

1,195,818



PATENT SPECIFICATION

DRAWINGS ATTACHED

1,195,818

Inventor: HANS BERTIL ANDERSSON

Date of Application (No. 14217/69) and filing Complete Specification: 18 March, 1969.

Application made in Sweden (No. 3961) on 25 March, 1968.

Complete Specification Published: 24 June, 1970.

Index at Acceptance:—H3 A (7P2, 7P62, 7P70).

International Classification:—H 03 d 13/00.

COMPLETE SPECIFICATION

Phase Detector

We, AKTIEBOLAGET BOPORS of 690 20 Bofors, Sweden, a joint stock company organised according to the laws of Sweden, 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:—

The invention relates to a phase detector for a direct voltage amplifying device in which the direct voltage which is to be amplified, is applied to a chopper operating with a certain frequency, and the chopped voltage from the output of the chopper is applied to an alternating voltage amplifier whose output is connected to a rectifying device for rectifying the output voltage of the alternating voltage amplifier.

In a conventional direct voltage amplifying device of this kind the polarity of the output direct voltage is independent of the polarity of the input direct voltage. However, it is often desirable to know the polarity of the input voltage and to make the polarity of the output voltage dependent on that of the input voltage. This can be accomplished by means of phase detection of the output alternating voltage from the alternating voltage amplifier, since the phase of this voltage becomes dependent of the polarity of the input direct voltage. A conventional phase detection, however, produces a direct voltage after the detector which is also dependent on the phase-shift of the alternating voltage amplifier. If this phase-shift differs from 0° or 180° the detected voltage is reduced from its correct value. Also the output direct voltage becomes at most equal to the rectified mean value of the alternating voltage at the output.

The object of the present invention is to provide a phase detector the output voltage

of which is only to a very small degree dependent of the phase-shift of the alternating voltage amplifier and is approximately equal to the crest value of the output voltage of the amplifier.

According to the invention at least one four-terminal network is connected to the output of the alternating voltage amplifier, said four-terminal network including in a first shunt branch a switch which is adapted to be periodically switched on and off with a frequency corresponding to the operating frequency of the chopper, and including in a series branch a rectifier and in a second shunt branch a capacitor adapted to be charged over said rectifier.

In the following the invention will be described more in particular with reference to the accompanying drawing.

Fig. 1 shows schematically an amplifier provided with a phase detector according to the invention.

Fig. 2 is a diagram illustrating the mode of operation of the phase detector.

Referring now to Fig. 1, A designates an alternating voltage amplifier and CH a chopper the output of which is connected to the input of amplifier A. The direct voltage which is to be amplified is fed to the chopper CH over the input IN. The chopper CH is controlled by an output voltage of a certain frequency from a vibrator V. The vibrator V produces an output voltage having a substantially rectangular wave form as shown in the figure.

The output alternating voltage from amplifier A is taken from the resistor R1, this resistor and a capacitor C1 forming part of the output circuit of the amplifier.

The phase detector comprises two four-terminal networks which are connected in parallel with each other to the output of amplifier A. Each network comprises in a

[Price 5s. 0d.]

series branch a resistor R11 and R21 respectively and a rectifier D12 and D22 respectively and in a first shunt branch a rectifier D11 and D21 respectively in series with the collector-emitter path of a transistor Q1 and Q2, respectively, and in an additional shunt branch a capacitor C11 and C21 respectively in parallel with a resistor R13 and R23 respectively. The transistors Q1 and Q2 have their base electrodes connected to the vibrator V, so that the transistors are alternately made conductive and non-conductive under the control of the control voltage from the vibrator. Thus, transistors Q1 and Q2 operate as switches. The base of transistor Q1 is directly connected to the vibrator V, while the base of transistor Q2 is connected to vibrator V over a phase-shifting device PS which produces a phase-shift of 180°. Hereby the transistors Q1 and Q2 will operate in phase opposition, so that one transistor is conductive when the other one is non-conductive and vice versa. The rectifier diodes D11 and D21 prevent the collector-emitter paths of the transistors from being subjected to voltage in the back direction.

Fig. 2 shows the output alternating voltage UAC from the alternating voltage amplifier A as a function of time. The full-drawn curve shows the voltage in the case that the phase-shift of amplifier A is exactly 0° or 180°. In this case the times at which the voltage UAC goes through zero will coincide with the times for the change of the conductive state of transistors Q1 and Q2, since these transistors are controlled in phase or in phase opposition respectively with the chopper CH. These times are indicated in Fig. 2 by dotted vertical lines and the time intervals between these times are indicated t1-t4.

The dotted curve in Fig. 2 indicates the output alternating voltage UAC in the case that the phase-shift of amplifier A differs from 0° or from 180°.

The voltage which is fed to amplifier A from the chopper CH has an approximately rectangular wave form. It is assumed that amplifier A is so designed that the second and higher harmonics of this voltage are suppressed to the larger part so that the output voltage UAC of the amplifier becomes approximately sinusoidal as shown in Fig. 2.

The device operates in the following manner:

It is assumed that the transistor Q1 is non-conductive and transistor Q2 conductive during the intervals t1 and t3, while conditions are reversed during intervals t2 and t4 (Fig. 2). If the output alternating voltage from amplifier A has a positive half-cycle during interval t1 (as shown by the full-drawn curve in Fig. 2) this voltage will be

applied over resistor R11 and diode D12 to the filter formed by capacitor C11 and resistor R13, and the terminal B receives a positive potential in relation to the grounded terminal C. Since transistor Q1 is non-conductive during this interval it does not affect the voltage. Transistor Q2, however, is conductive during this interval, and therefore, the voltage will be carried to ground over resistor R21, diode D21 and the conducting transistor Q2. The direct voltage after diode D22 becomes very small and about equal to the residual voltage across the conducting transistor Q2. Therefore, no appreciable direct voltage appears between terminals D and C.

The next half-cycle of the output voltage from amplifier A is negative (interval t2 in Fig. 2). This voltage is prevented by diodes D12 and D22 from arriving at terminals B and D respectively. The diodes D11 and D21 prevent the voltage from influencing transistors Q1 and Q2 respectively. During the following positive half-cycle in interval t3 the operation is the same as during interval t1.

If the input direct voltage has such polarity that the output alternating voltage from amplifier A has positive half-cycles during those intervals when transistor Q1 is not conducting and transistor Q2, conducting, the direct voltage terminal B will consequently have a positive polarity with respect to the terminal D. If the input direct voltage has such a polarity that the positive half-cycles of the output alternating voltage appears during those intervals when transistor Q1 is conducting and transistor Q2 non-conducting, the terminal D will obviously be positive with respect to terminal B, since in this case the conducting transistor Q1 passes the voltage directly to ground, while transistor Q2 is non-conductive and thus allows the full voltage to arrive over diode D2 to filter C21-R23 and terminal D.

The resistor R11 and R21 prevent the conducting transistor from short-circuiting the non-conducting transistor.

The capacitors C11 and C21 respectively are charged by the applied positive voltage across diode D12 and D22 respectively. This charge leaks away only slowly over resistor R13, and R23 and the load (not shown) connected to the output terminals. Therefore, capacitor C11 or C21 will receive a direct voltage which is only slightly lower than the crest voltage of the positive half-cycles of the output alternating voltage from amplifier A. Thus, the rectification in diodes D12 or D22 becomes a peak rectification, i.e. current flows through diode D12 or D22 respectively only during a minor portion around the peak of each positive half cycle. This means that if the phase-

shift in amplifier A differs from 0° or from 180° as shown by the dotted curve in Fig. 2, this does not affect the magnitude of the output direct voltage. Theoretically the phase-shift may differ by $\pm 90^\circ$ from 0° but in practice the permissible phase difference is somewhat smaller because the peak rectifier must utilize a certain part of the range around the peak for the rectification.

Thus, the phase detector according to the invention gives an output direct voltage which is independent of small phase deviations in the alternating voltage amplifier. Also this phase detector affords the advantage that the output direct voltage becomes practically equal to the crest value of the output alternating voltage from the amplifier, while in prior phase detectors the output direct voltage only becomes about equal to the mean value of the output voltage from the amplifier.

In certain cases it is desired to obtain an output direct voltage only when the input direct voltage has a certain polarity and no output direct voltage when the input voltage is of the opposite polarity. In this case one of the two four-terminal networks in the shown embodiment can be omitted and the output direct voltage taken from terminals B and C or D and C.

The embodiment shown and described above is given by way of example only and can be modified in many ways within the scope of the invention.

WHAT WE CLAIM IS:—

1. Phase detector for a direct voltage amplifying device in which the direct voltage which is to be amplified is fed to a chopper operating at a certain frequency, from the output of which the chopped voltage is fed to an alternating voltage amplifier, the output of which is connected to a rectifying device for rectification of the output voltage of the alternating voltage amplifier, characterized in that at least one four-terminal network is connected to the output of the alternating voltage amplifier (A), said four-terminal network including in a first shunt branch a switch (Q1) adapted to be periodically switched on and off at a rate corresponding to the operating frequency of said chopper (CH), and in a series branch a rectifier (D12) and in an additional shunt branch a capacitor (C11) adapted to

be charged over said rectifier (D12).

2. Phase detector as claimed in claim 1, characterized in that two four-terminal networks of the kind recited in claim 1 are connected to the output of the alternating voltage amplifier (A), the said switch (Q1) in one network being controlled in opposite phase to the switch (Q2) in the other network, so that one switch is off when the other is on and vice versa.

3. Phase detector as claimed in claim 1 or 2, characterized in that said four-terminal network or each of said four-terminal networks comprises a resistor (R11, R21) in series with said rectifier (D12, D22), said resistor being connected between the output of the alternating voltage amplifier (A) and said rectifier (D12, D22), and said first shunt branch (D11-Q1, D21-Q2) having one end connected to a junction point between the rectifier and the resistor.

4. Phase detector as claimed in any of claims 1-3, characterized in that the switch or each of said switches respectively consists of a transistor (Q1, Q2) having its collector-emitter path in said shunt branch and its base electrode connected to a source of control voltage for making the transistor alternately conductive and non-conductive at a rate corresponding to the operating frequency of said chopper (CH).

5. Phase detector as claimed in claims 2-4, characterized in that the base electrodes of said transistors (Q1, Q2) are connected to a vibrator (V) which is also connected to the chopper (CH), and that a phase-shifting device (PS) producing a phase-shift of 180° is connected between the base of one transistor (Q2) and the vibrator (V).

6. Phase detector as claimed in claim 4 or 5, characterized in that a rectifier (D11, D21) is connected in series with the transistor or in series with each of said transistors (Q1, Q2), said rectifier being so poled that it prevents the collector-emitter path of the transistor from being subjected to voltage in the back direction.

TREGEAR, THIEMANN & BLEACH,
Chartered Patent Agents,
Melbourne House,
Aldwych,
London, W.C.2.
Agents for the Applicants.

shift in amplifier A differs from 0° or from 180° as shown by the dotted curve in Fig. 2, this does not affect the magnitude of the output direct voltage. Theoretically the phase-shift may differ by $\pm 90^\circ$ from 0° but in practice the permissible phase difference is somewhat smaller because the peak rectifier must utilize a certain part of the range around the peak for the rectification.

Thus, the phase detector according to the invention gives an output direct voltage which is independent of small phase deviations in the alternating voltage amplifier. Also this phase detector affords the advantage that the output direct voltage becomes practically equal to the crest value of the output alternating voltage from the amplifier, while in prior phase detectors the output direct voltage only becomes about equal to the mean value of the output voltage from the amplifier.

In certain cases it is desired to obtain an output direct voltage only when the input direct voltage has a certain polarity and no output direct voltage when the input voltage is of the opposite polarity. In this case one of the two four-terminal networks in the shown embodiment can be omitted and the output direct voltage taken from terminals B and C or D and C.

The embodiment shown and described above is given by way of example only and can be modified in many ways within the scope of the invention.

WHAT WE CLAIM IS:—

1. Phase detector for a direct voltage amplifying device in which the direct voltage which is to be amplified is fed to a chopper operating at a certain frequency, from the output of which the chopped voltage is fed to an alternating voltage amplifier, the output of which is connected to a rectifying device for rectification of the output voltage of the alternating voltage amplifier, characterized in that at least one four-terminal network is connected to the output of the alternating voltage amplifier (A), said four-terminal network including in a first shunt branch a switch (Q1) adapted to be periodically switched on and off at a rate corresponding to the operating frequency of said chopper (CH), and in a series branch a rectifier (D12) and in an additional shunt branch a capacitor (C11) adapted to

be charged over said rectifier (D12).

2. Phase detector as claimed in claim 1, characterized in that two four-terminal networks of the kind recited in claim 1 are connected to the output of the alternating voltage amplifier (A), the said switch (Q1) in one network being controlled in opposite phase to the switch (Q2) in the other network, so that one switch is off when the other is on and vice versa.

3. Phase detector as claimed in claim 1 or 2, characterized in that said four-terminal network or each of said four-terminal networks comprises a resistor (R11, R21) in series with said rectifier (D12, D22), said resistor being connected between the output of the alternating voltage amplifier (A) and said rectifier (D12, D22), and said first shunt branch (D11-Q1, D21-Q2) having one end connected to a junction point between the rectifier and the resistor.

4. Phase detector as claimed in any of claims 1-3, characterized in that the switch or each of said switches respectively consists of a transistor (Q1, Q2) having its collector-emitter path in said shunt branch and its base electrode connected to a source of control voltage for making the transistor alternately conductive and non-conductive at a rate corresponding to the operating frequency of said chopper (CH).

5. Phase detector as claimed in claims 2-4, characterized in that the base electrodes of said transistors (Q1, Q2) are connected to a vibrator (V) which is also connected to the chopper (CH), and that a phase-shifting device (PS) producing a phase-shift of 180° is connected between the base of one transistor (Q2) and the vibrator (V).

6. Phase detector as claimed in claim 4 or 5, characterized in that a rectifier (D11, D21) is connected in series with the transistor or in series with each of said transistors (Q1, Q2), said rectifier being so poled that it prevents the collector-emitter path of the transistor from being subjected to voltage in the back direction.

TREGEAR, THIEMANN & BLEACH,
Chartered Patent Agents,
Melbourne House,
Aldwych,
London, W.C.2.
Agents for the Applicants.

