APPLICATION NOTE

Effective EMI shielding concepts

ANP043, BY LORANDT FÖLKEL

Despite all extensively discussed and recommended design rules for the EMC conformity design of components, the interaction between different functional groups within an apparatus can often lead to unwanted side effects when tested in the EMC laboratory. Although installed in a metal casing, it can happen that the emitted interference radiation is above the threshold.

1. What has happened?

Most of the times, the metal casing itself is not part of the electronics development but is developed by the construction/mechanical department. They make sure that the openings in the casing, e.g. for cable inlets and outlets, ventilation slots, operating buttons, speakers, transducers or displays and all of these can cause a massive reduction of the shielding action. But within the openings of the metal casing, it is not possible to have a complete seal of both halves and so without overlap the result is that RF emissions can pass through.

2. "Why?" is this happening

If you look at a flat metal surface microscopically, you begin to see the imperfections. You will find that the material is uneven, with roughness on the surface. Therefore in the metal case itself there is no continuous connection between these two surfaces. Consequently, the seal (or meeting point) is interrupted by slots and if you look at the joining from a RF-technical point of view, it is "highly vulnerable". These slots and apertures, which were formed due to the roughness, cause an open gate for shortwave radiation to break out/in from the shielding cage (see Figure 1).

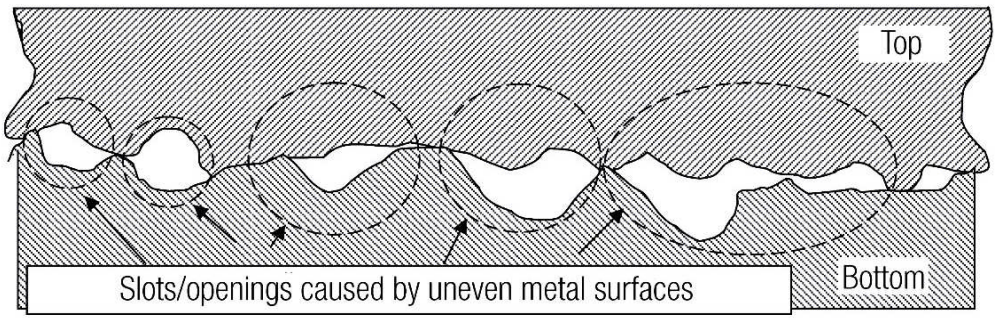

Fig. 1: Reduced shielding effect of casings due to apertures

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Suggestion to solve the problem:

The solution to the problem lies in the bridging and sealing of these apertures. For that purpose, our conductive textile gaskets WE-LT is an excellent fix (see Figure 2).

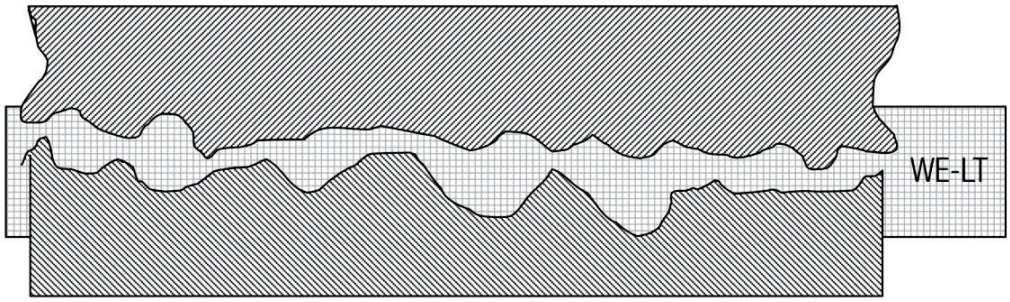

Fig. 2: Sealing of the slots and "apertures" using conductive gaskets WE-LT

The conductive gaskets are available in following profiles:

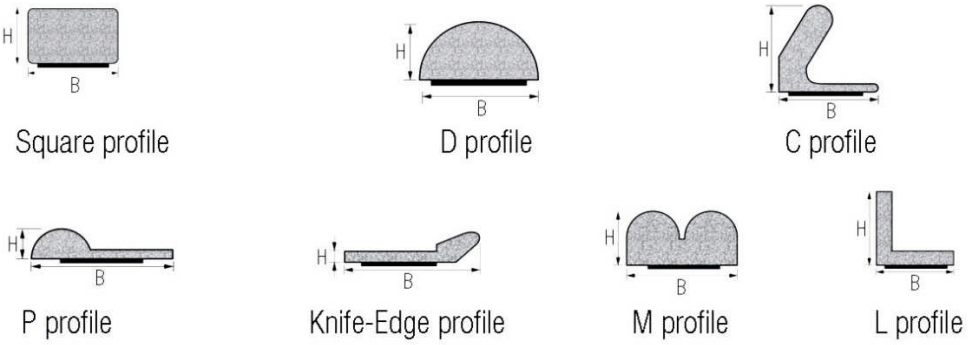

Fig. 3: Available profiles of the WE-LT

The conductive gasket requirements are always very different and depend on the purpose for which it is used. From practical experience the following minimum standard has proven itself:

- UL94-V0 approved material combinations (always necessary if the end product is for
- the US market)
- Protection against rough environmental conditions (dust/humidity)
- Good surface conductivity to obtain a low impedance connection
- Double-sided adhesive tape as fixation and mounting aid

For the application of conductive gaskets a certain minimum compression is necessary in order to keep the transitional resistance steadily low. Long term studies with different compressions have shown that the mounting compression of the gaskets influences the conductivity over time (see Figure 5). A steady compression for contact surfaces of at least 50% is necessary in order to keep the transitional resistance over a long period of time low and steady.

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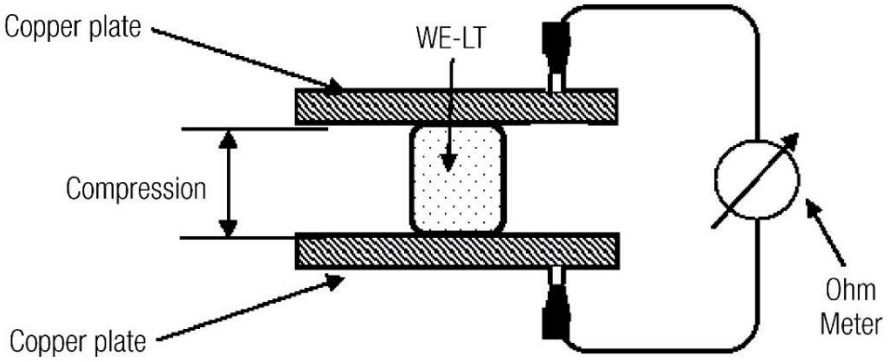

Fig. 4: Test setup surface resistance WE-LT vs. compression

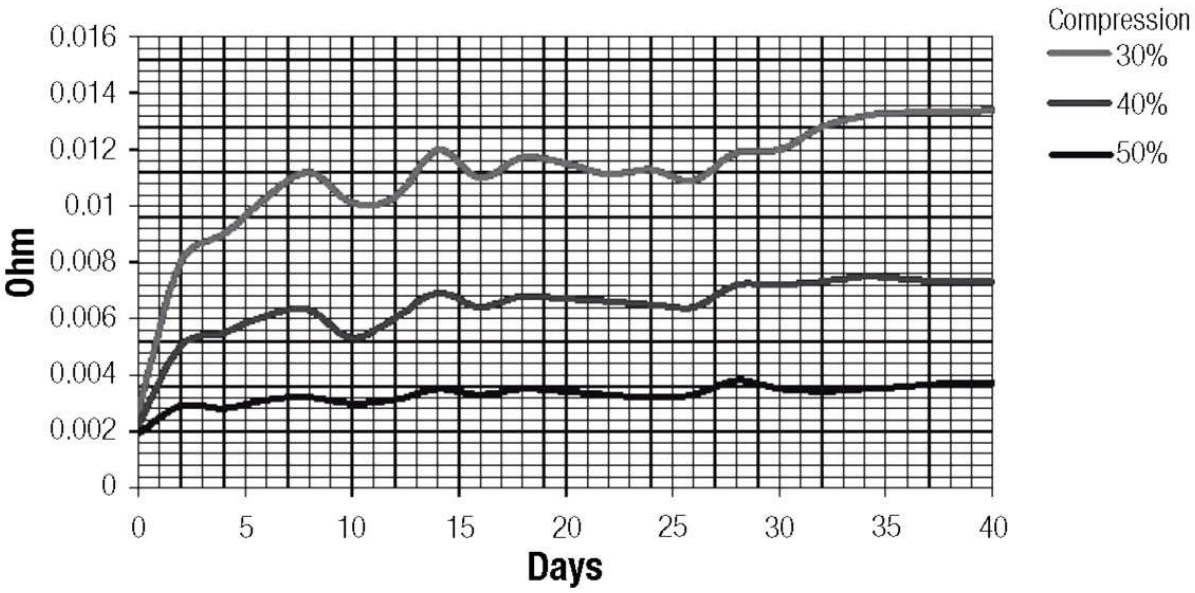

Fig. 5: Long-term run surface resistance vs. compression

The typical surface resistance of the series WE-LT is below **8 mOhm**. The achieved shielding effect is approx. 80 dB at 100 MHz and approx. 75 dB at 1 GHz (according to MIL 285 standard).

Positive side effect: At the same time the gaskets fulfill protection class IP54 for dust and water protection:

IP = International Protection

First Index: Foreign Body Protection, Solids	
IP0X	No special protection
IP1X	Back of hand, fist large foreign bodies, diam. >50 mm
IP2X	Finger medium-sized foreign bodies, diam. >12 mm
IP3X	Tools and wires etc. with a thickness >2.5 mm; Small foreign bodies, diam. >2.5 mm
IP4X	Tools and wires etc. with a thickness >1 mm; Granular foreign bodies, diam. >1 mm
IP5X	Complete protection (limited ingress permitted); Dust protected; dust deposits are permitted, must not affect the function of the unit
IP6X	Complete protection; dust-proof
Second Index: Water Protection, Liquids	
IPX0	No special protection
IPX1	Water dripping/falling vertically condensation/light rain
IPX2	Water sprayed at an angle (up to 15º degrees from the vertical), light rain with wind
IPX3	Spray water (any direction up to 60º degrees from the vertical), heavy rainstorm
IPX4	Spray water from all directions (limited ingress permitted), splashing
IPX5	Low pressure water jets from all directions (limited ingress permitted), hose down, residential
IPX6	High pressure jets from all directions (limited ingress permitted), hose down, commercial, eg Ship decks
IPX7	Temporary immersion, 15 cm to 1m immersion in tank
IPX8	Permanent immersion, under pressure for use on titanic recovery vehicle

Tab. 1: IP key numbers

When you put in contact different conductive materials, a galvanic process takes place, which leads to the corrosion of the contact surfaces. As a result the oxide layer, which has developed, isolates the two surfaces against each other instead of providing for a very good electric connection.

For practical applications the following table (Tab. 1) should be considered in order to prove the suitability of the material and hence guarantee long durability.

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Suitability of the material matching for WE-LT:			
+	Aluminium (Al)	++	Chrome / Silver stainless steel 13% Chrome (passive)
+	Iron (Fe)	++	Chromatized Steel 18%, Brass (La)
+	Rhodium (Rh)	++	stainless steel 13% Chrome (active)
++	Silver (Ag)	++	steinless steel 18% Chrome 8% Nickel (passive)
-	steel galavanized	--	Magnesium alloys
++	Titan (Ti)	++	Monel, Nickel (Ni), Cooper (Cu)
-	Zinc (Zn)	+	Platinum (Pl), Gold (Au), Carbon (C)
++	Stannous (Sn)		

Tab. 2: Material matching (– – unsuitable; – less recommended; + recommendable; ++ very suitable)

Effective mechanical/electrical connection to minimize the noise

Another shielding mistake which can occur when shielded cable connection to the GND, from a shielded cable, thought an intertwined connection (called “Pig Tails”) are kept too long are used.

The result is a high impedance connection and will not give a good path for the noise to travel to GND. It is recommended that all cable connection are using a shielding connection which are low impedance to the GND. This can be solved very easily, using Conductive Nylon Clips (Figure 6).

Fig. 6: Conductive Nylon Clips

Conductive Nylon Clips are available for cable from 3mm to 15mm in diameter. They are very flexible, extremely low weight and without sharp edges. In this way the cables are well connected and also well fixed to the board without damaging the shielding cable.

The connection between the PCB and casing (housing) should also be considered when thinking of EMC issues. Normally the steel spacer studs used are not the best solution because of undefined connection from the PCB to GND. The better solution would be to use **Earthing Belts** (Figure 7). These Earthing belts provide a solid connection, wider range of frequencies to travel through and so will reduce unwanted noise.

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Fig. 7: Earthing Belts

If the system contains several PCB's in same housing, very close to each other, some uncalculated coupling from PCB to PCB can occur. Those coupling are most in high frequencies and can be solved using metal cage around the PCB's. This system called "Zone Concept" can be useful, but most of the time too expensive.

A much more cost effective solution is the use of **Flexible Absorber Sheet's** (Figure 8) which are glued directly to the PCB. The Ferrite Sheet already has the double sided adhesive attached to it. These absorber materials do not need to be grounded or connected to any other device.

Because are very flexible they can be molded even over the components (please avoid high temperature!). The shielding are realized through the absorption principle the magnetic field energy are transformed into heat (ΔK can't be measured).

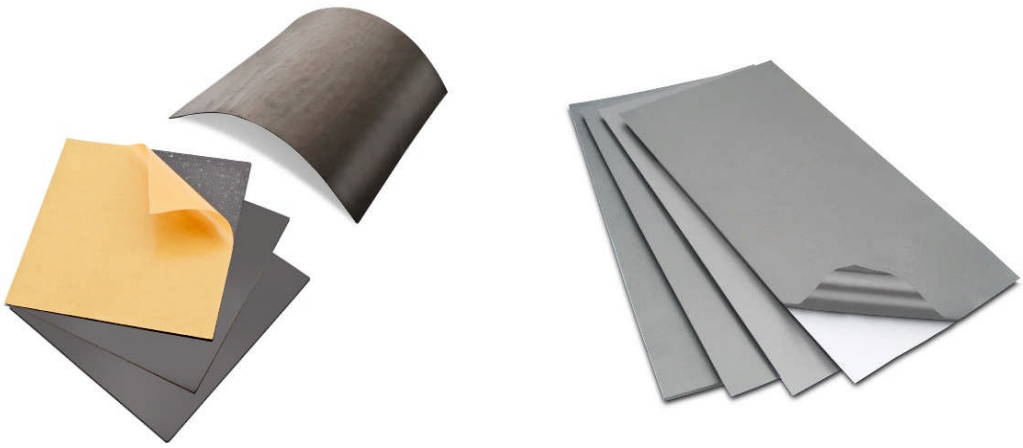

Fig. 8: Flexible Absorber Sheet's

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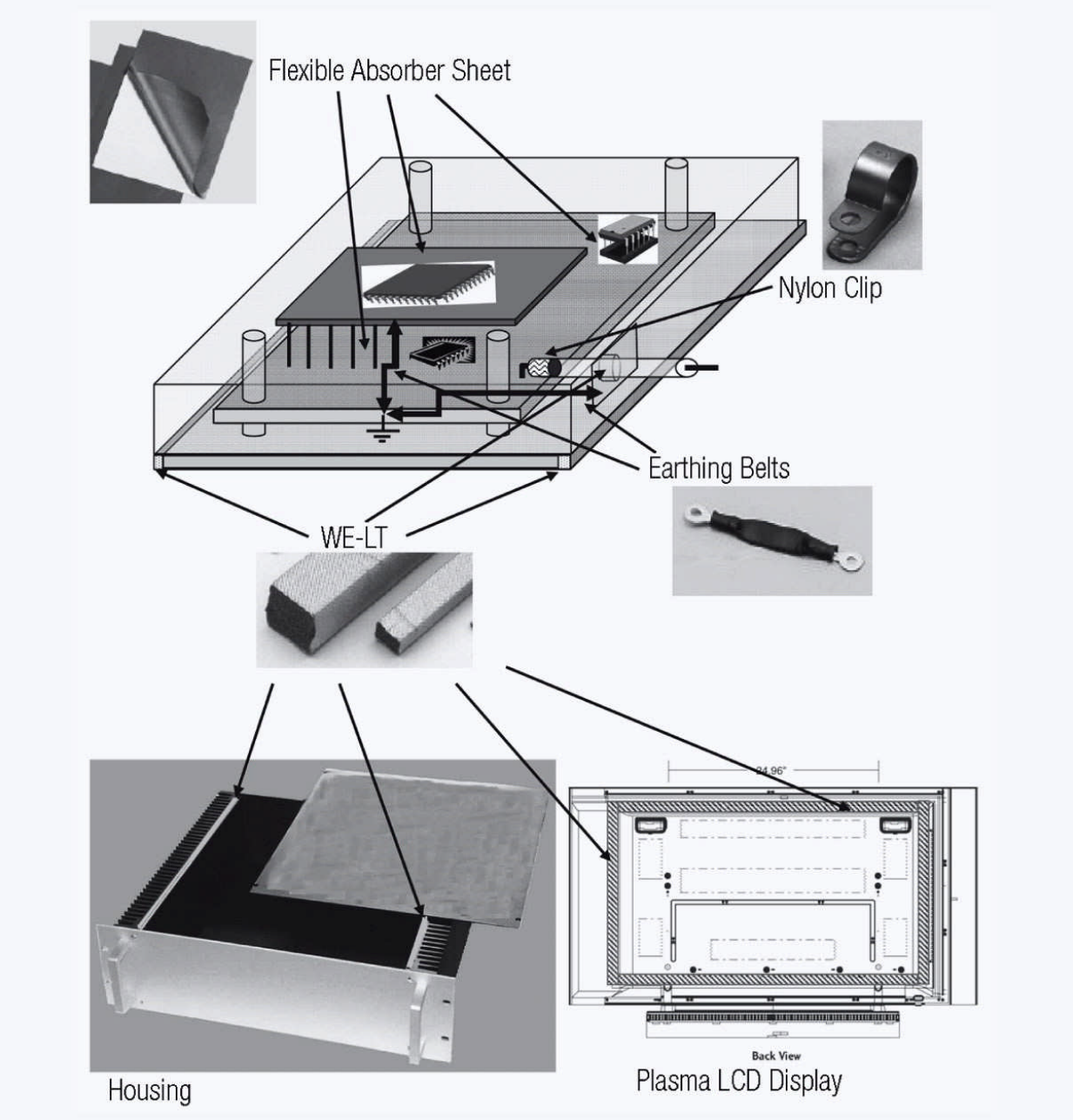

Fig. 9: Applications

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