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ASML Netherlands B.V. te Veldhoven

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72 Uitvinder(s):
Jeroen Earl van Wanrooij te Veldhoven

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ir. A.J.M. van Hoef te Veldhoven

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54 **ELECTRICAL CIRCUIT FOR EMULATING VARIABLE ELECTRICAL CHARACTERISTICS**

57 An electronic circuit configured to emulate an impedance, the electronic circuit comprising:
a first inverting amplifier comprising a first feedback circuit;
a second inverting amplifier comprising a second feedback circuit; and
a component having an input connected to an output of the first inverting amplifier and an output connected to an inverting input of the second inverting amplifier, wherein the component is configured to convert a voltage to a current which is adjustable by modification of a setting of the component;
, wherein the emulated impedance of the electronic circuit is defined between an inverting input of the first inverting amplifier and an output of the second inverting amplifier and adjustable by modification of the setting of the component.

ELECTRICAL CIRCUIT FOR EMULATING VARIABLE ELECTRICAL CHARACTERISTICS

BACKGROUND

Field of the invention

5 [0001] The invention relates to electrical circuits configured to emulate variable electrical impedance of a component. The impedance may be complex valued and hence a variable resistance, inductance or capacitance may be emulated.

Related Art

10 [0002] In many occasions, it is desired to provide an electrical circuit with a component configured to be able to adopt a variable resistance, variable inductance or a variable capacitance. A typical variable resistance component for example comprises a plurality of accurately manufactured resistors, one contact of each resistor is connected to a central reference and a switch providing selection of the current to run through a selected resistor out of the plurality of resistors. In other words, the plurality of resistors forms a parallel network of resistors, in which an electrical current
15 may be diverted through a selectable resistor out of the plurality of resistors. In a similar fashion, switchable parallel networks of capacitors and inductors may be used to provide a variable capacitance or inductance component. A disadvantage of currently variable resistors (circuits) is that the number of selectable resistance values is generally limited as typically constraints apply to the number of components (resistors, switches) that can be placed on a printed circuit board (PCB).
20 Additionally, such a variable resistance circuit may be expensive to manufacture when the desired resistance value needs to be within a narrow range. In the latter case, a potentially high amount of expensive low tolerance resistors need to be utilized.

25 SUMMARY OF THE INVENTION

[0003] The invention aims to provide a circuit configured to be able to simulate a selectable electrical characteristic out of many selectable electrical characteristic values, the circuit utilizing low cost components, many of which are utilized frequently on standard PCB's. It is a further objective to utilize standard component, to keep costs low and ensure compatibility with existing circuits of components applied to the PCB for which the variable electrical characteristic functionality needs
30 to be provided.

[0004] In a first aspect of the invention an electronic circuit configured to emulate an impedance is disclosed, the electronic circuit comprising: a first inverting amplifier comprising a first feedback circuit; a second inverting amplifier comprising a second feedback circuit; and a component having
35 an input connected to an output of the first inverting amplifier and an output connected to an inverting input of the second inverting amplifier, wherein the component is configured to convert a voltage to a current which is adjustable by modification of a setting of the component, wherein the

emulated impedance of the electronic circuit is defined between an inverting input of the first inverting amplifier and an output of the second inverting amplifier and adjustable by modification of the setting of the component.

5 [0005] In a second aspect of the invention an electronic circuit configured to emulate an impedance is disclosed, the electronic circuit comprising: a first inverting amplifier comprising a feedback circuit; and a Pulse Width Modulation DAC having an input connected to an output of the first inverting amplifier and an output, wherein the Pulse Width Modulation DAC is configured to convert a voltage to an adjustable voltage by modification of a setting of the Pulse Width Modulation DAC, wherein the emulated impedance of the electronic circuit is defined between an
10 inverting input of the first inverting amplifier and the output of the Pulse Width Modulation DAC and adjustable by modification of the setting of the Pulse Width Modulation DAC.

BRIEF DESCRIPTION OF THE DRAWINGS

15 [0006] Embodiments of the invention will now be described, by way of example only, with reference to the accompanying schematic drawings in which:

[0007] Figure 1 illustrates a schematic circuit of a variable resistor according to the state of the art.

[0008] Figure 2 illustrates an embodiment of the invention; a circuit configured to emulate a variable impedance.

20 DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0009] Typically, variable resistors are used for calibration and/or electrical testing purposes. The response of the variable resistor to, for example a measurement device (multimeter) configured to measure an Ohmic resistance, may be used to determine an exact value of the resistance for a certain setting of the variable resistor. In general, the measurement device (when configured as an Ohmic
25 measurement device) measures a current (Ampere) and a voltage across two contacts connected to the circuit or component of interest. Using Ohm's law, the resistance is then determined ($\text{Resistance} = V/I$, V being the voltage and I being the current). A variable resistor according to figure 1 comprises a parallel network of resistors, wherein the network is switchable (switches S1, S2, ..., Si) between a plurality of resistors, each of the resistors in general having an accurately designed
30 resistance value. The contacts between which the resistance is measured are denoted by 'CL' and 'CO'. The voltage 'V' delivered by the measurement device is normally fairly constant, hence switching between the various resistors 'R1', 'R2', ..., 'Ri' leads to a change in the measured current 'I' which is then used to determine the resistance. From figure 1 it is understood that a known variable resistor circuit potentially may comprise many components (resistors, switches).

35 [0010] A variable resistance circuit is proposed being adjustable to a wide range of resistance values without using many components. Figure 2 illustrates a variable resistance circuit according to an embodiment of the invention. A first pole of the measurement device is connected to the inverting

input 'CO' of a first Operational Amplifier (Opamp 1). The first Opamp forces the first pole 'CO' to a zero potential (virtual ground, the second pole 'P' of the first Opamp is grounded). The voltage at the output 'OO' is proportional to the current provided by the measurement device multiplied by the reference resistance R "REFERENCE" which is incorporated within the feedback circuit (OO-CO') of the first Opamp. The utilized configuration of the first Opamp is commonly referred to as an "inverting amplifier" as the voltage at the output of the Opamp is basically inverted (reversed sign) with respect to the input voltage. The output voltage at the output 'OO' is further scaled in a controllable manner using a DAC –second Opamp tandem. The output 'OO' is connected to the input 'Vref_in' of the DAC, which typically provides a current 'I_out' at the output of the DAC which is scalable by adjusting a setting of the DAC ("setpoint" of the DAC).. In case the DAC requires a certain polarity of the input (Vref_in) a voltage inverting component (not shown) may need to be placed between the output 'OO' and the input of the DAC.

[0011] The DAC output is buffered with a second Opamp "Opamp 2". Opamp 2 has a gain = "fixed_GAIN" and the second pole 'Q' is grounded (in analogy to Opamp 1, hence Opamp 2 is also an inverting amplifier). The gain is controlled by the resistance of the resistor R "GAIN" which is incorporated within the feedback circuit (DO-CL') of the second Opamp. When connecting the second pole of the measurement device to CL' it will measure a voltage "V_out" between the contacts 'CO' and 'CL'' proportional to its own measurement current, the reference resistance of the resistor R "REFERENCE", the DAC setting "setpoint" and the GAIN "fixed_GAIN". A measurement device operated to determine an Ohmic resistance and connected to the contacts 'CO' and 'CL' will then measure a resistance 'R_out' provided by the variable resistor circuit.

[0012] Controlling the voltage may be done electronically, while the components are standard and often already present on circuit boards (PCB) in case the variable resistor circuit is intended to be placed on existing electrical circuitry. The described circuit provides an accurately controllable voltage between the contacts 'CO' and 'CL'' which scales exactly with the current provided to the circuit. In case of a resistance measurement the measurement device will register a controllable voltage "V_out", which will be interpreted as the accurately controllable resistance R_out:

[0013] $R_{out} = R \text{ "REFERENCE"} * \text{setpoint} * \text{fixed_GAIN}$

[0014] A wide range of R_out are selectable by controlling the DAC value (setpoint of the DAC):

30 [0015] Of 0Ω: $(\text{setpoint} * \text{Fixed_GAIN}) = 0$

[0016] Far below R reference: $(\text{setpoint} * \text{Fixed_GAIN}) \ll 1$

[0017] Around R reference: $(\text{setpoint} * \text{Fixed_GAIN}) = 1$

[0018] Far above R reference: $(\text{setpoint} * \text{Fixed_GAIN}) \gg 1$

[0019] The key part of the circuit is the first Opamp which is connected in such a way that it generates a virtual-ground on the input terminal 'CO'. This subtracts the measurement offset voltage in R reference (due to the measurement current), that otherwise always would be present, and would force a value equal to R reference into the equation:

[0020] $R_{out_without_first_Opamp} = R_{reference} + (R_{REFERENCE} * setpoint * Fixed_GAIN)$

[0021] Next, the subtracted voltage (equal to measurement current * R "REFERENCE") is fed to the reference voltage input of a DAC. Depending on the setting of the DAC (0..full scale) that reference voltage is scaled. The final GAIN is done with an I to V converter (needed for the DAC), which functionality is provided by the second Opamp circuit.

[0022] The final gain may be done with 2 amplifiers (instead of one second Opamp), for extra buffering for example.

[0023] In case the feedback circuit(s) of the first Opamp and/or second Opamp have no known values the variable impedance circuit may still be utilized to emulate a (relative) impedance change. Hence the minimum configuration of a variable impedance emulating circuit would comprise two inverting amplifiers having a feedback circuit, both inverted amplifiers connected by a component converting the output voltage of the first inverting amplifier to a current which is provided to an inverting input of the second inverting amplifier. The emulated impedance is then defined between the inverting input CO' of the first inverting amplifier and an output of the second inverting amplifier, wherein the impedance may be changed by modification of a setting of the component (in case the component is a DAC, the DAC setting would scale the output current). In practical case such a variable voltage to current converting component is typically a Digital to Analog Converter (DAC).

[0024] In addition to providing variable resistance values the circuit of figure 2 may be adapted to also provide variable capacitance or variable inductance values. The reference resistor R "REFERENCE" may then be replaced by a reference capacitor or reference inductor. The current provided by the measurement device must then have an appropriate frequency in order to have the capacitor or inductor behave like a resistor. In general the variable resistance circuit may then be configured as a variable impedance circuit in case the reference resistor R "REFERENCE" does not have a real valued impedance but a complex valued impedance (the imaginary component of the impedance value associated with a capacitance and/or inductance). When providing an alternating current (by the measurement device) to the variable impedance circuit a resistance "R_out" will be measured which may be converted to a value of a resistance, capacitance or inductance.

[0025] The component providing the (adjustable) conversion of the voltage to a current may for example a traditional DAC. Alternatively a PWM (Pulse Width Modulation) DAC may be utilized, preferentially in a configuration that converts a (bipolar) voltage to an adjustable voltage (instead of a current) removing the need to provide additional means to convert the current to a voltage, for example by using the second inverting Operational Amplifier.

[0026] The PWM DAC design may be according to any suitable layout for adjusting a voltage in an adjustable manner. Figure 3 depicts a configuration of a PWM DAC according to an embodiment of the invention, the component comprises:

- a. two electronically controlled switches S1, S2
- b. a pulse generator P providing input to the electronically controlled switches S1 and S2, wherein a Phase Shift (PS) module is provided to assure that both switches are not exactly operated in phase with each other. The pulse generator P can provide adjustable pulse characteristics (in particular the duty cycle 'DC' of the pulse train).
- c. a resistor R1.
- d. a capacitor C1.
- e. The output OO of the first inverting amplifier is connected to the point OO of figure 3 and the point V_out depicted in figure 3 may be connected to CL (figure 2), CL being at an adjustable output voltage V_out which, in this configuration depends linearly on the voltage at OO and the pulse width (PW) / Duty Cycle (DC) of the pulse train provided by the pulse generator P. By adjusting the Pulse Width (PW) provided by the pulse generator P the voltage at the output can be controlled and the emulated impedance is controlled accordingly.
- f. In this basic configuration a second inverting operational amplifier is not needed.

[0027] Further embodiments of the invention are disclosed in the list of numbered embodiments below:

1. An electronic circuit configured to emulate an impedance, the electronic circuit comprising: a first inverting amplifier comprising a first feedback circuit; a second inverting amplifier comprising a second feedback circuit; and a component having an input connected to an output of the first inverting amplifier and an output connected to an inverting input of the second inverting amplifier, wherein the component is configured to convert a voltage to a current which is adjustable by modification of a setting of the component, wherein the emulated impedance of the electronic circuit is defined between an inverting input of the first inverting amplifier and an output of the second inverting amplifier and adjustable by modification of the setting of the component.
2. An electronic circuit according to embodiment 1, wherein the first feedback circuit has a reference impedance.
3. An electronic circuit according to embodiment 1 or 2, wherein the second feedback circuit has a resistance configured to provide a desired gain of the second inverting amplifier.
4. The electronic circuit according to embodiment 2, wherein the values of the emulated impedance and the reference impedance are real valued numbers, the emulated impedance and reference impedance associated with values of an Ohmic resistance.
5. The electronic circuit according to embodiment 2, wherein the values of the variable impedance and the reference impedance are complex valued numbers, the emulated impedance and reference impedance associated with values of a capacitance.
6. The electronic circuit according to embodiment 2, wherein the values of the variable impedance and the reference impedance are complex valued numbers, the emulated impedance and reference impedance associated with values of an inductance.

7. The electronic circuit according to any preceding embodiment, wherein the component is a digital to analog converter (DAC).
8. The electronic circuit according to any preceding embodiment, wherein the second inverting amplifier comprises at least two inverted amplifiers in cascade.
- 5 9. The electronic circuit according to any preceding embodiment, comprising a voltage inverting circuit between an output of the first inverting amplifier and an input of the component.
- 10 10. An electronic circuit configured to emulate an impedance, the electronic circuit comprising: a first inverting amplifier comprising a feedback circuit; and a Pulse Width Modulation DAC having an input connected to an output of the first inverting amplifier and an output, wherein the Pulse Width Modulation DAC is configured to convert a voltage to an adjustable voltage by modification of a setting of the Pulse Width Modulation DAC, wherein the emulated impedance of the electronic circuit is defined between an inverting input of the first inverting amplifier and the output of the Pulse Width Modulation DAC and adjustable by modification of the setting of the Pulse Width Modulation DAC.
- 15 **[0028]** The descriptions above are intended to be illustrative, not limiting. Thus, it will be apparent to one skilled in the art that modifications may be made to the invention as described without departing from the spirit and scope of the claims set out below. In addition, it should be appreciated that structural features or method steps shown or described in any one embodiment herein can be used in other embodiments as well.

Conclusies

1. Een elektronische schakeling geschikt voor het emuleren van een impedantie omvattende:
5 een eerste inverterende versterker omvattende een eerste terugkoppelingscircuit;
een tweede inverterende versterker omvattende een tweede terugkoppelingscircuit; en
een component waarvan een ingang is verbonden met een uitgang van de eerste
inverterende versterker en waarvan een uitgang is verbonden met een inverterende ingang van
de tweede inverterende versterker, de component is geconfigureerd om een voltage naar een
10 stroom om te zetten welke instelbaar is middels aanpassing van een instelling van de
component, waarin de geëmuleerde impedantie van de elektronische schakeling is
gedefinieerd tussen een inverterende ingang van de eerste inverterende versterker en een
uitgang van de tweede inverterende versterker en waarvan de waarde afhankelijk is van de
instelling van de component.
- 15 2. De elektronische schakeling van conclusie 1, waarin het eerste terugkoppelingscircuit een
referentie-impedantie heeft.
3. De elektronische schakeling van conclusie 1 of 2, waarin het tweede terugkoppelingscircuit
20 een weerstand heeft die zodanig is dat de tweede inverterende versterker een gewenste
versterkingsfactor heeft.
4. De elektronische schakeling van conclusie 2, waarin de waarden van de geëmuleerde
impedantie en de referentie-impedantie reële getallen zijn corresponderende met
25 respectievelijk een geëmuleerde Ohmse weerstand en een referentie Ohmse weerstand.
5. De elektronische schakeling van conclusie 2, waarin de waarden van de geëmuleerde
impedantie en de referentie-impedantie complexe getallen zijn corresponderende met
respectievelijk een geëmuleerde capaciteit en een referentie capaciteit.
- 30 6. De elektronische schakeling van conclusie 2, waarin de waarden van de geëmuleerde
impedantie en de referentie-impedantie complexe getallen zijn corresponderende met
respectievelijk een geëmuleerde inductie en een referentie inductie.
- 35 7. De elektronische schakeling van een van de voorgaande conclusies, waarin de component een
digitaal naar analoog omzetter (DAC) is.

8. De elektronische schakeling van een van de voorgaande conclusies, waarin de tweede inverterende versterker tenminste twee in cascade geplaatste inverterende versterkers omvat.
9. De elektronische schakeling van een van de voorgaande conclusies omvattende een voltage omzettende schakeling welke tussen een uitgang van de eerste inverterende versterker en een
5 ingang van de component is geplaatst.
10. Een elektronische schakeling geschikt voor het emuleren van een impedantie omvattende:
 een eerste inverterende versterker omvattende een terugkoppelingcircuit; en
10 een pulsbreedtemodulator omvattende een uitgang en een ingang welke is verbonden
 met een uitgang van de eerste inverterende versterker, de pulsbreedtemodulator is
 geconfigureerd om een voltage naar een instelbaar voltage om te zetten welke instelbaar is
 middels aanpassing van een instelling van de pulsbreedtemodulator, waarin de geëmuleerde
 impedantie van de elektronische schakeling gedefinieerd is tussen een inverterende ingang
15 van de eerste inverterende versterker en de uitgang van de pulsbreedtemodulator en instelbaar
 is door aanpassing van de instelling van de pulsbreedtemodulator.
11. De elektronische schakeling van conclusie 10, waarin de pulsbreedtemodulator de volgende
 componenten omvat:
- 20 a. Twee elektronische gestuurde schakelaars (S1, S2);
- b. Een pulsgenerator (P) omvattende een faseverschuivingsmodule (PS), de
 pulsgenerator is geconfigureerd om de twee elektronisch gestuurde schakelaars
 (S1,S2) aan te sturen en elektrische pulsen aan te bieden waarvan de pulsbreedte
 instelbaar is om het voltage aan de uitgang van de pulsbreedtemodulator zodanig
25 instelbaar te maken dat de geëmuleerde impedantie van de elektronische schakeling
 naar een gewenste waarde kan worden gebracht;
- c. Een weerstand R1 geplaatst tussen een schakelaar en de uitgang van de
 pulsbreedtemodulator; en
- d. Een condensator C1 welke de uitgang van de pulsbreedtemodulator verbindt met de
30 aarde.

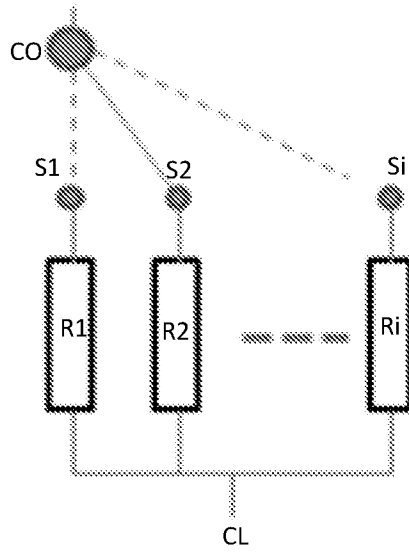


Figure 1

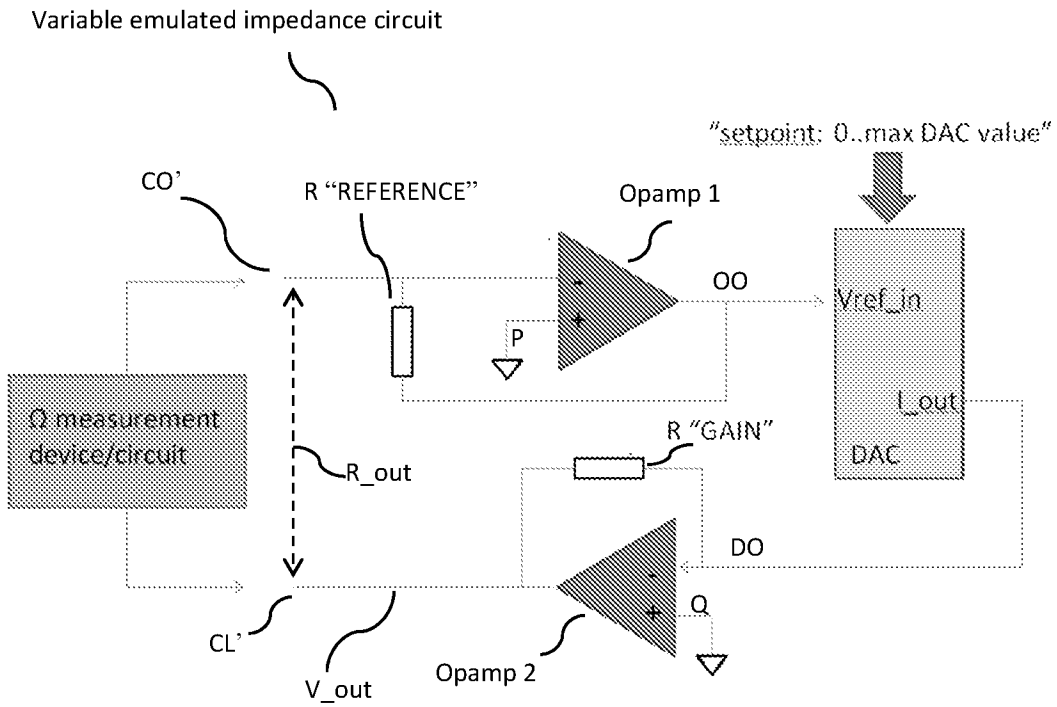


Figure 2

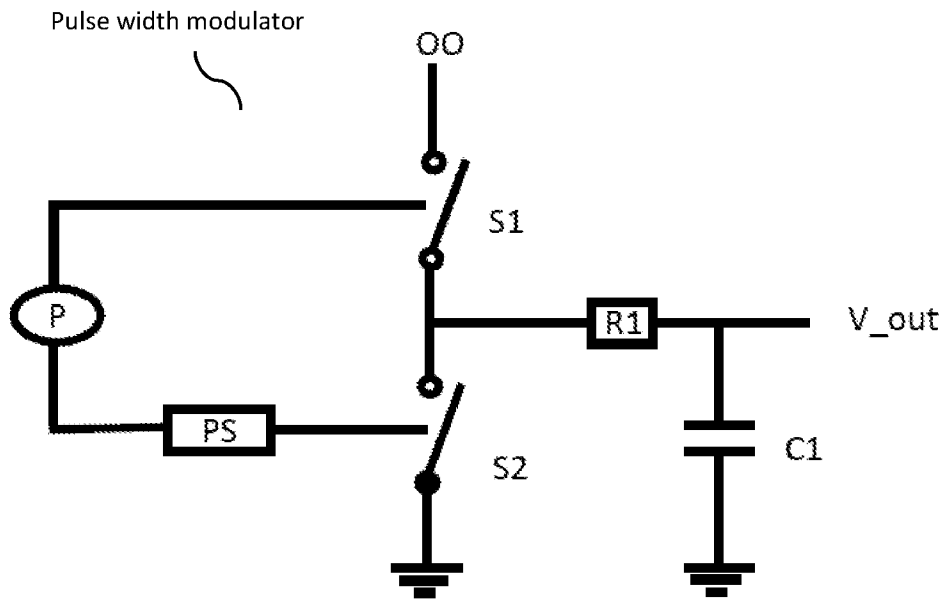


Figure 3



ONDERZOEKSRAPPORT

BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK

RELEVANTE LITERATUUR			
Categorie ¹	Literatuur met, voor zover nodig, aanduiding van speciaal van belang zijnde tekstgedeelten of figuren.	Van belang voor conclusie(s) nr.	Classificatie (IPC)
A	DE 39 01 314 A1 (KNICK ELEKT MESSGERAETE GMBH [DE]) 26 juli 1990 (1990-07-26) * kolom 5, regel 11 - kolom 6, regel 66; figuren 1, 2 * * kolom 7, regel 61 - regel 66 * -----	1-9	INV. H03H11/46 H03H11/48
X	EP 0 656 542 A2 (FLUKE CORP [US]) 7 juni 1995 (1995-06-07) * kolom 2, regel 27 - kolom 3, regel 37; figuur 1 * -----	1-9	
A	US 4 963 845 A (COLLIER ROBERT L [US]) 16 oktober 1990 (1990-10-16) * kolom 8, regel 13 - kolom 10, regel 20; figuren 3 - 5 * -----	1-9	
A	JP H04 46412 A (KOKUSAI SYSTEMS KK) 17 februari 1992 (1992-02-17) * samenvatting * -----	1-9	
A	DE 31 24 231 A1 (JUCHHEIM GMBH & CO M K [DE]) 30 december 1982 (1982-12-30) * bladzijde 9, regel 18 - bladzijde 13, regel 2; figuur 1 * -----	1-9	Onderzochte gebieden van de techniek H03H G01R
X	US 5 402 082 A (ECCLESTON LARRY E [US] ET AL) 28 maart 1995 (1995-03-28) * kolom 3, regel 66 - kolom 6, regel 35; figuren 1, 2 * -----	10,11	
Indien gewijzigde conclusies zijn ingediend, heeft dit rapport betrekking op de conclusies ingediend op:			

Plaats van onderzoek:

München

Datum waarop het onderzoek werd voltooid:

14 mei 2021

Bevoegd ambtenaar:

Trafidlo, Renata

¹ CATEGORIE VAN DE VERMELDE LITERATUUR

X: de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur
Y: de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht
A: niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft
O: niet-schriftelijke stand van de techniek
P: tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

T: na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvraag, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding
E: eerdere octrooi(aanvraag), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven
D: in de octrooiaanvraag vermeld
L: om andere redenen vermelde literatuur
&: lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

**AANHANGSEL BEHORENDE BIJ HET RAPPORT BETREFFENDE
HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK,
UITGEVOERD IN DE OCTROOIAANVRAGE NR.**

NO 140973
NL 2021237

Het aanhangsel bevat een opgave van elders gepubliceerde octrooiaanvragen of octrooien (zogenaamde leden van dezelfde octroofamilie), die overeenkomen met octrooischriften genoemd in het rapport.

De opgave is samengesteld aan de hand van gegevens uit het computerbestand van het Europees Octrooibureau per
De juistheid en volledigheid van deze opgave wordt noch door het Europees Octrooibureau, noch door het Bureau voor de Industriële eigendom gegarandeerd; de gegevens worden verstrekt voor informatiedoeleinden.

14-05-2021

In het rapport genoemd octrooigeschrift		Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
DE 3901314	A1	26-07-1990	GEEN	
EP 0656542	A2	07-06-1995	CA 2129556 A1 EP 0656542 A2 US 5485115 A	03-06-1995 07-06-1995 16-01-1996
US 4963845	A	16-10-1990	GEEN	
JP H0446412	A	17-02-1992	GEEN	
DE 3124231	A1	30-12-1982	DE 3124231 A1 FR 2508177 A1	30-12-1982 24-12-1982
US 5402082	A	28-03-1995	EP 0693692 A2 JP H0868809 A KR 960006265 A US 5402082 A	24-01-1996 12-03-1996 23-02-1996 28-03-1995

SCHRIFTELIJKE OPINIE

DOSSIER NUMMER NO140973	INDIENINGSDATUM 04.07.2018	VOORRANGSDATUM 26.07.2017	AANVRAAGNUMMER NL2021237
CLASSIFICATIE INV. H03H11/46 H03H11/48			
AANVRAGER ASML Netherlands B.V.			

Deze schriftelijke opinie bevat een toelichting op de volgende onderdelen:

- Onderdeel I Basis van de schriftelijke opinie
- Onderdeel II Voorrang
- Onderdeel III Vaststelling nieuwheid, inventiviteit en industriële toepasbaarheid niet mogelijk
- Onderdeel IV De aanvraag heeft betrekking op meer dan één uitvinding
- Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid
- Onderdeel VI Andere geciteerde documenten
- Onderdeel VII Overige gebreken
- Onderdeel VIII Overige opmerkingen

	DE BEVOEGDE AMBTENAAR Trafidlo, Renata
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Onderdeel I Basis van de Schriftelijke Opinie

1. Deze schriftelijke opinie is opgesteld op basis van de meest recente conclusies ingediend voor aanvang van het onderzoek.
2. Met betrekking tot **nucleotide en/of aminozuur sequenties** die genoemd worden in de aanvraag en relevant zijn voor de uitvinding zoals beschreven in de conclusies, is dit onderzoek gedaan op basis van:
 - a. type materiaal:
 - sequentie opsomming
 - tabel met betrekking tot de sequentie lijst
 - b. vorm van het materiaal:
 - op papier
 - in elektronische vorm
 - c. moment van indiening/aanlevering:
 - opgenomen in de aanvraag zoals ingediend
 - samen met de aanvraag elektronisch ingediend
 - later aangeleverd voor het onderzoek
3. In geval er meer dan één versie of kopie van een sequentie opsomming of tabel met betrekking op een sequentie is ingediend of aangeleverd, zijn de benodigde verklaringen ingediend dat de informatie in de latere of additionele kopieën identiek is aan de aanvraag zoals ingediend of niet meer informatie bevatten dan de aanvraag zoals oorspronkelijk werd ingediend.
4. Overige opmerkingen:

Onderdeel II Voorrang

Deze schriftelijke opinie is opgesteld onder de aanname dat eventueel ingeroepen voorrang geldig is, tenzij hieronder anders is aangegeven. Controleren van de voorrang maakt geen deel uit van het reguliere onderzoek naar de stand van de techniek.

Zie aparte bladzijde

Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid

1. Verklaring

Nieuwheid	Ja: Conclusies 1-9, 11 Nee: Conclusies 10
Inventiviteit	Ja: Conclusies Nee: Conclusies 1-11
Industriële toepasbaarheid	Ja: Conclusies 1-11 Nee: Conclusies

2. Citaties en toelichting:

Zie aparte bladzijde

Onderdeel VIII Overige opmerkingen

De volgende opmerkingen met betrekking tot de duidelijkheid van de conclusies, beschrijving, en figuren, of met betrekking tot de vraag of de conclusies nawerkbaar zijn, worden gemaakt:

Zie aparte bladzijde

Re Item II

Priority

1. Priority is not valid for **claims 10 and 11**, because they relate to a subject-matter not present in the priority document **EP 17 183 228.0**.

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following documents:

- D2 EP 0 656 542 A2 (FLUKE CORP [US]) 7 juni 1995 (1995-06-07)
- D6 US 5 402 082 A (ECCLESTON LARRY E [US] ET AL) 28 maart 1995
(1995-03-28)

2. Notwithstanding the lack of clarity mentioned in Item VIII-1, the subject-matter of **claim 10** is not new, and the subject-matter of **claim 1** does not involve an inventive step, and the criteria of patentability are therefore not met.

2.1 Document D2 (cf. D2: column 2, line 27 - column 3, line 37; figure 1) is regarded as being the prior art closest to the subject-matter of **claim 1**, and insofar as this claim can be understood (cf. Item VIII-1), this document shows the following features thereof:

An electronic circuit configured to emulate an impedance, the electronic circuit comprising:

- a first amplifier (16) comprising a first feedback circuit (26, 28);
- second inverting amplifier (32) comprising a second feedback circuit; and
- a component (30) having an input connected to an output of the first amplifier (16) and an output connected to an inverting input of the second inverting amplifier (32), wherein the component (30) is configured to convert a voltage *at the output of the first inverting amplifier* to a current which is adjustable by modification of a setting (Control Word) of the component (30);

wherein the emulated impedance of the electronic circuit is defined between an input of the first amplifier (16) and an output of the second inverting amplifier (32) and adjustable by modification of the setting of the component.

The subject-matter of **claim 1** therefore differs from this known electronic circuit in that:

- the first amplifier is an inverting amplifier and the emulated impedance of the electronic circuit is defined between an inverting input of the first amplifier and an output of the second inverting amplifier.

Realizing the circuit of D2: figure 1 with an inverting amplifier in place of the non-inverting amplifier (16), in particular when the multiplying DAC (30) requires a different polarity of the input, or with an inverting amplifier with the reference resistor in the feedback loop in place of the shunt reference resistor (22), comes within the scope of the customary practice followed by persons skilled in the art, especially as the advantages thus achieved can readily be foreseen.

Consequently, the subject-matter of **claim 1** lacks an inventive step.

2.2 Document D6 (cf. D6: column 3, line 66 - column 6, line 35; figures 1, 2) discloses:

An electronic circuit suitable for emulating an impedance comprising:
-- a first inverting amplifier (12) including a feedback circuit (14); and
-- a pulse width modulator (22, 32) comprising an output and an input connected to an output of the first inverting amplifier (12), the pulse width modulator (22, 32) is configured to convert a voltage (V_{in}) *at the output of the first inverting amplifier* to an adjustable voltage (V_{filter}) which is adjustable by adjusting a setting (Digital Control Word) of the pulse width modulator, in which the emulated impedance of the electronic circuit is defined between an inverting input (10) of the first inverting amplifier and the output (36) of the pulse width modulator and is adjustable by adjusting the setting of the pulse width modulator.

The subject-matter of **claim 10** is therefore not new.

3. Dependent **claims 2 - 9 and 11** do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of inventive step.

3.1 Generating a reference voltage using an inverting amplifier with a reference resistor in the feedback loop is a known alternative to generating a reference voltage using a reference resistor connected in shunt.

Hence, no inventive step is present in the subject-matter of **claim 2** in view of document D2 combined with general technical knowledge.

3.2 The additional feature of **claim 3** that the second feedback circuit has a resistance configured to provide a desired gain of the second inverting amplifier is disclosed in document D2. The resistance is a part of the resistance network of the multiplying DAC (30), cf. D2: column 2, line 53 - column 3, line 4.

3.3 The additional features of **claim 4** that the values of the emulated impedance and the reference impedance are real valued numbers, the emulated impedance and reference impedance associated with values of an Ohmic resistance are disclosed in document D2: column 3, lines 31 - 37.

3.4 The additional features of **claim 5** that the values of the variable impedance and the reference impedance are complex valued numbers, the emulated impedance and reference impedance associated with values of a capacitance are disclosed in document D2: column 3, lines 12 - 21.

3.4 The additional features of **claim 6** that the values of the variable impedance and the reference impedance are complex valued numbers, the emulated impedance and reference impedance associated with values of an inductance are disclosed in document D2: column 3, lines 22 - 30.

3.5 The additional features of **claim 7** that the component is a digital to analog converter (DAC) is explicitly disclosed in document D2: column 2, line 27 - column 3, line 11; figure 1.

3.6 Implementing further inverting amplifiers (with gain) to modify values of the emulated impedance comes within the scope of the customary practice followed by persons skilled in the art, especially as the advantages thus achieved can readily be foreseen.

Consequently, the subject-matter of **claim 8** also lacks an inventive step.

3.7 Similarly, implementing a voltage inverting circuit between an output of the first amplifier and an input of the component, for example in order to adjust a polarity of the input to the DAC to its requirements, is considered a routine in the art.

Hence, no inventive step is present in the subject-matter of **claim 9**.

3.8 Document D6 (cf. D6: column 3, line 66 - column 6, line 35; figures 1, 2) discloses the pulse width modulator (22, 32) including the following components:

- a. Two electronically controlled switches (S1, S2);
- b. A pulse generator (28), the pulse generator is configured to drive the two electronically controlled switches (S1, S2) and provide electrical pulses whose pulse width is adjustable to adjust the voltage at the output of the pulse width modulator, adjustable such that the emulated impedance of the electronic circuit can be brought to a desired value.

Implementing the low pass filter (32) with a series resistor and a shunt capacitor, as well as including a phase shift module in the PWM control (28) to generate the switch control signals are considered minor implementation details which come within the scope of the customary practice followed by persons skilled in the art.

Consequently, the subject-matter of **claim 11** also lacks an inventive step.

Re Item VIII

Certain observations on the application

1. **Claims 1 and 10** are not clear.

1.1 **Claims 1 and 10** are not supported by the description, as their scope is broader than justified by the description and drawings.

Claims 1 and 10 refer to "*a voltage*" without specifying which voltage is meant.

However, the description and drawings (see paragraphs [0010] and [0026]; figure 2) convey the impression that not an arbitrary voltage is meant but a voltage at the output of the first inverting amplifier, and no alternatives are envisaged.

Hence, **claims 1 and 10** are not supported by the description.

Claims 1 and 10 have been interpreted according to the description and figures.