

FUNCTION GENERATOR CONTROLLED BY PC

Nguyen Truong An, Bui Trong Tu, Nguyen Huu Phuong

Department of Electronics – Telecommunications
University of Natural Sciences, Vietnam National University – HCM

ABSTRACT

In electronic experiments, one needs an instrument that can generate various signal waveforms (called waveform generator or signal generator or function generator). On the market, there are many such instruments with a price range from medium to very high, depending on their specifications. However, almost all of them cannot be controlled from PC, which is required by our laboratory automation program. This project concentrates on designing and building a function generator controlled by PC. Data concerning the signal such as waveform, frequency, amplitude, are output from the PC and latched in the outer circuit. Afterwards, the PC is free to perform other tasks, and only updates the data when necessary. We present two different designs having different characteristics. One uses external static RAM (SRAM) and a Digital-to-Analog Converter (DAC) to generate the waveforms. This method can produce arbitrary waveforms at low frequencies. The other uses the waveform generator IC MAX038 (from Maxim) as the core of the system. We add some complementary circuits to enable the control from PC. This latter design can attain output frequency up to 20 MHz but cannot give arbitrary waveforms.

1. PC-CONTROLLED WAVEFORM GENERATOR USING SRAM AND DAC

The idea is to output the file containing all programmed signal waveform data to SRAM on the outside board through LPT port. Then, the counter circuit on the board scans SRAM address to give out the data to a DAC circuit whose analog output is the needed waveform.

Its frequency depends on the rate of counter scanning, and its amplitude can be changed by a controlled-gain amplifier.

1.1 Output data to external SRAM

The general view of the system is shown in Figure 1 and Figure 2 is the external board circuit.

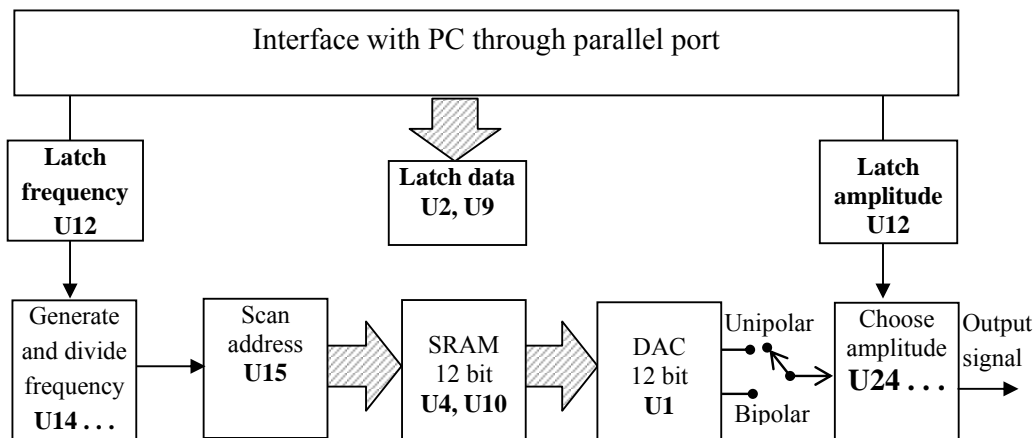


Fig.1 Block diagram of waveform generator using SRAM and DAC.

At first, we program the computer to create data for the desired signal (sine, square, triangle or anything we want). This is the set of quantized samples. This data will be loaded to SRAM 6264 on external board (U4 and U10). U4 contains low-byte data and U10 contains the high nibble. We have 12 bits in total whereas the parallel port has only 12-pin output so we need 2 latch IC 74LS374 (U2 and U9) to load 12-bit data to SRAM. Besides that, U12 is to latch amplitude and frequency values.

1.2 Generate analog signal

- Frequency: a 20 MHz quartz controlling oscillator circuit provides main frequency clock. By using some 74LS390 counters, this clock is divided into 15 different frequencies: 10 MHz, 5 MHz, 2.5 MHz, 2 MHz, 1 MHz, 500 kHz, 250 kHz, 200 kHz, 100 kHz, 50 kHz, 20 kHz, 10 kHz, 5 kHz, 2 kHz, and 1 kHz. They go to 15 input pins of multiplexer IC 74LS150 (U14). U12 will pick out 1 of 15 frequencies and send to CD4040 counter.

The 16th input pin of 74LS150 is directly controlled by OUT12 (pin 17) of parallel port and is used to load data to SRAM.

- Amplitude: unipolar or bipolar signal is chosen by a switch (Figure 1). The signal goes through a resistance bridge which creates 16 different amplitude levels. An analog switching circuit using CD4066 ICs and demultiplexer 74LS154 (U24) allow 1 out of 16 amplitude levels in range from $V_{pp}/16$ to V_{pp} ($V_{pp}= 5V$ for unipolar signal and $V_{pp}=10V$ for bipolar). The EN pin of 74LS154 comes from IC U12 loaded from PC. Signal with chosen amplitude will be amplified and output.

1.3 The software

Fig.3 is the program's interface. The functions are as follows:

1. Frequency of signal
2. Amplitude of signal ($V_{\text{peak-peak}}$)
3. Name of data file
4. File containing signal waveform.

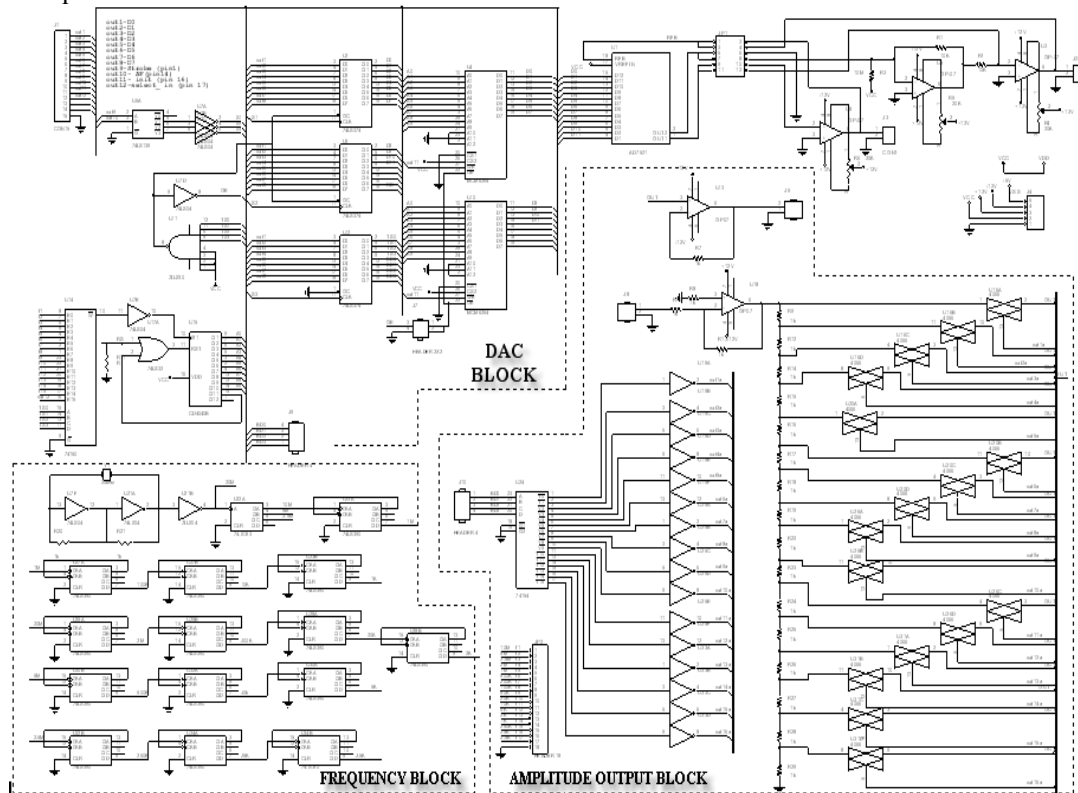


Fig.2 Schematic diagram of external board for generation of waveforms.

5. Load file to SRAM (we can use Oscilloscope to view signal waveform at output pin).
6. After changing frequency and/or amplitude, click this button.
7. Exit the program.

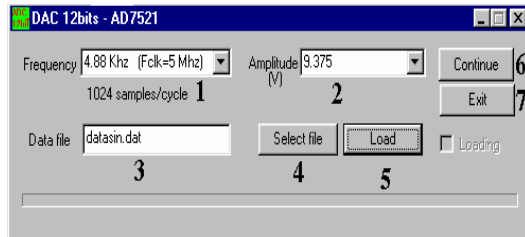


Fig.3 Program interface

1.4 Comment

This function generator has two advantages: First, it can generate any signal waveform include random signal; second, waveform, amplitude and frequency of signal are latched on to external board, and PC is free to execute other programs. When we wish to change the signal, PC will update the data quite fast. The only disadvantage, like other methods using PC combined with DAC, is that the frequency is limited, and signal waveform quality is lower than function generator using analog principle. With the present devices, we can only attain the maximum frequency of 10 kHz. In order to have higher operating frequency we need to use high frequency devices and to use PCI interface instead of parallel port (which will cost much more).

2. PC-CONTROLLED FUNCTION GENERATOR USING MAX038.

2.1 Introduction

MAX038 from MAXIM is a high frequency waveform generator with outstanding specs, especially it operates in the frequency range of 0.1 Hz to 20 MHz and can generate popular waveforms. The data sheet and application notes show us everything how to use the IC, except the interfacing and control from a PC. So we have to solve the latter problem to turn MAX 038 into a PC-controlled function generator.

2.2 The hardware

Figure 4 is the block diagram of the function generator. MAX038 can generate sine, square, and triangle waveforms, and the adjustable duty cycle makes it possible to build pulse

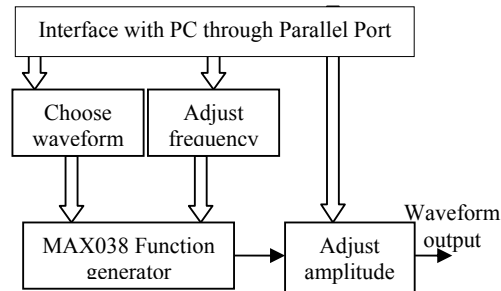


Fig.4 Block diagram of PC-controlled function generator using MAX038

and sawtooth waveforms. Inputs used for choosing waveform are TTL compatible but other inputs cannot be controlled digitally. So, we need to add some DAC ICs. The output waveform amplitude of MAX038 is scaled by a programmable-gain amplifier which is controlled from PC. Controlling data surpasses parallel port bandwidth, hence buffers must be used. Figure 5 is the circuit schematic. Once a waveform and its features are programmed and sent out to the board, the computer is free to perform other tasks.

2.3 The software

Figure 6 is the program interface.

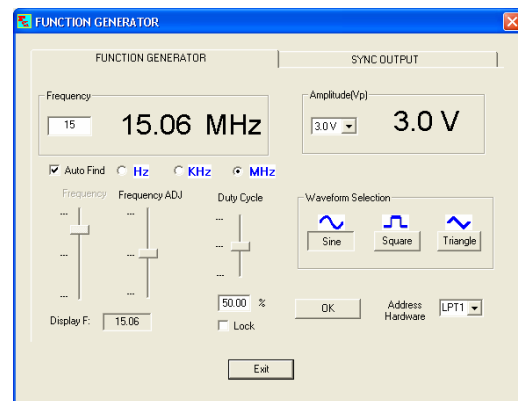


Fig.6 Program interface

2.4 Comment

This method is much better in many aspects: Cheaper, frequency range is large, waveform quality is high; but there is a drawback: We cannot generate arbitrary signals.

3. CONCLUSION

We present out two practical and inexpensive ways to build up a PC-controlled function generator. One uses external SRAM and ADC and the other uses, MAX038 waveform generator. Each method has its own advantages and limitations. With these PC-controlled function generators and PC-based two-channel digital oscilloscope [4] we can turn a PC into a

measurement center and link many such centers into a network (virtual laboratory).

REFERENCES

1. George C. Barney, Intelligent instrumentation – Microprocessor applications in measurement and control, Prentice Hall, New Jersey (1985).
2. V. Hall, Microprocessors and Interfacing – Programming and Hardware, 2nd edition, Douglas McGraw-Hill, New York (1992).
3. Data sheet and application notes of MAX038, MAXIM.
4. Nguyễn Trường An and Phạm Thị Thu Phương, Converting PC into two-channel digital oscilloscope, presented at the same ISEE05.

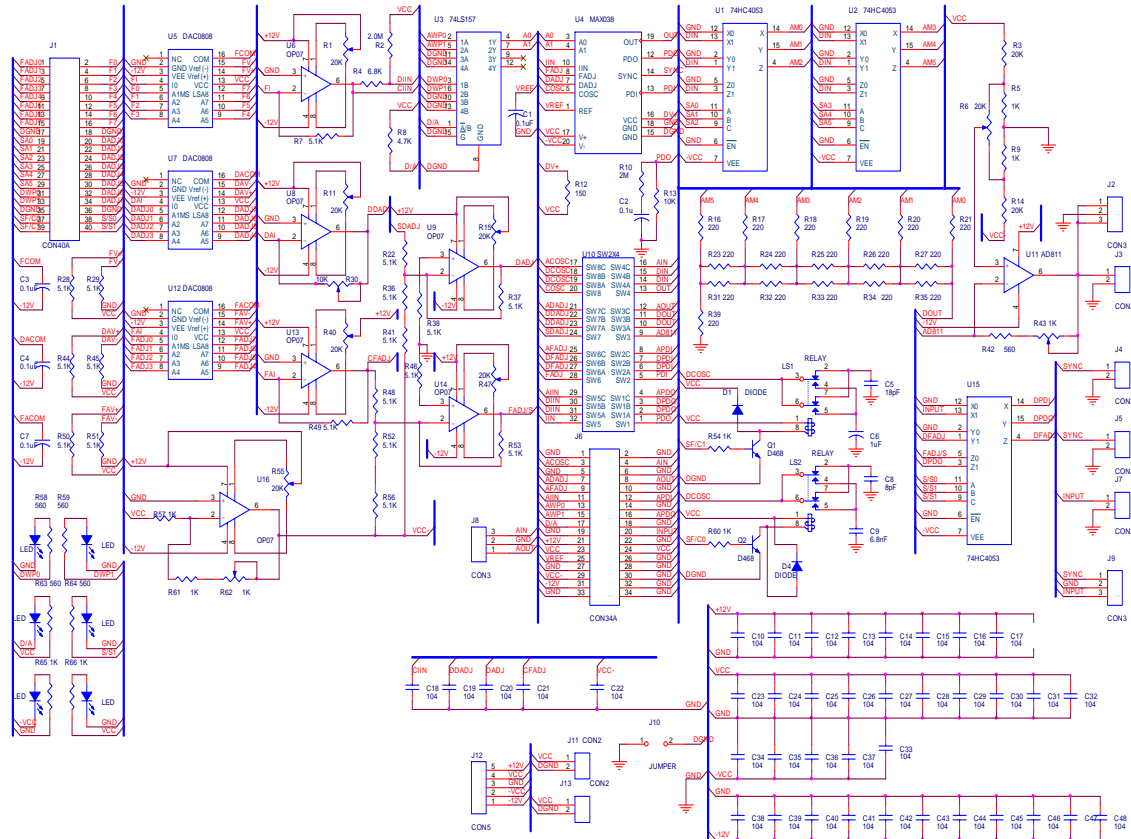


Fig.5 Circuit diagram of the PC-controlled MAX038