Bajog electronic GmbH
der EMV - Spezialist

Supply networks under sustained bombardment

Review and general regulations

Since January 1996 the EMC EN 55011.22 legislation has been valid throughout the European Union together with the different PFS (Product Family Standard) regulations. The EMC directives valid in Germany up to the 31st December 1995 originated in the high frequency appliance law. This law already regulated the determined and restricted interference limit values of electrical equipment and radio systems in connection with the existing radio legislation even before the beginning of the Second World War.

According to this legislative basis, for example, the VDE 0871 A/B was valid with a restricted range of 10KHz to >30MHz (conducted interference) up to 31st December 1995 and was replaced by the EN 55011 A/B.

Under the EU legislation harmonisation to 1st January 1996 Germany already declared willingness to accept the weakened EU draft in the EMC law.This EN 55011.. 22 directive only takes into consideration the frequency range from 150 kHz to 30 MHz.
The European Union member states feared competition from the postillion Germany in the future-oriented and up to then exemplary EMC legislation should Germany continue to insist on retaining the interference limit values from 10 KHz to 30 MHz existing up to then.

The EMC directives drafted up to that time were derived on the basis of the CISPR publications and concerned mainly matters of interference emission in the following sectors:

EN 55011 - Radio interference of equipment for general, industrial, scientific, medical and similar purposes
EN 55013 - Radio interference characteristics (interference transmissions) from radio receivers and connected equipment
EN 55014 - Electrical household appliances, handheld electrical tools and similar electrical equipment
EN 55015 - Fluorescent tube lamps and lighting fixtures-
EN 55020 - Interference resistance of radio receivers and connected equipment-
EN 55022 - Technical information equipment (ITE)

From practise:

Cycled power packs, generalised phase control systems, thyristor circuits, IGBTs and power transistors all cycle in the ms range and as a consequence in the lower KHz range (2-10KHz).
The 1st, 3rd and 5th harmonic wave is likewise in the lower KHz range as a result depending on cycle frequency and also causes high energy spikes and transients apart from considerable harmonic waves.

These high energy spikes and transients with a very high dU/dt (voltage increase over time) get into the supply network and frequently extend to 10KV/µs on the remote transmission output side to the motor and between 100V and >500V/µs on the network side.

A further not to be neglected destructive variable is lightning when striking into the network itself or above ground and as a consequence through the protective conductor (PE). The satellite evaluation over one day registers approx. 2000 storms/day and approx. 100 strokes of lightning per second on the earth.

Some 15-35 storm days are to be taken into account in the central European area over one year and with approx. 1-5 strokes of lightning/km2. The higher values are valid for the regions to the south.

General safety aspects:

Standard components such as X1, X2, Y or MKP capacitors which are to be operated parallel to the network are designed for a dU/dt compatibility up to 50V/µs depending upon quality. The film thicknesses of capacitors (2-6µmm) have to be all the more thinner and the voltage impulse and dU/dt load limit must be all that smaller in concord with the miniaturisation of the electronic assemblies.

Of course X1, X2 and Y classified capacitors are self-extinguishing and heal after a disruptive discharge but this process must only occur to a limited extent.
Capacity losses and increased current values in the disruptive discharge at the given time indicate the already progressive preliminary damage to the construction element until in the long run the last disruptive discharge occurs causing maximum current to flow and as a consequence also leads to the physical destruction of the capacitor.

3KV peak voltage values in living areas, caused by short circuits and other network effects and up to 10KV in industrial networks are no seldom occurrence.

Apart from the interference variables caused in the ms range (cycle frequencies) by switching operations, there are numerous consumers which cause broad band perturbation as massive interference to be fed into the network.

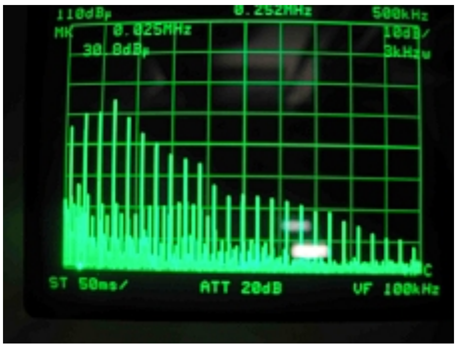

Figure 1 shows the network analysis in a Munich residential building

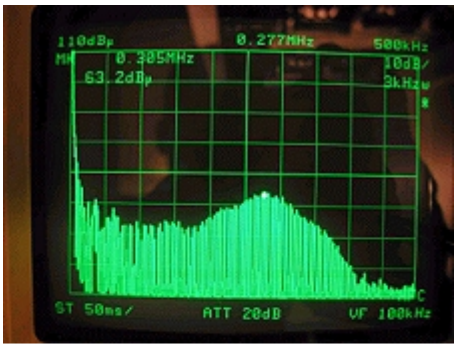

Figure 2 shows the disturbance in the network through the braking of a circular saw motor

A non-suppressed lift in a Munich residential building caused network disturbances and as a result destroyed three machine control systems, the logic system and 5 PCs in the immediate vicinity of the source of the interference within 4 weeks. This is shown in Figure 1.

Shown in Figure 2 is a solar changeover direction system which was destroyed within 6 weeks after being put into commission because an industrial circular saw motor (operating in a carpenter's shop) was switched off several times every day and caused considerable disturbances in the mains and, as a consequence the control system of the solar changeover direction system was continuously switched to "interference mode".

The measured power connected interference dependent on the network impedance status in both cases were 10KHz >140dBμV and 150KHz >100 dBμV, respectively.

The interference limit value in accordance with EN 55011-B (household standard) at 150 KHz provides only for 57dBμV (AV) (see hereto also Figures 2 and 4).

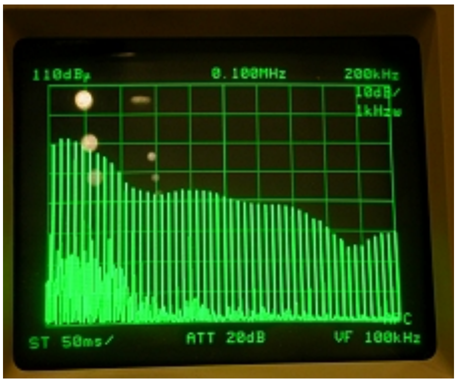

Figure 3 Phase L3 ceiling lighting dimmingin a television and sound studio

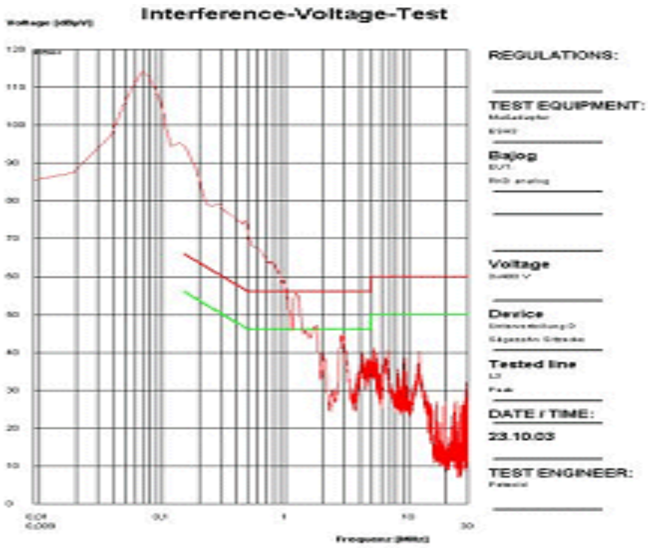

Figure 4 Evaluation of Figure 3 with a measurement receiver

The interference level in a film and sound studio ceiling and lighting system is shown in Figures 3 and 4.

These interferences were sufficient in magnitude to destroy the control equipment in the recording studio and the mixing desk circuit boards protected with active filters and caused crashes several times during the recording and mixing sessions. This involved a great deal of time, money and also caused considerable problems.

The failure statistics are also shown in this example. At least 90 of the 100 cases of EMC interference caused to massive interference < 150 kHz.

The question as to the dB (μV) ratio magnitude is often asked in respect of known voltage and current magnitudes.
Observed frequencies are generally registered as logarithmic ratio magnitudes and as a result can be clearly shown. This applies also for levels shown.The interference magnitudes can be described by referring to these levels. These include, for example, interference field strength, interference voltage, interference current, etc. The reference value for

voltage is Uo=1µV, for example.

Level as a logarithmic characteristic magnitude is a dimensionless magnitude.
The following are mentioned and shown in books of tables.

The following definitions are valid when applying decadic logarithms:

-Voltage level u/dB =20lg Ux/ Uo with Uo = 1µV;
-Current level i/dB =20lg Ix/ Io with Io = 1µA;
-Power level p/dB =10lg Px/ Po with Po = 1pW;
-E field strength level E/dB =20lg Ex/ Eo with Eo = 1µV/m;
- H field strength levelH/dB =20lg Hx/ Ho with Ho = 1µA/m;

The following overview shows the characteristic dB values for the respective appropriate ratio.

6dB 2:1
20B 10:1
40dB 100:1
60dB 1.000:1
80dB 10.000:1
100dB 100.000:1
120dB 1.000.000:1

End of table presentations.

No direct comparison can be made between an interference voltage curve in accordance with EN 55011… and the voltage or current content of a measured level. Supplementary measurements with suitable measuring instruments are required in this case.
However, for the respective CE certification / appliance approval, the directives laid down in EN 55011….22 are valid and these are based on measurements with a measurement receiver and the pre-stipulated appropriate interference limit values in dBµV.

From daily EMC practise:

What interference magnitudes have an effect on equipment and which of these lead to destruction?

As a general rule high frequency interference magnitudes (>1MHz) except for but a few exceptions cannot be directly destructive to other electronic components. The energy transmission caused by coupled capacities are often not adequate for this. However, these influences must not be considered to be harmless since these asymmetric interference magnitudes very often have a detrimental effect on the safe function of sensitive electronic assemblies, logic units, control systems and very frequently are responsible for undefined working situations in this case.

Over and above this high asymmetric compensation current flows and increases as a result of saturation effects of current compensated chokes amongst other things, which are actually to serve as protection components in network interference suppression filters. As a

consequence the systems and equipment are actually exposed to network attacks.
The following are further negative subsequent phenomena:

- Higher leakage currents and as a consequence current-operated c.l.c.i problems
- Skin effects and as a consequence inadequate common mode leakage in the case of higher frequencies
- Problems in complying with EMC directives

Equipment and systems with fast switching operations in the ms range caused by thyristor power controllers, IGBTs (remote transmission, rectifiers) etc. are effective as destructive magnitudes. Each switching operation is a one or two pole short circuit operation (in the case of 6 pulse rectifiers) and has a massive effect on the quality of the network. The energy density is sufficient to greatly influence or destroy these networks.

As a result of the short circuit currents the steep flanks of the trapezoidal shaped rectifier develops network current. These effects on the network are to be seen in Figure 1 and Figure 2.

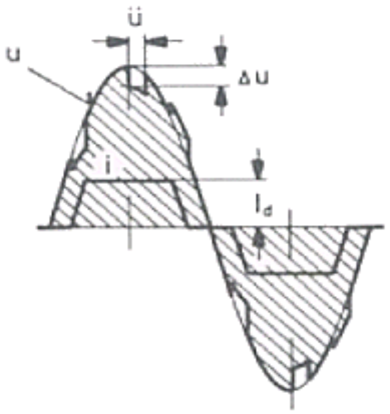

Figure.5 Sine distortion caused by current changes

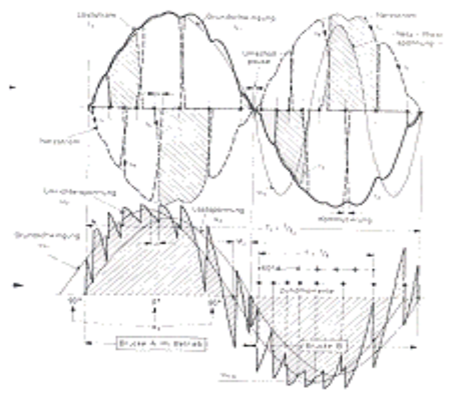

Figure. 6 Effects on the network caused by rectifier network disturbances

Figure 5 shows a distorted sine caused by the steep changes in rectifier current.
This switching characteristic is typical for equipment of this type but is not indicative of the quality of the product. Accordingly three factors play a significant role in the described EMC problems:

1) The continuous demand for always smaller equipment and plant in the network which force manufacturers to miniaturise construction elements with maximum use of energy.
2) The general necessity to save money in industry and supply competitive products from cheap wage countries also call for the use of "more cost favourable solutions" and "alternative materials“.
3) Far East products do not always meet CE standards

Unfortunately, the price advantage mainly influences any buying decision and forces real economic use and basic thoughts into the background.
The equipment and protective components (alibi filters) are no longer a hindrance to be taken seriously but generate the interference magnitudes described in the network. Capacitors in protective assemblies operated parallel to the network are very quickly damaged initially by the continuous high energy bombardment and are completely destroyed after varying periods of operation. The results are reflected in equipment files kept on the destruction of components. Even in the most harmless cases control systems, equipment, plant and computers are effected and fail.

The standardised employed inductiveness with low ground proportion are likewise no longer a barrier for the explained interference magnitudes. Asymmetric interference magnitudes force the core material into premature saturation. In this case still only effective are the actual resistance parts in the leads and transmission resistors in a conductor but these cannot weaken the penetrating energy content.

Aspects as seen by the consumer:

Plants and switch cabinet designers but also system operators and end users are confronted by the fact that the individual pieces of equipment available (controllers, drives, power packs, frequency converters, thyristor controllers, generalised controllers, etc.) have all been developed under laboratory conditions and as single pieces of equipment and plant comply with the valid EMC directives EN55011…..et seq. are suppressed and as a result fulfil the CE standards as well as the safety criteria.

The plant and equipment is to be purchased in good faith and integrated in own planned production process.

Very frequently after brief working times the EMC (Electro Magnetic Compatibility) is not safeguarded with due consideration to the different network impedances and the cycle frequency problems and because of the previously described network problems and the purchased utilisation of the plant is not provided. The customer is annoyed.
Here there is a great gap in the legislation.

On the one hand significant and urgently to be kept frequency ranges have been deleted in favour of third EU interests but on the other hand a grey zone has been created which cannot be overcome by the users suffering as a result of EMC who see their daily working processes, investments and as a consequence their economy being put at risk.

Without EMC experience and with little or even no knowledge in specific switching technology of the new purchased equipment and plant the end customer is faced with an absolutely unsolvable EMC problem. Very often left alone by the frequently very active salesman who promised the world before purchase and without any chance of support in the end the customer is left to solve the EMC problem on his own in the long run.

The general apology made by the equipment and plant suppliers in many known cases is as follows: "We maintain the EMC directives in the

laboratory and are also able to provide evidence of this“.Unfortunately this is even often correct to the sorrow of the end user concerned but this also does not help him any further.
With this argumentation the manufacturer withdraws from his responsibility and, as a consequence, reveals that even manufacturers are not able to face these EMC problems.

Over and above this the equipment and plant manufacturers refuse to take any responsibility when the product is integrated in a complete system or production process.

Making things more difficult is that both in Germany and Europe mainly service unfriendly companies are fighting for the market shares which are continuously becoming smaller and have still not recognised that service and highest quality safeguard their own future.

My motto is as follows: "Our customers are the most important asset we have"

Assistance

Continuous and frequent interruptions in processes or breakdowns cost a company a great deal of money, time, image and are the cause of internal disputes when trying to find who is responsible.

In 2003 alone the Bajog electronic company assisted a total of 106 small and large companies through practise-oriented EMC measurements and economic proposals to provide solutions and clean up and eliminate continuous failures in EMC influenced processes.This service is based on 21 years EMC practise in the military and civil development sector although at the very beginning the concentration was on the already existing group of customers of the Bajog electronic company.

Over and above this the Bajog electronic company has been involved in intensive material research and development work which assures the basis for suitable EMC solutions even under difficult space and application conditions.