

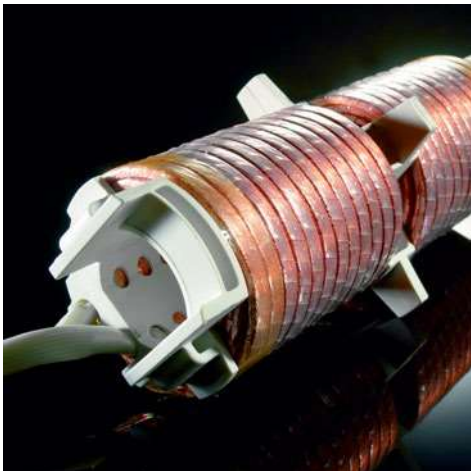
# Litz Wires for Electronic, Motor and Windgenerator Applications

High-Frequency litz wires consist of bunched, solderable, enamelled Soldex® wires. The enamel insulation is based on modified polyurethane. The bunched strands can be covered with one or two layers of natural silk or polyamide yarn.

High-frequency litz wires are directly solderable with the lapping and enamel still in place. Individual solderable Soldex wires in temperature classes 155 or 180 and enamel application classes Grade 0, Grade 1 and Grade 2 are used in our standard high-frequency litz wires, depending on customer requirements. The standard filaments used for the covering are either natural silk or polyamide (Nylon) yarns, but high-frequency litz wires can also be taped with polyester films.

All litz wires are also available without additional insulation.

## Applications



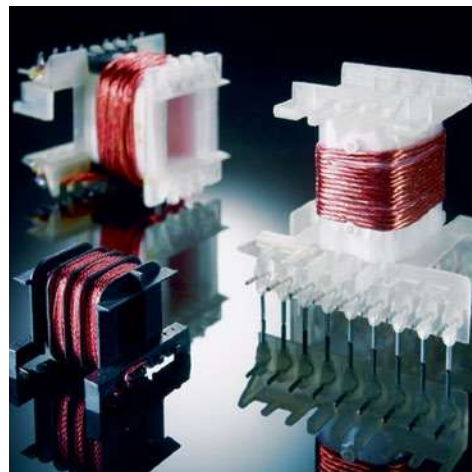
Primary coil high-frequency transformer



32 kW transformer for switched power supply  
© Vacuumschmelze GmbH



Toroid coil © Schaffner EMV



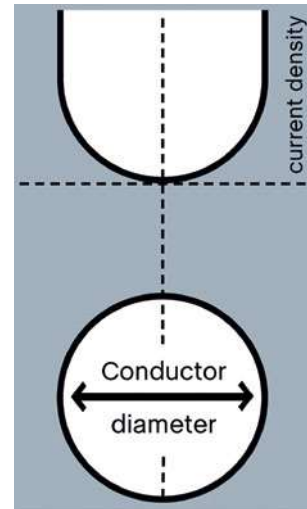
High-frequency transformers

## Why High-Frequency Litz Wires?

High-frequency litz wires consist of bunched enamelled strands. They are used to counteract the increase in conductor resistance (impedance) at higher frequencies. The fields of an alternating current cause eddy currents in an electrical conductor, and these work against the flow of current. The effect of these eddy currents increases at higher frequencies. Accordingly, a frequency-dependent AC resistance is added to the DC resistance. The eddy losses are at their greatest inside the conductor and fall off toward the outside.

The greatest part of the current therefore flows at the surface of the conductor (what is known as the skin effect). It is also called the skin depth of the current. In the case of the proximity effect, the eddy losses are caused by the fields of adjacent conductors. In order to minimize these losses, the cross-sectional area of the single conductor is reduced (lower eddy losses), and several conductors are run "in parallel." To balance out the effects of the fields on the individual conductors, the conductors are twisted together. The twist must be chosen so that, from the viewpoint of the length of the litz wire, the position of one wire alternates regularly between the core and the outside of the package. High-frequency litz wires should be used only up to approximately 2MHz, because the capacitance effect of the conductor becomes too great at higher frequencies. Approximate diameters of individual strands as a function of frequency are listed below:

Frequency	Individual strand diameter
50 Hz – 1 kHz	0.400 mm
1 kHz – 10 kHz	0.250 mm
10 kHz – 20 kHz	0.200 mm
20 kHz – 50 kHz	0.125 mm
50 kHz – 100 kHz	0.100 mm
100 kHz – 250 kHz	0.071 mm
250 kHz – 500 kHz	0.063 mm
500 kHz – 850 kHz	0.050 mm
850 kHz – 1.5 MHz	0.040 mm
1.5 MHz – 2.8 MHz	0.032 mm



Transrapid train © Thyssen Krupp



Electric cars



Induction hot plate

# Standard High-Frequency Litz Wires

Von Roll standard high-frequency litz wires comply with IEC 60317-11 and DIN 46447 standards.

However, our product range includes a much wider range of constructions.

Dimensions	
Single-wire diameter	0.03mm to 0.50mm
Number of strands	from 2 to several thousand

## Pitch (length of lay)

Pitch is a major factor in the construction of an high-frequency litz wire. It determines the flexibility, form stability, electrical resistance and winding characteristics of the litz wire.

A **short pitch** produces a litz wire with good form stability, fairly high resistance and a rounder profile.

A **long pitch** produces a more flexible and more economical litz wire.

Our standard pitches are:

Litz wires without covering	
≤ 1.50mm external Ø	approx. 10 to 25mm
> 1.50mm outer Ø	approx. 12 to 16 x outer Ø
Covered litz wires with braiding	
≤ 1.50mm external Ø	approx. 20 to 45mm
> 1.50mm outer Ø	approx. 16 to 26 x outer Ø

## Additional Insulation

Lapping/taping	Increase due to insulation		Characteristics
	1 layer	2 layers	
Without additional insulation			<ul style="list-style-type: none"> <li>» high copper fill factor</li> <li>» directly solderable without prior removal of the insulation</li> </ul>
Natural silk	30–40 µm	60–80 µm	<ul style="list-style-type: none"> <li>» thermal stability up to 110°C</li> <li>» directly solderable without prior removal of the insulation</li> <li>» small increase of insulation</li> <li>» suitable for honeycombed coils</li> </ul>
Polyamide yarn	40–50 µm	80–100 µm	<ul style="list-style-type: none"> <li>» thermal stability up to 130°C</li> <li>» no decomposition, only a buildup of molten pearls</li> <li>» heat-treated, therefore no unravelling when cut to length</li> </ul>
Polyester tape Thickness 12 to 23 µm	Depending on tape thickness and type of foil		<ul style="list-style-type: none"> <li>» high dielectric strength</li> </ul>

## Special Designs

We can supply a wide range of litz wire structures to suit customers' special applications. Depending on the application, bunching, stranding, pitch and twisting direction can be chosen individually.

### Round Litz Wires

Dimensions	
Single wire Ø	0.03 mm up to 1.00 mm
Number of strands	from 2 to several thousand
External Ø	up to 20 mm

### Selection of Single Wire

Bare or enamelled to Grade 0, Grade 1 or Grade 2

Type of enamel	Chemistry	Temperature class	Characteristics
Soldex®	PU	155, 180	solderable at approx. 375°C
Thermex® S180	PEI, modified	180	tinnable enamel at approx. 470°C / resistant to transformer oil
Thermex® 200	PEI + PAI	200	good thermal stability
Thermibond® 158	PEI + PAI + thermosetting adhesive	200	self-bonding
Thermofix	PU + thermoplastic adhesive	130, 155	solderable, self-bonding

### Additional Types of Insulations

- » One or more layers of lapping/braiding made of a range of yarns, e.g. polyamide, cotton, glass, polyester, aramide etc.
- » One or more layers made of polyester PET or PEN film, polyimide tape, aramide paper, glass tape or mica tapes Samica® with up to 75% overlap.
- » Insulation consisting of adhesive-coated films such as polyester tape and polyimide which are heat-treated to obtain a good bonding. Various combinations are possible.
- » Extruded litz wires (PUR, PVC, PE/XLPE, HFFR, silicone).



High-frequency litz wire



Various types of litz wire

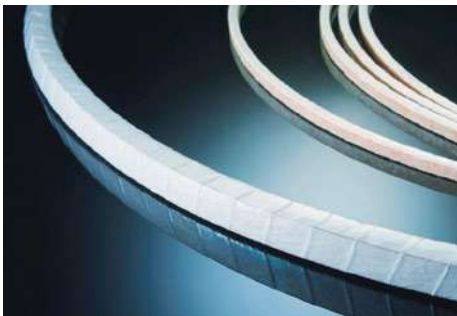
## Rectangular Litz Wires

To optimize the fill factor, it is preferable to use litz wires with a rectangular profile.

The filling factor is increased by:

- » compressing the litz wire
- » better filling of the winding space thanks to the rectangular geometry

Dimensions	
Single-wire diameter	from $\varnothing$ 0.10mm to 1.00mm
Standard diameters enamelled single wire	0.10, 0.20, 0.40, 0.50, 1.00mm
Standard diameters bare or SST single wire	0.30, 0.50, 1.00mm
Total copper cross-section	1.0 to 500mm <sup>2</sup>
Section ratio	1.25 : 1 to 4 : 1
Cross-section of the rectangular litz wire	approx. 160% of the copper cross-section for HF-litz wires approx. 130% of the copper cross-section for bare and SST litz wires



Rectangular litz wire taped with aramide paper



Rectangular litz wire without tape insulation

## Selection of Single Wire

Bare, special surface treated (SST) or enamelled to Grade 0, Grade 1 or Grade 2

Type of enamel	Chemistry	Temperature class	Characteristics
Thermex® S180	PEI, modified	180	tinnable enamel at approx. 470°C / resistant to transformer oil
Thermex® 200	PEI + PAI	200	good thermal stability
Thermibond® 158	PEI + PAI + thermosetting adhesive	200	self-bonding

## Additional Types of Insulations

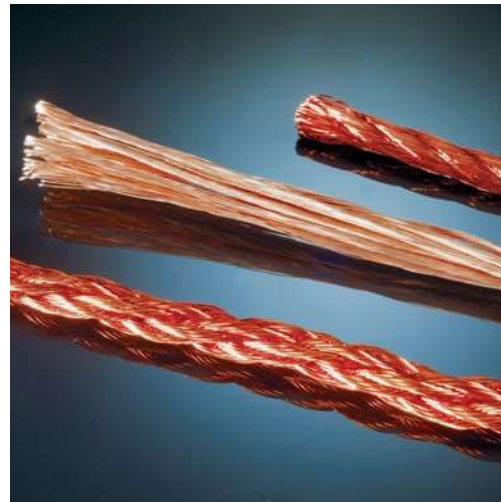
- » One or more layers made of polyester PET or PEN film, polyimide tape, aramide paper, glass tape or mica tapes Samica® with up to 75% overlap.
- » Insulation consisting of adhesive-coated films such as polyester tape and polyimide which are heat-treated to obtain a good bonding. Various combinations are possible.

## Overview of bare, SST and enamelled litz wires

Bare litz wires	SST litz wires	Enamelled litz wires
High Flexibility - especially for rectangular litz wire	High Flexibility - especially for rectangular litz wires and for high frequency applications	For high frequency applications
Flat rolled litz wires: Filling factor 76 to 80 %	Flat rolled litz wires: Filling factor 76 to 80 %	Flat rolled litz wires: Filling factor 66 to 78% (depending on cross-section and insulation increase of the enamel, e.g. Grade 2, Grade 1, Grade 0)
	Avoid losses caused by skin effect, proximity effect at lower frequencies (< 1 kHz)	Avoid losses caused by skin effect, proximity effect at high frequencies (> 1 kHz)
Easy connection	Easy connection	
Cheaper design		
Typical application examples		
Transformers	Low voltage, high voltage rotating machines	High frequency transformers
Converters	Wind turbine generators	Railway transformers
Uninterruptible power supplies		Switched power supply
Filters, chokes		Induction heating, induction hot plates
		Low voltage, high voltage rotating machines
		Contactless power transmission



High-frequency litz wire



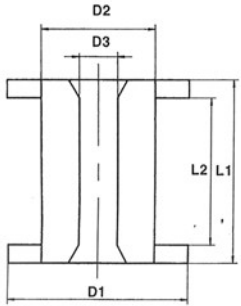
Various types of litz wire

### The Advantage to You

- » Leading manufacturer of electrical insulation systems
- » Wide range of machines for lapping, braiding and taping of litz wires
- » A large range of yarns (polyamide, polyester, natural silk, glass) and tapes (polyester PET, polyester PEN, polyimide, aramide paper, Samica®)
- » Worldwide service through our own sales offices and agents
- » Competent, customer-focused partners

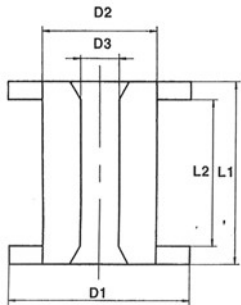
# Packaging of Litz and Winding Wires

Cylindrical reels acc. to IEC 60264-2, DIN 46399



Type	D1	D2	D3	D4	D5	L1	L2	Wire capacity	
								Round	Rectangular
160	160	100	22	–	–	160	128	6kg	–
200	200	125	22	–	–	200	160	12kg	–
250	250	160	22	–	–	200	160	20kg	–
355	355	224	36	–	–	200	160	40kg	45kg
500	500	315	36	–	–	250	180	80kg	100kg

Cylindrical reels acc. to DIN 46395 and others

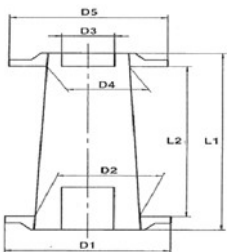


Type	D1	D2	D3	D4	D5	L1	L2	Wire capacity	
								Round (covered)	Rectangular
D710	710	500	41/51	–	–	250	180	180kg	200kg
VM 630	630	315	40	–	–	230	180	–	150kg
VM 800	800	380	42	–	–	270	195	–	350kg
E5*	500	250	127	–	–	250	200	–	120kg
T500**	500	360	40	–	–	235	200	–	80kg

\*one-way plastic reel

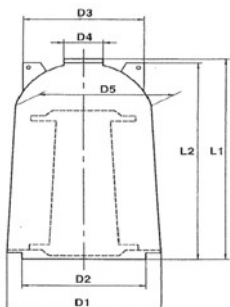
\*\* one-way wooden reel

Conical reels acc. to IEC 60263-3, DIN 46383



Type	D1	D2	D3	D4	D5	L1	L2	Wire capacity
								Round
250/400	250	160	100	140	236	400	335	45kg
315/500	315	200	100	180	300	500	425	90kg
400/630	400	250	100	224	375	630	530	180kg

Covers for conical reels



Type	D1	D2	D3	D4	D5	L1	L2
250/400	310	255	250	100	270	475	470
315/500	388	315	305	100	338	607	595
400/630	490	400	390	100	428	763	748