

# Embedded Systems

## ELEC3020

### Lab Assignment 2 – CPU Design

**Points: 10**

**NO TEAMS:** This lab is an individual assignment.  
**EQUIPMENT:** PC/Mac with ReTrO simulation system  
<https://robotics.ee.uwa.edu.au/retro/>

#### EXPERIMENT 1 (8 points)

Build a working CPU with 16-bit data bus (8-bit op-codes, and 8-bit operands / 8-bit addresses). Use a 16-bit wide RAM module. Implement the following ALU/CU functions:

0 v	<b>LOADC</b>	load constant into accumulator	$acc \leftarrow v$
1 a	<b>LOADM</b>	load memory value into accumulator	$acc \leftarrow mem[a]$
2 v	<b>ADDC</b>	add constant to accumulator	$acc \leftarrow acc + v$
3 a	<b>ADDM</b>	add memory value to accumulator	$acc \leftarrow acc + mem[a]$
4 a	<b>STORE</b>	store accumulator to memory (high byte 0)	$mem[a] \leftarrow acc$
5 *	<b>CLEAR</b>	set accumulator to zero	$acc \leftarrow 0$
6 a	<b>BRA</b>	branch always to address <i>a</i>	$pc \leftarrow a$
7 a	<b>BZ</b>	branch only if ( $acc=0$ ) to address <i>a</i>	if ( $acc=0$ ) then $pc \leftarrow a$

#### EXPERIMENT 2 (2 points)

Write a program to calculate  $1 + 2 + 3 \dots + m$ , for a given value *m* with  $m \geq 1$ .

$$result = \sum_{i=1}^m i$$

**Data locations:** value *m* in location \$A0  
*result* in location \$A1

**Algorithm:** clear result  
**loop:** add mem[*m*] to result  
 decrement mem[*m*]  
 if ( $m \neq 0$ ) **branch to loop**  
**done:** **branch to done** /\* finished: endless loop \*/

**Example:**

<i>m</i> in mem[A0]	<i>result</i> in mem[A1]
3	3
2	5
1	6
0	6