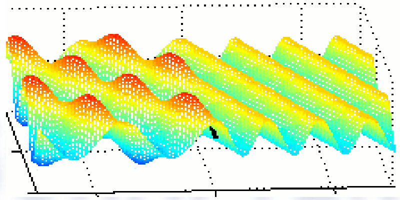
Welcome to Thesis presentation by **Sherwood A. Amankwah**



- General Overview of Topic

The focus of this thesis is;

“‘Local Oscillator for Zero – IF Direct Conversion Receiver“.

**IF = Intermdediate Frequency*

- Goal and motivation

  The project is to build and test an LC-Oscillator for 7MHz-band and to compare its RF properties with properties of an inexpensive Digital Direct Synthesizer (DDS20) available in the laboratory manufactured by Conrad Electronic GmbH.

L = Inductor C = Capacitor

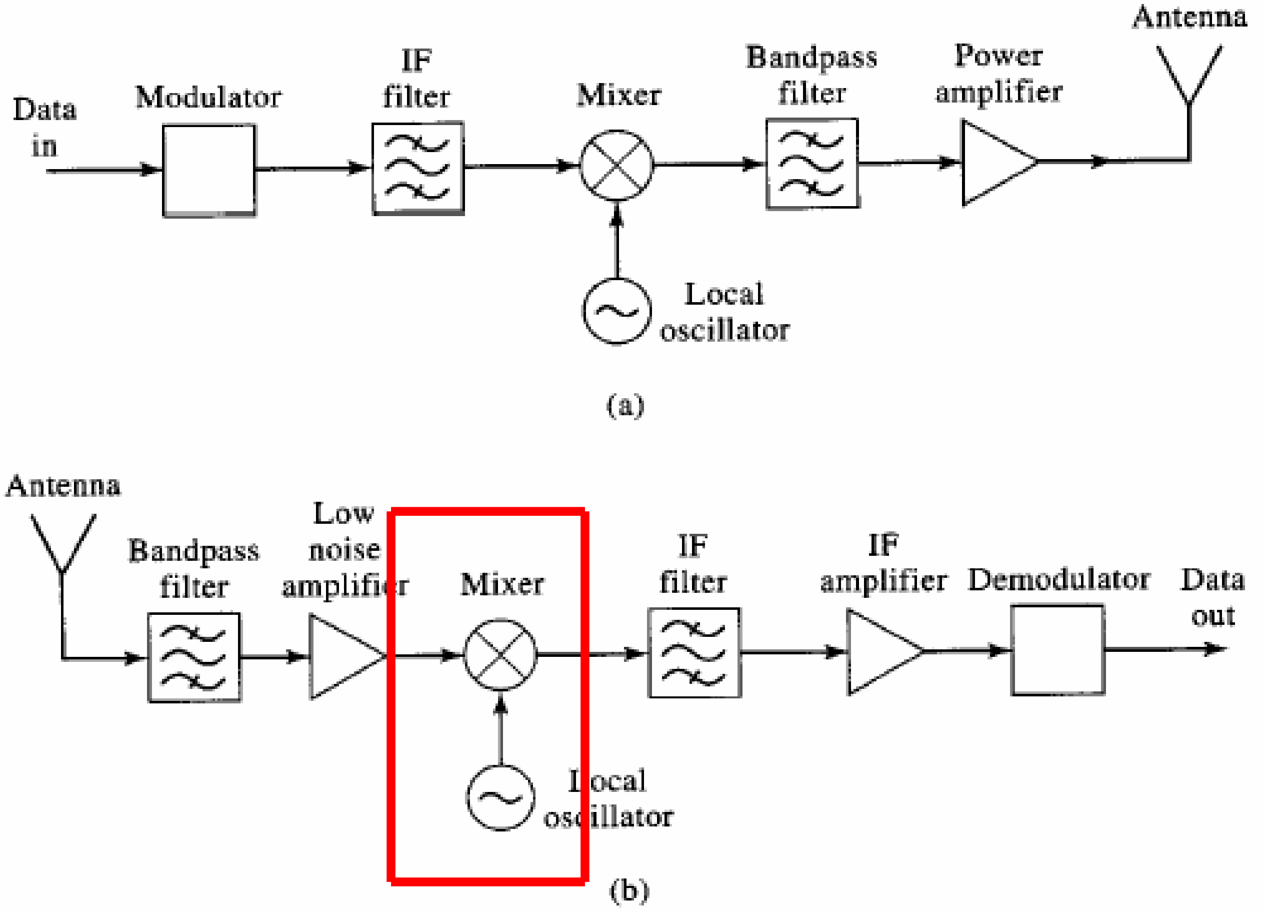
RF properties to be investigated for comparism include;

- Tuning characteristics of frequency vs. Varactor voltage
- Frequency stability due to drift over time and temperature, supply voltage pulling, noise and harmonic spectral analysis
- Other critical features

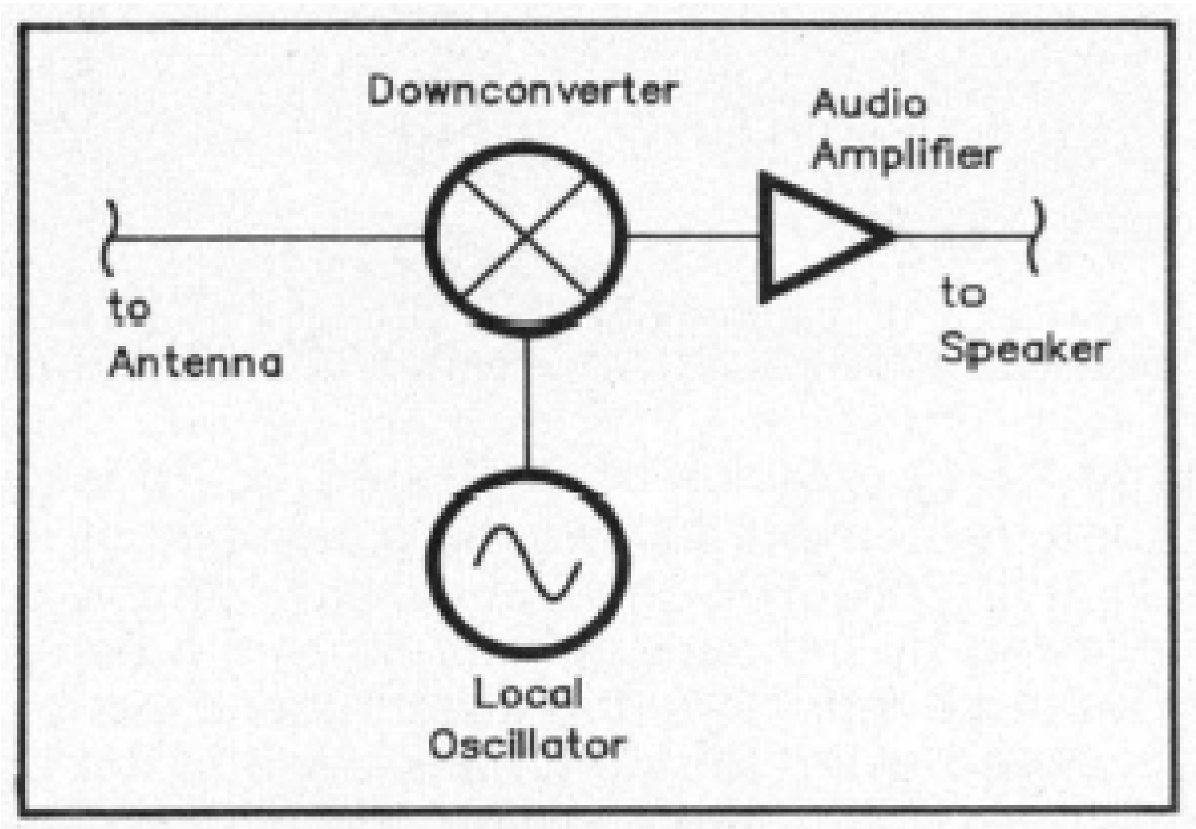
Structure

- Explanation of the task
- A little history about this project
- Theory
- Experimental Setup
- Measurements and Analysis
- Conclusion from analysis

- Task explanation: Full communication system



Direct conversion receiver



Mixer/Downconverter

Local Oscillator signal and the received radio signal frequencies are ‘‘multiplied“ in the mixer resulting in a product of sum and difference called intermediate frequency before an intermediate bandpass filter application. *In other words, it is a frequency converter.*

- Direct conversion is achieved when the IF is converted to a dc or 0Hz.

- Zero-IF Direct conversion receivers suffer defects such as distortions, noise, loss of signal integrity and originality due to I and Q mismatches, large frequency offset due to self-mixing of local oscillator from leakage and aging.

Carrier signal is modulated into amplitude and phase called „inphase“ and „quadrature“ carrier components respectively.

$I(t) = A\cos(2\pi(f_i - f_{res})t)$ INPHASE component

$Q(t) = A\sin(2\pi\,(f_i - f_{res})t)$ QUADRATURE component

- Example of mixer multiplication:

- $2\text{Cos}(\omega_1 t) * \text{Cos}(\omega_2 t) =$

  $\text{Cos}(\omega_1 t + \omega_2 t) + \text{Cos}(\omega_1 t - \omega_2 t)$

Oscillator

An oscillator is a circuit that is able to generate signals periodically, out of constants, comprising only one timing reference.

The signals can be rectangular, zig-zag or sinusoidal and are fed into the downconverter or Mixer

- Zero - Intermediate Frequency

The name Zero-IF is due to fact that the Intermediate frequency of the signal from the mixer is a direct current or at 0Hz

- Preview of previous works

  Rick Campbell, KK7B, article QST 1992 descirbe conventional LC-Oscillator with varactor tuning and special components to reduce initial frequency drift and also suggested a Digital Direct Synthesis as a solution.

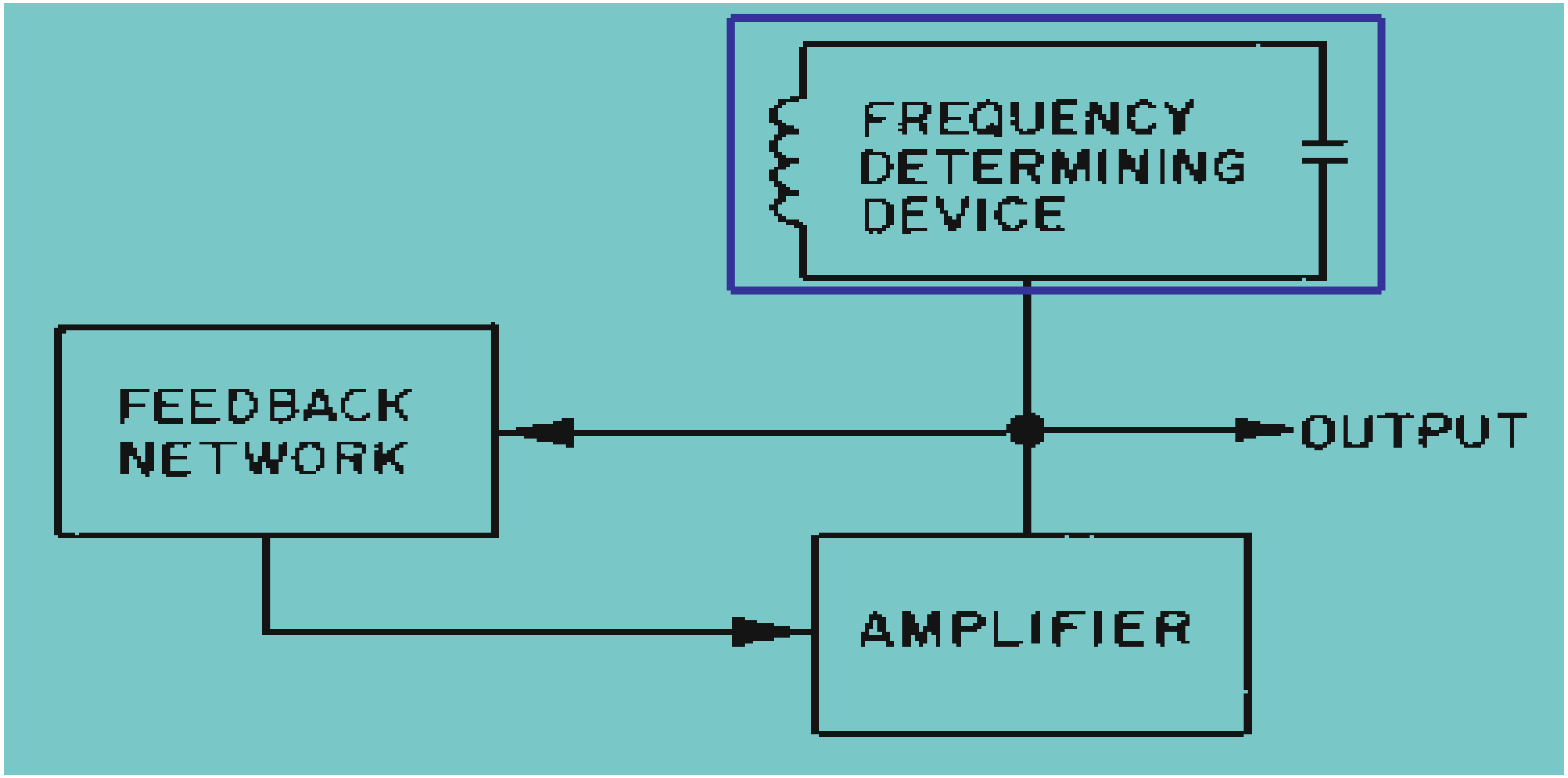
- Heinz Sarasch, DJ7RC, worked on Rick Campbell‘s article, and again using John Gurr‘s circuit, appreciable results were attained. He found appreciable stability in amplitude and the frequency drifted only some hundredth Herz.

Theory behind LC-Oscillators

- Consists of L and C components connected to form a circuit.

- Employs a feedback and amplifier in its operations

- LC-Oscillator circuit block



- L and C connected in parallel.
- With a current source, capacitor plates are charged, one positive and other negative creates an electric field around it.
- Discharges when fully charged, sending electrons to inductor, thereby creating magnetic field around the inductor which increases proportionally to discharge.
- When fully discharged, negative current flows to capacitor plates due to magnetic field around inductor.

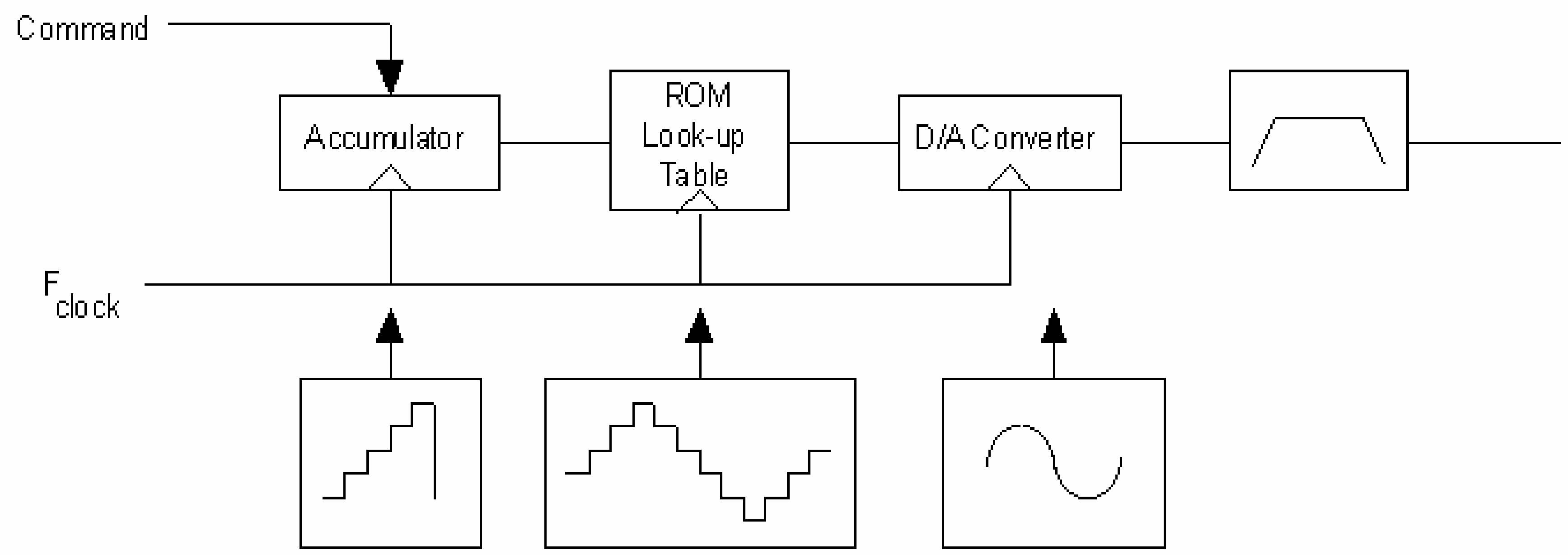
- Inductor loses ist magnetism whereas electric field starts to reform again at the capacitor plates.
- Alternation/Oscillation of electrical energy between L and C continues, producing sinusoidal waves at its output.
- Voltage is lost at every cycle
- To sustain the oscillation from dying due lost in voltage, a feedback network, connected to an amplifier, is in place. Part of energy is fed into feedback.

Theory of DDS

- Generate signals using digital techniques by D/A conversion at ist ends.
- Operates by storing points of waveform in digital format and recall these points to form a sinusoidal or rectangular wave.
- Rate of calling points to complete one wave determines the frequency

Operational block diagram of DDS

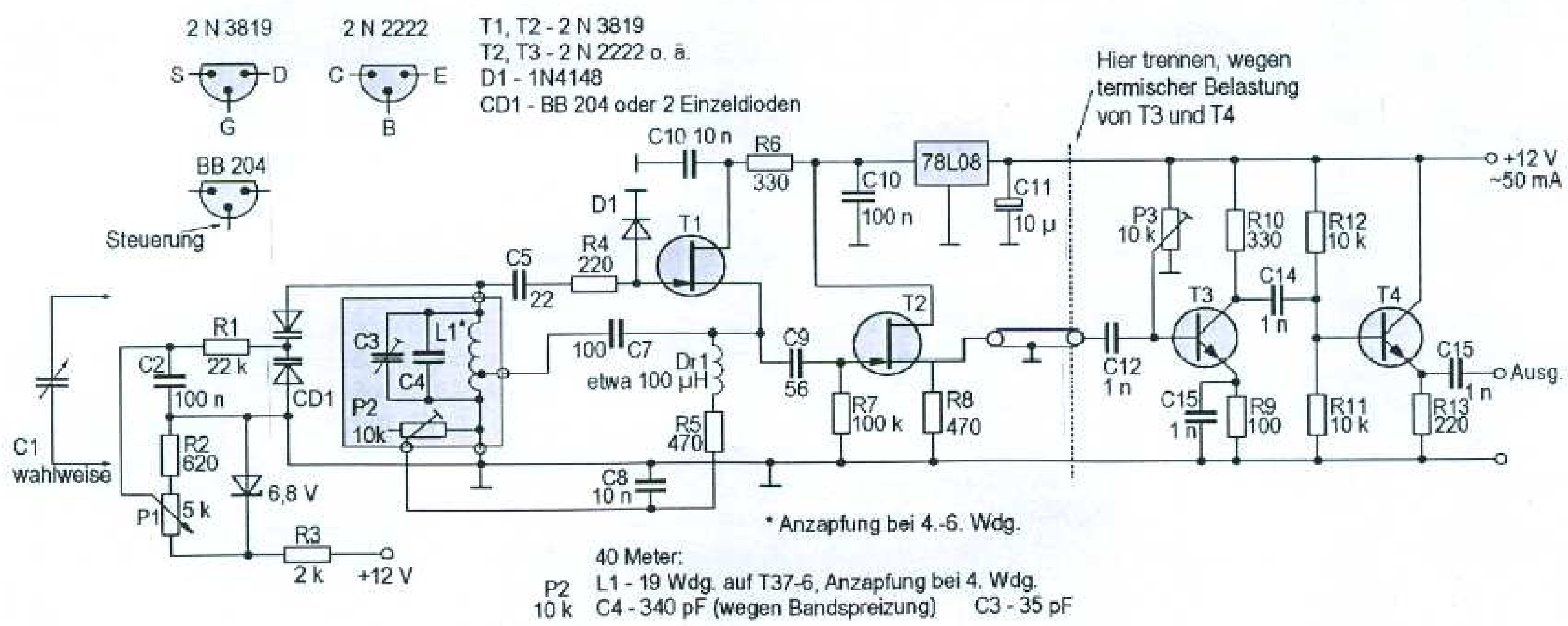
Consists of Phase accumulator, phase-sine-converter (or ROM Look-up table) and Digital/Analog converter.



- Command issues a digital number representing the phase and is held in the **phase accumulator**. Clocking adds up phases at regular intervals. It maintains output sinewave phases from 0 to 2**π.**
- **ROM-Look up table** is a form of a memory that stores a number corresponding to the voltage required for each phase on the sinewave. It periodically reads memory bits as addreses used to generate sinewaves
- D/A converter converts generated sinewave into discrete digital numbers.
- It is lowpassed to filter out disturbances from the D/A converter

Experimental Setup

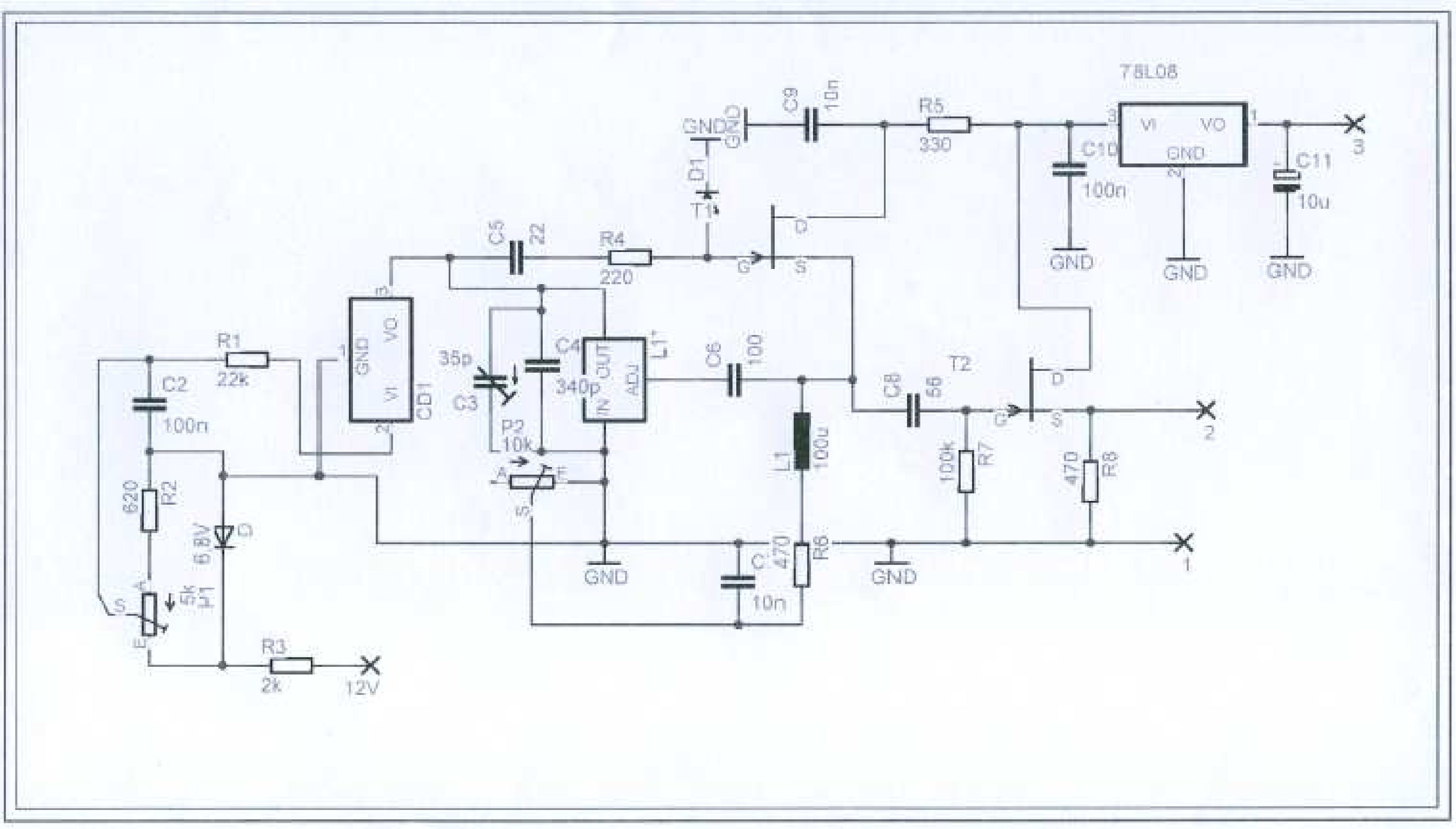
LC-Oscillator circuit was John Gurr‘s VFO circuit found in Heinz Sarasch‘s, DJ7RC, publication shown below:



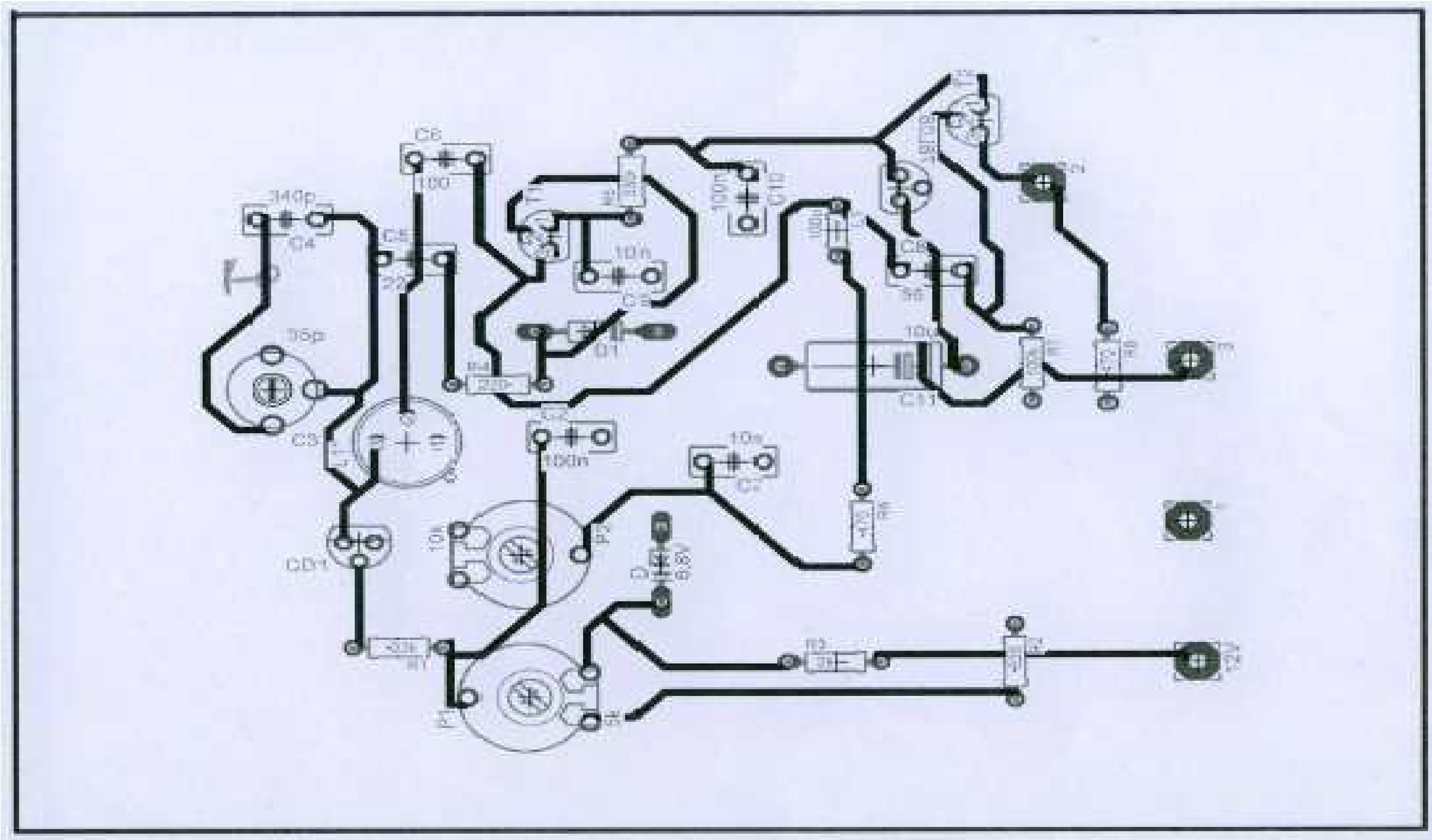
Schematic drawing

- Circuit was divided into two, the VFO and amplifier circuits.
- Easily Applicable Graphical Layout Editor (EAGLE) software was used.

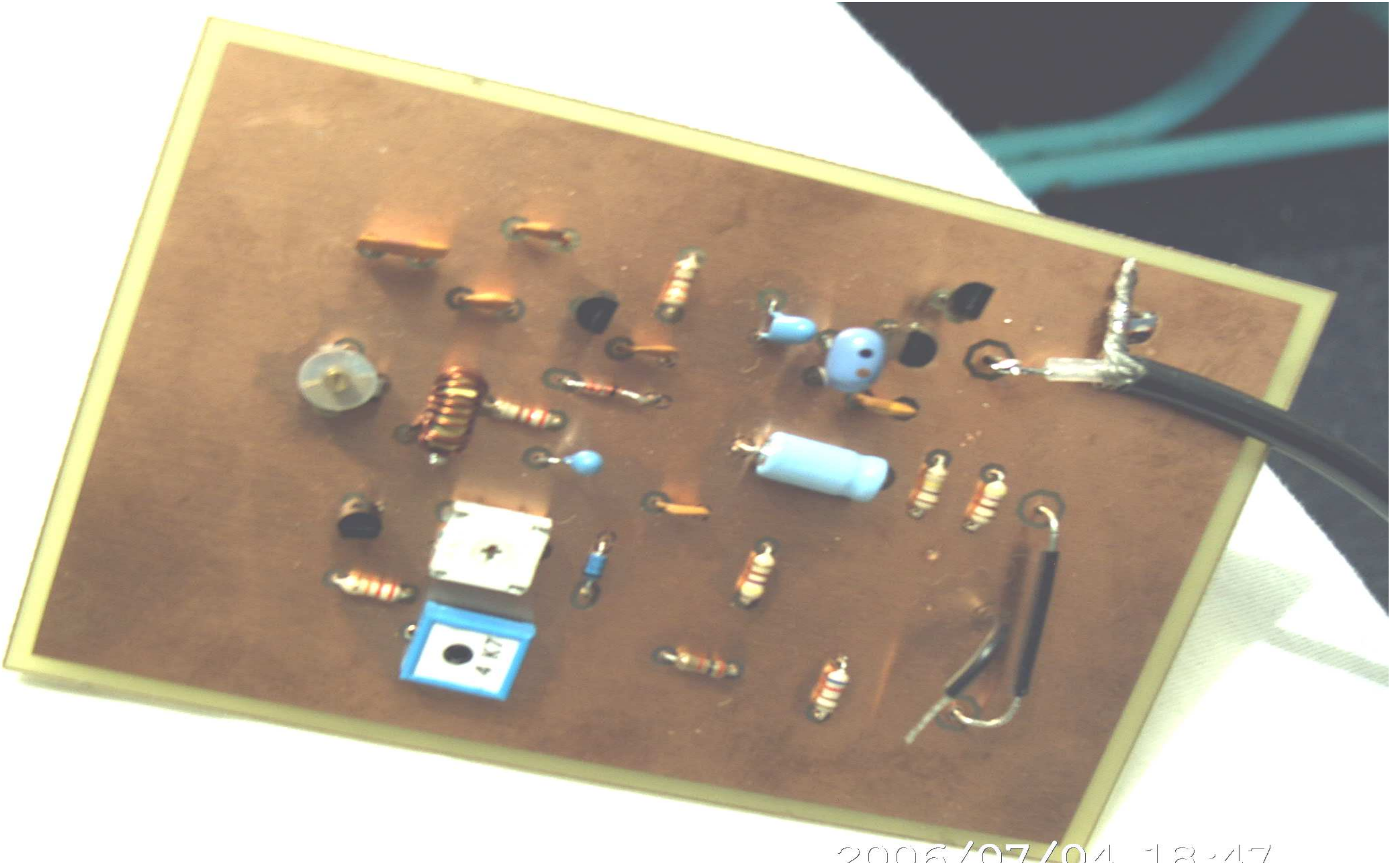
- Schematic drawing of VFO circuit



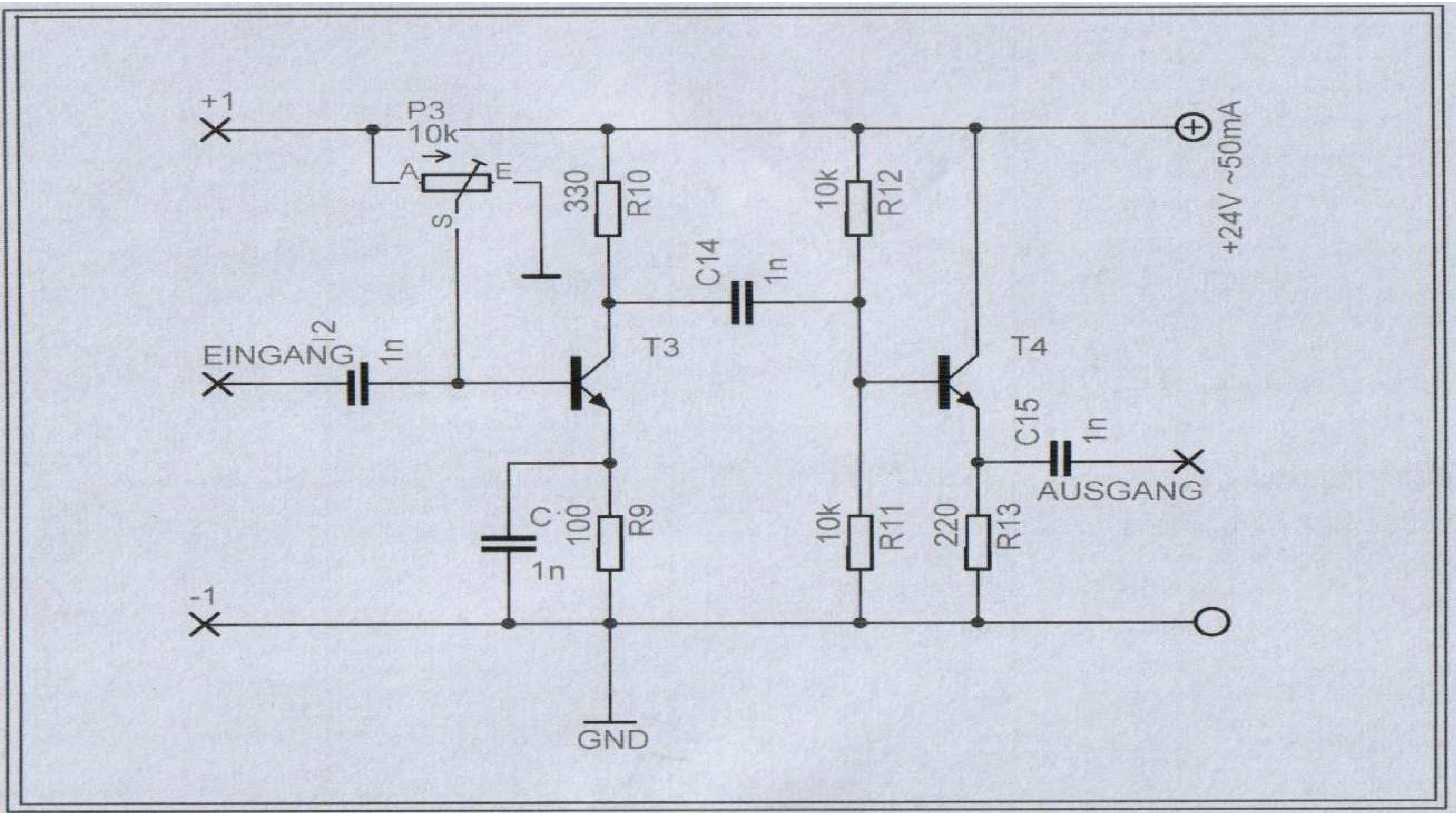
- VFO board



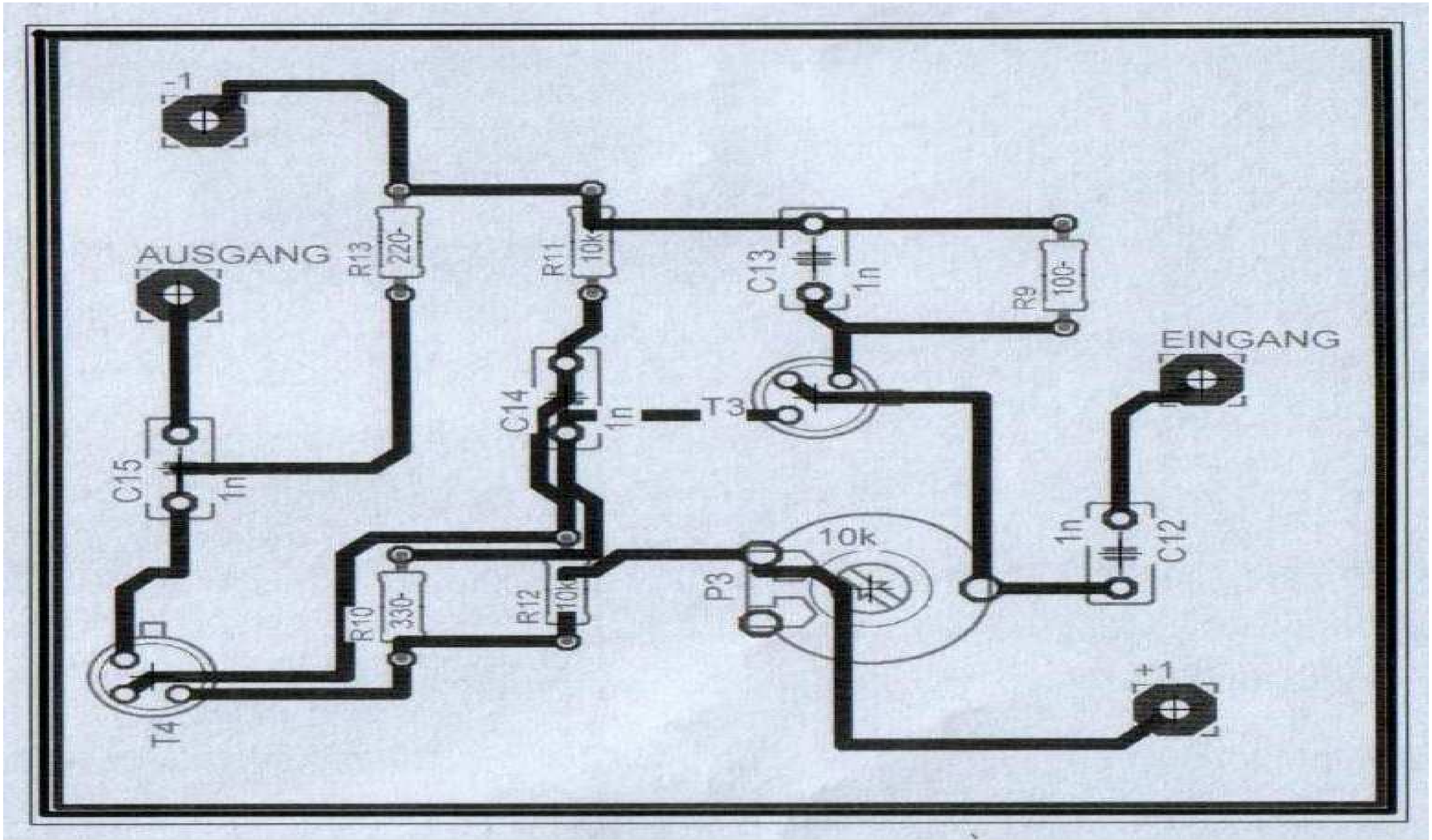
- Finished VFO board



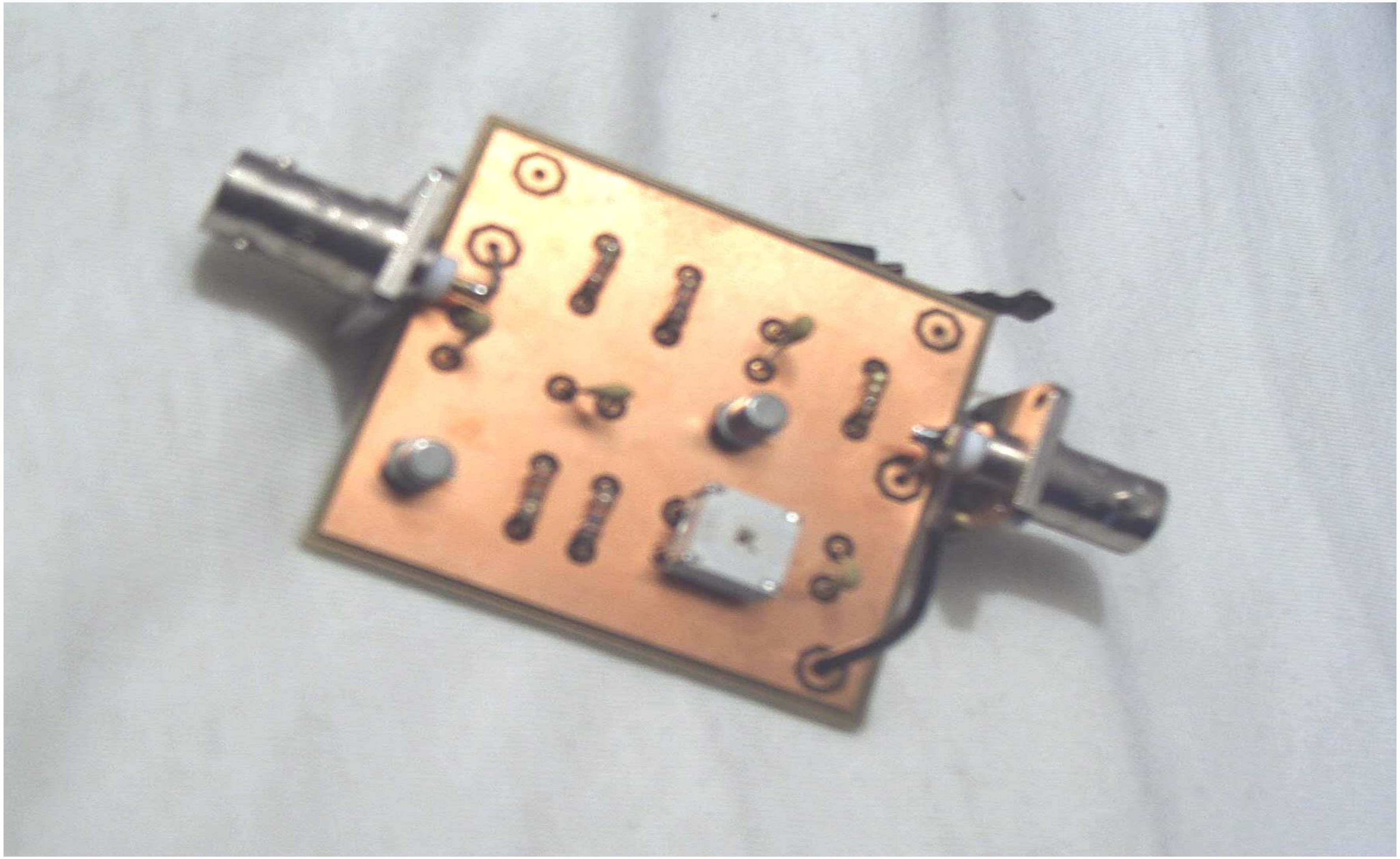
- Amplifier circuit



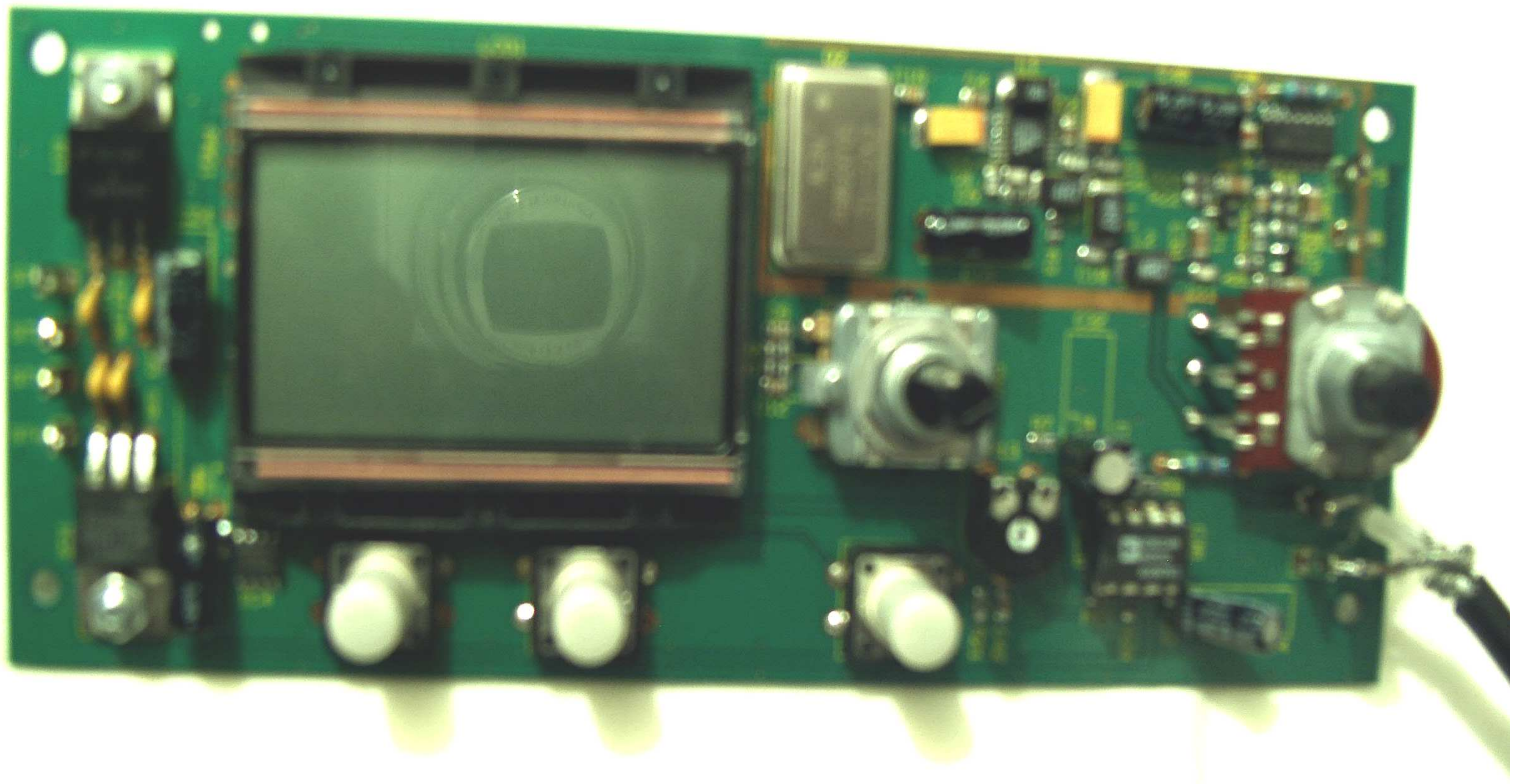
- Amplifier circuit board



- Finished amplifier board



- DDS20 from CONRAD Electronic



Measurements and results

- Finished boards were tested for their functionalities using oscilloscope.

Properties measured include:

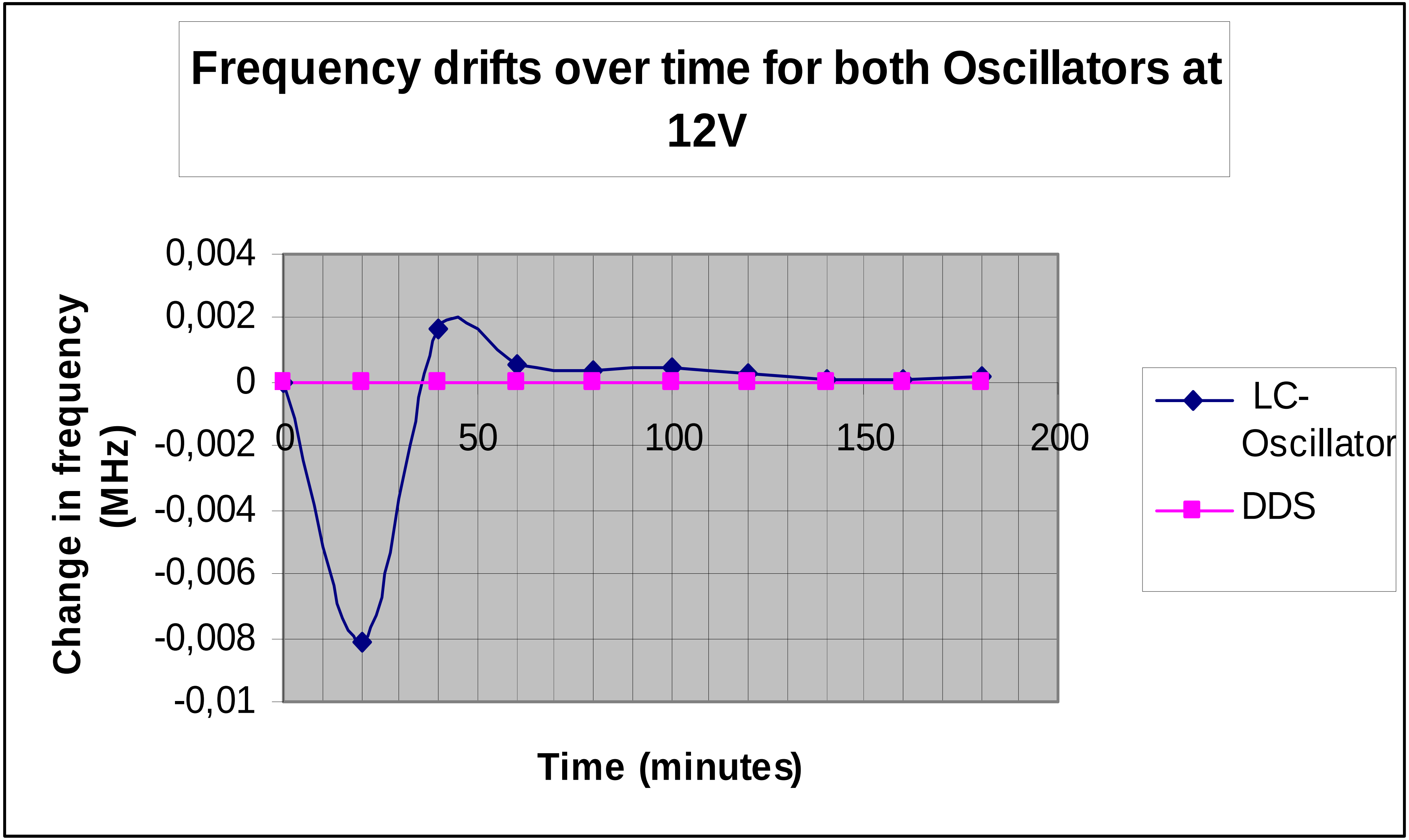
- Tuning characteristics
- Frequency stability
  1. frequency drift over time
  2. frequency drifts over temperature
  3. supply voltage pulling

Tuning Characteristics

- Voltage source of 12V, 50mA current source and spectrum analyzer were used.
- Tuning were made with and without amplification
  - Start frequency 4.0MHz
  - Stop frequency 50MHz
  - Center frequency 27MHz
  - Marker frequency 6.83MHz

Frequency drift over time at 12V for: LCO DDS20

Time (minutes)	$\Delta f = f_2 - f_1$	$\Delta f = f_2 - f_1$
0	0	0
20	-0.008130	-0.000024
40	0.001645	-0.000033
60	0.000542	-0.000005
80	0.000384	-0.000002
100	0.000444	0.000000
120	0.000285	-0.000001
140	0.000089	0.000001
160	0.000126	-0.000002
180	0.000189	0.000001


Frequency drifts over time for both Oscillators at 12V
0,004
0,002
0
-0,002
-0,004
-0,006
-0,008
-0,01
0
50
100
150
200
Change in frequency (MHz)
Time (minutes)
LC-Oscillator
DDS

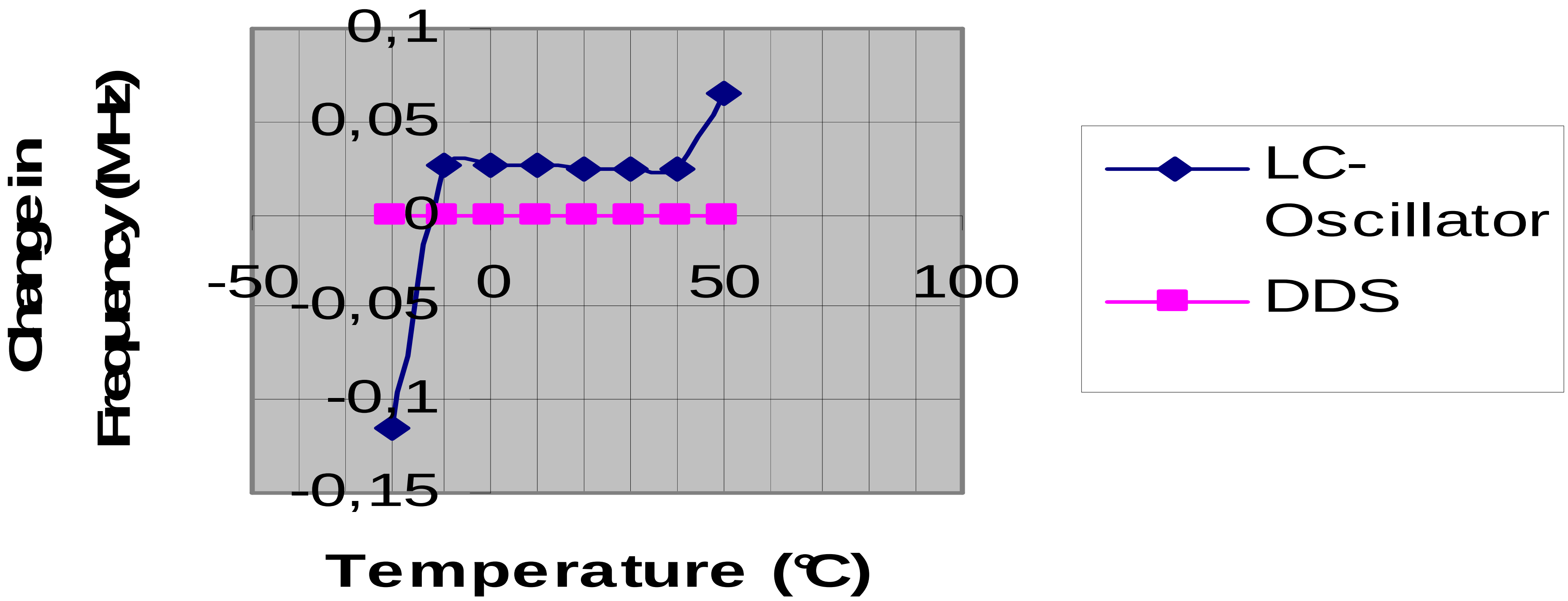
Frequency drift over temperature for LCO

Time (minutes)	Temperature (°C)	Frequency (MHz)	$\Delta f = f_2 - f_1$
Start		006.99 9745	
0	-20	006.88 4698	-0.01504
20	-10	006.91 1803	0.027105
40	0	006.93 7874	0.026071
60	10	006.96 3308	0.025434
80	20	006.98 8024	0.024716
100 (30 minutes)	30	007.01 3163	0.025139
120	40	007.03 7205	0.024042
140	50	007.10 2591	0.065386

- Frequency drift over temperature for DDS20

Time (minutes)	Temperature (°C)	Frequency (MHz)	$\Delta f = f_2 - f_1$
Start		007.00 0000	
0	-20	007.00 0104	0.000104
20	-10	007.00 0091	-0.000013
40	0	007.00 0063	-0.000028
60	10	007.00 0026	-0.000037
80	20	006.99 9982	-0.000044
100	30	006.99 9933	-0.000049
120	40	006.99 9886	-0.000047
140	50	006.99 9852	-0.000034

Frequency drifts over temperature for both Oscillators per 20 minutes interval



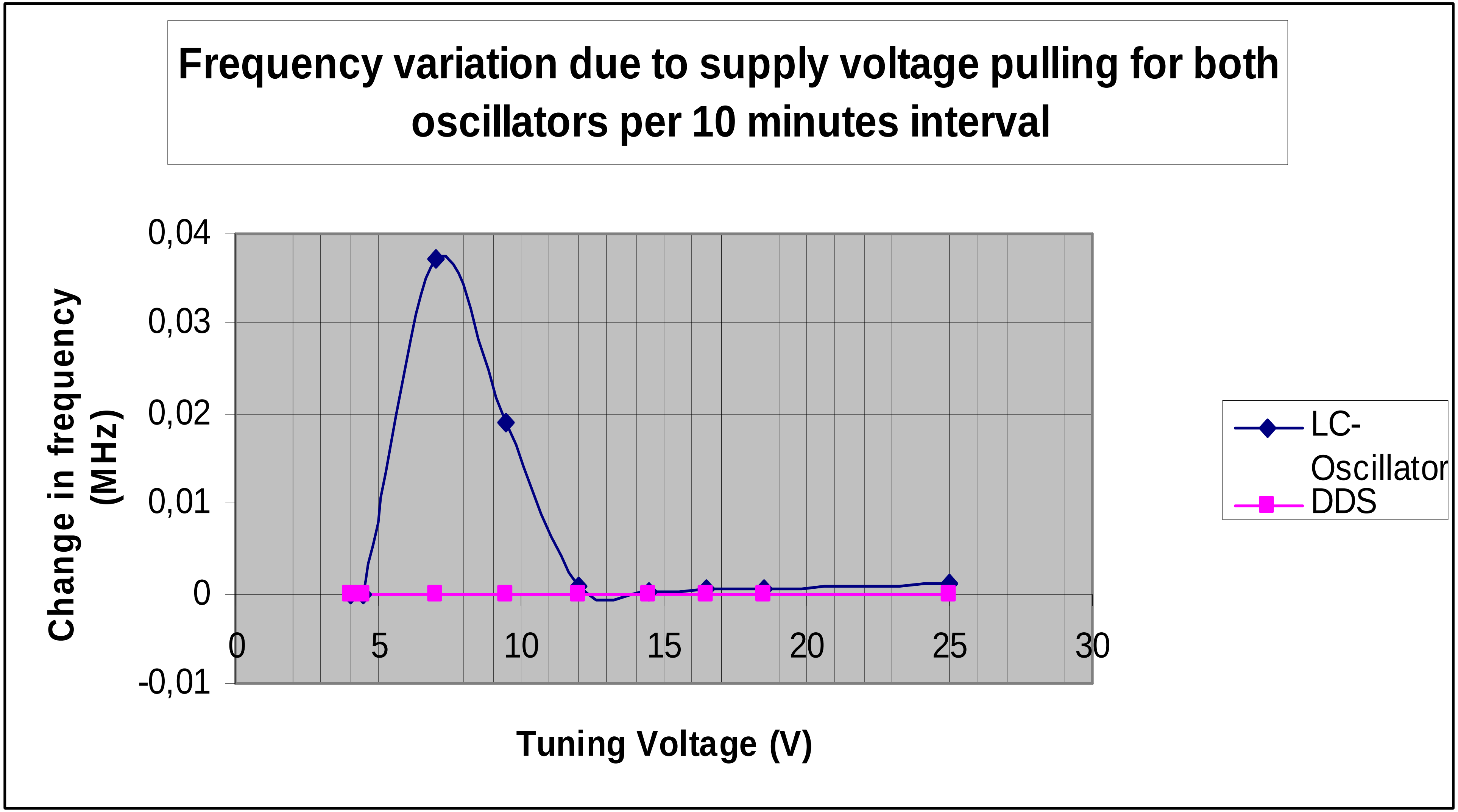
- At a temperature of 75°C, the DDS20 went off whereas the LCO was still operational.

- Supply voltage pulling for LCO

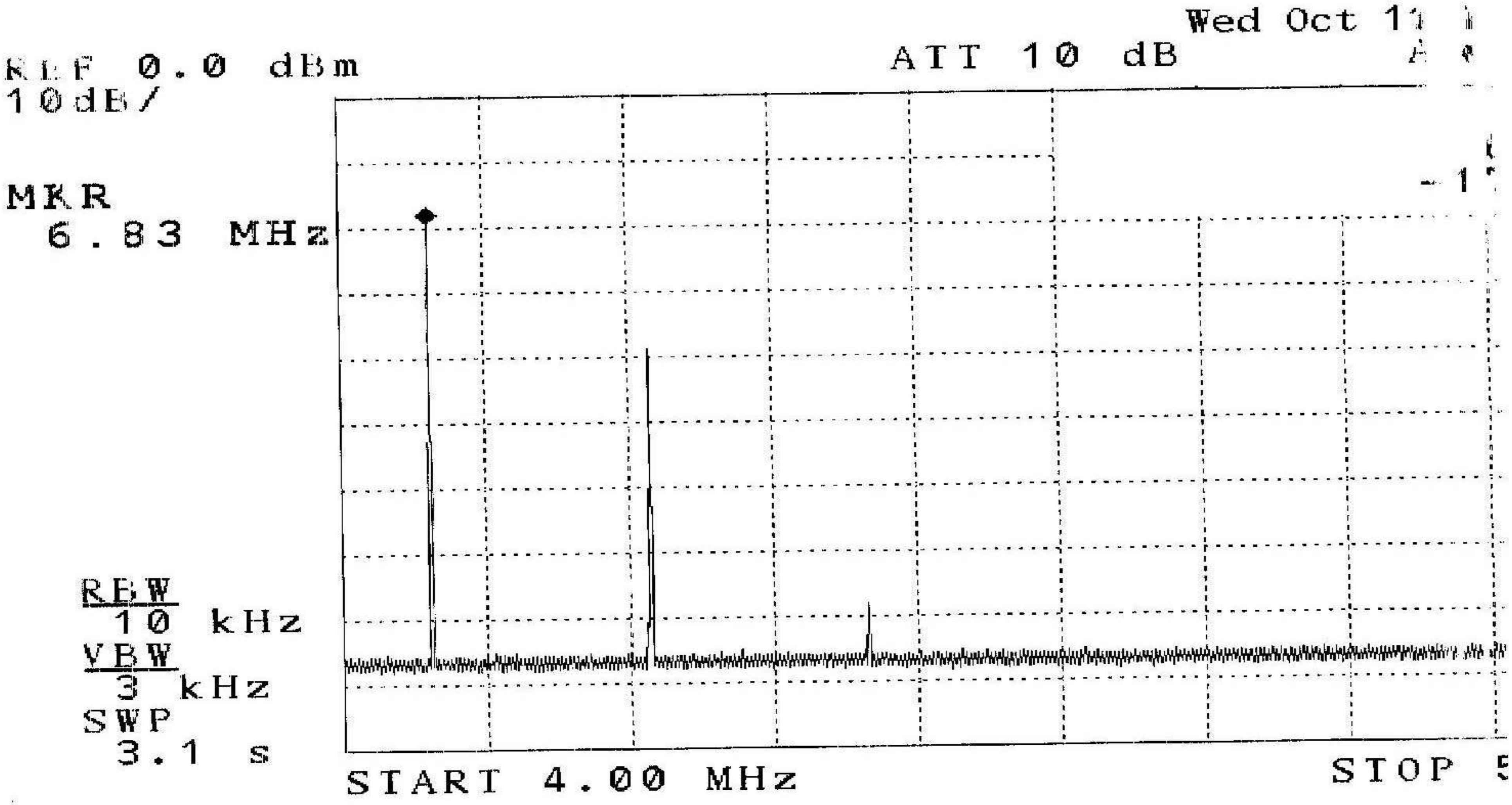
Time (minutes)	Tuning Voltage (V)	Frequency (MHz)	$\Delta f = f_2 - f_1$
0	4.5	006.93 6895	
10	7.0	006.97 4217	0.037323
20	9.5	006.99 3281	0.019064
30	12.0	006.99 3989	0.000708
40	14.5	006.99 4214	0.000225
50	16.5	006.99 4654	0.000440
60	18.5	006.99 5144	0.000490
70	25.0	006.99 6220	0.001076

- Supply voltage pulling for DDS20

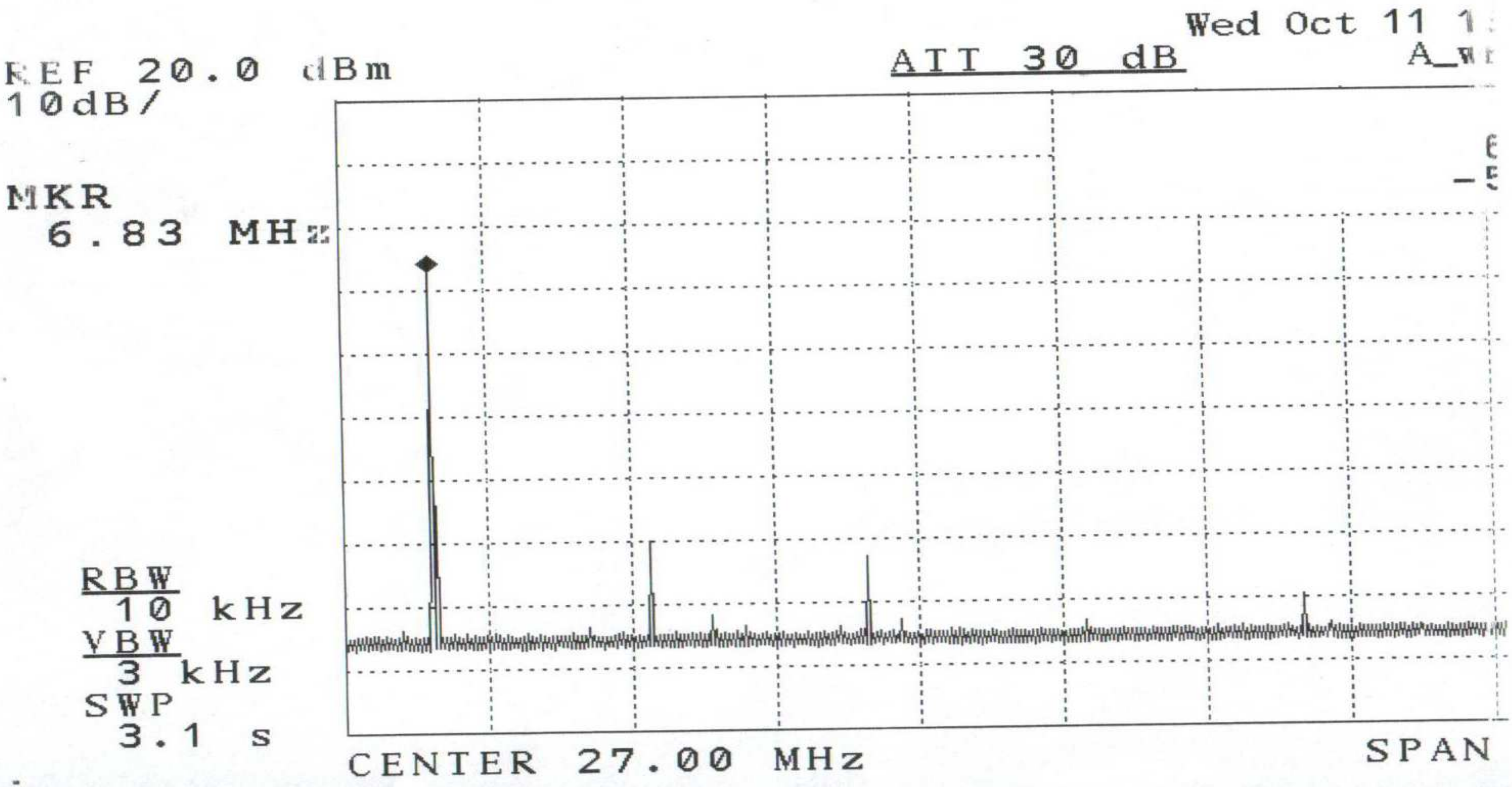
Time (minutes)	Tuning Voltage (V)	Frequency (MHz)	$\Delta f = f_2 - f_1$
0	4.0	006,93 1364	
10	7.0	006,93 1364	0.000000
20	9.5	006,93 1363	-0.000001
30	12.0	006,93 1362	-0.000001
40	14.5	006,93 1363	0.000001
50	16.5	006,93 1362	-0.000001
60	18.5	006,93 1362	0.000000
70	25.0	006,93 1362	0.000000


Frequency variation due to supply voltage pulling for both oscillators per 10 minutes interval
0,04
0,03
0,02
0,01
0
-0,01
0
5
10
15
20
25
30
Change in frequency (MHz)
Tuning Voltage (V)
LC-Oscillator
DDS

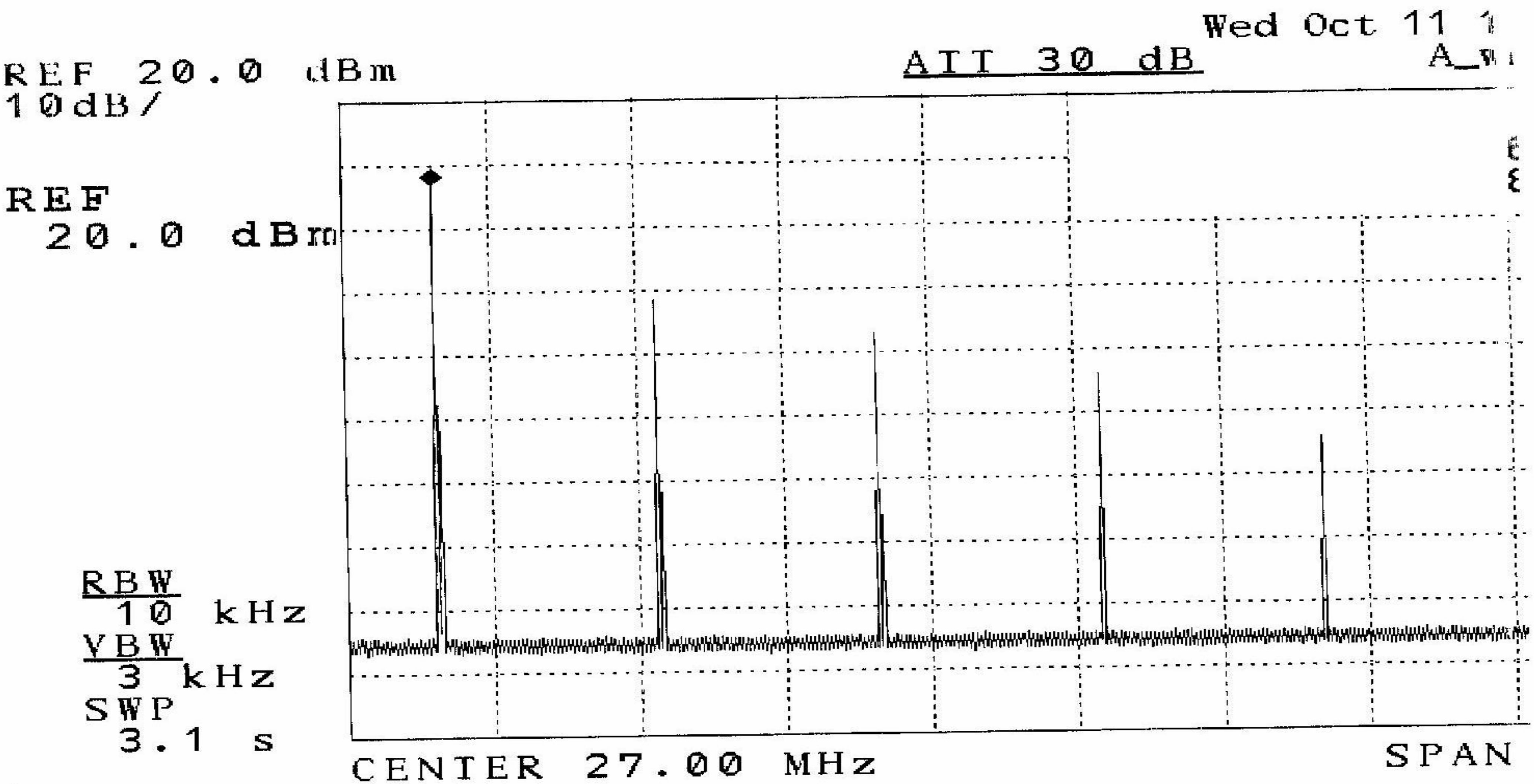
Output spectrum for LCO without amplification



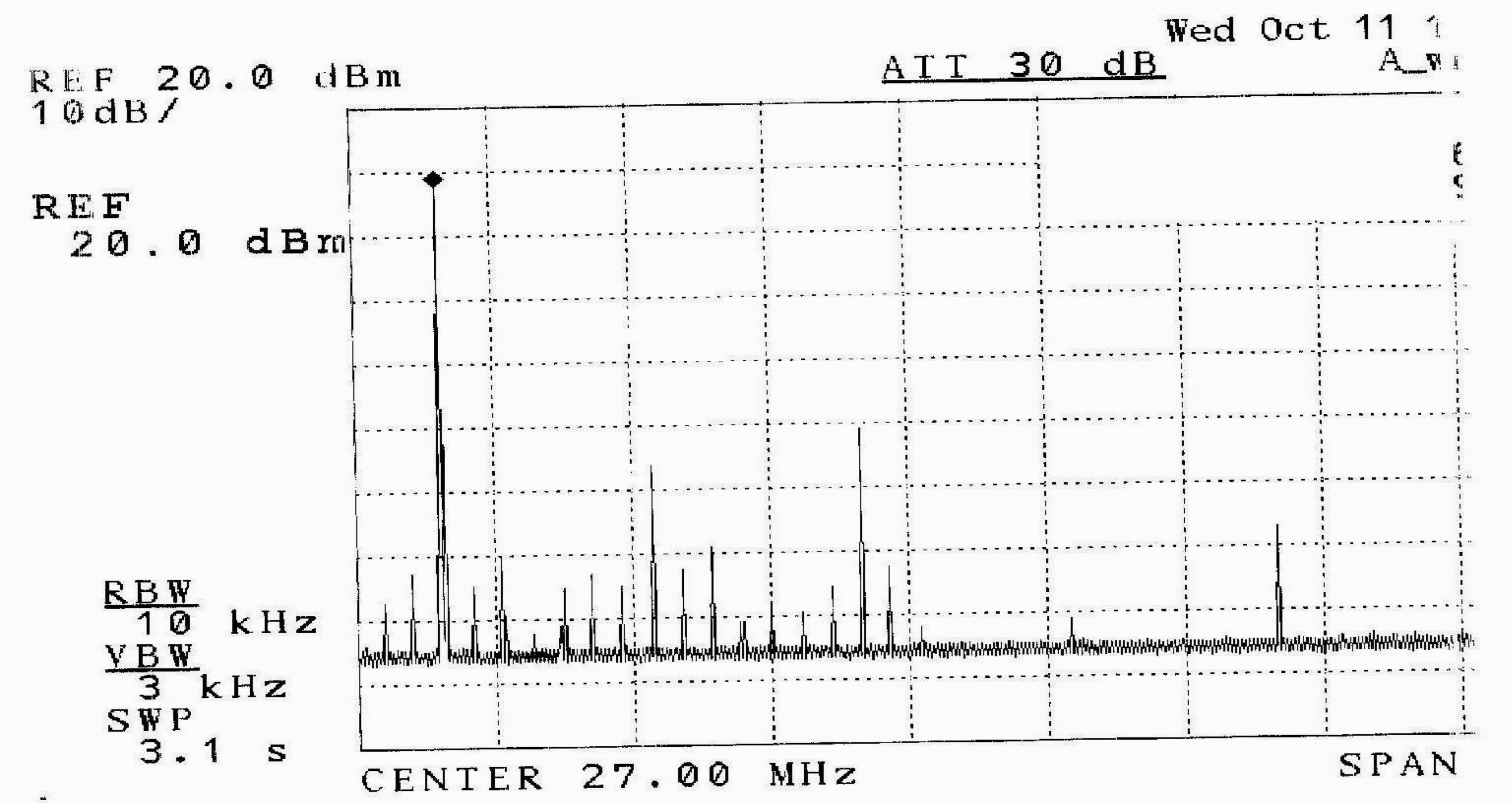
Output spectrum for DDS20 witout amplification



Output spectrum for LCO with amplification



Output spectrum for DDS20 with amplification



Conclusions

- Frequency variations in the LCO are possibly due to its internal variations called aging for the drift over time.
- Drift over temperature is also due to sensitivity to ambient temperature of the L and C components in the LC-tank.
- LCO withstood as high as 75°C but DDS went off.
- Amplified spectral analysis showed that the DDS was more affected by spurious and damping relative to fundamental signal than the LCO. This maybe partly due to instrument used.
- DDS is more cumbersome than the LCO.

- From literature, LCO is known to have higher quality factor, Q, than the DDS due to its crystal composition and smaller size.
- LCO is cheaper to build and when well designed, would give satisfactorily good results
- Therefore, LCO, from my analysis and based on economic factors, is a good choice and with a little improvement, will match better standards than the DDS.
- Current state of the art gives the DDS a perfect choice over the LCO.

The END!!!!!!!

Thank you!

Danke!