Operational characteristics in thermal elements of low voltage automated fuses due to supraharmonics

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The research content

Supraharmonics ????

What is this….?

2kHz – 150kHz

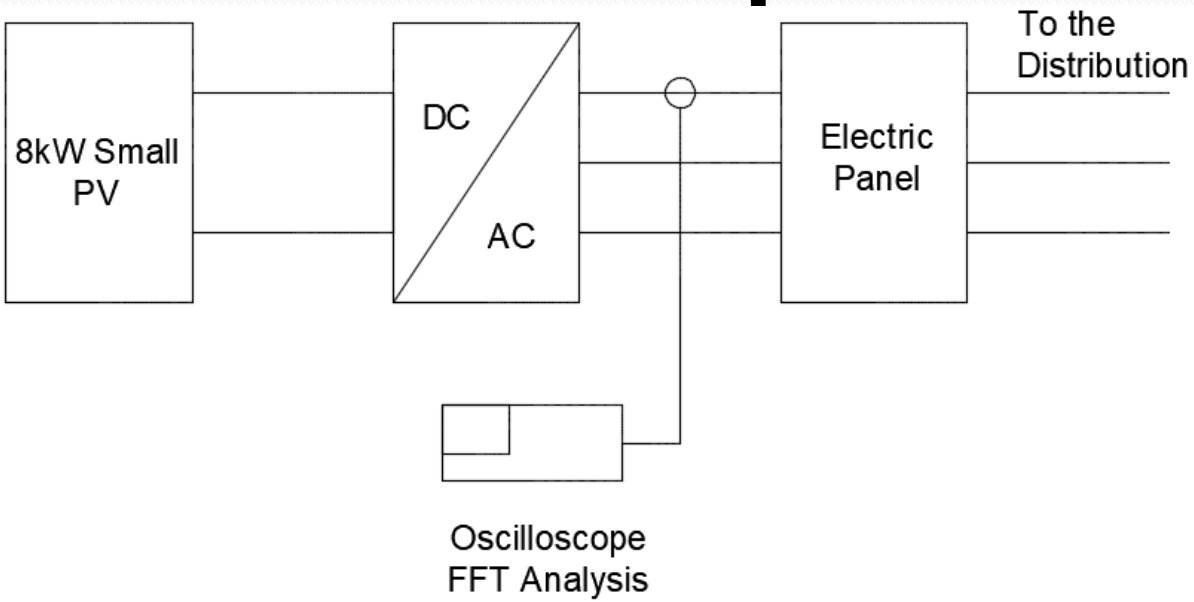
Supraharmonics

Distributed generation, is electrical generation and storage performed by a variety of small, grid-connected or distribution system connected devices.

Examples of sources generating supraharmonics:

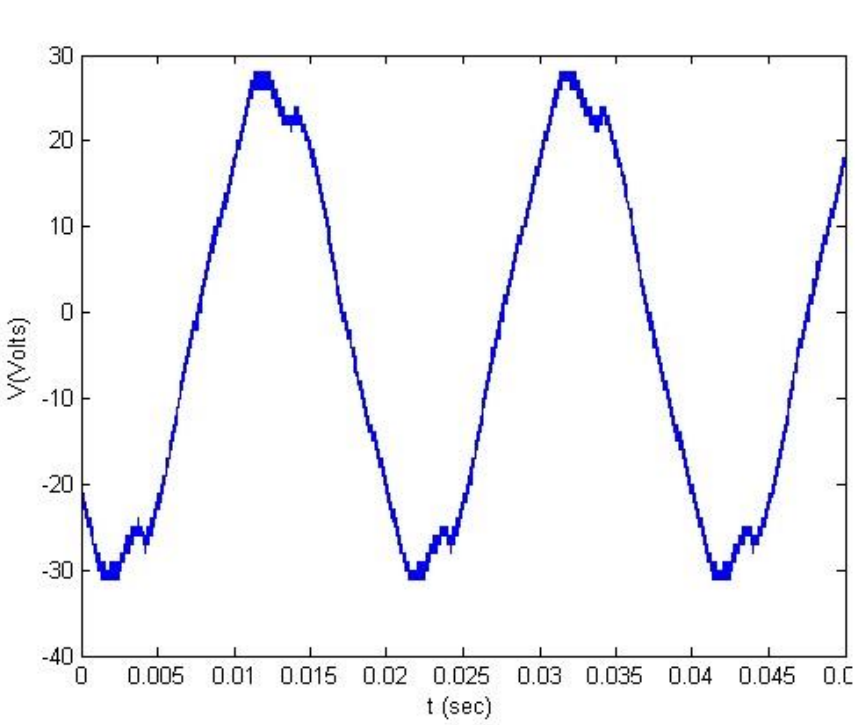
- **Industrial size converters (9 to 150 kHz)**
- **Oscillations around commutation notches (up to 10 kHz)**
- **Street lamps (up to 20 kHz)**
- **EV chargers (15 kHz to 100 kHz) • PV inverters (4 kHz to 20 kHz)**
- **Household devices (2 to 150 kHz)**
- **Power line communication, AMR (9 to 95 kHz)**

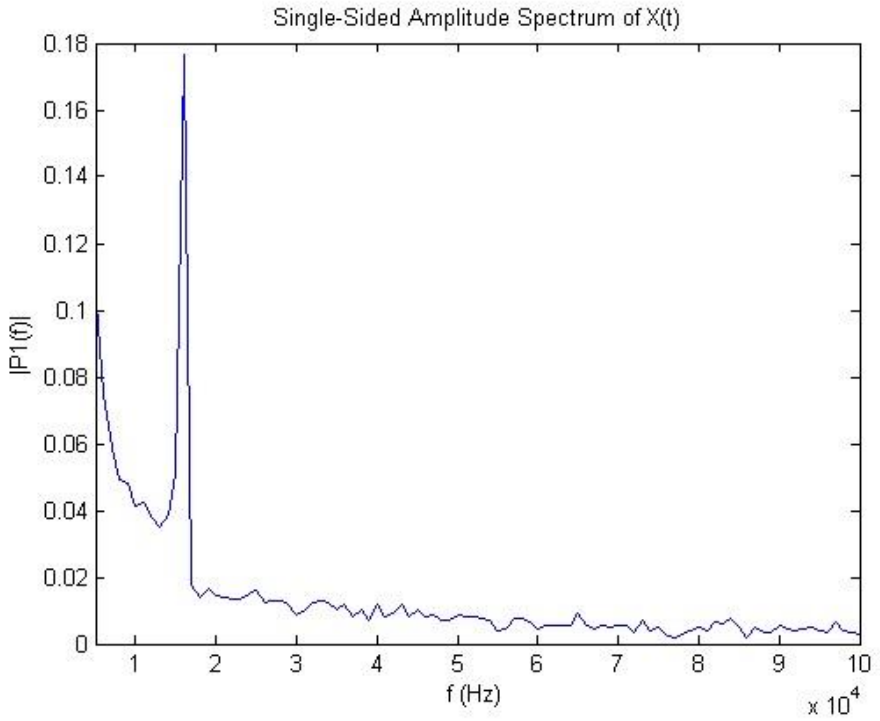
The Existence of Supraharmonics



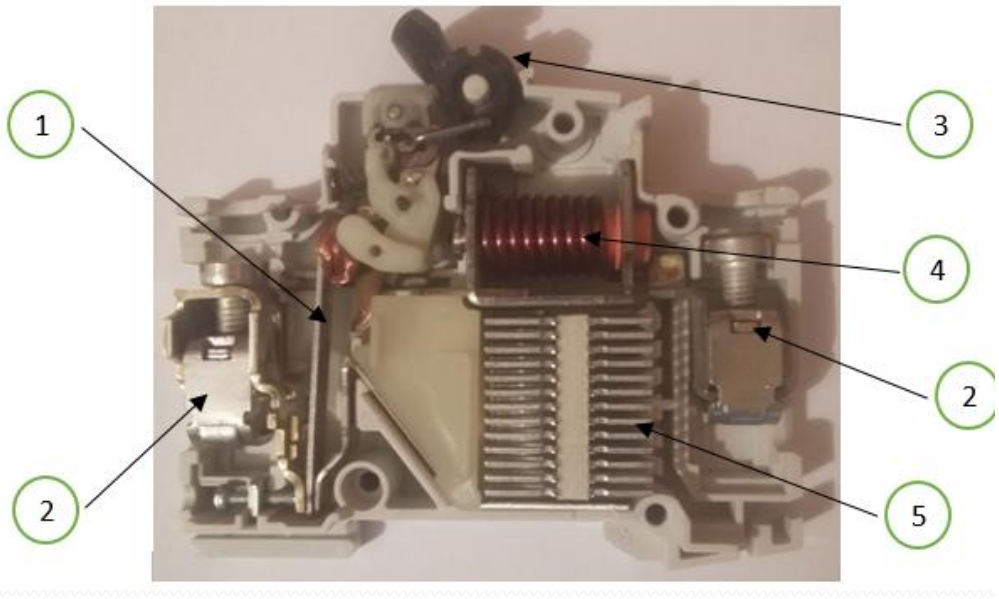
Description	Harmonic Current % = I_n/I_1						
Hz(Order)	150(3rd)	250(5th)	350(7th)	450(9th)	550(11th)	650(13th)	~16kHz(320)
L1	0.10	0.47	0.76	0.02	0.08	0.36	
L2	0.14	0.62	0.66	0.06	0.11	0.34	
L3	0.16	0.47	0.74	0.03	0.07	0.35	
Mean Value	0.13	0.52	0.71	0.04	0.09	0.35	0.54

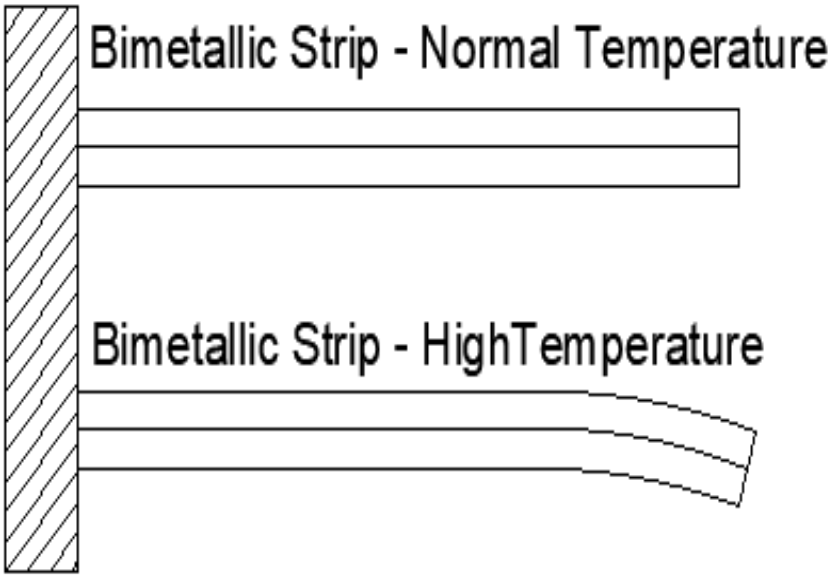
Measurement of Supraharmonics





Construction of An MCB





1. Bimetallic Strip, **2**. Contact Terminal, **3**. Operating Handle, **4**. Coil Assembly, **5**. Arc Chamber

The Equations 1/2

$$R_{hf} = K_c \, [\rho \cdot l/(2 \cdot (w+t) \cdot \delta)]$$

$\rho \sim$ Temperature

$$\delta = [\rho/(\pi \cdot f \cdot \mu)]^{0.5}$$

The Equations 2/2

$$K_c = 1 + F(f)\cdot[0.06 + 0.22\cdot\ln(w/t) + 0.28\cdot(t/w)^2]$$

$$F(f) = (1 - e^{-0.048\cdot p})$$

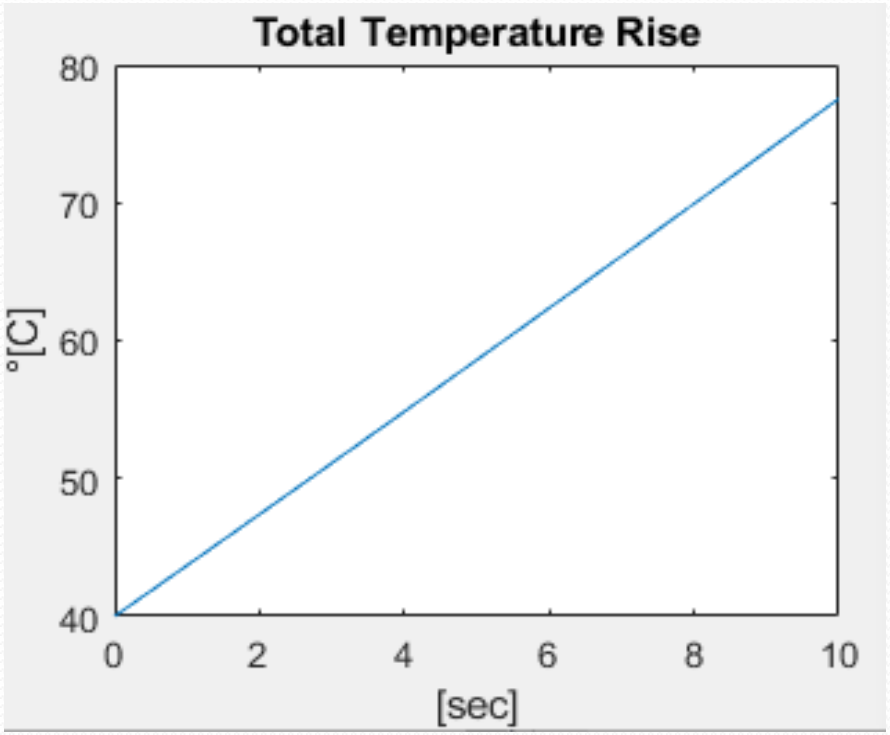
$$p = A^{0.5}/\ (1.26\cdot\ \delta)$$

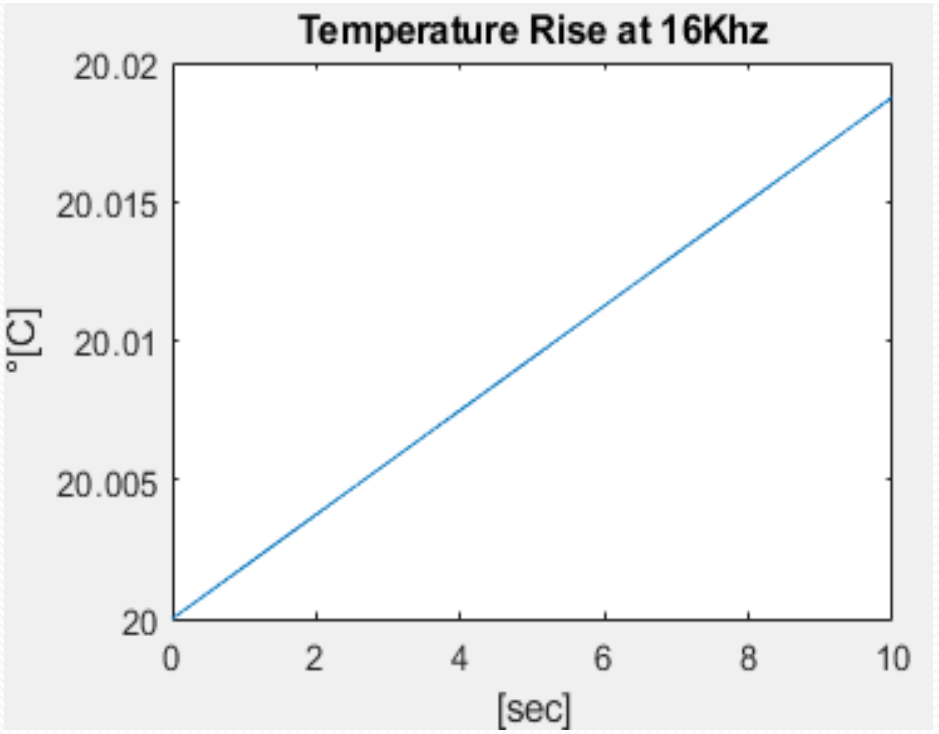
$$\Delta T = I^2_{rms}\cdot R\cdot\Delta t/[c\cdot m]$$

$$m = d\cdot l\cdot w\cdot t$$

$$\Delta T_{tot} = \Delta T_{50} + \Delta T_{16k}$$

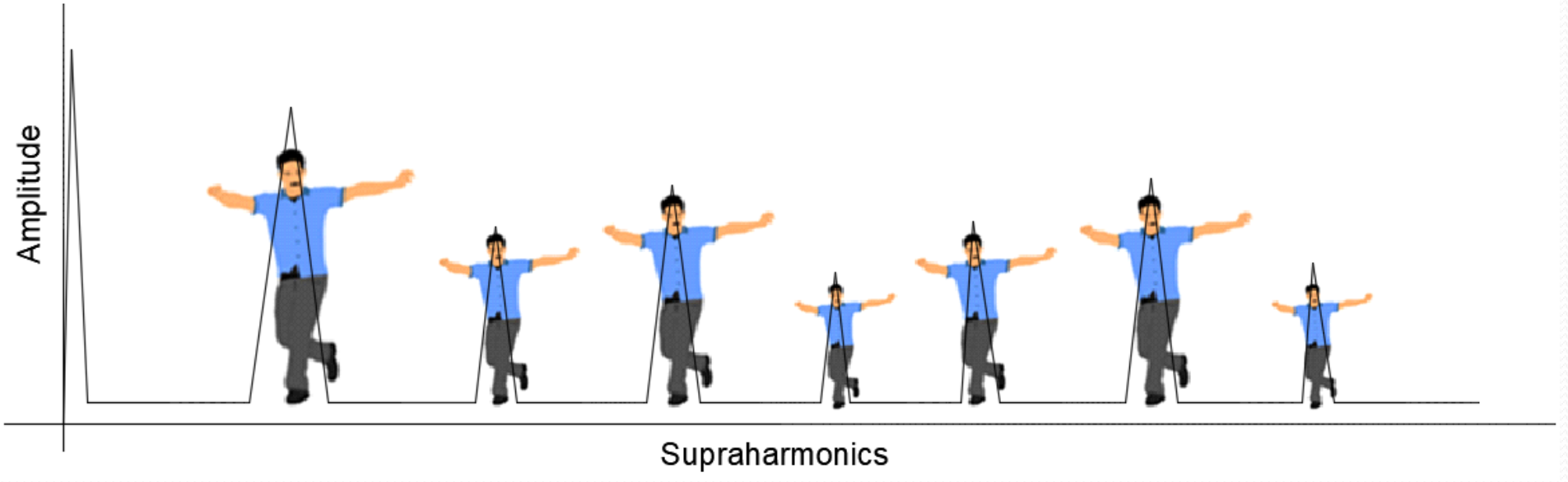
Results


Total Temperature Rise
80
70
60
50
40
°[C]
0
2
4
6
8
10
[sec]


Temperature Rise at 16Khz
20.02
20.015
20.01
20.005
20
°[C]
0
2
4
6
8
10
[sec]

Conclusions

- The harmonic current at 16kHz does not influence the bimetallic strip
- What happens when more harmonic currents at different frequencies and with different widths coexist in the electrical systems and especially in the low voltage side fuses at big generation systems such as PVs?
- The influence of a majority of supraharmonic current on the electric fuses must be considered by the electric fuses manufacturers



Thank you !!!