The invention relates to an electronic device which, fed from a sinusoidal or randomly variable network, makes it possible to supply the input of the converter with which it is equipped with a DC voltage, the receiver connected at the output also being fed with a DC voltage envelope, whereas the power factor of the current taken from the mains is kept at unitary value and said current is the image of the voltage which produces it. This device comprises a converter (12) whose high frequency output circuit loads the series circuit formed by the receiver (13) associated with impedance (16). The voltage developed across terminals of inductance (16) is rectified by bridge (15) mounted in series with the mains rectifier bridge (10) so that these voltages, added to the input of the converter (12), effect the envelope of a DC voltage, this also resulting in supplying a DC voltage envelope to receiver (13). The current taken from the mains has a unitary power factor whereas its envelope is homothetic of the voltage. This device is applicable to the majority of electronic converters used as ballasts, transformers, stabilized power supplies, and so on.
DESIGNATIONS OF "SU"

It is not yet known for which States of the former Soviet Union any designation of the Soviet Union has effect.

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Self-integration voltage converter.

The present invention relates to devices comprising an electronic energy converter which, fed from an AC distribution mains, may provide at its output a high frequency current whose readily adaptable potential is applicable to a majority of receivers, either directly or after previous rectification.

Known devices of this kind are numerous and could be classed in the two following types:

- the first one, illustrated in the accompanying figure 1, comprises a high frequency converter 5 whose biased input is shunted by the electrolytic smoothing capacitor 4, which is charged by the mains rectifier bridge 3 whose unbiased input is connected to the mains terminals 1a and 1b through the low pass filter 2 characterized by its considerable ferromagnetic inductance associated with capacities of values which are often high: the purpose of this filter is to limit the harmonic currents caused by charging of the smoothing capacitor 4 to the peak voltage of the mains, as well as to bring the shape factor of the current taken from the mains and the power factor of the device down to standardized values, whereby the voltage present between the input terminals of the converter 5 only has low residual modulation, which thus results in the fact that between its output terminals 6a and 6b the envelope of the high frequency AC voltage is only weakly modulated by the low frequency component of the rectified mains, thus lending itself to numerous applications, with or without rectification of the high frequency current;

- the second one, illustrated in the accompanying figure 2, still comprises a converter 5 but the input thereof is now only shunted by a decoupling capacitor 6 for the high frequencies, which capacitor has a sufficiently small capacity for charging thereof by the
mains rectifier bridge 3 not to create substantially harmonic currents on the current taken from the mains; thus, the voltage applied to converter 5, not being filtered by a high value capacitor, is modulated in accordance with the amplitude of the sinusoid of the mains, which results in equivalent modulation of the high frequency output current delivered by said converter; such a voltage envelope is satisfactory for few applications and thus, in most cases, it is necessary to rectify the high frequency current by means of the rectifier bridge 7 whose output current is filtered by the high value electrolytic capacitor 8, thus permitting a load applied between terminals 9a and 9b to be fed with substantially DC voltage.

Other devices have been envisaged, namely, the use of a complementary converter for charging said capacitor 4 with a good shape factor of the current taken from the mains, without having recourse to the bulky anti-harmonic filter 2.

Such devices have serious drawbacks, which are enumerated below.

In devices of the first type, which are the most widespread, filter 2, which is cumbersome and heavy, by its own losses, greatly reduces the electric efficiency of the unit while providing a suitable function only over a very reduced input voltage and frequency range; furthermore, for numerous applications, the long term reliability of the electrolytic capacitor 4 is unacceptable; this therefore restricts their field of application.

In devices of the second type, the supply current for converter 5, which is highly modulated, limits the electric efficiency which this latter might offer; moreover, the very high modulation of its high frequency output current renders it suitable for only a small number of applications if previous rectification is not provided.
by means of bridge 7 and filtering by means of the electrolytic capacitor 8 of a special and expensive type. Thus, with devices of this type a high frequency current only weakly modulated by the mains component cannot be delivered, which represents the majority of potential uses.

In so far as the devices using an auxiliary converter are concerned, the complexity of construction, the increase of high frequency parasite signals, control of the operation of the auxiliary converter and electric efficiency losses which it causes, have never made it possible to develop them industrially in a significant way.

Contrary to the known devices of the prior art, described above, the device of the invention completely overcomes all the above drawbacks, while only using a device of simple, economic and reliable construction.

In a general embodiment illustrated in the accompanying figure 3, the device of the invention comprises a converter 12 whose high frequency output voltage, present between terminals 12c and 12d, is applied to the series circuit comprising receiver 13 and an inductive or capacitive impedance of suitable value 16; the unbiased terminals 15c and 15d of the rectifier means 15 are connected to the terminals of said impedance 16, the voltage thus rectified, present between terminals 15a and 15b, is filtered by the low value capacitor 14 to be applied, on the one hand, to one of the common biased input terminals of converter 12 and, on the other hand, to a suitably oriented one of the biased terminals, of the mains rectifier means 10 whose other biased terminal is connected to the other of the common unbiased input terminals of converter 12, so that the high frequency voltage taken between the terminals of impedance 16 is added/integrated in series to the rectified mains voltage; a capacitor 11, of non critical value, integrates
the voltage sum thus provided, while ensuring decoupling of the input terminals 12a and 12b of said converter 12.

Under these conditions, if the impedance has a suitable reaction to the passage of the current flowing through receiver 13, the voltage recorded between the biased terminals 15a and 15b of the rectifier means 15 have the voltage envelope illustrated in the accompanying figure 5. Furthermore, the voltage of the mains applied between terminals 10a and 10b of the rectifier means 10, after rectification, presents between terminals 10c and 10d the voltage envelope illustrated in the accompanying figure 4.

Under these conditions, it can be seen that the integration/addition of these two voltages, suitably biased and of closely related maximum amplitude, after integration between the terminals of capacitor 11 will make it possible to obtain a resultant voltage close to the DC envelope 17. In fact, the synchronization of said voltages being provided by the period of the mains itself, it can be seen that the transfer of the hatched area 18 may take place on the empty area 19, their areas being substantially the same.

Such voltage summation is then integrated between the terminals of capacitor 11 which must only have a relatively small capacity, compatible with all the types of capacitors of restricted dimensions, whether they are of electrolytic or plastic film type.

Thus, the high frequency energy taken at the output of converter 12, via impedance 16, makes it possible to supply said converter with a substantially DC voltage, while exactly compensating for the current taken from the mains which remains perfectly sinusoidal.

Consequently, the voltage envelope applied to receiver 13 remains practically without mains modulation whereas converter 12 operates under excellent conditions
of efficiency.

To complete the device, a filter against high frequency parasites should be provided between the mains and terminals 10a and 10b.

It is obvious that the high frequency AC voltage thus applied between the terminals of receiver 13 could be previously rectified and filtered so as to feed the latter with DC voltage.

Such as it has just been described, the device of the invention overcomes the drawbacks inherent in the prior art devices. In fact, from the distribution mains it only takes a substantially sinusoidal current, in phase with the voltage, delivers to receiver 13 a voltage whose envelope is substantially DC, allows the converter fed with DC current to offer the maximum electric efficiency compatible with the standard components available on the market, ensures excellent regulation as a function of the variations of the mains voltage, of the current passing through the load 13 while eliminating the bulky and unreliable electrolytic capacitors in applications requiring the best MTBF.

According to the embodiment of the device of the invention illustrated in the accompanying figure 6, the transfer of the high frequency current to load 13 takes place via the transformer 20 whose primary and inductance 16 are mounted respectively in series and connected between the output terminals 12c and 12d of converter 12, the secondary of said transformer charging receiver 13, the general operation being moreover as described above.

In the embodiment of the device of the invention illustrated in the accompanying figure 7, the primary of transformer 20 is connected directly to the output terminals 12c and 12d of converter 12 and it is its secondary, mounted in series with impedance 16, as well as with the unbiased inputs 21a and 21b of the rectifier means 21, which will deliver the voltage to be applied to
the rectifier means 15. In this case, it is obvious that
the relative direction of this winding should be suitably
chosen, as well as the absolute value of impedance 16
which will be calculated proportionally to the
transformation ratio of said transformer, if the latter is
a voltage booster, and inversely proportional if it is a
step-down transformer. The purpose of the low value
capacitor 22, connected in parallel with the biased output
terminals 21c and 21d of the rectifier means 21, is to
eliminate the high frequency residual and allow a DC
current to be applied between the terminals of receiver
13.

The last two embodiments of the device are
particularly well adapted to the construction of high
frequency or DC supply transformers. In fact, over the
prior art they have either the advantage of not requiring
the use of a mains filter 2 whose losses and volume are
often equivalent to the ferromagnetic transformer which
they might replace or the advantage of offering a constant
output voltage envelope, which very considerably reduces
the high frequency rectification losses and the filtering
losses. Thus, at the present time, to obtain a compact
power supply, an electronic transformer must be used whose
peak output voltage is frequently twice the effective
voltage applied to the receiver, this being due to the
addition of parasites to the sector modulation. Under such
conditions, with high output current, the losses may be
reasonably assessed as follows: 10% for the converter,
10% for the high frequency rectification and 15% for
smoothing by the electrolytic output capacitor; this,
under ideal temperature conditions, leads to a maximum
efficiency of 68.85%.

In the case of a device constructed according to the
present invention, under the same conditions, the losses
are the following: 10% for the converter, 5% for the high
frequency rectification and 0% for smoothing, which leads
to a maximum efficiency of 85.5%. Moreover, since the latter device only uses plastic film capacitors whose loss angle tangent is less than 15/10000° over a temperature range from -40°C to +85°C, apparatus may be constructed whose bulk is reduced by 50% in the case of low power applications.

The accompanying figure 8 illustrates a practical application of the device of the invention. In this variant, said high frequency converter 12 is of the "semi-bridge" type equipped with switching means 23a and 23b, the output of the converted energy taking place between terminal 12c common to said switching means and one of the biased input terminals 12a and 12b of converter 12, which are shunted by the high frequency decoupling capacitor 11. A DC isolation capacitor 27 transmits the high frequency current to the series circuit formed by the limiting inductance 28, receiver 13 and capacitor 30 which plays the role of recovery impedance 16 described above.

When this series circuit has a given high frequency current flowing therethrough, this current limited by inductance 28 meets the reactance of capacitor 30 of defined value. This reactance develops between the terminals of the latter a voltage which, applied to one of the unbiased terminals of the rectifier bridge 15 used as a voltage doubler, will be rectified and filtered by the decoupling capacitor 14 between the biased terminals of said bridge. This rectifier bridge 15 has biased terminals connected in series with the biased terminals of the mains rectifier 10, themselves suitably oriented. Thus, the mains current applied between the unbiased terminals of the rectifier bridge 10 will have added thereto, after rectification and filtering, the voltage taken between the terminals of capacitor 30. The sum of these voltages is integrated between terminals 12a and 12b of capacitor 11, which are common to the input of converter 12.

Accessory, a capacitor 29 connected between the
terminal of receiver 13 not common to capacitor 30 and the
unbiased input of the rectifier bridge 15 which is not
common with capacitor 30, is provided to improve the
linearity of the voltage present at the terminals of
capacitor 14, by adding the voltage developed between the
terminals of the series circuit comprising the receiver 13
and the impedance of capacitor 30. In some cases, it may
be advantageous to connect the terminal of capacitor 29,
common to receiver 13, directly to the output 12c of
converter 12.

In order to prevent return of high frequency parasites towards the mains, the low value bifilar
inductance 32, in association with capacities 31a and 31b
whose middle point is grounded, is inserted between said
mains and the unbiased terminals of the rectifier bridge
10.

Such as it has been described, the device of the
invention provides self-smoothing of the modulation of the
mains voltage between terminals 12a and 12b, and hence
optimum efficiency operation of converter 12, as well as
the application of a constant voltage envelope between the
terminals of receiver 13. Under these conditions, the
current taken from the mains remains substantially
sinusoidal and perfectly in phase with the voltage: its
power factor equal to unity is not affected by the
variations of the input voltage nor by the variations
of the mains frequency, whether it is 50 or 60 Hz.

It is obvious that the embodiment of the device of the
invention described above could accept other converter
structures using all known types of switching means and
not only the bipolar transistors shown here for the sake
of convenience. Also, it is obvious that the receiver 13
could be preceded by a rectifier bridge and a decoupling
capacitor so as to be fed with DC current.

A variant of the device of the invention described
above is illustrated in the accompanying figure 9. In this
embodiment, everything remains the same, except that receiver 13 is no longer connected in series with inductance 28 but is connected between the terminals of a secondary winding 28' coupled to said inductance 28, capacitor 29 having one of its terminals connected to an intermediate tapping belonging to inductance 28. Under these conditions, the operation remains identical to what has been described above.

Such an embodiment makes it possible to isolate the receiver 13 galvanically from the mains.

All the above described devices are adapted to operate from a sinusoidal current distribution mains, but also from current coming from a source delivering a voltage whose envelope is randomly variable. Under these conditions, the current taken by the device for its power supply will be the image of the supply voltage, in phase therewith, whereas the voltage at the input of the converter 12, like the voltage applied to the terminals of load 13, will be of a substantially constant amplitude.

The device of the invention may be used in association with most types of converter. This device makes it possible, from an AC or randomly variable voltage mains, to feed such a converter with a current without substantial residual ripple, without altering the factor of the current taken from the mains nor its envelope which, over a wide frequency range, is maintained in the image of the voltage.

The device of the invention radically overcomes the defects of similar devices constructed according to the prior art. It may be used in all cases where it is desired to provide an economic DC power supply, an electronic transformer, an electronic ballast for fluorescent lamps, etc...

As is evident, and as it follows moreover from what has gone before, the invention is in no wise limited to the modes of application and embodiments which have been
more particularly considered; it includes, on the contrary, all variants thereof.
CLAIMS

1. Energy conversion device comprising an electronic converter 5 adapted to deliver between its output terminals a high frequency unitary value signal whose envelope is influenced by the form of the input voltage, characterized by the fact that the output terminals 12c and 12d of converter 12 deliver a high frequency current to the series circuit formed by the receiver 13 associated with the inductive or capacitive impedance 16, the latter being connected in parallel across the unbiased terminals of the rectifier means 15 whose biased outputs, decoupled by capacitor 14 and suitably oriented, are connected in series with the biased output terminals of the mains rectifier means 10 whose unbiased inputs are connected to the mains, so that the added voltage taken between the terminals of impedance 16, being integrated at the terminals of the decoupling capacitor 11, develops between the terminals thereof a substantially DC voltage which is re-applied between the biased input terminals 12a and 12b of converter 12, this involving for the latter optimum conditions of efficiency as well as the application of a DC envelope voltage to receiver 13, whereas the current taken from the input remains homothetic of the input voltage.

2. Device according to claim 1, characterized by the fact that in the output circuit of converter 12, connected between the terminals 12c and 12d, the receiver 13 is replaced by the primary of a transformer 20 whose secondary loads said receiver 13, all things being otherwise identical.

3. Device according to claim 1, characterized by the fact that the output circuit of converter 12 is closed again directly on the primary of transformer 20, whose secondary closes again on the series circuit comprising the impedance 16 and load 13 which is connected through
the rectifier means 21 whose biased terminals 21c and 21d are decoupled by capacitor 22, the rectifier means 15 having, as before, their unbiased inputs connected in parallel across said impedance 16, the operation of the device remaining otherwise identical.

4. Device according to claims 1, 2 and 3, characterized by the fact that the high frequency voltage available between the terminals of receiver 13 may be applied thereto, as it is, or after previous rectification by the rectifier means 21, followed by decoupling by capacitor 22.

5. Device according to claims 1, 2, 3 and 4, characterized by the fact that one of the output terminals of converter 12 is common to one of its input terminals and that its non common output terminal 12c corresponds to the middle point of the series formed by the switching means 23a and 23b having, for example, a "semi-bridge" structure, said output being isolated with respect to the DC current by means of a capacitor 27 for then closing again on one of the input terminals 12a or 12b through a series circuit formed by the current limiting inductance 28, receiver 13 and capacitor 30, representing said inductive or capacitive impedance 16, so that the voltage developed between the terminals of capacitor 30, applied to one of the unbiased inputs of the rectifier bridge 15, after rectification and filtering by the decoupling capacitor 14, is added, as mentioned above, to the mains voltage rectified by the rectifier bridge 10.

6. Device according to claim 1, characterized by the fact that a capacitor 29, connected between the unbiased free input of the rectifier bridge 15 and one of the terminals of impedance 28 provides, after rectification, the addition of a complementary voltage to the terminals of capacitor 14, this for linearizing the current taken from the mains as well as the voltage applied to receiver 13.
7. Device according to claim 6, characterized by the fact that load 13 is mounted in parallel with a winding 28' coupled to impedance 28, which is connected directly in series with the capacitor 30, capacitor 29 no longer being connected to one of the endmost terminals of impedance 28 but to a suitably chosen intermediate tapping, the general operation otherwise remaining the same.
1. (amended) Energy conversion device comprising an electronic converter adapted to deliver between its output terminals a high frequency unitary value signal to a load envelope is influenced by the form of the input voltage, whereby the output terminals of converter deliver a high frequency current to a circuit formed by the load associated with a inductive impedance, the latter being connected in parallel across the unbiased terminals of the rectifier means 15 whose biased outputs, are connected in series with the biased output terminals of the mains rectifier means whose unbiased inputs are connected to the mains, so that the added voltage taken between the terminals of impedance, being integrated characterized by the fact that the integration is made by capacitons whereby the added voltage taken between the terminals of the capacitive impedance (16, 30) is being integrated by the series connection of the two mentioned rectifiers (10, 15) at the terminals of the convertor 12 thereby developing between the terminals thereof a substantially DC voltage which is re-connected to the biased input terminals 12a and 12b of convertor 12, this involving for the latter optimum conditions of efficiency as well as the application of a DC envelope voltage to the load 13, whereas the current taken from the input remains homothetic of the input voltage.

2. (amended) Device according to claim 1, characterized by the fact that in the output circuit of convertor 12, connected between the terminals 12c and 12d, the receiver 13 ist replaced by the primary of a transformer 20 whose secondary loads are connected with the load 13.

3. (amended) Device according to claim 1, characterized by the fact the output circuit of convertor 12 is connected again directly on the primary of transformer 20, whose secon-
dary hindings are connected on the series circuit comprising the capacitive impedance 16 and load 13 which ist connected through the rectifier means 21 whose biased terminals 21 c and 21 d are bridged by capacitor 22, the rectifier means 15 having, as before, their unbiased inputs connected in parallel across said capacitive impedance 16, the operation of the device remaining otherwise identical.

4. (amended) Device according to claims 1, 2 and 3, characterized by the fact that the high frequency voltage available between the terminals of load 13 may be applied thereto, as it is, or after previous rectification by the rectifier means 21, followed by bridging by capacitor 22.

5. (amended) Device according to claims 1, 2, 3 and 4, characterized by the fact that one of the output terminals of converter 12 is common to one of its input terminals and that its non common output terminal 12 c corresponds to the middle point of the series formed by the switching means 23a and 23b having, for example, a "semi-bridge" structure, said output being isolated with respect to the DC current by means of a capacitor 27 for then closing again on one of the input terminals 12a or 12b through a series circuit formed by the current limiting inductance 28, load 13 and capacitor 30, representing said capacitive impedance 16, so that the voltage developed between the terminals of capacitor 30, applied to one of the unbiased inputs of the rectifier bridge 15, after rectification and filtering by the decoupling capacitor 14, is added, as mentioned above, to the mains voltage rectified by the rectifier bridge 10.

6. (amendé) Device according to claim 1, characterized by the fact that a capacitor 29, connected between the unbiased free input of the rectifier bridge 15 and one of the terminals of impedance 28 provides, after rectification, the addition
of a complementary voltage to the terminals of capacitor 14, this for linearizing the current taken from the mains as well as the voltage applied to load 13.

7. (as original filed) Device according to claim 6, characterized by the fact that load 13 is mounted in parallel with a winding 28' coupled to impedance 28, which is connected directly in series with the capacitor 30, capacitor 29 no longer being connected to one of the endmost terminals of impedance 28 but to a suitably chosen intermediate tapping, the general operation otherwise remaining the same.

8. (new) Device according to one of the proceeding claims, characterized by the fact that the load 13 is connected in series with the oscillator formed by capacitor 27 and inductivity 28.
I. CLASSIFICATION OF SUBJECT MATTER

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<td>Intelec '89 conference proceedings vol. 2, October 1989, Florence, Italy Chibani &amp; Nakaoka: &quot;New Sinusoidal Line-current PWM adaptive Control-based HF Link Converter&quot; see page 2, left-hand column; figure 7</td>
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IV. CERTIFICATION

Date of the Actual Completion of the International Search
07 MARCH 1991

Date of Mailing of this International Search Report
27 MAR 1991

International Searching Authority
EUROPEAN PATENT OFFICE

Signature of Authorized Officer
VAN DEN DOEL J.
This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EPO file on the European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 07/03/91

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For more details about this annex: see Official Journal of the European Patent Office, No. 12/82