Special Power Supply for Measuring Systems

Vaclav Papez[1], Stanislava Papezova[2]

[1]*CTU in Prague, Faculty of Electrical Engineering, Technicka 2, 166 27 Prague 6, Czech Republic, phone: +420 224 352 165, fax: +420 224 353 949, papez@feld.cvut.cz*
[2]*CTU in Prague, Faculty of Mechanical Engineering, Technicka 4, 166 07 Prague 6, Czech Republic, phone: +420 224 352 401, fax: +420 224 310 292, stanislava.papezova@fs.cvut.cz*

Abstract **-** 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 spread 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. In this paper there are analysed parameters of typical sources that are used for power supply of measuring instruments in laboratory. There is described the construction of a special source with minimal distortion too.

I. Electromagnetic distortion in measuring systems

Measuring systems in laboratories are usually constructed for power supply from distribution supply network of low voltage. If they are not supplied otherwise, their function and disturbance level, which they are exposure to, are affected by the quality of electrical power (supplied by supply network) dominant way. Standards EMC [1, 2] define the disturbance level in mains and requirements on the electromagnetic stability of these arrangements, which are supplied from supply network.

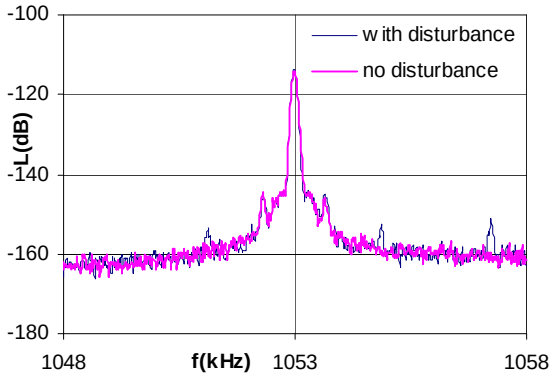

Figure 1. Measurement of phase noise of the oscillator.

However immunity (defined by the norm) does not guarantee insignificant, let us say a note less influence of acceptable disturbance on a measurement instrument. The disturbance also affects the analysed arrangement. An example is presented in Figure 1. There are compared two measurements of phase noise of the oscillator; the second during the transmission of ripple control. The disturbance expresses visibly as a wrong indicated high-level noise. The disturbance levels, that determine guaranteed quality of the electrical energy, which is supplied by supply network, are defined so that suppliers will be able to fulfil them. The low frequency power disturbance limit (frequency deviations, voltage, supply voltage dip and supply interruption, pulse disturbance, harmonic and enharmonic signal level up to 2 kHz, harmonic distortion) they are defined precisely. But a short no fulfilment of limit value is allowed. The disturbance level of expanding by power line in the range of radio frequency 150 kHz to 80 MHz and field intensity for disturbance expanding by radiation into 400 GHz are defined. On boundary-line of both ranges, in frequency band 2 to 150 kHz, are not set the limit values strictly.

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 20 Hz to 1 MHz. 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 supply 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 wasn't endangered safety of the electrical arrangement by its disconnection. Measuring has been provided in laboratories of Electrical Faculty in Prague. The spectrum on the transformer output is displayed in Figure 2. Results of measuring are good, separating transformer act also as a 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 signal in the range of RF frequencies match wideband noise, its level is approximately 70 dB above the thermal noise level. Probability of the disturbance causing is also minimal in circuits with very small wanted signal level, if circuits will be shielded (it is customary). Typical time dependencies of the RMS voltage in four following 200-second intervals are displayed in Figure 3. 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 dithering makes impossible measuring which analyse the influence of supply voltage changes on the using of the arrangement. Inner impedance source is approximately 6 Ω at load current change about 1 A.

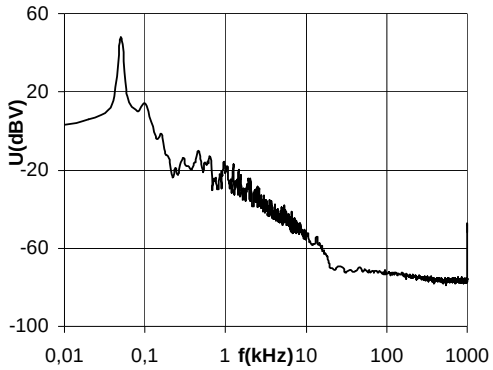

Figure 2. The voltage spectrum of supply network.

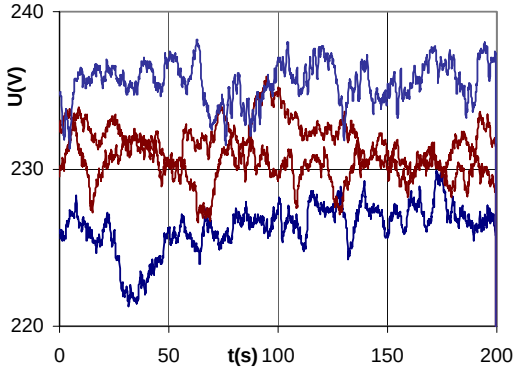

Figure 3. Typical time dependence of supply network voltage

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 Figure 4. 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 UPC 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 Figure 5. 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. 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 5 Ω.

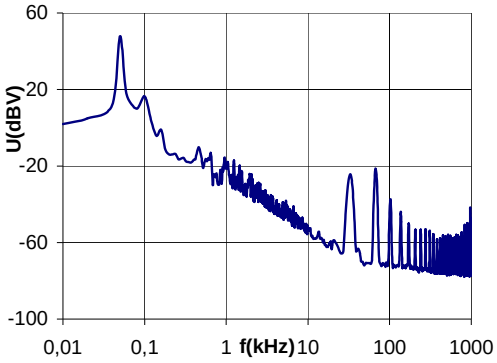

Figure 4. The voltage spectrum of testing power supply California.

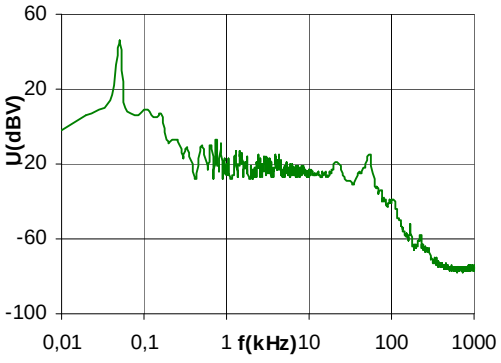

Figure 5. The voltage spectrum of UPC.

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 signal, which exceeds by a norm-defined limit approximately three times (see Figure 6). 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 is typical representative article, which should not be sold at all.

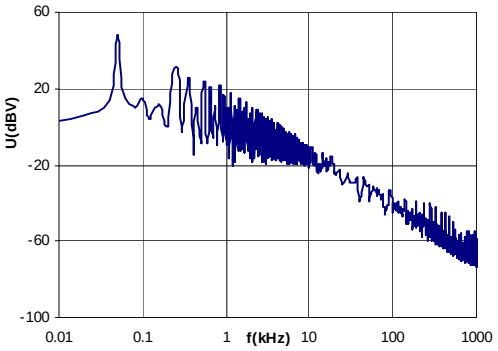

Figure 6. The voltage spectrum of commercial inverter

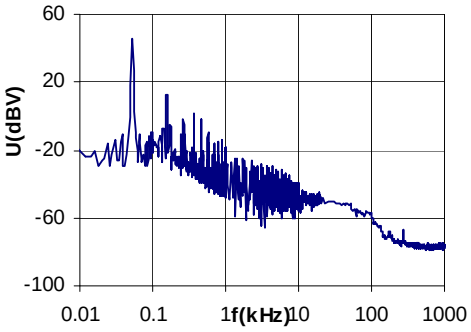

Figure 7. The voltage spectrum of inverter.

Inverter 500W/24V is an inverter of classic structure with bipolar transistors as switches and with a step-up transformer. The transformer works directly on the frequency 50 Hz. An output voltage of the converter has the form of rectangular impulses and a length approximately 75 % of a half-period, so the ratio of effective voltage value and peak voltage value is approximately preserved. This disposal is necessary at the using of the converter for power supply of appliances with simple rectifiers and with capacitive filters in supplies. The frequency spectrum of the output voltage of the converter is displayed in Figure 7. The disturbance has a low level in the range into 10 kHz, but its level is noticeable. In the range of radio frequencies is the disturbance already small, obviously therefore, that used switching transistors they are slow and they do not already generate these frequencies.

Inverter 250W/12V is a laboratory preparation designed as the source of a line voltage in an experimental laboratory photovoltaic system. The construction is similar as at the previous inverter 500W/24V, but it uses transistors MOSFET. More modern inverter generates high-level of disturbing signals at high frequencies. Less frequency stability of the inverter is noticeable too. It results obviously from a pursuit about a maximum simplification of the inverter.

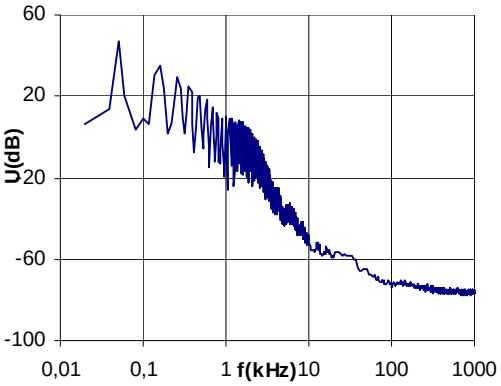

Figure 8. The voltage spectrum of inverter.

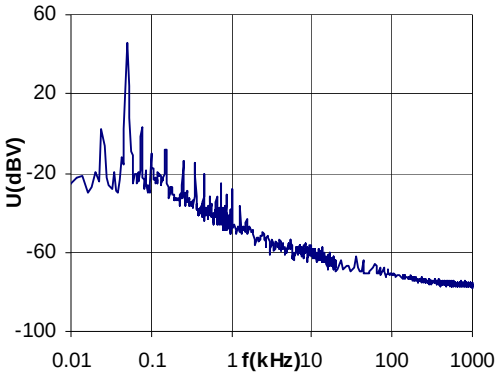

Figure 9. The voltage spectrum of generator.

Generating set E3200 SHHPI is a rotating generator with a combustion engine driving. It is equipment used as an emergency or reserve source of power. The generating set has not been assumed its using for the power supply of laboratory equipment, but it has been tested for a comparison and complement of set of data of evaluated arrangements. The frequency spectrum of the output voltage of the converter is displayed in Figure 9. The generator supplies a sinusoidal voltage with a low distortion and with a low level HF of interfering signal. An output voltage modulation of the frequency generator 25 Hz is unique on the output of the voltage generator; this modulation is probably caused by a irregularity of the operation of the actuating four-cycle engine.

III. Inverter with harmonic output voltage

The 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. Inverter 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 in order that disturbance may be minimized in spite of the decrease of the available effectivity of the inverter. A principle scheme of the arrangement is illustrated in Figure 10. Exciting sine signal with frequency 50 Hz is made in a generator. In the case, that its signal causes difficulties in the interference of eigenfrequency of the inverter with the mains frequency or mains disturbance, it is possible to use mains as the source of driving signal.

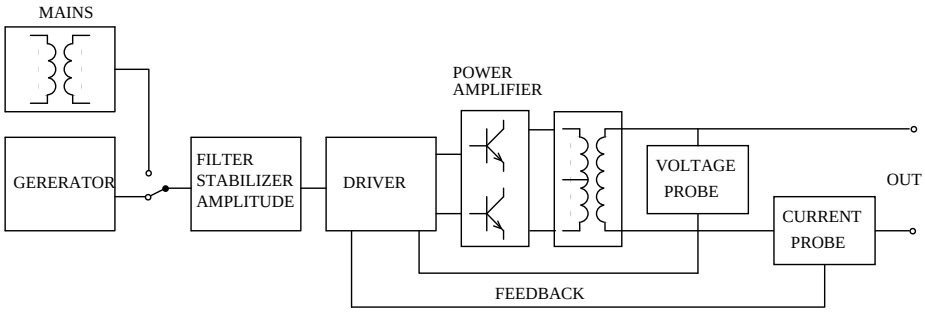

Figure 10. The inverter block diagram.

This driving signal is further processed in a filter and in an amplitude stabilizer, which further makes it possible to improve parameters of the driving signal. The voltage sine wave is restored in the case of a generation from mains; the signal level is stabilized independently on voltage mains. [3] In both of case there is reached the THD level 0,2 % and an amplitude set-up error ± 0,1 %. The driver ensures a power amplification of the signal on a level, which is necessary for an exciting of the high power amplifier. A power part of the converter is constructed as a linear high-power amplifier in push - pull stage wiring with an output transformer. Voltage and current negative feedback is fed out of the amplifier output into a driver to reduce the distortion and the influence of supply voltage changes onto the output voltage.

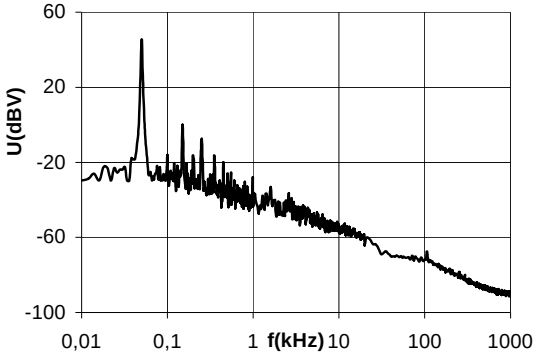

Figure 11. The voltage spectrum of harmonic inverter.

The amplifier makes it possible to achieve a THD less than 1% and except the produce of any disturbing signals of higher frequencies. A rated power of the inverter is 500 W, supply voltage 24 to 32 V. The output voltage spectrum at the loading 250 W is displayed in Figure 11. The third harmonic has the top level, perhaps 0,5 %, THD is in sum perhaps 0,7 %. The level of a disturbing signal decreases monotony on higher frequencies. 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 7 Ω at changes of the loading current about 1 A.

IV. Conclusion

The power supply of measuring instruments in laboratory is the simplest and mostly suitable from supply network, preferably each instruments through several, separated separation transformer too. If we have the luck, a disturbance in supply network is markedly less than the norm requires and the measuring does not take so long, in order that any impulse disturbing signal, a voltage dip or an over voltage or signal led by supply network may occur during the measuring, than mains power supply satisfies conditions. A problem is in the case of the precise measuring with a great resolution, there is usually used a wide averaging, spectra measuring, noise figures measuring, These measuring, if they are provided for a long time and in a wide frequency range, take a long time (measuring radio disturbance – tens minutes). It is simply impossible to suppress transient phenomenon in network. We cannot use common sources AC, which are available in laboratories, as a reserve source, because they produce theirs own disturbance with a high-level. Development inverter has been solved especially with regard on minimal disturbance. It has only a minimal level of harmonic on the output. In practice it does not produce RF disturbance. This source complies with sophisticated measuring too. Its disadvantage is only bigger dimensions and weight and limiting service time for one battery charge.

Acknowledgement

The research was supported by the research program No. MSM6840770015 "Research of Methods and Systems for Measurement of Physical Quantities and Measured Data Processing "of the CTU in Prague sponsored by the Ministry of Education, Youth and Sports of the Czech Republic.

References

[1] CSN EN 50160 European Standard: Voltage characteristics of electricity supplied by public distribution systems.

[2] CSN IEC 1000-2-3 European Standard: Electromagnetic compatibility (EMC) Part: Environment Section 3: Description of the environment – radiated and non network –frequency-related conducted phenomena.

[3] Kojecky, Papez, Samal: “Reliability of reverse properties of power semiconductor devices (Physical aspects and practical tests)” *ISPS Proceedings*, Prague 2006, 183-187.