A false colour PAL modulator

1. Introduction

Weather satellites are trasmitting images taken in different spectral bands, the most important are obviously those taken in the 11μm "thermal IR window." These images are known to have a relatively large dynamic range and require much more grey levels than VIS images to be properly displayed. Modern digital storage display units are able to handle the dynamic range of IR images, unfortunately our eyes are not able to appreciate small intensity changes on a black and white TV monitor. An interesting idea is to replace the grey scale of the image with a colour scale, since human eyes are much more sensitive on small colour variations than on small intensity variations. On the other hand, this simple trick seems to be useful also for VIS images: usually there are no objections if the sea and the sky appear dark blue, Europe appears green, the Sahara desert amber and high clouds pink/white.

The best results can be obtained using a professional colour TV monitor with separate RGB inputs. Accepting a slight degradation of the geometrical resolution due to band width limitations of the PAL system, a domestic colour TV receiver can be used. In order to avoid modifying the PAL receiver a simple PAL modulator can be built.

2. Description of the circuit

The block diagram of the false colour PAL modulator is displayed on fig. 1. The incoming composite video signal from the digital storage scan converter directly drives three functional units:

- the colour encoder to generate the two colour dif-

ference signals
- the RF modulator to generate the luminance signal and sync pulses
- the synchronization logic to generate the various pulses necessary for the PAL modulator.

A TBA 520 (IC5) is used as the PAL modulator. Since the PAL standard requires a very precise subcarrier frequency, a crystal controlled oscillator is necessary. The luminance signal is fed through a delay line before being combined with the chrominance signal in the RF modulator to compensate the delay introduced by the colour encoding and modulating stages. The RF modulator transposes the signal to a free VHF band I TVchannel. The whole circuit requires about 50 mA from a 12,6 V supply.

The colour encoder (fig. 2.) includes a DC shift stage (P_1 and T_1) and three level comparators (IC1, IC2 and IC3). P_1 is used to adjust the colour scale. An external potentiometer is recomended for P_1 since the modulation level varies during the day and it is different for VIS and for IR images. The 3080s used as comparators do not exhibit a very high gain and the transfer curve is smooth like in fig. 4. The output of the 3080 operational transconductance amplifier is a current (not a voltage), so the outputs can simply be tied together to sum the signals and DC shifting problems to interface the TBA 520 (IC 5 on fig. 3) are avoided. Due to the nature of the subject on both VIS and IR images it is recomended to have a better resolution in the darker parts of the image, so the reference voltage splitting network is not linear (4.7 Ω and 10 Ω resistors).

T_2 (BC 237) separates the sync pulses from the composite video. A monostable (built with the inverters of IC4) delays the horizontal sync pulses to obtain the burst gate pulses. These pulses also force the R-G and B-G signals to the required levels to generate constant burst pulses. Horizontal sync pulses are also used to clock the PAL flip-flop. Unfortunately they are not available during the vertical sync period. Since the frame generated by the digital storage unit has an integer, even number of lines (320) it is possible to use the vertical sync pulses to reset the PAL flip-flop at the beginning of each field.

The PAL subcarrier oscillator (fig.3.) supplies the two reference signals to the PAL modulator IC5. The B-G reference is obtained by a phase shifting network. The TBA 520 was designed as a PAL demodulator for colour TV receivers, however it can perform well also as a PAL modulator. IC5 (TBA 520) includes two balanced modulators, the PAL flip-flop and the PAL switch. The PAL flip-flop is a simple two-transistor circuit and requires two external capacitors for the operation. Pin 10 of IC5 is connected internally to a tap in the bias voltage divider network. During sync pulses it is grounded through D4 to suppress the chroma signal. The chroma signal is taken out from pin 5, originally designated as the G-Y output. Since the gains of the B-G and R-G modulators are not equal referred to pin 5 output, the R-G modulating signal should have a smaller amplitude than the B-G signal.

The chroma AGC inside a PAL receiver is controlled by the burst amplitude, the colour saturation is thus defined as the ratio between the chroma amplitude and the burst amplitude. This ratio is defined by the 1.5kΩ resistor in series with D5 connected to pin 5 of IC 5. (see also fig.5.)

Although usually not used in this circuit configuration, the S 042 P (IC6) is an excellent video modulator. The local oscillator section of the IC is used like the RF oscillator in the lower VHF band between 45MHz and 65MHz. The balanced modulator section of the IC should be obviously unbalanced (trimmer P_2) to obtain amplitude modulation. The modulated chroma signal is coupled through a small capacitor (2,2pF) to suppress the low frequency components present at the output of IC 5. The RF output signal at pin 2 of IC 6 has already a suitable amplitude level to drive a TV receiver.

3. Construction and alignment

The false colour PAL modulator is constructed on a single coated printed circuit board (fig.6.). The layout of the components is visible on fig.7. All the resistors and diodes are mounted horizontally. Note that two resistors are soldered on the copper side of the PCB and that the delay line is not mounted on the PCB.

L_{osc} is wound on a miniature IF transformer coilformer. The number of turns varies according to the desired frequency. It is recomended to select the proper coil using a grid-dip meter, the resonance capacitance at the desired frequency is around 15pF, including also the internal capacitances of IC6.

It is recomended to mount the PCB YU3UMV003 in a separate shielded container, since TV sets are very sensitive to the disturbs generated by the digital circuits of the memory unit, especially in the low VHF band. Also the RF connection to the TV set should be well shielded and correctly grounded both to prevent receiving disturbs and to avoid disturbing other TV sets.

The frequency of the PAL subcarrier oscillator should be precisely adjusted since an error of only a few hundred Hz might prevent the locking of the PAL demodulator in the TV receiver.

The PAL delay line in the TV receiver introduces a delay of exactly 64µs. If the line period generated by the digital storage unit is not exactly 64µs, then two superimposed images will appear on the TV screen. This can simply be corrected by adjusting the 1MHz clock oscillator (storage unit) precisely to 1MHz.

The oscillators in the false colour modulator and storage module are not phase dependent. Usually this does not cause problems, however in some unfortunate cases the various possible beatings may cause visible disturbs (flickering) on the image. In these cases it is recomended to slightly misalign the oscillators involved to remove the disturb.

4. Conclusion

The described PAL modulator transforms a black and white video signal in a false colour PAL signal. However it should also be possible to combine more video signals into one colour signal. For example, the video signal obtained from the VIS channel could control the intensity scale and the video signal obtained from the IR channel could control the colour scale. Obviously, two perfectly synchronized digital storage scan converters are needed for such an experiment.

Finally, one should notice that the synchronization logic accepts only the video signal generated by the described digital storage unit. If the PAL modulator is to be used with another storage unit, then the synchronization logic will probably have to be modified.

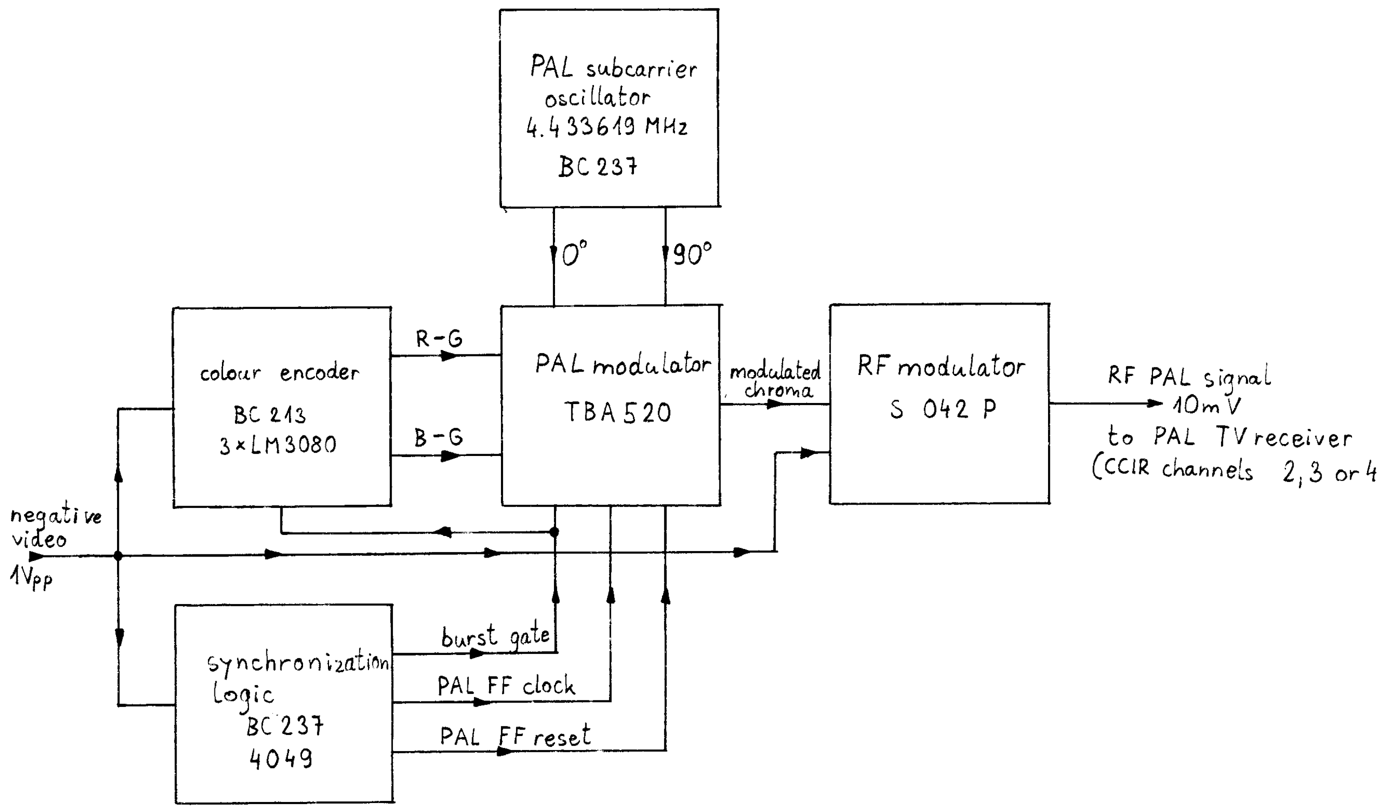

Fig. 1. - Block diagram of the false colour PAL modulator.

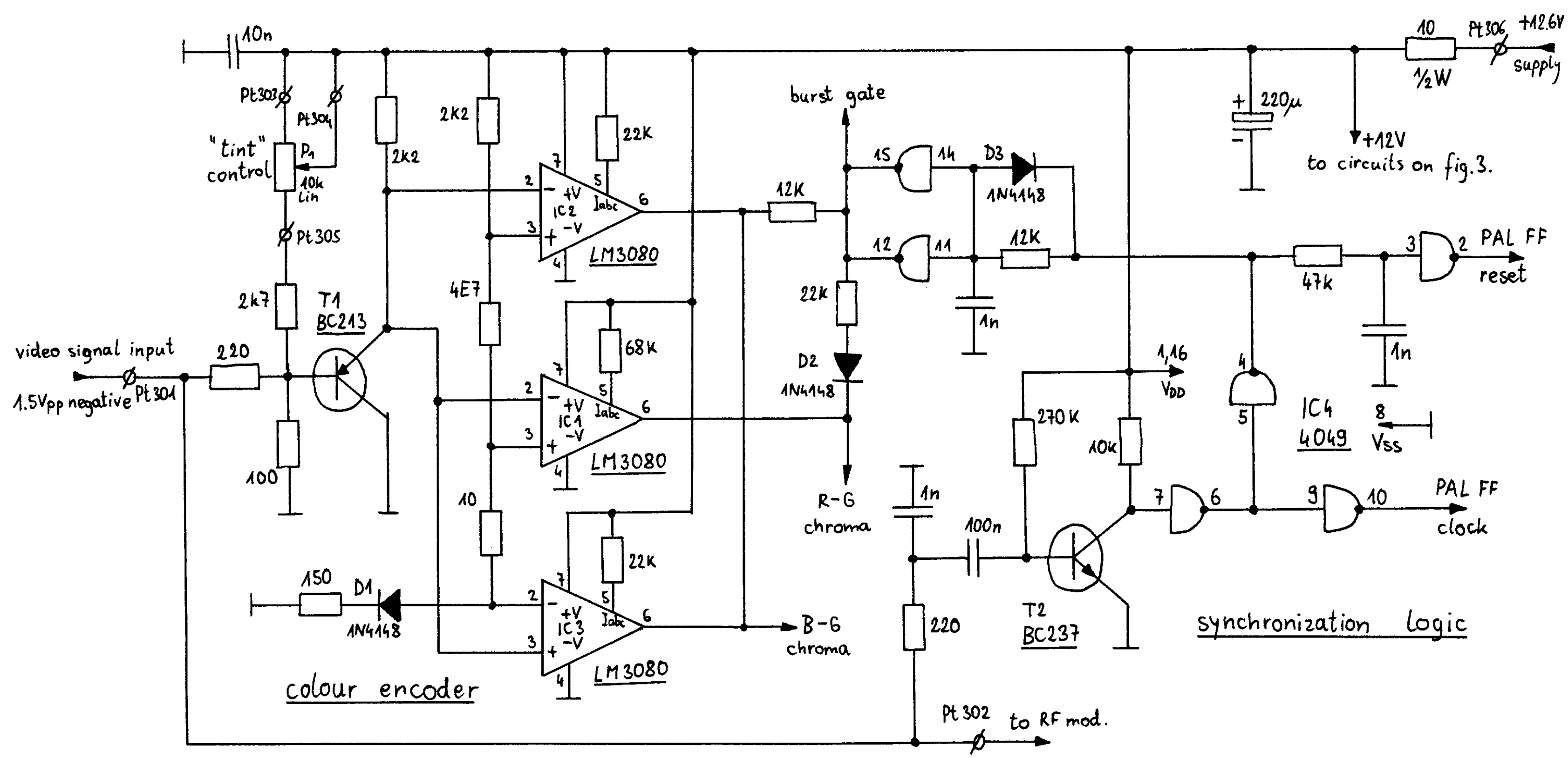

Fig. 2. - Colour encoder and synchronization logic.

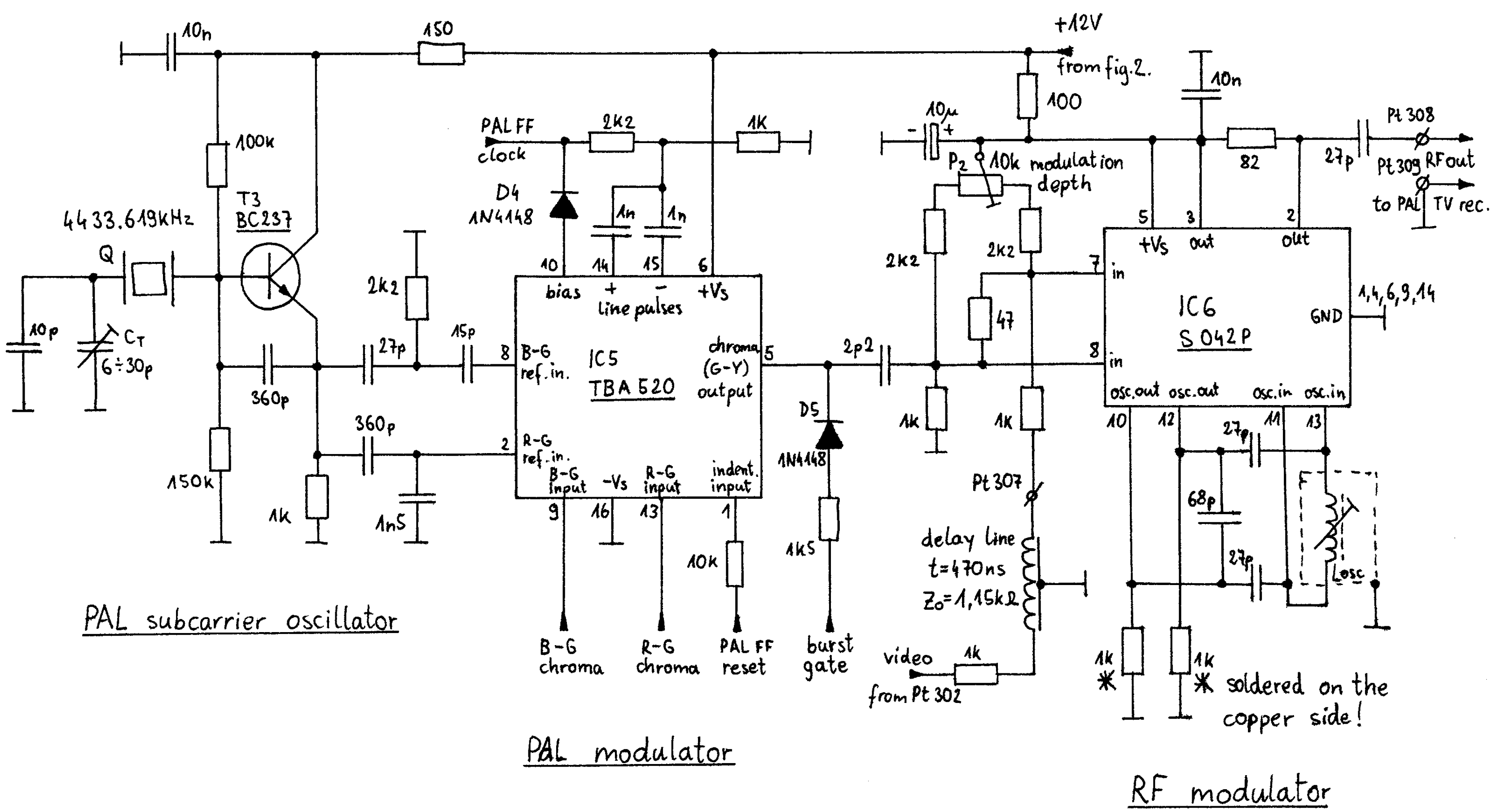

Fig. 3.- PAL subcarrier oscillator, PAL modulator and RF modulator.

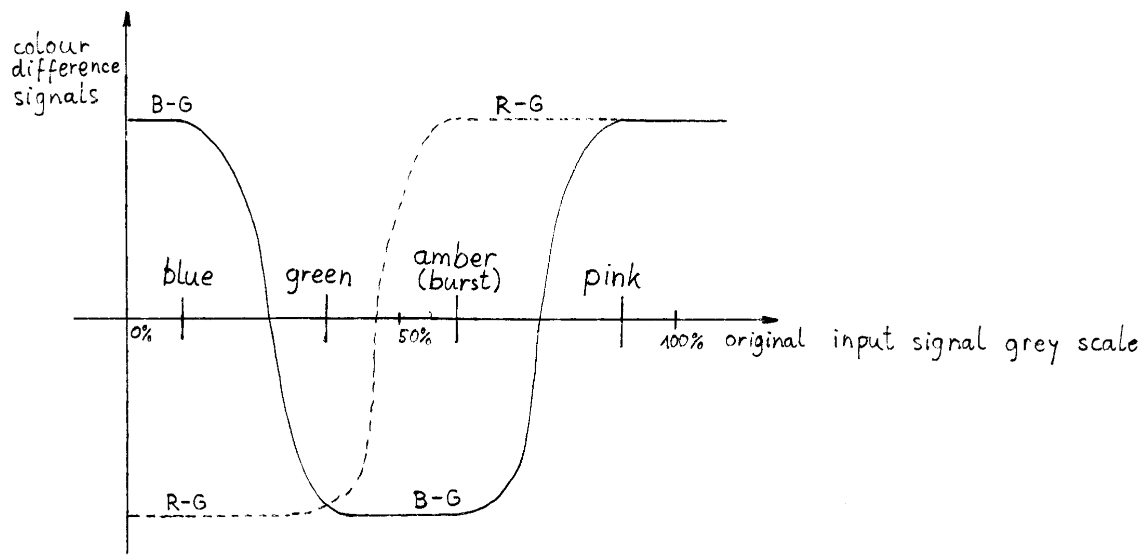

Fig. 4.- Colour encoder transfer function.

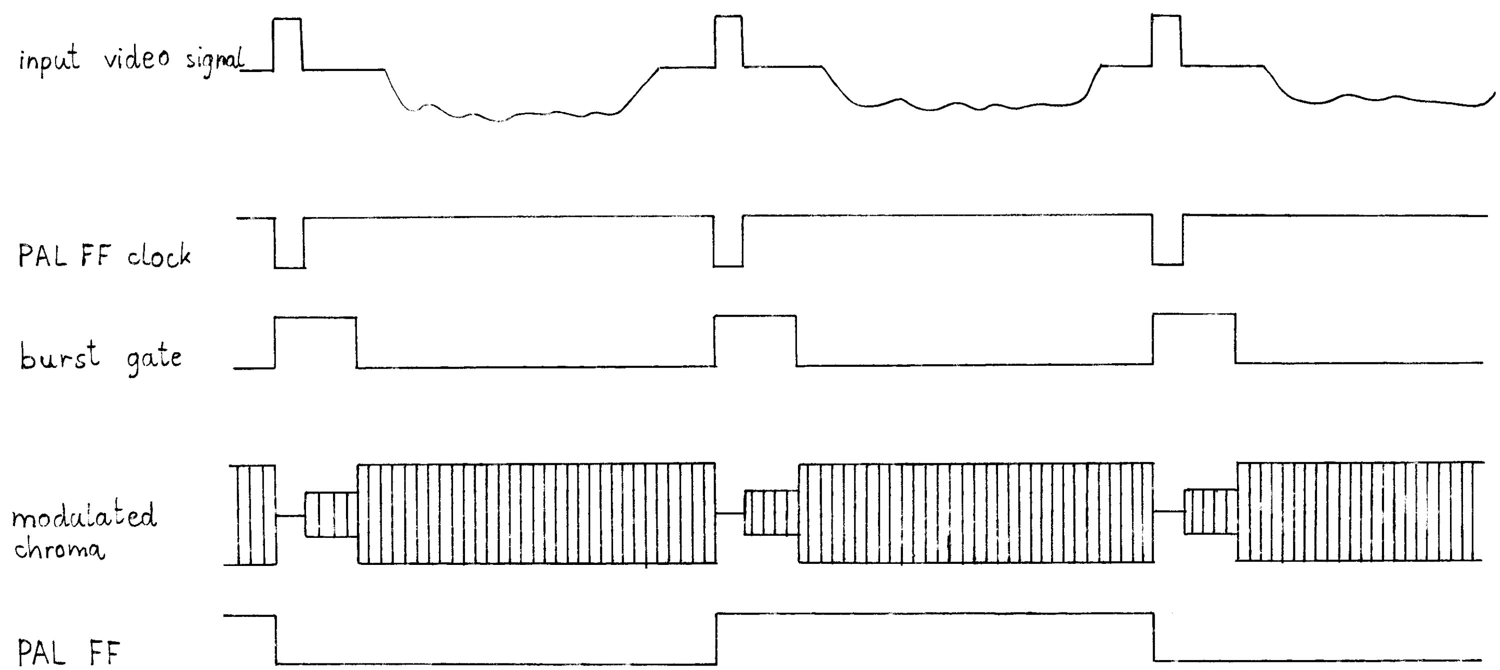

Fig. 5. - Generation of the chroma signal.

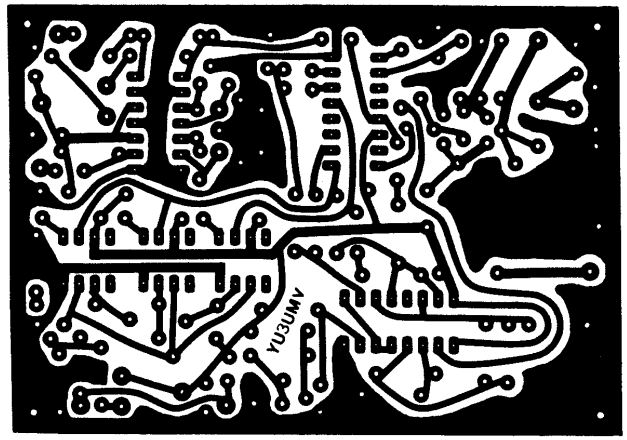

Fig. 6. - Printed circuit board, single coated, copper wiew.

NOTE: Two 1k resistors are soldered below IC6 (on the copper side) See fig. 3!

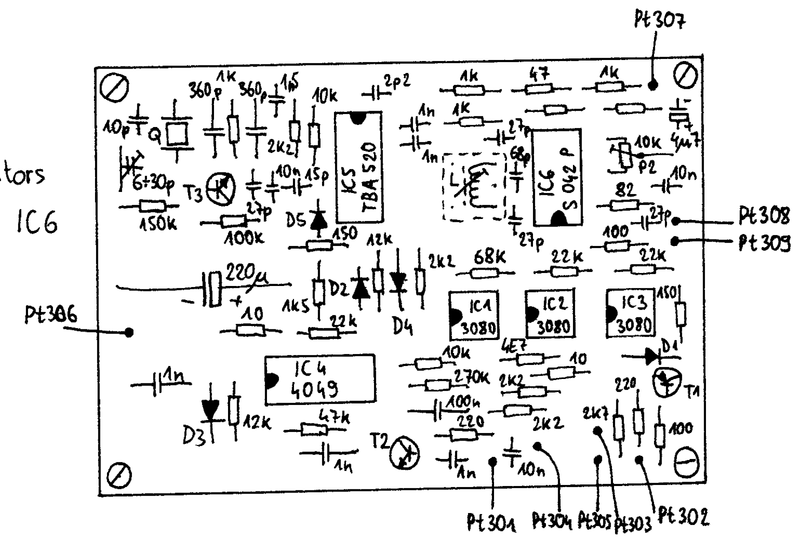

Fig. 7. - Location of the components on the PCB.

List of special components:

D1...D5	1N4148 or similar universal Si diodes
T1	BC213 or similar PNP Si for AF applications
T2, T3	BC237 or similar NPN Si for AF applications
IC1, IC2, IC3	LM3080 or CA3080, possibly with suffix "A" for tighter tolerances
IC4	4049 CMOS hex inverter / buffer
IC5	TBA 520 PAL modulator
IC6	S 042 P RF modulator
Q	PAL subcarrier crystal, 20÷30pF parallel resonance 4433.619 kHz
P_1	10kΩ lin trimmer or external potentiometer
P_2	10 kΩ trimmer
C_T	6÷30pF ceramic trimmer
L_{osc}	RF oscillator coil, ~5 turns on a miniature japanese 10.7 MHz IF coilformer, further data see text.

delay line, $t = 470ns$, $Z_0 = 1{,}15 k\Omega$ Philips type DL470, catalogue no 3122 138 99471