BackBit Cartridge Documentation v1.4.8

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Comparison

How does BackBit line up with other storage solutions for your vintage hardware? Let's find out!

	1541	BackBit	SD2IEC	EasyFlash[3]	Pi1541	Ultimate-II+
Boot directly to menu	N	Y	N	Y	N	Y
C128 Compatibility	Y	Y	Y	N	Y	Y
VIC 20 Compatibility	Y	Y	Y	N	Y	N
Power Supply Req'd	Y	N	N	N	Y	N
# of Cables Required	2	0	Up to 2*	0	2	1
Maximum Capacity	170KB (per disk)	32GB (per card)	32GB (per card)	8MB	n/a	n/a
Max. Capacity/File	n/a	4GB (BBT)	16MB (DNP)	1MB (CRT)	800KB (D81)	16MB (REU)
Fastloader Req'd for Maximum Speed	Y	N	Y	N	Y	varies***
D64 Compatibility	n/a	Partial#	Partial#	Minimal****	Full	Full
Transfer Mechanism	n/a	Micro-SD	SD	USB	varies	varies

 * SD2IEC variations exist: (1) no cables plugging directly into IEC & cassette port on C64 (incompatible w/ C128 and SX-64);
   (2) no cables internally mounted (assembly required); (3) single cable plugging directly into tape port (incompatible w/ SX-64).
 ** Speeds can be improved by using software fastloaders, KERNAL replacements (assembly required), and CRT format files.
 *** Ultimate-II+ requires a fastloader for multi-file disk images; for onefile programs and cartridges it does not.
 **** Using Disk2EasyFlash, it is possible to make conversions, but they are read-only and do not support SEQ/REL files.
 # Compatibility is close to 100% with programs that use only standard KERNAL routines.

Philosophy

When I had access to some Commodore 64s back in 2018, I was searching for the ideal solution to make it easy to load programs. The 1541 disk drive proved to be way too tedious, unreliable, and painfully slow.

I spent some time researching modern media solutions for the Commodore 64, like the ones listed in the table above. While these solutions did provide some convenience as compared to a 1541 disk drive, they did not meet my needs. Individually all of these devices have some impressive features, but they all require a steep learning curve. I wanted something that was more of an effortless all-in-one solution.

In 1990, Commodore made one last-ditch effort to market the Commodore 64 with the introduction of the C64GS. Its release came with some impressive titles up to 512KB in size (about 3 single sided disks worth of content) and with instant loading, unlike their disk or tape counterparts.

In 2009, EasyFlash expanded upon this decadence by making a programmable 1MB cartridge (twice the size of the largest C64GS cartridge). While these cartridges do offer an exciting experience for a single game (or 7 in the case of EasyFlash[3]), there is the tedious process of flashing the game on the cartridge, a process that typically takes a few minutes per game and requires additional hardware for the C64 or a complex driver setup for the PC.

Let's backtrack a couple of years to 2007 when a microprocessor-based device called MMC2IEC was introduced, eventually evolving into what is currently known as SD2IEC (or µIEC). These devices interface with the Commodore's IEC serial bus and use SD cards for storage. Unlike the EasyFlash which incorporates a non-removable type of memory, these devices can use media compatible with most modern computers. This dramatically decreases the learning curve required to use these devices as compared to a flashing cartridge. Unfortunately, they inherit a problem from using the Commodore's serial bus—slow loading to the tune of only a few hundred bytes per second. Fast loaders do increase this to a tolerable speed, but these devices are only compatible with a small selection of fast loaders, making complications inevitable.

What if you could take the speed of the EasyFlash, the convenience of the SD2IEC, and create a fun and effortless retro experience with a wide range of compatibility? That is the philosophy behind BackBit.

How It Works

BackBit works by tricking your Commodore into thinking it is accessing a real disk drive. By overriding the KERNAL vectors, it is able to hijack any software that obeys the guidelines of standard disk access.

This works for most BASIC programs and any program that does not incorporate a fast loader or direct serial access. Literally thousands of games are available that work perfectly on BackBit without any altering from their original form.

Single File Loading

BackBit can load any single program from a PRG, T64, or D64 file. These programs can be up to 62KB in size and will load in less than a second. Additionally, BackBit can load a variety of CRT files. Compatibility is perfect for all game cartridges released during the Commodore's lifespan.

Multiple File Loading

When using a disk image (D64, D71, D81, etc.), BackBit has perfect compatibility (read and write for PRG, SEQ, REL, and USR data) as long as only KERNAL vectored functions are used. If given the option, disable fast loading in your program as that will cause problems. Furthermore, copy protected titles or those that use direct serial access will not work.

For games that span multiple disks, there are 2 options: Combine them into a single large disk (like a D81 or D8B), or utilize the BackBit Tool to store the disks in a BBT file and patch the code to rotate disks automatically with the BackBit API.

BackBit-Specific Loading

A feature unique to BackBit is the ability to access up to 4GB of persistent data at near-instant speed. The performance is very similar to a GeoRAM device. This takes away the size barrier for creating content that is true to the original aesthetic of your vintage machine.

Anatomy
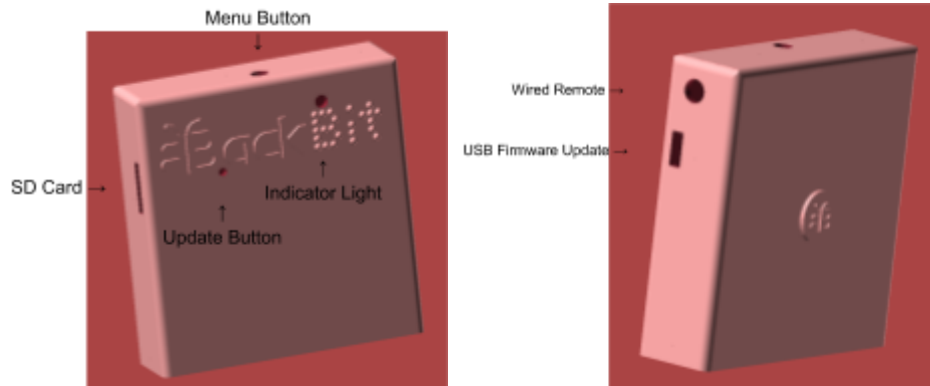
The **Menu Button** up top allows you to return to the menu once a program is running.
The **Indicator Light** lets you know when requests are being made to the cartridge.
The **Micro-SD Card** slot accepts any microSD card formatted to FAT32 or FAT16. The slot is designed so that cards will not "fall in" to the cartridge and will be easy to remove.

Connect a Micro USB cable to upgrade firmware. Once software is set up correctly, press the Update button to perform the update. It is not possible to "BRICK" the cartridge. In case of a failed update, you can easily restart the upgrade process.

You can connect a BackButton™ (available for purchase separately) to the **Wired Remote** port, which performs the same functionality as the **Menu Button** and **Indicator Light** at a distance.

Summary of Features

- Load programs from micro-SD card formatted with FAT16/32 (32GB limit);
- Upgrade firmware via included USB cable;
- "Rip & Burn" – built-in disk copier to facilitate archiving/reproducing real disks;
- Preserves disk images automatically so you don't lose your originals;
- Real time clock to facilitate accurate versioning of files (w/ replaceable CR2032 battery);
- Innovative BBT file format to assemble and run multi-disk programs w/o disk swapping;
- Extended data offers the performance of a large size virtual hard drive;
- Physical button and optional wired remote return to menu from active program;
- Auto boot on startup: Automatically start a specific program w/o user interaction;
- Presentation mode for exhibiting programs non-destructively;
- Optional wired remote control (available for purchase separately).
- Built-in SID player and Koala viewer

Firmware Upgrade

It is possible to upgrade the firmware via a USB cable. You will need a Micro USB cable and a paperclip to complete this process. Make sure the cable is a data cable, not merely a charging cable.

The latest firmware can be downloaded at http://backbit.io/downloads/Firmware.

The first time you upgrade, you will have to download some software: https://www.pjrc.com/teensy/loader.html

Instal the Teensy software as instructed for your operating system. Just download the program, you don't need the LED Blink example program. Once it is downloaded, you may want to copy it to a more accessible place (Applications for OSX or start menu for Windows).

Plug in the USB cable—one end to your computer and the other end to the USB port on the BackBit cartridge. It doesn't matter if the cartridge is plugged into the Commodore 64 or not, or whether or not the Commodore 64 is turned on.

Go to the File menu and click Open HEX File. Select the .HEX firmware file you downloaded (it will need to be extracted from the .ZIP container). Now use the paperclip and gently press the program button on the BackBit cartridge (through the hole on the top of the cartridge next to the logo, or if you have a bare cartridge it's the beige button next to the right of the SD slot.) You should see a progress bar indicating the firmware is transferring to the cartridge.

Once this process is complete, unplug the USB cable and reboot your Commodore 64. To verify the firmware version on the cartridge hold shift or activate shift-lock while the computer is booting up. The version is in the top-right corner.

Troubleshooting: If the Teensy application does not recognize the device, you may have to try rebooting your computer or using another cable.

File Browser

The BackBit file browser allows you to navigate the entire contents of your SD card. There are a couple restrictions in how your card must be arranged:
- Must be formatted in FAT32 (or FAT16);
- Folders over 1,000 files will show "<MORE>" at the end of the listing to browse additional files (due to memory restrictions of the device).

Key Conventions:
↑ Key functions the same as SHIFT + ⇑CRSR⇓.
← Key functions the same as SHIFT + ⇐CRSR⇒.
In many cases either Joystick #1 or Joystick #2 can be used instead of cursor keys.
Press any function key to see a reference of function commands on the status bar.

Browser Commands:
Up / ↑ **/ SHIFT +** ⇑**CRSR**⇓- Navigate to last files or item
Down / ⇑**CRSR**⇓ - Navigate to next file or item
Left / ← **/ SHIFT +** ⇐**CRSR**⇒ - Navigate to last page
Right / ⇐**CRSR**⇒ - Navigate to next page
Fire / RETURN - Choose selected item
CTRL + RETURN - Open selected disk without automatically starting
SHIFT + RETURN - Open selected item with application extension (see below for details)
CTRL + SHIFT + RETURN - Open current folder with application extension of selected item
A - Z / 0 - 9 / Space Bar - Search for title beginning with selected characters
CLR HOME - Reset search / Go to top of listing
INST DEL - Remove last search character / Close popup / Navigate to parent directory
RUN STOP - Open BASIC session
RESTORE - Refresh directory (useful after swapping SD Card or encountering error)
F1 / ESC - Show UTILS menu (not specific to any item), or hide if already visible.
F3 - Show PROPS for current item, or hide if already visible.
F5 - Show SAVES for current item, or hide if already visible.
F7 - Show TOOLS for current item, or hide if already visible.

Clock

BackBit comes with a Real Time Clock. This means that even when the power is shut off, your cartridge will remember the time of day. To set the clock for the first time, choose Set Clock from the UTILS menu. Use the cursor keys to navigate the fields and modify values. Be sure to set your time zone, indicated as an offset from UTC. Press return to save changes or menu button to abort.

Loading Programs

These file formats are supported:
- PRG/P00 (single program up to 62KB);
- T64 (only supports loading first program from tape image);
- BIN (generic 8K/16K/32K* cartridges);
- CRT (incl. generic 8K/16K/32K*/Ultimax, C64GS/System3, Dinamic, Epyx FastLoad, Funplay/Powerplay, Magic Desk, Ocean, Prophet 64, Simons Basic, Super Games, Zaxxon);
- VIC 20/VC20 cartridges: 20/40/60/70/A0/B0 (see more details in VIC 20/VC20 section below).
- D64/D71/D81 (1541/71/81 disk; emulated using KERNAL vectors);
- D8B (BackBit disk format; see D8B section);
- BBT (BackBit format; see BackBit Tool section).

(*32K cartridges only work on C128)

The file formats are unsupported at this time, but support may be added for them in the future:

- G64/NIB files: BackBit does not physically connect to a disk drive, so it cannot generate these advanced formats. Use NIBTools to convert these files to D64;
- TAP files: BackBit does not emulate tape loading. Convert these to a format BackBit can recognize, like PRG or D64;
- T64 files with more than 1 program: Try converting these to individual PRG/D64 files;
- Disk-based programs that access the serial port directly at $DDXX or through KERNAL serial device routines, incl. fastloaders: Since BackBit does not physically connect to the C64's serial port, it cannot handle these requests. Fortunately, there is a patching system being built into BackBit to make it possible to run a growing library of programs;
- Certain EasyFlash CRT files: These cartridges push the instant-access capacity of BackBit, however there is growing support to make the entire EasyFlash library work.

Presentation Mode

Accessible via the UTILS menu (F1), this puts the cartridge in Presentation Mode, identifiable with a blue border. This allows the cartridge to be used in an exhibit or party environment.

Presentation Mode operates similarly to the File Browser with these exceptions:
- Function Key menus and directory refresh are unavailable;
- The last directory navigated in the File Browser is the only one accessible;
- All contents of the current directory are recursively combined into one list;
- Hold menu button while physically resetting computer to disable Presentation Mode.

Autostart Mode

Accessible via the Tools menu (F7), this puts the cartridge in Autostart Mode. In this mode, the selected program is started automatically upon bootup. Aside from aesthetics, this mode can be helpful for some cartridges that work better on a clean boot.

While in Autostart Mode, the following restrictions apply:

- The File Browser is inaccessible;
- The menu button resets the program;
- Hold menu button while physically resetting computer to disable Autostart Mode.

Rip/Burn

With BackBit, it is possible to read and write disks with a real 1541 disk drive, simply by plugging the drive into your C64 at the same time the Cartridge is present.

To "Rip" a disk, select this option from the UTILS menu (F1). Then choose a device to read and press return. The disk will be saved as "New Disk" (or as a version inside that disk if one is already present).

To "Burn" a disk, select this option from the tools menu (F7). Only D64 images can be written to a 1541 drive. Then choose a device to write to and press return.

Dead Test/Diagnostic

BackBit has a built-in dead test & diagnostic cart! While holding the menu button on the cartridge is used to exit presentation mode, it is also used to activate dead test & diagnostic. Dead test is activated by 1 long press, followed by 1 short press. Whereas diagnostic is activated by 1 long press, followed by 2 short presses.

First, hold the menu button on the cartridge while turning on your machine. This is the long press. Let the light on the cartridge shine for about a second, then dim out. Now you know it's time to do the short presses, and you have limited time to do so.

During each short press, the light will glow, letting you know it's being pressed. Remember, it's 1 press now for dead test, or 2 for diagnostic. If activating dead test, be sure to power cycle your machine afterwards to experience an authentic dead test.

To go back to normal, just hold the button on startup like you were exiting presentation mode.

Application Extensions

Use any media viewer/player or disk browser of your choice*. To set up, select a PRG file (i.e. SIDPlay64 or CBM FileBrowser). Press **F7** and choose **Use As Extension** then confirm **Yes**.

Next, choose any content (SID,KLA,D64,TXT, etc) and press **F7**, then select **Open With** to cycle through the available extensions, i.e. the ones you configured with **Use As Extension**. Note that this will affect *all* files that have that extension, or in the case of disks, all disks (D64/D71/D81/D8B). You must do this soon after the first step, as any unused extensions will be erased on a device restart.

Once the extension has been configured, choose some content and press **SHIFT** + **RETURN** to open it with the extension (**RETURN** still opens it normally). If the content is not already a disk, it will be converted to disk format for the extension to use (modifications will not be preserved).

Note that a customized version of your player may be required to perform correctly.

VIC 20/VC20 Adapter

An optional adapter allows inserting the BackBit cartridge into your VIC. The BackBit cartridge will detect which system it is being plugged into automatically.

Once this adapter is installed, you will be able to boot into BackBit from your VIC computer with a limited 22-column screen. From the F1 menu, you can then select RAM Expansion, from 0K to 35K. Up to 24K will show up instantly in BASIC, and the rest will be accessible from machine code. Based on the amount selected, your program and screen location will change:

Expansion	Program start	Screen start	Color start
0K	$1000	$1E00	$9600
3K	$0400	$1E00	$9600
8K+	$1200	$1000	$9400

About VIC 20 cartridges: These are raw binaries with no header. The extension must match the first 2 hex characters of the loading address, i.e. a $A000-loading cartridge will be **.a0**. If you have a 2-part cartridge, i.e. some memory at $2000 and some at $A000, the autostart portion at $A000 can simply be binary-appended to the first part, as BackBit will detect the autostart code, i.e. **cat cart.20 cart.a0 > combined.20** on a unix-compatible command-line or **copy /b cart.20 + cart.a0 combined.20** on Windows.

C128 Mode

BackBit supports loading during "SLOW" mode, the default operating mode of the C128, and the mode required for 40-column usage. Use the "C128 Mode" option in the UTILS menu (F1) to activate C128 mode (otherwise C64 mode will be used). When using .BBT files, this setting will change automatically to accommodate the platform setting in the BBT file.
Note that if you lock the C128 in C64 mode by modifying the reset vector at $FFF8, it will not be able to start another C128 program without physically resetting the machine.

Properties

Access properties by pressing F3. This will give you detailed information about a file and allow you to rename it by pressing enter on the name.

You can rename a file by pressing enter on the name (you can press HOME to erase the current name).

You can view metadata and documentation for BBT files (if they have this info filled out).

Saves

Access saves by pressing F5. Then choose an item with RETURN and it will show a popup menu with actions. Normally when you open a disk image, it loads the most recent modifications that have been made, such as high scores, user progress or levels. By selecting the original version here, you can load the original unmodified version of the program. You can also do many things with modified versions of the program:

- Open a specific version, i.e. an adventure game with your user's progress;
- Rename the version;
- Duplicate, i.e. fork the version;
- Erase the version;
- Export to a regular disk image, so that the version doesn't have to be associated with the original disk anymore.

Options

These options are not necessary for most users, but advanced users may find them useful. You can find them in the UTILS menu (F1).

- **Boot Sequence**
  Normally, BackBit shows a title screen on bootup for a couple seconds while waiting for the directory to load. For advanced users, it may be advantageous to speed through this process, so you can set this option to "Fast" if a quick bootup is important to you. Note that fast mode may produce visual artifacts during loading.

- **Startup Disk**
  When going to BASIC with the Run-Stop key, the default is to have a regular single-sided double-density disk compatible with a 1541 drive (i.e. D64 file). If you prefer, you can change this to a 1571- or 1581-native disk (i.e. D71/D81 file). You can also turn the virtual disk off, leaving drive 8 open to other uses.

- **Startup Uses BBT**
  By default, the startup disk uses a D64/D71/D81 file compatible with emulators and other hardware. If you choose, you can utilize the BBT file format for saving content which allows multiple save versions of a disk to be consolidated into a single BBT file. (Normally the non-original save versions go in a hidden ".saves" folder.) Either way, you can still export versions to a D64/D71/D81 file.

- **CRT Support**
  BackBit natively supports cartridges up to 128KB, and uses an experimental patching system to support cartridges up to 1MB in size. Some C64 revisions may behave erratically with certain cartridges, so as a fallback option, try Compatibility Mode. In compatibility mode, EasyFlash cartridges will use a slightly less stable routine that supports a few more titles, and normal cartridges will use the patching system typically used for cartridges over 128KB.

- **Ultimax Support**
  Cartridges compatible with the Commodore MAX machine are supported on the Commodore 64 using a mode called Ultimax. BackBit will automatically patch these cartridges and instead load them as programs, which improves compatibility. Change this option to "Native" to use true Ultimax mode for these cartridges. Certain systems will show visual artifacts in this mode, and that is why "Emulated" is the recommended default. To utilize the Dead Test cartridge effectively, you must set this to "Native".

Destructive Operations

Preservation is a key goal in the BackBit user experience. By default, no original disk image will be modified. It's as though every disk in BackBit has a backup of the original stashed away. However, there are a few ways you can potentially destroy content, and they should be used with caution:

- Using the Erase option from the Tools menu (F7). There will be a popup that asks you if you are sure;
- In the Saves menu (F5), you can erase a specific version;
- Write errors may occur depending on the quality of the SD card you use, static electricity, or poor connections—so it is recommended that you periodically backup your data to another medium.

D8B Disk Format

Sometimes it's nice to combine a lot of files onto a single disk. It works well for programs that originally used a lot of disks. It's also analogous to how the BBT format supports up to 8 disk images. 8 disks is typically the max for 99% of programs, and that's why this number was chosen. See how the D8B format compares to other disk formats:

Format	D64	D71	D81	D8B
Tracks	35	70	80	40
Sectors	17-21	17-21	40	144
Directory Entries	144	144	296	**1120**
Directory Track	18	18/53	40	1
BAM Sector #	0	0	1-2	1-3
Directory Entry Sector #	1-18	1-18	3-39	4-143
BAM bytes/track	4	4	6	18
Blocks Available	664	1328	3160	5616
Capacity	164.7 KB	329.4 KB	783.8 KB	1.36 MB
Capacity vs D64	1x	2x	4.8x	**8.5x**

BackBit Tool

The BackBit Tool is an open source cross-platform application available for Linux (32-bit and 64-bit), Mac (64-bit) and Windows (32-bit and 64-bit). Using the tool, you can assemble BBT files which are composed of 3 parts:

1. An auto-start program, i.e. PRG file that will be executed on startup (this is optional, and if not present, a disk image must be present).
2. Up to 8 disk images (D64/D71/D81), assigned automatically to devices 8 through 15. If there is no auto-start program specified, the application will start with LOAD"*",8,1
3. A single binary file, no larger than 4GB that will be available through the API for extended data access.

The source code is available at https://github.com/evietron/BackBit-Tool.

The compiled application is free to download and available at http://backbit.io/downloads.

BackBit API

The API is made up of "peeks" and "pokes" to the I/O area in memory related to the expansion port, i.e. memory locations $DE00-$DFFF ($9800-$9FFF for VIC 20) in hex. You must have a knowledge of machine language programming to effectively implement features of this API, although it is also possible to use the BASIC programming language to work with most of these features. In that case, you will have to convert these hex numbers to decimal.

Peek Commands

This section describes what is obtained when peeking bytes from the I/O area at $DE00-$DFFF ($9800-$9FFF for VIC 20).

Peek Commands: CODE		
C64	**V20**	
$DE00 - $DE02	$9800 - $9802	**Identifier.** These bytes always return the sequence $BA $CB $17 while the cartridge is active.
$DEFF	$98FF	**Device Number Filter.** This is the maximum device # that the KERNAL emulation will bypass, so it will typically be one less than the first device # emulated, i.e. $07 if you are using device 8. If KERNAL emulation is not active, this will be $FF.

Peek Commands: DATA		
C64	**V20**	
$DF00 - $DFFF	$9C00 - $9CFF	**Requested data.** Data appears here in 256-byte blocks when requested from Extended Data or Real Time Clock. Poke to $DF## to configure which 256-byte block out of up to 64K can be accessible here, i.e. $DF00 to get the first block and $DFFF to get the last.

Poke Commands

The cartridge interprets poke commands based on the address written to, **WHILE IGNORING WHAT DATA IS WRITTEN**. This means that you can interchangeably use STA, STX, or STY instructions when writing to the cartridge at $DE00-DFFF ($9800-$9FFF for VIC 20), and can safely ignore the contents of the A/X/Y registers while doing so. The lower 8-bits of the address are interpreted as a command on the C64's I/O1 channel (or VIC 20's I/O2 channel) and as data on the C64's I/O2 channel (or VIC 20's I/O3 channel). For commands that require parameters, poke each parameter byte to $DF## / $9C##, then execute the command at $DE## / $98##.

When a command is executed, the cartridge will temporarily become unavailable. This does not interrupt the Commodore's CPU, but cartridge **memory**, **requests** & **KERNAL usage** become inaccessible until the command completes. To determine if the operation has completed, check for the 3-byte identifier (BA CB 17) at $DE00 ($9800 on VIC 20).
To prevent conflicts with programs that send non-BackBit requests to the $DE## ($98## on VIC 20) memory area, all commands, with the exception of disabling the cartridge memory, have a suffix of $BB.

Poke Commands: PARAMETERS		
C64	**V20**	
$DF00 - $DFFF	$9C00 - $9CFF	**Send parameter data.** This will add the low byte of this address to the parameter buffer, i.e. $DF00 will send $00 and $DF34 will send $34. The parameter buffer is limited to 256 bytes, after which it resets and wraps around. In loader or extended data mode, the most recent parameter byte written is used to specify the high address byte.

Poke Commands: CONTROL		
These requests control basic interaction with the cartridge.		
C64	**V20**	
$DE00	$9800	**Disable BackBit internals.** This hides BackBit from the active program, and if there is a cartridge loaded, it will become resident. Does not affect the I/O area at $DE00-$DFFF. *C64 Only.*
$DE01 [BB]	$9801 [BB]	**Enable BackBit internals.** This allows BackBit to hijack KERNAL routines, temporarily loading support code in ROML. *C64 Only.*
$DE02 [BB]	$9802 [BB]	**Return to browser.** Informs the cartridge that the program is done and should go back to the browser.
$DE03 [BB]	$9803 [BB]	**Turn on LED until next request.** LED remains <u>**on**</u> until next request.
$DE04 [Y# M# D# H# M# S# Z# BB]	$9804 [Y# M# D# H# M# S# Z# BB]	**Adjust real time clock.** Modifies the time to **Y**ear (+2K) / **M**onth (1-12) / **D**ay (1-31) **H**our:**M**in:**S**econd in **Z**one (signed, +/- UTC). Time is retained by the cartridge even after powering off the machine.
$DE05 [BB]	$9805 [BB]	**Request real time clock.** After calling, access the values here ($9CXX on VIC 20): $DF00 - $DF03: Year in ASCII $DF04 - $DF05: Month in ASCII $DF06 - $DF07: Day in ASCII $DF08 - $DF0B: Matches values you'd expect in $DC08 - $DC0B. $DF0C: Time zone (signed byte, +/- UTC).
$DE06 [BB]	$9806 [BB]	**Rotate mounted disks.** With a BBT that maps disks A,B,C to devices 8,9,10, after 1 rotation, they will be B,C,A. After 2, C,A,B, and finally after 3 rotations, back to the original order.

Poke Commands: EXTENDED DATA		
This feature allows BackBit to access up to 4GB of persistent storage from a single program. Accessing a 64K bank typically takes around 40ms. Requested data will be available at $DFXX with 256-byte bank switching triggered by writes to the same area. To write data, first configure the write offset, then write data 254 bytes at a time (which will increase the write offset). Data must be accessed again after writing to get updated version. Use the BackBit Tool to attach data to a BBT file which uses this feature.		
C64	**V20**	
$DED0 [A# BB]	$98D0 [A# BB]	**Access data.** Specify 8-bit 64K bank, i.e. $00**A#**0000
$DED1 [A# B# BB]	$98D1 [A# B# BB]	**Access data.** Specify 16-bit 64K bank, i.e. $**B#A#**0000
$DED2 [A# B# C# BB]	$98D2 [A# B# C# BB]	**Access data.** Specify 24-bit offset, i.e. $00**C#B#A#**
$DED3 [A# B# C# D# BB]	$98D3 [A# B# C# D# BB]	**Access data.** Specify 32-bit offset, i.e. $**D#C#B#A#**
$DED4 [A# B# C# D# BB]	$98D4 [A# B# C# D# BB]	**Assign write offset.** Specify 32-bit offset (**$D#C#B#A#**)
$DED5 [data… L# BB]	$98D5 [data… L# BB]	**Write data.** Writes **L#** (up to 254) bytes of data at current offset

Coding Examples

Example C64 BASIC program to turn on cartridge LED:
```
10 POKE 57275,0  This accesses location $DFBB, sending the $BB parameter
20 POKE 56835,0  This accesses location $DE03, sending the LED command
```

Example machine language program to access extended data at address $HHMMLL:
```
STA $DFHH ; access specified 64K data bank
STA $DFBB ; send BB command suffix
STA $DED0 ; extended data access command
JSR WaitForAlive ; make sure memory at $DE00...$DE02 returns $BA,$CB,$17
; note that while waiting for process to complete, KERNAL methods are inaccessible
STA $DFMM ; access 256-byte block of requested data bank
LDA $DFLL ; access single byte of specified 256-byte block
```

Note that you can make unlimited requests to data inside a 64K bank once the bank is requested, and you can make unlimited requests for a byte within a 256-byte block once it is requested. So in summary, these are the access times for any given data:
- 4-6 CPU cycles for the LDA/X/Y to access single byte (w/ optional increment and offset);
- 4-7 cycles for STA/X/Y (w/ optional increment/offset) to get next 256-byte block;
- Fraction of a second to queue up another 64K of data using command request and polling to determine when cartridge comes back online. During this time the C64 can perform other processing.

Optional Accessories

There are many fun and useful accessories to go along with your BackBit cartridge!

- BackButton™ wired remote: Allows you to reset your BackBit back to the menu without having to reach to the back of the cartridge (particularly convenient for models such as the C128D and SX-64).

- TwoBit™ joystick doubler: Lets one joystick control both ports.

- VIC 20 Adapter: Lets you use your BackBit cartridge with the VIC 20!

- GenAssister™: Lets you plug a Sega Genesis/MegaDrive joystick safely into your Commodore 64, and supports dual fire buttons.

- All accessories are available for purchase at http://store.backbit.io.

The BackBit Forum™

This cartridge is being actively supported, so if you have any trouble whatsoever, please join the public forum at http://forum.backbit.io.