

EconoPET 40/8096

(Hardware Revision A)



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"Daddy, can we make a computer?"
—Milo, age 8

Please Don't Sue Me

⚠ Disclaimer

This project is provided "**as is**," without warranty of any kind, express or implied. Use of this project is at your own risk. The authors and contributors are **not liable for any damages, injuries, including serious injury or death, or losses resulting from its use.**

⚠ Safety Warning

Please use caution when working inside Commodore PET/CBM machines. These systems contain **mains voltage** from the power supply, **high voltage** from the CRT, and **sharp metal edges** inside the case. The **CRT is under vacuum** and may **implode** if physically damaged.

Always **unplug the system before opening it** and be aware that the CRT can **retain a deadly high-voltage charge even when unplugged**. If you are not experienced with high-voltage electronics, seek guidance or supervision before proceeding.

Commodore PET/CBM machines **may contain hazardous materials**, including lead-based solder. Please use appropriate personal protective equipment (PPE). **Do not eat, drink, or smoke while working inside the system.**

Soldering involves **very high temperatures, molten metal and potentially harmful fumes**. Always work in a well-ventilated area and wear safety glasses. Handle the soldering iron carefully to avoid burns, keep flammable materials away, and unplug the iron when not in use.

⚠ Handling and Care Guidelines

To protect both the EconoPET and your original PET/CBM mainboard, **handle all boards using proper ESD precautions**. Always work on an ESD-safe surface or wear a grounded wrist strap. Avoid touching circuitry directly and store boards in anti-static bags when not in use.

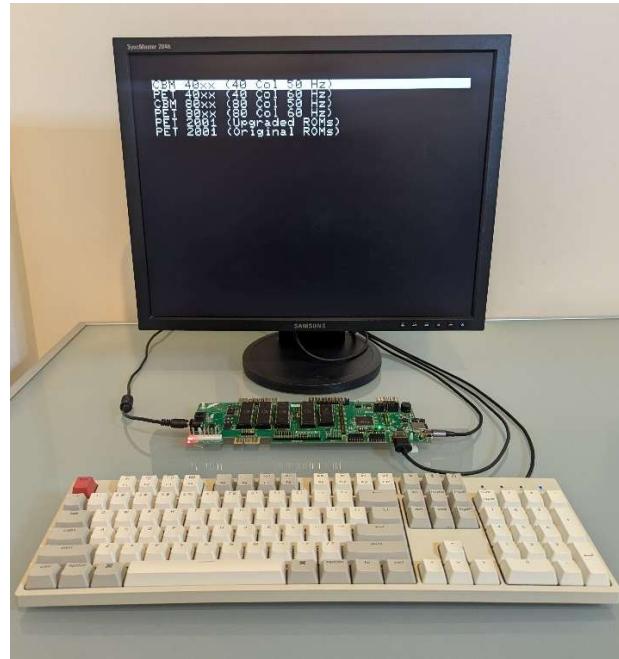
When installing or servicing, hold the board by its edges and **avoid flexing or bending**, as mechanical stress can damage traces and solder joints. **Keep boards away from moisture, dust, direct sunlight, and extreme temperatures** to ensure long-term reliability.

Introduction

The EconoPET 40/8096 is an open hardware recreation of the Commodore PET/CBM mainboard with some modern conveniences. It can be used to repair or upgrade a 2001 / 30xx / 40xx / 80xx series machine. The EconoPET can also be used independently with an HDMI display and USB keyboard.



EconoPET as mainboard replacement



EconoPET with modern peripherals

Functionally, the EconoPET 40/8096 hardware is most similar to the Universal Dynamic PET v2 mainboard with the 64KB Expansion Memory Board installed.

- 6502 CPU clocked at 1 MHz¹
- 96KB RAM (32KB base + 64KB banked expansion)
- Compatible PET I/O using PIA and VIA:
 - IEEE-488 port
 - User Port (with optional 5V supply on pin 2)
 - Two Cassette ports (with configurable device #)
- Native PET video generator:
 - Supports both 40 and 80 columns
 - Supports 9" (15 kHz) and 12" (20 kHz) displays

¹ The EconoPET requires the modern W65C02S. See the Limitations section for more details.

- Programmable CRTC (when using 12" monitor only)
- Support for both US graphics and business keyboard layouts
- Small internal speaker

The EconoPET also adds some modern conveniences. These include:

- Soft-ROM selectable via power-on menu:
 - 2001 original ROMs (BASIC 1, 40 columns, 60 Hz)
 - 2001 upgrade ROMs (BASIC 2, 40 columns, 60 Hz)
 - 40xx (BASIC 4, 40 columns, 50 or 60 Hz)
 - 80xx (BASIC 4, 80 columns, 50 or 60 Hz)
- A menu / reset button (short press = reset, long press = menu)
- 3.5mm Audio Jack (requires amplified speakers)
- Additional HDMI port for use with modern displays (720x480p 60Hz)
- Additional USB-C port for use with modern US keyboard
- Optional 5V power supply on User Port pin 2
- Updateable firmware via microSD card

For troubleshooting (and hackers), the EconoPET breaks out most board signals on convenient pin headers:

- IEEE-488 port (with 5V)
- User port (with 5V)
- Internal and External Cassette ports
- Keyboard-Ex (before BCD decoding with 5V, NMI, and RES)
- System bus (at 3v3 logic level)
- FPGA / MCU breakouts include:
 - FPGA <-> MCU communication (SPI, I2C, etc.)
 - Dual PMOD ports for future expansion
 - JTAG and SWD for programming/debugging

(For more details, refer to the schematics.)

Limitations

Known limitations of the EconoPET mainboard replacement include:

- The EconoPET is **not compatible with expansion boards that connect to CPU socket.** In the EconoPET design, the W65C02S operates at 3v3 logic levels to share the bus with the FPGA.

- Similarly, the EconoPET **does not have a PET compatible bus/memory expansion port**. However, it does expose a 3v3 system bus header for hackers.
- **The CRTC is only programmable when using a 12" monitor.** This is to prevent accidental damage to 9" monitors.
- **Max current for the USB-C port is 5V/900ma.** Consider a powered USB hub if using multiple devices or connecting devices with batteries. (Please don't use the EconoPET as a phone charger.)
- **ROM images are patched.** This is necessary to support hardware combinations not shipped by Commodore, such as 40 column displays with business keyboard.
- Finally, the **EconoPET is not a professionally designed product.** It is an amateur hobby project that seemed worth sharing. Please set expectations accordingly.

Configuration

First read the **Safety Warnings** and **Handling and Care Guidelines** at the beginning of this manual before proceeding. *If you are not experienced with high-voltage electronics, seek guidance or supervision before proceeding.*

Before installing the EconoPET replacement board, there are several important configurations that need to be completed:

- You must assign device numbers to the cassette ports.
- You must select the appropriate video configuration for your monitor.
- You must select the appropriate layout for your keyboard.
- You must choose whether user port pin 2 will provide a video signal or 5V.

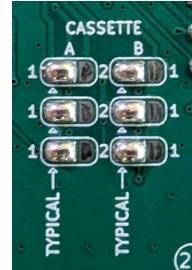
Each of these options is described in the following sections.

Cassette Port Device Number

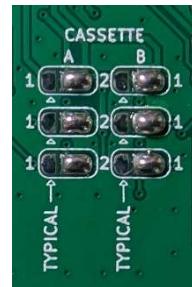
For most CBM/PET models, the cassette port on the back of the machine is assigned to device #1, while the other cassette port is assigned to device #2. The exception is the original PET 2001 model with a built-in Datasette. These machines assign the internal cassette port to device #1, making the built-in Datasette the primary device.

On the EconoPET the cassette ports are assigned to device #1 and #2 using solder jumpers on the back of the PCB.

Typical – Bridge all left and middle solder pads.



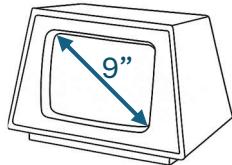
Built-in Datasette – Bridge all right and middle solder pads.



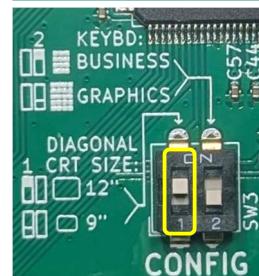
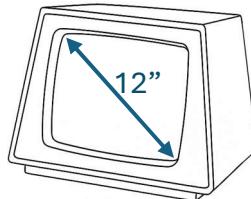
Monitor Type

CBM/PET machines with 9" and 12" monitors use different and incompatible video signals. To select the correct video signal for your setup, use the DIP switch #1 located on the top of the EconoPET PCB.

9" Monitor – Put DIP switch 1 in the down/off position.



12" Monitor – Put DIP switch 1 in the up/on position.



⚠ Important - If when powering on the CBM/PET you see a “bright spot” or “line” or hear a ticking sound, **turn the machine off immediately to prevent damage**.

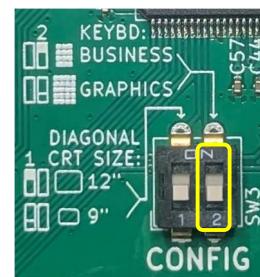
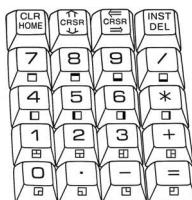
Keyboard Type

The CBM/PET series machines shipped with two different keyboard layouts. The original machines featured the "graphics" keyboard layout. This keyboard layout can be identified by the PETSCII graphics symbols and 16-button numeric keypad. (This includes the cash-register style "chicklet" keyboard on the original 2001 models.)

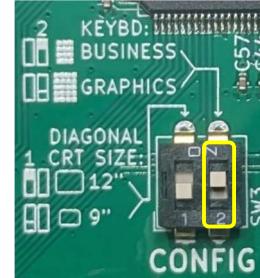
To appeal to business users, Commodore later introduced models with the business keyboard layout with a more familiar typewriter-like keyboard. This keyboard layout can be identified by number keys in the top row and 11-button numeric keypad.

The keyboard matrices of the graphics and business keyboards are incompatible with each other. To select the correct keyboard layout for your setup, use DIP switch #2 located on the top of the EconoPET PCB.

Graphics – Put DIP switch 2 in the down/off position.



Business – Put DIP switch 2 in the up/on position.



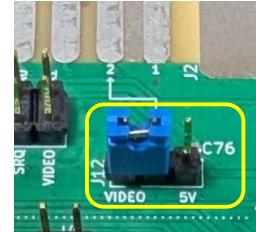
User Port Pin 2

The CBM/PET series machines did not provide a 5V supply at the user port. As a result, many user port peripherals require an adapter that pulls 5V from the cassette port, or a separate power supply.

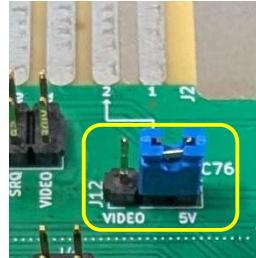
Later Commodore machines, like the VIC-20 and C64, use pin 2 of the user port to supply 5V. Some peripherals designed to work with both the CBM/PET and later machines can optionally receive 5V through pin 2. (Notably, the TexElec SNES adapter does this.)

For convenience, the EconoPET allows you to convert Pin 2 to a 5V supply using a jumper, allowing you to power peripherals directly from the user port.

Normal – Use the jumper shunt to bridge the left and middle pins. This connects pin 2 of the user port to the CBM/PET video signal.



5V – Use the jumper shunt to bridge the right and middle pins. This connects pin 2 of the user port to the +5V supply.



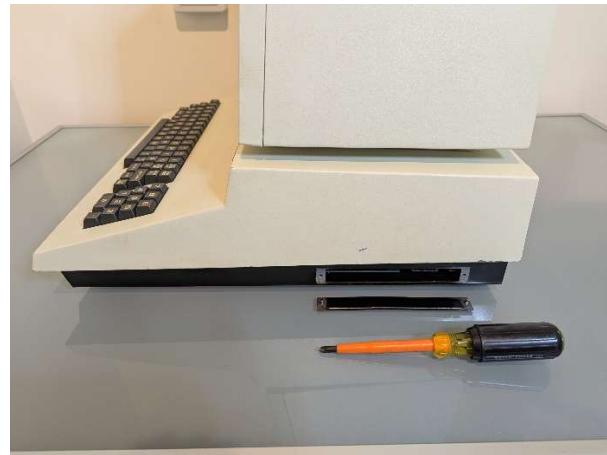
Installation

First read the **Safety Warnings** and **Handling and Care Guidelines** at the beginning of this manual before proceeding. *If you are not experienced with high-voltage electronics, seek guidance or supervision before proceeding.*

Step 1 – Make sure the machine is turned off and unplugged, then disconnect all external peripherals.



Step 2 – Unscrew and remove the expansion cover on the right side of the machine.



Step 3 – With the machine resting on its back, remove the two screws at the front that connect the bottom to the front.



Step 4 – Setting the machine upright, the case should now open like a clamshell.

⚠️ High Voltage Warning

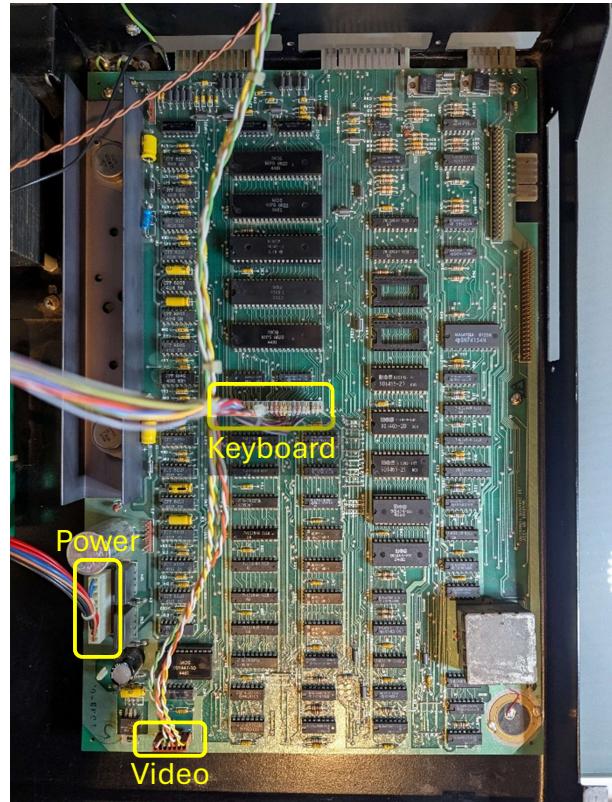
Never insert fingers, tools, or any objects through the hole accessing the monitor compartment. **CRTs (Cathode Ray Tubes) can retain a deadly high-voltage charge even when unplugged.**

If you are not experienced with high-voltage electronics, seek guidance or supervision before proceeding.



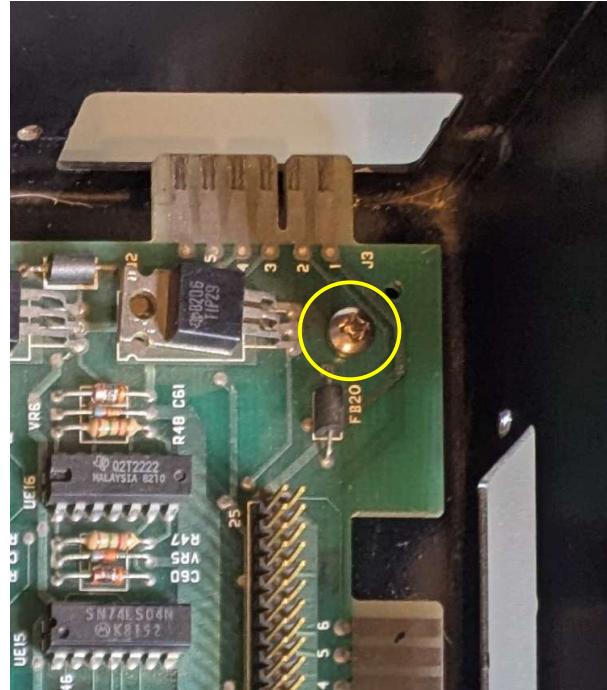
Step 5 – Disconnect the power, keyboard, and video connectors.

Note: The placement of the power, keyboard, and video connections varies between CBM/PET models.



Step 6 – Remove the screws that secure the mainboard to the case. (Save the screws, you'll need them later).

Note: The location and type of mounting hardware varies between CBM/PET models.



Step 7 – In addition to screws, the mainboard may be connected to the case by the tabs of plastics spacers.

Carefully pinch the tab flat with a pair of pliers while gently working the PCB free one hole at a time.



Step 8 – Prepare to install EconoPET

Before installing the EconoPET **check that you have completed the configuration steps** from the Configuration section.

To secure the EconoPET to the case, you will need two of the mounting screws from the original PCB as well as two 11mm nylon spacers to support the front of PCB.

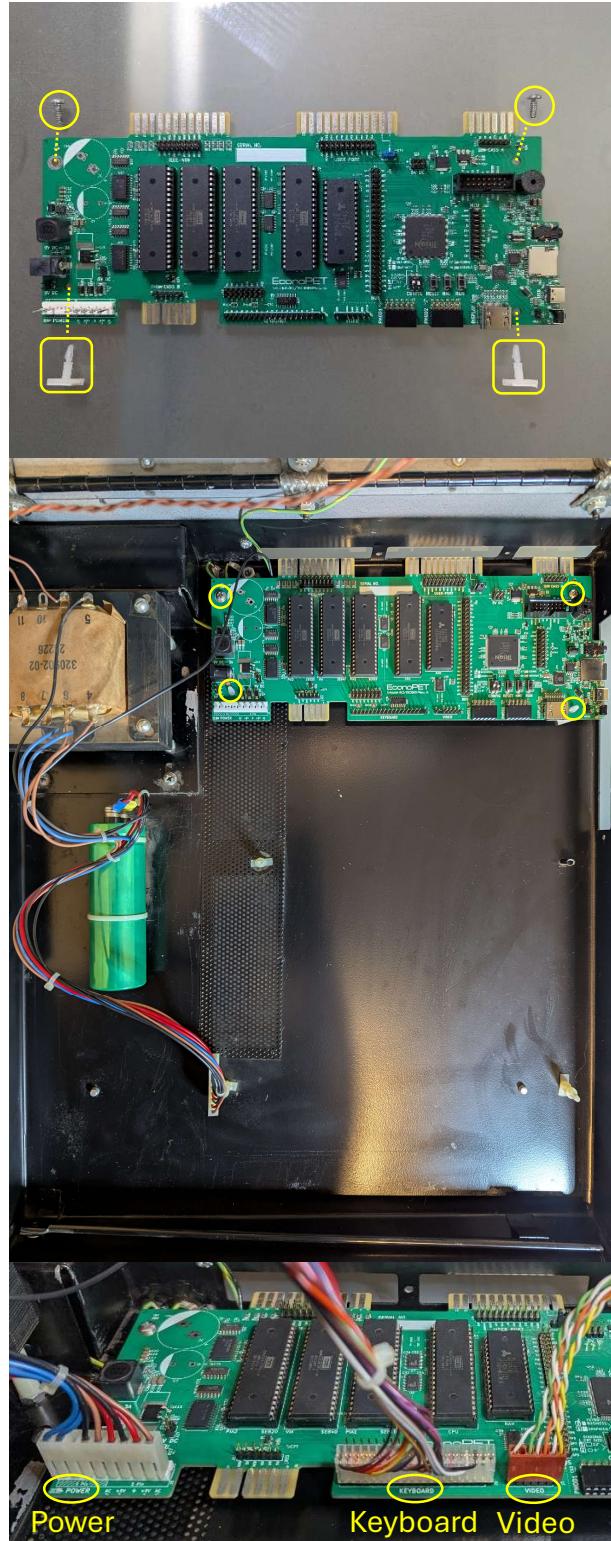
Step 9 – Mount the EconoPET PCB at the back of the case.

- Place the nylon spacers through the mounting holes near the power and HDMI connectors.
- Insert the top left screw through the PCB into the mounting hole, but do not tighten it.
- Rotate the board until the top right screw hole aligns with the mounting hole and insert screw.
- Tighten the two mounting screws until *just* snug. Be gentle and do not overtighten.

Step 10 – Reconnect the Power, Keyboard and Video cables.

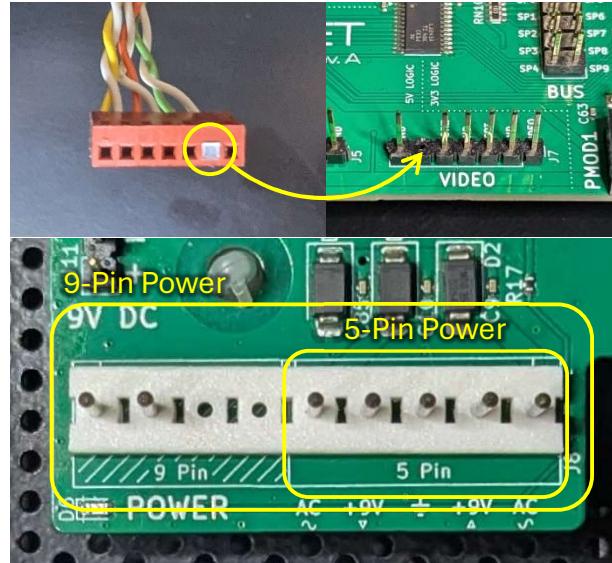
The keyboard, video, and 9-pin power connectors are keyed and can only be connected one way.

If your CBM/PET's power connector has only 5-pins, use the right-most 5-pins on the EconoPET. (The 5-pin connector is



symmetrical, so the orientation does not matter.)

Note: To avoid flexing the PCB when pressing down to insert connectors, gently support the underside of the PCB.



Step 11 – Close the CBM/PET case and reconnect power, leaving other peripherals disconnected for the time being.

Turn the CBM/PET power on. If all goes well, you should see the EconoPET menu.

⚠ Important - If when powering on the CBM/PET you see a “bright spot” or “line” or hear a ticking sound, **turn the machine off immediately to prevent damage.**



Troubleshooting

First read the **Safety Warnings** and **Handling and Care Guidelines** at the beginning of this manual before proceeding. *If you are not experienced with high-voltage electronics, seek guidance or supervision before proceeding.*

If you encounter issues with the EconoPET, the first step in troubleshooting is to **disconnect all peripherals**. This includes anything connected to the IEEE-488 port, User port, Cassette ports, USB-C port, and audio jack. By removing these connections, you can isolate the problem and determine if the issue lies with the EconoPET board or with one of the connected devices. If this does not identify the issue, please follow the steps below.

No Beep with No Video

If you do not hear a friendly 4-note beep from the EconoPET shortly after powering it on, first **ensure nothing is connected to the 3.5mm audio jack** (as this disconnects the internal speaker). If there is still no beep at power, look through the expansion port to observe the green status LED. Normally, this LED lights up for about one second when the machine is powered on and then goes out when the boot menu appears.

Green LED Stuck On: If the green LED remains lit, this typically indicates a problem with the microSD card. Ensure that the microSD card is properly inserted prior to power on. If that does not resolve the problem, reimage or replace your microSD card.

Green LED Does Not Light: If the green LED does not light up at all, this usually means there is a problem with the power supply to the board. Verify that the power supply is properly connected and delivering the correct voltage.

Beep with No Video / Bad Video

If you hear the friendly beep, but do not see the boot menu on the CRT, double check that the CBM/PET video cable is correctly connected and that DIP switch #1 is configured for the correct monitor type (see Monitor Type section).

⚠ Important - If when powering on the CBM/PET you see a “bright spot” or “line” or hear a ticking sound, **turn the machine off immediately to prevent damage**.

Error Message at Power On

If you see an error message at power on, this indicates a problem with the contents of the microSD card. Please reimage or replace your microSD card.



Resources

EconoPET 40/8096 Rev. A | GitHub

<https://dlehenbauer.github.io/econopet/40-8096-A.html>

Commodore PET / CBM Enthusiasts | Facebook

<https://www.facebook.com/groups/214556078753960>

Appendix A: Board Layout

