# OVERVIEW OF METHODS FOR MEASURING S-PARAMETERS OF MICROWAVE TRANSISTORS IN BIG SIGNAL MODE

***Vladimir A. Litovchenko***
Novosibirsk Higher Military Command School, 49, Ivanova St., Novosibirsk, 630117, Russia, Head of Instructor Group, Department of Educational Intelligence (and Airborne Training), phone: (383)332-50-45, e-mail: litovchienko.vladimir@mail.ru; Siberian State University of Geosystems and Technologies, 10, Plakhotnogo St., Novosibirsk, 630108, Russia, Ph. D. Student, phone: (923)100-89-86

***Natalia V. Zarzhetskaya***
Siberian State University of Geosystems and Technologies, 10, Plakhotnogo St., Novosibirsk, 630108, Russia, Ph. D. Student, Senior Lecturer, phone: (383)361-07-31, e-mail: zarjetskaya@yandex.ru

In the microwave range for measurement S-parameters of transistors they widely use the methods that do not adequately measure the S-parameters of transistors. It is necessary to identify the most effective method, among the methods of measuring the S-parameters of transistors, by identifying the advantages and disadvantages of the considered methods.

The article considers in chronological order: two-signal method of measurement of S-parameters of transistors, modification of this method and, developed on their basis, the method of adequate measurement of S-parameters of such devices. The methods are implemented by a coaxial simulator-analyzer of amplifiers and microwave autogenerators in both coordinated and non-coordinated with load measuring channels of this simulator-analyzer.

The scope of application and interrelation of the considered methods with indication of their advantages and disadvantages are analyzed. The technique of normalization of the transistor S-parameters and complex reflection coefficients of its loads measured in the coaxial measuring path of the simulator-analyzer, relative to the microstrip path, in which this device will be used during its operation, is also considered.

**Key words:** S-parameters, adequate measurement, two-signal measurement method, technical specification, coaxial simulator-analyzer, mathematical model, calibration, amplifiers, autogenerators.

## REFERENCES

1. Khibel', M. (2009). *Osnovy vektornogo analiza tsepey [Fundamentals of vector network analysis]*. S. M. Smolenskiy (Trans.). Moscow: MEI Publ., 500 p. [in Russian].

2. Measurement in "hot" mode with pulsed signals on a network analyzer. (n. d.). *R&SZVA*. Retrieved from at: www.rohde-schwarz.ru/439/ AN001rus_Hot S22_pulse.pdf [in Russian].

3. Root, D. E., Horn, J., Betts, L., Gillease, Ch., & Verspecht, J. (2009). X-parameters: the new paradigm for measurement, modeling, and design of nonlinear rf and microwave components. *Kontrol'-no-izmeritel'nye pribory i sistemy [Test & Measuring Instruments and Systems]*, 2, 20–24 [in Russian].

4. Nikulin, S. M., & Torgovanov, A. I. (2015). Large signal microwave transistor S-parameters measurements using spatially remote load. *Datchiki i sistemy [Sensors & Systems]*, 4(191), 14–18 [in Russian].

5. Savel'kaev, S. V. (2005). Methods of analysis stability of active microwave circuits and their measurement of S-parameters. *Metrologiya [Metrology]*, 4, 19–28 [in Russian].

6. Mazumder, S. R. (1978). Two-signal method of measuring the large-signal S-parameters of transistors. *IEEE Trans.*, *MTT-26*(6), 417–420 [in Russian].

7. Li, S. H., & Bosisio, R. G. (1982). Automatic analysis of two-port active microwave network. *Electronics Letters*, *18*(24), 1033–1034 [in Russian].

8. Savel'kaev, S. V., & Romas'ko, S. V (2017). Method of measurement S-parameters of two-port microwave, intended for inclusion in microstrip. *Vestnik SGUGiT [Vestnik SSUGT]*, *22*(2), 260–270 [in Russian].

9. Savel'kaev, S. V., & Romas'ko, S. V. (2017). A method of measuring the S-parameters of transistors on a simulator-analyzer of amplifiers and UNF self-excited oscillators. *Measurement Techniques*, *60*(6), 612–619 [in Russian].

10. Savel'kaev, S. V., Romas'ko, S. V., Litovchenko, V. A., & Zarzhetskaya, N. V. (2017). Theoretical basis for the design of simulator-analyzer active microwave circuits. *Uspekhi sovremennoy radiotekhniki [Achievements of Modern Radioelectronics]*, 2, 50–61 [in Russian].

11. Savel'kaev, S. V. (2005). Coaxial contact device. *Izmeritel'naya tekhnika [Measuring Equipment]*, 5, 65-68 [in Russian].

12. Savel'kaev S. V. (2006) Development and research of methods and precision means for measuring S-parameters of active microwave circuits. *Doctor's thesis*. Novosibirsk, 189 p. [in Russian].

13. Silaev, M. A., & Bryantsev, S. F. (1970). *Prilozhenie matrits i grafov k analizu SVCh ustroystv [Application of matrices and graphs to the analysis of microwave devices]*. Moscow: Sov. Radio Publ., 248 p. [in Russian].

14. Savel'kaev, S. V., Romas'ko, S. V., Litovchenko, V. A., & Zarzhetskaya, N. V. (2016). Theoretical basis for the design of simulator-analyzer active microwave circuits. *Vestnik SGUGiT [Vestnik SSUGT]*, 1(33), 175–188 [in Russian].

15. Savel'kaev, S. V., Romas'ko, S. V., Litovchenko, V. A., & Zarzhetskaya, N. V. (2017). Theoretical basis for the design of simulator-analyzer active microwave circuits. *Radioelektronika. [Radio Engineering]*, 1, 63–74 [in Russian].

16. Savel'kaev, S. V., & Zarzhetskaya, N. V. (2016). Calculation and design of self-excitation microwave devices in the S-parameters space. *Radioelektronika [Radio Engineering]*, 1, 41–53 [in Russian].

17. Etkina, V. S. (Ed.). (1975). *Poluprovodnikovye vkhodnye ustroystva SVCh: T. 1 [The semiconductor device of the microwave input: Vol. 1]*. Moscow: Sov. Radio Publ., 344 p. [in Russian].

18. Savel'kaev, S. V., Romas'ko, S. V., & Litovchenko, V. A. (2017). Mathematical model of the imitator of analyzer of amplifiers and autogenerators microwave. In *Sbornik materialov Inter-jekspo GEO-Sibir'-2017: Nacional'noy konferencii: T. 2. Nauka. Oborona. Bezopasnost'-2017 [Interexpo GEO-Siberia-2017: National Conference: Vol. 2. Science. Defense. Security-2017]* (pp. 131–137). Novosibirsk: SSUGT Publ. [in Russian].

19. Savel'kaev, S. V., Ayrapetyan. V. S, & Litovchenko, V. A. (2014). Calculation autogen-erators microwave in space S-parameters. In *Sbornik materialov Interekspo GEO-Sibir'-2014: Mezhdunarodnoy nauchnoy konferentsii: T. 2. SibOptika-2014 [Interexpo GEO-Siberia-2014: In-ternational Scientific Conference: Vol. 2. SibOptica-2014]* (pp. 164–171). Novosibirsk: SSGA Publ. [in Russian].

20. Litovchenko, V. A. (2015). Techniques for analysing active SHF-circuits stability and their S-parameters measurement. *Vestnik SGUGiT [Vestnik SSUGT]*, 1(29), 90–100 [in Russian].

21. Savel'kaev, S. V., Ayrapetyan, V. S, & Litovchenko, V. A. (2015). Three sectional drift-diffusion mathematical model of the field effect transistor with a schottky barrier. *Vestnik NGU. Seriya: Fizika tverdogo tela, poluprovodnikov nanostruktur [Bulletin of NSU. Series: Solid State Physics, Semiconductor Nanostructures]*, 10, 57–62 [in Russian].

22. Savel'kaev, S. V., & Litovchenko. V. A. (2015). A method for calibrating a stripe contact devices. In *Sbornik materialov Interekspo GEO-Sibir'-2015: Mezhdunarodnoy nauchnoy konfer-entsii: SibOptika T. 3. [Interexpo GEO-Siberia-2015: International Scientific Conference: SibOp-tics. Vol. 3]* (pp. 37–41). Novosibirsk: SSUGT Publ. [in Russian].

23. Savel'kaev, S. V., & Litovchenko, V. A. (2016). Method of calculation of the microwave oscillator in the space of S-parameters. *Elektromagnitnye volny i jelektronnye sistemy [Radio engi-neering. Journal of Electromagnetic Waves and Electronic Systems]*, 8, 36–46 [in Russian].

24. Savel'kaev, S. V., Romas'ko, S. V., Litovchenko, V. A., & Zarzhetskaya, N. V. (2016). Stability analysis method of active microwave circuits. In *Sbornik materialov Interekspo GEO-Sibir'-2016: Mezhdunarodnoy nauchnoy konferentsii: T. 5. SibOptika [Interexpo GEO-Siberia-2016: International Scientific Conference: Vol. 5. SibOptics]* (pp. 224–228). Novosibirsk: SSUGT publ. [in Russian].

25. Vladimirova, S. V., & Pal'chun Ju. A. (2012). Analysis of high-precision methods for measuring reflection parameters in coaxial paths. *Vestnik TGTU [Transactions of the TSTU]*, 18, 856–862 [in Russian].

26. Vladimirova, S. V., Pal'chun, Ju. A., & Kolpakov, A. V. (2010). Use the interpolations and extrapolations functions for definition calibration interval for coaxial load In *Sbornik materialov Interekspo GEO-Sibir'-2010: Mezhdunarodnoy nauchnoy konferentsii: T. 5. SibOptika [Interexpo GEO-Siberia-2010: International Scientific Conference: Vol. 5. SibOptics]* (pp. 127–129). Novosibirsk: SSGA Publ. [in Russian].

27. Vladimirova, S. V., Pal'chun, Ju. A., & Kolpakov, A. V. (2011). Algorithmic methods of definition of function of the amendment at measurement of parameters of reflection. In *Sbornik materialov Interekspo GEO-Sibir'-2011: Mezhdunarodnoy nauchnoy konferentsii: T. 5. SibOptika [Interexpo GEO-Siberia-2011: International Scientific Conference: Vol. 5. SibOptics]* (pp. 261–263). Novosibirsk: SSGA Publ. [in Russian].

28. Romas'ko, S. V. (2015). Technique of determination of coefficients of interpolation and extrapolation of the microwave oven of measures of easing for reflection coefficient module. In *Sbornik materialov Interekspo GEO-Sibir'-2015: Mezhdunarodnoy nauchnoy konferentsii: T. 5. SibOptika [Interexpo GEO-Siberia-2011: International Scientific Conference: Vol. 5. SibOptics]* (pp. 127–129). Novosibirsk: SSUGT Publ. [in Russian].

29. Savel'kaev, S. V. (2018). Variational methodology of estimation of the total merchant of measurement simulator-analyzer of microwave amplifiers and auto-generators. In *Sbornik materialov Interjekspo GEO-Sibir'-2018*: *Nacional'noy konferencii: T. 1. Nauka. Oborona. Bezopasnost'-2018 [Interexpo GEO-Siberia-2018: National Conference: Vol. 1. Science. Defense. Security-2018]* (pp. 2–12). Novosibirsk: SSUGT Publ. [in Russian].

Received 08.07.2019