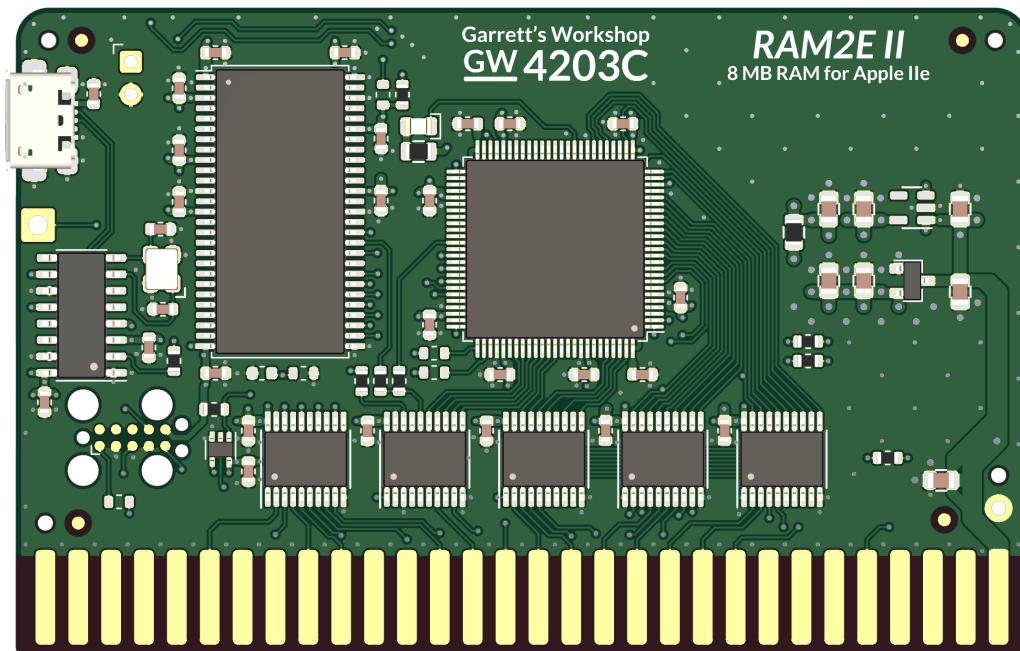# Garrett's Workshop

GW4203C "RAM2E II"

RAMWorks-compatible RAM Expansion Card for Apple IIe

User's Guide

RAM2E II was designed by Zane Kaminski and Garrett Fellers

Overview

RAM2E II (GW4203C) provides the Apple IIe with 8 MB of auxiliary memory and enables double-high-resolution graphics and 80-column text display modes.

Low-Power, SDRAM-Based Design

Thanks to a modern, low-power design, RAM2E II uses only 0.2 watts (40 mA @ 5V) in typical use and 0.5 watts (100 mA @ 5V) in heavy use with an accelerator[1]. In contrast, a typical 80-column card consumes over 1 watt of power, and a 1 MB RAMWorks III consumes 2 watts or more. Unlike other IIe auxiliary memory cards, which are built with vintage asynchronous DRAM chips, RAM2E 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

RAM2E II features a small board outline and is the thinnest Apple IIe auxiliary memory card ever produced, at under 4mm thin. Small and thin dimensions improve the mechanical compatibility between RAM2E II and peripheral cards installed into the IIe's Slot 1.

Adjustable Capacity, Highly Compatible

RAM2E II is highly compatible with existing software that utilizes RAMWorks memory standard. An adjustable capacity feature allows the memory size to be set to 64 kB, 512 kB, 1 MB, 4 MB, 8 MB, or 16 MB[2], improving compatibility with software expecting a particular memory capacity. Capacity settings can be set temporarily or saved in nonvolatile memory. The capacity adjustment utility is available on our website: http://garrettsworkshop.com

Ecologically Friendly, Gold-Plated PCB

RAM2E 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 RAM2E II.

Activity LED

All RAM2E II revision GW4203C cards are equipped with an activity LED. By default, the LED is disabled and will not illuminate. If enabled using the GWRAM utility, the LED will illuminate during RAM access cycles.

USB Firmware Update Capability

RAM2E II revision GW4203C includes USB firmware update capability. The firmware update utility requires a 64-bit Intel or ARM PC running Windows 10 or later. Supported systems also include Windows 10 or later running under Apple Boot Camp or Parallels Desktop on both Intel and ARM Macs.

Open-Source Design

RAM2E 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

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[1] Maximum power consumption measured with quadruple-unrolled auxiliary RAM read/write loop running on FastCHIP IIe accelerator at 16.6 MHz.

[2] 16 MB capacity is only available on units sold in 2021 and later.

Note for Revision A Apple IIe Owners

If you own the uncommon revision A Apple IIe and are interested in RAM2E II, please read this! RAM2E II revision GW4203C is compatible with the rev. A Apple IIe, but special firmware must be installed on the card to disable double high-resolution graphics (DHGR) functionality. Users can switch firmware versions at any time using the onboard USB connector, or we can flash the firmware before sending you the card.

Revision A machines can be identified by their part number "820-0064-A" printed at the top of the motherboard near the slots. If you have a rev. A Apple IIe, we encourage you to contact us before purchasing and we can flash the firmware before shipping your RAM2E unit. However, do note that with the special firmware, RAM2E II will not support the double-high-resolution graphics display mode on revision B and later Apple IIe machines.

The standard firmware, as well as the "DHGR disabled" firmware, required for rev. A Apple IIe machines, are both available on our website: https://garrettsworkshop.com

Note for A2Heaven VGA Scaler Owners

If you own the A2Heaven VGA Scaler and are interested in RAM2E II, please read this! There is a slight incompatibility between RAM2E II and the A2Heaven VGA Scaler as shipped.

As owners of the VGA Scaler will know, a long jumper wire is required to connect the VGA Scaler to the Apple IIe's 14.318 MHz clock signal. This arrangement causes glitches in the 14 MHz clock signal. Instead of attaching the clip for the 14.318 MHZ clock signal to a DIP chip on the Apple IIe's motherboard, clip it on to the dedicated connector pad on the left side of the RAM2E II card. The connector pad is shown in the picture to the right.
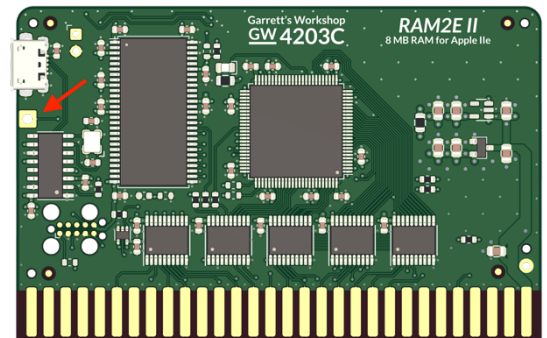
A technical description of the issue with the A2Heaven VGA Scaler follows:

The incompatibility involves the mishandling of the Apple II's 14.318 MHz master clock signal by the VGA Scaler. The VGA Scaler connects to the 14.318 MHz clock through a long wire. The addition to the clock signal line of this wire in combination with the input capacitance of the VGA Scaler's FPGA causes significant distortion to the clock waveform. This distortion includes ringing and long rise times. While the slower response time of the ICs in the Apple IIe makes the Apple itself insensitive to this distortion of the clock signal, a more modern card such as RAM2E II is susceptible to these clock signal artifacts. In our testing, the jumper wire arrangement can cause instability and periodic memory errors in RAM2E II. Adding an additional $50 \ \Omega$ series resistance to the clock wire going to the VGA Scaler minimizes the impact of the wire arrangement and allows the system to run stably. Alternatively, the 14 MHz clock can be buffered with a fast propagation delay buffer, thereby isolating the clock networks and mitigating the clock artifacts.

Installation

RAM2E II must be installed into the Apple IIe auxiliary slot. Do not install the card into one of the seven expansion card slots. Also ensure that RAM2E II is inserted in the correct orientation. Markings on the card indicate the side which must face towards the power supply of the Apple IIe.

Changing RAM Capacity

To maximize compatibility, the memory capacity of RAM2E II can be changed to 64 kilobytes, 512 kilobytes, 1 megabyte, 4 megabytes, or 8 megabytes. The capacity can be set either temporarily until the Apple IIe is powered off, or in nonvolatile memory where the setting will persist.

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

After launching GWRAM on an Apple IIe with a RAM2E II card, the following menu is shown:

For example, by pressing the "1" key, the capacity can be set to 64 kilobytes until the computer is powered off. By pressing Apple+1 (open-Apple or closed-Apple), the 64 kilobyte capacity setting can be saved in nonvolatile memory as well, so that it is restored on power-up.

16 MB Capacity (experimental)

Most RAM2E II cards support an experimental 16 MB capacity setting. With capacity set to 8 MB, the GWRAM utility will display the 16 MB option if available:

```
     -- RAM2E Capacity Settings --
     Current RAM2E capacity: 8192 kB

Select desired memory capacity:

     1. 64 kilobytes
     2. 512 kilobytes
     3. 1 megabyte
     4. 4 megabytes
     5. 8 megabytes
     6. 16 megabytes

LED disabled. Press [L] to enable LED.


Capacity will be saved until power-off.

To remember capacity setting in
nonvolatile memory, press Apple+number.

Press [Q] to quit without saving.
```

Enabling and Disabling Activity LED

The onboard activity LED can be enabled or disabled using the same GWRAM.SYSTEM program which is used to adjust the RAM capacity. The utility program is available from our GitHub at http://garrettsworkshop.github.io/GWRAM.SYSTEM/bin/GWRAM.po.

After launching the GWRAM utility, it displays the current LED enablement status. 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]:

Firmware Update

RAM2E II's firmware should only be updated as necessary to fix bugs or enable/disable DHGR graphics when used with a revision A Apple IIe. The latest firmware is available from our website: http://garrettsworkshop.com

To install the firmware update, make sure your Apple IIe is off and your Windows PC is on. Connect the RAM2E II card to your PC using a microUSB cable. Avoid using USB hubs or extenders and use only passive USB-C-to-A adapters. Install the RAM2E II card into your Apple II, then launch the update program and follow the instructions. If your PC does not have the correct drivers for the update adapter, the update program may request administrator permission to install them. After a firmware update is applied, you must power-cycle your Apple II before using your RAM2E II card.

Technical Specifications

Physical Dimensions

Parameter	Value
Height	50.038 mm $\pm$ 0.2 mm
Width	78.232 mm $\pm$ 0.2 mm
Thickness	< 4 mm
Weight	< 28 g

Electrical Specifications

Specifications are valid over temperature range of $0\ °C - 85\ °C$ 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 MD[7:0], C14M clock signal
	10 pF	all other signals
$I_{CC_{max}}$	120 mA	