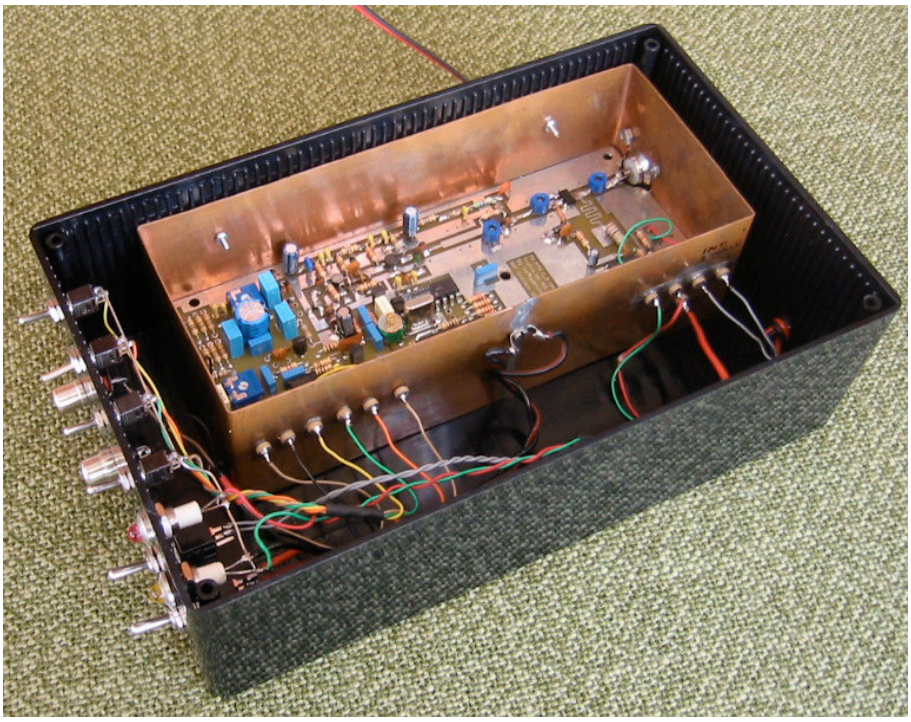
A.R.I.
Associazione
Radioamatori
Italiani
Ente Morale D.P.R. 368/1950

A.R.I Sezione di Bra
V. E. Milano n.18
12042 Bra (Cuneo)

ATV TRANSMITTER
23cm – 0,5W

From microwaves meeting (Treviso 2001)



ASSEMBLY MANUAL

by IW1FNW – IW1DGG
A.R.I. Sez. BRA

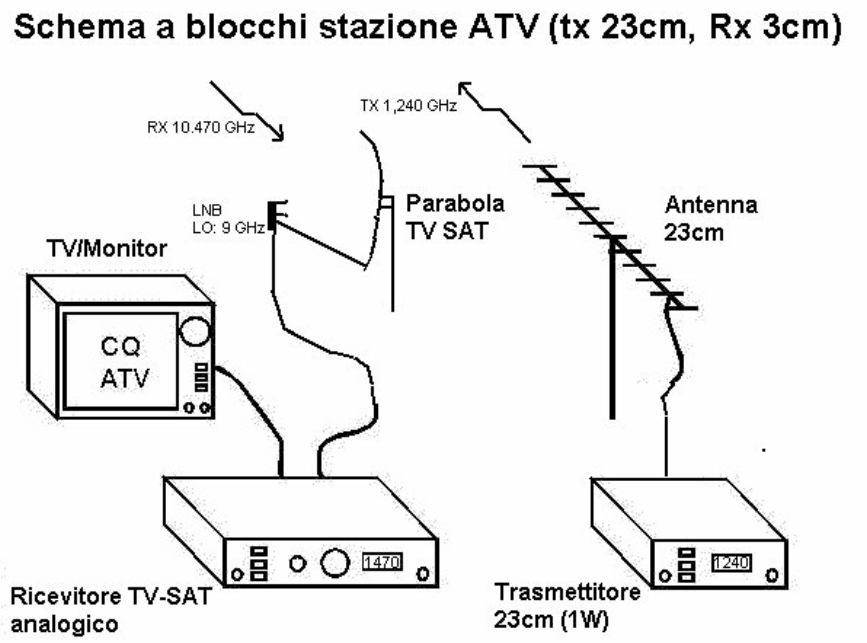
Ver. 1.0 – 05/08/2010

Introduction

Since several years, our Radio Club is working on Amateur Television and, since several OMs in our region (and not only) has started this activity, we decided to prepare a KIT for a transmitter in the 23 cm band easy to be assembled and allowing to set-up a low cost ATV station.

To set-up an ATV station has became really cheap thanks to the reusing of analog TV SAT equipment.

As shown in the block diagram below, it is needed:
- A TV SAT dish (40-80 cm), but if you are near to the repeater (30-40 km) the LNB can be sufficient
- A modified LNB converter, with Local Oscillator moved at 9 GHz (or even 9.1 – 9.4)
- An analog TV SAT receiver
- A 23 cm antenna (directive, 10-23 elements)
- A 23 cm transmitter (self-made, power ~1 W)
- A PAL video-camera



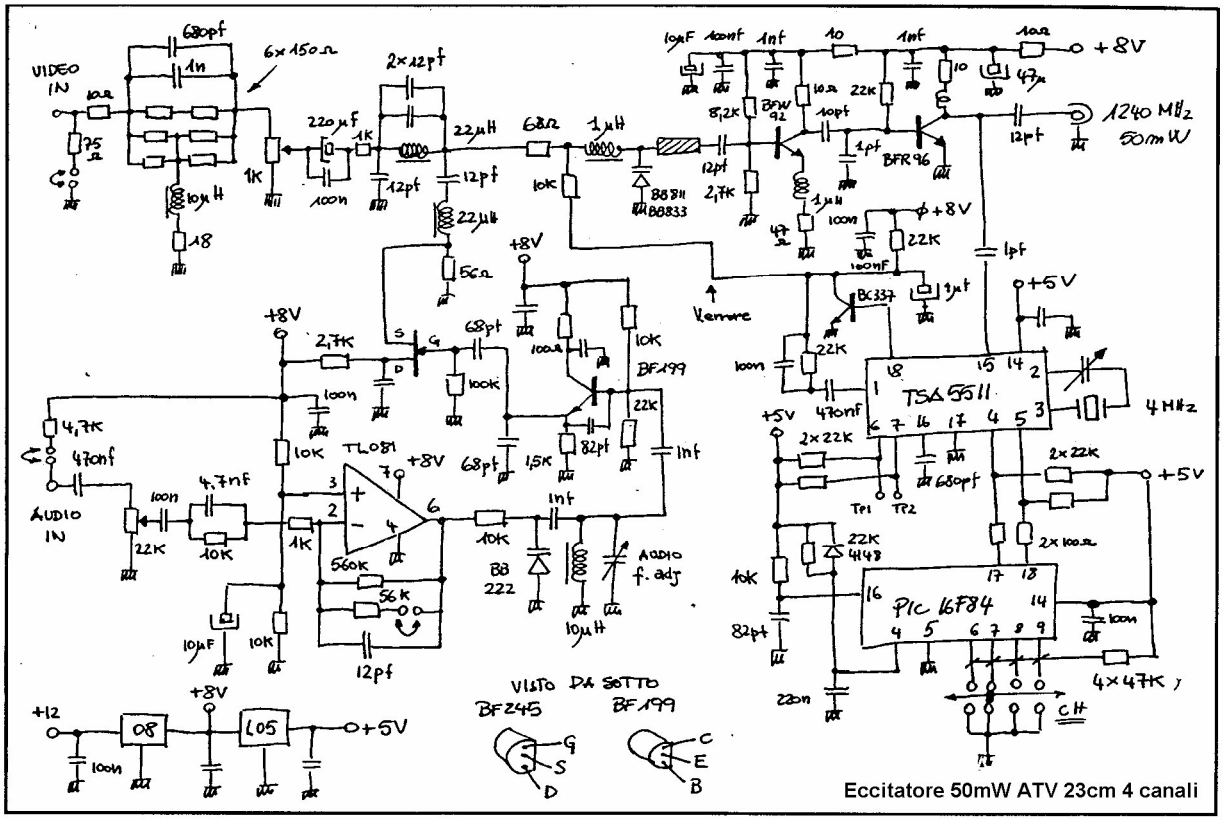
The frequencies in use in our area (downlink from repeaters) and the relevant configuration for the TV SAT receiver (with LNB at 9.1 GHz) are:

Monviso:	10.488 GHz, Horizontal Polarization	TVSAT RX:	1388 MHz
La Morra:	10.470 GHz, Horizontal Polarization	TVSAT RX:	1370 MHz

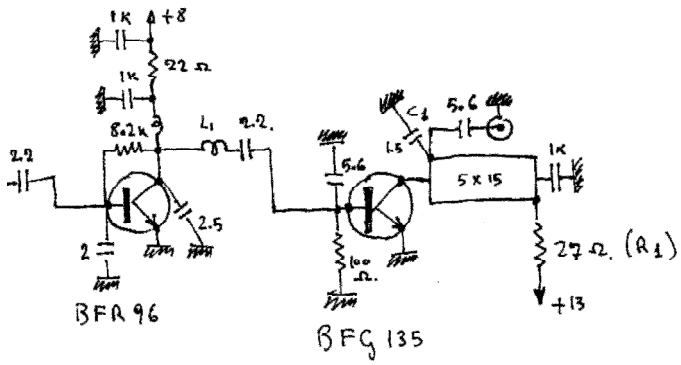
The audio subcarrier is usually at 6.5 MHz (mono).

Description of the Original Circuit

After this short introduction, we describe here after the transmitter.
The circuit has been taken from the A.R.I. Vittorio Veneto web site www.arivv.it. The schematic has been only slightly modified and it has been provided with a power amplifier stage based on a BFR96 and BFG35 (or BFG135) able to provide about 0.5W RF power. The PA has been designed based on suggestions from Marcello IK1YWB and taking as starting point PAs used years ago in Packet Radio RTX @ 23cm designed by Matjaz Vidmar.



Transmitter ATV 50 mW – ARI Vittorio Veneto



Power Amplifier 0,5 W – Marcello IK1YWB

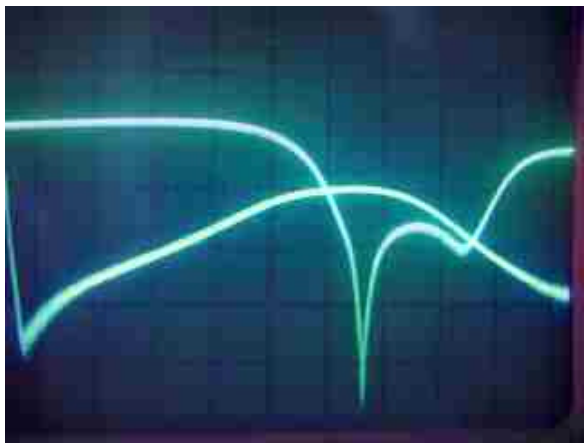
The following description is translated from the one taken from http://www.arivv.it/default.php?page=progetti_cs_txatv1240.

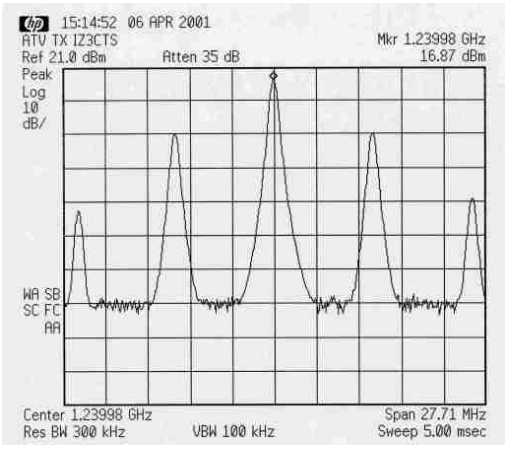
- Introduction

The circuit has been developed using wherever possible components easy to find on the market, using only standard inductors to avoid winding up them and trying to reduce tuning needs to the maximum extent.

- Electric Diagram

The video signal is applied to a pre-emphasis network, needed in any FM system to improve the overall signal-to-noise ratio. After trimming, it is fed to the AV mixer that also acts as a filter. This is a parallel LC resonant circuit implementing a Notch filter tuned at 6.5MHz since at this frequency it provides a high impedance for the video signal. The properly trimmed audio signal is applied to an operational amplifier that, in this case, introduces a pre-emphasis of 50 microseconds and also allows choosing between two gain levels. The first gain level - lower - is good for an "electret" microphone (it is also foreseen a resistor to supply it), while the second - higher - is for a line-in signal. At this point, the signal is applied on the varicap diode of the audio oscillator, modulating it.
The signal at 6.5MHz is buffered by a Source follower that provides a low impedance toward the second filter of the AV mixer for its correct operation. This filter consists of a series LC resonant circuit which provides a low impedance at the resonance frequency of 6.5MHz, allowing the audio signal passing through it. The following figure shows the bandwidth of both filters and gives an idea of the effect of the mixer.

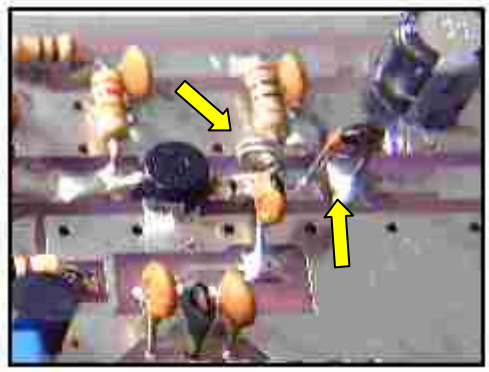




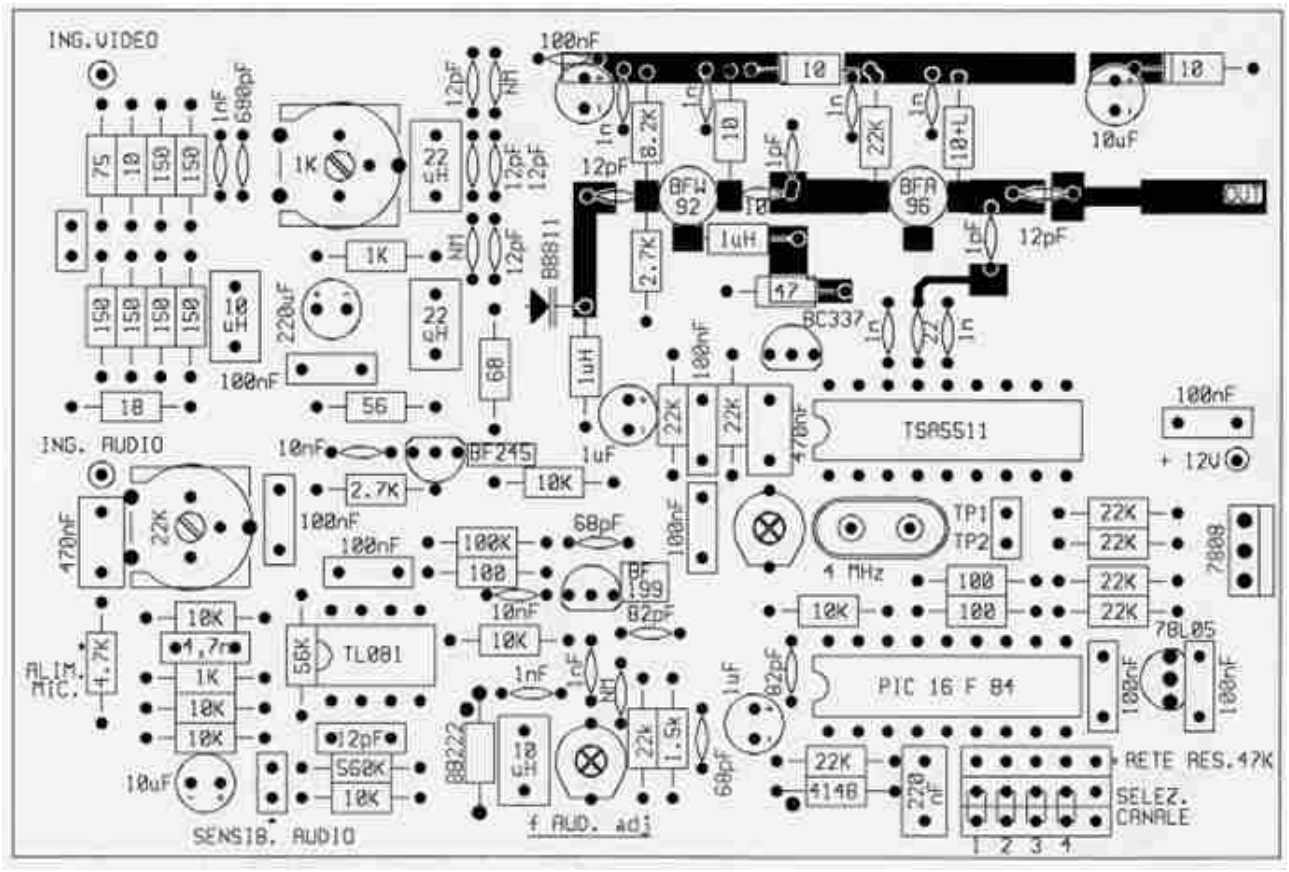
The video signal and the audio carrier mixed together modulate the VCO at 1.2GHz, implemented by the transistor BFW92, generating the RF signal shown in figure above. As can be seen, the audio carrier, 6.5MHz apart from the video signal, is attenuated by about 15dB (it could be even 20dB lower). This value can be adjusted by modifying the value of the resistor mounted on the Drain of the FET.
At this point, the RF signal generated by the VCO is applied to an amplifier made by the BFR96 which provides about 17 dBm (50 mW). A small amount of the carrier is applied to the IC TSA5511 (SDA3202), usually used in the RF section of a well know Italian TV brand. This IC, programmed by the microcontroller PIC16F84, allows the stabilization of the frequency on four selectable channels.
The slow lock-in time of the PLL (about 200ms) is desired and is due to the loop filter bandwidth, which is designed in order not to introduce distortion on the video signal. Therefore, it is sized so that

its cut-off frequency is about 10 times lower than the minimum modulating frequency, i.e. the vertical synch frequency of the video signal (50Hz).

- Assembly

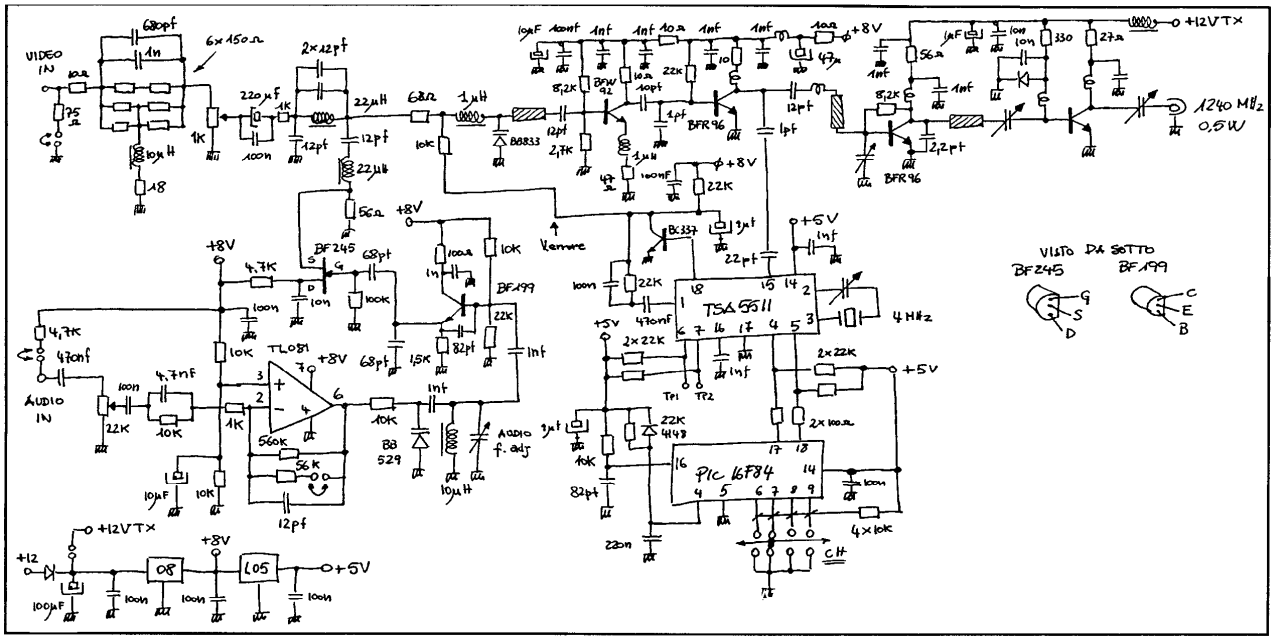


The assembly does not show any particular difficulty. Pay attention to the 10Ohm resistor on the collector of the BFR96, whose terminal has to be used to wind-up an inductor in air, consisting of 2 turns on a 2mm diameter. In the same area, pay attention to the 12pF capacitor that has to be soldered with its terminals at least few millimiters longs, as shown in the picture on the right.
For final test, it is only necessary to tune the capacitive trimmer to set the audio carrier at 6.5MHz. Done this, the transmitter is ready to be used to send its first video signal in the air. The output power is sufficient to perform some short distance QSO, and it is possible to strength the signal with a simple PA, but it is also good as a driver for transverters at 5 or 10 GHz.



Our circuit

Our circuit is in principle the same as the one described above. As already said, the only significant modification is the addition of the 0,5W RF amplifier. In the following figure it is shown the modified electric diagram.



Here after, you can find the complete component list, their disposition on the board and a picture of our prototype that could help in the assembly.

Our circuit foresees (on the right) the power input, the input/output for the PA switch and 2 LEDs (green/red) to show exciter ON and PA ON respectively. In this way it is possible to leave the exciter always ON with the PLL locked on the desired channel, and switch ON/OFF only the PA, to go in TX.
The VIDEO input is jumper J10, while AUDIO is jumper J12. J11 can be used to close the VIDEO input onto a 75Ohm load, while L9 is used to supply preamplified microphones ("ELECTRECT").

Components List

RESISTORS (1/4 W)
5 10Ω
1 18Ω
1 27Ω - 1W
1 47Ω
2 56Ω
1 68Ω
1 75Ω
3 100Ω
6 150Ω
1 330Ω
1 820Ω
3 1kΩ
1 1,5kΩ
1 2,7kΩ
2 4,7kΩ
2 8,2kΩ
11 10kΩ
9 22kΩ
1 56kΩ
1 100kΩ
1 560kΩ

HORIZONTAL TRIMMERS 10mm
1 1kΩ
1 22kΩ

POLYESTER CAPACITORS 5mm PITCH
1 4,7nF
10 100nF
1 220nF
2 470nF

DISC CERAMIC CAPACITORS 5mm PITCH
2 1pF
1 2,2pF
1 10pF
7 12pF
1 22pF
2 68pF
2 82pF
1 680pF
12 1nF
3 10nF

ELECTROLITIC CAPACITORS 16V
3 1uF
2 10uF
1 47uF
1 100uF
1 220uF

CAPACITIVE TRIMMERS TZ03 SERIE
1 VERDE
1 ROSSO
3 BLU

RADIAL INDUCTORS NEOSID 5mm PITCH
2 10uH
2 22uH

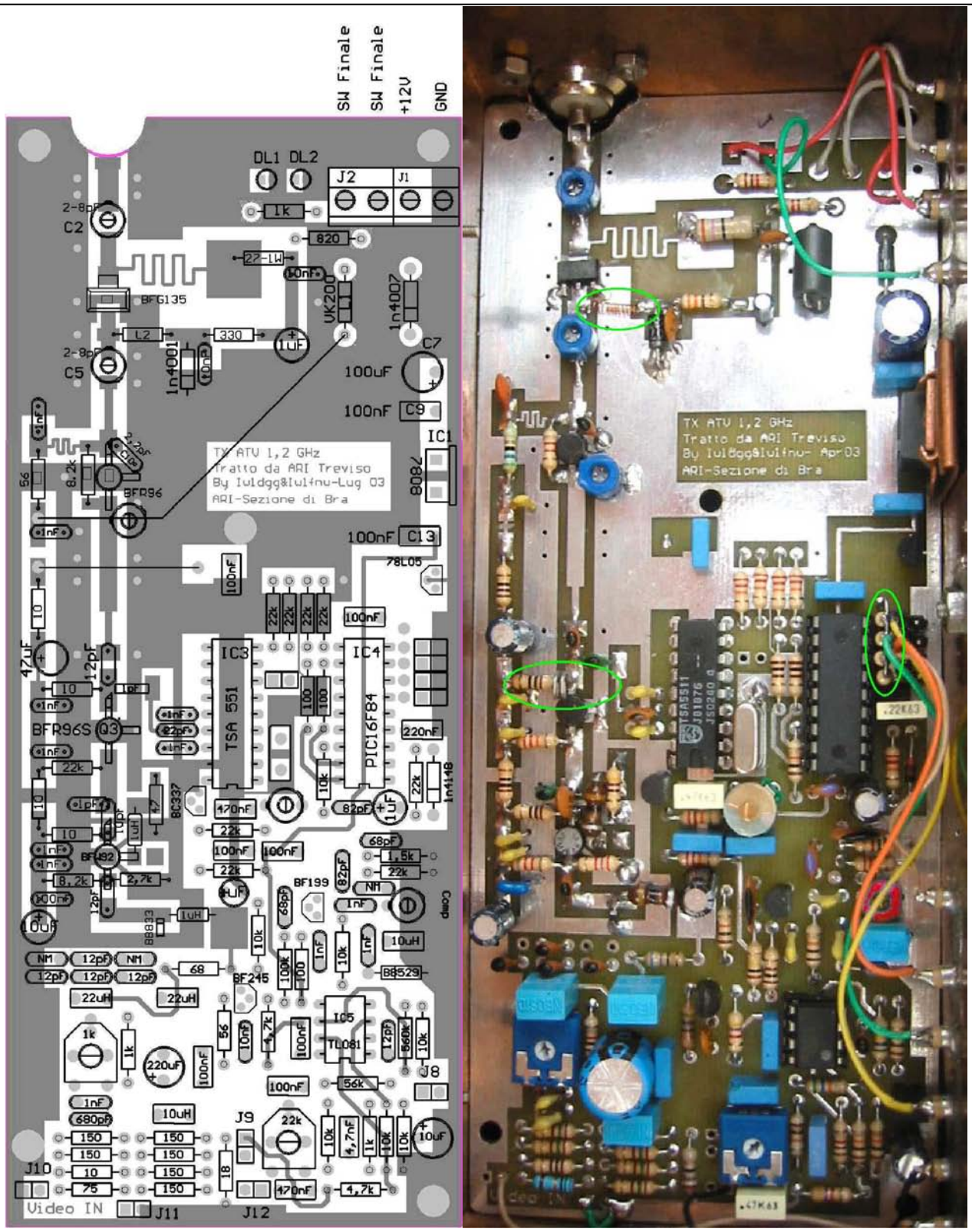
AXIAL INDUCTORS 10mm
2 1uH

TRANSISTORS
1 BF245
1 BF199
1 BC337
1 BFW92
2 BFR96s
1 BFG35

DIODS
1 1N4148
2 1N4007
1 BB529
1 BB833

ICs
1 78L05
1 7808
1 TL081
1 TSA5511
1 PIC 16F84

OTHER COMPONENTS
1 FERRITE VK200
1 QUARTZ 4MHz
1 STRIP-LINES CONNECTOR
3 JUMPERS
1 LED RED 3mm
1 LED GREEN 3mm
11 FEED-THROUGH CAPACITORS
1 FEMALE N-CONNECTOR 50Ω PANEL MOUNT WITH SQUARE FLANGE AND TEFLON DIELECTRIC
2 SWITCHES
1 SOCKET 4+4 PIN
1 SOCKET 9+9 PIN

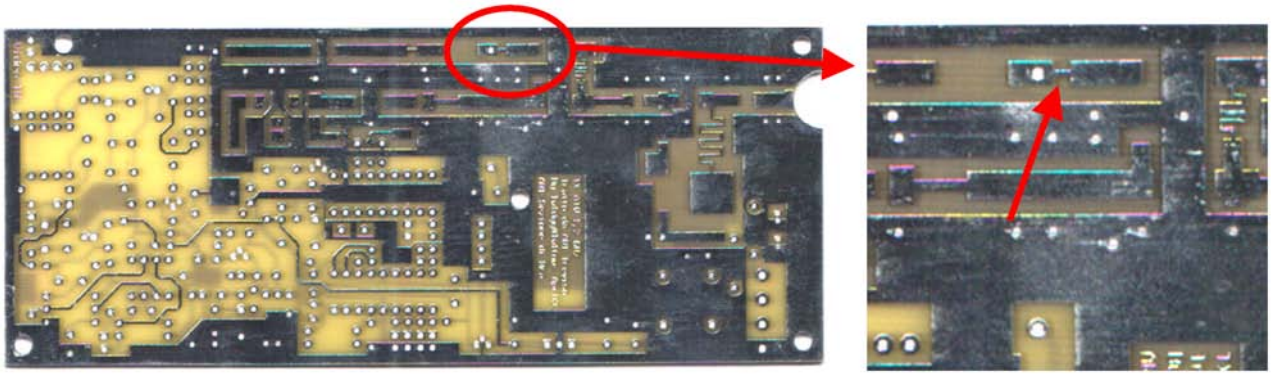


REMARK: The components that you find in our kit may differ in shape from those in the picture above. You should take as a reference the components layout on the left. The picture can be useful to understand how to mount some components (in particular the RF part).

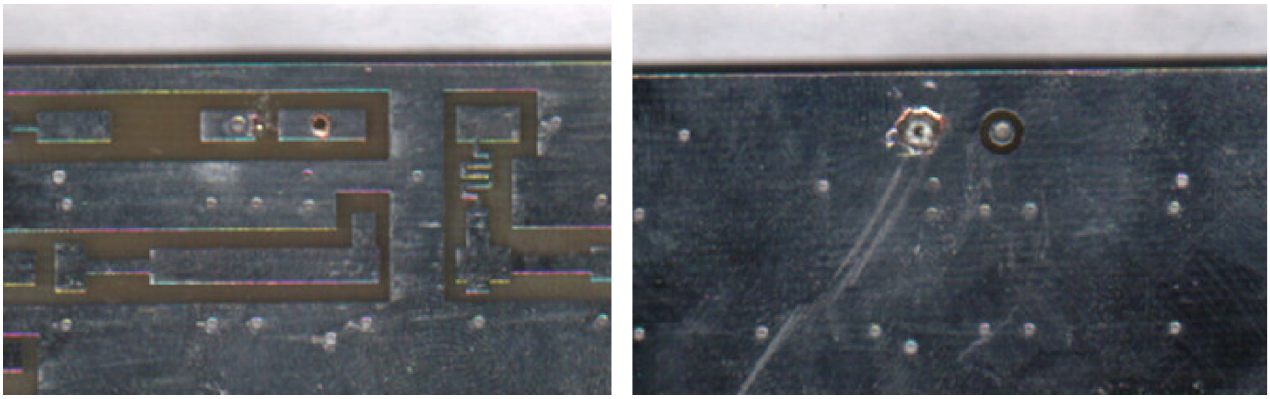
Before starting the assembly (modification to the PCB)

When we mounted the firsts prototypes, we discovered that the output level from the transmitter was still too high even with the PA switched off (i.e. with the BFR96 driver on, only). The simplest solution we found was to switch off the PA driver, too.
In order to do that, you have to modify the PCB as follows:

- cut the thin track between the two wider ones as indicated in the following two pictures.



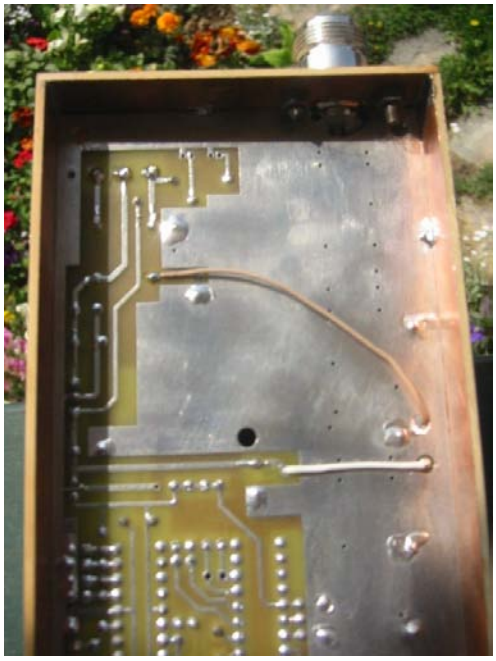
- make a through hole in the center of the right track (with respect to the cutting point) with a 1mm drill bit, and on the bottom side remove (e.g. with a cutter) the ground plane around the hole, so to leave few millimeters free from copper all around the hole (see following pictures).



Assembly procedure

We suggest to mount the components in the following sequence:
- Sockets for ICs (only for TL081 and PIC16F84, the PLL has to be soldered without socket)
- Resistors (horizontal), except those in the RF part
- Trimmer
- Capacitors and inductors, except those in the RF part. Warning: two 12 pF capacitors in the video pre-emphasis (lower left part of the PCB) and one 1 nF in the audio modulator (near the red capacitive trimmer) must not be mounted; compare the picture with the component layout above.

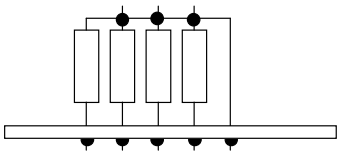
- Jumpers
- Transistors RF, resistors and capacitors on the microstrips in the RF part.
- Everything else (hi!)



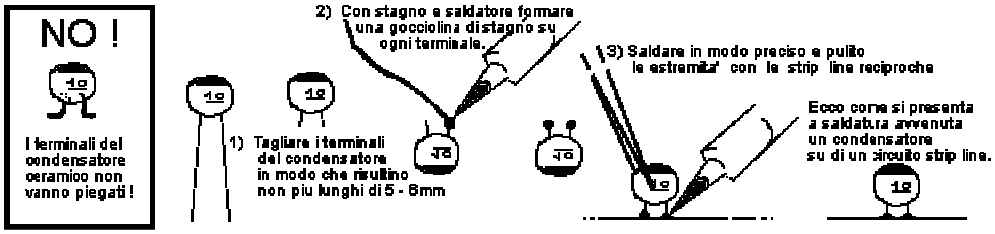
Finally, do not forget the two flying connections to be installed on the bottom side, one between the 100 nF capacitor and the 10 Ohm resistor and the other between the 56 Ohm resistor (through the hole made at the beginning) and the VK200 inductor.
The picture on the left shows where these two connections have to be soldered.

When you assemble the circuit, in particular the RF part, you should take care to the following points (also highlighted in the picture above):

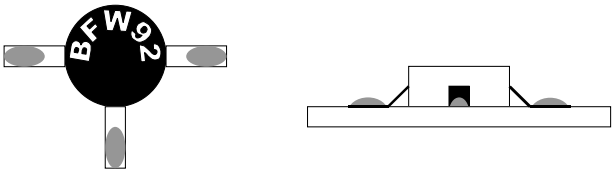
- Take care when you solder on the component side, not to melt other components in the vicinity (in particular capacitors that are higher than other components!)
- The four 10k Ohm pull-up resistors between the PIC and the jumpers to be closed for channel selection, must be mounted in vertical position and connected as shown in the picture below:



- The terminals of the components must not be bent but shall be soldered perpendicularly to the PCB (see picture).



- The RF transistors (BFW92, BFR96 e BFG35) shall be mounted face up, (so that their marking remains readable). The terminals shall be cut as short as possible and soldered as near as possible to the body in order to avoid parasitic inductances.



- One of the three terminals of the biggest green capacitive trimmer that has to be mounted near the quartz shall be cut away before mounting it.
- One of the terminals of the 10 Ohm resistor on the first BFR96 connector shall be used to wind up a 2 coils inductor on a 2 mm diameter (you can use a drill bit as support).
- In the same area the 12 pF capacitor shall be mounted with its terminals at least some millimeters long, as shown in the picture on page 5.
- The negative terminals of the 1 nF capacitors and of the electrolytic ones mounted on the power supply stripline (those nearer to the edge of the board) shall be soldered in through holes, so they have to be cut longer than the positive terminals to be soldered directly on the stripline.
- The L2 inductor is made by 12-13 coils of 0.15 mm insulated copper wire wind up over 1 mm diameter drill bit. Before winding up the inductor remove the insulation from the edges of copper wire to allow solder it...

In order to program the PIC you need the SW available on the www.aribra.it website. The SW that we provide does allow you to select the following channels:

- CH1: 1240 MHz
- CH2: 1245 MHz
- CH3: 1256 MHz
- CH4: 1272 MHz

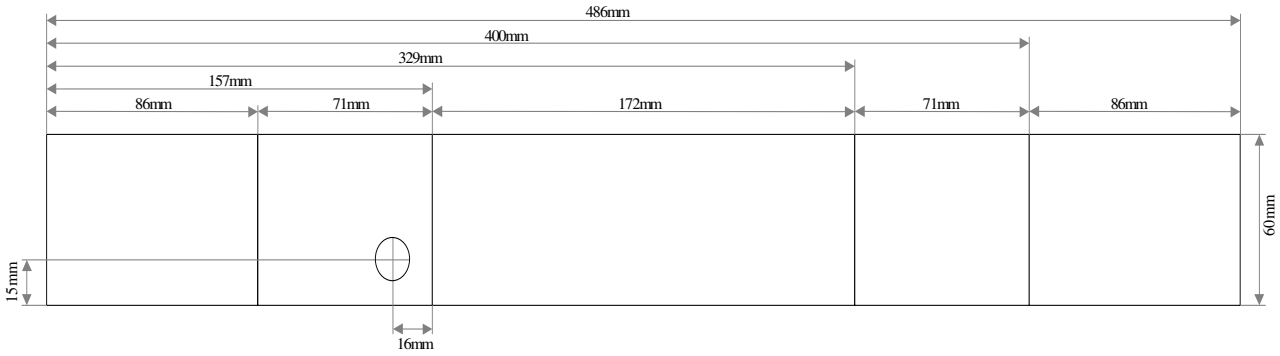
(the last 2 channels can be used for direct QSOs).
On the website, you can also find a simple SW to modify the channels frequencies directly in the .HEX file, allowing choosing whichever value you want within the PLL tracking range and within the output power tuning range.

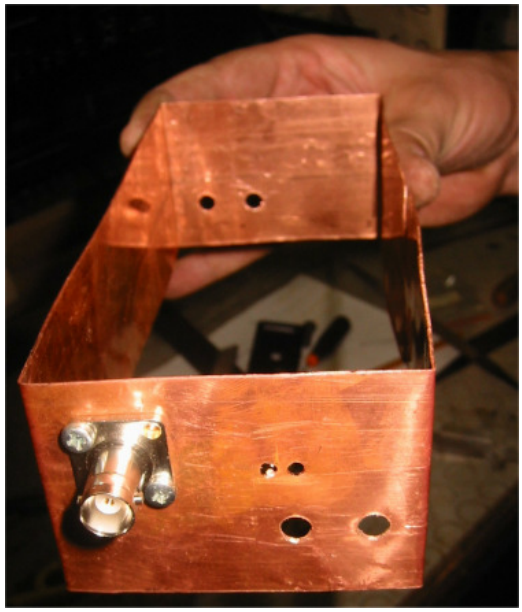
Final tuning and box realization

Before mounting the board in its box we suggest to test it.
Set the transmitter at 1240 MHz and switch it on (without switching on the final, otherwise...).
First of all, the RED capacitive trimmed near the TL081 has to be tuned in order to fix the frequency of the audio carrier at 6.5 MHz. To do this, you can use an FM HF receiver tuned at 6.5 MHz with a short piece of cable connected to the antenna port. The open end of the cable shall be kept near to the capacitive trimmer while tuning it until maximum signal is obtained on the RX and a clear sound can be heard (you can use an audio source or you can allow Larsen effect starts between RX and TX). During tuning, it may happen that the audio oscillator stops oscillate, for particular positions of the capacitive trimmer. The only way to start it again is to move the trimmer and switch off and then on the TX. On few models, we were not able to tune exactly the audio subcarrier frequency at 6.5 MHz. The problem is the varicap (BB529) polarization voltage. To minimize this problem we already replaced the capacitive trimmer with a RED one that allows achieving higher frequency. However, in case the frequency can still not be tuned to 6.5 MHz, the 10k Ohm resistor in the corner of the PCB where the TL081 is located, near to the 10uF electrolytic capacitor, can be replaced with a 12k Ohm one. With this modification, you should be able to raise the voltage on the varicap allowing it to oscillate at 6.5 MHz. Once completed this tuning you can pass to the RF part.
First step is to check the lock status of the PLL by measuring the voltage on the terminal of the 10k resistor near the BF245. If the voltage is about 4 V the PLL is locked, otherwise there is a problem on the PIC, on the TSA5511 or in the PLL (BFW92 and surrounding components). If the voltage is OK, take an analog TVSAT receiver, disconnect the antenna and replace it with a piece of wire or a resistor

and set the receiver frequency at 1240 MHz with audio subcarrier at 6.5 MHz. In this way, you should be able to receive the signal from the transmitter and see the video signal on the TV or monitor.

If everything works fine, you can put your board in a suitable box. You can build it by your self using copper sheet, as shown in the following figures.





A good alternative to the copper sheet is a new bakelite or epoxy resin board with at least one copper layer. We realized a couple of boxes using these boards and the final result was also good (this material is easy to be cut than the copper sheet). The measures can be taken from the figure above, taking into account that the size of the two longer faces has to be increased by two time the thickness of the board used (e.g. 1,6mm + 1,6mm).
Before installing the circuit inside the box, make all holes needed to mount the N connector (the picture shows a BNC that has been later replaced) paying attention to its right position with respect to the longer face of the box, since, at the end, its terminal shall coincide exactly with the output microstrip. We suggest to identify the position of the center of the connector hole inserting the circuit inside the box and making a mark in correspondence of the output line. You can make this hole slightly larger to have the possibility to adjust at a later stage the position of the connector.
For the input/output of signals and power lines we have foreseen 11 feed-through capacitors. These are:

- 2 for the audio and video inputs;
- 4 for the channel selection jumpers;
- 2 for the two LEDs;
- 1 for the power line input;
- 2 for the PA switch connection.

Once the box is completed, you can mount the circuit inside (remind that the N connector terminal must lay exactly on the output stripline where it has to be soldered). The ground plane on the bottom side must be soldered completely to the box. In order to do this, you need a sufficiently powerful soldering iron and a small one to be used simultaneously to realize a uniform tin strip along the board edges and on the box. Further, to avoid RF power losses, we suggest also to solder the top layer of the PCB to the box, at least near the output connector.

At this point you can test the final stage, too. To do this, the best approach would be to use a wattmeter (or an RF diode connecter to a tester as we did before we bought the wattmeter). Once wattmeter and load are connected (without load you risk to damage the BFG35!!!) you can try to adjust the BLU capacitive trimmers to achieve the maximum signal starting from the first one at PLL output till the last one, and repeating this operation few times. The power levels achieved by us on the first models were between 0.5 W and 0.7 W (significantly dependent on how much tin remains in excess on the striplines and on the coupling between N connector and PCB).
Pay attention that on some models the first capacitive trimmer resonates in two points but only one is the one giving the maximum output power.

In case of problems or for a more accurate tuning, you can contact us at out e-mail addresses.

Updates and suggestions useful for better operations

- If you connect the transmitter directly to the antenna without any external amplifier, you must use "big size" cable (e.g. RG8/RG213 or better). Smaller cables (RG58 or similar) have too high losses and you shall avoid them. Usually big cables mount N connectors (do not try PL connectors, since they are NOK) therefore with respect to first version of this kit, we replaced the panel mount BNC connector with an N-female still panel mount.

- We suggest housing the TX and relevant connections in a plastic box, placing the RCA connectors for audio and video signals, the ON/OFF and RX/TX switches, a 4 position switch for channel selection and whatever you need on the walls of this plastic box.

We remind you that in Italy the monitor frequencies to be used for ATV tests are:

144.750 FM according to band plan
435.925 at least used in Piemonte.

See you soon!

'73 de Iw1dgg & Iw1fnw

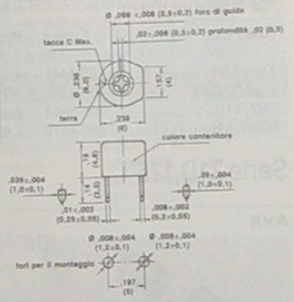
Useful data for the assembling

Capacitive Trimmers:

Ceramici

Serie TZ03

muRata



Trimmer a singolo giro con piedini dal passo 5 mm adatti per essere montati direttamente sulla basetta del circuito stampato. Aderiscono alla superficie del circuito stampato con un'altezza di montaggio inferiore ai 5 mm. Costruiti con dielettrico ceramico stazionario per consentire un coefficiente termico stabile e lineare.

Conforme alle norme MIL-C-81/8CV42.

Specifiche tecniche

Capacità (pF) min.	max.	Coefficiente termico	Q min. a 1MHz e C max.	Tensione di esercizio	Colore contenitore
1,5	5	±200 ppm/°C	300	100=	Blu
3	11	±300 ppm/°C	500	100=	Bianco
4,2	20	±300 ppm/°C	500	100=	Rosso
5,2	30	±300 ppm/°C	500	100=	Verde
6	50	±300 ppm/°C	300	50=	Arancione

Temperatura di funzionamento	da -55°C a +85°C
Prova di durata sopportata	220V= (modelli 100V) 110V= (modelli 50V)
Resistenza di isolamento	10^4 MΩ (min.)

Inductors: