1. SCALAR DOUBLE SHIFTS INSTRUCTIONS 056 i j k , 057 i j k
2. DECODE Ak $2^0 - 2^6$ FOR DOUBLE SHIFT, RIGHT SHIFT VALUE IS PUT INTO 2'S COMPLIMENT FORMAT BY HARDWARE.
3. Ak BITS $2^7 - 2^{23}$ MUST BE ZERO FOR SHIFTER OUTPUT.

Ak $2^0 - 2^6$

DECIMAL SHIFT VALUE	64_{10}	32_{10}	
BIT POSITION	2^6	2^5	
TERM	V16	V15	
TEST POINT	A01	A11'	CONTROL FOR J AND K TERMS
	0	0	P0 DS
	0	0	P4 LDS
	0	1	P1 32 DS
	0	1	P5 32 LDS
	1	0	P2 64 DS
	1	0	P6 64 RDS
	1	1	P3 96 DS
	1	1	P7 96 RDS
	0	0	P04 RDS=0

DECIMAL SHIFT VALUE	16_{10}	8_{10}	4_{10}	
BIT POSITION	2^4	2^3	2^2	
TERM	V14	V13	V12	
TEST POINT	A10'	B66'	B71'	CONTROL FOR N TERMS
	0	0	0	P20 SHIFT 0
	0	0	1	P21 SHIFT 4
	0	1	0	P22 SHIFT 8
	0	1	1	P23 SHIFT 12
				CONTROL FOR L TERMS
	1	0	0	P24 SHIFT 16
	1	0	1	P25 SHIFT 20
	1	1	0	P26 SHIFT 24
	1	1	1	P27 SHIFT 28

DECIMAL SHIFT VALUE	2_{10}	1_{10}	
BIT POSITION	2^1	2^0	
TERM	V11	V10	
TEST POINT	A04'	A03'	CONTROL FOR R TERMS
	0	0	P40 SHIFT 0
	0	1	P41 SHIFT 1
	1	0	P42 SHIFT 2
	1	1	P43 SHIFT 3

P32	P31	P30	CONTROL FOR M TERMS
0	0	0	SHIFT 0
0	0	1	SHIFT 4
0	1	0	SHIFT 8
0	1	1	SHIFT 12
1	0	0	SHIFT 16
1	0	1	SHIFT 20
1	1	0	SHIFT 24
1	1	1	SHIFT 28

A-5129A

CRAY X-MP SCALAR DOUBLE SHIFT CONTROL

INSTRUCTIONS USED

056 IJK

Shift (S_I) and (S_J) left

By (A_K) places to S_I

057 IJK

Shift (S_J) and (S_I) right

By (A_K) places to S_I

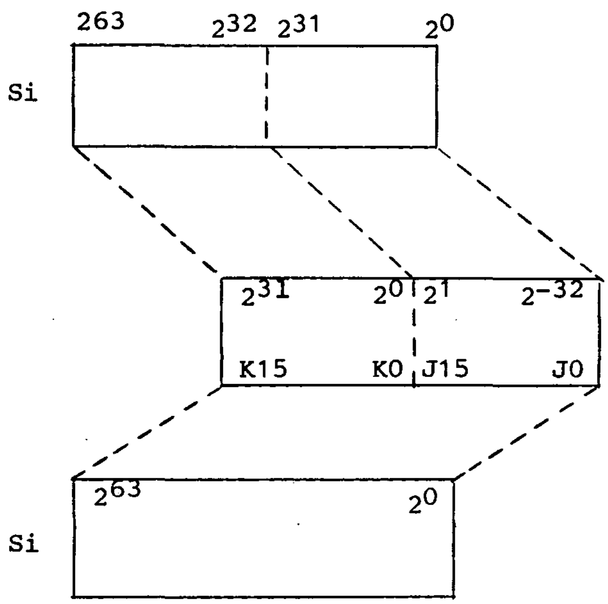
C.A.L. FORMAT

SI	SI, SJ < AK	Scalar double left shift (SI, SJ) by AK places
SI	SJ, SI > AK	Scalar shift double right shift (SJ, SI) by AK places

SPECIAL CASE:

056IJ0	SI	SI, SJ <1
056I0K	SI	SI, < AK

XV201S28M

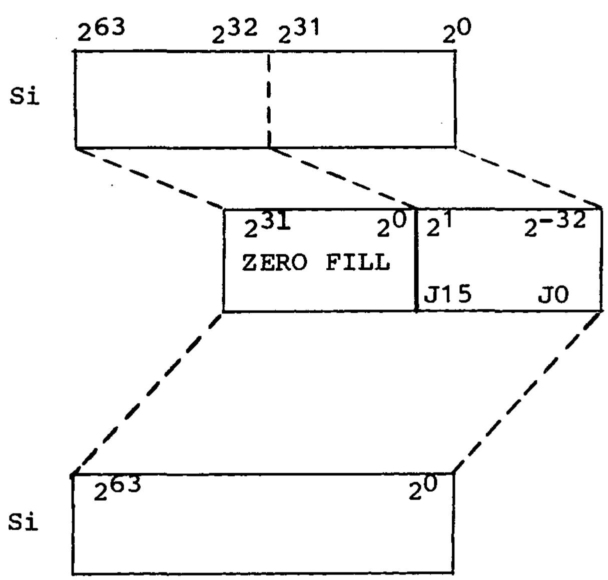


RIGHT SINGLE SHIFT 25_{10}

$25_{10} = 31_8$

$100_8 - 31_8 = 47_8$ (SHIFT COUNT)

2^5	2^4	2^3	2^2	2^1	2^0
1	0	0	1	1	1



RIGHT SINGLE SHIFT

$36_{10} = 44_8$

$100_8 - 44_8 = 34_8$ (SHIFT COUNT)

2^5	2^4	2^3	2^2	2^1	2^0
0	1	1	1	0	0

A-1195A

RIGHT SINGLE SHIFT

	2^{63} Sj	2^{0}	2^{63} Si	2^{0}	
EVEN	62 … 32	30 … 0	62 … 32	30 … 0	3GB F54/55
ODD	63 … 33	31 … 1	63 … 33	31 … 1	3GB F48/49

I TERMS

EVEN	I63 … I48	I47 … I32	I31 … I16	I15 … I0
ODD	I63 … I48	I47 … I32	I31 … I16	I15 … I0

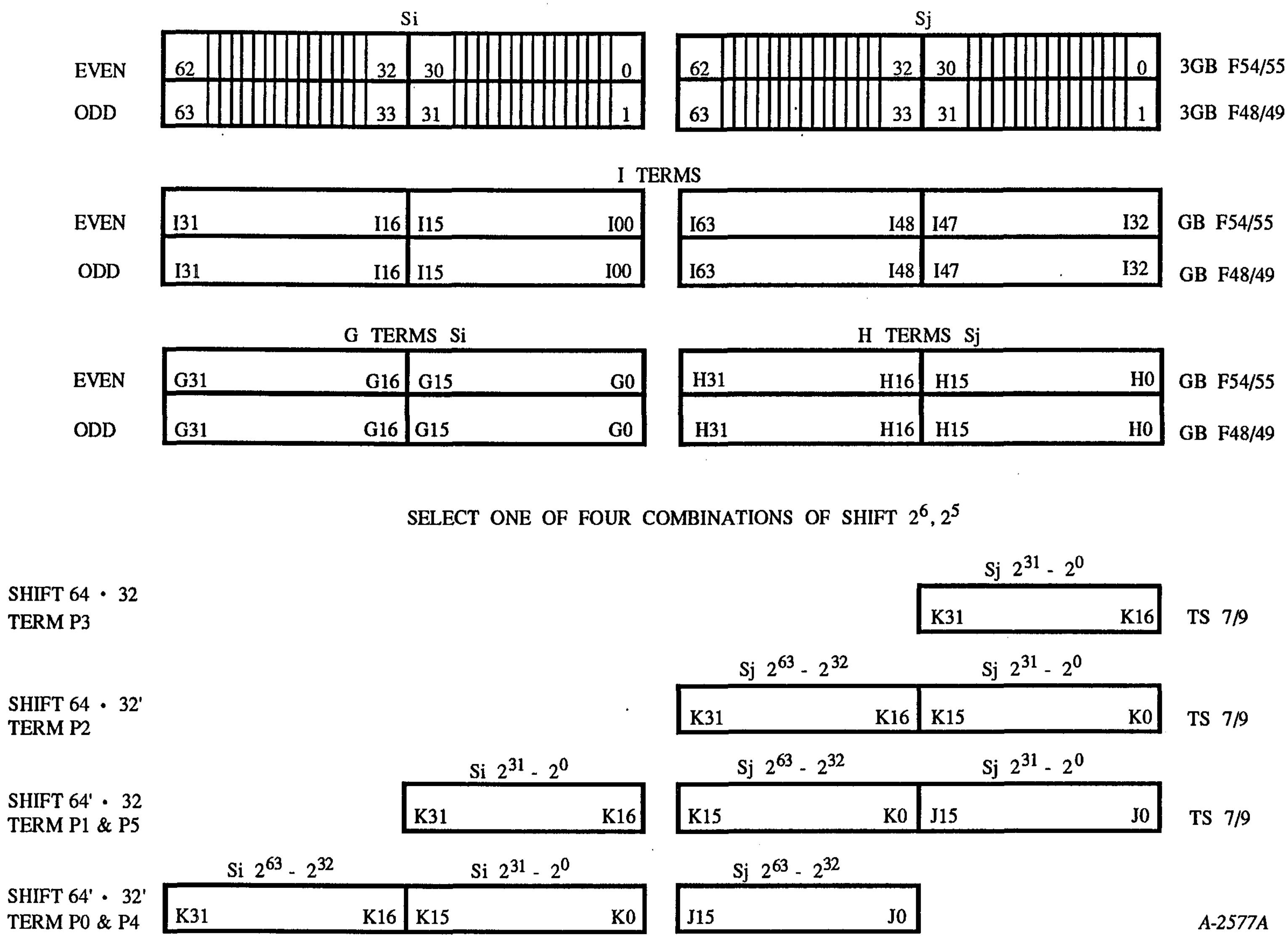
	H TERMS Sj		G TERMS Si	
EVEN	H31 … H16	H15 … H0	G31 … G16	G15 … G0
ODD	H31 … H16	H15 … H0	G31 … G16	G15 … G0

SELECT 1 OF 4 COMBINATIONS OF SHIFTS $2^6, 2^5$

SHIFT 64 • 32 TERMS P3 & P7		Sj $2^{31} - 2^{0}$: K31 … K16	Si $2^{63} - 2^{32}$: K15 … K0	Si $2^{31} - 2^{0}$: J15 … J0	T/S 7/9
SHIFT 64 • $\overline{32}$ TERMS P2 & P6	Sj $2^{63} - 2^{32}$: K31 … K16	Sj $2^{31} - 2^{0}$: K15 … K0	Si $2^{63} - 2^{32}$: J15 … J0		T/S 7/9
SHIFT $\overline{64}$ • 32 TERM P1	Sj $2^{63} - 2^{32}$: K15 … K0	Sj $2^{31} - 2^{0}$: J15 … J0			T/S 7/9
SHIFT $\overline{64}$ • $\overline{32}$ TERM P0	Sj $2^{63} - 2^{32}$: J15 … J0				T/S 7/9

NOTE: SHIFT DERIVED FROM 2's COMPLEMENT OF Ak

X2117C0101



CRAY X-MP SCALAR LEFT DOUBLE SHIFT

K31	K30	K29	K28	K27	K26	K25	K24	K23	K22	K21	K20	K19	K18	K17	K16	K15	K14	K13	K12	K11	K10	K9	K8	K7	K6	K5	K4	K3	K2	K1	K0	J15	J14	J13	J12	J11	J10	J9	J8	J7	J6	J5	J4	J3	J2	J1	J0	SHIFT BITS
TS 10/13																																																
N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10															SHIFT 0
		N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M37	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10													SHIFT 4
				N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10											SHIFT 8
						N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10									SHIFT 12
								M47	M45	M43	M41	M39	M37	M35	M33	M31	M209	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0							SHIFT 16
										M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0					SHIFT 20
												M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0			SHIFT 24
														M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0	SHIFT 28
M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0															
N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M7	M4	M2	M0	L12	L10															
TS 16/0																																																SHIFT BITS 2^1 2^0
R62	R60	R58	R56	R54	R52	R50	R48	R46	R44	R42	R40	R38	R36	R34	R32	R30	R28	R26	R24	R22	R20	R18	R16	R14	R12	R10	R8	R6	R4	R2	R0																	SHIFT 0
2^{62}	2^{60}	2^{58}	2^{56}	2^{54}	2^{52}	2^{50}	2^{48}	2^{46}	2^{44}	2^{42}	2^{40}	2^{38}	2^{36}	2^{34}	2^{32}	2^{30}	2^{28}	2^{26}	2^{24}	2^{22}	2^{20}	2^{18}	2^{16}	2^{14}	2^{12}	2^{10}	2^{8}	2^{6}	2^{4}	2^{2}	2^{0}																	F54/55
2^{63}	2^{61}	2^{59}	2^{57}	2^{55}	2^{53}	2^{51}	2^{49}	2^{47}	2^{45}	2^{43}	2^{41}	2^{39}	2^{37}	2^{35}	2^{33}	2^{31}	2^{29}	2^{27}	2^{25}	2^{23}	2^{21}	2^{19}	2^{17}	2^{15}	2^{13}	2^{11}	2^{9}	2^{7}	2^{5}	2^{3}	2^{1}																	F48/49
R63	R61	R59	R57	R55	R53	R51	R49	R47	R45	R43	R41	R39	R37	R35	R33	R31	R29	R24	R25	R23	R21	R19	R17	R15	R13	R11	R9	R7	R5	R3	R1	R64																SHIFT 1
2^{63}	2^{61}	2^{59}	2^{57}	2^{55}	2^{53}	2^{51}	2^{49}	2^{47}	2^{45}	2^{43}	2^{41}	2^{39}	2^{37}	2^{35}	2^{33}	2^{31}	2^{29}	2^{27}	2^{25}	2^{23}	2^{21}	2^{19}	2^{17}	2^{15}	2^{13}	2^{11}	2^{9}	2^{7}	2^{5}	2^{3}	2^{1}	2^{-1}																F54/55
	2^{62}	2^{60}	2^{58}	2^{56}	2^{54}	2^{52}	2^{50}	2^{48}	2^{46}	2^{44}	2^{42}	2^{40}	2^{38}	2^{36}	2^{34}	2^{32}	2^{30}	2^{28}	2^{26}	2^{24}	2^{22}	2^{20}	2^{18}	2^{16}	2^{14}	2^{12}	2^{10}	2^{8}	2^{6}	2^{4}	2^{2}	2^{0}																F48/49
	R62	R60	R58	R56	R54	R52	R50	R48	R46	R44	R42	R40	R38	R36	R34	R32	R30	R28	R26	R24	R22	R20	R18	R16	R14	R12	R10	R8	R6	R4	R2	R0																SHIFT 2
	2^{62}	2^{60}	2^{58}	2^{56}	2^{54}	2^{52}	2^{50}	2^{48}	2^{46}	2^{44}	2^{42}	2^{40}	2^{38}	2^{36}	2^{34}	2^{32}	2^{30}	2^{28}	2^{26}	2^{24}	2^{22}	2^{20}	2^{18}	2^{16}	2^{14}	2^{12}	2^{10}	2^{8}	2^{6}	2^{4}	2^{2}	2^{0}																F54/55
	2^{63}	2^{61}	2^{59}	2^{57}	2^{55}	2^{53}	2^{51}	2^{49}	2^{47}	2^{45}	2^{43}	2^{41}	2^{39}	2^{37}	2^{35}	2^{33}	2^{31}	2^{29}	2^{27}	2^{25}	2^{23}	2^{21}	2^{19}	2^{17}	2^{15}	2^{13}	2^{11}	2^{9}	2^{7}	2^{5}	2^{3}	2^{1}																F48/49
	R63	R61	R59	R57	R55	R53	R51	R49	R47	R45	R43	R41	R39	R37	R35	R33	R31	R29	R27	R25	R23	R21	R19	R17	R15	R13	R11	R9	R7	R5	R3	R1	R64															SHIFT 3
	2^{63}	2^{61}	2^{59}	2^{57}	2^{55}	2^{53}	2^{51}	2^{49}	2^{47}	2^{45}	2^{43}	2^{41}	2^{39}	2^{37}	2^{35}	2^{33}	2^{31}	2^{29}	2^{27}	2^{25}	2^{23}	2^{21}	2^{19}	2^{17}	2^{15}	2^{13}	2^{11}	2^{9}	2^{7}	2^{5}	2^{3}	2^{1}	2^{63}															F54/55
		2^{62}	2^{60}	2^{58}	2^{56}	2^{54}	2^{52}	2^{50}	2^{48}	2^{46}	2^{44}	2^{42}	2^{40}	2^{38}	2^{36}	2^{34}	2^{32}	2^{30}	2^{28}	2^{26}	2^{24}	2^{22}	2^{20}	2^{18}	2^{16}	2^{14}	2^{12}	2^{10}	2^{8}	2^{6}	2^{4}	2^{2}	2^{0}															F48/49
																	R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	R1	R0																TEST POINT
																	B5	B6	B14	B13	B12	B7	B15	B11	B2	B10	B18	B9	B8	B3	B4	B1																
																	R31	R30	R29	R28	R27	R26	R25	R24	R23	R22	R21	R20	R19	R18	R17	R16																TEST POINT
																	A53'	A69'	A47'	A52'	A16'	A50'	A21'	A19'	A64'	A67'	A68'	A51'	A70'	A71'	A65'	A66'																
																	R47	R46	R45	R44	R43	R42	R41	R40	R39	R38	R37	R36	R35	R34	R33	R32																TEST POINT
																	C27'	C65'	C63'	C64'	C23'	C2'	C1'	C21'	C25'	C68'	C66'	C69'	C67'	C71'	C70'	C72'																
															R65	R64	R63	R62	R61	R60	R59	R58	R57	R56	R55	R54	R53	R52	R51	R50	R49	R48																TEST POINT
															D4	A72'	D64	D35	D58	D53	D34	D32	D47	D39	D48	D2	C49	D66	D69	D6	D5	D1																

D-1201G

CRAY X-MP/2 SCALAR SHIFT DOUBLE LEFT/RIGHT SHIFT

3GB	Sj OPERAND TERM	Sj OPERAND F54/55 TP	Sj OPERAND F48/49 TP	Si OPERAND TERM	Si OPERAND F54/55 TP	Si OPERAND F48/49 TP	3GB	Sj OPERAND TERM	Sj OPERAND F54/55 TP	Sj OPERAND F48/49 TP	Si OPERAND TERM	Si OPERAND F54/55 TP	Si OPERAND F48/49 TP
2^{0}	H00	$\overline{B56}$		G00	$\overline{B54}$		2^{32}	H16	$\overline{B58}$		G16	$\overline{B60}$	
2^{1}	H00		$\overline{B56}$	G00		$\overline{B54}$	2^{33}	H16		$\overline{B58}$	G16		$\overline{B60}$
2^{2}	H01	$\overline{D67}$		G01	$\overline{D68}$		2^{34}	H17	$\overline{D65}$		G17	$\overline{D72}$	
2^{3}	H01		$\overline{D67}$	G01		$\overline{D68}$	2^{35}	H17		$\overline{D65}$	G17		$\overline{D72}$
2^{4}	H02	$\overline{B39}$		G02	$\overline{B34}$		2^{36}	H18	$\overline{B43}$		G18	$\overline{B41}$	
2^{5}	H02		$\overline{B39}$	G02		$\overline{B34}$	2^{37}	H18		$\overline{B43}$	G18		$\overline{B41}$
2^{6}	H03	$\overline{D36}$		G03	$\overline{D55}$		2^{38}	H19	$\overline{D37}$		G19	$\overline{D57}$	
2^{7}	H03		$\overline{D36}$	G03		$\overline{D55}$	2^{39}	H19		$\overline{D37}$	G19		$\overline{D57}$
2^{8}	H04	$\overline{A55}$		G04	$\overline{A36}$		2^{40}	H20	$\overline{A57}$		G20	$\overline{A33}$	
2^{9}	H04		$\overline{A55}$	G04		$\overline{A36}$	2^{41}	H20		$\overline{A57}$	G20		$\overline{A33}$
2^{10}	H05	$\overline{C40}$		G05	$\overline{C44}$		2^{42}	H21	$\overline{C35}$		G21	$\overline{C38}$	
2^{11}	H05		$\overline{C40}$	G05		$\overline{C44}$	2^{43}	H21		$\overline{C35}$	G21		$\overline{C38}$
2^{12}	H06	$\overline{A61}$		G06	$\overline{A29}$		2^{44}	H22	$\overline{A63}$		G22	$\overline{A31}$	
2^{13}	H06		$\overline{A61}$	G06		$\overline{A29}$	2^{45}	H22		$\overline{A63}$	G22		$\overline{A31}$
2^{14}	H07	$\overline{C50}$		G07	$\overline{C36}$		2^{46}	H23	$\overline{C52}$		G23	$\overline{C31}$	
2^{15}	H07		$\overline{C50}$	G07		$\overline{C36}$	2^{47}	H23		$\overline{C52}$	G23		$\overline{C31}$
2^{16}	H08	$\overline{A35}$		G08	$\overline{A23}$		2^{48}	H24	$\overline{A38}$		G24	$\overline{A27}$	
2^{17}	H08		$\overline{A35}$	G08		$\overline{A23}$	2^{49}	H24		$\overline{A38}$	G24		$\overline{A27}$
2^{18}	H09	$\overline{C12}$		G09	$\overline{C16}$		2^{50}	H25	$\overline{C10}$		G25	$\overline{C14}$	
2^{19}	H09		$\overline{C12}$	G09		$\overline{C16}$	2^{51}	H25		$\overline{C10}$	G25		$\overline{C14}$
2^{20}	H10	$\overline{A12}$		G10	$\overline{A20}$		2^{52}	H26	$\overline{A14}$		G26	$\overline{A25}$	
2^{21}	H10		$\overline{A12}$	G10		$\overline{A20}$	2^{53}	H26		$\overline{C14}$	G26		$\overline{A25}$
2^{22}	H11	$\overline{C06}$		G11	$\overline{C20}$		2^{54}	H27	$\overline{C08}$		G27	$\overline{C18}$	
2^{23}	H11		$\overline{C06}$	G11		$\overline{C20}$	2^{55}	H27		$\overline{A14}$	G27		$\overline{C18}$
2^{24}	H12	$\overline{A08}$		G12	$\overline{A18}$		2^{56}	H28	$\overline{A06}$		G28	$\overline{A16}$	
2^{25}	H12		$\overline{A08}$	G12		$\overline{A18}$	2^{57}	H28		$\overline{A06}$	G28		$\overline{A16}$
2^{26}	H13	$\overline{C42}$		G13	$\overline{C33}$		2^{58}	H29	$\overline{C48}$		G29	$\overline{C29}$	
2^{27}	H13		$\overline{C42}$	G13		$\overline{C33}$	2^{59}	H29		$\overline{C48}$	G29		$\overline{C29}$
2^{28}	H14	$\overline{B37}$		G14	$\overline{B49}$		2^{60}	H30	$\overline{B45}$		G30	$\overline{B51}$	
2^{29}	H14		$\overline{B37}$	G14		$\overline{B49}$	2^{61}	H30		$\overline{B45}$	G30		$\overline{B51}$
2^{30}	H15	$\overline{D44}$		G15	$\overline{D61}$		2^{62}	H31	$\overline{D45}$		G31	$\overline{D63}$	
2^{31}	H15		$\overline{D44}$	G15		$\overline{D61}$	2^{63}	H31		$\overline{D45}$	G31		$\overline{D63}$

B-1588B

CRAY X-MP SCALAR SHIFT
Sj AND Si SCOPE CHART

62 60 58 56 54 52 50 48 46 44 42 40 38 36 34 (32) 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0 3GB @ F54/55

63 61 59 57 55 53 51 49 47 45 43 41 39 37 35 33 31 29 27 25 23 21 19 17 15 13 11 9 7 5 3 1 3GB @ F48/49

31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 21 11 10 9 8 7 6 5 4 3 2 1 0 I TERMS

LEFT SINGLE SHIFT:
I0-I31 -- K0-K31 SHIFT $\overline{32}$
I0-I15 -- K16-K31 SHIFT 32

RIGHT SINGLE SHIFT:
I16-I31 -- K0-K15; I0-I15 -- J0-J15 SHIFT $\underline{32}$
I16-I31 -- J0-J15 SHIFT $\overline{32}$

K31 K30 K29 K28 K27 K26 K25 K24 K23 K22 K21 K20 K19 K18 K17 (K16) K15 K14 K13 K12 K11 K10 K9 K8 K7 K6 K5 K4 K3 K2 K1 K0 | J15 J14 J13 J12 J11 J10 J9 J8 J7 J6 J5 J4 J3 J2 J1 J0 SHIFT BITS

TS 10/13

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10 SHIFT 0

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10 SHIFT 4

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10 SHIFT 8

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10 SHIFT 12

M47 M45 M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0 SHIFT 16

M47 M45 M43 M41 M39 (M37) M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0 SHIFT 20

M47 M45 M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0 SHIFT 24

M47 M45 M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0 SHIFT 28

M47 M45 M43 M41 M39 (M37) M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10

TS 16/0

SHIFT BITS 2^1 2^0

R62 R60 R58 R56 R54 R52 R50 R48 R46 R44 R42 R40 R38 R36 R34 R32 R30 R28 R26 R24 R22 R20 R18 R16 R14 R12 R10 R8 R6 R4 R2 R0 SHIFT 0

2^{62} 2^{60} 2^{58} 2^{56} 2^{54} 2^{52} 2^{50} 2^{48} 2^{46} 2^{44} 2^{42} 2^{40} 2^{38} 2^{36} 2^{34} 2^{32} 2^{30} 2^{28} 2^{26} 2^{24} 2^{22} 2^{20} 2^{18} 2^{16} 2^{14} 2^{12} 2^{10} 2^{8} 2^{6} 2^{4} 2^{2} 2^{0} F54/55

2^{63} 2^{61} 2^{59} 2^{57} 2^{55} 2^{53} 2^{51} 2^{49} 2^{47} 2^{45} 2^{43} 2^{41} 2^{39} 2^{37} 2^{35} 2^{33} 2^{31} 2^{29} 2^{27} 2^{25} 2^{23} 2^{21} 2^{19} 2^{17} 2^{15} 2^{13} 2^{11} 2^{9} 2^{7} 2^{5} 2^{3} 2^{1} F48/49

R63 R61 R59 R57 R55 (R53) R51 R49 R47 R45 R43 R41 R39 R37 R35 R33 R31 R29 R27 R25 R23 R21 R19 R17 R15 R13 R11 R9 R7 R5 R3 R1 R64 SHIFT 1

2^{63} 2^{61} 2^{59} 2^{57} 2^{55} 2^{53} 2^{51} 2^{49} 2^{47} 2^{45} 2^{43} 2^{41} 2^{39} 2^{37} 2^{35} 2^{33} 2^{31} 2^{29} 2^{27} 2^{25} 2^{23} 2^{21} 2^{19} 2^{17} 2^{15} 2^{13} 2^{11} 2^{9} 2^{7} 2^{5} 2^{3} 2^{1} 2^{-01} F54/55

2^{62} 2^{60} 2^{58} 2^{56} 2^{54} 2^{52} 2^{50} 2^{48} 2^{46} 2^{44} 2^{42} 2^{40} 2^{38} 2^{36} 2^{34} 2^{32} 2^{30} 2^{28} 2^{26} 2^{24} 2^{22} 2^{20} 2^{18} 2^{16} 2^{14} 2^{12} 2^{10} 2^{8} 2^{6} 2^{4} 2^{2} 2^{0} F48/49

R62 R60 R58 R56 R54 R52 R50 R48 R46 R44 R42 R40 R38 R36 R34 R32 R30 R28 R26 R24 R22 R20 R18 R16 R14 R12 R10 R8 R6 R4 R2 R0 SHIFT 2

2^{62} 2^{60} 2^{58} 2^{56} 2^{54} 2^{52} 2^{50} 2^{48} 2^{46} 2^{44} 2^{42} 2^{40} 2^{38} 2^{36} 2^{34} 2^{32} 2^{30} 2^{28} 2^{26} 2^{24} 2^{22} 2^{20} 2^{18} 2^{16} 2^{14} 2^{12} 2^{10} 2^{8} 2^{6} 2^{4} 2^{2} 2^{0} F54/55

2^{63} 2^{61} 2^{59} 2^{57} 2^{55} 2^{53} 2^{51} 2^{49} 2^{47} 2^{45} 2^{43} 2^{41} 2^{39} 2^{37} 2^{35} 2^{33} 2^{31} 2^{29} 2^{27} 2^{25} 2^{23} 2^{21} 2^{19} 2^{17} 2^{15} 2^{13} 2^{11} 2^{9} 2^{7} 2^{5} 2^{3} 2^{1} F48/49

R63 R61 R59 R57 R55 R53 R51 R49 R47 R45 R43 R41 R39 R37 R35 R33 R31 R29 R27 R25 R23 R21 R19 R17 R15 R13 R11 R9 R7 R5 R3 R1 R64 SHIFT 3

2^{63} 2^{61} 2^{59} 2^{57} 2^{55} 2^{53} 2^{51} 2^{49} 2^{47} 2^{45} 2^{43} 2^{41} 2^{39} 2^{37} 2^{35} 2^{33} 2^{31} 2^{29} 2^{27} 2^{25} 2^{23} 2^{21} 2^{19} 2^{17} 2^{15} 2^{13} 2^{11} 2^{9} 2^{7} 2^{5} 2^{3} 2^{1} 2^{-01} F54/55

2^{62} 2^{60} 2^{58} 2^{56} 2^{54} 2^{52} 2^{50} 2^{48} 2^{46} 2^{44} 2^{42} 2^{40} 2^{38} 2^{36} 2^{34} 2^{32} 2^{30} 2^{28} 2^{26} 2^{24} 2^{22} 2^{20} 2^{18} 2^{16} 2^{14} 2^{12} 2^{10} 2^{8} 2^{6} 2^{4} 2^{2} 2^{0} F48/49

052ijk/054ijk
$Si=2^{32}$
$Jk=25_8=0$ 10101
21_{10}

		R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	R1	R0	TEST POINT
		B5	B6	B14	B13	B12	B7	B15	B11	B2	B10	B18	B9	B8	B3	B4	B1	
		R31	R30	R29	R28	R27	R26	R25	R24	R23	R22	R21	R20	R19	R18	R17	R16	TEST POINT
		A53	A69	A47	A52	A16	A50	A21	A19	A64	A67	A68	A51	A70	A71	A65	A66	
		R47	R46	R45	R44	R43	R42	R41	R40	R39	R38	R37	R36	R35	R34	R33	R32	TEST POINT
		C27	C65	C63	C64	C23	C2	C1	C21	C25	C68	C66	C69	C67	C71	C70	C72	
R65	R64	R63	R62	R61	R60	R59	R58	R57	R56	R55	R54	R53	R52	R51	R50	R49	R48	TEST POINT
D4	$\overline{A72}$	D64	D35	D58	D53	D34	D32	D47	D39	D48	D2	C49	D66	D69	D6	D5	D1	

D-1553D

CRAY X-MP/2 SCALAR SHIFT
SINGLE (LEFT)/RIGHT SHIFT

EXAMPLE NO. 1
HTV-0242

62 60 58 56 54 52 50 48 46 44 42 40 38 36 34 (32) 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0 3GB @ F54/55

63 61 59 57 55 53 51 49 47 45 43 41 39 37 35 33 31 29 27 25 23 21 19 17 15 13 11 9 7 5 3 1 3GB @ F48/49

31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 (16) 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 I TERMS

LEFT SINGLE SHIFT:
I0 - I31 -- K0 - K31 SHIFT 32'
I0 - I15 -- K16 - K31 SHIFT 32

RIGHT SINGLE SHIFT:
I16 - I31 -- K0 - K15; I0 - I15 -- J0 - J15 SHIFT 32
I16 - I31 -- J0 - J15 SHIFT 32'

K31 K30 K29 K28 K27 K26 K25 K24 K23 K22 K21 K20 K19 K18 K17 K16 | K15 K14 K13 K12 K11 K10 K9 K8 K7 K6 K5 K4 K3 K2 K1 (K0) | J15 J14 J13 J12 J11 J10 J9 J8 J7 J6 J5 J4 J3 J2 J1 J0 SHIFT BITS

TS 10/13

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10 SHIFT 0

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10 SHIFT 4

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 (M8) M6 M4 M2 M0 L12 L10 SHIFT 8

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10 SHIFT 12

M47 M45 M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0 SHIFT 16

M47 M45 M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0 SHIFT 20

M47 M45 M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0 SHIFT 24

M47 M45 M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0 SHIFT 28

M47 M45 M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 (M8) M7 M4 M2 M0 L12 L10

TS 16/0

SHIFT BITS 2^1 2^0

R62 R60 R58 R56 R54 R52 R50 R48 R46 R44 R42 R40 R38 R36 R34 R32 R30 R28 R26 R24 R22 R20 R18 R16 R14 R12 R10 R8 R6 R4 R2 R0 SHIFT 0

2^{62} 2^{60} 2^{58} 2^{56} 2^{54} 2^{52} 2^{50} 2^{48} 2^{46} 2^{44} 2^{42} 2^{40} 2^{38} 2^{36} 2^{34} 2^{32} 2^{30} 2^{28} 2^{26} 2^{24} 2^{22} 2^{20} 2^{18} 2^{16} 2^{14} 2^{12} 2^{10} 2^{8} 2^{6} 2^{4} 2^{2} 2^{0} F54/55

2^{63} 2^{61} 2^{59} 2^{57} 2^{55} 2^{53} 2^{51} 2^{49} 2^{47} 2^{45} 2^{43} 2^{41} 2^{39} 2^{37} 2^{35} 2^{33} 2^{31} 2^{29} 2^{27} 2^{25} 2^{23} 2^{21} 2^{19} 2^{17} 2^{15} 2^{13} 2^{11} 2^{9} 2^{7} 2^{5} 2^{3} 2^{1} F48/49

R63 R61 R59 R57 R55 R53 R51 R49 R47 R45 R43 R41 R39 R37 R35 R33 R31 R29 R24 R25 R23 R21 R19 R17 R15 R13 R11 R9 R7 R5 R3 R1 R64 SHIFT 1

2^{63} 2^{61} 2^{59} 2^{57} 2^{55} 2^{53} 2^{51} 2^{49} 2^{47} 2^{45} 2^{43} 2^{41} 2^{39} 2^{37} 2^{35} 2^{33} 2^{31} 2^{29} 2^{27} 2^{25} 2^{23} 2^{21} 2^{19} 2^{17} 2^{15} 2^{13} 2^{11} 2^{9} 2^{7} 2^{5} 2^{3} 2^{1} 2^{-1} F54/55

2^{62} 2^{60} 2^{58} 2^{56} 2^{54} 2^{52} 2^{50} 2^{48} 2^{46} 2^{44} 2^{42} 2^{40} 2^{38} 2^{36} 2^{34} 2^{32} 2^{30} 2^{28} 2^{26} 2^{24} 2^{22} 2^{20} 2^{18} 2^{16} 2^{14} 2^{12} 2^{10} 2^{8} 2^{6} 2^{4} 2^{2} 2^{0} F48/49

R62 R60 R58 R56 R54 R52 R50 R48 R46 R44 R42 R40 R38 R36 R34 R32 R30 R28 R26 R24 R22 R20 R18 R16 R14 R12 R10 R8 R6 R4 R2 R0 SHIFT 2

2^{62} 2^{60} 2^{58} 2^{56} 2^{54} 2^{52} 2^{50} 2^{48} 2^{46} 2^{44} 2^{42} 2^{40} 2^{38} 2^{36} 2^{34} 2^{32} 2^{30} 2^{28} 2^{26} 2^{24} 2^{22} 2^{20} 2^{18} 2^{16} 2^{14} 2^{12} 2^{10} 2^{8} 2^{6} 2^{4} 2^{2} 2^{0} F54/55

2^{63} 2^{61} 2^{59} 2^{57} 2^{55} 2^{53} 2^{51} 2^{49} 2^{47} 2^{45} 2^{43} 2^{41} 2^{39} 2^{37} 2^{35} 2^{33} 2^{31} 2^{29} 2^{27} 2^{25} 2^{23} 2^{21} 2^{19} 2^{17} 2^{15} 2^{13} 2^{11} 2^{9} 2^{7} 2^{5} 2^{3} 2^{1} F48/49

R63 R61 R59 R57 R55 R53 R51 R49 R47 R45 R43 R41 R39 R37 R35 R33 R31 R29 R27 R25 R23 R21 R19 R17 R15 R13 (R11) R9 R7 R5 R3 R1 R64 SHIFT 3

2^{63} 2^{61} 2^{59} 2^{57} 2^{55} 2^{53} 2^{51} 2^{49} 2^{47} 2^{45} 2^{43} 2^{41} 2^{39} 2^{37} 2^{35} 2^{33} 2^{31} 2^{29} 2^{27} 2^{25} 2^{23} 2^{21} 2^{19} 2^{17} 2^{15} 2^{13} (2^{11}) 2^{9} 2^{7} 2^{5} 2^{3} 2^{1} 2^{-1} F54/55

2^{62} 2^{60} 2^{58} 2^{56} 2^{54} 2^{52} 2^{50} 2^{48} 2^{46} 2^{44} 2^{42} 2^{40} 2^{38} 2^{36} 2^{34} 2^{32} 2^{30} 2^{28} 2^{26} 2^{24} 2^{22} 2^{20} 2^{18} 2^{16} 2^{14} 2^{12} 2^{10} 2^{8} 2^{6} 2^{4} 2^{2} 2^{0} F48/49

053ijk/055ijk
Si = 2^{32}
jk = 25_8
(AFTER TWOS COMPLEMENT)
jk = 53_8

R15 R14 R13 R12 R11 R10 R9 R8 R7 R6 R5 R4 R3 R2 R1 R0
B5 B6 B14 B13 B12 B7 B15 B11 B2 B10 B18 B9 B8 B3 B4 B1 TEST POINT

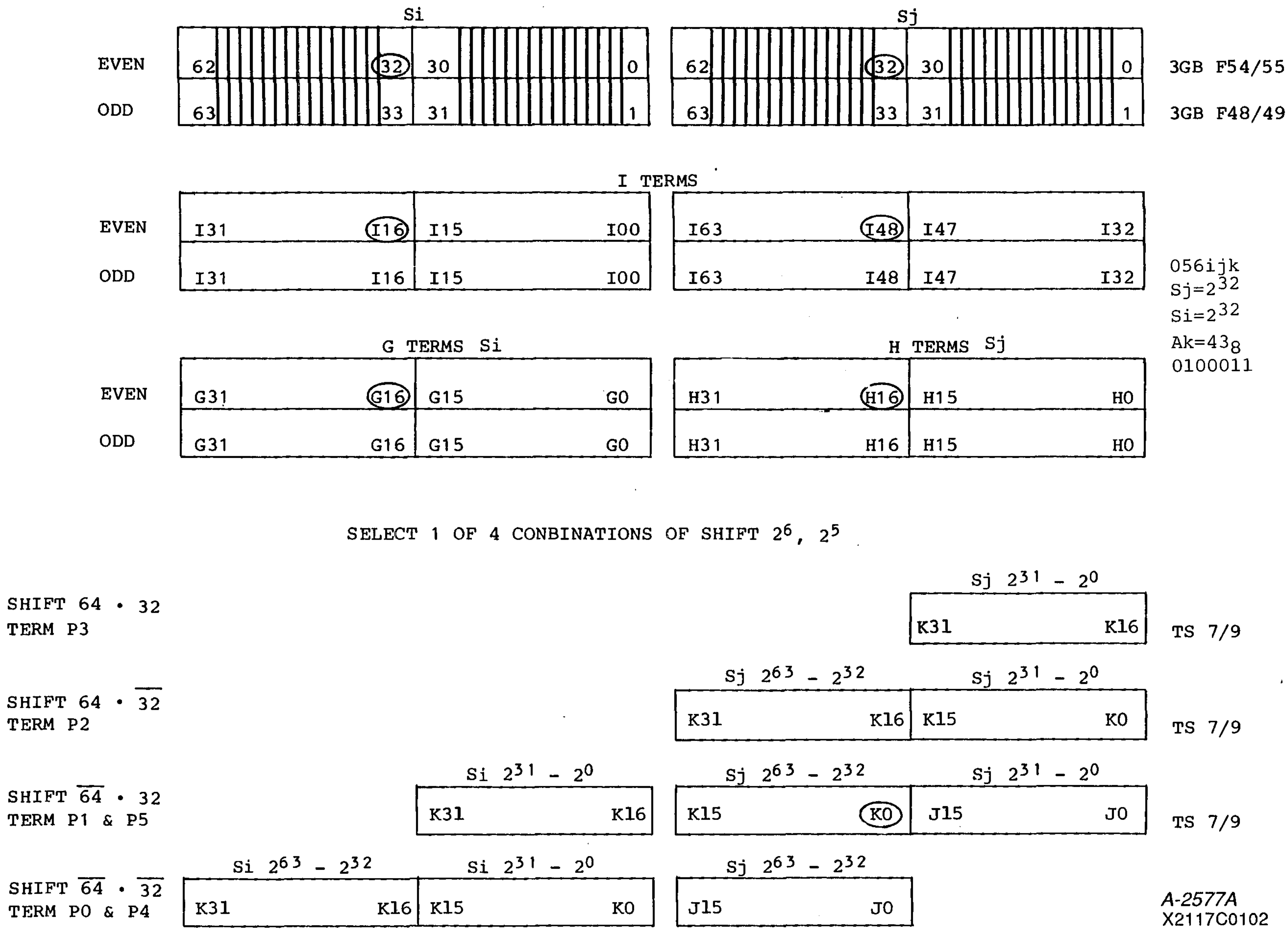
R31 R30 R29 R28 R27 R26 R25 R24 R23 R22 R21 R20 R19 R18 R17 R16
A53' A69' A47' A52' A16' A50' A21' A19' A64' A67' A68' A51' A70' A71' A65' A66' TEST POINT

R47 R46 R45 R44 R43 R42 R41 R40 R39 R38 R37 R36 R35 R34 R33 R32
C27' C65' C63' C64' C23' C2' C1' C21' C25' C68' C66' C69' C67' C71' C70' C72' TEST POINT

R65 R64 R63 R62 R61 R60 R59 R58 R57 R56 R55 R54 R53 R52 R51 R50 R49 R48
D4 A72' D64 D35 D58 D53 D34 D32 D47 D39 D48 D2 C49 D66 D69 D6 D5 D1 TEST POINT

A-6210

CRAY X-MP/2 SCALAR SHIFT SINGLE LEFT /(RIGHT) SHIFT



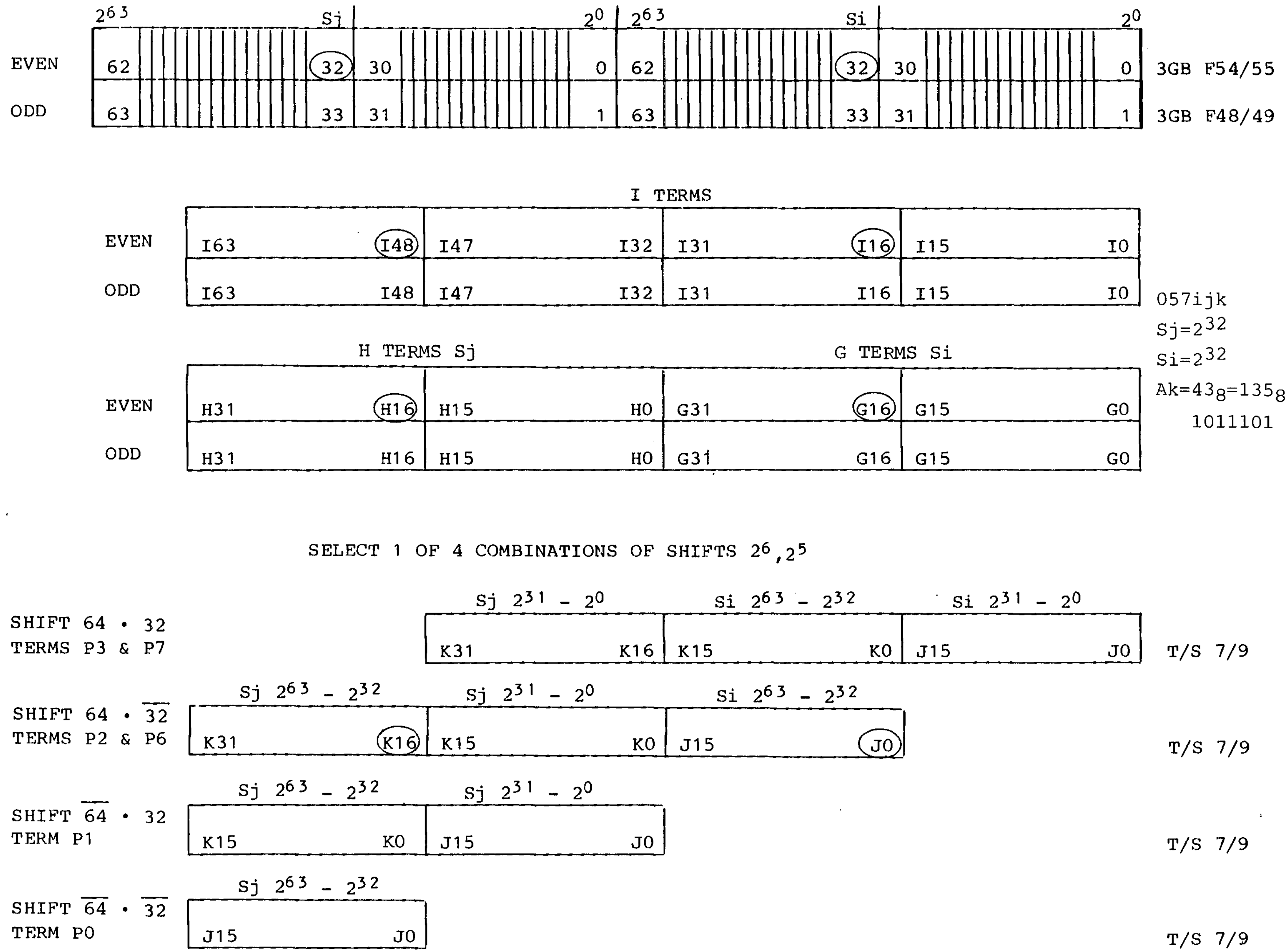
SCALAR LEFT DOUBLE SHIFT

K31	K30	K29	K28	K27	K26	K25	K24	K23	K22	K21	K20	K19	K18	K17	K16	K15	K14	K13	K12	K11	K10	K9	K8	K7	K6	K5	K4	K3	K2	K1	K0	J15	J14	J13	J12	J11	J10	J9	J8	J7	J6	J5	J4	J3	J2	J1	J0	SHIFT BITS
TS 10/13																																																
N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10															SHIFT 0
		N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10													SHIFT 4
				N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10											SHIFT 8
						N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10									SHIFT 12
								M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0							SHIFT 16
										M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0					SHIFT 20
												M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0			SHIFT 24
														M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0	SHIFT 28
M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0															
N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10															
TS 16/0																																			SHIFT BITS	2^1	2^0											
R62	R60	R58	R56	R54	R52	R50	R48	R46	R44	R42	R40	R38	R36	R34	R32	R30	R28	R26	R24	R22	R20	R18	R16	R14	R12	R10	R8	R6	R4	R2	R0																	SHIFT 0
2^{62}	2^{60}	2^{58}	2^{56}	2^{54}	2^{52}	2^{50}	2^{48}	2^{46}	2^{44}	2^{42}	2^{40}	2^{38}	2^{36}	2^{34}	2^{32}	2^{30}	2^{28}	2^{26}	2^{24}	2^{22}	2^{20}	2^{18}	2^{16}	2^{14}	2^{12}	2^{10}	2^{8}	2^{6}	2^{4}	2^{2}	2^{0}																	F54/55
2^{63}	2^{61}	2^{59}	2^{57}	2^{55}	2^{53}	2^{51}	2^{49}	2^{47}	2^{45}	2^{43}	2^{41}	2^{39}	2^{37}	2^{35}	2^{33}	2^{31}	2^{29}	2^{27}	2^{25}	2^{23}	2^{21}	2^{19}	2^{17}	2^{15}	2^{13}	2^{11}	2^{9}	2^{7}	2^{5}	2^{3}	2^{1}																	F48/49
R63	R61	R59	R57	R55	R53	R51	R49	R47	R45	R43	R41	R39	R37	R35	R33	R31	R29	R27	R25	R23	R21	R19	R17	R15	R13	R11	R9	R7	R5	R3	R1	R64																SHIFT 1
2^{63}	2^{61}	2^{59}	2^{57}	2^{55}	2^{53}	2^{51}	2^{49}	2^{47}	2^{45}	2^{43}	2^{41}	2^{39}	2^{37}	2^{35}	2^{33}	2^{31}	2^{29}	2^{27}	2^{25}	2^{23}	2^{21}	2^{19}	2^{17}	2^{15}	2^{13}	2^{11}	2^{9}	2^{7}	2^{5}	2^{3}	2^{1}	2^{-01}																F54/55
	2^{62}	2^{60}	2^{58}	2^{56}	2^{54}	2^{52}	2^{50}	2^{48}	2^{46}	2^{44}	2^{42}	2^{40}	2^{38}	2^{36}	2^{34}	2^{32}	2^{30}	2^{28}	2^{26}	2^{24}	2^{22}	2^{20}	2^{18}	2^{16}	2^{14}	2^{12}	2^{10}	2^{8}	2^{6}	2^{4}	2^{2}	2^{0}																F48/49
	R62	R60	R58	R56	R54	R52	R50	R48	R46	R44	R42	R40	R38	R36	R34	R32	R30	R28	R26	R24	R22	R20	R18	R16	R14	R12	R10	R8	R6	R4	R2	R0																SHIFT 2
	2^{62}	2^{60}	2^{58}	2^{56}	2^{54}	2^{52}	2^{50}	2^{48}	2^{46}	2^{44}	2^{42}	2^{40}	2^{38}	2^{36}	2^{34}	2^{32}	2^{30}	2^{28}	2^{26}	2^{24}	2^{22}	2^{20}	2^{18}	2^{16}	2^{14}	2^{12}	2^{10}	2^{8}	2^{6}	2^{4}	2^{2}	2^{0}																F54/55
	2^{63}	2^{61}	2^{59}	2^{57}	2^{55}	2^{53}	2^{51}	2^{49}	2^{47}	2^{45}	2^{43}	2^{41}	2^{39}	2^{37}	2^{35}	2^{33}	2^{31}	2^{29}	2^{27}	2^{25}	2^{23}	2^{21}	2^{19}	2^{17}	2^{15}	2^{13}	2^{11}	2^{9}	2^{7}	2^{5}	2^{3}	2^{1}																F48/49
	R63	R61	R59	R57	R55	R53	R51	R49	R47	R45	R43	R41	R39	R37	R35	R33	R31	R29	R27	R25	R23	R21	R19	R17	R15	R13	R11	R9	R7	R5	R3	R1	R64															SHIFT 3
	2^{63}	2^{61}	2^{59}	2^{57}	2^{55}	2^{53}	2^{51}	2^{49}	2^{47}	2^{45}	2^{43}	2^{41}	2^{39}	2^{37}	2^{35}	2^{33}	2^{31}	2^{29}	2^{27}	2^{25}	2^{23}	2^{21}	2^{19}	2^{17}	2^{15}	2^{13}	2^{11}	2^{9}	2^{7}	2^{5}	2^{3}	2^{1}	2^{-01}															F54/55
		2^{62}	2^{60}	2^{58}	2^{56}	2^{54}	2^{52}	2^{50}	2^{48}	2^{46}	2^{44}	2^{42}	2^{40}	2^{38}	2^{36}	2^{34}	2^{32}	2^{30}	2^{28}	2^{26}	2^{24}	2^{22}	2^{20}	2^{18}	2^{16}	2^{14}	2^{12}	2^{10}	2^{8}	2^{6}	2^{4}	2^{2}	2^{0}															F48/49
																	R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	R1	R0																
																	B5	B6	B14	B13	B12	B7	B15	B11	B2	B10	B18	B9	B8	B3	B4	B1																TEST POINT
																	R31/A53	R30/A69	R29/A47	R28/A52	R27/A16	R26/A50	R25/A21	R24/A19	R23/A64	R22/A67	R21/A68	R20/A51	R19/A70	R18/A71	R17/A65	R16/A66																TEST POINT
																	R47/C27	R46/C65	R45/C63	R44/C64	R43/C23	R42/C2	R41/C1	R40/C21	R39/C25	R38/C68	R37/C66	R36/C69	R35/C67	R34/C71	R33/C70	R32/C72																TEST POINT
															R65 D4	R64/A72	R63 D64	R62 D35	R61 D58	R60 D53	R59 D34	R58 D32	R57 D47	R56 D39	R55 D48	R54 D2	R53 D3	R52 D66	R51 D69	R50 D6	R49 D5	R48 D1																TEST POINT

D-1201G
X2100S0104

CRAY X-MP/2 SCALAR SHIFT
DOUBLE LEFT/RIGHT SHIFT

EXAMPLE NO. 1
HTV-0242



NOTE: SHIFT DERIVED FROM 2's COMPLEMENT OF Ak

A-2576C
X2117C0101

X-MP/2 SCALAR RIGHT DOUBLE SHIFT

K31 K30 K29 K28 K27 K26 K25 K24 K23 K22 K21 K20 K19 K18 K17 (K16) K15 K14 K13 K12 K11 K10 K9 K8 K7 K6 K5 K4 K3 K2 K1 K0 | J15 J14 J13 J12 J11 J10 J9 J8 J7 J6 J5 J4 J3 J2 J1 (J0) SHIFT BITS

TS 10/13

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10 SHIFT 0

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10 SHIFT 4

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10 SHIFT 8

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10 SHIFT 12

M47 M45 M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0 SHIFT 16

M47 M45 M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0 SHIFT 20

M47 M45 M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 L0 SHIFT 24

M47 (M45) M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 (L0) SHIFT 28

M47 (M45) M43 M41 M39 M37 M35 M33 M31 M29 M27 M25 M23 M21 M19 M17 M15 M13 M11 M9 M7 M5 M3 M1 L13 L11 L7 L6 L5 L4 L3 L2 L1 (L0)

N7 N6 N5 N4 N3 N2 N1 N0 M46 M44 M42 M40 M38 M36 M34 M32 M30 M28 M26 M24 M22 M20 M18 M16 M14 M12 M10 M8 M6 M4 M2 M0 L12 L10 SHIFT BITS 2^1 2^0

TS 16/0

R62 R60 R58 R56 R54 R52 R50 R48 R46 R44 R42 R40 R38 R36 R34 R32 R30 R28 R26 R24 R22 R20 R18 R16 R14 R12 R10 R8 R6 R4 R2 R0 SHIFT 0

2^{62} 2^{60} 2^{58} 2^{56} 2^{54} 2^{52} 2^{50} 2^{48} 2^{46} 2^{44} 2^{42} 2^{40} 2^{38} 2^{36} 2^{34} 2^{32} 2^{30} 2^{28} 2^{26} 2^{24} 2^{22} 2^{20} 2^{18} 2^{16} 2^{14} 2^{12} 2^{10} 2^{8} 2^{6} 2^{4} 2^{2} 2^{0} F54/55

2^{63} 2^{61} 2^{59} 2^{57} 2^{55} 2^{53} 2^{51} 2^{49} 2^{47} 2^{45} 2^{43} 2^{41} 2^{39} 2^{37} 2^{35} 2^{33} 2^{31} 2^{29} 2^{27} 2^{25} 2^{23} 2^{21} 2^{19} 2^{17} 2^{15} 2^{13} 2^{11} 2^{9} 2^{7} 2^{5} 2^{3} 2^{1} F48/49

R63 (R61) R59 R57 R55 R53 R51 R49 R47 R45 R43 R41 R39 R37 R35 R33 R31 R29 R27 R25 R23 R21 R19 R17 R15 R13 R11 R9 R7 R5 R3 R1 R64 SHIFT 1

2^{63} (2^{61}) 2^{59} 2^{57} 2^{55} 2^{53} 2^{51} 2^{49} 2^{47} 2^{45} 2^{43} 2^{41} 2^{39} 2^{37} 2^{35} 2^{33} 2^{31} 2^{29} 2^{27} 2^{25} 2^{23} 2^{21} 2^{19} 2^{17} 2^{15} 2^{13} 2^{11} 2^{9} 2^{7} 2^{5} 2^{3} 2^{1} 2^{-01} F54/55

(2^{62}) 2^{60} 2^{58} 2^{56} 2^{54} 2^{52} 2^{50} 2^{48} 2^{46} 2^{44} 2^{42} 2^{40} 2^{38} 2^{36} 2^{34} 2^{32} 2^{30} 2^{28} 2^{26} 2^{24} 2^{22} 2^{20} 2^{18} 2^{16} 2^{14} 2^{12} 2^{10} 2^{8} 2^{6} 2^{4} 2^{2} 2^{0} F48/49

R62 R60 R58 R56 R54 R52 R50 R48 R46 R44 R42 R40 R38 R36 R34 R32 R30 R28 R26 R24 R22 R20 R18 R16 R14 R12 R10 R8 R6 R4 R2 R0 SHIFT 2

2^{62} 2^{60} 2^{58} 2^{56} 2^{54} 2^{52} 2^{50} 2^{48} 2^{46} 2^{44} 2^{42} 2^{40} 2^{38} 2^{36} 2^{34} 2^{32} 2^{30} 2^{28} 2^{26} 2^{24} 2^{22} 2^{20} 2^{18} 2^{16} 2^{14} 2^{12} 2^{10} 2^{8} 2^{6} 2^{4} 2^{2} 2^{0} F54/55

2^{63} 2^{61} 2^{59} 2^{57} 2^{55} 2^{53} 2^{51} 2^{49} 2^{47} 2^{45} 2^{43} 2^{41} 2^{39} 2^{37} 2^{35} 2^{33} 2^{31} 2^{29} 2^{27} 2^{25} 2^{23} 2^{21} 2^{19} 2^{17} 2^{15} 2^{13} 2^{11} 2^{9} 2^{7} 2^{5} 2^{3} 2^{1} F48/49

R63 R61 R59 R57 R55 R53 R51 R49 R47 R45 R43 R41 R39 R37 R35 R33 R31 R29 R27 R25 R23 R21 R19 R17 R15 R13 R11 R9 R7 R5 R3 R1 R64 SHIFT 3

2^{63} 2^{61} 2^{59} 2^{57} 2^{55} 2^{53} 2^{51} 2^{49} 2^{47} 2^{45} 2^{43} 2^{41} 2^{39} 2^{37} 2^{35} 2^{33} 2^{31} 2^{29} 2^{27} 2^{25} 2^{23} 2^{21} 2^{19} 2^{17} 2^{15} 2^{13} 2^{11} 2^{9} 2^{7} 2^{5} 2^{3} 2^{1} 2^{-01} F54/55

2^{62} 2^{60} 2^{58} 2^{56} 2^{54} 2^{52} 2^{50} 2^{48} 2^{46} 2^{44} 2^{42} 2^{40} 2^{38} 2^{36} 2^{34} 2^{32} 2^{30} 2^{28} 2^{26} 2^{24} 2^{22} 2^{20} 2^{18} 2^{16} 2^{14} 2^{12} 2^{10} 2^{8} 2^{6} 2^{4} 2^{2} 2^{0} F48/49

R15 R14 R13 R12 R11 R10 R9 R8 R7 R6 R5 R4 R3 R2 R1 R0

B5 B6 B14 B13 B12 B7 B15 B11 B2 B10 B18 B9 B8 B3 B4 B1 TEST POINT

R31/A53 R30/A69 R29/A47 R28/A52 R27/A16 R26/A50 R25/A21 R24/A19 R23/A64 R22/A67 R21/A68 R20/A51 R19/A70 R18/A71 R17/A65 R16/A66 TEST POINT

R47/C27 R46/C65 R45/C63 R44/C64 R43/C23 R42/C2 R41/C1 R40/C21 R39/C25 R38/C68 R37/C66 R36/C69 R35/C67 R34/C71 R33/C70 R32/C72 TEST POINT

R65/D4 R64/A72 R63/D64 R62/D35 R61/D58 R60/D53 R59/D34 R58/D32 R57/D47 R56/D39 R55/D48 R54/D2 R53/D3 R52/D66 R51/D69 R50/D6 R49/D5 R48/D1 TEST POINT

D-1201H

CRAY X-MP/2 SCALAR SHIFT
DOUBLE LEFT/RIGHT SHIFT

K31	K30	K29	K28	K27	K26	K25	K24	K23	K22	K21	K20	K19	K18	K17	K16	K15	K14	K13	K12	K11	K10	K9	K8	K7	K6	K5	K4	K3	K2	K1	K0	J15	J14	J13	J12	J11	J10	J9	J8	J7	J6	J5	J4	J3	J2	J1	J0	SHIFT BITS
TS 10/13																																																
N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10															SHIFT 0
		N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M37	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10													SHIFT 4
				N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10											SHIFT 8
						N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10									SHIFT 12
								M47	M45	M43	M41	M39	M37	M35	M33	M31	M209	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0							SHIFT 16
										M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0					SHIFT 20
												M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0			SHIFT 24
														M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0	SHIFT 28
M47	M45	M43	M41	M39	M37	M35	M33	M31	M29	M27	M25	M23	M21	M19	M17	M15	M13	M11	M9	M7	M5	M3	M1	L13	L11	L7	L6	L5	L4	L3	L2	L1	L0															
N7	N6	N5	N4	N3	N2	N1	N0	M46	M44	M42	M40	M38	M36	M34	M32	M30	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M8	M6	M4	M2	M0	L12	L10															

TS 16/0																																		SHIFT BITS 2^1 2^0
R62	R60	R58	R56	R54	R52	R50	R48	R46	R44	R42	R40	R38	R36	R34	R32	R30	R28	R26	R24	R22	R20	R18	R16	R14	R12	R10	R8	R6	R4	R2	R0			SHIFT 0
2^{62}	2^{60}	2^{58}	2^{56}	2^{54}	2^{52}	2^{50}	2^{48}	2^{46}	2^{44}	2^{42}	2^{40}	2^{38}	2^{36}	2^{34}	2^{32}	2^{30}	2^{28}	2^{26}	2^{24}	2^{22}	2^{20}	2^{18}	2^{16}	2^{14}	2^{12}	2^{10}	2^{8}	2^{6}	2^{4}	2^{2}	2^{0}			F54/55
2^{63}	2^{61}	2^{59}	2^{57}	2^{55}	2^{53}	2^{51}	2^{49}	2^{47}	2^{45}	2^{43}	2^{41}	2^{39}	2^{37}	2^{35}	2^{33}	2^{31}	2^{29}	2^{27}	2^{25}	2^{23}	2^{21}	2^{19}	2^{17}	2^{15}	2^{13}	2^{11}	2^{9}	2^{7}	2^{5}	2^{3}	2^{1}			F48/49
R63	R61	R59	R57	R55	R53	R51	R49	R47	R45	R43	R41	R39	R37	R35	R33	R31	R29	R24	R25	R23	R21	R19	R17	R15	R13	R11	R9	R7	R5	R3	R1	R64		SHIFT 1
2^{63}	2^{61}	2^{59}	2^{57}	2^{55}	2^{53}	2^{51}	2^{49}	2^{47}	2^{45}	2^{43}	2^{41}	2^{39}	2^{37}	2^{35}	2^{33}	2^{31}	2^{29}	2^{27}	2^{25}	2^{23}	2^{21}	2^{19}	2^{17}	2^{15}	2^{13}	2^{11}	2^{9}	2^{7}	2^{5}	2^{3}	2^{1}	2^{-1}		F54/55
	2^{62}	2^{60}	2^{58}	2^{56}	2^{54}	2^{52}	2^{50}	2^{48}	2^{46}	2^{44}	2^{42}	2^{40}	2^{38}	2^{36}	2^{34}	2^{32}	2^{30}	2^{28}	2^{26}	2^{24}	2^{22}	2^{20}	2^{18}	2^{16}	2^{14}	2^{12}	2^{10}	2^{8}	2^{6}	2^{4}	2^{2}	2^{0}		F48/49
	R62	R60	R58	R56	R54	R52	R50	R48	R46	R44	R42	R40	R38	R36	R34	R32	R30	R28	R26	R24	R22	R20	R18	R16	R14	R12	R10	R8	R6	R4	R2	R0		SHIFT 2
	2^{62}	2^{60}	2^{58}	2^{56}	2^{54}	2^{52}	2^{50}	2^{48}	2^{46}	2^{44}	2^{42}	2^{40}	2^{38}	2^{36}	2^{34}	2^{32}	2^{30}	2^{28}	2^{26}	2^{24}	2^{22}	2^{20}	2^{18}	2^{16}	2^{14}	2^{12}	2^{10}	2^{8}	2^{6}	2^{4}	2^{2}	2^{0}		F54/55
	2^{63}	2^{61}	2^{59}	2^{57}	2^{55}	2^{53}	2^{51}	2^{49}	2^{47}	2^{45}	2^{43}	2^{41}	2^{39}	2^{37}	2^{35}	2^{33}	2^{31}	2^{29}	2^{27}	2^{25}	2^{23}	2^{21}	2^{19}	2^{17}	2^{15}	2^{13}	2^{11}	2^{9}	2^{7}	2^{5}	2^{3}	2^{1}		F48/49
	R63	R61	R59	R57	R55	R53	R51	R49	R47	R45	R43	R41	R39	R37	R35	R33	R31	R29	R27	R25	R23	R21	R19	R17	R15	R13	R11	R9	R7	R5	R3	R1	R64	SHIFT 3
	2^{63}	2^{61}	2^{59}	2^{57}	2^{55}	2^{53}	2^{51}	2^{49}	2^{47}	2^{45}	2^{43}	2^{41}	2^{39}	2^{37}	2^{35}	2^{33}	2^{31}	2^{29}	2^{27}	2^{25}	2^{23}	2^{21}	2^{19}	2^{17}	2^{15}	2^{13}	2^{11}	2^{9}	2^{7}	2^{5}	2^{3}	2^{1}	2^{-1}	F54/55
		2^{62}	2^{60}	2^{58}	2^{56}	2^{54}	2^{52}	2^{50}	2^{48}	2^{46}	2^{44}	2^{42}	2^{40}	2^{38}	2^{36}	2^{34}	2^{32}	2^{30}	2^{28}	2^{26}	2^{24}	2^{22}	2^{20}	2^{18}	2^{16}	2^{14}	2^{12}	2^{10}	2^{8}	2^{6}	2^{4}	2^{2}	2^{0}	F48/49

		R15	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	R1	R0	TEST POINT
		B5	B6	B14	B13	B12	B7	B15	B11	B2	B10	B18	B9	B8	B3	B4	B1	
		R31	R30	R29	R28	R27	R26	R25	R24	R23	R22	R21	R20	R19	R18	R17	R16	TEST POINT
		A53'	A69'	A47'	A52'	A16'	A50'	A21'	A19'	A64'	A67'	A68'	A51'	A70'	A71'	A65'	A66'	
		R47	R46	R45	R44	R43	R42	R41	R40	R39	R38	R37	R36	R35	R34	R33	R32	TEST POINT
		C27'	C65'	C63'	C64'	C23'	C2'	C1'	C21'	C25'	C68'	C66'	C69'	C67'	C71'	C70'	C72'	
R65	R64	R63	R62	R61	R60	R59	R58	R57	R56	R55	R54	R53	R52	R51	R50	R49	R48	TEST POINT
D4	A72'	D64	D35	D58	D53	D34	D32	D47	D39	D48	D2	C49	D66	D69	D6	D5	D1	

D-1201H

CRAY X-MP/2 SCALAR SHIFT DOUBLE LEFT/RIGHT SHIFT

VECTOR FUNCTIONAL UNITS

OBJECTIVES

With aid of the student reference material, upon completion of the course a student should be capable of:

I. Determining the failing module type, module location and chip, given the failing instruction or operation.

II. Describing the main function and differences of each of the following modules associated with the Vector Functional Units:

3VG for the Vector Add
3RI for the Vector Pop Count
3VF for the Vector Logical
3VE for the Vector Shift

III. Defining with respect to time and use, the Address and Control signals.

IV. Tracing operand through Vector Functional Unit.

V. Diagnostic Applications:

3VRA - Vector Add
3VPP - Vector Pop
3VRL - Vector Logical
3VRS - Vector Shift

XV201S29M

VECTOR LOGICAL

140iJK - Logical product of Sj and Vk elements to Vi elements

141iJK - Logical product of Vj elements and Vk elements to Vi elements

142iJK - Logical sum of Sj and Vk elements to Vi elements

143iJK - Logical sum of Vj elements and Vk elements to Vi elements

144iJK - Logical difference of Sj and Vk elements to Vi elements

145iJK - Logical difference of Vj elements and Vk elements to Vi elements

145iii - Clear Vi elements

146iJK - Vector merge of Sj and Vk elements to Vi elements

147iJK - Vector merge of Vj elements and Vk elements to Vi elements

VECTOR MASK

0030J0 - Transmit Sj to vector mask register

073i00 - Transmit vector mask to Si

1750J0 - Set vector mask bit based upon result of test of Vj elements
1 - K = 0 Vj elements equal zero
2 - K = 1 Vj elements not equal to zero
3 - K = 2 Vj elements positive
K = 3 Vj elements negative

VECTOR REGISTER FUNCTIONAL UNIT INSTRUCTIONS

VECTOR ADD/SUBTRACT

154iJK - Integer sum of Sj and Vk elements to Vi elements

155iJK - Integer sum of Vj elements and Vk elements to Vi elements

156iJK - Integer difference of Sj and Vk elements to Vi elements

156i0K - Transmit negative of Vk elements to Vi elements

157iJK - Integer difference of Vj elements and Vk elements to Vi elements

VECTOR POP/PARITY

174iJ1 - Population count of Vj elements to Vi elements

174iJ2 - Population count parity of Vj elements to Vi elements

VECTOR SINGLE SHIFT

150iJK - Shift Vj elements left Ak places to Vi elements

150iJ0 - Shift Vj elements left 1 places to Vi elements

151iJK - Shift Vk elements right Ak places to Vi elements

151iJ0 - Shift Vk elements right 1 place to Vi elements

VECTOR DOUBLE SHIFT

152iJK - Double shifts of Vj elements left Ak places to Vi elements

152iJ0 - Double shifts of Vj elements left 1 place to Vi elements

153iJK - Double shifts of Vj elements right Ak places to Vi elements

153iJ0 - Double shifts of Vj elements right 1 place to Vi elements

VECTOR ADD (Modules Involved)

3VG MODULE

When the 154ijk - 157ijk instructions are issued the 3VG will perform an integer add or integer subtract on the j and k operands. Twos complement arithmetic is performed on the k operand when a 156 or 157 instruction is issued. Depending on which instructions were issued, the 3VG must determine whether to select a Vj operand or an Sj operand.

Go Vector Add enables an Sj operand to enter the 3VG module where it is held for the duration of the Vector operation. The 3VG will perform an integer add or subtract operation for the Vector length element. The operands are in the Functional unit for 2cp's. The result is sent to a Vector register specified by the i field of the instruction.

A-1604

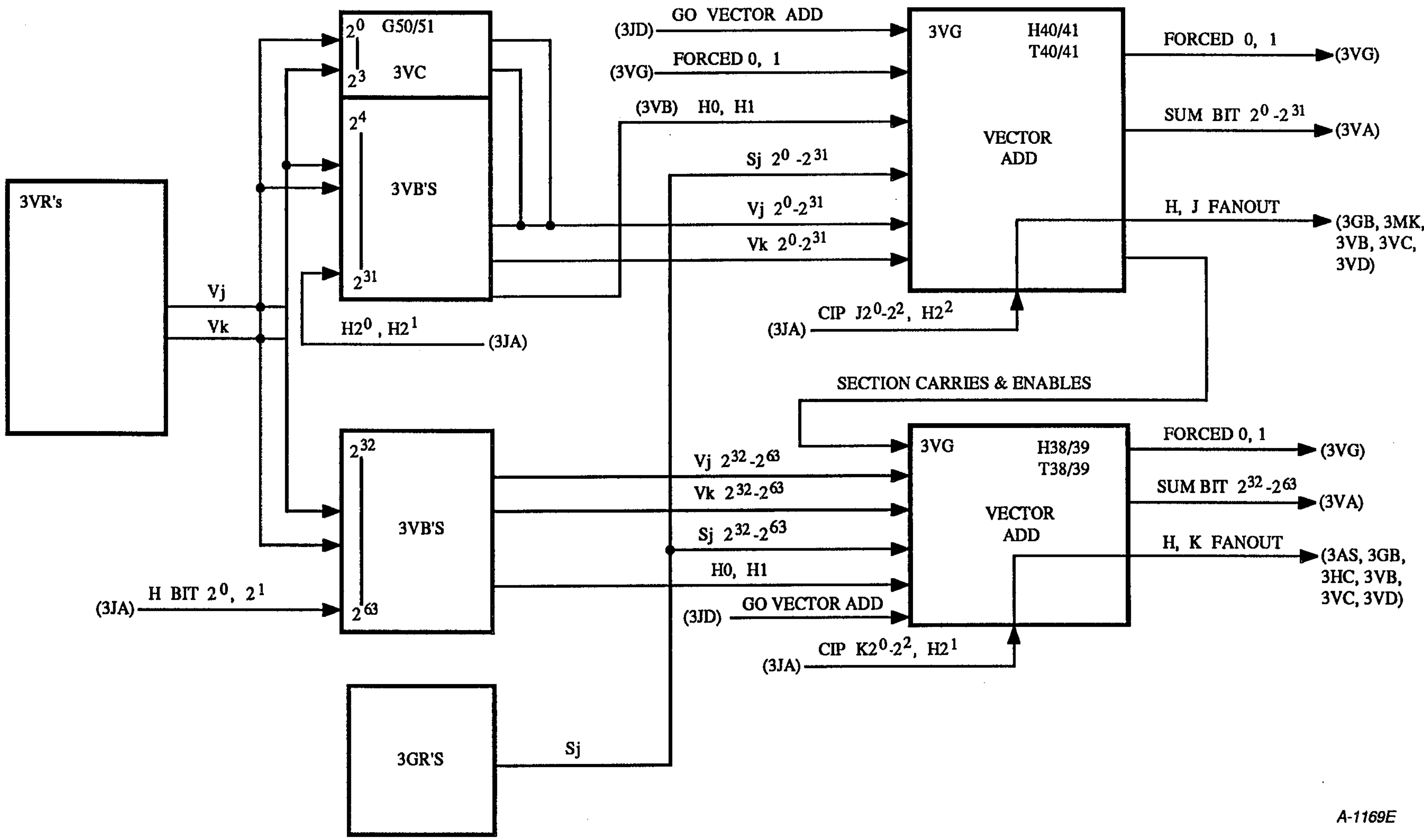
VECTOR REGISTER
ADD FUNCTIONAL UNIT
INSTRUCTIONS

154 IJK	Integer sum of (SJ) + (VK elements) to VI elements
154 IOK	Transmit (VK) to VI
155 IJK	Integer sum of (VJ elements) + (VK elements) to VI elements
156 IJK	Integer difference of (SJ) - (VK elements) to VI elements
156 I0K	Transmit negative of (VK elements) to VI elements
157 IJK	Integer difference of (VJ elements) - (VK elements) to VI elements

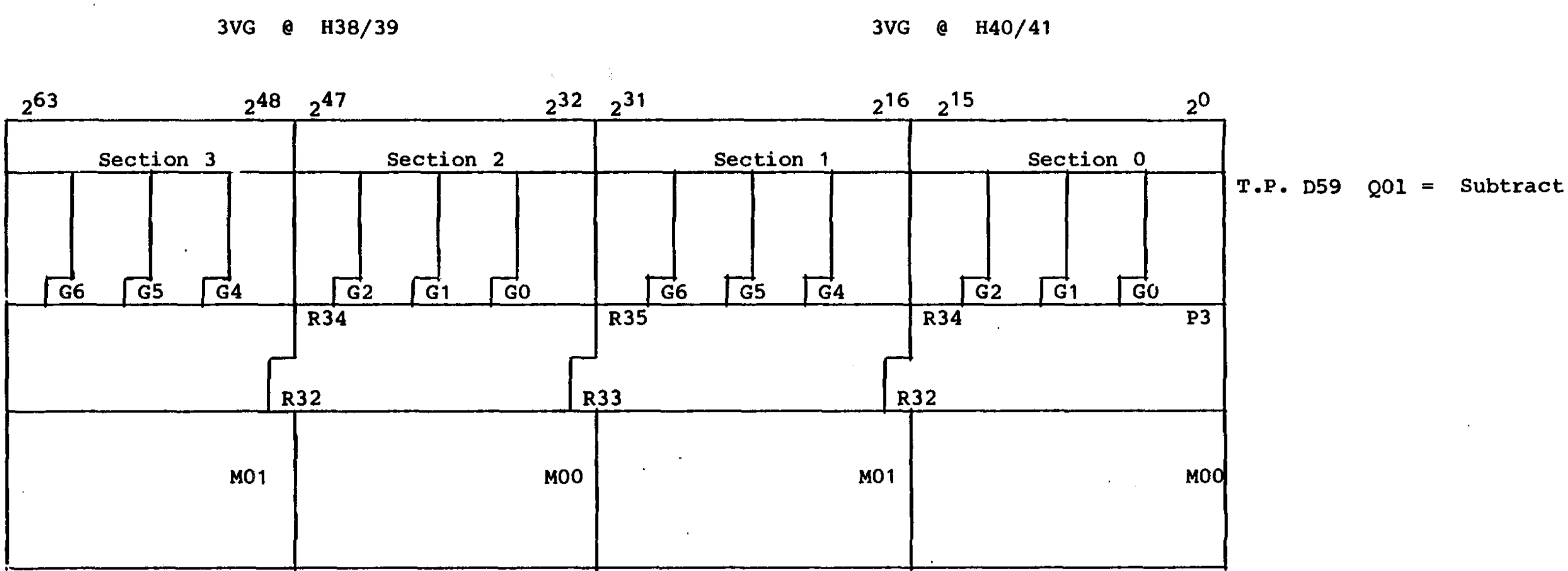
C.A.L. FORMAT

VI	SJ	+	VK	Sum of SJ and VK
VI	SJ	+	VK	Sum of VJ and VK
VI	SJ	-	VK	Difference of SJ - VK
VI	-	VK		Negative of VK
VI	VJ	-	VK	Difference of VJ - VK

XV201S30M



CRAY X-MP VECTOR INTEGER ADDER BLOCK DIAGRAM



R32 = Section 2 Carry
R34 = Section 2 Enable

I96 = R32 (3VG) H41 Section 0 Carry

I97 = R33 (3VG) H41 Section 1 Carry

I98 = R34 (3VG) H41 Section 0 Enable

I99 = R35 (3VG) H41 Section 1 Enable

M00 = [P3 + I96 + I97] [I98 + I96 + I97] [I99 + I97]

M00 = P3 I98 I99 + I96 I99 + I97

M01 = P3 I98 I99 R34 + I96 I99 R34 + I97 R34 + R32

R32 = Section 0 Carry
R34 = Section 0 Enable

I96 = R44 (3VG) H39 Forced 0

I97 = R44 (3VG) H41 Forced 0

I98 = R45 (3VG) H39 Forced 1

I99 = R45 (3VG) H41 Forced 1

P3 = Mode $h2^1$; Subtract

M00 = [P3 + I96 + I97] [I98 + I96 + I97] [I99 + I97]

M00 = P3

M01 = P3 I98 I99 R34 + I96 I99 R34 + I97 R34 + R32

M01 = P3 R34 + R32

B-1594

PROPAGATED ENABLES AND SECTION CARRIES

VECTOR ADD FUNCTION UNIT

Vector Add Control

P00 = $\overline{Q00}$ Select Sj h BIT 2^0=0

P01 = Q01 Subtract h BIT 2^1=1

P02 = Q02 Enter Parameters/GO Vector Add

P03 = Q03 Delayed H bit 2^0; Delayed Subtract

Boolean	N00 = MUX (I64, N00): DCD (P02); T2
	P02 = 1; Select I64
	P02 = 0; Select N00

N00 = Sj Data (I64) bit 2^0, 2^{32} if P02 = 1

Boolean	A00' = N00' p0 + I00' p0' + I32' p1' + I32 P1
	A00 = [N00 + P0'] [I00 + P0] [I32 + P1] [I32' + P1']

A00 = [(Select Sj Data) + (Select Vj Data)] [(Add Select Vk Data) + (Subtract Select Vk Data)]

A00 = Bit carry 2^0 or 2^{32} both operand equal a one

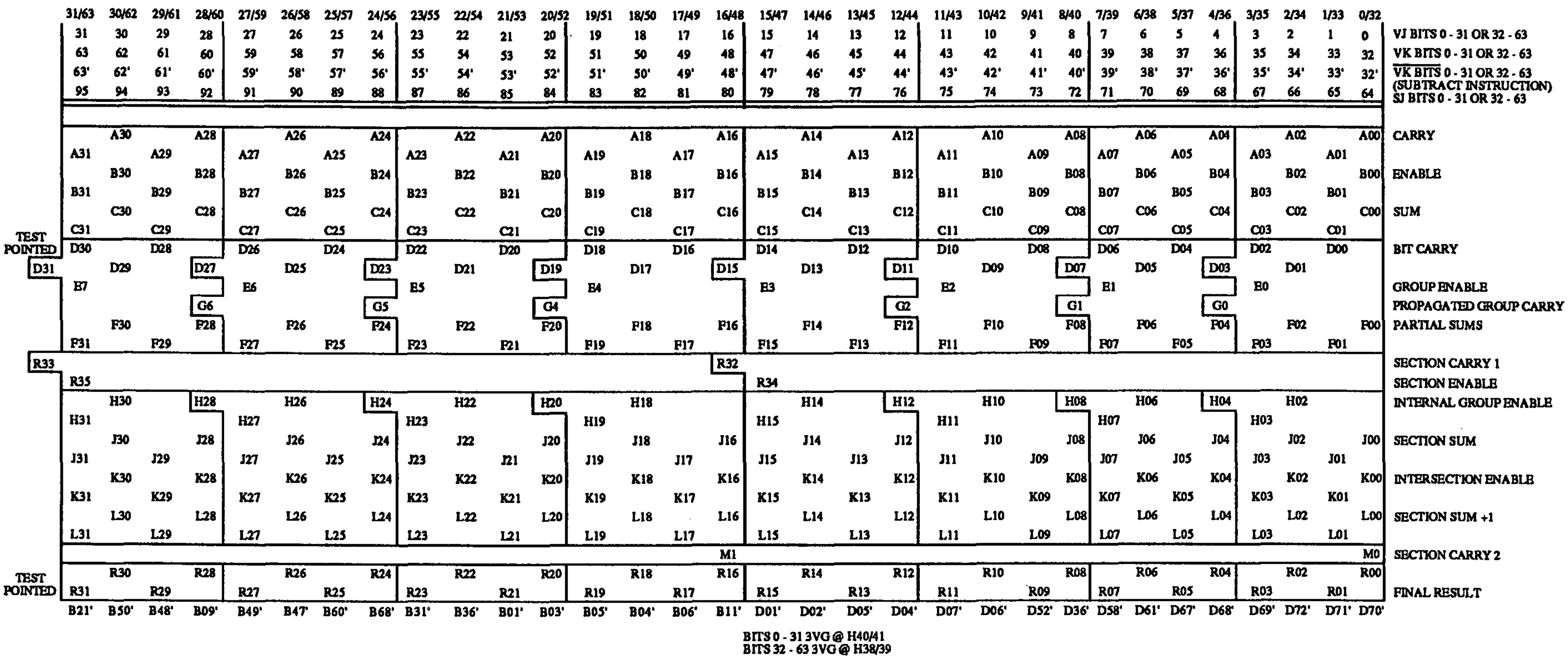
Boolean	M00' = P03' I96' I97' + I98' I96' I97' + I99' I97'
	M00 = [P03 + I96 + I97] [I98 + I96 + I97] [I99 + I97]

M00 = Section 0 or Section 2 enables

Boolean	M01 = R32 I97 I96 P03 ## R34 I99 I98 0 ##
	M01 = P03 I98 I99 R34 + I96 I99 R34 + I97 R34 + R32

M01 - Section 1 or 3 enables

A-1593A



1. SECTION CARRY R32 -> 3VG @ H38/39 AS I96 & I97
   SECTION ENABLE R34 -> 3VG @ H38/39 AS I98 & I99
   R32 - R35 ARE NOT OUPUTTED ON 3VG @ H38/39

2. M0 ON 3VG @ H40/41 = SUBTRACT
   M1 ON 3VG @ H40/41 = SECTION 0 CARRY OR SUBTRACT INSTRUCTION & SECTION 0 ENABLE

   M0 ON 3VG @ H38/39 = SECTION 1 CARRY OR SECTION 0 CARRY WITH SECTION 1 ENABLE OR SUBTRACT INSTRUCTION WITH SECTION 0, 1 ENABLES
   M1 ON 3VG @ H38/39 = SECTION 2 CARRY OR SECTION 1 CARRY WITH SECTION 2 ENABLE OR SECTION 0 CARRY WITH SECTION 1 & 2 ENABLES OR SUBTRACT INSTRUCTION WITH SECTION 0, 1, 2 ENABLES

C-1171C

CRAY X-MP VECTOR ADDER (3VG MODULE)

VECTOR POP COUNT (Module Involved)

3RI MODULE

The 3RI module performs the Vector Pop Count operation. The Vector Pop Count uses a 174 instruction which is also a decode for a Vector Reciprocal operation. The k field of the instruction tells the 3RI to send the result to Vi or to continue a reciprocal operation.

A 174ij1 instruction counts the number of 1 bits in each element of Vj for Vector length times and enters the results into a corresponding Vi element. All 1 bits set in the Vj element 0 would load a 100_8 into Vi element 0. All other bits of Vi element 0 are zeroed.

A 174ij2 instruction performs the same operation as the 174ij1 instruction except only the bit 2^0 of the result is sent to the corresponding Vi element. A 1 indicates odd parity and a 0 indicates even parity of the corresponding element.

Because the 3RI is also used by the Reciprocal Functional unit, the Vector Pop would reserve the Reciprocal functional unit for Vector Pop time. A Vector Reciprocal operation would then reserve the Vector Pop Count for the Reciprocal time.

X2100C0209

VECTOR REGISTER POP COUNT FUNCTIONAL UNIT INSTRUCTIONS

174IJ1 Vector Pop Count of (VJ) to VI

174IJ2 Vector Even Parity of (VJ) to VI

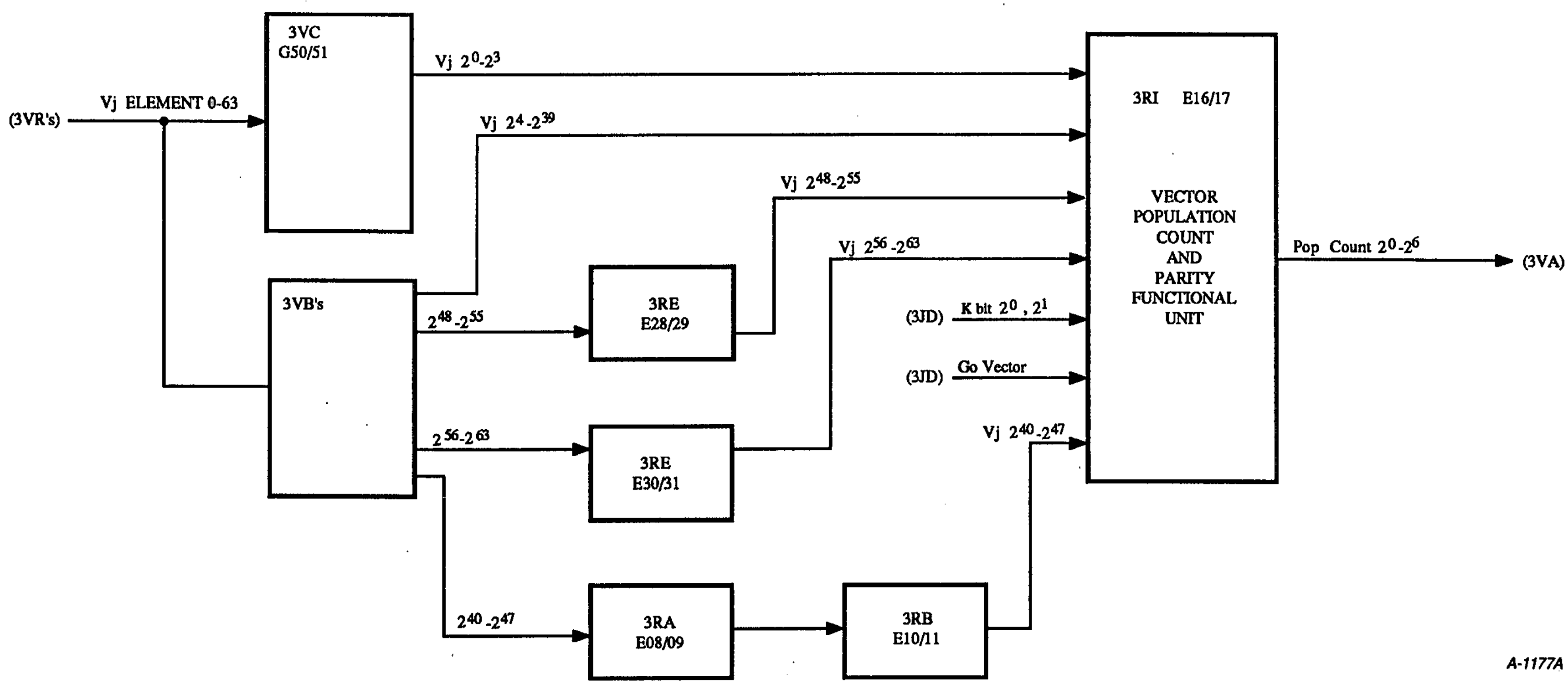
C.A.L. FORMAT

VI PVJ	Population count of (VJ) to VI
VI QVJ	Parity of (VJ) to VI

DIAGNOSTIC APPLICATION

3VPP

XV201S31M



CRAY X-MP VECTOR POP COUNT FUNCTIONAL UNIT BLOCK DIAGRAM

SYN	CHANNEL A	3RI T.P. $\overline{D72}$
	CHANNEL B	3RE, 3RA, 3RI

	2^{63}	2^{62}	2^{61}	2^{60}	2^{59}	2^{58}	2^{57}	2^{56}	2^{55}	2^{54}	2^{53}	2^{52}	2^{51}	2^{50}	2^{49}	2^{48}
	3RE	AT	E30/31						3RE	AT	E28/29					
T.P.	A45	$\overline{A53}$	B04	$\overline{B05}$	$\overline{B14}$	$\overline{B02}$	$\overline{B01}$	B03	A45	$\overline{A53}$	B04	$\overline{B05}$	$\overline{B14}$	$\overline{B02}$	$\overline{B01}$	B03
	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___

2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}
3RA	AT	E08/09						3RI	AT	E16/17					
$\overline{B61}$	A69	$\overline{A67}$	$\overline{A71}$	$\overline{B55}$	B66	$\overline{B20}$	$\overline{B63}$	$\overline{B34}$	$\overline{B39}$	$\overline{B21}$	$\overline{B37}$	$\overline{B26}$	$\overline{B71}$	$\overline{B47}$	$\overline{B69}$
___,	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___

2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}
3RI	AT	E16/17													
$\overline{B62}$	$\overline{B58}$	$\overline{B51}$	$\overline{B54}$	$\overline{B67}$	$\overline{B68}$	$\overline{B66}$	$\overline{B41}$	$\overline{B65}$	$\overline{A01}$	$\overline{A02}$	$\overline{A05}$	$\overline{A07}$	$\overline{A11}$	$\overline{A9}$	$\overline{A56}$
___,	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___

2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{09}	2^{08}	2^{07}	2^{06}	2^{05}	2^{04}	2^{03}	2^{02}	2^{01}	2^{00}
3RI	AT	E16/17													
$\overline{A22}$	$\overline{A13}$	$\overline{A54}$	$\overline{A39}$	$\overline{A41}$	A43	A66	A49	A60	A53	A58	A61	A63	A69	A71	A51
___,	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___

A-1642A
X2100C0207

CRAY X-MP/2 J OPERAND
VECTOR POPULATION COUNT SCOPE CHART

174ij1 - Vector Pop Count
174ij2 - Vector Pop Parity

I91 = R56	3JD @ F19	Go Data Vector Floating Recip.
I92 = R36	3JD @ F19	Mode K bit 2^0
I93 = R37	3JD @ F19	Mode K bit 2^1

Boolean W01' = I92 I93 + I92' I93' + I91'; T2

W01 = [I92' + I93'] [I92 + I93] [I91]; T2

W01 = Go Vector Pop or Parity

$\overline{\text{D68}}$	W04 = W01; T2
$\overline{\text{D03}}$	W07 = W04; T2
D08	W10 = W07; T2

Boolean W02' = I91' + I92' + I93 T2

W02 = [I91 I92 I93']

W02 = Go Vector Pop

$\overline{\text{D72}}$	W05 = W02; T2
D04	W08 = W05; T2
D07	W11 = W08; T2

T.P.	16/0	Pop Count
C66	R80 = S00 W10	Bit 2^0
C46	R81 = S01 W11	Bit 2^1
C63	R82 = S02 W11	Bit 2^2
C27	R83 = [$\overline{\text{S03}}$ + $\overline{\text{V00}}$] [S03 + V00] [W11]	Bit 2^3
C45	R84 = [$\overline{\text{S04}}$ + $\overline{\text{V01}}$] [S04 + V01] [W11]	Bit 2^4
C59	R85 = [S05 + V02] [S05 + V02] [W11]	Bit 2^5
C04	R86 = V03 W11	Bit 2^6

A-1603

VECTOR POP COUNT CONTROL

		2^1	2^0		2^2	2^1	2^0		2^3	2^2	2^1	2^0		2^3	2^2	2^1	2^0	TEST	POINT
2^0 - 2^{39} A0-A39	A0-A2	H1	H0	H0,H2,H4		J1	J0	J0,J2,J4			K1	K0	K0,K2,I100			L1	L0	D37	D30
(3VC,3VB)	A3-A5	H3	H2	H6,H8,H10		J3	J2	J6,H22,H24			K3	K2	I101-I103			L3	L2	D38	D40
	A6-A8	H5	H4	H12,H14,H16		J5	J4	J1,J3,J5		K5	K4		I104-I106			L5	L4	D22	D23
2^{40} - 2^{47} I80-I87	A9-A11	H7	H6	H18,H20,A39		J7	J6	J7,J8,J10		K7	K6		I107-I109			L7	L6	D41	D21
(3RB)	A12-A14	H9	H8	H1,H3,H5	J9	J8		J12,J14,H25		K9	K8		I110-I112			L9	L8	D17	D14
	A15-A17	H11	H10	H7,H9,H11	J11	J10		J9,J11,J13	K11	K10			I113-I115			L11	L10	D28	D16
2^{48} - 2^{63} I100-I115	A18-A20	H13	H12	H13,H15,H17	J13	J12							K1,K3,K4		L13	L12		A47	A45
(3RE)	A21-A23	H15	H14	H19,H21,H23	J15	J14							K6			L14			
	A24-A26	H17	H16	** H22									K8			L15			A21
	A27-A29	H19	H18	** H24				**J15					K5,K7,K9	L17	L16			A17	A15
	A30-A32	H21	H20	** H25									K10		L18				A19
	A33-A35	H23	H22										J15		L19				A36
** TIME DELAY	A36-A38	H25	H24										K11	L20					A34
	TS16/0 ** A39	TS 3/5				TS 7/9					TS 11/13					TS 16/0			

	2^3	2^2	2^1	2^0		2^4	2^3	2^2	2^1	2^0		2^4	2^3	2^2	2^1	2^0		2^4	2^3	2^2	2^1	2^0	TEST	POINT
L0,L2,L4			M1	M0	M0,M2				N1	N0	N0,I80,I81				01	00	00,02,04				P1	P0	D62	D71
L6,L8,L10			M3	M2	M1,M3,M4			N3	N2		I82-I84				03	02	01,03,05			P3	P2		D58	D56
L1,L3,L5		M5	M4		** M6						I85-I87				05	04	06,N2			P5	P4		D48	D36
L7,L9,L11		M7	M6		** M8						N1,M6,M8			07	06		07,08,N4		P7	P6			D46	D45
L12,L14,L15		M9	M8		M5,M7,L19		N5	N4			** N2						09,N5,N6	P9	P8				D54	D47
L13,L16,L18	M11	M10			** M9						N3,M9,M10		09	08			N7	P10						D53
** L19					** M10						** N4-N7													
** L17					M11,L17,L20	N7	N6																	
** L20			TS 3/5						TS 7/9						TS 11/13						TS 16/0			

	2^5	2^4	2^3	2^2	2^1	2^0		2^5	2^4	2^3	2^2	2^1	2^0		2^6	2^5	2^4	2^3	2^2	2^1	2^0
P1,P2,P4				Q1	Q0		P0						S0	U0				V0			
P3,P5,P6			Q3	Q2			Q0					S1		U0S3 + U1			V1				
P7,P8		Q5	Q4				Q1,Q2				S2			U0S3S4 + U1S4 + U2		V2					
P9,P10	Q7	Q6					Q3,Q4			S3				[U0S3S4S5 + U1S4S5 +	V3						
** P0							Q5,Q6		S4					U2S5]							
							Q7	S5				ENABLE									
							Q1,Q2			U0											
							Q3,Q4		U1												
				TS 3/5			Q5,Q6	U2		TS 7/9		CARRY				CARRY				TS 11/13	

B-11788

	2^6	2^5	2^4	2^3	2^2	2^1	2^0	TEST POINT
S0 W10							R80	C66
S1 W11						R81		C46
S2 W11					R82			C63
S3+V0 $\overline{S3+V0}$ W11				R83				C27
S4+V1 $\overline{S4+V1}$ W11			R84					C45
S5+V2 $\overline{S5+V2}$ W11		R85						C59
V3 W11	R86				TS 16/0			D20

FOR THE 174iJ1 INSTRUCTION, NEED W10 & W11
FOR THE 174iJ2 INSTRUCTION, NEED W10

VECTOR POP COUNT

FULL VECTOR LOGICAL (Module Involved).

3VF MODULE

The 3VF module performs the Vector Logical operation. This includes the AND, OR and EXCLUSIVE-OR functions on two vector elements or a scalar and one vector element. The 140-145 instructions perform these functions. Functional Unit time is 1 CP.

The 3VF also performs a merge of Sj, Vj or Vk element to Vi depending whether the Mask bit is a one or zero. If the Mask bit for the associated element is a one the 3VF selects Sj or Vj and loads it into the Vi element. If the mask bit equals a zero, the 3VF selects the Vk element and loads it into Vi elements. The 146 and 147 instruction performs these functions. Functional Unit time is 1 CP.

The 3VF at location E42/43 handles bits 2^0-2^{15} and bits 2^{32}-2^{47} of the Vector Mask register and the Sj, Vj, or Vk data bits. The 3VF at location E40/41 handles bits 2^{16}-2^{31} and bits 2^{48}-2^{63} of the Vector Mask register and the Sj, Vj, or Vk data bits.

SECOND VECTOR LOGICAL

The Second Vector Logical resides in the Floating Multiply Functional unit. Oddly enough the 140-145 instruction also share the same h-mode bits as the 160-165 instruction.

At the time of CIP for a 140-145 instruction, a decision is made as to which of the two Vector Logical units to use on the 3JD for X-MP/2, the Full Vector Logical unit or the Second Vector Logical unit. Issue to the Second Vector Logical unit is attempted first; if that unit is busy, a default to the Full Vector Logical unit occurs. If both Vector Logical units are busy, issue is held until one of the units becomes available.

Since the Second Vector Logical unit and the Floating Multiply unit share input and output paths, they cannot be used simultaneously. If one is busy, so is the other. Functional unit is busy for (VL) + 4 CPs.

The Second Vector Logical unit can be disabled through software by clearing bit 2^0 of word three in the exchange package of a user program. If this bit (Enable Second Vector Logical) is cleared, only the Full Vector Logical unit is available for use by the instructions 140-145.

The Second Vector Logical Function unit times is 3 CPs, of which 1 CP is spent to fanout the operand, 1 CP to perform the Logical operation and another CP to output the results. The Full Functional unit time takes 1 CP.

SECOND VECTOR LOGICAL (Module Involved)

3MK Module

The 3MK module is the control module. It is the replacement for the 3MH. The 3MK is the control module which allows the incoming data to be input to the Floating Multiply Functional unit. The data is then fanout using the Floating Multiply fanout paths. The 3MK receives the h-mode bits 2^0-2^2 from the 140-145 instruction decode. H-mode bit 2^0 determines if the instruction is a Scalar/Vector or a Vector/Vector. H-mode bit 2^1 and 2^2 determine what type of Logical operation is being performed. The 3MK monitors to control lines Go Vector Logical and Go Vector Floating Multiply, the absents of Go Vector Logical tells the 3MK that it is performing a Floating Multiply operation. The presence of both control terms tells the 3MK that it is performing a Logical operation. The 3MK is also responsible for gating the results off the Floating Multiply Functional unit by bringing up Go Logical at the appropriate time to the 3MJ module.

3MA, 3MB, 3MC and 3MD Modules

The modules listed above input the operand, form the appropriate Sj or Vj register and Vk register. The 3MC, 3MD along with the 3MJ modules perform the Logical Product, Logical Sum, or Logical Difference depending on which instruction was issued.

3MJ Module

The 3MJ module performs the Logical operation. On a portion of the operand it is the replacement for the 3MG module. The 3MJ is then responsible for outputting the final results to the 3VA when the Go Logical is present from the 3MK module.

X2002C0106

VECTOR LOGICAL
FUNCTIONAL UNIT INSTRUCTIONS

140ijk	Inst. (Sj) & (Vk) to Vi
141ijk	Inst. (Vj) & (Vk) to Vi
142ijk	Inst. (Sj) ! (Vk) to Vi
142i0k	Transmit (Vk) to Vi
143ijk	Inst. (Vj) ! (Vk) to Vi
144ijk	Inst. (Sj) / (Vk) to Vi
145ijk	Inst. (Vj) / (Vk) to Vi
145iii	Clear Vi

VECTOR MERGE

146ijk	Inst. if VM bit = 1 (Sj) to Vi Inst. if VM bit = 0 (Vk) to Vi
146i0k	Vector merge of (Vk) and 0 to Vi
147ijk	Inst. if VM bit = 1 (Vj) to Vi Inst. if VM bit = 0 (Vk) to Vi

VECTOR TESTS

1750jk	Inst. test (Vj elements) enter in VM
175ijk	Where if K = 0,4 VM = 1 if (Vj element) = 0 K = 1,5 VM = 1 if (Vj element) ≠ 0 K = 2,6 VM = 1 if (Vj element) is positive K = 3,7 VM = 1 if (Vj element) is negative

VECTOR MASK

0030j0	Inst. transmit (Sj) to vector mask register
073i00	Inst. transmit (VM) to Si
040ijkm	Transmit jkm to Si
041ijkm	Transmit exp = ones complement of jkm to Si
042ijk	Form zeros mask exp bits in Si from the left; jk field gets the exp
043ijk	Form ones mask exp bits in Si from the left; jk field gets the exp

DIAGNOSTIC APPLICATION

3VRL

140iJK LOGICAL PRODUCT SJ & VK ELEMENTS TO Vi
141iJK LOGICAL PRODUCT VJ ELEMENTS & VK ELEMENTS TO Vi

J	17 ---- 7	0 ---- 0	17 ---- 7	17 ---- 7	1 1 0 0
K	0 ---- 0	0 ---- 0	17 ---- 7	17 ---- 7	1 0 1 0
i	0 ---- 0	0 ---- 0	17 ---- 7	17 ---- 7	1 0 0 0

142iJK LOGICAL SUM SJ ! VK ELEMENTS TO Vi
143iJK LOGICAL SUM VJ ELEMENTS ! VK ELEMENTS TO Vi

J	17 ---- 7	0 ---- 0	17 ---- 7	17 ---- 7	1 1 0 0
K	0 ---- 0	0 ---- 0	17 ---- 7	17 ---- 7	1 0 1 0
i	17 ---- 7	0 ---- 0	17 ---- 7	17 ---- 7	1 1 1 0

144iJK LOGICAL DIFFERENCE SJ \ VK ELEMENTS TO Vi
145iJK LOGICAL DIFFERENCE VJ ELEMENTS \ VK ELEMENTS TO Vi

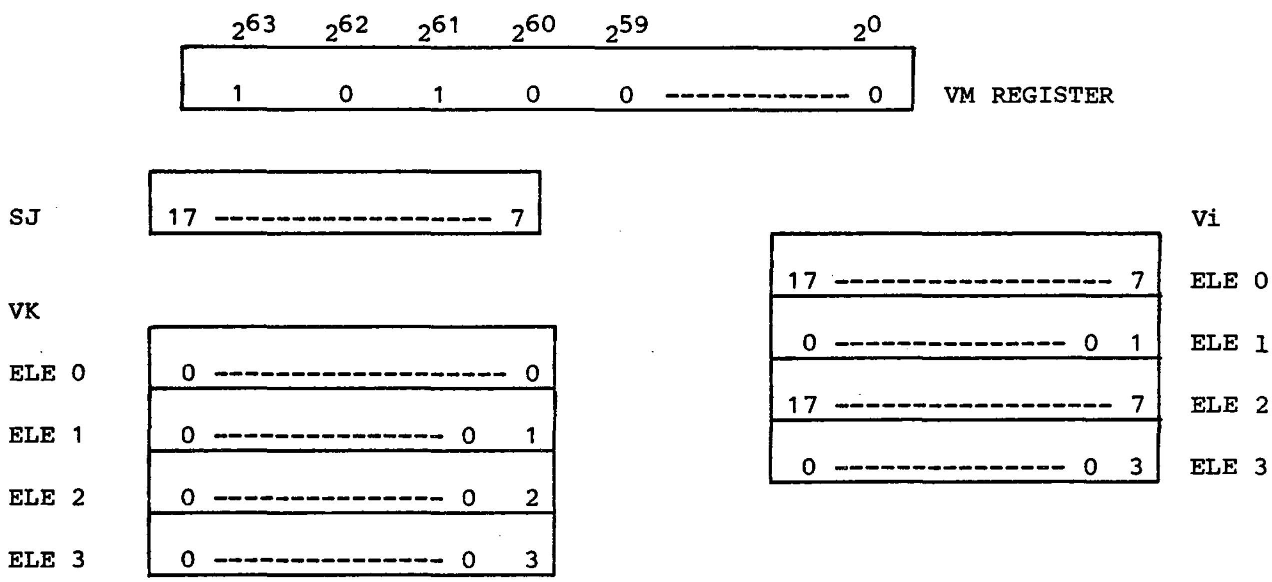
J	17 ---- 7	0 ---- 0	17 ---- 7	17 ---- 7	1 1 0 0
K	0 ---- 0	0 ---- 0	17 ---- 7	17 ---- 7	1 0 1 0
i	17 ---- 7	0 ---- 0	0 ---- 0	0 ---- 0	0 1 1 0

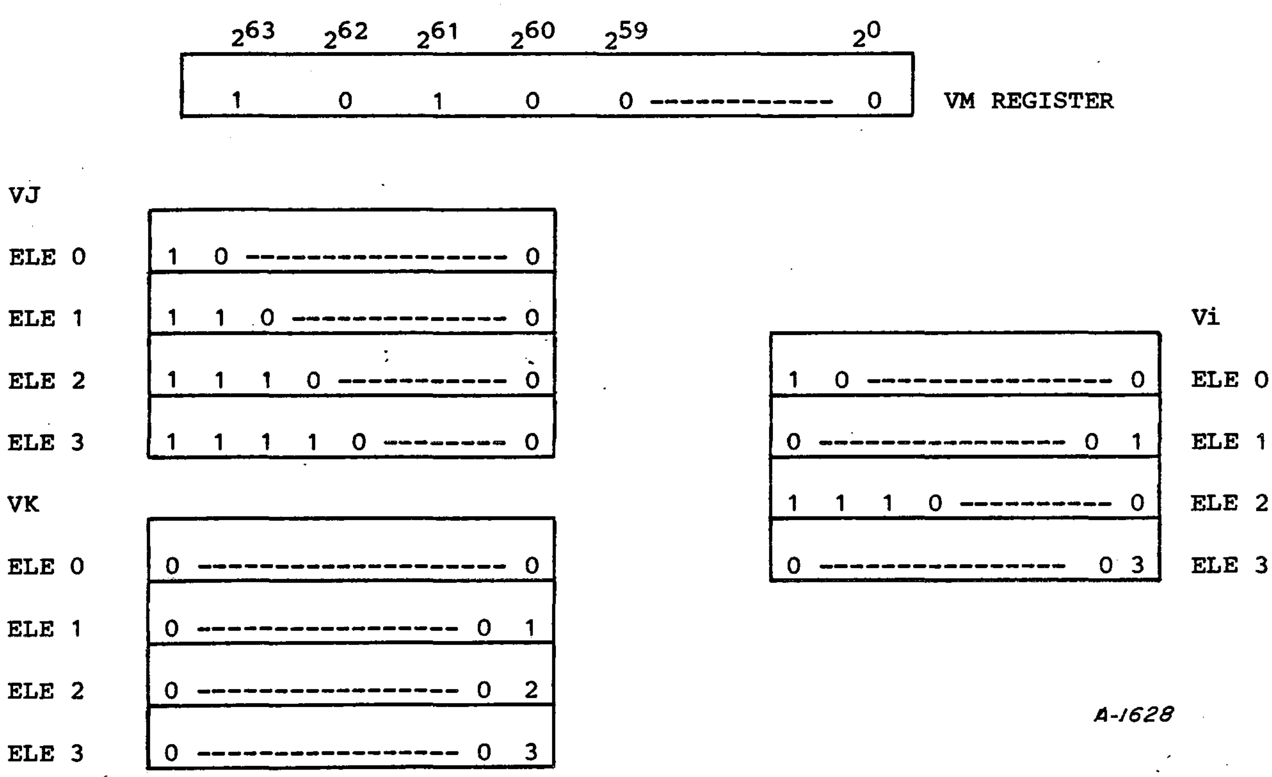
A-1233

VECTOR LOGICAL INSTRUCTIONS
(PAGE 1 of 3)

146iJK TRANSMIT SJ TO Vi ELEMENTS IF VM BIT = 1
TRANSMIT VK ELEMENTS TO Vi ELEMENTS IF VM BIT = 0

147iJK TRANSMIT VJ ELEMENTS TO Vi ELEMENTS IF VM BIT =1
TRANSMIT VK ELEMENTS TO Vi ELEMENTS IF VM BIT =0





VECTOR LOGICAL INSTRUCTIONS
(Page 2 of 3)

0030j0 TRANSMIT (Sj) TO VECTOR MASK

073i00 TRANSMIT VECTOR MASK TO Si

1750j0 - VM = 1 WHERE (Vj) = 0

	Vj ELEMENTS	VM REG.	
ELE 0	0 ——— 0	1	2^{63}
ELE 1	0 ——— 01	0	2^{62}
ELE 2	0 ——— 0	1	2^{61}
		0	2^{60}
		|	|
	VL = 3	0	2^0

1750j1 - VM = 1 WHERE (Vj) ≠ 0

	Vj ELEMENTS	VM REG.	
ELE 0	0 ——— 0	0	2^{63}
ELE 1	0 ——— 1	1	2^{62}
ELE 2	17 ——— 7	1	2^{61}
		0	2^{60}
		|	|
	VL = 3	0	2^0

1750j2 - VM = 1 WHERE (Vj) POSITIVE

	Vj ELEMENTS	VM REG.	
ELE 0	07 ——— 7	1	2^{63}
ELE 1	10 ——— 0	0	2^{62}
ELE 2	0 ——— 1	1	2^{61}
		0	2^{60}
		|	|
	VL = 3	0	2^0

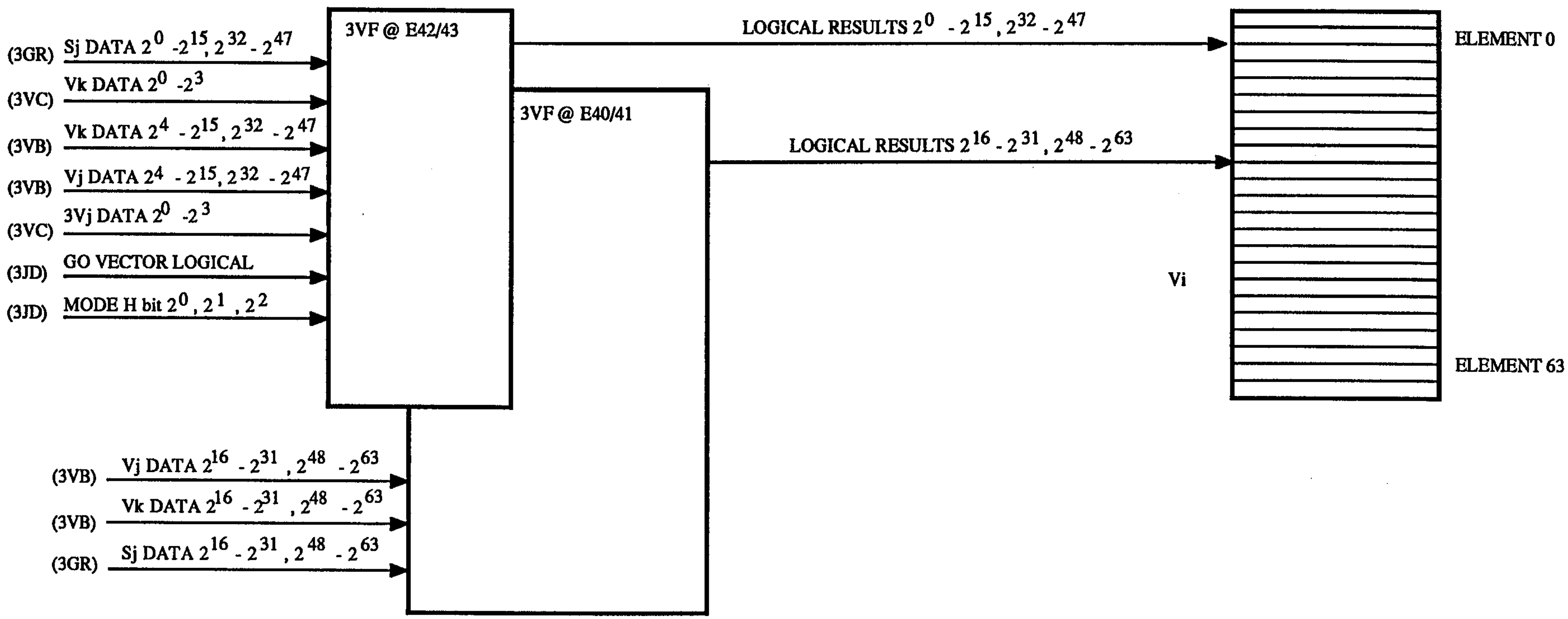
1750j3 - VM = 1 WHERE (Vj) NEGATIVE

	Vj ELEMENTS	VM REG.	
ELE 0	17 ——— 7	1	2^{63}
ELE 1	07 ——— 7	0	2^{62}
ELE 2	10 ——— 0	1	2^{61}
		0	2^{60}
		|	|
	VL = 3	0	2^0

A-1628

VECTOR LOGICAL INSTRUCTIONS
(Page 3 of 3)

140ijk	LOGICAL PRODUCT OF (Sj) AND (Vk) TO Vi
141ijk	LOGICAL PRODUCT OF (Vj) AND (Vk) TO Vi
142ijk	LOGICAL SUM OF (Sj) AND (Vk) TO Vi
143ijk	LOGICAL SUM OF (Vj) AND (Vk) TO Vi
144ijk	LOGICAL DIFFERENCE OF (Sj) AND (Vk) TO Vi
145ijk	LOGICAL DIFFERENCE OF (Vj) AND (Vk) TO Vi



CRAY X-MP VECTOR LOGICAL BLOCK DIAGRAM

B-1606

<u>LOGICAL PRODUCT: AND FUNCTION</u>

140ijk 141ijk

3VF Module

Q00 = I114; T2 Go Vector Logical cp2
N06 = Q00
I64 = Sj DATA bit 2^0

Boolean	D00 = MUX (I64 D00): DCD (N06); T2
	N06 = 1 LATCH I64
	N06 = 0 HOLD D00

D00 = HOLD Sj DATA
I110 = MODE h bit 2^0

Boolean	Q06 = MUX (I110 Q06): DCD (N06); T2
	N06 = 1 SELECT Sj or Vj
	N06 = 0 HOLD Q06

Q06 = HOLD h bit 2^0

N00 = $\overline{Q06}$, N00 = 1 take Sj, N00 = 0 take Vj
I32 = Vk DATA bit 2^0
I00 = Vj DATA bit 2^0

Boolean	A00 = D00 I32 N00 + I00 I32 N00'

A00 = LOGICAL PRODUCT OF (Sj * Vk) or (Vj * Vk)

M00 = $\overline{Q8}$ $\overline{Q7}$ MODE h bit 2^1 , 2^2 = ZERO's
N03 = M00 MODE h bit 2^2, 2^1 = 140, 141
N04 = M01
M01 = Q8$\overline{Q7}$ MODE h bit 2^2, 2^1= 144, 145

Boolean	R00' = A00' N03 + B00' N03' + A00 N4; T2
	R00 = [A00 + N03'] [B00 + N03] [A00' + N04']; T2

R00 = LOGICAL PRODUCT RESULT bit 2^0 or 2^{16}
R00 = LOGICAL SUM RESULT bit 2^0 or 2^{16}
R00 = LOGICAL DIFFERENCE RESULT bit 2^0 or 2^{16}
R00 = merge bit 2^0 or 216

A-1612

LOGICAL SUM: OR FUNCTION

142ijk 143ijk

3VF Module

D00 = Sj bit 2^0
I00 = Vj bit 2^0
I32 = Vk bit 2^0

N00 = $\overline{Q6}$ SELECT Sj or Vj DATA
N01 = R67 + I99 SELECT j

R67 = $\overline{M02}$ + J0J1N10 + R67$\overline{N10}$; T2 $\overline{M2}$ when 140,143
M02 = Q08 Q07 MODE bit 2^1, 2^2

$\overline{N02}$ = R67 M02 + I99 M02 SELECT Vk

Boolean B00 = D00 N00 N01 + I00 N00' N01 + I32 N02

B00 = Sj + Vj + Vk EQUALS A 1

LOGICAL DIFFERENCE

144ijk 145ijk

EXCLUSIVE-OR FUNCTION

A00 = j • k AND FUNCTION
B00 = j + k OR FUNCTION

N03 = M00
M00 = $\overline{Q8}$ $\overline{Q7}$ AND MODE h bit 2^2, 2^1

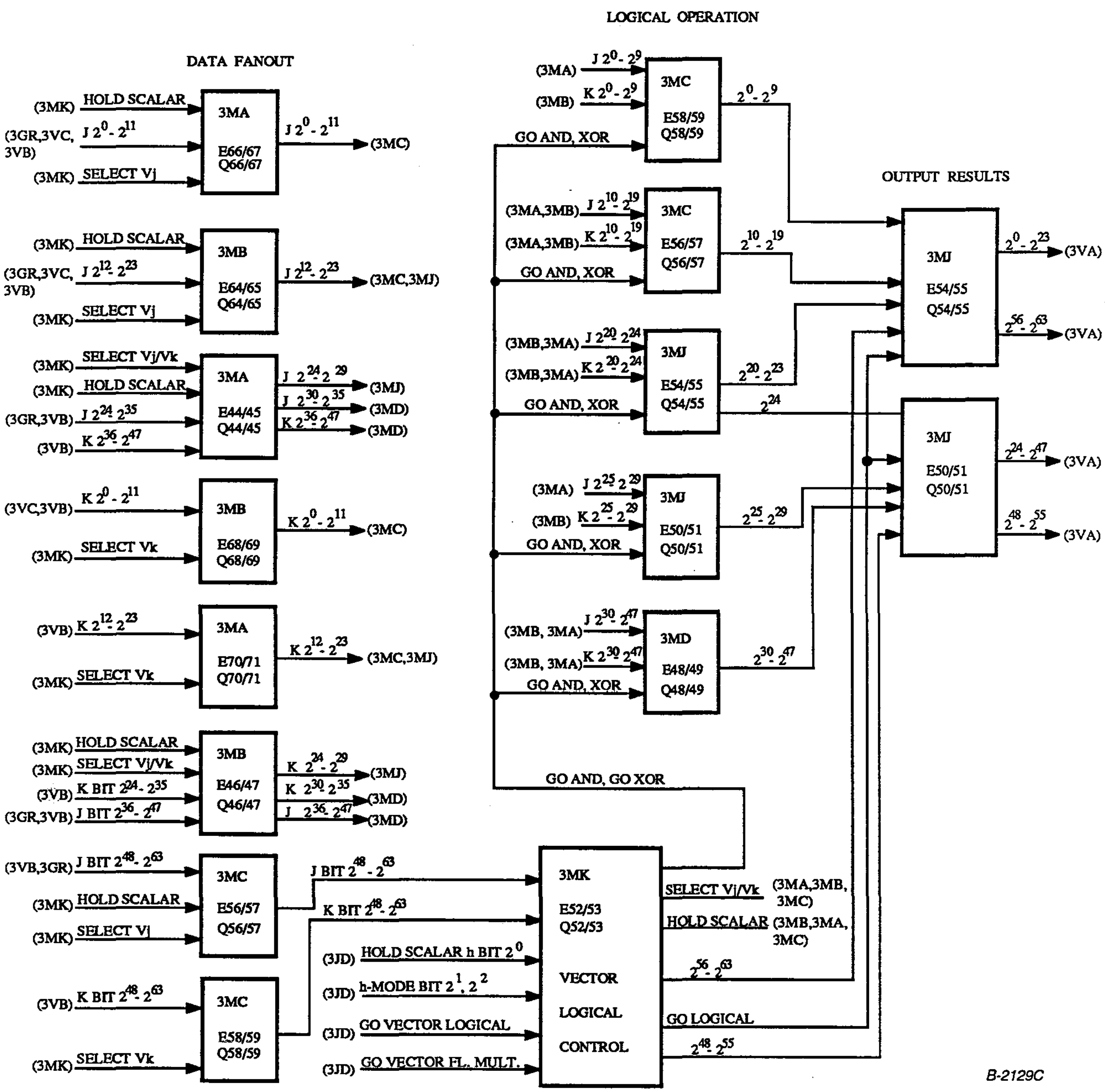
N04 = M01
M01 = Q8 $\overline{Q7}$ EXOR MODE h bit 2^2, 2^1

Boolean R00' = A00' N03 + B00' N03' + A00 N04; T2

R00 = [A00 + N03'] [B00 + N03] [A00' + N04']; T2

R00 = EXCLUSIVE OR of Bit 2^0 or 2^{16}

A-1613A



CRAY X-MP/1,2 - CPU 0 SECOND VECTOR LOGICAL FUNCTIONAL UNIT

3MC Module

AND, OR, XOR Operations

I100 = j operand bit 2^0

I110 = k operand bit 2^0

Boolean	V0 = I100 I110
	V9 = I109 I119

V0 = AND or Logical product of j bit 2^0
ANDed with k bit 2^0

Boolean	V10' = I100' I110'
	V19' = I109' I119'

V10 = ORed function or Logical Sum of
j bit 2^0 ORed with k bit 2^0

W00 = I120 Go AND 140/141 instruction from 3MK

W01 = I121 Go XOR 144/145 instruction from 3MK

Boolean	R50' = V0' W0 + V10' W0' + V0 W1; T2
	R50 = [V0 + W0'] [V10 + W0] [V0' + W1']; T2

R50 = AND operation made from V0
R50 = OR operation made from V10
R50 = XOR operation made from inverted V0 ANDed with V10

X2020S0101

3MK Module

Go Vector Logical Control

I33 = Go Data Vector Floating Multiply from 3JD

I41 = Go Vector Logical from 3JD

```
Boolean    H30' = I33' + #I41'; T2
           H30 = I33 I41; T2
           H31' = H30'
           K22 = H31
```

H30 = I33 I41 Need Vector Logical and Vector Floating Multiply, without Vector Logical your doing a Vector Floating Multiply.

K22 - Select Logical Results at cp3.

Go Add - Go XOR

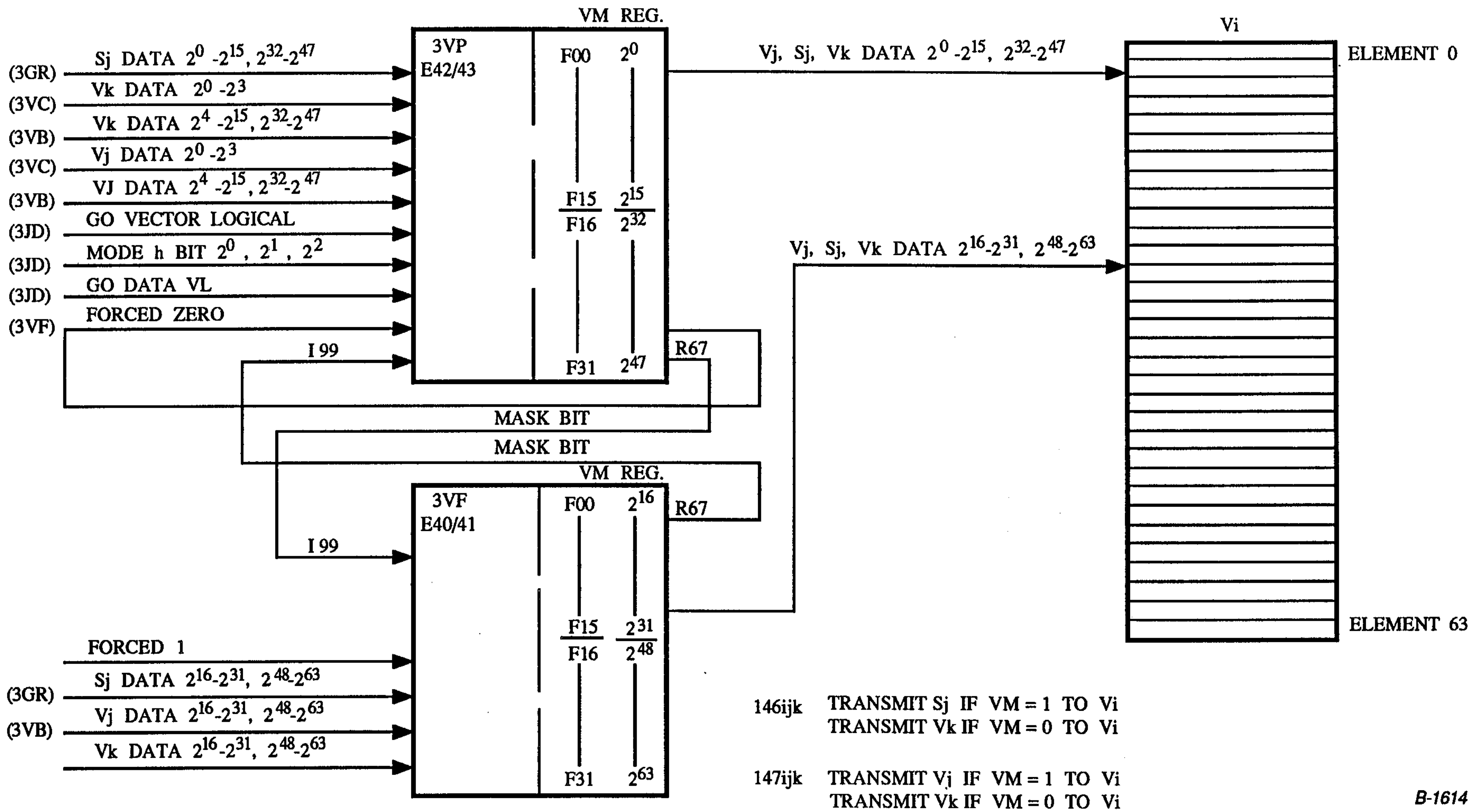
I36 = h-Mode bit 2^1 from 3JD
I37 = h-Mode bit 2^2 from 3JD
I32 = Go Scalar Floating Multiply

```
Boolean    H06 = I34 I32 + I36 I32'; T2

           H07 = I35 I32 + I37 I32'; T2
```

H06, H07 = Select h-mode bit 2^1 and 2^2 when your not doing a Scalar Floating Multiply

```
Boolean    K20 = H7' H6'
           R45' = K20' H30; T2

           K23 = H7 H6
           R46' = K23' H30; T2
```

R45 = Go Add 140, 141 instruction
R46 = Go XOR 144, 145 instruction



CRAY X-MP VECTOR MERGE BLOCK DIAGRAM

VECTOR MERGE
146ijk, 147ijk

```
N06   =   Q00                       CLEAR ELEMENT COUNTER
          Q00   =   I114            GO VECTOR LOGICAL CP2
```

E00	=	J10 $\overline{N6}$; T2	2^0	ELEMENT COUNTER
E01	=	J11 $\overline{N6}$; T2	2^1	
E02	=	J12 $\overline{N6}$; T2	2^2	
E03	=	J13 $\overline{N6}$; T2	2^3	
E04	=	J14 $\overline{N6}$; T2	2^4	
E05	=	J15 $\overline{N6}$; T2	2^5	

G7 G6 G5 G4 G3 G2 G1 G0 = DCD ($\overline{E2}$ $\overline{E1}$ $\overline{E0}$)/##

Z00	=	I117	FORCED 0 ON 3VF @ E42/43
Z00	=	I117	FORCED 1 ON 3VF @ E40/41

```
Boolean   G13' =  E03  +  E05  +  E04'  Z00'  +  E4  Z00

          G13  =  [E03'] [E05'] [E04 + Z00] [E4' + Z00']
```

G13 CAUSES ELEMENT COUNTER BIT 2^4 TO NOT BE SET ON 3VF @ E40/41.
ALSO CAUSES ELEMENT COUNTER BIT 2^4 TO BE SET ON THE 3VF @ E42/43.

H07 = F31 G13 READ VM BIT 2^{63}

```
Boolean   J00' =  H00'  G00  +  H01'  G01  +  H02'  G02  +  H03'  G03

          J00  =  [H00 + G00'] [H01 + G01'] [H02 + G02'] [H03 + G03']


          J01' =  H04'  G04  +  H05'  G05  +  H06'  G06  +  H07'  G07

          J01  =  [H04  +  G04'] [H05  +  G05'] [H06  +  G06'] [H07  +  G07']
```

J00 AND J01 ENABLE THE ADVANCE COUNTER SIGNAL.

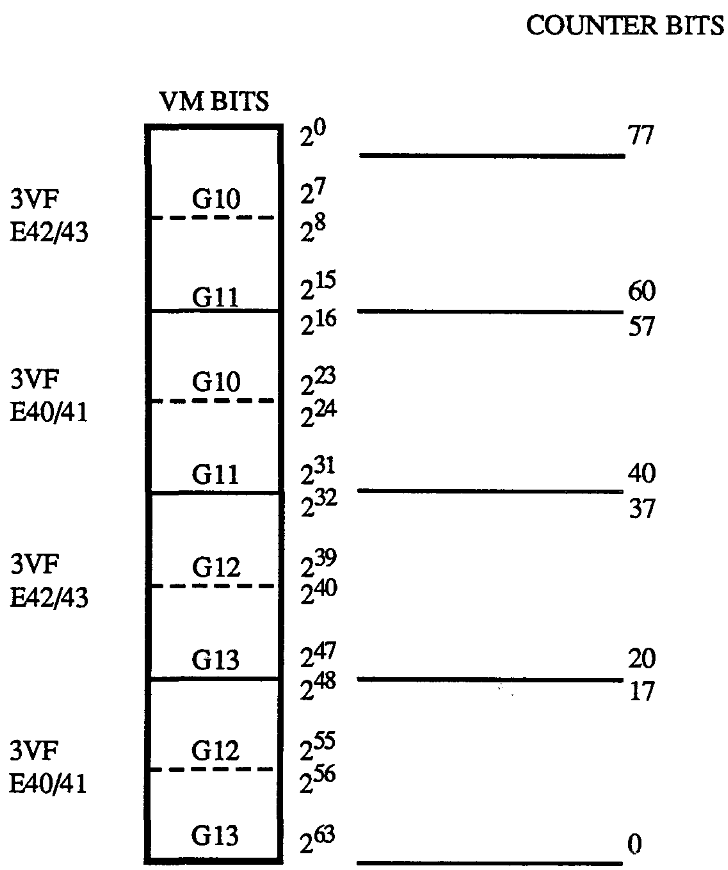
A-1607

3VF MODULE

E0 = J10 N06' ; T2	ELEMENT COUNT 2^0
E1 = J11 N06' ; T2	2^1
E2 = J12 N06' ; T2	2^2
E3 = J13 N06' ; T2	2^3
E4 = J14 N06' ; T2	2^4
E5 = J15 N06' ; T2	2^5

G7G6G5G4G3G2G1G0 = DCD (E02', E01', E00') /# #

VM REGISTER BIT LOCATIONS



A-5316

CRAY X-MP/2 VECTOR MASK COUNTER

N10 = M02 Q2 + M02 Q1 + Q3 Q9

M02 = Q8 Q7 MERGE 146, 147 INST.

Q2 = I115 ; T2 - GO DATA VL INCREMENT THE VECTOR ELEMENT COUNTER

Q1 = N6 ; T2 - GO VECTOR LOGICAL CP3

Booelan	R67 =	J00 J01 N10 + R67 N10' + $\overline{\text{M2}}$; T2
	R67 =	VECTOR MASK BIT 2^{63}

N01 = R67 + I99 VECTOR MASK BIT = 1 FROM THIS MODULE OR FROM THE OTHER 3VF MODULE.

Boolean	N02' =	R67 M02 + I99 M02
	N02 =	[R67' + M02'] [I99' + M02']

N02 = VECTOR MASK BIT = 0 FROM THIS MODULE OR THE OTHER 3VF MODULE.

A-1607A

<u>VECTOR MERGE</u>

146ijk, 147ijk

D00 = Sj DATA
I00 = Vj DATA
I32 = Vk DATA
N00 = $\overline{Q6}$ SELECT Sj or Vj DATA

Boolean B00 = D00 N00 N01 + I00 N00' N01 + I32 N02

B00 = SELECT Sj DATA OR Vj DATA IF N01 = 1
OR
SELECT Vk DATA IF N02 = 1

N03 = M00

M00 = $\overline{Q8}$ $\overline{Q7}$ 140, 141 INST. AND

N04 = M01

M01 = Q8 $\overline{Q7}$ 144, 145 INS EX OR

Boolean R00' = A00' N03 + B00' N03' + A00 N4 ; T2

R00 = [A00 + N03'] [B00 + N03] [A00' + N4'] ; T2

R00 = ALLOW Sj DATA
OR
Vj DATA
OR
Vk DATA TO Vi
IF YOU WERE NOT DOING an AND or EX OR operation.

A-1607

0030j0 - TRANSMIT (Sj) TO VM REGISTER

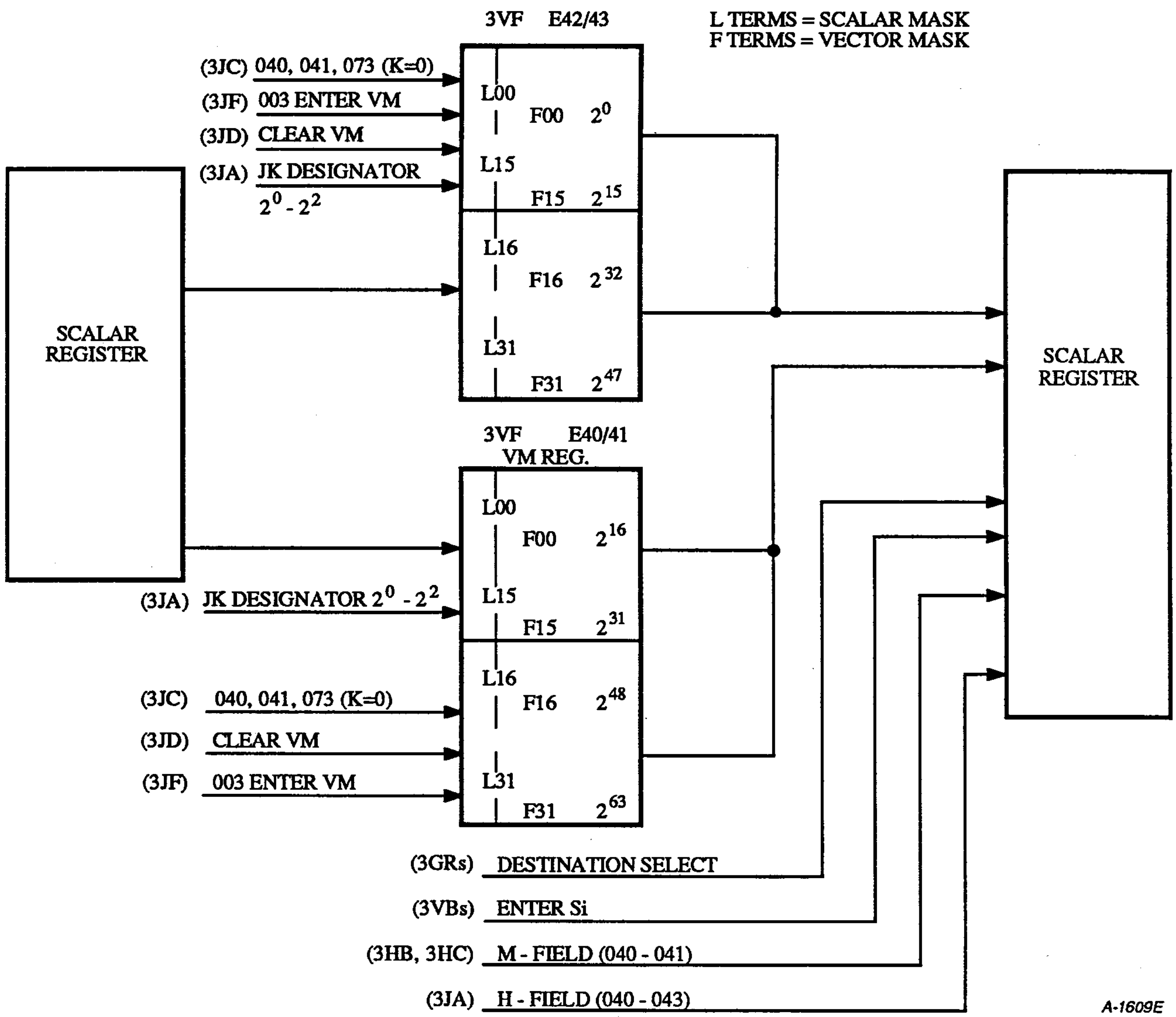
073i00 - TRANSMIT VECTOR MASK TO Si

040ijkm - TRANSMIT jkm TO Si

041ijkm - TRANSMIT EXP. = ONES COMPLEMENT OF jkm to Si

042ijk - FORM ZEROS MASK EXP. BITS IN Si FROM THE LEFT

043ijk - FORM ONES MASK EXP. BITS IN Si FROM THE LEFT



CRAY X-MP VECTOR MASK BLOCK DIAGRAM

0030j0 - TRANSMIT (Sj) TO VM REGISTER

I108 = 0030 ENTER VM
I113 = 175 INSTRUCTION CLEAR VM

Boolean Q11 = I113 N6 + I108 ; T2

Q10 = I113 N6 ; T2

Q11 = ENTER Sj TO VM

Q10 = CLEAR VM BEFORE LOADING DATA FROM THE S-REGISTER

P4 = $\overline{\text{Q11}}$ HOLD VM

P5 = $\overline{\text{Q10}}$ Q11 ENTER Sj TO VM

I64 = Sj BIT 2^0

Boolean F00 = G00 P00 + F00 P04 + I64 P05 ; T2

F00 = VECTOR MASK BIT 2^0 OR 2^{16}

073i00 - TRANSMIT VECTOR MASK TO Si

I106 = 040, 041, 073 (k=0) INSTRUCTION

I107 = 042, 043, 073 (k=0) INSTRUCTION

K21 = I106 I107 073 INSTRUCTION

$\overline{\text{Q14}}$ = $\overline{\text{K21}}$; T2 READ NOT VM TO Si

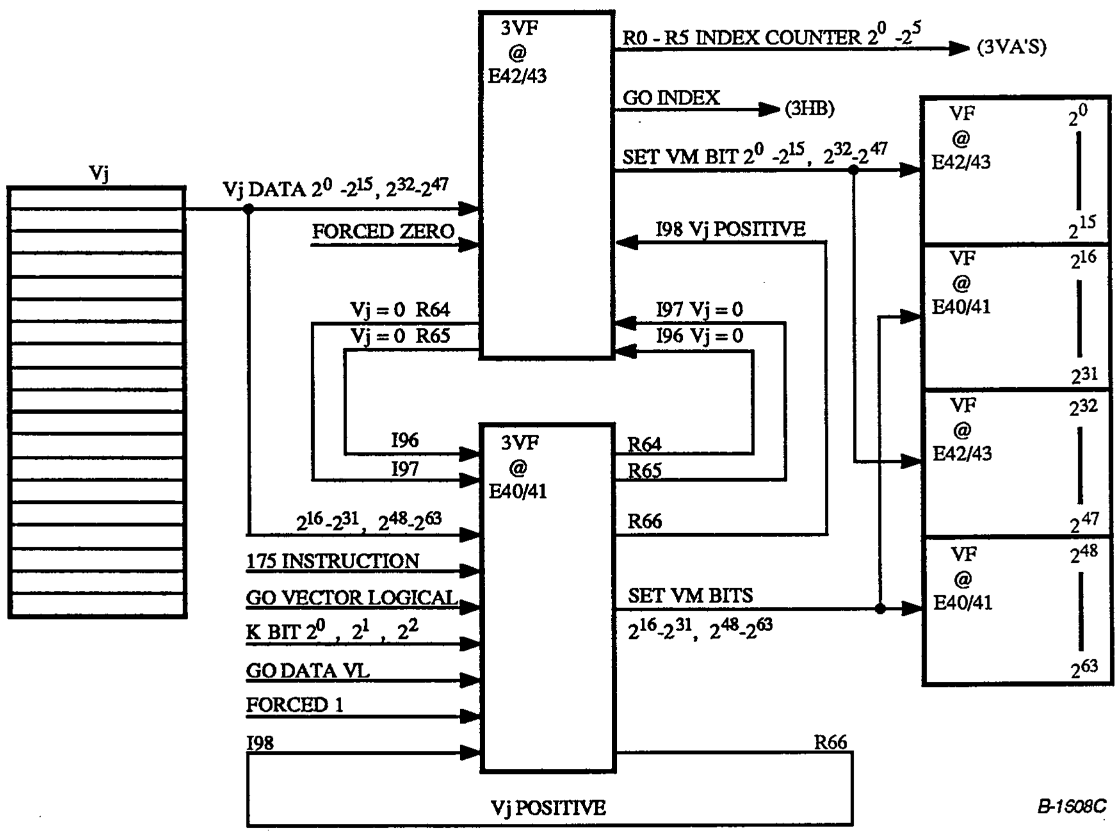
Boolean R63 = F31' Q14 + L31 Q13

R63 = VM BIT 2^{63} LEAVES INVERTED TO THE 3GR
3GR INVERT VM BITS TO ITS TRUE STATE.

A.-1610

175ijk INSTRUCTIONS

1750j0	SET VM = 1 IF (Vj) IS ZERO	175ij4	VM = 1 AND (Vi COMPRESS ELEMENT) = ELEMENT INDEX WHEN (Vj ELEMENT) = 0
1750j1	SET VM = 1 IF (Vj) IS NON-ZERO	175ij5	VM = 1 AND (Vi COMPRESS ELEMENT) = ELEMENT INDEX WHEN (Vj ELEMENT) NOT EQUAL TO 0
1750j2	SET VM = 1 IF (Vj) HAS A POSITIVE SIGN	175ij6	VM = 1 AND (Vi COMPRESS ELEMENT) = ELEMENT INDEX WHEN (Vj ELEMENT) POSITIVE
1750j3	SET VM = 1 IF (Vj) HAS A NEGATIVE SIGN	175ij7	VM = 1 AND (Vi COMPRESS ELEMENT) = ELEMENT INDEX WHEN (Vj ELEMENT) NEGATIVE



CRAY X-MP GENERATOR VECTOR MASK AND COMPRESSED INDEX BLOCK DIAGRAM

I113 = 175 INSTRUCTION

N06 = GO VECTOR LOGICAL

Boolean	Q09	=	MUX (I113 Q9) : DCD (N06) ; T2

Q9 = GO 175 INSTRUCTION

Q10 = I113 N06 ; T2 CLEAR VM

Q11 = I113 N06 + I108 ; T2
CLEAR VM REGISTER BEFORE GENERATING THE VM.

P04 = $\overline{\text{Q11}}$ DROP THE HOLD ON VM

P05 = $\overline{\text{Q10}}$ Q11 CLEAR VM

Boolean	F00	=	G00 P00 + F00 P04 + I64 P05 ; T2
	E00	=	J10 N06' ; T2

F00 = CLEAR VM REGISTER

E00 = CLEAR ELEMENT COUNT

I00-I31 Vj BIT 2^0-2^{15}, 2^{32}-2^{47} / 2^{16}-2^{31}, 2^{48}-2^{63}

Boolean	C00	=	I00' I01' I02' I03' I04' I05'

C00 = Vj BITS ARE ZEROS

Boolean	R64'	=	C00' + C01' + C02' ; T2
	R64	=	[C00 C01 C02] ; T2
	R65'	=	C03' + C04' + C05' ; T2
	R65	=	[C03 C04 C05] ; T2

R64 = Vj BITS ARE ZEROS

A-1611

R65 = Vj BITS ARE ZEROS

I96 = Vj BITS ARE ZEROS

I97 = Vj BITS ARE ZEROS

G15 = R64 R65 Vj BITS ARE ZEROS

Q4 = K BIT 2^0

Q5 = K BIT 2^1

I98 = Vj BIT 2^{63}

Boolean N05 = I96 I97 G15 Q5' + I98 Q5

N05 = 1 IF A 175xj0 AND Vj ELEMENT BITS ARE ALL 0's

OR

N05 = 1 A 175xj2 AND Vj ELEMENT BIT 2^{63} EQUALS A 0

Q2 = I115 ; T2 GO DATA VL

Q3 = Q2 GO DATA VL DELAYED

Q9 = 175 INSTRUCTION IN PROCESS

Q11 = ENTER Sj TO VM

N7 = Q03 Q9 Q11' A 175 INST IN PROCESS AND A GO DATA VL

ELEMENT COUNT

E0	=	J10	N6'	2^0
E1	=	J11	N6'	2^1
E2	=	J12	N6'	2^2
E3	=	J13	N6'	2^3
E4	=	J14	N6'	2^4
E5	=	J15	N6'	2^5

Boolean G7 G6 G5 G4 G3 G2 G1 G0 = DCD (E2' E1' E0') / # #

G7 = (E2' E1' E0') / # #

A-1.611

Z00 = FORCED ZERO ON E42/43

Z00 = FORCED ONE ON E40/41

Boolean	G13'	=	E03 + E05 + E4' Z00' + E4 Z00
	G13	=	[E3'] [E5'] [E4 + Z00] [E4' + Z00']

G13 = SELECT VM BIT 40-47 OR 56-63

Z00 = WHEN VM BIT NEEDS TO BE SET AND IT'S PHYSICALLY LOCATED ON THE OTHER MODULE, Z00 WILL ENABLE OR DISABLE G13-G10.

Boolean	P03'	=	N5' Q4' + N5 Q4 + N7' G13'
	P03	=	[N5 + Q4] [N5' + Q4'] [N7] [G13]

P03 = 1 IF A 175xj0 INST. AND Vj ELEMENT ARE ALL 0's

P03 = 1 IF A 175xj1 AND Vj ELEMENTS ARE 0's

P03 = 1 IF A 175xj2 AND Vj BIT 2^{63} = 0

P03 = 1 IF A 175xj3 AND Vj BIT 2^{63} = 1

N7 = A 175 INST IN PROCESS

G13 = VM BIT IS ON THIS MODULE

G07 = $\overline{E2}$ $\overline{E1}$ $\overline{E0}$

Boolean	F31	=	P3 G07 + F31 P4 + I95 P5 ; T2

F31 = VECTOR MASK BIT 2^{63} ON 3VF @ E40/41 OR 2^{47} ON 3VF @ E42/43.

A-1611A

3VF AN E40/41

Bit		Term	Test Point	Addrs.	Bit		Term	Test Point	Addrs.
2^{63}	-	F31	$\overline{C17}$	00	2^{31}	-	F15	$\overline{D46}$	40
2^{62}	-	F30	$\overline{C4}$	01	2^{30}	-	F14	$\overline{D58}$	41
2^{61}	-	F29	$\overline{C46}$	02	2^{29}	-	F13	$\overline{D53}$	42
2^{60}	-	F28	$\overline{C30}$	03	2^{28}	-	F12	$\overline{D56}$	43
2^{59}	-	F27	$\overline{A32}$	04	2^{27}	-	F11	$\overline{B8}$	44
2^{58}	-	F26	$\overline{A19}$	05	2^{26}	-	F10	$\overline{B56}$	45
2^{57}	-	F25	$\overline{A53}$	06	2^{25}	-	F9	$\overline{B42}$	46
2^{56}	-	F24	$\overline{A20}$	07	2^{24}	-	F8	$\overline{B54}$	47
2^{55}	-	F23	$\overline{C20}$	10	2^{23}	-	F7	$\overline{D48}$	50
2^{54}	-	F22		11	2^{22}	-	F6	$\overline{C11}$	51
2^{53}	-	F21	$\overline{C06}$	12	2^{21}	-	F5	$\overline{D54}$	52
2^{52}	-	F20	$\overline{C09}$	13	2^{20}	-	F4	$\overline{C10}$	53
2^{51}	-	F19	$\overline{A54}$	14	2^{19}	-	F3	$\overline{B2}$	54
2^{50}	-	F18	$\overline{A16}$	15	2^{18}	-	F2	$\overline{B72}$	55
2^{49}	-	F17	$\overline{A10}$	16	2^{17}	-	F1	$\overline{B39}$	56
2^{48}	-	F16	$\overline{A12}$	17	2^{16}	-	F0	$\overline{B69}$	57

3VF at E42/43

Bit		Term	Test Point	Addrs.	Bit		Term	Test Point	Addrs.
2^{47}	-	F31	$\overline{C17}$	20	2^{15}	-	F15	$\overline{D46}$	60
2^{46}	-	F30	$\overline{C4}$	21	2^{14}	-	F14	$\overline{D58}$	61
2^{45}	-	F29	$\overline{C46}$	22	2^{13}	-	F13	$\overline{D53}$	62
2^{44}	-	F28	$\overline{C30}$	23	2^{12}	-	F12	$\overline{D56}$	63
2^{43}	-	F27	$\overline{A32}$	24	2^{11}	-	F11	$\overline{B8}$	64
2^{42}	-	F26	$\overline{A19}$	25	2^{10}	-	F10	$\overline{B56}$	65
2^{41}	-	F25	$\overline{A53}$	26	2^{9}	-	F9	$\overline{B42}$	66
2^{40}	-	F24	$\overline{A20}$	27	2^{8}	-	F8	$\overline{B54}$	67
2^{39}	-	F23	$\overline{C20}$	30	2^{7}	-	F7	$\overline{D48}$	70
2^{38}	-	F22		31	2^{6}	-	F6	$\overline{C11}$	71
2^{37}	-	F21	$\overline{C6}$	32	2^{5}	-	F5	$\overline{D54}$	72
2^{36}	-	F20	$\overline{C9}$	33	2^{4}	-	F4	$\overline{C10}$	73
2^{35}	-	F19	$\overline{A54}$	34	2^{3}	-	F3	$\overline{B2}$	74
2^{34}	-	F18	$\overline{A16}$	35	2^{2}	-	F2	$\overline{B72}$	75
2^{33}	-	F17	$\overline{A10}$	36	2^{1}	-	F1	$\overline{B39}$	76
2^{32}	-	F16	$\overline{A12}$	37	2^{0}	-	F0	$\overline{B69}$	77

CRAY X-MP/2 VECTOR MASK REGISTER

XV201S33M

3VE MODULE

The 3VE modules are at H36/37 and H34/35. The 3VE at H36/37 handles all the even data bits of Vj, while the 3VE at H34/35 handles all the odd data bits of Vj elements. A shift of one place in the module is equivalent to a shift of 2 places in the Vector register.

The 150-153 instructions perform the Vector Shift operation. For the 151 and 153 instructions, the 3VE at H36/37 performs the two's complement on the shift count. This shift count is sent to both the 3VE modules at H34/35 and H36/37. Then the 3VE modules perform the shifts derived from the two's complement arithmetic.

The 3VE module at H36/37 generates the shift control terms for the 3VE at H34/35. The 152 instruction takes 3 cp's in the functional unit while the 153 instruction takes 2 cp's in the functional unit. The reason being that the 152 instruction's first shift is with element 0 and element 1 or element 0 and zero's if Vector length equals a 1. The 153 instruction's first shift is with zero's and element 0.

The 150 and 151 instructions perform the single shifts on Vj elements, one element at a time for Vector length.

VECTOR REGISTER SHIFT FUNCTIONAL UNIT INSTRUCTIONS

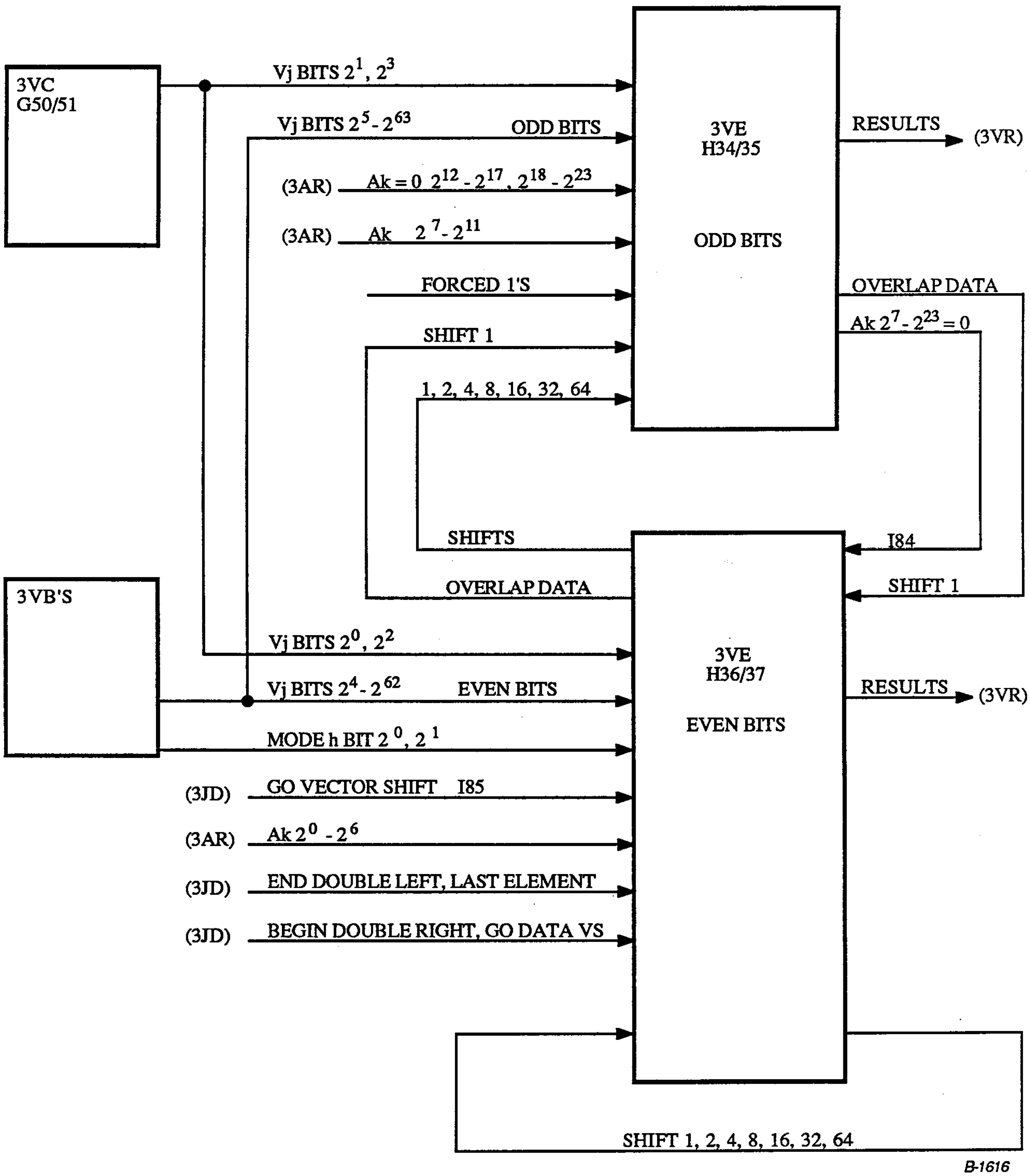
150IJK	Single shift of (VJ elements) left (AK) places to VI elements
150IJ0	Shift (VJ) left one place to VI
151IJK	Single shift of (VJ elements) right (AK) places to VI elements
151IJ0	Shift (VJ) right one place to VI
152IJK	Double shifts of (VJ elements) left (AK) places to VI elements
152IJ0	Double shift (VJ) left one place to VI
153IJK	Double shifts of (VJ elements) right (AK) places to VI elements
153IJ0	Double shift (VJ) right one place to VI

C.A.L. FORMAT

VI	VJ < AK	VJ shifted left to AK places
VI	VJ < 1	VJ shifted left 1 place to VI
VI	VJ > AK	VJ shifted right AK places to VI
VI	VJ > 1	VJ shifted right 1 place to VI
VI	VJ, VJ < AK	Double left shift AK places to VI
VI	VJ, VJ < 1	Double left shift 1 place to VI
VI	VJ, VJ > A	Double right shift AK places to VI
VI	VJ, VJ > 1	Double right shift 1 place to VI

DIAGNOSTIC APPLICATION

3VRS



CRAY X-MP VECTOR SHIFT BLOCK DIAGRAM

VECTOR SINGLE SHIFT CONTROL

◄- - - - - - Ak 2^5 - 2^0 - - - - - -►

	2^5	2^4	2^3	2^2	2^1	2^0	AK Bit Position
	32	16	8	4	2	1	Decimal Shift
	N00-N47	P08-P47	Q12-Q47	R32-R64		R00-R31	Data controlled

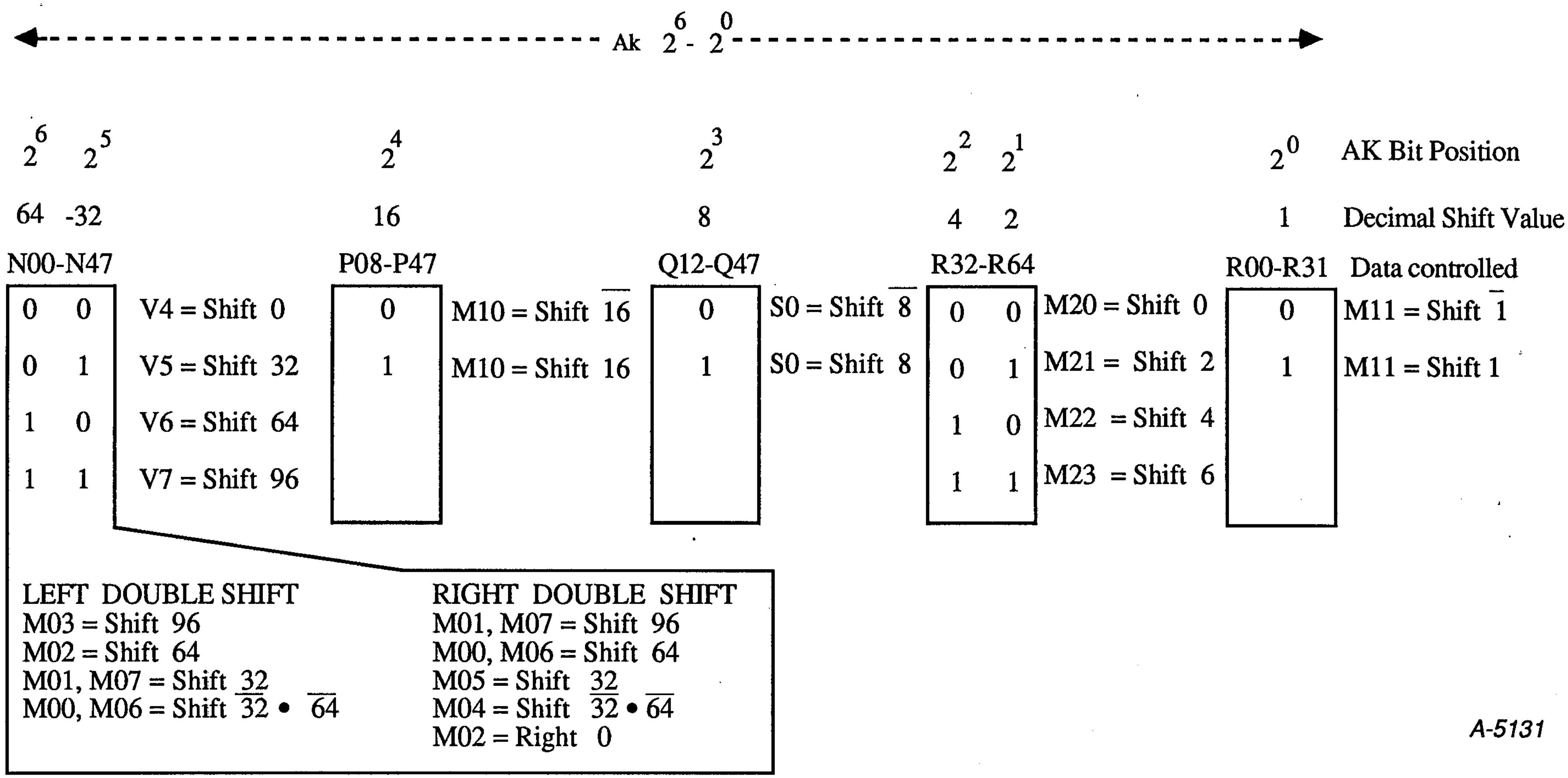
N00-N47		P08-P47		Q12-Q47		R32-R64 (2^2)	R32-R64 (2^1)		R00-R31	
0	M00 R.S.S. $\overline{32}$	0	M10 = Shift $\overline{16}$	0	S0 = Shift $\overline{8}$	0	0	M20 Shift 0	0	M11 = Shift $\overline{1}$
0	M02 L.S.S. $\overline{32}$	1	M10 = Shift 16	1	S0 = Shift 8	0	1	M21 Shift 2	1	M11 = Shift 1
1	MO1 R.S.S. 32					1	0	M22 Shift 4		
1	M03 L.S.S. 32					1	1	M23 Shift 6		
	M02 R.S.S.= 0									

150 i j k Shift (Vj) Left (Ak) Places to Vi

151 i j k Shift (Vj) Right (Ak) Places to Vi

A-5130

VECTOR DOUBLE SHIFT CONTROL

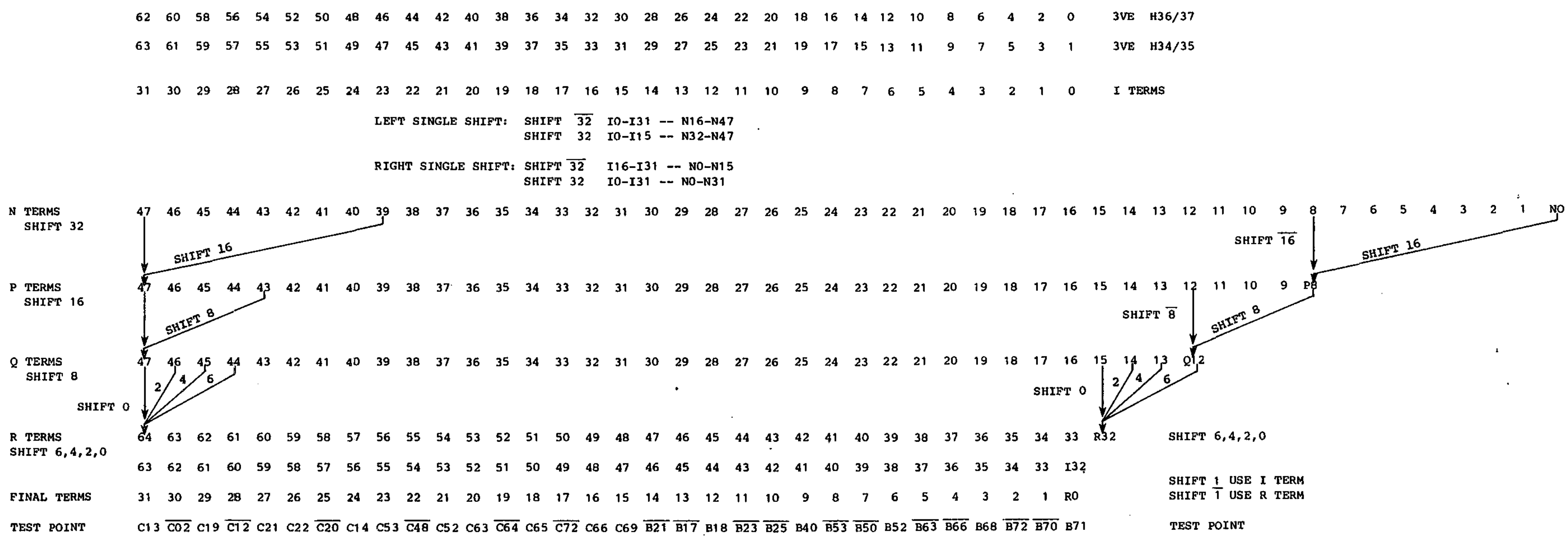


A-5131

DOUBLE SHIFT INSTRUCTIONS

152 ijk Double Shift (Vj) Left (AK) Places to Vi

153 ijk Double Shift (Vj) Right (AK) Places to Vi



C-1556A

OUTPUTS R32-R63 ON 3VE @ H34/35 INPUT AS I32-I63 ON 3VE @ H36/37; R64 NOT USED
OUTPUTS R33-R64 ON 3VE @ H36/37 INPUT AS I32-I63 ON 3VE @ H34/35; R32 NOT USED

EVEN BIT'S MODULE AND SHIFT 1 DROP STRAIGHT DOWN TO I32-I63
ODD BIT'S MODULE AND SHIFT 1 MOVE LEFT 1 TO I32-I63

VECTOR SHIFT
SINGLE LEFT/RIGHT SHIFT

SINGLE SHIFT   3VE   H36/37 & H34/35

150, 151 INSTRUCTION

	L TERMS (L31 — L00)	I TERMS (I31 — I00)	
		ELEMENT 0	N00 - N47
		ELEMENT 1	N00 - N47
VL = 4		ELEMENT 2	N00 - N47
		ELEMENT 3	N00 - N47

RIGHT DOUBLE   3VE   H36/37 & H34/35

153 INSTRUCTION

	L TERMS (L31 L00)	I TERMS (I31 I00)	
BEGIN DOUBLE RIGHT →	ZERO's	ELEMENT 0	N00 - N47
	ELEMENT 0	ELEMENT 1	N00 - N47
VL = 4	ELEMENT 1	ELEMENT 2	N00 - N47
	ELEMENT 2	ELEMENT 3	N00 - N47

LEFT DOUBLE   3VE   H36/37 & H34/35

152 INSTRUCTION

	L TERMS (L31 L00)	I TERMS (I31 I00)	
	STATIC	ELEMENT 0	
	ELEMENT 0	ELEMENT 1	N00 - N47
VL = 4	ELEMENT 1	ELEMENT 2	N00 - N47
	ELEMENT 2	ELEMENT 3	N00 - N47
	ELEMENT 3	ZERO'S	N00 - N47

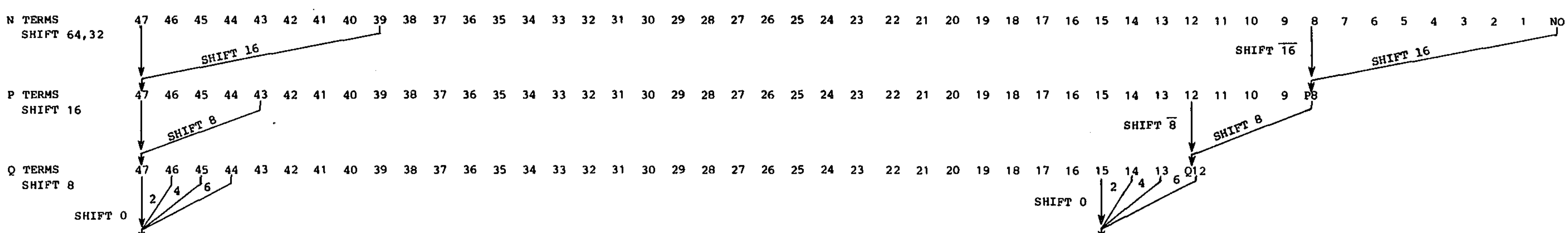
END DOUBLE LEFT → (ZERO'S)

A-1623

VECTOR SHIFT

62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2	0	3VE H36/37
63	61	59	57	55	53	51	49	47	45	43	41	39	37	35	33	31	29	27	25	23	21	19	17	15	13	11	9	7	5	3	1	3VE H34/35
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	I TERMS
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	L TERMS

LEFT DOUBLE SHIFT:	TERM	RIGHT DOUBLE SHIFT:	TERM	
I0-I15 -- N32-N47	M3	L0-L15 -- N32-N47; I0-I31 -- N0-N31	M7;M1	64 & 32 SHIFT
I0-I31 -- N16-N47	M2	L0-L31 -- N16-N47; I16-I31 -- N0-N15	M6;M0	64 & $\overline{32}$ SHIFT
L0-L15 -- N32-N47; I0-I31 -- N0-N31	M7;M1	L0-L31 -- N0-N31	M5	$\overline{64}$ & 32 SHIFT
L0-L31 -- N16-N47; I16-I31 -- N0-N15	M6;M0	L16-L31 -- N0-N15	M4	$\overline{64}$ & $\overline{32}$ SHIFT



R TERMS SHIFT 6,4,2,0	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	R32
	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	I32	
FINAL TERMS	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	R0	
TEST POINT	C13	$\overline{C02}$	C19	$\overline{C12}$	C21	C22	$\overline{C20}$	C14	C53	$\overline{C48}$	C52	C63	$\overline{C64}$	C65	$\overline{C72}$	C66	C69	$\overline{B21}$	$\overline{B17}$	B18	$\overline{B23}$	$\overline{B25}$	B40	$\overline{B53}$	$\overline{B50}$	B52	$\overline{B63}$	$\overline{B66}$	B68	$\overline{B72}$	$\overline{B70}$	B71	

SHIFT 6,4,2,0

SHIFT 1 USE I TERM
SHIFT $\overline{1}$ USE R TERM

TEST POINT

LAST ELEMENT: TERM X10-DROPS
M0-M3 ZEROING
N TERMS ON FINAL
ELEMENT

FIRST ELEMENT: TERM X11-DROPS
M4-M7 ZEROING
N TERMS ON FIRST
ELEMENT

OUTPUTS R32-R63 ON 3VE @ H34/35 INPUT AS I32-I63 ON 3VE @ H36/37; R64 NOT USED
OUTPUTS R33-R64 ON 3VE @ H36/37 INPUT AS I32-I63 ON 3VE @ H34/35; R32 NOT USED

EVEN BIT's MODULE AND SHIFT 1 DROP STRAIGHT DOWN TO I32-I63
ODD BIT's MODULE AND SHIFT 1 MOVE LEFT 1 TO I32-I63

C-1557C

VECTOR SHIFT
DOUBLE LEFT/RIGHT SHIFT

VECTOR SHIFT

Vj ELEMENT SCOPE CHART
L TERMS

3VE	H36/37 T.P.	H34/35 T.P.		H36/37 T.P.	H34/35 T.P.
2^{0}	$\overline{\text{A20}}$		2^{32}	$\overline{\text{A06}}$	
2^{1}		$\overline{\text{A20}}$	2^{33}		$\overline{\text{A06}}$
2^{2}	$\overline{\text{A16}}$		2^{34}	$\overline{\text{A18}}$	
2^{3}		$\overline{\text{A16}}$	2^{35}		$\overline{\text{A18}}$
2^{4}	$\overline{\text{A50}}$		2^{36}	$\overline{\text{A27}}$	
2^{5}		$\overline{\text{A50}}$	2^{37}		$\overline{\text{A27}}$
2^{6}	$\overline{\text{A57}}$		2^{38}	$\overline{\text{A52}}$	
2^{7}		$\overline{\text{A57}}$	2^{39}		$\overline{\text{A52}}$
2^{8}	$\overline{\text{D70}}$		2^{40}	$\overline{\text{D65}}$	
2^{9}		$\overline{\text{D70}}$	2^{41}		$\overline{\text{D65}}$
2^{10}	$\overline{\text{D50}}$		2^{42}	$\overline{\text{D55}}$	
2^{11}		$\overline{\text{D50}}$	2^{43}		$\overline{\text{D55}}$
2^{12}	$\overline{\text{D20}}$		2^{44}	$\overline{\text{D29}}$	
2^{13}		$\overline{\text{D20}}$	2^{45}		$\overline{\text{D29}}$
2^{14}	$\overline{\text{D31}}$		2^{46}	$\overline{\text{D38}}$	
2^{15}		$\overline{\text{D31}}$	2^{47}		$\overline{\text{D38}}$
2^{16}	$\overline{\text{A15}}$		2^{48}	$\overline{\text{A11}}$	
2^{17}		$\overline{\text{A15}}$	2^{49}		$\overline{\text{A11}}$
2^{18}	$\overline{\text{A23}}$		2^{50}	$\overline{\text{A12}}$	
2^{19}		$\overline{\text{A23}}$	2^{51}		$\overline{\text{A12}}$
2^{20}	$\overline{\text{A35}}$		2^{52}	$\overline{\text{A33}}$	
2^{21}		$\overline{\text{A35}}$	2^{53}		$\overline{\text{A33}}$
2^{22}	$\overline{\text{A63}}$		2^{54}	$\overline{\text{A55}}$	
2^{23}		$\overline{\text{A63}}$	2^{55}		$\overline{\text{A55}}$
2^{24}	$\overline{\text{D69}}$		2^{56}	$\overline{\text{D57}}$	
2^{25}		$\overline{\text{D69}}$	2^{57}		$\overline{\text{D57}}$
2^{26}	$\overline{\text{D52}}$		2^{58}	$\overline{\text{D40}}$	
2^{27}		$\overline{\text{D52}}$	2^{59}		$\overline{\text{D40}}$
2^{28}	$\overline{\text{D44}}$		2^{60}	$\overline{\text{D33}}$	
2^{29}		$\overline{\text{D44}}$	2^{61}		$\overline{\text{D33}}$
2^{30}	$\overline{\text{D42}}$		2^{62}	$\overline{\text{D16}}$	
2^{31}		$\overline{\text{D42}}$	2^{63}		$\overline{\text{D16}}$

SYNC. ON 3JD T.P. D07 FOR A 152 @ CP6
FOR A 153 @ CP5

VECTOR SHIFT CONTROL TERM

Boolean	U4	=	I86 U0 + U4 U0' ; T2
	U5	=	I87 U0 + U5 U0' ; T2

T.P. A70 U4 = MODE h BIT 2^0

T.P. A68 U5 = MODE h BIT 2^1

V00 = $\overline{U5}\ \overline{U4}$	LEFT SINGLE	150	INST
V01 = $\overline{U5}$ U4	RIGHT SINGLE	151	INST
V02 = U5 $\overline{U4}$	LEFT DOUBLE	152	INST
V03 = U5 U4	RIGHT DOUBLE	153	INST

SINGLE LEFT OR RIGHT SHIFT 32

	W00 = V4 V0	SHIFT 0 LEFT SINGLE
	X02 = W00	150 INSTRUCTION
3VE H36/37 & H34/35	R67 = X02	
	I66 = R67	
	M02 = I66	
	W08 = V7 V3	SHIFT 96 RIGHT DOUBLE
	X07 = W8	
3VE H36/37 & H34/35	R72 = X07	
	I71 = R72	
	M07 = I71	

Boolean	U9	=	U10' U11' U12' U13' U14' U15'
	W12	=	U4 V9 U16'

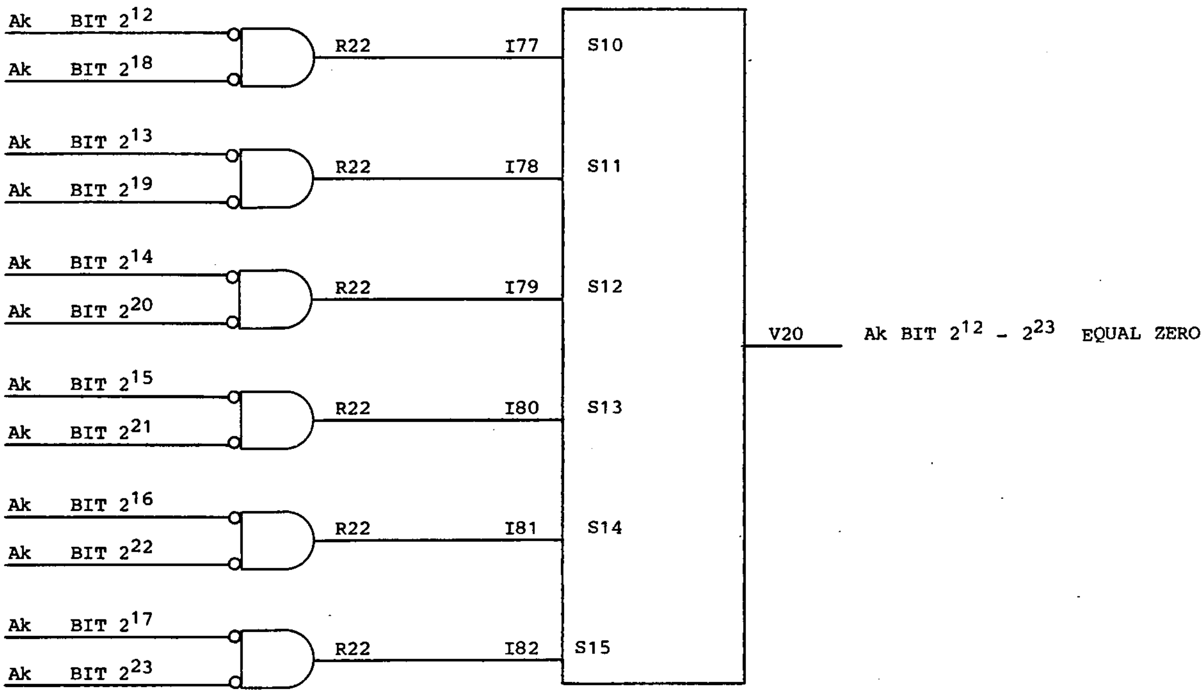
W12 = SHIFT BIT $2^0 - 2^6$ = ZERO OR A RIGHT SINGLE OR RIGHT DOUBLE

X2 = W12
R67 = X2
I66 = R67
M2 = I66

M2 - ALLOWS THE DATA TO ENTER THE N-TERMS WHEN THERE IS NO SHIFTS.

A-1619

Ak 2^7 - 2^{23} EQUAL ZERO'S



3VE @ H34/35

Boolean	V20'	=	S10 S11 S12 S13 S14 S15
	V20	=	S10' + S11' + S12' + S13' + S14' + S15'

V20 = Ak BITS 2^{12} - 2^{23} EQUAL ZERO

3VE @ H34/35

Boolean	S20	=	I83 I84 I85 I86 I87 # # # # # # ; T2
T.P. A42	S20	=	I87 + I86 + I85 + I84 + I83 ; T2

I87 = Ak BIT 2^{11} I85 = Ak BIT 2^9 I83 = Ak BIT 2^7
I86 = Ak BIT 2^{10} I84 = Ak BIT 2^8

Boolean	R78'	=	S20' V20'
	R78	=	S20 + V20

R78 ⟶ I84 TO 3VE @ H36/37

I84 = 0 WHEN Ak 2^7 - 2^{23} = 0's

U17 = I84

Boolean	U17	=	(U17 I84) ; DCD (U1') ; T2

V08 = U17

V08 = 0 WHEN Ak 2^7 - 2^{23} = 0's

B-1620

END DOUBLE LEFT 152 INSTRUCTION

V02 = U5 $\overline{U4}$ 152 INSTRUCTION, DOUBLE LEFT

I89 = LAST ELEMENT VECTOR SHIFT FROM 3JD

X10 = V2 I89 END DOUBLE LEFT

```
Boolean   R65'  =  X0'  +  V8  +  X10 ; T2


          R65   =  [X0   V8' X10'] ; T2
          R66   =  [X1   V8' X10'] ; T2
          R67   =  [X2'  V8' X10'] ; T2
          R68   =  [X3   V8' X10'] ; T2
```

3VE H36/37, H34/35

R65	= I64	I64	= M00	SHIFT 0
R66	= I65	I65	= M01	SHIFT 32
R67	= I66	I66	= M02	SHIFT 64
R68	= I67	I67	= M03	SHIFT 96

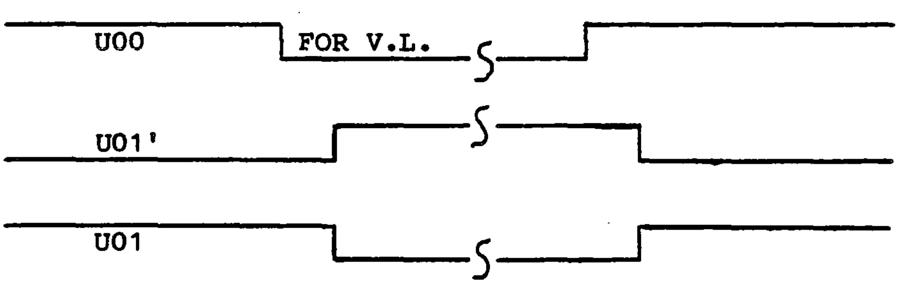
DO NOT MAKE THE N-TERMS

BEGIN DOUBLE RIGHT 153 INSTRUCTION

U00 = I85 ; T2 GO VECTOR SHIFT 3JD

```
Boolean   U01'  =  MUX (U0'  U0') : DCD (U1') ; T2

          U01'  =  0 WHEN U00 = 1
```

WHEN U00 GOES TO A 0, $\overline{U01}$ WILL STAY A 1 FOR 1 CP.



A-1621A

BEGIN DOUBLE RIGHT 153 INSTRUCTIONS

I88 = GO DATA VECTOR SHIFT; 153 INSTRUCTIONS

V3 = U5 U4 MODE h BIT 2^0, 2^1

oolean U20 = U20 I88' + U1 V3 ; T2

U20 = MAKE U20 WHEN A 153 INSTRUCTION OCCURS. DROP U20 WHEN I88 (GO DATA VECTOR SHIFT) ARRIVES.

oolean X11 = U20 I88'

X11' = U20' + I88

oolean R69' = W11' + V8 + X11 ; T2

R69 = [W11 V8' X11'] ; T2
R70 = [W10 V8' X11'] ; T2
R71 = [X6 V8' X11'] ; T2
R72 = [X7 V8' X11'] ; T2

3VE @ H36/37, H34/35

R69	=	I68	I68	=	M04	SHIFT 0
R70	=	I69	I69	=	M05	SHIFT 32
R71	=	I70	I70	=	M06	SHIFT 64
R72	=	I71	I71	=	M07	SHIFT 96

DO NOT MAKE THE N-TERMS

A-1622

OBJECTIVES - Floating-Point Functional Unit

With the aid of the student reference material, upon completion of the course a student will be able to:

- Determine the failing module type, module location, and chip, given the failing instruction and the data errors

- Describe the main function of each of the following modules:

  3AS, for the Floating-point Constants

  3FA, 3FB, 3FC, 3FD, 3FE, for the Floating-point Add Functional Unit

  3RA, 3RB, 3RC, 3RD, 3RE, 3RF, 3RG, 3RH, 3RI, for the Floating Reciprocal Functional Unit

  3MA, 3MB, 3MC, 3MD, 3ME, 3MF, 3MJ, 3MK, for the Floating Multiply Functional Unit

- Describe the CRAY representation of the Floating-point Numbers

- Describe with respect to time and use, the Address and Control signals

- Diagnostic Applications:

  3SFA - Scalar, Vector Floating Add
  3SFR - Scalar, Vector Floating Reciprocal
  3SFM - Scalar, Vector Floating Multiply
  3SMU - Scalar, Floating Multiply

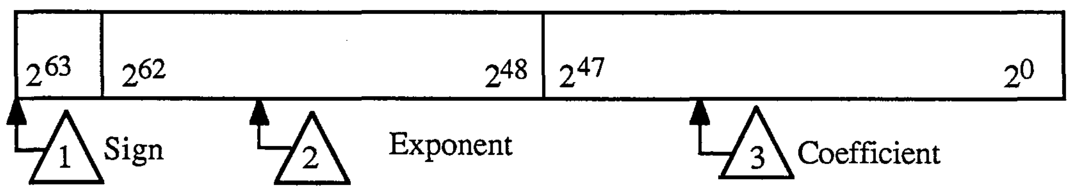
XV201W35A

FLOATING-POINT FORMAT

Floating-point Arithmetic Introduction

Floating-point numbers are represented in a standard format throughout the CPU. Floating-point numbers are used by the Floating-point functional units which are: Floating-point Add, Floating-point Multiply, and Floating-point Reciprocal. This format is a compact representation of a binary exponent and coefficient within a 64-bit word. The coefficient is in the hardware bit positions 2^{47}- 2^0 of the 64-bit word. The sign of the coefficient is in bit position 2^{63}. The exponent is in hardware bit positions 2^{62} - 2^{48}.

Floating-point Format



1 Sign - Sign of the coefficient is in bit position 2^{63}, 2^{63} = 0 and is a positive sign of the coefficient. 2^{63} = 1 is a negative sign of the coefficient.

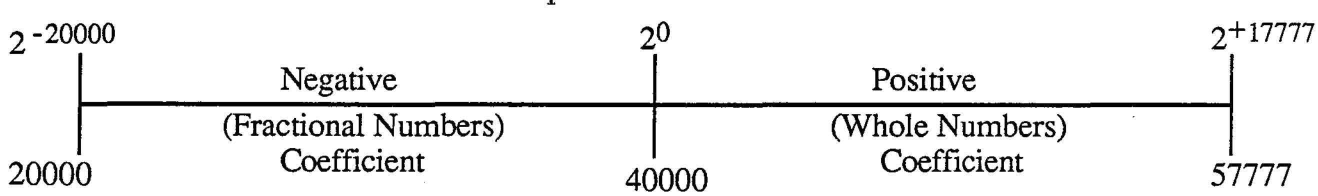
2 Exponent - The exponent of the floating-point format is represented as a biased integer number in bit positions 2^{62} - 2^{48}. Bit position 2^{61} represents the sign of this exponent. Bit position 2^{62} represents the bias.

3 Coefficient - The coefficient is a signed magnitude number. For a negative coefficient the sign bit 2^{63} is set to a "1".

Exponent Ranges

The exponent of the floating-point format is represented as a biased integer in bit positions 2^{62} - 2^{48}. The bias added to the exponent is 40000_8, which represents an exponent of 2^0. The positive range of the exponent is 40000_8 - 57777_8 and the negative range is 37777_8 - 20000_8. Thus, the unbiased range of the exponent is from 2^{-20000} - 2^{+17777}.

Exponent Number Line



The floating-point format of the CRAY X-MP allows the expression of numbers to be accurate to about 15 decimal digits in the approximate decimal range of 10^{-2466} - 10^{+2465}.
This gives the 48-bit coefficient the ability to become an extremely large or small number.

Hardware Trng.
XV201/47A J.E.S.

EXPONENT RANGE CHECKS, UNDERFLOW, OVERFLOW

Even the CRAY X-MP has its limitations. A hardware range check is made on the exponent to insure that numbers being represented in Floating-point functional units are within the limits of the Cray computer system. Double precision numbers can be used to increase the limitation.

Overflow

An Overflow condition occurs when the exponent has exceeded 57777. To check for this condition the hardware checks bit positions 2^{62} and 2^{61} of the exponent. If 2^{62} and 2^{61} both equal a "1", an Overflow condition exits or a number equal to or greater than 60000 has occurred in the functional unit.

When an Overflow condition occurs, a flag is set in the Exchange Package indicating a Floating-point Range error, and the exponent is forced to equal 60000. This will happen during a Floating-point Add, Floating-point Multiply, or Floating-point Reciprocal operation.

Underflow

An Underflow condition occurs when an Exponent is less than or equal to 17777_8, or, the exponent bits 2^{62} and 2^{61} are both equal to zero. For an Underflow condition no Error flag is set, however, the exponent and coefficient are both forced to zeroes. This occurs for a Floating-point Add and Floating-point Multiply operation. However, for the Floating-point Reciprocal operation, because the exponent is complemented and a value of two is added, an error occurs with an exponent value equal to 20001 or less. An Underflow condition in Floating-point Reciprocal will cause a bit to be set in the Exchange Package indicating Floating-point Range error and the exponent will be forced to 60000.

The Floating-point Multiply follows the underflow rules with the exception of when both of the exponents are equal to zero. If this occurs, the Floating-point Multiply allows the multiply to complete as an Integer Multiply, leaving the Exponent and Sign bit equal to zero.

Floating-point Add or Floating-point Multiply

	Sign	Exponent	Coefficient
Underflow =	0	0 ______ 0	0 ______ 0
	Sign	Exponent	Coefficient, no flag

	Sign	Exponent	Coefficient
Overflow =	0	60000	Calculated
	Sign	Exponent	Coefficient, flag set

Floating-point Reciprocal

Underflow =

Sign	Exponent	Coefficient, 2^{47} = 0 Flag set
0	60000	Calculated

Overflow =

Sign	Exponent	Coefficient, 2^{47} = 0 Flag set
0	60000	Calculated

Normalized Floating-point

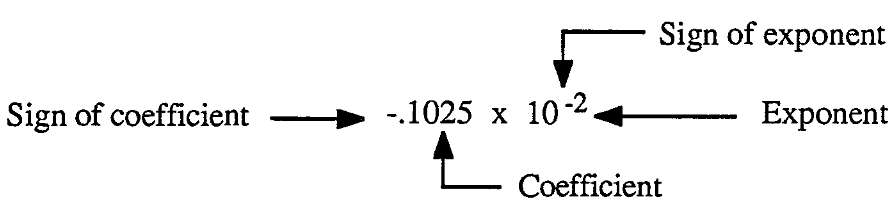
A floating-point number is considered normalized when bit 2^{47} of the coefficient is equal to a one. This condition of having a normalized coefficient implies that the coefficient has been shifted left as far as possible, and therefore, the floating-point number has no leading zeroes in the coefficient.

Each Floating-point functional unit has different requirements for its input operands. The **Reciprocal Approximation** function unit MUST receive a normalized operand in order to procude the correct results. However, there is nothing in the functional unit to detect that the operand is normalized, it is just assumed. The **Floating-point Multiply** functional unit does not require the operands to be normalized to produce the correct result. However, because the upper one half of the pyramid is kept and the lower half is truncated, more accurate results are produced if the two operand is normalized. Also, the functional unit will only produce normalized results when both operands are normalized. If either operand is unnormalized the result is not guaranteed to be normalized. The **Floating-point Add** functional unit does not require normalized operands. The last thing this functional unit does is normalize its results. In fact, floating-point numbers can be routed to this functional unit using the 062i0k, 063i0k, 170i0k, or 172i0k instructions to take advantage of this normalizing process. If we look closely at those instructions, we are taking the operand in the k field and adding it to zero (special case of the j operand) through the Floating-point Add functional unit the result is the normalized operand.

Conversion From Integer To Floating-point Format

When converting integers to floating-point, it is necessary to understand the construction of a floating-point number. The components of a CRAY X-MP floating-point number can be compared to a number written in scientific notation.

Example: The components of the floating-point format can be compared to the standard scientific notation in power of ten as follows:



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Note the effect on the Exponent with the shifting of the Coefficient's decimal point to the left. The following numbers all have the same values:

$$1025. \times 10^{-2}$$
$$102.5 \times 10^{-1}$$
$$10.25 \times 10^{0}$$
$$1.025 \times 10^{1}$$
$$.1025 \times 10^{2}$$

When converting an integer number to a Floating-point number on the CRAY-X-MP, the integer value of the number must remain the same. To accomplish this, the exponent of the Floating-point number will define where the binary point is in the actual number being represented by the Floating-point format. By definition, the binary point is located to the left of 2^{47} bit position. The exponent will define how many places to the right to move the binary point for a positive exponent, and how many places to the left for a negative exponent. In converting an integer number to Floating-point format (since the coefficient is only 48_{10} bit positions) the integer number is assumed to be less than 48_{10} bits. An exponent is given to the integer coefficient to reflect its value. Because all integer numbers in the CRAY-X-MP have the binary point at the right of the least significant bit or 2^0 bit position, it will also have to be defined there in the Floating-point format it will now be represented by. An exponent of 40060 is used for all integer to Floating-point conversions. The exponent value 40060 is a positive exponent which will move the point right 60_8 or 48_{10} places from its defined position and will now be to the right of 2^0 bit position. This is the same place the binary point is in all integer numbers. To normalize a Floating-point number the number of Leading Zeros is counted until the first 1-bit, and then the number of Leading Zeros is subtracted from the Exponent.

Example #1 - Issue a 071424 instruction to change (A4) into a Floating-point format.

#1 A4 = | 00001777 | A4 = a Integer, whole numbers

S4 = | 040060 | 000000 | 000000 | 001777 |

S4 = Floating-point numbers in CRAY-X-MP format

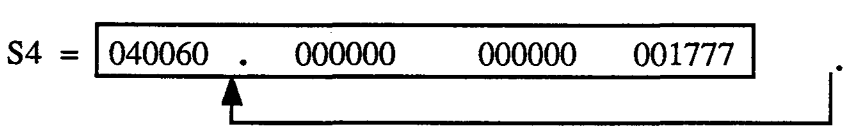
#2 Issue a 062404 to normalize S4

S4 = | 040012 | 1777000 | 000000 | 000000 | The number of Leading Zero's is subtracted from the Exponent.

Let's take a closer look at Example #1 A4 = 00001777 which is an Integer or whole number. A4 can also be represented as:

A4 = | 00001777.0×2^0 | Which is the same value that is in A4.

Because the coefficient has 48_{10} places and the binary point is moved to the left 48_{10} places or 60_8, as in S4. The exponent must have 60_8 added to the exponent to represent the number of places the binary point was moved, to keep the same number value. The Exponent now equals 40060 with the bias bit 2^{62} set, and 1777 in the lower position of Coefficient.



XV201S54M

To normalize S4 the Floating-point Add functional unit is used to take advantage of the normalizing capability that the Floating-point Add functional unit has. The 062404 instruction is used to normalize S4.

S4 = | 040012 . 1777000 000000 000000 |

When the Floating-point Add functional normalizes S4, it counts the number of Leading zeros and subtracts this value from the Exponent. It then adds in the bias. The coefficient is then left shifted 46_8 places, as represented in the normalized S4.

The sign of the integer number originally in A4 was positive or zero which is bit 2^{23} of an A-Register A4. To represent the sign of the Coefficient in S4, which is bit 2^{63}, it must also be set to a zero.

Example #2 - Issue a 071424 to represent the negative Integer numbers in A4 to Floating-point format.

#1 A4 = | 77777776 | Integer number in A4 equals a negative 2, in two's complement form.

S4 = | 140060 . 000000 000000 000002 | S4 is the result of the completion of the 071424 instruction.

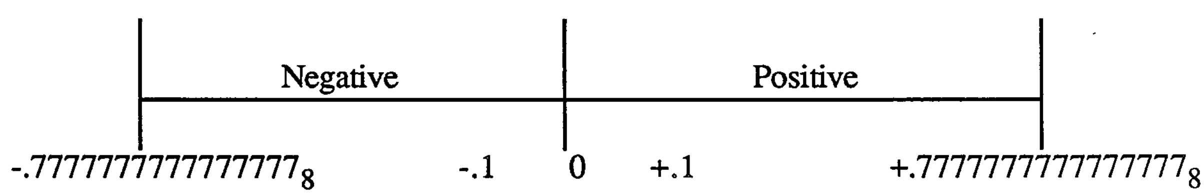
S4 has the sign bit set which is bit 2^{63} of S4 indicating that the Coefficient has a negative fraction that is two positions from zero, but on the negative side of the number line. The integer value has been two's complemented to give it an absolute value, and is shown in S4 as a negative signed magnitude number.

#2 Issue a 062404 to normalize S4.

S4 = | 140002 . 100000 000000 000000 |

Again, the sign bit 2^{63} is set indicating a negative number in the Coefficient. The number of Leading Zeros is subtracted from the Exponent to make the Exponent equal to 40002. The Coefficient is then left shifted 56_8 positions in the Floating Add Functional unit.

Coefficient Number Line



XV201S55M

FLOATING POINT CONSTANTS (Module Involved)

3AS Module

The 3AS module is used for the Scalar Leading zero count, the Address Adder, and to generate floating point constants. The 3AS module is also used to delay the 033 instruction from the 3JB when a 033 instruction is issued. The 033 is used to gate the error flag off the 3DJ to the 3AR.

To generate the floating point constants the 3AS module uses the 071i0k-071i70 instruction. The 071i2k instruction will take an integer number from an A register and convert the integer number into a un-normalized floating point number. To normalize this number, run the number through the Floating Add functional unit using a 062i0k instruction.

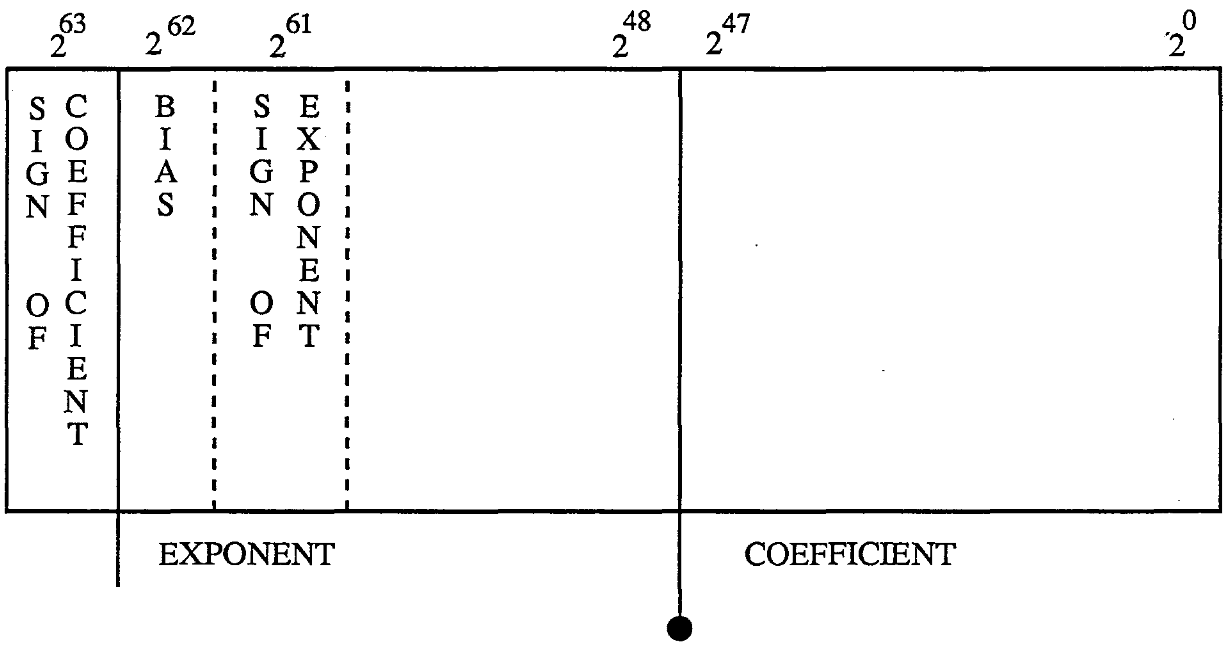
To convert an integer number in an S register which is greater than 24 bits, a three instruction algorithm is used.

The 071i0k will transfer the contents of an A register to an S register. Bits 2^{24}-2^{63} are zero filled in the S register.

The 071i1k instruction will transfer the contents of an A register to Si with sign extension from bit locations 2^{24}-2^{63}. This is equivalent to an integer number.

The 071i40-071i70 instructions generate floating point constants of $.4_8$, 1.0_8, 2.0_8 and 4.0_8.

The 071i30 is 2^{48} x $.6_8$ which equals 040060.140000 000000 000000.

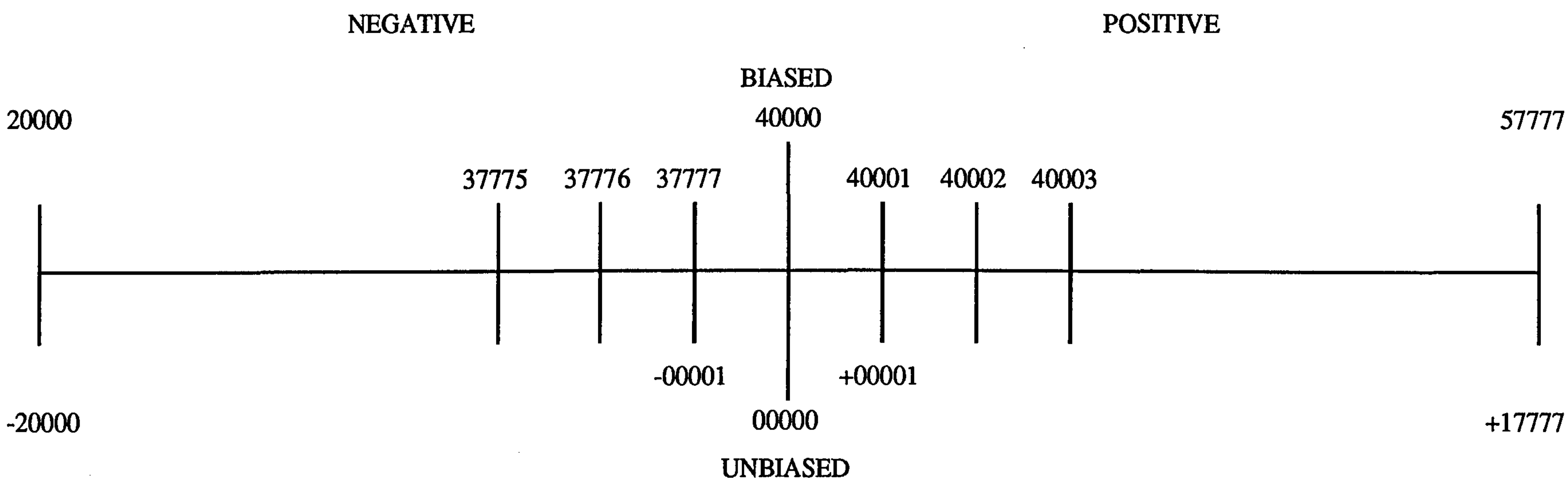


$2^{61} = 0$
UNDERFLOW
$2^{62} = 0$

$2^{61} = 1$
OVERFLOW
$2^{62} = 1$

A-5132

FLOATING-POINT REPRESENTATION



In terms of decimal values, the approximate decimal range is from 10^{-2466} through 10^{+2466}

A-5870

CRAY X-MP EXPONENT REAL NUMBER LINE

FLOATING POINT RANGE ERRORS

		EXPONENT	COEFFICIENT
FLOATING POINT ADD:			
	UNDERFLOW	000000	000000 000000 000000
	OVERFLOW	060000	CALCULATED PLUS ERROR
FLOATING POINT MULTIPLY:			
	UNDERFLOW	000000	000000 000000 000000
	OVERFLOW	060000	CALCULATED PLUS ERROR
FLOATING POINT RECIPROCAL:			
	UNDERFLOW	060000	CALCULATED PLUS ERROR *
	OVERFLOW	060000	CALCULATED PLUS ERROR *

* BIT 2^{47} WILL BE CLEAR

* BOTH SET ERROR FLAG

071i0k	Transmit (Ak) to Si with no sign extension
071i1k	Transmit (Ak) to Si with sign extension
071i2k	Transmit (Ak) to Si as unnormalized floating point number
071i30	Transmit constant $0.75_{10} \times 2^{48}$ to Si $0.6_8 \times 2^{60}$
071i40	Transmit constant 0.5_{10} to Si 0.4_8
071i50	Transmit constant 1.0 to Si
071i60	Transmit constant 2.0 to Si
071i70	Transmit constant 4.0 to Si

CAL FORMAT

071i0k	Si	Ak
071i1k	Si	+Ak
071i2k	Si	+FAk
071i30	Si	0.6
071i40	Si	0.4
071i50	Si	1.
071i60	Si	2.
071i70	Si	4.

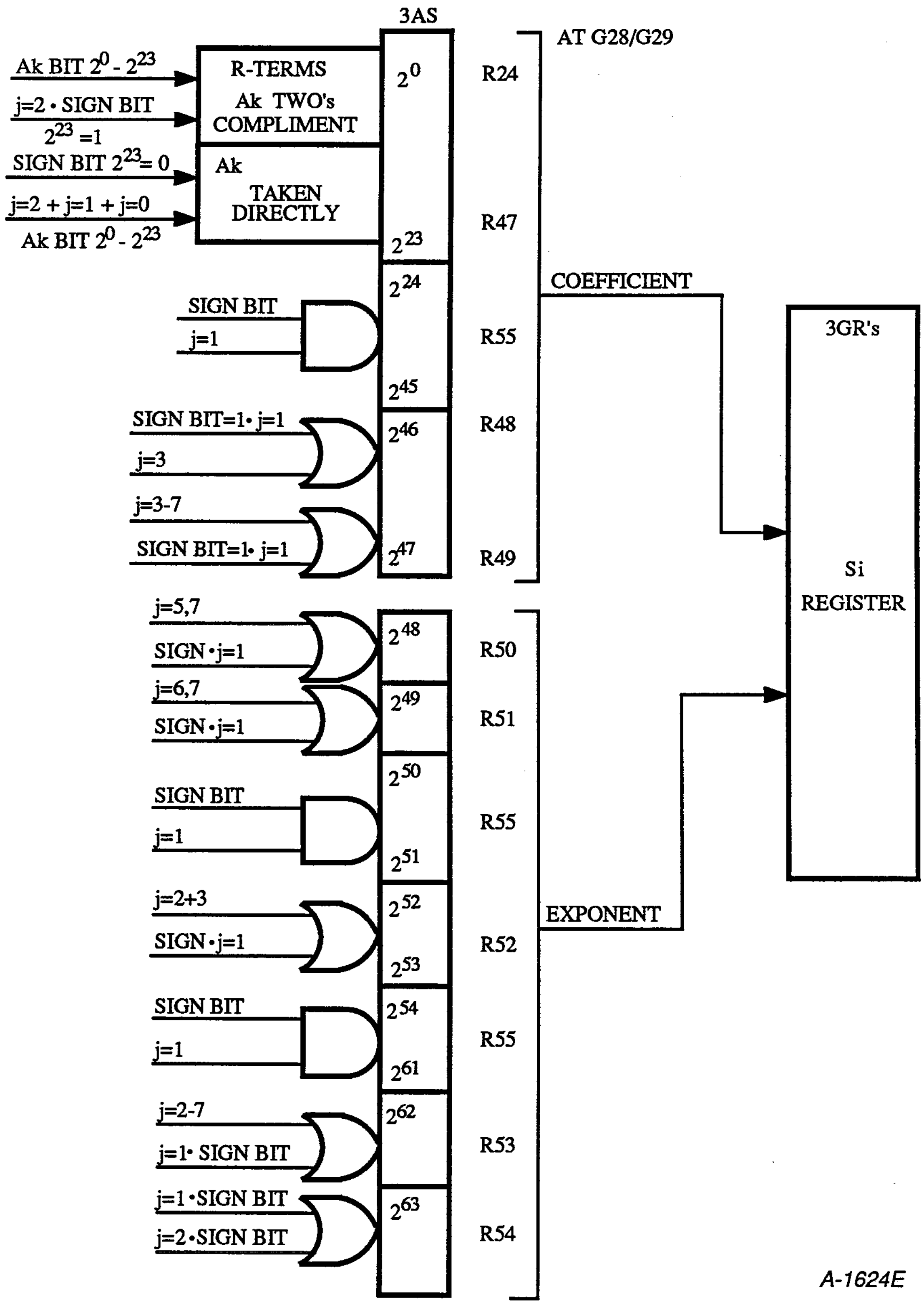
INTEGER VALUE IN S1 TO FLOATING POINT FORMAT IN S3

Where S1 = 000000 000000 173743 026721

ALGORITHM =	#1	071230	S2 =	$.75 \times 2^{48}$	
	#2	061121	S1 =	S2 - S1	
	#3	063321	S3 =	S2 - FS1	

#1 S2 =	040060	140000	000000	000000	
#2 S2 =	040060	140000	000000	000000	
-S1 =	000000	000000	173743	026721	
S2 =	040060	140000	000000	000000	
S1 =	177777	177777	004034	151056	1's Compliment
	040060	137777	004034	151056	
				+1	2's Compliment
S1 =	040060	137777	004034	151057	
#3 S2 =	040060	140000	000000	000000	
-S1 =	040060	137777	004034	151057	
S2 =	040060	037777	177777	177777	Retain J Exponent
	-	137777	004034	151057	Compliment J Coefficient
		177777	004034	151056	No Carry Across Binary Point
		000000	173743	026721	Compliment Result
S3 =	040060	000000	173743	026721	Unnormalized Result
S3 =	040040	173743	026721	000000	Normalized Result

XV201S37M



CRAY X-MP 071iIk - 071i70 INSTRUCTION

M03 = Q00 J bit 2^0
M04 = Q01 J bit 2^1
M05 = Q02 J bit 2^2

M02 = $\overline{Q02}$ Q01 $\overline{Q00}$ J = 2

N00 = I47 M02 Complement Ak

Boolean L00' = N0
L00 = N0'

L01' = J0 N0
L01 = $\overline{J0}$ + $\overline{N0}$

For a 071i0k instruction all the L terms are made

Boolean R24 = J0 ; T2
R25 = J1 L1 + J1' L1' ; T2

R24 = Si bit 2^0
R25 = Si bit 2^1

<u>071i1k - Transmit (Ak) to Si with sign extension</u>

I47 = Ak bit 2^{23}

Boolean N01' = I47' + M03' + M4 + M5

N01 = [I47][M03][M4'][M5']

N01 = Sign bit Ak bit 2^{23}

R55 = N01 Si bits 24-25; 50,51; 54-61
R48-R54 = Si bit 46-49; 52,53; 62,63

A-1626

<u>071i2k - Transmit (Ak) to Si as</u>
unnormalized floating point number

M02 = $\overline{Q00}$ Q01 $\overline{Q02}$ = j field = 2
I47 = Ak bit 2^{23}
N00 = I47 M02

Boolean	L00' = N0 L01' = J0 N0 L02 = J1' J0 + N0' L02' = [J1 + J0'][N0]

L00-L03 - Perform the two's complement on Ak bits 2^0-2^{23} if the sign bit of Ak is a 1

R24-R47 = L00-L23

R24-R47 = Two's complement form if Ak sign bit = 1

R24-R47 = Ak bit 2^0-2^{23} if Ak sign bit = 0

A-1626

FLOATING-POINT ADD FUNCTIONAL UNIT

The Floating-point Add Functional unit performs three operations. They are to equalize exponents, add coefficients and normalize the results.

To equalize the exponents the larger of the two exponents is retained. The coefficient is shifted right until both exponents are equal. Because the coefficient is only 48 bits, any shifting beyond 48 bits will result in the smaller operand's coefficient to become zeros.

The two operands are added after the exponents are equalized. If an add instruction was issued and the signs bits are the same, an add operation is performed. If the sign bits are different, a subtract operation is performed. This operation requires performing the ones complement arithmetic on the K-operand or J-operand and allowing an end around carry or toggling of the result. If a subtract instruction was issued and the sign bits are different, an add operation is performed. If the sign bits are the same for subtract instruction, a subtract operation is performed.

To normalize the results the coefficient is shifted to the left until a 1 bit is in front of the binary point. The exponent is decremented accordingly. If a carry across the binary point exists, a right shift of one place is performed to normalize the coefficient, and a 1 is added to the exponent.

FLOATING ADD (Module Involved)

3FA MODULE

The 3FA module receives the exponent bits 2^6 - 2^{15} or 2^{54} - 2^{63} of the word. The 3FA will receive Sj and Sk if a Scalar instruction is issued. The module will receive Sj or Vj and Vk for a Vector instruction. From the exponent bits 2^6 - 2^{15} the 3FA will generate some control terms. The terms will determine if the j exponent is greater than the k exponent or if $k > j$, if $j + 1 = k$ or $k + 1 = j$, or if the exponents are equal. Any other combination of the exponents will cause the lower valued exponent's coefficient to be zeroed. This will occur when the coefficient is right shifted to equalize the exponents.

The 3FA will also receive bits 2^0 - 2^5 of the exponent from the 3FB and 3FC modules. From these bits the 3FA can determine if the k exponent is greater than the j exponent or if $j = k$. The 3FA will retain the larger exponent for shifting to the left if normalization is needed.

The 3FA will handle over flow and under flow error conditions.

The 3FA will complement the k sign bit if a subtract instruction is issued.

The final exponent is sent from the 3FA to the 3GR or 3VA modules.

3FB/3FC MODULE

The 3FB module handles the j coefficient bits 2^0 - 2^{47}. The 3FC handles the k coefficent bits 2^0 - 2^{47}. The 3FB/3FC will either shift the coefficient right to equalize the exponents or leave the coefficient unshifted. The larger coefficient is left unshifted.

The shift counts for the 3FB/3FC is determined from the upper bits on the 3FA and the difference of the lower bits 2^0 - 2^5 of the j and k exponent. The final shifted coefficient and the unshifted coefficient are sent to the 3FD module.

3FD MODULE

The 3FD module will add the coefficients to finish the Floating Add operation. A check is made for a carry across the binary point. If it exists, the coefficient is right shifted by one place and the exponent increased by one.

The 3FD will then do a leading zero count on the coefficient. The number of leading zeros is broken down into shift counts. These counts are used on the 3FA module to decrease the exponents by the number of shifts needed to normalize the coefficient and to adjust the exponent accordingly.

3FE MODULE

The 3FE will normalize the coefficient by left shifting until a 1 bit is to the left of the binary point. The shift counts are recalculated from the number of leading zeros in the coefficient.

The final normalized coefficient is sent to the 3GR or 3VA along with the exponent from the 3FA. If an underflow condition is detected by the 3FA, the coefficient is blocked from leaving the 3FE module. This condition causes all zeros for a coefficient. The exponent is also zeroed from the 3FA module.

If an overflow condition exists, the coefficient is allowed to leave the 3FE. However, the exponent is forced to 060000 on the 3FA and a Floating-point Error flag is sent to the Exchange package.

FLOATING ADD INSTRUCTIONS

SCALAR

062IJK	Scalar Floating Sum of (SJ) and (SK) to SI
062IOK	Normalize (SK) to SI
063IJK	Scalar Floating Difference of (SJ) minus (SK) to SI
063IOK	Transmit normalized negative of (SK) to SI will normalize the coefficient and toggle the sign bit

VECTOR

170IJK	Vector Floating Sum of (SJ) and (VK ELEMENTS) to VI
170IOK	Normalize (VK ELEMENTS) to VI
171IJK	Vector Floating Sum of (VJ ELEMENTS) and (VK ELEMENTS) to VI
172IJK	Vector Floating Difference of (SJ) minus (VK ELEMENTS) to VI
172IOK	Transmit normalized negatives of (VK ELEMENTS) to VI will normalize the coefficient and toggle the sign bit
173IJK	Vector Floating Difference of (VJ ELEMENTS) minus (VK ELEMENTS) to VI

C.A.L. FORMAT

SCALAR

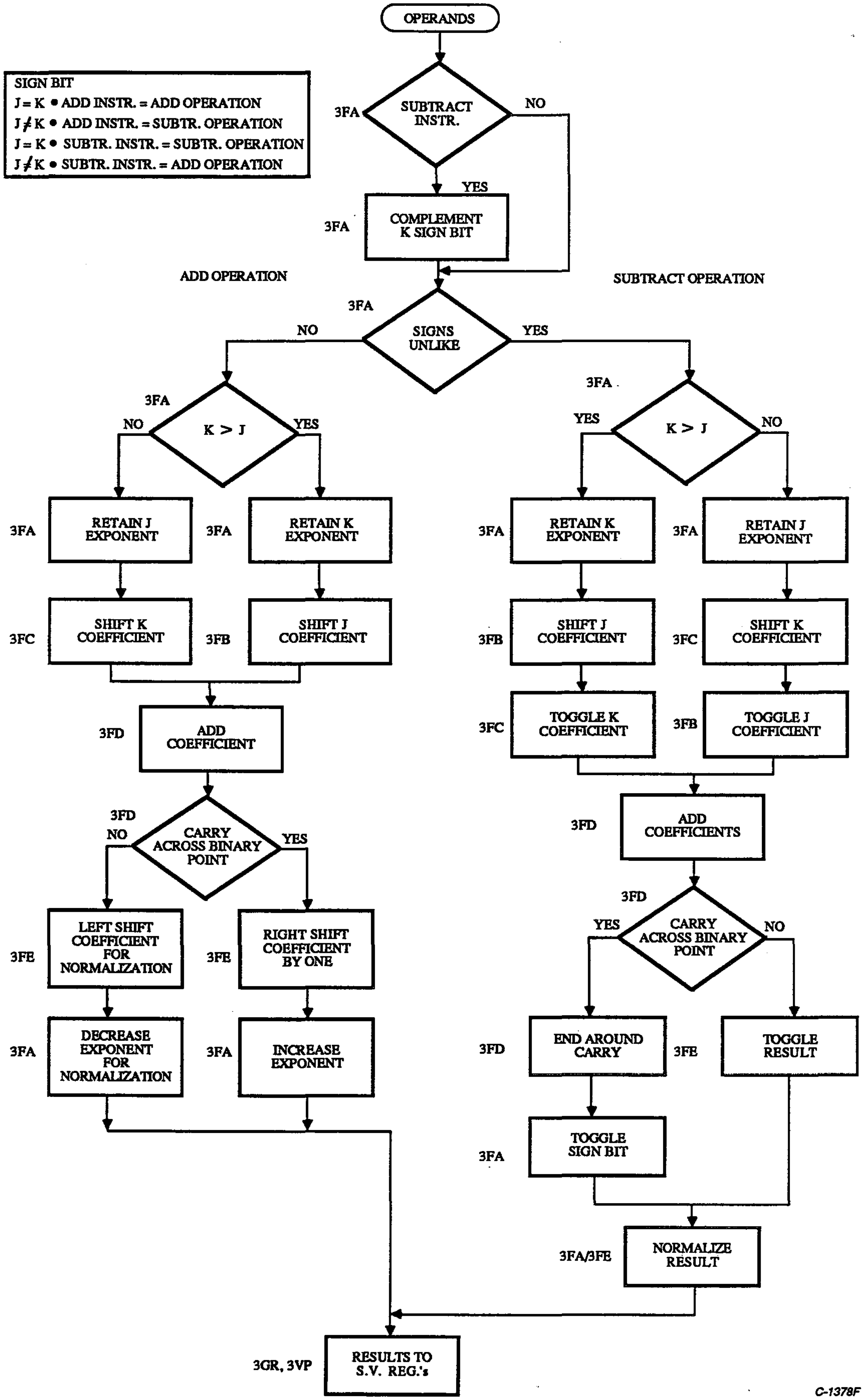
SI	SJ+FSK	Scalar Floating Add
SI	SJ+FSK	Scalar Normalized SK
SI	SJ-FSK	Scalar Floating Difference
SI	SJ-FSK	Scalar Normalized Negative SK

VECTOR

VI	SJ+FVK	Vector, Scalar Sum
VI	SJ+FVK	Vector, Normalized VK
VI	VJ+FVK	Vector, Vector Sum
VI	SJ+FVK	Vector, Scalar Difference
VI	SJ-FVK	Vector, Normalized Negative VK
VI	VJ+FVK	Vector, Vector Difference

DIAGNOSTIC APPLICATIONS

3SFA



CRAY X-MP/2 AND X-MP/48 FLOATING-POINT ADD FLOW CHART

FLOATING ADD EXAMPLES

ADD INSTRUCTION

J =	040004	004000	000000	000000	$.4_8$
K =	140003	140000	000000	000000	+ -6
					-5.4_8

SUBTRACT OPERATION

040004	004000	000000	000000	RETAIN J
140004	060000	000000	000000	SHIFT K
040004	173777	177777	177777	TOGGLE J
140004	060000	000000	000000	
040004	1.053777	177777	177777	ADD COEFFICIENTS CBP RETAIN EXPONENT & SIGN OF LARGER
040004	053777	177777	177777	
			+1	END AROUND CARRY
140004	054000	000000	000000	TOGGLE SIGN BIT
140003	130000	000000	000000	NORMALIZE

ADD INSTRUCTION

J =	040003	140000	000000	000000	6_8
K =	040002	140000	000000	000000	$+ 3_8$
					11_8

ADD OPERATION

040003	140000	000000	000000	RETAIN J
040003	060000	000000	000000	SHIFT K
040003	1.020000	000000	000000	ADD COEFFICIENTS CBP
040004	110000	000000	000000	NORMALIZE RESULT

FLOATING ADD EXAMPLES

ADD INSTRUCTION

J = 040002	140000	000000	000000	$+3_8$
K = 140003	140000	000000	000000	$+\ -6_8$
				-3_8

SUBTRACT OPERATION

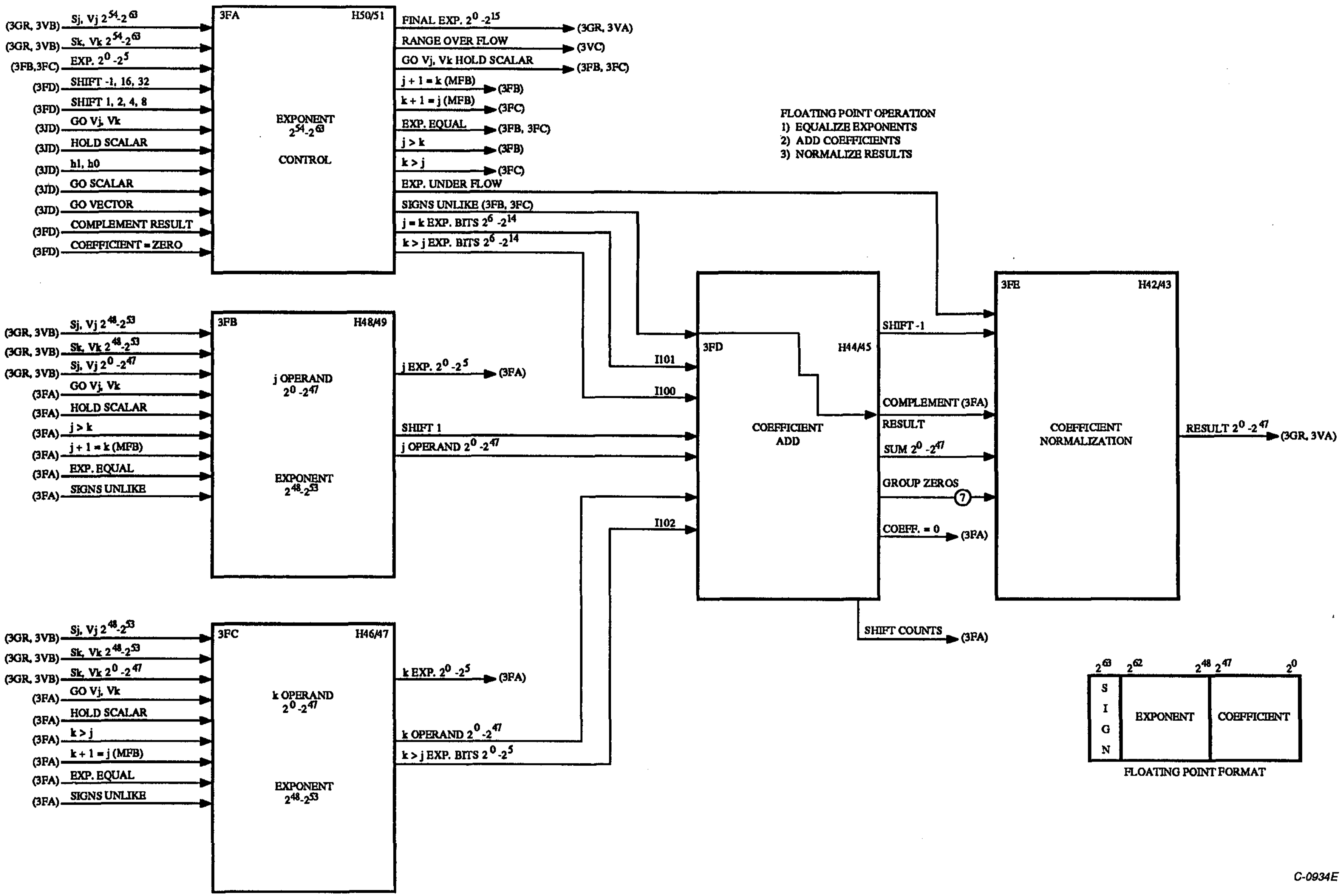
040003	060000	000000	000000	SHIFT J
140003	140000	000000	000000	RETAIN K
040003	060000	000000	000000	
140003	037777	177777	177777	TOGGLE K
140003	117777	177777	177777	ADD COEFFICIENTS CBP RETAIN EXPONENT & SIGN OF LARGER
140003	060000	000000	000000	TOGGLE RESULT
140002	140000	000000	000000	NORMALIZE

SUBTRACT INSTRUCTION

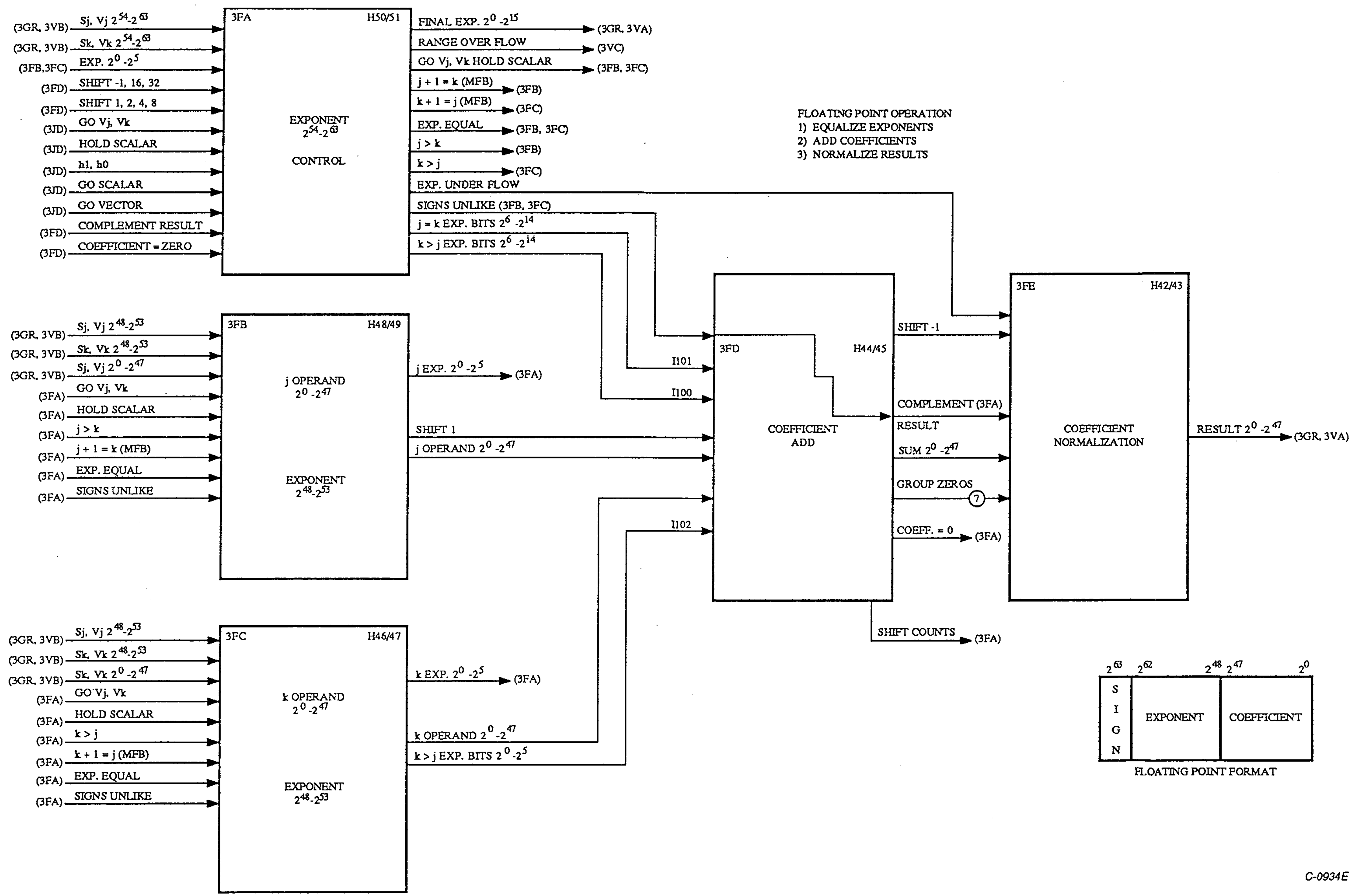
J = 040003	140000	000000	000000	6_8
K = 140002	140000	000000	000000	$-\ -3_8$
				11_8

ADD OPERATION

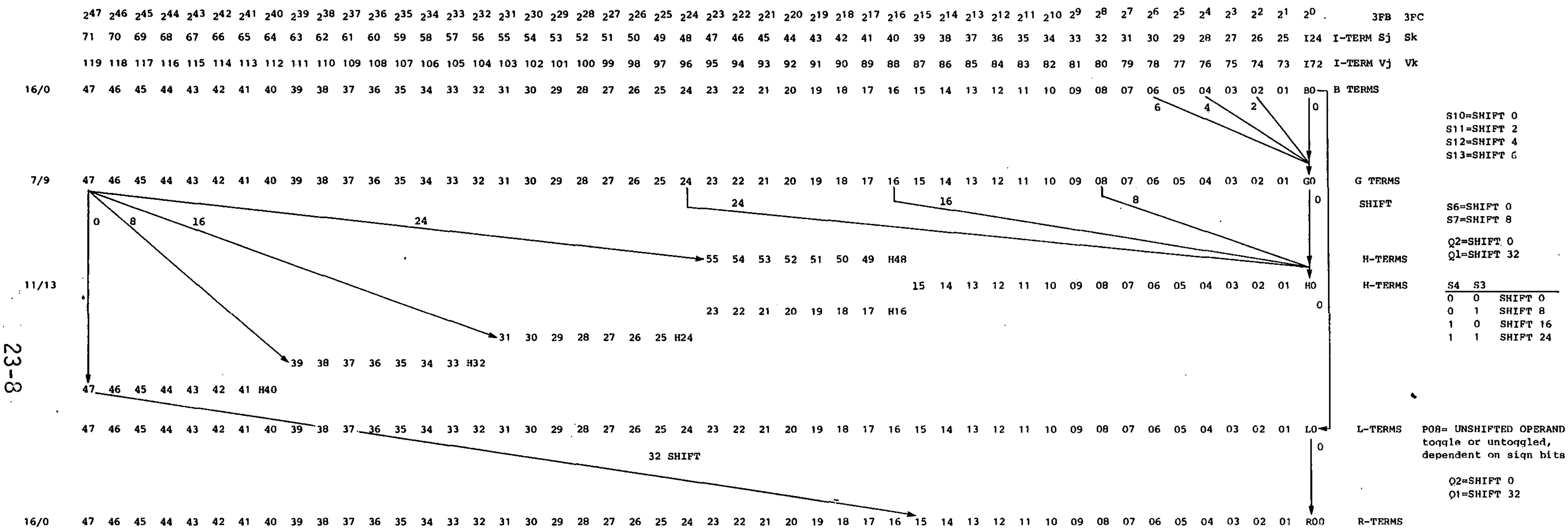
040003	140000	000000	000000	
040002	140000	000000	000000	COMPL. K SIGN BIT
040003	140000	000000	000000	RETAIN J
040003	060000	000000	000000	SHIFT K
040003	1.020000	000000	000000	ADD COEFFICIENTS CBP
040004	110000	000000	000000	SHIFT RIGHT TO NORMALIZE; ADJUST EXPONENTS



CRAY X-MP FLOATING-POINT ADD (CPU 0)



CRAY X-MP FLOATING-POINT ADD (CPU 0)



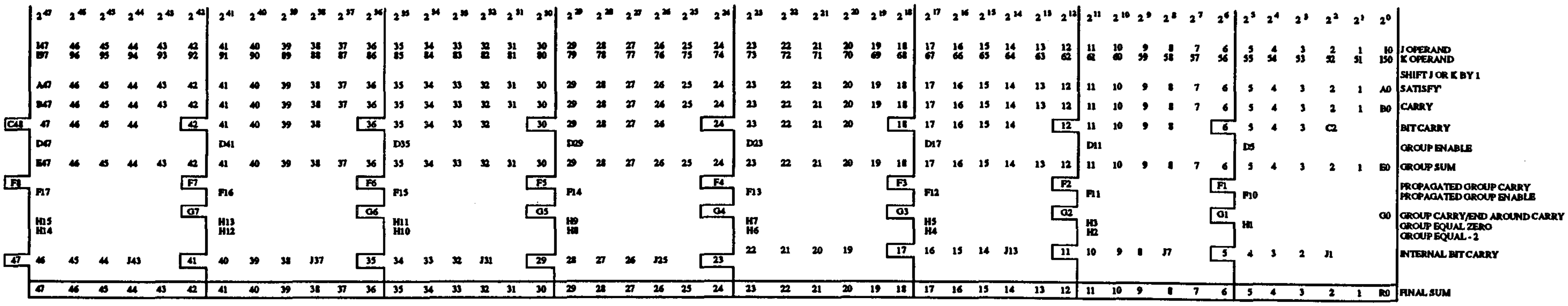
TEST POINTS

B-TERMS	2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}
	$\overline{D62}$	$\overline{A13}$	$\overline{D56}$	$\overline{A15}$	$\overline{D54}$	$\overline{A11}$	D59	A19	D64	A20	D65	A16	D41	A33	D46	A36	D53	A28	A43	A41	D30	A45	D32	A56	C26	B23	C72	B27	C57	B55	C36	C33	C22	B36	C24	B53	C27	B68	C17	B67	C19	B59	C25	C54	C20	B64	C21	B66
R-TERMS	D24	A55	D20	A58	D17	A68	D07	A72	D19	A54	D02	A69	D28	A70	D36	A71	D04	A65	D13	A64	D08	A67	D03	A66	C46	B20	C41	B03	C71	B21	C64	B26	C53	B56	C52	B52	C30	B57	C29	B58	C54	B04	C28	B06	C55	B19	C56	B22

C-1629C

NOTE: SHIFT OF 1 DONE ON 3FD

3FB/3FC MODULE DIAGRAM



E0 - B72'	E11 - B21'	E22 - A59'	E33 - D29'	E44 - C15'	F7 - D61'	F9 - A21' SIGNS UNLIKE
E1 - B70'	E12 - A23'	E23 - A72'	E34 - D44'	E45 - C20'	F8 - D20'	
E2 - B62'	E13 - A27'	E24 - D1'	E35 - D46'	E46 - C2'	F10 - B27'	
E3 - B53'	E14 - A29'	E25 - D2'	E36 - C51'	E47 - C1'	F11 - B25'	
E4 - A06'	E15 - A57'	E26 - D5'	E37 - C41'		F12 - B23'	
E5 - A05'	E16 - B13'	E27 - D14'	E38 - C33'	F1 - A16'	F13 - A48'	
E6 - A7'	E17 - B12'	E28 - C72'	E39 - C25'	F2 - A20'	F14 - A52	
E7 - A18'	E18 - B4'	E29 - C71'	E40 - D53'	F3 - B18'	F15 - C59'	
E8 - B32'	E19 - B16'	E30 - C67'	E41 - D63'	F4 - B20'	F16 - C70'	
E9 - B38'	E20 - A58'	E31 - C61'	E42 - D70'	F5 - A22'	F17 - D21	
E10 - B29'	E21 - A68'	E32 - D23'	E43 - D72'	F6 - D57'		

NOTE: If J < K and shift 1, A00/B00 is made from I01 and I50.

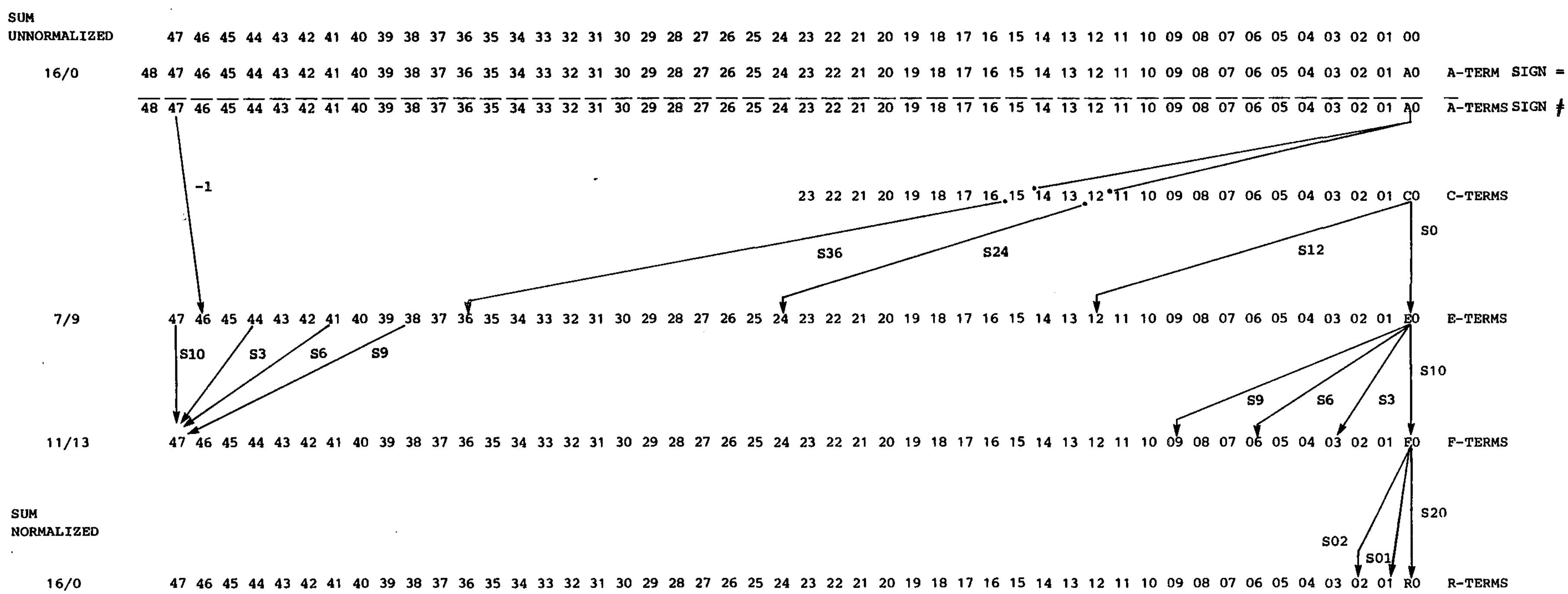
D-13798

CRAY X-MP COEFFICIENT ADDITION

3FD MODULE

FLOATING-POINT ADD FUNCTIONAL UNIT

3FE MODULE
COEFFICIENT UNNORMALIZED



SHIFT CONTROL TERMS

S77 = SHIFT -1 E47=1
S00 = SHIFT 0
S12 = SHIFT 12
S24 = SHIFT 24
S36 = SHIFT 36

S10 = SHIFT 0
S03 = SHIFT 3
S06 = SHIFT 6
S09 = SHIFT 9

S20 = SHIFT 0
S01 = SHIFT 1
S02 = SHIFT 2

B-1639A

3FE MODULE DIAGRAM

FLOATING POINT ADD

FINAL EXPONENT

3FA

2^{63}	2^{62}	2^{61}	2^{60}	2^{59}	2^{58}	2^{57}	2^{56}	2^{55}	2^{54}	2^{53}	2^{52}	2^{51}	2^{50}	2^{49}	2^{48}	
R15	R14	R13	R12	R11	R10	R09	R08	R07	R06	R05	R04	R03	R02	R01	R00	
$\overline{D01}$	$\overline{C49}$	$\overline{C50}$	C47	C40	C48	C52	C46	C39	C38	C21	C37	C02	C03	C20	$\overline{C01}$	TEST POINT
___,	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___	

NOTE: 062, 063 SYNC ON 3FA T.P. $\overline{D05}$ @ CP5 DATA @ CP7

X2100S0204

3FE @ H42/43 FINAL OUTPUT

062, 063 SYNC ON 3FA $\overline{D05}$ T.P. @ CP5. DATA @ CP7.

2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}	
R47	R46	R45	R44	R43	R42	R41	R40	R39	R38	R37	R36	R35	R34	R33	R32	
$\overline{C70}$	$\overline{C67}$	$\overline{C61}$	$\overline{C55}$	$\overline{C40}$	$\overline{C57}$	$\overline{C65}$	$\overline{C42}$	$\overline{C59}$	$\overline{C63}$	$\overline{C68}$	$\overline{C72}$	$\overline{D14}$	$\overline{D18}$	$\overline{D29}$	$\overline{D27}$	TEST POINT
____,	____	____	____,	____	____	____,	____	____	____,	____	____	____,	____	____	____	
2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	
R31	R30	R29	R28	R27	R26	R25	R24	R23	R22	R21	R20	R19	R18	R17	R16	
$\overline{D25}$	$\overline{D23}$	$\overline{D12}$	$\overline{D03}$	$\overline{D06}$	$\overline{D10}$	$\overline{D16}$	$\overline{D20}$	$\overline{A72}$	$\overline{A65}$	$\overline{A67}$	$\overline{A63}$	$\overline{A59}$	$\overline{A55}$	$\overline{A50}$	$\overline{A16}$	TEST POINT
____,	____	____	____,	____	____	____,	____	____	____,	____	____	____,	____	____	____	
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
R15	R14	R13	R12	R11	R10	R09	R08	R07	R06	R05	R04	R03	R02	R01	R00	
$\overline{A52}$	$\overline{A57}$	$\overline{A61}$	$\overline{A70}$	$\overline{B03}$	$\overline{B08}$	$\overline{B16}$	$\overline{B06}$	$\overline{B10}$	$\overline{B04}$	$\overline{B18}$	$\overline{B14}$	$\overline{B12}$	$\overline{B19}$	$\overline{B23}$	$\overline{B25}$	TEST POINT
____,	____	____	____,	____	____	____,	____	____	____,	____	____	____,	____	____	____	

A-1551B

FLOATING-POINT ADD
FINAL COEFFICIENT

P00 = I120 GO VECTOR J
P01 = $\overline{\text{I120}}$ $\overline{\text{I122}}$ GO SCALAR J
P02 = I122 HOLD SCALAR
P09 = I121 GO VECTOR K

I00 = Sj bit 2^{48} OF J EXPONENT
I112 = Sk bit 2^{48} OF K
I06 = Vj bit 2^{48} OF J
I18 = Vk bit 2^{48} OF K

Boolean A00 = I00 P01 + I06 P00 + R48 P02; T2

A06 = I12 P09' + I118 P09; T2

A00 = SELECT Sj OR Vj; HOLD Sj IF A HOLD SCALAR
A06 = SELECT Sk OR Vk

J EXPONENT > K EXPONENT
K EXPONENT > J EXPONENT

Boolean C00 = A00 A06'; T2

D00 = A00' A06; T2

E01 = A01 A07' + A01' A07; T2

C00 = J > K bit 2^{48}
D00 = K > J bit 2^{48}
E01 = J ≠ K bit 2^{49}

A-1627

Boolean N00 = D5 D4 D3 D2 D1 D0 C5' C4' C3' C2' C1'

N00 = D0 C1' C2' C3' C4' C5' + D1 C2' C3' C4' C5' +
D2 C3' C4' C5' + D3 C4' C5' + D4 C5' + D5

N00 = K > J

Boolean N01 = C5 C4 C3 C2 C1 C0 D5' D4' D3' D2' D1'

N01 = C0 D1' D2' D3' D4' D5' + C1 D2' D3' D4' D5'
C2 D3' D4' D5' + C3 D4' D5' + C4 D5' + C5

N01 = J > K

P04 = N00 S51 $\overline{\text{S52}}$ K > J + SHIFT 32
P05 = N01 S51 S52 J > K + SHIFT 32

Boolean R60 = A00 A6' + A00' A06; T2

R60 = SHIFT 1 TO 3FD

A-1627

SELECT CORRECT OPERANDS

R20 = I56; T2 - ADD SCALAR
R21 = I54; T2 - GO VECTOR J
R22 = I55; T2 - GO VECTOR K

S00 = R21 GO VECTOR J
S01 = $\overline{R21}\ \overline{R20}$ GO SCALAR J
S02 = R20 HOLD SCALAR
S03 = R22 GO VECTOR K

I00 = Sj bit 2^{54} or 2^{6}
I20 = Vj bit 2^{54}
I10 = Sk bit 2^{54}
I30 = Vk bit 2^{54}

BOOLEAN A20 = I00 S01 + I20 S00 + C00 S02

A30 = I10 S03' + I03 S03

A20 = SELECT Sj + Vj + HOLD Sj
A30 = SELECT Sk + Vk

SIGN BIT ADD/SUBTRACT

I19 = Sk OPERAND BIT 2^{63}, SIGN BIT
I39 = Vk OPERAND BIT 2^{63}
I52 = MODE h BIT 2^{0}
I53 = MODE h BIT 2^{1}

BOOLEAN A39 = I19 I52' S03' + I39 I53' S03

A40 = I19' I52 S03' + I39' I53 S03

A39 = IF AN ADD INSTRUCTION,
LEAVE THE SIGN BIT AS IT WAS

A40 = IF A SUBTRACT INSTRUCTION,
COMPLEMENT THE SIGN BIT

A-1638

SIGNS UNLIKE

A29 = J EXPONENT BIT 2^{15}

BOOLEAN	R46 = A29 A39' A40' + A29' A39 + A29' A40; T2
	R54 = R46; T2

R46 = SIGN BITS ARE UNLIKE; CHECKED AFTER THE K SIGN BIT IS COMPLEMENTED FOR A SUBTRACT OPERATION.

R54 = SENT TO THE 3FD, 3FB, 3FC

SELECT LARGER EXPONENT

R50 = K > J EXPONENT 2^6-2^{14}
R51 = K > J EXPONENT 2^6-2^{14}

R52 = R50 + R51 K > J BIT 2^6-2^{14}
R53 = E9 + E10 + E11 + E29 + E30 + E31 J = K bit 2^6-2^{14}

I59 = K > J BIT 2^0-2^5 FROM 3FC

F00 = I59 R53 + R52

BOOLEAN	G00 = MUX (I40 I46): DCD (F00'); T2
	↓
	G14 = MUX (C18 C08): DCD (F00'); T2
	G15 = C19 F00 + C09 F00'; T2

G0 - G15 - LARGER EXPONENT CAN BE SCOPED IN THE G-TERMS OR H-TERMS

A-1638

COMPLEMENT RESULT

I66 = COMPLEMENT RESULTS FROM 3FD
G20 = R46 SIGN NOT EQUAL
H20 = G20
L20 = H20 $\overline{\text{I66}}$
H15 = EXPONENT BIT 2^{15}, SIGN BIT

BOOLEAN M15 = H15 L20' + H15' L20; T2

M15 = TOGGLE SIGN BIT IF, SUBTRACT OPERATION, CARRY ACROSS BINARY POINT

RESULTS OUT OF RANGE

I67 = COEFFICIENT = ZERO FROM 3FD
L77 = I60 SHIFT -1 FROM 3FD
T.P. D27 M77 = L77; T2

J02 = EXPONENT = 57777

T.P. $\overline{\text{D03}}$ C20 = I57 + I58 GO ADD, SCALAR OR VECTOR
T.P. $\overline{\text{D06}}$ C21 = C20
T.P. $\overline{\text{D10}}$ G21 = C21
H21 = G21 DELAY GO ADD

T.P. $\overline{\text{C59}}$ M20 = H21 J02 L77; T2 OVERFLOW 57777

T.P. $\overline{\text{D14}}$ M21 = H21 H13 H14; T2 OVERFLOW 60000

T.P. $\overline{\text{C61}}$ M22 = $\overline{\text{H13}}$ $\overline{\text{H14}}$; T2 UNDERFLOW
R55 = $\overline{\text{H13}}$ $\overline{\text{H14}}$

BOOLEAN
Q10 = M20 + M21 + M22 + I67 M77'
Q11 = M20 + M21 I67'

Q10 = OVERFLOW OR UNDERFLOW OR EXPONENT MULTIPLIED BY ZERO

Q11 = OVERFLOW OR OVERFLOW AND COEFFICIENT NOT EQUAL TO ZERO

A-1638

FINAL EXPONENT

```
BOOLEAN        R00 = V00 Q10'; T2
                |
                ↓     .
               R12' = M12' U06'  +  V12 U06  +  Q10; T2
               R12 = [M12 + U06] [V12' = U06'] [Q10']; T2
```

R00 - R12 = ALL ZONES IF UNDERFLOW OR OVERFLOW OR EXPONENT MULTIPLIED BY ZERO

```
BOOLEAN        R13 = M13 U06' Q10'  +  V13' U06  +  Q11; T2

               R14 = M14 U06' Q10'  +  V14' U06  +  Q11; T2

               R15 = M15 Q10'; T2
```

R14, R13 = 1 IF OVERFLOW FROM Q11 TO MAKE EXPONENT EQUAL 60000

R15 = 0 IF UNDERFLOW OR OVERFLOW

A-1638

COEFFICIENT = ZERO

BOOLEAN	R61' = F05' F08' + F17' F8' + F9
	R61 = [F05 + F08] [F17 + F8] [F9']

R61 = SHIFT -1 CARRY ACROSS THE BINARY POINT. SHIFT BACK ONE PLACE AND INCREASE THE EXPONENT BY 1.
R61 = I60 ON 3FA, SHIFT -1

U40 = 1st 12 BIT ARE 0
U45 = UPPER 36 BIT ARE 0

BOOLEAN	R90 = U45 U40 R61'; T2

R90 = COEFFICIENT EQUAL ZERO'S - $\overline{\text{SHIFT -1}}$
R90 = I67 3FA COEFFICIENT = ZERO

COMPLEMENT RESULT
F9 = I103; T2 SIGNS NOT EQUAL
F8 = END AROUND CARRY
F5 = CARRY TO GROUP 5
F17 = GROUP 5-7 ENABLED

BOOLEAN	R60 = F5' F8' F9 + F17' F8' F9

TOGGLE RESULT IF SIGNS ARE NOT EQUAL, NO CARRY ACROSS THE BINARY POINT

A-1637

SHIFT J/K BY 1

I98 = J SHIFT 1 FROM 3FB
I100 = K > J BITS 2^6-2^{14} FROM 3FA
I101 = J = K BITS 2^6-2^{14} FROM 3FA
I102 = K > J LOWER EXPONENT

BOOLEAN F20' = I100' I101' + I100' I102' + I98'; T2

F20 = [I100 + I101] [I100 + I102] [I98]; T2

F20 = [K > J UPPER BIT] [SHIFT J BY 1] OR
[J = K ON UPPER BITS] [K > J LOWER BIT] [SHIFT J BY 1]

F21 = I98; T2 SHIFT J BY 1

S0 = F20 SHIFT J BY 1
S1 = $\overline{\text{F20}}$ F21 SHIFT K BY 1

I00 = J OPERAND BUT 2^0
I01 = J OPERAND BIT 2^1
I50 = K OPERAND BIT 2^0
I51 = K OPERAND BIT 2^1

BOOLEAN A00' = I00' I50' S0' S1' + I00' I51' S1 + I01' I50' S0

A00 = [I00 + I50 + S0 + S1] [I00 + I51 + S1'] [I01 + I50 + S0']

A00 = MADE IF AN ENABLE OR CARRY, BUT NOT A SATISFY

S00 = ENABLE SHIFT J BY 1
S01 = ENABLE SHIFT K BY 1

A-1637

FLOATING RECIPROCAL FUNCTIONAL UNIT

The Reciprocal Functional unit is used with the Multiply Functional unit to complete a Divide sequence. To find the reciprocal of a number Newton's iteration formula is used.

Two iterations are solved for in the Reciprocal Functional unit. Newton's iteration formula is $A_1 = 2A_0 - A_0^2B$. The Reciprocal Functional unit solves for $-A_1 = -2A_0+A_0^2B$ for the first iteration and $-A_2 = -2A_1+A_1^2B$ for the second iteration. A third iteration can be accomplished in the Multiply Functional unit if more accuracy is desired.

FLOATING RECIPROCAL (Modules Involved)

3RA Module

The 3RA module handles the coefficient bits 2^{47} - 2^{40} from which A_0 and A_0^2 are looked-up. A_0 is shifted 1 place and is complemented to make $-2A_0$ which is added in the A_1 pyramid on the 3RA and 3RB modules.

3RB Module

The 3RB module along with the 3RA module generate the A1 pyramid of $A_0^2{*}B$. It also adds the pyramid up using 3-bit adds. $-2A_0$ is added in for rounding and truncation purposes.

3RC Module

The 3RC performs the final summation of $A_0^2{*}B$ of which only 18 bits are kept. The 3RC will delay and complement 16 bits of A_1 for the A2 pyramid.

The 3RC will then multiply 18 bits of A_1 by 18 bits of A_1 to generate A_1^2. After A_1^2 pyramid is formed the 3RC will begin adding the pyramid using 3-bit adds.

3RD Module

The 3RD finishes the A_1^2 summation and sends the final result to the A_2 pyramid.

3RE, 3RF, 3RG Modules

These modules make up the A^2 pyramid where $A_1^2{*}B$ logical products will be performed and partial summation. $-2A_1$ will also be added into the summation of $A_1^2{*}B$. The 3RE's are also used for exponent delay.

3RH Module

The 3RH module will complete the summation on the A2 pyramid. The floating reciprocal value, which has completed two iteration, is now sent to the 3GR or 3VA modules. The coefficient of A_2 is 33 bits long of which only the upper 30 bits are accurate. The exponent also leaves on the 3RH along with the Sign bit. The exponent is complemented and a value of 2 is added into the exponent. If a floating point range error occurs, the 3RH sends an exponent of 060000 and the calculated coefficient sends a flag to the exchange package.

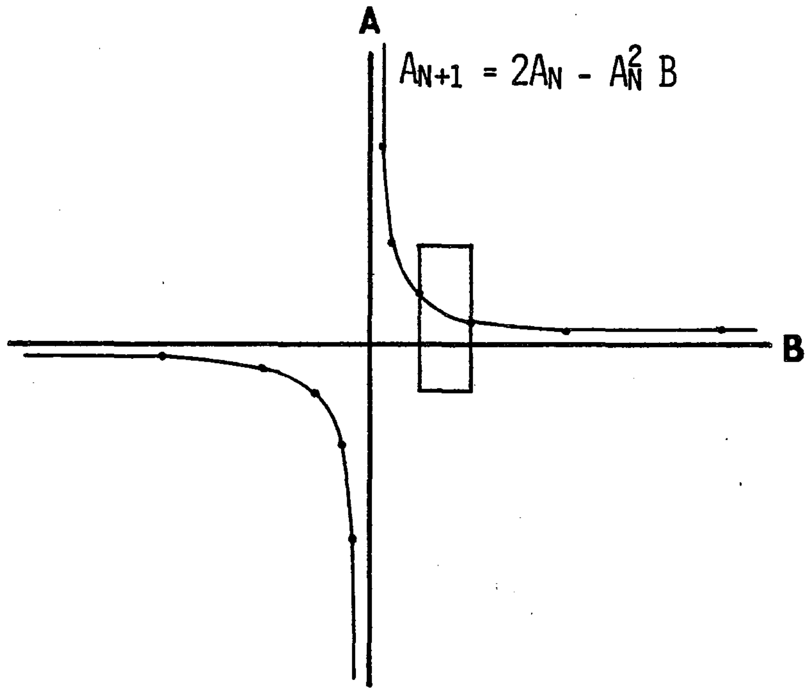
3RI Module

The 3RI module is mainly used for delay. The 3RI will delay the exponent, which is on its way to the 3RH module. The 3RI will also delay some of the bits of B1 and B2 for the A1 and A2 pyramids.

The 3RI was also used by the Vector Pop Count Functional unit. If a Floating Reciprocal instruction was issued, the Vector Pop Count is reserved for Floating Reciprocal Functional unit time. Similarly, a Vector Pop instruction will reserve the Reciprocal Functional unit for Vector Pop Functional unit time.

RECIPROCAL APPROXIMATION ITERATION FORMULA

The iteration formula is really the solution of a hyberbola.



By the CRAY X-MP using only absolute numbers eliminated the left curve as a possible answer.

By doing a left shift of one on the operand and always having a number larger than one and no greater than two we are left with only a small portion of the hyperbola in which to find our answer.

If we designate the vertical axis as A and the horizontal axis as B we then may solve for reciprocals by finding the point on a curve for a given B value and then reading the A value i.e.:

If B = 1, A = 1, or if B = 2, A = 1/2.

A-1640A

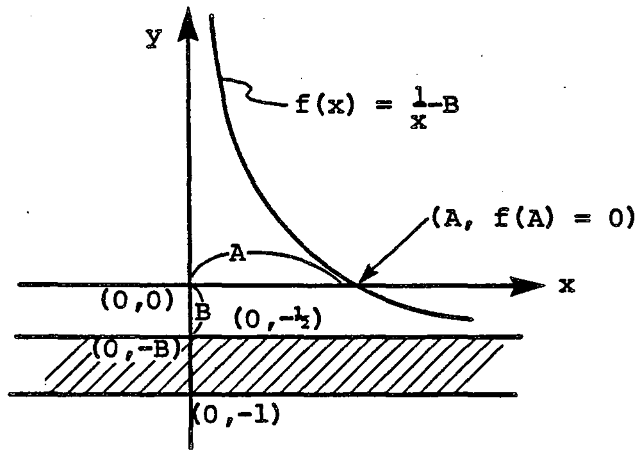
RECIPROCAL APPROXIMATION ITERATION FORMULA

> Problem: Given a number B such that B≥.5 or <1, find a number A such that $\frac{1}{A} = B$.

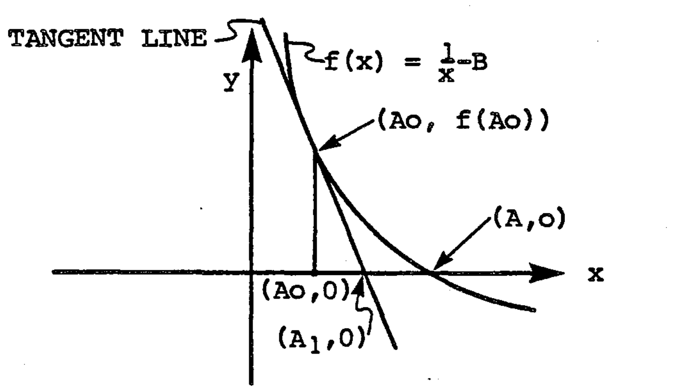
To find a good approximation value of A, first consider the function $f(x) = \frac{1}{x} - B$. Now find a number A, (A is a root or a solution to our problem), such that $f(A) = \frac{1}{A} - B = 0$.

From the graph, the value A is the x-coordinate of the point located at the intersection of the curve of f(x) and x-axis. To find the approximating value of A, use Newton's method for approximating the real roots of an arbitary equation f(x)=0:

Step 1: Select an initial value A_0 (by using the look-up tables in CRAY Hardware) which is close to the value of A.



Step 2: Draw a tangent line at $(A_0, f(A_0))$ and find A, where $(A_1, 0)$ is the intersection of the tangent line and the x-axis.



From the equation of the tangent line $y = \frac{-x}{A_0^2} - B + \frac{2}{A_0}$ substitute $x=A_1$, $y=0$ and factoring out $A_0 2$ we can find $A_1=2A_0-A_0^2B$

A-2034
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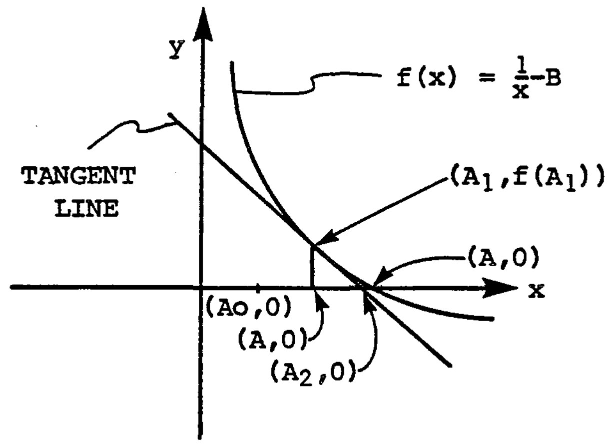
Step 3: Draw a tangent line at (A_1, $f(A_1)$) and find A_2, where (A_2, 0) is the intersection of the tangent line and the x-axis.



A-2035

From the equation of the tangent line $y = \frac{-x}{A_1^2} - B + \frac{2}{A_1}$ substitute $x=A_2$, $y=0$

and factoring out A_1^2, we can find $A_2=2A_1-A_1^2B$

As you see, A_2 is much closer to A than A_0, A_1. By repeating this process, a good approximation of the value A can be found.

An nth approximation formula for the value $A=\frac{1}{B}$ is $A_n=2A_{n-1}-A^2_{n-1}B$

Newton's formula derivation -

$$A_{(i+1)} = 2A_i - A^2{}_i B,$$

where:

$A_{(i+1)}$	= Next iteration	A_0 and $A_0{}^2$ in look-up table
A_i	= Current iteration	
B	= Divisor	

An initial guess starts the process with A_0, i.e.

$A_1 = 2A_0 - A_0{}^2\ B$	1st approximation
$A_2 = 2A_1 - A_1{}^2\ B$	2nd approximation result of reciprocal unit
$A_3 = 2A_2 - A_2{}^2\ B$	3rd approximation
$An = 2A_{(n-1)} - A^2{}_{(n-1)}\ B$	Nth approximation

The more iterations, the closer the approximation approaches true reciprocal value.

An example: $B = 2$, start with $A_0 = .2$

$A_1 = 2(.2) - (.2)^2 2$

$= .4 - .08$

$= .32$

$A_2 = 2(.32) - (.32)^2 2$

$= .64 - .2048$

$= .4352$

$A_3 = 2(.4352) - (.4352)^2 2$

$= .8704 - .378798$

$= .491602$

$A_4 = 2(.491602) - (.491602)^2 2$

$= .983204 - .483345$

$= .499859$

$A_5 = 2(.499859) - (.499859)^2 2$

$= .999718 - .499718$

$= .50000$

$A_6 = 2(.5) = (.25)2$

$= .50$

HANDLING OF B's EXPONENT

B =	40000 + E	1XXXXX	XXXXXX	XXXXXX
	EXPONENT	COEFFICIENT		

VALUE OF $B = 2^E * .1XXX{-}{-}{-}X$ NORMALIZE FLOATING-POINT NUMBER

$B = 2^{E-1} * 1.XXX{-}{-}{-}X$ LEFT SHIFT BY 1

LET $b = 1.XXX{-}{-}{-}X$

THEN $B = 2^{E-1} * b$

$$\frac{1}{B} = \frac{1}{2^{E-1} * b} = \frac{1}{2^{E-1}} * \frac{1}{b}$$

LET $n = E-1$

$$\frac{1}{2^n} = \frac{2^{-n}}{1} \quad \text{OR} \quad \frac{1}{2^{E-1}} = \frac{2^{-(E-1)}}{1} = \frac{2^{-E+1}}{1}$$

$$\frac{1}{B} = \frac{2^{-E+1}}{1} * \frac{1}{b}$$

EXAMPLE: Exponent = 51132
Bias = 40000

11132

-11132
+1

-11131

40000
-11131

26647

ANOTHER METHOD WHICH IS USED IN THE MAINFRAME:

	51132	EXPONENT
PERFORM 1's COMPLEMENT	26645	
	1	ADD ONE FOR NORMALIZATION
	1	ADD ONE FOR 2's COMPLEMENT
	26647	

FLOATING RECIPROCAL INSTRUCTIONS

SCALAR

070IJ0 Floating-Point Reciprocal approximation of (SJ) to SI

VECTOR

174IJ0 Floating-Point Reciprocal approximation of (VJ) to VI

C.A.L. FORMAT

SCALAR

SI /HSJ

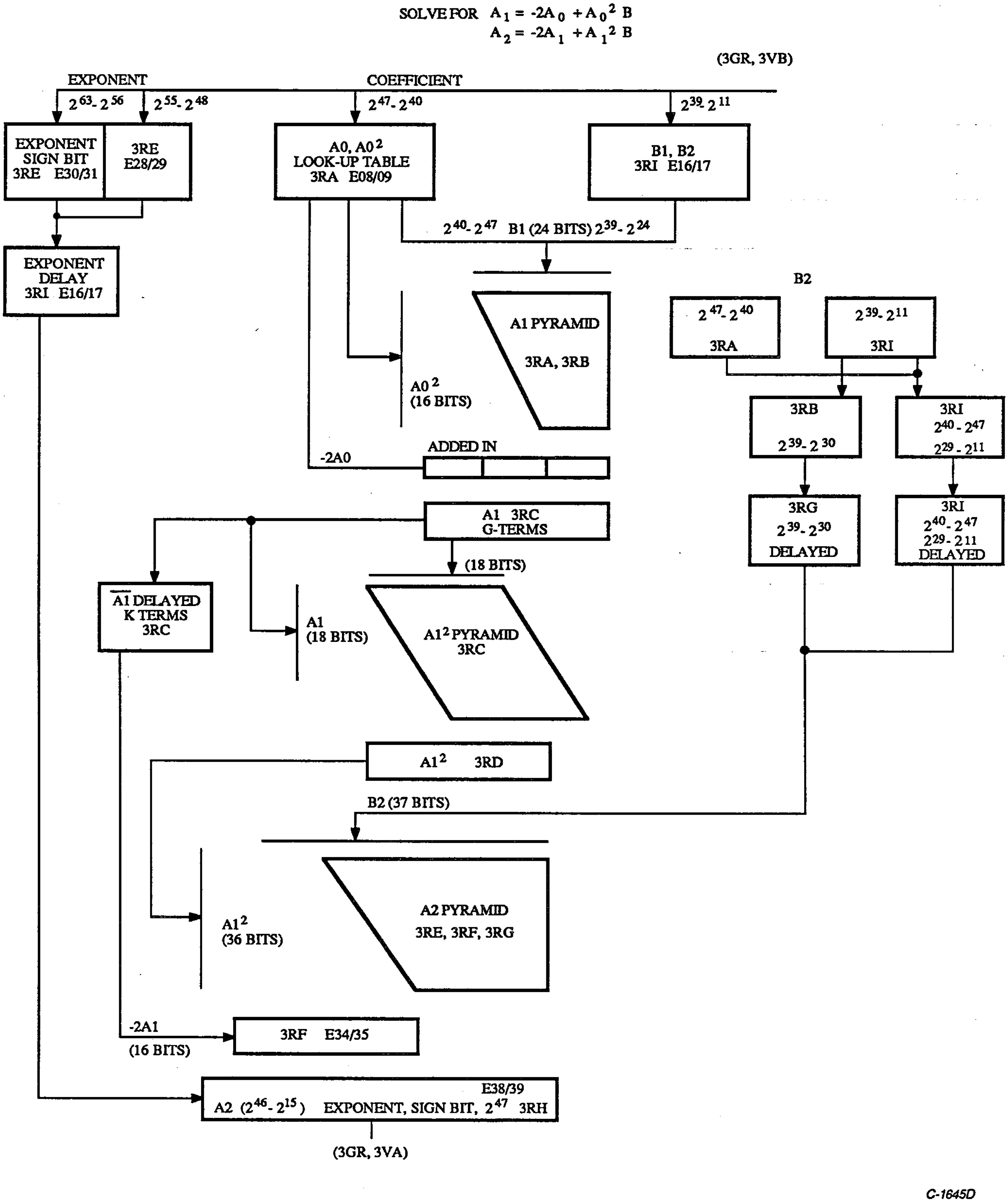
VECTOR

VI /HVJ

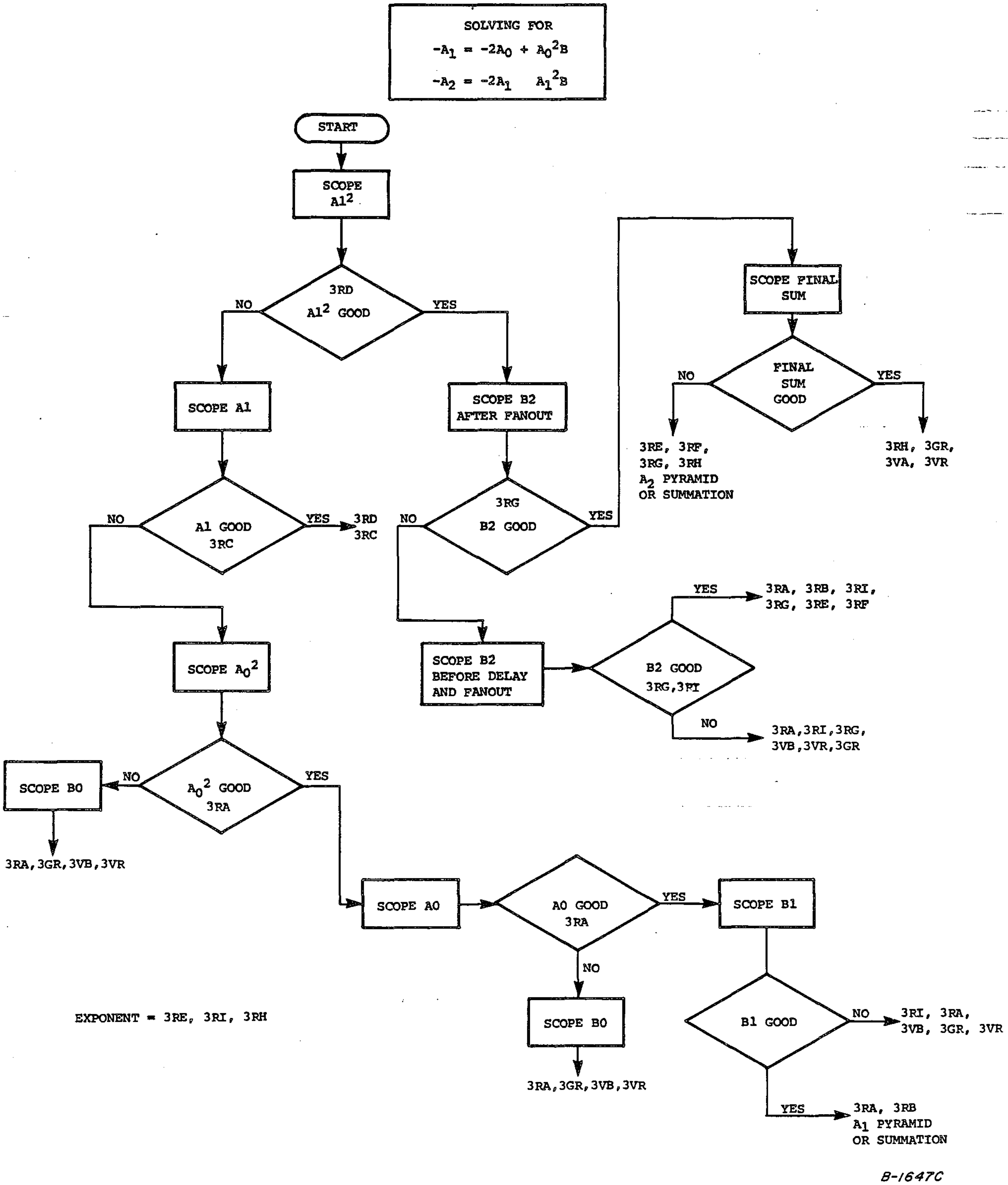
DIAGNOSTIC APPLICATIONS

3SFR

XVS01243M



CRAY X-MP FLOATING-POINT RECIPROCAL FUNCTIONAL UNIT



CRAY X-MP RECIPROCAL TROUBLESHOOTING FLOWCHART

Sync Channel A T.P. $\overline{\text{D67}}$ 3RI @ E16/17

Scope Channel B - 3RA @ E08/09 at the same time

-2A0	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}		
Test Point		B12	B5	B14	B10	$\overline{\text{B3}}$	B6	A72		
	0								$\overline{\text{A0}}$	
	1								A0	
	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}		
	0								$\overline{\text{2A0}}$	Shifted 1 Place

$A0^2$	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	2^{-16}	
Test Point	$\overline{\text{A55}}$	$\overline{\text{A65}}$	$\overline{\text{A70}}$	$\overline{\text{A57}}$	$\overline{\text{A61}}$	$\overline{\text{A63}}$	$\overline{\text{A25}}$	$\overline{\text{A50}}$	$\overline{\text{A23}}$	$\overline{\text{A52}}$	$\overline{\text{B70}}$	$\overline{\text{B72}}$	$\overline{\text{B65}}$	$\overline{\text{B69}}$		$\overline{\text{A68}}$	
																	$\overline{A0^2}$
															0		$A0^2$

A-1307E

CRAY X-MP A0 & $A0^2$ SCOPE CHART

Reciprocal table look-up values

B	A0	$A0^2$	$-2A_0$
1.000	.776	.774004	.000
1.004	.772	.764044	.010
1.010	.766	.754144	.020
1.014	.762	.744304	.030
1.020	.756	.734504	.040
1.024	.752	.724744	.050
1.030	.750	.721100	.054
1.034	.744	.711420	.064
1.040	.740	.702000	.074
1.044	.734	.672420	.104
1.050	.732	.666644	.110
1.054	.726	.657344	.120
1.060	.722	.650104	.130
1.064	.720	.644400	.134
1.070	.714	.635220	.144
1.074	.710	.626100	.154
1.100	.706	.622444	.160
1.104	.702	.613404	.170
1.110	.700	.610000	.174
1.114	.674	.601020	.204
1.120	.672	.575444	.210
1.124	.666	.566544	.220
1.130	.664	.563220	.224
1.134	.660	.554400	.234
1.140	.656	.551104	.240
1.144	.652	.542344	.250
1.150	.650	.537100	.254
1.154	.646	.533644	.260
1.160	.642	.525204	.270
1.164	.640	.522000	.274
1.170	.636	.516604	.300
1.174	.632	.510244	.310
1.200	.630	.505100	.314
1.204	.626	.501744	.320
1.210	.624	.476620	.324
1.214	.620	.470400	.334
1.220	.616	.465304	.340
1.224	.614	.462220	.344
1.230	.612	.457144	.350
1.234	.610	.454100	.354
1.240	.604	.446020	.364
1.244	.602	.443004	.370
1.250	.600	.440000	.374
1.254	.576	.435004	.400

X2124S0201

Reciprocal table look-up values (continued)

B	A0	$A0^2$	$-2A_0$
1.260	.574	.432020	.404
1.264	.572	.427044	.410
1.270	.570	.424100	.414
1.274	.566	.421144	.420
1.300	.564	.416220	.424
1.304	.562	.413304	.430
1.310	.560	.410400	.434
1.314	.556	.405504	.440
1.320	.554	.402620	.444
1.324	.552	.377744	.450
1.330	.550	.375100	.454
1.334	.546	.372244	.460
1.340	.544	.367420	.464
1.344	.542	.364604	.470
1.350	.540	.362000	.474
1.354	.536	.357204	.500
1.360	.534	.354420	.504
1.364	.532	.351644	.510
1.370	.530	.347100	.514
1.374	.526	.344344	.520
1.400	.524	.341620	.524
1.404	.522	.337104	.530
1.410	.520	.334400	.534
1.414	.520	.334400	.534
1.420	.516	.331704	.540
1.424	.514	.327220	.544
1.430	.512	.324544	.550
1.434	.510	.322100	.554
1.440	.506	.317444	.560
1.444	.506	.317444	.560
1.450	.504	.315020	.564
1.454	.502	.312404	.570
1.460	.500	.310000	.574
1.464	.476	.305404	.600
1.470	.476	.305404	.600
1.474	.474	.303020	.604
1.500	.472	.300444	.610
1.504	.470	.276100	.614
1.510	.470	.276100	.614
1.514	.466	.273544	.620
1.520	.464	.271220	.624

X2124S0201

Reciprocal table look-up values (continued)

B	A0	$A0^2$	$-2A_0$
1.524	.462	.266704	.630
1.530	.462	.266704	.630
1.534	.460	.264400	.634
1.540	.456	.262104	.640
1.544	.456	.262104	.640
1.550	.454	.257620	.644
1.554	.452	.255344	.650
1.560	.452	.255344	.650
1.564	.450	.253100	.654
1.570	.446	.250644	.660
1.574	.446	.250644	.660
1.600	.444	.246420	.664
1.604	.442	.244204	.670
1.610	.442	.244204	.670
1.614	.440	.242000	.674
1.620	.436	.237604	.700
1.624	.436	.237604	.700
1.630	.434	.235420	.704
1.634	.434	.235420	.704
1.640	.432	.233244	.710
1.644	.430	.231100	.714
1.650	.430	.231100	.714
1.654	.426	.226744	.720
1.660	.426	.226744	.720
1.664	.424	.224620	.724
1.670	.422	.222504	.730
1.674	.422	.222504	.730
1.700	.420	.220400	.734
1.704	.420	.220400	.734
1.710	.416	.216304	.740
1.714	.416	.216304	.740
1.720	.414	.214220	.744
1.724	.412	.212144	.750
1.730	.412	.212144	.750
1.734	.410	.210100	.754
1.740	.410	.210100	.754
1.744	.406	.206044	.760
1.750	.406	.206044	.760
1.754	.404	.204020	.764
1.760	.404	.204020	.764
1.764	.402	.202004	.770
1.770	.402	.202004	.770
1.774	.400	.200000	.774

X2124S0201

B_1

		2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	
		2^{-0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	2^{-16}	2^{-17}	2^{-18}	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	
	2^{-1}	E75	E77	E69	E68	E57	E67	E43	E42	E23	E41	E1	E0	D61	D60	D31	D30	D1	D0	F61	F60	F31	F30	F1	F0	
	2^{-2}		E76	E71	E70	E59	E58	E45	E44	E25	E24	E3	E2	D63	D62	D33	D32	D3	D2	F63	F62	F33	F32	F3	F2	
	2^{-3}			E73	E72	E61	E60	E47	E46	E27	E26	E5	E4	D65	D64	D35	D34	D5	D4	F65	F64	F35	F34	F5	F4	
	2^{-4}				E74	E63	E62	E49	E48	E29	E28	E7	E6	D67	D66	D37	D36	D7	D6	F67	F66	F37	F36	F7	F6	
	2^{-5}					E65	E64	E51	E50	E31	E30	E9	E8	D69	D68	D39	D38	D9	D8	F69	F68	F39	F38	F9	F8	
	2^{-6}						E66	E53	E52	E33	E32	E11	E10	D71	D70	D41	D40	D11	D10	F71	F70	F41	F40	F11	F10	
	2^{-7}							E55	E54	E35	E34	E13	E12	D73	D72	D43	D42	D13	D12	F73	F72	F43	F42	F13	F12	
$A0^2$	2^{-8}								E56	E37	E36	E15	E14	D75	D74	D45	D44	D15	D14	F75	F74	F45	F44	F15	F14	
	2^{-9}			3RB						E39	E38	E17	E16	D77	D76	D47	D46	D17	D16	F77	F76	F47	F46	F17	F16	3RA
	2^{-10}										E40	E19	E18	D79	D78	D49	D48	D19	D18	F79	F78	F49	F48	F19	F18	
	2^{-11}											E21	E20	D81	D80	D51	D50	D21	D20	F81	F80	F51	F50	F21	F20	
	2^{-12}												E22	D83	D82	D53	D52	D23	D22	F83	F82	F53	F52	F23	F22	
	2^{-13}													D85	D84	D55	D54	D25	D24	F85	F84	F55	F54	F25	F24	
	2^{-14}														D59	D57	D56	D27	D26	F87	F86	F57	F56	F27	F26	
	2^{-15}																									
	2^{-16}																D58	D29	D28	F89	F88	F59	F58	F29	F28	
																		1								
$\overline{2A0}$		2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	1	1	1	1	1	1	1	1		1	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	$\overline{2A0}$
																		7	6	5	4	3	2	1	0	(3RA) SUM BITS
		2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	2^{-16}	2^{-17}	2^{-18}	(3RC) SUM BIT						

$\overline{A1}$ →

A1 →

△1 $\overline{2A_0}$ IS ADDED INTO THE PYRAMID ON (3RA). THIS IS ADDED IN FOR ROUNDING PURPOSES AND DUE TO THE TRUNCATION ON THE (3RA) MODULE.

NOTE: * ONLY 8 BITS OF $2A_0$ ARE USED.
** WHEN LOOKING UP B0 ONLY, USE THE UPPER 8 BITS.
B0 = 2^{47}-2^{40}
B1 = 2^{47}-2^{24} } OF THE COEFFICIENT
B2 = 2^{47}-2^{11}

△2 DIAGONALLY FORM THE LOGICAL PRODUCTS. VERTICALLY SUM THE PYRAMID. SUM IS COMPLETED ON 3RC ONLY, RETAIN 2^{-1}-2^{-18} ON 3RC, CARRY IS LOST.

C-1314E
X2000S0110

CRAY X-MP FLOATING RECIPROCAL A1 PYRAMID

	2^{47} 2^{-0}	2^{46} 2^{-1}	2^{45} 2^{-2}	2^{44} 2^{-3}	2^{43} 2^{-4}	2^{42} 2^{-5}	2^{41} 2^{-6}	2^{40} 2^{-7}	2^{39} 2^{-8}	2^{38} 2^{-9}	2^{37} 2^{-10}	2^{36} 2^{-11}	2^{35} 2^{-12}	2^{34} 2^{-13}	2^{33} 2^{-14}	2^{32} 2^{-15}	2^{31} 2^{-16}	2^{30} 2^{-17}	2^{29} 2^{-18}	2^{28} 2^{-19}	2^{27} 2^{-20}	2^{26} 2^{-21}	2^{25} 2^{-22}	2^{24} 2^{-23}	
												*F51	*F41	*F31	*F21	*F11	*F01	*G51	*G41	*G31	*G21	*G11	*G01	G00	
3 RB												*F53	*F43	*F33	*F23	*F13	*F03	*G53	*G43	*G33	*G23	*G13	*G03	G02	3 RA
T.S. 11/13												*F55	*F45	*F35	*F25	*F15	*F05	*G55	*G45	*G35	*G25	*G15	*G05	G04	T.S. 7/8
												*F57	*F47	*F37	*F27	*F17	*F07	*G57	*G47	*G37	*G27	*G17	*G07	G06	
													*F49	*F39	*F29	*F19	*F09	*G59	*G49	*G39	*G29	*G19	*G09	G08	
													F50	F40	F30	F20	F10	R06	G50	G40	G30	G20	G10	R00	
													F52	F42	F32	F22	F12	F00	G52	G42	G32	G22	G12		
													F54	F44	F34	F24	F14	F02	G54	G44	G34	G24	G14		
													F56	F46	F36	F26	F16	F04	G56	G46	G36	G26	G16		
													D85	F48 (circled)	F38 (circled)	F28	F18	F06	G58	G48	G38	G28	G18		
																		F08	R05	R04	R03				
	*G100	*G97	*G93	*G89	*G84	*G78	*G72	*G66	*G59	*G51	*G40	*G33	*G26	*G19	*G12	*G05	*H41	*H33	*H25	*H17	*H11	*H05	*H01	H00	
3 RB	G101	G99	G96	*G91	*G86	*G80	*G74	*G68	*G61	*G53	*G42	*G35	*G28	*G21	*G14	*G07	*H43	*H35	*H27	*H19	*H13	*H07	*H03	H02	3 RA
T.S. 16/0	G102		G98	G92	G88	G83	*G76	*G70	*G63	*G55	*G44	*G37	*G30	*G23	*G16	*G09	*G01	*H37	*H29	*H21	*H15	*H09	H04		T.S. 11/13
				G94	G90	G85	G77	G71	G65	*G57	*G46	G39	G32	G25	G18	G11	*G03	*H39	*H31	*H23	H16	H10	H06		
				G95		G87	G79	G73	G67	G58	*G48	G41	G34	G27	G20	G13	G04	H40	H32	H24	H18	H12	H08		
							G81	G75 (circled)	G69	G60	G50	G43	G36	G29	G22	G15	G06	H42	H34	H26	H20	H14	R01		
							G82			G62	G52	G45	G38	G31	G24	G17	G08	G00	H36	H28	H22	(G28)	(G18)		
										G64	G54	G47					G10	G02	H38	H30		R02			
											G56 (circled)	G49													
	(G100)	*H57	*H55	*H53	*H51	*H47	*H43	*H39	*H33	*H27	*H21	*H17	*H13	*H09	*H05	*R54	*R51	*J24	*J18	*J13	*J07	*J02	*J00		
3 RB	(G101)	(G97)	H56	H54	H52	*H49	*H45	*H41	*H35	*H29	*H23	*H19	*H15	*H11	*H07	*H01	*R52	*J26	*J20	*J15	*J09	*J04	J01		3 RA
T.S.3/5	(G102)	(G99)		(G94)	(G90)	H50	H46	H42	*H37	*H31	*H25	H20	H16	H12	H08	*H03	R53 (circled)	J29	J23	J17	J12	J06	J03		T.S. 16/10
				(G95)		(G85)	H48	H44	H38	H32	H26	H22	H18	H14	H10	H04	H00	R50	J25	J19	J14	J08	J05		
						(G87)	(G82)		H40	H34	H28	H24	(G38)	(G31)	(G24)	H06	H02	(G00)	J27	J21	J16	J10			
										H36 (circled)	H30					(G17)	I51	(G02)	J28	J22		J11			
																I52		I50							

XX (circled) = FORCED SUM

(XX) = TERM DELAYED FROM PREVIOUS LEVEL OF SUMMATION

*XX = CARRY FROM PREVIOUS BIT POSITION

A-5135

A1 PYRAMID SUMMATION

	2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	
	2^{-0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	2^{-16}	2^{-17}	2^{-18}	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	
	(G100)	(H57)	*J45	*J43	*J41	(*J39)	*J37	*J33	*J29	*J25	*J21	*J17	*J13	*J09	*J05	*J03	*R55	*K13	*K09	*K07	*K03	*K01	K00		
3RB	(G101)	(G97)	(H55)	J44	J42	J40	J38	*J35	*J31	*J27	*J23	*J19	*J15	*J11	*J07	J04	*J01	*K15	*K11	K08	*K05	K02	(J05)		3RA
T.S. 7/9	(G102)	(G99)	(H56)	(G95)		(G85)	(H48)	J36	J32	J28	J24	J20	J16	J12	J08	J06	J02	K16	K12	K10	K06	K04			T.S. 3/5
						(G87)	(G82)	(H44)	(J34)	J30	J26	J22	J18	J14	J10		I53	J00	K14		(J14)				
																	I54				(J16)				
																	I55								
3RB	(G100)	(H57)	(J45)	(J43)	*K23	*K21	*K19	*K17	*K15	*K13	*K11	*K09	*K07	*K05	*K03	*K01	*R58	*R56	*L07	*L05	*L03	L02	L01		3RA
T.S. 11/13	(G101)	(G97)	(H55)	(J44)	(J41)	K22	K20	K18	K16	K14	K12	K10	K08	K06	K04	K02	K00	R57	L08	L06	L04				T.S. 7/9
	(G102)	(G99)	(H56)	(G95)	(J42)	(G85)	(H48)	(H44)	(J34)	(J30)	(J26)	(J22)	(J18)	(J14)	(J10)	K25	(K24)	(J00)	(K14)		(J14)				
																	I58	I56			(J16)				
																		I57							
*R35	*R33	*R31	*R29	*R27	*R25	*R23	*R21	*R19	*R17	*R15	*R13	*R11	*R09	*R07	*R05	*R03	*R01	R00	(L07)	*M03	M01				
3RB	R34	R32	R30	R28	R26	R24	R22	R20	R18	R16	R14	R12	R10	R08	R06	R04	R02		(L08)	(L05)	M02				3RA
T.S. 16/0																			(K14)	(L06)	(J16)				T.S. 11/13
																		*R64	*R62	*R60					3RA
																			R63	R61					T.S. 16/0
	I38	I36	I34	I32	I30	I28	I26	I24	I22	I20	I18	I16	I14	I12	I10	I08	I06	I04	I02	I00					3RC
	I39	I37	I35	I33	I31	I29	I27	I25	I23	I21	I19	I17	I15	I13	I11	I09	I07	I05	I03	I01					2 BIT A
	A19	A18	A17	A16	A15	A14	A13	A12	A11	A10	A09	A08	A07	A06	A05	A04	A03	A02	A01						BIT ENABLE
		B18	B17	B16	B15	B14	B13	B12	B11	B10	B09	B08	B07	B06	B05	B04	B03	B02	B01	B00					BIT CARRYS
	C19	C18	C17	C16	C15	C14	C13	C12	C11	C10	C09	C08	C07	C06	C05	C04	C03	C02							PROPAGATED CODE
			D12	D11	D10	D09	D08	D07	D06	D05	D04	D03	D02	D01											GROUP ENABLE
														E04	E03	E02	E01	E00							SUM BITS
	E17	E16	E15	E14	E13	E12	E11	E10	E09	E08	E07	E06	E05												BIT ENABLE
	F17	F16	F15	F14	F13	F12	F11	F10	F09	F08	F07	F06	F05												BIT CARRYS
	G17'	G16'	G15'	G14'	G13'	G12'	G11'	G10'	G09'	G08'	G07'	G06'	G05'	G04'	G03'	G02'	G01'	G00'							FINAL SUM
	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	2^{-16}	2^{-17}	2^{-18}							A1

A-5136A

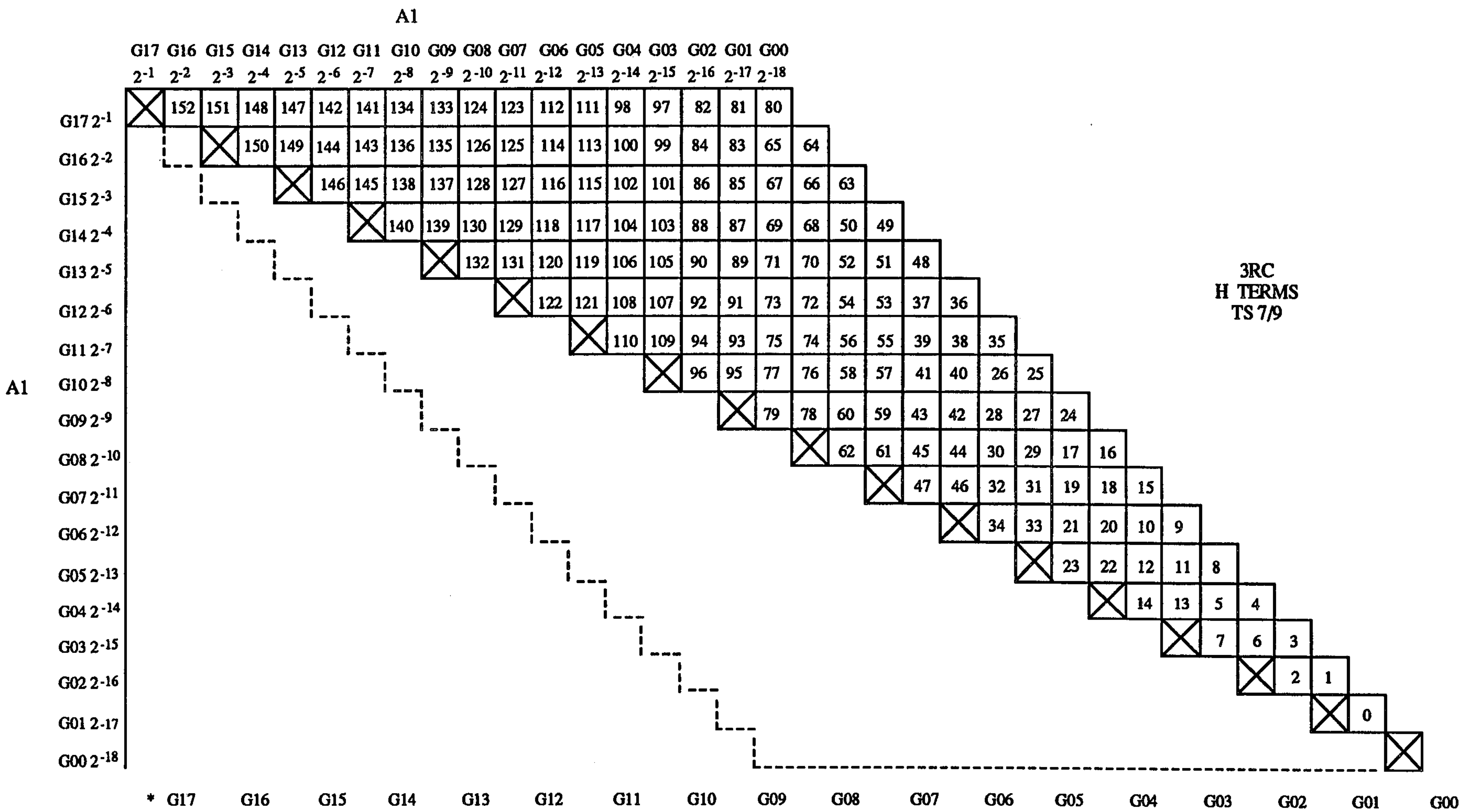
A1 PYRAMID SUMMATION

SYNC CHANNEL A T.P. $\overline{B38}$ 3RH @ E38/39
CHANNEL B 3RC @ E12/13 AT THE SAME TIME .005

	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	2^{-16}	2^{-17}	2^{-18}
TEST POINT			B04	B03	B01	B02	C03	D65	D14	D54	A11	D20	D26	D11	D03	C67	C58	C72
$\overline{A1}$	0	X																
A1	1	X																

A-1308C

A1 SCOPE CHART



* NOTE: To compensate for creating only half of the pyramid, the G terms are brought into the summation right shifted one place and then every other bit position.

A-5222A

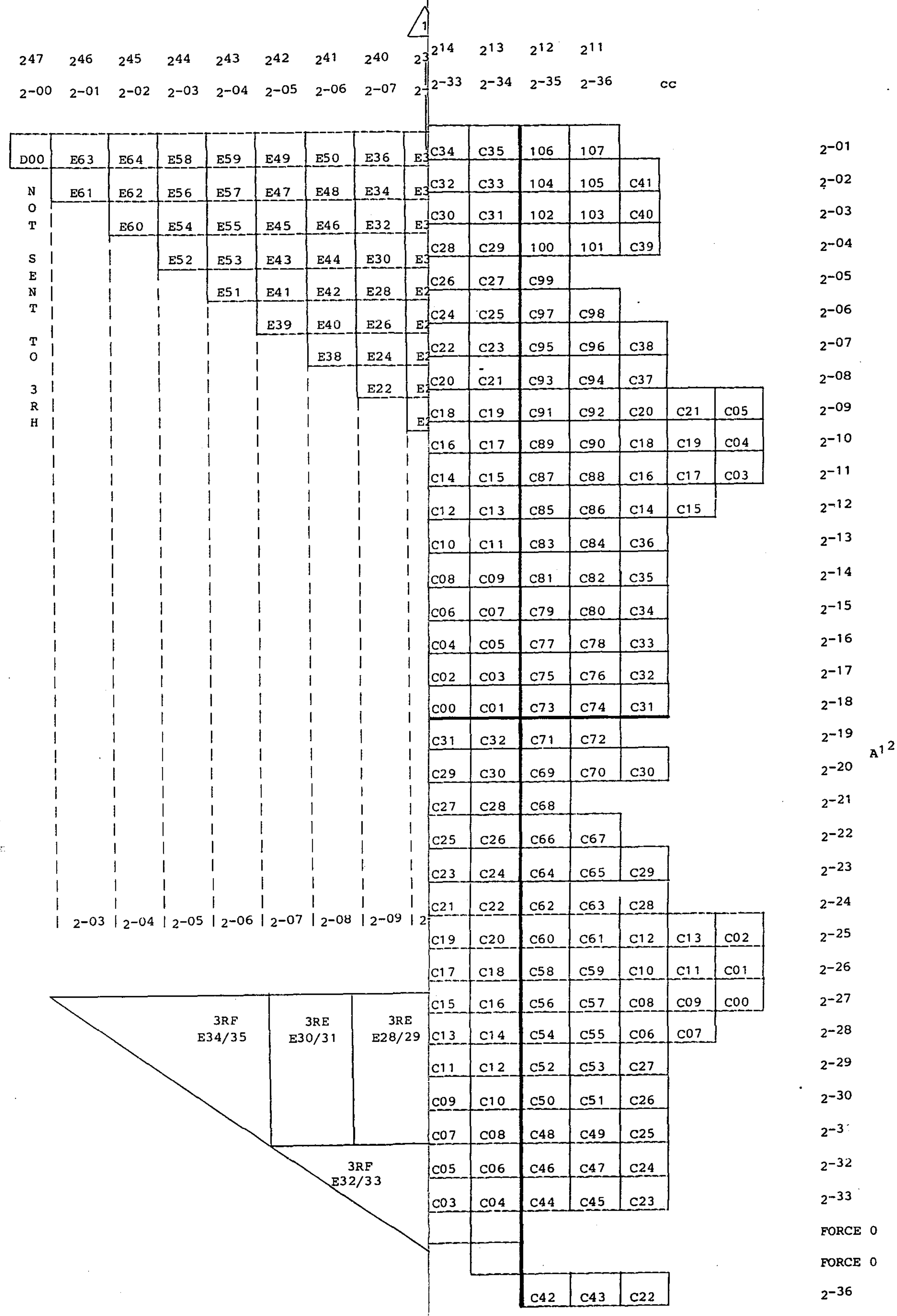
CRAY X-MP A1 SQUARED PYRAMID

	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	2^{-16}	2^{-17}	2^{-18}
3RC T.S. 11/13		(H152) (G17)	•J91 (H151)	J90	•J89 (H147) (H149)	•J87 J88 (G15)	•J85 J86	•J83 J84 (H140) (G14)	•J79 •J81 J82 (H139)	•J77 J78 J80	•J73 •J75 J76 (H129) (H131)	•J69 •J71 J72 J74 (G12)	•J65 •J67 J68 J70	•J61 •J63 J64 J66 (H110) (G11)	•J55 •J57 •J59 J60 J62 (H109)	•J51 •J53 J54 J56 J58	•J45 •J47 •J49 J50 J52 H93 H95	•J41 •J43 J44 J46 J48 (G9)
3RC T.S. 16/0		R115 R116	R113 R114	•R111 R112	•R109 R110	R108	•R104 R106 R107	•R101 R103 R105	•R99 R100 R102	•R95 R98	•R91 R94 R96 R97	•R88 R90 R92 R93	•R84 •R86 R87 R89	•R80 •R82 R83 R85	•R76 R79 R81	•R71 •R73 R75 R77 R78	•R67 •R69 R70 R72 R74	•R62 •R64 R66 R68
3RD T.S. 5		I95 I96	I93 I94	I91 I92	I89 I90	I88	I84 I86 I87	I81 I83 I85	I79 I80 I82	I75 I78	I71 I74 I76 I77	I68 I70 I72 I73	I64 I66 I67 I69	I60 I62 I63 I65	I56 I59 I61	I51 I53 I55 I57 I58	I47 I49 I50 I52 I54	I42 I44 I46 I48
3RD T.S. 7/9		(I95) (I96)	(I93) (I94)	(I91) (I92)	(I89) (I90)	(I88)	(I84) (I86) (I87)	(I81) (I83) (I85)	(I79) (I80) (I82)	•A33 (I75) (I78)	•A31 A32 (I77)	•A29 A30 (I73)	•A27 A28 (I69)	•A25 A26 (I60)	•A23 A24	•A21 A22 (I57) (I58)	•A19 A20 (I52) (I54)	•A15 •A17 A18 (I48)
3RD T.S. 11/13		(I95) (I96)	(I93) (I94)	(I91) (I92)	(I89) (I90)	•B47 (I88)	•B45 B46	•B43 B44	•B41 B42	•B39 B40	•B37 B38	•B35 B36	•B33 B34	B32	•B31 (A28) (A24)	•B29 B30 (A21)	•B27 B28 (A19)	•B25 B26 (A17)
3RD T.S. 16/0		C61 C62	C59 C60	C57 C58	C55 C56	C53 C54	C51 C52	C49 C50	C47 C48	C45 C46	C43 C44	C41 C42	C39 C40	•C37 C38	•C35 C36	•C33 C34	•C31 C32	•C29 C30
3RD T.S. 3/5 ENABLES		E34	E33	E32	E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18
CARRIES		F34	F33	F32	F31	F30	F29	F28	F27	F26	F25	F24	F23	F22	F21	F20	F19	F18
T.S. 7/9 PROPAGATED CARRIES	G35	G34	G33	G32	G31	G30	G29	G28	G27	G26	G25	G24	G23	G22	G21	G20	G19	G18
GROUP ENABLES		H34	H33	H32	H31	H30	H29	H28	H27	H26	H25	H24	H23	H22	H21	H20	H19	H18
T.S. 11/13 GROUP CARRIES					J03						J02						J01	
PARTIAL SUM		L34	L33	L32	L31	L30	L29	L28	L27	L26	L25	L24	L23	L22	L21	L20	L19	L18
T.S. 16/0 FINAL SUM	R35	R34	R33	R32	R31	R30	R29	R28	R27	R26	R25	R24	R23	R22	R21	R20	R19	R18
	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	2^{-16}	2^{-17}	2^{-18}

	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	2^{-24}	2^{-25}	2^{-26}	2^{-27}	2^{-28}	2^{-29}	2^{-30}	2^{-31}	2^{-32}	2^{-33}	2^{-34}	2^{-35}	2^{-36}
3RC T.S. 11/13	•J35 •J37 •J39 J40 J42 (H76) (H78)	•J31 •J33 J34 J36 J38	•J27 •J29 J30 J32 (H61)	•J23 •J25 J26 J28 (H48) (G7)	•J19 •J21 J22 J24	•J17 J18 J20 (G06)	•J13 •J15 J16 (H31) (H33)	•J11 J12 J14	•J09 J10 (H22)	•J07 J08 (H15) G04	•J05 J06	J04 G03	(H04) (H06) •J03	J02	•J01 (H01)	H00 G01		G00
3RC T.S. 16/0	•R58 •R60 R61 R63 R65	•R54 •R56 R57 R59	•R50 •R52 R53 R55	•R47 R49 R51	•R44 R46 R48	•R40 R43 R45	•R38 R39 R41 R42	•R36 R37	•R33 R35	R32 R34	R30 R31	•R27 R28 R29	R26	•R24 R25	R23			R20
3RD T.S. 5	I38 I40 I41 I43 I45	I34 I36 I37 I39	I30 I32 I33 I35	I27 I29 I31	I24 I26 I28	I20 I23 I25	I18 I19 I21 I22	I16 I17	I13 I15	I12 I14	I10 I11	I07 I08 I09	I06	I04 I05	I03			I00
3RD T.S. 7/9	•A13 A14 A16	•A11 A12 (I39)	•A09 A10 (I35)	•A07 A08	•A05 A06	•A03 A04	A02 (I22)	(I16) (I17)	(I13) (I15)	(I12) (I14)	(I10) (I11)	(I07) (I08) (I09)	•A1 (I06)	A0	(I03)			(I00)
3RD T.S. 11/13	•B23 B24	•B21 B22	•B19 B20	•B17 B18	•B15 B16	•B13 B14	•B11 B12	•B09 B10	•B07 B08	•B05 B06	•B03 B04	•B01 B02	B00	(A0)	(I03)			(I00)
3RD T.S. 16/0	•C27 C28	•C25 C26	•C23 C24	•C21 C22	•C19 C20	•C17 C18	•C15 C16	•C13 C14	•C11 C12	•C09 C10	•C07 C08	C06	C05	C04	C03			C00
3RD T.S. 3/5 ENABLES	E17	E16	E15	E14	E13	E12	E11	E10	E09	E08	E07							
CARRIES	F17	F16	F15	F14	F13	F12	F11	F10	F09	F08	F07							
T.S. 7/9 PROPAGATED CARRIES	G17	G16	G15	G14	G13	G12	G11	G10	G09	G08								
GROUP ENABLES	H17	H16	H15	H14	H13													
T.S. 11/13 GROUP CARRIES					J00													
PARTIAL SUM	L17	L16	L15	L14	L13	L12	L11	L10	L09	L08	L07							
T.S. 16/0 FINAL SUM	R17	R16	R15	R14	R13	R12	R11	R10	R09	R08	R07	R06	R05	R04	R03			R00
	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	2^{-24}	2^{-25}	2^{-26}	2^{-27}	2^{-28}	2^{-29}	2^{-30}	2^{-31}	2^{-32}	2^{-33}	2^{-34}	2^{-35}	2^{-36}

A-5224A

A1^2 SUMMATION



C - 1315D
X2100C0205

$A1^2$ SCOPE CHART

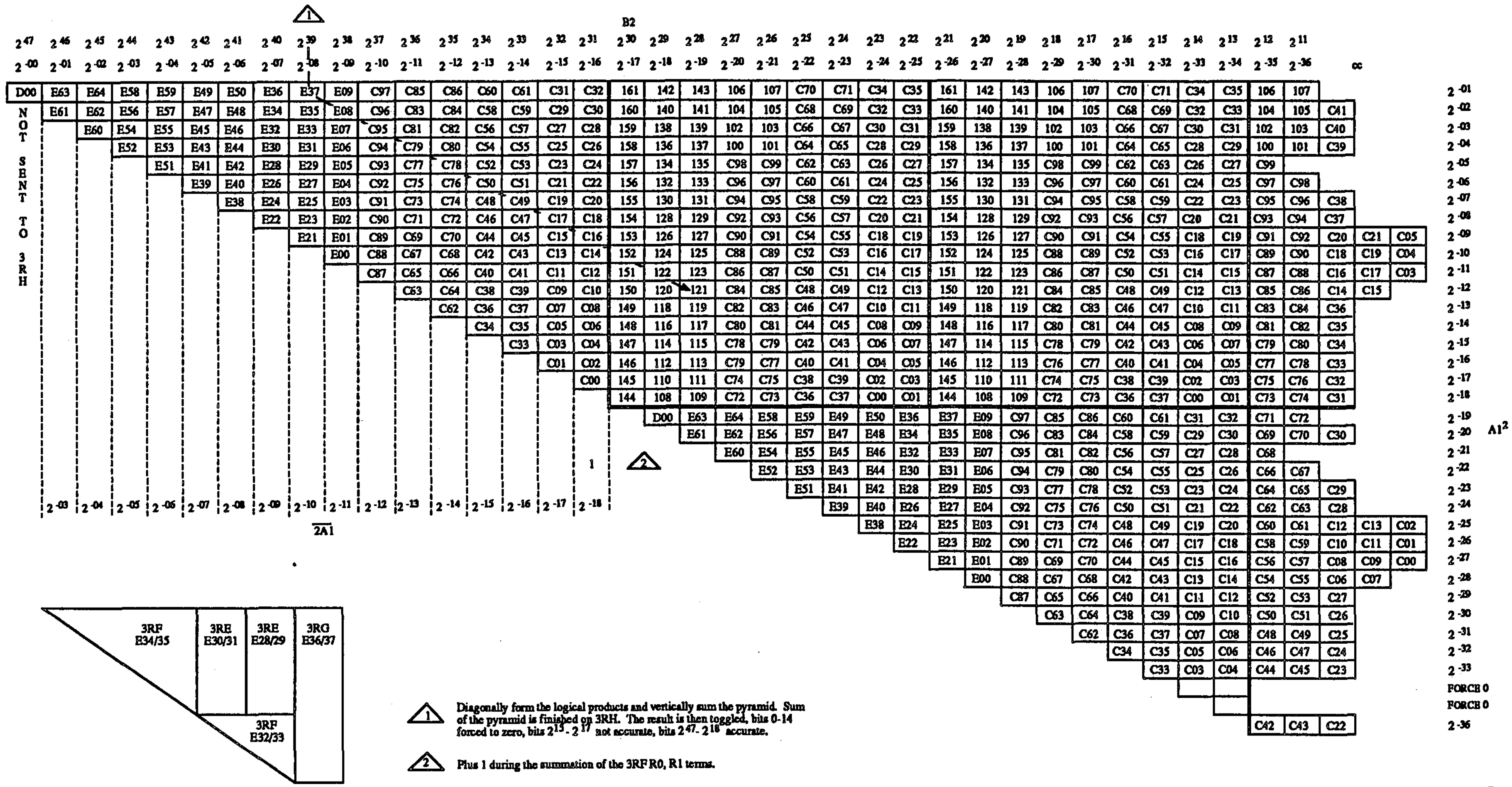
SYNC CHANNEL A T.P. $\overline{B24}$ 3RH @ E38/39
SCOPE CHANNEL B 3RD @ E14/15 AT THE SAME TIME

2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	2^{-16}	
$\overline{C32}$	$\overline{C52}$	$\overline{C58}$	$\overline{C54}$	$\overline{C3}$	$\overline{C4}$	$\overline{C2}$	$\overline{C1}$	$\overline{D54}$	$\overline{D53}$	$\overline{D17}$	$\overline{D18}$	$\overline{D72}$	$\overline{D65}$	$\overline{D71}$	$\overline{D70}$	
___,	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___	$\overline{A1^2}$
___,	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___	$A1^2$

2^{-17}	2^{-18}	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	2^{-24}	2^{-25}	2^{-26}	2^{-27}	2^{-28}	2^{-29}	2^{-30}	2^{-31}	2^{-32}	
$\overline{A40}$	$\overline{A7}$	$\overline{A6}$	$\overline{A38}$	$\overline{A39}$	$\overline{A1}$	$\overline{B69}$	$\overline{B70}$	$\overline{B72}$	$\overline{B71}$	$\overline{B68}$	$\overline{B66}$	$\overline{B67}$	$\overline{B65}$	$\overline{B41}$	$\overline{B39}$	
___,	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___	$\overline{A1^2}$
___,	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___	$A1^2$

2^{-33}	2^{-34}	2^{-35}	2^{-36}	
$\overline{B53}$			$\overline{B52}$	
___,	1	1	___	$\overline{A1^2}$
___,	0	0	___	$A1^2$

A-1309A

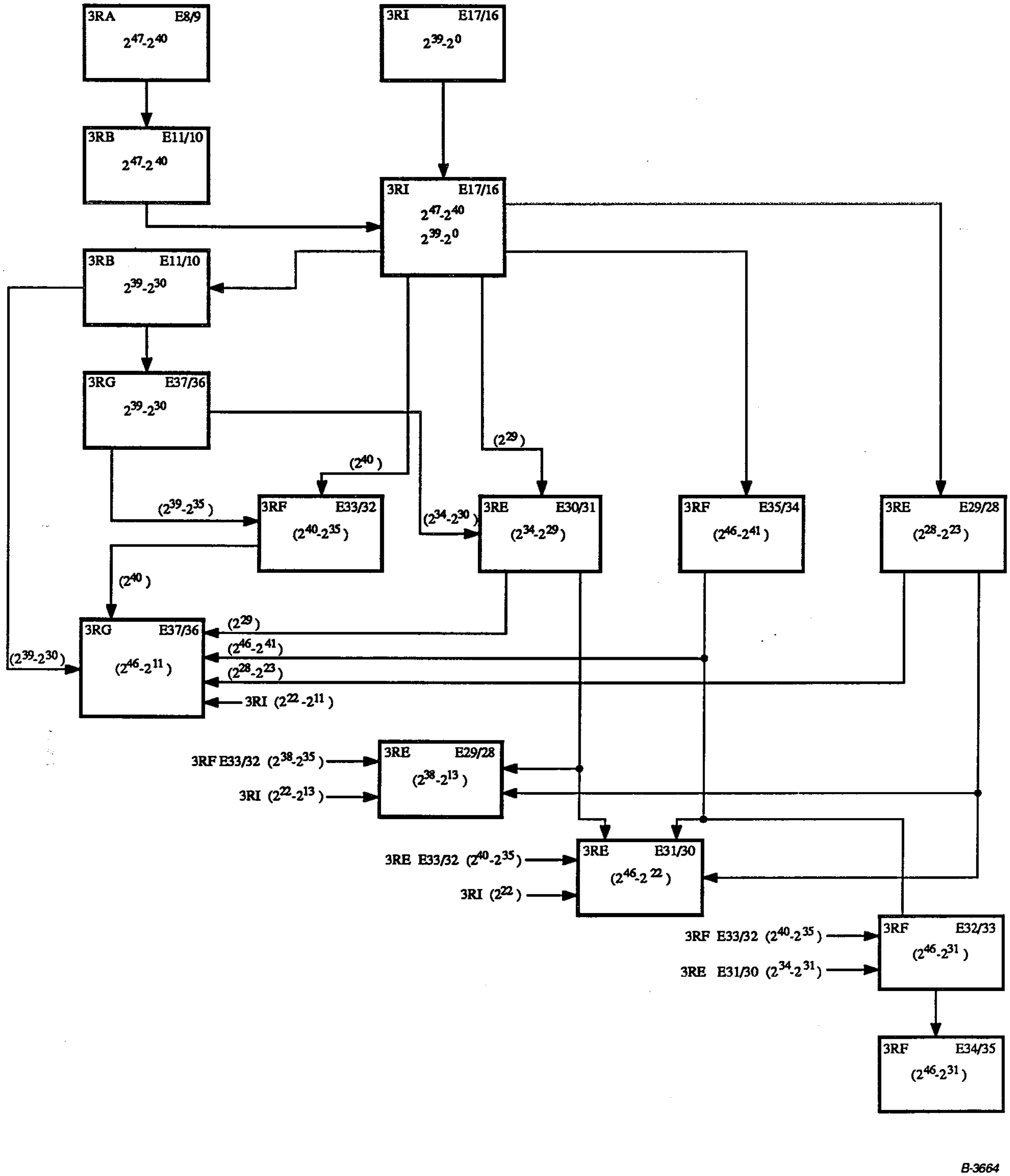


(1) Diagonally form the logical products and vertically sum the pyramid. Sum of the pyramid is finished on 3RH. The result is then toggled, bits 0-14 forced to zero, bits 2^{15} - 2^{17} not accurate, bits 2^{47}- 2^{18} accurate.

(2) Plus 1 during the summation of the 3RF R0, R1 terms.

C-1315E

CRAY X-MP/2 FLOATING RECIPROCAL A2 PYRAMID



CRAY X-MP/2 RECIPROCAL B2 FANOUTS

2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	
2^{-16}	2^{-17}	2^{-18}	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	2^{-24}	2^{-25}	2^{-26}	2^{-27}	2^{-28}	2^{-29}	2^{-30}	2^{-31}	2^{-32}	2^{-33}	2^{-34}	2^{-35}	2^{-36}	2^{-37}	2^{-38}	3RG @ E36/37
																		*D44	*D24	*D07	*D03	*D00	3RG
																		*D46	*D26	*D09	*D05	*D01	T.S. 11/13
																		*D48	*D28	*D11	D06	D02	
																		*D50	*D30	*D13	D08	D04	
																		*D52	*D32	*D15	D10	(C13)	
																		*D54	*D34	*D17	D12	(C21)	
																		*D56	*D36	*D19	D14		
																		*D58	*D38	*D21	D16		
																		*D60	*D40	*D22	D18		
																		*D62	*D42	D23	D20		
																		*D64	D43	D25	(C36)		
																			D45	D27			
																			D47	D29			
																			D49	D31			
																			D51	D33			
																			D53	D35			
																			D55	D37			
																			D57	D39			
																			D59	D41			
																			D61	(C105)			3RG
																			D63	(C107)			T.S. 16/0
																			(C106)				
																	*E38	*E23	*E09	*E03	*E00		
																	*E40	*E25	*E11	*E05	*E01		
																	*E42	*E27	*E13	*E06	E02		
																		*E29	*E15	*E07	E04		
																		*E31	*E17	E08			
																		*E33	*E19	E10			
																		*E35	*E21	E12			
																		E37	E22	E14			
																		E39	E24	E16			
																		E41	E26	E18			
																		E43	E28	E20			
																		E44	E30				
																			E32				
																			E34				
																			E36				

A-5214

A2 PYRAMID SUMMATION

2^{31} 2^{-16}	2^{30} 2^{-17}	2^{29} 2^{-18}	2^{28} 2^{-19}	2^{27} 2^{-20}	2^{26} 2^{-21}	2^{25} 2^{-22}	2^{24} 2^{-23}	2^{23} 2^{-24}	2^{22} 2^{-25}	2^{21} 2^{-26}	2^{20} 2^{-27}	2^{19} 2^{-28}	2^{18} 2^{-29}	2^{17} 2^{-30}	2^{16} 2^{-31}	2^{15} 2^{-32}	2^{14} 2^{-33}	2^{13} 2^{-34}	2^{12} 2^{-35}	2^{11} 2^{-36}	2^{10} 2^{-37}	2^{9} 2^{-38}	3RG @ E36/37
																*F29	*F21	*F11	*F03	*F01	F00		3RG
																	*F23	*F13	*F05	F02	(E04)		T.S. 3/5
																	*F25	*F15	*F07	F04			
																	*F27	*F17	*F09	(F06)			
																	F28	*F19	F10	F08			
																		F20	F12				
																		F22	F14				
																		F24	F16				
																		F26	F18				
																*G18	*G12	*G06	*G02	*G00			3RG
																*G20	*G14	*G08	*G04	G01			T.S. 7/9
																(F29)	*G16	*G10	G05	G03			
																	G17	G11	G07				
																	G19	G13	G09				I TERMS ARE FROM
																	I84	G15					I80, I82, I84, I86, I88, I90
																	I85	I80					3RE @ E28/29
																	I86	I81					I81, I83, I85, I87
																	I87	I82					3RF @ E32/33
																		I83					
							I97	I94	I92						*H18	*H12	*H06	*H02	*H00				3RG
							I98	I95	I93							*H14	*H08	*H04	H01				T.S. 11/13
							I99	I96								*H16	*H10	H05	H03				
																H17	H11	H07					
																I88	H13	H09					I TERMS FROM 3RE's AND
																I89	H15	(I83)					3RF @ E32/33
																I90							
																I91							
						*J21	*J19	J18	J16						*J10	*J06	*J02	*J00					
							J20		J17						*J12	*J08	*J04	J01					3RG
															J15	J09	J05	J03					T.S. 16/0
																J11	J07						
																J13							
																J14							

A-5215

A2 PYRAMID SUMMATION

2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	
2^{-16}	2^{-17}	2^{-18}	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	2^{-24}	2^{-25}	2^{-26}	2^{-27}	2^{-28}	2^{-29}	2^{-30}	2^{-31}	2^{-32}	2^{-33}	2^{-34}	2^{-35}	2^{-36}	2^{-37}	2^{-38}	3RG @ E36/37
	I151	I148	I144	I140	I136	I133	I130	I126	I122	I118	I114	I110	I106	*K08	*K04	*K02	*K00						3RG
	I152	I149	I145	I141	I137	I134	I131	I127	I123	I119	I115	I111	I107	I102	*K06	K03	K01						T.S. 3/5
	I153	I150	I146	I142	I138	I135	I132	I128	I124	I120	I116	I112	I108	I103	K07	K05	(J07)						
		I154	I147	I143	I139	(J21)	(J19)	I129	I125														I TERMS FROM 3RE's 3RF's
							(J20)	(J18)	(J16)														
									(J17)														
	*L36	*L34	*L32	*L30	*L28	*L24	*L20	*L16	*L14	*L12	*L10	*L08	*L06	*L04	*L02	*L00							
	L37	L35	L33	L31	L29	*L26	*L22	*L18	L15	L13	L11	L09	L07	L05	L03	L01							3RG
		(I154)	(I147)	(I143)	(I139)	L27	L23	L19	L17	(I121)	(I117)	(I117)	(I109)	(I104)	(I100)								T.S. 7/9
						(J21)	L25	L21						(I105)	(I101)								
	*M29	*M27	*M25	*M23	*M21	*M19	*M17	*M15	*M13	*M11	*M09	*M07	*M05	*M03	*M01	M00							
	(L36)	M28	M26	M24	M22	M20	M18	M16	M14	M12	M10	M08	M06	M04	M02								3RG
	(L37)					(L27)	(L25)	(L21)						(LO5)	(L03)								T.S. 11/13
*R30	*R28	*R26	*R24	*R22	*R20	*R18	*R16	*R14	*R12	*R10	*R08	*R06	*R04	*R02	R01	R00							3RG
	R29	R27	R25	R23	R21	R19	R17	R15	R13	R11	R09	R07	R05	R03									T.S. 16/0

A2 PYRAMID SUMMATION

A-5216

2^{-01}	2^{-00}	2^{-01}	2^{-02}	2^{-03}	2^{-04}	2^{-05}	2^{-06}	2^{-07}	2^{-08}	2^{-09}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	2^{-16}	2^{-17}	3 RF @ E34/35
2^{-17}	2^{18}	2^{-19}	2^{20}	2^{-21}	2^{-22}	2^{-23}	2^{-24}	2^{-25}	2^{-26}	2^{-27}	2^{-28}	2^{-29}	2^{-30}	2^{-31}	2^{32}	2^{33}	2^{-34}	2^{-35}	3 RF @ E32/33
		I57	I56	I55	I54	I53	I52	I51	I50	I49	I48	I47	I46	I43	I44	I41	I40		2A1 FROM 3RC SUM BITS FROM 3RE
															I45	I42			
										*F61	*F53	*F45	*F35	*F25	*F13	*F01	F00		
										*F63	*F55	*F47	*F37	*F27	*F15	*F03	F02		3 RF
										*F65	*F57	*F49	*F39	*F29	*F17	*F05	F04		T.S. 11/13
										*F67	*F59	*F51	*F41	*F31	*F19	*F07	F06		
											F60	F52	*F43	*F33	*F21	*F09	F08		
											F62	F54	F44	F34	*F23	*F11	F10		
											F64	F56	F46	F36	F24	F12			
											F66	F58	F48	F38	F26	F14			
													F50	F40	F28	F16			
													(C86)	F42	F30	F18			
															F32	F20			
																F22			
	*G94	*G91	*G87	*G83	*G78	*G72	*G66	*G59	*G49	*G43	*G37	*G29	*G22	*G13	*G05	*G01	G00		
	G95	G93	G90	*G85	*G80	*G74	*G68	*G61	*G51	*G45	*G39	*G31	*G24	*G15	*G07	*G03	G02		3RF
			G92	G86	G82	G77	*G70	*G63	*G53	G48	*G41	*G33	*G26	*G17	*G09	G04			T.S. 16/0
				G88	G84	G79	G71	G65	*G55	G50	G42	G36	G28	*G19	*G11	G06			
				G89		G81	G73	G67	*G57	G52	G44	G38	G30	G21	G12	G08			
							G75	G69	G58	G54	G46	G40	G32	G23	G14	G10			
							G76		G60	G56	G47		G34	G25	G16				
									G62				G35	G27	G18				
									G64						G20				

A-5137

A2 PYRAMID SUMMATION

2^{01} 2^{-17}	2^{-00} 2^{-18}	2^{-01} 2^{-19}	2^{-02} 2^{-20}	2^{-03} 2^{-21}	2^{-04} 2^{-22}	2^{-05} 2^{-23}	2^{-06} 2^{-24}	2^{07} 2^{-25}	2^{-08} 2^{-26}	2^{-09} 2^{-27}	2^{-10} 2^{-28}	2^{-11} 2^{-29}	2^{-12} 2^{-30}	2^{-13} 2^{-31}	2^{-14} 2^{-32}	2^{-15} 2^{-33}	2^{-16} 2^{34}	2^{-17} 2^{-35}	3RF @ E34/35 3RF @ E32/33
																R42	R40	I60	
																R43	R41	I61	
															I65	I64	I63	I62	3RF TS 3/5
	(G94)	*H55	*H53	*H51	*H49	*H45	*H41	*H35	*H31	*H27	*H23	*H17	*H11	*H05	*H01	H00			
	(G95)	(G91)	H54	H52	H50	*H47	*H43	*H37	*H33	*H29	*H25	*H19	*H13	*H07	*H03	H02			
		(G93)		(G88)	(G84)	H48	H44	*H39	H34	H30	H26	*H21	*H15	*H09	H04				
				(G89)		(G79)	H46	H40	H36	H32	H28	H22	H16	H10	H06				
						(G81)	(G76)	H42	H38	(G56)	(G47)	H24	H18	H12	H08				
													H20	H14					
															R44	I67	I66		3RF TS 7/9
															R45				
	*J48	J47	*J46	*J44	*J40	*J36	*J32	*J28	*J24	*J22	*J18	*J14	*J10	*J06	*J04	*J02	*J00		
	(G94)		(H53)	J45	*J42	*J38	*J34	*J30	*J26	J23	*J20	*J16	*J12	*J08	J05	J03	J01		
	(G95)		(H54)	(H52)	J43	J39	J35	J31	J27	J25	J21	J17	J13	J09	J07				
						J41	J37	J33	J29		(H26)	J19	J15	J11					
											(H28)								
*K33	K32	*K31	*K29	*K27	*K25	*K23	*K21	*K19	*K17	*K13	*K11	*K09	*K07	*K05	*K03	*K01	K00		
		(J47)	K30	K28	K26	K24	K22	K20	K18	*K15	K12	K10	K08	K06	K04	K02			3RF TS 11/13
						(J41)	(J37)	(J33)	(J29)	K16	K14	(J19)	(J15)	(J11)					
R33	*R31												*R35	R34					
	R32	*R29	*R27	*R25	*R23	*R21	*R19	*R17	*R15	*R13	*R11	*R09	*R07	*R05	*R03	*R01	R00		3RF TS 16/0
		R30	R28	R26	R24	R22	R20	R18	R16	R14	R12	R10	R08	R06	R04	R02			

R00 FORCES A SUM INTO THE SUMMATION

A-5138

A2 PYRAMID SUMMATION

2^{-23}	2^{-24}	2^{-25}	2^{-26}	2^{-27}	2^{-28}	2^{-29}	2^{-30}	2^{-31}	2^{-32}	2^{-33}	2^{-34}	3 RE @ E28/29
2^{-14}	2^{-15}	2^{-16}	2^{-17}	2^{-18}	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	2^{-24}	2^{-25}	3RE @ E30/31
		*D97	*D85	*D73	*D61	*D49	*D37	*D25	*D13	*D01	D00	3RE
		*D99	*D87	*D75	*D63	*D51	*D39	*D27	*D15	*D03	D02	T.S. 11/13
		*D101	*D89	*D77	*D65	*D53	*D41	*D29	*D17	*D05	D04	
		*D103	*D91	*D79	*D67	*D55	*D43	*D31	*D19	*D07	D06	
		*D105	*D93	*D81	*D69	*D57	*D45	*D33	*D21	*D09	D08	
		*D107	*D95	*D83	*D71	*D59	*D47	*D35	*D23	*D11	D10	
			D96	D84	D72	D60	D48	D36	D24	D12		
			D98	D86	D74	D62	D50	D38	D26	D14		
			D100	D88	D76	D64	D52	D40	D28	D16		
			D102	D90	D78	D66	D54	D42	D30	D18		
			D104	D92	D80	D68	D56	D44	D32	D20		
			D106	D94	D82	D70	D58	D46	D34	D22		
	*E69	*E61	*E53	*E45	*E37	*E29	*E21	*E13	*E05	*E01	E00	
	*E71	*E63	*E55	*E47	*E39	*E31	*E23	*E15	*E07	*E03	E02	3 RE
		*E65	*E57	*E49	*E41	*E33	*E25	*E17	*E09	E04		T.S. 16/0
		*E67	*E59	*E51	*E43	*E35	*E27	*E19	*E11	E06		
		E68	E60	E52	E44	E36	E28	E20	E12	E08		
		E70	E62	E54	E46	E38	E30	E22	E14	E10		
			E64	E56	E48	E40	E32	E24	E16	R42	R40	
			E66	E58	E50	E42	E34	E26	E18	R43	R41	
	*F31	*F27	*F23	*F19	*F15	*F11	*F07	*F03	*F00			
	*F33	*F29	*F25	*F21	*F17	*F13	*F09	*F05	*F01			3 RE
	(E69)	F30	F26	F22	F18	F14	F10	F06	F02			T.S. 3/5
		F32	F28	F24	F20	F16	F12	F08	F04			
			(E64)	(E56)	E48	(E40)	(E32)	(E24)	(E16)			
	R44		(E66)	(E58)	E50	(E42)	(E34)	(E26)	(E18)			

A-5133

A2 PYRAMID SUMMATION

2^{-23}	2^{-24}	2^{-25}	2^{-26}	2^{-27}	2^{-28}	2^{-29}	2^{-30}	2^{-31}	2^{-32}	2^{-33}	2^{-34}	3 RE @ E28/29
2^{-14}	2^{-15}	2^{-16}	2^{-17}	2^{-18}	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	2^{-24}	2^{-25}	3 RE @ E30/31
*R47	*G27	*G23	*G19	*G15	*G11	*G07	*G03	*G00	R45			3RE
	G28	*G25	*G21	*G17	*G13	*G09	*G05	*G01	R46			T.S. 7/9
		G26	G22	G18	G14	G10	G06	G02				
		(F32)	G24	G20	G16	G12	G08	G04				
	*H13	*H11	*H09	*H07	*H05	*H03	*H01	H00				
	(G27)	H12	H10	H08	H06	H04	H02	(G04)				3RE
	(G28)	(G26)	(G24)	(G20)	(G16)	(G12)	(G08)					T.S. 11/13
*R15	*R13	*R11	*R09	*R07	*R05	*R03	*R01	R00				3RE
	R14	R12	R10	R08	R06	R04	R02					T.S. 16/0

A-5134

A2 PYRAMID SUMMATION

2^{47} 2^{-01}	2^{46} 2^{-02}	2^{45} 2^{-03}	2^{44} 2^{-04}	2^{43} 2^{-05}	2^{42} 2^{-06}	2^{41} 2^{-07}	2^{40} 2^{-08}	2^{39} 2^{-09}	2^{38} 2^{-10}	2^{37} 2^{-11}	2^{36} 2^{-12}	2^{35} 2^{-13}	2^{34} 2^{-14}	2^{33} 2^{-15}	2^{32} 2^{-16}	2^{31} 2^{-17}	2^{30} 2^{-18}	2^{29} 2^{-19}	2^{28} 2^{-20}	2^{27} 2^{-21}	2^{26} 2^{-22}	2^{25} 2^{-23}	2^{24} 2^{-24}	2^{23} 2^{-25}	2^{22} 2^{-26}	2^{21} 2^{-27}	2^{20} 2^{-28}	2^{19} 2^{-29}	2^{18} 2^{-30}	2^{17} 2^{-31}	2^{16} 2^{-32}	2^{15} 2^{-33}	
	I60	I58	I56	I54	I52	I50	I48	I46	I44	I42	I40	I38	I36	I34	I32	I30	I28	I26	I24	I22	I20	I18	I16	I14	I12	I10	I08	I06	I04	I02	I01	I00	3RH @ E38/39
	I61	I59	I57	I55	I53	I51	I49	I47	I45	I43	I41	I39	I37	I35	I33	I31	I29	I27	I25	I23	I21	I19	I17	I15	I13	I11	I09	I07	I05	I03			
	A31	A30	A29	A28	A27	A26	A25	A24	A23	A22	A21	A20	A19	A18	A17	A16	A15	A14	A13	A12	A11	A10	A09	A08	A07	A06	A05	A04	A03	A02	A01	A00	ENABLES T.S. 7/9
		B30	B29	B28	B27	B26	B25	B24	B23	B22	B21	B20	B19	B18	B17	B16	B15	B14	B13	B12	B11	B10	B09	B08	B07	B06	B05	B04	B03	B02			CARRIES T.S. 7/9
		C30	C29	C28	C27	C26	C25	C24	C23	C22	C21	C20	C19	C18	C17	C16	C15	C14	C13	C12	C11	C10	C09	C08	C07	C06	C05	C04	C03				PROPAGATED CARRIES T.S. 11/13
							D03						D02						D01														GROUP ENABLE
	E31	E30	E29	E28	E27	E26	E25	E24	E23	E22	E21	E20	E19	E18	E17	E16	E15	E14	E13	E12	E11	E10	E09	E08	E07	E06	E05	E04	E03	E02	E01	E00	PARTIAL SUMS T.S. 16/0
						F03						F02						F01						F00									GROUP CARRY
	G31	G30	G29	G28	G27	G26	G25	G24	G23	G22	G21	G20	G19	G18	G17	G16	G15	G14	G13	G12	G11	G10	G09	G08									ENABLES T.S. 16/0
P15	H31	H30	H29	H28	H27	H26	H25	H24	H23	H22	H21	H20	H19	H18	H17	H16	H15	H14	H13	H12	H11	H10	H09	H08	H07	H06	H05	H04	H03	H02	H01	H00	FINAL SUM T.S. 7/9
R32	R31	R30	R29	R28	R27	R26	R25	R24	R23	R22	R21	R20	R19	R18	R17	R16	R15	R14	R13	R12	R11	R10	R09	R08	R07	R06	R05	R04	R03	R02	R01	R00	COEFFICIENT OUTPUT T.S. 16/0

A-5217

FINAL SUMMATION

SYNC CHANNEL A T.P. $\overline{\text{B23}}$ 3RH @ E38/39
SCOPE CHANNEL B AT PLUS 1 CLOCK PERIOD ON 3RH @ E38/39

2^{63}	2^{62}	2^{61}	2^{60}	2^{59}	2^{58}	2^{57}	2^{56}	2^{55}	2^{54}	2^{53}	2^{52}	2^{51}	2^{50}	2^{49}	2^{48}	
C33,	C20	C48	C17,	D5	D61	D24,	D63	A25	A20,	A29	A31	A11,	A10	B50	B49	TEST POINT
____,	____	____	____,	____	____	____,	____	____	____,	____	____	____,	____	____	____	

2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}	
A47,	C2	C13	C64,	C34	C35	D64,	C24	C1	C16,	D40	D39	D65,	D42	D1	D8	TEST POINT
____,	____	____	____,	____	____	____,	____	____	____,	____	____	____,	____	____	____	

2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	2^{15}	
D53,	D2	A45	A17,	A18	A48	A46,	B59	B51	B2,	B1	B6	B3,	B69	B62	B71,	B72,	TEST POINT
____,	____	____	____,	____	____	____,	____	____	____,	____	____	____,	____	____	____,	____,	

X2100S0202
A-1311C

FINAL SUM

ERROR CONDITION
TEST POINT, C36 J16 TERM EXPONENT OUT RANGE

B2 AFTER FANOUT

SFR LOCATION 1002

SYNC CHANNEL A T.P. $\overline{B24}$ (3RH) @ E38/39
SCOPE CHANNEL B 3RG @ E36/37 AT THE SAME TIME

2^{-00}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}	
	$\overline{A57}$	$\overline{B70}$	$\overline{B52}$	$\overline{B51}$	$\overline{A51}$	$\overline{A49}$	$\overline{A52}$	$\overline{B49}$	$\overline{A16}$	$\overline{A20}$	$\overline{A27}$	$\overline{A23}$	A21	$\overline{A29}$	$\overline{A14}$	
	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___	$\overline{B2}$
1,	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___	B2

2^{-16}	2^{-17}	2^{-18}	2^{-19}	2^{-20}	2^{-21}	2^{-22}	2^{-23}	2^{-24}	2^{-25}	2^{-26}	2^{-27}	2^{-28}	2^{-29}	2^{-30}	2^{-31}
$\overline{A18}$	$\overline{A38}$	$\overline{A2}$	$\overline{A4}$	$\overline{A25}$	$\overline{D40}$	$\overline{D38}$	$\overline{D33}$	$\overline{D31}$	$\overline{D52}$	$\overline{D50}$	$\overline{D35}$	$\overline{D37}$	C4	$\overline{C31}$	$\overline{C50}$
___,	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___
___,	___	___	___,	___	___	___,	___	___	___,	___	___	___,	___	___	___

2^{-32}	2^{-33}	2^{-34}	2^{-35}	2^{-36}	
$\overline{C10}$	$\overline{C29}$	$\overline{C12}$	$\overline{C27}$	$\overline{C23}$	
___,	___	___	___,	___	$\overline{B2}$
___,	___	___	___,	___	B2

A-1310 D

X2024C0101

SYNC CHANNEL A T.P. $\overline{\text{B23}}$ 3RH @ E38/39
SCOPE CHANNEL B AT PLUS 1 CLOCK PERIOD ON 3RH @ E38/39

2^{63}	2^{62}	2^{61}	2^{60}	2^{59}	2^{58}	2^{57}	2^{56}	2^{55}	2^{54}	2^{53}	2^{52}	2^{51}	2^{50}	2^{49}	2^{48}	
C33,	C20	C48	C17,	D5	D61	D23,	D63	A25	A20,	A29	A31	A11,	A10	B50	B49	TEST POINT
____,	____	____	____,	____	____	____,	____	____	____,	____	____	____,	____	____	____	

2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}	
A47,	C2	C13	C64,	C34	C35	D64,	C24	C1	C16,	D40	D39	D65,	D42	D1	D8	TEST POINT
____,	____	____	____,	____	____	____,	____	____	____,	____	____	____,	____	____	____	

2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	2^{15}	
D53,	D2	A45	A17,	A18	A48	A46,	B59	B51	B2,	B1	B6	B3,	B69	B62	B71,	B72,	TEST POINT
____,	____	____	____,	____	____	____,	____	____	____,	____	____	____,	____	____	____,	____,	

X2100S0202

FINAL SUM

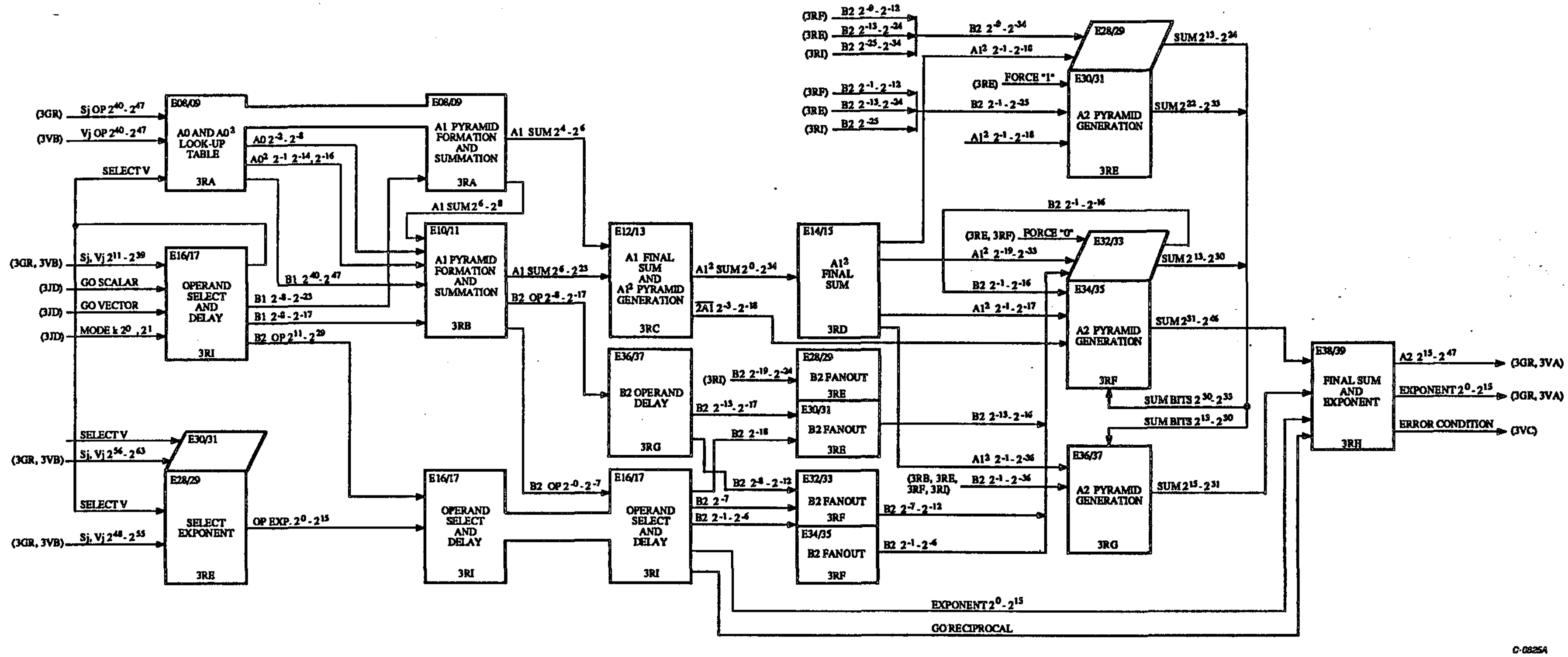
A-1311B

ERROR CONDITION
TEST POINT, C36 J16 TERM EXPONENT OUT RANGE

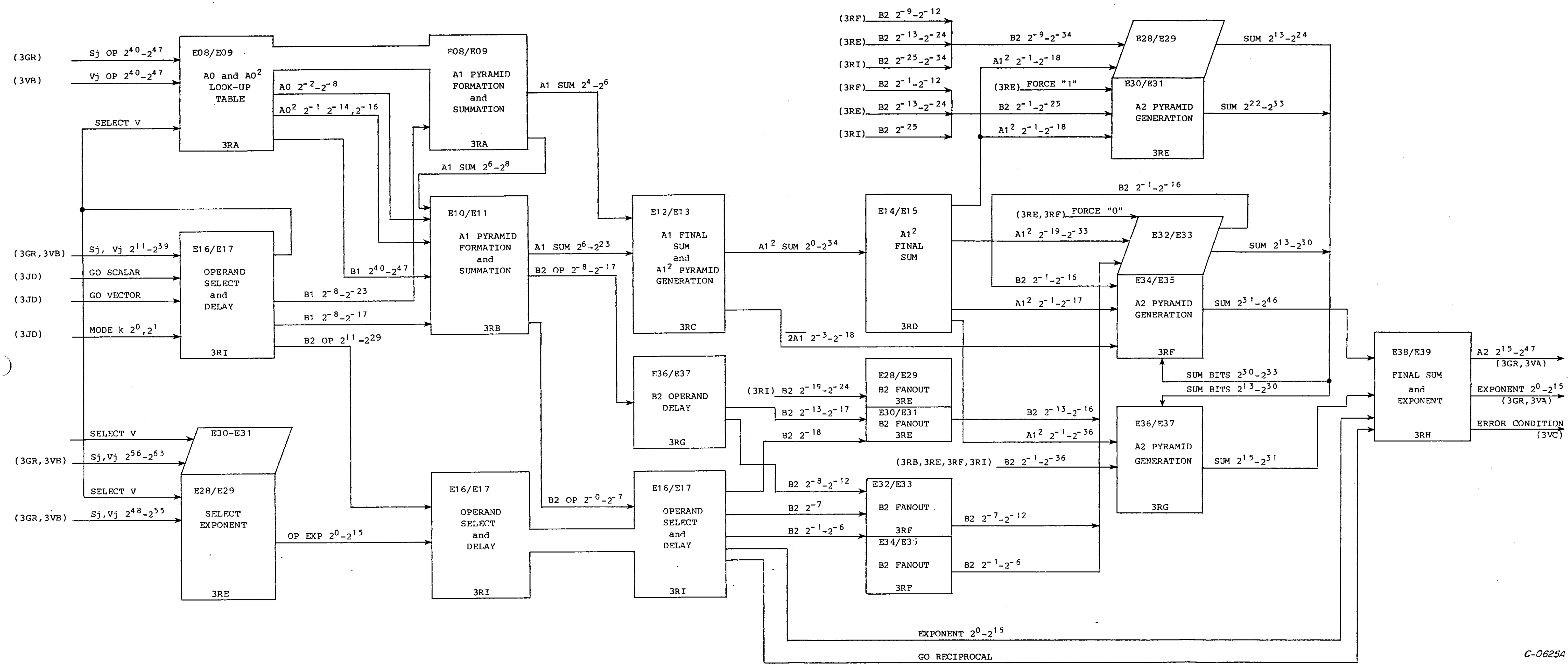
SYNC POINTS

SCALAR	CP2	CP3	CP4	CP5	CP6	CP7	CP8	CP9	CP10	CP11	CP12	CP13	CP14	
3RI	$\overline{C4}$	$\overline{D69}$	$\overline{D67}$	$\overline{D06}$	$\overline{D10}$		$\overline{B26}$	$\overline{B36}$	$\overline{B24}$	$\overline{B38}$	$\overline{B39}$	$\overline{B35}$	$\overline{B23}$	3RH
VECTOR	CP5	CP6	CP7	CP8	CP9	CP10	CP11	CP12	CP13	CP14	CP15	CP16	CP17	
3RI	$\overline{C4}$	$\overline{D69}$	$\overline{D67}$	$\overline{D6}$	$\overline{D10}$		$\overline{B26}$	$\overline{B36}$	$\overline{B24}$	$\overline{B38}$	$\overline{B39}$	$\overline{B35}$	$\overline{B23}$	3RH

A-1312A



CRAY X-MP FLOATING RECIPROCAL APPROXIMATION
FUNCTIONAL UNIT (CPU 0)



CRAY X-MP FLOATING RECIPROCAL APPROX. F.U. CPU - 0

3RE H28/29 AND H30/31

I90 = MODE SELECT Sj OR Vj
I60 = Vj BIT 2^{48} OR 2^{56}
I50 = Sj BIT 2^{48} OR 2^{56}

BOOLEAN R70 = MUX (I60 I50): DCD (I90); T2
⇩
R77 = I57 I90' + I67 I90; T2

EXPONENT BIT 248-2^{55} ON 3RE AT H28/29
EXPONENT BITS 2^{56}-2^{63} ON 3RE AT H30/31

3RI AT E16/E17

T.P. $\overline{C28}$ B48 = I100; T2 EXPONENT BIT 2^{0}-2^{15} DELAYED
T.P. $\overline{B03}$ C48 = B48; T2
T.P. B31 D48 = C48; T2
E48 = D48; T2
F48 = E48; T2
T.P. $\overline{C58}$ G48 = F48; T2
T.P. C13 R60 = G48; T2

3RH AT E38/39

I70 ⟶ R60 FROM 3RI

J00-J15 = I70 - I85 EXPONENT BIT 2^{0}-2^{15}

I83 = 2^{13} EXPONENT
I84 = 2^{14} EXPONENT

BOOLEAN J16 = I83 I84 + I83' I84' T2

J16 = OVERFLOW OR UNDERFLOW

A-1641

3RH At E38/39

T.P.	$\overline{\text{B15}}$	J00 = I70; T2	EXPONENT BIT 2^0-2^{15}
	$\overline{\text{B04}}$	K00 = J00; T2	
	$\overline{\text{B56}}$	L00 = K00; T2	
	B63	O00 = L00; T2	

COMPLEMENT EXPONENT AND ADD IN A TWO

T.P.	A43	O16 = L16; T2	EXPONENT OUT OF RANGE
	A37	O19 = N02; T2	EXPONENT = 20000 OR 20001

BOOLEAN
P15' = O19' O16'

P15 = O19 + O16

P15 = EXPONENT IS EQUAL TO 20000 OR 20001 OR OUT OF RANGE

Q3 = $\overline{\text{P15}}$ S06 — GO VECTOR/SCALAR IF NO OUT OF RANGE CONDITION

BOOLEAN
R40 = O00' Q03; T2
R41 = O01 Q03; T2
⇩
R53 = Q01 Q03 + P15 S06; T2
R54 = Q02 Q03 + P15 S06; T2
R55 = O15 S06; T2
R56 = P15 S06; T2

A-1641

R41 = ADD IN A 2 VALVE
R40 - R55 = EXPONENT BIT 2^0-2^{15}
R54 - R55 = FORCED TO A 1 IF A RANGE ERROR TO MAKE A 060000 EXPONENT OR 160000 EXPONENT
R56 = SENDS A FLOATING POINT ERROR FLAG TO THE EXCHANGE PACKAGE

Form $A_1 = -2A_0 + A_0^2 B$

Generate - $2A_0$ AND A_0^2

3RA @ E08/09

Generate $-2A_0$

P00 = I98 Select Vector
I00 = Sj bit 2^{40}
I10 = Vj bit 2^{40}

Boolean R40 = I00 P00' + I10 P00; T2

R47 = I07 P00' + I17 P00; T2

R40-R47 = Exponent 2^{40}-2^{47}
Scalar or Vector

A00 = R40 = becomes B0 data bit 2^{-7}

A06 = R46 = B0 data bit 2^0

1. Upper 8 bit of the coefficient are left shift by 1 place puts exponent in the range of 1.000 - 1.774.

2. Look-up value for A_0 and A_0^2.

3. A_0 becomes $-2A_0$

   a) Complement A0 for a -A0

   b) Shift -A0 left 1 place for a multiply by 2.

A-1644

Generate - $2A_0$ (continued)

c) Send the value of $-2A_0$ to the A_1 pyramid which is added in on the 3RB and 3RA.

```
Boolean  R0' = A00 D30 + A00' D31 + D32; T2

         R06' = A00' C51 + C87; T2
```

R0-R06 = $2A_0$ data bit 2^{-2} - 2^{-8} added in on the first 3 bit add on the 3RB for bit position 2^{41}-2^{47}.

R0-R05 = Are added in on the 3RA during the second 3 bit add for bit position 2^{24}-2^{29}.

Generate $A_0{}^2$

Look-up the value on 3RA which is $A_0 * A_0$

Form A1 pyramid $A_0{}^2$ B

$A_0{}^2 * B$ $A_0{}^2$ = Look-up value
B = Coefficient bits 2^{24}-2^{47} becomes 2^{-23}-2^{0}

1. Form the A_1 pyramid of $A_0{}^2 * B$ on 3RB and 3RA.
2. Add the pyramid using 3-bit add on 3RA and 3RB.
3. Finish the Add using 2-bit add on the 3RC.

A-1644A

A1 Final Sum

3RC E12/13

Boolean	G00' = E00	
	↓	
	G17' = E17 F17' + E17' F17	

G0-G17 are the final sum of A1 equation retain only upper 18 bits.

Delay 16 bit of $\overline{A1}$

Boolean	K00 = G00'; T2
	↓
	K15 = G15'; T2

	L00 = K00; T2	Delayed $\overline{A1}$ bit 2^{-18}
	M00 = L00; T2	
T.P. C72	R00 = M00; T2	Can scope A1 on R term on 3RC bit 2^{-18}

NOTE: $\overline{A1}$ can be partically scoped on the 3RC after it was delayed for 3 C.P.

18 bit of A1 were used to generate $A1^2$ 3 C.P. earlier. <u>You are not scoping the true A1 which was used to generate $A1^2$</u>.

A-1644A

Form $A2 = -2A_1 + A_1^2$

<u>Generate A_1^2</u>

3RC @ H12/13 generate $A_1 * A_1$

18 bits of A1 time 18 bits of A1 gives a total 36 bit results.

The logical products are generated on the 3RC and 3 levels of 3-bit add to sum the pyramid.

3RD @ H14/15 finishes adding $A_1 * A_1$ using 3 bit and 2 bit adds.

NOTE: The final A_1^2 can be scoped on the 3RD R terms.

R35 - R00

R35 = Bit 2^{-1} or bit 2^{47}

↓

R00 = Bit 2^{-35} or bit 2^{12}

<u>Delay B2 Bit 2^{11}-2^{46}</u>

3RI @ E16/17

X00 = R90 Select Vector

```
Boolean A11 = MUX (I11 I51) : DCD (X00'); T2
            ↓
        A39 = MUX (I79 I39) : DCD (X00) ; T2
```

A11-A39 B2 bit 2^{11}-2^{39}

3RA @ E08/09

P00 = Select Vector

```
Boolean  R40 = I00 P00' + I10 P00; T2
             ↓
         R47 = I07 P00' + I17 P00; T2
```

R40-R47 B0, B1, B2 bit 2^{40}-2^{47}

A-1644

3RI Bit 2^{11}-2^{39}

3RI module @ E16/17 sends bits 2^{39}-2^{30} to the 3RB and bit 2^{39}-2^{24} to the 3RA to generate the A1 pyramid. The 3RI retain bits 2^{11}-2^{29}.

The 3RB gives the 3RI bits 2^{40}-2^{47} to be delayed with 3RI's bits 2^{11}-2^{29}.

3RB sends bits 2^{39}-2^{30} to the 3RG to be delayed along with the 3RI bit 2^{11}-2^{29} and 2^{40}-2^{47}.

NOTE: B2 can be scoped after the fanout on the 3RG @ E36/37

Form A2 pyramid $A_1{}^2$ B

Fanout B2 and $A1^2$ to generate the A2 pyramid.

Perform the logical products and add the pyramid using 3-bit add on the 3RE, 3RF and 3RG modules.

Finish the summation on the 3RH and send the exponent and 33 bit of the coefficient to the 3GR or 3VA. Only upper 30 bits are accurate.

FLOATING-POINT MULTIPLY FUNCTIONAL UNIT

The Floating-point Multiply Functional unit is shared by the Scalar and Vector registers. Two Floating-point operands are sent to the functional unit. The exponents are added together and the sign bit of the coefficients are exclusive ORed. The coefficients are then multiplied. Only the upper half of the multiply pyramid is retained.

The Floating-point Multiply can also multiply the integer numbers together by leaving the exponent areas equal to zero in both operands.

The Floating-point Multiply can also perform a third iteration for more accuracy when doing a Reciprocal Approximation. This is the maximum number of iterations that can be generated and still receive correct results.

Floating-point Multiply has the same range error conditions as the Floating-point Add Functional unit. If an overflow condition exists the result registers will receive an exponent equal to 60000 and the calculated coefficient. A flag is sent to the exchange package indicating a floating-point range error. An underflow condition sends all zeros to the result register. This time a flag is not sent to the exchange package.

FLOATING-POINT MULTIPLY (Modules involved)

3MA MODULE

The 3MA module forms parts of the multiply pyramid by performing logical products. After the logical products are formed, the 3MA module will begin adding its portion of the pyramid using 3-bit adds. The 3MA will also fanout portions of the J and K operand to the 3MB modules.

3MB MODULE

The 3MB module performs the same functions as the 3MA module. However, the 3MB is handling different bits of the pyramid. The 3MB module will also fanout portions of the J and K operand to the 3MA module.

3MC MODULE

The 3MC module inputs portions of the J and K operand. Logical products are generated to form portions of the pyramid. After the logical products are formed the 3MC will begin adding the pyramid using 3-bit adds. The 3MC also inputs the exponent bit, 2^{48} - 2^{63}, which are sent to the 3MK module.

3MD MODULE

The 3MD module will input the J and K operand on the upper end of the pyramid. It will form the logical products and begin adding the pyramid using 3-bit adds. The 3MD module will also continue adding the pyramid from where the 3MB and 3MA modules left off.

3ME MODULE

The 3ME module will input J and K operands for a certain portion of the pyramids. It then forms the logical products and starts to add the pyramid using 3-bit adds. The 3ME will also continue to add the pyramid where the 3MC, 3MA, 3MB and 3MF modules left off.

3MF MODULE

The 3MF module will input certain portions of the J and K operands. It then forms the logical products and starts adding the pyramid using 3-bit adds. The 3MF sums the lower end and the middle of the pyramid.

3MJ MODULE

The 3MJ module completes the summation of the pyramid. It will output the exponent and coefficient to the 3GR and 3VR modules depending upon the type of instruction used, Scalar or Vector. The 3MJ will also output the results for the Second Vector Logical Functional Unit.

3MK MODULE

The 3MK module is the Floating-point Multiply control module. The 3MK module will decode the instruction. Depending on the instruction, it will generate the terms Strong Round, Strong Round Truncation, Weak Round, -1 Constants, or Complement Control. The 3MK also checks for underflow or overflow conditions. The 3MK module will add the exponents and generate the exponent and exponent -1 in the event that normalization is needed. The exponent and exponent -1 are sent to the 3MJ module where the 3MJ will make the decision to send the exponent or exponent -1 out to the 3GR or 3VR modules. The 3MK module also generates forced zeros and ones which are put into the summation of the pyramid. The 3MK also decodes the 140-145 instructions for the Second Vector Logical Functional Unit.

FLOATING MULTIPLY INSTRUCTIONS

SCALAR

064IJK	Scalar Floating Product of (SJ) times (SK) to SI
065IJK	Scalar Floating Product, half precision, (SJ) times (SK) to (SI)
066IJK	Scalar Floating Product, full precision, (SJ) times (SK) to SI
067IJK	Scalar Floating Product, 2 minus the product of (SJ) times (SK) to SI

C.A.L. FORMAT

SI	SJ*FSK	Scalar Floating Product
SI	SJ*HSK	Half Precision
SI	SJ*RSK	Full Precision
SI	SJ*ISK	Iteration, 2 - SJ*SK

DIAGNOSTIC APPLICATIONS

3SFM

3SMU

FLOATING MULTIPLY INSTRUCTIONS

VECTOR

160IJK	Vector Floating Product (SJ) times (VK ELEMENTS) to VI
161IJK	Vector Floating Product (VJ ELEMENTS) times (VK ELEMENTS) to VI
162IJK	Half Precision, (SJ) times (VK ELEMENTS) to VI
163IJK	Half Precision, (VJ ELEMENTS) times (VK ELEMENTS) to VI
164IJK	Full Precision, (SJ) times (VK ELEMENTS) to VI
165IJK	Full Precision, (VJ ELEMENTS) times (VK ELEMENTS) to VI
166IJK	Iteration, 2 - (SJ) times (VK ELEMENTS) to VI
167IJK	Iteration, 2 - (VJ ELEMENTS) times (VK ELEMENTS) to VI

C.A.L. FORMAT

VI	SJ*FVK	Vector, Scalar Product
VI	VJ*FVK	Vector, Vector Product
VI	SJ*HVK	Half Precision, Vector Scalar
VI	VJ*HVK	Half Precision, Vector Vector
VI	SJ*RVK	Full Precision, Vector Scalar
VI	VJ*RVK	Full Precision, Vector Vector
VI	SJ*IVK	Iteration, 2 minus Vector Scalar
VI	VJ*IVK	Iteration, 2 minus Vector Vector

FLOATING POINT MULTIPLY CONTROL

SCALAR		H^2	H^1	H^0		
	0 6	1	0	0	iJK	
	0 6	1	0	1	iJK	- Strong Round
	0 6	1	1	0	iJK	- Weak Round
	0 6	1	1	1	iJK	- Compliment Control

VECTOR		H^2	H^1	H^0		
	1 6	0	0	0	iJK	
	1 6	0	0	1	iJK	
	1 6	0	1	0	iJK	Strong Round
	1 6	0	1	1	iJK	
	1 6	1	0	0	iJK	Weak Round
	1 6	1	0	1	iJK	
	1 6	1	1	0	iJK	Compliment Control
	1 6	1	1	1	iJK	

A-1369

DIVIDE SEQUENCE

<u>S6 = S1/S2</u>

Accurate to 29 bits:

#1	070320	S3 = 1/S2
#2	065613	S6 = S1 * FS3

Accurate to 48 bits: <u>S6 = S1/S2</u>

#1	070320	S3 = 1/S2
#2	067432	S4 = (2-[S3*S2])
#3	064543	S5 = S4*S3
#4	066651	S6 = S5*S1

#1 $A_1 = 2A_0 - A_0{}^2B$ First Iteration

$A_2 = 2A_1 - A_1{}^2B$ Second Iteration

#2 $S4 = (2-(A_2{}^*B))$

Third Iteration

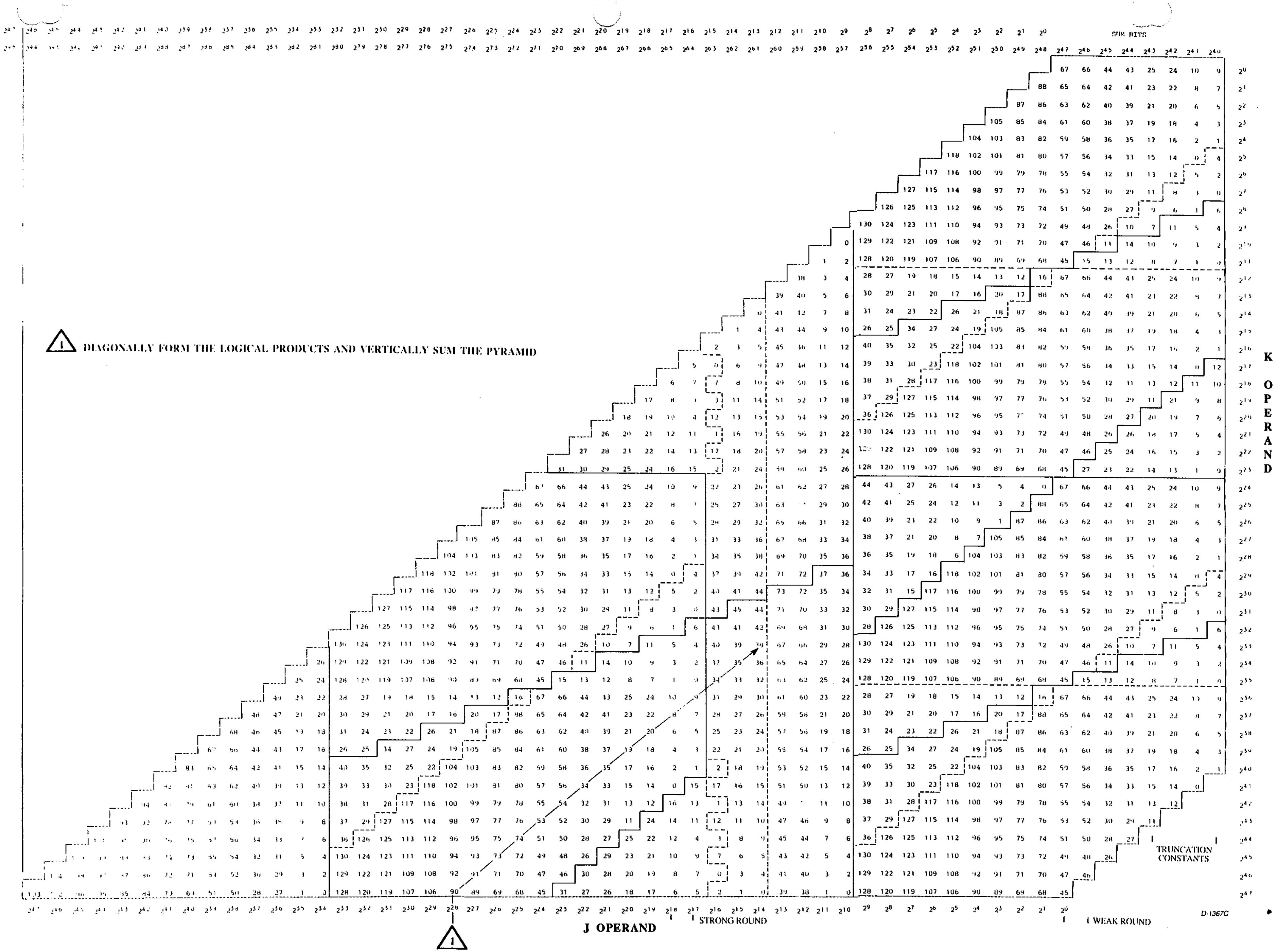
#3 $A_3 = A_2\,(2-(A_2{}^*B))$

OR

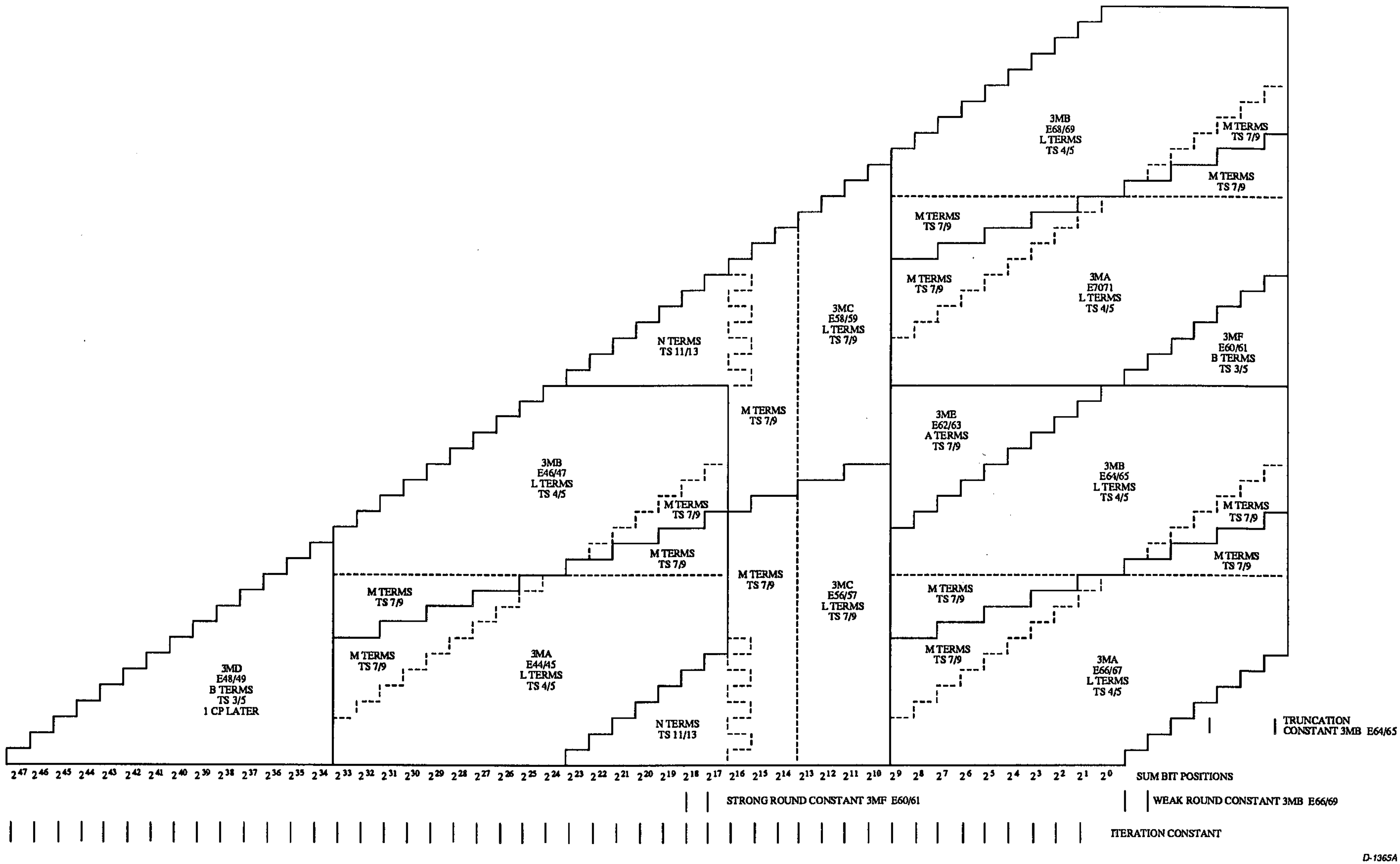
$A3 = 2A_2 - A_2{}^2B$

#4 $S6 = A_3{}^*S1$ Third Iteration * S1

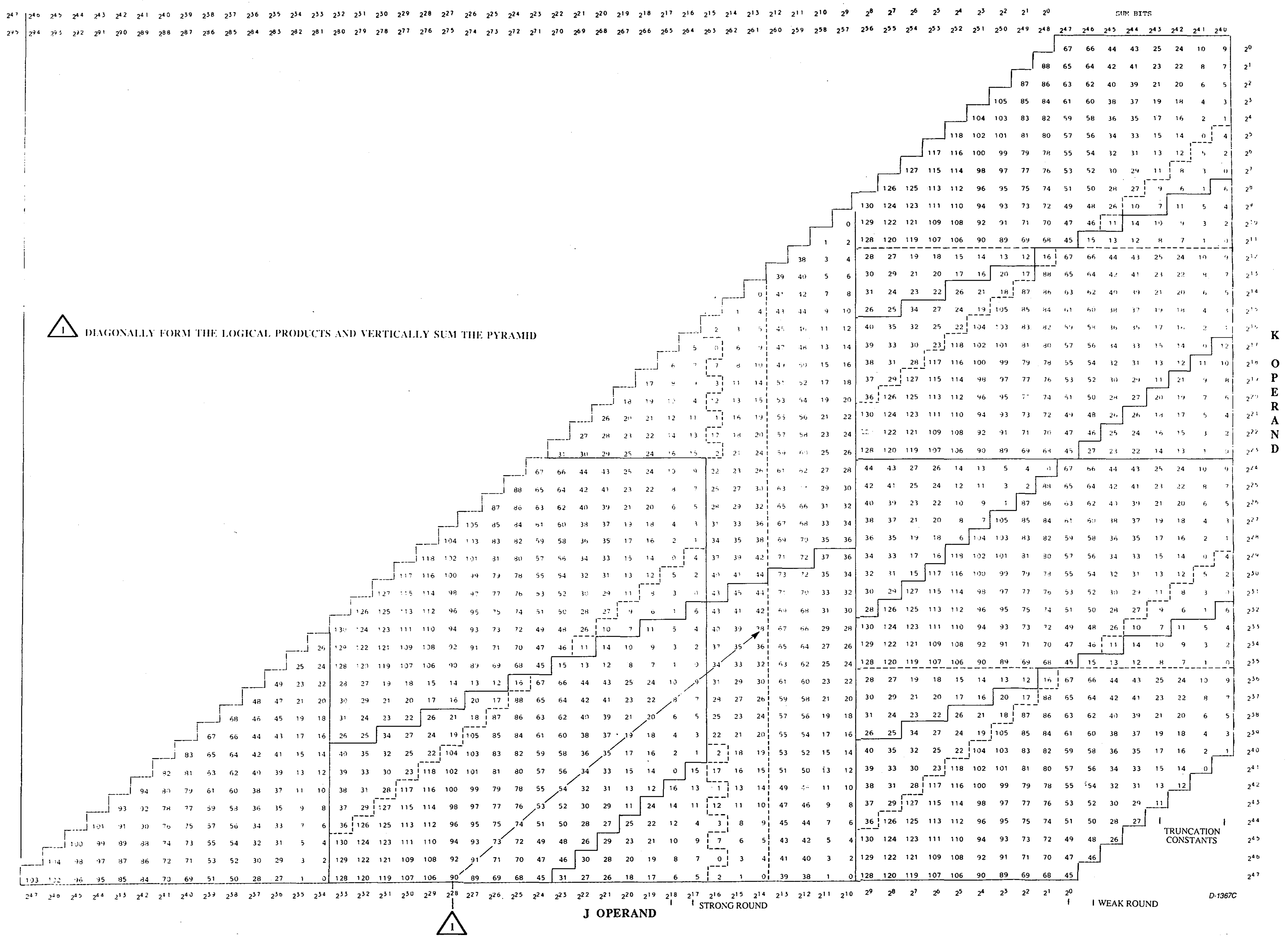
XV201S46M



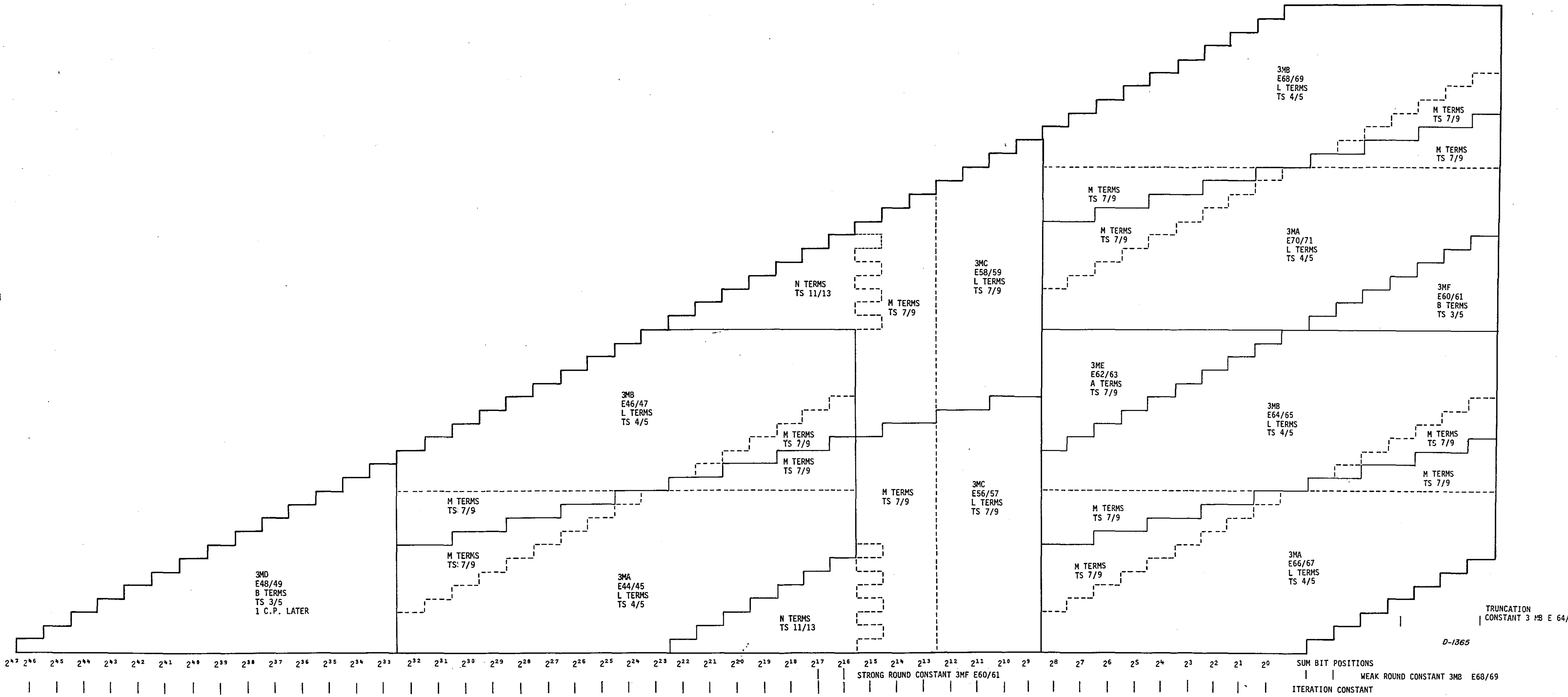
CRAY X-MP FLOATING POINT MULTIPLY
FUNCTIONAL UNIT PYRAMID GENERATION



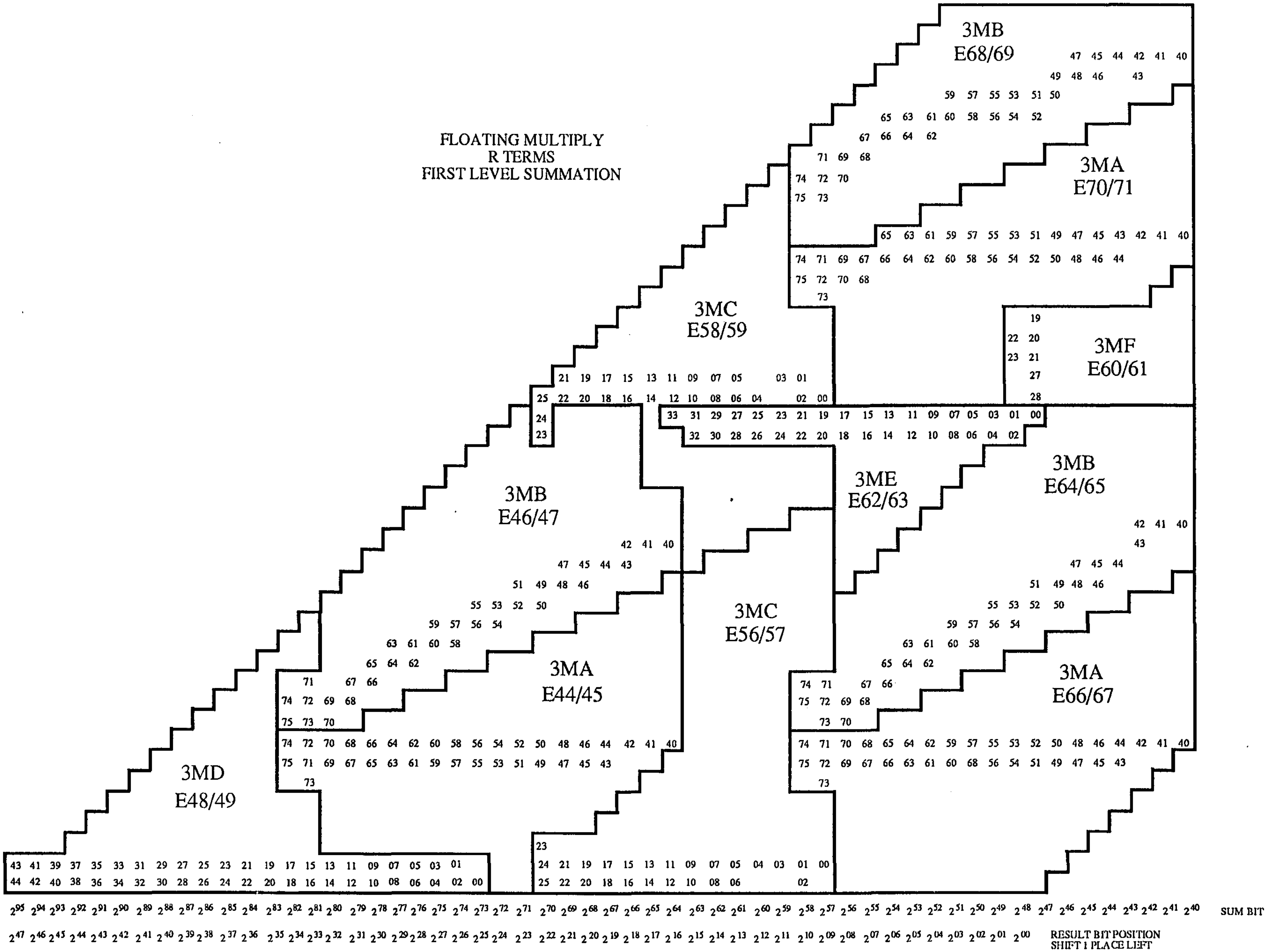
CRAY X-MP FLOATING-POINT MULTIPLY PYRAMID MODULE LOCATION



CRAY X-MP FLOATING POINT MULTIPLY
FUNCTIONAL UNIT PYRAMID GENERATION

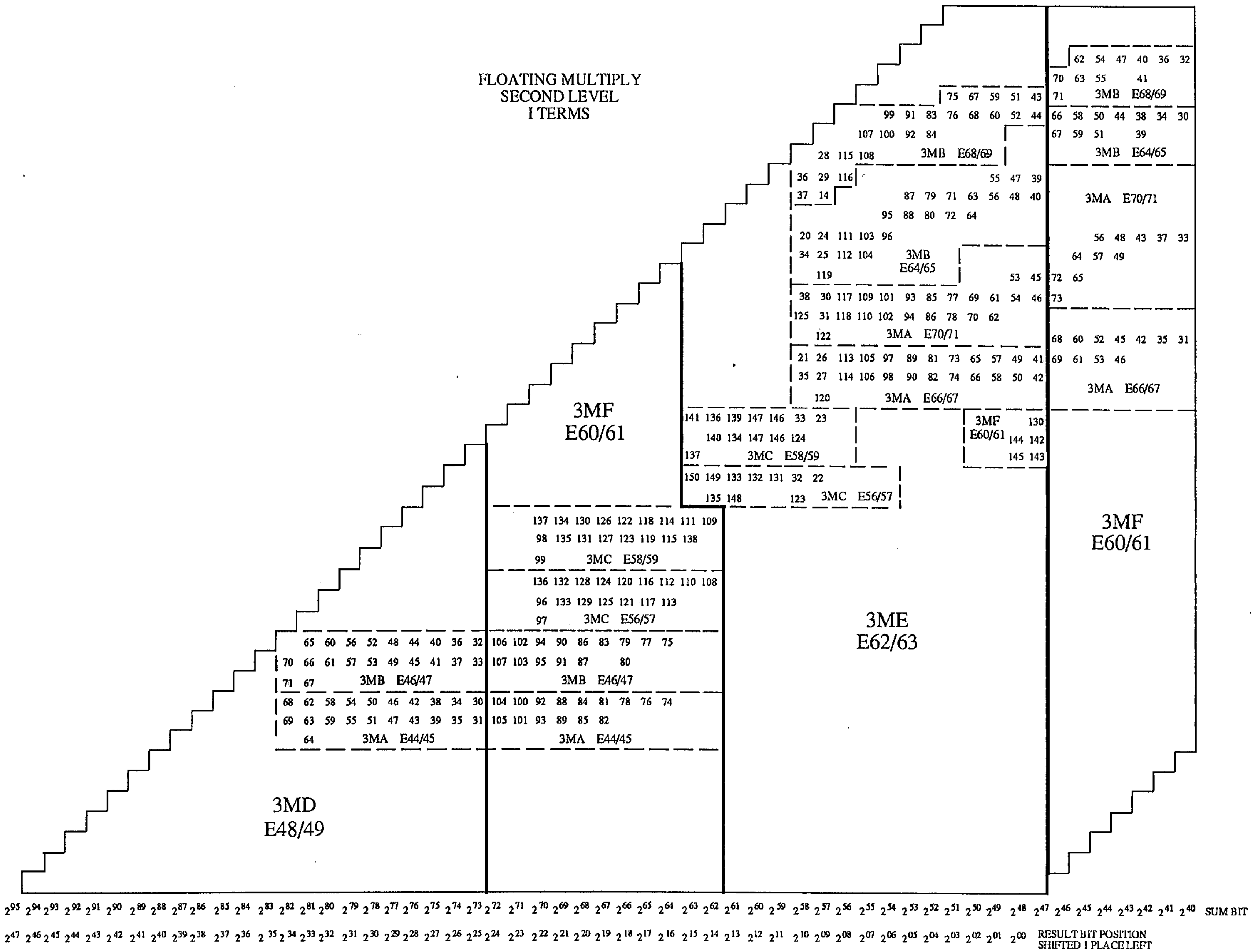


FLOATING POINT MULTIPLY PYRAMID MODULE LOCATION



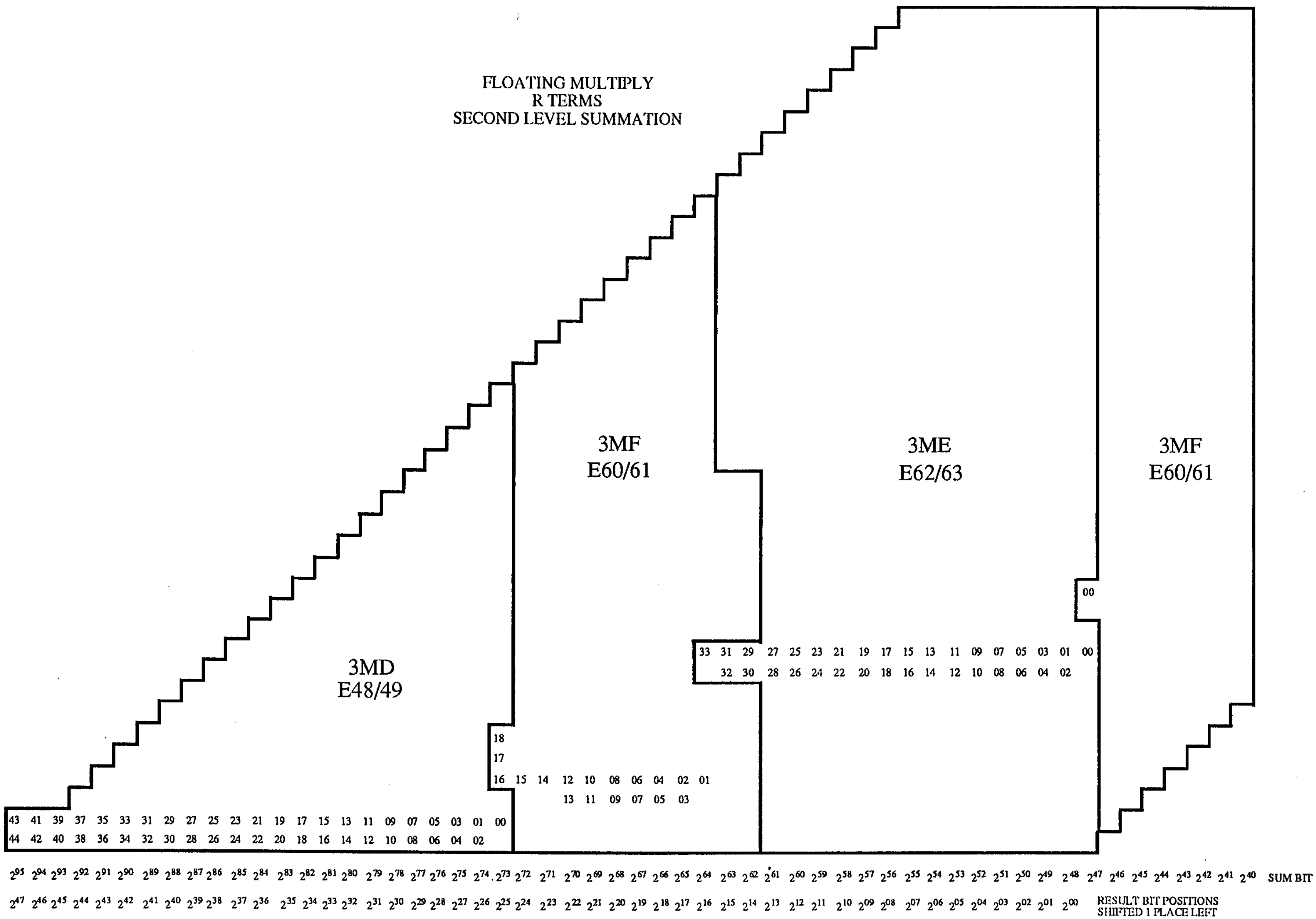
CRAY X-MP/2 FLOATING MULTIPLY
FIRST LEVEL SUMMATION
R TERMS
(SHEET 1 OF 4)

A-4441
X/202C01M
J.E.S.



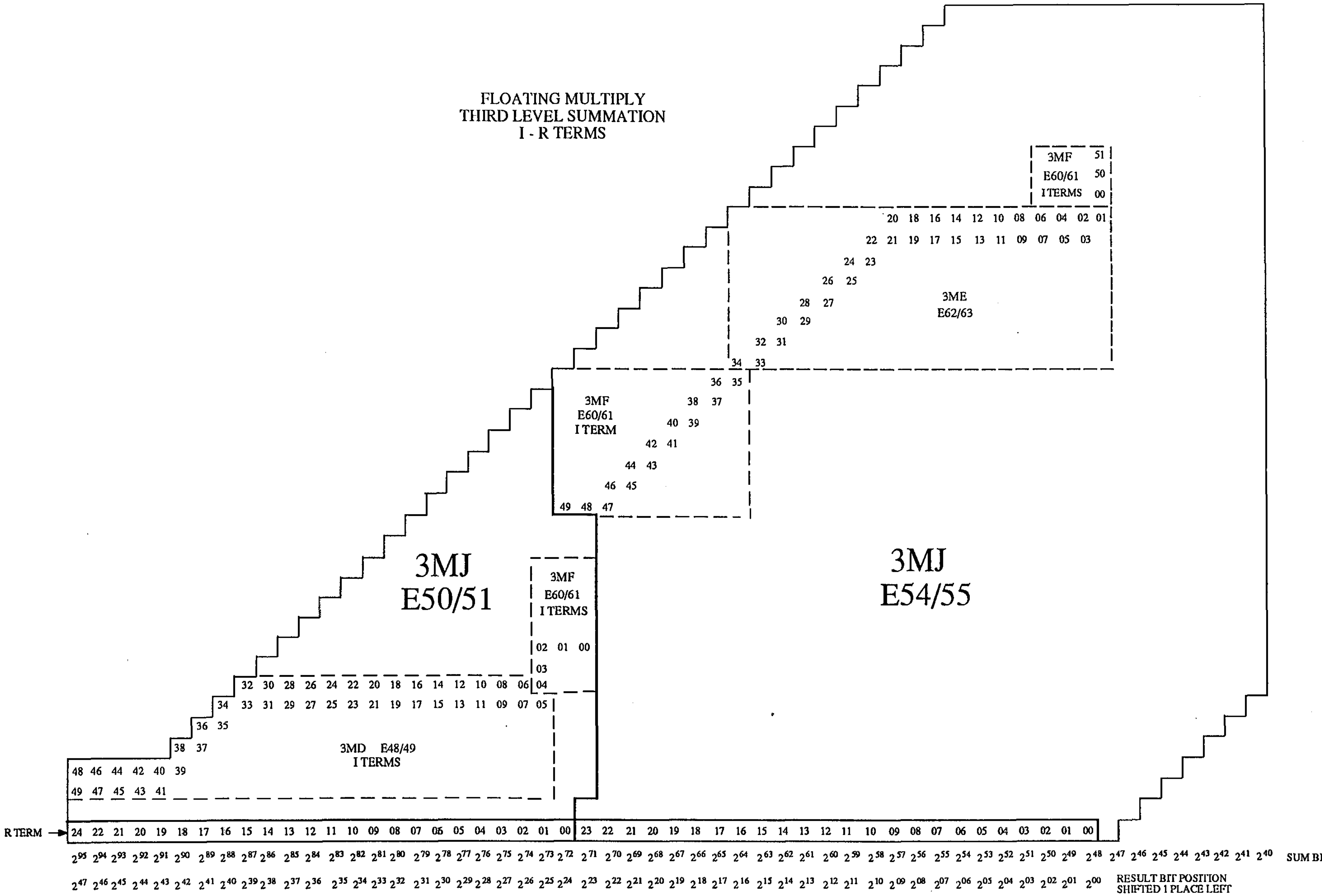
CRAY X-MP/2 FLOATING MULTIPLY SECOND LEVEL SUMMATION I TERMS (SHEET 2 OF 4)

A-4442
X/202C02M
J.E.S.



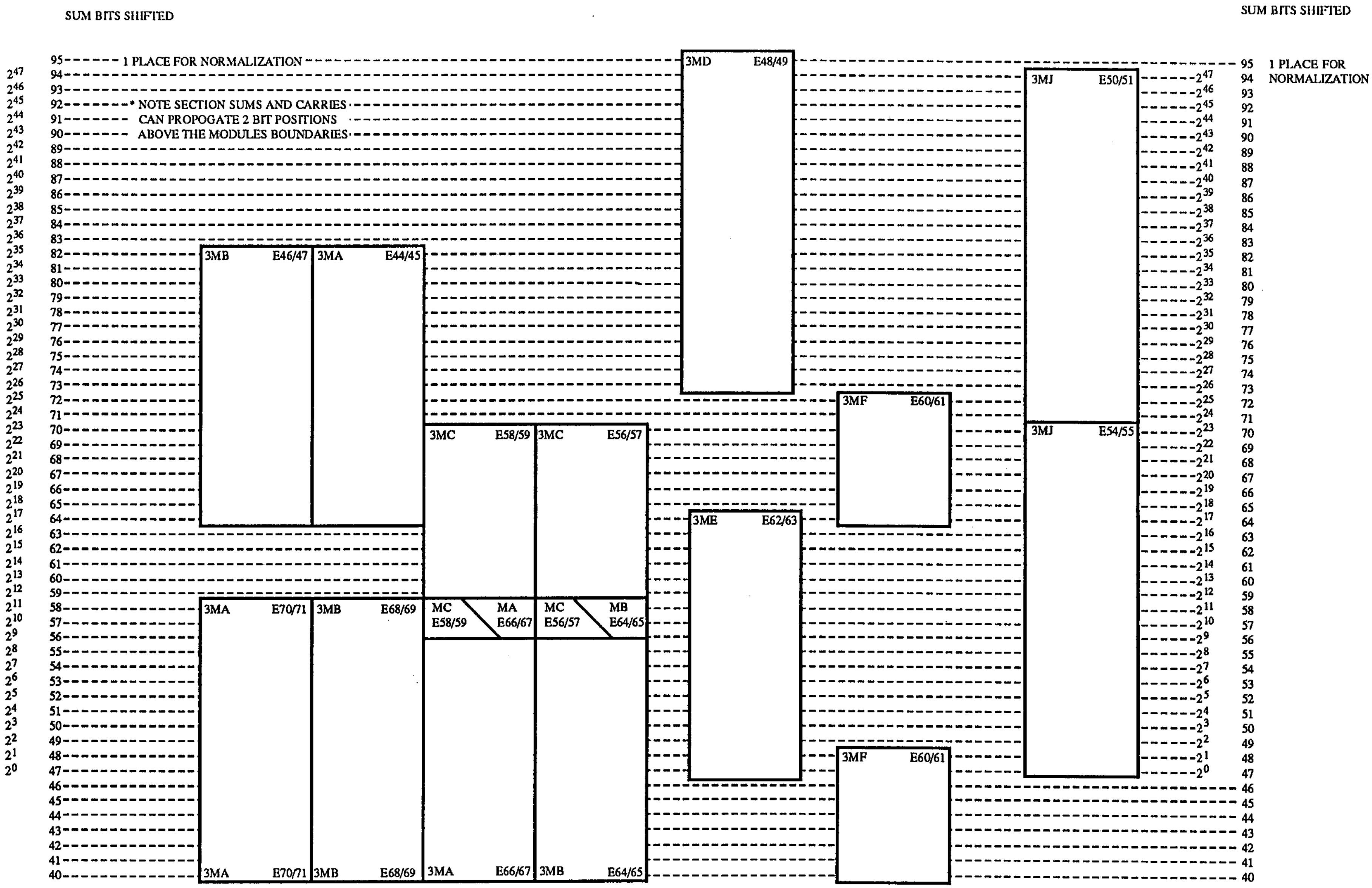
**CRAY X-MP/2 FLOATING MULTIPLY
SECOND LEVEL SUMMATION
R TERMS
(SHEET 3 OF 4)**

A-4443
X/202C03M
J.E.S.



CRAY X-MP/2 FLOATING MULTIPLY THIRD LEVEL SUMMATION AND FINAL SUM (SHEET 4 OF 4)

A-4444
X/202C04M
J.E.S.



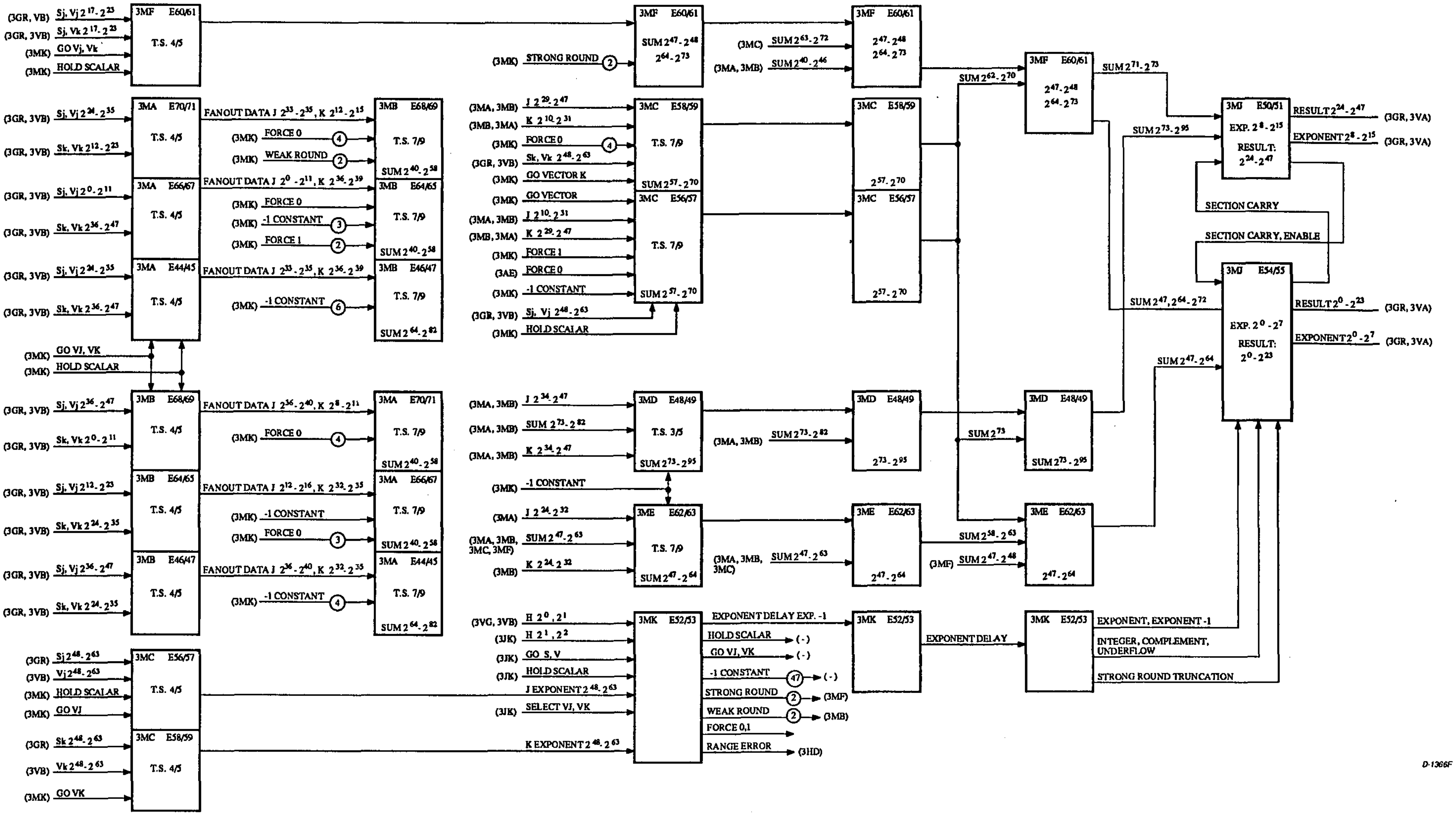
B-2030B

CRAY X-MP FLOATING-POINT MULTIPLY BIT ASSOCIATION

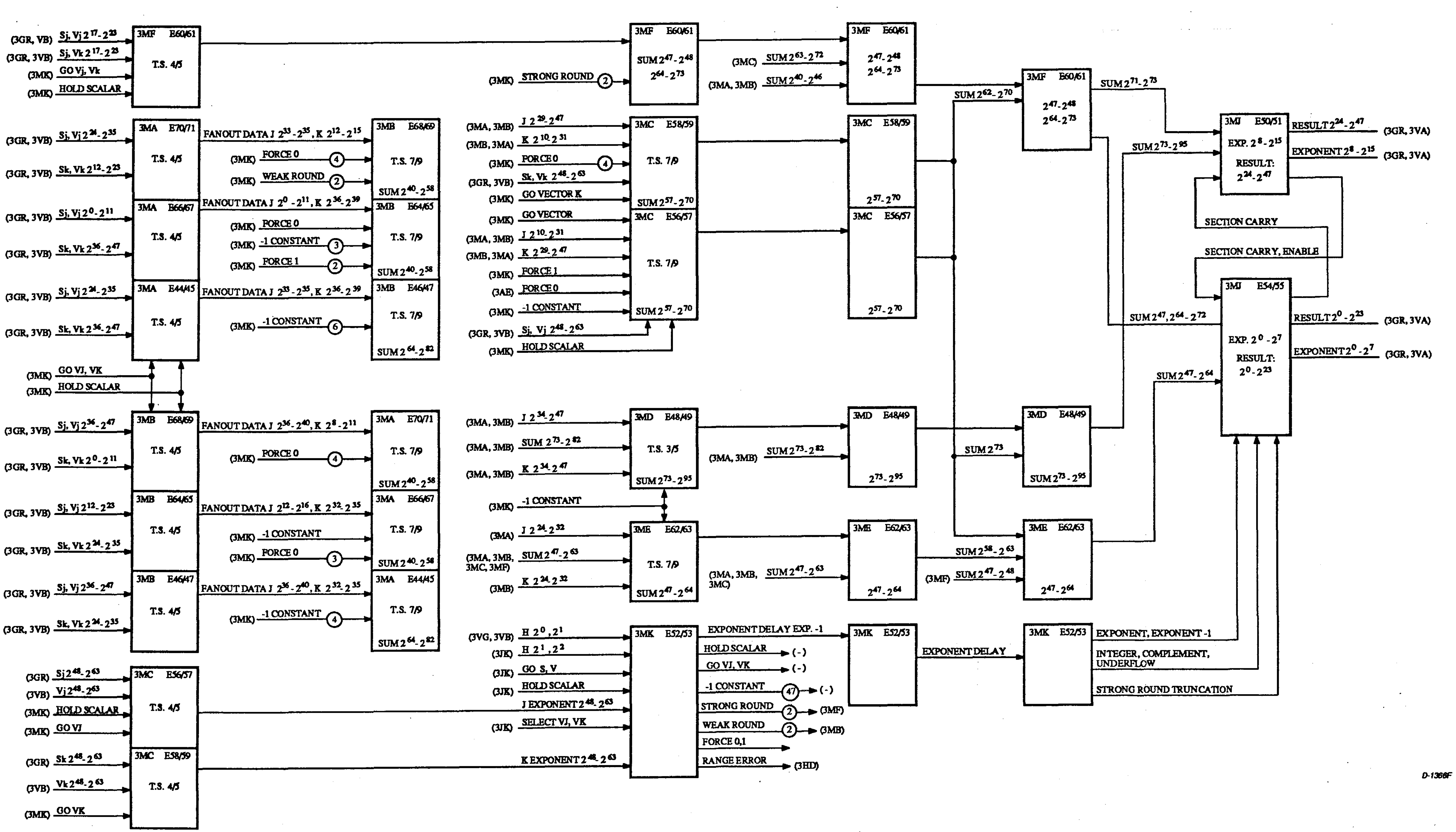
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
J EXPONENT	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	I00	I-TERMS
K EXPONENT	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	I16	
			A26	A24	A22	A20	A18	A16	A14	A12	A10	A08	A06	A04	A02	A00	A-TERMS ENABLE
SIGN BIT ARE EXCLUSIVE-ORed		A27	A25	A23	A21	A19	A17	A15	A13	A11	A09	A07	A05	A03	A01		A-TERMS CARRY
A28 = EXPONENTS SIGNS ALIKE		A28															
	A32			C02				C01				C00					C-TERMS GROUP CARRY
A29 = EXPONENTS BOTH POSITIVE		A29															
$\overline{A30}$ = EXPONENTS BOTH NEGATIVE		$\overline{A30}$			D01				D00								D-TERMS GROUP ENABLE
A32 = EXCLUSIVE-OR SIGN-BIT				E03				E02				E01					E-TERMS GROUP CARRY
		F14	F13	F12	F11	F10	F09	F08	F07	F06	F05	F04	F03	F02	F01		F-TERMS GROUP SUM
G14 = EXPONENT SIGNS SET OR NOT SET		G14	G13	G12	G11	G10	G09	G08	G07	G06	G05	G04	G03	G02	G01	G00	G-TERMS FINAL SUM
		K14	K13	K12	K11	K10	K09	K08	K07	K06	K05	K04	K03	K02	K01	K00	K-TERMS EXPONENT
	H15	L14	L13	L12	L11	L10	L09	L08	L07	L06	L05	L04	L03	L02	L01	L00	L-TERMS EXPONENT-1
	H16	N14	N13	N12	N11	N10	N09	N08	N07	N06	N05	N04	N03	N02	N01	N00	N-TERMS EXPONENT
		N30	N29	N28	N27	N26	N25	N24	N23	N22	N21	N20	N19	N18	N17	N16	
	R15	R14	R13	R12	R11	R10	R09	R08	R07	R06	R05	R04	R03	R02	R01	R00	EXPONENT
		R30	R29	R28	R27	R26	R25	R24	R23	R22	R21	R20	R19	R18	R17	R16	EXPONENT-1

B-1653D

CRAY X-MP 3MK MODULE DIAGRAM



CRAY X-MP FLOATING-POINT MULTIPLY EXPONENT AND COEFFICIENT DATA FLOW



CRAY X-MP FLOATING-POINT MULTIPLY EXPONENT AND COEFFICIENT DATA FLOW

INSTRUCTION CONTROL

I34= H BIT 2^0 SCALAR INSTRUCTIONS
I35= H BIT 2^1

I36= H BIT 2^1 VECTOR INSTRUCTIONS
I37= H BIT 2^2

I32= GO SCALAR MULTIPLY

```
BOOLEAN     H06 = I34 I32  +  I36 I32'; T2

            H07 = I35 I32  +  I37 I32'; T2
```

H06 = MODE H BIT 2^0 FOR SCALAR INSTRUCTION OR
MODE H BIT 2^1 FOR VECTOR INSTRUCTION

H07 = MODE H BIT 2^1 FOR SCALAR INSTRUCTION OR
MODE H BIT 2^2 FOR VECTOR INSTRUCTION

STRONG ROUND BIT = 065

```
BOOLEAN     H22' = H06'  +  H07; T2

            H22 = [H07'  •  H06]; T2
```

H22 = DECODE OF 065

R32 = H22 ADD 2 ROUND BITS INTO THE SUMMATION

STRONG ROUND TRUNCATION

```
BOOLEAN     R35' = H12'  +  H13; T2

            R35  = [H12  •  H13']
```

R35 = TRUNCATION THE LOWER 19 BITS OF THE RESULTS FOR A 065 INSTRUCTION

A-1652

GO MINUS ONE AND
COMPLEMENT CONTROL = 067

```
BOOLEAN    R31 = H06 H07; T2

           R31 = MUX (H07 0): DCD (H06); T2

               R31 = H07
```

R31 = WHEN H BIT 2^0 AND 2^1 EQUAL A 1 MAKE GO MINUS ONE FOR 067 INSTRUCTION. **48 1-BITS ARE ADDED IN** THE SUMMATION.

T.P.	$\overline{C20}$	H08 = H06; T2	H BIT 2^0
	$\overline{C19}$	H09 = H07; T2	H BIT 2^1
	$\overline{C14}$	H10 = H03; T2	
	$\overline{C16}$	H11 = H9; T2	
	C12	H12 = H10; T2	
	C10	H13 = H11; T2	

```
BOOLEAN    R34' = H12'  +  H13'

           R34 = [H12 • H13]
```

R34 = COMPLEMENT THE RESULTS ON THE OUTPUT TO MAKE $A_3=2A_2-A_2{}^2B$ ASSOCIATED WITH THE 067 INSTRUCTIONS.

WEAK ROUND = 066

```
BOOLEAN    R33' = MUX (# H07'): DCD (H06); T2

           R33' = H07'; T2

           R33 = H07; T2
```

R33 = ADD 2 ROUND BITS INTO THE SUMMATION

A-1652A

```
BOOLEAN   B00 = 0000 I00' I01' I02' I03' I04' ##; T2

          B05 = 0000 I26' I27' I28' I29' I30' ##; T2
```

B0-B05 EXPONENT BITS 2^0-2^{14} = 0
FOR J AND K OPERAND

```
D02 = B00 B01 B02   J EXPONENT = ZERO
D03 = B03 B04 B05   K EXPONENT = ZERO

      H00 = D02 D03; T2
      H05 = H00; T2
      R39 = H05; T2
```

R39 = BOTH EXPONENTS EQUAL ZERO, SO
ALLOW THE COEFFICIENT TO LEAVE.

RANGE ERROR

```
BOOLEAN   J02 = H03 G14'  +  H04' G13 G14  +  H02
```

J02 = H02	EXPONENTS EQUALS 60000
J02 = H04' G13 G14	EXPONENT EQUAL 60000 FROM A ADDING TO NEGATIVE EXPONENTS.
J02 = H3 G14'	EXPONENT EQUALS 60000 FROM ADD TO POSITIVE EXPONENTS

A-1652

BOOLEAN J03 = G13' G14' H00' H03' + H04 G14 + H01 H00'

J03 = H01 H00'	ONE EXPONENT EQUALS ZERO NOT AN INTEGER MULTIPLY
J03 = H04 G14	BOTH EXPONENTS NEGATIVE AFTER ADDING EXPONENTS, BUT NOT AN INTEGER MULTIPLY
J03 = G13' G14' H00' H03'	BOTH EXPONENTS POSITIVE BIT 2^{13} AND 2^{14} NOT SET AND NOT AN INTEGER MULTIPLY

SET FLAG REGISTER RANGE ERROR

H21 = H20; T2 GO MULTIPLY DELAYED

M00 = J02 $\overline{\text{J03}}$ M21

BOOLEAM N00 = G00 M00'; T2

⇩

H14' = G14' M00'; T2

N00-N14 = EXPONENT BITS 2^0-2^{14}. FORCE EXPONENT EQUAL TO 60000 IF RANGER ERROR

N31 = M00; T2	
N32 = N31; T2	
R41 = N32; T2	SET FLAG REGISTER
R44 = J03; T2	UNDER FLOW STOP CONTROL TERM GO MULTIPLY

A-1652

CHANNELS

OBJECTIVES

WITH THE AID OF STUDENT REFERENCE MATERIAL, UPON COMPLETION OF THE COURSE, A STUDENT SHOULD BE CAPABLE OF:

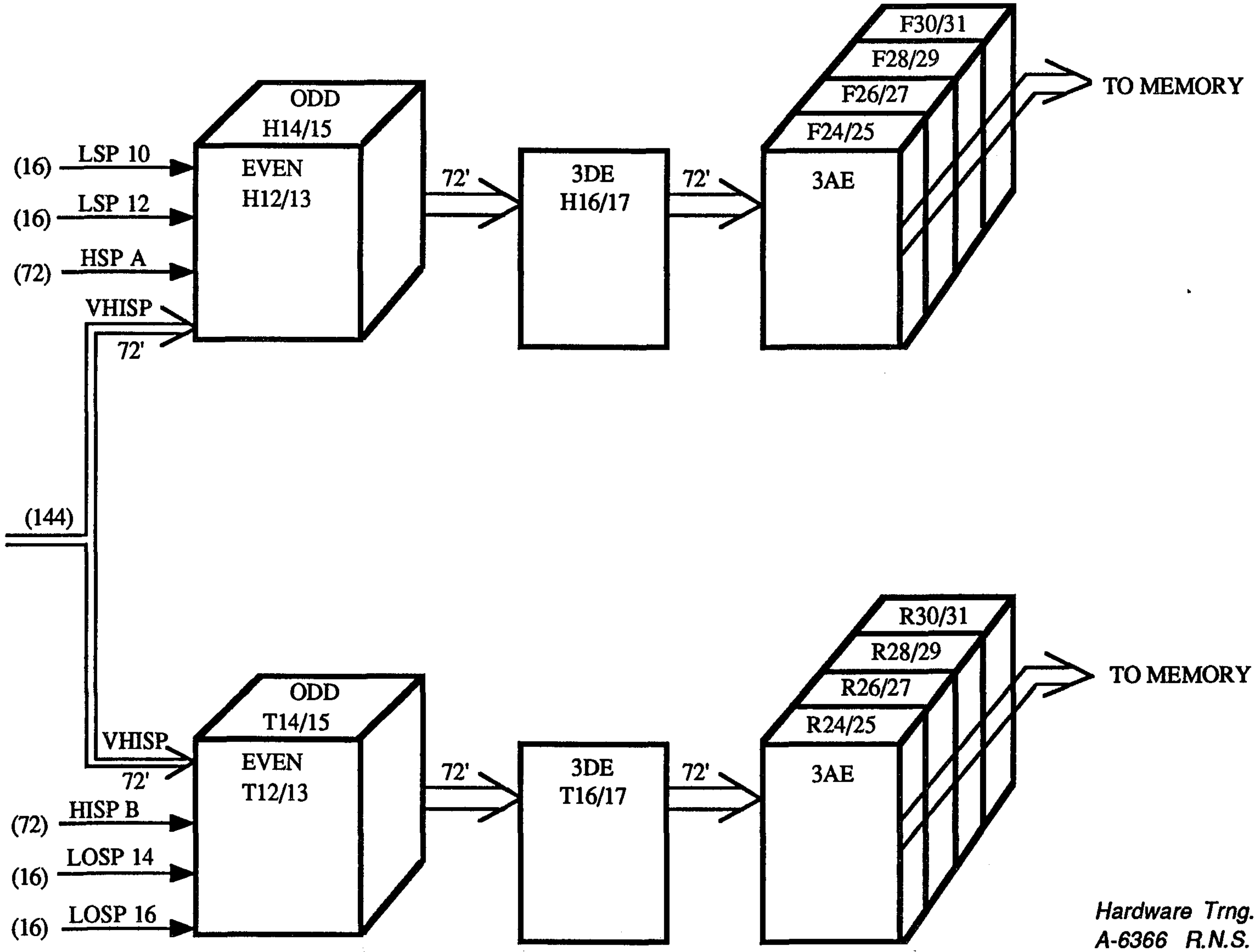
I. PROGRAMMING THE CHANNEL IN MACHINE LANGUAGE.

II. DEFINING THE CONTROL SIGNAL BETWEEN CHANNEL AND EXTERNAL DEVICE.

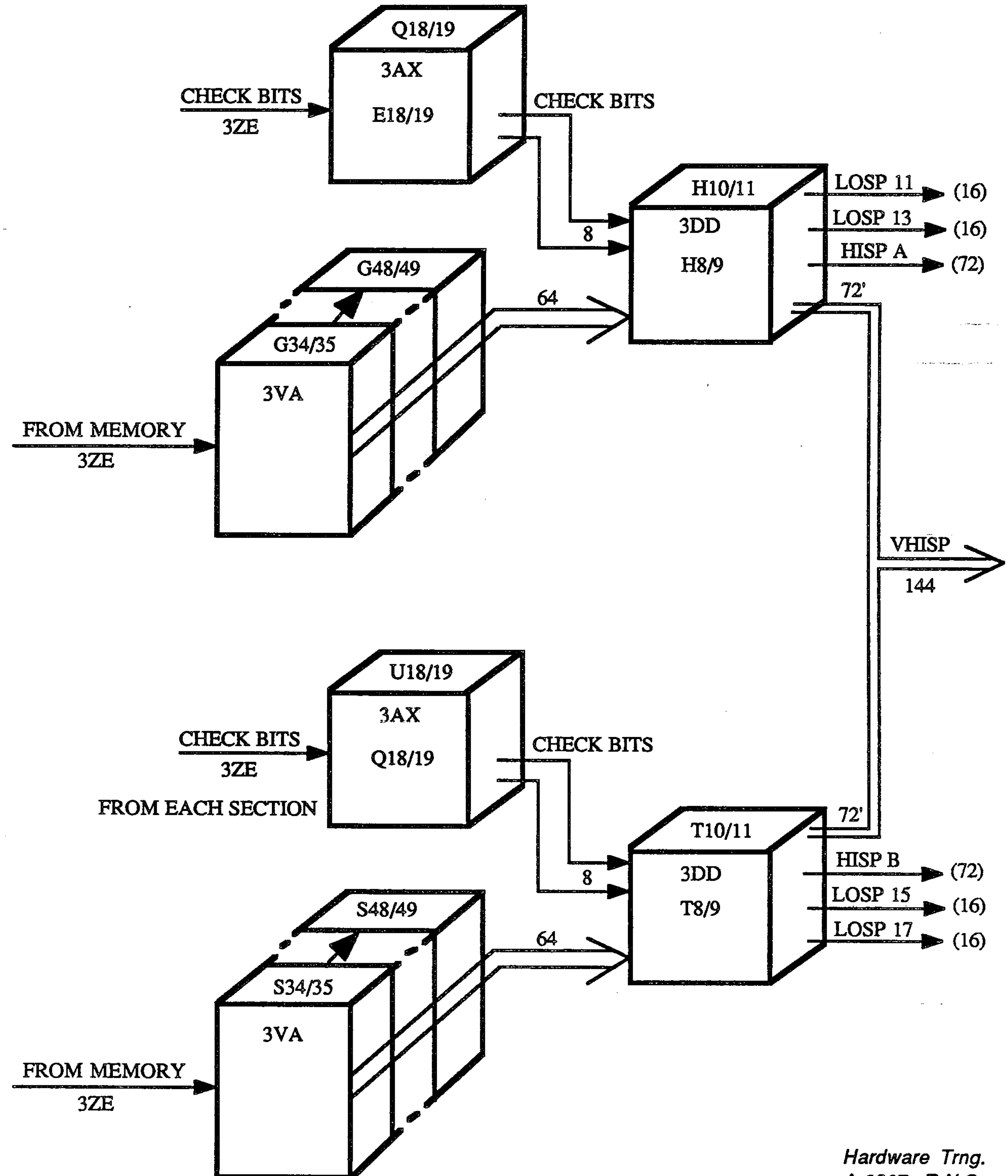
III. DESCRIBING THE CHANNEL MEMORY PRIORITY SCHEME AND HOW DATA IS ASSEMBLED AND DISASSEMBLED.

IV. TRACING A DATA BIT THROUGH THE CHANNEL.

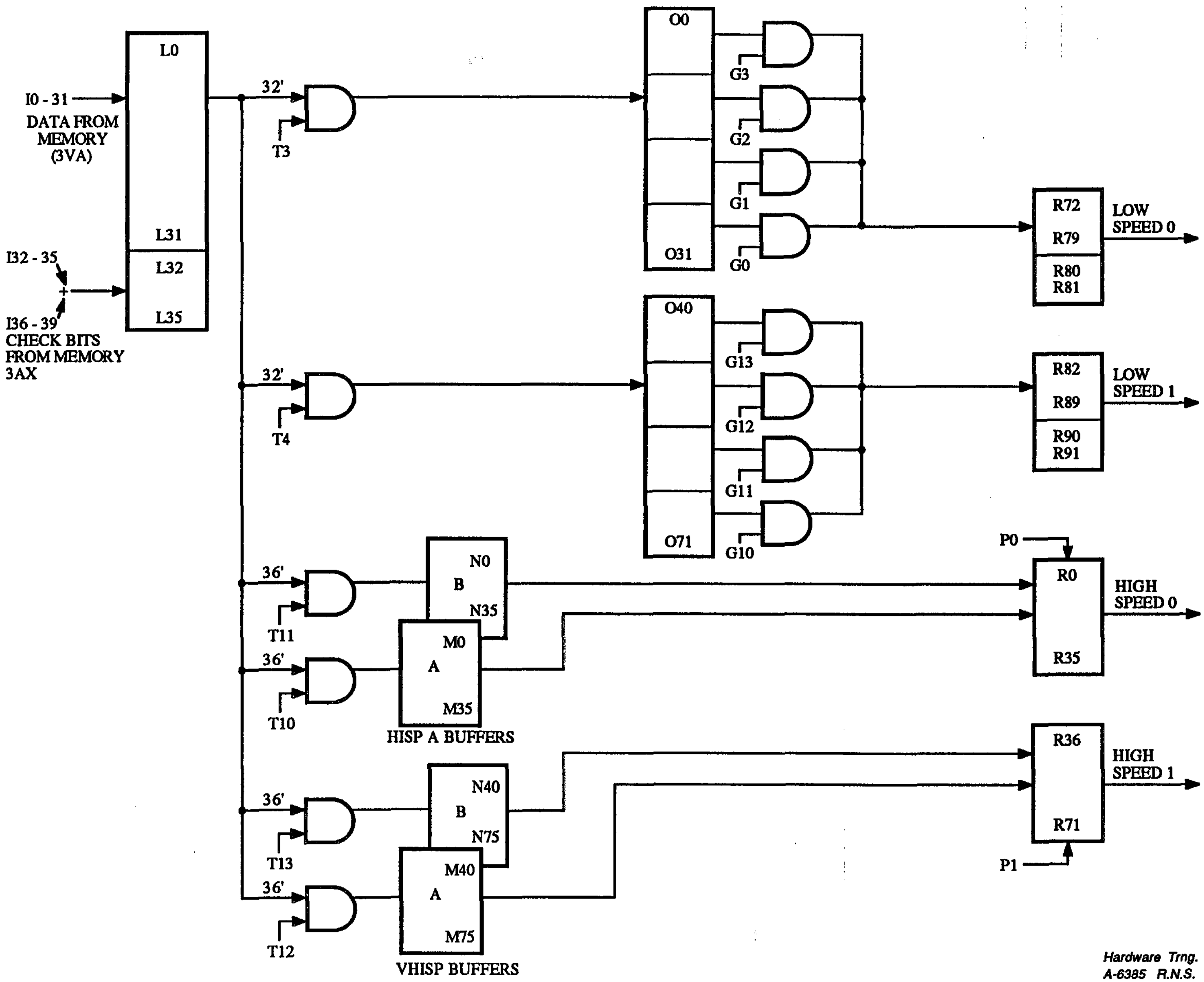
V. GENERALLY DESCRIBING THE SEQUENCE OF EVENTS WITHIN THE CHANNEL CONTROL MODULES FOR BOTH AN INPUT AND OUTPUT OPERATION.



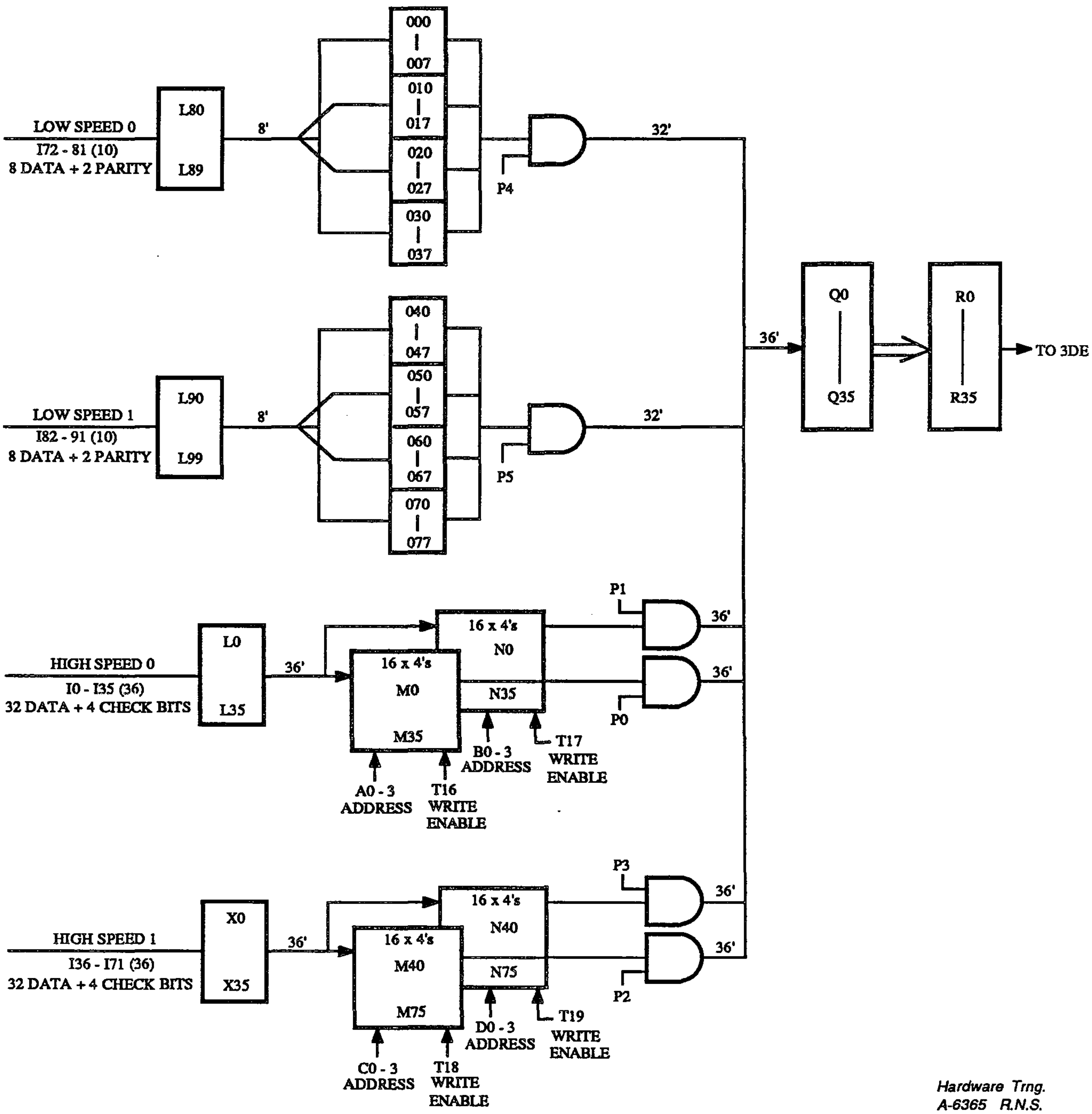
CRAY X-MP/2 I/O DATA PATHS (INPUT)



CRAY X-MP/2 I/O DATA PATHS (OUTPUT)



CRAY X-MP/2 3DD MODULE BLOCK DIAGRAM



Hardware Trng.
A-6365 R.N.S.

CRAY X-MP 3DJ MODULE BLOCK DIAGRAM

CRAY X-MP		IOS
LOSP 0 INPUT		IOP 0 LOSP/NSC MUX OUTPUT CHANNEL 21
LOSP 0 OUTPUT		IOP 0 LOSP/NSC MUX INPUT CHANNEL 20
LOSP 0 MCU CONTROL		IOP 0 MCU CONTROL CHANNEL 20/21
LOSP 1 INPUT LOSP 1 OUTPUT	LOOP BACK	
LOSP 2 INPUT LOSP 2 OUTPUT	LOOP BACK	
LOSP 3 INPUT LOSP 3 OUTPUT	LOOP BACK	

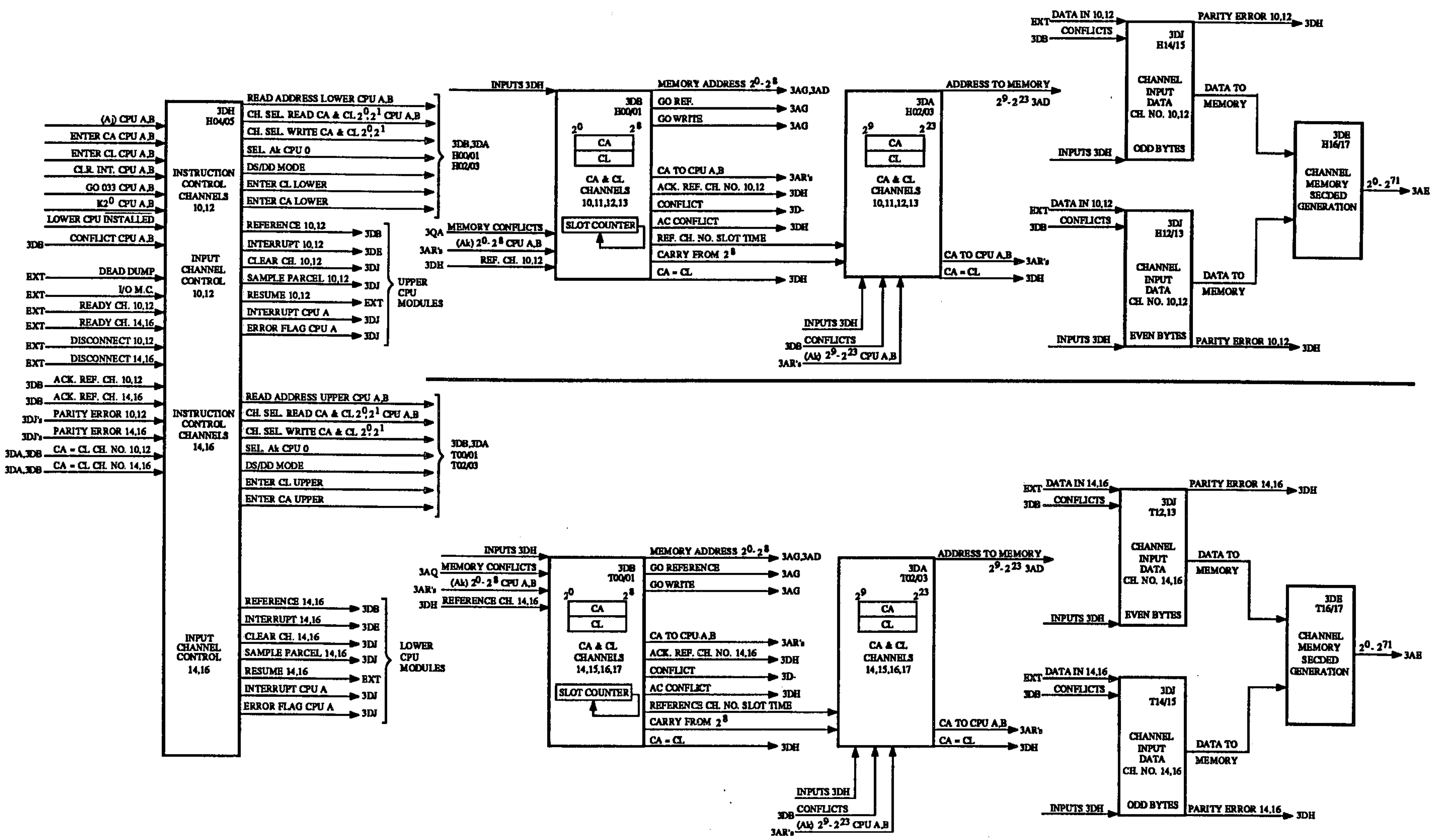
Hardware Trng.
A-6370 R.N.S.

CRAY X-MP/216 LOW SPEED CHANNEL CONFIGURATION

CRAY X-MP			IOS
HISP 0	IN	A1	IOP 0 HISP INPUT 00 - 23
		A2	IOP 0 HISP INPUT 24 - 47
		A3	IOP 0 HISP INPUT 48 - 63
		A4	IOP 0 HISP INPUT CONTROL
		A5	IOP 0 HISP IN/OUT ADDRESS EXPANSION
HISP 0	OUT	B1	IOP 0 HISP OUTPUT 00 - 23
		B2	IOP 0 HISP OUTPUT 24 - 47
		B3	IOP 0 HISP OUTPUT 48 - 63
		B4	IOP 0 HISP OUTPUT CONTROL
HISP 2	IN	E1	IOP 1 HISP INPUT 00 - 23
		E2	IOP 1 HISP INPUT 24 - 47
		E3	IOP 1 HISP INPUT 48 - 63
		E4	IOP 1 HISP INPUT CONTROL
		E5	IOP 1 HISP IN/OUT ADDRESS EXPANSION
HISP 2	OUT	F1	IOP 1 HISP OUTPUT 00 - 23
		F2	IOP 1 HISP OUTPUT 24 - 47
		F3	IOP 1 HISP OUTPUT 48 - 63
		F4	IOP 1 HISP OUTPUT CONTROL

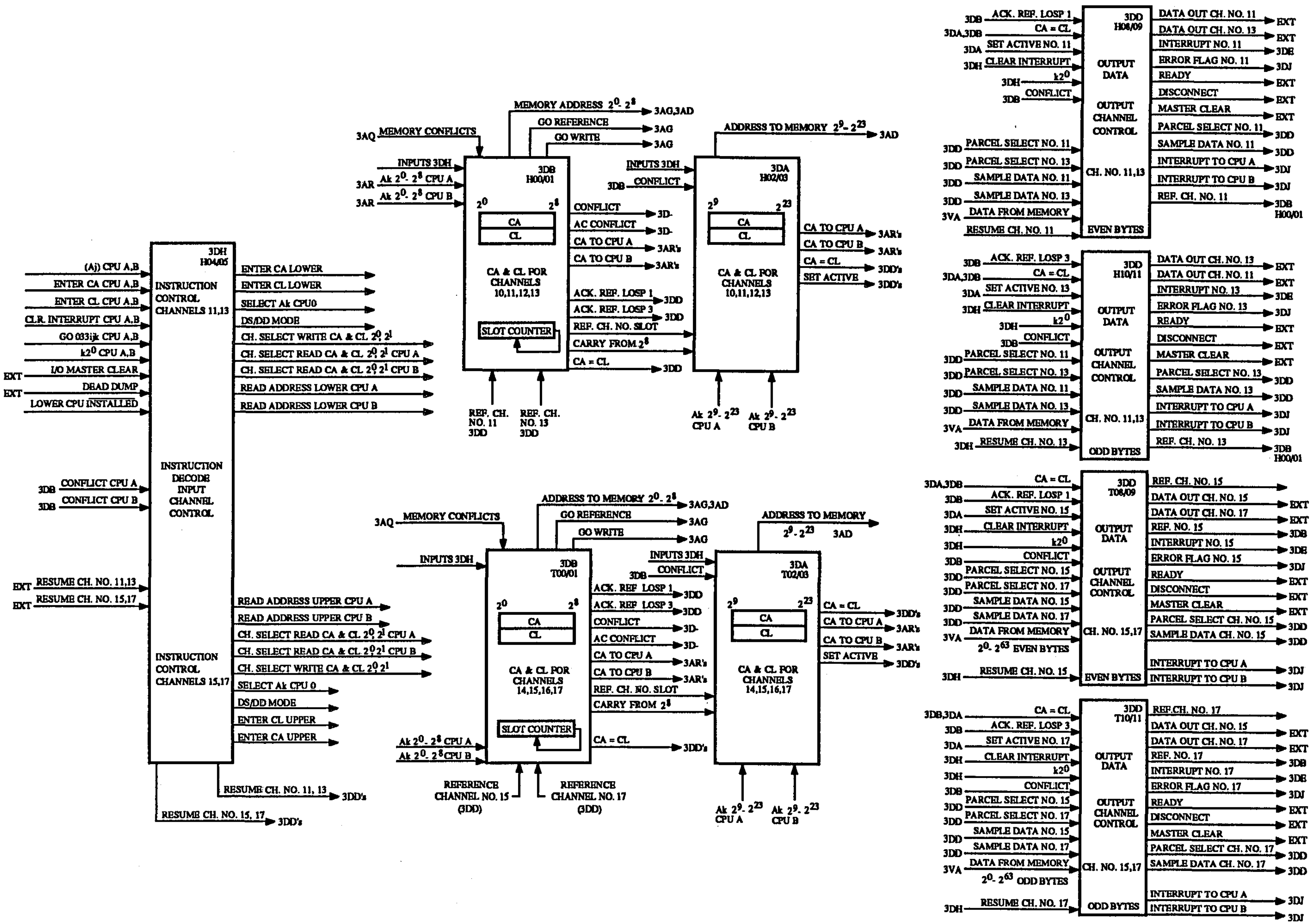
Hardware Trng.
A-6369 R.N.S.

CRAY X-MP/216 HIGH SPEED CHANNEL CONFIGURATION



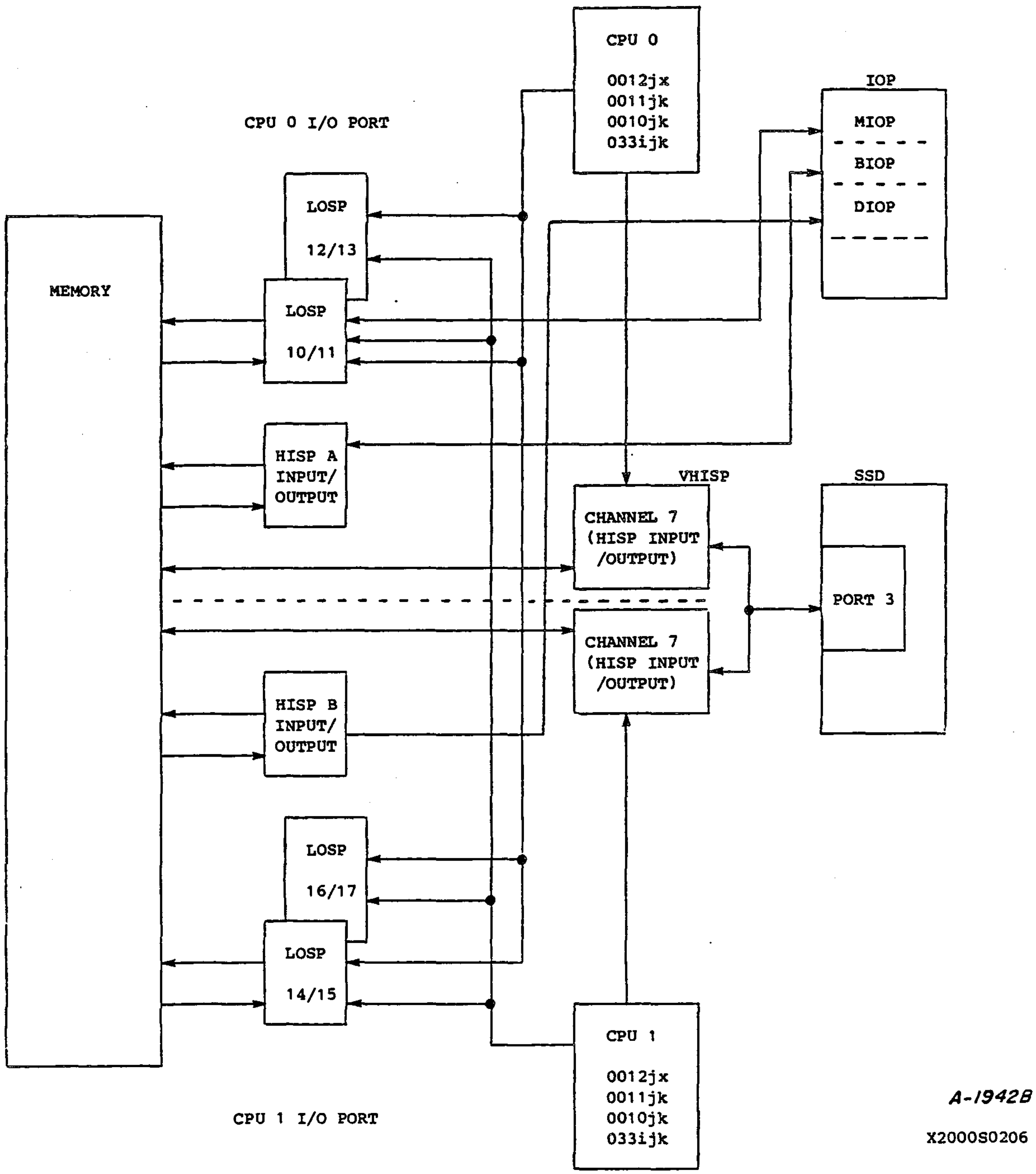
Hardware Trng.
A-5167A P.L.N.

X-MP/2 INPUT CHANNEL BLOCK DIAGRAM



X-MP/2 OUTPUT CHANNEL BLOCK DIAGRAM

Hardware Trng.
A-5166A P.L.N.



CRAY X-MP I/O LAYOUT

CABLE IDENTIFICATION

LOSP IDENTIFICATION

LOSP CHANNEL #		CABLE	DATA EVEN	DATA ODD
10	____________	LOSP 0 INPUT 3DJ	H12/13	H14/15
11	____________	LOSP 0 OUTPUT 3DD	H8/9	H10/11
		CONTROL		
12	____________	LOSP 1 INPUT 3DJ	H12/13	H14/15
13	____________	LOSP 1 OUTPUT 3DD	H8/9	H10/11
14	____________	LOSP 2 INPUT 3DJ	T12/13	T14/15
15	____________	LOSP 2 OUTPUT 3DD	T8/9	T10/11
16	____________	LOSP 3 INPUT 3DJ	T12/13	T14/15
17	____________	LOSP 3 OUTPUT 3DD	T8/9	T10/11

HISP IDENTIFICATION

HISP A - 9 CABLES, (4 INPUT CABLES, 4 OUTPUT CABLES AND 1 EXTEND ADDRESSING CABLE)

		CABLE			DATA EVEN	DATA ODD
HISP A PAIRS	HISP 0	A1 BITS 0-23	INPUT	3DJ	H12/13	H14/15
		A2 BITS 24-47				
		A3 BITS 48-71				
		A4 CONTROL				
		A5 CONTROL				
	HISP 0	B1 BITS 0-23	OUTPUT	3DD	H8/9	H10/11
		B2 BITS 24-47				
		B3 BITS 48-71				
		B4 CONTROL				

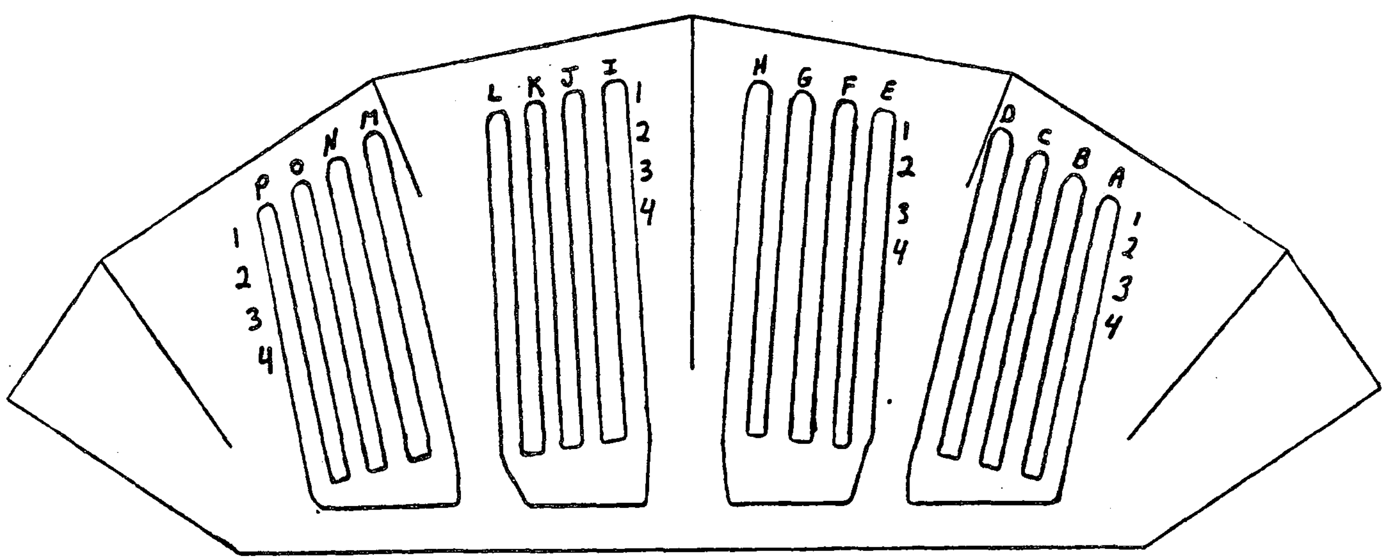
		CABLE			DATA EVEN	DATA ODD
HISP B PAIRS	HISP 2	E1 BITS 0-23	INPUT	3DJ	T12/13	T14/15
		E2 BITS 24-47				
		E3 BITS 48-71				
		E4 CONTROL				
		E5 CONTROL				
	HISP 2	F1 BITS 0-23	OUTPUT	3DD	T8/9	T10/11
		F2 BITS 24-47				
		F3 BITS 48-71				
		F4 CONTROL				

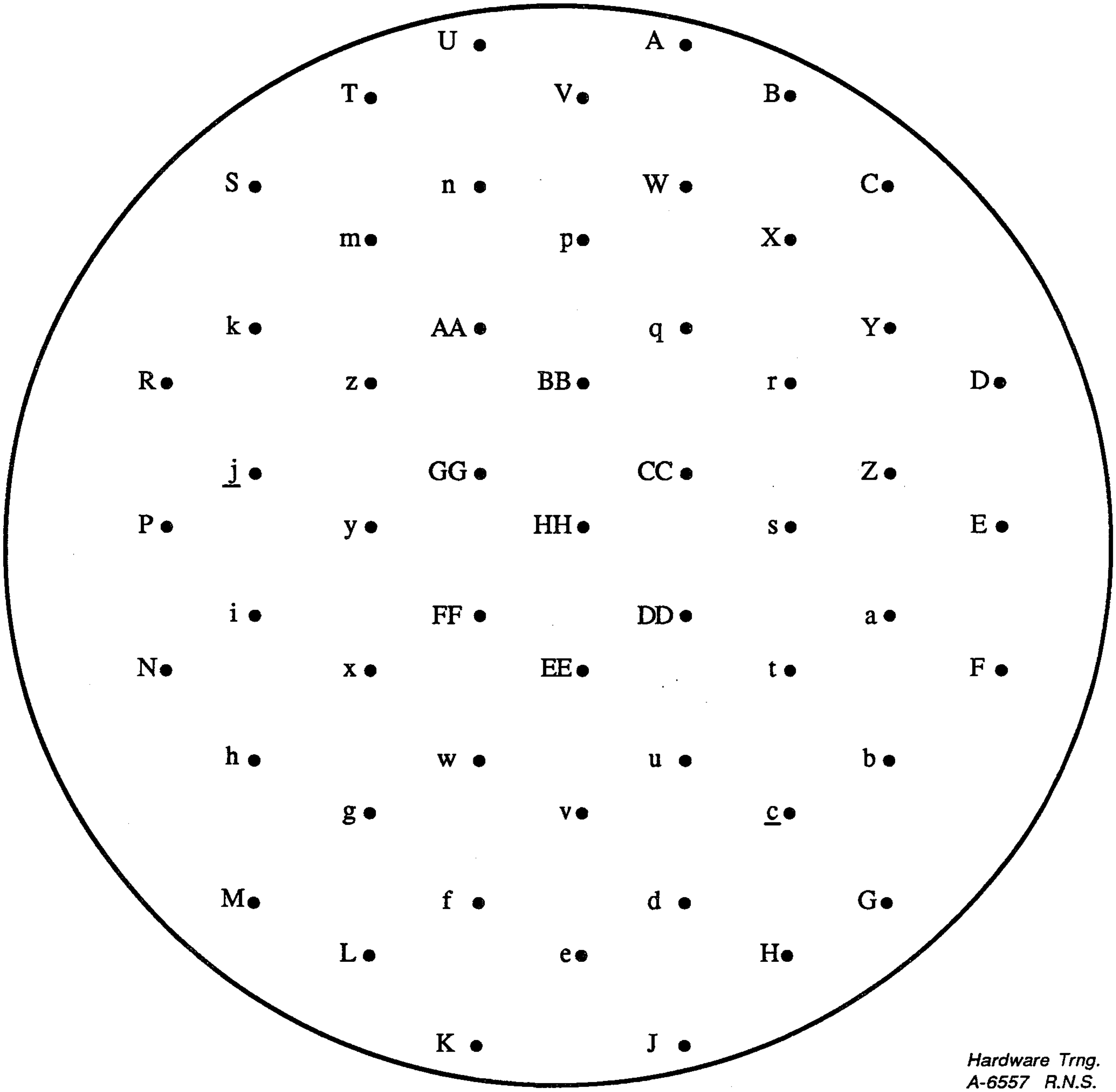
X2000S0205

CRAY-XMP STRAIN RELIEF CHART

SLOT #	DESCRIPTION
J2	LOSP 0 INPUT CHANNEL
K1	LOSP 0 OUTPUT CHANNEL
I4	LOSP 1 INPUT CHANNEL
J4	LOSP 1 OUTPUT CHANNEL
N2	LOSP 2 INPUT CHANNEL
N1	LOSP 2 OUTPUT CHANNEL
O3	LOSP 3 INPUT CHANNEL
M4	LOSP 3 OUTPUT CHANNEL
I3	HISP 0 INPUT CHANNEL A1
I2	HISP 0 INPUT CHANNEL A2
J1	HISP 0 INPUT CHANNEL A3
K4	HISP 0 INPUT CHANNEL A4
K5	HISP 0 IN/OUT CHANNEL A5
L2	MCU CONTROL CHANNEL
I1	ERROR CHANNEL A TO MICRO-MCU
O2	ERROR CHANNEL B TO MICRO-MCU

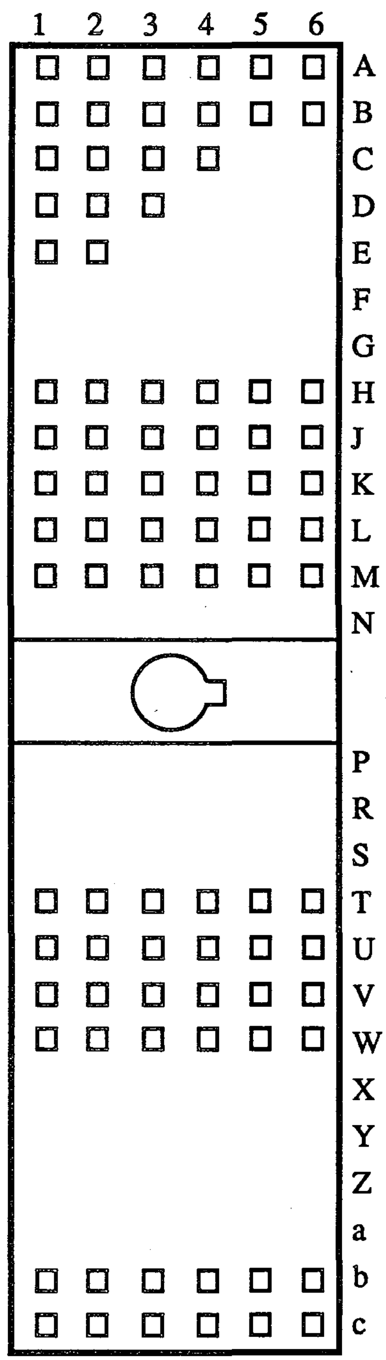
SLOT #	DESCRIPTION
J3	HISP 0 OUTPUT CHANNEL B1
K2	HISP 0 OUTPUT CHANNEL B2
K3	HISP 0 OUTPUT CHANNEL B3
L1	HISP 0 OUTPUT CHANNEL B4
O1	HISP 2 INPUT CHANNEL E1
N4	HISP 2 INPUT CHANNEL E2
N3	HISP 2 INPUT CHANNEL E3
L3	HISP 2 INPUT CHANNEL E4
M1	HISP 2 OUTPUT CHANNEL F1
M2	HISP 2 OUTPUT CHANNEL F2
M3	HISP 2 OUTPUT CHANNEL F3
L4	HISP 2 OUTPUT CHANNEL F4
L5	HISP 2 IN/OUT CHANNEL E5





CRAY X-MP 55 PIN CONNECTOR

IOS	X-MP SIDE
XP1	XP1
XP2	XP2
XP3	XP3
XP4	XP4
XP5	XP5



MALE SIDE

1/4 TURN
ON X-MP

↑ MOVEMENT OF CONNECTOR

↓ MOVEMENT OF CONNECTOR

IOS HAS STATIONARY PIN

156 PIN CONNECTOR

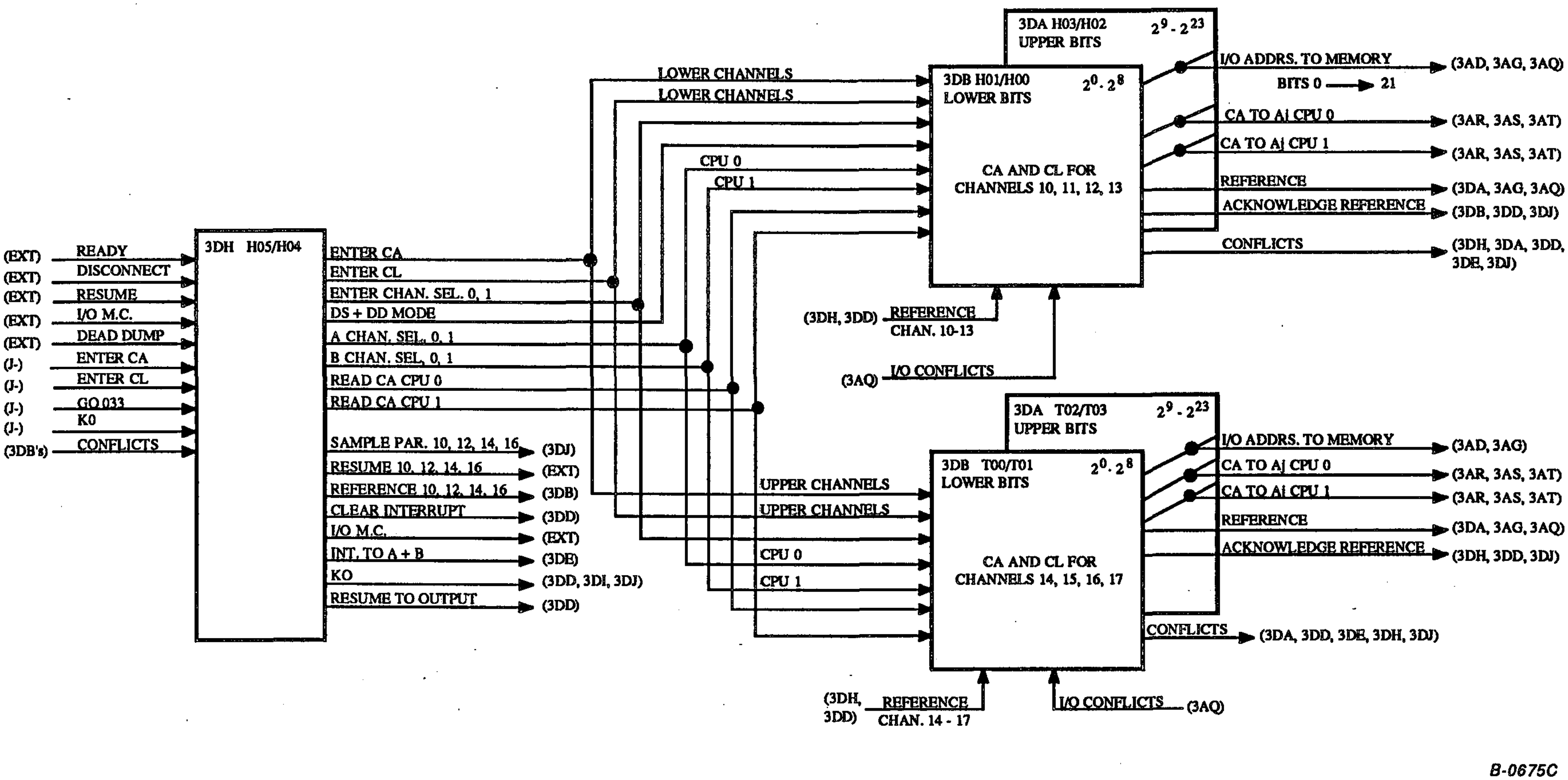
Hardware Trng.
A-6559 R.N.S.

CRAY X-MP VERY HIGH-SPEED CONNECTOR

I/O INSTRUCTION SET

** 0012J1		CLEAR THE INTERRUPT FLAG AND ERROR FLAG FOR THE CHANNEL INDICATED BY (AJ); SET DEVICE MASTER-CLEAR (OUTPUT CHANNEL); CLEAR DEVICE READY-HELD (INPUT CHANNEL)
** 0012J0		CLEAR THE INTERRUPT FLAG AND ERROR FLAG FOR THE CHANNEL INDICATED BY (AJ); CLEAR DEVICE MASTER-CLEAR (OUTPUT CHANNEL)
** 0011JK	CL, AJ AK	SET THE LIMIT ADDRESS (CL) REGISTER FOR THE CHANNEL INDICATED BY (AJ) TO (AK)
** 0010JK	CA, AJ AK	SET THE CURRENT ADDRESS (CA) REGISTER FOR CHANNEL INDICATED BY (AJ) TO (AK) AND ACTIVATE THE CHANNEL
033I00	AI CI	TRANSMIT INTERRUPTING CHANNEL NUMBER TO AI
033IJ0	AI CA, AJ	TRANSMIT ADDRESS OF CHANNEL (AJ) TO AI
033IJ1	AI CE, AJ	TRANSMIT ERROR FLAG OF CHANNEL (AJ) TO AI

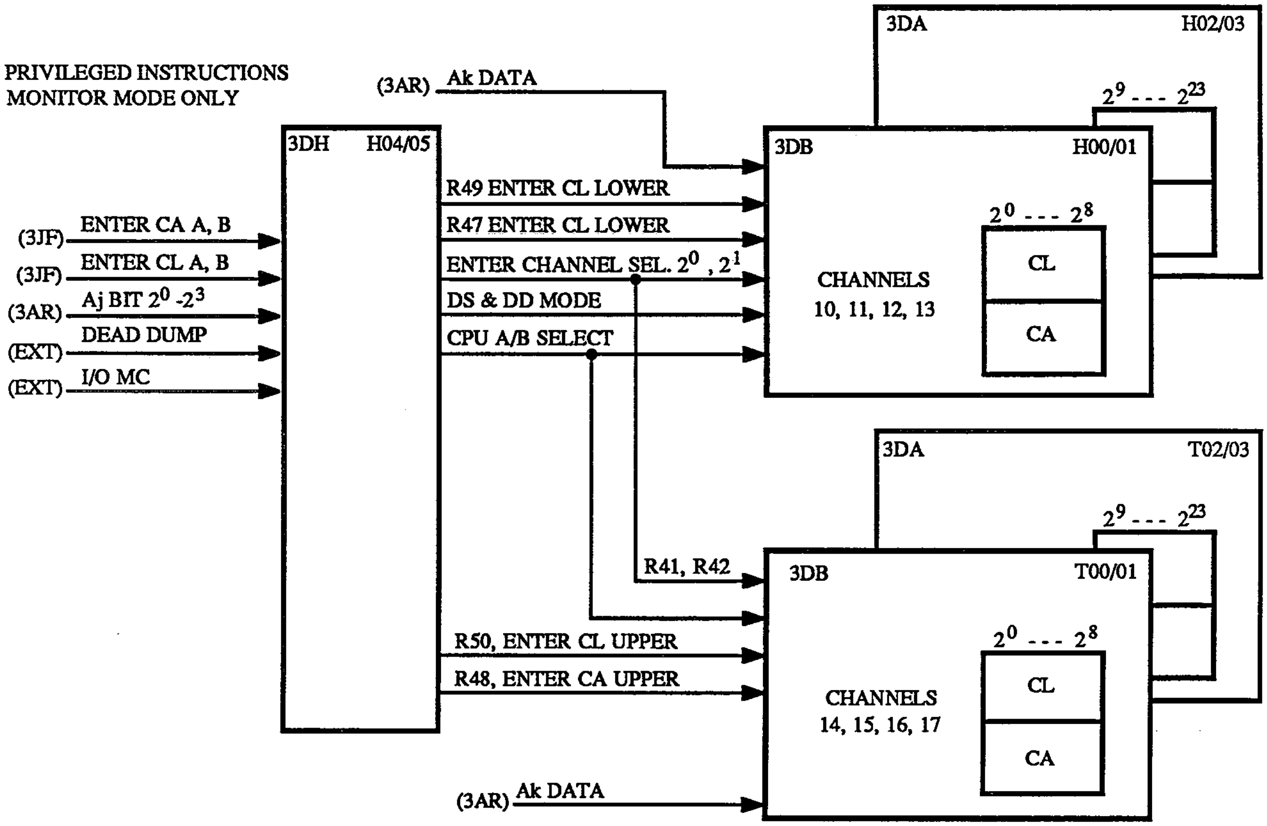
** PRIVILIGED INSTRUCTION - MONITOR MODE ONLY



CRAY X-MP LOSP CONTROL AND ADDRESS

0011jk **
0010jk **

* PRIVILEGED INSTRUCTIONS
MONITOR MODE ONLY



LOADING THE CL AND CA REGISTER

1. Execute a 0011jk instruction to load the CL register.
   Executing a 0010jk will load the CA register.

2. Aj is decoded on the 3DH to enter CA/CL in the upper/lower channels.
   Aj bit 2^2 and 2^3 select upper or lower channels. Aj bits 2^0 and 2^1 becomes enter channel select bit 2^0, 2^1.

3. Enter channel select bits 2^0, 2^1 will select 1 of 4 channels within the group.

4. Aj bit 2^2, 2^3 with enter CL/ CA will become enter CL/CA lower which will select the lower 4 channel while enter CL/CA upper will select the upper 4 channels.

5. The 3DB/3DA will decode the enter channel select bit and select 1 of 4 channels and load Ak data into the register. CPU A/B select will load Ak valve from either CPU 0 or CPU 1.

6. CL register is held until it is over written.

7. CA register is incremented each time Reference Valid comes up.

B-1567F

CRAY X-MP/2 LOAD CA/CL REGISTER, DS & DD

DEADSTART/DEAD DUMP MODE

:DD DELAY WC N

DELAY = 1 to 1000
WC = 1 to 1000
N = 1 PREVENT AN EXCHANGE

1. SET CPU MC AND I/O MC.

2. DROP I/O MC.

3. DROPPING I/O MC SET INPUT CHANNEL ACTIVE.

4. TRANSFER UP TO 1000_8 WORDS TO THE LOWER 1000 WORDS OF CRAY MEMORY.

5. DROP CPU MC WHEN TRANSFER IS COMPLETE; IF N=1 CPU MC WILL NOT DROP, THEREFORE PREVENTING AN EXCHANGE.

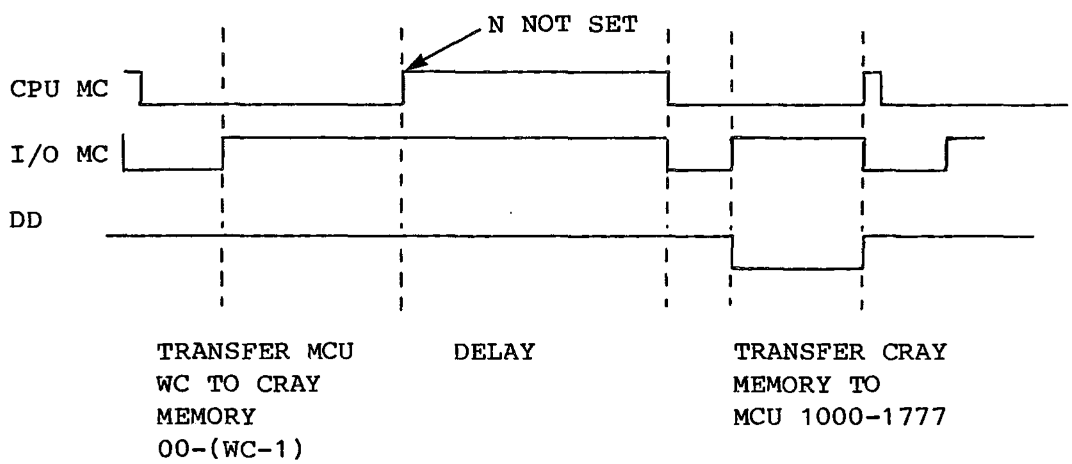
6. WAIT FOR TIME DELAY TO EXPIRE.

7. SET CPU MC AND I/O MC.

8. DROP I/O MC AND SET DD; DEAD DUMP PREVENTS CHANNEL 10 FROM GOING ACTIVE.

9. SETTING DD CAUSES CRAY TO OUTPUT 1000 WORDS.
   a) DD ACTIVATES THE OUTPUT CHANNEL
   b) CA=0
   c) CL=0

10. GO TO LINE 1



I/O MC - TEST POINTED ON 3DH T.P. A29 TERM M06
ACTIVE - CHANNEL 10 ON 3DH T.P. B53 TERM S02
CPU MC - TEST POINTED ON 3DF T.P. A33 TERM D00

X2000S0204

DEADSTART SEQUENCE

1. Set I/O MC and CPU MC.

   A) Setting I/O MC will set:

      CA = 0
      CL = 0

2. Input channel goes active when I/O MC drops.

3. Send CA to memory. Reference valid time increment CA register by 1.

4. Stop if:

   A) CA = CL
   B) Error
   C) Disconnect

5. Write 6000_8 words to memory for IOS or 4000_8 for MCU.

6. Drop CPU MC:

   A) Force an exchange with memory location $0\text{-}17_8$

7. Execute the program.

8. Monitor in the CPU, monitor has control of the machine.

9. Dependent on the monitor, monitor control I/O interrupt or never do another exchange.

10. With interrupt driven monitor now exchange from 160-177.

11. With monitor program send 6000_8 words to the IOP and cause exchange to 160-177.

LOSP CA REGISTER

	3DB'S	H00/01- T00/01		H00/01- T00/01		H00/01- T00/01		H00/01- T00/01	
	CHANNELS	10 & 14		11 & 15		12 & 16		13 & 17	
BIT		T.P.	TERM	T.P.	TERM	T.P.	TERM	T.P.	TERM
2^0	____	$\overline{B71}$	C00	$\overline{B29}$	C20	$\overline{B66}$	$\overline{C40}$	$\overline{B36}$	$\overline{C60}$
2^1	____	$\overline{B31}$	C01	$\overline{B28}$	C21	$\overline{B05}$	$\overline{C41}$	$\overline{B26}$	$\overline{C61}$
2^2	____	$\overline{B21}$	C02	$\overline{B22}$	C22	$\overline{B39}$	$\overline{C42}$	$\overline{B32}$	$\overline{C62}$
2^3	____	$\overline{B14}$	C03	$\overline{B19}$	C23	$\overline{B35}$	$\overline{C43}$	$\overline{B25}$	$\overline{C63}$
2^4	____	$\overline{B42}$	C04	$\overline{B06}$	C24	$\overline{B16}$	$\overline{C44}$	$\overline{B15}$	$\overline{C64}$
2^5	____	$\overline{B10}$	C05	$\overline{B49}$	C25	$\overline{B47}$	$\overline{C45}$	$\overline{B18}$	$\overline{C65}$
2^6	____	$\overline{A50}$	C06	$\overline{A10}$	C26	$\overline{A18}$	$\overline{C46}$	$\overline{A20}$	$\overline{C66}$
2^7	____	$\overline{A48}$	C07	$\overline{A16}$	C27	$\overline{A64}$	$\overline{C47}$	$\overline{A40}$	$\overline{C67}$
2^8	____	$\overline{A42}$	C08	$\overline{A25}$	C28	$\overline{A33}$	$\overline{C48}$	$\overline{A37}$	$\overline{C68}$
	3DA'S	H02/03- T02/03		H02/03- T02/03		H02/03- T02/03		H02/03- T02/03	
	CHAN.	10 & 14		11 & 15		12 & 16		13 & 17	
2^9	____	$\overline{A03}$	C00	$\overline{A18}$	C20	$\overline{A10}$	$\overline{C40}$	$\overline{A61}$	$\overline{C60}$
2^{10}	____	$\overline{A04}$	C01	$\overline{C33}$	C21	$\overline{A63}$	$\overline{C41}$	$\overline{A24}$	$\overline{C61}$
2^{11}	____	$\overline{A12}$	C02	$\overline{A23}$	C22	$\overline{A22}$	$\overline{C42}$	$\overline{A25}$	$\overline{C62}$
2^{12}	____	$\overline{C46}$	C03	$\overline{A44}$	C23	$\overline{A26}$	$\overline{C43}$	$\overline{A34}$	$\overline{C63}$
2^{13}	____	$\overline{A50}$	C04	$\overline{A43}$	C24	$\overline{A21}$	$\overline{C44}$	$\overline{A51}$	$\overline{C64}$
2^{14}	____	$\overline{A20}$	C05	$\overline{A29}$	C25	$\overline{A33}$	$\overline{C45}$	$\overline{A55}$	$\overline{C65}$
2^{15}	____	$\overline{A65}$	C06	$\overline{A48}$	C26	$\overline{A40}$	$\overline{C46}$	$\overline{A52}$	$\overline{C66}$
2^{16}	____	$\overline{C67}$	C07	$\overline{C70}$	C27	$\overline{C14}$	$\overline{C47}$	$\overline{C27}$	$\overline{C67}$
2^{17}	____	$\overline{C50}$	C08	$\overline{C68}$	C28	$\overline{C12}$	$\overline{C48}$	$\overline{C20}$	$\overline{C68}$
2^{18}	____	$\overline{C08}$	C09	$\overline{C23}$	C29	$\overline{C06}$	$\overline{C49}$	$\overline{C18}$	$\overline{C69}$
2^{19}	____	$\overline{C25}$	C10	$\overline{C38}$	C30	$\overline{C31}$	$\overline{C50}$	$\overline{C63}$	$\overline{C70}$
2^{20}	____	$\overline{C52}$	C11	$\overline{C65}$	C31	$\overline{C36}$	$\overline{C51}$	$\overline{C44}$	$\overline{C71}$
2^{21}	____	$\overline{C48}$	C12	$\overline{C40}$	C32	$\overline{C35}$	$\overline{C52}$	$\overline{C42}$	$\overline{C72}$
2^{22}	____	$\overline{A46}$	C13	$\overline{A57}$	C33	$\overline{A41}$	$\overline{C53}$	$\overline{A47}$	$\overline{C73}$
2^{23}	____	$\overline{A39}$	C14	$\overline{A45}$	C34	$\overline{A42}$	$\overline{C54}$	$\overline{A49}$	$\overline{C74}$

A-4108

LOSP CL REGISTER

BIT		T.P.	TERM	T.P.	TERM	T.P.	TERM	T.P.	TERM
3DB'S		H00/01-T00/01		H00/01-T00/01		H00/01-T00/01		H00/01-T00/01	
CHANNELS		10 & 14		11 & 15		12 & 16		13 & 17	
2^0	____	$\overline{B20}$	D00	$\overline{B37}$	D20	B57	$\overline{D40}$	B56	$\overline{D60}$
2^1	____	$\overline{B34}$	D01	$\overline{B23}$	D21	B11	$\overline{D41}$	B13	$\overline{D61}$
2^2	____	$\overline{B12}$	D02	$\overline{A66}$	D22	B53	$\overline{D42}$	B58	$\overline{D62}$
2^3	____	$\overline{B08}$	D03	$\overline{B02}$	D23	B17	$\overline{D43}$	B07	$\overline{D63}$
2^4	____	$\overline{B03}$	D04	$\overline{B09}$	D24	B55	$\overline{D44}$	B01	$\overline{D64}$
2^5	____	$\overline{B04}$	D05	$\overline{B30}$	D25	B54	$\overline{D45}$	B24	$\overline{D65}$
2^6	____	$\overline{A46}$	D06	$\overline{A57}$	D26	A41	$\overline{D46}$	A28	$\overline{D66}$
2^7	____	$\overline{A39}$	D07	$\overline{A62}$	D27	A43	$\overline{D47}$	A36	$\overline{D67}$
2^8	____	$\overline{A52}$	D08	$\overline{A61}$	D28	A38	$\overline{D48}$	A34	$\overline{D68}$
	3DA'S	H02/03-T02/03		H02/03-T02/03		H02/03-T02/03		H02/03-T02/03	
	CHAN.	10 & 14		11 & 15		12 & 16		13 & 17	
2^9	____	$\overline{B71}$	$\overline{D00}$	$\overline{B62}$	$\overline{D20}$	A09	D40	A07	D60
2^{10}	____	$\overline{B66}$	$\overline{D01}$	$\overline{B56}$	$\overline{D21}$	A15	D41	A17	D61
2^{11}	____	$\overline{B17}$	$\overline{D02}$	$\overline{B09}$	$\overline{D22}$	A11	D42	A13	D62
2^{12}	____	$\overline{B69}$	$\overline{D03}$	$\overline{B07}$	$\overline{D23}$	$\overline{A28}$	D43	$\overline{A30}$	D63
2^{13}	____	$\overline{B60}$	$\overline{D04}$	$\overline{B34}$	$\overline{D24}$	A19	D44	A56	D64
2^{14}	____	$\overline{B53}$	$\overline{D05}$	$\overline{B32}$	$\overline{D25}$	A32	D45	A54	D65
2^{15}	____	$\overline{B15}$	$\overline{D06}$	$\overline{B30}$	$\overline{D26}$	A27	D46	A53	D66
2^{16}	____	$\overline{D71}$	$\overline{D07}$	$\overline{D49}$	$\overline{D27}$	C07	D47	C17	D67
2^{17}	____	$\overline{D69}$	$\overline{D08}$	$\overline{D47}$	$\overline{D28}$	C11	D48	C21	D68
2^{18}	____	$\overline{D53}$	$\overline{D09}$	$\overline{D43}$	$\overline{D29}$	C09	D49	C22	D69
2^{19}	____	$\overline{D66}$	$\overline{D10}$	$\overline{D41}$	$\overline{D30}$	C30	D50	C41	D70
2^{20}	____	$\overline{D64}$	$\overline{D11}$	$\overline{D39}$	$\overline{D31}$	C39	D51	C43	D71
2^{21}	____	$\overline{D51}$	$\overline{D12}$	$\overline{D45}$	$\overline{D32}$	C34	D52	C37	D72
2^{22}	____	$\overline{B64}$	$\overline{D13}$	$\overline{B54}$	$\overline{D33}$	$\overline{A38}$	D53	$\overline{A37}$	D73
2^{23}	____	$\overline{B58}$	$\overline{D14}$	$\overline{B05}$	$\overline{D34}$	$\overline{A31}$	D54	$\overline{A36}$	D74

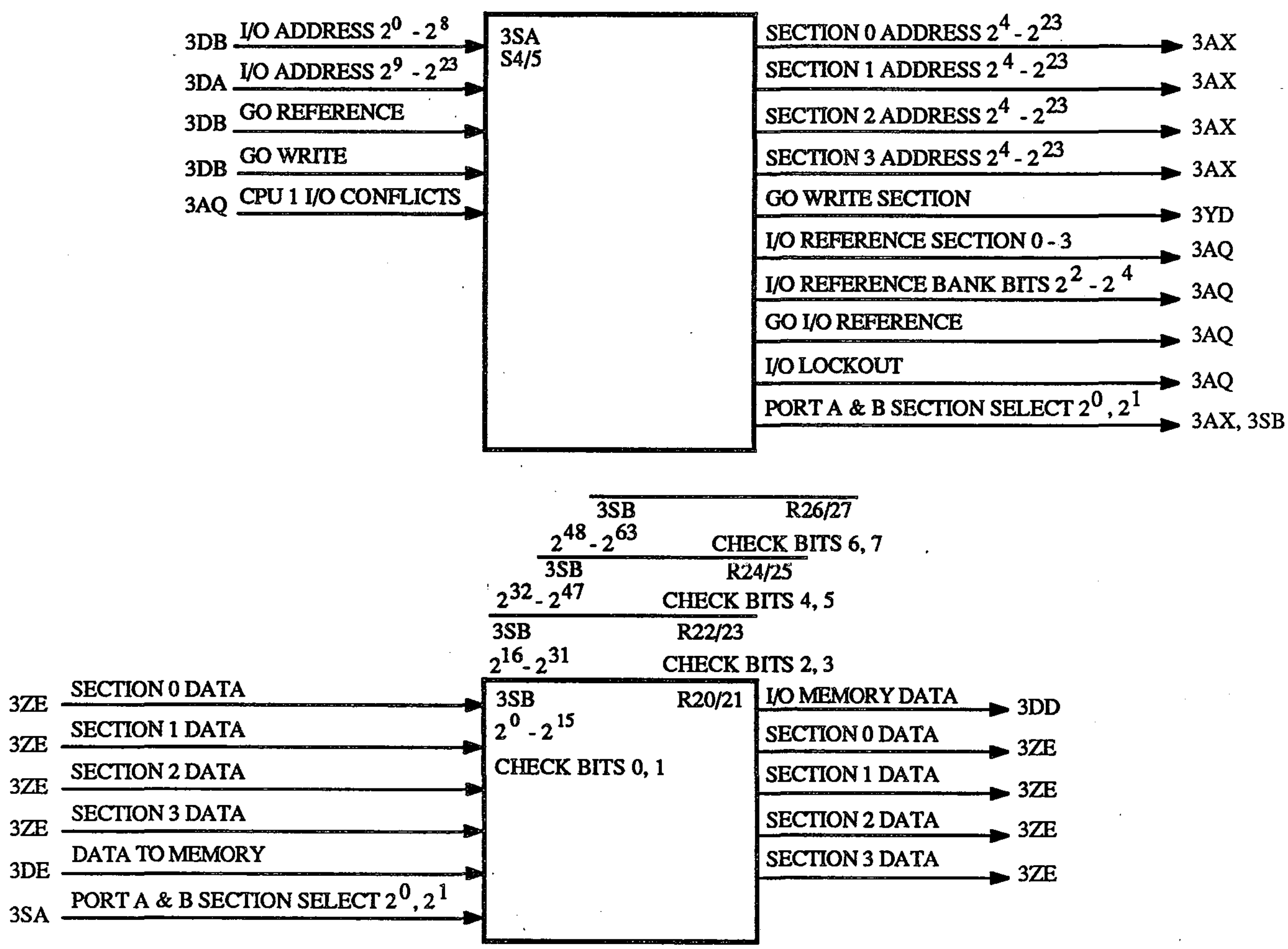
A-4109

3SA MODULE

The 3SA module is used in a CRAY X-MP/1 to replace the 3AO and 3AP modules that would normally be in the lower CPU of a two processsor machine. The 3SA module contains logic for address and control to memory.

3SB MODULE

The 3SB modules (four) contain logic to replace the 3AE and 3VA modules that would normally be in the lower CPU of a two processor machine. The 3SB handles both data to memory from the 3DE module and data from memory to the 3DD module for I/O paths.



If there are no lower I/O Channels, (LOSP 14 - 17, HISP B or VHISP) omit the modules at locations T00 - T17, R20 - R27, and S4/5. Add 3DQ - 2 modules in the following locations: T0, T2, T3, T4, T5, T9, T11, S5.

B-3188C

CRAY X-MP/1 SIX COLUMN
CPU 1 I/O ADDRESS/DATA PATH
SN 309 TO 332

Written By: John Spiegel

MTI Monitor

Using :TB Mode - The TB mode selects the MCU Basic as the test mode by default. The TB mode is frequently used for executing the Cray diagnostics. The TB mode oversees on going activity and expects the Cray to output to the MCU in a specified amount of time. If not, the TB will display a message saying "Time-out", "Write Hang", "Read Hang" or "CPU Not Responding".

Monitor - Causes the Cray to output an image to the MCU of the activity in the machine.

User - The user can be the diagnostic or scope loop. The user, utilizes the machines hardware.

Master Clear/Deadstart - Adv. MC/DS

Deadstart Sequence

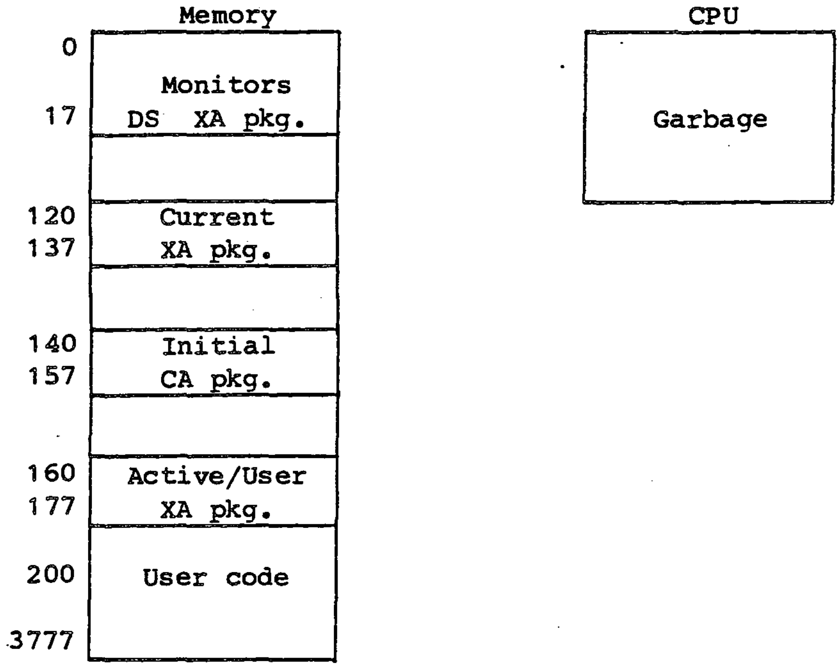
1. Set I/O MC and CPU MC
   a. Setting I/O MC will set
      CA = 0
      CL = 0

2. The input channel goes active when I/O MC drops.

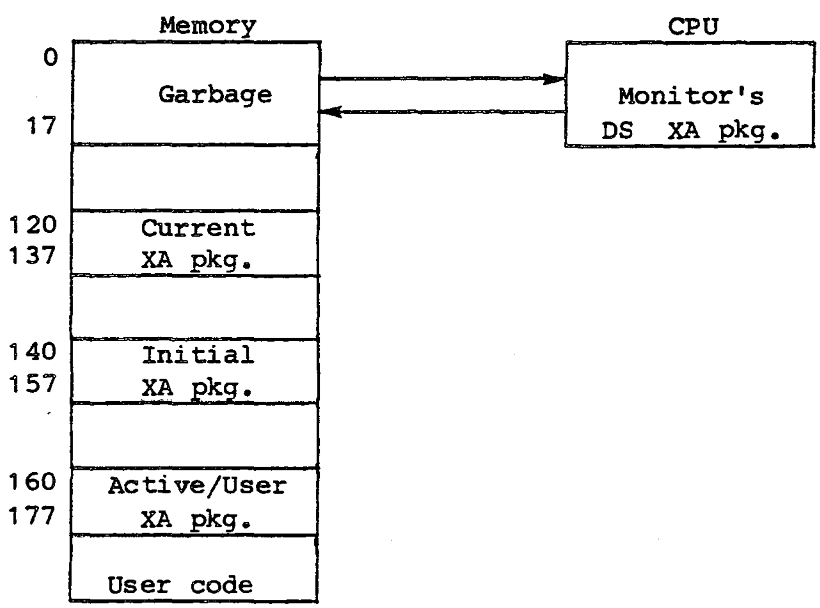
3. Send 4000_8 words from the MCU to the lower 4000 address in Cray memory.

4. Drop CPU MC when the transfer is complete. Dropping CPU MC causes an exchange with memory location 0-17.

A)

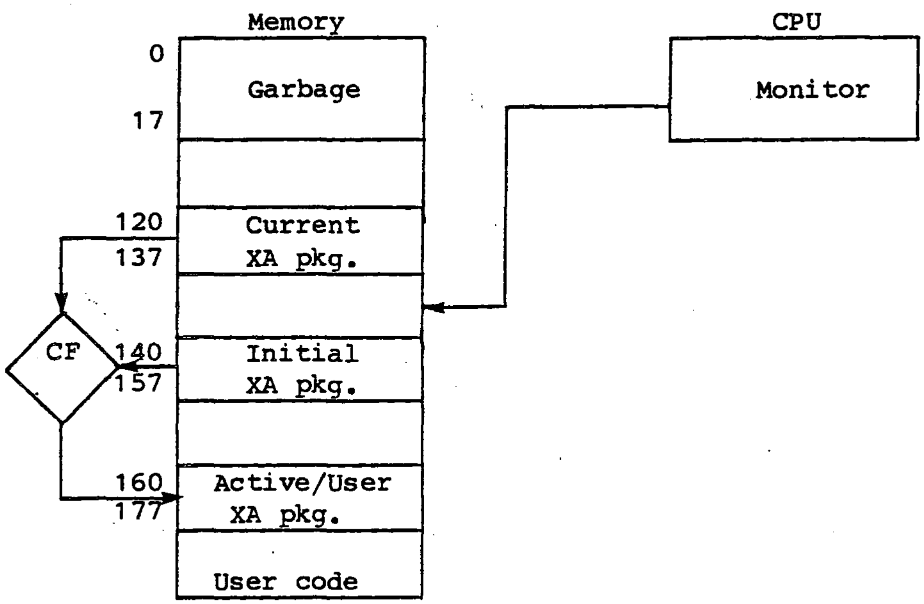


B) Drop CPU MC when the 4000 word transfer is complete. Dropping CPU MC causes an exchange with memory location $0\text{-}17_8$.

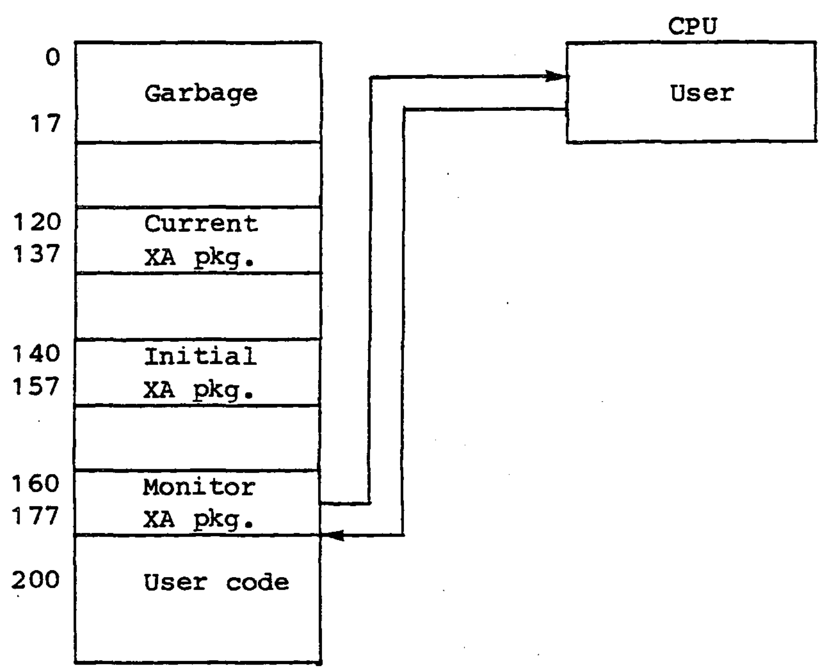


X3001S0104

C) Monitor copies XA pkg. 120 or XA pkg. 140 to XA pkg. 160; by default XA pkg. 140 to XA pkg. 160. If continue flag is set monitor copies XA pkg. 120 to XA pkg. 160. Continue flag is set by setting address 27 to a 1.

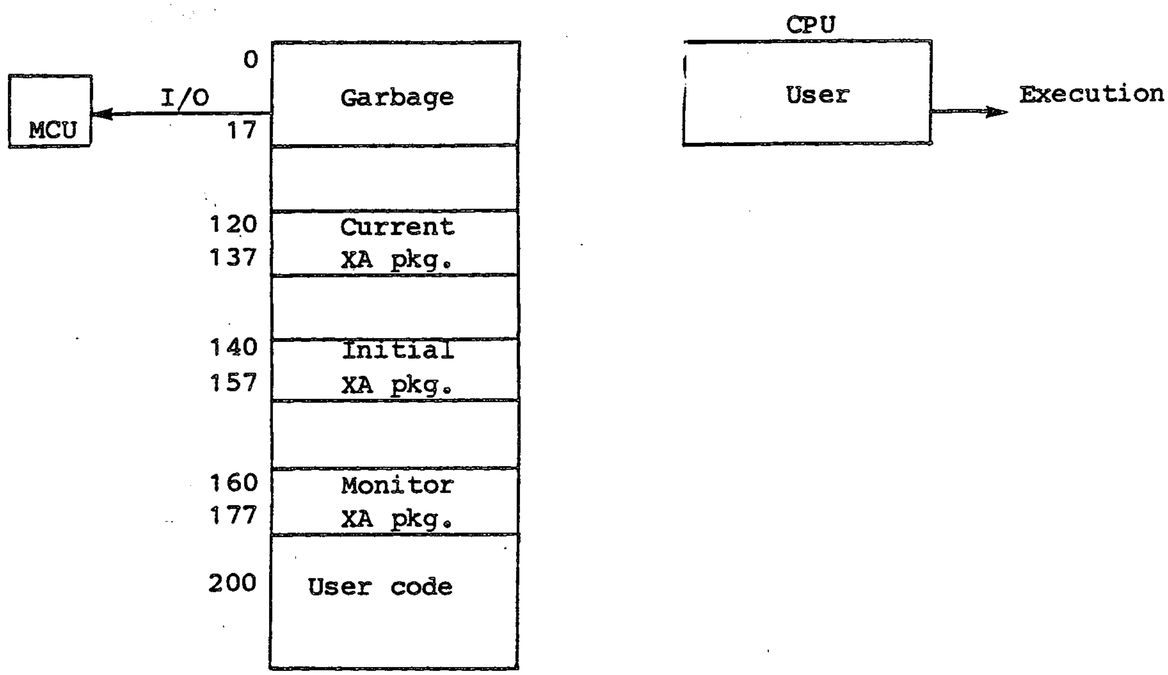


D) Monitor starts a 4000 word transfer to the MCU over the output channel. Monitor then forces an exchange which puts monitor into memory XA pkg. 160 and the user into the CPU.

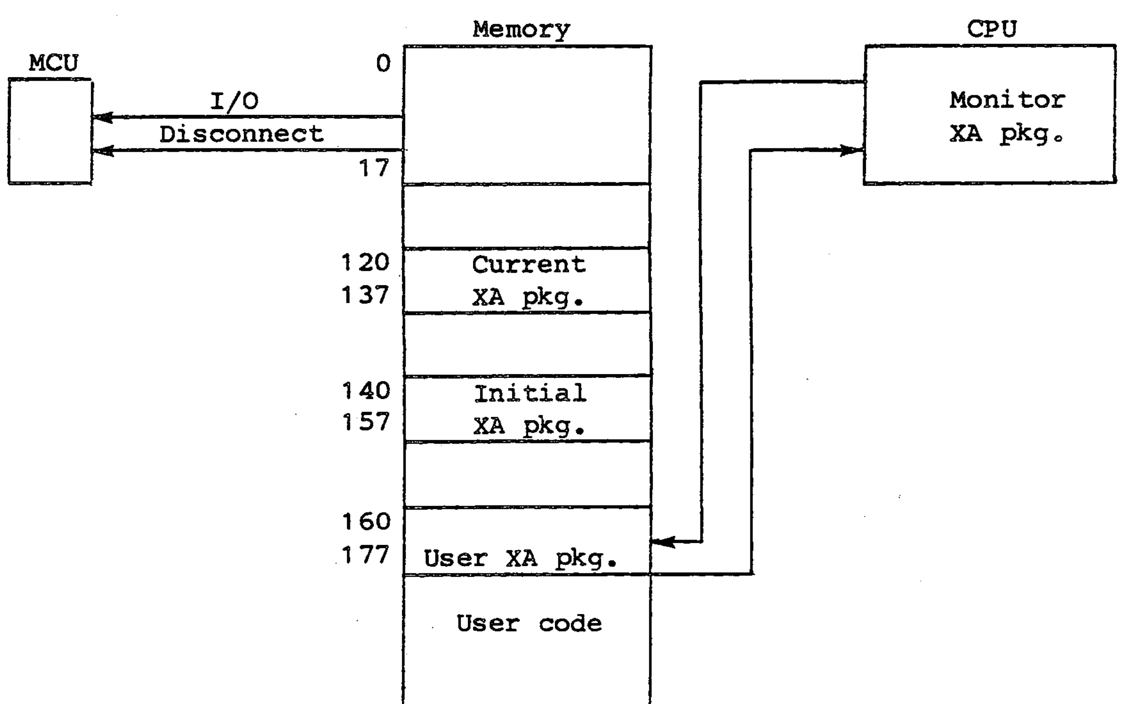


X3001S0105

E) User starts executing code starting at P register address which is 200-0. Also, the output channel continues outputing to the MCU.

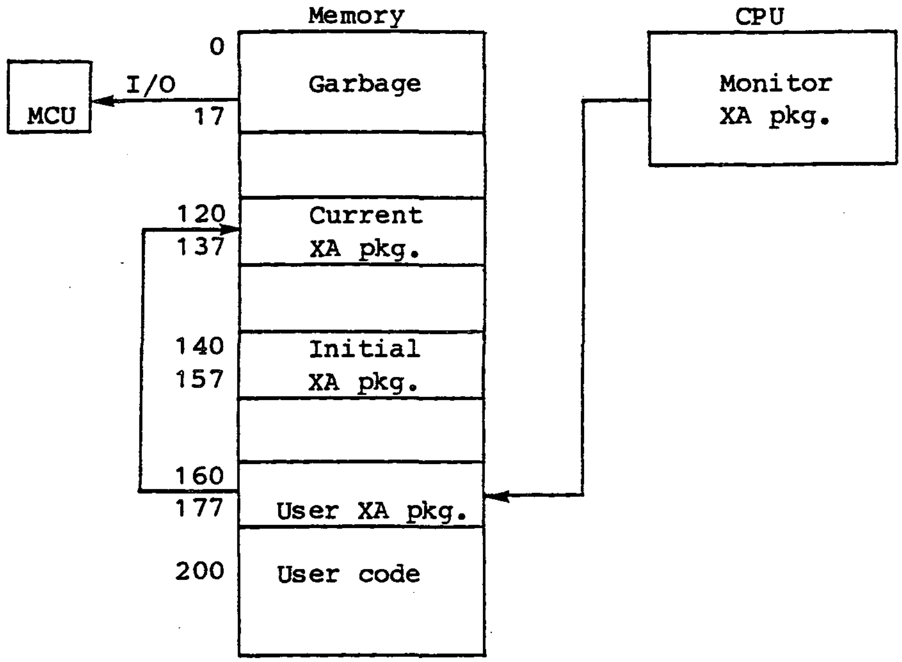


F) I/O interrupt occurs when CA=CL or 4000 word transfer is complete. I/O interrupt causes a disconnect on the output channel. I/O interrupt also causes an exchange which puts the user XA pkg. into memory at address 160-177. Monitor XA pkg. is then transferred into the CPU.

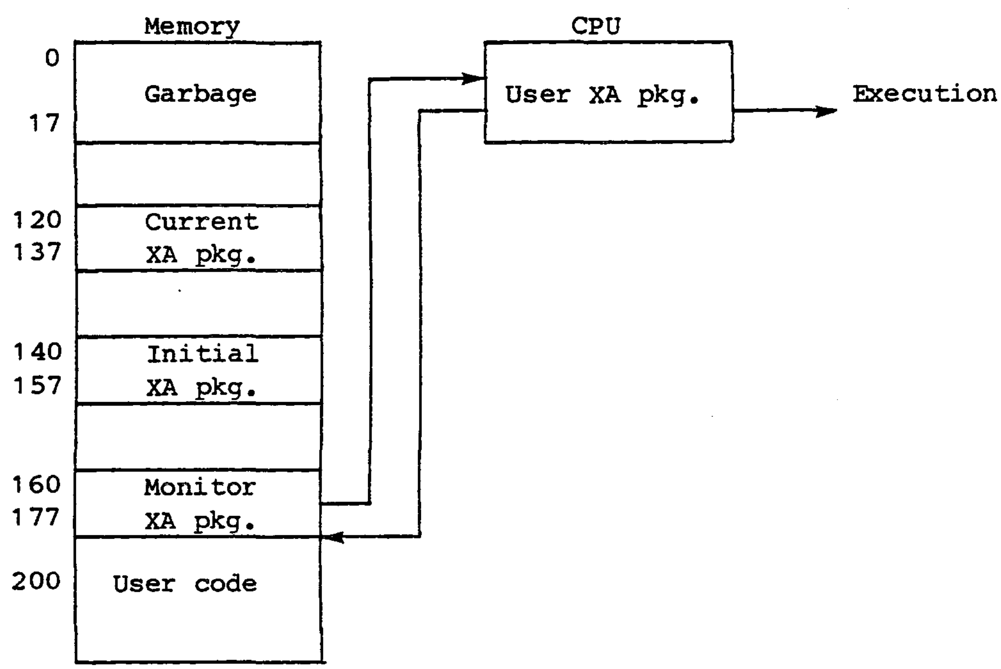


X3001S0106

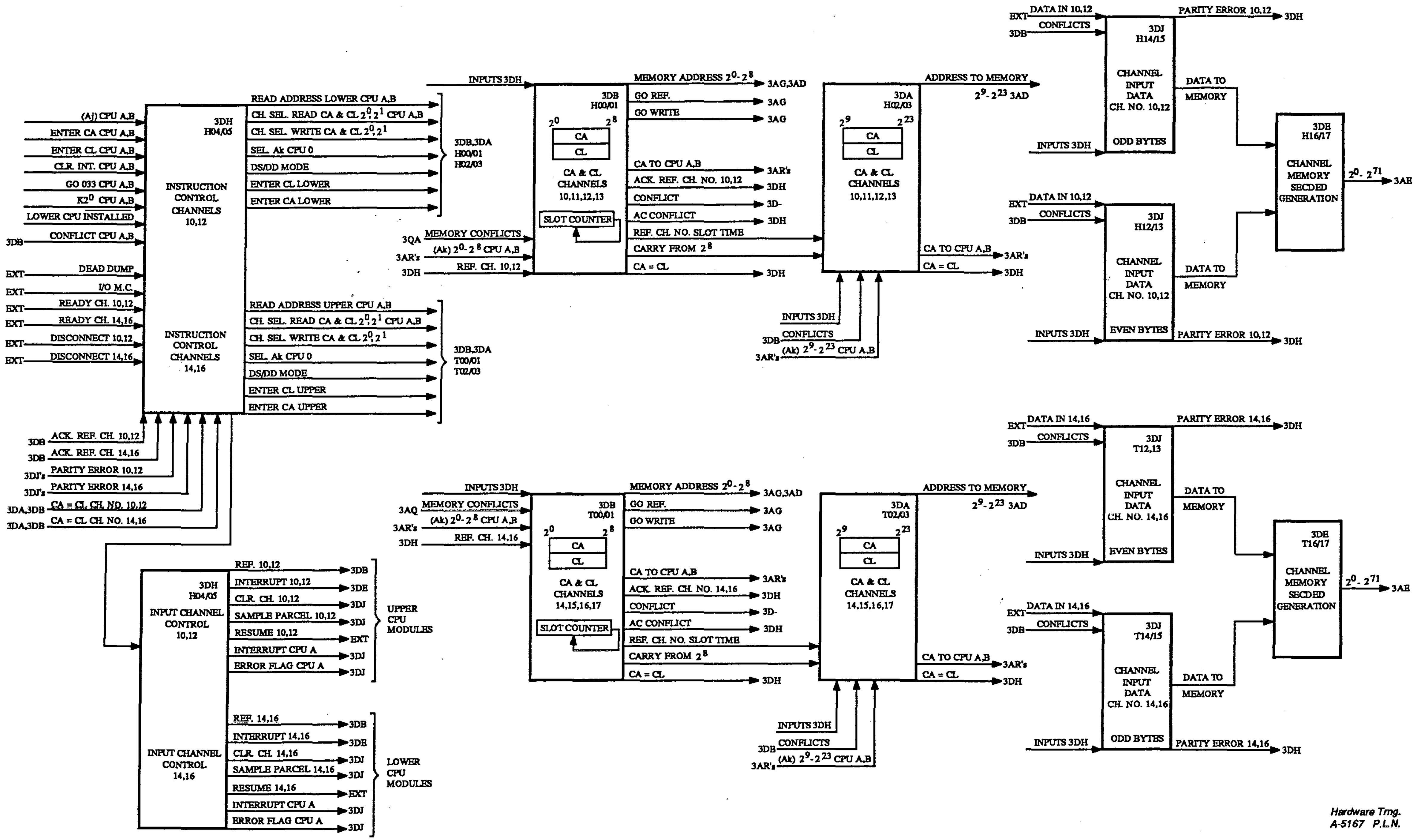
G) While the monitor is in the CPU it will copy exchange package 160 to XA pkg. 120. Monitor will then activate the output channel to transfer 4000 words to the MCU. This allows the user to observe the activity of the machine at the time the I/O interrupt occurred.



H) Monitor forces an exchange which puts the user XA pkg. back into the CPU. And monitor's XA pkg. in XA pkg. 160. This sequence reverts back to step E or until a MC is set from the MCU.

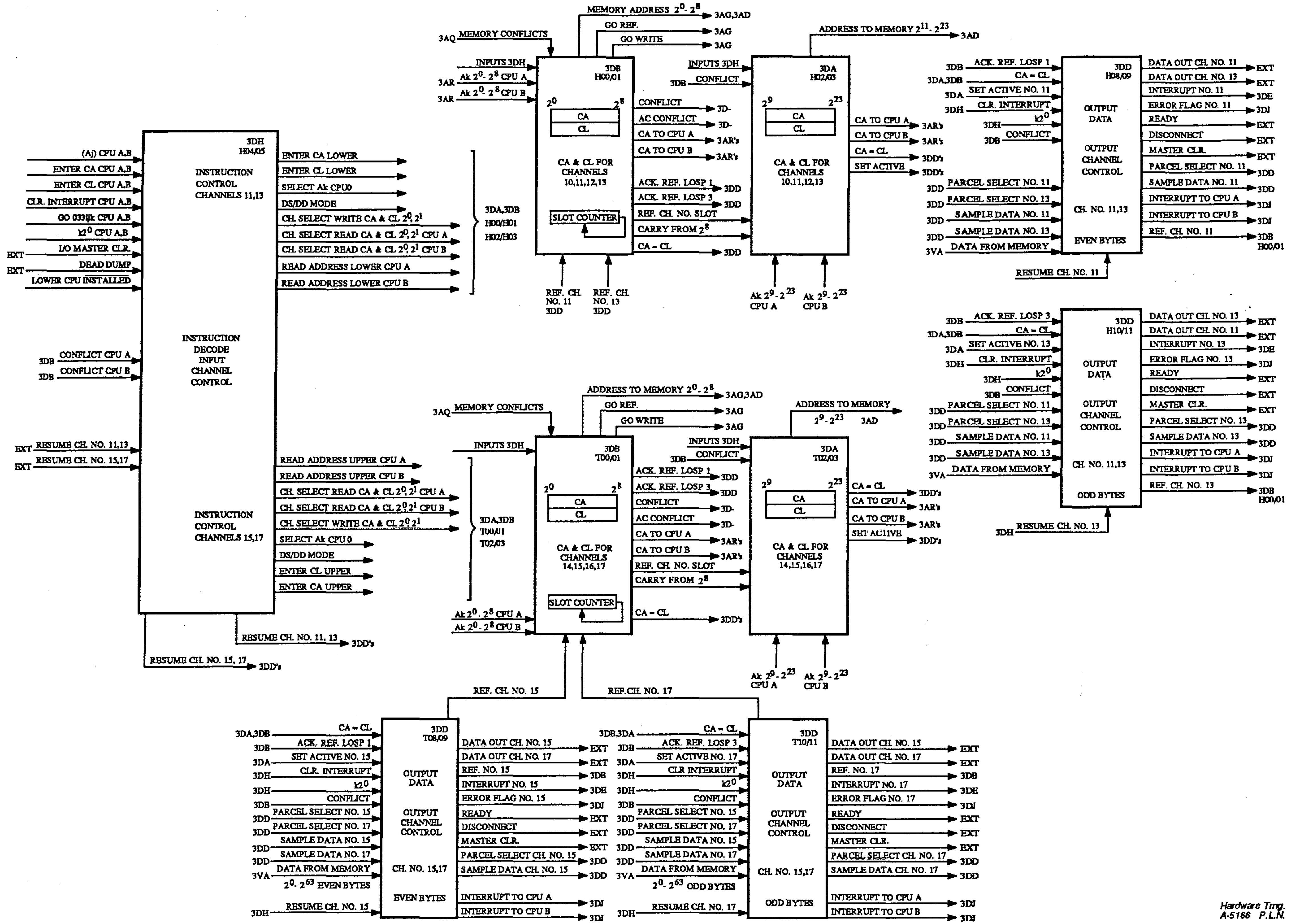


X3001S0107



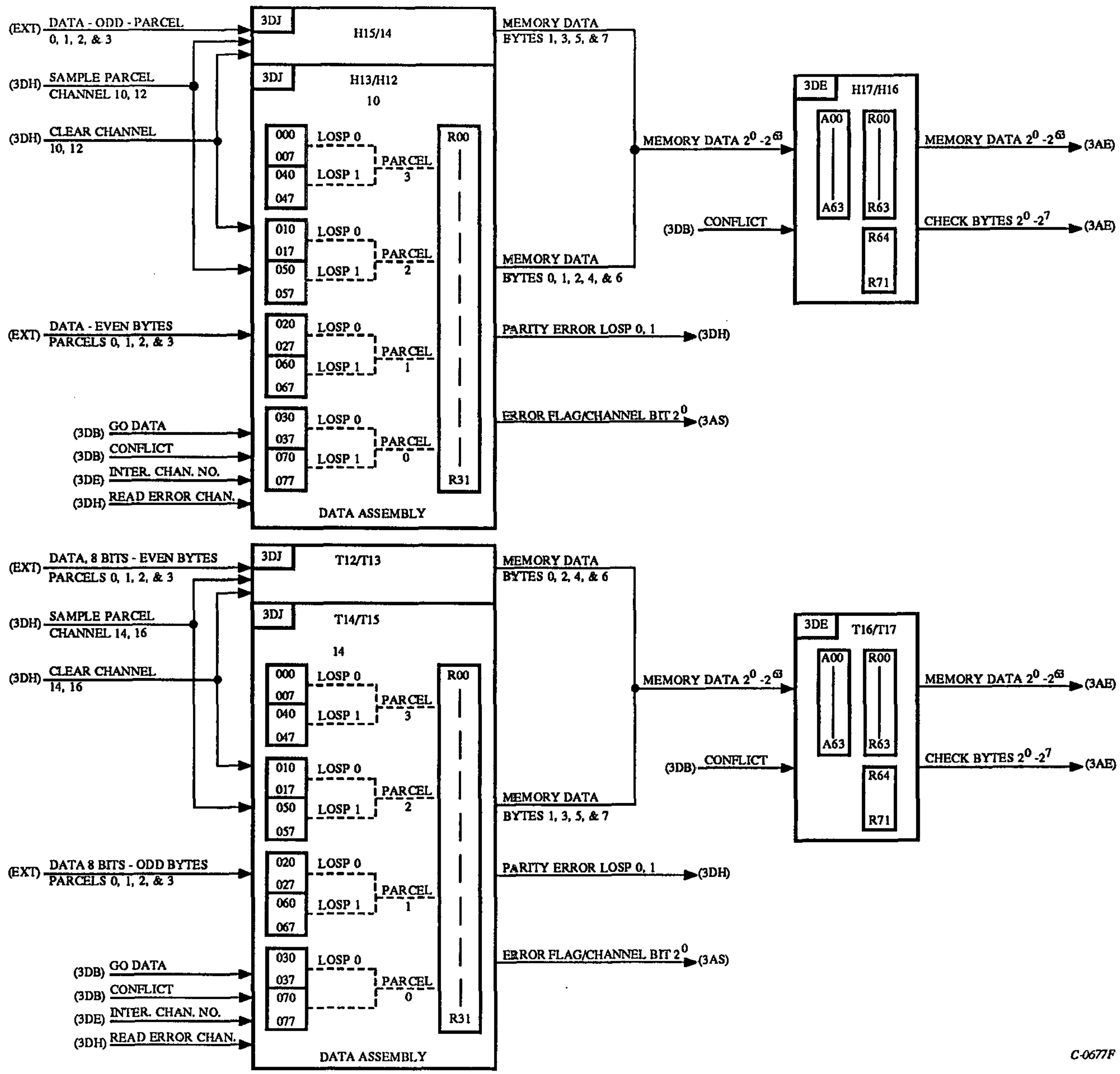
Hardware Trng.
A-5167 P.L.N.

X-MP/2 INPUT CHANNEL BLOCK DIAGRAM



Hardware Trng.
A-5166 P.L.N.

X-MP/2 OUTPUT CHANNEL BLOCK DIAGRAM

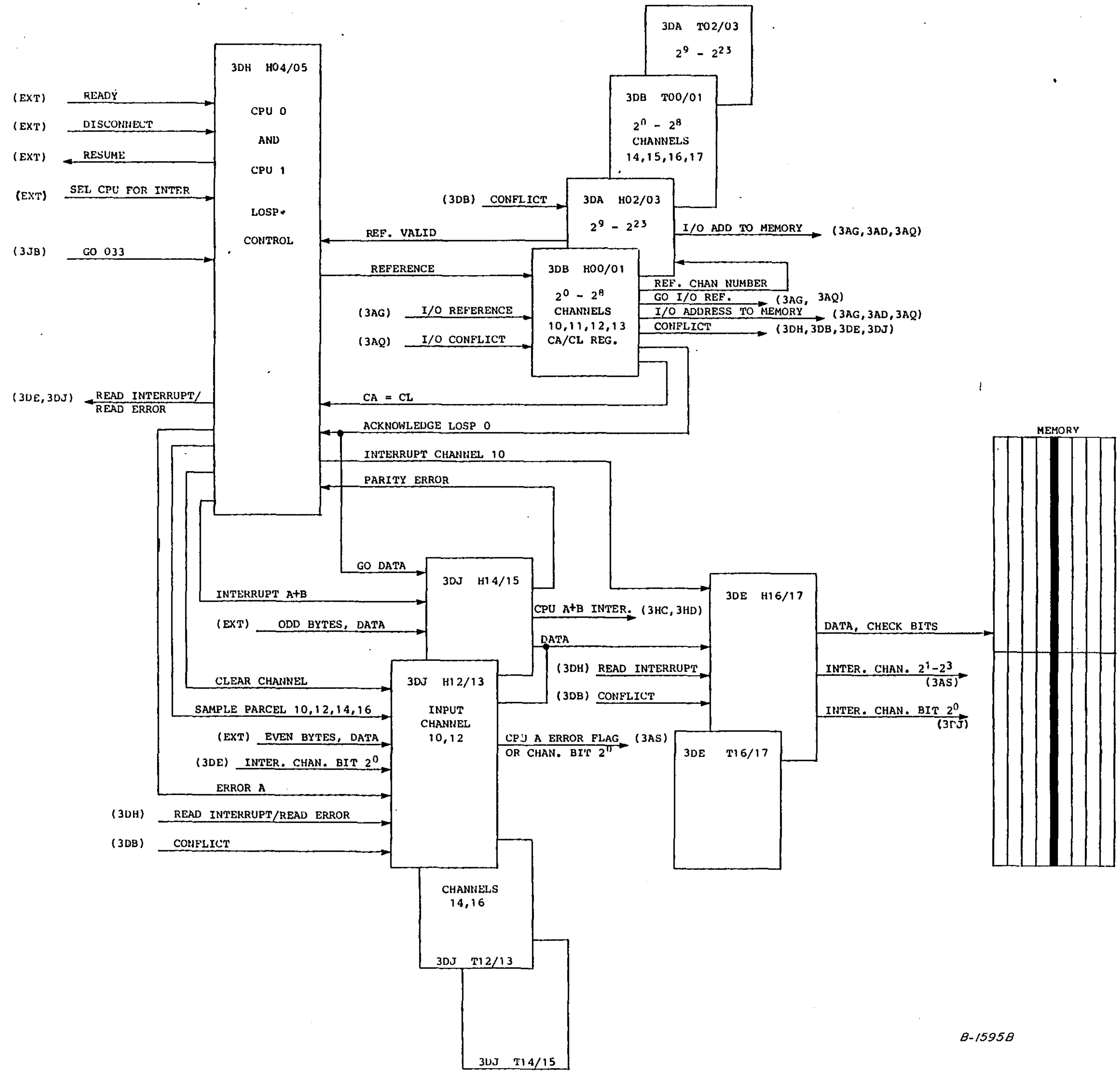


CRAY X-MP LOSP CHANNEL DATA INPUT

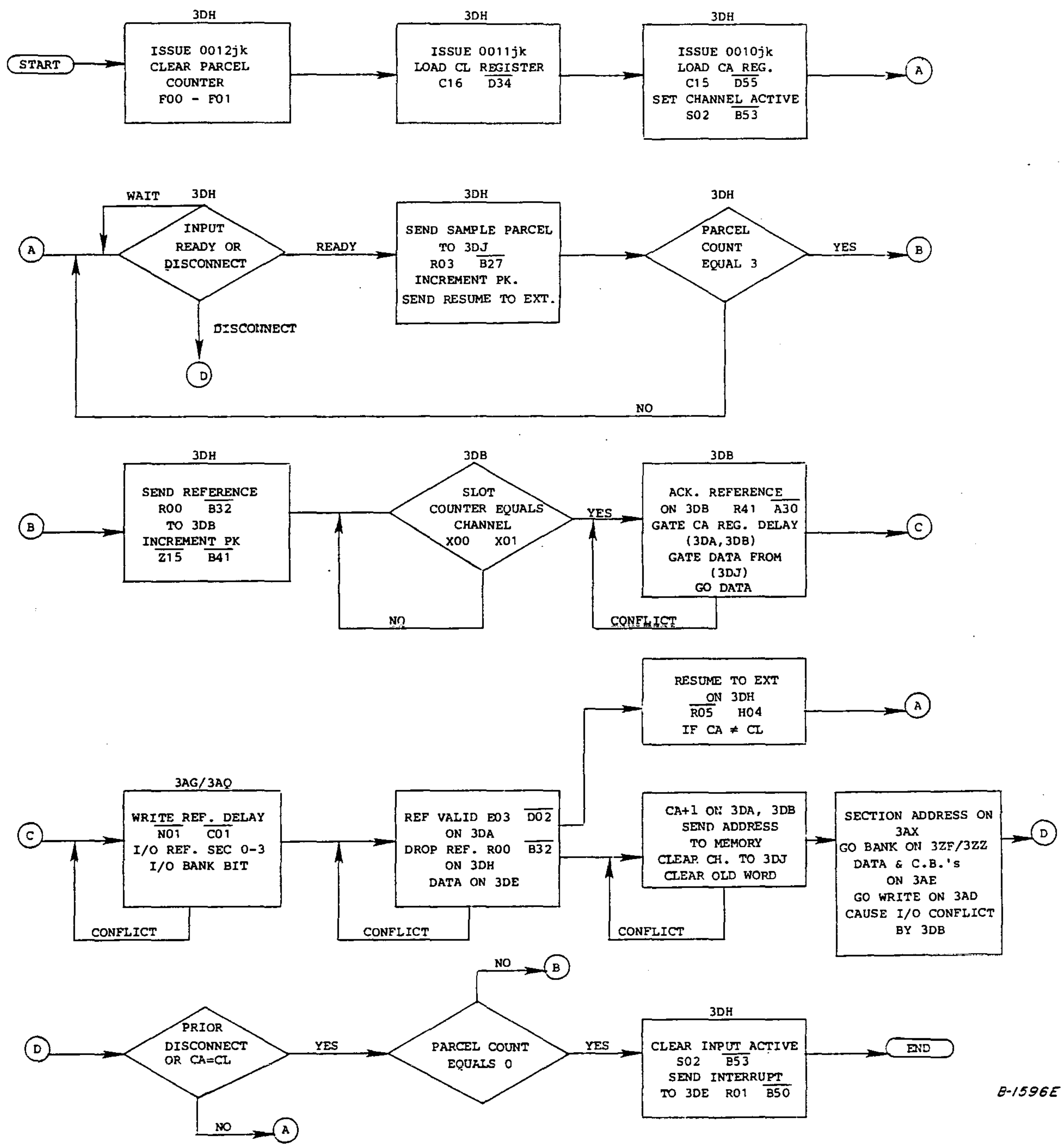
		3DJ H12/13 OR T12/13 EVEN BYTES CHANNEL 10 OR 14		CHANNEL 12 OR 16				3DJ H14/15 OR T14/15 ODD BYTES CHANNEL 10 OR 14		CHANNEL 12 OR 16	
		T.P.	TERM	T.P.	TERM			T.P.	TERM	T.P.	TERM
2^{0}		$\overline{D67}$	000	$\overline{B20}$	040	2^{8}		$\overline{B67}$	000	$\overline{B20}$	040
2^{1}		$\overline{D69}$	001	$\overline{B18}$	041	2^{9}		$\overline{B69}$	001	$\overline{B18}$	041
2^{2}		$\overline{B72}$	002	$\overline{B23}$	042	2^{10}		$\overline{B72}$	002	$\overline{B23}$	042
2^{3}		$\overline{B70}$	003	$\overline{B25}$	043	2^{11}		$\overline{B70}$	003	$\overline{B25}$	043
2^{4}		$\overline{B59}$	004	$\overline{B12}$	044	2^{12}		$\overline{B59}$	004	$\overline{B12}$	044
2^{5}		$\overline{B61}$	005	$\overline{B10}$	045	2^{13}		$\overline{B61}$	005	$\overline{B10}$	045
2^{6}		$\overline{B63}$	006	$\overline{B14}$	046	2^{14}		$\overline{B63}$	006	$\overline{B14}$	046
2^{7}		$\overline{B65}$	007	$\overline{B16}$	047	2^{15}		$\overline{B65}$	007	$\overline{B16}$	047
2^{16}		$\overline{A08}$	010	$\overline{A51}$	050	2^{24}		$\overline{A08}$	010	$\overline{A51}$	050
2^{17}		$\overline{A10}$	011	$\overline{A52}$	051	2^{25}		$\overline{A10}$	011	$\overline{A52}$	051
2^{18}		$\overline{A03}$	012	$\overline{A48}$	052	2^{26}		$\overline{A03}$	012	$\overline{A48}$	052
2^{19}		$\overline{A04}$	013	$\overline{A46}$	053	2^{27}		$\overline{A04}$	013	$\overline{A46}$	053
2^{20}		$\overline{A16}$	014	$\overline{A60}$	054	2^{28}		$\overline{A16}$	014	$\overline{A60}$	054
2^{21}		$\overline{A17}$	015	$\overline{A61}$	055	2^{29}		$\overline{A17}$	015	$\overline{A61}$	055
2^{22}		$\overline{A12}$	016	$\overline{A55}$	056	2^{30}		$\overline{A12}$	016	$\overline{A55}$	056
2^{23}		$\overline{A14}$	017	$\overline{A56}$	057	2^{31}		$\overline{A14}$	017	$\overline{A56}$	057
2^{32}		$\overline{D67}$	020	$\overline{D14}$	060	2^{40}		$\overline{D67}$	020	$\overline{D14}$	060
2^{33}		$\overline{D68}$	021	$\overline{D03}$	061	2^{41}		$\overline{D68}$	021	$\overline{D03}$	061
2^{34}		$\overline{D70}$	022	$\overline{D05}$	062	2^{42}		$\overline{D70}$	022	$\overline{D05}$	062
2^{35}		$\overline{D72}$	023	$\overline{D27}$	063	2^{43}		$\overline{D72}$	023	$\overline{D27}$	063
2^{36}		$\overline{D59}$	024	$\overline{D29}$	064	2^{44}		$\overline{D59}$	024	$\overline{D29}$	064
2^{37}		$\overline{D61}$	025	$\overline{D06}$	065	2^{45}		$\overline{D61}$	025	$\overline{D06}$	065
2^{38}		$\overline{D65}$	026	$\overline{D12}$	066	2^{46}		$\overline{D65}$	026	$\overline{D12}$	066
2^{39}		$\overline{D63}$	027	$\overline{D31}$	067	2^{47}		$\overline{D63}$	027	$\overline{D31}$	067
2^{48}		$\overline{C10}$	030	$\overline{C67}$	070	2^{56}		$\overline{C10}$	030	$\overline{C67}$	070
2^{49}		$\overline{C33}$	031	$\overline{C68}$	071	2^{57}		$\overline{C33}$	031	$\overline{C68}$	071
2^{50}		$\overline{C06}$	032	$\overline{C65}$	072	2^{58}		$\overline{C06}$	032	$\overline{C65}$	072
2^{51}		$\overline{C08}$	033	$\overline{C63}$	073	2^{59}		$\overline{C08}$	033	$\overline{C63}$	073
2^{52}		$\overline{C04}$	034	$\overline{C52}$	074	2^{60}		$\overline{C04}$	034	$\overline{C52}$	074
2^{53}		$\overline{C03}$	035	$\overline{C59}$	075	2^{61}		$\overline{C03}$	035	$\overline{C59}$	075
2^{54}		$\overline{C16}$	036	$\overline{C72}$	076	2^{62}		$\overline{C16}$	036	$\overline{C72}$	076
2^{55}		$\overline{C14}$	037	$\overline{C70}$	077	2^{63}		$\overline{C14}$	037	$\overline{C70}$	077

B-1656

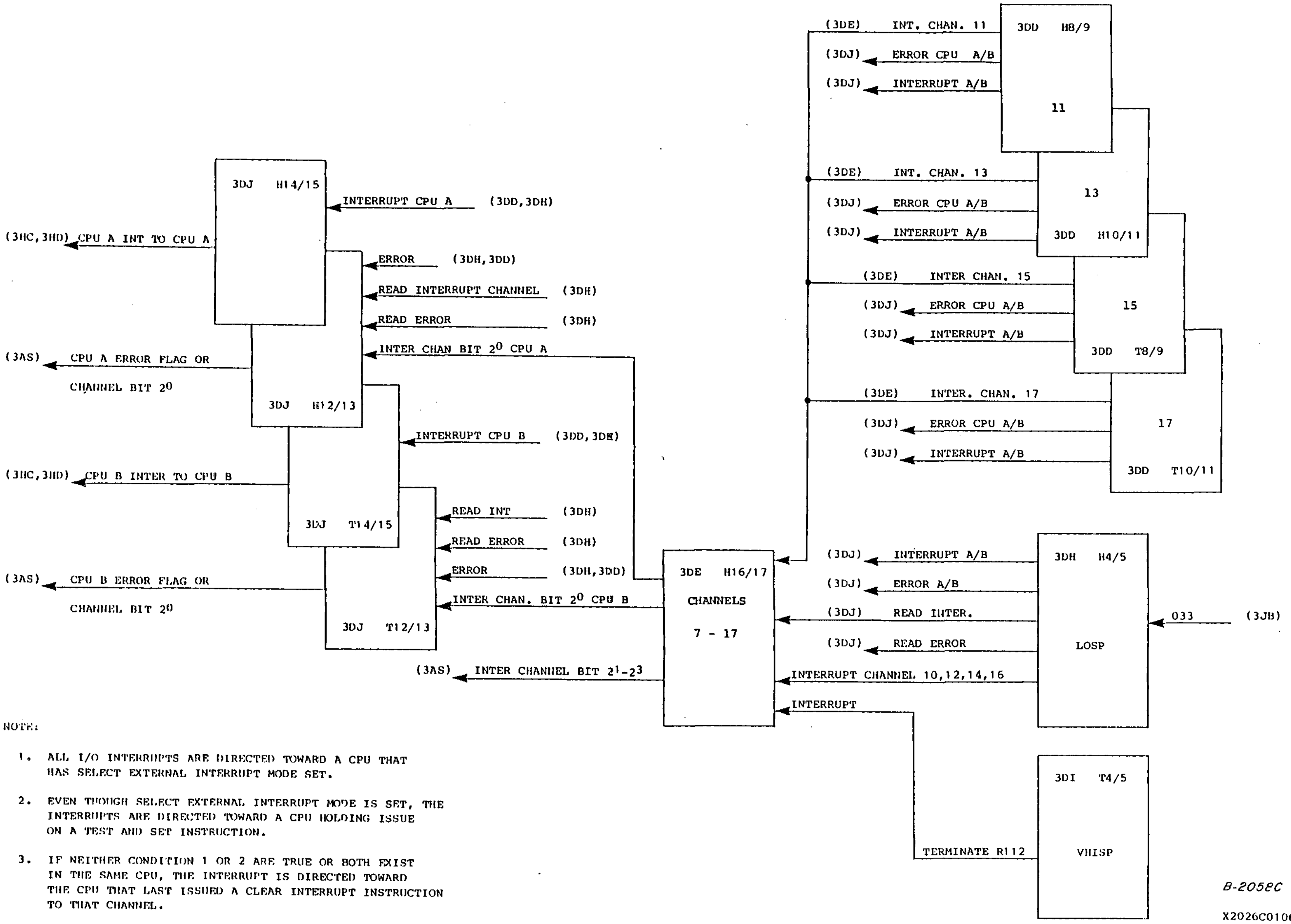
INPUT LOSP CHANNEL 3DJ SCOPE CHART



CHANNEL 10 INPUT BLOCK DIAGRAM



CHANNEL 10 INPUT FLOW CHART



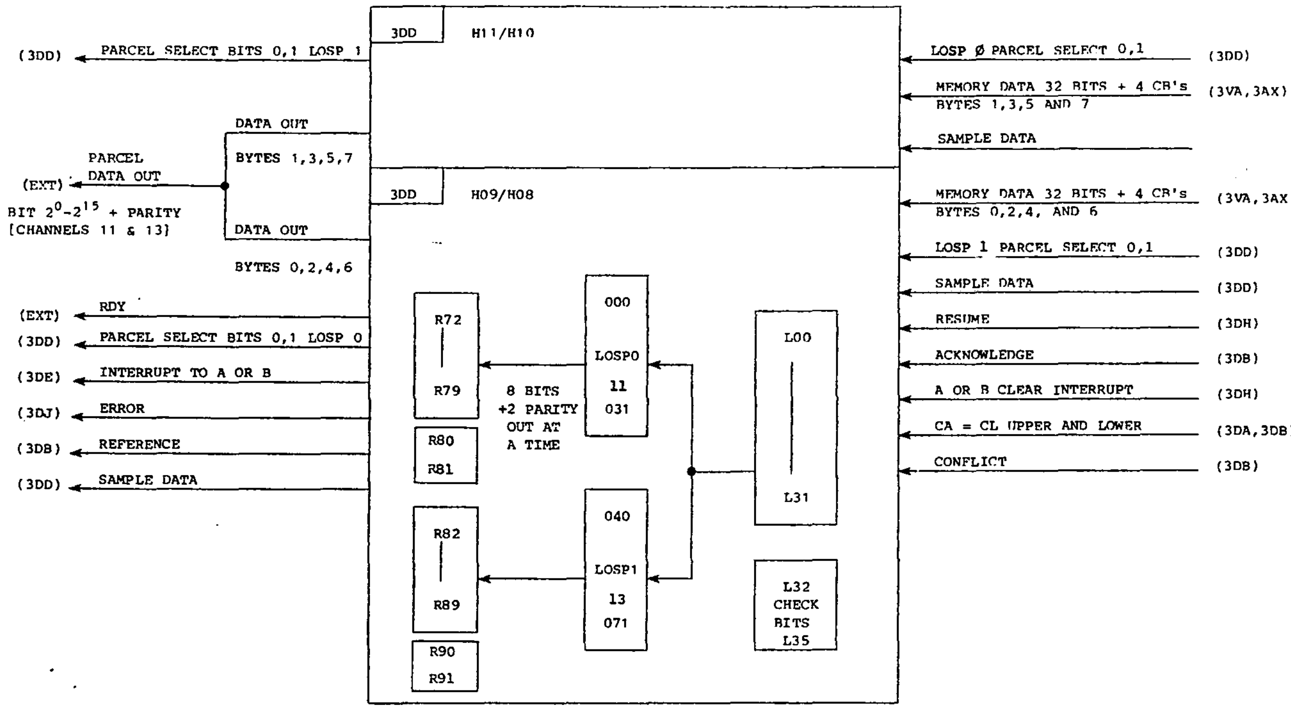
NOTE:

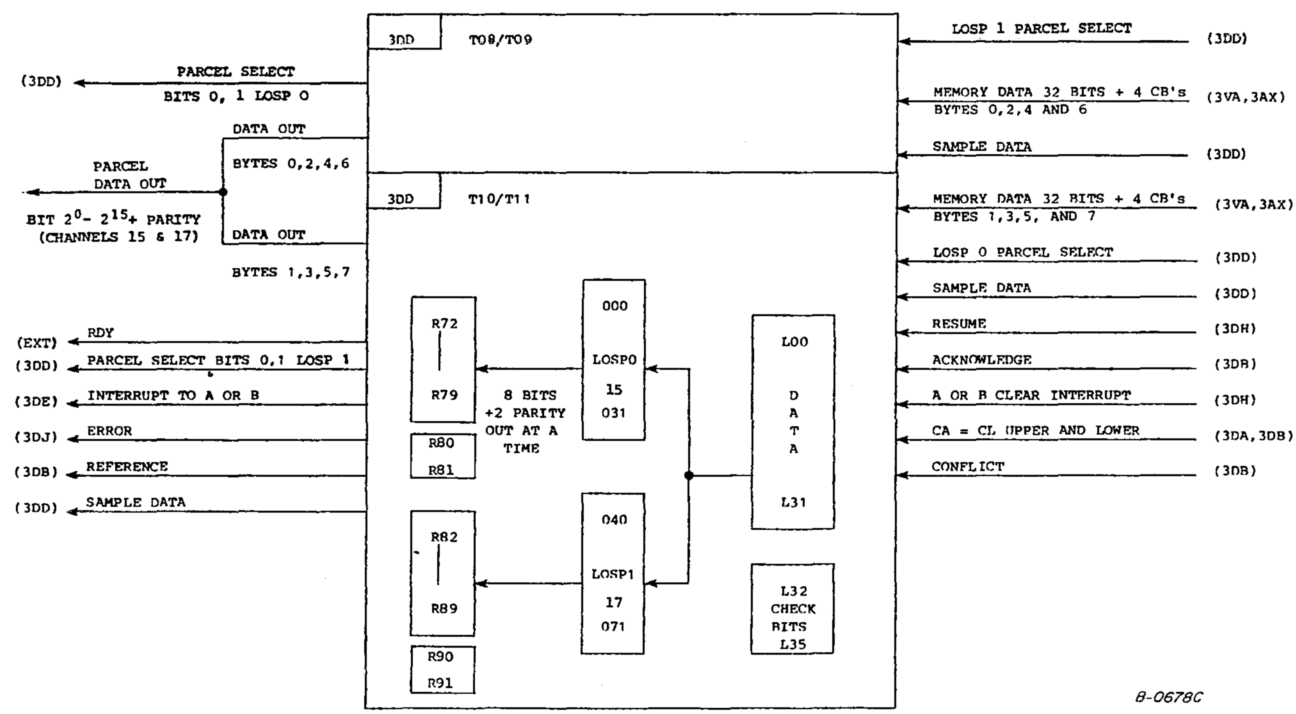
1. ALL I/O INTERRUPTS ARE DIRECTED TOWARD A CPU THAT HAS SELECT EXTERNAL INTERRUPT MODE SET.

2. EVEN THOUGH SELECT EXTERNAL INTERRUPT MODE IS SET, THE INTERRUPTS ARE DIRECTED TOWARD A CPU HOLDING ISSUE ON A TEST AND SET INSTRUCTION.

3. IF NEITHER CONDITION 1 OR 2 ARE TRUE OR BOTH EXIST IN THE SAME CPU, THE INTERRUPT IS DIRECTED TOWARD THE CPU THAT LAST ISSUED A CLEAR INTERRUPT INSTRUCTION TO THAT CHANNEL.

ERROR/INTERRUPT HANDLING



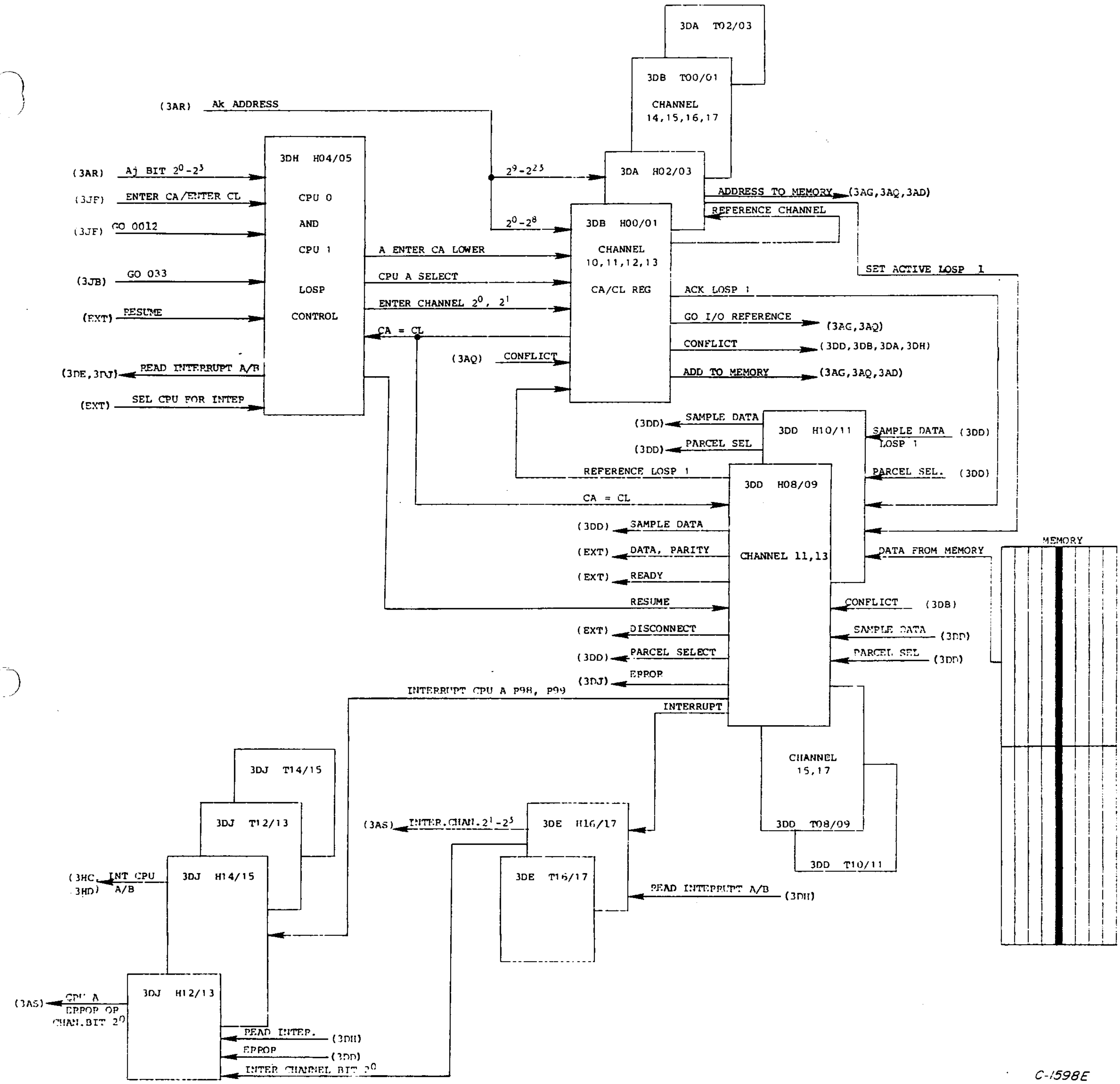


CRAY X-MP LOSP CHANNEL DATA OUTPUT

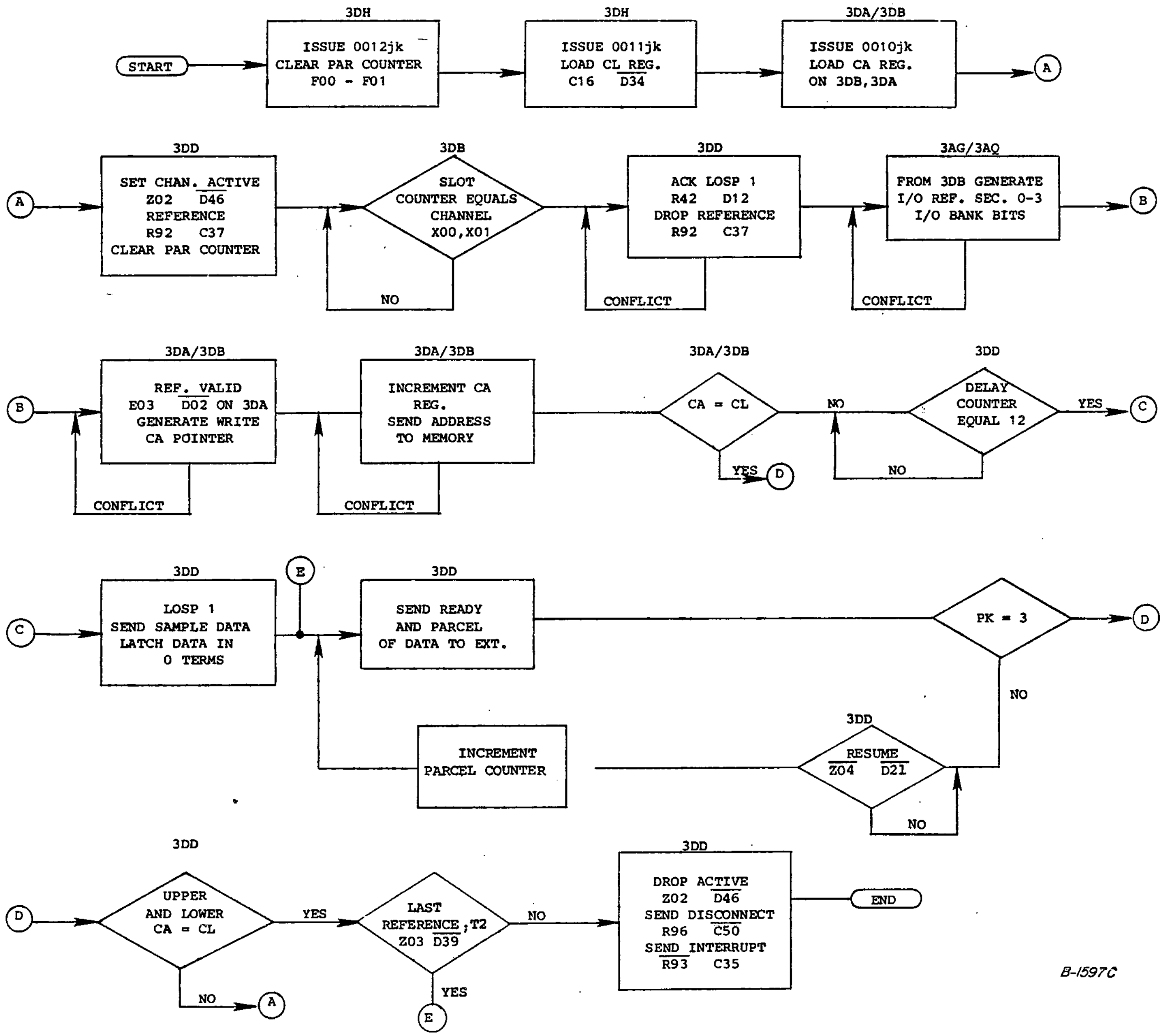
		3DD H08/09 OR T08/09 EVEN BYTES						3DD H10/11 OR T10/11 ODD BYTES			
		CHANNEL 11, 15		CHANNEL 13 OR 17				CHANNEL 11, 15		CHANNEL 13, 17	
		T.P.	TERM	T.P.	TERM			T.P.	TERM	T.P.	TERM
2^{0}		$\overline{\text{B03}}$	000	$\overline{\text{B52}}$	040	2^{8}		$\overline{\text{B03}}$	000	$\overline{\text{B52}}$	040
2^{1}		$\overline{\text{B04}}$	001	$\overline{\text{B50}}$	041	2^{9}		$\overline{\text{B04}}$	001	$\overline{\text{B50}}$	041
2^{2}		$\overline{\text{B06}}$	002	$\overline{\text{B57}}$	042	2^{10}		$\overline{\text{B06}}$	002	$\overline{\text{B57}}$	042
2^{3}		$\overline{\text{B08}}$	003	$\overline{\text{B55}}$	043	2^{11}		$\overline{\text{B08}}$	003	$\overline{\text{B55}}$	043
2^{4}		$\overline{\text{B10}}$	004	$\overline{\text{B59}}$	044	2^{12}		$\overline{\text{B10}}$	004	$\overline{\text{B59}}$	044
2^{5}		$\overline{\text{B12}}$	005	$\overline{\text{B61}}$	045	2^{13}		$\overline{\text{B12}}$	005	$\overline{\text{B61}}$	045
2^{6}		$\overline{\text{B14}}$	006	$\overline{\text{B65}}$	046	2^{14}		$\overline{\text{B14}}$	006	$\overline{\text{B65}}$	046
2^{7}		$\overline{\text{B16}}$	007	$\overline{\text{B63}}$	047	2^{15}		$\overline{\text{B16}}$	007	$\overline{\text{B63}}$	047
2^{16}		$\overline{\text{B18}}$	008	$\overline{\text{B67}}$	048	2^{24}		$\overline{\text{B18}}$	008	$\overline{\text{B67}}$	048
2^{17}		$\overline{\text{B20}}$	009	$\overline{\text{B69}}$	049	2^{25}		$\overline{\text{B20}}$	009	$\overline{\text{B69}}$	049
2^{18}		$\overline{\text{B23}}$	010	$\overline{\text{B72}}$	050	2^{26}		$\overline{\text{B23}}$	010	$\overline{\text{B72}}$	050
2^{19}		$\overline{\text{B25}}$	011	$\overline{\text{B70}}$	051	2^{27}		$\overline{\text{B25}}$	011	$\overline{\text{B70}}$	051
2^{20}		$\overline{\text{D03}}$	012	$\overline{\text{D50}}$	052	2^{28}		$\overline{\text{D03}}$	012	$\overline{\text{D50}}$	052
2^{21}		$\overline{\text{D04}}$	013	$\overline{\text{D52}}$	053	2^{29}		$\overline{\text{D04}}$	013	$\overline{\text{D52}}$	053
2^{22}		$\overline{\text{D06}}$	014	$\overline{\text{D55}}$	054	2^{30}		$\overline{\text{D06}}$	014	$\overline{\text{D55}}$	054
2^{23}		$\overline{\text{D08}}$	015	$\overline{\text{D57}}$	055	2^{31}		$\overline{\text{D08}}$	015	$\overline{\text{D57}}$	055
2^{32}		$\overline{\text{D10}}$	016	$\overline{\text{D59}}$	056	2^{40}		$\overline{\text{D10}}$	016	$\overline{\text{D59}}$	056
2^{33}		$\overline{\text{D12}}$	017	$\overline{\text{D61}}$	057	2^{41}		$\overline{\text{D12}}$	017	$\overline{\text{D61}}$	057
2^{34}		$\overline{\text{D14}}$	018	$\overline{\text{D63}}$	058	2^{42}		$\overline{\text{D14}}$	018	$\overline{\text{D63}}$	058
2^{35}		$\overline{\text{D16}}$	019	$\overline{\text{D65}}$	059	2^{43}		$\overline{\text{D16}}$	019	$\overline{\text{D65}}$	059
2^{36}		$\overline{\text{D18}}$	020	$\overline{\text{D67}}$	060	2^{44}		$\overline{\text{D18}}$	020	$\overline{\text{D67}}$	060
2^{37}		$\overline{\text{D20}}$	021	$\overline{\text{D69}}$	061	2^{45}		$\overline{\text{D20}}$	021	$\overline{\text{D69}}$	061
2^{38}		$\overline{\text{D25}}$	022	$\overline{\text{D72}}$	062	2^{46}		$\overline{\text{D25}}$	022	$\overline{\text{D72}}$	062
2^{39}		$\overline{\text{D23}}$	023	$\overline{\text{D70}}$	063	2^{47}		$\overline{\text{D23}}$	023	$\overline{\text{D70}}$	063
2^{48}		$\overline{\text{C63}}$	024	$\overline{\text{C06}}$	064	2^{56}		$\overline{\text{C63}}$	024	$\overline{\text{C06}}$	064
2^{49}		$\overline{\text{C65}}$	025	$\overline{\text{C08}}$	065	2^{57}		$\overline{\text{C65}}$	025	$\overline{\text{C08}}$	065
2^{50}		$\overline{\text{C59}}$	026	$\overline{\text{C04}}$	066	2^{58}		$\overline{\text{C59}}$	026	$\overline{\text{C04}}$	066
2^{51}		$\overline{\text{C61}}$	027	$\overline{\text{C02}}$	067	2^{59}		$\overline{\text{C61}}$	027	$\overline{\text{C02}}$	067
2^{52}		$\overline{\text{C72}}$	028	$\overline{\text{C14}}$	068	2^{60}		$\overline{\text{C72}}$	028	$\overline{\text{C14}}$	068
2^{53}		$\overline{\text{C70}}$	029	$\overline{\text{C16}}$	069	2^{61}		$\overline{\text{C70}}$	029	$\overline{\text{C16}}$	069
2^{54}		$\overline{\text{C67}}$	030	$\overline{\text{C12}}$	070	2^{62}		$\overline{\text{C67}}$	030	$\overline{\text{C12}}$	070
2^{55}		$\overline{\text{C68}}$	031	$\overline{\text{C10}}$	071	2^{63}		$\overline{\text{C68}}$	031	$\overline{\text{C10}}$	071

B-1655

OUTPUT LOSP CHANNEL 3DD SCOPE CHART

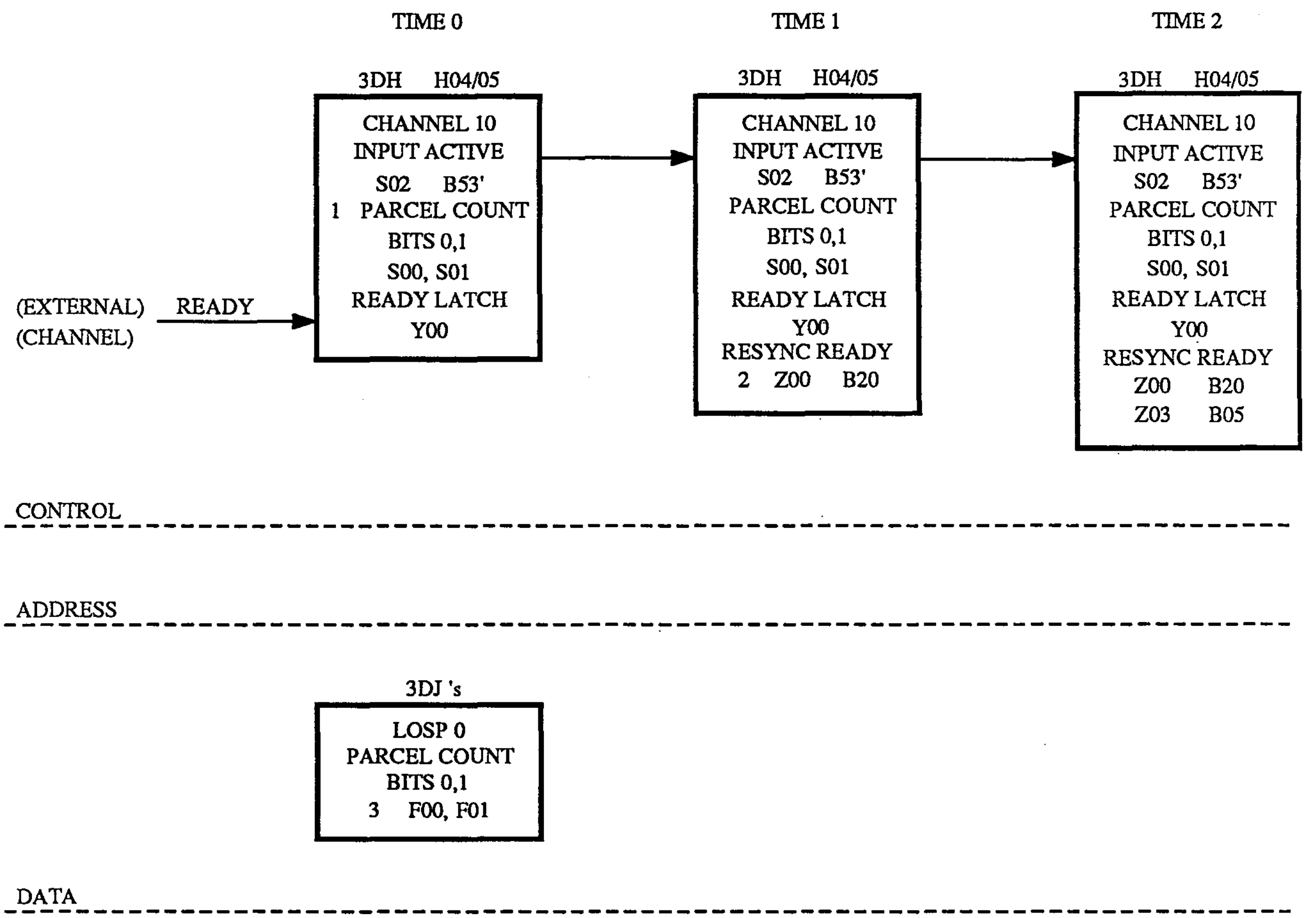


X-MP/2
CHANNEL 11 OUTPUT BLOCK DIAGRAM



CHANNEL 11 OUTPUT FLOW CHART

* NOTE: Timing of first ready and between subsequent readys dependent on external channel.



1 Parcel count will be set to zero by the issue of a 0012jk instruction.

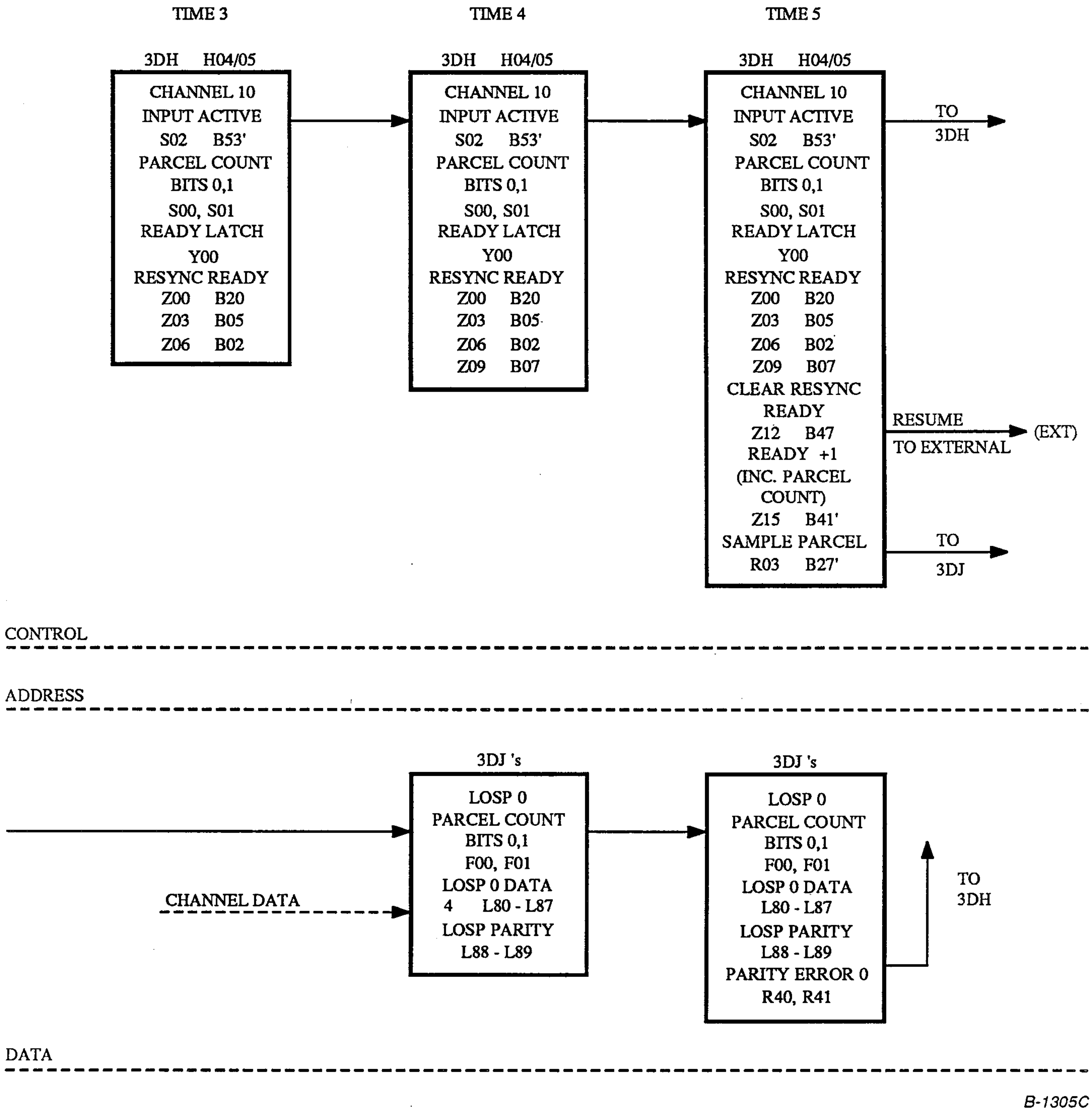
2 The resync latch that sets is dependent on what time the ready arrives on the 3DH. After the first one the rest will set in sequence.

3 Parcel count on 3DJ 's will be set to zero by the clear channel instruction (0012jk).

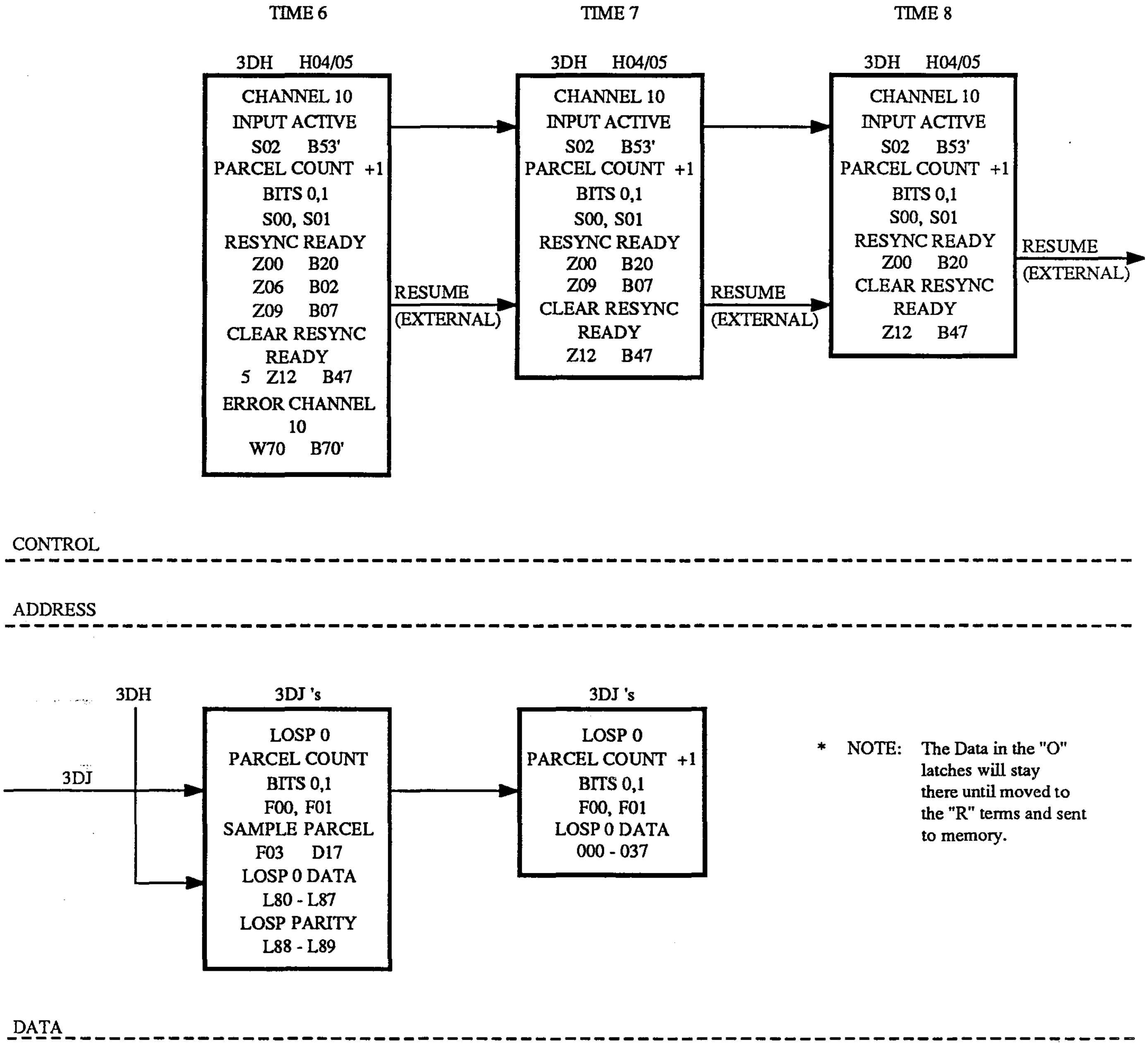
4 The LOSP Data will follow the ready, time dependent on the external device, but must be there before time six. The "L" terms on the 3DJ 's are line receivers not latches.

B-1305C

LOSP CHANNEL TIMING OF READY AND RESUME (INPUT)
CHANNEL 10 USED AS EXAMPLE (sheet 1 of 4)



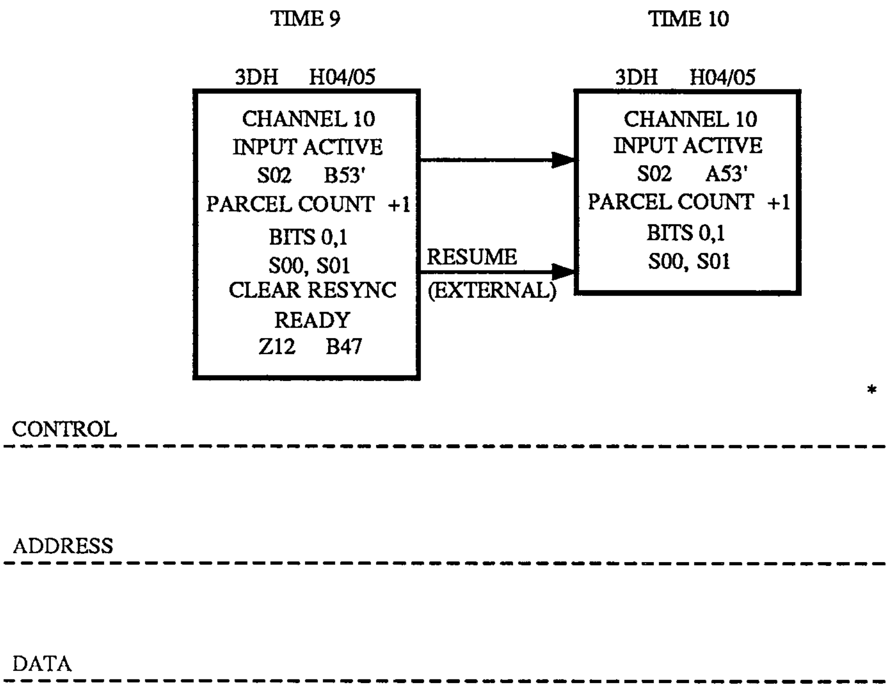
LOSP CHANNEL TIMING OF READY AND RESUME (INPUT)
CHANNEL 10 USED AS EXAMPLE (sheet 2 of 4)



5 Channel parity error setting will cause zeros to be loaded into memory, until CA = CL or until disconnect occurs. This will set an interrupt which can be read by an 033ijl instruction and will be cleared by an 0012j0 instruction.

B-1305C

LOSP CHANNEL TIMING OF READY AND RESUME (INPUT)
CHANNEL 10 USED AS EXAMPLE (sheet 3 of 4)



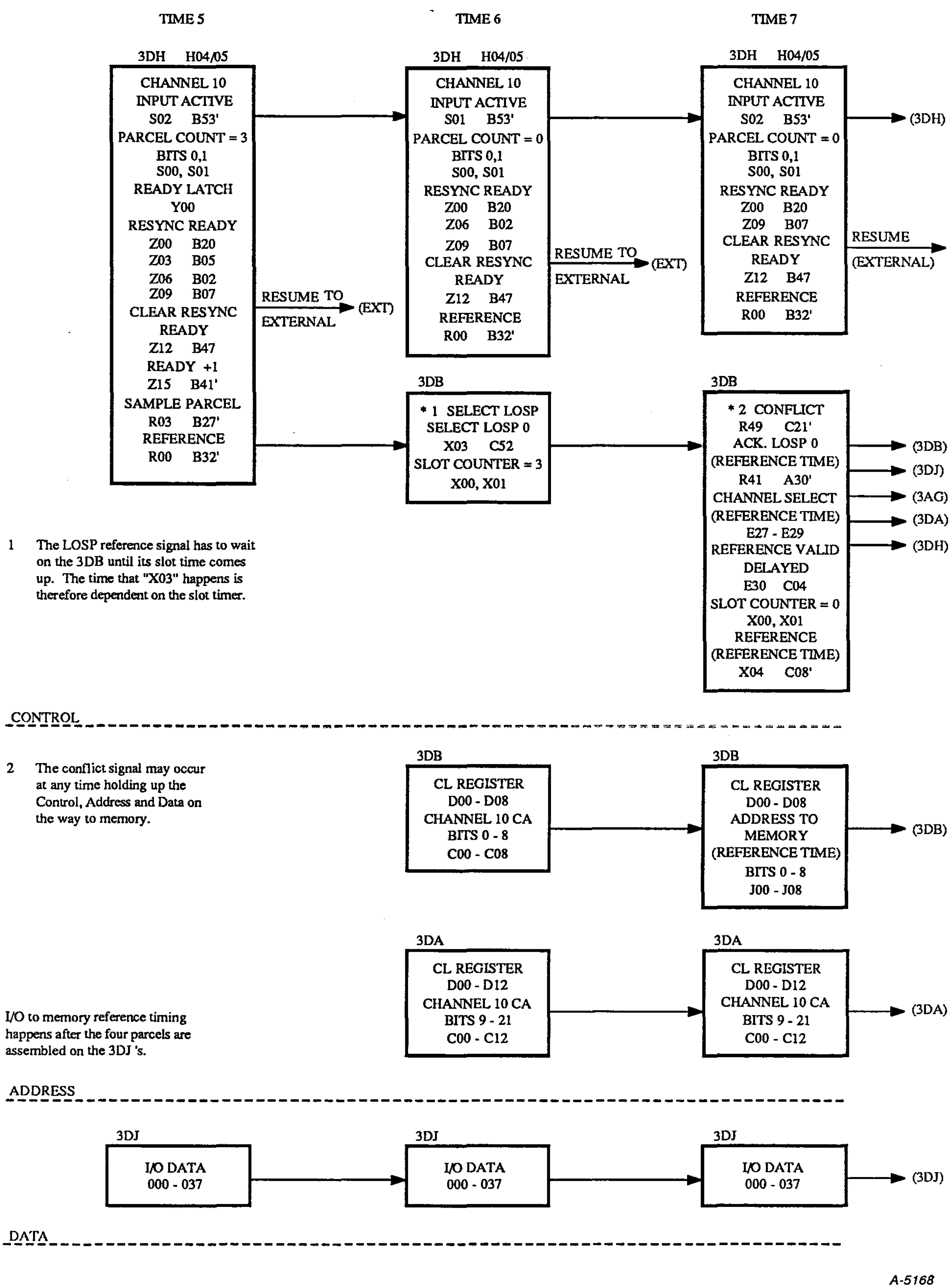
The Channel will go through this timing four times total. After which all four parcels of Data will be latched in the "O" terms. The Channel will then reference memory, send the Data word to memory and dependent on the word count (CA and CL) either continue or stop.

* NOTE: For reference timing and data transfers see reference timing diagram.

B-1305C

LOSP CHANNEL TIMING OF READY AND RESUME (INPUT)
CHANNEL 10 USED AS EXAMPLE (sheet 4 of 4)

TIMING STARTS AT TIME 5 AFTER RECEIVING
THE LAST READY AND LAST PARCEL OF DATA FROM EXTERNAL.

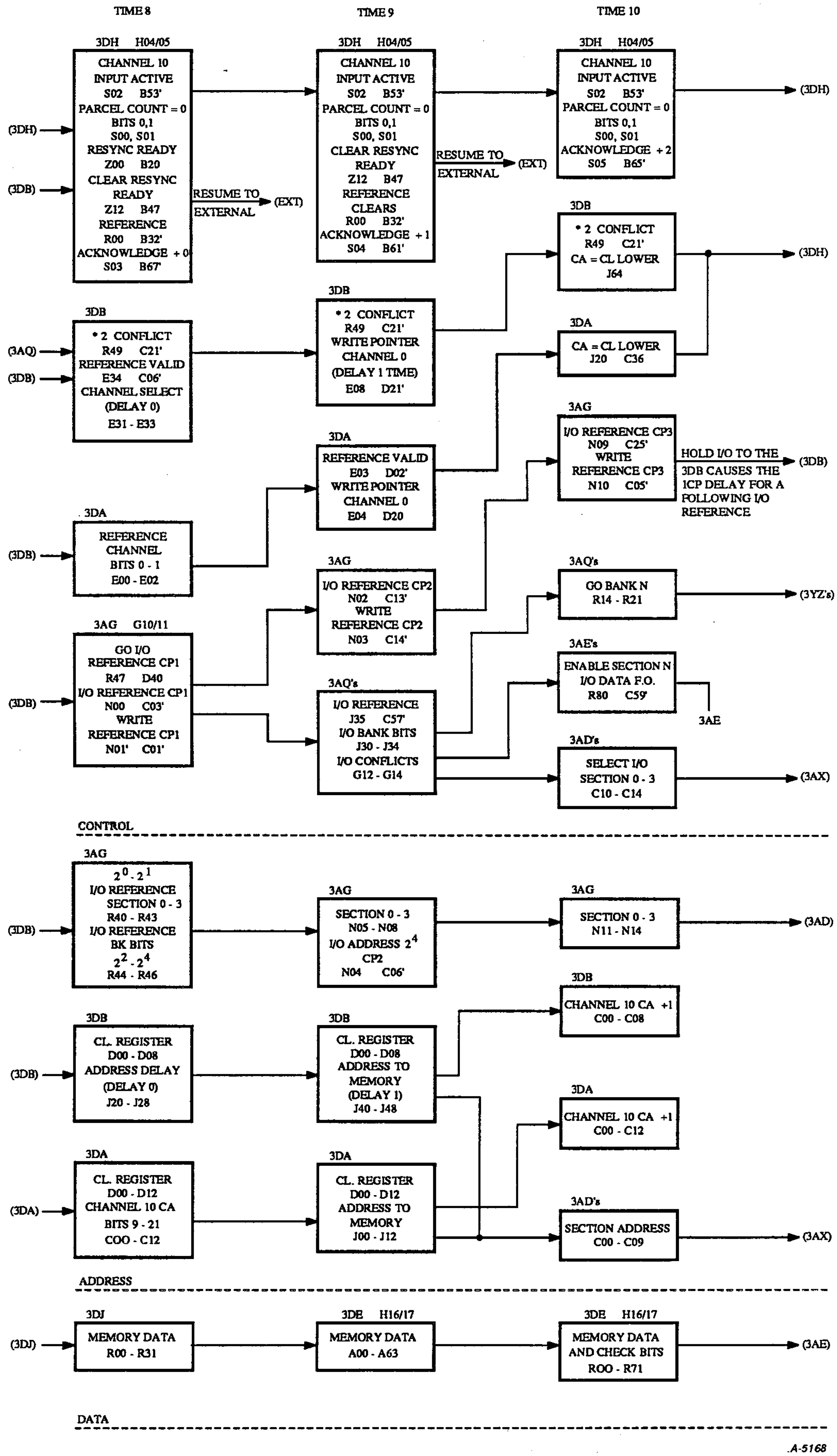


1 The LOSP reference signal has to wait on the 3DB until its slot time comes up. The time that "X03" happens is therefore dependent on the slot timer.

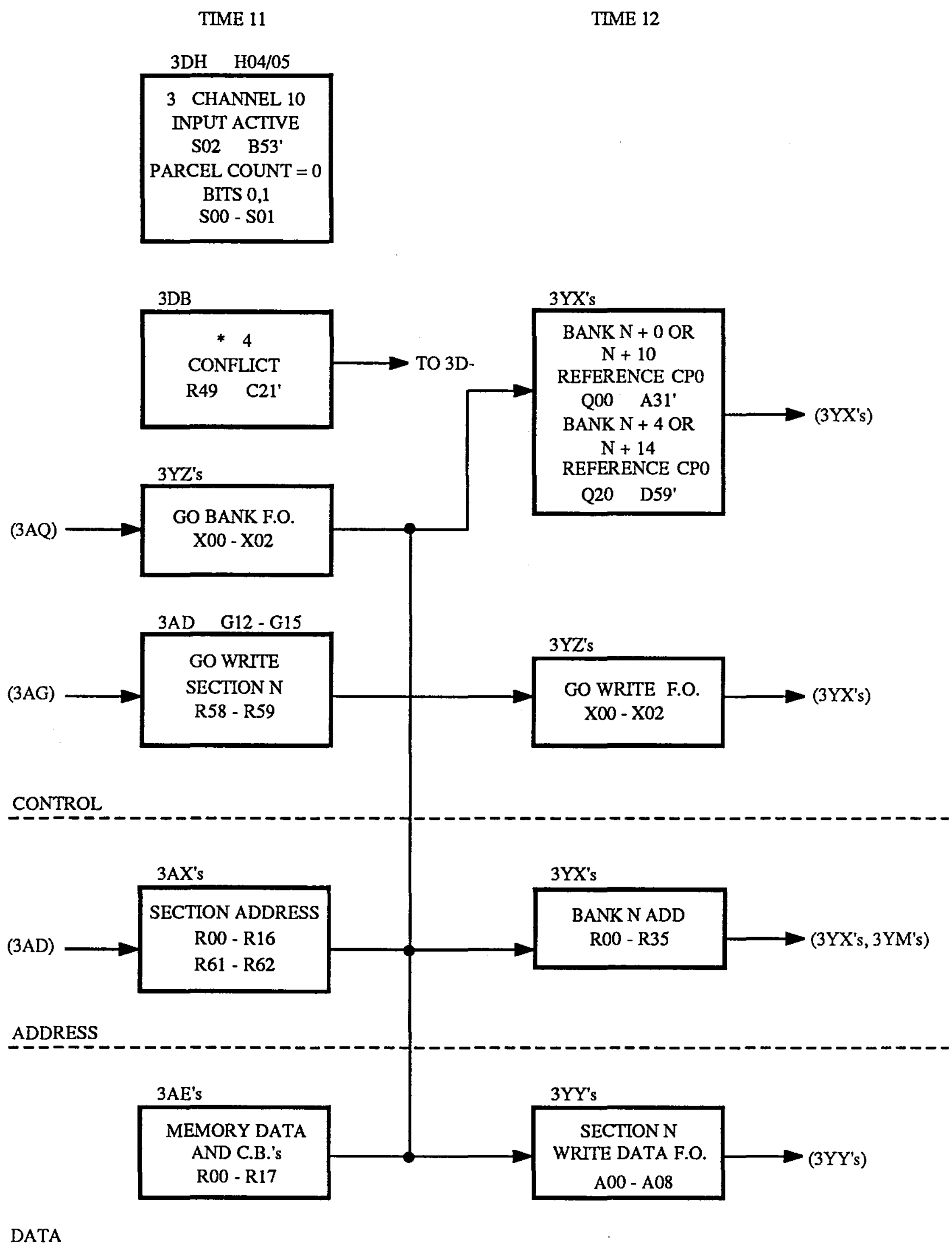
2 The conflict signal may occur at any time holding up the Control, Address and Data on the way to memory.

I/O to memory reference timing happens after the four parcels are assembled on the 3DJ 's.

INPUT CHANNEL TIMING REFERENCE (sheet 1 of 5)



INPUT CHANNEL TIMING REFERENCE (sheet 2 of 5)

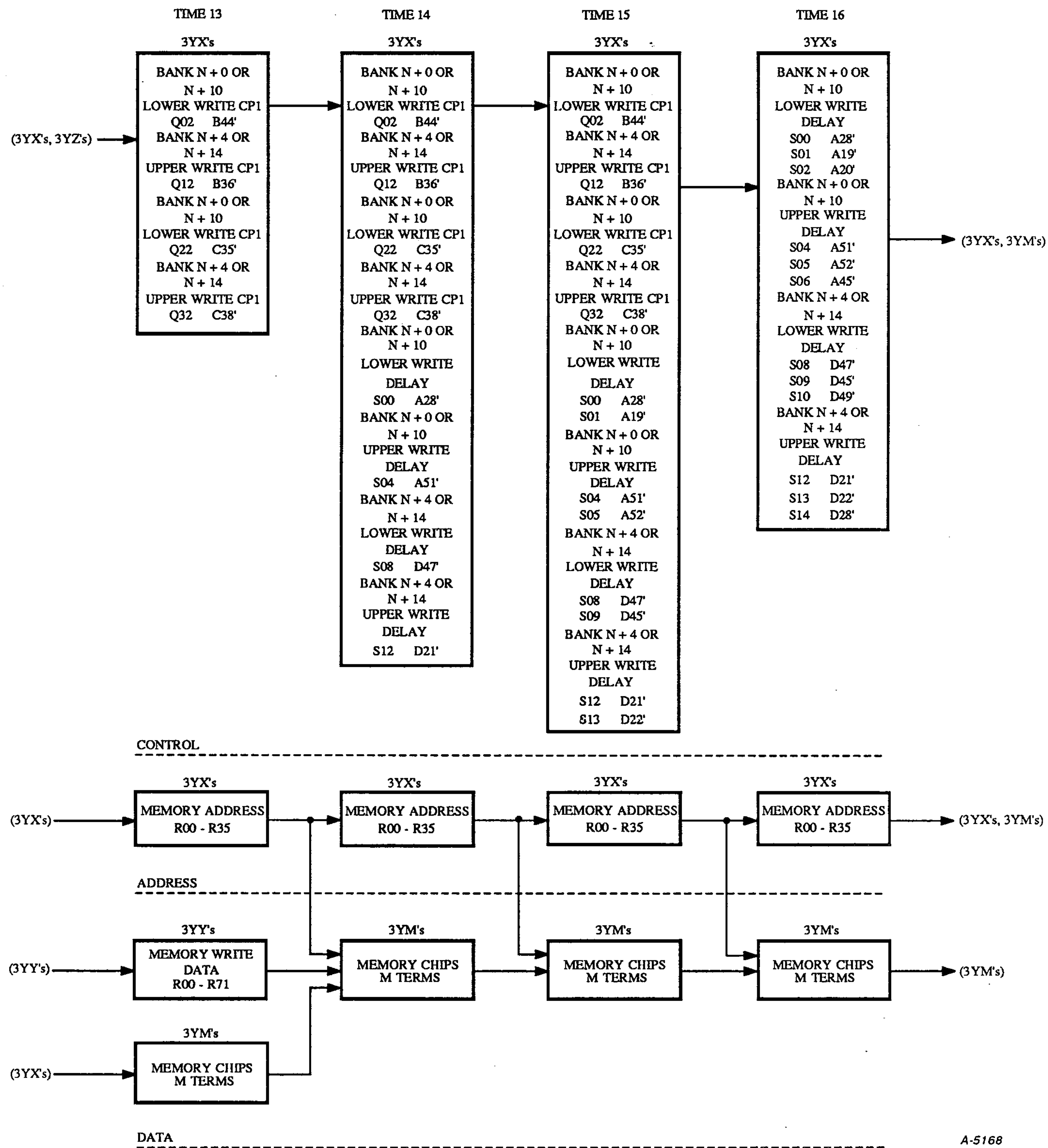


3 The Channel active would drop this time if CA = CL for this I/O transfer.

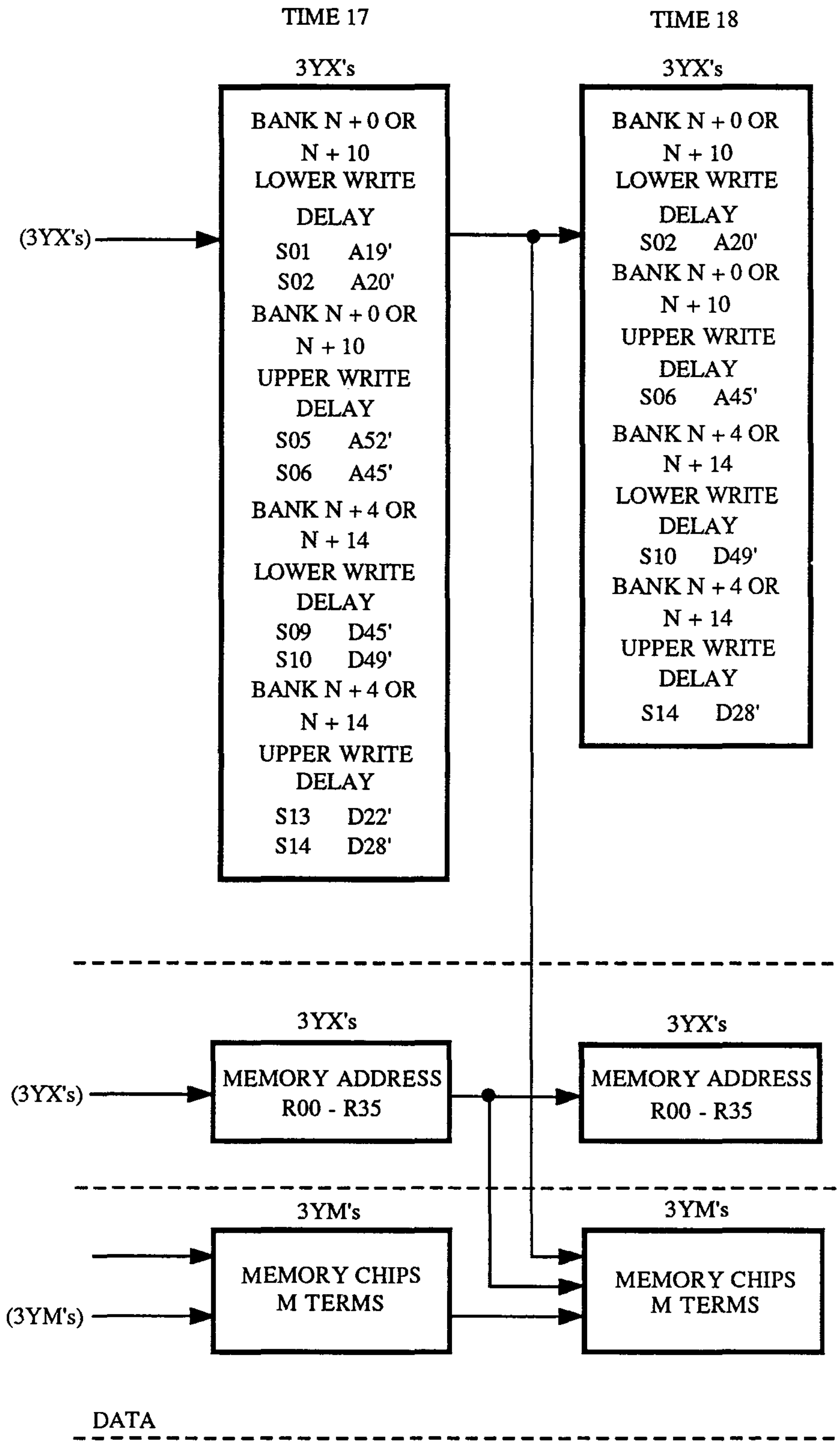
4 The hold I/O signal from the 3AG will make R49 on the 3DB. This signal will go out to all I/O modules to delay for 1CP any following I/O reference. It's sent to the following modules: 3DA, 3DJ, 3DE, 3DH, 3DD, 3DF, and 3DI.

A-5168

INPUT CHANNEL TIMING REFERENCE (SHEET 3 OF 5)

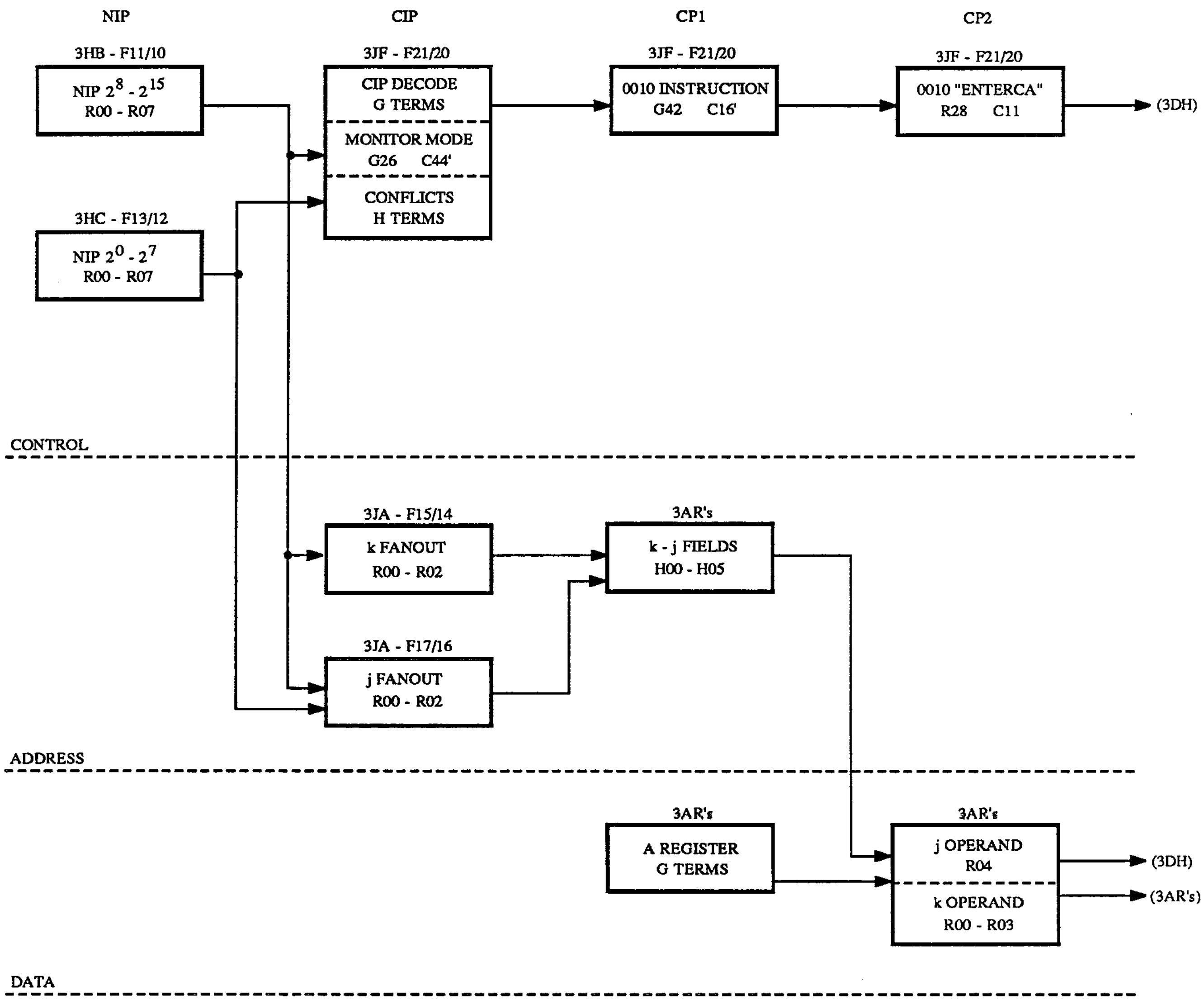


LOSP CHANNEL TIMING OF READY AND RESUME (INPUT)
CHANNEL 10 USED AS EXAMPLE (sheet 4 of 5)



A-5168

INPUT CHANNEL TIMING REFERENCE (sheet 5 of 5)

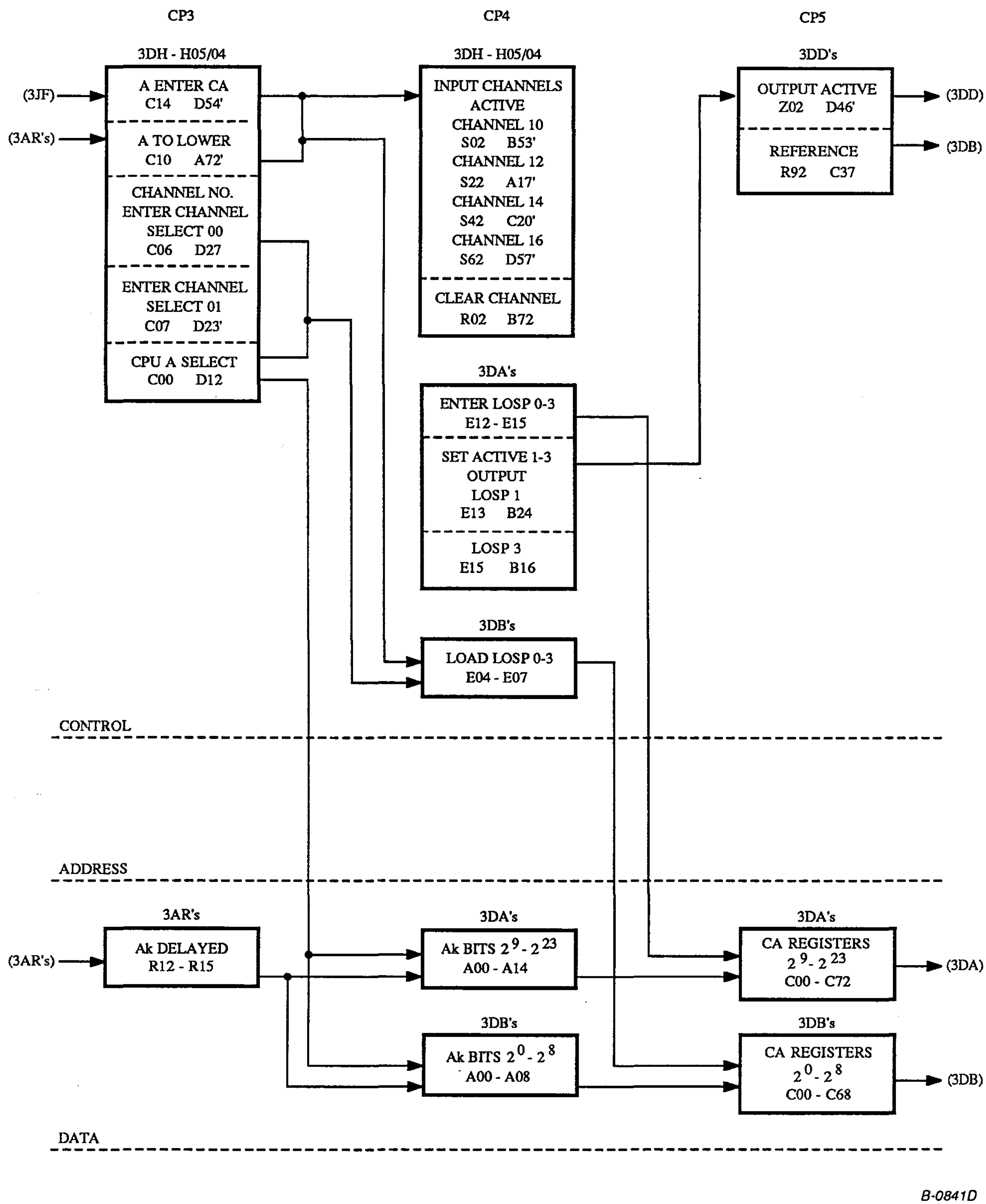


0010 INSTRUCTION - SET THE CURRENT ADDRESS (CA) REGISTER FOR THE CHANNEL INDICATED BY (AJ) TO (AK) AND ACTIVATE THE CHANNEL.

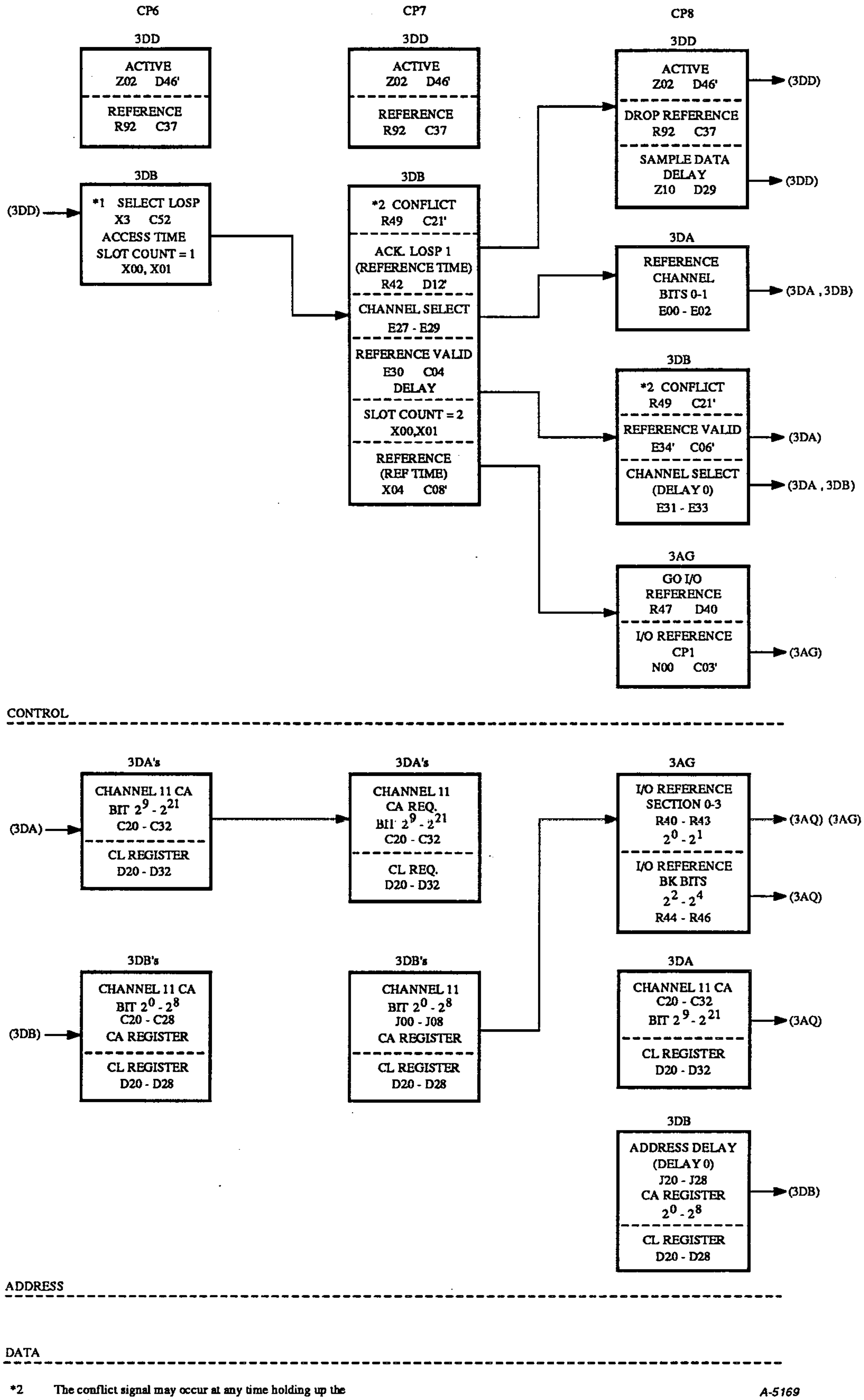
MONITOR MODE INSTRUCTION

B-0841D

OUTPUT TIMING SEQUENCE (sheet 1 of 11)

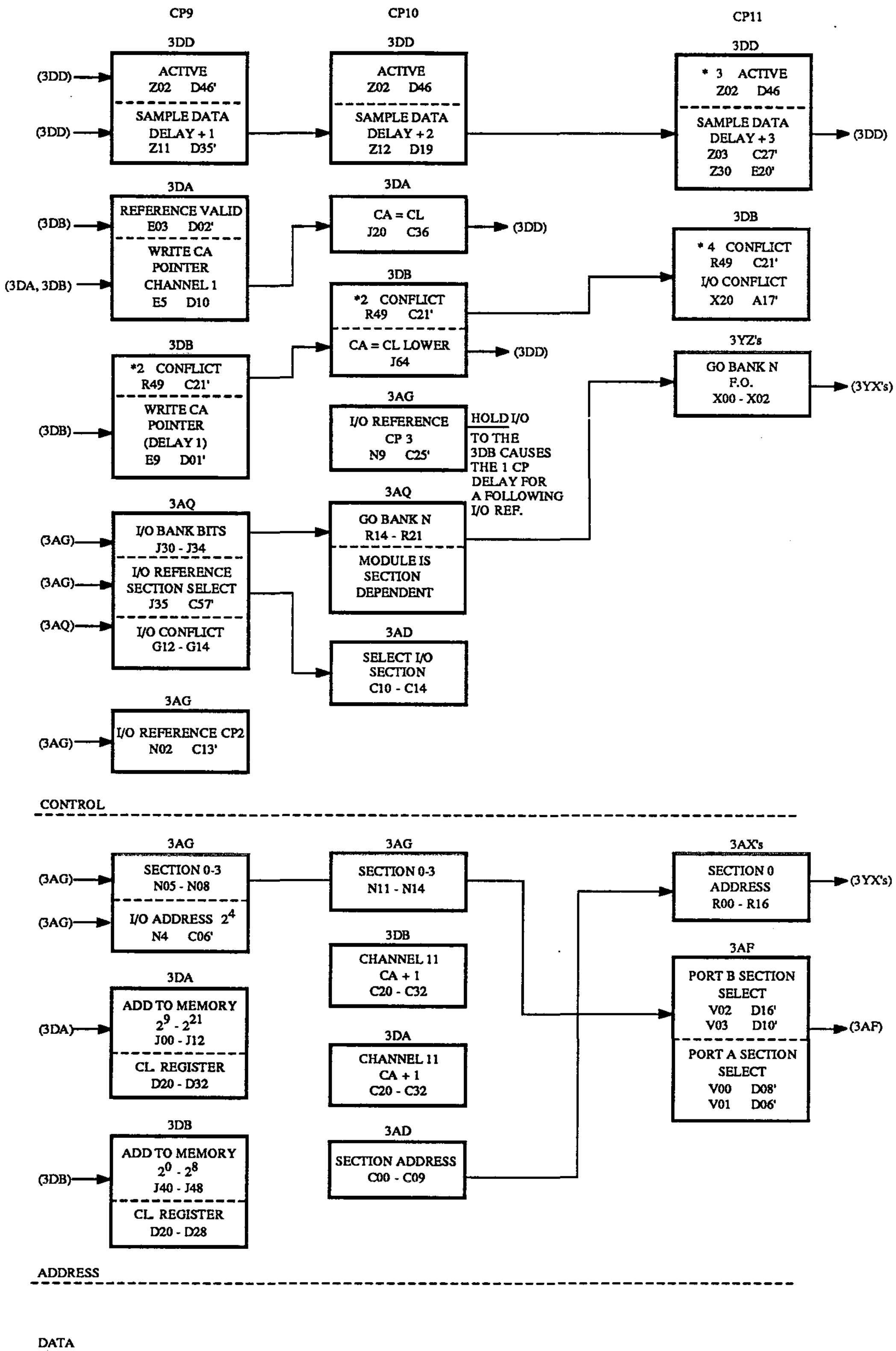


OUTPUT TIMING SEQUENCE (sheet 2 of 11)



*2 The conflict signal may occur at any time holding up the control and address on its way to memory.

OUTPUT TIMING SEQUENCE (sheet 3 of 11)

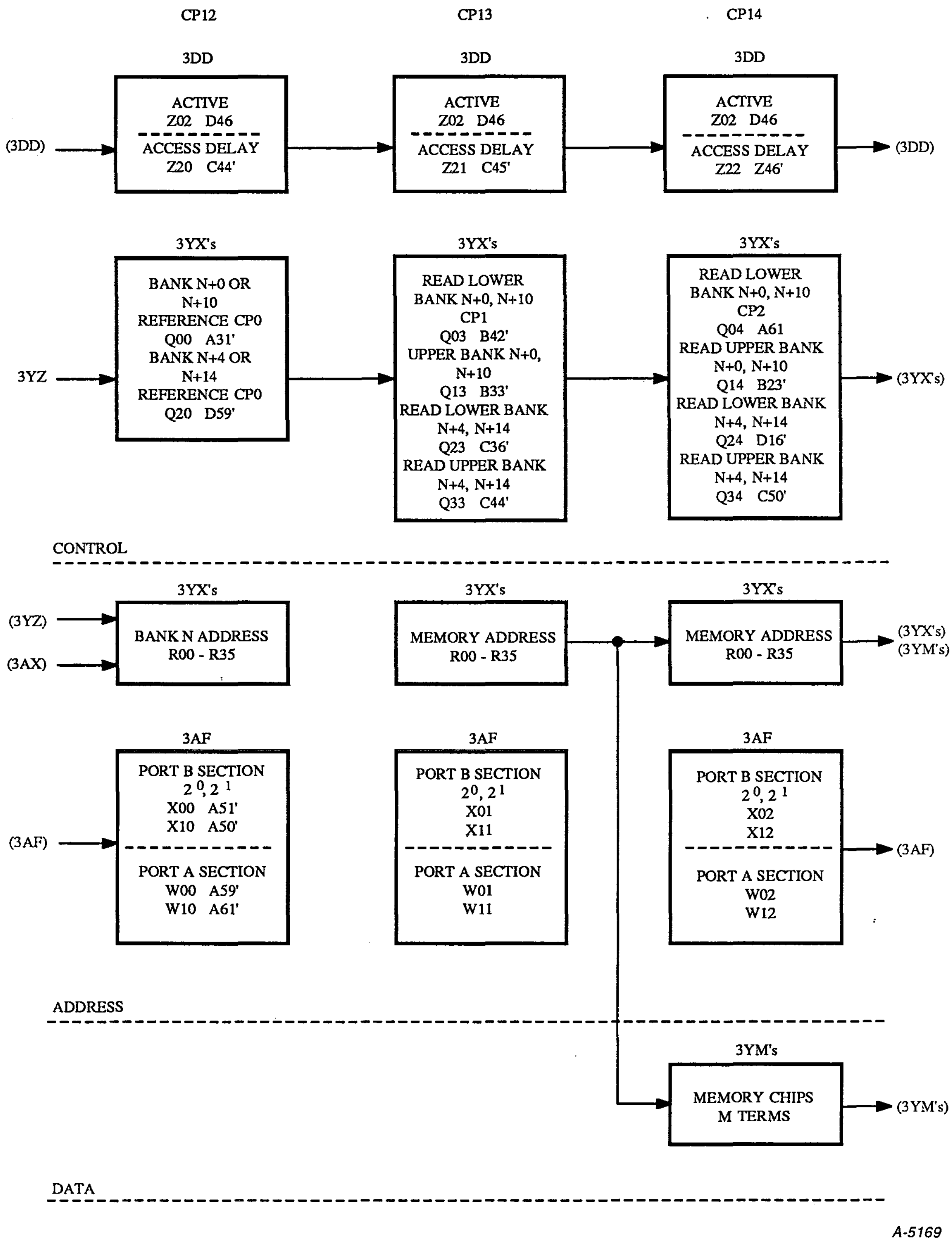


*3 The Channel active would drop this time if CA = CL for this I/O transfer.

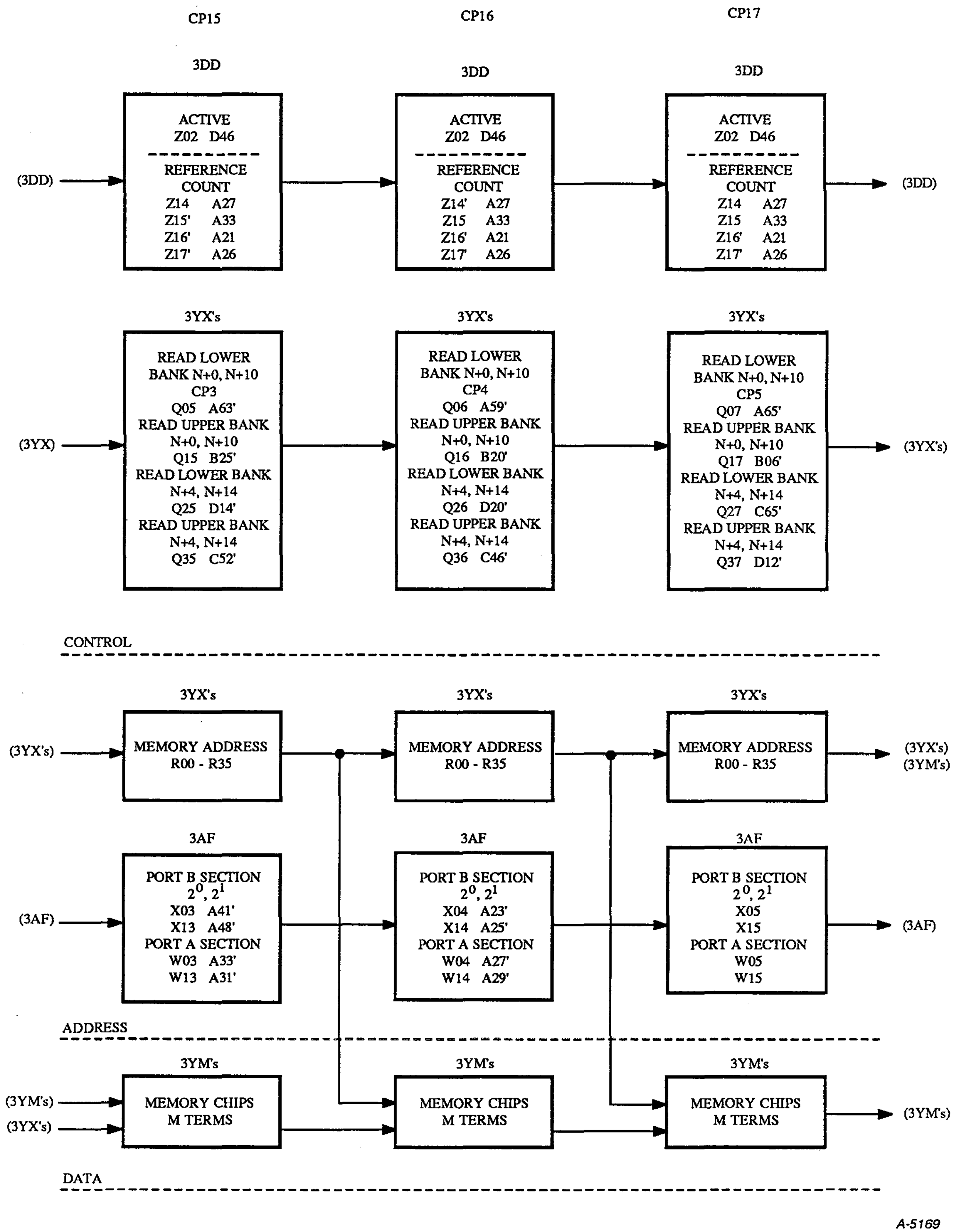
*4 The I/O signal from the 3AG will make R49 on the 3DB. This signal will go to all I/O modules to delay for 1CP any following I/O reference. It's sent to the following modules: 3DA, 3DE, 3DH, 3DD, 3DF, 3DL

A-5169

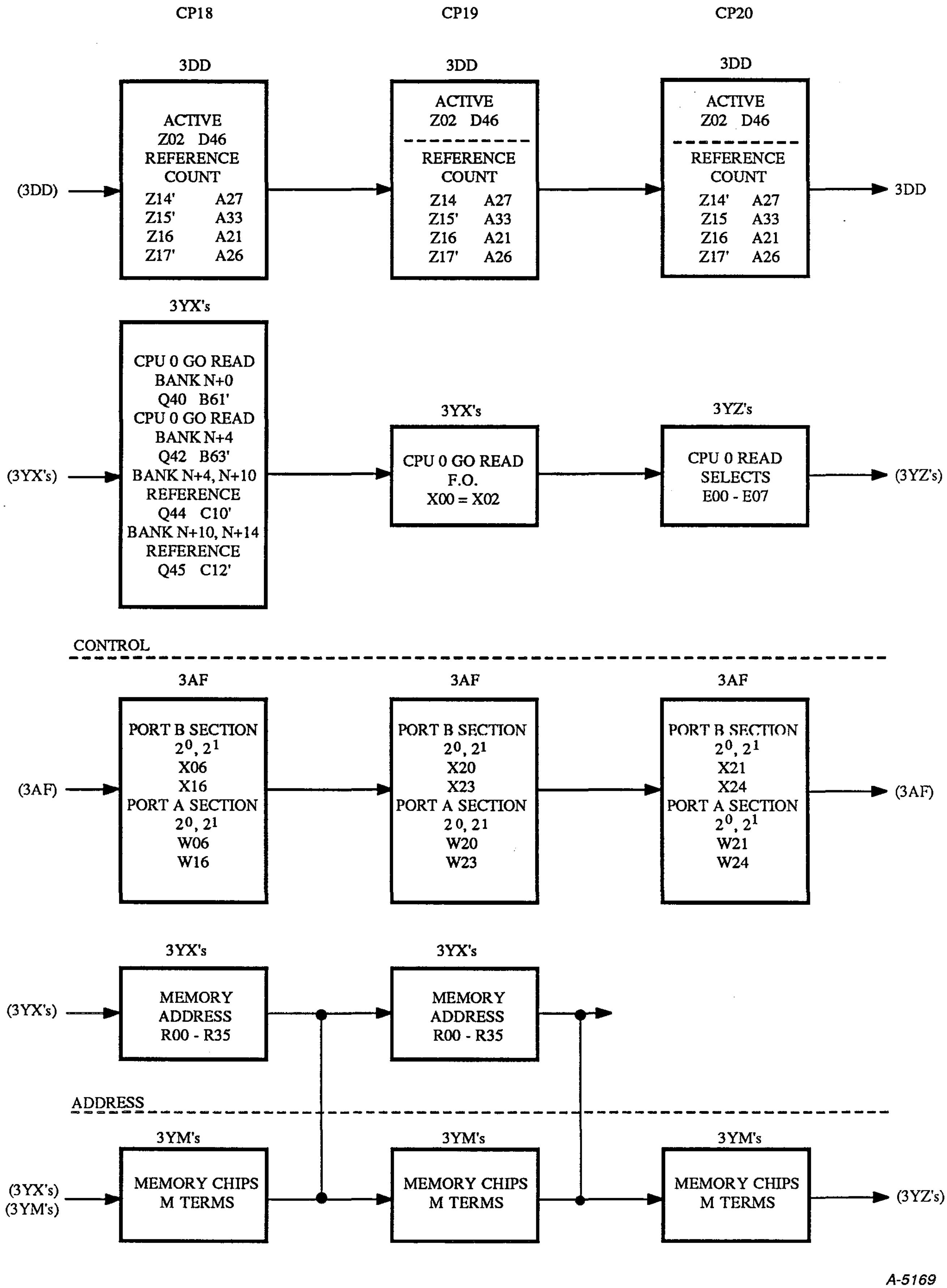
OUTPUT TIMING SEQUENCE (sheet 4 of 11)



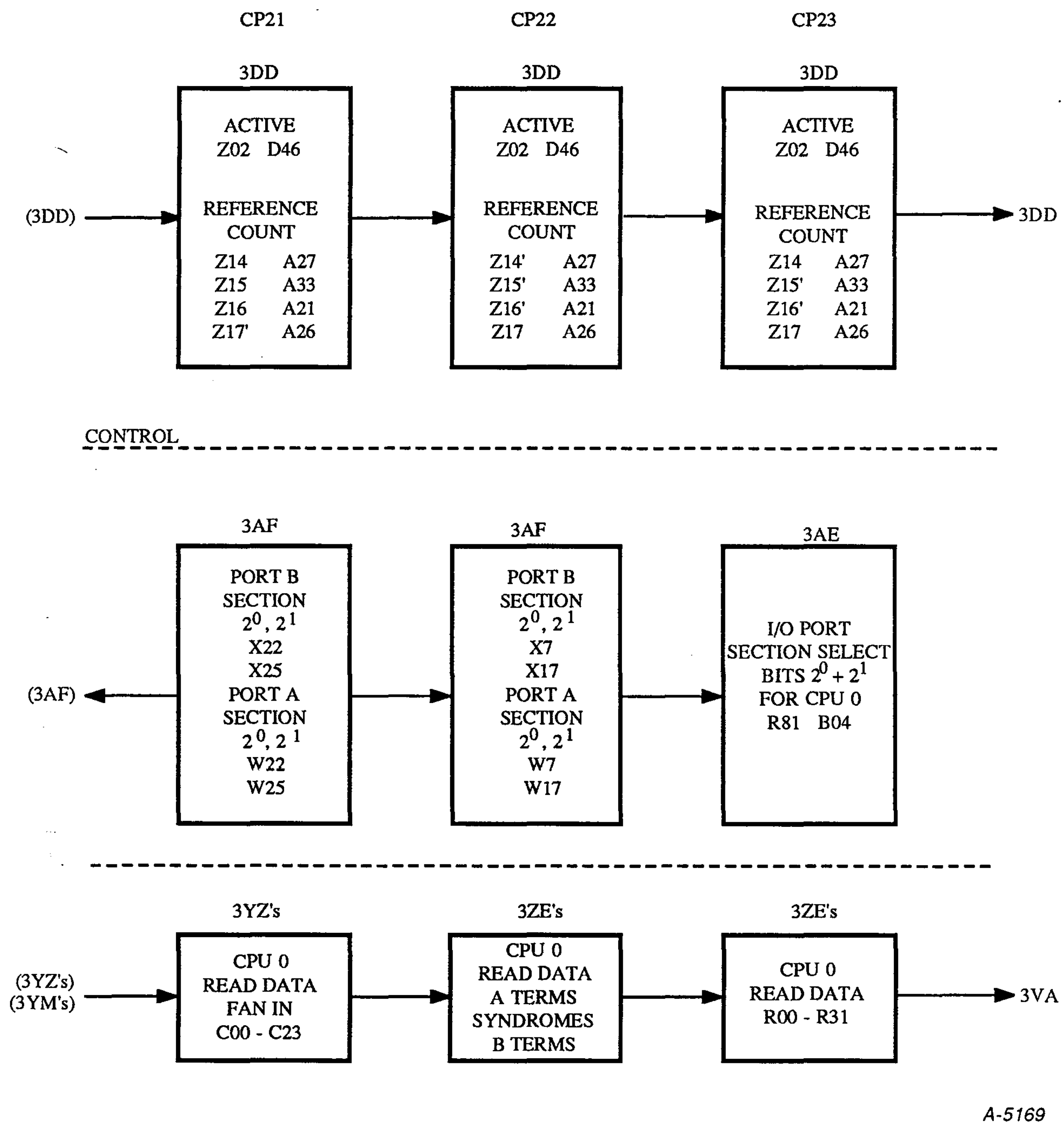
OUTPUT TIMING SEQUENCE (sheet 5 of 11)



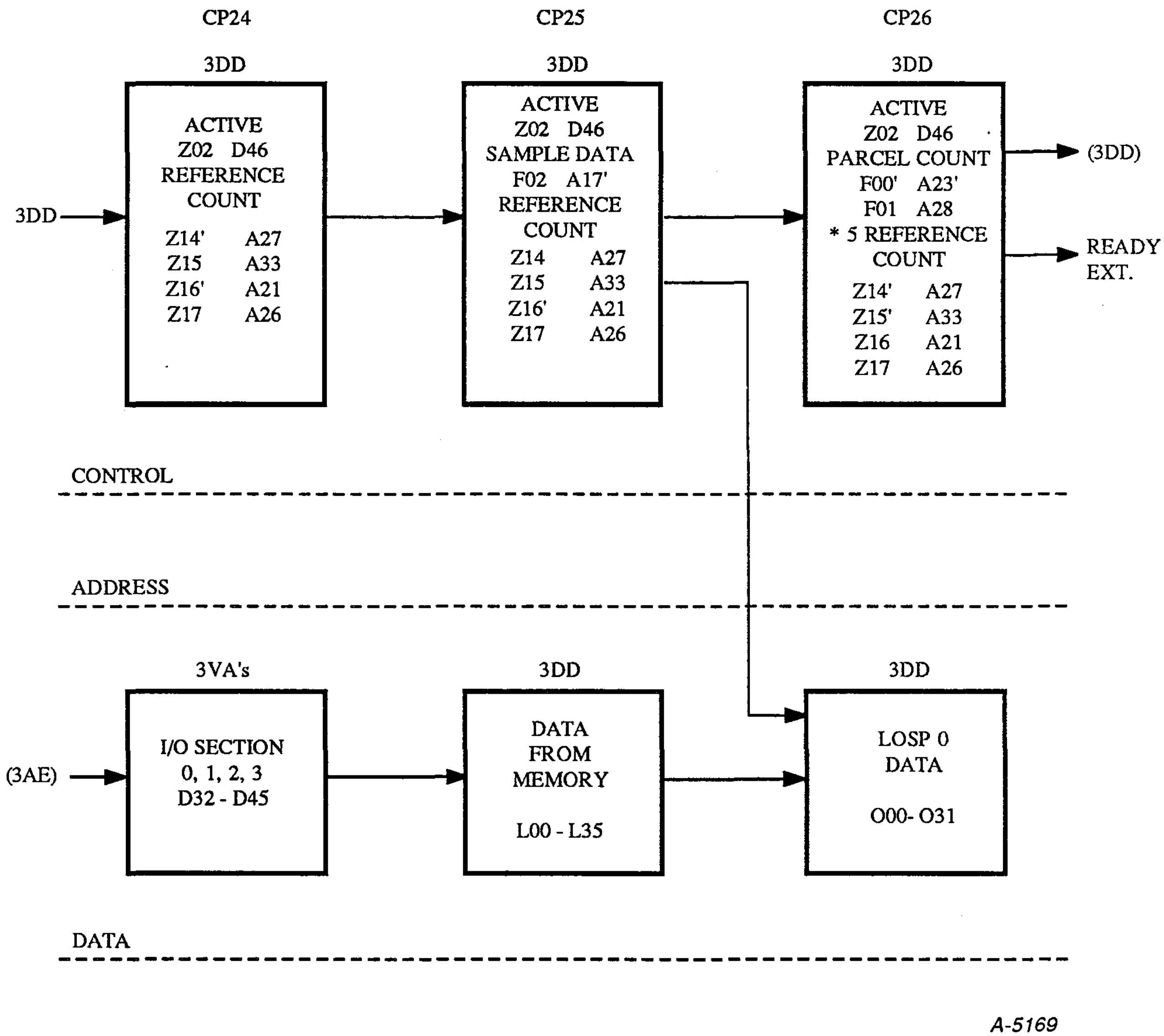
OUTPUT TIMING SEQUENCE (sheet 6 of 11)



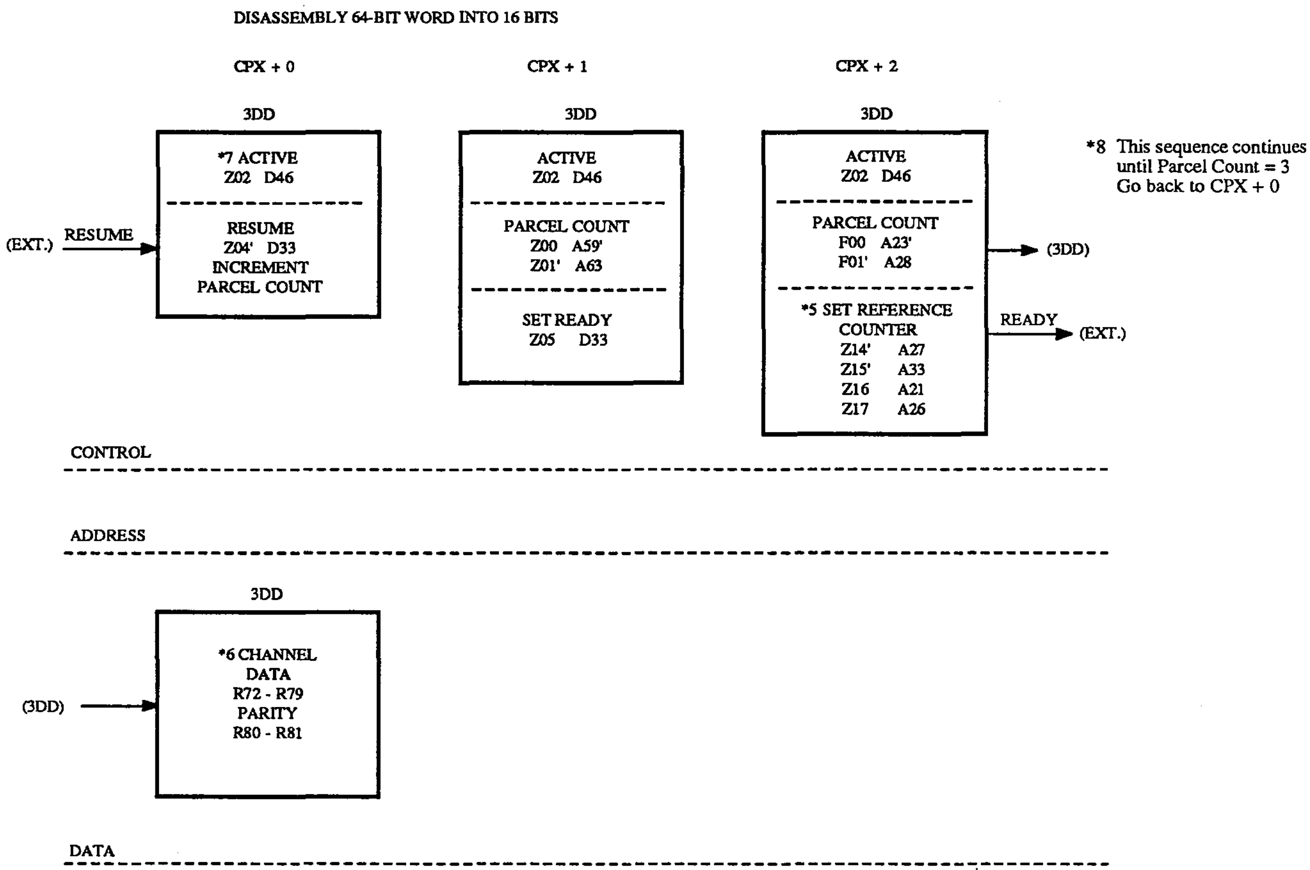
OUTPUT TIMING SEQUENCE (sheet 7 of 11)



OUTPUT TIMING SEQUENCE (sheet 8 of 11)



OUTPUT TIMING SEQUENCE (sheet 9 of 11)



*5 Ready drops when Z14, Z15, Z16, Z17 equals all ones or for another 3 CP's.

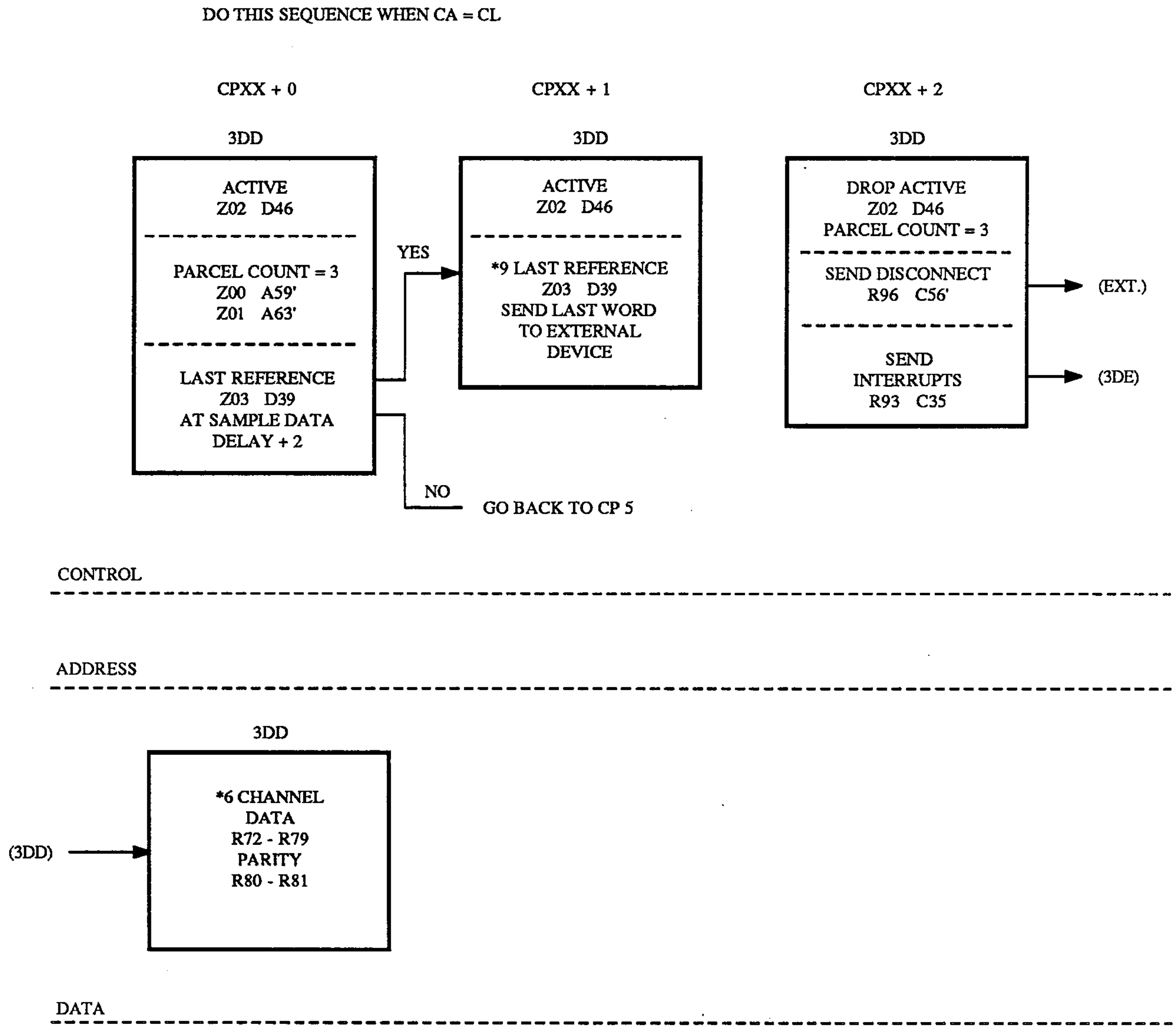
*6 16 bits of data and 2 parity bits are sent to the external device at TS 6/8.

*7 Time is dependent on Resume coming back from external device.

*8 Last reference stays up until active drops.

A-5169

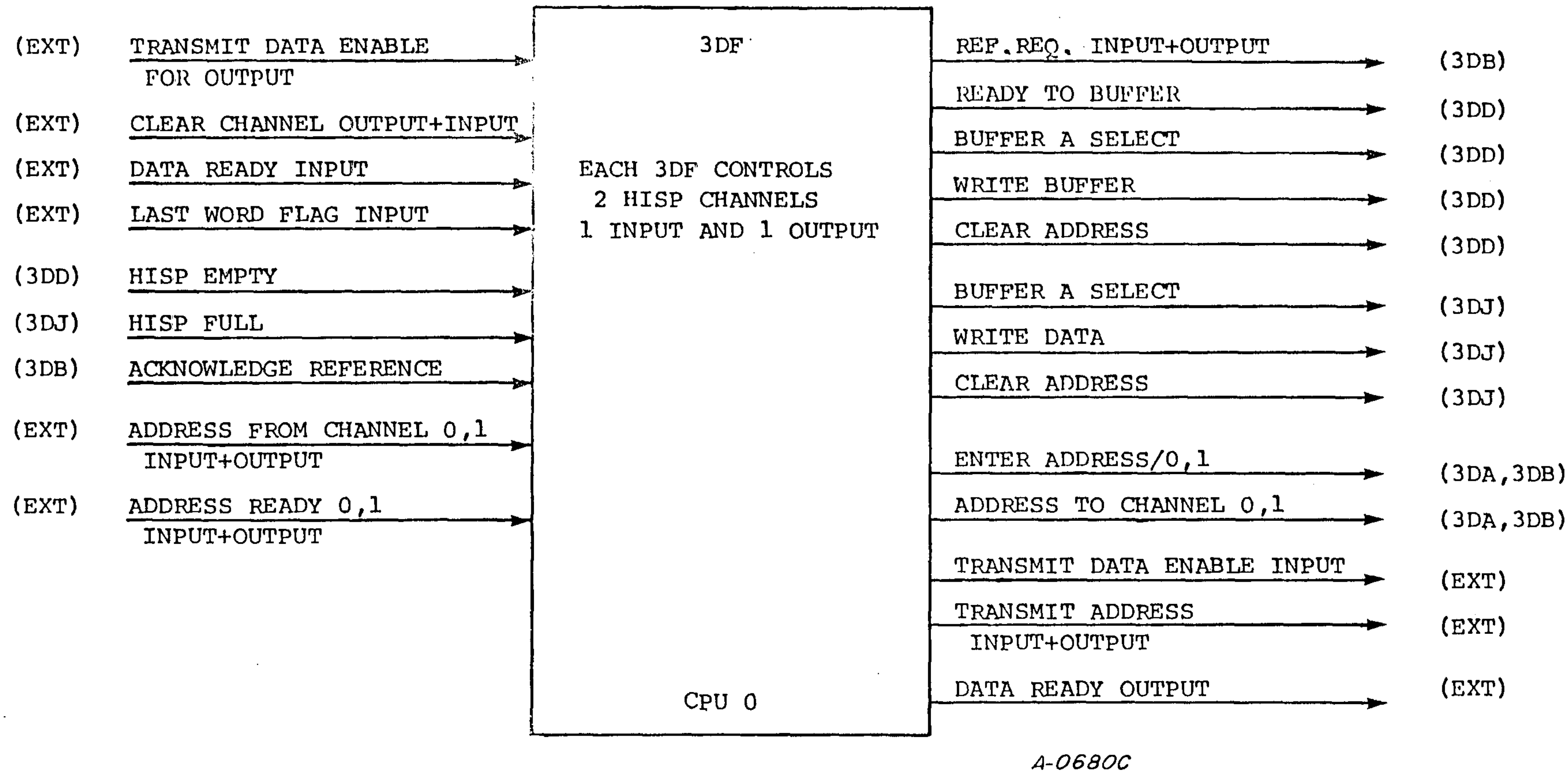
OUTPUT TIMING SEQUENCE (sheet 10 of 11)



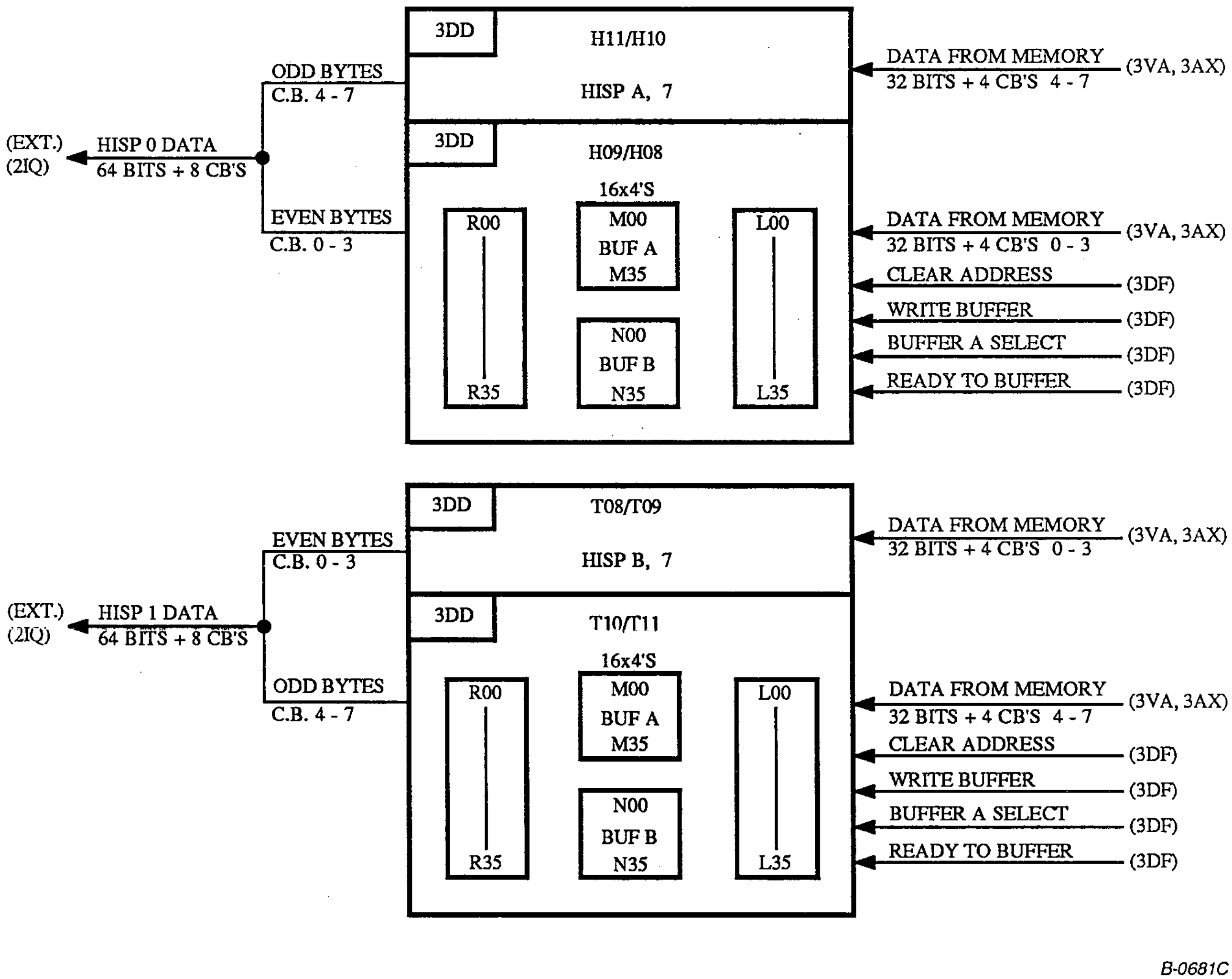
*9 LAST REFERENCE STAYS UP UNTIL ACTIVE DROPS.

A-5169

OUTPUT TIMING SEQUENCE (sheet 11 of 11)



CRAY X-MP HISP CHANNEL CONTROL



CRAY X-MP CHANNEL DATA OUTPUT

	3DF H06/07 HISP A INPUT HISP 0 T.P.	TERM	OUTPUT HISP 1 T.P.	TERM	3DF T06/07 HISP B INPUT HISP 0 T.P.	TERM	OUTPUT HISP 1 T.P.	TERM
2^0	D58	E00	D01	M00	D58	E00	D01	M00
2^1	D53	E01	D08	M01	D53	E01	D08	M01
2^2	D55	E02	D10	M02	D55	E02	D10	M02
2^3	D61	E03	D16	M03	D61	E03	D16	M03
2^4	D49	E04	D07	M04	D49	E04	D07	M04
2^5	D64	E05	D14	M05	D64	E05	D14	M05
2^6	D63	E06	D27	M06	D63	E06	D27	M06
2^7	D62	E07	D12	M07	D62	E07	D12	M07
2^8	D44	E08	D18	M08	D44	E08	D18	M08
2^9	D72	E09	D23	M09	D72	E09	D23	M09
2^{10}	D70	E10	D06	M10	D70	E10	D06	M10
2^{11}	D65	E11	D05	M11	D65	E11	D05	M11
2^{12}	D35	E12	D20	M12	D35	E12	D20	M12
2^{13}	D33	E13	D03	M13	D33	E13	D03	M13

	3DG @ T04/05 HISP C INPUT T.P.	TERM	OUTPUT T.P.	TERM	HISP D INPUT T.P.	TERM	OUTPUT T.P.	TERM
2^0		E00		M00	C03	E20	C19	M20
2^1		E01		M01	C06	E21	C31	M21
2^2	A08	E02		M02	C08	E22	C04	M22
2^3	A10	E03		M03	C18	E23	C23	M23
2^4	A12	E04		M04	C20	E24	C17	M24
2^5	A20	E05		M05	C33	E25	C29	M25
2^6	A23	E06		M06	C16	E26	C42	M26
2^7	A42	E07		M07	C14	E27	C12	M27
2^8	A18	E08		M08	C35	E28	C44	M28
2^9	A14	E09		M09	C10	E29	C27	M29
2^{10}	A48	E10		M10	C25	E30	C50	M30
2^{11}	A40	E11		M11	C36	E31	C46	M31
2^{12}	A25	E12		M12	C48	E32	C38	M32
2^{13}	A61	E13		M13	C55	E33	C40	M33

HISP D: Additional HISP not currently used

A-1874B

CRAY X-MP HISP BLOCK LENGTH REGISTER

3DB @ H00/01
T00/01

VHISP
CHANNEL 7

	HISP A/B INPUT HISP 0 T.P.	TERM	HISP A/B OUTPUT HISP 1 T.P.	TERM	INPUT HISP 2 T.P.	TERM	OUTPUT HISP 3 T.P.	TERM
2^0	D59'	B00'	D46'	B20'	D52'	B40	D49'	B60
2^1	D34'	B01'	D18'	B21'	D48'	B41	D45'	B61
2^2	D11'	B02'	D16'	B22'	D44'	B42	D35'	B62
2^3	D69'	B03'	D70'	B23'	D42'	B43	D36'	B63
2^4	D65'	B04'	D66'	B24'	D38'	B44	D31'	B64
2^5	D61'	B05'	D23'	B25'	D41'	B45	D30'	B65
2^6	D68'	B06'	D57'	B26'	D29'	B46	D26'	B66
2^7	B33'	B07'	D55'	B27'	D14'	B47	D20'	B67
2^8	D63'	B08'	D25'	B28'	D17'	B48	D22'	B68

3DA @ H02/03
T02/03

	T.P.	TERM	T.P.	TERM	T.P.	TERM	T.P.	TERM
2^9	B72'	B00'	B63'	B20'	B42'	B40	B65'	B60
2^{10}	B08'	B01'	B59'	B21'	B67'	B41	B57'	B61
2^{11}	B68'	B02'	B06'	B22'	B70'	B42	B61'	B62
2^{12}	B46'	B03'	B37'	B23'	B55'	B43	B47'	B63
2^{13}	B48'	B04'	B31'	B24'	B50'	B44	B41'	B64
2^{14}	B45'	B05'	B29'	B25'	B51'	B45	B49'	B65
2^{15}	B36'	B06'	B35'	B26'	B40'	B46	B52'	B66
2^{16}	D68'	B07'	D62'	B27'	D56'	B47	D33'	B67
2^{17}	D60'	B08'	D61'	B28'	D57'	B48	D31'	B68
2^{18}	D63'	B09'	D59'	B29'	D36'	B49	D29'	B69
2^{19}	D58'	B10'	D48'	B30'	D35'	B50	D27'	B70
2^{20}	D55'	B11'	D46'	B31'	D40'	B51	D25'	B71
2^{21}	D54'	B12'	D42'	B32'	D38'	B52	D23'	B72
2^{22}	B33'	B13'	B25'	B33'	B16'	B53	B39'	B73
2^{23}	B27'	B14'	B12'	B34'	B14'	B54	B38'	B74

A-1873C

CRAY X-MP HISP CHANNEL ADDRESS REGISTER

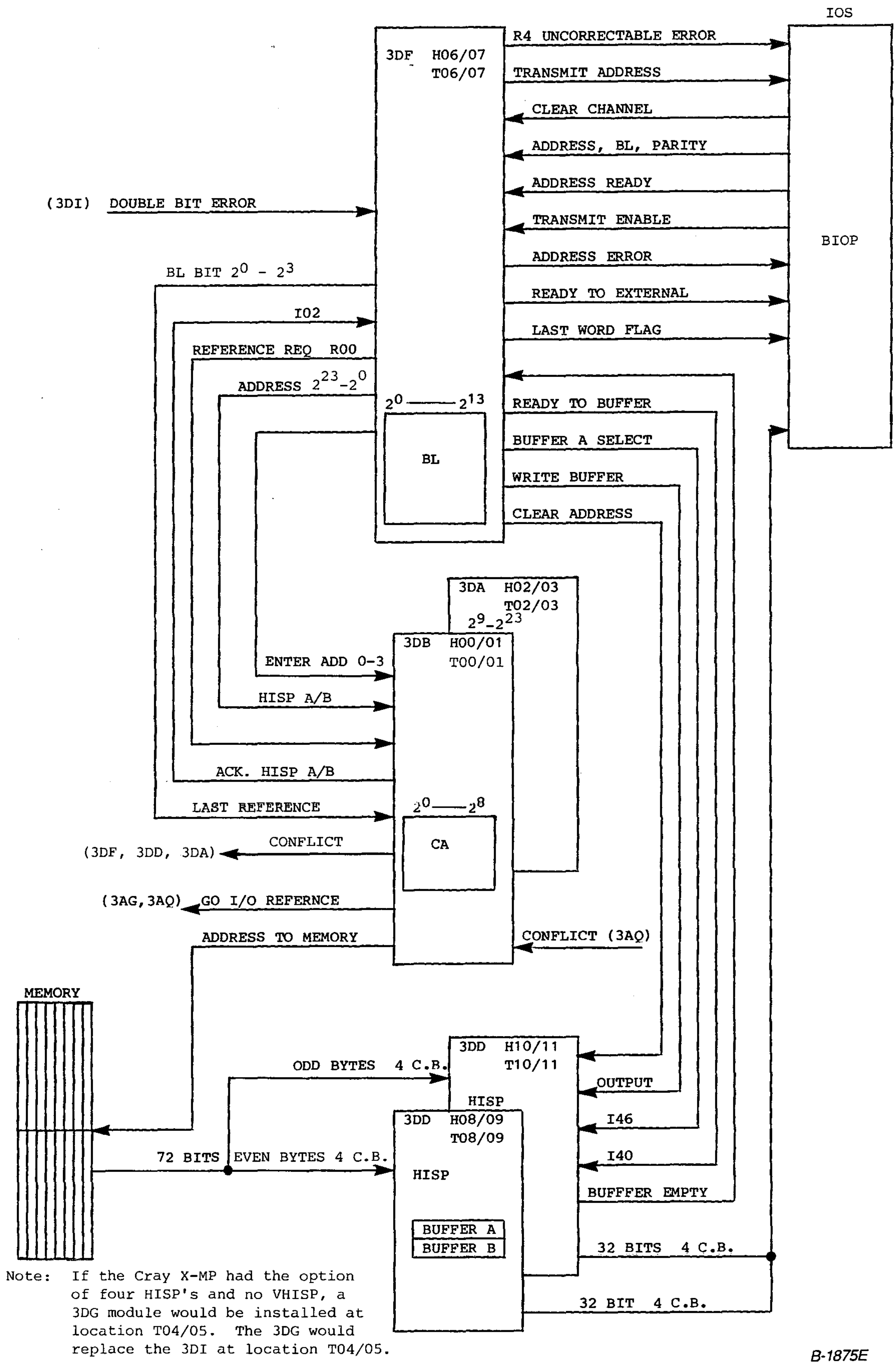
X-MP 16x4 MODULE LOCATOR

	DATA 0-3 / BITS 8-11		DATA 4-7 / BITS 12-15		DATA 16-19 / BITS 24-27		DATA 20-23 / BITS 28-31		DATA 32-35 / BITS 40-43		DATA 36-39 / BITS 44-47		DATA 48-51 / BITS 56-59		DATA 52-55 / BITS 60-63		CB 0-3 / CB 4-7		HISP A,7 INPUT: 3DJ H12/13, 3DJ H14/15, — HISP B,7 INPUT: T12/13, T14/15
	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	
3DJ	M00-03	BTK	M04-07	BUK	M08-11	AHB	M12-15	AIB	M16-19	DTI	M20-23	DUI	M24-27	CHD	M28-31	CID	M32-35	AJB	HISP BUFFER A
	N00-03	BTI	N04-07	BUI	N08-11	AHD	N12-15	AID	N16-19	DTK	N20-23	DUK	N24-27	CHB	N28-31	CIB	N32-35	DVK	HISP BUFFER B
	M40-43	BTB	M44-47	BUB	M48-51	AHK	M52-55	AIK	M56-59	DTD	M60-63	DUD	M64-67	CHI	M68-71	CII	M72-75	AJK	VHISP BUFFER A
	N40-43	BTD	N44-47	BUD	N48-51	AHI	N52-55	AII	N56-59	DTB	N60-63	DUB	N64-67	CHK	N68-71	CIK	N72-75	DVB	VHISP BUFFER B

27-5

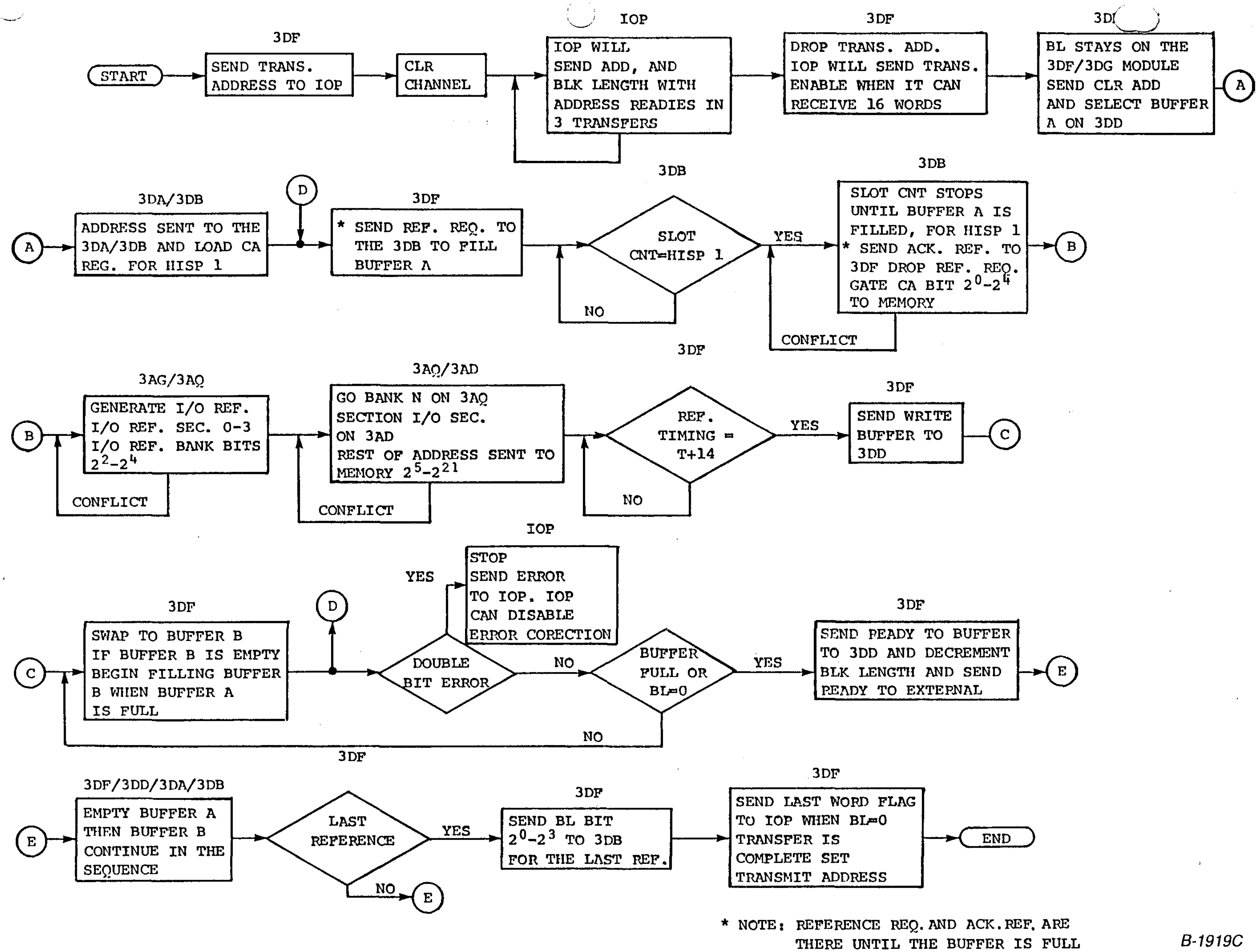
	DATA 0-3 / BITS 8-11		DATA 4-7 / BITS 12-15		DATA 16-19 / BITS 24-27		DATA 20-23 / BITS 28-31		DATA 32-35 / BITS 40-43		DATA 36-39 / BITS 44-47		DATA 48-51 / BITS 56-59		DATA 52-55 / BITS 60-63		CB 0-3 / CB 4-7		HISP A,7 OUTPUT: 3DD H08/09, 3DD H10/11, — HISP B,7 OUTPUT: T08/09, T10/11
	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	
3DD	M0-03	BQA	M04-07	BQB	M08-11	BQC	M12-15	DQA	M16-19	DQB	M20-23	DQC	M24-27	CEJ	M28-31	CEK	M32-35	CEL	HISP BUFFER A
	N0-03	BTA	N04-07	BTB	N08-11	BTC	N12-15	DTA	N16-19	DTB	N20-23	DTC	N24-27	CHJ	N28-31	CHK	N32-35	CHL	HISP BUFFER B
	M40-43	BQJ	M44-47	BQK	M48-51	BQL	M52-55	DQJ	M56-59	DQK	M60-63	DQL	M64-67	CEA	M68-71	CEB	M72-75	CEC	VHISP BUFFER A
	N40-43	BTJ	N44-47	BTK	N48-51	BTL	N52-55	DTJ	N56-59	DTK	N60-63	DTL	N64-67	CHA	N68-71	CHB	N72-75	CHC	VHISP BUFFER B

X2027C0101



Note: If the Cray X-MP had the option of four HISP's and no VHISP, a 3DG module would be installed at location T04/05. The 3DG would replace the 3DI at location T04/05.

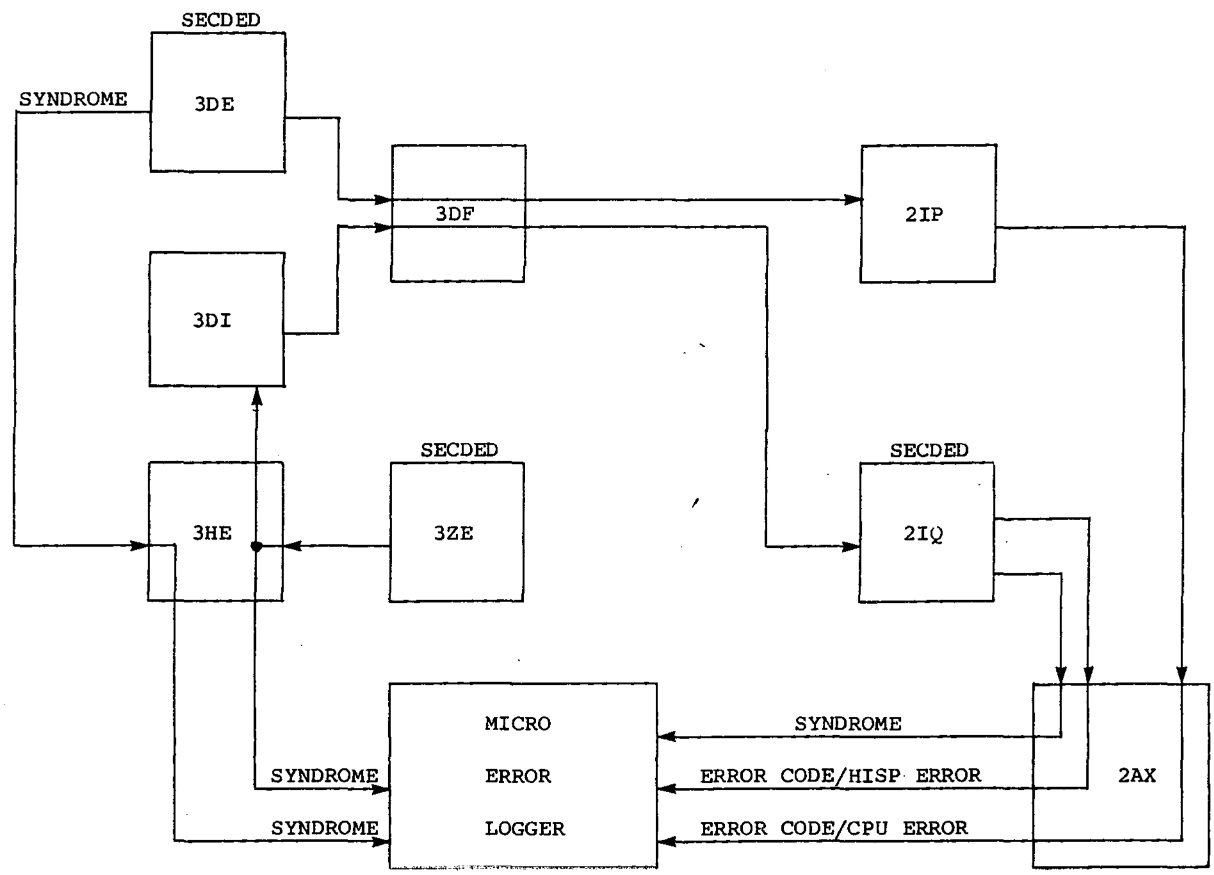
CRAY X-MP HISP OUTPUT CHANNEL



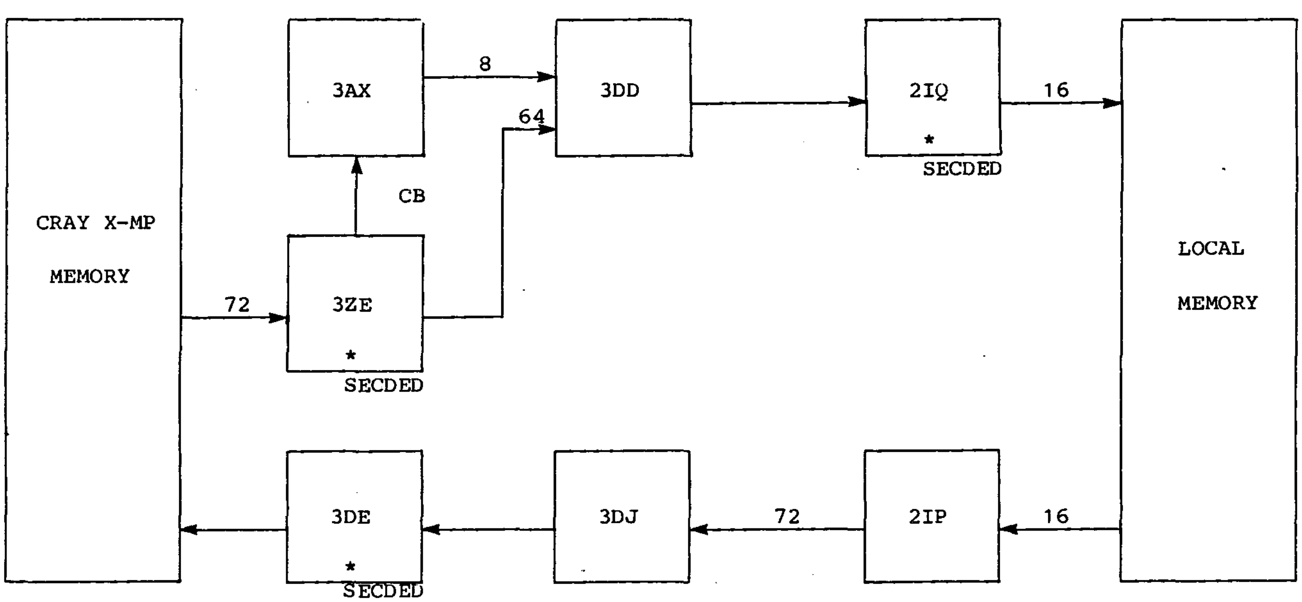
27-7

X-MP/2 FLOW CHART HISP 1 OUTPUT OPERATION

HISP ERROR LOGGING



HISP ERROR CORRECTION



B-2074
X2026C0107

SYNDROME CODES

0-OK	40-69	100-70	140-D	200-71	240-D	300-D	340-24
1-64	41-D	101-D	141-M	201-D	241-M	301-M	341-D
2-65	42-D	102-D	142-M	202-D	242-M	302-M	342-D
3-D	43-M	103-M	143-D	203-M	243-D	303-D	343-27
4-66	44-D	104-D	144-M	204-D	244-M	304-M	344-D
5-D	45-M	105-M	145-D	205-M	245-D	305-D	345-29
6-D	46-M	106-M	146-D	206-M	246-D	306-D	346-30
7-32	47-D	107-D	147-38	207-D	247-34	307-36	347-D
10-67	50-D	110-D	150-M	210-D	250-M	310-M	350-D
11-D	51-M	111-M	151-M	211-M	251-D	311-D	351-25
12-D	52-M	112-M	152-D	212-M	252-D	312-D	352-26
13-40	53-D	113-D	153-46	213-D	253-42	313-44	353-D
14-D	54-M	114-M	154-D	214-M	254-D	314-D	354-28
15-48	55-D	115-D	155-54	215-D	255-50	315-52	355-D
16-56	56-D	116-D	156-62	216-D	256-58	316-60	356-D
17-D	57-M	117-M	157-D	217-M	257-D	317-D	357-31
20-68	60-D	120-D	160-00	220-D	260-08	320-16	360-D
21-D	61-M	121-M	161-D	221-M	261-D	321-D	361-M
22-D	62-M	122-M	162-D	222-M	262-D	322-D	362-M
23-M	63-D	123-D	163-03	223-D	263-11	323-19	363-D
24-D	64-M	124-M	164-D	224-M	264-D	324-D	364-M
25-M	65-D	125-D	165-05	225-D	265-13	325-21	365-D
26-M	66-D	126-D	166-06	226-D	266-14	326-22	366-D
27-D	67-35	127-37	167-D	227-33	267-D	327-D	367-39
30-D	70-M	130-M	170-D	230-M	270-D	330-D	370-M
31-M	71-D	131-D	171-01	231-D	271-09	331-17	371-D
32-M	72-D	132-D	172-02	232-D	272-10	332-18	372-D
33-D	73-43	133-45	173-D	233-41	273-D	333-D	373-47
34-M	74-D	134-D	174-04	234-D	274-12	334-20	374-D
35-D	75-51	135-53	175-D	235-49	275-D	335-D	375-55
36-D	76-59	136-61	176-D	236-57	276-D	336-D	376-63
37-M	77-D	137-D	177-07	237-D	277-15	337-23	377-D

D - DOUBLE ERROR
M - MULTIPLE ERROR

TRANSFER ADDRESS AND BLOCK LENGTH

W10 = $\overline{Z6}\ \overline{Z7}$ ADDRESS SLOT Ø
W11 = $Z6\ \overline{Z7}$ SLOT 1
W12 = $\overline{Z6}\ Z7$ SLOT 2
W13 = $Z6\ Z7$ SLOT 3

W1 = ENABLE TRANSMIT ADDRESS

BOOLEAN	R24 = X10 W1; T2
	R25 = X11 W1; T2
	R26 = X12 W2; T2
	R27 = X13 W3; T2

R25 = TRANSMIT ADDRESS SENT TO IOP FOR HISP 1 OR 5

BOOLEAN	R28' = X1' Y8' + X10'; T2
	R29' = X1' Y8' + X11'; T2
	R30' = X1' Y8' + X12'; T2
	R31' = X' Y8' + X13'; T2
	R29 = [X1 + Y8] [X11]

R29 - LAST ADDRESS READY ENTER THE ADDRESS INTO 3DA/3DB MODULES FOR HISP 1 OR 5 OR ADDRESS ERROR.

ADDRESS ERROR

R32 = Y8; T2 SENT TO IOP

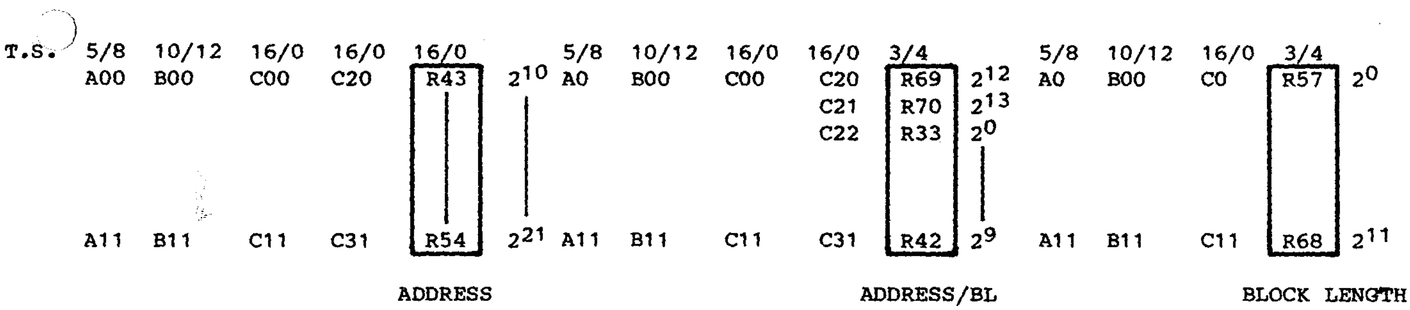
BOOLEAN	Y8 = W2 Z9 + X14 Z11 + X14 B40

Y8 = CNT = LIMIT AND SECOND ADDRESS READY + ADDRESS READY AND SEQUENCE IS OVER + ADDRESS READY AND PARITY ERROR

A-1870

TRANSFER ADDRESS AND BLOCK LENGTH

A00 = I20	ADDRESS HISP Ø
⇩	
A11 = I31	
A12 = I32	PARITY BIT Ø
A13 = I33	BIT 1
A14 = I34	BIT 2
A15 - I35	ADDRESS READY



ADDRESS 2^0-2^{21} - IS SENT TO THE 3DA/3DB MODULES

BLOCK LENGTH 2^0-2^{13} - REMAINS ON THE 3DF FOR HISP 0-3, FOR HISP 4-7 BLOCK LENGTH IS SENT TO THE 3DG.

A-1870A

REFERENCE REQUEST

BOOLEAN U01 = R29 R32' S5'

U01 = REFERENCE MEMORY FOR HISP 1
IF NO ADDRESS ERROR AND THE
CABLE IS NOT DISCONNECTED

V00 = U1 + Q0 $\overline{R3}$ - SET CHANNEL ACTIVE
R12 = U1 + V4; T2 - CLEAR ADDRESS ON 3DD's
R02 = R2 $\overline{V4}$ + $\overline{R2}$ V4 + U1; T2 - BUFFER A SELECT

BOOLEAN R00 = Q3 V3' + U1 + R0 M60'; T2

R00 = SEND REFERENCE REQUEST TO 3DB OR IF BUFFER
A OR B IS EMPTY SWAP THE BUFFER POINTER AND
GENERATE REFERENCE REQUEST TO FILL THE OTHER
BUFFER, OR DROP REFERENCE REQUEST WHEN
ACKNOWLEDGE REFERENCE COMES BACK FROM 3DB.

LAST REFERENCE BLOCK LENGTH $<20_8$

BOOLEAN M16' = MUX (C0' M16'): DCD (U7); T2

M17' = MUX (C1' M17'): DCD (U7); T2

M18' = MUX (C2' M18'): DCD (U7); T2

M19' = MUX (C3' M19): DCD (U7); T2

M16-M19 = LAST REFERENCE MAY BE LESS THE
16 WORD. HISP 1

A-1870

REFERENCE TIMING

M60 = I02 I3' + M60 I3; T2	READ ACKNOWLEDGE	+00
M61 = M60 I3' + M61 I3; T2	ADDRESS GENERATION	+01
M62 = M61 I3' + M62 I9; T2	ADDRESS GENERATION	+02
M63 = V8; T2	ADDRESS DISTRIBUTION	+03
M64 = M63; T2	ADDRESS FANOUT	+04
M65 = M64; T2	ADDRESS FANOUT	+05

M66 = M65 Y100 + M30 Y101 + M81 Y102 + M82 Y103; T2

ADDED DELAY FOR DIFFERENT REFERENCE TIMES
ON MEMORY CHIPS.

M67 = M66; T2	ADDRESS ON Z -	+06
M68 = M67; T2	ADDRESS ON Z -	+07
M69 = M68; T2	ADDRESS ON Z -	+08
M70 = M69; T2	READOUT Z -	+09
M71 = M70; T2	FANIN DATA ON ZR	+10
M72 = M71; T2	SECDED DATA ON ZE	+11
M73 = M72; T2	SECDED DATA ON ZE	+12
M74 = M73; T2	SELECT I/O DATA ON VA	+13
M75 = M74; T2	DATA ON DD	+14

WRITE BUFFER A

$\overline{R11} = \overline{M73}$ WRITE BUFFER

SWAP TO BUFFER B

Q1 = BUFFER FULL
Q2 = LAST REFERENCE $\leq 20_8$
Q3 = SWAP
S0 = ACTIVE NO ERROR
Z25 = TRANSMIT ENABLE
U00 = NO REFERENCE

BOOLEAN V04 = U0 Q1' Q2' Q3' S0 Z25

Q03 = V04; T2

V4 = SWAP BUFFERS
Q03 = LATCH V4

A-1870

SEND DATA TO IOP

READY TO BUFFER

Q01 = BUFFER FULL
Q03 = SWAP BUFFER
V06 = DELAY OVER

BOOLEAN	R01 = Q3 V6 + Q1 V6; T2
	P00 = M0 R1' + M0' R1

R01 = SENT READY TO BUFFER TO GET A DATA TO IOP

P00 = DECREMENT BLOCK LENGTH FOR EACH READY

DELAY READY

```
16/0      Q04 = R1 Z27; T2     MAKE Q4 IF NO
16/0      Q05 = Q4 Z27; T2     CLEAR CHANNEL
16/0      Q06 = Q5; T2
16/0      Q07 = Q06; T2
16/0      Q08 = Q07; T2
16/0      Q09 = Q08; T2

 8/9   U4 = R1' Q4' Q5' Q6'
       U5 = Q7' Q8' Q9'

11/13      V06 = U4 U5

16/0      R01 = Q3 V6  +  Q1 V6; T2
```

READY TO EXTERNAL

BOOLEAN	R10' = R01' Q4
	R10 = R01' + Q4

R10 = READY PRECEDES THE DATA BY 25 N SEC.

A-1870

LAST WORD FLAG

N6 = $\overline{M0}\ \overline{M1}\ \overline{M2}\ \overline{M3}$ BL = 0
N5 = $\overline{M16}\ \overline{M17}\ \overline{M18}\ \overline{M19}$ BL = 0
Q4 = READY + 1 TIME
Q2 = LAST BL $\leq 20_8$

```
BOOLEAN     R03 = Q4 N6 Q2  +  R3 U1'; T2
```

R03 = LAST WORD FLAG SENT TO THE IOP

ALLOW TRANSMIT ADDRESS

L0' = K0 $\overline{Z27}$; T2 ACTIVE
R4 = UNCORRECTABLE ERROR ON OUTPUT HISP

```
BOOLEAN     X10 = W10 L0' R4'

            R24 = X10 W1; T2'
```

R24 = CHANNEL NOT ACTIVE AND NO ERRORS THEN
SEND TRANSMIT ADDRESS

UNCORRECTABLE ERRORS

```
BOOLEAN      R4 = R4 Z27'  +  U2  +  M75 I1; T2
```

R4 = R4 $\overline{Z27}$ HOLD ERROR UNTIL CLEAR CHANNEL OCCURS

R4 = U2 ENTER ADDRESS AND ADDRESS ERROR

R4 = M75 I1 DOUBLE BIT ERROR FROM CRAY MEMORY

A-1870

E00 = I62; T2   ENTER ADDRESS INTO HISP Ø
E01 = I63; T2   ENTER ADDRESS INTO HISP 1

$E02 = I64\ F50 + I73\ \overline{F50}$ ENTER ADD INTO HISP 2 OR VHISP IF CHANNEL =7

$E03 = I65\ F50 + I73\ \overline{F50}$ ENTER ADD INTO HISP 3 OR VHISP IF CHANNEL =7

<u>LOAD HISP 1 CHANNEL ADDRESS</u>

BOOLEAN   B20' = MUX (I18' N0'): DCD (E1); T11

B28' = MUX (N8' I26'): DCD (E1'); T11

<u>SLOT EQUAL ACTIVE CHANNEL</u>

$U00 = \overline{X0}\ \overline{X1}$ SLOT 0 READ
$U01 = X0\ \overline{X1}$ SLOT 1 WRITE
$U02 = \overline{X0}\ X1$ SLOT 2 READ
$U03 = X0\ X1$ SLOT 3 WRITE

BOOLEAN   V01' = I43' U3 + I44 U0 + I45' U1 + I46' U2

V01 = [I43 + U3'] [I44 + U0'] [I45 + U1'] [I46 + U2']

V01 = SELECT HISP 0-3 DURING THE SLOT TIME IF THE CHANNEL IS ACTIVE

A-1871

BUFFER DATA FROM MEMORY

BOOLEAN	L00 = I00; T2	DATA FROM MEMORY BIT 2^0
	⇩	
	L35 = I35 + I39; T2	DATA FROM MEMORY C.B. N+3

J00 = I46 SELECT A BUFFER FROM 3DF
K04 = J0 I44 WRITE BUFFER FROM 3DF

A04 = K4; T2 WRITE A HISP 1
I40 = READY TO BUFFER

BOOLEAN	K00 = J0' I40 + A4

K00 = CAUSES THE ADDRESS TO BE INCREMENTED

BOOLEAN	M00 = L00: DCD (A3 A2 A1 A0)/# + T10
	⇩
	M35 = L35: DCD (A3' A2' A1' A0')/# + T10

M00-M35 = LOAD 16 x 4's WITH MEMORY BLOCK REFERENCE

BLOCK REFERENCE   REFERENCE 16 CRAY WORDS

Q4 = BLOCK LENGTH REGISTER GREATER THEN 20_8
Q5 = BLOCK REFERENCE = 1

```
BOOLEAN     P00 = P0' Q4  +  O0 Q4'; T3

            P01 = Q1' Q4  +  O1 Q4'; T3

            P02 = Q2' Q4  +  O2 Q4'; T3

            P03 = Q3' Q4  +  O3 Q4'; T3
```

P0-P3 = BLOCK REFERENCE COUNT INITIALLY SET TO 17_8 DECREMENT TO Ø TO REFERENCE 16 WORDS IN MEMORY TO FILL BUFFER A OR B

WHEN THE BLOCK LENGTH REGISTER IS LESS THAN 20_8. THE LAST BLOCK REFERENCE IS GENERATED FROM WHAT EVER THE LOWER 4 BITS OF BLOCK LENGTH REGISTER IS EQUAL TO.

```
BOOLEAN     Q3 Q2 Q1 = SUM (P3' P2' P1',1)/P0' ##
```

DECREMENTS THE BLOCK REFERENCE FROM 17 TO Ø

```
BOOLEAN     O00' = I27' U0  +  I31' U1  +  I35' U2  +  I39' U3

            O01' = I28' U0  +  I32' U1  +  I36' U2  +  I40' U3

            O02' = I29' U0  +  I33' U1  +  I37' U2  +  I41' U3

            O03  = I30' U0  +  I34' U1  +  I38' U2  +  I42' U3
```

O00-O03 USED TO LOAD THE LAST BLOCK REF.

A-1871

OUTPUT DATA FROM 16 x 4's

$\overline{P00}$ = $\overline{I46}$ HISP 0 SELECT BUFFER A

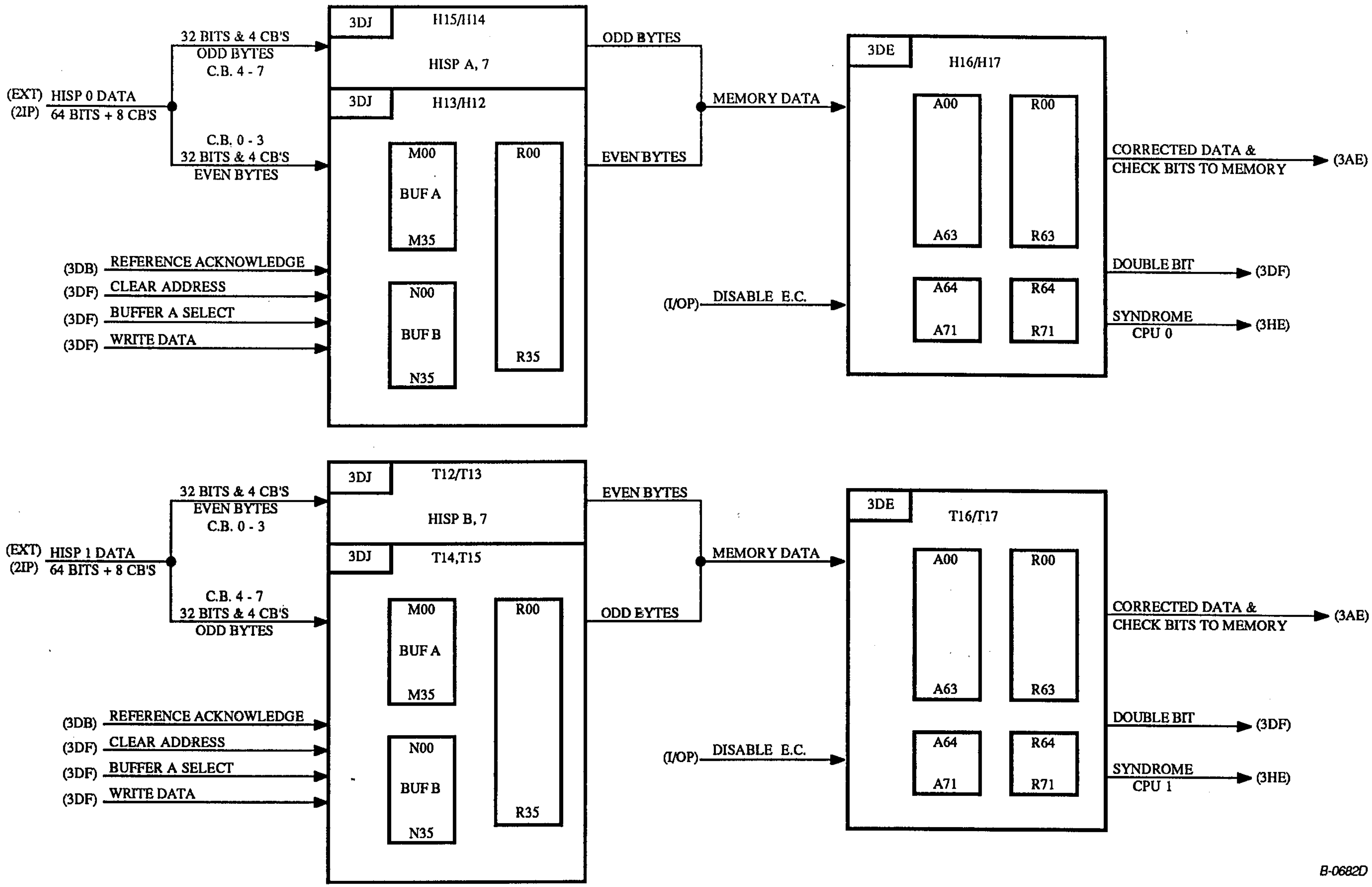
$\overline{T06}$ = T1 I40 READY TO BUFFER

R00 = MUX (M0 N0): DCD (P0'); T6

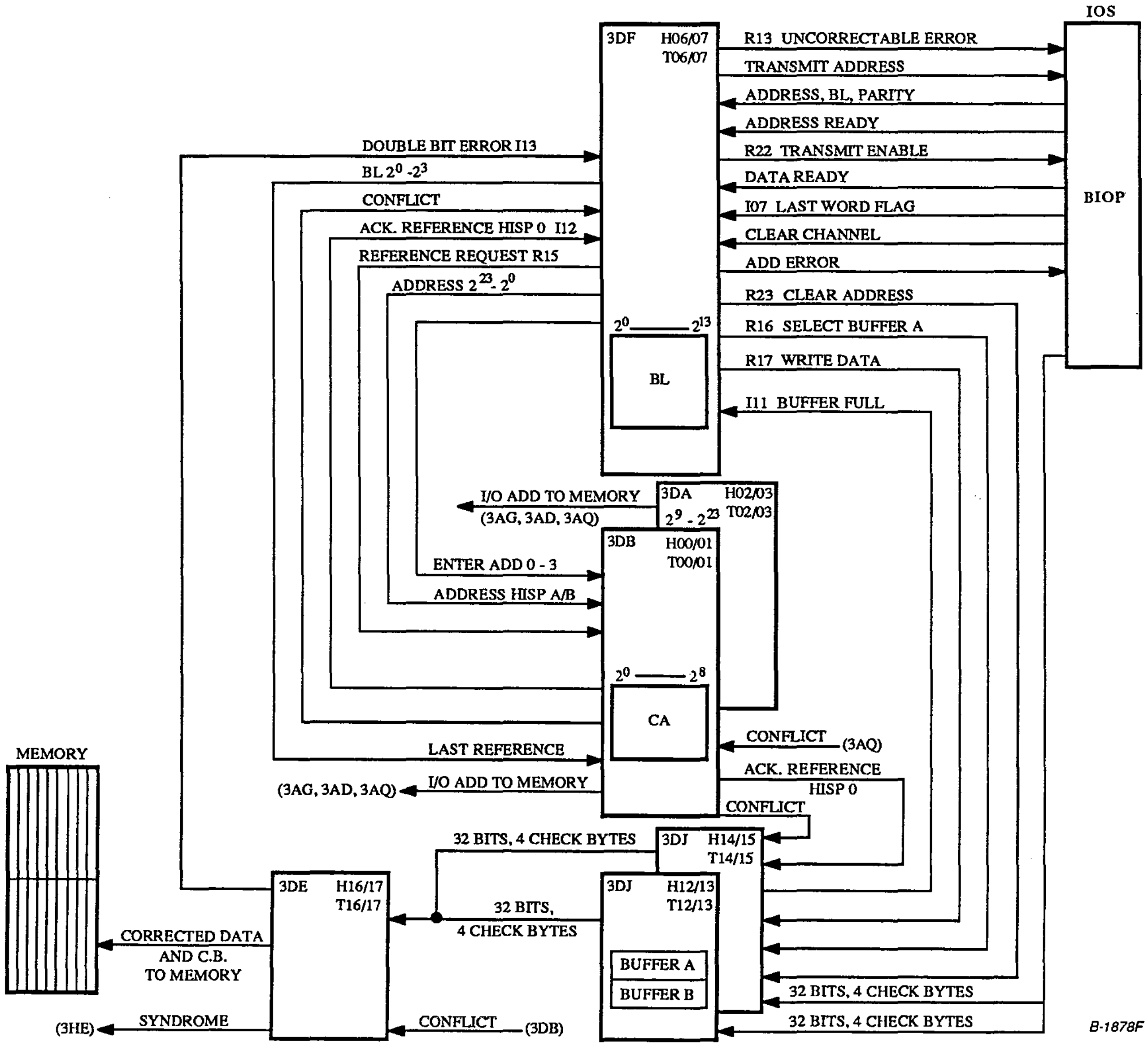
R35 = MUX (N35 M35): DCD (P0); T6

R00-R35 = BUFFER A OR B WORD SENT TO IOP
WHEN READY TO BUFFER

A-1872

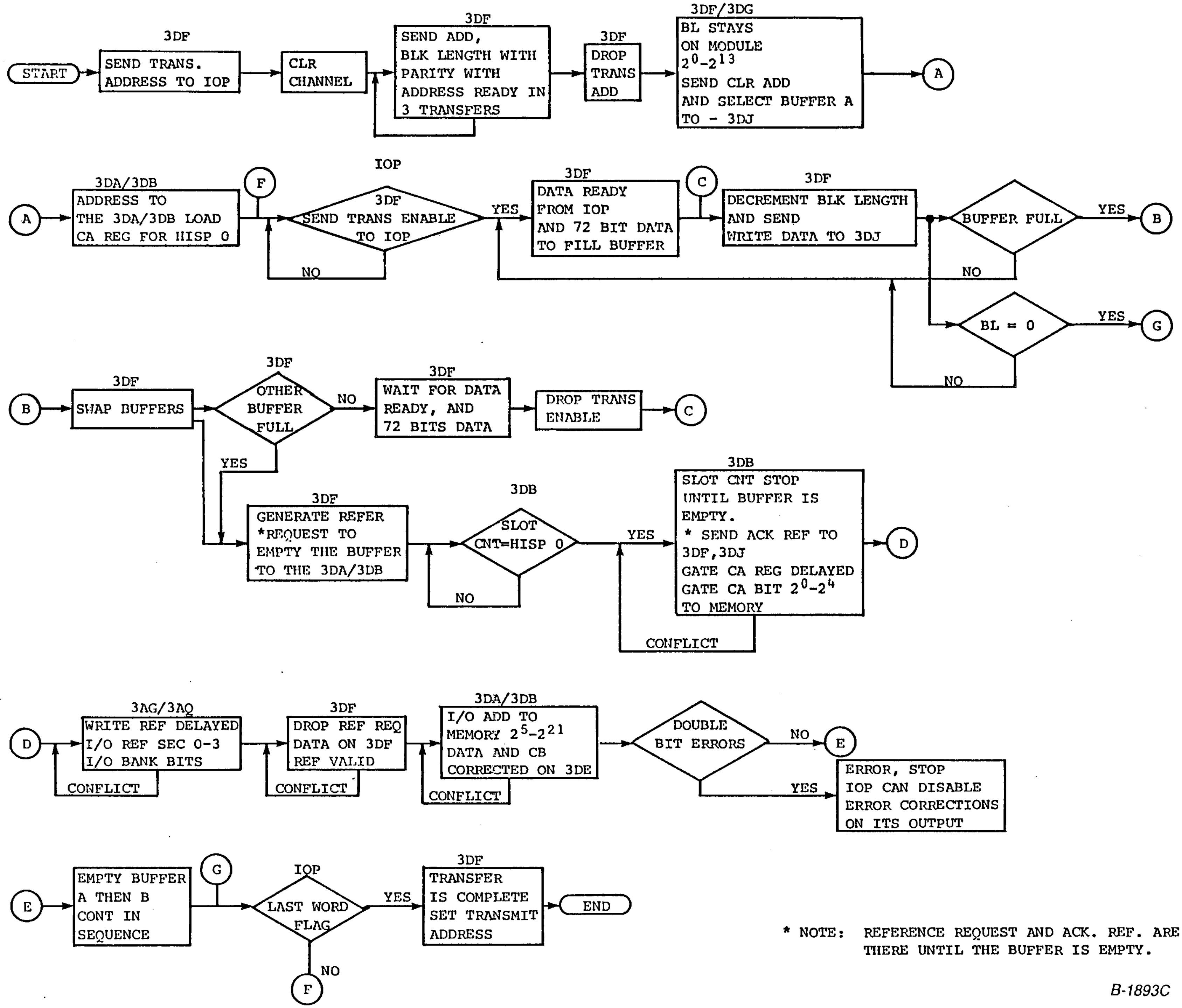


CRAY X-MP HISP CHANNEL INPUT/DATA



NOTE: If the CRAY X-MP had the option of four HISP and no VHISP, a 3DG module would be installed at location T04/05. The 3DG would replace the 3DI at location T04/05.

CRAY X-MP HISP INPUT CHANNEL



X-MP/2 FLOW CHART HISP 0 INPUT OPERATION

LOAD BUFFER A

$\overline{J01} = \overline{I98}$ SELECT BUFFER A INPUT

```
12/13   K04 = J1 I100     WRITE INTO BUFFER A
16/0    A04 = K04;T2
```

I92 = ACKN. REFERENCE FROM 3DB

```
BOOLEAN        K00 = J1' J0' I92  +  A4
```

K00 = INCREMENT 16 x4 ADDRESS WHEN WRITING INTO THE BUFFERS. OR INCREMENT THE ADDRESS WHEN READING THE BUFFERS.

```
T95 = T94 A4
T16 = T95
```

```
BOOLEAN        M00 = L00: DCD (A3' A2' A1' A0')/#  +  T16
                          ⇩
               M35 = L35: DCD (A3 A2 A1 A0)/#  +  T16
```

BUFFER FALL

```
BOOLEAN   R36' = E4' A0' E14' B0' Ø # J1' ## J1 J1; T2

          R36' = B0' J1'  +  E14' J1'  +  A0' J1  +  E4' J1; T2
```

R36 = BUFFER ADDRESS HAS REACHED THE LIMIT.
THEREFORE A BUFFER IS FULL.

A-1876

ACKNOWLEDGE REFERENCE

I92 = ACKNOWLEDGE REFERENCE HISP Ø

J00 - I06   CONFLICT
J01 = SELECT BUFFER

```
BOOLEAN    K00 = J1' J0' I92  +  A4

           P00 = I92 Z20'
```

K00 - INCREMENT ADDRESS TO READ BUFFER A
P00 = I92 $\overline{Z20}$ SELECT HISP Ø DATA

```
BOOLEAN  Q00 = M00 P0 + N00 P01 + M40 P2 + N40 P3 + O00 P4 + O40 P5

         Q35 = M34 P8 + N35 P9 + M75 P10 + N75 P11
```

Q00-Q35 - SELECT ONE OF THE HISP CHANNELS OR LOSP CHANNELS.
AND SEND THIS BUFFER OF DATA TO MEMORY

A-1876

TRANSMIT ENABLE

```
BOOLEAN   R28' = X1' Y8'  +  X10'; T2

          J00 = R28 R32' H2
```

J00 = MAKE HISP Ø ACTIVE IF NO ADDRESS ERRORS
AND CABLE IS CONNECTED

R22 = J0 SEND TRANSMIT ENABLE ON TRANSMIT DATA
TO IOP

TRANSMIT ENABLE, ENABLES A 16 WORD TRANSFER
TO FILL BUFFER A OR B.

R16 = J0 SELECT BUFFER A

DATA READY FROM IOP

X20 = I6 = DATA READY

```
BOOLEAN   Y21' = Y22 X20'

          Y22' = Y21 W5'
```

Y21, Y22 LATCH DATA READY

DATA READY RESYNC.

$\overline{Z20} = \overline{Y21}$; T5
$\overline{Z21} = \overline{Y21}$; T6
$\overline{Z22} = \overline{Y21}$; T7
$\overline{Z23} = \overline{Y21}$; T8

WRITE DATA/CLEAR ADD

R17 = Z20 Z21 Z22 Z23 WRITE DATA TO 3DJ

R23 = K5; T2 WHEN CHANNEL ACTIVE CLEAR THE
ADDRESS ON 3DJ

A-1877A

BUFFER FULL

J06 = CHANNEL ACTIVE, READY, NO ERROR
I11 = BUFFER FULL

```
BOOLEAN   L01 = L01 K2' Z29'  +  J6 I11  +  J6 X23; T2

          K02 = L1 H1 H0
```

L01 = BUFFER FULL, CHANNEL IS ACTIVE AND NO ERRORS

K02 = IF BUFFER A IS FULL SWAP TO BUFFER B AND BEGIN TO FILL BUFFER B.

REFERENCE HISP 0

L02 = K02 $\overline{\text{Z29}}$; T2

```
BOOLEAN   R15 = R15 L05'  +  L02; T2
```

R15 = SEND A REFERENCE TO 3DB WHEN BUFFER IS FULL. HOLD THE REFERENCE UNTIL WE GET AN ACK BACK FROM 3DB. ACKNOWLEDGE REF. IS ALSO SENT TO THE 3DJ TO BEGIN GATING THE DATA TO MEMORY. ACKNOWLEDGE WILL CAUSE THE REFERENCE TO DROP.

A-1877

I12 = ACKNOWLEDGE REFERENCE HISP Ø
I3 = CONFLICT

BOOLEAN L05 = I12 I3' + L5 I3; T2 ACK + 0
L06 = L05 I3' + L6 I3; T2 ACK + 1
L07 = 106 I3' + L7 I9; T2 ACK + 2

L05-L07 = DELAY ACKNOWLEDGE REFERENCE FOR 3 CPS IF THERE IS A CONFLICT WAIT UNTIL THE CONFLICT GOES AWAY. ALSO ALLOW DOUBLE BIT ERROR AT L7 TIME OR ACK + 2

BOOLEAN H01 = R15' L5' L6' L7' L2'

H01 = NO REFERENCE

J05 = $\overline{H1}$ W5 REFERENCE AND DATA READY

BOOLEAN R22 = R22 $\overline{J5}$ H0 + H0 H1 + J0; T2

R22 = SEND TRANSMIT ENABLE IF NO ERRORS AND CHANNEL ACTIVE. DROP TRANSMIT ENABLE IF THERE IS NO REFERENCE.

<u>LAST WORD FLAG</u>

X23 = I7 LAST WORD FLAG
J06 = H0 W5 READY + ACTIVE + NO ERROR

BOOLEAN L03 = J6 X23 + L3 $\overline{J0}$; T2

A-1877

L03 = LAST WORD FLAG

BLOCK LENGTH = Ø AND DROP ACTIVE

J04 - F2 F3 F4 BL = Ø
J02 = L3 $\overline{\text{L1}}$ H1 LWF AND NOT FULL + NO REFER.

BOOLEAN K00 = J0 + L0 $\overline{\text{J2}}$

L00 = K00 Z29'; T2

K00 = DROP ACTIVE WHEN LWF BUFFERS ARE NOT FULL AND THERE IS NO REFERENCE.

UNCORRECTABLE ERROR

L8 = J6; T2 READY + 1
I13 = DOUBLE BIT ERROR
L7 = ACK + 2 TIME

BOOLEAN K03 = L8 L3 J4' + L8 L3' J4 + L7 I13

K03 = UNCORRECTABLE ERROR CAN BE MADE FROM BL ≠ 0 AND CHANNEL NOT ACTIVE OR BL = Ø AND NO LWF OR DOUBLE BIT ERROR AT ACK + 2 TIME.

A-1877

INSTRUCTION SEQUENCE TO START AN OPERATION IS DEFINED WITH (AJ) = 7.

0012JØ	CI, AJ	CLEAR INTERRUPT
0010JK	CA, AJ AK	(AK) = SSD STARTING BLOCK ADDRESS
0010JK	CA, AJ AK	(AK) = X-MP MEMORY ADDRESS
0011JK	CL, AJ AK	(AK) = TRANSFER BLOCK LENGTH READ/WRITE MODE: TRANSFER INITIATED
------------------------------		WAIT FOR INTERRUPT ON (CHANNEL #7)
033I00		READ CHANNEL NUMBER TO AI
033IJ1	AI CE, AJ	READ ERROR FLAGS
0012JO	CI, AJ	CLEAR INTERRUPT/CLEAR INTERFACE

NOTES:

SSD STARTING BLOCK ADDRESS - ALL TRANSFERS TO OR FROM THE SSD MUST BE IN BLOCKS OF 64 WORDS.

X-MP MEMORY ADDRESS - ADDRESS USED TO TRANSFER INFORMATION INTO X-MP MEMORY.

BLOCK LENGTH - BLOCK LENGTH PERTAINS TO THE NUMBER OF 64_{10} WORD BLOCK TO BE TRANSFERRED. THE MAXIMUM BLOCK LENGTH IS 777777_8. IF AK REGISTER BIT 2^{23} IS CLEARED READ OPERATION (SSD TO X-MP MEMORY). IF 2^{23} IS SET IT'S A WRITE OPERATION (X-MP MEMORY TO SSD).

3DI MODULE @ T04/05

BLOCK COUNT REGISTER

BIT		T.P.	TERM
2^0	___	$\overline{C01}$	N00
2^1	___	$\overline{C03}$	N01
2^2	___	$\overline{C02}$	N02
2^3	___	$\overline{C04}$	N03
2^4	___	$\overline{C12}$	N04
2^5	___	$\overline{C13}$	N05
2^6	___	$\overline{C21}$	N06
2^7	___	$\overline{C23}$	N07
2^8	___	$\overline{C22}$	N08
2^9	___	$\overline{C24}$	N09
2^{10}	___	$\overline{C33}$	N10
2^{11}	___	$\overline{C34}$	N11
2^{12}	___	$\overline{C54}$	N12
2^{13}	___	$\overline{C53}$	N13
2^{14}	___	$\overline{C70}$	N14
2^{15}	___	$\overline{C71}$	N15
2^{16}	___	$\overline{C67}$	N16
2^{17}	___	$\overline{C68}$	N17
2^{23}	___	A70	R20

SSD BLOCK ADDRESS

BIT		T.P.	TERM
2^0	___	D66	$\overline{R40}$
2^1	___	$\overline{D61}$	$\overline{R41}$
2^2	___	D64	$\overline{R42}$
2^3	___	$\overline{D65}$	$\overline{R43}$
2^4	___	D55	$\overline{R44}$
2^5	___	$\overline{D59}$	$\overline{R45}$
2^6	___	D57	$\overline{R46}$
2^7	___	$\overline{D60}$	$\overline{R47}$
2^8	___	D24	$\overline{R48}$
2^9	___	$\overline{D38}$	$\overline{R49}$
2^{10}	___	D47	$\overline{R50}$
2^{11}	___	$\overline{D45}$	$\overline{R51}$
2^{12}	___	D22	$\overline{R52}$
2^{13}	___	$\overline{D27}$	$\overline{R53}$
2^{14}	___	D34	$\overline{R54}$
2^{15}	___	$\overline{D25}$	$\overline{R55}$
2^{16}	___	D01	$\overline{R56}$
2^{17}	___	$\overline{D03}$	$\overline{R57}$
2^{18}	___	D31	$\overline{R58}$
2^{19}	___	$\overline{D13}$	$\overline{R59}$
2^{20}	___	D20	$\overline{R60}$
2^{21}	___	D17	$\overline{R120}$
2^{22}	___	C72	$\overline{R121}$
2^{23}	___	D68	$\overline{R122}$

3DX MODULE @ AA07

BLOCK COUNT REGISTER

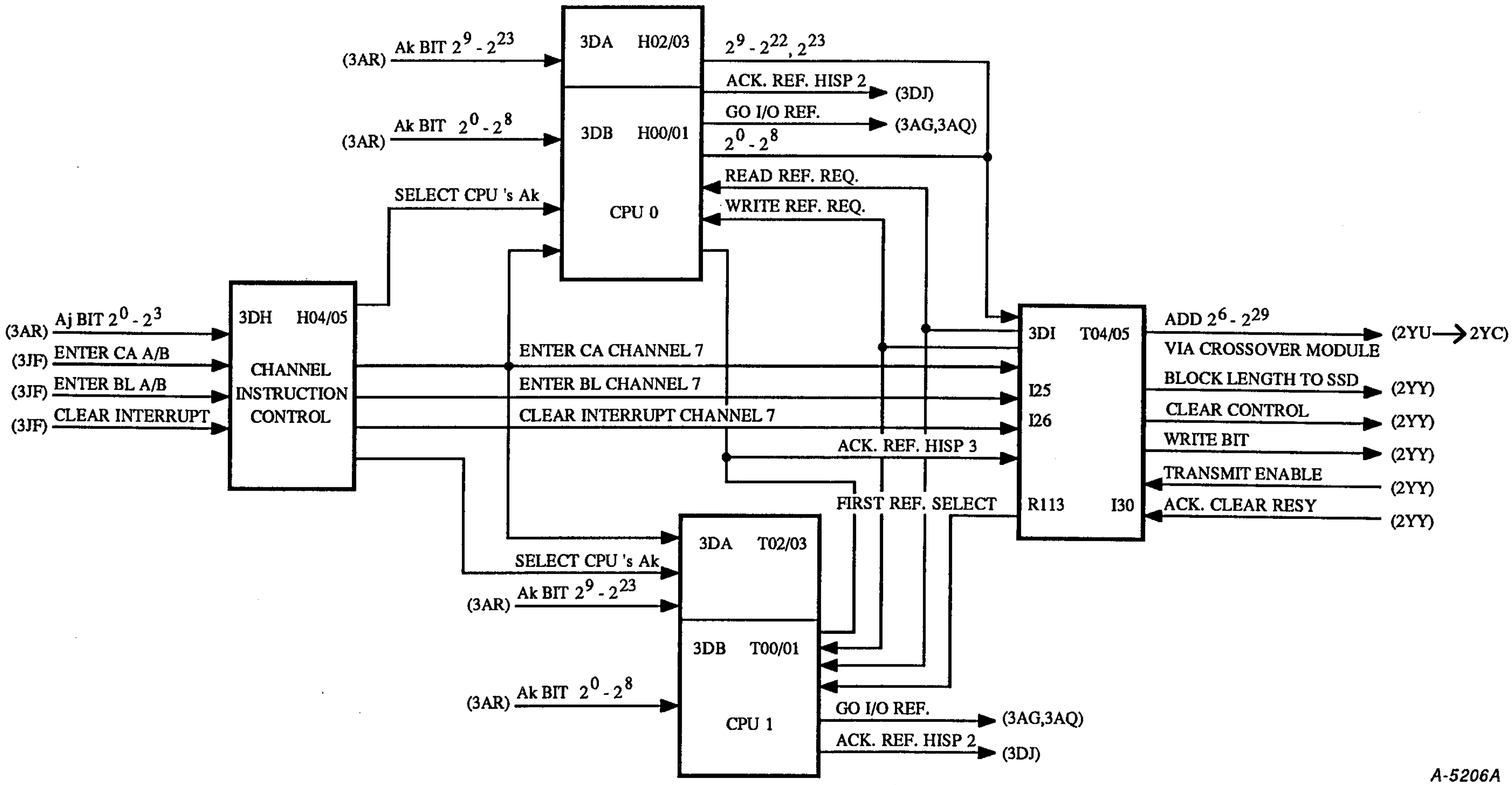
BIT		T.P.	TERM
2^0	___	A48	E40
2^1	___	A54	E41
2^2	___	A55	E42
2^3	___	A57	E43
2^4	___	A52	E44
2^5	___	A58	E45
2^6	___	A67	E46
2^7	___	A63	E47
2^8	___	A72	E48
2^9	___	B31	E49
2^{10}	___	B29	E50
2^{11}	___	B06	E51
2^{12}	___	B23	E52
2^{13}	___	B36	E53
2^{14}	___	B34	E54
2^{15}	___	B28	E55
2^{16}	___	B30	E56
2^{17}	___	B32	E57
2^{23}	___	$\overline{A61}$	E04

		T.P.	Term	Description
______	2^0	C01	N00	Block length bit 2^0
______	2^1	C03	N01	Block length bit 2^1
______	2^2	C02	N02	Block length bit 2^2
______	2^3	C04	N03	Block length bit 2^3
______	2^4	C12	N04	Block length bit 2^4
______	2^5	C13	N05	Block length bit 2^5
______	2^6	C21	N06	Block length bit 2^6
______	2^7	C23	N07	Block length bit 2^7
______	2^8	C22	N08	Block length bit 2^8
______	2^9	C24	N09	Block length bit 2^9
______	2^{10}	C33	N10	Block length bit 2^{10}
______	2^{11}	C34	N11	Block length bit 2^{11}
______	2^{12}	C54	N12	Block length bit 2^{12}
______	2^{13}	C53	N13	Block length bit 2^{13}
______	2^{14}	C70	N14	Block length bit 2^{14}
______	2^{15}	C71	N15	Block length bit 2^{15}
______	2^{16}	C67	N16	Block length bit 2^{16}
______	2^{17}	C68	N17	Block length bit 2^{17}
______	2^{18}	A04	M02	Req. in progress
______	2^{19}	D68	M25	SSD single bit error
______	2^{20}	D30	M12	Block length error
______	2^{21}	D46	M23	SSD double bit error
______	2^{22}	D50	M28	CPU double bit error
______	2^{23}	D29	M13	Fatal error

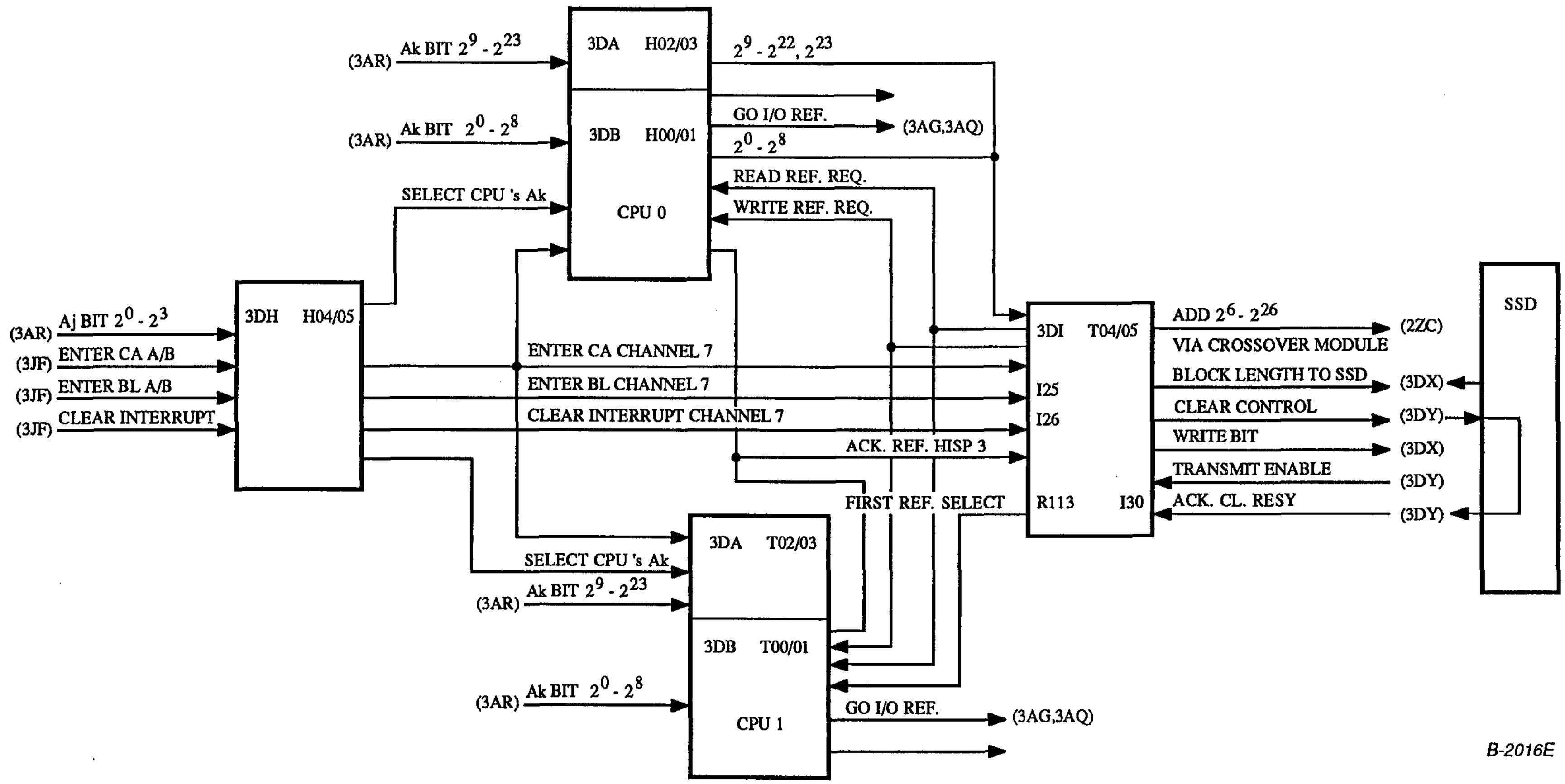
* Also loaded into Ai register from 003ij1 instruction. Aj equals a 7.

CRAY X-MP/2 SSD STATUS WORD

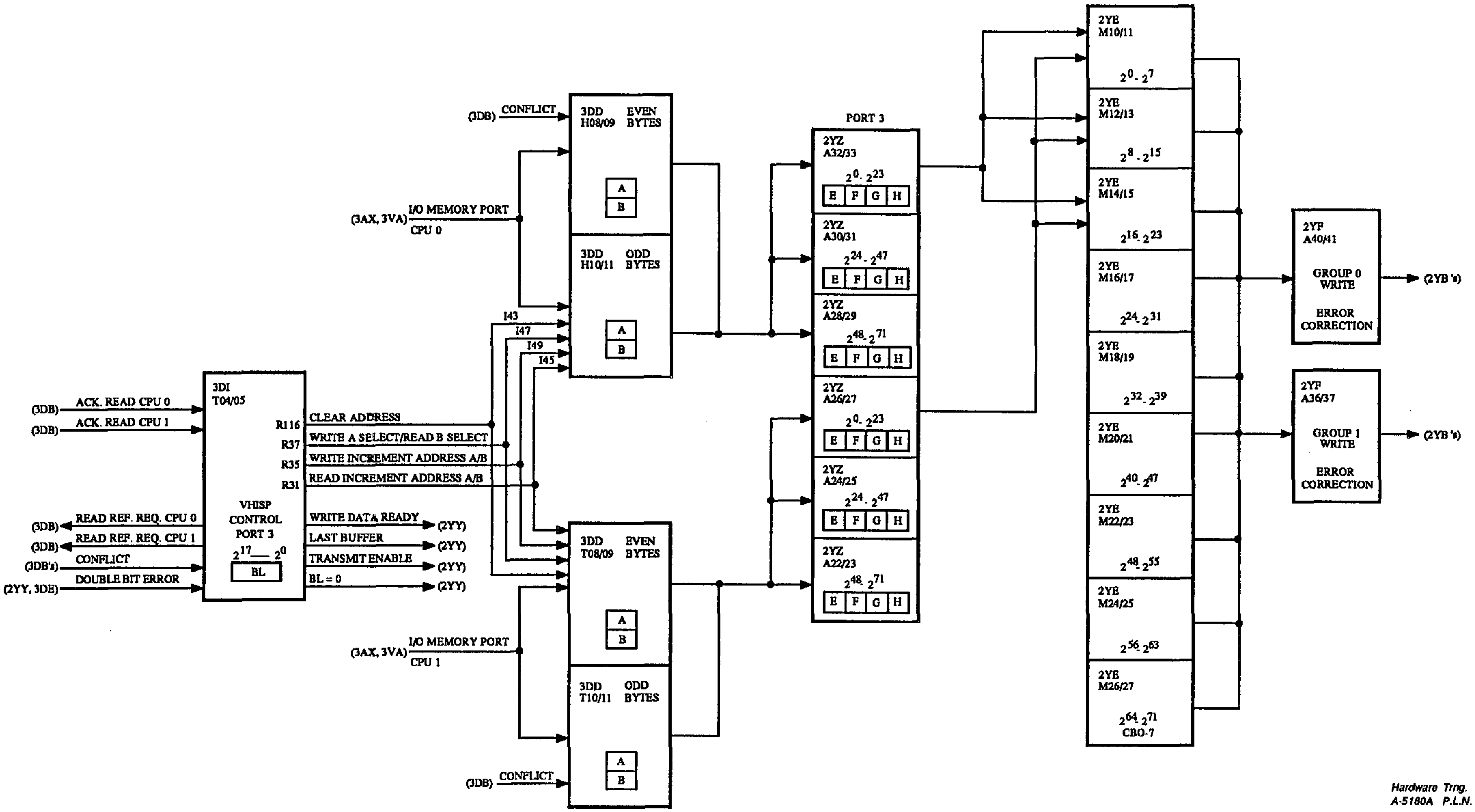
X2002L0502



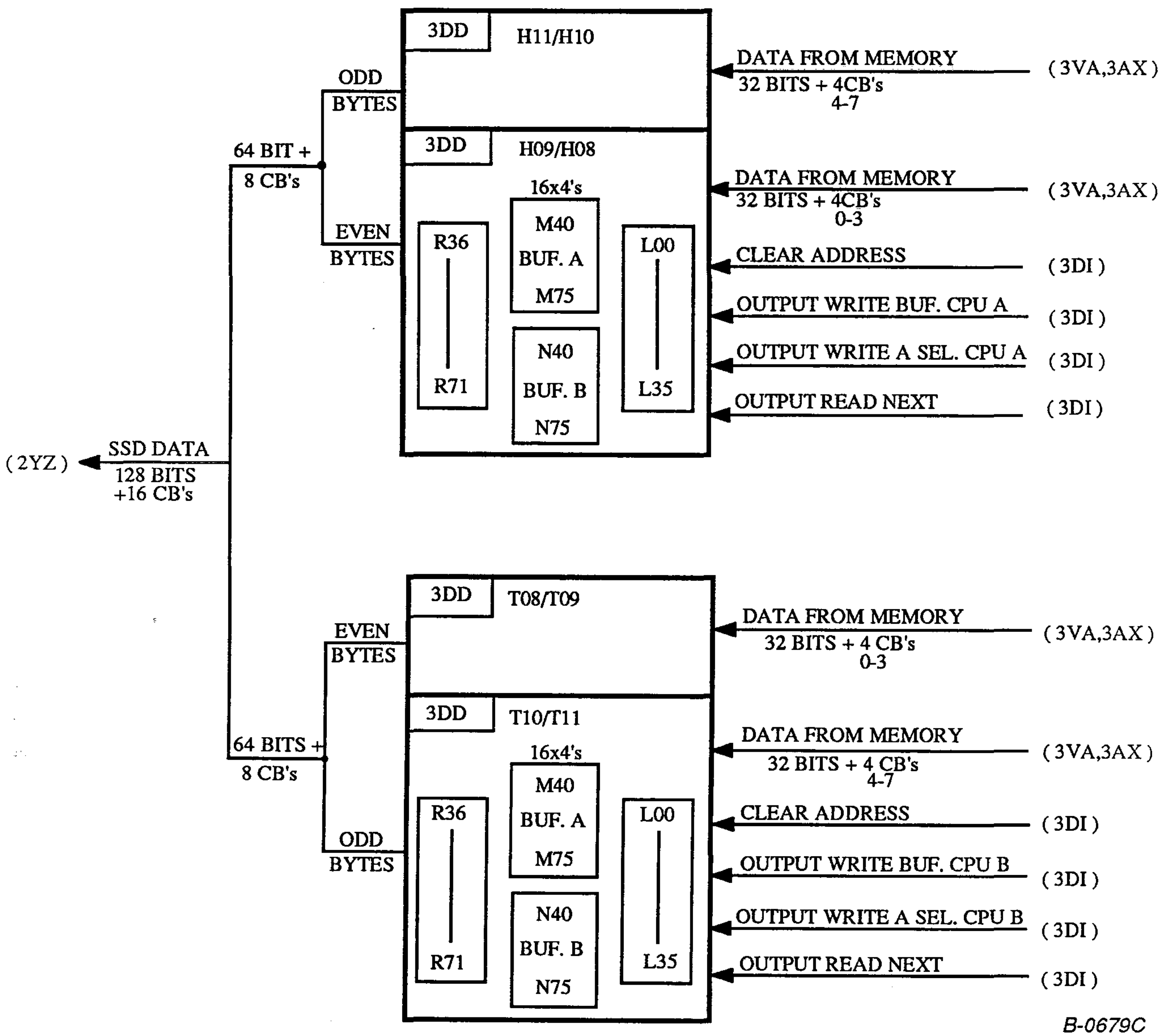
VHISP READ/WRITE ADDRESS PATH
MODEL "C" SSD



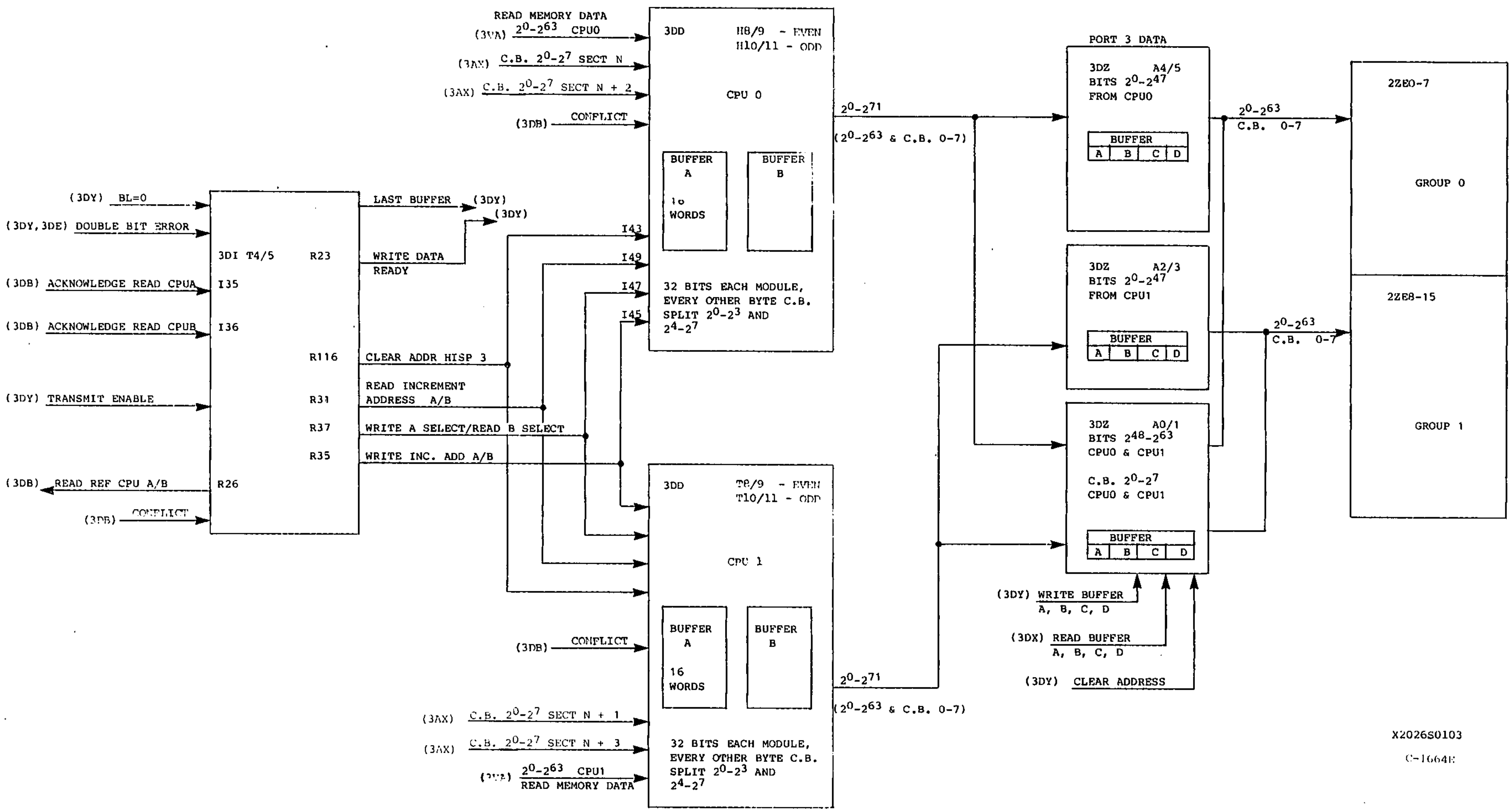
VHISP READ/WRITE ADDRESS PATH
MODEL B

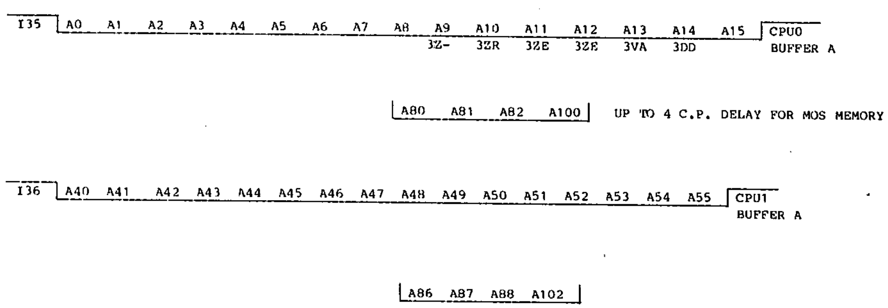


X-MP/2 VHISP WRITE DATA PATH
MODEL "C"



CRAY X-MP VHISP CHANNEL OUTPUT DATA
(MODEL C SSD)





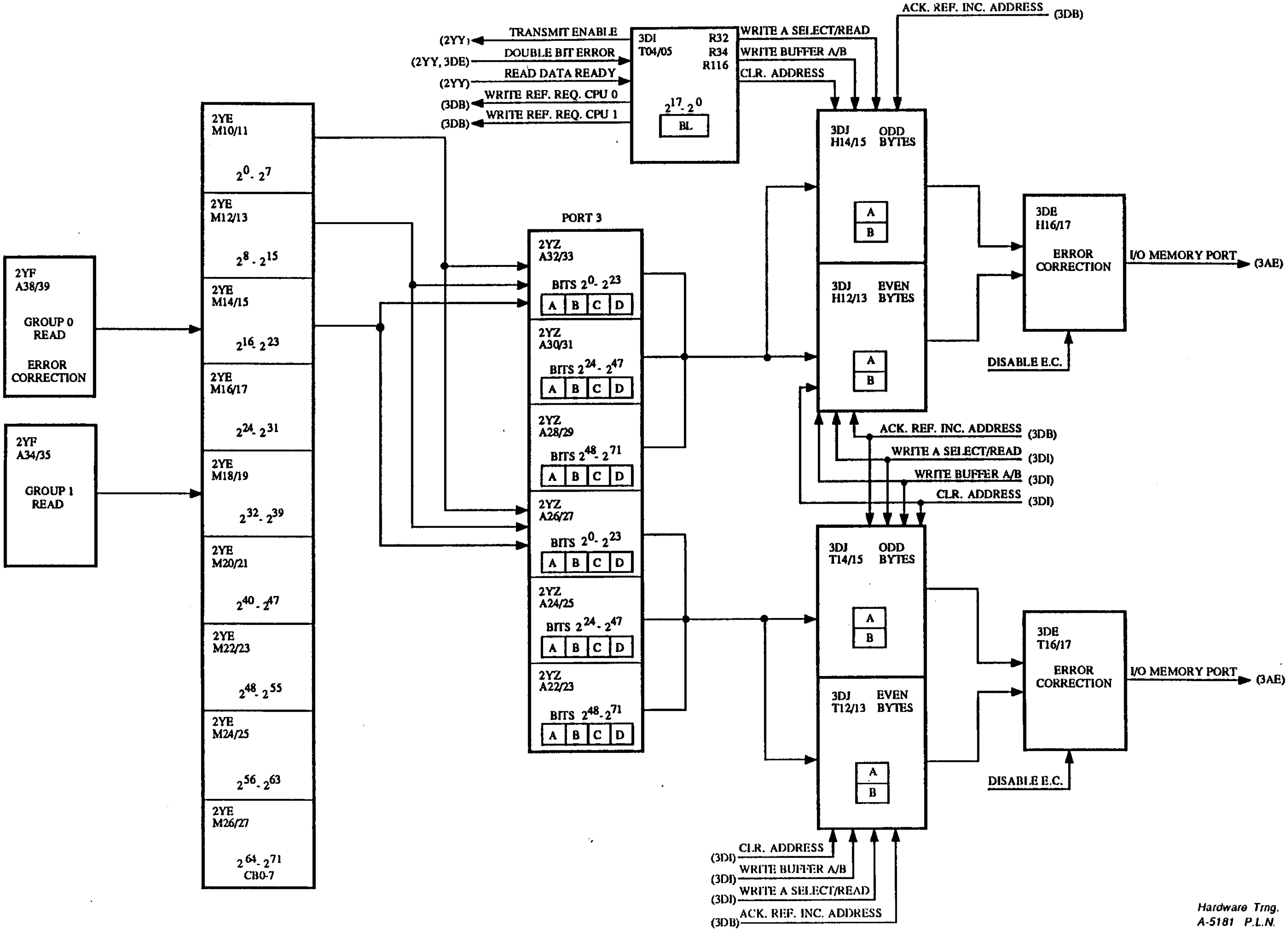
3DI

R116 - CLEAR ADDER HISP 3 - WHEN SET ACTIVE AFTER ACKNOWLEDGE CLEAR
R31 - INCREMENT ADDRESS - GO DATA READY OR WORD COUNT = 17
R37 - WRITE A SELECT HISP 3 - CPU0 SELECT BUFFER A
R35 - WRITE BUFFER HISP 3 - NEXT CLOCK PERIOD DATA ON 3DD MODULE
R23 - ONE WRITE DATA READY PER 16 - 144 BIT TRANSFER PRECEDES THE DATA BY 2 CP'S

3DD

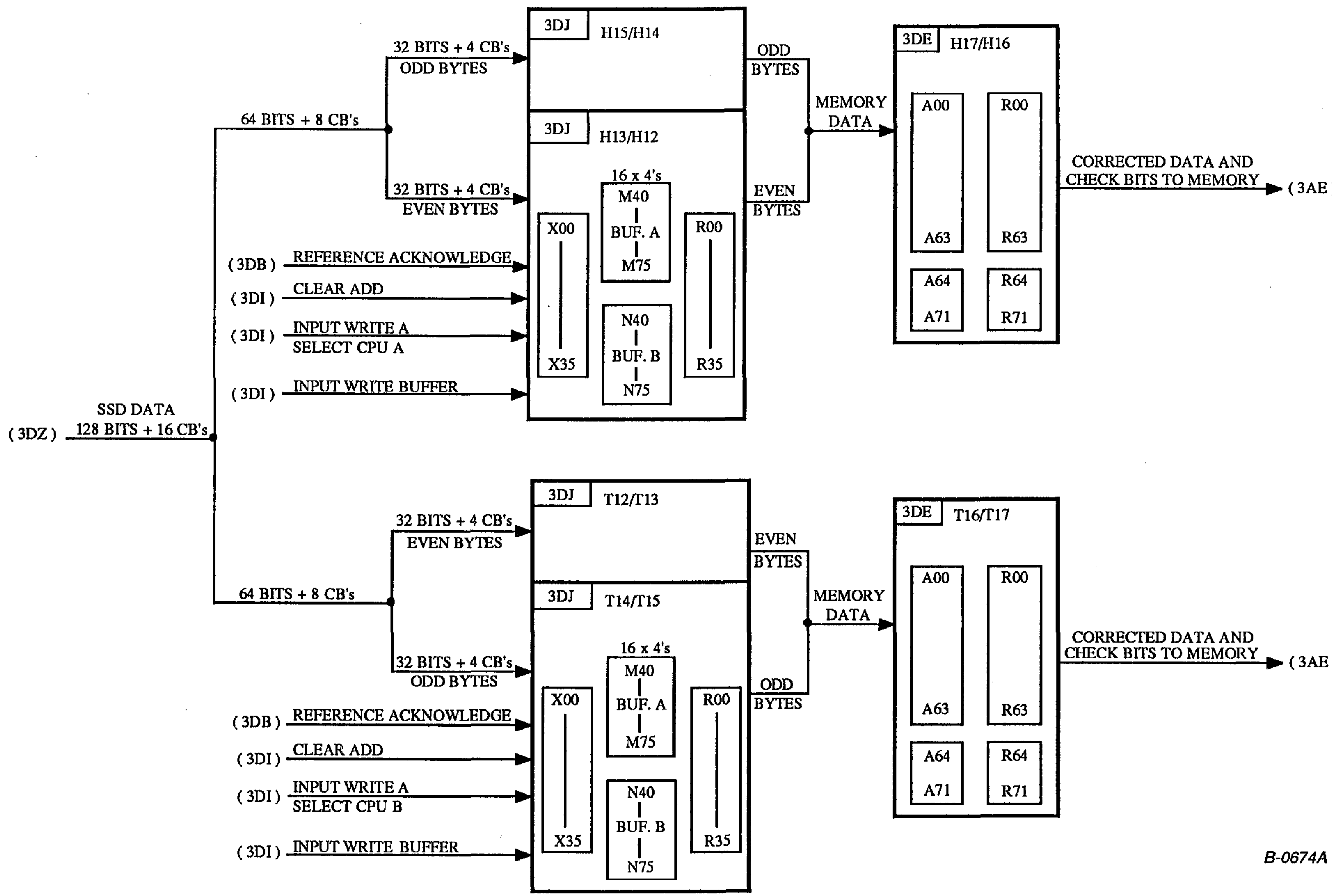
I43 - CLEARS BUFFER A AND BUFFER B COUNTERS FOR HISP 3
I49 - ALLOWS C OR D TERMS (COUNTERS FOR BUFFER A AND B) TO BE ADVANCED
I47 - SELECTS HISP 3 BUFFER A
I45 - MAKES WRITE ENABLE FOR BUFFER A OR BUFFER B; THE ABSENT OF WRITE ENABLE MEANS THE 16x4 ARE BEING READ TO THE SSD

VHISP WRITE TO SSD PATH
'MODEL B'

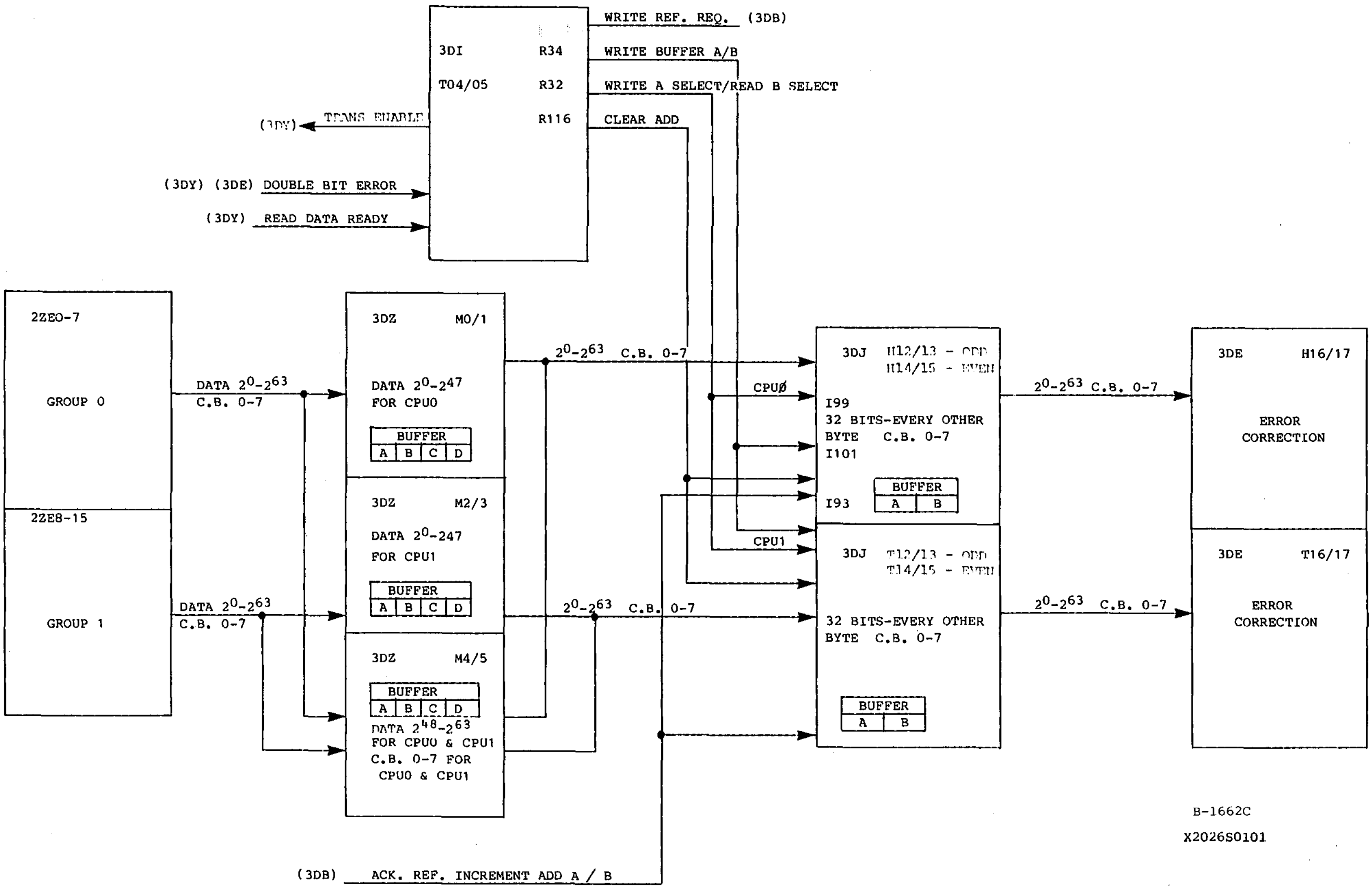


Hardware Trng.
A-5181 P.L.N.

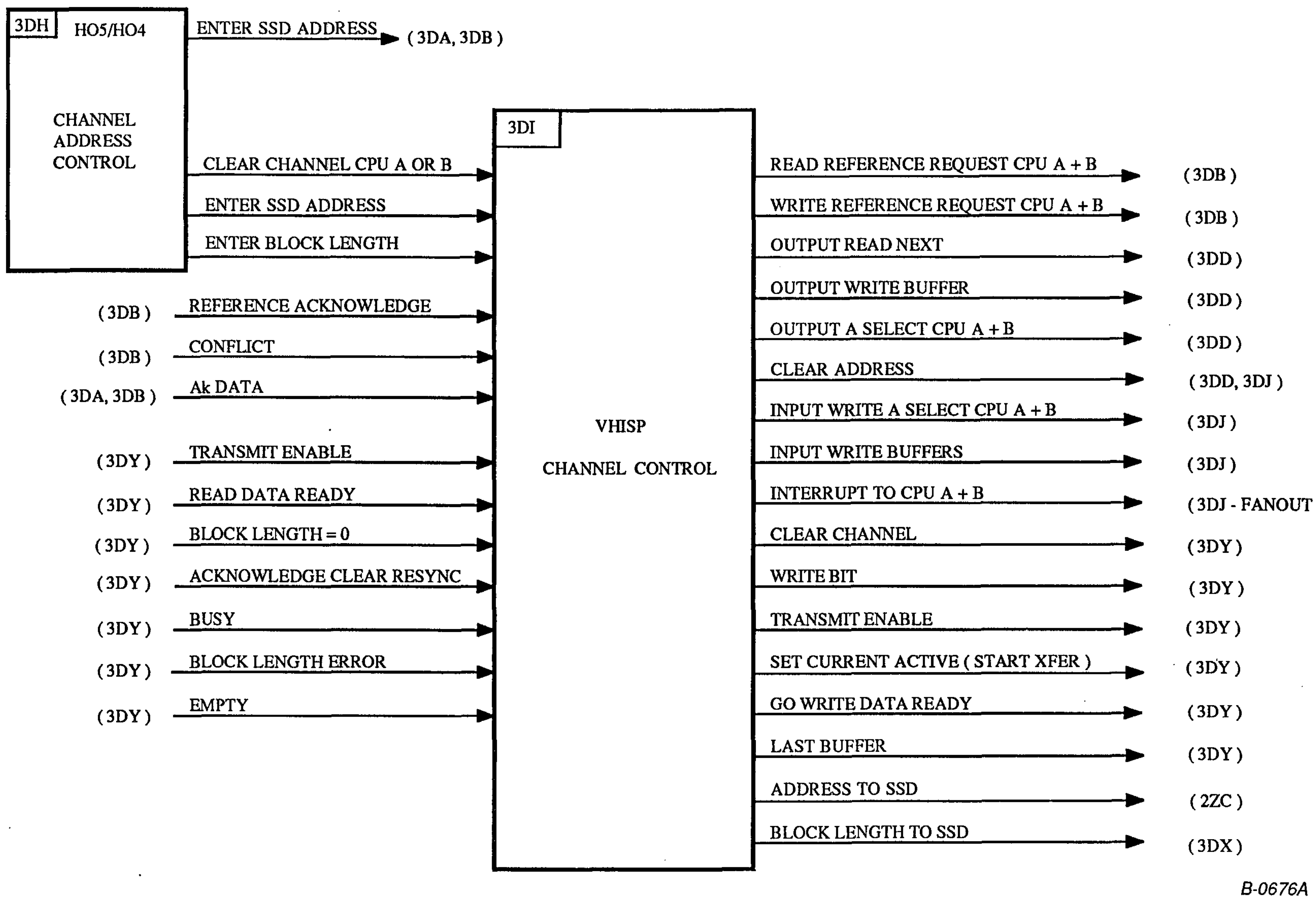
X-MP/2 VHISP READ DATA PATH
MODEL "C"



CRAY X-MP VHISP CHANNEL INPUT DATA
MODEL C



READ FROM SSD DATA PATH
"MODEL B'



CRAY X-MP VHISP CHANNEL CONTROL
MODEL C

X-MP 16x4 MODULE LOCATOR

																			HISP A,7 INPUT	HISP B,7 INPUT
	DATA 0-3		4-7		16-19		20-23		32-35		36-39		48-51		52-55		CB 0-3		3DJ H12/13,	T12/13
	BITS 8-11		12-15		24-27		28-31		40-43		44-47		56-59		60-63		CB 4-7		3DJ H14/15,	T14/15
	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.		
3DJ	M00-03	BTK	M04-07	BUK	M08-11	AHB	M12-15	AIB	M16-19	DTI	M20-23	DUI	M24-27	CHD	M28-31	CID	M32-35	AJB	HISP BUFFER A	
	N00-03	BTI	N04-07	BUI	N08-11	AHD	N12-15	AID	N16-19	DTK	N20-23	DUK	N24-27	CHB	N28-31	CIB	N32-35	DVK	HISP BUFFER B	
	M40-43	BTB	M44-47	BUB	M48-51	AHK	M52-55	AIK	M56-59	DTD	M60-63	DUD	M64-67	CHI	M68-71	CII	M72-75	AJK	VHISP BUFFER A	
	N40-43	BTD	N44-47	BUD	N48-51	AHI	N52-55	AII	N56-59	DTB	N60-63	DUB	N64-67	CHK	N68-71	CIK	N72-75	DVB	VHISP BUFFER B	

																			HISP A,7 OUTPUT	HISP B,7 OUTPUT
	DATA 0-3		4-7		16-19		20-23		32-35		36-39		48-51		52-55		CB 0-3		3DD H08/09,	T08/09
	BITS 8-11		12-15		24-27		28-31		40-43		44-47		56-59		60-63		CB 4-7		3DD H10/11,	T10/11
	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.	TERM	LOC.		
3DD	M0-03	BQA	M04-07	BQB	M08-11	BQC	M12-15	DQA	M16-19	DQB	M20-23	DQC	M24-27	CEJ	M28-31	CEK	M32-35	CEL	HISP BUFFER A	
	N0-03	BTA	N04-07	BTB	N08-11	BTC	N12-15	DTA	N16-19	DTB	N20-23	DTC	N24-27	CHJ	N28-31	CHK	N32-35	CHL	HISP BUFFER B	
	M40-43	BQJ	M44-47	BQK	M48-51	BQL	M52-55	DQJ	M56-59	DQK	M60-63	DQL	M64-67	CEA	M68-71	CEB	M72-75	CEC	VHISP BUFFER A	
	N40-43	BTJ	N44-47	BTK	N48-51	BTL	N52-55	DTJ	N56-59	DTK	N60-63	DTL	N64-67	CHA	N68-71	CHB	N72-75	CHC	VHISP BUFFER B	

X2027C0101

NOTE: Odd or even words are the results of the number of words transferred.

Port 3

2YZ @ A32/33 Handles the even Cray words bits 2^0-2^{23}
2YZ @ A30/31 Handles the even Cray words bits 2^{24}-2^{47}
2YZ @ A28/29 Handles the even Cray words bits 2^{48}-2^{71}

2YZ @ A26/27 Handles the odd Cray words bits 2^0-2^{23}
2YZ @ A24/25 Handles the odd Cray words bits 2^{24}-2^{47}
2YZ @ A22/23 Handles the odd Cray words bits 2^{48}-2^{71}

Failing addrs. equals current addrs. minus starting addrs.

Failing addrs.:
2^6 2^5 = 00 Buffer A/E
2^6 2^5 = 01 Buffer B/F
2^6 2^5 = 10 Buffer C/G
2^6 2^5 = 11 Buffer D/H

Port 4

2YZ @ A12/13 Handles the even Cray words bits 2^0-2^{23}
2YZ @ A10/11 Handles the even Cray words bits 2^{24}-2^{47}
2YZ @ A08/09 Handles the even Cray words bits 2^{48}-2^{71}

2YZ @ A06/07 Handles the odd Cray words bits 2^0-2^{23}
2YZ @ A04/05 Handles the odd Cray words bits 2^{24}-2^{47}
2YZ @ A02/03 Handles the odd Cray words bits 2^{48}-2^{71}

Data	0 - 3 24 - 27 48 - 51		4 - 7 28 - 31 52 - 55		8 - 11 32 - 35 56 - 59		12 - 15 36 - 39 60 - 63		16 - 19 40 - 43 64 - 67		20 - 23 44 - 47 68 - 71	
Port 3 or Port 4 Read from SSD	TERM	LOC	TERM	LOC	TERM	LOC	TERM	LOC	TERM	LOC	TERM	LOC
Buffer A	J00-03	BRI	J04/07	BRK	J08-11	AFC	J12-15	BRC	J16-19	AFI	J20-23	AFK
Buffer B	K00-03	BSI	K04-07	BSK	K08-11	AGC	K12-15	BSC	K16-19	AGI	K20-23	AGK
Buffer C	L00-03	BTI	L04-07	BTK	L08-11	AHC	L12-15	BTC	L16-19	AHI	L20-23	AHK
Buffer D	M00-03	BUI	M04-07	BUK	M08-11	AIC	M12-15	BUC	M16-19	AII	M20-23	AIK

Port 3 or Port 4 Write to SSD	TERM	LOC	TERM	LOC	TERM	LOC	TERM	LOC	TERM	LOC	TERM	LOC
Buffer E	N00-03	DRI	N04-07	DRK	N08-11	CFC	N12-15	DRC	N16-19	CFI	N20-23	CFK
Buffer F	O00-03	DSI	O04-07	DSK	O08-11	CG	O12-15	DSC	O16-19	CGI	O20-23	CGK
Buffer G	P00-03	DTI	P04-07	DTK	P08-11	CH	P12-15	DTC	P16-19	CHI	P20-23	CHK
Buffer H	Q00-03	DUI	Q04-07	DUK	Q08-11	CI	Q12-15	DUC	Q16-19	CII	Q20-23	CIK

X2002L0501

16X4 VHISP MODULE LOCATOR
ON SSD "MODEL C"

16x4 VERY HIGH SPEED MODULE LOCATOR

WRITE TO SSD

3DZ @ AA 4/5 handles the EVEN Cray Words to the SSD bits 0-47.
3DZ @ AA 2/3 handles the ODD Cray Words to the SSD bits 0-47.
3DZ @ AA 0/1 handles the EVEN and ODD Words to the SSD bits 48-63 and CB 0-7. (R0-R23 on 3DZ is EVEN R24-47 is ODD).

READ FROM SSD

3DZ @ MM 0/1 handles the EVEN Cray Words from the SSD bits 0-47.
3DZ @ MM 2/3 handles the ODD Cray Words from the SSD bits 0-47.
3DZ @ MM 4/5 handles the EVEN and ODD Words from the SSD bits 48-63 and CB 0-7. (R0-R23 on 3DZ is EVEN, R24-47 is ODD).

	DATA	0-3	4-7	8-11	12-15	16-19	20-23	24-27	28-31	32-35	36-39	40-43	44-47
		EVEN						ODD					
	BITS	48-51	52-55	56-59	60-63	CB0-3	CB4-7	48-51	52-55	56-59	60-63	CB0-3	CB4-7
		TERM LOC.	TERM LOC.	TERM LOC.	TERM LOC.	TERM LOC.	TERM LOC.	TERM LOC.	TERM LOC.	TERM LOC.	TERM LOC.	TERM LOC.	TERM LOC.
3 D Z	BUFFER A	M0-08 AFC	M04-07 BRI	M08-11 BRC	M12-15 AFK	M16-19 BRK	M20-23 DRK	M24-27 AFI	M28-31 CFC	M32-35 DRI	M36-39 DRC	M40-43 CFI	M44-47 CFK
	BUFFER B	N0-03 AGC	N4-7 BSI	N8-11 BSC	N12-15 AGK	N16-19 BSK	N20-23 DSK	N24-27 AGI	N28-31 CGC	N32-35 DSI	N36-39 DSC	N40-43 CGI	N44-47 CGK
	BUFFER C	P0-03 AHC	P4-7 BTI	P8-11 BTC	P12-15 AHK	P16-19 BTK	P20-23 DTK	P24-27 AHI	P28-31 CHC	P32-35 DTI	P36-39 DTC	P40-43 CHI	P44-47 CHK
	BUFFER D	Q0-03 AIC	Q4-7 BUI	Q8-11 BUC	Q12-15 AIK	Q16-19 BUK	Q20-23 DUK	Q24-27 AII	Q28-31 CIC	Q32-35 DUI	Q36-39 DUC	Q40-43 CII	Q44-47 CIK

B-2017A

NOTE; ODD OR EVEN WORDS ARE THE RESULT OF THE NUMBER OF WORDS TRANSFERED.

X2027C0103

16X4 VERY HIGH SPEED MODULE LOCATOR

PORT 3 GENERAL DESCRIPTION

Port 3 of the SSD is the interface between SSD Memory and the CRAY X-MP. The port is capable of maintaining transfer speed of 2-64 Bit words every 9.5 N sec. clock period.

Port 3 is utilized when accessing the SSD from a X-MP/22, 24 or from CPU 0/1 of a X-MP/48. Port 4 is used when accessing the SSD from CPU 2/3 of a X-MP/48.

The port is given a starting SSD Address and a starting Block Length. The Block length relates to the number of 64-64Bit words to be transferred. The transfer may only be active in one direction at a time.

There are 2 module types which make up Port 3. They are the 2YY and the 2YZ modules. One (1) 2YY module is used and is defined as Port Control. Six (6) 2YZ modules are Buffer modules, used for data transfer to and from the X-MP and the SSD. Each 2YZ module contains 4 input and 4 output Buffers. Each Buffer is 16 words in length.

Both the 2YY and the 2YZ modules need the CPU and SSD clock rates of 9.5 N sec.

SIGNAL DEFINITIONS

CRAY X-MP to Port 3

Block length - (2^0-2^{17}) Supplies Port 3 with the initial number of 64-64 Bit word blocks of data for a Read or Write transfer.

Last Buffer Write - Informs Port 3 that this is the last buffer to be transferred.

Write Data Ready - A one clock period pulse sent when a buffer of data is to be transferred. One Signal per 16-144 Bit words transferred. Precedes data by two clock periods.

Transmit Enable - Informs Port 3 that the X-MP Buffers are ready, and the port can transfer at least one buffers worth of data to the CRAY X-MP.

Port 3 Address 2^6-2^{26} - Starting address for a SSD transfer; either Read or Write. SSD Address resides on a 100_8 Word Boundary.

Clear Control - Clears and initializes Port 3.

Write Bit - Indicates to Port 3 to perform a Write (1) or a Read (0) transfer.

Write Data - 144 Bits (128 Data - 16 check Bits) used for transferring data to Port 3.

Start Transfer - Becomes true when the X-MP Control outputs Block Length and becomes active.

PORT 3 to CRAY X-MP

Read Data Ready - Signal sent to the X-MP for one clock period when a buffers worth of data is to be transferred. Read Data Ready is sent for each 16-144 Bit word transfer. Read Data Ready precedes data by two clock periods.

Empty - Signals to CRAY X-MP the SSD is $\overline{\text{Busy}}$ and Read buffers are no longer full. Signal will clear when SSD goes busy.

Block Length Error - May occur during a Write to SSD. Occurs when X-MP sends Last Buffer Flag and Ports $BL \neq 0$ and there is still a Write Buffer full.

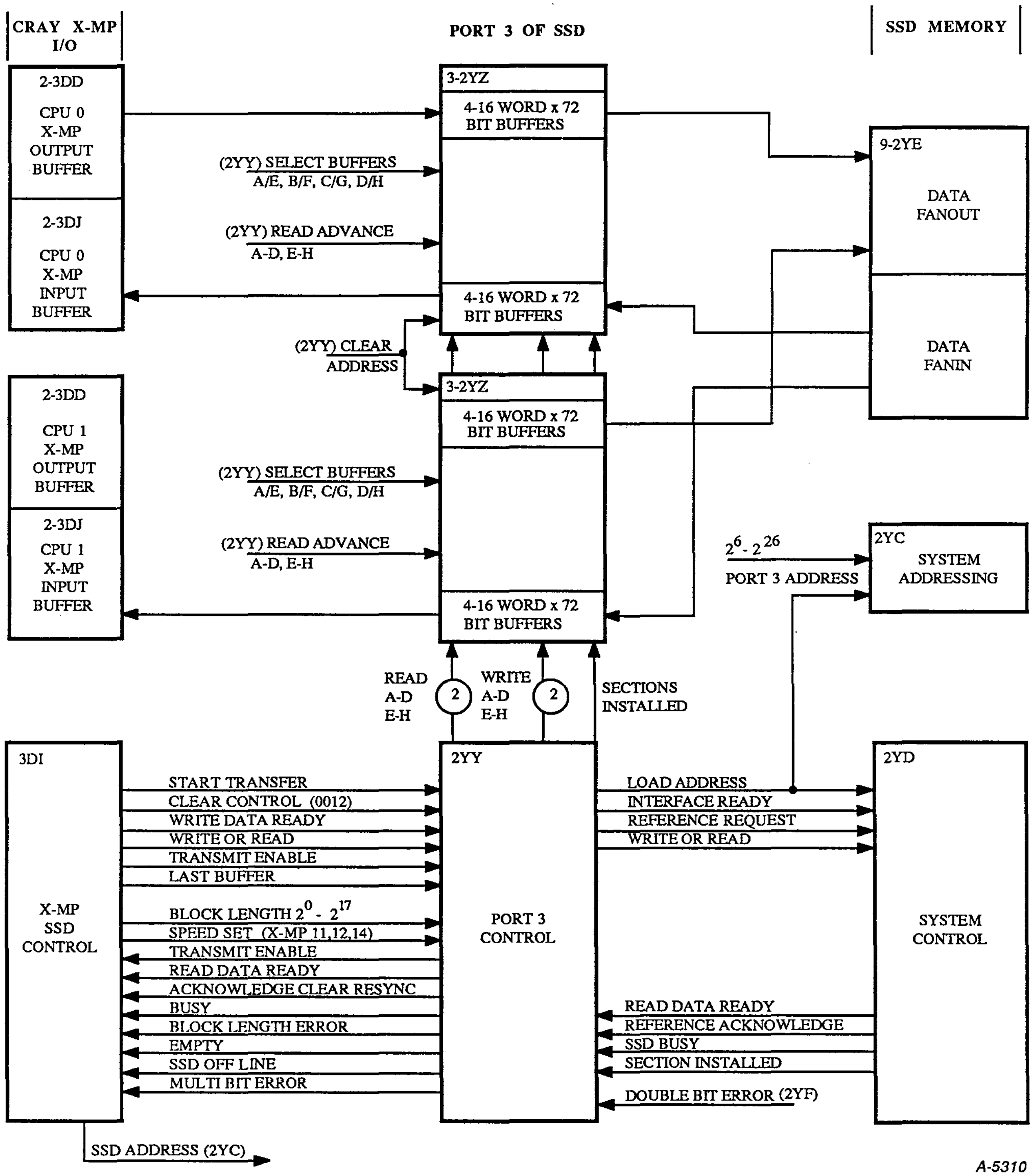
Multi-Bit Error - Sets when an error is detected on data transfer between Port 3 and SSD Memory. Clears when Clear Control is present.

Busy - Indicates that the port is active with a Read or Write transfer.

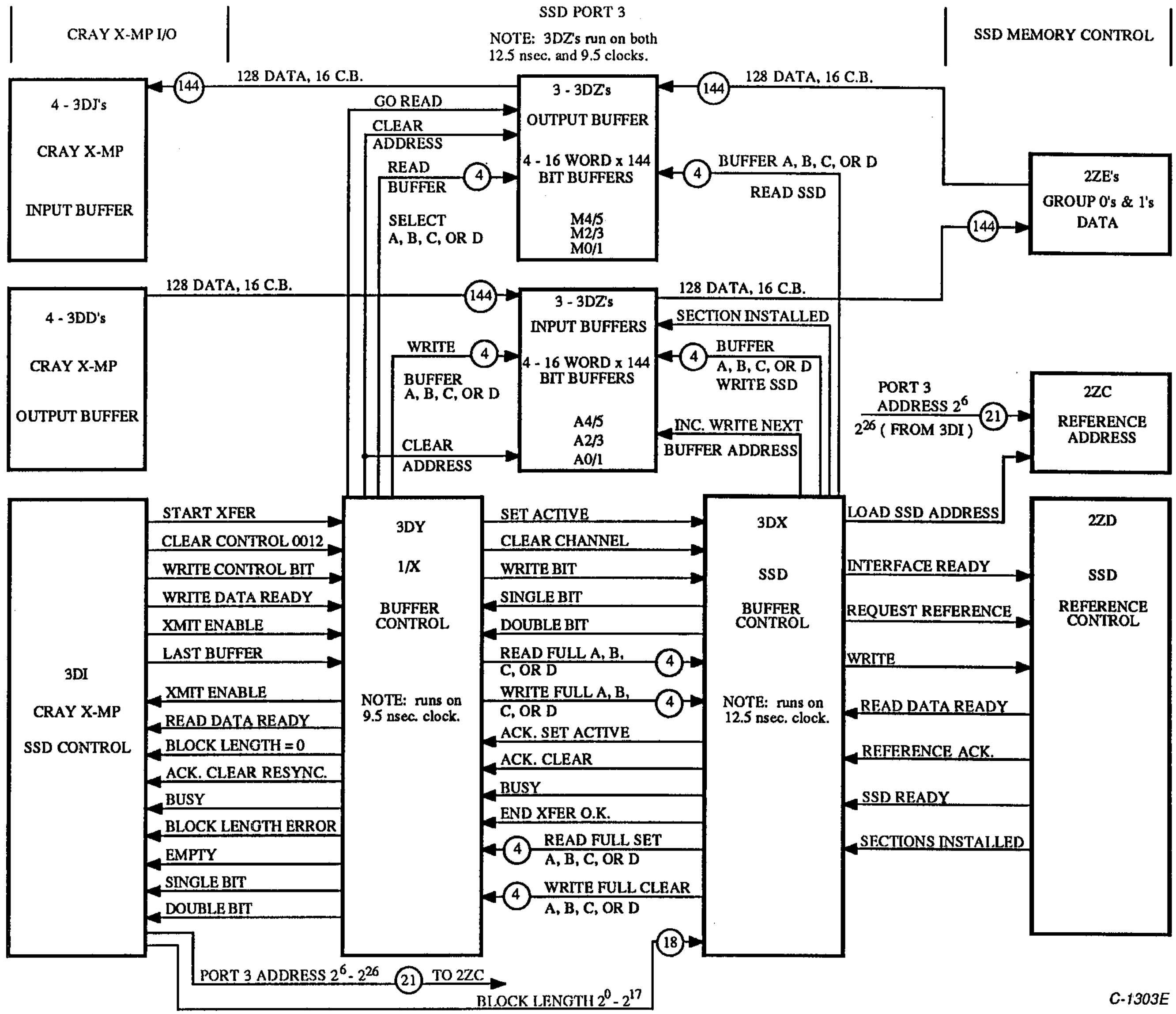
Acknowledge Clear Resync - Signal sent to the X-MP to indicate the Port is clear.

Read Data - 144 Bit (128 Data and 16 check bits) used for transferring data from Port 3 to the X-MP.

Transmit Enable - Informs the CRAY X-MP that at least one input buffer is empty and is free to be filled.



PORT 3 INTERFACE FLOW & EXTERNAL SIGNALS
MODEL "C"



CRAY X-MP PORT 3 INTERFACE BASIC AND EXTERNAL SIGNAL
MODEL B

Port to SSD

Load Address - Signals the SSD to capture the ports Address for a pending reference.

Interface Ready - Informs the SSD that the port is ready to communicate to the Memory. The port is on-line.

Request - Signals the SSD that the port wants to make a transfer; either Read or Write.

Write - Informs the SSD that the Reference will be a Write transfer. Request without Write indicates a Read Reference.

SSD to Port

Read Data Ready - Informs the port that there is Valid data on the lines in the next clock period. This signal goes out every time there is Valid data from the SSD.

Reference Acknowledge - Signals the port that its Reference has been accepted and a transfer will take place.

SSD Busy - Informs the port that the SSD is currently Busy and the port cannot make a request.

Sections Installed - Signals the port how many words to send or receive per Memory cycle.

SSD WRITE SEQUENCE

1. CRAY X-MP (3DI Module) Sends Clear Control to the 2YY module. The 2YY Resyncs Clear Control and Sends Acknowledge Clear Resync to the 3DI. The 3DI Sends SSD Address to the SSD. The 2YY initialize their control for the Buffers on the 2YZ to point to Buffers E-H. The 2YY Sends Interface Ready to the SSD.

2. The 3DI drops Clear Control and outputs Block length, Write Control Bit and Start transfer to the 2YY. The 2YY Resyncs Set active, latches Block length and latches the Write Control Bit. The 2YY Sends Load Address and Write Bit to the SSD. The 2YY Sends Busy and Transmit Enable to the 3DI.

3. The 3DI will Send Write Data Ready 2 clock periods prior to sending 16-144 Bit words. Data leaves the X-MP Buffers (3DD modules) and inputs to Port 3 Buffers (2YZ modules).

4. The 3DI/3DD will continue to Send blocks of data to the 2YZ module as long as Transmit Enable is true and $BL \neq 0$.

5. When the 2YY Sends Write Full for Buffer E the 2YY checks for SSD Ready and if Ready sends Request Reference and the Write Control Bit to the SSD. The SSD drops Ready after it receives Request from the Port.

6. The SSD will Send Reference Acknowledge to the 2YY when the SSD can accept the Buffer of data. The 2YY will take into consideration the number of sections installed and output accordingly. i.e. Buffer E loads 16 words from Address $0\text{-}17_8$ on the Write, but Reads the Buffer $17_8\text{-}0$ on the Read (4 sections). For 1 or 2 Section SSD's the number of words per transfer decreases. Two Section SSD's transfer 8 words per Memory cycle and One Section SSD's transfer 4 words per Memory cycle.

7. Upon Emptying the Buffer to the SSD the 2YY will tell itself Full Clear for the Buffer indicating the buffer is empty. The process of filling and emptying the buffers will continue as long as the Block Length $\neq 0$.

8. As soon as the last buffer is transferred to the SSD the 2YY drops Ready. The 2YY drops Busy to the 3DI and Sends Empty to the 3DI when all buffers are empty.

SSD Read Sequence

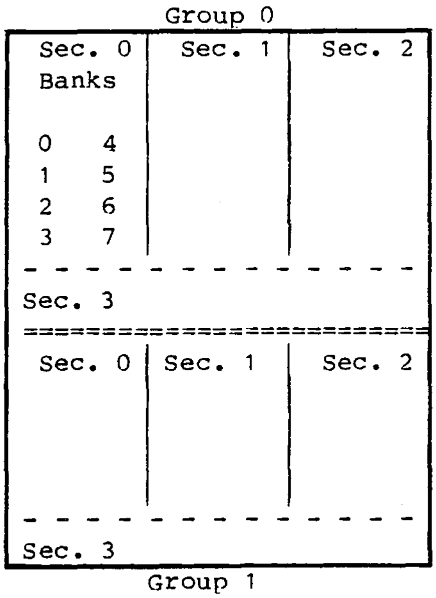
1. The CRAY X-MP (3DI) Sends Clear Control to the SSD (2YY). The 2YY Resyncs Clear Control and Sends Acknowledge Clear Resync to the 3DI. The 3DI also Sends SSD Address 2^6-2^{26} to the SSD. The 2YY initializes the buffers to point to Buffer A-D. The 2YY Sends Interface Ready to the SSD.

2. The 3DI drops Clear Control and outputs Block Length and Start Transfer to the 2YY (Write Control Bit = 0). The 2YY Resyncs Set Active and latches Block Length. The 2YY Sends Load Address to the SSD and verifies that the SSD is Ready. If SSD is Ready (Busy) and an output Buffer is empty, a Request Reference is made to the SSD. Also, Busy is sent to the 3DI.

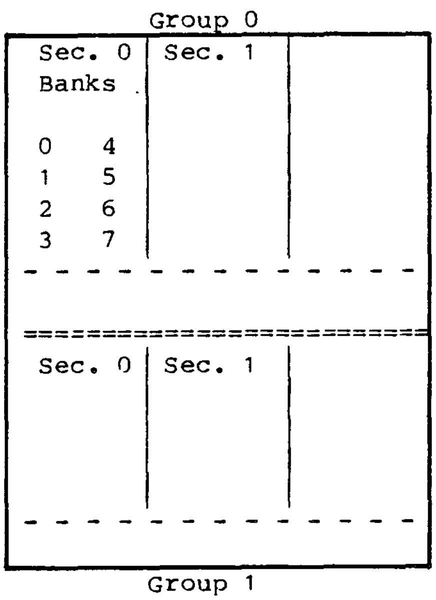
3. The SSD will Send Reference Acknowledge to the 2YY when the Request has been accepted. Block Length is decremented every time Reference Acknowledge is received that will fill a buffer. The SSD will Send Read Data Ready for every 144 Bit word transferred. The Ready precedes the data by 2 clock periods.

4. The 2YY controls the loading of buffers on the 2YZ modules. Once a buffer is full, the 2YY samples Transmit Enable from the 3DI to see if a buffer can be transferred to the X-MP. If Transmit Enable is true, the 2YY will Send a Read Data Ready to the 3DI and control the output of the Buffer to the X-MP. One Read Data Ready is sent to the 3DI for every 16-144 Bit words. The Ready precedes the data by 2 clock periods.

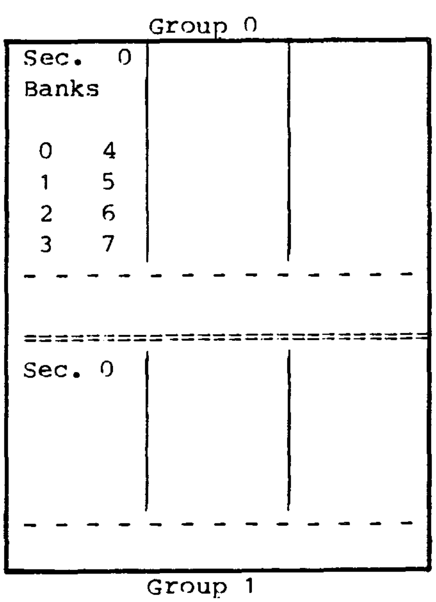
5. The 2YY and 2YZ modules will continue to fill the buffers and Send data to the X-MP until the Block Length = 0.



4 Sections/Group
2 Memory cycles
32 Million words of storage with 64K chips
128 Million words of storage with 256K chips



2 Sections/Group
4 Memory cycles
16 Million words of storage
64 Million words of storage with 256K.



1 Section/Group
8 Memory cycles
8 Million words of storage
32 Million words of storage with 256K.

"MODEL B" SSD
SECTIONS INSTALLED

X2026S0102

Clear Channel 7

I42 I41 I40 = CPU 0 Aj inst. Decode
I52 I51 I50 = CPU 1 Aj inst. Decode

```
Boolean    B7  B6  B5  B4  B3  B2  B1  B0  =  DCD (I42 I41 I40)/##

           B17 B16 B15 B14 B13 B12 B11 B10 =  DCD (I52 I51 I50)/##
```

B7 = CPU 0 select channel 7
B17 = CPU 1 select channel 7
B20 = I/O MC or Dead Dump

```
Boolean    C26 = B07 A2' + 0 A4' + B20; T2

           C27 = 0 A2' + B17 A4' + B20; T2
```

C26 = Select channel 7 CPU 0
C27 = Select channel 7 CPU 1

I46 = Clear Interrupt from 3JB
0012j0 decode for CPU0

I56 = Clear Interrupt CPU 1
A12 = I56 P100[1]

```
Boolean    C18 = I46 + B20; T2

           C19 = MUX (A12#): DCD (B20'); T2
```

C18 = Clear Interrupt CPU 0
C19 = Clear Interrupt CPU 1
if CPU 1 is installed

```
Boolean    R69 = C26 C18

           R74 = C27 C19
```

R69 = Clear Interrupt channel 7 from CPU 0
R74 = Clear Interrupt channel 7 from CPU 1

X2028S0101

3DB MODULE

Load SSD Block Address

First 0010jk Instruction

```
Boolean     A00 = MUX (I0 I09): DCD (I51); T2

            A08 = MUX (I17 I8): DCD (I51'); T2
```

A00-A08 = Is loaded with the value of Ak depending on which CPU's Ak value you want

```
Boolean     R09' = A0'

            R17' = A8'
```

R9-R17 = Block Address bit 2^0-2^8 sent to 3DI

3DI MODULE

I25 = Enter CA channel 7 from 3DH
I47, I48 = Clear interrupt channel 7

```
Boolean     M03 = M03 I47' I48' + I25; T2
```

M03 = Make M03 if enter CA for channel 7 is present and hold M03 until a clear interrupt instruction is issued

Enter Current Address

C14 = I44; T2	Enter CA from 3JB 0010jk decode from CPU 0
A10 = I54 P100'	Select CPU 1 and Enter BL Add. if CPU 1 is installed

C15 = A10; T2
C26 = CPU 0 channel 7
C27 = CPU 1 channel 7

Boolean D00 = C14 C26 + C15 C27

R51 = D00

R51 = Enter Current Address for Channel 7

Transfer Block Length

C16 = I45; T2	Enter BL from 3JB 0011jk decode from CPU 0
A11 = I55 P100'	Select CPU 1 and enter BL
C17 = A11; T2	Enter BL from 3JB 0011jk decode from CPU 1 if CPU 1 is installed

Boolean R52 = C16 C26 + C17 C27

R52 = Transfer the Block Length sent to 3DI

3DI MODULE

M04 = M03; T2 — Delay enter CA M04=0 when address arrives from the 3DA/3DB

T04 = T01 $\overline{\text{M04}}$ — The next clock M04=1 making T4=0 which will hold the address until a clear interrupt is issued

Boolean R40' = I00'; T4

R60' = I20'; T4

R40-R60 = The current SSD address sent to the 2ZX module as address bit 2^6-2^{26}

Load Central Memory Address

Second 0010jk Instruction

3DB Module

I72 = Forced zero for VHISP
Forced one if HISP

F50 = I72

Boolean A40 = I18 F50 + A0 F50'

A48 = I26 F50 + A8 F50'

A40-A48 = Select central memory address Ak bits 2^0-2^8

Load Central Memory Address

I73 = Enter CA channel 7 up for 1 cp

```
Boolean    E02 = I64 F50 + I73 F50'; T2

           E03 = I65 F50 + I73 F50'; T2
```

E2, E3 = Decode to load CA address

```
Boolean    F26' = E14' E2'
           F26  = E14 + E2

           F27' = E15' E3'
           F27  = E15 + E3
```

F26,F27 = Enable the CA address to be loaded or incremented

```
Boolean    B40 = MUX (A40 N0): DCD (E2); T12

           B48 = MUX (N8 A48): DCD (E2'); T12
```

B40-B48 = Load CA address into Input Register. Next cp E2=0 enabling the address to be incremented by 2

```
Boolean    B60 = MUX (A40 N0): DCD (E3); T13

           B68 = MUX (N8 A48): DCD (E3'); T13
```

B60-B68 = Load CA address into Output Register. Next cp E3=0 enabling the address to be incremented by 2

Transfer Block Length

I26 = Enter BL sent from the 3DH module when an 0011jk instruction is issued

M05 = I26; T2 M05 = set the BL

I00–I17 = Block Length sent by the 3DA/3DB 2^0–2^{17}

```
Boolean     J00' = M05' E22' U14'
            J00  = M05 + E22 + U14

            T03 = T01 J00
```

J00 = Enter the Block Length Register from Ak when issuing a 0011jk instruction, or Bump the WC when a 64 word block is transferred

```
Boolean     N00 = MUX (I00 S00): DCD (M05); T3
                         ↓
            N17 = MUX (S17 I17): DCD (M05'); T3
```

N00–N17 = Block Count Register – the Block Count is decremented each time a 64_{10} word block is transferred

Transfer Block Length

```
Boolean          R00 = N00
                    ⇩
                 R17 = N17
```

R00-R17 = Block Length sent to the 3DX module

Write Bit

I23 = Ak bit 2^{23} = 1 write
Ak bit 2^{23} = 0 read

M05 = Set Block Length

```
Boolean     R20 = I23 M05 + R20 M05'; T2
```

R20 = Write bit sent to the 3DX

M00 = Wait clear

```
Boolean     M06 = M06 M00 R21' + M05; T2

            K02 = M06 M00'

            R113 = R113 L01' M00' + K02; T2
```

R113 = First Reference Select will increment address by one in CPU 1

Read Reference Request

Boolean	M08 = 0 I46' + 0 I46 + R113 L01; T2

M08 = Set Channel Active

$\overline{\text{R116}}$ = $\overline{\text{M08}}$ - clear 16x4 Address on 3DD

I23 = Ak bit 2^{23} write control

M05 = Enter Block Length

Boolean	R20 = I23 M05 + R20 M05'; T2
	G14 = M08 R20

G14 = 1 if a Write Reference to SSD

Boolean	H00 = R26 G00' + G14 + E07 R26'
	H01 = R27 G01' + G14 + E08 R27' + K02 R20

H00 = Reference CPU 0
H01 = Reference CPU 1

R26 = H00; T2 Read Request CPU 0 of X-MP
R27 = H01; T2 Read Request CPU 1 of X-MP

I36, I35 = Ack. Read from 3DB when slot counter equals HISP 3 starts a delay chain

Write Buffer A/B from X-MP

A13 = Delayed I35 Acknowledged Reference from 3DB,
HISP 3 for Buffer A

Boolean	R35' = A13' A33'
	R36 = A53' A73'

R35 = Write to Buffer A/B on 3DD for CPU 0

R36 = Write to Buffer A/B on 3DD for CPU 1

Increment Address on 3DD

J01 = Clear Channel Enabled by an 0012 instruction

E10 = G10 J01'
E11 = G11 J01'
E12 = G12 J01'
E13 = G13 J01'

H5 = F00 E10 + J01   Count = 17

Boolean	E14 = R31 H5; T2
	R31' = R23' E14'
	R31 = R23 + E14

R31 = Sent to the 3DD to increment the address until the Buffer is filled

Write Data Ready

E4 = Buffers full for CPU 0
E5 = Buffers full for CPU 1

G07 = E4 E5 Both CPU's Buffers are full

I30 = Transmit Enable informs the X-MP that at least one buffer on the SSD is empty.

Boolean	R23 - G07 I30 R31'; T2
	R31' = R23' E14'

R23 = Send Go Data Ready to the 3DY 2cp ahead of the data to the SSD. R31 will drop R23 the next up.

One Write Data Ready per 16-144 bit word tranfers.

Ready Buffers A Both CPU's to SSD

Go Data - Increment Add

Boolean	E14 = R31 H05'; T2
	R31' = R23' E14'

R31 = Increment Address to Read 16x4's on the 3DD to be written into the SSD.

Decrement the Block Length

G14 = M08 R20 Channel active on a Write to SSD

Boolean	E06 = E06 H8' J01' + G14; T2
	E07 + E07 R26 J01' + R23 E06 + G14; T2
	E08 = E09 M09 J01' + R23 E06 + G14; T2

E07, E08 - Hold the Reference on CPU 0 and CPU 1
until BL=0 or an error.

H00 = Ref. CPU 0
H01 = Ref. CPU 1
E20 - Ref. A Buffer

Boolean	E21 = H00 R26'; T2
	E22 = E20 E21; T2
	E23 - E20' E21; T2

E22 = Bump WC, have currently transferred 1 Block of 64 words to SSD. When Ref. is back to Buffer A.

E23 = Enable the check for BL=0

Boolean	J00' = M05' E22' U14'
	J00 = M05 + E22 + U14

J00 = Enable the BL to be decremented

Decrement Block Length

T03 = T01 J00 - Enable Enter Block Length

Boolean	N00 = MUX (I00 S00): DCD (M05); T3
	N17 = MUX (S17 I17): DCD (M05'); T3

N00-N17 - Decrement Block Length by 1 after transferring 64 words.

Boolean	P00 = N2' N1' N0'
	P05 = N17' N16' N15'

Q00 = P01 P03 P04 P05 Block Length = 0

Last Buffers

M12 - Block Length Error from 3DY
M23 - Double Bit Error from 3DY
M28 - CPU Double Error from 3DE

Boolean	M13 = M12 + M23 + M28
	H08 = E23 Q00 + M13

M13 - Error
H8 - Terminate if BL=0 or an error

Last Buffer

J01 = Clear channel 0012
H8 = Terminate
M13 = Error

Busy — M9 = I28 SSD Busy from 3DY. Sets when SSD is active, and clears when the transfer is complete.

Boolean	E09 = E09 M09 J01' + H8 M13'; T2
	R25 = E09 R37 R23; T2

R25 = Last Buffer generated to the 3DY
E09 = Error; BL=0 or Double bit error
R37 = Wait until the last buffer has transferred Ref. Buffer A
R23 = BL=0

Read Block Length Error

I46 = Empty sets when Busy clears and No Read reads Buffers full on SSD
W14 = Buffer is empty and BL=0
W15 = Buffer is empty and BL=0
L01 = SSD Busy

Boolean	M10 = W14 I46' + W15 I46 + 0 L01; T2

M10 = Read of SSD Block Length Error

Write Block Length Error

I45 = Block Length Error
I48 = Clear Interrupt
E06 = Active on a Write to SSD
M9 = SSD Busy

Boolean	M11 = M9' E6 + I45 + 0 I48'; T2

M11 - Write Block Length Error

Read of SSD Memory
to become a write of CRAY X-MP Memory

3DI MODULE

Read Data from SSD; Write to CRAY X-MP

W06 = Count = 17
I29 = Read Data Ready from SSD
R34 = Sent to the 3DJ as I101

Boolean	U02 = I29 + W17 W06'; T2
	W17 = U02 J01'
	R34' = U02'

U02 = Will generate input write Buffer to the 3DJ.
Write Buffer will be held-up until a count of 17_8

W00 = $\overline{\text{U10}}$ U02 Add 1 to the Write word count

Boolean	U10 = W00 J01'; T2
	⇩
	U13 = W03 J01'; T2

U10 - U13 = Increment write word count

T10 = T95
T11 = T96

T95 = T94 A4

A4 = K4; T2 Write A

T96 = T94 B4

B4 = K5; T2 Write B

K04 = J1 I44 Write Buffer from 3DI select A Buffer
K05 = J0' I44
→ Select B Buffer

K6 = J1 I45 Select A Write
K7 = J1' I45 Select B Write

I45 = Write Buffer HSP 1
I01 = I47; Select A

C04 = K06; T2
D04 = K7; T2

~~When A is selected and being written, Buffer B is being read.~~

X2028S0115

SAFETY PRACTICES

All Field Engineers are expected to follow reasonable and appropriate precautions with respect to electrical, mechanical, and personal safety hazards while working on computer system equipment. You should pay careful attention to entries in the maintenance documentation labeled "DANGER" or "WARNING", which identify hazardous areas or procedures encountered in maintaining the system equipment. The following additional procedures should be followed when working on equipment:

Personal

1. You are responsible for insuring that no action on your part causes unsafe conditions that may expose personnel to hazards in any device.

2. You should never work alone on equipment having exposed operating mechanical parts or exposed hazardous power components. If you MUST do so, notify your EIC or manager. In any case, the following precautions must be observed:

   a. Someone familiar with the power-off controls must be in the immediate area.

   b. Personal jewelry (rings, wristwatches, bracelets, necklaces, etc.) shall be removed. A small box in the FE tool kit makes a good storage place for these items.

   c. If using one hand, keep the other one in your pocket.

   d. Avoid wearing loose articles of clothing that can be snagged and drawn into moving machinery. Wear short-sleeve shirts or pull sleeves above the elbow. Neckties, where required, should be tucked in between the second and third shirt button or fastened about three inches from the end with a tietack or tieclasp, preferably non-conductive. Don't use tie chains. Clip-on type neckties are preferable to the regular ones; if caught they will pull free without causing injury.

   f. While working in equipment put red tape strips across any power controls, or use "DO NOT OPERATE" tags where available.

3. Keep FE tool kits out of walkways; put them on or under a desk or table.

4. Put doors and covers removed from a machine in a safe, out-of-the-way location where nobody will trip over them or cause them to fall on top of someone. All machine covers MUST be restored in place before the machine is returned to the customer.

5. All safety covers, guards, shields, groundstraps, panels, etc., shall be properly reinstalled after maintenance is finished.

6. Maintain good housekeeping practices during and following each maintenance activity. Do not permit tools, manuals, wipers, paper, trash and the like to accumulate in the work area, and CLEAN UP AFTER YOURSELF.

Electrical

1. Remove ALL AC and DC power when removing or installing major assemblies, working inside power supplies or power control enclosures, performing detailed mechanical maintenance procedures, or doing wiring and/or module changes in the machine. If possible, turn off and lock or tag the circuit breaker in the service panel on the wall; unplug the main power supply cord.

2. Only use well-insulated pliers, screwdrivers, test leads, etc., when working on or near live circuits.

3. Do not disconnect or otherwise disable safety grounding systems even if the equipment is powered off. These are installed for YOUR protection.

4. Avoid coming in contact with grounds, such as equipment frames, metal floor tile edgings, electrical conduits, and the like. If possible, locally purchase rubber or vinyl mats.

Mechanical

1. Do not use chemicals, greases, oils or solvents that have not been specifically approved by the equipment manufacturer for that device. His recommendations are usually based on extensive experience with this equipment in service.

2. Use the proper tools for the job. Improper use of tools can result in personal injury or equipment damage.

3. Replace worn or broken tools or test equipment as quickly as possible.

4. If the machine is running, DO NOT reach in to the works; remember, they are YOUR fingers and you only get one set per lifetime.

5. If using a strobelight on mechanical devices, DON'T TOUCH ANYTHING; it may be moving.

6. Safety glasses or goggles must be used if you are:

   a. Driving pins, riveting, swedging, and similar activities.

   b. Using an electric drill, grinder, reamer, etc.

   c. Installing or removing springs under tension or compression.

   d. Using any type of solvent, spray, or chemical for cleaning or touch-up painting.

   e. Any other activity which may endanger the eyes. They are YOUR eyes, and you need them for this type of work.

7. When lifting, use a method (bent knees, straight back) that will not injure the spine or strain back muscles. Be realistic as to what your capacity for lifting really is.

ABOVE ALL, USE GOOD JUDGEMENT AND COMMON SENSE - A MOMENT OF THOUGHT BEFORE YOU ACT CAN SAVE HOURS OF AGONIZING AFTERTHOUGHT.

SAFETY PRECAUTIONS

Power Tool Precautions

Power tools can be hazardous when improperly used. There are several types of power tools, based on the power source they use: electric, pneumatic, liquid fuel, hydraulic, and powder-actuated.

Employees should be trained in the use and limitations of their power tools. They should understand potential hazards and safety precautions to prevent those hazards from occurring.

The following general precautions should be observed by power tool users:

- Never carry a tool by the cord or hose.
- Never yank the cord or the hose to disconnect from the receptacle.
- Keep cords and hoses away from heat, oil, and sharp edges.
- Disconnect tools when not in use, before servicing, and when changing accessories such a blades, bits, and cutters.
- All observers should be kept at a safe distance from the work area.
- Secure work with clamps or a vise, freeing both hands to operate the tool.
- Avoid accidental starting. The worker should not hold a finger on the switch button while carrying a plugged-in tool.
- Tools should be maintained with care. They should be kept sharp and clean for the best performance. Follow instructions in the user's manual for lubricating and changing accessories.
- Be sure to keep good footing and maintain good balance.
- The proper apparel should be worn. Loose clothing, ties, or jewelry can become caught in moving parts.
- All portable electric tools that are damaged must be removed, or tagged "DO NOT USE."

Guards

Hazardous moving parts of a power tool need to be safeguarded. For example, belts, gears, shafts, pulley, sprockets, spindles, drums, fly wheels, chains, or other reciprocating, rotating or moving parts of equipment must be guarded if such parts are exposed to contact by employees.

Guards, as necessary, should be provided to protect the operator and others from:

- Point of operation
- In-running nip points, rotating parts
- Flying chips and sparks

Safety guards must never be removed when the tool is being used. For example, portable circular saws must be equipped with guards. An upper guard must cover the entire blade of the saw. A retractable lower guard must cover the teeth of the saw, except when it makes contact with the work material. The lower guard must automatically return to the covering position when the tool is withdrawn from the work.

Safety Switches

The following hand-held powered tools must be equipped with a momentary contact "on/off" control switch: drills, tappers, fastener drivers, horizontal, vertical and angle grinders with wheels larger than two inches in diameter, disc sanders, belt sanders, reciprocating saws, saber saws, and other similar operations. These tools may also be equipped with a lock-on control provided that turn off can be accomplished by a single motion of the same finger or fingers that turn it on.

The following hand-held powered tools may be equipped with only a positive "On-off" control switch: platen sanders, grinders with wheels two inches or less in diameter, routers, planers, laminate trimmers, nibblers, shears, scroll saws, and jigsaws with blade shanks one-fourth inch wide or less.

Other hand-held powered tools such as circular saws, chain saws, and percussion tools without positive accessory holding means must be equipped with a constant pressure switch that will shut off the power when the pressure is released.

Electric Tools

Employees using electric tools must be aware of several dangers; the most serious is the possibility of electrocution.

Among the chief hazards of electric-powered tools are burns and slight shocks which can lead to injuries or even heart failure. Under certain conditions, even a slight shock can result in fibrillation of the heart and eventual death. A shock also can cause the user to fall off a ladder or other elevated work surface.

To protect the user from shock, tools must either have a three-wire cord with ground or be double insulated. Three-wire cords contain two current-carrying conductors and a grounding conductor. One end of the grounding conductor connects to the tool's metal housing. The other end is grounded through a prong on the plug. Anytime an adapter is used to accommodate a two-hole receptacle, the adapter wire must be attached to a known ground. The third prong should never be removed from the plug.

Double insulation is more convenient. The user and the tools are protected in two ways: by normal insulation on the wires inside, and by a housing that cannot conduct electricity to the operator in the event of a malfunction.

The following general practices should be followed when using electric tools:

- Electric tools should be operated within their design limitations.
- Gloves and safety footwear are recommended during use of electric tools.
- When not in use tools should be stored in a dry place.
- Electric tools should not be used in damp or wet locations.
- Work areas should be well lighted.

SHOCKS

How Shocks Occur

Electricity travels in closed circuits, and its normal route is through a conductor. Shock occurs when the body becomes a part of the electrical circuit. The current must enter the body at one point and leave at another. Shock normally occurs in one of three ways. The person must come in contact with the following: both wires of the electrical circuit; one wire of an energized circuit and the ground; or a metallic part that has become "hot" by being in contact with an energized wire, while the person is also in contact with the ground.

The metal parts of electrical tools and machines may become "hot" if there is a break in the insulation of the tool or machine wiring. The worker using these tools and machines is made less vulnerable to electrical shock when a low-resistance path from the metallic case of the tool or machine to the ground is established. This is done through the use of an equipment grounding conductor - a low-resistance wire that causes the unwanted current to pass directly to the ground rather than through the body of the person in contact with the tool or machine. If the equipment grounding conductor has been properly installed, it has a low resistance to ground, and the worker is being protected.

Severity of the Shock

The severity of the shock received when a person becomes a part of an electrical circuit is affected by three primary factors: the amount of current flowing through the body (measured in amperes); the path of the current through the body; and the length of time the body is in the circuit. Other factors which may affect the severity of shock are the frequency of the current, the phase of the heart cycle when shock occurs, and the general health of the person prior to shock.

The effects from electric shock depend upon the type of circuit, its voltage, resistance, amperage, pathway through the body, and duration of the contact. Effects can range from a barely perceptible tingle to immediate cardiac arrest. Although there are not absolute limits or even known values which show the exact injury from any given amperage, the following table shows the general relationship between the degree of injury and amount of amperage for a 60-cycle hand-to-foot path of one second's duration of shock.

Effects of Electrical Current in the Human Body

CURRENT	REACTION
1 Milliampere	Preception level. Just a faint tingle.
5 Milliamperes	Slight shock felt; not painful but disturbing. Average individual can let go. However, strong involuntary reactions to shocks in this range can lead to injuries.
6-25 Milliamperes (women)	Painful shock, muscular control is lost.
9-30 Milliamperes (men)	This is called the freezing current or "let-go" range.
50-150 Milliamperes	Extreme pain, respiratory arrest, severe muscular contractions*. Individual cannot let go. Death is possible.
1,000-4,300 Milliamperes	Ventricular fibrillation. (The rhythmic pumping action of the heart ceases.) Muscular contraction and nerve damage occur. Death is most likely.
10,000 Milliamperes	Cardiac arrest, severe burns and probable death.

* If the extensor muscles are excited by the shock, the person may be thrown away from the circuit.

PERSONAL PROTECTION

Arm and Hand Protection

Examples of injuries to arms and hands are burns, cuts, electrical shock, amputation, and absorption of chemicals.

There is a wide assortment of gloves, hand pads, sleeves, and wristlets for protection from various hazardous situations.

The protective device should be selected to fit the job. For example, some gloves are designed to protect against specific chemical hazards. Employees may need to use gloves which have been tested and provide insulation from burns and cuts such as, wire mesh, leather, and canvas. The employee should become acquainted with the limitations of the clothing used.

Ear Protection

Exposure to high noise levels can cause hearing loss or impairment. It can create physical and psychological stress. There is no cure for noise-induced hearing loss, so the prevention of excessive noise exposure is the only way to avoid hearing damage. Specifically designed protection is required, depending on the type of noise encountered.

Performed or molded ear plugs should be individually fitted by a professional. Waxed cotton, foam, or fiberglass wool earplugs are self-forming. When properly inserted, they work as well as most molded earplugs.

Some earplugs are disposable, to be used one time and then thrown away. The non-disposable type should be cleaned after each use for proper protection. Plain cotton is ineffective as protection against hazardous noise.

Earmuffs need to make a perfect seal around the ear to be effective. Glasses, long sideburns, long hair and facial movements, such as chewing, can reduce protection. Special equipment is available for use with glasses or beards.

For extremely noisy situations, earplugs should be worn in addition to earmuffs. When used together, earplugs and earmuffs change the nature of sounds; all sounds are reduced including one's own voice, but other voices or warning signals are easier to hear.

Eye and Face Protection

Eye and face protective equipment is required by OSHA where there is a reasonable probability of preventable injury when such equipment is used. Employers must provide a type of protector suitable for work to be performed and employees must use the protectors. These stipulations apply also to supervisors, management personnel, and visitors while they are in hazardous areas.

The BLS study found that about 60 percent of workers who suffered eye injuries were not wearing eye protective equipment. When asked why they were not wearing face protection at the time of the accident, workers indicated that face protection was not normally used or practiced in their type of work, or it was not required for the type of work performed at the time of the accident.

Suitable eye protectors must be provided where machines or operations present the hazard of flying objects, glare, liquids, injurious radiation, or a combination of these hazards. Protectors must meet the following minimum requirements:

- Provide adequate protection against particular hazards for which they are designed.
- Be reasonably comfortable when worn under the designated conditions.
- Fit snugly without interfering with the movements or vision of the wearer.
- Be durable.
- Be capable of being disinfected.
- Be easily cleanable.
- Be kept clean and in good repair.

Respiratory Protection

Hazards to the lungs are not always easy to detect. Some of the most common hazards are lack of oxygen and presence of harmful dust, fogs, smokes, mists, fumes, gases, vapors, or sprays including substances which may cause cancer, lung impairment, other diseases, or death. Respirators prevent entry of harmful substances into the body during breathing and make sure that the user has an adequate supply of clean air. Some respirators also provide a separate supply of air so work can be done where there is inadequate oxygen.

Prevention of atmospheric contamination at the worksite generally should be accomplished as far as feasible by engineering control measures (for example, enclosure or confinement of the contaminant-producing operation, general and local ventilation) or by work-practice controls such as substitution of less toxic materials. Historically, the industrial hygiene profession has sought to control hazardous air contamination through engineering or work-practice means. However, when effective engineering controls are not feasible, or while those controls are being installed, appropriate respirators must be used. The user should be aware that respirators have their limitations and are not a substitute for effective engineering controls. Where respirators are necessary for health protection, specific procedures are necessary to overcome potential deficiencies and to assure effectiveness.

EVALUATION OF MATERIALS

Your opinion about the quality of our training materials is important to us! Please take a moment, and in the space below, tell us how you would rate the effectiveness of our materials. Whenever possible, use specific manual numbers and page numbers to note errors or areas of confusion. An instructor will collect this page from you when you complete the course. Thank you for your valuable input!