSC	C193707	3.82
53	CP2104-F03-GMR	U4	QFN-44_L7D-W7-P0-0030-BLEP2.6	1	CP2104-F03-GMR	SILICON LABS	LSC	C47015	2.361
54	AP5640L-350	U5	SOT-23-3_L2.9-W1.6-P1.90-L5.2-8-BR	1	AP5640L-350-5N	Diodes Incorporated	LSC	C143831	0.001
55	AP5640S-35A-7	U6	SOT-23-3_L2.9-W1.6-P1.90-L5.2-8-BR	1	AP5640S-35A-7	Diodes Incorporated	LSC	C29554	0.087
56	SNT4UIC1G250BIR	U7/U8	SOT-23-5_L3_W1.7-P1.90-L5.2-8-BR	2	SNT4UIC1G250BIR	TI	LSC	C7827	0.112
57	SNT4UIC1G250BIR	U9	SOT-23-5_L3_W1.7-P1.90-L5.2-8-BR	1	SNT4UIC1G250BIR	TE Connectivity	LSC	C86461	0.407
58	U77HDF1550DICHARRINGVA	U10	U77HDF1550DICHARRINGVA	1					
59	222303-1	U77HDF1550DICHARRINGVA	U11	292303-1					
60	61300621721	ZD1	SHDR46W64P254254	1	SHDR46W64P254254	Yuanli	LSC	C499319	0.062
61	TS-1093A-A12B3-D2	RST	KEY-TI_4P_L7-1_W12-A4_P4_S01_L52.5	1	TS-1093A-A12B3-D2	Yuanli	LSC		



The Byte Attic's

# Agon light™

PCB

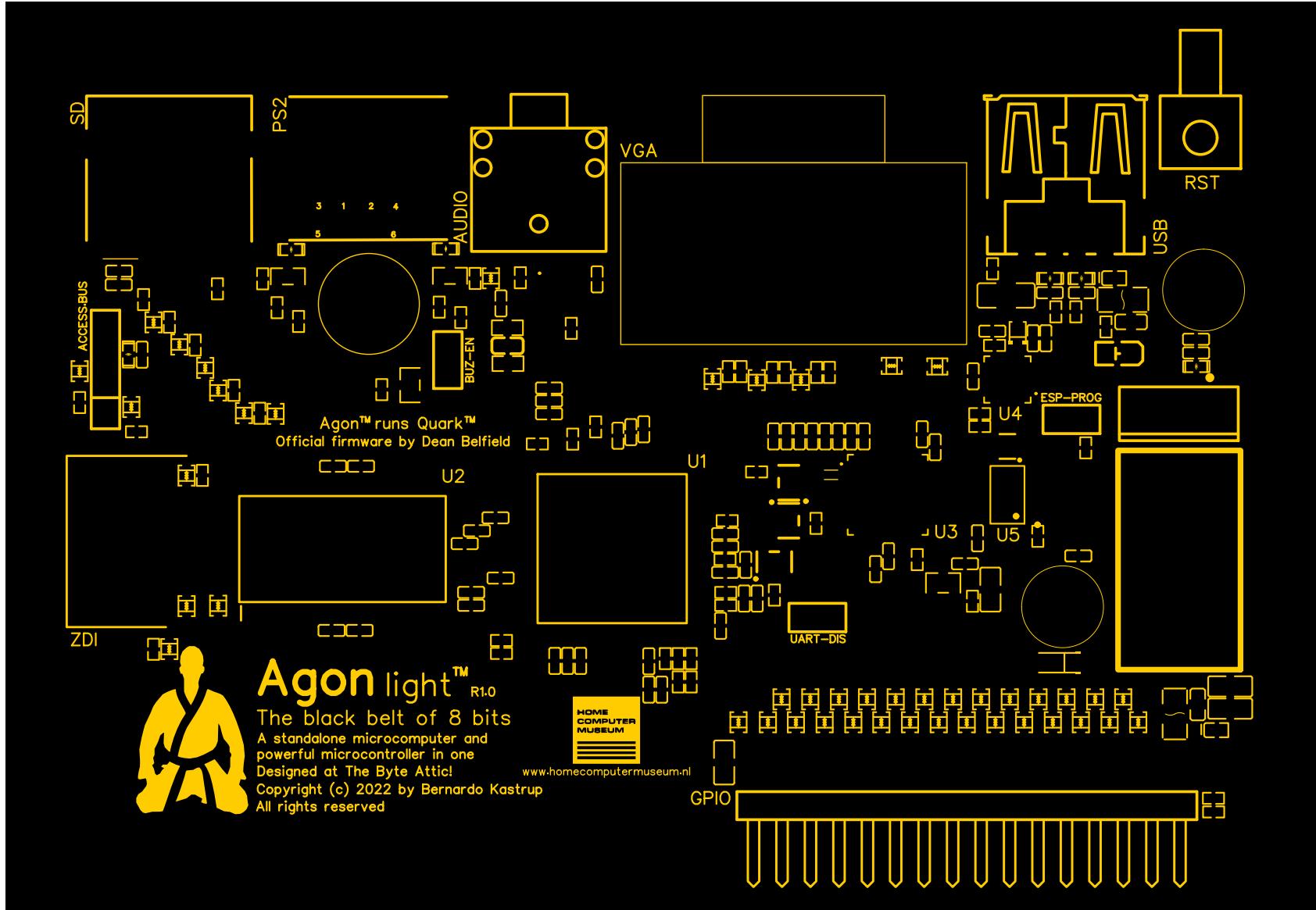


# PCB dimensions (diagram *not* to scale)

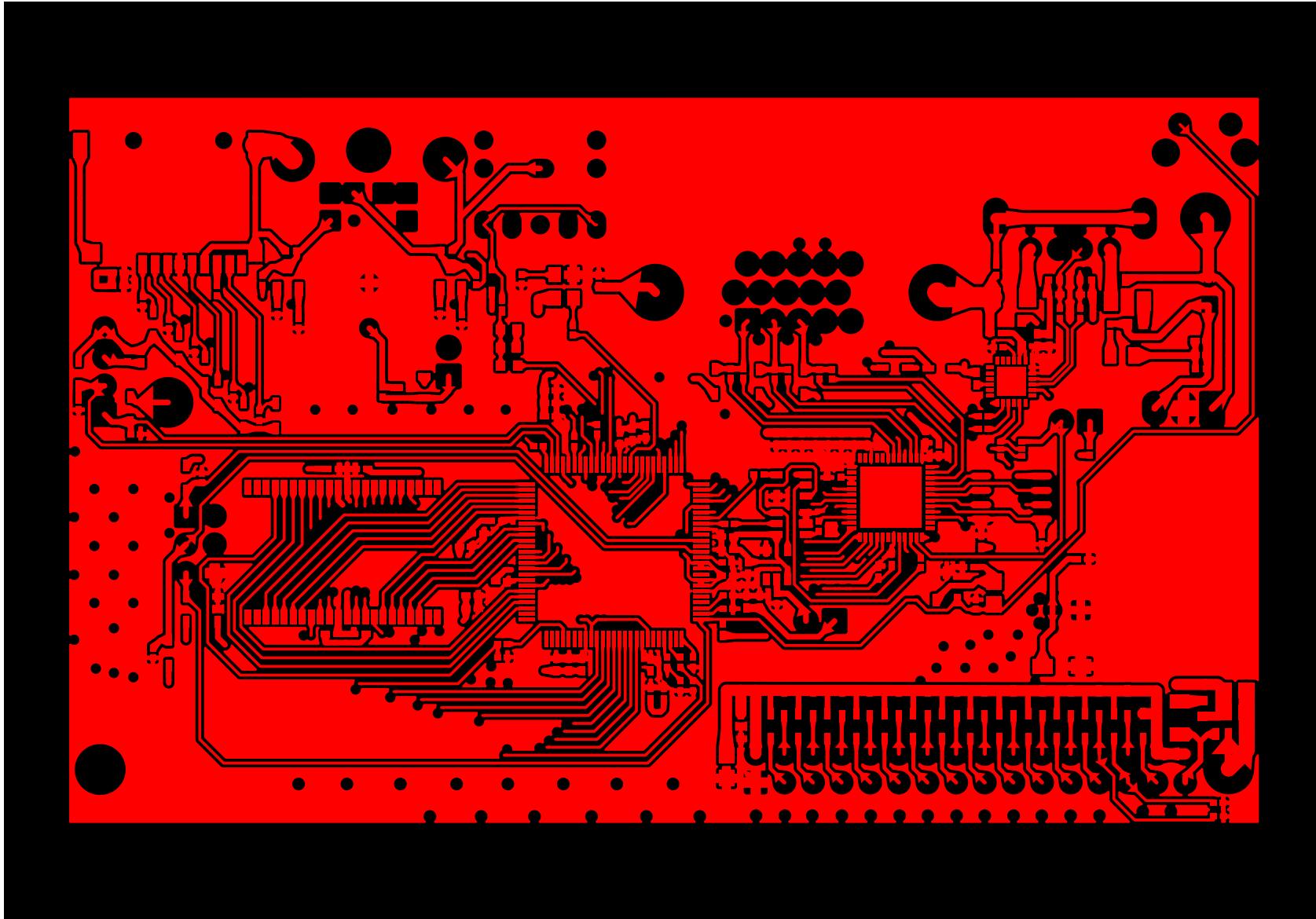


All holes  
are  
2.505mm  
in  
diameter

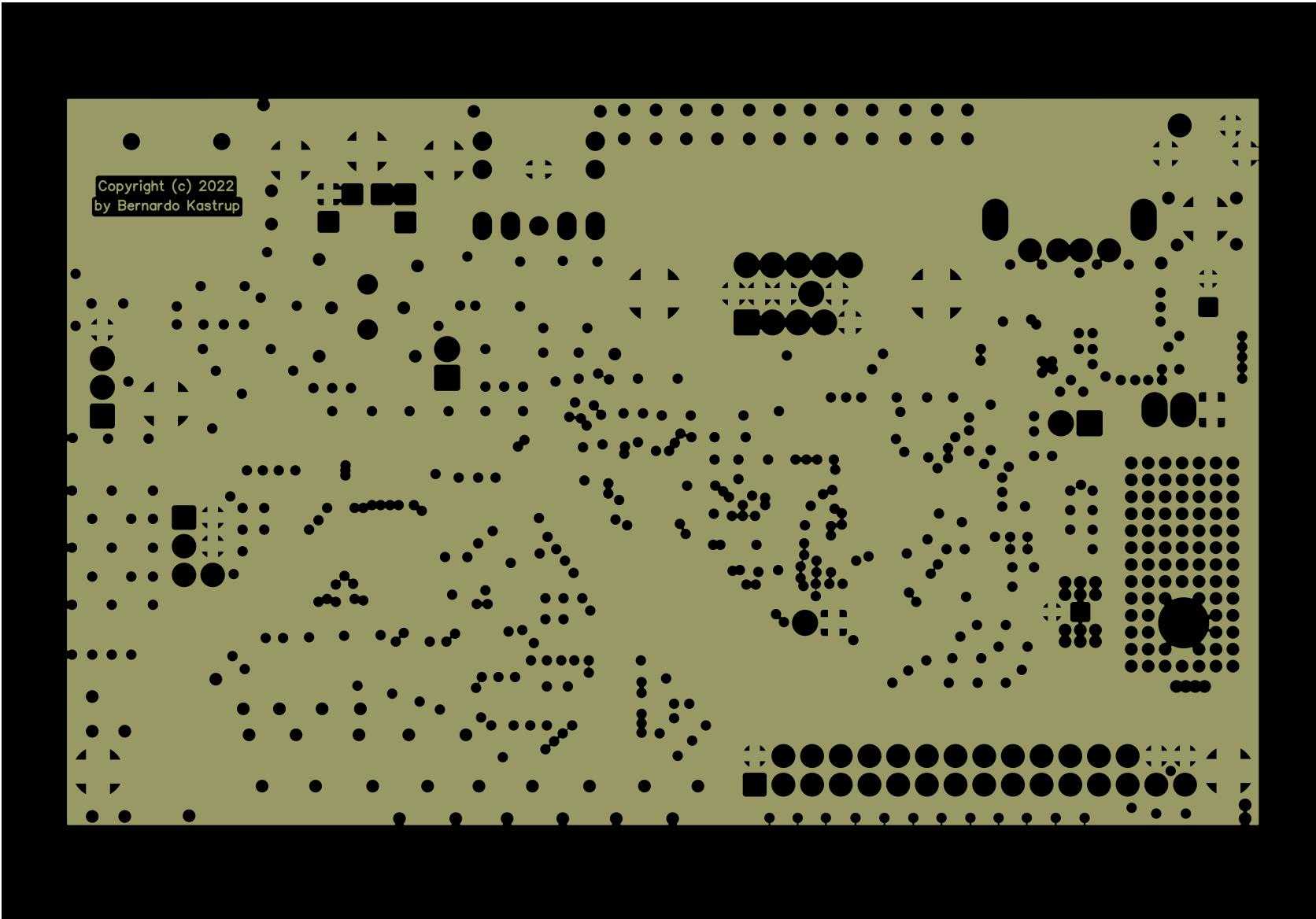
# Top silkscreen



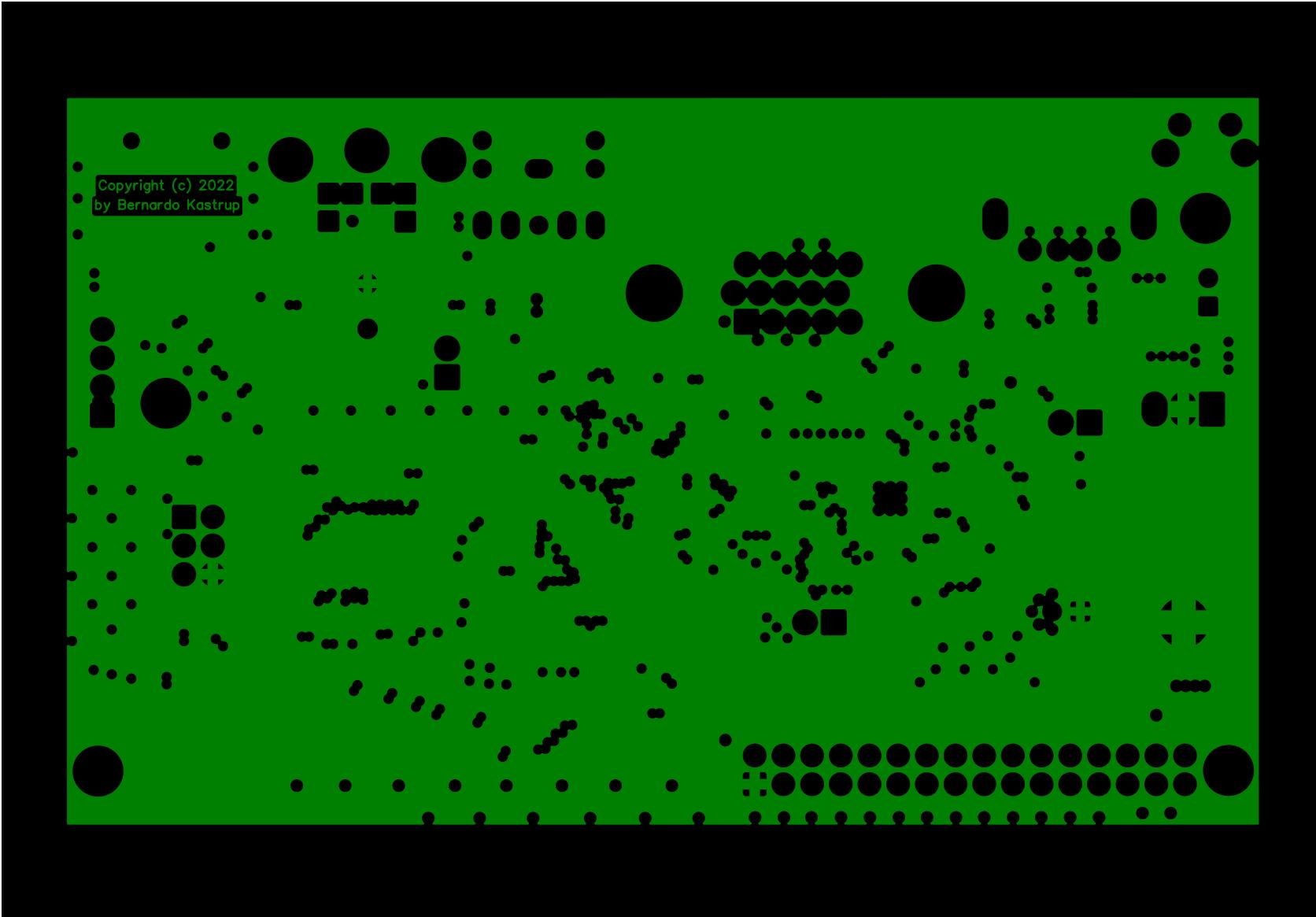
Top metal layer (3.3V filled)



## First inner plane (GND)



## Second inner plane (3.3V)



Bottom metal layer (GND filled)

