What's inside a K1701G Satellite Downconverter ?

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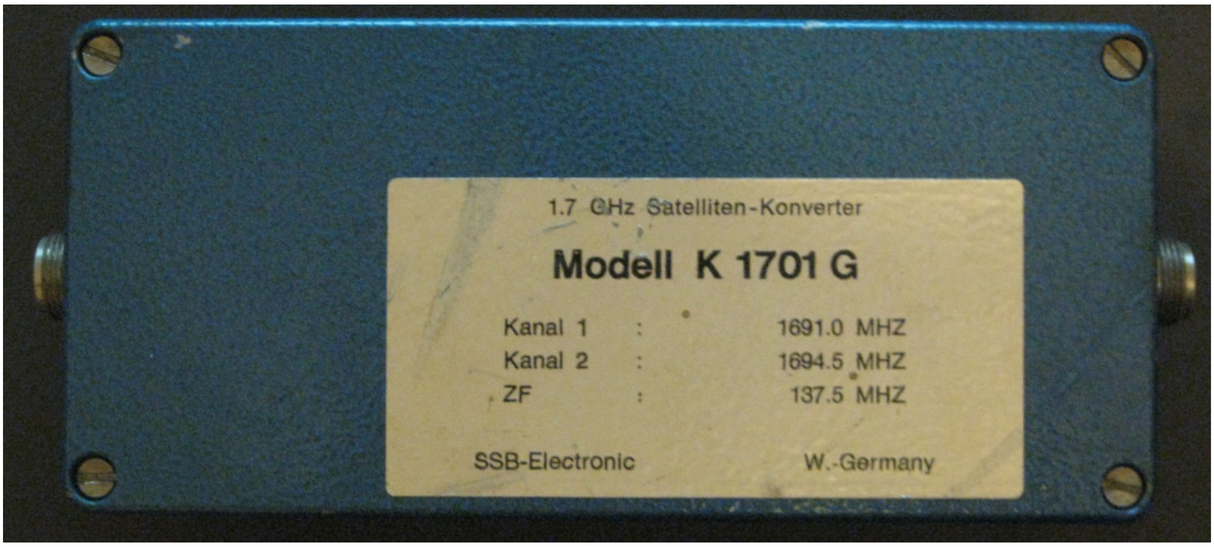
Matthias Bopp, DD1US, borrowed to me this nice little box made by SSB Electronic containing a downconverter for Meteosat reception on 1.7 GHz. Being curious about its content, I had a look inside this device.

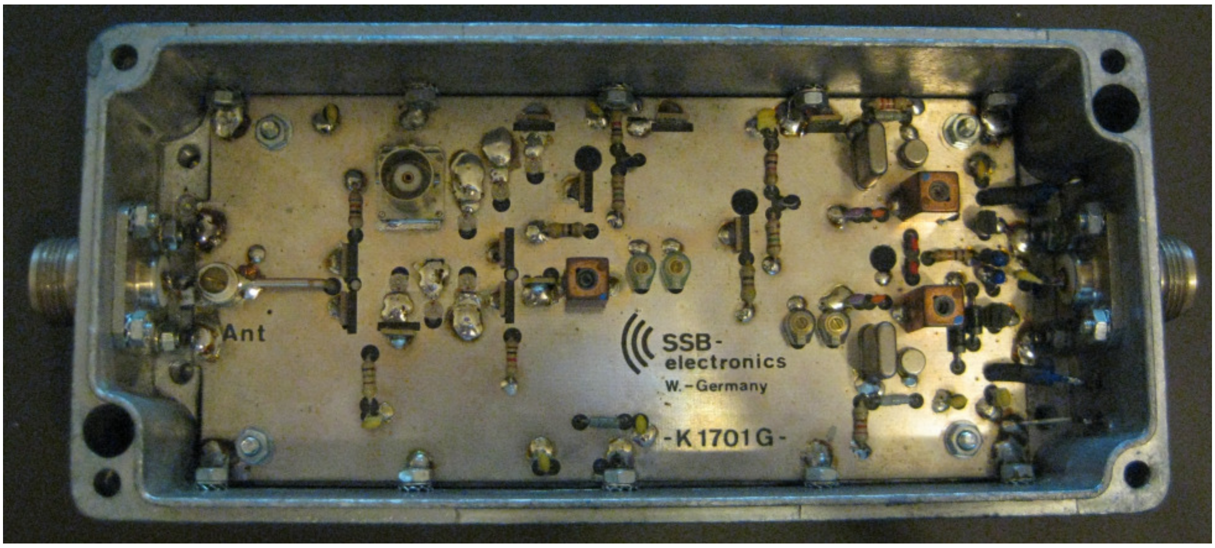


The satellites of the first Meteosat generation (Meteosat 1 – 7) used to transmit analogue WEFAX images on two L-Band frequencies: 1691.0 MHz (Channel A) and 1694.5 MHz (Channel B). Today only two satellites of the first generation – Meteosat 6 & 7 – are active, but they are not positioned at 0° longitude any more (instead they have been moved over the Indian Ocean at 67.5° E, respectively 57.5° E). The satellites of Meteosat second generation (MSG – Meteosat 8 & 9) that are positioned at 9.5° E and 0° are not transmitting analogue WEFAX on the 1.7 GHz channels any more. Digital data from these satellites can only be received via Eumetcast relay transmision from Eutelsat Eurobird 9 in encrypted DVB-S mode. With a good antenna the direct reception of Meteosat 7 at 57.5° E should still be possible in Central Europe (as of July 2011).

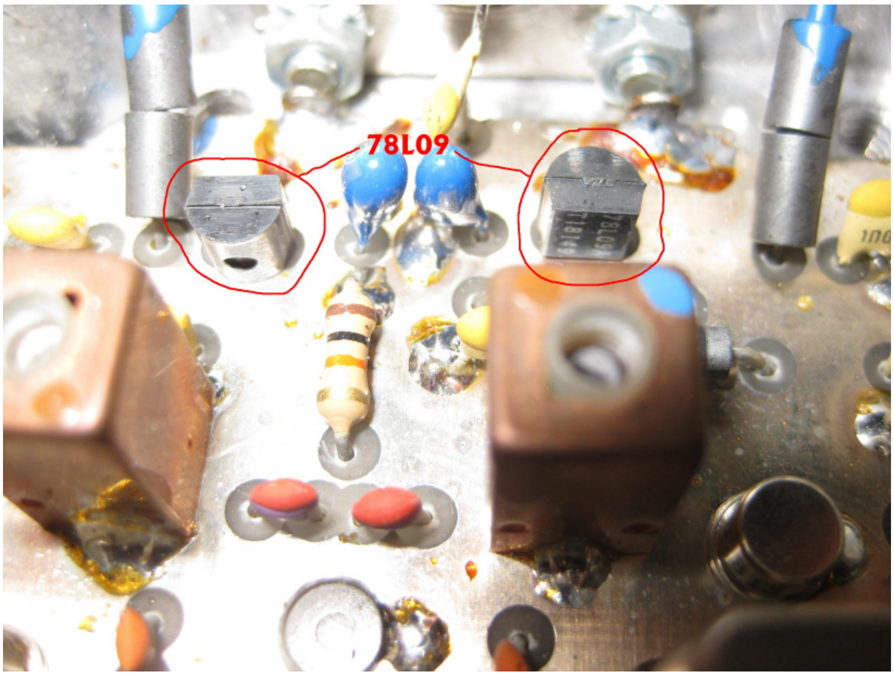
The K1701G converted the receiving frequencies of channel A and channel B to a common IF frequency of 137.5 MHz. This frequency is at the same time a downlink frequency for APT images from polar orbiting satellites (NOAA-17), so there exist a couple of types of receivers for it (e. g. the MST 100 from Grundig). The 1.7 GHz downconverter could be used as a frontend for these receivers.

The manufacturing date of this unit is unfortunately not known but from the "W.-Germany" print on the label one can assume that it has been produced before 1990.

OK, let's remove the top cover and have a look inside.



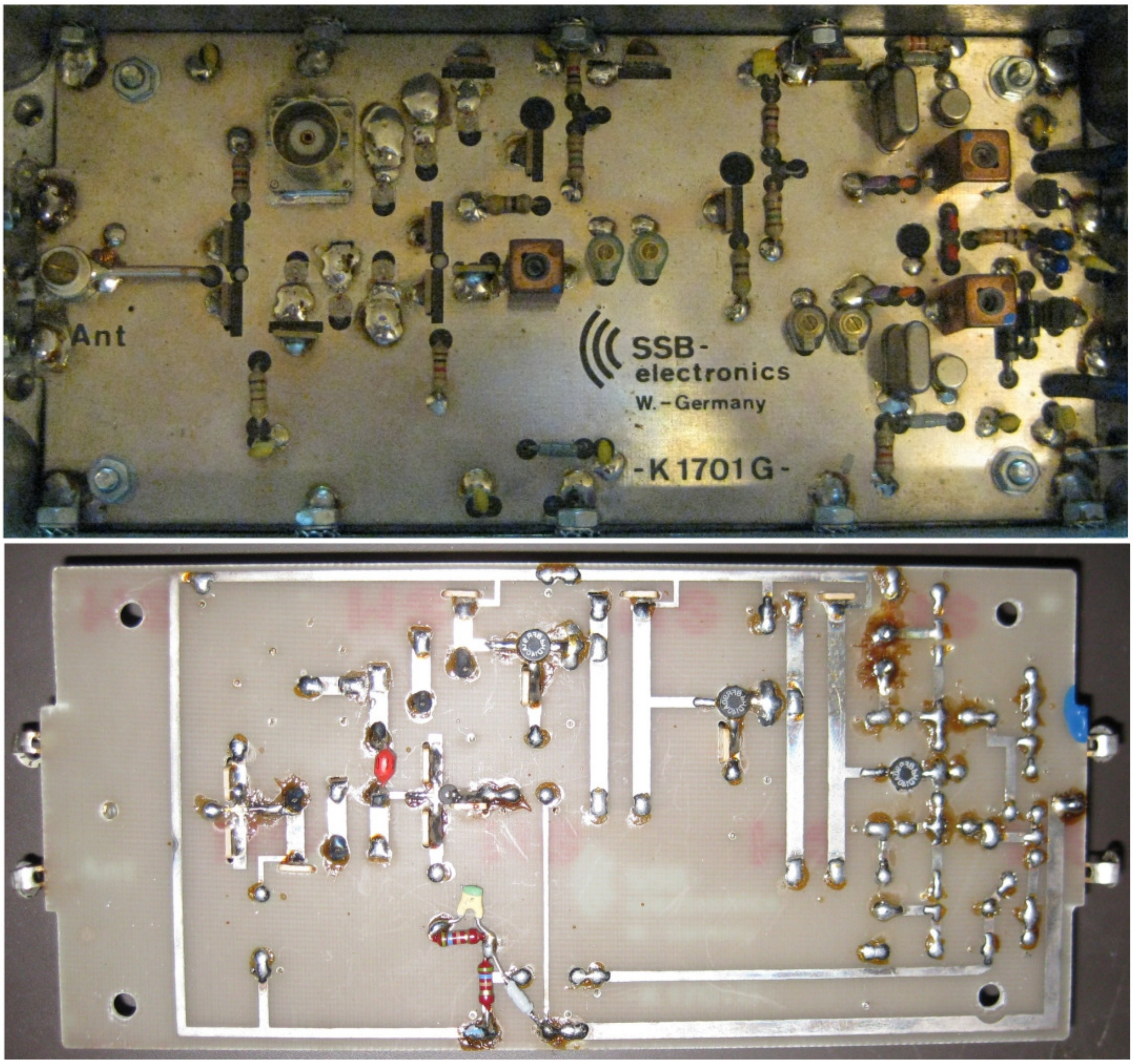
On the left side you can see the input jack for the 1.7 GHz signal. The 137.5 MHz IF signal leaves the device at the opposite side on the right. Both connectors are of high quality N type. Power is deliverd to the unit through three feed-through capacitors also on the right side under the output jack. As only one of the two possible input channels can be converted to the IF frequency at the same time, there are separate input pins for each channel. By applying power to one of them, the desired channel can be selected. The third pin is used for the common Ground connection. There is no information about the operating voltage printed on the label of the unit, but as the voltage regulators that are used are of the type 78L09, the input voltage should be +12 V and current draw should not exceed 100 mA.



Each channel of the downconverter has its own voltage regulator. I recognized the two ferrit beads per channel that are threadlocked to the power input wires.

As all of the circuit tracks are on the bottom side of the PCB, I had to remove it from the enclosure in order to get a detailed view of the downconverter circuit. This was not an easy task because 22 screws had to be unfastened first…

The following picture shows the top versus the bottom side of the PCB. Please note that the bottom view has been vertically mirrored bebause it makes it easier to assign the tracks to the corresponding devices on the top.



Now the functionality of the devices in the single PCB areas can be assumed.

On the right side you can see the two crystal oscillators for each channel of the unit, working close to 97 MHz. Their signal is amplified by a RF transistor that also produces harmonic multiplies of the LO frequency. A frequency of 4x 97 MHz is selected by a parallel coupled microstrip bandpass filter and feeds a second amplifier stage that also produces harmonic multiplies of its input frequency. The second harmonic frequency is selected by another parallel coupled microstrip bandpass filter. So the frequency at its output is now 2x 4x 97 MHz. This frequency is once more doubled by a third amplifier stage and finally the frequency of 2x 2x 4x 97 MHz = 1552 MHz is selected by an edge coupled microstrip bandpass filter.

The 1.7 GHz satellite signal is entering the PCB on the left side. It is isolated from signals on other frequencies by a parallel resonant circuit consisting of a Tronser airtubular microwave trimmer capacitor and an airwound inductor. Then it is fed to the input low noise amplifier which is a GaAs FET transistor. The amplified signal passes through a parallel coupled microstrip bandpass filter tuned to 1.7 GHz which also helps to surpress the image frequency of the following mixer at ~1415 MHz. A second GaAs FET transistor of the same type follows. This transistor acts as the mixer of the downconverter circuit and therefor the amplified satellite input signal and the signal from the LO chain are fed together into its gate. At the output of the mixer transistor the desired IF of ~1700 – ~1552 ≈ 137.5 MHz occurs. It is once again selected by a resonant LC filter tuned to 137.5 MHz. A microstrip track leads to the right side of the PCB where the IF signal is coupled to the output jack.

I was curious about the schematics of this downconverter. As searching on the internet didn't reveal any results I redraw it from the PCB. You can see it on the following page.

There are some details about this circuit design to mention:

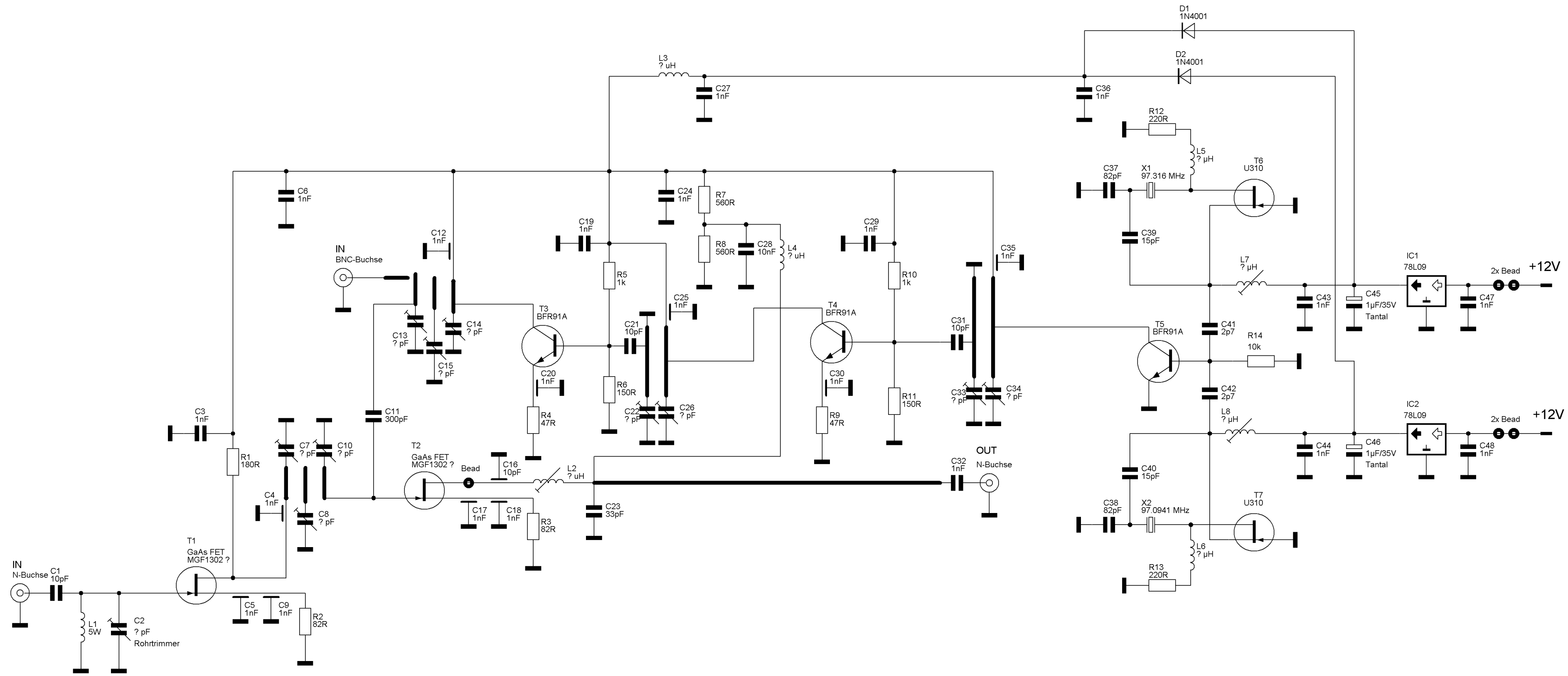
The LO source is a Collpits oscillator made up from the wellknown U310 JFET transistor used in a common gate circuit. The crystal is a series resonant ~19 MHz crystal oscillating at the 5^{th} overtone around 97 MHz. This LO circuit has been used by some other modules from SSB Electronic, too, like the XLO-1 LO module. Have a look at this interesting paper at http://wiki.oevsv.at/index.php/Transverter_Technik_im_Wandel_der_Zeit (valid as of July 2011). The crystal frequencies are 97.316 MHz for Channel B and 97.0941 MHz for Channel A.

The parallel coupled microstrip bandpass filters in the LO multiplying chain can also be found in several other designs from SSB Electronic. Other downconverter circuits make also extensive use of them, e. g. have a look at "UHF-Unterlage Part V" or at "UKW-Berichte/VHF Communications 1/1990" where another Meteosat downconverter is presented by DF9DA. I'm still missing a good tutorial about how this kind of bandpass filter can be dimensioned for other frequencies. Any hints, anyone ?

It is not 100% clear which types of GaAs FETs are used for the input amplifier and the mixer stage. There is no visible marking on them. But from their size and color it can be assumed that they both could be of type Mitsubishi MGF1302. This GaAs FET was very popular with various LNA circuits in the 1980s. Its datasheet states it has a noise figure of 1.4 dB. The three transistors in the LO multiplying chain are of the bipolar type BFR90S, also very common in such dircuits. The 1 nF decoupling capacitors of the amplifier stages are all Stettner trapezoidal type, except for the ones in the crystal oscillator part and the solely DC parts of the circuit.

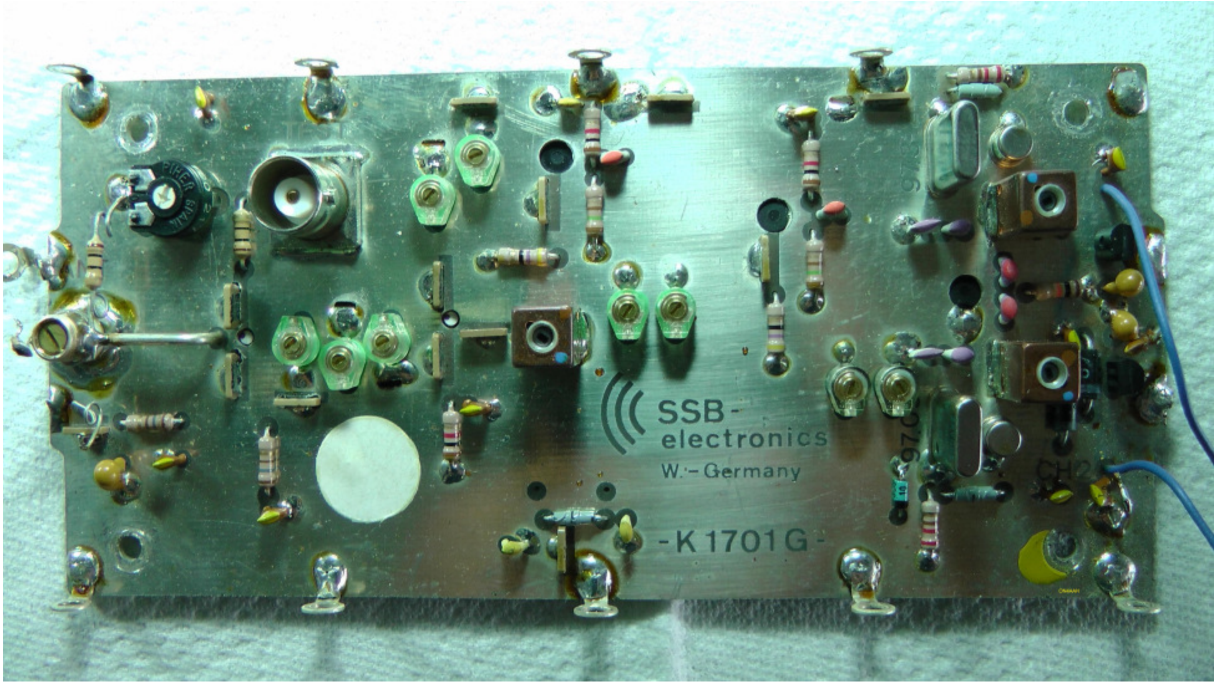
It is interesting that the multiplied LO signal is injected into the gate of the mixer FET via a lumped capacitor. Most other downconverter designs (even from SSB Electronic) regularly use a sort of microstrip coupling instead.
Also note the BNC jack on the left side of the PCB. At this connection an external LO signal can be fed into the mixer FET for tuning purposes.

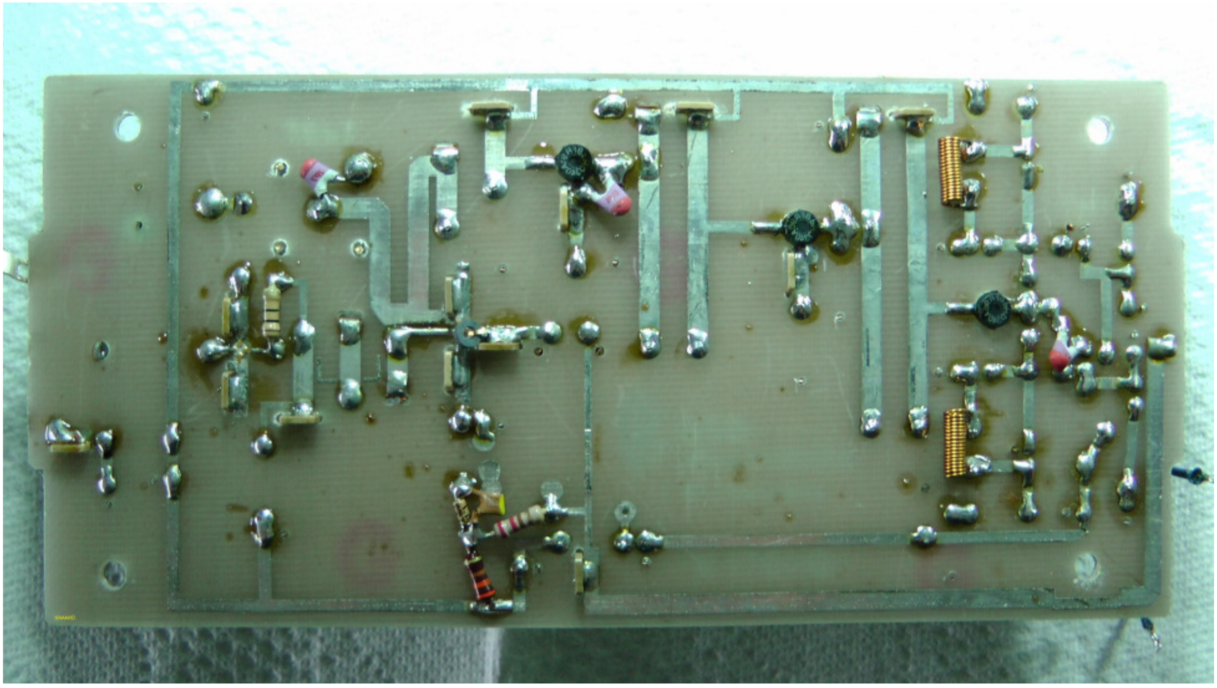
The PCB is very well layouted with the whole top side acting as a ground layer.



IN
N-Buchse
C1
10pF
L1
5W
C2
? pF
Rohrtrimmer
T1
GaAs FET
MGF1302 ?
C3
1nF
R1
180R
C5
1nF
C9
1nF
R2
82R
C4
1nF
C7
? pF
C8
? pF
C10
? pF
C6
1nF
IN
BNC-Buchse
C12
1nF
C13
? pF
C14
? pF
C15
? pF
C11
300pF
T2
GaAs FET
MGF1302 ?
Bead
C16
10pF
C17
1nF
C18
1nF
R3
82R
L2
? uH
T3
BFR91A
C20
1nF
R4
47R
L3
? uH
C27
1nF
C19
1nF
R5
1k
R6
150R
C21
10pF
C22
? pF
C24
1nF
C25
1nF
C26
? pF
R7
560R
R8
560R
C28
10nF
L4
? uH
C23
33pF
T4
BFR91A
C29
1nF
R10
1k
R11
150R
C30
1nF
R9
47R
C31
10pF
C33
? pF
C34
? pF
C35
1nF
OUT
N-Buchse
C32
1nF
D1
1N4001
D2
1N4001
C36
1nF
R12
220R
L5
? µH
T6
U310
C37
82pF
X1
97.316 MHz
C39
15pF
L7
? µH
T5
BFR91A
C41
2p7
R14
10k
C42
2p7
L8
? µH
C40
15pF
C38
82pF
X2
97.0941 MHz
T7
U310
L6
? µH
R13
220R
IC1
78L09
C43
1nF
C45
1µF/35V
Tantal
C47
1nF
2x Bead
+12V
IC2
78L09
C44
1nF
C46
1µF/35V
Tantal
C48
1nF
2x Bead
+12V

On August 3rd 2011, I got an e-mail from Albert, ON4AAH from Belgium.
He sent me two pictures from the inside of his K1701G downconverter. They diver slightly from the ones of the downconverter I've described above. The assumption is that he has a newer version of the K1701G. Thanks to Albert for this contribution.





The LO sections have been modified a little bit, air-wound coils are soldered parallel to the pins of the crystals. The gate bias voltage of the first GaAs FET can be adjusted by a Piher trimmer resistor (seen on the left in the upper picture). A 10 Ohm resistor has been looped-in between its drain pin and the input of the following microstrip bandpass filter. The bandpass filter at the output of the LO chain section consists only of two microstrip elements instead of three and the LO chain output signal is coupled to the mixer GaAs FET through a parallel microstrip line instead of a lumbed capacitor.

If you have comments or corrections
to this article, please contact me at the
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