(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 March 2001 (29.03.2001)

PCT

(10) International Publication Number
WO 01/22405 A1

(51) International Patent Classification[7]: G11B 5/008, 5/584

(21) International Application Number: PCT/NL00/00676

(22) International Filing Date: 22 September 2000 (22.09.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1013117 22 September 1999 (22.09.1999) NL

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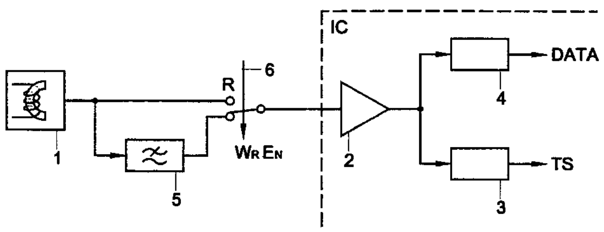
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

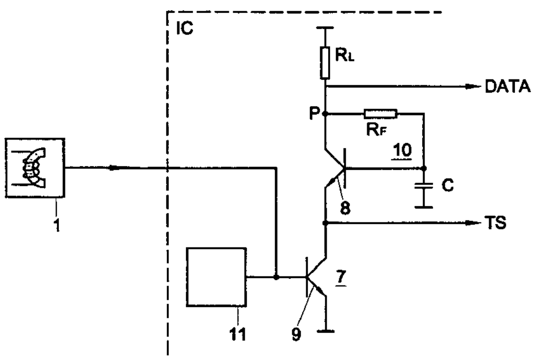
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*
— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

[Continued on next page]

(54) Title: ADR SYSTEM





(57) **Abstract:** An ADR (advanced digital recording) system for reading and writing information on a magnetic tape using a thin film head (1) with a read part and a write part, whereby track sensing signals on the tape can be read out and data signals can be written on the tape and read out, comprises a preamplifier (2) and, connected thereto, readout channels (3, 4) for track sensing signals and data signals, as well as a low pass filter for the track sensing signals. Both the channel separation for track sensing signals and data signals and the filtering of track sensing signals take place in the preamplifier (7, 8) provided on an IC.

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Title: ADR system

The present invention relates to an ADR (advanced digital recording) system for reading and writing information on a magnetic tape using a thin film head with a read part and a write part, whereby track sensing signals on the tape can be read out and data signals can be written on the tape and read out, which ADR system comprises a preamplifier and, connected thereto, readout channels for track sensing signals and data signals, as well as a low pass filter for the track sensing signals.

The track sensing signals are stored deeply in the magnetic tape and contain information that is of importance for the positioning and the servo control of the film head with respect to the tape and the time control signals needed. The data signals have been, or are, stored closely under the surface of the tape and contain read data signals which are read from the tape and write data signals which are provided by a processing IC in order to be written on the tape. In a read mode, track sensing signals and data signals on the tape are read out. In a write mode, track sensing signals on the tape are read out and data signals are written on the tape. In a read/write mode, track sensing signals on the tape are read out, data signals are written on the tape and also, in particular for verification purposes, read out. In the latter case, two physically separate film heads will be present, one being active in the read mode and the other in the write mode, while the head which is active for writing data signals on the tape is also active for reading out track sensing signals from the tape.

Both in the write mode and the read/write mode, data signals are written during the readout of track sensing signals, and because this is done with the same film head, crosstalk will occur. In particular, this involves problems associated with the fact that the signal strength of the track sensing signals to be read out differs strongly from that of the data signals to be written; the strength of the track sensing signals is typically in the order of 1 mVpp, while that of the data signals is in the order of 1.2 Vpp. The track sensing signals to be read out and the data signals read out simultaneously therewith owing to crosstalk are passed to a preamplifier IC; these signals, due to the strong crosstalk signals, are limited in the preamplifier, so that track sensing information may be lost.

To solve this problem, it has previously been proposed to prevent the clipping that occurs in the preamplifier by including a low pass filter between the film head and the preamplifier IC in the read mode and the read/write mode. As the bandwidth of the track sensing signals is typically in the order of 500 Hz to 10 kHz, and that of the data signals is in the order of 1.5 kHz to a few MHz, it is thus possible to obtain a separation of track sensing signals and data signals present due to crosstalk. The data signals present due to crosstalk are suppressed, while the track sensing signals are passed and amplified. Switching-on of the low pass filter at the input of the preamplifier is controlled by a write control signal (write-enable signal WrEn) which becomes active when the write mode is activated.

As the ohmic resistance of a thin film head is in principle less than 100Ω and the input resistance of the preamplifier is greater than 1.5kΩ, the capacitor, to effect the desired filtering, must have such a large capacitance (in the order of 1μF) that it cannot efficiently be integrated on an IC together with the preamplifier. An impedance increase between the head and the input resistance to thereby obtain a lower value for the capacitance is conceivable, but leads to a deterioration of the signal to noise ratio, since an impedance increase leads to stronger noise. For that matter, the attenuation caused by the impedance increase can be compensated by a greater amplification.

The disadvantage of the above, known solution, whereby the low pass filter is abruptly switched on and off, is that an "offset" voltage jump is introduced into the preamplifier. This offset voltage jump can disturb zero crossings in the track sensing signal with the result that time control errors and errors in the servo control of the tape occur. Further, the necessity of including components needed to realize the low pass filter, outside of the preamplifier present in IC form means that this solution is relatively expensive.

The object of the invention is to remove the problems mentioned, at least to limit them to a considerable extent, and to provide an ADR system, in which, in an efficient manner and in IC form, the track sensing signals on the one hand and the data signals present during writing (in the write mode or in the read/write mode) due to crosstalk and the "useful" data signals read out at readout (in the read mode) on the other, can be separated from each other. In the following, for the sake of brevity, reference will be made to the separation of track sensing signals and data signals.

According to the invention, to that end, the ADR system such as it is described in the opening paragraph hereof is characterized in that both the channel separation for track sensing signals and data signals and the filtering of track sensing signals take place in the preamplifier provided on an IC. This means in particular that during the readout of track sensing signals in the write mode or in the read/write mode, it is in the preamplifier, i.e., in IC form, that the signals as read are filtered and separated from the data signals read out simultaneously due to crosstalk.

In particular, the preamplifier comprises an emitter amplifier with a collector resistance (resistor R_L) and a cascode stage included in the collector circuit, while between the collector and the base of the cascode stage a decoupling circuit is present, which provides that the output voltage of the emitter amplifier exhibits a low pass characteristic, whereby it is also accomplished that the additional noise contribution which is caused by the decoupling circuit is negligible.

Through this measure, it appears that, given a suitable dimensioning of the decoupling circuit, a low pass characteristic can be obtained at the output of the emitter amplifier, while the capacitance can be chosen to be so small that a design thereof in IC form is rendered possible. Although the decoupling circuit will cause an additional noise contribution at the output of the emitter amplifier with respect to the output at the collector resistor, this additional noise contribution is virtually negligible with respect to the noise caused by the magnetic tape and the film head.

The output of the emitter amplifier provides track sensing signals and the output voltage at the collector of said transistor data signals.

It should be noted that the cascode stage can be formed by one or more transistors or by one or more FETs. Where reference is made to a transistor, this should be understood to encompass a FET; naturally, the words collector, base and emitter are then to be understood to mean drain, gate and source.

In addition to an implementation in IC form now being possible, the ADR system according to the invention has the further advantage that no write control signal, such as the WrEn signal in the prior art, is needed anymore, so that no offset voltage jump with the associated disadvantages occurs. Owing to a saving on external components, that is, components not present in IC form, the manufacturing costs are lower.

Although filters of a higher order can be used, in a simple embodiment the cascode stage is formed by a transistor and the decoupling circuit by a feedback resistor (resistor R_F) arranged between the collector and the base of this transistor and a decoupling capacitor (capacitance C) linked to the base of the transistor.

In connection with an optimum voltage amplification, the emitter amplifier is formed by a single-stage grounded emitter amplifier, while the preamplifier further comprises a circuit for a dc setting of the base of the emitter amplifier.

Through a proper dimensioning, it is rendered possible to give the output voltage TS of the emitter amplifier, with respect to the input voltage V_i thereof, a transfer characteristic which, in approximation, can be represented by:

$$\frac{TS}{V_i} = -g_{M1} * R_L * \frac{1}{1 + j\omega C\left(R_F + R_L\right)}$$

and to give the output voltage DATA at the collector of said transistor, with respect to said input voltage V_i, a transfer characteristic which, in approximation, can be represented by:

$$\frac{DATA}{V_i} = -g_{M1} * R_L$$

wherein $R_F >> R_L$ and $(R_F + R_L) >> 1/g_{M1}$ and g_{M1} represents the inverse value of the intrinsic emitter resistance of the transistor in the single-stage grounded emitter amplifier. In other words, the amplification both of the track sensing signals and of the data signals is determined within the bandwidth in question by the factor $g_{M1} * R_L$, i.e., by the voltage amplification of the emitter amplifier. It is noted here that the transfer function for the data signals in said approximation is represented within the bandwidth for this channel, viz. a bandwidth of $1/g_{M2}$, where g_{M2} represents the inverse value of the intrinsic emitter resistance of the transistor 8. This bandwidth, however, is considerably larger than that of the track sensing signals.

By choosing values, in the decoupling circuit, for R_L and R_F of, for instance, 2k7 and 330k, respectively, a capacitance of the decoupling capacitor C of about 22pF will suffice. Such a capacitance is easy to realize in IC form.

As already mentioned hereinbefore, filtering of the track sensing signals takes place in such a manner that, as a consequence, within the bandwidth of the track sensing signals an additional noise contribution is introduced, which is negligible with respect to the noise caused by the film head and the magnetic tape. In particular, the output of the emitter amplifier, with respect to the output on the collector resistor, will contain an additional noise contribution which is caused by the feedback resistor R_F. This additional noise contribution, when calculated back to the input of the emitter amplifier (equivalent voltage noise), can be represented in approximation by:

$$\left(\frac{R_F}{R_L} * \frac{1}{g_{M1}}\right)\sqrt{\frac{4kTB}{R_F}}$$

wherein k represents Boltzmann's constant, T the absolute temperature and B the noise bandwidth. This additional noise contribution in the output channel for the track sensing signals, given the chosen values for R_L and R_F, only leads to an absolute difference in noise in the order of 2dB with respect to the output channel for the data signals. This is an altogether minor noise contribution with respect to the noise which is caused by the magnetic tape and the film head. The noise introduced by these is typically higher by 10dB or more. The amplification of the track sensing signals (within the pass band) and the data signals, viz. $g_{M1}*R_L$, is in the order of 40dB.

The invention will now be further explained with reference to the accompanying drawings. In the drawings:

Fig. 1 schematically shows the low pass filter and the preamplifier according to the prior art; and

Fig. 2 schematically shows an embodiment of the preamplifier with input circuit according to the invention.

Fig. 1 shows a thin film head 1 and an IC including inter alia a preamplifier 2 and a reading channel 3 via which read-out track sensing signals (TS) are passed on and a reading channel 4 via which read-out data signals (DATA) are passed on. During readout of a tape, the information read out is passed directly from the film head 1 and the preamplifier 2 over either of the channels 3 or 4. In the write mode and the read/write mode, the track sensing signals are to be filtered because then, due to crosstalk, data signals are being read out at the same time. To that end, a low pass filter 5 is present, which, when a switch is made to the write mode or the read/write mode, is switched on via a switch 6 by a write enable signal WrEn. As already mentioned hereinbefore, such a filter technique already known is not satisfactory.

Fig. 2 shows a filter technique according to the invention, whereby on an IC a channel separation for track sensing signals and for data signals is realized in the preamplifier itself, while at the same time the track sensing signals are filtered. The preamplifier arranged on an IC in Fig. 2 comprises an emitter amplifier 7 with a collector resistor R_L and a cascode stage, included in the collector circuit, in the form of a transistor 8 in cascode configuration. The emitter amplifier 7 is designed as a single-stage grounded emitter amplifier with a transistor 9. between the collector and the base of the transistor 8, a decoupling circuit 10 is present, which provides that the output voltage of the emitter amplifier 7 exhibits a low pass characteristic; accordingly, via this output the track sensing signals are delivered. At the collector output of the transistor 8, in the read mode, the data signals are delivered and in the read/write mode or - although not particularly relevant for practice - in the write mode during the readout of the track sensing signals the data signals present through crosstalk.

The decoupling circuit 10 is formed by a feedback resistor R_F arranged between the collector and the base of the transistor 8, and a decoupling capacitor C arranged between the base of this transistor and earth.

Because the dc setting of the cascode stage, i.e., of the transistor 8, occurs via the feedback resistor R_F from the nodal point P, the TS output 7 is less sensitive to overload of the transistor 9. The setting current of the transistor 8 is determined by the transistor 9; even if the collector of the cascode stage becomes saturated due to relatively large interference signals at the input (crosstalk), still a filtered and undistorted or substantially undistorted output signal TS can be obtained.

The signals of the thin film head 1 are supplied as input signals V_i to the base of the transistor 9. The preamplifier includes a circuit 11 for a dc setting of the transistor 9.

The transfer functions of the preamplifier described here can be represented by the following relations:

$$\frac{TS}{V_i} = -g_{M1} * R_L * \frac{1}{1 + j\omega C(R_F + R_L)}$$

$$\frac{DATA}{V_i} = -g_{M1} * R_L$$

It is noted here that the transfer function for the data signals is represented within the bandwidth for this channel, viz. a bandwidth of $1/g_{M2}$, wherein g_{M2} represents the inverse value of the intrinsic emitter resistance of the transistor 8. This bandwidth, however, is considerably larger than that of the track sensing signals.

It appears from the relations shown that within the respective bandwidths the amplification is determined by the amplification factor of the emitter amplifier $g_{M1} * R_L$, while the track sensing signals TS have been subjected to a low pass filtering, while due to the relatively high values of R_L and R_F the capacitance C can be kept relatively low, at least with respect to the capacitance of the capacitor in the filter according to the prior art represented in Fig. 1, so that this capacitance can also be implemented in IC form.

The amplification of the data signals and - within the bandwidth of the low pass filter - the track sensing signals, with $1/g_{M1}$ = 25 Ohm and R_L, as mentioned above, 2k7, equals about 100, that is, 40dB.

When the additional noise contribution in the output for the track sensing signals by the low pass filter is taken into account, viz. a noise contribution calculated back to the input of the emitter amplifier:

$$\left(\frac{R_F}{R_L} * \frac{1}{g_{M1}}\right)\sqrt{\frac{4kTB}{R_F}},$$

then it holds, with k= $1.38.10^{-23}$ J/K°, T 300 K°, and assuming B is 1 Hz, that this additional noise contribution is about 0.67 nV/√Hz, which, over the entire bandwidth at the output of the emitter amplifier leads to a reduction of the absolute difference in noise by about 2dB. The noise at the DATA output in this example is about 0.85 nV/√Hz, and at the TS output about $[(0.85)^2+(0.67)^2]^{1/2} = 1.1$ nV/√Hz.

Finally, it should be pointed out that in particular a FET has good utility when the supply voltage is low. It is then possible to choose a higher value for R_F and a still lower value for the capacitance C.

CLAIMS

1. An ADR (advanced digital recording) system for reading and writing information on a magnetic tape using a thin film head with a read part and a write part, whereby track sensing signals on the tape can be read out and data signals can be written on the tape and read out, which ADR system comprises a preamplifier and, connected thereto, readout channels for track sensing signals and data signals, as well as a low pass filter for the track sensing signals, characterized in that both the channel separation for track sensing signals and data signals and the filtering of track sensing signals take place in the preamplifier provided on an IC.

2. An ADR system according to claim 1, characterized in that the preamplifier comprises an emitter amplifier with a collector resistance (resistor R_L) and a transistor in cascode configuration, included in the collector circuit, while between the collector and the base of said transistor a decoupling circuit is present, which provides that the output voltage of the emitter amplifier exhibits a low pass characteristic and within the respective bandwidth hardly any additional noise is introduced by the decoupling circuit.

3. An ADR system according to claim 2, characterized in that the output of the emitter amplifier provides the track sensing signals and the output voltage at the collector of said transistor the data signals present through crosstalk.

4. An ADR system according to claim 2 or 3, characterized in that the decoupling circuit is formed by a feedback resistance (resistor R_L) arranged between the collector and the base of said transistor, and a decoupling capacitor (capacitance C) linked to the base of the transistor.

5. An ADR system according to any one of claims 2-4, characterized in that the emitter amplifier is formed by a single-stage earthed emitter amplifier, the preamplifier further comprising a circuit for a dc setting of the base of the emitter amplifier.

6. An ADR system according to claim 4 or 5, insofar as this claim refers back to claim 4, characterized in that the output voltage TS of the emitter amplifier, with respect to the input voltage V_i thereof, has a transfer characteristic which can be represented in approximation by:

$$\frac{TS}{V_i} = -g_{M1} * R_L * \frac{1}{1 + j\omega C\left(R_F + R_L\right)}$$

and the output voltage DATA at the collector of said transistor, with respect to said input voltage V_i, has a transfer characteristic which can be represented in approximation by:

$$\frac{DATA}{V_i} = -g_{M1} * R_L$$

wherein $R_F >> R_L$ and $(R_F + R_L) >> 1/g_{M1}$ and g_{M1} represents the inverse value of the intrinsic emitter resistance of the transistor in the single-stage earthed emitter amplifier.

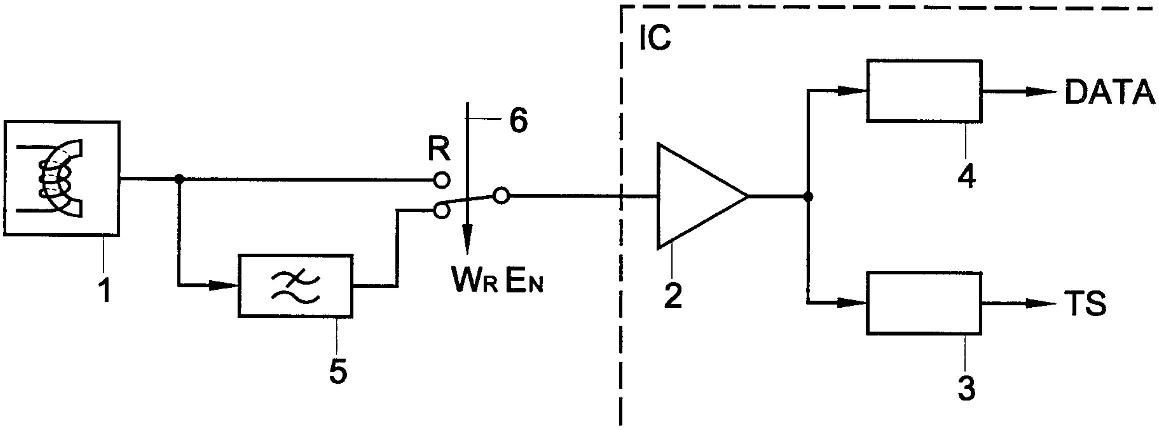

Fig. 1

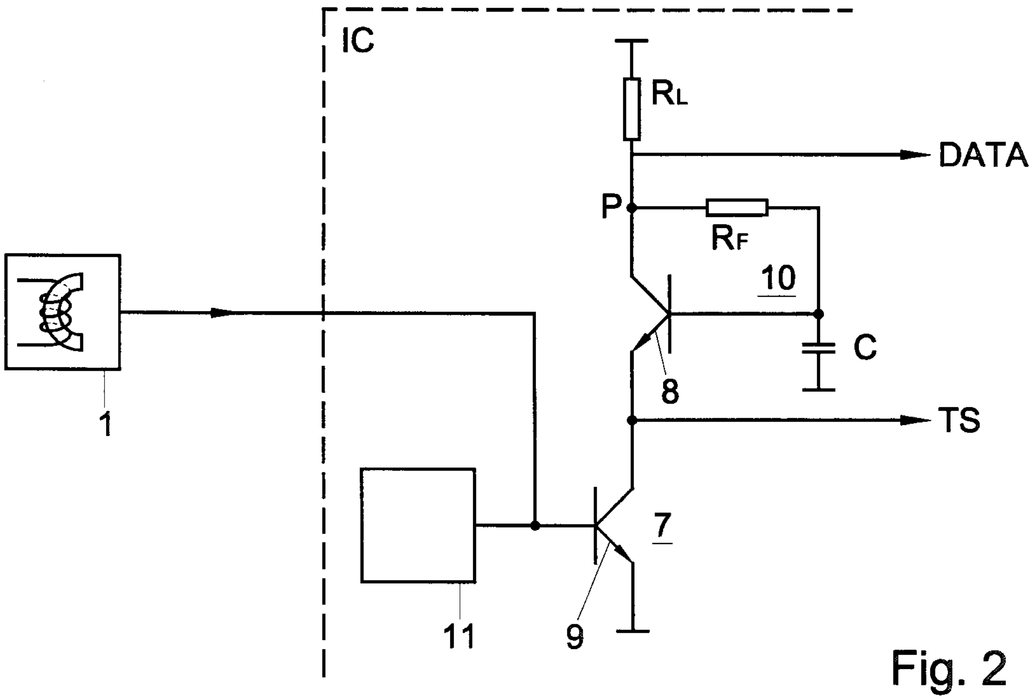

Fig. 2

INTERNATIONAL SEARCH REPORT

Inter ıal Application No
PCT/NL 00/00676

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G11B5/008 G11B5/584

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	GUOJIN LIANG ET AL: "THE DEVELOPMENT OF CMOS AUTO-TRACK FINDING IC" PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON CONSUMER ELECTRONICS. (ICCE),US,NEW YORK, IEEE, vol. CONF. 11, 1992, pages 416-417, XP000369312 ISBN: 0-7803-0480-2 the whole document --- -/--	1

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
16 January 2001	24/01/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Fux, J

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Inten nal Application No
PCT/NL 00/00676

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	SATOSHI MIZOGUCHI ET AL: "BI-CMOS TRACKING SERVO LSI FOR 8 MM VCR" PROCEEDINGS OF THE CUSTOM INTEGRATED CIRCUITS CONFERENCE,US,NEW YORK, IEEE, vol. CONF. 10, 1988, pages 1271-1274, XP000124816 the whole document ---	1
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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter. nal Application No
PCT/NL 00/00676

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