

INSTRUCTION SET IN DIRECT MODE

Revision 3
Oct.21.2022

CODING

OPC	MNEMONIC	FLAGS			CODE											
					OPCODE				OPERAND X OPCODE				OPERAND Y			
1	ADD RX,RY	V	Z	C	0	0	0	1	X	X	X	X	Y	Y	Y	Y
2	ADC RX,RY	V	Z	C	0	0	1	0	X	X	X	X	Y	Y	Y	Y
3	SUB RX,RY	V	Z	C	0	0	1	1	X	X	X	X	Y	Y	Y	Y
4	SBB RX,RY	V	Z	C	0	1	0	0	X	X	X	X	Y	Y	Y	Y
5	OR RX,RY		Z		0	1	0	1	X	X	X	X	Y	Y	Y	Y
6	AND RX,RY		Z		0	1	1	0	X	X	X	X	Y	Y	Y	Y
7	XOR RX,RY		Z		0	1	1	1	X	X	X	X	Y	Y	Y	Y
8	MOV RX,RY				1	0	0	0	X	X	X	X	Y	Y	Y	Y
02	INC RY		Z	C	0	0	0	0	0	0	1	0	Y	Y	Y	Y
03	DEC RY		Z	C	0	0	0	0	0	0	1	1	Y	Y	Y	Y
0D	RRC RY		Z	C	0	0	0	0	1	1	0	1	Y	Y	Y	Y

ADD X,Y

Add register Y to register X

Syntax: {label} ADD X, Y

Operands: $X \in \#0...\#15$
 $Y \in \#0...\#15$

Operation: $X \leftarrow X + Y$

Description: Add with Carry contents of the register Y to the contents of the register X and place the result in the register X.

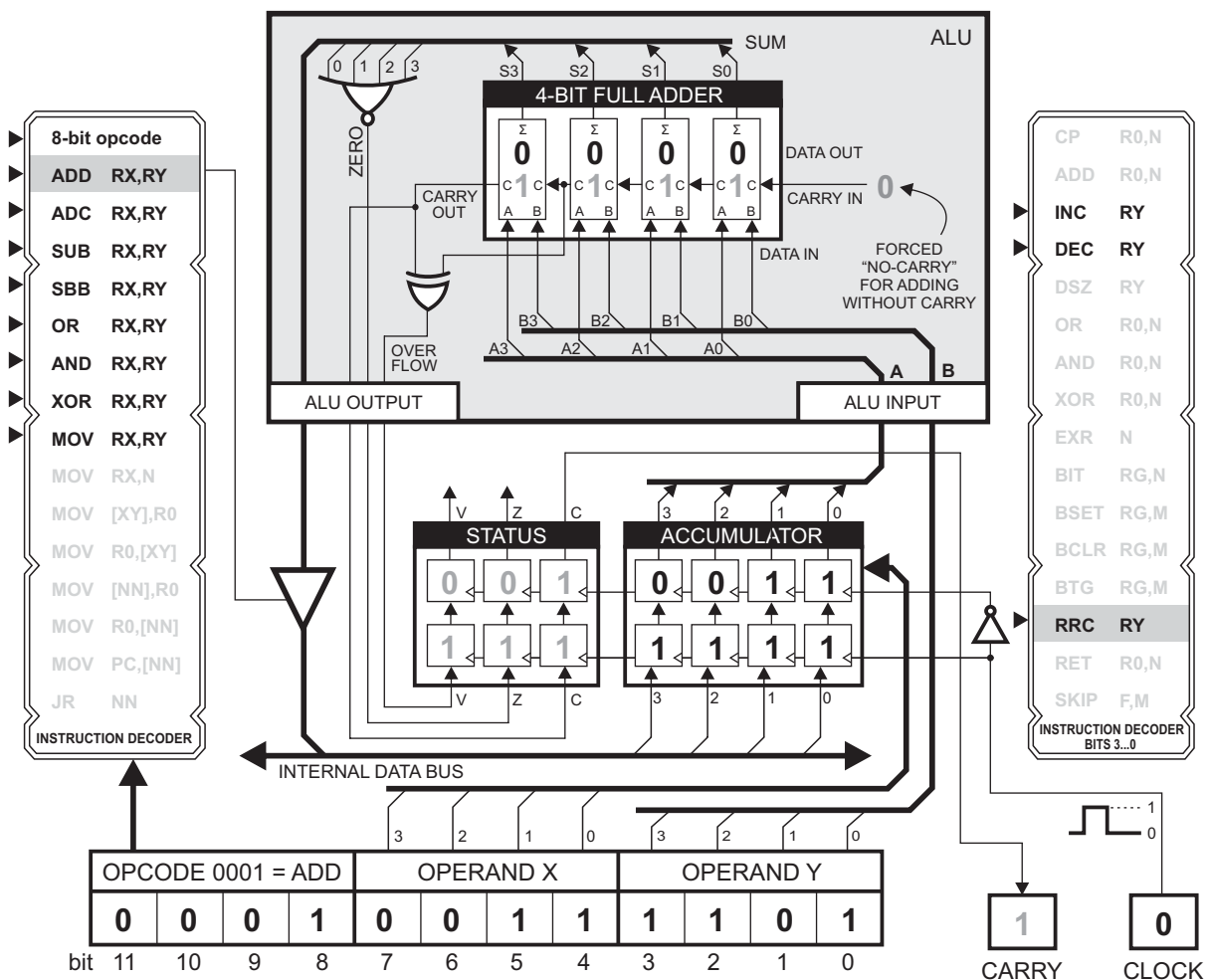
Flags affected: If there is the overflow (if $X + Y > 15$), set C.
 Otherwise, reset C.
 If result = 0000 after operation, set Z. Otherwise, reset Z.
 If there is the underflow for signed representation, set V.

Encoding:

bit	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	1	X	X	X	X	Y	Y	Y	Y

The "0001" bits are the ADD X,Y opcode
 The "XXXX" bits are the contents of register X
 The "YYYY" bits are the contents of register Y

Example: **ADD 3, 13**



ADC X,Y

Add with Carry register Y to register X

Syntax: {label} ADC X, Y

Operands: $X \in \#0...\#15$
 $Y \in \#0...\#15$

Operation: $X \leftarrow X + Y + \text{Carry}$

Description: Add with Carry contents of the register Y to the contents of the register X and place the result in the register X.

Flags affected: If there is the overflow (if $X + Y + \text{Carry} > 15$), set C.
 Otherwise, reset C.
 If result = 0000 after operation, set Z. Otherwise, reset Z.
 If there is the underflow for signed representation, set V.

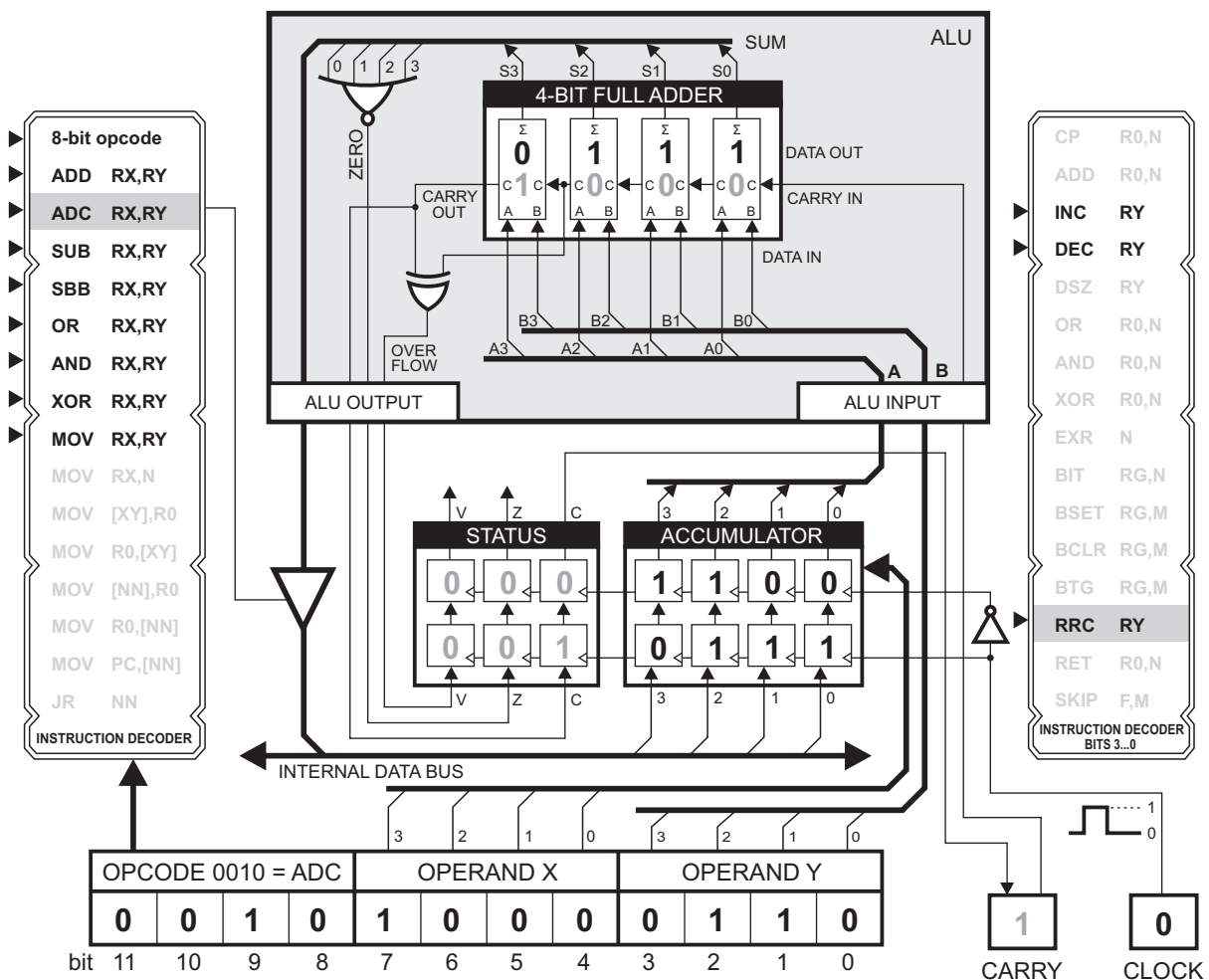
Encoding:

bit	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	1	0	X	X	X	X	Y	Y	Y	Y

The "0010" bits are the ADD X,Y opcode
 The "XXXX" bits are the contents of register X
 The "YYYY" bits are the contents of register Y

Example:

ADC 8, 6 (Carry set)



SUB X,Y

Subtract register Y from register X

Syntax: {label} SUB X, Y

Operands: $X \in \#0...\#15$
 $Y \in \#0...\#15$

Operation: $X \leftarrow X - Y$

Description: Subtract the contents of the register Y from the contents of the register X and place the result in the register X.

Flags affected: If there is the underflow (if $Y < X$), reset C.
 Otherwise, set C. (note: Borrow is inverse C)
 If result = 0000 after operation, set Z. Otherwise, reset Z.
 If there is the underflow for signed representation, set V.

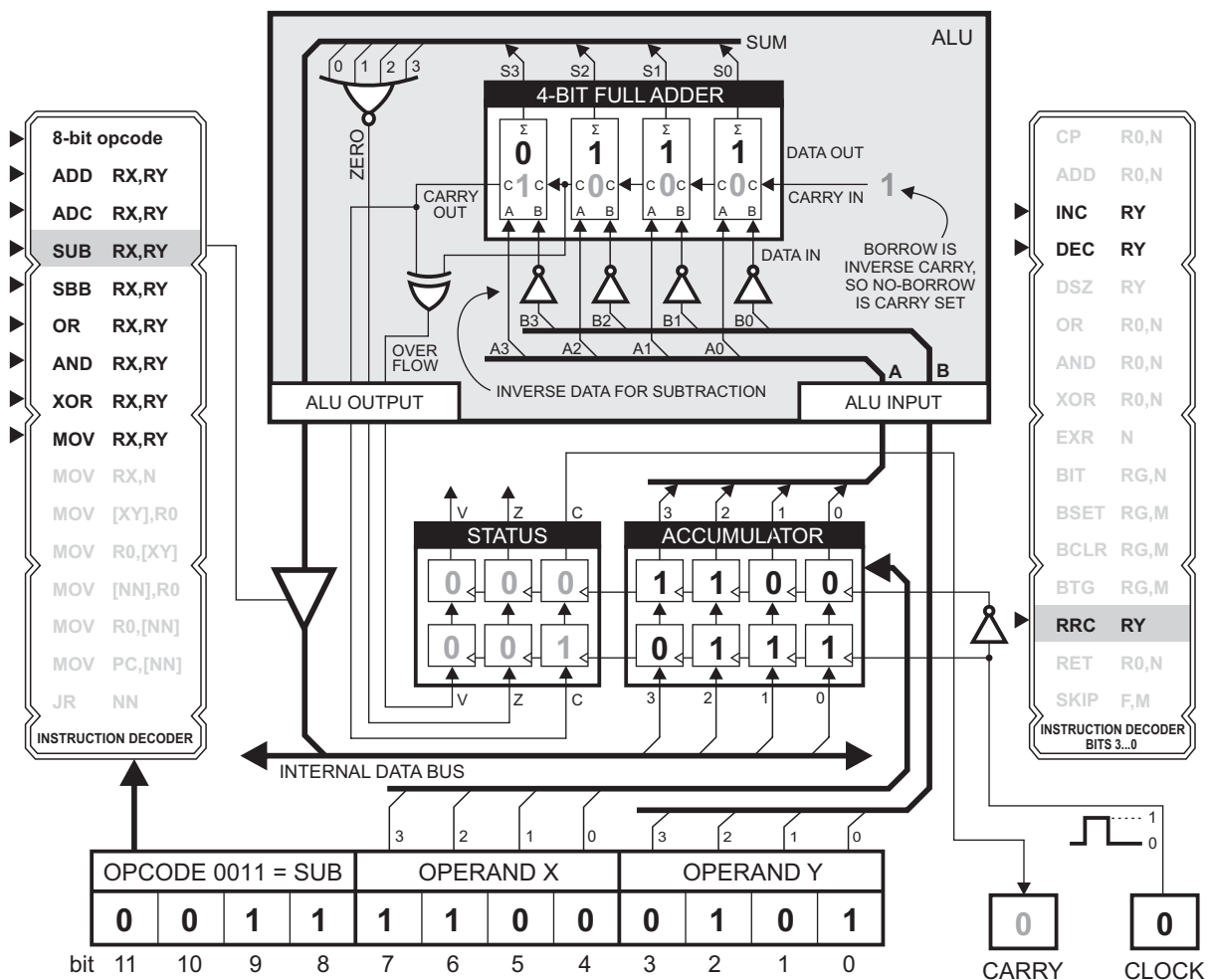
Encoding:

bit	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	1	1	X	X	X	X	Y	Y	Y	Y

The "0011" bits are the SUB X,Y opcode
 The "XXXX" bits are the contents of register X
 The "YYYY" bits are the contents of register Y

Example:

SUB 12, 5



SBB X,Y

Subtract register Y from register X with borrow

Syntax: {label} SBB X, Y

Operands:
 $X \in \#0\ldots\#15$
 $Y \in \#0\ldots\#15$

Operation: $X \leftarrow X - Y - \overline{\text{Carry}}$

Description: Subtract the contents of the register Y and inverse Carry flag from the contents of the register X and place the result in the register X.

Flags affected: If there is the underflow (if $Y < X$), reset C.
 Otherwise, set C. (note: Borrow is inverse C)
 If result = 0000 after operation, set Z. Otherwise, reset Z.
 If there is the underflow for signed representation, set V.

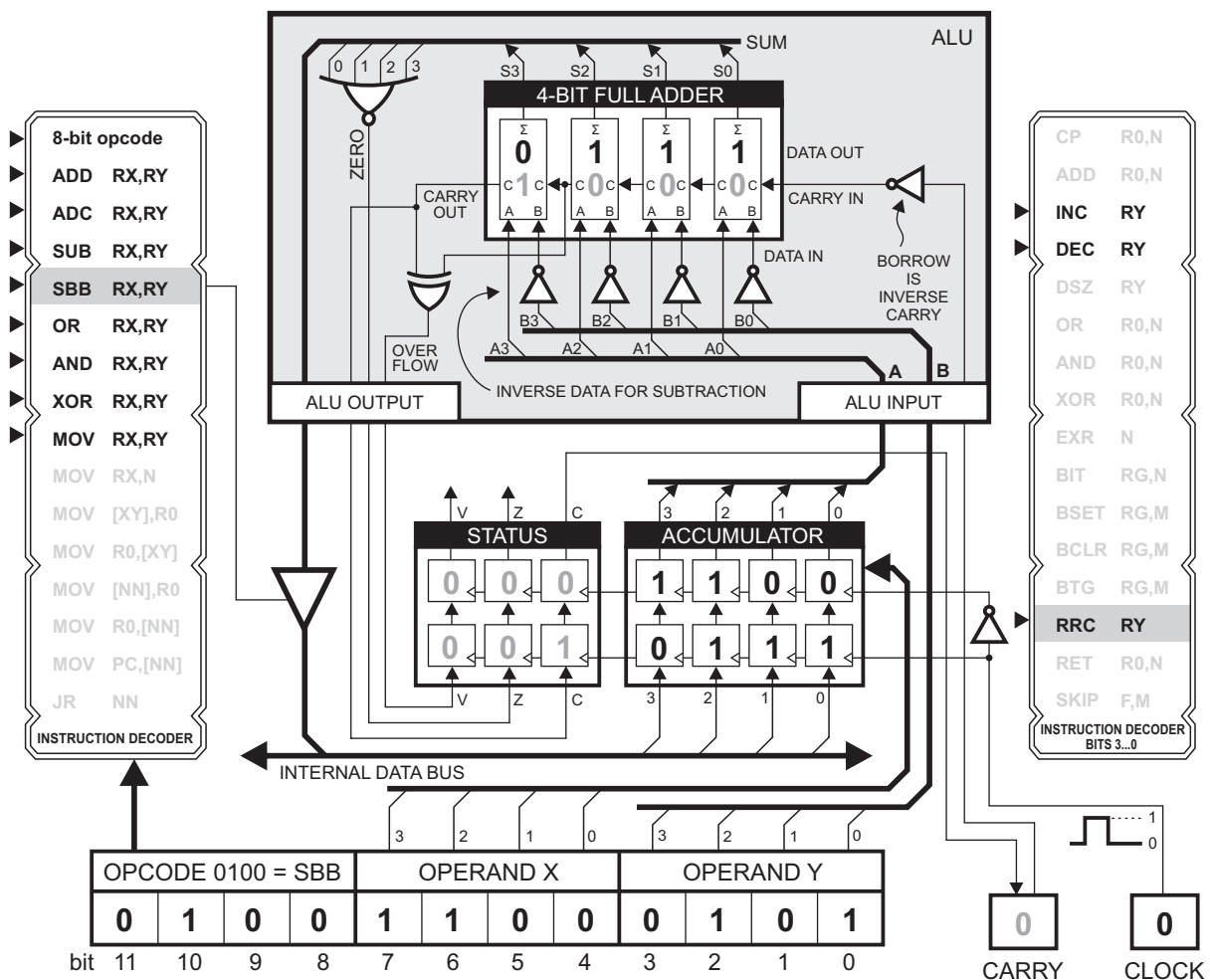
Encoding:

bit	11	10	9	8	7	6	5	4	3	2	1	0
	0	1	0	0	X	X	X	X	Y	Y	Y	Y

The "0100" bits are the Sbb X,Y opcode
 The "XXXX" bits are the contents of register X
 The "YYYY" bits are the contents of register Y

Example:

SBB 12, 5



OR X,Y

Inclusive OR registers X and Y

Syntax: {label} OR X, Y

Operands: $X \in \#0\ldots\#15$
 $Y \in \#0\ldots\#15$

Operation: $X \leftarrow X .OR. Y$

Description: Compute the logical inclusive OR operation of register X and register Y and place the result into the register X.

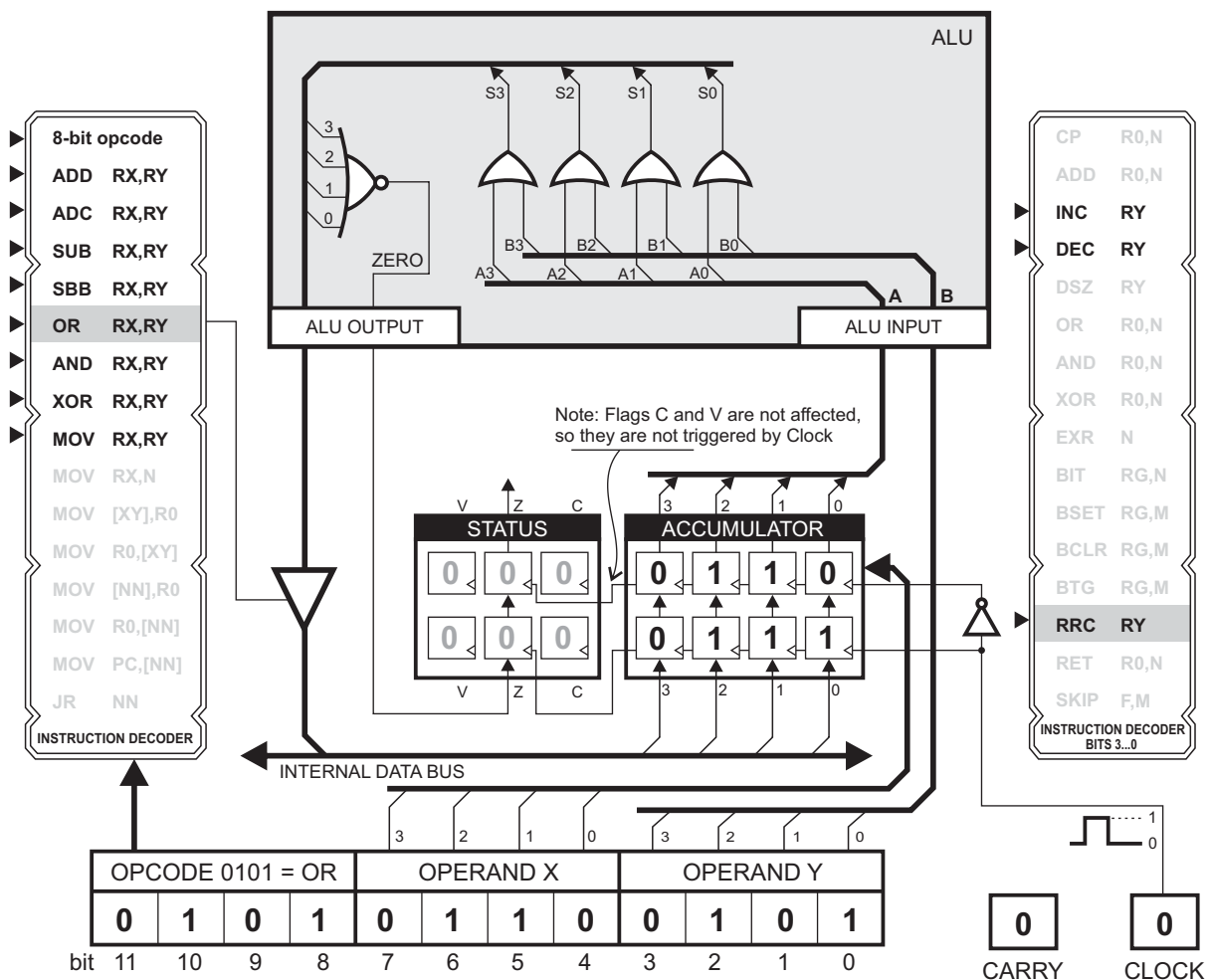
Flags affected: Flag C is not affected.
 If result = 0000 after operation, set Z. Otherwise, reset Z.

Encoding:

bit	11	10	9	8	7	6	5	4	3	2	1	0
	0	1	0	1	X	X	X	X	Y	Y	Y	Y

The "0101" bits are the OR X,Y opcode
 The "XXXX" bits are the contents of register X
 The "YYYY" bits are the contents of register Y

Example: **OR 6, 5**



AND X,Y

Logical AND registers X and Y

Syntax: {label} AND X, Y

Operands: $X \in \#0\ldots\#15$
 $Y \in \#0\ldots\#15$

Operation: $X \leftarrow X \text{ .AND. } Y$

Description: Compute the logical inclusive OR operation of register X and register Y and place the result into the register X.

Flags affected: Flag C is not affected.
 If result = 0000 after operation, set Z. Otherwise, reset Z.

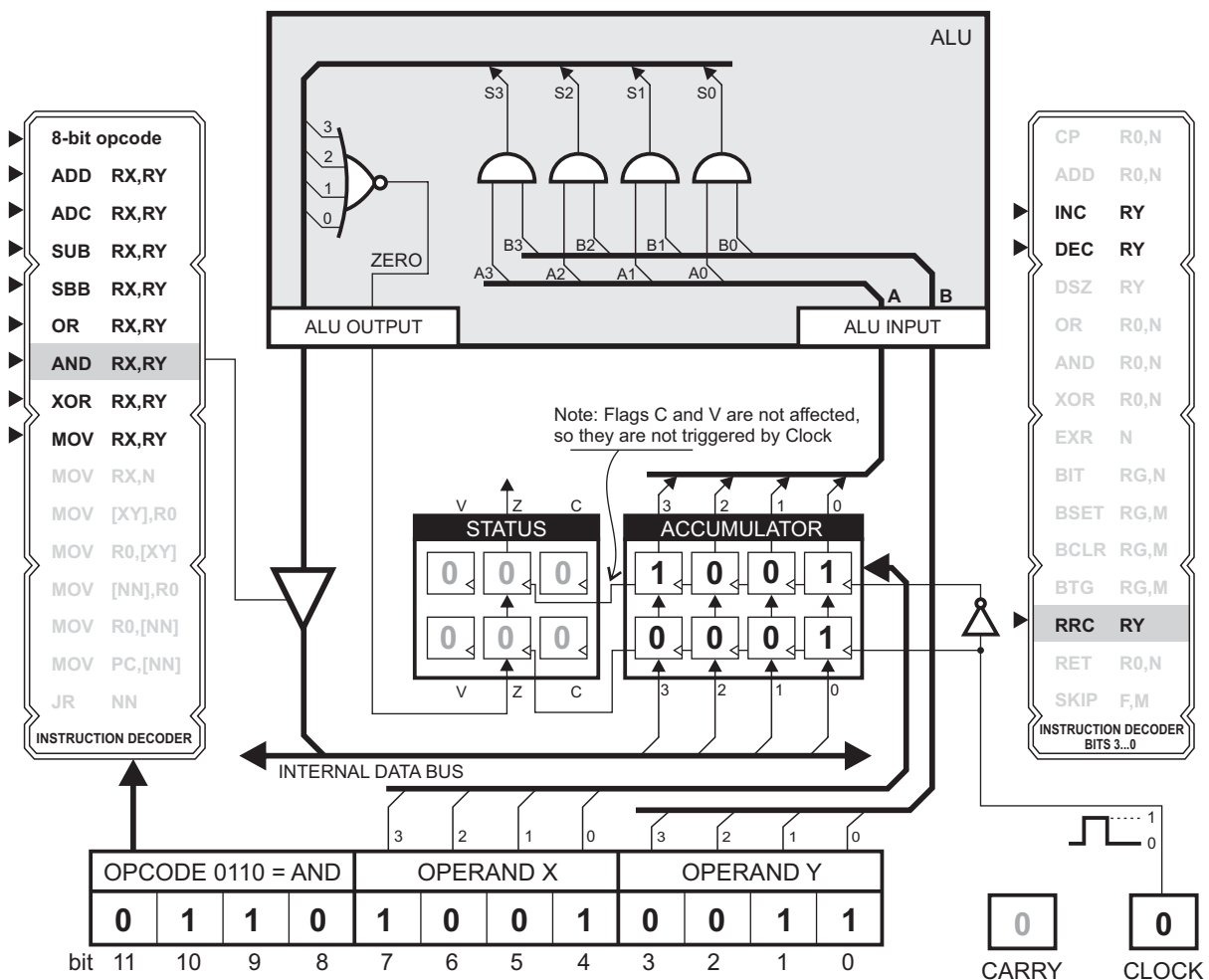
Encoding:

bit	11	10	9	8	7	6	5	4	3	2	1	0
	0	1	1	0	X	X	X	X	Y	Y	Y	Y

The "0110" bits are the AND X,Y opcode
 The "XXXX" bits are the contents of register X
 The "YYYY" bits are the contents of register Y

Example:

AND 9, 3



XOR X,Y

Exclusive OR registers X and Y

Syntax: {label} XOR X, Y

Operands:
 $X \in \#0\ldots\#15$
 $Y \in \#0\ldots\#15$

Operation: $X \leftarrow X .OR. Y$

Description: Compute the logical exclusive OR operation of register X and register Y and place the result into the register X.

Flags affected: Flag C is not affected.
 If result = 0000 after operation, set Z. Otherwise, reset Z.

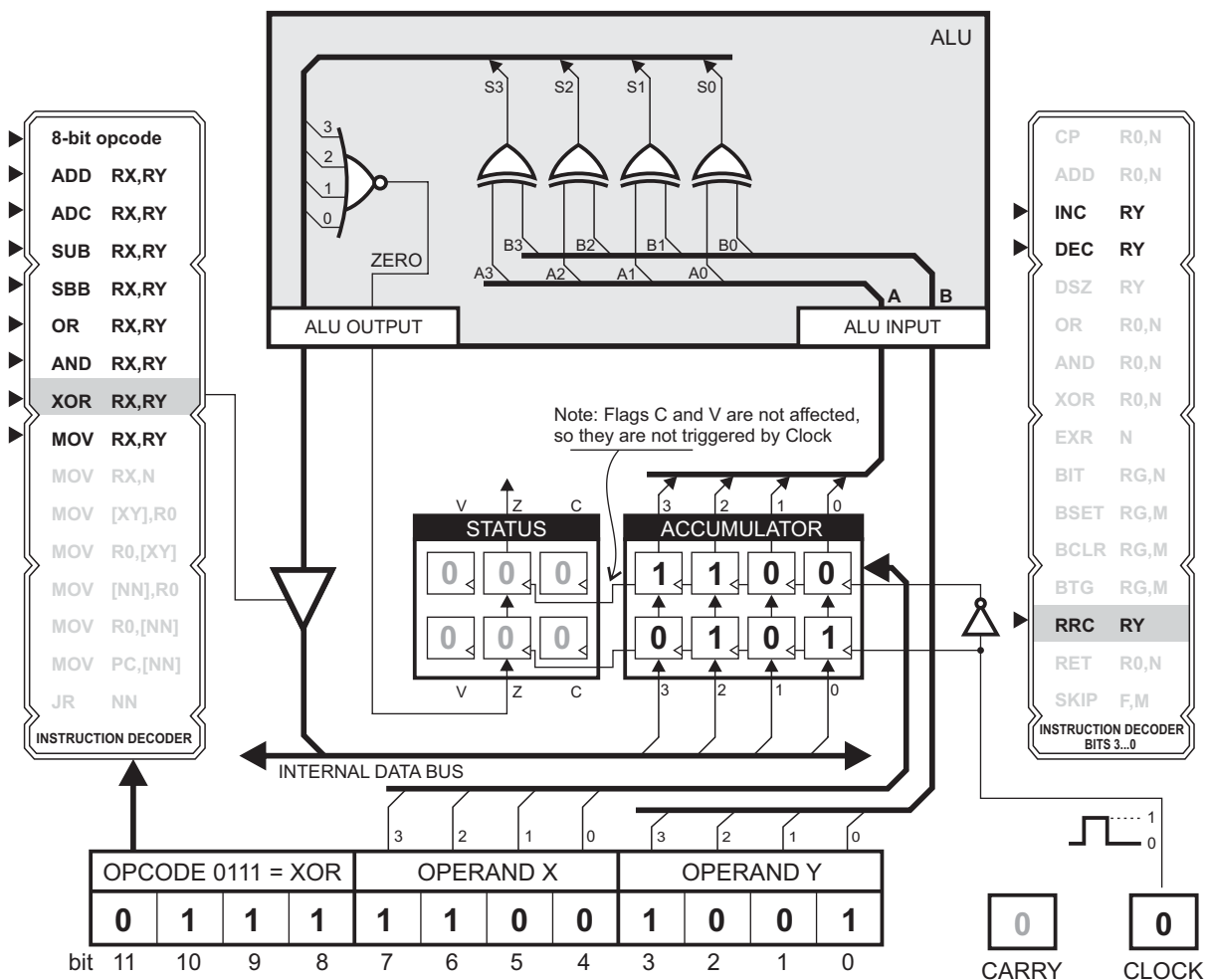
Encoding:

bit	11	10	9	8	7	6	5	4	3	2	1	0
	0	1	1	1	X	X	X	X	Y	Y	Y	Y

The "0111" bits are the XOR X,Y opcode
 The "XXXX" bits are the contents of register X
 The "YYYY" bits are the contents of register Y

Example:

XOR 12, 9



MOV X,Y

Move contents of register Y to register X

Syntax: {label} MOV X, Y

Operands: $X \in \#0\ldots\#15$
 $Y \in \#0\ldots\#15$

Operation: $X \leftarrow Y$

Description: Move the contents of the register Y to register X. Value of the register Y is unchanged.

Flags affected: None.

Encoding:

bit	11	10	9	8	7	6	5	4	3	2	1	0
	1	0	0	0	X	X	X	X	Y	Y	Y	Y

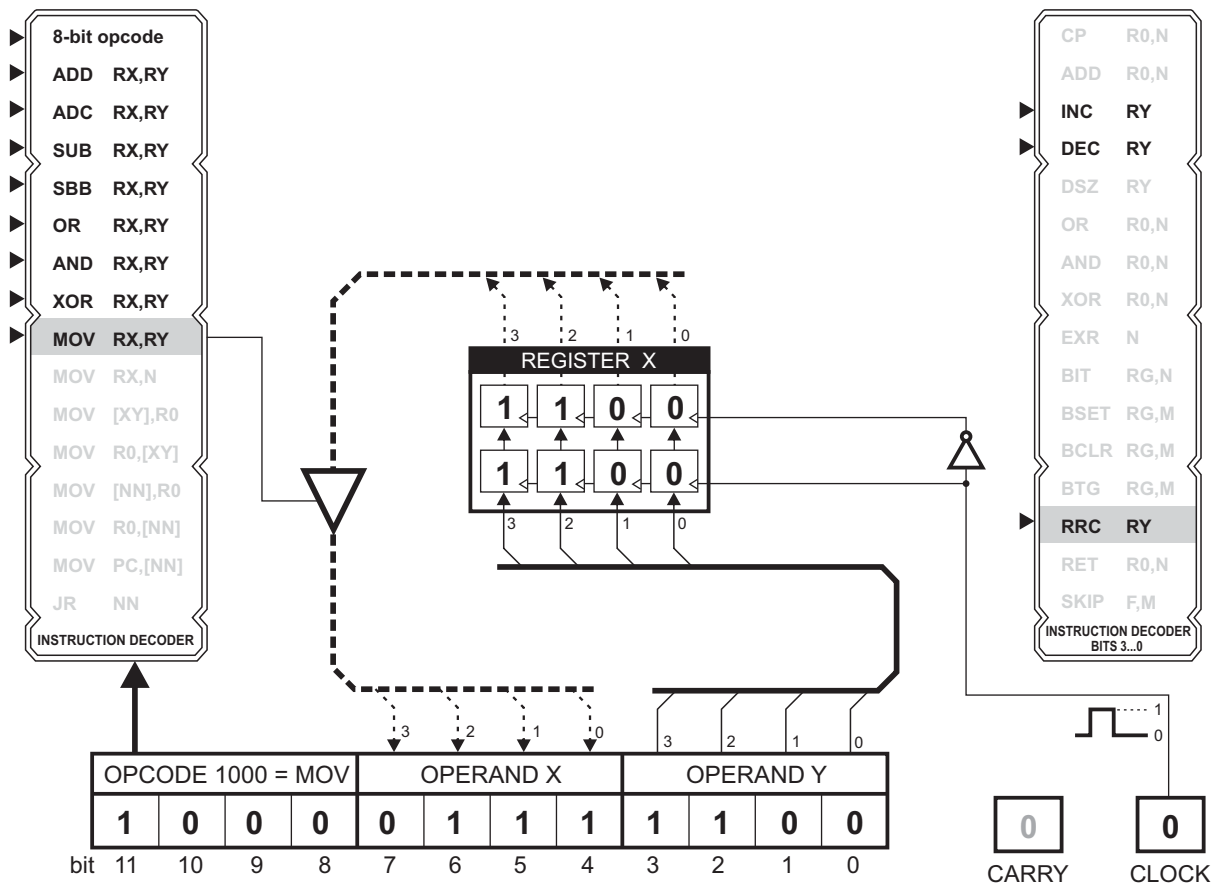
The "1000" bits are the MOV X,Y opcode

The "XXXX" bits are the old contents of register X

The "YYYY" bits are the contents of register Y

Example:

MOV 7, 12



INC Y

Increment the value of register Y

Syntax: {label} INC Y

Operands: $Y \in \#0...\#15$

Operation: $Y \leftarrow Y + 1$

Description: Add 1 to the contents of the 4-bit register Y and place the result back into the register Y.

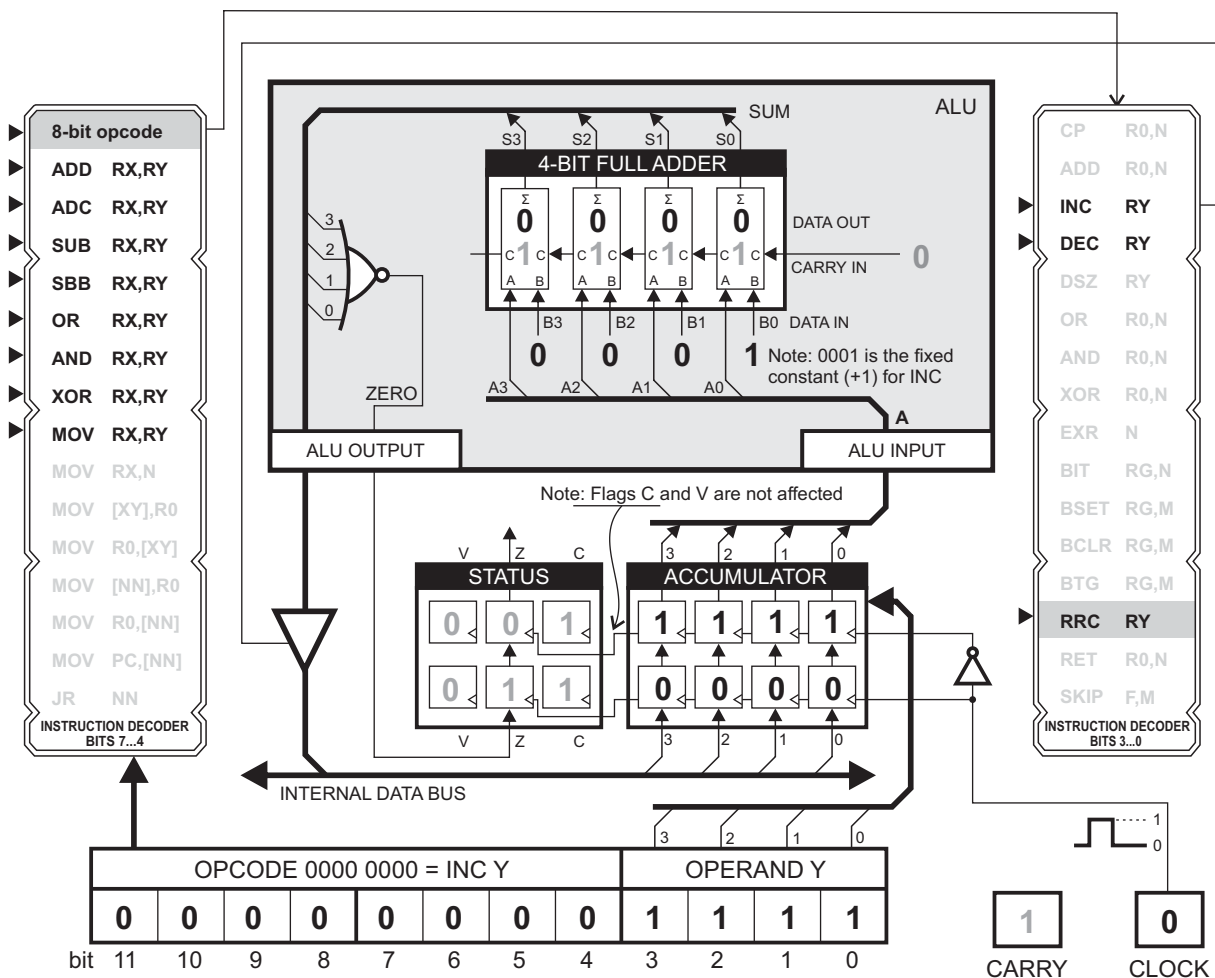
Flags affected: Flag C is not affected.
If result = 0000 after operation, set Z. Otherwise, reset Z.

Encoding:

bit	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	0	Y	Y	Y	Y

The "0000 0000" bits are the INC Y opcode
The "YYYY" bits are the contents of register Y

Example: **INC 15**



DEC Y

Decrement the value of register Y

Syntax: {label} DEC Y

Operands: $Y \in \#0...\#15$

Operation: $Y \leftarrow Y - 1$

Description: Add -1 to the contents of the 4-bit register Y and place the result back into the register Y.

Flags affected: Flag C is not affected.
If result = 0000 after operation, set Z. Otherwise, reset Z.

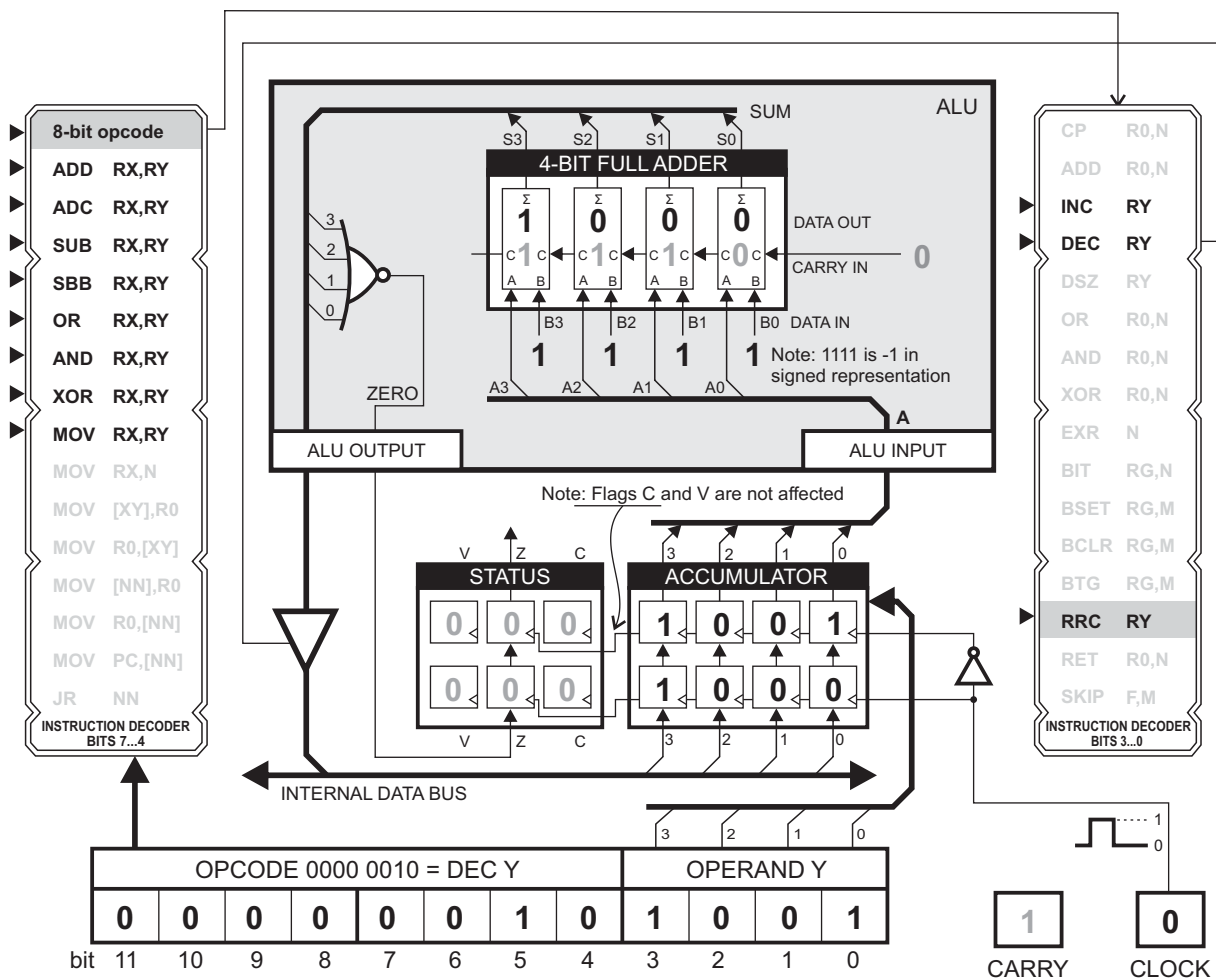
Encoding:

bit	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	1	Y	Y	Y	Y

The "0000 0001" bits are the DEC Y opcode
The "YYYY" bits are the contents of register Y

Example:

DEC 9



RRC Y

Rotate right through Carry the value of register Y

Syntax: {label} RRC Y

Operands: $Y \in \#0...\#15$

Operation: $C \leftarrow Y0, Y3 \leftarrow C, Y2 \leftarrow Y3, Y1 \leftarrow Y2, Y0 \leftarrow Y1$

Description: Rotate the contents of the register Y one bit to the right through Carry and place the result back in the register Y. The Carry flag is shifted into the Bit 7 of register Y, and Carry is overwritten with the Bit 0 of register Y.

Flags affected: Flag C is not affected.
If result = 0000 after operation, set Z. Otherwise, reset Z.

Encoding:

bit	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	1	0	Y	Y	Y	Y

The "0000 0010" bits are the RRC Y opcode
The "YYYY" bits are the contents of register Y

Example:

RRC 6

