Decoding the 406 MHz beacons
Display on 4 lines of the message information

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This 406 message decoder has been built as a second year project of the National Engineering School of Energy, Water and Environment (ENSE3), at Polytechnic Institute of Grenoble (INPG). The study, programmation and construction was carried out by a group of 8 students: Aurélien QUATRINI, Bertille MIELLIN, Valentin BESSON, Van Binh DINH, Henri HITIER, Xavier MALIGNE, Benoît DEGOUY and Thibault VAILLANT, under the direction of F1LVT, Jean-Paul YONNET.

The objective of the project is both technical and management: project management and encountered problems is as important as the technical part itself.

The building of this autonomous decoder was not an explicit objective of the project, but a step in a larger study. The original subject was both receiving decoding and transmitting information of 406 frames from listening stations on mountains or high level points. Finally retransmission part has not been finalized, but the decoding and display of the message part works fine. This part on decoding and display was isolated from the project, and it has been transformed into an autonomous module presented in this article. The system performs the decoding and display of 406 MHz beacon message on a wide 4-line display.

The first article shows the operation. It will be followed by a second article on the interior of the decoder, and a third one describing the construction step by step.

How to decode 406 message

In the radioamateur field, the first 406 message decoder was made by Jean F6HCC . It works with a microcontroller type 80C52 and a display with 2 lines of 20 characters [1]. It is a remarkable, reliable and efficient system. Other radioamateurs have worked on these message decoders as the University of St Quentin (02), or F4EQD (35).

The objective of our work was not to compete with these systems, but it was listening on high level point on the mountains and then retransmit the information to reception stations in the valleys. We need to identify the system that retransmits, determine when the reception was held , then retransmit the received message.

All the information is displayed on a single screen with 4 lines of 20 characters. To achieve this, the information is condensed. As exemple, the presence of a 121.5 MHz emission is indicated only by a "+". Each page that contains all the information of a frame is stored in the microcontroller memory. Previous messages can be recalled and displayed.

A particular care has been taken to the message reception when the signal is noisy. In principle, the rising and falling edges are separated by intervals of 1.25 ms or 2.5 ms (transmission rate of 400 baud). [2] The noise results in additional spikes in addition to the useful signals. The standard lengths of crenels are no longer respected, but a reconstruction algorithm has been integrated into the PIC software to read the message in the presence of noise. This algorithm gives a fairly high sensitivity system.

The peculiarities of our system

The main interest of the system are:
- The display on one screen of all the information contained in the message. Some are very abbreviated, but many information can be read directly on the page: the country, the identification code in hexadecimal, the position if it is transmitted, etc..
- The decoder saves and displays the time of the alert. The time is captured by a GPS connected, in UTC. In the absence of GPS, the time information is replaced by 8888.
- The decoder saves 5 previous frames. Playing with push-buttons, they can be displayed. If you let run your decoder and if several frames are recorded, you can know whether the received frame is unique or if it is a series of frames every 50 seconds.
- The decoder is completely autonomous. You put it on and you forget it. If a frame is transmitted, the time is automatically recorded and saved.

Photo 1: The frame decoder with the display of the homepage.
Everything is ready for operation

- The system is relatively small. The size is defined by the four display lines (100 mm x 60 mm). The signal processing card has exactly the same width and it is positioned under the display. We even put a 9 volt battery on the card. All is situated under the display and makes the system completely autonomous. With this power supply you have about 5-6 hours of battery life. This does not prevent you from connecting 12V to supply the decoder or to recharge the battery.

At the start, the decoder displays a home page. As soon as a 406 message is received, the display switches to shows all the decoded information. This page remains displayed until it receives another 406 message. Previous pages are stored in memory by the microcontroller and can be recalled.

An LED indicates the operation of decoding. For each receiving it lights. The drive signal of the LED (transition to 5V) can be also used to drive a warning of receiving a frame .

The input circuit is used to shape the peaks corresponding to the phase change and transform them into crenels. We kept the F6HCC device that works well. However, be careful to the adjustment of the input circuit. If the level is too large, the sensitivity is reduced by the noise. If the level is too low, the sensitivity is too low. The problem is that each receptor provides a signal amplitude and noise of its own. To maximize sensitivity, we must look at the signals to the oscilloscope and adjust the decoder to the receiver. It's easy to do when you have a test beacon, it is much less easy to do without equipment.

<u>Decoder connections</u>

On the circuit board (Photo 1 and 2), on the left side, one can successively see the 2.5 mm Jack for the GPS connection, in the middle is situated the switch on-off and the power jack which also serves as a terminal battery charging, and the 3.5mm Jack to connect the output of a receiver tuned to the beacon frequency.

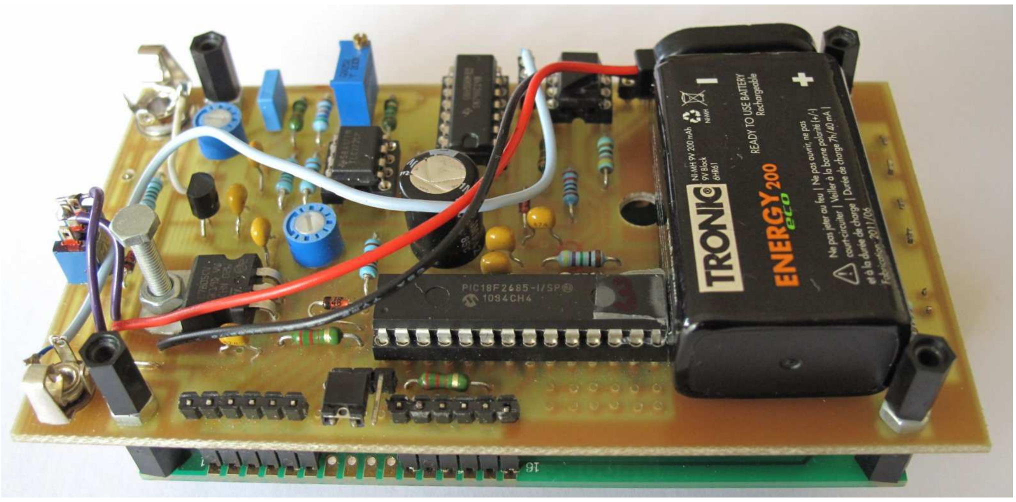

Photo 2: Bottom view of the decoder. The PIC 16F2685 is the 28 pins IC.
The 9V battery makes it completely autonomous.

On the right side, the LED is used to monitor the operation, and two push-buttons to navigate through the memories (Photo 1). As the system permanently write in the memory the new message data, it is best to disconnect the input when you want to view the pages in memory.

For the link with the receptor, although the decoding should work on the LF output "headphones", it is far preferable to mount the receiver in a direct exit "discriminator". This output at a constant level allows you to set once the input to the decoder level and to obtain a reliable operation.

Decoder operation

Welcoming page

At the power on, the display shows a welcoming page. It is listening, ready to operate.

R	e	c	e	p	t	e	u	r		T	r	a	m	e	s		4	0	6
P	r	o	j	e	t	-	C	o		E	N	S	E	3		2	0	1	2
		F	1	L	V	T					I	n	i	t	:	O	K		
A	t	t	e	n	t	e		d	e		t	r	a	m	e		.	.	.

Figure 1: Welcoming page
“406 message receiver … waiting for message”

Once a message is received and decoded, the LED beside pushbutton lights to indicate the reception and processing. Each time a new message is received, it is displayed and it is possible to display the previous message by scrolling through the memories.

Message reception page

Details and relationships with the provided information:

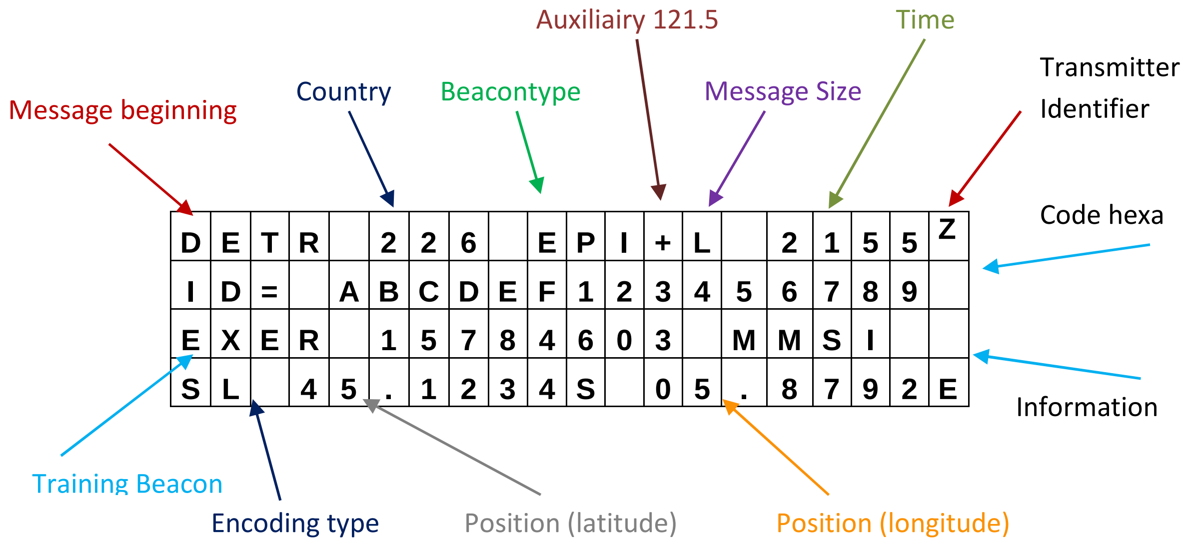

Figure 2: message information display

First line

- In the Figure 2 example, DETR (for DISTRESS) is given by the beginning of the message. If it is a beacon test, these 4 letters are replaced by TEST.
- The 3 numbers that follow indicate the country of registration of the tag. Values 226, 227 and 228 correspond to France.

- The following three letters give the type of beacon. It can be: EPI (for EPIRB boat beacon) , ELT (airplane beacon) or PLB (personal location beacon).
- The "+" sign appearing after these 3 letters indicates the presence of 121.5 MHz emission in addition to the 406 MHz.
- The letter " L" or " C " gives the message type " L" for a long message and "C" for a short message.
- The following four characters indicate the time in UTC when the decoder is connected to a GPS. In the absence of the GPS information, 8888 is displayed and stored.
- Finally, the last character of the line is used when multiple receivers with retransmission are used. In the absence of a multiple receiver system, the letter Z is used then it can be interpreted as " Zulu time " .

Second line
This is the message identification with 15 hexadecimal characters. When there is an abnormal reading, this identification is framed by the signs "/".

Third line
- The first 3 characters are either "REEL" (for almost all cases it is a REAL distress beacon and not a training beacon) or "EXER" (for a training beacon, used for exercices).
- Following the line gives some information contained in the message. This information depends on the beacon type and the coding type.

Fourth line
- The first two characters provide the type of encoding of the frame protocol: SL for Standard Location, UP for User Protocol, and NL for National Location.
- The position is given as "Latitude" and "Longitude", in degrees and fractions of degrees. Example: 45.1234N 05.6789E

Even if the beacon is coded in degrees - minutes - seconds with an accuracy of 4 seconds in the best case, we believe it is better to show the position in degrees and fractions of degrees " dd,dddd " because it is much easier to use on the ground that the sexagesimal degrees.

When the information does not correspond to the possible choices, the display is replaced by "ERR" or "ER". If the filler data table overflows, then the frame is displayed, but the identifier is framed by "/". In this case, the beginning of the frame is often correct (country, Identification), but the end (the position) can be erroneous.

Operation example

The Photo 3 shows an example of message reception.

Photo 3: Example of decoded message

On the first line, you can see:

- This is a test of beacon
- The country is 366: United States
- This is an ELT (aircraft beacon), which also emits 121.5 MHz (sign “+”)
- The message is of short type (sign C)
- The time has not been recorded (8888, probably because the local GPS is not connected)

The second line gives the 15-digit identifier (in hexadecimal): ADCC05819E00401
The third line indicates the type of operation and the serial number of the beacon.
Finally, the UP is "User Protocol". The beacon does not transmit its position, otherwise it would be displayed on the fourth line.

Message format: Not provided in 15 hex id

Protocol:	User
Country code:	366 - **United States of America**
User type:	Serial User
Serial Type:	ELT with Serial Identification

Cospas-Sarsat Certificate Number in bits 74-83: No

Serial Number:	90215

All 0s or National Use

C/S Number or National Use (bit 43 refers): Nationally Assigned (not Cospas-Sarsat)

Aux radio device:	121.5 MHz
15 Hex ID:	ADCC05819E00401

Figure 3: decoding of the frame by the site COSPAS SARSAT [3]

Some other examples of display

The following photos (Photo 4 and 5) correspond to a plane beacon ("ELT") in TEST mode. The message is a long message ("L"), which contains the position displayed on the fourth line.

On Photo 4 example, all the information is present except the time of reception. This is because the GPS was not connected to the decoder. Against by the GPS beacon transmitted the position shown on the last line (you can look for where the beacon was ...).

To obtain the time from a GPS, we have programmed the detection of message type $GPGGA. Most often, we run our prototypes with a GPS Trimble Copernicus recovered in a radiosonde Modem. The operation was also verified with other GPS like Garmin GPS18 or Garmin Etrex kind.

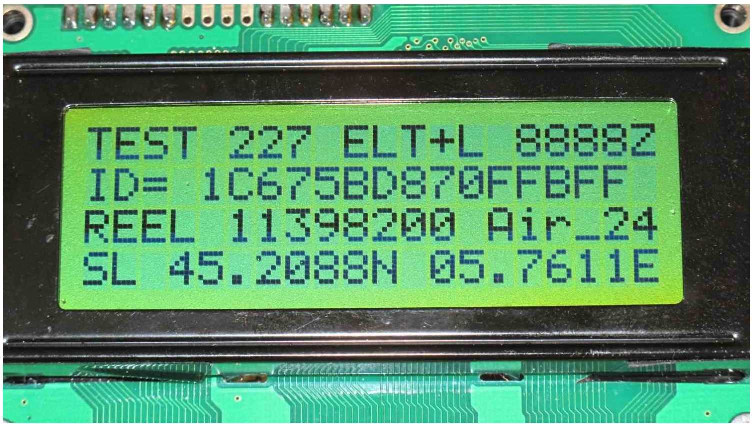

Photo 4 : Message received without GPS connected giving time.
The position is transmitted by the beacon.

Now the GPS is connected to the receiver, and the time is read and recorded. But we have removed the GPS from the beacon. The transmitted position is a default position (127 ° N and 255 °E : a point which is difficult to locat e). The decoder correctly identifies the default position and display "Position Absente" (Missing Position).

Photo 5 : Message transmitted by a beacon that should give its position, but the GPS of the beacon does not work. The time of reception is displayed.

Conclusion

This decoder is very simple to operate. On 4 lines, you can read all the information contained in the frame in a condensed form: message type, identification, position, etc. Previous five frames are recorded and can be recalled.

The two key components of the decoder are the 20x4 display and the PIC. These two components can be found for less than $30. The other components are very common.

The construction of the decoder will be described in the second part of the article [4].

References

[1] Website F6HCC <http://f6hcc.free.fr/decodargos.htm>

[2] Document COSPAS SARSAT:

- “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

[3] http://www.cospas-sarsat.org/en/component/beacondecode/?task=showBeacon

[4] Website <http://www. F1LVT.com>

Original article in French: Oct 2012
Translation in English: March 2014