

Center of ultrasonic technologies

Electronic generator of ultrasonic frequency

www.u-sonic.ru, www.u-sonic.com

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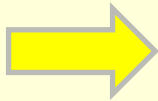
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Ultrasonic devices

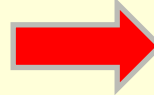
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Electrical
energy



Ultrasonic
devices

Ultrasonic
energy

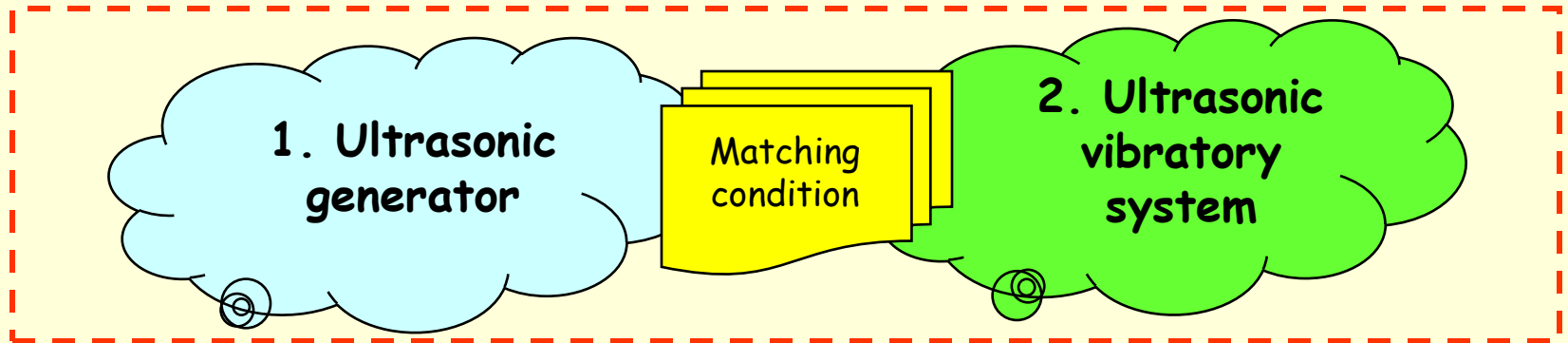


Processing
mediums:
gas, liquid, solid



US devices: convert electrical energy to ultrasonic energy.

Two main elements of ultrasonic devices



- generation a voltage with a resonance frequency of the vibratory system
- provide enough voltage on the vibratory system
- provide electrical matching generator and vibratory system



- Vibratory system parameters:
1. Resonance frequency
 2. Quality factor
 3. Impedance on resonance frequency
 4. Limit power

Ultrasonic vibratory system

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Basic elements of vibratory system:

electromechanical transducer

piezoelectric type

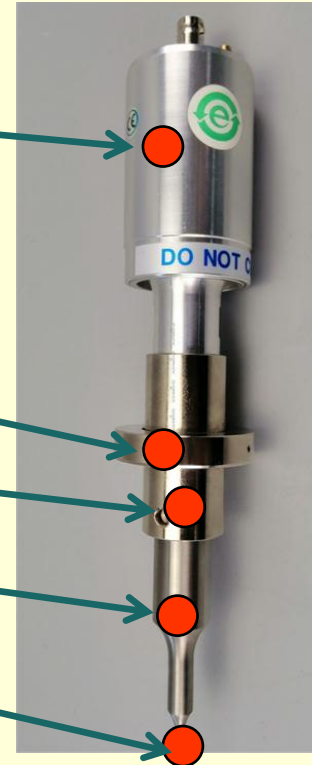
magnetostrictive type

elements for mounting

sonotrode

booster

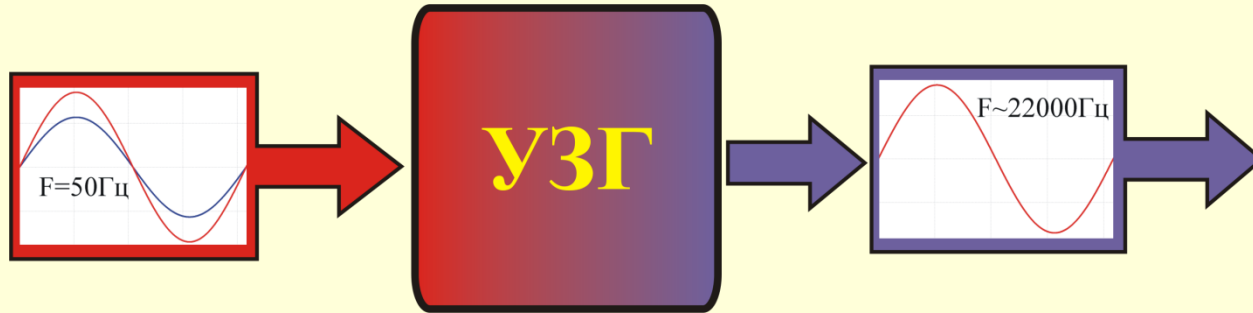
working tools



The vibratory system determines the all main parameters of the generators!!!

Ultrasonic electronic generators

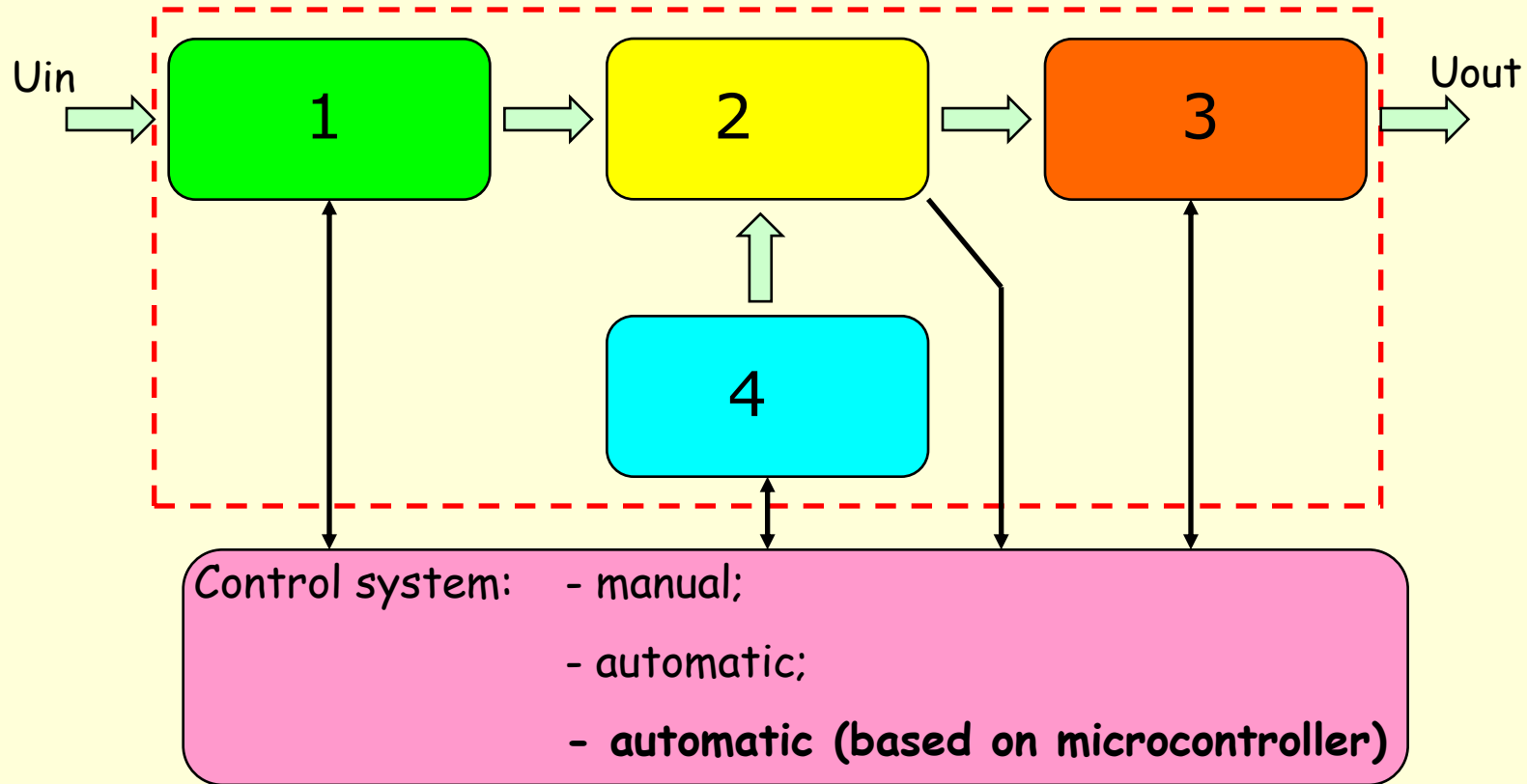
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basic requirements to electronic generators :

- required power reserve.
- frequency reserve.
- power control.
- frequency control.
- optimal matching to vibratory system.
- electrical and thermal protect system.
- sinusoidal shape voltage on vibratory system .

Structure of ultrasonic electronic generator

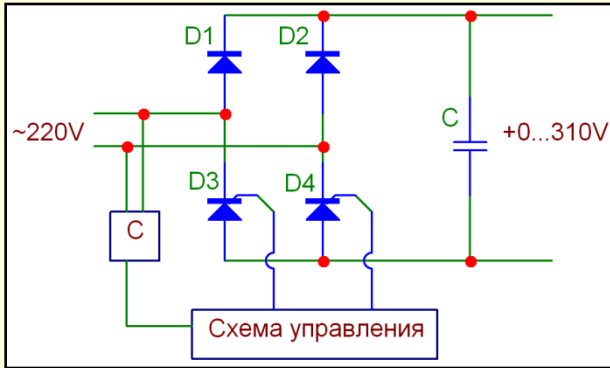


- 1** Input power circuit.
- 2** High-frequency converter.
- 3** Matching circuit.
- 4** Controllable low voltage generator of ultrasonic frequency

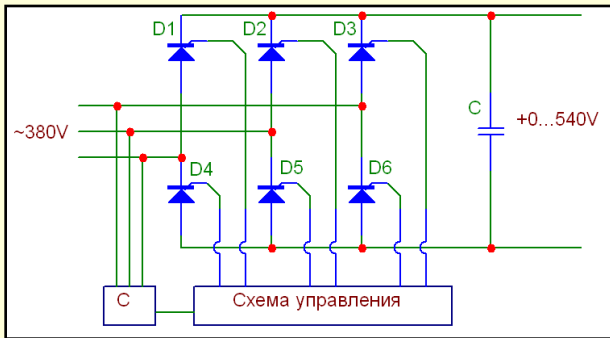
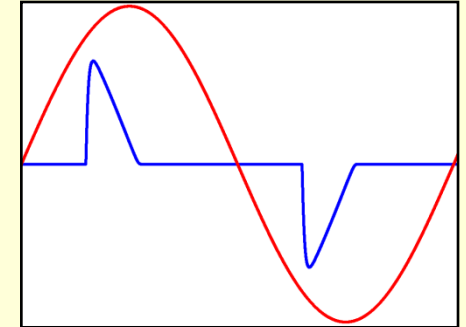
U_{in} , U_{out} - input and output voltage of electronic generator

1

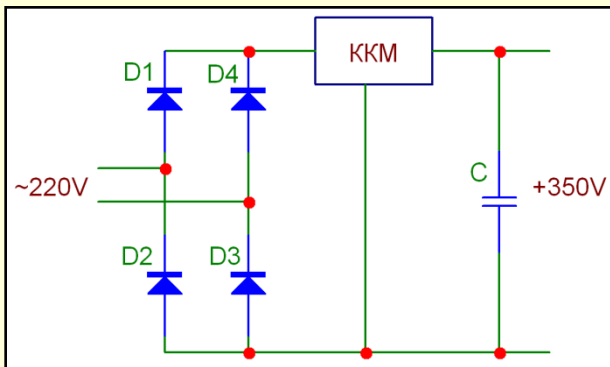
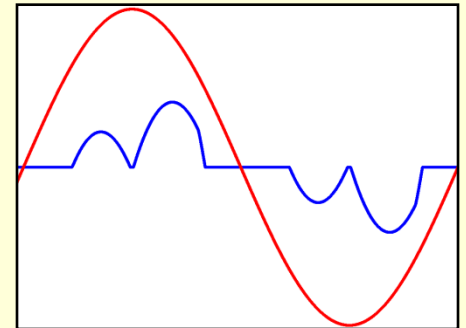
Input circuit of ultrasonic generators



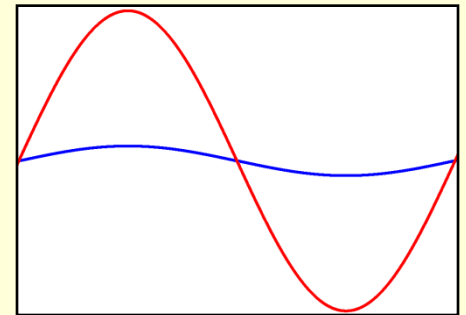
controllable single phase rectifier



controllable 3 - phase rectifier

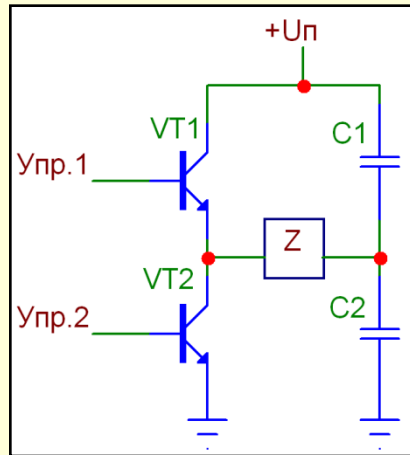


single phase rectifier with PFC circuit

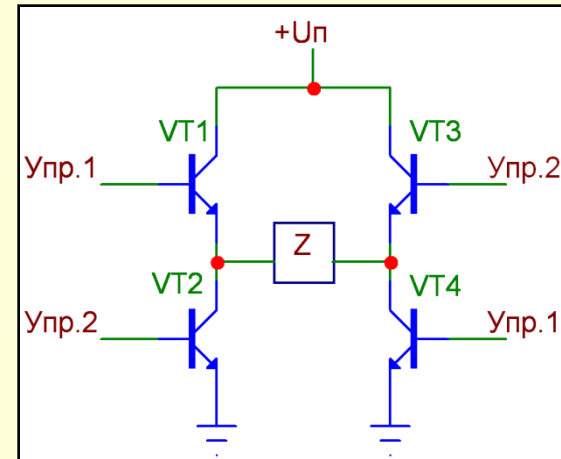


█ - Input voltage
█ - Input current

Half-bridge



Full bridge



Active element of high-frequency converter

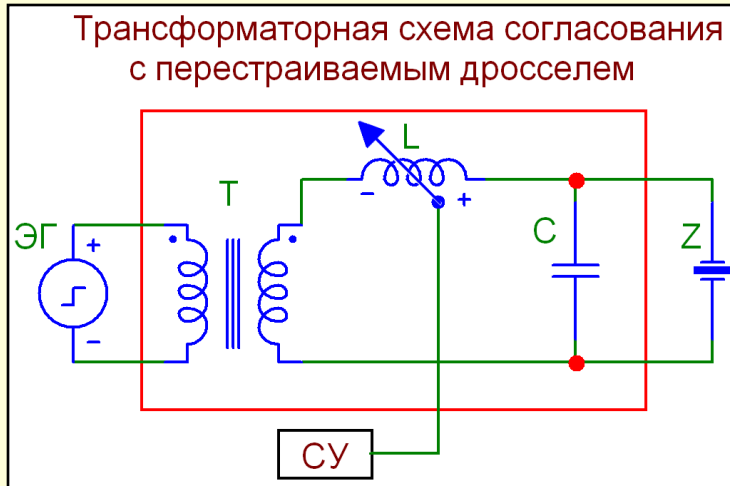
- discrete bipolar transistor
- discrete MOSFET transistor
- discrete IGBT transistor
- IGBT modules
- IPM modules

Z - ultrasonic vibratory system

The matching circuits between generator and vibratory system

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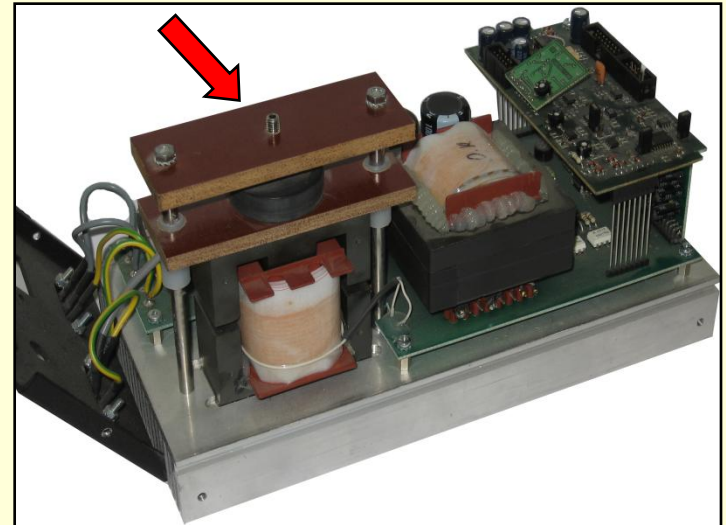
Transformer matching circuit with adjustable inductor

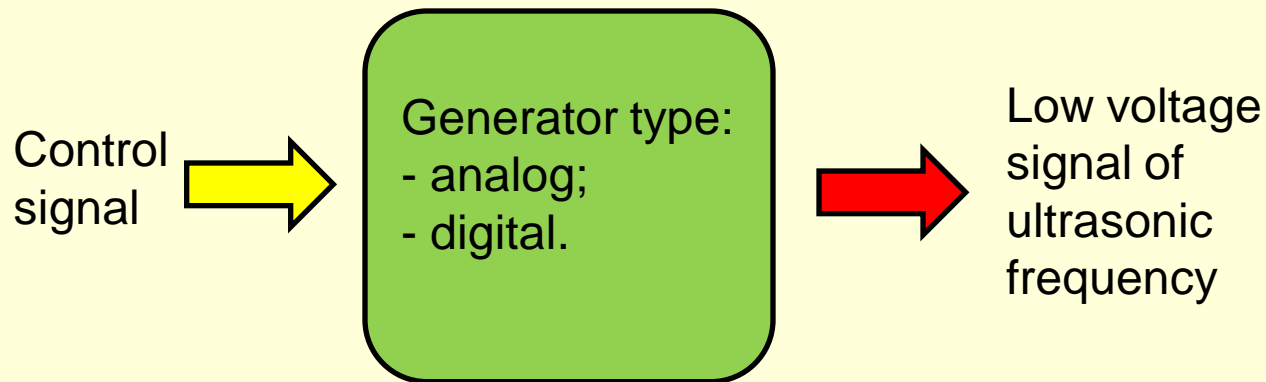


СУ - inductor control system
ЭГ - electronic generator
Z - ultrasonic vibratory system

Inductor with movable core by step motor

Generator «MasterSonic» with manually matching inductor



**Basic requirements:**

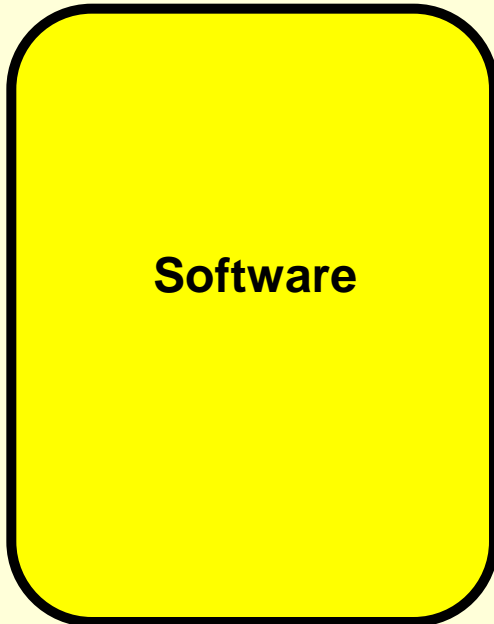
- ability of frequency adjusting;
- required range of frequency adjustment.



Control system of ultrasonic generator

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**Microcontroller
(Atmel, **STM**)**



Function of microcontroller:

Power control.

Amplitude control.

Frequency control:

- mode of search for the resonant frequency;
- mode of frequency lost detection;
- restart mode;
- mode of mechanical error detection.

Mode of electrical overload detection.

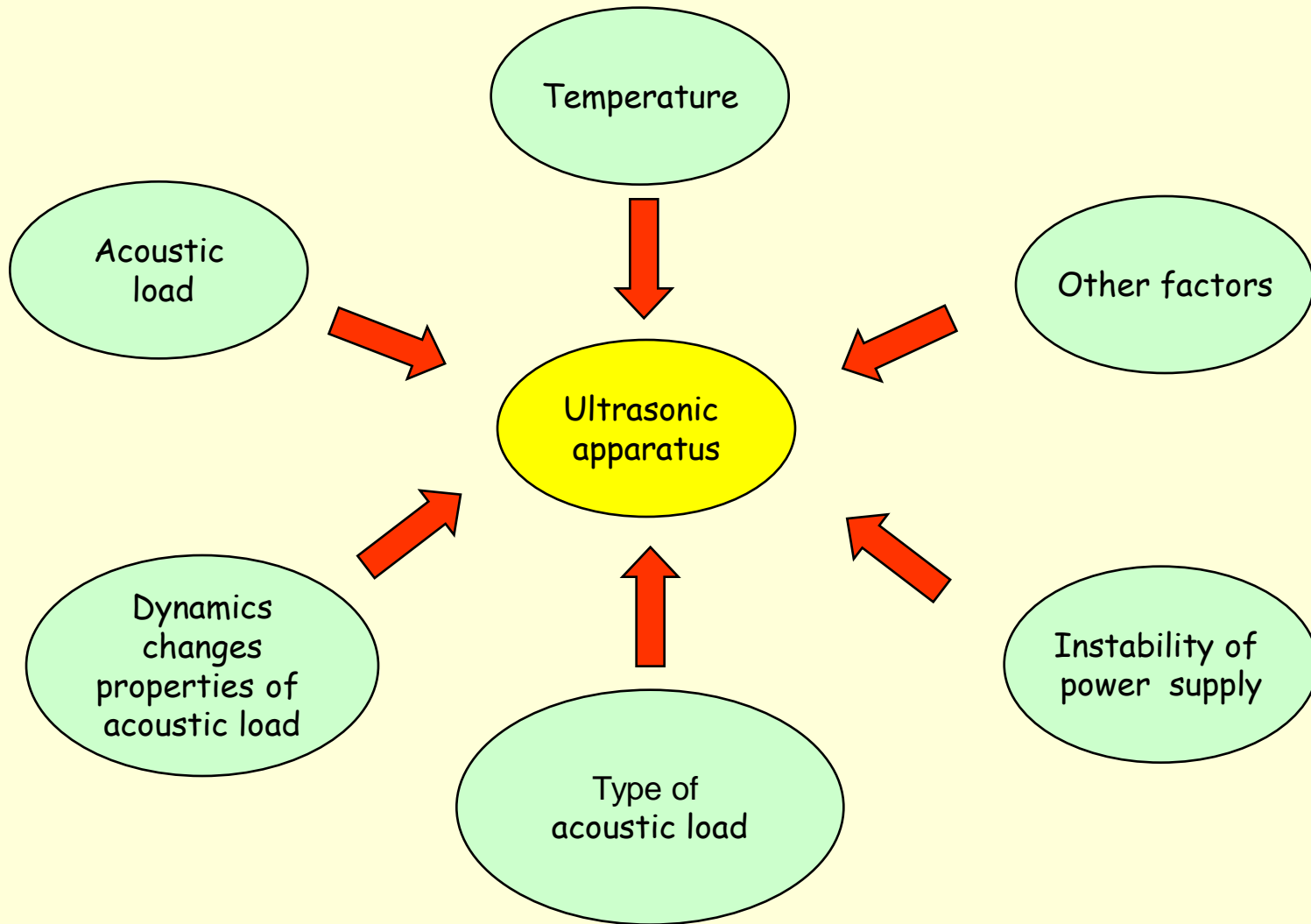
Communication with control panel.

Communication with external device.

Define work logic of the device as a whole.

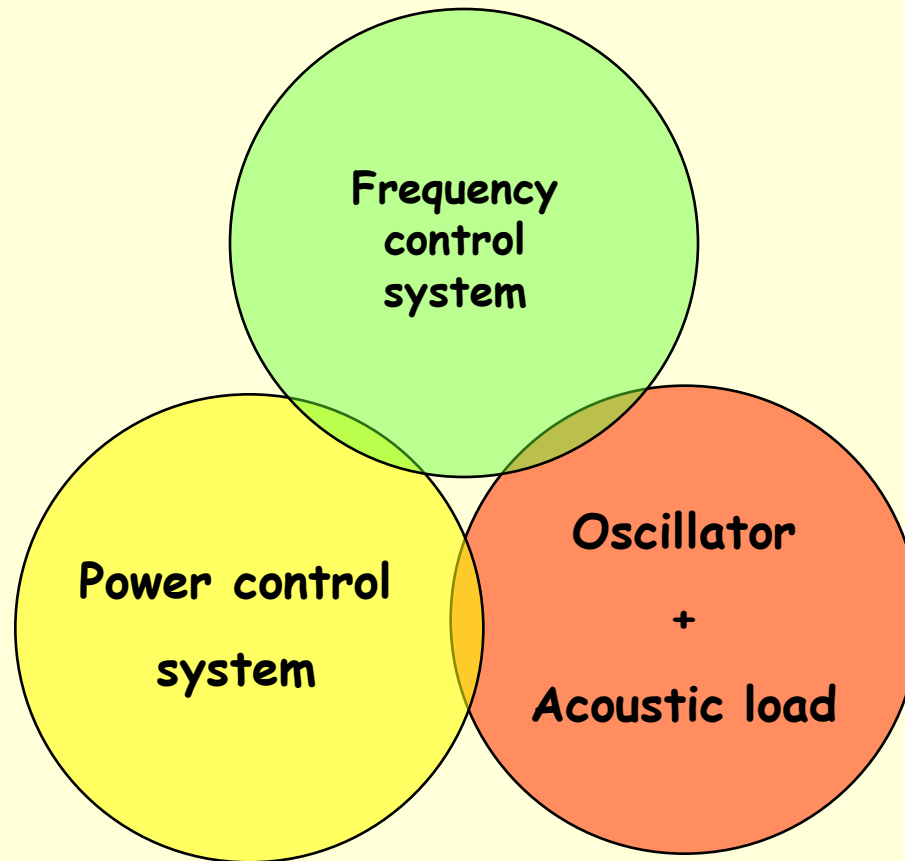
Other functions.

Destabilizing factors affecting to ultrasonic devices



Main system and elements of ultrasonic generators

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Areas of ultrasonic generators usage

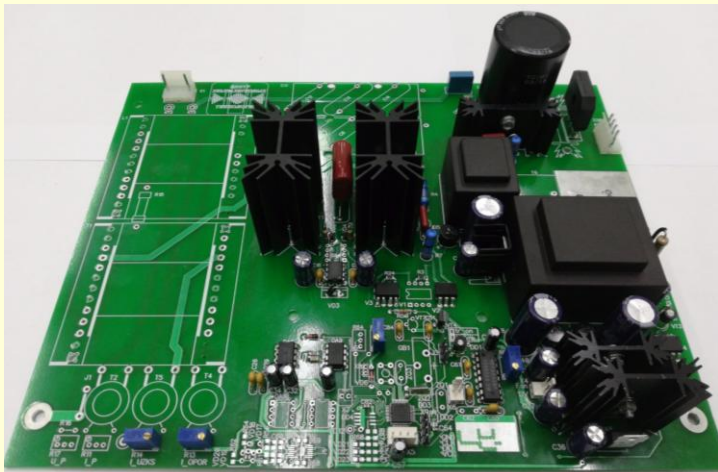
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Main parameters of ultrasonic generators	Ultrasonic technology		
	Gas environment	Solid environment	Liquid environment
Frequency range: up to 140 KHz. Power range: up to 5 KW.	<ol style="list-style-type: none">1. Foam destruction2. Coagulation3. Drying	<ol style="list-style-type: none">1. Drilling2. Welding of metal3. Welding of plastic4. Cutting5. Metal processing	<ol style="list-style-type: none">1. Extraction2. Emulsification3. Dispersion4. Processing of metal melts5. Acceleration of chemical reactions

Main function of electronic parts of ultrasonic generator

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Main board
(UVT-1, UVT-2, UVT-3)



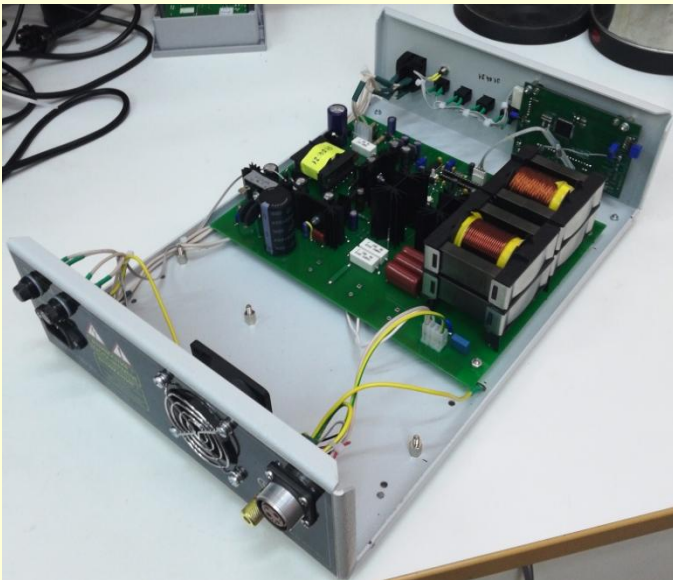
Features:

- Control unit: microcontroller;
- Microcontroller type: stm32f103;
- Amplitude stabilization: yes;
- External control: yes;
- Resonance loss restart system: yes;
- Oscillation system type: piezoelectric;
- Power supply : AC power;
- Automatic frequency control system: yes;
- Vibratory system parameter monitoring system: yes;
- Power measuring: yes;

Types of arrangement of electronic generators

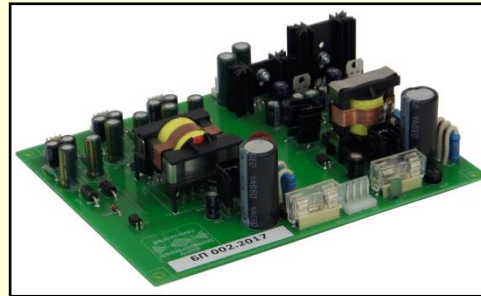
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Single-board generator

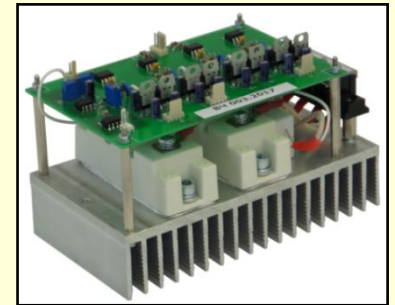


Modular generators

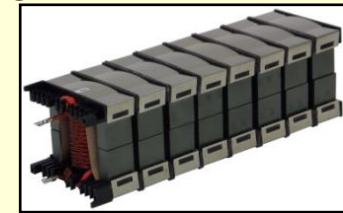
Power supply module



High-frequency inverter



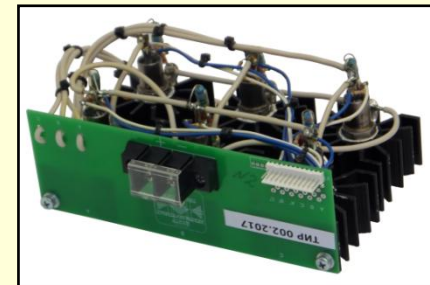
Matching modules



Main board

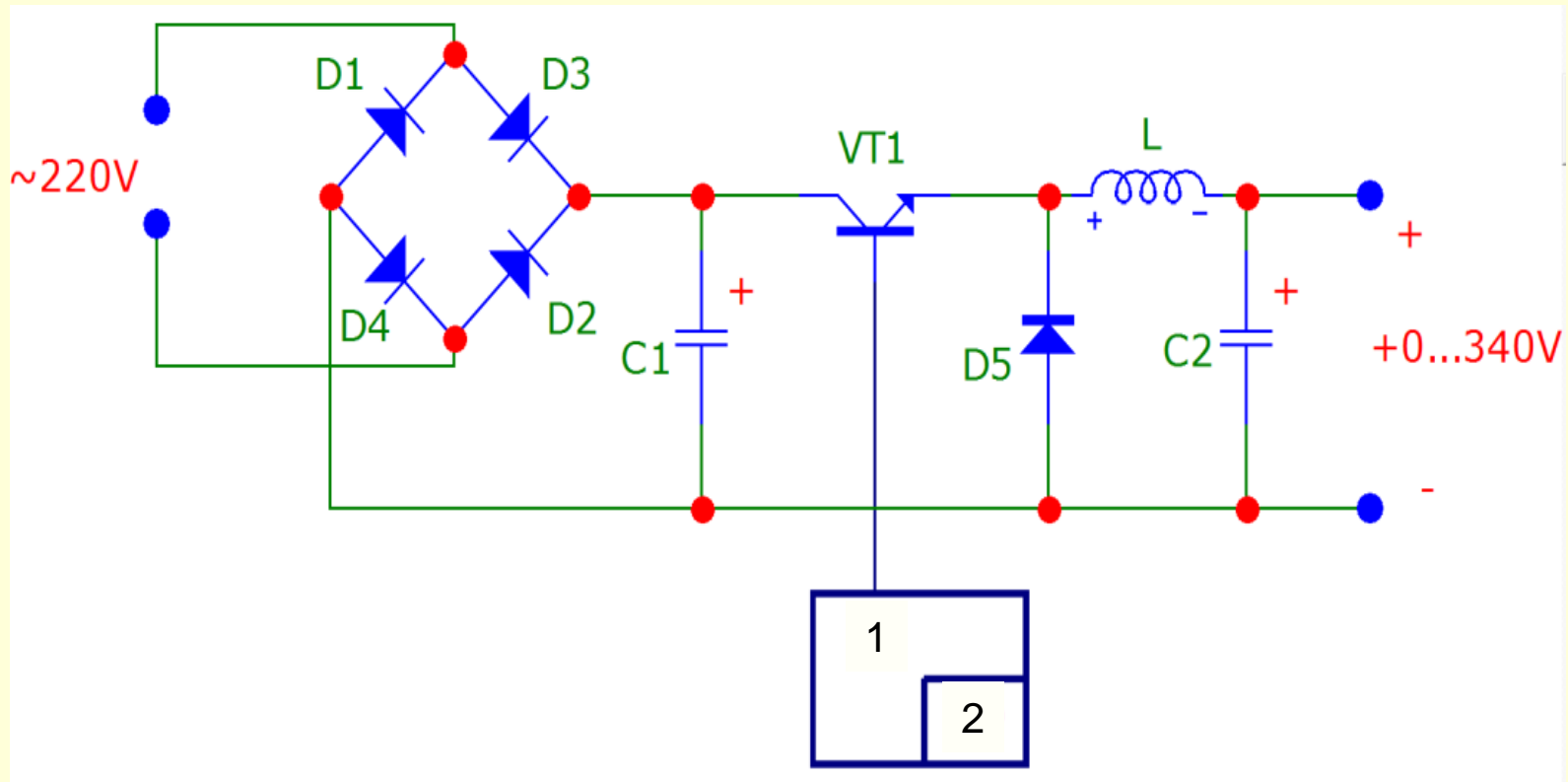


Power regulator module



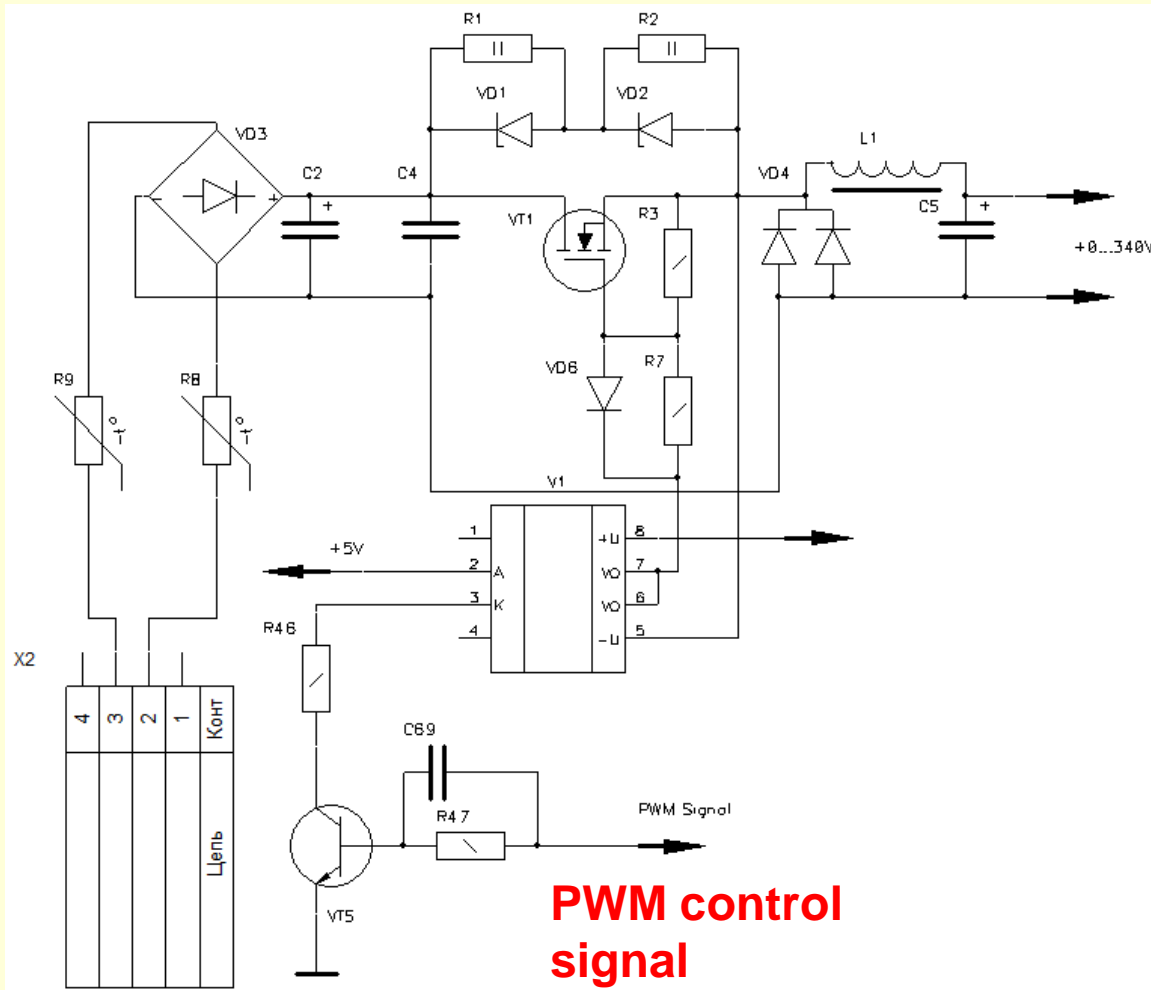
Typical circuit solutions of the main board of electronic generators

Switch-mode step-down power regulator



1 – microcontroller;
2 – control program

Circuit of switch-mode step-down power regulator



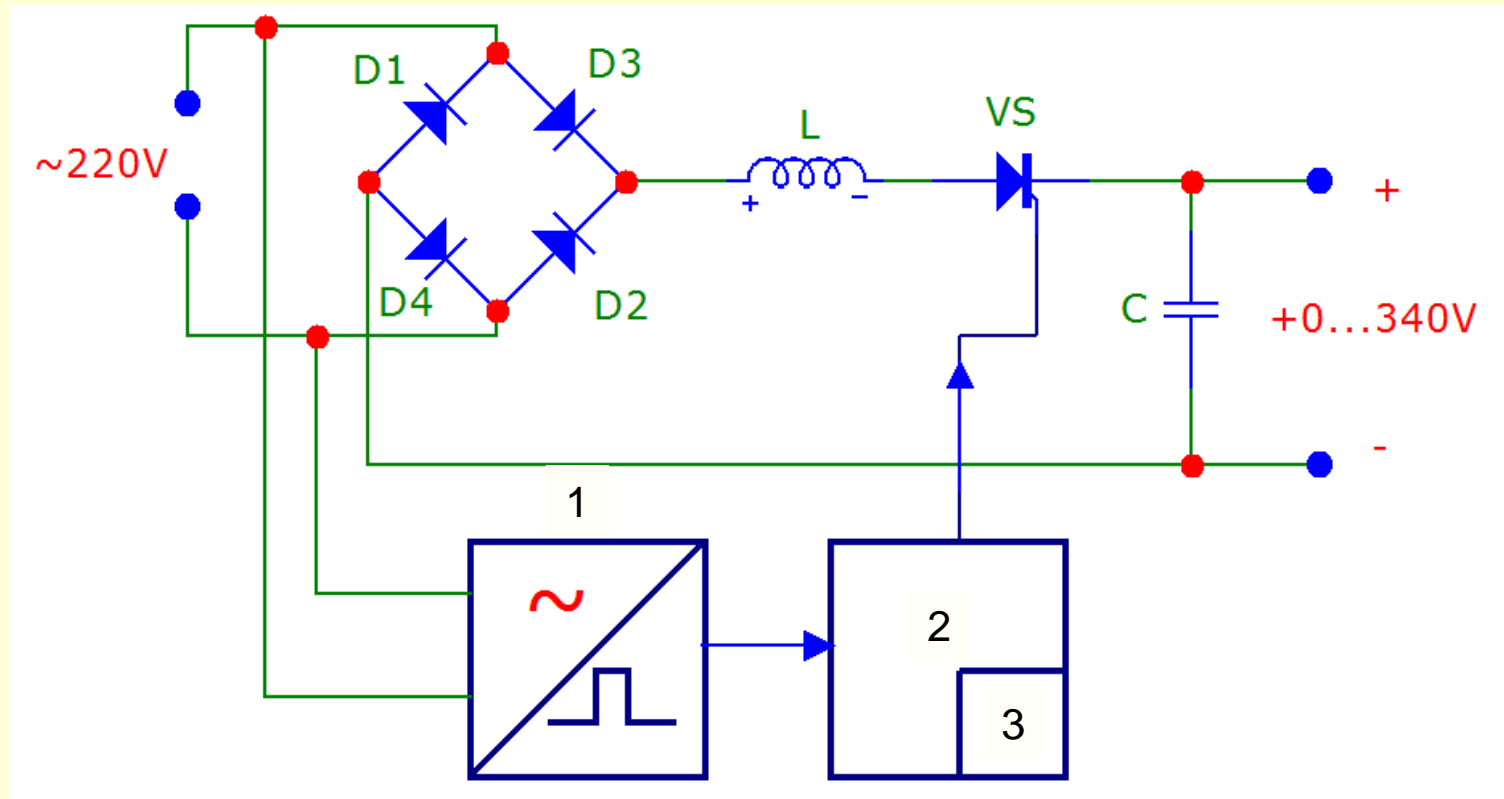
to high-frequency inverter of ultrasonic generator

- frequency of PWM control signal is 60kHz
- APFC factor = 0.8

PWM control signal

to single-phase AC power line

Thyristor power regulator



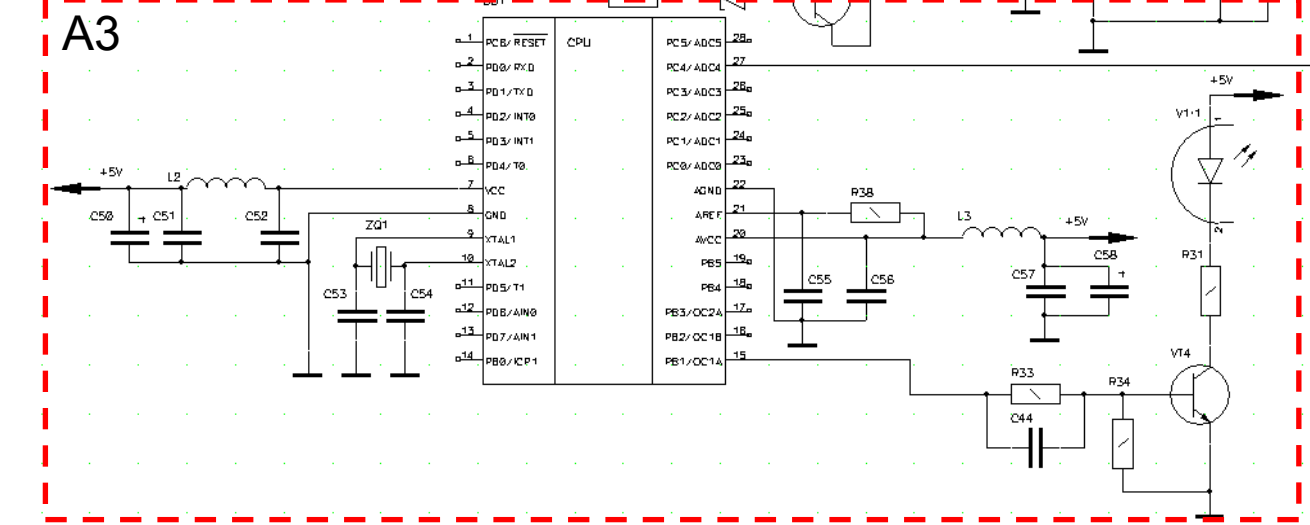
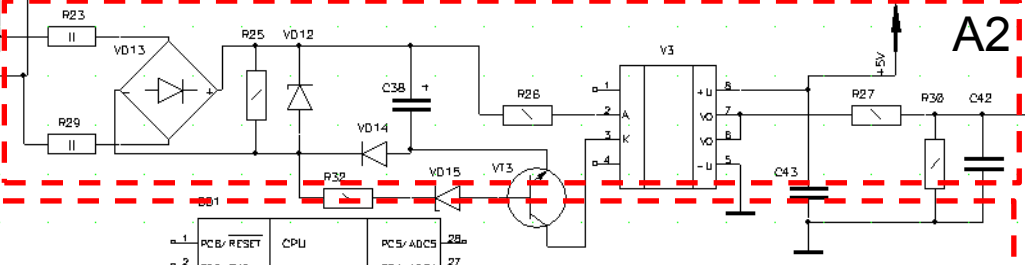
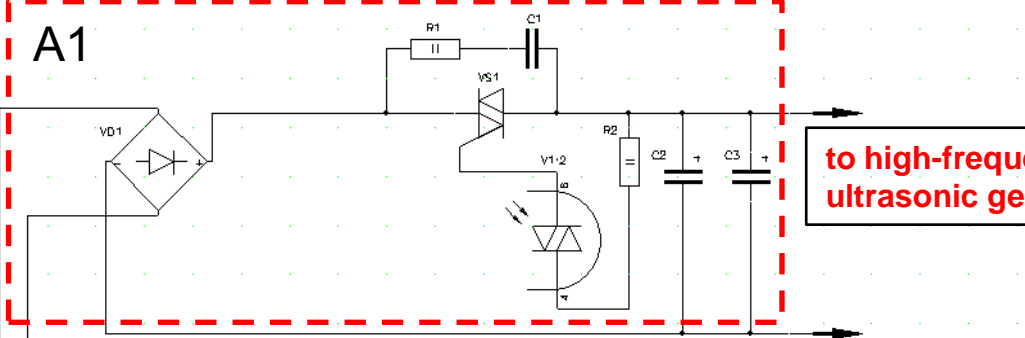
- 1 – zero crossing circuit;
- 2 – microcontroller;
- 3 – control program.

Circuit of single-phase thyristor power regulator

to single-phase AC power line

to high-frequency inverter of ultrasonic generator

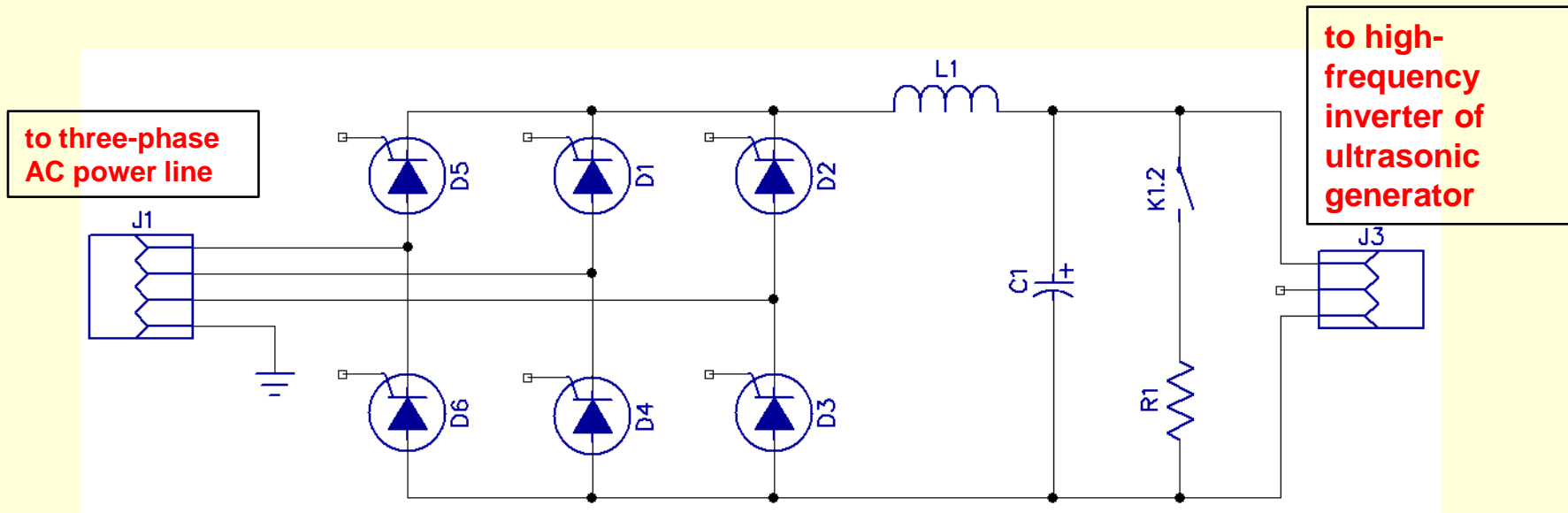
Цепь	Конт
1	
2	
3	
4	



A1 – power line of the regulator;
 A2 – synchro-pulse generation unit;
 A3 - microcontroller unit

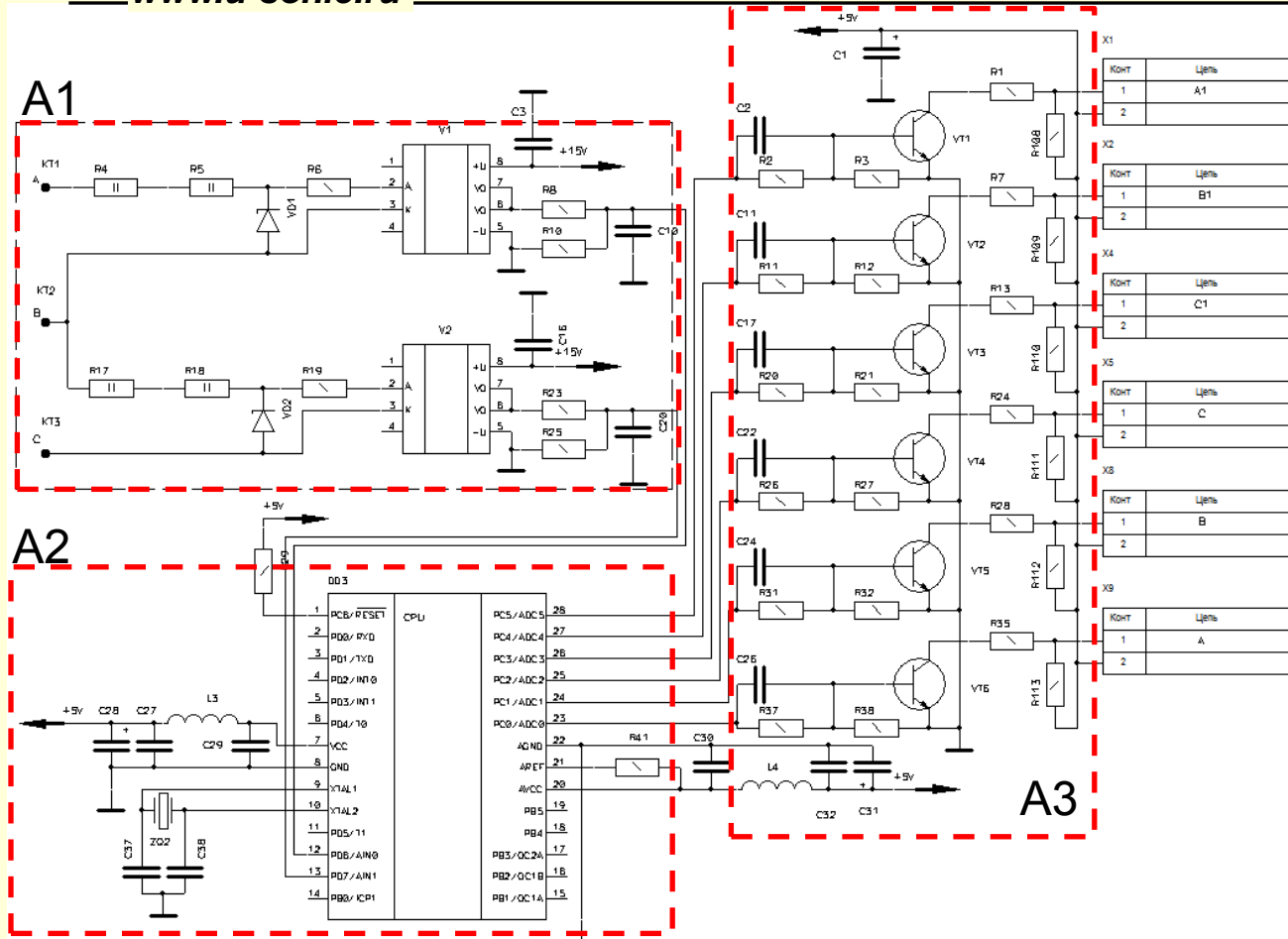
Three-phase power regulator thyristor switch unit

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Circuit of control unit of three-phase power regulator

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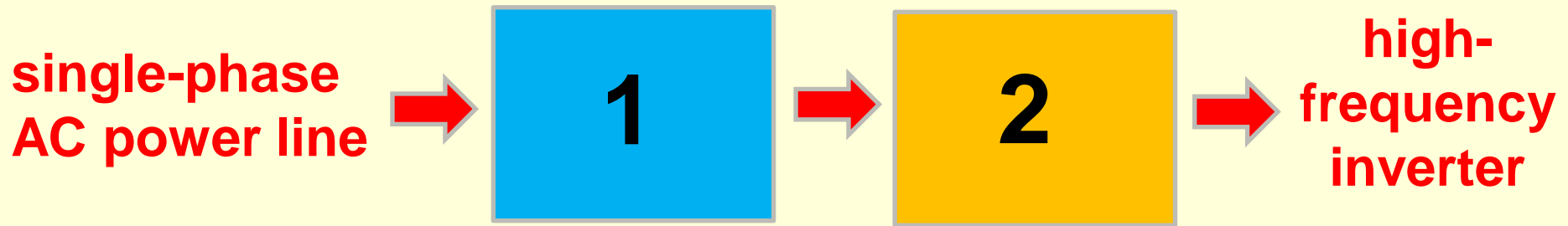


To the thyristor switches of the power regulator

- A1 - synchro-pulse generation unit;
- A2 – microcontroller unit;
- A3 – switches unit

Switch-mode step down regulator with APFC

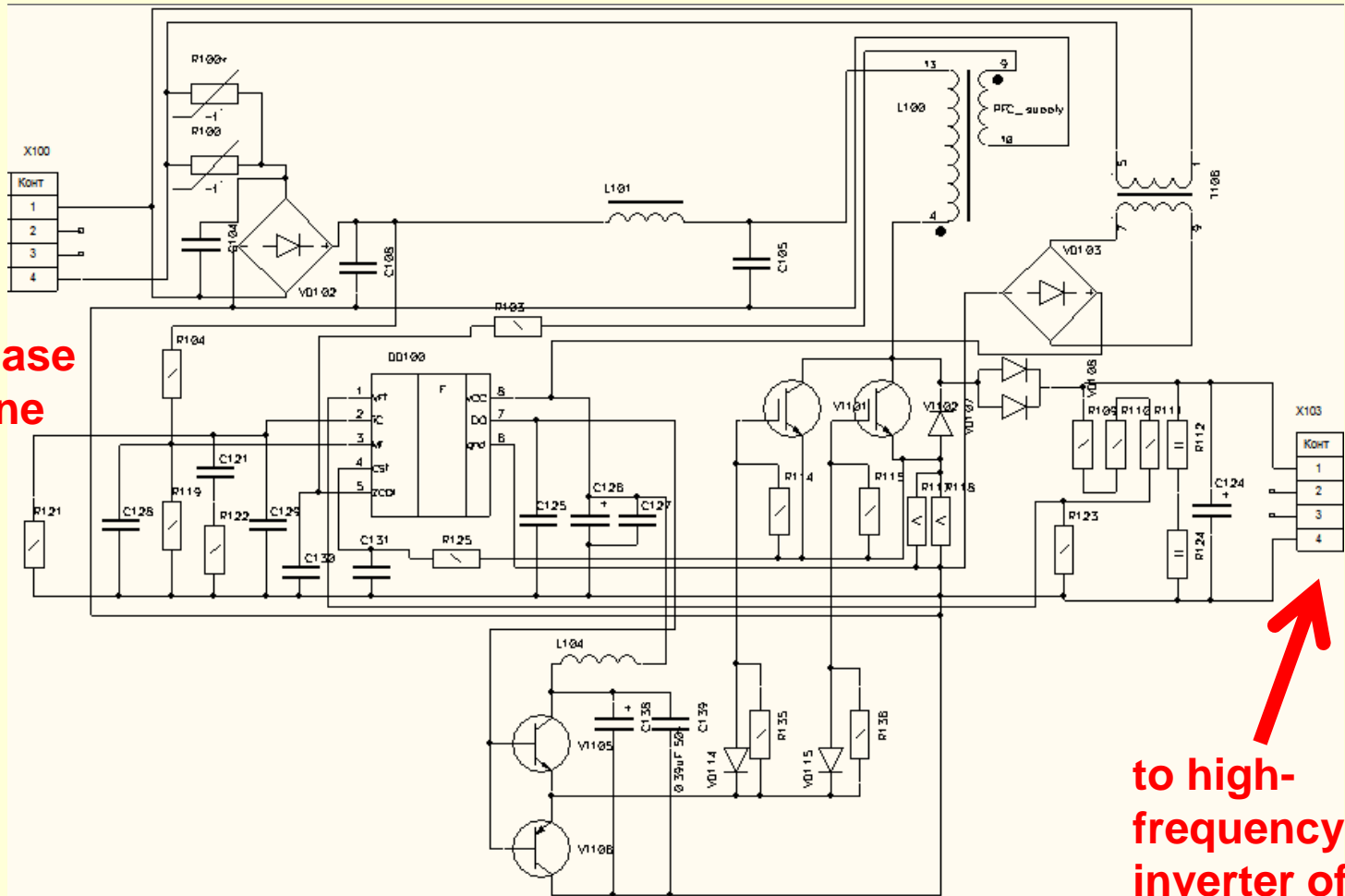
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1 – APFC;
2 – Switch-mode step down regulator;

- APFC frequency no more 90 kHz;
- frequency of PWM control signal is 60kHz;
- APFC factor = 0.99.

APFC circuit

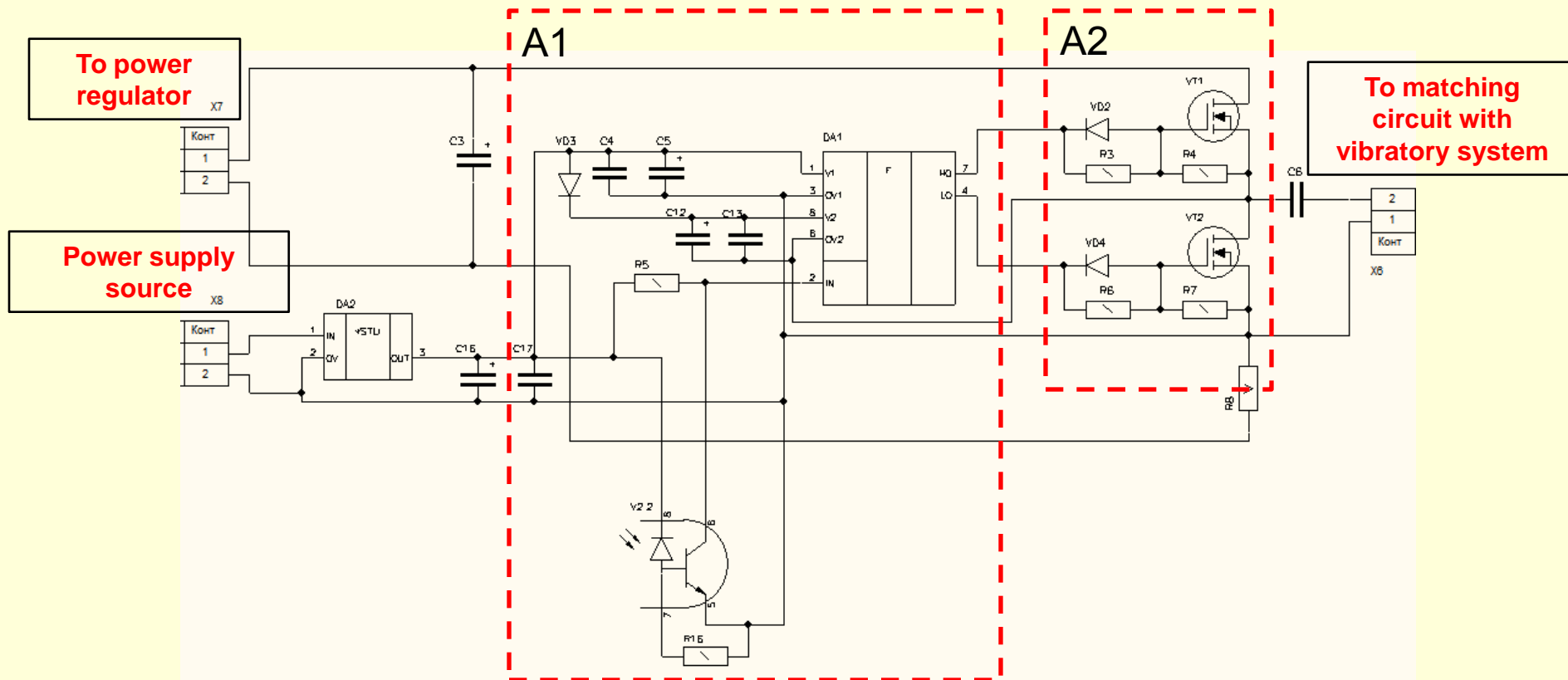


to single-phase AC power line

to high-frequency inverter of ultrasonic generator

Typical circuit of half-bridge inverter with driver

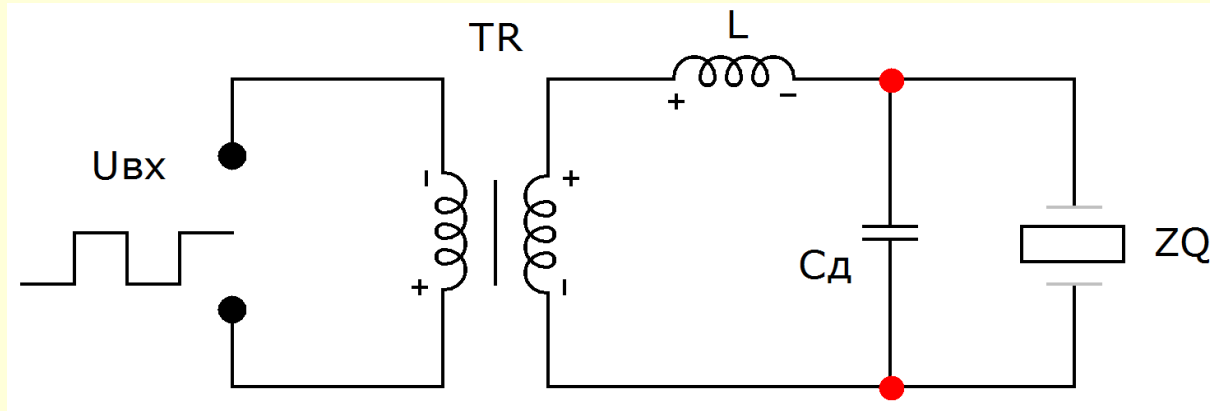
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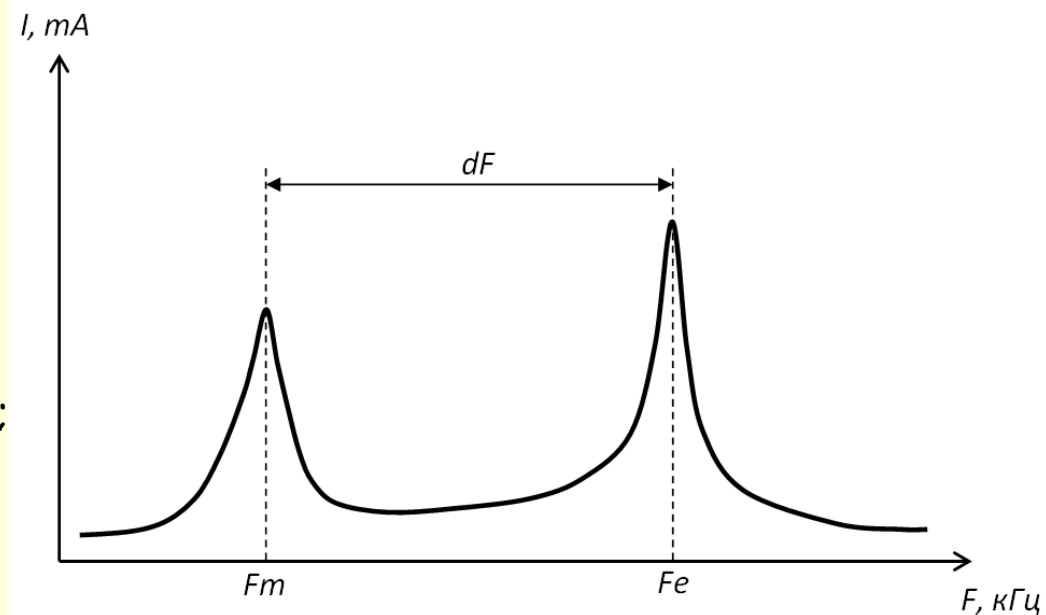
A1 - transistor half-bridge;
A2 - transistor half-bridge driver;

Matching circuit of vibratory system with output of electronic generator

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L, C, TR - parts of matching circuit;
 ZQ - transducer of ultrasonic vibratory system;
 F_m - frequency of mechanical resonance;
 F_e - frequency of electrical resonance;

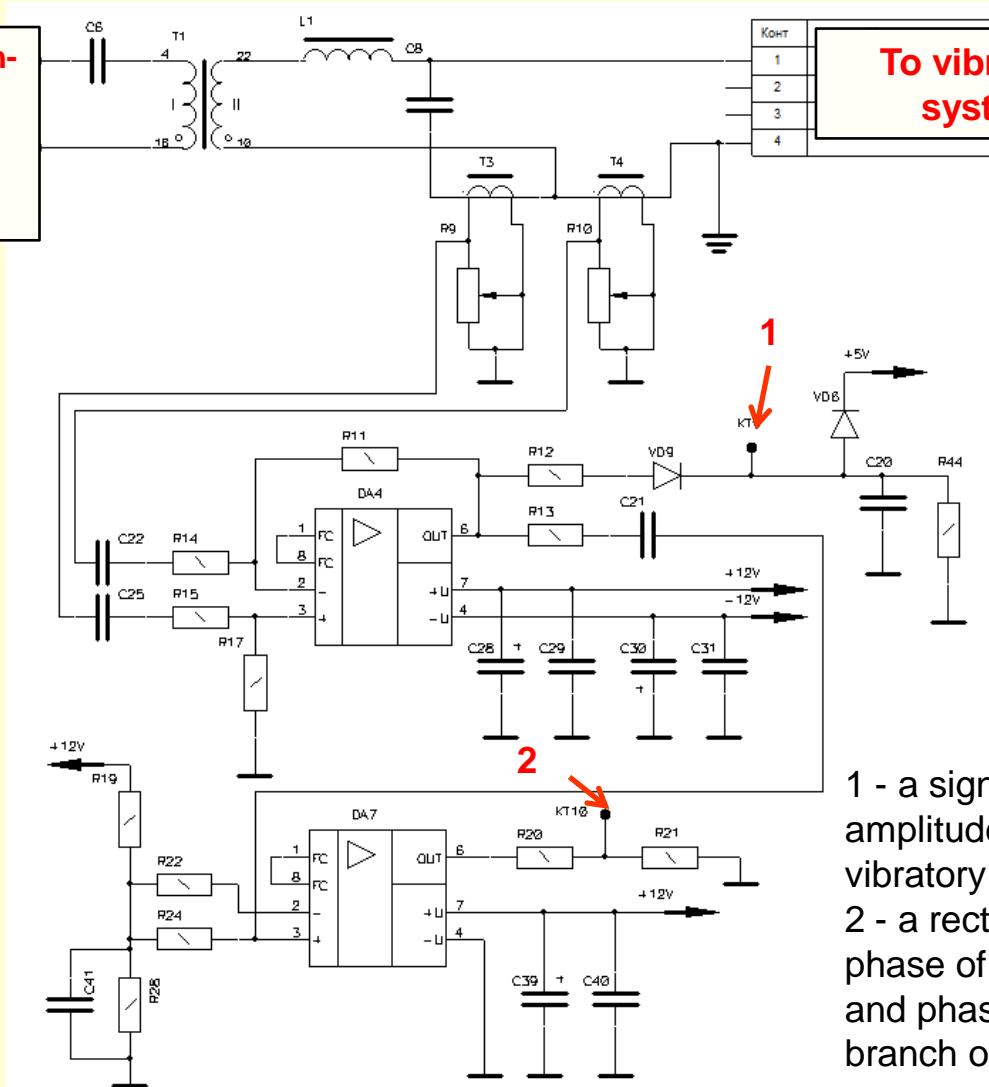


The circuit of feedback signals of the ultrasonic generator

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to output of high-frequency inverter of ultrasonic generator

To vibratory system

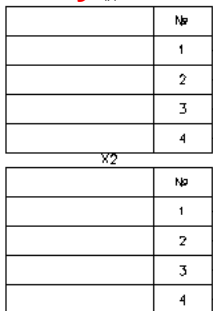


- 1 - a signal proportional to the current amplitude of the mechanical branch of a vibratory system;
- 2 - a rectangular signal, the frequency and phase of which correspond to the frequency and phase of the current of the mechanical branch of a vibratory system;

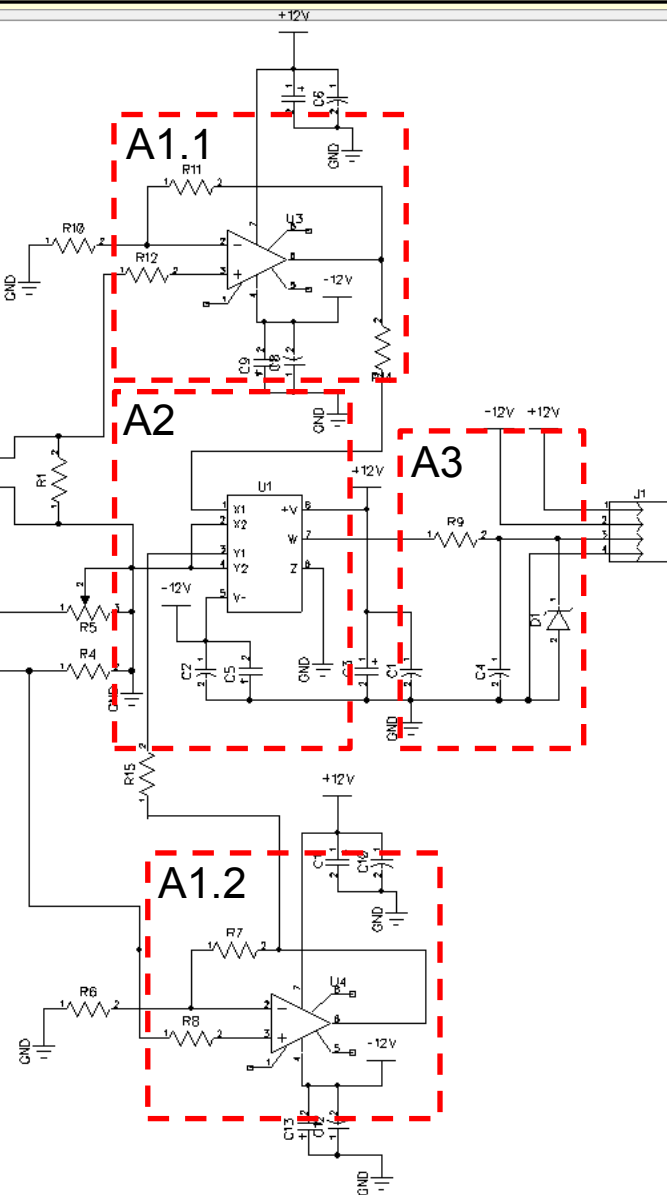
Monitoring circuit of vibratory system power consumption

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To vibratory system



To output of generator



Signal proportional to the measured power

- A1 - normalizing amplifiers;
- A2 - Analog multiplier AD633;
- A3 - Peak detector

Ultrasonic generators

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Up to 2000W



More 3000W



Up to 500W



Generators combined with actuators

Up to 100W



Monograph about ultrasonic devices

