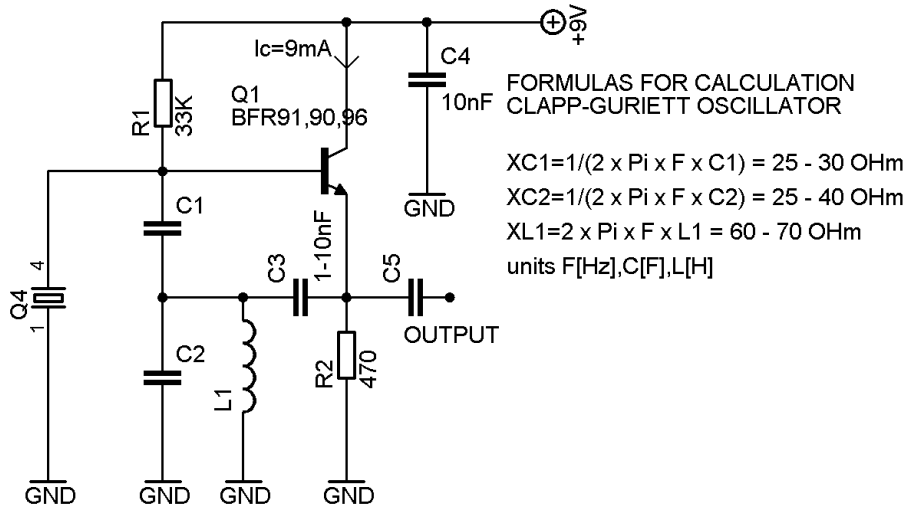
An universal HF / VHF Low Noise Crystal Oscillator with Switching 4 Crystal Unit Possibility – Make it Simple as Possible with Outstanding Performances

Dipl. Ing Tasić Siniša-Tasa YU1LM/QRP

I made great number different oscillators, crystal fundamental and harmonic mode and VCO starting from KHz range to the GHz region in past. Some my designs ware low noise, ultra low noise, some broad-band, some narrow-band, oven…… My design motto is and it was make it simple as possible with outstanding performances.

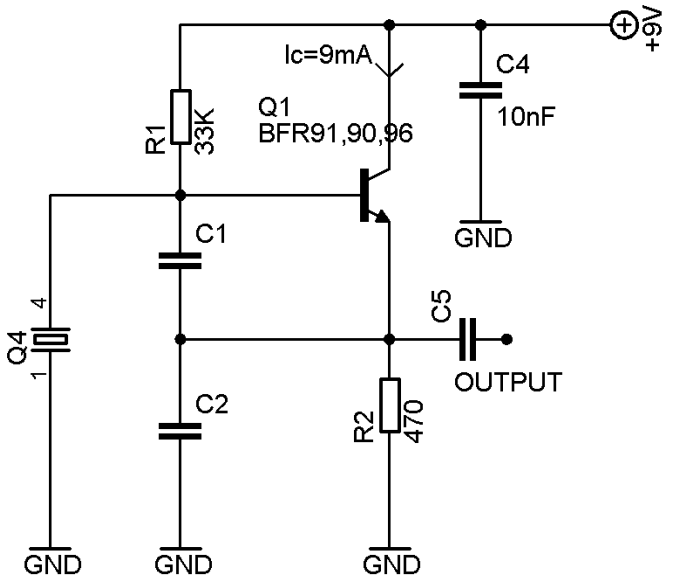
This design started when I was decided to make LO (local oscillator) with DDS IC AD9850 few years ago. I was looking through many articles and book trying to find some good and simple design for REF DDS oscillator. In reference 2 I find very interesting schematic for Clapp-Guriett harmonic (overtone) oscillator in VHF range 30 -200 MHz. I made similar design few time early but I didn't examining seriously like I did now. I started classic oscillator design with freeware software ANSOFT serenade SV8.7. With CAD help I find initial values for oscillator components. Freeware Serenade SV8.7 hasn't possibility oscillator and nonlinear analyses. My good friend Steven A. Thompson offered me help in oscillator design with "full" Serenade 8.7 version. I have to bring him endless acknowledge for great effort in correction my design and production really nice screen shots down in text.

I tried design with classic BJT transistors series BFR90, BFR91, BFR96 and at the similar way oscillator was working SMD transistor BFR93 also. There is no big difference between scillators performances realized with different transistor except that some samples BFR90 wasn't able to give the same output power as other (power was lower for 1-2 dB) can. It is very important to say that I haven't possibility to check such low oscillator phase noise and maybe it is too much optimistic predicted. From my previously experience oscillator phase noise close to carrier in region 0-200,400 Hz around depend mainly from how it is suppressed power supply noise. Predicted oscillator output waveform I checked with 300 MHz oscilloscope and they were very similar to predicted simulation screen shoot. Output spectrum at SA(spectrum analyzer) were very close to predicted. This facts gave me belief that there are good correspondence between design and realization. First I am giving you basic schematics for calculation without output drive transistor and additional LP (low pass).



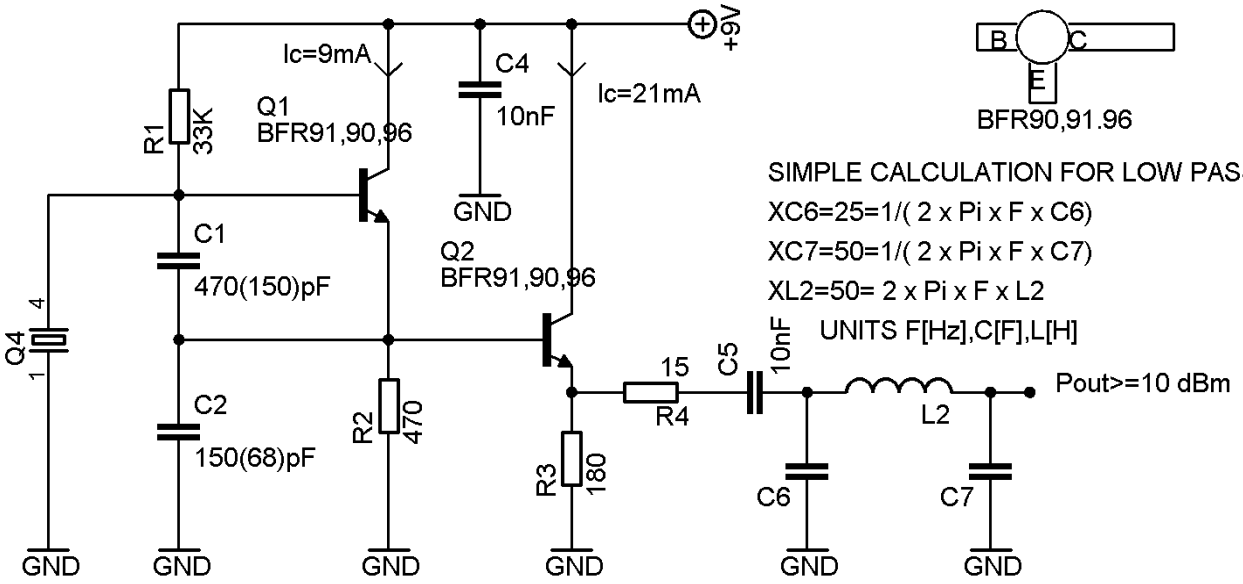
Output low pass filter is very important for my receivers with diode mixer as demodulator and non optimum SDR receivers like DR2C... For them it is very important that LO drive square or sinusoidal have close 50/50 ratio for optimal work. Non optimal LO drive lead SDR RX demodulator to a lot of problems like harmonic receiving are. Other my SDR receivers which have FF Flip-Flop at LO input are not sensitive to the signal shape except input level. Of course good LO drive shape will help us to obtain optimum performances from RX/TX and

TRCV. The Clapp-Guriett oscillator can work with adequate elements from few MHz to 200 MHz. This oscillator is possible simplify transforming it to Colpitts oscillator for Quartz xtal fundamental mode to 30 MHz see picture down



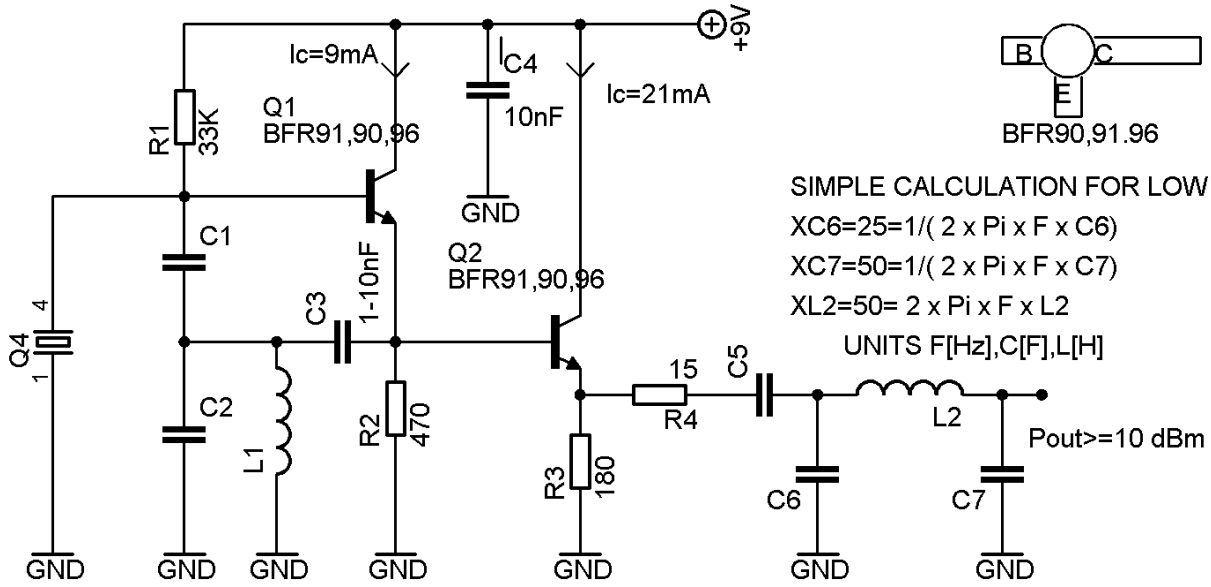
CLAPP-GURIETT OSCILLATOR TRANSFORMED TO COLPITTS OSCILLATOR
FOR XTAL FUNDAMENTAL FREQUENCIES MODE F<=30 MHz

Oscillator transistors have very high Ft transient frequency in region 4-6 GHz. To prevent unwanted UHF oscillation it is very important that all components leads including transistors are short as possible. If this unwanted oscillation have happened after all precautions solder small classic size capacitor 10-33 pF or SMT 100pF from bottom side close to transistor collectors to the ground.



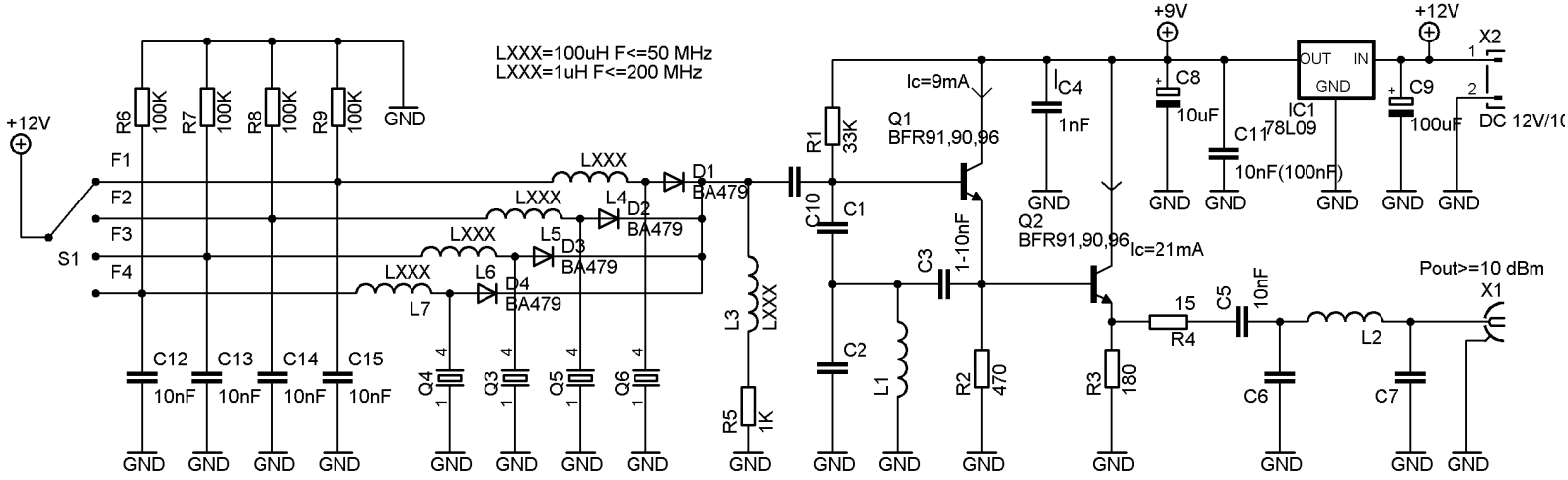
C1,C2 ( ) VALUES FOR F>=20 MHz HIGHER Pout

HF(2-30 MHz) COLPITTS OSCILLATOR WITH BUFFER STAGE

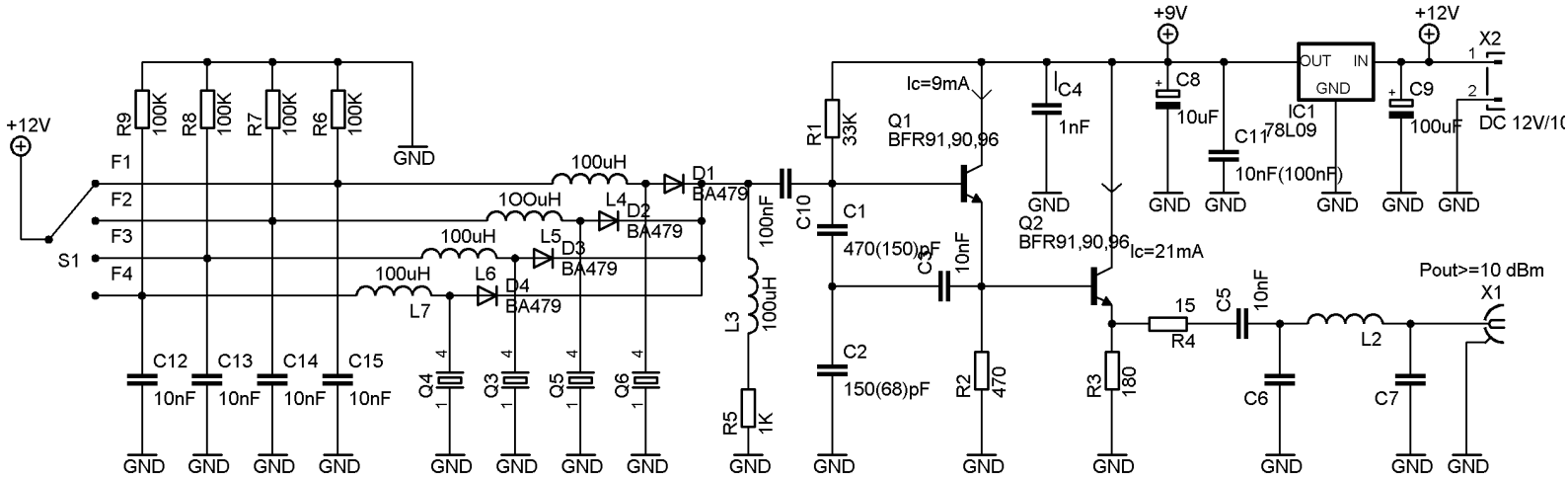


CLAPP-GURIETT OSCILLATOR WITH BUFFER STAGE

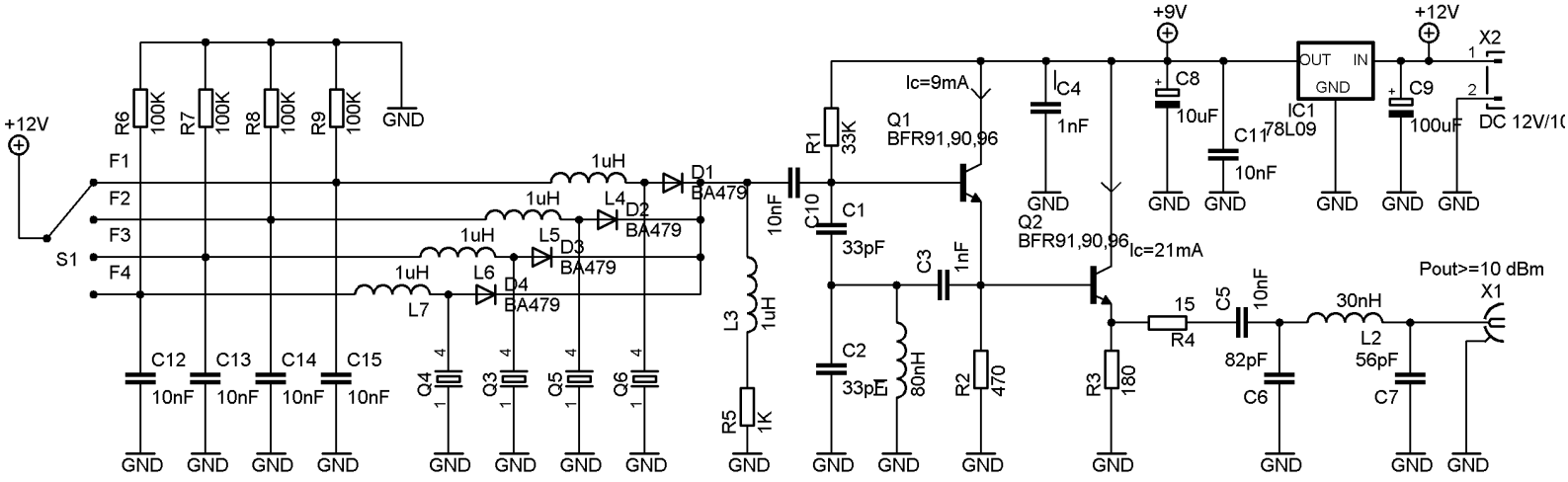
Schematics for Clapp-Guriett and Colpitts oscillator with switching possibility



CLAPP-GURIETT OSCILLATOR WITH BUFFER STAGE AND XTAL SWITCHING

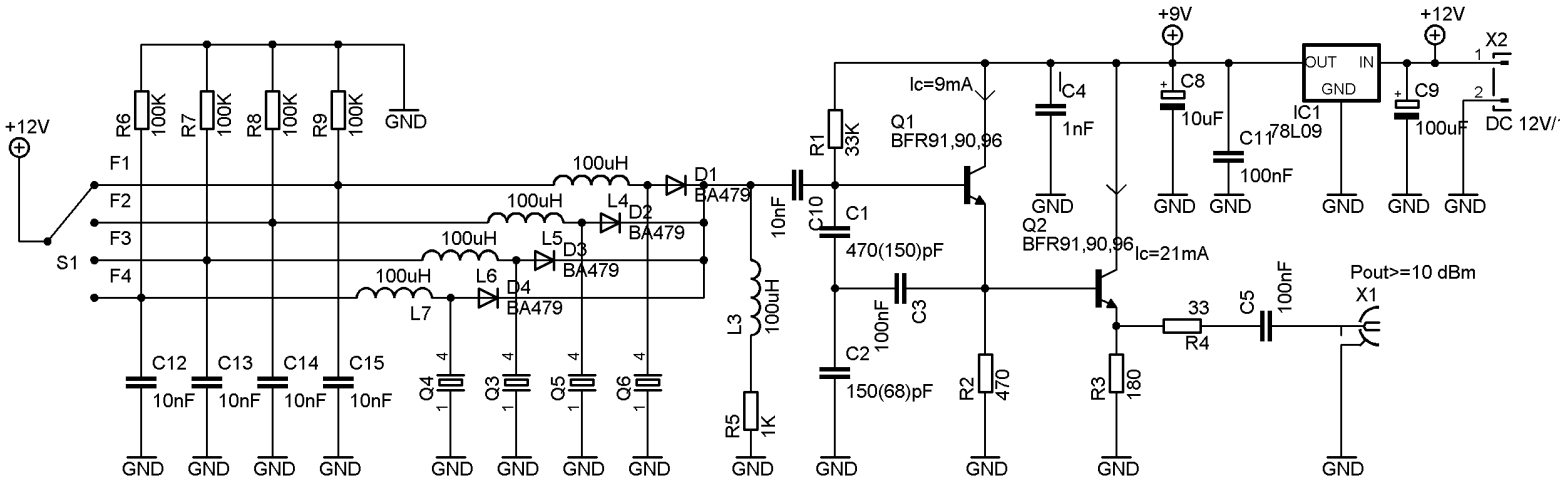


COLPITTS OSCILLATOR F<=30 MHz WITH BUFFER STAGE, LOW PASS AND XTAL SWITCHING



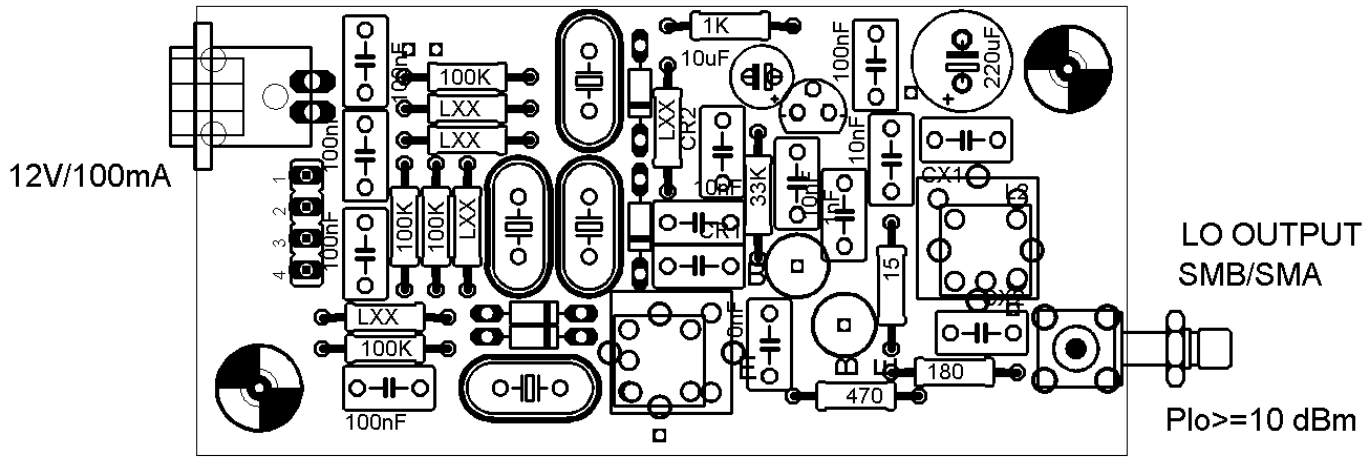
L1=6 TURNS SELF SUPORTED COIL ID=5mm CU WIRE 1mm Qo=110
L2=3 TURNS SELF SUPORTED COIL ID=5mm CU WIRE 1mm Qo=110

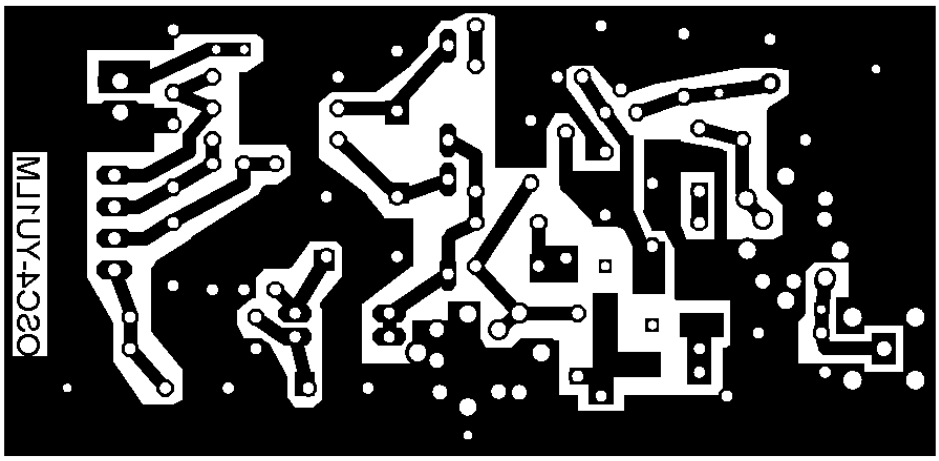
144 MHz CLAPP-GURIETT OSCILLATOR WITH BUFFER STAGE AND XTAL SWITCHING



HF COLPITTS OSCILLATOR WITH BUFFER STAGE WITHOUT LOW PASS AND XTAL SWITCHING

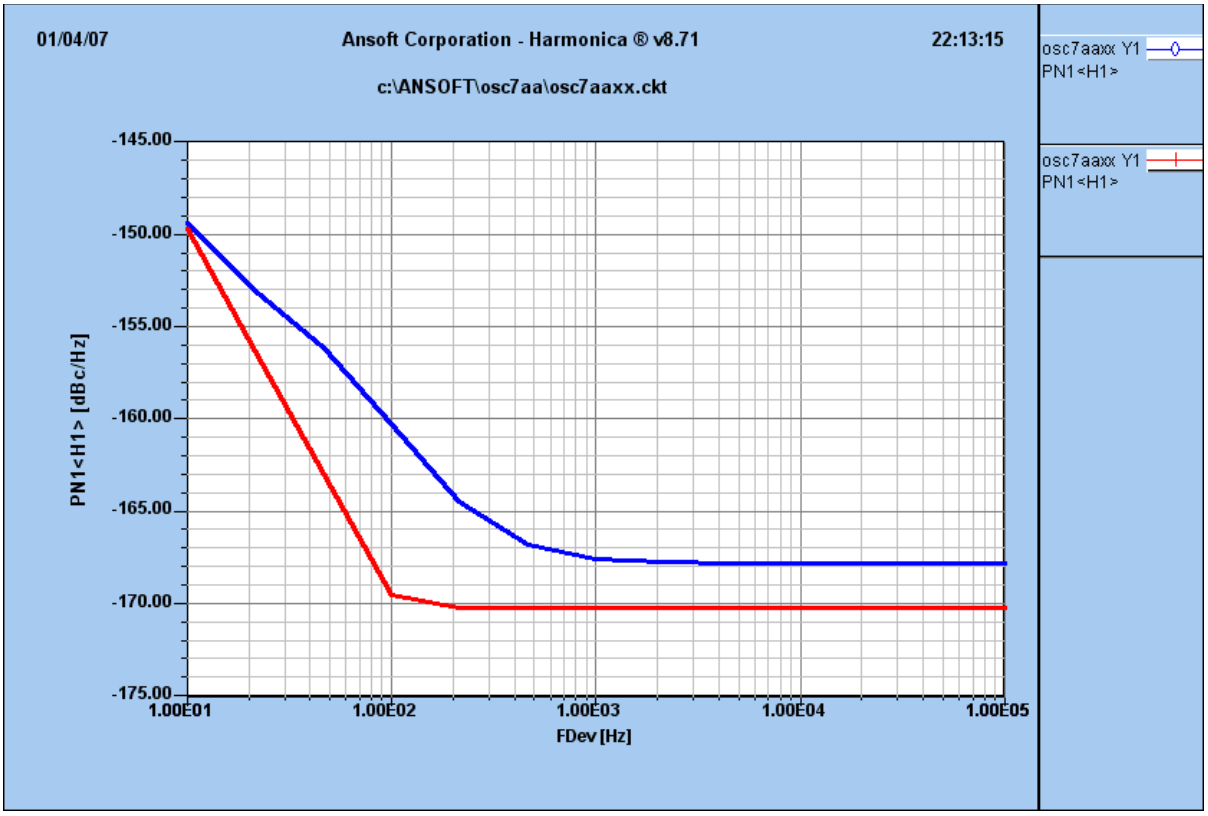
PCB and parts placement for OSC4 are at pictures down



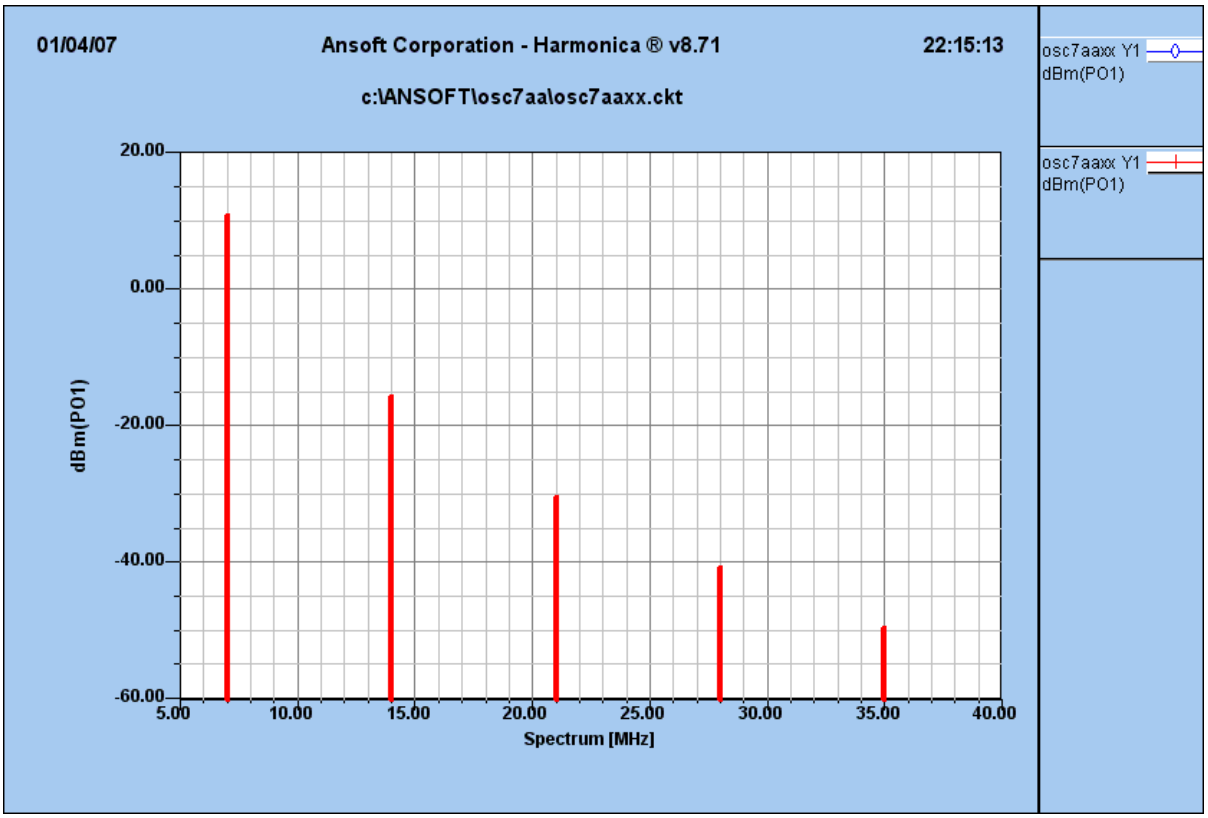


Single side PCB for OSC4 dimensions are 75 x 35 mm

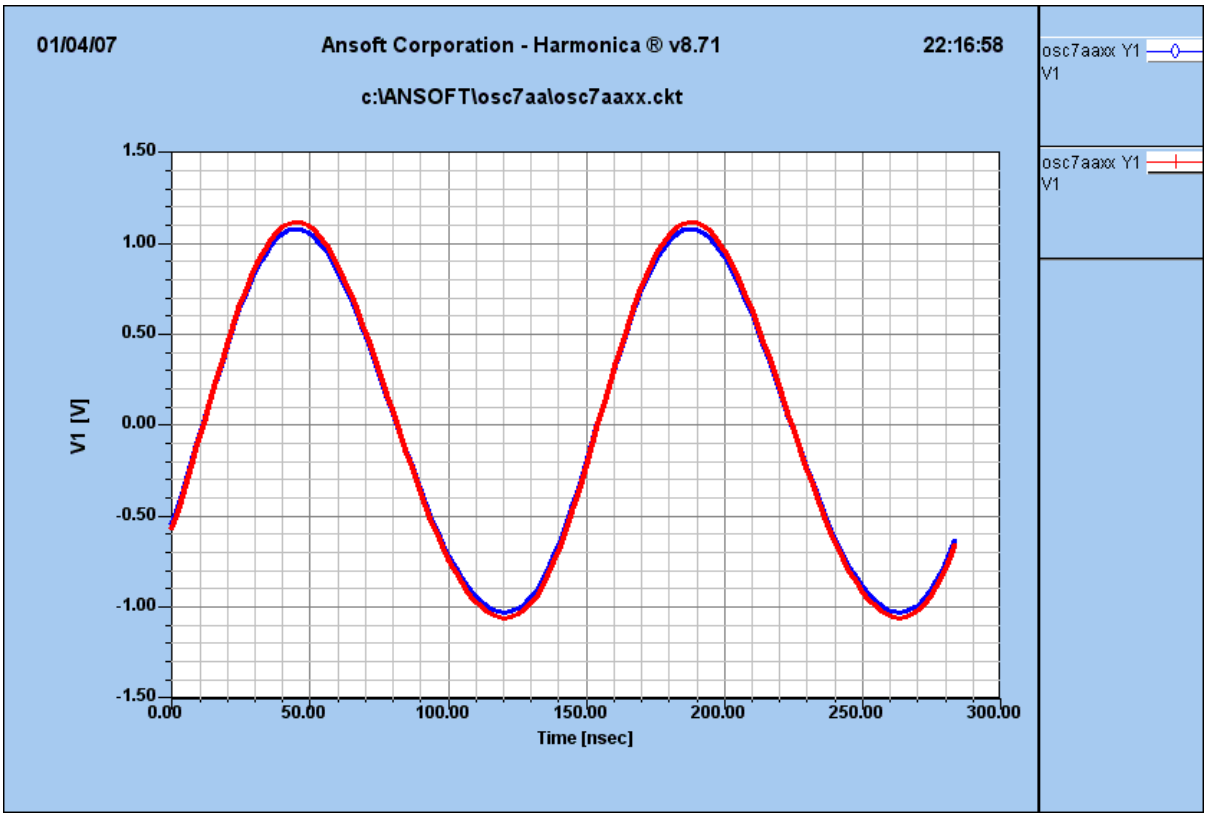
Some practical hints are. Drill holes with borer 5 mm for transistor BFR… soldering from bottom side. Coils L1,L2 are self supported
REF 120 MHz oscillator for mine DDS have very good stability +/- 20 Hz after warm up period from 30 min. After that stability stay in range +/- 5 Hz for hour or better what is excellent result Qo of used crystal in oscillator was 80 000!!!!



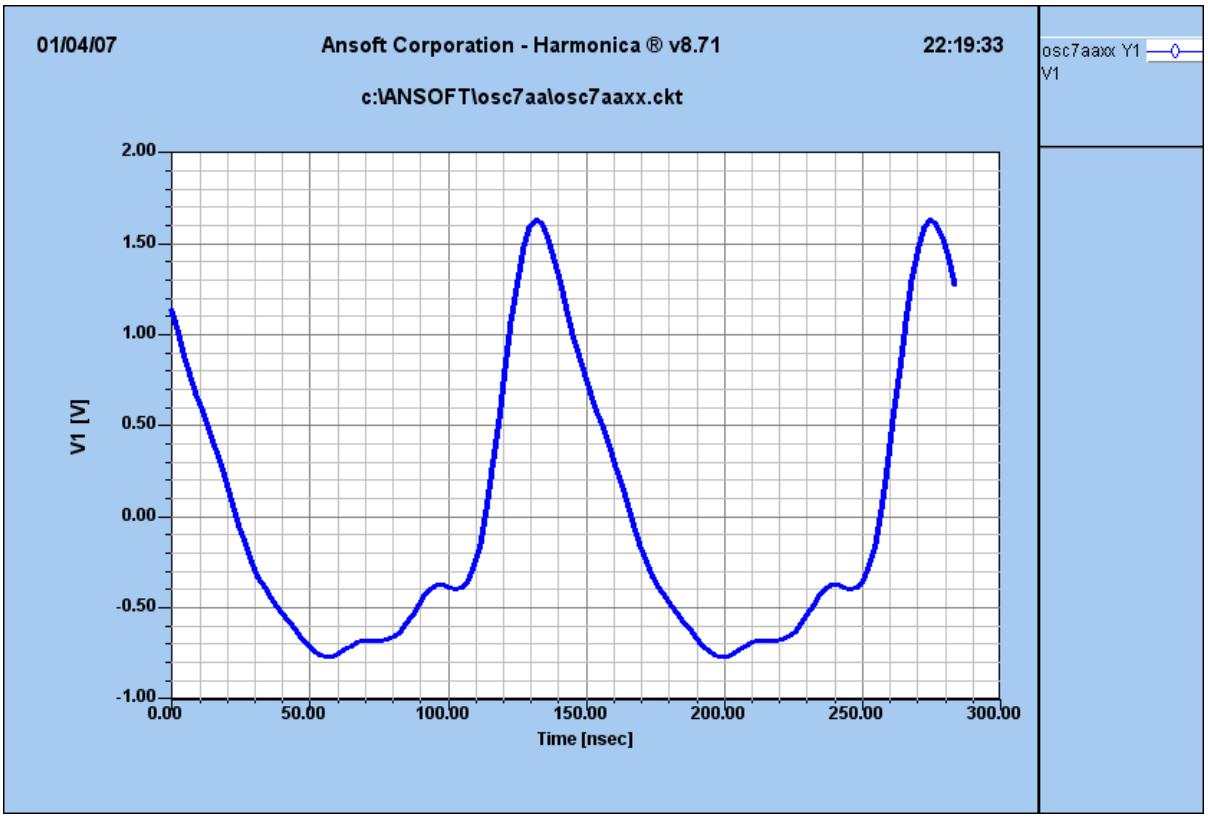
Oscillator phase noise 7MHz (simulation) blue line is single oscillator without switching diodes (red line) with switching diodes Quartz Qo=60000



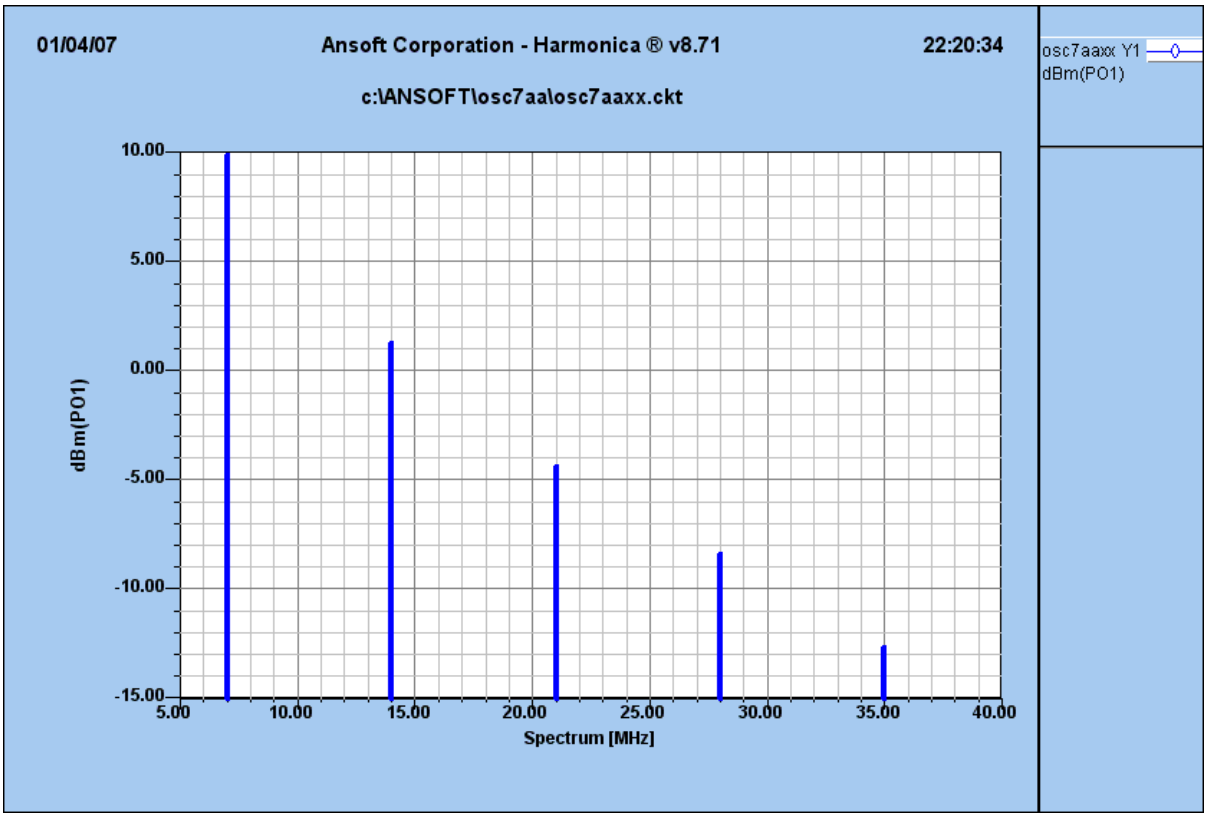
Output spectrum LP elements C6=1nF L2=1uH C7=820 pF



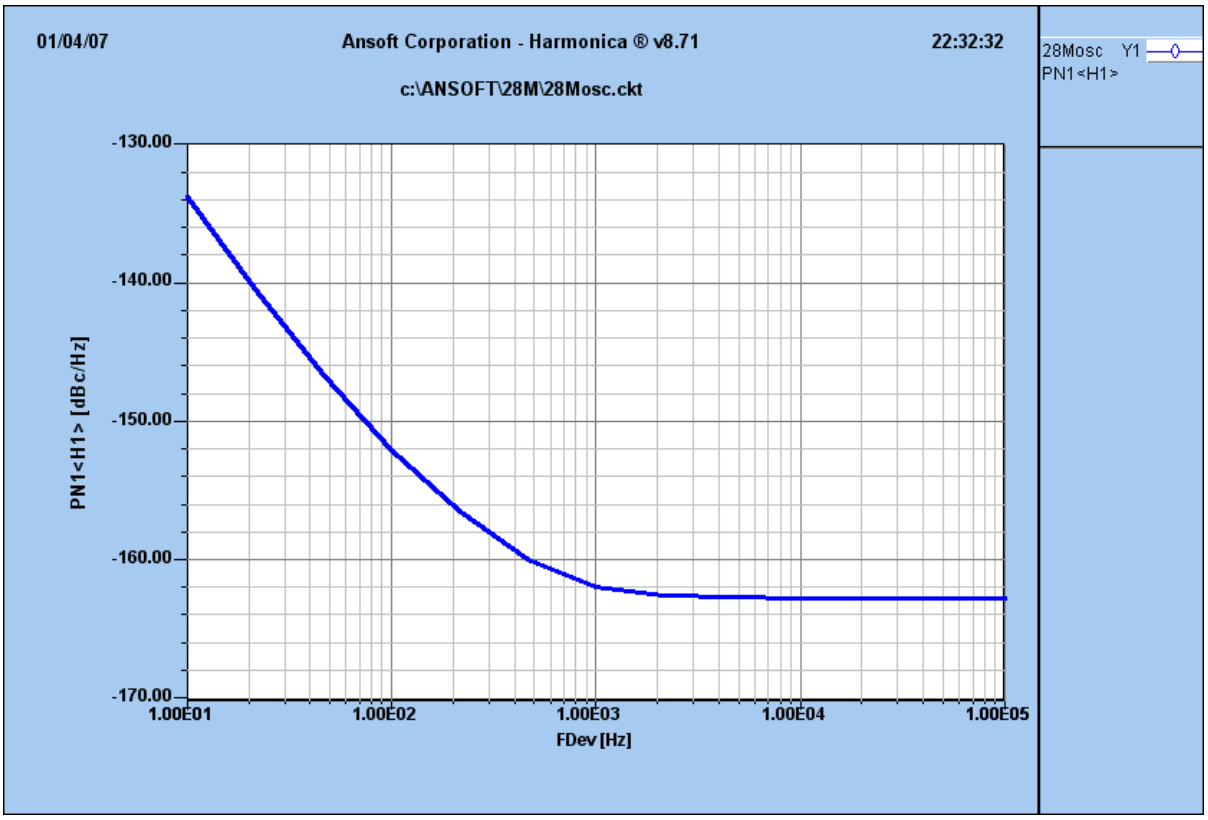
Output waveform at 50 Ohms with LP filter



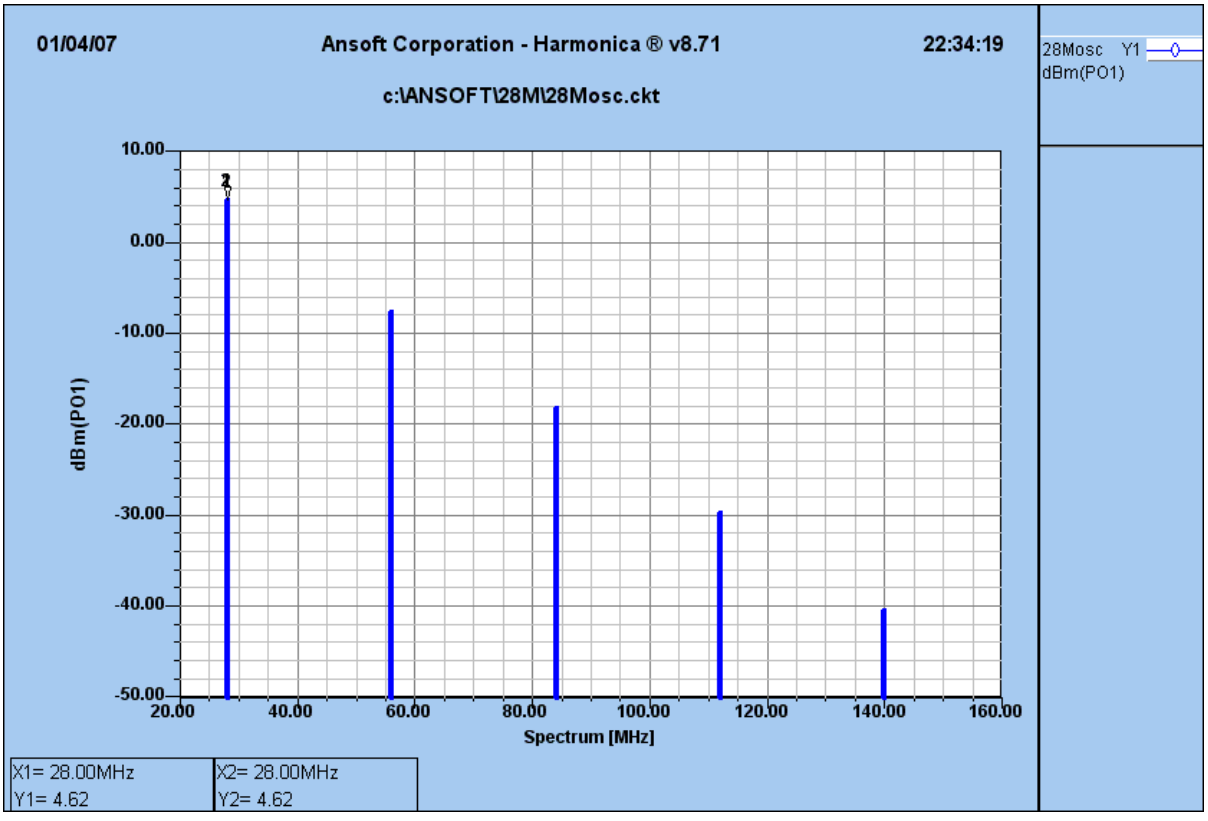
Output waveform without LP R4=33 ohms for better output match



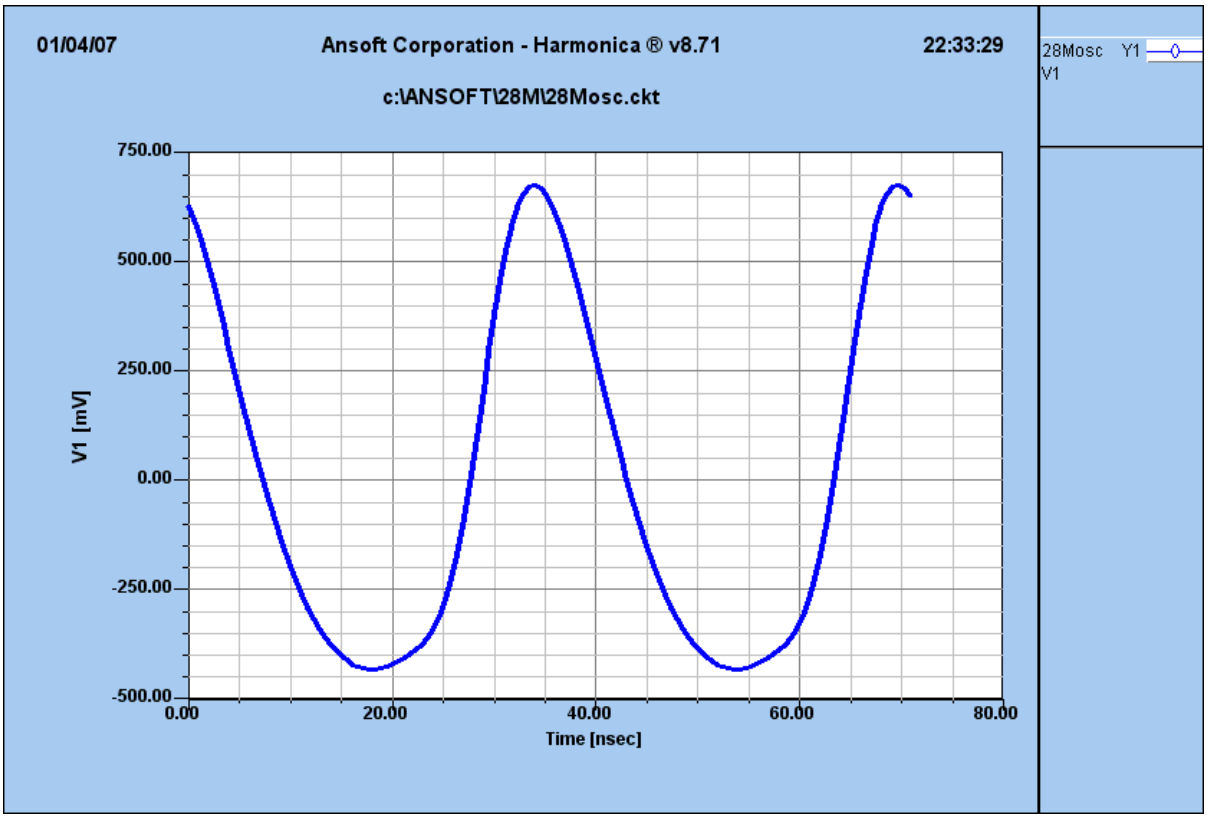
Output spectrum without LP R4=33 Ohms



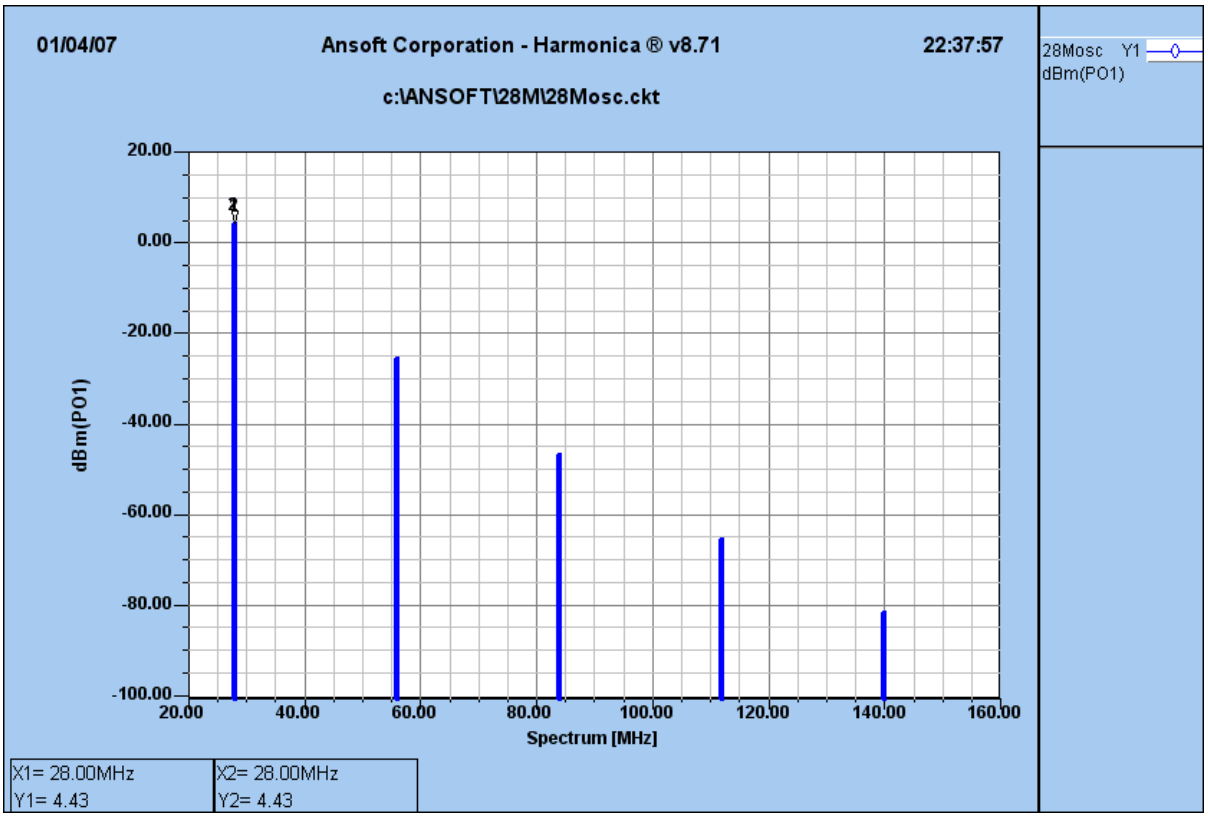
Oscillator phase noise for 28 MHz xtal Qo=60000 LP 220pF 220pF 1500Nh



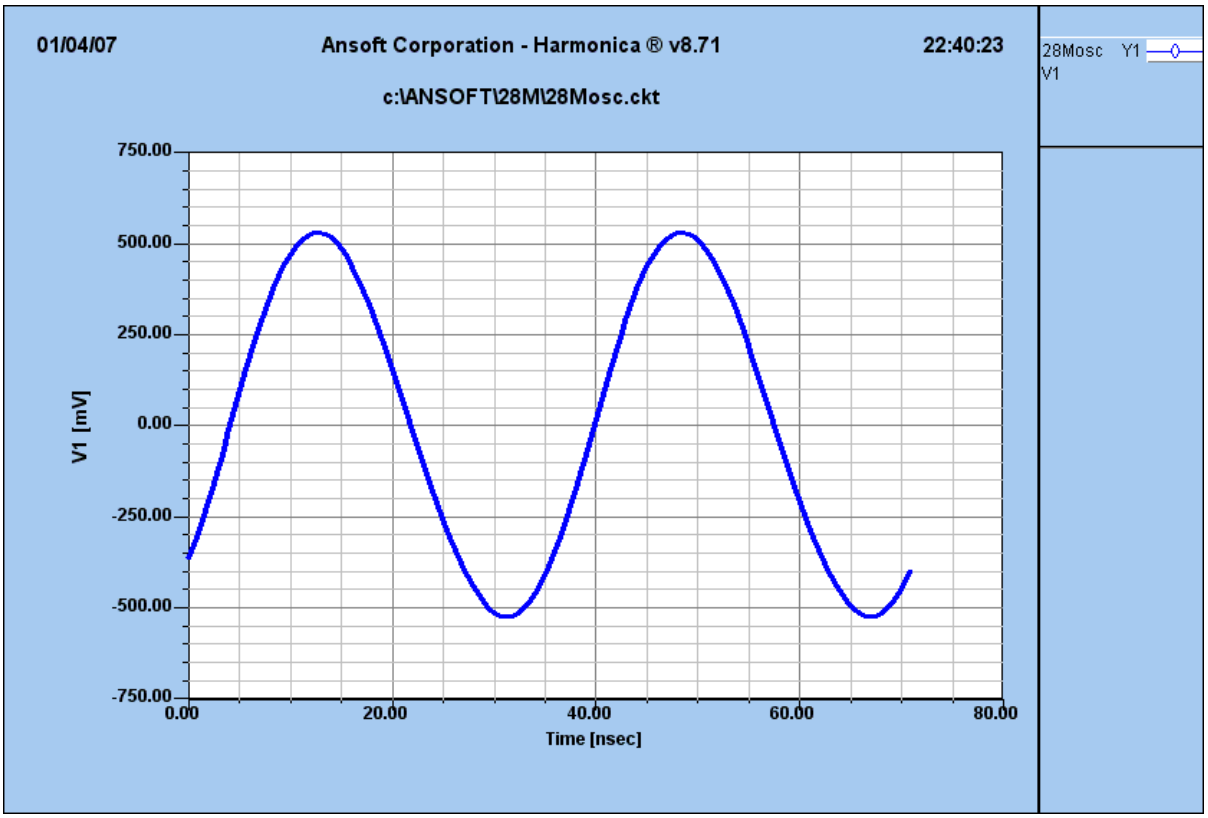
Output spectrum 28 Mhz without LP



Output waveform without LP

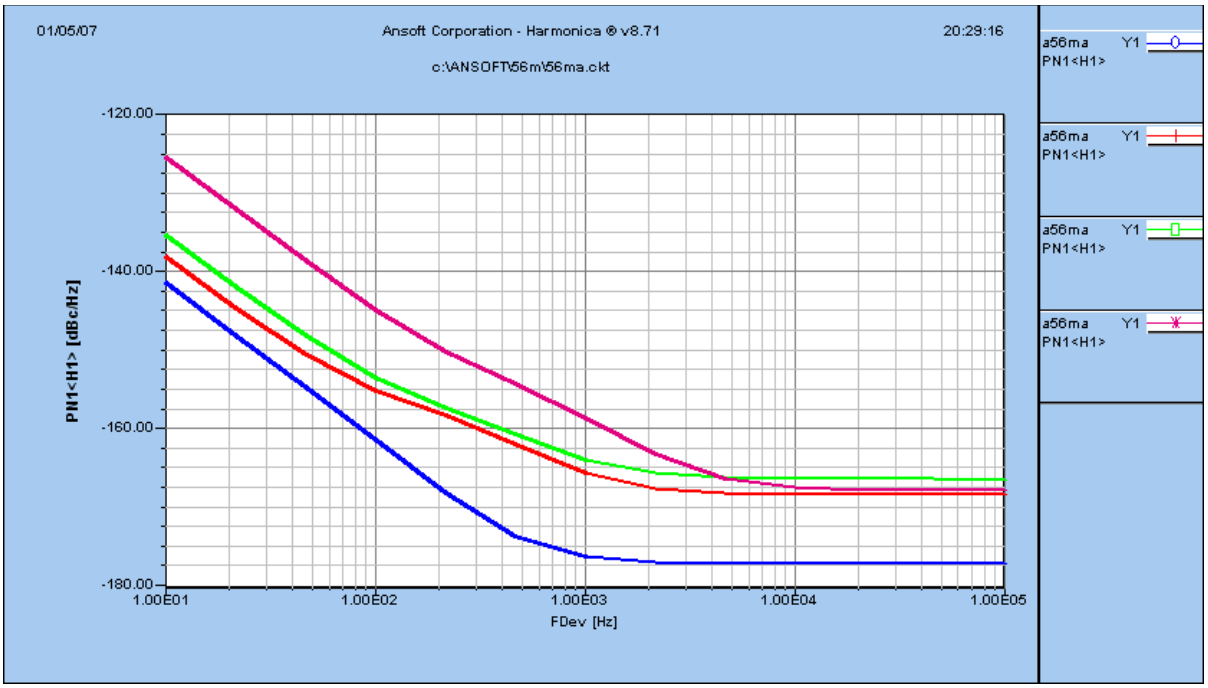


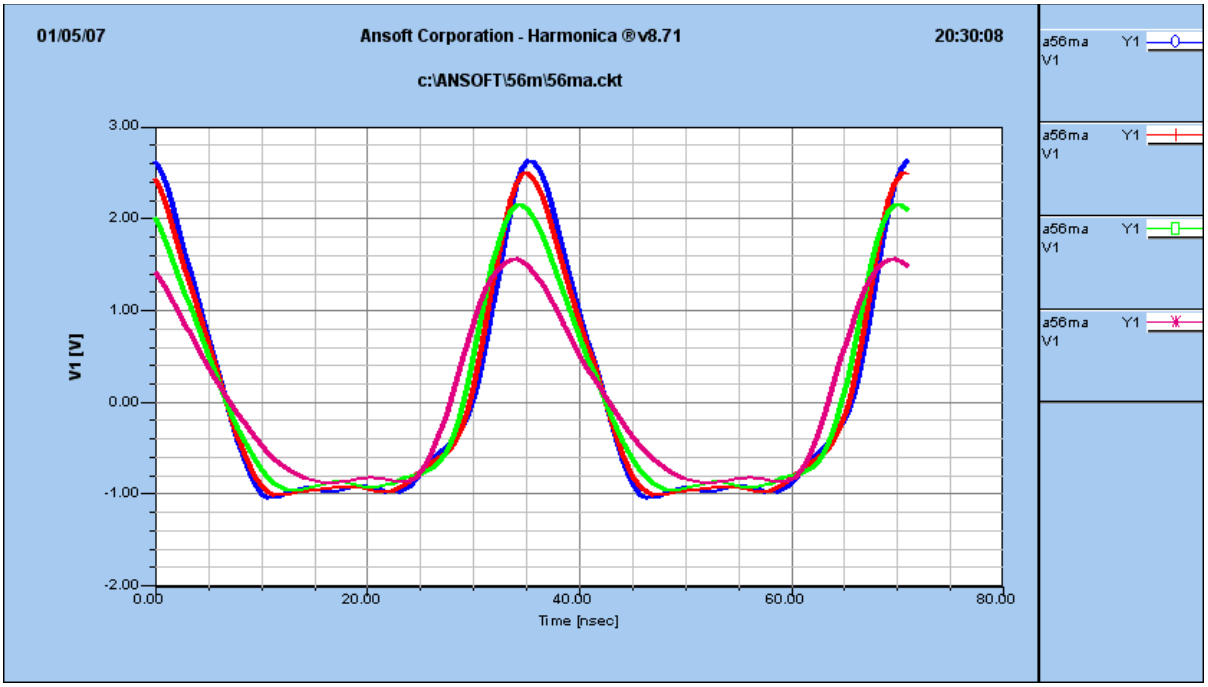
Output spectrum with LP C6=330 pF L2=220nH C7=220pF



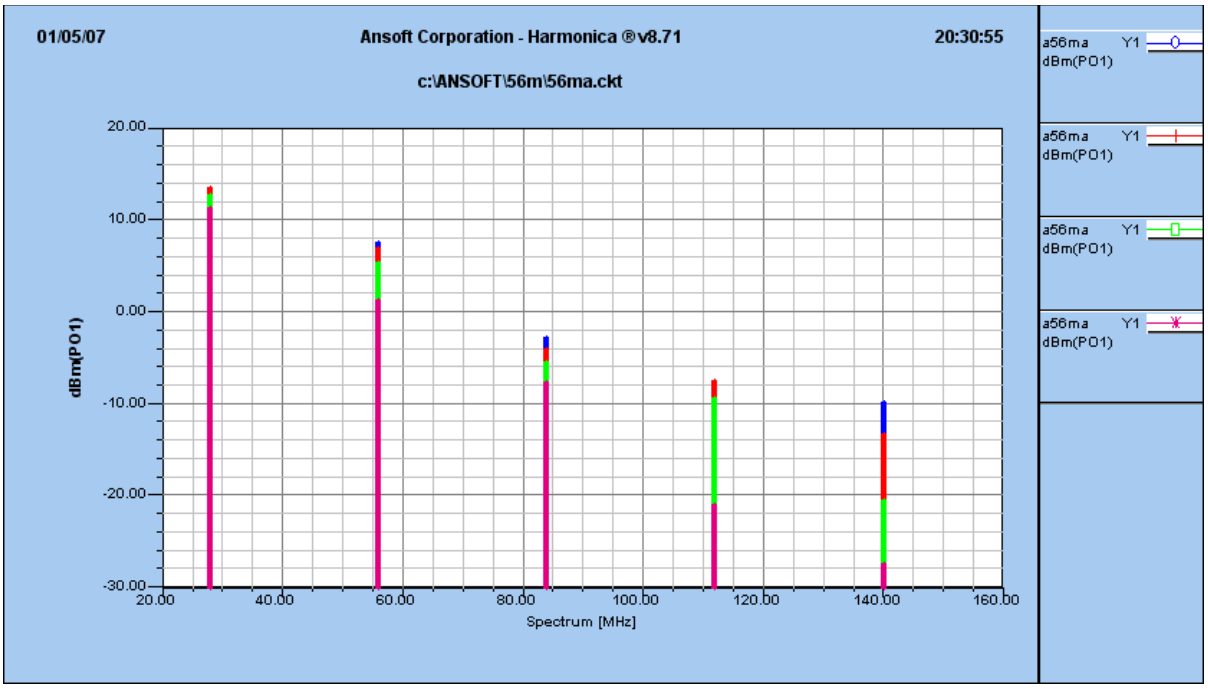
Output spectrum with LP

I changed feedback values in Colpitts 28 MHz oscillator to obtain higher output power. Phase noise change starting from Qo=80000(blue) to 20000(pink) trace in 20 000 steps.
Feedback capacitors are C1=150 pF and C2=68 pF oscillator phase noise



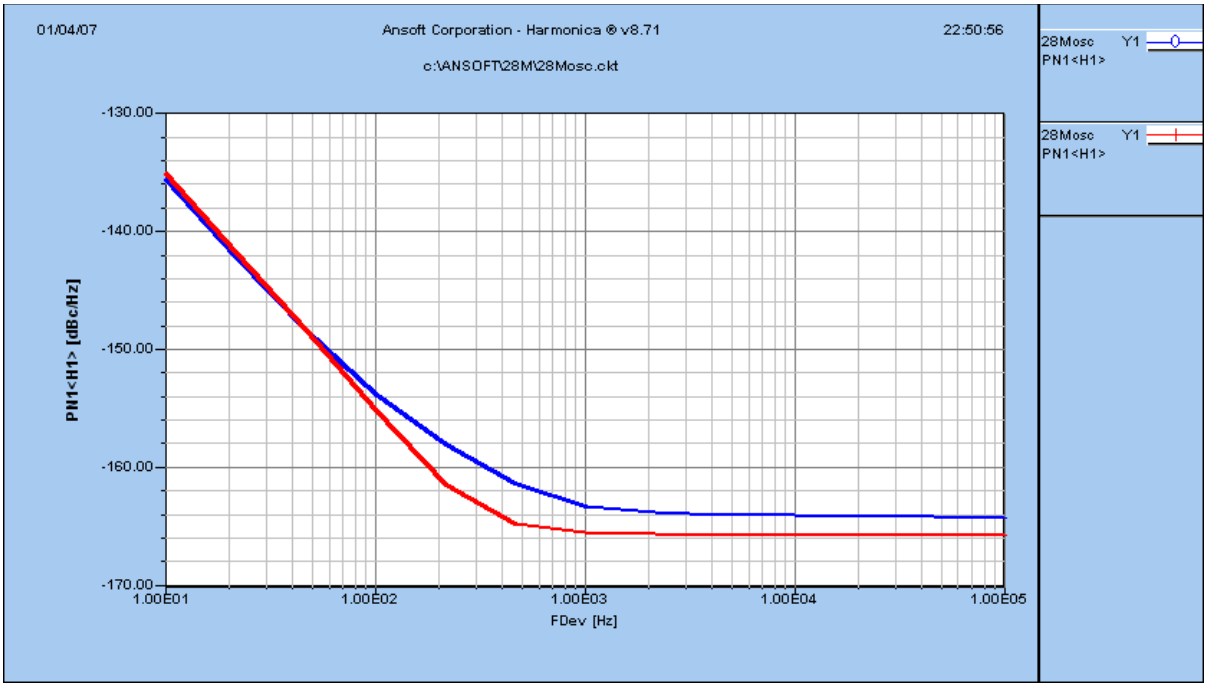


Output waveform changes with Qo change without LP at output

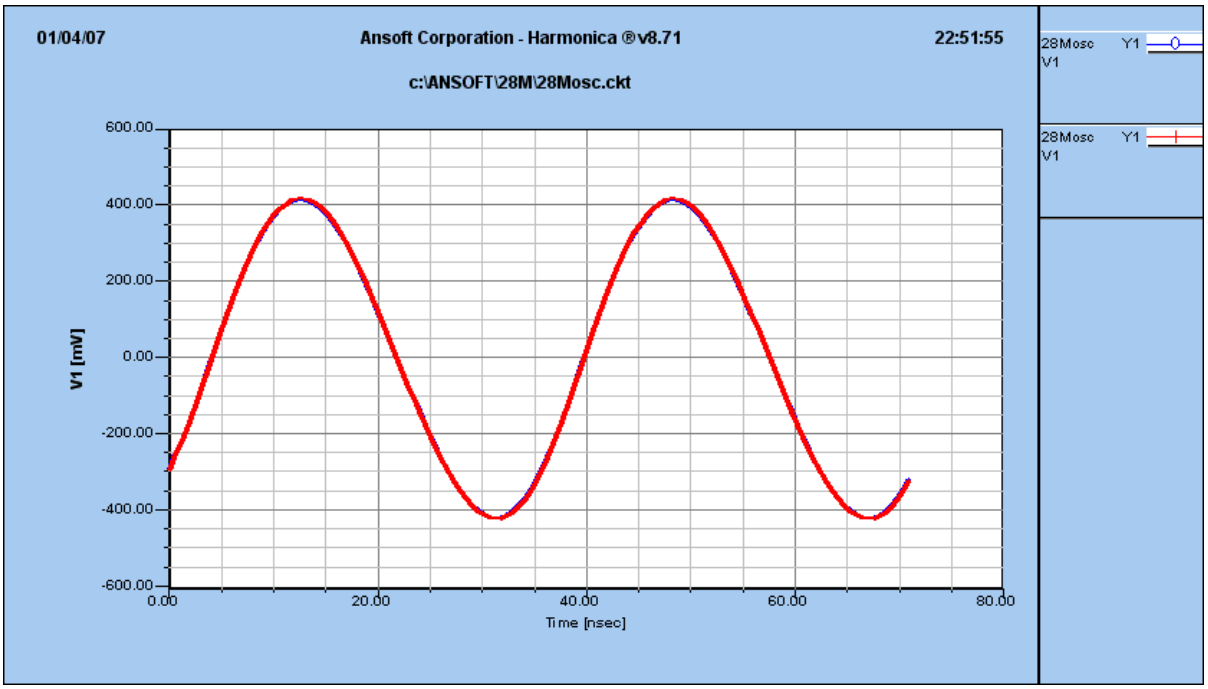


Output spectrum with out LP filter at output

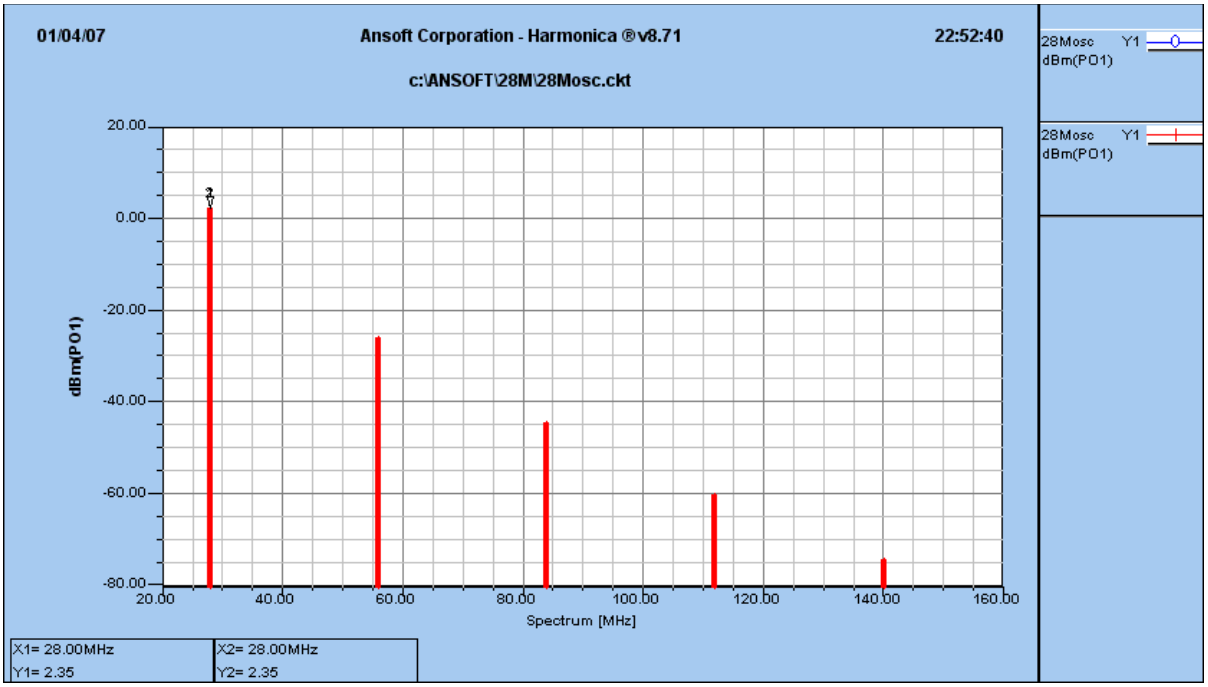
Clapp Guriout OSC 28 MHz with LP



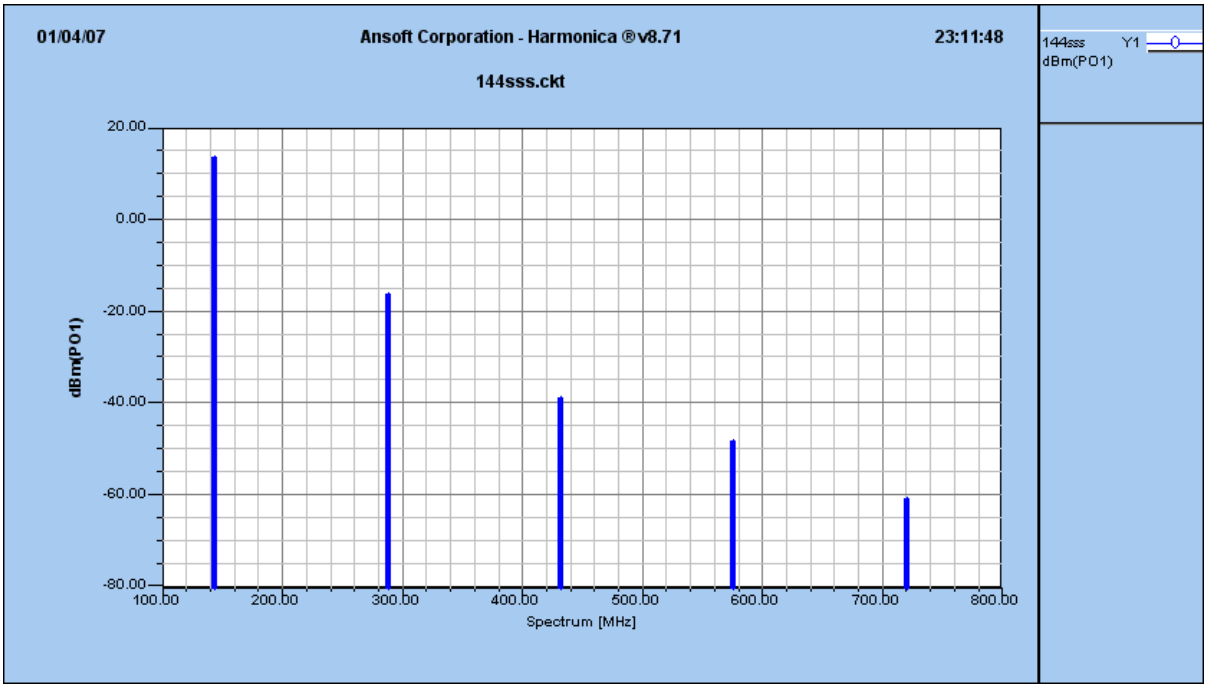
Red line is 28 MHz oscillator with switching diodes



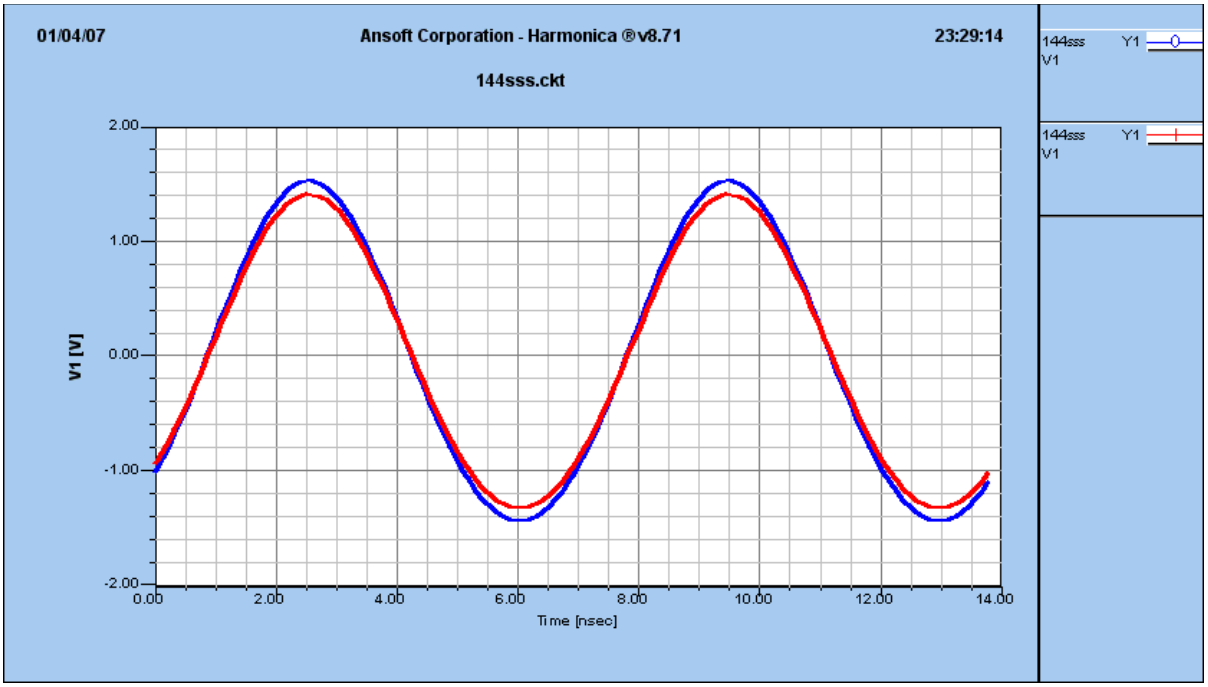
Output waveform with LP(low pass)



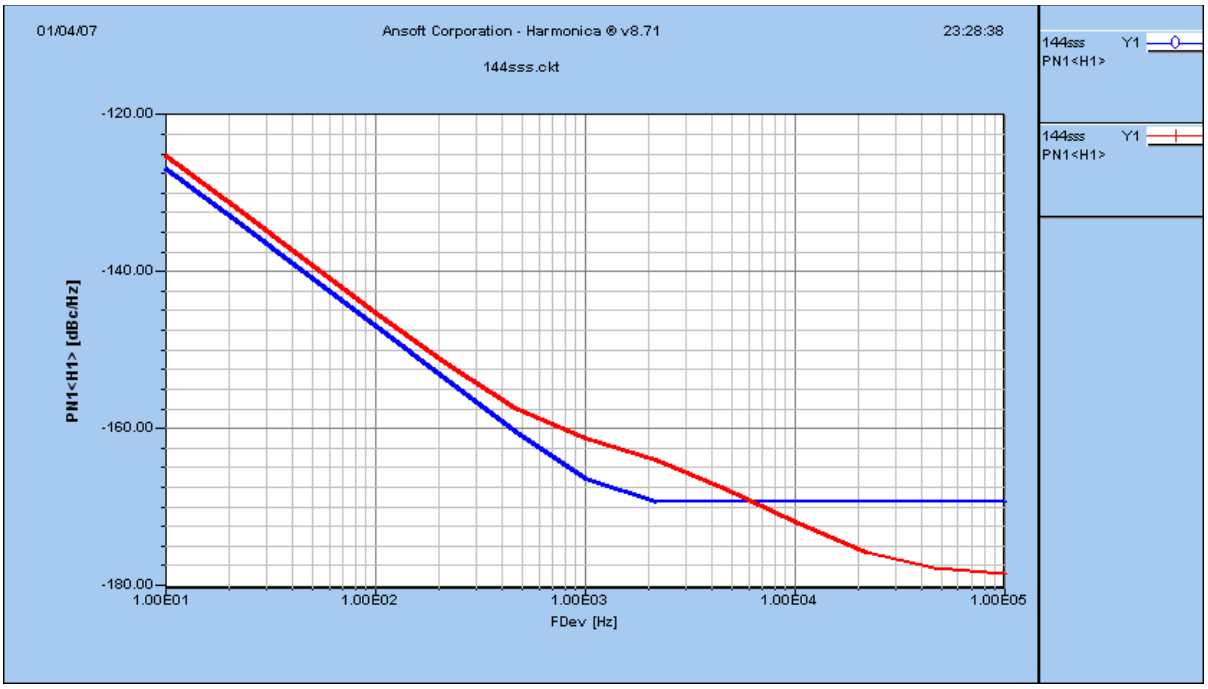
7 th overtone 144 MHz Clapp- Guriout oscillator with xtal Qo=75000 C1=33pf C2=33pf L1=80 nH LP C6=82pF L2=30nH L7=56 pF



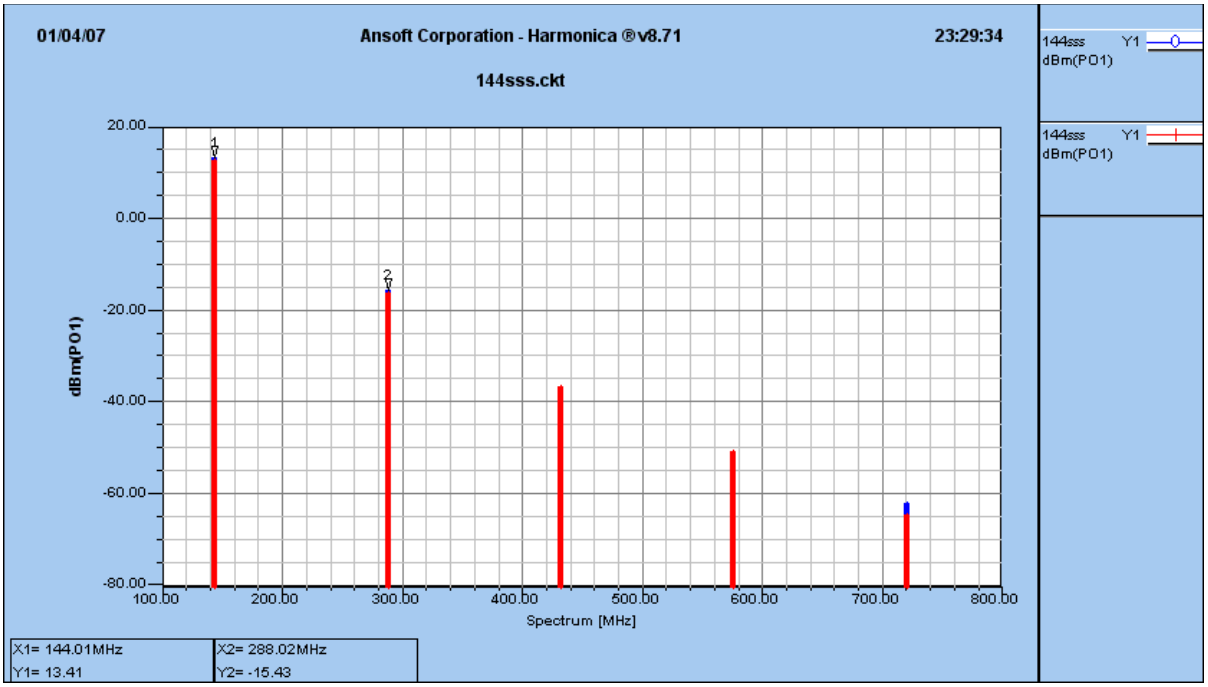
Output spectrum

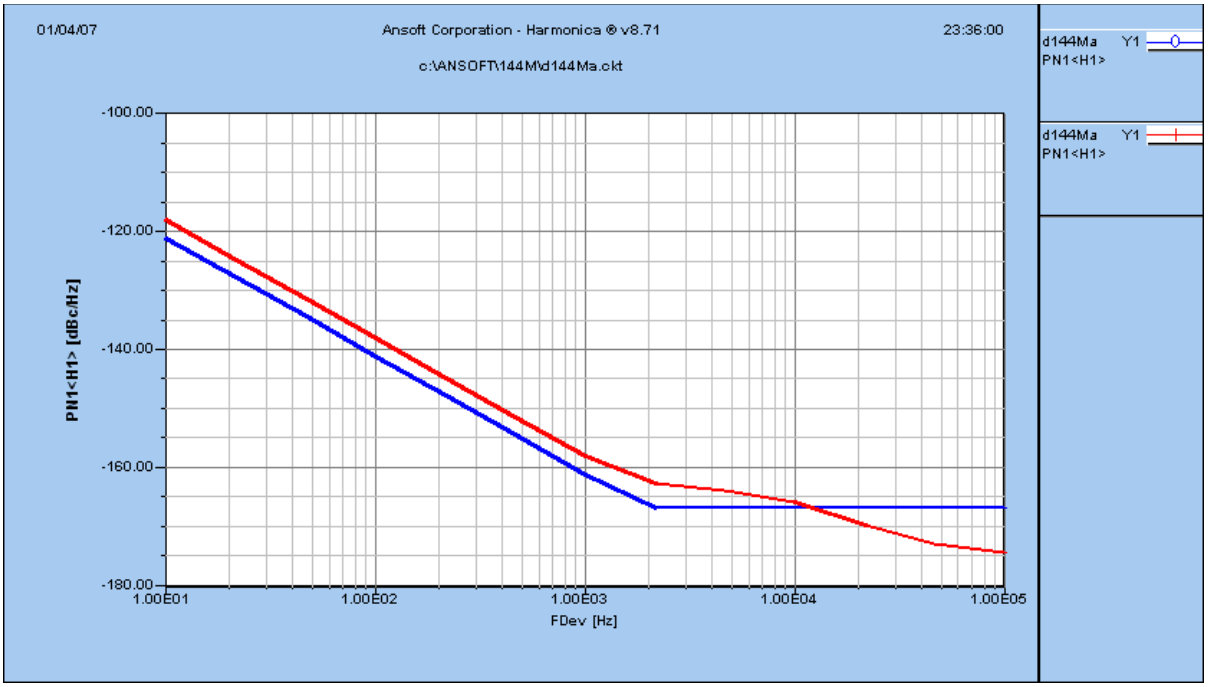


Output waveform

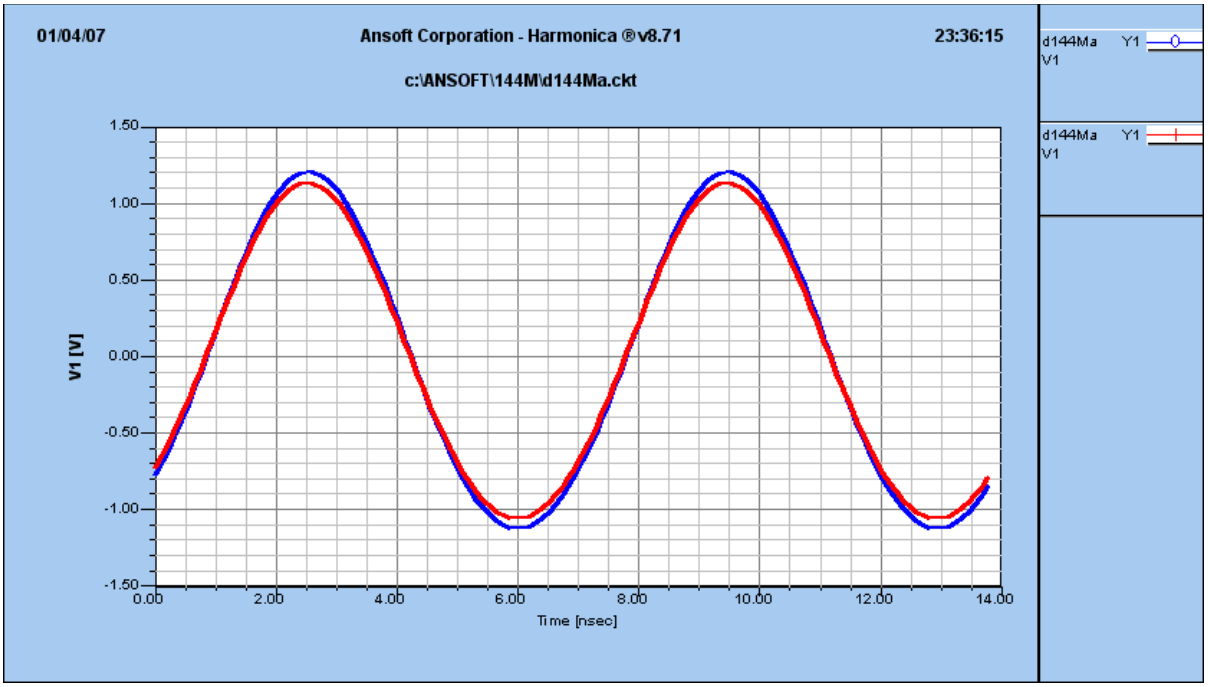


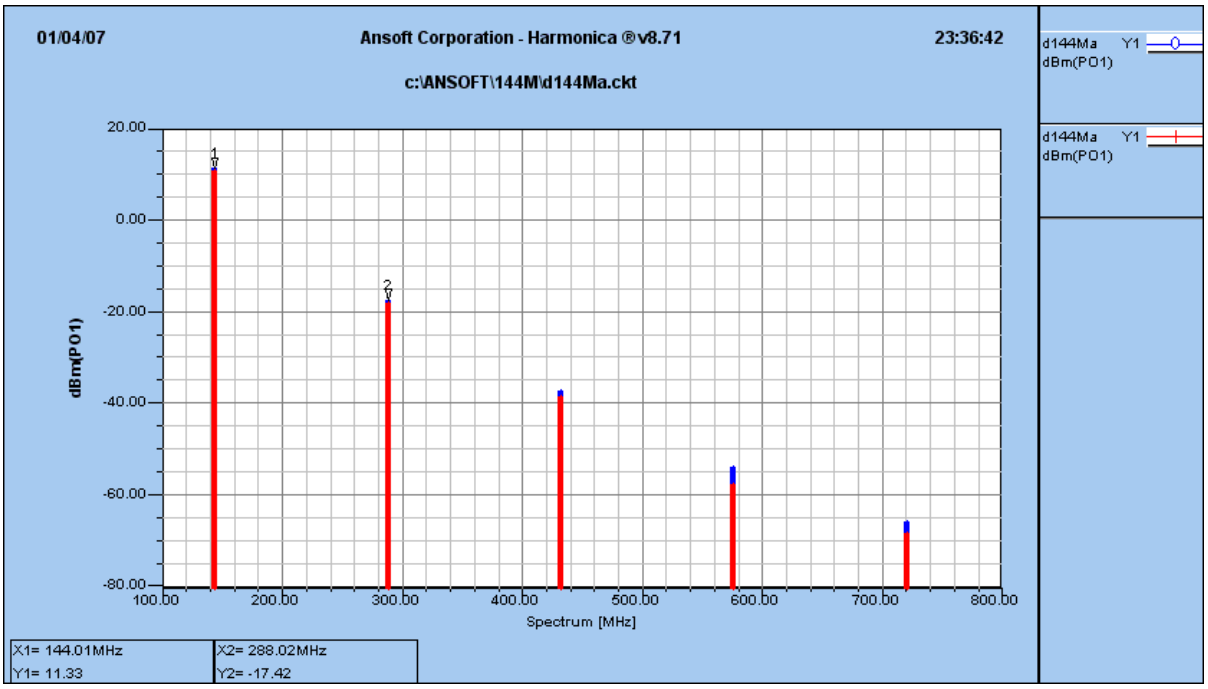
Oscillator phase noise 144 MHz XTAL Qo=40000 C1=33pf C2=33pf L1=80 nH LP C6=82pF L2=30nH L7=56 pF



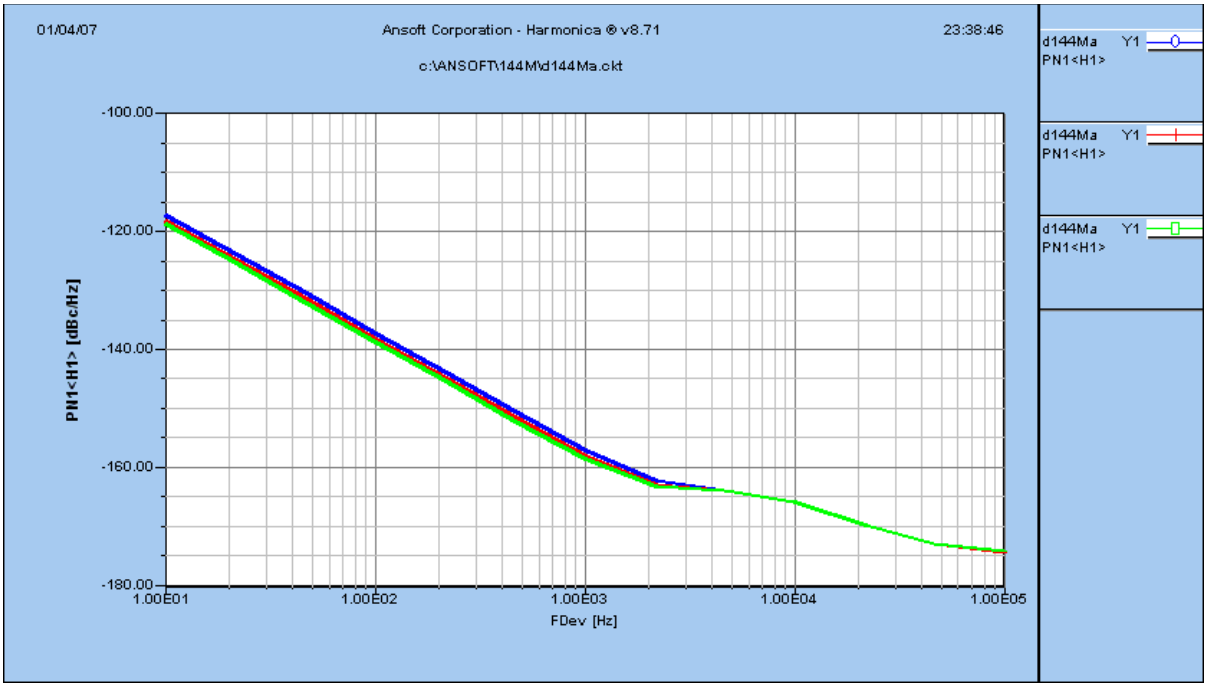


Oscillator phase noise without switching (blue) and with switching diodes (red)

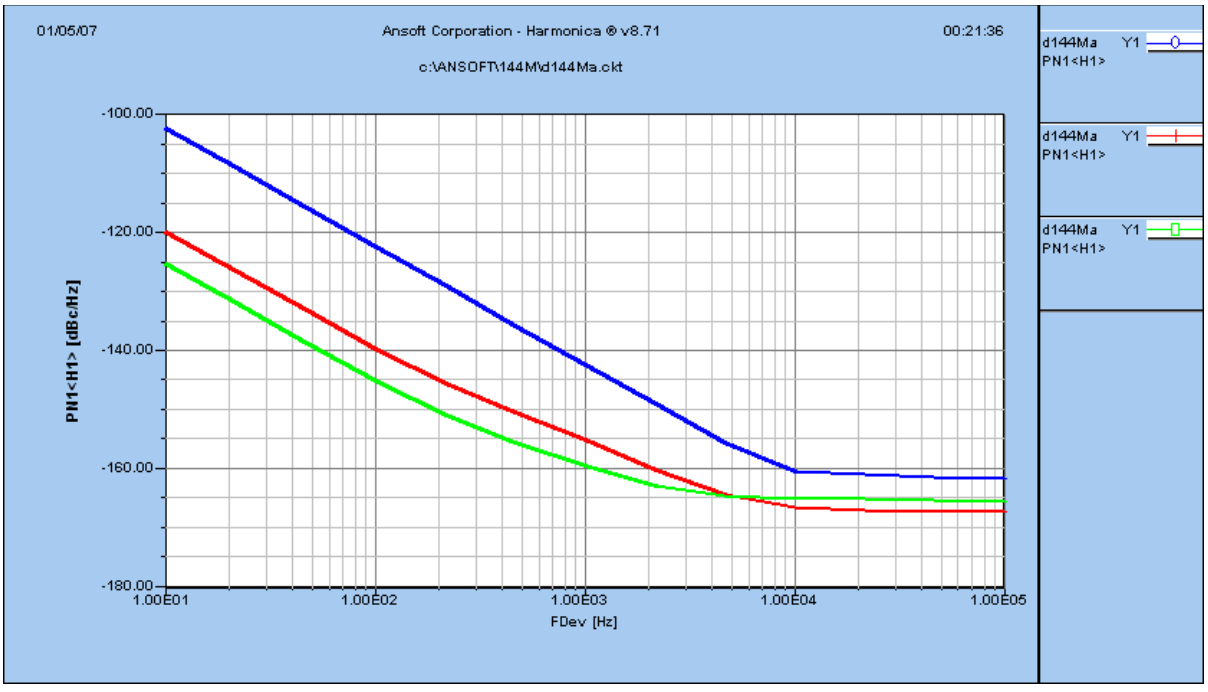




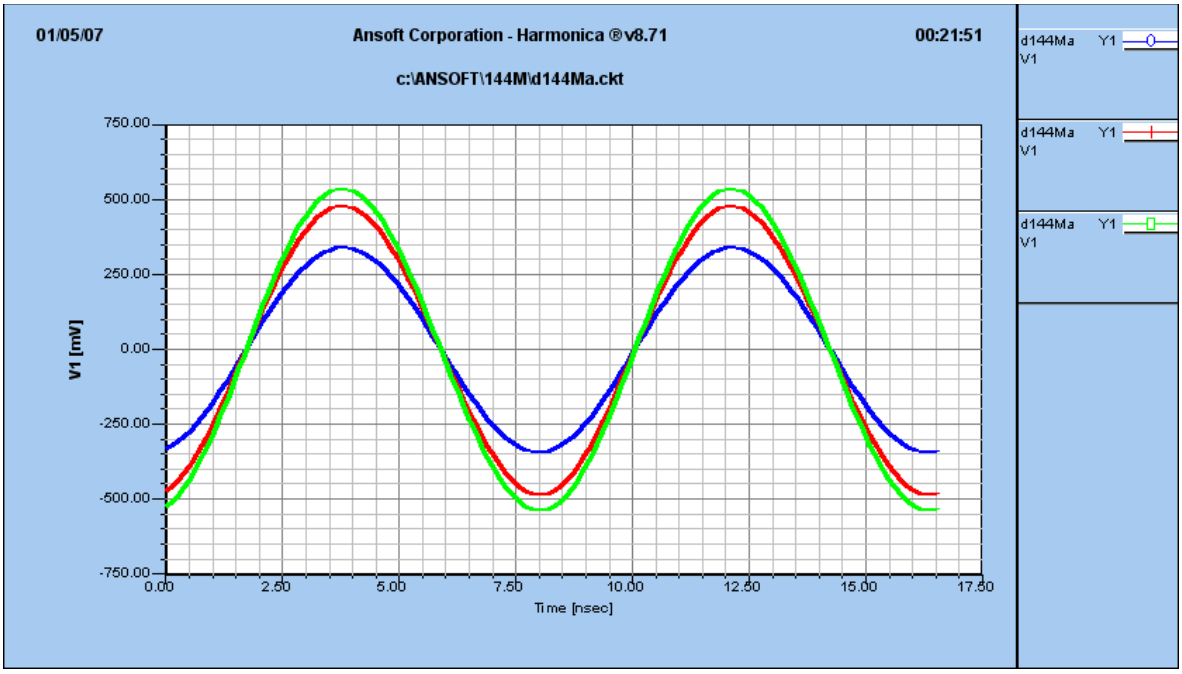
Phase noise with L1=70(blue), 80, 90 (green) nH respectively



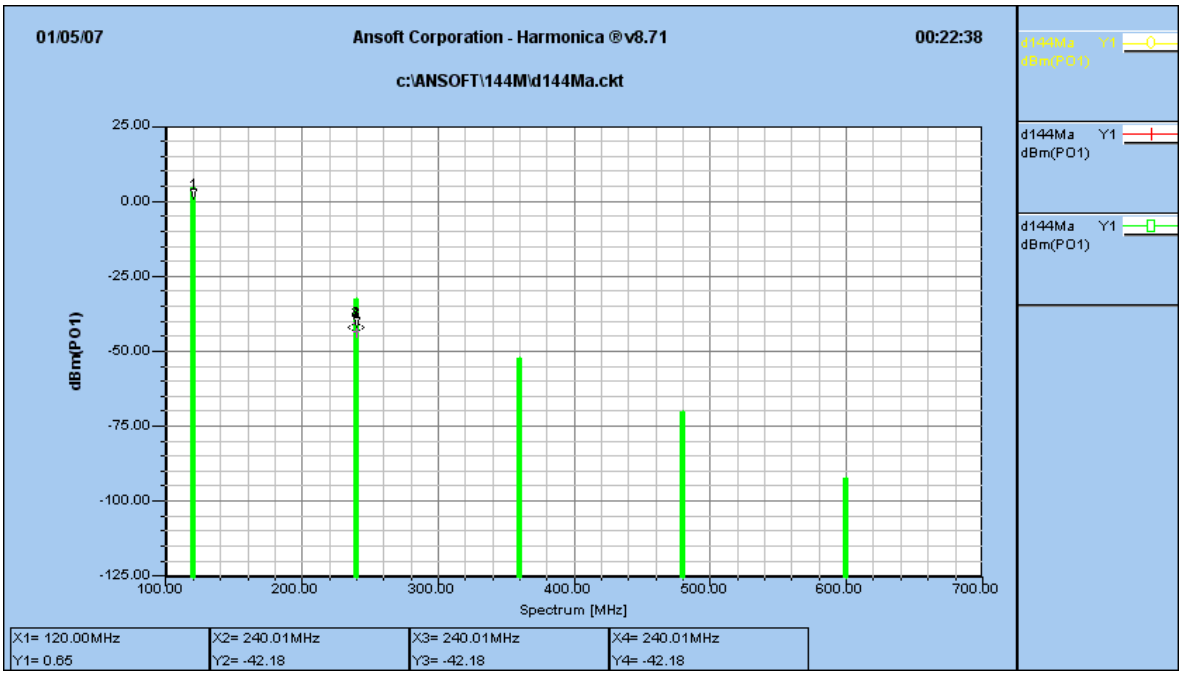
REF OSC 120 MHz Qo=40000(blue) 60000(red) 80000 (green) C1=39pf L1=150 nH(q=120) 9 turns self supported coil ID=5 mm length 10 mm Cu=1 mm Qo=118 C2=39 pF and LP C6=100pF L2=40 nH C7=68 pF (L1=100 nH Qo=70 blue 120 red 200green)



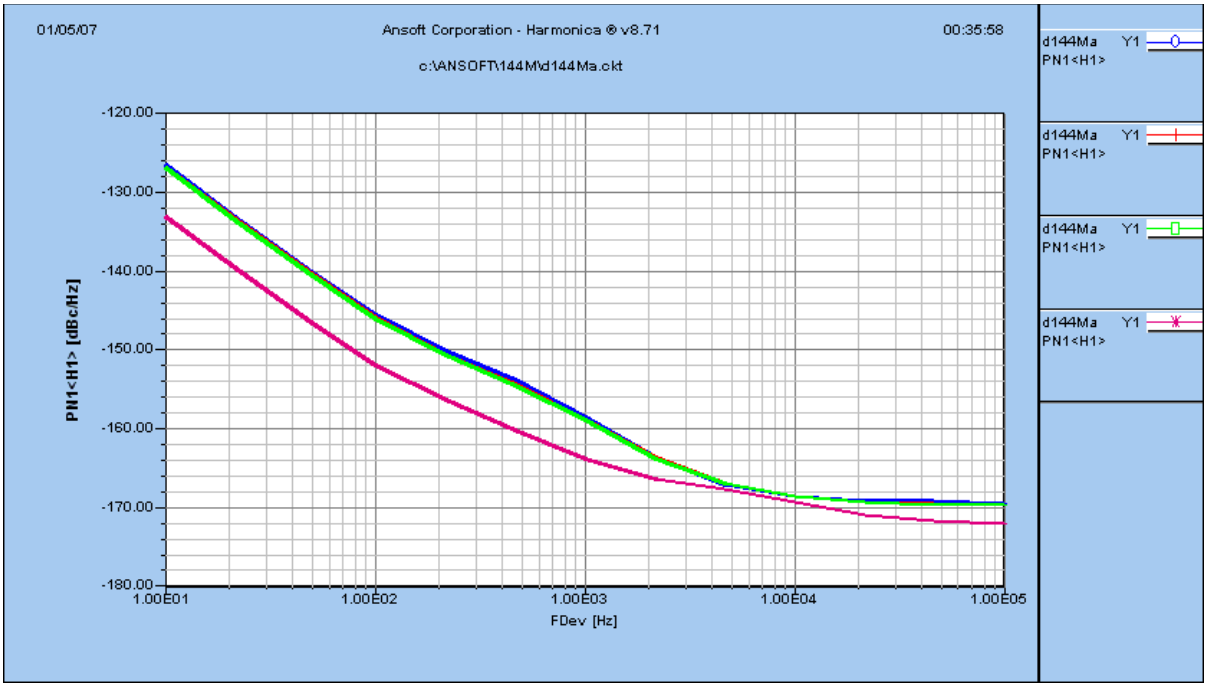
Oscillator phase noise



Output waveform for different xtal Qo



Clapp-Guriett oscillator 56MHz Qo=50000 red Qo=80 000 C1=68pF L1=330nH C2=68 pF LP C6=220pF L2=80nH C7=150Pf


01/05/07
Ansoft Corporation - Harmonica ® v8.71
00:35:58
c:\ANSOFT\144M\d144Ma.ckt
-120.00
-130.00
-140.00
-150.00
-160.00
-170.00
-180.00
PN1<H1> [dBc/Hz]
1.00E01
1.00E02
1.00E03
1.00E04
1.00E05
FDev [Hz]
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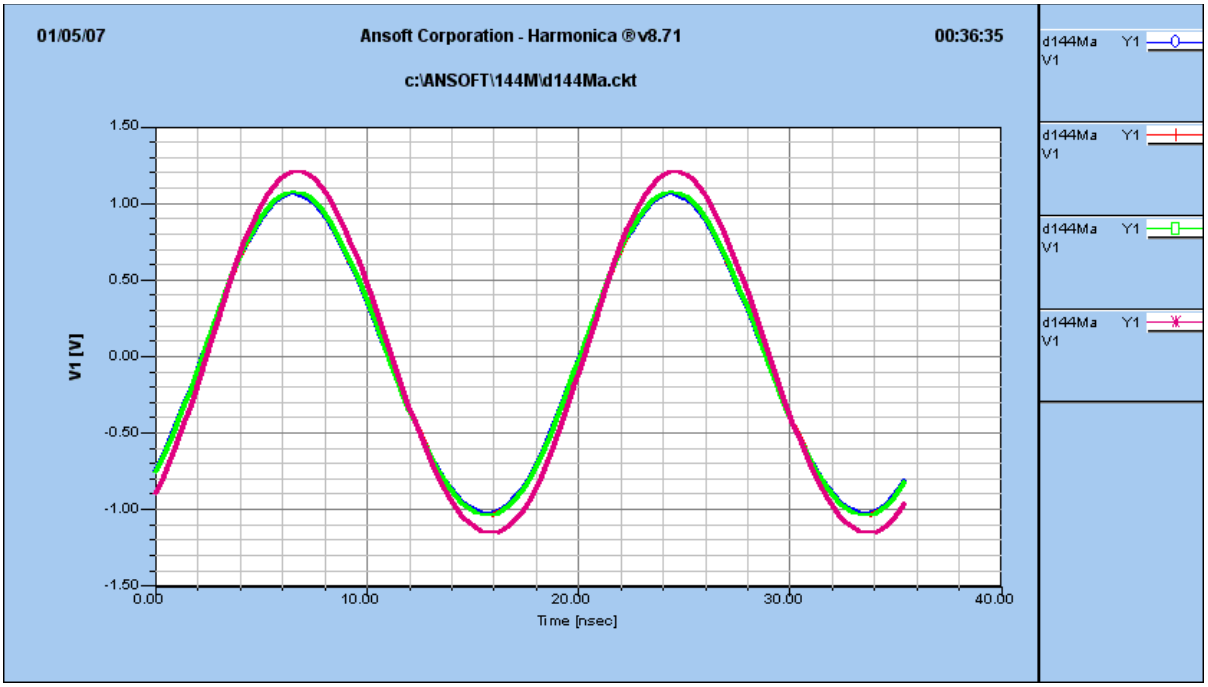
01/05/07
Ansoft Corporation - Harmonica ® v8.71
00:36:35
c:\ANSOFT\144M\d144Ma.ckt
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
V1 [V]
0.00
10.00
20.00
30.00
40.00
Time [nsec]
d144Ma Y1
V1
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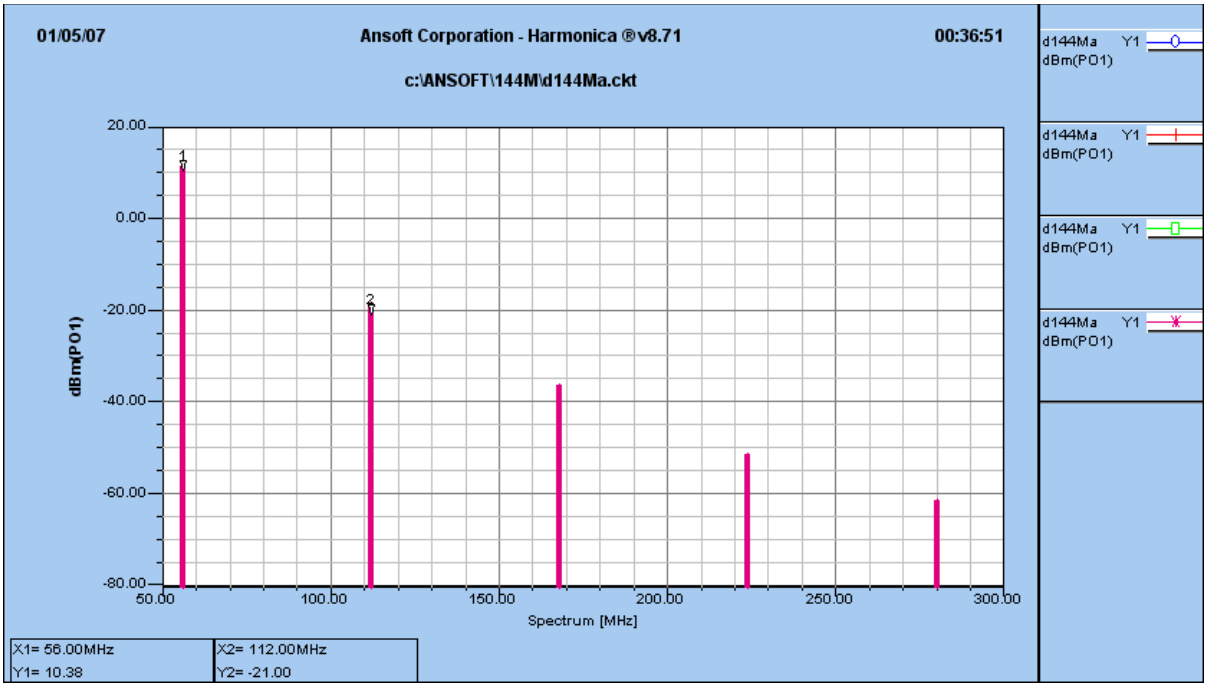
V1
d144Ma Y1
V1
d144Ma Y1
V1



I made great effort to make different projects and share them with all who are interesting for. Anyway send me your comments positive or negative, results or photos of your realization please.

VY 73/72 and GL in homebrew Tasa YU1LM/QRP
tasa@imtel-mikrotalasi.co.yu
stasic@eunet.yu

References:

1. ANSOFT Serenade ver 8.7 and SV8.7 (freeware)
2. Design of Crystal and Other Harmonic Oscillators-Benjamin Parzen
3. Oscillator Design & Computer simulation-Randall Rhea
4. Microwave And Wireless Synthesizers-Theory and Design-Ulrich Rohde
5. Frequency Synthesizers Design Handbook –James Crawford
6. Low Noise VHF Crystal Oscillators-Gerhard Hoffmann DK4XP-Dubus 4/2000