

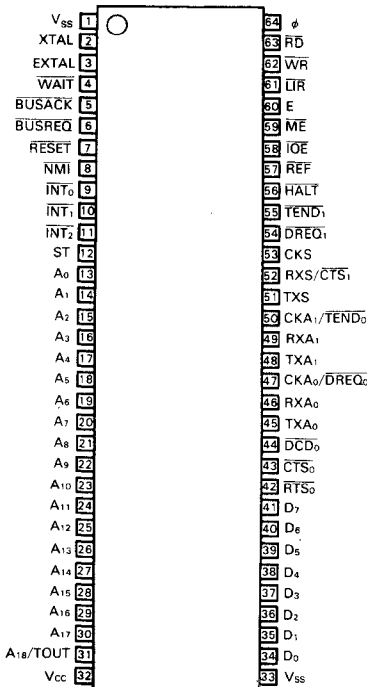
Hitachi 8-Bit Microprocessor
HD64180
Hardware Manual



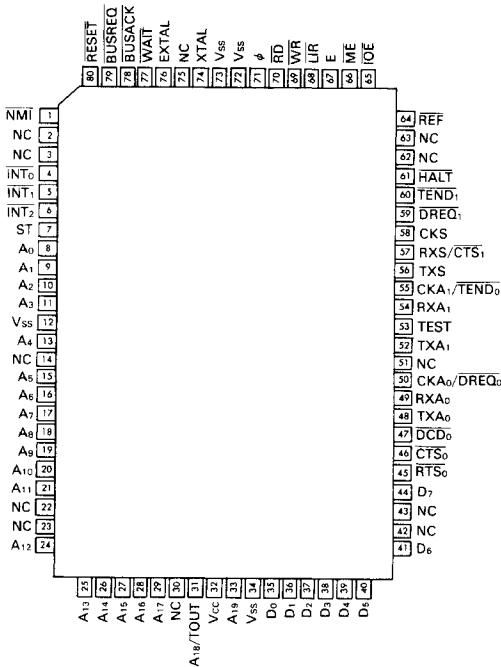
ADE-602-002C

1.2 Pin Assignment (Top View)

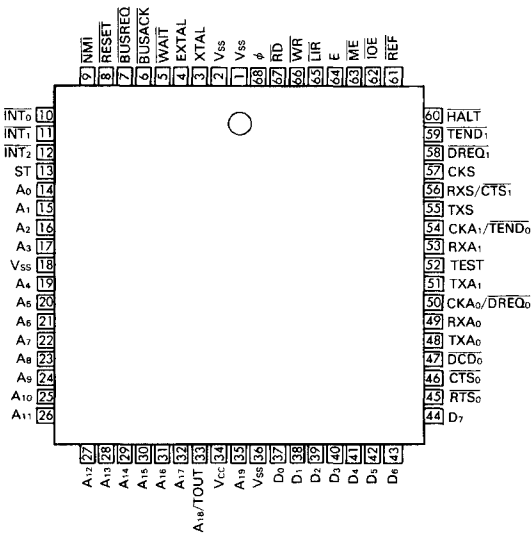
HD64180Z



(DP-64S)



(FP-80B)



(CP-68)

Please leave the TEST pin open.

2.6 Memory Management Unit (MMU)

The HD64180 contains an on-chip MMU which performs the translation of the CPU 64k bytes (16-bit addresses- 0000H to FFFFH) logical memory address space into a 512k bytes (19-bit addresses- 00000H to 7FFFFH) or 1M bytes (20-bit addresses- 00000H to FFFFFFFH) physical memory address space. Address translation occurs internally in parallel with other CPU operation.

2.6.1 Logical address spaces

The 64k bytes CPU logical address space is interpreted by the MMU as consisting of up to three separate logical address areas, Common Area 0, Bank Area and Common Area 1.

As shown in Fig. 2.6.1 a variety of logical memory configurations are possible. The boundaries between the Common and Bank Areas can be programmed with 4k bytes resolution.

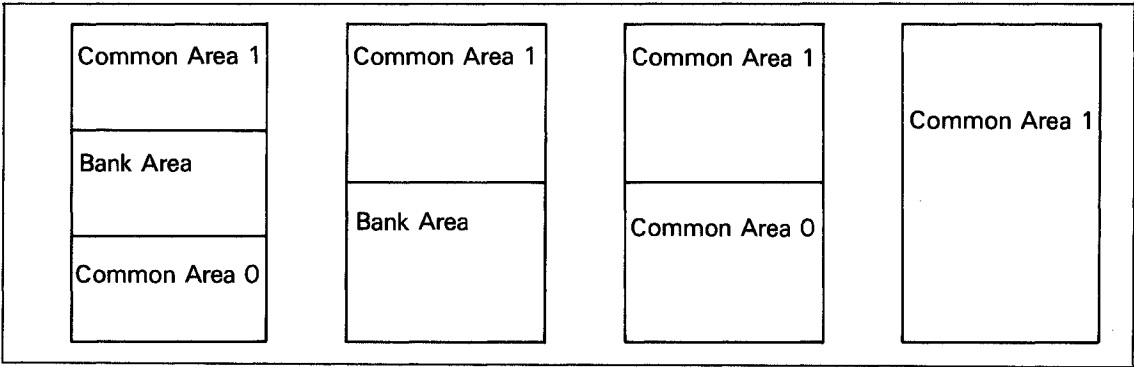


Figure 2.6.1 Logical Address Mapping Examples

2.6.2 Logical to physical address translation

Fig. 2.6.2 shows an example in which the three logical address space portions are mapped into a 512k (1M) bytes physical address space. The important points to note are that Common and Bank Areas can overlap and that Common Area 1 and Bank Area can be freely relocated (on 4k bytes physical address boundaries). Common Area 0 (if it exists) is always based at physical address 00000H.

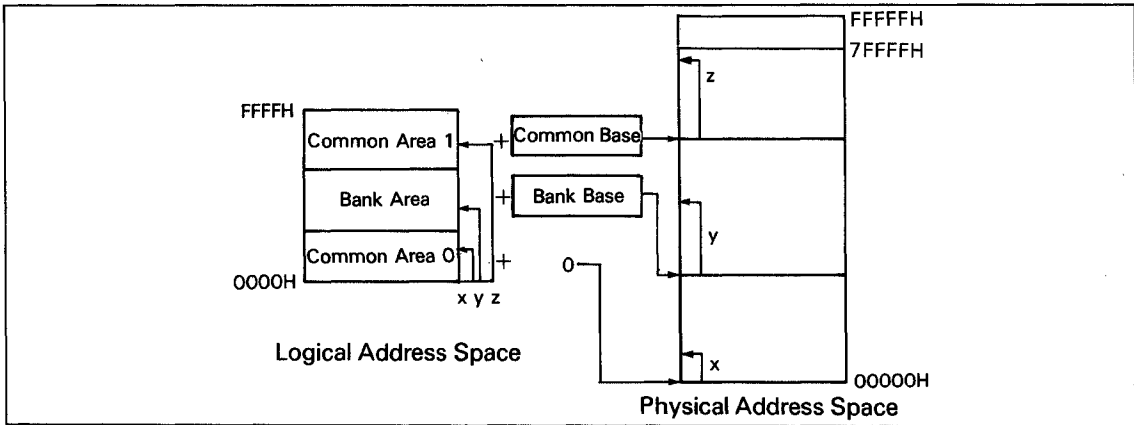


Figure 2.6.2 Logical to Physical Memory Mapping Example

2.6.3 MMU block diagram

The MMU block diagram is shown in Fig. 2.6.3. The MMU translates internal 16-bit logical addresses to external 19-bit or 20-bit physical addresses.

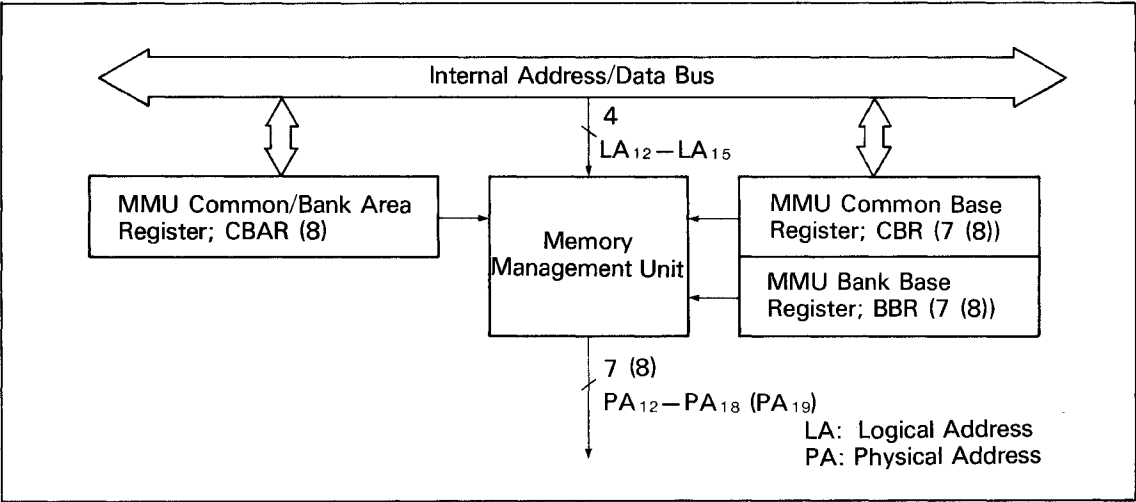


Figure 2.6.3 MMU Block Diagram

Whether address translation takes place depends on the type of CPU cycle as follows.

(1) Memory Cycles

Address Translation occurs for all memory access cycles including instruction and operand fetches, memory data reads and writes, hardware interrupt vector fetch and software interrupt restarts.

(2) I/O Cycles

The MMU is logically bypassed for I/O cycles. The 16-bit logical I/O address space corresponds directly with the 16 bit physical I/O address space. The three high order bits (A₁₆—A₁₈ (A₁₉)) of the physical address are always 0 during I/O cycles.

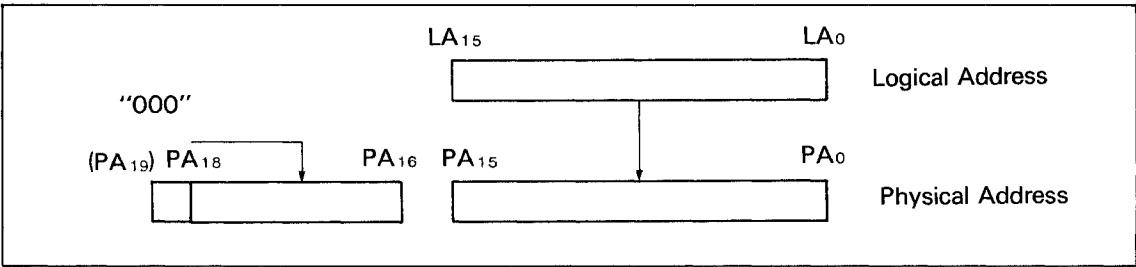


Figure 2.6.4 I/O Address Translation

(3) DMA Cycles

When the HD64180 on-chip DMAC is using the external bus, the MMU is physically bypassed. The 19-bit or 20-bit source and destination registers in the DMAC are directly output on the physical address bus (A₀—A₁₈ (A₁₉)).

2.6.4 MMU registers

Three MMU registers are used to program a specific configuration of logical and physical memory.

- (1) MMU Common/Bank Area Register (CBAR)
- (2) MMU Common Base Register (CBR)
- (3) MMU Bank Base Register (BBR)

CBAR is used to define the logical memory organization, while CBR and BBR are used to relocate logical areas within the 512k (1M) bytes physical address space. The resolution for both setting boundaries within the logical space and relocation within the physical space is 4k bytes.

The CAR field of CBAR determines the start address of Common Area 1 (Upper Common) and by default, the end address of the Bank Area. The BAR field determines the start address of the Bank Area and by default, the end address of Common Area 0 (Lower Common).

The CA and BA fields of CBAR may be freely programmed subject only to the restriction that CA may never be less than BA. Fig. 2.6.5 and Fig. 2.6.6 shows example of logical memory organizations associated with different values of CA and BA.

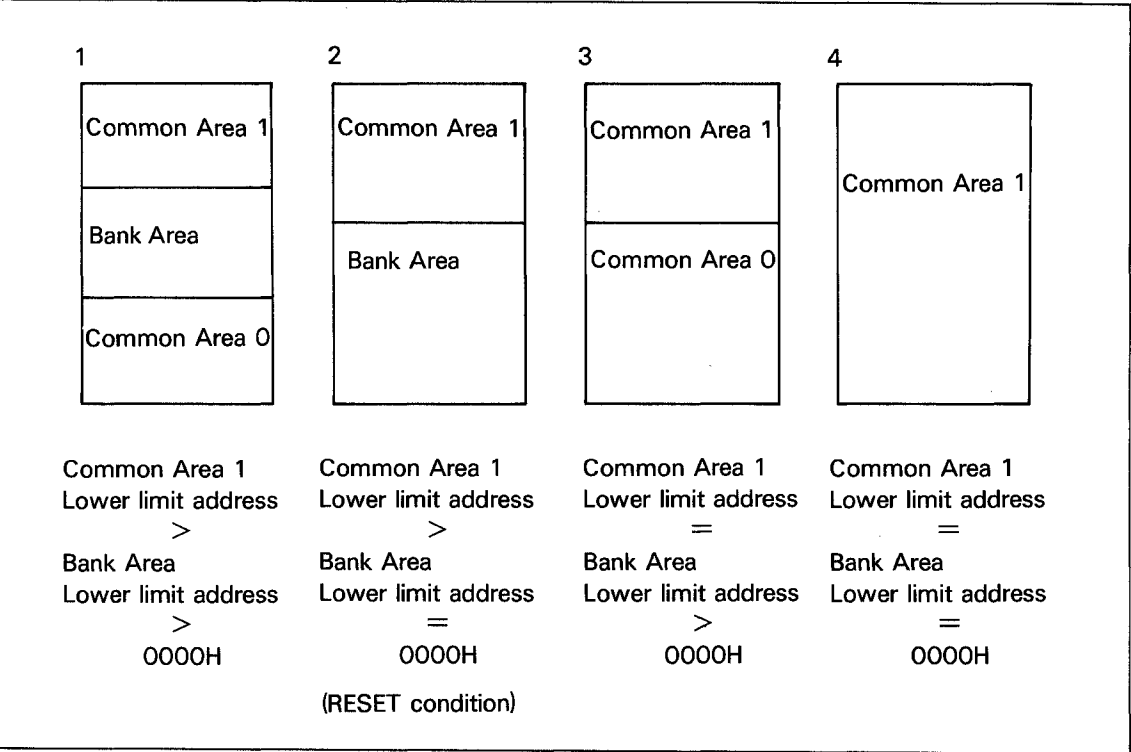


Figure 2.6.5 Logical Memory Organization

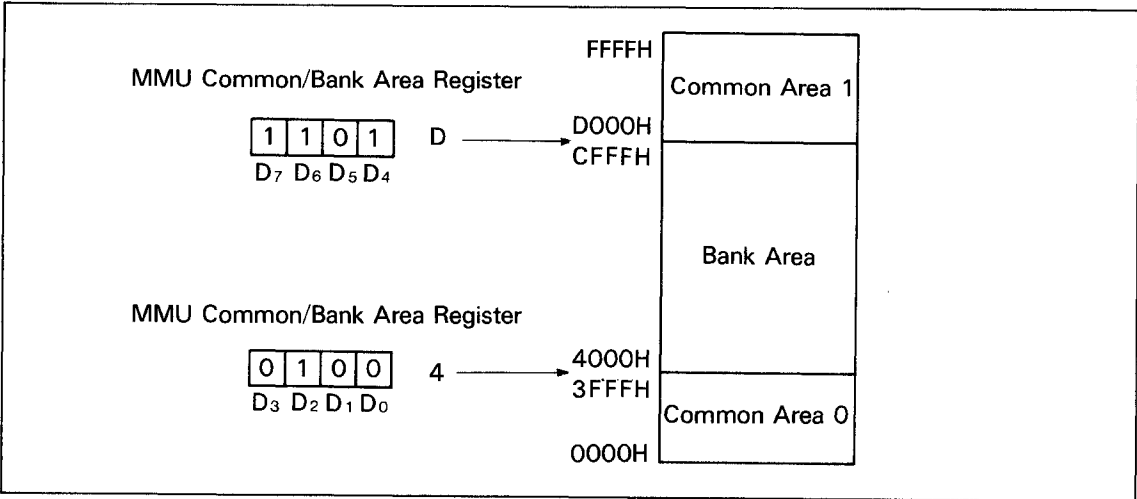


Figure 2.6.6 Logical Space Configuration (Example)

MMU REGISTER DESCRIPTION

MMU Common/Bank Area Register (CBAR)

CBAR specifies boundaries within the HD64180 64k bytes logical address space for up to three areas, Common Area 0, Bank Area and Common Area 1.

MMU Common/Bank Area Register (CBAR : I/O Address = 3AH)

bit	7	6	5	4	3	2	1	0
	CA3	CA2	CA1	CA0	BA3	BA2	BA1	BA0
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

○ **CA3-CA0: CA (bits 7-4)**

CA specifies the start (low) address (on 4k bytes boundaries) for the Common Area 1. This also determines the last address of the Bank Area. All bits of CA are set to 1 during RESET.

○ **BA3-BA0: BA (bits 3-0)**

BA specifies the start (low) address (on 4k bytes boundaries) for the Bank Area. This also determines the last address of the Common Area 0. All bits of BA are reset to 0 during RESET.

MMU Common Base Register (CBR)

CBR specifies the base address (on 4k bytes boundaries) used to generate a 19-bit or 20-bit physical address for Common Area 1 accesses. All bits of CBR are reset to 0 during RESET.

MMU Common Base Register (CBR : I/O Address = 38H)

bit	7	6	5	4	3	2	1	0
	CB7*	CB6	CB5	CB4	CB3	CB2	CB1	CB0
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

MMU Bank Base Register (BBR)

BBR specifies the base address (on 4k bytes boundaries) used to generate a 19-bit or 20-bit physical address for Bank Area accesses. All bits of BBR are reset to 0 during RESET.

MMU Bank Base Register (BBR : I/O Address = 39H)

bit	7	6	5	4	3	2	1	0
	BB7*	BB6	BB5	BB4	BB3	BB2	BB1	BB0
	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

2.6.5 Physical address translation

Fig. 2.6.7 shows the way in which physical addresses are generated based on the contents of CBAR, CBR and BBR. MMU comparators classify an access by logical area as defined by CBAR. Depending on which of the three potential logical areas (Common Area 1, Bank Area or Common Area 0) is being accessed, the appropriate 7-bit base address is added to the high-order 4 bits of the logical address, yielding a 19-bit or 20-bit physical address. CBR is associated with Common Area 1 accesses. Common Area 0 accesses use a (non-accessible, internal) base register which contains 0. Thus, Common Area 0, if defined, is always based at physical address 00000H. Figure 2.6.8 shows an example of the correspondence between logical space and physical space.

* CBR and BBR are expanded from 7 bits to 8 bits in the package version of CP-68 and FP-80B.

2.6.6 MMU and RESET

During RESET, all bits of the CA field of CBAR are set to 1 while all bits of the BA field of CBAR, CBR and BBR are reset to 0. The logical 64k bytes address space corresponds directly with the first 64k bytes (0000H to FFFFH) of the 512k bytes (00000H to 7FFFFH) physical address space. Thus, after RESET, the HD64180 will begin execution at logical and physical address 0.

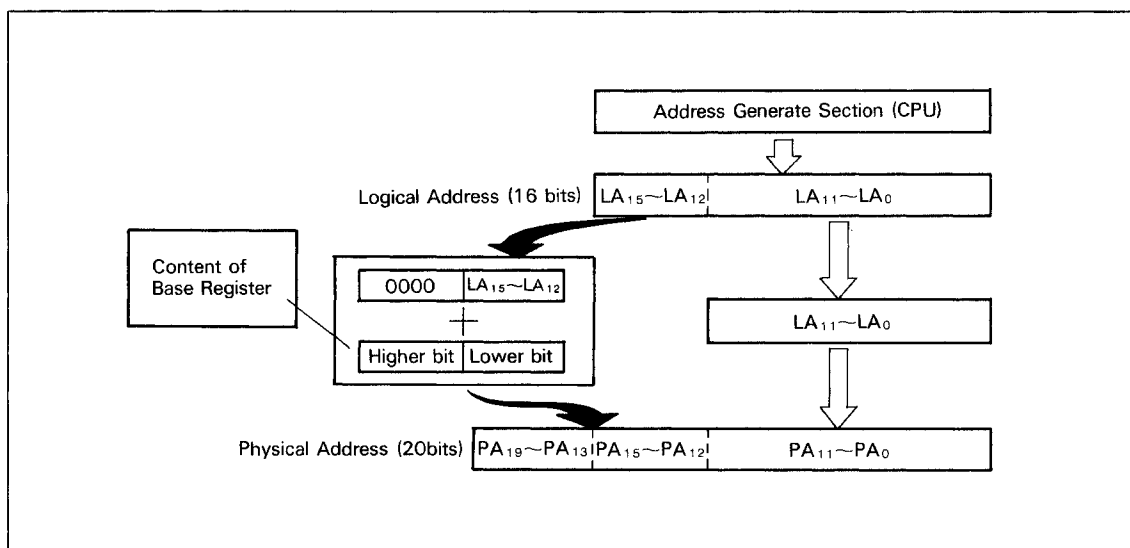


Figure 2.6.7 Physical Address Generation

2.6.7 MMU register access timing

When data is written into CBAR, CBR or BBR, the value will be effective from the cycle immediately following the I/O write cycle which updates these registers.

Care must be taken during MMU programming to insure that CPU program execution is not disrupted. Observe that the next cycle following MMU register programming will normally be an op-code fetch from the newly translated address. One simple technique is to localize all MMU programming routines in a Common Area that is always enabled.

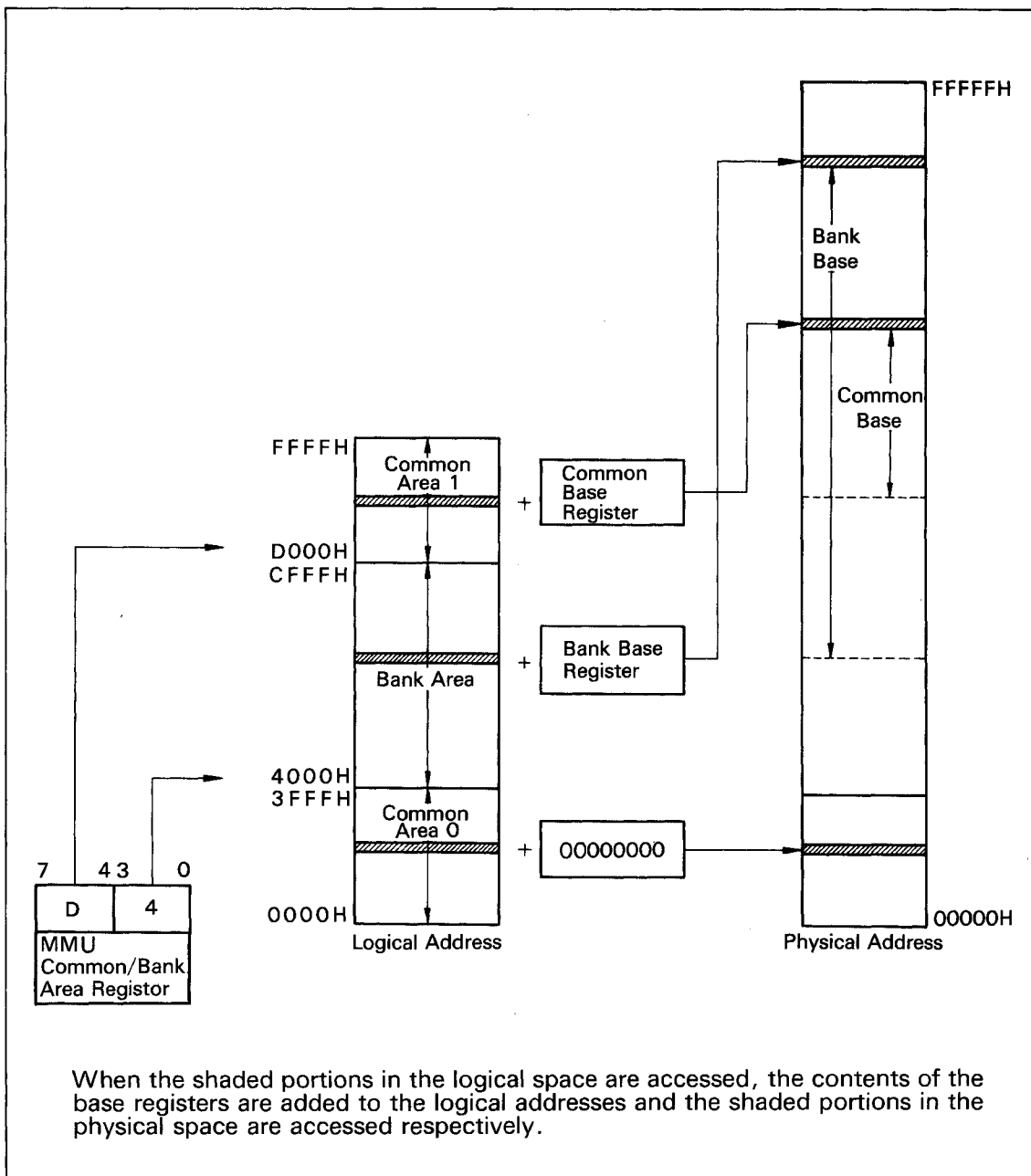


Figure 2.6.8 Example of the Correspondence between Logical Space and Physical Space

B. Instruction Summary in Alphabetical Order

**** : Added new instructions to Z80**

MNEMONICS	Bytes	Machine Cycles	States
ADC A,m	2	2	6
ADC A,g	1	2	4
ADC A, (HL)	1	2	6
ADC A, (IX+d)	3	6	14
ADC A, (IY+d)	3	6	14
ADD A,m	2	2	6
ADD A,g	1	2	4
ADD A, (HL)	1	2	6
ADD A, (IX+d)	3	6	14
ADD A, (IY+d)	3	6	14
ADC HL,ww	2	6	10
ADD HL,ww	1	5	7
ADD IX,xx	2	6	10
ADD IY,yy	2	6	10
AND m	2	2	6
AND g	1	2	4
AND (HL)	1	2	6
AND (IX+d)	3	6	14
AND (IY+d)	3	6	14
BIT b, (HL)	2	3	9
BIT b, (IX+d)	4	5	15
BIT b, (IY+d)	4	5	15
BIT b,g	2	2	6
CALL f,mn	3	2	6
			(If condition is false)
	3	6	16
			(If condition is true)

(to be continued)

MNEMONICS	Bytes	Machine Cycles	States
CALL mn	3	6	16
CCF	1	1	3
CPD	2	6	12
CPDR	2	8	14
			(If $BC_R \neq 0$ and $Ar \neq (HL)_M$)
	2	6	12
			(If $BC_R = 0$ or $Ar = (HL)_M$)
CP (HL)	1	2	6
CPI	2	6	12
CPIR	2	8	14
			(If $BC_R \neq 0$ and $Ar \neq (HL)_M$)
	2	6	12
			(If $BC_R = 0$ or $Ar = (HL)_M$)
CP (IX+d)	3	6	14
CP (IY+d)	3	6	14
CPL	1	1	3
CP m	2	2	6
CP g	1	2	4
DAA	1	2	4
DEC (HL)	1	4	10
DEC IX	2	3	7
DEC IY	2	3	7
DEC (IX+d)	3	8	18
DEC (IY+d)	3	8	18
DEC g	1	2	4
DEC ww	1	2	4
DI	1	1	3

(to be continued)

MNEMONICS	Bytes	Machine Cycles	States
DJNZ j	2	5	9 (If Br≠0)
	2	3	7 (If Br=0)
EI	1	1	3
EX AF,AF'	1	2	4
EX DE,HL	1	1	3
EX (SP),HL	1	6	16
EX (SP),IX	2	7	19
EX (SP),IY	2	7	19
EXX	1	1	3
HALT	1	1	3
IM 0	2	2	6
IM 1	2	2	6
IM 2	2	2	6
INC g	1	2	4
INC (HL)	1	4	10
INC (IX+d)	3	8	18
INC (IY+d)	3	8	18
INC ww	1	2	4
INC IX	2	3	7
INC IY	2	3	7
IN A,(m)	2	3	9
IN g,(C)	2	3	9
INI	2	4	12
INIR	2	6	14 (If Br≠0)
	2	4	12 (If Br=0)
IND	2	4	12
INDR	2	6	14 (If Br≠0)

(to be continued)

MNEMONICS	Bytes	Machine Cycles	States
INDR	2	4	12 (If Br= 0)
INO g,(m)**	3	4	12
JP f,mn	3	2	6
			(If f is false)
	3	3	9
			(If f is true)
JP (HL)	1	1	3
JP (IX)	2	2	6
JP (IY)	2	2	6
JP mn	3	3	9
JR j	2	4	8
JR C,j	2	2	6
			(If condition is false)
	2	4	8
			(If condition is true)
JR NC,j	2	2	6
			(If condition is false)
	2	4	8
			(If condition is true)
JR Z,j	2	2	6
			(If condition is false)
	2	4	8
			(If condition is true)
JR NZ,j	2	2	6
			(If condition is false)
	2	4	8
			(If condition is true)

(to be continued)

MNEMONICS	Bytes	Machine Cycles	States
LD A, (BC)	1	2	6
LD A, (DE)	1	2	6
LD A,I	2	2	6
LD A, (mn)	3	4	12
LD A,R	2	2	6
LD (BC),A	1	3	7
LDD	2	4	12
LD (DE),A	1	3	7
LD ww,mn	3	3	9
LD ww,(mn)	4	6	18
LDDR	2	6	14 (If $BC_R \neq 0$)
	2	4	12 (If $BC_R = 0$)
LD (HL),m	2	3	9
LD HL,(mn)	3	5	15
LD (HL),g	1	3	7
LDI	2	4	12
LD I,A	2	2	6
LDIR	2	6	14 (If $BC_R \neq 0$)
	2	4	12 (If $BC_R = 0$)
LD IX,mn	4	4	12
LD IX,(mn)	4	6	18
LD (IX+d),m	4	5	15
LD (IX+d),g	3	7	15
LD IY,mn	4	4	12
LD IY,(mn)	4	6	18
LD (IY+d),m	4	5	15
LD (IY+d),g	3	7	15

(to be continued)

MNEMONICS	Bytes	Machine Cycles	States
LD (mn),A	3	5	13
LD (mn),ww	4	7	19
LD (mn),HL	3	6	16
LD (mn),IX	4	7	19
LD (mn),IY	4	7	19
LD R,A	2	2	6
LD g,(HL)	1	2	6
LD g,(IX+d)	3	6	14
LD g,(IY+d)	3	6	14
LD g,m	2	2	6
LD g,g'	1	2	4
LD SP,HL	1	2	4
LD SP,IX	2	3	7
LD SP,IY	2	3	7
MLT ww**	2	13	17
NEG	2	2	6
NOP	1	1	3
OR (HL)	1	2	6
OR (IX+d)	3	6	14
OR (IY+d)	3	6	14
OR m	2	2	6
OR g	1	2	4
OTDM**	2	6	14
OTDMR**	2	8	16 (If Br \neq 0)
	2	6	14 (If Br=0)
OTDR	2	6	14 (If Br \neq 0)
	2	4	12 (If Br=0)

(to be continued)

MNEMONICS	Bytes	Machine Cycles	States
OTIM**	2	6	14
OTIMR**	2	8	16 (If Br≠0)
	2	6	14 (If Br=0)
OTIR	2	6	14 (If Br≠0)
	2	4	12 (If Br=0)
OUTD	2	4	12
OUTI	2	4	12
OUT (m),A	2	4	10
OUT (C),g	2	4	10
OUTO (m),g**	3	5	13
POP IX	2	4	12
POP IY	2	4	12
POP zz	1	3	9
PUSH IX	2	6	14
PUSH IY	2	6	14
PUSH zz	1	5	11
RES b,(HL)	2	5	13
RES b,(IX+d)	4	7	19
RES b,(IY+d)	4	7	19
RES b,g	2	3	7
RET	1	3	9
RET f	1	3	5
			(If condition is false)
	1	4	10
			(If condition is true)
RETI	2	10 (Z)	22 (Z)
		4 (R1)	12 (R1)
RETN	2	4	12

(to be continued)

MNEMONICS	Bytes	Machine Cycles	States
RLA	1	1	3
RLCA	1	1	3
RLC (HL)	2	5	13
RLC (IX+d)	4	7	19
RLC (IY+d)	4	7	19
RLC g	2	3	7
RLD	2	8	16
RL (HL)	2	5	13
RL (IX+d)	4	7	19
RL (IY+d)	4	7	19
RL g	2	3	7
RRA	1	1	3
RRCA	1	1	3
RRC (HL)	2	5	13
RRC (IX+d)	4	7	19
RRC (IY+d)	4	7	19
RRC g	2	3	7
RRD	2	8	16
RR (HL)	2	5	13
RR (IX+d)	4	7	19
RR (IY+d)	4	7	19
RR g	2	3	7
RST v	1	5	11
SBC A,(HL)	1	2	6
SBC A,(IX+d)	3	6	14
SBC A,(IY+d)	3	6	14
SBC A,m	2	2	6

(to be continued)

MNEMONICS	Bytes	Machine Cycles	States
SBC A,g	1	2	4
SBC HL,ww	2	6	10
SCF	1	1	3
SET b,(HL)	2	5	13
SET b,(IX+d)	4	7	19
SET b,(IY+d)	4	7	19
SET b,g	2	3	7
SLA (HL)	2	5	13
SLA (IX+d)	4	7	19
SLA (IY+d)	4	7	19
SLA g	2	3	7
SLP**	2	2	8
SRA (HL)	2	5	13
SRA (IX+d)	4	7	19
SRA (IY+d)	4	7	19
SRA g	2	3	7
SRL (HL)	2	5	13
SRL (IX+d)	4	7	19
SRL (IY+d)	4	7	19
SRL g	2	3	7
SUB (HL)	1	2	6
SUB (IX+d)	3	6	14
SUB (IY+d)	3	6	14
SUB m	2	2	6
SUB g	1	2	4
**TSTIO m	3	4	12
**TST g	2	3	7

(to be continued)

MNEMONICS	Bytes	Machine Cycles	States
TST m**	3	3	9
TST (HL)**	2	4	10
XOR (HL)	1	2	6
XOR (IX+d)	3	6	14
XOR (IY+d)	3	6	14
XOR m	2	2	6
XOR g	1	2	4

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