CPC Universal 512K Ram Expansion RC-5-Elephant Release Notes

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Summary

This is 512KByte memory expansion card which is suitable for all Amstrad CPC computers.

The card has an MX4 type connector, so requires an expansion board [1] or suitable ribbon cable connection to hook up to the computer.

On the CPC6128 and later computers the board provides a full 512K RAM expansion following the DK'Tronics/Amstrad specification.

Adding RAM to the older CPC464/664 computers is generally much more problematic than with the later models. Many of the card features are specific to these machines.

Like other RAM cards, it provides full DK'Tronics compatibility when used with the CPC464 and CPC664. This is sufficient to run the vast majority of software requiring additional RAM including CP/M Plus, demos such as Phortem and Batman Forever and many games.

The card also provides a unique 'shadow mode' which enables perfect Amstrad CPC6128 video mode C3 operation on CPC464/664 computers[2]. In shadow mode these older machines can now run FutureOS and other software relying on this video mode and which previously would run only on CPC6128s and later machines. Shadow mode can also enable a 464 to run entirely from the card RAM without using base RAM other than for the video display. This may be useful for reviving or at least diagnosing CPC464s with faulty internal RAM.

RAM Card features are controlled by a bank of 4 DIP switches which, used in combination, provide the following controls:

- Overdrive ON or OFF
    - select 464/664 mode (ON) or 6128/Plus mode (OFF)
- IO Port HIGH/LOW
    - maps Memory either to IO port &7Fxx (HIGH) or &7Exx (LOW)
    - allows two cards to work together to provide up to 1MB of RAM
- Shadow Mode ON or OFF [464 mode only]
    - ON provides 'perfect' C3 mode/ OFF provides DK'Tronics C3 mode
    - NB Shadow mode requires 64KB of RAM, reducing the effective capacity of the card to 448KB
- Full or Partial Shadow mode [464 mode only]
    - Partial shadow mode uses shadow memory only for reads from remapped RAM area in mode C3
    - Full shadow mode services all CPU base RAM reads from expansion card RAM

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      - ▪ Base RAM still used for video output via the CRTC
    - o Full shadow may be useful for reviving '464s with faulty base RAM or at least diagnosing related problems but partial shadow is the default.
- Shadow bank HIGH or LOW [464 mode only]
  - o Maps shadow bank to either Bank 3 (low) or Bank 7 (high)
  - o Use Low if using DK'T silicon disk which doesn't do a good check for available RAM
  - o Use High - more generally to have contiguous banks 0-6 available rather than 0-2,4-7

DIP Switch Settings

The new DIP settings and effects are listed below:

Config	DIP 1234	464/Z80 overdrive	Port	Shadow/ Bank	RAM	C3 Mode
0	0000	OFF	7Fxx	None/x	512KB	AMS
1	0001	OFF	7Fxx	None/x	512KB	AMS
2	0010	OFF	7Exx	None/x	512KB	AMS
3	0011	OFF	7Exx	None/x	512KB	AMS
4	0100	ON	7Fxx	None/x	512KB	DK'T
5	0101	ON	7Fxx	None/x	512KB	DK'T
6	0110	ON	7Exx	None/x	512KB	DK'T
7	0111	ON	7Exx	None/x	512KB	DK'T
8	1000	ON	7Fxx	Partial/lo	448KB	AMS
9	1001	ON	7Fxx	Partial/hi	448KB	AMS
10	1010	ON	7Exx	Partial/lo	448KB	AMS
11	1011	ON	7Exx	Partial/hi	448KB	AMS
12	1100	ON	7Fxx	Full/lo	448KB	AMS
13	1101	ON	7Fxx	Full/hi	448KB	AMS
14	1110	ON	7Exx	Full/lo	448KB	AMS
15	1111	ON	7Exx	Full/hi	448KB	AMS

Recommended (and tested) configurations for the RAM card on its own are shown in bold in the table. E.g.

- 0 for CPC6128 providing standard 512KB expansion
- 4 for CPC464 providing standard 512KB expansion with DK'Tronics C3 mode
- 8 for CPC464 providing standard 448KB expansion with Amstrad C3 mode

Specification of other configurations is untested and may be changed in any future revisions.

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Using the RAM card in pairs or with X-MEM/Y-MEM

Two RAM cards can be used together to provide up to 1MByte of expansion on all CPCs. On a CPC6128 it's also possible to use one RAM card together with an X-MEM or Y-MEM to get 1MByte of RAM expansion.

To use two RAM cards together to get a 1MB expansion, one card must be set up to map memory to IO Port &7Fxx and the other to IO Port &7E00.

On a 6128 or later machine the following combinations of cards will all provide 1 MByte of RAM expansion

Slot 1	IO Port	Config	Slot 2	IO Port	Config	Expansion Size	Comment
RAM	&7exx	0010	RAM	&7fxx	0000	1MByte	
Y-MEM	&7exx	-	RAM	&7fxx	0000	1MByte	
RAM	&7exx	0010	X-MEM	&7fxx	-	1MByte	

It's not recommended to mix X-MEM/Y-MEM and the RAM card on a 464 due to the different ways with which these cards deal with the Z80 signal backdriving. Also, on a 464/664 when using two RAM cards together there are some restrictions due to the potential for clashing of overdrive signals when mixing modes. However, it is still possible to get either full 1MByte RAM expansion with DK'Tronics C3 mode, or a 960KByte expansion with perfect Amstrad C3 mode (e.g. for FutureOS) using one of these two settings as appropriate:

Slot 1 Config (IO Port)	Slot 2 Config (IO Port)	Expansion	C3 Mode	Comment
0110 (&7exx)	0000 (&7Fxx)	1MByte	DK'Tronics	Card in slot1 does all overdriving
1010 (&7exx)	0000 (&7Fxx)	960KByte	Amstrad	Card in Slot 1 does all overdriving and provides shadow RAM

Release Notes

RC-5-Elephant is a beta test candidate.

This release is based on RC-4-Dolphin, but fixes an incompatibility with the M4 multi-function card which prevented the latter being used as a ROM board.

The problem was found to be in two parts and related to the unusual tactic of the RAM card in

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driving the RD_B line low to write protect CPC464 base memory when writing to external RAM, rather than the more usual driving of MREQ_B high.

The first issue occurs at the start of the write cycle. The low going edge on the overdriven RD_B signal triggers the M4's interrupt mechanism and the M4 then inspects only IORQ_B and WR_B to determine if a ROM access is occurring. The M4 keeps track internally of whether and which ROMs are enabled, so doesn't query the ROMEN_B line from the gate array for each access. So, although the RD_B pulse doesn't cause a new ROMEN_B to be issued by the gate array, the M4 can still interpret this as a ROM read. When this happens the M4 drives the databus with ROM data at the same time the CPU is writing to external RAM. The fix for this is for the RAM card to blip WR_B low simultaneously with the low going RD_B and hold it low for just the high phase of the clock. This is enough to invalidate the M4 ROM access check. The WR_B signal does not go to the gate array, which instead uses only RD_B as a writeNotRead type signal. So for all RAM accesses on the main board the WR_B signal is a don't care.

The second issue occurs at the end of a memory write cycle. At this point the RAM card is still driving RD_B low, but it is possible for this signal to glitch when the address bus changes. Again, the gate array and hardware ROM cards are unaffected by a glitch on RD_B but the M4 interrupt can be triggered by the low going glitch on RD_B. At this time WR_B and IORQ_B are usually both high and so again the M4 can attempt to drive the databus as if a ROM access were occurring. The fix for this is to prevent the glitch and this has been done by latching the signal which indicates an expansion RAM access inside the CPLD.

Other changes in this update are related to use of the card in pairs or with X-Mem/Y-Mem on a 6128.

Using IO Port &7Exx is no longer disabled when the card in is shadow mode, but care needs to be taken picking suitable modes for pairs of cards as described above.

Overdriving signals are no longer disabled when the card is currently not selected. Again, take care in picking suitable modes for pairs of cards but this change allows one card to operate in overdrive mode and provide shadow memory while the other is run in '6128' mode and so provide the maximum of 960KB expansion and still have the perfect Amstrad C3 mode.

Finally, one additional change to the schematic relates to the values of pull-up and pull-down resistors on the DIP pins. Originally the pulldown value was 47Kohms and pullup 10Kohms. This would normally be sufficient to provide good logic 0 (0V) and logic 1 (~4.1V) on the shared GPIOs which are latched on startup. However, the CPLD pins themselves have an internal pullup of at least 50Kohm (usually more) which can't be overridden. This means that in practice the pull down on the PCB is not sufficient to guarantee the CPLD reading a valid '0' level. There is no change to the PCB to address this but new boards will be fitted with a 6K8 pull down and external 3K3 pullup. These provide much better logic levels to the CPLD at the expense of some additional operating current (of the order of 1mA per shared pin).

Testing Results

RAM cards have been tested on different combinations of CPC main boards and components including

operating current (of the order of 1mA per shared pin).

RAM cards have been tested on different combinations of CPC main boards and components including

- 3 CPC 464 main board types on 6 different CPC464 machines
- 1 CPC 6128 main board type on 2 different CPC6128 machines
- Type 0,1 and 2 CRTCs
- Z80 CPUs from Zilog, NEC, SGS-Thomson and Sharp as well as the UA880 CPU used in the KC Compact
- both 40010 and 40007 gate arrays

Cards have been tested using different expansion boards shared with other peripherals

- Mother X4, Revaldinho Backplane, LambdaBoard expansions cards
- SixROM, FourROM, X-MEM, ROMBO REDUX ROM boards
- DDI-3 SD Card and DDI-1 Disk interfaces
- M4 multi-function card

A standard test suite has been used made up of

- Memory test programs including Duke's 512kb test and Gerald's memory test ROM (for the full shadow mode) and others
- Application tests: DK'Tronics silicon disk and bank switching software
- Operating systems: FutureOS and CP/M Plus
- Demos: Phortem and Batman Forever[4]
- Games: including Zaptball, Prehistorik II, R-Type, Gryzor, Robocop and others

All tests have been run either using power from the CPC +5V edge connector pin or a 4.5V bench supply.

Selected tests have been swept across voltage from 4.35V to 5.5V.

Full Test results are visible on Google Sheets here (see the RC-5-Elephant Tab)

https://docs.google.com/spreadsheets/d/11wxhIDWy2wNmKSXZwBqjqQjMN2nNZDtILEvy6_GrM8I/edit?usp=sharing

Footnotes

[1] Compatible expansion boards include ToTO's Mother X3, Revaldinho CPC Backplane, LambdaMikel LambdaBoard.
[2] When using shadow mode the card size is effectively reduced to 448KBytes
[3] Shadow mode cannot presently be used when deplying pairs of RAM cards or in conjunction with other RAM cards.
[4] The Batman Forever demo does not run on CTRC Type 2 machines

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