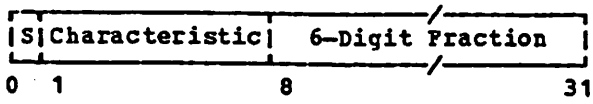
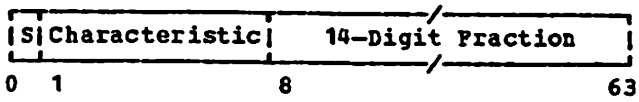
IBM S/370 FLOATING POINT FORMAT

Short Floating-Point Number

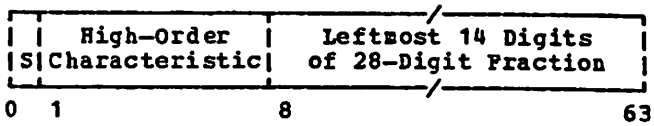


Long Floating-Point Number

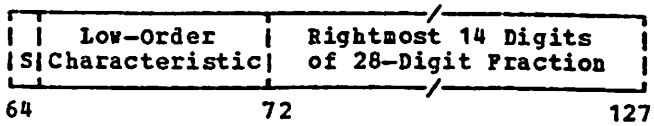


Extended Floating-Point Number

High-Order Part



Low-Order Part



Normalized range: 16^{-65} to $(1-\delta) \times 16^{63}$ or

$\sim 5.4 \times 10^{-79}$ to $\sim 7.2 \times 10^{75}$

No NaNs

No $\pm\infty$

-0 allowed, not generated

Denormals (usually) tolerated, not (usually) generated

No H/W gradual u'flow; user trap routine can generate

Results chopped (except LRER and LRDR)

Larry Breed
14 July 1986

IBM VS FORTRAN

Exception	*Default*	*Alternative*
$x/0$	Message and 0 if x=0 else signed MAXREAL	User trap; DVCHK
Overflow	Message and signed MAXREAL	User trap; OVERFL
Underflow	Message and 0	User trap; OVERFL; XUFLOW
Inexact	Not available	None
Invalid Op'n	Message and see next pages	User trap

User can reset max # errors before halt (up to ∞)
User can reset max # messages produced for each error
User can trap on error to user-written (FORTRAN) routine
List of errors and count of each produced at pgm end

IBM VS FORTRAN

User trap example

```
external DIVIDE_FIX,OVER_AND_UNDERFLOW_FIX
...
call ERRSET(207, 10, 5,0,DIVIDE_FIX,207)
call ERRSET(208,256,-1,0,OVER_AND_UNDERFLOW_FIX,209)
...
```

User-written error handler for divide-by-zero (error 207) is named DIVIDE_FIX. Up to 10 errors can occur before program halt but standard error messages are printed for only the first 5. The handler for underflow and overflow (errors 208-209) is named OVER_AND_UNDERFLOW_FIX. Unlimited numbers of each may occur, but no messages are generated.

```
subroutine over_and_underflow_fix(icode,ierr,qval,iexponent)
real*16 qval
data huge/Z65100000/
if(ierrno.eq.209)go to 209          !fix overflows down below
if(qval.lt.huge)then
qval=0   !Number too small.  Generate true zero.
else     !Generate denormal result.
...
```

Error Code	FORTRAN Reference[1]	Invalid Argument Range	Options Standard Corrective Action[2, 3]	Options Parameters Passed to User Exit[4]
118	XA=X**Y	X < 0, Y ≠0	XA=|X|**Y	A, B, X, Y
119	DA=D**DB	D < 0, DB ≠ 0	DA=|D|**DB	A, B, D, DB
241	K=I**J	I=0, J≤0	K=0	A, B, I, J
242 [5]	Y=X**I	X=0, I≤0	If I=0, Y=1 If I < 0, Y=•	A, B, X, I
243 [5]	DA=D**I	D=0, I≤0	If I=0, Y=1 IF I < 0, Y=•	A, B, D, I
244	XA=X**Y	X=0, Y≤0	If Y=0, XA=1 If Y<0, XA=•	A, B, X, Y
245	DA=D**DB	D=0, DB ≤0	If DB=0, DA=1 If DB<0, DA=•	A, B, D, DB
246	CA=C**I	C=0 + 0i, I≤0	If I=0, C=1 + 0i IF I < 0, C=• + 0i	A, B, C, I
247	CDA=CD**I	C=0 + 0i, I≤0	If I=0, C=1 + 0i If I < 0, C=•+ 0i	A, B, CD, I
248 [5]	Q=QA**J	QA=0, J≤0	J < 0, Q=• J=0, Q=1	A, B, QA, J
249	Q=QA**QB	QA=0, QB≤0	QB < 0, Q=• QB=0, Q=1	A, B, QA, QB
		QA < 0, QB≠0	Q=|QA|**QB	
250	Q=QA**QB	$\log_2(QA) \times QB \geq 252$	Q=•	A, B, QA, QB
251	Y=SQRT (X)	X < 0	$Y=\|X\|^{1/2}$	A, B, X
252	Y=EXP (X)	X > 174.673	Y•	A, B, X
253	Y=ALOG (X)	X=0 X < 0	Y=-• Y=log|X|	A, B, X A, B, X
	Y=ALOG10 (X)	X=0 X lt 0	Y=-• $Y=\log_{10}\|X\|$	A, B, X
254	Y=COS (X) Y=SIN (X)	$\|X\| \geq (2^{18})\pi$	$Y = \sqrt{2/2}$	
255	Y=ATAN2 (X,XA)	X=0, XA=0	Y=0	A, B, X, XA
256	Y=SINH (X) Y=COSH (X)	|H| ≥ 175.366	Y=(SIGN of X)• Y=•	A, B, X
257	Y=ASIN (X)	|X| > 1	If X > 1.0, ASIN (X)=π/2 If X < - 1.0, ASIN (X)= − π/2	
	Y=ACOS (X)		If X > 1.0, ACCOS=0 If X <- 1.0, ACOS=π	
258	Y=TAN(X) Y=COTAN(X)	$\|X\| \geq (2^{18})\pi$	Y=1	
	Y=COTAN (X)	X=0	Y=•	
260	Q=2**QA	QA >252	Q=•	A, B, QA
261	DA=DSQRT (D)	D < 0	$DA=\|D\|^{1/2}$	A, B, D
262	DA + DEXP (D)	D > 174.673	D=•	A, B, D
263	DA=DLOG (D)	D=0 D < 0	DA= −• DA=log|X|	
	DA=DLOG10 (D)	D=0 D < 0	DA=-• $DA=\log_{10}\|X\|$	A, B, D

Figure 55 (Part 1 of 3). Corrective Action after Mathematical Subroutine Error

Error Code	FORTRAN Reference[1]	Invalid Argument Range	Options Standard Corrective Action[2, 3]	Options Parameters Passed to User Exit[4]
264	DA=DSIN (D) DA=DCOS (D)	$\|D\| \geq (2^{50})\pi$	DA=$\sqrt{2/2}$	A, B, D
265	DA=DATAN2 (D.DB)	D=0, DB=0	DA=0	A, B, D, DB
266	DA=DSINH (D) DA=DCOSH (D)	$\|D\| \geq 175.366$	DA=(SIGN of X)• DA=•	A, B, D
267	DA=DASIN (D)	$\|D\| > 1$	If D > 1.0, DASIN=$\pi/2$ If D < -1.0, DASIN= $-\pi/2$	
	DA=DACOS (D)		If D > 1.0, DACOS (D)=0 If D < - 1.0, DACOS (D)=π	
268	DA=DTAN (D) DA=DCOTAN (D)	$\|X\| \geq (2^{50})\pi$	DA=1	A, B, D
	DA=DCOTAN (D)	D=0	DA=•	A, B, D
270[6]	CQ=CQA**J	CQA=0 + 0i J≤ 0	J=0, CQ=1 + 0,i J < 0, CQ=•+ 0,i	A, B, CQA, J
271[7]	Z=CEXP (C)	$X_1 < 174.673$	Z=•(cos X_2 + iSIN X_2)	A, B, C
272	Z=CEXP (C)	$\|X_2\| \geq (2^{18})\pi$	Z=e^x + 0i	A, B, C
273	Z=CLOG (C)	C=0 + 0i	Z=-• + 0i	A, B, C
274	Z=CSIN (C)	$\|X_1\| \geq (2^{18})\pi$	Z=0 + SINH (X_2)π	A, B, C
	Z=CCOS (C)		Z=COSH (X_2) + 0i	A, B, C
275	Z=CSIN (C)	$X_2 < 174.673$	Z=$\frac{•}{2}$ (SIN X_1 + iCOS X_1)	A, B, C
	Z=CCOS (C)		Z=$\frac{•}{2}$ (COS X_1 − iSIN X_1)	A, B, C
275	Z=CSIN (C)	$X_2 < -174.673$	Z=$\frac{•}{2}$ (SIN X_1 − iCOS X_1)	A, B, C
	Z=CCOS (C)		Z=$\frac{•}{2}$ (COS X_1 + iSIN X_1)	A, B, C
276[8]	Z=CQEXP (CQ)	$X_1 > 174.673$	Z=•(COS X_2 + iSIN X_2)	A, B, CQ
277	Z=CQEXP (CQ)	$\|X_2\| > 2_{100}$	Z=e_{x1} + 0i	A, B, CQ
278	Z=CQLOG (CQ)	CQ=0 + 0i	Z=-• + 0i	A, B, CQ
279	Z=CQCOS (CQ) Z=CQCOS (CQ)	$\|X_1\| \geq 2^{100}$	Z=0 + DSINH (X_2)i Z=DCOSH (X_2) + 0i	A, B, CQ
280	Z=CQSIN (CQ)	$X_2 > 174.673$	Z=$\frac{•}{2}$ (SIN X_1 + iCOS X_1)	A, B, CQ
	Z=CQCOS (CQ)		Z=$\frac{•}{2}$ (COS X_1 = iSIN X_1)	A, B, CQ
	Z=CQSIN (CQ)	$X_2 < -174.673$	Z=$\frac{•}{2}$ (COS X_1 = iSIN X_1)	A, B, C Q
	Z=CQCOS (CQ)		Z=$\frac{•}{2}$ (COS X_1 = iSIN X_1)	
281[9]	Z=CDEXP (CD)	$X_1 > 174.673$	Z=•(COS X_2 + iSIN X_2)	A, B, CD
282	Z=CDEXP (CD)	$\|X_2\| \geq (2^{50})\pi$	Z=$e^x{}_1$ + 0i	A, B, CD
283	Z=CDLOG (CD)	CD = 0 + 0i	Z=- • + 0i	A, B, CD
284	Z=CDSIN (DC)	$\|X_1\| \geq (2^{50})\pi$	Z=0 + SINH (X_2)i	A, B, CD

Figure 55 (Part 2 of 3). Corrective Action after Mathematical Subroutine Error

Error Code	FORTRAN Reference[1]	Invalid Argument Range	Options Standard Corrective Action[2, 3]	Options Parameters Passed to User Exit[4]
	Z=CDCOS (CD)		Z=COSH (X_2) + 0i	A, B, CD
285	Z=CDSIN (CD)	$X_2 > 174.673$	$Z=\frac{\bullet}{2}(\text{SIN } X_1 + i\text{COS } X_1)$	A, B, CD
	Z=CDCOS (CD)		$Z=\frac{\bullet}{2}(\text{COS } X_1 - i\text{SIN } X_1)$	A, B, CD
	Z=CDSIN (CD)	$X_2 < -174.673$	$Z=\frac{\bullet}{2}(\text{SIN } X_1 - i\text{COS } X_1)$	A, B, CD
	Z=CDCOS (CD)		$Z=\frac{\bullet}{2}(\text{COS } X_1 + i\text{SIN } X_1)$	A, B, CD
289	QA=QSQRT (Q)	Q < 0	$QA=\lvert Q\rvert^{1/2}$	A, B, Q
290	Y=GAMMA (X)	$X \le 2^{-252}$ or $X \ge 57.5744$	Y=•	A, B, X
291	Y=ALGAMA (X)	$X \le 0$ or $X \ge 4.2937 \times 10^{73}$	Y=•	A, B, X
292	QA=QEXP (Q)	Q > 174.673	QA=•	A, B, Q
293	QA=QLOG (Q)	Q=0 Q < 0	QA=-• QA=log|X|	A, B, Q
	QA=QLOG10 (Q)	Q=0 Q < 0	QA=• $QA=\log_{10}\lvert X\rvert$	A, B, Q A, B, Q
294	QA=QSIN (Q) QA=QCOS (Q)	$\lvert Q\rvert \ge 2^{100}$	$QA=\sqrt{2}/2$	A, B, Q
295	QA=QATAN2 (Q, QB)	Q=0, QB=0	QA=0	A, B, Q, QB
296	QA=QSINH (Q) QA=QCOSH (Q)	$\lvert Q\rvert \ge 175.366$	QA=•(SIGN Q) QA=•	A, B, Q
297	QA=QARSIN (Q)	|Q| > 1	If Q > 1.0, QARSIN=$\pi/2$ If Q < -1.0, QARSIN=$\pi/2$	A, B, Q A, B, Q
	QA=QARCOS (Q)		If Q > 1.0, QARCOS (Q)=0 If Q < -1.0, QARCOS (Q)=π	
298	QA=QTAN (Q) QA=QCOTAN (Q)	$\lvert Q\rvert > 2^{100}$	QA=1	A, B, Q
299	QA=QTAN (Q)	Q is too close to an odd multiple of $\pi/2$	QA=•	A, B, Q
	QA=QCOTAN (Q)	Q is too close to a multiple of π	QA=•	A, B, Q
300	DA=DGAMMA (D)	$D \le 2^{-252}$ or $D \ge 57.5774$	DA=•	A, B, D
301	DA=DLGAMA (D)	$D \le 0$ or $D \ge 4.2937\ 10^{73}$	DA=•	

Figure 55 (Part 3 of 3). Corrective Action after Mathematical Subroutine Error