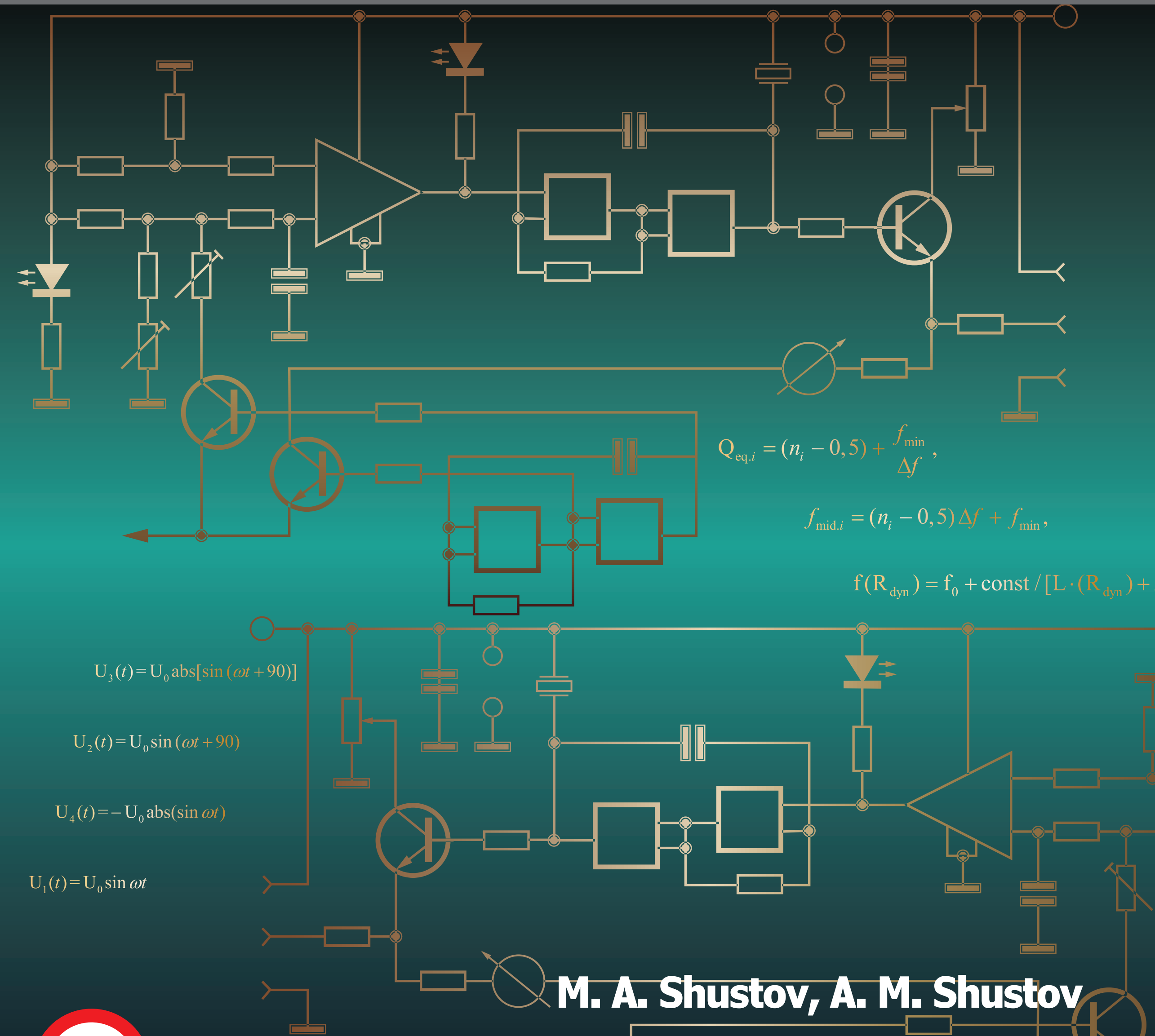
ELECTRONIC CIRCUITS FOR ALL



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Electronic Circuits for All

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Declaration

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This book includes new and original radio electronic multipurpose circuits. The first chapters of the book are devoted to power electronics and measuring equipment and contain numerous original circuits of generators, amplifiers, filters, electronic switches based on thyristors and CMOS switch elements.

Wired and wireless systems as well as security and safety systems are presented. Due to the high relevance and increased interest of readers in little-known or not readily available information in electronics, the chapters of this book describe the use of electronic devices in industrial electronics and for research, as well as new instruments and equipment for medical use, gas-discharge or Kirlian photography. The book, perhaps for the first time, provides in detail systematical information on the instrumented study of unusual phenomena.

Most of the devices described in the book are based on widely used, cheap and available elements. Most devices use transistors which have a special notation, such as n-p-n and p-n-p Type.

Device operation is confirmed experimentally in terms of hardware, and is tested using Multisim and Microcap circuit simulation software.

This book contains more than 400 simple electronic circuits which are developed and tested in practice by the authors. These should be useful for both radio amateurs and professionals.

Table of Contents

Introduction

The book provides numerous radio electronic devices developed by the authors. The devices are classified and described in the sections of approximately equal volume and relevance. All the sections of modern radio electronics cannot be incorporated into this book for a simple reason: “It is impossible to embrace the unembraceable”.

The technical solutions can be protected by patents after creative modification, or, at least, stimulate the creative imagination of readers and broaden the area of thought. This should allow readers to look beyond the horizons of possibilities and use ordinary electronic items for a new purpose.

Some electronic circuits are presented for informational purposes and can be used in practice in accordance with current legislation or regulations of a resident country.

A number of technical devices are related to the field of exploration (in radio-electronics). These developments are related to understanding the mysteries of the earth, nature and human beings by using radio electronic devices.

Chapter 1 • Power electronics

1.1 • Barrier-resistor elements – baristors and their application

In power electronics, Thyristors and Triacs are known as commutation elements which are switched from a non-conducting state to a conducting state when a voltage is applied to their control electrode. They turn off if their anode voltage approaches zero.

Thyristors and Triacs allow the "right" part of a sine wave signal to be cut with adjustable width for further use.

Thyristors and triacs have a number of disadvantages: the impossibility of tripping without interrupting the current in them, low operating frequencies, distortion of shape of sinusoidal oscillations, low power factor and low efficiency.

Using Thyristors and Triacs in industrial and consumer electronics causes distortion of the sine wave of the supplying voltage due to adding higher harmonics reducing the efficiency of using of electrical energy.

The barrier-resistor element (barrier + resistor = baristor) is a switch element of power and analogue electronics, where electrical "Input-Output" resistance changes abruptly from a conducting state to a non-conducting state or vice versa. A change occurs when voltage at the input of the element exceeds a predetermined threshold (barrier).

Symbaristor – symmetric baristor – is designed to operate with AC-current.

Baristors and Symbaristors allow an AC-current signal to be divided into segments of adjustable width, using them according to the needs of customers:

- By a summation principle – to regulate or stabilize the power consumption of the heating and lighting devices;
- To use in power supply units for generation of several different output voltages, etc.

Baristors are a "Thyristors vice versa": considering the diagram "Voltage – Time" – for Thyristors and Triacs, switching occurs on the horizontal (time) axis. In the case of baristors, switching occurs on the vertical axis (voltage) axis.

This feature of the baristor opens fundamentally new opportunities for its use in communications equipment and power electronics.

Baristors are designed to separate signals with amplitude above or below a predetermined threshold value (barrier) set by a user.

Such devices, at low level output, should pass the input signal without distortion if amplitude does not reach the threshold (barrier) value. Upon exceeding the threshold (barrier) value, the input signal automatically switches over to pass undistorted at high level output.

Baristors (see Figure 1-1 on page 16) can be categorized as:

- Controlled and uncontrolled (with a controlled or uncontrolled threshold value (barrier));
- AC- or DC-current (asymmetric and symmetric baristors – symbaristors);
- Single-channel or multi-channel (multi-level, multi-threshold baristors);
- Switches as ON/OFF/switch-over.

The schematic symbols for the main types of the barrier-resistor elements are shown in Figure 1-1.

- **High-level baristor** – the voltage at its output occurs only in the case when input voltage level exceeds a certain threshold value.
- **Low-level baristor** – the voltage is applied at its output until the input voltage level exceeds a certain threshold value. After that the baristor changes its state and turns-off the load.
- **Switching single-threshold baristors** – by continuous increasing of the input voltage, the output voltage is initially present at the output of the low-level signal. After exceeding a certain threshold value, the input signal is automatically switched over to the high-level output.

  The I–V curves of the baristor, the shape of input and output signals, and the examples for the application of a baristor in power supply units are shown in Figure 1-1 to Figure 1-8.

- **Switching multi-threshold baristors** – with a continuous increase/decrease in input voltage, the baristor output switches are sequentially switched. The input signal passes on the corresponding output of the baristor (see Figure 1-1).

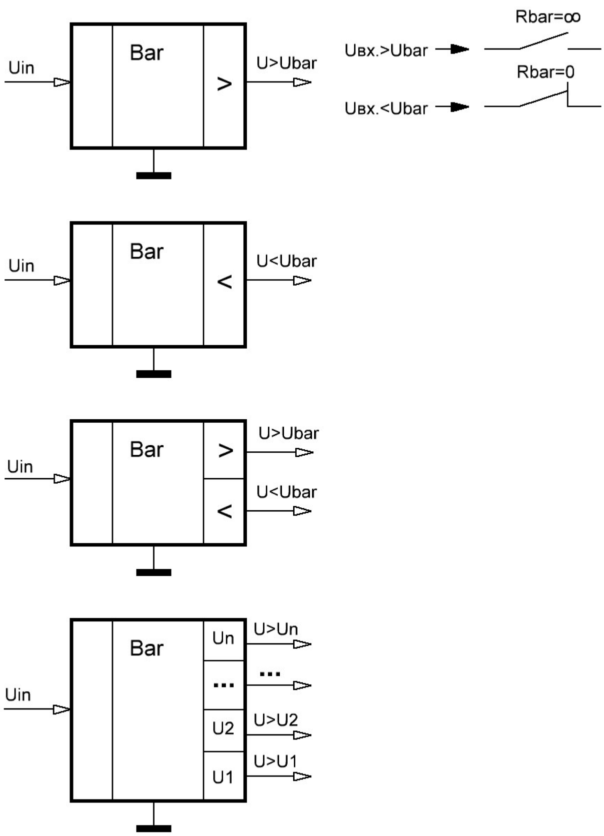

Figure 1-1 Schematic symbols of the main barrier-resistor elements

Figure 1-2 on page 17 demonstrates the operation of a baristor. A semiconductor device with an S-shaped current-voltage or "zener diode" characteristic is used as a threshold (barrier) Z-element determining the response threshold of the device, for example, dynistors, thyristors, zener diodes, bipolar avalanche transistors or controlled and uncontrolled semiconductor analogs. If input voltage does not exceed the switching voltage of the barrier Z-element, then its resistance is infinitely high. The low-level voltage is applied to the control input of one of the switch elements; the inverted high-level voltage is applied to the second input of the second switch element lossless.

As a result, the input signal passes through a used (powered on) switch element. When the input voltage exceeds the response threshold, the resistance of the Z-element is abruptly decreased up to a certain final value. This results in an automatic switchover of the switch elements.

Figure 1-3 and Figure 1-4 show schematically a baristor and its current-voltage characteristics (CVC) for a certain load resistance R_{load}. Figure 1-5 to Figure 1-7 demonstrate the use of single-threshold baristors as a part of the power supply to gain on its output a voltage of one or two levels. The practical use of the baristor as a part of the power supply with an adjustable output voltage is shown in Figure 1-8 on page 19.

The signal diagrams on the input and outputs of the baristor (Figure 1-4 and Figure 1-7) are shown in Figure 1-9 on page 20.

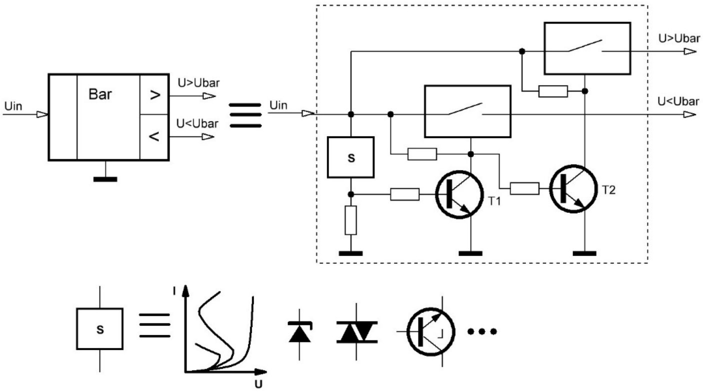

Figure 1-2 Schematic views of a switching single-threshold baristor

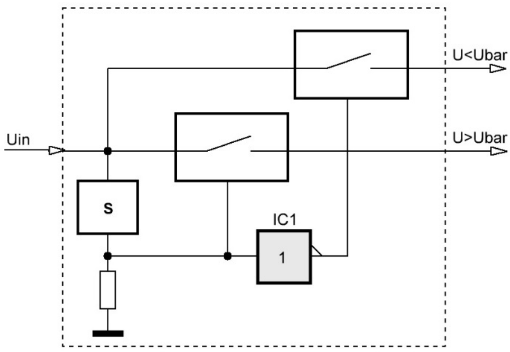

Figure 1-3 Variant of baristor with one threshold

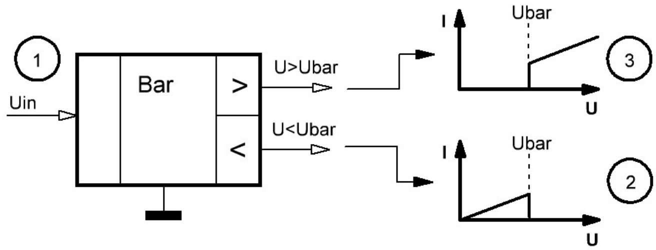

Figure 1-4 Current-voltage characteristics of a switching baristor

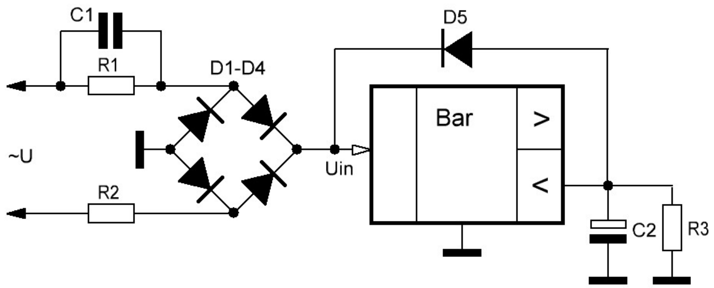

Figure 1-5 Transformerless power supply with baristor use

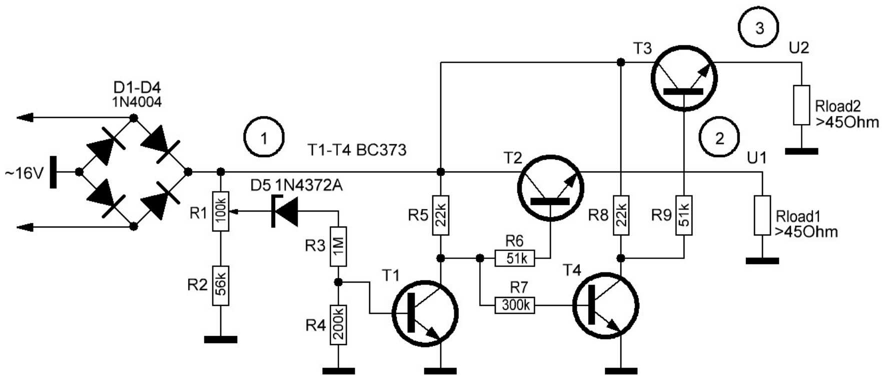

Figure 1-6 Using of a switching single-threshold baristor in a power supply unit

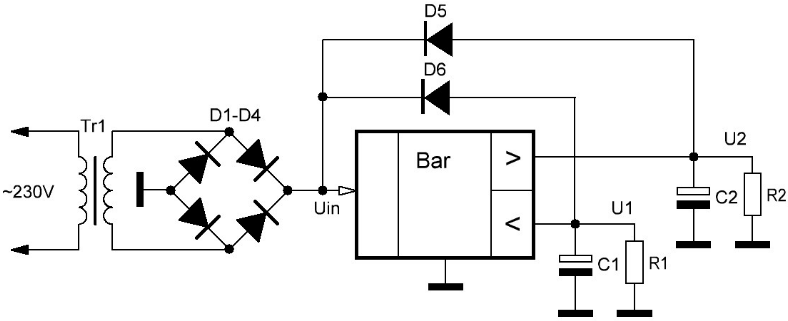

Figure 1-7 Switching single-threshold baristor on the basis of discrete elements

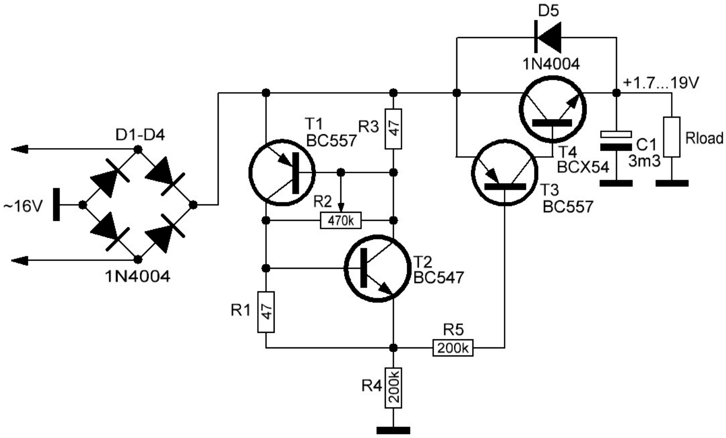

Figure 1-8 Practical power supply scheme based on regulated single-threshold baristor switch type

Baristors can be also used in analog electronics for signal separation, which amplitude is higher or lower than the predetermined threshold value.

Using Baristors and Symbaristors allows the AC-power to be distributed or re-distributed between consumers of electric energy, to filter-out higher harmonics of supply voltage, to increase (to correct) the power factor, to use rationally a part of the sine wave, which is useless lost in Thyristors and Triacs controllers and rectifiers, and as a result, to increase significantly the efficiency of electric energy use, thus increasing economic effectiveness.

Barrier-resistor elements can be used:

- in miniature economic power supply units with low-losses;
- in voltage converters and voltage stabilizers;
- for the control of voltage, current, power;
- for the protection of electronic components, circuits, of electric power equipment, and communication lines;

- in systems for multichannel remote control, communication systems including a HF signal superimposed on the two-wire line;
- in measuring instruments and transducers;
- in devices of pulse technology;
- for separation or generation of signals.

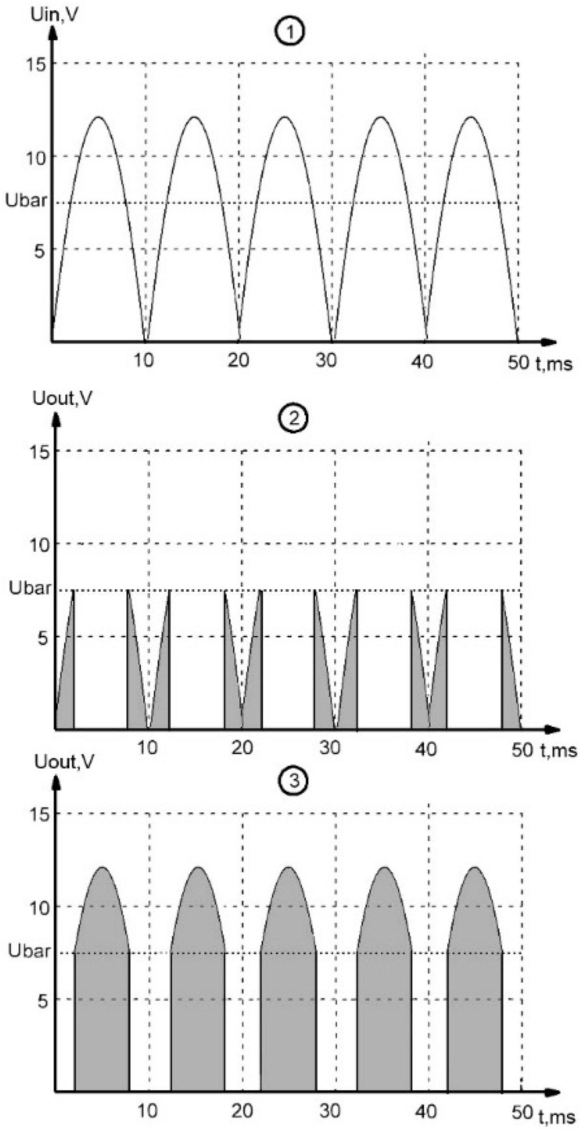

Figure 1-9 The shape of the signals observed at various points of the baristor

1.2 • Low-voltage converters for LED power supply

LED sources of optical emission are widely used as indicative devices for data transmission through optical communication channels, room lighting, in voltage converters (current)/light intensity, and for recording information on photosensitive materials.

LEDs cannot be lit in the visible wavelength range at a voltage lower than 1.6 to 1.8V due to construction features, regardless of their undeniable advantages: their small size, high lighting intensity at minimal current (mA), and efficient performance.

It is known that the lower limit of values for the forward bias U_{fb} at which the lighting of a light-emitting diode is observed can be calculated by the approximate formula λ(nm) = 1236/U_{fb}(V), where λ is the LED light wavelength.

This limit is determined by the width of the LED semiconductor band gap and is a constant value. So, for the visible wavelength range with the conditional boundaries of 750nm (red) and 400nm (blue), the minimum LED power-supply voltage cannot be lower than 1.65 and 3.09V, respectively.

The impracticality of creating light-emitting diodes, the lighting of which is visible in the wavelength range with a forward bias voltage lower than 1.60 to 1.65V confines the use of LED emitters in the devices with low-voltage power supply. It should be noted that galvanic battery voltage is 1.65V and 1.2V for NiCad or NiMn batteries.

The use of voltage converters can solve the problem of LED power supply from reduced voltage sources.

LED emitters with low-voltage (0.13 to 1.6V) power supplies can be used to indicate high and low frequency voltages, power supply voltages and data transmission through optical channels. When using thermal batteries, such devices can be used to indicate the temperature of refrigeration units, radiators, irons, electric and gas stoves and other heating or cooling elements. Ultra-low-voltage electrochemical elements with an electrolyte from moist soil, biologically active media, etc. can be used for the power supply of LED emitters.

The basic circuits for LED power supply with use of low-voltage sources (0.12 of 1.6V) are summarized below. The diversity of these circuits can be reduced to two types of voltage transformation to convert low-voltage to high. These circuits have **capacitive** and/or **inductive** energy storages: pulse generators with output voltage multiplication, LC-type generators, transformers, and combined circuits.

Figure 1-10 on page 22 shows a power supply circuit of an LED emitter which uses the principle of the power supply voltage doubling. A low frequency pulse generator with a pulse repetition frequency determined by the product of R1C1 and duration determined by the product of R2C1 is based on p-n-p and n-p-n transistors. Short pulses are applied to the base of transistor T3 from the output of the generator through resistor R4. Resistor R5 is connected in the collector circuit of transistor T3.

Red light emitting diode HL1 and resistor R6 (or the forward-biased germanium diode) connected in series are connected in parallel with the power supply. C2 electrolytic high capacity capacitor C2 is connected between the output of the pulse generator and the connection point of the LED and resistor R6 (germanium diode).

During a prolonged pause between pulses, transistors T2 and T3 are closed and do not conduct current. Current also does not pass through the LED. Capacitor C2 is charged through resistors R5 and R6 up to the voltage of power supply. When short pulses are generated, transistors T2 and T3 are opening. The negatively charged plate of capacitor C2 is thereby connected with a positive power bus through LED HL1; the positively charged plate coating is connected with a common power bus through open transistor T3. Charged capacitor C2 is then connected in series with the power supply and loads the chain of LED HL1 and collector-emitter junction of transistor T3. Thus, almost doubled voltage of the power supply is for a short period of time applied to the LED: a bright flash occurs. After that the C2 capacitor charge-discharge process is periodically repeated.

When using an LED with a voltage corresponding to the barely noticeable glow (1.35 to 1.4 V) or with a higher voltage of 1.6 to 1.7 V, at which, without limiting resistance, the current through the LED reaches 20mA, operating voltage range of the generator is 0.8 to 6V. The boundaries of this range are as follows: the lower value corresponds to a barely noticeable glow of the LED; the upper value corresponds to the current consumed by the entire device system (including the converter and LED) at approx. 20mA (bright glow of the LED).

If a germanium diode is used instead of resistor R6, the operation range of the power supply voltage is narrowed to the range of 0.8 to 1.6V.

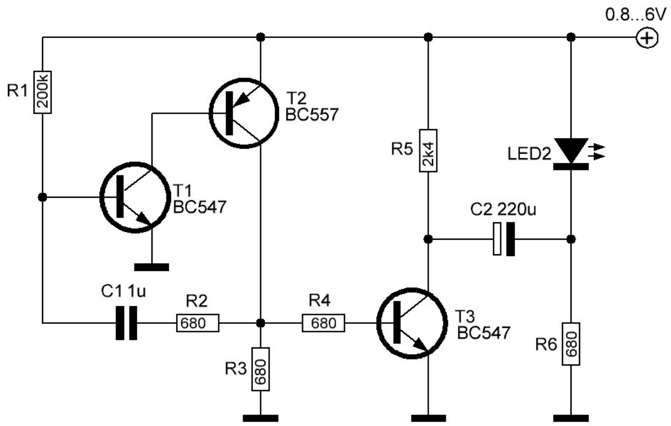

Figure 1-10 Voltage converter of capacitor type with the pulse-periodic power supply of the LED

Figure 1-11 and Figure 1-12 show the circuits of similar converters operating in a narrower range of power supply voltages.

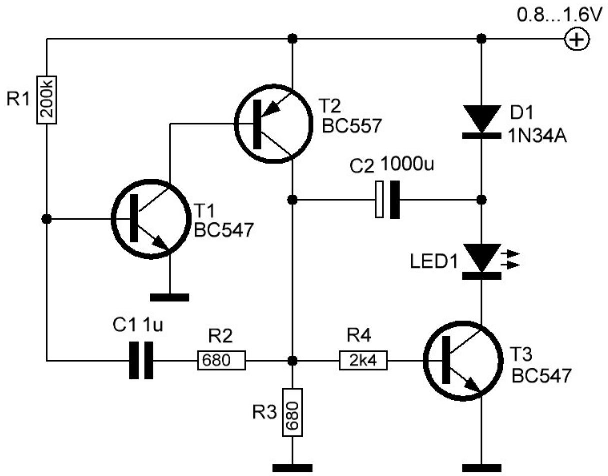

Figure 1-11 Voltage converter with the pulse-periodic power supply of the LED (variant)

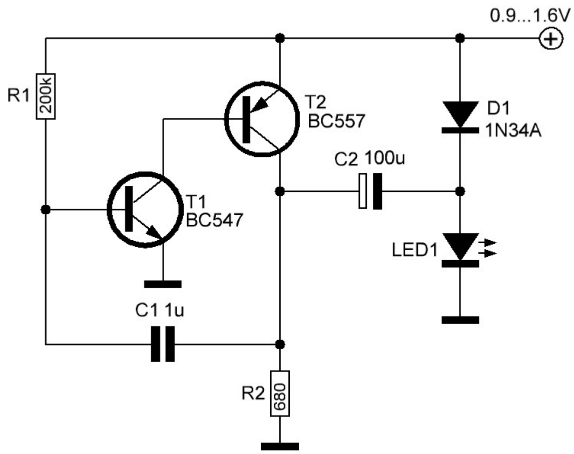

Figure 1-12 Simplified version of the voltage converter

The following circuit (Figure 1-13 on page 24) is based on the principle of voltage doubling in combination with a voltage converter of inductive type.

The low-frequency pulse generator is based on transistors of different structures. The load of the generator is the inductance (phone capsule element). The output voltage of the generator is applied through capacitor C2 of small capacity to the junction point of LED HL1 and germanium diode D1 connected in series.

When capacitor C2 is periodically connected alternately to the power bus and to the inductive energy storage, the voltage of the power source and voltage charged on the plates of the capacitor C2 are periodically summed. As a result, LED HL1 begins to glow when power supply voltage exceeds 0.7V.

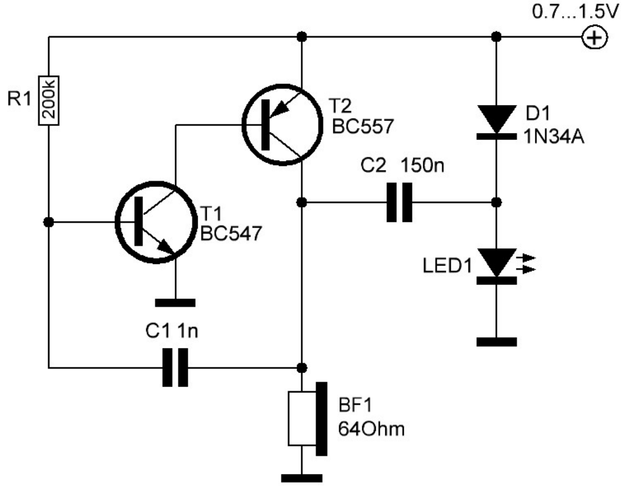

Figure 1-13 Voltage converter with a sound indication for the LED power supply by the low constant voltage

The voltage converter with pulse-periodic LED power supply and sound indication (Figure 1-14), is a modification of the voltage converter of capacitor type Figure 1-10 on page 22.

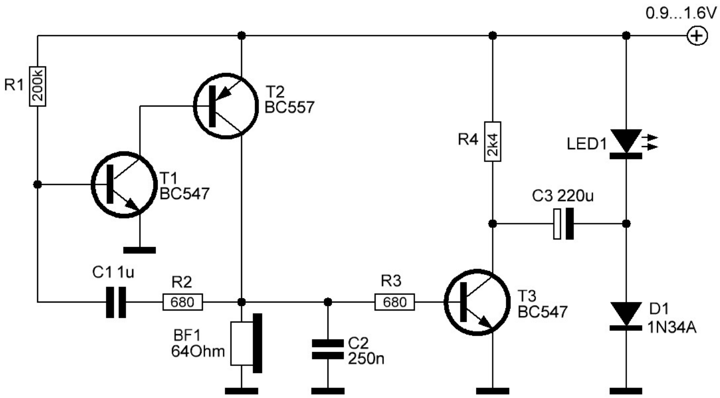

Figure 1-14 Voltage converter with the pulse-periodic LED power supply and sound indication

The sources of low-voltage power supply for LED emitters based on multivibrators are shown in Figure 1-15 and Figure 1-16. The first source (Figure 1-15) is based on an asymmetrical multivibrator generating short pulses with extended pause between pulses. Here, the energy accumulator is an electrolytic capacitor C3 that is periodically charged by the power supply source and discharged into the LED by summing its voltage and power supply voltage.

The generator in Figure 1-16 provides constant LED lighting. This device is based on the symmetric multivibrator and operates at high frequencies. In this connection, the capacities of the capacitors in this circuit are 3–4 orders of magnitude lower. At the same time, the intensity of lighting is significantly reduced, and the average current consumed by the generator does not exceed 3mA when power supply voltage is 1.5V.

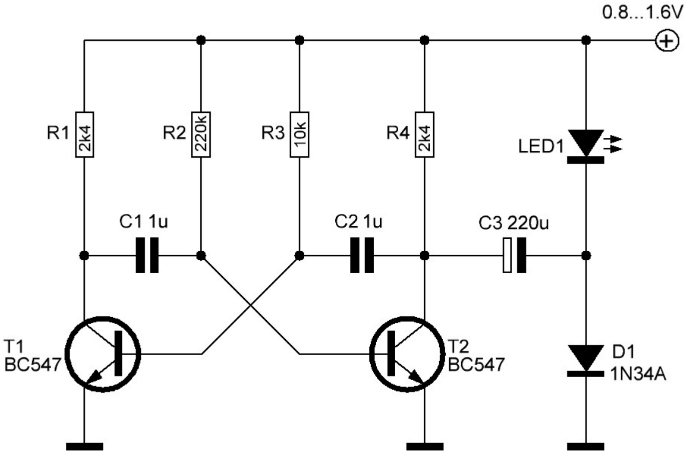

Figure 1-15 Voltage converter based on an asymmetric multivibrator with pulse-periodic LED power supply

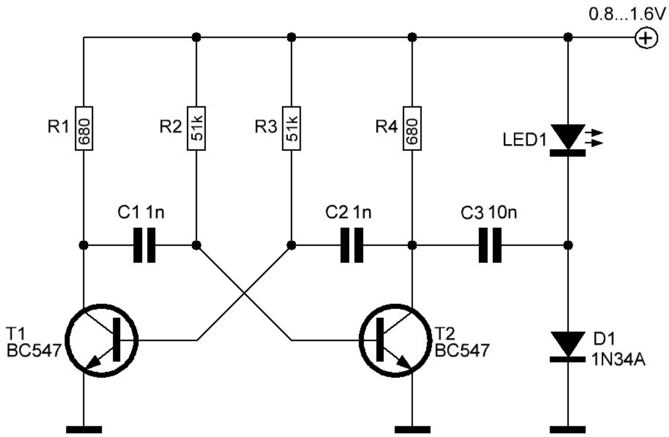

Figure 1-16 Voltage converter based on a symmetric multivibrator with constant LED lighting

The following picture (Figure 1-17), shows a simple voltage converter, based on back-to-back transistors of a different structure, with pulse-periodic LED power supply.

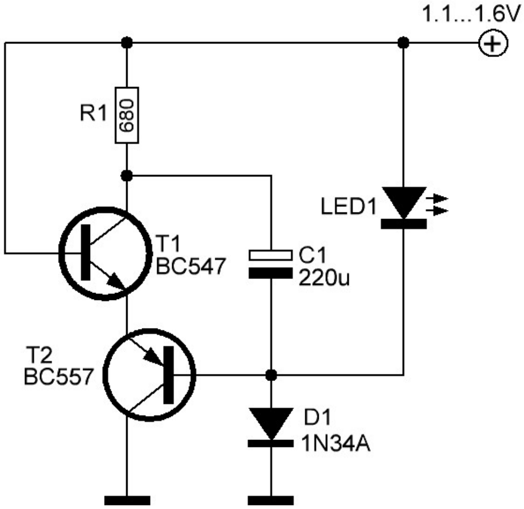

Figure 1-17 Voltage converter with pulse-periodic LED power supply

The capacitor voltage converter (with doubling voltage) used for power supply of LED emitters can theoretically provide a reduction in the operating power supply voltage up to 60% (ideal limiting value is 50%).

Converters with inductive energy storage are more promising in terms of further reducing the power supply voltage of LED emitters while maintaining high efficiency.

The voltage converters for the LED power supply (Figure 1-18 and Figure 1-19), are based on the analogs of injection-field-effect transistors. The first converter (Figure 1-18 on page 27), uses an inductive capacitive circuit for increasing output voltage by combining the principle of capacitive voltage doubling in order to obtain higher voltage using a commutated inductance.

Phone BF1 and capacitor C1 are elements which determine frequency oscillation. The periodic short switching-on/off of transistor T2 leads to discharge/charge of the capacitive energy accumulator (capacitor C1). The operation of such a converter is similar to that of the constructions described above. At the same time, the lower voltage limit of the power supply for the LED emitter is decreased by 120mV due to the inductive load of the pulse generator compared to non-inductive analogs.

The simplest generator is based on the analog of the injection-field-effect transistor (Figure 1-19 on page 27), where the LED is a load of the generator and simultaneously acts as a capacitor.

This device operates in a narrow range of power supply voltages; however the intensity of LED lighting is quite high. The converter (Figure 1-19 on page 27), is inductive and has a high efficiency coefficient. An intermediate frequency coil of the radio receiver with an inductance of 260uH was used as an inductance coil.

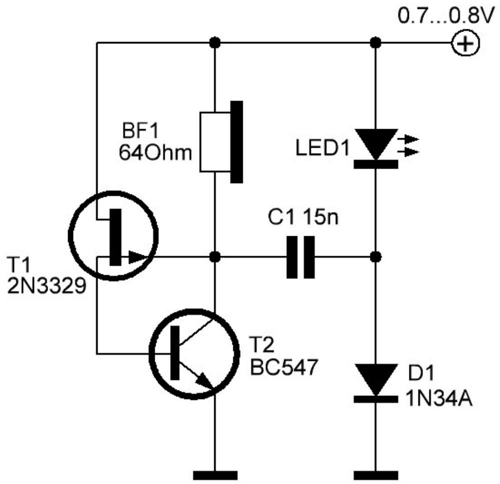

Figure 1-18 Inductive capacitive voltage converter for LED power supply with sound indication

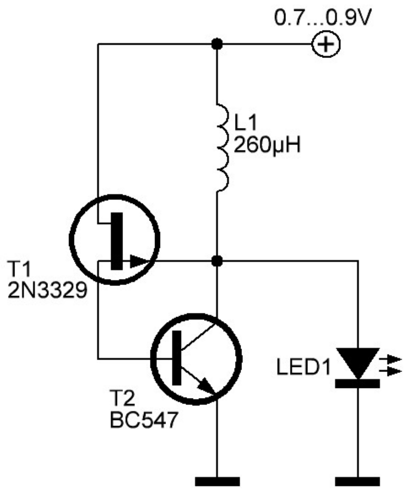

Figure 1-19 Inductive voltage converter based on the analog of the injection-field-effect transistor for the LED power supply

Figure 1-20 to Figure 1-23 show the voltage converter circuits based on analogs of the injection-field-effect transistors for LED power supply

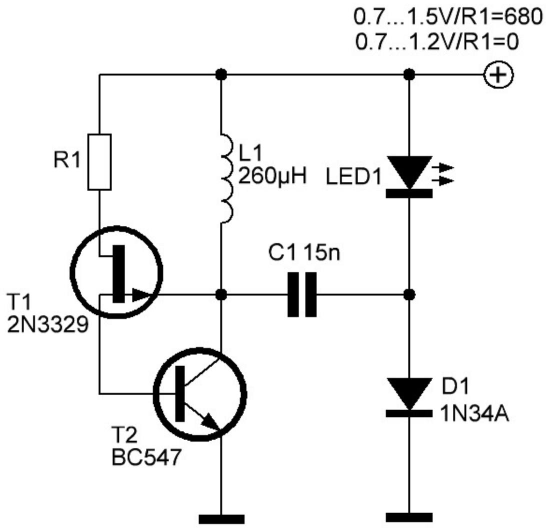

Figure 1-20 Inductive capacitive voltage converter for LED power supply

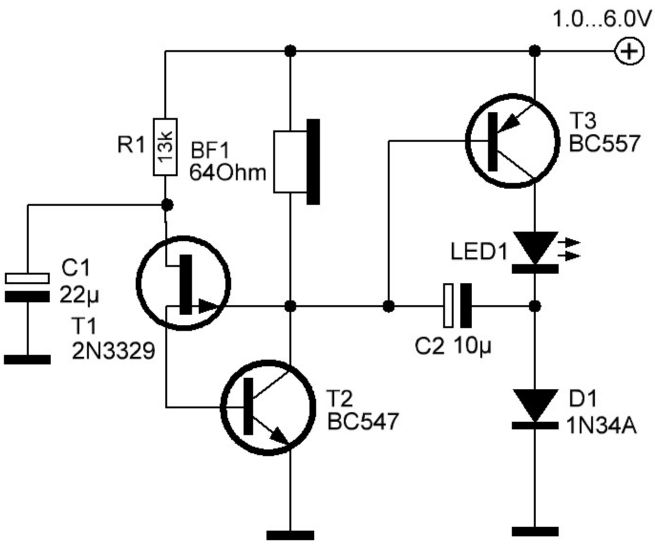

Figure 1-21 Inductive capacitive voltage converter for LED power supply (variant)

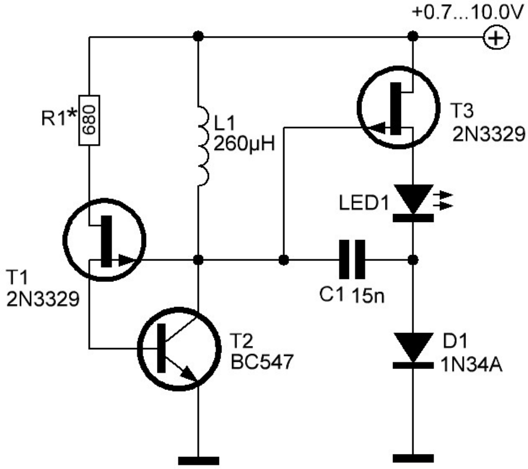

Figure 1-22 Inductive capacitive voltage converter for LED power supply (variant)

Figure 1-23 to Figure 1-26 are related to inductive converters and are used as an active element for the series connection of transistors with a different conductivity type and positive feedback. LED HL1 is used both as an element of the oscillatory circuit and the load of the generator according to the "Colpitts circuit".

The phone cap is used as the inductive energy accumulator in the converter circuit (Figure 1-23 on page 29). The generator produces acoustic signals simultaneously with light emission.

The increase in capacitance up to 200uF leads to the fact that the generator switches over to an economical pulse operation mode, generating discontinuous light and sound signals.

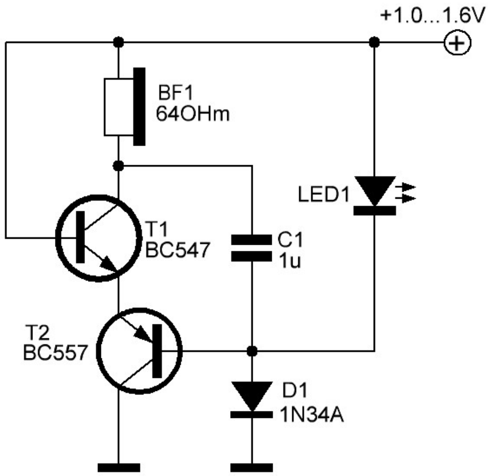

Figure 1-23 Voltage converter for LED power supply with sound indication