CHARACTERISTICS OF PARAMETRIC AMPLIFICATION OF LOW-FREQUENCY REGIONS

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Abstract: We have carried out experiments about parametric amplification capacity at regions having low pumping frequency and characteristics of these regions. From then showed that parametric amplification could be determined at points corresponding to maximum and minimum voltage-pumping amplitudes of parametric resonance regions of some different points. These new amplification regions could have practical applications, especially in case of using low frequency pumping source.

As known that using a secondary resonance circuit (the contour I), which has the low resonance frequency f_{10}, can excited high-level parametric regions corresponding to roots among the ones of differential equation which contains time-varying parametric (Mathieu's equations, N = 1, 3, 5, 7, 9), [1,2]. In these cases (except the case of N = 1), the pumping frequency f_b is lower than the resonance one ($f_b < f_{20} = f_{th}$) and also lower than the signal frequency f_{th} many times. On the basis of experimental parametric modulus, we have carried out to measure parametric gain at the points neighboring self-exciting parametric regions having different frequencies.

The experimental circuit is shown in Fig. 2, [1]. The input signal has small value to make current source. Because the signal is non-directional (taken out from the same position, $U^{(1)}_{out}$, or $U^{(2)}_{out}$) and also due to the beat, the gain is measured by comparing the maximum output amplitude with pumping and without pumping. Although this measurement could be unable to affirm the accurate gain completely, it also showed the amplification characteristic of the parametric system.

Because the pumping amplitude at the down-threshold of the parametric generating region (U^N_b) is rather high, so there are frequency multiplying regions appeared among parametric generating regions. We had also checked to affirm that there is no parametric amplification at the thresholds of these frequency multiplying regions because non-linear effects of the varactors create high-level harmonics. That is also one feature to determine parametric exciting and amplifying regions.

Recognizing that there is parametric amplification under the down-threshold of the parametric generating regions N = 3, 5, 7, 9 corresponding to $f_b \approx (2/3)f_{20}$, $f_b \approx (2/5)f_{20}$, $f_b \approx (2/7)f_{20}$, $f_b \approx (2/9)f_{20}$, (f_{10} = 202 KHz, f_{20} = 694 KHz, E_0 = 0V, shown in Fig. 3, [1]), the gain under the down-threshold of all these regions had been measured when bias voltage is zero (E_0 = 0V).

In case of N = 3: the pumping frequency: f_b = 463 KHz, the pumping amplitude: U_b = 0.7V, the signal frequency: f_{th} = 695.9 KHz, the signal amplitude: U_{th} = 2.5 mV, the output amplitude: $U^{(2)}_{out}$ = 47.5 mV (taken out the contour II – Fig.2, [1]), the parametric gain: K = 19,

N = 5: f_b = 262 KHz, U_b = - 4.7db, f_{th} = 655.04 KHz, U_{th} = 2.5 mV, $U^{(2)}_{out}$ = 60 mV, K = 24,

N = 7, f_b = 179 KHz, U_b = 3.3db, f_{th} = 626.26 KHz, U_{th} = 2.5 mV, $U^{(2)}_{out}$ = 70 mV, K = 28,

N = 9, f_b = 137.2 KHz, U_b = 8.3db, f_{th} = 617.37 KHz, U_{th} = 2.5 mV, $U^{(2)}_{out}$ = 95 mV, K = 38.

Beside these regions (as the signal f_{th} changes), there are still some neighboring regions having effect of amplification. We need to study these regions carefully.

To compare had also measured the capacity of amplification of the region N = 1 under its down-threshold:

f_b = 404 KHz, U_b = -18.4db, f_{th} = 201 KHz, U_{th} = 4 mV, $U^{(2)}_{out}$ = 100 mV, K = 25.

With a two-contour parametric amplification system: $f_b \approx f_{10} + f_{20}$, $f_{th} \approx f_{20}$, having regeneration and no frequency transformation: $f_b = f_{10} + f_{20}$ = 896.2 KHz, U_b = 1.7db, $f_{th}^{(2)}$ = 710 KHz, $U_{th}^{(2)}$ = 3.25 mV, $U^{(2)}_{out}$ = 67.5mV, K = 20.

Under the threshold of the modulated region located at the left of the fifth region N = 5, the measured gain is:

f_b = 256 KHz, U_b = 9.8db, f_{th} = 647.18 KHz, U_{th} = 1.5 mV, $U^{(2)}_{out}$ = 150 mV, K = 100.

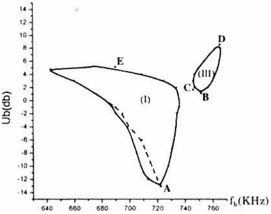

Fig.1. Studying the parametric amplification of the parametric regions N = 1 and N = 3

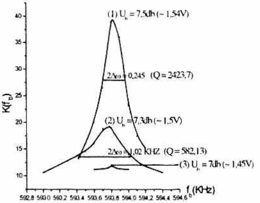

Fig.2. The amplification response $K(f_b)$ under the down-threshold of the region N = 5

In low Q-factor systems (Q_1 and Q_2 are about 40 ÷ 50 or lower), if the multiple-deviation coefficient $n = f_{20}/f_{10} > 3$, [2], the gain at points neighboring these regions was measured.

The third generating region, N = 3, is shown in the Fig.1. Realize that two regions N = 1 và N = 3 are far away about 15KHz.

Measured the gain K and the Q-factor of the region N = 1:

- Under its down-threshold: f_b = 721.6 KHz, U_b = -12.9db (about 0.15V), f_{th} = 366 KHz, U_{th} = 20 mV, K = 8, Q = 328.

- Upper its up-threshold: f_b = 690 KHz, U_b =5db (about 1.35V), f_0 = 365KHz, f_{th} = 350KHz, U_{th} = 2 mV, $U^{(1)}_{ra}$ = 32.5 mV, K = 16, Q = 328.

Also measured the gain K and the Q-factor of the region N = 3:

- Under its down-threshold: f_b = 751.9KHz, U_b = 1.1db(about 0.75V), $f_{th} \approx f_{20}$=1120KHz, U_{th} = 3 mV, K = 25, Q = 560.

- Neighboring the up-threshold: f_b =748.09KHz, U_b = 2db(about 0.85V), f_{th} =1120KHz, U_{th} = 0.35 mV, K = 17.

- Upper the up-threshold: f_b = 764.9 KHz, U_b = 8.4db (about 1.7V), f_{th} = 1150 KHz, U_{th} = 2 mV, K = 85, high-Q.

Realize that there is parametric amplification not only under the down-threshold of the parametric generating region N = 3 but also upper the up-threshold and neighboring this region. In such cases of the rather high pumping amplitude, it is necessary to determine the role of noise, from then the role of parametric amplitude at these points might be affirmed clearly.

With the fifth region N = 5, there is also parametric amplification similar to one of the region N = 3. Three curves $K(f_b)$ corresponding to different pumping amplitudes U_b ($U_b < U_b^N$ = 7.4db) are shown in the Fig. 2. When U_b approach to U_b^N, the gain increases (Q = 2423.7 - curve (1)), frequency band is narrow ($2\Delta f_b$ = 0.245 KHz).

A common phenomenon of these parametric regions is always to have beats when the K-factor is tuned to maximum. The beat frequency could be able to approach to zero as the case of incoherent reception of single parametric amplification.

Conclusions

* The parametric amplification can be realised at various regions, near N = 3, 5, 7 (under down-threshold , upper up-theshold and neighboring regions).

* When K-factor is tuned to maximum, it always have the beats (beat frequencies could be to approach to zero comme incoherent case)

* It can be used some low pumping frequencies for high signal, if f_{th} and f_b are tuned correctly.

References

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