

PicoGAME SPGA

Manual version 0.1

PCB version 1.0

Mixtel 90 - OCT. 2024.

A games and experimenters home computer based on the Pimorini PGA2350 module. This uses the Raspberry Pi RP2350B chip, with 8MB of PSRAM and 16MB of flash memory.

Uses **MMBasic** by Geoff Graham and Peter Mather.

- Highly configurable.
- Can be built using all through-hole components and modules.
- 16-colour VGA video output.
- Multi-purpose DE-9M connector for joysticks, controllers etc.
- Built in 4-port USB hub with two front sockets.
- VS1053 digital audio codec module with stereo headphone socket.
- Optional JDY-41 module.
- GPIO port with up to 17 pins available to the user, up to 7 of them can be ADC inputs.
- SD card socket.
- Real time clock/calendar.
- A rear panel LED is used for the usual "Heartbeat" indication.
- An optional 5mm WS2812 programmable LED can be fitted to the front panel using a clip. This is completely under software control.

The DE-9M connector supports Atari joysticks, NES/SNES controllers, I2C controllers and analogue joysticks and paddles. It can also be used as a 3.3V serial port. It is compatible with Port A of previous PicoGAME boards, with the exception that the ADC inputs have to be on different pins (GP26-GP28 are not ADC pins on the PGA2350).

Under MMBasic the VS1053 codec module will play MP3, FLAC, WAV, MOD and MIDI formats. As well as this it can be used for arbitrary waveform generation. You can optionally install additional components to get a line output signal (you can't use the headphone socket for this as the common is at about 1.23VDC above ground and there is a 6MHz carrier signal as well. It must not be connected to ground.).

The GPIO port has 20 pins and is a polarized box header. There is a 3V3 pin and two GND pins. Another pin, marked AUX, can be connected to GP30 , 3V3) or +5V using an internal jumper. Pins GP30-GP39 are general purpose pins, GP40-GP46 can also be used as ADC inputs. Pin GP47 is used to select the PSRAM on board the PGA2350 module and is not brought out. All GPIO pins are rated for 3.3V operation.

The Real time clock/calendar is one with a built-in battery, a model intended for the Raspberry Pi. Normally these are treated as disposable items, but the PCB has space for an external coin cell (CR1220 or CR2032) which can be easily connected once the dead battery has been removed.

The JDY-41 is a wireless serial port and remote control module. This allows serial communication with a similar device using the 2.4GHz band. Communication is error-checked and uses a system of "channels" and ID numbers so several devices can share the same frequency.

An optional LM4040-3V0 can be fitted to provide an ADC reference voltage. This is a surface mount device, so a jumper is provided to disconnect it. This jumper can also be used to connect other 2-pin reference devices.

The PCB fits a standard Hammond R2015S enclosure, which is easily obtainable and very reasonably priced. Front and rear panel designs are also available to provide pre-cut and pre-lettered panels. These can be made by your PCB manufacturer in whatever colour solder resist they have!

Programming MMBasic into the PGA2350 is via a 5-pin header, which accepts a commonly available USB female socket breakout board. Alternatively there is a vertical USB-C breakout module available which can be soldered directly to the PCB instead of the header.

BILL OF MATERIALS

Please note that some components are specified as optional below. Of course, you can actually leave off any functionality that you don't need. :)

Name	Value	Comment
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B1	CR2032 battery + holder (optional)	
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C1	100uF	electrolytic capacitor
C2	22uF	electrolytic capacitor
C3	100n	Ceramic cap
C4	100uF	electrolytic capacitor
C5	47uF	electrolytic capacitor
C6	100n	Ceramic cap
C7	10uF	electrolytic capacitor
C8	100n	Ceramic cap
C9	10uF	electrolytic capacitor
C10	100n	Ceramic cap
C11	100n	Ceramic cap
C12	100n	Ceramic cap
C13	10uF	electrolytic capacitor
C14	100n	Ceramic cap
C15	100n	Ceramic cap
C40	3n3	capacitor
C41	3n3	capacitor
C42	10uF	electrolytic capacitor
C43	10uF	electrolytic capacitor

D1	1N5158Schottky diode (or similar)	
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D2	LED	green 3mm
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H1	2x10 way	male box header, 90 degree, polarized
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H2	5-way	0.1in female socket header
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H3	3-way	0.1in female socket header
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H4	3-way	0.1in male pin header
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H5	2x5 way	0.1in female socket header
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H6	5-way	0.1in male pin header
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H7	1x6	2mm female SIP socket
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H8	3-way	0.1in male pin header
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H9	3-way	0.1in male pin header
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J1	2-way	0.1in male pin header with jumper
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J2	2-way	0.1in male pin header with jumper
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J3	3-wak	0.1in male pin header with jumper
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J4	3-wak	0.1in male pin header with jumper
----	-------	-----------------------------------

J5	3-wak	0.1in male pin header with jumper
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J6	3-wak	0.1in male pin header with jumper
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J7	2-way	0.1in male pin header with jumper
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J8	2-way	0.1in male pin header with jumper
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J9	3-way	0.1in male pin header with jumper
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J10A	2-way	0.1in male pin header
J10B	2-way	0.1in male pin header
J10C	2-way	0.1in male pin header with jumper
LK1		link pad on PCB
LK2		link pad on PCB
LK3		link pad on PCB
LK4		link pad on PCB
P1	11mm	MM or MF M3 nylon post c/w hardware
P1	11mm	MM or MF M3 nylon post c/w hardware
P1	11mm	MM or MF M3 nylon post c/w hardware
P1	11mm	MM or MF M3 nylon post c/w hardware
PF1	0.2A	Polyswitch fuse RXE020
PF2	0.2A	Polyswitch fuse RXE020
R1	270R	resistor
R2	820R	resistor
R3	390R	resistor
R4	270R	resistor
R5	10K	resistor
R6	10K	resistor
R7	10K	resistor
R8	10K	resistor
R9	10K	resistor
R10	10K	resistor
R11	120R	resistor
R12	2R2	resistor
R13	1K	resistor
R14	10K	resistor
R15	10K	resistor
R40	470R	resistor
R41	470R	resistor
R42	100K	resistor
R43	100K	resistor
R44	470R	resistor
S1	B3F-315n	Horizontal 6x6 tactile switch c/w B32cap
S2	tactile switch	6x6
SK1	USB-A vert.	
SK2	USB-A vert.	
SK3	HD15 VGA	compact 90 degree VGA socket
SK4	USB-A vert.	
SK5	DB9M socket	NorComp 182-009-213R531
SK7	USB-A vert.	
SK6A	DM1AA-SF-PEJ(72)	Push-push SD card connector
SK6B	XF-40T	Push-pull SD card connector
SK6C		USB-C socket module BTE17-06B

U1	CH340E USB-C to TTL converter (purple)
U2	LM1117T-3V3 TO220 LDO regulator
U3	PGA2350 Pimorini module
U4	FE11SX4 USB2 hub module
U5	RTC module mini "Raspberry Pi" type
U6	VS1053 audio codec module
U7	LM4040-3V0 3V0 voltage reference
PCB	custom
PCB (panels)	custom
Enclosure	Hammond RM2015S

COMPONENT ILLUSTRATIONS



U1



SK3



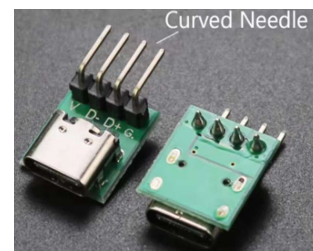
U4



U5



SK6C



Optional vertical USB-C



U6

COMPONENT NOTES

Most of the components are available from the like of AliExpress. I got the case from Rapid Electronics in the UK, but it is readily available from many suppliers.

When ordering PCBs the main PCB is 1.2mm thick and the front and rear panels are 1.6mm thick. If ordering from JLCPCB use the option to specify the position of the order number.

1. PF1 and PF2 are not actually essential, but are recommended. Link out if not required.
2. SK6 can be any of the three alternatives A, B or C.
3. U7 and J9 are for the ADC voltage reference and are optional.
4. If you are installing a JDY-40 or JDY-41 you will also require a 2mm pitch 6-way strip of male pin header.
5. On the VS1053 the line input and the microphone do nothing. They are not supported under MMBasic.
6. The main PCB should be specified as 1.2mm thick and the front & rear panels PCB should be specified as 1.6mm thick.

ASSEMBLY NOTES

Mount the lowest components first. It makes life a lot easier. (Ignore this advice at your peril! ;))

It might be an idea to use some good quality double-sided tape under the USB-C to TTL converter as there is quite a bit of strain on the connections to this.

No arrangement has been specified for mounting the PGA2350. The easiest way is to use four 2x8 0.1" female sockets staggered round in a square.

A JDY-40 can be used as an alternative to the JDY-41 but it is much more limited and the difference in cost is minimal. The two are not software compatible and cannot communicate with each other. However, the JDY-40 is far easier to configure.

If you choose to use the micro SD card socket module it does not line up with the centre of the slot in the front panel. Sorry. :)

H4 is intended to connect a front panel LED mounted in a holder above the Reset button. It can be used in various ways:

LED + resistor from 3V3 to GND

LED from GP5 to GND (either switched or PWM controlled)

WS2812B using the 3V3 supply and DI connected to GP5

You may even decide to use it for something else entirely. :)

CONFIGURATION

The default configuration should be set up as follows:

Soldered pads on the PCB:

LK1	IO-GND link	Normally open. Closed if the vertical USB-C socket module has been fitted.
LK2	5V isolation	Normally closed. Open to prevent 5V from being applied to the GPIO port.
LK3	Ground plane	Normally closed. Links the bottom copper layer to the top one.
LK4	3V3 enable	Normally open. Close to disable 3V3 from PGA2350. Development use only.

Removable jumpers

J1	USB D- isol.	closed for normal operation.
J2	USB D+ isol.	closed for normal operation.
J3	Pin 5 res.	left (UP) for pull-up.
J4	Pin 5 mode.	left (GP45 Analogue/digital)
J5	Pin 9 res.	left (UP) for pull-up.
J6	Pin 9 mode.	left (GP46 Analogue/digital)
J7	JDY CS	closed (COM1 used for transparent wireless serial port)
J8	JDY SET	open (Only closed while changing the configuration settings)
J9	AV	3V-GND (AVREF disabled).
J10	AUX pin	GP30

The **PicoMiteVGAUSB** version of MMBasic should be installed as follows:

Remove the jumpers from J1 and J2.

Plug in the USB-C socket breakout board if it is being used.

Connect the USB lead from the PC to the USB-C socket (either the USB-C socket breakout board or the vertical USB-C socket module) - do not plug in the PC end.

Hold down the BOOTSEL button while plugging the other end of the programming cable into the PC. (this is far easier if a switched USB hub is being used from the PC!)

The board should then be recognised as a new drive. Follow the firmware installation instructions in the MMBasic manual.

After MMBasic is installed you will have to unplug the programming lead as the USB port is now in Host mode. Replace jumpers J1 and J2. Connect the USB lead to the USB-C connector on the rear. After the Pico boots you should be able to connect via the console with your terminal program set to 115200 baud.

The software options should then be configured at the command line using:

```
OPTION PICO OFF
OPTION VGA PINS GP23, GP26
OPTION SYSTEM I2C GP18, GP19
OPTION RTC AUTO ENABLE
OPTION SDCARD GP22, GP20, GP21, GP4
OPTION AUDIO VS1053 GP10, GP11, GP12, GP15, GP6, GP13, GP7
```

After setting the configuration save it with:

```
OPTION DISK SAVE "a:/spgaoptions
```

This will save a file called "spgaoptions.opt" to drive A: (the built-in flash drive).

It is a good idea to also save it to a SD card. This is drive B:, so save it using:

```
OPTION DISK SAVE "b:/spgaoptions
```

In both cases you can use the FILES command to check that it has been saved.

You can restore all the options at once in future using:

```
OPTION DISK RESTORE "a:/spgaoptions
```

or

```
OPTION DISK RESTORE "b:/spgaoptions
```

Once the options have been configured the VGA display will be active and the console socket is only being used to supply 5V to the PicoGAME SPGA.

USAGE

The DE-9M joystick/controller port has several options and, as noted previously, is multi-purpose. It has been necessary to change the pins used for ADC inputs. The pins are as follows:

PIN	GPIO	JOYSTICK	NES/SNES	I2C	COM
1	GP0	Up	-	I2C SDA	COM1 TX
2	GP1	Down	Data	I2C SCL	COM1 RX
3	GP2	Left	Latch	-	-
4	GP3	Right	Clock	-	-
5	GP45	Analogue1	-	<i>I2C2 SCL</i>	-
6	GP14	Fire	3V3	-	-
7	3V3	-	-	3V3	3V3
8	GND	GND	GND	GND	GND
9	GP46	Analogue2	-	<i>I2C2 SDA</i>	-

When used for an Atari joystick:

Pins 1-4 have fixed 10K pull up resistors. for the direction switches.

Pin 14 has a low value fixed pull-up resistor for the fire button.

When used for a NES or SNES controller:

Pin 14 provides a current-limited 3V3 supply to the controller.

Pin 2 is Data, Pin 3 is Latch and Pin 4 is Clock.

It is possible to use the same Latch and Clock signals for two NES/SNES controllers, using Pin 1 as the second data input. This requires an adapter cable and changes in the way in which the controllers are read.

Additionally, pin 1 (GP0) and pin 2 (GP1) can be allocated as I2C SDA and I2C SCL respectively. Note that pins 3 and 4 cannot be used for I2C2 as this is already allocated to other pins.

Pins 5 and 9 can have three different purposes. They can be additional digital switch inputs, analogue inputs, COM1 (if the JDY-41 is omitted) or System I2C (I2C2 - used by the Wii Classic and Nunchuck game controllers).

Configuration is by using four jumpers on the PCB.

All four of these (J4 to J8) are normally set to the leftmost position. This sets both inputs as analogue or digital with pull-up resistors.

If used as digital input as above they are active low, like the joystick direction and fire buttons, and can be used as additional joystick switches. The pull up resistors can be changed to pull down using J3 or J5, in which case the inputs are active high.

A potentiometer can be connected between GND and 3V3 with its slider on pin 5 or pin 9. Remove the jumper on J3 or J5 to remove the biasing resistor. The analogue input can then be read over the full range of the potentiometer.

If the JDY-41 is not installed then GP45 (on pin 5) and GP46 (on pin 9) can be configured as COM1 RX and COM1 TX respectively. Pull up resistors are optional.

J4 and J6 disconnect the pins from GP45 and GP46 and connect them instead to the System I2C port (I2C2 SCL on pin 5 and I2C2 SDA on pin 9). This is shared with the real-time clock. The resistors controlled by J3 and J5 are ignored in this case. The I2C port has 5K pull up resistors installed.

GP45 (ADC5) and GP46 (ADC6) also appear on the GPIO connector and are not intended to be used simultaneously when jumpers connect them to the D9 connector.

ADDITIONAL NOTES

If the audio line output isn't required then omit C40-C43, R40-R43. If it is required then in addition to these you will need a 3.5mm panel mount stereo jack socket. There is sufficient space to mount this above the USB-C socket on the rear panel. It should be connected via screened lead to a female Dupont socket to plug into H9. H8 should have a similar connector for H8. This has two wires and connects to the L and R headphone socket connections on the VS1053 module.

There is a good reason why there is no power switch! Don't be tempted to fit one. The USB-C to TTL converter has 5V outputs. The PGA2350 can tolerate 5V on its pins but only while it is powered up. You can't remove the 5V supply that is coming from the USB-C to TTL converter so you mustn't lose the 3V3 power from the PGA2350 or the GPIO pins may be damaged.

It may appear strange that the GPIO port and USB hub supplies should be protected by 200mA Polyfuses. In fact, a 200mA Polyfuse doesn't start to trip until the current through it is 400mA. The Polyfuse will then increase its resistance to the point where it passes less than 200mA. The USB-C to TTL converter powering the whole device has a 500mA fuse on it as this is the maximum specified current from a USB-A port.

On this board the voltage regulator is not optional. It powers all 3V3 components *except* the PGA2350, the RTC, I2C pull up resistors and the DE-9M socket together with its associated pull up resistors. The switching supply on the PGA2350 continues to run. and there is no user option provided to disable it (LK4 should not be used).

Some on-chip devices are used on the PCB and are not available to the user. You must not allocate these devices to other pins.

GP8 / GP9	COM2	Used for the console connection only.
GP18 / GP19	I2C2	Used as System I2C. Can be made available on the D connector.
GP16 / GP17	COM1	Used by the JDY-41 module.
GP10 - GP12	SPI2	Used by the VS1053 module

GP25 is used to control a LED on the rear panel. This is normally the Heartbeat LED that you would find on a Pico, but isn't fitted on a PGA2350. This pin isn't brought out.

If the JDY-41 is not installed you can re-allocate COM1 to different pins such as GP45 and GP46. These can then be made available on the DE-9M connector.

If the PSRAM isn't required it is possible to connect GP47 to the AUX pin of the GPIO port. To do this break the link LK2 on the bottom of the PCB and connect a wire link from the small pad adjacent to it to GP47. This is marked *> on the bottom of the PCB. Set J10 to the 5V position. You must then break the "solder blob" link beneath the PGA2350 adjacent to GP47. You can still change J10 to either 3V3 or GP30 when required, but the 5V option is no longer available.

When assembling the PCB into the enclosure you will have to unplug the VS1053 to get to a fixing screw (or leave that screw out!). Sorry. :)