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(54) SIGNAL SIMULATOR

(71) We, ELTRO GmbH GESELLSCHAFT FÜR STRAHLUNGSTECHNIK, a German limited liability company, of 6900 Heidelberg 1, Kurpfalzring 106, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

This invention relates to a simulator for simulating the output signal or signals of a goniometer in a weapon system. A goniometer is used in the guidance system for a weapon to detect infrared signal emission from the weapon. Such a goniometer is disclosed in British Specifications Nos. 771,488 and 817,486, and is used for instance in the Franco-German HOT, MILAN and ROLAND weapon systems. It is an expensive matter to test a weapon guidance system by firing a test missile, since each shot may cost several thousand pounds.

It is thus an object of this invention to provide a simulator by which the functions of the goniometer may be simulated without the need for firing a test shot, and thus for example simulating the conditions, including the presence of noise in the system, which arise in actual use.

According to this invention there is provided a simulator for simulating an electrical output signal of a goniometer in a weapon system, which signal represents the deviation of a projectile or target radiation emitter from the optical axis of the goniometer in terms of polar coordinates centred on the said axis, wherein the simulator includes:–

a first a.c. signal operable at a first, higher frequency;

a second a.c. signal source and a frequency divider operable to produce a deviation signal at a second, lower frequency, the second source being linked to the first source via the divider to generate a simulated goniometer output signal having characteristics determined by both source; and

amplitude control means for controlling the level of the deviation signal thereby to control one of the output signal characteristics; and

wherein an output signal characteristic determined by the first source is representative of radiation intensity fluctuations produced by the goniometer, and output signal characteristics determined by the deviation signal are representative of the magnitude and angle coordinates of the deviation.

Thus it is possible in a reliable and relatively simple way to simulate signals produced by an infrared emitter situated anywhere within a defined image area.

The first signal source may be a sweep signal generator emitting sinusoidal signals and a noise signal generator which superimposes a predetermined noise amplitude on the sinusoidal signals, while the second signal source may be a reference signal generator emitting signals at the sweep frequency of the sweep generator and synchronous reference signals for a coordinates converter. The synchronous simulation of sweep and reference signals is necessary because the goniometer pick-up, whose output is to be simulated, is mechanically rigidly coupled to the frequency modulation device of the goniometer modulator.

With regard to the individual component units selected, it is of advantage for the part of the frequency divider chain linking the sweep signal generator and the reference signal generator to comprise, in the direction of action, a first bistable multivibrator, a switch permitting a 90° switch-over, a monostable multivibrator, a second bistable multivibrator, a positive-negative switch (for 180° switch-over), an active filter and a potentiometer. While each bistable multivibrator serves for frequency division, the monostable multivibrator serves for continuous phase displacement by 150°, the active filter converts square wave into sinusoidal signals and the potentiometer regulates the sweep width, and the two switches in the frequency divider chain provide in one case a 90° switch-over (Y-Z) and in the other a 180° switch-over or a switch-over from positive to negative polarity and *vice versa.*

The bistable multivibrator adjacent the reference generator, through its two outputs - in the direction of action - operates for each output a channel associated with the output and to operate the co-ordinates converter *via* a terminal, in which case the two channels are each composed of a bistable multivibrator and a transformer.

With regard to the two switches, one can be used for connecting the input of the monostable multivibrator in each case to one of the two outputs of one bistable multivibrator while the other can be used to connect the input of the active filter to one of the two outputs of the other bistable multivibrator.

The sweep signal generator and the noise signal generator outputs may be connected to a common combining stage, and a potentiometer may be connected between the sweep generator and the combining stage. The potentiometer can thus serve for adjustment of signal amplitude. The potentiometers can be in the form of ten-turn helical potentiometers and can be mounted on a common control panel, it having been found favourable from the structural point of view for an integer angular deviation, measured in radians, to correspond to one rotation.

According to further features of the invention, sweep generator, noise generator and combining stages on the one hand and reference generator, filter and all the multivibrators on the other, may be mounted on printed circuits boards. It is of advantage for all generators, the combining stage and the associated potentiometers together with the frequency divider chain to be constructed as one compact structural unit.

An embodiment of the invention will now be described with reference to the single Figure of the drawing which is a block diagram.

A first sweep generator 1 with a centre frequency of for example 1800 Hz constitutes the signal source for a simulated target display. This generator simulates the mechanical movement of the modulator of a well-known goniometer. By means of a noise generator 2, a predetermined noise amplitude is superimposed on the sinusoidal signal emanating from the generator 1. In this form, the signal passes *via* a combining stage 3 which doubles as an output amplifier, to an output terminal 16. The amplitude of the signal is regulated by a potentiometer 5. The latter can for example be of the ten-turn type and have a resistance of 100 kΩ. The generator 1 and the noise generator 2, together with the output amplifier 3, are mounted on a printed circuit board 21.

A second generator 4 with a frequency of for example 120 Hz constitutes a reference signal source for the phase angle of the simulated target display in polar co-ordinates. It is also mounted on a printed circuit board, together with a plurality of multivibrators and a filter, and provides on the one hand the reference signals for co-ordinates convertors 17 operating at a frequency of for example 30 Hz, and on the other hand and synchronously therewith the sweep frequency of for example 30 Hz for the generator 1.

In order to be able to simulate any target location within an image area apart from the continuous phase displacement (for example 150°) by means of a monostable multivibrator 10, H two switches 8 and 9 are provided. By means of the switch 8, it is possible to connect the input 26 of the monostable multivibrator 10 to the output 12 or the output 13 of a bistable multivibrator 11, and by means of the switch 9 the input 27 of an active filter 20 can be connected to the output 28 or the output 29 of a bistable multivibrator 19. In consequence, the switch 8 provides a 90° switch-over for Y and Z co-ordinates and the switch 9 a 180° switch-over from "positive" to "negative" and *vice versa.* The reference signals to operate the co-ordinate converter 17 are derived from the second generator 4 and converted by the bistable multivibrator 11 to for example 60 Hz. The two outputs 12 and 13 head to further divider stages in the form of two bistable multivibrators 6 and 7 which bring the frequency from 60 Hz to for example 30 Hz. The two 90° phase-displaced rectangular signals U_Y and U_Z are fed through transformers 14 and 15 to output terminals 16. The signal is virtually sinusoidal and floating.

Downstream of the divider stage 4, 11, i.e. in the present embodiment after division of the frequency from 120 Hz to 60 Hz, the monostable multivibrator 10 is operated and this permits continuous phase displacement of 150° in respect of the reference signal. A potentiometer 18 mounted on a control panel (not shown) constitutes the variable resistance part of a phase-determining RC element 18, 18′. This potentiometer can be for example of the ten-turn type having a resistance of 10 kΩ. After frequency division by the bistable multivibrator 19 from 60 Hz to 30 Hz, the 30 Hz square wave signal 24 is converted by the active filter 20 into a sinusoidal sweep signal 25. A potentiometer 23 is connected to the output of the filter 20 to vary the signal amplitude. Thus the generator 1 receives a deviation signal which is variable in amplitude so as to enable the magnitude of the simulated deviation, i.e. the deviation of the radiation emitter from the optical axis, to be varied by varying the sweep width. Reference 30 denotes a fixed resistance. By operating the helical potentiometer 5, it is possible to adjust the amplitude of the output signal from the sweep generator 1 before it is fed to the combining stage 3.

As indicated by the dash-dot lines, in the present embodiment the generators 1, 2, 4, the decoupling output amplifier stage 3 and the entire frequency divider chain 9 to 16 and 18 to 30 are constructed as a single, compact unit 31. Other embodiments (not shown) may provide for sub-division into a plurality of structural units. The invention is not limited to the stated phase angles and frequencies. Other values could be used as required, with correspondingly selected components.

WHAT WE CLAIM IS:–

1. A simulator for simulating an electrical output signal of a goniometer in a weapon system, which signal represents the deviation of a projectile or target radiation emitter from the optical axis of the goniometer in terms of

polar coordinates centred on the said axis, wherein the simulator includes:—

a first a.c. signal source operable at a first, higher frequency;

a second a.c. signal source and a frequency divided operable to produce a deviation signal at a second, lower frequency, the second source being linked to the first source via the divider to generate a simulted goniometer output signal having characteristics determined by both sources; and

amplitude control means for controlling the level of the deviation signal thereby to control one of the output signal characteristics; and

wherein an output signal characteristic determined by the first source is representative of radiation intensity fluctuations produced by the goniometer, and output signal characteristics determined by the deviation signal are representative of the magnitude and angle coordinates of the deviation.

2. A simulator according to Claim 1 wherein the frequency divider is connected to the first source to frequency modulate the output signal of that source, the modulation amplitude being variable by the amplitude control means to vary the magnitude coordinate of the simulated deviation.

3. A simulator according to Claim 1 or Claim 2 wherein the frequency divider includes a plurality of individual divider stages and, associated with the said stages, switching means operable to change the phase of the deviation signal relative to a reference signal source thereby to change the angle coordinate of the simulated deviation.

4. A simulator according to Claim 3 wherein the second signal source constitutes the reference source, the output of which source is coupled to a coordinates converter.

5. A simulator according to any preceeding claim including an electrical noise generator for introducing a noise component of predetermined level into the simulated output signal.

6. A simulator according to Claim 5 wherein the outputs of the first signal source and the noise generator are coupled to a combining stage, the simulator including further amplitude control means operable to adjust the level of the output signal from the first signal source before it is fed to the combining stage.

7. A simulator according to Claim 3 wherein the frequency divider comprises, in the direction of signal flow, a first bistable multivibrator coupled to the output of the second signal source, a first switch operable to produce a 90° phase shift in the deviation signal, a monostable multivibrator, a second bistable multivibrator, a second switch operable to produce a 180° phase shift in the deviation signal and a filter.

8. A simulator according to Claim 3 wherein at least one stage of the frequency divider comprises a bistable multivibrator having two complementary outputs connected to opposite terminals of a changeover switching device, so that operation of the switching device causes a 90° phase shift in the deviation signal.

9. A simulator according to Claim 3 wherein at least one stage of the frequency divider comprises a bistable multivibrator having two complementary outputs, each output being connected to a respective transformer-coupled reference output stage.

10. A simulator according to Claim 9 wherein each reference output stage comprises a bistable multivibrator having two outputs connected to a transformer primary winding.

11. A simulator according to Claim 7 wherein the input of the filter can be connected via the second switch to either one of two outputs of the second bistable multivibrator.

12. A simulator according to Claim 6 wherein the said second amplitude control means comprises a potentiometer connected between the first source and the combining stage.

13. A simulator according to Claim 6 or Claim 12 wherein the first and second amplitude control means comprise ten-turn helical potentiometers mounted on a common board.

14. A simulator according to any preceeding claim wherein the frequency divider includes a multi-turn potentiometer operable to vary continuously the phase of the deviation signal with one turn of the potentiometer corresponding to an integer change of the deviation angle measured in radians.

15. A simulator constructed and arranged substantially as herein described and shown in the drawing.

WITHERS & ROGERS
Chartered Patent Agents
4 Dyer's Buildings
Holborn London
EC1N 2JT
Agents for the Applicant

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*