Acta Scientific Applied Physics
Volume 1 Issue 1 December 2019
Editorial

Compact EPR Analyzer

M Jadan*

Department of Physics, College of Science, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

***Corresponding Author:** M Jadan, Department of Physics, College of Science, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia.

Received: December 06, 2019; **Published:** December 07, 2019

EPR spectroscopy is currently beyond the scope of pure research applications associated with the structural identification of various physicochemical objects, being extensively used to solve the applied problems in industry, medicine, geology, agriculture, transportation, etc. [1,2]. Rather often, however, the radio spectrometric equipment produced fails to meet the requirements imposed in science, engineering, and educational process. Besides, new possibilities are offered by the latest achievements in microwave and computer engineering, by modern elemental base.

Traditionally, the tendency in EPR technology is towards the production and use of sophisticated multipurpose devices, the functional capabilities of which are above the needs of a specific user. Conventional EPR spectrometers are bulky weighting from 500 to 5000 kg, necessitate a special large-area place for the installation, require the use of water cooling, high power supply up to 10 kW (see Figure 1). All these factors result in lowered efficiency of using such expensive equipment and in the inadequately realized potentialities.

Figure 1: Radio PAN SE/X- 2543 EPR Spectrometer.

The area occupied by the RadioPAN SE/X- 2543 EPR Spectrometer is no less than 15 m^2.

When designing specialized EPR analyzers of the latest generation, one should take into consideration modern trends in instrument making: elimination of redundant functions and ridding of versatility in the case of specialized problem solving, orientation to the extensive use of the advances in microelectronics, technological effectiveness of units, well-balanced technological parameters of the components determining the performance of the device as a whole. New-generation EPR analyzers are distinguished (1) by the fundamentally novel microwave unit, (2) by complete automation of measuring procedures and data processing (Figure 2).

Figure 2: Specialized compact Minsk 22 EPR Analyzer (SEPR 2).

Microwave components play a key role in radiospectrometry, setting its class and usability including the dimensions, energy properties, reliability, sensitivity, resolution, etc. A new level of radiospectrometric equipment may be attained only with the use of advance microwave components. A microwave unit of the new-generation EPR analyzer represents a structurally complete module (Figure 3) [3]. It features small weight and dimensions, low energy consumption, technological effectiveness, and performance due to the use of the latest achievements in microwave semiconductor electronics, extensive usage of modern microwave components. Because of this, it is possible to lower the price of a microwave member of the analyzer and, finally, to aim for the radical (by a factor of several hundreds) reduction in dimensions, metal content, energy consumption, for the improved structure and simplified operation of radiospectroscopic equipment without sacrifice in its metrological potentialities.

Figure 3: Exterior view of a microwave module (left) and measuring resonator (right) of the new-generation EPR analyzer.

A sensitivity of the analyzer is governed by the signal/noise ratio at the output of a recording system. A microwave module is distinguished from the conventional ones by the sensitivity-increasing technique. Traditionally, the sensitivity of EPR equipment may be increased due to the improved Q-factor of the measuring resonator and higher power of the microwave generator used. The new-generation EPR analyzer is characterized by broadband resonators, and also by a lowered noise level of microwave generator and detector.

Instead of the conventional microwave detector, the signal recording unit uses a modern low-noise amplifier (LNA) [3,4]. Owing to the use of LNA with the currently typical parameters, there is the possibility for lowering noise of the microwave detector and hence for increasing of the EPR analyzer sensitivity. Moreover, due to growing superhigh frequency power, in LNA there is the possibility for operation of the analyzer at low power levels of the microwave generator, enabling one to study the samples with low energy of paramagnetic saturation and with low paramagnetic-center concentration, especially important for a great number of applications [4-6].

With the elevated amplification factors, LNA is constructed according to the super heterodyne scheme [3,4]. But in this case there are difficulties with operation in the high-power mode of the microwave generator, associated with several destabilizing factors (temperature, mechanical and the like) which may lead to inadmissible changes in the output signal level and to saturation of the microwave amplifier. To provide good operation of an EPR analyzer with LNA over a wide range of powers of the EPR signal and to simplify the operation, one should use the coupling factor automatic adjustment for the measuring resonator with the microwave signal path [7,8]. When the microwave generator power level is deviated from the prescribed nominal value, an error signal is formed and fed to the control input of the coupling factor automatic regulator, changing its value. By this way, an intolerable power deviation is compensated automatically, offering the efficient work of the analyzer in a wide range of powers of the microwave generator with simultaneous simplification of the operation. At low and medium powers the signal/noise ratio at the output of a microwave unit is increased due to compensation of temperature and mechanical fluctuations of the microwave detector output signal and to the concurrent stable operation of an automatic frequency-adjustment system of the microwave generator.

EPR analyzers feature automatic frequency adjustment (AFA) of the microwave generator, enabling one to eliminate effectively the slowly-varying frequency instabilities, as a rule, caused by the external factors [9]. But AFA turns to be ineffective at short-time instabilities due to the microwave generator phase noise. Because of this, lowering of the noise created by active elements of the microwave generator is of particular importance in designing highly sensitive radiospectroscopic equipment. The microwave module is also characterized by the use of latest-generation transistors as active elements for the microwave generator. Modern transistor generators meet all the requirements to a microwave generator of the EPR analyzer, the output power requirement (hundreds of milliwatt and more) including. Besides, they outperform the conventional EPR generators based on reflex klystrons, even the Gunn diode generators still manufactured by the producers. They are characterized by the following features:

- Considerably lower level of the amplitude and phase noise (decreased by 30 dB and more);
- High efficiency (higher by an order of magnitude compared to Gunn diodes and by two orders of magnitude compared to klystrons);
- Low supply voltages (reduced by several orders compared to klystrons);
- High reliability;
- Optimal weigh and dimensions.

The majority of the limitations characteristic for the conventional active elements for microwave generators are resultant from their operational principle: using of "hot" charge carriers. Because of this, modern microwave transistors using "cool" carriers with ballistic electron transfer, at the possibility for frequency stabilization by the high-Q resonators, are greatly suitable and useful for the new-generation EPR analyzer. Sensitivity of such an analyzer approaches the ultimate values limited by quantum noise. Owing to the potentialities of personal computers, a sensitivity of the EPR spectral analysis may be increased due to new processing techniques for radiospectroscopic data, other characteristics of EPR analyzers may be greatly improved too [9].

Bibliography

1. Adashkevich SV., *et al*. "Small-sized specialized electron paramagnetic resonance analyzers". 8th International Crimean Conference "Microwave Technology and Telecommunication Technologies": Conference proceedings. - Sevastopol. - 1998.
2. Akunets VV., *et al*. The analyzer of electronic paramagnetic resonance: a training manual - Mn .: UP "Technoprint" (2002).
3. Akunets VV and Stelmakh VF. "Small-sized microwave module for new generation radio spectrometers". 10th International Crimean Conference "Microwave Techniques and Telecommunication Technologies": Conference proceedings. - Sevastopol (2000).
4. Akunets VV and Stelmakh VF. "Features of the EPR spectrometer device for the study of fullerenes by stationary and nonstationary methods". Fullerenes and fullerene-containing materials: Sat. scientific tr International Symposium "Fullerenes and Fullerene-like Structures in Condensed Matter" [Minsk, June 5-8, 2000].
5. Akunets VV., *et al*. "Features of the EPR of two-component defects in irradiated alkali halide crystals". - In the book: 3rd International Conference "Interaction of Radiation with a Solid" VITT-99. Conference proceedings. [Minsk, October 6-8. 1999]. Minsk: BSU, 1999.
6. Akunets VV., *et al*. "Paramagnetic Frenkel defects in g-irradiated alkali-halide crystals". *Journal of Applied Spectroscopy. T* 67 (2000); 344-369.

7. Akunets VV and Stelmakh VF. "Highly sensitive EPR analyzer with an extended microwave power tuning range". - In the book: 9th International Crimean Conference "Microwave Technology and Telecommunication Technologies". Conference proceedings. [Sevastopol, September 13-16. 1999]. Sevastopol: Weber (1999).
8. Akunets VV., *et al*. Electronic Paramagnetic Resonance Spectrometer - Utility Model Patent RB No. 4444. MKI G01N / 24.
9. Adashkevich SV., *et al*. "Features of magnetic resonance radio spectroscopy during self-tuning of ultra-high frequency". In the book: 14th International Crimean Conference "Microwave Technology and Telecommunication Technologies". Conference proceedings. [Sevastopol, September 13-17. 2004]. Sevastopol: Weber (2004).

Volume 1 Issue 1 December 2019