Conversion of Sinusoidal Signals into Periodic Signals of Arbitrary Form

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1 Mathematical description of the converter

Let us observe Figure 1 and examine individual signals which are fed as inputs to the multiplier. We can see right away that the voltage v_2 at the input 2 of the multiplier is constant and has the value of

$$v_2(t) = \frac{1}{4}\sqrt[4]{V_m}$$

It is also obvious that the voltage v_4, which is fed to the input 4 of the multiplier, takes the following form:

$$v_4(t) = \sqrt[4]{V_m}\ \sin(\omega t)$$

The remaining two signals, coming to the inputs 1 and 3 of the multiplier have a more complex form. Namely, by a closer examination of Figure 1 it becomes clear that the voltage v_1 consists of two components. The first component is the constant $3\sqrt[4]{V_m}$, whereas the second component is time-dependent and has the value of $-\sqrt[4]{V_m}\ |\sin(\omega t)|$. The combination of these two components gives the final form of the signal v_1:

$$v_1(t) = 3\sqrt[4]{V_m} - \sqrt[4]{V_m}\ |\sin(\omega t)| = \sqrt[4]{V_m}\ (3 - |\sin(\omega t)|)$$

Similarly, the voltage v_3 consists of two components, whose combinatination gives the following form:

$$v_3(t) = 2\sqrt[4]{V_m} - \sqrt[4]{V_m}\ |\cos(\omega t)| = \sqrt[4]{V_m}\ (2 - |\cos(\omega t)|)$$

Now we can calculate the output signal which is the product of the voltages v_1, v_2, v_3 and v_4:

$$\begin{aligned} v_{out}(t) &= v_1(t)\ v_2(t)\ v_3(t)\ v_4(t) = \\ &= \sqrt[4]{V_m}\ (3 - |\sin(\omega t)|)\ \frac{1}{4}\sqrt[4]{V_m}\ \sqrt[4]{V_m}\ (2 - |\cos(\omega t)|)\ \sqrt[4]{V_m}\ \sin(\omega t) \end{aligned}$$

The resulting form of the output voltage v_{out} is:

$$v_{out}(t) = \frac{1}{4}V_m(2 - |\cos(\omega t)|)(3 - |\sin(\omega t)|)\sin(\omega t)$$

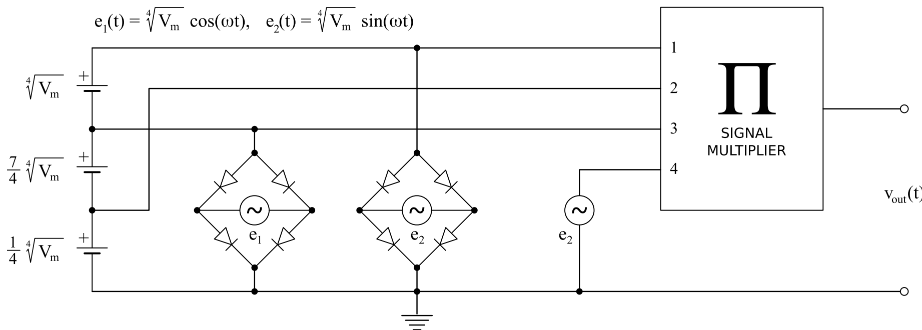

Figure 1: A schematic of a sample converter, which converts a sinusoidal signal into a triangular periodic signal of the same frequency

Figure 2 shows the graph of the output voltage v_{out}.

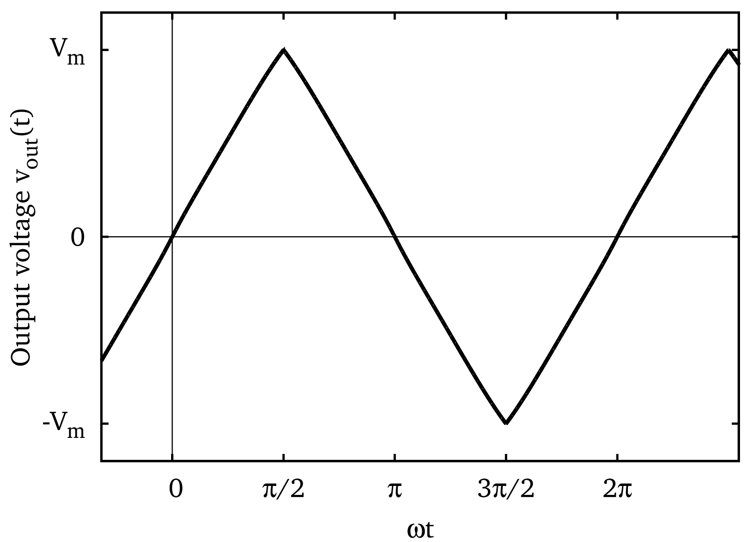

Figure 2: The form of the output signal $v_{out}(t)$

2 Deviation of the function $v_{out}(t)$ from an ideal triangular periodic signal

A the first glance the graph shown in Figure 2 looks like an ideal triangular periodic signal. There is, however, a certain deviation of the signal $v_{out}(t)$ from an ideal triangular signal. To see this, we need a bigger representation of both signals, which is provided in Figure 3.

Figure 3 contains graphs of functions $v_{out}(t)$ and $v_{linear}(t) = \frac{2V_m}{\pi}\omega t$ for $\omega t \in [0, \frac{\pi}{2}]$. It is obvious that $v_{out}(t) > v_{linear}(t)$ on the given interval.

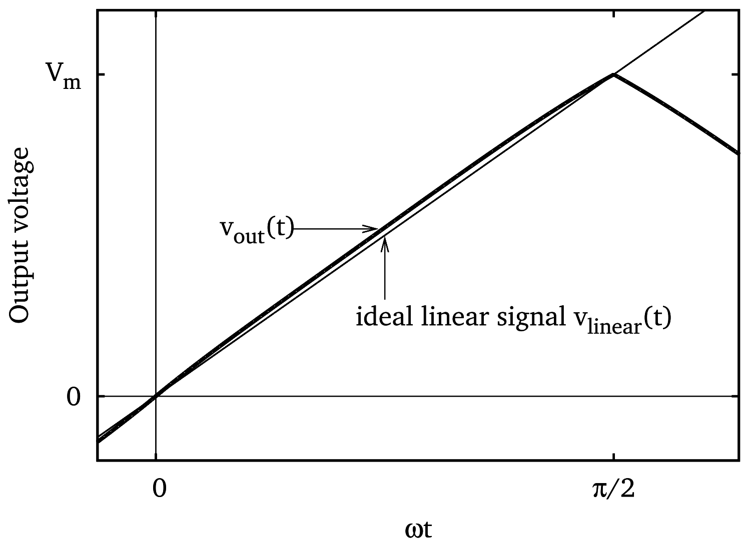

Figure 3: Graphs of the output signal $v_{out}(t)$ and the ideal linear signal $v_{linear}(t)$

3 Summary

The described procedure of converting a sinusoidal signal into a triangular signal is just a proof of a theoretical concept, which should allow for conversion of sinusoidal signals into periodic signals of arbitrary form. The next step should be establishing of an experimental framework, which would allow for building of a prototype of the converter.

The essence of the presented method is the multiplication of signals which are fed as inputs to the multiplier. By feeding different combinations of signals into the multiplier we can generate various forms of the output signal.