AY3-8910/YM2149 based sound-card for Z50Bus

Assembly guide

Version 0.1

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Introduction

The Z50AYMSound is a chip-sound card designed around the General Instuments AY3-8910 and the compatible Yamaha YM2149 sound chips. The AY3-8910 is a 3-voice programmable sound generator, and was a widely used chip, appearing in famous computers such as the Amstrad CPC, the MSX-line and probably most famously was used with the ZX Spectrum computer from Sinclair. The YM2149 is a directly pin-compatible version of the '8910 made by Yamaha, and used in the Atari ST. As such there exists a vast library of music created for these chips, much of it in ProTracker format which can be played directly using the Z50AYMSound card. Of course the card is not limited to playing back tunes created by others. What you use the card for is fully in your control.

The card features:

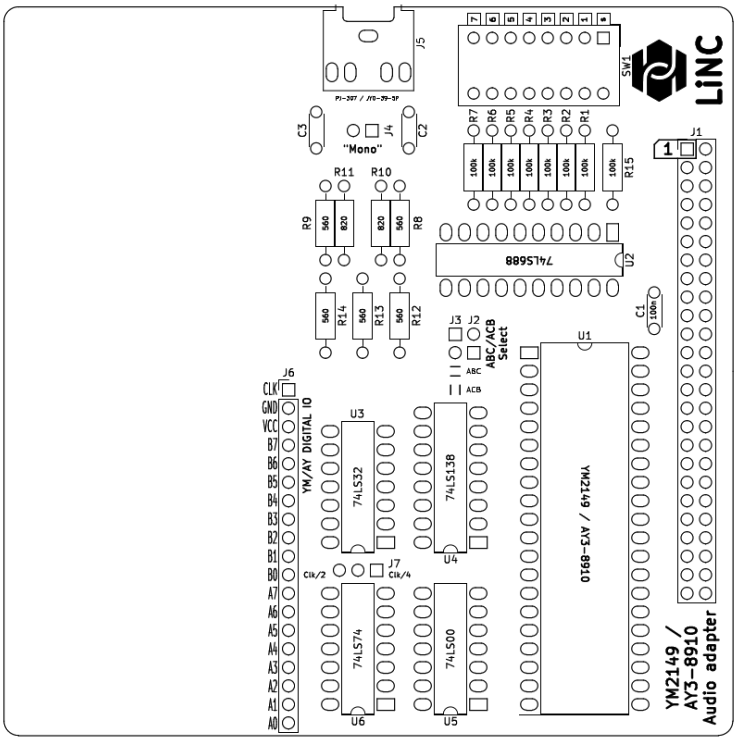
- Z50Bus interface, designed to work with LiNC80 SBC1 and other Z50Bus based microcomputers.
- Stereo line out, user selectable ABC/ACB.
- Header for the two 8-bit digital I/O ports that the sound chip has built-in.
- I/O address fully decoded to any even base address.
- Generous prototyping area where you can build your own clock- or filter-circuits, or anything else you want.
- The audio frequency clock is by default derived from the CPU clock, and can be set to Clk/4 (YM) or Clk/4 (AY).

Note the the YM and AY chips are both end of life. eBay often has these available, which are either pulled from old hardware or Chinese clones. Because of this, I will only supply this kit without the YM/AY chip, and you will have to source this yourself.

KiCAD schematic and layout, as well as example code, can be located at https://github.com/linc80/Z50AYMSound

Parts list

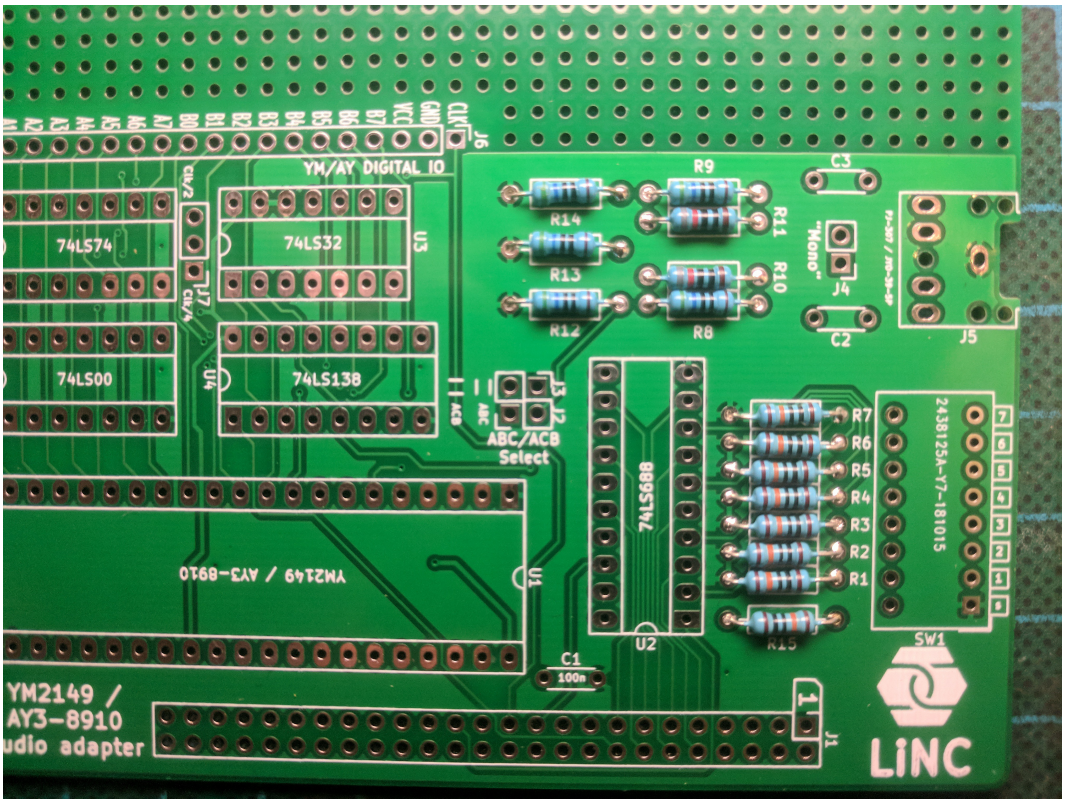
Part type	Value/designation	Positions
1x Capacitor, ceramic	100n	C1
2x Capacitor, ceramic	220n	C2,C3
8x Resistor, radial	100k	R1,R2,R3,R4,R5,R6,R7,R15
5x Resistor, radial	560R	R8,R9,R12,R13,R14
2x Resistor, radial	820R	R10,R11
1x Sound Chip	AY3-8910 or YM2149	U1 **(Not included in kit)**
1x Logic IC	74LS688	U2
1x Logic IC	74LS32	U3
1x Logic IC	74LS138	U4
1x Logic IC	74LS00	U5
1x Logic IC	74LS74	U6
1x Connector, 50 pin male angled	Z50Bus	J1
1x Stereo Jack connector	PJ-307 / JYO-39-5P	J6
3x Pin headers w/jumpers	2x2, 1x2, 1x3	J2+J3, J4, J5
1x DIP Switch, 8 positions	SW_DIP_x08	SW1
6x Sockets	Assorted	1 per IC
1x PCB		



Assembly

Step 1: Add resistors

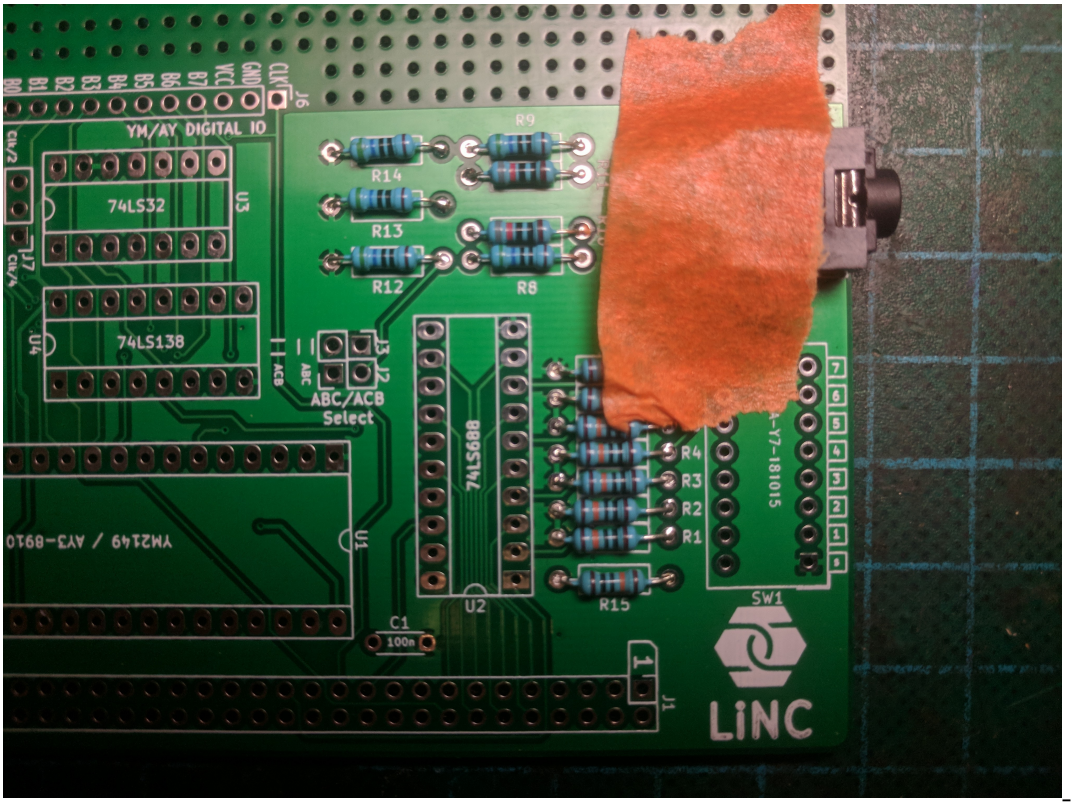
Start with the 100k resistors. These are all located between U2 and the DIP-switch SW1, and are labeled R1 through R7, and R15. Next, add the two 820Ohm resistors R10 and R11. You should now have five remaining resistors to mount, all 560Ohm, with labels R8, R9, R12, R13 and R14.



All resistors mounted. Pay attention to the values when assembling.

Step 2: Add audio jack

The location J6 for the audio jack is fairly easy to spot, as there is a notch on the side of the PCB as part of it's position. Place it in its location, and add a piece of tape across it to hold it in place while you flip the board. Secure it by soldering in the middle pin, then remove the tape and inspect that the connector sits close and flat with the board. Adjust if needed by heating the middle pin while applying pressure to the connector. When the connector is properly aligned, solder the remaining four pins.

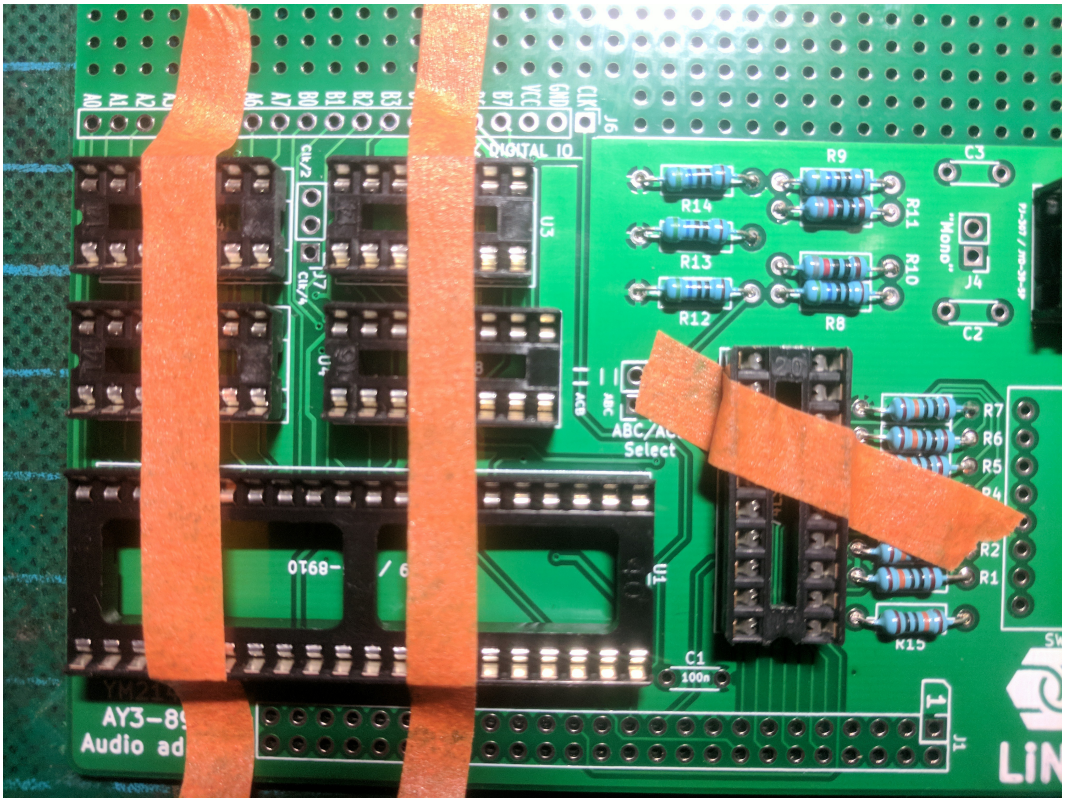


Audio jack covers the notch in the side of the card in this picture.

Step 3: Add IC sockets

There are three 14-pin IC sockets, one 16-pin, one 14 pin and one 40 pin socket. Make note of their orientation, fit them with the notch matching the legend on the PCB. By making sure the socket clearly indicates the correct orientation in relation to pin one, you avoid mistakes when the IC components get installed later.

One suggested tip for mounting the sockets follows:
Place all the sockets in their positions before soldering. Use painters masking tape to hold the sockets in position, so they stay in place when you turn the board over. Once the board is turned so the pins are facing you, solder the pins on opposing corners of each socket. You can now remove the painters tape. Inspect how well seated the sockets are. If a socket is misaligned, heating the already soldered pins lets you tweak its position. Once all sockets are properly located, the remaining pins can be soldered in one go.



Using painters tape to temporarily hold IC sockets

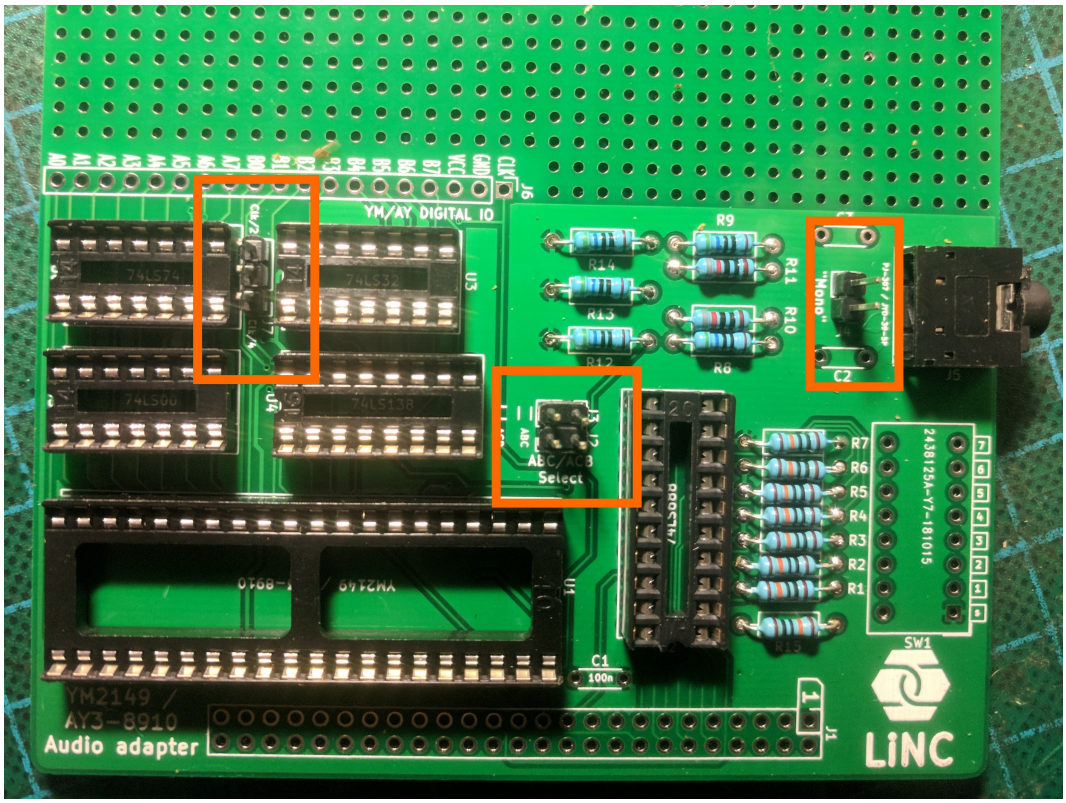
Step 4: Add the jumpers

The build uses one 1x2 pin jumper (J4), one 2x2 pin jumper set (J2+J3) and one 1x3 pin jumper (J7).

J4 can be used to short Right and Left audio channels to create a “pseudo mono” output (note that you can not use a Mono jack connector with J4 shorted, as this will short all audio to Ground). This jumper is located next to the audio jack.

J2+J3 allows selection of ABC or ACB stereo. The location for this ABC/ACB selector is next to pin 1 of the U1 AY/YM socket.

J7 is located between U3 and U6, and is used to source the audio clock for the AY/YM chip. The options allow selection between CPU-clock divided by four (jumper pins 1-2, jumper on the side of U1), divide by two (jumper pins 2-3, jumper on side of the prototyping area), or you can omit the jumper, and build your own clock source on the prototyping area and feed its clock output to the middle pin (pin 2 of J7).



Jumper locations, seen left-to-right are J7, J2+J3, J4

Step 5: Add the DIP switch

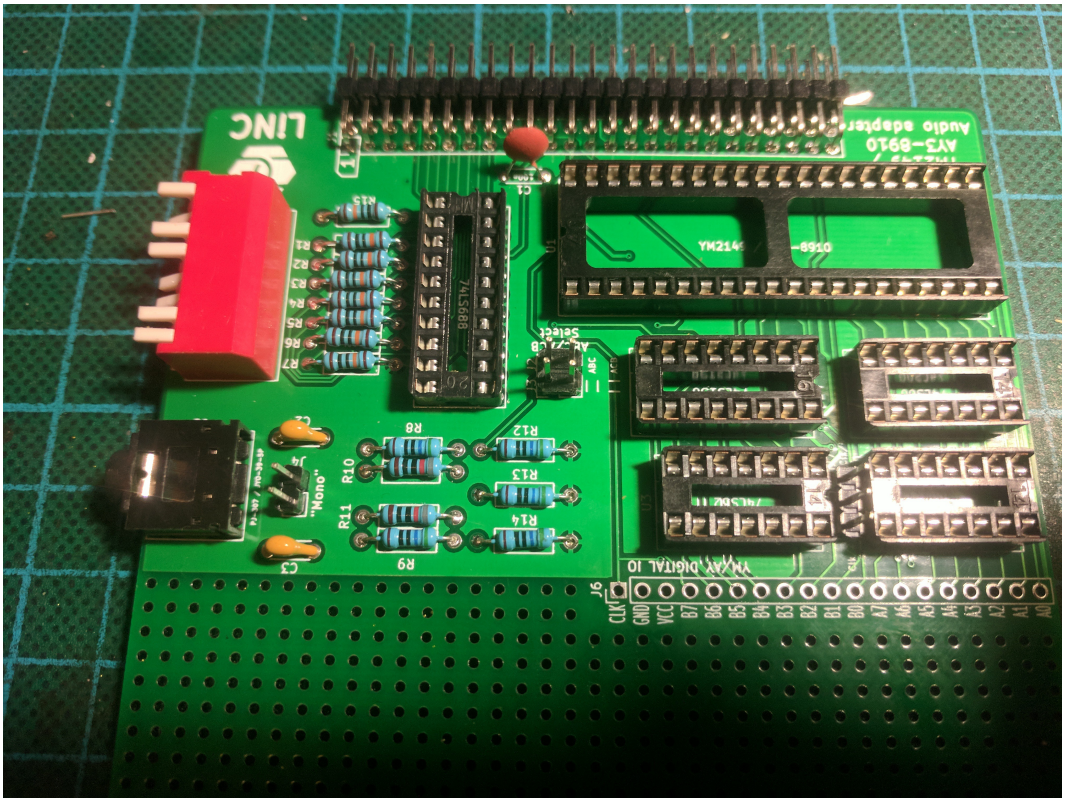
For the 8-position DIP switch, you can use the trick of holding them in place with painters tape while starting the soldering. Your kit may contain either sliding style or piano style switches. For the piano style, it is preferential to follow the silkscreen when orienting. For the sliding style, observe the switch body marking for ON position, and select an orientation that makes sense to you.

Step 6: Add the Z50Bus connector

The right-angled 50-pin connector gets fitted so the pins extend out over the edge of the PCB, so that it can be inserted into your host Z50Bus or back-plane. Insert and align the connector, and tack it in place on two diagonally opposed pins. Check the alignment, and adjust as needed before proceeding to solder the remaining pins.

Step 7: Add the capacitors

The decoupling capacitor C1 (100nF) is located directly next to the 50 pin Z50Bus connector. The audio output capacitors C2 and C3 (220nF) are located directly next to the audio jack. The 220nF caps included in the kit as C2/C3 are selected for good dynamic when used as a line-out signal, feeding an amplifier or active speakers. If you plan on primarily using headphones, these should be replaced with capacitors of value in the 10-47uF range. If you do this, and use electrolytic caps, use 12V or higher rated ones, and place them so the negative polarity points to the jack connector.



Location of Z50Bus connector and capacitors, and orientation of connector. Also shows the default address 0x32 selected on the DIP switch SW1

Step 8: Clean and dry the board, inspect

The typical implementation of a Z50Bus is unbuffered, which means that any impedance issues on an expansion card may make the whole system unstable, or inoperable. An example of an unbuffered Z50Bus system is the LiNC80 SBC1. You may be surprised that most rosin based fluxes are to some degree conductive. This is extra true if the flux has by accident been overheated and started carbonizing. Because of this, the board needs to be thoroughly cleaned when the soldering has been completed.

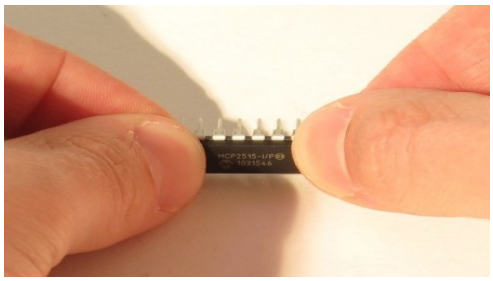
To dissolve organic rosin based fluxes denatured alcohol (methylated spirits) or citrus based cleaners work very well. Do NOT use acetone or acetone based cleaners, as they will damage the plastic parts assembled on the board. Isopropyl/isopropanol is not suited, as it fails to properly dissolve the organic rosin (even if it otherwise is a very good cleaning agent). Use a toothbrush or similar brush to clean the board. You may after cleaning with alcohol or spirits use mineral-free water to rinse the underside of the board. If you used a citrus based cleaner, rinsing is required. After cleaning, the board needs to dry completely.

After cleaning, do a thorough and complete inspection. Look for solder bridges, cold or incomplete joints and similar defects. If you find problems during inspection, you should be able to correct them, but remember to clean the board again if you need to add (or remove) solder.

Step 8: Installing integrated circuits.

When installing (and preparing to install) the integrated circuits into their sockets, remember that these are all static sensitive devices, and should be treated with ESD precautions.

When you first receive just about any DIP IC, the legs will not be perpendicular to the main chip body. They will bend out slightly. To be able to install them in sockets without issues, the pins will need to be adjusted slightly. Carefully bend either row of pins evenly inwards by a small amount by pressing against a flat surface (eg. tabletop).



When installing the components, pay attention to pin one, normally indicated by a dot by pin one and/or a half-circle on the short edge where pin 1 is located. Pin one is indicated on the silk-screen by a half-circle/crescent on the pin-one side.

Preparing for use

The DIP switch SW1 selects the I/O address of the card. This simple digital I/O card uses a pair of I/O address in the 0x00 to 0xFF range. The address is selected by setting SW1 so it creates an even 8-bit value for the address bus (the second, odd address in the pair, is taken from the LSB of the address bus).

The switch has indicators 7 through 1, and “s”, where “s” is connected to an YM2149's clock select line, and the numbers 7 through 1 represent the address lines A7...A1. A7 is the most significant bit, A1 the second least significant. Setting an address switch to the OFF position (up for piano-style, away from the ON marker for sliding style) provides a Low signal through pull-down resistors, and a High when set to the ON position. The Select line is inverse of this, with a Pull-up resistor in the OFF, and conneecting the line to Ground in the ON position (when using an AY3-8910, leave the “s” switch in the OFF position).

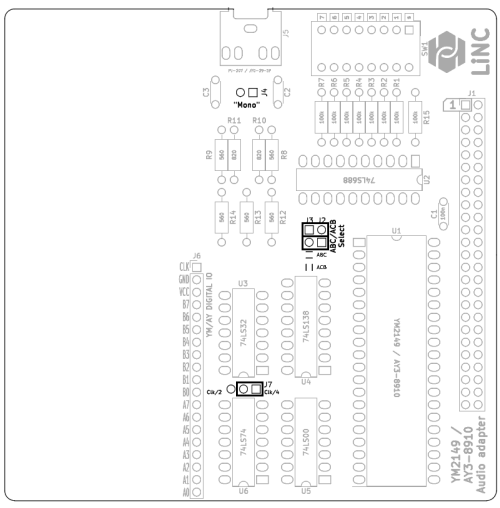
The “default” or “official” address is 0x32, as this is the address used in the example source code, and allocated in the LiNC80 official add-on address map.

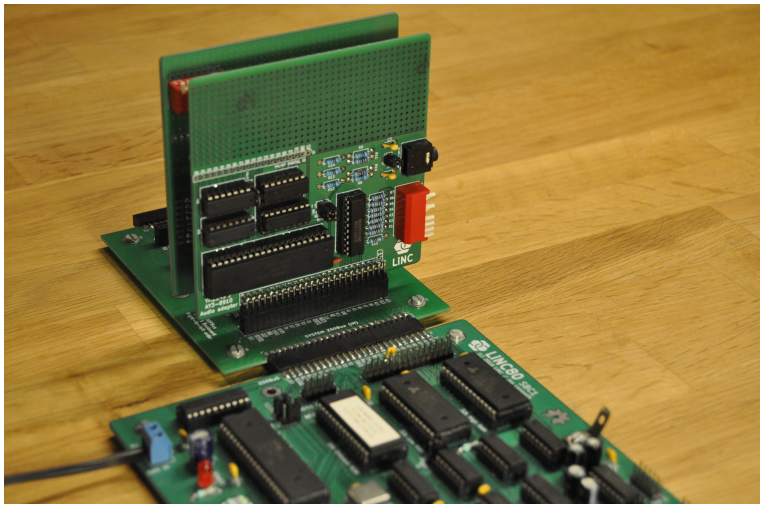
The following picture shows the default jumper settings. The audio clock speed jumper J7 is set to Clk/4 (quarter CPU-clock). The “Mono” jumper J4 is left un-jumpered.

The ABC/ACB selection decides how the three AY-3-8912 output channels (A, B and C) are mixed to create stereo output channels (left and right). This stereo mixing scheme is based on, and correctly reproduces music made for, the stereo capable AY3-8910 sound devices (or modifications) created for 8-bit computers like the Sinclair ZX Spectrum. This means that if you want to hear a song as it was arranged, you should select the correct channel mixing. There are two common mixing standards:

- ABC: A is mixed to right, B to left and right, and C to left (common in west-Europe).
- ACB: A is mixed to right, C to left and right, and B to left (common in east-Europe).

The ABC/ACB jumpers is set to ABC by straddling J2 and J3 (if you prefer or will be playing mostly ACB sound, set the jumpers 90 degrees to what is shown in the picture)





Card installed on a LiNC80 with Z50Bus back-plane,
with address set to non-default 0x50, and jumpered for ACB stereo.

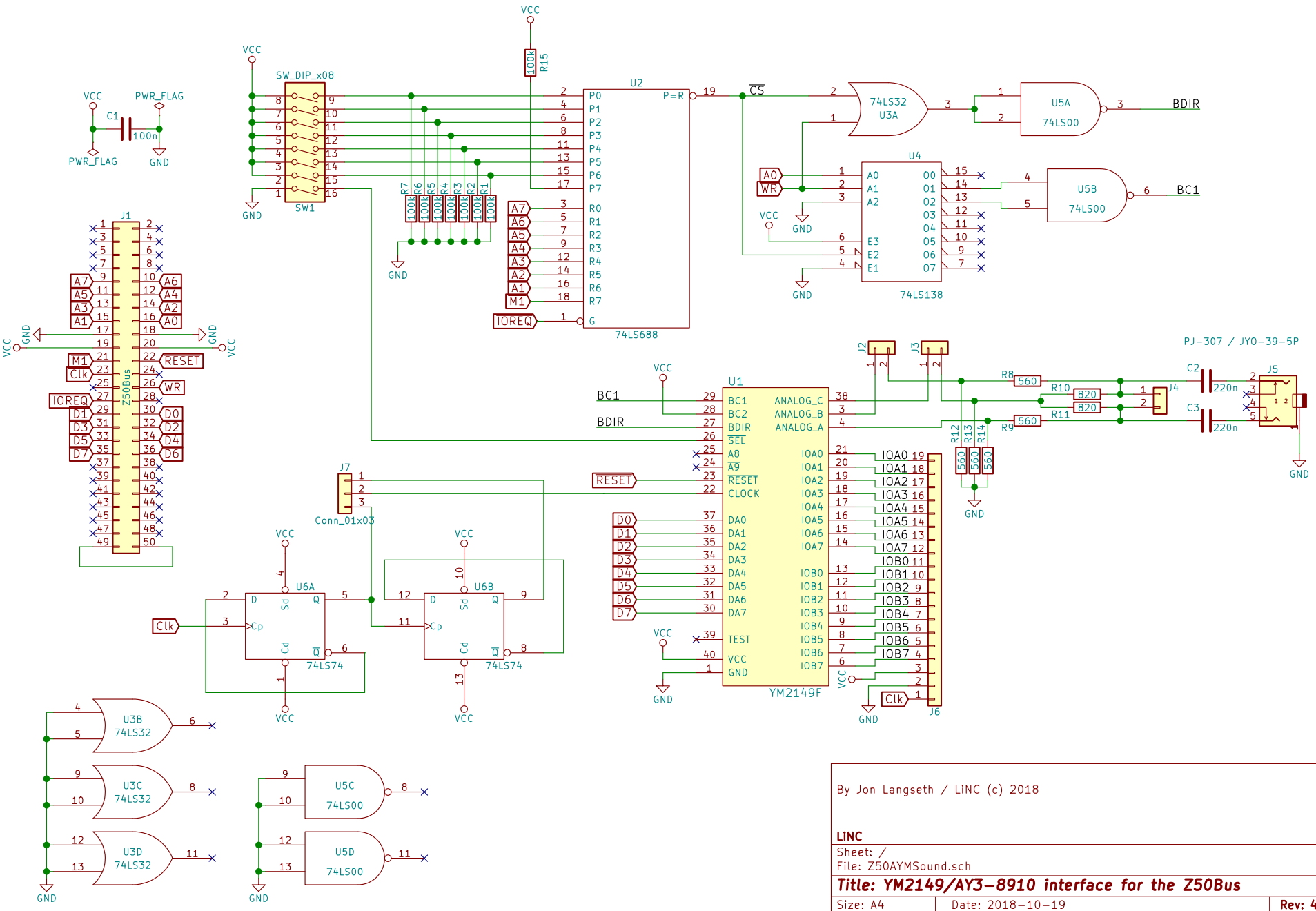
When your card is fully soldered, cleaned and assembled, and your jumpers and DIP settings set to their defaults, you are ready to install it onto a Z50Bus. Install it either on a backplane, or directly to the host microcomputer. Connect the stereo jack output to the Line in of an audio system or powered speakers. If you choose to use headphones, and did not substitute the output capacitors as described in Step 7, it will work, but the sound will be “tinny”.

You can start testing the sound output directly from SCMonitor on your LiNC80 SBC1:

SCMon command	Description
o 33 7	Select Mixer register
o 32 ff	All mixer channels off
o 33 8	Select Channel A Volume register
o 32 9	Fixed Volume = 9 (01001 binary)
o 33 9	Select Channel B Volume register
o 32 0	Fixed Volume = 0
o 33 a	Select Channel C Volume register
o 32 0	Fixed Volume = 0
o 33 1	Select Channel A frequency, coarse tune
o 32 1	Rough tone adjust = 1
o 33 0	Select Channel A frequency, fine tune
o 32 ff	Fine tone adjust = ff
o 33 7	Select Mixer register
o 32 fe	Turn on Channel A Tone only

More examples using SCMonitor and BASIC, as well as the schematics, documentation for the AY/YM chip, and a port of the famous PTxPlayer along with some example tunes can be downloaded from the source repository at https://github.com/linc80/Z50AYMSound/

More info and links are located at http://linc.no/products/z50bus-ay3-8910-ym2149-sound-card/


VCC
PWR_FLAG
C1
100n
GND
SW_DIP_x08
SW1
R15
100k
R7
R6
R5
R4
R3
R2
R1
U2
74LS688
P=R
CS
74LS32
U3A
U5A
74LS00
BDIR
U4
74LS138
A0
WR
U5B
BC1
J1
Z50Bus
RESET
IOREQ
M1
Clk
D0
D1
D2
D3
D4
D5
D6
D7
U1
YM2149F
BC1
BDIR
SEL
RESET
CLOCK
TEST
ANALOG_A
ANALOG_B
ANALOG_C
J2
J3
J4
J5
J6
J7
Conn_01x03
PJ-307 / JYO-39-5P
R8
R9
R10
R11
R12
R13
R14
560
820
C2
C3
220n
U6A
U6B
74LS74
U3B
U3C
U3D
U5C
U5D
74LS00
By Jon Langseth / LiNC (c) 2018
LiNC
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Title: YM2149/AY3-8910 interface for the Z50Bus
Size: A4
Date: 2018-10-19
Rev: 4
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Id: 1/1