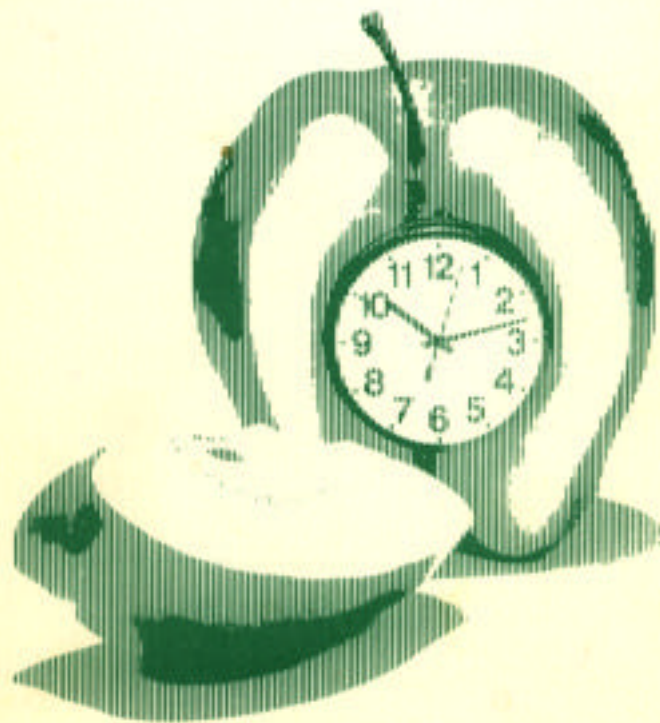


THUNDERCLOCK PLUS™

INSTALLATION AND OPERATING MANUAL

USER'S GUIDE



THUNDERWARE INCORPORATED

THUNDERCLOCK PLUS USER'S GUIDE

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NOTICE

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P.O. BOX 1299
Orinda, CA 94563

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CHAPTER I GETTING STARTED

INTRODUCTION

The THUNDERCLOCK PLUS you have purchased will give you and your APPLE a whole new realm of capabilities. You can use it to print the time and date on reports or listings, to time events, or to enhance the usefulness of the many software packages for data-base management, business applications, communications, and time management which can use the THUNDERCLOCK PLUS (see Chapter II).

By adding THUNDERWARE s X-10 INTERFACE OPTION your APPLE can control your BSR/X-10 HOME CONTROL SYSTEM, giving you remote control of AC outlets so you can turn things on or off at scheduled times. See Chapter III for more details on the X-10 INTERFACE OPTION.

For PASCAL. users there is the THUNDERWARE PASCAL SOFTWARE Disk which contains the assembly language PROCEDURES needed to use the THUNDERCLOCK PLUS features from PASCAL. It also contains several PASCAL demo programs and a program you can install to automatically set the F)ILER date each time you boot your PASCAL system.

And THUNDERWAREs optional DOS-DATER software will upgrade the standard, non-copy-protected DOS 3.3 on your disks so that DOS will use the THUNDERCLOCK to time and date stamp disk files. Every time a program is saved or a file is modified, the current date and time to the minute are stored in the CATALOG with the file's name.

UNPACKING

First you need to locate the packing list enclosed in the shipping box. This list indicates what should be included in the box please check that everything has been included. If anything is missing, contact your dealer. Please locate the Warranty card. It is very important that this card be filled out completely and returned to THUNDERWARE in a timely manner. This card will register you as the owner of the product and allow us to better serve you in the unlikely event that you should have any problems. It will allow THUNDERWARE to inform you of any updates, new software packages, and new product offerings.

HANDLING

The THUNDERCLOCK PLUS printed circuit (PC) card is uniquely different from most others you have handled. The primary difference is that part of the circuitry of the card has power applied and is running even when it is Out of your APPLE II. Please follow these handling precautions:

1. Retain the pink plastic shipping bag in which the printed circuit card was packed. It has been treated with an anti-static compound which will protect the card from being ZAPPED by static electricity. NEVER use aluminum foil, black foam, or black plastic, which will actually conduct electricity and quite possibly discharge the batteries on the card, or drastically change the time to which the THUNDERCLOCK is set. Any time you remove or transport your THUNDERCLOCK PLUS be sure to place it into its pink plastic bag. This will protect it from static discharge and accidental discharge of the batteries.

2. ALWAYS TURN OFF POWER TO THE APPLE II BEFORE INSTALLING OR REMOVING ANY PC CARD, INCLUDING THE THUNDERCLOCK PLUS. Failure to do this will almost certainly damage your APPLE and every PC card installed in it! IF YOU DAMAGE YOUR THUNDERCLOCK PLUS BY INSERTING OR REMOVING IT FROM YOUR APPLE WITHOUT TURNING OFF THE POWER. IT WILL VOID YOUR WARRANTY !

3. DO NOT TOUCH the GOLD colored fingers at the bottom of the PC card. These fingers carry information between the APPLE and the PC card, and so it's a good habit to handle the card only by its edges. Furthermore, touching certain components and parts of the PC card around the SET/PROTECT SWITCH (at the top center of the card) can cause the clock to lose time. No permanent damage should result, however. Handle the card by its edges and keep it in its plastic bag when it's not installed in your APPLE II.

INSTALLING YOUR THUNDERCLOCK PLUS

FIRST BE SURE YOUR APPLE IS TURNED OFF. Your THUNDERCLOCK PLUS must be installed in one of the I/O slots inside your APPLE II. The I/O slots are located to the rear of the APPLE (away from the keyboard). Remove the top cover of the APPLE II by popping it free at the rear, lifting up slightly, and pulling the cover to the rear. This will expose the APPLE's main logic board. The I/O slots are the rectangular plastic/metal elements at the very rear of the logic board. The large rectangular metal box to the left is the power supply. The left-most slot (next to the power supply) is slot #0, the next one is #1, and so on until you reach slot #7 at the right side of the logic board. If you look carefully to the front or rear of the I/O slot connectors you will see the number for each slot. Your THUNDERCLOCK PLUS will operate in any slot 1 through 7 of your APPLE II.

NOW MAKE CERTAIN THAT THE POWER TO YOUR APPLE IS TURNED OFF.

Find the power supply (the large rectangular metal box inside your APPLE on the left) and touch it momentarily to be sure you have grounded any static charge your body might be carrying. Insert the gold fingers of the THUNDERCLOCK PLUS PC card into the I/O slot you have selected by gently rocking the PC card as you gently push it into the I/O slot connector. Be sure that the PC card is completely seated in the connector -not tilted to the front or rear, but square with the main logic board of the APPLE II. Replace the cover on your APPLE.

CHECKING IT OUT

You are now ready to check that your THUNDERCLOCK PLUS is properly installed and operating. Place the THUNDERCLOCK BASIC Disk that came with your THUNDERCLOCK in your boot drive and close the disk drive door. (If your APPLE doesn't have a disk drive, see the next page). Now turn on the power to your APPLE, which should behave normally and boot the diskette. If your APPLE does not act normally, TURN OFF the APPLE's power. Check that all the PC cards are fully seated and turn the APPLE on again. If this still does not work, see the section on TROUBLE SHOOTING.

If your THUNDERCLOCK is properly installed and working, the HELLO program on the THUNDERCLOCK BASIC disk will be run and will display the time on your screen with a HI-RES clock face. Note that it was set to Pacific Coast Time during its final test at the factory. You can set it to your local time by running the SET TIME program supplied on the THUNDERCLOCK BASIC Disk (see Chapter II).

IF YOU DON'T HAVE A DISK DRIVE

If your system is not equipped with a disk drive, you can enter and then RUN one of the short BASIC programs below. Select either the APPLESOFT or INTEGER BASIC version depending on which BASIC your APPLE II has installed. Type the NEW command, then enter the program as shown. Then type the RUN command. It will print the date and time on the screen if your THUNDERCLOCK is working properly. Be sure to substitute the slot number of your THUNDERCLOCK for the question marks (?):

<u>APPLESOFT BASIC</u>	<u>INTEGER BASIC</u>
10 PR#?: IN#?	10 DIM T\$(25)
20 INPUT "%";T\$	20 PR#?; IN#?
30 PR#0: IN#0	30 INPUT ">",T\$
40 PRINT T\$	40 PR#0: IN#0
	50 PRINT T\$

If this doesn't work, be sure you have entered the program correctly and have specified the proper slot number for the question marks. If you still have a problem, go to the Appendix on TROUBLE SHOOTING.

ABOUT BATTERIES

The batteries which come installed on your THUNDERCLOCK PLUS are high quality ALKALINE type 'N' cells. With proper handling they will last many years, regardless of whether your APPLE II is turned on or not.

SYMPTOMS OF DYING BATTERIES

A THUNDERCLOCK with dying batteries generally becomes 'flakey'. The timekeeping accuracy may change significantly. The time string returned from the THUNDERCLOCK may say SUN ERR 0 12:00:00 AM. If your THUNDERCLOCK has been in service a number of years, or has been mishandled, you may wish to have the battery voltage checked. Your dealer can do this for you. Check Appendix "B" for the procedure for testing and replacing batteries. This appendix also contains a list of manufacturer's part numbers for replacement batteries and where to find them.

INSTALLING THE BSR/X-10 ULTRASONIC TRANSDUCER

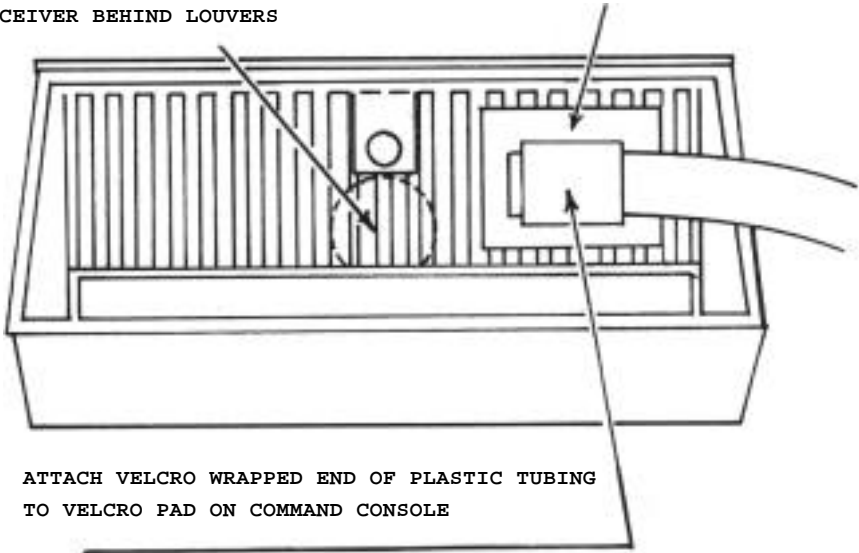
If you have purchased the X-10 ULTRASONIC INTERFACE OPTION with your THUNDERCLOCK PLUS, you will want to install the ultrasonic interface now. This interface assembly has a snail cylindrical transducer in the middle with a length of plastic tubing a one end and a short length of cable with a 2-pin female connector at the other. This transducer converts the electrical signals produced by the THUNDERCLOCK PLUS to ultra-sound which is then "piped" thru the plastic tubing to your BSR/X-10 COMMAND CONSOLE.

TURN OFF THE POWER TO YOUR APPLE, and remove the top cover. On the front of the THUNDERCLOCK PLUS PC card (end nearest the keyboard), at the extreme top of the card, you will notice a small 2-pin plug. The white legend on the PC card identifies this plug as 'P1'. The connector on the cable is not polarized, which means the transducer doesn't care whether the cable is rotated 180 degrees, as long as the pins of the plug are fully mated with the cable contacts. Gently push this mate onto the 2-pin connector on the PC card as far as it will go. The cylindrical transducer should rest inside your APPLE II, and the plastic tube should be guided out thru one of the openings in the back of your APPLE. Now find the small rectangular piece of Velcro that came in the box with the ultrasonic interface. This piece of Velcro has a peel-off backing which exposes a VERY sticky adhesive. You should remove the backing and place this rectangular piece of Velcro on your BSR/X-10 COMMAND CONSOLE as shown in Figure 1 below.

COMMAND CONSOLE ULTRASONIC

ADHESIVE BACKED VELCRO PAD

RECEIVER BEHIND LOUVERS



ATTACH VELCRO WRAPPED END OF PLASTIC TUBING
TO VELCRO PAD ON COMMAND CONSOLE

Now attach the end of the plastic tube with the Velcro on it to the Velcro pad on your COMMAND CONSOLE as shown. Place your COMMAND CONSOLE as far from your APPLE and its TV monitor as the plastic tube allows, since they sometimes produce high frequency sounds which may interfere with the proper operation of the ULTRASONIC COMMAND CONSOLE.

Replace the cover on your APPLE and turn on the power. It should behave normally. To verify that the BSR/X-10 ultrasonic interface is properly connected and positioned with respect to your BSR/X-10 ULTRASONIC COMMAND CONSOLE, enter the following short BASIC program. Substitute the slot number of your THUNDERCLOCK PLUS for the "?" below:

APPLESOFT OR INTEGER BASIC>

```
10 PR#?  
20 PRINT "*AS"  
30 GOTO 20
```

Now 'RUN" the program. You should see the red light on the front of your BSR/X-10 ULTRASONIC COMMAND CONSOLE flash on and off about 4 times per second. If the red light doesn't flash, or flashes irregularly, try re-positioning the plastic tube on the Velcro pad. Make sure you have positioned it properly and that your BSR/X-10 COMMAND CONSOLE is the ULTRASONIC model (designated as BSR model UC 301, or as Sear's model X10-014301). If you still have problems, go to the Appendix on TROUBLE SHOOTING. See Chapter III for complete details of the use of your BSR/X-10 ULTRASONIC INTERFACE OPTION. To stop the program, press the <RESET> key.

CHAPTER II

USING YOUR THUNDERCLOCK PLUS

Your THUNDERCLOCK PLUS has a wide range of applications. You can use it in your own BASIC, PASCAL, or assembly language programs. And many of today's important software packages for data-base management, business applications, communications, bulletin-board systems, and time management are designed to use the THUNDERCLOCK. If you add the X-10 INTERFACE OPTION, you can use your APPLE II to control your BSR/X-10 HOME CONTROL SYSTEM, so your APPLE can turn on your lights, water your lawn.. whatever you desire, according to schedules you create.

APPLICATIONS SOFTWARE PACKAGES SUPPORTING THE THUNDERCLOCK PLUS

The software packages listed here are designed to use your THUNDERCLOCK PLUS. If you have or plan to purchase any of these packages, your THUNDERCLOCK will greatly enhance their usefulness on your APPLE II. These software packages include:

- * DB Master (Stoneware)
- * Visidex (Visicorp)
- * Micro-Courier (Microcom)
- * Micro-Telegram (Microcom)
- * Time Manager (Microsoft)
- * Cashier (High Technology)
- * Executive Secretary (Personal Business Systems)
- * Net-Works (Advanced Data Systems)
- * Desk Calendar II (Telephone Software Connection)
- * Store Manager (High Technology)
- * Data-Dex (Information Unlimited Software)
- * Transcend 3 (SSM)
- * Accounting Plus Super/E (Software Dimensions)
- * CPAPartner (Software Dimensions)
- * PROPartner (Software Dimensions)
- * Softerm (Softronics)
- * Z-Term, The Professional (Southwestern Data Systems)
- * OS9 (Stellation Two)
- * Pascal Speedup Kit (Stellation Two)

You should refer to the manuals supplied with these packages for specific instructions for using your THUNDERCLOCK with them. If you have an early version of VISIDEX, you may need to use the VISIFIX program supplied on your THUNDERCLOCK BASIC Disk (see page 2-4).

And with the THUNDERCLOCK's "Mountain Computer Apple Clock" compatible format, your THUNDERCLOCK can be used with many other existing programs written to use the Mountain Computer Clock.

THE THUNDERCLOCK BASIC DISK

The THUNDERCLOCK BASIC Disk that comes with your THUNDERCLOCK contains a number of programs that allow you to display the time in different ways, set the time, verify proper operation of your THUNDERCLOCK, and assist you in learning how to use it in your own programs. You should make a copy of the THUNDERCLOCK BASIC Disk for your day-to-day use, and put the original in a safe place. If you examine the BASIC programs, you will see that most of them use the TCPUTIL (ThunderClock Plus UTILity) assembly language program. TCPUTIL is discussed in detail in Chapter V of this manual. TCPUTIL is used to find the slot your THUNDERCLOCK is in, and to disable/enable interrupts during DOS calls so you can run interrupt driven programs (like SCREEN or the SCHEDULER) while using DOS. Here are the programs you will find on your THUNDERCLOCK BASIC Disk and a short explanation of their use:

RUN SET TIME

SET TIME is a program for setting your THUNDERCLOCK PLUS. It's easy to use and asks you for all the information it needs. Remember you will have to put the SET PROTECT/ENABLE switch on your THUNDERCLOCK PC card to the ENABLE position to set it. The SET PROTECT/ENABLE switch is located at the top-center of the THUNDERCLOCK card. It is a small plastic box with two buttons on the bottom and two buttons on top. To set the time, you must put the switches in the SET ENABLE position by pushing the two bottom buttons IN so that the two top buttons are OUT (refer to the picture in Appendix 'F'). After you have set the time you should put the switches back into the PROTECT position by pushing the two top buttons IN so that the two bottom buttons are OUT.

RUN CLOCK

CLOCK is a program which displays a HI-RES wall clock on the screen. The hands move and an audible "ticking" can be heard as the time passes second by second. The current date and time are both displayed as an ASCII string at the bottom of the screen. Press the <ESC> key to terminate the CLOCK program.

RUN TIME

The TIME program displays the time from the THUNDERCLOCK PLUS in three different formats on the screen: the AM/PM, the 24-hour, and Mountain Computer Apple Clock formats. The last line displays the time as the day-of-month and fraction. The TIME program also allows you to set the time by pressing the <5> key. The current values of the time will be displayed on the screen and the cursor will be left positioned so you can curse over the ones that are correct and change any you wish to change. When you press <RETURN>

at the end of the line the THUNDERCLOCK will be Set to the new time. You must place the SET PROTECT/ENABLE switch on your THUNDERCLOCK to the ENABLED position to do this. Remember to set it back to the PROTECTED position when you are done. You should exit the TIME program by pressing the <ESC> key.

RUN FRAME

FRAME is a program that displays the current time from your THUNDERCLOCK in a framed border on your screen. Press the <ESC> key to exit.

RUN DEMO

DEMO is a program which demonstrates the various features of the THUNDERCLOCK(PLUS. It displays a menu of possible options. You select the feature you want to examine or demonstrate and the DEMO program shows you how to use that feature in BASIC. If you have the X-10 OPTION installed, you can sent commands to your BSR/X-10 system from the keyboard.

RUN ADIGCLK RUN IDIGCLK

These two programs are the sane. One version (ADIGCLK) is written in APPLESOFT BASIC, the other version (IDIGCLK) is written in INTEGER. They show the time as a LO-RES color digital display on the screen. You can change the colors or exit the program by pressing the <ESC> key.

BRUN SCREEN

The SCREEN program displays the current time in a corner of the screen using interrupts. This program runs "in the background" so you can do other things with your APPLE in the "foreground". SCREEN will ask you which corner and what format you want. The time will then be displayed and continuously updated in the corner of the screen and you will be returned to the BASIC prompt. You can do a CATALOG, run a program, or enter a new program from the keyboard. Your APPLE is doing two things at once! Displaying the time under interrupt control in the background and executing your commands from the keyboard. If you press (RESET> or if you change the "text window" parameters, the time display will be disrupted or stopped. You cannot run another interrupt-driven program (such as the SCHEDULER) or boot another disk without first terminating this "background" program. When you want to terminate SCREEN you must use the BACKOFF program (discussed below) . NOTE: If you want to transfer the SCREEN program (or TSCREEN or BSCREEN below) to another disk, be sure to transfer the SDTIME.0 file as well, since it is used by all three SCREEN programs.

BRUN TSCREEN BRUN BSCREEN

TSCREEN and BSCREEN are just like the SCREEN program, but they don't ask or the format or corner questions. They both display the time in the AM/PM format, TSCREEN places it at the top-right corner and BSCREEN places it at the bottom-right corner.

RUN LASTBOOT

LASTBOOT displays the current time and then reads the file BOOTIME from your disk to see when it was last booted. It then re-writes BOOTIME with the current time. Then it runs the INTRO program. LASTBOOT is run at the end of the HELLO program. If you have write-protected your disk, LASTBOOT will terminate with a WRITE-PROTECT error.

BRUN BACKOFF

BACKOFF is the program you use to turn off the interrupt driven SCREEN programs and the SCHEDULER. It turns off interrupts and frees up the space these programs use. When you want to turn off one of these background programs you should do it using BACKOFF, otherwise you will lose the space they use or accidentally get interrupts turned back on when you don't want them. That can lead to strange results. Turning your APPLE off, then back on and rebooting always turns interrupts off and starts you afresh.

RUN SLOTFINDER

SLOTFINDER is a simple program that locates the slot your THUNDERCLOCK is in. It examines the first three bytes of firmware on each card in your APPLE to see if any of them match the first three bytes of the firmware on the THUNDERCLOCK PLUS PC card. You could use the TCPUTIL program to do this, but SLOTFINDER shows you how to do it in BASIC.

RUN VISIFIX

If you have an early version of the VISIDEX program from Visicorp, you can use the VISIFIX program to update it to be compatible for use with your THUNDERCLOCK PLUS. Once you have run the VISIFIX program on your VISIDEX disk, VISIDEX will be able to use your THUNDERCLOCK for its system clock. The VISIFIX program will give you step by step instructions when you run it.

RUN TEST

The TEST program checks to see that your THUNDERCLOCK is working correctly. You should see Appendix "U" for complete details on its use.

RUN DO AT

The DO AT program allows you to run a program, boot a disk, or execute a DOS command at a time you specify. It will ask you for the time at which you want to perform a DOS command and the command to be performed. It will then wait until the time you specified and execute the DOS command. You can specify any valid DOS command such as RUN MYPROGRAM, BRUN SOMETHING, CATALOG, or PR#6 to boot the disk in Drive 1. Be sure to remember to put the disk with the program you want to run in Drive 1 after you have answered the DO AT questions. DO AT is very useful for starting up some particular program or application at a specific time with unattended operation.

BLOAD RDTIME

RDTIME is an assembly language subroutine which allows you to read the time without using the on-card firmware. It is discussed in Chapters IV and V, and Appendix "E" contains a listing of RDTIME.

THE SUPPORT UTILITIES

The SUPPORT UTILITIES are programs and files on your THUNDERCLOCK BASIC Disk used by the DOS system and the other programs on the disk. With the exception of the HELLO program, you will probably never need to use them directly. They are discussed here so that you will understand how they are used.

HELLO APPLESOFT

One of these two programs will be run when you boot your disk. If your APPLE has APPLESOFT BASIC in ROM, the HELLO program is run; if it has INTEGER BASIC in ROM, the APPLESOFT program is run. These programs check to see if your APPLE has a Language Card. If it does, it is loaded with the language not in ROM (FPBASIC or INTBASIC). After this is done, the INTRO program is run if the APPLESOFT BASIC language is available. If only INTEGER BASIC is available, the IDIGCLK program is run instead.

TCPUTIL

The TCPUTIL program is used by many of the BASIC programs on this disk. Its described in detail in Chapter V of this manual.

SDTIME.O

When you run the SCREEN program, it loads SDTIME.O between DOS and its buffers. SDTIME.O is the assembly language program which actually displays the time on the screen under interrupt control.

TEST.O

TEST.O is an collection of assembly language subroutines used by the THUNDERCLOCK TEST program.

VISIO.8

This file is used by the VISIFIX program when it updates your VISIDEX program disk to be compatible for use with the THUNDERCLOCK PLUS.

BOOTIME

This is a small text file maintained and used by the LASTBOOT program. It contains the time the LASTBOOT program was run.

PROGRAMMING IN BASIC

The THUNDERCLOCK PLUS is an input/output device: you can read characters from it or write characters to it. What happens when you read the THUNDERCLOCK PLUS is determined by the READ MODE, and what happens when you write to it is determined by the WRITE MODE. The READ MODE selects the format in which the time is returned on a read, while the WRITE MODE decides what the THUNDERCLOCK PLUS does with characters written to it. These two modes are set by writing special characters to the THUNDERCLOCK PLUS. These special characters are called MODE CONTROL characters.

SETTING THE READ MODE

The READ MODE is selected by writing special MODE CONTROL characters to the THUNDERCLOCK PLUS. In BASIC this can be done conveniently as part of the INPUT statement used to read the time. For example, if you wanted to read the time in the AM/PM format from a THUNDERCLOCK PLUS in slot 4 into the string variable T\$ you would use an input statement like this:

```
<APPLESOFT BASIC>
```

```
10 D$=CHR$(4): REM CNTL/D
20 PRINT D$;"PR#4'
30 PRINT D$;"IN#4"
40 INPUT "%";T$
50 PRINT D$;'PR#0"
60 PRINT D$;"IN#0'
<INTEGER BASIC>
```

```
10 DIM T$(25)
20 D$="": REM CNTL/D
30 PRINT D$;"PR#4"
40 PRINT DS;'IN34"
50 INPUT "> ",T$
60 PRINT D$;"PR#0"
70 PRINT DS;"IN#0"
```

First the INPUT statement writes the character "%" or ">" to the THUNDERCLOCK PLUS, setting the READ MODE to the AM/PM format. The INPUT statement then reads from the THUNDERCLOCK PLUS and the time is returned in T\$ in the AM/PM format.

READ MODE CONTROL CHARACTERS

Here are the READ MODE control characters and their effects:

"%"

Sets the READ MODE to return the time in the AM/PM ASCII string format. After executing the APPLESOFT BASIC statement

```
INPUT "%";T$
```

the string variable T\$ will contain a string such as

```
TUE MAY 12 4:32:55 PM
```

">"

Sets the READ MODE to return the time in the AM/PM ASCII string format. After executing the INTEGER BASIC statement

```
INPUT ">`,`T$
```

the string variable 1\$ will contain a string such as

```
TUE MAY 12 4:32:55 PM
```

"&"

Sets the READ MODE to return the time in the 24 hour ASCII string format. After executing the APPLESOFT BASIC statement

```
INPUT "&`;T$
```

the string variable 1\$ will contain a string such as

```
TUE MAY 12 16:32:55
```

"<"

Sets the READ MODE to return the time in the 24 hour ASCII string format. After executing the INTEGER BASIC statement

```
INPUT `<`,`T$
```

the string variable 1\$ will contain a string such as

```
TUE MAY 12 16:32:55
```

" "(SPACE)

Sets the READ MODE to return the time in the Mountain Computer Apple Clock Format. After executing the APPLESOFT BASIC statement

INPUT

or the INTEGER BASIC statement

INPUT " ":T\$

the string variable T\$ will contain a string such as

05/12 16:32:55.OOO

"#"

Sets the READ MODE to return the time in the numeric format. After executing the APPLESOFT BASIC statement

INPUT "#";MO,DW,DT,HR,MN,SEC

or the INTEGER BASIC statement

INPUT "#",MO,DW,DT,HR,MN,SEC

the variables in the variable list will contain the following integer values:

MO The current month (1 thru 12).
DW The current day-of-the-week (0-6)
 where 0=Sunday, 1=Monday 6=Saturday.
DT The current date (1 thru 31).
HR The current hour (0 thru 23).
MN The current minute (0 thru 59).
SEC The current second (0 thru 59).

SETTING THE WRITE MODE

The WRITE MODE is selected in the same manner as the READ MODE, by writing special MODE CONTROL characters to the THUNDERCLOCK PLUS. From BASIC this is done by using the PRINT statement. Setting the WRITE MODE determines what the THUNDERCLOCK PLUS will do with subsequent characters written to it. Unless told otherwise, the THUNDERCLOCK PLUS assumes that characters written to it should be

interpreted as BSR/X-10 commands and should be sent to the BSR/X-10 ULTRASONIC COMMAND CONSOLE (see the chapter on the BSR/X-10 INTERFACE). We will only summarize the WRITE MODE control characters here, they are discussed in more detail in other sections of the manual:

! Alerts the THUNDERCLOCK PLUS that the characters that follow, up to the next <RETURN>, are to be used to set the time (see SETTING THE TIME below).

* Alerts the THUNDERCLOCK PLUS that the next character should be interpreted as a "COMMAND DURATION" for subsequent BSR/X-10 commands (see the chapter on the BSR/X-10 INTERFACE).

**

."

"/" Selects one of the three interrupt rates the THUNDERCLOCK PLUS can generate. See the chapter on USING INTERRUPTS.

SETTING THE TIME FROM BASIC

The first step in setting your THUNDERCLOCK is to place the SET PROTECT/ENABLE SWITCH on the PC card to the SET-ENABLE position (see the SET TIME program on page 2-2). Setting the time from BASIC is done by setting the WRITE MODE to the "SET TIME MODE" and passing a string of characters in the proper format to the THUNDERCLOCK PLUS. The character "!" alerts the THUNDERCLOCK PLUS that the characters that follow should be used to set the time. The "!" must be followed by the time in the exact format shown below:

```
!NM W DO HE MM SS<RETURN>
```

Note that each field is separated by a <SPACE> character and the entire string is terminated with a <RETURN>. The fields have the following meanings:

NM Two ASCII digits (01-12) defining the month, where 01=JAN, 02=FEB,..., 12=DEC.

W One digit (0-6) defining the day-of-the-week, where 0=SUN, 1=MON,..., 6=SAT.

DO Two digits (01-31) defining the date in the month.

HR Two digits (00-23) defining the hour in 24-hour time, where 00=midnite, 01=1 AM,...,11=11AM, 12=noon, 13=1PM,..., 23=11PM).

MM Two digits (00-59) defining the minute.

SS Two digits (00-59) defining the second.

When the string is written to the THUNDERCLOCK PLUS, and the SET/PROTECT switches are in the SET position, the time base in the THUNDERCLOCK PLUS will be set to the time specified in the string. For example, let's say you wanted to set the time to Thursday, March 7th 2:08:30 PM. Since the time is PM we add 12 hours to convert to 24-hour time and get 14 hours. Thursday is the 4th day-of-the week. Let's say the THUNDERCLOCK PLUS is in slot #3. The BASIC program:

```

10 PRINT D$;"PR#3"
20 PRINT "!O3 4 07 14 08 30"
30 PRINT D$;"PR#0"

```

sets the time as we wanted. NOTE THAT YOU MUST INCLUDE THE LEADING "0" IN TWO-DIGIT FIELDS IF THE VALUE IS LESS THAN 10. Here is short and simple BASIC time-setting program, one version for APPLESOFT and the other for INTEGER:

<APPLESOFT BASIC>

```

10 D$=CHR$(4): REM CNTL/D
20 PRINT "TIME? MM W DD HH MM SS";
30 HTAB 7
40 INPUT " "; S$
50 PRINT D$; "PR#3"
60 PRINT D$; "IN#3"
70 PRINT "!";S$
80 INPUT "%";T$
90 PRINT D$;"PR#0"
100 PRINT D$;"IN#0"
110 PRINT T$

```

<INTEGER BASIC>

```

10 DIM T$(25),S$(25)
20 D$="":REM CNTL/D
25 CALL -936
30 PRINT "TIME? NM W DD HH MM SS";
40 VTAB 1: TAB 7
50 INPUT " ",S$
60 PRINT D$;"PR#3"
70 PRINT D$; "IN#3"
80 PRINT "!";S$
90 INPUT ">",T$
100 PRINT D$;"PR#0"
110 PRINT D$;"IN#0"
120 PRINT T$
130 END

```

This program asks you for the time and prints the fields that need to be entered. It then sets the clock, reads the time back, and

prints it for your verification. Be sure to put the SET/PROTECT switches back into the PROTECT position after setting the time to insure absolute time base integrity against accidentally clobbering by programs that bomb or go astray.

CHAPTER III

THE BSR/X-10 INTERFACE

THUNDERWARE's X-10 ULTRASONIC INTERFACE OPTION allows your APPLE II to transmit control signals to your BSRIX-10 ULTRASONIC COMMAND CONSOLE. The COMMAND CONSOLE then impresses these control signals on your already existing 110V AC wiring to remotely control lights, appliances, or almost any electrical device you plug into a BSR/X-10 REMOTE MODULE. The THUNDERCLOCK PLUS BSR/X-10 ultrasonic interface is designed to operate with the BSR/X-10 ULTRASONIC COMMAND CONSOLE, model UC 301 or model X10-014301 (SEAR'S). This is the COMMAND CONSOLE that operates with the BSR/X-10 CORDLESS CONTROLLER. Be sure you have the right model COMMAND CONSOLE or it will be unable to "hear" the signals from your THUNDERCLOCK PLUS BSR/X-10 ultrasonic interface.

You should read the OWNER'S MANUAL that came with your BSR/X-10 system and understand the terms used to describe the various components of the BSR/X-10 system. We will use them extensively in this discussion. It would be a good idea to spend some time learning how to use the BSR/X-10 system manually so you understand how the various functions (ON, OFF, DIM, BRIGHT, etc.) work.

The THUNDERCLOCK PLUS BSR/X-10 ultrasonic interface consists of an ultrasonic transducer which converts the electrical signals sent by your THUNDERCLOCK PLUS into ultrasonic signals which can be detected by the BSR/X-10 ULTRASONIC COMMAND CONSOLE. The COMMAND CONSOLE then impresses these control signals onto the 110V AC wiring in your home or business. The BSR/X-10 REMOTE MODULES plugged into the 110V AC wiring detect these signals and perform the specified actions.

Before going any farther, be sure that your THUNDERCLOCK PLUS ultrasonic transducer is properly installed. See the section on INSTALLING THE BSR/X-10 ULTRASONIC TRANSDUCER in CHAPTER 1.

THE THUNDERWARE SCHEDULER SOFTWARE

The THUNDERWARE SCHEDULER SOFTWARE package is a powerful tool which allows you to define schedules for controlling your BSR/X-10 REMOTE MODULES. Our menu-driven software allows you to define complex schedules easily and save them on disk. The SCHEDULER runs in~ the background under interrupt control, while you run another program in the foreground. The SCHEDULER SOFTWARE, along with a number of demo, time setting, and utility programs for the THUNDERCLOCK PLUS, comes on disk with the X-10 ULTRASONIC INTERFACE OPTION.

SENDING BSR/S-10 COMMANDS FROM YOUR OWN BASIC PROGRAMS

Your BSRIX-10 COMMAND CONSOLE has 22 buttons for sending commands. These are labeled thru 16, ON, OFF, BRIGHT, DIM, ALL LIGHTS ON, AND ALL OFF. The THUNDERCLOCK PLUS X-10 ULTRASONIC INTERFACE can send all 22 of these commands. You also have control over the "duration" of the commands, that is, how long a command is transmitted. When you use your BSR/X-10 COMMAND CONSOLE manually, YOU determine the duration by how long you press the button. The "duration" control feature is used primarily in conjunction with the DIM and BRIGHT controls.

To send commands to your BSR/X-10 ULTRASONIC COMMAND CONSOLE thru the THUNDERCLOCK PLUS, you just write the characters corresponding to the command buttons to the THUNDERCLOCK PLUS. These characters are:

<u>BUTTON</u>	<u>CHARACTER</u>	<u>BUTTON</u>	<u>CHARACTER</u>
1	A	12	L
2	B	13	M
3	C	14	N
4	D	15	O
5	E	16	P
6	F	ON	Q
7	G	OFF	R
8	H	BRIGHT	S
9	I	DIM	T
10	J	ALL LITES ON	U
11	K	ALL OFF	V

Your program writes these characters to the THUNDERCLOCK PLUS using the BASIC "PRINT" statement. For example, suppose your THUNDERCLOCK PLUS is in slot 4. The program:

```
<APPLESOFT OR INTEGER BASIC>
```

```
10 D$="": REM CNTL/D
20 PRINT D$;"PR#4"
30 PRINT "ADQJKR"
40 PRINT D$;"PR#0"
```

would turn REMOTE MODULES 1 and 4 ON and REMOTE MODULES 10 and 11 OFF.

At this point we are ready for some "hands on" experience. You will need to get two of your REMOTE MODULES. For these experiments you should have one LAMP MODULE with its UNIT CODE dial set to "1" and one APPLIANCE MODULE with its UNIT CODE dial set to "4". Be sure that both REMOTE MODULES and your COMMAND CONSOLE "HOUSE CODE" dials are set to the SAME letter. Plug both REMOTE MODULES into wall outlets nearby. Plug an incandescent light into the LAMP MODULE and be sure the light is turned ON. You need not plug anything into the APPLIANCE MODULE, as it makes an audible "click" when it is

activated. Be sure your COMMAND CONSOLE is plugged in. To be sure everything is setup properly, open the cover on your COMMAND CONSOLE and press the buttons "is, and "4", then press "ON" and "OFF". You should have heard the APPLIANCE MODULE "click" and the light should have gone off. If not, check that you have things set up properly and try again.

Now let's enter a short BASIC program that will allow us to exercise the THUNDERCLOCK PLUS BSR/X-10 command capability. Substitute the slot number where you've placed your THUNDERCLOCK PLUS for the "?" below:

<APPLESOFT BASIC>	<INTEGER BASIC>
10 D\$=CHR\$(4): REM CNTL/D	10 DIM C\$(80)
20 INPUT "COMMANDS: ";C\$	20 DS="": REM CNTL/D
30 PRINT D\$;"PR#?"	30 INPUT "COMMANDS: ",CS
40 PRINT CS	40 PRINT D\$;"PR#?"
50 PRINT D\$; "PR#0"	50 PRINT CS
60 GOTO 20	60 PRINT D\$;"PR#0"

Now if we run this program it asks:

COMMANDS:

Let's type the letter "A" followed by a return. Did you see the red light on the front of your COMMAND CONSOLE come on momentarily? Try it again. If the red light didn't go on, make sure the THUNDERCLOCK PLUS ultrasonic transducer is properly connected and positioned.

Now let's try turning REMOTE MODULES 1 and 4 ON and OFF. Type "ADQR" followed by return. The red light should flash, you should see the light plugged into the LAMP MODULE go on and off, and hear the APPLIANCE MODULE click. If you type "ADQRQRQR" followed by return, the light and APPLIANCE MODULE should go on and off several times. Getting the hang of it? Try typing "ATS", that should dim and then brighten the light in module 1. Which brings us to the DIM and BRIGHT functions.

BRIGHT AND DIM CONTROL

Both the BSR/X-10 LAMP MODULE and WALL SWITCH MODULE have DIM and BRIGHT control capability. The APPLIANCE MODULES do not (you wouldn't want to DIM your washer, would you?). How DIM or BRIGHT a light gets depends on how long you hold down the DIM or BRIGHT button on your COMMAND CONSOLE. This is called the "duration" of the DIM or BRIGHT command.

The BSR/X-10 REMOTE MODULES have a total range of 128 separate steps between fully BRIGHT and totally DIM. The THUNDERCLOCK PLUS ultrasonic interface allows you to specify the duration of a DIM or BRIGHT command. This is accomplished by writing a special WRITE MODE CONTROL character to the THUNDERCLOCK PLUS. When the character "*"

(asterisk) is written to the THUNDERCLOCK PLUS, it alerts it that the next character it receives should be interpreted as the DURATION of any further commands. The characters used to define the duration are "A" thru "Z". "A" sets the duration to its shortest value (0.1 seconds) , "Z" to its longest (5 .3 seconds). The letters "A" thru "Z" used here for duration control should not be confused with the letters "A" thru "V" used as commands. The THUNDERCLOCK PLUS interpretes only the first non-space character after a "*" as a duration code. A duration of approximately 3.4 seconds will traverse the full BRIGHT-to-DIM or DIM-to-BRIGHT range in one operation. The exact duration in seconds corresponding to each duration control character can be found in the QUIK-REFERENCE SUMMARY on the last page on this manual. If you wanted to traverse, say, 64% of the full range, you would send the duration control character whose duration was closest to 64% of 3.4 seconds (2.17 seconds). That would be the duration control character "K".

Each time you "initialize" the THUNDERCLOCK PLUS by executing a "PR#n: IN#n" statement in BASIC, a default duration code is set, equivalent to the duration code "E". Once a duration has been set, it remains in effect for all following commands until a new duration code is set or until you do another PR/IN to the THUNDERCLOCK PLUS.

Let's try using the duration control feature in our program above. In response to the "COMMAND:" prompt let's type

```
"A RQ *R TS"
```

followed by a return, we have put some spaces in the line to make it more readable. The THUNDERCLOCK PLUS will ignore the spaces, so we can use them freely. This command sequence reads: Module 1, OFF, ON, set duration of following commands to "R", DIM, BRIGHT. The light plugged into REMOTE MODULE 1 should go OFF, then ON, then it should go fully DIM, then go back to fully BRIGHT. When the THUNDERCLOCK PLUS sees the "*" it knows that the next character, "R", is the duration code for the following DIM ("T") and BRIGHT ("5") commands. Let's try that again, but this time we'll run the light thru several DIM/BRIGHT cycles with:

```
"A *R TSTSTSTSTS"
```

The smallest DIM/BRIGHT duration code is the character "A". Each DIM/BRIGHT command we send using this duration will increase or decrease the brightness by 1/128th of the full range. Let's dim the light connected to REMOTE MODULE "1" to about 3/4 full brightness, then dim in the smallest steps possible:

```
**M T *A TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT"
```

The "*" sets the "duration" to about 2.6 seconds, so when the following DIM command ("T") is executed it dims the light to about 3/4 its full brightness. The "*"A" then sets the "duration" to the shortest possible value, about 0.1 seconds, and the DIM commands that follow step the brightness down by 1/128th each.

Note that commands other than DIM and BRIGHT should be sent with duration codes of "C" or greater. The BSR/X-10 system may not work reliably if you use duration codes "A" and "B" with any commands other than DIM and BRIGHT.

Now that you understand how to use your THUNDERCLOCK PLUS to send BSR commands, try writing some simple BASIC programs that send commands to your REMOTE MODULES at specific times or intervals of time using the clock function of the THUNDERCLOCK PLUS. Here's a little program that alternately dims and brightens the light connected to REMOTE MODULE "1" every minute (replace the "?" with your slot number):

<APPLESOFT BASIC>

```
5 D$-CHR$(4): REM CNTL/D
10 PRINT D$;"PR#?"
15 PRINT D$;"IN#?"
20 INPUT "#";MO,DW,DT,HR,NN,SEC
30 IF SEC = 0 THEN PRINT "*D A *N T"
40 IF SEC = 30 THEN PRINT "*D A *N S"
50 GOTO 20
```

<INTEGER BASIC>

```
5 D$-"" : REM CNTL/D
10 PRINT D$;"PR#?"
15 PRINT D$;"IN#?"
20 INPUT "#",MO,DW,DT,HR,MN,SHC
30 IF SEC = 0 THEN PRINT "*D A *N T"
40 IF SEC = 30 THEN PRINT "*D A *N S"
50 GOTO 20
```

CHAPTER IV

USING YOUR THUNDERCLOCK FROM ASSEMBLY LANGUAGE

You can use all the features of the THUNDERCLOCK PLUS from assembly language. The same READ MODE and WRITE MODE control characters previously described apply in this discussion. There are two entry points in the firmware used to READ and WRITE the THUNDERCLOCK PLUS. The WRITE entry point is at address \$CNOB and the READ entry point is at address \$CNO8. The "N" in these two addresses represents the slot number of the THUNDERCLOCK PLUS. Reading and writing is accomplished by a simple subroutine call. On a WRITE call, the character to be written to the THUNDERCLOCK PLUS should be in the A-REGISTER. For the purposes of this discussion, let's assume you have placed the following definitions at the start of your program:

```
EIJTCP EQU $CNO8 ;READ ENTRY POINT
WTTCP EQU $CNOB ;WRITE ENTRY POINT
```

READING THE TIME

After you have set the READ MODE by writing the appropriate READ MODE CONTROL character to the THUNDERCLOCK PLUS, you read the time by executing a "JSR RDTCP". Upon return from this subroutine call, the time will be stored as an ASCII string in the GETLN input buffer at address \$200. The format of the string is determined by the READ MODE last set. Upon return, the X-REGISTER will contain the length of the string in the GETLN buffer. The last character stored in the time string will be a CARRIAGE RETURN character (\$80).

For example, if you wanted to read the time in the AM/PM ASCII string format, your code would look like this:

```
LDA #$BE ;">"
JSR WTTCP ;SET AM/PM READ MODE
JSR RDTCP ;READ TIME INTO GETLN BUFFER
```

The first character placed in the GETLN buffer is used to "fake" the BASIC input routines so they will accept the character ":" which occurs in the time strings without giving the "EXTRA IGNORED" MESSAGE. For READ MODES "%" and "&" the first character in the GETLN buffer will be the double-quote character (\$A2) . For READ MODES ">" and "<" the first character will be a space (\$A0).

When you read the time in the numeric mode ("#"), the format is different than that for ASCII strings. The time is returned as a series of fields separated by commas. Each field consists of two

ASCII characters ("0" through "9") representing the decimal values of month, day-of-week, date, hour, minute, and second. If your program looked like this:

```
LDA  #A3  ;"#"  
JSR  WTTCP ;SET NUMERIC READ MODE  
JSR  RDTCP ;PUT VALUES IN GETLN BUFFER
```

Then upon return from the RDTCP subroutine call the GETLN buffer at \$200 would contain a character string of the form:

```
09,01,17,22,46,57
```

which would translate as:

```
09 = The month, OCTOBER (01=JAN,...,12=DEC)  
01 = The day-of-week, MONDAY (00=SUN,...,06=SAT)  
17 = The date, 17th (00-31)  
22 = The hour, 10 PM (00-23)  
46 = The minute (00-59)  
57 = The second (00-59)
```

THE MOUNTAIN CLOCK FORMAT

If you want to read the time in the Mountain Computer Apple Clock format from assembly language, you handle things a little differently. Writing a space character (\$AO) to the THUNDERCLOCK will NOT return the Mountain format on the next read. Instead, you must write a \$00 to one of the peripheral slot scratchpad memory addresses immediately before calling the READ entry point. This address is \$5F8+N, where N is the slot number of your THUNDERCLOCK. Here's an example for a THUNDERCLOCK in slot 4:

```
LDY #4      ;THUNDERCLOCK SLOT #  
LDA #0  
STA $5F8,T  ;SET MHC FORMAT  
JSR RDTCP   ;PUT TIME IN BUFFER
```

Upon return from the READ call the time string, in the Mountain Computer format, will be in the GETLN buffer starting at \$200.

SETTING THE TIME

Setting the time from assembly language requires successive writes to the THUNDERCLOCK PLUS in the exact format described in SETTING THE TIME in Chapter II. Remember that the first character of the time setting string must be a "!" and the last character must be a carriage return.

READING THE TIME DIRECTLY WITHOUT USING THE FIRMWARE

The firmware supplied on the THUNDERCLOCK PLUS makes it easy to read the time from BASIC or assembly language. But there may be times when you wish to access the time without calling the firmware. The THUNDERCLOCK firmware uses the expansion ROM memory space (sometimes referred to as the "shared I/O space") from \$C800 thru \$CBFF (1024 BYTES). This memory space is enabled whenever you call the THUNDERCLOCK's firmware. If the time must be read from an interrupt-level program (see Chapter V), or you do not want the \$C800 "shared" I/O space enabled, you will have to read the time without accessing the firmware. The THUNDERCLOCK PLUS uses a clock chip (NEC uPD1990C), which maintains the time and date information as 40 bits (ten 4-bit nibbles) in registers internal to the clock chip. These registers are not directly accessible from the APPLE's data bus. Instead, these 40-bits must be shifted, out of the clock chip serially. Appendix "E" is a listing of the short assembly language program RDTIME which can be called as a subroutine to read the time and date and place their values in memory. It contains the required control routines and can be used as a guide in designing your own RAM-based driver. A version assembled to BLOAD at \$7000 is supplied on the THUNDERCLOCK BASIC disk.

SENDING BSR/X-10 COMMANDS

You send BSR/X-10 commands using the same "command button characters" described in Chapter III. Here's a sample program that sends a string of BSR/X-10 commands to a THUNDERCLOCK in slot 3:

```
WTTCP EQU SC30B
*
START LDX #0 ;INITIALIZE STRING POINTER
*

LOOP LDA CMDSTR,X ;GET A BSR COMMAND CHAR
     BEQ DONE ;BRANCH IF END OF STRING
     JSR WTTCP ;SEND TO THUNDERCLOCK
     INX ;BUMP STRING POINTER
     BNE LOOP ;AND CONTINUE
*
DONE JMP $FF69 ;DONE, GO TO MONITOR
*
*****
* THE BSR COMMANDS STRING:
* SET DURATION TO "C", 1 AND 2 OFF, THEN ON,
* SET DURATION TO "M", DIM, BRIGHT
*

CMDSTR ASC " *C ABRQ *M TS"
        HEX 00
        END
```

CHAPTER V

ALL ABOUT INTERRUPTS

The THUNDERCLOCK PLUS can generate interrupts at three different rates: 64Hz, 256Hz, and 2048HZ. Before getting into the details of using interrupts with the THUNDERCLOCK PLUS, a general discussion of interrupt use in the APPLE II is in order. Although this next section is somewhat complex, read on, it get's more BASIC later on.

When an interrupt is generated by a peripheral card in the APPLE II, the processor (the 6502) ignores it if the INTERRUPT DISABLE FLAG in the PROCESSOR STATUS REGISTER is set (=1) or acknowledges it if the INTERRUPT DISABLE FLAG is clear (0). When it acknowledges the interrupt, the following sequence of events occurs:

The current contents of the PROCESSOR STATUS REGISTER (P) and the PROGRAM COUNTER (PC) are pushed onto the stack. The next instruction is taken from the address contained in locations \$FFFE and \$FFFF. In the APPLE II MONITOR ROMS this address points to a routine in the MONITOR called "IRQ". This routine saves the contents of the A-REGISTER in PAGE ZERO location \$45, and pulls the contents of the PROCESSOR STATUS REGISTER saved when the interrupt occurred from the stack and inspects it to see if the interrupt was caused by a "break" instruction (a \$00). If not, it assumes that it's a real interrupt and jumps to the interrupt routine beginning at the address contained in locations \$3FE and \$3FF. The "INTERRUPT ROUTINE" should save the contents of the K and Y REGISTERS, reset the INTERRUPT REQUEST hardware logic on the peripheral card, and do whatever needs to be done (the interrupt task). When it is done, it should restore the saved contents of the X and Y REGISTERS, load the A-REGISTER with the contents of PAGE 0 location \$45 (saved at the beginning by the MONITOR) and return to the interrupted program by executing an RTI instruction.

ENABLING INTERRUPTS

In normal operation the THUNDERCLOCK PLUS does not generate interrupts. It takes a specific set of actions to enable interrupts. You must first put the address of the machine language "INTERRUPT ROUTINE" in locations \$3FE/\$3FF, with the LEAST SIGNIFICANT 8 bits of the address going into \$3FE and the MOST SIGNIFICANT 8 bits of the address going into \$3FF. To actually enable interrupts, two actions must be performed: (1) A value of \$40 must be written to the THUNDERCLOCK PLUS INTERRUPT CONTROL REGISTER. (2) A "CLI" (Clear Interrupt Mask) instruction must be executed to be sure the processor will recognize interrupts.

This is done by the following sequence of instructions:

```
LDY SLOTNO
LDA #$40
STA $C080,Y
CLI
```

where the Y-REGISTER is loaded with the SLOT number of the THUNDERCLOCK PLUS in the upper 4 bits (\$10 for SLOT #1, \$20 for SLOT #2,..., \$70 for SLOT #7). PLEASE NOTE that the THUNDERCLOCK CONTROL REGISTER must always be addressed using the indexed-Y mode. Referencing the CONTROL REGISTER using an absolute address will not work properly.

Now when an interrupt from the THUNDERCLOCK PLUS occurs, the processor will transfer control to the "INTERRUPT ROUTINE" whose address you placed in \$3FE/\$3FF. After saving the X and Y Registers, you must clear the interrupt generated by the hardware logic on the THUNDERCLOCK PLUS peripheral card. This is done by the following sequence of instructions:

```
LDY SLOTNO
LDA $C088,Y
LDA $C080,Y
```

The INTERRUPT ROUTINE may now perform whatever task needs to be done. At completion, it needs to restore the saved contents of the X and Y REGISTERS, load the A-REGISTER with the saved contents in \$45, and execute an RTI.

DISABLING INTERRUPTS

Interrupts from the THUNDERCLOCK PLUS can be disabled (turned off) in any one of four ways:

- (1) By writing a zero (\$00) into the THUNDERCLOCK PLUS INTERRUPT CONTROL REGISTER at address \$C080,Y. This resets (turns off) the THUNDERCLOCK PLUS interrupt generating hardware.
- (2) By hitting the RESET key on the keyboard. This resets the THUNDERCLOCK PLUS interrupt generating hardware.
- (3) By READING or WRITING the THUNDERCLOCK PLUS. This resets the THUNDERCLOCK PLUS interrupt generating hardware (see below).
- (4) By executing a "SEI" (set interrupt mask) instruction, which does not turn off the interrupts being generated by the THUNDERCLOCK PLUS, but prevents the 6502 processor from "seeing" them. This is a convenient way to temporarily suspend interrupts. You can turn them on again by executing a "CLI" instruction.

There may be occasions when you want to be able to read or write the THUNDERCLOCK from the foreground while leaving Interrupts running. Normally interrupts would be left disabled after you read or wrote the THUNDERCLOCK. If you want interrupts to be left enabled after a read or write, you must place the value of \$40 in two "screen" bytes as well as in the THUNDERCLOCK INTERRUPT CONTROL REGISTER. The addresses of the screen bytes are \$478+n and \$7F8+n, where "n" is the slot number is the lower 4 bits. You should be sure to zero these two bytes when you want to disable interrupts completely.

READING THE TIME FROM AN INTERRUPT-LEVEL ROUTINE

If it is necessary to read the time from an interrupt-level routine, care must be taken. If you attempt to read the time from the THUNDERCLOCK by calling the on-card firmware, some undesirable side effects will occur. The THUNDERCLOCK's firmware will place the time in the GETLN buffer at \$200, possibly destroying characters being put there by the user thru the keyboard for the foreground program. Also, because the THUNDERCLOCK's firmware uses the \$C800 "shared" I/O space, you may cause conflicts with other peripheral cards using that space. If your foreground program has called a peripheral using the \$C800 space and an interrupt from the THUNDERCLOCK occurs, you don't want to call the THUNDERCLOCK's firmware because it will turn off the foreground peripheral's \$C800 space. When you return from the THUNDERCLOCK's interrupt routine, the foreground peripheral's \$C800 firmware will be "gone", and the results are usually catastrophic.

Instead of calling the THUNDERCLOCK's firmware from your interrupt-level routine to read the time, you should incorporate the assembly language subroutine "RDTIME" to do this for you. This short subroutine is listed in Appendix "E" and a version assembled to run at \$7000 can be found on the THUNDERCLOCK BASIC Disk that came with your THUNDERCLOCK.

POLLING FOR INTERRUPTS

If there is more than one peripheral in your APPLE generating IRQ interrupts at the same time, you need to be able to tell which peripheral has caused the interrupt. If, for example, you had both the THUNDERCLOCK and a serial-card generating interrupts, then when an IRQ interrupt occurs you must determine whether that interrupt was caused by the THUNDERCLOCK or the serial-card. You can determine if the interrupt was caused by the THUNDERCLOCK by examining the THUNDERCLOCK's "interrupt asserted flag" in the THUNDERCLOCK CONTROL REGISTER. When the THUNDERCLOCK causes an interrupt, bit 5 will be set (-1). If this bit is clear (=0), then some other device

is causing the IRQ interrupt. The following sequence of instructions checks that the interrupting peripheral is the THUNDERCLOCK PLUS:

```
LDY SLOTNO      ;
LDA $C080,Y     ;GET CONTROL REGISTER
AND #$20        ;CHECK BIT 5
BEQ NOTTTC      ;BRANCH IF CLEAR, NOT THUNDERCLOCK
LDA $C080,Y     ;CLEAR THE INTERRUPT
LDA $C088,Y     ;WE JUST RECEIVED
```

Note that the "interrupt asserted bit" is automatically cleared when you clear the interrupt with the last two instructions above.

NOW THAT YOU KNOW ABOUT INTERRUPTS WHAT CAN YOU DO WITH THEM?

Interrupts can be used for a variety of purposes. Most frequently they are used to assure that something happens at regular intervals of time. Such things as analog-to-digital conversion, periodically checking the "RING" indicator of a MODEM for an incoming call, toggling an output at regular intervals, or accurately timing an interval between events. The THUNDERCLOCK PLUS can generate interrupts at any one of three software selectable rates: 64HZ, 256HZ, or 2048HZ. The interrupt rate is set to 64HZ automatically whenever you SET THE TIME using the "1" WRITE MODE control character. To set the interrupt rate, you must write the appropriate INTERRUPT RATE MODE CONTROL character to the THUNDERCLOCK PLUS. NOTE: The SET/PROTECT switch on the THUNDERCLOCK PLUS peripheral card must be in the SET position in order to change the interrupt rate. These characters and their meanings are:

```
"," Set the interrupt rate to 64HZ
"." Set the interrupt rate to 256Hz
"/" Set the interrupt rate to 2048HZ
```

From BASIC you can use the "PRINT" statement. For example, the program below sets the interrupt rate to 256HZ on a THUNDERCLOCK PLUS in slot 4:

```
200 PRINT D$;"PR#4"
300 PRINT "."
400 PRINT D$;"PR#0"
```

Remember that writing these control characters and setting the interrupt rates DOES NOT ENABLE interrupts, but rather only selects the rate at which they will occur when they are ENABLED (see ENABLING INTERRUPTS above).

INTERRUPTS, MADE EASY

Appendix "C" is a listing of the program TCPUTIL. It "BLOADS" into memory at \$300 (generally not used by either BASIC or the MONITOR) and contains a number of useful subroutines that can be CALVed from BASIC for dealing with interrupts. You will find this program included on the THUNDERCLOCK BASIC diskette that came with your THUNDERCLOCK. If you wish to use these interrupt utility subroutines in your BASIC program, you should put the following statements at the beginning:

```
<APPLESOFT OR INTEGER BASIC>
```

```
100 D$="": REM CONTROL/D
110 PRINT D$;"BLOAD TCPUTIL"
120 LCNT=768
130 HCNT=769
140 SLOTNO=770
150 GTSLOT=775
160 STROBE=817
170 ZERO=833
180 IGO=877
190 IHLT=897
200 ENABLE=895
210 DISABLE=905
220 SOUND=907
230 MUTE=911
```

After you have executed these statements at the beginning of your BASIC program, you can use the following subroutines:

CALL GTSLOT

GTSLOT is a convenient little subroutine which searches the APPLE II peripheral slots to see where your THUNDERCLOCK PLUS is. It places the SLOT number in "SLOTNO". Then if you say:

```
SN =PEEK(SLOTNO)
```

the variable SN will have the value of the THUNDERCLOCK PLUS slot number (1-7). If it can't find a THUNDERCLOCK PLUS, it sets SLOTNO to 0. GTSLOT also sets up some information for the other utility subroutines, so you should call it before any others, even if your program does not care which slot the THUNDERCLOCK PLUS is in.

CALL GO

IGO puts the address of its interrupt routine into \$3FE/\$3FF and turns on the interrupts. The interrupt routine increments a 16-bit counter in memory once each time an interrupt occurs.

CALL ZERO

ZERO sets to zero the 16-bit counter above.

CALL STROBE

STROBE reads the 16-bit counter and makes its value available in HCNT and LCNT. The BASIC statement:

```
CNT = PEEK(HCNT)*256 + PEEK(LCNT)
```

results in the variable CNT having the count.

CALL DISABLE

DISABLE masks further interrupts by executing an "SEI" instruction.

CALL ENABLE

ENABLE unmaskes interrupts suspended by the DISABLE call by executing a "CLI" instruction.

CALL SOUND

SOUND causes the interrupt routine to toggle the APPLE II speaker once each interrupt, producing a tone at a frequency equal to the interrupt rate. The 16-bit counter keeps counting as well.

CALL MUTE

MUTE turns off the toggling of the speaker.

CALL IHLT

IHLT turns off interrupts by resetting the THUNDERCLOCK PLUS interrupt generating hardware. Interrupts cannot occur until IGO is called again.

USING INTERRUPTS WITH DOS

DOS and the MONITOR are neighbors. They live on the same block (or should we say board) and most of the time they get along very well, sharing the resources they need to do their jobs and respecting each others priorities and territories. But on one point they have a dispute, namely, who really gets to use PAGE 0 location \$45? This dispute arose when an APPLE programmer or programmers unknown assigned DOS that Page 0 location \$45 as a temporary location for calculating certain parameters in DOS calls. As you remember from our discussion on interrupts earlier in this chapter, we saw that the MONITOR also uses location \$45 to save the contents of the A-REGISTER when an interrupt occurs.

What this means is that if an interrupt occurs at just the right (actually wrong) instant while a DOS command is in progress, DOS may give you a funny error message such as "RANGE ERROR" or "SYNTAX ERROR" or "NO BUFFERS AVAILABLE". WORSE, IT COULD DAMAGE DATA being transferred to or from the disk. Remember that any BASIC "PRINT" statement that starts with a CONTROL/D is interpreted as a DOS command. DOS is always the loser when this conflict over location \$45 arises, the interrupt always wins.

But you can solve this problem very simply so you can use DOS calls in your programs with interrupts running. All you need to do is temporarily disable interrupts WHENEVER your program executes a DOS command. You can do this by using the "CALL DISABLE" and "CALL ENABLE" utility subroutines in TCPUTIL. Just CALL DISABLE before the DOS command and CALL ENABLE afterwards as in these examples below:

```
345 CALL DISABLE
350 PRINT D$;"BLOAD MYFILE,A$7000"
355 CALL ENABLE
```

or...

```
1040 CALL DISABLE
1050 PRINT D$;"PR#0"
1060 PRINT D$;"IN#0"
1070 CALL ENABLE
```

By doing things this way, you can use interrupts and DOS calls in your programs and take full advantage of all of your APPLE II's power and flexibility!

SLOWER INTERRUPT RATES AND OVERHEAD

You may want to do things less frequently than 64 times per second, say once per minute, or once per hour using interrupts. You can set the THUNDERCLOCK PLUS to interrupt at 64HZ and then just count the number of interrupts you receive until the desired period has passed. If, for example, you wanted to do something every minute, that means that 64×60 interrupts would occur in a 1 minute interval. So your interrupt routine would count interrupts until $64 \times 60 = 3840$ interrupts had occurred, do whatever you wanted to do, and clear the interrupt counter. Then when your interrupt routine had counted another 3840 interrupts, another minute will have elapsed. Or you could expand this technique to read the time from the THUNDERCLOCK PLUS each minute and perform some action at a specific time or times. Remember that reading the time from the THUNDERCLOCK PLUS will turn off the interrupt hardware, so if you read the time in an interrupt routine be sure to write a \$40 into the THUNDERCLOCK PLUS INTERRUPT CONTROL REGISTER before exiting the interrupt routine to re-enable them.

Will interrupts make my APPLE run slower? How much "overhead" will interrupts take? It is generally good practice to keep interrupt routines as short as possible. If an interrupt routine has, say, 100 assembly language instructions, that means it will take about 400 microseconds to execute. It will be executed each time an interrupt occurs, and at 64HZ that means 400×64 microseconds out of each second will be spent processing interrupts. That figures out to $(400 \times 64 / 1,000,000)$ or about 2% overhead. At 256HZ the overhead rises to 10%, and at 2048HZ your interrupt routine will consume 80% of the APPLE II's time.

APPENDIX A

ADJUSTING YOUR THUNDERCLOCK

At the heart of your THUNDERCLOCK PLUS is a tiny tuning-fork quartz crystal which vibrates at a precise frequency. The THUNDERCLOCK maintains the correct time by counting these vibrations. If the frequency of the vibrations is too fast or too slow then after a long period of time you will see this error in the time read out of the THUNDERCLOCK. If the crystal vibrates too fast, the clock will gain time. If the crystal vibrates too slow, the clock will lose time. There are several factors which affect the frequency at which the crystal vibrates, these are:

1. The average temperature in your APPLE.
2. Ageing of the crystal.
3. Battery voltage (to a very slight degree)

After you have set the correct time and your THUNDERCLOCK has been running in your APPLE for a few days, you may see that it is gaining or losing time. Be sure to use an accurate time reference for this comparison, such as the Telephone company's time service, or a radio network news service chiming at the beginning of the hour.

Your THUNDERCLOCK has been carefully adjusted at the factory for the typical operating temperature within an APPLE II. If your APPLE is always on, the clock may run slightly slow. If your APPLE is seldom turned on, the clock may run slightly fast.

Adjacent to the SET/PROTECT switch is a small ceramic element which has a slotted screw on its front. See the picture of the THUNDERCLOCK PLUS PC card in Appendix "F". This is the trimming capacitor, used to calibrate the clocks crystal frequency source. The legend on the PC card identifies this capacitor as 'CS'. With the THUNDERCLOCK still installed in your APPLE, BUT WITH THE POWER TURNED OFF, this capacitor may be used for fast/slow adjustment. Steady the PC card with one hand while carefully using a very small bladed screwdriver with the other hand, and rotate the slotted screw in the capacitor very slightly counter-clockwise if the clock has been running fast, (you want to slow down the clock) .and very slightly clockwise if the clock has been running slow (you want to speed up the clock) .The slightest movement may be all that is required. Several degrees of rotation of the adjustment screw of CS will correspond to a few seconds per week accumulated difference.

Now that you have adjusted the clock, you must RE-SET THE TIME so that you will know what effect your calibration has had on its timekeeping accuracy. During the next week you will be able to observe how well your THUNDERCLOCK is keeping time.

APPENDIX B

BATTERY TESTING AND REPLACEMENT

TESTING THE BATTERIES

FIRST BE SURE YOUR APPLE II IS TURNED OFF. Carefully remove the THUNDERCLOCK PLUS PC card from its I/O slot. To check the battery voltage, it is best to measure it directly at the 1990c clock chip at location 3-A. Using a voltmeter or DMM with a minimum of 1000 Ohm/Volt rating, place the positive lead of the meter on pin #14 of the 1990c, and the negative lead of the meter on pin #7. New batteries will read just above 3.0 Volts. The THUNDERCLOCK PLUS should function properly down to about 2.1 Volts. At a reading of 2.2 Volts you should plan to buy new batteries soon, even if there are no symptoms of the clock behaving abnormally. This will allow YOU to decide a convenient time, rather than having it decided for you. If the clock behaves abnormally, and the voltage is below 2.3 Volts, you should replace the batteries anyway.

REPLACING THE BATTERIES

The only batteries which will work properly in the THUNDERCLOCK PLUS are Alkaline Batteries. These will give long years of performance and most importantly they will not leak. Leakage is the number one enemy of electronic equipment — it induces CORROSION. USE OF ANY NON-ALKALINE BATTERY WILL VOID YOUR WARRANTY !

The industry standard size of the cell is NEDA #910A. THUNDERWARE recommends:

1. EVEREADY #E90 (type N)
2. DURACELL #MN9100
3. ANSI #L20
4. IEC #LR1
5. PANASONIC/NATIONAL #AM5
6. VARTA #4001

The EVEREADY cell is preferred because it has a better contact geometry. This type cell is primarily used in photo applications, and is almost always available in photo/camera shops. Some discount stores have these batteries in their camera sections. Many of the electronic supply houses also stock this cell.

TURN OFF THE POWER TO YOUR APPLE II. Remove the top cover and carefully remove the THUNDERCLOCK PLUS PC card from its I/O slot. Place it component side up on a flat, NON-CONDUCTIVE surface. A dry

towel or newspaper is good. It also keeps the PC card from scratching the surface it's on. Mark the tops or sides of the old cells with a scratch or piece of tape before you remove them so you'll be able to distinguish them from the new cells if they get mixed up. Then, using a prying instrument such as a small screwdriver, key, or other strong, slender device, use one battery as a fulcrum and pry up one end of the old cell. With one end free, simply pull the old cell from the holder. NOTE the POLARITY of the batteries. The PLUS(+) terminal of BOTH cells must be UP - away from the gold contact fingers of the board. The PC board has a (+) and (-) legended by the battery holders. Keeping the cell relatively flat on the working surface, push the (+) contact of the cell into the holder while using your prying instrument to GENTLY PUSH the lower, negative(-) contact of the holder back, away from the cell. Now you may simply push the cell the rest of the way into the holder. Be certain that the side clips engage the cell fully and the battery holder end contacts make firm contact with the top and bottom of the cell. Now using the newly installed cell as a fulcrum, pry out the remaining old cell (the one you scratched or taped, as a marker), and install the other new cell in its place in the sane manner as you did for the first new cell. Be certain to properly discard the old cells — safely in the garbage. Never subject any battery to fire - they can explode violently. Also make certain that they are out of reach of children. Even spent batteries contain caustic substances.

AFTER MAKING SURE THE POWER TO YOUR APPLE IS TURNED OFF, you can put the THUNDERCLOCK PLUS PC card back in its I/O slot. You will now have to set the time to make certain that the new batteries are supplying power to the THUNDERCLOCK. It will have lost all sense of time when the batteries were being replaced.

APPENDIX C

TCPUTIL LISTING

ORG \$300

```

2 *
*****
4 *
5 * TCPUTIL: THUNDERCLOCK PLUS UTILITY SUBROUTINES
6 * LOADED AT $300
7 *
*****
9 *
0300: 00 10 CNTL DW 0 ;16-BIT COUNTER (LSB)
0301: 00 11 CNTH DW 0 ;16-BIT COUNTER (MSB)
12 *
0302: 00 13 SLOTNO DW 0 ;THUNDERCLOCK PLUS SLOT NUMBER
0303: 00 14 YSLOT DW 0 ;SLOT # IN UPPER 4 BITS
0304: 00 15 SNDFLG DW 0 ;SOUND/MUTE FLAG
16 *
0305: 00 17 ICNTL DW 0
0306: 00 18 ICNTH DW 0
19 *
*****
21 *
22 * FIND OUT WHICH SLOT THE THUNDERCLOCK PLUS
23 * IS IN. PUT THE SLOT # IN SLOTNO AND IN
24 * THE UPPER 4-BITS OF YSLOT. WE FIND IT
25 * BY LOOKING AT THE FIRST 3 BYTES OF EACH
26 * SLOT TO SEE IF THEY MATCH THE UNIQUE
27 * 3 BYTES OF THE THUNDERCLOCK FIRMWARE.
28 *
0307: A2 C7 29 GTSLOT LDX #C7 ;START LOOKING IN SLOT 7
0309: EO CO 30 GTSI CPX #CO ;IF WE REACH SLOT ZERO,
030B: FO 13 31 BEQ GTS4 ;THEN IT'S NOT THERE!
030D: 8E 17 03 32 STX GTS3+2;SETUP THE SLOT ADDRESS
0310: AO 03 33 LDY #3 ;GONNA LOOK AT 3 BYTES
34 *
0312: 88 35 GTS2 DEY
0313: 30 OB 36 BMI GTS4 ;BRANCH IF LOOKED AT 3
0315: B9 00 CO 37 GTS3 LDA $COOO,Y ;GET A BYTE FROM THE SLOT
0318: D9 2E 03 38 CMP SFDATA,Y ;DOES IT MATCH?
031B: FO F5 39 BEQ GTS2 ;BRANCH IF YES
40 *
031D: CA 41 DEX ;TRY NEXT LOWER SLOT
031E: DO E9 42 BNE GTS1
43 *
0320: 8A 44 GTS4 TXA
0321: 29 OF 45 AND #$F ;PICK OUT SLOT #
0323: 8D 02 03 46 STA SLOTNO;SAVE IN SLOTNO
0326: OA 47 ASL
0327: OA 48 ASL
0328: OA 49 ASL
0329: OA 50 ASL
032A: 8D 03 03 51 STA YSLOT ;SLOT # IN UPPER 4-BITS
032D: 60 52 RTS
53 *
032E: 08 78 28 54 SFDATA HEX 087828;IST 3 BYTES OF FIRMWARE

```

```

55 *
*****
57 *
58 * STROBE: STROBE THE 16-BIT COUNTER AND
59 * SAVE IN CNTL,CNTH. INTERRUPTS MUST BE
60 * TEMPORARILY DISABLED TO PREVENT "ROLL-
61 * OVER" DURING COUNTER READ.
62 *
0331: 08      63 STROBE  PHP           ;SAVE STATUS FLAGS
0332: 78      64         SEI           ;DISABLE INTERRUPTS
0333: AD 05 03 65         LDA ICNTL    ;STROBE THE 16-BIT COUNTER
0336: 8D 00 03 66         STA CNTL
0339: AD 06 03 67         LDA ICNTH
033C: 8D 01 03 68         STA CNTH
033F: 28      69         PLP           ;RESTORE STATUS FLAGS
0340: 60      70         RTS
71 *
*****
73 *
74 * ZERO: SET THE 16-BIT COUNTER TO ZERO.
75 *
0341: 08      76 ZERO    PHP
0342: 78      77         SEI
0343: A9 00    78         LDA #0
0345: SD 05 03 79         STA ICNTL
0348: 8D 06 03 80         STA ICNTH
034B: 28      81         PLP
034C: 60      82         RTS
83 *
*****
85 *
86 * THE INTERRUPT SERVICE ROUTINE. EXECUTED
87 * EACH TIME AN INTERRUPT OCCURS. INCREMENT
88 * THE 16-BIT COUNTER AND TOGGLE THE SPEAKER
89 * IF SNDFLG IS SET. A-REG ALREADY SAVED IN
90 * $45 BY MONITOR. WE SAVE Y-REG ON STACK.
91 * NO NEED TO SAVE X-REG SINCE WE DON'T
92 * USE IT IN THIS INTERRUPT ROUTINE.
93 *
034D: 98      94 INTEFT  TYA
034E: 48      95         PHA           ;SAVE Y ON STACK
034F: AC 03 03 96         LDY YSLOT    ;SLOT INDEX TO Y-REG
0352: B9 88 CO 97         LDA $C088,Y;CLEAR THE INTERRUPT
0355: B9 80 CO 98         LDA $C080,Y;WE JUST RECEIVED
0358: EE 05 03 99         INC ICNTL    ;INCREMENT THE 16-BIT COUNTER
035B: DO 03    100        BNE INT1    ;BRANCH IF NO CARRY
035D: EE 06 03 101        INC ICNTH    ;INCREMENT MSB COUNTER
102 *
0360: AD 04 03 103 INT1    LDA SNDFLG    ;SHOULD WE TOGGLE SPEAKER?
0363: P0 03    104        BEQ INT2    ;BRANCH IF NOT
0365: AD 30 CO 105        LDA $C030    ;TOGGLE SPEAKER
106 *
0368: 68      107 INT2    PLA
0369: A8      108         TAY           ;RESTORE SAVED Y-REG
036A: AS 45    109         LD $45        ;RESTORE SAVED A-REG
036C: 40      110         RTI           ;RETURN FROM INTERRUPT
111

```

```

*****
*
113
*
114 * IGO: STUFF INTERRUPT ROUTINE ADDRESS
115 * IN $3FE/$3FF AND TURN ON INTERRUPTS.
116
036D: A9 4D 117 IGO LDA #<INTRPT
036F: 8D FE 03 118 STA $3FE
0372: A9 03 119 LDA #>INTRPT ;PUT INTERRUPT ROUTINE
0374: SD FF 03 120 STA $3FF ;ADDRESS INTO $3FE/$3FF
0377: AC 03 03 121 LDY YSLOT
037A: A9 40 122 LDA #$40 ;INTERRUPT ENABLE BIT
037C: 99 80 C0 123 STA $C080,Y ;START INTERRUPTS
124
*
*****
126
*
127 * ENABLE: ALLOW THE PROCESSOR TO RECOGNIZE
128 * INTERRUPTS.
129
037F: 58 130 ENABLE CLI
0380: 60 131 RTS
132
*
*****
134
*
135 * ISTOP: TURN OFF INTERRUPTS
136
0381: AC 03 03 137 ISTOP LDY YSLOT ;GET SLOT INDEX
0384: A9 00 138 LDA #0
0386: 99 80 C0 139 STA $C080,Y ;CLEAR INTERRUPT ENABLE BIT
140
*
*****
142
*
143 * INHIBIT THE PROCESSOR FROM RECOGNIZING
144 * INTERRUPTS.
145
0389: 78 146 DISABL SEI
038A: 60 147 RTS
148
*
*****
150
*
151 * SOUND: SET THE SPEAKER TOGGLE FLAG
152
038B: A9 01 153 SOUND LDA #1
038D: DO 02 154 BNE MUTE0
155
*
*****
157
*
158 * MUTE: CLEAR THE SPEAKER TOGGLE FLAG
159
038F: A9 00 160 MUTE LDA #0
0391: 8D 04 03 161 MUTE0 STA SNDFLG
0394: 60 162 RTS

```

-- END ASSEMBLY --

TOTAL ERRORS: 0

149 BYTES GENERATED THIS ASSEMBLY

APPENDIX D

TROUBLE SHOOTING

Your THUNDERCLOCK is designed to give you many years of trouble free service. If you experience problems with your THUNDERCLOCK, please follow these trouble-shooting procedures in the order they are presented. Problems can often be caused by other peripherals or by the APPLE II itself. You want to be sure the problem is caused by the THUNDERCLOCK. The THUNDERCLOCK BASIC Disk that came with your THUNDERCLOCK contains a TEST program. You should first check the following list of symptoms, then use the TEST program discussed on page D-3 if the problem persists, or isn't listed below.

RAPIDLY CHANGING RANDOM TIME DISPLAY

The values of month, day-of-the-week, date, hour, minute, and seconds all appear to be randomly changing. This may mean the battery power to the clock was temporarily disconnected. If you have just replaced the batteries, this is normal. Resetting the time should correct this problem. Following the procedure for SETTING THE TIME on page 2-2. Be sure the SET/PROTECT switch on the THUNDERCLOCK is in the "SET ENABLE" position when you try to set the time.

TIME IS ALWAYS "SUN ERR 0 12:00:00 AM"

If the time string contains the word "ERR" for the day of the week, it may mean your batteries are weak or dead, or not making good contact with the battery holders. See Appendix "B" and replace the batteries if needed. If new batteries do not correct this problem, your THUNDERCLOCK should be returned for inspection. See Appendix "H".

TIME GETS CLOBBERED OCCASIONALLY

If the time base seems to get set to some other time, you may not have put the SET/PROTECT switch to the PROTECT position when you last set the time. Program bugs and crashes can clobber the clock's time base if the switch isn't in the PROTECT position. Be sure the switch is set to the PROTECT position (see page 2-2). Make sure your batteries are good and making good contact with their holders (see Appendix "B"). If the problem persists, you should return your THUNDERCLOCK for inspection (see Appendix "H")

CLOCK RUNS CONSISTENTLY TOO FAST OR TOO SLOW

Make sure you use an accurate, reliable reference for setting and checking the time. Radio network news is good, National Bureau of Standards station WWV is the ultimate, available on 2.5, 5.0, 10, 15, 20, and 25 MHZ on SHORTWAVE. If your THUNDERCLOCK gains or loses time, see Appendix "A" on CALIBRATION.

TROUBLE SENDING COMMANDS TO THE BSR/X-10 SYSTEM

If you cannot send BSR/X-10 commands, make sure the X-10 ultrasonic interface is properly attached. See the section on X-10 TRANSDUCER INSTALLATION AND CHECKOUT. When you are sending BSR/X-10 commands, and place the end of the plastic tubing near your ear, you should hear what sounds like a little insect buzzing around inside. Try attaching the end of the plastic tubing to different places on the Velcro pad on the COMMAND CONSOLE. Your COMMAND CONSOLE should be positioned as far away from your APPLE and its TV monitor as the plastic tube allows. Make sure you have the BSR/X-10 ULTRASONIC COMMAND CONSOLE model (the last 3 digits of the model number should be 301). If the little red light on your COMMAND CONSOLE flashes when you send commands, but the REMOTE MODULES don't seem to respond, be sure that the HOUSE CODE dials on your COMMAND CONSOLE AND REMOTE MODULES are all set to the same LETTER.

APPLE WILL NOT BOOT/RESET WILL NOT WORK

If your APPLE will not boot a disk, or "hangs" when you turn on the power, or <RESET> won't work, TURN OFF THE POWER. Remove the APPLE's cover and remove all the peripheral cards except the Disk II Controller card, the THUNDERCLOCK, and the Language card if your system has one. Now turn on the APPLE's power again. If your APPLE still "hangs", TURN OFF THE POWER and remove the THUNDERCLOCK. See if your APPLE works with the THUNDERCLOCK removed. If not, the problem is with your APPLE. If your APPLE operates normally without the THUNDERCLOCK, then you should return your THUNDERCLOCK for inspection (see Appendix "H"). This "hang" problem is most often caused when the THUNDERCLOCK or some other peripheral card was inserted or removed from your APPLE without TURNING OFF THE POWER!

PROGRAM CRASHES OR HANGS WHEN THUNDERCLOCK IS ACCESSED

If your program crashes (you wind up in the MONITOR, your program goes "berserk", or just "goes away" when it tries to read the time or send BSR/X-10 commands, you should run the TEST program discussed on the next page.

RUNNING THE THUNDERCLOCK TEST PROGRAM

The THUNDERCLOCK TEST program checks to see that your THUNDERCLOCK is working properly. The TEST program will report its findings to you at the end of the test. Please follow these steps:

1. TURN OFF THE POWER TO YOUR APPLE, and remove the top cover.
2. Carefully remove all the peripherals cards EXCEPT the DISK II Controller card, your THUNDERCLOCK, and the Language Card if your system has one.
3. Put the cover back on your APPLE.
4. Place your DOS 3.3 MASTER (not the THUNDERCLOCK BASIC Disk) in your BOOT drive and turn on your APPLE. Your DOS 3.3 MASTER should boot normally and leave you with the BASIC prompt.
5. Remove your DOS 3.3 MASTER and place the THUNDERCLOCK BASIC Disk in the drive and RUN the TEST program.
6. The TEST program will tell you what its doing and report its results. If it reports a problem, see Appendix "H".

APPENDIX E

RDTIME SUBROUTINE

```

*****
2   *
3   RDTIME SUBROUTINE: READ THE TIME FROM THE
4   THUNDERCLOCK WITHOUT USING THE ON-CARD
5   FIRMWARE. THE A-REGISTER SHOULD CONTAIN
6   THE SLOT # OF THE THUNDERCLOCK WHEN YOU
7   CALL RDTIME, AND UPON RETURN, THE TIME
8   WILL BE STORED IN THE LOCATIONS SHOWN
9   BELOW. THIS EXAMPLE HAS BEEN ASSEMBLED
10  AT $7000, BUT YOU COULD ASSEMBLE A COPY
11  TO BE RUN WHEREVER YOU CHOOSE.
12
*****
14  *
15  * UPD1990C REGISTER BIT DEFS
16  *
17  CREG   EQU   $C080   ;COMMAND REG ADDR
18  CLK    EQU   $2      ;CLOCK ON BIT 1
19  STB    EQU   $4      ;STROBE ON BIT 2
20  REGHLD EQU   $0      ;REGISTER HOLD
21  REGSHF EQU   $8      ;REGISTER SHIFT
22  TIMED  EQU   $18     ;TIME READ
23  *
24          ORG   $7000
25  *
*****
27  *
28  * ENTER WITH SLOT # OF THUNDERCLOCK
29  * IN A-REGISTER.
30  *
7000: 0A   31  RDTIME ASL
7001: 0A   32          ASL
7002: 0A   33          ASL
7003: 0A   34          ASL
7004: AS    35          TAY
7005: A9 18  36          LDA   #TIMRD   ;STROBE COUNTERS TO
7007: 20 1B 70 37          JSR   SETCTL   ; SHIFT REGISTER
38  *
700A: A9 08  39          LDA   #REGSHF
700C: 20 1B 70 40          JSR   SETCTL   ;SET SHIFT MODE
41  *
700F: A2 QA  42          LDX   #10     ;GOING TO GET TEN NIBBLES
43  *
7011: 20 33 70 44  GTNBL JSR   SHIFT   ;GET NIBBLE
7014: 9D 69 70 45          STA   TIME-1,X ;STORE TIME NIBBLE
7017: CA     46          DEX
7018: D0 F7  47          BNE   GTNHL   ;BRANCH IF MORE
48  *
701A: 60     49          RTS
50  *

```

```

*****
52 *
53 * SETCTL-STROBE COMMMAND IN A-REG
54 * INTO THE UPD1990. HOLD STROBE
55 * HIGH FOR 40US MINIMUM.
56 *
701B: 99 80 C0 57 SETCTL STA CREG,Y ;SETUP CTL BITS
701E: 09 04 58 ORA # STB ;"OR" IN STROBE
7020: 99 80 C0 59 STA GREG ,Y ;RAISE STROBE
7023: 20 2B 70 60 JSR STEBLY ;DELAY >40US
7026: 49 04 61 EOR #STB ;CLR STROBE BIT
7028: 99 80 C0 62 STA CREG,Y ;DROP STROBE
63 *
702B: 20 2E 70 64 STBDLY JSR STBDL1
702E: 48 65 STBOL1 PHA
702F: 48 66 PHA
7030: 68 67 PLA
7031: 68 68 PLA ;KILL SOME TIME
7032: 60 69 RTS
70 *
*****
72 *
73 * SHIFT - SHIFT DATA IN & OUT.
74 * ENTER WITH DATA TO BE SHIFTED IN
75 * IN LOW 4 BITS OF A-REG.
76 * DATA SHIFTED OUT RETURNED
77 * IN LOW 4 BITS OF A-REG.
78 *
7033: 48 79 SHIFT PHA ;SAVE DATA-IN NIBBLE
7034: A9 04 80 LDA #4
7036: 8D 68 70 81 STA TEMP 1 ;4 BITS/NIBBLE
7039: A9 00 82 LDA #0
703B: 8D 69 70 83 STA TEMP 2 ;CLR DATA-OUT BYTE
84 *
703E: B9 80 C0 85 SHLOOP LDA CREG,Y ;GET DATA-OUT BIT
7041: 0A 86 ASL ;DATA-OUT BIT TO CARRY
7042: 6E 69 70 87 ROR TEMP2 ;COMBINE
7045: 68 88 PLA
7046: 48 89 PHA ;GET & RESAVE DATA-IN
7047: 29 01 90 AND #1 ;BIT 0 ONLY
7049: 99 80 C0 91 STA CREG,Y ;OUTPUT DATA
704C: 09 02 92 ORA #CLK
704E: 99 80 C0 93 STA CREG,Y ;RAISE CLOCK
7051: 49 02 94 EOR #CLK
7053: 99 80 C0 95 STA CREG,Y ;DROP CLOCK
7056: 68 96 PLA
7057: 6A 97 ROR ;SHIFT DATA-IN NEXT BIT
7058: 48 98 PHA ;SAVE
7059: CE 68 70 99 DEC TEMP1 ;DONE 4 BITS?
705C: DO EO 100 BNE SHLOOP ;BRANCH IF NOT
101 *
705E: 68 102 PLA ;ADJUST STACK
705F: AD 69 70 103 LDA TEMP2 ;GET DATA-OUT NIBBLE

```



```

7062: 18      104      CLC
7063: 6A      105  ROR4   ROR
7064: 6A      106      ROR
7065: 6A      107      ROR
7066: 6A      108      ROR      ;RIGHT JUSTIFY IN BYTE
7067: 60      109      RTS
          110
7068: 00      111  TEMP1  DW      0
7069: 00      112  TEMP2  DW      0
          113  *
          *****
          115  *
          116  * UPON RETURN FROM THE SUBROUTINE
          117  * CALL TO RDTIME, THE TIME WILL BE
          118  * STORED IN THE LOCATIONS BELOW.
          119  *
          120  TIME    EQU
          121  *
706A: 00      122  MONTH  DW      0      ;MONTH (1-12 BINARY)
7063: 00      123  DOW     DW      0      ;DAY-OF-WEEK (0-6 BCD)
          124  *
706C: 00      125  DATEMS  DW      0      ;DATE TENS (0-3 BCD)
706D: 00      126  DATELS  DW      0      ;DATE UNITS (0-9 BCD)
          127  *
706E: 00      128  HRMS   DW      0      ;HOUR TENS (0-2 BCD)
706F: 00      129  HRLS   DW      0      ;HOUR UNITS (0-9 BCD)
          130  *
7070: 00      131  MINMS  DW      0      ;MINUTE TENS (0-5 BCD)
7071: 00      132  MINLS  DW      0      ;MINUTE UNITS (0-9 BCD)
          133  *
7072: 00      134  SECMS  DW      0      ;SECOND TENS (0-5 BCD)
7073: 00      135  SECLS  DW      0      ;SECOND UNITS (0-9 BCD)
          136  *

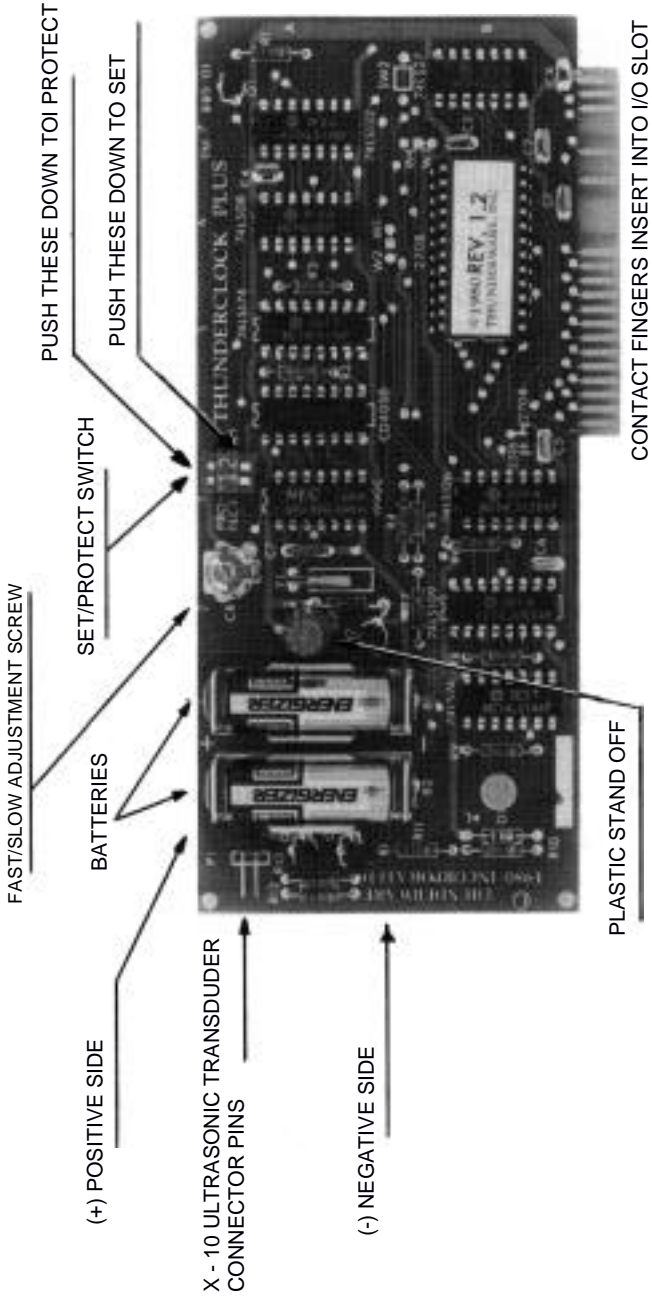
```

--- END ASSEMBLY ---

TOTAL ERRORS: 0

116 BYTES GENERATED THIS ASSEMBLY

APPENDIX F THUNDERCLOCK PLUS PC CARD DIAGRAM



APPENDIX G

THUNDERCLOCK PLUS TECHNICAL SPECIFICATIONS

- * Real-time clock/calendar with optional BSR/X-10 ultrasonic transducer interface. Provides month, date, day-of-week, hour, minute, and seconds. Three software-selectable interrupt rates: 64, 256, or 2048 interrupts/second. Resides in any APPLE II slot 1 through 7.
- * Printed circuit board: FR4 glass epoxy, solder masked on both sides, silk screened legend. Board dimensions: 2.75 x 6.30 inches (excluding contact fingers). Gold plated edge connectors: 30 micro-inch 99% gold over 75 micro-inch low-stress nickel.
- * Environmental operating range: 0 to 55 degrees Centigrade, 0 to 90% humidity (non-condensing).
- * Power consumption: 0.65 watts typical.
- * Clock/calendar set enable/disable switch assures time-base integrity.
- * On-card 1,024 byte EPROM contains all firmware for easy reading and setting of clock/calendar, interrupt selection, and transmission of BSR/X-10 ultrasonic commands.
- * On-card batteries keep clock/calendar running when AC power is off. Uses 2 readily available 1.5V alkaline "N" cells. Battery current consumption typically less than 10 micro-amps. Typical battery life of 3 to 4 years.
- * Calibrated quartz crystal controlled time-base with typical accuracy of +0.001%.
- * Certified to comply with the limits for a Class B computing device pursuant to Subpart J of Part 15 of the Federal Communications Commission Rules. FCC ID: BR5SZ2THDRCLKPLS.

APPENDIX H RETURNING YOUR THUNDERCLOCK FOR REPAIR

If it is necessary to return your THUNDERCLOCK PLUS for repair, please follow these procedures. They will assure that you get the fastest possible service. You must include proof of date purchased. Units returned without proof of date of purchase or out of warranty units will be repaired or replaced (at Thunderware's option) and the customer will be charged for parts, labor, and handling.

1. Call Thunderware's Customer Support number (415)-652-1737, and get a Return Material Authorization number (RMA number).
2. If possible, pack the THUNDERCLOCK PLUS in its original pink plastic shipping bag and box.
3. If you don't have the original box, pack the THUNDERCLOCK in a sturdy corrugated box and cushion it with NON-STATIC material such as newsprint. DO NOT USE highly static or conductive materials such as plastic or styrofoam, or any type of metallic material. They will damage your THUNDERCLOCK in transit. Damage resulting from improper return packaging will not be covered under warranty.
4. Be sure to enclose the following with your THUNDERCLOCK:

NAME
ADDRESS
CITY, STATE, ZIP
TELEPHONE NUMBER
RETURN MATERIAL AUTHORIZATION NUMBER (RMA)
PROOF OF DATE OF PURCHASE
A SHORT PROBLEM DESCRIPTION

5. All units returned to Thunderware for service should be shipped UPS or U.S. Mail prepaid. Thunderware recommends UPS as preferred method of shipment. Units should be insured when they are shipped. Thunderware will not accept units that have been shipped C.O.D.
6. Ship the package to the appropriate address below, depending on method of shipment. Be sure to write your RMA number on the outside of the box below the address:

SHIPMENTS VIA U.S. MAIL

Thunderware, Inc.
Customer Service
21 Orinda Way
Orinda, CA 94563
RMA#

Thunderware, Inc.
Customer Service
P.O. Box 1299
Orinda, CA 94563
RMA#

APPENDIX I

FCC-SUPPLIED INFORMATION FOR USERS

The Federal Communications Commission has established technical standards regarding radiation or radio frequency energy by computing devices. The THUNDERCLOCK PLUS falls under the rules of a Class B computing device and the following information must be supplied to the user in accordance with paragraph 15.838 of the FCC standard Part 15, Subpart J.

The equipment described in this manual generates and uses radio frequency energy. If it is not installed and used properly, that is, in strict accordance with our instructions, it may cause interference to radio and television reception.

This equipment has been tested and complies with the limits for a Class B computing device in accordance with the specifications in Subpart J of Part 15 of FCC rules. These rules are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that the interference will not occur in a particular installation.

You can determine whether your computer is causing interference by turning it off. If the interference stops, it was probably caused by the computer. If your computer does cause interference to radio or television reception, you can try to correct the interference by using one or more of the following measures:

- * Turn the TV or radio antenna until the interference stops.
- * Move the computer to one side or the other of the TV or radio.
- * Move the computer farther away from the TV or radio.
- * Plug the computer into an outlet that is on a different circuit from the TV or radio. (That is, make certain the computer and the TV or radio are on circuits controlled by different circuit breakers or fuses.)

If necessary, you should consult your dealer or an experienced radio/television technician for additional suggestions. You may find the following booklet prepared by the Federal Communications Commission helpful : "[How to Identify and Resolve Radio-TV Interference Problems.](#)"

The booklet is available from the U.S. Government Printing Office, Washington, DC 20402, Stock number 004-000-00345-4.

APPENDIX J

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THUNDERCLOCK PLUS QUIK-REFERENCE SUMMARY

WRITING THESE "READ MODE" CONTROL CHARACTERS RESULTS IN THE TIME BEING RETURNED IN THE FOLLOWING FORMATS:

```
"%" TUE MAY 12 4:32:55 PM (APPLESOFT AM/PM FORMAT)
">" TUE MAY 12 4:32:55 PM (INTEGER AM/PM FORMAT)
"&" TUE MAY 12 16:32:55 (APPLESOFT 24-HOUR FORMAT)
"<" TUE MAY 12 16:32:55 (INTEGER 24-HOUR FORMAT)
" " 05/12 16:32:55.000 (APPLESOFT/INTEGER M. H. FORMAT)
"# " RETURNS INTEGER VALUES OF TIME/DATE
```

BSR/X-10 COMMAND CHARACTERS:

BUTTON	CHARACTER	BUTTON	CHARACTER
1	A	12	L
2	B	13	M
3	C	14	N
4	D	15	O
5	E	16	P
6	F	ON	Q
7	G	OFF	R
8	H	BRIGHT	S
9	I	DIM	T
10	J	ALL LITES ON	U
11	K	ALL OFF	V

WRITING THE CHARACTER "*" ALERTS THE THUNDERCLOCK PLUS TO INTERPRET THE FOLLOWING CHARACTERS AS "DURATION CODES" FOR ANT FOLLOWING BSR/X-10 COMMANDS:

CHARACTER	DURATION(SEC)	CHARACTER	DURATION(SEC)
A	0.10	N	2.81
B	0.31	O	3.02
C	0.52	P	3.22
D	0.73	Q	3.43
E	0.94	R	3.64
F	1.14	S	3.85
G	1.35	T	4.06
H	1.56	U	4.26
I	1.77	V	4.47
J	1.98	W	4.68
K	2.18	X	4.89
L	2.39	Y	5.10
M	2.60	Z	5.30