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TITLE	EAE FORTRAN Patch for the PDP-8
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SOURCE LANGUAGE	FORTRAN

## EAE FORTRAN

These few paragraphs summarize the revisions made to the PDP-8 FORTRAN operating system to utilize the extended arithmetic unit option (Type 182 EAE). Four arithmetic routines were rewritten—alignment, normalize, multiply and divide. The reduction in execution time that was achieved was quite significant.

For example, an iterative-type problem that used several function subroutines (sin, cos, etc.) had been averaging 35 seconds per printout with non-EAE FORTRAN. This execution time was cut to 17 seconds with the EAE FORTRAN package. Comparative execution times of the subroutines for non-EAE FORTRAN versus EAE FORTRAN are shown in Table I.

Another improvement besides the faster execution time was gained with EAE FORTRAN. Since the multiply routine calculates a full 48-bit product and rounds instead of truncates to 24 bits, an increase in significance of the product was noted. For example, starting with 0.1 and successively multiplying by 10 for 100 times should yield 0.100000E+100. Non-EAE FORTRAN yielded 0.999973E+99, while EAE FORTRAN yielded 0.999999E+99.

These modifications work with the FORTRAN operating system of March 2, 1967. They have not been tested with any other version, but would "probably" work. No changes must be made in operating procedure or any other portion of the program, as this modification loads over the regular arithmetic subroutines.

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TABLE I

Comparative Execution Times of EAE and Non-EAE Arithmetic Subroutines

Routine	Execution Time (usec)					
	Minimum		Average		Maximum	
	<u>EAE</u>	<u>Non-EAE</u>	<u>EAE</u>	<u>Non-EAE</u>	<u>EAE</u>	<u>Non-EAE</u>
Alignment	119	90	125	423	130	750
Normalize	41	102	51	469	61	836
Multiply	239	1116	303	1160	366	1204
Divide	128	1893	183	1936	237	1978

/EAE FORTRAN MODIFICATIONS

\*103

0103 2224 ALGN

\*141

0141 2322 MP2

0142 2320 MP4

/NORMALIZE ROUTINE FOR EAE FORTRAN

\*2200

2200	0000	NORM,	0	
2201	7300		CLA CLL	
2202	1445		TAD I L2	
2203	7450		SNA	/IS LEAST SIG. 0?
2204	5220		JMP ZCHECK	/YES, CHECK MOST SIG.
2205	7421	B1,	MQL	/LEAST SIG. TO MQ
2206	1444		TAD I H2	/MOST SIG. TO AC
2207	7411		NM:	/NORMALIZE
2210	3444		DCA I H2	/DEPOSIT INTO 2ND ARG.
2211	7501		MQA	
2212	3445		DCA I L2	
2213	7641		SCA CLA	/GET STEP COUNTER
2214	7041		CIA	/NEGATE
2215	1443		TAD I X2	/ADD EXPONENT
2216	3443	B2,	DCA I X2	
2217	5500		JMP I NORM	/EXIT
2220	1444	ZCHECK	TAD I H2	
2221	7640		SZA CLA	/MOST SIG. 0?
2222	5205		JMP B1	
2223	5216		JMP B2	/YES, 0 TO EXPONENT

/ALIGNMENT ROUTINE FOR EAE FORTRAN

2224	0000	ALGN,	0	
2225	7300		CLA CLL	
2226	3303		DCA ID	
2227	1440		TAD I X1	
2230	7041		CIA	
2231	1443		TAD I X2	
2232	7450		SNA	/EXPONENTS EQUAL?
2233	5275		JMP DONE	/YES
2234	7510		SPA	/X2 GREATER
2235	5246		JMP TWO	

2236	7041		CIA	
2237	7040		CMA	/X2-X1-1
2240	3271		DCA SHFT	/NUMBER OF SHIFTS
2241	7340		CLA CLL CMA	
2242	3303		DCA ID	
2243	1041		TAD HI	
2244	3304		DCA PNT	/SET POINTER
2245	5254		JMP BOTH	
2246	7040	TWO	CMA	/X1-X2-1
2247	3271		DCA SHFT	/NUMBER OF SHIFTS
2250	1044		TAD H2	
2251	3304		DCA PNT	/SET POINTER
2252	1440		TAD I X1	
2253	3443		DCA I X2	/X2=X1
2254	1271	BOTH,	TAD SHFT	
2255	1306		TAD M24B	
2256	7700		SMA CLA	/TOO MANY SHIFTS?
2257	5300		JMP NOGO	/YES
2260	7101		CLL IAC	
2261	1304		TAD PNT	
2262	3305		DCA PNT+1	
2263	1705		TAD I PNT+1	
2264	7421		MLQ	/LEAST SIG. TO MQ
2265	1704		TAD I PNT	/MOST SIG. TO AC
2266	7510		SPA	/POSITIVE?
2267	7020		CML	/NO, SET MINUS SIGN
2270	7415		ASR	/SHIFT RIGHT
2271	0000	SHFT,	0	
2272	3704		DCA I PNT	
2273	7501		MQA	
2274	3705		DCA I PNT+1	
2275	7300	DONE,	CLA CLL	
2276	2224		ISZ ALGN	
2277	5624		JMP I ALGN	/EXIT
2300	2303	NOGO,	ISZ ID	
2301	4561		JMS I SWP	/MAKE ARG2 LARGEST
2302	5624		JMP I ALGN	/EXIT
2303	0000	ID,	0	
2304	0000	PNT,	0	
2305	0000		0	
2306	7750	M24B,	-30	

/DIVIDE ROUTINE FOR EAE FORTRAN

/CALLING ROUTINE MODIFICATIONS

\*2051

2051 7000 NOP

\*2063

2063 1005 TAD SIGN  
2064 7710 SPA CLA

\*2153

2153 1005 TAD SIGN  
2154 7700 SMA CLA  
2155 5500 JMP I INT I  
2156 1444 TAD I H2  
2157 7041 CIA  
2160 3444 DCA I H2  
2161 5500 JMP I INT I

\*2400

2400	0000	DDVD,	Ø	
2401	4672		JMS I SN	/CHECK SIGNS
2402	3006		DCA DIVID	/CLEAR FLAG
2403	1442		TAD I L1	
2404	7104		CLL RAL	
2405	3224		DCA DDVD3	/SHIFT DIVISOR LEFT
2406	1441		TAD I HI	
2407	7004		RAL	
2410	3245		DCA DDVD4	
2411	1245		TAD DDVD4	
2412	3217		DCA DDVD2	
2413	1445		TAD I L2	
2414	7421		MQL	/LEAST SIG. TO MQ
2415	1444		TAD I H2	/MOST SIG. TO AC
2416	7407		DV1	/(MS2+LS2*2**-12)/MS1
2417	0000	DDVD2	Ø	
2420	3217		DCA DDVD2	/REMAINDER
2421	7501		MQA	
2422	3444		DCA I H2	/QUOTIENT
2423	7405		MUY	
2424	0000	DDVD3	Ø	/QUO.*LS1*2**-12
2425	7141		CLL CMA IAC	/NEGATE PRODUCT
2426	1217		TAD DDVD2	
2427	7450		SNA	
2430	5673		JMP I DV5 I	/HI PROD.=REM. (L=1)
2431	7420		SNL	
2432	5250		JMP DDVD6	/HI PROD.>REM.



\*2307

2307	7110	DDVD7,	CLL RAR
2310	3444		DCA I H2
2311	1445		TAD I L2
2312	7010		RAR
2313	3445		DCA I L2
2314	2443		ISZ I X2
2315	5717		JMP I RETI
2316	5717		JMP I RETI
2317	2471	RETI,	RDB

/SHIFT QUO. RIGHT



/MULTIPLY ROUTINE FOR EAE FORTRAN

\*2600

2600	0000	DMUL,	Ø	
2601	4264		JMS SGN	/CHECK SIGNS
2602	1064		TAD M2	
2603	3361		DCA CNT1	
2604	1254		TAD BSTKAD	
2605	3017		DCA TEMC	/PRODUCT TABLE POINTER
2606	7040		CMA	
2607	1041		TAD H1	
2610	3015		DCA TEMA	/ARG1 POINTER
2611	1064	A2LO,	TAD M2	
2612	3362		DCA CNT2	
2613	7040		CMA	
2614	1044		TAD H2	
2615	3016		DCA TEMA	/ARG2 POINTER
2616	1415		TAD I TEMA	/GET ARG1
2617	3222		DCA MUL	
2620	1416	A3LO,	TAD I TEMA	/GET ARG2
2621	7425		MQL MUY	
2622	0000	MUL,	Ø	
2623	3417		DCA I TEMC	/STORE IN PRODUCT TABLE
2624	7501		MQA	
2625	3417		DCA I TEMC	
2626	2362		ISZ CNT2	
2627	5220		JMP A3LO	
2630	2361		ISZ CNT1	
2631	5211		JMP A2LO	
2632	1263		TAD A	/ADD PRODUCTS FROM TABLE
2633	1262		TAD B	
2634	1260		TAD D	
2635	7004		RAL	/CARRY
2636	7630		SZL CLA	
2637	7001		IAC	/ROUND
2640	7100		CLL	
2641	1261		TAD C	
2642	1257		TAD E	
2643	1256		TAD F	
2644	3445		DCA I L2	
2645	7004		RAL	
2646	1255		TAD G	
2647	3444		DCA I H2	
2650	1005		TAD SIGN	
2651	7710		SPA CLA	
2652	4537		JMS I NEG	
2653	5600		JMP I DMUL	

2654	2654	BSTKAD,	G-1	
2655	0000	G,	0	
2656	0000	F,	0	
2657	0000	E,	0	
2660	0000	D,	0	
2661	0000	C,	0	
2662	0000	B,	0	
2663	0000	A,	0	
2664	0000	SGN,	0	
2665	1444		TAD I H2	
2666	0300		AND MASK	
2667	1441		TAD I HI	
2670	3005		DCA SIGN	/SIGN OF PROD. OR QUO.
2671	1444		TAD I H2	
2672	7710		SPA CLA	
2673	4537		JMS I NEG	
2674	1441		TAD I HI	
2675	7710		SPA CLA	
2676	4536		JMS I NEG1	
2677	5664		JMP I SGN	
2700	4000	MASK,	4000	

\*2761

2761	0000	CNT1,	0	
2762	0000	CNT2,	0	

/MULTIPLY FOR XTRA-SPECIAL INDEX CALCULATOR

\*2320

2320	0000	MP4,	0	
2321	7425		MQL MUY	
2322	0000	MP2,	0	
2323	5720		JMP I MP4	

/ DEFINITIONS FOR EAE FORTRAN

X1=4Ø  
H1=41  
L1=42  
X2=43  
H2=44  
L2=45  
SIGN=5  
TEMA=15  
TEMB=16  
TEMC=17  
M2=64  
SWP=151  
INTI=1ØØ  
DIVID=6  
NEG=137  
NEG1=136  
DVI=74Ø7  
NMI=7411  
SHL=7413  
ASR=7415  
MQL=7421  
MUY=74Ø5  
MQA=75Ø1  
SCA=7441

A	2663	NEG	Ø137
AAADIV	27Ø1	NEGI	Ø136
ALGN	2224	NMI	7411
ASR	7415	NOGO	23ØØ
A2LO	261Ø	NORM	22ØØ
A3LO	2616	PNT	23Ø4
B	2662	RØV	2471
BOTH	2254	RET	2715
BSTKAD	2654	RETI	2317
B1	22Ø5	SCA	7441
B2	2216	SGN	2664
C	2661	SHFT	2271
CNT1	2652	SHL	7413
CNT2	2653	SIGN	ØØØ5
D	266Ø	SN	2472
DDVD	24ØØ	SWP	Ø161
DDVD2	2417	TEMA	ØØ15
DDVD3	2424	TEMB	ØØ16
DDVD4	2445	TEMC	ØØ17
DDVD5	27Ø5	TWO	2246
DDVD6	245Ø	X1	ØØ4Ø
DDVD7	23Ø7	X2	ØØ43
DIVID	ØØØ6	ZCHECK	222Ø
DMUL	26ØØ		
DONE	2275		
DVI	74Ø7		
DV5I	2473		
DV5M1	247Ø		
DV7I	2716		
E	2657		
F	2656		
G	2655		
H1	ØØ41		
H2	ØØ44		
ID	23Ø3		
INT1	Ø1ØØ		
L1	ØØ42		
L2	ØØ45		
MASK	27ØØ		
MP2	2322		
MP4	232Ø		
MQA	75Ø1		
SQL	7421		
MUL	262Ø		
MUY	74Ø5		
M2	ØØ64		
M24B	23Ø6		