

REPORT ON THE USE OF THIRD HARMONIC SCREENING TO TEST THE LINEARITY OF THE EMI 82 RESISTOR

1.0 BACKGROUND

Vibrations within a wire will produce wave patterns. The lowest possible frequency at which a wire can vibrate to form a standing wave pattern is known as the fundamental frequency or the first harmonic. The second lowest frequency at which a wire can vibrate is known as the second harmonic; the third lowest frequency is the third harmonic (TH), etc. These phenomena are illustrated below:

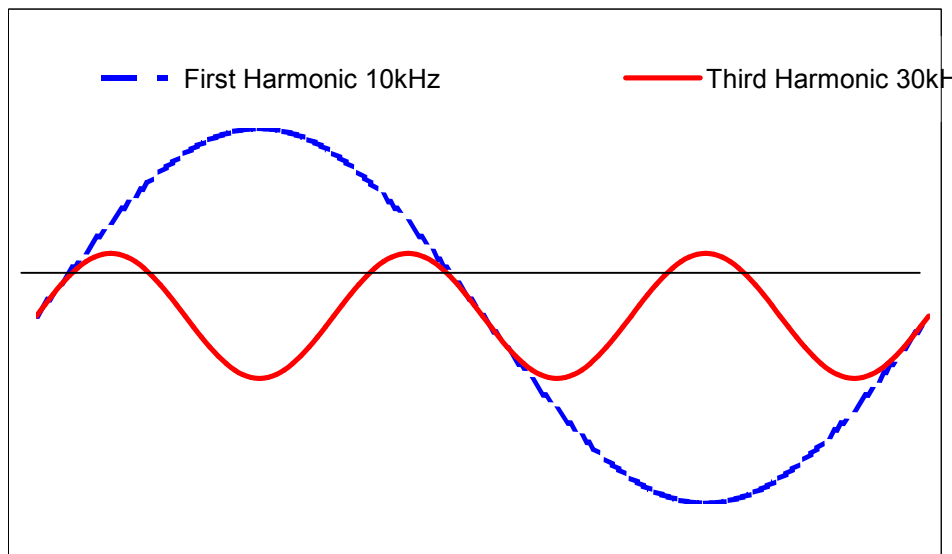


Figure 1: Application of a perfect AC signal of 10kHz on the resistor, measuring the TH distortion voltage of 30kHz.

In a physical system, such as the resistance wire of a resistor, there is a connection between the first, second and TH. The application of the perfect sine wave to the component will cause it to generate a signal containing a number of multiples (harmonics) of the fundamental signal frequency. The amplitude of these harmonics are all smaller than that of the fundamental applied signal and vary depending on the distortion occurring within the resistor.

These signal distortions can then be expressed as the ratio between the sum of all higher harmonics and the fundamental signal. However in practice it would be very difficult and time consuming to conduct a measurement of all higher harmonics and hence it has been shown that the TH represents a dominating part of all higher harmonics and provides a satisfactory measure of the distortion within the resistive component.

It has been shown that TH Testing is capable of detecting the following distortions within wirewound resistors:

- Inhomogeneities within the resistance wire
- Electrically shorted resistance wire turns
- Poor or weak resistance wire to termination cap welds

2.0 APPLICATION

TH testing can verify whether a resistor is electrically good by checking its linearity, i.e. if it follows Ohm's Law $V=IR$ correctly. A component with good linearity, which generates minor TH distortion, is not deemed to be weak.

The non-linearity of a component is tested by applying an AC load with voltage V_1 and fundamental frequency $f=10\text{kHz}$ and measuring the TH voltage V_3 with $f=30\text{kHz}$. 10^{-8}V is defined as 0dB, i.e. a signal of 10^{-8}V is expressed as $20 \log 1$ (=0dB) or 100V as $20 \log 10^{10}$ (=200dB).

The non-linearity of a component is referred to as the Third Harmonic Index (THI) and is expressed in dB as follows:

$$\text{THI (dB)} = 20 \log V_1 - 20 \log V_3$$

EMI 82 Example

The THI figure for a EMI82 – 2K0 component rated at 5W can be calculated as follows:

Calculated Voltage Applied at $f=10\text{kHz}$, V_1

$$V_1 = \sqrt{PR} = \sqrt{(5 \times 2000)} = 100\text{V}$$

Recorded TH Distortion Voltage at $f=30\text{kHz}$, V_3

$$V_3 = 100\mu\text{V}$$

Calculated THI

$$\begin{aligned}\text{THI} &= (20 \log 1 \times 10^{10}) - (20 \log 100 \times 10^2) \\ &= 200 - 80 \\ &= \mathbf{120 \text{ dB}}\end{aligned}$$

In general THI limits for resistors are empirical and vary with resistance value and component size. Thus the main use of the test is to check the distribution of a sample and screen out non-typical parts.

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