

"El Cuatro" - a 4-Band FM QRP Transceiver for 23, 13, 9, and 6cm, Fred, OE8FNK

Introduction and background: Commercial amateur radio transceivers are being built today with impressive technical specifications and a variety of operating options. And, of course, any amateur radio device has to have a high sensitivity, selectivity, good output power and a multitude of buttons and filters. And all has to be "state of the art", with lots of DSP and remote control.

The presented transceiver "El Cuatro" does **NOT have this all**. It was built with the goal (A) of being able to make a QSO on as many bands as possible with (B) with the easiest possible way of reproduction.

There is only one control knob for frequency and band selection, the power is in the milliwatt range. When receiving, there is no filtering of the image frequency (thus the sensitivity is reduced by 3db).

But it works: In the last 1.5 years, very positive experiences have been made in the use of the first prototypes. Surprisingly, there were a lot of QSOs (activity contest page: <http://mikrowelle.oevsv.at>) with the lowest performance and not quite perfect input sensitivity, but on condition that there is actually a line of sight between the two stations. Distances up to 100km have also been made on 3cm.

Description of the El Cuatro "transceiver" concept:

"El Cuatro" project is a "transceiver" that essentially works as a **receive converter** when receiving, but directly generates the transmit frequency when transmitting. The output is currently always on 144,5 Mhz, and there is an optional FM receiver (DRA818V) on board. If you want to listen to CW and SSB, you have to attach your own receiver or SDR.

So there is no need for a TX-mixer, and no need for a filter. The signal is fed directly from the VCO to the output (with amplification). This allows NBFM modulation, Narrow Band Frequency Modulation, with some 12khz bandwidth). CW is still in the works, there is currently no other OM here locally for QSO testing, but its only a matter of El Cuatro firmware.

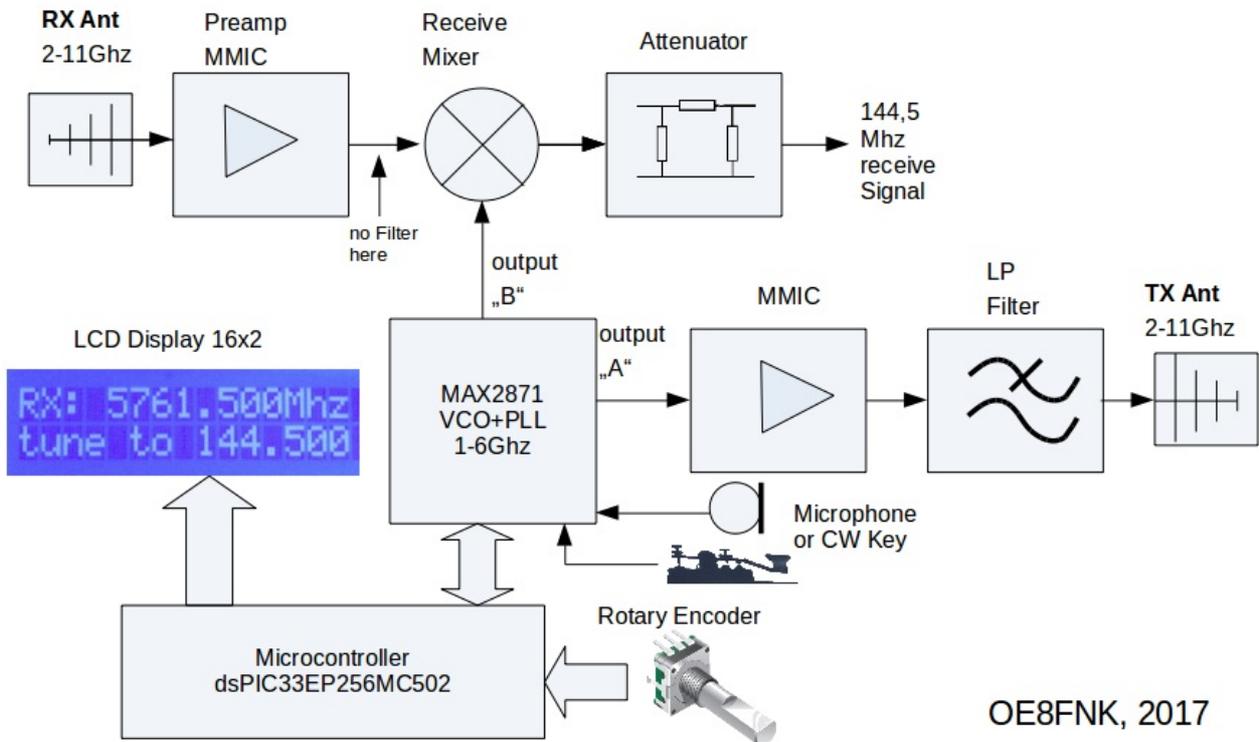
The 80x99mm PCB is made of 0.6mm thin 2-sided FR4, where one side of the PCB is used as ground plane. Some connections have to be made with 0.2mm wires. Nearly all parts are SMD, size 0603 and 0805, just a few 0402 and 1206. One important feature is the use of an EMI Shield, which shields Controller, Reference Oscillator and VCO. There are nearly 300 vias on the PCB that connect to ground.



El Cuatro with WA5VJB 2-11Ghz log-per. antenna and earphone.

El Cuatro Block Diagram:

„El Cuatro“ Transceiver: A Multiband Receive-Converter and Transmitter for 23-13-9-6cm



OE8FNK, 2017

With this **simple concept**, various amateur radio applications have been realized:

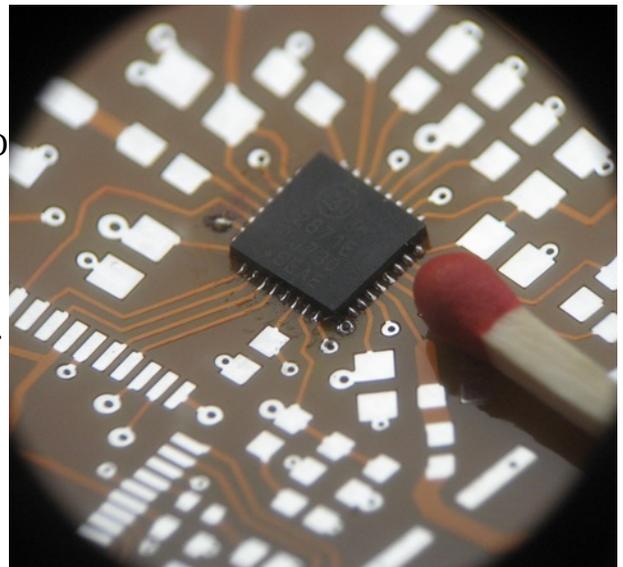
- The 4-band El Cuatro 23cm, 13cm, 9cm, 6cm (described herein)
- The 5-band El Cuatro 23cm, 13cm, 9cm, 6cm, 3cm
- a 24Ghz FM Transceiver based on BGT24LTR11 radar chip (with PLL). (24Ghz, 1.2cm)
- A PLL for the HB100 radar module (3cm, 10368-10370Mhz), which could also be used for gunplexers.

Where does the name come from:

To explain: "El Cuatro" (Spanish: the four, with only one "t") is used here as a name for a radio with 4 bands. And, there is a guitar in Venezuela called "el cuatro" that has 4 strings. For simplicity, this device is called a "transceiver", although in some cases a separate 144.5 Mhz FM receiver is used.

The 4-Band El Cuatro (23cm, 13cm, 9cm, 6cm):

After searching for an easier method to be active on microwaves for decades, I finally came across the VCO chip "MAX2871", which contains a frequency generator with PLL from 24 Mhz to 6 Ghz. There are two outputs that can be turned on by software separately to produce (A) the frequency for the transmitter and (B) the frequency for the receive mixer. That was the essential point for me, as it makes the send / receive switching task much easier. This **simple concept** was presented at the amateur radio club meeting in Villach on 18.7.2016, a board



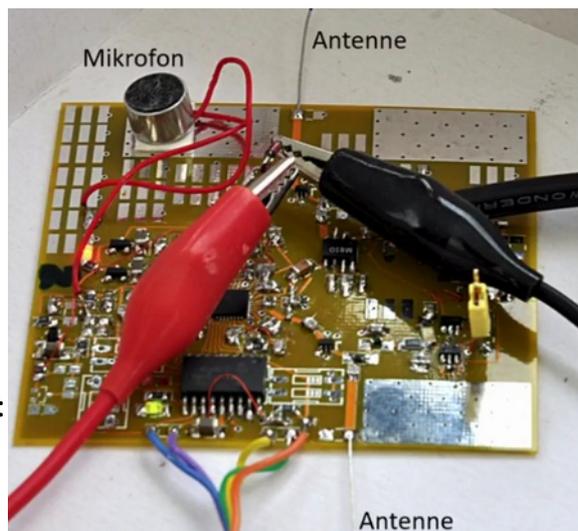
was designed with Fritzing and ordered at pcbway.com in China. A week later, the first version of the El Cuatro board was there. A major challenge was soldering the MAX2871 chip. The pads have a 0.5mm pitch, the gap between the pads is only 0.2mm.

First QSO, first El Cuatro PCB:

Thus, on 21. Aug. 2016 - one month after the presentation of the concept - the first 9cm QSOs was made, at least the first in Carinthia, with the 2 devices: EC1 (El Cuatro 1) and EC2. The switching between RX and TX was made with a jumper. A video of this QSO about the distance of 15m(!) can be found here: <https://www.youtube.com/watch?v=l1zUZEPmDtM>

The key data of the concept are.

- Small power (23 + 13cm, > 50mW, 9cm: 20mW, 6cm: 4mW)
- Only a single housing (Includes both transmitter, receiver converter and optional receiver), batteries.
- Operation with 5xAA NIMH batteries
- One encoder for operation (frequency and band switching)
- PTT switch (is actually a switch to talk, but makes logging much easier).
- Built-in electret microphone
- Optional built-in receiver (DRA818V) or receiver output: 144.5Mhz (eg for SDR receivers)



Q: What can you do with El Cuatro?

- You can make QSOs on line-of-sight at 13, 9 and 6cm (*), given that there is a direct clear sight between the stations. Any tree, leaf or any obstruction cause severe attenuation. We always have to check carefully for a clear path in order to make a contact.
- El Cuatro is perfect for testing other equipment.
- El Cuatro is just filling the "gap" between 23cm and 3cm band.
- El Cuatro is perfect to make contacts with other "big gun stations".
- The frequencies are defined in software, there are no filters. The frequency bands can be adjusted to any suitable frequencies worldwide, the total number of programmed frequencies cannot exceed 10000. (which is usually 1000 x 2khz for each 2 Mhz wide band).

(*) What is with 23cm? At 23cm we are usually using other equipment, which is either a commercial transceiver (TS-790e, FT-736, Alinco G7), or transverters with higher power, so we have no experience in using the El Cuatro on 23cm. We just have not tried it yet. On 13, 9 and 6cm we covered 96km in Carinthia regularly, we have no longer distances available, as better locations would not be easily accessible by car. If you want to use El Cuatro on 23cm, you have to use a resonant antenna and a lowpass filter. The harmonics on 23cm are not attenuated enough.

What El Cuatro can not do:

- connections that go beyond line of sight. A tree or even a few leaves or branches are enough to stop the signal entirely. Although no transmission in SSB mode is possible, SSB **reception** is possible if a capable receiver is used as intermediate frequency receiver.
- There is no band filter, the image frequency is not filtered out, so the noise figure with >7 db (estimated) is not state of the art, but fortunately for line-of-sight contacts this does not matter much. At 6cm, the noise figure is significantly worse.
- There may be some other mobile service at the mirror frequency, which is not attenuated at all, which could impact strongly on the receiving performance of the El Cuatro.
- Rainscatter is not possible. No DX, No QSO via reflections.

Harmonics + measurements:

Hans, OE2JOM carried out a measurement on the spectrum analyzer at the VHF Awards ceremony in January 2017, with all harmonics at 13cm, 9cm and 6cm in the range of <-30dbm, which is a sufficient value. For 23cm this value has not yet been reached, an external low pass filter is required. Since the transmission signal is generated directly by the VCO (without mixer!), there are just no "unwanted" waves, the only detectable emissions are the 2nd and 3rd harmonic. I am currently (June 2018) in the works to make CE certification for the El Cuatro.

Q: Is El Cuatro a replacement for a transverter?

NO, it should not be a transverter and can not replace a transverter. Receive sensitivity is a good solution with a noise figure estimated at > 7db for this budget and the number of amateur bands. It is an independent device that can be used for itself as a transmitter or beacon. A transmission in SSB is not possible. It is roughly comparable to an FM mobile that just can not do SSB. But a "mobile" that features 23cm, 13cm, 9cm and 6cm can. Generally it is a portable device, and not built as a fixed station.

Q: Can you use El Cuatro as (remote) receive converter?

Yes, you can program any single fix frequency from 1-6 Ghz with a pickit 3 programmer. Software Source Code for setting one single frequency (that is also active on startup) is available on request. And you can also use a low noise amplifier and bandfilter at the antenna input of the El Cuatro.

Frequency setting: The frequency setting is made in 2khz steps. Although these are programmed as 8000 individual "channels", the tuning feels like a VFO. The frequency is already corrected in software individually to each reference oscillator, and is "good" after some 4min. E.g. commercial FM transceivers für 23cm are often more "off-frequency" than the El Cuatro.

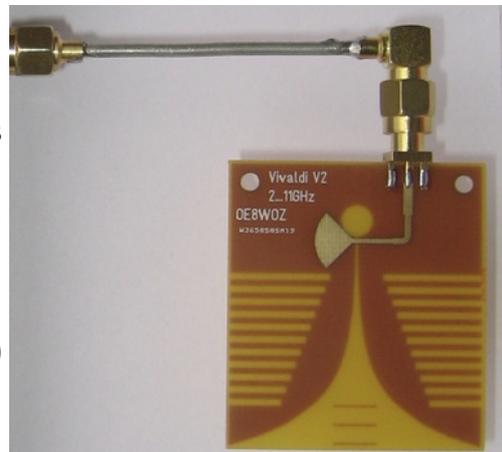
Antennas:

For the sake of simplicity, I often use broadband antennas.

(1) The logarithmic peridodic antenna of WA5VJB (2-11 Ghz) , which works vom 13-3cm, and which is also used as feed in the 60cm offset dish.

(2) the Vivaldi antenna in the designed by Wolfgang, OE8WOZ, which is good for 9cm up to 3cm.

Of course it is also possible to use a separate (narrow band) antenna for the respective band.



El Cuatro Firmware: The software for the operation of the microcontroller is written in "C", where inline assembly commands were also used. An update of the current firmware is possible via the programming interface e.g. PicKit3. El Cuatro Firmware updates are provided as a HEX file.

There is optional software source code available for (1) using the El Cuatro as receive converter for a single frequency, and (2) using the El Cuatro as frequency generator (1-6Ghz).

Band switching: The push button on the rotary encoder works as a band switch, always switching to the next FM call frequency. Here we use the following frequencies, each 1.5 MHz above the beginning of the narrowband range:

23cm: 1297,500 Mhz

13cm: 2321,500 Mhz

9cm: 3401,500 Mhz

6cm: 5761,500 Mhz

Any other (licensed) frequency bands of your choice can be defined in software.

With and without 144,500 Mhz receiver:

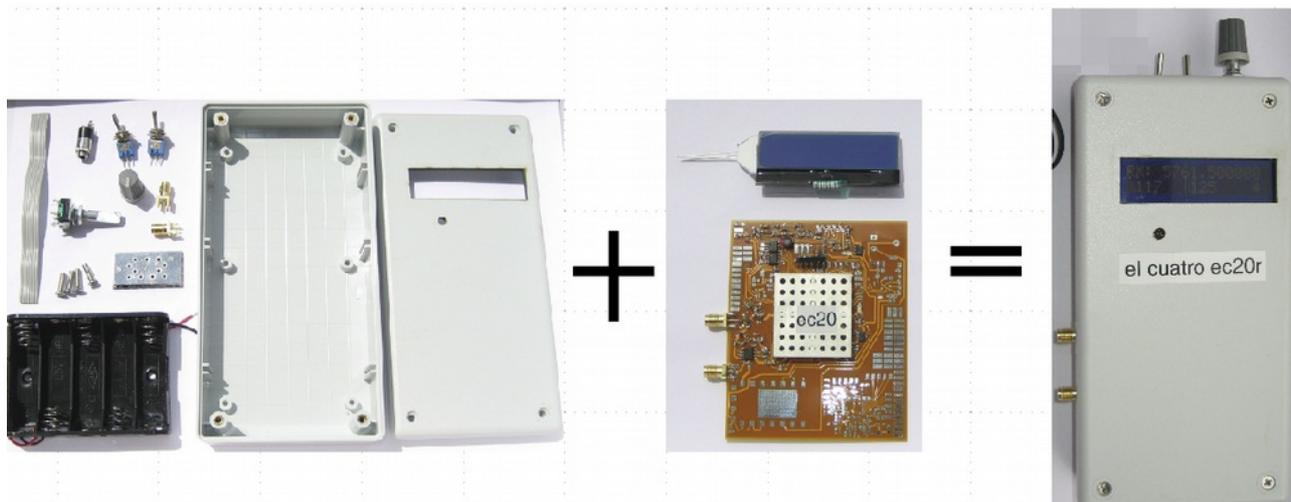
The "r" version so z.b. EC20r already includes a 144,500 Mhz receiver. For operation only a headphone and a small antenna is necessary. The version without "r" is recommended for connection to a separate receiver or SDR receiver.

Availability:

El Cuatro (4-band) is currently (June 2018) only available for sale through a workshop which is held at different locations throughout Austria, starting 2nd half of 2018. In this workshop every participant helps to integrate the (already fully populated) PCB into the case, connect all switches and the incremental decoder, and to make the cutouts to the case.

At the moment the price for the El Cuatro, when participating in the DIY El Cuatro Workshop is EUR 149.- If there is interest in your group, club or city, I am willing to come over to you. In case of interest please email oe8fnk@aon.at

El Cuatro Workshop - included Parts:



What is with 3cm?:

Similar to 23cm, the 3cm is IMHO a real band for use with a real power, sensitive equipment and good antenna, in order to also have fun using contacts that exceed line-of-sight, through reflection, refraction, backscatter or rainscatter. There are also many OMs here in Europe that have 3cm available for contests and rainscatter. So it makes sense to use "real, QRO-Equipment" on 3cm.

There are 2 reasons for me to come to this conclusion:

(A) 3cm is the highest band to make dx, and due to the availability of the rainscatter mode, 3cm is just more interesting than any other band.

(B) Including the 3cm band means **twice the time spent on building the El Cuatro** (5-band).

Twice the number of receive stages, mixers, outputs, connectors. And requires an expensive coaxial relay for antenna switching.

Acknowledgments: Thank you for supporting this project to all participants, especially OE8WOZ, OE8PZY, OE4WOG, OE3FKS, OE8PKR, OE8YHQ, OE8AIR, OE8EGK, OE8EBK, OE8WUR, OE8BCK, OE8KVK, OE8PGQ, OE8CHK, OE8GPG, OE6RKE, OE6POD, OE5JKL, OE2JOM and the Smartlab team the FH Carinthia in Villach.

Q: Will you publish construction plans?

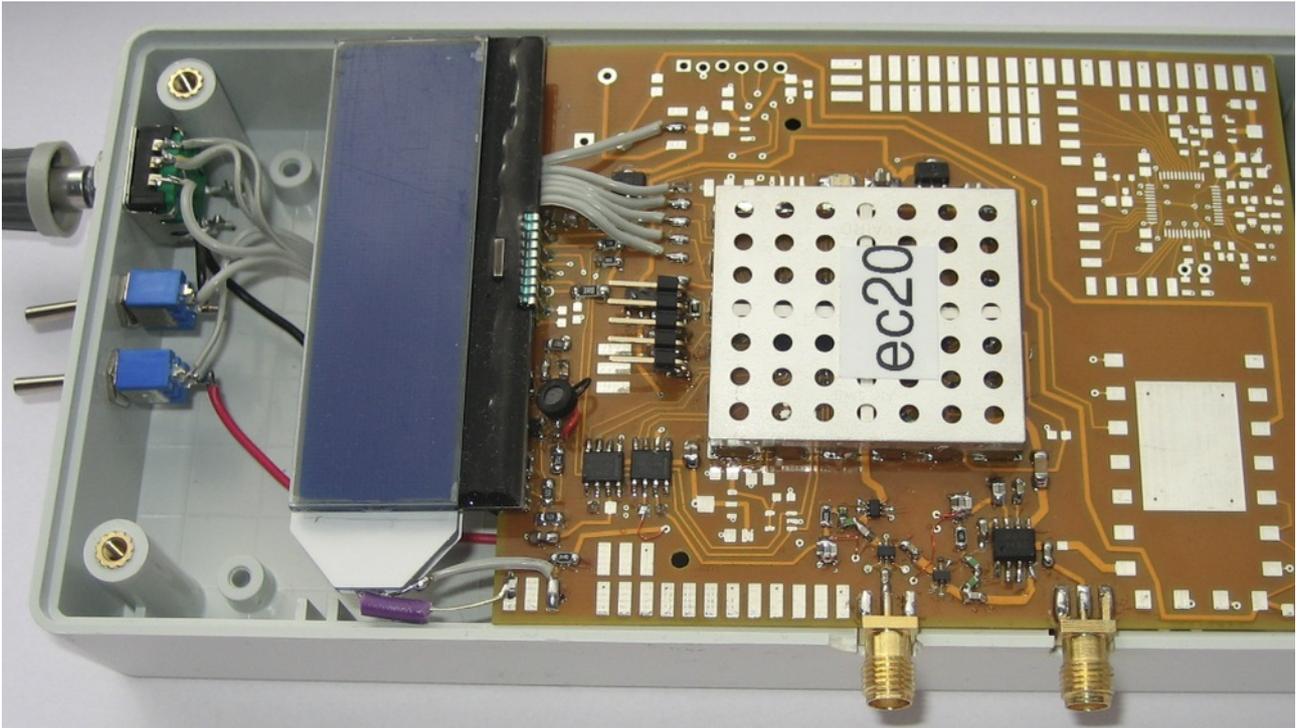
There are 2 roadblocks for DIY:

1st: There are some 95 SMD Parts to solder, giving a total of 356 solder points. The parts are not only SMD, but in order to fit into the available space, the distance between the parts is at some places really, really small.

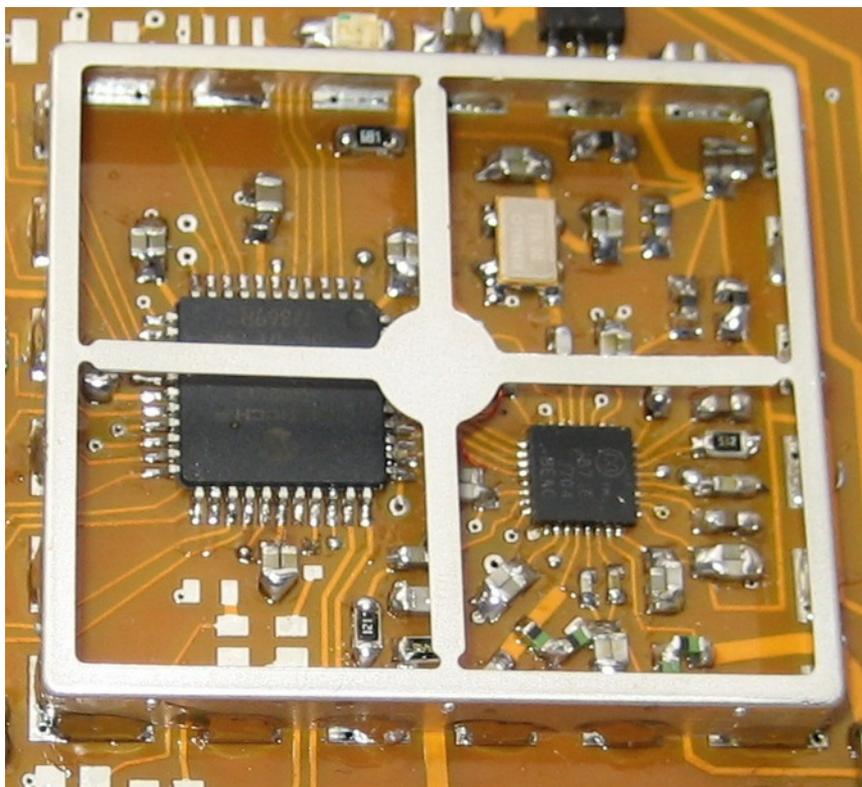
2nd: The activation of the controller and PLL has too many different failure possibilities. While I can work that out on my desk, it would be impossible for me to fix things remotely.

Alternatively the fully assembled and tested PCB will be available, which includes frequency correction für the reference oscillator.

Finally a photo of the PCB:



**And a view
"under the
hood":**



Thats it.

More informations on the El Cuatro are available at www.uhf.at , starting from June 25, 2018.

Any questions? Please do not hesitate to contact oe8fnk@aon.at