

# THUNDER USER'S GUIDE

by

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<u>Rev</u>	<u>Date</u>	<u>For use with software version</u>
0	02/09/90	002090
1	02/20/90	002200
2	04/01/90	003232
3	05/28/90	005280 and higher

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# INTRODUCTION

Designed by synthesizer pioneer Don Buchla, THUNDER is a high-performance controller for interfacing with MIDI-equipped instrumentation. Rather than emulate the input structure of an existing acoustic instrument, THUNDER offers alternative strategies for sensing and responding to musical gesture.

THUNDER is played with the hands. Based on sealed membrane technology, its playing surface consists of an array of keys organized to complement the shape of the human hand. THUNDER's keys can sense multi-dimensional aspects of touch (velocity, location, and pressure) and can be individually programmed to produce a variety of musical responses.

To facilitate editing, THUNDER is equipped with a large backlit character display, software-labeled edit keys, and controls specifically dedicated to data entry. A sophisticated operating language provides the user with the capability of specifying complex and expressive relationships between input gesture and musical response. Instrument setups can be stored internally or on plug-in memory cards.

In addition to configuring itself, THUNDER can direct other equipment to follow suit. Multiple MIDI program change messages can be routed to any combination of MIDI channels and instruments. System exclusive messages can be captured by THUNDER, stored on memory cards, and transmitted on command.

Additional MIDI features implemented by THUNDER include full precision pitch bending, scalable velocity, polyphonic pressure (aftertouch), and release velocity. THUNDER can address all MIDI controller types, and transmits MIDI auxiliary messages (system reset, active sensing, and channelized all notes off).

THUNDER's features includes key-triggered effects with seemingly endless possibilities. Completely user definable, THUNDER's effects can create a flurry of gesture-controlled multiple echoes combined with transpositions, fades and conditional branches.

With the Riff function, THUNDER can remember and recall phrases in real time, in altered tempi, transposed, fading in and out, or exactly as played.

THUNDER is housed in a cast aluminum cabinet designed to withstand less than ideal environments. Compact and light weight, it can be played on a tabletop, or can be supported by standard instrument mounting hardware. Its circuitry is entirely CMOS, resulting in low power consumption and excellent reliability.

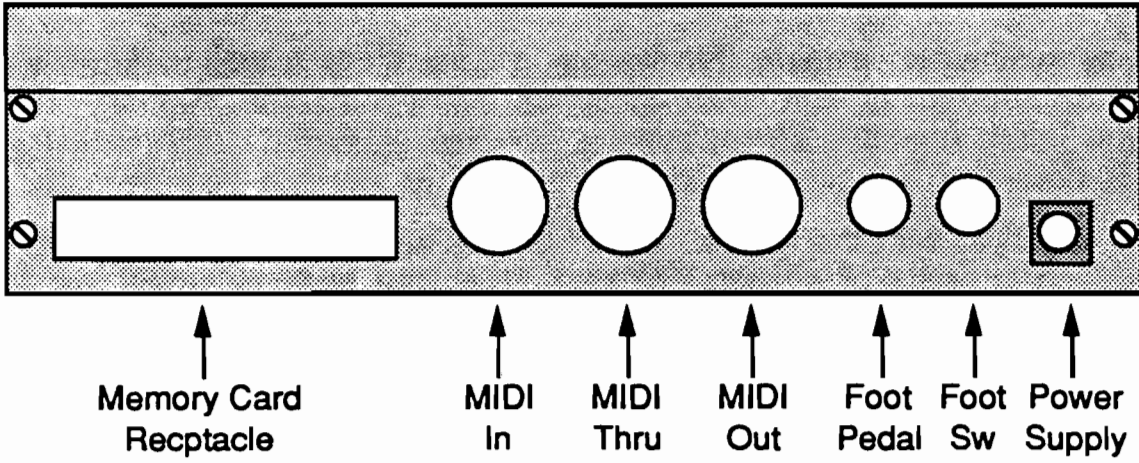


Figure 1

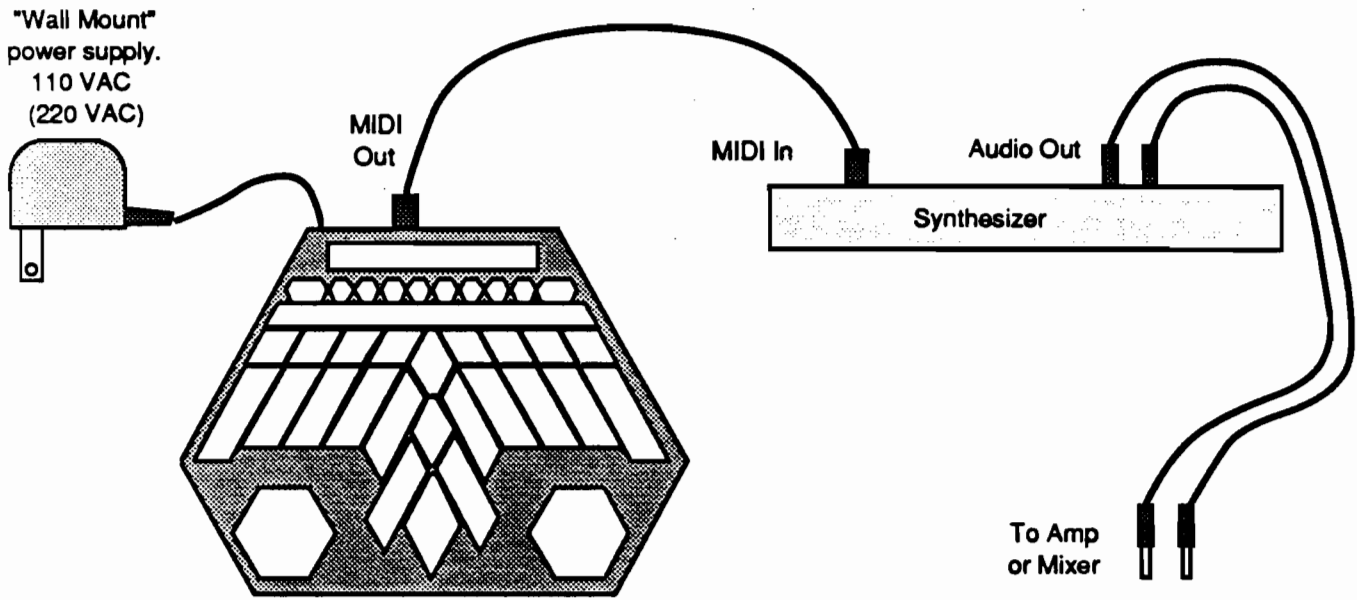


Figure 2

# HOOK UP

Before using THUNDER, please read all instructions, and kindly respect the following safety guidelines:

**Do not use THUNDER near water; do not take THUNDER into your bath, sauna or hot tub. Take care not to spill liquids into THUNDER.**

**Locate THUNDER away from heat sources such as radiators, fireplaces, stoves or solar cookers.**

**Exercise close supervision when using THUNDER near children.**

**THUNDER's power supply is for indoor use only. Do not use a damaged or alternate supply.**

**Refer all servicing to qualified personnel. There are no user servicable parts or adjustments inside THUNDER.**

Setting up THUNDER for basic use requires only the connection of MIDI out and power. The rear panel is diagrammed on THUNDER's bottom plate, and appears on the LCD display when you press ENTER from the main menu. Figure 1 depicts the rear panel .

THUNDER requires 9V DC power at 500 ma, using a standard barrel plug with the inner conductor positive. A power supply for 110 VAC or 220 VAC is provided with THUNDER.

Connect the MIDI output to the synthesizer's MIDI input, and the synth to an sound system and THUNDER is ready to go.

MIDI In is used for loading system exclusive messages into THUNDER and MIDI Through allows this incoming information to be "daisy chained" to other MIDI devices. The MIDI Through port can alternatively transmit WIMP (Wideband Interface for Musical Performance).

The Foot pedal accepts an analog control voltage (0-10v) on the tip of a mono phone plug.

The Foot switch accepts a normally open momentary switch or an array of three paralleled switches wired as diagrammed in appendix A.

The Memory card Receptacle accepts RAM or ROM cards that conform to the THUNDER standard. Do not attempt to use other cards.

THUNDER can be mounted using readily available hardware. Four screw holes in the bottom accept an adapter that will mount on 1.25" diameter tubular stands. Tripods are available from Buchla and Associates; additional auxiliary hardware is available from Ultimate Support Systems dealers.

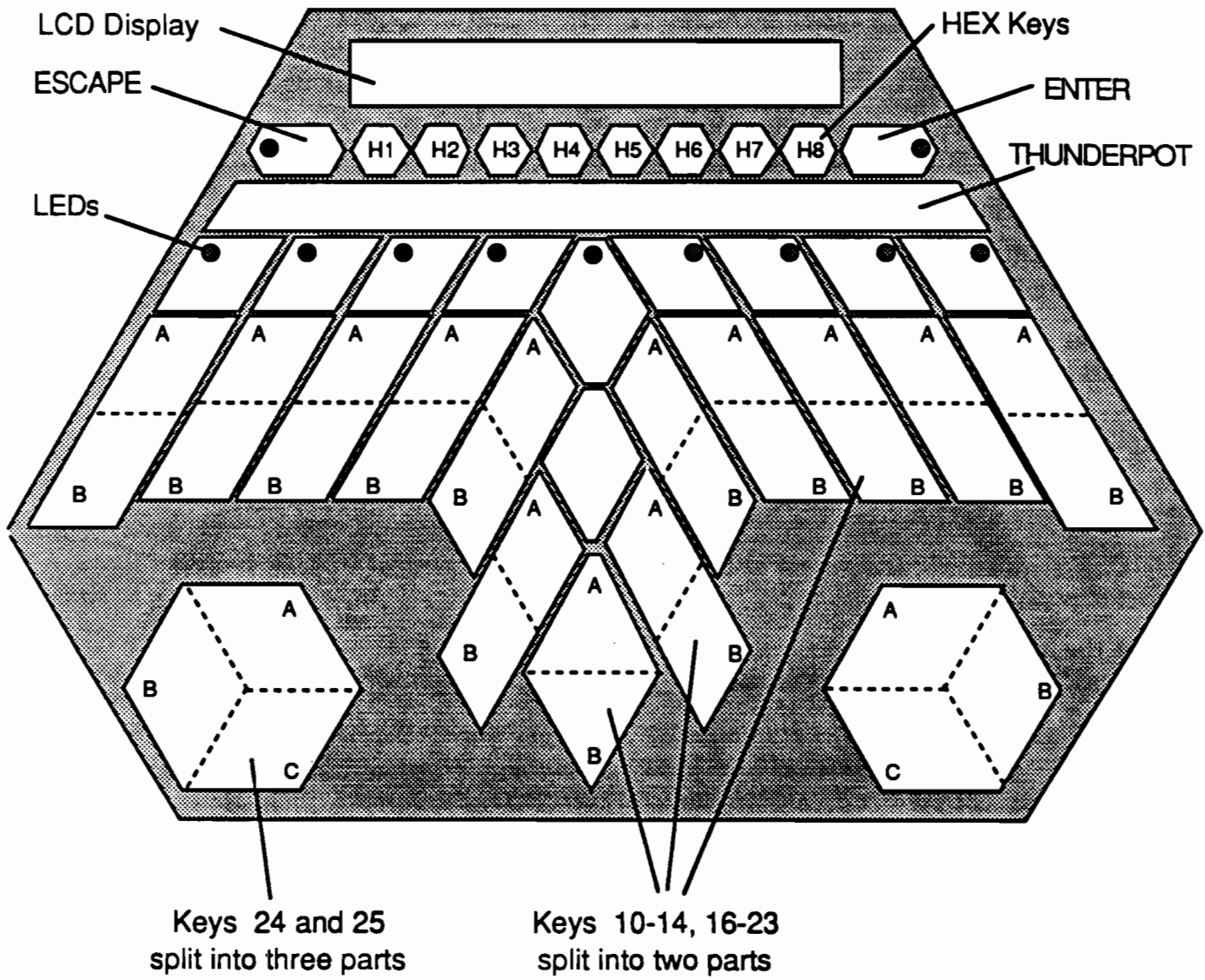


Figure 3

# GENERAL

THUNDER's top ten keys are specifically dedicated to editing. Conventions apply to selection of menu items and entry of data. Menus are arranged in a logical tree-like manner. (Appendix B is a condensed diagram of THUNDER's menu and display structure.) Once familiar with the where and the how, THUNDER's flexibility is easily accessed.

## DESCRIPTION OF THE USER INTERFACE

Below is a brief description of THUNDER's keys and displays.

**HEX KEYS** Menu items are selected with the eight hexagon shaped keys that are located immediately under the display (fig 3). Shortly after applying power, THUNDER's main menu appears, which consists of labels for the hex keys:

Cnfg	Riff	Efct	Key	File	Sett	Prog	Card
Slct	Edit	Edit	Edit	Xfer	ings	Chng	Chng

Touching a hex key below a menu item will select that item, which (in most cases) will cause a sub-menu to appear. From these sub-menus, most hex keys will select data fields for editing; some will select additional menus.

**ENTER** Displayed data is entered into THUNDER's memory with the ENTER key. The LED (light emitting diode) in this key will be lit if its activation might result in a change. Occasionally, the (unlit) ENTER key is used to select a second page in a display.

**ESCAPE** The ESCAPE key serves two functions. When in the middle of a data entry procedure, touching ESCAPE aborts the process, resulting in no change to THUNDER's memory and restoring the former display. Otherwise, ESCAPE retrieves the next higher menu. When in the Main Menu, its LED is extinguished, and its activation does nothing.

**THUNDERPOT** Data values are set with THUNDERPOT. Sliding your finger to the right increases values to be entered, sliding to the left decreases values. The extreme ends can be used to rapidly change values. THUNDERPOT can also serve as a MIDI controller.

**PERFORMANCE KEYS** Keys numbered 1 thru 25 are used to play the instrument; in one case they also function to select keys for editing.

**LCD DISPLAY** THUNDER employs a 2 line by 40 character LCD display to advise you of its innermost feelings. Its contrast and lighting can be adjusted for optimal viewing.

**LEDs** Built into keys 1-9 are light emitting diodes (LEDs) that can be programmed to indicate various states or actions.

## SYNTHESIZER SELECTION

The nature of the synthesizer used with THUNDER will influence how you program THUNDER and will affect the range and nature of the sounds and effects you will be able to achieve. Synthesizers differ in their features and capabilities. Here are some things to consider when selecting a synthesizer.

**MULTI-TIMBRAL** One powerful aspect of THUNDER is its ability to assign different sounds to various keys or zones on its playing surface. To realize this capability, a multi-timbral synthesizer is necessary - that is, one in which each MIDI channel can be assigned a unique sound.

**MIDI MODE** MIDI mode determines how the voices of a synth are mapped to the various MIDI channels. There are three combinations in common use:

**MODE 1 OMNI ON, POLY** The synth responds to all note information on all channels. This provides a useful method of ascertaining that THUNDER and the receiving synth are properly connected as the synth will probably make sound no matter how the MIDI channels are assigned. All sounds will be the same, as MODE 1 does not support Multi-timbral information.

**MODE 3 OMNI OFF, POLY** This is similar to mode 1 in that it is not multi-timbral; however the synth will only respond to note information on one selected MIDI channel. Since THUNDER can output a considerable variety of musical information on a single channel, synths that operate in this mode can be very useful. By daisy-chaining poly mode synths with other synths using MIDI In's and Thru's you can effectively achieve a multi-timbral system. (Yamaha DX 7, TX 7, Roland Juno 106)

**MODE 4 OMNI OFF, MONO** This is the most powerful configuration for a MIDI synth, allowing it to receive on many MIDI channels simultaneously. Mono mode synths are generally multi-timbral but not always. A multi-timbral mono mode synth behaves like many independent synths in one box. Also many mono synths offer a legato mode that THUNDER can effectively utilize. This works when only one note is assigned to a MIDI channel and the note-on command for the next note is sent before the note-off command of the previous note. The result is a change in pitch without a re-triggering of the envelope, or a legato type slur. Many synthesizers have an extension to Mono mode called Multi. This allows many polyphonic channels instead of many monophonic channels.

**NUMBER OF VOICES** The more the better. Since THUNDER can produce multiple events at the touch of a key, the number of voices is an important consideration. While an eight voice synth will be perfectly adequate, THUNDER will make good use of 12, 16, or even 32 voices.

**DYNAMIC VOICE ASSIGNMENT** Some synths, especially those designed to be the recipients of sequencer data, incorporate a dynamic voice assignment scheme, (Ensoniq ESQ, VFX, Kurzweil, and Emu Proteus). These synths operate on a scheme of thievery in which the user does not have to specify how many voices will be assigned to each channel. Based upon the order and quantity of notes received via MIDI they dynamically allocate voices to meet the need, stealing the "oldest" voices to be used for the most recent commands, and effectively getting a lot more mileage from each voice. Other things being equal, we would certainly recommend this feature.

**CONTINUOUS CONTROLLERS** With MIDI systems, continuous controllers provide the means to implement expressive control of various acoustic parameters. They can affect the pitch, volume, placement, and various timbral aspects of a MIDI voice. THUNDER allows you to send multiple continuous controllers from each pad; to take advantage of this power it is necessary that a synth be able to respond to them. Virtually all synths can respond to pitch bend and to modulation (controller #1). Other synths will also respond to aftertouch (polyphonic or channel pressure), breath (controller #2), volume (controller #7), etc. These controllers need to be defined at both the transmitting (THUNDER) end and the receiving (synth) end of the MIDI cable. In general, the more continuous controllers that a synth will meaningfully respond to simultaneously, the more intimate the feel it can have when being played.

**SYSTEM EXCLUSIVE** MIDI devices use system exclusive (Sysex) messages to communicate non-real-time information about current status or programs. THUNDER uses Sysex commands to communicate to other devices either configurations of THUNDER or presets of the synth. THUNDER can store a program dump of the setups for a given synth on a memory card. This is very useful for maintaining THUNDER setups along with the synth voices and setups they are designed to control. Most modern synthesizers respond to and transmit Sysex messages. We recommend selecting a synth with Sysex fully implemented.

# KEY EDITING

Key Edit is where the responses of THUNDER's performance keys (1-25) are defined. THUNDER starts life in silent bliss - touching a key results in continued silence until said key has been properly instructed. While this circumstance may seem unusual, this capability of individually programming each and every key provides THUNDER with considerable flexibility and generality.

A common function for a key is to initiate a note on one or more MIDI channels whenever it is touched.

Alternatively, a key might be programmed to simply transpose the note values (pitches) that other keys transmit when touched.

A key could be defined so that its activation elicited an EFFECT that could cause subsequent key closures to initiate a note at a given pitch, wait half a second; turn on a note a fifth higher; wait a tenth of a second; and sound yet another note with a random pitch and subdued amplitude. This peculiar effect could be programmed to happen twice, thirty seven times or for however long the calling key was touched. See section on Effects for more information.

Still other keys could be defined so that an increase of pressure on the key compresses the time values in the above example.

LEDs are located in Keys 1-9. These can be controlled from any performance keys and are useful for indicating the status of keys, effects, and transpositions .

Keys 10 -14 and 16-23 can be split into two sections and keys 24 and 25 into three sections, each functioning as an independent key with its own set of definable parameters.

Each of THUNDER's keys is sensitive to impact (how hard it is struck), pressure (how firmly it is being pressed), and, for those keys marked on the bottom with abstract green feathers, location (where along its length it is being touched). This information can be output to MIDI continuous controllers and can also be used to control various internal aspects of THUNDER's operation.

The optimal technique for playing THUNDER deserves mention here: THUNDER's keys respond to the area of contact, and are most effectively played with the hand positioned low and flat, so as to establish contact with the balls of the fingers, rather than tips and nails. Sensitivity is very high - your slightest touch will be detected; modest pressure will achieve full scale response. Practice developing a gentle technique that utilizes THUNDER's full dynamic range, and for you stick players, save 'em for the skins.

## PROGRAMMING THE KEYS

From the Main Menu touch hex key 4 under Key Asgn in the display. The display will now show the Key Edit Menu:

Key	Ch/m	Num/f	Trn/f	E/I	Vel	Ptch	Ctrlr
1	01	042	+02	1 *	Impt	Loc	*

To select the key to program touch hex key 1. The word Key in the display will change to all upper case (KEY). Then touch the actual key you wish to program. To program a feathered key, which may have split sections, touch the portion of the key that corresponds to the section to be programmed. Refer to figure 3.

## CHANNEL SELECTION

To enter the MIDI channel menu touch the hex key that resides under the label "Ch/m" (Ch = MIDI Channel/ m= mode). The following menu will appear:

Key	Ch/m	1
1		

To set the MIDI channel(s) that the selected key will transmit on, use hex key 2 to select "Ch/m". This field will be highlighted by changing to uppercase characters ("CH/M"), and the enter LED will ignite, indicating THUNDER's readiness to accept data. Use THUNDERPOT to set the desired channel numbers, followed by ENTER to enter the data into THUNDER's memory. The same procedure will remove already selected channels.

If only one channel is selected its number will appear under the word Ch/m in the key edit display. If more than one channel is assigned to this key an asterisk will be displayed. Note that if no channel is assigned to a key, that key will produce no response.

## MODE

The same field (Ch/m) also displays the operating mode for the selected key. Use the same hex key (2) to toggle through the four possible modes, and when the desired mode appears, touch ENTER to store it. Keys may operate with the following modes:

- (blank) (No character displayed) This is the normal mode, in which a key behaves much like a momentary switch. Any assigned actions will be asserted while it is being touched and will stop when it is released. If a key is programmed to transmit MIDI note information (see Num/f below) a note will sound while the key is activated and will stop when it is released.
- C & R (Closure and Release) Keys programmed with the closure only mode (C) will initiate programmed actions when touched. Releasing such keys will have no effect. To terminate actions initiated by keys operating in this mode requires a release by another key, which must address the same action(s) and channel(s), and in the case of notes, must address the same note number. By way of illustration, consider two keys programmed to address the same MIDI note number (G#4, for instance), with one operating in the closure only mode (C) and the other in the release only mode (R). Playing the (C) key will transmit a note on command, causing a G# to sound, and activation of the (R) key will terminate the note with a note off command.
- T (Toggled) Applies only to keys 10 - 25. Activation of keys operating in this mode (T) will result in alternate closures and releases. If a toggled key is assigned to transmit MIDI note information, a note will sound when the key is first activated and will continue to sound until the key is touched again.
- L (LED Tracking) Keys 1 -9 contain light emitting diodes (LEDs) that can serve as status indicators. Keys operating in this mode track the LED status; when the LED is on, the key is on. See section entitled "LED Programming".

## KEY SPLITS

Keys 10-14 and 16-23 can be divided into two sections and Keys 24 and 25 into three, with each section functioning as an independent key with unique definable parameters.

To split a key touch hex key 1 under the word Key in the key assignment menu, select the key to be split by touching it, and then touch hex key 1 two more times. The letter "A" will appear next to the key number to indicate that the key has been split. To unsplit a key select the A section of the desired key and again touch hex key 1 twice.

Note that split keys do not respond to location.

## PITCH ASSIGNMENT

To program a key to initiate a note, touch the hex key in the key assignment display under the word Num/f (Num= MIDI note number; f= flag). The label will become capitalized. Now use THUNDERPOT followed by ENTER to enter the MIDI note number.

If you are unfamiliar with MIDI note numbers or prefer conventional sharp/flat notation, repeated activation of hex key 3 will implement appropriate displays. Lettered notes are followed by the selected accidental sign followed by the octave number. Middle C (MIDI note number 60) would thus appear as "C 4", and the note one semitone above middle C could be alternatively displayed as "61", "C#4", or "Db4".

## TRANSPOSITION

A specialized memory, called a transposition register, is associated with each channel. These registers can be set or modified by data contained in the "Trn/f" field; register contents will transpose all notes originating on the associated channels. Register data represents a displacement of MIDI key numbers, which for standard 12 tone tuning, is reflected as a number of semi tones (5= 4th, 7= 5th, 12= octave etc.). An exception to this representation occurs when THUNDER's "note filter", described subsequently, is engaged.

Enter a transposition by first selecting "Trn/f" with hex key 4. Repeated activation changes the direction and nature of the transposition to be applied; the amount of transposition is dialed in with THUNDERPOT. The first character of the transposition data field signifies the type and direction:

- + The transposition amount is in a plus (sharp) direction (+12 would shift all notes on the selected MIDI channel up an octave).
- The transposition amount is in a minus (flat) direction (-07 would shift all notes on the selected MIDI channel down a fifth).
- A The transposition register is modified by adding the datum to its contents each time the key is activated. (A02 would shift notes on the selected MIDI channel(s) up a major 2nd for each key closure.) An A00 has no effect; when entered, the field is blanked.
- S The transposition register is modified by subtracting the datum for each key activation. (S03 would shift all notes on the selected MIDI channel(s) down a minor 3rd each time the key is touched.)
- R The transposition amount is random, with the datum specifying the number of states of randomness allowed. (R05 would randomly shift all notes on the selected MIDI Channel(s) within a 5 note range centered on the original non-transposed pitch.)

## CONDITIONAL TRANSPOSITION

By using "flags" associated with the transposition registers, transpositions called by one key can be made to depend on the execution order of other keys.

There are three flags for each of the transposition registers, called "X", "Y", and "Z". If one of these flags appears as part of the "Trn/f" field, the transposition data contained in that field will be used only if the flag is set. (If no flag is entered, then the transposition data is always applied.)

To enter flag data into the "Trn/f" field, first select the field with hex key 4; toggle the flag types with hex key 5; and enter the desired type with Enter. Flags are set by activation of keys programmed to do so. To instruct a key to set a flag when activated, use hex key 3 to select the "Num/f" field; then use hex key 4 to toggle the three flag types. Again, enter the flag data with ENTER.

Those flags not addressed by a key are cleared by that key's activation. Note that only those flags associated with the channel(s) that the key is addressing are set and/or cleared. Note also that if paralleled keys (A & B) address the same MIDI channel, the results get complicated. (Might be useful to know that "A" keys are executed before "B".)

These conditional transpositions are quite useful in their musical context, but the logic may be tricky to comprehend. An example will hopefully shed some light:

To make the transposition of Key 1 conditional on Key 2 first set up a transposition on Key 1. (Make sure both Key 1 and Key 2 are on the same MIDI channel as transpositions only affect notes on the same channel).

For Key 1, touch hex key 3 from the key assignment menu to capitalize the word NUM and give this Key a pitch of 60; touch ENTER. Select Trn/f by touching hex key 4. Enter a value such as A05. Then touch hex key 5. When the word TRN is capitalized hex key 5 will select which of the flag registers will gate the transposition. Repeated touching of hex key 5 will move among X, Y, Z, or none. Select X and touch ENTER.

Now select Key 2. Touch hex key 3 to capitalize the word NUM. Use hex key 4 to choose which flag will be set by Key 2. Select X and touch ENTER. Key 2 need not have a pitch.

Playing Key 1 will elicit a note with a pitch of pitch of 60. Repeated playing will sound the same pitch. Touch Key 2, play Key 1. Each touch of Key 1 will now transpose the pitch of Key 1 by 5 semitones.

A third key with no flags assigned to its Num value would clear the flags on that MIDI channel and inhibit further transposition by key.

## EFFECTS

Effects can be called from the THUNDER Keys by touching hex key 5 in the Key Assignment menu under the word E/l (E= Effect/ l= LED) and selecting 1 of the 8 Effect groups using THUNDERPOT followed by ENTER.

When the Key is touched the assigned effect will be asserted (See the section on Effects for a thorough description).

Remember that a key's operating mode (selected from Ch/m in the Key Assignment menu) will determine how the effect is asserted. T will toggle the effect off and on with repeated touches, C will initiate the effect when the key is touched and it will take another key on the same MIDI channel with R selected in the mode field and the same effect (or effect 0) chosen in the effect field to turn the effect off. For a key operating in the normal mode (blank mode field), the effect is asserted only while the key is touched. And effects called by keys that track LED's (L mode) are engaged while the LED's are on.

## LED PROGRAMMING

The LEDs located within hex keys 1-9 can be programmed to react to key closures. This can be extremely handy for keeping track of what effects or transpositions are currently active, especially if the the keys that call the effects possess LEDs.

Touching hex key 5 twice under the label "E/l" will bring up the following menu:

Key	1	2	3	4	5	6	7	8	9
01	On	Off	Tgl						

The key number displayed to the left is the key that we are programming to command one or more LED's to change state. These commands are displayed under the numbers 1 - 9, corresponding to the LED's located in keys 1 - 9. To alter these commands, touch the key associated with the LED in question.

The options are:

- Tgl Toggle. The LED will change its state every time the calling key is touched.
- On The LED will be turned on with the touch of the calling key.
- Off The LED will be turned off with the touch of the calling key.
- none The calling key has no affect on the LED.

Note that a key can affect more than one LED. This can be useful to turn the LED array into a "last is on" display so that touching of a key will extinguish the other LEDs while lighting its own. To accomplish this, set each of the keys 1-9 to have the key toggle its own LED and turn off the other 8 as in the following menu for key 1:

Key	1	2	3	4	5	6	7	8	9
1	Tgl	Off	Off	Off	Off	Off	Off	Off	Off

Repeat for the eight other keys, having each key Tgl itself and turning all other keys Off. Now when one of the keys 1-9 are touched it will light its own LED and extinguish all the others. If there are specific transpositions assigned to each of these 9 keys, the status of the transpositions can be easily monitored. Similarly for effects.

## VELOCITY

MIDI velocity is sent every time a note is turned on. The source for this value can be selected by touching hex key 6 under the word Vel.

The default controller for velocity is Impact, which refers to the speed with which a key is touched. Repeated touching of the hex key will scroll through the other options.

Location will transmit a velocity value that is determined by the striking point of the finger on the key. This value increases as you move your finger higher on the key.

A fixed value can be sent whenever the key is touched. The default value is 000 which appears as one of the options. When 000 appears the desired value can be altered with THUNDERPOT and stored with the Enter key.

Velocity values can be inverted for specific channels. When inverted values are enabled a down pointing arrow will appear next to the word Vel. See the section on Settings to find out how to reverse channels.

## PITCH BEND

Pitch bend values are sent continuously from active keys, except when assigned to impact or specified as a fixed value, in which case a new value is transmitted only when a key is struck. The location options apply only to those keys that respond to location: keys 10 - 14 and 16 - 23. Keep in mind that split keys do not respond to location.

The options are:

- Loc      Raw location information is sent to the pitch bender. The value is based on where the key is touched so unless you hit it right in the middle the key will not have an unbent beginning. Sliding up is positive bend, down is negative bend. (unless bend is reversed)
- Loc  $\Delta$       Delta location. The amount of bend is not limited by the length of the key. Sliding up to the end of the key and then replacing the finger on the key again will pickup where the last bend left off.
- Loc  $\updownarrow$       Delta location with zero. When the finger touches the key, the pitch bend is zeroed; any change in location from this point is sent out as bend.
- Pres      Pressure on the key will vary the bend amount. Note that for location sensitive keys (10-14 and 16-23) pressure on the top portion of the key will bend notes up, while pressure applied to the lower portion will bend notes down. Intermediate positions bend pitch less, with the mid position resulting in minimal pitch deviation.
- Impt      Impact. This differs from pressure in that the firmness of the initial strike on the key will determine the bend amount and cannot be varied with gradual pressure changes.
- +00      Fixed value. This entry can be set by THUNDERPOT from -64 to +64 and will be sent when the key is touched. A value of zero clears the channel bend.
- none      No bend information is sent.

## CONTINUOUS CONTROLLER

This the page where gestures are mapped to the 6 continuous controller channels and aftertouch. (These 6 are selected from the Settings MIDI Assignment page under Ctlr.)

Touch hex key 8 under the label Ctlr (an asterisk under "Ctlr" indicates that controllers are assigned for this key) and the following display appears:

Key	Tch	Mod	Bre	Vol	Pan	Bal	Fot
1		Pres	75	Impt	Lctn	50	Pres

Touching the hex key under the controller to be assigned a source will capitalize the word. Repeated touching of the hex key will scroll through the available options:

- Loc      Location information is sent to the controller channel. The value will be based on where the key is touched. Sliding up will increase the value and down will decrease the value. (unless controller is reversed)
- Pres     Pressure on the key will vary the controller amount, with increased pressure transmitting larger values.
- Impt    Impact. The firmness of the initial strike on the key will determine the bend amount and cannot be varied with gradual pressure changes.
- 000     Fixed value. This entry can be varied with THUNDERPOT from 000 to 127 and this value will be sent when the key is touched.
- Rand    Random. A new random value will be sent to the controller each time the key is touched.
- Ran0-5  More randomness. Sometimes known as the "drunken walk", this one varies the controller value in a continuous but unpredictable fashion. The number indicates the probable rate of change, with 0 corresponding to rapid fluctuations (expect occasional full scale changes in about a second), and 5 calling for slow movement (in the order of 30 seconds minimum for full scale changes). Note that the random motion takes place only while the calling key is active, retaining its last value on release of the key.
- none    No controller information is sent.

Once the desired value is chosen touch ENTER.

## KEY COPY

Key Copy is a time-saving feature that allows the copying of one key's data fields to those of another. Two versions of this procedure are available. For the first version, only those fields containing data are actually copied. Blank fields are ignored, and the equivalent fields in the target keys are left intact, rather than overwritten. If, by way of example, you wanted to change only the MIDI channel assignments of several keys, you could create a source key that had only the new MIDI channel numbers written into it and no other data and copy this onto previously programmed target keys.

To copy a key, touch hex key one under Key in the Key Assignment menu and then touch the key that will serve as the source for the copy. So far its just the same as selecting a key for editing. Now touch hex key 1 followed by ENTER. The following display appears:

Copying active data from key \_\_\_\_ . Select  
targets now. ESC to abort; ENT to copy.

This display will show the source key in the blank. When the first target key is touched it will appear in the lower line of the display. Up to 10 keys can be selected. To complete the copy procedure, touch ENTER; to abandon, touch ESCAPE.

The second version of Key Copy is accessed by touching ENTER twice after touching hex key 1. The above display will change appropriately, and target keys will end up containing all of the source keys' data - not just the active data. To clear a key (or keys), simply copy from a blank key.

Note that when copying between LED keys (1 - 9) and non - LED keys, that mode types change from L's (LED track) to T's (toggled) and vice versa.

# EFFECTS

Effects enable you to describe rhythmic, melodic, and volume changes in a precise sequential manner. While an effect is active for a particular MIDI channel, key closures addressed to that channel will be processed by the effect.

THUNDER has 8 programmable effects that can be used to modify key events on any combination of MIDI channels. Effects allow you to transpose, change dynamics, place specified time intervals between events, direct variations according to key status, cause the effect or portions thereof to repeat a specified number of times, dynamically modify time elements from a key, and specify how the effect will end. Additionally, an effect can transmit real time MIDI timing messages and respond to same.

Each of the 8 effects has 16 event slots which are displayed on 2 "pages" of the display. The events of an effect are selected from the top line of the display and are entered into the bottom line of the display. When the effect is initiated, the events are executed sequentially from left to right as they appear on the bottom row of the display.

An effect is applied to the MIDI channel(s) of the calling key. If the key that calls the effect is on MIDI channel 1 then all other key events on channel 1 will be processed by the effect (while it is active). There can only be one active effect per channel at a given time. A second effect applied to the same MIDI channel will replace the first one, but note that effects already in progress will proceed to their programmed endings. If an effect is initiated by several keys, multiple copies will be created, and all will independently proceed.

There is an upper limit of 32 simultaneously assigned effects. When this limit is exceeded, further assignments will be ignored, and the ESCAPE LED will blink, alerting the user to the situation.

Effect #0 is a special case that when applied to one or several channel(s), will immediately terminate all effects currently in progress on that (those) channel(s).

## SELECTING EFFECTS

To select an Effect, touch hex key 3 in the main menu under the label Efct Edit. This will display the most recently edited effect, as in the menu below:

Ef1a	Trns	Fade	Jump	Stop	Time	Scaling	Cl
------	------	------	------	------	------	---------	----

The upper leftmost word is the current effect number followed by the letter a or b to indicate which page or half of the effect is being edited. Page a holds the first 8 steps of the effect and page b the next 8 for a total of 16 events per effect. Step 9 of page b will automatically follow step 8 of page a. Touch ENTER to switch the displayed page.

To select an effect for display or editing, touch hex key 1 under the word Ef1a. This will produce a display of 8 numbers as follows:

Ef1a	Trns	Fade	Jump	Stop	Time	Scaling	Cl
1*	2	3	4	5	6	7	8

Effects that have been programmed are flagged with asterisks. Touch the hex key under the number of the effect you wish to edit.

## PROGRAMMING AN EFFECT

Effects consist of strings of events arranged in a desired order of execution. Events fall into 5 major categories, called Event Types, which appear in the top row of the effect display. Beneath this row are 8 blank slots where events are placed. Select an Event Type by touching the hex key under the Event Type's name (it will become capitalized) and then place it in a slot by touching the hex key below the desired slot. Subsequent touching of the hex key under the slot where an Event Type has just been placed will scroll through the range of possible events and their attributes, which are as follows:

**Trns** Transposition. This sends a MIDI note transposed by the indicated amount, which is set with THUNDERPOT. Touching the hex key under the event slot where a Trns has been placed will scroll through its attributes and alternate possibilities:

**T+, T-** Absolute signed transposition, offset from the note that started the effect.

**TA, TS** Relative added (A) or subtracted (S) transposition. Each execution increments or decrements the transposition by the specified amount.

**TR** Random transposition. The transposition will be randomized symmetrically around the key number, with the number of allowed intervals indicated by the datum. For a random transposition that would permit excursions within one octave of the key number the display would read TR25. For a transposition of TR02, THUNDER would randomly select between the original note and the next higher note. (Even numbers are biased upwards.)

**S** Slide transposition. (when followed by one of the above code letters or signs). With this variation of transposition, pitches change but envelopes are not re-triggered. Not all synthesizers understand this convention (see Legato Mode in the section entitled Synthesizer Selection).

**Tx, Sx** The number contained in the x field is transmitted as a MIDI note number.

**Fade** The Fade event will cause a change in the volume of successive notes by altering their MIDI velocity numbers. To be useful and effective, the synthesizer must respond to MIDI velocity. The attributes of the Fade Event Type are:

**F+,F-** Fade up or down. To increase (or decrease) the velocity numbers of the affected MIDI channel by xx amount the display will read F+xx (or F-xx).

**FR** Fade Random. To randomly change the velocity numbers of the affected MIDI channel within a range of xx amount the display will read FRxx.

**Jump** The steps of an effect are executed in a sequential manner. The Jump Effect Type is a "Go To" command, so when a jump is encountered the effect will go to the indicated step. The attributes of the Jump Effect Type are:

**JxxI** Inactive. The jump occurs only if the key that initiated the effect is released. A jump to the eighth event of the string that will only happen when the calling key is released would be displayed as J08I.

**JxxA** Active. The jump occurs only if the key that initiated the effect is still closed. A jump to the beginning of the event string that will only happen while the calling key is still closed would be displayed as J01A.

**Jxx** Unconditional. The jump always occurs.

**R xx** Repeat. This causes previous steps of the event string (back to the beginning or to the last Repeat) to repeat a specified number of times. To cause the previous portion of the string to repeat 7 times, insert a R 07. An R 00 can be used to establish an alternate starting point for a subsequent repeat.

**Stop** Stop unconditionally ends an effect. Variations of this Event Type are:

**Sust** Sustain suspends the effect until the initiating key is released.

**Enbl** Enable. This continues the effect as long as the initiating key is active, otherwise stopping it.

Also hiding under the Stop Event Type is an Output Pulse command with four possible destinations, and an Off command that is useful for defining note durations independently of interval. When an effect encounters an Output Pulse it sends a MIDI System Real Time message as follows:

**OutA** Transmits a MIDI Start message.

**OutB** Transmits a MIDI Continue message.

**OutC** Transmits a MIDI Stop message.

**OutD** Transmits a MIDI Timing Clock.

**Off** Transmits a MIDI Note Off, thus terminating the currently sounding note.

**Time** Time inserts a delay between events. Times are expressed in seconds, and can range from .01 to 9.99 seconds. Times can be modified in performance by assigning Scaling as described subsequently. Note that each event imposes an additional .01 second delay, an important consideration for those interested in military drum rolls.

If desired, timing information can be derived from MIDI System Real Time messages; the available sources, lettered A-D, correspond to the destinations described above. The number following the source letter is the number of incoming pulses counted before proceeding to the next event. An entry of D 14 will delay the next event until THUNDER has received 14 MIDI Timing Clocks.

In addition to transmitting and responding to MIDI messages, THUNDER utilizes these pulses internally; pulses generated by one effect may be used to influence the progress of another effect within the same instrument. (The possibilities boggle the mind.) Note that if an effect containing pulse counting events is initiated and no such events are received, that the effect will be effectively stopped but still active. There is a finite number of simultaneously running effects possible (32), after which effects will cease to sound and the ESCAPE LED will blink annoyingly. Application of the appropriate pulses or of a System Reset will restore this aspect of the world.

**Scal-** This selects the source and adjusts the degree to which it will affect time values. Scaling is used to lengthen or shorten time values in an effect. Repeated touching of hex key 7 will select the source of the modifier from among pressure, location, THUNDERPOT, pedal, random, velocity, or exponential (in which the time value is multiplied by itself). THUNDERPOT is used to adjust the scale factor from .12 to 8. The various degrees of randomness refer to the probable rate of change of an effect's speed, and are elucidated in the section entitled "continuous controllers".

**Cl** Clear is used to edit an effect. Select clear and insert it on the event to be altered. Repeated touching of the target hex key will toggle its status:

**CL** Clear removes the event and leaves an opening where the event was.

**DL** Delete removes the event and adjusts subsequent events to fill the gap.

**IN** Inserts a blank by moving subsequent events to the right.

Ef1a	Trns	Fade	Jump	Stop	Time	Prs x .50	Cl
T+12	.50	T-07	.12	F-10	J03A		

The sample effect in the above display would transpose the calling key up one octave (T+12), wait half a second (.50), play a note transposed down a fifth (-07), wait an eighth second (.12), fade the velocity value down by ten (F-10), jump to the third slot (J03A) and repeat steps 3-7 for as long as the calling key remained closed. Time values would be shortened up to one half by applying pressure to the key that initiated the effect.

# RIFFS

A Riff is a short sequence of key actions stored in real time and immediately accessible in a performance situation. There are 8 riffs per configuration. A total of 99 key events (closures and releases) can be stored among the 8 riffs. Riffs do not store any gestural information such as pressure or location.

Riffs can be edited and made to repeat (loop) up to 99 times, or Till Doomsday. Loudness can be programmed to change for each repetition. Transpositions and altered tempos can also be applied to riffs. Access to THUNDER's riff facility is immediate, with real-time recording and playback easily accomplished.

## RECORD AND PLAYBACK

Select Riff Edit from the main menu by touching the corresponding hex key (hex key 2). This brings you to the Riff Edit menu. Touch hex key 2 under the label Rec/Play. This brings you to the riff control menu where you select riffs to record and play. Notice that from the main menu, that touching the same hex key twice brings you quickly to the Record/Play display.

1/37	2/08	3/00	4/	5/	6/	7/	8/
	play	RCRD					

To record a Riff touch Enter (its LED will flash) followed by the hex key under the number of the Riff to be recorded. As soon as any performance key (1-25) is touched the recorder will start. In the above display riff 2 with 8 events is playing and riff 3 is waiting to record.

To end recording touch the hex key under the riff being recorded.

To end the recording and start the immediate playback of the just recorded riff touch ENTER. The first note of the riff will start exactly at the touch of ENTER. This is useful for real time establishment of rhythmic patterns.

The number of events recorded per riff is displayed in the top row of the display after the "/". The total number of events is limited to 99 distributed among the 8 riffs. If during recording this number is exceeded, the most recent events will be stored. You will not be able to select a new riff to record into when the note limit has been reached.

Recording over an already occupied riff will replace the previous recording. A riff may be erased by recording zero events into it.

## RIFF EVENT EDITOR

THUNDER has an editor for modifying previously recorded riffs. Touching hex key 3 under "Evt Edit" in the Riff menu will bring up the following display:

Riff	Step	Begin	End	Time	Play	Loop	Erase
2	20	01	32	0.25	*		

- Riff** Touching Riff will display the numbers 1-8 on the bottom line. These numbers refer to the 8 riffs and touching the hex key under the number of the riff to be edited will select that riff.
- Step** Step displays the current event of the riff. Touching the hex key under Step will cause that event to sound for the length of time it was recorded. Arrows highlight the step number for as long as the event sounds. At the end of the interval, the step number will increment. If there are no more events in the riff the step number will wrap around to the beginning of the riff.
- Begin** Select Begin to alter the start point of the riff. Touch hex key 3 and Begin will change case to all capitals. Use Thunderpot to set the new start point. Touch ENTER. **WARNING!** When you leave this display, events prior to the start point will be history. The riff's new length will be displayed in the Rec/Play menu.
- End** Select End to change the end point of the riff. The procedure parallels the editing of the start point. So does the warning.
- Time** Time displays the value in seconds to the next step in the riff from the presently displayed step. Advancing the number under the word Step will let you view all the times between events of the riff. To edit a time value, touch hex key 5 under the word Time and enter the new value with THUNDERPOT; then touch ENTER. Times can range from .01 to 9.99 seconds.
- Play** Touching Play will cause the riff being edited to play. This allows you to hear changes without leaving the Edit page. An asterisk (\*) will appear to indicate that the riff is playing.
- Loop** Touching Loop will cause the riff to cycle continuously. An asterisk (\*) indicates that the riff is looping.
- Erase** Erase erases the currently selected riff. Touch hex key 8 under the word Erase and then touch ENTER. The riff is gone.

## RIFF MODIFICATIONS

From the Riff menu each riff can globally modified with respect to pitch, dynamics, and tempo. To select the riff to be modified touch hex key 1 under the word Riff. Then select the riff to be modified by touching the appropriate hex key. The display will now show the settings for that riff.

Riff	Rec/	Evnt	Tran	Dynm	Fade	Rept	Tempo
2	Play	Edit	+12	100	\_00	99	2/1

The following modifications can be performed:

- Tran** Performs a positive or negative transposition (expressed in semitones) for the selected riff.
- Dynm** This provides an overall scaling of the velocity numbers as a percentage with 100 being no change to the velocity values.
- Fade** Fade allows a riff to change its dynamics through modifying the velocity values associated with each key with every repeat of the riff. Fades can be up or down depending on the slope of the indicator and the value will relate to the percentage of change of the original velocity values. The three sorts of slope indication, \\_, /\_, and /\\_, correspond to the processes: fade out, fade in, and fade in followed by fade out. **Remember that for fade to be effective the synth voice must respond to velocity.**
- Rept** Repeat determines the number of times the riff will play. Values of up to 99 or forever (TD) are possible.
- Tempo** Tempo allows scaling of the originally recorded time values. The tempo can be multiplied or divided by factors up to 8.

# SETTINGS

The Settings menu provides for a variety of adjustments within THUNDER and defines certain modes of interaction with other MIDI instrumentation. The Settings menu is selected by touching hex key 6 in the main menu under the word Settings:

Tune	Dsp	Sens	SysEx	Note	Midi	Range
+000	4	Off	On 1	Filt	Asgn	0-128

## TUNE

Tune adjusts the Fine Tuning of the receiving synthesizer if the synth is capable of responding to this message (check your manual). The Tune command is a part of the MIDI System Common Message and should not be confused with Micro Tunings or de-tunings within a voice.

To tune the synth touch hex key 1 under the word Tune in the Settings menu. Use THUNDERPOT to dial in the tuning change desired and touch ENTER.

The tuning range is from -999 to +999 cents.

The channels on which fine tune messages will be sent are selected in the Tune page from the MIDI Assignment menu.

## FINE TUNE CHANNEL ASSIGNMENT

This menu is accessed under MIDI Assignments (Midi Asgn) in the Settings menu.

The MIDI fine tuning command discussed above and accessed in the Settings menu can be channelized so that fine tuning messages will only be sent on selected channels.

Selecting channels is accomplished in the usual manner.

## DISPLAY

Touching hex key 2 in the Settings menu under the word Dsp will allow you to adjust the display's contrast and backlighting for maximum viewing ease.

Touching hex key 2 once will capitalize the word DSP. Now THUNDERPOT will adjust the brightness of the LCD elements, 0 being the lightest and 7 being the darkest, with maximum contrast occurring somewhere in between.

To toggle the LCD backlighting touch hex key 2 twice. Subsequent touches will alternate between backlight on and off. Touch ENTER to store.

## ACTIVE SENSING

Active Sense (Sens) is a signal transmitted by a controller that assures a synth that the controller is still there. If the synth misses this message, it assumes the MIDI cable got yanked and turns any sounding notes off.

THUNDER's transmission of Active Sense is enabled or disabled by toggling the Sens status with hex key 3.

## SYSTEM EXCLUSIVE SELECT

The sending and receiving of SysEx information can be enabled or inhibited by toggling hex key 4 under the word SYSEX in the Settings menu.

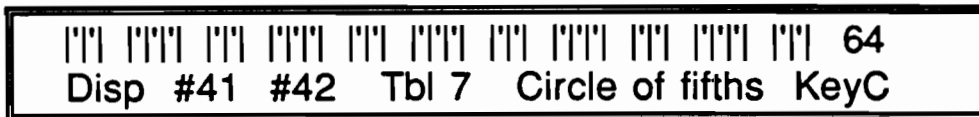
If multiple THUNDERS are used in a MIDI network the individual instruments can be given a device ID number by selecting SysEx and entering a value with THUNDERPOT. When doing any data transfer to or from THUNDER this number must be set and made to agree with the device number that was valid when the data was previously stored. Otherwise SysEx data will be ignored.

## NOTE FILTER

Since THUNDER can transpose and offset key pitch values in a variety of controlled and random manners it is often possible to move outside of any key center you thought you were playing in. To rescue you from such a fate we have provided extensive and intelligent note filtering to keep any or all aspects of your playing in the chosen key, or within a chosen set of pitches.

Hex key 4 accesses the note filter, which implements a scheme for interpreting intervals such that only notes from pre-arranged pitch sets are sounded. The note filter will shift played notes into the selected pitch set and, will treat transpositions as scale degrees instead of semitones. For example, with the note filter set to a diatonic scale, a transposition of 5 will result in a change of 5 degrees of the scale or a fifth. Without the note filter a transposition of 5 results in 5 semitones.

Selecting Note Filter will display the following:



The long and short vertical bars represent the natural and accidental notes of the 12 tone default MIDI tuning. The long bars correspond to the white keys and the short bars to the black keys of an extended, but otherwise traditional piano keyboard. Only half the keyboard can be displayed at once. Touch ENTER to toggle between display of the lower half (note numbers 0-64) or the upper half (note numbers 65-127).

THUNDERPOT selects adjacent key pairs for editing and displays their note numbers above hex keys 2 and 3, as for note numbers 41 and 42 in the display above. Use these keys to toggle the status of selected notes. Those "keys" with little lines under them are enabled for sounding; un-selected notes are skipped by transpositions.

Hex key 4 calls some named alternative tunings, and hex key 8 establishes their key signature. These tunings, once entered, can be modified as described above. The final tuning is stored as part of the configuration. The name of the source table is not stored.

Tunings available are:

Tbl 1	Diatonic	Tbl 4	Major Thirds	Tbl 7	Pentatonic
Tbl 2	Whole Tone	Tbl 5	Tritone	Tbl 8	Black Notes
Tbl 3	Minor Thirds	Tbl 6	Major Triads	Tbl 9	Circle of 5ths

The note filter tuning is invoked only for channels enabled from the "Filt assignment" display, as described below. Additionally, the MIDI filter can be assigned to riffs only, effects only, riffs and effects, or riffs, effects and keys.

## FILTER CHANNEL ASSIGNMENT

This menu (Filt) is accessed from MIDI Assignments (Midi Asgn) in the Settings menu.

The note filter can affect notes on selected MIDI channels and notes that are generated by effects, riffs, or key closures or combinations thereof.

By selecting MIDI channels in the usual manner you can on which channels events will be subject to note filtering. This can be useful for constraining a given area of THUNDER to a given scale while allowing others to be fully chromatic.

Also the source of the generated notes that are allowed to enter the filter can be selected from this page. By toggling hex key 7 the display will scroll through 4 possible sources: notes originating from riffs, from effects, from both riffs and effects, or all which includes any notes from riffs and effects plus any notes played from THUNDER's keys.

## MIDI ASSIGNMENT

MIDI Assignments is where THUNDERPOT and foot switches are assigned to continuous controllers, note ranges are limited, fine tuning channels are selected, note filters are assigned, reversals are mapped to specified channels, active controllers are selected, and the base MIDI channel that SysEx messages are sent on is specified.

MIDI Assignment	_____	Base
Thun Foot Limt	Tune Filt Rvrs Ctlr	01

## THUNDERPOT

In addition to entering data, THUNDERPOT can serve as a continuous controller for performance. Touch hex key 1 under the word Thun in the MIDI Assign menu:

Chan	1	2	4	8	15	16
Thunderpot	Assignment				Ctl #	00

Select the channels that THUNDERPOT will send on by first touching hex key 1 under the word Chan. Use THUNDERPOT to select a channel and touch ENTER. Multiple channels can be selected. To remove a channel, select it a second time and touch ENTER.

Once the channels are chosen a controller must be selected. Touch hex key 7 under the word Ctl#. It will capitalize. Select a controller number with THUNDERPOT. Then touch ENTER.

## FOOT PEDAL AND SWITCHES

On the rear panel of THUNDER are two phone jacks that will accept a footswitch array and a control pedal. These can then be assigned as MIDI continuous controllers.

To access the Footswitch menu touch hex key 2 under the word Foot in the MIDI Assignment page. This will display the Following:

Chan	1	2	4	8	15	16
Foot	Pedal	Assignment			Ctrl #	00

Channel and controller numbers are entered exactly as for the Thunderpot above.

To access the three Footswitches touch hex key 2 under the word Pedal and Switch #1 will be available for assignment. Subsequent closures of hex key 2 will display the remaining two switches and the pedal.

It may be advantageous to keep track of what controller numbers are in use in order to avoid simultaneous assignment to more than one source. Such multiple assignment may result in abrupt (and likely unintended) changes in controller values.

## NOTE LIMIT

MIDI allows for over 10 octaves of semitones (128 note numbers). Most synthesizers are not capable of producing this entire range, especially in the upper end. When sent an out-of-range note, some synths sound the correct pitch but in a different octave; others sound the highest (or lowest) note of their range; a few try valiantly but only manage inharmonic squeaks. With Limit you can set lower and upper boundaries to THUNDER's transmitted key numbers that match the synthesizer's range, and thus avoid the sounding of unintended notes and timbres.

## CONTROLLER SELECTION

THUNDER can simultaneously address six controllers in addition to velocity and aftertouch. Controllers can be inverted on chosen channels, a feature that allows crossfading volume or timbre between voices on different MIDI channels. To specify the controllers available to a particular configuration, touch hex key 7 under the word Ctlr in the MIDI assignment page. The following display will appear:

Vel	Tch	Mod	Bre	Vol	Pan	Bal	Fot
	Poly	01	02	07	10	08	04

Velocity (Vel) appears here for the purpose of reversal only. It can not be removed or reassigned. (The next section will explain reversal.)

Touch (Tch) refers not to the amount of force your finger exerts on the THUNDER playing surface, but to the MIDI messages known as channel or key pressure (a.k.a. aftertouch).

Channel pressure (sometimes called common pressure) refers to the information that is transmitted from a piano style keyboard based upon the hardest that any of the keys are pressed. It is a monophonic variable meaning that only one pressure value is sent per channel. Even if some piano keys are pressed firmly and others not so firmly, the highest pressure value is the one that is sent. When this information is received by the synthesizer it affects all the voices on the MIDI channel.

Poly pressure (sometimes called key pressure) is similar to channel pressure except that a separate value is transmitted for each key, making it a polyphonic controller.

THUNDER can send channel pressure, key pressure, or both. Selection is made by touching hex key 2 and toggling through the options.

The 6 controllers on the right of the display (Mod, Breath, Volume, Pan, Bal and Foot) are the default settings, and were selected for their popularity. The third controller, which THUNDER normally applies to volume is routed through a transformation that converts a synthesizer's exponential volume response to a function appropriate to timbral cross-fades, which THUNDER is particularly adept at. (See Controller Reversal, under Settings.)

Please note that just because THUNDER sends information on a particular continuous controller channel doesn't guarantee that the synthesizer will respond. Although most synths recognize Mod and Volume without any prompting, other controllers may be ignored. As always, refer to the synth operation manual to learn how to assign controllers to affect various aspects of your synthesizer's voices.

To select other continuous controllers to appear in the Ctlr page of the key assignment menu touch the hex key under the name of the controller to be changed. It will become capitalized. Then, using THUNDERPOT, dial in the desired controller. The names of commonly used controllers will be displayed above the controller number. Otherwise the controller number preceded by the letter "C" will be displayed.

## CONTROLLER REVERSAL

THUNDER allows selected controllers to be inverted on chosen MIDI channels.

One useful application of this feature is the implementation of panning between two sounds from a single key. Let us direct key #10 to send a pitch to MIDI channels 1 and 2. The synthesizer is programmed for different timbres on channels 1 and 2, and touching key 10 produces the two sounds in unison. Now assign location to volume in the Ctrl page of the key assignment, so that sliding your finger forward on the surface increases the sounds' volume. You can see a possibility here - if one of those volume commands could be reversed, timbre1 would increase as timbre 2 decreased, resulting in a smooth panning between them.

To accomplish controller reversal two steps must taken:

1. The desired controller(s) to be reversed must be selected.
2. The MIDI channel(s) that will send the inverted form of the controller must be specified. (Inversion sent on both channels would only yield increased volume from sliding your finger down instead of up.)

Controllers to be reversed are selected from the Ctlr menu under MIDI assignments. (Same page as controller selection above). Velocity and aftertouch can also be reversed. Touching the hex key under the controller to be reversed will capitalize its name. Touching it again will cause a down pointing arrow to appear to the right of the name. Touch ENTER to store. The controller is now selected for reversal.

The display below shows volume selected for reversal:

Vel	Tch	Mod	Bre	Vol↓	Pan	Bal	Fot
	Poly	01	02	07	10	08	04

To select the MIDI channel(s) that the inverted controller will send on touch hex key 6 under the word Rvrs in the MIDI Assignment page. The following menu will be displayed:

Chan	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Invert					↓							↓				

Touch hex key 1 under the word Chan and CHAN will capitalize. Dial in the channel number with the Thunderpot and touch ENTER. A down pointing arrow will appear under the appropriate channel number. Channels 5 and 12 above are selected for reversal.

To deselect a channel, enter its number as above; the arrow will disappear and the channel will no longer send reversed controller information.

## MIDI BASE CHANNEL

Hex key 8 selects the last item in the MIDI assignment page which is the base channel. This is the channel on which THUNDER sends and receives System Exclusive messages. When communicating with another device the channel numbers of both devices must be the same.

## PROGRAM CHANGE RANGE

Manufacturers can't seem to agree on a consistent numbering convention for MIDI program change numbers. Select a range that is appropriate to your equipment (sending program change 3 should be acknowledged as program change 3, not 2 or 4). The choices are 0 - 127 or 1 - 128.

## LOCK

Repeated actuation of hex key 8 from the Settings menu will produce the displays "LOCK ENTR" and "LOCK DATA" followed by a blank display. Use the ENTER key to engage either of these modes. Lock Entr will inhibit further actuation of the ENTER key, and thus prevent modification of data in the current or any stored configuration. Lock Data locks out all the edit keys, constraining the user to the current configuration, with no access to riffs or program changes. To reactivate THUNDER's normal editing mode requires removing and reapplying power.

# PROGRAM CHANGE

THUNDER stores 8 presets of MIDI program changes per configuration. Each preset contains program changes for each of the 16 MIDI channels. Program changes can select voicings, performance patches, effects, reverbs, etc.

Select Program Change by touching hex key 7 under the words Prog Chng in the main menu. The following display will appear:

Program Change Preset							
>1*	2	3	4	5	6*	7	8

The arrow that appears to the left of a preset number points to the currently active preset; the asterisks to the right indicate those presets to which program changes have been assigned. A set of program changes is transmitted by touching a labeled hex key.

To edit or view a preset's program change information, touch the corresponding hex key, followed by ENTER. The preset number will appear in the upper left hand corner and up to 16 associated program change numbers will occupy the remainder of the display.

There are 16 locations for entering program change numbers, corresponding to the 16 MIDI channels. Touch hex keys 1-8 to select the desired channel. . Hex key 1 selects for MIDI channel 1, hex key 2 , channel 2, etc. Touching hex key 1 twice selects MIDI channel 9, touching hex key 2 twice accesses channel 10, etc. The display below depicts the organization of channels.

6	001	002	003	004	005	006	007	008
	009	010	011	012	013	014	015	016

Use THUNDERPOT to place a program change number in a selected slot; ENTER to store it. Touch ENTER (when un-illuminated) to return to the previous page; ESCAPE to return to the main menu.

Whenever a new configuration is selected THUNDER automatically transmits the program changes contained in Preset 1. If no program changes are wanted when accessing a new configuration, leave Preset 1 blank.

# CONFIGURATIONS

THUNDER is a programmable controller and, like all such devices, requires instruction to specify its response to a player's actions. A set of such instructions is called a configuration. A configuration defines the relationship between gesture and response and is fundamental to THUNDER's role as the input portion of a musical instrument.

Configurations may be simple or complex; they will vary according to a player's whim, the musical context, and the nature of the synth(s) to be controlled. Some players will prefer to develop just one configuration, perhaps with variations; others may create a new configuration for every musical occasion. Most will choose an intermediate path, refining and becoming dextrous with a small number of personalized configurations.

THUNDER is always operating from a "current" configuration. THUNDER's memory can hold 8 additional configurations which comprise the "library". Eight more configurations can be stored in an external memory card that may be inserted into the slot on the rear panel of THUNDER.

Configurations can be moved back and forth from the internal Library to the external Card. They can be named and numbered for easy reference.

## CARD CHANGE

Before inserting or removing memory cards it is advisable to activate "Card Chnge" to guarantee the continued integrity of THUNDER's data. From the main menu, touch hex key 8 followed by ENTER.

## READING A CONFIGURATION

From the Main Menu touch hex key 1 under Cnfg Slct in the display. The following menu will be displayed:

Cf 0	This is a name.	Read from	_____			
Next	Prev	Name	Clear	R/W	LIB	Card

From the configuration menu you can choose whether to read or write a configuration from the library or the card.

Touching hex key 5 under the label "R/W" will toggle the display between READ and WRITE. Select "READ".

To select from the library configurations touch hex key 6 under "Lib".

To select from the card configurations touch hex key 7 under the display "Card". After choosing Read or Write and the source, touch ENTER to display the following directory:

1	Configuration 1	3	Configuration 3
2	Configuration 2	4	Configuration 4

If the configuration has been named its name will follow its number. If unnamed it will be blank. To view configurations 5 - 8, touch ENTER.

Touching hex key 1 will select Configuration 1 (or 5).

Touching hex key 2 will select Configuration 2 (or 6).

Touching hex key 5 will select Configuration 3 (or 7).

Touching hex key 6 will select Configuration 4 (or 8).

Note that hex keys 1, 2, 5, and 6 (not 1, 2, 3, 4,) select configurations.

## NEXT AND PREVIOUS

From the configuration menu, touching hex key 1 under the word "Next" will select the next configuration; touching hex key 2 (under "Prev") will select the previous one. The source of this configuration will be the library or card, one of which will be capitalized to indicate the current selection.

## NAMING A CONFIGURATION

It is often easier to remember a configuration by name than by number. To name the current configuration, touch hex key 3 under "Name" in the display. A "conceptual typewriter" will appear:

Cf 0	This is a name	^	<	>																										
a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	()	/*%	#&={}\$	"	.

The underline in the name field is the entry cursor.

Hex keys 7 and 8 will move the entry cursor in the name field.

Sliding your finger along THUNDERPOT will select a character from the string of characters on the bottom of the display. Touching ENTER will place that character in the name field.

Hex key 6 will change the case of the available characters.

To erase a character from the name field place the cursor under the unwanted character, select the blank at the extreme right and touch ENTER.

Touching ESCAPE will return you to the configuration menu.

## STORING A CONFIGURATION

After you have edited and named the current configuration you may wish to store it. In the configuration menu touch hex key 5 under the label "R/W" until the display reads:

Cf	This is a name.	WRITE to	_____				
Next	Prev	Name	Clear	R/W	LIB	Card	Midi

To store the configuration in the library touch hex key 6 under Lib, to store into the card touch the key under Card. To store configurations on a card that contains Sysex files, you must first erase the card (see following section). Configurations and Sysex files cannot co-exist on the same card.

Once you have selected either the library or card touch ENTER to reveal the directory. An additional activation of ENTER will cause the display of the names of configurations 5 - 8. And so on.

1	Configuration 1	3	Configuration 3
2	Configuration 2	4	Configuration 4

Touching hex key 1 will store to configuration 1 (or 5).

Touching hex key 2 will store to configuration 2 (or 6).

Touching hex key 5 will store to configuration 3 (or 7).

Touching hex key 6 will store to configuration 4 (or 8).

Note that hex keys 1, 2, 5 and 6 are used to store configurations (not 1, 2, 3, 4).

## CLEARING A CONFIGURATION, LIBRARY OR CARD

To erase the current configuration, card or library go to the configuration menu and touch hex key 4 under the word Clear.

The display will change to CURNT. Touching hex key 4 again will change the display to CARD or LIBRARY. When the display shows the desired area to be cleared touch ENTER.

**This action will erase key assignments, riffs, effects, transpositions, program changes and all other data associated with the cleared configurations. So be careful.**

# FILE TRANSFER

THUNDER's software includes a resource for transferring files between the library , memory cards and MIDI. This is accessed by touching hex key 5 under File Xfer in the main menu, which causes this display to appear:

Copy	from	_____	to	_____	Mem:C
SysX		Card Midi		Card Midi	08192

Hex key #1 selects one of two kinds of transaction:

Copy  
SysX            Controls the transfer of SysEx files.

Copy  
Cnfg            Allows the copying or transmission of entire cards or libraries.

The next three hex keys (2,3 and 4) select the source of copy or erase operations from among Library, Card or Midi. The selection will become capitalized.

If Midi is selected THUNDER patiently waits for system exclusive messages, adding to existing files until available memory is filled. If more than 10 seconds elapse before the first such action, or if more than 2 seconds elapse between subsequent files, THUNDER ceases waiting and resumes normal behavior.

Hex keys 5-7 select the destination for copy operations from among Library, Card, or Midi. The selection will become capitalized.

After selecting a source and destination, touch ENTER to initiate the transaction.

Memory available for system exclusive files is displayed for Card when it is the selected destination. Maximum is 16,384 bytes.

When sending or receiving System Exclusive information over MIDI it is essential that SysEx is on, and the device numbers agree (Settings page), and that the THUNDER MIDI base channel (Midi Asgn page) is in agreement with the device THUNDER is talking to.

# SYSTEM RESET

From the main menu, two activations of hex key 8 will change its label to "SYST RSET". Activation of ENTER will then reset the system. System Reset performs the following functions:

1. Initializes THUNDER without affecting the data in the memory.
2. Sends a MIDI "all notes off" message.
3. Sets the default controllers to their initial values.
4. Suspends transmission of MIDI active sensing (assuming active sense is on). This will persuade some external devices to reset themselves.

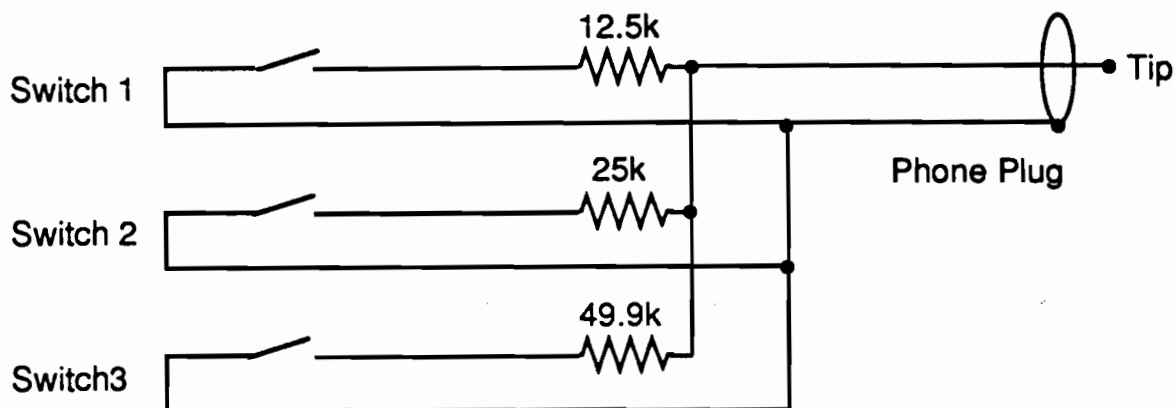
Avoid touching the keyboard while THUNDER is performing a reset.

## Appendix A - Foot Pedal and Switches

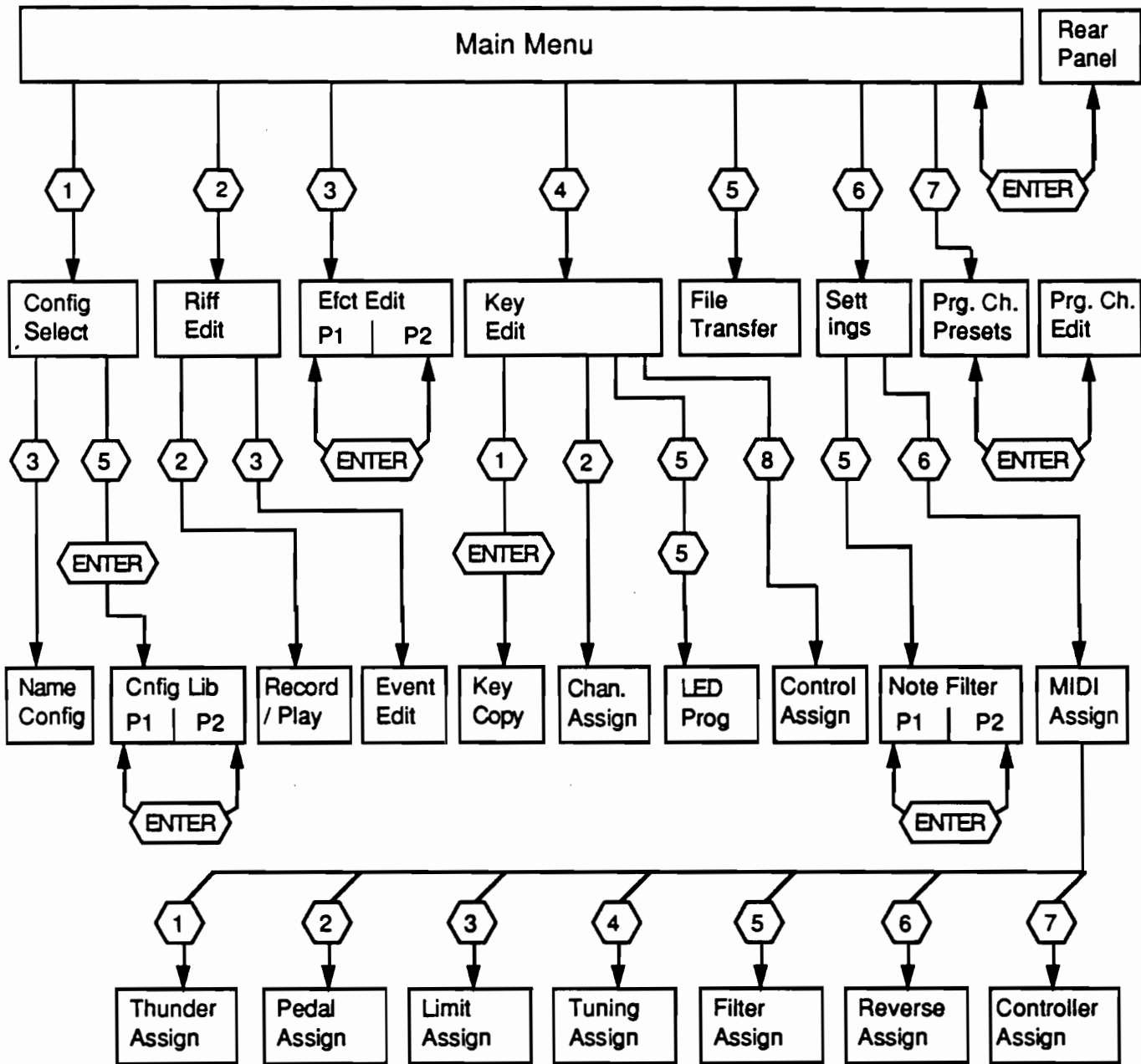
THUNDER's foot pedal input accepts a 0 to +10 volt control voltage appearing on the tip of a 1/4" phone plug.

THUNDER's foot switch input will accept a normally open, momentarily closed foot switch terminated in a 1/4" phone plug. This switch will trigger all three of THUNDER's programmable switches.

Alternatively, with a little minor surgery, THUNDER can accept 3 foot switches connected to its single switch input. The circuitry necessary to achieve such independent operation is diagrammed below:



# Appendix B - Storm Menu Tree



Thunder utilizes a four level hierarchal menu organization. Hex keys, occasionally accompanied with ENTER, are used to access lower menu levels. ESCAPE is used to move to higher levels. ENTER is used to toggle between multiple pages on the same level.

# Appendix C - MIDI Controller Names

Controller Number	Controller Function
0	Undefined
1	Modulation Wheel
2	Breath Controller
3	Undefined
4	Foot Controller
5	Portamento Time
6	Data Entry MSB
7	Main Volume
8	Balance
9	Undefined
10	Pan
11	Expression Controller
12-15	Undefined
16-19	General Purpose 1-4
20-31	Undefined
32-63	LSB for values 0-31
64	Damper Pedal (sustain)
65	Portamento
66	Sostenuto
67	Soft Pedal
68	Undefined
69	Hold 2
70-79	Undefined
80-83	General Purpose 5-8
84-90	Undefined
91	External Effects Depth
92	Tremolo Depth
93	Chorus Depth
94	Celeste (Detune) Depth
95	Phaser Depth
96	Data increment
97	Data decrement
98	Non-Registered Parameter LSB
99	Non-Registered Parameter MSB
100	Registered Parameter LSB
101	Registered Parameter MSB
102-120	Undefined
121-127	Reserved for Channel Mode Messages

# Appendix D - Tactile Template

The following page is a full sized representation of THUNDER's playing surface. We find it handy for making notes on organizational aspects of configurations and thought you might also. It makes a good Xerox master, and if cut out along the heavy border, can serve as a play-through label for THUNDER's keys.

# Appendix E - Configuration Listing

The following four pages are forms for documenting configurations for those few occasions where hard copy is needed. Space is provided for every variable in a configuration. Xerox as needed.











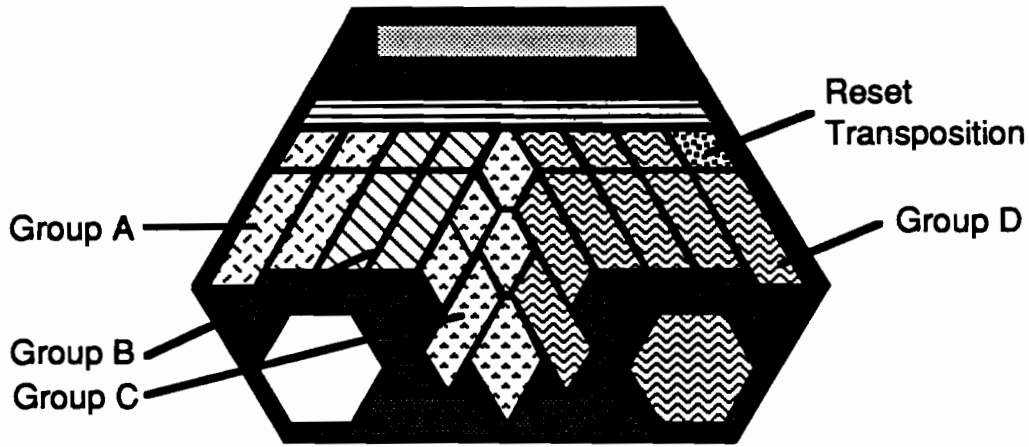








# Appendix F - Sample Configuration



## Group A (Keys 1-2, 10-11)

Keys 10 & 11 are on MIDI Channel 2 and have pressure assigned to MIDI Volume, and Location assigned to MIDI Pan. Keys 1 & 2 turn on Effects for keys 10 & 11.

## Group B (Keys 3-4, 12-13)

Keys 12 & 13 transmit on MIDI Channels 3 and 4, with channel 4 having its Volume reversed. This allows crossfading between two sounds with Location which is assigned to MIDI Volume. Keys 3 & 4 turn on Effects for keys 12 & 13.

## Group C (Keys 5, 14, 15, 21-22)

This group is on MIDI Channel 5 and plays a whole tone scale using the transposition field in Key assign. Repeated presses on a key will step the pitch up or down by a fixed amount.

## Group D (Keys 6-8, 16-20, 23 and 25)

Keys 16-20, and 23 are on MIDI Channel 1, and have location assigned to Pitch Bend, and pressure assigned to Mod. They are tuned to a pentatonic scale. The group 16-20 also use the Flags for conditional transposition by octaves. To transpose up, play Key 16, followed by 17,18 and/or 19, then key 20, which sets flag Y. Now if you play Key 16 again, it will "see" Flag Y, and will add an octave of transposition. If you do the same pattern again it will transpose up another octave. The opposite pattern (20, then 17,18 and/or 19, then 16) will leave the X flag set so that key 20 will "see" it and subtract an octaves transposition. Keys 6-8 call up Effects for this group.









# Appendix G - MIDI Implementation Chart

Thunder Version: 1.0 Date:2/12/90

Function...		Transmitted	Recognized	Remarks
<b>Basic Channel</b>	Default Changed	1 1-16		
<b>Mode</b>	Default Messages Altered			
<b>Note Number</b>	True voice	0-127 0-127		
<b>Velocity</b>	Note On Note Off	o o		
<b>After Touch</b>	Key's Channel	o o		
<b>Pitch Bend</b>			o	
<b>Control Change</b>	Any 6	o		
<b>Program Change</b>	True Number	o 0-127 / 1-128	o 0-7	
<b>System Exclusive</b>		o	o	
<b>System Common</b>	Song Position Song Select Tune Request	x x x		
<b>System Real Time</b>	Clock Commands	Timing Clock Start, Cont, Stop	Timing Clock Start, Cont, Stop	
<b>Aux Messages</b>	Local On/Off All Notes Off Active Sensing System Reset	x o o o		
<b>Notes</b>				

Mode 1: Omni On, Poly  
Mode 3: Omni On, Poly

Mode 2: Omni On, Mono  
Mode 4: Omni Off, Mono

o: Yes  
x: No

## Appendix H - System Exclusive Implementation

MIDI System Exclusive transmissions are the means by which computer-based Patch Editors and Librarians communicate with synthesizers and controllers. The information in this section is provided so that programmers can write code that can talk to THUNDER and understand what it transmits in response. Most users will find the information in this section of little use.

General SysEx Message Format

The generic Thunder MIDI system exclusive (SysEx) message format is as follows:

byte	0	1	2	3	4	5	6	7		n-1	n	
data	F0	00	mm	mm	pp	uu	tt	xx	...	xx	cc	F7

where:

- mm mm                    bytes 2 and 3: the Buchla MIDI Manufacturer ID  
                               NOTE: not yet assigned, temporarily 07FH 07FH.
- pp                        byte 4: 001H -- the Thunder product ID code
- uu                        byte 5: the unit number you're talking to (0..8)
- tt                        byte 6: the message type (see below)
- xx ... xx                bytes 7..n-2: the data for the message, in groups of 3 bytes for each 16 bit word (see below)
- cc                        byte n-1: the checksum (see below)

Packing and Unpacking 16 bit words

All data in Thunder SysEx messages are defined in terms of 16 bit words.

Since MIDI uses 7 bits per byte we have to transfer each 16 bit word as 3 MIDI data bytes. This is done by sending the 4 MS bits of the word, then the 6 middle bits of the word, followed by the 6 LS bits, as follows:

1st byte	bits 15..12 of the word in bits 03..00 of the byte
2nd byte	bits 11..06 of the word in bits 05..00 of the byte
3rd byte	bits 05..00 of the word in bits 05..00 of the byte

For example, to send a 16 bit value of:

01234H	0001 001000 110100
--------	--------------------

we would send the 3 MIDI bytes:

001H	0000 0001	MS bits 15..12
008H	00 001000	middle bits 11..06
034H	00 110100	LS bits 05..00

Checksums  
-----

The checksum is calculated over bytes 6..n-1 and is their 7 bit sum, with overflow discarded, such that when the checksum byte is added to the sum of the other bytes of the message the result is zero (0 residue).

This is done by setting a counter to the value of the message type byte and then adding the 7 LS bits of each byte as it is read or sent. The checksum byte on transmission is sent as the 7 bit 2's complement of the accumulated sum of the message bytes. On reception this will cause the final checksum to be zero if all bytes have been received without error.

Messages  
-----

Message 0 -- Write word  
-----

2 message words:

offset into the configuration (0..975),  
data to write.

This message writes a 16 bit word into the current configuration.

This would typically be used in editing a configuration with a MIDI librarian.

Message 1 -- Write current configuration  
-----

976 message words:

configuration data (see below).

This message replaces the current configuration with the configuration in the message data.

Message 2 -- Write library  
-----

7808 message words:

library data (see below).

This message replaces the library with the library in the message data.

Message 3 -- Send word  
-----

1 message word:

offset into current configuration.

This message causes Thunder to respond with the contents of the specified word in the current configuration. The response is sent as a type 0 message.

This message would typically be used by a MIDI librarian to examine the current value of a configuration parameter.

Message 4 -- Send current configuration  
-----

No message words.

This message causes Thunder to respond by sending the contents of the current configuration. The response is sent as a type 1 message.

Message 5 -- Send library  
-----

No message words.

This message causes Thunder to respond by sending the contents of the library. The response is sent as a type 2 message.

## Configuration Format

A configuration in Thunder defines the mapping of performance gestures onto MIDI messages and provides storage for control information, riffs and effects.

Each configuration occupies 976 words, formatted as follows:

Offset Hex Dec	Name	Length Decimal	Purpose
0000 0	CFGNAM	8	Configuration name -- packed byte string (15 chars.)
0008 8	PGMTB1	8	MIDI program change table # 1
	PGMTB1[0]	BIT15..08	program number for channel 1
	PGMTB1[0]	BIT07..00	program number for channel 2
	PGMTB1[1]	BIT15..08	program number for channel 3
	PGMTB1[1]	BIT07..00	program number for channel 4
	PGMTB1[2]	BIT15..08	program number for channel 5
	PGMTB1[2]	BIT07..00	program number for channel 6
	PGMTB1[3]	BIT15..08	program number for channel 7
	PGMTB1[3]	BIT07..00	program number for channel 8
	PGMTB1[4]	BIT15..08	program number for channel 9
	PGMTB1[4]	BIT07..00	program number for channel 10
	PGMTB1[5]	BIT15..08	program number for channel 11
	PGMTB1[5]	BIT07..00	program number for channel 12
	PGMTB1[6]	BIT15..08	program number for channel 13
	PGMTB1[6]	BIT07..00	program number for channel 14
	PGMTB1[7]	BIT15..08	program number for channel 15
	PGMTB1[7]	BIT07..00	program number for channel 16

program numbers are coded as 0..128 with 0 EQ blank

0010 16 PGMTB2 8 MIDI program change table # 2

same format as PGMTB1

0018 24 PGMTB3 8 MIDI program change table # 3

same format as PGMTB1

0020 32 PGMTB4 8 MIDI program change table # 4

same format as PGMTB1

0028 40 PGMTB5 8 MIDI program change table # 5

same format as PGMTB1

0030 48 PGMTB6 8 MIDI program change table # 6

same format as PGMTB1

0038 56 PGMTB7 8 MIDI program change table # 7

same format as PGMTB1

0040 64 PGMTB8 8 MIDI program change table # 8

same format as PGMTB1

0048 72 CTLMAP 6 Controller assignment map -- CTLMAP[6]:

CTLMAP[0]	Ctrl 0 MIDI controller number assignment	(0..95)
CTLMAP[1]	Ctrl 1 MIDI controller number assignment	(0..95)
CTLMAP[2]	Ctrl 2 MIDI controller number assignment	(0..95)
CTLMAP[3]	Ctrl 3 MIDI controller number assignment	(0..95)
CTLMAP[4]	Ctrl 4 MIDI controller number assignment	(0..95)
CTLMAP[5]	Ctrl 5 MIDI controller number assignment	(0..95)

004E 78 FLAGWD 4 Flag words -- FLAGWD[4]:

FLAGWD[0] bit assignments:

BIT00	1 = disable channel pressure
BIT01	1 = disable polyphonic pressure
BIT02	Program change display base, 0 or 1
BIT04..05	MIDI filter mode:
BIT04	filter effects
BIT05	filter riffs

FLAGWD[1] is reserved and must be zero

FLAGWD[2] is reserved and must be zero

FLAGWD[3] is reserved and must be zero

```

0052 82    RIFTOP      1      Number of riff events used (0..99)
0053 83    -----      1      - reserved, must be zero -
0054 84    PEDCT1     1      Foot pedal MIDI controller number (0..95)
0055 85    FSW1CT     1      Foot switch 1 MIDI controller number (0..95)
0056 86    FSW2CT     1      Foot switch 2 MIDI controller number (0..95)
0057 87    FSW3CT     1      Foot switch 3 MIDI controller number (0..95)
0058 88    MASTHC     1      Thunder strip MIDI controller number (0..95)
0059 89    PEDAS1     1      Foot pedal output channels:
                        BIT15  MIDI channel 16 -- 0 = disabled, 1 = enabled
                        ...
                        ...
                        BIT00  MIDI channel 1 -- 0 = disabled, 1 = enabled
005A 90    FSW1AS     1      Foot switch 1 output channels:
                        BIT15  MIDI channel 16 -- 0 = disabled, 1 = enabled
                        ...
                        ...
                        BIT00  MIDI channel 1 -- 0 = disabled, 1 = enabled
005B 91    FSW2AS     1      Foot switch 2 output channels:
                        BIT15  MIDI channel 16 -- 0 = disabled, 1 = enabled
                        ...
                        ...
                        BIT00  MIDI channel 1 -- 0 = disabled, 1 = enabled
005C 92    FSW3AS     1      Foot switch 3 output channels:
                        BIT15  MIDI channel 16 -- 0 = disabled, 1 = enabled
                        ...
                        ...
                        BIT00  MIDI channel 1 -- 0 = disabled, 1 = enabled
005D 93    MASTHN     1      Thunder strip output channels:
                        BIT15  MIDI channel 16 -- 0 = disabled, 1 = enabled
                        ...
                        ...
                        BIT00  MIDI channel 1 -- 0 = disabled, 1 = enabled
005E 94    MASTUN     1      MIDI fine tuning output channels:
                        BIT15  MIDI channel 16 -- 0 = disabled, 1 = enabled
                        ...
                        ...
                        BIT00  MIDI channel 1 -- 0 = disabled, 1 = enabled

```

005F 95 MFILTR 1 MIDI filter channel assignments:  
BIT15 MIDI channel 16 -- 0 = disabled, 1 = enabled  
...  
...  
BIT00 MIDI channel 1 -- 0 = disabled, 1 = enabled

0060 96 KEYASG 336 Key assignments -- KEYASG[42][8]:

Each key assignment takes 8 words, as follows:

KEYASG[n][0] bit assignments:

BIT15 S bit -- key is split  
BIT14 K bit -- MIDI key number is present  
BIT13 E bit -- effect field is present  
BIT12 L bit -- LED change activity  
BIT11 C bit -- channel assignment is present

BIT10..09 Key output mode:

00 blank (all)  
01 C -- closure  
10 R -- release  
11 T -- toggle / track

BIT08..00 LED AND mask -- BIT8 = LED 1

KEYASG[n][1] bit assignments:

BIT15 Z bit -- effect is zero  
BIT14..11 effect number -- 0..7  
BIT10..09 - reserved, must be zero -  
BIT08..00 LED XOR mask -- BIT8 = LED 1

KEYASG[n][2] channel mask for this key:

BIT15 MIDI channel 16 -- 0 = disabled, 1 = enabled  
...  
...  
BIT00 MIDI channel 1 -- 0 = disabled, 1 = enabled

KEYASG[n][3] bit assignments:

BIT15	pitch type:
0	source in BIT14..08:
0	blank (none)
1	Location -- absolute
2	Location -- relative
3	Location -- relative, reset to zero
4	Pressure
5	Impact
6..11	Lightning variables
6	LVer Left Vertical
7	LHor Left Horizontal
8	LRot Left Rotation
9	RVer Right Vertical
10	RHor Right Horizontal
11	RRot Right Rotation
12..127	- reserved, do not use -
1	constant in BIT14..8, offset binary, value of -64..+63 represented as 0..127
BIT14..08	pitch value (format according to BIT15 above)

KEYASG[n][4] bit assignments:

BIT15..13	Transpose mode:
0	A -- add delta value
1	S -- subtract delta value
2	+ -- positive absolute value
3	- -- negative absolute value
4	R -- random absolute value (value is range)
5..7	- reserved, do not use -
BIT12	- reserved, must be zero -
BIT11..10	Flag control -- test bits:
00	blank (always)
01	test X flag
10	test Y flag
11	test Z flag
BIT09..08	Flag control -- set bits:
00	blank (none)
01	set X flag
10	set Y flag
11	set Z flag
BIT07..00	Transpose value (see BIT15..13 above)

KEYASG[n][5] bit assignments:

BIT15..10 - reserved, must be zero -

BIT09..05 Velocity assignment:

- 0 none
- 1 Impact
- 2 Location

3..23 Velocity constant code:

Code	Value
----	-----
3	0
4	6
5	12
6	18
7	24
8	30
9	36
10	42
11	48
12	56
13	64
14	72
15	80
16	86
17	92
18	98
19	104
20	110
21	116
22	122
23	127

24..29 Lightning variables

24	LVer	Left Vertical
25	LHor	Left Horizontal
26	LRot	Left Rotation
27	RVer	Right Vertical
28	RHor	Right Horizontal
29	RRot	Right Rotation

30..31 - reserved, do not use -

BIT4..0 Touch assignment:

- 0 none
- 1 Location
- 2 Pressure
- 3 - reserved, do not use -

4..24 Touch constant code:

Code	Value
----	-----
4	0
5	6
6	12
7	18
8	24
9	30
10	36
11	42
12	48
13	56
14	64
15	72
16	80
17	86
18	92
19	98
20	104
21	110
22	116
23	122
24	127

25..30 Lightning variables

25	LVer	Left Vertical
26	LHor	Left Horizontal
27	LRot	Left Rotation
28	RVer	Right Vertical
29	RHor	Right Horizontal
30	RRot	Right Rotation

31 - reserved, do not use -

KEYASG[n][6] bit assignments:

BIT15 - reserved, must be 0 -

BIT14..10 Ctrl 2 assignment

- 0 none
- 1 Location
- 2 Pressure
- 3 Impact

4..24 Touch constant code:

Code	Value
----	-----
4	0
5	6
6	12
7	18
8	24
9	30
10	36
11	42
12	48
13	56
14	64
15	72
16	80
17	86
18	92
19	98
20	104
21	110
22	116
23	122
24	127

BIT9..5 Ctrl 1 assignment -- same format as Ctrl 2

BIT4..0 Ctrl 0 assignment -- same format as Ctrl 2

KEYASG[n][7] bit assignments:

BIT15 - reserved, must be zero -

BIT14..10 Ctrl 5 assignment -- same format as Ctrl 2

BIT9..5 Ctrl 4 assignment -- same format as Ctrl 2

BIT4..0 Ctrl 3 assignment -- same format as Ctrl 2

01B0 432 EFXHDR 8 Effect headers -- EFXHDR[8]:

BIT15..08 - reserved, must be zero -

BIT07..04 Source type:

0000		none
0001	Prs	Pressure
0010	Loc	Location
0011	Thn	Thunder strip
0100	Ped	Pedal
0101	Ran	Random
0110	Exp	Time
0111	Lvr	Lightning Left Vertical
1000	Lhr	Lightning Left Horizontal
1001	Lrt	Lightning Left Rotation
1010	Rvr	Lightning Right Vertical
1011	Rrt	Lightning Right Horizontal
1100	Rrt	Lightning Right Rotation
1101	Vel	Velocity
1110	???	- reserved, do not use -
1111	???	- reserved, do not use -

BIT03..00 Multiplier index

Code	Multiplier
----	-----
0	x .12
1	x .25
2	x .50
3	x .75
4	x 1.0
5	x 1.5
6	x 2.0
7	x 4.0
8	x 8.0

01BB 440 SLOTS 128 Effect slots -- SLOTS[8][16]

Each of the 8 effects has 16 action slots.

Each effect action takes 1 word. The first 3 bits [15..13] specify the type of action, and the next 3 bits [12..10] specify the sub-type, and the remaining 10 bits [09..00] are the associated parameter.

Type	Action/Sub-type	Parameter
000	Null	bits 12..00 must be set to zeros
001	Delay	bits 12..10 are the delay sub-type: 000 delay count (10 milliseconds / LSB) 001 A event count 010 B event count 011 C event count 100 D event count 101 - reserved, do not use - 110 - reserved, do not use - 111 - reserved, do not use - bits 09..00 are the delay count 0..1023
010	Control	bits 12..10 are the action sub-type: 000 Control group 0: bits 09..03 are zeros bits 02..00 are the control sub-type: 000 Stop 001 Sustain 010 Enable 011 Off 100 OutA (A event - MIDI OFAH - Start) 101 OutB (B event - MIDI OFBH - Continue) 110 OutC (C event - MIDI OFCH - Stop) 111 OutD (D event - MIDI OFDH - Timing Clock) 001 Control group 1 - reserved, do not use - 010 Control group 2 - reserved, do not use - 011 Control group 3 - reserved, do not use - 100 Control group 4 - reserved, do not use - 101 Control group 5 - reserved, do not use - 110 Control group 6 - reserved, do not use - 111 Control group 7 - reserved, do not use -
011	Repeat n times	bits 12..10 are zeros bits 09..00 are the repeat count 0..99

Type	Action/Sub-type	Parameter
100	Jump	bits 12..10 are the jump sub-type: 000 jump if inactive, 001 jump if active 010 jump unconditionally 011 - reserved, do not use - 100 - reserved, do not use - 101 - reserved, do not use - 110 - reserved, do not use - 111 - reserved, do not use - bits 09..00 are the jump target 0..15
101	Transpose	bits 12..10 are the value sub-type: 000 A add the value to the transpose register 001 S subtract the value from the transpose register 010 + set the transpose register to positive value 011 - set the transpose register to negative value 100 R add signed random value to transpose register 101 nnn output untransposed MIDI note number 0..127 110 - reserved, do not use - 111 - reserved, do not use - bits 09..00 are the value 0..99 or 0..127
110	Slide	bits 12..10 are the value sub-type: 000 A add the value to the transpose register 001 S subtract the value from the transpose register 010 + set the transpose register to positive value 011 - set the transpose register to negative value 100 R add signed random value to transpose register 101 nnn output untransposed MIDI note number 0..127 110 - reserved, do not use - 111 - reserved, do not use - bits 09..00 are the value 0..99 or 0..127
111	Fade	bits 12..10 are the value sub-type: 000 positive constant 001 - reserved, do not use - 010 negative constant 011 - reserved, do not use - 100 random 101 - reserved, do not use - 110 - reserved, do not use - 111 - reserved, do not use - bits 09..00 are the value 0..99

0238 568 RIFCBS 32 Riff control blocks -- R[FCBS[8][4]

RIFCBS[n][0] bit assignments:

BIT15..8 number of events, 0..100

BIT7..0 first event number, 0..99

RIFCBS[n][1] bit assignments:

BIT15..8 - reserved, must be zero -

BIT7..0 transposition value, -99..0..+99,  
2's complement

RIFCBS[n][2] bit assignments:

BIT15..8 dynamic value

BIT7..6 dynamic type:

0	fade in
1	fade out
2	fade in, then fade out
3	- reserved, do not use -

BIT5..0 dynamic increment, 0..63

RIFCBS[n][3] bit assignments:

BIT15..8 repeat count

BIT7..0 Tempo:

0	1/8
1	1/5
2	1/4
3	1/3
4	2/5
5	1/2
6	3/5
7	2/3
8	3/4
9	1/1
10	4/3
11	3/2
12	5/3
13	2/1
14	5/2
15	3/1
16	4/1
17	5/1
18	8/1

19..127 - reserved, do not use -

0258 600 RIFEVT 300 Riff events -- RIFEVT[100][3]

RIFEVT[n][0] interval to next note.  
LS bit = 10 milliseconds

RIFEVT[n][1] bit assignments:

BIT15..8 - reserved, must be zero -

BIT7..0 note duration,  
LS bit = 10 milliseconds

RIFEVT[n][2] bit assignments:

BIT15..8 velocity, 0..127

BIT7..0 key index number, 0..41

0384 900 REVCHN 1 Channel reversal enable mask

BIT15 MIDI channel 16 -- 0 = disabled, 1 = enabled

...

...

BIT0 MIDI channel 1 -- 0 = disabled, 1 = enabled

0385 901 REVFLG 1 Variable reversal enable flags

REVFLG bit assignments:

INVVEL BIT0 invert velocity  
INVTCH BIT1 invert aftertouch (pressure)  
INVMOD BIT2 invert Ctrl 0  
INVBRE BIT3 invert Ctrl 1  
INVGP1 BIT4 invert Ctrl 2  
INVGP2 BIT5 invert Ctrl 3  
INVGP3 BIT6 invert Ctrl 4  
INVGP4 BIT7 invert Ctrl 5

0386 902	BITMAP	8	MIDI note filter bit map, 1 bit for each MIDI key number, 0 = disabled, 1 = enabled, BIT15 of BITMAP[0] is MIDI key # 0, BIT0 of BITMAP[7] is MIDI key # 127
038E 910	LIMITS	1	MIDI key number output limits:
	BIT15..8		High MIDI key number output limit 0..127
	BIT7..0		Low MIDI key number output limit 0..127
038F 911	LIMITC	1	MIDI key number output limits channel mask
	BIT15		MIDI channel 16 -- 0 = disabled, 1 = enabled
	...		
	...		
	BIT0		MIDI channel 1 -- 0 = disabled, 1 = enabled
0390 912	SPARES	63	Spares -- reserved, must be zero
03CF 975	CFGSUM	1	Configuration checksum, 16 bit, 2's complement, 0 residue

Library Format

The library consists of 8 configurations, requiring 7808 words as follows:

0000..0975	Configuration 1 (see above for format)
0976..1951	Configuration 2
1952..2927	Configuration 3
2928..3903	Configuration 4
3904..4879	Configuration 5
4880..5855	Configuration 6
5856..6831	Configuration 7
6832..7807	Configuration 8

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