Tubes radio FM band extension – Nordmende Tannhäuser 57-3D adaptation

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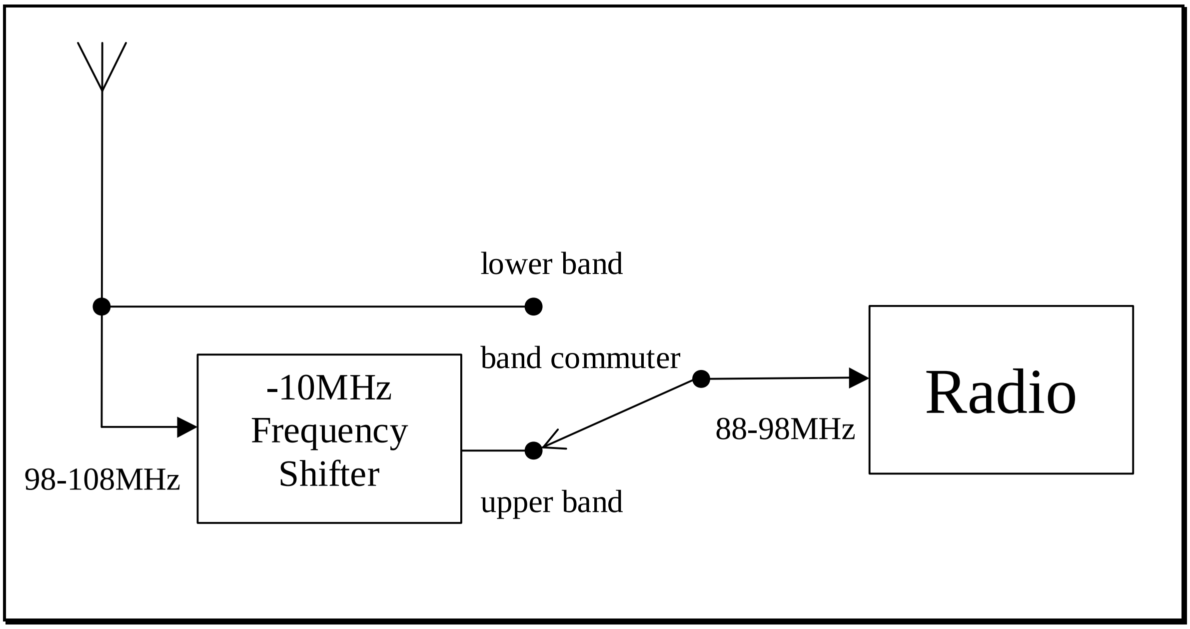
Introduction

FM band has been introduced in (West) Germany just after WWII. At this period the FM band was not the 88-108MHz international FM band that we know today. For example the 1957 Tannhäuser has an 87-100MHz FM band. It should be suitable to extend this band to allow listening the stations in band 100-108MHz. This paper shows a method to do it without modifying too deeply the radio. This method can be easily adapted to various radios of this period. We show here an adaptation for the Nordmende Tannhäuser 57-3D radio.

Approach

The approach used here is to shift down the antenna signal frequency. Using this approach we do not modify too deeply the radio.



The frequency shifter used here subtracts 10MHz to the antenna signal. So a 103Mhz station is shifted down to 93MHz, which is inside the band of the radio.

To build a frequency shifter we use a signal multiplier:

since: $\cos a \cdot \cos b = \frac{1}{2} (\cos (a+b) + \cos (a-b))$
we have: $\cos 2\pi t.f1 \cdot \cos 2\pi t.f2 = \frac{1}{2} (\cos 2\pi t.(f1+f2) + \cos 2\pi t.(f1-f2))$

We see two terms in the result of the product. The **first term** is an addition of frequencies ($\cos 2\pi t.(f1+f2)$); the **second term** is a subtraction of frequencies ($\cos 2\pi t.(f1-f2)$).

In our application the f2 frequency is a constant and equals 10MHz.

The first term of the product (cos 2πt.(f1+f2)) is not suitable for a –10MHz frequency shifter. But in our case it is not too disturbing:

> for example, a 93MHz station at the output of the multiplier could come from a 83MHz station shifted by +10MHz (produced by the term cos 2πt.(f1+f2)) or an 103MHz station shifted by -10MHz (produced by the term cos 2πt.(f1-f2)). Happily here in France there is no station in 80-87.7MHz band. So the risk of overlap could only come from a station closed to 88MHz overlapped with a station closed to 108MHz.

Application

Our application is built around a SA602 (or NE602) integrated circuit.

The SA602 includes:

- a RF signal multiplier (double balanced mixer)
- a RF oscillator
- a voltage regulator

SA602 characteristics

PARAMETER	MIN	TYP	MAX	UNIT
Power supply	**4.5**		**8.0**	V
DC current drain		2.4	2.8	mA
Input signal frequency		**500**		MHz
Oscillator frequency		**200**		MHz
Noise figure (at 45MHz)		5.0	5.5	dB
Third-order intercept point		-13	-15	dBm
Conversion gain (at 45MHz)	14	**17**		dB
RF input resistance	**1.5**			kΩ
RF input capacitance		3	3.5	pF
Mixer output resistance		**1.5**		kΩ

Description

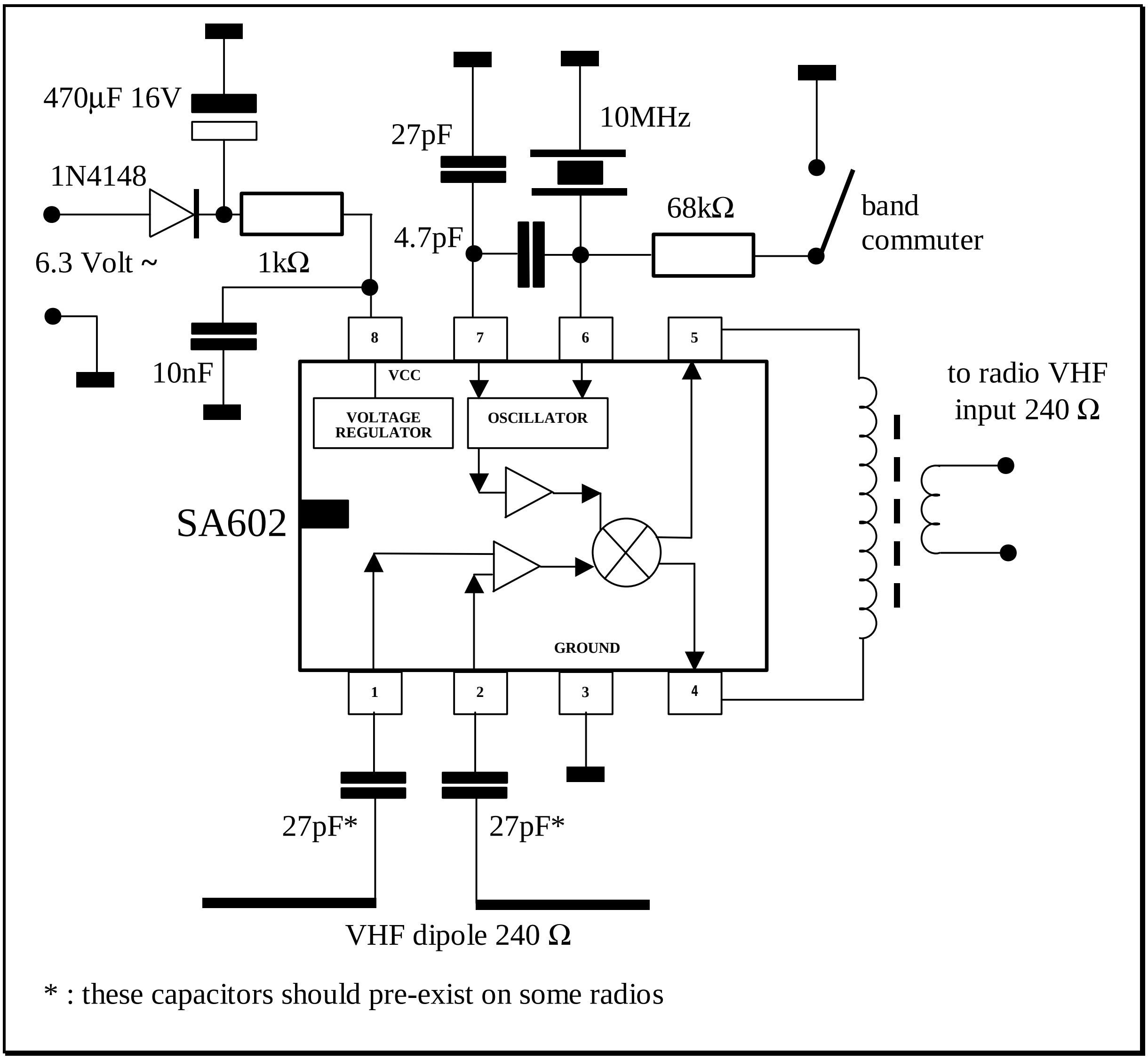
The power supply uses the 6.3V~ heater supply. It is half-wave rectified then smoothed by a capacitor. The 1kΩ resistor decreases the voltage between [4.5V, 8V]. The ground is connected to the frame of the radio.

The RF input is direct via liaison capacitors of 27pF. It is not adapted. Since antenna impedance is 240Ω (I was told that it is 240Ω) and IC input impedance is 1500Ω, the impedance mismatch loss is -3.2dB = 10Log(1-(1260/1740)^2). I choose to have some loss because the IC has a +17dB conversion gain.

The RF output is adapted. Since IC output is 1500Ω and radio input is 240Ω so impedance ratio is 6.25. The RF transformer uses a VHF ferrite ring. A 10/4 turns ratio should be used. The impedance ratio is the square of turns ratio, that gives 100/16 which is perfect. Replacing the transformer by a couple a liaison capacitors as done for the input could be tried. Then the impedance mismatch loss should be -3.2dB as for the input.

The oscillator uses a 10MHz quartz. To emulate the band commuter, I use a switch to shut down the oscillator by adding a 68kΩ resistor in oscillator circuit. When the oscillator is off, then f2 is 0Hz and there is no frequency shift.

Schematics



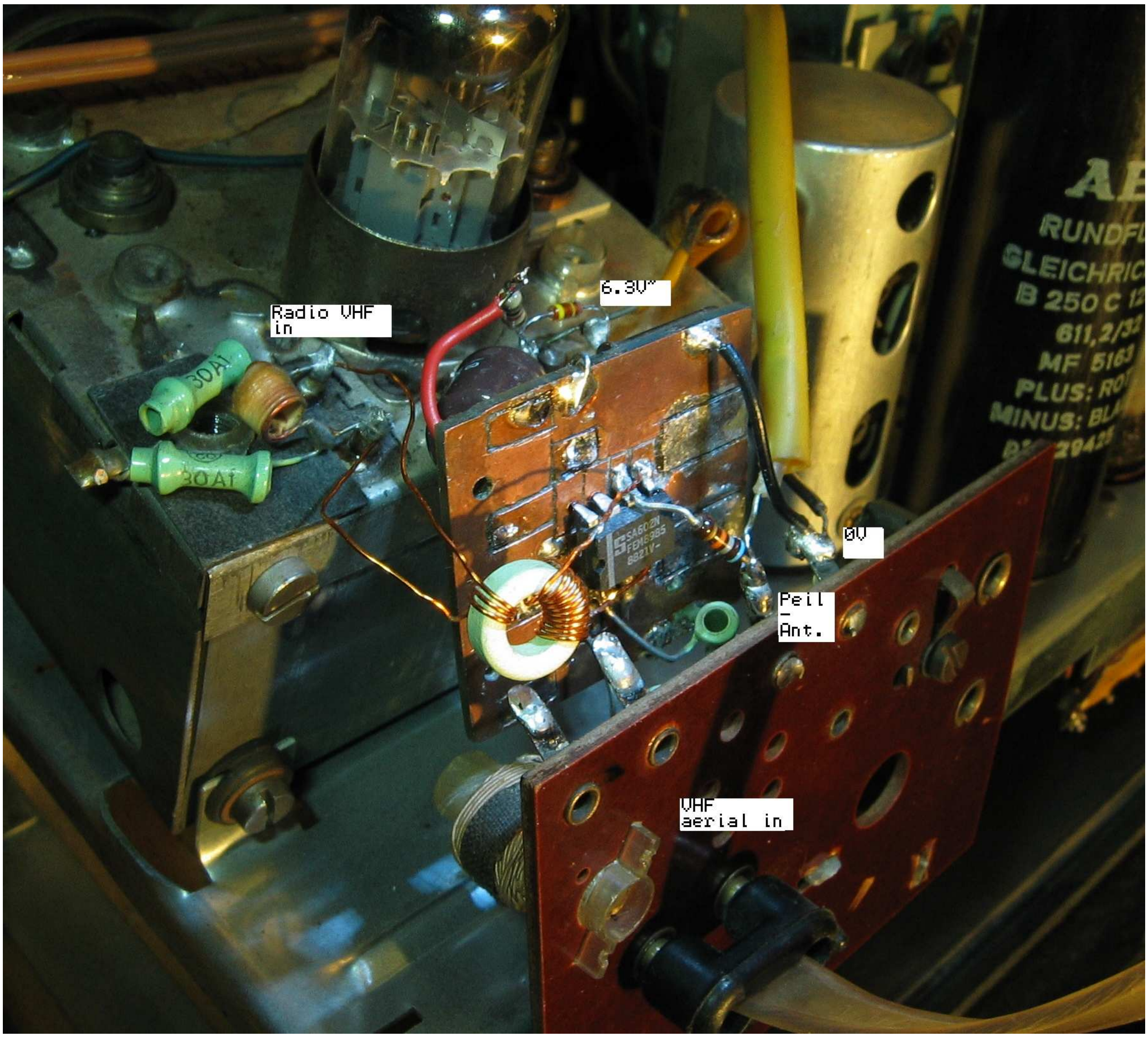
Nordmende Tannhäuser 57-3D adaptation

The adaptation on this radio is very easy. The entire job takes few hours, and the result is perfect since the band commutation is integrated and done by the “Peil-Ant.” front panel button. This button may be used in AM to choose between internal and external aerial. The choice of this button doesn’t seam to have any consequence on short waves reception using external aerial.

Process

Dismount the back paperboard. Locate the VHF aerial input Bakelite board (bottom left). Dismount this board. Disconnect the VHF aerial from VHF radio input. This connection is done via a couple of 30pF liaison capacitors. Keep these capacitors to replace the 27pF* couple of the schematics. Insert the frequency shifter between the VHF aerial and the radio VHF input. The 6.3Volt ~ is available close to the board.

The band commuter uses “Peil-Ant.” button. A connection to this button is available closed to the board. When “Peil-Ant.” button is up the upper band is available (97, 110MHz) and 10MHz are to be added to the front panel’s frequency. When it is down the usual (lower) band is available (87, 100MHz).



Picture 1: frequency shifter insertion is very easy since all is located around the VHF input stage. Note that the turn ratio of the VHF transformer is not perfect on the photo since I thought that the VHF input impedance was 150Ω, actually it is 240Ω.