

Source for a Power Supply of Measuring Systems in Laboratory

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Abstract- In this paper there are analysed parameters of typical sources that are used for power supply of measuring instruments in laboratory. The functions of measuring instruments and measured equipments are always affected by technical parameters of the electrical energy, which supplies apparatus and arrangements. Disturbing signals, which are propagate by power line along the supply system or by the form of radiated electromagnetic waves, get through measuring circuits. The relevance of all effects grows up with the increasing of the accuracy and sensitivity of taken measurements. There is described the construction of a special source with minimal distortion too.

I. Disturbances made by power supply in measuring systems

Measuring systems in laboratory are usually constructed for power supply from the distribution supply network of low voltage. A quality of the electrical energy supplied by power net and disturbance level, expanding together with the delivery power, affect then their function too. This problem is solved by means of standards EMC [1] in common practice. These standards EMC define a disturbance level in power net and also electromagnetic immunity requirements of an arrangement that are supplied by the power net.

But a permanent performance of standard parameters is impossible to guarantee in laboratory, that is supply from power net. By norms defined arrangement immunity against the disturbance guarantees only a limited influence of the acceptable disturbance on measuring apparatus, this disturbance also affects analyzed arrangements. The disturbance levels that are also multiple less than the one, that the norm allows, are often noticeable in measuring results.

Disturbance levels, which guarantee the quality of the electrical power supplied by power net, are defined so, that suppliers could them realize easy. Limits for low-frequency power disturbance (frequency and voltage deviations, a voltage drop and drop-out, an impulse disturbance, a level of harmonic and in harmonic signals up to 2 kHz, a harmonic distortion) are defined exactly, but a temporary non-performance of limiting values is allowed. In the range of radio frequencies there're defined levels of disturbance that propagates along line in the range 150 kHz to 80 MHz, and field intensity for disturbance that propagates as a radiation up to 400 GHz. Limit values are not strictly set at the boundary of both ranges, in the frequency band 2 to 150 kHz.

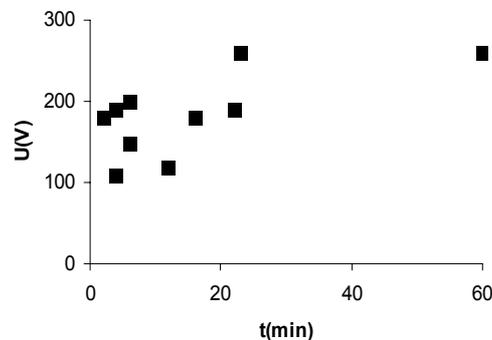
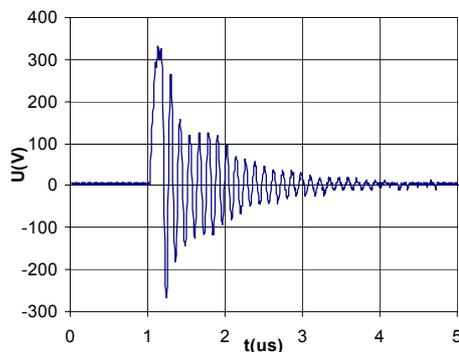


Fig. 1. The time dependence of voltage response Fig. 2. Vvoltage peak values of transient processes

Disturbances due to random transient processes are a relatively rarely watched area. It is usually possible to watch this disturbance as a short radio pulse that is similar to a damped harmonic ringing. Its peak can reaches of order hundreds of volts and takes several μ s and occurs several times in a minute.

Fig. 1 illustrates this effect. There is displayed the voltage time response, that has been measured between a protective conductor PE and physical quality ground in laboratory. In the case of classic protection by connection to neutral, this voltage is as matter of fact on a frame of all measuring instruments in laboratory too. If they only cause a devaluation of measurement results and no a damage of measuring apparatus and measuring network, we can talk about good results.

Recording of voltage peak values of transient processes with voltage peak greater than 100 V within an hour is displayed in Fig. 2.

II. AC power supplies in laboratory

Quality of delivery electrical power has been analysed by chosen parameters according to [1]. The selection has been also made with regard to the influence of the disturbance on measured and measuring equipments. Disturbing signals have been analysed by means of the voltage spectrum in frequency range 10 Hz to 10 MHz with the loading current about 1 A. Deviations, voltage fluctuations, declines and supply voltage interruptions have been evaluated in agreement with the time dependence of effective voltage value and according to the source impedance.

AC power supply for supplying by the power network is realized only by separating transformer. It is necessary to use a separating transformer in order that we may disconnect the network of protective conductor between devices in measuring system. It is mostly a source of an appreciable disturbance and there was not endangered safety of the electrical arrangement by its disconnection. Measuring has been provided in laboratories of Electrical Faculty in Prague. The voltage course on the transformer output is displayed in Fig. 3.

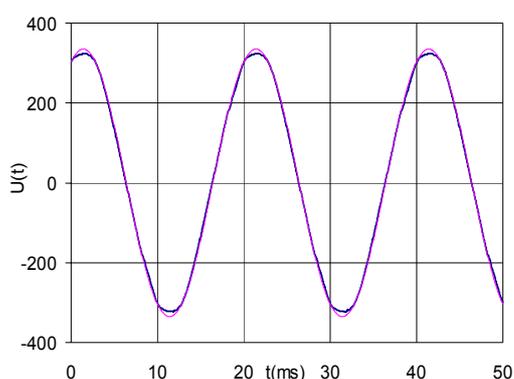


Fig. 3. The voltage course of power network and function sin

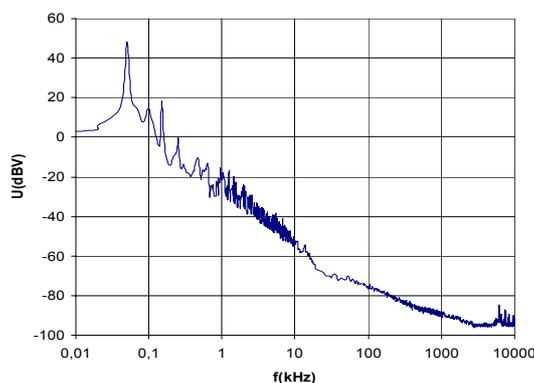


Fig. 4. The voltage spectrum of power network

There is noticeable a gentle voltage deviation of the sine wave, obviously due to the amount of switched power supplies, which are connected to power network and which do not consume harmonic current from power net.

The spectrum on the transformer output is displayed in Fig. 4. Results of measuring are good, separating transformer act also as a small RF noise suppressing filter, a suppression of harmonic and disturbing signals of higher frequencies is minimal about one order higher then is required in [1]. But these values are not guaranteed.

Disturbing signals of low frequencies (harmonics of the main frequency) do not penetrate into measuring circuits and do not cause disturbance. Disturbing signal in the range of RF frequencies match wideband noise, its level is approximately 70 dB above the thermal noise level. But the line voltage fluctuation can cause problems.

Typical time dependencies of the RMS line voltage in 800-second interval are displayed in Fig. 5. The indicated voltage variation is approximately 6 %. This change often implicates the generation of a measuring inaccuracy up to 0,1 % also in the case of top quality measuring apparatus in the process of measuring. This change implicates adequate effect of order per cent for devices, which are supplied without stabilization directly from the source. In practice this line voltage fluctuation makes impossible measuring which analyse the influence of supply voltage changes on the using of the arrangement.

Random transient processes make further problems (see Fig. 1). These are not much suppressed, only approximately about 20 dB and only by use of a separating transformer, which has a capacity 100 to 500 pF between primary and secondary winding. Penetrating disturbing signals with amplitude of several tens volts cause mistakes especially at measuring, which take longer than several tens seconds.

Inner impedance source is approximately 6Ω at load current change about 1 A. With regard to these facts above-mentioned, further possibilities of the power supply of measuring instruments in laboratory were tested. They enable superior separation of measuring instruments and power network.

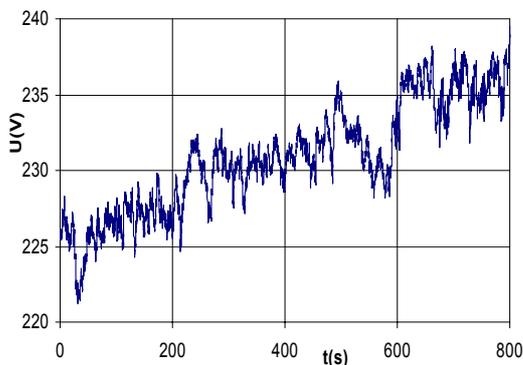


Fig. 5. Typical time fluctuations of power network voltage

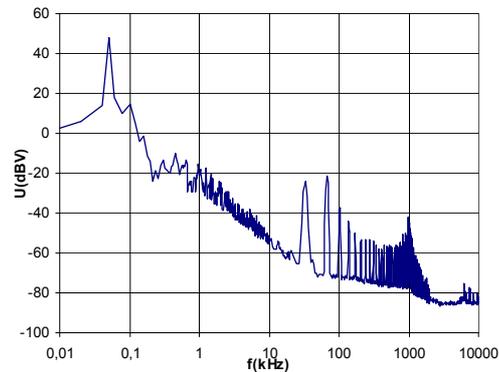


Fig. 6. Voltage spectrum of testing power supply California

Testing AC power supply California Instruments 3001ix is a stabilized source with the correction of a form distortion of voltage; it is intended especially for the monitoring of the back influence current-using equipment on a network in the area of an energy disturbance. A spectrum on the output of the source is displayed in Fig. 6. This source embodies minimal harmonic content in frequency range approximately into 30 kHz. It is minimal about one order smaller, than there is required in [1] which matches its assignment accurately. Coherent disturbing signals native out of PWM occur in the range of higher frequency, and they are reaching the level approximately 0,1V. These signals are danger in the case of the measuring in frequency range 60 kHz to 10 MHz, e.g. at measuring of disturbing signal within the measuring of EMC. Output voltage fluctuation and output impedance fluctuation are minimal, only a few of tenths V (Ω).

UPS power supply APC SMART UPS 1000 VA is uninterruptible power supply. It has been tested in connection with a possibility of its using as an autonomous source of the electrical energy. The spectrum on the output of the source is displayed in Fig. 7. This source embodies a small harmonic content in the frequency area approximately to 2 kHz. In the area of higher frequencies, approximately to 150 kHz, there is a broad-spectrum of disturbing signals, which reach the level up to several tenths V. If they were carried into measured circuit of a measurement system, they will implicate measurement errors. The disturbance level is small in the range of RF frequencies and it is possible to suppose, that disturbance will not implicate problems. The voltage drop is approximately 10 V during a working time (depends on loading), source impedance rough 5Ω .

Inverter INTELLIGENT SP 600/24V is a converter designed for the power conversion from 24 V accumulators to AC voltage corresponding LV mains. Inverter generates a high-level of the disturbing

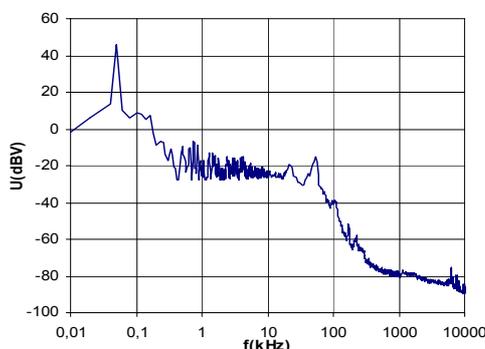


Fig. 7. Voltage spectrum of UPS

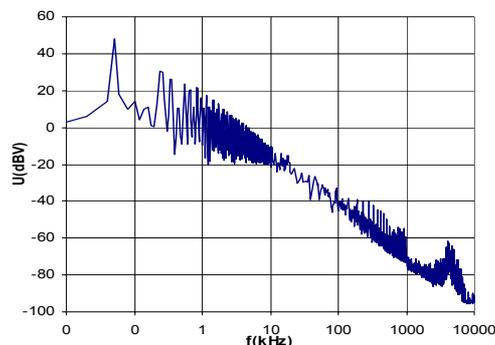


Fig. 8. Voltage spectrum of commercial inverter

signal, which exceeds by a norm-defined limit approximately three times (see Fig. 8). Inverter disturbs in its surroundings also a broadcasting reception, it can be used neither for the power supply of the measuring systems nor function in their neighbourhood.

Inverter with harmonic output voltage has been developed as the source for power supply of

measuring equipment. Our goal has been to attain a minimal disturbance on the output in all frequency ranges, minimal disturbance by the radiation and the output voltage stability during the service. The first specimen inverter has output power 600 W, supply voltage 24 V. It can be engaged in autonomous running at the power supply from an accumulator, or it can be supply from the direct stabilized supply (provided that D.C. source does not disturb). Inverter is engineered as a linear amplifier without use of impulse modulation. A block diagram of the arrangement is illustrated in Fig. 9.

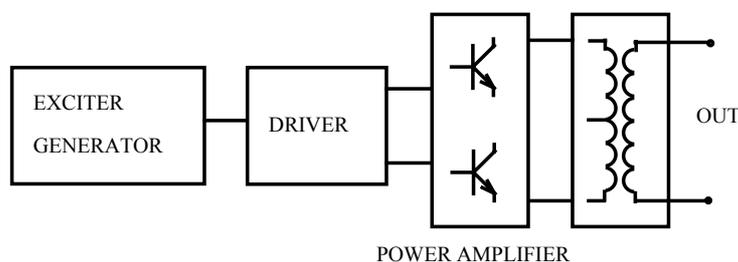


Fig. 9. Block diagram of the harmonic inverter

A special line of controlled generators was used as driver of the inverter. In case, that self-signal causes difficulties in the interference of eigenfrequency of the inverter with the mains frequency, it is possible to use mains as the source of a driving signal [2].

This driving signal is further processed in a filter and in an amplitude stabilizer. The voltage sine wave is restored of a generation from mains; the signal level is stabilized independently on voltage mains, the frequency and phase are identical with frequency and phase of the mains. For the THD is reached the level 0,2 % and an amplitude set-up error $\pm 0,1$ %.

A power part of the converter is constructed as a linear high-power amplifier in push -pull stage wiring with an output transformer.

The output voltage spectrum is displayed in Fig. 10. Low frequency THD is in sum approximate 0,7 %, on higher frequencies the level of a disturbing signal decreases monotonically. This signal matches a wideband noise, which is generated by the amplifier. In the area of RF frequencies the disturbance matches a thermal noise; its level is about 60 dB above the level of the thermal noise. Output voltage fluctuations at a constant loading and the change of the output voltage at changes of the input voltage are minimal, only into several tenths V. The inner impedance of the inverter is approximately 7Ω at changes of the loading current about 1 A. It is advisable to use an inverter for power supply of sensitive measuring equipments. A necessity of using of a big supply accumulator for autonomous running is its disadvantage. Suitable accumulator, with capacity 120 ampere-hours, weighs 150 kg. Its volume is $0,2 \text{ m}^3$ and it has to be charged. It requires a servicing too.

The second specimen inverter has been realized by use of commercial audio amplifier.

It is possible to acquire the commercial amplifier at the lower price than it is the retail price of used components, so that its realization in laboratory is high inconvenient. Engineering characteristics of available amplifiers for using in converter correspond. Common 1000 W audio amplifier works well at frequency 50 Hz. It has the distortion THD and also IMD less than 0,02 %, signal-to-noise ratio at the output is better than 100 dB. The same generator is used as an exciter for the amplifier at the first specimen inverter, which is reaching THD the 0,1 % here.

Output transformer is solved with regard on a minimal capacity between the primary and secondary winding (perhaps 100 pF) in order to minimize a transmission of a disturbing signal from mains, which also go through the amplifier power source.

The output voltage spectrum is displayed in Fig. 11. Low frequency THD is in sum approximate 0,1 %, on higher frequencies the level of a disturbing signal decreases monotonically. Only spectral lines create exception due to powerful broadcast transmitters at medium and short waves frequencies.

The output voltage change is approximately 1,5 V upon line voltage changes in the range 200 till 245 V. The inner impedance of the inverter is approximately 3Ω , at changes of the loading current about 1 A. Inverter input power without load is 25 W, power effectivity is approximately 50 % at the loading 100 to 1000 W at the output. The inverter has the volume $0,06 \text{ m}^3$ and weighs 34 kg.

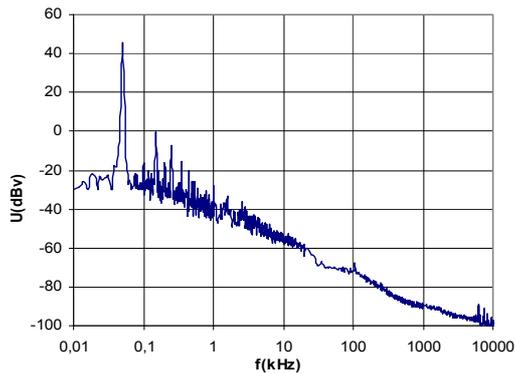


Fig. 10. Voltage spectrum of the first specimen of harmonic inverter

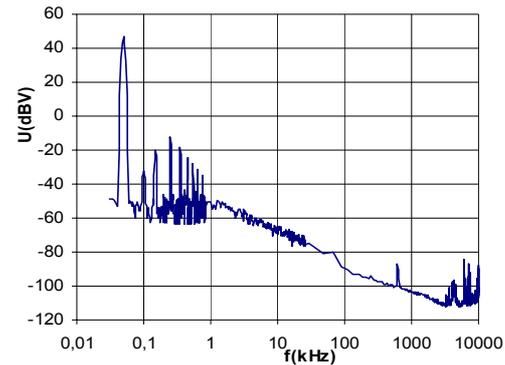


Fig. 11. Voltage spectrum of the second specimen of harmonic inverter

Power supply with motor-generator set is a line conditioner, which was primarily designed with regard on the possibility of the achievement of minimum disturbance level on the output. No inverters, neither switching regulators nor contact brush are used in this arrangement. A squirrel-charge induction engine is used for driving.

In view of loading to the limit 2,5 kW, an engine with nominal output 11 kW is used it practically works as a synchronous motor with very small slip to the limit 0,2 % at small load [3].

The motor is provided by resistance starter for current reducing at the start, so that power supply with protection 16 A sufficed for supplying of the motor-generator set.

Singled phase brush less generator is used as a generator [4]. Engine and generator cannot be themselves disturbance sources; they do not have slip rings or slipping contacts. Perfect galvanic separation of the primary and the secondary circuit of the source allow mechanical power transmission between the motor and the generator. Parasitic coupling between circuits is done only by a small capacity approximately 10 to 20 pF. It is further possible to reduce coupling by using of the shielding. The maximal output power of realised power supply is 2 kW, aggregate dimensions, volume and weighs are comparable to accumulator of inverter with the harmonic output voltage – volume 0,25 m³, weighs 120 kg. Realized motor-generator set is displayed in figure. 12.



Fig. 12. Realized motor-generator set

The output voltage spectrum is displayed in Fig. 13. Low frequency THD is in sum approximately 1,3 %, on higher frequencies the level of a disturbing signal decreases monotonic. In the area of RF frequencies the disturbance matches a thermal noise; its level is about 40 dB above the level of the thermal noise. Output voltage fluctuations at a constant loading and the change of the output voltage

practically depend only on the frequency of the input voltage. Because the mains frequency is today relatively stable, the changes of output voltage are minimal.

The voltage change on the output is less than 0.1 V at changes of the line voltage from 240 to 210 V. The output frequency deviation from the main frequency is 0.07 Hz and frequency change is lower than 0,01 Hz. Output voltage drop reaches about 0,5 V by further main voltage drop on 200 V and frequency drop about 0,025 Hz.

The inner impedance of the supply is approximately 2Ω at changes of the loading current about 1 A. An engine noise at the running and small power efficiency of the arrangement is disadvantages of this motor-generator set

Outer cooling ventilator of the engine was demounted for noise reduction and input power reducing at a small load. The natural air flow suffices for its cooling with regard to considerable over designing of this engine. Input of the motor-generator set without load is 900 W, input 1800 W at the output loading 500 W, and input 2200 W at loading 1000 W, so the maximal power effectivity is approximately 45 %.

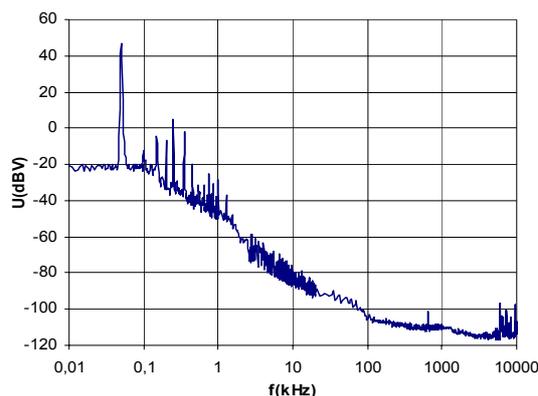


Fig. 13. Voltage spectrum of rotary generator

III. Conclusions

The power supply of measuring instruments in laboratory is the simplest and mostly suitable from power network, preferably each instruments through several, separated separation transformer too. A problem is in the case of the precise measuring with a great resolution. They are provided for a long time and in a wide frequency range, because they are often disturbed by transient processes from net. The source with a high-level of the disturbance suppression must not generate a disturbance alone and it has to be galvanic separated from power network. It's possible to fulfil it by using of the linear inverter with DC intermediate circuit with stabilized voltage or of the one, that works in autonomic mode with the power supply from a storage battery. It is also suitable to use a rotating line conditioner, even if nowadays it may seem to be anachronism, because it ensures the highest suppression of undesirable disturbance of all systems.

IV. Acknowledgements

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