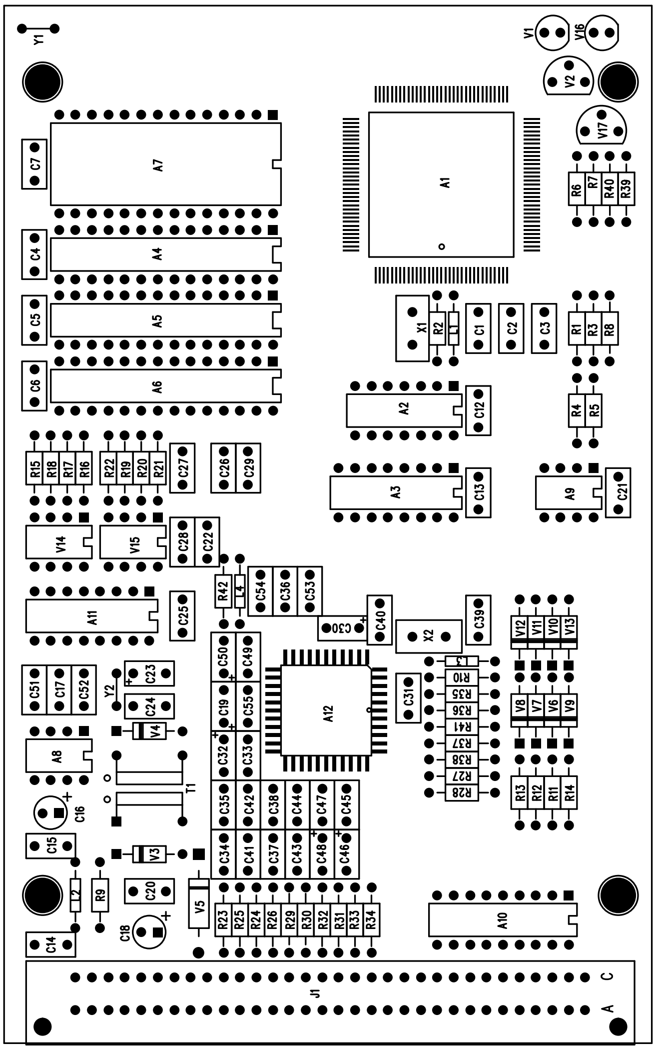

Figure 32: The PCB of the DSP CARD 4.

Take the DSP out of the container **very carefully!** The leads are very thin and very easy to bend. Put the chip on its place and while your husband/wife/boyfriend/girlfriend[10] is holding it steady, solder one lead on one corner. After this the chip can be moved a little bit and now you should adjust it as accurately as possible to its final place. As the pads are very close each other it is not helping the soldering if the leads are in the middle of the gaps, figure 33. When you think the chip is on right place (a magnifying glass may help to make the decision) you can solder rest of the corners. This is the last moment to check if the chip is right way round, the dot should be towards the euro connector.

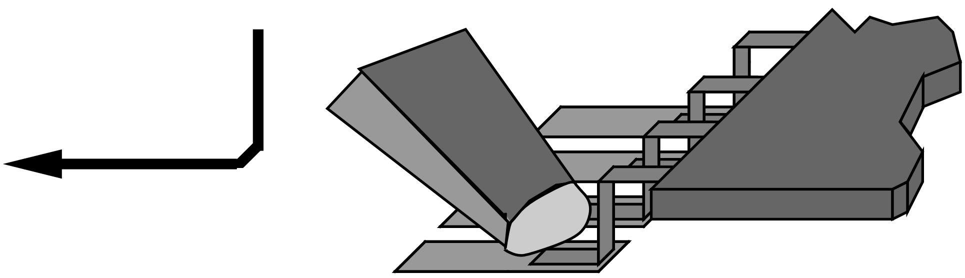

Figure 33: Soldering the DSP.

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[10]Please select the most appropriate item in your case.

Tilt the board so that the extra solder will flow out from the chip and not between the legs (of the chip I mean..). Solder two-three leads at time. Keep the (always clean) tip on the ends of the leads to heat them and pads some seconds and add solder. At almost the same instant pull the tip down towards you to remove any extra solder.

Then the secret to a good result: be brave! (It should be easy since if you were chicken-shit you weren't even reading this.) By hesitating you certainly mess up the whole thing. If you get short circuits between the legs add solder!! This might seem contradictory but this really helps since shorts and bridges are usually generated because of lack of flux. If you have electronics grade loose flux, it is of course best to use it. If the short circuit is very difficult, remove extra solder by normal means and then add fresh solder with flux. **DON'T PANIC!**

We have soldered now four boards with this technique and they are all working. In case of difficulties, a good magnifying glass or microscope is very helpful. If the board reboots when you tap on it or twist it, it is a clear sign of bad soldering joint in this chip.

Finally some encouraging words: totally ten DSP-chips have been tortured during the history of Alef Null and all of them are still working today. For example in the first experiment of soldering a CQFP a blowtorch was used (not exactly but very nearly...). The PCB darkened and the DSP was so hot that water was boiling on it[11]. After soldering the chip with the method described in the preceding paragraph, it was functioning perfectly. The chips have been dropped from the table, handled after handling a cat during a very cold weather, used accidentally with a supply voltage of 6 Volts and short-circuited some output signals to ground. What a robust chip!

Soldering the codec

Codec is in a PLCC package, which has leads bended under the chip. Again solder one corner first (the slit in the corner is towards the codec crystal) and then fine-adjust the orientation. Push the soldering tip between a pad and lead and warm a couple of seconds. Then add solder and pull the tip away. The solder should fill the gap between the pad and the lead, figure 34.

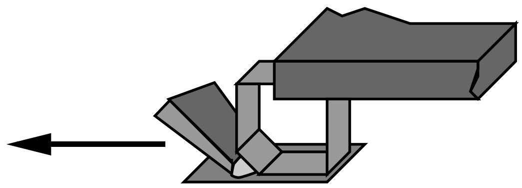

Figure 34: Soldering the codec.

Soldering resistors and diodes.

The rest should be easy, solder the lowest components first and twist the leads a little, so that the components stay on place during soldering. All resistors and diodes are using 10.2 mm (400 mils) pitch, you may therefore make your life easier by constructing a jig for bending the leads. Warm the pad until solder fills the holes. Note polarity of the diodes, cathode is marked by a line (or circle) in both the diodes and the silk screen.

IC's and sockets

We have decided to use sockets only with four IC's: the regulator (MAX 738A, A8), RS232 line interface (MAX 232A or MAX202, A11), the output driver (ULN 2803, A10) and EPROM/FLASH (27256, A7). One good way to solder the DIL components is to hold them in place with a finger while turning the PCB around and soldering first two corner pins (don't put your finger on the pin you are soldering!). All the DIL's are oriented so that when the euro connector is at left, the slit marking pin 1 is towards you.

[11]Alef Null is not encouraging the imaginative experimenter to reconstruct this experiment...

The rest of the components

Note again the polarity of the LED's, transistors and tantalum capacitors which are, clearly marked on the silk screen. All the capacitors have 5.1 mm (200 mils) pitch (except electrolytes which are 100 mils), so you are advised to do your shopping according to that. Leave the crystals a half of a millimetre off from the board so that the metallic case won't short circuit the tracks under the crystal (it is not very probable, thanks to the solder mask, but it's best to be sure).

Ground connection for scope

Note the component Y1, which is a small loop of bare wire to connect the oscilloscope ground during difficulties.

Power isolation loop

The component Y2 is also a small loop of bare wire to connect power supply to the +5V power line to the rest of the board. This loop can be used to isolate the power supply from the rest of the components on the board. This is usefull when testing the power supply or when injecting an own +5V source to the board.

Euro connector

First install the connector mechanically with 2.5 mm (or equivalent) screws and after that solder it on its place. You are advised to use the connector, since it makes debugging a lot easier.

Chip caps

There are places for four 100 nF chip capacitors underneath the DSP chip. They damp the high-frequency current spikes the DSP is generating. Most likely they also lower the EMI noise level of the board.

Solder one side first. As you notice, when you heat the pad you can move the component easily (or it moves by itself...). A toothpick is very good tool holding it still. After you have it on the right position, let the connection to cool and solder the other end very quickly so that the first connection won't melt.

You may use normal capacitors with very short leads, although we haven't tried them.

Testing

Power supply

Do not solder the loop Y2 first. When all components are soldered on the board, then it is time to connect power to the board. Connect an 50Ω 0.5W resistor from Y2 to ground. This is light load for the switcher chip. Then connect the power to the `POWER` pin and gound pin. Correct voltage level of the input power is between 6–16V. Check that the voltage level on the Y2 is between 4.75–5.25V. If not check A8 and V3. Vary the input voltage between 5–6V and notice that the switcher should shut down itself properly when the voltage gets too low (lower than about 5.7V).

General operation

After you have checked the operation of the switching power supply it is time to remove the 50Ω load resistor and install the wire loop to the Y2. When you now reapply the power to the board, the green led should start blinking at a heart beat rate and the red light should lit for about one second. This means that the chips A1–A9 are ok and the LEONID monitor has been taken the command of the DSP CARD 4. Now you have some life in your board.

GREEN LED	RED LED	MEANING
blinking at a heart beat rate	off	system operating correctly
blinking at a heart beat rate	on	LEONID monitor is waiting for a command from serial line
off	off	DSP56001 does not boot at all, or there is no power
blinking at a heart beat rate	blinking at a heart beat rate	LEONID has received incorrect or incomplete command from the serial line
blinking at 10Hz	blinking at 10Hz	self check has found error in ROM
blinking at 10Hz	blinking at 5Hz	self check has found error in RAM

Table 4: Description of DSP CARD 4 led operation

DSP56001 loads an external program from the EPROM **immediately** after reset (that is generated by the A9 chip). In this small program loaded there are some simple diagnostic routines that test the validity of the DSP CARD 4. These tests checks the whole RAM and EPROM/FLASH EPROM memories. If there are some problems found, they will be reported via blinking leds (V1 and V16) on the card. Table 4 contains description of the led patterns.

If there are no led activity on your card it could mean that

- A9 is broken (check for continuous reset pulses from A9, pin 6)
- A2 is damaged (check for pulses at A2, pin 11)
- A7 is damaged (try to replace it)
- A1 is broken (check visually that all solderings are good)

On the offical $\aleph_0$ Alef Null EPROM there is autoboot program called Greetings which generates voice message via LOUTL pin. If you can hear that, the communication to the codec chip (A12) is ok also. If you have this EPROM on the board, then immediately after the red led is off, the voice message begins.

When you are experimenting with the board look out for making contact to the MAX738A pins. It is posible to generate such a transient that the switcher goes to a much higer 5V output voltage and destructs V5. Mostly you need only to replace V5 after such an error. When there is a problem in the switcher the 5V goes mostly to a to high voltage and V5 starts to conduct. Mostly V5 dissipates such a power that it goes very fast to hot. All modern zenerdiodes are stud mounted and go to short.

After you have verified that your board is blinking leds and the codec is running it is time to check the serial interface to the PC. Connect a cable from the PC's serial port to the DSP CARD 4. Then give the command `DL -x` from the PC. This command tries to reset the DSP CARD 4. If everything is ok, then you should get the responce ‘`DSP CARD 4 RESET`’. In case of error you will get the ‘`No responce from the DSP CARD 4`’ message. This may mean that your secondary power supply is not good, check the voltage between pins 15 and 16 of the A11. This should be between 4.5–5.5V, if not check the windings of T1.

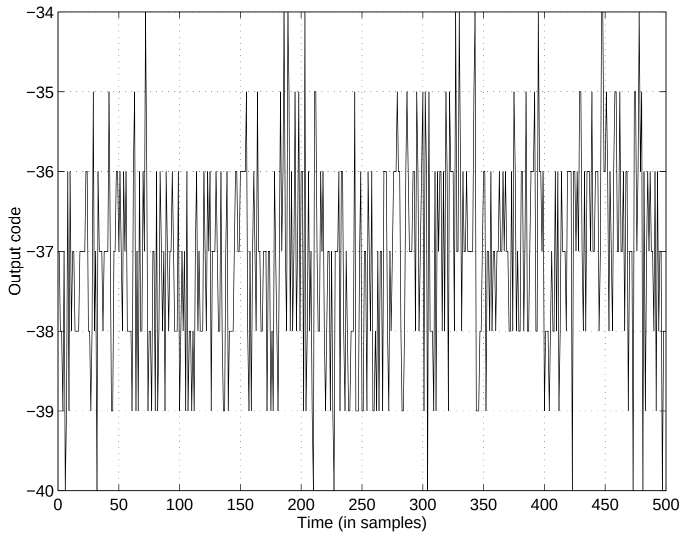

Figure 35: Output of the codec when the input is grounded and fs = 48kHz.

Codec performance testing

Limited performance testing of the A/D converter can be made by grounding the input of the codec and run the `spy` program to register the output of the converter. Circuit noise causes the output of the codec to give a range of output codes instead of a single code output. We can estimate this if know the ac specifications of the codec (S/N ratio for example). From these specs we can find the magnitude of the rms converter noise relative to full scale. The noise will in all likelihood have Gaussian amplitude distribution, so the standard deviation (sd) of the distribution equals the rms value. This also means that the codes that appear will not have equal probability of occurring. Using the fact that 99.7% of a Gaussian distribution occurs within ±3 standard deviations from the mean, it is possible to estimate the peak-to-peak noise voltage at six times the standard deviation. In general, if the signal-to-noise ratio of converter expresses noise power relative to full scale, we have the number of codes seen at the output of the A/D converter as [45]

$$N_B = 2.12 \times 2^b \times 10^{-\mathrm{SNR}/20},$$

where b in the number of bits in the output word. In our case we have SNR=84dB (data spects tell this as 'typical') and b=16 [49]. In this case N_B is 8.8. We can therefore expect at worst either 9 or 10 different codes to appear at the codec output when the input is grounded.

In order to the the input performace of the codec first make a short circuit from the left channel to the ground. The use the `spy` program to show the output of the codec. There should be less than 10 different output codes seen from the plot. One sample plot from the first DSP CARD 4 Rev 2.3 assembled that shows the circuit noise is shown in figure 35. It can be seen from the figure that there are 7 different output codes which is less than the requirement.

Congratulations

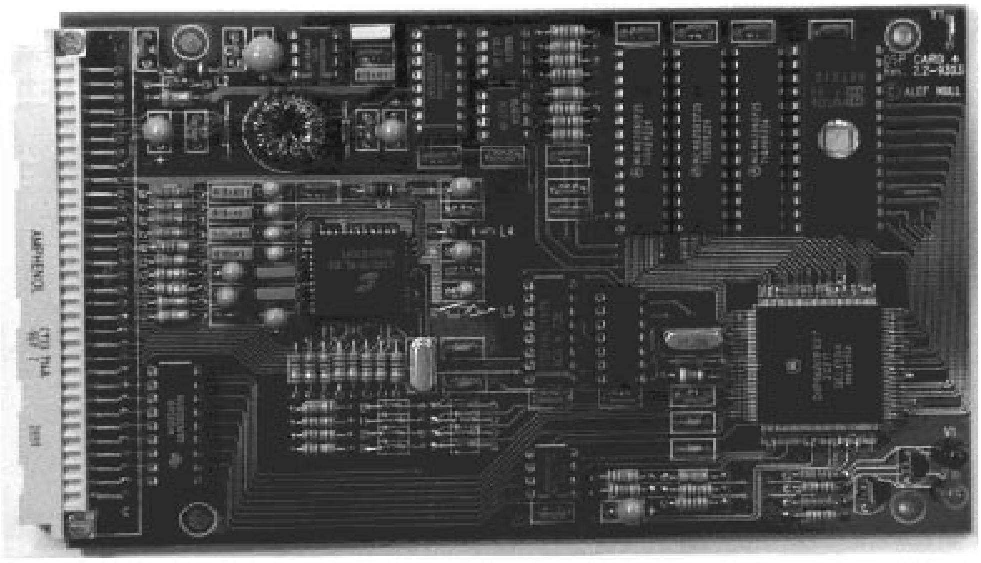

Figure 36: Figure of the first Rev 2.2 batch DSP CARD 4 PCB. We have CQFP version of DSP56001 on this first board, but PQFP is ok also (and it is cheaper).

You can be proud of yourself, building this board takes time, nerves, tobacco (if you are on to that foolish habit) and above all 'sisu' as we Finns say!

Mechanical testing

As a test procedure we have used a simple arrangement. The tests were conducted with periodic bicycle trips between Otaniemi and Tapiola test sites (distance approx. 2.5 km). Ambient temperature was around -10°C, effective wind speed was about 2–10 m/s and there was abt. 30 cm show on the test road. Despite a few fallings (fortunately only minor damage to the test person were reported after the test) the DSP CARD 4 was functioning perfectly.

Spurious emissions from the DSP CARD 4

After the board is completed it is time to put the DSP CARD 4 to the box. One reason for this is the aesthetics, but maybe the more important motive is to shield this board. We found that the DSP CARD 4 generates a lot of noise. Especially the CS4215 codec makes a great amount of noise, mainly because it contains a lot of extremely high speed digital filters. On the other side, DSP56001 is not a very noisy chip and four layer board reduces those emissions.

Noise spectra of the DSP CARD 4 is shown in figure 37. It is measured by a simple wire of 1 m in length connected to the input of the HP 8561 spectrum analyzer. Automatic averaging of 100 measurements in order to reduce the variance of the results was used. The Codec crystal was 19.2 MHz, and the DSP crystal was 27.115 MHz, and there were an additional quadrature down-converter board with 42.76 MHz local crystal oscillator connected to the DSP CARD 4. As we see from the figure, the Codec creates the highest noise peak.

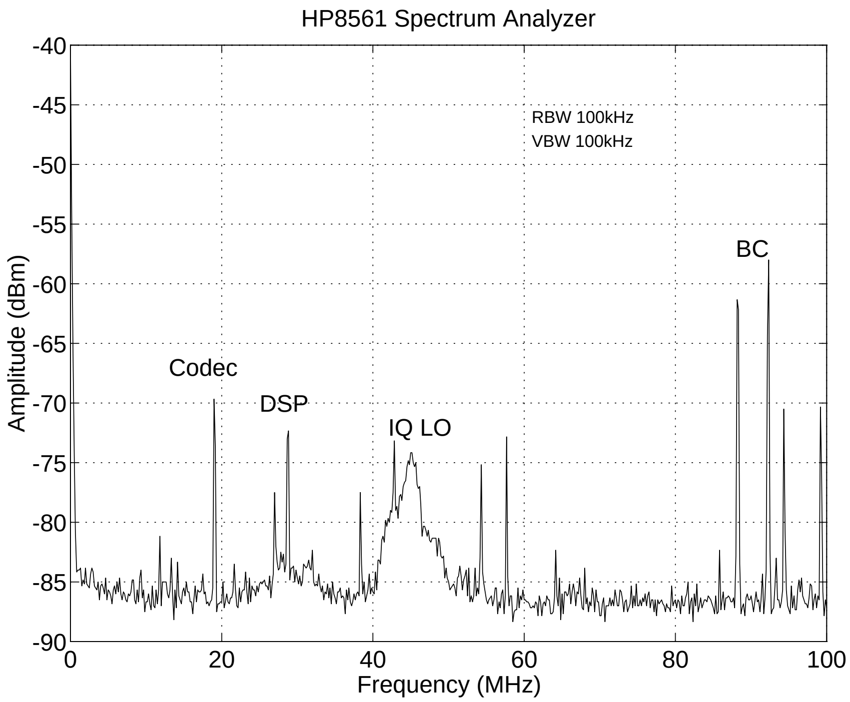

Figure 37: Noise spectra of DSP CARD 4 when in open environment.

Our intentions was to use ICOM R100 wideband receiver with indoor antenna and DSP CARD 4 connected to its intermediate frequency (10.7 MHz). We connected the DSP CARD 4 and down-converter board combination to the receiver, but the reception of weak signals was impossible because of the high level of spurious emissions from the cards. Therefore we put those boards in the metal box in order to minimize the spurious emissions. But what we found, was no rejection of emissions at all, as it is seen from the figure 38. In fact, emissions has been amplified!

The reason for this was found to be those wires (power, signal input, RS-232 interface, etc.) coming out of the box. Those wires behaved as small antennas, radiating energy from inside the box to outside world. This can be prevented by bypassing **all** the wires going out from the box to the ground with a parallel combination of 100pF and 100nF capacitors. Small inductors (1 μH) can also be added in serial to those lines if necessary.