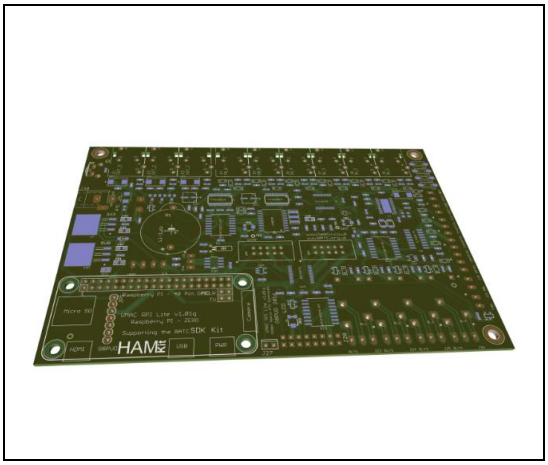
Amateur Radio and Television Electronic Educational Projects and Kits

HAMKit VMAC RPI Lite - User Manual v1.01g SDK (Draft)

User Manual



Updated: Friday, 16 September 2016

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www.hamkit.co.uk

Document Revisions

This manual is a living document and is subject to continued and varied update as the product evolves.

Updates to the product design and components used, are subject to change and improvements.

Should you note any errors, omissions or have any inclusions that maybe of interest to other users, please contact us via our website or email admin@hamkit.co.uk

Date	Initials	Comments
11h Sep 2016	DW	First draft of manual
16th Sep 2016	DW	Updates to first published draft

Table of Contents

Introduction

Thank you for purchasing one of our HAMKit products / kits, all of which are designed for use within the Amateur Radio and Television Electronics hobby.

In this day and age, the humble manual is often left to one side, or in the box, and unless absolutely necessary it may only get to have a subtle peep at the contents while nobody is looking.

We welcome you to do the opposite, put the kettle on and then take a few moments to relax with this manual over a nice refreshing brew, as this could save you time and more importantly make the whole project more enjoyable and rewarding.

Whilst we take great care in the electronic and mechanical design and construction details of our products, we are human and are open to learn, and so constantly strive to improve all of our processes based on your valued feedback.

Thank you and we trust you will enjoy the building and use of our product.

The HAMKit Team.

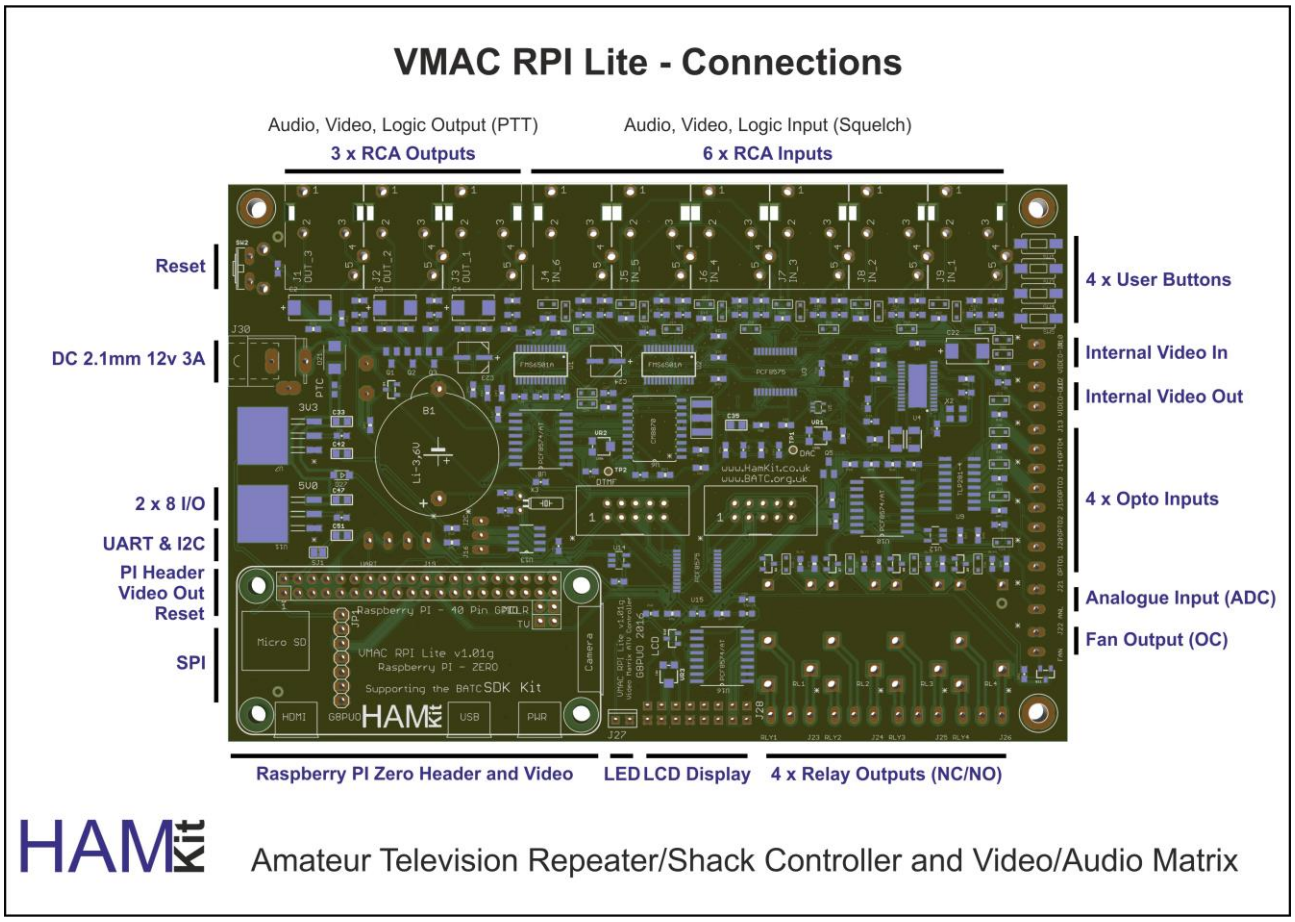
In memory of Peter Blakeborough, G3PYB, who was an inspiration and pioneer to many in television, ATV and DATV, and to which the VMAC project is dedicated too.

Supporting the BATC, British Amateur Television Club. www.batc.org.uk

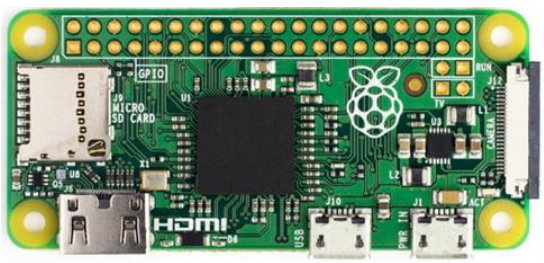
Product Overview

The VMAC, Video Matrix ATV Controller, project, is an audio and video switching matrix board that can be used for Amateur Television (ATV/DATV), repeater logic, Audio/Video switching, FM repeater logic, or CCTV type projects and development.

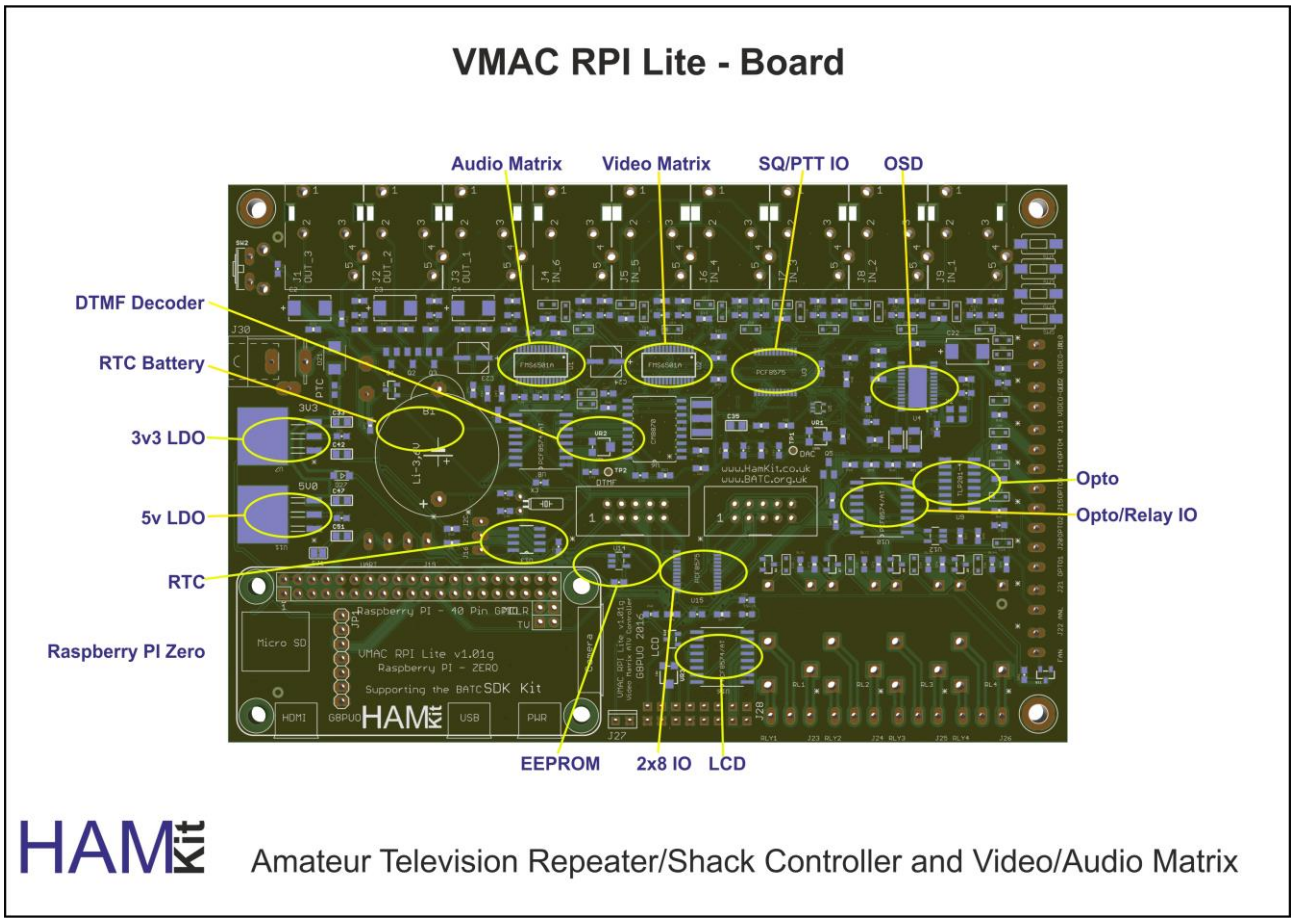
VMAC RPI Lite, is the first in a planned series of boards and is aimed as a SDK, Software Development Kit, in order to develop, educate and experiment within an Amateur Radio Open Source community.



The processing heart of VMAC is based around the Raspberry PI Zero, with the on-board 40 pin and 2+2 pin connectors being used to make all the required connections, including video out and reset. A standard PI could also be used.



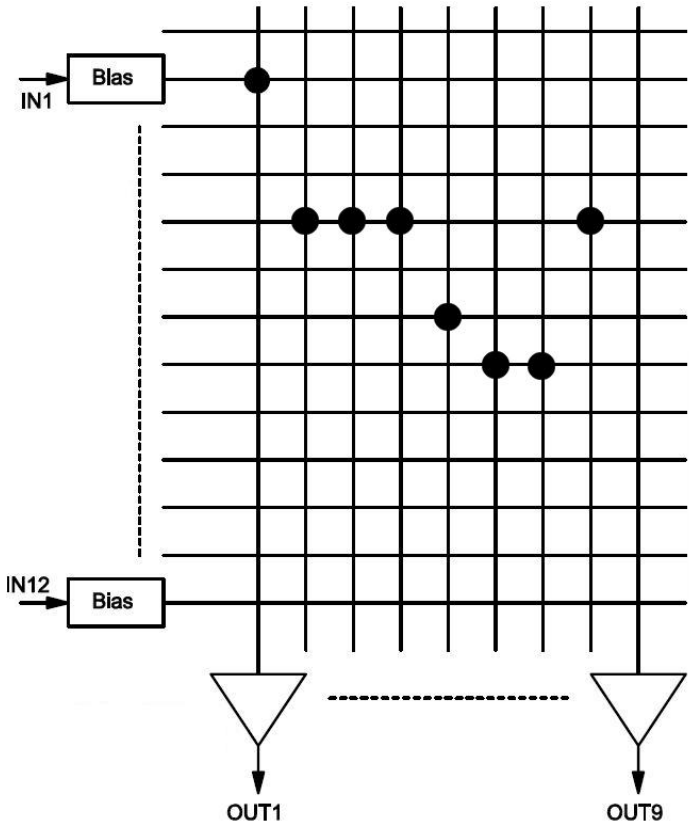
The VMAC board is reasonably compact and largely made up from surface mount components, with most being 0603 in size to save space. As VMAC RPI Lite is a SDK, the initial board is set out as a quality two layer (may go to four), through plated and containing as many options as feasible for experimentation and development. RCA three socket connectors are used for A/V inputs and outputs. Screw terminal blocks are mostly used for other connections such as opto inputs and relay outputs.



All of the VMAC switching is based around the Fairchild Semiconductor FMS6501A which offers 12 Inputs to 9 Output Video Switch Matrix. Using the right software settings and interfacing, this IC provides excellent video and audio switching features.

The FMS6501A is a one-to-many matrix, so enables any input to any single output, or multiple single inputs to multiple outputs. It does not allow mixing, so you cannot have two inputs to one output.

An example of the matrix is shown, input 1 going to output 1, input 4 going to outputs 2, 3, 4 and 7. All of this is made under software control.



As VMAC has two FMS6501A ICs, software control can allow simultaneous settings for both audio and video matrix configuration, or independently drive video and audio matrix separately. The reason for this is to provide total flexibility for the user.

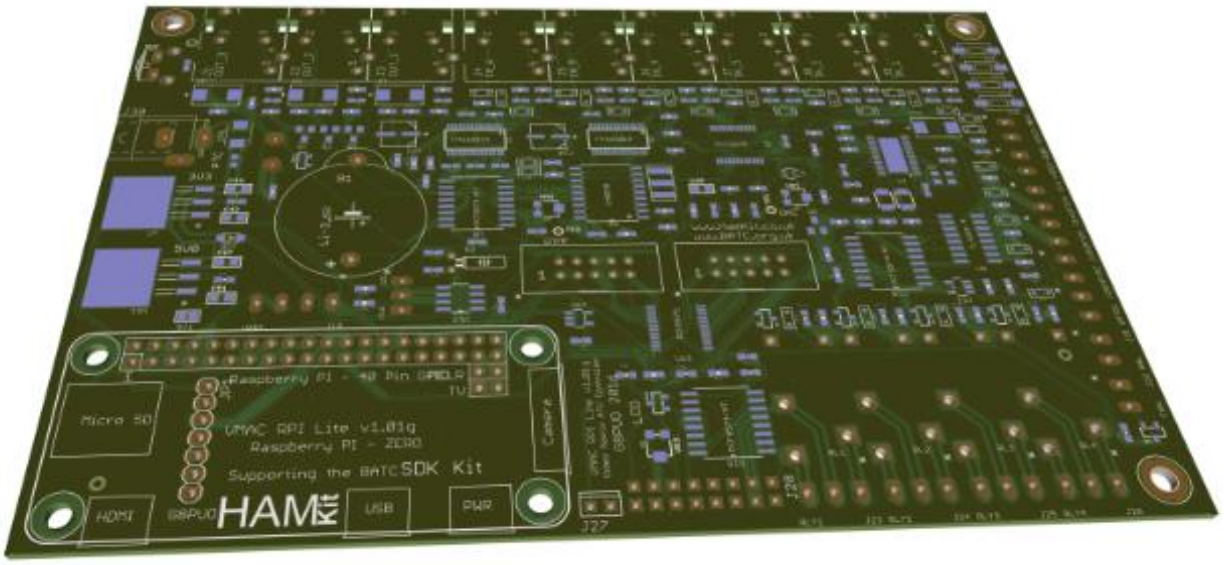
The OSD display is provided via a trusty MAX7456 which is a Single-Channel Monochrome On-Screen Display. Using the video matrix features, it is possible to then change the inputs and outputs under software control.

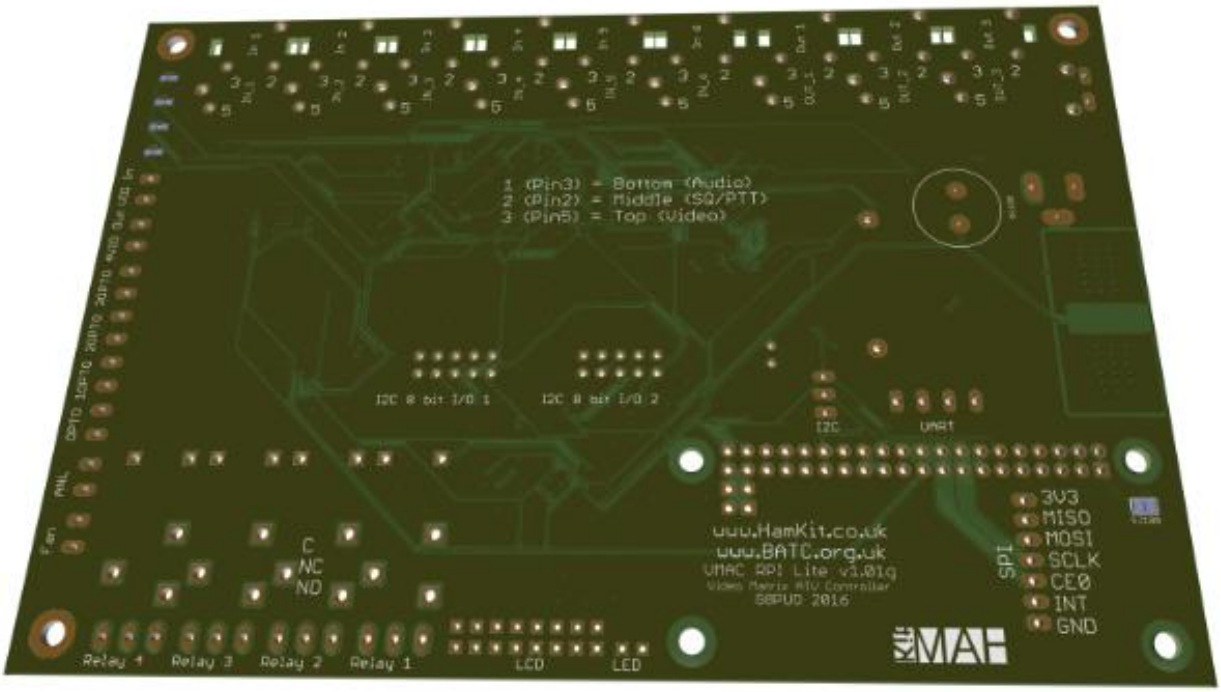
VMAC RPI Lite is self-contained and allows six inputs to three outputs. An additional video input and output is provided for internal use such as monitor, test card generator etc.

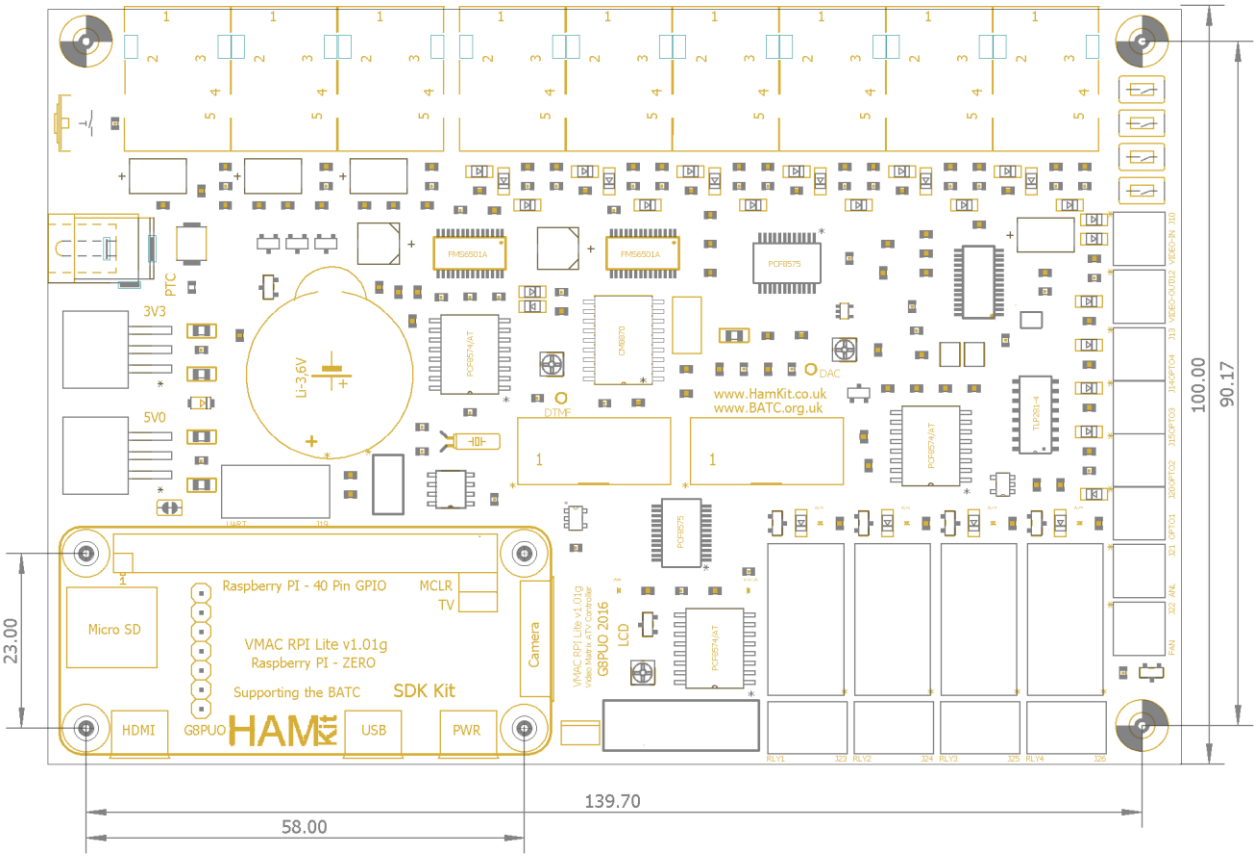
The DTMF decoder samples the audio in and the PI audio DAC output can be fed into the audio bus and through to the audio matrix for Morse idents and alert tones.

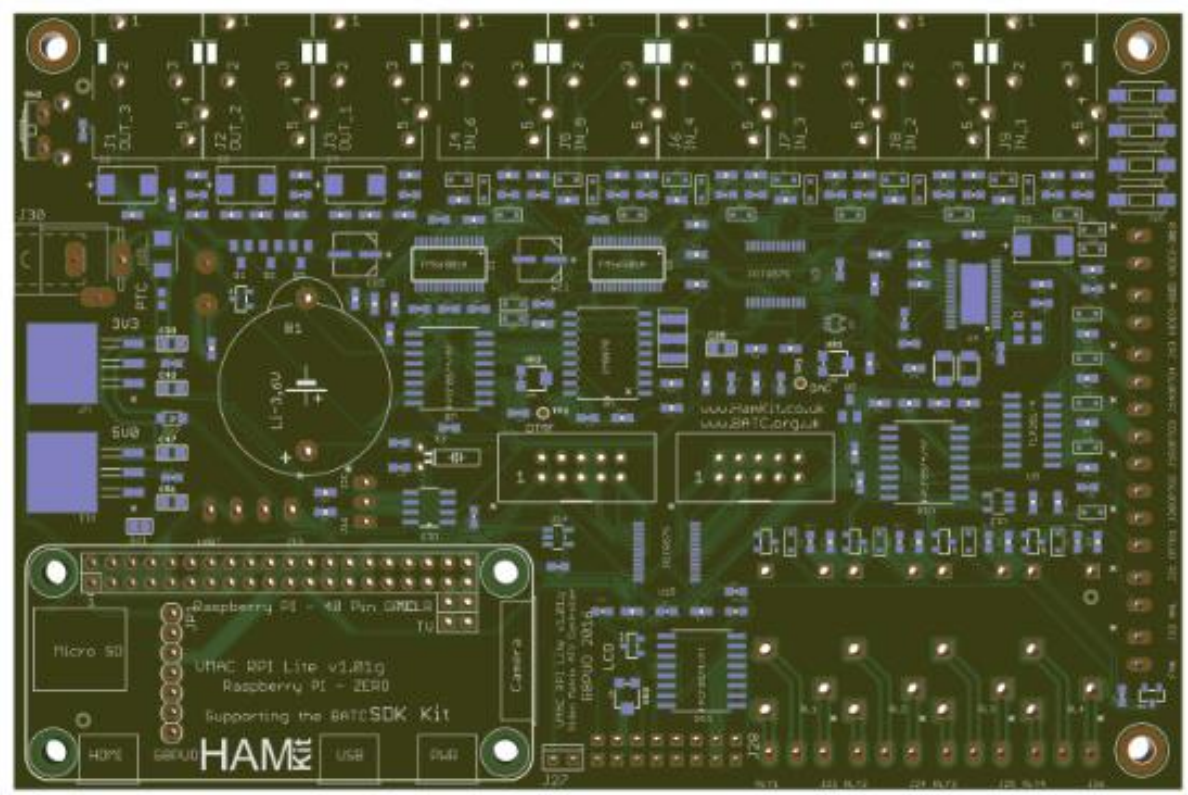
The on-board battery backed Real Time Clock is coupled to the I2C bus, alongside the various IO switches. An ADC is used to sample the DC input and can used to monitor battery volts or other sensor requirements. SPI connector can be used to add Ethernet or WLAN to the PI, allowing easy remote control and access.

Pictorials


VMAC RPI Lite v1.01g
Raspberry PI - ZERO
Supporting the BATC SDK Kit
Micro SD
HDMI
USB
PWR
Camera
TV
J27


1 (Pin3) = Bottom (Audio)
2 (Pin2) = Middle (SQ/PTT)
3 (Pin5) = Top (Video)
I2C 8 bit I/O 1
I2C 8 bit I/O 2
I2C
UART
www.HamKit.co.uk
www.BATC.org.uk
VMAC RPI Lite v1.01g
Video Matrix RTV Controller
G8PUD 2016
3V3
MISO
MOSI
SCLK
CE0
INT
GND
SPI
C
NC
NO
Relay 4
Relay 3
Relay 2
Relay 1
LED
LED





Specification

- Standard Raspberry PI 40 pin header
- PI ZERO Video out and Reset header
- Open source software for community involvement
- 6 x video/audio inputs with squelch or controlling logic input (PCB mounted stacked RCA sockets, software configurable)
- 3 x video/audio outputs with PTT or controlling logic output (PCB mounted stacked RCA sockets, software configurable)
- 4 x Optical isolated inputs (PCB Screw Blocks, software configurable)
- 4 x Relay isolated outputs (PCB Screw Blocks, software configurable NO/NC)
- 16 (2x8) x I/O for push buttons, LED etc. (Header, software configurable, 3V3 Level)
- Fan output (PCB Screw Block, software configurable OC)
- Analogue input (software configurable)
- Local video input for test card use etc. (PCB Screw Block, software configurable)
- Local video output for monitor use etc. (PCB Screw Block, software configurable)
- LCD display controller (Header)
- On-Board LEDS (for Relays and Status/Testing)
- On-Screen Display (software configurable)
- DTMF decoder (software configurable)
- I2C bus (Header, 3V3 Level)
- UART (Header RX/TX/RTS, configurable, 3V3 Level)
- ADC (configurable)
- DAC (configurable)
- SPI (Header, 3V3 Level)
- Real-time clock (on board CR2032 battery)
- Audio Idents (software configurable)
- EEPROM
- Sounder
- 12v DC input (~3A, 2.1mm Socket)
- Board only 150mm x 100mm

Package Contents / Bill of Materials

Please take a moment to check that your kit has the following package contents:

- 1 x VMAC RPI Lite PCB (semi-populated kit)
- Components
  - 9 x RCA Sockets
  - 2 x RCA to BNC Adaptors
  - 1 x DC 2.1mm Socket
  - 1 x DC 2.1mm Plug
  - 4 x Relays
  - 1 x Reset Button
  - 4 x 3 Pin Screw Block
  - 8 x 2 Pin Screw Block
  - 1 x Battery Holder
  - 1 x CR2032 Battery
  - 1 x 3 Way Header Pins
  - 1 x 4 Way Header (2+2) Pins
  - 1 x 4 Way Header (2+2) Socket (Optional Fit)
  - 1 x 4 Way Header Pins
  - 1 x 7 Way Header Pins
  - 2 x 10 Way Headers Pins
  - 1 x 16 Way Header Pins
  - 1 x 40 Way Header Pins
  - 1 x 40 Way Header Socket (Optional fit)
  - 1 x Buzzer
- 1 x USB Stick (Software and Manuals)

Special Instructions

*

User Guide

This project is aimed at beginners, through to the more advanced experimenters and developers, all of whom could see this board being used for a range of different uses, such as:

- SDK
  - Software Development Kit for Audio and Video control and matrix switching
- ATV or DATV Repeater Logic
  - Switching in a range of video/audio inputs with multiple receivers and auto selection and output up to three repeaters or local/remote monitoring or streaming
- FM Repeater Logic
  - Control of a traditional Amateur Radio Repeater, or simultaneous control of up to three repeaters with a single logic board
- Home ATV or DATV Station
  - Video and Audio Matrix Switch of a number of inputs such as a cameras or other sources, out to monitors and streaming
- CCTV – Home Automation
  - Home CCTV automation with remote switching and control

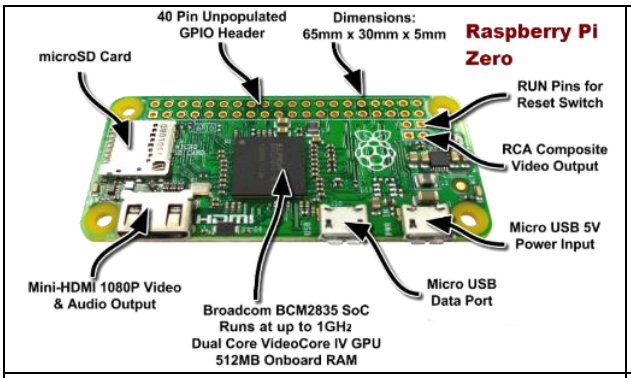
These uses cover such as wide area of functions in order to nurture ideas and gain community involvement, rather than just provide a single application. By allowing the software to be completely open source, we are hopefully able to encourage a range of individuals, clubs and groups.

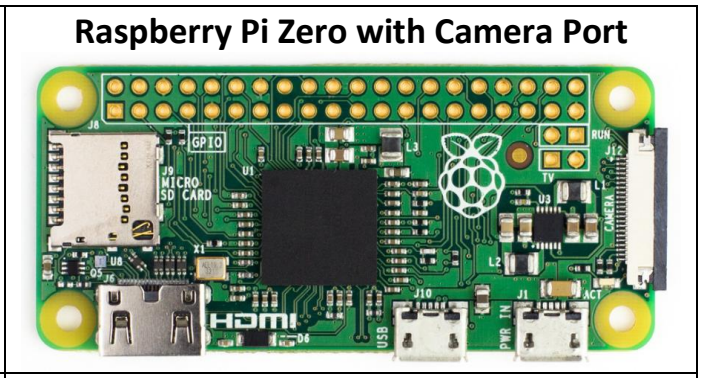
The Humble PI

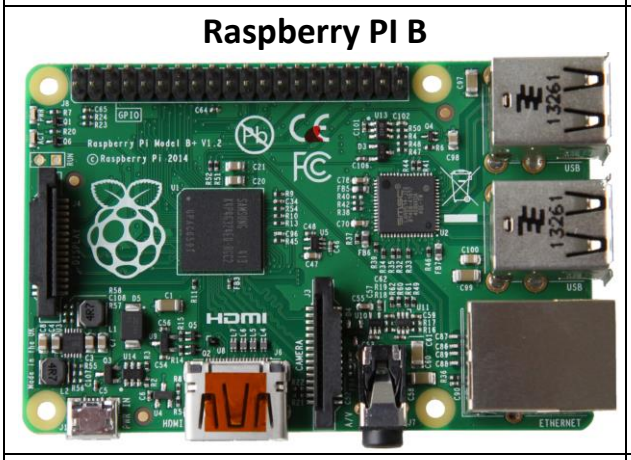
We have such as vast range of small micro-boards available to us today that choosing a route for VMAC was given some thought.

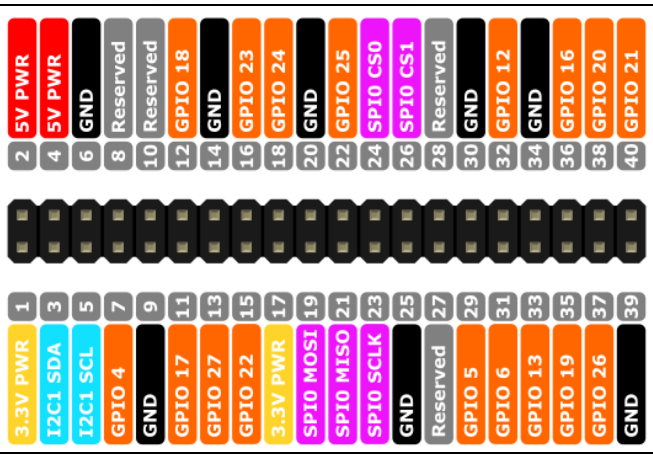
Originally the VMAC board was designed with an embedded Microchip but then thoughts wandered to the Arduino camp and another design was drafted. Finally with the Zero back in circulation, following manufacturing delays, this proved an ideal form factor and also low cost – so the RPI version of VMAC was formed.

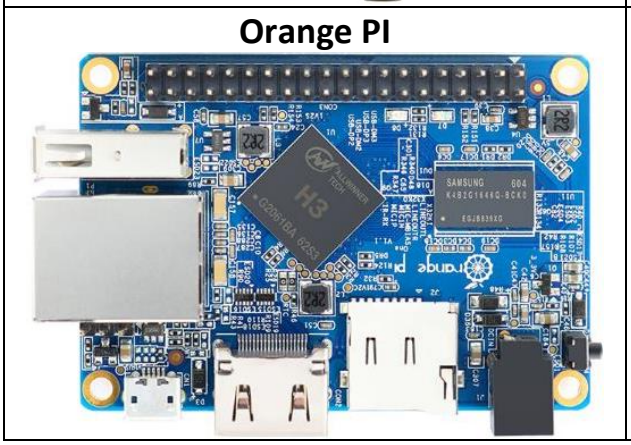
The advantage of using a PI is that we have a number of flavours available not only from Raspberry (as shown below), most of which use the standard 40 pin connector and most, if not all, can also run the same Raspberry PI software images.

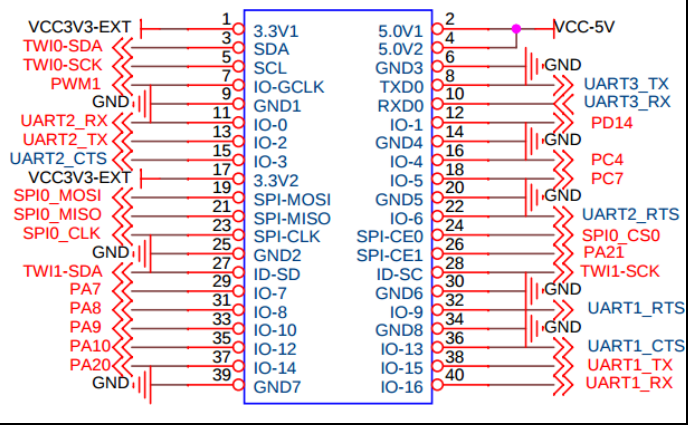




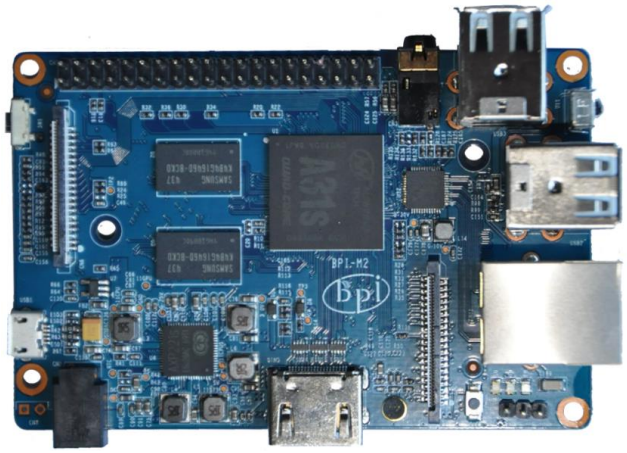




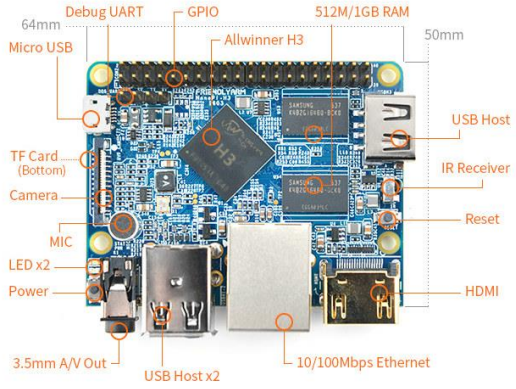


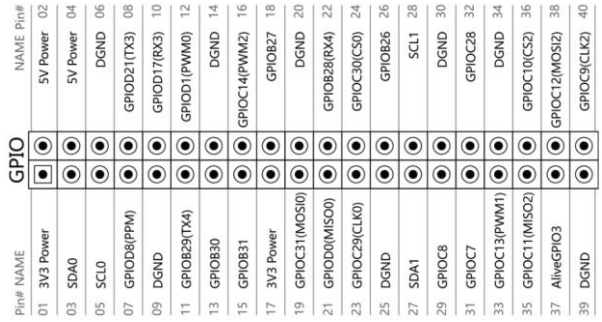


Banana PI



FriendlyARM M1





Raspberry Pi B
Rev 1 P1 GPIO Header

	Pin No.		
3.3V	1	2	5V
GPIO0	3	4	5V
GPIO1	5	6	GND
GPIO4	7	8	GPIO14
GND	9	10	GPIO15
GPIO17	11	12	GPIO18
GPIO21	13	14	GND
GPIO22	15	16	GPIO23
3.3V	17	18	GPIO24
GPIO10	19	20	GND
GPIO9	21	22	GPIO25
GPIO11	23	24	GPIO8
GND	25	26	GPIO7

Raspberry Pi A/B
Rev 2 P1 GPIO Header

	Pin No.		
3.3V	1	2	5V
GPIO2	3	4	5V
GPIO3	5	6	GND
GPIO4	7	8	GPIO14
GND	9	10	GPIO15
GPIO17	11	12	GPIO18
GPIO27	13	14	GND
GPIO22	15	16	GPIO23
3.3V	17	18	GPIO24
GPIO10	19	20	GND
GPIO9	21	22	GPIO25
GPIO11	23	24	GPIO8
GND	25	26	GPIO7

Raspberry Pi B+
B+ J8 GPIO Header

	Pin No.		
3.3V	1	2	5V
GPIO2	3	4	5V
GPIO3	5	6	GND
GPIO4	7	8	GPIO14
GND	9	10	GPIO15
GPIO17	11	12	GPIO18
GPIO27	13	14	GND
GPIO22	15	16	GPIO23
3.3V	17	18	GPIO24
GPIO10	19	20	GND
GPIO9	21	22	GPIO25
GPIO11	23	24	GPIO8
GND	25	26	GPIO7
DNC	27	28	DNC
GPIO5	29	30	GND
GPIO6	31	32	GPIO12
GPIO13	33	34	GND
GPIO19	35	36	GPIO16
GPIO26	37	38	GPIO20
GND	39	40	GPIO21

Key

Power +	UART
GND	SPI
I²C	GPIO

I2C and SPI Bus

We need to look at how to communicate with the various IC and peripherals. Flexibility and electrical ease were the consideration, hence I2C bus was adopted.

Apart from the EEPROM (and optional external Ethernet/WiFI Interface), which are connected to a SPI bus, the other peripherals are all connected to the I2C bus and have the following addresses:

Device	Function	IC	Address
FMS6501A	Video Matrix Switch	U2	06h
PCF8575C	2x8 I/O (Panel Controls)	U15	40h/41h
PCF8575C	8bit I/O (SQ/PTT)	U3	44h/45h
MCP7940N	Real-Time Clock	U13	6Fh
PCF8574A	8bit I/O (LCD Driver/LED)	U16	70h/71h
PCF8574A	8bit I/O (Opto/Relay)	U10	72h/73h
PCF8574A	8bit I/O (DTMF plus Outputs)	U8	78h/79h
FMS6501A	Audio Matrix Switch	U1	86h
MCP3221	ADC	U12	A0h

The I2C bus is also exposed as a 3 pin header (SDA, SCL, GND), which allows external peripherals to be connected.

Please ensure that you do not connect any devices that have the same I2C addresses as the above!

Note: The I2C bus is connected to the 3V3 supply rail, so all lines will be at this potential when high and NOT 5V. Should you wish to connect I2C devices which are on a 5V rail, then you will need to include 3V3 to 5V level shifters.

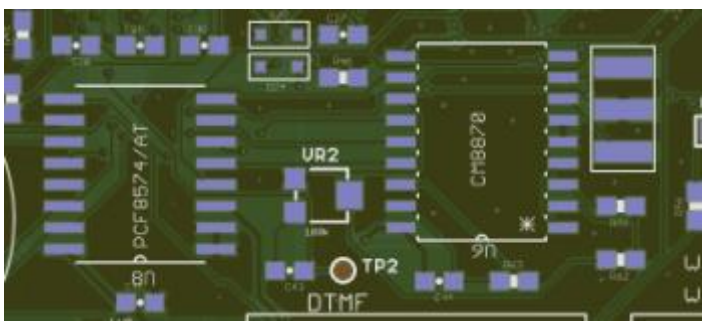
DTMF Decoder

DTMF decode is via the CM8870 that outputs the below into an 8 bit I/O PCF8574A which is placed on the I2C bus.

Due to varying audio levels, you will require to adjust the decoder audio input level so not to operate with too little level, or too high, which may cause false decoding and triggering. Overall the IC is robust and reliable once set.

F_{LOW}	F_{HIGH}	KEY	TOW	Q_4	Q_3	Q_2	Q_1
697	1209	1	H	0	0	0	1
697	1336	2	H	0	0	1	0
697	1477	3	H	0	0	1	1
770	1209	4	H	0	1	0	0
770	1336	5	H	0	1	0	1
770	1477	6	H	0	1	1	0
852	1209	7	H	0	1	1	1
852	1336	8	H	1	0	0	0
852	1477	9	H	1	0	0	1
941	1209	0	H	1	0	1	0
941	1336	*	H	1	0	1	1
941	1477	#	H	1	1	0	0
697	1633	A	H	1	1	0	1
770	1633	B	H	1	1	1	0
852	1633	C	H	1	1	1	1
941	1633	D	H	0	0	0	0
-	-	ANY	L	Z	Z	Z	Z
L = logic Low, H = Logic High, Z = High Impedance							

VR2 allows for level adjustment into the DTMF decoder. TP2 can be used to check the actual level on a scope.



2x8 I/O Functions

The I2C 16-bit I/O expander is split out to two x 8 bit ports which can be used for front panel controls such as push buttons and LEDs.

Tip: An example for VMAC in the shack is to add 9 buttons, 6 for video/audio inputs and 3 for video/audio outputs. Then you can quickly select any input and direct to any output(s), so making a fast matrix switcher. Suitable software scripts or app would be require managing this function but is not difficult.

All 16 pins default to inputs upon power up or reset and each has a weak internal pull-up 100 uA current source so enabling switches and buttons to be connected to ground, with no external pull-up resistors. Should you add longer leads away from the board or use in a sensitive electrical environment, then you may require adding some pull-ups or decoupling caps.

Note: Should you require to add external pull-up resistors, please note that the I/O expander is connected to the 3V3 supply rail and so you must NOT pull an input to 5V or you will damage the IC.

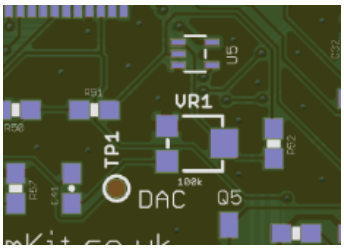
The outputs are latched with a 25mA sink capability for directly driving LEDs via a resistor. You may of course drive other logic, transistors or MOSFETs as needed.

Note: The I/O expander is connected to the 3V3 supply rail, so all outputs will be at this potential when high and NOT 5V. Should you wish to drive 5V logic, then you will need a 3V3 to 5V level shifter.

PI Video and Audio

Both composite video and audio is taken from the PI. Video is directed to the video matrix and the audio is taken from the DAC output of the PI and fed through an RC filtering network, then on to the audio matrix.

U5 is used to switch in an attenuator, allowing software controlled levels and VR1 used to set overall level into the audio matrix switch. TP1 is an output test point.



Video Matrix Switching

The FMS6501A has 12 inputs and 9 outputs (75 ohms). On VMAC RPI Lite, these are:

Inputs

- IN1-IN6: 6 x Video In from RCA Connectors
- IN7-8: Spare and Unused on Lite
- IN9 –from OSD Video Output
- IN10: Internal Video In from Connection Block
- IN11: from RPI Video Output (PICVBS)
- IN12: Spare and Unused on Lite

Outputs

- OUT1-OUT3: 3 x Video Out to RCA Connectors
- OUT4-OUT6: Unused on Lite
- OUT8: Internal Video Out to Connection Block for Monitor etc.
- OUT9: to OSD Video Input

Audio Matrix Switching

The FMS6501A has 12 inputs and 9 outputs (600 ohms). On VMAC RPI Lite, we are exposing the below:

Inputs

- IN1-IN6: 6 x Audio In from RCA Connectors
- IN7-IN8: Spare and Unused on Lite
- IN9: Audio from PI DAC
- IN10-IN12: Spare and Unused on Lite

Output

- OUT1-OUT3: 3 x Audio Out to RCA Connectors
- OUT4: Spare and Unused on Lite
- OUT5: Mixed Audio to OUT1
- OUT6: Mixed Audio to OUT2
- OUT7: Mixed Audio to OUT3
- OUT8: Spare and Unused on Lite
- OUT9: Audio Out to DTMF Decoder

Squelch and PTT I/O

A PCF8575C, I2C 16-bit I/O expander is split out to two x 8 bit ports and used to connect to the radio squelch, user buttons and radio PTT.

- P0-P7: Squelch Inputs from RCA
- P10-P13: Inputs from 4 x User Buttons
- P14-P16: PTT Outputs to RCA
- P17: Spare and Unused on Lite

Inputs

Although the inputs are aimed for use by control from the radio squelch, they could be used for a trigger or push button for selection of the required input. Simply pull low to activate.

The inputs are pulled high and protected via a diode to stop any higher voltages (>3V3), reaching the expander inputs.

Outputs

The outputs are controlled via a N Channel FET, so normally set to pull low on PTT. This could be reversed in software as needed. The FET devices are good for switching up to 50v, have low on resistance of ~ 6 ohms and sinking around 200mA.

LCD Display Driver

A connection for a standard Hitachi HD44780 LCD controller (alphanumeric dot matrix), is provided.

We only require four address lines and control, so this is driven from a PCF8575 I2C 8bit I/O expander.

A user board mounted LED is connected to P5, for diagnostic or testing purposes.

The LCD backlight can be turned on and off via P7.

VR3 is used to adjust the contrast of the display.

OPTO and Relay I/O

A PCF8575 I2C 8bit I/O expander used to detect the OPTO isolator inputs and also driver the Relays.

- P0-P3: from OPTO Inputs
- P4-P7: to Relay Transistor drivers

The relays also have a visual board mounted LED on each to show which are active.

Inputs

With a series resistance of 365 ohms, the OPTO inputs are reverse polarity protected and designed to accept around +5V.

Outputs

Logic high on the outputs will turn on the relays and associated on-board LEDS.

The relays are single pole change over, so you have a Normally Open and Normally Close contact, with a rating of 5A @ 30V.

Note: These relays must not be used to switch mains voltages.

Power LED

The power LED is tied across the 3V3 rail.

The 5V rail is primarily used to power the PI Zero, although it is also used for the OSD.

SPI Port

A separate SPI port is provided under the Zero, this is to allow optional connection of the PI to an Ethernet or WLAN board. An example is an ENC28J60 based Ethernet board.

Further details on this can be found at:

http://raspi.tv/2015/ethernet-on-pi-zero-how-to-put-an-ethernet-port-on-your-pi

*

Software

Flexibility is key to ideas and user experimentation, so full control of all the VMAC functions maybe made under software functions, scripts etc.

Development of VMAC software has been aimed at being totally open source from the start and we welcome input, and feedback, from users, through to developers.

Please visit our website for the latest software release, scripts and applications.

www.hamkit.co.uk/downloads/vmac

*

Test Suite

This is a small application and bunch of scripts that allows for board bring-up testing, with its primary functions being to check the peripherals:

Outputs

- Toggle Relays 1-4
- Toggle Fan Output
- Toggle On-Board LED
- Toggle PTTs x 3
- Display Test Message on LCD Display

Inputs

- Check Opto's x 4
- Check DC Sensing
- Check User Buttons x 4
- Check Squelch or Receiver Triggers x 4

Other

- Write and Read EEPROM
- Set and Read RTC
- Monitor DTMF Decoder for Input
- Check I/O Ports 2x8
- Cycle Inputs and Outputs via OSD

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Assembly and Construction

The VMAC RPI Lite is provided with all surface mount components and some through hole populated. This allows experimenter flexibility.

Your kit of parts will include the stacked RCA connectors and other components in readiness for final kit completion.

Note: A Raspberry Pi Zero is NOT included. Due to manufacture restricted supply, you will currently require to purchase (around £4), a basic PI Zero directly from below and then add our software image. Once these are more readily available, we will make Zeros available.

- https://shop.pimoroni.com/products/raspberry-pi-zero
- https://thepihut.com/products/raspberry-pi-zero?utm_medium=cpc&utm_source=googlepla&variant=14062693508

Should you prefer not to use Raspberry Pi Zero, you could use a standard Raspberry Pi and short ribbon cable or stacked header. The video output and reset connector only aligns with a Zero, so you will need to wire this manually.

Whichever PI you use, the same software can be loaded. Some users plan to experiment with other flavours such as the Orange PI and Banana PI, which should work as they use the same 40 pin header.

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Block Diagram

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Drawings and Schematics

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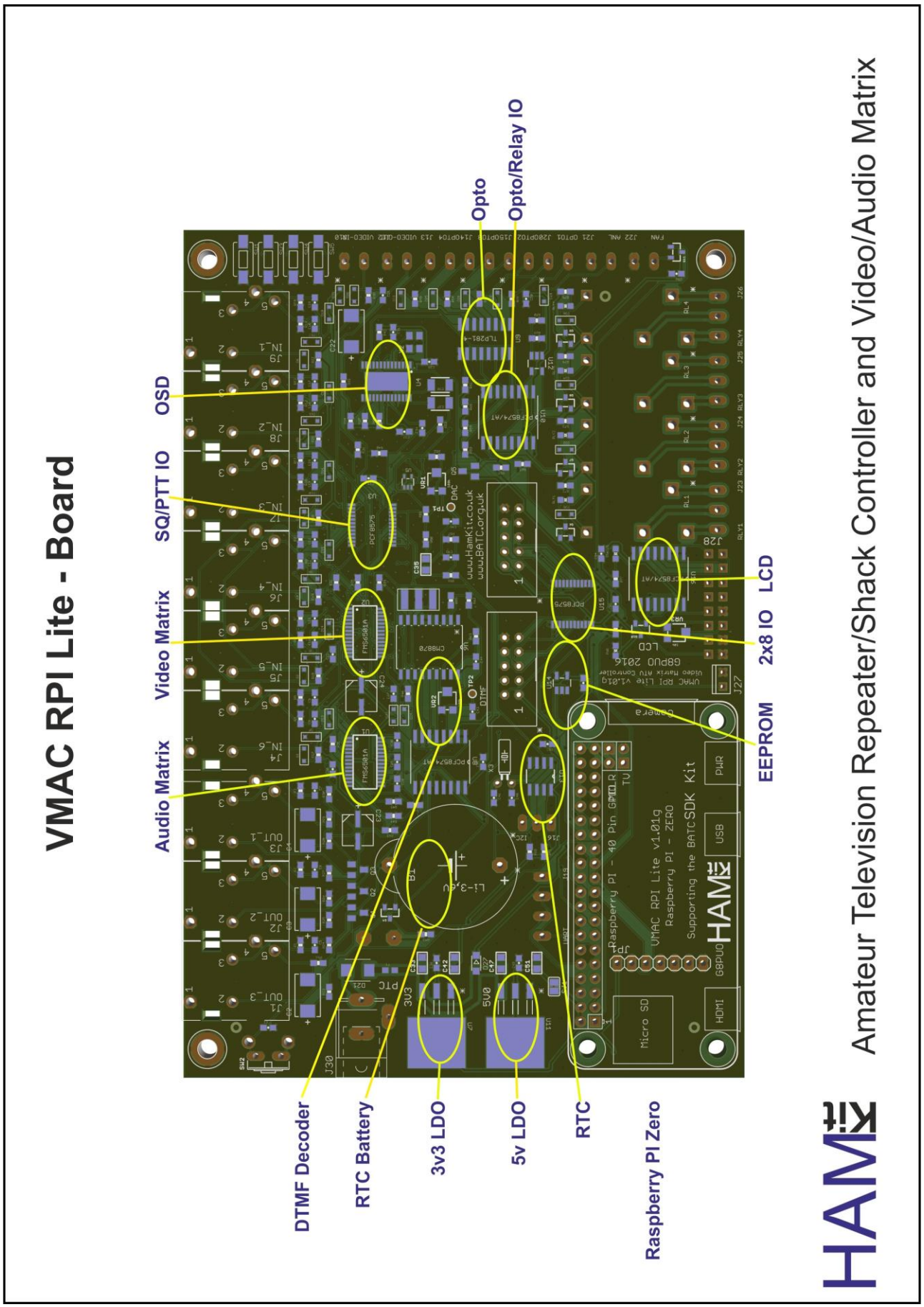
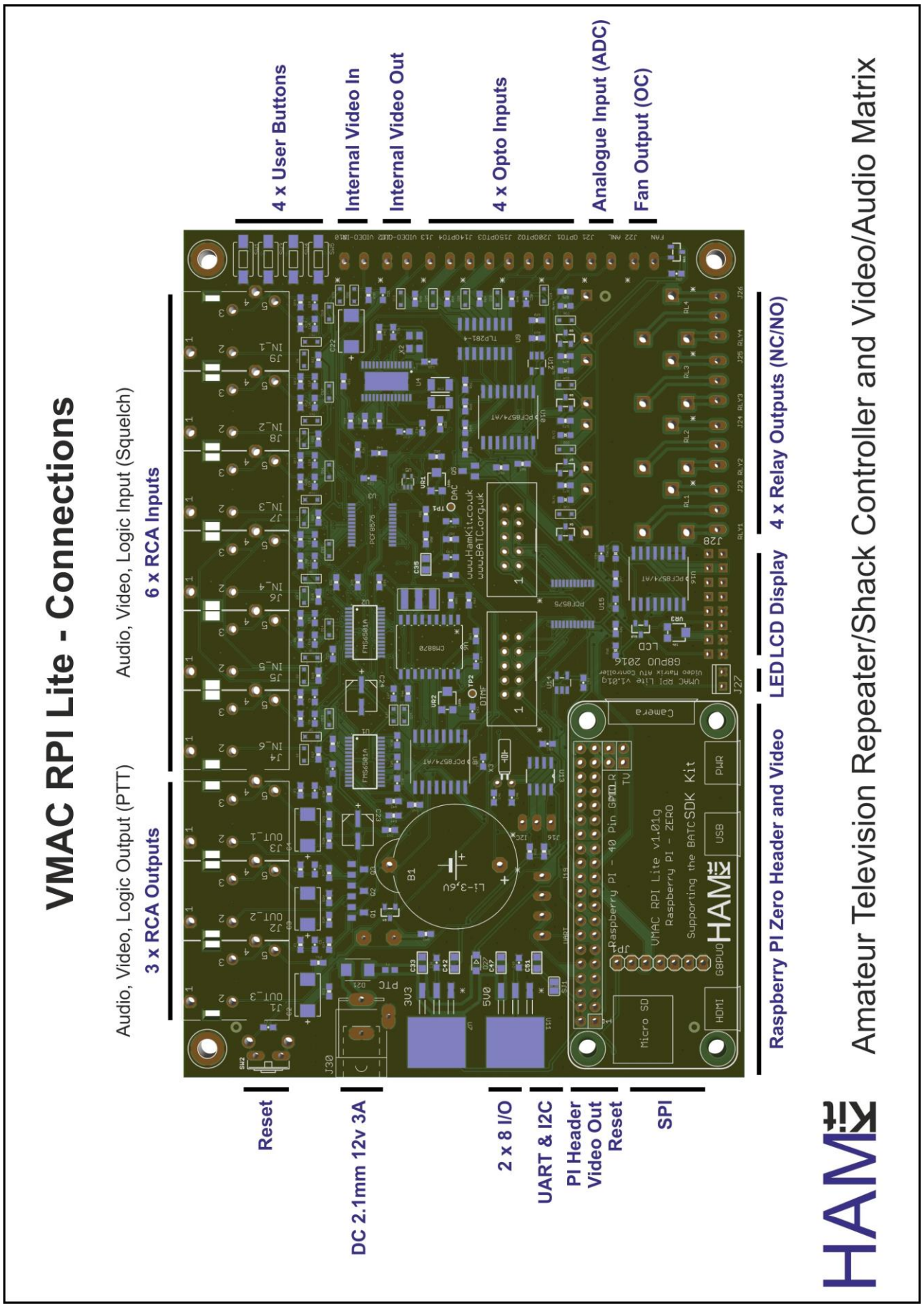
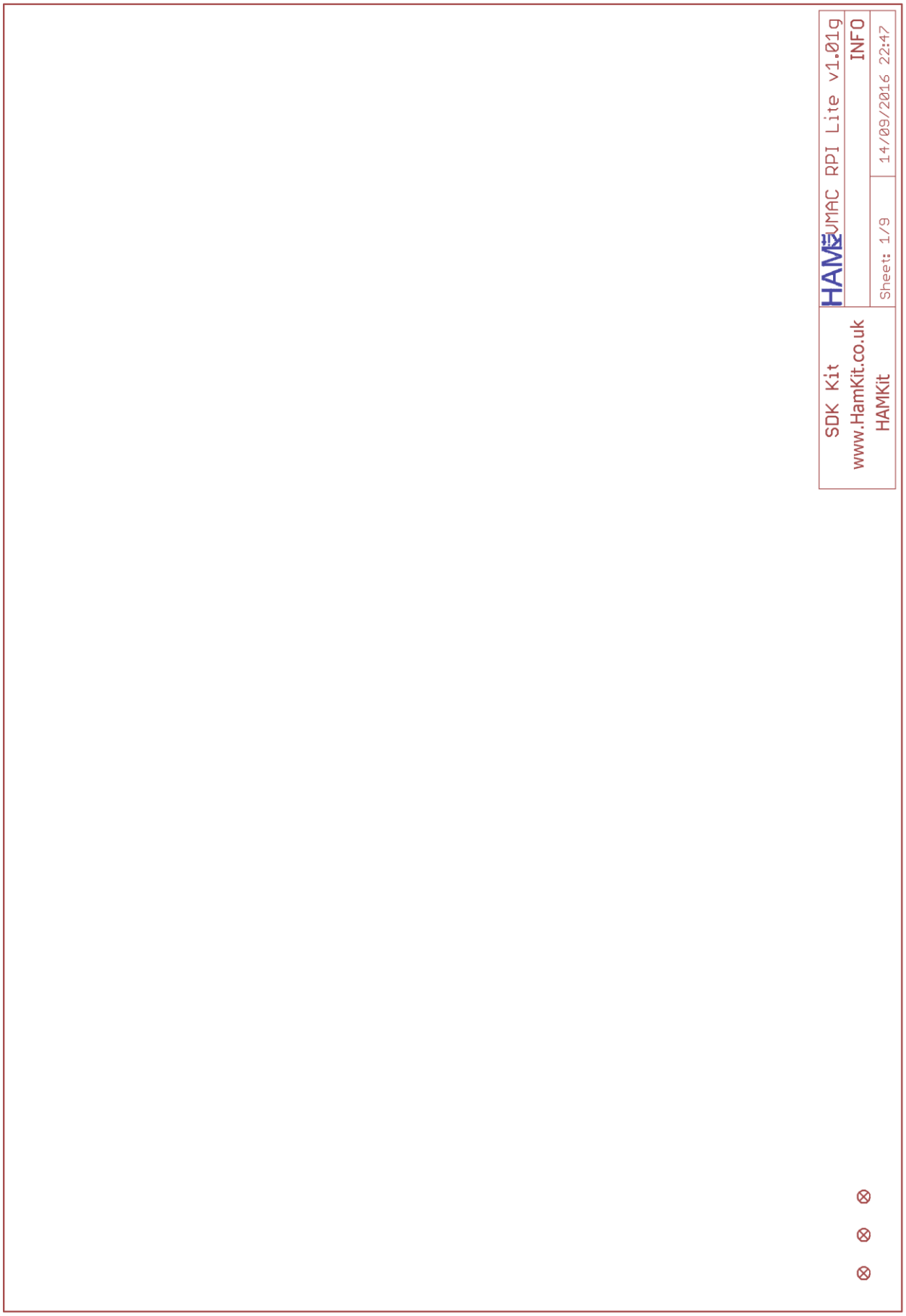
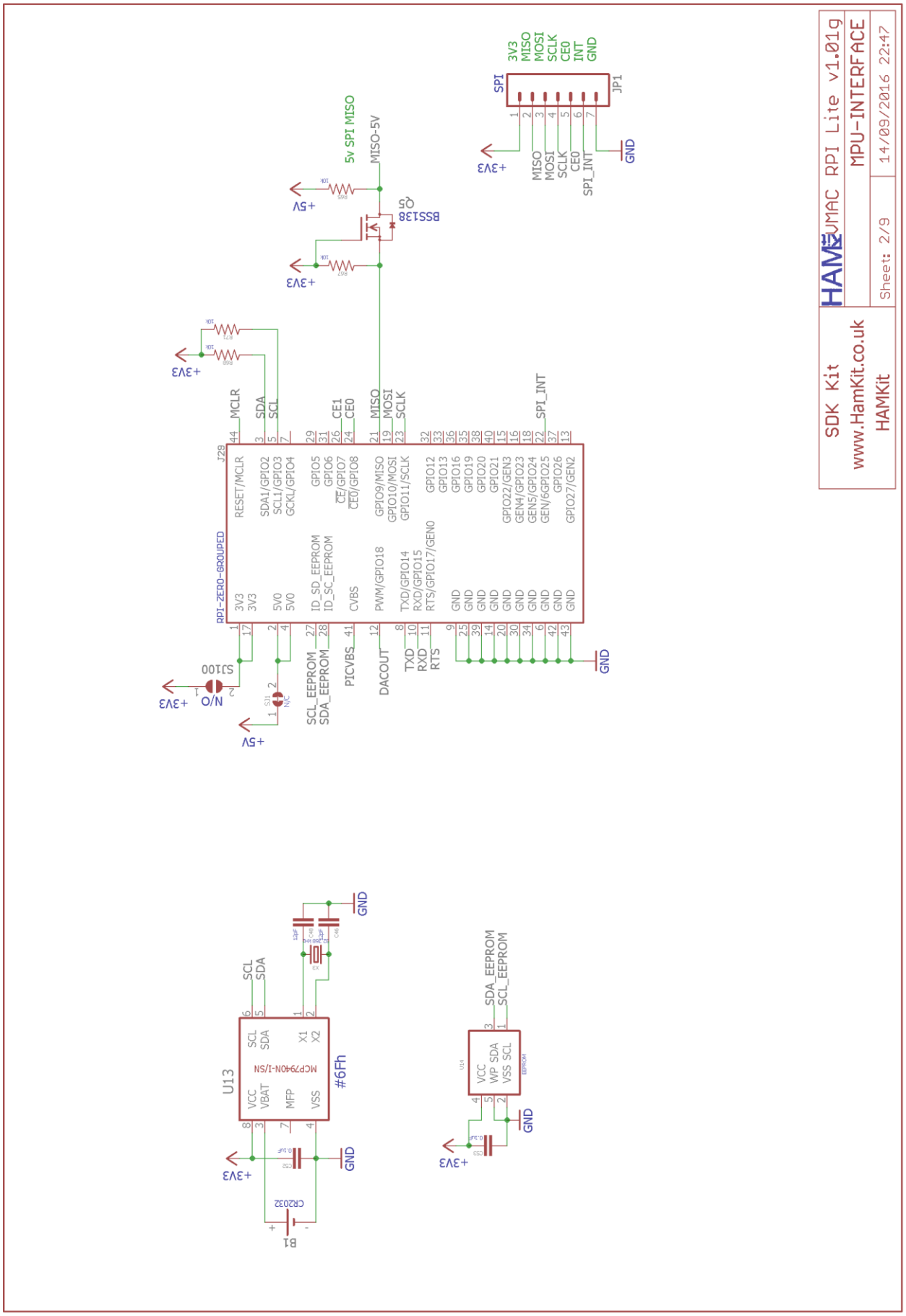
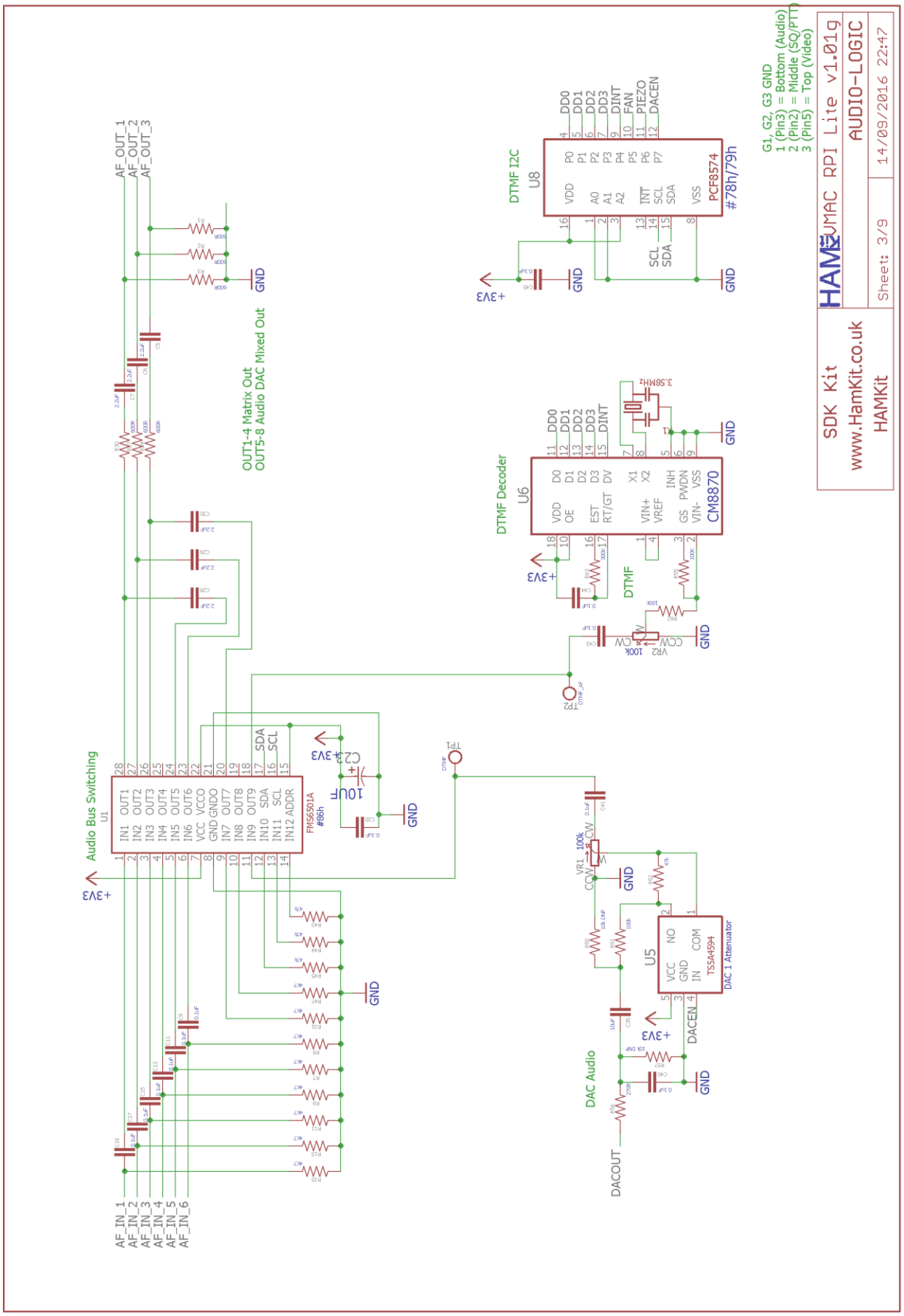
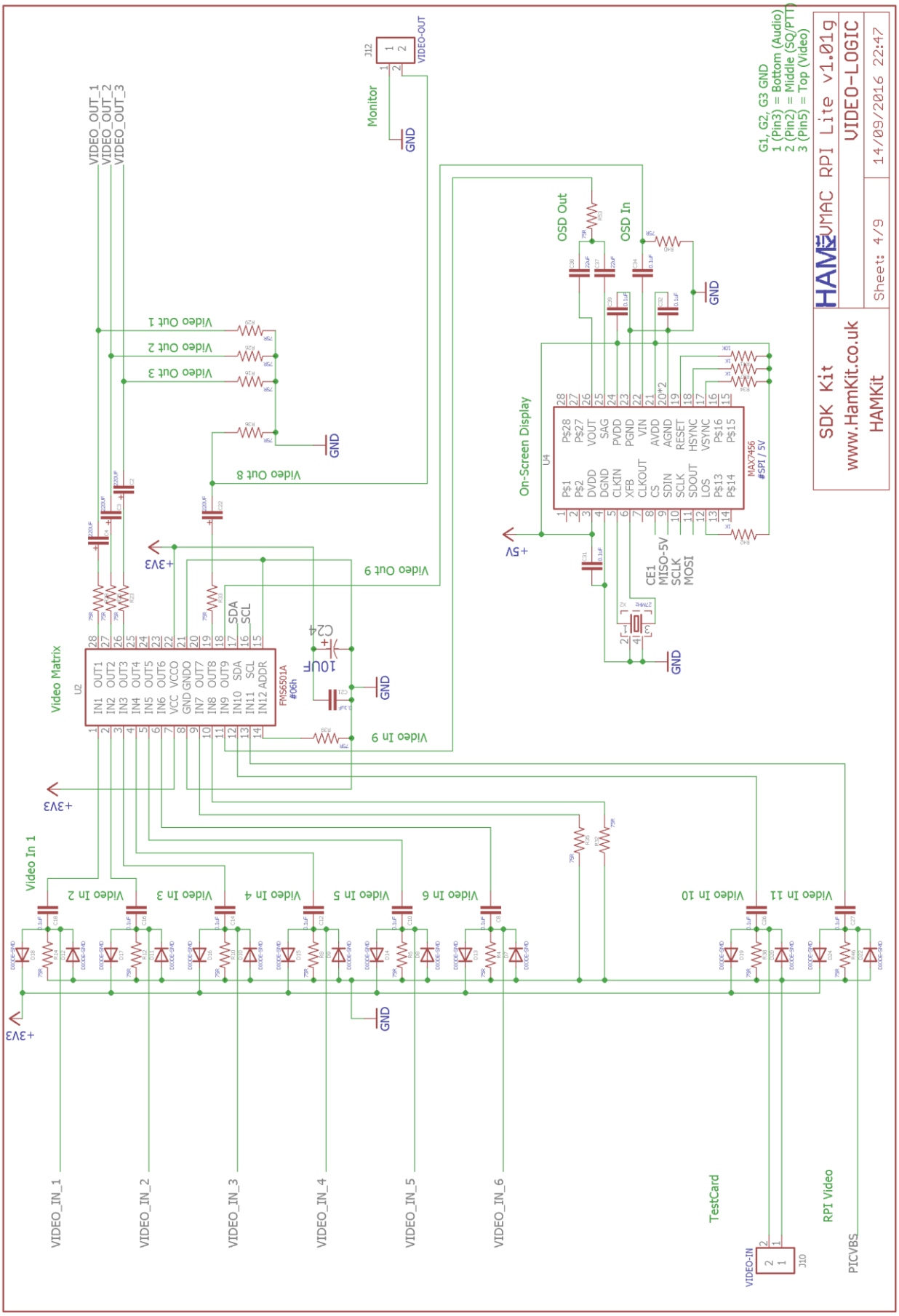

VMAC RPI Lite - Board
Amateur Television Repeater/Shack Controller and Video/Audio Matrix
OSD
SQ/PTT IO
Video Matrix
Audio Matrix
Opto
Opto/Relay IO
LCD
2x8 IO
EEPROM
DTMF Decoder
RTC Battery
3v3 LDO
5v LDO
RTC
Raspberry PI Zero

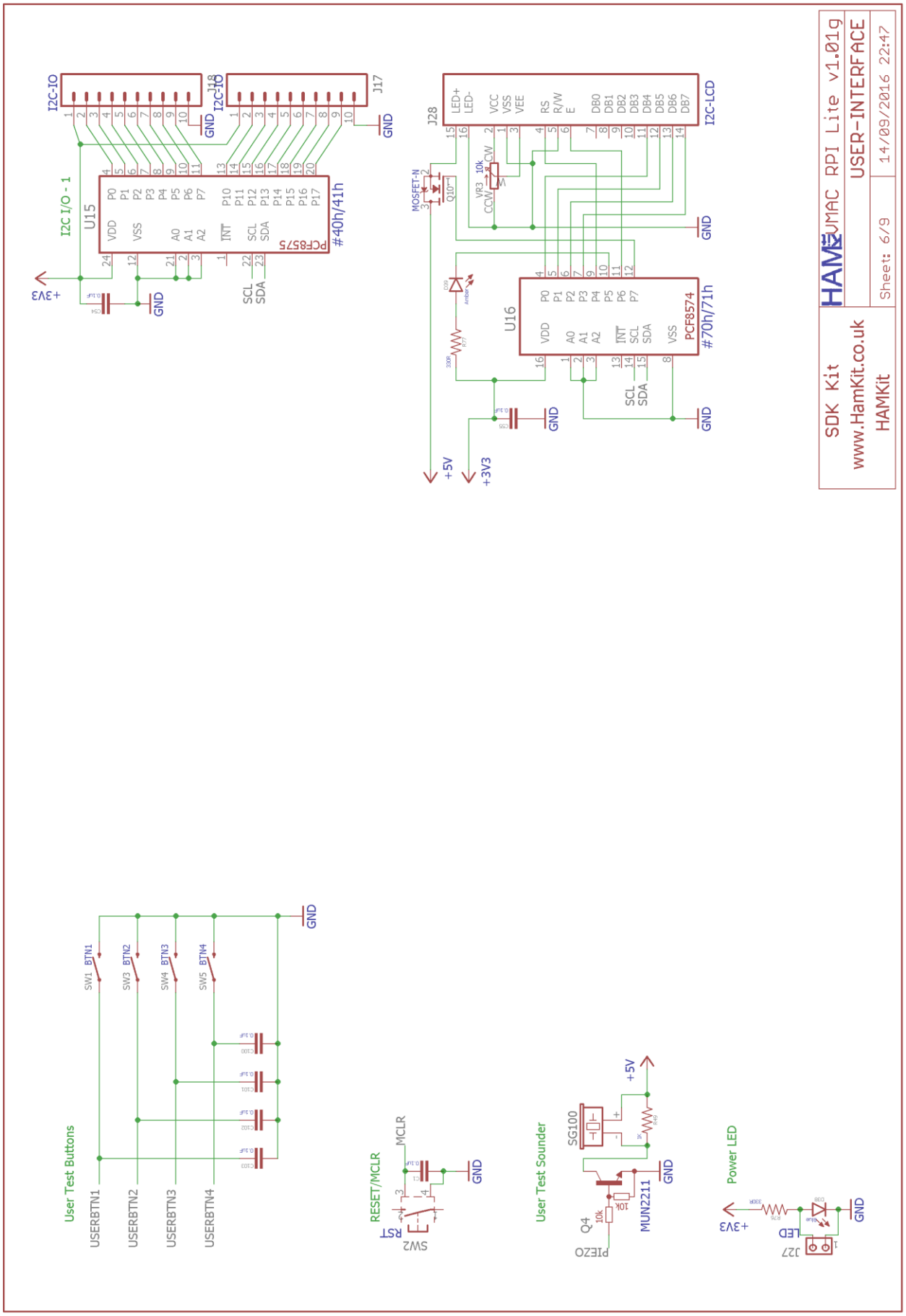


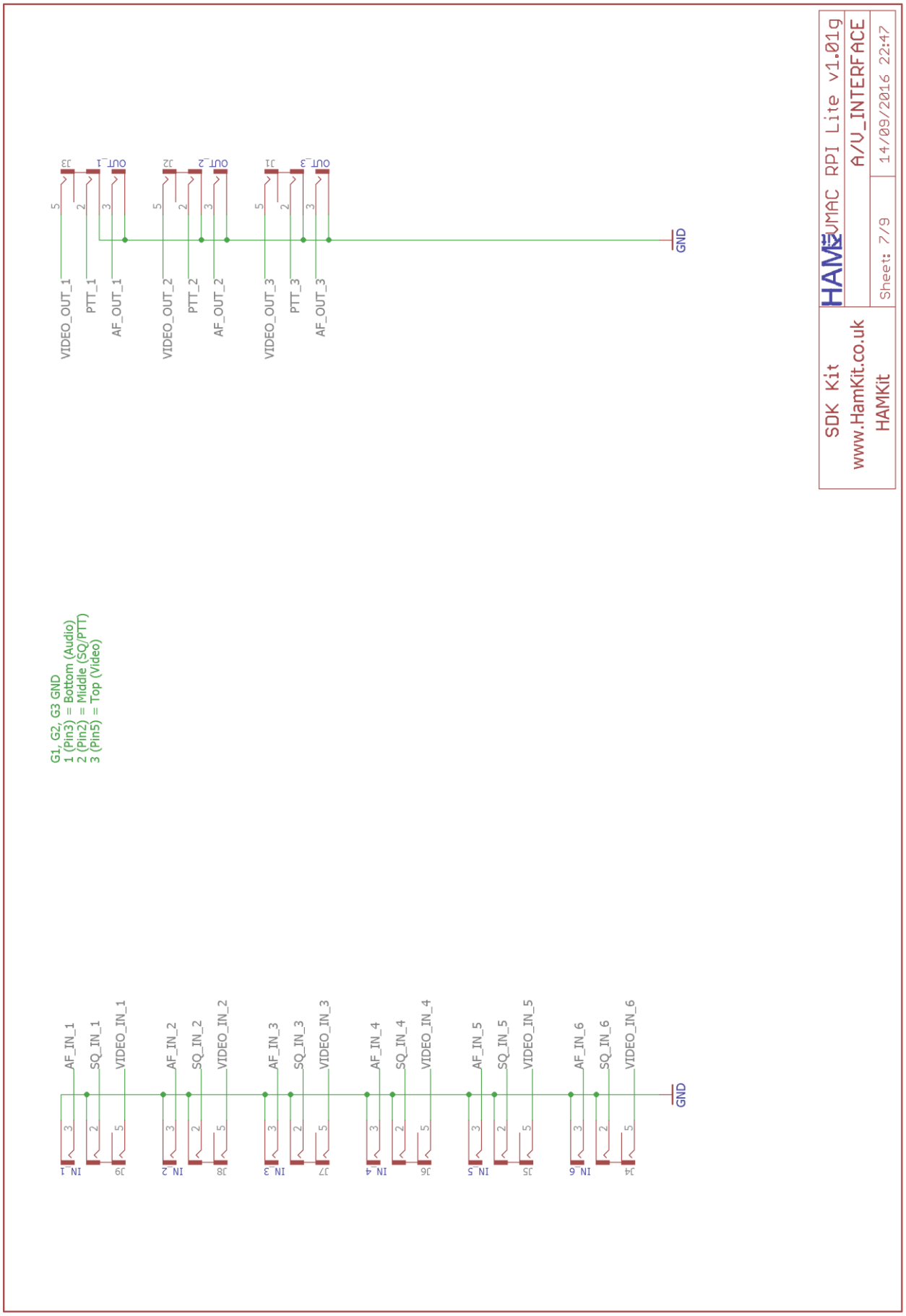


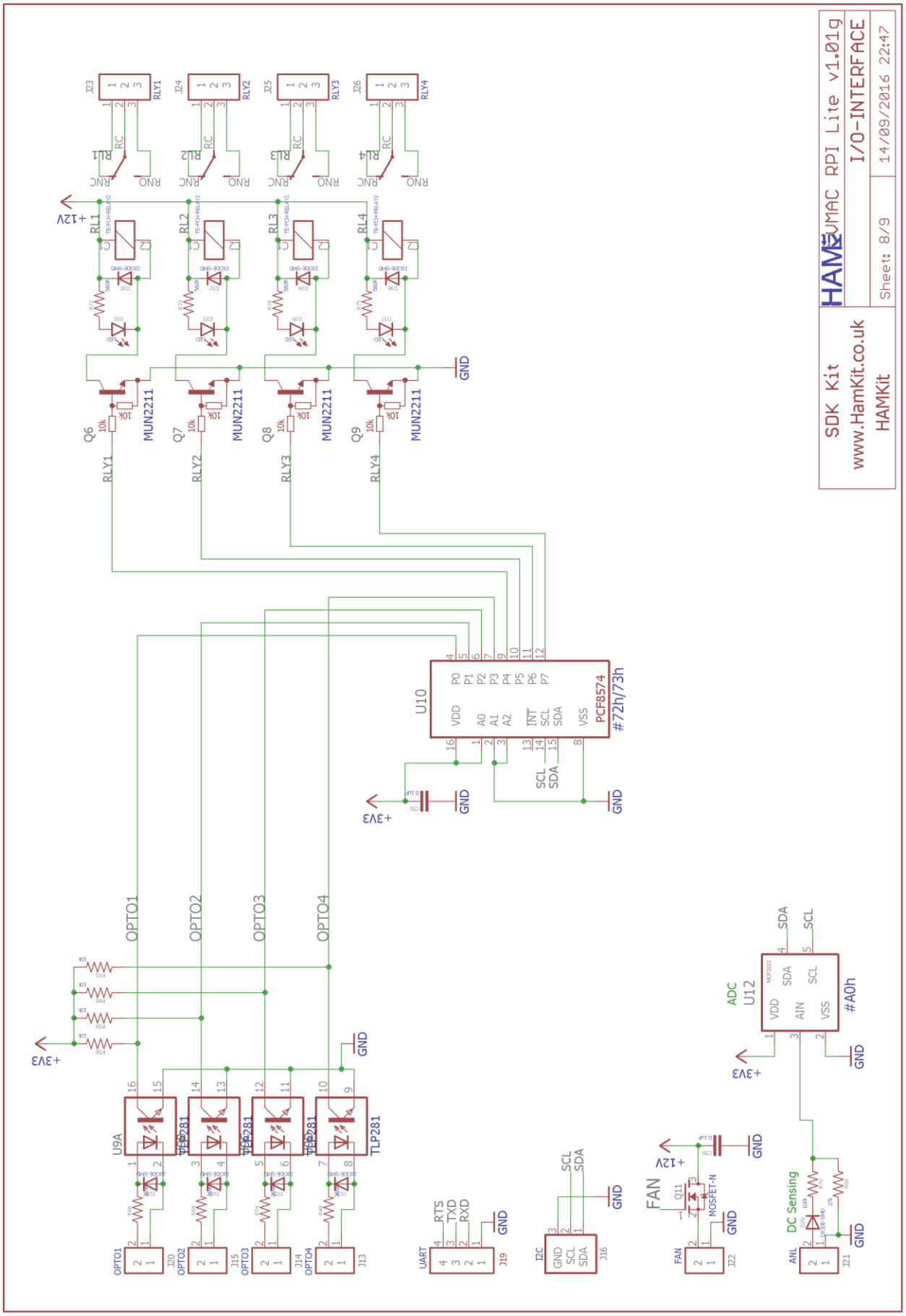











VMAC RPI Lite v1.01g
I/O-INTERFACE
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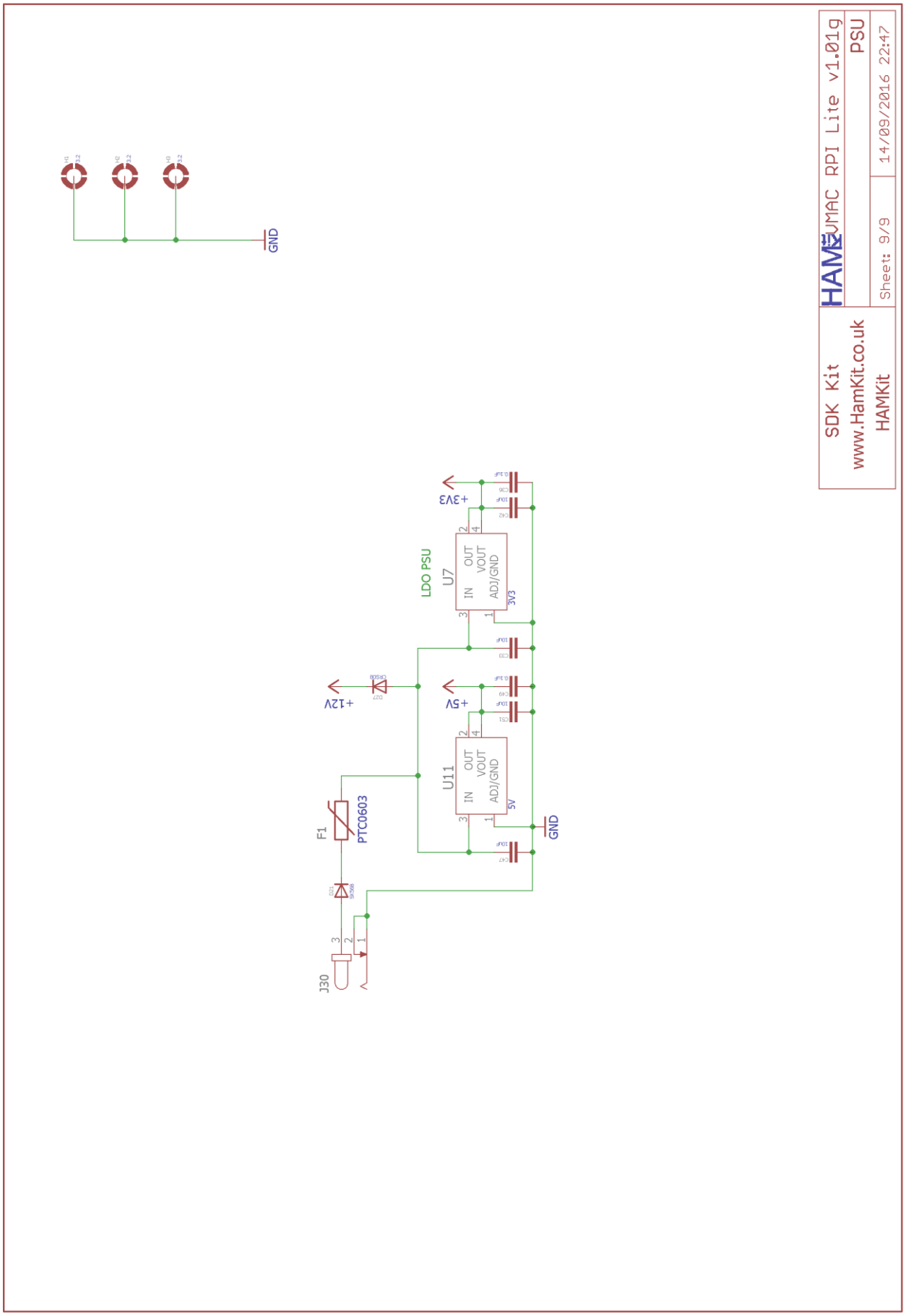
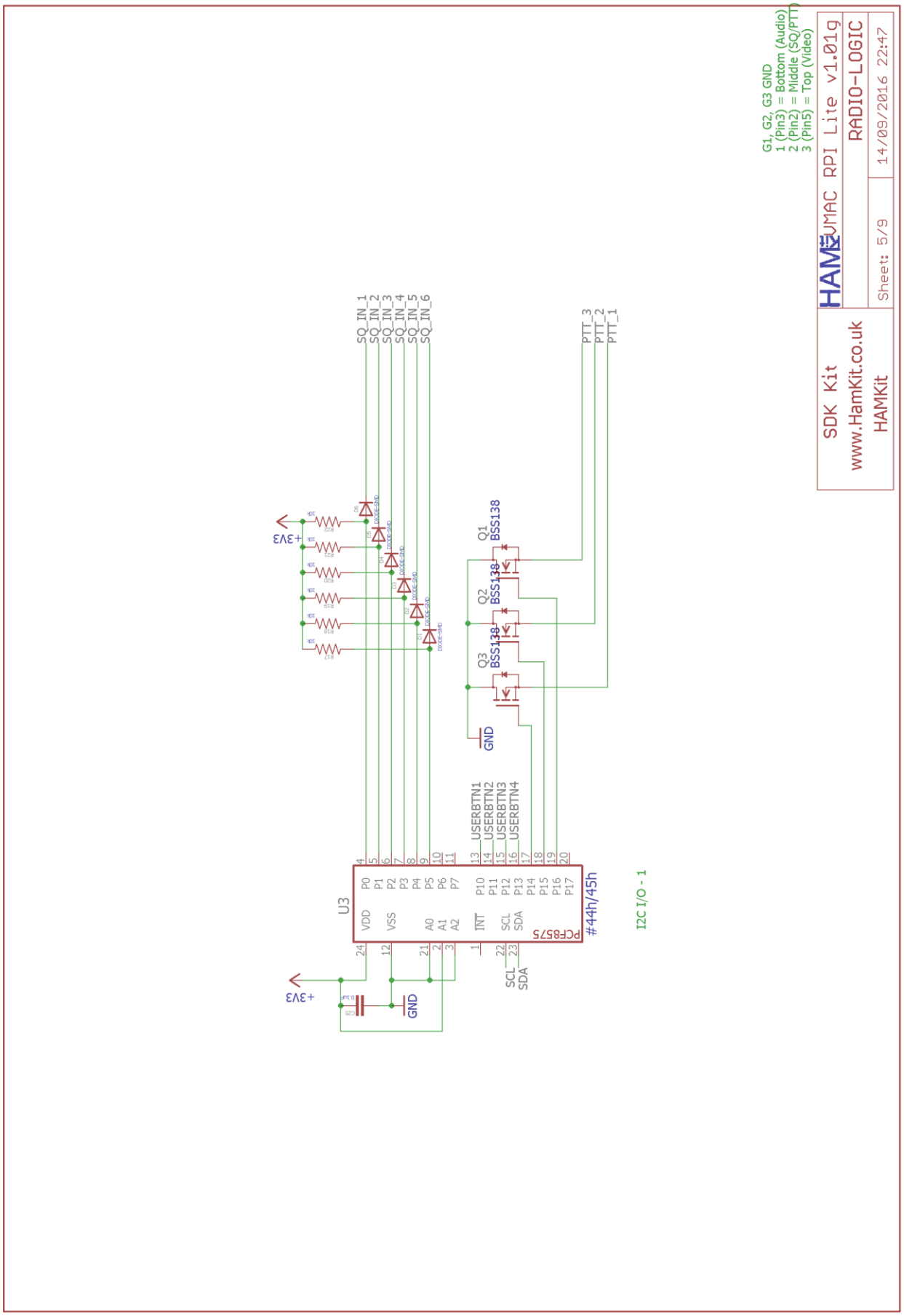
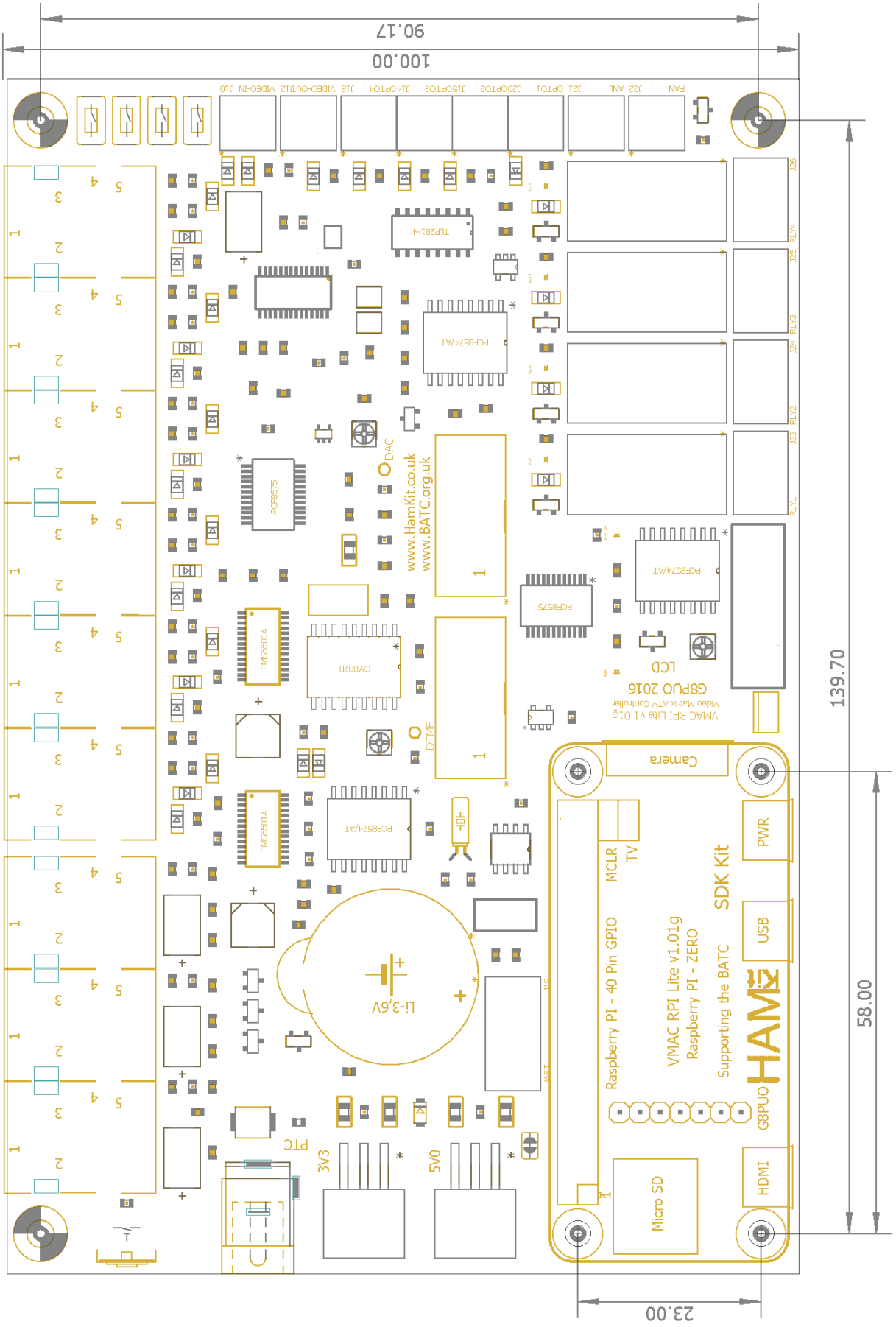
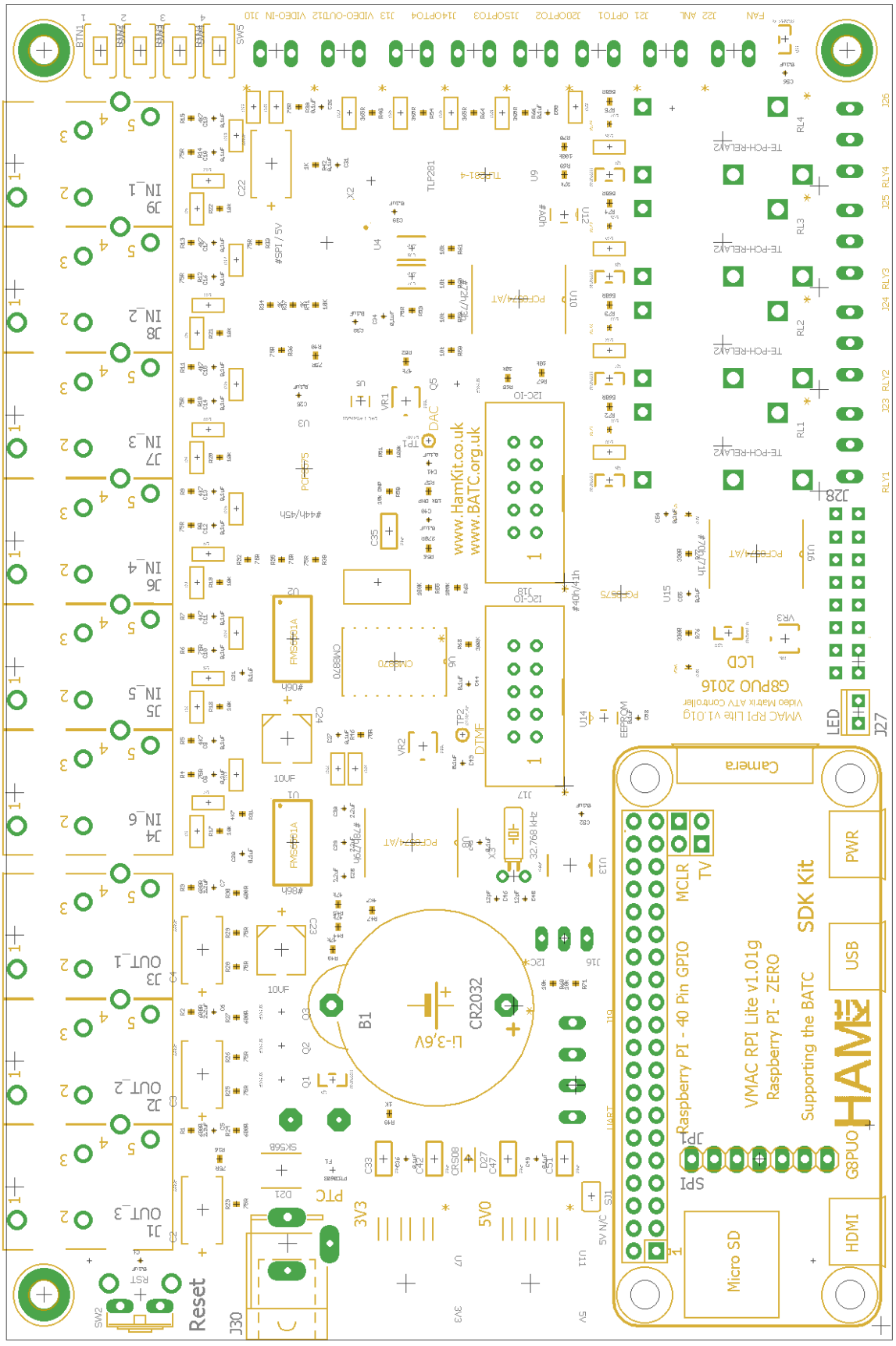
Sheet: 8/9
SDK Kit
www.HamKit.co.uk
HAMKit
RLY1
RLY2
RLY3
RLY4
MUN2211
PCF8574
#72h/73h
TLP281
OPTO1
OPTO2
OPTO3
OPTO4
ADC
U12
#A0h
FAN
MOSFET-N
DC Sensing
UART
I2C
+12V
+3V3
GND
SCL
SDA
RTS
TXD
RXD

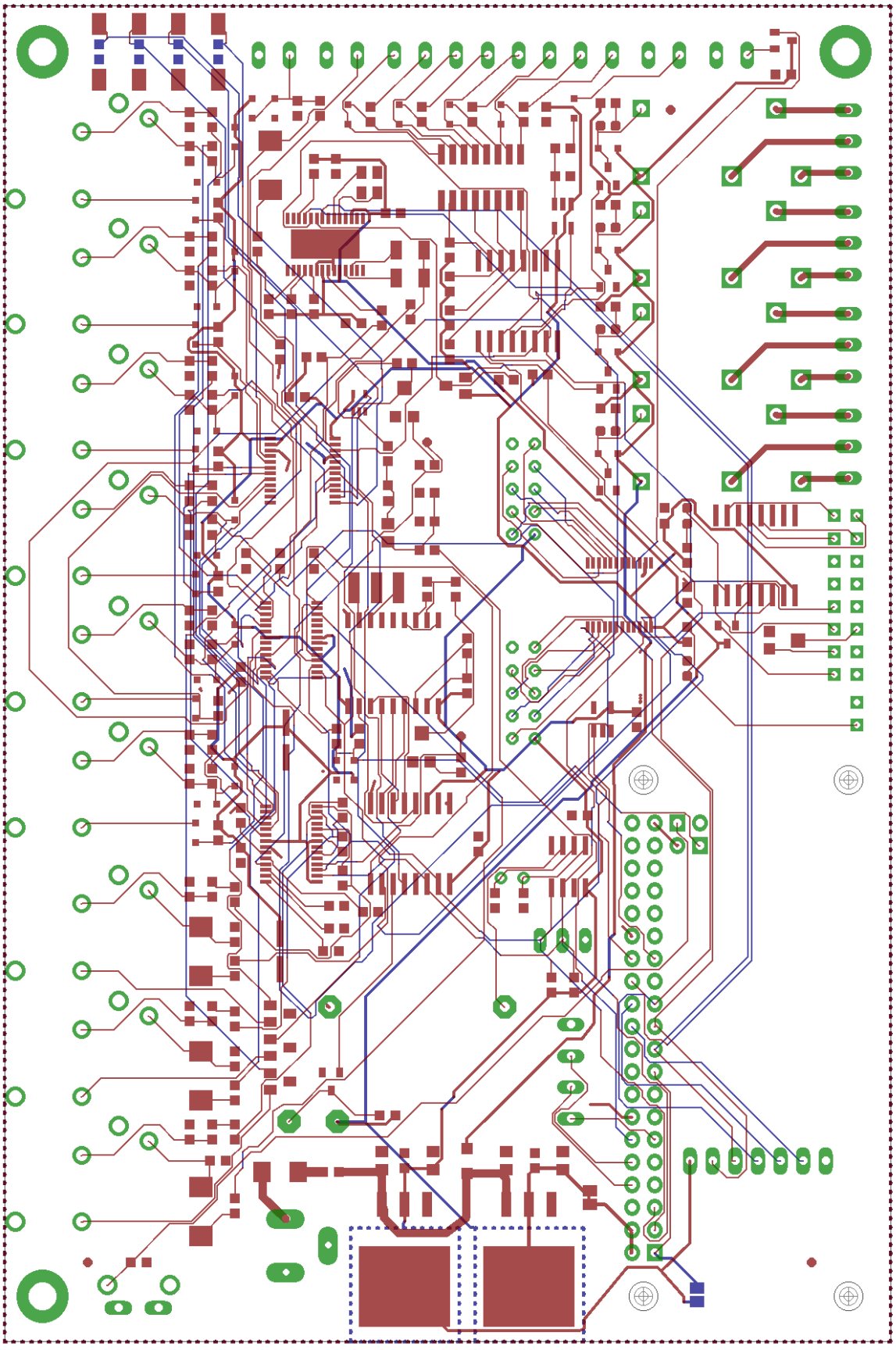


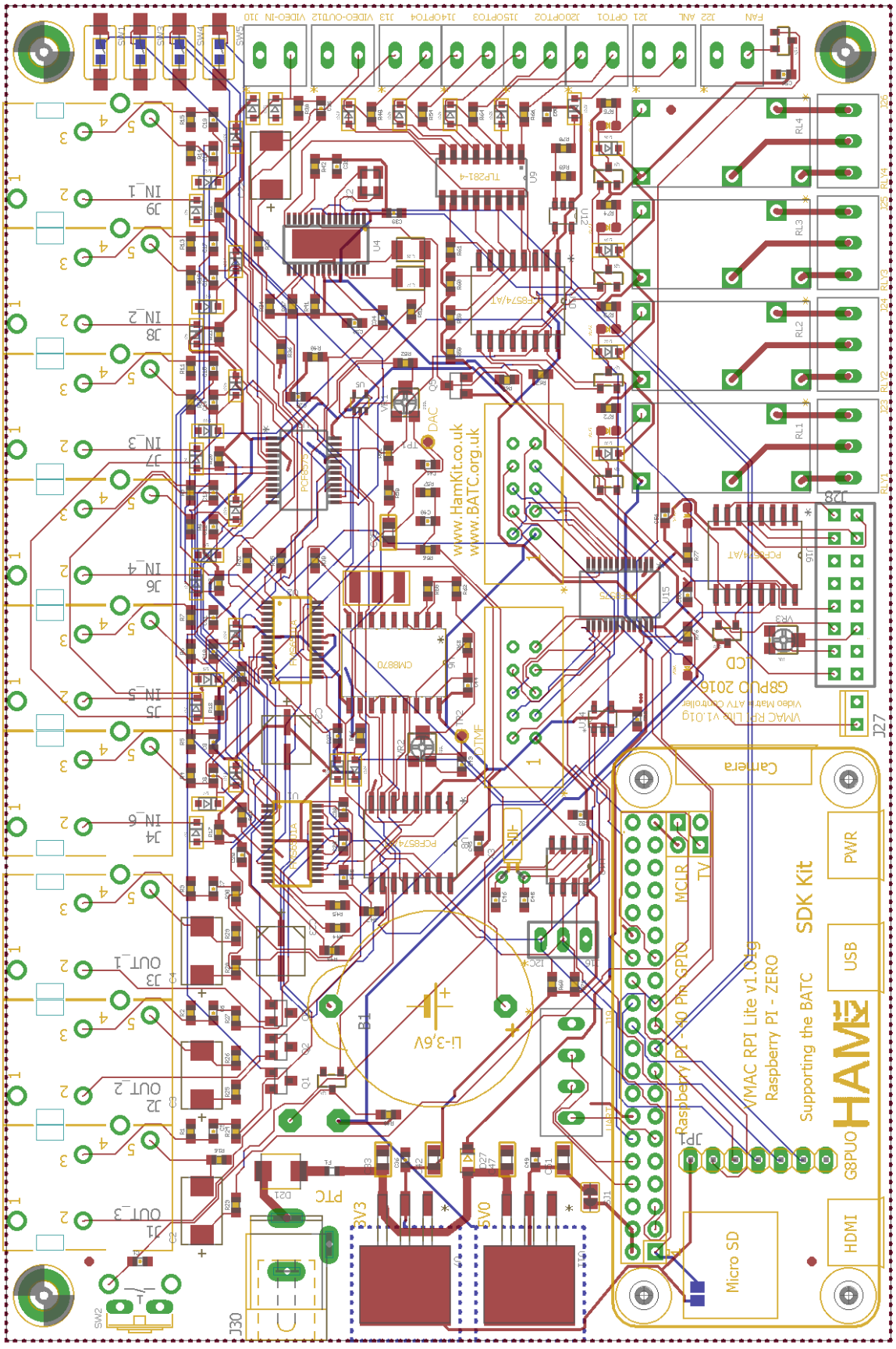


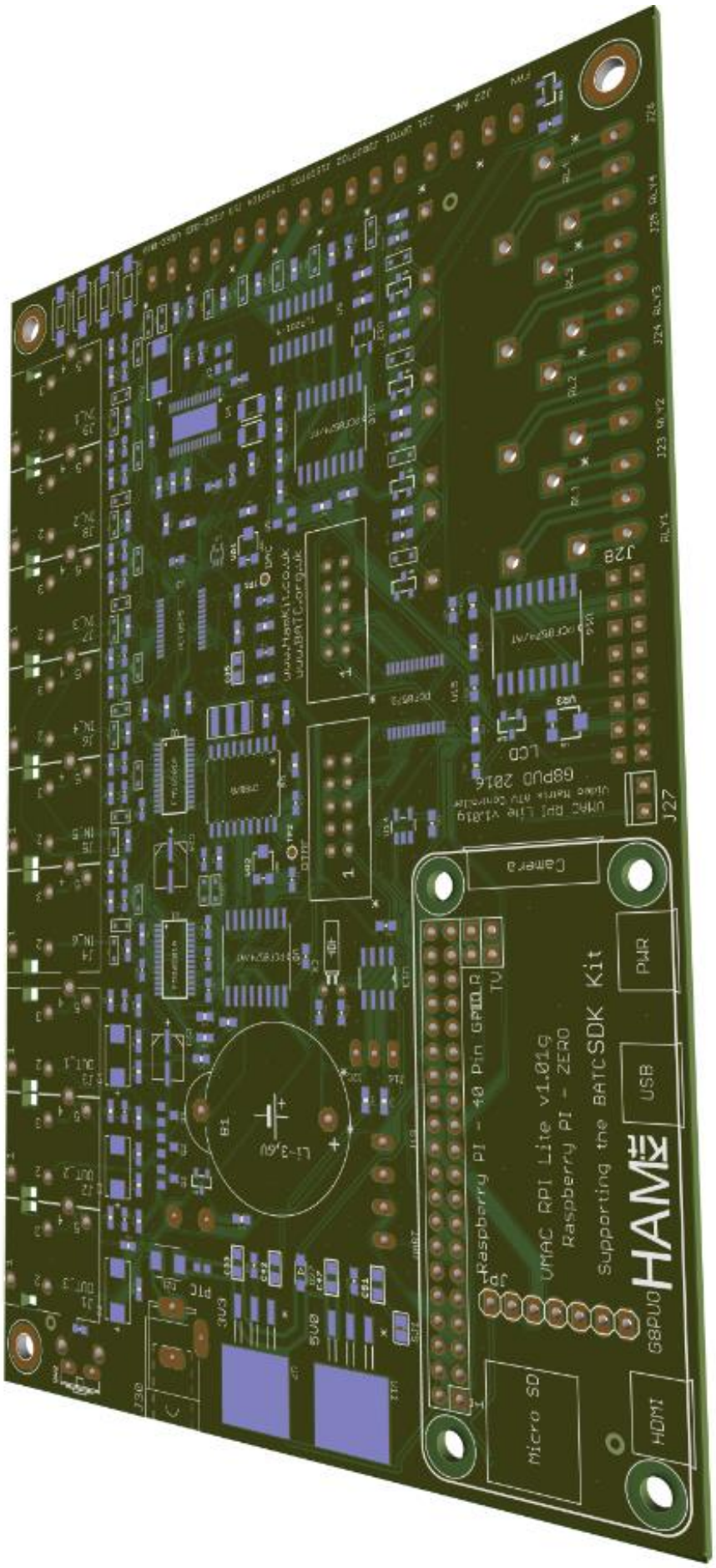
PCB

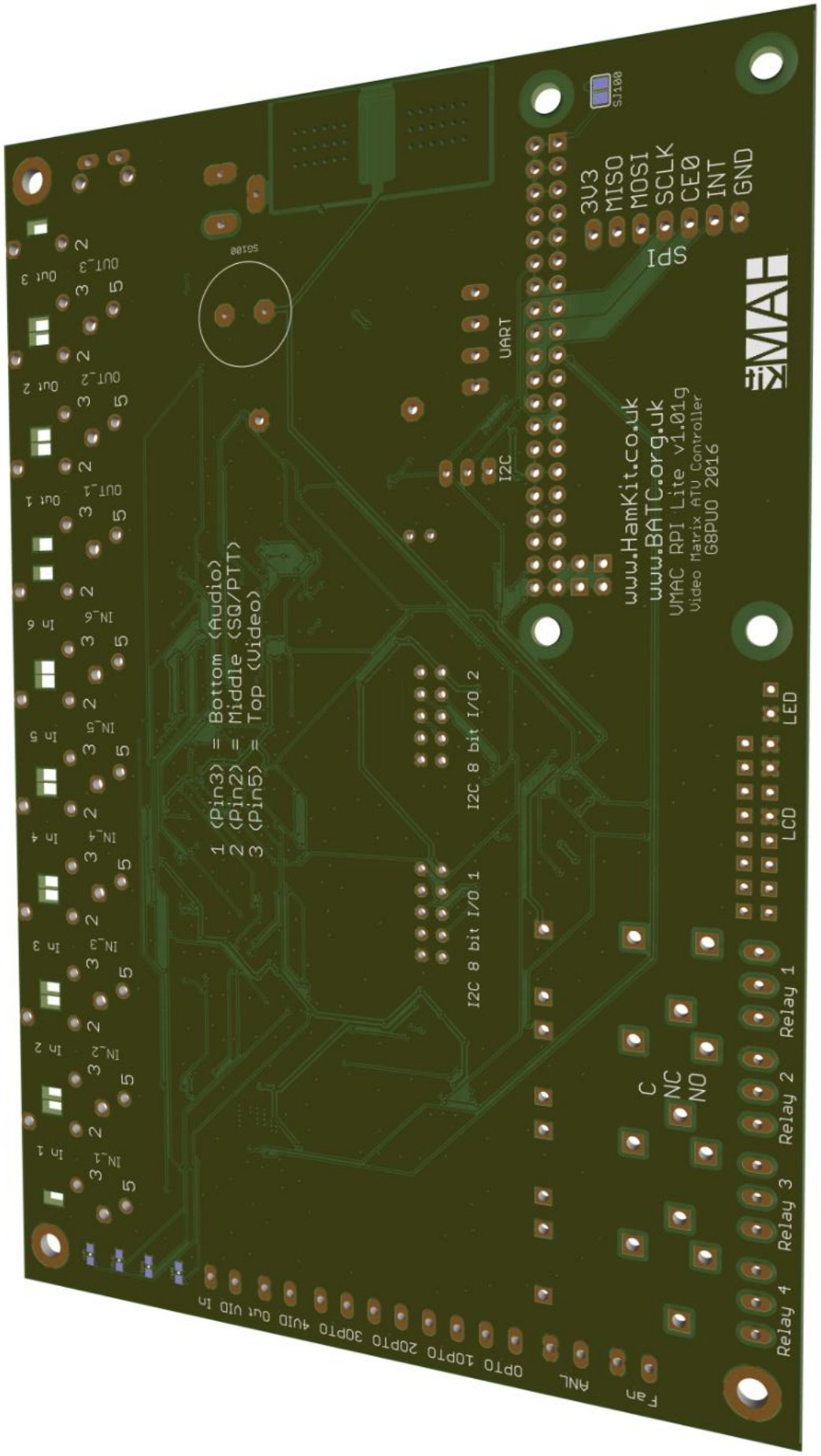


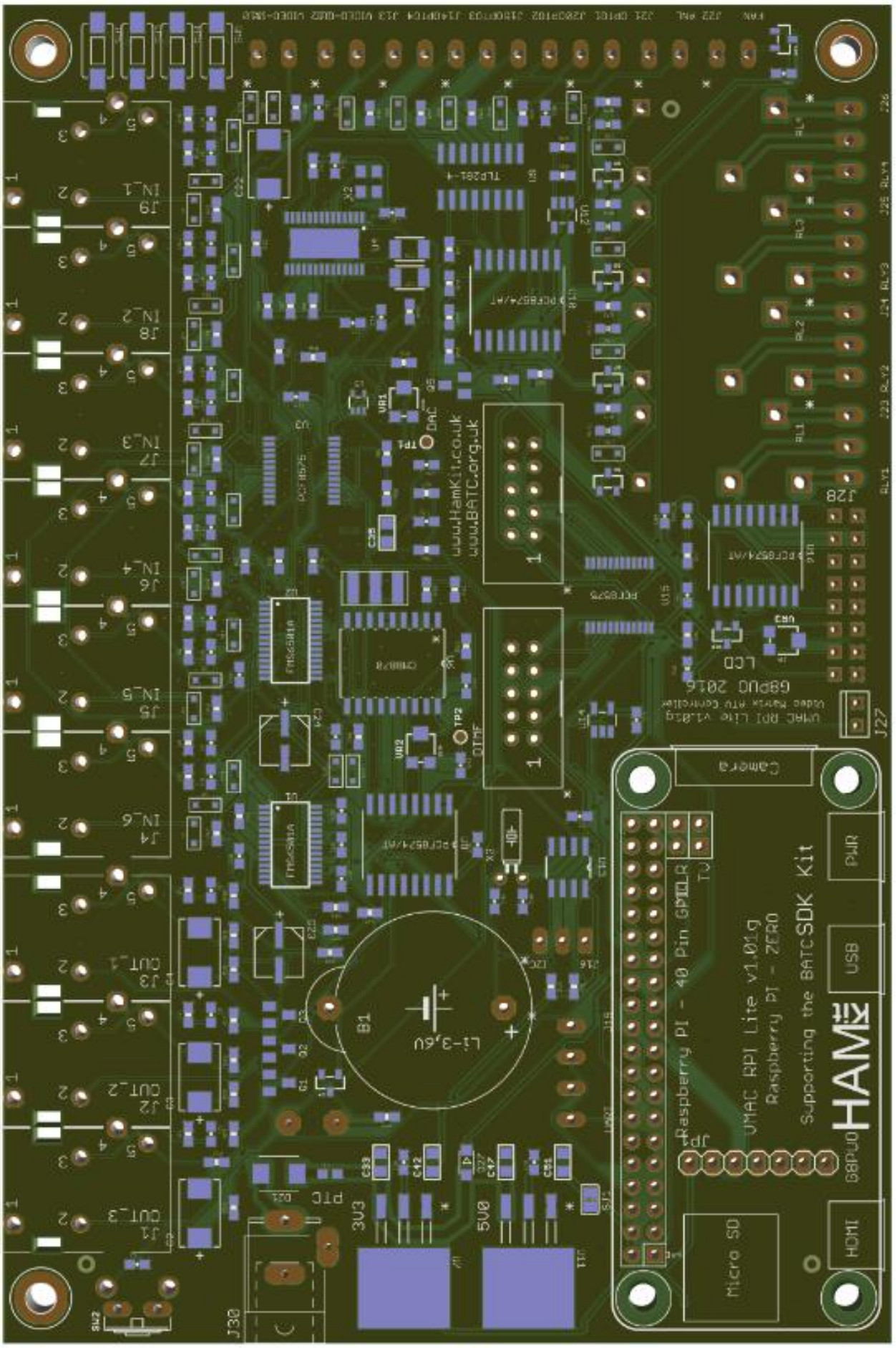


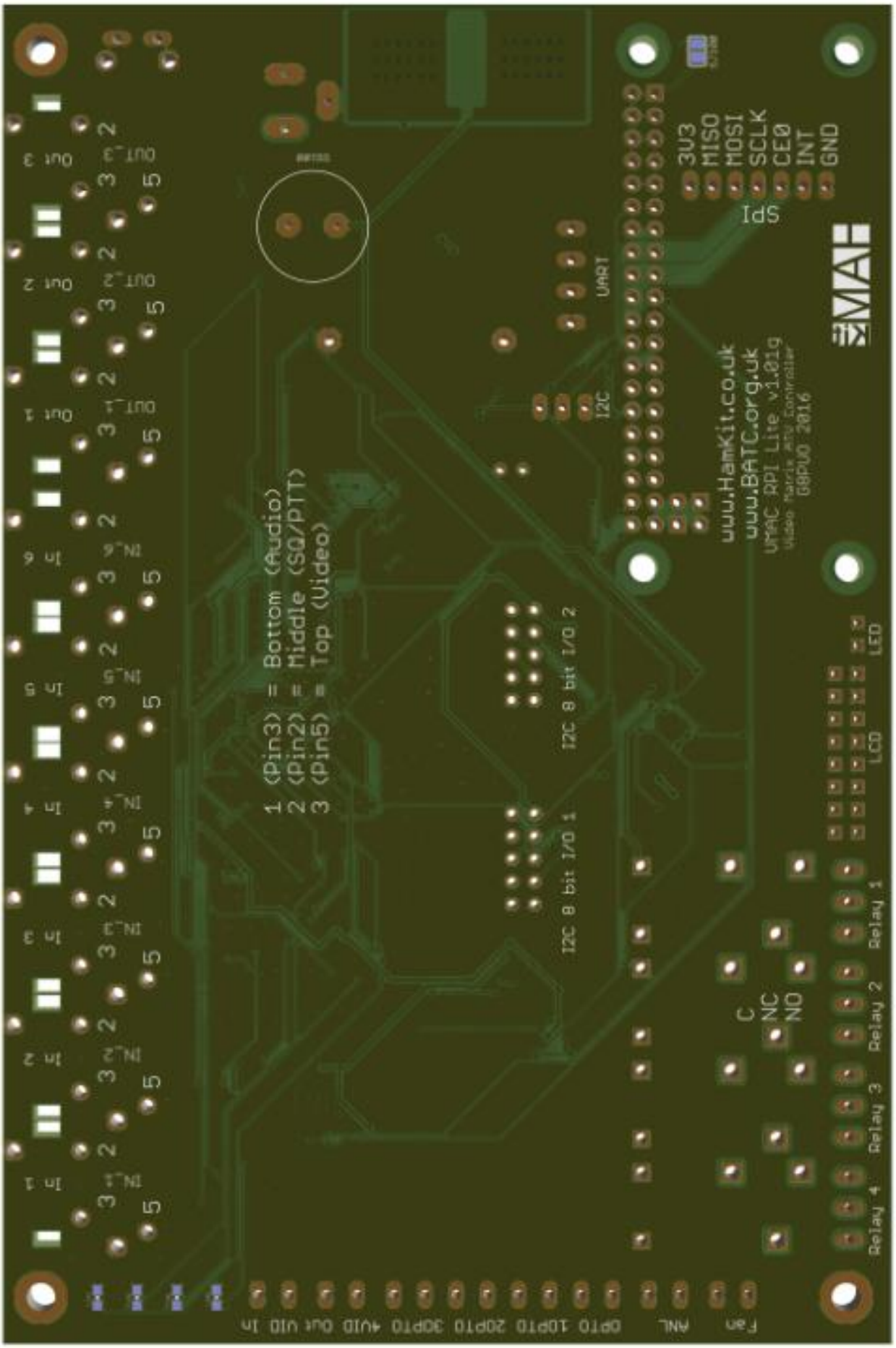



www.HamKit.co.uk
www.BATC.org.uk
VMAC RPI Lite v1.01g
Raspberry PI - ZERO
Supporting the BATC
SDK Kit
Camera
PWR
USB
HDMI
Micro SD
G8PUO
Li-3,6V
PTC
3V3
5V0









Frequently Asked Questions

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Useful Information

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Regulatory

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Warranty and Returns

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