


GNU as Assembler for HC11

- Modern, "single pass" assembler
 - Converts mnemonics to machine code
 - Labels sections (*e.g.*, code)
 - Labels entry points (*e.g.*, function)
 - Handles forward and backward references
 - Can choose smallest jump instruction (jmp/bra, etc)
 - Can generate a listing and map
 - Reports any errors
 - Generates ELF (Executable and Linking Format)
 - In particular, a "relocatable file"
 - Code and data sections located later by linker
- Used automatically by gcc (C++ compiler)


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Assembler labels

- Labels are not limited in length
- Regular labels must be unique in source file
 - Must be unique among all files if global
- Begin with A-Z a-z . \$ _
- Legal subsequent characters (0-9 A-Z a-z \$ _)
- The colon (:) terminates a label

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Local assembler labels

- Local labels are 1 to maxPositiveInteger
- Scope
 - Back to same label or beginning of file
 - Forward to same label or end of file
- Must specify whether you want the
 - next (f – forward) matching label
 - or the previous (b – backward) one
 - Otherwise, the number is interpreted as a relative addressing mode offset!

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Local label example

```

int g;                ldx word_g
char h, i;           cpx #100
...                  bge 1f
if (g < 100)         ldaa #5
    h = 5;           staa byte_h
else                 bra 2f
    i = 2;           1: ldaa #2
...                  staa byte_i
                    2: ...

```

Draw a flow chart for both pieces of code.

Numbers

- Radix prefixes
 - 0b, 0B – binary (0b11000001)
 - 0 – octal (0377)
 - 0x, 0X – hexadecimal (0xFF, 0x5a)
- All values decimal unless specified

Sections

- .section *name*
 - Standard ones are:
 - .bss – uninitialized, mutable data (“block started by symbol”)
 - .data – initialized, mutable data
 - .rodata – initialized, read-only data
 - .text – code

Data storage (1/2)

	Byte	Word
Reserve but don't initialize	.space N .rmb N	.ds N
Reserve and initialize	.byte 0xAB,fcb 0x3F,word 0x1234, ...

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Data storage (2/2)


- Strings
 - .ascii "string" – stores ASCII characters
 - .asciz "string" – zero byte inserted at end (standard C string termination)
- Data in .bss will not be initialized (*i.e.*, not included in download image), **even if** you use .byte, .word, etc.

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Other Assembler Directives

- .global sym1 – define global symbols
 - For linking multiple modules
- .include "name" – include another source file


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Invoking the assembler

- `as`
 - `-o output.o` – specify output file
 - `input.s` – specify input file(s)
 - `-a` – output a listing (only relative addresses)
 - `-v` – version information
- Documentation:
 - GNU 68HC11 | Assembler


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Invoking the linker

- `ld`
 - `scriptname.x` – usually `.x` (e.g., `fox11w.x`), linker configuration, especially memory layout – where to put the sections in memory (RAM, ROM, data, code, etc.)
 - `-o output.elf` – specify output file
 - `input.o` – specify input files (extension doesn't matter, internal data does)
 - `-r` – relocatable link (incremental)
 - `-v -V` – version information (and more)
 - `-relax` – replace extended addressing mode with relative or direct mode when possible

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Simulator

- Wookie, latest version 1.71
- Simulator
- Can view memory, registers
- Emulates a matrix keypad (but not Fox11's)
- Can see port status (but not Fox11 special ports)
- Can single step even through interrupts
- Missing: A/D, handshaking

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