MUZIK81

audio

USER'S MANUAL

ZX81 VERSION 1.Ø1

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AUDIO PROCESSOR

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1. INTRODUCTION

A revolutionary device in the MUZIX81 line is the audio processor, based upon a Sinclair ZX81 computer with a 64K memory. The MUZIX81 audio processor is digitizing and processing audio signals in real time, up to a 37 kHz sampling rate. It is using advanced digitalization techniques with compression and expansion for better signal-to-noise ratios and with 4th order filters both at the input and the output for reducing aliasing and sampling noise. Several software packages are available with this product, and there are still more to come!

AUDIO EFFECTS

Contains four subprograms, each having 9 pre-programmable presets. All the the 36 presets are directly available in real time from the keyboard.

- Echo: A programmable digital delay line, with maximal delays up to 10 seconds, containing also a FREEZE option.
- Reverb: Reverb effects can be realized by programming two different delay times.
- Transposer: Similar to the Eventide HARMONIZER, transposes the incoming signal immediately by a few semitones. The ZX81 keys can be preset to different pitch transpositions, up to +12 to -24 semitones and delay times.
- Dual Transposer: Plays two different transpositions of the incoming signal. Some shocking 'QUEEN-like' vocal effects can be achieved live ! The presets to different harmonies are available here as well.

SIMULATOR:

Connect your synthesizer CV output to the MUZIX81 box, then record a guitar, a flute, a drum or any other instrument through a microphone into the memory of the computer. Now the computer will reproduce the recorded instrument as you play on the synthesizer keyboard, a feature so far only available on very expensive systems. One can save and load these sounds in digital form. Later tapes with several prerecorded sounds will be available.

All these effects are created with the same inexpensive box. Try to estimate the cost of all the devices producing these effects, and you will find the MUZIX81 unbelievably cheap !

2. GENERAL INFORMATION

2.1 Tape loading

Both sides of the cassette begin with the same short program which is to be loaded the usual way. This is a rather short program, containing only a new loader program itself. From this point on you have to use these new SAVE-LOAD routines, which are about 30 times faster than the original ones in the ZX81. These programs use the precision hardware inside the MUZIX box, so now connect your cassette recorder's EAR out to the EAR socket on the box. You will find that the these programs are not only faster than the original, but also much more reliable and less dependent on the volume of the cassette recorder. Usually the optimal volume level is slightly lower than the original. You can be sure that the volume is optimal, if at the beginning of the file - the header - the overload lights up for a moment, but it does not light any more.

On Side 1. of the cassette you will find the SIMULATOR program, recorded twice for safety and on Side 2. the AUDIO EFFECTS, also twice. Then there are two demonstration sound samples recorded on the tape, one on each side. Both of these belong to the SIMULATOR, of course.

Do not forget that the EAR input of the MUZIX box is not separated from the AUDIO IN, so always turn the GAIN and FEEDBACK pot to zero, while loading programs, otherwise your programs will be corrupted.

If you have problems with loading either the loader itself or programs and sound samples, then the most probable causes of a tape loading error can be:

i/ bad quality cassette
ii/ tape head is dirty or worn out
iii/ position of tape head incorrect (tilted)
iv/ tape recorder speed incorrect (wow)

2.2 Escaping from Machine Code

Since the AUDIO PROCESSOR deals with digital audio signals in highly efficient machine code programs, it has no time to waste for the display, so the screen disappears when you enter one of these programs. For convenience in all these programs the Ø key will turn the screen on again. The programs check the state of the ZX keyboard only once in a delay loop, therefore the best practice is to hold the Ø key down until the screen reappears.

2.3 Changing Parameters

Both programs prompt you to enter several numeric values (delay loops, trigger level, transposition, etc.). Do not be surprised if the value appearing on the screen will sometimes be different from the one you have just typed, it is rounded to the nearest acceptable value.

2.4 Input Level

In both programs you have to set the input level with the GAIN pot. Do not worry if the overload LED lights up sometimes. This merely indicates that a clipping occured in the compressor. Make your own experiments, how much can you increase the GAIN without a serious distortion to keep noise as low as possible.

3. MUZIX81 SIMULATOR

If you have a synthesizer with a 1 V/octave CV OUT socket and a TRIG or GATE OUT, you can use the SIMULATOR program. You can use a guitar synthesizer as well. Guitarists are no more limited to the simple synthesizer or guitar sounds! The trigger out should be a voltage trigger, so old synthesizers with a switch trigger output (e.g. MINI MOOG) require an inverter with one transistor or so. First connect these outputs to the appropriate inputs on the MUZIX box.

3.1 MENU Screen

The following screen will appear:

```
R-REC  D-DISP T-TUNE P-PLAY
I-INP  C-CKEY L-LOOP N-NR/L
V-TRIG U-USER B-BKWD G-G/TR
5-<=TR S-SAVE J-LOAD 8-TR=>
```

```
PLAY MODE           NATURAL
DIRECTION           FORWARD
TRUNCATION POINT    16ØØ  MS
LOOP LENGTH         36.5  MS
PEAK VALUE          1Ø    DB
TRIGGER LEVEL       -1Ø   DB
TUNE STATUS         Ø   CENT
KYBD:CKEY;MODE      19  ;TRIG
```

As you see, the screen is divided into two windows, the upper one contains the menu options, the lower one displays the status of the system. In order to explain the meaning of the various options and status parameters in the MENU, let us consider how the program works. Then the different commands will be explained in detail.

The program with the help of the hardware can record, store, edit and replay various musical sound samples. The sound buffer is 44K, it can store sounds approximately 1.6 sec long.

The replay can be made in NATURAL mode, or LOOP mode. Pressing the key N on the ZX keyboard will switch you between these two modes. The presently active mode is shown as PLAY MODE. In NATURAL mode the sound is replayed from the beginning to the end (the so called TRUNCATION POINT) as it was recorded. Use of LOOP mode enables you to play sounds longer than you recorded, because as the end of the sound sample is reached, you can go back somewhere to the middle of the sample (to the LOOP POINT) and start toward the end again, and so on, as long as you hold down a key on the synthesizer. It continues even after you released the key, but then the sound dies out with a RELEASE time given by the setting of the potentiometer on the MUZIX box.

Of course, you cannot jump everywhere in the sample, you have to select the LOOP POINT carefully. There are three ways of doing this, AUTO, QUESTION or MANUAL. For details see the section on LOOP.

The amplitude spectrum as a function of time is displayed in a graphic form by pressing D for DISPLAY on the lower part of the screen. One column indicates the amplitude of the sound averaged over 1K of memory (or about 37 msec). This averaging does not show the PEAK VALUE, though, so it is printed both as a status parameter, and both on the spectrum.

The recording can be made by connecting an external audio source, a microphone, a guitar or a tape recorder to the AUDIO INPUT. The pot GAIN can adjust the input volume, to avoid overload. Pressing R for RECORD will put the system into wait mode: it is waiting for the audio signal to arrive. As soon as the audio signal reaches a pre-determined threshold, the TRIGGER LEVEL, the recording starts, and lasts until the whole sound buffer is full. This TRIGGER LEVEL is also shown as a status parameter.

After the recording was made, it can be replayed, but the system has to learn, where do you want to place it on the keyboard. So you have to select a CENTER KEY (CKEY), which will replay the sample without any frequency shift. Starting from this key, frequency shifts up to one octave and down to any range are possible, activated by pressing the corresponding keys. Also, you can set whether you want to use the keyboard in GATE or TRIG mode (if you have a synthesizer with a GATE out): in GATE mode the sample starts again only after all keys on the synth had been released, in TRIG mode pressing a new key will start the sample from the beginning. You can alternate between them by pressing G on the ZX. The replay can be made either FORWARD or BACKWARD. The two modes can be alternated by pressing B. The status is shown as DIRECTION. Make sure that you entered the CKEY, before you start playing.

The total keyboard can be retuned, up to a semitone, if necessary. The detune is given in cents (100 cent = 1 semitone), it should be entered also that way. The present TUNE STATUS is shown on the lower window as well. A custom tuning is also possible, by pressing U for USER DEFINED TUNE. By pressing a key on the synth then entering its relative tuning in semitones (like 13.26) it can be tuned <u>anywhere</u>, quite far off from the standard chromatic tuning, if you wish to do so.

The detailed description of each of the MENU options is described in the following chapters for reference. Pressing P will put the system into PLAY mode, you can start playing on the synthesizer. Have fun !

3.2 DETAILED COMMANDS

R - REC (Record mode)

Before recording you have to set the correct recording level with the GAIN pot.

On entering RECORD mode the screen disappears and the program waits for an incoming signal. If you decide to escape, you can still do it by pressing 0. The actual recording starts only when the signal level exceeds the predetermined TRIGGER LEVEL. Then the whole available buffer is filled with an approximately 1.6 sec long sample of the input. When this is done, the program automatically displays the bar-chart amplitude diagram of the recorded sample. Pressing any key returns the usual numerical status in the lower window.

I - INP (Input test)

Tests and displays both the control voltage (CV IN) and the AUDIO IN inputs. In the communication lines the following is printed:

```
      PRESENT INPUT  VALUES
  KEYBOARD:    0    AUDIO: 128
```

If there is nothing connected to the MUZIX box, then these readings should appear. The keyboard values are the key serial numbers, so the number should change by 12 for an octave step. In opposite case, or if the keyboard values are not stable, your box needs a slight retune, see CV IN ADJUSTMENT.

If the AUDIO reading is wildly off from 127-128, then follow step vii/ in the CV IN ADJUSTMENT procedure.

V - TRIG (Trigger level adjustment)

The following message appears:

```
   ENTER TRIGGER LEVEL
    IN DECIBEL UNITS
```

Do as it says. The default value at the beginning is -10 dB.

D - DISP (Display sample)

The amplitude spectrum as a function of time is displayed in a graphic form (bar chart) in the lower window. One column indicates the amplitude of the sound averaged over 1K of memory (or about 37 msec). This averaging does not show the PEAK VALUE, though, so it is printed both as a status parameter, and both on the spectrum. The end of the sample is always at the TRUNCATION POINT. If we move this, the sample will be rotated around in memory physically.

C - CKEY (Center key definition)

The prompt is:

PRESS THE MID KEY
PRESS ANY KEY TO CONT

Then the screen disappears, and recovers in about 5 seconds. The proper tuning status of each individual key was calculated during this time.

U - USER (User defined tuning)

Each individual key can be tuned to any relative pitch shift, in a range of +1 to -4 octaves. The following promt will appear:

PRESS NEXT USER KEY
PRESS ANY KEY TO CONT

Press the key to be tuned on the synthesizer, then any key on the ZX.

ENTER TUNING IN SEMITONES

Now enter the tuning of that key in semitones relative to the original pitch of the recorded sample. The value can be fractional, like -3.666. Such a way one can obtain natural scales as opposed to chromatic. When finished, just press NEWLINE.

T - TUNE (Tune the whole kbd)

The prompt that appears is the following:

ENTER TUNING IN CENTS

You can tune the whole keyboard to a chromatic scale this way. The CKEY will also be shifted in pitch, by the amount that you enter. 100 cents are equal to 1 semitone, so you can detune really accurately. It will also be displayed in these units.

L - LOOP (Loop point definition)

The LOOP POINT can be adjusted in this option, which is needed to obtain sustained sounds from a finite length sample. At replay in LOOP mode as the end (TRUNCATION POINT) is reached in the sample, the program jumps back to the LOOP point and plays the sample from there infinitely. The precise adjustment of the LOOP POINT is critical, because incorrect adjustment due to 'rough splicing' causes an audible click or glitch. There are three ways of adjusting the LOOP POINT here. Use them all to get closer and closer to the inaudible loop splicing.

Q:QUESTION A:AUTO M:MANUAL

Pressing Q will give the next prompt:

APPROX LOOP LENGTH IN MSEC?

Typing the appropriate value will overwrite the present LOOP POINT.

Pressing A will call the AUTOMATIC LOOP SEARCH program. It will give the best match for zero glitch in the neighbourhood of the present LOOP POINT.

Pressing M will get you into PLAY mode, the screen disappears. You can press any key on the synthesizer and listen to the sound. Holding 5 or 8 on the ZX will move the LOOP POINT one byte to the left or right, respectively in each loop. If this is slow, holding down 9 and 5 or 8 will move 10 bytes at the time. You can always stop and listen for best match. Press 0 on the ZX to exit for the MENU.

B - BKWD (Backward/forward)

Pressing this key will switch the play direction. It will physically reverse the content of the sound buffer from the beginning to the TRUNCATE POINT, but leaves the rest (beyond TRPT) intact. With a few experiments you will master this. Try to play piano or guitar sounds backwards for shocking effects.

P - PLAY

Puts the system into PLAY mode. The screen disappears, and now you can play on the synthesizer keyboard, you will hear the replayed sample on the output. You can exit by pressing Ø. If playing on the keyboard some of the keys cause a terrible noise, do not panic, only a slight retune is necessary (see CV IN adjustment).

N - NR/L (Natural/loop)

The replay can be made in NATURAL mode, or LOOP mode. Pressing the key N on the ZX keyboard will switch you between these two modes. The presently active mode is shown as PLAY MODE. In NATURAL mode the sound is replayed from the beginning to the end (the TRUNCATION POINT) as it was recorded. Use of LOOP mode enables you to play sustained sounds longer than you recorded, because as the end of the sound sample is reached, you can go back somewhere to the middle of the sample (to the LOOP POINT) and start toward the end again, and so on, as long as you hold down a key on the synthesizer. It continues even after you released the key, but then the sound dies out with a RELEASE time given by the setting of the potentiometer on the MUZIX box.

G - G/TR

You can select whether you want to use the keyboard in GATE or TRIG mode: in GATE mode the sample starts again only after all keys on the synth had been released, in TRIG mode pressing a new key will start the sample from the beginning. Neither of these modes is better than the other, only the music you play can determine which is preferable to the other. You can alternate between them by pressing G on the ZX.

5 - <=TR and 8 - TR=>

After the recording was made, the sound can be shorter than the available space in the sound buffer, so the end of the note can be adjusted, moved around. The replay will always be made until a certain endpoint is reached. This flexible endpoint is called the TRUNCATION POINT. This can be moved only in 256 byte steps, by the keys 5 (left) and 8 (right). Holding down the keys will repeat the function. The samples outside the TRPT will not be lost, however. The changing of the TRTP will physically rotate the sample in the buffer.

S - SAVE and J - LOAD

One can save and load the sound samples on cassette. This is a fast SAVE and LOAD, therefore connect the cassette to the MUZIX box EAR or MIC sockets, then press the appropriate key. If you decide to stop SAVE/LOAD, the usual Ø key will return to the menu.

The keyboard tuning (in order to save tedious USER key definitions) can also be saved and loaded to/from tape, by pressing shift/S and shift/J.

If there is an error in the sample read from the tape,

TAPE LOADING ERROR appears.

The same thing happens if you terminate loading. If the sound sample contains an error, you can try to play, nothing disastrous happens, but if the keyboard table contains an error, the program might crash.

3.3 Advanced Tricks

Note, that you can reverse a part of a recording by using the BACKWARD command in a clever way. Here is an example:

- i/ while in FORWARD, record a single spoken word through a microphone.
- ii/ set the TRPT halfway through the word, so you can play the first half only.
- iii/ press B for BACKWARD
- iv/ now play the first half backwards
- v/ move the TRPT back to the end, so the second half (still in FORWARD mode) is spliced to the end of the reversed first.

The MUZIX box contains a software controllable glitch filter. When you play a sound and then you press a new key, the sample starts again from the beginning. This sudden change usually causes an audible glitch in the sound. The glitch filter is a lowpass filter, which is activated only in the critical 2 ms, and smoothly adopts to the new signal.

Very sharp percussive sounds may still sound better without this filter. Stop the program with the BREAK key, then type

```
POKE 16361,64        to disable the filter
POKE 16361,255       to re-enable the filter.
GOTO 3000    takes back to the main menu.
```

4. AUDIO EFFECTS

All audio effect programs on the MUZIX81 Audio Processor are used for real-time processing of audio signals. When using them, first of all disconnect the synthesizer keyboard and the gate/trigger connection, or permanently latch a key on the keyboard, otherwise the VCA at the output will remain closed, and no audio signal will be heard. The incoming signal (DRY) and the processed signal (EFF) can be mixed with the second pot. A feedback of the EFF output to the input can be made (before the final mix) with the FEEDBACK pot. The present effects are ECHO, REVERB, TRANSPOSER and a DUAL TRANSPOSER. These effects are parts of a single program, called AUDIO EFFECTS. Nine presets can be defined in each effect, and these can be called instantly at the touch of a key.

After the logo appears press any key to continue. Then the main menu is shown:

```
E  -  ECHO          S  -  SAVE
R  -  REVERB        J  -  LOAD
T  -  TRANSPOSER    P  -  PLAY
D  -  DUAL TRANS    Ø  -  ESC
```

Each of the keys (E,R,T,D) will select the corresponding effect. SAVE/LOAD will save/load the presets for later use, P puts the system into the real-time processing machine code loop, while Ø allows you to escape from this loop.

While in the machine code loop, say in ECHO mode, the keyboard is scanned only once in every delay loop, so if you use a 2 sec delay, hold the Ø key down at least that long ! If you press key 3 during PLAY then the preset #3 (within ECHO) is selected. If you press say T then nothing happens first, but after you press a number, say 5, then the Preset TRANSPOSER #5 is reached without going between the menu screens.

In each of the effect screens the key X will get you back to the main menu, P will start PLAY, and Ø will let you escape. Now let us discuss the individual effects a little more in detail.

4.1 ECHO

The ECHO program will produce delays from 1 to 9999 msec. Nine preset delay times are programmable. The presets can be changed on the screen by pressing the appropriate cursor keys, then entering the new values. For each preset the phase can be selected (+ or -). The extreme long delay times can only be realized by decreasing the sampling frequency continously, this is made beyond 1390 ms. For delays shorter than this value the full sampling frequency is used.

Pressing F (for FREEZE) will terminate the input, and whatever sound is currently in the memory will be 'frozen', and will be repeated on and on. Pressing U (for UN-FREEZE) will enable the input again. This can be an exteremely useful effect !

4.2 REVERB

Setting two independent delay times with noninteger realtions to each other and setting an appropriate feedback produces interesting reverb effects. Two delay times are programmable, with their phases. Delay times can be 1-1480 ms. The first delay time should always be longer than the second.

4.3 TRANSPOSER

The TRANSPOSER program will shift the pitch of the incoming signal within a +1 to -2 octave range. The nine presets allow the selection of the pitch shift value in signed fractional semitones (like -1.1) and of the loop length (in msec) where the sample is processed and spliced. Too short loops will give a frequent small click at the splicing point, too long loops will give sometimes a too long delay. Experiment with the loop length for any particular sound. Use of a strong feedback with a long delay can produce interesting scales!

4.4 DUAL TRANSPOSER

The DUAL TRANSPOSER will shift the incoming signal to two different frequencies simultaneously. The presets work otherwise like before. There are three possible volume ratios between the two voices, move between them by pressing V. The loop length cannot be arbitrary in this program. You can enter arbitrary values (up to 700 msec), but they will be rounded to the nearest allowed values.

5. CV IN ADJUSTMENT

Although the MUZIX81 AUDIO BOX has been adjusted carefully to 1 V/octave, it may be necessary to tune it to your synthesizer. In order to do this, take the following steps:

i/ Unscrew the bottom plate, and you will find 4 holes on the main circuit board. You can access the trimming pots 1-4 through these holes. The functions of these pots are :

1 - AUDIO OFFSET
2 - GENERAL OFFSET
3 - CV GAIN
4 - VCA OFFSET

#2 and #3 are involved in tuning to your synthesizer.

ii/ Load the SIMULATOR program and enter I (INP) mode. On the left of the screen you can see the keyboard input values. If there is no keyboard connected, the number should be Ø.

iii/ Now connect your synthesizer, then press the key at the low end of your keyboard. A small number should appear, but it must be at least 1. Say, it is 4. Now adjust pot #2 until the number fluctuates between 4 and 5, and turn the pot back slightly, until you get a steady reading of 4 on the screen.

iv/ Press a one octave higher key. Normally, a value 12 higher should appear (1 octave = 12 semitones), 16 in our example. Now adjust pot #3 up to the point where the number changes to 17, then turn slightly back, until you reach a steady 16.

v/ Repeat this procedure several times, if necessary. Also try differences of two octaves or more. If it is correct, then the CV GAIN is correctly adjusted now.

vi/ Press the original key and adjust pot #2 left and right; note the point where it flips between 4 and 5, and where it flips between 3 and 4 (in our example). Set it halfway between these points.

vii/ All through this procedure the AUDIO INPUT reading should be 127 or 128. Adjust it with pot #1, if necessary.

viii/ The pot #4 can minimize the glitch caused by opening the VCA but it is unlikely, that you have to adjust this.

6. TECHNICAL SPECIFICATIONS

- Uses Sinclair ZX81 computer with 64K memory, also the 8-16K area is used by the programs. Recommended memory is DOWNSWAY 64K.
- Sound samples are stored in 44K.

The box has four potmeters and a LED overload indicator. The potmeters have the following functions (left to right):

a/ GAIN - sensitivity of the audio input
b/ MIX - mixes the EFFECT output to the incoming (DRY) signal
c/ FEEDBACK - feeds back the EFFECT output to the audio input
d/ RELEASE - release time of an envelope driving a VCA, controlled by the GATE IN.

The pots b/ and c/ are used in the AUDIO EFFECTS programs, d/ is used in the SIMULATOR.

Here are some technical details presented about the Audio Processor:

AUDIO INPUT	: 6.3 mm jack
input level	: 400 mV
AUDIO OUTPUT	: 6.3 mm jack
output level	: 800 mV
EAR (input from cassette)	: 3.5 mm jack
acceptable level	: 25 mV to 2500 mV
optimal level	: 250 mV
MIC (output to cassette)	: 3.5 mm jack
output level	: 5 mV
CV IN	: 6.3 mm jack
input scale	: 1 V/oct quantized
GATE IN	: 6.3 mm jack
input range	: 12 V > U > 3.5 V - key on 2 V > U > -5 V - key off
Total signal to noise ratio	: 80 dB
Sampling rate	: 24 kHz to 37 kHz depending upon the software
Power consumption	: 9V and 160 mA, from the ZX bus