========== PicoGAME - Constructors Notes ==========

These notes are for PCB version 1.4 Only.

Specification

5V DC supply via 3.5mm/1.3mm barrel jack socket
5V DC output via USB-A socket
On-board 3V3 linear regulator
Load current was measured at 98mA at 5V while playing a WAV music file through headphones.
VGA output socket
PS/2 keyboard input socket
3.5mm Audio Jack socket
Two Controllers can be used, or one joystick. If a single Controller or Joystick is used it will normally be in Port A. Port B can be used for a second Controller, a Paddle/potentiometer or for simple networking.

If pins 5 & 9 on Port A (or JS1, which uses the same connections) are not being used then a small RTC module can be plugged in. This uses GP26 as I2C2_SDA and GP27 as I2C2_SCL. Note that this does not affect other functions of either port as only those two PicoMite pins are used.

Game port A DB9M socket:

		Controller mode	Paddle / Analogue stick mode	Switched Joystick mode	RTC_mode
1	GP0	n.c.	n.c.	Up	
2	GP1	Data	n.c.	Down	
3	GP2	Latch	n.c.	Left	
4	GP3	Clock	n.c.	Right	
5	GP26	n.c.	Pad B / Pot Y	(See Commodore)	I2C2 SDA
6	GP14	3V3	Fire / Trigger	Fire / Trigger	
7	3V3	n.c.	3V3	3V3	
8	GND	GND	GND	GND	
9	GP27	n.c.	Pad A / Pot X	See Atart ST & Commodore)	I2C2 SCL

Game port B DB9M socket:

		Controller mode	Paddle mode	Network mode
1	n.c.	n.c.	n.c.	n.c.
2	GP4	Data	n.c.	COM1 TX
3	GP5	Latch	n.c.	COM1 RX
4	GP22	Clock	n.c.	n.c.
5	n.c.	n.c.	n.c.	n.c.
6	GP15	3V3	Fire / Trigger	n.c.
7	3V3	n.c.	3V3	n.c.
8	GND	GND	GND	GND
9	GP28	n.c.	Pad A	n.c.

The 3V3 supplies on Pin 7 are not short-circuit protected (other than any protection given by the regulator). This allows built-in electronics such as rapid fire circuits to have the best chance of operating. The Pin 6 supplies pins are current limited to 22mA each. as these will be shorted to GND by Fire / Trigger buttons. All joystick switch inputs are active-low.

Several variations of joysticks can be used:
Atari 800/VCS has switches, Pad A and Pad B. There is a single Fire button as above.
Atari ST is switched only. It has an additional button on pin 9
Commodore Amiga, Vic20, C64 & C128 have switches, Pot X (Button 2) & Pot Y (Button 3). Pin 6 is Button 1.

Do not use joysticks intended for the built-in ports on the Sinclair Spectrum +2, +2A or +3. These are wired differently and are incompatible.

JS1 is a low cost analogue "thumb" joystick module, widely available from many sources. It includes a "press to fire" switch. One of these can, optionally, be fitted to the PCB. Unfortunately this joystick seems to be difficult to get without the 90 degree male headers already soldered in place. This makes it a little difficult to connect to a PCB header.

The Controllers use Data, Latch and Clock lines. They are similar to those used for the NES/Famicom types in operation but have DB9F plugs. They are obtainable from Aliexpress at very reasonable cost. You can also build your own as the components (if you use ordinary buttons) are inexpensive. There is one CD4021B parallel/serial shift register chip, 8 10k resistors and 8 buttons.

========== Bill Of Materials ==========

All resistors can be 0.25W 5% carbon film. Metal film 0.25W 1% are preferable for the 220R value.

QTY Description & Source

1 PicoGAME PCB
1 Hammond 1593WBK enclosure (optional) - Mouser 546-1593WBK, Digikey 164-1593WBK-ND, RS 228-7399
(White and Transparent blue options also available e.g. RS white 229-1681, blue 228-7400)

1 K1 - 3.5mm/1.3mm barrel jack connector - Mouser 490-PJ-031D, ebay
1 K2 - Upright USB-A PCB Socket Right Angle - Amphenol FCI 73725-0110BLF, RS 771-0048, Mouser 649-73725-0110BLF
1 K3 - 15-pin 3-row DB15F 90 degree VGA connector
RS 481-443, AMP 1-1734530-1, MULTICOMP SPC15430, Element14 1557991, Toby Electronics HL15S
1 K4 - PS/2 female socket - ebay - HA1607
2 K6, K7 - 9-pin DB9M 90 degree connector - TE Connectivity Amplimite 5747840-6, RS 446-5209, Toby Electronics DMR09P

1 D1 - SB140, 1N5818 or similar 1A Schottky diode.
1 U2 - MCP1700 3V3 250mA voltage regulator - Bitsbox QD314
1 U3 - Raspberry Pi Pico with PicoMite VGA firmware and male pins on bottom
2 20-way female SIP connector for PicoMite
2 D4, D5 - BAT48, BAT85 or similar small signal Schottky diode - Bitsbox QD113
1 D6 - LED (optional - power indication)
1 C2 - 220uF 10v 2.5mm pitch aluminium can electrolytic - Bitsbox HC220U10
1 C4 - 22uF 10v tantalum electrolytic - Bitsbox CT22U10A
6 C3, C7, C8, C9, C10, C11 - 100nF multilayer ceramic - Bitsbox CC004 (It's worth getting 10 just in case :))
2 R18, R29 - 220R
9 R19, R22, R24, R25, R26, R27, R30, R31, R32 - 10k
1 R20 - 680R
1 R21 - 27k
2 R23, R28 - 150R
1 LB1 - 3x2 and 3x1 male link headers (or 1 3x3)
1 LB2 - 3x2 male link header
5 0.1" jumper to fit above - Bitsbox CN059
1 5-way female SIP connector for JS1 (optional)
1 5-way male SIP connector for RTC (optional)

1 Right-angle 6mm tactile switch - Bitsbox SW059, RS 234-7918
1 JS1 - Joystick module - ebay. Often found in Arduino sensor kits or advertised as a PS4 spare part. (Optional)

Optional pre-regulator
0 U1 - Not normally fitted. Link out as shown on PCB - Bitsbox M058 or equivalent
0 C1A - Not normally fitted
0 C1B - Not normally fitted

PS/2 Keyboard level shifter
Option 1
1 U4 - 4-way level shifting module - ebay
OR
Option 2
2 Q1, Q2 - N-channel mosfet TN0702. 2N7000 are also reported to work.
4 R38, R39, R40, R41 - 10k

Audio output socket
2 R1, R4, - 1k
4 R2, R3, R5, R6 - 2k2
2 R7, R8 - 470R (These set the max. volume for headphones. Do not reduce below 270R)
2 C5, C6 - 47nF 100v polyester film - Bitsbox PY47N
Option 1
1 K5 - 3.5mm jack socket - Pro Signal PSG03613 - ebay, CPC Farnell AV21208
OR
Option 2
1 K5 - 3.5mm SMD jack socket

SDcard storage
1 R9 - 2R2
Option 1
1 U5 - Micro SDcard module - ebay. Note, not the version with a regulator or level shifting
1 C9 - 100nF multilayer ceramic
OR
Option 2
1 U5 - Full size SD-card socket Hirose DM1AA-SF-PEJ(72) - RS 685-0799
1 C9 - 100uF 10V electrolytic

VGA circuit
7 R10, R11, R12, R13, R14, R15, R17 - 220R
1 VR1 - 100R 6mm preset - Bitsbox V6R100R
1 R16 - 180R
2 D2, D3 - 1N4148 or 1N914

Component substitutions:

- If you wish you can replace R16 and VR1 with a single 200R multi-turn preset with in-line pins. There are marks on the PCB showing the corner locations of it. You can fit it either way round.
- If you wish to get the lowest noise level on the low level audio output then it's worth trying this modification suggested by Volhout: Instead of the specified components for R1-R6, C4 and C5 install the following:- Change R1 and R4 to 3K3. Change R2 and R5 to 1K. Replace R3 and R6 with 15nF capacitors. Replace C5 and C6 with 1N4148 diodes with their cathodes to GND (pointing towards R8 on the PCB). This works well even if the SMPS is being used to obtain 3V3.
- I used 100uF rather than 220uF for C2 and omitted C4 completely, with no apparent problems :)

Constructional notes:

This PCB has several options which can be set up during construction. Some are not easy to change later so it's best to make sure you know what you want to achieve in advance. :)

1: By default the board uses a 5V supply fed via K1. There is a space for a pre-regulator, U1, which is not normally used and is normally linked out using a wire link. You can use a higher voltage supply such as 12V or 24V to run the board from off-grid batteries. To do this you must install a 5V 78xx-compatible regulator as U1. This should preferably be a self-contained switching type to keep heat down (there is very little space for a heat sink). You should also install an input capacitor and small bypass capacitor as C1A and C1B. The voltage rating of these must be suitable for your incoming supply. The resulting 5V supply is fed to the USB-A 5V output socket, the keyboard and the main regulator.

2: The USB-A 5V output socket is intended to power a VGA-HDMI converter. There are two types of these sockets, one for LH and one for RH mounting. By default, using one of the part numbers in the BOM, the PCB is correct. If you get the wrong socket from somewhere else you may get a reverse polarity output. There are solder blob links on the bottom of the PCB that will allow you to correct the polarity in this case.

3: It has been reported that there are problems in obtaining the specified MCP1700 250mA regulator (U2) in some areas. There are several options available:

- It should be possible to use the 150mA rated MCP1701 3V3 type.
- It is possible, if the input isn't going to exceed 5V, to use the TO-220 regulator position for a 78xx-compatible LDO regulator. To do this, use the solder blob pads which allow the keyboard supply to be routed from U1 input rather than U1 output. Don't install a level shifter. Link out the S and D pins of Q1 and Q2 and install R34 and R36.
- Re-enable the PicoMite's on-board SMPS to produce the 3V3 supply. This has the problem that it increases noise on the audio output, especially if headphones are being used. It would be an idea to increase R7 and R8 to 680R or even 1k to improve the audio. To make this change break the 3EN link under the PCB and close the VSYS solder blob link.

5: The maximum audio level for headphones is set by the value of R7 and R8. This may need adjusting to suit your particular headphones. The audio level can be set in software using PLAY VOLUME left, right where left and right are values from 0 to 100. Note that best audio quality is with this set to 100 for both channels and that the quality degrades as the volume is reduced in this manner. It is best to set R7 and R8 not too low, so that PLAY VOLUME can be kept as high as possible in normal use.

Constructional hints:

If you are using the level shifter module then fit it *before* the PS/2 and VGA sockets - you need room to work. You can either plug it into female headers or fully solder it. I chose the latter. If you are using the pins that come with it note that they are very hard to cut and will damage your best wire snips - use big chunky wire cutters or, and I speak from experience, they will lose the fight with a cutting disk in a Dremel. :) Alternatively, as there are only 8 connections, you can use bits of component leads, although it's a bit fiddly to do. I managed this on a second prototype. Plugging it in is probably the easier option for this module, but the necessary headers to do that are not shown in the Bill Of Materials as I didn't use them.

The pins on the microSDcard module do really need to be soldered directly for rigidity. A plug-in connection isn't recommended here. (Note that it is soldered to the PCB "upside down", with the USB socket next to the PCB). I trimmed the pins down before soldering them - it was far easier than using the Dremel to take the excess off after. If you are going to fit the board into a case then you can mount the module quite high from the PCB. This will let you cut a slot into the top edge of the case side instead of cuttting a slot through the side - which is far more difficult. Unfortunately you don't have this option with the full size SDcard socket and cutting a slot is the only option.

Please don't be put off soldering the surface mount SDcard socket and audio jack socket. Neither of these is particularly difficult to fit if you do so early enough, without having other components in the way.

The Reset button, in my case, had to have the actuator shortened as it proved to be impossible to get the PCB into a case unless this was done. (This can be fixed! Cut a slot in the case rather than drill a hole. The button is close to the case join anyway). The item listed in the BOM has a square actuator with a notch in it, which is perfect for trimming it to a shorter length. You can also get these buttons with a low actuator height which would be better really. The intention is to operate it with a thin object through a hole in the case.

Commisioning

PicoGAME runs a normal version of the PicoMite VGA Edition firmware by Geoff Graham & Peter Mather. It is recommended that you download & install the latest version together with the manual from https://geoffg.net/picomite.html

When setting up remember that the PicoMIte's 3V3 output is disabled so it depends on the 5V input to the PCB for power. You may need to connect the USB lead in addition to that supply if you need console access rather than VGA.The USB and external supplies are isolated from each other by diodes so no damage will occur.

Setup for the board should include, as a minimum, the following to enable the hardware:

For a full size SDcard socket use this:
OPTION SDCARD GP10, GP12, GP110, GP13
For the microSDcard module use this:
OPTION SDCARD GP13, GP11, GP12, GP10

OPTION AUDIO GP6, GP7

Link blocks
LB1 has the middle row of pins connected to the analogue inputs via 10k resistors. It can be used in 3 ways:

With no link - the analogue pin is simply connected to the port. An input voltage is provided by a potentiometer between GND and 3V3.
With the link set to UP the resistor is connected as a pull-up to 3V3. This allows the input to be used for an active-low button input. e.g. for joysticks that have multiple buttons like the Atari ST.

With the link set to DN the resistor is connected as a pull-down to GND. This is the usual connection when a "Paddle" is used. They have one end connected to 3V3 and the other to the analogue input.

LB2 sets the audio output level. H is Headphones/High and L is Line/Low. Each of the links controls its channel independently.

If the male header is fitted, it is possible to install a small RTC module on the PCB. This uses the analogue inputs GP26 and GP27 so it is no longer possible to use an analogue joystick or paddles on Port A. The module used has its own battery so it can easily be removed when not required. If this is used then the following option needs to be set:

OPTION SYSTEM I2C GP26, GP27

Date$ and Time$ can then be set automatically if the following option is set:

OPTION RTC AUTO ENABLE

Known Problems:

None at present.

Document Revision

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