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*      LUCAS NASCOM      *
*                        *
*  256K RAM MEMORY CARD  *
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1. INTRODUCTION

The 256K RAM card is supplied with either 64K or 256K of memory ready fitted. The card is suitable for use with any Nascom 2 or 3 computer, or the Lucas LX computer. It is **not** suitable for use with the Nascom 1 computer which requires the use of an extra memory control line. When fitted it allows the user access to the maximum amount of directly addressable user memory in the computer system. This will normally be limited to 60K due to the presence of the NAS-SYS or CP/M operating system and the video display and system workspace memory. In machines fitted with Nascom ROM BASIC a further 8K is unavailable when operating with NAS-SYS, and the NAS-DOS disc operating system occupies an additional 4K of EPROM memory.

Although the internal construction of the Z80 microprocessor only allows the direct addressing of 64K of memory, the 256K RAM card employs additional facilities which enable the switching of different blocks of memory into this directly addressable space. Using these facilites with several 256K memory cards allows up to 2Mbytes of memory to be addressed by the computer.

The 256K RAM card is simply installed in your computer by plugging it into any one of the 77-way connector fitted on the backplane of the computer. This will give immediate access to 64K of memory, although some of this may be occupied by system functions as described previously. When using the 256K version of the card the availability of the extra memory to the user depends on the programs used. Normal languages (BASIC, Pascal etc) do not have any facilities for accessing memory outside the normal 64K space, and therefore the additional memory will normally need to be controlled by user machine code programs.

The most common method of using additional memory outside the 64K direct addressing space is to use it for data storage. CP/M users can make use of a 'virtual disc' facility. This enables the additional memory to be treated as if it were a disc in which programs and/or data are stored, but giving extremely fast access. This technique can produce great improvements in the speed of operation of programs such as Wordstar, or data base management programs, which make extensive use of discs. The support package to allow use of virtual discs with CP/M is available free of charge from Nascom Microcomputers, but you must quote both your registered CP/M and RAM board serial numbers and supply a blank disc if you wish to take advantage of this offer.

This manual describes how to install your 256K RAM card and how to configure it for more specialised applications. Instructions are given on the method of controlling access to the additional memory from your own programs, and in its use as a 'virtual disc' from CP/M.

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2. INSTALLATION

Carefully unpack the 256K RAM card and inspect it for damage in transit. If there are any signs of damage you should contact your supplier immediately - do not attempt to use the card. The card is supplied fully tested.

If you are only going to use this one RAM card in your system you need only to fit the card into the card frame and make sure that it is fully pushed home into the 77-way edge connector. The card can be fitted in any position in the system. Note that it should be installed with the components in the same orientation as other cards (components uppermost in Nascom 3's or to the left, as seen from the rear, in the Lucas LX). The edge connector is keyed to ensure that the card is fitted the correct way round. Do not use force in fitting the card - if it will not go in ensure that the key and keyway are correctly aligned.

If you are intending to use more than the one memory card you should refer to Section 3 of this manual, which describes the setting of the linkblocks on the card for different addressing options.

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3. ADDRESSING OPTIONS

This section describes how you can select the mode of operation of your RAM card by means of links on the board.

Remember, if you have only the one memory board in your system you do not need to set any links - just plug in the board as described in section 2 and use it.

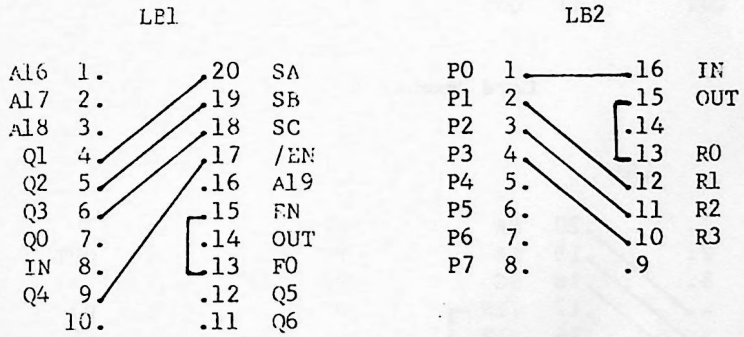
3.1 SETTING ADDRESS LINKS ON THE 256K RAM CARD

There are two link blocks fitted to this card which are used in selecting the addressing in a system using several memory boards. These link blocks are marked LB1 and LB2. When soldering links on these blocks we recommend that you leave them in their sockets - this avoids the header softening with the heat and the pins being displaced.

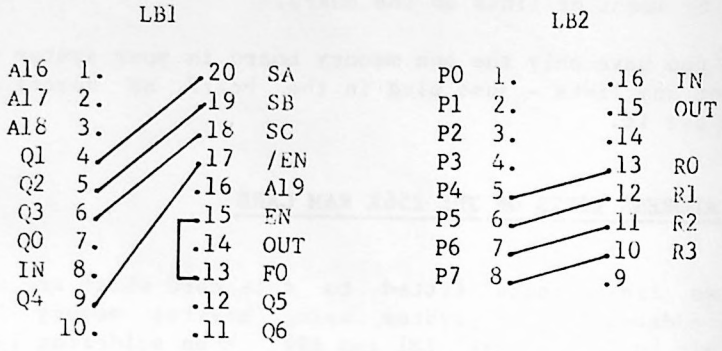
Each RAM card can hold up to four rows of 8 off RAM chips. These rows are referred to as R0 to R4. When setting the links on LB1 **do not** enable rows which are not fitted with RAM chips.

The standard configuration for fitting up to four of the 256K RAM cards is as shown below - note that all cards are supplied wired as for card 1 as standard:

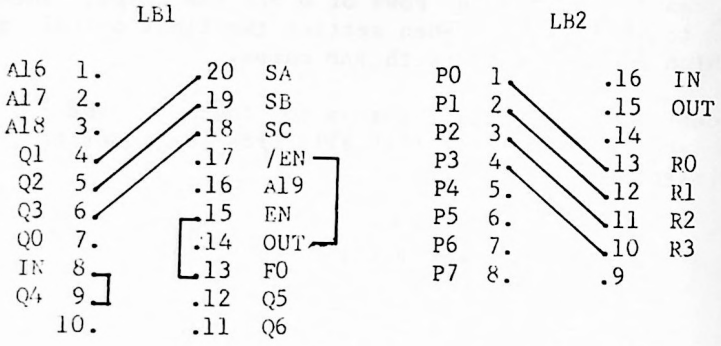
Card Number 1



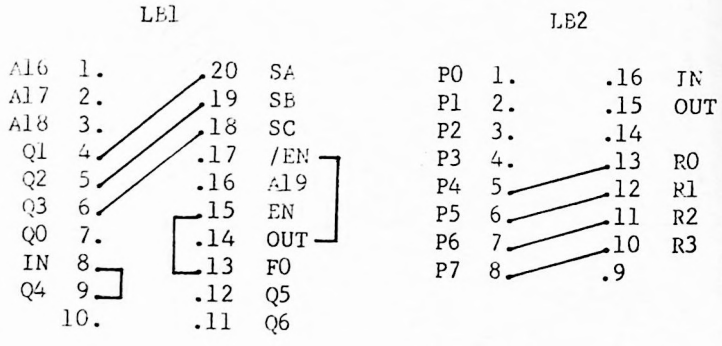
Card Number 2



Card Number 3



Card Number 4



3.2 USE WITH EXISTING RAM MEMORY CARDS

3.2.1 Nascom RAM A Card

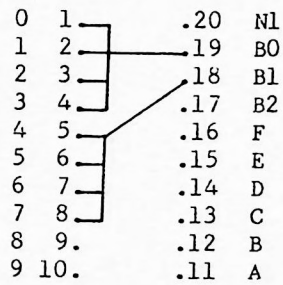
The Nascom RAM A card cannot be used as it does not incorporate any paging control.

3.2.2 Nascom RAM B Card

The RAM B card must be fitted with the page mode kit, to allow it to be paged in and out of memory. It should be enabled for a page other than zero, so that when the system is re-set only the 256K RAM card is selected.

When using the 64K page mode (in which case the controlling software must reside in the priority memory on the main computer board) the 256K RAM cards should be paged out by outputting a non-existent page number on port 0FE (see section 4 for further details of paging control from programs). Now output the page number of the RAM B card on port 0FF, and the RAM B card will be paged into the memory map.

When using the more common 32K mode you can use 32K of the RAM B card only. This may be selected for either the top or bottom 32K, but this must be selected in hardware by links, rather than in software as in the 256K RAM cards. For example, to have 32K of the RAM B card selected into the lower 32K of the memory map link SK1 on the RAM B card as shown below:



If the card is to be paged into the top 32K of address space the address pins 8 - F should be used instead of 0 - 7.

Page select should be set to 3.

To select this page of 32K first switch out the 256K RAM cards - for example (assuming there is less than the full 1Mbyte of memory!):

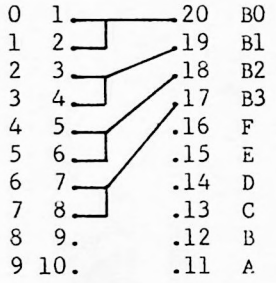
```
LD A,0FF        ;Select non-existent area
OUT (0FE),A
LD A,088        ;Page mode select RAM B
OUT (0FF),A     ;in page 3
```

The reverse procedure would be followed in paging out the RAM B -

```
LD A,00         ;Page zero to disable RAM B
OUT (0FF),A
LD A,0C0        ;Select first page of 256K
OUT (0FE),A
```

3.2.3 Gemini G802 RAM Card

This card is used in a similar way to the Nascom RAM B card, as described above. However, as this is a 64K card it is possible to use both blocks of 32K in the 32K mode, although this requires a modification to the G802 card. First locate the plated through hole by pin 5 of IC53. Either drill through this plated through hole or cut the track running from it **on the top of the board.** Now connect a wire from the PG SELECT switch pin 2 and the above plated through hole on the **underside** of the board. You can then use the software method described above for paging out the 256K RAM and paging in the first 32K of the G802 card. the second 32K of the G802 is paged in by outputting the code 0C((instead of 088) to port 0FF. Note that the header of the G802 card should be wired as shown below (for paging into the lower 32K - use 8 - F in place of 0 - 7 for paging into the upper 32K).



The page should again be set to 3.

4. APPLICATION

When fitted with 64K of memory the memory card can be directly addressed by the computer, and gives the user access to a full 64K of memory on the computer. Note that the operating system, work space and video memory are also contained in this 64K, so that in practice a maximum of 60K of memory is available under CP/M, or usually 48K when using the NAS-DOS operating system.

The installation of additional memory, up to 256K on a single card, opens up further possibilities. Since the Z80 microprocessor used in the computer can only address directly 64K of memory it is **not** possible to write programs which, with their associated data, exceed a length of 64K without including special control facilities. Two methods of accessing the additional memory are normally used.

1. Memory paging or memory mapping

This involves the use of machine code routines to switch different sections of the total memory into the directly addressable area of 64K. These routines will need to be written by the user, and called at appropriate points in the program. Although it is potentially possible to include automatic page mode control from a high level language interpreter or compiler (eg BASIC) this has not yet been implemented. Information on accessing the paging control is given in section 4.1 below.

2. Virtual disc operation

This method treats the additional memory beyond the directly addressable 64K area as an external storage device - a virtual disc. Data and programs are read from, and written to, this memory using the same instructions as would be used to access a disc. The operating system of the computer is modified so that when the selected disc drive number of the virtual disc is specified it performs the appropriate actions to the extended memory area rather than to a normal disc. The advantage over using a real disc is the much faster speed of access to this memory. Under the CP/M operating system a suitable procedure to allow inclusion of this virtual disc operation into the normal CP/M system is available - see section 4.2 of this manual.

4.1 PROGRAM CONTROL OF PAGING

To control the paging of memory from a program a number of points should be born in mind:

1. The program/routine which performs the paging must **not** page itself out - if it did do this there would be no way to continue operation after the page switching instruction is issued.

2. The stack area used by the computer as workspace should generally not be switched by the paging operation as this will result in the loss of subroutine return addresses, registers which were stored

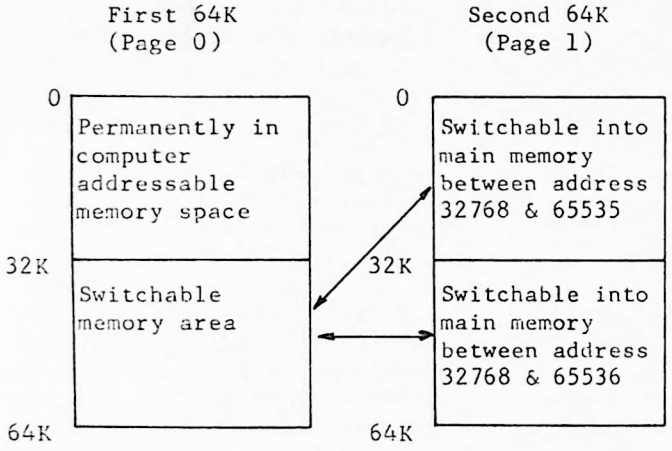
temporarily etc.

Paging of the memory is achieved by sending appropriate page control instructions to the output port which controls page selection - port FE. The pages selected will be specified by the data output to this port. The pages selected are fixed by the 8 data bits sent to the port as follows:

Bit	Function
0	Select upper (1) or lower (0) 32K block from 64K*
1	
2	
3	Selects the 64K page (bit 5 not used in 32K mode)
4	
5	
6	Select upper (1) or lower (0) 32K as permanent*
7	Select 32K (1) or 64K (0) page mode

* Bits 0 and 6 are only significant if 32K page mode is selected.

Suppose we wish to run with memory switched as shown below:



We retain the bottom 32K of memory constant and switch into the top 32K of directly addressable space different blocks of memory out of the remaining memory on the card.

Thus if you wish to swap the top 32K of memory with the next 32K of memory you would use the following instructions (in assembly language):

```
LD A,082      ;82 is the data value to select
OUT (0FE),A   ;next page - output to control port
```

Bit 0 = 0 - Lower 32K block from 64K to be switched in
Bit 1 = 1 - From the first 64K page after the base 64K
Bit 2 - 5 = 0 - First of the 64K blocks
Bit 6 = 0 - Bottom 32K permanent (top 32K switched)
Bit 7 = 1 - 32K page mode

ie 082 hex as the control word.

We could then select the next 32K page and place this in the top 32K of the memory map by outputting the data value 83 hex - as above, but this time the top half of the first 64K block (bit 0 = 1).

You could then return to the normal (zero) page as follows:

```
LD A,081      ;Normal zero page
OUT (0FE),A   ;Send to control port
```

Other pages can be switched in and out of the directly addressable memory space in the same way.

4.2 USE UNDER CP/M

The most convenient way to use additional memory (beyond the basic 64K) on the RAM card with CP/M is to treat this memory as a disc drive - a virtual disc. This means that the RAM is handled as a data and program storage device using program and command instructions which would normally be used with disc files. Support for operation of this additional memory as a virtual disc is provided from CP/M using a special support package. This is available from your dealer, or Nascom Microcomputers, free of charge provided that you supply a disc on which to load the file and specify the serial number of you RAM card and registered serial number of CP/M.

The use of the memory as a virtual disc is described in the manual 'Operation of Virtual Disc Software with CP/M' supplied separately with this manual.

Using the memory card as a virtual disc gives enormous speed increases in applications where substantial amounts of disc access are performed - the Wordstar word processor, or database management programs, for example.

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5. METHOD OF OPERATION

The memory card allows 64K of RAM memory on the card be to be addressed directly by the Z80 processor. This 64K of RAM can be selected from a maximum of 256K of memory components on the card, and up to four cards can be used in a system. The control of which blocks of memory are to be addressed is achieved via IC46, which can be addressed as output port 0FE by the processor. This leaves the existing port 0FF used in previous Nascom paging systems unaffected. IC46 (a 74LS273 8-bit latch) will produce a code representing which block of memory is to be enabled, and this is further decoded by IC47, a 74LS138 3 to 8 line decoder. LB1 is used to link the outputs Q1, Q2 and Q3 from IC46 to SA, SB and SC (select A, B and C) on IC47, and further decoding is provided by Q4 and Q5 which are linked to EN and /EN on IC47. Either Q4 or Q5 can be inverted by linking through IN and OUT on LB1). The net result is a 5-bit decode, which on pages of 64K would give control of up to 2 Megabytes of memory. The 8 page selects available simultaneously on an individual card from IC47 are provided at LB2 (P0 to P7). P0 to P3 are linked to select the RAM blocks R0 to R3 on the first of each pair of card, and P4 to P7 select R0 to R3 on the second.

The scheme described assumes the switching of blocks of 64K of memory. The controlling program, which must not, of course, itself be switched would reside in memory on the main computer board, which is given priority over memory on any other cards. This is normally not a particularly convenient method of operation, since most systems do not use the memory on the main computer board. The preferred method is therefore to use a scheme of switching blocks of 32K of memory. Either the upper or lower 32K of memory will be left permanently paged into the system, and will contain the control program, while the other 32K directly addressed by the processor can be selected from any 32K block from any 64K page on a memory card.

The block of 32K to be paged in is selected by outputing the appropriate code to port 0FE, and hence IC46. The use of 32K or 64K paging can be controlled by setting the appropriate bits on IC46. Bit 7 reset (0) selects 64K paging, while setting that bit to 1 selects 32K paging. Bit 6 reset (0) selects the lower 32K of page 0 as being permanently in memory, or if set to 1 it selects the top 32K as being permanently resident. Bits 1 to 4 are used to select which of the 64K pages is to be addressed, and bit 0 specifies whether it is the upper or lower 32K of that 64K which is paged in. The status of bits 0 and 6 are only significant if 32K paging has been selected (ie bit 7 = 1).

Using this 32K paging method up to 1Mbyte of memory can be controlled. These signals are routed through the link blocks LB1 and LB2. When bit 7 of IC46 is set 32K paging is operative. If bit 6 is 0 whenever the processor accesses the lower 32K of memory (addresses 00000 - 07FFF) pin F0 ('Force page 0') on LB1 goes low and this is connected to EN so that all the pages of RAM are disabled. This same signal is then used to enable page 0. The P0 select on LB2 is ANDed with F0 by diverting it through IN and OUT. If bit 6 is set to 1 then F0 will go low when addresses 08000 to 0FFFF are accessed. Bits 0 and 6 are XORed, ORed and ANDed as required in 32K page mode in order to invert

the A15 address line if required so that the upper 32K of a page can be paged into the lower 32K of directly addressable memory and vice versa.

The significance of the control bits output to the port 0FE is fully described in section 4.1 of this manual.

6. UPGRADING A RAM CARD

Cards fitted with less than the full 256K of RAM can readily be upgraded by installing the additional memory components and associated decoupling capacitors. These are 64k dynamic RAM's of the 4164/4864/4564 type - **not Texas 256 cycle refresh or pin 1 refresh types.** The devices should be 200nS or faster. These components should be soldered carefully into the spare rows of the board, starting with the rows nearest the edge connector. They must then be enabled by installing the necessary additional links on LB2 - see section 4 of this manual. Your dealer will be pleased to carry out this work for you at a small charge if you do not wish to undertake the job yourself.