IBM 7090/7094 Simulator Usage

Robert M Supnik

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- COPYRIGHT NOTICE and LICENSE

This memorandum documents the IBM 7094 simulator.

Simulator Files

To compile the IBM 7094, you must define `USE_INT64` as part of the compilation command line.

Subdirectory	***File***
	scp.h
	sim_console.h
	sim_defs.h
	sim_fio.h
	sim_rev.h
	sim_sock.h
	sim_tape.h
	sim_timer.h
	sim_tmxr.h
	scp.c
	sim_console.c
	sim_fio.c
	sim_sock.c
	sim_tape.c
	sim_timer.c
	sim_tmxr.c
i7094/	i7094_defs.h
	i7094_dat.h
	i7094_cd.c
	i7094_clk.c
	i7094_com.c
	i7094_cpu.c
	i7094_cpu1.c
	i7094_drm.c
	i7094_dsk.c
	i7094_io.c
	i7094_lp.c
	i7094_mt.c
	i7094_sys.c

IBM 7090/7094 Features

The IBM 7090/7094 simulator is configured as follows:

device name(s)	simulates
CPU	7090, 7094, or 7094 with CTSS RPQ's CPU with 32KW, 32KW, or 64KW of memory, respectively
CLK	interval timer (RPQ F89349) and Chronolog clock
CHANA	7607 channel (required)
CHANB	..CHANH additional 7607, 7289, or 7909 channels
MTA	magnetic tape controller, channel A (required)
MTB	..MTH additional magnetic tape controllers, channels B to H
CDR	711 card reader
CDP	721 card punch
LPT	716 line printer
DSK	7631 file control with up to 10 modules (disks or drums)
DRM	7289 fast drum control
COM	7750 communications control
COML	7750 communications lines

Channels B through H, the corresponding magnetic tape controllers, and the file control, drum control, and communications control are initially set DISABLED. The file control, drum control, and communications control can be assigned to any channel in the range B through H.

Stop conditions

The 7090/7094 simulator implements several unique stop condition:

- Undefined CPU instruction
- Undefined channel instruction
- XEC nesting exceeds limit
- Divide check on a divide and halt instruction
- Select of a non-existent channel
- 7607 select of a 7909 channel
- Write select of a write protected device
- Invalid file control format
- Invalid message to 7750
- No buffer storage available for input character on 7750
- No buffer storage available for output character on 7750

The LOAD command is not implemented.

CPU

The CPU options allow the user to specify a 7090, a 7094, or a 7094 with CTSS RPQ's.

```
SET CPU 7090                7090
SET CPU 7094                Standard 7094
SET CPU CTSS                7094 with CTSS RPQ's.
```

Memory size is 32KW on a 7090 or 7094 CPU, 64KW on a CTSS CPU.

CTSS mode enables access to the Chronolog clock as magtape unit A7.

Registers

CPU registers include the visible state of the processor as well as the control registers for the interrupt system.

name	size	comments
PC	15	program counter
AC	38	accumulator
MQ	36	multiplier-quotient
SI	36	storage indicators
KEYS	36	front panel keys
XR1..XR7	15	index registers 1 to 7[7090 uses only XR1, XR2, XR4]
SS1..SS6	1	sense switches 1 to 6
SL1..4	1	sense lights 1 to 4
OVF	1	AC overflow indicator
MQO	1	MQ overflow indicator
DVC	1	divide check indicator
IOC	1	I/O check indicator
TTRAP	1	transfer trap enable
CTRAP	1	copy trap enable
STRAP	1	select trap enable
FTRAP	1	floating point trap enable
STORN	1	storage nullification mode enable
MULTI	1	multiple-tag mode enable [always 1 on 7090]
CHREQ	8	channel request flags
CHTR_PEND	1	channel trap pending
CHTR_INHT	1	channel trap inhibit
CHTR_INHI	1	channel trap instruction inhibit
CHTR_ENAB	30	channel trap enable flags
USERM	1	user mode flag [CTSS only]
IMEM	1	instruction B-core flag [CTSS only]
DMEM	1	data B-core flag [CTSS only]
RELOC	8	relocation base block [CTSS only]
START	8	address start block [CTSS only]

name	size	comments
LIMIT	8	address limit block [CTSS only]
OLDPC	15	PC at start of instruction
PCQ[0:63]	15	PC prior to last jump or interrupt; most recent PC change first
HTPEND	1	halt and transfer pending
HTADDR	15	halt and transfer address
XECMAX	8	XEC chain limit
WRU	8	interrupt character
STOP_ILL	1	stop on undefined instruction

The CPU can maintain a history of the most recently executed instructions. This is controlled by the SET CPU HISTORY and SHOW CPU HISTORY commands:

```
SET CPU HISTORY             clear history buffer
SET CPU HISTORY=0           disable history
SET CPU HISTORY=n           enable history, length = n
SHOW CPU HISTORY            print CPU history
SHOW CPU HISTORY=n          print first n entries of CPU history
```

If switch -C is set, channel commands are also included in the CPU history. The maximum length for the history is 262144 entries.

Interval Timer (CLK)

The timer (CLK) implements a 60Hz interval timer. It is disabled by default.

The timer has the following registers:

Registers

name	size	comments
TRAP	1	interval timer trap flag
TIME	24	tick delay

I/O Channels (CHANA..CHANH)

The 709X supports up to 8 channels. Channel models include

```
7607                        standard multiplexer channel
7289                        high speed drum channel
7909                        advanced capabilities channel
```

Channel A is required and is always a 7607. Channels B through H are disabled by default. Channels B through H can be enabled. When a channel is enabled, the attached device must also be specified:

```
SET CHANx ENABLED{=[729|TAPE|7289|DRUM|7631|FILE|7750|COMM]}
```

If no device type is specified, TAPE is assumed.

Setting a channel to 729 (synonym TAPE) defines the channel as a 7607 and enables the corresponding magnetic tape controller.

Setting a channel to 7289 (synonym DRUM) defines the channel as a 7289 and enables the high-speed drum control.

Setting a channel to 7631 defines the channel as a 7909 and enables the file control.

Setting a channel to 7750 (synonym COMM) defines the channel as a 7909 and enables the communications control. Only one high-speed drum control, one file control, and one communications control are supported per system.

As an example, the following commands set up the 1971 CTSS configuration:

```
SET CPU CTSS
SET CLK ENABLED
SET CHANB ENABLED=TAPE
SET CHANC ENABLED=DISK
SET CHANE ENABLED=COMM
SET CHANG ENABLED=DRUM
```

Registers

Channels have the following registers:

name	type	size	comments
STATE	all	8	channel state
DSC	7607,7289	4	data select
DSU	7607,7289	9	data select unit
NDSC	7607,7289	4	non-data select
NDSU	7607,7289	9	non-data select unit
FLAGS	all	30	channel flags
IDF	all	2	input data flags
OP	all	5	channel opcode
CLC	all	16	channel location counter
WC	all	15	channel word counter
CA	all	16	channel current address
AR	all	36	channel assembly register
CND	7909	6	channel interrupt conditions
LCC	7909	6	channel control counter
SMS	7909	7	channel options mask

Channel A Devices

711 Card Reader (CDR)

The card reader (CDR) reads data from a disk file.

Cards are simulated as ASCII lines with terminating newlines.

The POS register specifies the number of the next data item to be read. Thus, by changing POS, the user can backspace or advance the reader.

Card reader files can either be text (one character per column) or column binary (two characters per column). The file type can be specified with a set command:

```
SET CDR TEXT                set text mode
SET CDR BINARY              set column binary mode
```

or in the ATTACH command:

```
ATT -T CDR <file>           set text mode
ATT    CDR <file>.TXT       set text mode
ATT -C CDR <file>           set column binary mode
ATT    CDR <file>.CBN       set column binary mode
```

The card reader supports the BOOT command. `BOOT CDR` starts the standard card reader bootstrap at location 0.

Registers The card reader implements these registers:

name	size	comments
STATE	2	reader state
BPTR	5	binary buffer pointer
BUF[0:23]	36	binary buffer
POS	32	position in the input file
TSTART	24	card start delay
TSTOP	24	card stop delay
TLEFT	24	delay between row halves
TRIGHT	24	delay between rows

Error handling Error handling is as follows:

error	processed as
not attached	report error and stop
end of file	out of cards
OS I/O error	report error and stop

721 Card Punch (CDP)

The card reader (CDP) writes data to a disk file. Cards are simulated as ASCII lines with terminating newlines. The POS register specifies the number of the next data item to be written. Thus, by changing POS, the user can backspace or advance the punch.

Card punch files can either be text (one character per column) or column binary (two characters per column). The file type can be specified with a set command:

```
SET CDP TEXT set text mode
SET CDP BINARY set column binary mode
```

or in the ATTACH command:

```
ATT -T CDP <file>           set text mode
ATT    CDP <file>.TXT       set text mode
ATT -C CDP <file>           set column binary mode
ATT    CDP <file>.CBN       set column binary mode
```

The card punch supports both the business (1403 print chain A) and Fortran (1403 print chain H) character sets:

```
SET CDP BUSINESS            business character set
SET CDP FORTRAN             Fortran character set
```

The Fortran character set is the default.

Registers The card punch implements these registers:

name	size	comments
STATE	2	reader state
CHOB	36	channel output buffer
CHOBV	1	output buffer valid flag
BPTR	5	binary buffer pointer
BUF[0:23]	36	binary buffer
POS	32	position in the output file
TSTART	24	card start delay
TSTOP	24	card stop delay
TLEFT	24	delay between row halves
TRIGHT	24	delay between rows

Error handling Error handling is as follows:

error	processed as
not attached	report error and stop
OS I/O error	report error and stop

716 Line Printer (LPT)

The line printer (LPT) writes data to a disk file as ASCII text with terminating newlines.

The POS register specifies the number of the next data item to be written. Thus, by changing POS, the user can backspace or advance the printer.

The line printer implements both 48- and 64-character print chains:

```
SET LPT 64                  64-character print chain
SET LPT 48                  48-character print chain
```

The line printer also implements both the business (1403 print chain A) and Fortran (1403 H chain) character sets:

```
SET LPT BUSINESS            business print character set
SET LPT FORTRAN             Fortran character set
```

The default is 64 characters, Fortran set.

Finally, because the line printer was used for status output messages, its output can be redirected to the controlling terminal window if no file is attached:

```
SET LPT DEFAULT             default output to console window
SET LPT NODEFAULT           no default output, error if not attached
```

Registers The line printer implements these registers:

name	size	comments
STATE	2	printer state
CMD	2	printer command
CHOB	36	channel output buffer
CHOBV	1	output buffer valid flag
BPTR	5	binary buffer pointer
BUF[0:23]	36	binary buffer
EBUF[0:22]	36	echo buffer
POS	32	position in the output file
TSTART	24	line start delay
TSTOP	24	line print delay
TLEFT	24	delay between row halves
TRIGHT	24	delay between rows

Error handling Error handling is as follows:

error	processed as
not attached	report error and stop
OS I/O error	report error and stop

729 Magnetic Tape (MTA...MTH)

Every 7607 channel can support up to ten seven-track magnetic tape units (MTx1...MTx10).

Magnetic tape options include the ability to make units write enabled or write locked.

```
SET MTn LOCKED              set unit n write locked
SET MTn WRITEENABLED        set unit n write enabled
```

Magnetic tape units can be set to a specific reel capacity in MB, or to unlimited capacity:

```
SET MTn CAPAC=m             set unit n capacity to m MB (0 = unlimited)
SHOW MTn CAPAC              show unit n capacity in MB
```

Units can also be set ENABLED or DISABLED.

The magnetic tape simulator supports the BOOT command. `BOOT MTxn` starts the standard magnetic tape load program at location 0.

Registers

The magnetic tape controllers implement the following registers:

name	size	comments
UNIT	5	unit select code
CHOB	36	channel output buffer
CHOBV	1	output buffer valid flag
BPTR	16	buffer pointer
BLNT	16	buffer length
BUF	7	character buffer (with parity)
TWEF	24	wait time for end of file
TSHORT	24	wait time for “immediate” commands
TSTART	24	wait time for unit start
TSTOP	24	wait time for unit stop
TWORD	24	wait time between word transfers
UST[1:10]	5	unit state, drives 1 to 10
POS[1:10]	32	position, drives 1 to 10

Error handling

Error handling is as follows:

error	processed as
not attached	report error and stop
end of file	set error indicator

error	processed as
OS I/O error	print error messageset error indicatorreport error and stop

7631 File Control (DSK)

The 7631 file control supports up to ten devices, which can be 7320 drums, 1301 disks, 1302 disks, or 2302 disks. Unit types are specified with the SET command. The type can be set only if the unit (and the next unit in sequence) is unattached, and the unit number is even:

```
SET DSKn 7320               unit n is a drum (unit n+1 is disabled)
SET DSKn 1301               unit n is a 1301 disk (unit n+1 is the same)
SET DSKn 1302               unit n is a 1302 disk (unit n+1 is the same)
SET DSKn 2302               unit n is a 2302 disk (unit n+1 is the same)
```

Units can be SET ENABLED or DISABLED. In addition, units can be set to enable or disable formatting:

```
SET DSKn FORMAT             enable formatting
SET DSKn NOFORMAT           disable formatting
```

Formatting is disabled by default. The current format can be shown with the command:

```
SHOW DSKn FORMAT            display format information
```

Registers

The 7631 implements the following registers:

name	size	comments
STATE	6	file control state
ACCESS	1	currently selected access
MODULE	4	currently selected module (0-9)
RECORD	36	record address (6 BCD characters)
MODE	4	disk I/O mode
SENSE	60	sense data (10 BCD characters)
BCDCMD	60	most recent command (10 BCD characters)
CHOB	36	channel output buffer
CHOBV	1	output buffer valid flag
STOP	1	channel stop flag
FCNTR	13	format track character counter
BUF[0:999]	36	track buffer
RBASE	10	offset to record base
RPTR	10	offset to current word
RLIM	10	offset to record end

name	size	comments
STIME	24	seek delay
RTIME	24	rotational delay
WTIME	24	inter-word delay
GTIME	24	end-of-sector (gap) delay
CTIME	24	command processing delay
TRACK[0:19]	10	current track number[0:9] module n, access 0[10:19] module n, access 1

Error handling

Error handling is as follows:

error	processed as
not attached	report error and stop
OS I/O error	report error and stop

7289 High-Speed Drum (DRM)

The 7289 (also known as the 7320A) high-speed drum was a late addition to CTSS. Very little is known about the device, other than what is used in the CTSS sources.

Registers

The drum implements these registers:

name	size	comments
STATE	2	drum state
DA	18	drum address register
OP	1	read/write flag
CHOB	36	channel output buffer
CHOBV	1	output buffer valid flag
TIME	24	inter-word delay

Error handling

Error handling is as follows:

error	processed as
not attached	report error and stop

Drum data files are buffered in memory; therefore, end of file and OS I/O errors cannot occur.

7750 Communications Controller (COM and COML)

The 7750 is modeled as a terminal multiplexer with 33 lines. It consists of two devices: COM is the multiplexer controller, and COML is the individual lines.

For the first 32 lines, the 7750 performs input and output through Telnet sessions connected via a user-specified listening port.

The 33rd line is permanently attached to the simulator console window.

The ATTACH command specifies the port to be used for Telnet sessions:

```
ATTACH COM <port>            set up listening port
```

where port is a decimal number between 1 and 65535 that is not being used for other TCP/IP activities.

Each line (each unit of COML) can be set to one of two modes: KSR-35 and KSR-37. In KSR-35 mode, lower case input and output characters are converted automatically to upper case, and parity is ignored. In KSR-37 mode, lower case characters are left alone, and even parity is generated on input. KSR-37 is the default.

Once COM is attached and the simulator is running, the 7750 listens for connections on the specified port. It assumes that any incoming connection is a Telnet connection. A connection remains open until disconnected either by the Telnet client, a SET COM DISCONNECT command, or a DETACH COM command.

The 7750 implements the following special SHOW commands

```
SHOW COM CONNECTIONS          displays current connections to the 7750
SHOW COM STATISTICS          displays statistics for active connections
SHOW COM FREEQ               displays the character buffer free list
SHOW COM INPQ                displays the character input queue
SHOW COM OUTQ                displays the output queues for all lines
SHOW COMn OUTQ               displays the output queue for line n
```

The 7750 implements the following special SET commands:

```
SET COM DISCONNECT=n         disconnect line n
SET COMLn DISCONNECT         disconnect line n
SET COMLn LOG=filename       log output of line n to filename
SET COMLn NOLOG              disable logging and close log file
SET COMLn KSR35              set line n to KSR-35
SET COMLn KSR37              set line n to KSR-37
```

Registers

The controller (COM) implements these registers:

name	size	comments
ENABLE	1	enable flag
STATE	6	controller state
MSGNUM	12	input message sequence number
CHOB	36	channel output buffer
CHOBV	1	output buffer valid flag
STOP	1	channel stop flag
BUF[0:119]	36	channel buffer
BPTR	7	channel buffer pointer
BLIM	7	channel buffer limit
FREEQ[0:1]	16	free queue header
INPQ[0:1]	16	input queue header
OUTQ[0:65]	16	output queue headers, lines 0 to 32
PKTB[0:32767]	16	character buffer entries

Queue headers consist of two 16b words; both are subscripts into the character buffer array. The first word is the buffer subscript for the queue head; the second is the buffer subscript for the queue tail. In an empty queue, both words are 0.

Character buffer entries also consist of two 16b words. The first is the buffer subscript for the next entry in the queue; 0 indicates end of queue. The second is the data element, typically a 12b character.

The lines (COML) implements these registers:

name	size	comments
TIME[0:32]	24	transmit time, lines 0 to 32

The 7750 does not support save and restore. All open connections, except the permanent connection to the console window, are lost when the simulator shuts down or COM is detached.

Symbolic Display and Input

The IBM 7094 simulator implements symbolic display and input. Display is controlled by command line switches:

`-c`	`display as character`
`-s`	`display as character string`
`-m`	`display instruction mnemonics`
`-i`	`display as 7607 IO instruction`
`-n`	`display as 7909 IO instruction`

Character and string display is further qualified by switches that specify the character coding and conversion conventions:

-b	BCD data (default is nine-code)
-a	business character set (default is Fortran)

The default data coding is nine-code, and the default character set is Fortran.

Note that 7094 BCD and IBM 1401 BCD differ in one important regard: the 7094 interprets 0 as code 20, the 1401 as code 12.

Input parsing is controlled by the first character typed in or by command line switches:

' or -c	character
" or -s	string
alphabetic	instruction mnemonic
numeric	octal number

Instruction input uses standard 7094 assembler syntax. There are two basic instruction classes: memory reference and index reference.

Memory reference instructions have the format

```
memref{*} address{,tag}
```

Index reference instructions have the format

```
idxref{*} address,{tag},decrement
```

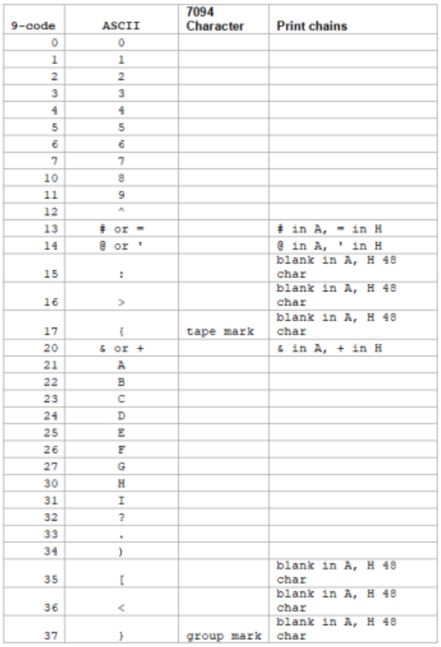
Specific instructions may disallow indirect addressing or limit the size of the tag, address, or decrement fields.

Channel (I/O) instructions have the same basic two formats.

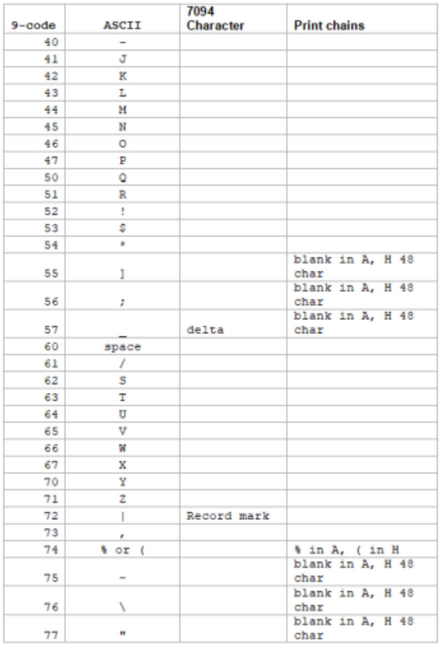
Character Sets

The IBM 7094 uses a 6b character code called 9-code, a variation (with permuted zones) of the ubiquitous BCD (binary coded decimal). The 7094 also uses BCD for communicating with the card reader/punch and the line printer. In both 9-code and BCD, some of the characters have no equivalent in ASCII and require different representations.

This is the mapping for 9-code used by the simulator:

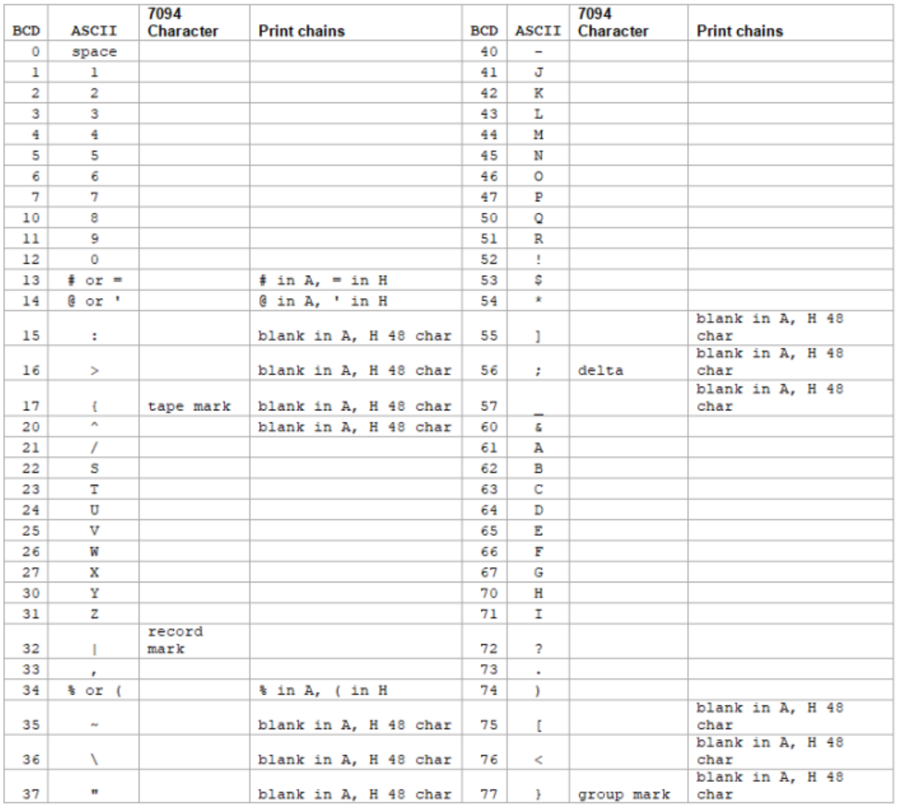


9-code	ASCII	7094 Character	Print chains
0	0		
1	1		
2	2		
3	3		
4	4		
5	5		
6	6		
7	7		
10	8		
11	9		
12	^		
13	# or =		# in A, = in H
14	@ or '		@ in A, ' in H
15	:		blank in A, H 48 char
16	>		blank in A, H 48 char
17	{	tape mark	blank in A, H 48 char
20	& or +		& in A, + in H
21	A		
22	B		
23	C		
24	D		
25	E		
26	F		
27	G		
30	H		
31	I		
32	?		
33	.		
34	)		
35	[		blank in A, H 48 char
36	<		blank in A, H 48 char
37	}	group mark	blank in A, H 48 char



9-code	ASCII	7094 Character	Print chains
40	-		
41	J		
42	K		
43	L		
44	M		
45	N		
46	O		
47	P		
50	Q		
51	R		
52	!		
53	$		
54	*		
55	]		blank in A, H 48 char
56	;		blank in A, H 48 char
57	_	delta	blank in A, H 48 char
60	space		
61	/		
62	S		
63	T		
64	U		
65	V		
66	W		
67	X		
70	Y		
71	Z		
72	|	Record mark	
73	,		
74	% or (		% in A, (in H
75	~		blank in A, H 48 char
76	\		blank in A, H 48 char
77	"		blank in A, H 48 char

This is the mapping for BCD code used by the simulator:



BCD	ASCII	7094 Character	Print chains	BCD	ASCII	7094 Character	Print chains
0	space			40	-		
1	1			41	J		
2	2			42	K		
3	3			43	L		
4	4			44	M		
5	5			45	N		
6	6			46	O		
7	7			47	P		
10	8			50	Q		
11	9			51	R		
12	0			52	!		
13	# or =		# in A, = in H	53	$		
14	@ or '		@ in A, ' in H	54	*		
15	:		blank in A, H 48 char	55	]		blank in A, H 48 char
16	>		blank in A, H 48 char	56	;	delta	blank in A, H 48 char
17	{	tape mark	blank in A, H 48 char	57	_		blank in A, H 48 char
20	^		blank in A, H 48 char	60	&		
21	/			61	A		
22	S			62	B		
23	T			63	C		
24	U			64	D		
25	V			65	E		
26	W			66	F		
27	X			67	G		
30	Y			70	H		
31	Z			71	I		
32	|	record mark		72	?		
33	,			73	.		
34	% or (		% in A, (in H	74	)		
35	~		blank in A, H 48 char	75	[		blank in A, H 48 char
36	\		blank in A, H 48 char	76	<		blank in A, H 48 char
37	"		blank in A, H 48 char	77	}	group mark	blank in A, H 48 char

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