Resilience of Digital Protection Relay's Power Supplies to Powerful Nanosecond Pulses

Vladimir Gurevich
Central Electric Laboratory, Israel Electric Corp.

Abstract **- This article suggests the results of attenuation measurements provided by various types of high-quality two-stage electromagnetic filters and offers the best two types. Test results are provided of digital protection relay (DPR) equipped with 316NN63 power supply sources fitted with one of the best filter types. It is also suggested that using these filters in combination with voltage suppressors connected before power supply of high-sensitivity equipment implemented in the power industry can significantly increase its noise-resistance.**

Keywords **-electromagnetic filters, noise, DPR, digital protection relay, HEMP, Electrical Fast Transient**

I. INTRODUCTION

Testing of DPR power supplies' resistance to electrical fast transient (EFT) and its results were detailed by the author in [1]. The main result was that the majority of participating DPR types were really resistant to all types of test impacts. There was only one that failed to pass the test which was the REC316, manufactured by ABB with 316NN63 power supply. The issue was that some output voltages, and consequently some internal modules, switched off starting from 1 kV amplitude of a standard EFT. Later on, they automatically returned into operational conditions within several seconds upon termination of test pulse impact. It should be noted that the LEDs on the front panel continued detecting the DPR's status change subject to test pulse impact. An attempt to increase the DPR's noise-resistance using a special external FN 2090-3-06 filter connected before the power source was not successful.

II. PURPOSE

The range of electromagnetic filters available todayon the market is very broad: there are both quite sophisticated inexpensive two-stage filters with fair specifications and very simple and cheap filters. These high-quality filters cost 10–40 US Dollars and even cheaper (made in China). The choice is complicated by the fact that various manufacturers use different methods and equipment to measure filter parameters and provide promotional or even erroneous information (discovered by the author) in their specifications. This necessitated conducting comparative trials of the best filter samples from the leading manufacturers under the same method and using the same equipment, and then testing REC316 DPR with 316NN63 power source in combination with the best filter sample. The DPR with the above-mentioned power supply is a good indicator of EFT impact and thus, filter efficiency can be estimated based on its response.

III. RESULTS AND DISCUSSION

In order to conduct the tests, I ordered two-stage filters received from various companies (Fig. 1).

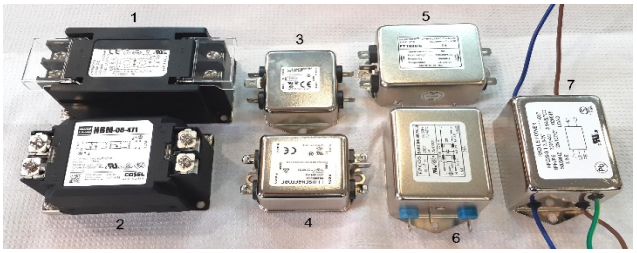

Fig. 1. Two-stage EMC LC-filters of various types with improved specifications: 1 – 62-MTB-060-4-21 (API Technologies); 2 - NBM-06-471 (Cosel); 3 - FN2090-1-06 (Schafner); 4 – FN2060-3-06 (Schafner); 5 - FT1200-6 (Jinan Filtemc Electronic Equipment); 6 - B84113H0000M030 (Epcos); 7 – RP225-3.1.3.3-W (Radius Power).

Attenuation measurements were taken by means of the PLANAR TR1300/1 Vector Network Analyzer (VNA) and its corresponding computer software (Fig. 2).

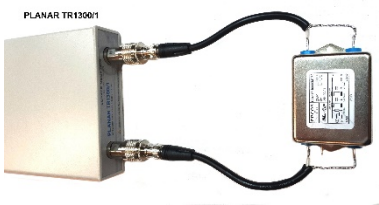

Fig. 2. Measuring attenuation provided by the filter by means of the PLANAR TR1300/1 VNA (connected to the filter) and an RG58C coaxial cable with a 50 Ohm wave resistance.

Attenuation values provided by different EMC filters are shown in Fig. 3.

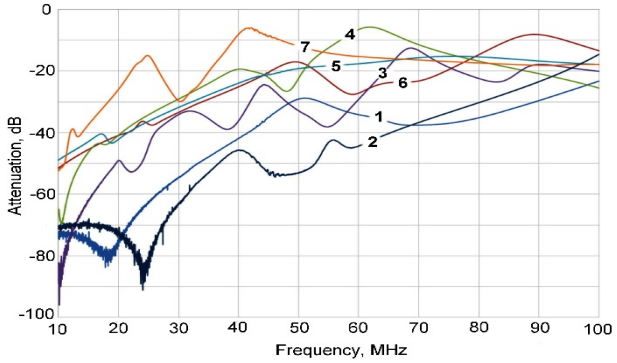

Fig. 3a. Attenuation provided by various EMC filters within 10 MHz – 100 MHz frequency range.

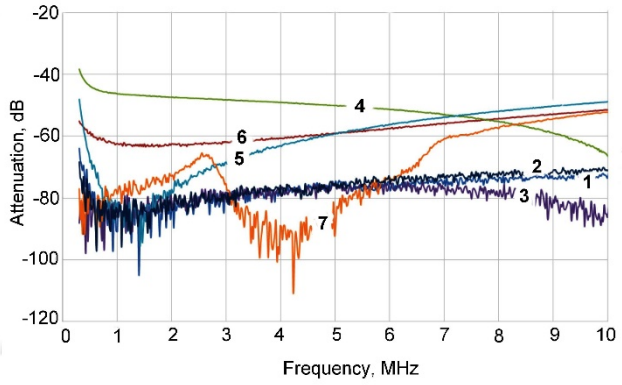

Fig. 3b. Attenuation provided by various EMC filters within 0.3 MHz – 10 MHz frequency range

The obtained results show that 62-MTB-060-4-21 and NBM-06-471 filters feature the best parameters within the required frequency range – 100 kHz–100 MHz [2]. However, the latter is three times cheaper than 62-MTB-060-4-21, thus these two filter types were used in combination with DPR for testing purposes.

The VNA PLANAR TR1300/1 was used to measure attenuation specifications introduced by the own 316NN63 power source and further by the power source's filters connected in series and one of supplemental external filters (Fig. 4).

The test of the second (62-MTB-060-4-21) filter returned very similar specifications, thus it is not shown here.

The obtained results show that the supplementary external filter (though high-quality) is effective within a very narrow frequency range only (from 1 to 20 MHz). This frequency range is far from that of the EFT source, and at a first glance it may seem that it is unnecessary to expect any change in the DPR's response to such pulses, even when using the best of the above mentioned filters as a supplement.

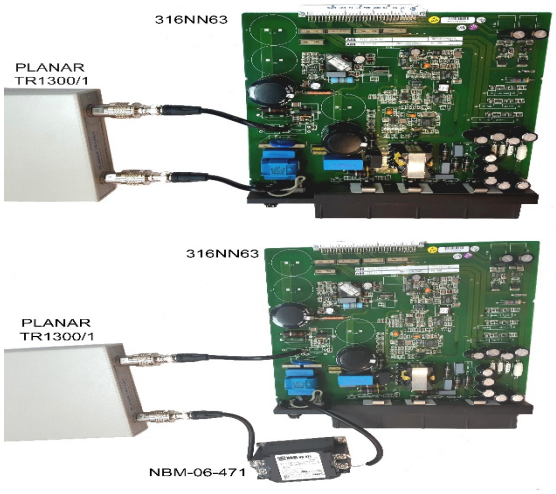

Fig. 4. Measuring attenuation introduced by the own internal filter of 316NN63 power supply (upper) and supplemental external NBM-06-471 filter connected to 316NN63 power supply's filter in series (lower).

The obtained attenuation specifications are presented in Fig. 5.

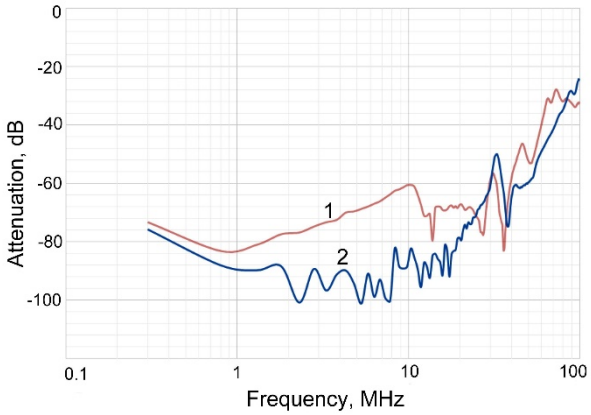

Fig. 5. Attenuation specifications: 1 - introduced by the own internal filter of 316NN63 power supply; 2 - introduced by the supplemental external NBM-06-471 filter and the power supply's own filter.

Nevertheless, these tests were conducted and the results contradicted these expectations (Fig. 6). This can be explained by the fact that parameters of a pulse, which consists of an aggregate of inductiveness and capacitance, coming to the filter's input change significantly. As a result, the efficiency of these filters is high, even for very short EFT pulses.

Fig. 6. Testing EFT resistance of a DPR fitted with 316NN63 power supply and external NBM-06-471 filter connected in series. 1 – EFT generator (EFT500N8); 2 – NBM-06-471 filter; 3 – varistor; 4 – REC316 type (ABB) DPR.

Testing of a DPR fitted with 316NN63 power supply revealed that the faults during DPR's operation occurred:

1) when delivering an EFT pulse [1] with 1kV (and more) amplitude to the power supply's input;
2) when delivering an EFT pulse [1] with 2.6 kV (and more) amplitude to the input of the power supply with an NBM-06-471 filter connected in series;
3) when delivering an EFT pulse [1] with 4 kV (and more) amplitude to the input of the power source with an NBM-06-471 filter fitted with a varistor at the input.

Thus, we see efficient operation of the selected filter type compared to those that we previously used [1], especially the filter fitted with a varistor at the input (earlier tests of less efficient filters showed no varistor effect).

IV. Conclusions

The electromagnetic filters of specific type selected as a result of testing, which are connected before the DPR's power supply, may significantly improve electronic equipment's resistance to EFT and HEMP when fitted with a varistor at the input. Concurrently, these filter types are not very expensive (1,500–2,000 US Dollars) and are as bulky as ordinary HEMP filters, but cheap (40 US Dollars) and small-size general purpose filters. These filters fitted with varistors can be recommended for extensive use in the power industry, in case of any noise-resistance issues with electronic equipment and for HEMP-protection purposes.

References

[1]. Gurevich V. Resilience of Digital Protection Relay's Power Supplies to Powerful Nanosecond Pulses. – International Journal of Research Studies in Electrical and Electronics Engineering, 2019, Vol. 5, Issue 1, pp. 38 – 45.

[2]. IEC 61000-2-9 Electromagnetic compatibility (EMC) - Part 2: Environment - Section 9: Description of HEMP environment - Radiated disturbance. BasicEMCpublication, 1996.

[3]. Gurevich V. Protecting Electrical Equipment. Good Practices for Preventing High Altitude Electromagnetic Pulse Impacts. – De Gruyter, Berlin, 2019. – 386 p.