

# 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 6128 and later computers the board provides a full 512K RAM expansion following the DK'Tronics/Amstrad specification.

Adding RAM to the older 464/664 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 CPC464/664 computers. 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 6128s 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 1MB of RAM
    - Valid only when shadow mode is not being used - in shadow mode the IO port is fixed at &7Fxx
- Shadow Mode ON or OFF [464 mode only]
  - works only in 464 mode
  - ON provides 'perfect' C3 mode / OFF provides DK'Tronics C3 mode

- ON provides perfect C3 mode/ OFF provides DK'TROMS 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 is the default - use shadow only for reads from remapped RAM area in mode C3
  - Full shadow services all CPU base RAM reads from expansion card RAM
    - Base RAM still used for video output via the CRTIC
  - Full shadow may be useful for reviving '464s with faulty base RAM or at least diagnosing related problems.
  - Full shadow mode tested using Gerald's RAM test ROM
- Shadow bank HIGH or LOW [464 mode only]
  - Maps shadow bank to either Bank 3 (low) or Bank 7 (high)
  - Use Low if using DK'T silicon disk which doesn't do a good check for available RAM
  - Use High - maybe more generally useful 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 and are the same as the previous RC-4-Dolphin release candidate.

| Config    | DIP 1234    | 464/Z80 overdrive | Port        | Shadow/ Bank      | Compatibility X-MEM | Y-MEM      | RAM          | C3 Mode     |
|-----------|-------------|-------------------|-------------|-------------------|---------------------|------------|--------------|-------------|
| <b>0</b>  | <b>0000</b> | <b>OFF</b>        | <b>7Fxx</b> | <b>None/x</b>     | <b>No</b>           | <b>Yes</b> | <b>512KB</b> | <b>AMS</b>  |
| 1         | 0001        | OFF               | 7Fxx        | None/x            | No                  | Yes        | 512KB        | AMS         |
| <b>2</b>  | <b>0010</b> | <b>OFF</b>        | <b>7Exx</b> | <b>None/x</b>     | <b>Yes</b>          | <b>No</b>  | <b>512KB</b> | <b>AMS</b>  |
| 3         | 0011        | OFF               | 7Exx        | None/x            | Yes                 | No         | 512KB        | AMS         |
| <b>4</b>  | <b>0100</b> | <b>ON</b>         | <b>7Fxx</b> | <b>None/x</b>     | <b>No</b>           | <b>Yes</b> | <b>512KB</b> | <b>DK'T</b> |
| 5         | 0101        | ON                | 7Fxx        | None/x            | No                  | Yes        | 512KB        | DK'T        |
| <b>6</b>  | <b>0110</b> | <b>ON</b>         | <b>7Exx</b> | <b>None/x</b>     | <b>Yes</b>          | <b>No</b>  | <b>512KB</b> | <b>DK'T</b> |
| 7         | 0111        | ON                | 7Exx        | None/x            | Yes                 | No         | 512KB        | DK'T        |
| <b>8</b>  | <b>1000</b> | <b>ON</b>         | <b>7Fxx</b> | <b>Partial/lo</b> | <b>No</b>           | <b>No</b>  | <b>448KB</b> | <b>AMS</b>  |
| <b>9</b>  | <b>1001</b> | <b>ON</b>         | <b>7Fxx</b> | <b>Partial/hi</b> | <b>No</b>           | <b>No</b>  | <b>448KB</b> | <b>AMS</b>  |
| 10        | 1010        | ON                | 7Fxx        | Partial/lo        | No                  | No         | 448KB        | AMS         |
| 11        | 1011        | ON                | 7Fxx        | Partial/hi        | No                  | No         | 448KB        | AMS         |
| <b>12</b> | <b>1100</b> | <b>ON</b>         | <b>7Fxx</b> | <b>Full/lo</b>    | <b>No</b>           | <b>No</b>  | <b>448KB</b> | <b>AMS</b>  |
| <b>13</b> | <b>1101</b> | <b>ON</b>         | <b>7Fxx</b> | <b>Full/hi</b>    | <b>No</b>           | <b>No</b>  | <b>448KB</b> | <b>AMS</b>  |
| 14        | 1110        | ON                | 7Fxx        | Full/lo           | No                  | No         | 448KB        | AMS         |
| 15        | 1111        | ON                | 7Fxx        | Full/hi           | No                  | No         | 448KB        | AMS         |

|    |      |      |       |       |       |       |       |       |
|----|------|------|-------|-------|-------|-------|-------|-------|
| -- | ---- | ---- | ----- | ----- | ----- | ----- | ----- | ----- |
|----|------|------|-------|-------|-------|-------|-------|-------|

In the table above, the compatibility columns show the settings which can be used with an X-MEM or Y-MEM to get a total of 1MB RAM expansion.

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.

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

To use two RAM card in pairs 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.

When using a RAM card with X-MEM or Y-MEM the RAM card needs to have DIP switches set so that the memory IO port don't clash.

- X-MEM maps memory to IO port &7Fxx so set the RAM card DIP to select &7Exx
- Y-MEM maps memory to IO port &7exx so set the RAM card DIP to select &7Fxx

Shadow memory modes are not supported when using cards in pairs or with other RAM cards.

## 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 it being used as a ROM board.

The problem was found to be twofold and related to the unusual tactic of the RAM card in 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. It is ironic that driving WR\_B low is now used to write protect internal memory, but in fact 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.

No other significant changes have been made in this release.

## Testing Results

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](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 deploying pairs of RAM cards or in conjunction with other RAM cards.

[4] The Batman Forever demo does not run on CTRC Type 2 machines

