Construction of the "4 lines decoder"
for reading information contained in 406 beacon message

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We will describe the construction of the "four lines" decoder step by step. This decoder is able to read messages of 406 beacons and it can display on 4 lines the information contained in the message [1,2]. The time of reception is recorded and displayed, and it is possible to recall the previous messages. Associated with a receiver tuned on the beacon frequency, the decoder operates completely independent. To get a good reception, it is better to use the output "discriminator" on the receiver.

For the decoder construction, all the key components must be collected: the programmed PIC 18F2685 (now it is the version vB2E or vB2F), the display 4 lines of 20 characters, the printed circuit board / PCB [3] and all the peripheral components. The version V24 of the PIC program can be downloaded on the website www.F1LVT.com. The latest version (vB2E or vB2F) are only available on programmed PIC (contact F1LVT).

For the 20 x 4 characters display module, we prefer using black lettering on green background with green backlight (or possibly yellow). These displays are very readable, even without backlighting.
Reversed display also exists, where the characters are white on a blue background, which must be backlit. No display backlight, and display requiring a negative voltage to operate must be avoided.

Note: the PCB described in the article presenting the decoder ("Display on 4 lines of information contained in the message of a 406 beacon") [1, 2, 3] is a general support for multiple variants.
-- For example, most capacitors have three holes implantation allowing the use of 5.1 mm or 7.6 mm step.
-- The power supply of input signals circuit can be installed either independently with a 78L05 or a 78L08, or shared with the 5V PIC power supply (7805). In the latter case, it is necessary to add a bridge between the power supplies.
-- It is possible to build an autonomous system with a small 9V battery. The tracks allow mounting with a series resistor and a LED to show that the battery is charging.

We will describe in this paper only the construction of the basic system, power supplied by 12V (at least 8V), with all circuits powered by a single 5V regulator, a 7805 IC.

The steps of construction

During the construction, a series of tests has been defined. If the decoder does not correctly respond to these tests, don't go further. Look first at the fault origin.

We will describe the construction steps.

1 –

Drill the PCB with a 0.8 mm drill. Five holes (4 for fixing the display and 1 for the7805 IC) must be enlarged to 3 mm. Before soldering, be sure that the PCB is correctly etched and degreased.

2 –

Fit the 4 wire bridges. Two are situated under the PIC, one is under the 74HC14 IC (ground connection), and an optional one close to Push Buttons (ground connection) (Photo 1).

Be careful there are also three bridges on the PCB, on the copper side. These connections are explained later in the description of the construction (see step 4 for 5V, step 9 to PIC pin 1 / optional, and step 12 for the lighting of the display).

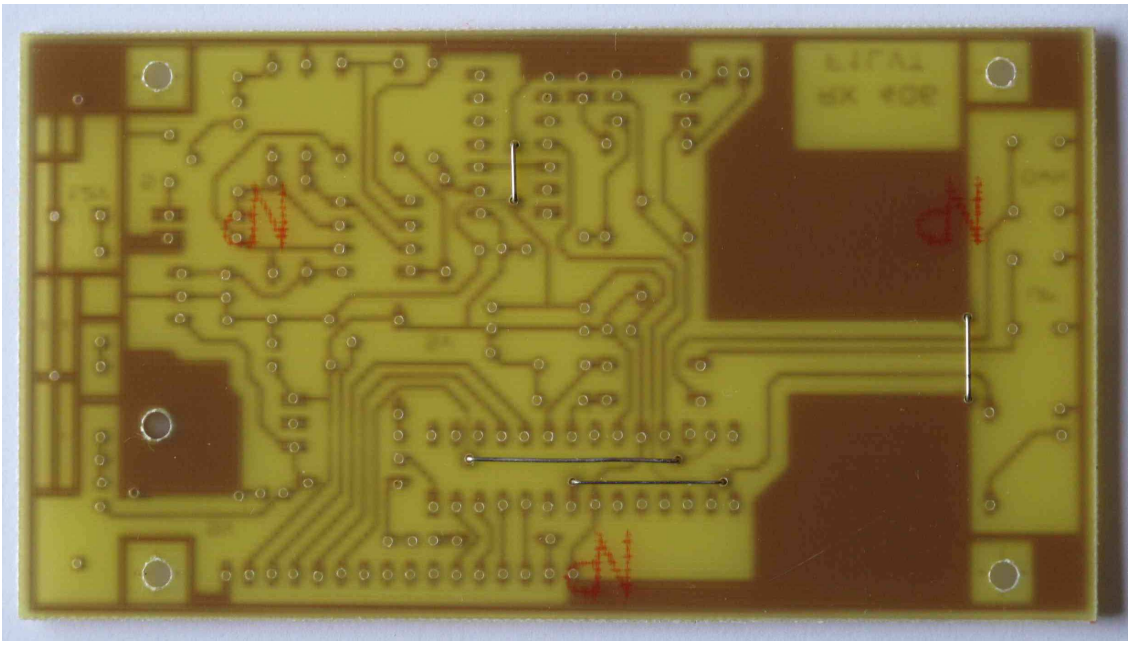


Photo 1: The PCB and the bridges to be realized

3 –

Solder the three IC sockets (8 pins for the amp, 28 pins for the PIC and to 14 pins for the Schmitt Trigger gates). For each socket, the pin 1 can be recognized on the PCB by its rectangular shape.

4 –

Solder the components of the power supply: the 7805 regulator with its filter capacitors (C41, C42, C43) (Figure 1). Solder the capacitors of the power supplies IC (C11, C23, C24) and the potentiometer 10 kΩ (P11).

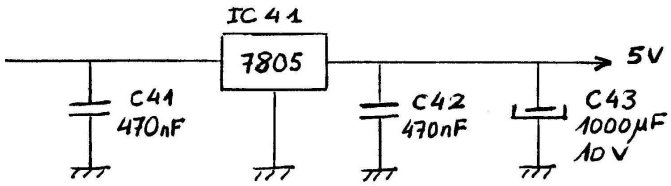


Figure 1: The power supply

To mount the 7805 regulator, enlarge the connection holes to 1 mm. The ground is connected by the radiator, so it is imperative to put a screw securing the 7805 heatsink on the PCB (Photo 2). Elsewhere, make a connection between the middle pin of the 7805 IC and the ground.

The PCB allows the installation of a separate regulator for the amplifier TLC272, to be able to power it with a higher voltage, for example with 8V regulator. The location of the regulator is next to the capacitor C23. With all circuits powered by a single 5V regulator (the case of the basic construction that we are doing), add a connection between the supply tracks. This link appears in green on the Figure showing the component position, between the TLC272 and R11.

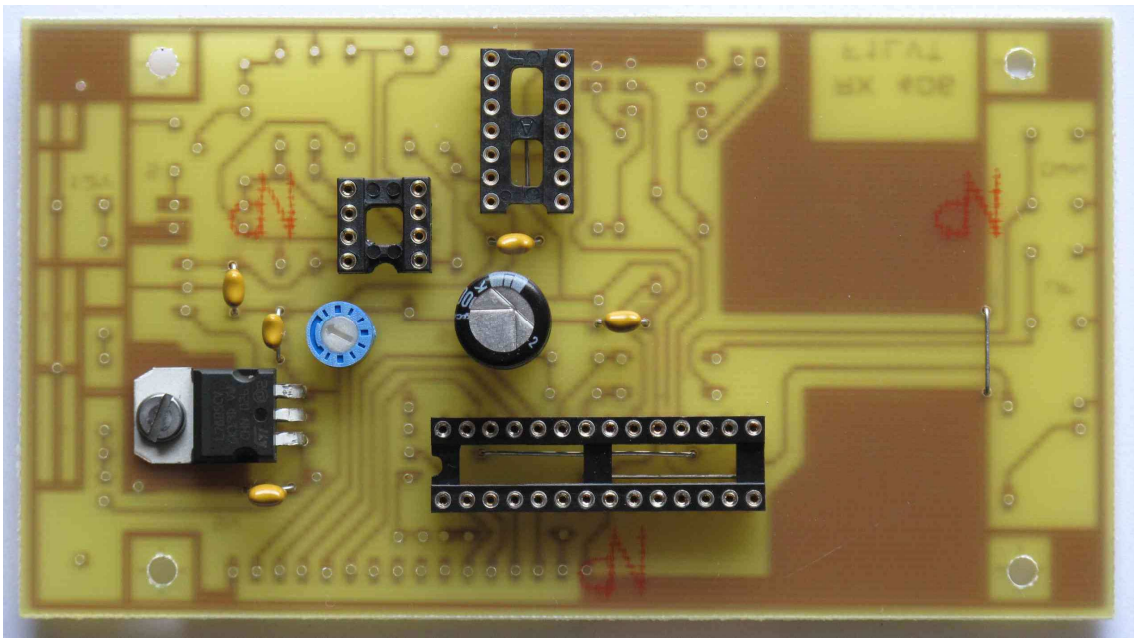


Photo 2: The power supply components and the IC sockets on the PCB.
For the construction with only one regulator, do not forget to bridge the 5V copper tracks.

5 –

Solder the 2 wires of the power supply.

Test # 1

To verify that the power supply is correctly working, it is necessary to power the system by 12 V (8 to 15 V) and check that the voltage is 5V on pin 20 of PIC socket, on pin 14 of 74HC14 socket, and particularly check the 5V on pin 8 of the TLC272. It is a common failure of forgotten bridge between the 5V power supplies (see Step 4).

6 –

Place the 2 sockets 6-pin male on the PCB, on the copper side (see Photo 3). When the pins were introduced, push pins with pliers to get them out to the maximum on the copper track side. On the component side, only the thickness of the support is remaining. The pins must be soldered on the copper side.

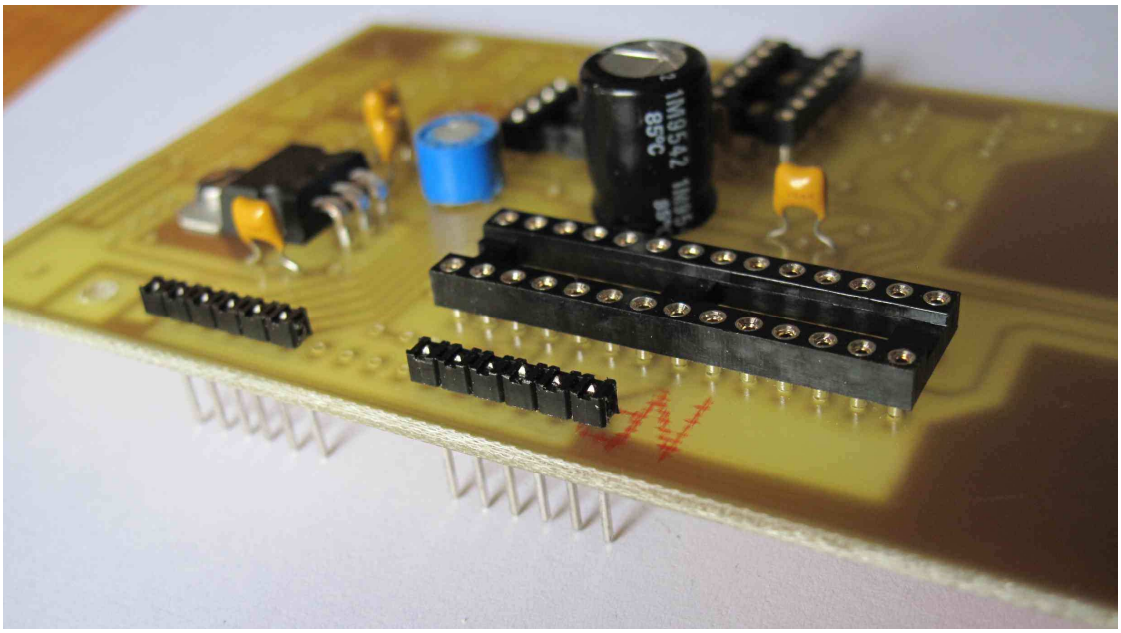


Photo 3: The two 6-pin connectors which are soldered on the copper side

7 –

Solder the two 6-pin female connector for the display connection (pins 1-6 and 11-16 of the display) (Photo 4). As display holes are metallized, it is possible to solder on the display side.

8 –

Use spacers of 10 mm long to obtain a parallel position between the PCB and the display plane. The display can be disassembled and reassembled easily.

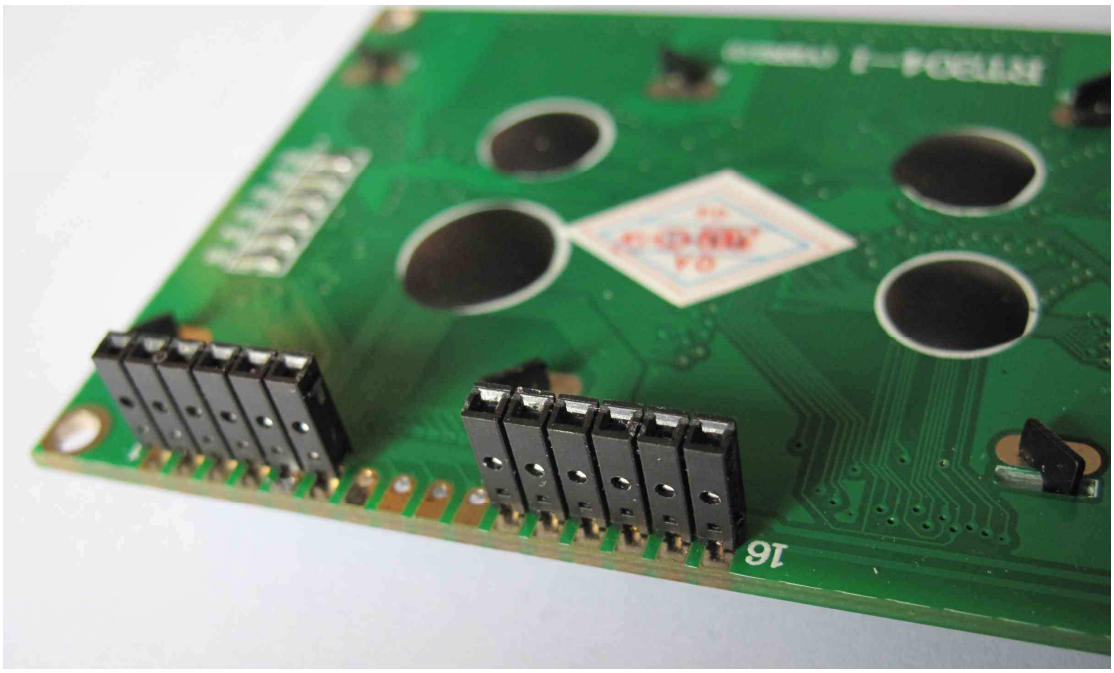


Photo 4: The two 6-pin female connectors soldered under the display

Test # 2 / Adjustment # 1

Power ON with the installed display and adjust the potentiometer 10 kilohms to make appearing a series of black squares ▓ on the first and third line of the display (Photo 5).

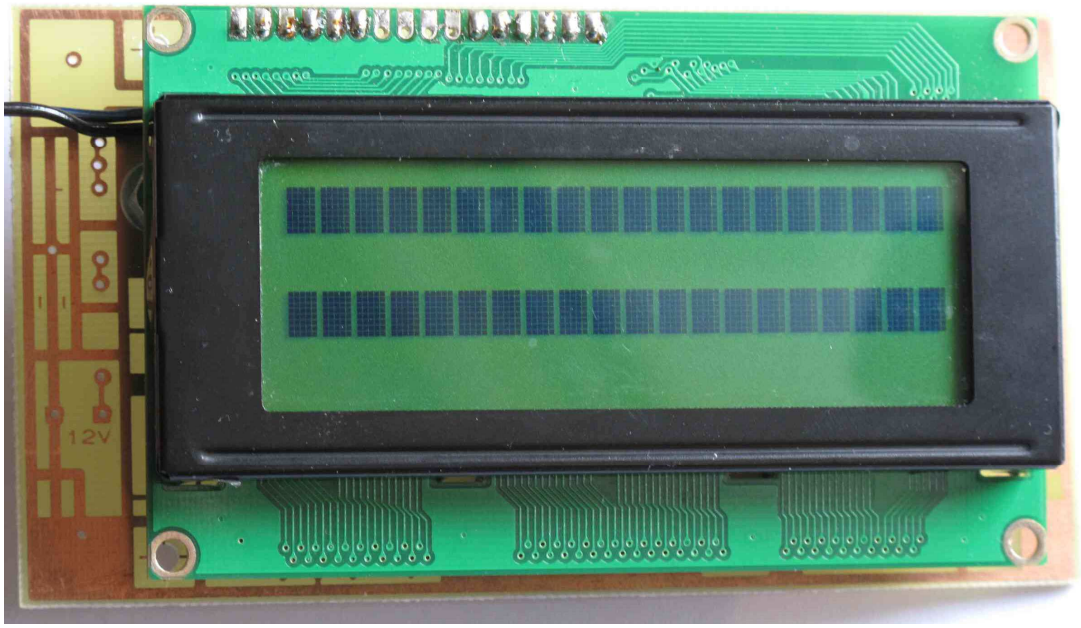


Photo 5: Setting the display contrast

9 –

Power Off, the PIC is now inserted in its socket (Photo 6).

It is not necessary to solder R11. The PIC uses its internal reset. R11 and diode 1N4148 series are only used when programming the PIC directly on the PCB. With an already programmed PIC, R11 and the diode (not shown in Scheme 2) are not necessary. You can make a bypass at the location of said diode (labeled in green color on the layout diagram).

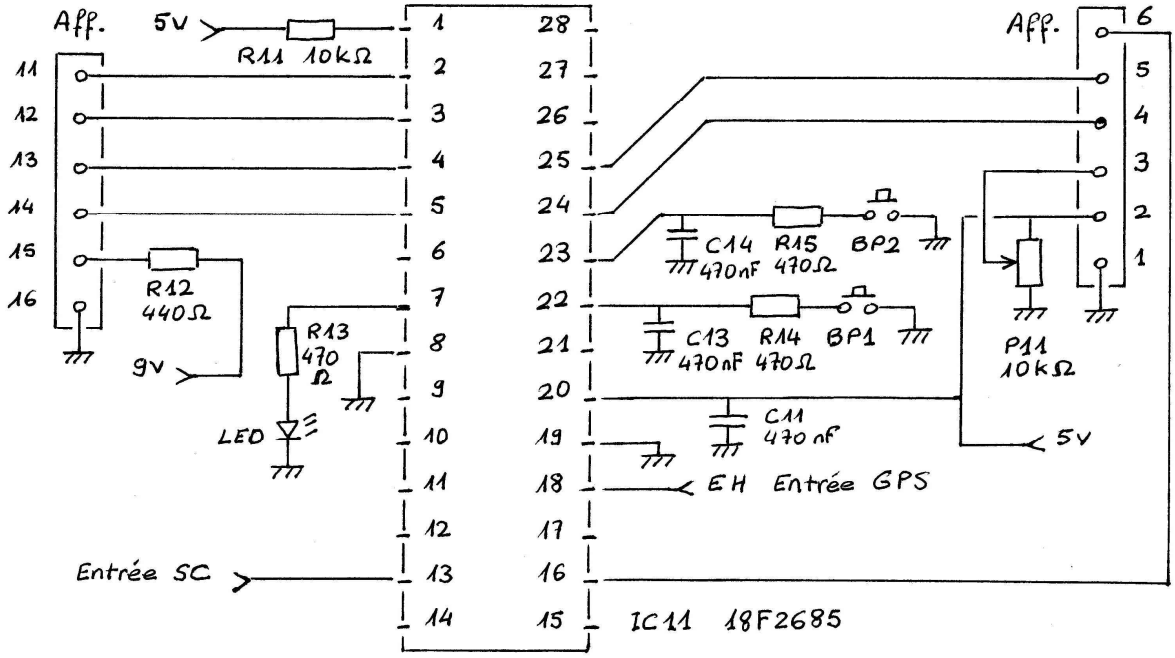


Figure 2: The PIC and the display

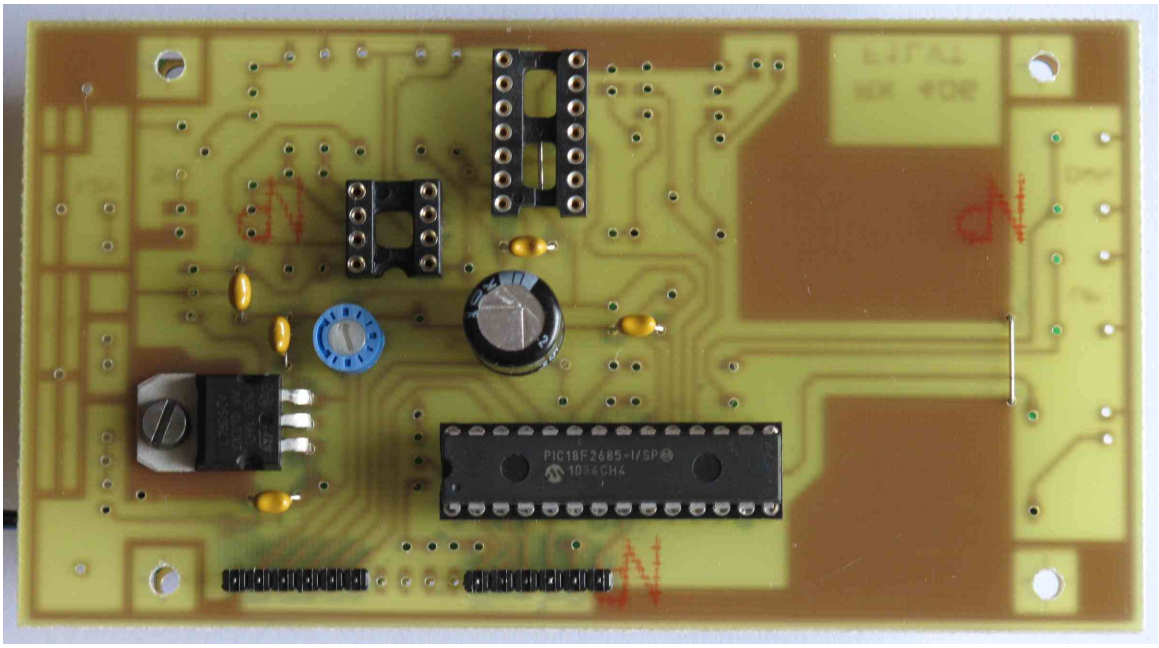


Photo 6: The PIC is placed on its socket

Test # 3

Power ON with the display and the PIC; the home page should appear on the 4 lines display (Photo 7).

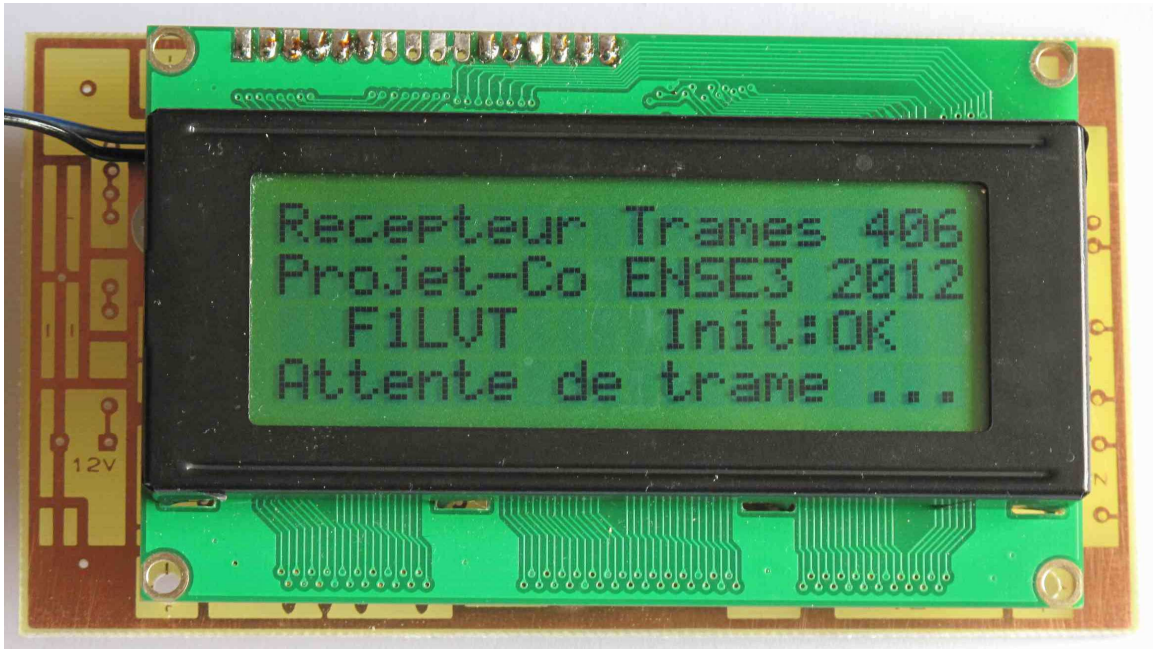


Photo 7: With programmed PIC putted on its socket, the home screen appears when power ON

10 –

Mount all components of the input circuit (Figure 3). Adjust the level potentiometer at halfway (Photo 8).

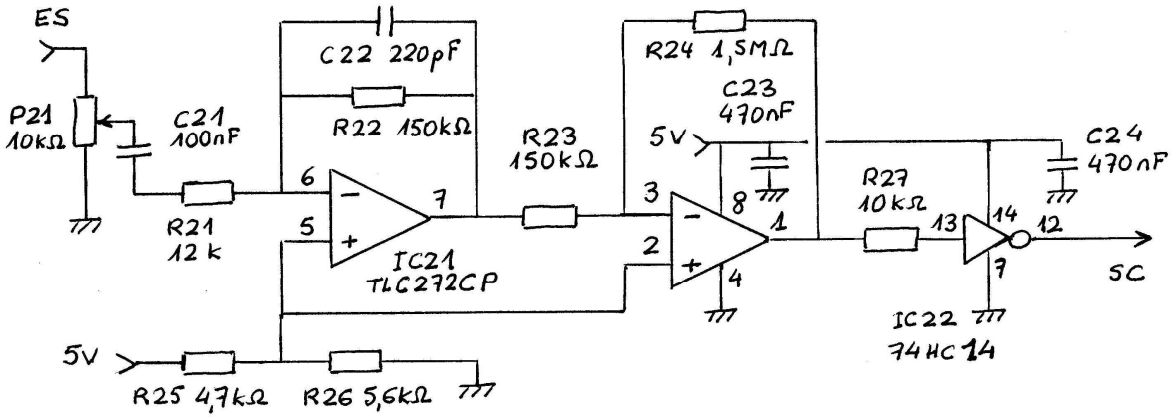


Figure 3: The signal input and circuit. It has been previously used by F6HCC.

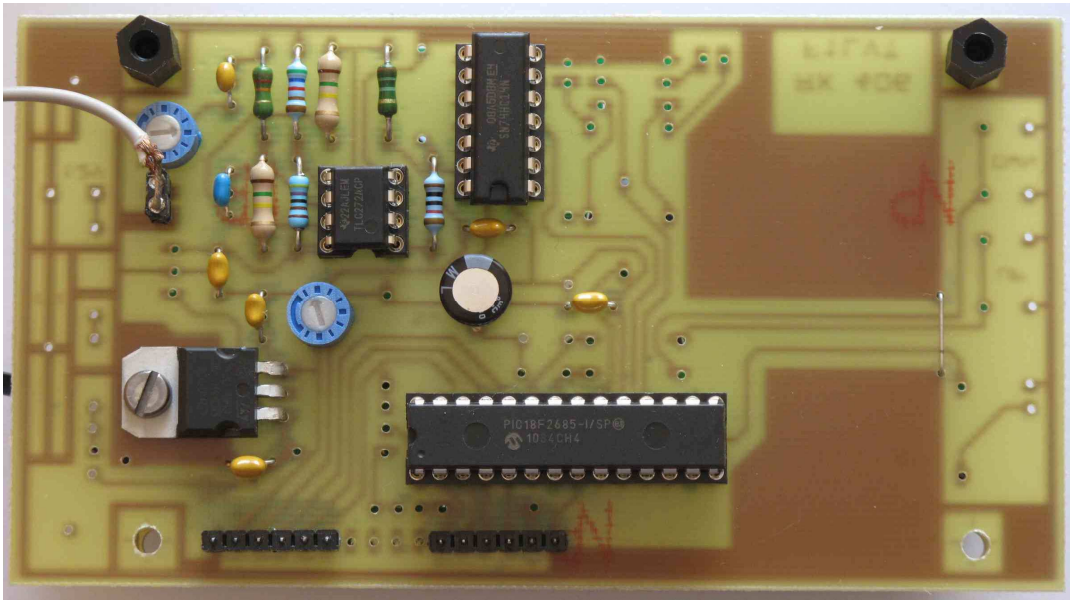


Photo 8: Addition of the input circuit components.
Preposition the potentiometer P21 at halfway

Test # 4 / Adjustment # 2

Preposition the potentiometer P21 at halfway. Apply power and send a signal to the input. This signal can be given either by a frame generator, or by a recorded frame. The message should be displayed.

The input level (P21 potentiometer) can be slightly adjusted for adaptation to the source and to find the best position. This level depends on the receiver.

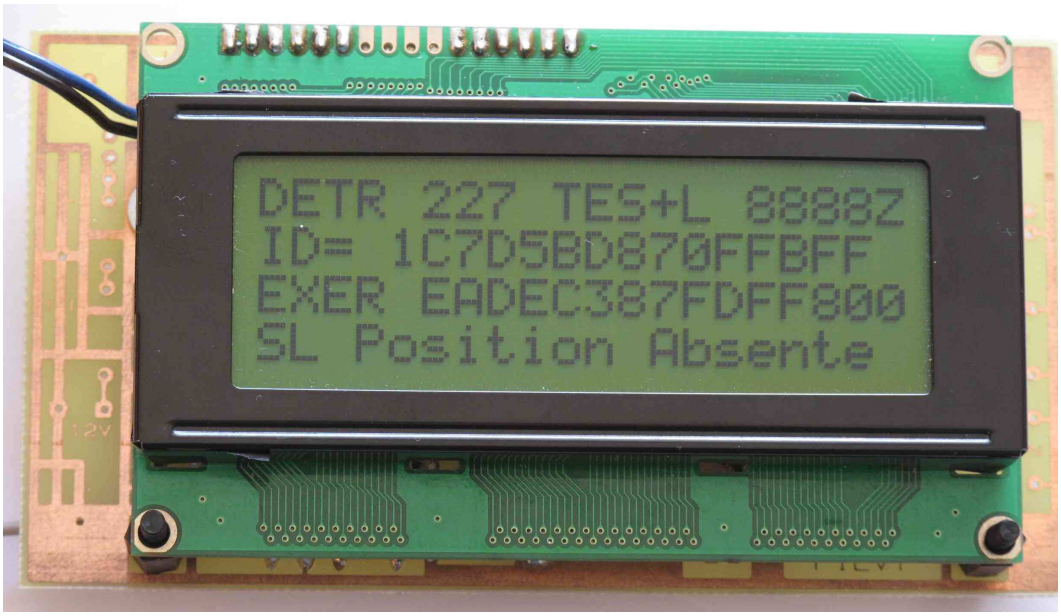


Photo 9: Information included in the beacon message is displayed.

Photo 10 shows all the components which must be soldered on the PCB of the decoder circuit.

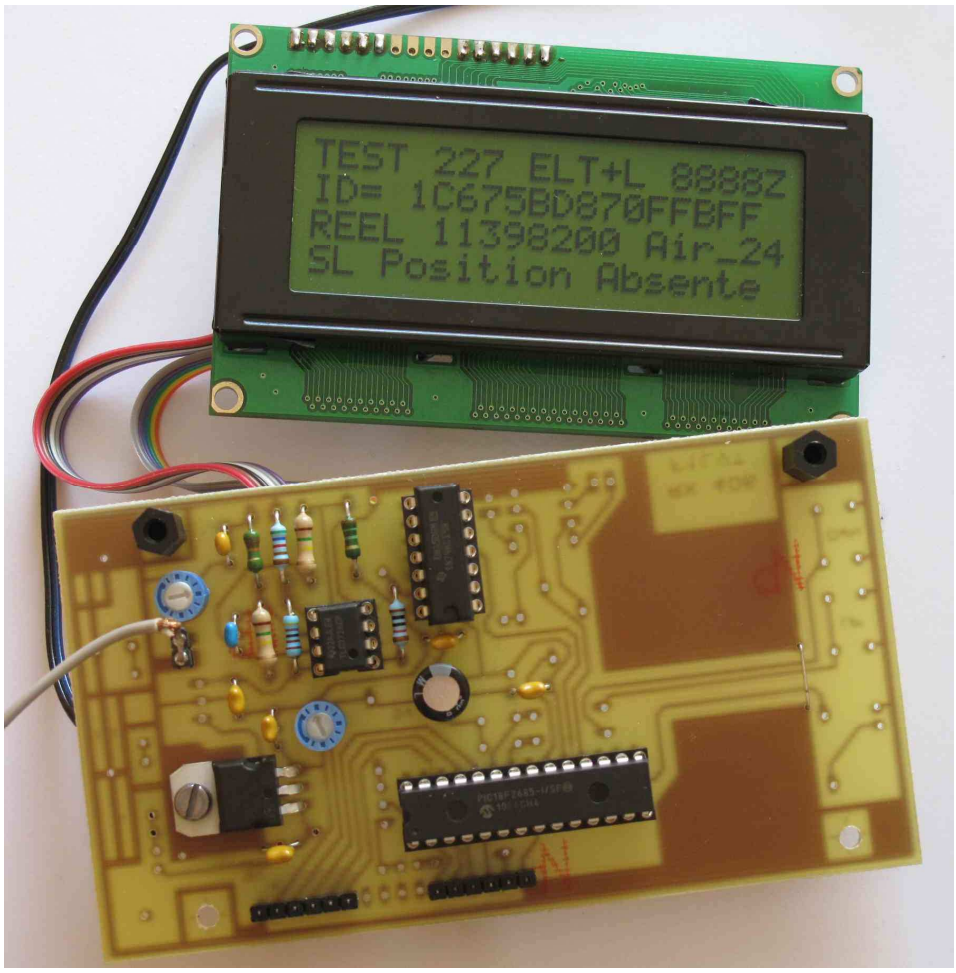


Photo 10: The decoding of another message beacon.
The display is connected to the map by a series of wires

11 –

Mount the LED and its load resistor R13. The LED should be soldered on the copper side of the PCB to be seen from the display side.

In operation, the LED should light up during the signal processing by the PIC.

LED lights up by supply of 5V voltage on pin 7 of the PIC. In order to put the LED in the good position, you can remove the PIC and put a wire between pins 7 and 20 on the socket of the PIC, and power ON: the LED should light continuously.

12 –

The display illumination (D41 and R12) is not mandatory, but it helps readability. For the resistor R12, 220 Ω is noted in the list of components, 440 Ω on Figure 2 and 470 Ω on the component position (Figure 6 and 7). In fact the resistance R12 supplies the LED lighting of the display. The value depends on the used display module. According to the manufacturers and to the type of display and its backlight, the value of R12 must be adjusted by testing. Attention to the power dissipated by the resistance. Put two resistors in parallel if the heating is too important.

Besides R12, it is possible to mount a 3-pin socket with a strap, which can be used to power or not lighting. When this function is not used, add a connection between the tracks, which appears in blue on the color layout diagram (Figure 7).

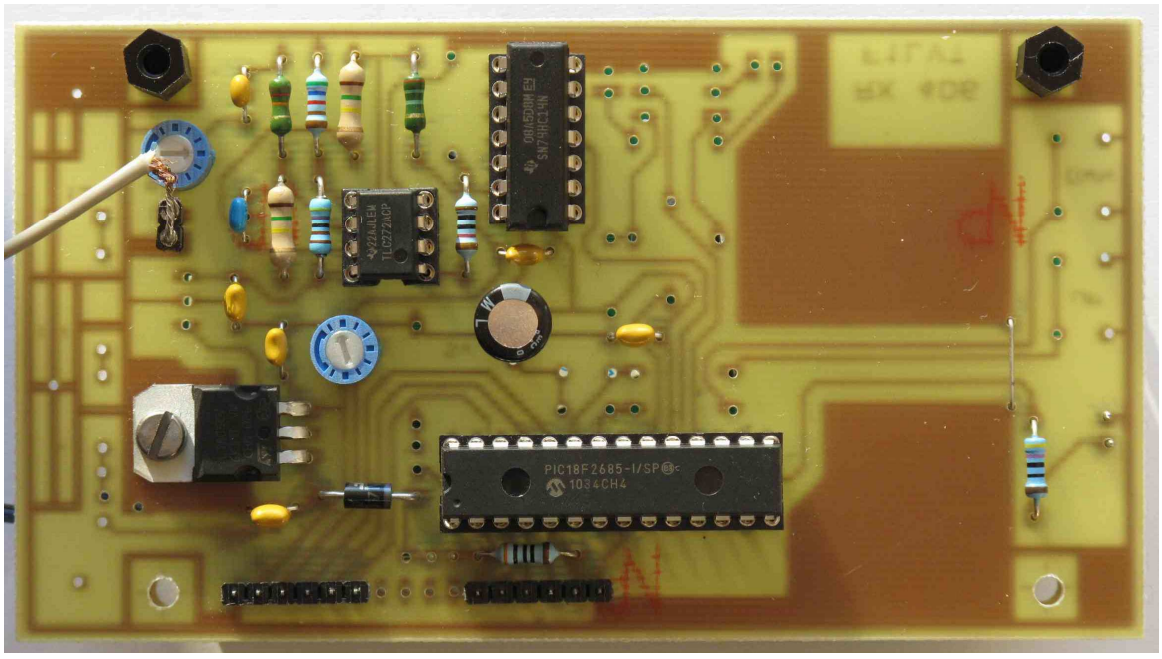


Photo 11: PCB with the display lighting circuit,
the LED displaying the decoding is soldered on the other side

Operation test

At this step of construction, the decoder is fully operational for decoding received beacon message. By sending a 406 message (recorded message or message provided by a frame generator), the LED should light up and the display will show the information on 4 lines.

13 -

To finish the construction, the components of the accessories parts must be added:

- Installation of GPS reception parts,
- Mounting the two pushbuttons to access to the memories.

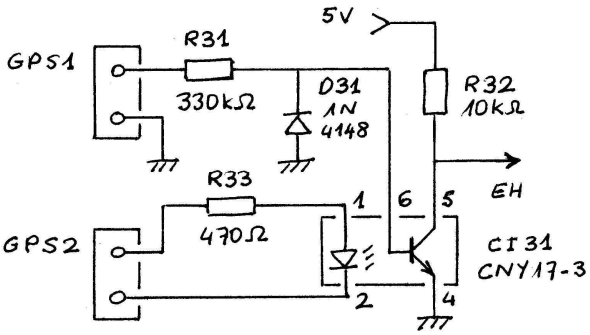


Figure 4: Reading time by receiving GPS data

Notes

-- If the receiver is powered by a 9V battery, limit the value of capacitor C43 to 47 µF or 100 µF for a fast enough voltage rise at startup.

-- Between IC22 and R24, a resistor location is unoccupied when only one 5V regulator is used. A resistor must be putted if a higher voltage than 5V is used for the input circuit (TLC272), for example 8V, to match the levels between the amplifier output and 74HC14.

-- Same remark for the unoccupied location next to C23. It is the place of the second regulator if a separate power supply is used for the amplifier.

-- The edge of the PCB (which is marked 12V) is not used. If the decoder is supplied by a 9V battery, this section allows you to place a series resistor and a LED. At the top and bottom of this section, a socket-3.5mm input for the beacon signal and a base of 2.5 Jack for the arrival of the GPS signal can be placed.

-- The decoder has been designed with a PIC, which complete reference is "18F2685 I-SP". It can also work with a “18LF” instead of “18F”, or a “E-SP” version in place of the “I / SP” [5].

-- The software inside the PIC has slightly evolved. The version “V24” (2012) is now updated to version “vB2E” (in English) or “vB2F” (in French). In particular, the memories management has been improved. The first version “V24” is freely available on the website www.F1LVT.com. The following versions are available only with preprogrammed PIC and cannot be copied from a PIC to another one.

Notes on operation

-- For a correct working, do not you take the signal to the LF Jack (headphone Jack). The output "discriminator" of the receiver must be used, that is to say the direct output signal of the demodulator

The website "discriminator.nl" [6] is very well documented to explain how to install an outlet "discriminator" in a receiver.

-- At the signal input of the decoder, the level (setting of P21) depends on the receiver. Ideally it would adjust the level using an adjustable beacon signal level, and make the adjustment on the limit of decoding. In practice, the adjustment at halfway of P21 corresponds to a value well suited to many receivers.

-- The decoder works with both positive signals (start of frame by $\Delta\varphi$ +) and negative signals (start of frame by $-\Delta\varphi$).

-- The use of GPS is optional; decoding works fine without GPS. The GPS allows recording the time of arrival of the 406 signal. If the GPS is not connected, the display of the time indicates “8888”. The letter “Z” after the time is added by the decoder (as a reminder that this is GMT).

-- With the version “V24”, the reading of memories is a secondary function. This reading must be done when no new data is recorded. Ideally with “V24”, unplug the entrance.

With more recent versions, the reception of a new signal has priority on memories reading, allowing a full compatibility between the memories reading and the new 406 signal reception.

Références

[1] http://www.f1lvt.com/files/321Eng-Decodeur406-Part1.149.pdf

http://www.f1lvt.com/files/321-Decodeur406-Part1.81.pdf

[2] http://www.f1lvt.com/files/321Eng-Decodeur406-Part1.149.pdf

http://www.f1lvt.com/files/322-Decodeur406-Part2-V2.123.pdf

[3] http://www.f1lvt.com/files/323-CI-RxTrames406-V2.156.pdf

[4] http://www.f1lvt.com/files/324-RX406-V24.83.hex

[5] http://www.f1lvt.com/files/326-VariantesPIC.132.pdf

[6] http://discriminator.nl/index-en.html

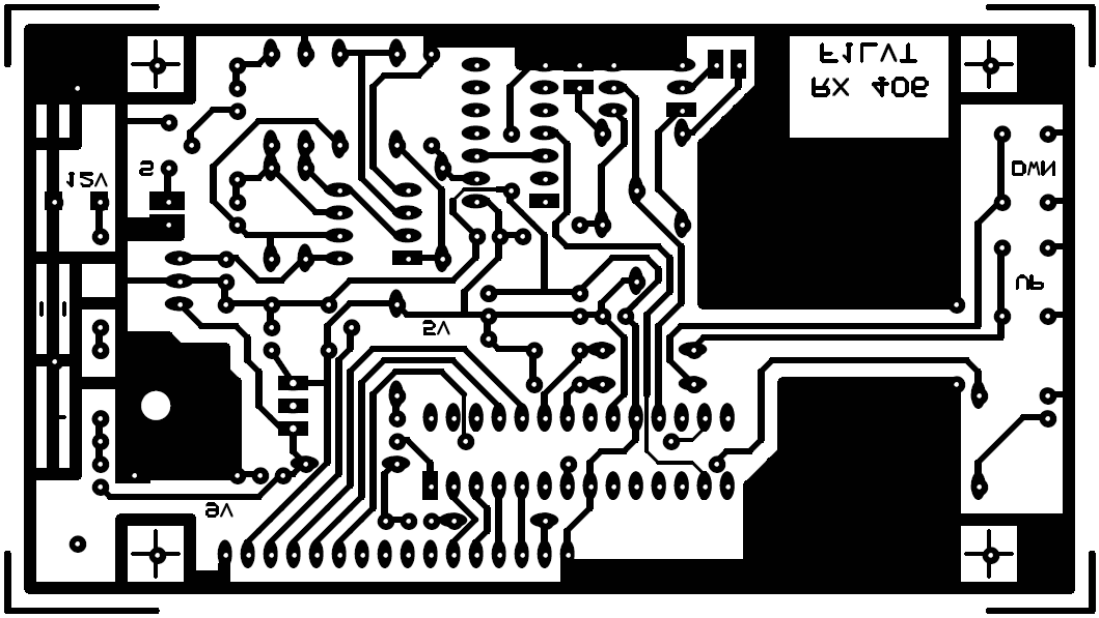


Figure 5: PCB (seen through epoxy)

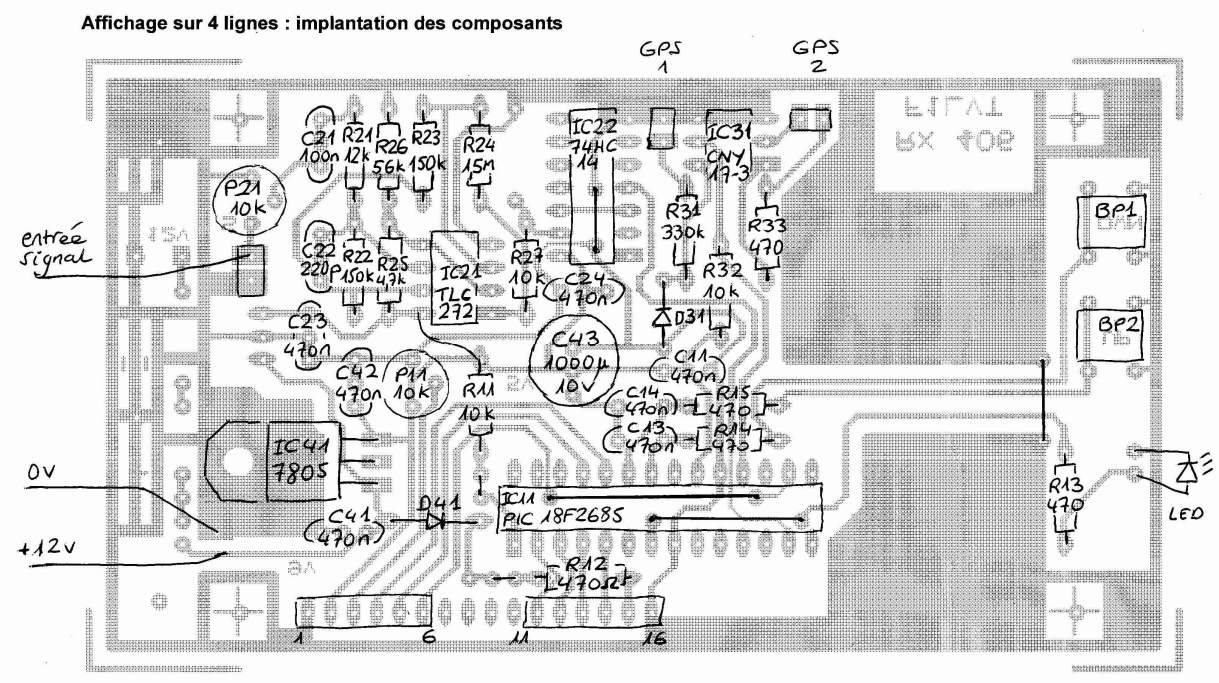
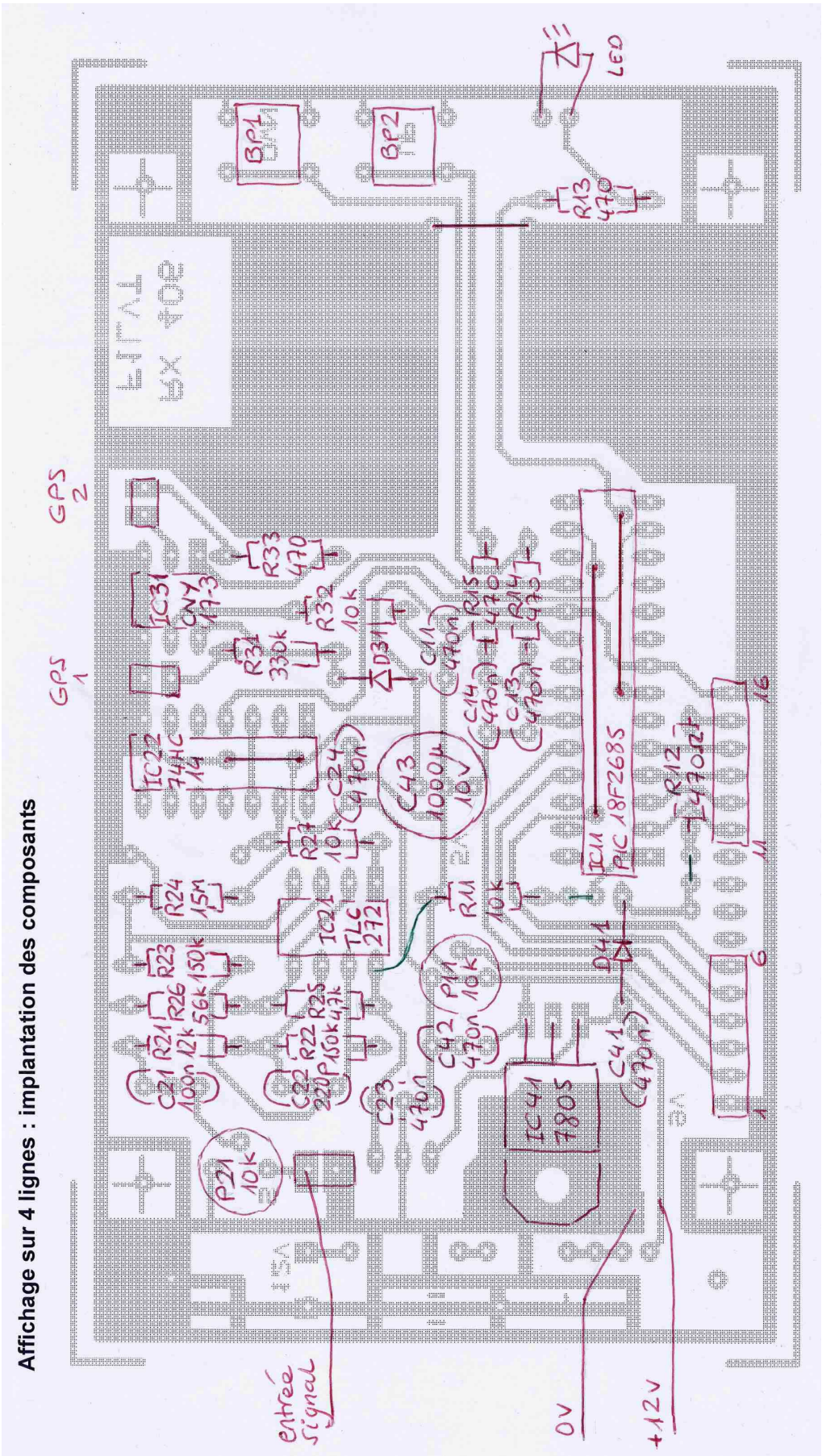


Figure 6: Component position

Figure 7 (next page): Component position in color



Affichage sur 4 lignes : implantation des composants

Component list

Active Components:

IC11	Microcontroller	IC11	PIC 18F2685-I/SP	DIL28
IC21	Amplifier	IC21	TLC272	DIL8
IC22		IC22	74HC14	DIL14
IC31	Opto-coupler	CNY 17-3		DIL6
IC41	Regulator	7805		
LED		Red Φ3 mm (eventually 5 mm)		
D31		1N4148 (or equivalent)		
D41		1N4004 (1N4001 to 1N4007)		
Display		LCD 20 x 4 (dimensions 98 x 60 mm)		

Resistors

R11	10 kΩ (facultative / See text)
R12	220 Ω (to be adapted at the lighting level)
R13, R14, R15	470 Ω
R21	12 kΩ
R22, R23	150 kΩ
R24	1,5 MΩ
R25	4,7 kΩ
R26	5,6 kΩ
R27	10 kΩ
R31	330 kΩ
R32	10 kΩ
R33	470 Ω
R41	100 Ω
P11, P21	10 kΩ linear potentiometer for PCB

Condensators

C11, C13, C14	470 nF
C21	100 nF
C22	220 pF
C23, C24	470 nF
C41, C42	470 nF
C43	1000µF/10V electrochemical (between 100 et 1000µF)

For the filtering condensators (C11, C13, C14, C23, C24, C41, C42) of 470nF, other values like 220nF, or 100 nF can be used.

Complement

K	Switch ON – OFF
BP1, BP2	2 Push Buttons
CI sockets	28 pins, 14 pins, 8 pins, 6 pins

Chassis Jack 3,5 (connexion récepteur)
Chassis Jack 2,5 (connexion GPS)
Display connector for the display (2 connectors with 6 pins)

Several examples of the « 4 lines Decoder » construction

Photo E1: "4 lines decoder" in construction by F1AVR.
Test with an Exercice Beacon

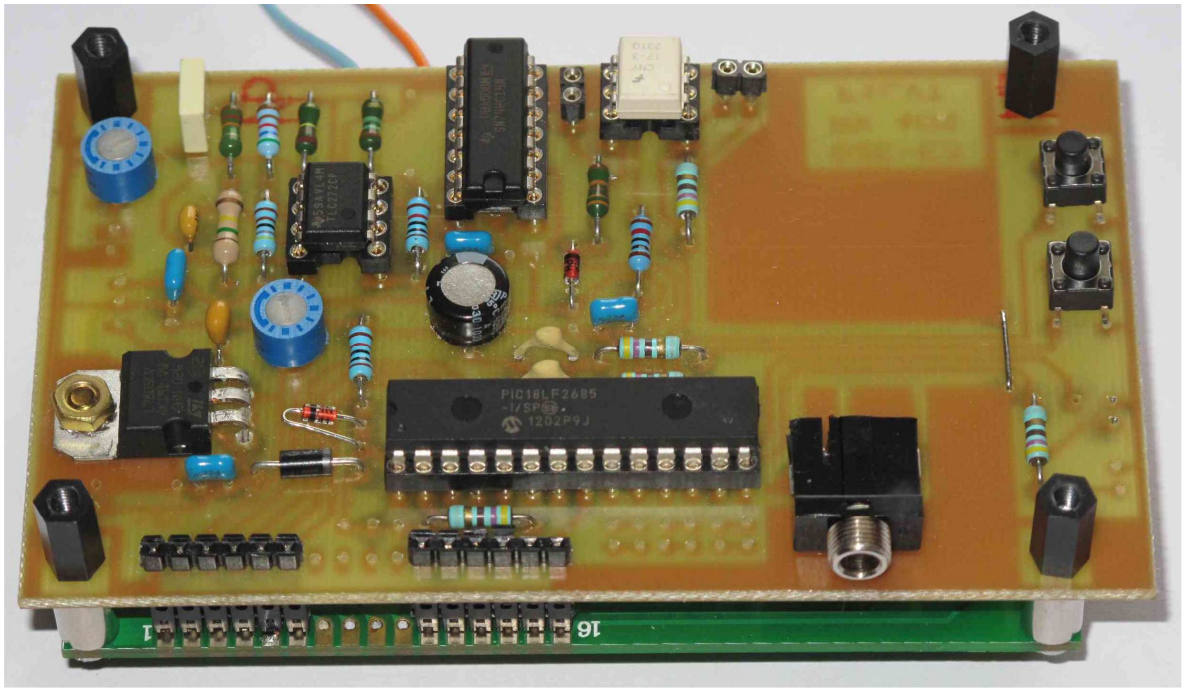
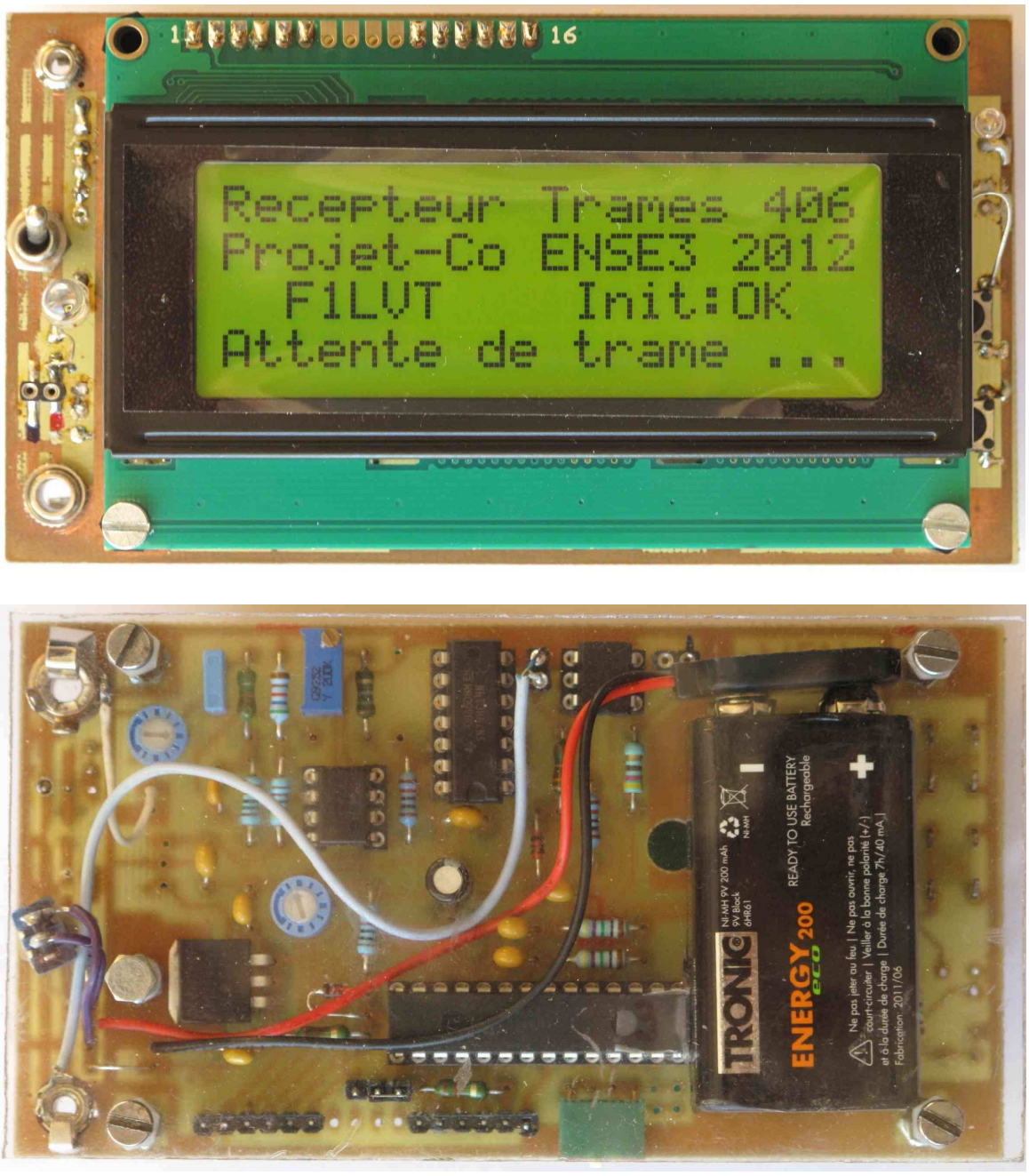


Photo E2: Another version seen from bottom. The ground plane near the PIC has been used to place a chassis Jack 3.5 for the input signal



Photos E3: Prototype supplied by a 9V battery.
The autonomy is about 10 hours of operation.