



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), audio (2 identical mono channels), accepts a PS/2 keyboard and has µSD-card storage
- Features a control port with SPI, I²C, 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



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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
 - 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 (384 kilobits per second), featuring flow control

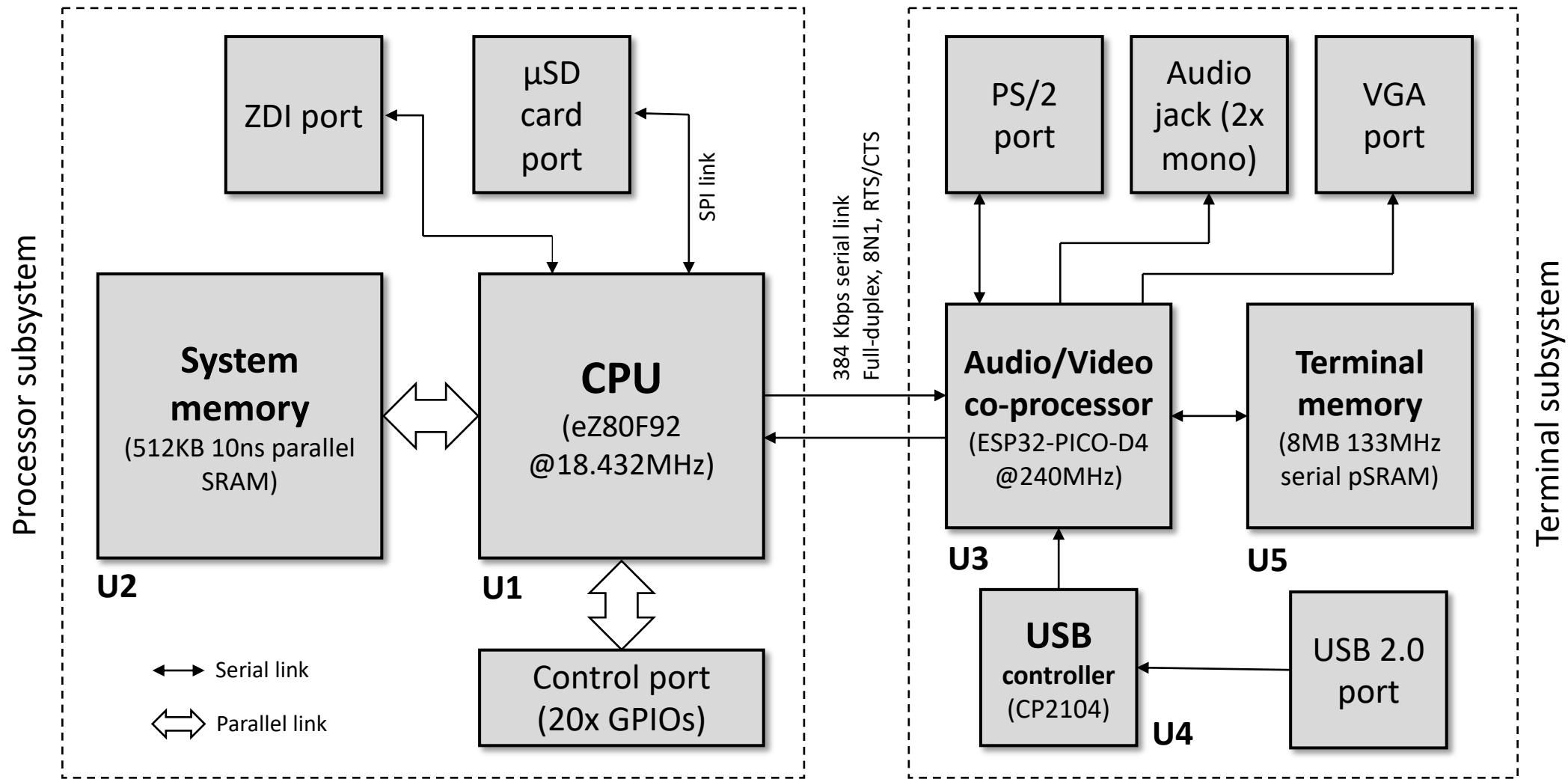
* Requires installation of Quark™ firmware

Theory of operation

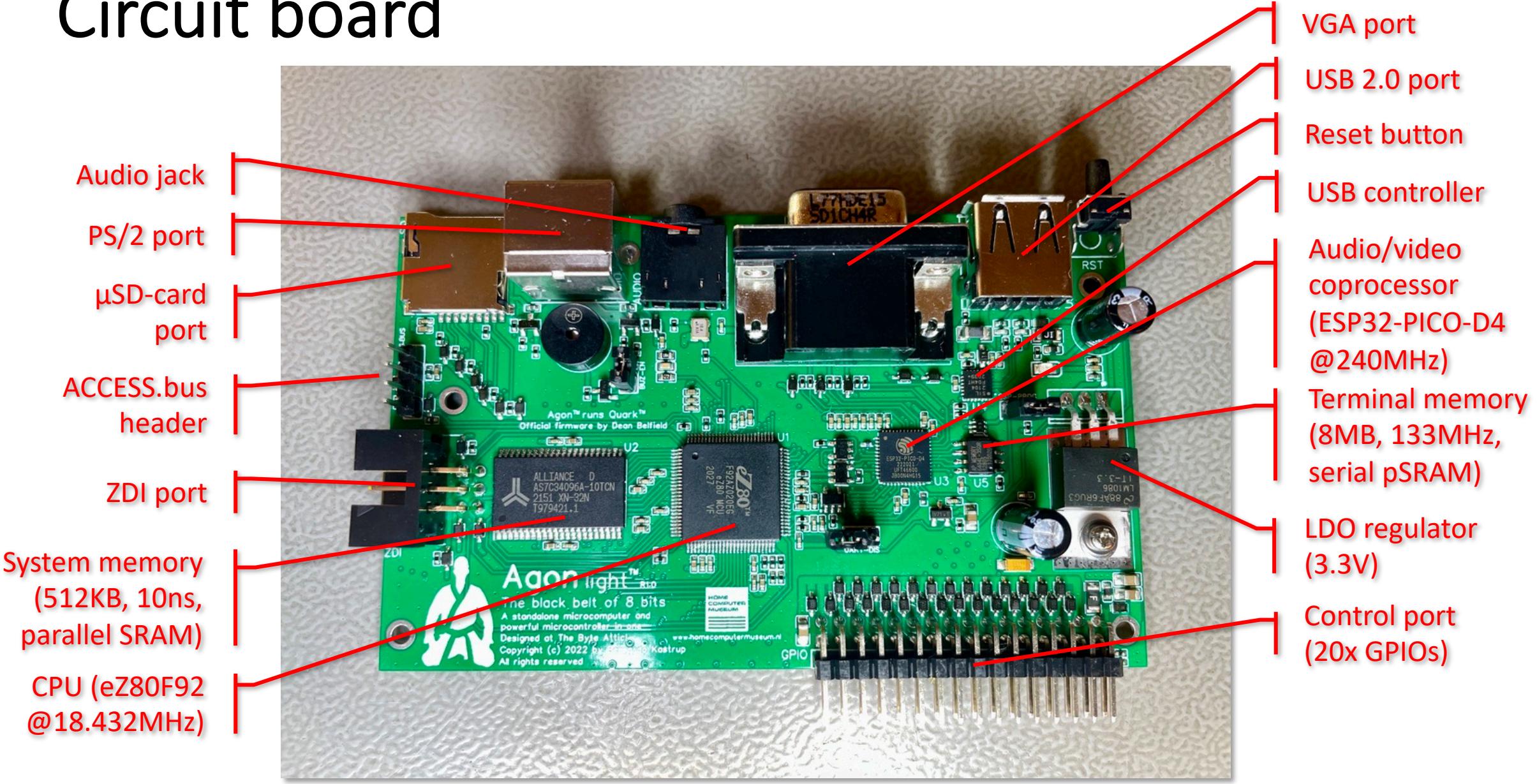
- The *terminal subsystem*:
 - Reads out the (PS/2) keyboard and sends the corresponding keypress tokens to the CPU via a high-speed serial link
 - Generates the screen based on display-list commands issued by the CPU and sent to the ESP32 via a high-speed serial link
 - Produces the VGA & audio signals
 - 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 (μ SD-card)

* Requires installation of Quark™ firmware

System diagram



Circuit board

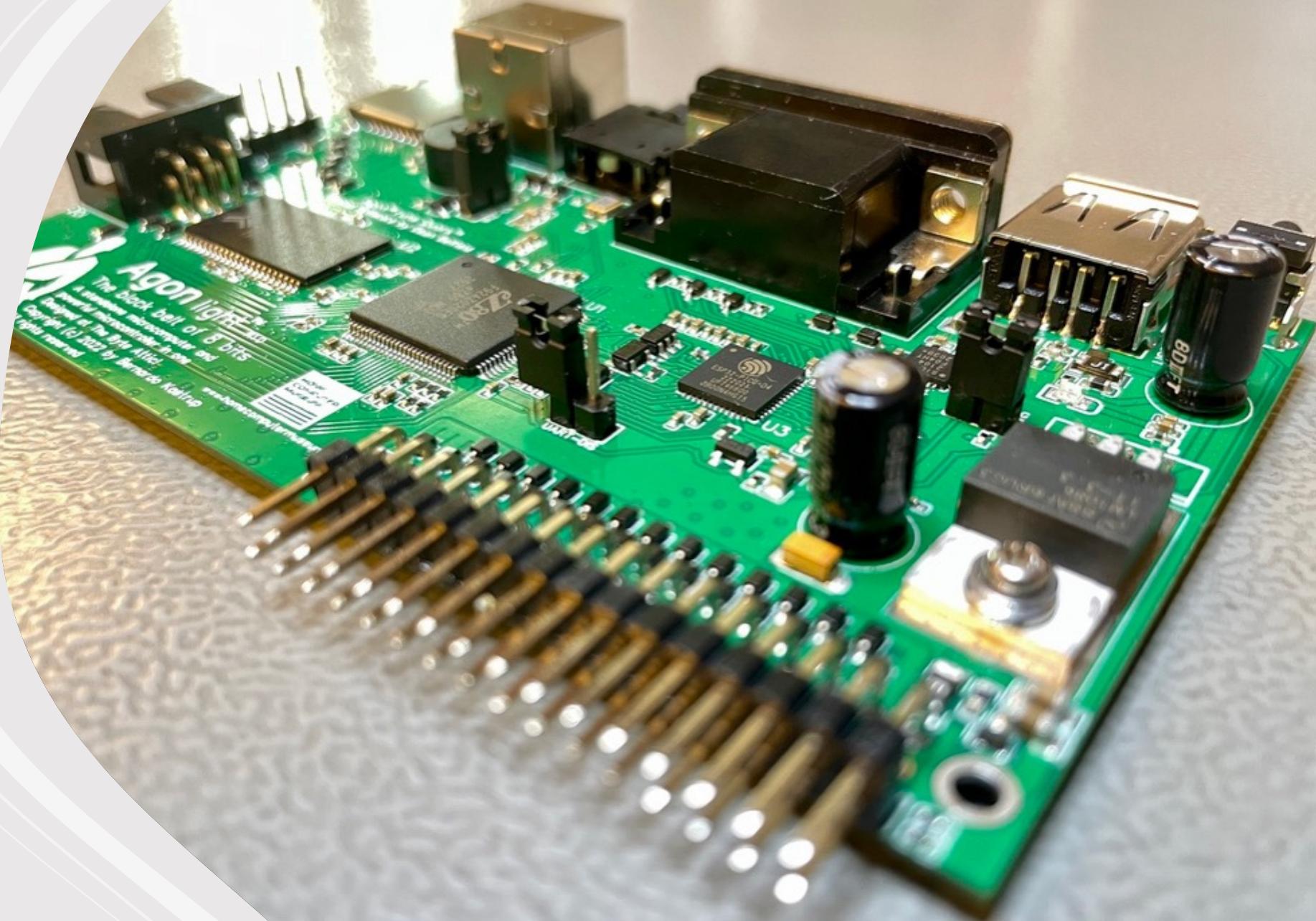




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User's
guide

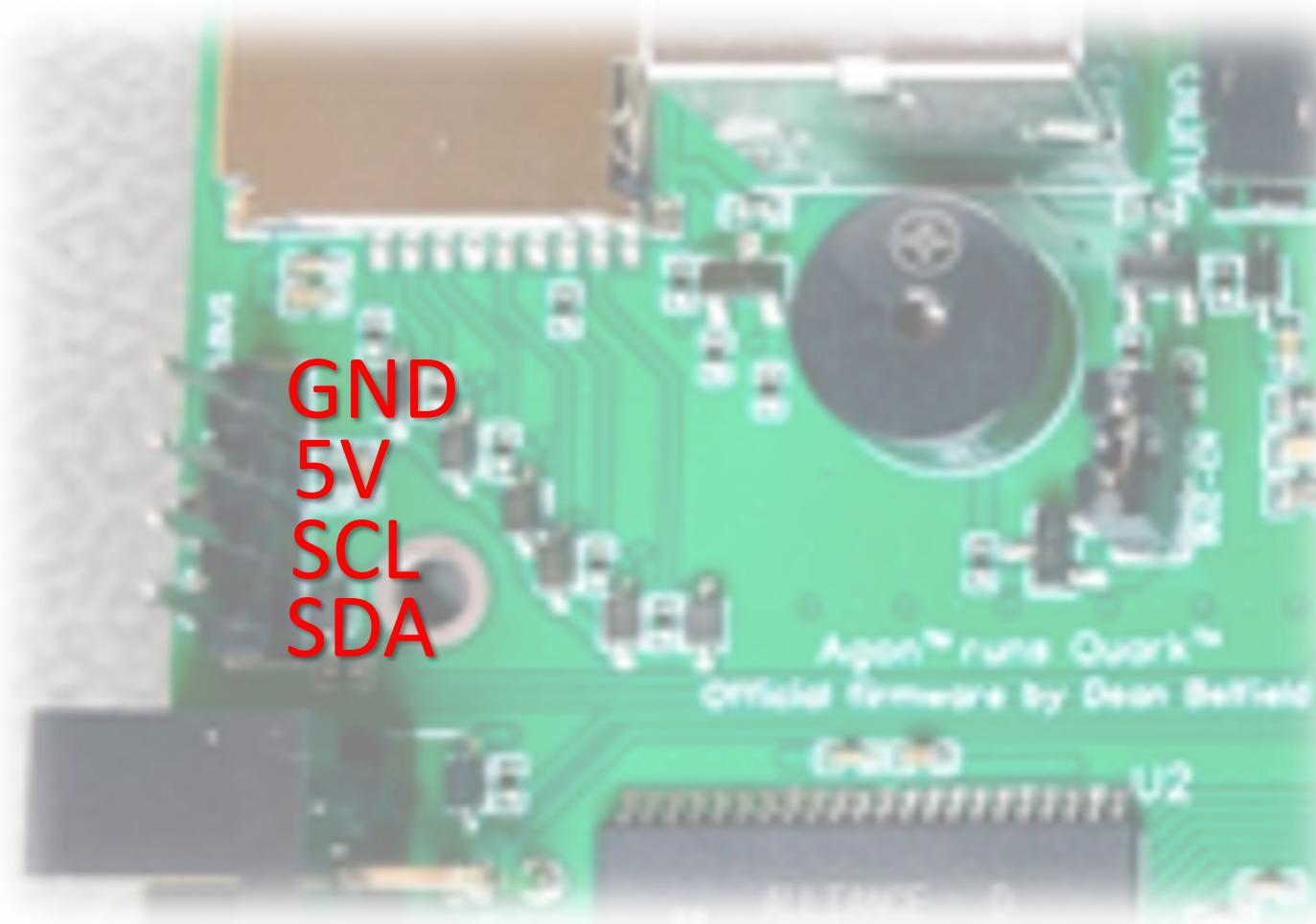


Control port pinout

3.3V	GND
MOSI	SCK
SCL	SDA
CLKOUT	MISO
PB5	EZ80CS
PC7	PC6
PC5	PC4
PC3	PC2
PC1	PC0
PD7	PD6
PD5	PD4
ESPI37	ESPI38
ESPI39	ESPI26
ESPI27	ESPI35
ESPI36	GND
5V	GND

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

Channel: full duplex, asynchronous

Baud rate: 384,000 bits per second

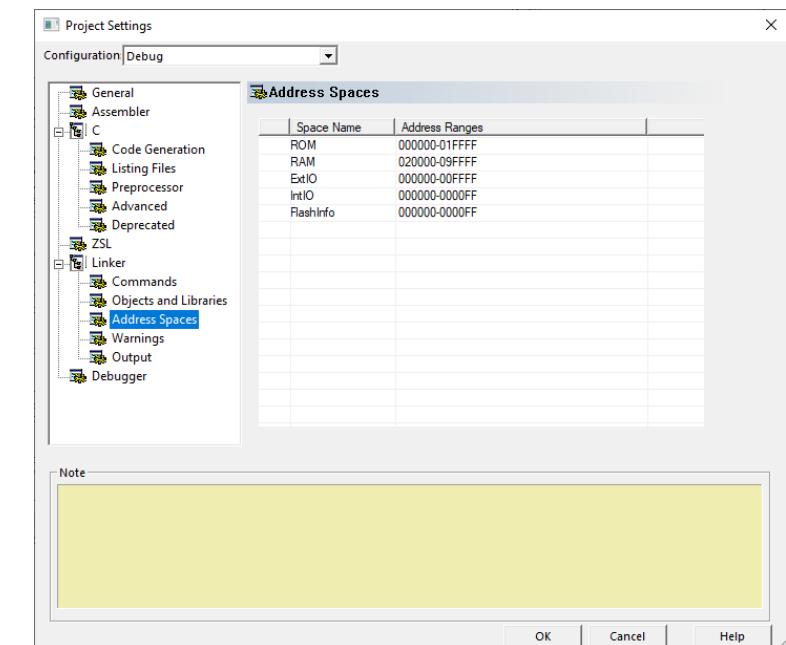
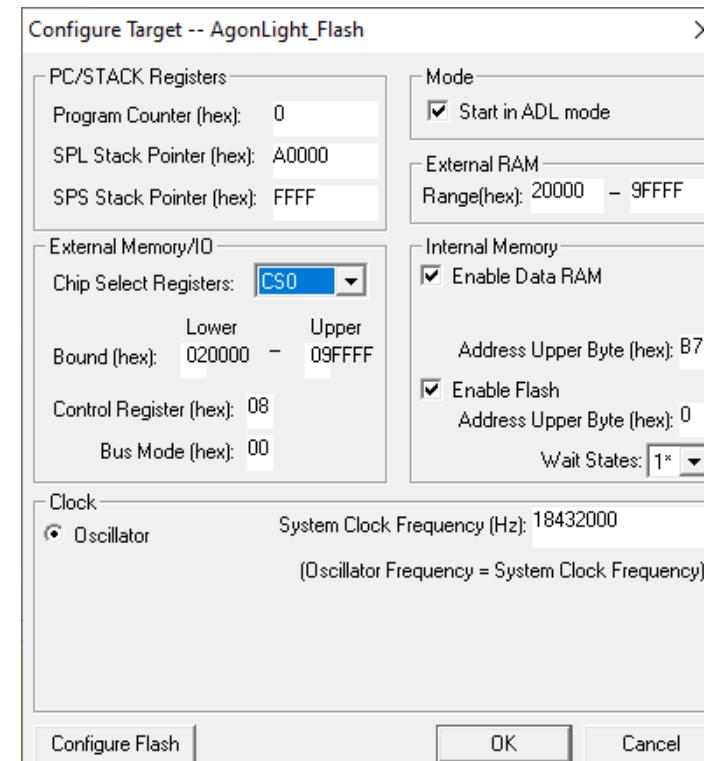
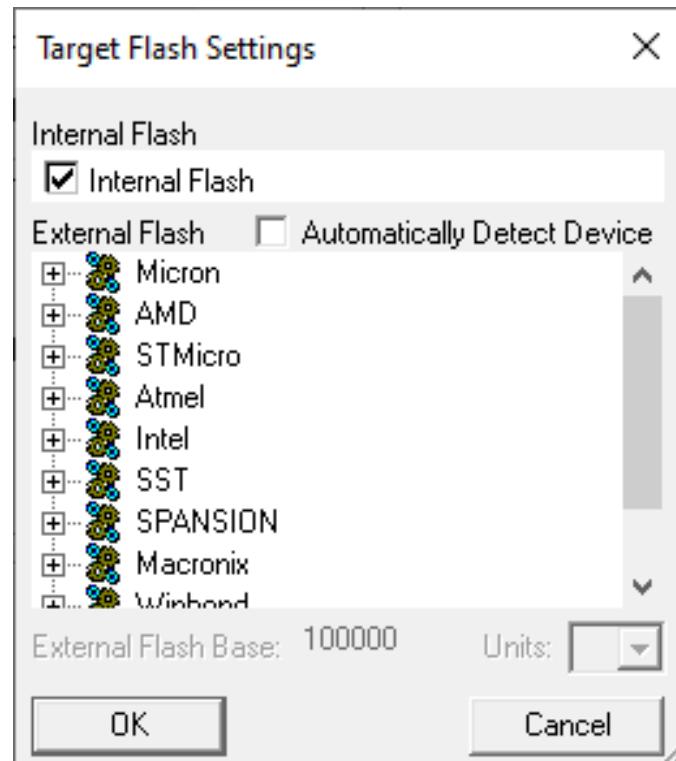
Signal structure: 1 start bit, 8 data bits, 1 stop bit,
no parity bit (8N1)

Flow control: CTS/RTS

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

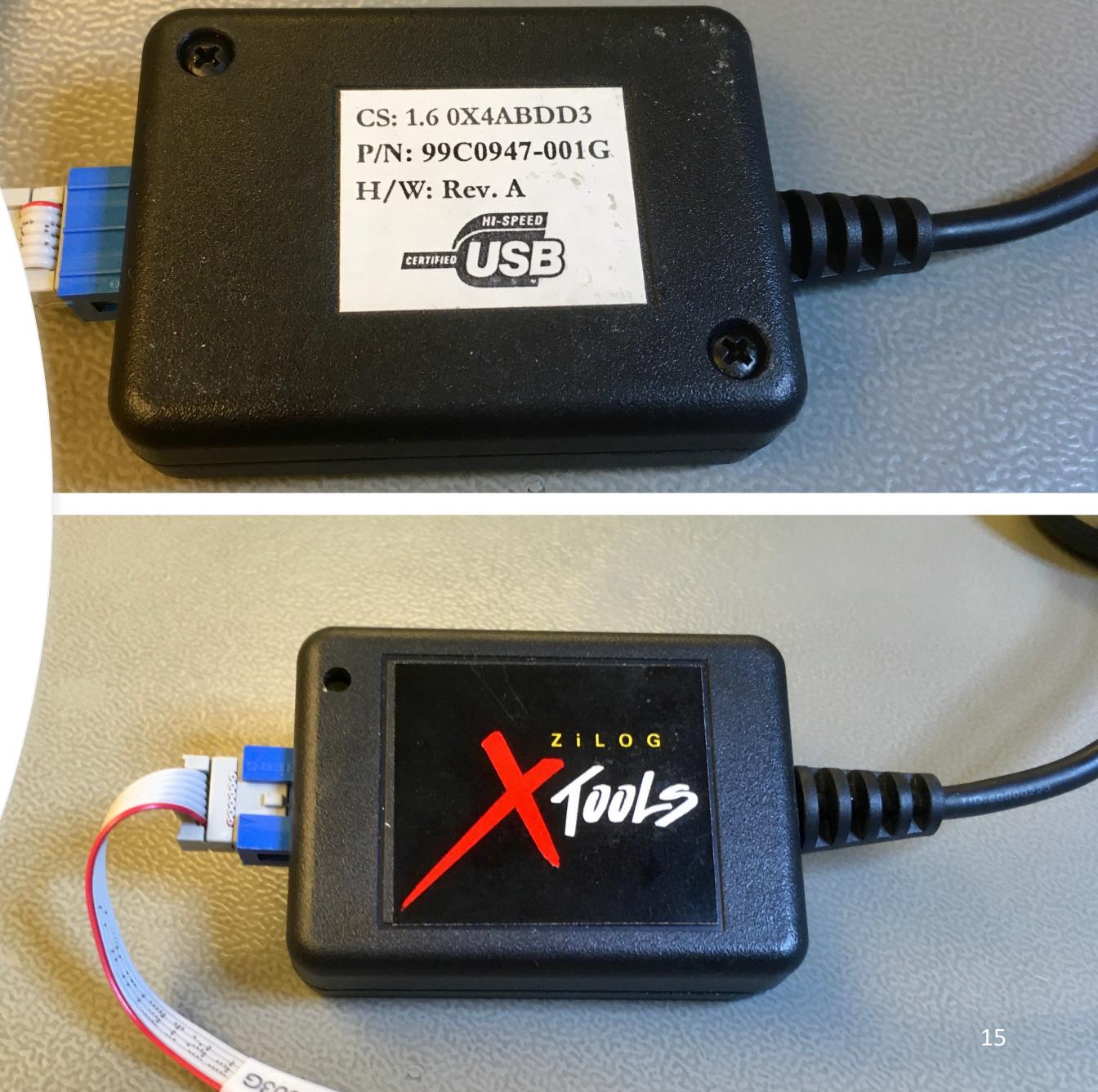
Developing firmware for the eZ80F92

- Use the freely-available Zilog ZDS-II™ IDE
- Installation files and documentation are provided in the Agon light Github repository, in the directories /Third party tools and /Third party documentation, respectively
- Configure your project as per the figures below (CS1, CS2 and CS3 are *not* used in Agon light, so their settings don't matter)



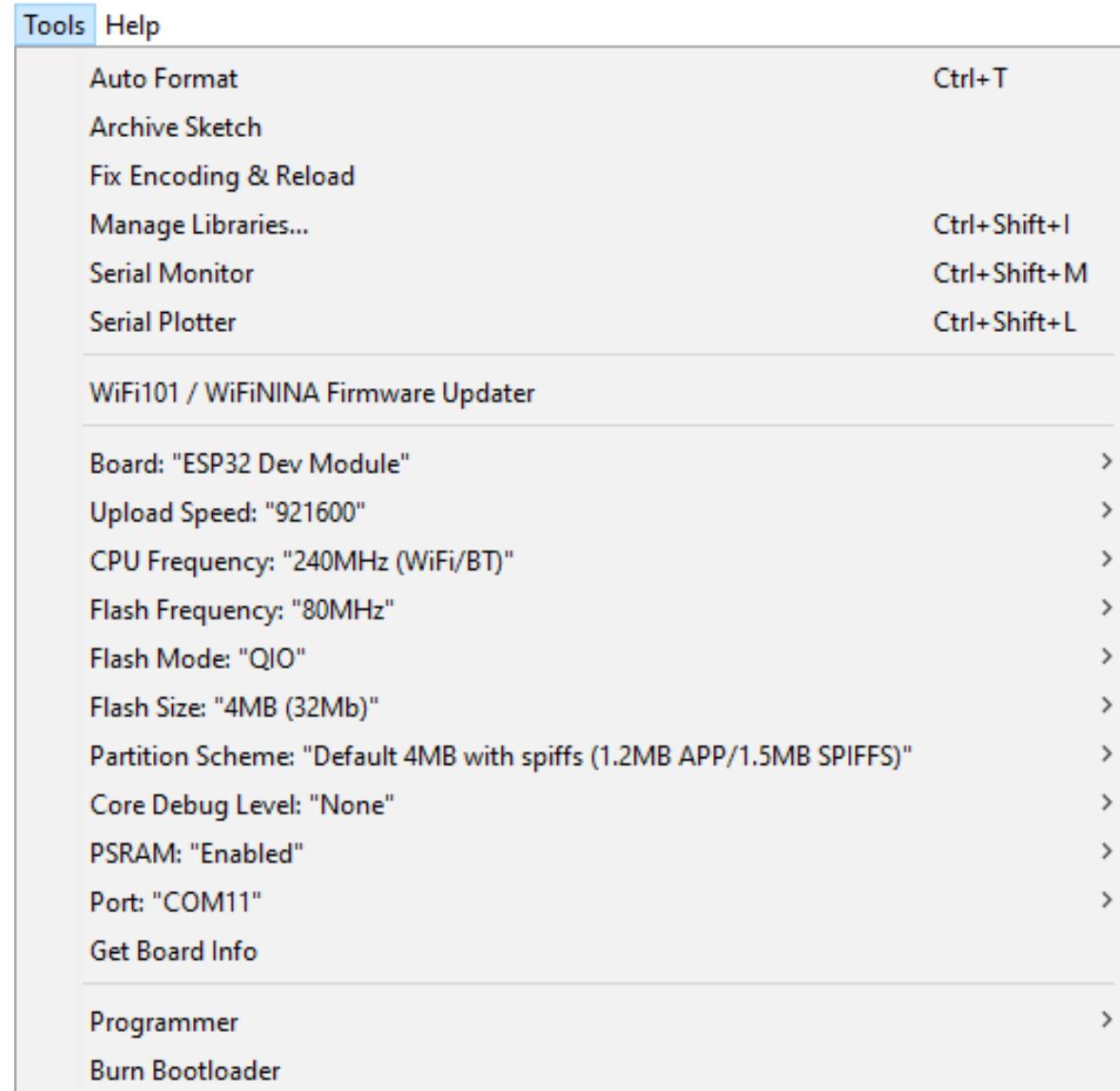
Required programming/debugging USB smart capable

- 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

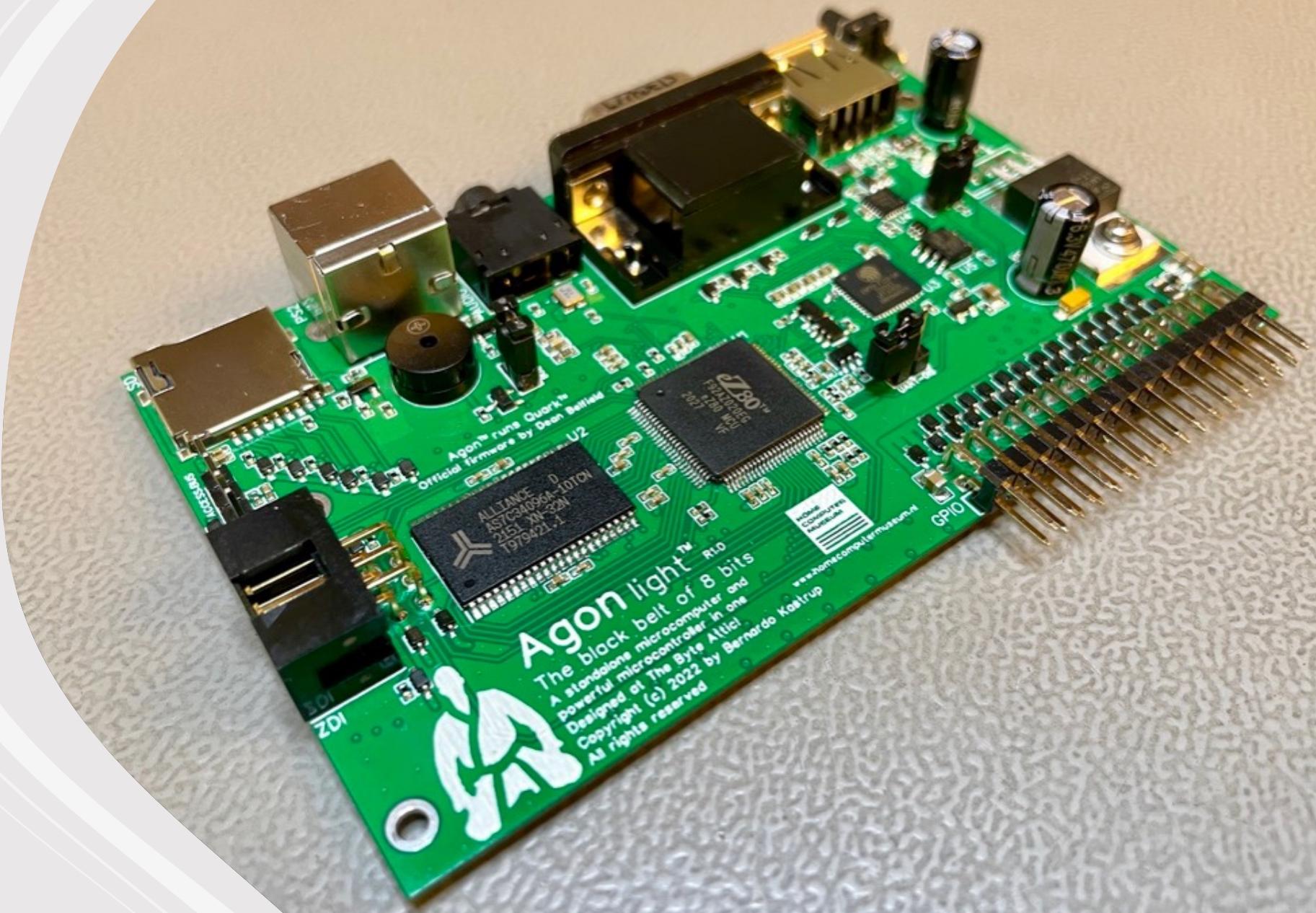




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Assembly
guide

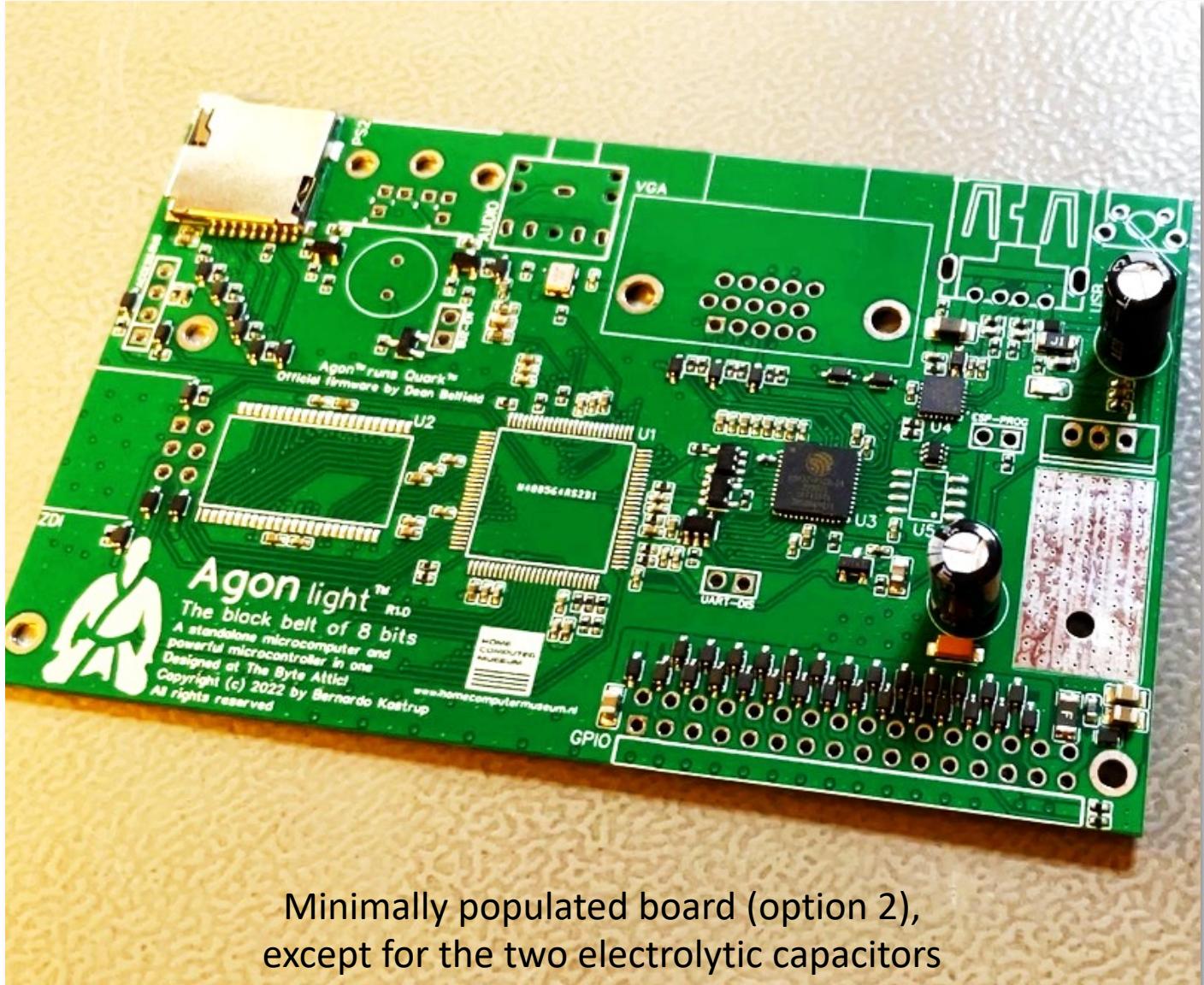


Assembly options

- 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

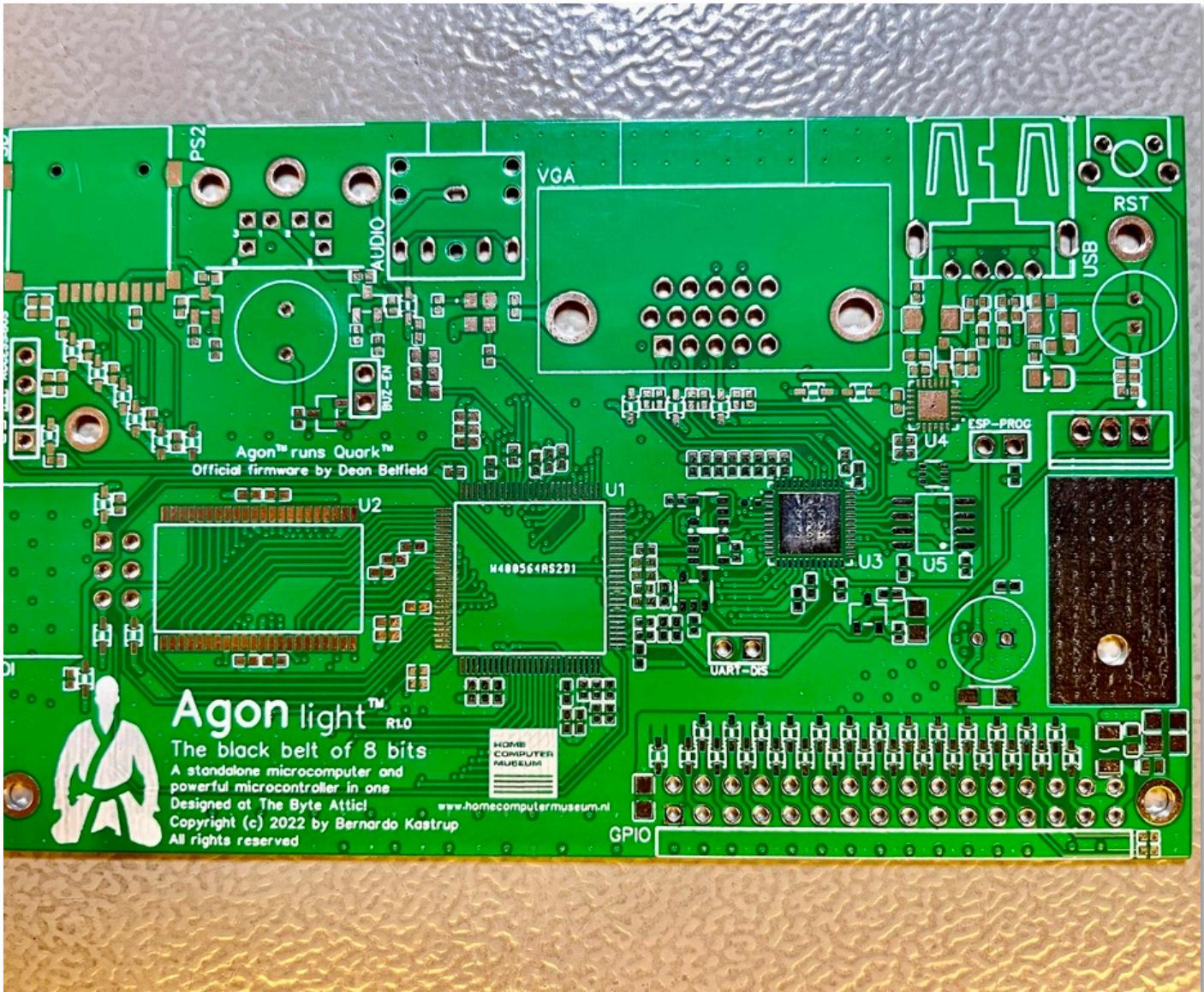
- All files are available in the /Manufacturing directory of Agon light's Github repository at:
<https://github.com/TheByteAttic/AgonLight>
- For option (4), send the following files to your PCB manufacturer, next to the Gerber file (`Gerber_PCB_AgonLight_R1.0.zip`):
 - `PickAndPlace_PCB_AgonLight_R1.0.csv`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

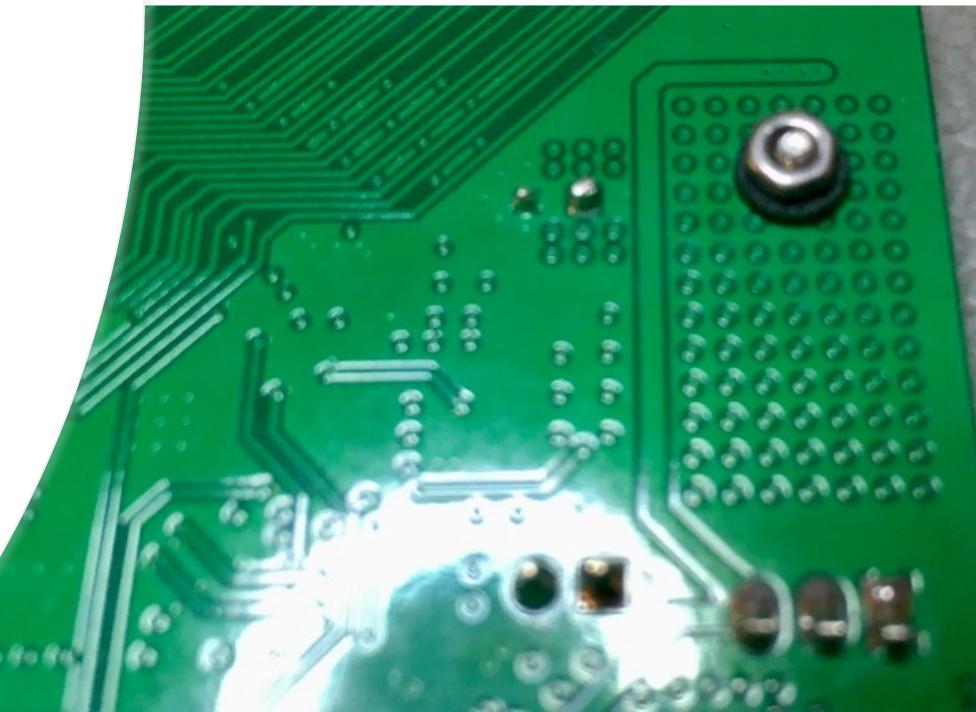
PCB layer stack

- 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 flood)
 - *Inner1* (GND plane)
 - *Inner2* (3.3V plane)
 - *BottomLayer* (signals + GND copper flood)
- Agon light has tiny Vias: **0.4mm** diameter with **0.205mm** drill holes, so choose a compatible process with your manufacturer
- I recommend total PCB thickness of **0.8mm**, so to improve signal integrity

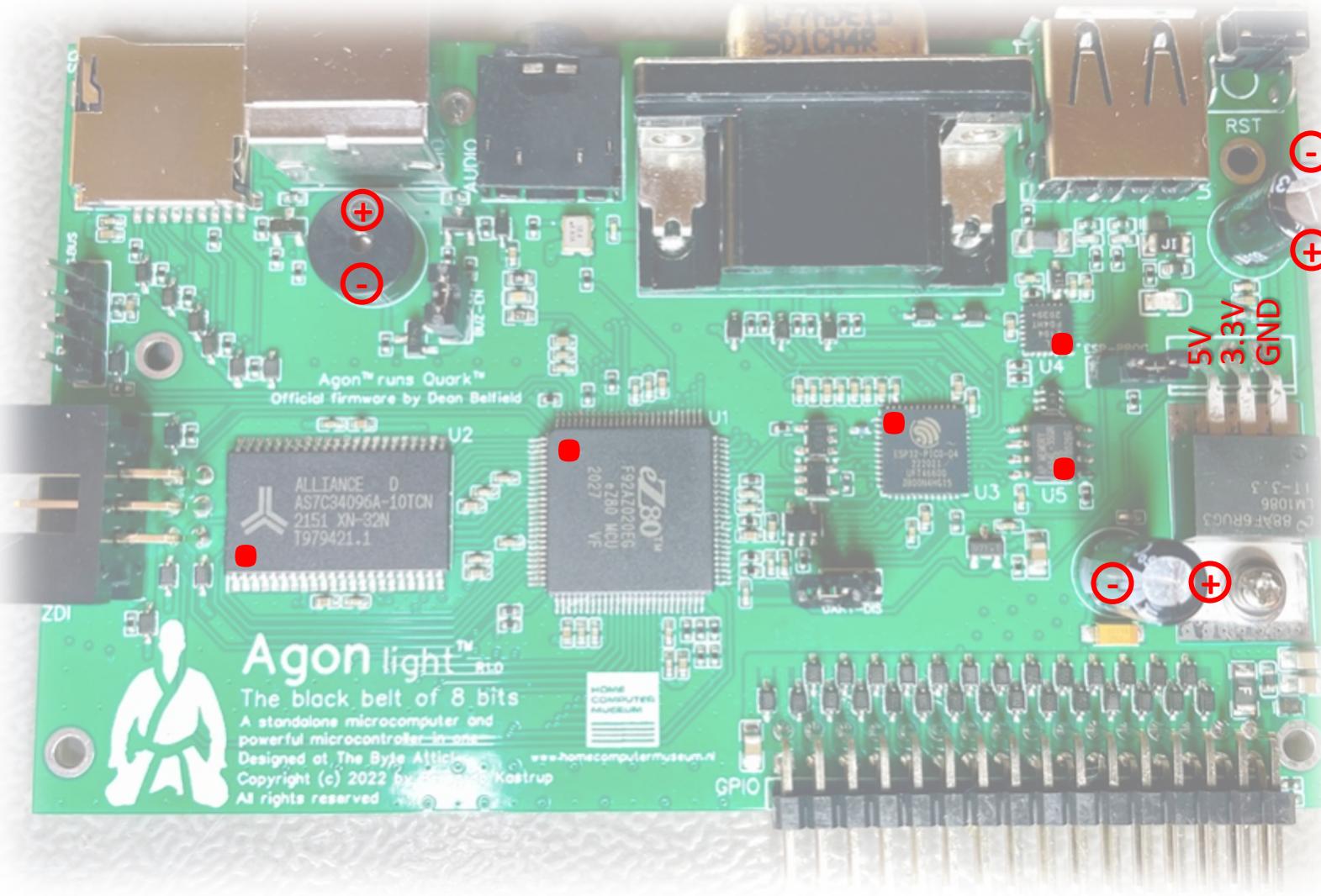


Mounting the LDO regulator

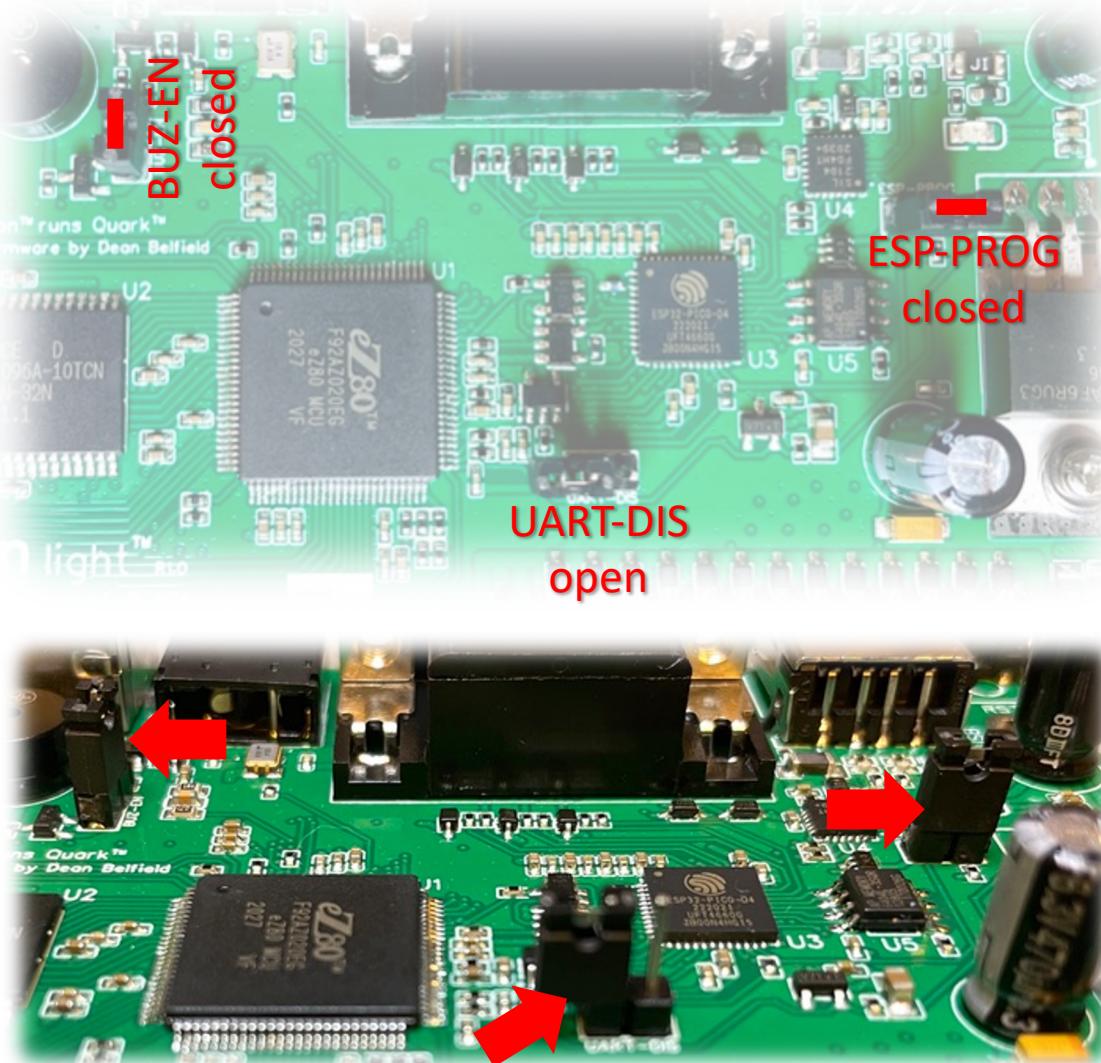
- Agon light's 3.3V V_{cc} rail is provided by a Low-DropOut (LDO) linear regulator
- The regulator must be mounted flush against the corresponding exposed metal area on the top of the PCB (see top-right photo)
- The regulator's tab (chassis) is at 3.3V, as is the exposed copper area on which it is to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

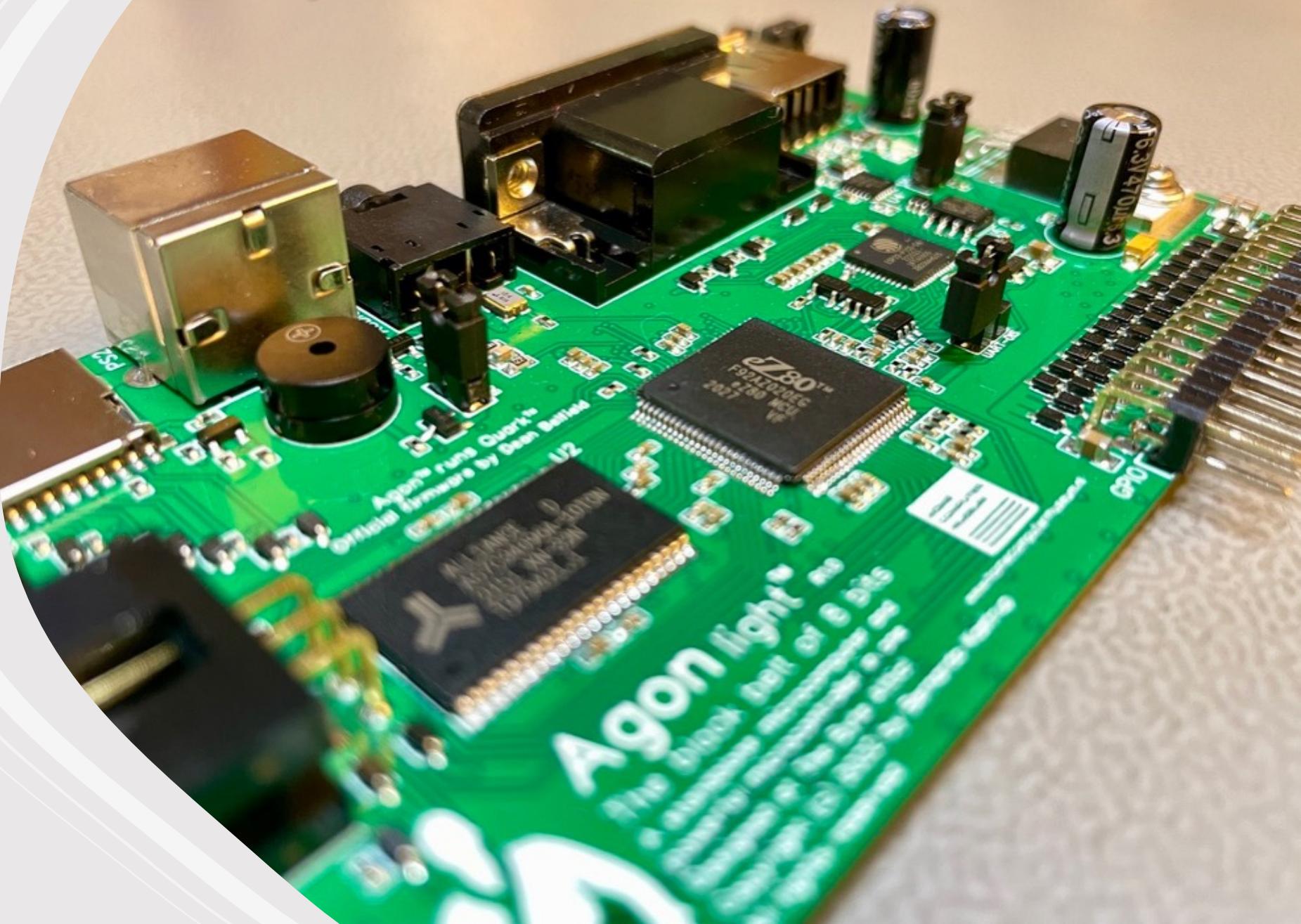


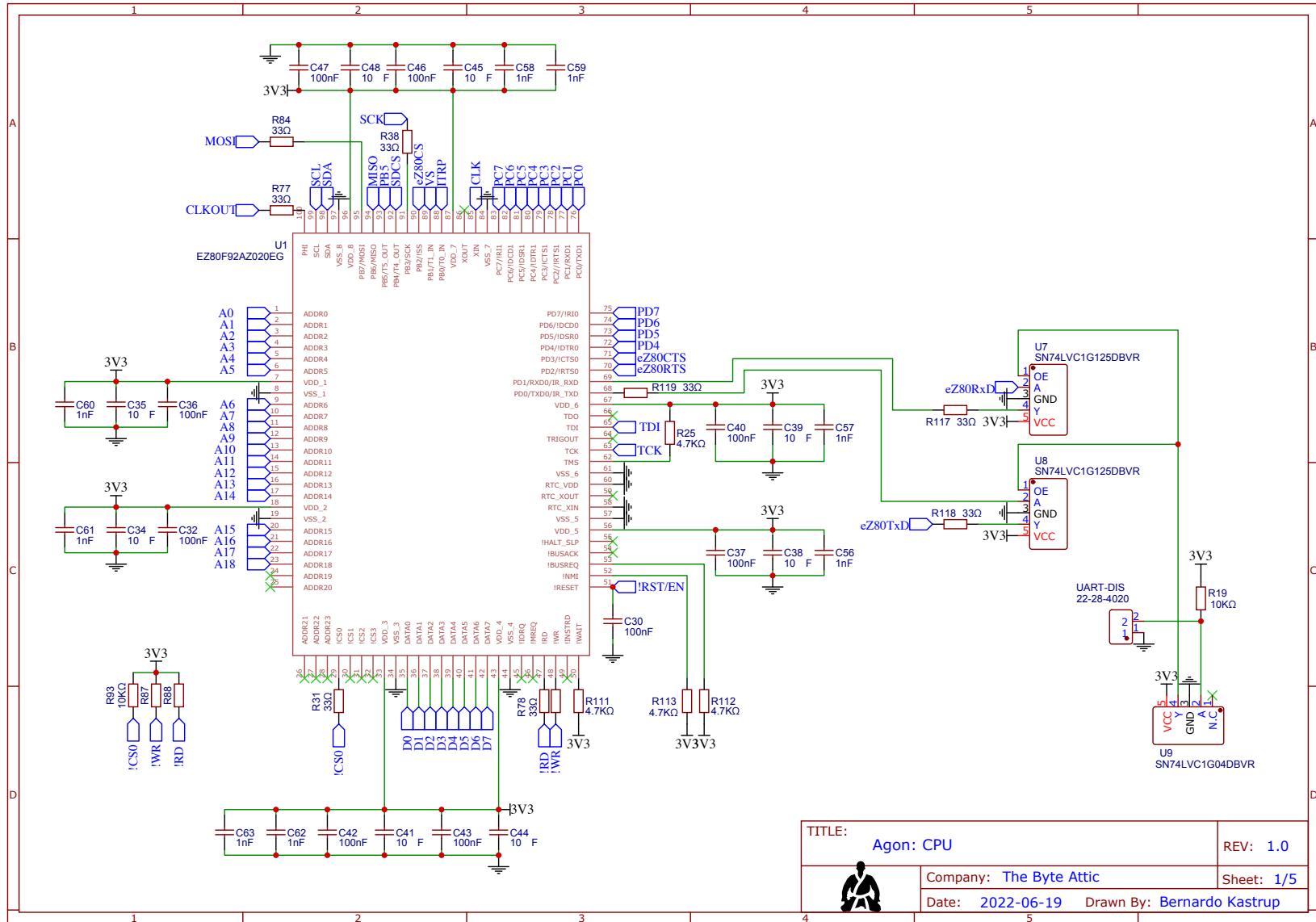
When to change jumper settings

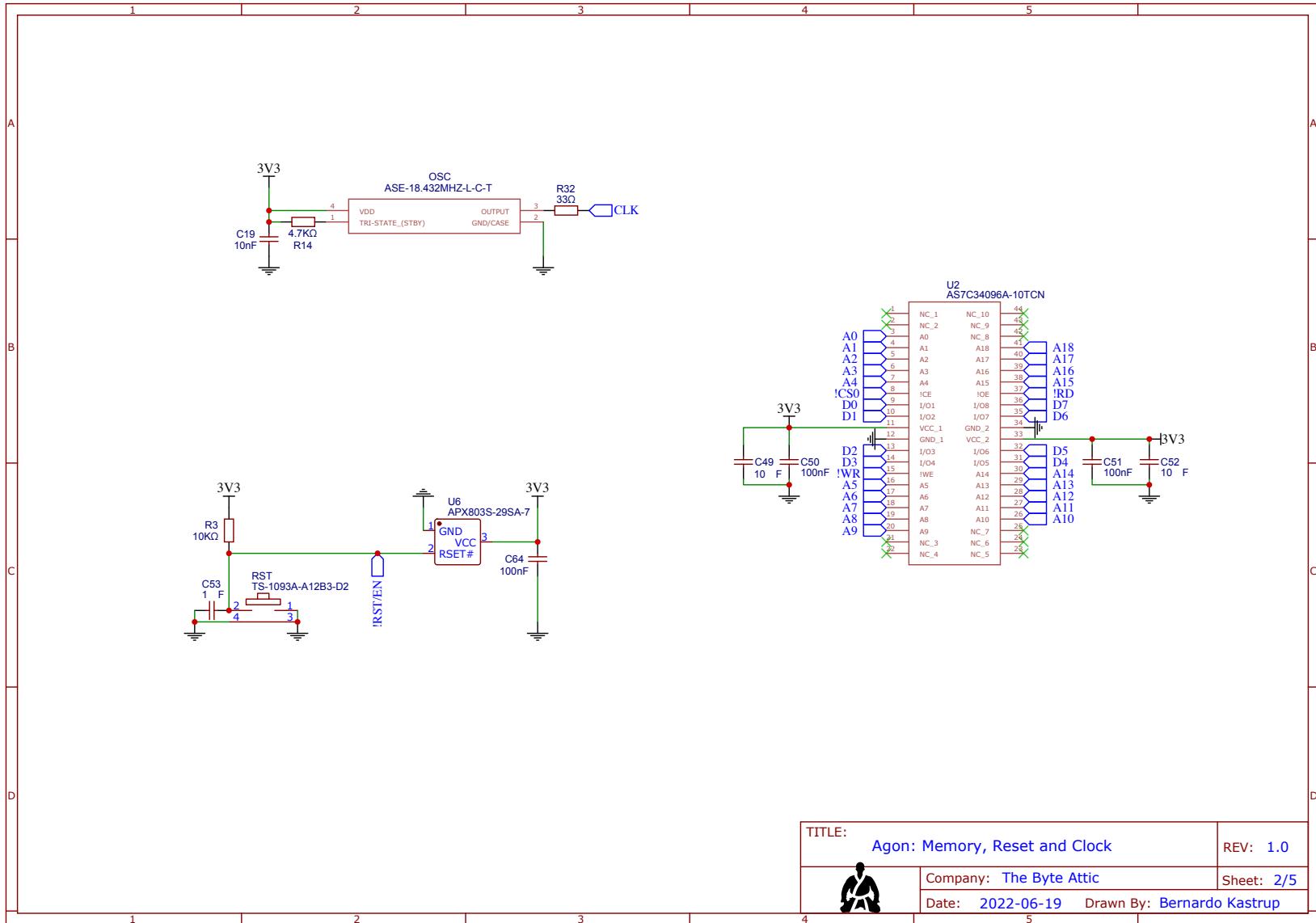
- Agon light should operate normally during both firmware programming and application execution with the default jumper settings (see previous page), but the ESP32 is known to be a sensitive device
 - Therefore, Agon light has built-in resources to deal with that sensitivity
- If the ESP32 goes into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

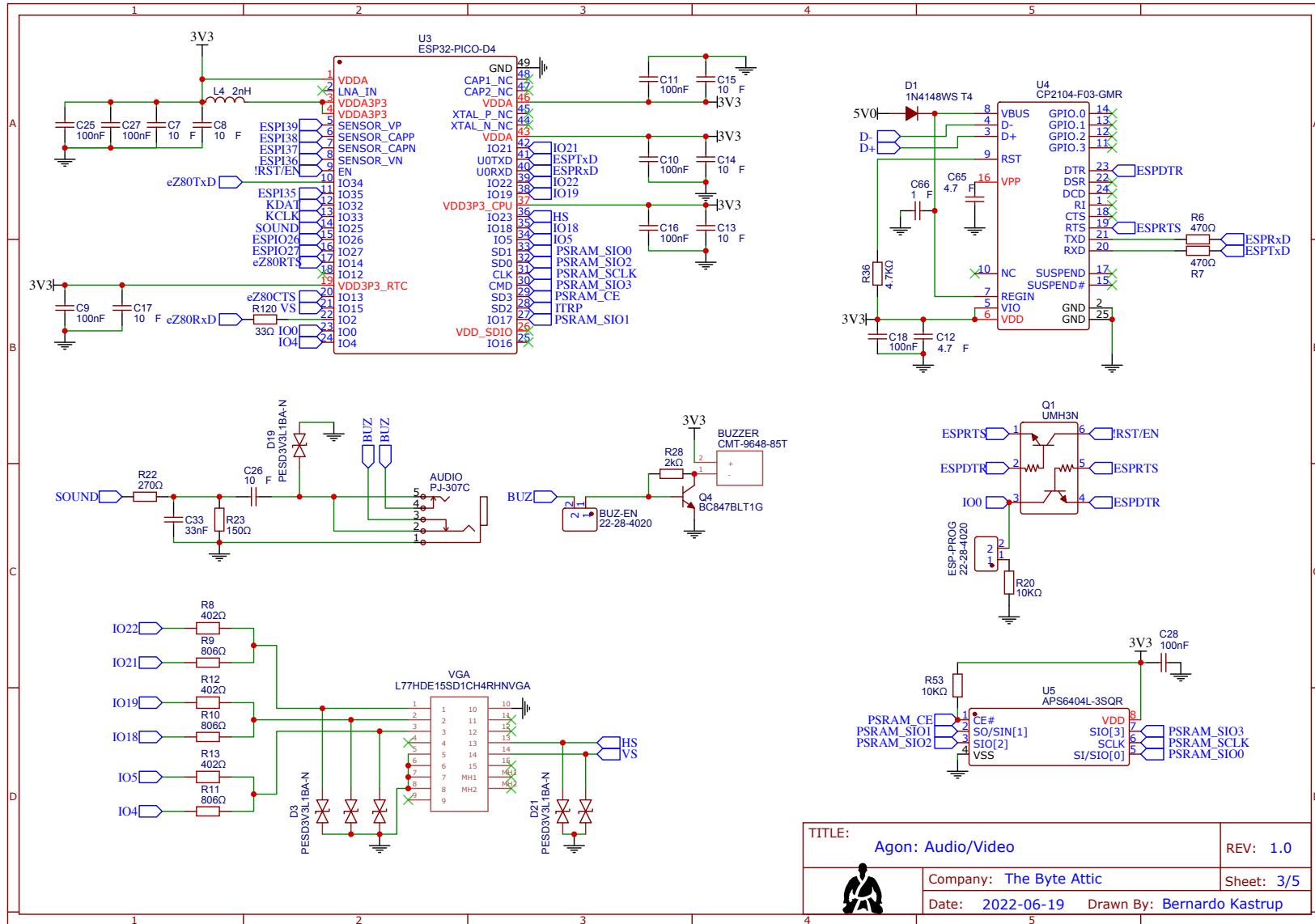


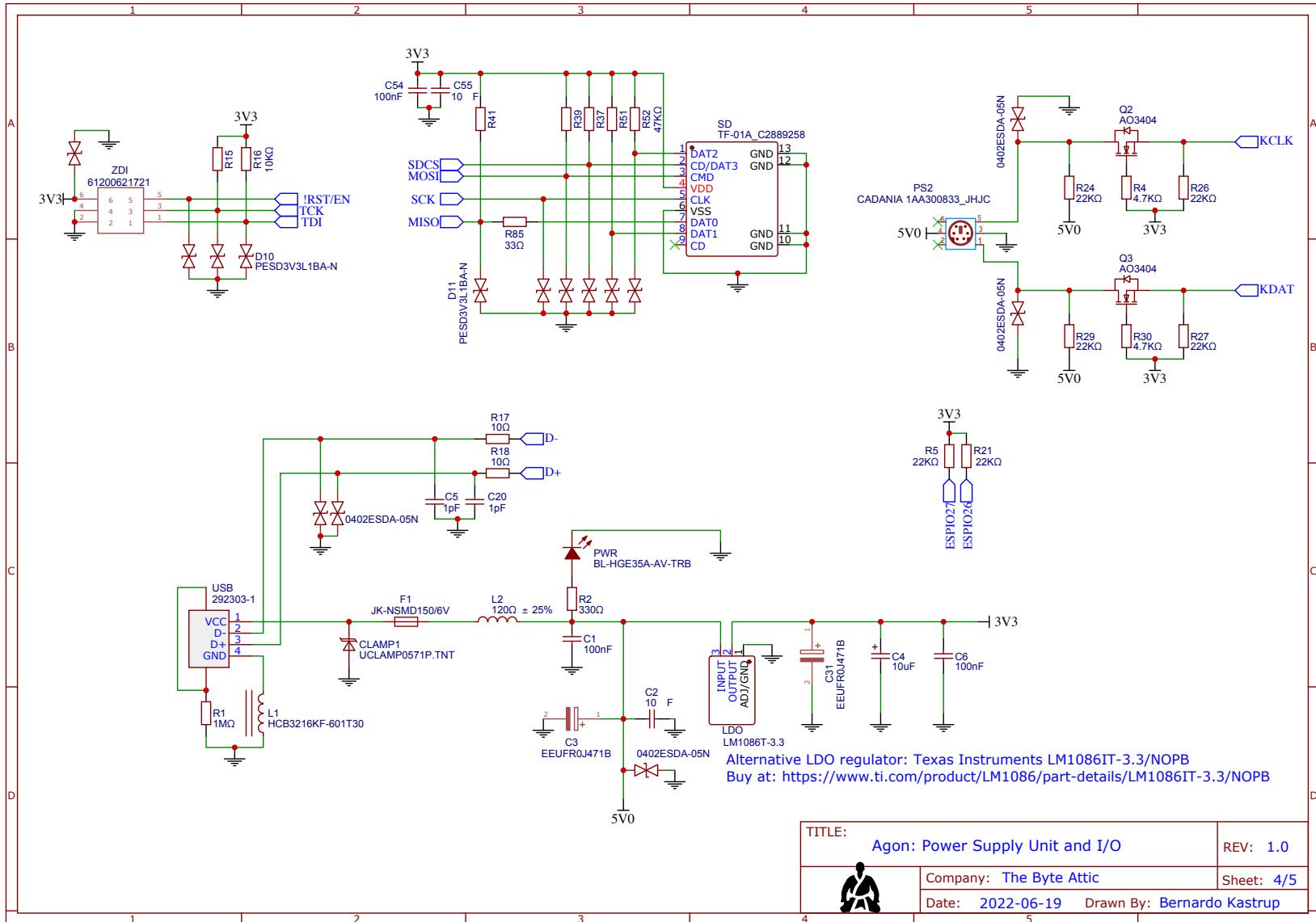
The Byte Attic's
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Schematics

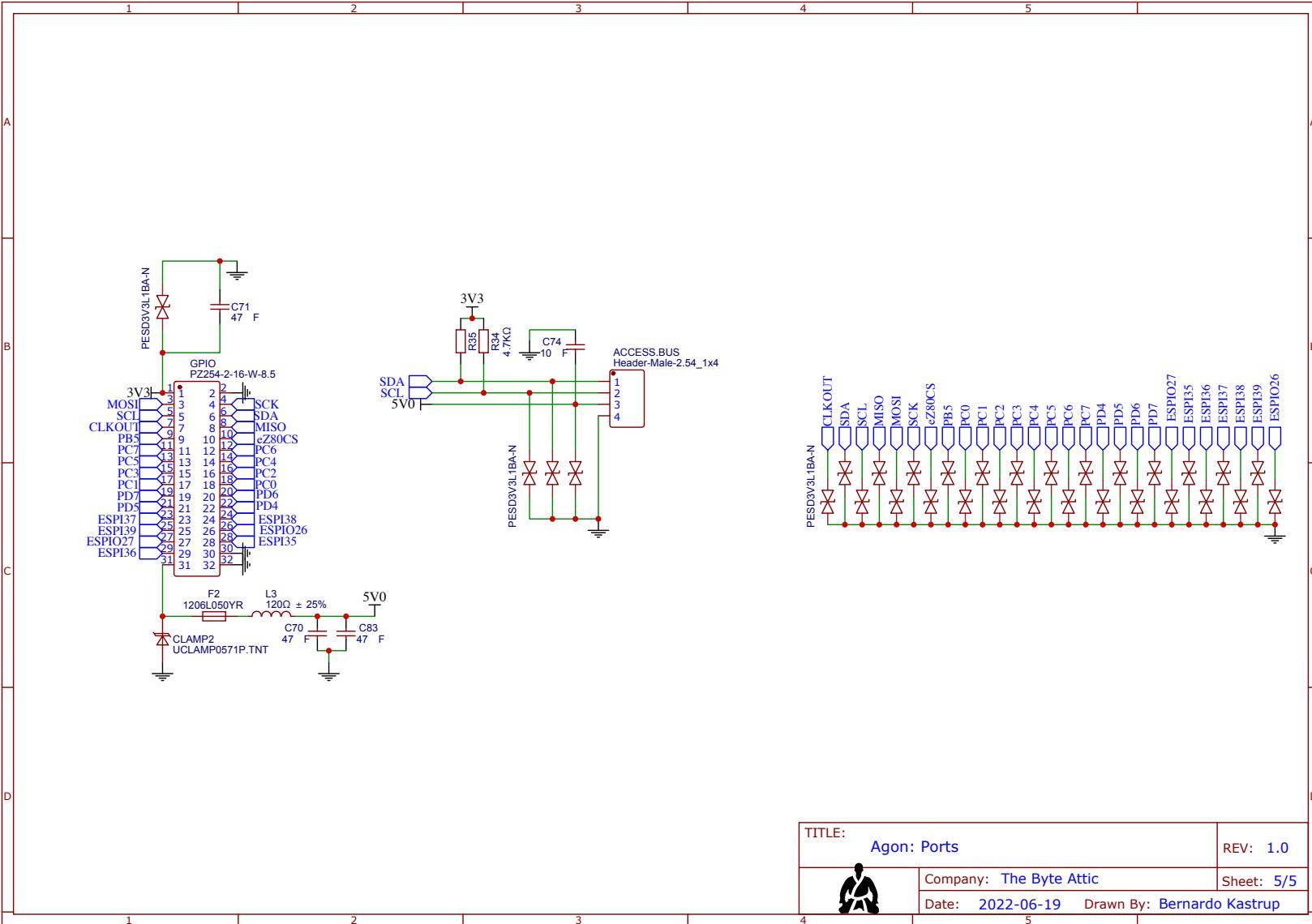










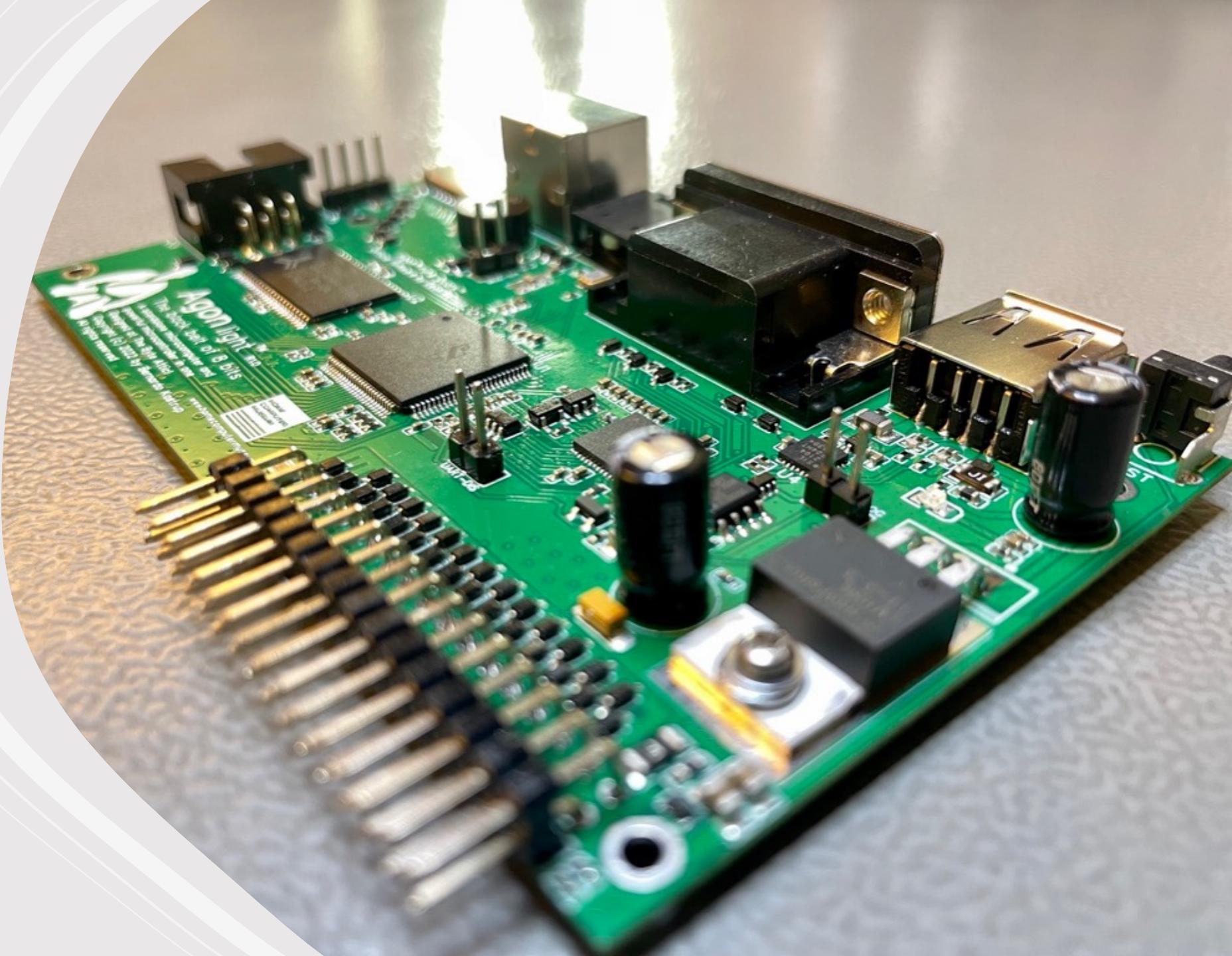




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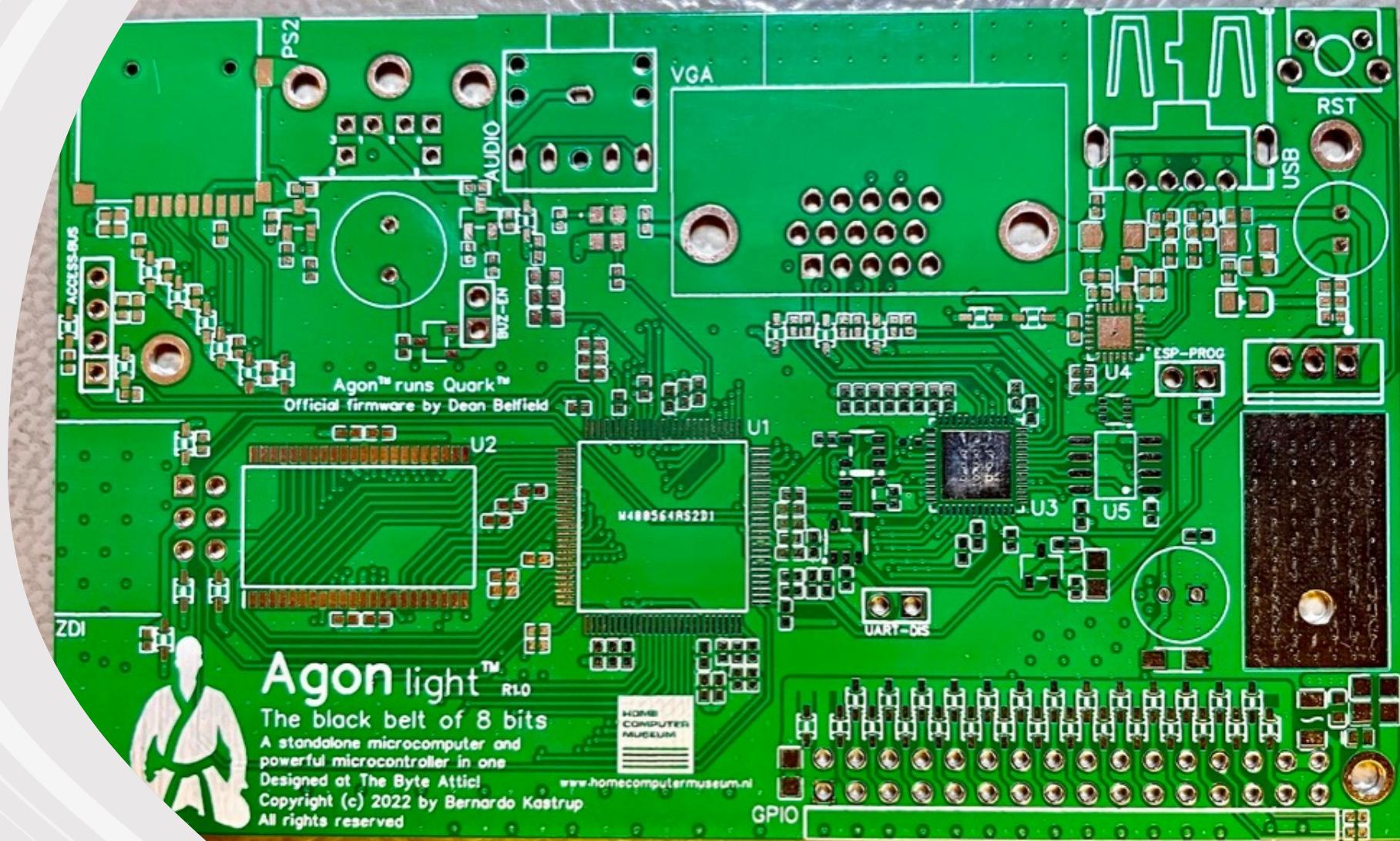
Bill of
Materials



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	A5E18432MHZLCLCT	1	A5E18432MHZLCLCT	ABRACON	Mouser	815-A5E18.432MHzLCLCT	0.384
4	A57C34096A-10TCN	U2	SOP8B9P118X120-144N	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	E2224-2.54-V4-S.5	NETL(华阳天利)	LSC	C284956	0.049
6	Header-Male-2.54-1x4	ACCESS_BUS	HOB-TH-32P-2.54-1H-44-R2_CTS-52-54	1	4P_L=1.0MM_GND+P	Centow	LSC	C14378	0.049
7	PJ-30TC	PI	AUDIO	1	PI-30TC	BOOMLE	LSC	C16684	0.043
8	22-28-4020	BIZ_ENP-ESP-PROG-UART-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	C0402-NEW	23	CLO5B10405NNINC	SAMSUNG	LSC	C1525	0.001
11	10pF	C9	C0402	20	CLO5A105M05NUINC	SAMSUNG	LSC	C15525	0.005
12	1pF	C5	C0402	2	0402CG3100C50NT	FH	LSC	C1550	0.001
13	4.7μF	C7	C0402	2	CLO5A475UMPNINC	SAMSUNG	LSC	C27733	0.006
14	10nf	C10	C0402	1	CLO5B103MB5BNINC	SAMSUNG	LSC	C15195	0.001
15	1nF	C56	C0402	8	CLO5A10205C50NT	FH	LSC	C1523	0.001
16	1uf	C66	C0402	1	CLO5A105K05NNINC	SAMSUNG	LSC	C29266	0.003
17	ELUF040471B	CX-C11	CAP-SDM-13.2-W1.6-R-RD	2	EU-F040471B	Panasonic	LSC	657-EU-F040471B	0.098
18	10uf	C4	C0402	1	TAJA06061BNJ	AVX	LSC	C7171	0.006
19	33nF	C3	C0402	1	CL10033MB8BNINC	SAMSUNG	LSC	C21117	0.006
20	1uf	C53	C0405	1	CL2105GBF8BNINC	SAMSUNG	LSC	C28333	0.009
21	47uF	C70	C0405	3	CL21426M0MNINN	SAMSUNG	LSC	C16780	0.026
22	UC1AM985712-TNT	CLAMP-DIODE	SGP1650N12A	2	UGLMAR95712-TNT	SEATECH	LSC	C51287	0.043
23	IN4148W5T4	D1	SOD-323_L1.8-W1.3-L5.2-RD	1	IN4148W5T4	C	LSC	C2128	0.013
24	PESD3V31BA-N		SOD-323_L1.8-W1.3-L5.2-BI	46	PESD3V31BA-N	Bourne Semicon (Shenzhen)	LSC	C346020	0.051
25	E5D3	DB	DO402-BI	1	0402LS04-05N	Bourne Semicon (Shenzhen)	LSC	C316049	0.019
26	0402ESD-PROT-LED-PROT2-SDSPNP013	F1	DO402-BI	5	0402LS04-05N	Bourne Semicon (Shenzhen)	LSC	C316049	0.019
27	JK-15MAD150V6	F2	F1306	1	JK-15MAD150V6	JK(金科)	LSC	C280249	0.036
28	1206LS050R	F2	F1306	1	1206LS050R	Uitec	LSC	C163512	0.065
29	IC03216MF-601730	L1	F1306	1	HE21616K-601730	TAITEC	LSC	C37023	0.028
30	120n ±25%	L1, L3	F1306	2	BLUM18KG121T10	Multata	LSC	C88811	0.017
31	3.0nH	L4	IND-SMD_1.2-L2-W0.6	2	BLUM18KG121T10	Abracon	LSC	C188816	0.224
32	UM1086T-3.3	LDD	TO-220-3_L10-W4.5-P2.54-L	1	UM1086T-3.3	HSSEM	C, Directec, I	C444381	0.241
33	CADANIA_JA30833_JHJC	PS2	PS2-PORT	1	BL-HGE55A-AV-TB	Bright LED Elec.	LSC	C165984	
34	BL-HGE33A-AV-TB	PWR	LEDO805-0-RD	1	UM3B3	LSC	C65882	0.047	
35	UM3B3	Q1	SC76-6_12.2-W1.3_P1.90-L5.2-BR	2	AQ3404	GumGum HomeTech	LSC	C192925	0.049
36	A03404	Q2, Q3	SOT-23-3_L2-W1.3_P1.90-L5.2-BR	1	0402WGF10MTC	LSI	C26983	0.001	
37	1MΩ	R1	R0402	1	0402WGF10MTC	LSI	C2104	0.001	
38	3kΩ	R2	R0402	1	0402WGF100TC	LSI	C2744	0.001	
39	10kΩ	R3, R93	R0402	9	0402WGF100TC	LSI	C2744	0.001	
40	4.7kΩ	R4, R14, R25, R30, R34, R35, R36, R111	R0402	10	0402WGF470TC	LSI	C25900	0.001	
41	2kΩ	R5, R11, R12, R13, R17, R18	R0402	6	0402WGF522TC	LSI	C27948	0.001	
42	47kΩ	R6, R7	R0402	2	0402WGF470TC	LSI	C25117	0.001	
43	40kΩ	R8, R12, R13	R0402	3	PTF04024024BKN9	RES(研祥)	LSC	C262862	0.079
44	80kΩ	R9, R10, R11	R0402	3	TC0228B8600TC	Unipac Elec	LSC	C150511	0.061
45	100	R12, R18	R0402	2	0402WGF100TC	LSI	C25077	0.001	
46	330	R31, R32, R33, R34, R35, R36, R85	R0402	12	0402WGF330TC	LSI	C25105	0.001	
47	47kΩ	R37, R39, R41, R51, R52	R0402	5	0402WGF470TC	LSI	C27942	0.001	
49	150Ω	R22	R0402	1	0603WAF1500TSE	Unidom	LSC	C22966	0.002
50	TF-01A, C2B891258	R23	R0402	1	TF-01A, C2B891258	Vlandi(台湾元通)	LSC	C28208	0.002
51	EZ0809242020EG	U1	QFP55PQFP160X160X160-100N	1	E2809242020EG	Zilog	LSC	C2889378	0.088
52	ESP2104-F00-D4	U3	QFN-44_L7D-W7-P0.50-0.50-BLEP2.6	1	ESP2104-F00-D4	Espresso Systems	LSC	C193707	3.82
53	CP2104-F00-GMR	U4	QFN-44_L4.0-W4.0-P0.50-0.50-BLEP2.6	1	CP2104-F00-GMR	SILICON LABS	LSC	C47015	2.361
54	AP5640L-350	U5	SOT-23-3_L2-W1.6-P1.90-L5.2-BR	1	AP5640L-350-01	Diodes Incorporated	LSC	C43831	0.001
55	AP5640S-35A-7	U6	SOT-23-3_L2-W1.6-P1.90-L5.2-BR	1	AP5640S-35A-7	Diodes Incorporated	LSC	C29554	0.087
56	SNT4UICIG250BIR	U7, U8	SOT-23-5_L3_W1.7-P1.90-L5.2-BR	2	SNT4UICIG250BIR	Unipac Elec	LSC	C7827	0.112
57	SNT4UICIG250BIR	U9	SOT-23-5_L3_W1.7-P1.90-L5.2-BR	1	SNT4UICIG250BIR	Unipac Elec	LSC	C84641	0.407
58	U7710P12510C4HNNVCA	U8	U7710P12510C4HNNVCA	1	292303-1	TE Connectivity	LSC		
59	222303-1	U9							
60	61300621721	ZD1	SHDR46W64P254254	1	1523X88				
61	TS-1093A-A12B3-D2	RST	KEY-TI_4P_L7.1-W12.4-P4_S50-L5.25	1	TS-1093A-A12B3-D2	Vlandi	LSC	C499319	0.062



The Byte Attic's
Agon
light™
PCB
dimensions



PCB dimensions (diagram *not* to scale)



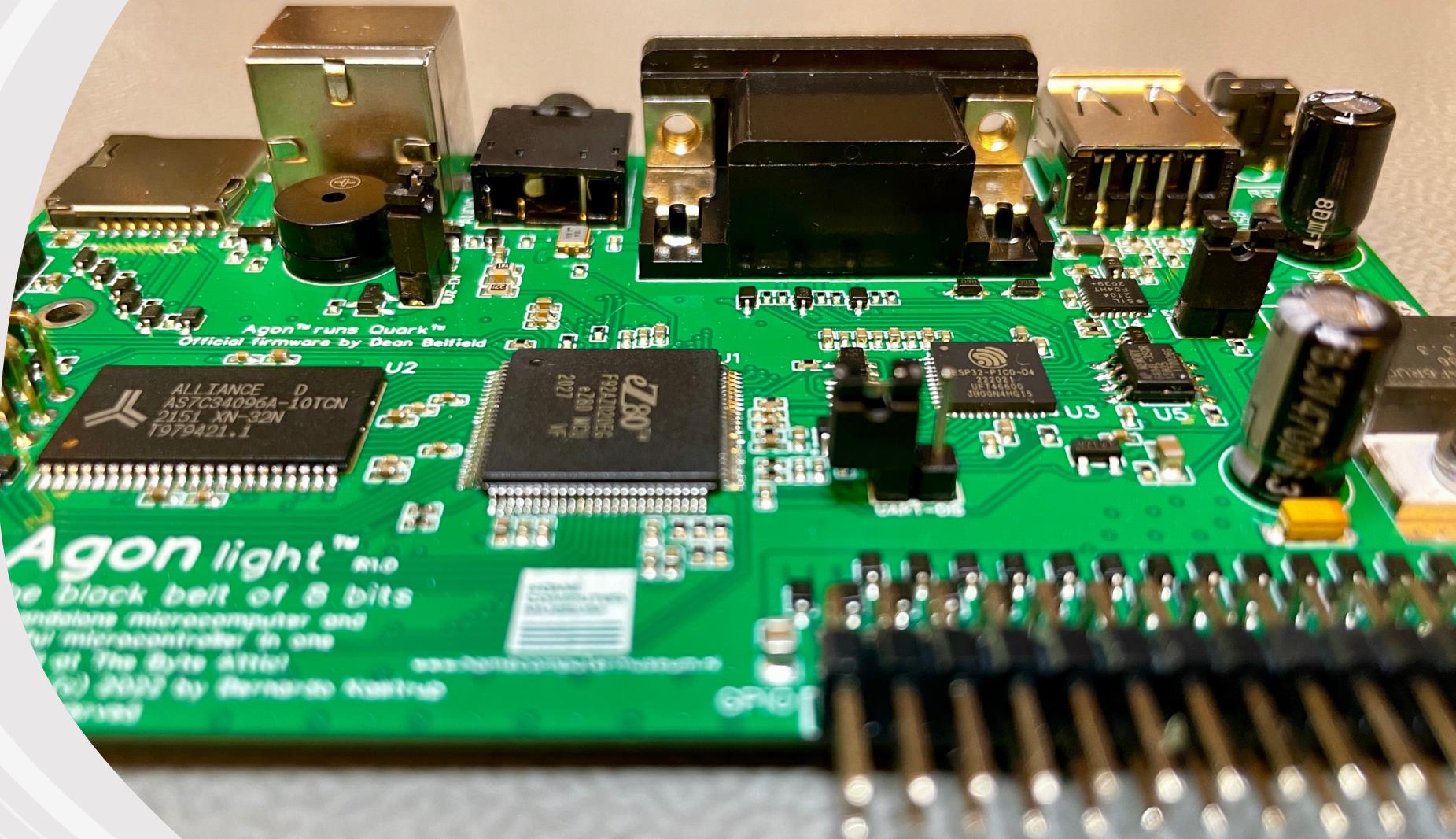
All holes
are
2.505mm
in
diameter



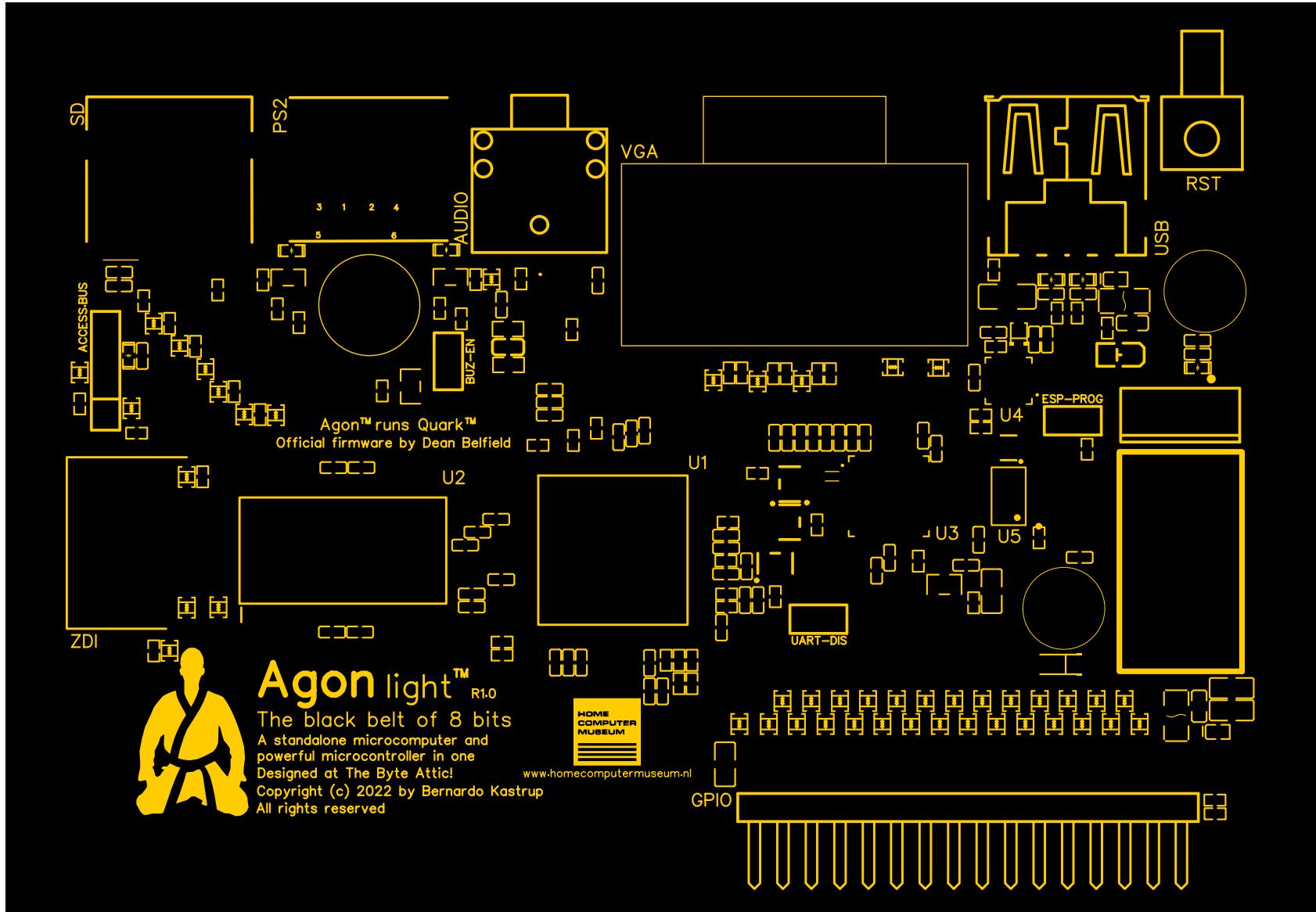
The Byte Attic's

Agon light™

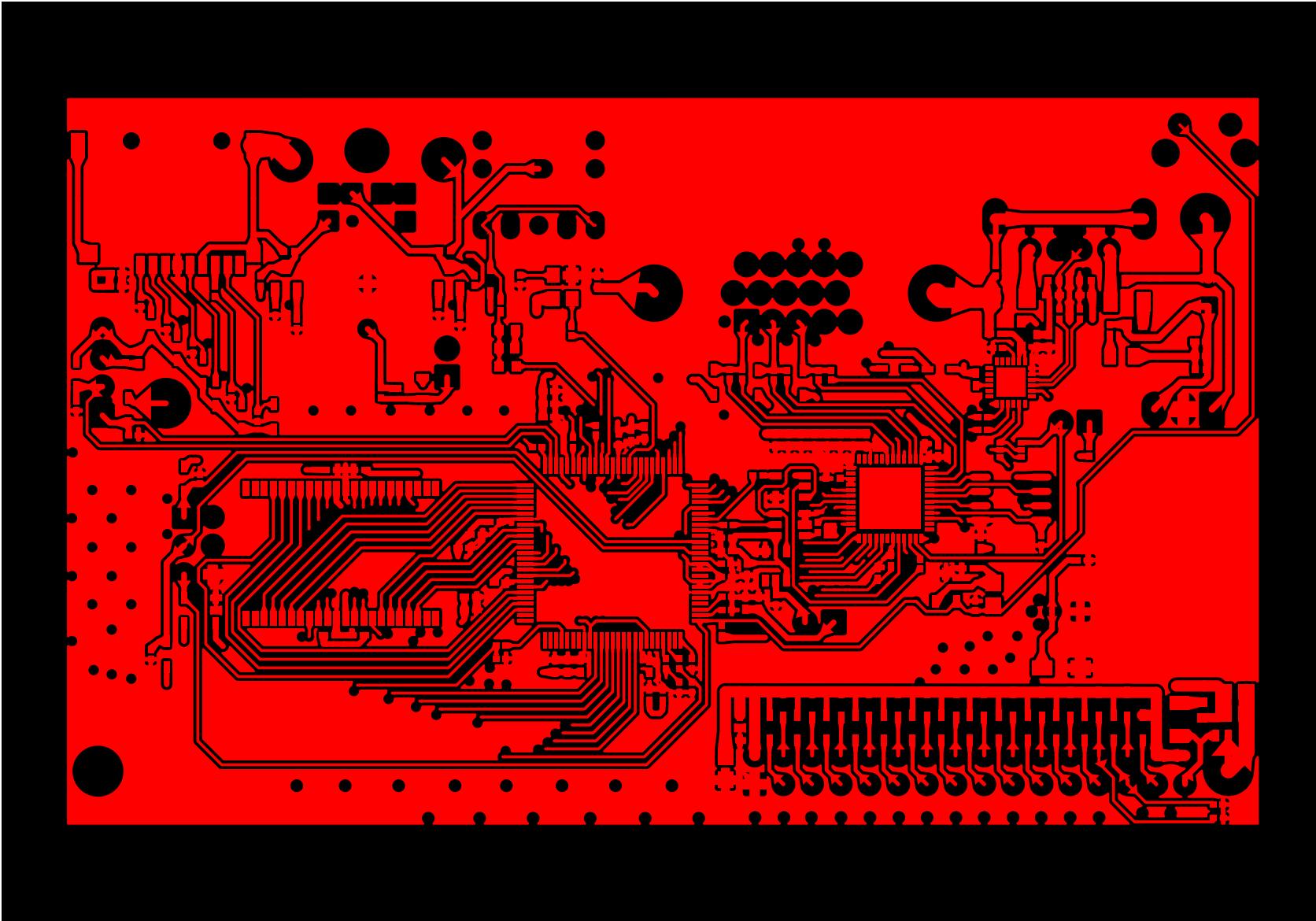
PCB layers
design



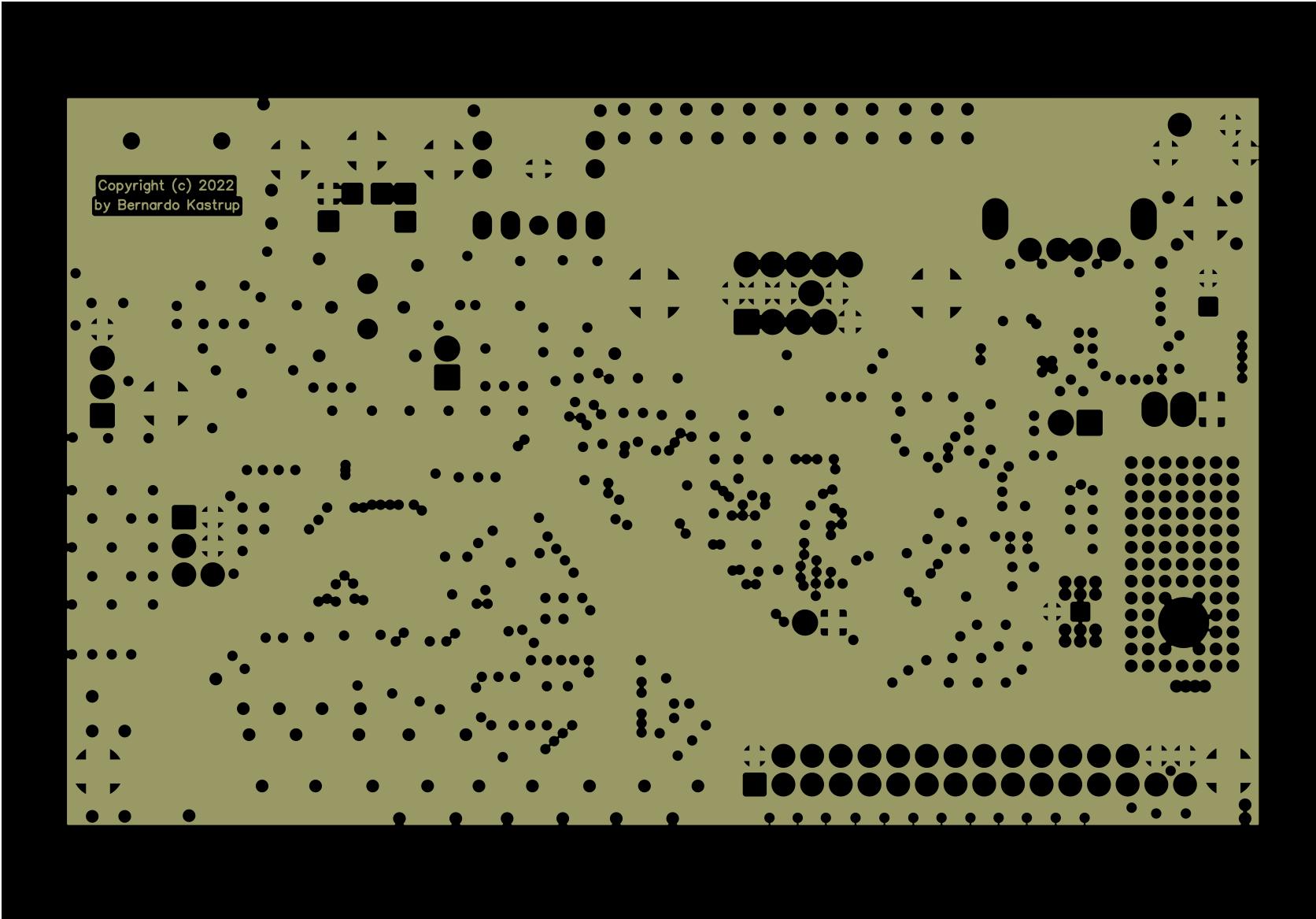
Top silkscreen



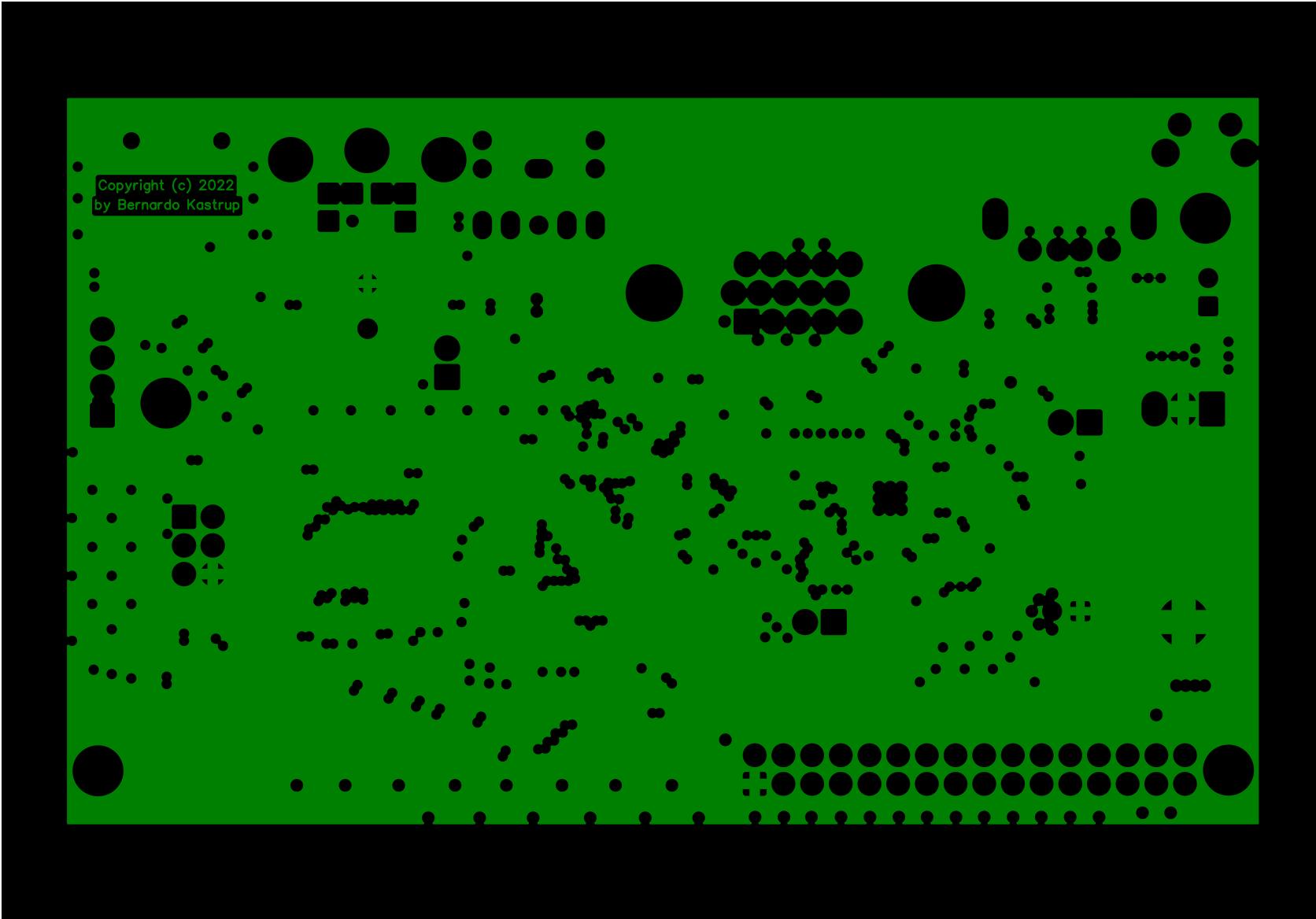
Top metal layer (3.3V filled)



First inner plane (GND)



Second inner plane (3.3V)



Bottom metal layer (GND filled)

