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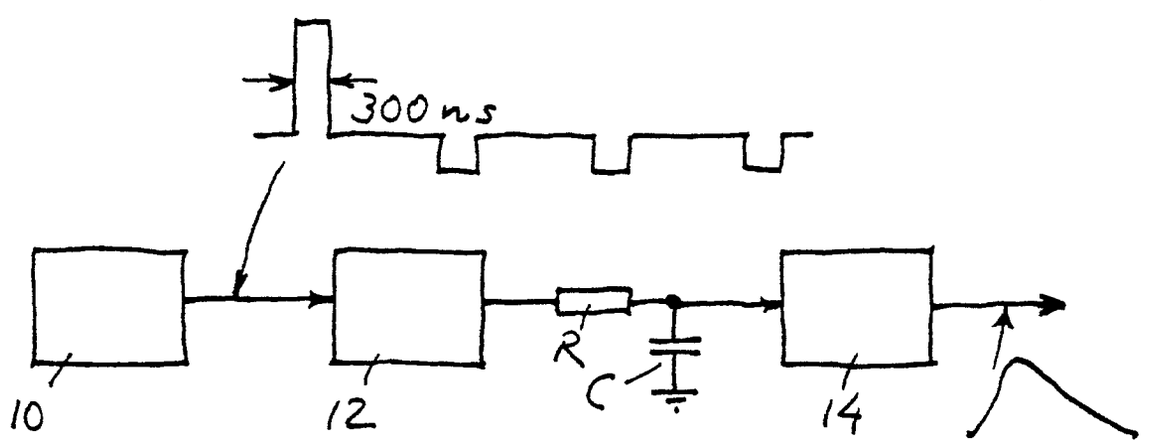
(71) Applicant: **Hohner Electronique S.A.**
Zone Industrielle
F-21140 Semur-en-Auxois(FR)

(72) Inventor: **Deforeit, Christian J.**
6, rue de l'Hôpital
F-21140 Semur-en-Auxois(FR)

(74) Representative: **Dipl.-Ing. H. Marsch Dipl.-Ing.**
K. Sparing Dipl.-Phys.Dr. W.H. Röhl
Patentanwälte
Rethelstrasse 123
D-4000 Düsseldorf(DE)

(54) **A digital-to-analog converter circuit.**

(57) In an electronic musical instrument, sounds to be produced are represented by a pulse sequence comprised of pulses having equal width, the magnitudes thereof representing amplitude differences of wave form samples of complex audio sounds. An RC network is used to convert the pulse sequence into audio signals whereby an automatic brilliance control is provided.



EP 0 264 512 A1

A Digital-to-Analog Converter Circuit

The present invention relates to electronic musical instruments and in particular to a digital-to-analog converter circuit by means of which samples of a complex audio waveform produced by digital circuitry of the instrument are converted into the respective audio waveform.

Modern electronic musical instruments, as electronic organs, comprise memories for one or several wave forms from which amplitude samples are read under the control of signals produced by the player via at least one manual, stops, tabs, and switches. The output of the digital part of the circuitry is a data stream comprised of pulses having equal durations, the magnitude of the pulses being representative of the sample amplitude, and the repetition frequency of the pulses being representative of the audio frequency to be produced.

If the pulse magnitude is simply proportional to the sample amplitude, the respective D-A-converter is usually a simple RC lowpass. If, however, the pulses each represent the amplitude difference of the respective sample relative to the preceding sample, the D-A-converter comprises an integrator circuit including an operational amplifier.

Usually, the audio signal is passed via filters and amplifiers to a loudspeaker system so that, for example, the character of the sound may be affected at will. Frequently, the "brilliance" of the sound is to be modified. "Brilliance" means that in a sound comprising treble and bass compo nent, the treble components are emphasized.

It is the object of the present invention to provide a D-A-converter for instruments wherein the pulse magnitudes represent the amplitude differences of the respective sample amplitudes which convert, moreover, provides an "automatic brilliance control", i.e. the converter provides an attenuation of the bass frequencies only if and when there are also treble components in the sound. In other words, the player once selects a particular bass/treble balance, and this is automatically adapted during play with a tendency to more "brilliance".

The converter circuit according to the invention is defined in patent claim 1. Surprising enough, the complex effects outlined above require only a simple RC network provided that its time constant be substantially longer than the duration of each pulse. It is preferred to have this time constant in the order of magnitude of one period of the highest audio frequency to be produced. With such figures, the magnitude of the analog signal on the capacitor is sufficiently high to provide a satisfactory signal to noise ration.

The attached drawing is a simplified circuit diagram of the converter circuit according to the invention.

Block 10 symbolizes the digital circuitry of an electronic organ adapted to produce a pulse sequence wherein all pulses are of identical duration (or "width"), the repetition frequency is commensurate with the audio frequency to be generated, and the pulse magnitude is representative of the amplitude difference of successive wave form samples.

The pulse duration, in the embodiment, is 300 nanoseconds for each pulse.

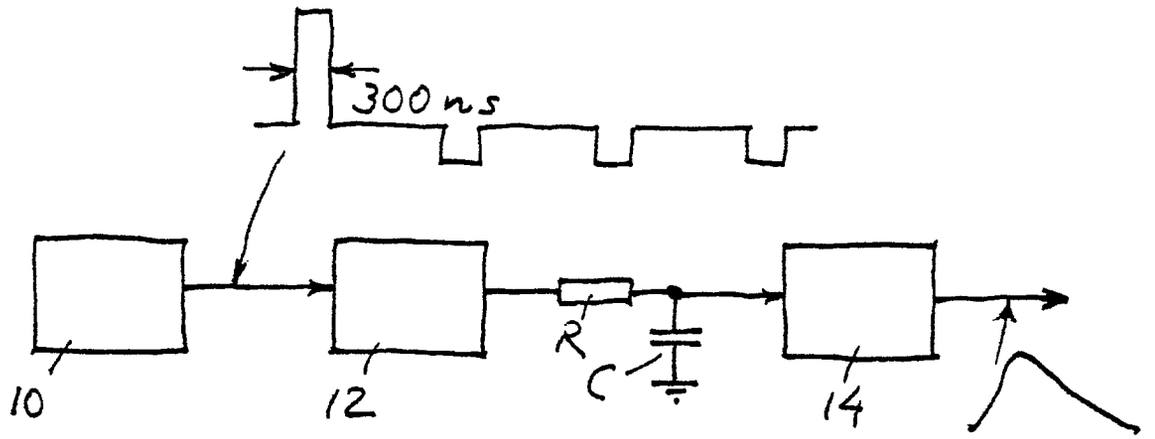
Block 12 symbolizes a multiplex switch, e.g. of the CMOS type 4051. Its purpose is to decouple block 10 from the converter during interpulse intervals so to make the pulse feeding circuitry have a high output impedance.

The very converter comprises resistor R having a value of 3.9 KiloOhm and a shunt capacitor C of 22 nanoFarad in the present embodiment. One terminal of the capacitor is connected to ground as reference potential. An amplifier 14 having a high input impedance is connected to the R-C-junction.

Claims

1. - Feeding circuit means having a high output impedance and supplying pulses of equal duration, the magnitude of said pulses representing samples of an audio wave form such that each pulse magnitude is the difference of the amplitude of the represented sample relative to the preceding sample (Delta modulation), the repetition frequency of said pulses being representative of the audio frequency of said audio wave,
-a resistor connected with its terminals respectively to said high impedance output of said feeding circuit means and to a first terminal of a capacitor whose other terminal is connected to a reference potential,
wherein said resistor has a value R and said capacitor has a value C such that the product R.C is substantially greater than said pulse duration.

2. A converter as defined in claim 1 wherein said product R.C is substantially equal to one period of the highest audio frequency to be generated.


300 ns
R
C
10
12
14

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EUROPEAN SEARCH REPORT

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EP 86 40 2371

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	US-A-2 605 361 (C.C. CUTLER) * Column 2; column 3, lines 44-75; column 4, lines 1-40; column 5, lines 6-25; figures 1,2,4 *	1	G 10 H 1/12
X	DE-A-3 004 720 (S. TAKAHASHI) * Page 11, lines 15-24; page 12, lines 1-19; figures 1,4-6 *	1,2	
A	US-A-4 111 090 (R. DEUTSCH) * Column 5, lines 3-13; figure 1 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

G 10 H
H 04 B
H 03 M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23-06-1987	PULLUARD R.J.P.A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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