ELLIOTT 903

Volume 1: FUNCTIONAL SPECIFICATION

Part 2: THE BASIC 903 COMPUTER UNIT

Section 2: WORD FORMAT AND INSTRUCTION CODE

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Chapter 1: INTRODUCTION

1.1 General.

The 903 is a conventional stored program computer operating in the parallel binary mode. In the computer each word of information consists of an 18-bit binary pattern which may represent either an instruction or an operand of an instruction (e.g. a constant).

The accumulator (A-register) usually holds the result of executing an instruction, and this result is then available as one of the operands for the next instruction. For some purposes - chiefly during the arithmetic functions of multiplication and division - the less significant end of the accumulator is extended by the addition of the 17 most significant bits of the Q register, to hold a 35-bit operand.

Instructions are stored and obeyed sequentially and without gaps. A number of registers apart from A may be used while instructions are being obeyed. Some registers are accessible to program and they are dealt with fully in Section 1. 2. 1; those not accessible to program are dealt briefly in Section 1. 2. 1. and explained fully in Part 1 of Volume 4.

Chapter 2: WORD FORMAT

2. 1 General.

The binary bits of a word are referred to as bits 18, 17, 16..... 3, 2, 1, bit 1 being the least significant.

2. 2 Representation of Numbers.

When a word represents a number, bit 18 is the sign bit and indicates whether the number following is positive or negative; the binary point is placed immediately after bit 18. Numbers are represented as fractions and when bit 18 is zero the following 17 bits represent a positive number; when it is 1 a negative number is represented. Positive numbers are represented by the appropriate digits of bits 17-1 being set to 1, and negative numbers are represented inversely in "two's complement" form.

The value that may be attributed to each digit of a word is as follows:

Bit no. 18, 17, 16..... 3, 2, 1

Value $-1, 2^{-1}, 2^{-2}.....2^{-15}, 2^{-16}, 2^{-17}$

Thus the largest positive number that may be represented is:

0. 11 111 111 111 111 111 $(1 - 2^{-17})$

The smallest positive number is:

0. 00 000 000 000 000 001 (2^{-17})

The negative number with the largest possible modulus is:

1. 00 000 000 000 000 000 (-1)

The negative number with the smallest possible modulus is:

1. 11 111 111 111 111 111 (-2^{-17})

2. 3 Representation of Instructions.

Instructions are of the single address type and when a word represents an instruction, its bits are grouped as follows:-

Group symbol	B	F	N
Bits per group	1	4	13

Bit 18 B This is the B-modifier marker and has significance as follows:-

0 - the instruction is obeyed as stored

1 - the address part of the instruction is modified by the addition of the contents of the B register before the function is obeyed. The function part of the instruction remains unaltered by modification. The contents of the B register must be set by program before the instruction is obeyed.

Bits 17-14 F This may represent any one of the 16 functions (0 to 15), which specifies the operation to be carried out by the computer, normally on the contents of the store location specified by N (see Chapter 3 of this Section).

Bits 13-1 N These are the address bits which may specify any one of 8192 store locations, addressable from 0 to 8191. Therefore N, without modification, may address any location in the basic store unit. The B-modifier facility allows extra store to be addressed (see Section 1. 3. 4 for details).

2. 4 Coded form of instructions.

In the written form of a machine code instruction the function and address groups are represented by integers in the range 0 to 15 and 0 to 8191 respectively. If B-line modification is intended, a solidus (/) must be written immediately preceding the function digits.

Example:

Written Form		Stored Binary Form		
		B	F	N
4	256	0	0100	0000100000000
/14	8126	1	1110	1111110111110

Chapter 3: INSTRUCTION CODE

3. 1 Instruction Table.

NOTES: (1) The following symbols are used in this table:

p = number of places shifted

z = number of words transferred

dr = device response time

For significance of all other symbols used in this table see Introduction to the 903 Manual.

(2) All times specified are for unmodified instructions and are subject to a ± 10% tolerance. For a modified instruction 7. 2 μs must be added to the times specified.

(3) The obeying of any instruction in these tables means that s:=s + 1 unless otherwise stated.

(4) If an instruction is to be modified, q is altered in an undefined manner before the instruction is obeyed.

FUNCTION	DESCRIPTION	EFFECT OF INSTRUCTION	REGISTERS NOT AFFECTED	INSTRUCTION TIMES (μS)	NOTES
0	Set B-Register	b: = m q: = m	A	29.5	an INTERRUPT cannot take place after this instruction.
1	Add	a: = a+m	Q,B	23.0	
2	Negate and Add	a: = -a+m q: = m	B	26.0	
3	Store Auxiliary Register	m18: = 0 m17-1: =q18-2	A,Q,B	24.5 24.5	
4	Load	a: = m	Q,B	23.0	
5	Store	m: = a	A,Q,B	24.5	
6	Collate	a: = a & m	Q,B	23.0	This function generates the logical product of a and m
7	Jump if a zero	Provided a = o, s13-1: = n s16-14 unchanged s18, 17 undefined q undefined If a $\neq$ 0, s:=s+1	A,B	If a=0, 27.5 If a>0, 21.0 If a<0, 19.5	
8	Jump unconditionally	Whether a is negative, zero or positive (not tested), the effect is as for Function 7, except that s:=m	A,Q,B	23.0	
9	Jump if a -ve	Provided a<0, the effect is as for Function 7. If a ≥ 0, s:=s+1	A,B	If a<0, 25.0 If a$\geq$0, 19.5	
10	Count in store	m: = m+2^{-17}	A,Q,B	23.5	
11	Store SCR	q18-17 undefined q16-14:=s16-14 q13-1:=0 m13-1:=s13-1 m18-14:=0	A,B	30.0	q18, q17 are undefined because s18, s17 are undefined
12	Multiply	(a, q18-2):=axm q1 undefined	B	78.5	

FUNCTION	DESCRIPTION	EFFECT OF INSTRUCTION	REGISTERS NOT AFFECTED	INSTRUCTION TIMES (μs)	NOTES
13	Divide	$a := \frac{a,q\,18\text{-}2}{n} \pm 2^{-17}$ $q := \frac{a,q\,18\text{-}2}{n} - 2^{-17} \pm 2^{-17}$ a1:=1 q1:=0	B	79.0	It is not in general possible to say when the result in A is greater or less than the true quotient. If, however, the quotient can be expressed exactly in 17 or fewer bits (counting from the sign digit) then the following alternatives apply:- a) Divisor positive. The correct quotient is in Q; A contains the correct quotient plus 2^{-17} b) Divisor negative. The correct quotient is $A + 2^{-17}$; the contents of Q are the correct quotient less 2^{-16}.
14	Shift				
	Left Shift	Provided $0 \leq n \leq 47$ $(a,q) := (a,q) \times 2^n$	B		The effect of trying to shift more than 48 places is not defined.
	Right Shift	Provided $8144 \leq n \leq 8191$ $(a,q) := (a,q) \times 2^{n-8192}$	B		The sign bit is regenerated.
	Block transfer			23.5+(7+dr)z	
	Block input	Provided $2048 \leq n \leq 4095$ Transfer x words from the peripheral device specified by bits n11-1 into store locations y to y+x-1 y=a x=q 12-1 (i.e. $x \leq 4095$) If x=0 the instruction has no effect.	B		Before the instruction is issued A must contain the address of the first location to which data is to be input. q12-1 must specify the number of locations to which data is to be input. On completion of the instruction, A contains the last word input.
	Block output	Provided $4096 \leq n \leq 6143$ Transfer x words to the peripheral device specified by bits n11-1 from store locations y to y+x-1 y=a x=q12-1 (i.e. $x \leq 4095$) If x=0 the instruction has no effect.	B		Before the instruction is issued A must contain the address of the first location from which data is to be output. q12-1 must specify the number of locations from which data is to be output. One completion of the instruction, A contains the last word output.

FUNCTION	DESCRIPTION	EFFECT OF INSTRUCTION	REGISTERS NOT AFFECTED	INSTRUCTION TIMES (μs)	NOTES
15	Input			20.5+dr	
	Input information from peripheral device	Provided $0 \leq n \leq 2047$ a:= one 18-bit word from the device specified by bits n11-1	Q,B		
	Input from Tape Reader	Provided n=2048, a shifted left 7 places a8-1: = 8-bit character input from tape reader	Q,B		If both a1=0 before left shift takes place, and bit 8 of character read by tape reader = 0, a8=0; if a1 was a one, bit 8 of the character read by tape reader = 1
	Input from Teleprinter	Provided n = 2052, a shifted left 7 places a8-1:= 8-bit character input from teleprinter	Q,B		m16 - 14 are ignored
	Output			19.0+dr	
	Output information to peripheral device	Provided $4096 \leq n \leq 6143$ one 18-bit word output from A to the device specified by bits n11-1	Q,B		
	Output information to Tape Punch	Provided n = 6144 a8-1 output to paper tape punch	Q,B		
	Output information to Teleprinter	Provided n = 6148, a 8-1 output to teleprinter	Q,B		m16-14 are ignored
	Program terminate	Provided $7168 \leq n \leq 8191$ current program level is terminated.	To be explained in Section 1.2.4 of this manual	19.0	The effect of this instruction on S will be explained in Section 1.2.4 of this manual.

This order code encompasses that of the MCD 920A computer. The following features are extensions to the 920A instruction code:

Block input

Block output

Preservation of Q by instructions 6 and 8.