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Research paper

Experimental Investigation of the LTC5553 Microcircuit in the Frequency Multiplication Mode

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Abstract

Mixer chips have wide functionality, which is not always declared by the manufacturer. The purpose of the experimental study is to prove the possibility of implementing a frequency multiplier based on the mixer chip LTC5553. An experimental study of the LTC5553 chip in the mode of frequency multiplication was performed 2, 4 and 6 times. The second harmonic transmission coefficient is not less than minus 17.25 dB, for the fourth harmonic not less than minus 35 dB, for the sixth harmonic - not less than minus 42.67 dB. The transmission power factor depends little on the input power. Recommendations for modes of using a mixer as a frequency multiplier are given.

Keywords: *Frequency multiplier, microwave frequencies, amplitude characteristic, spectrum of harmonics, multiplicity of frequency multiplication.*

1. Introduction

Frequency multipliers are the most important components of signal generation devices and radio transmitting devices (along with power amplifiers and master oscillators). They allow:
- increase frequency stability due to lowering the frequencies of the master oscillator;
- significantly expand the range of radio transmitter tuning with a smaller adjustment range of the master oscillator;
- increase the stability of the radio transmitter by loosening the feedback (in the frequency multiplier, the input and output circuits are tuned to different frequencies);
- increase the absolute frequency deviation for the frequency or phase during phase modulation. Finally, frequency multipliers allow to obtain harmonic oscillations in those frequency bands where their direct generation is for some reason difficult or impossible.

Due to the described properties, frequency multipliers are used in frequency synthesizers, heterodynes, reference frequency generators.

The principles underlying frequency multiplication are described in detail in monographs [1-6] and in articles for example in [7]. However, the appearance of a new element base stimulates further investigation of frequency multipliers. First of all, this applies to microcircuits of mixers of different firms. Indeed, mixer chips, as a rule, can perform a number of other functions not declared by the manufacturer. It has been experimentally proven that mixer ICs can perform functions such as frequency multiplication [8,9], amplitude and phase modulation, demodulation, synchronous detection. In 2017 a new microcircuit for the LTC5553 mixer from Linear Technologies is appeared [10,11]. The manufacturer in [10,11] describes in detail only the features of the functioning of the microcircuit as a mixer in the frequency range 3 ... 20 GHz. This determines the relevance of experimental studies to demonstrate the possibility of frequency multiplication based on the LTC5553 chip

2. . Results and Discussion

The LTC5553 is a passive dual balanced mixer with a range of input frequencies from 3 to 20 GHz and an intermediate frequency range of 5.5 to 9 GHz. The IP3 intercept point for it is 23.9 dBm at 14 GHz. The chip contains a buffer amplifier in the heterodyne path, which allows the mixer to be operated at a local oscillator power of 0 dBm. The mixer includes balancing transformers, so that all ports are matched with a 50 ohm impedance. The chip has a body size of 2x3 mm, powered by 3.3 V and consumes a current of 132 mA. It has an on / off input (EN) with a speed of 0.2 µs.

The experimental study of the frequency multiplier on the LTC5553 chip was carried out on an installation, the block diagram of which is shown in Figure 1.

The source of the input signal was an E8257D generator from Agilent Technologies. The error in setting the power level did not exceed ± 0.8 dB [12]. As a frequency, power and spectrum meter, there was a spectrum analyzer of the same firm type PXA. The error in measuring the level was ± 0.19 dB [12]. To reduce the noise component of the error, the bandwidth of the spectrum analyzer BW = 10 kHz was set.

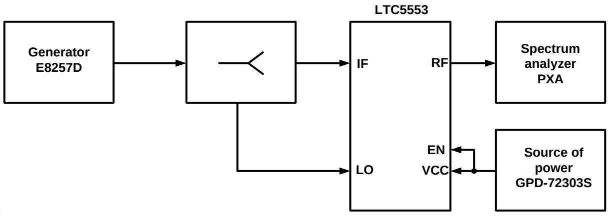

Fig. 1. Block diagram of a measuring installation with a equipotential power divider

At the output of the chip there was no constant component. This allowed directly connecting the chip to the input of the PXA spectrum analyzer. The source of power supply was the device type GPD-72303S. The power divider was the Tesla IDVB device with losses of 3 ... 3.5 dB.

A general idea of the spectrum of the output signal is provided by the photo from the spectrum analyzer screen in Figure 2. At the same time, a signal of 10 dBm

It is clearly seen that even harmonics have significantly more power than odd harmonics. Therefore, in the following experiment, the amplitude characteristics of only even harmonics were investigated experimentally.

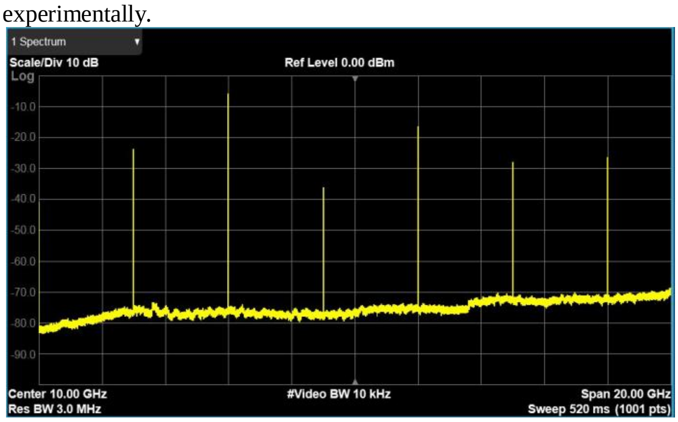

Fig. 2. Spectrum of the signal at the output of the frequency multiplier on the LTC 5553 chip with a power divider, at P_{in} = 10 dBm; f_{in} = 3 GHz.

3. Experimental

During the experiment, a signal with a frequency of 3 GHz and a power from minus 10 dBm to plus 10 dBm in 2 dB steps was applied to the input of the power divider.

According to the data of measurements, the graphs in Fig. 6 are plotted. It can be seen from them that the dependence of the output power almost linearly depends on the input power. This can be explained by the limitation of the signal in the heterodyne part of the LTC5553 chip. The multiplier transfer coefficient is almost constant in the range of the investigated capacities.

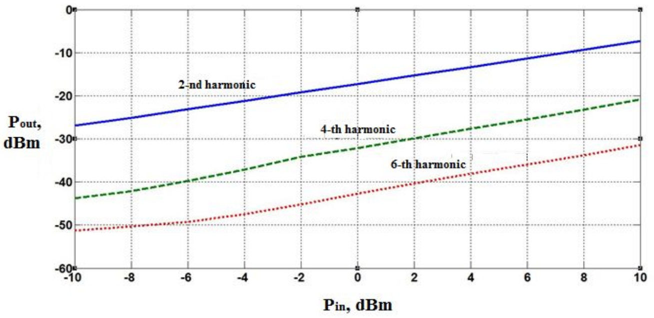

Fig. 3 - Amplitude characteristics in the mode of frequency multiplication for three even harmonics Divider of power is the equal-arms.

Figure 3 shows that the transmission coefficient for the second harmonic is at least minus 17.25 dB, for the fourth harmonic, is at least minus 35 dB, for the sixth harmonic, is at least minus 42.67 dB.

Suppression of unused harmonics of the input frequency should be carried out by high-pass bandpass filters with a wide band of stop-band (for example, comb filters).

The power transmission coefficient depends little on the input power, which is due to the presence of an amplifier-limiter in the heterodyne circuit of the LTC5553 chip.

Table 1 compares the frequency multiplier studied with the frequency multipliers of known manufacturers [13-18].

Table 1. Comparison of the investigated frequency multiplier with frequency multipliers of known foreign firms

Firm	Analog Devices (Hittite)		Mini-Circuits	
Type	HMC189 [13]	HMC188 [14]	KBA-40 [15]	KC-2-50 [16]
f_{in}	2-4	1,25-3	2,7-4,8	3,5-5
f_{out}	4-8	2,5-6	5,4-9,6	7-10
Losses, dB	13-17	16-19	12,3-19	12,5-16
Harmonic suppression, dB	33	35-50	8-18	8-20
P_{in}, dBm	15	20	10…16	7…12

Continuation of **Table 1**

Firm	M/A COM		Linear Technologies
Type	FD93 [18]	FDC2310 [19]	LTC5553 as multiplier by 2
f_{in}	2-9	1,5-8	1,5-9
f_{out}	4-18	3-16	3-18
Losses, dB	10-12	11-14,5	13
Harmonic suppression, dB	16-25	19-35	10
P_{in}, dBm	12	10	10

Table 1 shows that the multiplier studied has parameters comparable with the parameters of the frequency multipliers of known manufacturers [13-18]. The functionality of the investigated frequency multiplier is wider, since it allows us to distinguish the fourth and sixth harmonics of the input signal.

4. Conclusion

1. In some cases it is permissible to use the mixer chip in the frequency multiplying mode. It is preferable to use even harmonics of the input frequency.
2. The power transmission ratio for the second harmonic of the input frequency of 3 GHz and the input power of 0 dBm is not less than -17.25 dB.
3. The power transmission ratio for the fourth harmonic of the input frequency of 3 GHz and the input power of 0 dBm is not less than -32 dB.
4. The transmission power factor for the sixth harmonic of the input frequency of 3 GHz and the input power of 0 dBm is not less than -42.67 dB.
5. The suppression of unused harmonics of the input frequency should be effected by high-pass band filters with a wide band of barrier (for example, comb filters).

References

[1] Gribov E.B. Nonlinear phenomena in the receiving-transmitting tract of communications equipment on transistors. - Moscow: Sviaz, 1971, 243 p.
[2] Zhabotinsky M.E., Sverdlov Yu.L. Fundamentals of the theory and technique of frequency multiplication. - Moscow: Sov. radio, 1964, 327 p.Author, *Title of the Book*, Publisher, (200X), pp:XXX-YYY.
[3] Kishchinsky A.A. Frequency multipliers on field-effect transistors with a Schottky barrier. Surveys on electronic engineering. Series 1. Electronics microwave. Issue. 10 (1558) - Moscow: TsNII "Electronics", 1990, 32 pFauci AS, Braunwald E, Kasper DL & Hauser SL (2008), Principles of Harrison's Internal Medicine, Vol. 9, 17thedn. *McGraw-Hill*, New York, NY, pp.2275–2304.
[4] Savelyev V.S. Multipliers of the microwave frequency range on transistors. Surveys on electronic engineering. Series 1. Electronics

microwave. Issue. 17 (1220) - Moscow: TsNII "Electronics", 1986, 27 p.

[5] Measuring equipment of microwave and EHF. Nodal and element bases. Ed. A.M. Kudryavtseva. - Moscow: Radiotehnika, 2006, 208 p.

[6] Radio transmitting devices on semiconductor devices. Design and calculation. Ed. R.A. Valitova and I.A. Popova. - Moscow: Sov. radio, 1973, 464 p.

[7] Zikiy A.N., Zlaman P.N., Vlasenko D.V., Shipulin M.V. Multiplier of the frequency of the millimeter range. Information Counteraction to Terrorism Threats, 2011, No. 17

[8] Zikiy A.N., Zlaman P.N., Mukhin N.A., Plenkin A.P. Modeling and experimental study of a subharmonic mixer. Information Counteraction to Terrorism Threats, 2011, No. 17

[9] Zikiy A.N., Zlaman P.N., Mukhin N.A., Plenkin A.P. Experimental study of a subharmonic mixer. Information Counteraction to Terrorism Threats, 2011, No. 17

[10] Microwave Mixer LTC5553. Linear Technology. Data Sheet, 16 p.

[11] Demo Manual DC2566A. Passive Bidirectional Mixer. Linear Technology, 6 p.

[12] KeySight Technologies. Control and measuring solutions. Catalog 2015, 476 p

[13] HMC189AMS8 / 189AMS8E GaAs MMIC SMT Passive frequency Doubler, 2-4 GHz input. Analog Devices (Hittite), v.03.0714

[14] HMC188MS8 / 188MS8E GaAs MMIC SMT Passive frequency Doubler, 1.25-3.0 GHz input. Analog Devices (Hittite), v.04.0709.

[15] Frequency Multiplier KBA-40 + / KBA-40. Mini-Circuits. Rev.E.

[16] Frequency Multiplier KC2-50 +. Mini-Circuits. Rev.C.

[17] Frequency Doubler FD93 / FD93C. M / A COM. Rev. v2

[18] Open Carrier Frequency Doubler For Microvawe Telecommunications. M / A COM. Rev. v1