01

Fundamentals of Embedded C Programming

Embedded C Programming

Automation Engineers

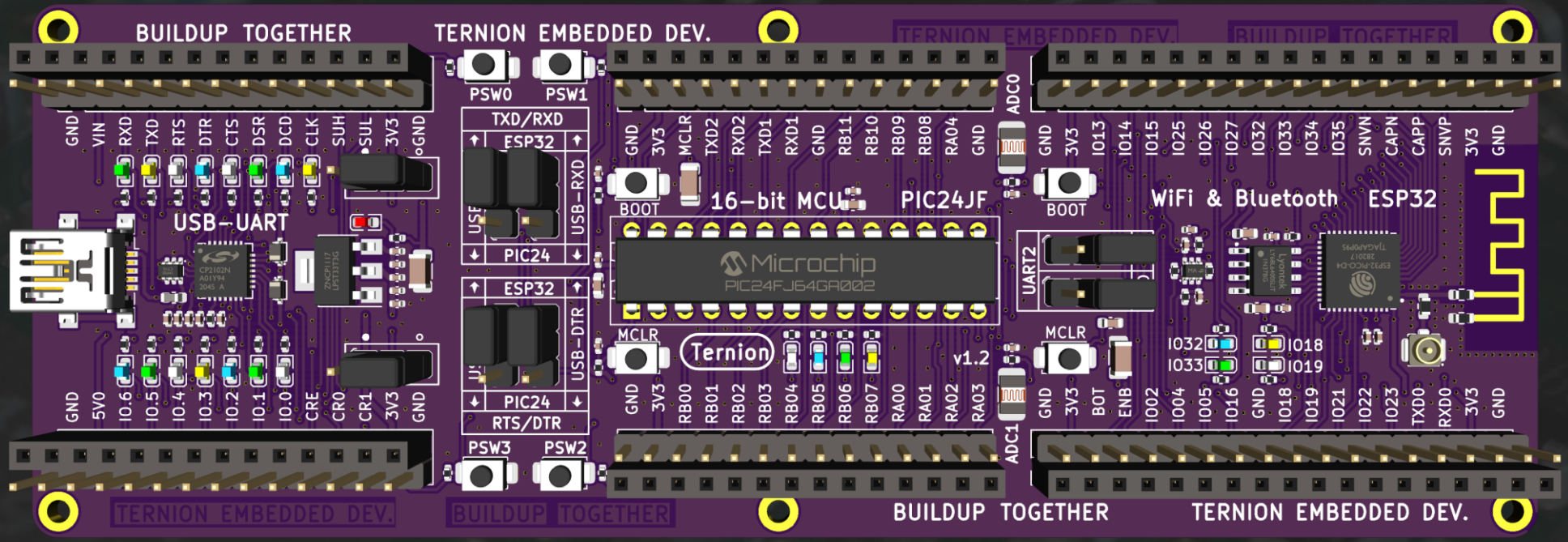
Embedded Systems

Hardware

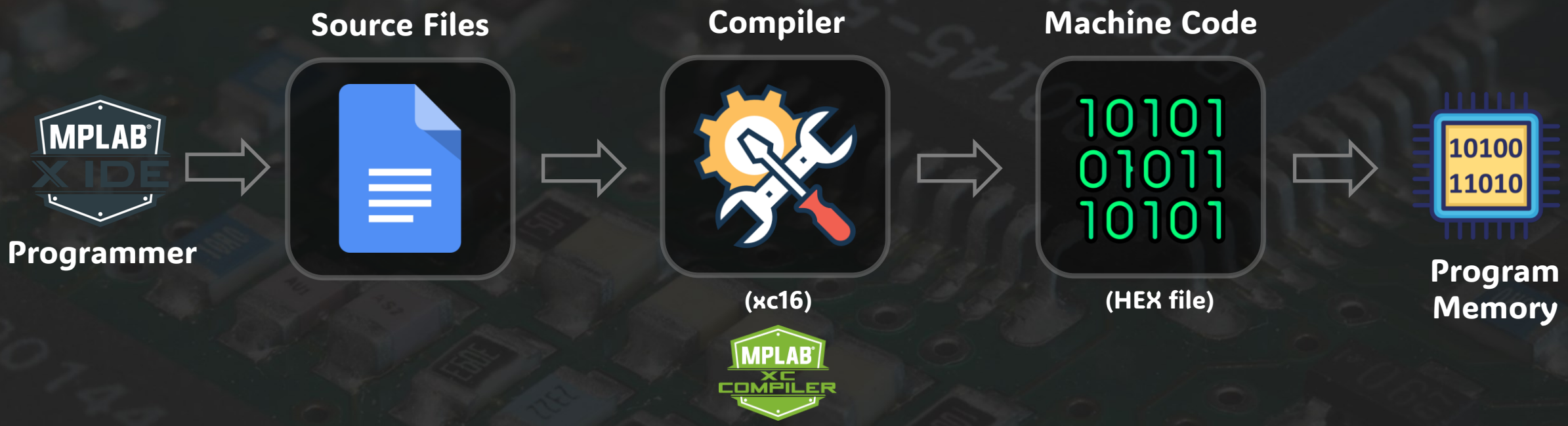
Electronic & Digital Circuits

Software (Firmware)

Assembly & C Programming

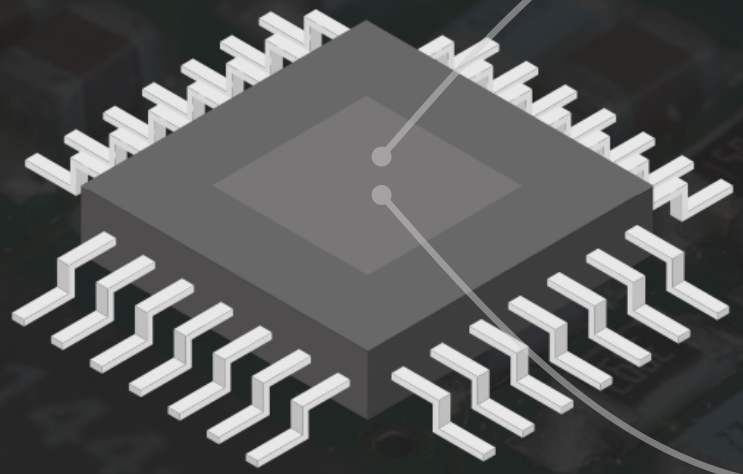


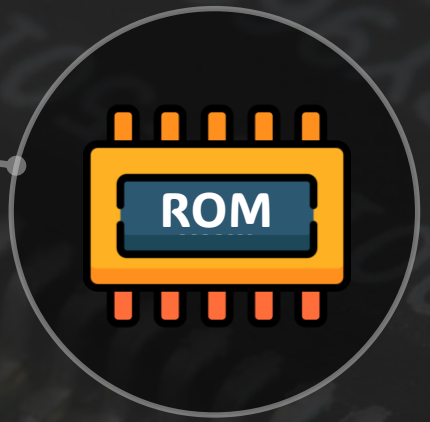
C Program (Code) → Machine Code



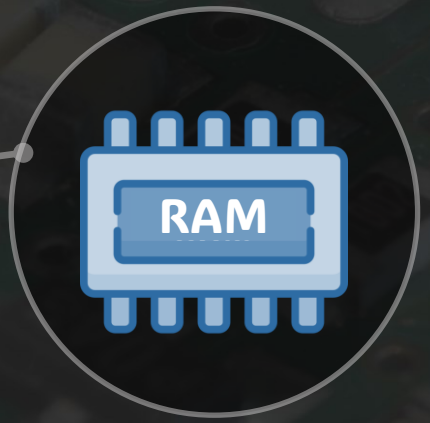
C source files will be compiled to machine code and sent to the program memory of the microcontroller

ROM and RAM



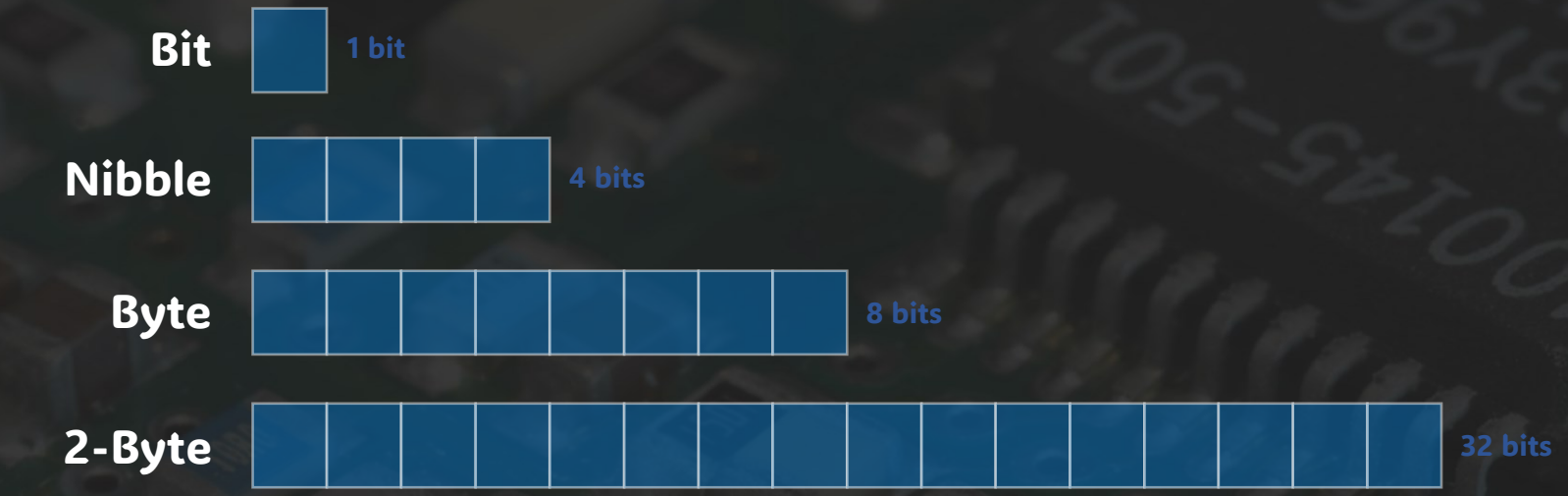


ROM: Read-Only Memory
(Program Memory)



RAM: Random-Access Memory
(Data Memory)

Data



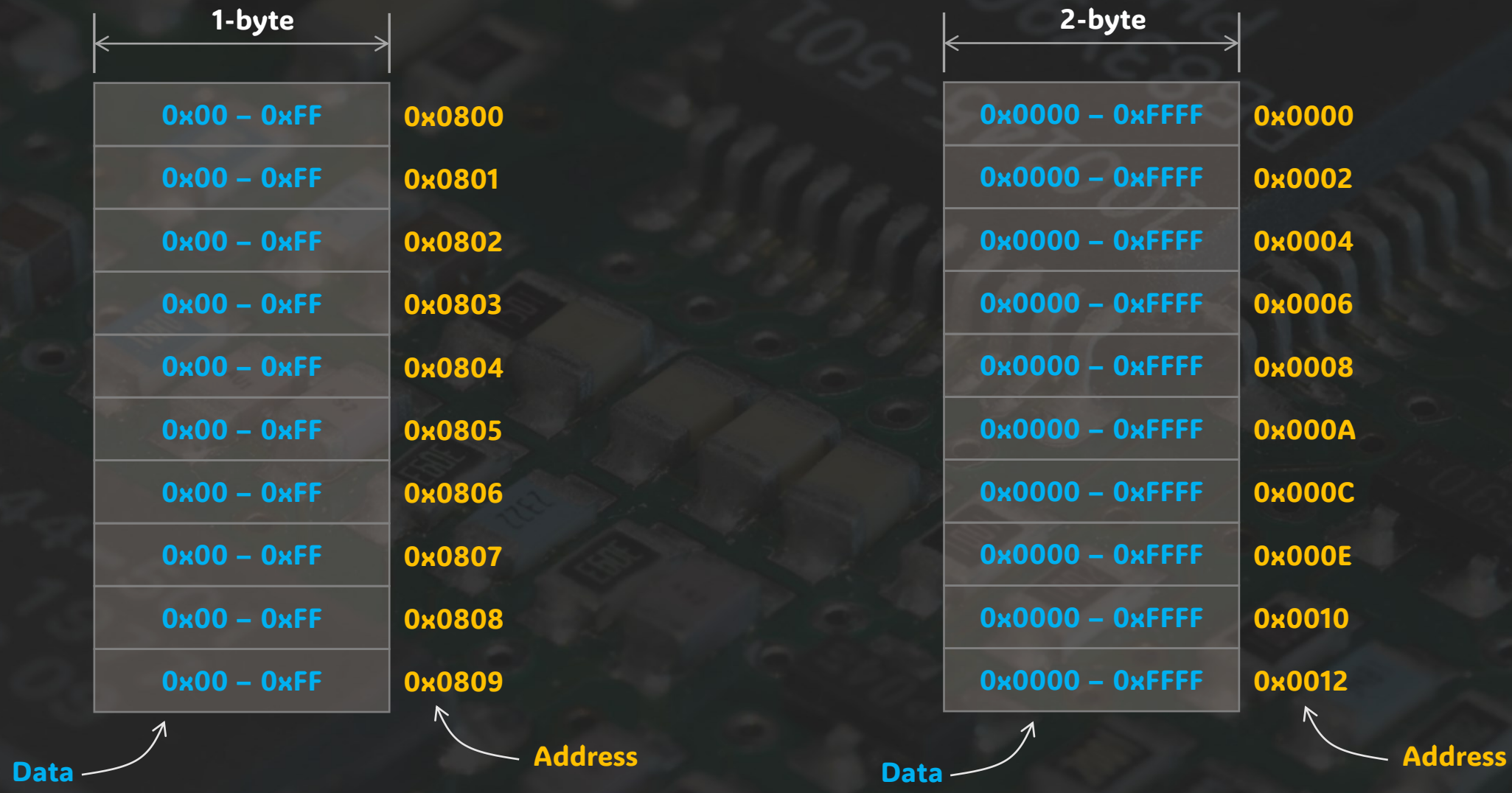
signed unsigned	bool char int long float double

4, 8, 16, 32, 64, ...

In digital computers, DATA serves as the versatile representation of various entities. computers, the DATA are used to represent anything.

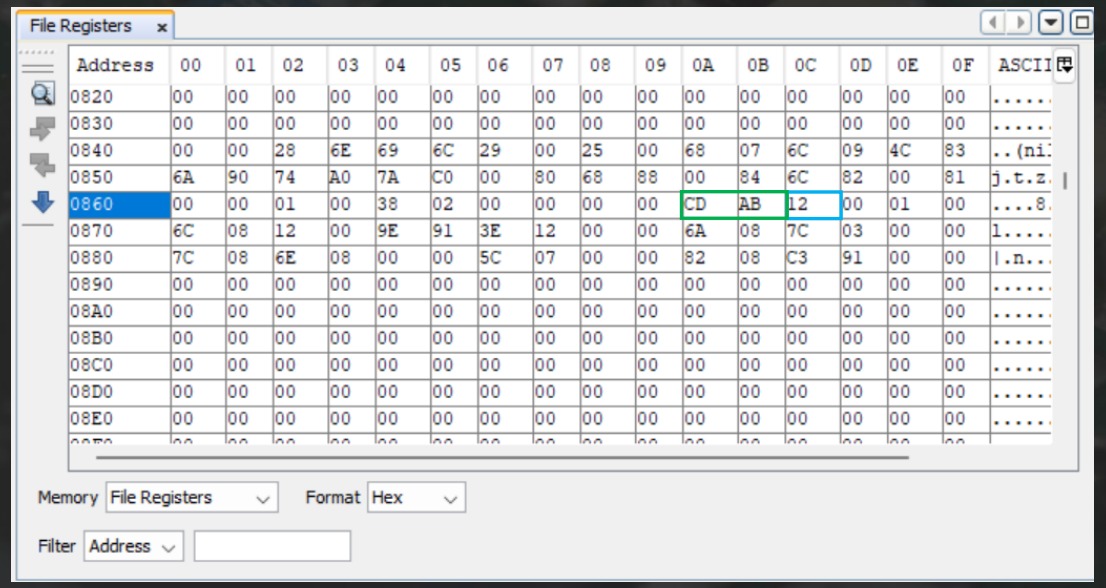
Programmers need a clear understanding of both data types and data sizes.

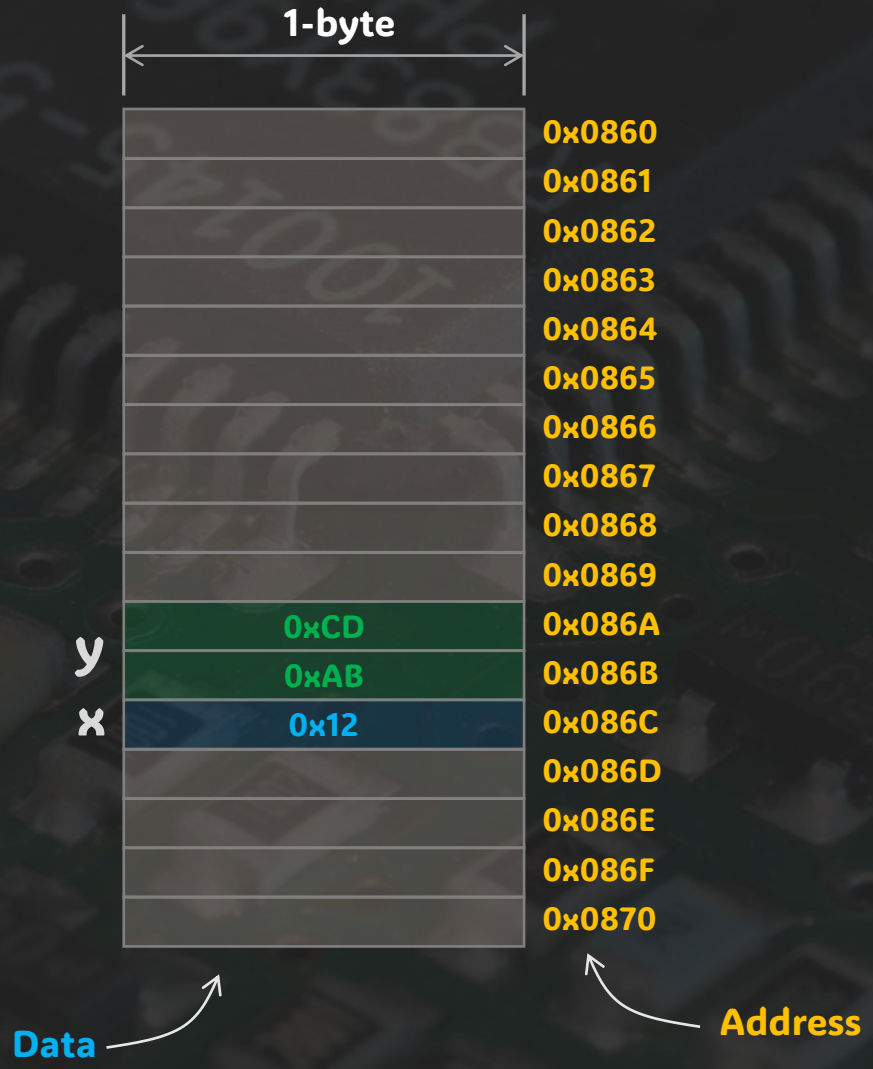
Memory (Data, Address, Size)



Variables → Data Memory (RAM)

```
unsigned char x = 0x12;
unsigned char y = 0x34AB;
```





C Code → Assembly Code → Machine Code → Program Memory (ROM)

C Code

```
1
2   #include "xc.h"
3   #include <stdio.h>
4   int main(void) {
5       unsigned char x = 0x12;
6       unsigned int y = 0xABCD;
7       unsigned long z = x + y;
8       return 0;
9   }
10
```

Assembly Code

```
1   !int main(void) {
2   0x2CE: LNK #0x8
3   !    unsigned char x = 0x12;
4   0x2D0: MOV.B #0x12, W0
5   0x2D2: MOV.B W0, [W14]
6   !    unsigned int y = 0xABCD;
7   0x2D4: MOV #0xABCD, W0
8   0x2D6: MOV W0, [W14+2]
9   !    unsigned long z = x + y;
10  0x2D8: ZE [W14], W1
11  0x2DA: MOV [W14+2], W0
12  0x2DC: ADD W1, W0, W0
13  0x2DE: CLR W1
14  0x2E0: MOV W0, [W14+4]
15  0x2E2: MOV W1, [W14+6]
16  !    return 0;
17  0x2E4: CLR W0
18  !}
```

Machine Code

Address					ASCII
0260	4484E2	B4A032	BA0699	4484E2	..D.2... ......D.
0268	B4A032	EB0600	DE6F47	B207FD	2....... Go......
0270	E16C63	3A0003	07FFEB	EB0000	cl....:. ....
0278	37000A	E16C60	3A0004	EB5D00	..7.`l.. ..:...].
0280	E9058B	3EFFFD	370004	E16861	......>. ..7.ah..
0288	320001	EB8600	07000B	BAC719	..2..... ....
0290	BA0519	E0040E	3A0003	E0000A	....:.....
0298	3AFFE0	060000	B207FE	88019E	..:..... ....
02A0	78048A	37FFF5	BA5D39	E9058B	..x...7. 9]......
02A8	32000C	BA5D29	E9058B	320008	..2.]... ......2.
02B0	E0000C	3A0003	4484E2	B4A032	......:. ..D.2...
02B8	37FFF5	BADD19	E9058B	3AFFFA	..7..... ......:.
02C0	E80489	4484E1	B4A032	060000	.....D. 2.......
02C8	DA4000	FE0000	050000	FA0008	.@...... ....
02D0	B3C120	784F00	2ABCD0	980710	....0x. ..*.....
02D8	FB809E	90001E	408000	EB0080	....@.....
02E0	980720	980731	EB0000	FA8000	...1... ....
02E8	060000	FFFFFF	FFFFFF	FFFFFF	....
02F0	FFFFFF	FFFFFF	FFFFFF	FFFFFF	....
02F8	FFFFFF	FFFFFF	FFFFFF	FFFFFF	....
0300	FFFFFF	FFFFFF	FFFFFF	FFFFFF	....
0308	FFFFFF	FFFFFF	FFFFFF	FFFFFF	....
0310	FFFFFF	FFFFFF	FFFFFF	FFFFFF	....
0318	FFFFFF	FFFFFF	FFFFFF	FFFFFF	....

Memory: Program Memory Format: Hex

Filter: Address

3-byte

Machine Code	Address
0xFA0008	0x02CE
0xB3C120	0x02D0
0x784F00	0x02D2
0x2ABCD0	0x02D4
0x980710	0x02D6
0xFB809E	0x02D8
0x90001E	0x02DA
0x408000	0x02DC
0xEB0080	0x02DE
0x980720	0x02E0
0x980731	0x02E2
0xEB0000	0x02E4
0xFA8000	0x02E6
0x060000	0x02E8
0xFFFFFF	0x02EA
0xFFFFFF	0x02EC
0xFFFFFF	0x02EE

For PIC24, each block of program memory has 3 bytes, and it takes 2 addresses.

Machine Code

Address

Let's Programming (MPLAB X IDE)