SUPPORT NOTE

SN018 | Cracks on Molded Power Inductors

Mohamed Koobar, Tobias Frei, Brendon Weber

1. INTRODUCTION

This support note aims to explain the influence of visual surface irregularities around the core which may occur during the manufacturing process of molded inductors.

The key advantages of inductors produced by molding technology are high saturation current and high power density which exhibit soft saturation characteristics, low core losses, high operating temperature, and a small footprint. Unlike most power inductor cores, the molding material is not a ferrite, but a mixture of metal powder and resin binder which is pressed around the inductor coil. The resin binder creates a distributed air gap and greatly enhances the electrical characteristics of the inductor. After pressing, the mixture is cured along with the inductor coil in an oven to increase the bonding strength between resin binder and metal powder. Unlike other manufacturers, all WE molded inductors have a surface coating to prevent rust which could affect the reliability of the product.

2. VISUAL APPEARANCE & EFFECTS

The previously described molding process, as well as the physical properties of the core material, imposes limitations on achieving a perfectly uniform visual appearance. However, because a good appearance and performance are desirable, this support note explains visual non-uniformities that may be observed in a molded power inductor.

Cracks around the core are nearly impossible to eliminate as the molding process involves curing the resin binder and metal powder together. During the manufacturing process small scratches can be caused by surface friction when ejecting the component. Small to medium-sized cracks can occur in addition to the superficial scratches due to the materials. These are considered as optical appearances which have no influence on the performance of the product.

Product Series' name			
WE-PMCI	WE-LHMI	WE-MAPI	WE-PMFI
WE-LHMD	WE-MXGI	WE-XHMI	WE-MCRI

Table 1: Product Series.

Samples of products from the Table 1, with and without visual irregularities, have passed all industry standard tests including thermal shock, mechanical shock, terminal strength, vibration, humidity, moisture resistance, operational life, and others, as defined by the AECQ-200 specification. Moreover, these irregularities do not affect the reliability or performance of the product. Würth Elektronik eiSos has established internal standards to evaluate such cracks in order to ensure consistently high quality and the specified electrical parameters according to the datasheet. A summary is presented in the following section.

3. CRACKS

Cracks and scratches are classified as either acceptable or rejectable . To be judged as a rejectable part, all of the rejectable conditions (e.g. number, length, width) of at least one surface have to be met.

All of the pictures below are based on the WE-LHMI product series. The acceptable and rejectable criteria are applicable for all the molded inductor products from WE listed in Table 1..

Acceptable cracks

In general, cracks which are hard to recognize with the human eye, are acceptable.

Rejectable cracks

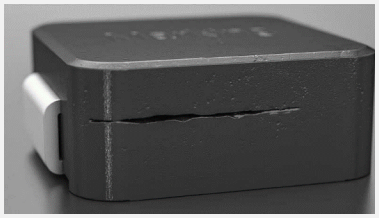
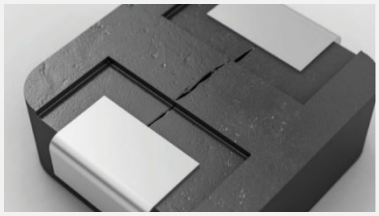
Type of irregularity	Surface	Picture	Visual	Number of irregularities	Length	Width
Crack / scratch	Top		Easy to identify by human eye and clear cut in the component	> 1 crack	≥ 1/2 of affected surface length	≥ 0.2 mm
Crack / scratch	Side without clip		Easy to identify by human eye and clear cut in the component	> 2 cracks	≥ 2/3 of affected surface length	≥ 0.2 mm
Crack / scratch	Side with clip		Easy to identify by human eye and clear cut in the component	> 2 cracks	≥ 1/2 of affected surface length	≥ 0.2 mm
Crack / scratch	Bottom		Easy to identify by human eye and clear cut in the component	> 1 crack	≥ 2/3 of affected surface length	≥ 0.2 mm

Table 2: List of the various rejactable cracks

4. CHIP OFFS

Chip offs can occur through the handling of the components during the manufacturing process. Even though the chip offs do not affect the function of the part until the coil is exposed or broken, Würth Elektronik eiSos has established internal standards to evaluate the chip offs. Chipping may occur on the surface, edges and corners of the inductor (Figure 1):

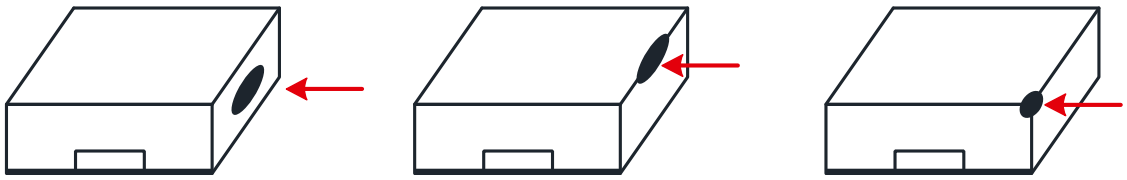


Figure 1: Chip off at various locations.

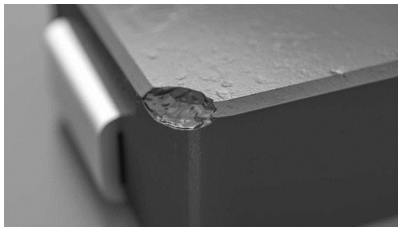
Type of irregularity	Picture	Number of irregularities	Length	Width	Area
Chip offs		> 2 chip-offs	≥ 1/2 of affected surface length	≥ 1/4 of affected surface width	≥ 1/16 of affected surface area

Table 3 Examples for assessment of rejectable chip offs

5. ELECTRICAL PERFORMANCE

Based on the design and construction similarities between WE-LHMI and the series listed in Table 1, as well as on our internal experience, including comparable mechanical structure, material system, termination design, binder composition, and other key elements of molded inductor architecture, the conclusions obtained from the tested part below can reasonably be extrapolated to the other product series. A synchronous step down switching regulator is implemented using an LTC3810 controller and a WE-LHMI 74437368068 inductor without visual imperfections.

The DC/DC converter has the following specifications:

- 60 W power
- 250 kHz switching frequency
- 24 V input
- 12 V output at 5 A

The WE-LHMI 74437368068 with an inductance value of 6.8 µH achieved following test results:

11.78 V, 5.02 A with 93% efficiency.

A large chip, approximately 15% of the volume, was broken off the original inductor intentionally (please refer to Figure 2) and the part was retested in the circuit.

Figure 2: Broken edge on WE-LHMI 74437368068.

This inductor achieved the same operating results as the original part without chipping.
The waveforms of the inductors with and without chipping are shown in Figure 3.

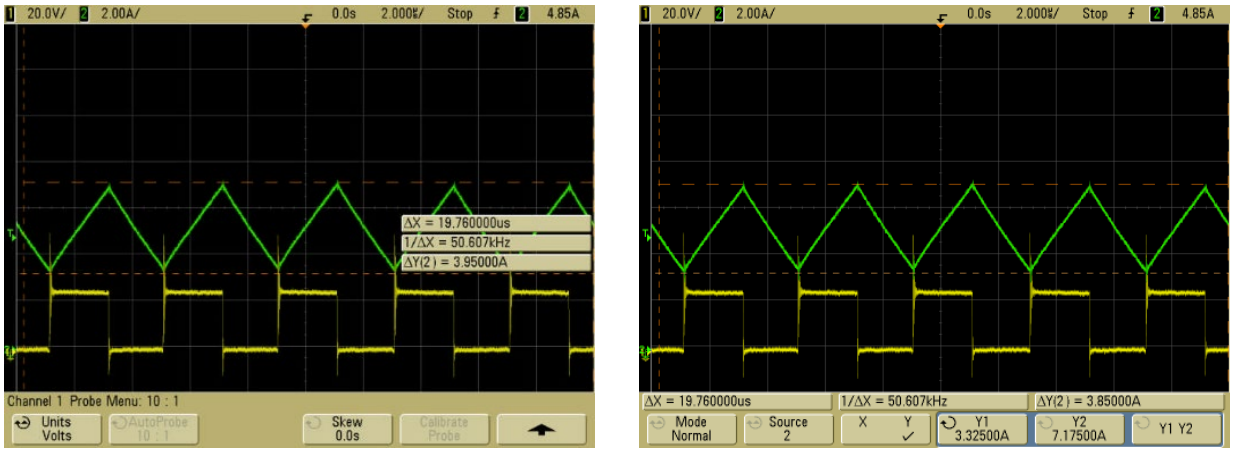


Figure 3: Waveform of the inductor current and switching voltage with inductance without visual features (left side) and with 15% chipping on the inductor core (right side).

The green waveform represents the current measured through the inductor using a Hall effect probe and the yellow waveform represents the voltage measured at the drain of the MOSFET.

The reasons for the consistent performance even with large, unacceptable cracks as well as chip offs are:

- The high flux density in the core only occurs in the closest area next to the windings
- The core material has a distributed "air gap" and the resulting lower relative permeability of the material drastically reduces the effect of discontinuities in the material (cracks).
- The magnetic cross-sectional area on the sides of the inductor is much larger than the center therefore the flux density is lower. As demonstrated, even with large chips, the flux can easily distribute to other areas without affecting performance.

6. SUMMARY

Molded inductors meet the requirements of modern electronic circuits by offering stable inductance at high currents while maintaining a compact design. Composite molding technology offers many advantages; however, due to the underlying physical principles, minor irregularities may occur. These do not affect the performance or electrical parameters of the component, provided they remain within the limits specified above.

IMPORTANT NOTICE

The Application Note is based on our knowledge and experience of typical requirements concerning these areas. It serves as general guidance and should not be construed as a commitment for the suitability for customer applications by Würth Elektronik eiSos GmbH & Co. KG. The information in the Application Note is subject to change without notice. This document and parts thereof must not be reproduced or copied without written permission, and contents thereof must not be imparted to a third party nor be used for any unauthorized purpose.

Würth Elektronik eiSos GmbH & Co. KG and its subsidiaries and affiliates (WE) are not liable for application assistance of any kind. Customers may use WE's assistance and product recommendations for their applications and design. The responsibility for the applicability and use of WE Products in a particular customer design is always solely within the authority of the customer. Due to this fact it is up to the customer to evaluate and investigate, where appropriate, and decide whether the device with the specific product characteristics described in the product specification is valid and suitable for the respective customer application or not.

The technical specifications are stated in the current data sheet of the products. Therefore the customers shall use the data sheets and are cautioned to verify that data sheets are current. The current data sheets can be downloaded at www.we-online.com. Customers shall strictly observe any product-specific notes, cautions and warnings. WE reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services.

WE DOES NOT WARRANT OR REPRESENT THAT ANY LICENSE, EITHER EXPRESS OR IMPLIED, IS GRANTED UNDER ANY PATENT RIGHT, COPYRIGHT, MASK WORK RIGHT, OR OTHER INTELLECTUAL PROPERTY RIGHT RELATING TO ANY COMBINATION, MACHINE, OR PROCESS IN WHICH WE PRODUCTS OR SERVICES ARE USED. INFORMATION PUBLISHED BY WE REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE A LICENSE FROM WE TO USE SUCH PRODUCTS OR SERVICES OR A WARRANTY OR ENDORSEMENT THEREOF.

WE products are not authorized for use in safety-critical applications, or where a failure of the product is reasonably expected to cause severe personal injury or death. Moreover, WE products are neither designed nor intended for use in areas such as military, aerospace, aviation, nuclear control, submarine, transportation (automotive control, train control, ship control), transportation signal, disaster prevention, medical, public information network etc. Customers shall inform WE about the intent of such usage before design-in stage. In certain customer applications requiring a very high level of safety and in which the malfunction or failure of an electronic component could endanger human life or health, customers must ensure that they have all necessary expertise in the safety and regulatory ramifications of their applications. Customers acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of WE products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by WE.

CUSTOMERS SHALL INDEMNIFY WE AGAINST ANY DAMAGES ARISING OUT OF THE USE OF WE PRODUCTS IN SUCH SAFETY-CRITICAL APPLICATION.

USEFUL LINKS

Application Notes
www.we-online.com/appnotes

REDEXPERT Design Platform
www.we-online.com/redexpert

Toolbox
www.we-online.com/toolbox

Product Catalog
www.we-online.com/products

CONTACT INFORMATION

appnotes@we-online.com
Tel. +49 7942 945 - 0

Würth Elektronik eiSos GmbH & Co. KG
Max-Eyth-Str. 1 74638 Waldenburg Germany
www.we-online.com

REVISION HISTORY

Document Version	Release Date	Changes
SN018a	2021/07/12	Initial release of the application note
SN018b	2026/06/23	New layout, overall update,text improvements

Note: *The current version of the document and the release date are indicated in the footer of each page of this document.*