SINUSOIDAL AND IMPULSE GENERATOR, BUILT ON THE BASES OF A DIRECT DIGITAL SYNTHEZER

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This paper describes a variant of sinusoidal and impulse generator, built on the bases of a direct digital synthezer. Usage of such kind of generator for testing and researches is of frequent occurrence. There are strong requirements to this generator, which are difficult to be implemented in a single device. Usually the variation in its basic parameters i.e. frequency and output amplitude, have to be done in rather wide limits with a minimal step. Due to these requirements, the schemes are very complicated and a generator has limited characteristics. The direct digital synthezers (DDS), give the possibility to create a generator with output frequency, varying from mHz to GHz wit a constant step of change - mHz. In this paper is demonstrated a variant of generator, on the bases of DDS architecture, controlled by microcontroller connected with personal computer.

Keywords: DDS, Generator

1. BASIC FEATURES OF THE GENERATOR

The demonstrated device is built on the basis of DDS IC AD9852 (Analog Devices, Inc.) and has:

- Form of output signal from DDS, which is always sinusoidal. Some times this is not enough and a comparator is used to create digital impulses.
- Output frequency bandwidth is from 1 mHz to 100 MHz.
- Step of change of frequency – mHz.
- Output amplitude: for digital impulses - 3,3V and 5V; for the sinusoidal signal – from 0 to 4V unipolar and –4V to +4V bipolar output signal.
- Frequency stability of output signal – depends on implemented in DDS output DAC (Digital to Analog Converter) (SFDR - 48dB at 100 MHz) and on the reference clock that is driving the DDS. The used clock source is SG615PB with frequency stability +/- 50 ppm .
- Modulation of the output signal – ASK, FSK, BPSK, linear and not linear FSK and chirp FSK.
- Control of the generator – by PC and local keyboard and LCD display.

2. BLOCK DIAGRAM OF THE GENERATOR

The main blocks of the generator are shown in Figure 1. One of them is the direct digital sintezer and its components necessary for its proper work. It is used microcontroler PIC16F877 (powered at +5V), which controls AD9852 (powered at +3,3V). To unify these signal levels between the microcontroler and DDC, buffers are used. Proper buffers are IC 74LVC04 or 74XVC04. A local keyboard and LCD display as well as RS232 and USB, are included also for control of the device. The output signal from DDS being current is not proper to be used directly. That is why an amplifier is added to amplify the output amplitude and to create a voltage output. Also, a LC low-pass filter is used to reject high frequency and to remove aliased images in output spectrum. To minimize the influence of digital part of the scheme over the analog part, two power supplies (+3,3V) are included. They are connected on PCB in a single point.

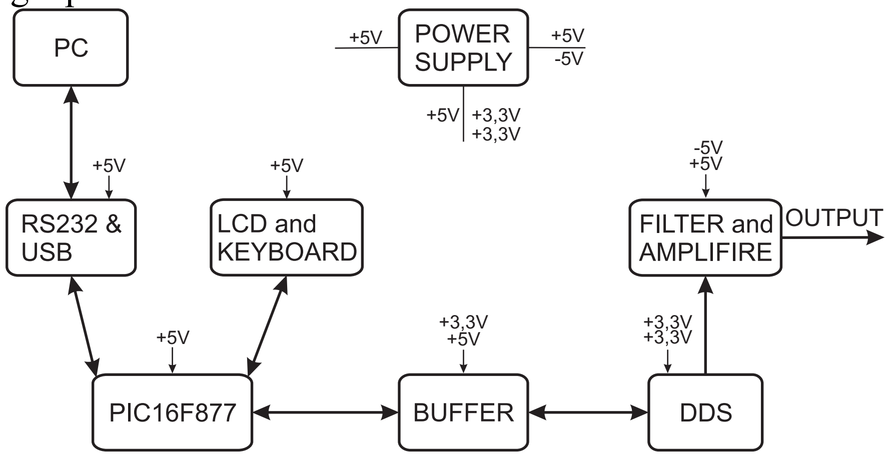


Figure 1

3. Form of the Digital Sintezer Output Signal and Filtration

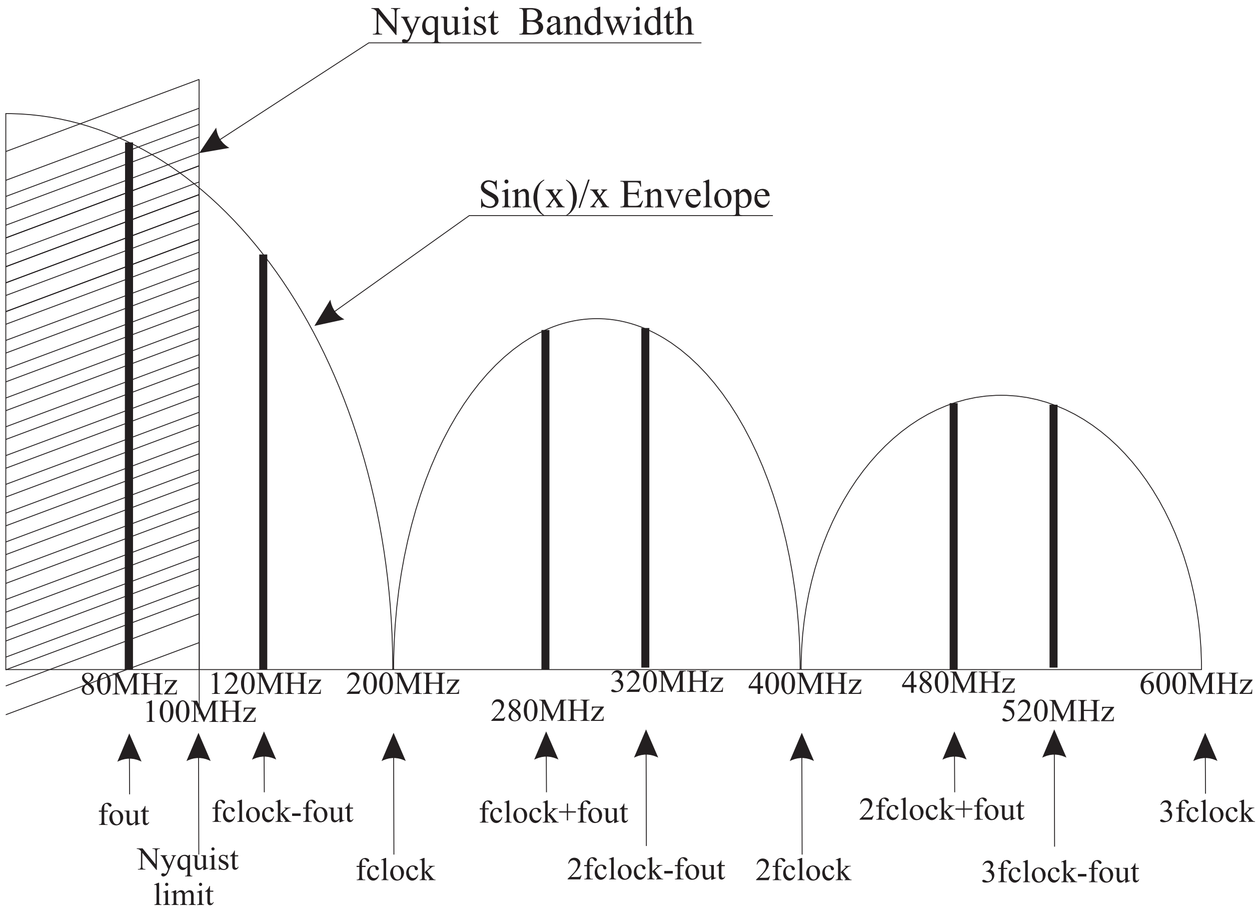


Figure 2

The output spectrum of DDS digital sintezer is shown in Figure 2. As an example, an output frequency of 80 MHz and clock frequency of 200 MHz are used. According to Nyquist Theorum two samples are necessary at minimum per a cycle for obtaining the desired output waveform. Images responses are created in the sampled output spectrum at $f_{CLOCK} \pm f_{OUT}$. The 1st image response occurs in this example at $f_{CLOCK} - f_{OUT}$ or 120 MHz . The 3rd, 4th, and 5th images appear at 280 MHz, 320 MHz, 480 MHz, and 520 MHz (respectively). Notice that nulls appear at multiples of the sampling frequency.

As can be seen in Figure 2, the amplitude of the f_{OUT} and the image responses follows a sin(X)/X envelope curve. This is due to the quantized nature of the sampled output. The amplitude of the fundamental and any given image response can be calculated using the sin(X)/X formula. The amplitude of the fundamental output decreases inversely to increases in its tuned frequency. The amplitude decrease due to sin(X)/X envelope curve in a DDS system is –3.92 dB over its DC to Nyquist bandwidth. DDS architecture includes an inverse SINC filtering which pre-compensates for the sin(X)/X envelope curve and maintains a flat output amplitude (± 0,1 dB) from the DAC for a bandwidth of up to 80% of Nyquist. It is important to note in the sin(X)/X envelope curve shown in Figure 2, that the amplitude of the 1st image is substantial: it is within 3 dB of the amplitude of the fundamental at $f_{OUT} = 0{,}33\ f_{CLOCK}$.

In order to remove these undesired images, as well as clock frequency, a LC low-pass filter is synthesized, which is illustrated on Figure 3.

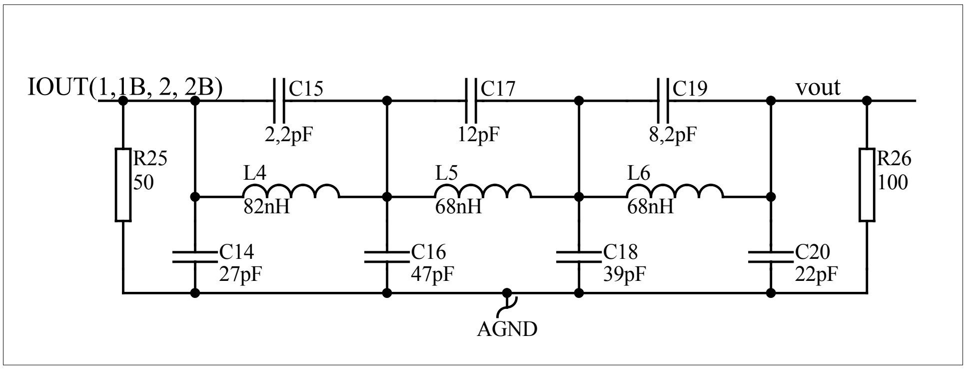


Figure 3

One of the major advantages of this filter is that, up to 100 MHz of its bandwidth it has a deviation of ±0,2 dB and less than ±0,02 dB for frequencies in the range of DC to 10 MHz (Fig. 4). At the same time, the amplitude - frequency characteristic of the filter has a decrease of amplitude with more than 200 dB/dec after the bandwidth range of 100 MHz. Also, there is a minimum in the amplitude - frequency response exactly at frequency of 200 MHz, which provides a best filtration of sampling reference clock.

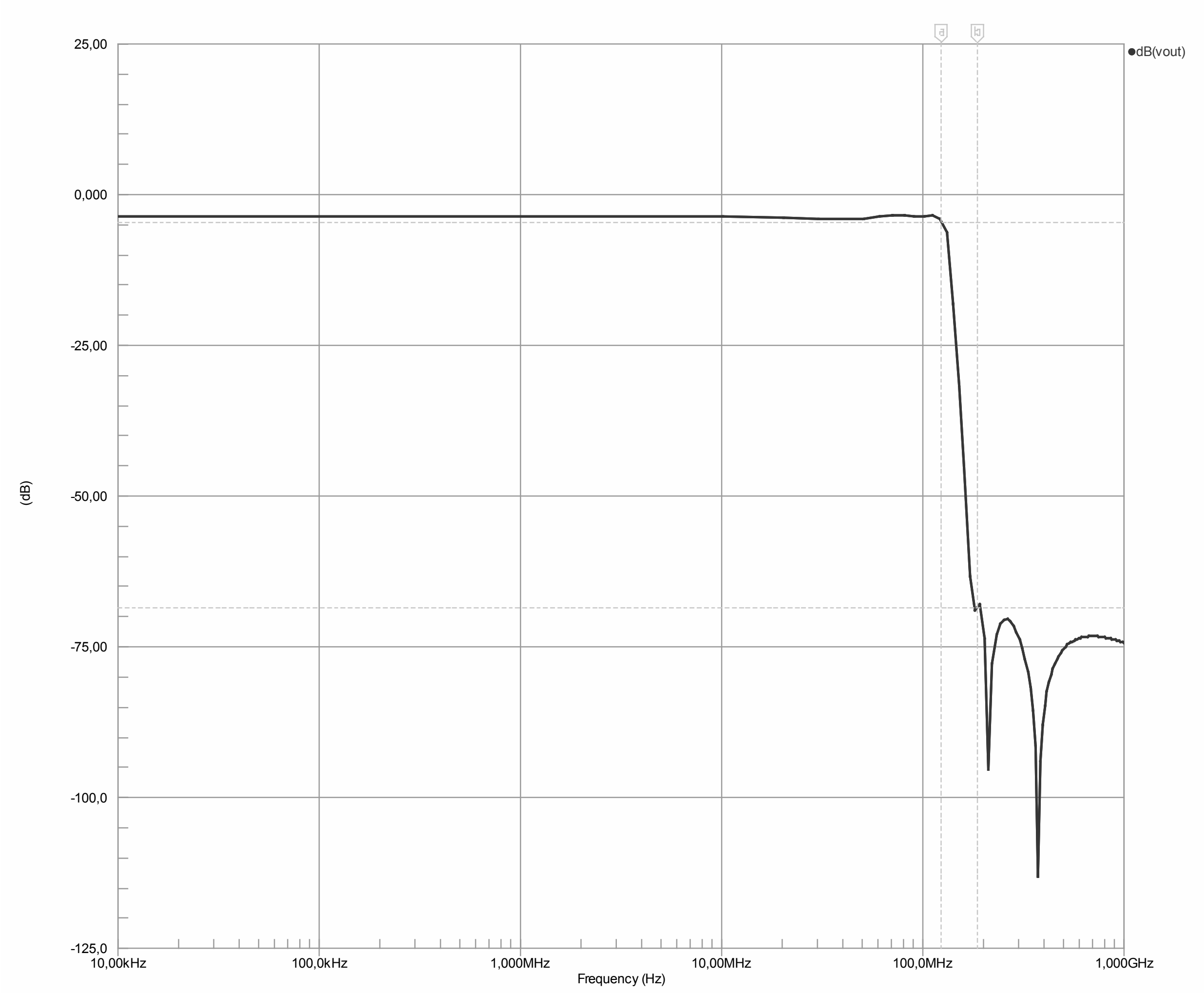
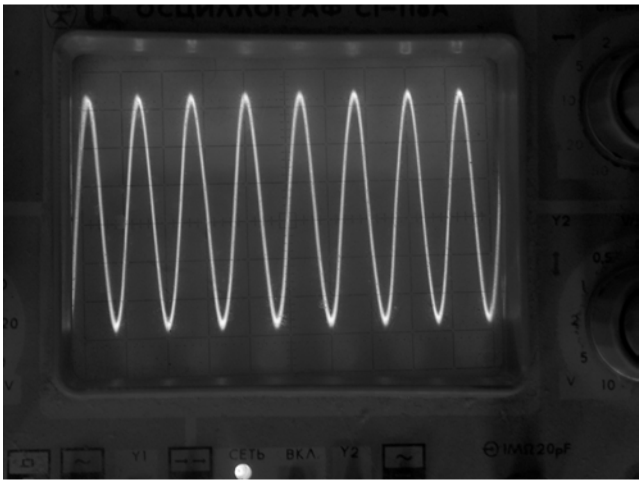
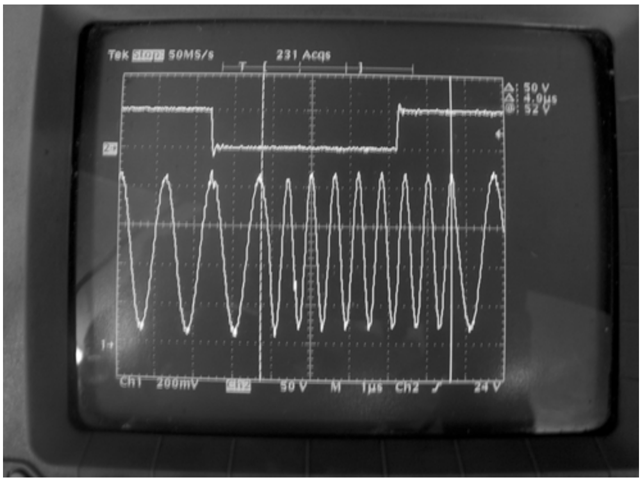


Figure 4

4. Experimental Results



SINGLE-TONE mode, frequency of 2 MHz



FSK mode, frequency F1 = 1.666 MHz and F2 = 833 kHz;
F1 to F2 is switched by digital signal

5. Conclusions

The described generator has a very good performance regarding stability of output frequency and provides possibility of immediate change of frequency with step of mHz in all working range. Another main advantage of the device is that the control is completely digital. This provides the possibility to automate the processes, completed with said generator. It is possible to generate signals with several kind of modulations. Amplitude control is also digital with 10 bits resolution.

6. References

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