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

These notes are for PCB version 2.0 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 output jack socket

Much enhanced audio filter designed by Volhout, allowing use with 32R headphones or line audio with excellent audio quality.

Two Controllers or switch-type joysticks can be used, or Port A can also be used with an analogue 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 or joystick, a Paddle/potentiometer or for simple wired serial port.

Optional local COM port over wireless communication is supported using a 2.4GHz connection.

If pins 5 & 9 on Port A (or JS1, which uses the same connections) are not being used then a small RTC (real-time clock and calendar) module can be plugged in.

Credits

- Geoff Graham - for creating MMBasic in the first place and making it freely available. Also for his excellent documentation, which puts most others to shame. :)
- Peter Mather - for his incredible efforts in enhancing MMBasic and in porting it to so many different platforms. Without him the PicoMite VGA which makes the PicoGAME possible wouldn't exist.
- Volhout - for his work in making much better PWM audio filters. My hearing thanks you. :)
- Thwill - for being my guinea pig (and providing me with a couple of PCBs) when building the prototype PicoGAME.

Also thanks to others on the Back Shed Forum for all your comments and suggestions.

Port Connections

The two 9-pin ports at the front of the PicoGAME can be used in several different ways. Port A is the left-hand socket and port B is at the right-hand side.

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 Atari ST & Commodore)	I2C2 SCL

Game port B DB9M socket:

		Controller mode	Paddle mode	Switched Joystick mode	Serial port mode
1	GP28	n.c.	n.c.	Up (LB3 closed)	n.c.
2	GP4	Data	n.c.	Down	COM1 TX
3	GP5	Latch	n.c.	Left	COM1 RX
4	GP22	Clock	n.c.	Right	n.c.
5	n.c.	n.c.	n.c.	n.c.	n.c.
6	GP15	3V3	Fire / Trigger	Fire / Trigger	n.c.
7	3V3	n.c.	3V3	3V3	n.c.
8	GND	GND	GND	GND	GND
9	GP28	n.c.	Pad A	Do not connect	SET (via LB2)

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 plugged into the PCB and supported by fixing pillars in holes provided. 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 connector for JS1 has another possible purpose. As previously mentioned, the two analogue pins can be connected to a RTC module using a I2C interface. Note that this does not affect other functions of either port as only those two PicoMite pins are used. It's possible to connect other I2C devices (a little LCD display or an I/O module for example) in addition to the RTC module (if they have different addresses). They can be connected to the JS1 connector thus:
Pin
1 - GND
2 - 3V3
3 - I2C2_SDA
4 - I2C2_SCL
5 - not used (GP14)

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.

When using controllers GP14 and/or GP15 can be set high to provide additional current to the controller if necessary. I have not needed to do this during testing with the recommended controllers. **Never do this when controllers are not being used** as a Fire / Trigger button will short the GP pin to ground.

As noted in the above chart, Port B supports serial port COM1. This is a simple serial port, with a few components on the board to give some protection to the PicoMite pins. If two PicoGAME machines are connected using GND, TXD and RXD (with TXD and RXD crossed over in the cable) then it's possible to send messages between them.

There is an option to install a JDY-40 wireless communications module on the PCB. This connects to the same COM1 pins as Port B so, when enabled, you can send messages wirelessly rather than using a cable

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. :) Some of the options involve cutting and linking "solder blob" pads on the PCB, others are component changes.

Power Supplies

The default system works as follows:
A 5V supply is connected via the 3.5mm barrel jack K1. It is fed to a 3.3V linear regulator U2, which provides the main 3V3 supply. The SMPS on the PicoMite is disabled, as pin 3V3EN is grounded. This reduces electrical noise on the audio output.

Several options are available:

1: 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 (you could, for example, build a 12V version for a caravan). 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 (although there is a little space allocated on the PCB for a small 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.

2: The USB-A 5V output socket is intended to power a VGA-HDMI converter but it could also be used for a phone charger in some cases (depending on the data line connections). 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. Note that the supply from this socket is only available if the system is powered via K1 as a computer USB socket will only provide very limited charging capabilities and may not be able to power a VGA-HDMI converter in addition to the PicoGAME and PS/2 keyboard.

3. The input to the main regulator can be taken from either Vin or from the VBUS output on the PicoMite. This allows the system to be powered via the micro USB port. The same input supply also feeds the PS/2 keyboard.

4. The SMPS on the PicoMite can be used to provide the 3V3 supply instead of using U2. You need to break the 3V3EN and analogue regulator output links and close the VSYS input link to do this. Make sure that the output from the linear regulator is not connected at the same time as the SMPS.

========== 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

Basic build

1 PicoGAME PCB (version 1.5)
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.
2 D4, D5 - BAT48, BAT85 or similar small signal Schottky diode - Bitsbox QD113

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

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)
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 wireless communications

1 JDY-40 wireless communications module
1 LB2 - 1x3 male link header
1 LB4 - 1x2 male link header
2 0.1" jumper to fit above - Bitsbox CN059

Power indication LED

Option 1 - simple power-on indication
1 D6 - 3mm LED (power indication only. Install between GRN and CATHODE)
Link GP28 to Port B at LB2
OR
Option 2 - controlled by JDY-40
1 D6 - 3mm Red/Green 3-wire common cathode LED
1 D7 - 1N4148, 1N914 or similar
1 R39 - 10k
1 Q3 - Small PNP transistor - BC327 or similar

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 R33, R34, R35, R36 - 10k

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
OR
Option 3
1 U5 - microSD card holder, surface mount. molex 104031
1 C9 - 100uF 10V electrolytic

Audio output components

Option 1 - Output is up to 19kHz -3dB - This is a Hi-fi specification

2 R1, R4, - 150R
2 R2,, R5 - 220R
2 R3, R6 - 470R
2 R7, R8 - 10k
2 C11, C12 - 47uF electrolytic
2 L1 - 2.2mH 15R inductor - Farnell 608622
2 C5, C9 - 33nF
2 C7, C8 - 6.8nF 5%
2 C9, C10 - 68nF

OR

Option 2 - Output is up to 12kHz -3dB - This is fine for most people.

2 R1, R4 - 220R
2 R2, R5 - Link out
2 R3, R6 - Omit
2 L1 - 4.7mH 20R inductor - RS 191-1197
2 C5, C6 - 33nF
2 C7, C8 - 2.7nF 5%
2 C9, C10 - 68nF

In both cases C11 and C12 can be linked out and R7 and R8 omitted. The only problem is that the output signal contains some DC, which is not a good idea if you have good quality headphones.

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 - RS 705-1490

VGA circuit

Option 1 - This should work on even awkward monitors.

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

OR

Option 2 - This simplified version should be fine on most monitors.

2 R10. R11 - 270R
1 R13 - 820R
1 R12 - 390R
Link out R14. Omit R15, R16, R17, VR1, D2 & D3

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.
- I used 100uF rather than 220uF for C2 and omitted C4 completely, with no apparent problems :)

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 cutting a slot through the side - which is far more difficult. Unfortunately you don't have this option with the surface mounted sockets and cutting a slot is the only option.

I would recommend fitting all surface mount parts first as access to some of the pads gets progressively more difficult during the build. Please don't be put off soldering the full size 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. They both have locating pegs that line up with holes in the PCB so there are no problems with alignment. The surface mount microSD socket is more fiddly. I recommend using solder paste, liquid or gel flux and a hot air gun for this.

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. 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.

When installing L1 and L2 don't bend the leads tight against the body of the inductor as it's possible to break the winding where it connects to the leads. This area is usually protected by resin. The holes on the PCB are just slightly further apart than the minimum bending distance for the 4.7mH value of inductor.

Commissioning

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 (unlessd you have re-enabled it) 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:
OPTION SDCARD GP10, GP12, GP11, GP13 (For either surface mount SDcard socket)
or
OPTION SDCARD GP13, GP11, GP12, GP10 (For the microSDcard module)

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. Set GP28 to UP unless you want to use the "Paddle" input on Port B.
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 changes the allocation of GP28 to either it's normal Port B usage or to the SET pin of the JDY-40 module.

LB3 links pins 1 and 9 of Port B. This connects GP28 to pin 1, allowing it to be used for the Up input for a switched joystick.

LB4 is used to enable the JDY-40 wireless module if fitted. The device is disabled unless this link is fitted.

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

and the system time and date set.

Date$ and Time$ can then be set automatically on boot and periodically if the following option is set:
OPTION RTC AUTO ENABLE

Usage

5V Supply Output
This is available via the USB-A socket at the rear of the PCB. The supply comes from the output of the pre-regulator U1, so is available whenever the board is powered via the barrel jack connector K1. The data pins are linked together, which allows it to be used as a phone charger in many cases, but the charge current may be low.

JDY-40
There is a quite good manual available for this on the internet. You will need it if you wish to change most of the settings.
Indoor range is about 15m at most. By default, all that is required to use this is to fit the link at LB4. This will enable the JDY-40 for communication at 9600 baud, using the usual commands for COM1. If LB2 is moved to the SET position then GP28 is connected to the SET pin of the module (LB1 for GP28 must be set to UP). Setting this low allows AT commands to be sent to it to configure operating frequency, transmit power etc. Setting it high returns to normal communications mode.

The JDY-40 can also run in a different mode, as a remote control receiver. This mode is selected by closing LB4, setting LB2 to SET, setting GP28 low and sending AT command AT+CLSSC4 for momentary action or AT+CLSSC5 for toggle action). GP28 is then set high, LB4 opened and lGP28 can then be assigned to Port B.

The default signal from the JDY-40 is output low, so the power LED will change to red.

A second, remote, JDY-40 is configured using the command AT+CLSSCC0 or AL+CLSSC1. If input GPIO4 is made high then the power LED will return to green. If CLSSC4 has been used then releasing the input will then set the LED to red. If CLSSC5 has been used then each switching of GPIO3 will toggle the red/green status of the LED. Four additional GPIO pins (GPIO5-GPIO8) are brought out to pads on the bottom of the PCB. They could be connected to LEDs via 1k resistors or to PicoMite inputs if required. Note that the transmitting JDY-40 also has CS disconnected. This puts it into a very low current mode that only transmits when an input changes. It is quite feasible to run this from two AA batteries for a year or more.

Why did I include this? Because I could. :)

Known Problems:
None at the time of writing.

Document Revision
1.0 - 13/07/22 - First issue.