A BACAR-ready 10 GHz beacon to exercise your Es'hail-2 receiver

19 May 2018

Hannes Coetzee, ZS6BZP, B.Eng. Electronics (Pretoria), M.Sc. Space Physics (Rhodes)

Introduction

If all goes according to plan the Qatar Satellite Company (Es'hailSat) will place its second satellite, Es'hail-2, in a geostationary orbit with the help of a Space-X Falcon-9 rocket. This will hopefully happen before the end of 2018. Es'hail-2 will carry an AMSAT linear transponder as a secondary payload, giving amateurs for the first time access to a geostationary satellite. The launch was originally planned for the second half of 2016 but has since been postpone numerous times. Some radio amateurs have already built receivers for Es'hail-2's X-band downlink but aren't able to test them as there are not any suitable beacons on the air.

A 10 GHz beacon implemented as a BAlloon Carrying Amateur Radio (BACAR) payload will be very handy in this respect and will also offer radio amateurs the opportunity to join the BACAR fun.

Possible Es'hail-2 Receiver Chain

The downlink of Es'hail-2 will be on 10.489 GHz with a bandwidth of 250 kHz. The transponder is intended for narrowband CW and SSB signals but most receive setups will also be able to receive wideband FM signals.

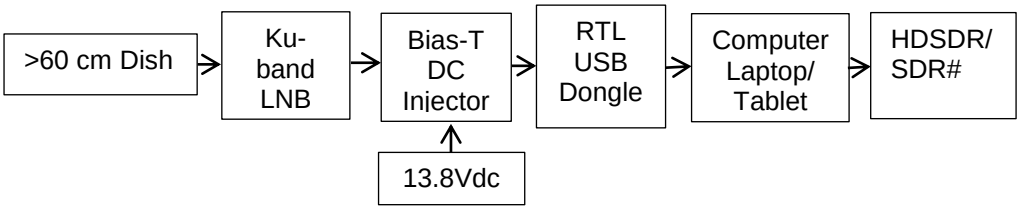

Figure 1: Possible Es'hail-2 ground station receiver chain.

A wideband FM voice beacon will not only allow the high stability, PLL based LNB's as required by Es'hail-2 to be exercised but it will also make it possible to receive and demodulate the signal with a surplus, DSTV LNB seeing that you already own an USB SDR dongle (don't you???). The voice message will make it easy to identify the BACAR signal.

10.489 GHz Transmitter

Many moons ago wideband 10 GHz equipment operated on the Gunn-Plexer principle with a Gunn-diode and a mixer diode mounted in a waveguide acting as the transmitter and receive down converter. Nowadays it is a bit difficult (and expensive) to procure such equipment, and even if you can get hold of it, it is still bulky and a bit heavy to hang underneath a balloon. Another solution is preferred to generate a 10 GHz signal from BACAR.

Fortunately technology is evolving at a rapid rate and Gunn and Point Contact diodes have largely been replaced by Dielectric Resonator Oscillators (DROs) and Schottkey mixer diodes in Doppler motion sensors. Browsing the Internet revealed that a suitable module in the form of the HB-100 Doppler motion sensor was available at reasonable cost. The frequency allocated to motion sensors is 10.525 GHz, conveniently close to the target frequency of 10.489 GHz.

Figure 2: HB-100 X-band motion sensor.

The interesting bids of an HB-100 are covered by the metal shielding can. The can is easily removed to reveal the DR stabilised oscillator as well as the diode mixer.

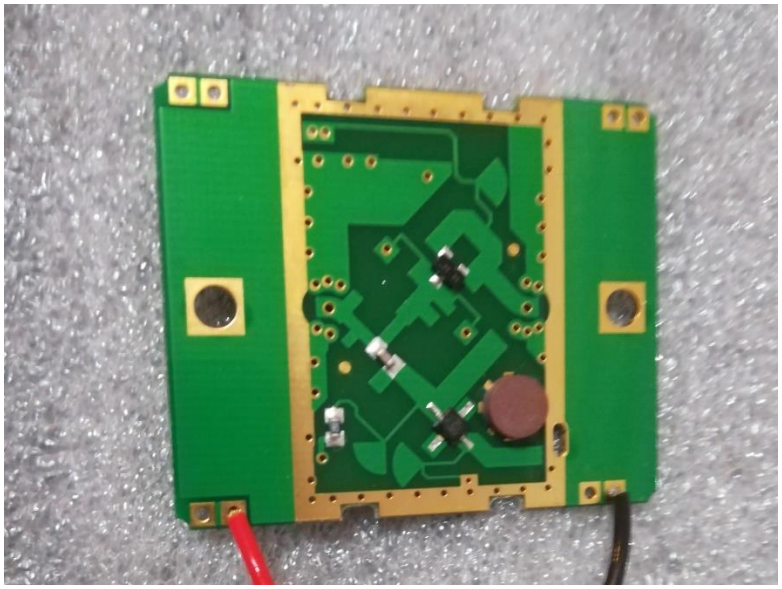

Figure 3: HB-100 X-band motion sensor with metal cover removed.

The reverse side of the PCB contains four patch antennas, two for transmitting and two for receiving.

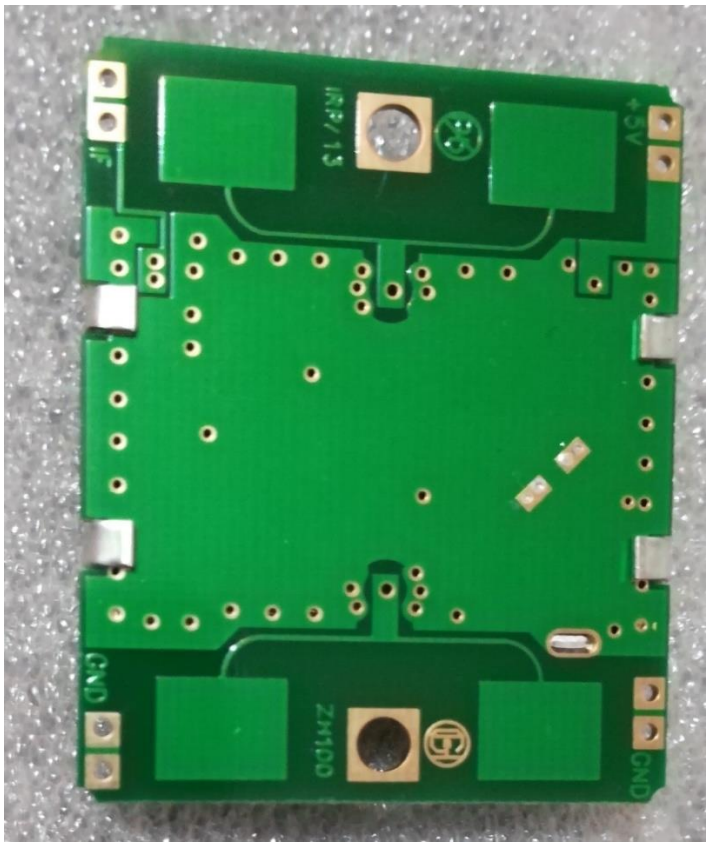

Figure 4: Dual patch antenna pairs for transmitting and receiving.

The datasheet of the HB-100 states that with a supply voltage of 5 Volt the transmitting output power is 15 mWatt, which is comparable to that of the Gunn-diodes of yester year. Contacts were established over hundreds of kilometres with Gunn-Plexer type equipment, indicating that it should also work well as a BACAR beacon. An Es'hail-2 receiver making use of a Ku-band LNB is however considerably more sensitive than a Gunn-Plexer based receiver. This should make it possible to receive the beacon signal from BACAR over any line-of-sight path. It will be interesting to see where the signal can all be received considering that BACAR typically achieves altitudes of more than 28 km above the earth.

Turning the HB-100 Transmitter into a Wideband FM Beacon

DROs can be frequency modulated (FM) by varying the supply voltage slightly in a similar fashion to that used to modulate a Gunn-diode oscillator. This is easily achieved with a common 3-pin voltage regulator.

A low cost, voice storage unit capable of repeating the stored message in an infinite loop was procured from Electrothing [www.electrothing.co.za]. This unit requires a 5 Volt (unmodulated☺) supply and features a built-in microphone as

well as an amplifier capable of driving a small loudspeaker for playback purposes. A 15 second message can be stored, all-in-all making it ideal for the planned beacon.

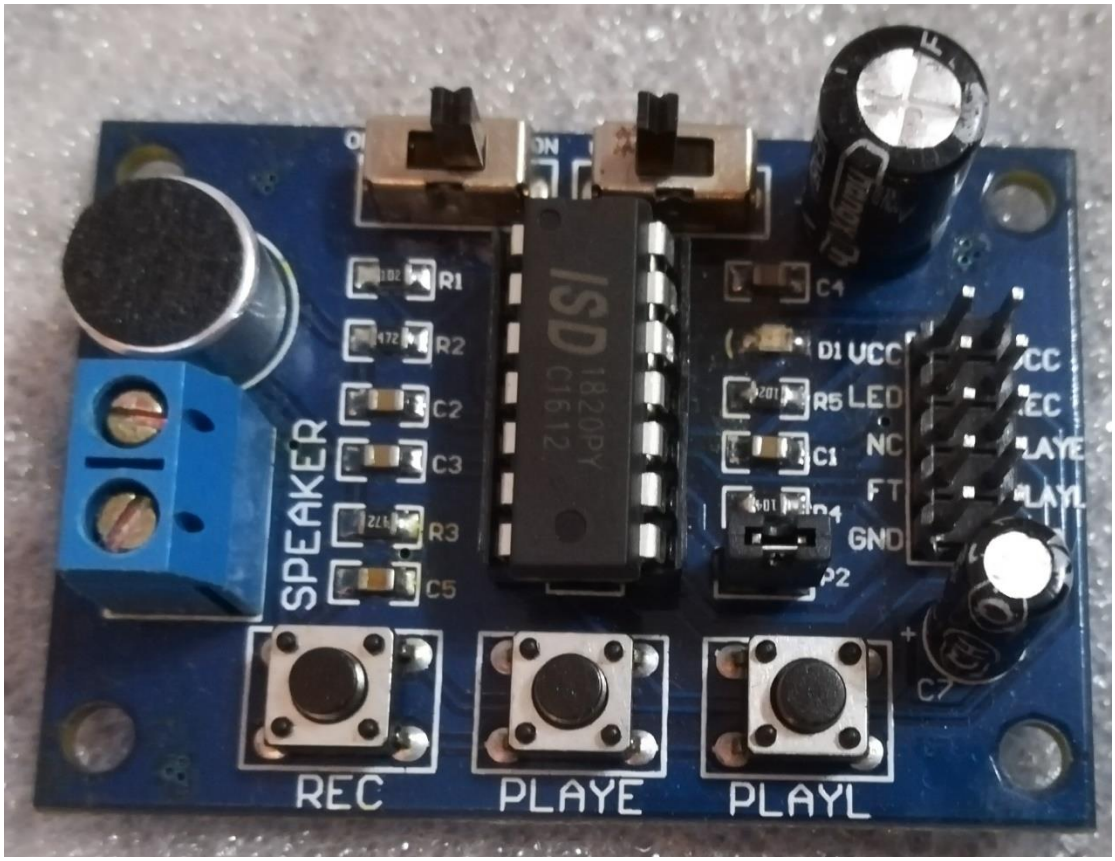

Figure 5: Electrothing voice storage module.

The plan is to operate the beacon from a low weight, two-cell, 7.4 Volt Lithium-Polymer battery commonly used for radio controlled aircraft. Low-dropout (LDO), 5V regulators are thus required.

The output of the voice storage module is used to modulate the reference pin of the 5V LDO regulator feeding the HB-100. A pre-set potentiometer sets the required deviation.

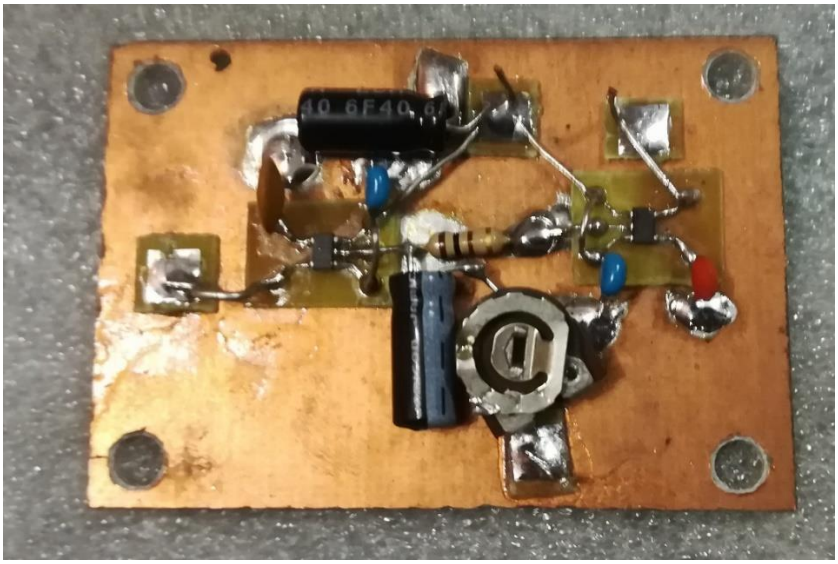

Figure 6: Two, Low Dropout Regulators are used in the beacon transmitter.

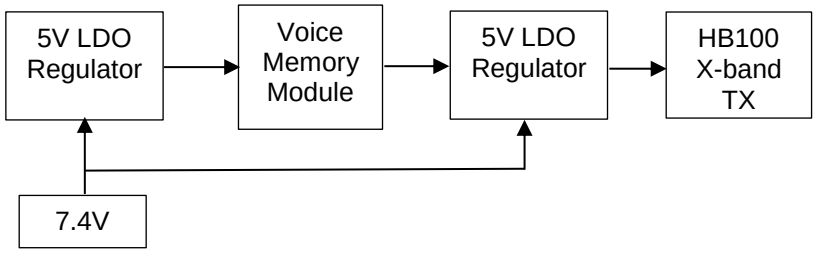

Figure 7: 10.489 GHz wideband FM transmitter.

Achieving acceptable frequency stability is a big challenge on 10 GHz. Mechanically everything must be very rigidly mounted and any flexing of the HB-100 PCB must be avoided. The unit must also be thermally very well insulated to keep frequency drift within reasonable limits. Fortunately the wideband waterfall display of USB SDR dongles will allow the signal to be easily spotted even if it drifts a couple of hundred kHz off frequency.

Summary

A 10.489 GHz wideband FM voice beacon was developed as a payload for the next BACAR flight. This voice beacon is an ideal test signal for an Es'hail-2 receiver.

The voice module can store a 15 second message that is transmitted in an infinite loop. The wideband FM signal can be received by the high stability, phase-locked, Ku-band LNB's required for Es'hail-2 reception and also by common, garden variety, low cost DSTV LNB's. This enables anybody with a surplus DSTV LNB and a USB dongle-based SDR to join the BACAR fun.