



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
16.04.2003 Bulletin 2003/16

(51) Int Cl.7: **H01Q 1/12, H01Q 13/02,
H01Q 19/02**

(21) Application number: **01402635.5**

(22) Date of filing: **11.10.2001**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR**
Designated Extension States:
AL LT LV MK RO SI

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(54) **Method and system for polarization alignment of an earth station antenna with the polarization axis of a satellite antenna**

(57) The invention relates to a method for the polarization alignment of an antenna of an earth station with the polarization axis of the antenna of a satellite emitting linearly polarized beacon signals.

This method is characterized in that the cross-polar

component of the received linearly polarized beacon signal is used as information representative of an antenna polarization misalignment.

The invention can be used for the polarization alignment of VSAT earth station antenna.

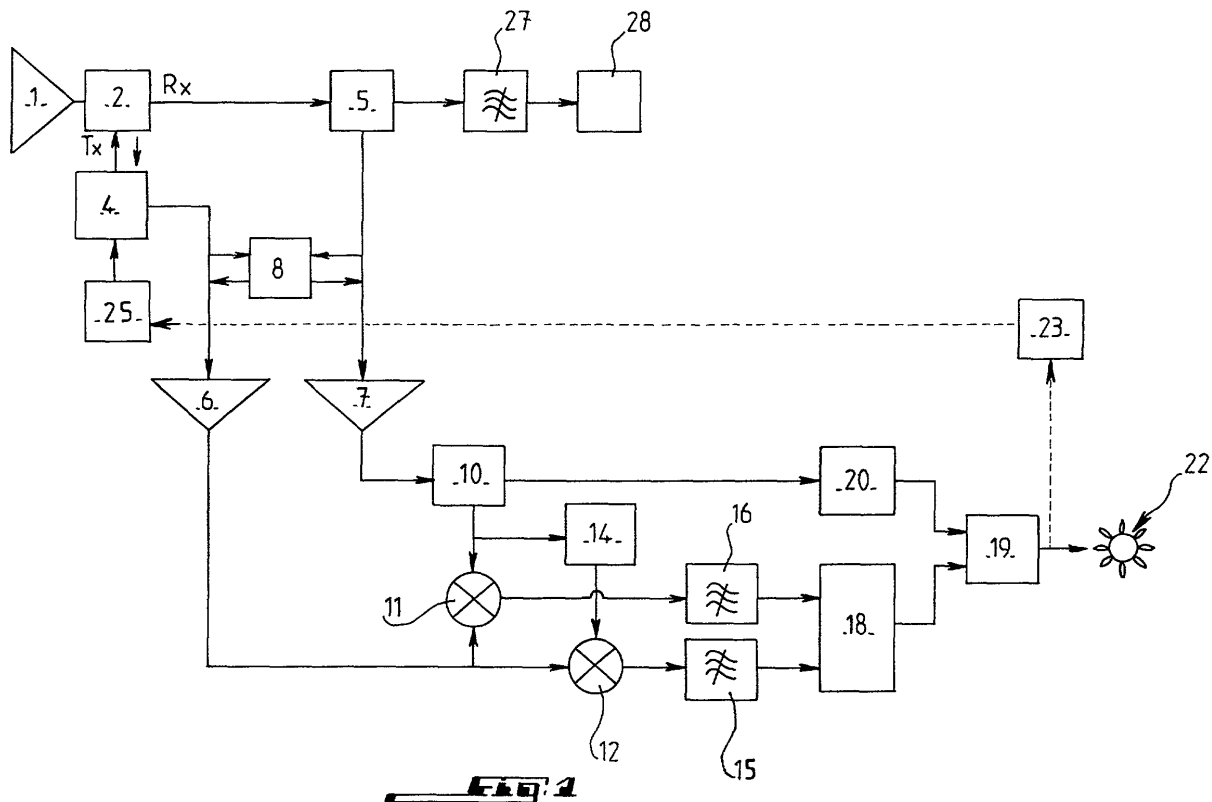


Fig. 1

Description

[0001] The invention relates to a method for the polarization alignment of an antenna of an earth station with the polarization axis of the antenna of a satellite emitting linearly polarized beacon signals and a system for putting into practice said method.

[0002] For each newly installed earth station antenna, operators are requested to perform an initial polarization alignment and subsequent continuous verification of it. Two methods are actually used for such a polarization alignment. The first one utilises a central site, such as the Hub, to monitor a co-polar and cross-polar components of the signal from the earth station under test, using a good quality spectrum analyser. The second method requires the use of a spectrum analyser at each earth station.

[0003] However, these two methods are not adapted for being used in small earth stations, called very small aperture terminals (VSAT).

[0004] The object of the invention is to develop a polarization alignment method and system for low cost VAST earth station which is simple to operate.

[0005] For realizing this object, the method according to the invention is characterized in that the cross polar component of the received linearly polarized beacon signal is used as information representative of the antenna polarization misalignment.

[0006] According to a feature of the invention the polarization misalignment signal is developed by comparison of the co-polar and cross-polar beacon signal components.

[0007] According to another feature of the invention, said polarization misalignment signal is a variable level signal such as a voltage signal and is used to activate visual or audible indicator means.

[0008] The system for putting into practice the method is characterized in that it comprises an orthomode transducer having a TX port and a RX port at which are available the cross-polar and the co-polar beacon signal components, that the cross-polar path comprises mixer means for mixing the cross-polar component with two phase orthogonal components of the same reference co-polar beacon component and adder-integrator means for producing the scalar product signal therefrom which is clear from frequency and phase ambiguities and in that it comprises a comparator receiving at its inputs said scalar product signal and the co-polar beacon component, said comparator producing the polarization misalignment signal.

[0009] According to another embodiment the system is characterized in that it comprises an orthomode transducer having a TX port and a RX port at which are available the cross-polar and co-polar beacon signal components, down converter means for down converting the cross-polar and co-polar beacon signal components to a band of a few hundreds of KHz, coherent demodulator means adapted to extract the amplitude information re-

lated to the beacon signal components and amplitude comparator means for producing said polarization misalignment signal.

[0010] The invention will be better understood and its objects, features, details and advantages will appear more clearly in the following explanatory description referring to the annexed schematic diagram cited as mere exemples illustrating two embodiments of the invention and in which :

- Figure 1 is a block diagram of a first embodiment of the invention, and
- Figure 2 is a block diagram of a second embodiment of the invention.

[0011] The invention concerns small earth stations, i. e. VSAT stations, having an antenna the polarization axes of which are to be aligned with the polarization axes of the satellite antenna to which the station shall transmit. Accordingly an initial polarization alignment is to be performed and subsequent continuous verification of it.

[0012] The invention is based upon the finding that the satellite beacon signal coming from the satellite can be used for the polarization alignment of the antenna of the VSAT earth station and in particular the cross polar component of the received beacon signal. This beacon signal is used to feed a device that is easy to interface to the typical feed sub-systems of any VSAT station. The output of the device consists of a variable level which is obtained from the processing of the beacon signal and which can be used for instance in order to activate visual or audible indications. These indications will notify unexperienced operators whether or not the VSAT station is correctly aligned and will guide the operator in reestablishing nominal, optimum, cross-polarization alignment conditions, despite of the non-visibility of the uplink carrier spectrum at the control center of the VSAT stations. Since this device should be a low cost device simple to operate, the electronic components to integrate in this device are all commercially available and low cost.

[0013] The first embodiment of the polarization alignment system according to the invention, in accordance to figure 1, comprises, downstream from the antenna feed 1 an orthomode transducer 2 having an RX port and a TX port. The co-polar component of the beacon signal is available at the RX port and aligned along the RX carrier and hence the cross-polar beacon component is available at the TX port and aligned along the VSAT TX carrier. However, it is to be noted that it is possible to operate the system also in the opposite polarization, by using a simple switch as will be shown below.

[0014] The beacon signal components are picked up by means of wave guide couplers with a high directivity in order to not affect the RX port and to properly isolate the TX high power amplifier from the system. Therefore, the cross-polar path or branch comprises a coupler which should be a diplexer 4 or a combination of a cir-

culator and a band-pass filter and the co-polar branch or pass comprises a coupler 5 which is a normal coupler with a pass-band filter. In both cases, the band-width of the pass-band filter is dimensioned in such a way to let the beacon pass, taking into account the beacon short and long term frequency deviations. To amplify both the co-polar and cross-polar signals, each branch comprises a low noise amplifier (LNA) respectively 6 and 7. Between the inputs of both LNAs 6 and 7 is mounted a switch 8 for operating the system in the opposite polarization, as indicated above.

[0015] The beacon cross-polar signal component is mixed with two components of the same reference co-polar beacon signal component coming from the output of a phase locked loop (PLL) 10. The PLL is connected to the output of the LNA 7. The PLL 10 reduces the noise induced by the beacon frequency variations. The beacon cross-polar component is mixed by a first mixer 11 with the co-polar component coming from the PLL 10 and by a second mixer 12 with the co-polar beacon component made phase-orthogonal by providing a $\lambda/4$ delay line 14 between the output of the PLL 10 and the input of the mixer 12. The step of mixing the cross-polar signal with two components of the same reference co-polar beacon signal, but phase-orthogonal to each other allows to achieve a maximum sensitivity and is to avoid that different phase delays along the two branches of the system could result in orthogonal signals in same conditions and hence to give a notch of error signal. In fact, the mixing of the cross-polar component with the reference co-polar component is equivalent to a scalar product which is equal to 0 when the phase shift between the relevant vectors is 90° . Thus at the outputs of the two mixers the following signals are obtained :

$$I = kA \cdot X \cdot \cos. \beta$$

$$Q = kA \cdot X \cdot \cos. (90 - \beta) = kA \cdot X \cdot \text{sine } \beta.$$

[0016] These two cross-polar components I and Q are applied each through a narrow band pass filter respectively 15 and 16 to an adder-integrator device 18 which produces the scalar product signal $(I^2 + Q^2)^{1/2}$, which is the beacon cross-polar signal cleaned from frequency and phase ambiguities. This scalar product is applied to a first input of a comparator 19 the second input of which is coupled to the output of an integrator 20 receiving the output of the PLL 10.

[0017] Thus, the scalar product at the output of the device 18 is compared with the co-polar beacon signal component used as a bench mark to compensate for the beacon level variations due to propagation effects.

[0018] The resulting comparison signal at the output of the comparator 19 which is a voltage level will be used to activate audible/visible alarm means 22 or a switch 23 for switching off the radio unit power supply which is

coupled to the diplexer 4 and indicated in 25. For completing the description of the figure 1, it is to be noted that the output of the coupler 5 is applied through a band-pass filter 27 to a low noise block down converter (LNB) 28.

[0019] The system has been described above as operating in the case that the signal transmitted from the VSAT station is in the opposite polarization of the received (co-polar) beacon. To make the device capable of operating also when the VSAT station is transmitting in the X polarization, i.e. receiving in the polarization opposite to the received beacon signal, the switch 8 is inserted in the system between the inputs of the two low noise amplifiers 6 and 7. This switch inverts the connection between the ports of the OMT 2 and the inputs of the co-polar and cross-polar branches of the device. The switch can be obtained by a stripline or microstrip network including properly polarised PIN diodes.

[0020] A second embodiment of the invention is shown on figure 2. This embodiment comprises an orthomode transducer (OMT) such as the OMT 2 of figure 1 coupled to an antenna feed 1 and comprising the ports RX and TX at which are available respectively the co-polar beacon signal component and the cross-polar beacon signal component. The RX port branch comprises a low noise block down converter (LNB) 13 and the TX branch includes a diplexer 31 coupled to a low noise block down converter (LNB) 32. These LNAs are phase-locked loop (PLL) LNB with an external reference oscillator.

[0021] The output of the RX branch LNB 30 is splitted at 33 into two lines, a first line 34 which is made available for an external L band receiver and another line 35 which is coupled to a second down converter 36 comprising a local oscillator 37, a mixer 38 and before and behind this mixer a filter respectively 39 and 40.

[0022] The LNB 32 is also coupled to a second down converter of the same kind as the down converter 36 and carrying the reference 36' with a mixer 38' and input and output band-pass filters 39' and 40'.

[0023] The local oscillator 37 is provided with a reference oscillator 42 which is also used as a reference oscillator for the LNAs 30 and 32. A DC/reference injector module 42, 42' is inserted between each LNB and the second down converter 36 and 36'.

[0024] It is to be noted that the filters of the down converters are used for the selection of the beacon signal and the attenuation of the other signal received by the antenna.

[0025] The outputs of the second down converters 36 and 36' are coupled to a dual channel DSP coherent receiver. The down converted signal in the band of few hundreds of kHz at the output of the converter 36 is applied to the main channel of the DSP coherent receiver 45 where it is used to synchronise a numerically controlled oscillator (NCO) 46 that demodulates both the co-polar and cross-polar down converted beacon signal components at the outputs of the down converters 36

and 36' by multiplication followed by digital filtering.

[0026] More precisely, the output of the down converter 36 is coupled to an analogue-digital converter (A/D) 47 the output of which is connected to the NCO 46 and a coherent amplitude demodulator the output of which is coupled through a filter 49 to the co-polar input of an integrator and amplitude comparator 50.

[0027] The output of the down converter 36' is coupled through an analogue-digital converter 47' to a coherent I/Q demodulator 51 the I output and the Q output of which are each coupled through a filter 52 to a I and Q input of comparator 50.

[0028] The proposed solution to downconvert the co-polar and cross-polar beacon signal to few hundreds of kHz will allow a digital implementation of the amplitude comparison between the two signals.

[0029] Due to the very low signal to noise factor of the beacon cross-polar component, it will be necessary to implement a coherent demodulation to extract the amplitude information related to the beacon signals. These demodulators are realized by means of multiplication of the signal to be detected, converted into digital format, with a sinusoidal signal with the same frequency and phase as the first one, but fixed amplitude. The latter signal will be obtained by synchronizing the NCO 46 to the input co-polar beacon signal component that is less noisy than the cross-polar beacon signal component because of its higher level.

[0030] The same NCO sinusoidal signal will be used to demodulate the cross-polar beacon signal obtaining the detection of both the in phase and in quadrature components of the signal. The quadrature demodulation will avoid the holes in the signal detection due to the different phase between the co-polar branch and the cross-polar branch.

[0031] The signals obtained from the multiplication are digitally filtered by the filters 49 and 52 in order to eliminate the double frequency term catching the only baseband component that contains the amplitude information A_{co} for the co-polar signal component and $(I_{cx}; Q_{cx})$ for the cross-polar component. The comparison between $\sqrt{I_{cx}^2 + Q_{cx}^2}$ and a fraction of A_{co} will activate the alarm for the polarization misalignment to be corrected manually by the operator. The polarization misalignment alarm means are indicated in 55.

[0032] It results from the foregoing that the system proposed by the invention is suitable to let the operator know the deviation from the antenna polarization alignment and then to manually restore the right condition. The system allows also to check and to optimize the reception of the beacon on the reference polarization at any time during the operations of the earth station.

[0033] The invention provides also the possibility, in case of a specific application named SKYPLEX to digitally encode the polarization alignment signal and to incapsulate it via a suitable interface in the message packets emitted by the earth station to the satellite, so that the polarization misalignment information can be re-

ceived and decoded at a central supervision and management station controlling all earth stations.

5 Claims

1. Method for the polarization alignment of an antenna of an earth station with the polarization axis of the antenna of a satellite emitting linearly polarized beacon signals, **characterized in that** the cross-polar component of the received linearly polarized beacon signal is used as information representative of an antenna polarization misalignment.
2. Method according to claim 1, **characterized in that** a polarization misalignment signal is developed by comparison of the co-polar and cross-polar beacon signal components.
3. Method according to claim 2, **characterized in that** said polarization misalignment signal is a variable level signal such as a voltage signal and is used to activate visual or audible indicator means.
4. Method according to claim 3, **characterized in that** said visual and audible indicator means are activated when said voltage level is greater than a predetermined threshold level.
5. Method according to any of the foregoing claims, **characterized in that** said polarization misalignment signal is, in case of a specific application named SKYPLEX, digitally encoded and incapsulated in the message packets emitted by the earth station to a satellite, in order to be received and decoded by a central supervision and management station.
6. System for putting into practice the method according to any of claims 1 to 5, **characterized in that** it comprises an orthomode transducer (2) having a TX port and a RX port at which are available the cross-polar and the co-polar beacon signal components, that the cross-polar path comprises mixer means (11,12) for mixing the cross-polar component with two phase orthogonal components of the same reference co-polar beacon component and adder-integrator means (18) for producing the scalar product signal therefrom which is clear from frequency and phase ambiguities and **in that** it comprises a comparator (19) receiving at its inputs said scalar product signal and the co-polar beacon component, said comparator producing the polarization misalignment signal.
7. System for putting into practice the method of any of claims 1 to 5, **characterized in that** it comprises an orthomode transducer (21) having a TX port and

a RX port at which are available the cross-polar and co-polar beacon signal components, down converter means (30, 32, 36, 36') for down converting the cross-polar and co-polar beacon signal components to a band of a few hundreds of KHz, coherent demodulator means adapted to extract the amplitude information related to the beacon signal components and amplitude comparator means for producing said polarization misalignment signal.

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- 8. System according to any of claims 6 and 7, **characterized in that** it comprises a switch means (8) for switching between operation modes where the earth station transmits in a linear polarization which is orthogonal to the polarization of the received beacon signal and in the same polarization as the latter.

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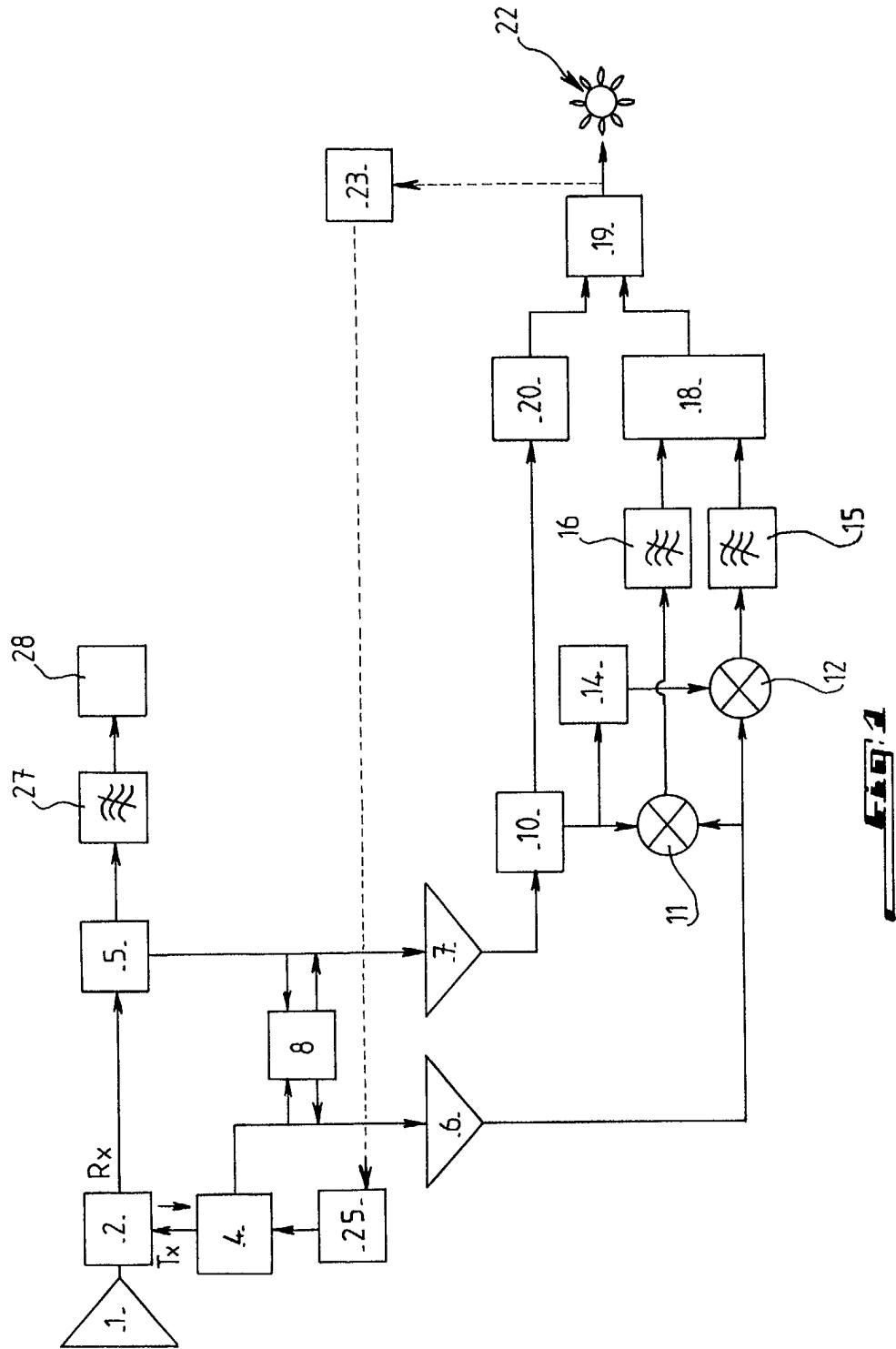


Fig. 1

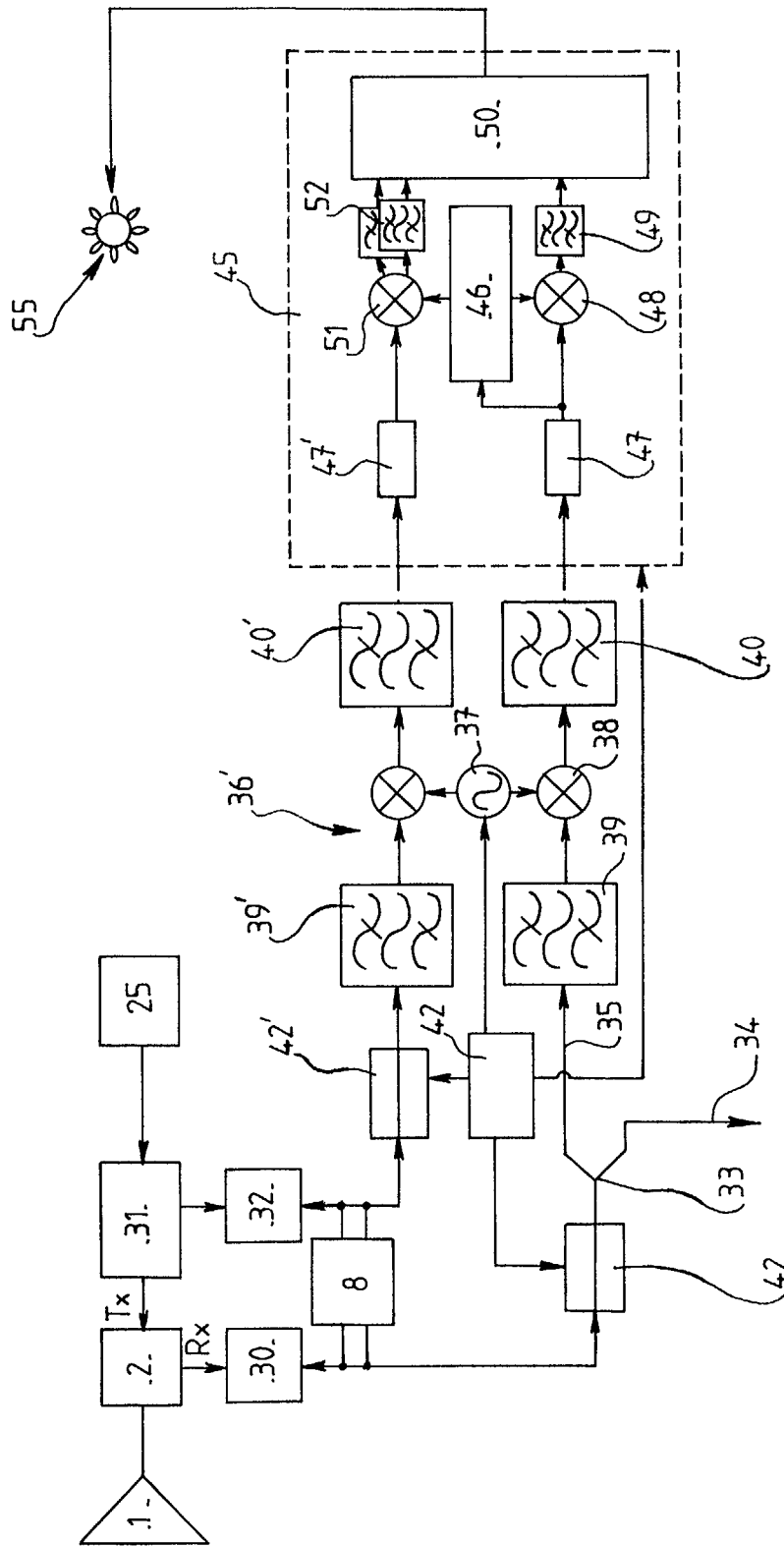


FIG. 2



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 40 2635

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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 12 February 2002	Examiner Angrabeit, F
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
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EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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