

# Grundig Yacht Boy 400 – Low Cost DRM Mod

## *Introduction*

In this document we present a modification to the Grundig YB400 short-wave receiver to make it suitable for DRM down-frequency conversion. As we do not have schematics of this receiver, we have been forced to make tests by ourselves... and four receivers later we have achieved a suitable modification which has been able to decode a **-87 dBm** channel power signal.

This receiver adaptation allows a low cost solution (about ~~250€~~) for DRM reception. The output signal can be decoded by a software receiver which gets it from the sound card line input.

## *Receiver Modification*

The modification consists in the following three steps:

- Get a 455 KHz IF signal with a bandwidth greater than 10 KHz, tuned to the desired RF channel.
- Down-convert it to a 12 KHz IF signal.
- Amplify this last signal.

The desired 455 KHz IF signal can be found in the pad remarked in figure 1.



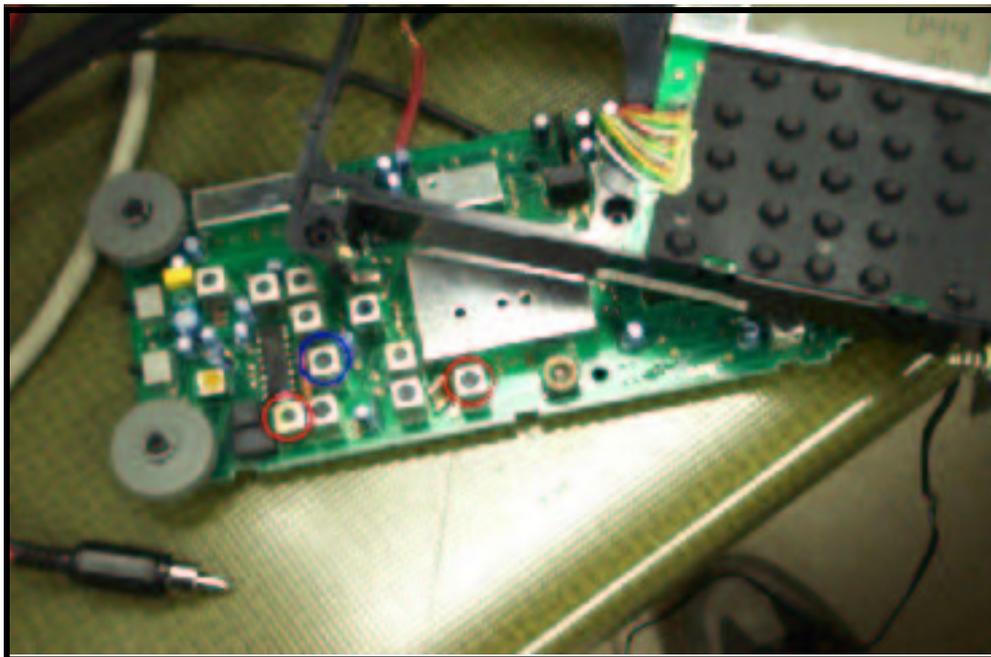
*Figure 1. 455 KHz IF output (without filtering).*

It must be taken into account that the signal level at this point is not affected by the AGC (Automatic Gain Control), so it will not be very powerful. We are working it out by now but, for the moment, an audio amplifier at the output does the work. This will be explained later.

This frequency is set to be 455 KHz although it could be shipped with a centering error. We have found it to be as big as 300 Hz in one model. This can be solved just by adjusting a resonator blue marked in figure 2.

Another important fact about this signal bandwidth is that it is only limited by the RF and IF1 (55.85 MHz) filters, which is quite wide (a 50 KHz BW was measured). The effects of this greater bandwidth are a noise increment and the appearance of the image frequency (current transmissions are isolated enough to avoid this last one). A simple filter design will be presented soon, for the moment an unfiltered signal is still suitable.

The last fact relating to this filter is that it may have not been correctly tuned in the manufacturing process, causing an asymmetric response. This does not have a visible effect in the base band AM signal (aside from a Signal to Noise Ratio reduction), but it has for the 12 KHz DRM output. This effect can be solved just by tuning a couple of resonators while monitoring it in a spectrum analyzer. These two points are red marked in the following figure:



*Figure 2. IF filter tuning.*

The second step, the down-conversion to a 12 KHz IF, has been solved using the 467 KHz mixer used in the other receivers modifications presented in this site. This output would suffice for the line input of the sound card, but without the AGC working an extra powering is needed.

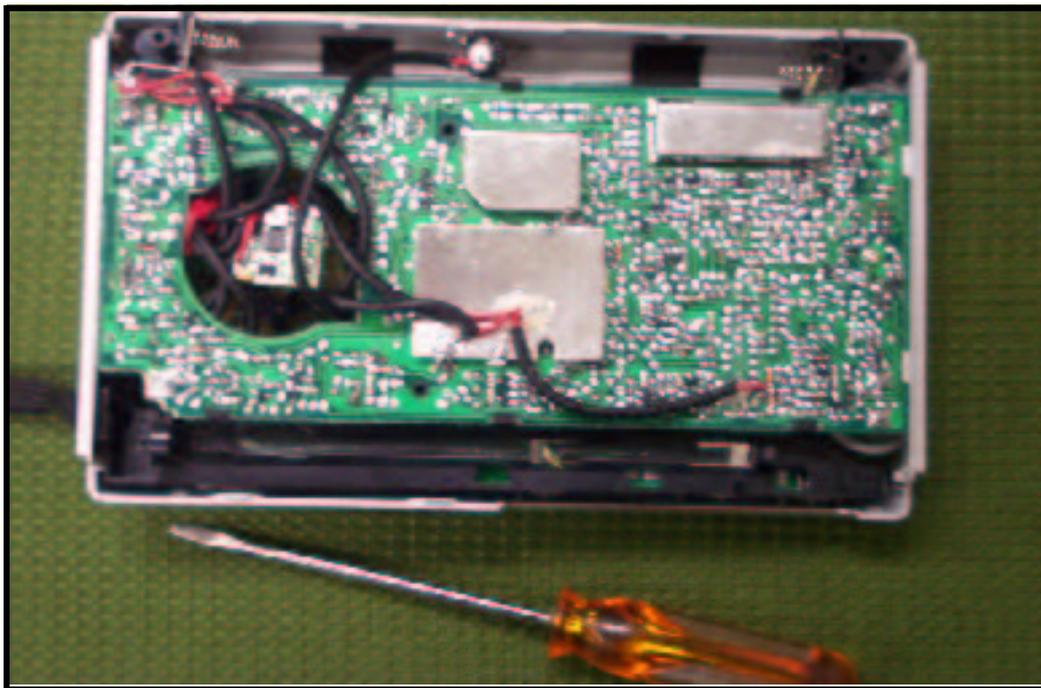
In order to achieve this extra powering a CEBEK (PM-4) audio line amplifier has been used. We have removed the internal radio speaker to make room for this module as shown in figure 3.

The need for this amplification in the last stage, at 12 KHz, is determined by the digital nature of the sound card. This card, a PC standard one, has an ADC after the anti-aliasing filter. The ADC ideally should be excited with a normalized signal to its dynamic margin, otherwise the quantification error will increase about 6 dB of extra noise for each unused bit of the digital generated word. Although the S/N in the 12 KHz output may be good enough, this effect could derive in a smaller S/N in the digitalized 12 KHz signal.

Experimentally, without the BB amplifier and good RF conditions the program synchronisation is possible and audio is available at the PC speakers. The ongoing work in filters and AGC use, to normalize the signal at the PC input, will minimize the RF conditions effect.

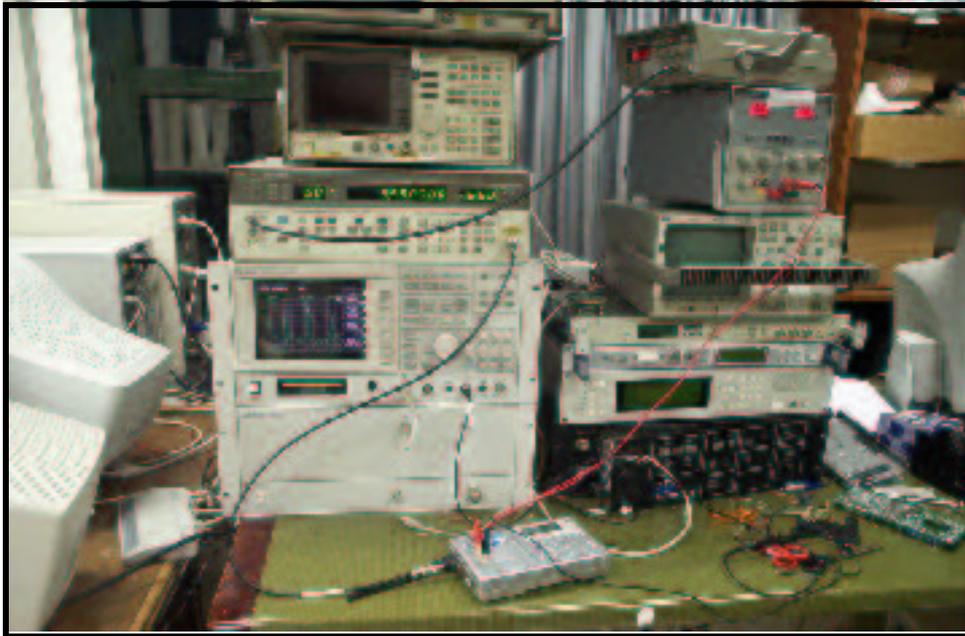
## **Results**

The complete modification with the 455 KHz down-converter and the audio amplifier is shown in figure 3.



*Figure 3. Complete DRM modification to the Grundig YB400 receiver.*

The extra connections have been made to present a nice front-end to this DRM modification as depicted in figure 4.



*Figure 4. External interface of the DRM modification to the Grundig YB400 receiver.*

The software receiver output is shown in figure 5.



*Figure 5. Software receiver output.*

## ***Acknowledgements***

This receiver modification for DRM down-conversion has been carried out by the DRM group of the Electronics and Telecommunications Department of the Universidad del País Vasco.

Any comments or suggestions will be welcome. You can contact us at our DRM mailing list: [drm@bips78.bi.ehu.es](mailto:drm@bips78.bi.ehu.es).