Topic AY8910 from EPARTS FAQ base

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 From : Leonid Kirillov                    2:5030/106.11   Thu 06 Apr 95 14:00
 Subj : AY-8912
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The AY-3-8910/8912 sound synthesizer IC.
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Overview
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The AY-3-8910/8912 is a sound generator IC containing three tone generators
and a white noise generator. In addition to its sound producing capabilities,
the AY-3-8910 has two 8-bit I/O ports and the AY-3-8912 has one.

Pinouts (for the AY-3-8912 only)
--------------------------------

               +----+--+----+
Channel C out -+  1 |__| 28 +- DA0
               |            |
       Test 1 -+            +- DA1
               |            |
          +5V -+            +- DA2
               |            |
Channel B out -+            +- DA3
               |            |
Channel A out -+            +- DA4
               |            |
          GND -+            +- DA5
               |            |
         IOA7 -+            +- DA6
               |            |
         IOA6 -+            +- DA7
               |            |
         IOA5 -+            +- BC1
               |            |
         IOA4 -+            +- BC2
               |            |
         IOA3 -+            +- BDIR
               |            |
         IOA2 -+            +- A8
               |            |  _____
         IOA1 -+            +- RESET
               |            |
         IOA0 -+ 14      15 +- CLK
               +------------+


DA0-DA7 are multiplexed data and address lines, as used in the range of GI
processors that this IC was originally part of. The BC1 and BDIR pins are
used to control the IC as follows:

Function       BDIR   BC1

Inactive         0     0
Read             0     1
Write            1     0
```

Latch address 1 1

In addition to using BC1 and BDIR, A8 should be taken high to enable the chip. IOA0-IOA7 are the input/output pins (the AY-3-8910 has an additional set marked IOB0-IOB7). The IC does not contain an internal oscillator - the clock input to the CLK pin should fall between 1MHz-2MHz, so a typical Z80 system's clock would need to be divided.

Registers

The AY-3-8910/8912 contains 16 internal registers as follows:

Register	Function	Range
0	Channel A fine pitch	8-bit (0-255)
1	Channel A course pitch	4-bit (0-15)
2	Channel B fine pitch	8-bit (0-255)
3	Channel B course pitch	4-bit (0-15)
4	Channel C fine pitch	8-bit (0-255)
5	Channel C course pitch	4-bit (0-15)
6	Noise pitch	5-bit (0-31)
7	Mixer	8-bit (see below)
8	Channel A volume	4-bit (0-15, see below)
9	Channel B volume	4-bit (0-15, see below)
10	Channel C volume	4-bit (0-15, see below)
11	Envelope fine duration	8-bit (0-255)
12	Envelope course duration	8-bit (0-255)
13	Envelope shape	4-bit (0-15)
14	I/O port A	8-bit (0-255)
15	I/O port B	8-bit (0-255)

Notes:

- The AY-3-8912 does not contain register 15.
- The volume registers (8, 9 and 10) contain a 4-bit setting but if bit 5 is set then that channel uses the envelope defined by register 13 and ignores its volume setting.
- The mixer (register 7) is made up of the following bits (low=enabled):

Bit: 7	6	5	4	3	2	1	0
I/O B	I/O A	Noise C	Noise B	Noise A	Tone C	Tone B	Tone A

The AY-3-8912 ignores bit 7 of this register.

Envelopes

The AY-3-8910/8912 contains the following preset envelopes or waveforms (set using control register 13). Note that these affect volume only and not the pitch:

0	_____	single decay then off
4	/|_____	single attack then off
8	\\|\\|\\|\\|\\|\\	repeated decay
9	_____	single decay then off
10	\/\/\/\/\/\	repeated decay-attack
11	\\|‾‾‾‾‾	single decay then hold
12	/|/|/|/|/|/	repeated attack
13	/‾‾‾‾‾	single attack then hold

```
14      /\/\/\/\/\      repeated attack-decay

15      /|_________     single attack then off
```

Pitch values

The course and fine pitch registers for each channel are used in the following fashion (assuming channel A):

Registers 0 and 1 operate together to form channel A's final pitch. The eight least significant bits are sent to register 0 and the four most significant bits are sent to register 1. The output frequency is equal to the IC's incoming clock frequency divided by 16 and then further divided by the number written to the course and fine pitch registers, so the higher the number written to these, the lower the pitch. For example, if a frequency of 1KHz was required and the IC's clock frequency was 1MHz, a total division rate of 1000 would be needed. The sound generator itself divides by 16 so the course and fine pitch registers must provide a further division by 62.5 (due to the fact that 1000/16 is 62.5). A division rate of 62 or 63 will be accurate enough, since the registers can only store whole numbers. Therefore, 62 or 63 would be written to register 0 and 0 would be written to register 1.

The following frequency table may be useful in musical applications:

Note	Frequency (Hz)	Note	Frequency (Hz)
A	220	D#	311.1
A#	233.3	E	329.63
B	246.94	F	349.23
middle C	261.63	F#	370
C#	277.2	G	392
D	293.66	G#	415.3

Applications

The AY-3-8910/8912 (and derivatives) has found its way into a variety of home computers and games consoles including the following:

- Sinclair ZX Spectrum 128/+2/+3
- Amstrad CPC 464/664/6128
- Mattel Intellivision
- BBC Micro
- Atari ST
- Sega Master System

There are also a couple of emulators available at the time of writing:

- "Z80" - the Spectrum emulator by Gerton Lunter for PCs and compatibles which utilises the Adlib sound generator present on most Soundblaster-compatible cards. This package fully emulates the Spectrum 48/128 and is well worth looking at.
- "DeliAY" - by Patrik Rak for the Commodore Amiga. This comes as an add-on for "DeliTracker" (a music player) and emulates a Z80 and AY-3-8912 (in a Spectrum-like fashion) giving very accurate results. A growing number of Spectrum tunes are being gathered together to run under this player.

ZX Spectrum 128 specifics

The Spectrum's "control" and "data" output ports are as follows:

- control = 65533
- data = 49149

So, to produce a simple sound from BASIC ...

```
10 LET ayctrl=65533
```

```
        20 LET aydata = 49149
        30 OUT ayctrl,7 : REM select the mixer register
        40 OUT aydata,62 : REM enable channel A only
        50 OUT ayctrl,1 : REM channel A course pitch
        60 OUT aydata,50 : REM set it
        70 OUT ayctrl,8 : REM channel A volume
        80 OUT aydata,15 : REM set it to maximum
```

.... or from assembler ...

```
        ayctrl  EQU     65533
        aydata  EQU     49149

        start   ld      d,7             ; select the mixer register
                ld      e,62            ; enable channel A only
                call    outer           ; send it to PSG
                ld      d,1             ; channel A course pitch
                ld      e,50            ; pitch value
                call    outer           ; send it to PSG
                ld      d,8             ; channel A volume
                ld      e,15            ; maximum
                call    outer           ; send it to PSG
                ret

        outer   ld      bc,ayctrl       ; select control port
                out     (c),d           ; send specified value
                ld      bc,aydata       ; select data port
                out     (c),e           ; send specified value
                ret
```

For an easy way to generate the required course and fine pitch values, try the following program:

```
        10 INPUT "Note value ",n
        20 INPUT "Octave ",o
        30 LET f=INT(n/2^o)
        40 LET c=INT(f/256)
        50 PRINT "Fine = ";f;"  Course = ";c
```

The pitch values required by this program are as follows:

Note	Value	Note	Value
C	3421	F#	2419
C#	3228	G	2283
D	3047	G#	2155
D#	2876	A	2034
E	2715	A#	1920
F	2562	B	1892

References

Micro Interfacing Circuits - Book 2, by R. A. Penfold, ISBN 0-85934-106-2,
Spectrum 128 manual, (c) 1986 Sinclair Research Ltd,
Sinclair User magazine, 1986 (issue unknown).

This text was entered by Alastair Booker on 4th April 1995. Please feel free to contact me regarding anything contained in this document. I have produced a generic AY-3-8912 interface circuit for Z80-based systems and will make this available to anyone who requires it.

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