Display on 4 lines of the information contained in the message of a 406 MHz beacon: decoder construction

Jean-Paul YONNET
F1LVT / ADRASEC 38
F1LVT@yahoo.fr

This article follows the first one entitled "Decoding the 406 MHz beacons: Display on 4 lines of the message information" [1]. This second part is devoted to the description of the construction of the 406 message decoder.

Construction of the decoder

The heart of the circuit is a microcontroller PIC from Microchip: the 18F2685.The microcontroller decodes the message, drives the display, and saves the previous frames. The microcontroller must be programmed with the software "RX406-V24.hex". This software can be obtained from the author, and it available on the website www.F1LVT.com [2] . Voluntarily, the PIC has not been reading protected (Protection Code), which enables the recovery of the internal program from a microcontroller already programmed.

The PIC uses its internal clock, reducing the external components, especially of the quartz time base . Several pins of the PIC are used for development, when in situ programming. In the final assembly , these tabs are not used but are still accessible (pin 1 / VPP pin 28 / PGD , pin 27 / PGC pin 20 / +5 V , pin 19 / 0V) .

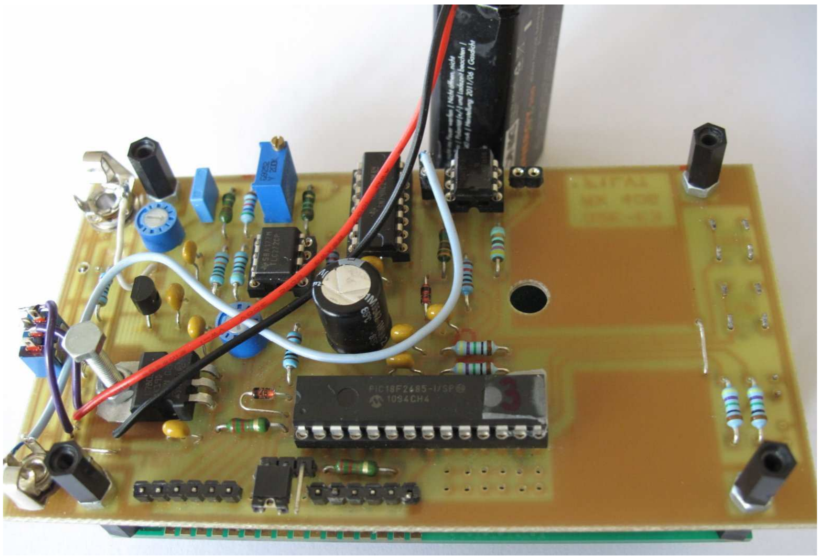

Photo 1: Above view of the decoder card

The system was designed to be independent and portable (Photo 1). It works in 12V, but it can be powered by a 9V battery or a small 9V battery 6F22 size [1]. The advantage of the 9V supply is to obtain a completely autonomous system that can be carried, even in a backpack. The system consumes 32 mA in listening, and 40 mA decoding phase. With a 9V battery of 200 mAh , its autonomy is about 5 to 6 hours. To recharge the 9V battery, connect the system for 7 to 8 hours. But even if the battery shows signs of weakness, just supply the decoder with 12V to keep it operational. To reduce consumption, display lighting power can be disconnected. Just move a jumper on the board of our prototypes. This lighting consumes about 10 mA.

Schematics

The schematics are presented in four parts: the PIC and the display, the input and formatting of signals, the GPS input for recording time, and the power circuit.

The PIC and display

The PIC works only with a few peripheral components, and controls the display. Direct entries are SC (Square Signals) and EH (Clock Input) (Figure 1).

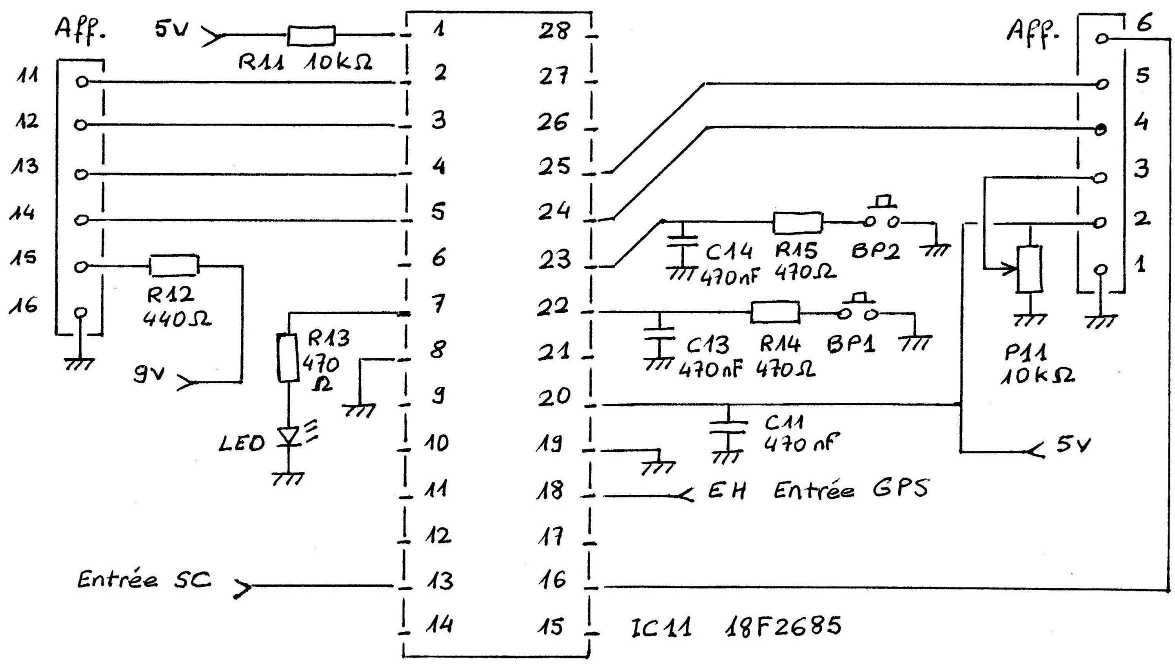

Figure 1: PIC and display connection

The connections of the display are presented in two blocks: pins 1-6 and pins 11 to 16. On the display all these pins are aligned. The pins 7-10 are not used. Pin 3 allows adjusting the contrast using the potentiometer P11. The backlight is powered by pins 15 and 16. Resistor R12 limits the current consumed by the lighting. With 440 Ω (2 x 220 Ω resistors in series), this current is quite low, of the order of ten milliamperes. You can read the screen at night without drawing too much power on the battery. To see a little better the display, you should reduce this value to 220 Ω for example.

For the PIC, we have built our prototypes with 18F2685-I/SP version DIL 28. We have also tested the 18LF2685 version, which works as well. An adapted version of the software should be able to run on the 18F2682, the brother of the 18F2685.

The PIC sotfware includes an algorithm of reconstruction of crenels when the reception is disturbed by the noise. When crenels are shorter than the 1.25 ms or 2.50 ms expected (transmission at 400 baud), they are reconstituted. It just necessary that 15 consecutive crenels in the initial synchronization are received correctly without disturbance to trigger the acquisition.

The input circuit and formatting signals

We used the mounting of F6HCC, the pioneer in decoding of message by radioamateurs [3]. The received signals are filtered and amplified (TLC272) and put into crenels (74HC14) (Figure 2). As operational amplifier, we used a TLC272 for his ability to work with 5V single voltage. The first filter stage is followed by an amplifier with a gain of 10. The third step is achieved by a trigger to send the PIC well square wave signals.

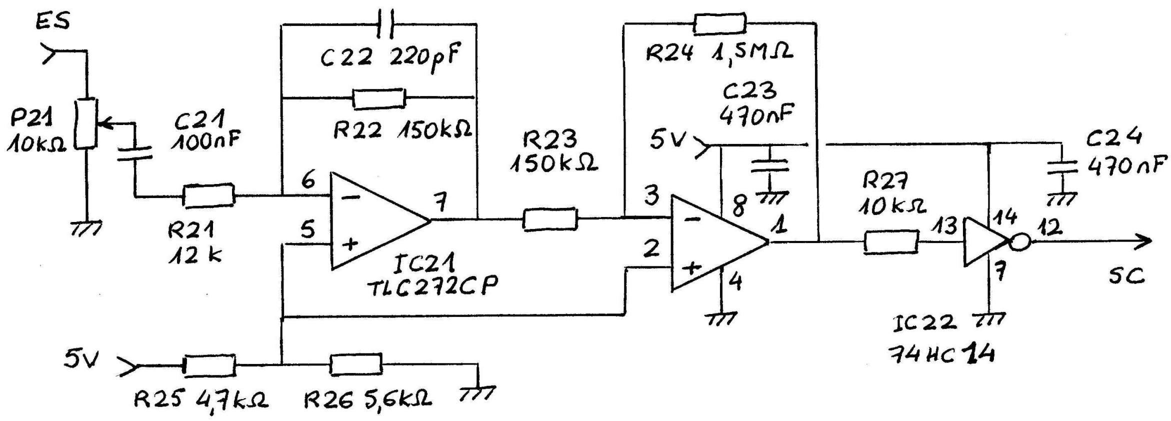

Figure 2: The input circuit and shaping signals

In the diagram, ES represents the input signal (connected to the output "discriminator" of the receiver), and the SC output crenels that goes to the PIC.

First observation: the PIC has been programmed to accept either the signals in positive or negative logic. The passage through the trigger (74HC14) inverses signals. So it is possible to use 2 triggers (or more) in cascade instead of if it can facilitate the design of the printed circuit board.

Second point, to obtain the highest possible sensitivity, we must act on P21 at the entrance and possibly gain the second floor (ratio R24 to R23). But increasing the gain of the second stage also amplifies noise. The higher sensitivity is obtained when the system is able to decode the message in the lowest possible radio signals. And it is not by increasing the gain that gets this high sensitivity. For example we did our tests with a portable receiver AOR 8000. The receiver was equipped with a "discriminator" output with a resistance of 10 kiloohms in series. The largest decoding sensitivity was obtained for P21 at the third of its stroke (input signal divided by 3).

Setting this input stage is crucial because high sensitivity allows receiving and decoding of 406 messages at great distance. The problem is that each receiver provides a decoded signal associated with a noise level of its own. The input of the decoder should be set with the receiver. For our tests, we used an exercise very low power beacon, which has exactly the characteristics and frequency modulation of a real beacon, but provides only a few milliwatts (it lacks the stage power to exit 5W). With this microbeacon and a calibrated attenuator, we can easily adjust the settings of the decoder to obtain the highest possible sensitivity.

The GPS input

The GPS is used to retrieve the time. It is read in message of type $GPGGA. The input GPS1 is at high impedance (R31 = 330 kOhms), while GPS2 input is isolated by an optocoupler (CNY 17-3) (Figure 3). EH output is the "Input Clock" of the PIC .

The system was tested with Garmin Etrex or as the GPS 18 and GPS Trimble. We use a GPS from a head of a radiosonde Modem (Trimble Copernicus), but any GPS capable of transmitting message $GPGGA in the standard MNEA can work (this is a standard message transmitted by the GPS).

The GPS entry is optional. Decoding works fine without a GPS connection. The displayed time then remains 8888Z.

As for the letter Z, initially chosen for the identification of the decoder that receives the message in a network operation, it can only be changed in the software.

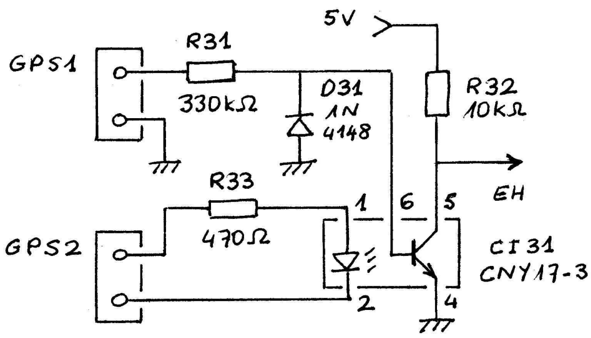

Figure 3: Reading time by receiving GPS

The power supply circuit

The system was designed to operate 9V or 12V (Figure 4).

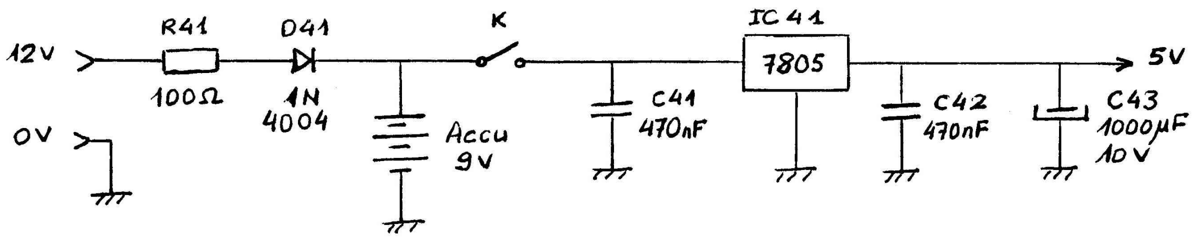

Figure 4: The power supply

For the filtering on the power supply line, we used 470 nF (C11, C12, C13, C23, C24, C41, C42). This value is not critical: capacitor of 100 nF or 220 nF may also be suitable.

<u>PCB</u>

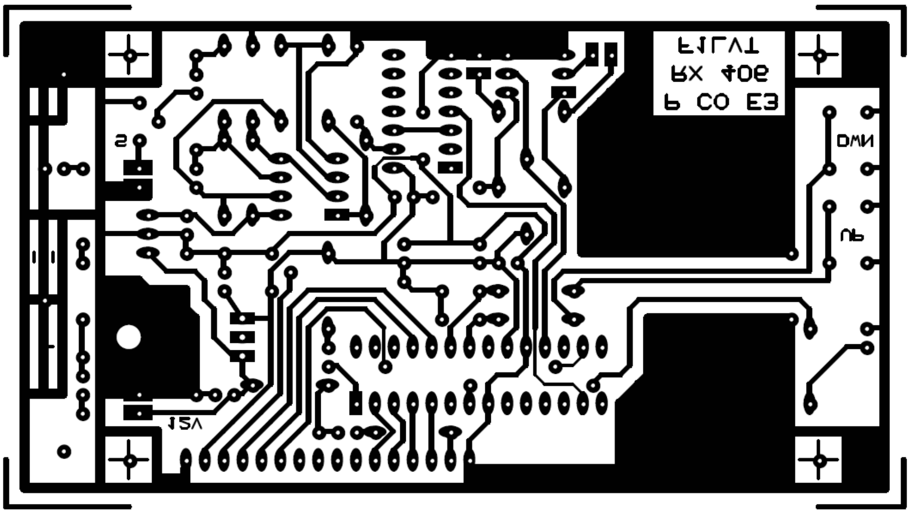

Figure 5: Drawing of the printed circuit

The printed circuit is shown in Figure 5. Additional holes were added to use capacitors with 2.54 or 5.08 mm.

The circuit has been designed for many variants, such as power of input circuit (op amp) can be 8V (as mounting F6HCC) or 5V. With power by 9V battery, all circuits are powered with 5V stabilized. We can then use only one regulator, a 7805, and bridge the second regulator.

The point marked 12V is the arrival point of the supply voltage when the circuit is powered by 12V. If the system is wired with a 9V battery to make an autonomous system, use the left side of the circuit for R41 D41 and the switch, and this point is then to 9V.

The "pdf" scale version 1 should be available on the website <www.F1LVT.com> [2], or from the author.

Attention before mounting the supports of integrated circuits, do not forget to wire the strap under the 74HC14 and 2 straps under the PIC.

List of components

Active components:

IC11	Microcontroller	IC11	PIC 18F2685-I/SP	DIL28
IC21	Op Amp	IC21	TLC272	DIL8
IC22		IC22	74HC14	DIL14
IC31	Optocoupl	CNY 17-3		DIL6
IC41	Regulator	7805		
LED		Rouge Φ3 mm		
D31		1N4148		
D41		1N4004		
Display		LCD 20 x 4 (see the paragraph on the display)		

Resistances

R11	10 kΩ
R12	220 Ω
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

Condensators

C11, C12, C13	470 nF
C21	100 nF
C22	220 pF
C23, C24	470 nF
C41, C42	470 nF
C43	1000µF / 10V electrochemical

Divers

K	Switch On-Off
BP1, BP2	2 Push buttons
IC supports	28 p, 14 p, 8 p, 6 p

Chassis Jack 3,5 (receiver connection)
Chassis Jack 2,5 (GPS connection)
Display connector

Approximate cost of critical components:
PIC 18F2685: $12 - $15
LCD Display 20x4: $15 - $20
All other components are standard.

Displays 4 lines of 20 characters

The only problem we had during development, it is the LED displays 4 lines of 20 characters. Displays ordered from Farnell, reference POWERTIP PC2004LRU - AWB -HQ have never accepted to work! We realized that the voltage to be applied to the contrast was a negative voltage, which is much more complicated when only 5V is supplied on the card. It was not explained on the Farnell website or on the display documentation.

As an alternative solution, we found displays that work very well within $15 shipping included (Photo 2). Preferably choose a backlit model allowing reading by night. There are different colors of the white character type on blue background or black on yellow background. We preferred the classic black character on green background with backlight, but it is a matter of taste. This display is quite readable without backlight (to save battery), and with the lighting, you can use the decoder by night.

Photo 2: Display 4 lines of 20 characters
" HD44780 20X4 Character LCD Display backlight Green ".

Construction and adjustment

After assembling all components, there remains the settings .

The first phase is to put the power on without the CI nor the display and check if the voltage of 5V is correct . If it's good, put in place all the elements.

The second phase is the test with the power. The home page must appear: " Recepteur Trames 406 ...". If nothing appears, reduce the voltage contrast. When black squares appear on the front lines, this means that the display works but not the microcontroller. If you see the home page, all is good ...

The third phase is to put an audio signal on the input and test the overall operation. You can do it with recorded frames that can be found for example on the site F6HCC [3]. Another solution is to use the frame generator described in <F1LVT.com> [2, 5], which sends one 406 message every 5s.

In summary, this 406 message decoder is relatively easy to build, and its use is very simple. All information contained in the message is displayed on the screen (Photo 3).

Photo 3: The decoder after reception of a 406 message

References

[1] F1LVT "Decoding the 406 MHz beacons: Display on 4 lines of the message information"
[2] Website <www.F1LVT.com>
[3] Website F6HCC <http://f6hcc.free.fr/decodargos.htm>
[4] COSPAS SARSAT documents:
-- "Specifications for COSPAS SARSAT 406 MHz Distress Beacons", C/S T.001 n°, Rev 10, Oct 2009
-- "COSPAS-SARSAT Guidelines on 406 MHz Beacon Coding, Registration and Type Approval", C/S G.005, n°2 Rev 4, Oct 2009
[5] « Générateur de trames de balise 406 MHz pour la vérification du fonctionnement des décodeurs de trames, et pour la construction de balises d'exercice ».
RASEC Infos Techniques, n°1, Mai 2011, p 8 – 14

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