A Design for Transmitting an Ambient Temperature via RF Modulation

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Abstract: In this paper, a circuit is designed to transmit an ambient temperature via RF modulation. As a modulating signal, a ambient temperature is used and the modulation method is choosen as frequency modulation.

1. INTRODUCTION

Baseband signals produced by various information sources are not always suitable for direct transmission over a given channel. These signals are usually further modified to facilitate transmission. This conversion process is known as modulation. In this process, the baseband signal is used to modify some parameters of a high-frequency carrier signal. A carrier is a sinusoid of high frequency and one of its parameters such as amplitude, frequency or phase is varied in proportion to the baseband signal. At the receiver, the modulated signal must pass through a reverse process called demodulation in order to retrieve the baseband signal.

In this paper, an ambient temperature T_a is the modulating signal *m(t)*. For reasonable antenna dimensions the frequency modulation (FM) is choosen to modulate the signal. Another reason of using FM is the constant amplitude of FM makes it less susceptible to nonlinearities [1].

2. DESCRIPTION OF THE SYSTEM

This system consists of two main parts. As shown in Figure 1, the transmitting system has the devices; a sensor, a temperature-to-frequency converter, a frequency-to-voltage converter, a differantial amplifier, a transmitter and a display which shows the measured temperature T_a .

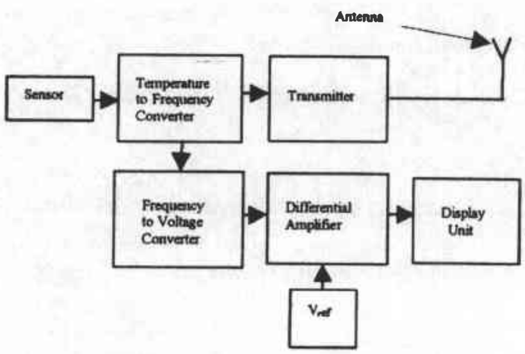

Figure 1. The Transmitting System.

The receiving system shown in Figure 2 has the following devices; a receiver, a frequency-to-voltage converter, a differantial amplifier and a display which indicates the recovered temperature T_a.

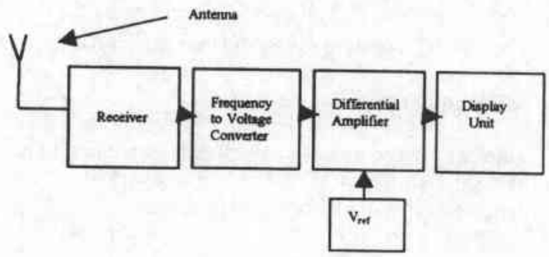

Figure 2. The Receiving System.

2.1 Sensing Ambient Temperature T_a

In most applications, the measure of temperature is realized by using various sensor components. A sensor is known to be a component which is sensitive to any physical value. Since we interested in the temperature measuring, the sensor should have a characteristic which changes with temperature. In this design, a 3-terminal Adjustable Current Source (LM334) is used as a temperature sensor. This element has an excellent current regulation and a wide dynamic voltage range of 1V to 40V. Current is established with one external resistor and no other parts are required. Initial current accuracy is ± 3%. The LM334 is quaranteed over a temperature range of 0 °C to +70 °C [2].

2.2 Converting T_a to Frequency Value.

In order to use an ambient temperature as a modulating signal, we must convert this value to a signal which has a constant amplitude and its frequency depends on temperature variation. For this reason, it is used a converter circuit. In this design, a precision voltage-to-frequency converter (LM331) is choosen to realize this operation. The converter generates a pulse train at a frequency precisely proportional to the applied input voltage. The applied input voltage is the output of the sensor. With the LM334, the circuit shown in Figure 3 senses the temperature in Kelvin (°K) and this value changes the frequency of the pulse train. So the modulating signal *m(t)* which contains the T_a is obtained.

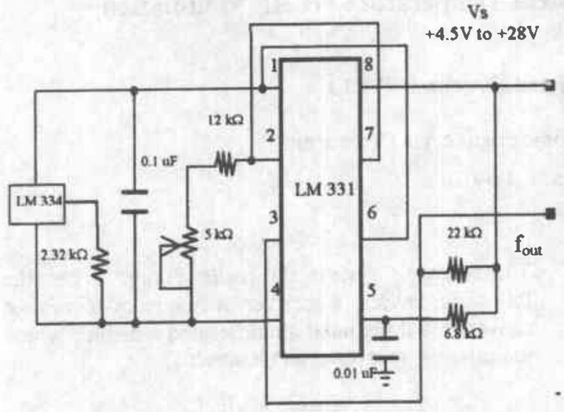

Figure 3. Generating the modulating signal *m(t)*.

2.3 Modulation

Because of the reasons which are mentioned in the introduction, the FM is used to transmit the T_a .A frequency modulated signal is given as

$$m_m(t)=A\cos\left[2\pi f_c t+2\pi k_f \int_0^t m(t)dt\right] \quad (1)$$

where f_c is the carrier frequency and *m(t)* is the modulating signal (T_a). The output of the voltage-to-frequency converter is fed to the modulator as a modulating signal. Since the modulating signal frequency is in the audio range, a matched operation is realized. Carrier frequecy f_c is choosen as 104.2 MHz.

2.4 Recovering Ambient Temperature T_a

In the Frequency Demodulation process, it is desired to recover the transmitted signal knowledge. Because of the temperature value is embedded in the pulse train, it must be used a frequency-to-voltage converter to recover the T_a . This converter generates a voltage according to the pulse train frequency [3]. The circuit which is realized with using a precision voltage-to-frequency converter is shown in Figure 4.

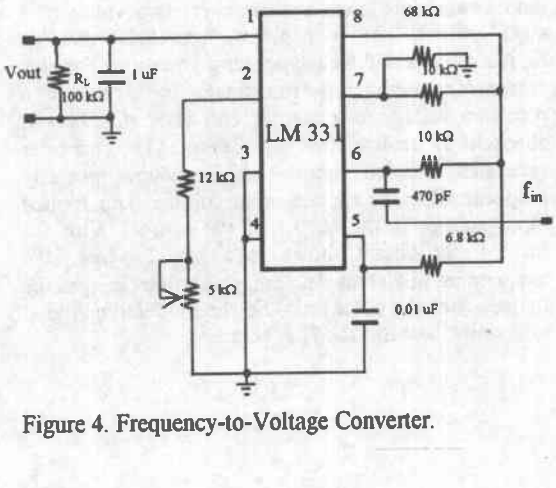

Figure 4. Frequency-to-Voltage Converter.

2.5 Transforming The Ambient Temperature T_a from Kelvin to Celcius

A differential amplifier which consists of LM 358 is used to transform the Kelvin to the Celcius. The required reference constant is 2.73 V and substracted from the input voltage. As shown in Figure 5, V_1 represents the reference value and V_2 represents the port which is fed by an input voltage. The output V_0 can be calculated as below

$$V_0=(1+(657/73))\times(V_2-V_1)=10(V_2-V_1) \quad (2)$$

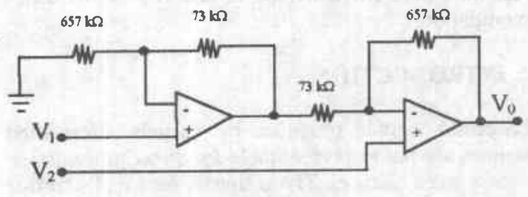

Figure 5. The Differential Amplifier.

The V_0 output voltage then is applied to a display driver. The process is completed by recovering and displaying the ambient temperature [4].

3. CONCLUSION

A design is developed to transmit an ambient temperature via RF modulation. The system descripted above is realized and practical results are obtained. The carrier frequency is choosen as 104.2 MHz and this value is confirmed by a spectrum analyser. This system gives a good performance if the transmitting and receiving systems are in the circle whose radius is more or less 150 meter. In this circle, deviation (or error) between the recovered temperature and the sensing temperature is observed approximately ± 5 %.

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