PicoGAME 4

Version 1.01

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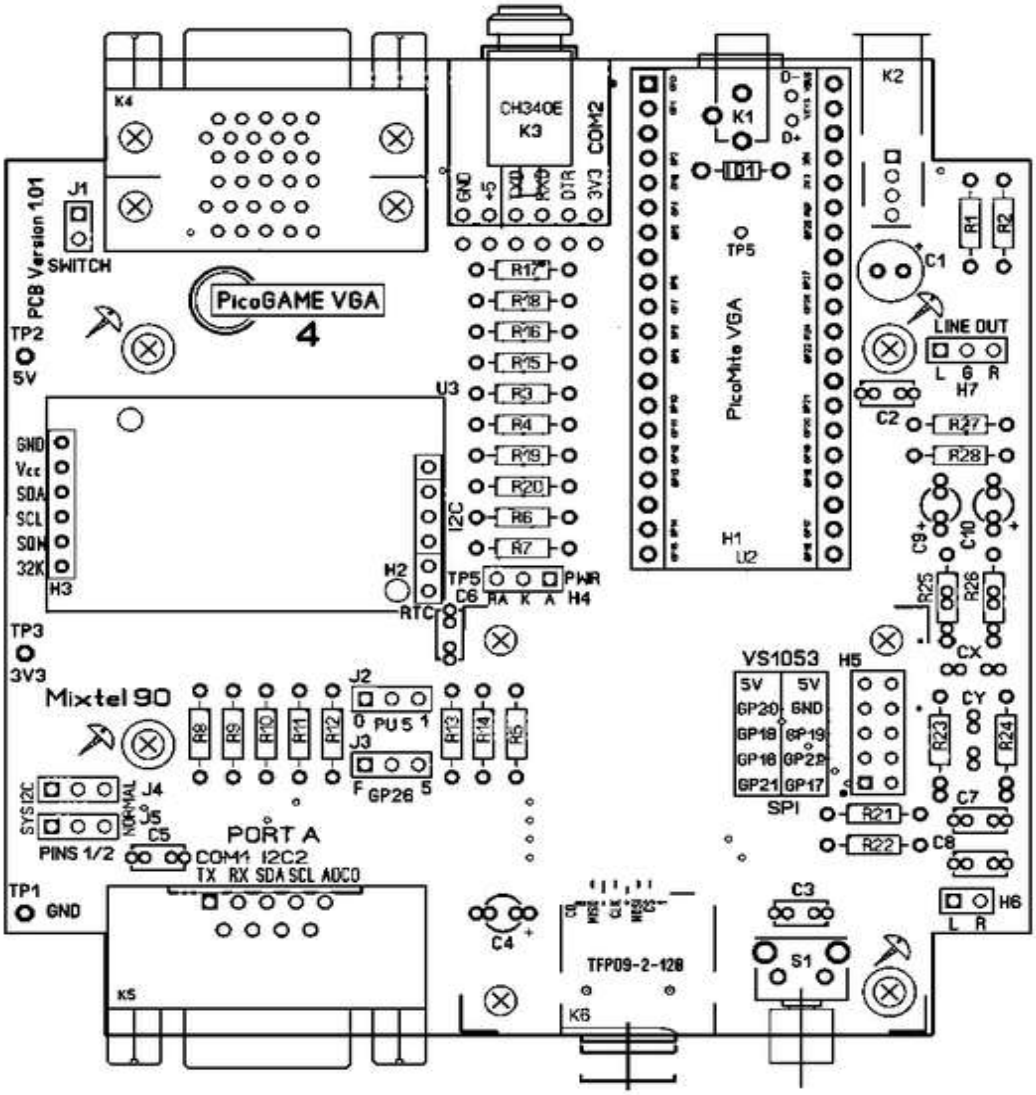
PicoGAME 4 continues the PicoGAME series, by adding support for the VS1053 codec board and USB host mode.

The same Hammond 1593W enclosure has been used for this version.



There are alternatives for the following components:
Two different VGA connectors.
Two (or more) USB to TTL converters.
The audio Line Out socket is now panel mounting so any type can be used.
The audio codec header (H5) could be used for other things, including PWM audio.
The audio output filter can be changed or omitted.
Two alternative RTC modules.

There are a few enhancements over the PicoGAME 2:
Everything is on the front and rear panels. There is no need to cut the sides of the case.
USB host support via the micro USB connector on the Pico or via the USB-A connector.
Enhanced audio capabilities.
Push-push micro SD card socket.
Large size RTC can be used.
Various arrangements are possible for a panel indicator light.
It is now possible to fit a power off/on switch.

There are some restrictions:
There is only a single controller port (but adapters can be used to give flexibility).
The pre-regulator has been removed so power is now at 5V only.
For correct operation the barrel jack power inlet socket MUST be used. No provision has been made to power the board via the USB-TTL adapter.
Only the correct orientation of USB-A socket can be used.
Some USB-TTL converters won't fit in the available space.
Only an official Raspberry Pi Pico is guaranteed to work.
Although a Pico W can be used, there is no access to GP25 for an indicator light.
Unless the board is fitted into a case there is nowhere to mount the audio Line Out socket!

This board is designed to use only the USB VGA version of the PicoMite firmware. Nothing else will work. In particular, the VGA pins are different to those used in older versions of the firmware

There is a reasonably sized "sea of holes" area beneath the large RTC module on the left but it wasn't possible to show this on the above diagram. It can be used for whatever you wish but at the moment all the GPIO pins of the PicoMite are allocated to something.

There is only one SMD component on the board, the SDcard socket. This is not too difficult to solder, but the PicoMite will work without it anyway, just using the A: drive in the flash memory.

Future developments

My intention is to release two alternative audio modules that can be used instead of the VS1053.

HA1: uses PWM output with a LC filter and a LM4881 headphone amplifier with volume control.

DAC1: uses a MCP4822 DAC chip and also has a headphone socket but no volume control.

Both would have a direct line output header for connection to the rear socket. These would be direct plug-in replacements, fitting in the same position and using the same fixing hole positions.

Another intention is to produce a design for PCBs for the front and rear panels of the recommended case. These would be silk screened and available in whatever colours your supplier can use for the solder resist and silk screen. :)

All of these are at advanced design stages so I know that they are definitely feasible.

Bill Of Materials

These are for a standard build with default options. Please see other sections of this manual for variations that can be made.

C1	100uF	electrolytic
C2	100nF	ceramic
C3	100nF	ceramic
C4	10uF	tantalum
C5	100nF	ceramic
C6	100nF	ceramic
C7	3n3	
C8	3n3	
C9	10uF	
C10	10uF	

D1	1N5817	(or similar) 1A Schottky diode

H1	1x20	2off female SIP socket
H2		If U3 is RTC with CR2032 and flash RAM - 1x6 female SIP socket. if U3 is tiny RTC with yellow battery - 1x5 male pin header.
H3	1x6	female SIP socket (not needed for tiny RTC)
H4	1x3	male pin header
H5	2x5	Long pin female header
H6	1x2	male pin header
H7	1x3	male pin header

J1	1x2	male pin header & jumper
J2	1x3	male pin header & jumper
J3	1x3	male pin header & jumper
J4	1x3	male pin header & jumper
J5	1x3	male pin header & jumper

K1	DC socket	1.35 x3.5mm barrel jack socket (I got mine on ebay)
K2	USB-A Vert.	FCI 73725-0110BLF (RS 771-0048)
K3	3.5mm jack	Lumberg KLB4 3.5mm panel mounting socket
K4	VGA socket	"Compact" or "Normal" size
K5	DB9M	NorComp 182-009-213R531 right-angle PCB socket
K6	microSD skt	push=push type TFP09-2-12B

R1	15K
R2	15K
R3	1K
R4	1K
R5	820R
R6	10K
R7	10K
R8	3K3
R9	3K3
R10	3K3
R11	3K3
R12	150R
R13	3K3
R14	2R2
R15	270R
R16	680R
R17	390R
R18	270R
R19	56R
R20	56R

R21	470R
R22	470R
R23	470R
R24	470R
R25	100K
R26	100K
R27	100K
R28	100K

S1	Horizontal 6x6 tactile switch Omron B3F with B32 6mm dia cap

U1	CH340 USB-C-TTL converter (I got mine from AliExpress)
U2	Raspberry Pi Pico
U3	RTC module with memory & battery
U4	VS1053 audio codec module

You will also require some hardware:
1off USB to 1.35x3.5 DC plug lead (I got mine on ebay)
1off Hammond 1593W enclosure.
This is available as 1593WBK (black), 1593WGY (grey) or 1593WTBU (translucent blue).
I think the latter is particularly "Cool!". :)
4off #6 x 6mm self tapping screws to mount PCB in the enclosure.
3off M3 x 15mm female/female spacer to mount the VS1053 module.
6off M3 x 6mm screws for the above.

Components sourced from ebay etc.

"Mini" RTC module

"Large" RTC module

CH340E USB-C to TTL converter

CH9340C USB-C to TTL converter

"Compact" VGA connector

"Standard" VGA connector

DC barrel jack connector

VS1053 audio codec module

Construction Notes

When mounting the USB-TTL converter I recommend sticking it to the PCB using double-sided tape then soldering wire links through the pin locations for GND, RXD and TXD only. Don't use a socket or male headers here. Good tape will be strong enough, but if you wish you could put more wire links through. Note that other converter modules may fit but I haven't checked. The suggested items are cheap and easy to get on AliExpress.

Either RTC module can be used but the connectors are different. For the Mini version fit a strip of 5 male header pins into the front five holes of H2. H3 isn't required. For the Large version fit a row of 4 female headers into the rear four holes of H2. H3 is optional. Note that the board will not fit into the case if the horizontal male header pins are fitted to the larger module.

The VS1053 socket has long pins and **MUST NOT** be soldered down onto the PCB! Plug it into the VS1053. Then mount the VS1053 on it's 15mm spacers, preferably with the fixing screws. Now solder the pins of the socket to the PCB. The VS1053 can now be removed.

If installing this board into the suggested case then it will be necessary to cut some of the PCB mounting pillars down to enable the board to fit. This is unfortunate, but the front and rear edges of the board are very cramped and it was impossible to avoid all the mounting points. No drillings are required in the sides of the case, which makes things easier.

Some connections have to be ,made to the underside of the Pico module. Connect three thin wires to the USB data pads TP2 (D-) and TP3 (D+) and to the GP25 pad TP5. Something like kynar wire is ideal for this as there is no flex on the connections after installation. The TP2 and TP3 wires should be gently twisted together. The other ends of the wires should be soldered to the pads on the PCB beneath the Pico then the Pico is plugged into its SIP sockets. TP5 can't be used on a Pico W.

The DC barrel jack connector has been changed in size. The new size, 1.35 x 3.5mm, appears to be more readily available than the previous, smaller, size. I have deliberately avoided the more common larger sizes as there is a danger of connecting a 12V supply when using those. If you already have a barrel jack and lead for the earlier versions then this can be fitted instead as the PCB footprint is the same.

Configuration

Either pin 1 or pin 2 of the USB-TTL converter will be used for GND. Close the appropriate solder blob link beneath the PCB. Neither is connected by default as the non-ground pin will be at 3V3 from the regulator on the converter module.

Fit a link to J1 if no switch is installed.
Fit link to 0 on J2
Fit link to F on J3
Fit links to the Normal position on J4 and J5.

Without installing the RTC or VS1053, and with the Pico unplugged, power up the board from the barrel jack input.
Check the 5V supply between TP1 (GND) and TP2 (5V). If this is correct, and has the correct polarity check for the correct polarity output on the USB-A socket. This is best done by plugging in a USB power lead which will almost always be centre positive. If the polarity of TP1 and TP2 is correct but the USB polarity is wrong then you have fitted a reversed USB-A socket.
Power off, plug in the Pico and power up the system again. The Pico should boot normally.
Check for 3V3 between TP1 (GND) and TP3 (3V3). If this is correct the system can be powered off and the RTC and VS1053 installed.

A 5V power source should then be connected to the barrel jack input and a USB keyboard plugged into the USB-A socket directly. There should be no connection to the USB socket on the Pico. A console connection is available via the USB-TTL converter socket, which should be connected to a computer running a terminal program such as Tera Term. You will need to set the baud rate to 115200 baud. With this established the essential hardware OPTION settings can be entered:

OPTION VGA PINS GP10, GP4
OPTION SYSTEM I2C GP12, GP13
OPTION SDCARD GP27, GP15, GP28, GP14
OPTION AUDIO VS1053 GP18, GP19, GP20, GP17, GP21, GP22, GP16

Note that until the VGA PINS option has been set up there will be no VGA display available.
Other options such as the keyboard, display and editor colours etc. can also be set up according to instructions in the manual.

Updating the firmware

Disconnect the barrel jack and USB-A connector and power the system using the Pico USB socket whenever updating the firmware in the Pico. The Pico (or Pico W) must be loaded with the appropriate VGA USB version of the firmware using the Boot button in the usual manner. Once the firmware has been loaded the Pico USB connection should be removed.

Adding a power switch

The design allows for a small toggle switch to be fitted beneath the VS1053, over the top of the PCB fixing screw. There isn't a lot of space and the Line Input header has to be removed from the VS1053 board. The power switch is connected to J1, at the opposite corner of the PCB. It switches the 5V input from the barrel jack socket.

Adding a front panel LED

It is possible to connect a LED in various ways.:

1 - Simple power LED (any colour)
Anode to H4 PWR, cathode to H4 K

2. Heartbeat LED (not available for Pico W)
Red LED. Anode to H4 TP5, cathode to H4 K. This has to be red.

3. Combined LED
Red/Green 3-wire common cathode type. Connected as 1 and 2 above.

Installing the VS1053 audio codec board

This module supports headphone output directly from the front 3.5mm jack socket (32R impedance and upwards). The common connection to the headphones is not at GND potential (it is at about 1.6V DC above GND) so it is unsuitable for use as a line output directly. However it is possible to obtain a line output from it.

You need to connect two wires from the L and R connectiions of the headphone jack on the rear of the PCB. These go to L and R on H6. The filter removes some of the high frequencies and provides DC isolation for the output.

The output connector, H7, provides L, R and GND signals to a suitable jack socket mounted on the back panel. This connection should ideally be in twin screened lead, but merely tightly twisting the three wires will probably be sufficient.

Note that if the VS1053 isn't required then the entire filter area of the PCB can be left unpopulated.

Using the game controller port

This is virtually identical to Port A of previous versions of the PicoGAME. The main differences are:
There is only one ADC pin available (GP26).
GP26 is also used as the Fire button input for an Atari joystick.

The various operating modes are as follows:
(Note that "no connection" simply means that a pin isn't required. It may still be connected internally)
Unless using an Atari joystick or a single NES/SNES controller it will probably be necessary to use some sort of adapter.

Atari Joystick (direct plug-in)
Fit J3 with a link to F: Fit links to Normal on J4 and J5
Pin 1 - GP0 - Up
Pin 2 - GP1 - Down
Pin 3 - GP2 - Left
Pin 4 - GP3 - Right
Pin 5 - no connection
Pin 6 - GP26 - Fire
Pin 7 - no connection
Pin 8 - GND
Pin 9 - no connection

Single NES or SNES controller (direct plug-in if fitted with DB9 plug)
Fit J3 with a link to F: Fit links to Normal on J4 and J5
Pin 1 - no connection
Pin 2 - GP1 - Data
Pin 3 - GP2 - Latch
Pin 4 - GP3 - Clock
Pin 5 - no connection
Pin 6 - 3V3 supply
Pin 7 - alternative 3V3 supply
Pin 8 - GND
Pin 9 - no connection

Two NES or SNES controllers can be used by using common Latch and Clock signals but connecting the second controller's data outout to Pin 1.

I2C controller (using I2C2, not on System I2C)
Fit J3 with a link to F: Fit links to Normal on J4 and J5
Pin 1 - no connection
Pin 2 - no connection
Pin 3 - GP2 - I2C2_SDA
Pin 4 - GP3 - I2C2_SCL
Pin 5 - no connection
Pin 6 - no connection
Pin 7 - 3V3
Pin 8 - GND
Pin 9 - no connection

I2C controller (using System I2C)
Fit J3 with a link to F: Fit links to SYS I2C on J4 and J5
Pin 1 - GP12 - I2C SDA
Pin 2 - GP13 - I2C SCL
Pin 3 - no connection
Pin 4 - no connection
Pin 5 - no connection
Pin 6 - no connection
Pin 7 - 3V3
Pin 8 - GND
Pin 9 - no connection

Note that if I2C controllers are addressable then several may be fitted to the same I2C port. It is possible to use both I2C ports at the same time. I2C SDA and I2C SCL are not available on pins 1 and 2 unless the links on J4 and J5 are in the SYS I2C position as I2C is already allocated to the RTC vie GP12 and GP13 rather than GP0 and GP1..

Pins 1 and 2 can also be used as the COM1 serial port (with J4 and J5 in the NORMAL position).

ADC input
Set J3 link to 5. Setting J2 to 1 connects an optional 3K3 pull-up resistor.
Pin 1 - no connection
Pin 3 - no connection
Pin 4 - no connection
Pin 5 - GP26 (ADC0)
Pin 6 - no connection
Pin 7 - 3V3
Pin 8 - GND
Pin 9 - no connection
Pin 2 - no connection

Additionally, MMBasic also supports some USB controllers. A small non-powered USB hub can be plugged into the USB-A connector to allow simultaneous connection of a keyboard, mouse and game controller.

The audio system

There are alternative ways to equip this PCB for audio output. The default system (recommended) is to use the VS1053 board as previously described. However, the VS1053 puts a heavy load on the CPU in some cases and, particularly where the CPU power is required elsewhere, it may be preferred to use one of the following systems. These are both line output sources so you will need to use PLAY VOLUME to set the output level. You can use them for headphones, but you will probably find that they are too loud. You can play with the resistor values, but they give best results when fed into an amplifier with a volume control, in which case PLAY VOLUME should be left at maximum.

Basic PWM audio
This is a very basic system with relatively poor filtering. It is usable for headphones (32R upwards) and gives a line output of approximately 1V peak to peak.
Connect H6 R to GP19 on H5
Connect H6 L to GP18 on H5
Connect the Line Out jack to H7
Change R21 and R22 to 1K
Change C7 and C8 to 47nF
Change R23, R24, R25 and R26 to 2K2
Commission this with OPTION AUDIO GP18, GP19

Improved filter PWM mode
This uses a filter designed by Volhout, which is much improved and can give high quality audio.
Connect H6 R to GP19 on H5
Connect H6 L to GP18 on H5
Connect the Line Out jack to H7
Change R21 and R22 to 220R
Change C7 and C8 to 100nF
Change R23 and R24 for 6.8mH inductors
Change R25 and R26 to 100nF capacitors
Add 2n7 capacitors as CX and CY
Commission this with OPTION AUDIO GP18, GP19

In both cases C9 and C10 severely limit the bass output if headphones are used. You can increase these to 100uF or more for a better result. You can actually short them out for the best bass, but there will be a slight DC level present on the output. In many cases this won't be a problem

Unused GPIO pins GP18-GP22 on H5 can be used for other purposes..