TI CC-40

16 x 32K ROM Cartridge

or

16 x 32K RAM Cartridge

USER GUIDE

Version 1.2
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References

1. Texas Instruments CC-40 8K Constant Memory RAM Manual
   http://www.datamath.org/Graphing/CC-40_RAM8K.htm

2. https://ftp.whtech.com/#CC40 - load the *CC-40 Release.zip*

3. Microchip FLASH SST39SF010A
   https://ww1.microchip.com/downloads/en/DeviceDoc/20005022C.pdf

4. Alliance RAM AS6C1008-55TIN
   https://www.alliancememory.com/wp-content/uploads/pdf/AS6C1008feb2007.pdf

5. MT DAR Video provides an example of programming the FLASH in a similar design.
   https://www.youtube.com/watch?v=CejyLsI0HIw

Welcome to the CC-40 Cartridge User Guide

Introduction

The TI CC-40 has a cartridge port that can accommodate either a plug-in cartridge with pre-loaded applications in a ROM (e.g., Finance, Statistics, etc.), or RAM cartridges that can have 8K bytes or 16K bytes of constant memory. Unfortunately, the TI CC-40 was not well supported by TI during its lifetime thus making the ROM or RAM cartridges hard to obtain. A new memory cartridge is described in this User Guide that offers a unique approach to providing ROM or RAM based storage.

The new memory cartridge can function as either a ROM or RAM cartridge with the simple slide of a switch. When selected, the ROM section has 16 x 32K byte pages available, each page can be selected by using the rotary HEX switch. When the RAM is selected, this can function as either a 16K byte addition, or overlay, to the main RAM used by BASIC or as 16 x 32K byte pages that can be selected by the rotary HEX switch. The 16 x 32K byte RAM pages, in conjunction with a machine code app (see Annex), can be used to store program images from the main CC-40 memory.

The RAM section uses a 512K byte static RAM chip that has battery backup powered by a CR2032 button cell battery. The CR2032 should provide backup power to the RAM for a few months if the cartridge is without power from the TI CC-40's AA batteries. The backup battery is intended to protect the memory while the main AA batteries are being swapped. They also allow the cartridge to be moved to other machines while preserving the contents. Although, it is always good practice to backup any work in the RAM cartridge before replacing the AA batteries or removing the cartridge.

Further information about RAM cartridges can be found in the *Texas Instruments CC-40 8K Constant Memory RAM Manual*. The manual covers the CC-40 memory maps and how to operate the cartridge. Although the manual covers the 8K RAM cartridge the ideas can easily be extended to a 16K cartridge.

#The ">" is used to represent a hexadecimal number in line with TI CC-40 nomenclature.

Hardware Installation

Installation of the cartridge is very straightforward. If you are not comfortable working with the CC-40 at the hardware level, then do not proceed further. **Any damage to the CC-40, ROM/RAM Cartridge or data loss from use of the cartridge is the user's responsibility.** Always take the necessary anti-static precautions when handling the module.

Before undertaking any insertion or removal of the ROM/RAM cartridge make sure the CC-40 is OFF.

First, remove the cover from the cartridge bay on the CC-40. Next, ensuring the side of the ROM/RAM cartridge with the button cell is facing up, gently insert the memory module into the memory expansion connector. Again, be gentle as this should require **only minimal force**. If the force seems excessive, check that the card edge is lined up with the connector slot correctly. The ROM/RAM cartridge should be pushed in until the edge connector is just on the edge of the contacts. Keep the cartridge at right angles to the connector. Replace the cover when finished to protect the cartridge.

To remove a ROM/RAM Module, first make sure the CC-40 is OFF. To help remove the ROM/RAM cartridge the button cell holder can be used to very gently pull the cartridge out of the connector.

⚡WARNING⚡

The ROM/RAM cartridge is static sensitive like any other piece of electronic equipment. Make sure to store the ROM/RAM cartridge in a static-proof bag when not in use – the shipping bag should be retained for this purpose. When handling the memory module do so by the edges and refrain from touching the exposed edge connector or components.

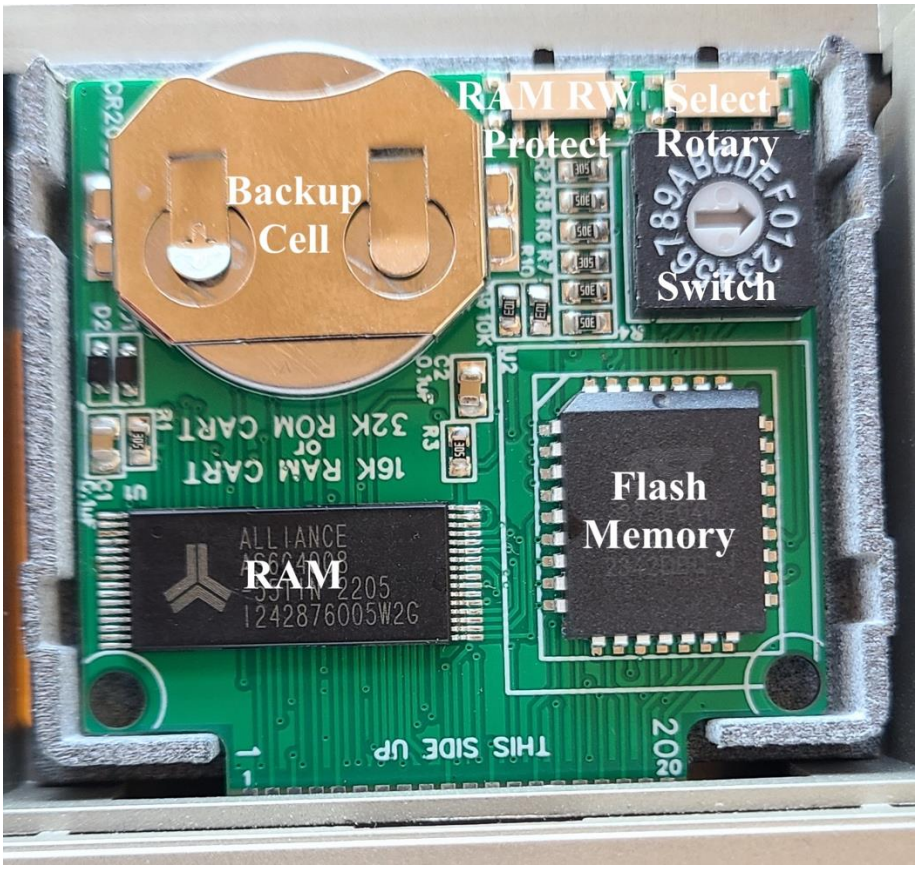

Figure 1: Top of CC-40 ROM/RAM Cartridge

Figure 2: Bottom of CC-40 Cartridge

CC-40 ROM Cartridge Operation

To use ROM preloaded programs, set the CS slide switch to FLASH (see FIG 1 & 2) . The CC-40 can only use either the ROM *or* RAM, not both together. The ROM cartridge, as shipped, contain 8 preloaded programs that are selected as shown in the table below. The main ROM image was created by several TI CC-40 enthusiasts who reverse engineered the individual TI ROM cartridge implementations. The *Readme* included with the ROM image has the names of those that created the ROM. Thanks to them we have this CC-40 ROM!

The developers of the ROM image simply repeated the programs as currently there are only 8 programs available – the ROM can take 16. If you have any ROM images, the developers would like to get hold of a copy.

Manuals for the various ROMs can be found online. The manual for the Mathematics cartridge seems to be missing. If you have the Mathematics cartridge manual, users would appreciate a copy for the archives. The manual for the Editor/Assembler does not seem to match the features in the preloaded program on the ROM.

You can also program your own ROM images if you have FLASH programmer (e.g., Xgecu TL866II Plus) and a reversed PLCC programming adapter. To program your own ROM images, make sure the PROG (see FIG 2) solder bridge is open and use a reversed 32-pin PLCC connector adapter. Once the programming is complete remake the solder bridge. Only program the ROM when the cartridge has been removed from the CC-40. Creation of new images is quite complex; information can be found online in the https://forums.atariage.com/ forums.

If the preloaded programs are not required, the option has been added to allow software programming of the FLASH, this would require the shorting of the PGM- solder bridge. Reference should be made to the FLASH datasheet. Programming of the flash via software is beyond the scope of this User Guide.

Further info and the source of ROM image: https://ftp.whtech.com/#CC40 load the CC-40 Release.zip

Switch	ROM Program	To use the program
F	Electronics Cart	RUN "DIR"
E*	Editor/Assembler	RUN "ALDS"
D	Finance Cart	RUN "DIR
C	Games 1	RUN "DIR"
B	Mathematics	RUN "DIR"
A$	Memo Processor	RUN "MP"
9	Pascal Cart	RUN "PASCAL"
8	Statistics Cart	RUN "DIR"
7	Electronics Cart	RUN "DIR"
6*	Editor/Assembler	RUN "ALDS"
5	Finance Cart	RUN "DIR
4	Games 1	RUN "DIR"
3	Mathematics Cart	RUN "DIR"
2$	Memo Processor	RUN "MP"
1	Pascal Cart	RUN "PASCAL"
0	Statistics Cart	RUN "DIR"

Notes on the ROM Programs:
* - The available Manual and ROM program seem to be different versions.
$ - The Memo processor behaves in an odd way when loading saved files. It appears to treat the header it saves as part of the memo on reading in the file. This shows up as random data at the start of a memo, it can be safely deleted.

CC-40 RAM Cartridge Operation

The RAM cart is enabled by setting the CS switch to RAM and the rotary switch to 0. The RW switch can be used to protect the RAM contents when the cartridge is removed by setting it to PROT (see FIG 1 and 2). The RAM cartridge uses a 512K byte static RAM chip, this will gives 16 x 32K byte pages. Although the pages are split into 32K sections the CC40 can only take advantage of 16K bytes of the page when used as add-on, or overlay, RAM.

To allow experimentation by expert users, the CC-40 page control bits, PA25.2 and PA23.3, can be connected to the A15 and A16 address lines respectively via two solder bridges. With additional software it should be possible to implement page switching of the RAM when it is selected. The user should refer to the CC-40 documentation to understand how paging works and how the CC-40 PAGE CONTROL REGISTER is configured, this topic is beyond the scope of this guide.

NOTE: The cartridge can only use either the RAM *or* ROM, not both simultaneously.

There are two possible options to use the RAM Cart.

1. **Adding the Cartridge Memory to BASIC:** To use the RAM cartridge as additional BASIC memory it must be added to the CC-40 memory map using `call addmem`. This step should add 16K bytes to the main RAM – 16K bytes is the maximum size of cartridge RAM that can be added. The new RAM space is added, or overlaid, onto the main memory starting at 0x1000 for main memory sizes less than 18K. (*See appendix J of the CC-40 User Manual for further information*.) With a 6K byte CC-40 adding the 16K bytes from the cartridge would give 18K bytes on the CC-40. This can be confirmed by using `fre(0)` which should produce 18431

   NOTE: Changing the rotary switch when the RAM has been added to the main address space will cause the CC-40 to initialize. Extra software would be required to allow paging to format the RAM. A 32K page switched RAM did exist as a custom TI product so it should be possible to implement such a feature. However, this is outside the scope of this User Guide.

2. **Using the Cartridge as a Storage Device:** This option is described in the *8K Constant Memory RAM Manual*. This scheme requires the use of the program reproduced in Annex A and in the manual. This program must be entered and run by you, the user. When complete it will have `POKE`'d a small program into the lower areas of the cartridge memory. The program can then be called using `CALL EXEC` statements to either copy the contents of the CC-40 BASIC memory into the cartridge or load the contents of the cartridge to the CC-40 BASIC memory. The contents on the CC-40 memory will be overwritten with the program from the cartridge and vice-versa. The memory image on the cartridge will remain there until it is either overwritten or the power is removed from the RAM. The program in Annex A will work with the 6K byte CC-40. It could be altered to work with larger memory CC-40 but anything over 6K would require the machine code routine to be re-written. Again this is outside the scope of this User Guide.

   After entering the program type `run`, then:
   - To save an image of the CC-40 RAM to the cart use: `call exec (36923)`
   - To retrieve the image from the cart use: `call exec (36910)`

If option 2 is selected, then it is possible to use the cart to store 16 different programs. First the machine code for saving and restoring the CC-40 memory must be `POKE'd` to all the pages. After which it can be used to save/restore at any time.

1. Select each RAM page in turn using the rotary HEX switch and run the save/restore program to POKE the machine code into the selected page.
2. Select the page for the desired CC-40 RAM image. Use `call exec (36923)` to save an image or `call exec (36910)` to retrieve an image.

Annex A: RAM Cartridge Initialization program

See the *8K Constant Memory RAM Manual* for details.

BASIC Program

```
100 CALL POKE(36910,142,144,77,136,175,255,102,136,31,255,104,224,11)
110 CALL POKE(36923,142,144,77,136,31,255,102,136,175,255,104)
120 CALL POKE(36934,136,24,0,106,142,248,12,136,0,102,1,140,248,54)
```

ASSEMBLY PROGRAM

```
                    IDT 'SAVEOLD'

902E        AORG 36910
            *CALL EXEC routines to
            *save to or load from
            *battery-backed-up RAM cartridges

            STARTAD  EQU >66   ;Start address for the move
            NEWAD    EQU >68   ;New location to move
            MOVLEN   EQU >68   ;Length of data to be moved
            MOVUP    EQU >F80C
            CALPAG   EQU >F836
            TRSHDY   EQU >0066

902E        OLD   ;Routine to copy from Cartridge
902E        8E          CALL @CLEAN
902F        904D
9031        88          MOVD %>AFFF,STRTAD  ;Location in Cartridge
9032        AFFF
9034        66
9035        88          MOVD %>1FFF,NEWAD   ;Location in CC-40 memory
9036        1FFF
9038        68
9038        E0          JMP MOVE            ;Move the data
903A        0B
903B        SAVE   ;Routine to copy to Cartridge
903B        8E          CALL @CLEAN
903C        904D
903E        88          MOVD %>1FFF,NEWAD   ;Location in CC-40 memory
903F        1FFF
9041        66
9042        88          MOVD %>AFFF,STRTAD  ;Location in Cartridge
9043        AFFF
9045        68
9046        MOVE ;Move function
9046        88          MOVD %6*1024,MOVLEN  ;Length of data to be move =
6Kbytes
9047        1800
9049        6A
904A        8E          CALL @MOVUP
904B        F80C
904D        CLEAN ;
904D        88          MOVD %TRSHDY,B
904E        0066
9050        01
9051        8C          BR @CALPAG
```

```
9052        F836
            END
```

Annex B: RAM Cartridge Test Program for 32K bytes

See the *8K Constant Memory RAM Manual* for details. This program can be used to test the RAM Cartridge.

BASIC Program

```
110 CALL GETMEM(69,ADR)
120 CALL POKE(ADR,82,165,98,136,207,255,118,136,127,255,120,155)
130 CALL POKE(ADR+12,118,190,219,118,219,120,227,247,98,136,207)
140 CALL POKE(ADR+23,255,118,136,127,255,120,157,118,230,13,190)
150 CALL POKE(ADR+34,219,118,219,120,227,245,196,93,90,226,213,10)
160 CALL POKE(ADR+46,139,(ADR+65)/256,ADR+65,18,117)
170 CALL POKE(ADR+51,139,(ADR+66)/256,ADR+66,18,118)
180 CALL POKE(ADR+56,139,(ADR+67)/256,ADR+67,154,118)
190 CALL POKE(ADR+61,139,(ADR+68)/256,ADR+68,10,0,0,0,0)
200 CALL EXEC(ADR):CALL PEEK(ADR+65,TVAL,ADR1,ADR2,BVAL)
210 IF TVAL=0 THEN PRINT "No Errors":GOTO 230
220 PRINT "Error at";ADR1*256+ADR2;"test=";TVAL;"bad=";BVAL
230 PAUSE:CALL RELMEM(ADR)
```

ASSEMBLY PROGRAM

```
* 32K RAM Cart test program
* Runs through the 32K using >A5 then runs through with >5A
* as the test pattern.  The STATUS field is used to store the
* result for printing out.
* The starting address for the code is obtained via GETMEM @ line 110

           52    MOV %>A5,B      ;Test pattern
           A5
RAM10      62    MOV B,A
           88    MOVD %>CFFF,R76 ;END RAM
           CFFF
           76
           88    MOVD %>7FFF,R78 ;RAM Size
           7FFF
           78
STORE      9B    STA  R76 ;Store A (Test Pattern)in address pointed to
by R76
           76
           BE    RL A       ;Rotate Test pattern
           DB    DEC R76    ;R76--
           76
           DB    DEC R78    ;R78--
           78
           E3    JC STORE
           F7
           62    MOV B,A
           88    MOVD %>CFFF,R76 ;R76--
           CFFF
           76
           88    MOVD %>7FFF,R78 ;R78--
           7FFF
           78
```

```
RAM30       9D    CMP R76
            76
            E6    JNZ ERROR
            0D
            BE    RL A
            DB    DEC R76
            76
            DB    DEC R78
            78
            E3    JC RAM30
            F5
            C4    INV B
            5D    CMP %>5A,B
            5A
            E2    JEQ RAM10
            D5
DONE        0A    RETS

*Test error store the result in the STATUS region
ERROR       8B    STA @STATUS
            ????
            12    MOV FAC+1,A
            75
            8B    STA @STATUS+1
            ????
            12    MOV FAC+1,A
            76
            8B    STA @STATUS+2
            ????
            9A    LDA *FAC+3
            76
            8B    STA @STATUS+3
            ????
            0A    RETS
*Storage area for the result. 0 = No Errors.
STATUS      00
            00
            00
            00
```