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

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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.

Oscillator transistors have very high $F_t$ 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.

HF(2-30 MHz) COLPITTS OSCILLATOR WITH BUFFER STAGE
Schematics for Clapp-Guriett and Colpitts oscillator with switching possibility

CLAPP-GURIETT OSCILLATOR WITH BUFFER STAGE

CLAPP-GURIETT OSCILLATOR WITH BUFFER STAGE AND XTAL SWITCHING

COLPITTS OSCILLATOR \( f = \leq 30 \text{ MHz} \) WITH BUFFER STAGE, LOW PASS AND XTAL SWITCHING
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

LO OUTPUT
SMB/SMA

Plo>=10 dBm
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
I changed feedback values in Colpitts 28 MHz oscillator to obtain higher output power. Phase noise change starting from $Q_0=80000$ (blue) to $20000$ (pink) trace in 20 000 steps.

Feedback capacitors are $C_1=150 \, \text{pF}$ and $C_2=68 \, \text{pF}$ 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
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=39 pf 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=100 pF L2=40 nH C7=68 pF (L1=100 nH Qo=70 blue 120 red 200 green)

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
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

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