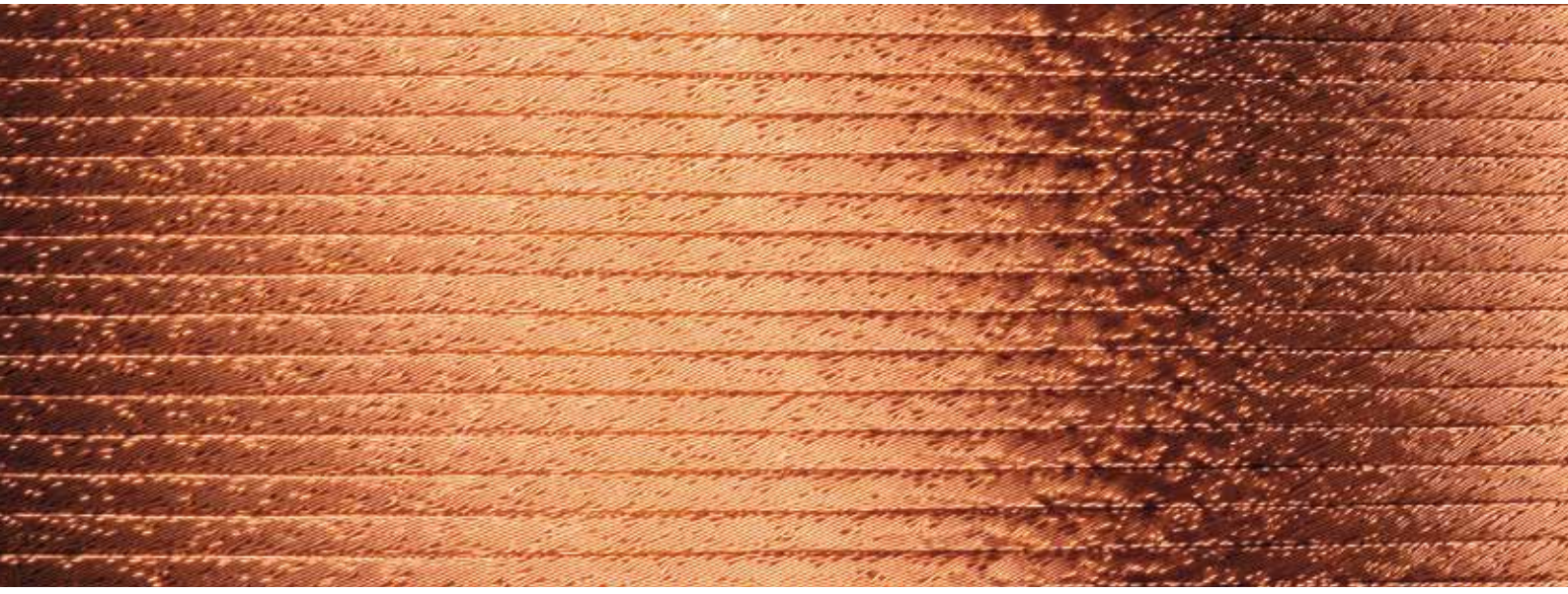
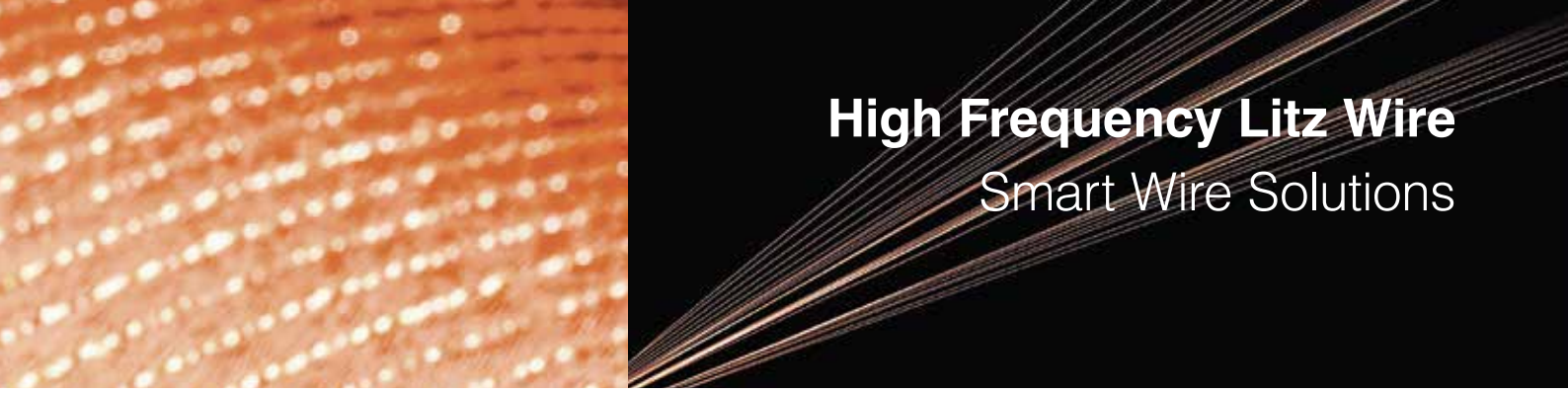
ELEKTRISOLA



High Frequency Litz Wire

Product Program and Technical Data

Content



High Frequency Litz Wire
Smart Wire Solutions

Innovation starts with us / It all starts with wire

To exceed the boundaries of what is possible requires a comprehensive and steady focus on development. Since its establishment in 1948, ELEKTRISOLA has developed new products and manufacturing processes concentrating specifically in the optimization of its fine wire products. This focus on fine wire development has resulted in numerous improvements in quality and performance, for example in automotive ignition systems and RFID applications where our products are recognized as the global quality standard.

Our global presence and unique international network of manufacturing and development competence allows ELEKTRISOLA to respond effectively to demands from multiple industrial fields at short notice. The response to customer demand for specific solutions has resulted in innovative wire products. Nowadays, our litz wire products utilize not only copper but also different alloys and plating variations for conductors. Furthermore, specially selected insulations for both single conductor and litz wire applications have been developed. In terms of litz wire applications not only additional methods of insulation i.e. serving, extruding or taping have been put in place, but also technologies to shape litz wire rectangulary for optimized filling factors.

Our 60+ years experience working with customers in developing insulated wire products has resulted in broad application knowledge in the field of transformers and power supplies, especially in the area of miniaturization and ultra fine wires. Today, this expertise is utilized extensively in cooperation with our customers in new product development of litz wire in components for consumer, medical, automotive, photovoltaic, smart textiles, power supply or aerospace uses.

ELEKTRISOLA´s reliability, especially in high risk or challenging applications, even beyond the Earth´s boundaries, is clearly demonstrated by selection of our ultra fine wire for implementation in the electrical drives of the “Rover” and “Beagle 2” used in space exploration. New fields evolving today such as e-mobility, wireless power, alternative power and renewable energy all utilize ELEKTRISOLA knowledge and process capabilities in magnet and litz wire to develop innovative products for the future.

Basics.
High Frequency Litz Wire

Litz Wire typically is used in applications operating within a frequency range of 10 kHz to 5 MHz. For products operating beyond this frequency range, special litz products may be supplied. Individually insulated single conductors make up the basic components of any litz construction whereby electrical current flows evenly distributed through each conductor cross section at higher frequencies.

Increasing frequencies cause the current to flow in the edge area or even along the surface of each conductor; this is known as the “skin effect”. At higher frequencies the skin effect phenomenon reduces the effective cross section of each conductor’s current carrying capability. Similar losses at higher frequencies are caused by the “proximity effect”, where the neighboring electrical field negatively affects the electromagnetic distribution against each other. Litz wire’s engineered twisted construction utilizing multiple individually insulated conductors can effectively minimize these high frequency losses when used in high frequency applications.

These aspects are already considered in the very first phase of litz wire design. The conversion of the sophisticated construction is achieved by utilizing optimal production parameters and a fine tuned litz wire production process, ensuring utmost quality and consistent performance in the customer products.

Frequency-dependent Skin Effect (Copper Conductor)

Frequency	δ
10 kHz	0.66 mm
50 kHz	0.30 mm
100 kHz	0.21 mm
500 kHz	0.094 mm = 94 µm
1 MHz	0.066 mm = 66 µm
10 MHz	0.021 mm = 21 µm
100 MHz	0.0066 mm = 6.6 µm

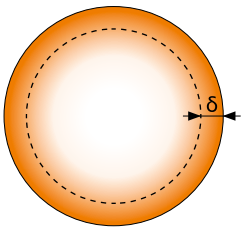
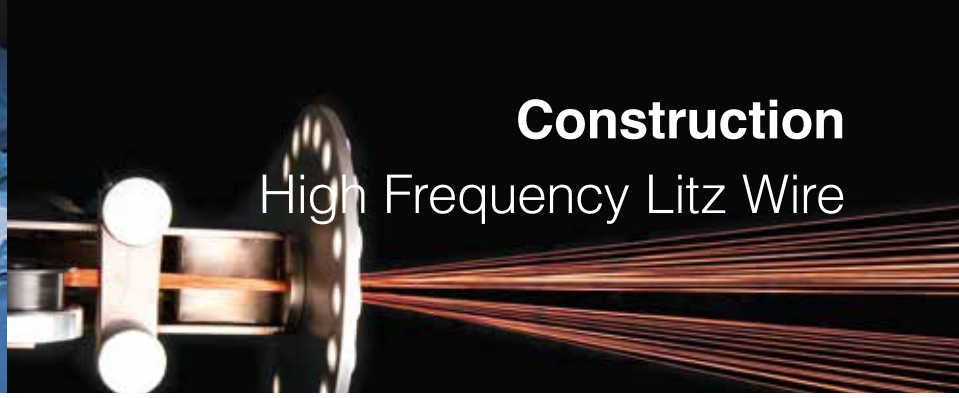


Fig. Skin-Effect



Construction
High Frequency Litz Wire

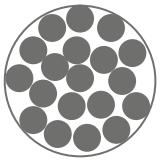
Litz Wire Construction

Directly Bunched Litz Wires

Any number of single wires are directly bunched so each individual wire is freely located. Larger litz constructions can be produced combining multiple sub-bundles of wires in additional bunching operations. Each bunched construction can be further differentiated through the length of lay (tightness of the twist), and pitch direction (twist direction).

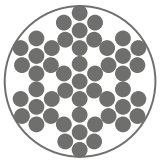
Concentrically Bunched Litz Wires

The individual wires are positioned in one or more layers concentrically around the litz wire center conductor. In this design configuration each single wire naturally moves into its predefined position during the twisting operation resulting in consistent dimensions and working properties.



Single Step Construction

Concentric Design



Multi-step Concentrical Design

S- Lay
(counter-clockwise)

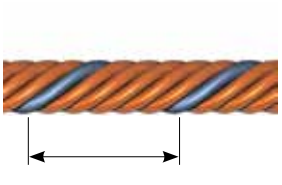
Z-Lay
(clockwise)

Pitch Direction

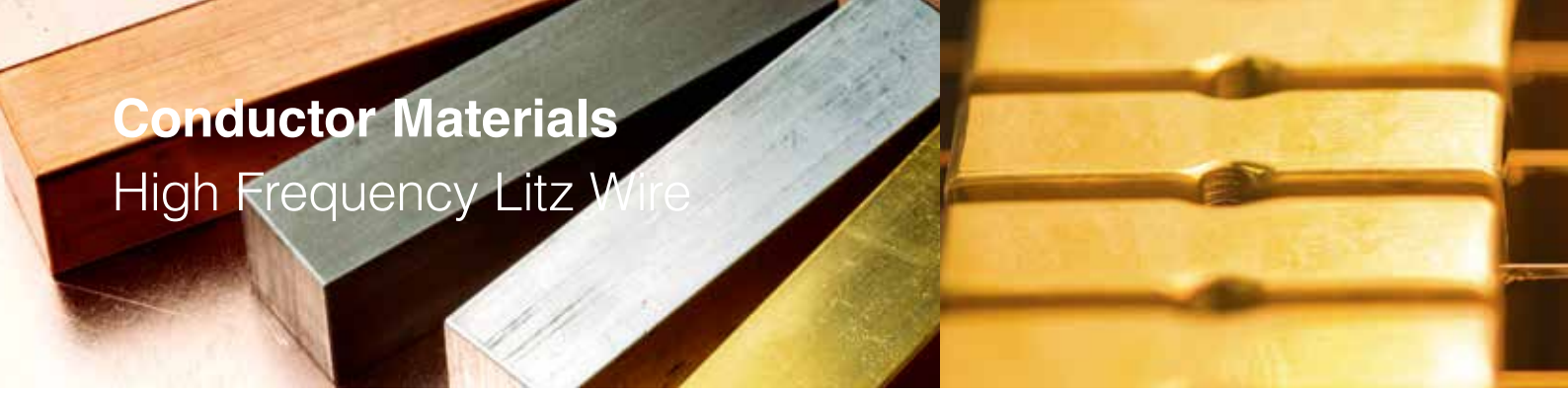
The pitch direction indicates the twist or bunching direction of the bundled wire construction. Z-lay is bunched in a clockwise direction while S-lay is the opposite, or counter-clockwise twist direction.

Length of Lay

The length of lay describes the distance which a single wire needs for one complete rotation around the litz wire circumference (360 degrees).



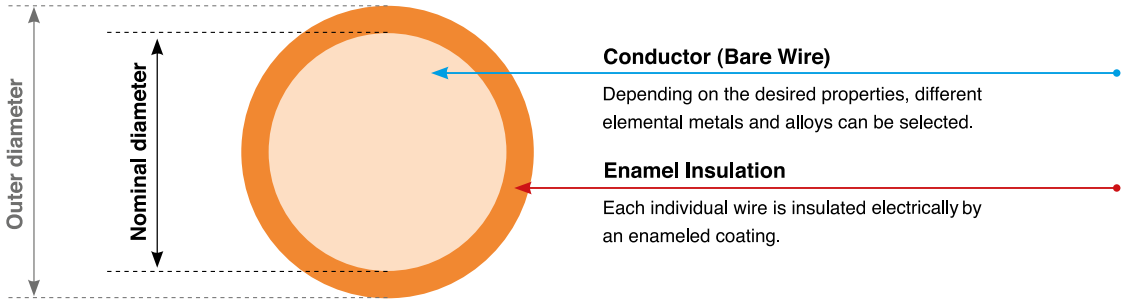
Length of Lay



Conductor Materials
High Frequency Litz Wire

The basic component of a litz wire is the single wire. Conductor material or alloy and enamel insulation can be combined optimally to meet the demands of specific applications.

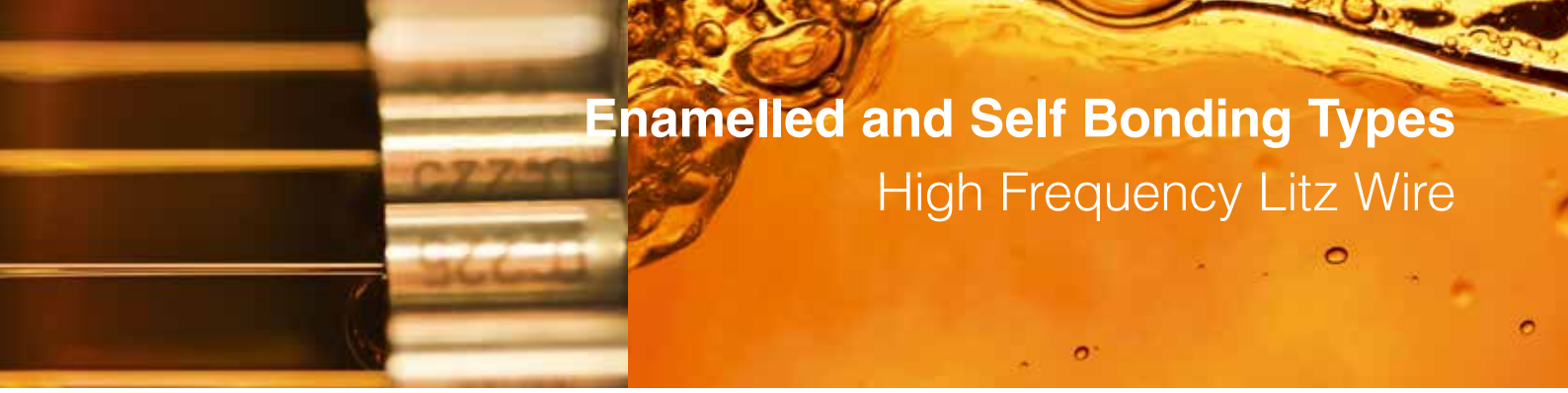
Construction Enamelled Copper Wire



Conductor Materials

Metal	Conductivity [Sm/mm²]	Spec. Resistance [Ω mm²/m]	Tensile Strength [N/mm²] Min.	Tensile Strength [N/mm²] Max.	Conductivity*	Tensile Strength*	Corrosion Protection*	Flex Life Test*
Metals:								
Copper (Cu)	58.5	0.0171	220	320	high	medium	low	medium
Aluminium (Al)	36	0.0278	120	140	medium	low	high	low
Alloys:								
Copper-Silver:								
AgCu1	57.5	0.0174	220	310	high	medium	high	medium
Copper-Nickel:								
CuNi2	20	0.0513	290	370	low	high	high	high
CuNi6	10	0.1000	310	380	low	high	high	high
CuNi10	6.7	0.1538	320	380	low	high	high	high
CuNi44	2	0.5000	520	680	low	high	high	high
Copper-Zinc (Brass)::								
CuZn30 (Ms70)	15	0.0667	470	540	low	high	high	high
High tension Wires:								
ITW	55	0.0182	290	370	high	high	high	low
HTW	54	0.0185	350	400	high	high	high	medium
XHTW	51	0.0196	380	450	high	high	high	high
Plated Wires:								
CCA10% (Cu/Al)	37.7	0.0265	130	180	medium	low	medium	medium
CCA15% (Cu/Al)	39.2	0.0255	170	230	medium	low	medium	medium
Silver plated copper (Cu/Ag)	58.5	0.0171	220	270	high	medium	medium	medium

*by tendency



Enamelled and Self Bonding Types
High Frequency Litz Wire

Insulation Types

Different insulation types can be specified for the individual wires depending upon the final product's thermal and chemical resistance requirements. Different insulation thickness tolerances (see below "Enamel Build") can be specified according to international standards or customer specification, depending upon the final product's dielectric demand expectation.

ELEKTRISOLA-Name ELEKTRISOLA-Code	Polysol 155 P155	Polysol 180 P180	Estersol 180 E180	Amidester 200 A200	Amidester 210 AI210	ML240
Standards						
IEC 60317	-20	-51	-23	-8	-13	-47
NEMA	MW 79	MW 82	MW 77	MW 74	MW 35, MW 37	MW 16, MW 20
UL-approval E331840	yes	yes	yes	yes	yes	
1. Temperature Range						
Temperature index 20.000 h acc. to IEC 172	158 °C	192 °C	195 °C	210 °C	212 °C	245 °C
Cut through temperature min °C acc. to IEC 851.6.4	≥ 200 °C	≥ 200 °C	≥ 265 °C	≥ 300 °C	≥ 320 °C	≥ 400 °C
Elektrisola typical values for 0.05 mm, Grade 1	225 °C	260 °C	315 °C	350 °C	365 °C	450 °C
2. Electrical values						
Breakdown voltage (V/µm) Elektrisola typical values to cylinder test 0.05 mm Grade 1	240	240	240	240	230	240
3. Solderability						
Acc. to IEC 60851.4.5	yes	yes	yes	–	–	–

Self-Bonding Types

If a design requires the individual wires to adhere to each other, a wire-to-wire bond can be accomplished through the use of self-bonding adhesives. An adhesive overcoat is applied to the surface of the basecoat enamel insulation during the production of the individual wires. Different adhesives can be specified depending upon the activation process used by the customer (heat or solvent activation) and/or the ultimate bond strength and re-softening temperature characteristics desired.

ELEKTRISOLA-Name ELEKTRISOLA-Code	Butybond AB15	Solabond FS15	Solabond FSP18	Solabond DSP15	Thermobond QT18	Thermobond VT22
General Description:						
Base Coat	P155	P155	P180	P155p	E180	I220
Bond Coat (Group Label)	PVB	PA	PA	PA	PA	mod. PES
Standards						
IEC 60317	**-37**	**-37**	–	**-37**	**-36**	–
NEMA	MW 131-C	MW 131-C	–	MW 131-C	–	–
1. Electrical values						
Breakdown voltage (V/µm) Elektrisola typical values to cylinder test 0.05 mm, Grade 1	160	160	160	160	160	160
2. Bonding of wire						
Recommended bonding temperature	120–140 °C	150–170 °C	150–170 °C	150–170 °C	200–220 °C	260–280 °C

Enamel Build

IEC: Grad 1, Grad 2, Grad 3
NEMA: Single, Heavy, Triple Build,
JIS: Class 3, Class 2, Class 1, Class 0

More information and properties can be found in our brochures "Enamelled Wire" and "Self-Bonding Wire Tapes"

High Frequency Litz Wire

High frequency litz wire is either used for frequency or heating-related applications. Ultra fine litz wires provide solutions for both technologies regardless of frequency or impedance range. Electrical, mechanical and cost aspects need to be considered carefully during the design phase.

Benefits of Litz Wire for high frequency applications

- Cost-effective design
- Resistance or frequency-related construction
- Increased tensile strength by using additional strain relief

Benefits of Litz Wire for heating applications

- Precise resistance-related manufacturing
- Very broad field of application (drying, heating, warming up)
- Resilient base materials

Properties of Litz Wires

	For high frequency applications	For heating applications
Conductivity	high	medium
Resistance	medium	high
Tensile strength	low - medium	high
Looping behavior	low	high
Splicing	medium	high
Bending cycle behavior	high	high

Applications

- RF transformers
- Chokes
- Medical application
- Sensors
- Ballasts
- Switching power supplies
- Resistance wires for heating applications

Typical length of lay

Single stage: 2-26 mm
Multi-stage: 20-60 mm

Selection criteria for lengths of lay:

- Larger length of lay enables lower cost
- Smaller length of lay increases the physical stiffness
- Smaller length of lay reduces the splicing behaviour and supports the round shape

Construction of high frequency applications

The construction of a litz wire product depends upon the number of individual wire strands and the diameter of each wire. In general, our process can bunch a maximum of 60 individual wire strands in one operation. Litz wire constructions requiring more than 60 strands must be produced in multiple operations using sub-bundles twisted together. Example: Litz wire of 600 strands of 0.10 mm conductor could be construed using 24 x 5 x 5 x 0.10 mm.

Dimensions

Content		
Diameter of single wires	0.010–0.50	mm
Number of single wires	2–25,000	pcs
Outer diameter of litz wires	0.095–10.0	mm

Typical connection technologies are soldering, thermocompression welding, ultrasound welding, resistance welding and flame brazing.

Serving
High Frequency Litz Wire

High frequency litz wire served with natural silk or nylon is characterized by an increase in mechanical performance and excellent dimensional stability.

The precise serving quality guarantees a high degree of flexibility and prevents splicing during the process of cutting the litz wire and therefore allows for optimal contacting.

Features and Benefits

- Additional protection against mechanical stress
- Excellent dimensional and physical stability
- High flexibility
- Resistance to prevent splicing
- High thermal resistance
- Good solderable above temperatures of 375 °C
- Compliance with air gap distances
- Improved immersion
- UL 331840

Applications

- Inverters
- RF transformers
- RF transceivers
- RF chokes

Dimensions

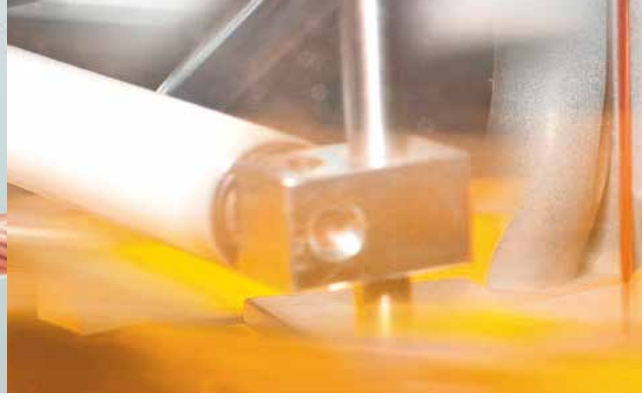
Content	Silk	Nylon	
Diameter of single wires[1]	0.020–0.30	0.020–0.30	mm
Number of single wires[2]	2–23,000	2–23,000	pcs
Outer diameter of litz wires	0.071–4.0	0.071–10.0	mm
Number of layers	2	2	
Serving Materials*			
Colour	white, green	white	
Thermal properties			
Recommended permanent use temperature	110	120	°C
Resoftening temperature	–	220–240	°C
Electrical properties			
Dielectric constant	1.4	3.4	ε_r
Mechanical properties			
Elongation at break (dry)	13–25	25–46	%
Moisture absorption (65% rel. humidity, 21°C)	9	4–4.5	%

[1] other diameters on demand

[2] depending on the number of single wires

*customized solution on demand (thermo adhesive yarns)

Taping
High Frequency Litz Wire



Taped high frequency litz wire constructions are mainly suitable for applications requiring a high break down voltage. Taping gives litz wire improved capability to withstand flexing and mechanical stress.

Self-adhesive tape material increases protection against re-opening during and after manufacturing processes and thus secures the compliance with defined creepage distances.

Some tapes can be thermally sealed, when used in conjunction with certain enameled types. On the individual wires excellent adhesion and bonding characteristics can be achieved. Thermally sealed tapes can be selected from a number of material types for special applications all promoting various degrees of flexibility and mechanical protection for the litz wire construction.

Features and Benefits of Tapes

Variants	Dielectric strength	Flexibility	Splicing	Contacting
Standard	high	very good	good	very good
Thermally Sealed	elevated	medium	very good	very good
Self-Adhesive	very high	good	very good	good

Applications

- Inverters
- RF transformers
- RF transducers
- RF chokes
- Inductive charging

Dimensions

Content		
Diameter of single wires	0.040–0.500	mm
Outer diameter of litz wires	0.50–10.0	mm
Overlapping single tape	50 or 67	%
Numbers of tapes (max.)	2	

Taping
High Frequency Litz Wire

Technical Data Sheet of Tapes

		PET	PEN	PI
Description		Polyester	Polyethylene Naphthalat	Polyimide
Colour		transparent	transparent	brown
Standard				
Breakdown voltage	kV	5.0 (VDE 0345)	>5.0 (JIS C 2318)	5.0 (ASTM D 149)
Insulation class (UL)	°C	105 (A)	180 (H)	200 (C)
Insulation class (VDE)	°C	130 (B)	–	200 (C)
Dielectric constant	ε_r	3.3 (VDE 0345)	2.9 (JIS C 2318)	3.4 (ASTM D 150-92)
Flammability	°C	400 (VDE 0345)	VT-M (UL 94)	V-0 (IEC 60695-11-10; UL 94)
UL- File No. Tapes*		E53895	E206562	E39505
Processing		fusible	fusible	mechanical stripping
Thermally Sealed				
Breakdown voltage	kV	5.4 (ASTM D 149-81)	–	5.0 (ASTM D 149)
Insulation class (UL)	°C	105 (A)	–	200 (C)
Insulation class (VDE)	°C	130 (B)	–	200 (C)
Dielectric constant	ε_r	3.26 (ASTM D 150-81)	–	3.4 (ASTM D 150-92)
Flammability		n.a.	–	V-0 (IEC 60695-11-10; UL 94)
UL- File No. Tapes*		E93687	–	E39505
Processing		fusible	–	mechanical stripping
Self-Adhesive				
Breakdown voltage[1]	kV	5.0	5.0	5.0
Insulation class (UL)	°C	130 (B)	180 (H)	180 (H)
Dielectric constant	ε_r	3.2 (JIS C 2318)	2.9 (JIS C 2318)	3.3 (JIS C 2318)
Flammability		–	flame retardant (UL 501)	flame retardant (UL 501)
UL- File No. Tapes*		E178430	E206562	E178430
Processing		fusible	fusible	mechanical stripping

[1] approximate value

* the used foils are variants of UL recognized products

Litz Wire with self adhesive PEN tape 1 x 67 for different diameters:

VDE– test according to specification

DIN EN 60950, annex U

DIN EN 61558, annex K

DIN EN 60601, annex L

Other materials on demand

Extrusion

High Frequency Litz Wires

Extruded coatings applied to high frequency litz wires promote increased flexibility, mechanical robustness, resistance-to chemical substances, as well as increased break down voltage. The flex life performance of extruded litz wire is also improved considerably in comparison to standard constructions. Extrusion materials, wall thickness tolerance and litz wire construction details can be selected and combined for optimal performance in a wide range of applications.

Features and Benefits

- High resistance to mechanical stress
- Excellent flexibility
- Good resistance against oils and grease
- Increased dielectric strength
- Solderable above 400 ° C

Applications

- Resistance wires for heating applications
- Smart Textiles
- Patient Comfort

Dimensions

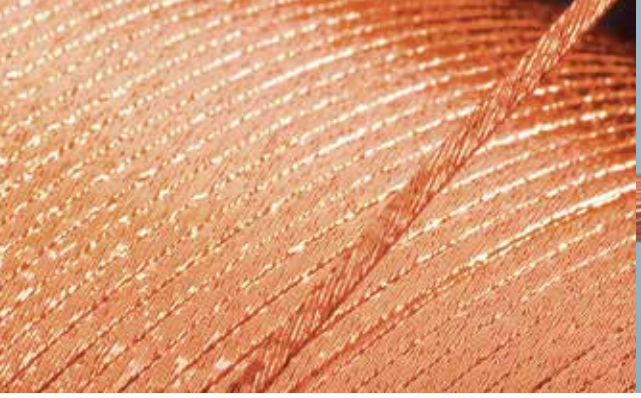
Content		
Diameter of single wires	0.032–0.50	mm
Outer diameter of litz wires	0.5–5.2	mm

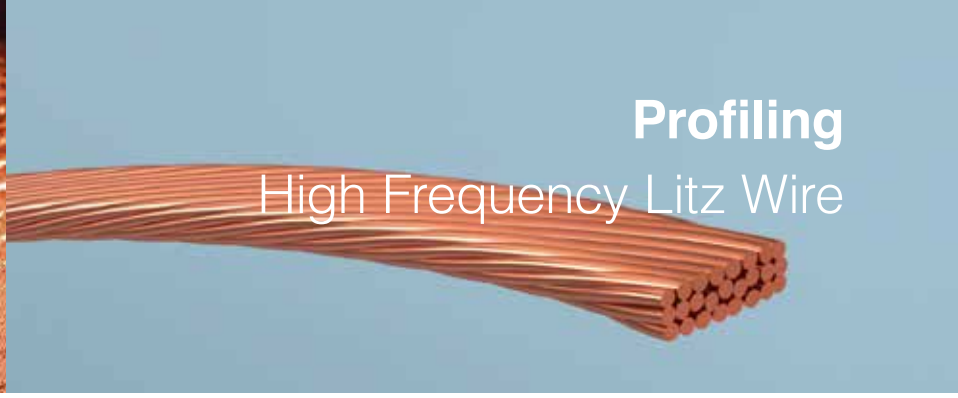
Extrusion Materials

Characteristics	PA-F mod. Polyamide	PA-M mod. Polyamide	PA-T mod. Polyamide	PB-A Polyether Block Amide	PB-B Polyether Block Amide	TPE-E Polyester-Elastomer	TPE-F Polyester-Elastomer, flame retardant	TPE-S Polyester-Elastomer
Melting temperature °C	170–180	175–185	170–180	155–165	165–175	205–230	205–230	125
Max. usage temperature °C	90	90	115	100	120	140	140	90
Min. break down voltage kV *	4	3	3	3	3	3.5	3	3
Colour	transparent	transparent	transparent	transparent	transparent	transparent	white	white

* at wall thickness of 0.2 mm

Other materials on demand





Profiling
High Frequency Litz Wire

Profiled (mechanically shaped) litz wires allow optimal utilization of available winding area due to the superior filling factor of rectangular or square litz wire cross sections. In comparison to a standard round cross section construction, profiled litz wire can increase the filling factor by up to 20%. The design advantages of profiled litz wire can only be fully realized using products with consistent, precise dimensions. This dimensional stability is only possible with exact control over each process step.

Features and Benefits

- Consistent winding and layering performance
- Good memory behavior
- Simplified and economical production of coils without spools
- Profiled dimensions to customer specification
- Increased filling factor of up to 20%
- Dimensionally stable
- Profiling also possible without any additional coatings

Applications

- Induction hobs
- RF transformers
- RF transducers
- E-Motors

Dimensions

Content		
Smallest sizes (width x height)	1.2 x 1.2	mm
Ratio (width : height)	1 : 1.7	mm
Tolerance (±)	0.1	mm
Diameter of single wires	0.020–0.50	mm

Increased filling factor by profiling

Profiling Materials

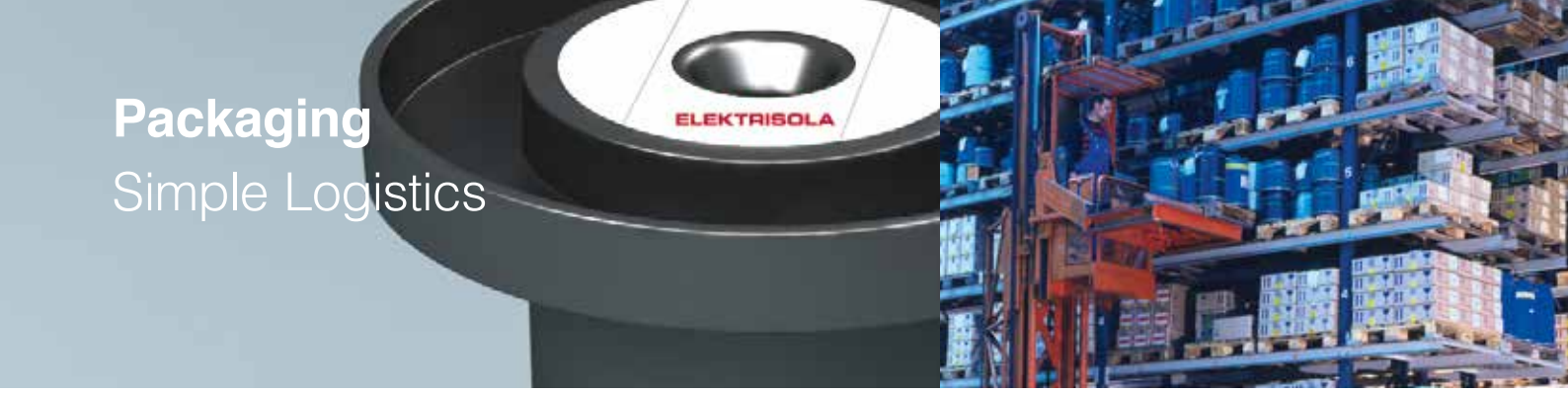
Yarn

Nylon (63)

Tape

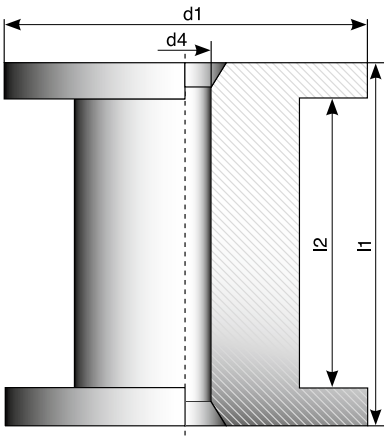
Polyester (PET)
Polyethylene Naphthalat (PEN)
Polyimide (PI)

Other dimensions and materials on demand



Packaging
Simple Logistics

A wide variety of spools and packaging materials designed specifically for each spool type is available. The selection of spools is made in close cooperation with the customer taking into account the customer's production process and the availability of spool types.



Dimension of the spool:

d1 → Flange diameter
d4 → Barrel diameter

l1 → Overall width
l2 → Traverse

Spool Type	d1 [mm]	d4 [mm]	l1 [mm]	l2 [mm]	Spool weight [g]	Filling weight* [kg]	Filling weight [kg] served & taped litz wire*	Filling weight [kg] extruded litz wire*	Spool per box	Units per pallet
125K	125	16	125	100	200	2.0	1.3	–	4/6/9	max. 216
160K	160	22	160	128	350	4.8	3.2	2.0	4	max. 96
200K	200	22	200	160	600	8.9	5.9	3.9	2	max. 42
250K	250	22	200	160	1050	16.6	11.0	7.3	1	max. 36
355K	355	36	200	160	1850	32.4	–	–	–	palett max. 12
VMV630	630	56	475	361	18500	214.0	178.0	–	–	palett max. 1
VM 710	710	52	250	180	18000	–	81.0 (taped)	–	–	palett max. 4
400/56-275	400	56	275	241	4590	81.0	67.5 (taped)	–	–	palett max. 4

*approximate values

Customer Support
High Frequency Litz Wire

Our labs are equipped with many proprietary test and analytical capabilities developed exclusively for testing of litz and magnet wire products. We offer our customers the following support services:

- Expert analysis of insulation enamels, magnet wires and litz wires
- Diagnostic tests according to IEC 60851 and other recognized international standards, for example:
  - Mechanical tests according to 60851-3: elongation, flexibility and adherence, abrasion
  - Electrical tests according to 60851-5: breakdown voltage, electrical resistance, dielectric dissipation factor
  - Thermal tests according to 60851-6: heat shock test, cut through test
- Chemical analysis and material compatibility
- Mechanical stress test (tensile strength, flex life)
- Insulation evaluation (dielectric, thermal, surface condition) for enameled conductors
- Process and application support for litz wire

State of the art in-house developed tooling in combination with sophisticated quality systems and monitoring ensures utmost product quality and thus allow for meaningful quality certificates.

All ELEKTRISOLA plants are certified according to ISO 9001 and TS 16949.

Wired to the Environment

ELEKTRISOLA is family owned and actively managed by the second generation following closely the original philosophy of mutual respect for customers and the environment. The ELEKTRISOLA headquarter in Eckenhagen, Germany is located in the natural landscape of the “Oberbergischer Kreis”. A similar rural environment was selected for all its locations worldwide not only for access to clean air and water, but also recognizing that the workers who live in these areas already possess a sense of responsibility to protect and manage these natural resources. As a result of this original ownership commitment, ELEKTRISOLA was an early advocate and innovator in environmentally responsible packaging, recycling and elimination of waste which continues today on all levels. It is only natural that ELEKTRISOLA today is at the forefront of developing new technologies in sustainable energy and wireless technology to make life better for everyone and the environment.

Consequently our largest manufacturing plants in Malaysia and China are certified according to ISO 14001.

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