



Method and facility for time/voltage conversion

The invention concerns a method for converting time values which correspond to the duration of an impulse into voltage values according to the preamble of the main claim, as well as a facility for executing the invention-type method according to the preamble of the first device claim.

From the prior application P 39 30 259.8, which presents a triggering circuit for a liquid crystal display, a current amplifier is known which represents a combination of a voltage/time converter and a time/voltage converter. In this the voltage/time converter converts a video input signal into a pulse width modulated signal with impulses of differing durations that depend on the level of the video input voltage.

This pulse width modulated signal is subsequently converted by the time/voltage converter into a voltage value which depends on the duration of the respective impulse.

One possible realization of the time/voltage converter presented there contains a MOS transistor the gate of which is fed with the pulse width modulated signal. A voltage is applied to the source electrode of the MOS transistor which drops with a constant gradient from a maximum value to zero volts. A capacitor connected to the drain electrode is, thereby, charged by means of a ramp voltage. A respective voltage can be picked up at the capacitor.

The voltage/time converter known from the named application supplies impulses which have differing lengths but whose voltage curve (path) during the respective pulse duration is essentially constant. It has become apparent

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that such pulses are not yet converted into voltage values by means of the named time/voltage converter with sufficient accuracy.

It is, therefore, the object of the present invention to enable a more accurate conversion of time values, corresponding to the duration of an impulse, into voltage values.

This task is solved by the method according to claim 1 or respectively, through a suitable facility for executing the invention-type method according to the first device claim.

According to the invention, the voltage curve of an input pulse is adapted to the curve of an auxiliary voltage with a ramp-shaped progression, hereinafter abbreviated to ramp voltage, insofar as the gap between the impulse voltage curve and the ramp voltage curve lies within predetermined values.

Further advantages of the invention are, for one thing, that the electrical tension of transistors used is lower. For another thing, owing to a shorter disconnection (switch-off) time with small data voltages, the end of the ramp of the ramp voltage is shifted closer, time-wise, to the end of a line which is to be triggered. This results in a greater accuracy.

Embodiment examples of the invention are illustrated in the drawing and are more closely described in the following. The drawings show in:

Fig. 1 a known amplifier facility with a voltage/time converter and a time/voltage converter,

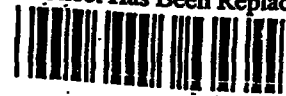


Fig. 2a...c voltage curves for an amplifier facility

Fig. 3 according to Figure 1,

Fig. 4 a first embodiment example according to the invention,

Fig. 5a...c voltage curves for the embodiment example of

Fig. 6 Figure 4,

Fig. 7 a second embodiment example according to the invention.

Before referring to the description of the embodiment examples in more detail, attention should be drawn to the fact that the blocks shown individually in the figures merely serve to aid a better understanding of the invention. Usually, individual ones or several of these blocks are combined into units. These can be realized in integrated or hybrid technology or as a program-controlled microcomputer, or as a part of a program suitable for its control.

It should also be pointed out that the elements contained in the individual stages can also be provided separately.

Figure 1 shows a known amplification facility 10 which contains a voltage/time converter 11 (U/t converter) and a time/voltage converter 12 (t/U converter). The voltage/time converter 11 forms a pulse width modulated signal U_i from an input signal U_e and sends said signal U_i to a first input of the time/voltage converter 12. This is also coupled, via a second input, with a ramp voltage generator 13 from which it receives the ramp voltage U_R . Based on the signal U_i and the ramp voltage U_R , the time/voltage converter 12 forms an output signal U_a which is available at its output.



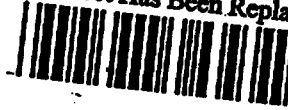
The time/voltage converter 12 consists of, for example, a MOS transistor 12', the source terminal of which is fed with the ramp voltage U_R and the drain terminal of which leads to a first terminal of a capacitor 12''. The signal U_i is fed to the gate connector of transistor 12' and a second terminal of capacitor 12'' is connected to ground. The output signal U_a can be picked up at the common junction of the transistor 12' and the capacitor 12''.

The method of operation of the amplification facility 10 according to Figure 1 is described in the aforementioned prior application and it will only be explained in the following insofar as is necessary for the understanding of the present invention.

The voltage/time converter 11 generates impulses as shown in idealized fashion by the dotted lines in Figure 2 which consists of Figures 2a, b, c. These impulses have - depending on the different input voltages U_e fed to the converter 11 - differing temporal lengths t_1 , t_2 or t_3 respectively, and their voltage value is always essentially constant over the entire duration of the pulse.

In Figure 2 solid (continuous) lines are used to draw true impulse curves are drawn such as are being supplied to the time/voltage converter 12 from the voltage/time converter 11. These curves deviate from the idealized curves insofar as their flanks (edges) are rounded off, caused by, for example, parasitic capacitances. The significance of a threshold value U_s drawn in Figure 2 will be explained below.

In Figure 3 curves U_i are illustrated which correspond to the right-hand edges of the true impulses of Figure 2. In addition, a curve b is drawn in Figure 3 which essentially corresponds to the temporal curve of the ramp



voltage UR which in this known facility, exhibits a ramp form, for example, only after the expiration of the time period t_1 , which especially serves for the capacitor 12b being first fully charged and the voltage U_a applied to it being subsequently mainly determined by the ramp voltage UR.

The time/voltage converter 12 supplies the output voltage U_a with a value which is determined at the time at which the curve U_i intersects the curve b.

At this point attention should be drawn to the fact that when realizing the time/voltage converter by means of semiconductor components, appropriate threshold values are to be taken into consideration which, besides the ramp voltage UR, are then contained in the curve b.

At time t_1' , at which the first idealized pulse in Figure 2a has finished, the curve b has the value U_1 . However, owing to the rounding off, the curve of the first true impulse first intersects the curve b at a time $T_1 = t_1' + d_1$ at a value v_1 .

At time t_2 , at which the second idealized pulse in Figure 2b has finished, the curve b has the value U_2 . However, owing to the rounding off of the second impulse, the voltage value of the second true impulse first intersects the curve b at a time $T_2 = t_2' + d_2$ at a voltage value v_2 , and, in an analog manner, the rounded-off edge of the third impulse from Figure 2c first intersects the curve b at a time $T_3 = t_3' + d_3$ at a voltage value v_3 instead of a voltage value U_3 .

The differences $v_1 - U_1$, $v_2 - U_2$ and $v_3 - U_3$ are not of equal magnitude, a condition resulting from the different length time differences d_1 , d_2 and d_3 with a regular-shaped edge progression.



This means that non-linearities appear with a time/voltage conversion according to the Figures 1 through 3.

With the help of Figures 4 through 7, the present invention will be described by means of two embodiment examples. In said Figures, elements and voltages which perform the same function or produce the same effect as in Figures 1 through 3 are provided with the same reference designations. These will only be referred to in the following insofar as is essential for the understanding of the present invention.

Figure 4 illustrates a first embodiment example of the facility according to the invention. A facility for time/voltage conversion 12a has an impulse converter 14 which contains a threshold stage 15 at the input of which the signal U_i is present and the output of which is coupled with a control input of a switching facility 16. A first switch terminal (switching connector) of this switching facility 16 is coupled with a first terminal of a first resistor 17, the second terminal of which is coupled with the output of the ramp voltage generator 13.

A second switch terminal in the switching facility 16 is, for one thing, coupled with the first terminal of a second resistor 18, as well as with the first input of the time/voltage converter 12. The second terminal of the second resistor 18 is connected to ground.

The ramp voltage U_R is fed to the time/voltage converter 12 via a reducing module 22 which reduces the ramp voltage U_R in an additive manner, for example, by subtracting a voltage, and/or in a multiplicative manner, for example, by using a suitable attenuator (amplification



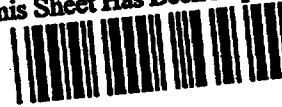
factor less than one), and transmits this reduced voltage to the second input of the time/voltage converter 12.

The operation of the facility according to the invention according to Figure 4 will now be explained with the help of Figure 2 which consists of the Figures 2a, b, c and Figure 5 which consists of the Figures 5a, b, c.

The signal U_i , which exhibits the true impulse according to Figure 2, is fed to the threshold stage 15 which actuates the switching facility 16 when the predetermined threshold value U_s is exceeded so that the connection between the first resistor 17 and the second resistor 18 is produced. When said threshold value U_s is no longer exceeded, the switching facility 16 opens again. The temporal curve of an appropriate trigger signal for the switching facility 16 essentially corresponds to the idealized pulses of Figure 2. The position of the threshold value U_s is preferably determined conditional upon the rounding-off of the true impulse U_i (Fig. 2) in such a way that the time in which the switching facility 16 is always closed corresponds to the duration of the ideal pulse U_i (Fig. 2).

When the contacts of the switching facility 16 are closed, the two resistors 17, 18 form a voltage divider. True impulses, i.e. impulses with rounded flanks, of a signal U_i' supplied to the time/voltage converter 12 are drawn with a solid line in Fig. 5. What is significant is that the voltage curve of the pulses is not constant during the respective impulse duration but, rather, is influenced by the ramp voltage U_R .

If a curve for the ramp according to curve b of Fig. 3 is assumed, i.e. the ramp-shaped dropping progression first begins from time t_1' , then the first impulse U_i (Fig. 2),



which has a duration t_1 , retains its curve upon transmission to the first input of the time/voltage converter 12 insofar as that its voltage curve U_i (Fig. 5a) is essentially constant during its entire duration.

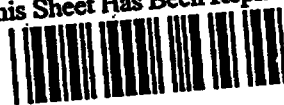
The second impulse U_i (Fig. 2b) with the duration t_2 , however, has a modified voltage curve U_i' (Fig. 5b) at the said input such that its original constant voltage curve drops linearly after the expiration of the period t_1 . The third impulse also exhibits a comparable curve.

The said impulses applied to the first input of the time/voltage converter 12 are also included in Figure 6 in which the curve b is also drawn.

The interval between the curves U_i' and the curve b is predetermined by the reducing module 22. It is essential that the curve of the voltages U_i' lies above the curve b when an impulse U_i is applied, i.e. in this embodiment example when the switching facility 16 is closed.

From the modified curve of the impulses it results that the first pulse intersects the curve b at a time $T_1' = t_1' + d_1'$ at a voltage value v_1' , the second pulse intersects the curve b at a time $T_2' = t_2' + d_2'$ at a voltage value v_2' , and the third pulse at a time $T_3' = t_3' + d_3'$ at a voltage value v_3' .

If an identical rounding of the right-hand edges of the impulses is assumed, then the time differences d_1' , d_2' , d_3' are of equal size owing to the essentially parallel path of the envelopes of the curves U_i and the curve b . That has the effect, with a uniform ramp curve, of making the voltage differences $v_1' - U_1$, $v_2' - U_2$ and $v_3' - U_3$ constant. Thereby, inaccuracies in the time/voltage conversion are avoided.



When using the facility 12a according to the invention for time/voltage conversion as a part of the amplification unit 10, therefore, an essentially linear amplification is rendered possible.

If it is necessary to invert the signal of the voltage/time converter 11 before it is fed to the time/voltage converter 12, then the second embodiment example according to Fig. 7 can be used.

The inverting facility 12b for the time/voltage conversion contains, instead of the impulse converter stage 14, an inverter 19 as is illustrated, for example, in Figure 7.

This inverter 19 has a first MOS transistor 20 and a second MOS transistor 21. The source electrode of the first transistor 20 is coupled with its gate electrode and with the ramp voltage generator 13. The drain electrode of the first transistor 20 is coupled with the source electrode of the second transistor 21. The pulse width modulated signal U_i is applied to the gate electrode of the second transistor 21, and the drain electrode of the second transistor 21 is connected to ground. At the common junction of the two transistors 20, 21, a voltage U_i^* can be picked up which represents an inversion of the signal U_i weighted with the voltage curve of the ramp voltage U_R .

It should be pointed out here that, owing to the symmetrical structure of MOS transistors, the designations source and drain electrodes are interchangeable.

With another, not shown variation of the invention, the output voltage is not dependent on the ramp-type curve of the ramp voltage U_R but rather, is dependent on a voltage



applied to the capacitor coupled to a source which impresses a current with predetermined values on the capacitor and/or feeds a voltage with predetermined values to it.

In this case the voltage of the impulses of the signals U_i' or U_i^* respectively must be appropriately adapted.

Versions of the aforementioned embodiment examples can possess at least one the following variations:

- instead of the reducing module 22 or in addition to this, a means can be provided between the ramp voltage generator 13 and the impulse converter 14 or, respectively, the inverter 19, which increases the ramp voltage U_R in an additive manner, for example, by adding a voltage, and/or in a multiplicative manner, for example, by using amplification, and sends this increased voltage to the impulse converter 14 or, respectively, the inverter 19;
- the curve of the impulse given out from the impulse converter 14 or the inverter 19 respectively can be such that the impulse voltages do not run parallel to an auxiliary voltage, which corresponds to the ramp voltage U_R or to a voltage applied to components, but rather that their separation changes within predetermined limits. This corresponds to an additive and/or multiplicative combination of the voltage values of the impulses with the values of the functions of the temporal functions of the auxiliary voltage and can be attained, for example, through supplementary components such as diodes or other semiconductor elements which may be connected singly or in combination in parallel and/or in series with the components shown. Thereby, for example, non-linearities which, somewhere within a system to which the time/voltage converter belongs, can be minimized or avoided.



Consequently, according to the invention a system, consisting of a method and a preferred facility for executing the method according to the invention, is presented which determines voltage values which correspond to the duration of impulses.

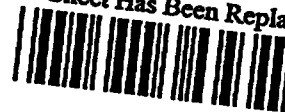
In order to avoid non-linearities upon conversion, the voltages of the impulses, whose duration serves the time/voltage conversion, are matched to the curve of an auxiliary voltage which serves for the formation of the output voltage. This auxiliary voltage may be a ramp voltage supplied by a ramp voltage generator, or another voltage applied to components of the facility according to the invention.

By use of the invention, non-linearities with the time/voltage conversion can be reduced or avoided.

Therefore, with an application as a part of a whole system, for example, an amplification unit, corresponding non-linearities can be at least reduced or compensated for.

The system according to the invention can preferably be used as a part of an amplification unit which is realized in thin-film technology and serves for triggering a liquid crystal display.

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P a t e n t C l a i m s



1. Method for converting a time value, which corresponds to the duration of an impulse with a voltage curve which can be predetermined, into a voltage value by means of an auxiliary voltage, the values of which corresponds to a temporal function, characterized in that the voltage curve of the impulse is determined conditional upon the temporal function.
2. Method according to claim 1, characterized in that the voltage curve of the impulse essentially follows the temporal function of the auxiliary voltage.
3. Method according to one of the claims 1 or 2, characterized in that the temporal function is, at least part-time, a temporally linearly increasing or decreasing function.
4. Method according to one of the claims 1 through 3, characterized in that values of the voltage curve for the impulse correspond to an additive and/or multiplicative combination with values of functions of the temporal function.
5. Facility for converting a time value, which corresponds to the duration of an impulse with a voltage curve which can be predetermined, into a voltage value (U_a) by means of an auxiliary voltage (U_R), the values of which corresponds to a temporal function, characterized in that means (22, 14; 19) are provided which determine the



voltage curve of the impulse conditional upon the temporal function.

6. Facility according to claim 5, characterized in that the means (14, 19) are designed in such a way that the voltage curve of the impulse essentially follows the temporal function.
7. Facility according to one of the claims 5 or 6, characterized in that the temporal function is, at least part-time, a temporally linearly increasing or decreasing function.
8. Facility according to one of the claims 5 through 7, characterized in that means (22, 14; 19) are provided which combine, in additive and/or multiplicative fashion, the values of the voltage curve for the impulse with values of functions of the temporal function.

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