



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 link (384 kilobits per second), featuring flow control

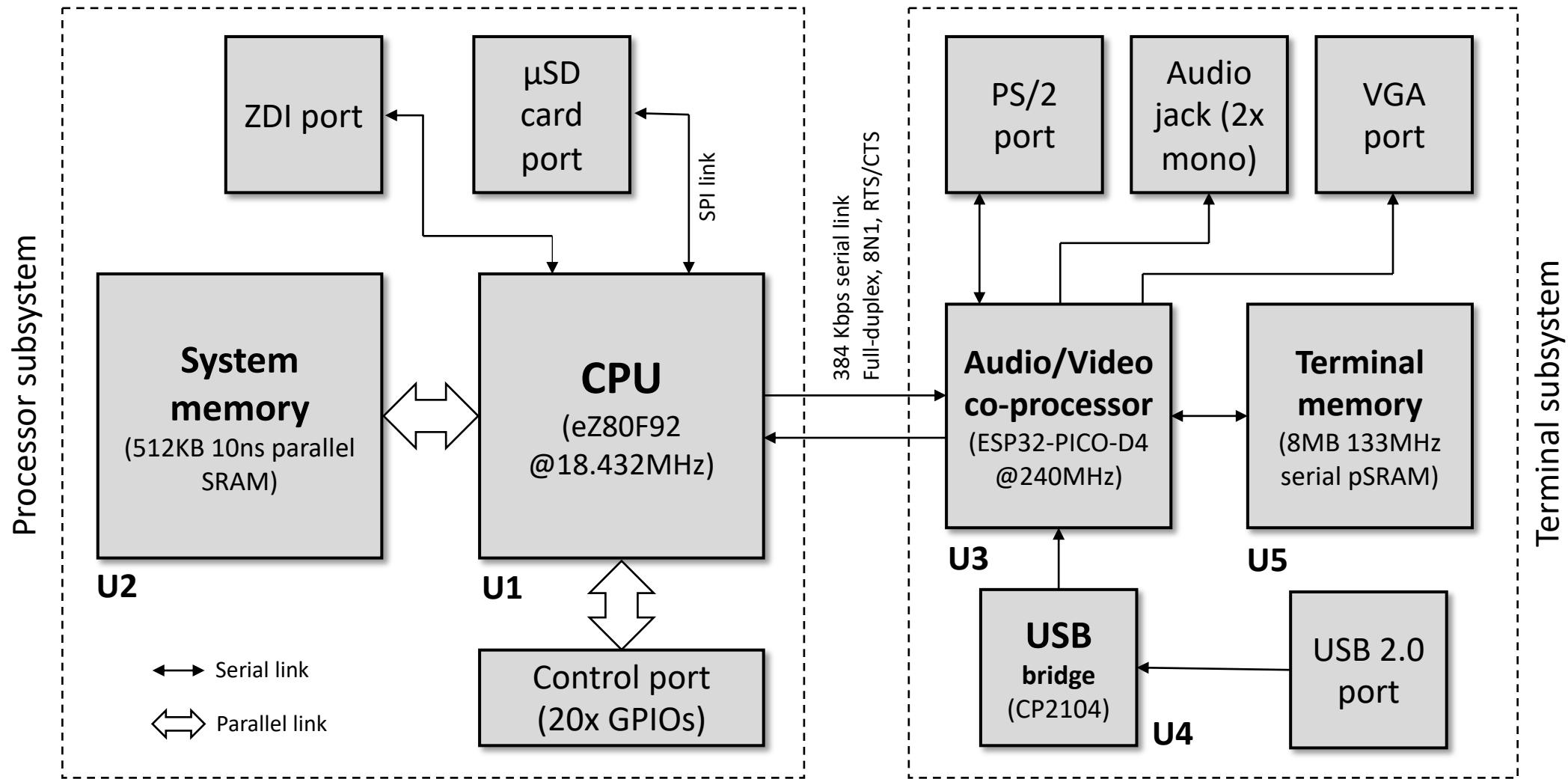
* Requires installation of Quark™ firmware

Theory of operation

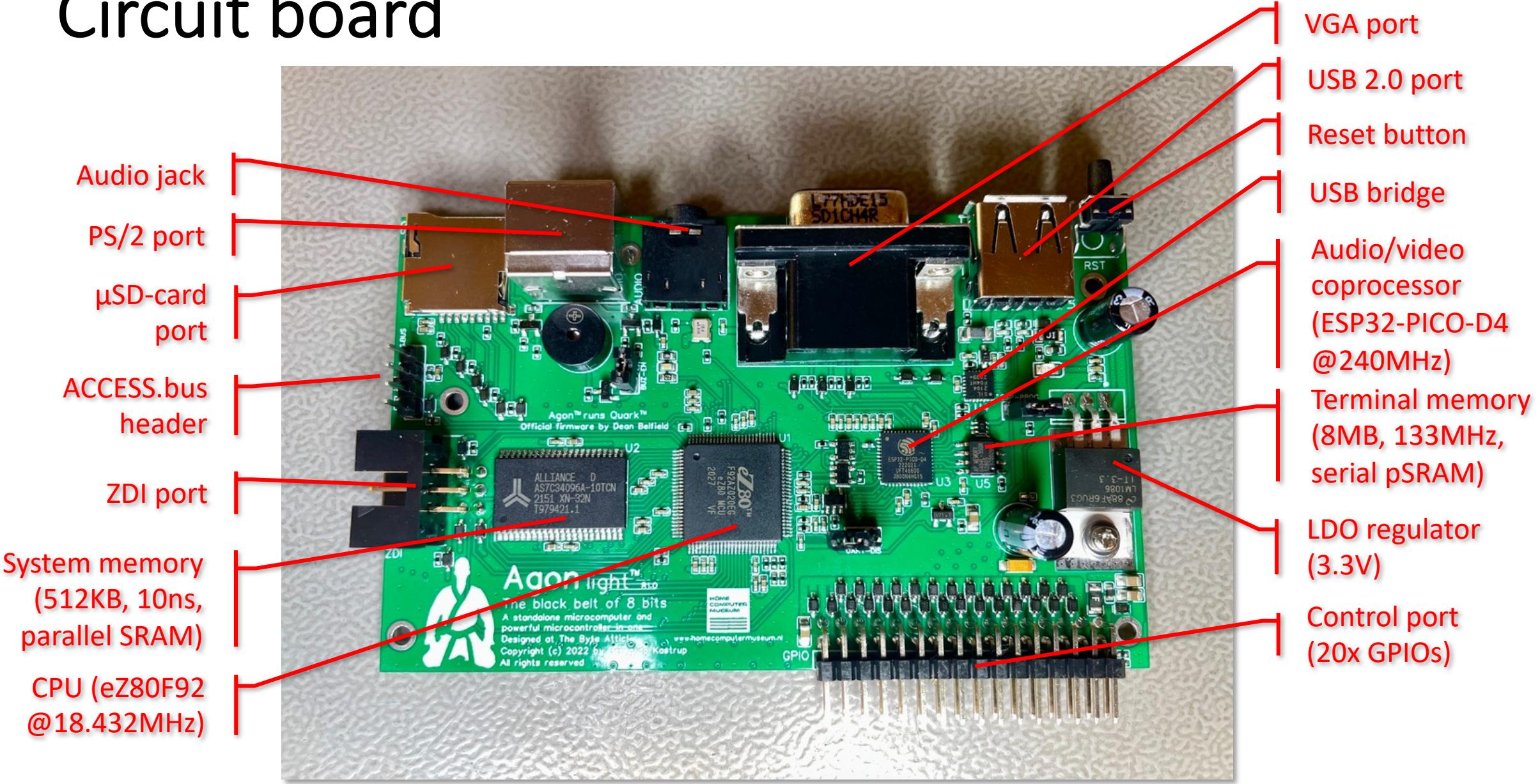
- The *terminal subsystem*:
 - Reads out the (PS/2) keyboard and sends the corresponding keypress tokens to the CPU via a high-speed serial link
 - Generates the screen based on display-list commands issued by the CPU and sent to the ESP32 via a high-speed serial link
 - Produces the VGA & audio signals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

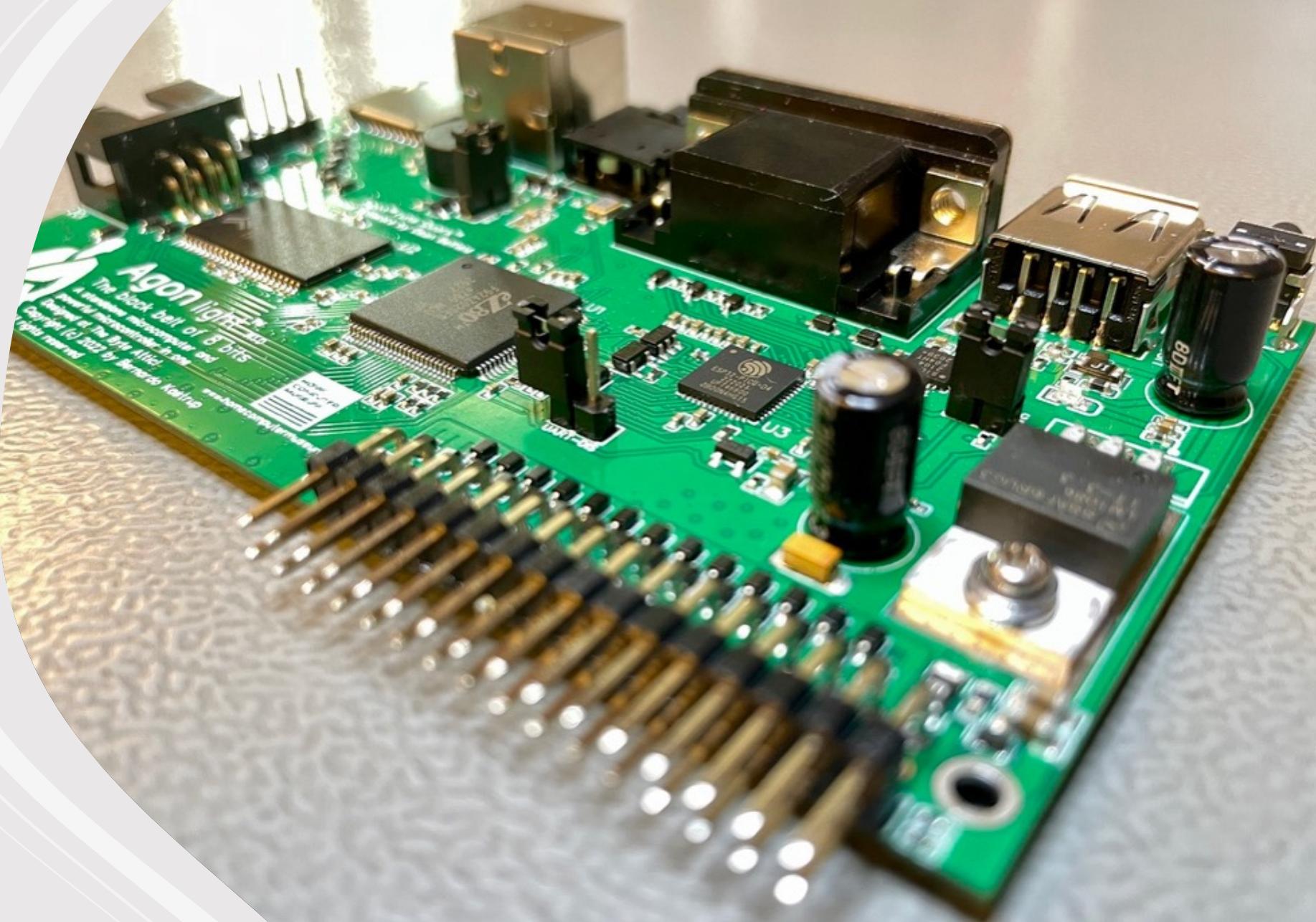




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User's
guide

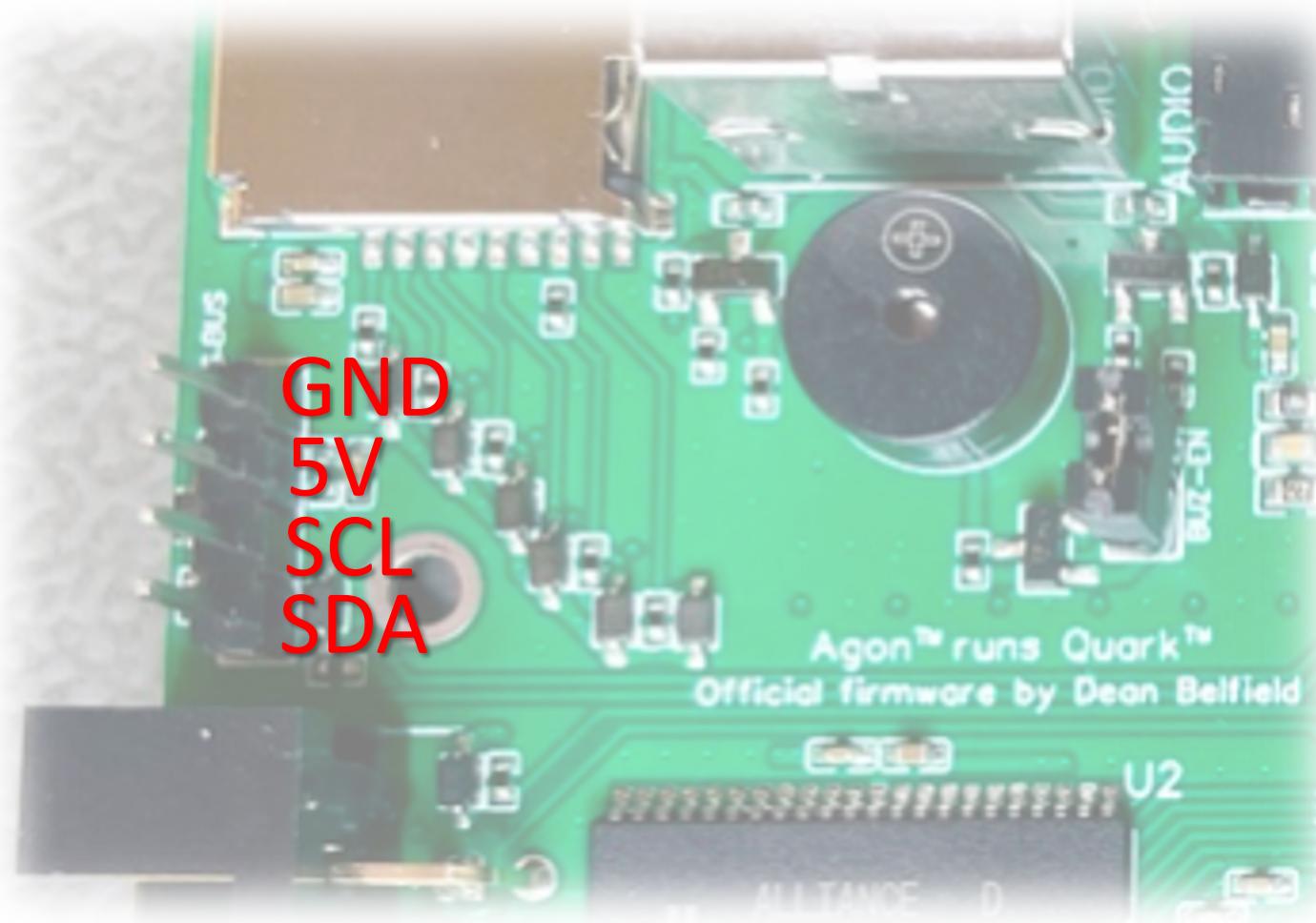


Control port pinout

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

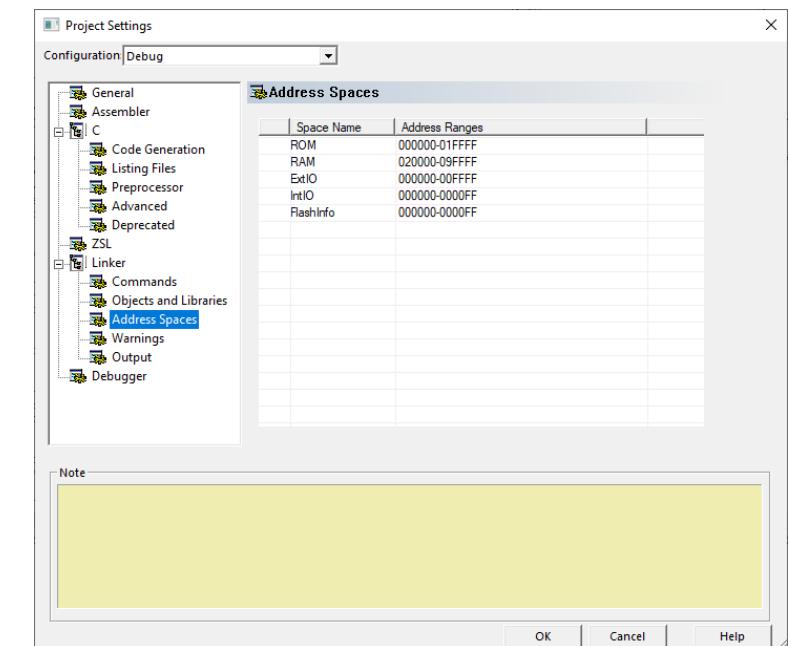
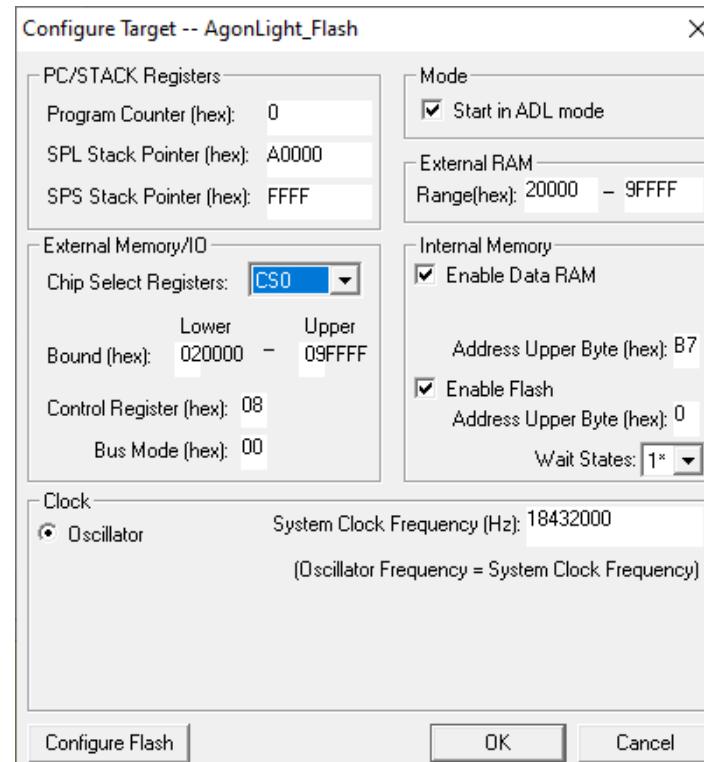
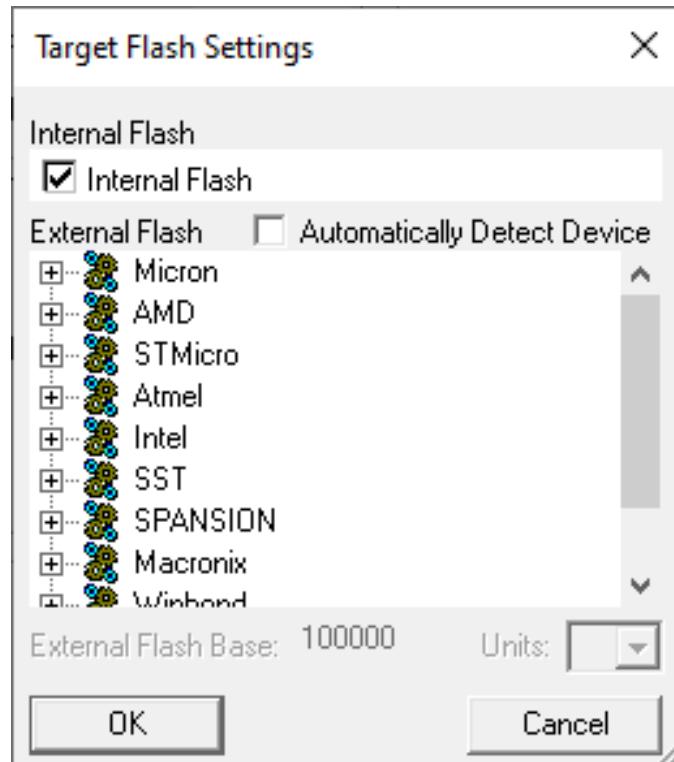
Signal structure: 1 start bit, 8 data bits, 1 stop bit,
no parity bit (8N1)

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, downloadable from:
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)



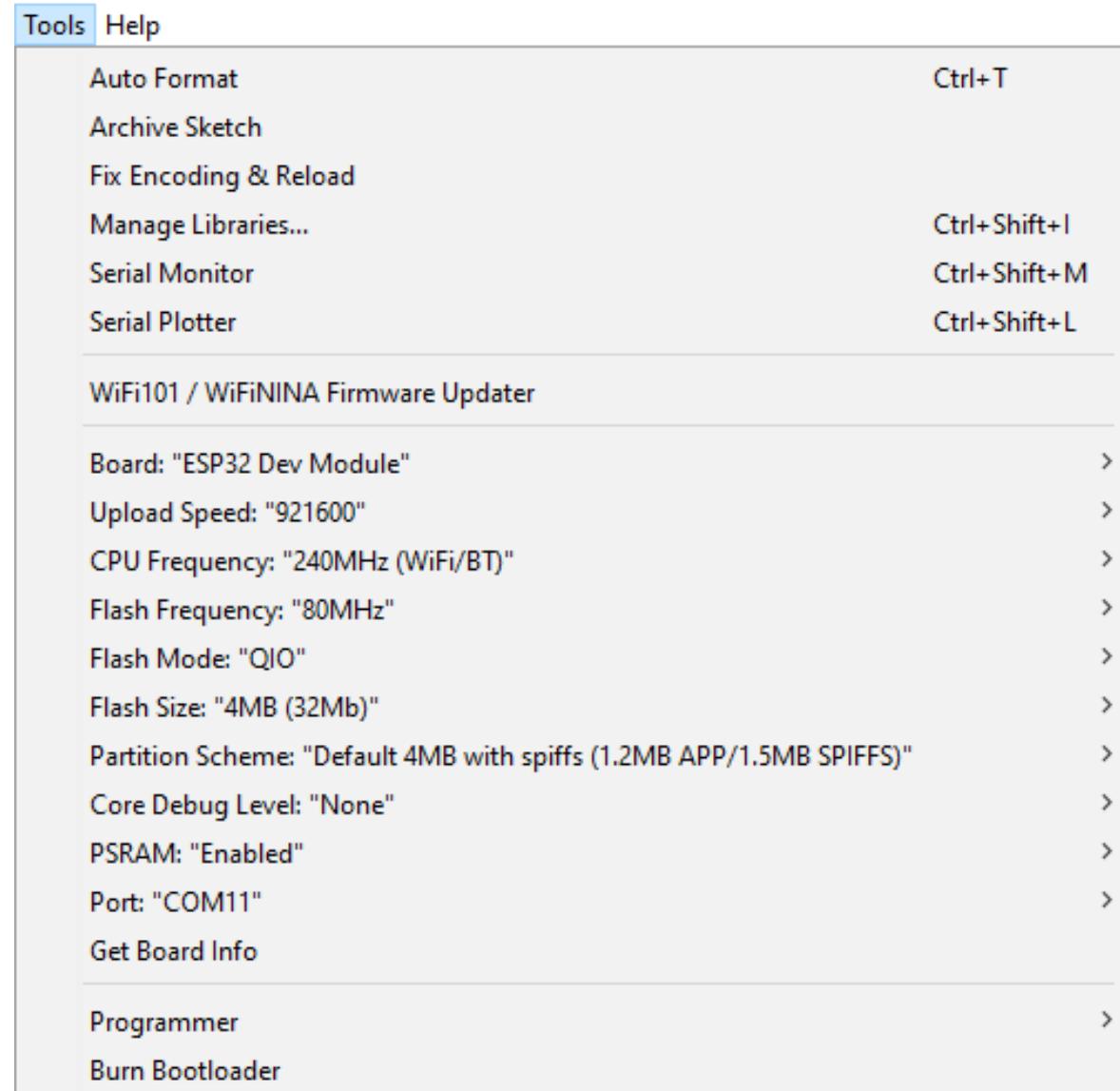
Required programming/debugging USB smart capable

- 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

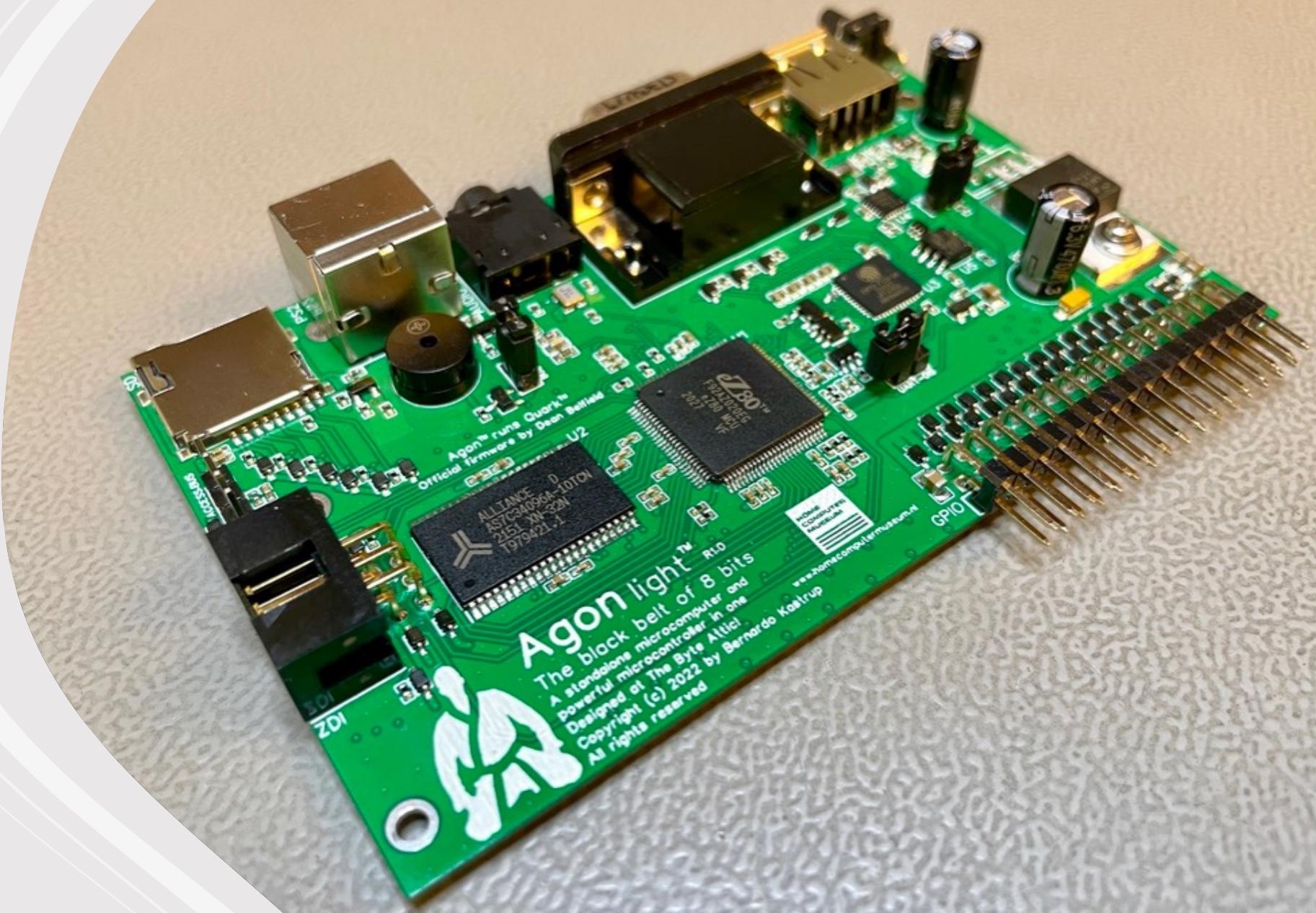
- Agon light can be powered (5V) *either* from its USB port *or* from the 5V pin in its control port
- If Agon light is powered from the USB port, then the 5V pin in the control port can be used to power an external circuit connected to Agon light
- Similarly, the 3.3V pin in the control port can be 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
 - 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 logic signals on the control port (including all GPIOs) are referenced to 3.3V and, therefore, are *not* TTL-level



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Assembly
guide

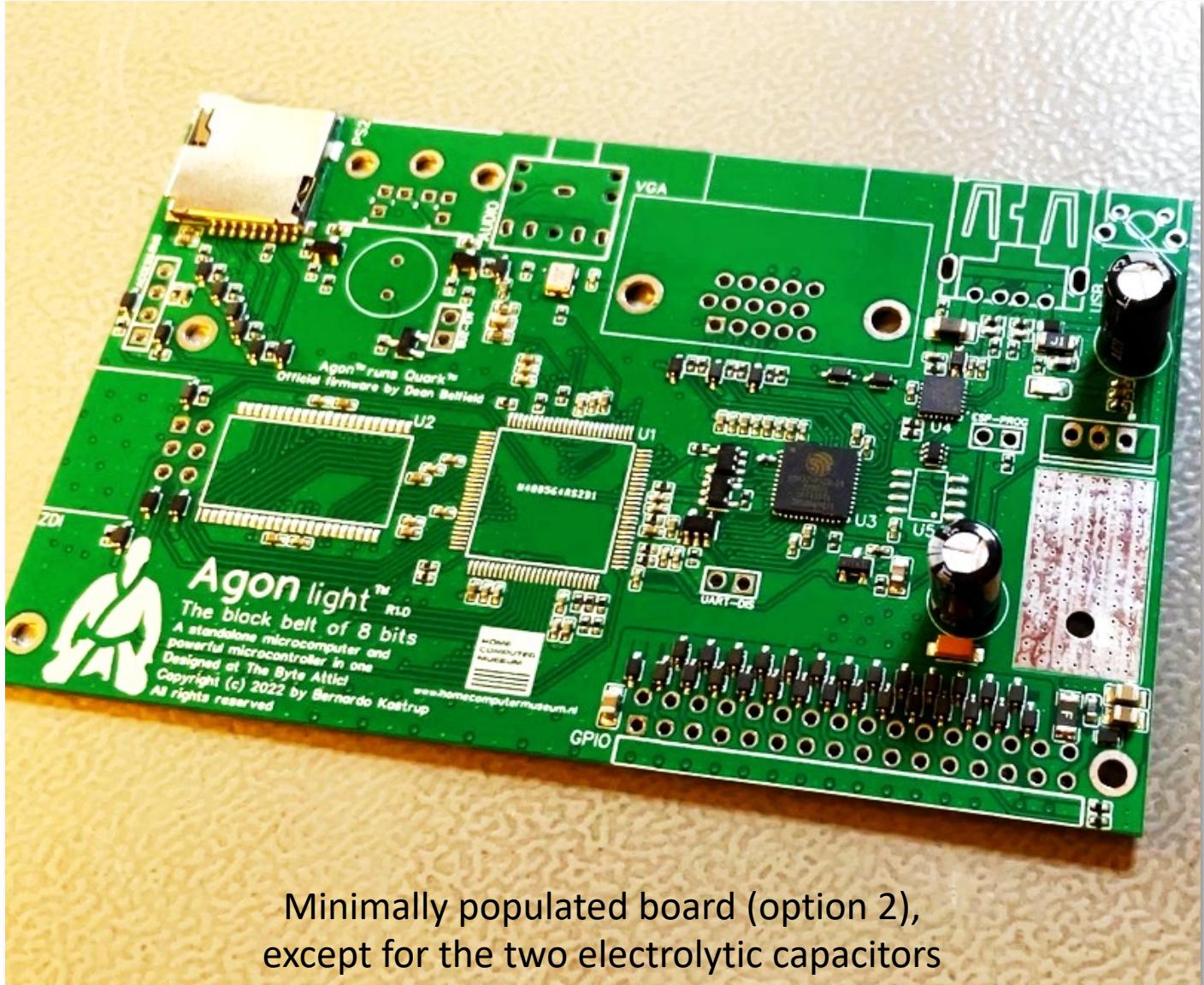


Assembly options

- 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

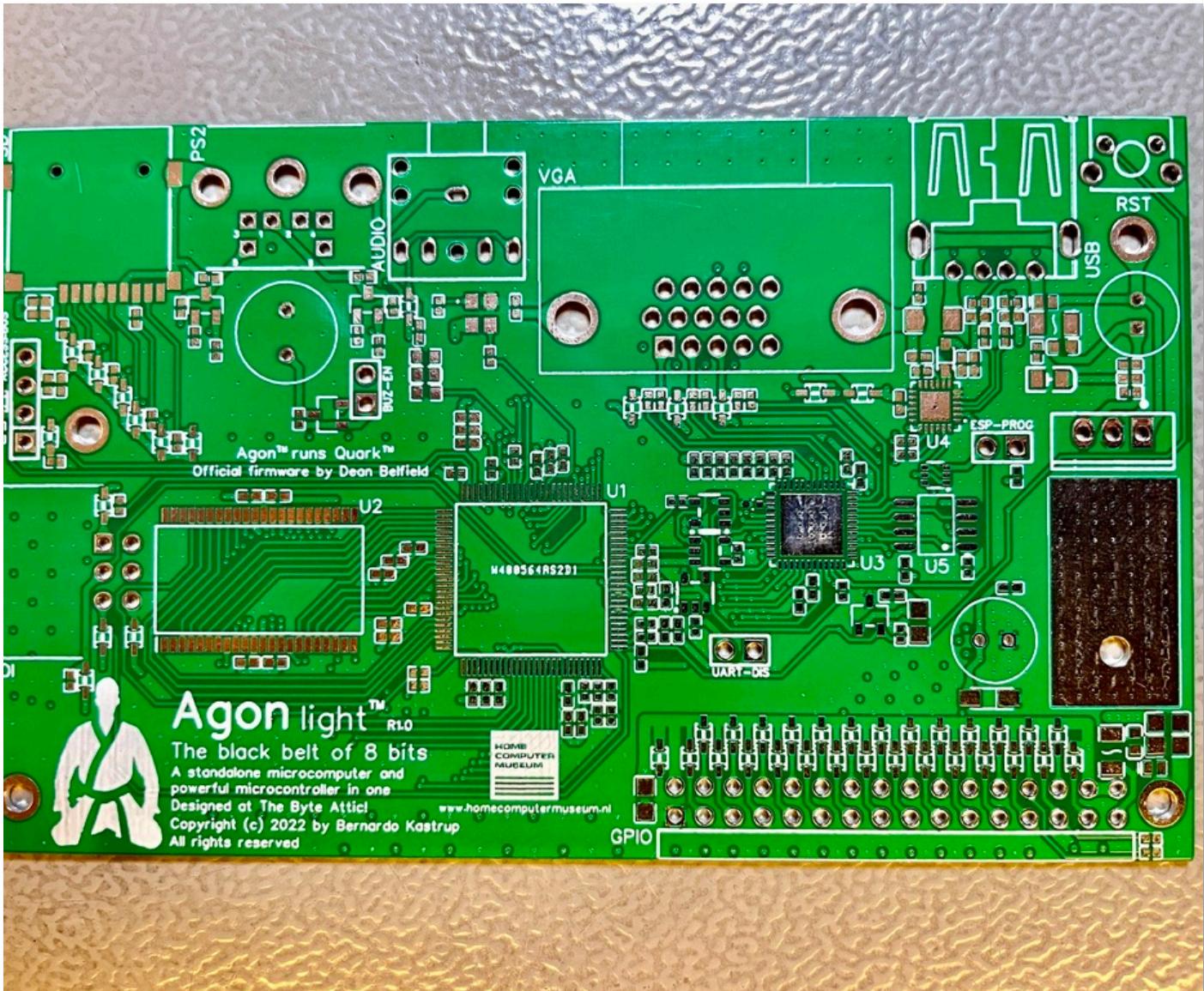
- All files are available in the /Manufacturing directory of Agon light's Github repository at:
<https://github.com/TheByteAttic/AgonLight>
- For option (4), send the following files to your PCB manufacturer, next to the Gerber file (`Gerber_PCB_AgonLight_R1.0.zip`):
 - `PickAndPlace_PCB_AgonLight_R1.0.csv`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

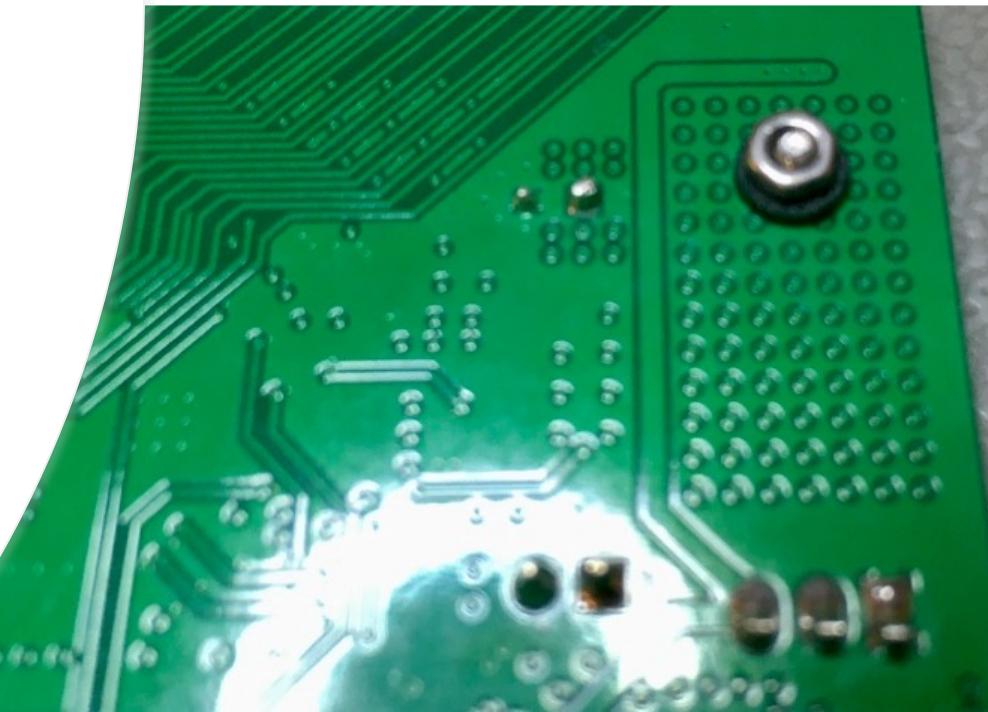
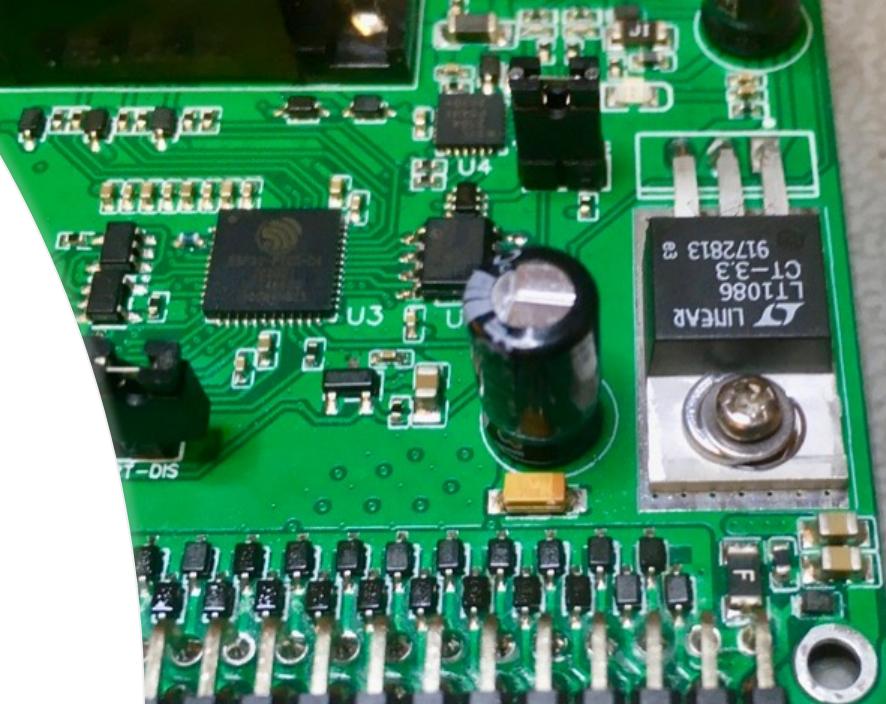
PCB layer stack

- 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

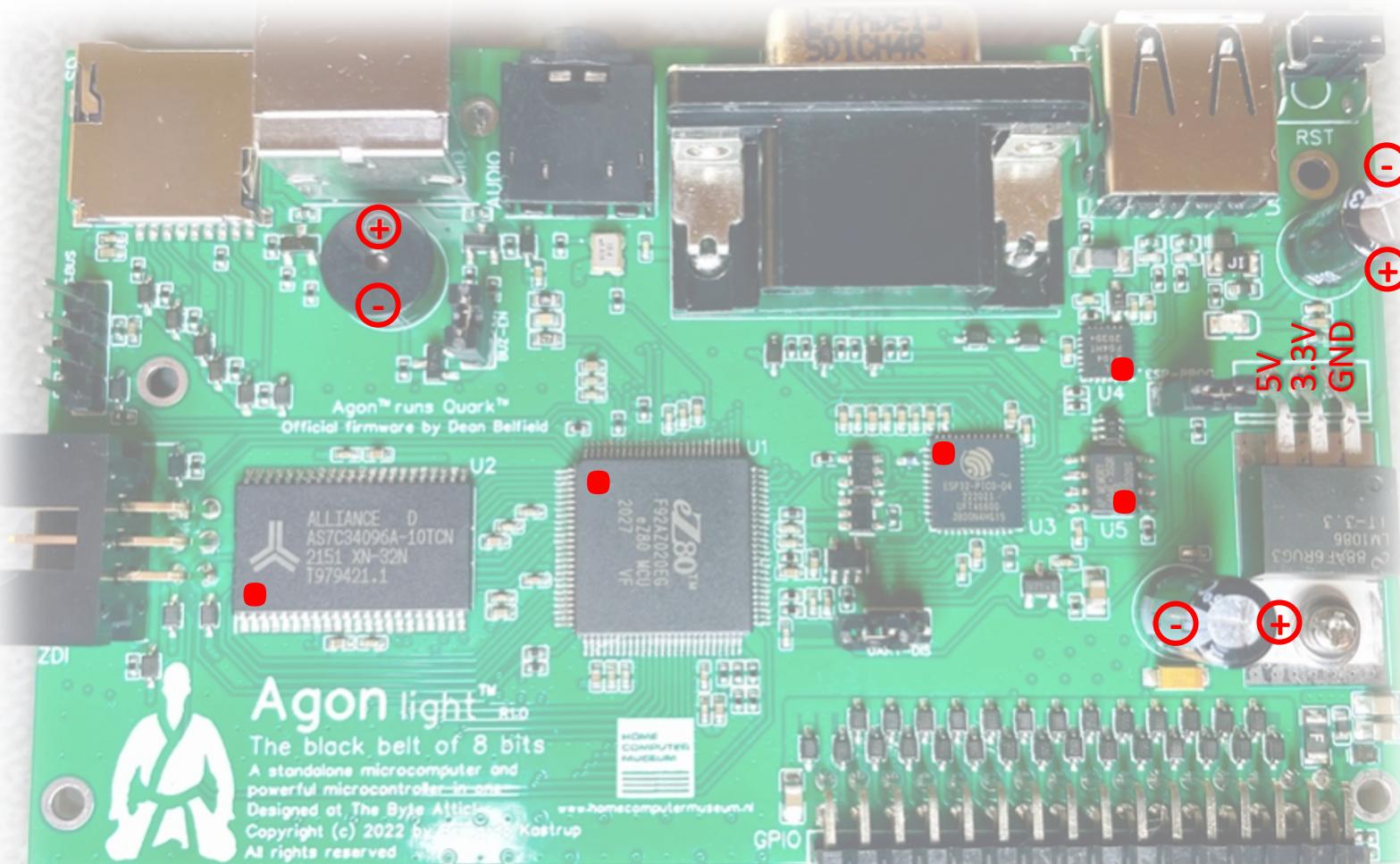


Mounting the LDO regulator

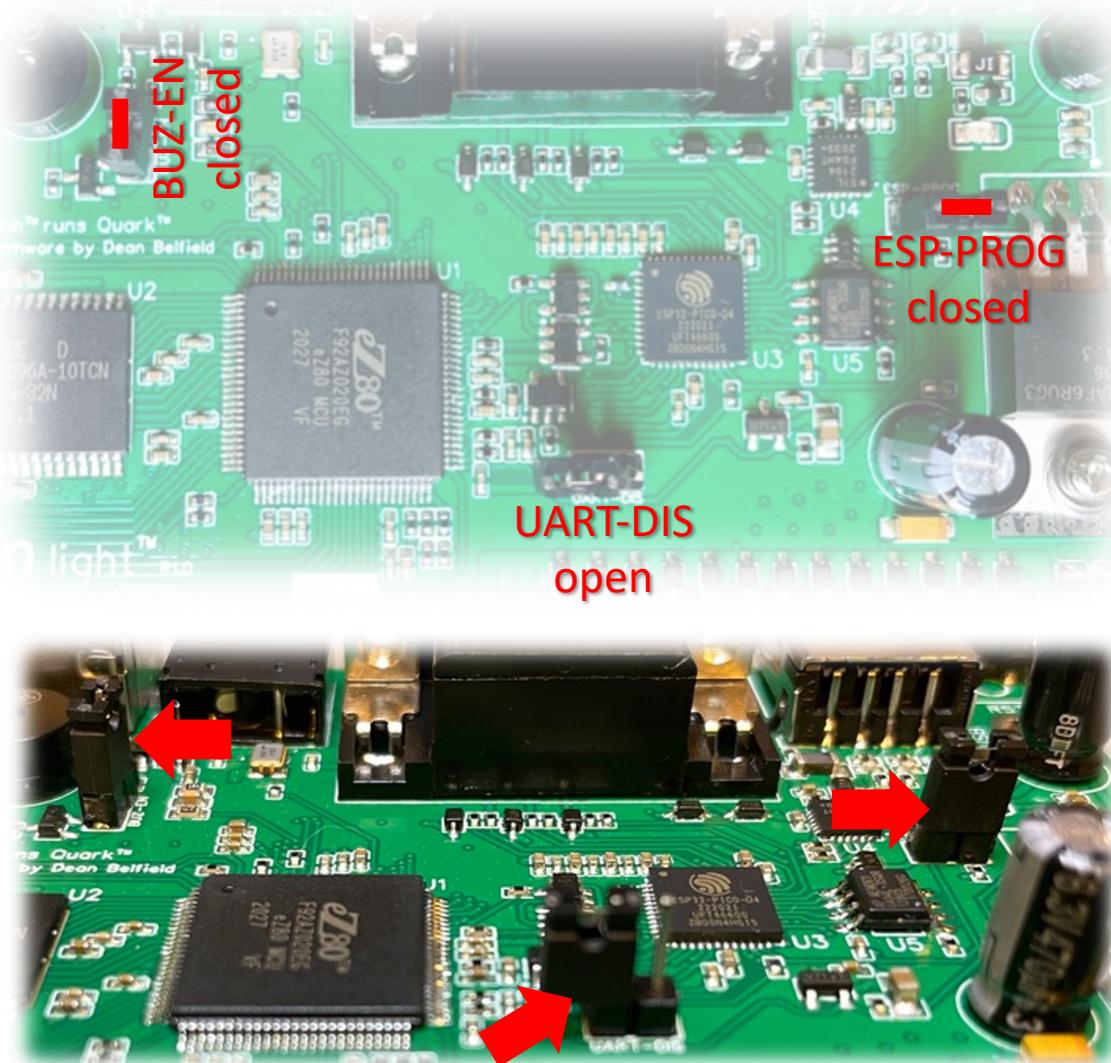
- Agon light's 3.3V V_{cc} rail is provided by a Low-DropOut (LDO) linear regulator
- The regulator must be mounted flush against the corresponding exposed metal area on the top of the PCB (see top-right photo)
- The regulator's tab (chassis) is at 3.3V, as is the exposed copper area on which it is to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

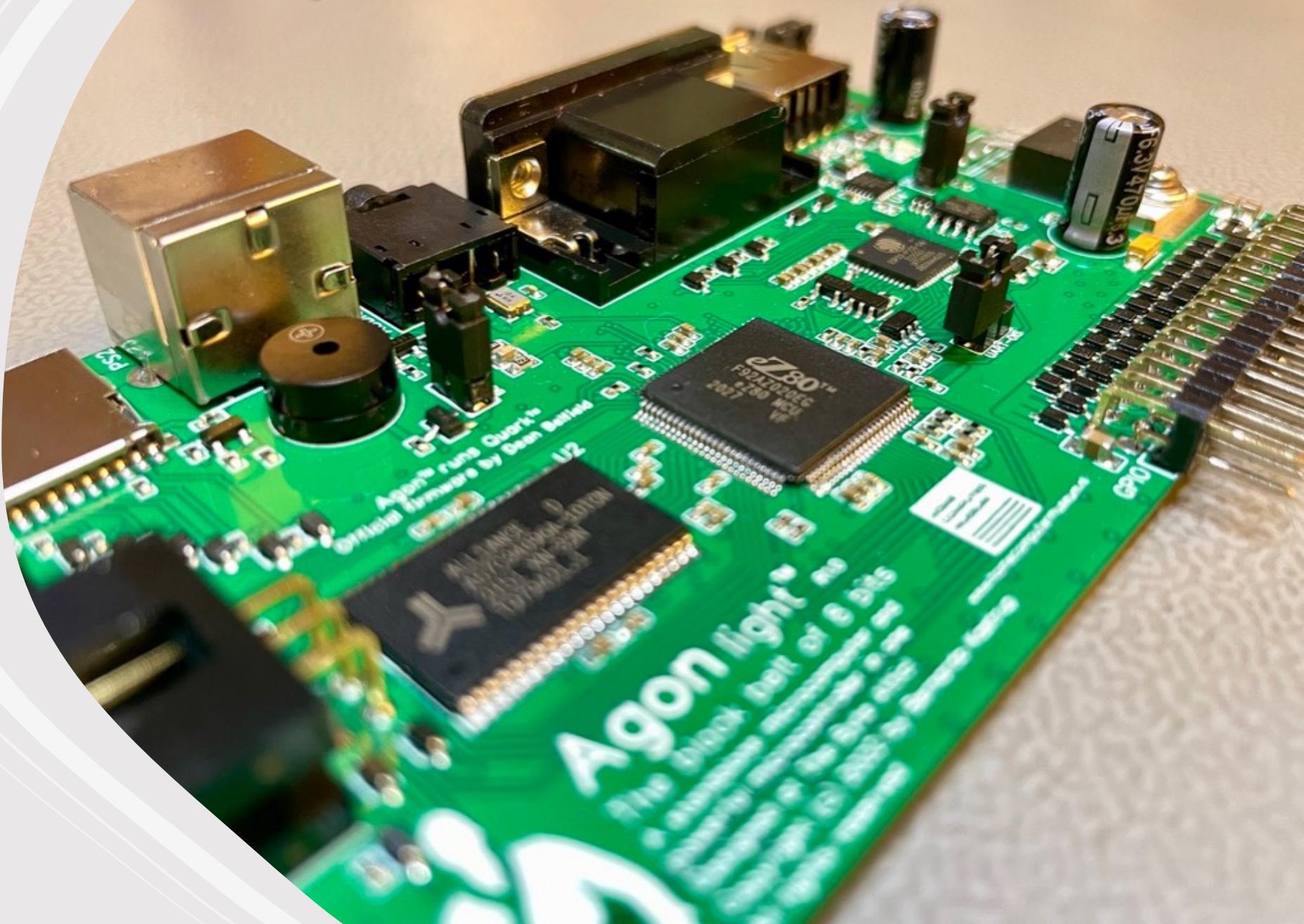


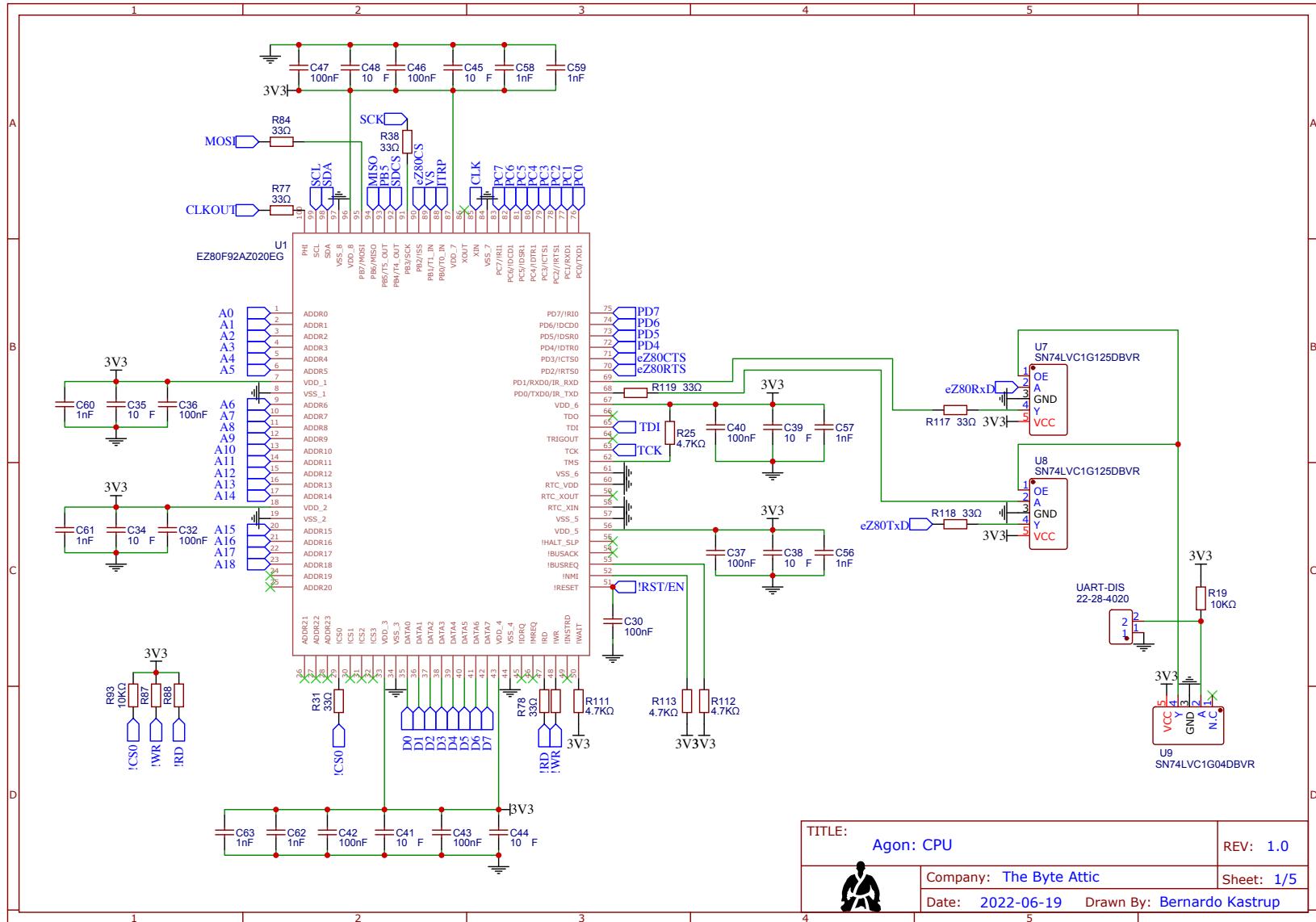
When to change jumper settings

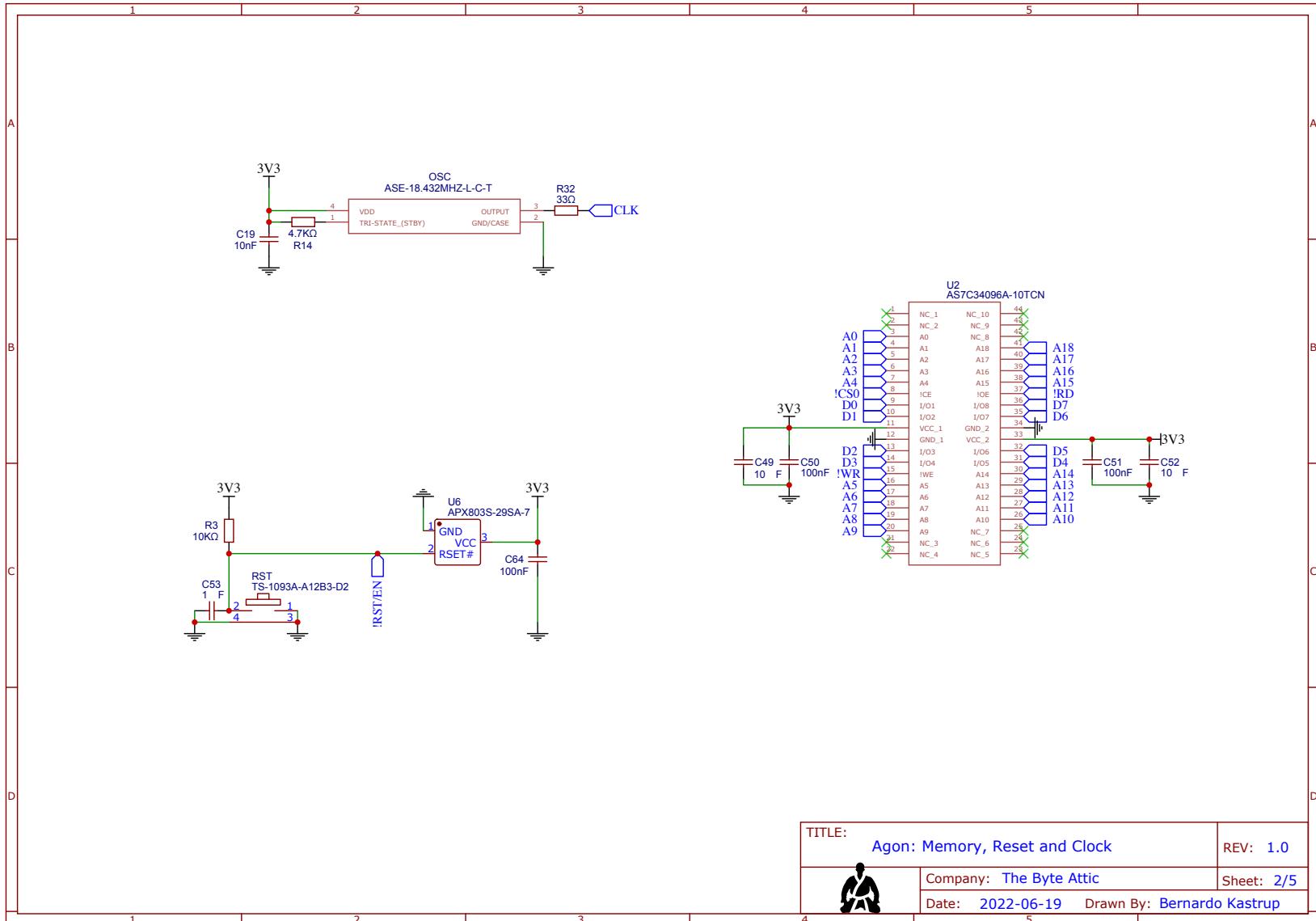
- Agon light should operate normally during both firmware programming and application execution with the default jumper settings (see previous page), but the ESP32 is known to be a sensitive device
 - Therefore, Agon light has built-in resources to deal with that sensitivity
- If the ESP32 goes into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

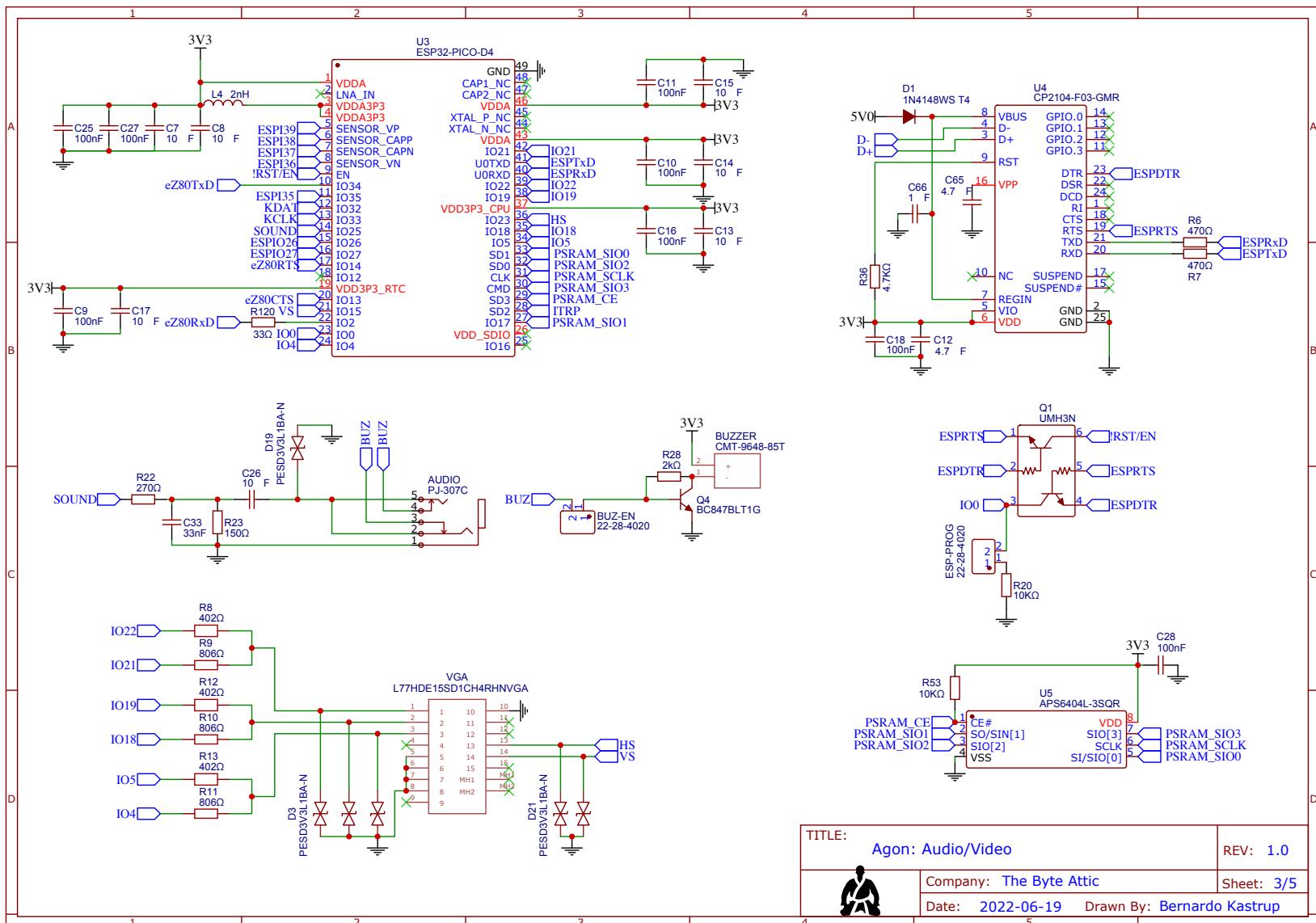


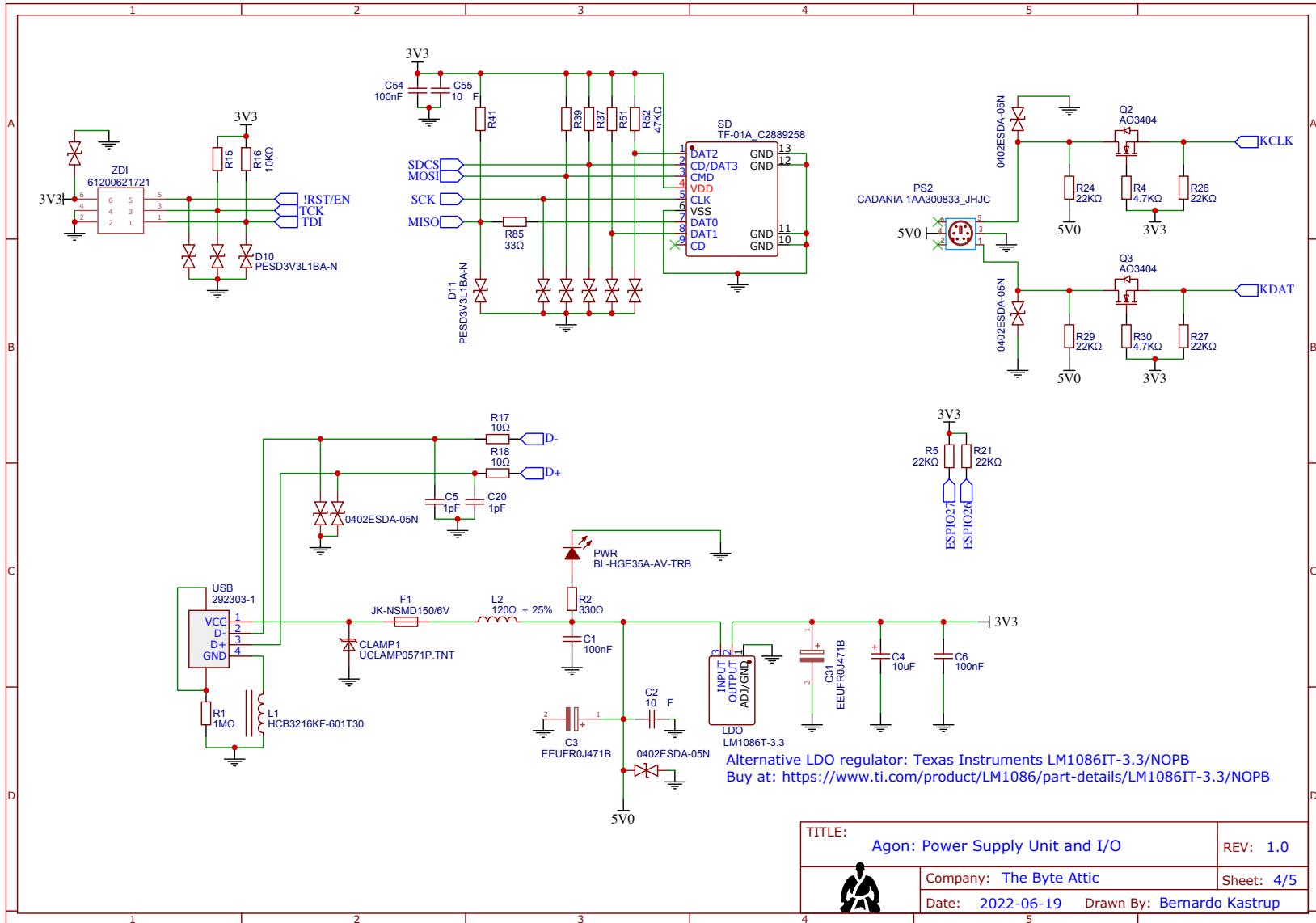
The Byte Attic's
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Schematics

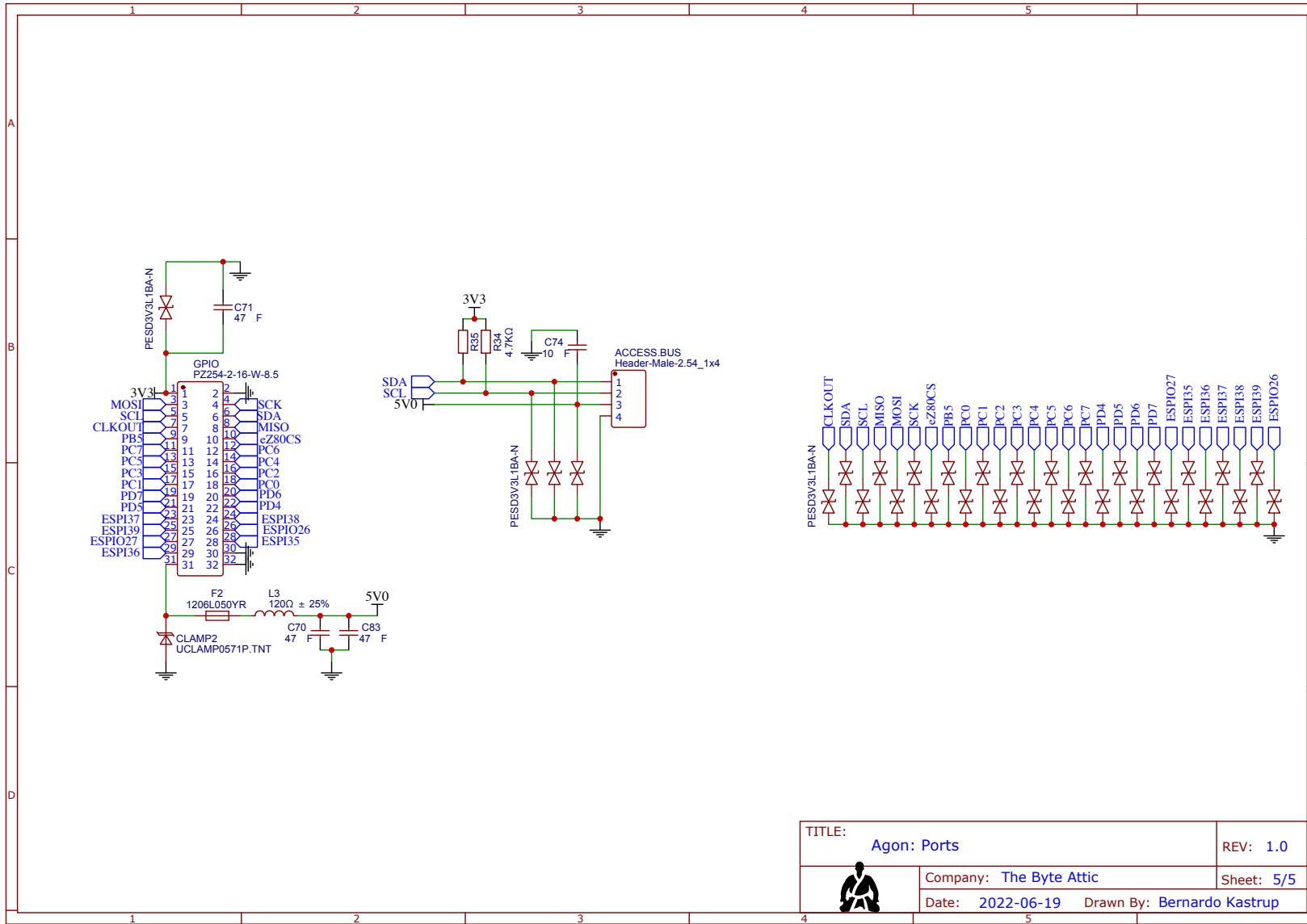










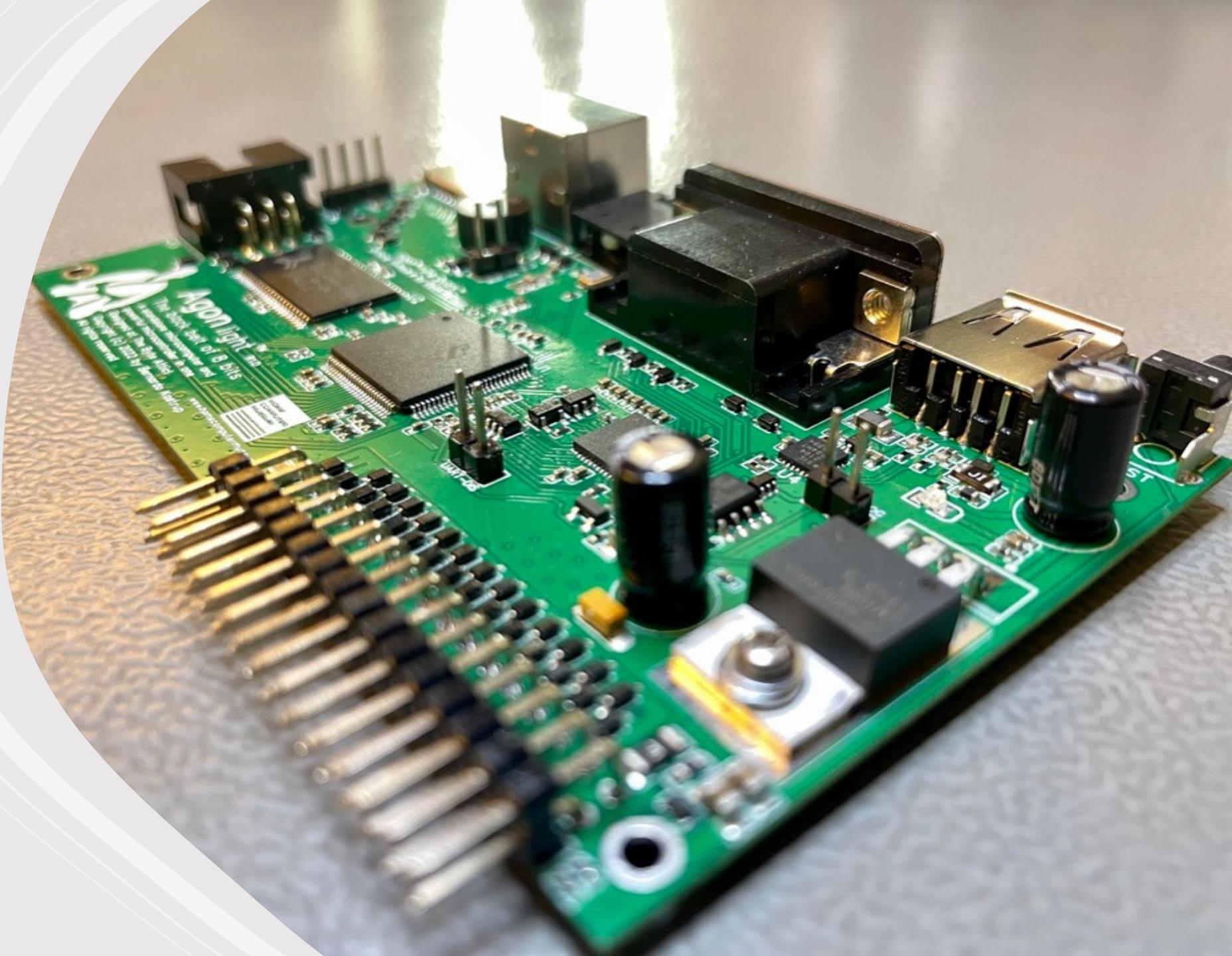




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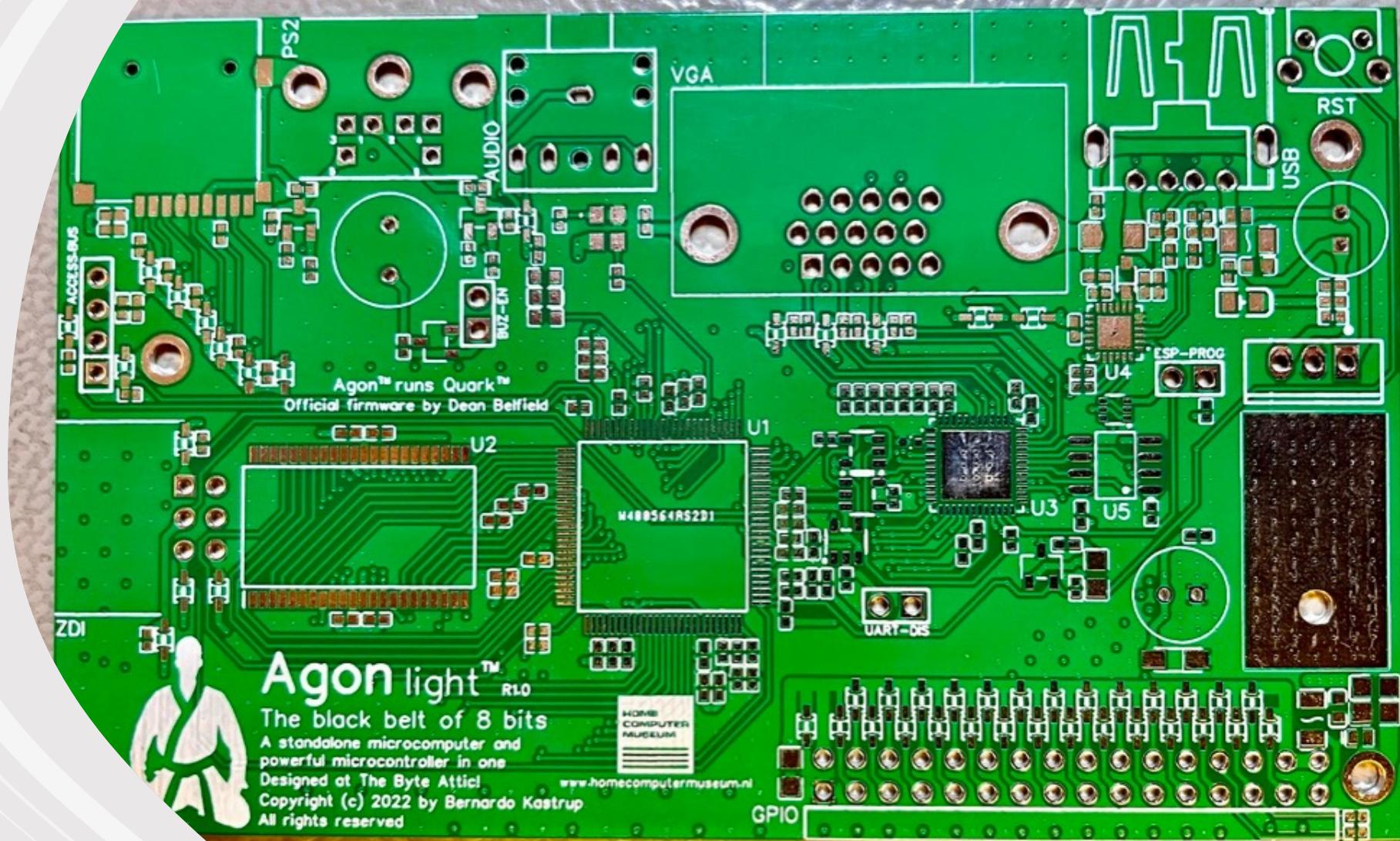
Bill of
Materials



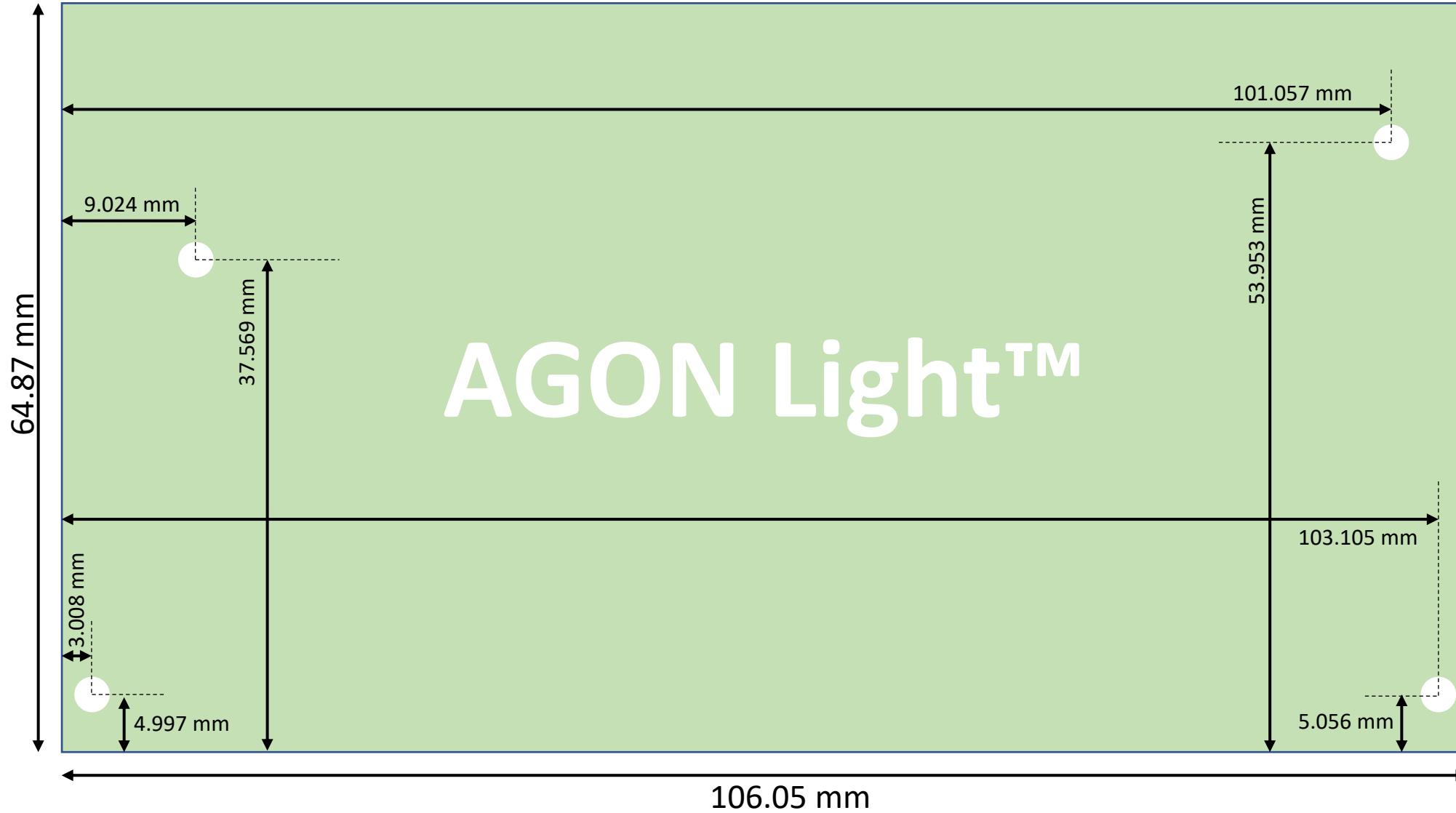
ID	Name	Designator	Footprint	Quantity	Manufacturer Part	Manufacturer	Supplier	Supplier Part	Price
1	B08478UTIG	Q4	SOT-23-3_L2-W1.6-P1.90-L52-8-BR	1	BC8478L1T1G	ON	LSC	C4393	0.035
2	R28	R28	R0402	1	0402WGF2001CE	Unidom	LSC	C4109	0.001
3	A5E-18.432MHz-LC-T	OSC	A5E18432MHZLCLCT	1	A5E18A33MHZ-LC-T	ABRACON	LSC	815-A5E18.432MHzLCLCT	0.384
4	A57C34096A-10TCN	U2	SOP8B9P118X120-144N	1	A57C34096A-10TCN	Maxeler	LSC	913-A57C34096A-10TCN	0.043
5	PZ256-2.16-W-8.5	GPIO	HOB-TH-32P-2.54-1144-82-CHS-52-54	1	PZ256-2.16-W-8.5	NETL(华阳天美)	LSC	C284956	0.049
6	Header-Male-2.54-1x4	ACCESS_BUS	HOB-TH-32P-2.54-1144-82-CHS-52-54	1	4P_L=1.0MM_GND/plat	Centow	LSC	C14378	0.049
7	PJ-307C	AUDIO	AUDIO-TH_P1307C	1	PJ-307C	BOOMLE	LSC	C16684	0.043
8	22-28-4020	BIZ_ENP-ESP-PROG-UART-DIS	HOB-TH-3P-2.54-VW-M-1	3	22-28-4020	MOLEX	LSC	C234182	0.076
9	CMT-9648-85T	BUZZER	CMT964885T	1					
10	10nf	C0402-NEW	C0402-NEW	23	C105B104050NNINC	SAMSUNG	LSC	C1525	0.001
11	10pF	C0402	C0402	20	C105A106M050NUINC	SAMSUNG	LSC	C1525	0.005
12	1pF	C0402	C0402	2	0402CG3100C50NT	FH	LSC	C1550	0.001
13	4.7μF	C0402	C0402	2	C105A475UMPNINC	SAMSUNG	LSC	C22733	0.006
14	10nf	C105	C105	1	C105103UB35BNINC	SAMSUNG	LSC	C1595	0.001
15	1nF	C0402	C0402	8	C105A0105050NUINC	FH	LSC	C1523	0.001
16	1nf	C0402	C0402	1	C105A105050NNINC	SAMSUNG	LSC	C2266	0.003
17	ELUF10471B	C3-01	CAP-SDM-13.2-W1.6-R-RD	2	ELU-FR0471B	Panasonic	LSC	657-ELU-FR0471B	0.098
18	10nf	C4	CAP-SMD-13.2-W1.6-R-RD	1	TAJA06061BNJ	AVX	LSC	C7171	0.006
19	33nf	C3	C0003	1	C105333B8BNINC	SAMSUNG	LSC	C21117	0.006
20	1nf	C3	C0005	1	C105105GBPNINC	SAMSUNG	LSC	C28333	0.009
21	47μF	C702C17C03	C0805	3	C105A475UMPNINC	SAMSUNG	LSC	C16780	0.026
22	UC1AM985712-TNT	CLAMP-DIODE	SGP1650N12-1A-0.91-RD	2	UGLAM985712-TNT	SEATECH	LSC	C51287	0.043
23	IN4148W5/14	D1	SOD-323-1L-8-W1.3-L5.2-RD	1	IN4148W5/14	C	LSC	C2128	0.013
24	PESD3V31BA-N	D2-033-04-05-06-07-08-09-01-01	2.013-03-04-015-016-017-019-020-023-028-031-032-034-035-036-037-038-039-040-041-042-043-044-045-046-047-048-049-050-051-052-053-054-055-056-057-058-059-060-061-062-063-064-065-066-067-068-069-070-071-072	PESD3V31BA-N	Bourne Semicon (Shenzhen)	LSC	C346020	0.051	
25	E5D3	DB8-ED84-LED-PROT-LED-DB8	DB402-8I	1	0402LS04-05N	Bourne Semicon (Shenzhen)	LSC	C316049	0.019
26	0402ESD-PROT-LED-DB8	PROT2-SDP-PROT3	DB402-8I	5	0402LS04-05N	Bourne Semicon (Shenzhen)	LSC	C316049	0.019
27	JK-15MAD150V6	F1	F1306	1	JK-15MAD150V6	JK(金利)	LSC	C280249	0.036
28	1206LS050R	F2	F1206	1	1206LS050R	Uitec	LSC	C163512	0.065
29	IC03216MF-601730	L1	L106	1	HE03216MF-601730	TAITEC	LSC	C37023	0.028
30	120nf ±25%	L2-13	L0603	2	BLUM18KG121TND	Multata	LSC	C88811	0.017
31	3.1H	L2-13	IND-SMD-12.2-W0.6	1	ASIC-0042-2801-T	Abracon	LSC	C188816	0.224
32	UM1086T-3.3	LDO	TO-220-3_1.0-0.945-0.5-0.54-L	1	UM1086T-3.3	HSSEM	C	C444381	0.241
33	CADANIA_JA30833_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	SC76-6_12.2-W1.3-PI-90-1.5-L5-1.8-R	2	A03404	GumGum HomeTech	LSC	C192925	0.001
36	A03404	Q2-03	SOT-23-3_L2-W1.3-PI-90-1.5-L5-2.4-R	1	0402WGF1040TCE	Unidom	LSC	C26983	0.001
37	1mA	R1	R0402	1	0402WGF1040TCE	Unidom	LSC	C2104	0.001
38	3mA	R2	R0402	1	0402WGF1002CE	Unidom	LSC	C2744	0.001
39	10kΩ	R3_R15.16.19_R30.18.19_R36.11.11	R0402	9	0402WGF1002CE	Unidom	LSC	C25077	0.001
40	4.7kΩ	R4_R14_R25.13.30_R34.13.35_R36.11.11	R0402	10	0402WGF4701CE	Unidom	LSC	C25900	0.001
41	2kΩ	R5_R11.12.13.14_R15.16.17.18	R0402	6	0402WGF6220TCE	Unidom	LSC	C27948	0.001
42	47kΩ	R6_R17	R0402	2	0402WGF4702TCE	Unidom	LSC	C25117	0.001
43	40kΩ	R8_R12.13	R0402	3	PTF0402402402N9	RES(研华)	LSC	C262862	0.079
44	80kΩ	R9_R10.11	R0402	3	TC0228B8600TCE	Uniroyal Elec	LSC	C150511	0.061
45	100	R10_R18	R0402	2	0402WGF1001CE	Unidom	LSC	C25077	0.001
46	330	R31_R32_R33_R34_R35_R36_R37_R38_R39_R40_R41_R42	R0402	12	0402WGF330TCE	Unidom	LSC	C25105	0.001
47	47kΩ	R37_R39_R41_R42	R0402	5	0402WGF4702TCE	Unidom	LSC	C27942	0.001
49	1500	R23	R0603	1	0603WAF1500TSE	Unidom	LSC	C22966	0.002
50	TF-01A_C2B89128	SD	TF-01A_C2B89128	1	TF-01A_C2B89128	Vuand(台湾元通)	LSC	C28208	0.002
51	EZ0809242020EG	U1	QFP55PQF160X160X160-100N	1	EZ0809242020EG	Zilog	LSC	C288937	0.088
52	ESP2104-F03-GMR	U3	QFN-44_L7D-W7-04-010-030-030-BLEP2.6	1	ESP2104-F03-GMR	Espresso Systems	LSC	C193707	3.82
53	CP2104-F03-GMR	U4	QFN-44_L7D-W7-04-010-030-030-BLEP2.6	1	CP2104-F03-GMR	SILICON LABS	LSC	C47015	2.361
54	AP5640L-350	U5	SOT-23-3_L2-W1.6-P1-90-1.5-L5-2.4-R	1	AP5640L-350-GR	Maxeler	LSC	C27944	0.001
55	AP5640S-350A-7	U6	SOT-23-3_L2-W1.6-P1-90-1.5-L5-2.4-R	1	AP5640S-350A-7	Diodes Incorporated	LSC	C43831	0.001
56	SNT4UIC1G250BIR	U7_U8	SOT-23-5_L3_W1.5-P1-90-1.5-L5-2.4-R	2	SNT4UIC1G250BIR	TI	LSC	C29554	0.087
57	SNT4UIC1G250BIR	U9	SOT-23-5_L3_W1.5-P1-90-1.5-L5-2.4-R	1	SNT4UIC1G250BIR	TI	LSC	C7827	0.112
58	U77HDF1550D1C4HNNVCA	U8	U77HDF1550D1C4HNNVCA	1	29293-1	TE Connectivity	LSC	C86461	0.407
59	61300621721	ZD1	SHDR46W64P254254_2X152XB8	1					
61	TS-1093A-A12B3-D2	RST	KEY-TI_4P_L7-1_W12-4P_G450L52.5	1	TS-1093A-A12B3-D2	Vuand	LSC	C499319	0.062



The Byte Attic's
Agon
light™
PCB
dimensions



PCB dimensions (diagram *not* to scale)

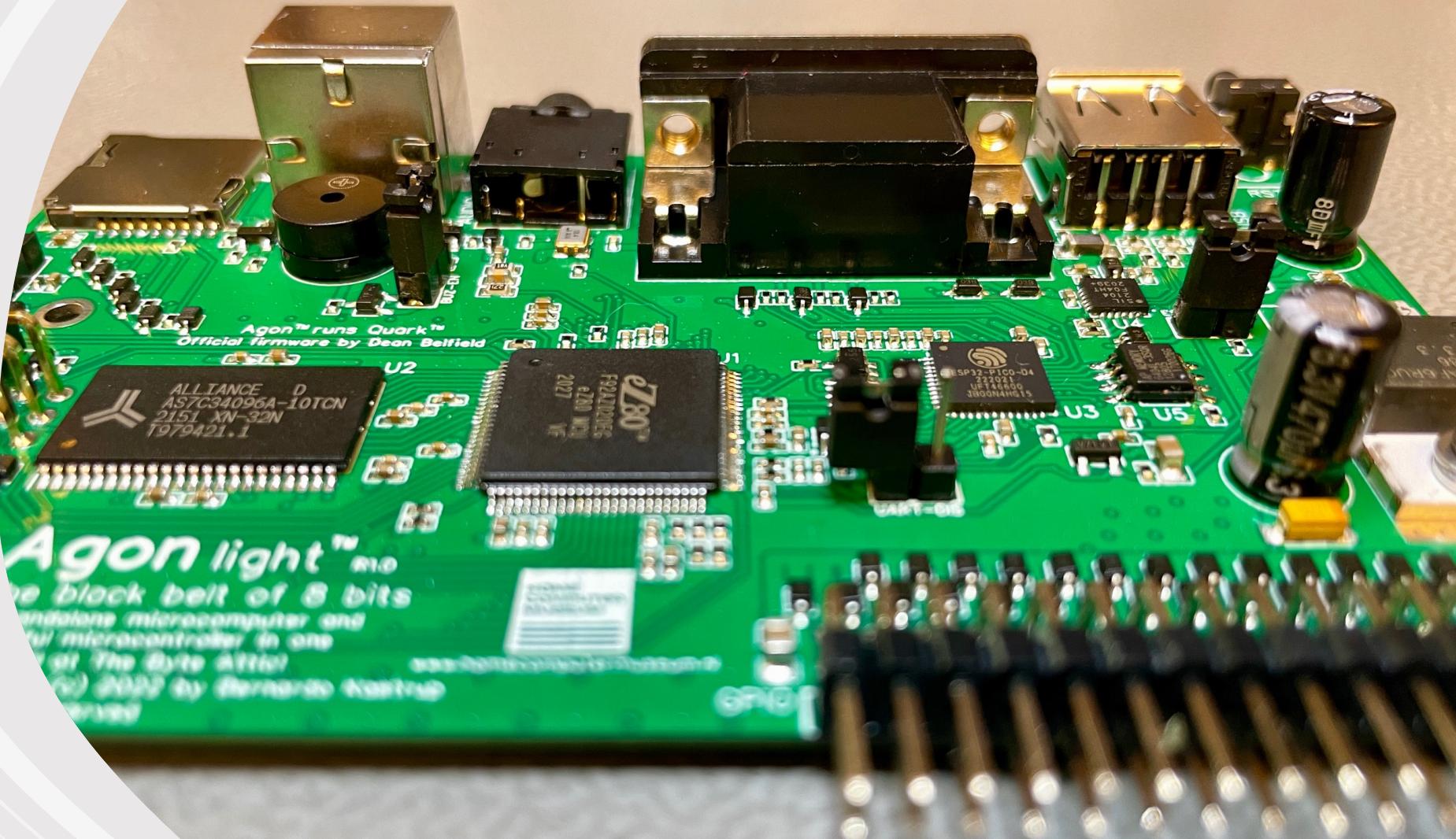




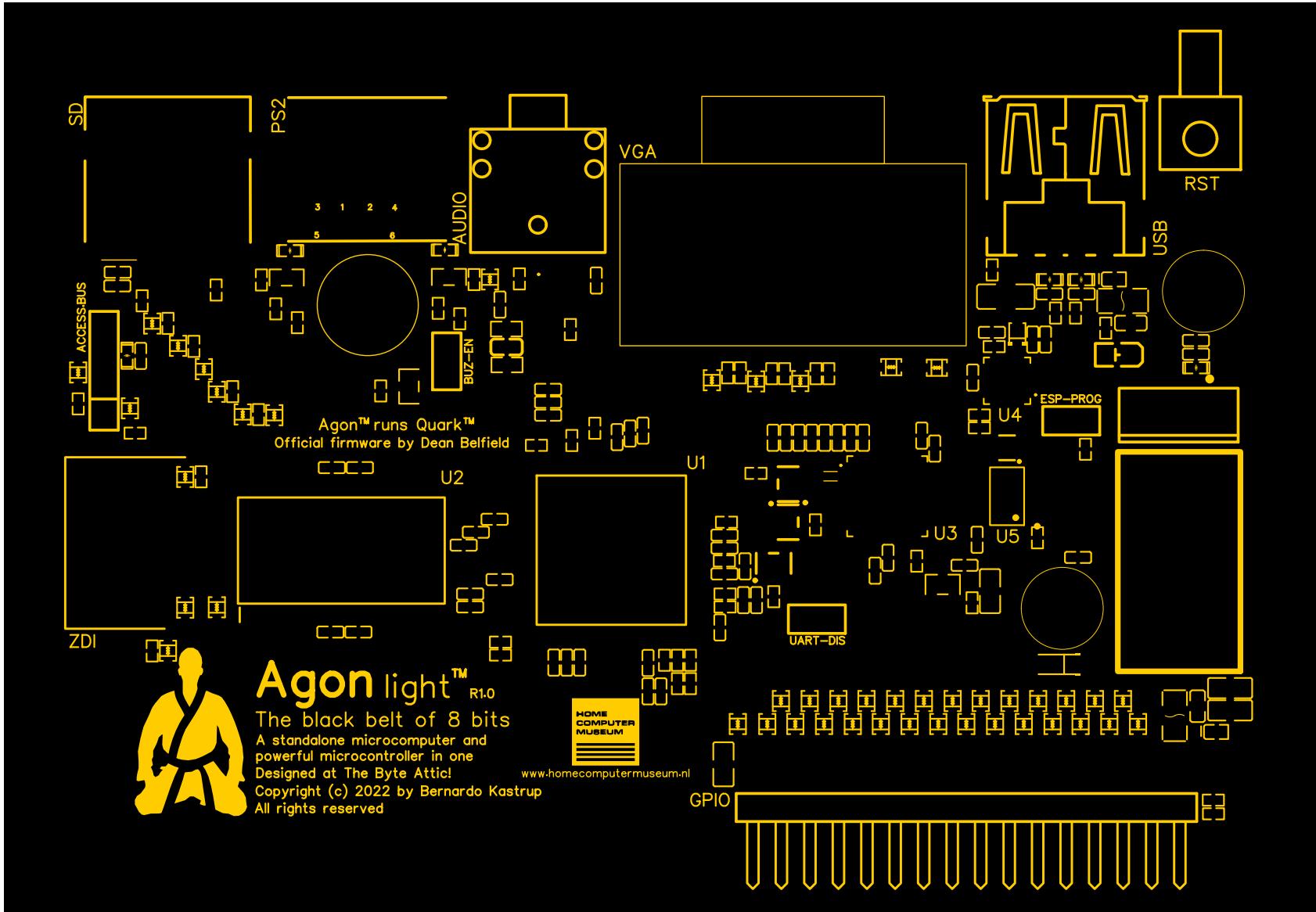
The Byte Attic's

Agon light™

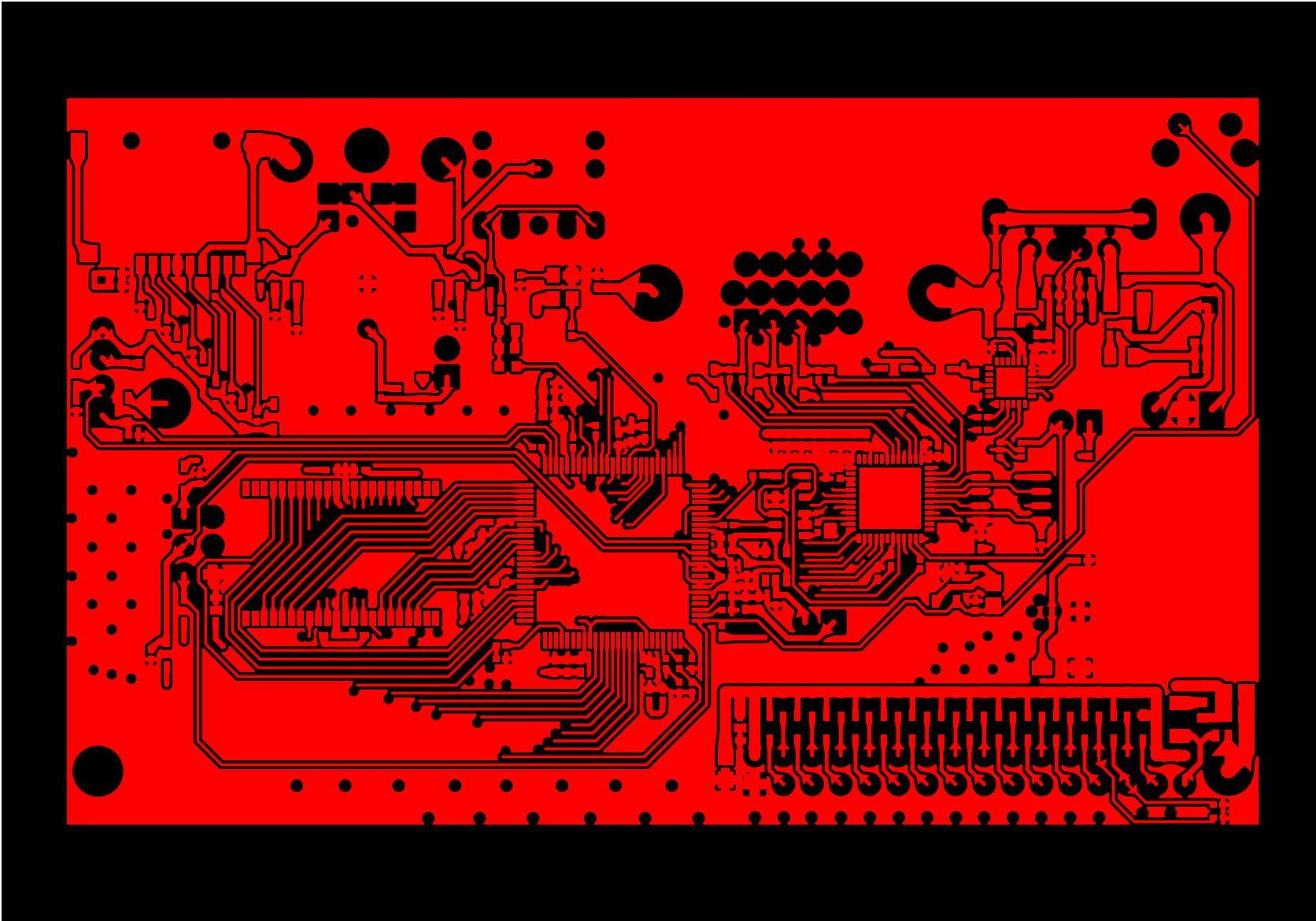
PCB layers
design



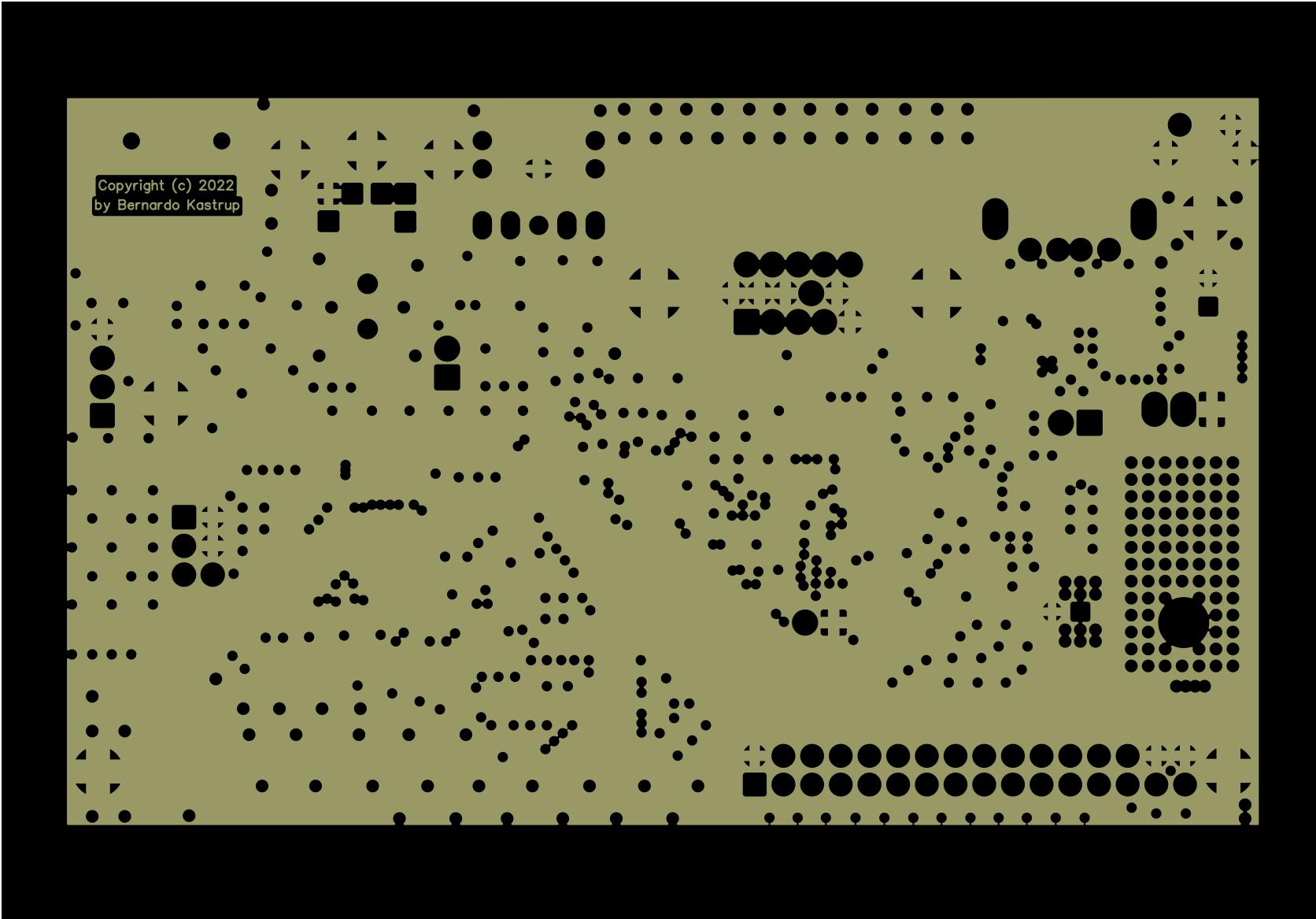
Top silkscreen



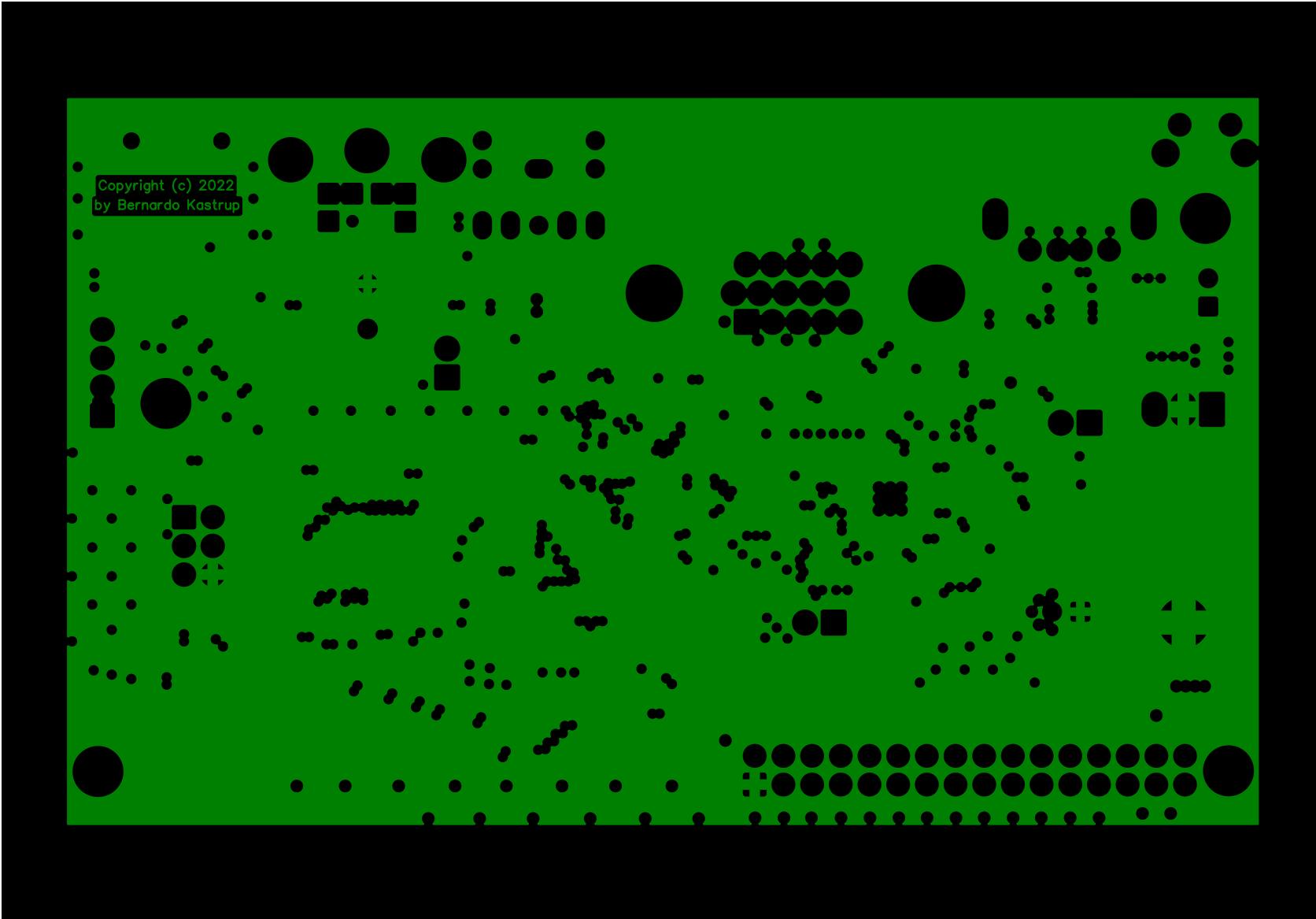
Top metal layer (3.3V filled)



First inner plane (GND)



Second inner plane (3.3V)



Bottom metal layer (GND filled)

