register 5.

4. ASN translation, which uses an ASN-first-table origin, bits 20-31 of control register 14.

5. ASN authorization.

6. DAS tracing.

7. The following instructions:

   EXTRACT PRIMARY ASN (EPAR)
   EXTRACT SECONDARY ASN (ESAR)
   INSERT ADDRESS SPACE CONTROL (IAC)
   INSERT VIRTUAL STORAGE KEY (IVSK)
   LOAD ADDRESS SPACE PARAMETERS (LASP)
   MOVE TO PRIMARY (MVCP)
   MOVE TO SECONDARY (MVCS)
   MOVE WITH KEY (MVKC)
   PROGRAM CALL (PC)
   PROGRAM TRANSFER (PT)
   SET ADDRESS SPACE CONTROL (SAC)
   SET SECONDARY ASN (SSAR)

8. Nine new exception or event conditions which result in a program interruption. These conditions are:

   AFX-translation exception
   ASN-translation-specification exception
   ASX-translation exception
   EX-translation exception
   LX-translation exception
   PC-translation-specification exception
   Primary-authority exception
   Secondary-authority exception
   Space-switch event

   For page- and segment-translation exceptions, a bit is stored with the translation-exception address. This bit indicates whether the address was translated by using the primary or secondary segment-table designation.

The following System/370 instructions are changed or affected by the installation of DAS, as noted:

- Execution of the SET PSW KEY FROM ADDRESS instruction is permitted in the problem state, subject to the contents of bit positions 0-15 of control register 3. When the bit in the control register corresponding to the PSW-key value to be set is one, execution is allowed; otherwise, a privileged-operation exception is recognized. The contents of control register 3 are ignored in the supervisor state.

- Execution of the INSERT PSW KEY instruction is permitted in the problem state when bit 4 of control register 0, the extraction-authority control, is one. When the bit is zero and the problem state is specified, the operation is suppressed, and a privileged-operation exception is recognized. The extraction-authority control is ignored in the supervisor state.

- LOAD REAL ADDRESS uses the contents of control register 7, instead of the contents of control register 1, when PSW bit 16 is one. Thus the second operand is translated either as a primary virtual address or as a secondary virtual address, depending on the mode specified in the PSW.

- The second-operand address of EXECUTE is defined to be an instruction address rather than a logical address. In secondary-space mode, it is thus unpredictable whether the target instruction is fetched from the primary space or the secondary space.

EXTENDED

Includes the instructions INVALIDATE PAGE TABLE ENTRY and TEST PROTECTION, the common-segment facility and the associated bit position in the segment-table entry, low-address protection and the associated control-register position for the low-address-protection control bit, and 12 MVS-dependent instructions. INVALIDATE PAGE TABLE ENTRY includes revisions to the READ DIRECT and WRITE DIRECT instructions to make the operand addresses real instead of logical.

EXTENDED-PRECISION FLOATING POINT

Includes the extended-precision floating-point instructions (listed in Appendix B).

EXTENDED REAL ADDRESSING

Provides for a 26-bit page-frame real address in the page-table entry for 4K-byte pages.

EXTERNAL SIGNALS

Includes the extension to external interruptions for external signals, the control-register position for the external-signal mask, and the means to accept external signals.

FAST RELEASE

Provides the start-I/O-fast-release (SIOF) function on the channel when the START I/O FAST RELEASE instruction is executed. This function provides for fast release of the CPU, which occurs before the device-selection procedure is completed, reducing the CPU delay associated with the initiation of the I/O operation. When the SIOF function is not implemented, START I/O FAST RELEASE is executed as START I/O.

FLOATING POINT

Includes the floating-point instructions (listed in Appendix B) and the floating-point registers. The floating-point facility, together with the commercial instruction set, is sometimes referred to as the universal instruction set.

HALT DEVICE

Provides the halt-device (HDV) function on a channel when the HALT DEVICE instruction is executed. When the HDV function is not implemented, HALT DEVICE is executed as HALT I/O.

I/O EXTENDED LOGOUT

Provides for the storing of detailed channel-error information in a storage area designed by a pointer.

LIMITED CHANNEL LOGOUT

Provides four bytes of channel-status information for model-independent recovery from channel errors.

MOVE INVERSE

Includes the MOVE INVERSE instruction.

MULTIPROCESSING

Includes the following facilities, which permit the formation of a multiprocessing configuration:

- Shared Main Storage
- Prefixing
- CPU-Address Identification
- CPU Signaling and Response
- TOD-Clock Synchronization

These facilities include four extensions to the external interruption (external call, emergency signal, TOD-clock-sync check, and malfunction alert), control-register positions for the TOD-clock-sync-control bit and for the masks for the four external-interruption conditions, and the instructions SET PREFIX, SIGNAL PROCESSOR, STORE CPU ADDRESS, and STORE PREFIX.

PSW-KEY HANDLING

Includes the instructions SET PSW KEY FROM ADDRESS and INSERT PSW KEY.

RECOVERY EXTENSIONS

Includes the following:

- Machine-check external-damage code at real locations 244-247, the external-damage-code-validity bit (bit 26 of the machine-check-interruption code), and the channel-not-operational indication in the machine-check external-damage code.
- The clear-channel (CLRCH) function in a channel when the CLEAR CHANNEL instruction is executed; when the CLRCH function is not implemented, CLEAR CHANNEL is executed as TEST CHANNEL.
- The logout-valid bit (bit 15) and the interface-inoperative bit (bit 27) in the limited channel logout.

SEGMENT PROTECTION

Provides a segment-protection bit in the segment-table entry. When the bit is one, an attempt to store in the segment causes a protection exception to be recognized.

SERVICE SIGNAL

Provides an external interruption which is used by the service processor to signal model-dependent information to the control program.

START-I/O-FAST QUEUING

Provides for fast release of the CPU by the channel during the execution of START I/O FAST RELEASE and the queuing of the operation at the subchannel when the control unit or device is busy rather than termination of the operation via an I/O interruption with a deferred-condition-code-1 indication. The queuing of the operation at the subchannel appears to the program as if no busy indication had been encountered. Includes the ability to store a nonzero value in the measurement byte at location 185.

STORAGE-KEY-INSTRUCTION EXTENSIONS

Provides the instructions INSERT STORAGE KEY EXTENDED, RESET REFERENCE BIT EXTENDED, and SET STORAGE KEY EXTENDED. These instructions provide 31-bit addresses and operate on the storage keys associated with a 4K-byte block of storage.

STORAGE-KEY 4K-BYTE BLOCK

Provides for a single key associated with each 4K-byte block of storage, and the storage-key-exception control, bit 7 of control register 0. When this facility is not installed, a separate storage key is associated with each 2K-byte block of storage.

SUSPEND AND RESUME

Provides a suspend bit in the CCW which may indicate that the channel program is to be suspended, as well as a bit in the CAW that controls whether the suspend bit should be examined and a new bit in the channel-status word which indicates that a channel program has been suspended. A new instruction, RESUME I/O, causes a suspended channel program to be resumed.

TEST BLOCK

Includes the TEST BLOCK instruction for testing the usability of a 4K-byte block of main storage.

TRANSLATION

Includes the following facilities:

- Dynamic Address Translation (DAT). The DAT facility includes the translation mechanism, with the associated control-register positions and program-interruption codes, and reference and change recording. Includes controls for 4K-byte and 2K-byte page size and 64K-byte and 1M-byte segment size.
- Program-Event Recording (PER). The PER facility includes the associated control-register positions and extensions to the program-interruption code.
- Extended-Control (EC) Mode.
- SSM Suppression. This facility includes the control-register position for the SSM-suppression-control bit and the program-interruption code for special operation.
- Store Status and Noninitializing Manual Reset.

As part of these facilities, the following instructions are provided: LOAD REAL ADDRESS, PURGE TLB, RESET REFERENCE BIT, STORE THEN AND SYSTEM MASK, and STORE THEN OR SYSTEM MASK.

On some models, no provision is made to include controls for the 1M-byte-segment size in dynamic address translation; in those models, controls are provided for the 4K-byte-page and 2K-byte-page size and 64K-byte-segment size. On some models, no provision is made for the 1M-byte-segment size or the 2K-byte-page size in dynamic address translation; in those models, control are provided only for the 4K-byte-page size and the 64K-byte-segment size.

31-BIT IDAWS

Extends the size of the address field in the indirect-data-address word to 31 bits.

AVAILABILITY OF FACILITIES

Facilities @	115	125	135	135-3	138	145	145-3	148	155	158	158-3
Commercial instruction set	S	S	S	S	S	S	S	S	S	S	S
Block-multiplexer channels	#	#	BL¢	BL¢	S	BL	S	S	S	S	S
Branch and save	–	–	–	–	–	–	–	–	–	–	–
Byte-multiplexer channels	BY¢	BY¢	S	S	S	S	S	S	S	S	S
Channel indirect data addressing	S	S	S	S	S	S	S	S	PQ	S	S
Channel-set switching	–	–	–	–	–	–	–	–	–	–	–
Clear I/O**	–	–	–	–	–	APS	S	S	PQ	S	S
Command retry	–	–	S	S	S	S	S	S	S	S	S
Conditional swapping	S	S	SW	S	S	SW	S	S	PQ	S	S
CPU timer and clock comparator	S	S	CK	S	S	CK	S	S	PQ	S	S
Direct control	–	–	DC	DC	DC	DC	DC	DC	DC	DC	DC
Dual address space	–	–	–	–	–	–	–	–	–	–	–
Extended	–	–	–	–	–	–	–	–	–	EF	EF
Extended-precision floating point	FXP	FXP	XP	S	S	FXP	S	S	XP	XP	XP
Extended real addressing	–	–	–	–	–	–	–	–	–	–	–
External signals	ES	ES	DC	DC	DC	DC	DC	DC	DC	DC	DC
Fast release**	–	–	–	–	–	–	–	–	–	–	–
Floating point	FP	FXP	FP	S	S	FXP	S	S	S	S	S
Halt device**	S	S	S	S	S	S	S	S	S	S	S
I/O extended logout	–	–	–	–	–	S	S	S	–	–	–
Limited channel logout	S	S	S	S	S	S	S	S	S	S	S
Move inverse	–	–	–	–	–	–	–	–	–	–	–
Multiprocessing	–	–	–	–	–	–	–	–	–	AMP	AMP
PSW-key handling	–	–	–	S	S	APS	S	S	PQ	S	S
Recovery extensions	–	–	–	–	–	–	–	–	–	–	–
Segment protection	–	–	–	–	–	–	–	–	–	–	–
Selector channels	¢	¢	SE¢	–	–	S	–	–	–	–	–
Service signal	–	–	–	–	–	–	–	–	–	–	–
Start-I/O-fast queuing	–	–	–	–	–	–	–	–	–	–	–
Storage-key-instruction extensions	–	–	–	–	–	–	–	–	–	–	–
Storage-key 4K-byte block	–	–	–	–	–	–	–	–	–	–	–
Suspend and resume	–	–	–	–	–	–	–	–	–	–	–
Test block	–	–	–	–	–	–	–	–	–	–	–
Translation	S	S	S	S	S	S	S	S	PQ	S	S
31-bit IDAWs	–	–	–	–	–	–	–	–	–	–	–

Availability of Facilities (Part 1 of 3)

Facilities @	165	168	168-3	195	3031	3032	3033	3081	3083	4321	4331	4341
Commercial instruction set	S*	S	S	S	S	S	S	S	S	S	S	S
Block-multiplexer channels	2880	2880	2880	2880	S	S	S	S	S	#	BLø	S
Branch and save	-	-	-	-	-	-	-	S	S	-	-	-
Byte-multiplexer channels	2870	2870	2870	2870	S	S	S	S	S	#	BL#	S
Channel indirect data addressing	A	A	A	-	S	S	S	S	S	S	S	S
Channel-set switching	-	-	-	-	-	-	CSS	S	S	-	-	-
Clear I/O**	PQ	B	B	-	S	S	S	S	S	S	S	S
Command retry	B	B	B	B	S	S	S	S	S	S	S	S
Conditional swapping	PQ	S	S	-	S	S	S	S	S	S	S	S
CPU timer and clock comparator	PQ	S	S	-	S	S	S	S	S	S	S	S
Direct control	S	S	S	S	DC	S	S	-	-	-	-	-
Dual address space	-	-	-	-	DAS[1]	-	33X	S	S	-	-	DAS[2]
Extended	-	EF	EF	-	S	S	S	S	S	-	-	ECP
Extended-precision floating point	S	S	S	S	S	S	S	S	S	S	S	S
Extended real addressing	-	-	-	-	-	-	EA	S	S	-	-	-
External signals	S	S	S	S	DC	S	S	-	-	-	ES	S
Fast release**	B	B	B	B	S	S	S	S	S	-	-	-
Floating point	S	S	S	S	S	S	S	S	S	S	S	S
Halt device**	B	B	B	B	S	S	S	S	S	S	S	S
I/O extended logout	B	B	B	B	S	S	S	S	S	-	-	-
Limited channel logout	-	-	-	-	S	S	S	S	S	S	S	S
Move inverse	-	-	-	-	-	-	-	-	-	S	S	S
Multiprocessing	-	MP	MP	-	MP	-	MP	S	&	-	-	-
PSW-key handling	PQ	S	S	-	S	S	S	S	S	S	S	S
Recovery extensions	-	-	-	-	S	S	S	S	S	-	-	-
Segment protection	-	-	-	-	-	-	-	S	S	-	-	-
Selector channels	2860	2860	2860	2860	-	-	-	-	-	-	-	-
Service signal	-	-	-	-	-	-	-	S	S	-	-	-
Start-I/O-fast queuing	-	-	-	-	-	-	33X	S	S	-	-	-
Storage-key-instruction extensions	-	-	-	-	-	-	EA	S	S	-	-	-
Storage-key 4K-byte block	-	-	-	-	-	-	4K[1]	4K[2]	4K	-	-	-
Suspend and resume	-	-	-	-	-	-	33X	S	S	-	-	-
Test block	-	-	-	-	-	-	-	S	S	-	-	-
Translation	PQ	S	S	-	S	S	S	S[1]	S[2]	S	S	S
31-bit IDAWs	-	-	-	-	-	-	EA	S	S	-	-	-

Availability of Facilities (Part 2 of 3)

Explanation:

A	Channel indirect data addressing is available as an option on the 2860, 2870, and 2880 channels.
APS	Advanced-control-program-support feature.
B	Facility is only available as a standard part of the 2880 channel.
BL	Block-multiplexer-channel feature.
BY	Byte-multiplexer-channel feature.
CK	CPU-timer and clock-comparator feature.
CSS	Channel-set-switching facility is provided along with the multiprocessing feature.
DAS[1]	Provided as an optional engineering change.
DAS[2]	Included as part of the ECPS:MVS feature.
DC	Direct-control feature.
EA	Extended-addressing feature.
ECP	Included, but without low-address protection, as part of the ECPS:MVS feature.
EF	System/370 extended feature.
ES	External-signal feature.
FP	Floating-point feature.
FXP	Floating-point and extended-precision floating-point feature.
MP	Multiprocessing or attached-processor feature.
PQ	These items are available for field installation only on purchased models.
S	Facility is standard.
S[1]	A modified translation facility is standard; that is, (1) only the 64K-byte segment size is provided and (2) only the 4K-byte page size is provided, except for 3081-D16, which provides both 2K-byte and 4K-byte page sizes.
S[2]	A modified translation facility is standard; that is, (1) only the 64K-byte segment size is provided and (2) only the 4K-byte page size is provided.
SE	Selector-channel feature.
SW	Conditional-swapping feature.
XP	Extended-precision floating-point feature.
-	Facility is not available, except that Requests for Price Quotation (RPQs) may provide the facility on some models.
&	A multiple-CPU configuration is not provided; however, prefixing, CPU-address identification, and CPU-signaling-and-response are standard. Shared main storage, TOD-clock synchronization, and malfunction alert are not provided.
#	These facilities are provided by standard integrated I/O adapters.
¢	These facilities are provided by optional integrated I/O adapters.
@	This table applies only to models operating in the System/370 mode.
*	The 165 includes MONITOR CALL only as part of the translation facility.
**	This facility provides the required function on the channel.
2860	Selector channel for models 165, 168, 168-3, and 195.
2870	Byte-multiplexer channel for models 165, 168, 168-3, and 195.
2880	Block-multiplexer channel for models 165, 168, 168-3, and 195.
33X	3033 extension feature.
4K	A single storage key is provided for each 4K-byte block.
4K[1]	A storage key is provided for each 2K-byte block, except for the 3033-U24 and 3033-A24; on those models, whether a storage key is provided for each 2K-byte block or for each 4K-byte block depends on the physical storage configuration.
4K[2]	A storage key is provided for each 4K-byte block, except the 3081-D16, which provides a storage key for each 2K-byte block.

Availability of Facilities (Part 3 of 3)

FACILITIES AND FEATURES NOT DESCRIBED IN THE PRINCIPLES OF OPERATION

The following additional facilities and features are available on some models. Included with each entry are references indicating where additional information can be found on the subject.

APL Assist

"An APL Emulator on System/370," A. Hassitt and L. E. Lyon, IBM Systems Journal, Volume 15, Number 4, 1976. Article available in reprint, G321-5041.

Data Streaming

System/360 and System/370 Channel to Control Unit I/O Interface OEMI, GA22-6974.

ECPS:MVS (MVS-Dependent Instructions)

Those MVS-dependent instructions that are part of the ECPS:MVS facility are described in Assists for MVS, GA22-7079.

ECPS:VM/370

IBM Virtual Machine Facility/370: System Programmer's Guide, GC20-1807

IBM Virtual Machine Facility/370: System Logic and Problem Determination Guide, Volume 1, Appendix A, SY20-0886

ECPS:VS1

IBM OS/VS1 Supervisor Logic, SY24-5155, and IBM OS/VS1 I/O Supervisor Logic, SY24-5156

Extended Facility (MVS-Dependent Instructions)

Those MVS-dependent instructions that are part of the extended facility are described in Assists for MVS, GA22-7079.

OS/DOS Compatibility

DOS to OS/VS Emulation: Logic, Prog. No. 5744-AS1, SY33-7015

Shadow-Table-Bypass Assist

IBM Virtual-Machine Assist and Shadow-Table-Bypass Assist, GA22-7074

Virtual-Machine Assist (VMA)

IBM Virtual-Machine Assist and Shadow-Table-Bypass Assist, GA22-7074

3033 Extension Feature (MVS-Dependent Instructions)

Those MVS-dependent instructions that are part of the 3033 extension feature are described in Assists for MVS, GA22-7079.

APPENDIX E. TABLE OF POWERS OF 2

PLUS		*MINUS*
1	0	1.0
2	1	0.5
4	2	0.25
8	3	0.125
16	4	0.0625
32	5	0.03125
64	6	0.01562 5
128	7	0.00781 25
256	8	0.00390 625
512	9	0.00195 3125
1,024	10	0.00097 65625
2,048	11	0.00048 82812 5
4,096	12	0.00024 41406 25
8,192	13	0.00012 20703 125
16,384	14	0.00006 10351 5625
32,768	15	0.00003 05175 78125
65,536	16	0.00001 52587 89062 5
131,072	17	0.00000 76293 94531 25
262,144	18	0.00000 38146 97265 625
524,288	19	0.00000 19073 48632 8125
1,048,576	20	0.00000 09536 74316 40625
2,097,152	21	0.00000 04768 37158 20312 5
4,194,304	22	0.00000 02384 18579 10156 25
8,388,608	23	0.00000 01192 09289 55078 125
16,777,216	24	0.00000 00596 04644 77539 0625
33,554,432	25	0.00000 00298 02322 38769 53125
67,108,864	26	0.00000 00149 01161 19384 76562 5
134,217,728	27	0.00000 00074 50580 59692 38281 25
268,435,456	28	0.00000 00037 25290 29846 19140 625
536,870,912	29	0.00000 00018 62645 14923 09570 3125
1,073,741,824	30	0.00000 00009 31322 57461 54785 15625
2,147,483,648	31	0.00000 00004 65661 28730 77392 57812 5
4,294,967,296	32	0.00000 00002 32830 64365 38696 28906 25
8,589,934,592	33	0.00000 00001 16415 32182 69348 14453 125
17,179,869,184	34	0.00000 00000 58207 66091 34674 07226 5625
34,359,738,368	35	0.00000 00000 29103 83045 67337 03613 28125
68,719,476,736	36	0.00000 00000 14551 91522 83668 51806 64062 5
137,438,953,472	37	0.00000 00000 07275 95761 41834 25903 32031 25
274,877,906,944	38	0.00000 00000 03637 97880 70917 12951 66015 625
549,755,813,888	39	0.00000 00000 01818 98940 35458 56475 83007 8125
1,099,511,627,776	40	0.00000 00000 00909 49470 17729 28237 91503 90625
2,199,023,255,552	41	0.00000 00000 00454 74735 08864 64118 95751 95312 5
4,398,046,511,104	42	0.00000 00000 00227 37367 54432 32059 47875 97656 25
8,796,093,022,208	43	0.00000 00000 00113 68683 77216 16029 73937 98828 125
17,592,186,044,416	44	0.00000 00000 00056 84341 88608 08014 86968 99414 0625
35,184,372,088,832	45	0.00000 00000 00028 42170 94304 04007 43484 49707 03125
70,368,744,177,664	46	0.00000 00000 00014 21085 47152 02003 71742 24853 51562 5
140,737,488,355,328	47	0.00000 00000 00007 10542 73576 01001 85871 12426 75781 25
281,474,976,710,656	48	0.00000 00000 00003 55271 36788 00500 92935 56213 37890 625
562,949,953,421,312	49	0.00000 00000 00001 77635 68394 00250 46467 78106 68945 3125
1,125,899,906,842,624	50	0.00000 00000 00000 88817 84197 00125 23233 89053 34472 65625
2,251,799,813,685,248	51	0.00000 00000 00000 44408 92098 50062 61616 94526 67236 32812 5
4,503,599,627,370,496	52	0.00000 00000 00000 22204 46049 25031 30808 47263 33618 16406 25
9,007,199,254,740,992	53	0.00000 00000 00000 11102 23024 62515 65404 23631 66809 08203 125
18,014,398,509,481,984	54	0.00000 00000 00000 05551 11512 31257 82702 11815 83404 54101 5625
36,028,797,018,963,968	55	0.00000 00000 00000 02775 55756 15628 91351 05907 91702 27050 78125
72,057,594,037,927,936	56	0.00000 00000 00000 01387 77878 07814 45675 52953 95851 13525 39062 5
144,115,188,075,855,872	57	0.00000 00000 00000 00693 88939 03907 22837 76476 97925 56762 69531 25
288,230,376,151,711,744	58	0.00000 00000 00000 00346 94469 51953 61418 88238 48962 78381 34765 625
576,460,752,303,423,488	59	0.00000 00000 00000 00173 47234 75976 80709 44119 24481 39190 67382 8125
1,152,921,504,606,846,976	60	0.00000 00000 00000 00086 73617 37988 40354 72059 62240 69595 33691 40625
2,305,843,009,213,693,952	61	0.00000 00000 00000 00043 36808 68994 20177 36029 81120 34797 66845 70312 5
4,611,686,018,427,387,904	62	0.00000 00000 00000 00021 68404 34497 10088 68014 90560 17398 83422 85156 25
9,223,372,036,854,775,808	63	0.00000 00000 00000 00010 84202 17248 55044 34007 45280 08699 41711 42578 125
18,446,744,073,709,551,616	64	0.00000 00000 00000 00005 42101 08624 27522 17003 72640 04349 70855 71289 0625

Powers of 2 (Part 1 of 2)

18,446,744,073,709,551,616	64
36,893,488,147,419,103,232	65
73,786,976,294,838,206,464	66
147,573,952,589,676,412,928	67
295,147,905,179,352,825,856	68
590,295,810,358,705,651,712	69
1,180,591,620,717,411,303,424	70
2,361,183,241,434,822,606,848	71
4,722,366,482,869,645,213,696	72
9,444,732,965,739,290,427,392	73
18,889,465,931,478,580,854,784	74
37,778,931,862,957,161,709,568	75
75,557,863,725,914,323,419,136	76
151,115,727,451,828,646,838,272	77
302,231,454,903,657,293,676,544	78
604,462,909,807,314,587,353,088	79
1,208,925,819,614,629,174,706,176	80
2,417,851,639,229,258,349,412,352	81
4,835,703,278,458,516,698,824,704	82
9,671,406,556,917,033,397,649,408	83
19,342,813,113,834,066,795,298,816	84
38,685,626,227,668,133,590,597,632	85
77,371,252,455,336,267,181,195,264	86
154,742,504,910,672,534,362,390,528	87
309,485,009,821,345,068,724,781,056	88
618,970,019,642,690,137,449,562,112	89
1,237,940,039,285,380,274,899,124,224	90
2,475,880,078,570,760,549,798,248,448	91
4,951,760,157,141,521,099,596,496,896	92
9,903,520,314,283,042,199,192,993,792	93
19,807,040,628,566,084,398,385,987,584	94
39,614,081,257,132,168,796,771,975,168	95
79,228,162,514,264,337,593,543,950,336	96
158,456,325,028,528,675,187,087,900,672	97
316,912,650,057,057,350,374,175,801,344	98
633,825,300,114,114,700,748,351,602,688	99
1,267,650,600,228,229,401,496,703,205,376	100
2,535,301,200,456,458,802,993,406,410,752	101
5,070,602,400,912,917,605,986,812,821,504	102
10,141,204,801,825,835,211,973,625,643,008	103
20,282,409,603,651,670,423,947,251,286,016	104
40,564,819,207,303,340,847,894,502,572,032	105
81,129,638,414,606,681,695,789,005,144,064	106
162,259,276,829,213,363,391,578,010,288,128	107
324,518,553,658,426,726,783,156,020,576,256	108
649,037,107,316,853,453,566,312,041,152,512	109
1,298,074,214,633,706,907,132,624,082,305,024	110
2,596,148,429,267,413,814,265,248,164,610,048	111
5,192,296,858,534,827,628,530,496,329,220,096	112
10,384,593,717,069,655,257,060,992,658,440,192	113
20,769,187,434,139,310,514,121,985,316,880,384	114
41,538,374,868,278,621,028,243,970,633,760,768	115
83,076,749,736,557,242,056,487,941,267,521,536	116
166,153,499,473,114,484,112,975,882,535,043,072	117
332,306,998,946,228,968,225,951,765,070,086,144	118
664,613,997,892,457,936,451,903,530,140,172,288	119
1,329,227,995,784,915,872,903,807,060,280,344,576	120
2,658,455,991,569,831,745,807,614,120,560,689,152	121
5,316,911,983,139,663,491,615,228,241,121,378,304	122
10,633,823,966,279,326,983,230,456,482,242,756,608	123
21,267,647,932,558,653,966,460,912,964,485,513,216	124
42,535,295,865,117,307,932,921,825,928,971,026,432	125
85,070,591,730,234,615,865,843,651,857,942,052,864	126
170,141,183,460,469,231,731,687,303,715,884,105,728	127
340,282,366,920,938,463,463,374,607,431,768,211,456	128

Powers of 2 (Part 2 of 2)

The following tables aid in converting hexadecimal values to decimal values, or the reverse.

Direct Conversion Table

This table provides direct conversion of decimal and hexadecimal numbers in these ranges:

Hexadecimal	Decimal
000 to FFF	0000 to 4095

To convert numbers outside these ranges, and to convert fractions, use the hexadecimal and decimal conversion tables that follow the direct conversion table in this Appendix.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00_	0000	0001	0002	0003	0004	0005	0006	0007	0008	0009	0010	0011	0012	0013	0014	0015
01_	0016	0017	0018	0019	0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031
02_	0032	0033	0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047
03_	0048	0049	0050	0051	0052	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063
04_	0064	0065	0066	0067	0068	0069	0070	0071	0072	0073	0074	0075	0076	0077	0078	0079
05_	0080	0081	0082	0083	0084	0085	0086	0087	0088	0089	0090	0091	0092	0093	0094	0095
06_	0096	0097	0098	0099	0100	0101	0102	0103	0104	0105	0106	0107	0108	0109	0110	0111
07_	0112	0113	0114	0115	0116	0117	0118	0119	0120	0121	0122	0123	0124	0125	0126	0127
08_	0128	0129	0130	0131	0132	0133	0134	0135	0136	0137	0138	0139	0140	0141	0142	0143
09_	0144	0145	0146	0147	0148	0149	0150	0151	0152	0153	0154	0155	0156	0157	0158	0159
0A_	0160	0161	0162	0163	0164	0165	0166	0167	0168	0169	0170	0171	0172	0173	0174	0175
0B_	0176	0177	0178	0179	0180	0181	0182	0183	0184	0185	0186	0187	0188	0189	0190	0191
0C_	0192	0193	0194	0195	0196	0197	0198	0199	0200	0201	0202	0203	0204	0205	0206	0207
0D_	0208	0209	0210	0211	0212	0213	0214	0215	0216	0217	0218	0219	0220	0221	0222	0223
0E_	0224	0225	0226	0227	0228	0229	0230	0231	0232	0233	0234	0235	0236	0237	0238	0239
0F_	0240	0241	0242	0243	0244	0245	0246	0247	0248	0249	0250	0251	0252	0253	0254	0255
10_	0256	0257	0258	0259	0260	0261	0262	0263	0264	0265	0266	0267	0268	0269	0270	0271
11_	0272	0273	0274	0275	0276	0277	0278	0279	0280	0281	0282	0283	0284	0285	0286	0287
12_	0288	0289	0290	0291	0292	0293	0294	0295	0296	0297	0298	0299	0300	0301	0302	0303
13_	0304	0305	0306	0307	0308	0309	0310	0311	0312	0313	0314	0315	0316	0317	0318	0319
14_	0320	0321	0322	0323	0324	0325	0326	0327	0328	0329	0330	0331	0332	0333	0334	0335
15_	0336	0337	0338	0339	0340	0341	0342	0343	0344	0345	0346	0347	0348	0349	0350	0351
16_	0352	0353	0354	0355	0356	0357	0358	0359	0360	0361	0362	0363	0364	0365	0366	0367
17_	0368	0369	0370	0371	0372	0373	0374	0375	0376	0377	0378	0379	0380	0381	0382	0383
18_	0384	0385	0386	0387	0388	0389	0390	0391	0392	0393	0394	0395	0396	0397	0398	0399
19_	0400	0401	0402	0403	0404	0405	0406	0407	0408	0409	0410	0411	0412	0413	0414	0415
1A_	0416	0417	0418	0419	0420	0421	0422	0423	0424	0425	0426	0427	0428	0429	0430	0431
1B_	0432	0433	0434	0435	0436	0437	0438	0439	0440	0441	0442	0443	0444	0445	0446	0447
1C_	0448	0449	0450	0451	0452	0453	0454	0455	0456	0457	0458	0459	0460	0461	0462	0463
1D_	0464	0465	0466	0467	0468	0469	0470	0471	0472	0473	0474	0475	0476	0477	0478	0479
1E_	0480	0481	0482	0483	0484	0485	0486	0487	0488	0489	0490	0491	0492	0493	0494	0495
1F_	0496	0497	0498	0499	0500	0501	0502	0503	0504	0505	0506	0507	0508	0509	0510	0511

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
20_	0512	0513	0514	0515	0516	0517	0518	0519	0520	0521	0522	0523	0524	0525	0526	0527
21_	0528	0529	0530	0531	0532	0533	0534	0535	0536	0537	0538	0539	0540	0541	0542	0543
22_	0544	0545	0546	0547	0548	0549	0550	0551	0552	0553	0554	0555	0556	0557	0558	0559
23_	0560	0561	0562	0563	0564	0565	0566	0567	0568	0569	0570	0571	0572	0573	0574	0575
24_	0576	0577	0578	0579	0580	0581	0582	0583	0584	0585	0586	0587	0588	0589	0590	0591
25_	0592	0593	0594	0595	0596	0597	0598	0599	0600	0601	0602	0603	0604	0605	0606	0607
26_	0608	0609	0610	0611	0612	0613	0614	0615	0616	0617	0618	0619	0620	0621	0622	0623
27_	0624	0625	0626	0627	0628	0629	0630	0631	0632	0633	0634	0635	0636	0637	0638	0639
28_	0640	0641	0642	0643	0644	0645	0646	0647	0648	0649	0650	0651	0652	0653	0654	0655
29_	0656	0657	0658	0659	0660	0661	0662	0663	0664	0665	0666	0667	0668	0669	0670	0671
2A_	0672	0673	0674	0675	0676	0677	0678	0679	0680	0681	0682	0683	0684	0685	0686	0687
2B_	0688	0689	0690	0691	0692	0693	0694	0695	0696	0697	0698	0699	0700	0701	0702	0703
2C_	0704	0705	0706	0707	0708	0709	0710	0711	0712	0713	0714	0715	0716	0717	0718	0719
2D_	0720	0721	0722	0723	0724	0725	0726	0727	0728	0729	0730	0731	0732	0733	0734	0735
2E_	0736	0737	0738	0739	0740	0741	0742	0743	0744	0745	0746	0747	0748	0749	0750	0751
2F_	0752	0753	0754	0755	0756	0757	0758	0759	0760	0761	0762	0763	0764	0765	0766	0767
30_	0768	0769	0770	0771	0772	0773	0774	0775	0776	0777	0778	0779	0780	0781	0782	0783
31_	0784	0785	0786	0787	0788	0789	0790	0791	0792	0793	0794	0795	0796	0797	0798	0799
32_	0800	0801	0802	0803	0804	0805	0806	0807	0808	0809	0810	0811	0812	0813	0814	0815
33_	0816	0817	0818	0819	0820	0821	0822	0823	0824	0825	0826	0827	0828	0829	0830	0831
34_	0832	0833	0834	0835	0836	0837	0838	0839	0840	0841	0842	0843	0844	0845	0846	0847
35_	0848	0849	0850	0851	0852	0853	0854	0855	0856	0857	0858	0859	0860	0861	0862	0863
36_	0864	0865	0866	0867	0868	0869	0870	0871	0872	0873	0874	0875	0876	0877	0878	0879
37_	0880	0881	0882	0883	0884	0885	0886	0887	0888	0889	0890	0891	0892	0893	0894	0895
38_	0896	0897	0898	0899	0900	0901	0902	0903	0904	0905	0906	0907	0908	0909	0910	0911
39_	0912	0913	0914	0915	0916	0917	0918	0919	0920	0921	0922	0923	0924	0925	0926	0927
3A_	0928	0929	0930	0931	0932	0933	0934	0935	0936	0937	0938	0939	0940	0941	0942	0943
3B_	0944	0945	0946	0947	0948	0949	0950	0951	0952	0953	0954	0955	0956	0957	0958	0959
3C_	0960	0961	0962	0963	0964	0965	0966	0967	0968	0969	0970	0971	0972	0973	0974	0975
3D_	0976	0977	0978	0979	0980	0981	0982	0983	0984	0985	0986	0987	0988	0989	0990	0991
3E_	0992	0993	0994	0995	0996	0997	0998	0999	1000	1001	1002	1003	1004	1005	1006	1007
3F_	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
40_	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039
41_	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055
42_	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071
43_	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087
44_	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103
45_	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119
46_	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135
47_	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151
48_	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167
49_	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183
4A_	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199
4B_	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215
4C_	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231
4D_	1232	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247
4E_	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263
4F_	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279
50_	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295
51_	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311
52_	1312	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327
53_	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339	1340	1341	1342	1343
54_	1344	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357	1358	1359
55_	1360	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375
56_	1376	1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390	1391
57_	1392	1393	1394	1395	1396	1397	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407
58_	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419	1420	1421	1422	1423
59_	1424	1425	1426	1427	1428	1429	1430	1431	1432	1433	1434	1435	1436	1437	1438	1439
5A_	1440	1441	1442	1443	1444	1445	1446	1447	1448	1449	1450	1451	1452	1453	1454	1455
5B_	1456	1457	1458	1459	1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471
5C_	1472	1473	1474	1475	1476	1477	1478	1479	1480	1481	1482	1483	1484	1485	1486	1487
5D_	1488	1489	1490	1491	1492	1493	1494	1495	1496	1497	1498	1499	1500	1501	1502	1503
5E_	1504	1505	1506	1507	1508	1509	1510	1511	1512	1513	1514	1515	1516	1517	1518	1519
5F_	1520	1521	1522	1523	1524	1525	1526	1527	1528	1529	1530	1531	1532	1533	1534	1535

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
60_	1536	1537	1538	1539	1540	1541	1542	1543	1544	1545	1546	1547	1548	1549	1550	1551
61_	1552	1553	1554	1555	1556	1557	1558	1559	1560	1561	1562	1563	1564	1565	1566	1567
62_	1568	1569	1570	1571	1572	1573	1574	1575	1576	1577	1578	1579	1580	1581	1582	1583
63_	1584	1585	1586	1587	1588	1589	1590	1591	1592	1593	1594	1595	1596	1597	1598	1599
64_	1600	1601	1602	1603	1604	1605	1606	1607	1608	1609	1610	1611	1612	1613	1614	1615
65_	1616	1617	1618	1619	1620	1621	1622	1623	1624	1625	1626	1627	1628	1629	1630	1631
66_	1632	1633	1634	1635	1636	1637	1638	1639	1640	1641	1642	1643	1644	1645	1646	1647
67_	1648	1649	1650	1651	1652	1653	1654	1655	1656	1657	1658	1659	1660	1661	1662	1663
68_	1664	1665	1666	1667	1668	1669	1670	1671	1672	1673	1674	1675	1676	1677	1678	1679
69_	1680	1681	1682	1683	1684	1685	1686	1687	1688	1689	1690	1691	1692	1693	1694	1695
6A_	1696	1697	1698	1699	1700	1701	1702	1703	1704	1705	1706	1707	1708	1709	1710	1711
6B_	1712	1713	1714	1715	1716	1717	1718	1719	1720	1721	1722	1723	1724	1725	1726	1727
6C_	1728	1729	1730	1731	1732	1733	1734	1735	1736	1737	1738	1739	1740	1741	1742	1743
6D_	1744	1745	1746	1747	1748	1749	1750	1751	1752	1753	1754	1755	1756	1757	1758	1759
6E_	1760	1761	1762	1763	1764	1765	1766	1767	1768	1769	1770	1771	1772	1773	1774	1775
6F_	1776	1777	1778	1779	1780	1781	1782	1783	1784	1785	1786	1787	1788	1789	1790	1791
70_	1792	1793	1794	1795	1796	1797	1798	1799	1800	1801	1802	1803	1804	1805	1806	1807
71_	1808	1809	1810	1811	1812	1813	1814	1815	1816	1817	1818	1819	1820	1821	1822	1823
72_	1824	1825	1826	1827	1828	1829	1830	1831	1832	1833	1834	1835	1836	1837	1838	1839
73_	1840	1841	1842	1843	1844	1845	1846	1847	1848	1849	1850	1851	1852	1853	1854	1855
74_	1856	1857	1858	1859	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871
75_	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887
76_	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903
77_	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
78_	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935
79_	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951
7A_	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
7B_	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
7C_	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
7D_	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
7E_	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
7F_	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
80_	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063
81_	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079
82_	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095
83_	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111
84_	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127
85_	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143
86_	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159
87_	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175
88_	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191
89_	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207
8A_	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223
8B_	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239
8C_	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255
8D_	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271
8E_	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287
8F_	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303
90_	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319
91_	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335
92_	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351
93_	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367
94_	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383
95_	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399
96_	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415
97_	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431
98_	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447
99_	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463
9A_	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479
9B_	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495
9C_	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511
9D_	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527
9E_	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543
9F_	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
A0_	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575
A1_	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591
A2_	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607
A3_	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623
A4_	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639
A5_	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655
A6_	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671
A7_	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687
A8_	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703
A9_	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719
AA_	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735
AB_	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751
AC_	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767
AD_	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783
AE_	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799
AF_	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815
B0_	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831
B1_	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847
B2_	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863
B3_	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879
B4_	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895
B5_	2896	2897	2898	2899	2900	2901	2902	2903	2904	2905	2906	2907	2908	2909	2910	2911
B6_	2912	2913	2914	2915	2916	2917	2918	2919	2920	2921	2922	2923	2924	2925	2926	2927
B7_	2928	2929	2930	2931	2932	2933	2934	2935	2936	2937	2938	2939	2940	2941	2942	2943
B8_	2944	2945	2946	2947	2948	2949	2950	2951	2952	2953	2954	2955	2956	2957	2958	2959
B9_	2960	2961	2962	2963	2964	2965	2966	2967	2968	2969	2970	2971	2972	2973	2974	2975
BA_	2976	2977	2978	2979	2980	2981	2982	2983	2984	2985	2986	2987	2988	2989	2990	2991
BB_	2992	2993	2994	2995	2996	2997	2998	2999	3000	3001	3002	3003	3004	3005	3006	3007
BC_	3008	3009	3010	3011	3012	3013	3014	3015	3016	3017	3018	3019	3020	3021	3022	3023
BD_	3024	3025	3026	3027	3028	3029	3030	3031	3032	3033	3034	3035	3036	3037	3038	3039
BE_	3040	3041	3042	3043	3044	3045	3046	3047	3048	3049	3050	3051	3052	3053	3054	3055
BF_	3056	3057	3058	3059	3060	3061	3062	3063	3064	3065	3066	3067	3068	3069	3070	3071

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
C0_	3072	3073	3074	3075	3076	3077	3078	3079	3080	3081	3082	3083	3084	3085	3086	3087
C1_	3088	3089	3090	3091	3092	3093	3094	3095	3096	3097	3098	3099	3100	3101	3102	3103
C2_	3104	3105	3106	3107	3108	3109	3110	3111	3112	3113	3114	3115	3116	3117	3118	3119
C3_	3120	3121	3122	3123	3124	3125	3126	3127	3128	3129	3130	3131	3132	3133	3134	3135
C4_	3136	3137	3138	3139	3140	3141	3142	3143	3144	3145	3146	3147	3148	3149	3150	3151
C5_	3152	3153	3154	3155	3156	3157	3158	3159	3160	3161	3162	3163	3164	3165	3166	3167
C6_	3168	3169	3170	3171	3172	3173	3174	3175	3176	3177	3178	3179	3180	3181	3182	3183
C7_	3184	3185	3186	3187	3188	3189	3190	3191	3192	3193	3194	3195	3196	3197	3198	3199
C8_	3200	3201	3202	3203	3204	3205	3206	3207	3208	3209	3210	3211	3212	3213	3214	3215
C9_	3216	3217	3218	3219	3220	3221	3222	3223	3224	3225	3226	3227	3228	3229	3230	3231
CA_	3232	3233	3234	3235	3236	3237	3238	3239	3240	3241	3242	3243	3244	3245	3246	3247
CB_	3248	3249	3250	3251	3252	3253	3254	3255	3256	3257	3258	3259	3260	3261	3262	3263
CC_	3264	3265	3266	3267	3268	3269	3270	3271	3272	3273	3274	3275	3276	3277	3278	3279
CD_	3280	3281	3282	3283	3284	3285	3286	3287	3288	3289	3290	3291	3292	3293	3294	3295
CE_	3296	3297	3298	3299	3300	3301	3302	3303	3304	3305	3306	3307	3308	3309	3310	3311
CF_	3312	3313	3314	3315	3316	3317	3318	3319	3320	3321	3322	3323	3324	3325	3326	3327
D0_	3328	3329	3330	3331	3332	3333	3334	3335	3336	3337	3338	3339	3340	3341	3342	3343
D1_	3344	3345	3346	3347	3348	3349	3350	3351	3352	3353	3354	3355	3356	3357	3358	3359
D2_	3360	3361	3362	3363	3364	3365	3366	3367	3368	3369	3370	3371	3372	3373	3374	3375
D3_	3376	3377	3378	3379	3380	3381	3382	3383	3384	3385	3386	3387	3388	3389	3390	3391
D4_	3392	3393	3394	3395	3396	3397	3398	3399	3400	3401	3402	3403	3404	3405	3406	3407
D5_	3408	3409	3410	3411	3412	3413	3414	3415	3416	3417	3418	3419	3420	3421	3422	3423
D6_	3424	3425	3426	3427	3428	3429	3430	3431	3432	3433	3434	3435	3436	3437	3438	3439
D7_	3440	3441	3442	3443	3444	3445	3446	3447	3448	3449	3450	3451	3452	3453	3454	3455
D8_	3456	3457	3458	3459	3460	3461	3462	3463	3464	3465	3466	3467	3468	3469	3470	3471
D9_	3472	3473	3474	3475	3476	3477	3478	3479	3480	3481	3482	3483	3484	3485	3486	3487
DA_	3488	3489	3490	3491	3492	3493	3494	3495	3496	3497	3498	3499	3500	3501	3502	3503
DB_	3504	3505	3506	3507	3508	3509	3510	3511	3512	3513	3514	3515	3516	3517	3518	3519
DC_	3520	3521	3522	3523	3524	3525	3526	3527	3528	3529	3530	3531	3532	3533	3534	3535
DD_	3536	3537	3538	3539	3540	3541	3542	3543	3544	3545	3546	3547	3548	3549	3550	3551
DE_	3552	3553	3554	3555	3556	3557	3558	3559	3560	3561	3562	3563	3564	3565	3566	3567
DF_	3568	3569	3570	3571	3572	3573	3574	3575	3576	3577	3578	3579	3580	3581	3582	3583

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
E0_	3584	3585	3586	3587	3588	3589	3590	3591	3592	3593	3594	3595	3596	3597	3598	3599
E1_	3600	3601	3602	3603	3604	3605	3606	3607	3608	3609	3610	3611	3612	3613	3614	3615
E2_	3616	3617	3618	3619	3620	3621	3622	3623	3624	3625	3626	3627	3628	3629	3630	3631
E3_	3632	3633	3634	3635	3636	3637	3638	3639	3640	3641	3642	3643	3644	3645	3646	3647
E4_	3648	3649	3650	3651	3652	3653	3654	3655	3656	3657	3658	3659	3660	3661	3662	3663
E5_	3664	3665	3666	3667	3668	3669	3670	3671	3672	3673	3674	3675	3676	3677	3678	3679
E6_	3680	3681	3682	3683	3684	3685	3686	3687	3688	3689	3690	3691	3692	3693	3694	3695
E7_	3696	3697	3698	3699	3700	3701	3702	3703	3704	3705	3706	3707	3708	3709	3710	3711
E8_	3712	3713	3714	3715	3716	3717	3718	3719	3720	3721	3722	3723	3724	3725	3726	3727
E9_	3728	3729	3730	3731	3732	3733	3734	3735	3736	3737	3738	3739	3740	3741	3742	3743
EA_	3744	3745	3746	3747	3748	3749	3750	3751	3752	3753	3754	3755	3756	3757	3758	3759
EB_	3760	3761	3762	3763	3764	3765	3766	3767	3768	3769	3770	3771	3772	3773	3774	3775
EC_	3776	3777	3778	3779	3780	3781	3782	3783	3784	3785	3786	3787	3788	3789	3790	3791
ED_	3792	3793	3794	3795	3796	3797	3798	3799	3800	3801	3802	3803	3804	3805	3806	3807
EE_	3808	3809	3810	3811	3812	3813	3814	3815	3816	3817	3818	3819	3820	3821	3822	3823
EF_	3824	3825	3826	3827	3828	3829	3830	3831	3832	3833	3834	3835	3836	3837	3838	3839
F0_	3840	3841	3842	3843	3844	3845	3846	3847	3848	3849	3850	3851	3852	3853	3854	3855
F1_	3856	3857	3858	3859	3860	3861	3862	3863	3864	3865	3866	3867	3868	3869	3870	3871
F2_	3872	3873	3874	3875	3876	3877	3878	3879	3880	3881	3882	3883	3884	3885	3886	3887
F3_	3888	3889	3890	3891	3892	3893	3894	3895	3896	3897	3898	3899	3900	3901	3902	3903
F4_	3904	3905	3906	3907	3908	3909	3910	3911	3912	3913	3914	3915	3916	3917	3918	3919
F5_	3920	3921	3922	3923	3924	3925	3926	3927	3928	3929	3930	3931	3932	3933	3934	3935
F6_	3936	3937	3938	3939	3940	3941	3942	3943	3944	3945	3946	3947	3948	3949	3950	3951
F7_	3952	3953	3954	3955	3956	3957	3958	3959	3960	3961	3962	3963	3964	3965	3966	3967
F8_	3968	3969	3970	3971	3972	3973	3974	3975	3976	3977	3978	3979	3980	3981	3982	3983
F9_	3984	3985	3986	3987	3988	3989	3990	3991	3992	3993	3994	3995	3996	3997	3998	3999
FA_	4000	4001	4002	4003	4004	4005	4006	4007	4008	4009	4010	4011	4012	4013	4014	4015
FB_	4016	4017	4018	4019	4020	4021	4022	4023	4024	4025	4026	4027	4028	4029	4030	4031
FC_	4032	4033	4034	4035	4036	4037	4038	4039	4040	4041	4042	4043	4044	4045	4046	4047
FD_	4048	4049	4050	4051	4052	4053	4054	4055	4056	4057	4058	4059	4060	4061	4062	4063
FE_	4064	4065	4066	4067	4068	4069	4070	4071	4072	4073	4074	4075	4076	4077	4078	4079
FF_	4080	4081	4082	4083	4084	4085	4086	4087	4088	4089	4090	4091	4092	4093	4094	4095

Conversion Table: Hexadecimal and Decimal Integers

HALFWORD								HALFWORD							
BYTE				BYTE				BYTE				BYTE			
BITS: 0123		4567		0123		4567		0123		4567		0123		4567	
Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	268,435,456	1	16,777,216	1	1,048,576	1	65,536	1	4,096	1	256	1	16	1	1
2	536,870,912	2	33,554,432	2	2,097,152	2	131,072	2	8,192	2	512	2	32	2	2
3	805,306,368	3	50,331,648	3	3,145,728	3	196,608	3	12,288	3	768	3	48	3	3
4	1,073,741,824	4	67,108,864	4	4,194,304	4	262,144	4	16,384	4	1,024	4	64	4	4
5	1,342,177,280	5	83,886,080	5	5,242,880	5	327,680	5	20,480	5	1,280	5	80	5	5
6	1,610,612,736	6	100,663,296	6	6,291,456	6	393,216	6	24,576	6	1,536	6	96	6	6
7	1,879,048,192	7	117,440,512	7	7,340,032	7	458,752	7	28,672	7	1,792	7	112	7	7
8	2,147,483,648	8	134,217,728	8	8,388,608	8	524,288	8	32,768	8	2,048	8	128	8	8
9	2,415,919,104	9	150,994,944	9	9,437,184	9	589,824	9	36,864	9	2,304	9	144	9	9
A	2,684,354,560	A	167,772,160	A	10,485,760	A	655,360	A	40,960	A	2,560	A	160	A	10
B	2,952,790,016	B	184,549,376	B	11,534,336	B	720,896	B	45,056	B	2,816	B	176	B	11
C	3,221,225,472	C	201,326,592	C	12,582,912	C	786,432	C	49,152	C	3,072	C	192	C	12
D	3,489,660,928	D	218,103,808	D	13,631,488	D	851,968	D	53,248	D	3,328	D	208	D	13
E	3,758,096,384	E	234,881,024	E	14,680,064	E	917,504	E	57,344	E	3,584	E	224	E	14
F	4,026,531,840	F	251,658,240	F	15,728,640	F	983,040	F	61,440	F	3,840	F	240	F	15
8		7		6		5		4		3		2		1	

TO CONVERT HEXADECIMAL TO DECIMAL

1. Locate the column of decimal numbers corresponding to the left-most digit or letter of the hexadecimal; select from this column and record the number that corresponds to the position of the hexadecimal digit or letter.
2. Repeat step 1 for the next (second from the left) position.
3. Repeat step 1 for the units (third from the left) position.
4. Add the numbers selected from the table to form the decimal number.

EXAMPLE

Conversion of Hexadecimal Value	D34
1. D	3328
2. 3	48
3. 4	4
4. Decimal	3380

TO CONVERT DECIMAL TO HEXADECIMAL

1. (a) Select from the table the highest decimal number that is equal to or less than the number to be converted.
   (b) Record the hexadecimal of the column containing the selected number.
   (c) Subtract the selected decimal from the number to be converted.
2. Using the remainder from step 1(c) repeat all of step 1 to develop the second position of the hexadecimal (and a remainder).
3. Using the remainder from step 2 repeat all of step 1 to develop the units position of the hexadecimal.
4. Combine terms to form the hexadecimal number.

EXAMPLE

Conversion of Decimal Value	3380
1. D	-3328
	52
2. 3	-48
	4
3. 4	-4
4. Hexadecimal	D34

To convert integer numbers greater than the capacity of table, use the techniques below:

HEXADECIMAL TO DECIMAL

Successive cumulative multiplication from left to right, adding units position.

Example: $D34_{16} = 3380_{10}$

D = 13
x16
208
3 = + 3
211
x16
3376
4 = +4
3380

DECIMAL TO HEXADECIMAL

Divide and collect the remainder in reverse order.

Example: $3380_{10} = X_{16}$

		remainder
16 | 3380		4
16 | 211		3
16 | 13		D

$3380_{10} = D34_{16}$

POWERS OF 16 TABLE

Example: $268,435,456_{10} = (2.68435456 \times 10^8)_{10} = 1000\ 0000_{16} = (10^7)_{16}$

16^n	n
1	0
16	1
256	2
4 096	3
65 536	4
1 048 576	5
16 777 216	6
268 435 456	7
4 294 967 296	8
68 719 476 736	9
1 099 511 627 776	10 = A
17 592 186 044 416	11 = B
281 474 976 710 656	12 = C
4 503 599 627 370 496	13 = D
72 057 594 037 927 936	14 = E
1 152 921 504 606 846 976	15 = F

Decimal Values

Conversion Table: Hexadecimal and Decimal Fractions

HALFWORD												
BYTE					BYTE							
BITS 0123		4567			0123				4567			
Hex	Decimal	Hex	Decimal		Hex	Decimal			Hex	Decimal Equivalent		
.0	.0000	.00	.0000	0000	.000	.0000	0000	0000	.0000	.0000	0000	0000	0000
.1	.0625	.01	.0039	0625	.001	.0002	4414	0625	.0001	.0000	1525	8789	0625
.2	.1250	.02	.0078	1250	.002	.0004	8828	1250	.0002	.0000	3051	7578	1250
.3	.1875	.03	.0117	1875	.003	.0007	3242	1875	.0003	.0000	4577	6367	1875
.4	.2500	.04	.0156	2500	.004	.0009	7656	2500	.0004	.0000	6103	5156	2500
.5	.3125	.05	.0195	3125	.005	.0012	2070	3125	.0005	.0000	7629	3945	3125
.6	.3750	.06	.0234	3750	.006	.0014	6484	3750	.0006	.0000	9155	2734	3750
.7	.4375	.07	.0273	4375	.007	.0017	0898	4375	.0007	.0001	0681	1523	4375
.8	.5000	.08	.0312	5000	.008	.0019	5312	5000	.0008	.0001	2207	0312	5000
.9	.5625	.09	.0351	5625	.009	.0021	9726	5625	.0009	.0001	3732	9101	5625
.A	.6250	.0A	.0390	6250	.00A	.0024	4140	6250	.000A	.0001	5258	7890	6250
.B	.6875	.0B	.0429	6875	.00B	.0026	8554	6875	.000B	.0001	6784	6679	6875
.C	.7500	.0C	.0468	7500	.00C	.0029	2968	7500	.000C	.0001	8310	5468	7500
.D	.8125	.0D	.0507	8125	.00D	.0031	7382	8125	.000D	.0001	9836	4257	8125
.E	.8750	.0E	.0546	8750	.00E	.0034	1796	8750	.000E	.0002	1362	3046	8750
.F	.9375	.0F	.0585	9375	.00F	.0036	6210	9375	.000F	.0002	2888	1835	9375
1		2			3				4				

TO CONVERT .ABC HEXADECIMAL TO DECIMAL

Find .A in position 1 .6250

Find .0B in position 2 .0429 6875

Find .00C in position 3 .0029 2968 7500

.ABC Hex is equal to .6708 9843 7500

TO CONVERT .13 DECIMAL TO HEXADECIMAL

1. Find .1250 next lowest to .1300
   subtract -.1250 = .2 Hex
2. Find .0039 0625 next lowest to .0050 0000
   -.0039 0625 = .01
3. Find .0009 7656 2500 .0010 9375 0000
   -.0009 7656 2500 = .004
4. Find .0001 0681 1523 4375 .0001 1718 7500 0000
   -.0001 0681 1523 4375 = .0007
   .0000 1037 5976 5625 = .2147 Hex
5. .13 Decimal is approximately equal to ↑

To convert fractions beyond the capacity of table, use techniques below:

HEXADECIMAL FRACTION TO DECIMAL

Convert the hexadecimal fraction to its decimal equivalent using the same technique as for integer numbers. Divide the results by 16^n (n is the number of fraction positions).

Example: $.8A7 = .540771_{10}$

$8A7_{16} = 2215_{10}$

$16^3 = 4096$

$$4096\overline{)2215.000000}\quad .540771$$

DECIMAL FRACTION TO HEXADECIMAL

Collect integer parts of product in the order of calculation.

Example: $.5408_{10} = .8A7_{16}$

.5408 x16

8 ← [8].6528 x16

A ← [10].4448 x16

7 ← [7].1168

Hexadecimal Addition and Subtraction Table

Example: 6 + 2 = 8, 8 - 2 = 6, and 8 - 6 = 2

	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
1	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10
2	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11
3	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12
4	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13
5	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	14
6	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	14	15
7	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	14	15	16
8	09	0A	0B	0C	0D	0E	0F	10	11	12	13	14	15	16	17
9	0A	0B	0C	0D	0E	0F	10	11	12	13	14	15	16	17	18
A	0B	0C	0D	0E	0F	10	11	12	13	14	15	16	17	18	19
B	0C	0D	0E	0F	10	11	12	13	14	15	16	17	18	19	1A
C	0D	0E	0F	10	11	12	13	14	15	16	17	18	19	1A	1B
D	0E	0F	10	11	12	13	14	15	16	17	18	19	1A	1B	1C
E	0F	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D
F	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E

Hexadecimal Multiplication Table

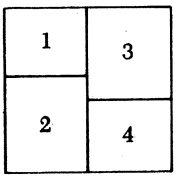
Example: 2 x 4 = 08, F x 2 = 1E

	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
1	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
2	02	04	06	08	0A	0C	0E	10	12	14	16	18	1A	1C	1E
3	03	06	09	0C	0F	12	15	18	1B	1E	21	24	27	2A	2D
4	04	08	0C	10	14	18	1C	20	24	28	2C	30	34	38	3C
5	05	0A	0F	14	19	1E	23	28	2D	32	37	3C	41	46	4B
6	06	0C	12	18	1E	24	2A	30	36	3C	42	48	4E	54	5A
7	07	0E	15	1C	23	2A	31	38	3F	46	4D	54	5B	62	69
8	08	10	18	20	28	30	38	40	48	50	58	60	68	70	78
9	09	12	1B	24	2D	36	3F	48	51	5A	63	6C	75	7E	87
A	0A	14	1E	28	32	3C	46	50	5A	64	6E	78	82	8C	96
B	0B	16	21	2C	37	42	4D	58	63	6E	79	84	8F	9A	A5
C	0C	18	24	30	3C	48	54	60	6C	78	84	90	9C	A8	B4
D	0D	1A	27	34	41	4E	5B	68	75	82	8F	9C	A9	B6	C3
E	0E	1C	2A	38	46	54	62	70	7E	8C	9A	A8	B6	C4	D2
F	0F	1E	2D	3C	4B	5A	69	78	87	96	A5	B4	C3	D2	E1

Extended Binary-Coded-Decimal Interchange Code (EBCDIC)

The 256-position EBCDIC table, outlined by the heavy black lines, shows the graphic characters and control character representations for EBCDIC. The bit-position numbers, bit patterns, hexadecimal representations and card hole patterns for these and other possible EBCDIC characters are also shown.

To find the card hole patterns for most characters, partition the 256-position table into four blocks as follows:



Block 1: Zone punches at top of table; digit punches at left
Block 2: Zone punches at bottom of table; digit punches at left
Block 3: Zone punches at top of table; digit punches at right
Block 4: Zone punches at bottom of table; digit punches at right

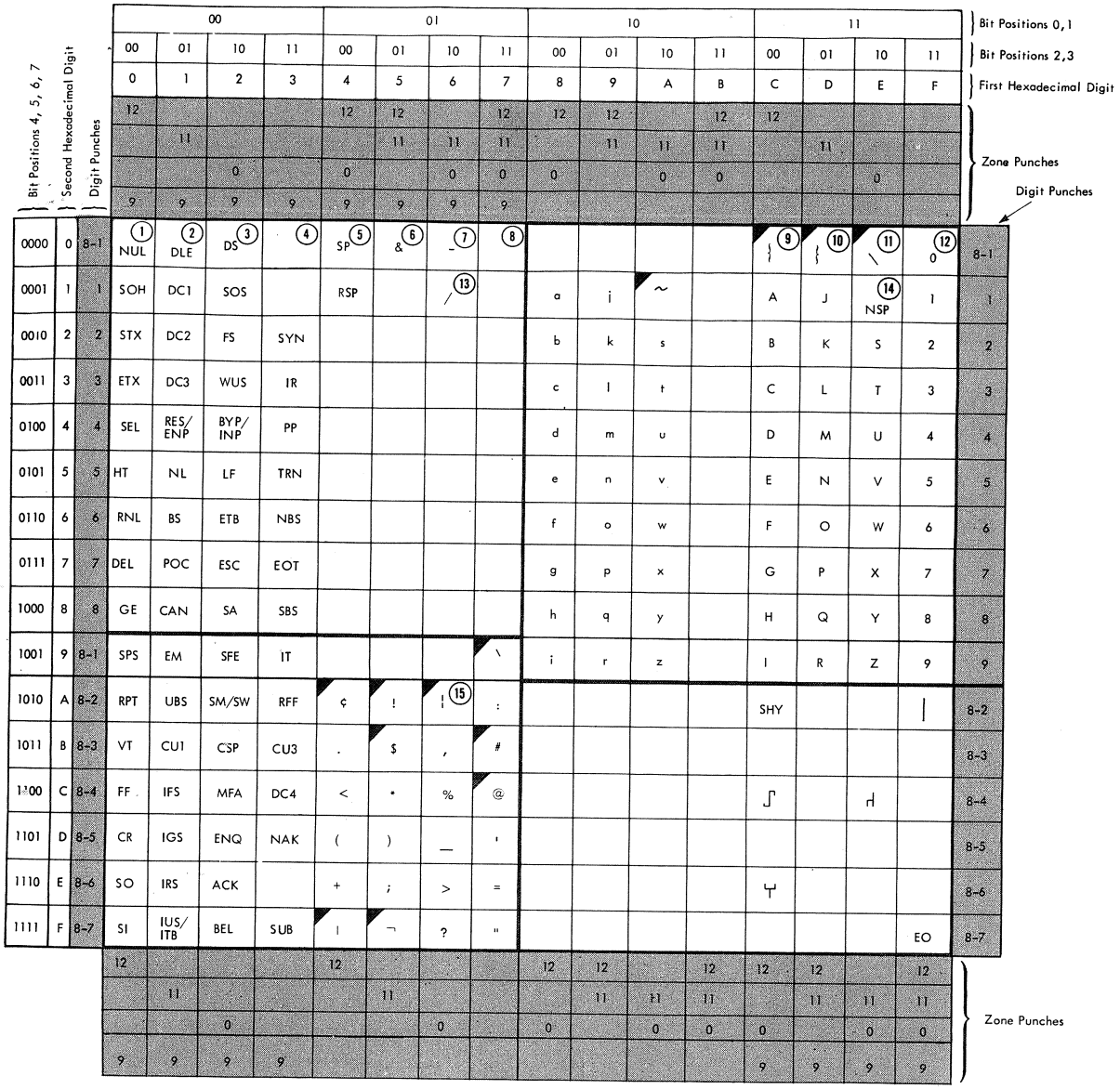
Fifteen positions in the table are exceptions to the above arrangement. These positions are indicated by small numbers in the upper right corners of their boxes in the table. The card hole patterns for these positions are given at the bottom of the table. Bit-position numbers, bit patterns, and hexadecimal representations for these positions are found in the usual manner.

Thirteen EBCDIC positions (hexadecimal 4A, 4F, 5A, 5B, 5F, 6A, 79, 7B, 7C, A1, C0, D0, and E0) are defined as Data Processing National Use positions. In the code table, these positions contain a triangle in the top left corner (◩). The actual graphic characters provided in these positions on printing and display devices may differ from one country to another. The characters used in the U.S. are representively shown in this table.

Following are some examples of the use of the EBCDIC table:

Character	Type	Bit Pattern	Hex	Hole Pattern	
				Zone Punches	Digit Punches
SEL	Control Character	00 00 0100	04	12 - 9	- 4
%	Special Graphic	01 10 1100	6C	0	- 8 - 4
R	Upper Case	11 01 1001	D9	11	- 9
a	Lower Case	10 00 0001	81	12 - 0	- 1
	Control Character, function not yet assigned	00 11 0000	30	12 - 11 - 0 - 9	- 8 - 1

Bit Positions
01 23 4567



Card Hole Patterns

1. 12-0-9-8-1
2. 12-11-9-8-1
3. 11-0-9-8-1
4. 12-11-0-9-8-1
5. No Punches
6. 12
7. 11
8. 12-11-0
9. 12-0
10. 11-0
11. 0-8-2
12. 0
13. 0-1
14. 11-0-9-1
15. 12-11

Formatting Character Representations

NSP	Numeric Space
RSP	Required Space
SP	Space
SHY	Syllable Hyphen

Control Character Representations

ACK	Acknowledge	ETX	End of Text	RFF	Required Form Feed
BEL	Bell	FF	Form Feed	RNL	Required New Line
BS	Backspace	FS	Field Separator	RPT	Repeat
BYP/INP	Bypass/Inhibit Presentation	GE	Graphic Escape	SA	Set Attribute
CAN	Cancel	HT	Horizontal Tab	SBS	Subscript
CR	Carriage Return	IFS	Interchange File Separator	SEL	Select
CSP	Control Sequence Prefix	IGS	Interchange Group Separator	SFE	Start Field Extended
CU1	Customer Use 1	IR	Index Return	SI	Shift In
CU3	Customer Use 3	IRS	Interchange Record Separator	SM/SW	Set Mode/Switch
DC1	Device Control 1	IT	Indent Tab	SO	Shift Out
DC2	Device Control 2	IUS/ITB	Interchange Unit Separator/ Intermediate Transmission Block	SOH	Start of Heading
DC3	Device Control 3			SOS	Start of Significance
DC4	Device Control 4	LF	Line Feed	SPS	Superscript
DEL	Delete	MFA	Modify Field Attribute	STX	Start of Text
DLE	Data Link Escape	NAK	Negative Acknowledge	SUB	Substitute
DS	Digit Select	NBS	Numeric Backspace	SYN	Synchronous Idle
EM	End of Medium	NL	New Line	TRN	Transparent
ENQ	Enquiry	NUL	Null	UBS	Unit Backspace
EO	Eight Ones	POC	Program-Operator Communication	VT	Vertical Tab
EOT	End of Transmission	PP	Presentation Position	WUS	Word Underscore
ESC	Escape	RES/ENP	Restore/Enable Presentation		
ETB	End of Transmission Block				

Special Graphic Characters

¢	Cent Sign	>	Greater-than Sign
.	Period, Decimal Point	?	Question Mark
<	Less-than Sign	`	Grave Accent
(	Left Parenthesis	:	Colon
+	Plus Sign	#	Number Sign
|	Logical OR	@	At Sign
&	Ampersand	'	Prime, Apostrophe
!	Exclamation Point	=	Equal Sign
$	Dollar Sign	"	Quotation Mark
*	Asterisk	~	Tilde
)	Right Parenthesis	{	Opening Brace
;	Semicolon	⌐	Hook
¬	Logical NOT	⊦	Fork
-	Minus Sign, Hyphen	}	Closing Brace
/	Slash	\	Reverse Slant
¦	Vertical Line	⊤	Chair
,	Comma	|	Long Vertical Mark
%	Percent		
_	Underscore		

APPENDIX H. CHANGES AFFECTING COMPATIBILITY BETWEEN SYSTEM/360 AND SYSTEM/370

This appendix summarizes those changes included in the System/370 architecture that may affect whether or not a program written according to the System/360 architecture runs on machines implementing the System/370 architecture described in this publication. Not included are descriptions of System/370 functions which are compatible extensions, that is, (1) those that are suppressed on initialization, such as block multiplexing, and (2) those that are specified in such a manner that they cause program exceptions on System/360, such as new instructions.

REMOVAL OF USASCII-8 MODE

System/360 provides for USASCII-8 by a mode under control of PSW bit 12. USASCII-8 was a proposed zoned-decimal code that has since been rejected. When bit 12 of the System/360 PSW is one, the preferred codes for USASCII-8 are generated for decimal results. When PSW bit 12 is zero, the preferred codes for EBCDIC are generated.

In System/370, the USASCII-8 mode and the associated meaning of PSW bit 12 are removed. In System/370, all instructions whose execution in System/360 depends on the setting of PSW bit 12 are executed generating the preferred codes for EBCDIC.

Bit 12 of the PSW is handled in System/370 as follows:

- In models that do not have the translation facility installed, a one in PSW bit position 12 causes a program interruption for specification exception.
- In models that have the translation facility installed, a one in PSW bit position 12 causes the CPU to operate in the extended-control (EC) mode.

OPERATION CODES OF I/O INSTRUCTIONS

In System/360, the operation codes of the four I/O instructions (HALT I/O, START I/O, TEST CHANNEL, and TEST I/O) are one byte in length, and bits 8-15 of the I/O instructions are ignored. In System/370, the operation codes of all I/O instructions are the first two bytes of the instruction. System/360 programs that execute I/O instructions in which any of bits 8-15 is not zero may perform a different function when executed on a System/370 CPU, as explained below.

Halt I/O

In System/370, HALT I/O (HIO) is assigned the operation code 9E00 hex and HALT DEVICE (HDV) the operation code 9E01. Because bits 8-14 are ignored in both instructions, an instruction executed as HALT I/O in System/360 will still be executed as HALT I/O in System/370 if the third hex digit is any value and the fourth hex digit is an even value. However, in System/370, if bit 15 of the instruction is one, the function performed will be the HIO function or the HDV function, depending on the design of the channel.

Start I/O

In System/370, START I/O is assigned the operation code 9C00 and RESUME I/O is assigned the operation code 9C02. Therefore, an instruction executed as START I/O in System/360 will be executed as RESUME I/O in System/370 if bits 8-15 of the instruction contain the value 02 hex and the suspend-and-resume facility is installed. When the suspend-and-resume facility is installed, operation codes in

the range 9C03 through 9CFF cause an operation exception to be recognized. If the suspend-and-resume facility is not installed, bits 8-14 of the instruction are always ignored, and bit 15 is ignored when the block-multiplexing-control bit (bit 0 of control register 0) is zero at the time the instruction is executed.

Test Channel

In System/370, TEST CHANNEL is assigned the operation code 9F00 and CLEAR CHANNEL (CLRCH) the operation code 9F01 hex. Because bits 8-14 of the instruction are ignored in both instructions, an instruction executed as TEST CHANNEL in System/360 will still be executed as TEST CHANNEL in System/370 if the third hex digit is any value and the fourth hex digit is an even value. However, in System/370, if bit 15 of the instruction is one, the CLRCH function is performed if the recovery-extension facility is installed; otherwise, the TCH function is performed.

Test I/O

In System/370, TEST I/O (TIO) is assigned the operation code 9D00 and CLEAR I/O (CLRIO) the operation code 9D01 hex. Because bits 8-14 of the instruction are ignored in both instructions, an instruction executed as TEST I/O in System/360 will still be executed as TEST I/O in System/370 if the third hex digit is any value and the fourth hex digit is an even value. However, in System/370, if bit 15 of the instruction is one, the function performed will be the TIO function or the CLRIO function, depending on the design of the channel.

LOGOUT

In System/360, the logout area starts with location 128 and extends through as many locations as the given model requires. Portions of this area are used for machine-check logout, and other portions may be used for channel logout. While no limit is set on the size of the logout area, the extent of the area used on most System/360 models is less than that stored by a comparable System/370 model.

On System/370, the machine-check interruption causes information to be stored at locations 216-239, 244-255, and 352-511. Additionally, the model may store logout information in the fixed logout area, locations 256-351, and the model may also have a machine-check extended logout (MCEL) area, which, on initialization, is specified to start at location 512. Channels may place logout information in the limited channel logout area, locations 176-179, and in the fixed logout area, locations 256-351.

In System/360, logout is not permitted on data check. System/370 permits logout to occur when the channel causes an I/O interruption with the data-check indication.

COMMAND RETRY

System/370 channels may provide command retry, whereby the channel, in response to a signal from the device, can retry the execution of a channel command. Since I/O devices announced prior to System/370 do not signal for command retry, no problem of compatibility exists on these devices. However, some new devices, which would otherwise be compatible with former devices, do signal for command retry.

The effects of command retry usually are not significant; however, the following is a list of some of the differences which command retry can cause:

1. An immediate command specifying no chaining may result in setting condition code 0 rather than condition code 1.
2. Multiple PCI interruptions may be generated for a single CCW with the PCI flag.
3. Since CCWs may be refetched, programs which dynamically modify CCWs may be affected.
4. The residual count in the CSW reflects only the last execution of the command and does not necessarily reflect the maximum storage used in previous executions.

CHANNEL PREFETCHING

In System/360, on an output operation, as many as 16 bytes may be prefetched and buffered; similarly, with data chaining specified, the channel may prefetch the new CCW when up to 16 bytes remain to be transferred under control of the current CCW. In System/370, the restriction of 16 bytes is removed.

VALIDITY OF DATA

In System/360, the contents of main storage are preserved when power is turned off. In System/370, because main storage may be volatile or nonvolatile, the program must not depend on the validity of data in main storage after system power has been lost or turned off and then restored.

APPENDIX I. CHANGES AFFECTING COMPATIBILITY WITHIN SYSTEM/370

This appendix summarizes those changes included in the System/370 architecture that may affect whether or not a program written according to the original System/370 architecture runs on machines implementing the architecture described in this publication. Not included here are descriptions of compatible extensions, such as new facilities incorporated in System/370 that make use of unassigned operation codes and format.

READ DIRECT AND WRITE DIRECT

When the instruction INVALIDATE PAGE TABLE ENTRY is installed, the following changes apply:

- Both READ DIRECT and WRITE DIRECT are changed to use real instead of logical addresses.
- Program-event recording does not apply to the storage alteration performed by READ DIRECT.

STORE ACCESSES

The following changes are made as to when an access to storage for storing can take place.

- When the execution of the instruction is nullified or suppressed because of certain program exceptions, an update may occur at the operand location. Originally no storage access was permitted. In some of these situations, the channel may observe intermediate results which differ from the final result. See the section "Exceptions to Nullification and Suppression" in Chapter 5, "Program Execution."
- When the mask in STORE CHARACTERS UNDER MASK is zero, an update may occur at the byte location designated by the operand address. Originally no storage access was permitted.
- When the result of comparison in COMPARE AND SWAP or COMPARE DOUBLE AND SWAP is unequal, an update may occur at the operand location. Originally no storage access was permitted.
- When the result of the store operation is defined to be unpredictable, such as for STORE CLOCK with the clock in the error state, the store access may be omitted.

Whether or not a store access takes place is visible to the program in four ways: an access exception may be indicated, the change bit may be set, a PER storage-alteration event may be indicated, and, for stores that are part of an update, the channel may observe the distinct accesses for fetching and storing. The fetch and store parts of an update appear interlocked to another CPU.

FETCH ACCESSES

Originally the definition required that, with the exception of some compare instructions, access exceptions on fetching be indicated for the unused portion of an operand. The changed definition permits the indication of the access exception for the unused parts to be unpredictable, except that an access exception still must be indicated for TEST UNDER MASK, INSERT CHARACTERS UNDER MASK, and COMPARE LOGICAL CHARACTERS UNDER MASK when the mask is zero.

OPERAND-ACCESS CONSISTENCY

Originally the access for the operand of LOAD MULTIPLE was specified to be doubleword-concurrent; that is, all bytes within a doubleword appear to all CPUs to be accessed concurrently. This definition is changed to require doubleword concurrency only if the operand is designated on a word boundary.

The restriction is removed that, during the padding portion of a MOVE LONG execution, another CPU can observe the operand to be stored only once and only in the left-to-right sequence.

CHANGE BIT

Originally the System/370 architecture specified that the change bit be set to one each time information is stored in the corresponding storage block. This definition is changed as follows:

- The change bit now is necessarily set to one only when the contents of the corresponding storage block are changed. In situations where execution of the instruction can be completed without making a store access, such as in MOVE (MVC) with coincident operands or in OR (OI) with an immediate operand of zeros, the change bit may be unaffected. However, even when the change bit is not set, any applicable access exceptions or PER storage-alteration events are still indicated.
- The change bit may be set to one as a result of those situations described in the section "Store Accesses" in this appendix.
- Because of CPU retry, the change bit may be set to one for locations which the program has not accessed.

SUBCHANNEL INTERRUPTION-PENDING STATE

Originally only status associated with the termination of an I/O operation at the subchannel could cause the subchannel to enter the interruption-pending state. Status not associated with the termination of an I/O operation at the subchannel was held pending at the device, and the subchannel would be available. The changed definition allows status not associated with the termination of an I/O operation at the subchannel to be accepted into the subchannel. As a result of this change, a subchannel that is shared among multiple devices may cause condition code 2 to be returned to a START I/O, START I/O FAST RELEASE, or TEST I/O even if no previous START I/O or START I/O FAST RELEASE had been issued to the addressed device. This busy state persists until the interruption condition is cleared.

START I/O AND START I/O FAST RELEASE

Originally the System/370 architecture specified START I/O and START I/O FAST RELEASE as having the operation codes 9C00 and 9C01, respectively, with bits 8-14 of the operation code ignored by the CPU. Now, however, when the suspend-and-resume facility is installed, bits 8-14 of the operation code for START I/O and START I/O FAST RELEASE are no longer ignored by the CPU.

Operation codes 9CX0, 9CX2, 9CX4, 9CX6, 9CX8, 9CXA, 9CXC, and 9CXE (with X representing any hex digit) all were executed as START I/O. Similarly, operation codes 9CX1, 9CX3, 9CX5, 9CX7, 9CX9, 9CXB, 9CXD, and 9CXF all were executed as START I/O FAST RELEASE. When the suspend-and-resume facility is installed, only operation code 9C00 is executed as START I/O, and only operation code 9C01 is executed as START I/O FAST RELEASE; operation code 9C02 is executed as RESUME I/O, and all operation codes in the range 9C03 through 9CFF cause an operation exception to be recognized.

IBM System/370
Principles of Operation

Order No. GA22-7000-9

READER'S COMMENT FORM

This manual is part of a library that serves as a reference source for systems analysts, programmers, and operators of IBM systems. You may use this form to communicate your comments about this publication, its organization, or subject matter, with the understanding that IBM may use or distribute whatever information you supply in any way it believes appropriate without incurring any obligation to you.

Your comments will be sent to the author's department for whatever review and action, if any, are deemed appropriate.

Note: *Copies of IBM publications are not stocked at the location to which this form is addressed. Please direct any requests for copies of publications, or for assistance in using your IBM system, to your IBM representative or to the IBM branch office serving your locality.*

Possible topics for comment are:

Clarity Accuracy Completeness Organization Coding Retrieval Legibility

If you wish a reply, give your name, company, mailing address, and date:

_____

_____

_____

_____

Note: Staples can cause problems with automated mail sorting equipment. Please use pressure-sensitive or other gummed tape to seal this form.

What is your occupation? _____

Number of latest Newsletter associated with this publication: _____

Thank you for your cooperation. No postage stamp necessary if mailed in the U.S.A. (Elsewhere, an IBM office or representative will be happy to forward your comments or you may mail directly to the address in the Edition Notice on the back of the front cover or title page.)

GA22-7000-9

Reader's Comment Form

Cut or Fold Along Line

Fold and tape | Please Do Not Staple | Fold and tape

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 40 ARMONK, N.Y.

POSTAGE WILL BE PAID BY ADDRESSEE:

International Business Machines Corporation
Department B98
P.O. Box 390
Poughkeepsie, New York 12602

Fold and tape | Please Do Not Staple | Fold and tape

IBM®

IBM System/370 Principles of Operation (File No. S370-01) Printed in U.S.A. GA22-7000-9

IBM System/370
Principles of Operation
Order No. GA22-7000-9

READER'S COMMENT FORM

This manual is part of a library that serves as a reference source for systems analysts, programmers, and operators of IBM systems. You may use this form to communicate your comments about this publication, its organization, or subject matter, with the understanding that IBM may use or distribute whatever information you supply in any way it believes appropriate without incurring any obligation to you.

Your comments will be sent to the author's department for whatever review and action, if any, are deemed appropriate.

Note: *Copies of IBM publications are not stocked at the location to which this form is addressed. Please direct any requests for copies of publications, or for assistance in using your IBM system, to your IBM representative or to the IBM branch office serving your locality.*

Possible topics for comment are:

Clarity Accuracy Completeness Organization Coding Retrieval Legibility

If you wish a reply, give your name, company, mailing address, and date:

_____

_____

_____

_____

Note: Staples can cause problems with automated mail sorting equipment. Please use pressure-sensitive or other gummed tape to seal this form.

What is your occupation? _____

Number of latest Newsletter associated with this publication: _____

Thank you for your cooperation. No postage stamp necessary if mailed in the U.S.A. (Elsewhere, an IBM office or representative will be happy to forward your comments or you may mail directly to the address in the Edition Notice on the back of the front cover or title page.)

GA22-7000-9

Reader's Comment Form

Cut or Fold Along Line

Fold and tape | Please Do Not Staple | Fold and tape

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 40 ARMONK, N.Y.

POSTAGE WILL BE PAID BY ADDRESSEE:

International Business Machines Corporation
Department B98
P.O. Box 390
Poughkeepsie, New York 12602

Fold and tape | Please Do Not Staple | Fold and tape

IBM

IBM System/370 Principles of Operation (File No. S370-01) Printed in U.S.A. GA22-7000-9