Garrett's Workshop

GW4201D "RAM2GS II"

RAM Expansion Card for Apple IIgs

User's Guide

RAM2GS II was designed by Zane Kaminski and Garrett Fellers
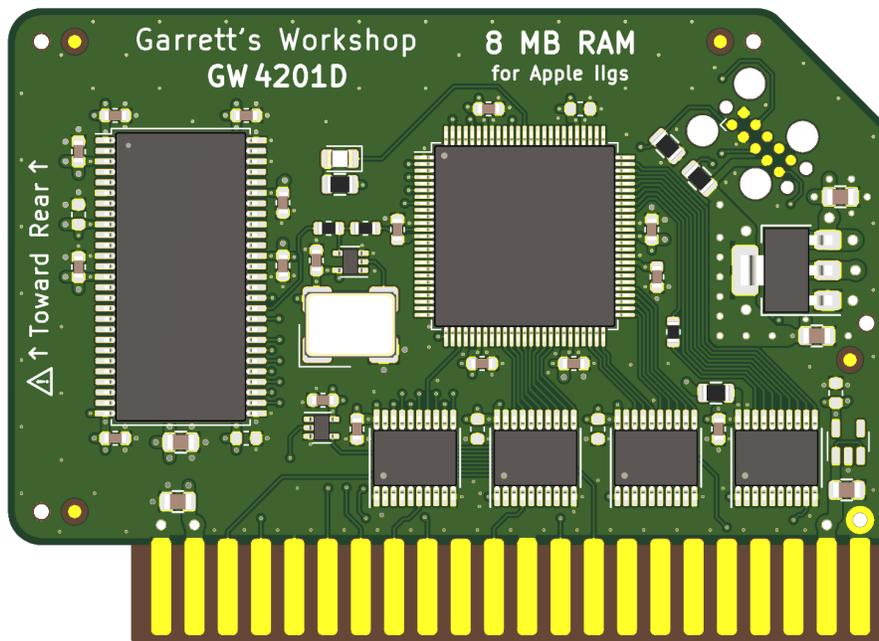
Overview

RAM2GS II (model GW4201D) expands the Apple IIgs's fast memory to 8 MB. The RAM capacity can be reduced to 4 MB using the GWRAM.SYSTEM utility program.

Low-Power, SDRAM-Based Design

Thanks to a modern, low-power design, RAM2GS II uses a maximum of 0.15 watts when idle (30 mA @ 5V) and 0.5W in active use (100mA @ 5V). These are worst-case figures and typical power consumption is much lower. Unlike other IIgs RAM expansion cards, which are built with vintage asynchronous DRAM chips, RAM2GS II uses modern SDRAM. This design allows for low power consumption and improved reliability over other memory cards using 15+ year old chips.

Small Size, Low-Profile

RAM2GS II features a small board outline and is the thinnest Apple IIgs expansion memory card ever produced, at under 4.5 mm thin. Small and thin dimensions improve the mechanical compatibility between RAM2GS II and peripheral cards installed into the IIgs's Slot 7.

Adjustable Capacity, Highly Compatible

The Apple IIgs can utilize up to 8 MB of fast memory, but due to limitations of the Apple IIgs hardware, not all 8 MB is considered "DMA-compatible." Only 4 MB of the 8 MB provided by an expansion RAM card such as the RAM2GS II is DMA-compatible, and peripheral cards which use DMA are not able to access expansion memory beyond 4 MB. RAM2GS II implements an adjustable capacity feature, allowing the user to select between fully DMA-compatible 4 MB capacity, or partially DMA-compatible 8MB capacity. Capacity settings can be set temporarily or saved in nonvolatile memory. The capacity adjustment utility, known as GWRAM.SYSTEM, is available on our website: https://garrettsworkshop.com

Activity LED

All RAM2GS II cards sold since 2023 are equipped with an activity LED. By default, the LED is disabled and will not illuminate. If enabled using the GWRAM.SYSTEM utility, the LED will illuminate during RAM access cycles.

Ecologically Friendly, Gold-Plated PCB

RAM2GS II is built with a lead-free, ENIG gold-plated, 4-layer PCB and is fully EU RoHS-compliant. All units are tested extensively before shipment, and only new parts are used to build RAM2GS II.

Open-Source Design

RAM2GS II's design is fully open-source. The schematics, board layouts, CPLD firmware, and utility software are all freely available for commercial and noncommercial use. To download the design files, visit the Garrett's Workshop GitHub page: https://github.com/garrettsworkshop

Compatibility Notes

8 MB RAM Disk Support on ROM03 Apple IIgs

A defect in the ROM03 firmware of the Apple IIgs prevents initialization of a RAM disk on machines with 8 MB of RAM. It is consequently impossible to create a RAM disk of any size on an 8 MB ROM03 machine without resorting to software beyond the machine's built-in ROM firmware. This issue does not affect ROM01 systems, which are able to initialize the RAM disk correctly on 8 MB systems. GS/OS 6.0.4 works around this issue by directly initializing the RAM disk without calling the ROM. After booting GS/OS, the RAM disk will be correctly initialized for any subsequent operations, even after rebooting into ProDOS. The current suggested workaround for ROM03 users who wish to use the RAM disk is to either boot GS/OS to initialize the RAM disk, or to set the RAM capacity of the RAM2GS II card to 4 MB.

Installation

RAM2GS must be installed into the Apple IIgs memory expansion slot. Do not install RAM2GS into one of the seven expansion card slots. Ensure that RAM2GS is inserted in the correct orientation. Markings on the card indicate the side which must face towards the rear ports and slots of the IIgs.

Changing RAM Capacity

To maximize compatibility, the memory capacity of RAM2GS II can be changed to either 4 megabytes or 8 megabytes. The capacity can be set either temporarily until the Apple IIgs is powered off, or in nonvolatile memory where the setting will persist.

Capacity adjustment is accomplished using the GWRAM.SYSTEM utility program available from our website at https://garrettsworkshop.com. The program is packaged as a 140 kB .po format disk image containing the GWRAM.SYSTEM utility and ProDOS 2.4.2.

After launching the program on an Apple IIgs equipped with a RAM2GS II card, the program presents the following menu:

By pressing the "1" key, the capacity can be set to 4 megabytes until the computer is powered off, and by pressing the "2" key, the capacity can be set to 8 megabytes. By pressing Apple+1 or Apple+2 (open-Apple or closed-Apple), the corresponding setting can be saved in nonvolatile memory as well, so that it is restored on power-up. After changing the capacity, it is required to reboot your Apple IIgs by pressing Ctrl+Apple+Reset. Pressing Ctrl+Reset alone is not sufficient for the IIgs firmware to recognize the capacity change.

Enabling and Disabling Activity LED

For RAM2GS II cards sold in 2023 and after with the onboard activity LED, the LED can be enabled or disabled using the same GWRAM.SYSTEM program used to adjust the RAM capacity. The utility program is available from our website at https://garrettsworkshop.com. The program is packaged as a 140 kB .po format disk image containing the GWRAM.SYSTEM utility and ProDOS 2.4.2.

On RAM2GS II cards with the activity LED, the GWRAM.SYSTEM utility indicates whether the LED is enabled:

```
        -- RAM2GS Capacity Settings --
        Current RAM2GS capacity: 8192 kB

    Select desired memory capacity:
        1. 4 megabytes
        2. 8 megabytes



    LED enabled. Press [L] to disable LED.

    Capacity will be saved until power-off.
    To remember capacity and LED setting in
    nonvolatile memory, press Apple+number.
    Press [Q] to quit without saving.
```

By pressing the "L" key, the activity LED can be toggled on and off. The LED setting is retained until power-off. To store the LED setting in nonvolatile memory, select the desired LED setting with the "L" key and then make a RAM capacity choice by pressing Apple+[number]:

Technical Specifications

Physical Dimensions

Parameter	Value
Height	48.514 mm $\pm$ 0.2 mm
Width	67.183 mm $\pm$ 0.327 mm
Thickness	< 4.5 mm
Weight	< 28 g

Electrical Specifications

Specifications are valid over temperature range of $0\ ^\circ C - 85\ ^\circ C$ and $V_{CC} = 4.5\ V - 5.5\ V$.

Parameter	Value	Conditions
$V_{IH_{min}}$	2.0 V	
$V_{IL_{max}}$	0.8 V	
$V_{OH_{min}}$	3.8 V	$I_{OH} = -8\ mA$
$V_{OL_{max}}$	0.5 V	$I_{OL} = 8\ mA$
Output Slew Rate	< 1.5 V/ns	
$I_{I_{max}}$	$\pm$ 20 µA	$V_{in} = 0\ V - 5.5\ V$
$C_{IO_{max}}$	20 pF	data bus D[7:0]
	10 pF	all other signals
$I_{CC_{max}}$	120 mA	

Information for Developers: Theory of Operation

The operation of RAM2GS II is somewhat different from that of other expansion RAM cards for the Apple IIgs. While other cards are implemented with asynchronous DRAM chips, RAM2GS II uses modern synchronous DRAM (SDRAM).

Since the IIgs's memory expansion slot was designed for use with asynchronous DRAM, additional circuitry on the RAM2GS II card is required to interface the IIgs with SDRAM. There are numerous differences between asynchronous DRAM and SDRAM, but the most significant is that in SDRAM, operation is pipelined over multiple clock cycles. Although SDRAM is a much newer technology than asynchronous DRAM, and therefore much faster, multiple clock cycle "steps" are required to perform an SDRAM access.

No sufficiently fast clock signal is supplied by the Apple IIgs to the memory expansion card, so the RAM2GS II coordinates SDRAM access using an onboard 60 MHz clock oscillator. RAM2GS II, running at 60 MHz, detects memory access and refresh commands given by the Apple IIgs and responds by issuing corresponding SDRAM commands to service the command.

RAM2GS II also supports a proprietary command set which allows software to adjust the RAM capacity and access other features. For more information on this command set, see the RAM2GS and GWRAM.SYSTEM utility program source code on the Garrett's Workshop GitHub page at https://github.com/garrettsworkshop.