

Domestic Series of the LORNET NON-LINEAR JUNCTION DETECTORS

The article deals with the history of development and the specifications of the series-produced non-linear junction detectors under the general title LORNET. Each new model, when it appeared on the market, proved to be innovative in the field of information security. The recent development was no exception - Lornet Star - the world's first non-linear junction detector with visual display of the reemitted from the object harmonic spectrum.

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It is well known, that a non-linear junction detector providing detection of semiconductor elements, is a binding instrument for a specialist dealing with technical means of information security [1-3].

As soon as the works on the development of non-linear junction detectors started, ELVIRA manufacturing company aimed at developing innovative products applying technological base, which was set during the production of state-of-the-art metrology equipment - spectrum analyzers of the BELAN series.

It is worth noting that only four (!) countries mastered the issue of modern spectrum analyzers with frequency range of 9 kHz to 40 GHz. These are the United States (Agilent), Germany (Rohde @ Schwarz), Japan (Anritsu) and the Russian Federation (ELVIRA) [4].

That made it possible - right from the beginning and until now - to offer customers non-linear junction detectors with unique

characteristics, including minimal weight and dimensions.

The main technological feature of the LORNET products is the minimal variation of parameters within similar products and a hundred-percent pre-sales testing on shakers and climatic chambers. Another important feature of the series is the ease of control. A 15-minute training course is enough to start operating the device.

Of course, this is true only for the experienced users, as efficient operation of any similar device largely depends on human factor, and that requires considerable practice and understanding of the operation principles of non-linear junction detectors. Those have been described in various sources, for example [5, 6], theoretical basis of the Lornet series concept being specified in [7].

Any non-linear junction detector can be assessed basing on its capabilities to detect non-linear objects, their classification

(distinction), easy operation of the device and its safety for the operator (the correspondence of the electromagnetic interference levels to SanPin standards [8]). Detection capabilities depend on frequency range and probing signal type, its power, sensitivity of the receivers and the characteristics of antenna feeder circuit.

Real characteristics of the LORNET series devices provide wide range of opportunities of detection under various application conditions.

One of the major tasks when using non-linear junction detector is to provide clear distinction between natural and artificial non-linear objects.

It is believed that when a non-linear object is exposed to a probing signal, and the level of the received signal of the 3rd harmonics exceeds the level of 2nd harmonics, that, as a rule, characterizes a non-linear object as natural - MOM (metal - oxyde - metal), and vice versa - as an artificial (semiconductor).



Figure 1:
Non-linear Junction Detectors
of the LORNET series

In practice this rule is not always true. More subtle mechanism to determine the type of a non-linear object is to listen to parasitic modulation level after the distance to the object or the demodulated response at the 2nd and 3rd harmonics changed, after the object has been exposed to mechanical way (tapping). For this purpose most modern non-linear junction detectors apply the so-called "20K" mode with listening to parasitic AM (FM) modulation through headphones. Note that when tapping, a MOM-object changes its geometrical dimensions, which leads to a change in its non-linear characteristics, which an operator tries to analyze by ear.

Nomenclature of nonlinear junction detectors of the LORNET series is specified in Fig. 1.

All non linear locators of this series have the following common characteristics:

- Two types of probing signal: pulse with high relative pulse duration and continuous (or pulse with low off-duty factor to provide envelope demodulation, the so-called 20K mode)
- Automatic tuning away from narrowband interference according to the criteria of minimum interference in the 2nd harmonics in-band
- Automatic and manual adjustment of probing signal power and indication of its level;
- Indication of received signal level at 2nd and 3rd harmonics,
- Use of wireless headphones to listen to parasitic demodulation of signals of 2nd and 3rd harmonics
- Very simple unified push-button control
- Minimal weight and size within product range
- Removable Li-ION rechargeable battery with an extra battery in a standard delivery set (implemented in modification of 2014),
- Environmentally safe, as stated in Hygiene Expert Certificate available for each type of device.

Let us examine some of the features of different types of non-linear junction detectors of the LORNET series. The table below shows a comparison of non-linear junction detectors within the LORNET series according to several easily verifiable parameters. In particular, it should be noted that the frequent comparison of non-linear junction detectors according to the sensitivity of the receivers is not always correct, as this is an internal parameter, and the construction of any non-linear junction detector does not allow the user to measure it.

Table: Some features of the different types of LORNET non-linear junction detectors

| Item | Year of production | Probing signal frequency range | Weight | Antenna beam pattern width (1st harmonics, 3 dB level) up to | Antenna gain coefficient (1st harmonics) at least | Detection range for a SIM card of a cell phone |
|----------------|--------------------------|--------------------------------|--------|--|---|--|
| Lornet | 2006 | 900 MHz | 1 kg | 90 deg. | 6 dB | Unavailable |
| Lornet 24 | 2008 | 2400 MHz | 0,7 kg | 90 deg. | 6 dB | 10-20 cm |
| Lornet 36 | 2009 | 3600 MHz | 1,4 kg | 16 deg. | 20 dB | 80-120 cm |
| Lornet 36 mini | 2013 | 3600 MHz | 1,0 kg | 24 deg. | 16 dB | 60-80 cm |
| | | 800 MHz | 1,0 kg | 90 deg. | 6 dB | Unavailable |
| Lornet 0836 | 2012 | 3600 MHz | 1,0 kg | 16 deg. | 20 dB | 80-100 cm |
| | | 800 MHz (optional) | 1,0 kg | 90 deg. | 6 dB | Unavailable |
| | | 2400 MHz | 1,0 kg | 90 deg. | 6 dB | 10-20 cm |
| Lornet Star | 2014 (series since 2015) | 3600 MHz (optional) | 1,0 kg | 24 deg. | 16 dB | 60-80 cm |

The first LORNET non-linear junction detector operating with the probing signal in the regular frequency band of 800-900 MHz appeared on the market of information protection in 2006. This device suits ideally the purposes of inspecting office premises for eavesdropping devices.

In 2008 the LORNET 24 product appeared on the market to represent the world's first non-linear junction detector featuring probing signal within frequency band of 2400 MHz. The application of the new range enabled it to reduce weight and dimensions of the product and, what is more important, provide the opportunity to detect a whole range of semiconductor elements that were not detected by the devices operating in standard frequency band. The most vivid example of such elements is a SIM card of cell phones. LORNET 24 also made it

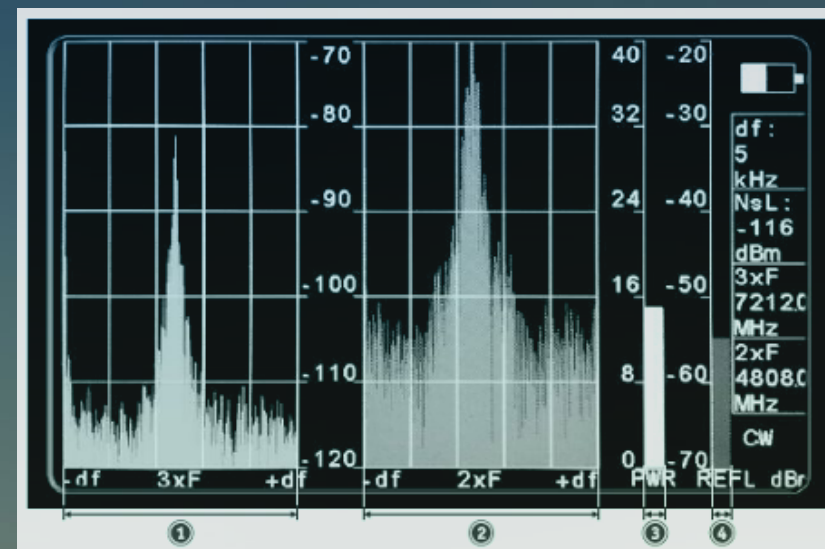
possible to improve the detection parameters of small semiconductor elements, e.g. uncased modifications of the EDIC recorder series.

It should be noted that the world's best-known manufacturers of non-linear junction detectors, such as REY (USA), WINKELMANN (UK), SST-GROUP (Russia) recognized the novelty of the ELVIRA production company. They tried to bring their products operating in 2400 MHz to the market, but with a delay of 3-5 years !!!

The design of the device resembles a manual metal detector. The LORNET device is designed for a personal inspection, use on business trips and local inspections of office premises.

LORNET 24 was modified in 2009 and 2014.

In late 2009 Lornet 36 appears on the market representing the world's first and only (for five years up to date) non-linear junction detector featuring probing signal within the frequency band of 3600 MHz. Lornet 36 is designed to test any premises, having proved itself as a means of counterterrorism when searching for radio explosives. The application of a new range of microwave frequency with parabolic antenna system enabled it to achieve a narrow (about 16 degrees) angle of the directional pattern of the antenna. That made it possible for the first time to carry out spatial selection of target using a non-linear junction detector. This product has proved itself as a means of counterterrorism when examining suspicious items (bags, etc.) for electronic components at a distance of 3-7 meters. SIM card of



1. Spectrum of re-emitted signal of 3rd harmonics
2. Spectrum of re-emitted signal of 2nd harmonics
3. Probing signal level
4. Level of signal reflected by the object

Figure 2:
Indication panel of Lornet-Star non-linear junction detector

a cell phone can be detected from a distance of not less than 1 meter, which is the world's best parameter performance. The application of a new microwave range also improved the detection of semiconductor elements placed in shielded (but not ground) structures and objects with narrow slits. LORNET 36 was modified in 2014.

In 2013 a new set of the Lornet 36 mini products was released to represent a Lornet 36 product with modified compact parabolic antenna. The Lornet 36 mini is intended to inspect the premises (selective in space) from a distance of 1-2 meters without considerable removal of legal electronic devices.

In 2012 (latest modification in 2013) Lornet 0836 appears on the market to represent the world's first and only non-linear dual-frequency

junction detector featuring probing signal within the frequency band of 800 MHz and 3600 MHz.

The Lornet 0836 product is applied in anti-terrorist activities when detecting electronic components in the field environment at a distance of 3-7 meters with an efficient algorithm: the initial detection and subsequent selection of the target.

The device combines the advantages of the 800 MHz range (all-weather detection) and the range of 3.6 GHz (spatial selection of targets).

The construction weighting 1 kg, applies newest materials and comprises transmitters of upper and lower range and the receivers at 2nd and 3rd harmonics with corresponding antenna feeder circuits. The transmitters of probing signals of upper and lower range can

operate simultaneously, their power being adjusted independently. Visual indication of the levels of the 2nd and 3rd harmonics is carried out simultaneously for each operating range.

In October 2014 at the Interpolitekh 2014 International Exhibition in Moscow, a prototype of a new non-linear junction detector Lornet Star with unusual technical characteristics was submitted to the judges' approval. The device applies a new fundamentally different way of a more accurate classification of a non-linear object. For the first time in the world, they proposed and implemented spectrum analyzer of 2nd and 3rd harmonics in a compact block with the resolution of 40 Hz and 10 kHz analysis band.

This built-in spectrum analyzer proves to be more informative for the operator reducing time on decision making, as compared to listening through headphones. Figure 2 illustrates spectrum of received signals being analyzed.

In particular, while tapping the location of a natural non-linear object, the spectrum of re-emitted signal at 2nd harmonics visually changes significantly (jumps / falls apart), in contrast to the tapping the location of artificial non-linear object, that does not substantially affect the spectrum of re-emitted signal at 2nd harmonics.

Direct visual spectrum analysis allows the operator to "monitor" interference environment live. In the future, it will be possible to identify objects according to a more "subtle" analysis of the spectrum, including in software.

To determine the metallization degree of the object under study, the new device has the display of the level of the signal reflected from the object at a probing frequency.

The control of Lornet Star non-linear junction detector does not differ much from the one of a usual LORNET device. Standard delivery set of a non-linear junction detector is to include receive/transmit unit with built-in spectrum analyzer with probing signal in the range 2400 MHz and a removable rod 70 cm long. The basic kit will represent both search and security-check sets of a non-linear junction detector. As additional options, the package may include two receive/transmit units with probing signals at frequencies in the range 800 and 3600 MHz. Thus, a complete set of Lornet Star non-linear junction detector will take the advantages of all three frequency ranges:

- 800 MHz (optional) - all-weather and relatively low attenuation of signals in dense medium (brick, concrete, etc.);
- 2400 MHz - the opportunity to detect SIM cards and small (about 1 cm²) semiconductor devices;
- 3600 MHz (optional) - spatial selection, facilitates the search operation in the presence of legal electronic devices.

REFERENCES

1. Khorev A. A. Ways and means of information protection. Moscow: MORF, 1998. p. 316 .
2. Boldyrev A.I., Vasilevsky I.V., Stalenkov S.Y. Searching and neutralizing eavesdropping means ZAO NPC Firma Nelk, 2001. p.138
3. Buzov G.A. Practical Guide to identify special technical means of unauthorized information retrieval. Moscow: Goryachaya Liniya - Telekom, 2010. p. 240
4. Belchikov S.A., Belchikov A.V., Dzisyak A.B. The range of domestic spectrum analyzers "CK4 Belan 140/240/280/400" to 40 GHz Components and Technology. 2012, №4, pp. 6-91; № 5, pp. 114-122; № 6, pp. 56-60.
5. T. Jones Overview of nonlinear location technology Special equipment. 1998, № 5.
6. Lobashev A.K. Non-linear junction detectors and their application to search for eavesdropping devices Devices // Special equipment. 2006, № 6.
7. Belchikov A.V., Mishustin B.A., Dzisyak A.B., Zaitsev V.K. View of the developers of the LORNET non-linear junction detectors on some present-day issues of non-linear location Special equipment. 2011, № 5.
8. SanPin 2.2.4 / 2.1.8.055-96. Microwave electromagnetic emission.