

DesTest VIC20 Cartridge

DesTest VIC20 Kernal

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Table of Contents

Introduction.....	3
DesTest VIC20 Cartridge.....	3
DesTest VIC20 Kernal.....	3
Running the Diagnostics.....	4
Startup Tests.....	4
VIC Test Failure.....	5
Zero Page or Stack Page Failure.....	5
Code Checksum Failure.....	6
Main Tests.....	6
Interference in the Border.....	7
ROM Checksum Display.....	7
Interrupts.....	8
IRQ.....	8
BRK.....	8
NMI.....	9
Limitations.....	9
Border-o-matic bit indicator.....	10
Testing methodology.....	11
VIC20 Hardware Considerations.....	11
RAM data bit / address to IC mapping.....	11
From Matt.....	12

Introduction

The two DesTest VIC20 (or DesTest '20 if you like) solutions can each test both the internal 5K and up-to 35K of expansion memory using the excellent March-B memory testing algorithm.

DesTest '20 comes in two flavours: a kernal replacement ROM and a standard cartridge. The cartridge is a little easier to use (just plug it in) though isn't quite as flexible as the kernal version. Each version has its pros and cons as described below:

DesTest VIC20 Cartridge

The cartridge version of DesTest '20 isn't quite a true 'DeadTest': it does require that the computer's kernal-ROM and a little bit of the stack-page RAM are working in order to start. This is true of any purely VIC20 cartridge-based diagnostics.

A DesTest '20 Cartridge is able to test up to 27K of external memory due to the fact that the cartridge-ROM itself occupies the 8K BLK5 (\$A000-\$BFFF) address space. Additionally, testing external, cartridge-based memory expanders will require a VIC1010 Slot Expander or similar.

Any VIC20 cartridge PCB available on the internet should suffice for this purpose so long as it supports 8K ROMs at the BLK5 (\$A000-\$BFFF) location.

DesTest VIC20 Kernal

The kernal version of DesTest '20 replaces the system kernal and as such is indeed a true DeadTest: no RAM or other ROM-code is required to start.

The kernal version of DesTest'20 can test up to 35K of external memory since it allows the BLK5 (\$A000-\$BFFF) to be populated with memory.

While your VIC20 doesn't need to be fully working in order to run DesTest '20 Kernal, the CPU and VIC must be functional.

As the name implies, the DesTest '20 Kernal code replaces that of the VIC20 kernal. This generally means that the kernal ROM (UD6) needs to be replaced with a PROM that contains the DesTest '20 Kernal code.

De-soldering the original ROM and replacing it with a socket are beyond the scope of this manual though advice is not hard to find on the internet.

Ideally you'd be able to program the perfect PROM to fit in the kernal socket. Unfortunately the correct EPROM for the 8K kernal ROMs (2564) aren't particularly commonplace these days so some kind of adapter or alternate technology is required:

2364 to 2764 DIP adapters are available on the web and will allow 2764 compatible PROMs to replace the kernal ROM.

Additionally, kernal-switching solutions (that use a larger PROM than necessary to allow multiple 8K kernal images) can also be used. Just program DesTest '20 Kernal into one of the available 'slots' for kernal images.

If you only have larger, pin-compatible, PROMs, you may need to program the device with 2, 4 or 8 duplicates of the 8K DesTest '20 Kernal binary image depending on the adapter solution you choose.

Running the Diagnostics

Exactly what you see when you power on your machine with a DesTest '20 Cartridge or Kernal installed depends on exactly what is wrong with the system:

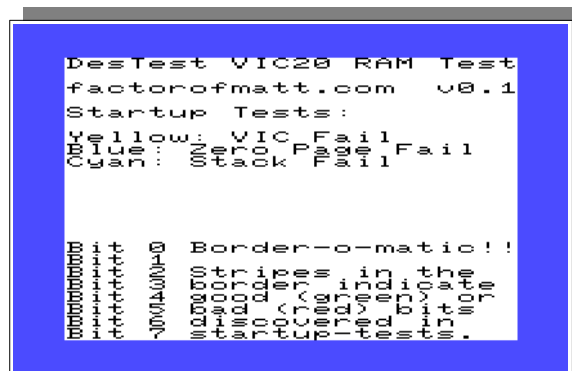
A faulty character-ROM will likely cause nonsense (or blank) characters to appear on the screen. All is not lost, however, as any RAM faults detected elsewhere will be indicated in the border.

The video display is made up from an area of main RAM, and a separate area of colour information. If either region of memory is bad then the display will likely be garbage. As with a faulty character ROM, border information can be used to get information about what has failed.

See the specific tests below for information about what is tested and how faults are displayed.

Startup Tests

When DesTest '20 first starts it tests the VIC, Zero-Page, the Stack Page and the checksum of its own ROM. The startup screen will be displayed immediately upon cartridge startup and remains only for a few seconds while the startup tests run.



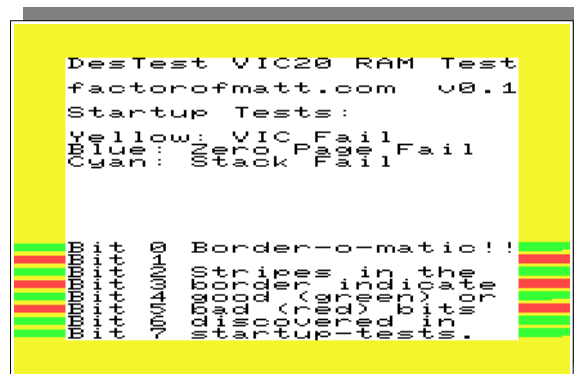
- The VIC has 16 registers mapped into the \$9000 block of address space. We don't use all the features of the VIC during testing, so five of these registers can be considered as general read/write 'memory'. Testing is performed on these registers to verify that they can be written and read as expected.

- The Zero Page is one of the two 256-byte memory pages treated specially by the 6510. It would be impractical to write a full memory test without using at least some of zero-page, so we test it early here. The test does not use zero-page (or the stack) to do so.
- The Stack Page is the other 256-byte memory page treated specially by the 6510. The stack allows the use of subroutines (JSR/RTS). We test the stack page (without using it or zero-page) so that we have some confidence we can use subroutines for the more comprehensive tests.
- A 16-bit checksum is calculated for the entire contents of the DesTest '20 code (\$E000-\$FFFF for kernal, \$A000-\$BFFF for cartridge). If the checksum is incorrect the EPROM image could be corrupt or could indicate that address decoding logic in the VIC20 is faulty.

An error detected in any of these first 3 tests will cease testing and the display updated to indicate the failure:

VIC Test Failure

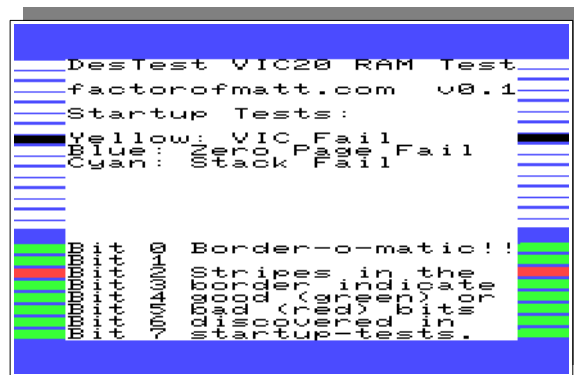
A failure during the VIC test results in a grey border with the failing bits displayed in the bottom part of the screen:



The border-stripes show data bits (D0-D7, top to bottom) that showed inconsistencies while testing the VIC registers. Here we see that data bits 1, 3 and 5 were detected as bad. This may be of diagnostic use if another data attached chip in the system is corrupting the bus – or it may simply indicate a marginal VIC.

Zero Page or Stack Page Failure

A failure during either of these tests results in a blue (zero-page) or cyan (stack page) border plus stripes indicating the fail-address and failed bits:



The border stripes show address bits (A0-A15, top-to-bottom) and data bits (D0-D7, top to bottom). A black address bit is 1, light grey is 0. A green data bit indicates a good bit, red indicates bad. Here we see that data bit 2 was detected as bad and that the most recent memory location found to be bad was \$0080.

Code Checksum Failure

A checksum failure is indicated by a white border and a message indicating the checksum error. Under certain circumstances, the text of this screen may be garbled or otherwise unintelligible. See the Limitations section for details.



Main Tests

After the startup tests complete, we have enough confidence in the system to go ahead and test the rest of available memory. Depending on how much memory is good/present or if the VIC can “see” it properly this screen may be garbled. There are 7 or 8 tests here:

- **Base Memory Tests**
- 0K-1K (blue border) : first 1024 bytes (including the Zero and Stack pages)
- 4K-8K (cyan border): the main 4096 bytes built into the VIC20.
- Colour RAM (purple border): VIC colour information is stored in this region
- **Expanded Memory Tests**
- 1K-4K (yellow border): 3072 bytes such as from a 3K RAM expander.
- 8K-16K (blue border): 8K located at the 8K position (BLK1)
- 16K-24K (cyan border): 8K located at the 16K position (BLK2).

- 24K-32K (purple border): 8K located at the 24K position (BLK3).
- 40K-48K (yellow border): 8K located at the 40K position (BLK5).

Please note: DesTest VIC20 always tests the expanded memory areas if you have this memory installed or not: it really can't tell the difference between completely bad memory and memory that isn't installed. For this reason, the tests will not stop if an error is found in the expanded memory areas.

At the bottom of the screen is the count of the number of times we've looped through all the tests. Each cycle takes less than 30 seconds.

```

DesTest VIC20 RAM Test
Base-Mem
00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000
Expanded-Mem
00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000
Basic-ROM: 0f81381
Character-ROM: 1a48881
* Do Not Distribute! *
Count: 00000
Visit factorofmatt.com

```

The tests will loop forever if no failures are determined.

Any test failure will halt testing, though tests in the current cycle (except possibly All RAM) are finished first: we might as well collect as much information as we can.

The Zero Page, Stack Page, 0K-1K and All RAM tests do not collect error information (since it would be overwritten by the destructive nature of the tests).

Interference in the Border

As each of the memory tests is running you'll notice that the border flickers slightly (it may look like interference). This is entirely intentional and acts to inform you that the tests are still running.

ROM Checksum Display

After each test, the extended (24-bit) checksum of the BASIC and character ROMs are calculated and displayed (kernel checksum too for the cartridge version). If the checksums match those of known 'good' ROMs, then the checksum is displayed in green. If the checksum is unknown, then it is displayed in RED. Should a bad-checksum seem to change after each test, then that is a decent indication that the ROM in question is having electrical issues.

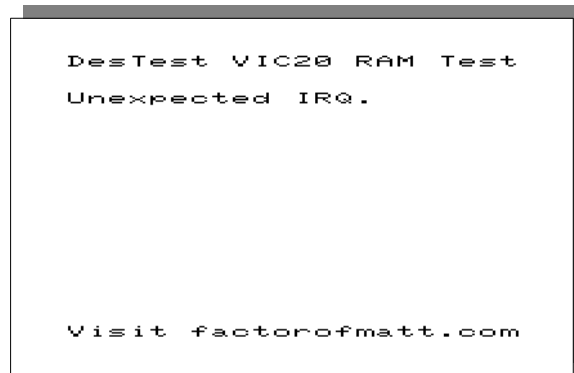
Note: a red checksum doesn't necessarily indicate a bad ROM, just that DesTest VIC20 doesn't recognise it.

Interrupts

An unwanted interrupt could cause havoc during the middle of a test: interrupts write to the stack which really wouldn't be great if we're testing that memory or if that memory is suspect.

IRQ

Under normal circumstances no IRQs should occur during normal DesTestMAX operation. The CPU is left free to respond to IRQs and will display the following screen should any occur.



The receipt of an IRQ during the execution of tests could very well indicate something wrong with the interrupt-signal path or a misbehaving interrupt source (VIC-II, CIA etc.).

BRK

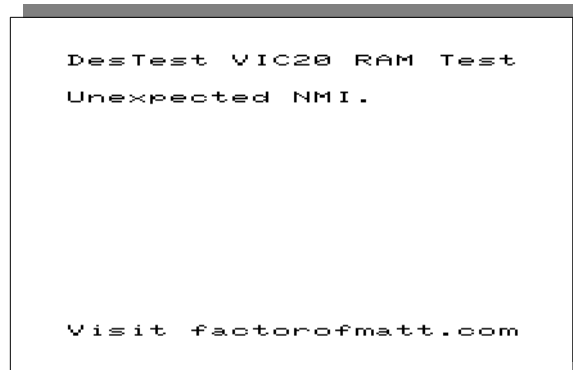
The BRK instruction of the 6502/6510 will interrupt the CPU in much the same way that an IRQ does – though it is straightforward to differentiate the two.



If you see this screen then the CPU has somehow executed a BRK instruction – something that won't happen during the normal operation of DesTestKernal. This might indicate a marginal 6510, PLA or other chip that is affecting data reads.

NMI

NMIs cannot be disabled. The best we can hope is to ensure that any sources of an NMI are disabled. Unfortunately, the RESTORE key when tapped will always generate an NMI and there's really nothing that can be done about it. If an NMI is received, the following screen is displayed:



If you see this screen and did not hit RESTORE then something (CIA) generated an NMI or something is wrong in the NMI signal path.

If you hit the RESTORE key (possibly in frustration if nothing seems to be happening) and you see this screen, then at least you know the CPU works.

Limitations

DesTest '20 does not test memory in the block 2 or 3 I/O regions.

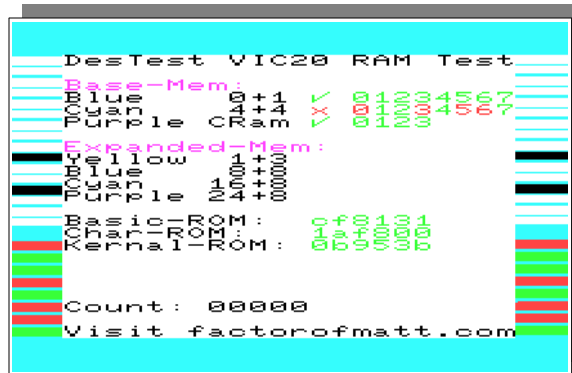
The VIC20 uses main system memory for the display. If this memory is somehow bad then the display may not be readable. In such a case, the border-o-matic bit indicator (see below) can be used to determine which memory chip has the fault.

A bad character ROM will almost certainly cause a corrupt display. While the testing process will continue as normal, the colour of the border and the border-o-matic bit indicator (see below) will really be the only indication of a failure. If the tests continue to run (the border still has interference and changes colour every 30 seconds or so) then your RAM is likely at least good.

Note: DesTest '20 does not currently attempt to copy character data into RAM and display from there. This may change in future versions.

Border-o-matic bit indicator

This silly name refers to the method used to display address and bit information should the VIC-II otherwise not be trusted to generate a useful text display. This simple technique has been used for other retro computer systems and it seems like a cool way to impart diagnostic information when all else fails.



The border is split into 24 'stripes' each that represents a bit:

- A0-A15 (top to bottom) – Address bits.
 - Black for '1', White for '0'.
 - This number represents an address where the memory-test most recently found an error.
 - In cases where no address information can be captured, these 16 stripes are absent.
- D0-D7 (top to bottom) – Data bits.
 - Green for 'good', Red for 'bad'.
 - This value represents a map of RAM data-bits bits where an error was detected. Multiple bits can be flagged as 'bad' and indeed individual bad bits could come from different addresses.

The address shown (if present) will be that of the most-recent error found. This will usually correspond to the lowest faulty memory address of the region being scanned by nature of how the memory is tested. The good/bad bits do not represent any specific byte in memory, rather just an indication of bit-positions that showed an error at some address or other. Different revisions of the VIC20 use different configurations of physical RAM chips for storage. To map a bit number to a specific chip, See the VIC20 Hardware Considerations section.

If the border-stripes are shown then testing ceases so the information conveyed may be recorded. A power-cycle or reset is required to re-run the tests.

Testing methodology

The memory testing algorithm used in DesTest '20 is called March-B. A good description of common memory problems and test methodologies can be found here:

<<https://redirect.cs.umbc.edu/~reza2/courses/418/Slides/15MemoryTest.pdf>>

The March B test performs 4 testing passes over the memory-region-under-test and ultimately verifies that any read or operation performed on a given bit is correct and doesn't affect any other bits in the region. The test is order $17N$ meaning that each bit under test is written and read a total of 17 times during the test. The test of the entire 37K VIC20 memory space takes about 2 minutes.

Good care has been taken to ensure that no assumptions are made about the validity of memory before it has been tested. Neither Zero Page nor the Stack are used before those two memory regions have been verified since errors in either would cause havoc with the running code.

VIC20 Hardware Considerations

Commodore released multiple revisions of the VIC20 motherboard over the years. While these revisions remain mostly compatible with each other, there are a few differences that should be considered when attempting to diagnose a faulty machine.

RAM data bit / address to IC mapping

DesTestKernal helpfully indicates which RAM data-bits seem to be misbehaving but does not indicate the specific ICs that need to be replaced or investigated. This is for the simple reason that different revisions of the motherboard have different arrangements of RAM ICs and differing part identification numbers. This table will help you map bit numbers to specific ICs on your motherboard.

Assy 32400? (2 pin power connector)				Assy 250403 (7 pin power connector)		
Address	Data Bits	Rev D	Rev E	Address	Data Bits	IC
		IC	IC			
0K-1K	0-3	UD2	UB2	0K-1K	0-3	UD2
	4-7	UE2	UA2		4-7	UE2
4K-5K	0-3	UD3	UB3	4K-6K	0-7	U15
	4-7	UE3	UA3			
5K-6K	0-3	UD4	UB4	6K-8K	0-7	U14
	4-7	UE4	UA4			
6K-7K	0-3	UD5	UB5	6K-8K	0-7	U14
	4-7	UE5	UA5			
7K-8K	0-4	UD6	UB6	Colour	0-3	UE1
	4-7	UE6	UB6			
Colour	0-3	E1	UC3	Colour	0-3	UE1

From Matt

Though I've worked hard to ensure that DesTest '20 will give reliable, accurate results under the widest set of circumstances I just haven't been able to physically test much more than removing chips and inducing incorrect behaviour with jumper wires.

I'd like to see how DesTest '20 works out there in the real world. I'd like to hear about your experiences:

- Does it work at all for you?
- Does it reliably show a specific, traceable fault?
- Does it give misleading or plainly incorrect results?
- Could it be made more useful?

Please send feedback to destest@factorofmatt.com

Thank you, -M@