United States Patent [19]

Lin

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[54] **BLENDING FUNCTION AND BLENDING FUNCTION GENERATOR**

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[52] **U.S. Cl.** ..... **343/106 D;** 328/28

[51] **Int. Cl.** **G01s 1/40**

[58] **Field of Search** .... 343/106 D, 113 DE; 328/13, 328/59, 28

[56] **References Cited**

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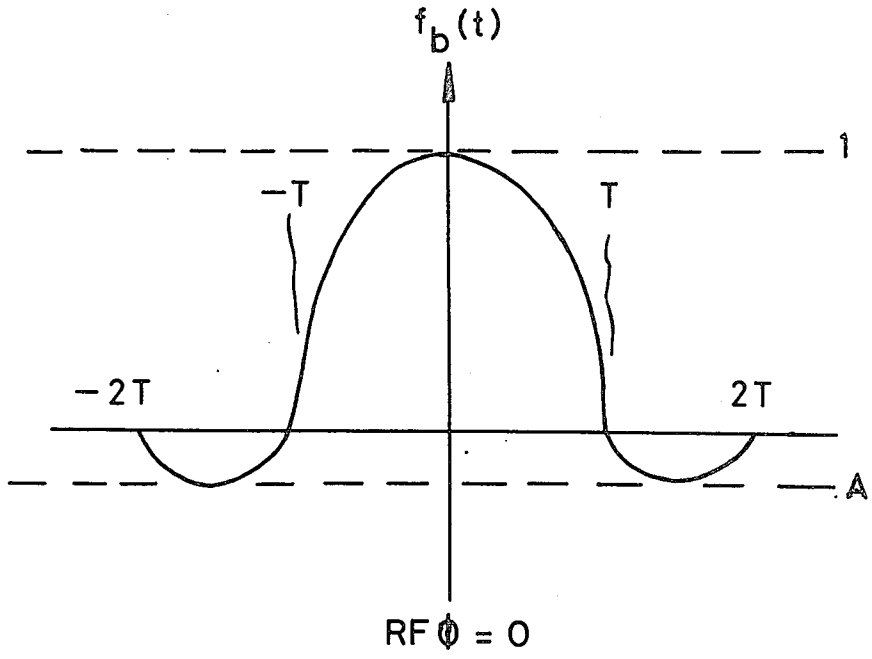
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Attorney, Agent, or Firm—Browne, Beveridge, DeGrandi & Kline

[57] **ABSTRACT**

A blending function generator for use in the electronic commutation of a ring of antenna elements in doppler omni-range (DVOR) systems. The blending function comprises a first lobe flanked by second and third lobes, the first lobe consisting of a cosine lobe having a period of 2T seconds where $T=Ymn$ where m is a number and n is a whole number, the second and third lobes each consisting of a cosine lobe having a period of T seconds, the second and third lobes being of the same phase and of opposite phase to the first lobe.

2 Claims, 3 Drawing Figures



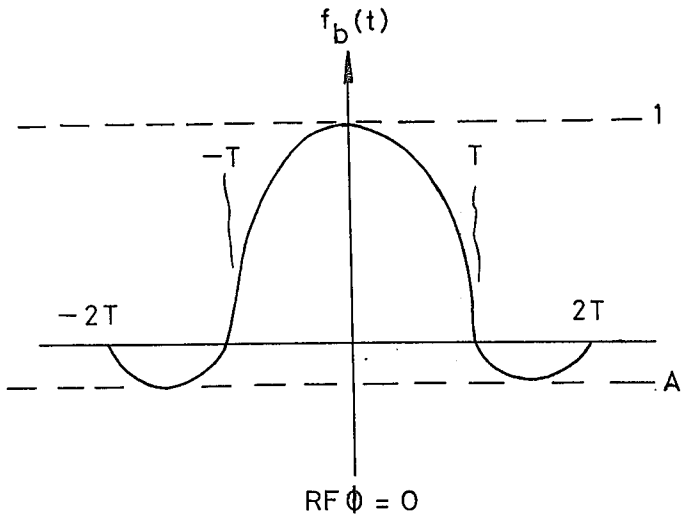

$f_b(t)$
1
-T
T
-2T
2T
A
RF Φ = 0

FIG. 1.

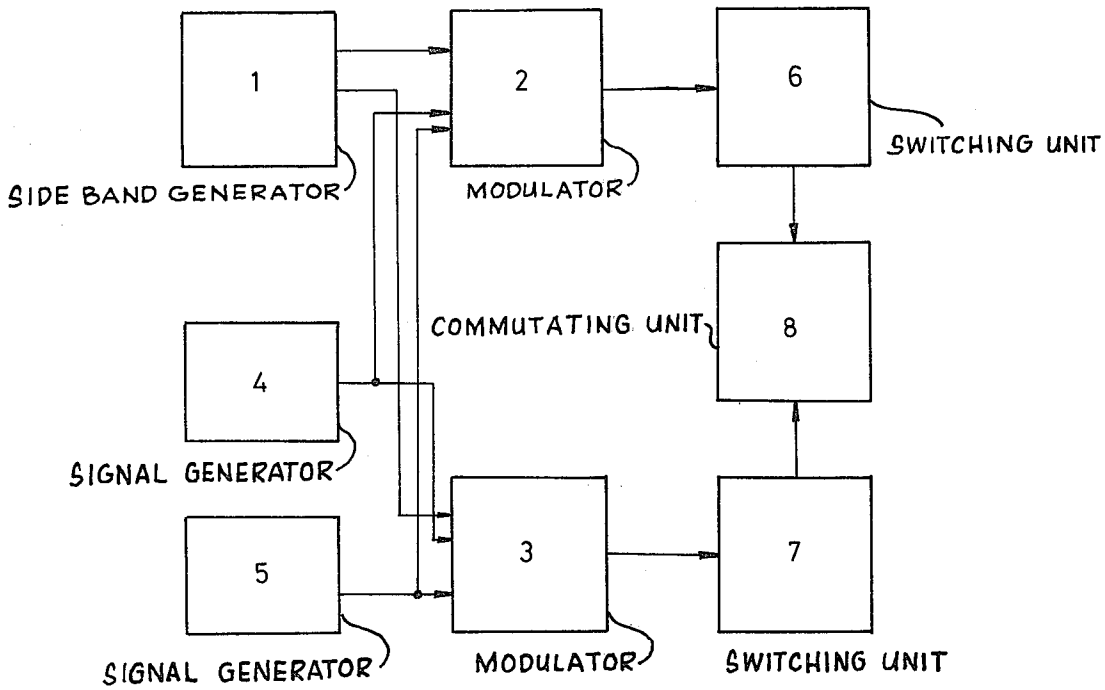

1
SIDE BAND GENERATOR
2
MODULATOR
6
SWITCHING UNIT
COMMUTATING UNIT
8
4
SIGNAL GENERATOR
5
SIGNAL GENERATOR
3
MODULATOR
7
SWITCHING UNIT

FIG. 3.

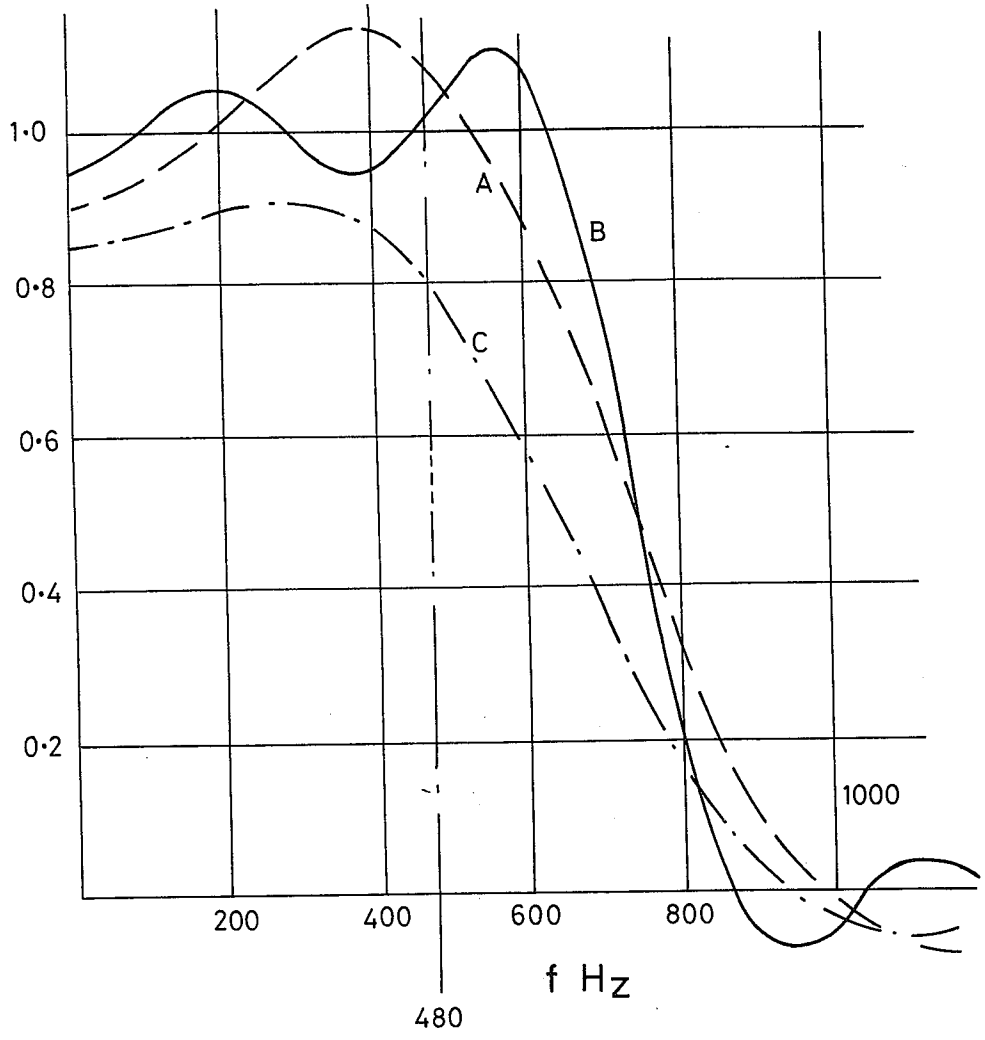


FIG. 2.

BLENDING FUNCTION AND BLENDING FUNCTION GENERATOR

The object of this invention is the provision of an improved blending function and blending function generator for use where a plurality of loads is electronically commutated to a source of energy. This invention is primarily but not exclusively intended for use in doppler VHF omni-range (DVOR) systems, and will therefore be described in relation to such systems.

The term "blending function" describes the transfer function which determines the current versus time characteristic applicable during each connection of a load to the source of energy. As permitted by the text of this specification, the term indicates both the function itself and a train of energy modulated by the function. Similarly, the term "blending function generator" describes means of determining the blending function and means of producing a train of energy modulated by the function. This approach has been adopted because, as will be seen later, the synthesisation of the function itself and the production of a train of energy modulated by the function occur simultaneously in practice.

DVOR systems include means for simulating the rotation of a radiating antenna on a radius which may typically be of the order of 22.5 feet about a central point. In modern systems the simulation means consists of a ring of individual antenna elements disposed on the periphery of a circle, and an arrangement for cyclically translating one or more signals from signal generators to one or more of the individual antenna elements, that is, a commutating arrangement. Electronic commutating means are presently used, not only because they avoid the disadvantages associated with mechanical arrangements, but because they lend themselves more readily to the realisation of a desirable transfer function during the switching process.

In an arrangement involving a plurality of antenna elements disposed on the periphery of a circle, and the cyclic translation of one or more signals to one or more antenna elements in order to simulate a constant-speed rotation of one or more antenna elements around the said periphery, the transfer function during the switching process is of great importance. In order to approach as closely as possible to the ideal simulation of antenna motion, it is essential that the antenna element current versus time characteristic be carefully controlled by a transfer function during the connection of the antenna element by the commutating arrangement.

Published results of an analysis of the sampling effect of the cyclic energisation of antenna elements in the described situation have shown that the application of a square burst of RF energy to each antenna element is not correct, and have suggested that the desirable function is a true sinX/X modulation, usually termed the blending function. This function is provided by a blending function generation. The sinX/X function, even in the truncated form in which it has been used in practice, is difficult to generate. This use of a less than perfect function has lead to degraded performance characteristics in DVOR systems, and this is clearly a matter of considerable concern in a system used for navigational purposes. In particular, the use of a less than optimum transfer function increases amplitude and phase modulation of the signals to be transmitted, resulting in degradation of bearing accuracy.

Further, given a sinX/X function, the number of lobes associated with the function has a bearing on the production of undesired amplitude and phase modulation of the signals to be transmitted. Thus, a seven-lobe sinX/X function produces less amplitude modulation of the frequency-modulated sub-carrier than a three-lobe sinX/X function, this frequency-modulated sub-carrier containing, in a DVOR system, the azimuth bearing information. Clearly, a seven-lobe sinX/X function is more difficult to generate than a three-lobe sinX/X function.

Herein the word "lobe" is used to define a segment of modulated radio frequency energy, between two consecutive zero vaues, forming part of a blending function, and/or its graphical representation.

As opposed to current practice, this invention abandons the use of a sinX/X function and introduces instead the concept of a synthesised blending function using three cosine lobes.

A blending function as described herein in accordance with this invention comprises a first lobe flanked on either side by second and third lobes, the first lobe consisting of a cosine lobe having a period 2T seconds where $T = 1/mn$ where m is a number and n is a whole number, the second and third lobes each consisting of a cosine lobe having a period T seconds, wherein the second and third lobes are of the same phase and are of opposite phase referred to the first lobe.

A blending function generator as defined herein in accordance with this invention comprises first means for delivering a cosine-modulated train of radio frequency energy wherein each cosine-modulated lobe has a period 2T seconds where $T = 1/mn$ where m is a number and n is a whole number, second means for delivering a cosine-modulated train of radio frequency energy wherein each cosine-modulated lobe has a period T seconds, wherein the radio frequency energy of the second means has the same frequency as that of the first means but opposite phase and wherein zeros in the cosine-modulated train delivered by the first means coincide with zeros in the cosine-modulated train delivered by the second means, and electronic switching means operative to select and deliver to an output terminal in contiguous successive time intervals a first cosine lobe derived from the second means, a second cosine lobe derived from the first means, and a third cosine lobe derived from the second means.

In a DVOR beacon in which a plurality of antenna elements is electronically commutated to an energising source, this invention is characterised by first means for delivering a cosine-modulated train of radio frequency energy wherein each cosine-modulated lobe has a period 2T seconds where $T = 1/30n$ where n is the number of antenna elements, second means for delivering a cosine-modulated train of radio frequency energy wherein each cosine-modulated lobe has a period T seconds, wherein the radio frequency energy of the second means has the same frequency as that of the first means but opposite phase and wherein zeros in the cosine-modulated train delivered by the first means coincide with zeros in the cosine-modulated train delivered by the second means, and electronic switching means operative to select and deliver to an output terminal in contiguous successive time intervals a first cosine lobe derived from the second means, a second cosine lobe derived from the first means, and a third cosine lobe derived from the second means.

In the drawings:

FIG. 1 shows the blending function;

FIG. 2 shows curves illustrating the improvements effected by the invention; and

FIG. 3 shows an embodiment of the invention.

The synthesisation of the novel blending function based on the use of three cosine lobes is illustrated in FIG. 1. As shown in the figure, the central lobe has a period 2T seconds, where $T = 1/30n$, n being the number of antenna elements in the aforementioned circular array of antenna elements. The two side lobes, attenuated by a factor A, are of opposite RF phase with respect to the RF phase of the central lobe, and the period of each side lobe is T. The novel blending function of FIG. 1 can be synthesised with comparative ease by electronic switching of two cosine-modulated RF trains of constant phase, one RF train corresponding to the central lobe and the other RF train corresponding to the two side lobes. The electronic switching involved in the synthesisation of the blending function is assisted by the fact that the switching occurs at times when the RF energy is zero. The production of the "cosine" blending function is seen to be clearly less difficult than the production of a sinX/X function; it remains to be seen how the cosine blending function performs.

Analysis has shown that the performance of the novel blending function is comparable with that of a seven-lobe sinX/X function, and is much better than that of a three-lobe sinX/X function. This is illustrated in FIG. 2, which shows a frequency spectrum related to the equivalent system filter bandwidth. The ordinate represents amplitude modulation, in this case amplitude modulation of the frequency-modulated sub-carrier which contains the azimuth information in a DVOR system, and the abscissa represents the frequency deviation of the same sub-carrier resulting from the customary 30 Hz modulation. This deviation in present systems is ± 480 Hz.

In FIG. 2, curve A represents a three-lobe sinX/X function in use, and the corresponding amount of amplitude modulation that results. Curve B shows the improvement over the three-lobe sinX/X function that is available from the use of a seven-lobe sinX/X function. Curve C shows the effect of the use of the novel cosine blending function in accordance with this invention. It will be seen that the cosine blending function offers improved performance as compared with the three-lobe sinX/X function, and a performance which is comparable with that obtained with the seven-lobe sinX/X function.

The invention will now be described in more detail with reference to FIG. 3 of the accompanying drawings, which shows one embodiment of the invention as applied to a DVOR system.

In the embodiment of FIG. 3 the DVOR system is assumed to be of the double sideband type, in which an upper sideband is radiated from one antenna element of a ring of elements at the same time as the lower sideband is radiated from the diametrically opposite antenna element, and the sideband signals are commutated around the ring of elements so as to simulate the rotation of a radiating antenna. A carrier frequency signal is continuously radiated from a centrally-located antenna (not further described).

In FIG. 3 a sideband generator, represented by 1, is fed with a carrier frequency voltage f_o and a modulating voltage f_m and produces at separate outputs the upper sideband $f_o + f_m$ and the lower sideband $f_o - f_m$. These outputs are fed respectively to modulators 2 and 3, which preferably take the form of varactor diode bridges.

Blocks 4 and 5 represent modulating signal generators which, by full-wave rectification of low-frequency oscillations, produce trains of half-cosine waves of opposite polarity and different amplitude and having periods of T and 2T respectively. Both these wavetrains are fed to modulators 2 and 3, where they modulate the sideband energy to produce corresponding trains of radio-frequency waves. The modulated outputs from 2 and 3 are fed to switching units 6 and 7, which, by successive selection of lobes of modulated radio-frequency energy of periods T, 2T and T respectively, produce the blending function as described herein. Outputs from switching units 6 and 7, which are blending functions of upper and lower sideband energy respectively, are fed to commutating unit 8 by which the blending functions are fed to appropriate antenna elements and are commutated around the ring of elements.

Timing means (not shown) control the entire operation so that the various processes are correctly synchronised and antenna commutation is at the required rate.

I claim:

1. A blending function generator as defined herein comprising first means for delivering a cosine-modulated train of radio frequency energy wherein each cosine-modulated lobe has a period 2T seconds where $T = 1/mn$ where m is a number and n is a whole number, second means for delivering a cosine-modulated train of radio frequency energy wherein each cosine-modulated lobe has a period T seconds, wherein the radio frequency energy of the second means has the same frequency as that of the first means but opposite phase and wherein zeros in the cosine-modulated train delivered by the first means coincide with zeros in the cosine-modulated train delivered by the second means, and electronic switching means operative to select and deliver to an output terminal in contiguous successive time intervals a first cosine lobe derived from the second means, a second cosine lobe derived from the first means, and a third cosine lobe derived from the second means.

2. In a DVOR beacon in which a plurality of antenna elements is electronically commutated to an energizing source, a blending function generator as claimed in claim 1 wherein $T=1/30n$ where n is the number of antenna elements.

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