CeraPlas™ HF series

Piezoelectric based plasma generator

Series/Type: **CeraPlas™ HF type - Prototype**
Ordering code: **Z63000Z2910Z 1Z60**

Date: 2018-06-29
Version: 02

Features

- Direct high voltage discharge unit for generation of plasma
  - No high voltage wiring
  - No high voltage plugs
  - Ready to use with TDK CeraPlas™ driving stage
- High ionization rate and efficient ozone generation rate
- Multi gas ignition
- Low power
- High efficiency
- No magnetic fields
- Package design ready for easy assembly
- Demo-Kit available

Application fields

- Ionization of various gases at atmospheric pressure and ambient temperature conditions
- Non-thermal atmospheric pressure plasma generation
- Smell reduction and decontamination of air
- Surface treatment processing like activation, cleaning and purifying

Applications

- Integration in ionization or plasma generating modules
- Implementation in handheld and plug connected devices

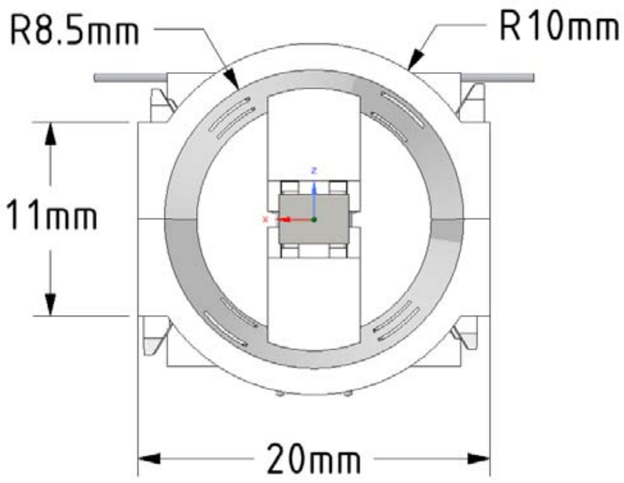
Construction

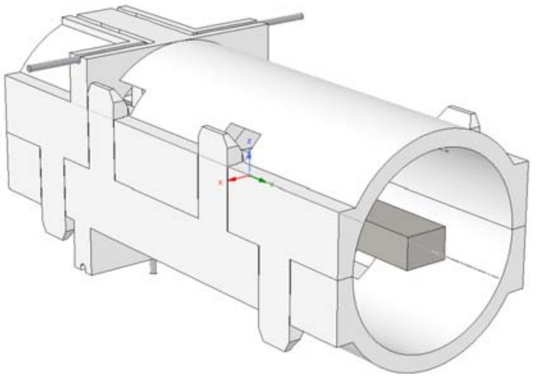
- RoHS compatible PZT ceramic
- Plastic package
- Solderable Cu wires

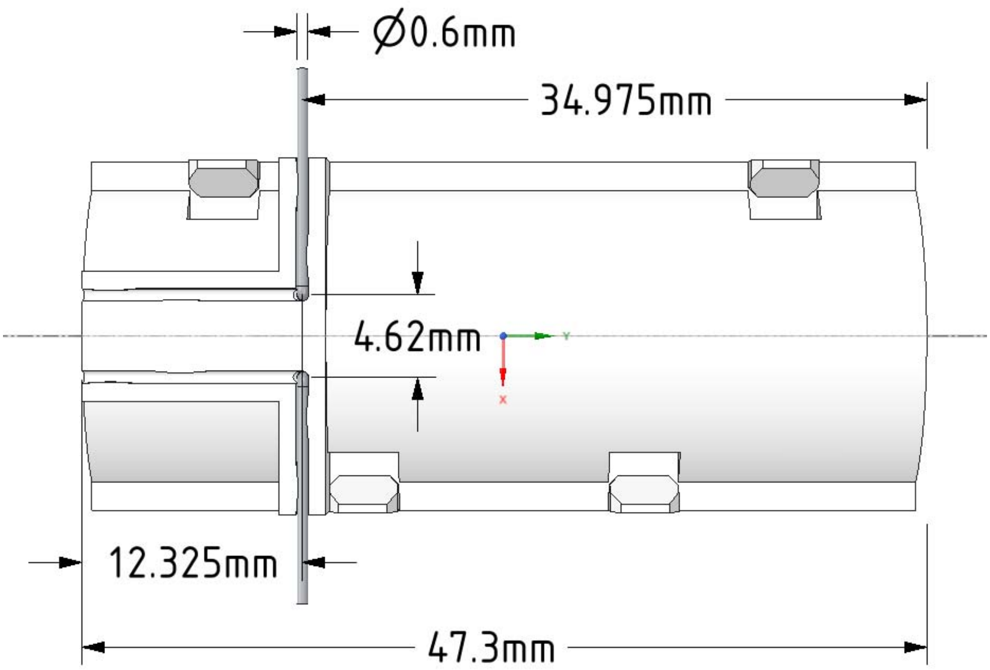
Preliminary data

Dimensions

Material: PBT GF30







Notes: Material and dimensions under development.
Changes without notification!

Preliminary data

Specifications

Material type and features Piezoelectric High Coupling
High stiffness
High stability of mechanical quality factor

Excitation waveform for operation Sinusoidal wave

Parameter	Symbol	Value	Unit
Maximum voltage for continuous operation	V_{in}	7	V [1)]
Maximum continuous operation input power	P_{in}	5	W
Operating frequency (2nd harmonic anti-resonance)	f_{res} typ.	82	kHz
Typical input capacitance @ V_{in} = 0.1 V, 1 kHz, 25 °C	C_{in}	0.74	µF
Operating temperature range	T_{op}	0 … +60	°C
Storage temperature range	T_{st}	−25 … +60	°C
Weight approx.	m	3.8	g

Tolerances to be qualified; Performance to be qualified

1) Unless otherwise noted voltages and currents are rated in rms-values

Preliminary data

Input impedance in dependence on frequency (T_{device} = 25°C)

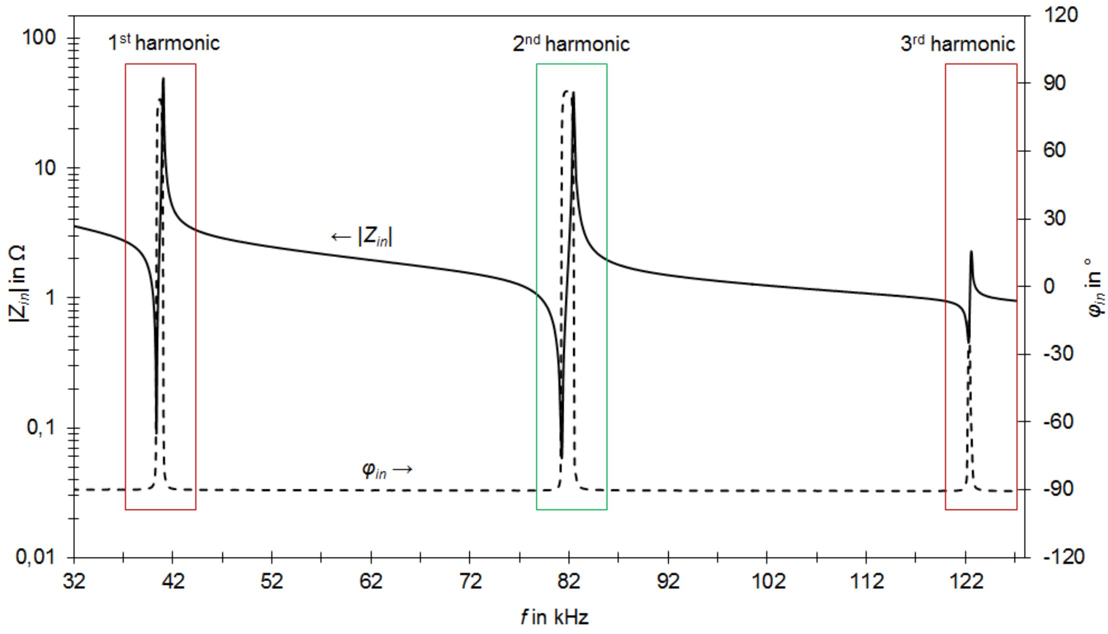


Fig. 1. Typical input impedance at open-circuit output (Vin = 0.1 V, no plasma).

The CeraPlas™ HF has its first resonance around 41 kHz. It is designed to be driven at its 2nd harmonic around 82 kHz, shown in detail in Fig. 2.

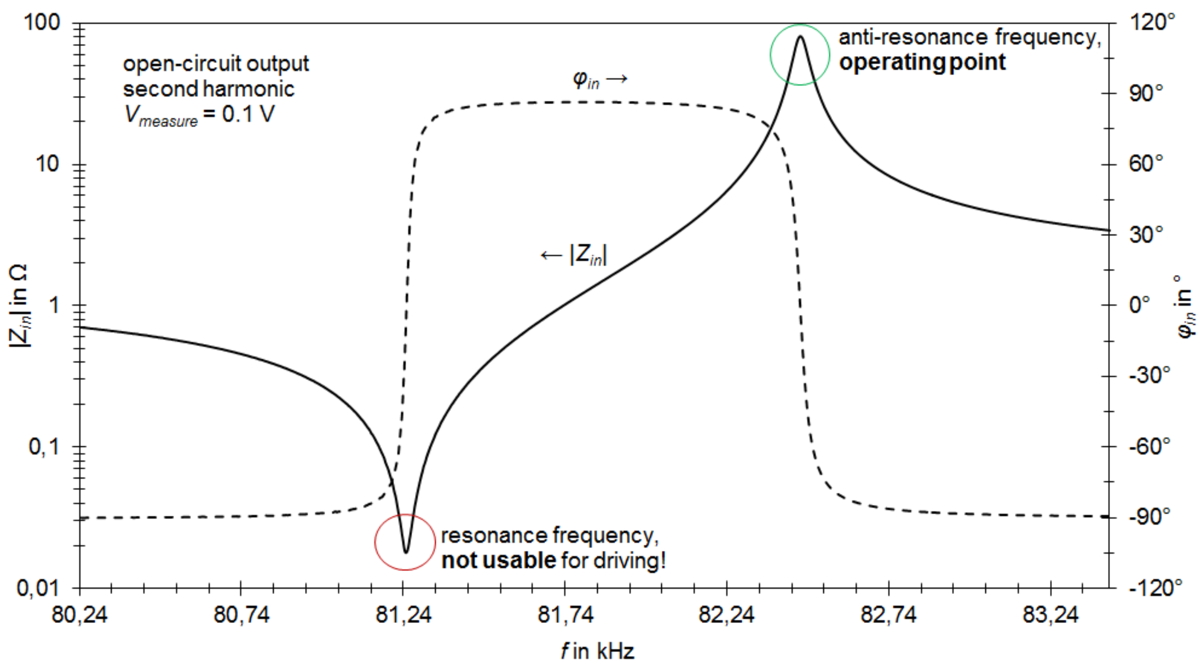


Fig. 2. Typical input impedance around 2nd harmonic at open-circuit output (Vin = 0.1 V, no plasma).

At resonance frequency the impedance is close to the minimum, at anti-resonance the impedance is close to the maximum. In both cases the phase is 0°. The CeraPlas™ HF is designed to be driven at the 2nd harmonic anti-resonance frequency/maximum impedance. Driving at resonance frequency/minimum impedance has to be avoided.

Input impedance in dependence on input voltage

By increasing the input voltage at 2nd harmonic anti-resonance frequency the output voltage increases. At a distinct threshold input voltage the output voltage is sufficient to start ignition of plasma, visible as small plasma dots at the corners of the output. The ignition of plasma presents a load at the output of the CeraPlas™ HF. Thus, the load at the output depends on the input voltage. The load widely depends on the operating gas and environmental conditions, too. It is not possible to measure plasma impedance without influencing the output electric field. Nevertheless, to get an impression about how the load is changing the resonance behavior a simulation of resonance curves for different loads is depicted in Fig. 3. Be aware that the resonance frequencies are shifted with varying loads!

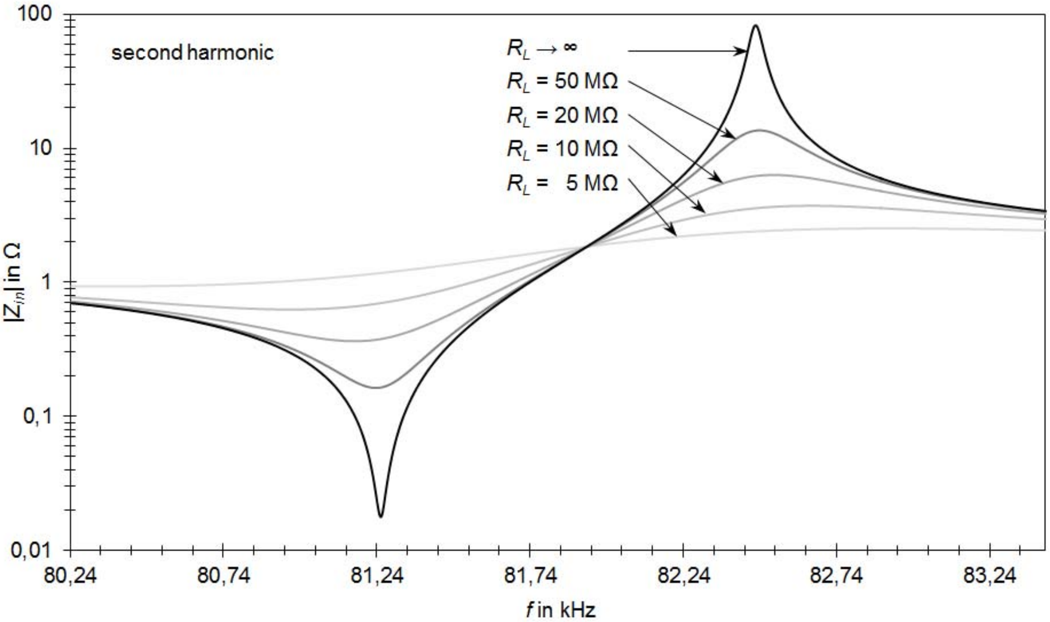


Fig. 3. Simulated input impedance for different loads R_L.

Input voltage selection

Due to the variations in the substrate material, operating gases, environmental conditions, and set-up arrangements it is not possible to define a definite input voltage for plasma generation.

In order to find an input voltage that satisfies the application's requirements start with low voltages and increase the voltage step by step. For every step re-adjust the frequency to find anti-resonance. This procedure is limited by the temperature and maximum power capabilities of the CeraPlas™ HF. The CeraPlas™ HF can then be operated between ignition threshold and maximum temperature/power conditions (see page 4). A typical threshold voltage can be clearly seen as jump towards lower impedance.

Driving at maximum efficiency

It is recommended to drive the CeraPlas™ HF at maximum efficiency under all conditions to avoid overheating. Depending on applied power the maximum efficiency is located at three different conditions:

1. Input power approximately < 1.5 W: As shown in Fig. 2 the CeraPlas™ HF has to be driven at anti-resonance frequency, hence maximum impedance, corresponding to 0°.
2. Input power between 1.5 W and 5 W: Plasma is changing the input impedance. Maximum impedance does not correspond with 0° anymore. Maximum efficiency is located at 0°. At maximum impedance the efficiency is lower.
3. Input power > 5 W (not recommended for continuous operation): A phase of 0° cannot be found anymore. In this case the maximum efficiency will be located at a frequency where the (in this case always negative phase) absolute value of the phase shows a minimum.

The controlling criteria for operation at maximum efficiency are given in Table 2.

Pin	Criterion
< 1.5 W	$\max\lvert Z_{in}\rvert$, $\varphi_{in} = 0°$
< 5 W	$\varphi_{in} = 0°$, $\approx \max\lvert Z_{in}\rvert$
≥ 5 W	$\min\lvert\varphi_{in}\rvert$, $\neq \max\lvert Z_{in}\rvert$

Table 2: Controlling criteria for driving the CeraPlas™ HF at maximum efficiency.

Therefore, mainly two frequency controlling techniques can be used:

1. **Current-controlled:** voltage is given, frequency at minimum current is used. Simple solution, works fine at low powers, high losses at higher powers.
2. **Phase-controlled:** voltage is given, frequency is changed by decreasing Δf until $\Delta\varphi/\Delta f \approx 0$. Complex solution, phase has to be measured. Works fine at any powers.

Preliminary data

Further typical characteristics and process recommendation

- Temperatures should not exceed 85 °C during processing and operation
- The temperatures of the package should not exceed 85°C temperatures during soldering of the wires
- For mounting and contacting of the CeraPlas™ HF element the following steps have to be considered:
  - The recommended electrical contacting of CeraPlas™ HF are
    - soldering of the wires on PCB
    - soldering of conductive wires with diameter >0.6 mm
  - For mounting of the element (especially the output) take special precautions for isolating properties of the used materials around the part (distance of < 2cm NO CONDUCTIVE MATERIALS!)
  - Prevent any damping of the vibrations due to any clamping of the element.
  - Please take care to prevent any ignition to the surroundings due to the local high electrical field
  - The housing material must be non-conductive!
  - The components shall be delivered in trays

Cautions and warnings

General

Some parts of this publication contain statements about the suitability of our ceramic multilayer Piezo components (CeraPlas™) for certain areas of application, including recommendations about incorporation/design-in of these products into customer applications. The statements are based on our knowledge of typical requirements made of our devices in the particular areas. We nevertheless expressly point out that such statements cannot be regarded as binding statements about the suitability of our CeraPlas™ components for a particular customer application. As a rule, EPCOS is either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always incumbent on the customer to check and decide whether the CeraPlas™ devices with the properties described in the product specification are suitable for use in a particular customer application.

- Do not use EPCOS CeraPlas™ components for purposes not identified in our specifications, application notes and data books.
- Ensure the suitability of a CeraPlas™ component in particular by testing it for reliability during design-in. Always evaluate a CeraPlas™ component under worst-case conditions.
- Pay special attention to the reliability of CeraPlas™ devices intended for use in safety-critical applications (e.g. medical equipment, automotive, spacecraft, nuclear power plant).

Design notes

- Always connect a CeraPlas™ component with the electronic driving circuit.
- Consider maximum rated power dissipation if a CeraPlas™ device has insufficient time to cool down between a number of pulses occurring within a specified isolated time period**.** Ensure that surface temperature does not increase above ambient temperature + 35°C and that electrical characteristics do not degrade.
- Consider derating at higher operating temperatures.
- Surge currents beyond specified values will puncture a CeraPlas™ component. In extreme cases a CeraPlas™ device will rupture.
- If steep surge current edges are to be expected, make sure your design is as low-inductive as possible.
- In some cases the malfunctioning of passive electronic components or failure before the end of their service life cannot be completely ruled out in the current state of the art, even if they are operated as specified. In applications requiring a very high level of operational safety and especially when the malfunction or failure of a passive electronic component could endanger human life or health (e.g. in accident prevention, life-saving systems, or automotive battery line applications such as clamp 30), ensure by suitable design of the application or other measures (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of such a malfunction or failure. Do not use CeraPlas™components in safety-relevant applications.
- Specified values only apply to CeraPlas™ components that have not been subject to prior electrical, mechanical or thermal damage.

Storage

- Only store CeraPlas™ devices in their original packaging. Do not open the package before storage.
- Storage conditions in original packaging: temperature −25 to +60°C, relative humidity ≤75% annual average, maximum 95%, dew precipitation is inadmissible.
- Do not store CeraPlas™ devices where they are exposed to heat or direct sunlight. Otherwise the packaging material may be deformed or CeraPlas™ components may stick together, causing problems during mounting.
- Avoid contamination of the CeraPlas™ components surface during storage, handling and processing.
- Avoid storing CeraPlas™ devices in harmful environments where they are exposed to corrosive gases (for example SO_x, Cl).
- Use CeraPlas™ components as soon as possible after opening factory seals such as polyvinyl-sealed packages.
- Bond CeraPlas™ components after shipment from EPCOS within the time specified:
  - CeraPlas™ devices, 3 months

Handling

- Do not drop CeraPlas™ components and allow them to be chipped.
- Do not touch CeraPlas™ devices with your bare hands - gloves are recommended.
- Avoid contamination of the CeraPlas™ component surface during handling.
- Do not touch CeraPlas™ devices during operation (danger of high voltage, damping the acoustic wave inside the ceramic body, damaging the ceramic body)

Mounting

- Do not encapsulate with sealing material or overmould CeraPlas™ devices with plastic material to prevent a damping of the device's vibrations.
- Do not put the package of the CeraPlas™ under pressure and do not deform the package to prevent a damping of the device's vibrations
- Make sure the housing is not scratched before, during or after the mounting process.
- Make sure contacts and housings used for assembly with CeraPlas™ components are clean before mounting.
- The surface temperature of an operating CeraPlas™ device can be higher. Ensure that adjacent components are placed at a sufficient distance from a CeraPlas™ component to allow proper cooling.
- Avoid contamination of the CeraPlas™ device surface during processing.
- For mounting of the package element (output) take special precautions for isolating properties of the used materials (NO CONDUCTIVE MATERIALS!)
- Prevent any damping of the vibrations due to any clamping of the element or the package of the element
- Please take care to prevent any ignition to the surroundings due to the local high electrical field (from the output nodal point to the tip of the output part) by a minimum distance of >4.5mm from the element's edge to the inner wall of any housing. The housing material must be non-conductive.

Soldering

- Iron soldering process is recommended for contacting of the wires
- Device is not designed for reflow soldering
- Prevent reflow soldering for contacting of the wires or mounting of the part
- Complete removal of flux is recommended to avoid surface contamination that can result in an instable and/or high leakage current.
- Use resin-type or non-activated flux.
- Temperature of the CeraPlas™ component in the housing shall not exceed 150°C to avoid desoldering or shift of the wires connecter to the ceramic part
- The temperature of housing shall not exceed 60°C
- Bear in mind that insufficient preheating may cause ceramic cracks.
- Rapid cooling by dipping in solvent is not recommended, otherwise a component may crack.
- For Pb free soldering a solder paste containing Ag (e. g. SAC solder) is recommended

Operation

- Use CeraPlas™ component only within the specified operating temperature range.
- Use CeraPlas™ component only within specified voltage and current ranges.
- Use CeraPlas™ component only within the specified frequency range.
- The CeraPlas™ component has to be operated in a dry atmosphere which must not contain any additional chemical vapour or substances.
- Environmental conditions must not harm a CeraPlas™ device. Only use them in normal atmospheric conditions.
- Prevent a CeraPlas™ component from contacting liquids and solvents. Make sure that no water enters a CeraPlas™ device.
- Avoid dewing and condensation.

- CeraPlas™ components are mainly designed for encased applications. Under all circumstances avoid exposure to:
  - direct sunlight
  - rain or condensation
  - steam, saline spray
  - corrosive gases or atmosphere with reduced oxygen content

- Avoid electrical conducting materials near (less than 20 mm, sharp tips less than 30 mm) the output side of the CeraPlas™. In this case arcing could occur, yielding high transformer power and transformer failure.
- Discharging towards an electrical conducting material near the output side of the transformer can lead to overheating of the CeraPlas™ even if the load is isolated
- High voltage hazard! The output side of the CeraPlas™ can reach voltages of up to 10 kV!
- Take special care of the toxicity of ozone! Use a ventilation system to remove the ozone. Depending on air-flow around the output of the transformer the ozone concentration can reach very high values!
- Use air or inert gases only! Do not use flammable working gases!
- EPCOS is not responsible for any harm during operating and testing of CeraPlas™!

This listing does not claim to be complete, but merely reflects the experience of EPCOS AG

Display of ordering codes for EPCOS products

The ordering code for one and the same EPCOS product can be represented differently in data sheets, data books, other publications, on the EPCOS website, or in order-related documents such as shipping notes, order confirmations and product labels. **The varying representations of the ordering codes are due to different processes employed and do not affect the specifications of the respective products**. Detailed information can be found on the Internet under www.epcos.com/orderingcodes

Important notes

The following applies to all products named in this publication:

1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out **that such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application.** As a rule, EPCOS is either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether an EPCOS product with the properties described in the product specification is suitable for use in a particular customer application.
2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified.** In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.
3. **The warnings, cautions and product-specific notes must be observed.**
4. In order to satisfy certain technical requirements, **some of the products described in this publication may contain substances subject to restrictions in certain jurisdictions (e.g. because they are classed as hazardous)**. Useful information on this will be found in our Material Data Sheets on the Internet (www.epcos.com/material). Should you have any more detailed questions, please contact our sales offices.
5. We constantly strive to improve our products. Consequently, **the products described in this publication may change from time to time**. The same is true of the corresponding product specifications. Please check therefore to what extent product descriptions and specifications contained in this publication are still applicable before or when you place an order. We also **reserve the right to discontinue production and delivery of products**. Consequently, we cannot guarantee that all products named in this publication will always be available. The aforementioned does not apply in the case of individual agreements deviating from the foregoing for customer-specific products.
6. Unless otherwise agreed in individual contracts, **all orders are subject to the current version of the "General Terms of Delivery for Products and Services in the Electrical Industry" published by the German Electrical and Electronics Industry Association (ZVEI)**.
7. **Our manufacturing sites serving the automotive business apply the IATF 16949 standard.** The IATF certifications confirm our compliance with requirements regarding the quality management system in the automotive industry. Referring to customer requirements and customer specific requirements ("CSR") TDK always has and will continue to have the policy of respecting individual agreements. Even if IATF 16949 may appear to support the acceptance of unilateral requirements, we hereby like to emphasize that **only requirements mutually agreed upon can and will be implemented in our Quality Management System.** For clarification purposes we like to point out that obligations from IATF 16949 shall only become legally binding if individually agreed upon.

Important notes

8. The trade names EPCOS, CeraCharge, CeraDiode, CeraLink, CeraPad, CeraPlas, CSMP, CTVS, DeltaCap, DigiSiMic, ExoCore, FilterCap, FormFit, LeaXield, MiniBlue, MiniCell, MKD, MKK, MotorCap, PCC, PhaseCap, PhaseCube, PhaseMod, PhiCap, PowerHap, PQSine, PQvar, SIFERRIT, SIFI, SIKOREL, SilverCap, SIMDAD, SiMic, SIMID, SineFormer, SIOV, ThermoFuse, WindCap are **trademarks registered or pending** in Europe and in other countries. Further information will be found on the Internet at www.epcos.com/trademarks.

Release 2018-06