DIGITAL VFO

INSTRUCTION MANUAL

(Software V1.5)

Last update : December 1 2004

DISPLAY & FUNCTIONS

DDS-VFO DISPLAY DESCRIPTION:

The DISPLAY shows the current frequency, the VFO used, the functions selected and the BAND number, for the correct position of BAND SWITCH, in the receiver and transmitter, It depends on the tuned frequency (this last feature is available only if The Drake or Collins mode is selected).

DDS VFO KEYS DESCRIPTION:

- **VFO** Switches between VFO A and VFO B

- **SPL** Pressing this switch it selects "split operation". It is possible to receive with VFO A and transmit with VFO B

- **RIT** Pressing this switch it activates the RIT operation. It is possible to change the received frequency with KEY "+" or KEY "-", with step of 10 Hz. (+/-2000Hz)

- **BAND** This key has three functions: **BAND - STEP - TUNING**

    BAND : Pressing KEY "+" or KEY "-" it selects "up / down" on HAM BANDS.
    The DDS-4 current VFO has the tuning programmed for centre frequency when a Ham band is selected.

    STEP : Pressing KEY "+" or KEY "-" it changes the tuning step (1, 10, 50, 100 Hz,…....0.5, 1 MHz steps are selectable)

    TUNING: Pressing KEY "+" or KEY "-" it tunes with selected step, when main tuning knob is not used.

- **FUN +** Pressing this switch it selects the required function (see above)

- **- KEY +** Pressing this switch it changes the value of the selected function

DDS-4 FUNCTIONS DESCRIPTION:

- **LOCK** This switch locks the main tuning knob. The tuning is available only with the Key. Pressing **KEY "+"** it sets the fan ON / OFF.

- **TX TIME** When PTT is depressed the display shows the time run during transmission. Pushing **KEY "+"** it sets the fan ON / OFF.

- **MEM WRITE**: The current tuned frequency (VFOA or VFOB) is stored in the selected memory position.
  To select the memory position press KEY "+" KEY "-" to scroll through the 20 memories.
  To write into memory press the **BAND** red key.

- **MEM READ**: Recall a frequency from memory.
  Press KEY "+" KEY "-" to scroll through the 20 memories.
  If a memory is empty, the receiver is muted.

- **SCAN A --> B**:   The scan runs from **VFO A to VFO B**.
  Tune VFO A to the start frequency
  Tune VFO B to the stop frequency
  Pressing **KEY "-"**, STORE message is displayed to confirm the SCAN function is ready.
  Press **KEY "+"** to START or to STOP scanning. When SCAN is stopped the VFO can be tuned manually to the required frequency; if KEY "+" is pressed again the scan restarts from the actual frequency.

- **SCAN MEM**: The scan runs selecting memories. Push **KEY+** to START or to STOP scanning.

- **VFO A = B**:   Pressing this switch it copies the frequency of VFO B to VFO A.

- **VFO B = A**:   Pressing this switch it copies the frequency of VFO A to VFO B.

- **SWL BAND**: Pressing KEY "+" or KEY "-" it moves up / down on SWL BANDS.
  The DDS-4 current VFO has the tuning programmed for centre frequency when a SWL Band is selected.

- **DDS Level** : the DDS output level can be programmed from +8 dBm (16385 on the display to – inf. (0 on the display) . The steps levels are 128. These are necessary to setup the correct injection level to the receiver mixer or when using the VFO as a signal generator. The level is stored permanently in the EEPROM.

USING Digital VFO

The DDS digital VFO gives you the full control of your receiver and transmitter, with performance like modern commercial transceivers.

The IF frequency value can be programmed (i.e. 5.645 KHz for Drake, 4915 KHz for Elecraft K1 or K2, xx MHz for many other commercial or homebrew transceivers) You can set it for zero beat in your receiver, for exact calibration if the carrier oscillator of your receiver is not correct.
It is possible to set-up different IF offsets for RX and TX, as it maybe the case some homebrew transceivers, where the TX IF is different from the RX IF.
The specific set-up is reported in the following description.

To change the **IF RX** frequency value, simply tune the frequency required, i.e. 5645.125, and press keys **SPL** and **RIT** for 2 seconds, at the same time.
Now the new IF value for the RX is stored in memory. (the VFO output frequency has a positive offset frequency equal to " Frequency displayed + IF")

To change the **IF TX** frequency value, simply tune the frequency required, i.e. 5.645.125, and press keys **VFO** and **SPL** for 2 seconds, at the same time.
The new IF value for the TX is stored in memory. (the VFO output frequency has a positive offset frequency equal to " Frequency displayed + IF")

To have the TX functionality is necessary to put a GND to PIC I/O pin 15 (PORT C4). You can use the PTT mike line of your transceiver for this control.

It is very important to use a "contact" not powered, due to the fact that any voltage present on this line can destroy the PIC controller.

If a different voltage is present on the MUTE contact (i.e. in the Drake there are -50V) an opto-coupler is necessary to interface the PIC.

If you want to use your VFO like a signal generator, or for a Direct Conversion receiver, simply set the IF value to 0, for RX and TX. Now the frequency output is the same as the one displayed.

When turning ON the VFO, this will tune to the same frequency previously set; both VFOs are set on this frequency.

When you are tuning with fast steps, control the VFO band indication on the display. You must change the band switch in receiver mode and peak the preselector for correct listening (this feature is useful in Drake receivers or on similar homebrew radio).

Typical of all DDS is the presence of some "Spurs", particularly on the higher HF bands. With the new DDS employed (AD9951), including a 14 bit DAC, these "spurs" are all very low (less than -130 dBm).
These "spurs" can be easily recognized due to the fact that they are very narrow (less then 7 Hz bandwidth). A small frequency offset, typical 10 Hz, is sufficient to eliminate the interference. This frequency offset can be done automatically with the RIT function; it is only necessary to switch RIT mode to "ON". With this action, generally, the spurs are suppressed; if this is not happening, the offset should be modified further of + or – 10 Hz. If the interference is wider (i.e. > 20 Hz) this is not a DDS spur.

In the Drake DDS version it has been tested that some very low intensity spurs are received only in the 28 MHz band (less then 3-4 significant spurs with level of about – 130 dBm)

There are some default set-up at start-up:

- **STEP 50 Hz.**
- **TX TIME OFF**
- **RIT OFF**
- **SPLIT OFF**
- **LOCK OFF**

Start-up programming:

There are some parameters that can be programmed into the DDS VFO.
The following parameters can be programmed when the controller is switched "ON" when pressing some specific KEYs.

OSCILLATOR SET_UP:
Switch "ON" the controller with KEY "VFO" pressed till "Oscillator Set-up" is shown on the display:
Press Key "+" or Key "−" to change the values of oscillator frequency, as second as the type installed on the DDS board, and the PLL multiplier.
Once values have been programmed, turn off the controller to store values.

Some oscillator values are reported in the following table:

External Oscillator Freq.	Programmed parameter:	Internal PLL Frq.	DDS Internal Clock
20 MHz	116 (PLL multiplier = 20)	400 MHz	400 MHz
40 MHz	84 (PLL multiplier = 10)	400 MHz	400 MHz
50 MHz	68 (PLL multiplier = 8)	400 MHz	400 MHz
80 MHz	44 (PLL multiplier = 5)	400 MHz	400 MHz
100 MHz	36 (PLL multiplier = 4)	400 MHz	400 MHz
100 MHz *	0 (PLL bypassed)	-	100 MHz
133 MHz *	0 (PLL bypassed)	-	133 MHz
400 MHz *	0 (PLL bypassed)	-	400 MHz
500 MHz *	0 (PLL bypassed)	-	500 MHz

* for these oscillator modes it is also necessary to program the "oscillator Mode set-up"

With other parameter codes (in the range 0 – 255) it is possible to program many others functions.
See the CFR1 DDS register (Bit 0-7) in the AD9951data-sheet for a complete register description.

Oscillator mode set-up
This set-up is necessary to select the reference clock used internally in the DDS.
This clock can be the internal PLL clock or the external oscillator if the PLL is bypassed (with 0 parameter in the CFR1 Register).
To adjust the internal DDS oscillator press the "Band" Key (red key) and switch "ON" the controller, then select the internal DDS clock frequency (100 – 500 MHz)

DDS Maximum frequency:

The AD9951, with an internal clock of 400 MHz, is able to generate about 40 % of clock frequency. This means that 40 % of 400 MHz is equal to 160 MHz. This is the maximum frequency that can be generated.
Once programmed, turn off the controller to store value.

In many applications it is more convenient to stop the maximum Frequency to a lower value. (I.e. in the Drake Line this limit is 30 MHz).
To adjust the maximum Frequency Limit press the "Split" Key and switch "ON" the controller.
The display will show: DDS F. MAX.
Press Key "+" or Key "–" to change the value from 10 to 160 MHz (10 MHz step)

DISPLAY MODE:
It is possible to have band selection menu if a Drake or Collins transceiver is used.
When the DDS is used for general use, this menu can be suppressed.
Switch "ON" the controller with KEY "RIT" pressed and select "Drake Mode" or "Collins Mode", "Homebrew Mode" or I/Q mode with Key "+" key "-".
Once programmed, turn off the controller to store value.
Note regarding Drake and Collins mode:
When controller is set with one of these two modes, the IF offset is always positive (Display frequency + IF)
Note regarding "Homebrew Mode":
In this mode, if the RF frequency is lower than 10 MHz the IF split is positive, otherwise it is negative (i.e.: RF signal is in the 7 MHz band and the IF is 5 MHz, the DDS frequency is 7+5 = 12 MHZ. RF signal is in the 14 MHz band and IF is 5 MHz, the DDS frequency is 14-5= 9 MHz). This mode is useful to switch automatically from LSB, in lower bands to USB on the higher bands. In the other display modes the IF shift is always positive.
Note regarding the I/Q mode:
When in this mode, the oscillator frequency displayed is a fourth of the output signal generated by the DDS.
This mode allows the generation, by the DDS, of two signal clocks with phase offset of 90° (displayed as ¼ of generated frequency). The oscillator frequency, at a quarter, to drive a mixer can be obtained with a divide by 4, external to the DDS board.
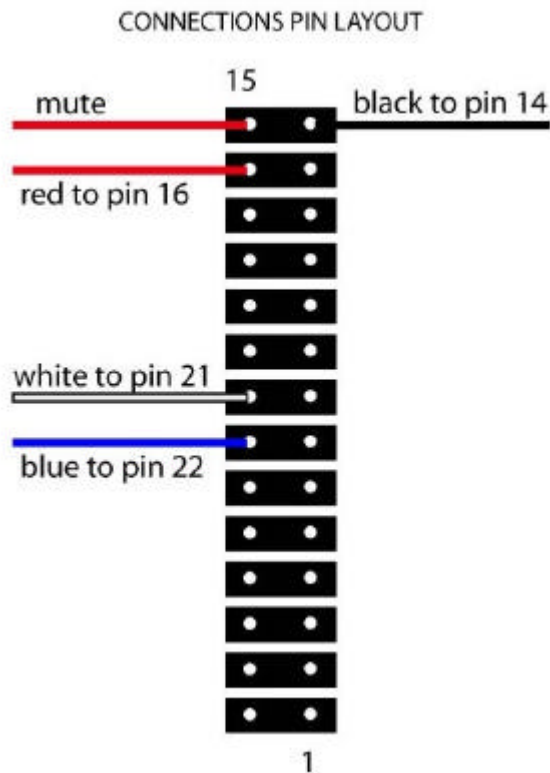This mode can be used on same direct conversion receivers.

DDS to PIC board connection.

Data connection:
Note that J7 connector is near the DDS PCB border

DDS board connector	Wire colour	PIC controller Connector	DDS Signal
J1-2	Blue	22	IO-Update
J1-3	White	21	Data
J7-3	Red	16	Sclk
J7-4	Black	14	Iosy

CONNECTIONS PIN LAYOUT

**See connection from DDS and PIC board on the PIC connector
(this connector is pin to pin with PIC18F252)**

To have the TX functionality it is necessary to put a GND to the PIC I/O pin 15 (PORT C4) **MUTE I/O**. You can use the PTT mike line of your transceiver for this control.

It is very important to use a not powered contact, any voltage present on this line can destroy the PIC controller.

If a voltage is present on the MUTE contact (in the Drake there is -50V) an opto-coupler is necessary to interface the PIC.

DDS power supply:
Connect a +5V DC power to the +5Vdc terminal; this is used to power the DDS with +3.3V e +1.8 V using two internal psu regulators.
Connect +12V Dc to the 12 V terminals; this is used to supply the output power amplifier.

Very important notes:
1) Wiring from DDS to PIC board must have a maximum length of 20 cm.
2) Use a good GND connection from DDS to PIC board.
3) Use a +5V common power supply for both DDS and PIC, generated from the same psu regulator (I.e. the PIC board regulator). This is necessary to have the power-up at the same time for both, to avoid incorrect initialization.

PIC CONTROLLER schematic
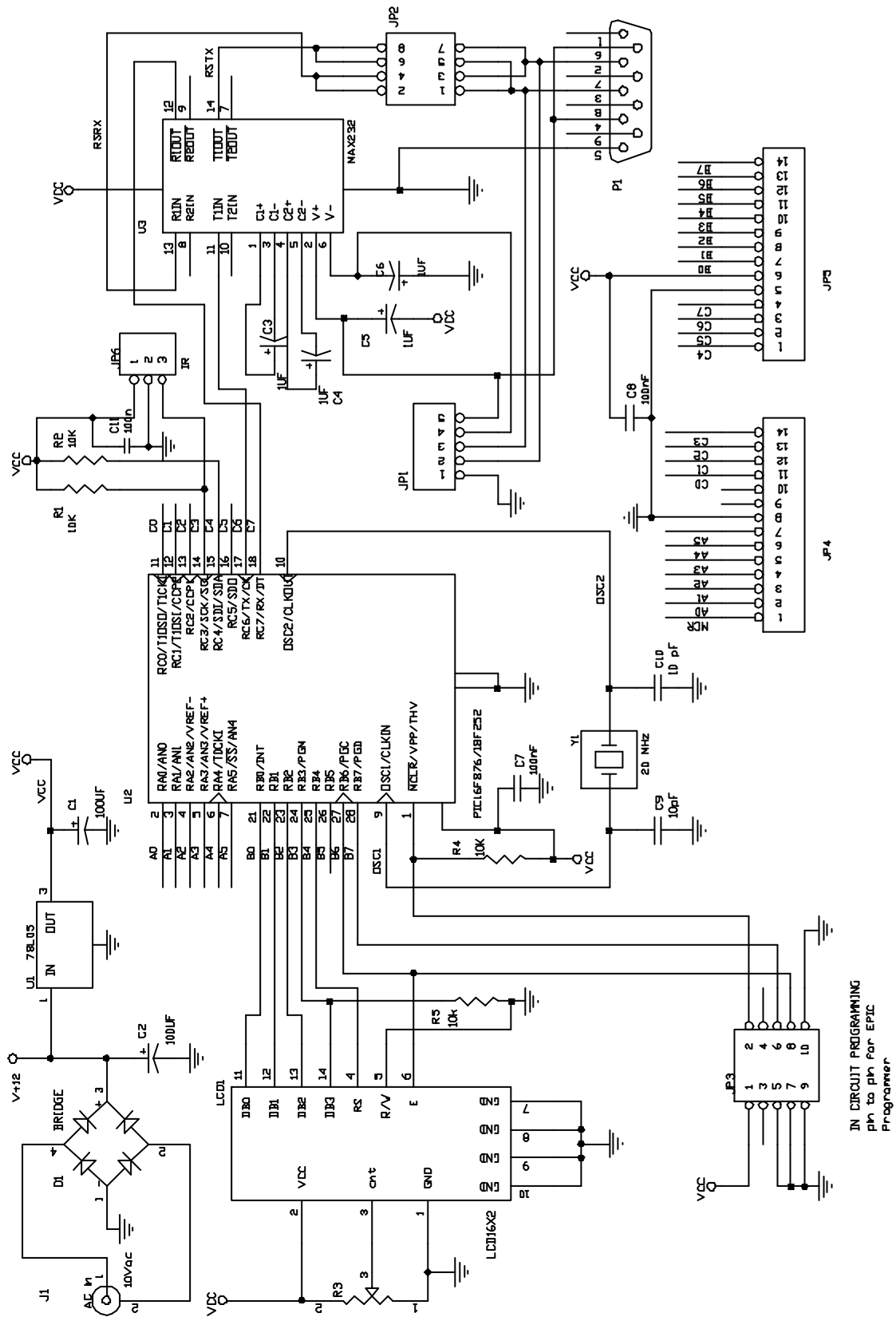
KEYBOARD AND ENCODER schematic
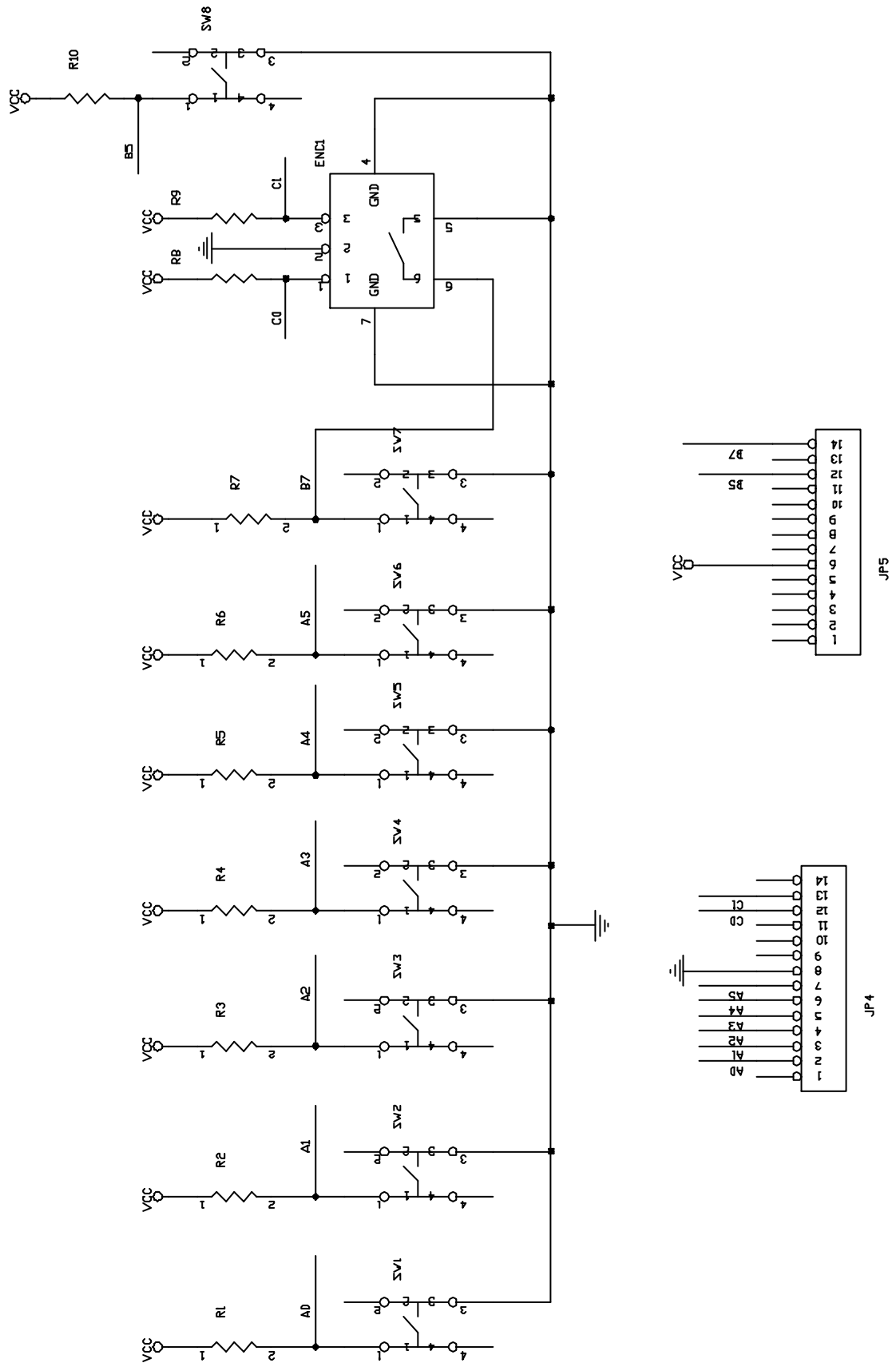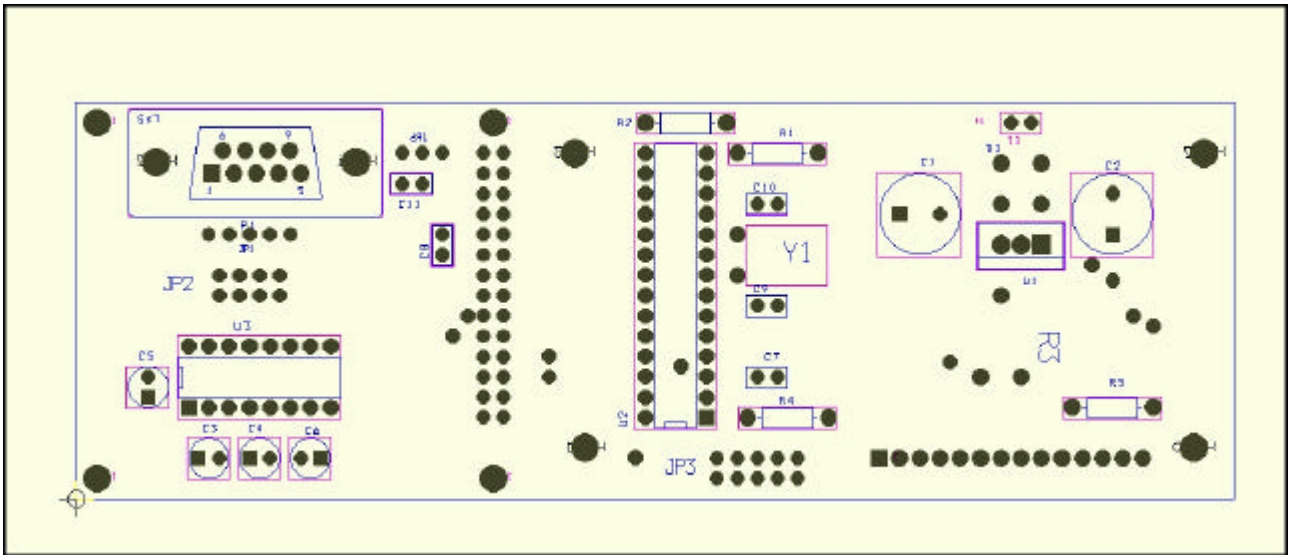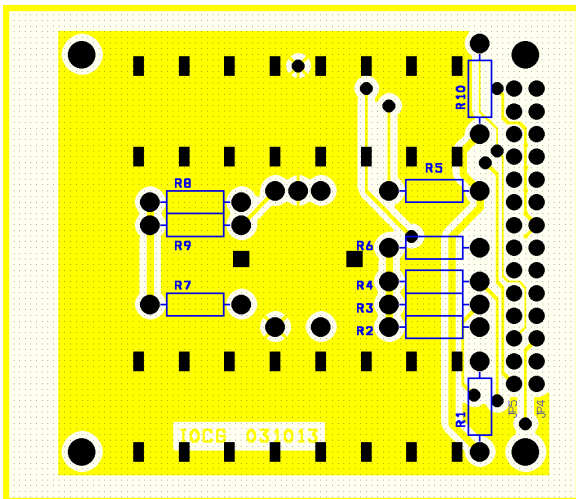
Layout – Top View
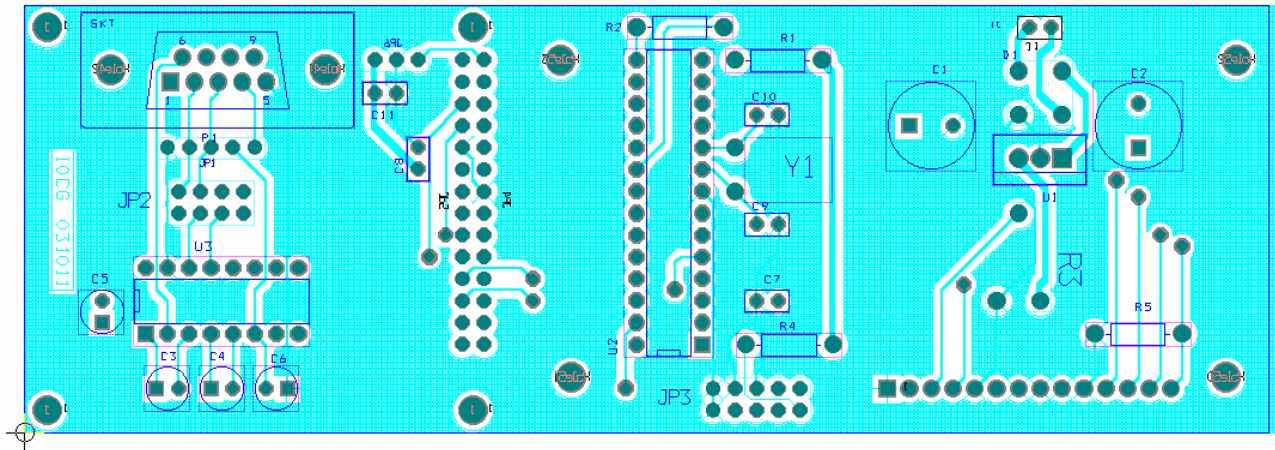
PCB – Top View
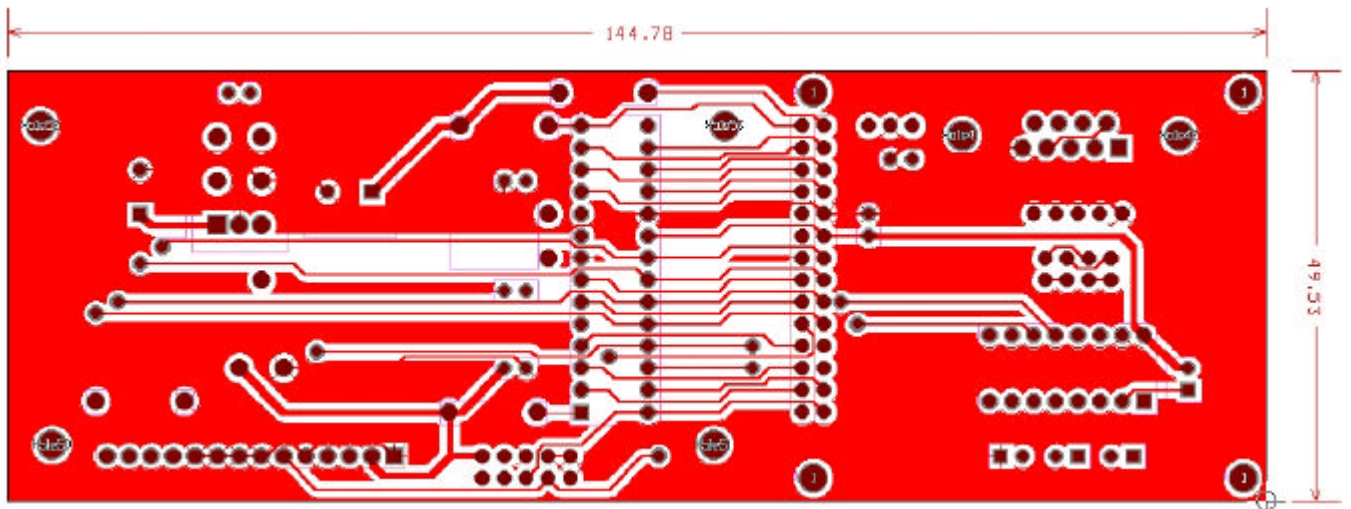
PCB – Bottom View
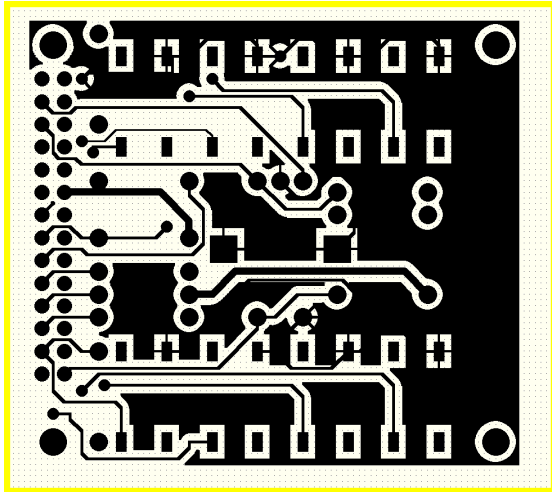
Top Layer (SMD bottom side)
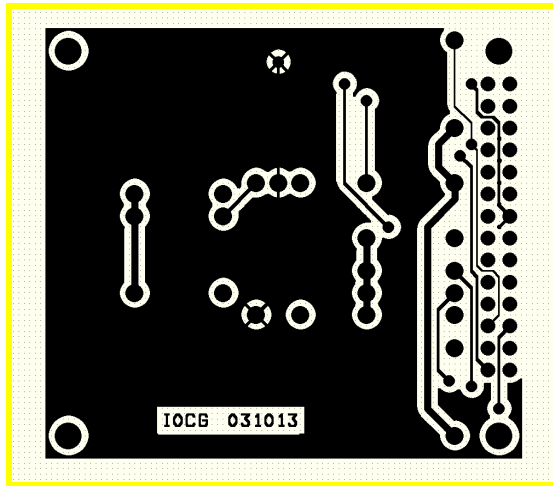
Bottom layer (resistor side)


PCB Layout

Notes regarding DDS components:

1) On the schematic C23 has a wrong value: exact value is 1 uF
2) with ERA1 amplifier L6 can be omitted
3) C15 and C16, decoupling capacitors, can be of a lower value (in the schematic are 20 uF) if DDS is not used for Audio Frequency applications:
   - with 10 uF DDS minimum Freq. start at 300 Hz (@ -3 dB)
   - with 1 uF minimum Freq. start at 3 KHz
   - with 0.1 uF minimum Freq. start at 30 KHz

   These frequencies values are intended without the push-pull transformer installed.

Same notes regarding the DDS board:

1) The transformer can be omitted, but the output level is lower
2) The Minicircuit transformer TX5-R5 (SMD) can be used (output level + 7 dBm)
3) If an external oscillator is used, it is necessary to install R8 and not R9
4) If a Quartz xtal is used, it is necessary to install R9 and not R8.
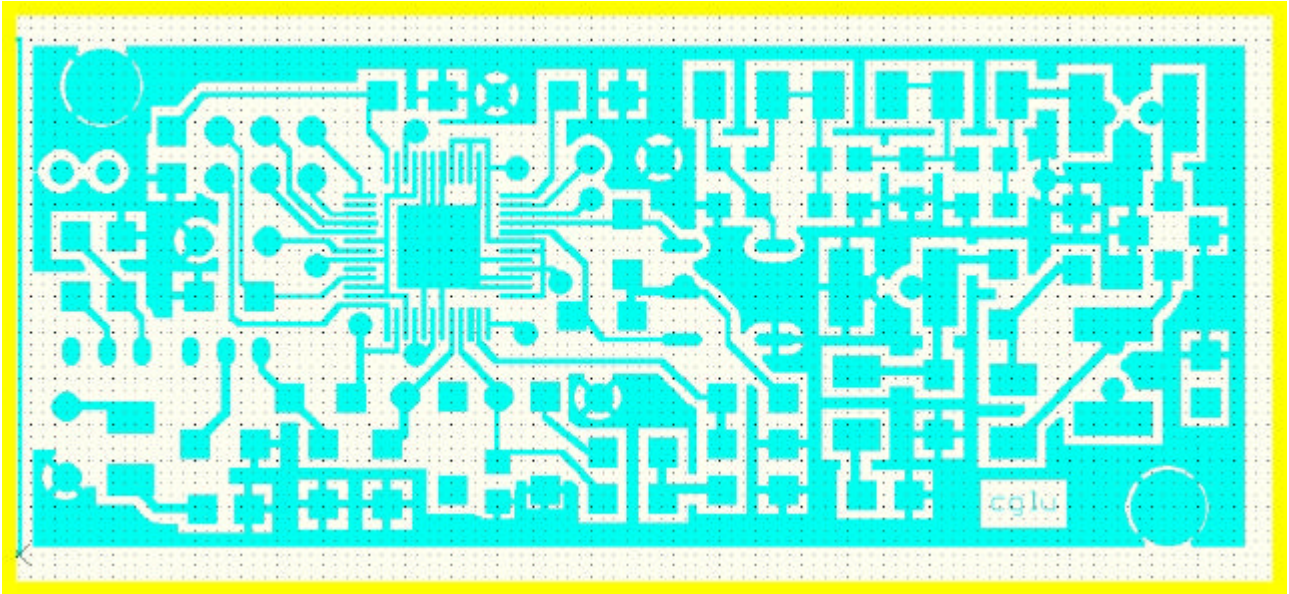
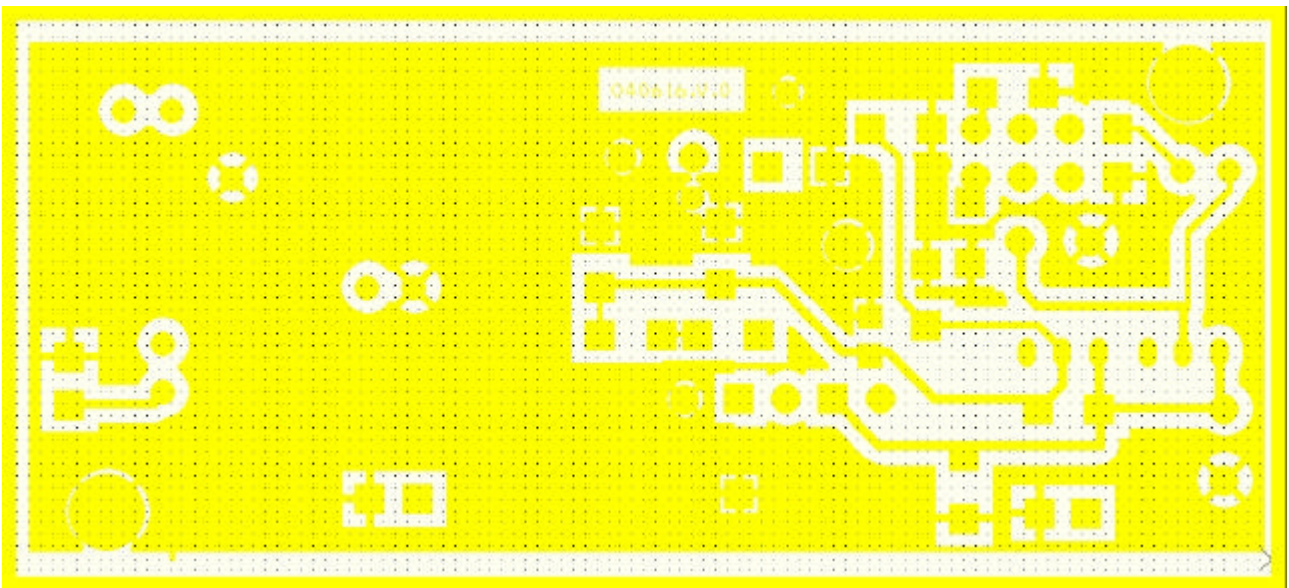# DDS AD9951 (ED2) schematic
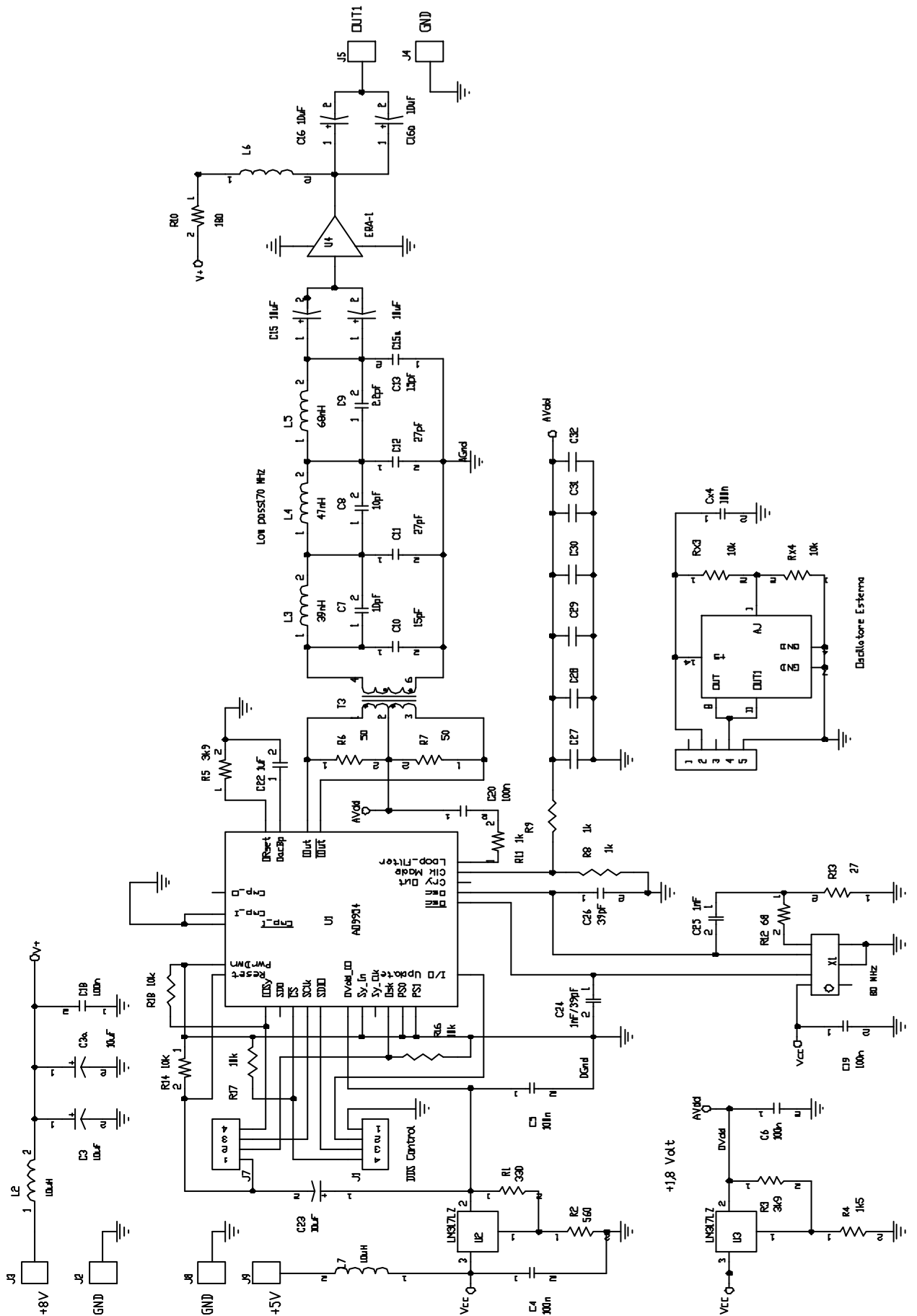
DDS Layout
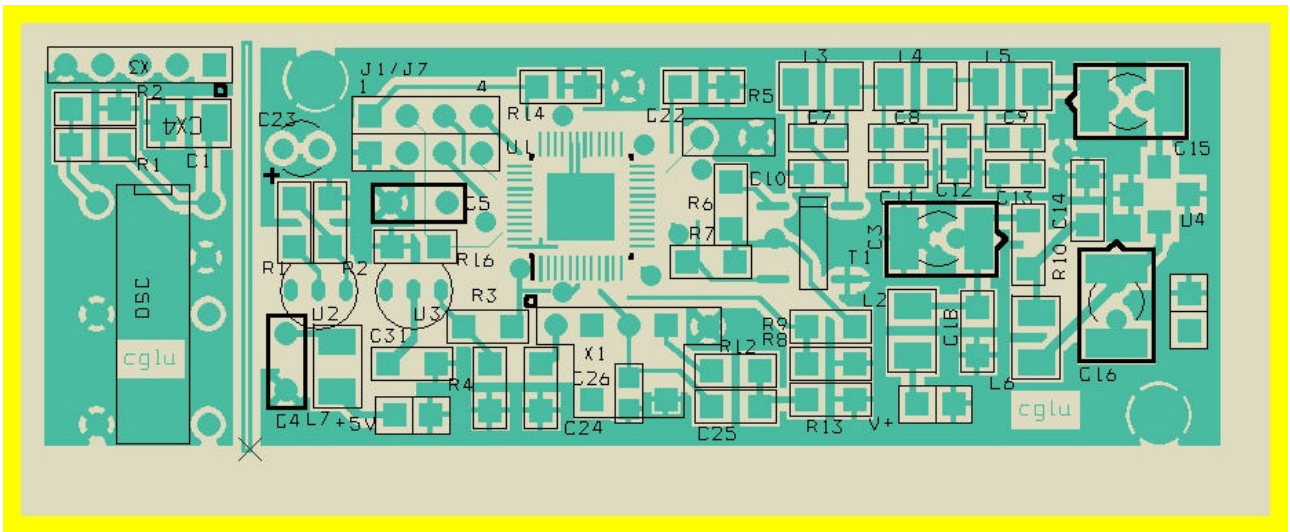
Layout – Top View
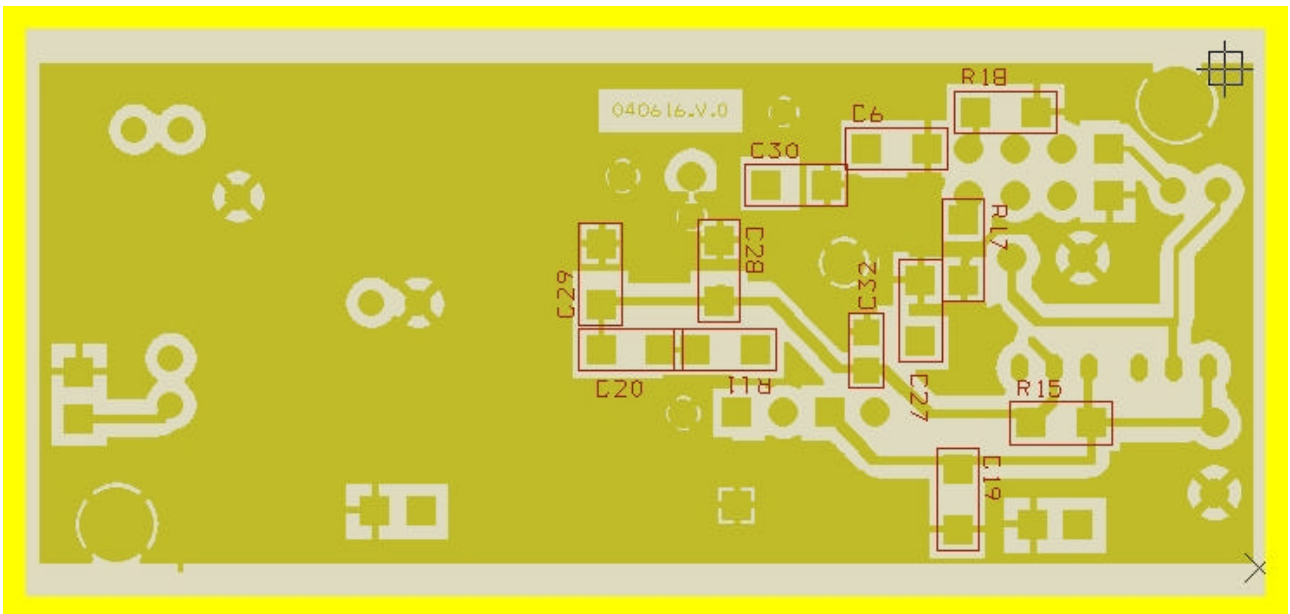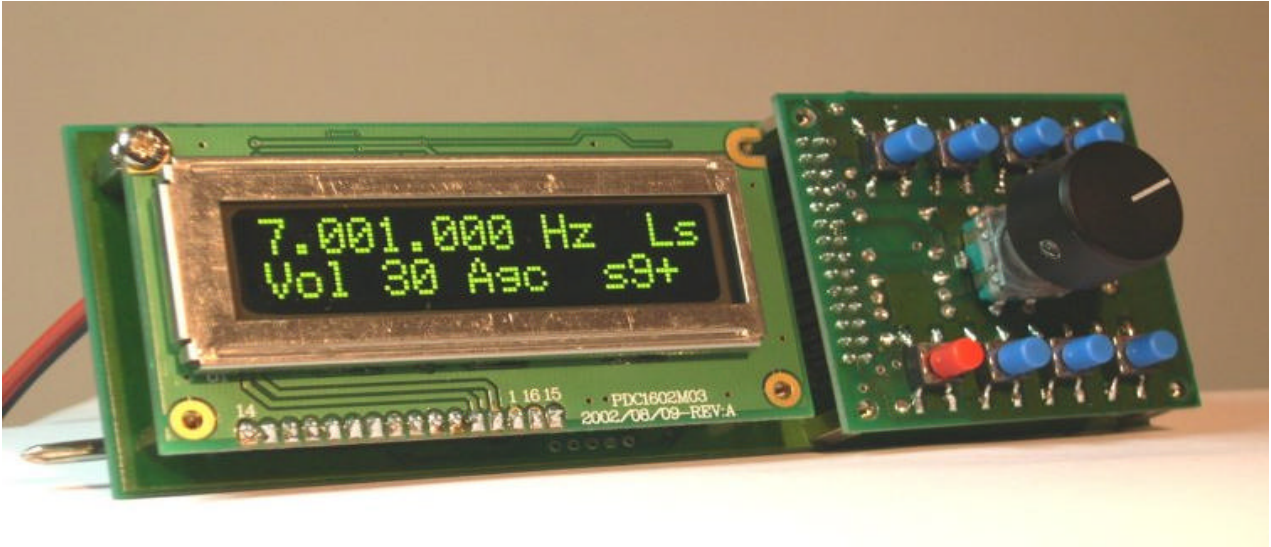

Layout – Bottom View
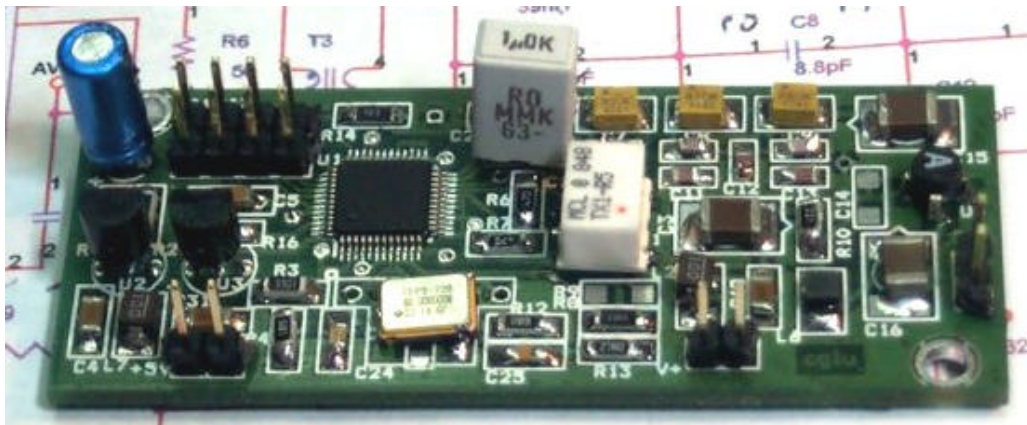
Top layer

Bottom Layer

THE PIC CONTROL PANEL ASSEMBLED

(the picture does not display the DDS-4 application software)

PIC controller

**DDS board (ED2)**

DIGITAL VFO CONTROL USING RS-232 INTERFACE

Some of the DDS VFO Functions can be controlled by a PC running software like Ham Radio Deluxe, by Simon Brown, HB9DRV. http://hb9drv.ham-radio.ch/ (free software).

The VFO uses a serial protocol like the K2 transceiver by Elecraft; Ham Radio Deluxe must have appropriate configuration:
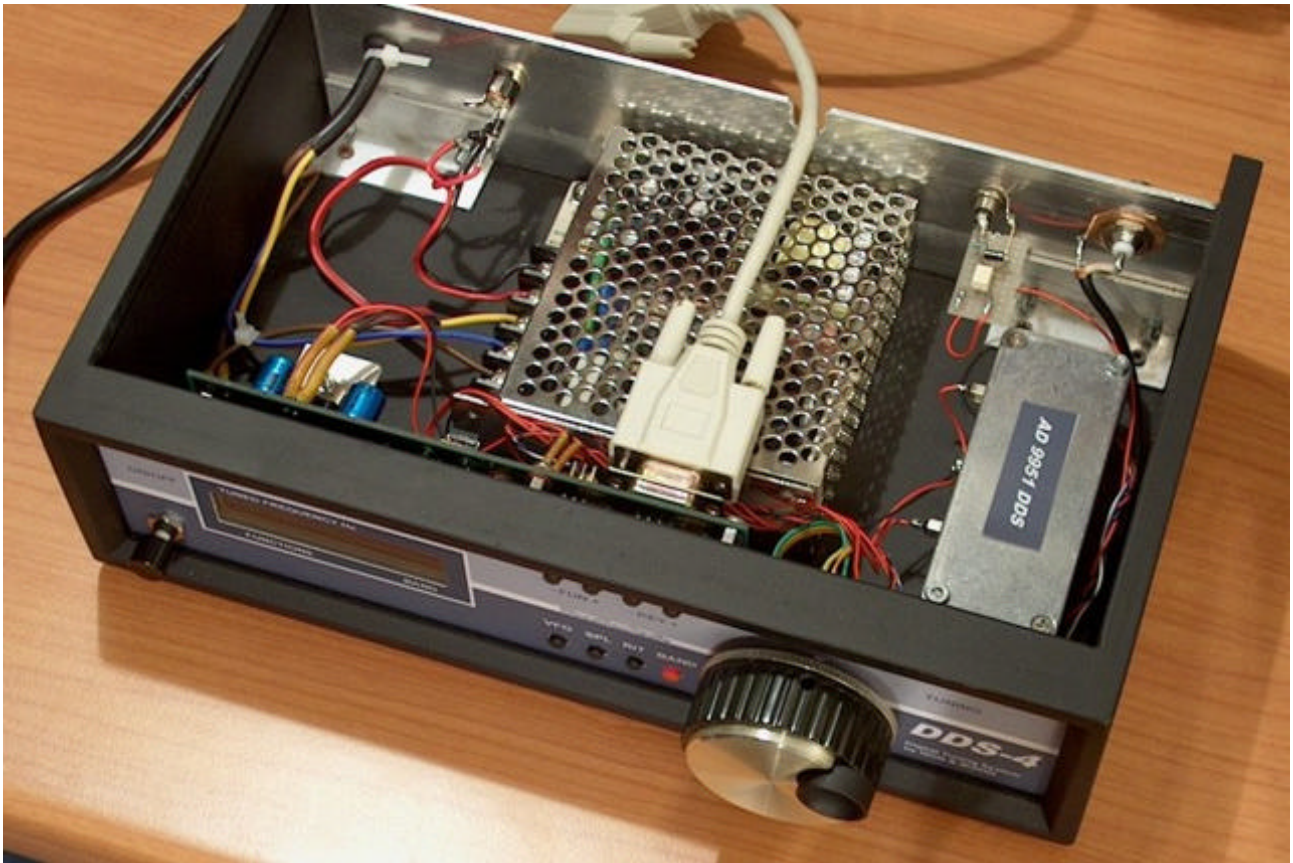
Radio: K2
Baud rate: 4800

and file **dds4_1.txt,** included in CD, added in the following directory:

C:\WINDOWS\Application Data\Simon Brown, HB9DRV\Ham Radio Deluxe
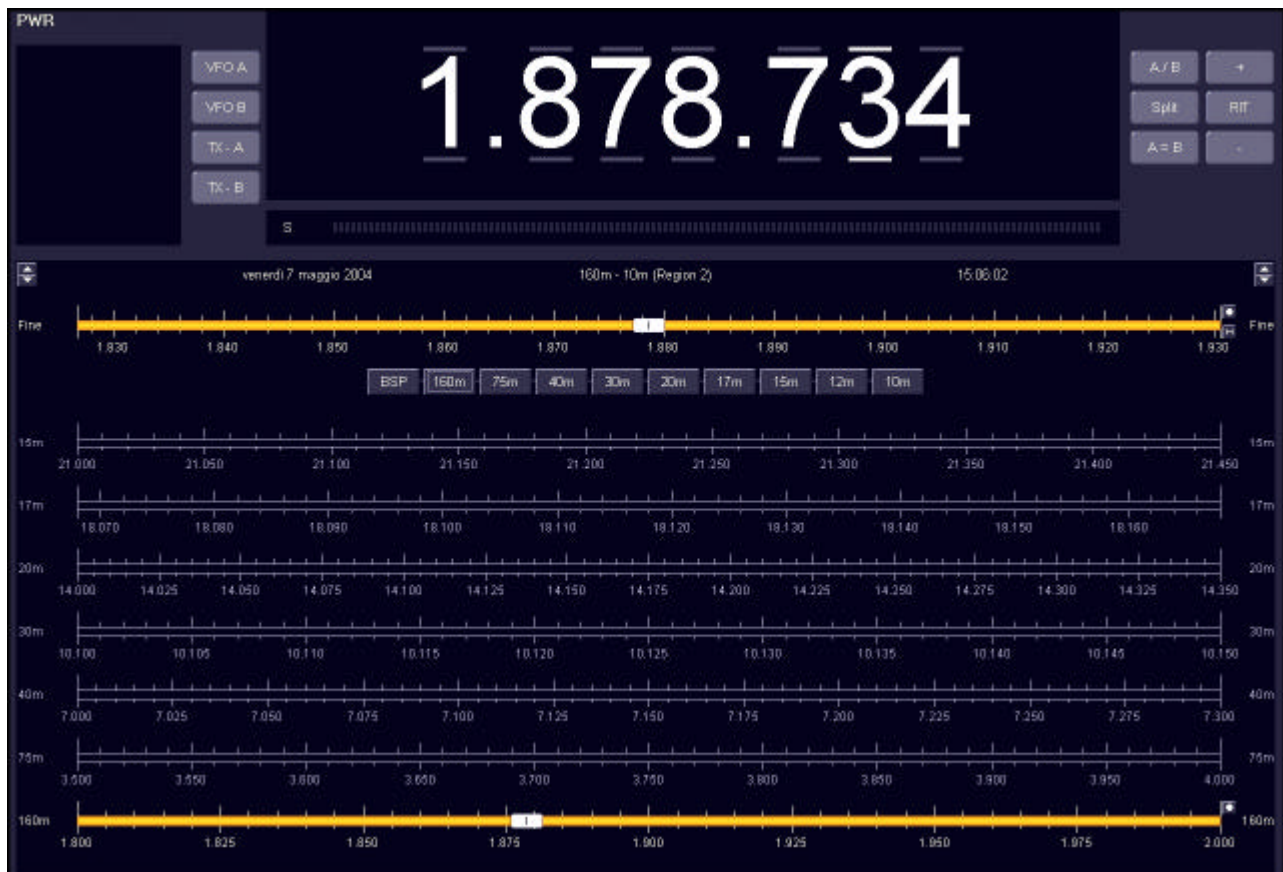
Ham Radio Deluxe PC Screen Display

The Digital VFO assembled for DRAKE line transceivers.

Slide back the top cover of DDS-4 to connect the serial cable and pass this through the rear panel.

Close the top cover and connect the serial cable to one free COM PORT on the controlling PC. DDS-4 is now ready for PC remote control.
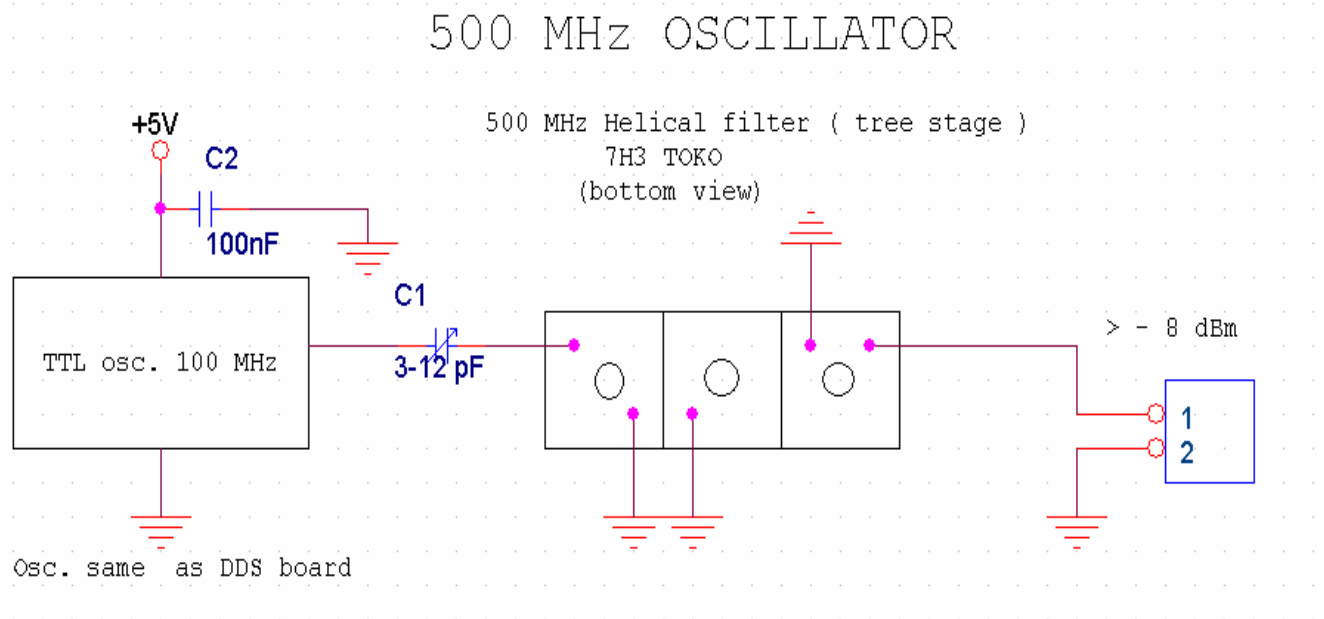
500 MHz oscillator

This very simple oscillator can be assembled using only tree components:
1) C1: 3 – 12 pF trimmer
2) Helical: three stages helical filter 500 MHz, TOKO 7H3 series or MXPR-1110D available
   from: http://www.rfmicrowave.it/
3) Monolithic 100 MHz oscillator.

If this oscillator is used, the internal PLL, inside DDS, can be removed.
With this oscillator a more clean DDS output is available (less spurs and better phase noise)

Adjust C1 and tune 500 MHz helical filter for maximum output.
Level must be > of -8 dBm.
The oscillator and helical filter must be placed on a copper PCB.
Install all components inside a small metal box.

The 500 MHz signal output must be connected to DDS PIN 9 (first remove or disable the internal DDS Oscillator).

# CONNECT DDS-4 TO DRAKE "4" EQUIPMENTS

Connection of DDS-4 to R4 receiver:

Connect the output of DDS-4 to INJ input on the rear panel of your receiver and put the R4 XTAL switch in empty position. Turn ON DDS-4, now your R4 is controlled by DDS-4 and the original PTO is disabled. For return to normal use of R4 turn OFF the DDS-4 and return the XTALS switch in normal position.

Connection of DDS-4 to R4/T4 receiver/transmitter:

Connect the output of DDS-4 to INJ input on rear panel of your R4 and share this connection with a Y adaptor to the INJ input of T4. Connect the CONTROL input of DDS-4 to the MUTE line of R4/T4 with a Y adaptor. Put the XTALS switch in empty crystal position, turn ON DDS-4, now your R4/T4 is controlled by DDS-4 and the original PTO is disabled. The T4 TRANSCEIVE switch must be in RCVR position. For return to normal use of R4/T4 turn OFF the DDS-4 and return the XTALS switch in normal position.
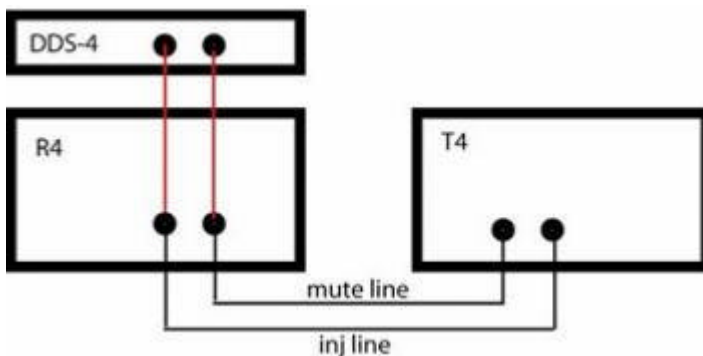
CONNECT DDS-7 TO DRAKE TR7 TRANSCEIVER

DDS-7 substitute all the original tuning system of TR7, generating a frequency range required by first MIXER in UP-CONVERTER module. The signal generated from 48.050 to 78.050 Khz. is applied to this module and the original signal generated by VCO/PTO units is disable. At this point the tuning is performed by DDS-7, the VCO/PTO are active but disconnected, the original RIT function is disable and performed by DDS-7 only.

In TX mode, a voltage of +10 V is present in the PCB of TR7 and we can use it for "tell" to DDS-7 when swicth the TX functions like SPLIT or TX TIME and to generate the correct TX frequency when RIT is active. The +10 V (called 10T in TR7 PCB) is routed to a optoisolator interface wich provide to ground the specified I/O in PIC microcontroller.
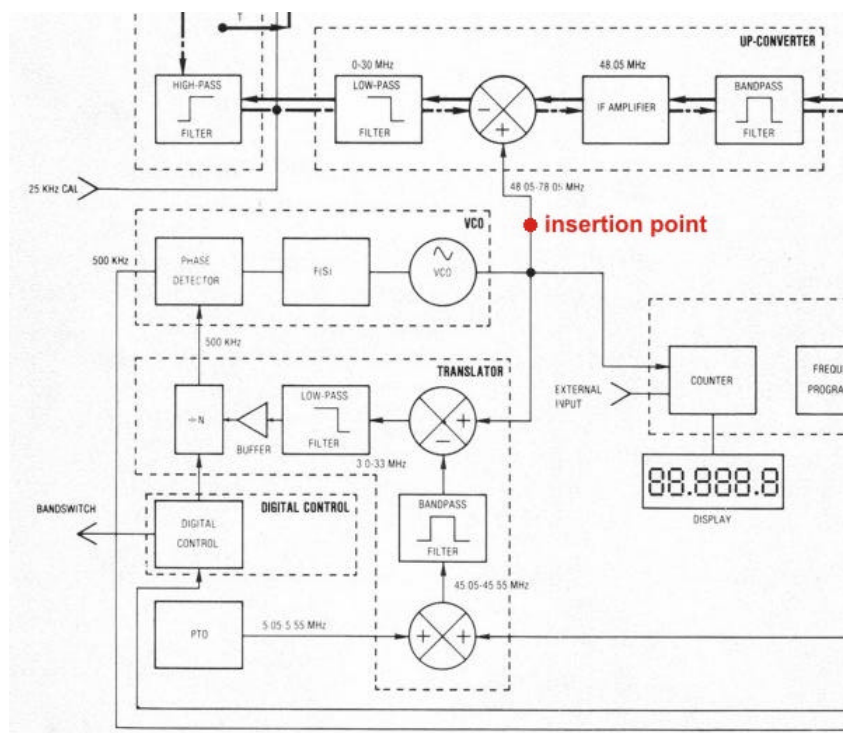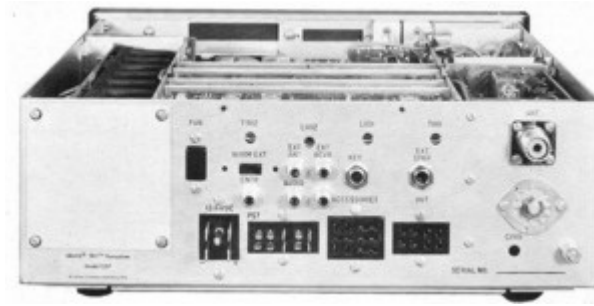
Use the supplied connection/switch box used to interface TR7 with DDS-7.
It is fitted in TR7 rear panel using one or two original screws and the ground contact.

There are 3 RCA female and 1 two position switch:

 * DDS-7 IN: the signal coming from DDS-7
 * 13.8 V: the power source for DDS-7
 * TX-CNT: the +10 V routed to optoisolator int.
 * SWITCH: used to change from internal tuning system or the external DDS-7

Using the little ole marked C1901 we can get out the four cable used for connections, they are:

 * VCO OUT: black coax cable
 * DDS IN: black coax cable
 * 13.8 V: red wire
 * 10 V: green wire
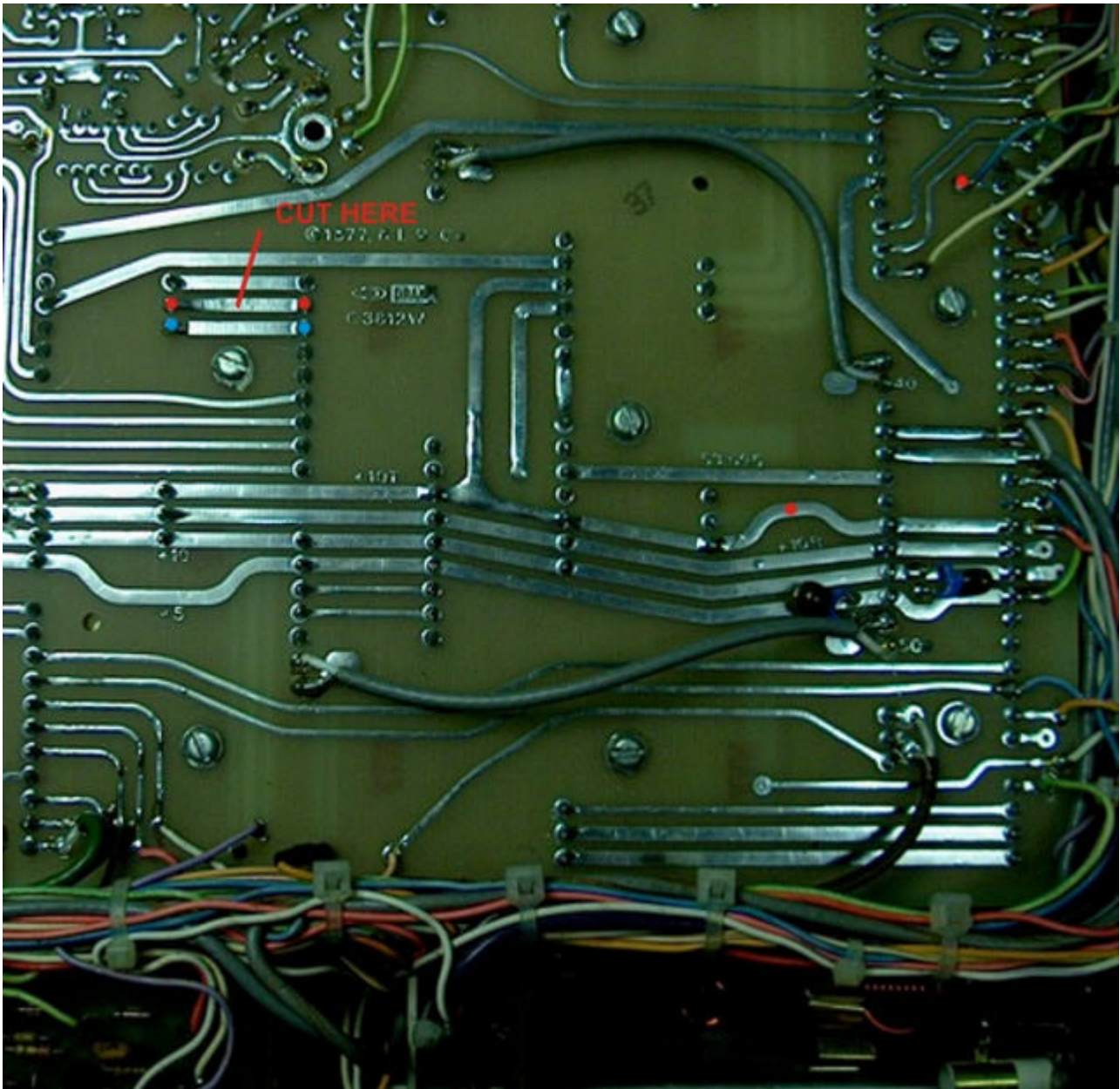
This is the bottom of the main PCB BUS of TR7, acces it removing the bottom enclosure's panel after the main slide top cover.

In the picture you can see some RED and BLUE dots, they are the solder point for the cables coming from the connection box, through the C1901 hole. Is necessary to cut the trace indicated in the picture in order to break the signal coming from VCO module to UP-CONVERTER module.

This operation is easy to do with a common CUTTER.
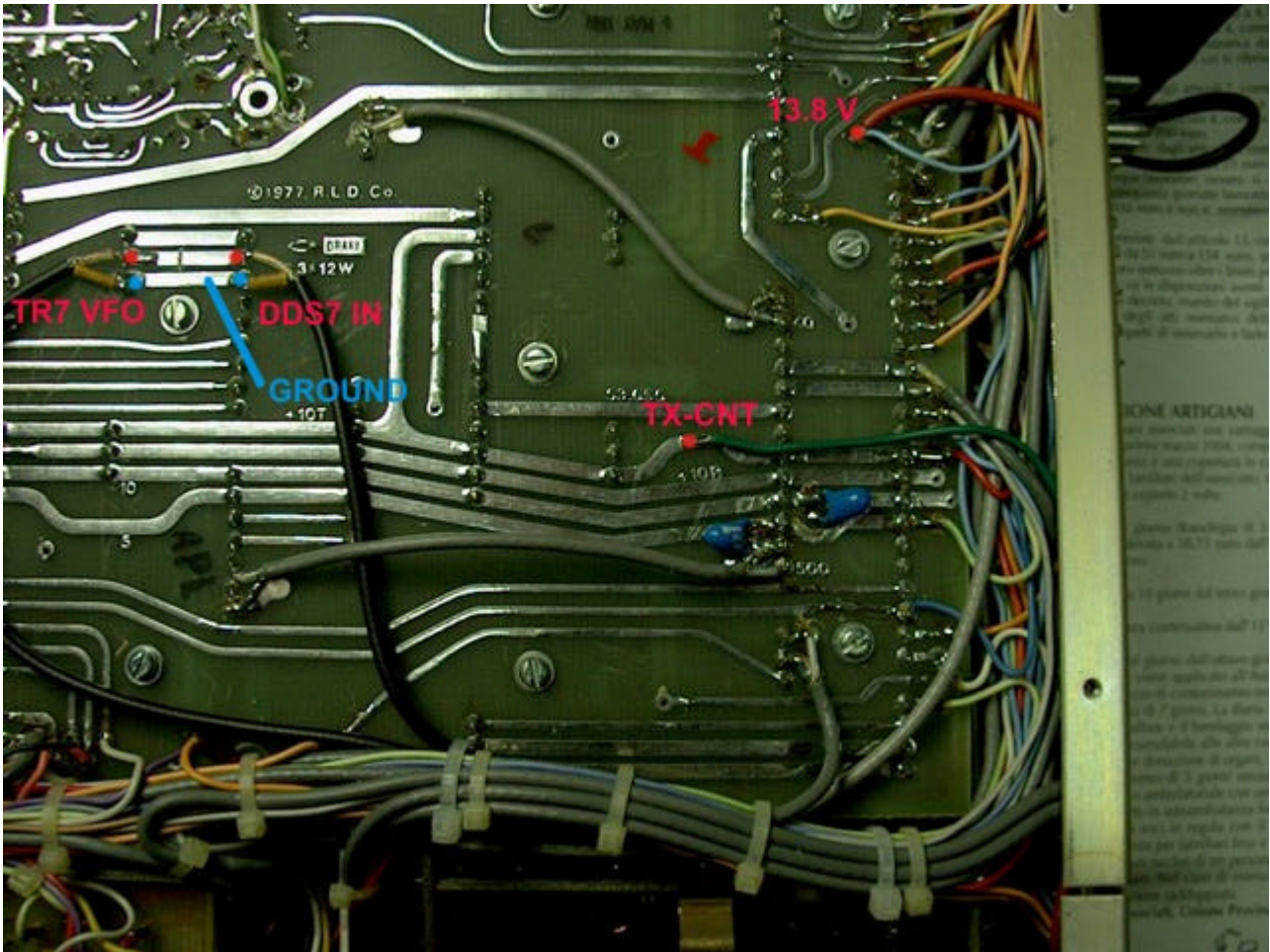
Solder the two coax cable coming from connections box to the indicated positions by the RED and BLUE dot:

    * in the RED dot the center pole of coaxial cable
    * in the BLUE dot the shield

Solder the RED and GREEN wires in the indicated position by the red dot.

After a general control of all operations you can reassemble the TR7 enclosure and connect the cables supplied with DDS-7:

    * the signal coaxial cable to DDS-7 IN RCA female
    * the power supply cable to 13.8 V RCA female
    * the control cable to TX-CNT RCA female

Turn ON the TR7 and after the DDS-7, put the switch in DDS-7 position, and tune.