Pico2350 - Gamma

A Boot-to-BASIC computer implementation for the Raspberry Pi Pico 2

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Manual version 1.0

This manual covers two versions of Gamma. The version x.yA uses the Adafruit DVI breakout board , which incorporates the series resistors, and can be built without any surface mount parts. The other version requires soldering the HDMI connector and several 1206 size SMD resistors. This version can also be built to use VGA rather than DVI/HDMI but this isn't recommended for general use.

The PicoGAME Gamma

- Uses the Pico 2, a "Pico" style module using a RP2350A control chip. This has 2MB of flash and no PSRAM. However, as it is pin compatible with the earlier Pico it is quite likely that that and some of the clone modules will also fit providing that the VGA output is used.
- Uses a PCB less than 100mm x 100mm which is very cheaply available.
- Has an internal GPIO connector with 5 GPIO pins including all three available ADC pins and the ADC voltage reference pin
- Uses a basic "disposable" clock/calendar module with soldered-in battery

Both systems

- Use the same version of MMBasic
- Use the same low cost enclosure
- Have an internal USB hub with four standard USB-A sockets, one on the front
- Have a DVI/HDMI video output.
- Have a USB-C socket for 5V power and console connection
- Have a push-push micro SD card socket (by default, but can also use a through-hole module)
- Have a LM4881 headphone amplifier with manual volume control and 3.5mm jack socket
- Have a socket with connections to the system I2C port and a further I2C/COM port
- Have provision for a ESP8266-01S (this shares the above COM port on the Gamma)
- Have a WS2812B (or similar) programmable LED

The video connector used is the same as that used for HDMI, but the video capability is actually DVI, which is partially compatible with HDMI at this level. You should find that most HDMI inputs will accept the DVI signal, but this is not guaranteed in all cases. This connector sources 5V at up to 100mA on pin 18, in accordance with the HDMI specification. It is protected by a self-resetting fuse.

The I2C socket on the front panel is a general purpose controller and expansion port. It is a type RJ12 6P6C "telephone" type connector and can accept both 4-pin and 6-pin plugs. When used with a 4-pin plug you are provided with 3V3, GND and the system I2C signals (I2C2). If a 6-pin plug is used you get the I2C/COM1 signals in addition to these. Consequently you can have both I2C ports or system I2C and COM1 simultaneously. The additional signals have optional pull up resistors. If the clock/calender isn't installed (and the ESP8266) then all four pins are available as digital IO (GP0 to GP3).

The RP2350 is initially loaded with MMBasic using a special connection, after which it's USB port runs in Host mode and connects via the hub. Keyboards, mice and some game controllers are supported (not USB memory sticks or drives).

Audio uses Volhout's excellent passive LC filter followed by a manual volume control and a good quality headphone amplifier.

Ports Used

GP0	I2C SDA	Front panel - with optional pull up resistor
	COM1 TX	Front panel and ESP8266 RX
GP1	I2C SCL	Front panel - with optional pull up resistor
	COM1 RX	Front panel and ESP8266 TX
GP2	I2C2 SDA	System I2C and front panel (with fixed pull up resistor)
GP3	I2C2 SCL	System I2C and front panel (with fixed pull up resistor)
GP4, GP5, GP6, GP7		micro SD card
GP8, GP9		Console serial port
GP10, GP11		PWM audio
GP12 to GP19		Video output
GP20		WS2812B data signa

The internal GPIO header gives the following signals:
3V3
GND
VREF
GP21
GP22
GP26
GP27
GP28

There are some options that are available at build time. Some of these cannot be changed later. Others require the setting or changing of "solder blob"configuration links on the PCB.

Normally a HDMI socket will be installed, but it is possible to fit a compact VGA connector instead. In this case R2-R5 are the "colour" network,R8 & R9 can be low value or shorted out (sync signals). R6 & R7 do nothing and can be omitted. A "solder blob" (JP1) is used to bridge the common "green" signals to the VGA connector. R2 and R5 should be 270R, R3 should be 680R and R4 390R. Use OPTION VGA PINS GP14, GP16 to set up the VGA output.

The headphone amplifier is powered from the 3V3 regulator by default. You can get a higher output from it, albeit by increasing the power supply noise, by changing over the "solder blob" JP2. This changes the supply to the incoming 5V rail. Headphones of 8R impedance or greater are supporrted.

If you prefer a line output instead of headphones then omit the headphone amplifier U6 and fit wire links from GND in to GND out, L in to Lout and R in to R out. The volume control is still operational and the output is isolated from DC.

A power switch is optional. There is sufficient space on the front panel for a miniature toggle switch and a header (H6) is provided to connect one.

Assembly notes

Components have generally been sourced from sellers on AliExpress or ebay unless otherwise stated. This was purely to keep costs down. JLCPCB charge appreciably more for PCBs larger than 100mm x 100mm, which is why the PCB is the size that it is. (A bit of history. This project originally started out as an "all in one" design using a RP2040-Zero on the cheapest board in the cheapest sensible case. Then Raspberry Pi announced the RP2350 and everything changed!)

In general, follow the good practice of fitting the lowest components first then working up in order of height. However I'd recommend fitting the DVI/HDMI connector and micro SD card socket at an early stage.

The difficult part is soldering the HDMI socket. I would recommend using a good gel flux on the mating contacts and, using a fine soldering iron, apply a blob of solder to the tip then wipe the contacts

towards you. It doesn't matter too much if you get small solder bridges. Then, using a larger iron and some fine solder wick, lift off any excess solder.

After that the micro SD card socket should be relatively easy and the resistors no trouble at all! :)

Note that the USB hub,& USB-C converter should be mounted flat to the PCB, their connections being made using short bits of bare wire soldered on both sides. It is advantageous to use double-sided tape (especially for for the USB-C socket). It's up to you whether you socket mount the headphone amplifier.

The enclosure is a Hammond part, number RM2015S. These are quite easy to find and can be remarkably cheap (I got mine from Rapid Electronics in the UK for less than £4 each).

H7 is a 5-way female SIP socket and H8 a 2-way female SIP socket mounted below the D+ and D- sockets. These sockets have "vertical" links, linking the two headers together at D+ and D-. The 5-way D+/D- spckets go directly to the PGA2350 (there are no connections to VDD and ID) and the 2-way sockets go to the USB hub. These links must be installed for normal operation. The links are best made using a small piece of stripboard with male header pins. This makes it less likely to plug them in incorrectly. TP2 and TP3 have to be hard wired to the two marked pads.

Alternatively a cut-down micro USB lead can be used, wired from the USB hub connetions or the H8 pads,

The USB connection to the Pico 2 is via a cut down mini USB lead. Only the data cores are used. Normally these colours are used:

Red	+5V
Black	GND
White	D+
Green	D-

Rarely you may find these colours used:

Orange	+5V
White	GND
Green	D+
Blue	D-

For our purposes power is always supplied via the USB-C connector so only the D+ abd D- wires are connected.

Connecting to a PC to install MMBasic

Power is supplied by connecting the USB-C connector to your PC. A second USB lead is used for programming. First connect the USB lead as follows:

The Gamma can be connected to the PicoMite directly using a micro USB lead, however it is also possible to install H7 and H8 and use a micro USB breakout board plugged into H7. You may find that this is better as it is easier than manoevering the micro USB plug in and out of the Pico.

With the USB hub out of circuit and the USB lead connected hold down BOOTSEL and connect the power lead then realease BOOTSEL.

(If fiddling with the power lead is awkward, try this. Disconnect the USB hub and connect the Pico USB to the PC. Connect the power lead. The Pico will boot up. Press BOOTSEL and hold it down. Press RESET and keep it pressed while you release BOOTSEL, then release RESET.)

Installation of MMBasic then proceeds as usual. You may have to cycle the power after firmware installation.

Don't forget to reconnect the USB hub after programming!

Bill Of Materials

& = See additional notes at end of list

PCB		custom
Enclosure	RM2015S	manufactured by Hammond
Knob		17mm diameter. (max) Push-on or screw type
C1	100uF	electrolytic capacitor
C2	100n	Ceramic cap
C3	22uF	electrolytic capacitor
C4	100n	Ceramic cap
C5	100n	Ceramic cap
C6	100n	Ceramic cap
C7	100n	Ceramic cap
C8	100n	Ceramic cap
C9	10uF	electrolytic capacitor
C10	100n	Ceramic cap
C11	100uF	electrolytic capacitor
C12 &	33nF	capacitor
C13 &	33nF	capacitor
C14 &	2n7	capacitor
C15 &	2n7	capacitor
C16 &	68nF	capacitor
C17 &	68nF	capacitor
C18	1uF	electrolytic capacitor
C19	1uF	electrolytic capacitor
D1 &	WS2812B	programmable LED
FS1 &	RXE010	100mA Polyswitch fuse (or similar)
H1	2x4	0.1in male pin header
H2	2-way	0.1in male pin header + link
H3	2-way	0.1in male pin header
H4	5-way	0.1in male pin header
H5	2x4	0.1in female socket header
H6	2-way	0.1in male pin header + link
H7	5-way	0.1in female SIP socket
H8	2-way	0.1in female SIP socket
JP1	open (DVI)	configuration link
JP2	3V3	configuration link
L1	4.7mH	Epcos B78108S +value
L2	4.7mH	Epcos B78108S +value
R1		There is no R1. Reserved reference.
R2	270R	1206 SMD resistor
R3	270R	1206 SMD resistor
R4	270R	1206 SMD resistor
R5	270R	1206 SMD resistor
R6	270R	1206 SMD resistor
R7	270R	1206 SMD resistor
R8	270R	1206 SMD resistor

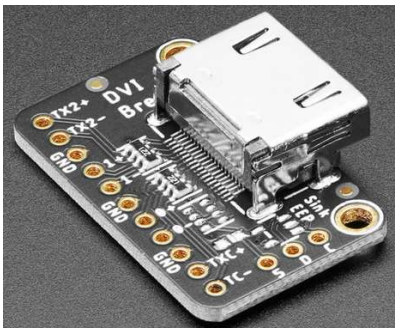
R9	270R	1206 SMD resistor
R10	2R2	resistor
R11	4K7	resistor
R12	4K7	resistor
R13	2R2	resistor
R14	4K7	resistor
R15	4K7	resistor
R16	220R	resistor
R17	220R	resistor
R18	47K	resistor
R19	47K	resistor
R20	10k	1206 SMD resistor
R21	10k	1206 SMD resistor
R22	10k	1206 SMD resistor
R23	10k	1206 SMD resistor
R24	10k	1206 SMD resistor
S1		Horizontal 6x6 tactile switch. Omron B3F-315n, with B32 round cap
SK1	USB-A Vert.	FCI 73725-0110BLF (RS 771-0048)
SK2		Dual horizontal USB-A socket
SK3		HDMI connector
SK4	USB-A Vert.	FCI 73725-0110BLF (RS 771-0048)
SK5 &	TFP09-2-12B	push-push micro SD card socket
SK6		RJ12 6P6C AliExpress - RS 331-6421
SK7 &	550384	Switch Electronics switched jack socket
SK3 Alt &		compact VGA socket (VGA alternative only)
TR1	2N7000	N-channel MOSFET
TR2	2N7000	N-channel MOSFET
U1		USB-C Converter BTE17-06B
U2	LM1117T	3V3 LDO regulator
U3		PicoMite 2
U4		RTC
U5	FE11SX4	USB hub module
U6	LM4881	headphone amplifier module
VR1	10K LOG	ALPS 402146. Rapid Electronics 55-0304

Notes:

C12-C17	These values are also available in the popular green Mylar packages, which can be used successfully here and may be a little cheaper.
D1	Try to get the diffused version if possible. They look a little better. Some of these appear to be "clones". Red and green channels are reversed. This isn't a fault and luckily it's not too bad to work around in software.
FS1	These are rated by their holding current, their tripping current is about twice that. We have a maximum supply current of 500mA so FS1 must not be rated at more than about 250mA.
SK3 Alt	This is a compact version that I have only found from Chinese suppliers.
SK5	This micro SD socket can be replaced by a small breakout module that has the socket mountef "upside down". This includes a capacitor so C9 could be omitted. Note - it Must be mounted "upside down" with the pins on the same side as the socket. No other types can be used here.
SK7	These little jack sockets appear to be in plentiful supply everywhere, some with a silver trim and some in pastel colours! You need to trim off the front two tiny locating pegs as these appeared right on the edge of the PCB. :(
VR1	This has a 6mm shaft diameter with a flat. Similar style devices are available on AE but without the metal bracket. Try not to get a linear one. This is Log or "audio taper".

SK1

SK1 - Version x.yA board



SK5 - Alternative

SK1 VGA Alternative

U1

U5

U6

U7

VR1

Programming connector
for Gamma