CHAPTER - ONE

Introduction

1.1) ROLE OF RMS MEASUREMENT

RMS measurement gives the root-mean-square value (rms) of the measurand. Basically it is a measure of statistical error to express stability of standards and product tolerances. Secondly, rms value is the measure of heating power of a signal. Thirdly, rms value is the conventional measure of signal amplitude. These basic measurements can be extended to measure various signal and device characteristics.

A conventional a.c. instrument however is either average or peak responding instrument calibrated to read rms of a sinusoid. The true rms measurement is a must for signals with unknown complex waveforms. In modern digital and sampled data systems, in SCR controlled power circuits and in noise control and measurement circuits, the waveform are complex. Thus, the true rms measurement is indispensable today.

1.2) DEFINITION OF RMS

Next to a mathematician an electrical engineer is interested in the term 'rms'. The rms is a mathematical function of variable 'x' defined as (Ref. 1).

\[
\text{rms} = \left( \frac{1}{T} \int_{a}^{a+T} x^2 \, dt \right)^{0.5}
\]

In electrical engineering, the rms value is a measure of signal amplitude. A signal's rms value is equal to the dc signal that would dissipate the same amount of power as the signal dissipates.
1.3) BASIC METHODS OF RMS MEASUREMENT

Basically there are three methods of rms measurement: (1) To use a proper scale factor on conventional a. c. instruments. (2) To use a true rms instrument that consists of a heater and a converter like a thermopile. (3) To simulate the rms computation with the help of analog or digital computing circuits.

The first method is useful for sinusoidal and slightly distorted signals. It can be used for complex signal if its crest factor or form-factor is known. The amount of error introduced in the measurement without using the correction factor is found in many references (Ref. 2 to 7). As quoted by Scheingold & Counts, the rectifier type a. c. instrument reads 11% high on dc or symmetrical square waves, 4 percent low on triangular and sawtooth waves and 11.3% low on gaussian noise.

The second method is widely used. It can claim the highest accuracy because its action is directly based on the rms definition. However, there are certain limitations imposed by basic characteristics of the converter. As discussed by Baird and others (Ref. 8) a thermocouple device has (1) a sluggish response (2) inaccuracy at low level inputs, (3) susceptibility to burn out and (4) thermal problems.

The third method is also based on the rms definition and can claim the highest accuracy. This method is still in the development stage. True-rms function generators are available commercially, e.g. Teledyne Philbrick's 4370, Burr Browns 4340. Still, there is a want of true rms computing instrument which will measure the true rms value easily, quickly and accurately irrespective of the signal waveform.

Historical developments of rms instrument can be grouped in three parts. (1) Before 1960 electromechanical and thermal devices were used, (2) between 1960 and 1970, various square-law devices e.g. diode, transistor-bipolar and field effect. thermistor etc., were used. (3) Though the diode function generator was used for rms measurement as early as in 1960, the real era of the computing rms techniques has started since 1970.
1.4) THE PROBLEM

The application note on the digital voltmeter by H. P. (Ref. 9) says. It should be mentioned that there is a third type of a. c. converter known as quasi-rms converter. A quasi rms technique simulates true rms response using operational amplifiers to square input, take the average of the square then take the square root. This type of converter holds a lot of promise but is not widely used. This synthesized rms response is not mathematically perfect and for that reason is limited to symmetrical wave shapes.

Thus, the problem of simulation of true rms computation using operational amplifiers is taken up.

The problems encountered in rms measurement are systematically analyzed in the second chapter by using a novel concept of an idealized rms detector. Various rms computing techniques and their areas of applications are presented in the third chapter. The fourth chapter compared various techniques for squaring, averaging and square-rooting. Based on the results of the comparative study of devices and techniques appropriate recommendations are made for rms measurement on high crest-factor signals. The development of the rms detector for high crest-factor signals is presented in the fifth chapter.

Thus, a solution to the problem of rms measurement on high crest-factor signal is presented in this thesis.
References


4) Siess, K.: ‘Exact measurement of a. c. voltages’ Radio Electronik Schau. (Austria) No. 11, 1972, P. 676 (German)


