Study of the load variation for an electrical consumer

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Abstract. In this paper we study the load variation for an electrical consumer when it remains powered by an emergency power supply through an uninterruptable power supply due to a circuit failure and the way that the load varies when the main and backup power supply comes on. The study was conducted due to the fact that when the main power supply tripped, the emergency power supply, ensured by a diesel power generator with a time delay of 30 seconds, always tripped immediately after connecting, thus leaving the consumer powered by the uninterruptable power supply which has a 10 minutes limited supply.

1. Introduction
We conducted the study due to the fact that the electrical consumer [1] had to be powered at all time and when the main power supply tripped, the emergency power supply, ensured by a diesel power generator with a time delay of 30 seconds, always tripped immediately after connecting, thus leaving the consumer powered by the uninterruptable power supply which has a 10 minutes limited supply.

The simplified electrical scheme of the circuit is presented in Figure 1 in which we can see the point in which we connected with a Fluke 1760 Three-Phase Power Quality Recorder (shown in Figure 2).

Figure 1. The simplified electrical scheme
Figure 2. Fluke 1760 Three-Phase Power Quality Recorder
The Fluke 1760 recorder is designed for analysis of utility and industrial power distribution systems, in medium and low-voltage networks. It captures the most comprehensive details on user-selected parameters. The supplied PQ Analyze application software (shown in Figure 3) enables users to use the in depth measurement and produce sophisticated analysis and reports.

![Figure 3. The PQ Analyze application software](image)

2. Measurement tests done with the Fluke 1760 recording the data
To find out what the problem was and why did the electrical consumer trip when the emergency power supply connects, we conducted the following scenarios:

2.1. Measurements made with the electrical consumer connected at its average load
In this scenario we simulated a fault in the network and left the main power supply unpowered. After a time delay of 30 seconds, in which a PLC (programmable logic controller) device started the diesel power generator and monitored that the main power supply is still unpowered, the PLC device issues the connect command of the generator to power up the consumer [2]. Shortly after the generator connected, it tripped.

The Fluke 1760 recorded the following data:
- in Figure 4 we can see that when the diesel generator connects, the average 12 kVA load of the consumer is restored in three power spikes [3]. The second spike is the most relevant one and it appears approximately 1.25 seconds after the generator connects with a maximum value of 20.7 kVA, value which exceeds the generators nominal power and thus leads to the generator trip from the overload protection [4];
- in Figure 5 we can see the evolution of currents and frequency during the three power spikes. We can see when the diesel generator connects, the frequency increases to a maximum value of 51.6 Hz and during the power spikes it drops to a minimum value of 49.5 Hz. The nominal value of 50 Hz is reached only after the power spikes pay off.
**Figure 4.** Graphic regarding the evolution of load and voltage when the diesel power generator connects with the consumer at its average load of 12 kVA

**Figure 5.** Graphic regarding the evolution of currents and frequency when the diesel power generator connects with the consumer at its average load of 12 kVA
2.2. Measurements made with the electrical consumer connected at a lower load
In this scenario we reduced the load of the consumer from 12 kVA to 6 kVA and left the main power
supply unpowered. We conducted this scenario in order to see if the power spikes will appear again at
a lower load or will the load restore uniformly.
The Fluke 1760 recorded the following data:
- in Figure 6 we can see that when the diesel generator connects, the 6 kVA load of the consumer
is again restored in three power spikes. The second spike is the biggest one and it appears again
approximately 1.25 seconds after the generator connects with a maximum value of 12 kVA;
- in Figure 7 we can see the evolution of currents and frequency during the three power spikes. We
can see when the diesel generator connects, the frequency is stable very close to its nominal value of
50 Hz.

![Figure 6](image_url)

**Figure 6.** Graphic regarding the evolution of load and voltage when the diesel power
generator connects with the consumer at a load of 6 kVA

![Figure 7](image_url)

**Figure 7.** Graphic regarding the evolution of currents and frequency when the diesel
power generator connects with the consumer at a load of 6 kVA
2.3. Measurements made with the electrical consumer connected directly to the power supplies

If this scenario we took the uninterruptable power supply out the power scheme thus leaving the electrical consumer connected directly to the two power supplies. The new power scheme is shown in Figure 8. The load of the consumer was reduced even more.

![Figure 8. The electrical consumer connected directly to the power supplies](image)

The Fluke 1760 recorded the following data:

- in Figure 9 we can see that when the diesel generator connects, the 3 kVA load of the consumer is restored uniformly. There are no more power spikes in the process;
- in Figure 10 we can see the evolution of currents and frequency during the load restore duration. We can see that when we switch the load from the main power supply to the diesel generator, there are no important spikes in currents and frequency.

![Figure 9. Graphic regarding the evolution of load and voltage when the diesel power generator connects with the uninterruptable power supply out of the power scheme](image)
3. Conclusions

Based on the results obtained from data processing and on the technical analysis of these data, we concluded the followings:

- when the diesel power generator takes a 12 kVA load, power spikes appear up to a maximum value of 20.7 kVA, value which exceeds the 20 kVA nominal power value of the generator and thus leading to the generator trip by the overload protection;
- after the Uninterruptable Power Supply was taken out of the scheme and the load reduced to 3 kVA, when the diesel power generator or main power supply connects, the load is uniformly distributed;
- the power spikes are caused by the Uninterruptable Power Supply and so it is recommended that when powering a n kVA consumer, to equip a $2 \times n$ kVA nominal power value backup generator.

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References

[1] Şurianu F D 2007 Electric Power Consumers, Orizonturi Universitare, Timisoara, Romania
[2] ***C.N.T.E.E. Transelectrica S.A. (private communication)
[3] Fanica V, Petru P and Ana P 2013 Electric Power Quality, SIER, Bucuresti, Romania
[4] Andrea P 2002 Automation and protection of installations and power systems, Orizonturi Universitare, Timisoara, Romania (in Romanian)