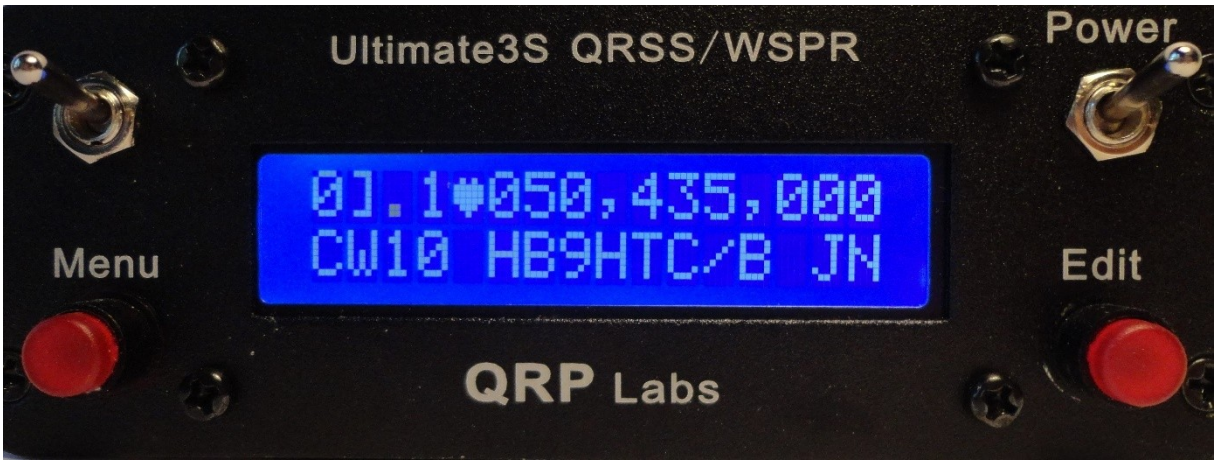
6m Beacon HB9HTC/B

by Hugo HB9BMD



1 What prompted me to build and operate a 6m beacon?

Beacons are an ideal means of checking propagation on the 6m band. These are located around the world, and it is always interesting to observe how a given beacon might be heard with a vertically polarized antenna but not with a horizontally polarized antenna or vice-versa.

To check propagation on HF, hams can use the Reverse Beacon Network (RBN) and thus special beacons are not necessary, except perhaps for the 10m band.

I am on the air frequently with CW on 6m between May and September, so beacons are a reliable means for me to evaluate conditions.

Previously, I used a beacon located on Mount Säntis. If I heard it with a strength of S4 or better using my horizontal dipole, then I knew QSOs were possible in Europe. Unfortunately, though, the beacon at the QTH is no longer in operation.

The Swiss plateau (Mittelland) is an empty area as concerns 6m beacons, and I wanted to not only profit from what other hams had built up and operated, I also wanted to make my contribution.

The technical challenges, the homebrewing and not least being able to successfully complete such a project were motivation enough for me.

From the initial concept through to actual implementation took a solid 2 years, and during this project I learned a great deal as regards the technology. Further, I was also the beneficiary of considerable “ham spirit” – indeed, it is still alive and well!

2 Technical specifications for the beacon

Parameter	**Value**	**Comments**
Frequency	50.435 MHz	Supported with GPS
Modulation	A1A (CW)	
Speed	10 wpm	
Output power	3W into 50 Ω	
Message sent	_ carrier 10 sec _HB9HTC/B_JN37WJ_ (continuous loop)	
Antenna	Slim Jim	With 450 Ω ladder line
Polarization	Vertical	
Installation height	6.5 m	

3 Project history

I put the first version of the beacon into operation on 24 July, 2021. I was delighted to see that in only three days I had already received a reception report from southern Spain.

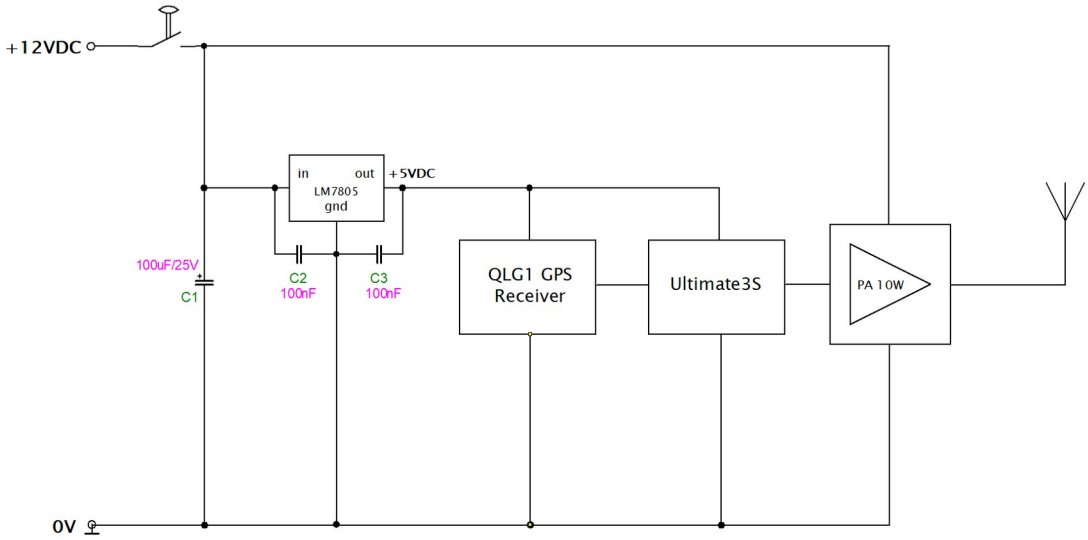
The power amplifier on this original beacon configuration required a cooling fan. Its noise was so disruptive that I decided to design a new power amp stage that could operate without any auxiliary cooling.

I ultimately chose the 10W liner power amp from QRP Labs. This decision also eliminated the need to monitor the temperature of the heat sinks and run the associated shutdown circuitry.

Here I must note that construction of this 10W amplifier kit is something suited only for experienced builders. The layout is very compact and you must wind toroids with multiple turns and insert them into the circuit so the phases are all correct. Based on the experience I gathered, I offer my assistance to anyone attempting this task.

Redesigning the beacon required considerably more effort that I had expected!

4 Operating principle: circuit diagram with short description



The beacon consists primarily of three modules: the QLG1 GPS receiver, the Ultimate3S QRSS/WSPR unit, and the 10W HF linear power amp. All three modules are available in kit form from QRP Labs.

The +12V dc supply is routed through the main power switch. In transmit mode, the beacon draws 1.2A, while in standby mode it consumes 250 mA. A LM7805 voltage regular provides the +5V dc for the Ultimate3S and the GPS receiver. In the Ultimate3S, all operating parameters – such as frequency, type of modulation, type of lowpass filter, the text to transmit, etc. – are stored in the nonvolatile EEPROM of the onboard ATmega328 microcontroller. System parameterization is explained and illustrated very well in the QRP

Labs documentation. The HF output of the Ultimate3S generates a maximum of 110 mW, which is quite adequate to drive the power amplifier. That amp has a maximum gain of 22 dB at 50 MHz, and it is set up for 3W continuous wave. In this way, the output power of the Ultimate3S is set to 20 mW.

5 Photos with details

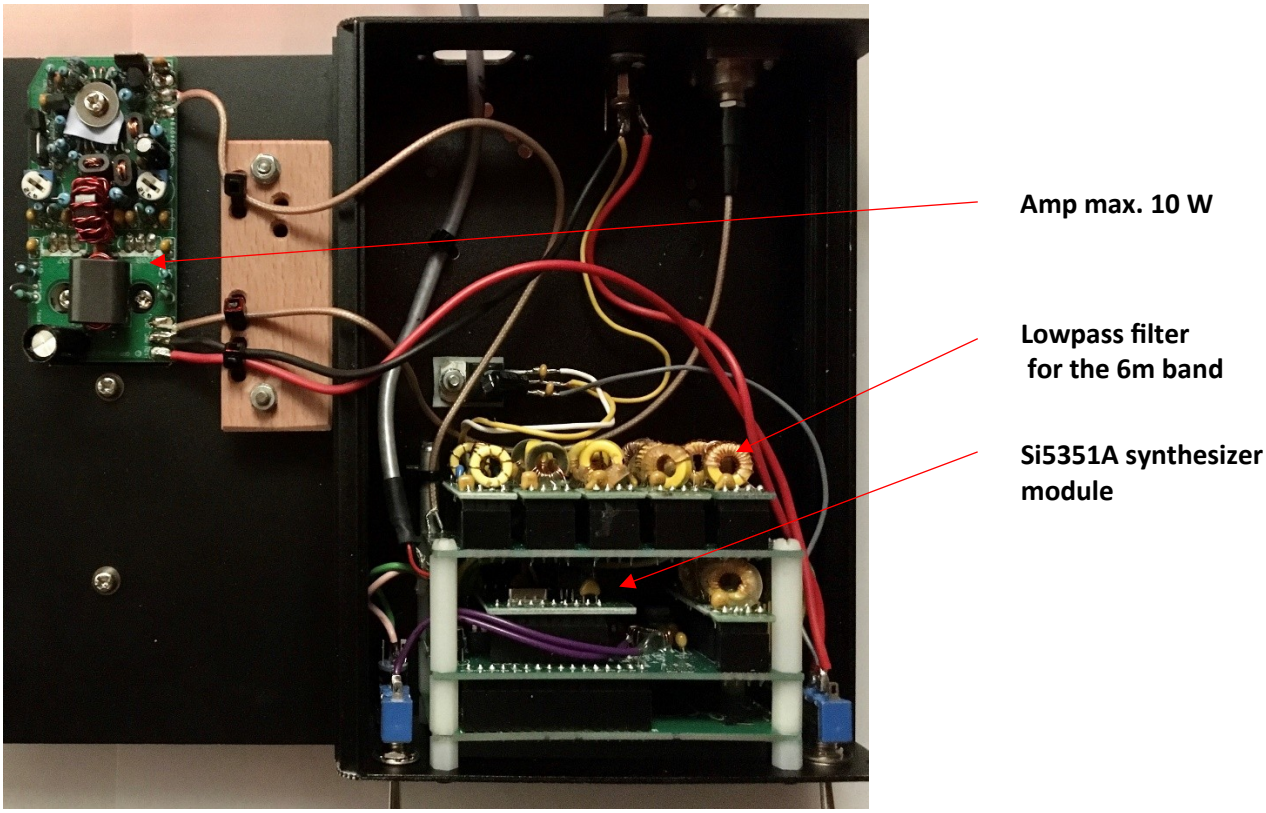
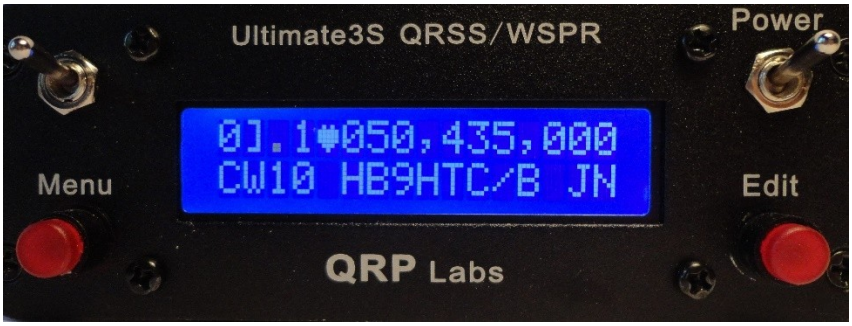


Figure 1: Open chassis view



Switches and display elements, from upper left to lower right:

- Switch on the upper left, currently unassigned: with it, the display backlighting will be turned on and off
- Display “1”: 6m lowpass filter is activated
- Display “heart” symbol: the 1 pps signal from the GPS is being received

- Display “50,435,000”: beacon transmit frequency
- Display “CW”: Modulation type A1A
- Display “10”: CW speed in words per minute
- Display “HB9HTC/B JN …”: text being transmitted in a continuous loop
- Switch on the bottom left: Used to select the desired parameter from a menu
- Switch on the bottom right: Used to set the value of the selected parameter

Figure 2: View from above with the well-dimensioned heat sink

During continuous operation at 3W, the heat sink temperature remains below 45° C at room temperature.
The heat sink is screwed down securely to the upper part of the chassis, resulting in additional cooling surface.

6 GPS Receiver

To keep the beacon's frequency stable over the long term, it is continually compared to the 1 PPS signal from a GPS receiver. A GPS patch antenna is integrated into the housing with the QLG1 GPS receiver.

The following section provides a functional description. The transmitted signal is generated using a Si5351A "programmable any frequency generator" from Silicon Labs. For the frequency reference, the system uses a 27-MHz quartz oscillator, which allows generation of frequencies as high as roughly 200 MHz. With appropriate setup, the beacon's frequency is created for the 6 meter band.

The consistency of this frequency depends on the frequency reference, in this case the 27-MHz quartz oscillator. For it, the transient response, temperature behavior and aging play a role. A conventional quartz oscillator (not using an oven to maintain a uniform temperature) has a deviation of an estimated ±25 ppm over the temperature range from -40 to +85°C. Because the beacon is located in a heated room, this device can readily be used in practical applications.

The frequency's long-term stability is considerably improved with minimal extra effort by means of a connection to a GPS timebase. Here we refer to a GPS disciplined oscillator (GPSDO). As soon as the GPS receiver has locked into enough satellites, it generates a digital impulse every second (PPS, pulse per second), which is used as a long-term stable target value for a control loop.

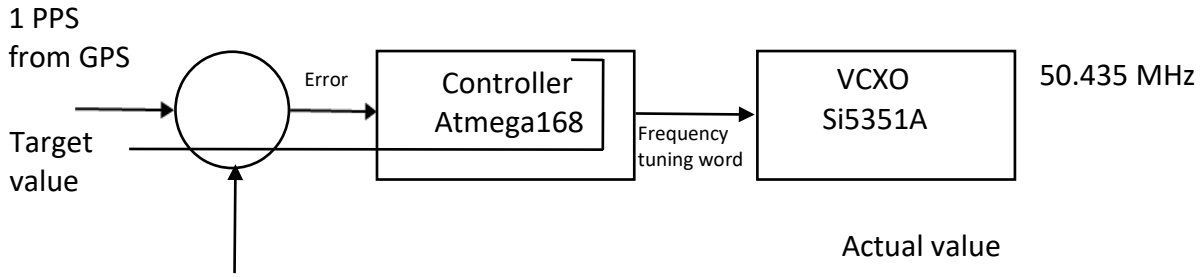


Diagram of the control loop for maintaining a constant frequency

The signal from the Si5351A is fed to a counter in the microcontroller and is counted between the duration of two PPS impulses, doing so in order to determine the actual value. The PPS impulses suffer from random jitter that can be compensated for by means of averaging out over a given amount of time. The code in the microcontroller continuously corrects for any errors in the quartz oscillator by comparing the target and actual values and a continuous adjusting of the settings of the Si5351A.

You can also imagine the functionality in this way: Using the actual value from the oscillator, a time interval of presumably 1 second is created. This 1 PPS signal is compared with the precise 1 PPS signal from the GPS receiver. Using this resulting error signal, the local oscillator is corrected in small steps by adjusting values in the configuration of the Si5351A.

The momentary properties of the oscillator signal are determined by the quartz oscillator. The long-term stability of the oscillator signal is determine by the GPS. If the GPS impulse is no longer available, the oscillator continues to function using a crystal.

Figure 4: The QLG1 from QRPLabs installed in a separate housing.

7 Beacon QTH and requirements

When selecting a QTH for the beacon, it is important that there is no other radio activity on the same frequency band, otherwise it would be necessary to deactivate the beacon during these times.

Locator	JN37WJ
Location	CH-4634 Wisen, Canton Solothurn (Jura Mountains)
Altitude	724m ASL

8 Selecting an antenna

An obvious question is whether to use a horizontally or vertically polarized antenna. In lists of beacons both types are represented with roughly the same numbers.
I ultimately decided or a vertically polarized antenna because of its omnidirectlonal radiation characteristics and the amount of space needed.
The problem with a vertical dipole is that the coax cable must be run away from the antenna at a right angle, which would be mechanically difficult to implement.
Unfortunately, the Diamond Model F61 vertically polarized antenna that I use at my home QTH is no longer available.
Because I have already built many Slim Jim antennas and also because this type is often mentioned in the list of beacons, I decided to make one of them for the beacon. It now hangs from a roof ridge at the QTH (Figure 9).

RF choke made with RG-58 wound on a piece of PVC pipe

Coax being fed to the 450Ω ladder line

Completed antenna with protective tube covering

Figures 5 – 7: Details of antenna design

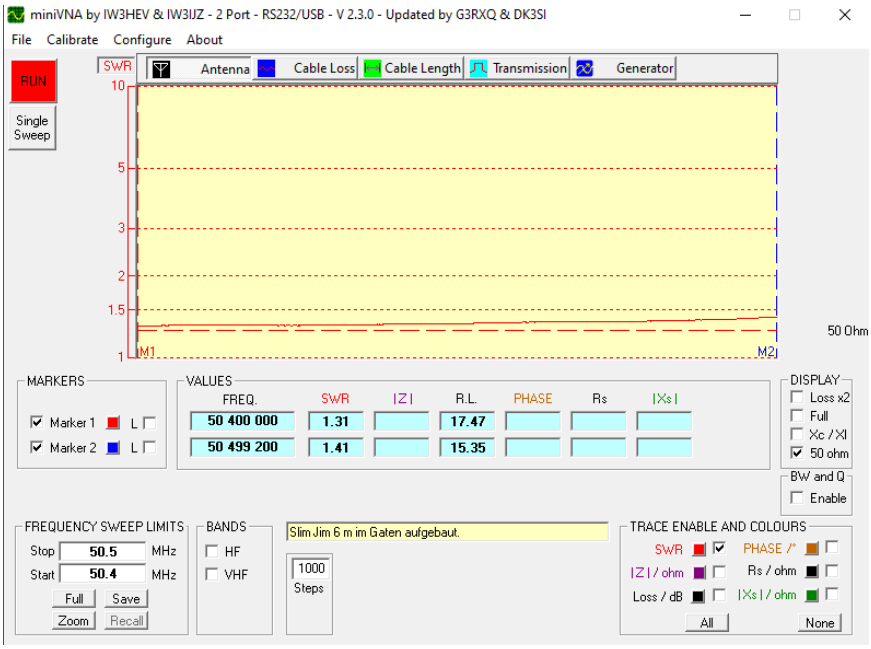


Figure 8: Measurements on the Slim Jim antenna

Figure 9: Antenna hanging from the roof ridge at the QTH in Wisen (Canton Solothurn).

9 Reception reports and QSLs

We would be pleased to receive reception reports so we can better evaluate the beacon's performance. For this purpose, we have set up a form on our club website that you can fill in and submit: Helvetia Telegraphy Club HTC (D1) - 6m Bake HB9HTC/B (clubdesk.com). All reports are forwarded directly to me.

On this form, you can also indicate if you would like to receive a QSL card; further note that we do not require you to send us a QSL card, the info on the website reporting form is sufficient.

HB9HTC/B Confirming **6m** SWL-Report

To Amateur Radio Station:

Via:

Specifications:

Frequency: **50.435 MHz**
Modulation: **A1A (CW)**
Speed: 10 WpM
Power: 3 W
Beacon Message:
carrier 10sec_HB9HTC/B_JN37WJ_ (cont.)
Antenna: Slim Jim - with 450Ω ladder line
Polarization: Vertical
QTH Locator: JN37WJ (CH-4634 Wisen/SO)
Altitude: 720 m.a.s.l
Operating time: 24h

Date			*Time*	*Signal report*
Day	Month	Year	UT	RST dbm etc

We appriciated your signal report
and thank you 73

Beacon Team:
HB9BMD Hugo and HB9ARK Martin

10 Responsible parties

Function	Person	Comment
Operator	HB9HTC, represented by HB9AFH Hugo Huber	HTC club president
Technical Manager for the Helvetia Telegraphy Club HB9HTC	HB9AFH Hugo Huber	Contact with telecom authorities
Project Manager	HB9BMD Hugo Ulrich	Responsible for technical aspects
Assistant Project Manager	HB9ARK Martin Klaper	Responsible for technical aspects

11 Support and acknowledgments

It didn't take me long to realize that completing such a project all on my own would be quite difficult and also that the beacon could not be located at my home QTH.
The necessary technical support and assistance with administrative matters soon expanded to include all those just mentioned.
Because an automatically controlled beacon may only be operated by a club, I turned to the generosity and cooperation of the Helvetia Telegraphy Club HTC so that I could get permission to use the callsign HB9HTC/B. My request was then approved by the club's Annual General Meeting, for which I thank them greatly.

I would like to express my grateful thanks to:

- The Helvetia Telegraphy Club (HTC) and its President HB9AFH. Hugo has always been very open-minded about my ideas and this project. He handled the administrative aspects of this project, submission of the concept to the telecom authorities and its presentation on the club website.

- HB9CJX/PP5ZX Marco for his strong support during the presentation of HB9HTC/B on www.qrz.com.

- HB9DST Paul for the English translation.

- HB9ARK Martin. When I asked Martin if he would be willing to act as the Assistant Technical Manager, he agreed immediately. Martin, with his immense expertise and ham spirit, is a true godsend. Even better, we both live in the same village.

- DL2EWN Harald for repairing the 5W PA that I blew up, doing so at no charge. That is true ham spirit!

- G0UPL Hans for responding to all my questions about the operating parameters for the Ultimate3S.

- HB9AYR Werner for loaning us his professional HF measurement equipment.

- HB9BXQ Renato, who is the frequency coordinator for automatically controlled amateur radio stations, for his assistance in assigning this beacon a frequency and for his interfacing with IARU Region 1.

- My very good friend and inactive ham Rolf. When I approached him he was immediately ready to let me locate the antenna on his property and put the beacon in his home. Another true godsend.

- My two friends René, unfortunately also an inactive ham, and Urs, for their considerable assistance when assembling the antenna and locating the beacon at its QTH.

12 Looking ahead

Of course, when working on such a project, many ideas for new ways of doing things and improvements come to mind, and you can expect many other hams to contribute valuable inputs. Among them are:

- Switching back and forth from a horizontally to a vertically polarized antenna.
- Reducing power output on each of these two antennas in steps, e.g. 10W / 5W / 2.5W / 1W / 0.5W, at 1-minute intervals.
- Working within the scope of the IARU Synchronized 50 MHz Beacon Project
- This list could go on and on...

13 Summary

I am quite satisfied with the results as presented here, and I am anxiously awaiting the first reports of received signals. It was extremely inspirational for me to have the opportunity to experience first-hand what we hams have the privilege to do, specifically for us as individuals to design, build and operate radio systems.
The construction and assembly of the Ultimate3S and the 10W amp kits demanded a great deal of patience, skill and concentration. With great satisfaction I can say that during this project I learned a great deal and was able to gain very valuable experience. Ham spirit truly lives, indeed!

14 List of resources

- The supplier of the Ultimate 3S QRSS / WSPR and 10W power amp: QRP Labs, https://www.qrp-labs.com/
- Beacon list, http://www.dl8wx.de/baken_50.htm
- *Funkamateur* Magazine, FA 2/21 and 3/21, “Praxistipps zur Kühlung von Halbleiterbauelementen”

15 Final remarks

This report is also available for downloading on the HTC club website at Helvetia Telegraphy Club HTC (D1) - 6m Bake HB9HTC/B (clubdesk.com). Here you can also find the latest news and developments about the beacon.

04 November 2021
HB9BMD, Hugo Ulrich
HB9ARK, Martin Klaper

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