

bso2 Monitor Reference

Target: W65C02EDU | Source: SRC/bso2.asm | Generated: 2026-02-14

0) Naming

bso2 is the preferred written form in this manual.

It is intentionally dual-meaning and retro-styled:

- b = Basic
- s = System
- 0 = Operations (also read as letter O)
- 2 = /2 and 6502 lineage

Stylized-glyph note: 6 can stand in for lowercase b, and 5 can stand in for lowercase s.

That makes 6502 a visual shorthand for bso2 (6=b, 5=s, 0=o, 2=/2).

Expanded meaning: Basic System Operations/2.

1) Startup / Prompt Behavior

On reset with valid reset cookie, boot choices are C/W/M:

C = clear RAM (confirm Y/N)

W = warm start

M = enter monitor

After clear/startup, the sign-on banner (BS02_INIT) is printed:

```
**** basic system operations/2 ****
****   b s o / 2  v0 . 9   ****
****       6 5 0 2       ****
```

Monitor prompt is a single - character on a new line.

2) Command Summary

Cmd	Syntax	Behavior / Output	Flags / Notes
?	?	Short help line.	Quick command list only.
H	H	Full multi-line help.	Includes interactive caveats.
Z	Z	Clear RAM after Y/N confirmation.	Zeroes \$0200-\$7EFF. Does not zero \$0000-\$01FF (ZP/stack) or \$7F00-\$7FFF (I/O area).
W	W	Warm start back into monitor.	No args.

D	D [START [END]]	Hex+ASCII dump. END is inclusive.	D alone repeats last span from next address. Hex/ASCII fields show an 8+8 split.
U	U START END	Disassemble as 65C02 mnemonics and operands.	END is inclusive. Emits ADDR: MNM OPERAND .
A	A START [INSN]	Tiny 65C02 assembler, interactive at next address.	Example: A 1000 LDA #FF then prompt A 1002: . . exits. No labels/forward refs. Relative branches accept absolute hex targets and are range-checked. Explicit accumulator form like INC A is supported.
X	X START	Execute from absolute address.	Transfers control via RTS trampoline. NMI while running under X breaks back to monitor; target RTS also returns to monitor.
R	R [A=HH] [X=HH] [Y=HH]	Resume last debug context.	Restores A/X/Y/P/SP/PC from latest debug snapshot and resumes via RTI . Optional A/X/Y overrides are applied first. Up-arrow repeat is useful for single-step resume loops.
N	N	Run to next sequential instruction.	Implements next-stop by patching a temporary BRK at PC+len(opcode) . RAM only; ROM/I/O patch targets are rejected. Debug output restores and displays the original stepped-to instruction in PREV: .

M	M [START [B0..B15]]	Modify/deposit memory. Inline deposit supports up to 16 bytes.	Interactive mode: CR/LF = next, . ends. CRLF pair counts as one next.
F	F START END B0..B15	Fill inclusive range with repeating 1..16 byte pattern.	No interactive mode. Verifies each write.
C	C SRC_START SRC_END DST_START	Copy inclusive source range to destination.	Overlap-safe (forward/backward selection). Verifies each write.
!	! F ..., ! M ..., ! C ..., ! A ..., ! N	Force-prefix for protected commands.	Allows access to protected low RAM (\$0000-\$03FF).
Q	Q	Enter WAI halt loop.	IRQ masked. Resume by NMI (or Reset). NMI latch returns cleanly to monitor.
V	V	Show vector jump chains.	Displays HW vector to final code path.

3) Interactive Caveats

- **M** interactive: two hex digits are required per byte write (00..FF).
- **A** interactive: type one mnemonic/operand per prompt, . exits assembler mode.
- . exits interactive modify and retains next-address state for subsequent **M**.
- CR or lone LF advances to next address.
- CRLF pair is consumed as a single next-step.
- **F** does not support interactive mode.
- At an empty monitor prompt, Up Arrow (ESC [A) repeats and executes the previous command.
- F/M/C/A/N block access to \$0000-\$03FF unless prefixed with **!**. **D** is always allowed.

4) Verify / Error Outputs

Operation	Message / Behavior
Modify verify fail	M VERIFY FAILED AT ADDR + failing address.
Fill verify fail	F VERIFY FAILED AT ADDR + failing address.
Copy verify fail	C VERIFY FAILED AT ADDR + failing address.
Dump range error	D RANGE ERROR .
Unassemble range error	U RANGE ERROR .
Assembler branch range error	A BRANCH RANGE ERROR .
BRK debug context	Printed as three lines: PREV: (instruction at BRK opcode), TRAP: (register/status line), then NEXT: (instruction at resume PC). For

	N-generated temporary breaks, PREV: shows the restored original instruction.
Bad syntax	Per-command usage lines (e.g. USAGE: M [START [B0..B15]]).

5) API Reference (Macros and Functions)

Use this section when calling monitor functionality from your own assembly code.

5.1) Macro Reference (macros.inc)

Macro	Parameters	Behavior / Notes
PUSH	PUSH p1 [,p2] [,p3] [,p4]	Pushes listed registers in given order. Supported tokens: A/X/Y/P (case-insensitive).
PULL	PULL p1 [,p2] [,p3] [,p4]	Pops listed registers in given order. Keep ordering compatible with prior PUSH.
REPEAT	REPEAT Routine, Count	Calls JSR Routine repeatedly Count times. Preserves X via push/pull.
PRT_CSTRING	PRT_CSTRING Label	Prints null-terminated string at Label via PRT_C_STRING.
DUMP	DUMP Start, EndExclusive	Convenience wrapper for MEM_DUMP with explicit exclusive end.
FILL	FILL Start, EndInclusive, B0 [,B1] [,B2] [,B3] [,B4]	Loads pattern bytes (1..5) and calls MEM_FILL_PATTERN. End is inclusive in macro syntax.
COPY	COPY SrcStart, SrcEndInclusive, DstStart	Calls overlap-safe MEM_COPY_RANGE. Source end is inclusive in macro syntax.
COPY_BLOCK	COPY_BLOCK SrcStart, Length, DstStart	Compatibility wrapper that expands to COPY SrcStart,(SrcStart+Length-1),DstStart.
CMP_CSTRING	CMP_CSTRING AddrA, AddrB	Wrapper for project-specific string compare symbols/routine (STRCMP_PTR*, STR_COMPARE). Use only when those symbols are provided by your build.

5.2) Callable Function Reference

Practical entry points for extensions and integration.

Routine	Input	Output	Flags	ZP / Memory Use
INIT_SERIAL	None	UART initialized	Unchanged	None
WRITE_BYTE	A=char	Char sent to UART, LED updated	Unchanged	None
READ_BYTE	None	A=received char (ROM read)	ROM-defined	None
CHECK_BYTE	None	A=status	C=1 if RX empty	None

RBUF_INIT	None	Input ring reset	Unchanged	Uses generic buffer descriptor core
BUF_INIT	Active descriptor pointers set	Head/Tail/Count zeroed	Unchanged	Uses BUF_*_PTR
BUF_PUT_A	A =byte	Byte queued	C=0 stored, C=1 full	Uses BUF_*_PTR , BUF_SIZE
BUF_GET_A	None	A =byte	C=0 byte, C=1 empty	Uses BUF_*_PTR , BUF_SIZE
CMD_DISPATCH	A =command letter	Handler called from table	C=0 handled, C=1 unknown	Uses CMD_TABLE , CMD_POST_ACTION
MEM_DUMP	PTR_DUMP_CUR =start (inc), PTR_TEMP =end (exc)	Formatted hex+ASCII dump with 8+8 separator	Unchanged	Uses PTR_DUMP_CUR , PTR_DUMP_END , PTR_LEG , MEM_DUMP_CNT
MEM_DISASM_65C02	PTR_DUMP_CUR =start (inc), PTR_TEMP =end (inc)	65C02 disassembly output (ADDR: MNM OPERAND)	Unchanged	Uses PTR_DUMP_CUR , PTR_DUMP_END , PTR_TEMP , PTR_LEG , DIS_*
MEM_FILL_PATTERN	PTR_DUMP_CUR =start (inc), PTR_DUMP_END =end (exc), F_COUNT =pattern length, F_PATTERN =pattern bytes	Fills range with repeating pattern	C=0 complete, C=1 aborted (verify/protect)	Uses PTR_DUMP_CUR , PTR_DUMP_END , F_COUNT , F_PATTERN , F_PAT_IDX
MEM_COPY_RANGE	PTR_LEG =src start (inc), PTR_DUMP_END =src end (exc), PTR_TEMP =dst start	Copies source to destination (overlap-safe)	C=0 complete, C=1 aborted (verify/protect)	Uses PTR_LEG , PTR_DUMP_CUR , PTR_DUMP_END , PTR_TEMP , CMD_PARSE_VAL
CMD_DO_ASM	CMD_LINE = A START [INSN]	Interactive tiny assembler	. exits	Uses CMD_LINE , PTR_TEMP , opcode tables, and ASM_* / DIS_* scratch

6) Parser and Buffer Limits

- CMD_MAX_LEN = 31 characters (excluding null terminator).
- RBUF_SIZE = 32 bytes.
- One-command history is kept for up-arrow repeat (CMD_LAST_LINE).
- Hex token parser accepts 1..4 hex digits, optional \$ prefix.

- `M` and `F` inline byte lists: max 16 bytes each.
- `!` is consumed as a command prefix, then normal parsing continues.

7) Memory Usage

Build Section Usage (current)

Section	ORG	Size (hex)	Size (dec)
PAGE0	\$0040	\$4A	74
CODE	\$8000	\$1A22	6690
KDATA	\$E000	\$B25	2853
UDATA	\$0200	\$7A	122
Total	-	\$260B	9739

RAM Layout Highlights

- PAGE0 starts at \$0040. Includes parser state, dump state, debug snapshot, vector hooks, and active buffer descriptor pointers.
- UDATA starts at \$0200:

```

RBUF_DATA    32 bytes
CMD_LINE     32 bytes (31 + NUL)
CMD_LAST_LINE 32 bytes (31 + NUL)
RESET_COOKIE  4 bytes
F_PATTERN    16 bytes
DBG_TAG_BUF   6 bytes

```

8) Notes for Integrators

- Command parser uppercases incoming command bytes before parse/dispatch.
- Command execution is table-driven via `CMD_TABLE`.
- Input buffering now uses a generic descriptor-based core bound to the ring buffer.
- `Q` path relies on NMI latch (`SYSF_NMI_FLAG_M`) and then re-enters monitor cleanly.

9) Planned Commands (Appendix, Provisional)

This appendix documents planned command architecture and roadmap intent only.

Proviso: change is constant. These plans are not stable API and may change before publish.

9.1) Grammar Direction

- Primary model: noun verb [args...] (namespace first, action second).
- Direct-action commands may still exist where practical (for example jump/execute style flow).
- Parser should accept both spaced and fused forms for operator speed.

9.2) Canonical Input Compatibility

- `X S` and `XS` should map to the same internal command key.
- `X R` and `XR` should map to the same internal command key.
- `M D` and `MD` should map to the same internal command key.
- `I O V` and `IOV` should map to the same internal command key.
- One canonical dispatch representation is preferred to avoid duplicate handlers.

9.3) Namespace Plan

Root	Planned Role	Notes
B	Bank / FLASH	Reserved for FLASH-related operations (read/program/erase/verify family).
I	Info root	Carries nested subfamilies such as time and I/O.
I T	Time	Time moves under Info; top-level T is freed.
T	Terminal	Repurposed top-level namespace for terminal-related operations.
I O P	PIA	Top-level P is freed; PIA moves under Info/I/O.
I O V	VIA	Top-level V is freed; VIA moves under Info/I/O.
I O V T	VIA timers	Hardware timers are expected under VIA tree.
J	Jump / Execute	Preferred home for execute flow if top-level execute letter changes.
X	Transfer / XMODEM	At minimum: send and receive support.
S	Search	Text and binary search families.
M	Memory family	Supports compact forms such as MD/MM as aliases.
O	Deferred decision	Candidate: chained execution wrapper; decision postponed.

9.4) Search Family Detail

- Planned base forms: **S C** START END <text> and **S B** START END <pattern...>.
- S C** mode: unquoted text stops at first whitespace.
- S C** mode: quoted delimiters can include `"`, `'`, and ```.
- S C** mode: delimiter escape by doubling delimiter character.
- S C** mode wildcards: `?` matches exactly one character, `*` matches zero or more characters.
- S C** mode literals: `??` matches literal `?`, and `**` matches literal `*`.
- S B** mode tokens: **HH** byte, **HHHH** little-endian word, nibble wildcard (`?A/A?/??`), and `*` byte wildcard.
- Candidate extensions: Pascal strings and high-bit-set text search modes.

9.5) XMODEM Requirement

- Before publish, provide both XMODEM receive and send paths.
- Preferred forms: **X R ...** and **X S ...** with fused aliases (**XR**, **XS**).

9.6) Vector + Safety Direction (Pre-Publish Requirement)

- Vector updates must support dynamic atomic update behavior.
- Critical windows include vector commit and FLASH routines.
- During critical windows, all EDU LEDs should flash to signal that NMI should not be pressed.
- NMI path should be guarded/deferred during critical windows instead of normal debug flow.
- Staged-update plus atomic-commit behavior is the intended implementation pattern.
- Mandate (non-changing requirement): any operation that mutates FLASH state or vector state must assert critical indication/guard behavior, including module/transient load paths; implementation detail may change, requirement does not.

9.7) Deferred Item

- O** command semantics are intentionally deferred.

- If adopted as an operation chain wrapper, error policy and guard policy must be defined explicitly.

9.8) Compression + TX Ring (Priority 0)

- Priority 0 roadmap item: reduce monitor-text ROM footprint with compression.
- Planned model: tokenized text plus RLE.
- RLE threshold: encode runs of 3 or more consecutive bytes.
- Frequent-byte run tokens are planned for `space`, `-`, `0`, `1`, and `*`.
- Decompression direction is ROM compressed stream to output sink (UART stream directly or TX/RAM staging).
- A dedicated TX ring buffer is planned for nonblocking output.
- Decoder should be pausable/resumable when TX ring space is exhausted.
- RX and TX buffers remain separate.
- Default virtual-stream plan: one shared TX ring with scheduling/priority policy.
- Per-stream TX rings are optional and should be introduced only if stream isolation/QoS is required.
- Raw/uncompressed source strings remain in assembly source as authoring truth.
- Planned build flow: marked header/trailer string regions are consumed by a GNU C packer that generates an assembler include.

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