HOW TO MAKE A CARTRIDGE

By Scott Julian

I've always wanted to design and build my very own cartridge; it's always been an area of the Commodore 64 that has interested me for quite some time. In the late eighties I managed to assemble a few using blank cartridge boards designed and manufactured by Jason Rainhiem (US company famous for the Promenade C1 EPROM programmer) but that was a long time ago and these boards are no longer available. So I thought that it would be a great challenge to design and manufacture my very own cartridge from the ground up and this is the tale of how that occurred.

Firstly I needed to understand what was required in order to not only build a Printed Circuit Board otherwise known as a PCB but how to design one that would work on a Commodore 64. Where to start? Well the Internet is a wonderful place so I headed straight to my favourite search engine and began keying in words that should have given me choices galore, but to my surprise all I found where sites referring to Atari's, both the classic VCS and Atari 800 but little to nothing on the 64.

Although it was a let down at first I decided to work with what I had, thinking that the Atari couldn't that different. I began reading all the information I had found on the Atari's in a vag attempt to locate Commodore related information hidden somewhere in all those pages.

After weeks of reading both online and in printed form (the later is great for the hour long train trip I have each day to and from work) I discovered that all the information that I really needed I already had. You see many of these articles I had read talk in great detail of how to modify or reverse engineer existing cartridges and I already owned a few classic Commodore cartridges so I set about pulling them apart to find out how they worked.

I disassembled a few cartridges from my collection, some from Commodore and others such as the ones manufactured by H.E.S (Home Entertainment Suppliers Australia) not to mention a Jason Rainhiem cartridge I picked up via EBay. Using the pages from within the Commodore Programmers Reference Guide to understand what the pin outs from the 64 expansion port where I was able to build a schematic (drawing of the cartridge).

Now cartridges come in a variety of formats, more than I probably understand so I'll mention just three types in this article.

8K Cartridge – The simplest of all cartridges in one that replaces RAM in locations $8000-$9FFF.

16K Cartridge – This type of cartridge replaces RAM in locations $8000-$9FFF just as the 8K does, but it also replaces BASIC ROM at $A000- $BFFF.

Bank Switched – 16 K is the maximum amount of computer memory that the cartridge can take control of, but you can have cartridges large that 16 K. If for example you had a 32 K cartridge, then the computer can only access half of it at a time. But by alternating which half it is looking at, you can effectively access all 32 K within the cartridge. This is called bank switching and generally requires an additional IC to be installed to accomplish the task.

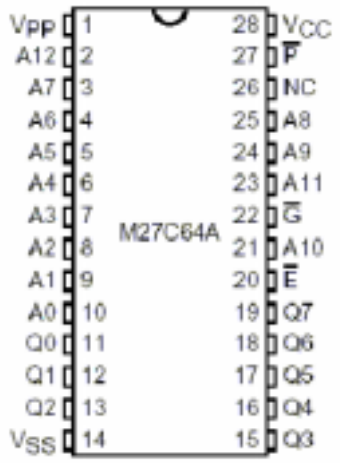
For the purpose of this article I'm going to assume that each of you understands how to programme and EPROM, now before you stop reading because to haven't a clue about the how to do that I'll be doing a follow-up article on that very topic. So keep reading and stay tuned for upcoming Commodore Scenes.

To understand the remainder of this article I would suggest that get out your copy of the Programmers Reference Guide and turn to the pages on the expansion port.

Expansion Port

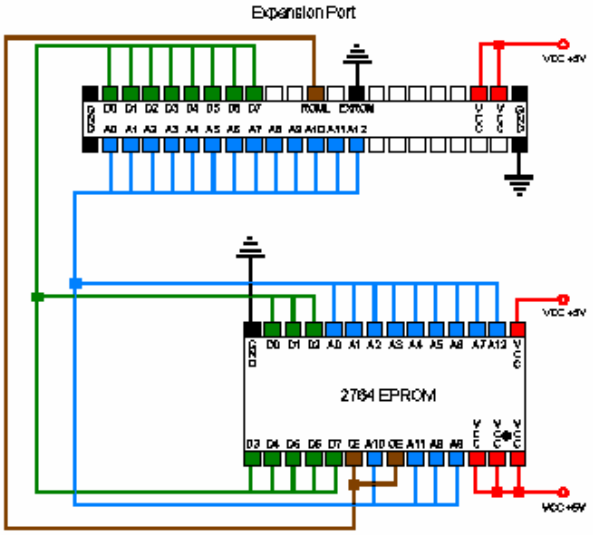
Pin	Signal	Pin	Signal
22	GND	Z	GND
21	CD0	Y	CA0
20	CD1	X	CA1
19	CD2	W	CA2
18	CD3	V	CA3
17	CD4	U	CA4
16	CD5	T	CA5
15	CD6	S	CA6
14	CD7	R	CA7
13	DMA	P	CA8
12	BA	N	CA9
11	R/W	M	CA10
10	D0E	L	CA11
9	EXROM	K	CA12
8	GAME	J	CA13
7	1/O1	H	CA14
6	Dot Clock	F	CA15
5	IRQ	E	Φ2
4	R/W	D	NMI
3	+5V	C	RESET
2	+5V	B	ROMH
1	GND	A	GND

One thing common to all EPROM's found in cartridges is that the eight data lines from the expansion port (pins 14 - 21) need to connect to the eight data pins on the EPROM (pins 11 – 13, and 15 – 19). The same applies to the Address Lines A0 – A12 (pins K – Y). Connect these straight to the appropriate pins on the EPROM.



Now that we have done the easy part we are left with the all important connections. Firstly connect the +5 volts to EPROM pins 1, 26, 27 and 28. Follow this by connecting GROUND to EPROM pin 14.

What's left now in order to get an EPROM to work is to connection ROML (expansion pin 11) to both CE and OE (Chip and Output Enable) on the EPROM (pins 20 and 22). The connection is for the EXROM line from the expansion port directly to GROUND.



Now that we have designed the cartridge and hopefully programmed the EPROM correctly all that is left for us to do is solder the EPROM to the PCB. That's it. You now have a working 8 K cartridge for the Commodore 64.

Okay, you have read the article from beginning to end and your thinking great, but how do I make the cartridge? How do I take that diagram and turn it into a PCB? And how do I make the PCB? These are all good questions, which in the fullness of time will be answered in upcoming Commodore Scene articles. So for now just examine the diagrams and get some ideas together on what you are going to put into that EPROM, maybe DOS Wedge, a calculator or even your favourite utility.

MMC64

Developer Oliver Achten has finished his first product that will be produced by individual Computers: **MMC64** is an MMC- and SD-card interface for the C64 computer. It uses the multimedia and Secure Digital flash cards that are known from the PDA world. That means that after you power up the computer, you can access any MMC or SD card that's FAT16-formatted - up to the size of 4GB! The built-in and flashable BIOS with integrated file browser allows the user to load games and other programs, play SID-files with the built-in player, or write D64 images to a floppy drive.

MMC64 has a clockport for expansions like RR-Net, and a pass-through for other expansion cards. This pass-through is 100% compatible with the Retro Replay - both expansions can be used in their full functionality at the same time.

MMC64 will be available for • 49 starting february 2005, and will be demonstrated for the first time at the TUM party in Hemsbach, Germany (december 27th to 29th, 2004).