**07 – Experimental characterization of a tuned amplifier with variable tuning frequency**

18/11/2018 – Diego Tuzi – 50435 – diego.tuzi@studentmail.unicas.it

### Test and calibration of the tuned amplifier

Feed the amplifier with Vcc=12V, red (+) and black (-) bush.
Connect a "Vcontr" voltage, variable between 1V and 12V, by means of a crocodile clip.
Use the second section of the power supply as the "Vcontr" voltage.
Insert a resistor R4=5,6 kΩ between emitter and ground.
Close the feed-back loop by inserting the "Retro" jumper.
Connect the BNC connector to the oscilloscope by a BNC cable.

Set Vcontr=0V and measure the oscillation frequency. Trim the inductor in such a way to obtain an oscillation frequency below 98.7MHz.

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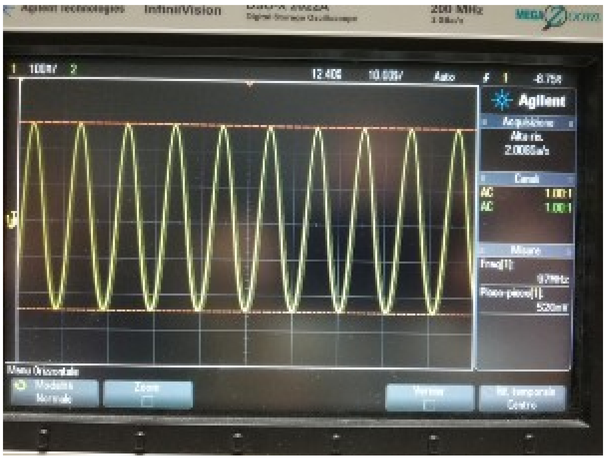
|---|---|
|  |  |
| **Power supply**<br>Vcc=12V; Vcontr=0V | **Oscilloscope**<br>Frequency=97MHz; Amplitude 520mV |

Set Vcontr=10V and verify that the oscillation frequency is larger than 118.7MHz. If this is not true regulate the values of T1, C4 e C5 in such a way to obtain an oscillation frequency close to 118.7MHz.

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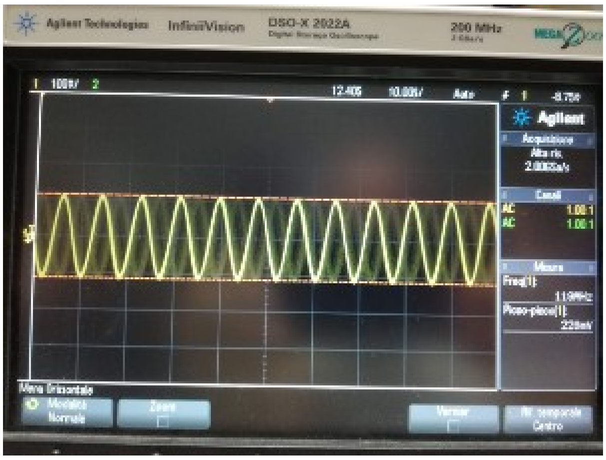
|  |  |
| **Power supply**<br>Vcc=12V; Vcont=12V | **Oscilloscope**<br>Frequency=120MHz; Amplitude=230mV |

Open the feed-back loop by removing the "Retro" jumper.
Measure the frequency response between the "in" lead (on R4) and "TPout" by means of the "network analyzer". Note: do not forget to perform the instrument calibration before performing the measurement.

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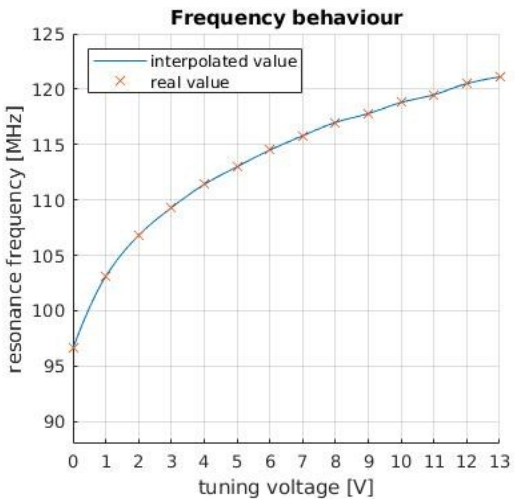
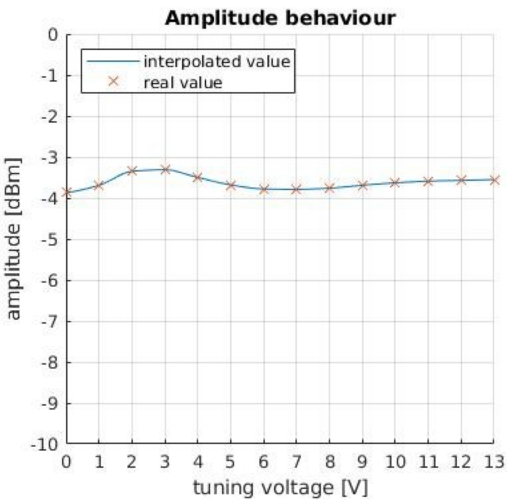
| | |
|---|---|
|  |  |
| **Network analyzer**<br>Vcc=12V; Vcont=0V<br>Source amplitude=0 dBm<br>Selective behaviour with center frequency at 96.6 MHz<br>Amplitude at center frequency=-3.87 dBm | **Network analyzer**<br>Vcc=12V; Vcont=9.1V<br>Source amplitude=0 dBm<br>Selective behaviour with center frequency at 118.1 MHz<br>Amplitude at center frequency=-3.61 dBm |

Note: the misured gain is very low because of impedance mismatch between circuit and instrument.

Measure the frequency and the peak amplitude of the output voltage for the control voltage varying from 0.0V-13V, with 1V step. Report results on an x-y plot.




Use the “network analyzer” for acquiring data regarding the resonance waveforms at f=98MHz and f=118MHz. Measure Q of the circuit. Note: the measured value of Q is much lower than the one obtained with PSPICE because the input resistance of the “network analyzer” is 50Ω.

| **Measurement n.1** | **Measurement n.2** |
|---|---|
| Vcc=12V<br>Vcont=0,2V<br>Center Frequency=97,8 MHz<br>Gain=-3,84<br>Bandwidth=2,8 MHz<br>**Q=34,9** | Vcc=12V<br>Vcont=9,1V<br>Center Frequency=108 MHz<br>Gain=-3,65<br>Bandwidth=5,6 MHz<br>**Q=21,1** |

**Verification and tuning of the local oscillator (LO)**

Close the feedback loop using the jumper “Retro”.

Set Vcontr to 0V. Measure amplitude and frequency of the output signal with the oscilloscope and verify that this oscillation frequency is lower than 98MHz.

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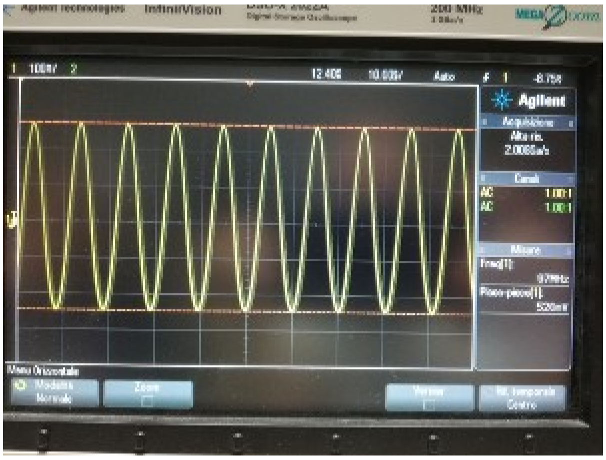
<td>
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</tr>
<tr>
<td>Power supply<br>Vcc=12V; Vcontr=0V</td>
<td>Oscilloscope<br>Oscillation frequency=97MHz; Amplitude 520mV</td>
</tr>
</table>

Set Vcontr to 13V, measure amplitude and frequency of the output signal and verify that it is larger than 118MHz.

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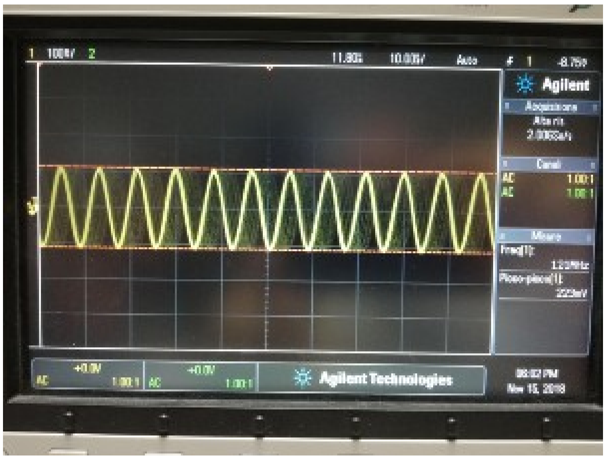
<td>
</td>
</tr>
<tr>
<td>Power supply<br>Vcc=12V; Vcont=13V</td>
<td>Oscilloscope<br>Oscillation frequency=121MHz; Amplitude=226mV</td>
</tr>
</table>

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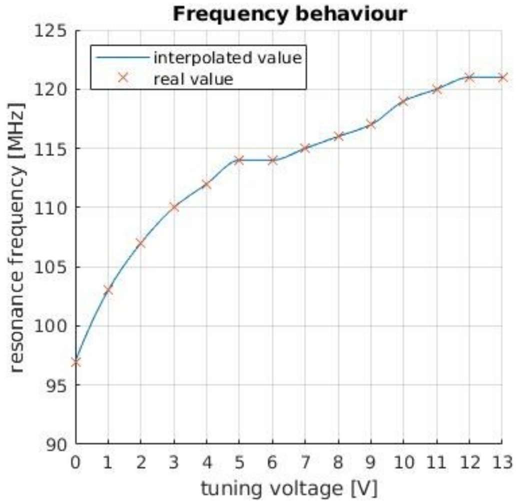
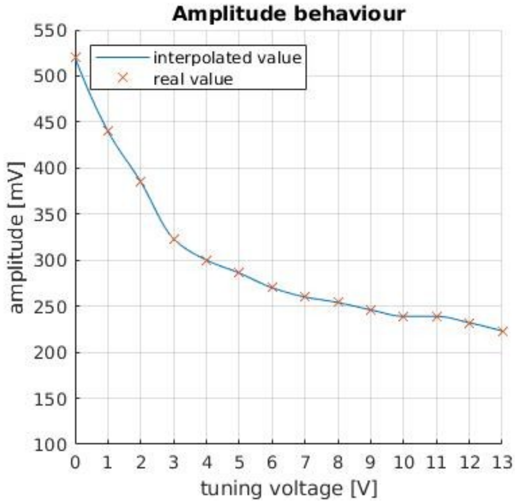
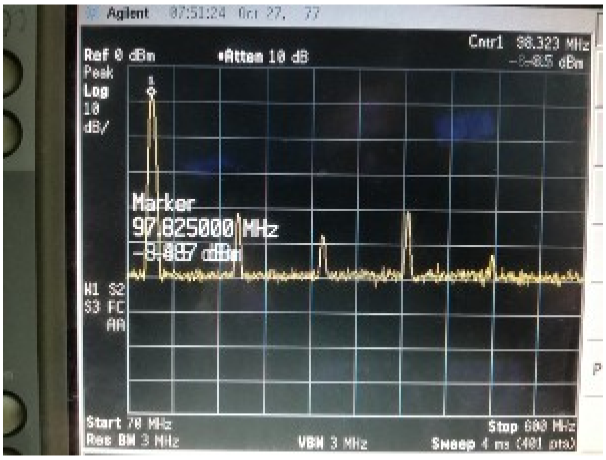
Measure amplitude and frequency of the output signal varying Vcontr in the range 0V-13V, with 1V step. Report data on an x-y plot.



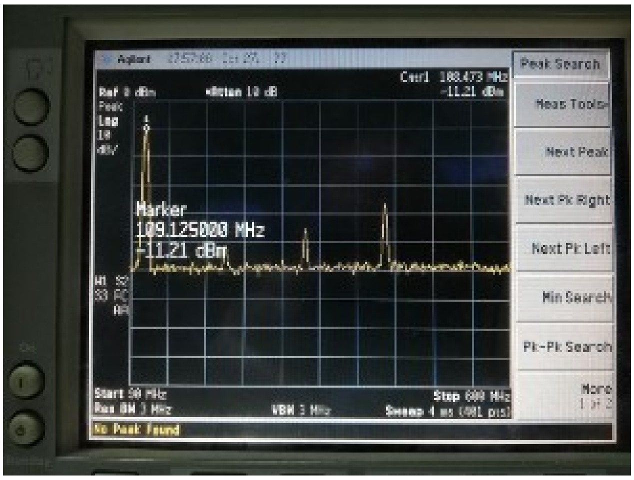




Disconnect the oscilloscope and connect the Spectrum analyzer.
Measure the spectrum of the output signal up to the 5th harmonic for values of the frequency f=98MHz and compute the THD (total harmonic distortion).




| Harmonic (number) | Frequency (MHz) | Amplitude (dBm) |
|---|---|---|
| 1st | 97.80 | -8.50 |
| 2nd | 197.20 | -41.30 |
| 3rd | 295.10 | -47.00 |
| 4th | 393.00 | -40.00 |
| 5th | 491.50 | -55.00 |
| **THD (%) = 3.74** | | |

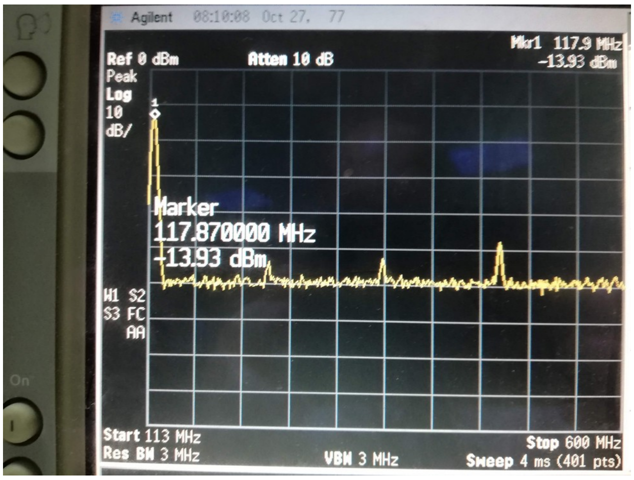
Measure the spectrum of the output signal up to the 5th harmonic for values of the frequency f=108MHz and compute the THD (total harmonic distortion).




| Harmonic (number) | Frequency (MHz) | Amplitude (dBm) |
|---|---|---|
| 1st | 108.37 | -11.10 |
| 2nd | 217.00 | -51.00 |
| 3rd | 326.10 | -46.00 |
| 4th | 433.75 | -37.00 |
| 5th | 542.30 | -69.00 |

**THD (%) = 5.48**

Measure the spectrum of the output signal up to the 5th harmonic for values of the frequency f=118MHz and compute the THD (total harmonic distortion).



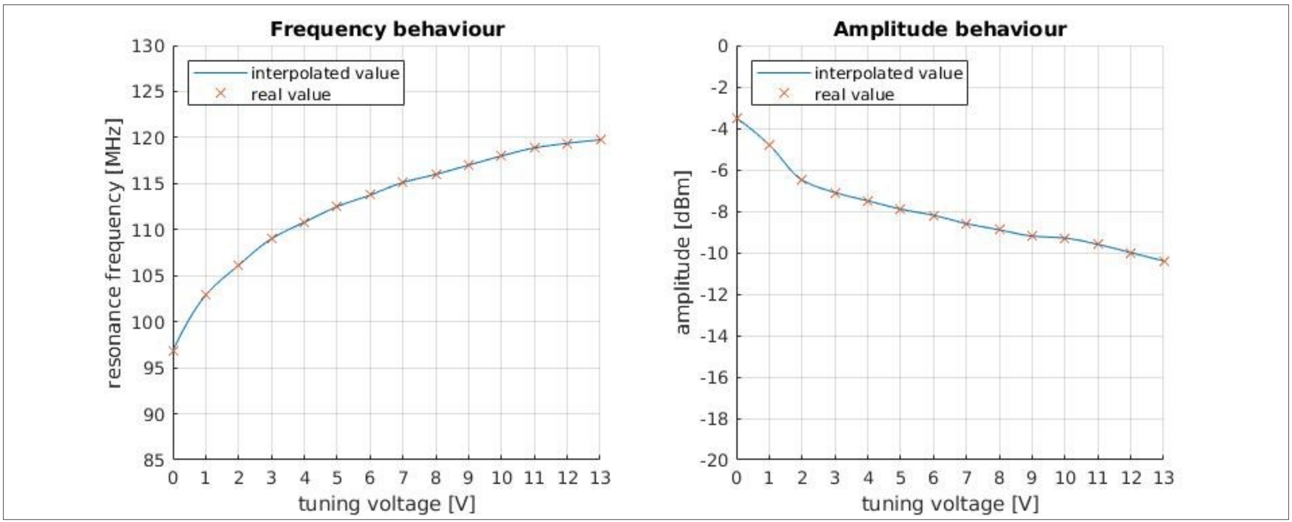

| Harmonic (number) | Frequency (MHz) | Amplitude (dBm) |
|---|---|---|
| 1st | 118.00 | -13.00 |
| 2nd | 235.00 | -55.00 |
| 3rd | 354.00 | -54.00 |
| 4th | 473.00 | -48.00 |
| 5th | 590.00 | -63.00 |

**THD (%) = 2.17**

**Analysis of the dependence LO parameters from the biasing point**

Change the BJT bias point inserting R4=3.3kΩ on the emitter.

Measure amplitude and frequency of the output signal varying Vcontr in the range 0V-13V, with 1V step. Report data on an x-y plot.

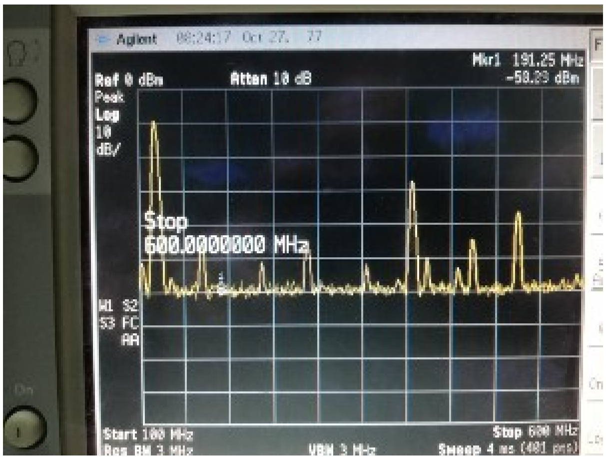



Disconnect the oscilloscope and connect the Spectrum analyzer.

Measure the spectrum of the output signal up to the 5 th harmonic for three values of the frequency, namely f=98MHz, 108MHz and 118MHz. Compute the THD in the three cases.

| *f=98MHz* | | |
|---|---|---|
| Harmonic (number) | Frequency (MHz) | Amplitude (dBm) |
| 1st | 98.00 | -3.70 |
| 2nd | 196.80 | -33.00 |
| 3rd | 295.65 | -43.00 |
| 4th | 393.15 | -34.00 |
| 5th | 491.96 | -46.00 |
| **THD (%) = 4.78** | | |

| *f=108MHz* | | |
|---|---|---|
| Harmonic (number) | Frequency (MHz) | Amplitude (dBm) |
| 1st | 108.50 | -6.90 |
| 2nd | 216.60 | -49.00 |
| 3rd | 324.64 | -43.00 |
| 4th | 432.67 | -31.00 |
| 5th | 540.71 | -48.00 |
| **THD (%) = 6,54** | | |

| *f=118 MHz* | |
|---|---|
|   | Total harmonic distortion not available due to inter-modulation products. |

Change the BJT bias point inserting R4=47kΩ on the emitter.

| |
|---|
| No oscillation using R4= 47kΩ. Because of small gain, Barkhausen condition is not satisfied. |