CHAPTER 6

6.1 General

Two types of cassettes may be used as external data storages: an external audio cassette and the built-in microcassette (plug-in option). Data sent to cassettes is recorded sequentially. The average speed of data communication with cassettes is 1300 BPS. The format of data stored in the external audio cassette and that of the built-in microcassette are the same so the two types of cassettes are compatible. The only control line used for the external audio cassette is the remote ON/OFF line (REM). The built-in microcassette, however, is controlled by software and performs fast forward, rewind, write, and playback operations in response to commands in BASIC. The tape counter value is also recorded and displayed by software.

6.2 Data storage (SAVE)

(1) Format of one bit

In the recording format of the cassette, one bit is represented by one pulse (Fig. 6-1).

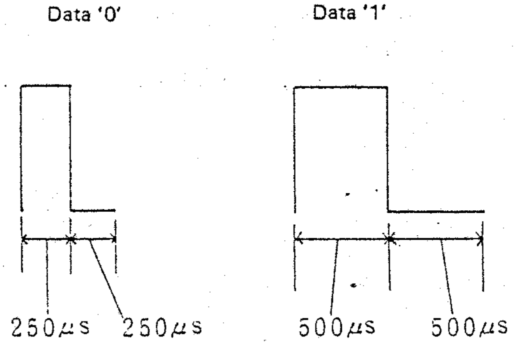


Fig. 6-1 Recording Format for One Bit

Each byte, consisting of 8 data bits and one stop bit, is sent from bit 0. The last bit of a byte is the stop bit (data '1'). (Fig. 6-2.)

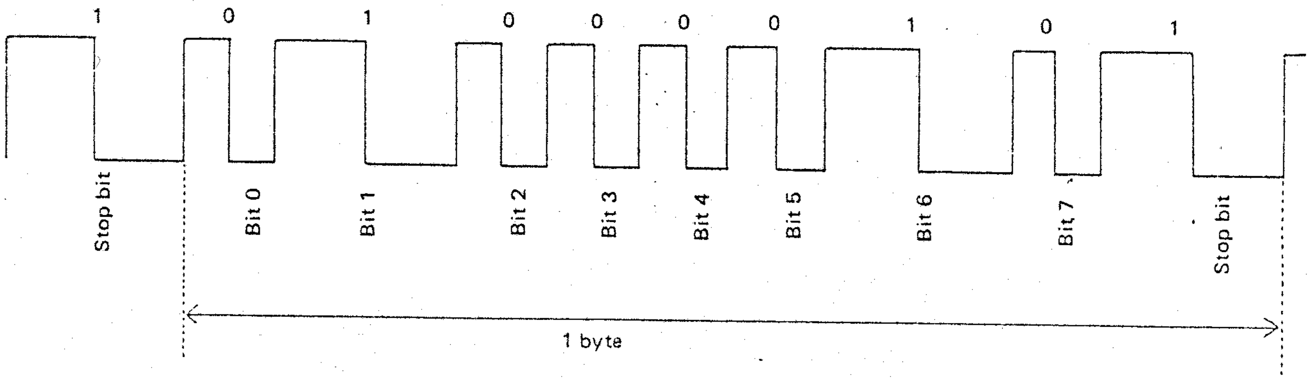


Fig. 6-2 Format of One Byte

(2) Synchronization

The first bit with data '1' which appears after 40 or more bits of data '0' is taken as the first bit (bit 0) of the synchronization character. Synchronization is performed when the data of this first byte is FF and that of the next byte sent is AA (Fig. 6-3).

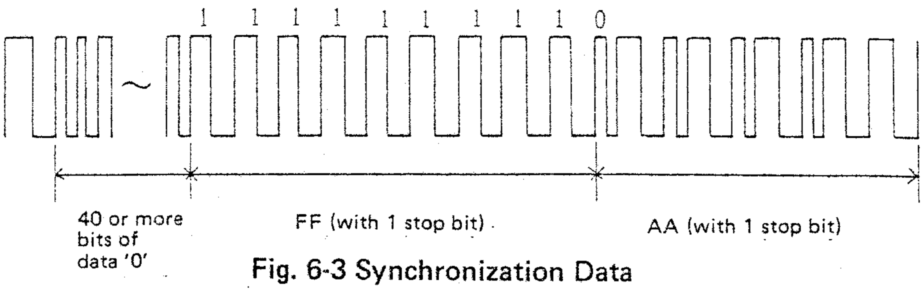


Fig. 6-3 Synchronization Data

The next data sent following the synchronization data will be used as actual data.

(3) Reverse waveform
The normal recording format for data bits is as shown in Fig. 6-1. However, depending on the cassette used, when the signal passes through the playback circuit of the HX-2Ø, the high/low levels of the waveform may be reversed. (Fig. 6-4).

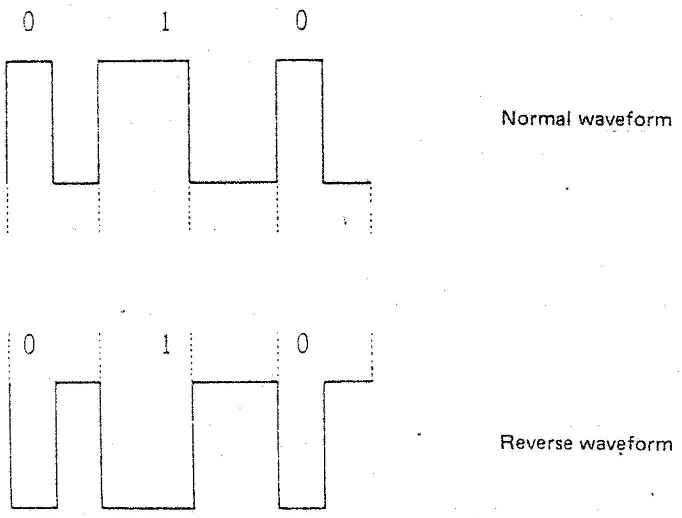


Fig. 6-4 Reverse Waveform

The type of a waveform is determined when synchronization is performed and then data read is performed. The waveform of the built-in microcassette is inverted.

(4) Bit judgement
To judge whether a bit is 'Ø' or '1', the interval between the rise of the first pulse and that of the second is measured. If the measured value is above a specified value (approx. 75Ø µsec), the bit is judged to be logic '1' (Fig. 6-5)

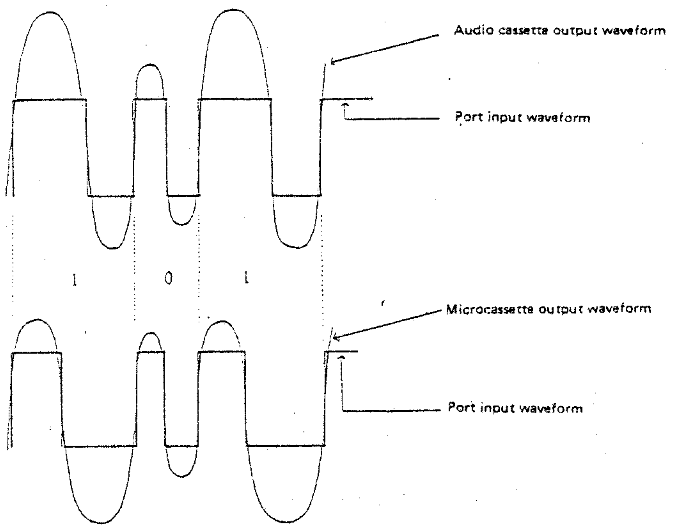


Fig. 6-5 Output Waveforms

6.3 I/O Ports

Table 6-1 lists the I/O ports related to the external cassette.
Table 6-2 lists the I/O ports related to the microcassette.

Table 6-1 I/O Ports Related to the External Cassette

	Port	Description
Master MCU	P12	Input. Connected to port P34 of the slave MCU, this port informs the master MCU of the slave MCU's error status.
Slave MCU	P3Ø	Output. This port is used for the cassette REM output. 1: Off Ø: On
	P32	Input. This port is used to input data from the external cassette. 1: High Ø: Low
	P33	Output. This port is used to output data to the external cassette. 1: High Ø: Low
	P34	Output. This port is connected to port P12 of the master MCU.

Table 6-2 I/O Ports Related to the Microcassette

	Port	Description
Master MCU	P12	Input. This port is connected to port P34 of the slave MCU and informs the master MCU of the slave MCU's error status.
	P17	Input. This port is used to input the counter status or to judge the plug-in option.
Slave MCU	P2Ø	Input. This port is used to input data (1: High, Ø: Low) or to judge the the write protection. The handling of the input contents of this port depends on the value of P45.
	P21	Output. This port is used to output data to the microcassette. 1: High Ø: Low
	P42	Output. This port is used to turn the microcassette power ON/OFF. 1: ON Ø: OFF
	P43	Output. This port is used to set microcassette commands.
	P44	Output. This port supplies a serial clock for timing the microcassette commands. 1: High Ø: Low
	P45	Output. This port is used to select the P2Ø input. Ø: RS-232C 1: Microcassette
	P46	Input. This port is used to input the counter status when port P44 is Ø and the head switch status when it is 1.

6.4 Block format

Cassette data is recorded in blocks. Each block consists of the items listed in Table 6-3.

Table 6-3 Block Configuration

Field	Description
Synchronization field	Contains 80 bits of data 'Ø'.
Preamble	Contains data FF, AA (2 bytes).
Block identification field	This field consists of 4 bytes. The function of each byte is as follows. Byte Ø: Block identifier field indicating the type of the block. H: Header D: Data E: End of file (EOD) Bytes 1 and 2: Indicate the 2-byte block number and must be ØØØØ to FFFF. Byte 3: Block identification number. This is used to identify blocks which are written twice to improve a reliability. Values ØØ through FF can be assigned to a block but the values actually used are ØØ and Ø1.
Data field	Stores data. An 8Ø-byte data field is assigned for header (the block identifier field begins with H) and EOF blocks (block identifier field begins with E). In all other cases, the data field size is defined by the header block.
BCC (Block Check Character) field	Performs CRC (Cyclic Redundancy Check) for the range from the beginning of the block to the BCC field. The two BCC bytes and CRC-CCITT are used for this check.
Postamble	Contains values AA, ØØ (2 bytes).

6.5 File structure

Only sequential files are supported. Sequential file data is fixed-length and blocked. Each sequential file consists of an 8Ø-byte header block (the length of the data field excluding the preamble, block identification field, BCC, and postamble), one or more data blocks (256 bytes each), and an EOF block. The block numbers assigned for each file begin with header block ØØ, followed by Ø1, Ø2 ... ending with the EOF block. Each block is written twice to improve reliability.

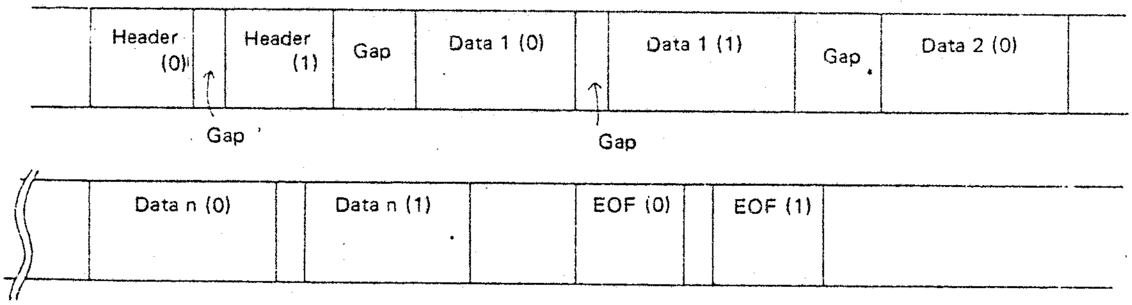


Fig. 6-6 Configuration of Sequential Files

A 5-sec tape feed (data FF) is provided at the beginning and end of each file as a gap to separate files.

6.6 Format of header and EOF blocks
The data format of the header block is shown in Table 6-4 and that of the EOF block is shown in Table 6-5.

Table 6-4 Format of Header Block

Column from	to	Byte size	Item	Description
0	3	4	ID field	Data HDR1. Indicates, in ASCII code, that the block is a header
4	11	8	Filename	Stores the filename.
12	19	8	File type .	Stores the file type.
20		1	Record type	This byte specifies the record type. The following record types can be specified. F : Fixed length V : Variable length 2 : Each fixed-length block is written twice. HX-20 currently supports only record type 2.
21		1	Interblock gap length	This byte specifies the interblock gap length "Δ": Interblock gap long enough for the tape to stop (long gap) "S": Interblock gap length not long enough for the tape to stop (short gap)
22	26	5	Block length	Indicates the data length of the block. Must be 00000 to 65535 (ASCII code).
27	31	4		Empty
32	37	6	Creation date	Indicates the date of file creation in "Month, Day, Year" format (ASCII code). Month, day, and year are represented by 2 bytes of data each.
38	43	6	Creation time	Indicates the time of file creation in "Hour, Minutes, Seconds" format (ASCII code). Hour, minute, and second are represented by 2 bytes of data each. Hour is the indicated by the 24-hour system (0 to 23).
44	49			Empty
50	51		Volume serial number	Indicates the tape volume number in ASCII code. (01 ~).
52	59	8	System name	Indicates the name of the system that created the file (ASCII code). "HX-20ΔΔΔ"
60	79	20		Empty

Table 6-5 Format of EOF Block

Column from	to	Byte size	Item	Description
0	3	4	ID field	"EOFΔ".
4	79	66		Empty

6.7 Interblock Gaps

There are two types of interblock gaps: long and short. The length of an interblock gap depends on whether the tape will stops at the gap. An interblock gap of approx. 10 bytes (the length of tape require to write a single block twice) is secured between block where the tape will not stop. This is a short gap. An interblock gap of approx. 100 bytes is required when the tape stops between blocks. This type of gap (long gap) enables the motor of the tape drive to reach a constant rotation speed from a halt state. The length of the interblock gap is specified by the header.

6.8 Writing Blocks

Data is written to cassettes by the slave MCU in units of one block. Commands for block write are exchanged between the master and the slave MCUs as shown in Fig. 6-7. The master MCU must send the write data within 4 msec after receiving ACK from the slave. The tape drive must already be running when data is sent to the slave MCU.
The data sent consists of the block ID ("H") and the contents of the data block (84 bytes for the header). CRC calculations are performed solely by the slave MCU.

Master MCU		Slave MCU
64 (Single block write command)	⇄	01 (ACK)
00 (Secures a long gap before output)	⇄	61 (ACK)
01 (The tape does not stop after a block is written.)	⇄	61
00 (Upper byte of the number of data in the block)	⇄	61
54 (Lower byte of the number of data in the block) SCI interrupt enable	⇄	61
"H" (Data 1, block ID)	⇄	61
00 (Data 2, upper byte of the block number)	⇄	61
00 (Data 3, lower byte of the block number)	⇄	61
00 (Data 4, block identification number)	⇄	61
d5 (Data 5, actual data 1)	⇄	61
d6 (Data 6, actual data 2)	⇄	61
⋮ ⋮		
d84 (Data 84, actual data 80) SCI interrupt disable	⇄	61

Fig. 6-7 Exchange of Commands for Write Operation for a Single Block (Header)

When the RIE (Receive Interrupt Enable) mask of the SCI (Serial Communication Interface) is opened, the main MCU uses the interrupt routine to transmit the data from "H" to d84 in Fig. 6-7 to the slave MCU. When master MCU receives data 61 from the slave MCU, an SCI interrupt is generated and the master MCU sends next data to the slave MCU.

The RIE mask is closed after one block has been transmitted. The master MCU can transmit data to the slave MCU without generating an SCI interrupt but the current transmission procedure uses the SCI interrupt.

6.9 Reading blocks

Command 28 (26, 27) is used to read a block from the external cassette. Command 68 (66, 67) is used to read a block from the microcassette. The slave MCU transmits to the master MCU the contents of the block, from the beginning of the block identification field to the beginning of the BCC. Redundant bytes used for the CRC check are not sent to the main MCU. When one block has been sent, the slave MCU sends a completion code (22 for the external cassette and 62 for the built-in microcassette) to the master MCU. When the master MCU receives the completion code, it inputs a BCC value to the slave MCU and evaluates the results of the CRC check. CRC check is performed for the range from the block identification field to the CRC redundant byte. If the result of the CRC check is 0, this indicates that the data write operation has been correctly performed. Next, the block number is checked. If block 4 is input when block 5 should be input, the next block must be input. If 6 is input, this means that the desired block has already passed. When a single block has been correctly input, this is taken as the completion of input processing. Otherwise, input processing is aborted or the input procedure for the next block is begun. The master MCU receives the data sent from the slave MCU via the SCI using SCI receive interrupt processing and stores this data in the specified buffer.

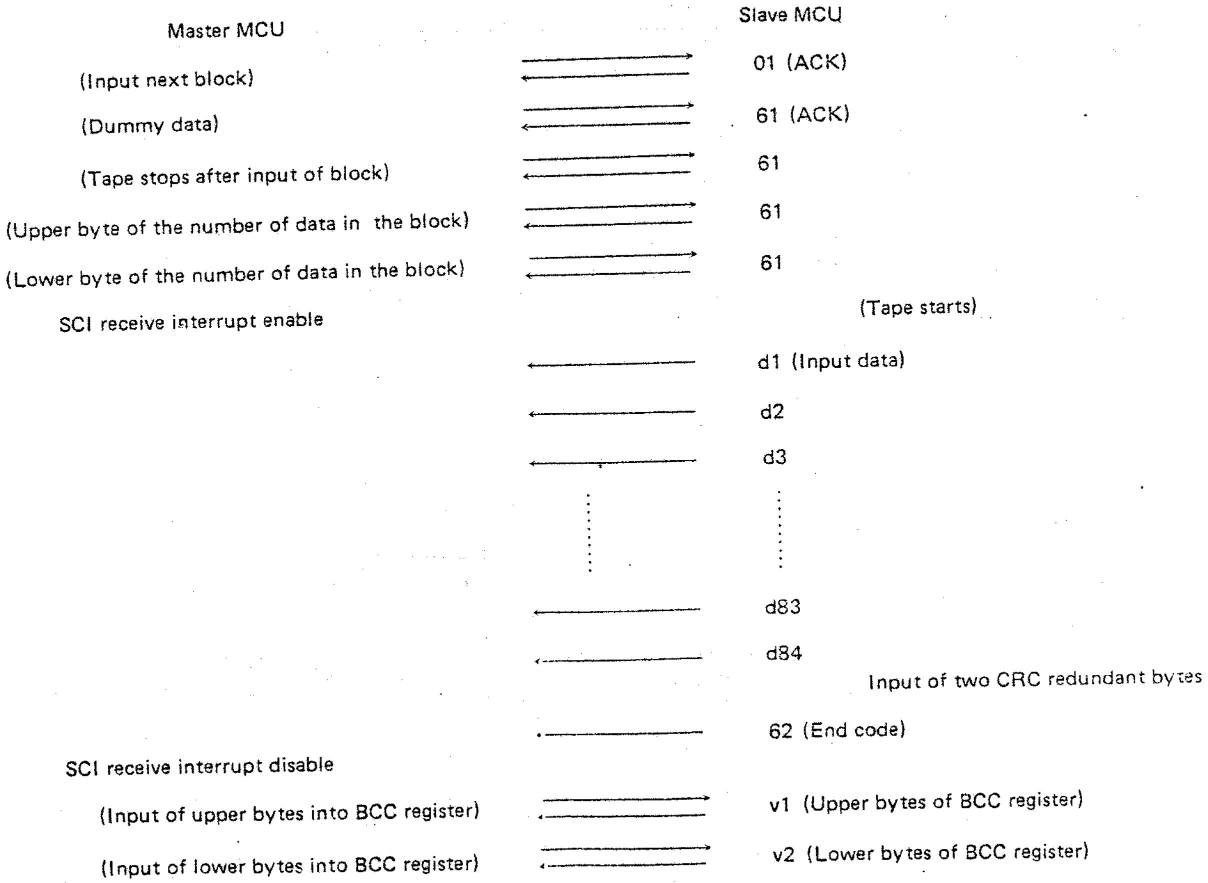

Master MCU
Slave MCU
(Input next block)
01 (ACK)
(Dummy data)
61 (ACK)
(Tape stops after input of block)
61
(Upper byte of the number of data in the block)
61
(Lower byte of the number of data in the block)
61
(Tape starts)
SCI receive interrupt enable
d1 (Input data)
d2
d3
d83
d84
Input of two CRC redundant bytes
62 (End code)
SCI receive interrupt disable
(Input of upper bytes into BCC register)
v1 (Upper bytes of BCC register)
(Input of lower bytes into BCC register)
v2 (Lower bytes of BCC register)

Fig. 6-8 Exchange of Commands for Read Operation for a Single Block (Header)

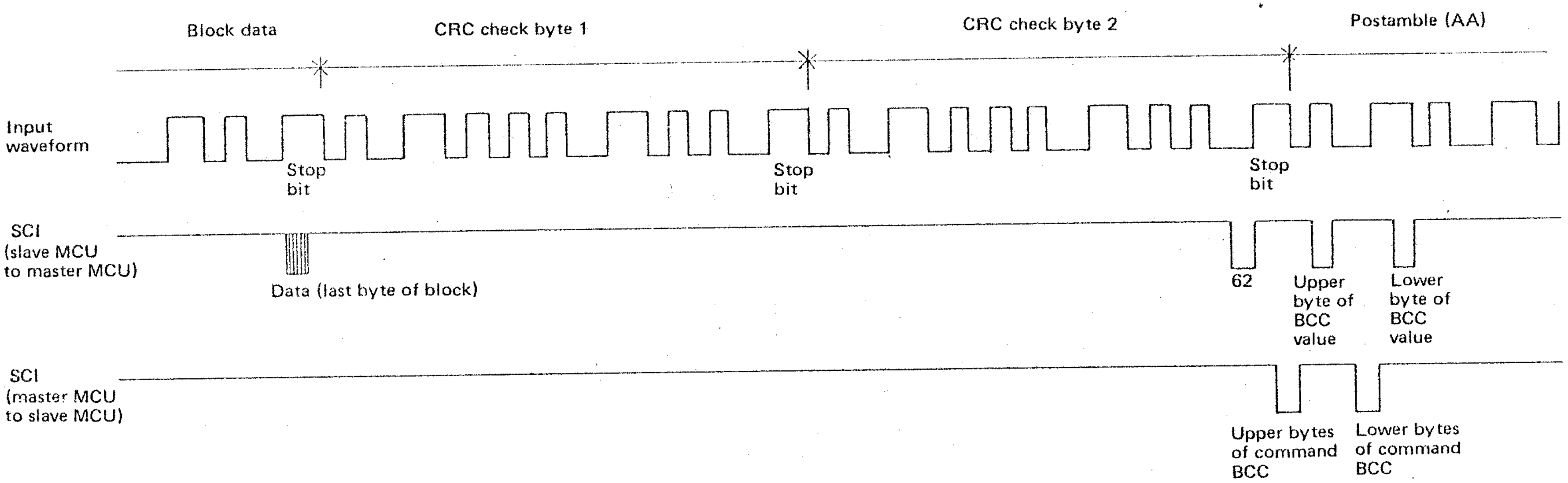


Fig. 6-9 Input Timing for Block Data

6.10 File output

Files are output to cassettes using the following three procedures.

(1) File open

Subroutine OPNWMS is used to open files for output to the built-in microcassette and subroutine OPNWCS performs the same function for the external cassette. When a file is opened for output, the header is output and internal preparations are made for data block output. Specification for the tape to stop after the head block has been output is included.

(2) Output of one byte to a tape file

Subroutine WRITMS outputs data to the built-in microcassette and subroutine WRITCS to the external cassette. Data is written to a buffer (256 bytes of data + block identification data). Actual output to the microcassette or external cassette is performed when the buffer becomes full.

(3) File close

Subroutine CLSMS closes the built-in microcassette file and subroutine CLSCS closes the external cassette file. If any data remains in the buffer when the file is closed, it is output as a data block. An EOF block is then output and the tape stops.

Double write

As a measure to improve reliability, the contents of the buffer are output twice (each block is written twice). This procedure is followed for all blocks (header, data and EOF).

6.11 File open

Files are input from cassettes using the following three procedures.

(1) File open

Subroutines SRCRCS and OPNRCS are used to open files for input from an the external cassette and subroutines SRCRMS and OPNRMS perform the same function for the built-in microcassette. These subroutines search a specified file by inputting a header from the tape and comparing this with the specified file. After the header of the specified file has been input the tape stops and data input is internally prepared.

(2) Input of one byte from a tape file

Subroutine READMS inputs one byte of data from the microcassette and subroutine READCS from the external cassette. Data is fetched one byte at a time from the 256-byte buffer. When the buffer is empty, the next block is written to it from the tape and data fetch continues.

(3) File close
Subroutine CLSMS closes the microcassette file and subroutine CLSCS closes the external microcassette file. The tape stops when one of these subroutines is called. When a file is closed, the corresponding input device is released.

6.12 Functions unique to the built-in microcassette

Fast forward and rewind of the microcassette are performed by the slave MCU in response to commands sent from the master MCU. The slave MCU also starts and stops the motor and reads the tape counter value. The following 4 subroutines are provided.

1. MCSMAN: Performs the operations of the manual operation mode.
2. REWMCS: Rewinds the tape to the beginning.
3. SEKMCS: Winds the tape to the specified tape counter value.
4. CNTMCS: Sets or reads the microcassette tape counter value.

Counter read
The main MCU controls the counter during data input or output. The slave MCU controls the counter at all other times. If there is no change in the counter signal for a specified length of time, it is judged that either no tape is set in the drive or that the tape has been wound to the BOT or EOT position. The tape then stops. Port P17 of the main MCU is used to input the tape counter status. This port value indicates whether the tape counter signal is high or low. The tape counter value is indicated by number of changes in the tape counter signal. When data is being input or output, the main MCU inputs the tape counter signal and performs sampling using a TOF interrupt (Ø.1-sec interval). The slave MCU controls the counter when fast forward or rewind is being performed.

6.13 Notes on I/O

(1) Polynominals generated for CRC check
The default value ($X^{16} + X^{12} + X^5 + 1$) for polynominal expressions generated for CRC check is set by the slave MCU after reset. This value can be modified by using slave MCU command 48. If the polynominal expression generated at the time of input is different from that generated at the time of output, the system assumes that a CRC error has occurred and no data can be input.

(2) Interblock gaps
When the REM terminal is used for data output to an external cassette, data write will not be correctly performed if the tape drive takes too much time to reach constant running speed from a fully stopped state. When using a tape recorder where such a condition occurs, the interblock gap must be lengthened (slave MCU command 21).

(3) Number of input data in a block

When one of slave MCU commands 28 or 68 (input one block) is input, if the first data input is H or E (header or EOF block), 84 bytes is assumed as the length of the data field of the block and the number of data specified by the command is ignored.

6.14 External cassette subroutines

Subroutine name	Entry point	Description
PONFCS	FF46	Turns ON/OFF the remote (REM) terminal. Parameters: At Entry (A): 0: Turns the REM terminal OFF 1: Turns the REM terminal ON. (Bit 0 is used.) At Return (C): Abnormal I/O flag (A): Return codes 00: Normal (00 is always set in the current version.) Registers retained (B) and (X) Subroutines referenced SNSCOM and CHKRS Variables used None
OPNRCS	FF43	Opens the cassette file for input and searches the specified file until it is found. Parameters: At Entry (X): Starting address of a data packet Data packet 1. Interblock stop mode (1 byte) 00: Tape stops at the interblock gap. 01: Tape does not stop at the interblock gap. FF: According to the header specification. 2. Starting address of input buffer (two bytes, high- to low-byte order) Input buffer size is 260 bytes. 3. 8-byte filename (ASCII code) 4. 8-byte file type (ASCII code) NOTE: If "*" is specified in the character string of a data packet filename, matching terminates at this asterisk position. "*" can also be used in a file type. A file whose filename and type match the specified filename and type is assumed to be the specified file. For example, if the filename is "FILE" and any file type is acceptable, the filename should be specified as "FILEΔΔΔΔ" and the file type as "*ΔΔ". To specify the first file in the tape, both filename and type should be "*ΔΔΔΔΔΔΔ". At Return (C): Abnormal I/O flag (A): Return codes 00: Normal 85: File error (Z): According to the value of (A).

		Registers retained None Subroutines referenced SNSCOM, CRDBHD, and CRDBEF Variables used R1, R2, R3, R4 and R5
SRCRCS	FF40	Opens the cassette file when the first file found is the specified file. Returns the found filename.
		Parameters: At Entry (X): Top address of data packet Data packet 1. Interblock stop mode Same as for subroutine OPNRCS. 2. Starting address of the input buffer Same as for subroutine OPNRCS. 3. Filename Same as for subroutine OPNRCS. 4. File type Same as for subroutine OPNRCS. 5. Found filename (8 bytes) 6. Found file type (8 bytes) Note: The function of "*" in the specification of filename and type is the same as for subroutine OPNRCS. At Return (C): Abnormal I/O flag (A): Return codes 00: Normal 85: File error 8B: The file found is not the specified file. (Z): According to the value of (A). Registers retained None Subroutines referenced SNSCOM, CRDBHD and CRDBEF Variables used R0, R1, R2, R3, R4 and R5
READCS	FF3D	Inputs one byte of data from the external cassette. Input data is fetched from the 256-byte buffer one byte at a time. When the buffer becomes empty, the next block is automatically written to the buffer.
		Parameters: At Entry None At Return (C): Abnormal I/O flag (A): 1-byte input data (B): Return codes 00: Normal 01: End of file (EOF) 84: The input file is not open. 81: Read error (Z): According to the value of (B).

		Registers retained (X) Subroutines referenced CRDBLK Variables used RØ, R1, R2, R3, R4 and R5
OPNWCS	FF3A	Opens the external cassette file for output.
		Parameters: At Entry (X): Top address of a data packet Data packet 1. Interblock stop mode (1 byte) ØØ: Tape stops at the interblock gap. Ø1: Tape does not stop at the interblock gap. 2. Starting address of output buffer (buffer size is 26Ø bytes) 3. 8-byte filename (ASCII code) 4. 8-byte file type (ASCII code) At Return (C): Abnormal I/O flag (A): Return codes ØØ: Normal 88: File is already open. 91: Output error (Z): According to the value of (A). Registers retained None Subroutines referenced CWRHED Variables used RØ, R1, R2, R3, R4 and R5
WRITCS	FF37	Outputs one byte of data to the external cassette. Output data is written to the 26Ø-byte buffer. When the buffer becomes full, data is automatically written to the file.
		Parameters: At Entry (A): 1-byte output data At Return (C): Abnormal I/O flag (B): Return codes ØØ: Normal 94: File is not open. 91: Output error (Z): According to the value of (B). Registers retained (A) and (X) Subroutines referenced CWRBLK

		Variables used RØ, R1, R2, R3, R4 and R5
CLSCS	FF34	Closes the external cassette file. When an output file is closed, any data remaining in the buffer is output to the cassette followed by an EOF block. When an input file is closed, input operation simply terminates.
		Parameters: At Entry None At Return (C): Abnormal I/O flag (A): Return codes ØØ: Normal 87: File is not open. 91: Output error (Z) According to the value of (A). Registers retained None Subroutines referenced WRTCCS, CWRHED and SNSCOM Variables used RØ, R1, R2, R3, R4 and R5

6.15 Built-in microcassette subroutines

Subroutine name	Entry point	Description
MCSMAN	FF0D	Performs FF (fast forward) and REW (rewind), etc., according to the keyboard input and displays the tape counter value on the LCD. The keys used for the manual operation mode are as follows. PF1: FF PF2: Slow forward PF3: Stop PF4: REW PF5: Quit. returns from the subroutine PF6: Counter reset This subroutine preserves the contents of the virtual screen while the HX-20 is in the manual operation mode.
		Parameters: At Entry None At Return (C): Abnormal I/O flag (A): Return codes 00: Normal 80: Microcassette is not mounted. (Z): According to the value of (A). Registers retained None Subroutines referenced SNSCOM, KEYIN, KEYSTS, DSPLCN, BINDEC and LRECV Variables used None
OPNRMS	FF0A	Opens the microcassette file for input and searches the specified file until it is found. (see subroutine OPNRCS.)
		Parameters: At Entry and Return Same as subroutine OPNRCS except that return code 80 is also used. Registers retained Same as subroutine OPNRCS Variables used Same as subroutine OPNRCS Subroutines referenced MWRHED
SRCRMS	FF07	Opens the microcassette file. The function of this subroutine is the same as that of subroutine SRCRCS.
		Parameters: At Entry and Return Same as subroutine SRCRCS except that return code 80 is also used. Registers retained Same as subroutine SNSCOS Variables used Same as subroutine SNSCOS Subroutines referenced SNSOOM, MRDBHD and MRDBEF
READMS	FF04	Inputs one byte of data from the microcassette. The function of this subroutine is the same as that of subroutine READCS.

		Parameters: At Entry and Return Same as subroutine READCS except that return code 80 is also used. Registers retained Same as subroutine READCS Variables used Same as subroutine READCS Subroutines referenced WRTMCS, MWRHED and SNSCOM
OPNWMS	FF01	Opens the microcassette file.
		Parameters: At Entry and Return Same as subroutine OPNWCS except that return code 80 is also used. Registers retained Same as subroutine OPNWCS Variables used Same as subroutine OPNWCS Subroutines referenced MWRHED
WRITMS	FEFE	Outputs one byte of data to the microcassette. The function of this subroutine is the same as that of subroutine WRITCS.
		Parameters: At Entry and Return Same as subroutine WRITCS except that return code 80 is also used. Registers retained Same as subroutine WRITCS Variables used Same as subroutine WRITCS Subroutines referenced MWRBLK
CLSMS	FEFB	Closes the microcassette file. The function of this subroutine is the same as that of subroutine CLSCS.
		Parameters: At Entry and Return Same as subroutine CLSCS except that return code 80 is also used. Registers retained Same as subroutine CLSCS Variables used Same as subroutine CLSCS Subroutines referenced WRTMCS, MWRHED and SNSCOM
REWMCS	FEF5	Rewinds the microcassette tape to the beginning.
		Parameters: At Entry None At Return (C): Abnormal I/O flag (A): Return codes 00: Normal 80: Microcassette not mounted. (X): Tape counter value after rewind (-32768 to 32767) (Z): According to the value of (A) Registers retained None Subroutines referenced

		CHKMCS and SNSCOM Variables used R0
SEKMCS	FEF2	Winds the microcassette tape to the specified tape counter value.
		Parameters: At Entry (X): Specified value of the binary counter. (-32768 through 32767) At Return (C): Abnormal I/O flag (A): Return codes 00: Normal 80: Microcassette not mounted. (Z): According to the value of (A). (X): Counter value after wind Registers retained None Subroutines referenced CHKMCS and SNSCOM Variables used R0
CNTMCS	FEEF	Sets or reads the microcassette tape counter value.
		Parameters: At Entry (A): Specifies setting or reading of the tape counter value. 00: Reads the tape counter value. 01: Sets the tape counter value. (Any value other than 00 is taken as 01.) (X): Counter value (A≠00) Return parameters (C): Abnormal I/O flag (0 is always set on return.) (X): Counter value (A=00 at entry) Registers retained (B) Subroutines referenced None Variables used None

6.16 Work areas for external cassette

Address	Variable name	Byte count	Description
15D 1D5	CSMOD	1	Current mode Bits Ø and 1: Format (Bits 1 and Ø) = (Ø, Ø): EPSON format Other than (Ø, Ø): Format other than EPSON format Bits 2 and 3: File open status (bit 3, bit 2) = (Ø, Ø): File not open (Ø, 1): Open for input (1, Ø): Open for output (1, 1): Undefined Bits 4 to 7: Undefined
1D6 1D7	CSBLNO	2	Block number
1D8 1D9	CSBCC	2	BCC register value (CRC check for a single block)
1DA 1DB	CSBLSZ	2	Unused
1DC 1DC	CSBSTP	1	Interblock gap tape stop mode Ø: Tape stops at the interblock gap. 1: Tape does not stop at the interblock gap.
1DD 1DD	CSSTS	1	Error status (Logic '1' in any bit indicates an error.) Bit Ø: EOF (EOF detected during input.) Bits 1 to 3: Underfined Bit 4: Underfined Bit 5: Write error Bit 6: Read error Bit 7: Buffer overflow
1DE 1DF	CSBFAD	2	Starting address of cassette buffer
1EØ 1E1	CSBFBT	2	Ending address of cassette buffer plus 1
1E2 1E3	CSBFSZ	2	Cassette buffer size (in bytes)
1E4 1E5	CSBFIP	2	Pointer indicating the next address to be stored in the cassette buffer
1E6 1E7	CSBFOP	2	Pointer indicating the next address to be fetched from the cassette buffer
1E8 1E9	CSBFCM	2	Number of data in buffer
1EA 1EA	CSRDTR	1	Upper limit for the number of block input trials
1EB 1EB	CSRDCN	1	Number of block input trials

6.17 Work areas for built-in microcassette

Address	Variable name	Byte count	Description
1EC 1EC	MSMOD	1	Current mode Bits 0 and 1: Format (Bits 1 and 0) = (0, 0): EPSON format Other than (0, 0): Format other than EPSON format Bits 2 and 3: File open status (0, 0): File not open (0, 1): Open for input (1, 0): Open for output (1, 1): Undefined Bits 4 to 7: Undefined
1ED 1EE	MSGLNO	2	Block number
1EE 1F0	MSBCC	2	BCC register value (CRC check for a single block)
1F1 1F2	MSBLSZ	2	Unused
1F3 1F3	MSBSTP	1	Interblock gap tape stop mode 0: The tape stops at the interblock gap. 1: The tape does not stop at the interblock gap.
1F4 1F4	MSSTS	1	Error status (Logic '1' in any bit indicates an error.) Bit 0: EOF (EOF detected during input.) Bits 1 through 3: Underfined Bit 4: Counter not updated Bit 5: Write error Bit 6: Read error Bit 7: Buffer overflow
1F5 1F6	MSBFAD	2	Starting address of microcassette buffer
1F7 1F8	MSBFBT	2	Ending address of microcassette buffer +1
1F9 1FA	MSBFSZ	2	Microcassette buffer size (in bytes)
1F9 1FC	MSBFIP	2	Pointer indicating the next address to be stored in the buffer
1FD 1FE	MSBFOP	2	Pointer indicating the next address to be fetched from the buffer
1FF 200	MSBFCM	2	Number of data in buffer
201 201	MSRDIR	1	Upper limit for the number of block input trials
202 202	MSRDCN	1	Number of block input trials
203 204	MSCNTR	2	Counter value
205 205	MSMNCM	1	Manual command currently being executed
206 206	MTOFCN	1	Sampling timeout counter for data I/O
207 207	MSPLMD	1	Counter pulse status (low or high)

6.18 Work areas for external cassette headers

Address	Variable name	Byte count	Description
2DØ 2DØ	CHBLID	1	'H'
2D1 2D2	CHBLNO	2	Block number (binary, Ø ...)
2D3 2D3	CHBLBU	1	Same block, block number (Ø, 1 ...)
2D4 2D7	CID	4	HDR
2D8 2DF	CFNAME	8	Filename
2EØ 2E7	CFTYPE	8	File type
2E8 2E8	CRTYPE	1	Record type (2: Double write)
2E9 2E9	CBMODE	1	Block mode S: Short gap Δ: Interblock gap stop
2EA 2EE	CBLNG	5	Block length (ΔΔ256: 256)
2EF 2F3		5	
2F4 2F9	CDATE	6	Data (MMDDYY)
2FA 2FF	CTIME	6	Time (HHMMSS)
3ØØ 3Ø5		6	
3Ø6 3Ø7	CVOLN	2	Volume number
3Ø8 3ØF	CSYSN	8	System name (HX-2ØΔΔΔ)
31Ø 323		2Ø	

6.19 Work areas for built-in microcassette headers

Address	Variable name	Byte count	Description
324 324	MHBLID	1	'H'
325 326	MHBLNO	2	Block number
327 327	MHBLBU	1	Same block, block number
328 32B	MID	4	HDR1
32C 333	MFNAME	8	Filename
334 33B	MFTYPE	8	File type
33C 33C	MRTYPE	1	Record type (2: Double write)
33D 33D	MBMODE	1	Block mode S: Short gap Δ: Interblock gap stop
33E 342	MBLNG	5	Block length (ΔΔΔ256: 256)
343 347		5	
348 34D	MDATE	6	Date (MMDDYY)
34E 353	MTIME	6	Time (HHMMSS)
354 359		6	
35A 35B	MVOLN	2	Volume number
35C 363	CSYSN	8	System name (HX-2ØΔΔΔ)
364 377		2Ø	
378 47B	CASBUF	26Ø	Buffer used by the microcassette

CHAPTER 7 MICROPRINTER

7.1 General

The built-in microprinter is a dot matrix printer with a print width of 144 dots. Printing is performed by a single print head driven by four solenoids. Print mode is unidirectional and paper feed is performed each time the print head is returned. The I/O ports related to printing are connected to the slave MCU which controls printing. The bit patterns for printing, however, are supplied by the master MCU.

7.2 Print Head and Solenoids

The microprinter has one print head and four solenoids: A, B, C and D. Each solenoid prints 36 dots during a single pass of the print head. (Fig. 7.1). Only unidirectional printing is performed and line feed of one dot-line is performed when the head is returned (Fig. 7-2).

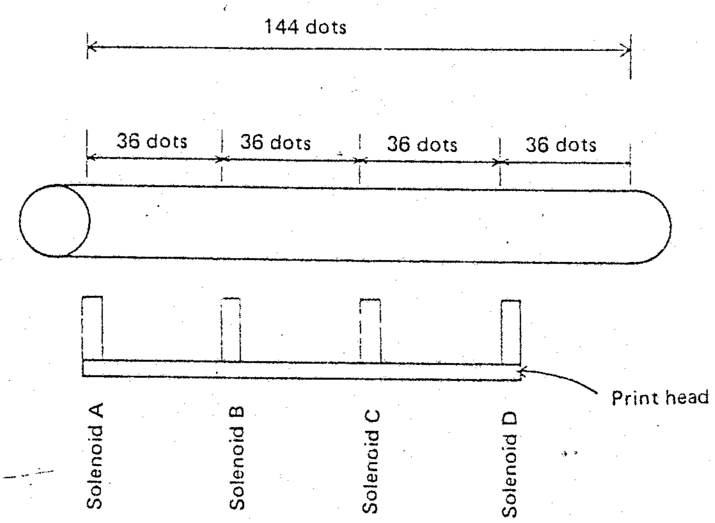


Fig. 7-1 Print Area of Each Solenoid

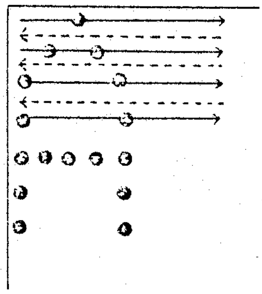


Fig. 7-2 Print Head Operation

Thus, to print a single 6 x 8-dot character pattern, the print head must make 8 passes in each direction.

When printing "ABCDEFGHIJKLMNOPQRSTUVWX", characters "ABCDEF" are printed by solenoid A, "GHIJKL" are printed by solenoid B, "MNOPQR" by solenoid C, and "STUVWX" by solenoid D.

The printer is controlled by the slave MCU, but actual printing is performed in response to commands sent from the master MCU.

7.3 Ports

The I/O ports related to the printer are as follows.

	Port	Input/ Output	Function		
Slave MCU	P1Ø	Output	Print solenoid 1	1: ON	Ø: OFF
	P11	Output	Print solenoid 2	1: ON	Ø: OFF
	P12	Output	Print solenoid 3	1: ON	Ø: OFF
	P13	Output	Print solenoid 4	1: ON	Ø: OFF
	P14	Output	Motor output	1: ON	Ø: OFF
	P15	Input	Reset signal input	1: High	Ø: Low
	P16	Input	Timing pulse	1: High	Ø: Low
	P17	Output	Motor break	1: Break ON	Ø: Break OFF

NOTE:
Commands must not be sent from the master MCU which will operate the above ports to supply current to the print solenoids for more than a few seconds or to supply a BREAK signal while motor output is specified (P14 is 1).

7.4 Slave MCU Commands

The slave MCU is provided with a command for printing 6 dots of print data. This command is sent from the master MCU 24 times to print one dot-line. Therefore, sending this command 48 times will print 2 dot-lines and sending it 192 (24 x 8) times will print one line of 6 x 8-dot character patterns.

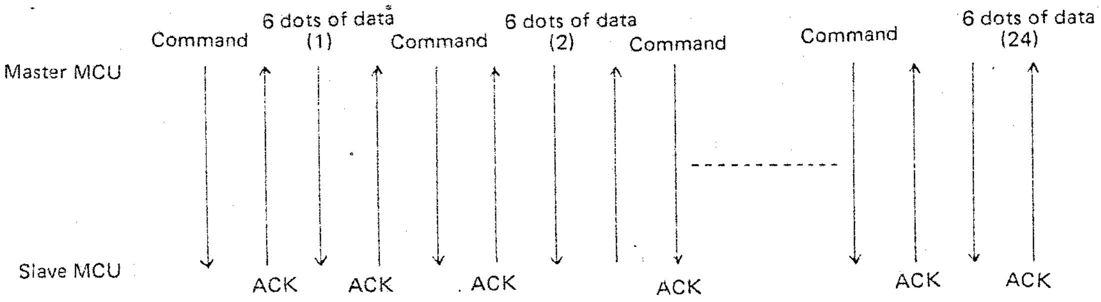
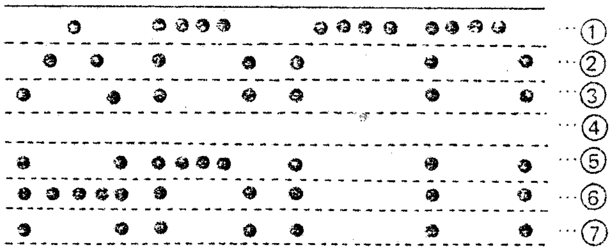


Fig. 7-3 Transmission of Slave MCU Command

If printing is resumed after being interrupted (the print head stops), a blank of one dot-line will occur. This is due to the automatic paper feed (one pitch) when the print head is returned and to the fact that the head stop and restart operation has not finished within the duration of the head's return pass across the page.



Lines ①, ② and ③ are printed normally. If printing is stopped after line ③, one dot line will be left blank by automatic line feed when the printing lines.

Fig. 7-4 One Blank Dot-line when Print Head Stops

After the slave MCU restarts printing on the printer and a new line is to be printed, if there are less than 24 bytes of data in the data buffer, printing is stopped automatically. When continuously printing a given print pattern, if an interrupt in command transmission from the master to the slave MCU of approx. 300msec occurs, data may be lost (Fig. 7-5).

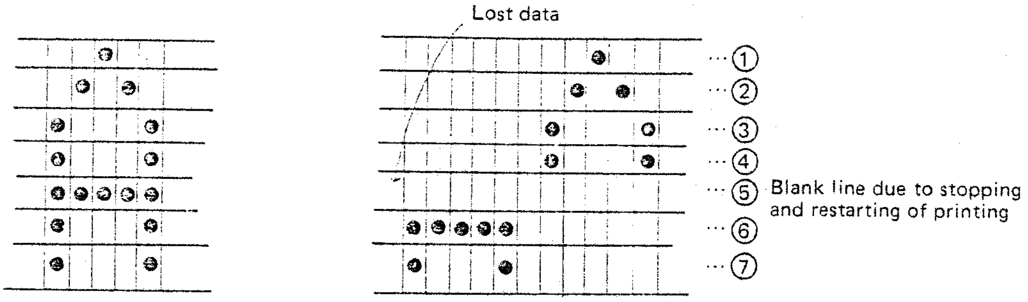
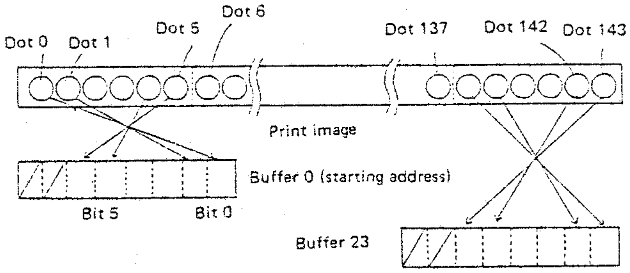


Fig. 7-5 Loss of Print Data

In Fig. 7-5, printing of an A pattern has been attempted. After the data on line 4 has been sent to the slave MCU and blank time has passed, data transmission is performed. Since there is only one byte of data in the slave MCU, printing is stopped. The data in the buffer at this time will be lost.
Printing is resumed when the contents of the buffer exceed 24 bytes. This results in lost print data, as shown in Fig. 7-5.
When printing a line of characters (subroutine "LNPRNT"), after 8 dot-lines of data have been sent, a 2-dot line feed command is sent from the master MCU. In this way, data loss due to timing is prevented (since the feed command processed by the slave MCU stops fetching of the dot pattern data to the buffer).

7.5 List of Printer Subroutines

Subroutine Name	Entry Point	Contents
CHPRNT	FF97	Outputs one character to the microprinter. All control codes (ØØ-1F) except CR(ØD) and LF (ØA) are ignored. For CR, the buffer column position is set to Ø (first position) and the contents of the buffer are cleared. For LF control codes, the contents of the buffer are printed. After printing, the buffer is cleared and the column position is set to Ø.
		Parameters: At Entry (A): Character code (ASCII) At Return (C) Abnormal I/O flag Registered retained (A), (B), (X) Subroutines referenced LNPRNT, CLRB Variables used None
LNPRNT	FF94	Outputs 1 line of characters on the microprinter. Checks for printer switch ON or OFF. If OFF, the output procedure is ignored. Prints 24 characters of the printer buffer contents (ASCII). After printing, the contents of the buffer remain unchanged.
		Parameters: At Entry (X): Starting address of buffer Buffer size: 24 bytes Data is in ASCII code. At Return (C) Abnormal I/O flag Registers retained (A), (B), (X) Subroutines referenced SNSCO, NDFEED, CHKSWT, CHKRS Variables used RØ, R1
PRTDOT	FF91	Prints one dot-line of bit-image data. One dot-line of bit-image print consists of 144 dots and is specified by the 24 bytes in the buffer. Data is entered into the buffer as follows.

Subroutine Name	Entry Point	Contents
		 Dot 0 Dot 1 Dot 5 Dot 6 Dot 137 Dot 142 Dot 143 Print image Buffer 0 (starting address) Bit 5 Bit 0 Buffer 23 Bit 6 and bit 7 of each byte of the buffer have no meaning. NOTE: If during the printing of an image an empty interval occurs until this subroutine is called, a 1-dot blank line will result.
		Parameters: At Entry (X): Starting address of buffer At Return (C) Abnormal I/O flag Registers retained (A), (B), (X) Subroutines referenced SNSCOW, CHKSWT, CHKRS Variables used R0H [Example] When the following is printed. ○●●○○○●●○○○○……… LDX BUFF JSR PRTDOT BUFF FCB $06, $03, ...
NDFEED	FF8F	Performs paper feed for n dot-lines.
		Parameters: At Entry (A): Number of dot-lines of line feed performed At Return (C): Abnormal I/O flag Registers retained (A), (B), (X) Subroutines referenced SNSCOW, CHKRS Variables used None

Subroutine Name	Entry Point	Contents
SCRCPY	FF8B	Copies the data displayed on the LCD on the microprinter. The width of the LCD is 120 dots and that of the printer, 144 dots. The data is left-justified and the remaining 24 dots remain blank.
		Parameters: At Entry None At Return (C): Abnormal I/O flag Registers protect (A), (B), (X) Subroutine referenced SNSCOW, SNSCOM, WRTP26, CHKSWT, LCDMOD Variables used None

7.6 Microprinter Work Areas

Addresses		Variable	Byte	Contents
(From)	(To)	Name	Count	
190	195	CHRPTN	6	Work Area for character font (for 1 character).
196	196	COLCNT	1	Data count in buffer (0~24 bytes)
197	1AE	CHRDAT	24	Buffer data for 1 line of characters.

```
    00001                                 *
    00002                                        NAM    PRINT
    00003                                        TTL    --- PRINT FULL GRAPHIC PATTERN ---
    00004                                        OPT    LOAD
    00005                                        OPT    PAGE=55
    00006                                 *
    00007                                 * PRINT FULL GRAPHIC PATTERN TO INTERNAL MICRO PRINTER.
    00008                                 * FILE NAME    'EX34'    BY  K.A
    00009                                 *
    00010A 1000                                  ORG    $1000
    00011                                 *
    00012                                 *
    00013            FF91  A              PRTDOT EQU    $FF91
    00014                                 *
    00015                                 *  PRINT PATTERN OF OBLIQUE LINES.
    00016                                 *     .  .  .  .  .  .  .  .  .
    00017                                 *      .  .  .  .  .  .  .  .  .
    00018                                 *       .  .  .  .  .  .  .  .  .
    00019                                 *     .  .  .  .  .  .  .  .  .
    00020                                 *      .  .  .  .  .  .  .  .  .
    00021                                 *       .  .  .  .  .  .  .  .  .
    00022                                 *     .  .  .  .  .  .  .  .  .
    00023                                 *
    00024                                 *
    00025A 1000 86 08     A                      LDA A  #8         * (A): REPAETING TIMES
    00026A 1002 C6 03     A               PRTR10 LDA B  #3         * (B): PATTERN NUMBER (3 2 1)
    00027                                 *
    00028A 1004 CE 101F   A               PRTRPT LDX    #PATN1     * SET ADDRESS OF PRINT PATTERN
    00029A 1007 C1 03     A                      CMP B  #3         * IF (B)=3, PATTERN 1
    00030A 1009 27 0A 1015                       BEQ    PRTR30
    00031A 100B CE 1037   A                      LDX    #PATN2     * IF (B)=2, PATTERN 2
    00032A 100E C1 02     A                      CMP B  #2
    00033A 1010 27 03 1015                       BEQ    PRTR30
    00034A 1012 CE 104F   A                      LDX    #PATN3     * IF (B)=1, PATTERN 3
    00035A 1015 BD FF91   A               PRTR30 JSR    PRTDOT     * PRINT BY GRAPHIC IMAGE.
    00036A 1018 5A                               DEC B
    00037A 1019 26 E9 1004                       BNE    PRTRPT
    00038A 101B 4A                               DEC A             * FINISHED ?
    00039A 101C 26 E4 1002                       BNE    PRTR10
    00040                                 *
    00041A 101E 39                               RTS
    00042                                 *
    00043A 101F     09    A               PATN1  FCB    $09,$09,$09,$09,$09,$09
         A 1020     09    A
         A 1021     09    A
         A 1022     09    A
         A 1023     09    A
         A 1024     09    A
    00044A 1025     09    A                      FCB    $09,$09,$09,$09,$09,$09
         A 1026     09    A
         A 1027     09    A
         A 1028     09    A
         A 1029     09    A
         A 102A     09    A
    00045A 102B     09    A                      FCB    $09,$09,$09,$09,$09,$09
```

```
       A 102C    09    A
       A 102D    09    A
       A 102E    09    A
       A 102F    09    A
       A 1030    09    A
  00046A 1031    09    A                FCB    $09,$09,$09,$09,$09,$09
       A 1032    09    A
       A 1033    09    A
       A 1034    09    A
       A 1035    09    A
       A 1036    09    A
  00047A 1037    12    A         PATN2  FCB    $12,$12,$12,$12,$12,$12
       A 1038    12    A
       A 1039    12    A
       A 103A    12    A
       A 103B    12    A
       A 103C    12    A
  00048A 103D    12    A                FCB    $12,$12,$12,$12,$12,$12
       A 103E    12    A
       A 103F    12    A
       A 1040    12    A
       A 1041    12    A
       A 1042    12    A
  00049A 1043    12    A                FCB    $12,$12,$12,$12,$12,$12
       A 1044    12    A
       A 1045    12    A
       A 1046    12    A
       A 1047    12    A
       A 1048    12    A
  00050A 1049    12    A                FCB    $12,$12,$12,$12,$12,$12
       A 104A    12    A
       A 104B    12    A
       A 104C    12    A
       A 104D    12    A
       A 104E    12    A
  00051A 104F    24    A         PATN3  FCB    $24,$24,$24,$24,$24,$24
       A 1050    24    A
       A 1051    24    A
       A 1052    24    A
       A 1053    24    A
       A 1054    24    A
  00052A 1055    24    A                FCB    $24,$24,$24,$24,$24,$24
       A 1056    24    A
       A 1057    24    A
       A 1058    24    A
       A 1059    24    A
       A 105A    24    A
  00053A 105B    24    A                FCB    $24,$24,$24,$24,$24,$24
       A 105C    24    A
       A 105D    24    A
       A 105E    24    A
       A 105F    24    A
       A 1060    24    A
  00054A 1061    24    A                FCB    $24,$24,$24,$24,$24,$24
       A 1062    24    A
```

```
          *** 6301 CROSS MACROASSEMBLER   VER1.0 ***                                               10/21/82    09:41:28
ERR   SEQ   LOC  OBJECT      PROGRAM  PRINT      --- PRINT FULL GRAPHIC PATTERN ---

          A 1063     24     A
          A 1064     24     A
          A 1065     24     A
          A 1066     24     A
     00055                              *
     00056                              *
     00057                              *
     00058           0000   A                  END
***** TOTAL ERRORS      0
```