A Comparative Study of Various Methods of RMS-To-DC Conversion: An Overview

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***Abstract*— RMS-to-DC conversion is the truest way for the measurement of the energy contained in an AC waveforms. There are many methods for RMS-to-DC conversion. Linear technology's simple, true RMS-to-DC converters use an innovative delta sigma computational technique that features high linearity and accuracy suitable for a wide variety of AC measurement applications.**

***Index Terms*— RMS-to-DC, conversion, AC measurement**

I. Introduction

RMS amplitude is the consistent, fair and standard way to measure and compare dynamic signals of all shapes and sizes. Simply stated, the RMS amplitude is the heating potential of a dynamic waveform. Defined practically: the RMS value assigned to an ac signal is the amount of DC required to produce an equivalent amount of heat in the same load. Mathematically, RMS is the "Root of the Mean of the Square".

$$Erms = \sqrt{AVG(V^2)}$$

This involves squaring the signal, taking the average, and obtaining the square root. The averaging time must be sufficiently long to allow filtering at the lowest frequencies of operation desired. Therefore, RMS-to-DC converters came. These converters are used in wide variety of applications where precision, low power measurement of ac signal is the prime objective. A RMS-to-DC converter offers 'real time' measurements, i.e. there are no latency issues such as those that limit the frequency response of other technologies – the dc output is simply equivalent of the RMS input, over a wide range of input frequencies, and for complex waveforms not limited to sine- waves.

METHODS

Thermal RMS-to-DC conversion

Thermal conversion is the simplest method in theory; yet, in practice, it is the most difficult and expensive to implement. This method involves comparing the heating value of an unknown AC signal to the heating value of known calibrated DC reference voltage. When the calibrated voltage reference is adjusted to null the temperature difference between the reference resistor (R2) and the signal resistor (R1), the power dissipated in these two matched resistors will be equal. Therefore, by the basic definition of RMS, the value of the DC reference voltage will equal the RMS value of the unknown signal voltage. Each thermal unit contains a stable, low-TC resistor (R1, R2) which is in thermal contact, (S1, S2). The output voltage of S1 (S2) varies in proportion to the mean square of Vin; the first order temperature/voltage ratio will vary as K Vin/R1.

The circuit of Figure 1 typically has very low error (approximately 0.1%) s well as wide bandwidth. However, the fixed time constant of the thermal unit (R1,S1, R2, S2) limits the low frequency effectiveness of this RMS computational scheme.

In addition, there are also variable gain thermal converters available which can overcome the dynamic range limitations of fixed gain converters at the expense of increased complexity and cost.

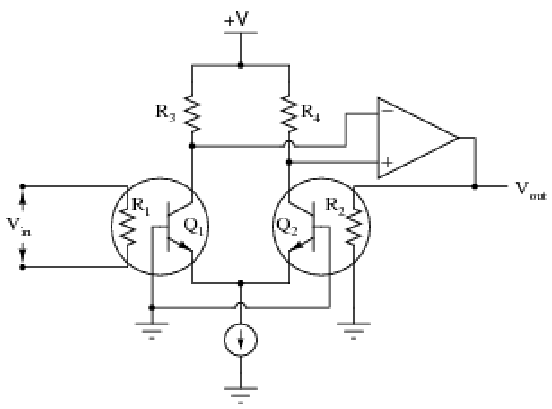

Figure 1: Thermal RMS-to-DC Conversion

II. Direct or Explicit Computation Method

The most obvious method of computing RMS value is to perform functions of squaring, averaging, and square rooting in a straight-forward manner using multipliers and operational amplifiers. The direct or explicit method of computation has a limited dynamic range because the stages following the squarer must try to deal with a signal that varies enormously in amplitude. For example, an input signal that varies over a 100 to 1 dynamic range (10mV to 1V) would have a dynamic range of 10,000 to 1 at the output of squarer (1mV to 10 V).

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These practical limitations restrict this method to inputs which have maximum of approximately 10:1 dynamic range. System errors can be as little as ±0.1% of full scale using a high quality multiplier and square rooter. Excellent bandwidth and high speed accuracy can also be achieved using this method.

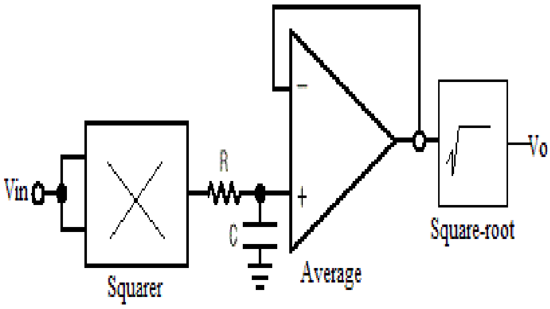

Figure 3: Explicit Computation Method

III. Indirect or Implicit Computation Method

A generally better computing scheme uses feedback to perform the square root function implicitly or indirectly at the input of the circuit as shown in Figure 3. Divided by the average of the output, the average signal levels now vary linearly with the RMS level of the input. This considerably increases the dynamic range of the implicit circuit, as compared to explicit RMS circuits.

The advantages of this method are fewer components, greater dynamic range, and generally lower cost. A disadvantage of this method is that it generally has less bandwidth than either thermal or explicit computation. An implicit computing scheme may use direct multiplication and division, or it may use any of several log-antilog circuit techniques.

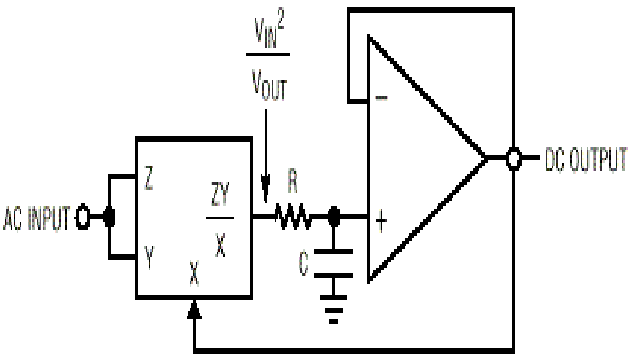

Figure 2: Implicit Computation Method

IV. Applications

- Wideband RMS voltmeters
- RF levelling loops
- Wideband AGC
- High crest factor measurements
- SCR power monitoring
- LTC1996 RMS-to-DC Converter
- AD536A - Wide Range RMS Converter
- AD636 - Low Power/Low level Operation RMS Converter
- AD637 - High Performance RMS Converter

V. Conclusion

These various methods of RMS-to-DC conversion give a new level of accuracy to RMS measurements of all type AC signals.

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