IBM S/370 FLOATING POINT FORMAT

Short Floating-Point Number

```
 _____/_____
|S|Characteristic|  6-Digit Fraction  |
|_|_____|__/_____|
0 1              8                   31
```

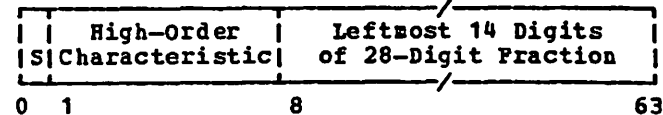Long Floating-Point Number

```
 _____/_____
|S|Characteristic|  14-Digit Fraction  |
|_|_____|__/_____|
0 1              8                   63
```
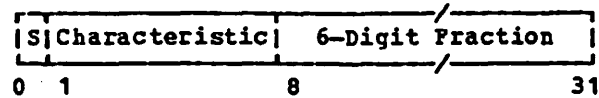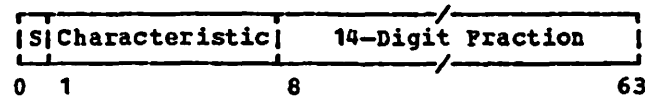
Extended Floating-Point Number

High-Order Part

```
 _____/_____
| |    High-Order    |  Leftmost 14 Digits  |
|S|Characteristic|  of 28-Digit Fraction  |
|_|_____|__/_____|
0 1              8                       63
```

Low-Order Part

```
 _____/_____
| |    Low-Order     |  Rightmost 14 Digits  |
|S|Characteristic|  of 28-Digit Fraction  |
|_|_____|__/_____|
64              72                     127
```
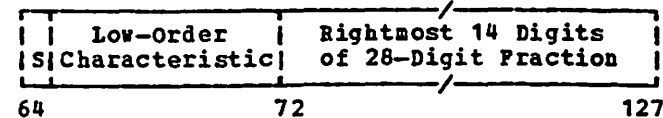
Normalized range: 16^{-65} to $(1 - \delta) \times 16^{63}$ or

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

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 1988

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	log₂(QA) × QB ≥ 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=log₁₀|X|	A, B, X
254	Y=COS (X) Y=SIN (X)	|X| ≥ (2^18)π	Y = √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| ≥ (2^18)π	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=log₁₀|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=√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=$\frac{\bullet}{2}$ (SIN X$_1$ + iCOS X$_1$)	A, B, CD
	Z=CDCOS (CD)		Z=$\frac{\bullet}{2}$ (COS X$_1$ − iSIN X$_1$)	A, B, CD
	Z=CDSIN (CD)	X$_2$ < - 174.673	Z=$\frac{\bullet}{2}$ (SIN X$_1$ − iCOS X$_1$)	A, B, CD
	Z=CDCOS (CD)		Z=$\frac{\bullet}{2}$ (COS X$_1$ + iSIN X$_1$)	A, B, CD
289	QA=QSQRT (Q)	Q < 0	QA=|Q|$^{1/2}$	A, B, Q
290	Y=GAMMA (X)	X ≤ 2^{-252} or X ≥ 57.5744	Y=•	A, B, X
291	Y=ALGAMA (X)	X ≤ 0 or X ≥ 4.2937 × 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$_{10}$|X|	A, B, Q A, B, Q
294	QA=QSIN (Q) QA=QCOS (Q)	|Q| ≥ 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)	|Q| ≥ 175.366	QA=•(SIGN Q) QA=•	A, B, Q
297	QA=QARSIN (Q)	|Q| > 1	If Q > 1.0, QARSIN=π/2 If Q < -1.0, QARSIN=π/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)	|Q| > 2^{100}	QA=1	A, B, Q
299	QA=QTAN (Q)	Q is too close to an odd multiple of π/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 ≤ 2^{-252} or D ≥ 57.5774	DA=•	A, B, D
301	DA=DLGAMA (D)	D ≤ 0 or D ≥ 4.2937 10^{73}	DA=•	

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