Code space (binary)	Code space (hex)	Type	Number of instructions	Note
00_0000_0000_0000	00h	Special instruction (S type)	1	NOP (no operation)
00_0000_0001_0000 – 00_0000_0001_1111	10h-1Fh	Special instruction (S type)	1	01h-1Fh: comparator
00_0001_0000_0000 – 00_0001_1111_1111	100h-1FFh	Unconditional jump (I type)	1	GOTO
00_0010_0000_0000 – 00_0010_1111_1111	200h – 3FFh	ALU instructions (M type)	32	16 instructions, 2 destination choises
00_0100_0000_0000 – 00_0111_1111_1111	400h – 7FFh	Conditional jump (I type)	4	JZ, JC, JS, JO
00_1000_0000_0000 – 00_1111_1111_1111	800h - FFFh	ALU instructions (I type)	8	Currently 7 used, 1 free slot
10_0000_0000_0000 – 11_1111_1111_1111	2000h – 3FFFh	UART instructions (U type)	2	Transmit (TX) and Receive (RX)

S type:

00_0000_0000_0000: No operation.

00_0000_0001_0000 – 00_0000_0001_1111: **4-bit comparator** - bits [0:3] are compared to bits [0:3] of Accumulator.

I type:

00_0001_0000_0000 – 00_0001_1111_1111: **Unconditional jump** – bits [0:7] are the destination of the jump (PC = [0:7]).

00_0100_0000_0000 – 00_0111_1111_1111: **Conditional jump** – bits [8:9] determine which condition is required for jump, bits [0:7] are the destination of the jump. If condition is not met, PC is incremented by 1 (by ADDER).

00_1000_0000_0000 – 00_1111_1111_1111: **ALU instructions** – operations done on value in Acc [0:7] and bits [0:7]. Bits [8:10] determine the ALU operation.

M type:

00_0010_0000_0000 – 00_0010_1111_1111: **ALU instructions** – operations done on value in DR [7:0] (Data memory) and value in Acc [7:0].
Bits [0:3] are the address of data memory (DMEM [ ]), bits [4:7] determine the ALU operation.

U type:

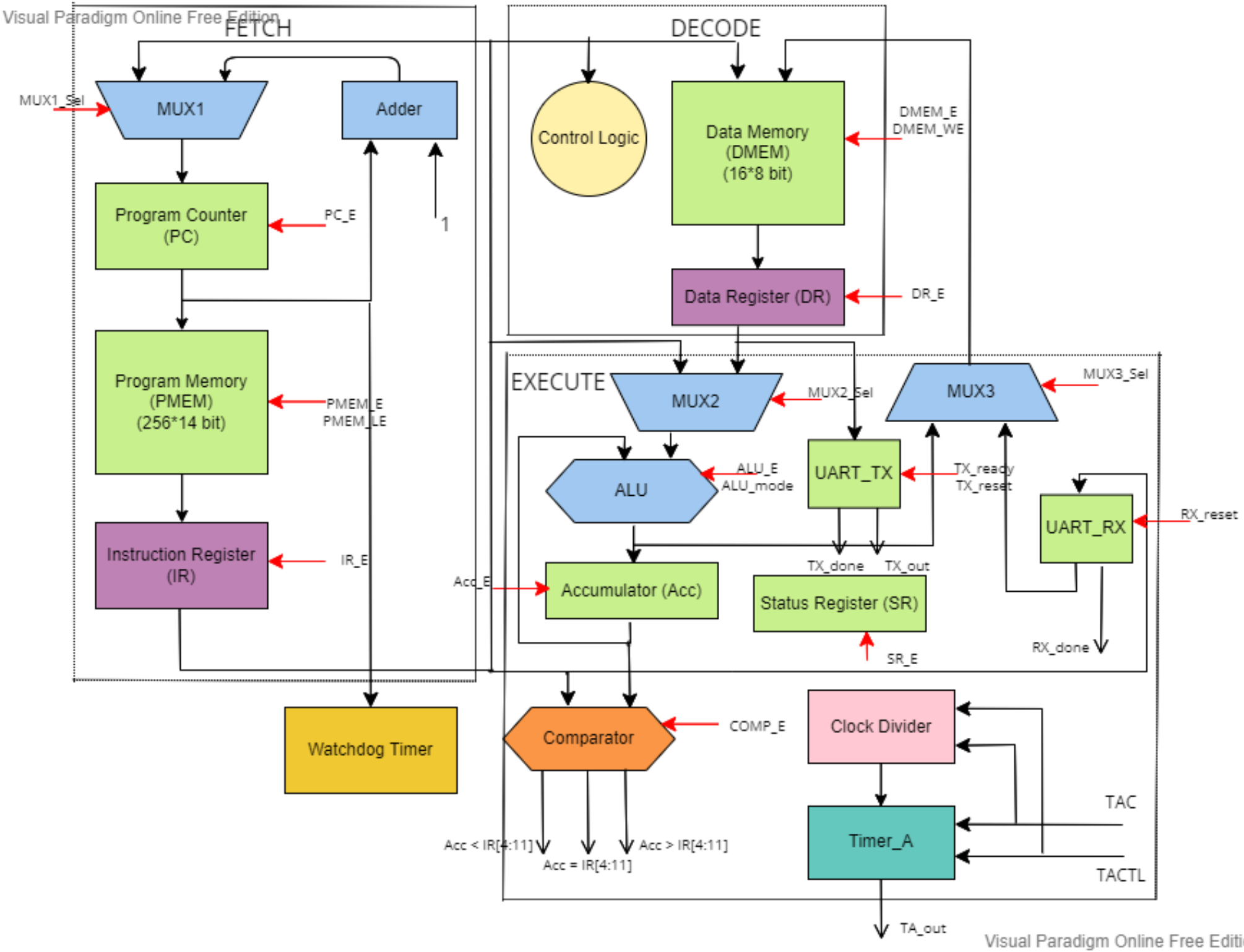
10_0000_0000_0000 – 11_1111_1111_1111: **UART instructions** – bit [12] determines the instruction (RX or TX), bits [0:3] are the address to write to or read from, bits [4:11] are the value to write into Data memory (DMEM [ ]).

Timer_A

Bits [0:3]: clock input divider 0001 – 1111 -> /1 - /15
Bit 4: enable timer
Bits [5:6]: 00 Stop mode: the timer is halted.
01 Up mode: the timer counts up to TAC.
10 Continuous mode: the timer counts up to 0FFh.
11 Up/Down mode: the timer counts up to TAC then down to 00h.

Watchdog Timer (Starts at a number and counts down every clock cycle, if it gets to zero and it did not detect a value change resets the system).

Infinite Program Counter (PC) loop: if in 16 clock cycles PC is not changed the Watchdog timer resets the microcontroller to LOAD mode.



Original Diagram of microprocessor from: https: //www.fpga4student.com/2016/11/verilog-code-for-microcontroller.html