

# Tiny CPU – Data Path (2B)

---

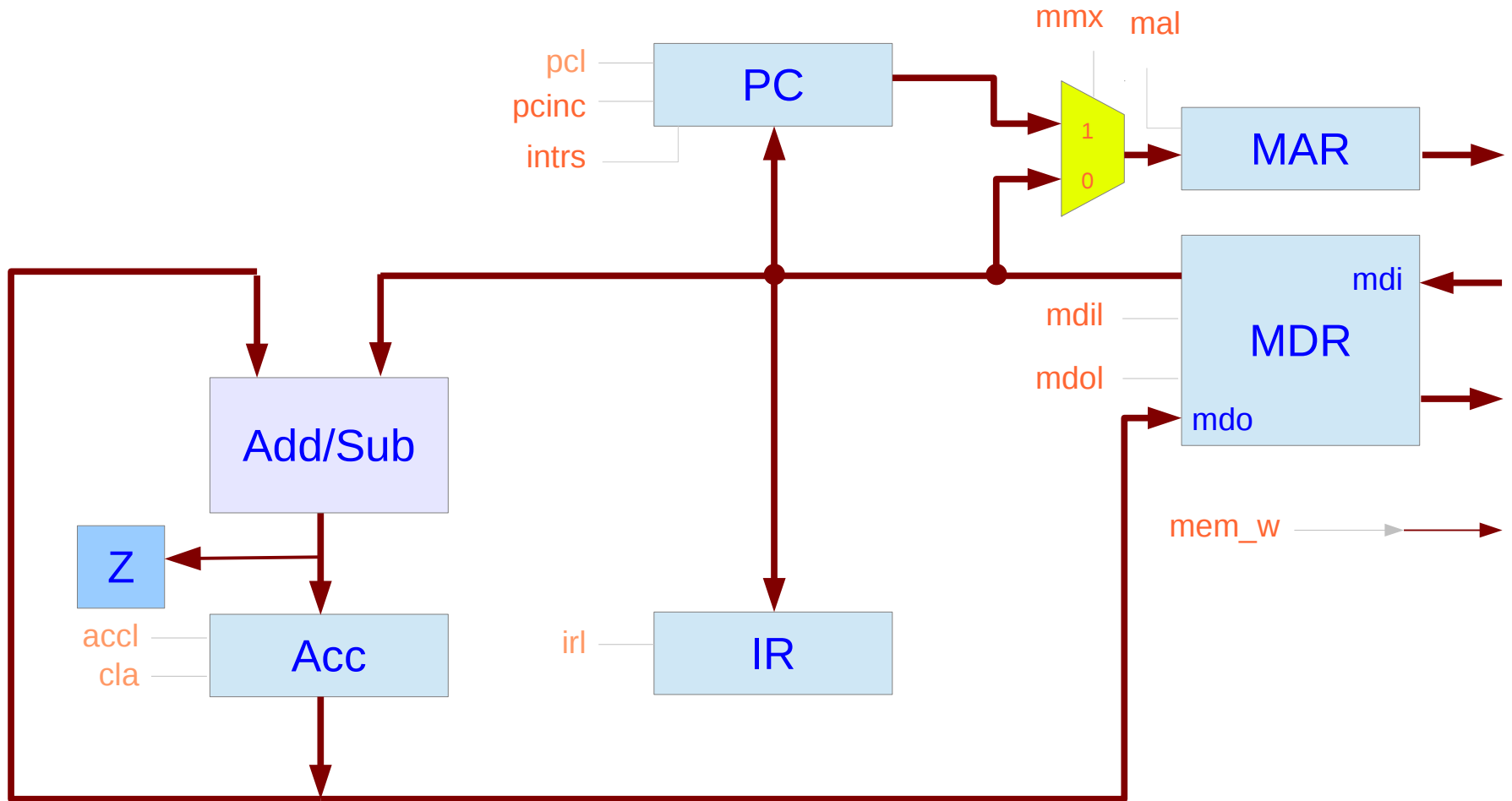
Copyright (c) 2014 - 2016 Young W. Lim.

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled "GNU Free Documentation License".

Please send corrections (or suggestions) to [youngwlim@hotmail.com](mailto:youngwlim@hotmail.com).

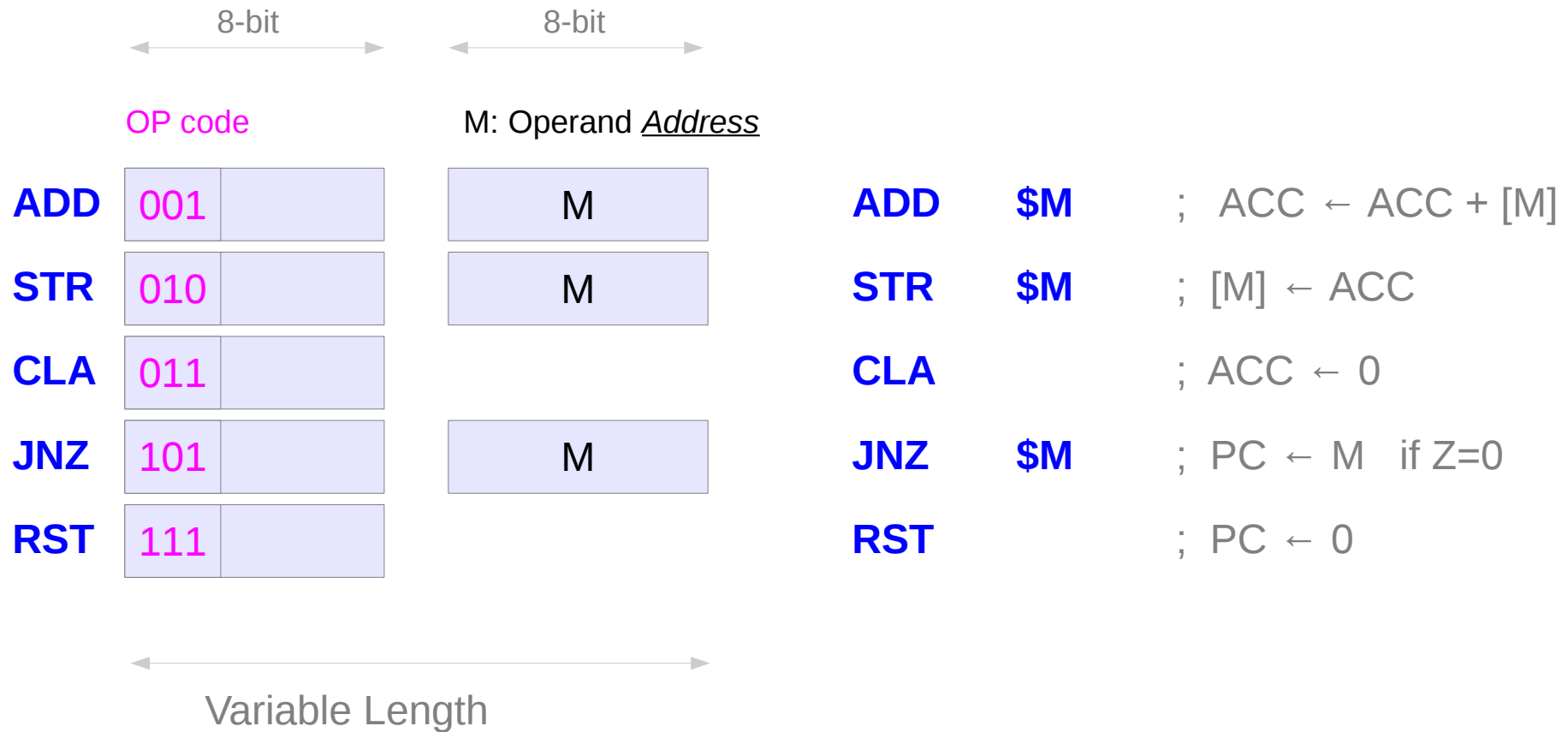
This document was produced by using OpenOffice and Octave.

# Data Path



Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

# Instruction Set Architecture



Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

# Instruction Cycles

## common cycles

c1 MAR  $\leftarrow$  PC; MEM\_RD;  
c2 MDR  $\leftarrow$  MEM; PC  $\leftarrow$  PC+1;  
c3 IR  $\leftarrow$  MDR

## ADD specific cycles

c4 MAR  $\leftarrow$  PC; MEM\_RD  
c5 MDR  $\leftarrow$  MEM; PC  $\leftarrow$  PC+1  
c6 MAR  $\leftarrow$  MDR; MEM\_RD  
c7 MDR  $\leftarrow$  MEM;  
c8 ACC  $\leftarrow$  ACC + MDR;

## CLA specific cycles

c4 ACC  $\leftarrow$  "00"

## RST specific cycles

c4 PC  $\leftarrow$  "00"

Opcode\_RD  
Operand\_RD

## STR specific cycles

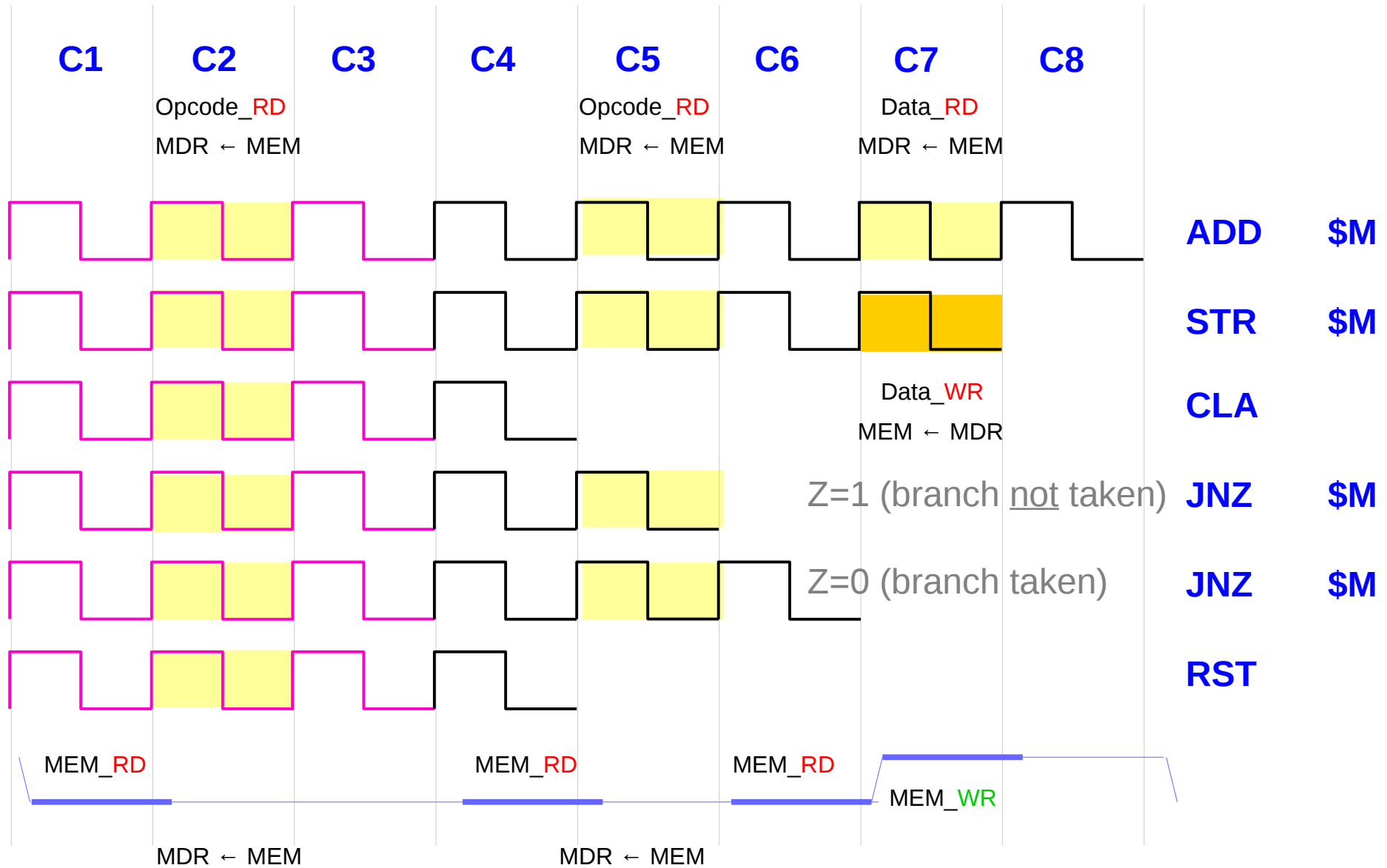
c4 MAR  $\leftarrow$  PC; MEM\_RD  
c5 MDR  $\leftarrow$  MEM; PC  $\leftarrow$  PC + 1  
c6 MAR  $\leftarrow$  MDR; MDR  $\leftarrow$  ACC  
c7 MEM\_WR;

## JNZ specific cycles

c4 MAR  $\leftarrow$  PC; MEM\_RD;  
c5 MDR  $\leftarrow$  MEM; PC  $\leftarrow$  PC + 1  
c6 If (Z=='0') PC  $\leftarrow$  MDR;

Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

# Clock Cycle Counts



Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

Data Path (IF: S1, S2, S3)

Data Path (ADD: A1, A2, A3, A4, A5)

Data Path (STR: T1, T2, T3, T4)

Data Path (CLA, A1)

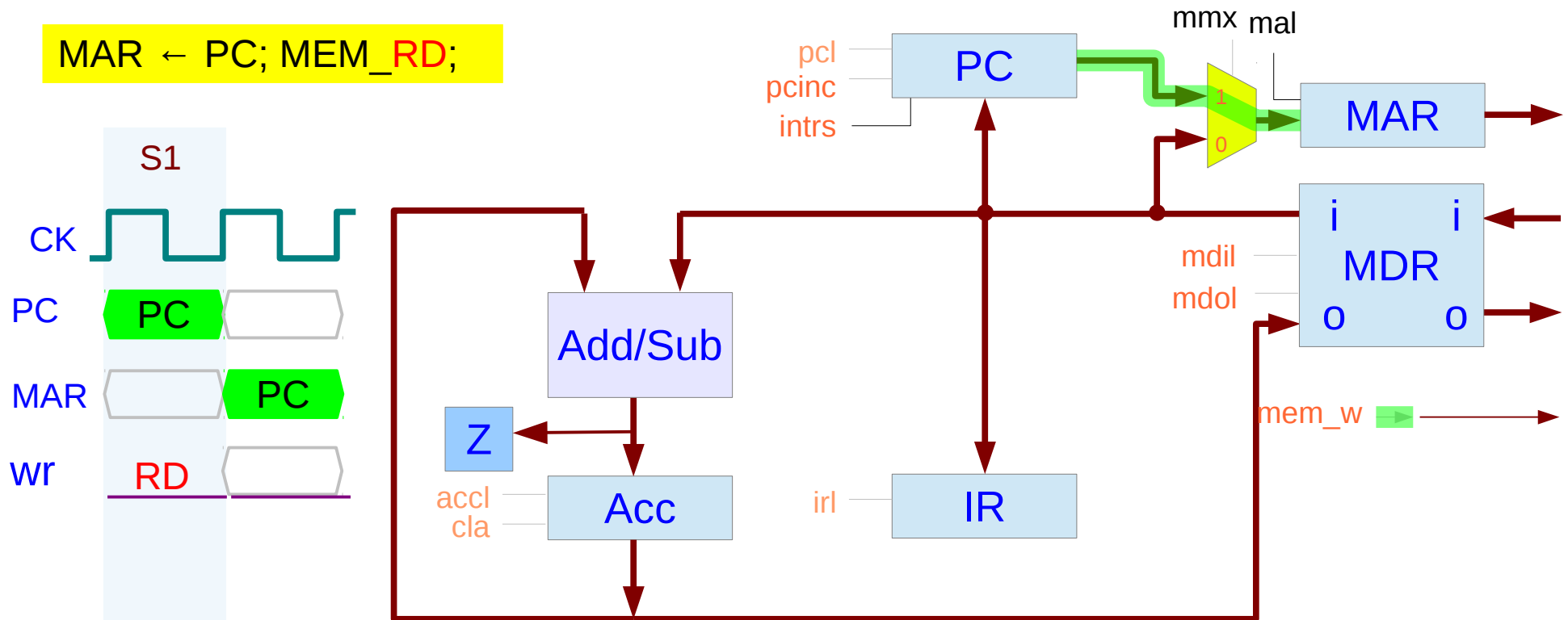
Data Path (JNZ, J1, J2, J3)

Data Path (RST, R1)

c1 MAR  $\leftarrow$  PC; MEM\_RD;  
c2 MDR  $\leftarrow$  MEM; PC  $\leftarrow$  PC+1;  
c3 IR  $\leftarrow$  MDR

# Data Path (IF, S1)

MAR ← PC; MEM\_RD;



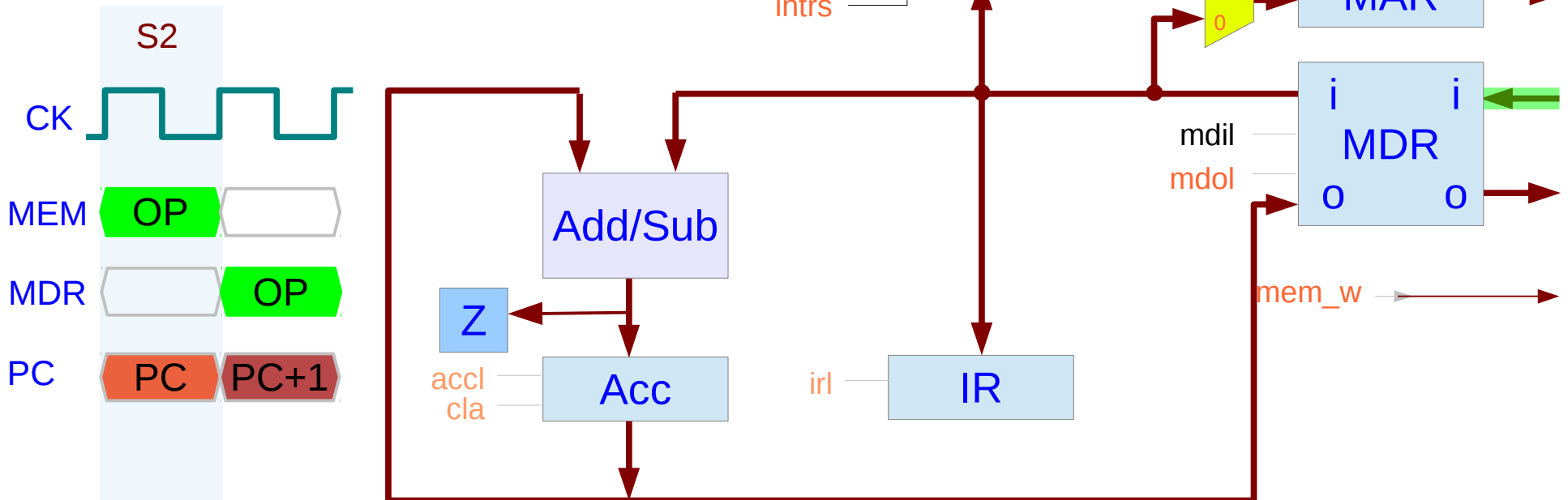
mmx,  
mal

Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>



# Data Path (IF, S2)

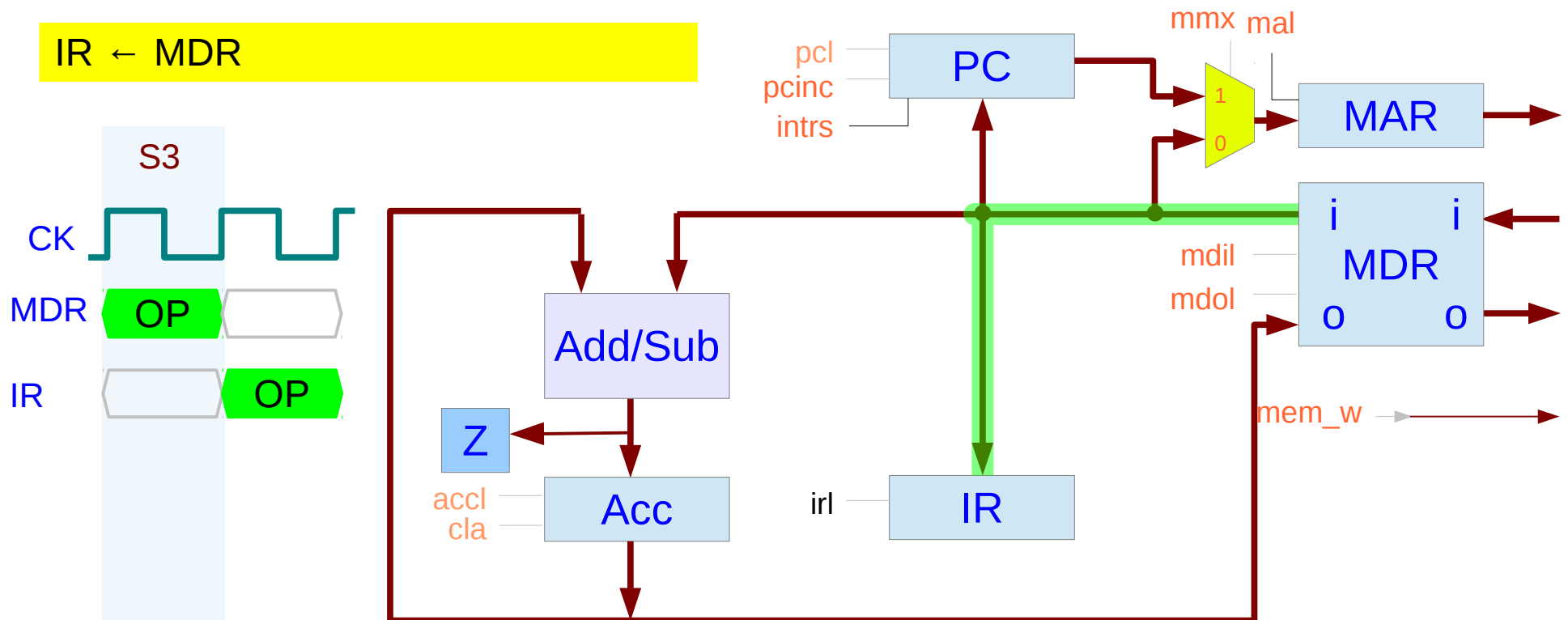
MDR ← MEM; PC ← PC+1;



mdil,  
pcinc,

Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

# Data Path (IF, S3)



irl

Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

Data Path (IF: S1, S2, S3)

Data Path (ADD: A1, A2, A3, A4, A5)

Data Path (STR: T1, T2, T3, T4)

Data Path (CLA, A1)

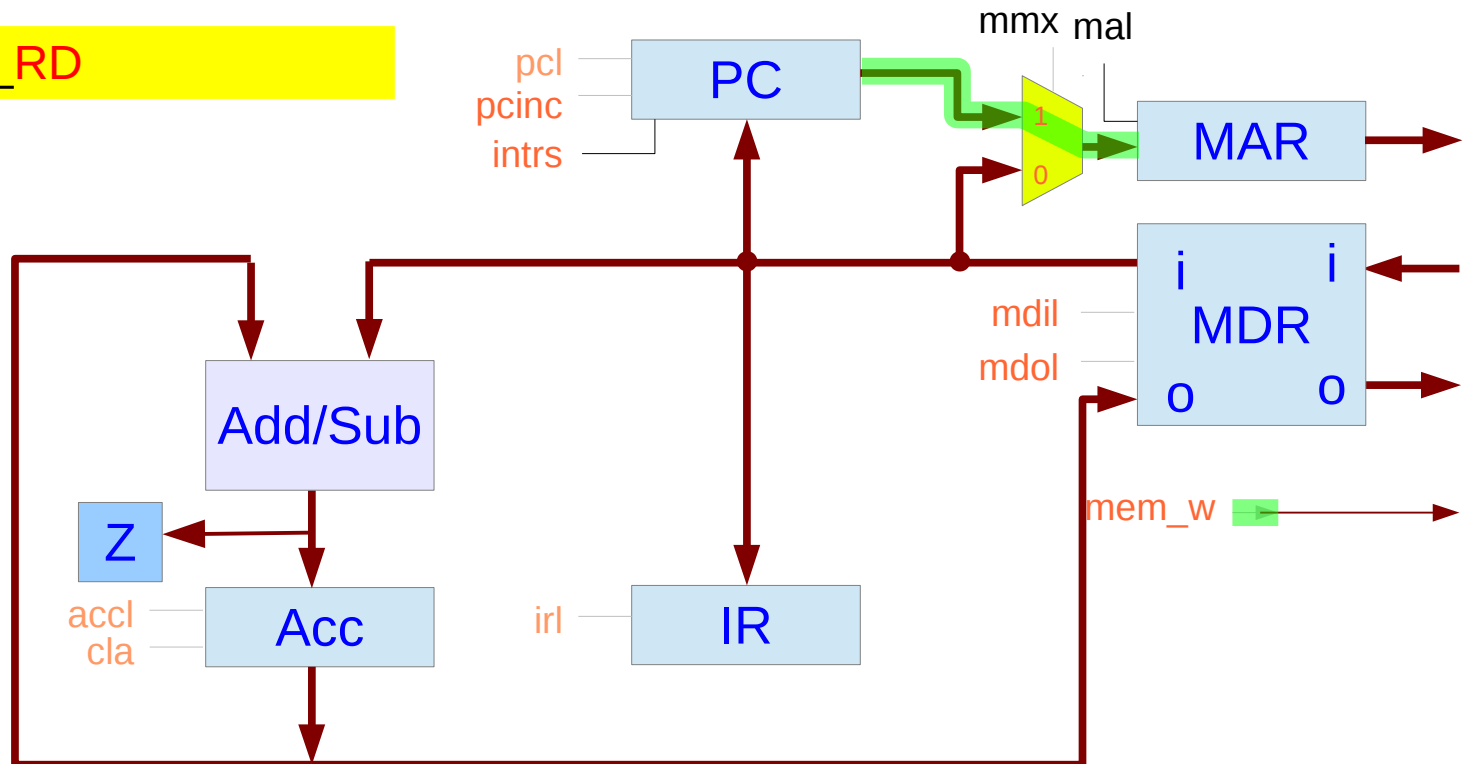
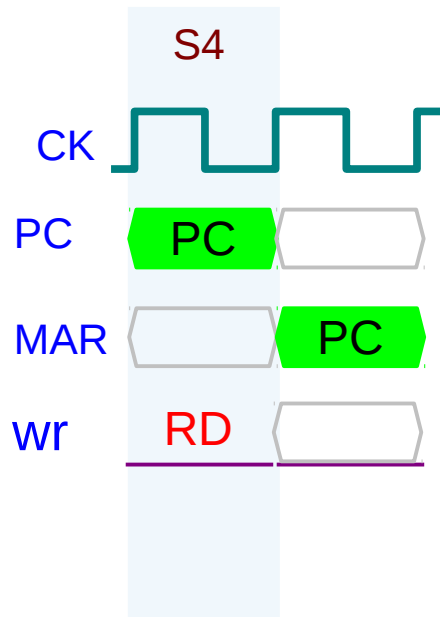
Data Path (JNZ, J1, J2, J3)

Data Path (RST, R1)

c4 MAR  $\leftarrow$  PC; MEM\_RD  
c5 MDR  $\leftarrow$  MEM; PC  $\leftarrow$  PC+1  
c6 MAR  $\leftarrow$  MDR; MEM\_RD  
c7 MDR  $\leftarrow$  MEM;  
c8 ACC  $\leftarrow$  ACC + MDR;

# Data Path (ADD, A1)

MAR ← PC; MEM\_RD

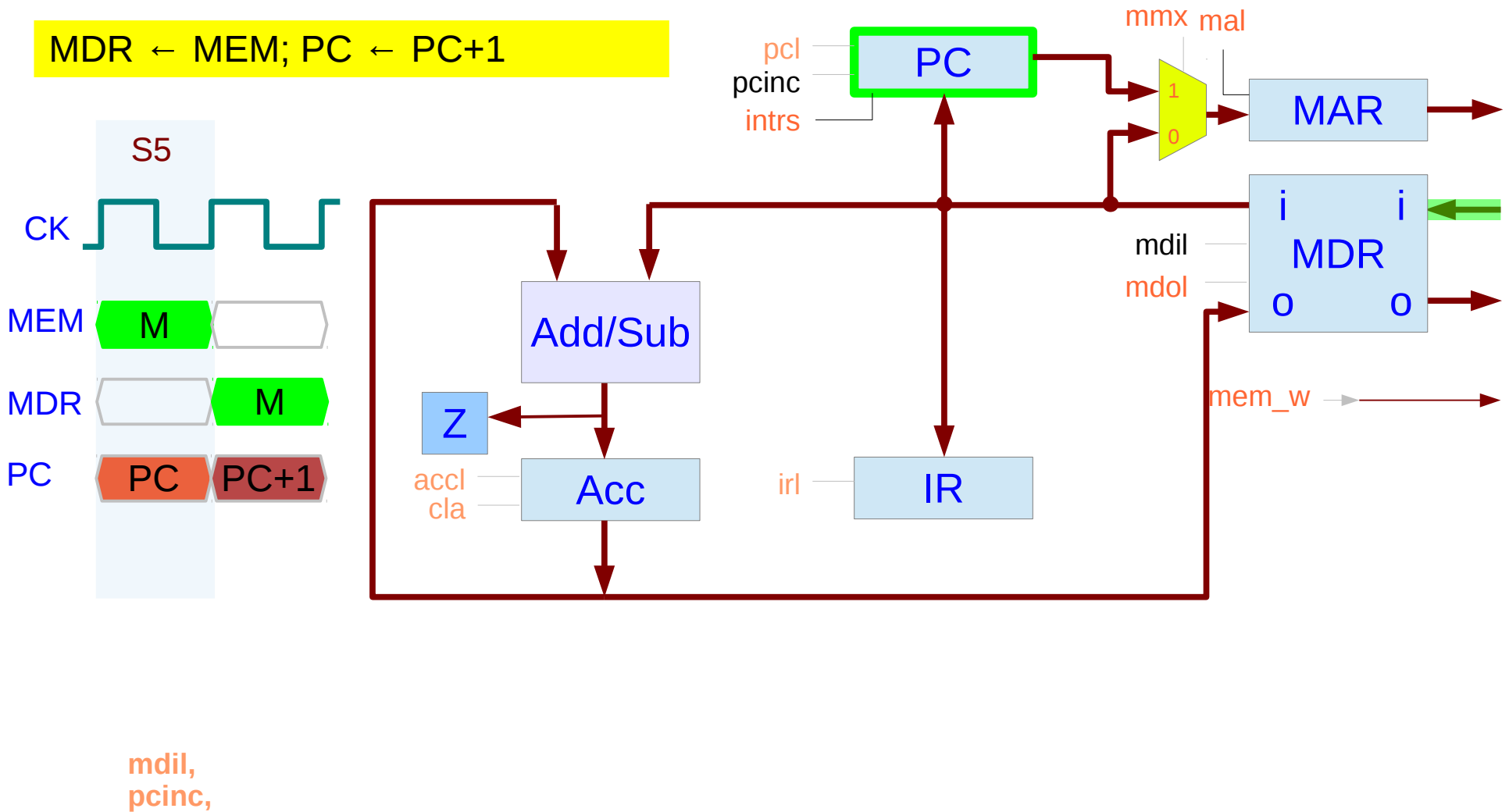


mmx,  
mal

Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

# Data Path (ADD, A2)

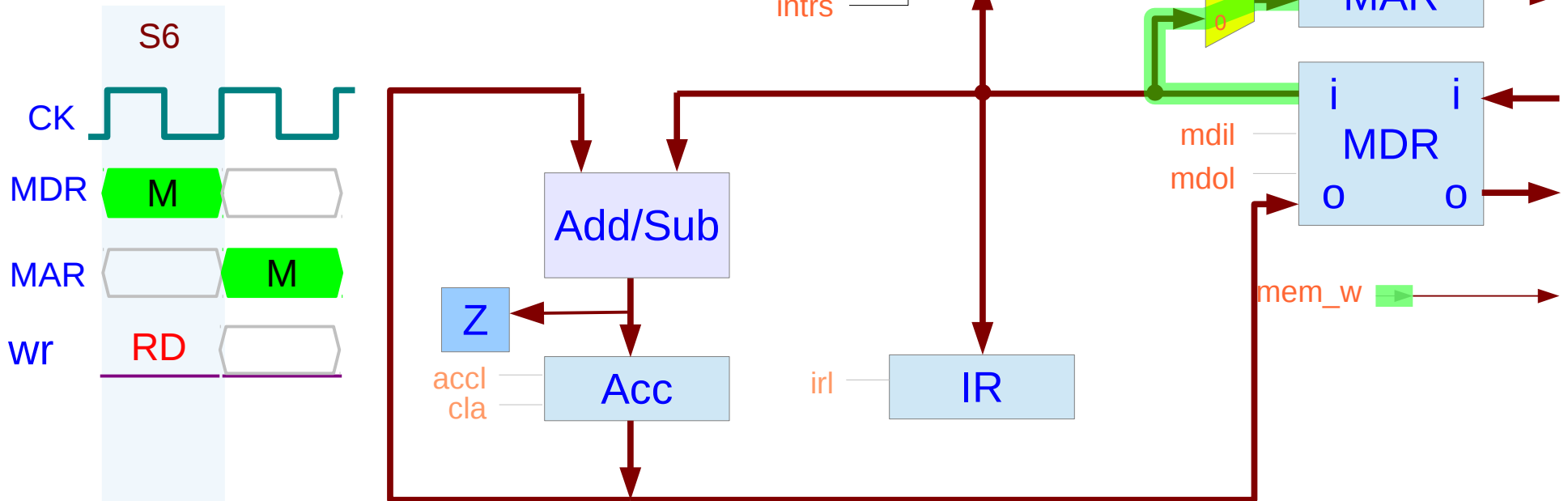
MDR ← MEM; PC ← PC+1



Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

# Data Path (ADD, A3)

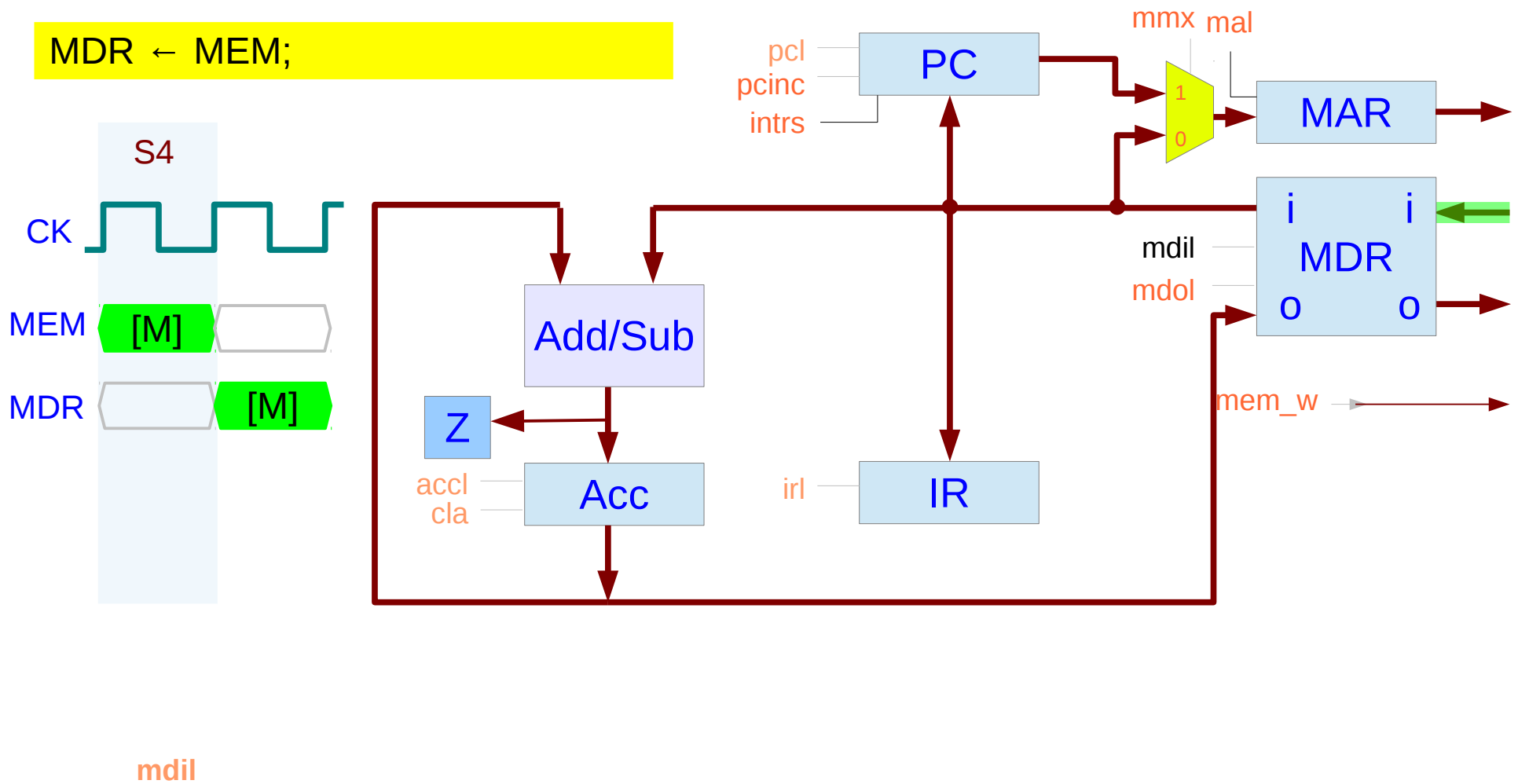
MAR ← MDR; MEM\_RD



mal

Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

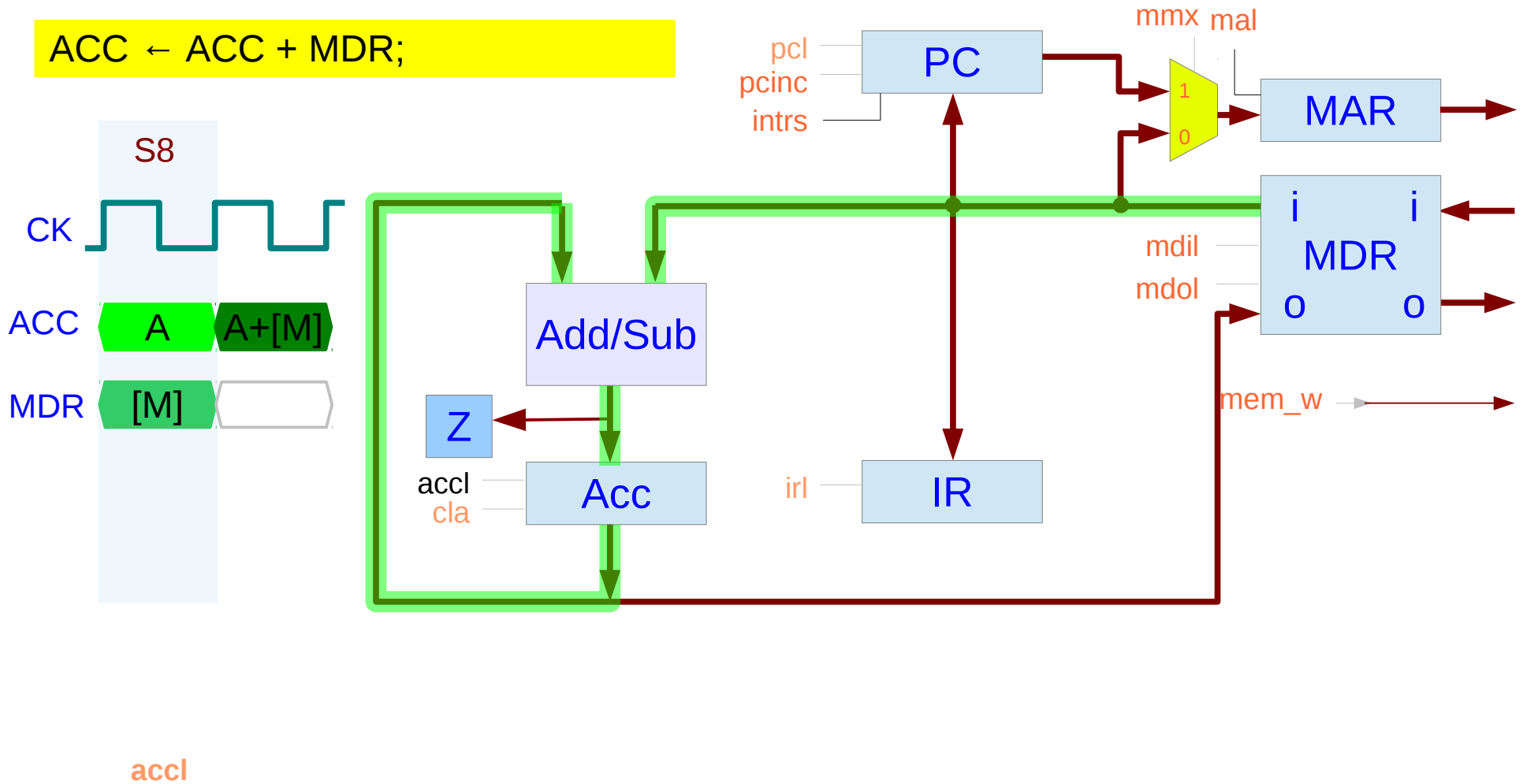
# Data Path (ADD, A4)



Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

# Data Path (ADD, A5)

ACC ← ACC + MDR;



Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>



Data Path (IF: S1, S2, S3)

Data Path (ADD: A1, A2, A3, A4, A5)

Data Path (STR: T1, T2, T3, T4)

Data Path (CLA, A1)

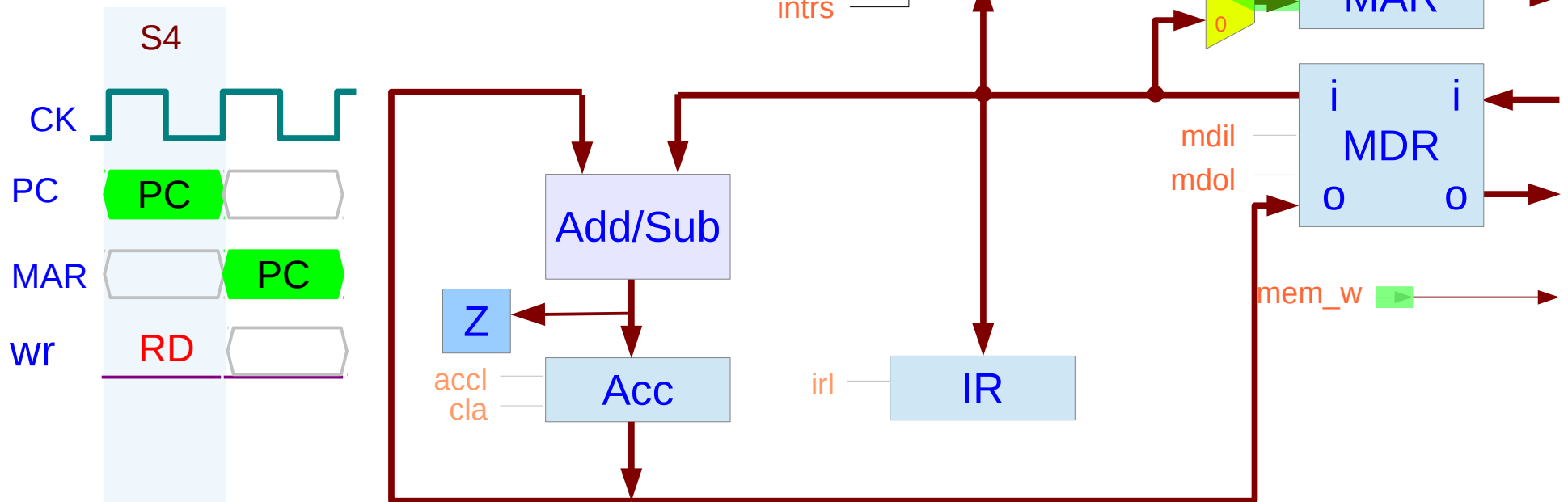
Data Path (JNZ, J1, J2, J3)

Data Path (RST, R1)

c4 MAR  $\leftarrow$  PC; MEM\_RD  
c5 MDR  $\leftarrow$  MEM; PC  $\leftarrow$  PC + 1  
c6 MAR  $\leftarrow$  MDR; MDR  $\leftarrow$  ACC  
c7 MEM\_WR;

# Data Path (STR, T1)

MAR ← PC; MEM\_RD

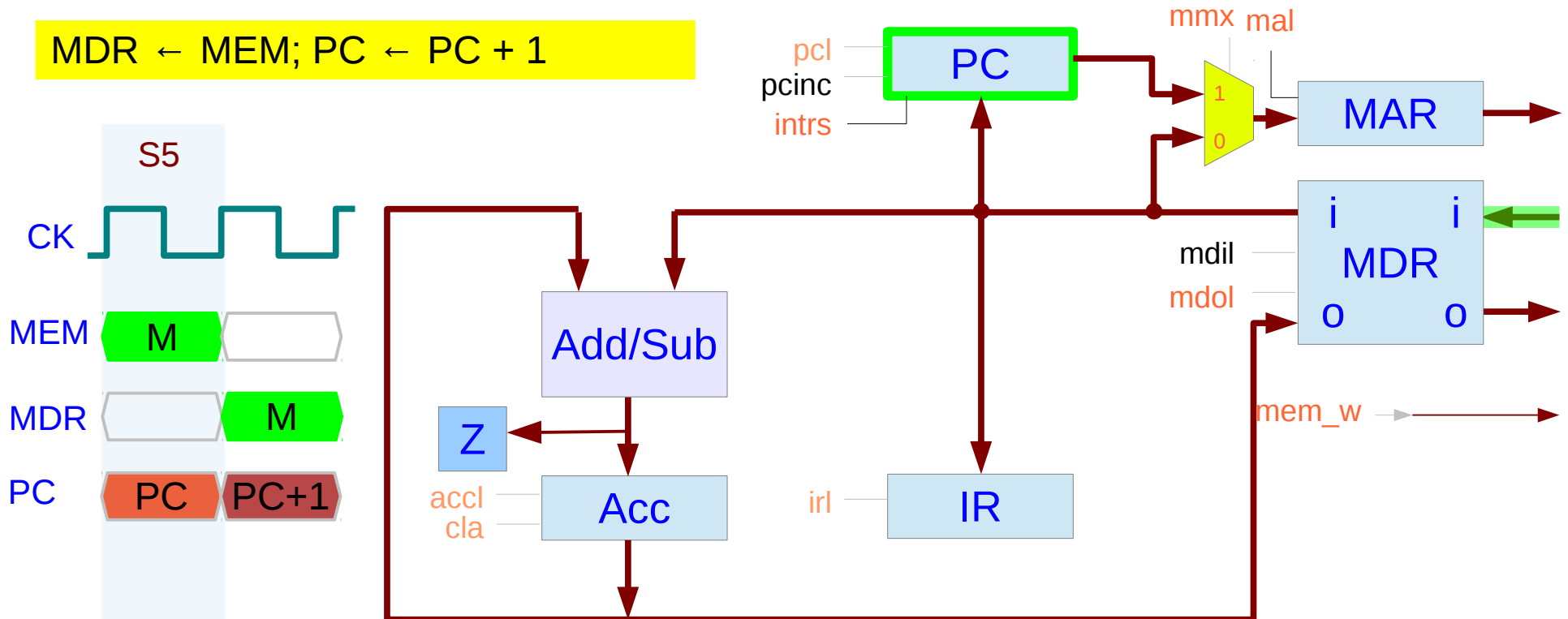


mmx,  
mal

Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

# Data Path (STR, T2)

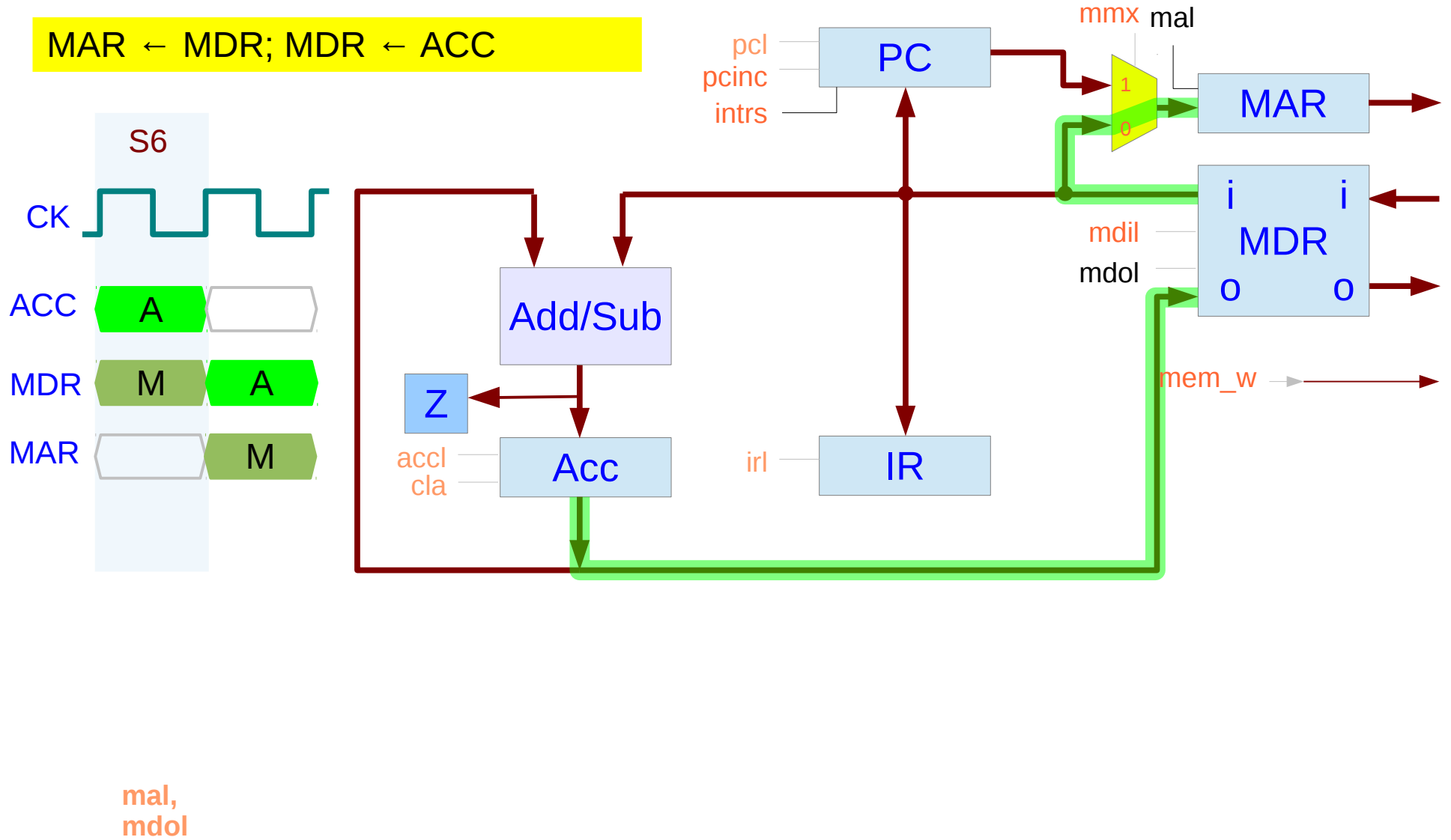
MDR ← MEM; PC ← PC + 1



mdil,  
pcinc

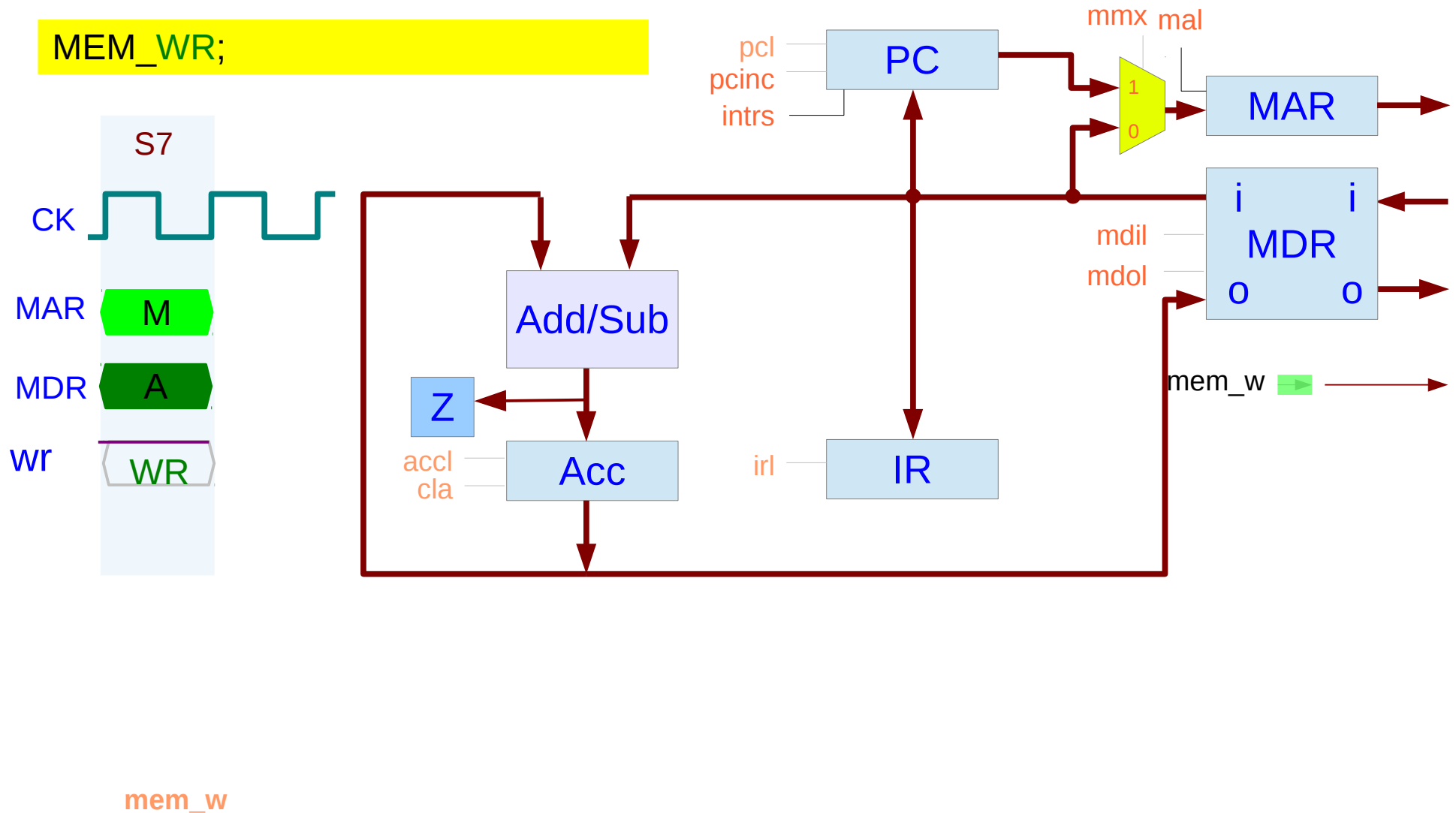
Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

# Data Path (STR, T3)



Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

# Data Path (STR, T4)



Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

Data Path (IF: S1, S2, S3)

Data Path (ADD: A1, A2, A3, A4, A5)

Data Path (STR: T1, T2, T3, T4)

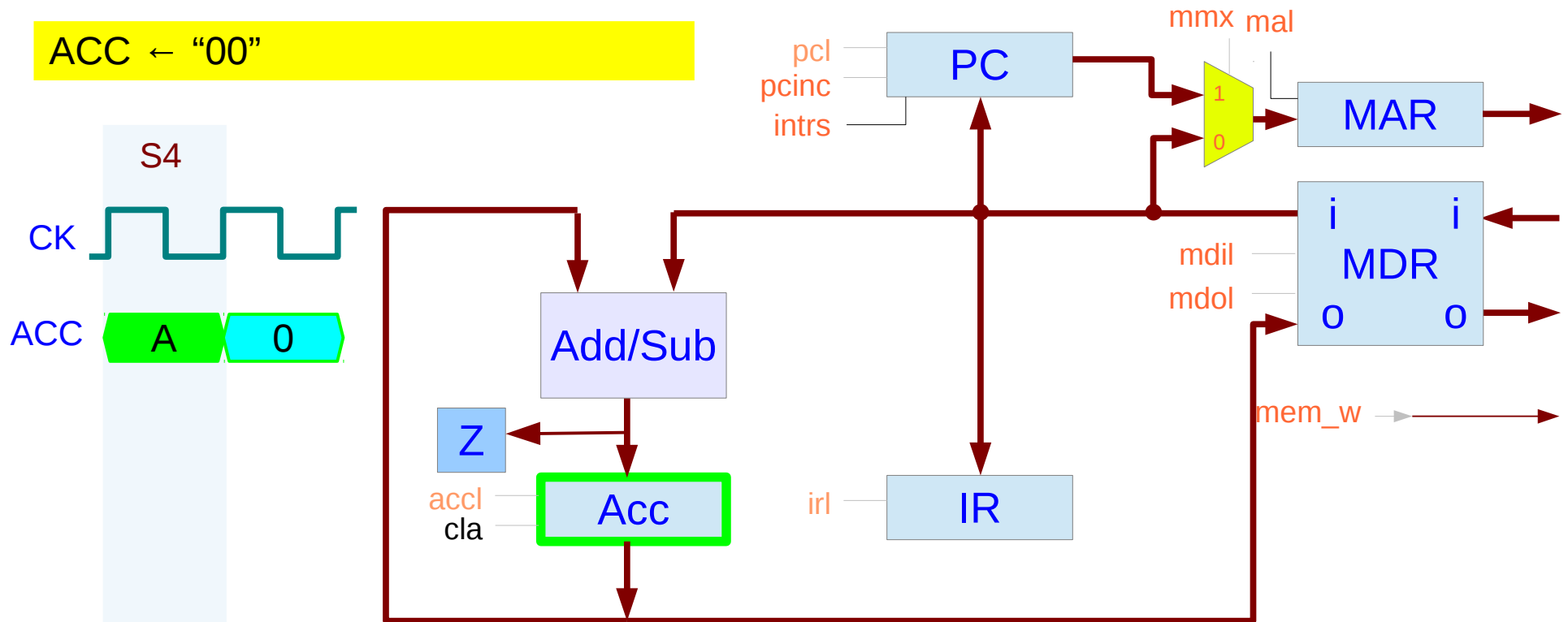
Data Path (CLA, A1)

Data Path (JNZ, J1, J2, J3)

Data Path (RST, R1)

c4 ACC ← "00"

# Data Path (CLA, C1)



cla

Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

Data Path (IF: S1, S2, S3)

Data Path (ADD: A1, A2, A3, A4, A5)

Data Path (STR: T1, T2, T3, T4)

Data Path (CLA, A1)

Data Path (JNZ, J1, J2, J3)

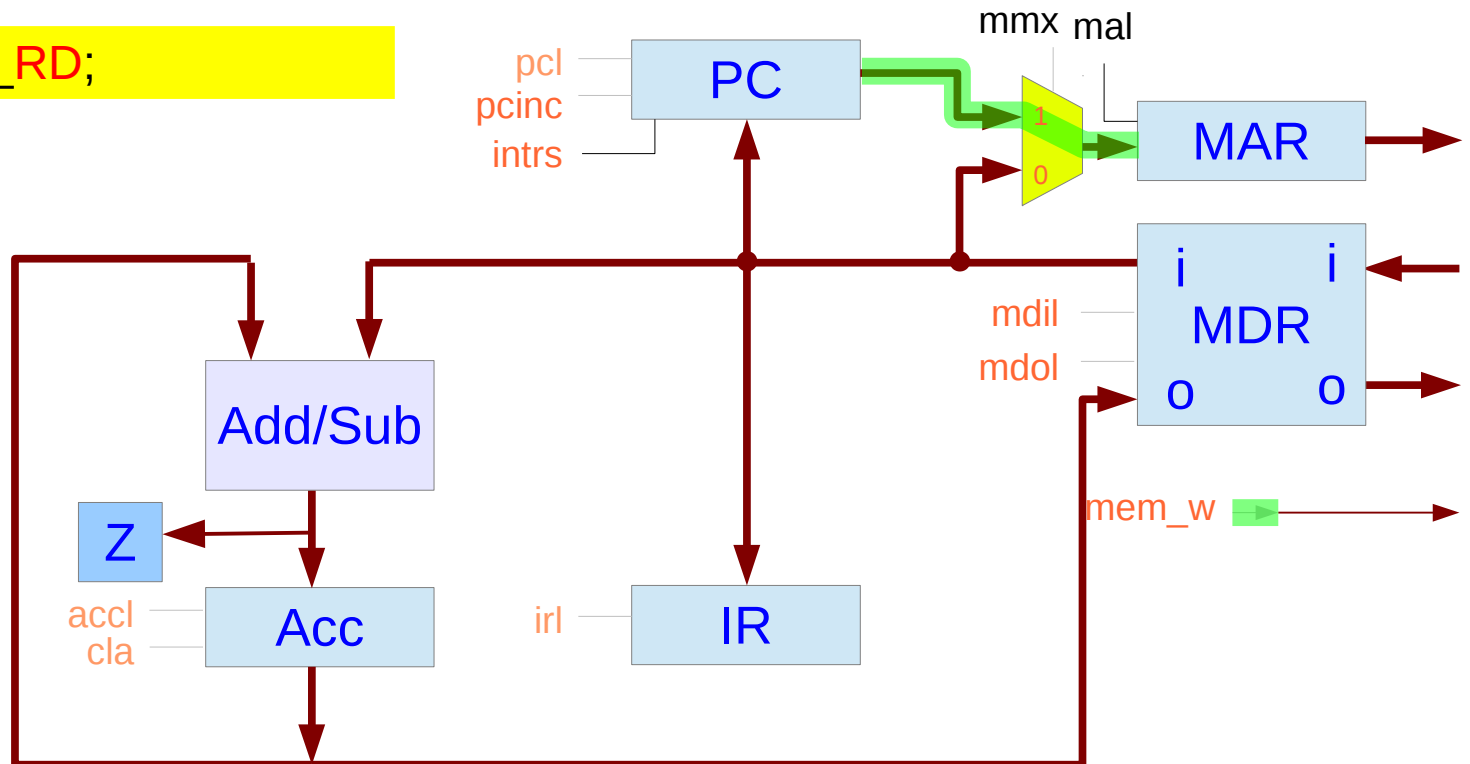
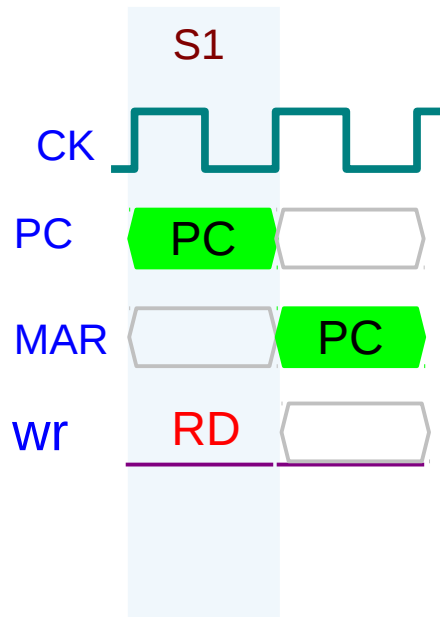
Data Path (RST, R1)

```
c4 MAR ← PC; MEM_RD;  
c5 MDR ← MEM; PC ← PC + 1  
c6 If (Z=='0') PC ← MDR;
```



# Data Path (JNZ, J1)

MAR ← PC; MEM\_RD;

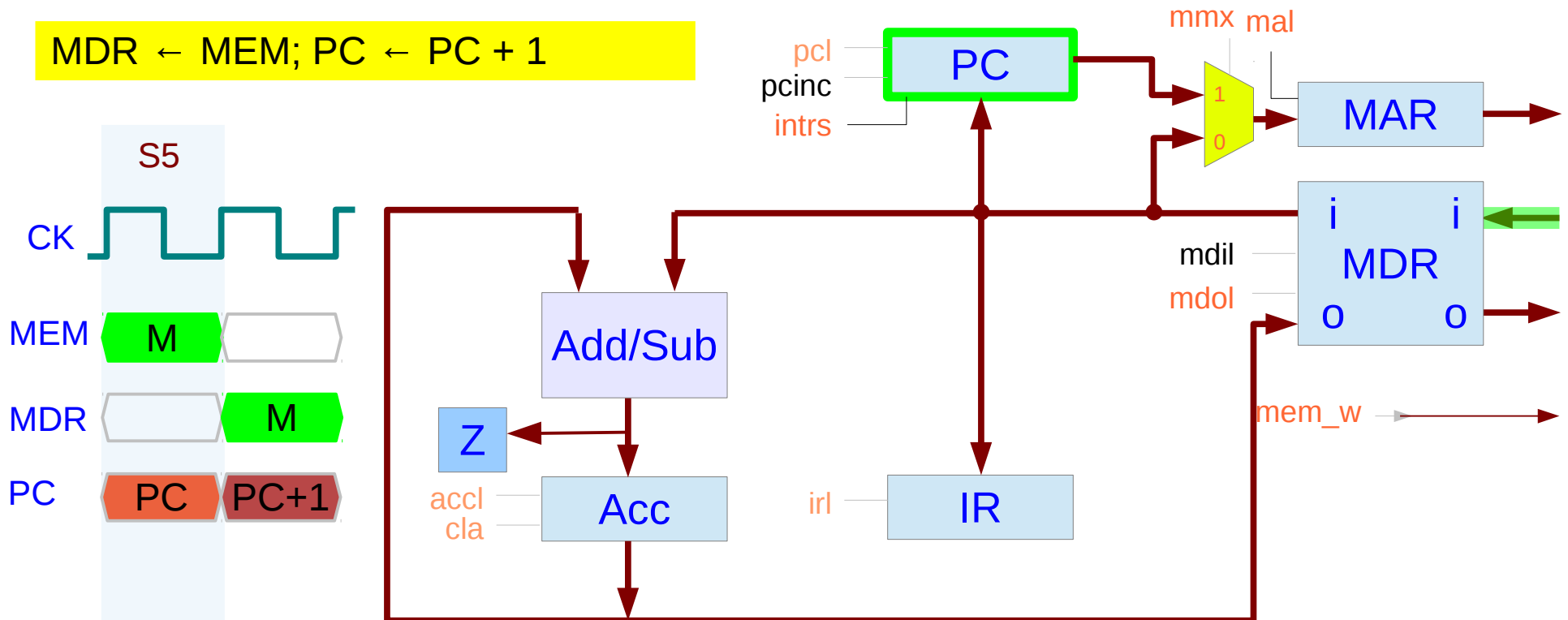


mmx,  
mal

Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

# Data Path (JNZ, J2)

MDR ← MEM; PC ← PC + 1

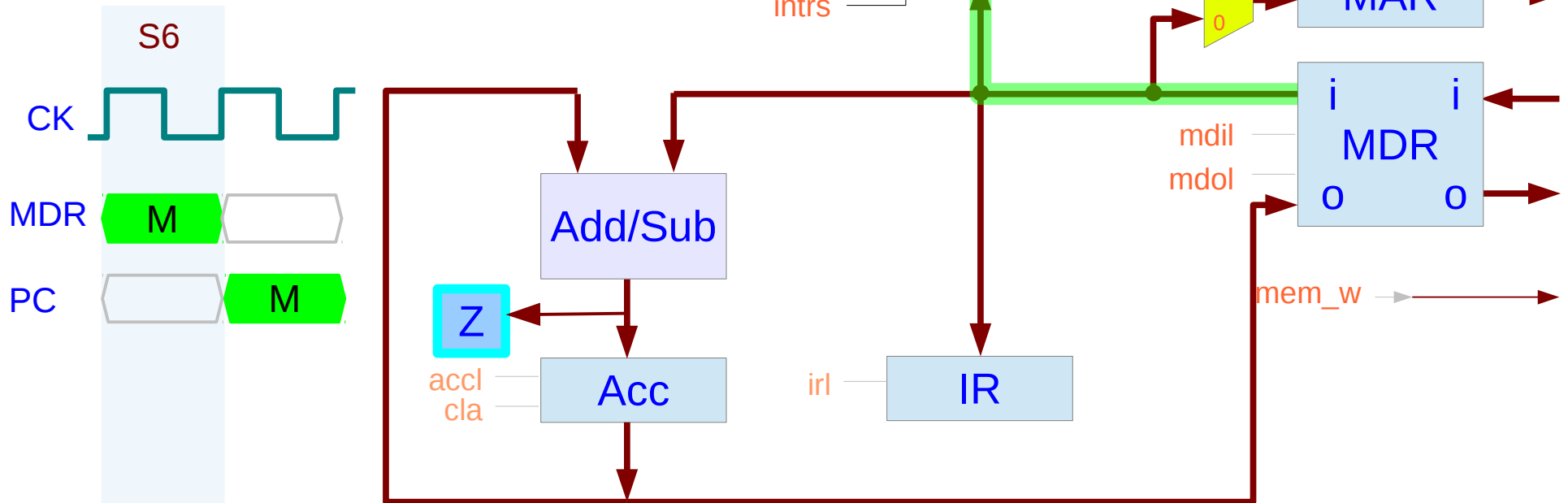


*mdil,*  
*pcinc*

Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

# Data Path (JNZ, J3)

If (Z=='0') PC ← MDR;



*pcl*

Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

Data Path (IF: S1, S2, S3)

Data Path (ADD: A1, A2, A3, A4, A5)

Data Path (STR: T1, T2, T3, T4)

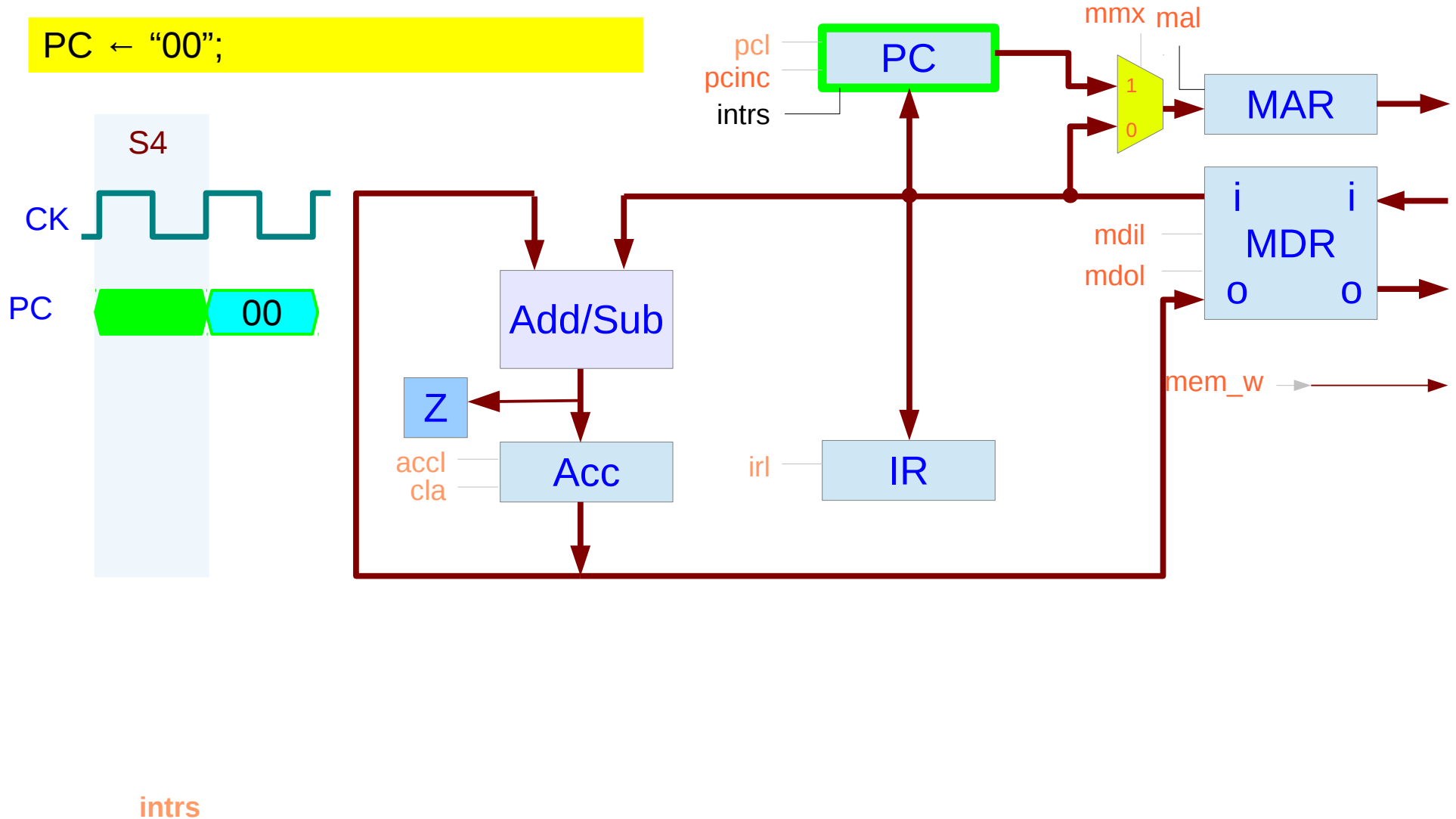
Data Path (CLA, A1)

Data Path (JNZ, J1, J2, J3)

Data Path (RST, R1)

c4 PC ← "00"

# Data Path (RST, R1)



Based on <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>

## References

- [1] <http://en.wikipedia.org/>
- [2] [https://en.wikiversity.org/wiki/The\\_necessities\\_in\\_SOC\\_Design](https://en.wikiversity.org/wiki/The_necessities_in_SOC_Design)
- [3] [https://en.wikiversity.org/wiki/The\\_necessities\\_in\\_Digital\\_Design](https://en.wikiversity.org/wiki/The_necessities_in_Digital_Design)
- [4] [https://en.wikiversity.org/wiki/The\\_necessities\\_in\\_Computer\\_Design](https://en.wikiversity.org/wiki/The_necessities_in_Computer_Design)
- [5] [https://en.wikiversity.org/wiki/The\\_necessities\\_in\\_Computer\\_Architecture](https://en.wikiversity.org/wiki/The_necessities_in_Computer_Architecture)
- [6] [https://en.wikiversity.org/wiki/The\\_necessities\\_in\\_Computer\\_Organization](https://en.wikiversity.org/wiki/The_necessities_in_Computer_Organization)
- [7] [https://en.wikiversity.org/wiki/Understanding\\_Embedded\\_Software](https://en.wikiversity.org/wiki/Understanding_Embedded_Software)
- [8] Digital Systems, Hill, Peterson, 1987
- [9] <http://en.wikipedia.org/>
- [10] <http://www.ele.uri.edu/Courses/ele306/f01/Tinydoc.pdf>