CHAPTER 13 MISCELLANEOUS I/O

13.1 Speaker Output

Slave MCU port 15 supplies the output to the speaker. The required square wave frequencies are obtained by dividing this signal and outputting them to the piezoelectric speaker.
To obtain a 1,000Hz output at the piezoelectric speaker, the output at port 15 should be as shown in Fig. 13-1.

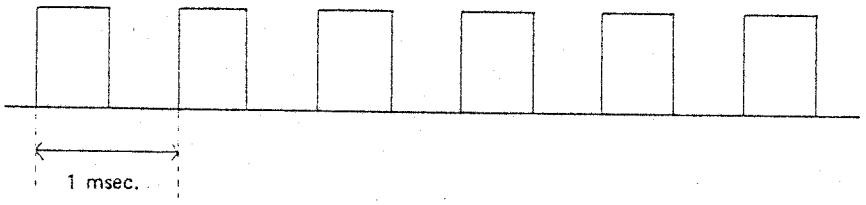

Fig. 13-1 Output to the Piezoelectric Speaker

The SOUND subroutine has been provided to specify the tone and duration of the speaker output.

13.2 Expansion Unit

The expansion unit features a 16K-byte RAM and 16K-byte ROM (only socket is provided). Addresses 0080 to 7FFF can be used as a RAM. A ROM, addresses 8000 to BFFF, may be selected by switching the HX-20 and expansion unit banks.

(1) Memory area
When the expansion unit is connected, addresses 4000 to 7FFF (16K bytes) may be used as a RAM. Data in the RAM is battery-backed up and protected. The ROM (8000-BFFF) is assigned as follows: bank 0 to the HX-20 and bank 1 to the expansion unit. Several memory configurations for the expansion unit are available. For details, refer to the hardware section of this manual.

(2) Switching ROM banks
When the ROM is mounted in the expansion unit, it is selected by switching banks. Banks are switched as follows.
(a) To select the expansion unit ROM (bank 1), access address 0030 (either input or output is fine).
(b) To select the ROM of the HX-20 (bank 0), access address 0032 or 0033 (either input or output is fine).
None of these operations will be possible if the expansion unit is not connected to the HX-20. Also, switching can be performed for ROM area of the expansion unit. The HX-20 ROM (bank 0) is automatically selected when power is turned ON or upon reset.

13.3 Clock applications

The HX-20 clocks may be classified into two types: MCU clocks and IC clocks. The ports and registers related to clocks used in the HX-20 are as follows.

MCU clocks
OCR (Output Compare Register)
(1) Keyboard input sampling
    (Uses OCR interrupt)
(2) RS-232C output timing setting
ICR (Input Capture Register)
(1) Barcode reader timing setting
TOF (Overflow of free running counter)
(1) Built-in microcassette counter sampling
Real-time clock
The real-time clock uses MCU area 4E to 7F as a RAM.

(1) Use of clocks with application software
    (a) OCR
        An OCF interrupt is generated using OCR when a key on the keyboard is pressed. Sampling (key scanning) is then performed. Therefore, when OCR is used for this purpose, there is a strong chance that input from the keyboard will not be accepted.
        A function is also provided whereby, when OCF is set, RS-232C output will be performed by outputting the value of bit 0 of TCSR to P21.
    (b) TOF
        Counter sampling is executed using the TOF interrupt (at approx. 0.1 sec intervals) during I/O of files by the built-in microcassette.
    (c) ICR
        This register is used for barcode reader input. ICR measures the interval between pulse edges. However, barcode reader input software is not supported in the basic system of the HX-20.
    (d) Real-time clock
        The real-time clock is normally employed only to maintain the date and time. It can therefore be used freely in various applications. Sampling may be performed at intervals ranging from 4 to 500msec. Clock registers and RAMs are allocated as shown in Table 13-1.

Table 13-1 Memory Map of Real-time Clock

Address	Input/Output	Description
0040	I/O	Seconds
0041	I/O	Alarm (sec.)
0042	I/O	Minutes
0043	I/O	Alarm (min.)
0044	I/O	Hour
0045	I/O	Alarm (hour)
0046	I/O	Day
0047	I/O	Date
0048	I/O	Month
0049	I/O	Year
004A		Control register A
004B		Control register B
004C		Control register C
004D		Control register D
004E~007F		RAM 50 bytes

A 32.768Hz clock pulse is used as the master clock. RAM area 004E to 007F is used as an I/O flag area. Accessing this area can cause an I/O overrun.

13.4 Interrupts

MCU interrupt vectors are assigned as follows in ROM area FFEE~FFFF (Table 13-2).

Table 13-2 Interrupt Vectors

Address	Value	Description
FFEE, FFEF	0106	TRAP
FFF0, FFF1	0109	SCI interrupt

Address	Value	Description
FFF2, FFF3	010C	OCF interrupt
FFF4, FFF5	010F	OCF interrupt
FFF6, FFF7	0112	ICF interrupt
FFF8, FFF9	0115	IRQ1 (Keyboard, power supply switch, clock, voltage down and external interrupts)
FFFA, FFFB	0118	SWI
FFFC, FFFD	011B	NMI
FFFE, FFFF	E000	Reset

Addresses 0106 to 011D are RAM addresses and addresses 0100 to 0105 are used as entry points for interrupts. The initial values for addresses 0110 to 011D are stored in addresses FFB5 to FFCC (Table 13-4). Currently, 5 kinds of IRQ1 interrupts are supported.

Table 13-3: RAM Area Entry Points for Interrupt Processing

Address	Description	Initialize timing
0100~0102	'JMP XXX' command Referenced by IRQ1 interrupt routine (not supported in version 1) when IRQ1 clock interrupt is generated.	Reset (power ON)
0103~0105	'JMP XXX' command Referenced by IRQ1 interrupt routine when external IRQ1 interrupt is generated	Reset (power ON)
0106~0108	'JMP XXX' command (TRAP)	Reset (power ON)
0109~010B	'JNP XXX' command (SCI)	Reset (power ON)
010C~010E	'JNP XXX' command (TOF)	Reset (power ON)
010F~0111	'JNP XXX' command (OCF)	Reset (power ON)
0112~0114	'JNP XXX' command (ICF)	Reset (power ON)
0115~0117	'JNP XXX' command (IRQ1)	Reset (power ON)
0118~011A	Value not set (SWI)	No initialization
011B~011D	Value not set (NMI)	No initialization

Table 13-4 Initial Values for Interrupt Entry Points

Address	Description
FFB5~FFB7	'JMP XXX' command Initial values for addresses 0100 to 0102 (Entry point for clock interrupt)
FFB8~FFBA	'JMP XXX' command Initial values for addresses 0103 to 0105
FFBB~FFBD	'JMP XXX' command Initial values for addresses 0106 to 0108
FFBE~FFC0	'JMP XXX' command Initial values for addresses 0109 to 010B
FFC1~FFC3	'JMP XXX' command Initial values for addresses 010C to 010E
FFC4~FFC6	'JMP XXX' command Initial values for addresses 010F to 0111
FFC7~FFC9	'JMP XXX' command Initial values for addresses 0112 to 0114
FFCA~FFCC	'JMP XXX' command Initial values for addresses 0115 to 0117

Table 13-5 IRQ1 Interrupts

Item	Description	Interrupt confirmation	Interrupt mask
Keyboard	Interrupt is generated while a key is being pressed	P15=0	Set P264 to '0'
Battery Voltage	Interrupt is generated when the battery voltage falls below a specified level	P14=0	None
External interrupt	External bus terminal	P13=0	None
Power switch	Interrupt generated when power switch is turned OFF	P286=0	None
Real-time clock	Real-time clock interrupt is generated	One of the address 004C bits 4, 5, 6 or 7 is set to '1'.	Set address 004B bits 3, 4, 5 and 6 to '0'.

13.5 I/O Initializion and Termination

When the BREAK key is pressed, the interrupt processing routine issues a break command to the slave MCU to terminate the current I/O processing. Then bit 7 of address 007C (variable name SIOSTS) and bit 7 of address 007D (MIOSTS) are turned ON. When the bits 7 of SIOSTS and MIOSTS have been turned ON, the I/O routine assumes that I/O processing has been aborted by BREAK, sets the carry bit to logic '1' and terminates processing.
The following subroutines have been provided to initialize or restart I/O processing.

(1) I/O initialization
Subroutine INITIO initializes I/O operations. Initialization is performed for the keyboard, LCD, microprinter, cassette I/O, ROM cartridge input and RS-232C input. Variables SIOSTS and MIOSTS are cleared. The serial communication driver is not informed. An initialize command is issued to the slave MCU.

(2) I/O restart
Subroutine RSTRIO is used to restart I/O operations. Variables SIOSTS and MIOSTS are cleared. I/O flags for the external cassette, built-in microcassette, ROM cartridge and RS-232C port are also cleared. The microprinter output buffer is also cleared.

(3) Warm start initialization
Subroutine HSTRIO performs warm start initialization. The operation is identical to (1) I/O initialization, above, except that keyboard and LCD initialization are not performed.

(4) Cold start
Subroutine REQINI is provided for cold start processing. The RAM is cleared when the current date and time are entered from the keyboard. The RAM area is checked and the last address of the RAM +1 and stored in addresses 012C, 012D and 0134, 0135. From this point, the processing is the same as that when power is turned ON.

13.6 Master MCU Sleep

The master MCU may be set in the sleep mode to reduce power consumption. The master MCU is reactivated when an interrupt is generated. In the current version, the master MCU enters the sleep mode while awaiting key input. There are restriction on the sleep mode and subroutine SLEEP is called to set the master MCU in the sleep mode.

13.7 Output of Address 26 Port

The value of output port 26 is not actually read. Instead this value is set in address 004F (variable name 'P26') and the value of address 0026 can be obtained by inputting the contents of address 004F. Output of this value is performed by subroutine WRT26.

13.8 General-purpose Subroutines

Entry points have been provided for the following two general-purpose subroutines.

(1) Subroutine HEXBIN converts an ASCII code hexadecimal number into a binary number.
(2) Subroutine BINDEC converts an unsigned 16-bit binary number into an ASCII code decimal number.

13.9 Subroutine Table

Subroutine name	Entry Point	Description
SOUND	FF64	Sounds the speaker Parameters: At Entry (A):Tone:00=pause, 06=440Hz, 0D=880Hz 1,2,3.... 1C:4-octave major scale (from C) 1D, 1E....38:4 octaves a half-tone higher than that for 1,2,3...IC. 39-FF : assumed to be 0 (B):Duration: 1 specifies a duration of 0.1 sec. Duration may be specified in the range 01 to FF. Speaker is not activated when 00 is specified. At Return (C) Abnormal I/O flag Registers retained (A), (B), (X) Subroutines referenced SNSCOM, SNSCOW, CHKRS Variables used None
SLEEP	FFA9	Sets the master MCU in the sleep mode. Control is returned from the SLEEP subroutine when the sleep mode is exited. Parameters: At Entry None At Return None Registers retained (A), (B), (C) Subroutines referenced None Variables used None
CHKPLG	FF2E	Identifies plug-in options currently connected. The value of register (A) is also stored in variable PLGSTS (address 0079). Parameters: At Entry None At Return (C): Abnormal I/O flag (A): Connected device code Bit 2 Bit 1 Bit 0 0 0 0 ROM cartridge 0 0 1 Reserved 0 1 0 Not connected 0 1 1 Reserved 1 x x Microcassette (X: don't care) Registers retained (B), (X) Subroutines referenced CHKRS, SNSCOM Variables used None

PWROFF	FFAC	Turns power supply of the HX-20 OFF. (The power switch is not actually turned OFF.) There is therefore no exit from this subroutine.
		Parameters: At Entry None Subroutines referenced SNSCOM Variables used None
PWRDWN	FF1F	Displays the message "CHARGE BATTERY!" on the LCD. Control is returned from this subroutine when power supply voltage recovers. Otherwise, the power supply is turned OFF after the message has been flashed on the LCD 60 times.
		Parameters: At Entry None At Return None Subroutines referenced DSPLCN, PWROFF Variables used None
REQINI	FF13	Outputs the message "Enter DATE and TIME" at cold start. When the date and time are entered, the extent of the RAM is checked and the memory is cleared. Jumps to the entry point for reset.
		Parameters: At Entry None Subroutines referenced DSPLCN, DSPLCH, KEYIN, HEXBIN
WRTP26	FED4	Port 26 data output. This subroutine is used to output data to port 26. Address 26 data is retained by address 4F.
		Parameters: At Entry (A):Bit positions to be output (for each bit, '1' indicates output and '0', that the bit is not to be output.) (To specify output of bits 0 and 1, set 05 in this register, that is, bits 0 and 1 ON) (B):Output data (Bits not specified in (A) are ignored) Registers retained (A), (B), (X) Subroutines referenced None Variables used ROH (Value is recovered)
BREKIO	FFA3	I/O break. Executes break processing sequence for the slave MCU and turns bits 7 of variables MIOSTS and SIOSTS ON (logic '1').
		Parameters: At Entry None At Return None

Subroutine name	Entry Point	Description
		Registers retained None Subroutines referenced WRTP26, SNSCOM, RSONOF Variables used None
RSTRI0	FFA6	Sets the value of variables to enable restarting of I/O processing after BREAK. Bits 0, 1 and 2 of the following variables are set to '0': MIOSTS, SIOSTS, CSMOD (external cassette status), PRMSTS (ROM cartridge status) and SRSTS. Print buffer is cleared and interrupt is enabled.
		Paramaters: At Entry None At Return None Registers retained (X) Subroutines referenced None Variables used None
CONTIO	FFAF	Clears bits 7 of variables MI0STS and SIOSTS and restarts RS-232C input.
		Parameters: At Entry None At Return None Registers retained None Subroutines referenced CHKRS Variables used None
INITIO	FFCD	Initializes I/O, keyboard and LCD. Sends command 02 to the slave MCU (initialize command). Subroutine RSTRO initialize also performed. Identifies plug-in options and removes interrupt mask. Does not perform initialization for serial communication.
		Paramaters: At Entry None At Return None Registers retained None Subroutines referenced INITKY, INITLC, SNSCOM, HSTRIO, RSTRIO Variables used None

Subroutine name	Entry Point	Description
HSTRIO	FED1	Initializes I/O operation. Does not initialize keyboard and LCD.
		Parameters: At Entry None At Return None Registers retained None Subroutines referenced SNSCOM Variables used None
HEXBIN	FF2B	Converts an ASCII code hexadecimal number into a binary number. Data is not converted in series but only 1 byte of data can be converted.
		Parameters: At Entry (A, B):ASCII code 2-digit hexadecimal number At Return (A) Binary number (result of conversion) (B) Return code 00: Normal 01: Data error ((A, B) not in range 0 to F) (Z) According to the value of (B) Subroutines retained None Variables used Other Reentrant
BINDEC	FF28	Converts unsigned 16-bit binary number into an ASCII code decimal number.
		Parameters: At Entry (A, B):Unsigned 16-bit binary number (0-65535) (X): Address for storing 5-bit result of conversion. Zero are not supressed. At Return None Registers retained (X) Subroutines referenced None Variables used None Others Reentrant

Subroutine name	Entry Point	Description
GETCLK	FF31	Inputs the current date and time from the real-time clock (version 2 or better).
		Parameters: At Entry (X): Starting address of the memory area where the input data is to be stored. Data is 6 bytes: Month, Day, Year, Hour, Minutes, Seconds. Each item is in a 2-digit BCD code (one byte). At Return The result is entered in the specified memory address. Registers retained (X) Subroutines referenced None Variables used None
SETCLK	FFF8	Sets the current date in the real-time clock (version 2 or better).
		Parameters: At Entry (X): The starting address of the memory where the specified data is to be stored. The format of the data is the same as for GETCLK. At Return None Registers retained None Subroutines referenced None Variables used None

```
ERR   SEQ   LOC  OBJECT      PROGRAM  ALARM      --- ALARM INTERRUPT (BASIC) ---

    00001                                NAM     ALARM
    00002                                TTL     --- ALARM INTERRUPT (BASIC) ---
    00003                                OPT     LOAD
    00004                                OPT     PAGE=55
    00005                          *
    00006                          * SAMPLE PROGRAM OF 'ALARM INTERRUPT'
    00007                          *  DISPLAY CURRENT TIME.
    00008                          *  THE MOLODY IS PLAYED WHEN MINUTES IS UPDATED (SECOND = 00).  BECAUS
    00009                          * ALARM INTERRUPT IS CAUSED AND MELODY COMMANDS ARE SENDED TO SLAVE MC
    00010                          * IN INTERRUPT ROUTINE.
    00011                          *
    00012                          *  FILE NAME   'EX$C'   BY  K.A
    00013                          * BASIC PROGRAM
    00014                          * 10 CLS
    00015                          * 20 FOR I=&H800 TO &H806
    00016                          * 30  READ J
    00017                          * 40  POKE I,J
    00018                          * 50 NEXT I
    00019                          * 60 FOR I=&H810 TO &H845
    00020                          * 70  READ J
    00021                          * 80  POKE I,J
    00022                          * 90 NEXT I
    00023                          * 100 EXEC &H800
    00024                          * 105 'WRITE INTERRUPT VECTOR
    00025                          * 110 POKE &H116,&H08
    00026                          * 120 POKE &H117,&H10
    00027                          * 130 POKE &H7E,&H80
    00028                          * 135 'ENABLE ALARM INTERRUPT
    00029                          * 140 POKE &H43,&H22
    00030                          * 150 POKE &H41,&H00
    00031                          * 160 POKE &H43,&HFF
    00032                          * 170 POKE &H45,&HFF
    00033                          * 180 LOCATE 5,2
    00034                          * 190 PRINT TIME$
    00035                          * 200 GOTO 180
    00036                          * 1000 DATA &HFC,&HFF,&HCB,&HFD,&H0B,&H07,&H39
    00037                          * 1010 DATA &H96,&H4C,&H23,&H05,&HFE,&H0B,&H07,&H6E,&H00
    00038                          * 1020 DATA &HCE,&H0B,&H33,&H86,&H34,&H8D,&HFF,&H19,&HA6,&H00,&H36
    00039                          * 1030 DATA &H8D,&HFF,&H19,&H32,&H08,&H81,&HFF,&H26,&HF4
    00040                          * 1040 DATA &H86,&H35,&H8D,&HFF,&H19,&H3B
    00041                          * 1050 DATA 17,06,44,06,17,C6,44,06,17,06,14,06,16,06,15,06,13,18,&HFF
    00042                          *
    00043                          *
    00044                          *
    00045A 0800                          ORG     $800
    00046                          *
    00047                          * STORE INTERRUPT VECTOR
    00048          FF19  A         SNSCOM EQU     $FF19
    00049          FFCA  A         INTIR1 EQU     $FFCA      * IRQ1 INTERRUPT INITIAL ADDRESS
    00050                          *
    00051A 0800 FC FFCB  A               LDD     INTIR1+1
    00052A 0803 FD 0807  A               STD     SAVADD
    00053A 0806 39                       RTS
    00054                          *
    00055A 0807    0002  A         SAVADD RMB     2
```

ERR SEQ LOC OBJECT PROGRAM ALARM --- ALARM INTERRUPT (BASIC) ---

```
00056                          * IRQ1 INTERRUPT ROUTINE
00057A 0810                            ORG     $810
00058A 0810 96 4C      A               LDA A   $4C         * IS INTERRUPT CAUSED BY CLOCK ?
00059A 0812 2B 05 0819                 BMI     CLKINT
00060A 0814 FE 0807    A               LDX     SAVADD
00061A 0817 6E 00      A               JMP     0,X
00062                          *
00063                          * SEND SLAVE MCU DATA OF MELODY.
00064A 0819 CE 0833    A       CLKINT  LDX     #MELTBL     * (X):THE ADDRESS WHERE MELODY DATA ARE STORE
00065A 081C 86 34      A               LDA A   #$34        * SEND DATA TO SLAVE MCU.
00066A 081E BD FF19    A               JSR     SNSCOM      * COMMAND 34: SET MELODY DATA
00067A 0821 A6 00      A       SLV10   LDA A   0,X         * SET DATA
00068A 0823 36                         PSH A
00069A 0824 BD FF19    A               JSR     SNSCOM
00070A 0827 32                         PUL A
00071A 0828 08                         INX
00072A 0829 81 FF      A               CMP A   #$FF        * LAST CHARACTER IS $FF
00073A 082B 26 F4 0821                 BNE     SLV10
00074                          *
00075                          * PLAY MELODY.
00076A 082D 86 35      A               LDA A   #$35
00077A 082F BD FF19    A               JSR     SNSCOM
00078A 0832 3B                         RTI
00079                          *
00080                          * MELODY TABLE (FOR ELISE)
00081A 0833     11     A       MELTBL  FCB     17,06,44,06,17,06,44,06
      A 0834     06     A
      A 0835     2C     A
      A 0836     06     A
      A 0837     11     A
      A 0838     06     A
      A 0839     2C     A
      A 083A     06     A
00082A 083B     11     A               FCB     17,06,14,06,16,06,15,06
      A 083C     06     A
      A 083D     0E     A
      A 083E     06     A
      A 083F     10     A
      A 0840     06     A
      A 0841     0F     A
      A 0842     06     A
00083A 0843     0D     A               FCB     13,18
      A 0844     12     A
00084A 0845     FF     A               FCB     $FF
00085                          *
00086           0000   A               END
***** TOTAL ERRORS     0
```

CHAPTER 14 MEMORY MAP

14.1 Memory Allocation

The memory of HX-20 is divided into the following areas.

Table 14-1 Memory Map

Address	Without expansion unit	With expansion unit	Applications
0000 to 004D	I/O ports	←	This area is used by I/O routines as work and flag area.
004E to 007F	RAM (Real-time clock)	←	
0080 to 00FF	RAM	←	This area is used as a work area by the BASIC interpreter.
0100 to 04AF	RAM	←	This area is used by I/O routines as work area and and I/O buffer.
04B0 to 0A3F	RAM	←	This area is used as a work area by the BASIC interpreter.
0A40 to 3FFF	RAM	←	
4000 to 5FFF	None	RAM (in expansion unit)	
6000 to 7FFF	ROM (ROM5) (Only socket provided.)	RAM (in expansion unit)	
8000 to 9FFF	ROM (ROM4)	ROM (ROM2) Can be switched to ROM in expansion unit.	ROM in the HX-20 is the BASIC interpreter.
A000 to BFFF	ROM (ROM3)	ROM (ROM1). Can be switched to ROM in expansion unit.	ROM in the HX-20 is the BASIC interpreter.
C000 to DFFF	ROM (ROM2)	←	C000 to CFFF is memory area for the BASIC interpreter. D000 to DFFF contains Menu, Monitor and virtual screen routines.

Address	Without expansion unit	With expansion unit	Applications
E000 to FFFF	ROM (ROM1)	←	This area is used by I/O routines.

14.2 Jump Table

Jump tables show the entry points of various subroutines. Entry points are indicated by a 3-byte address specification. Initial byte specifies 7E (JPM command) followed by high and low bytes of the address.

Table 14-2 Jump Table

Address (from)	(to)	Contents		Remarks	For details, refer to this manual, Chapter:
FED1	FED3	JMP	HSTRIO	I/O restart, Initialize	13
FED4	FED6	JMP	WRTP26	Address 26 port output	13
FED7	FED9	JMP	BILOAD	Memory Load: Load, Close after end of processing	9
FEDA	FEDC	JMP	OPNLOD	Memory Load: Load Open	9
FEOD	FEDF	JMP	BIDUMP	Memory Dump: Dump and Close after end of processing	9
FEEO	FEE2	JMP	OPNDMP	Memory Dump: Dump Open	9
FEE3	FEE5	JMP	DIRPRM	Read PROM cartridge directory	8
FEE6	FEE8	JMP	CLSPRM	Closes PROM cartridge file.	8
FEE9	FEEB	JMP	REDPRM	Reads 1 character from PROM cartridge file.	8
FEEC	FEEE	JMP	OPNPRM	Opens PROM cartridge file.	8
FEEF	FEF1	JMP	CNTMCS	Read/Write to built-in microcassette counter value.	6
FEF2	FEF4	JMP	SECMCS	Advances tape to the specified built-in microcasette counter value.	6
FEF5	FEF7	JMP	REWMCS	Rewinds built-in microcasette.	6
FEF8	FEFA	JMP	SETCLK	Inputs time and date. (Version 2 or better)	6
FEFB	FEFD	JMP	CLSMCS	Closes built-in microcassette files.	6
FEFE	FEF0	JMP	WRTMCS	Outputs one character to built-in microcassette.	6
FF01	FF03	JMP	OPNWMS	Opens built-in microcassette file for output.	6
FF04	FF06	JMP	READMS	Inputs one character from built-in microcassette.	6
FF07	FF09	JMP	SRCRMS	Opens built-in microcassette file for input (initializes file).	6
FF0A	FF0C	JMP	OPNRMS	Opens built-in microcassette file for input (searches specified file).	6
FF0D	FF0F	JMP	MCSMAN	Sets built-in microcassette in manual operation mode.	6
FF10	FF12	JMP	$DFF7	Jumps to address DFF7.	
FF13	FF15	JMP	REQINI	Initializes HX-20 cold start.	13
FF16	FF18	JMP	CHKRS	RS-232C recovery after aborting input processing	5
FF19	FF1B	JMP	SNSCOM	Sends one command byte to slave CPU.	11
FF1C	FF1E	JMP	SRINIT	Initializes high-speed serial communication.	4
FF1F	FF21	JMP	PWRDWN	Battery Low message	13
FF22	FF24	JMP	KYSSTK	Stores data in the initial key stack.	2
FF25	FF27	JMP	$DFFD	Jumps to address DFFD (MENU).	
FF28	FF2A	JMP	BINDEC	Converts binary numbers into ACSII decimal code.	13
FF2B	FF2D	JMP	HEXBIN	Converts ASCII hexadecimal code into binary code.	13
FF2E	FF30	JMP	CHKPLG	Identification of plug-in options	13
FF31	FF33	JMP	GETCLK	Sets time and date (Version 2 or better)	13
FF34	FF36	JMP	CLSCS	Closes external cassette file.	6
FF37	FF39	JMP	WRITCS	Outputs one byte to external cassette file.	6

Address (from)	(to)	Contents	Remarks	For details, refer to this manual, Chapter:
FF3A	FF3C	JMP OPNWCS	Opens external cassette file for output.	6
FF3D	FF3F	JMP READCS	Inputs 1 byte from external cassette file.	6
FF40	FF42	JMP SRCRCS	Opens external cassette file for input (initializes file).	6
FF43	FF45	JMP OPNRCS	Opens external cassette file for input.	6
FF46	FF48	JMP OPNFCS	External cassette file remote (ON/OFF)	6
FF49	FF4B	JMP DSPLCN	Displays n characters on LCD (Physical screen).	3
FF4C	FF4E	JMP DSPLCH	Displays one character on LCD (Physical screen).	3
FF4F	FF51	JMP $DFFI	Displays one character on virtual screen.	15
FF52	FF54	JMP LCADDR	Link table for LCD routines. Selects LCD driver.	
FF55	FF57	JMP LCDMOO	Link table for LCD routines. Selects LCD driver mode.	
FF58	FF5A	JMP DATMOD	Link table for LCD routines. Outputs data to LCD driver.	
FF5B	FF5D	JMP DISPIT	Displays one character on LCD. (Data is not entered in physical screen buffer.)	3
FF5E	FF60	JMP $DFF4	Calls virtual screen function.	4
FF61	FF63	JMP $DFEE	Displays (recovers) current virtual screen data.	
FF64	FF66	JMP SOUND	Speaker output	13
FF67	FF69	JMP CHRGEN	Generates character font.	3
FF6A	FF6C	JMP KEYSCN	Scans key matrix.	2
FF6D	FF6F	JMP SERIN	High-speed serial data input	4
FF70	FF72	JMP SEROUT	High-speed serial data output	4
FF73	FF75	JMP SERONF	High-speed driver ON/OFF	4
FF76	FF78	JMP RSPUT	Outputs one character to RS-232C.	5
FF79	FF7B	JMP RSGET	Inputs one character to RS-232C.	5
FF7C	FF7E	JMP RSGSTS	Inputs RS-232C status register value.	5
FF7F	FF81	JMP RSCLOS	Closes RS-232C input.	5
FF83	FF84	JMP RSOPEN	Opens RS-232C output.	5
FF85	FF87	JMP RSONOF	Controls RS-232C driver (ON/OFF)	5
FF88	FF8A	JMP RSMST	Sets RS-232C status register mode.	5
FF8B	FF8D	JMP SCRCPY	Screen copy (LCD to micro-printer).	7
FF8E	FF90	JMP NFEED	Performs n dot-lines of line feed on microprinter.	
FF91	FF93	JMP PRTDOT	Prints one dot-line (bit pattern) on the microprinter.	7
FF94	FF96	JMP LNPRNT	Prints one character-line on the microprinter.	7
FF97	FF99	JMP CHPRNT	Prints one character on the microprinter.	7
FF9A	FF9C	JMP KEYIN	Enters one character from keyboard.	2
FF9D	FF9F	JMP KEYSTS	Enters keyboard key status.	2
FFA0	FFA2	JMP INITKY	Initializes keyboard.	2
FFA3	FFA5	JMP BREKIO	I/O break	13
FFA6	FFA8	JMP RSTRIO	Restart after I/O break	13
FFA9	FFAB	JMP SLEEP	Master MCU sleep	13

Address (from)	(to)	Contents	Remarks	For details, refer to this manual, Chapter:
FFAC	FFAE	JMP PWROFF	Power supply OFF	13
FFAF	FFB1	JMP CONTIO	Continuation after I/O break	13
FFB2	FFB4	JMP BRKIN	Entry point after break break key has been pressed.)	
FFB5	FFB7	JMP CLKINT	Initial value for clock interrupt entry point	
FFB8	FFBA	JMP IRQI80	Initial value for IRQ1 external interrupt entry point	
FFBB	FFBD	JMP SDFFA	Initial value for TRAP interrupt entry point	
FFBE	FFC0	JMP SERINT	Initial value for SCI interrupt entry point	
FFC1	FFC3	JMP TOFINT	Initial value for TOF interrupt entry point	
FFC4	FFC6	JMP OCFINT	Initial value for OCF interrupt entry point	
FFC7	FFC9	JMP IRQI80	Initial value for ICF interrupt entry point	
FFCA	FFCC	JMP IRQINT	Initial value for IRQ1 interrupt entry point	
FFCD	FFCF	JMP INITIO	I/O initialize	

(1) ROM (ROM2) jump tables (Addresses C000 to DFFF)

Address	Contents	Notes
DFEE to DFF0	JMP LCRECV	Covers the virtual screen and rewrites only the physical screen.
DFF1 to DFF3	JMP SCRCHR	Displays one character on the virtual screen.
DFF4 to DFF6	JMP SCRFNC	Screen functions of the virtual screen.
DFF7 to DFF9	JMP MON	Monitor entry
DFFA to DFFC	JMP MONTRP	Monitor entry on TRAP
DFFD to DFFF	JMP MENU	Menu entry

14.3 ROM Vectors

Address (from) (to)	Variable name	Number of bytes	Description
FFD0 FFD1	NEWKTB	2	Shows the address at which the matrix data is stored after key scanning (NEWKTB).
FFD2 FFD3	COLCNT	2	Shows the address where the amount of data in the built-in microprinter buffer is stored (COLCNT).
FFD4 FFD5	CSBFCM	2	Shows the address where the amount of data in the external cassette buffer is stored (CSBFCM). Used for data read and write.
FFD6 FFD7	MSBFCM	2	Shows the address where the amount of data in built-in microcassette buffer is stored (MSBFCM). Used for data read and write.
FFD8 FFD9	RSDCNT	2	Shows the address where the amount of data in the RS-232C input buffer is stored (RSDCNT).
FFDA FFDB		2	Shows the starting address of the LCD physical screen buffer.
FFDC FFDD	CASBUF	2	Shows the starting address of the 260-byte buffer used by the monitor (CASBUF).
FFDE FFEF		2	Shows the address where the scroll speed data is stored.
FFE0 FFE1	CSHBUF	2	Shows the starting address of the external cassette header buffer (CSHBUF).
FFE2 FFE3	MSHBUF	2	Shows the starting address of the built-in microcassette header buffer (MSHBUF).
FFE4 FFE5	KEYMOD	2	Shows the address where the key input mode data is stored (KEYMOD).

NOTE: Addresses are shown as two bytes in upper- and lower-byte sequence.

FFEE FFEF		2	Shows the address where the TRAP entry point is stored. Set to 0106.
FFF0 FFF1		2	Shows the address where the SCI interrupt entry point is stored. Set to 0109.
FFF2 FFF3		2	Shows the address where the TOF interrupt entry point is stored. Set to 010C.
FFF4 FFF5		2	Shows the address where the OCF interrupt entry point is stored. Set to 010F.
FFF6 FFF7		2	Shows the address where the ICF interrupt entry point is stored. Set to 0112.

Address (from) (to)	Variable name	Number of bytes	Description
FFF8 FFF9		2	Shows the address where the IRQ1 interrupt entry point is stored. Set to 0115.
FFFA FFFB		2	Shows the address where the SWI interrupt entry point is stored. Set to 0118.
FFFC FFFD		2	Shows the address where the NMI interrupt entry point is stored. Set to 011B.
FFFE FFFF		2	Shows the address where the RESET interrupt entry point is stored. Set to E000.

14.4 RAM page 0 vectors

Address (from)(to)	Variable name	Number of bytes	Description
4E 4E	PWRFLG	1	Bits 0 to 3: Reserved for selecting processing to be executed when power supply is turned ON. Bits 4 to 7: Indicates the processing to be executed when power supply is turned OFF. Bit 7 Bit 6 Bit 5 Bit 4 0 0 0 0 No operation 0 0 0 1 Executes the subroutine specified in addresses 132~133 (POFADR) prior to turning OFF the power supply. All other bit values No operation.
4F 4F	P26	1	Address 26 port data. Note: Read of address 26 is inhibited.
50 51	R0	2	This area is used as a work area by I/O routine.
52 53	R1	2	Same as R0
54 55	R2	2	Same as R0
56 57	R4	2	Same as R0
58 59	R3	2	Same as R0
5A 5B	R5	2	Same as R0
5C 5D	R6	2	Same as R0
5E 5F	R7	2	Same as R0
60 61	M0	2	This area is used as a work area by Monitor and screen routines.

Address (from)	(to)	Variable name	Number of bytes	Description
62	63	M1	2	Same as M0
64	65	M2	2	Same as M0
66	67	M3	2	Same as M0
68	69	M4	2	Same as M0
6A	6B	M5	2	Same as M0
6C	6D	M6	2	Same as M0
6E	6F	M7	2	Same as M0
70	71	K0	2	The area is used as a work area by the key input routine.
72	73	K1	2	Same as K0
74	75	S0	2	Same as K0
76	77	S1	2	Same as K0
78	78	INIFL1	1	Indicates application program cold start. For each bit, '0' indicates cold start and '1', warm start Bit 1: Bit 2: Bit 3: Bit 4: Bit 5: Bit 6: BASIC application programs Bit 7: BASIC interpreter
79	79	PLGSTS	1	Bits 0 to 2: Indicate the plug-in option. Bit 2 Bit 1 Bit 0 0 0 0 ROM cassette 0 0 1 Reserved 0 1 0 Not connected 0 1 1 Reserved 1 x x Microcassette (x: don't care) Bit 3: 0 Bits 4 to 6: not used Bit 7: Specifies whether RS-232C driver will be turned OFF when the BREAK key is pressed. 0: Not turned OFF 1: Turned OFF.

Address (from)	(to)	Variable name	Number of bytes	Description
7A	7A	SRSTS	1	Bits 0 to 2: Indicate current RS-232C status. Bit 2 Bit 1 Bit 0 0 0 0 Input operation is not being performed. 0 0 1 Input operation is being executed. 0 1 x Not used in current version 1 0 0 Undefined. 1 0 1 Input. Operation enters wait state when the slave MCU is busy with other I/O devices such as microprinter. 1 1 x Undefined Bit 3: Indicates RS-232C driver status (ON/OFF) 0: OFF 1: ON Bit 4: Serial I/F driver status The same driver is used as the RS-232C and Serial I/F driver. However, in terms of operation by software, they are treated independently. Bits 5 to 7: SCI (Serial Communication Interface) interrupt mode Bit 7 Bit 6 Bit 5 0 0 0 Input of external cassette data 0 0 1 Input of internal microcassette data 0 1 0 RS-232C data input 0 1 1 Serial I/F data input 1 0 0 Output of external cassette data 1 0 1 Output of built-in microcassette data 1 1 x Undefined
7B	7B	RUNMOD	1	Program execution mode Bits 0 to 3: Reserved for specifying program number, etc. Bits 4 to 5: Undefined Bit 6: Flag indicating whether the virtual screen is being used 0: Virtual screen being used 1: Virtual not being used Bit 7: Indicates the interpreter mode 0: Machine language mode 1: Interpreter mode

Address (from)	(to)	Variable name	Number of bytes	Description
				NOTE: In machine language mode, the program jumps to the specified address when the BREAK key is poressed, power is turned OFF or the voltage falls. In interpreter mode when one of these interrupts is generated, the appropriate flag is set (MIOSIS) and control is returned. In BASIC the values of bit 7 and bit 6 are 1, 0 and in Monitor 0, 1.
7C	7D	SIOSTS	1	Flags to indicate the current I/O status of the slave MCU I/O Bit 0: Microprinter control (1: being executed) Bit 1: External cassette Read/Write (1: being executed) Bit 2: Internal microcassette Read/ Write or control (1: being executed) Bit 3: RS-232C Receive (1: being executed) Bit 5: ROM cartridge power supply (1: ON) Bit 6: Bar-code reader power supply (1: ON) Bit 7: BREAK (1: Slave MCU I/O control forcibly terminated by master MCU).
7D	7D	MIOSTS	1	Indicates the I/O status of the master MCU. Bit 0: Read/Write to LCD (1: being executed) Bit 1: Commant transmit and response with slave MCU (1: being executed) Bit 2: Data communication using the external serial port (Floppy disk unit), (1: being executed) Bit 3: Clock interrupt (alarm, square wave, update), (1: Interrupt) Bit 4: Voltage low (1: Voltage low interrupt) Bit 5: Power OFF (1: Power switch interrupt) Bit 6: PAUSE key ON (1: PAUSE key pressed) Bit 7: BREAK key ON (1: BREAK key pressed)
7E	7E	SDIPS1	1	Software switch Bit 0, Bit 1: Specify the type of waveform from the external cassette. Bit 0 Bit 1 0 x Decided automatically 1 0 Normal waveform 1 1 Reverse waveform

Address (from) (to)	Variable name	Number of bytes	Description
			Bit 2, Bit 3 Specify the type of waveform from internal microcassette Bit 3 Bit 2 0 x Decided automatically 1 0 Normal waveform 1 1 Reverse waveform Bit 4, Bit 5 Memory bank selection Bit 6: Indicates the memory bank in which the BASIC in terpreter is located. (Value is set when the menu is initialized.) 0: Bank 0 1: Bank 1 Bit 7: Specifies access of addresses 0000 to 004D 0: Access disabled 1: Access enabled
7E 7F	SDIPS2	1	Software switch Bits 0 to 3: Correspond to DIP switches 1 to 4 0: OFF 1: ON Bit 4: Flag indicating whether DIP switches 1 to 4 will be controlled by software (bits 0 to 3 above) or by the actual setting. 0: Actual DIP switch setting 1: Bits 0 to 3 Bit 5: Flag indicating whether bit 7 will control the printer ON/OFF switch. 0: Actual printer ON/OFF switch setting 1: Bit 7 Bit 6: Undefined Bit 7: Controls the printer ON/OFF switch 0: OFF 1: ON Note: These switches are included in the key matrix. The values of these switches are therefore set in the key matrix (NEWKTB) after key scanning.

14.5 RAM system variables

Address (from)	(to)	Variable name	Number of bytes	Description
0100	0102	INTCLK	3	Address of real-time clock interrupt routine (for alarm, etc.) Address 0100 contains 7E (JMP command) and 0101, 0102 the upper and lower bytes of the jump address. Address values are initialized on reset.
0103	0105	INTEXT	3	Address of IRQ1 external port interrupt routine. Contents are identical to INTCLK.
0106	0108		3	Address of TRAP interrupt routine. Contents are identical to INTCLK.
0109	010B		3	Address of the IRQ1 SCI interrupt routine. Contents are identical to INTCLK.
010C	010E	INTOF	3	Address of the IRQ1 TOF interrupt routine. Contents are identical to INTCLK.
010F	0111		3	Address of the IRQ1 OCF routine. Contents are identical to INTCLK.
0112	0114		3	Address of the IRQ1 ICF routine. Contents are identical to INTCLK.
0115	0117		3	Address of the IRQ1 interrupt routine. Contents are identical to INTCLK.
0118	011A	INTSW1	3	Address of the SW1 routine. Three bytes are reserved.
011B	011D		3	Address of the NMI interrupt routine. Three bytes are reserved.
011E	011F	FNTGPN	2	Address of the character fonts for codes E0-FF (Upper- and lower-byte sequence).
0120	0121	BRKADR	2	Address of the subroutine to be executed when the BREAK key is pressed. This specification is valid only when RUNMOD is in machine language mode.
0122	0123	MENADR	2	Address of the subroutine to be executed when the MENU key is pressed. Contents are identical to BRKADR.
0124	0125	PAUADR	2	Address of the subroutine to be executed when the PAUSE key is pressed. Contents are identical to BRKADR.

Address (from)	(to)	Variable name	Number of bytes	Description
0126	0127	CT3ADR	2	Address of the subroutine to be executed when CTRL/PS3 key is pressed. Control jumps unconditionally to this address. Address value is initialized at reset.
0128	0129		2	Address of the subroutine to be executed when CTRL/PF4 key is pressed. Contents are identical to CT3ADR.
012A	012B		2	Address of the subroutine to be executed when CTRL/PF5 key is pressed. Contents are identical to CT3ADR.
012C	012D	RMBADR	2	Shows the end of the RAM area. This variable is set when the RAM is checked at initialization (CTRL/@ input from MENU). Last address of the RAM +1 is stored in upper- and lower-byte sequence.
012E	012F	PRMCNT	2	Address where the amount of data remaining in the PROM cartridge file data is stored.
0130	0131	WAKADR	2	Address of the subroutine executed by the clock alarm interrupt at reset (Power ON). Address is in upper- and lower-byte sequence. This address is initialized at reset.
0132	0133	POFADR	2	Address of the last subroutine called prior to turning OFF the power supply. Address is in upper- and lower- byte sequence. This address is initialized at reset.
0134	0135	BSWTAD	2	Starting address of the BASIC application area. Value of RMBADR is set at MENU initialization (CTRL/@). Set to same value as RMBADR.
0136	0137	BSWBAD	2	Starting address of BASIC program area.
0138	0139		2	Address of the BASIC work area save and condense routine.
013A	013A	BITMP0	1	Bank 0 bit map.
013B	013B	BITMP1	1	Bank 1 bit map.
013C	013F	LNKTBL	4	Address of the RAM application program link table.

14.6 RAM area used by I/O routines

Memory range	Description
004E to 007F	Flag and work area
0100 to 0110	Interrupt entry pointer
011E to 0139	Vector
013A to 013F	Menu and Link tables
0140 to 018F	Keyboard work area
0190 to 01AE	Microprinter work area
01AF to 01C3	RS-232C work area
01C4 to 01D5	Serial communication work area
01D6 to 01EB	External cassette work area
01EC to 0207	Built-in microcassette work area
0208 to 020E	ROM cartridge work area

Memory range	Description
020F to 021A	Binary memory dump, memory load work area.
021B to 021F	Reserved
0220 to 029F	Screen (including LCD routine) routine work area.
02A0 to 02CF	Monitor work area
02D0 to 0323	External cassette header work area.
0324 to 0377	Built-in microcassette header work area.
0380 to 047C	Reserved for system buffer (260 bytes)