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Method and system for displaying the amplitude distortions
of a transmission channel

The invention starts out from a method according to the
5 preamble of the main claim.

In order to measure the characteristics of a transmission
channel with regard to non-linear amplitude distortions,
the amplitude distribution of a measurement signal to be
10 transmitted, which has an amplitude distribution that is
known in theory, can be used. Deviations from this ideal
amplitude distribution can thus be attributed to the
influence of the transmission channel. Limiting power
output stages of high-frequency transmitters and the like
15 can be measured in this way for example with regard to non-
linear amplitude distortions.

The object of the invention is to present a particularly
clear and for the user advantageous display of the
20 measuring result of such a measurement of the amplitude
distribution.

This object is achieved starting out from a method
according to the preamble of the main claim by its
25 characterizing features. Advantageous developments ensue
from the sub-claims.

Due to the evaluation according to the invention of the
frequency distribution of the multitude of amplitude
30 measured values that are measured in succession, with
simultaneous matching data reduction and display of the
frequency distribution in frequency values combined to give
amplitude windows, a particularly clear and rapidly



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evaluatable display is created for the user of a corresponding measuring receiver, as shown in Figure 3.

The method according to the invention is explained in
5 greater detail below with reference to schematic drawings.

The successive amplitude measured values measured by a measuring receiver for example at the output of a transmitter output stage to be measured are digitized via
10 an A/D converter and processed further as successive digital values via a processor according to Fig. 1. For a first representation, a predetermined number $n_{\max}$ of digital values, which correspond to a predetermined measuring time, is evaluated, in practice 100000 successive measured values
15 for example. These successive measured values are now sorted according to frequency, to do this the respective memory cell of memory A from $s_{\max} + 1$ memory cells with an address corresponding to the amplitude value of the measured value evaluated in each case is incremented for
20 each measured value AD (n) according to Figure 1 (theoretically possible amplitude values: 0 to $s_{\max}$). In the example according to Figure 1, the amplitude values 4, 6, 1, thus integer numerical values respectively, are measured in succession, for example. As indicated by the
25 arrows drawn, their frequency is counted in the related memory cells $s = 0$ to $s_{\max}$, at the end following the evaluation of all $n_{\max}$ amplitude values their frequency distribution is thus stored in memory A. In practice memory A has for example 1024 successive memory cells.

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A reference value, for example the root-mean-square value, that is used in the final display as the reference value is then calculated from these stored frequency values. For a logarithmic display scale, the root-mean-square value is

the most suitable. The reference value Ref is calculated by way of the formula indicated in Figure 1 from the sum of the amplitude frequency HAD, the number of amplitude stages $s_{\max} + 1$ of the memory A and the evaluated number $n_{\max}$ of
5 amplitude values.

To simplify the display of the amplitude distribution of the output signal measured still further, the amplitude frequency values of the memory A above the reference value
10 Ref are respectively combined and added to give so-called amplitude windows $F = 1$ to $F_{\max}$. The lower and upper limits of the amplitude windows F are respectively designated s_1 and s_2 . In the case of window boundaries that do not
15 precisely meet the middle between two amplitude stages of the measured values supplied by the A/D converter, the value of the frequency of the amplitude stage concerned must be distributed weightedly to two windows to increase
the accuracy of the result. Due to this combination of frequency values, the absolute frequency AH (F) is finally
20 obtained for each amplitude window F and displayed. In the example shown according to Figure 1, 20 adjacently connected amplitude windows F for example are provided above the reference value of 0 dB calculated as the root-mean-square value, the range 0 to 1 dB being assigned to
25 the first window, 1 to 2 dB to the second window, 2 to 3 dB to the third window etc.

Figure 3 shows the display derived therefrom on a screen or due to a printout by means of a printer. The 1-dB
30 amplitude windows F are entered in a horizontal direction, and the amplitude distribution, i.e. the number of measured values in the respective amplitude window relative to the number of measured values recorded in total, in a vertical direction as bars. $1E-2$ means for example that 10^{-2} , thus 1

% of all measured values, are located within this 1-dB window.

The crest factor, the calculation formula of which is indicated in Figure 1, can also be calculated easily from the greatest amplitude stage s of the memory A actually occurring and from the reference value Ref calculated as the root-mean-square value, and displayed.

A certain number z of measured values $AD(n)$ is required for a statistically significant statement regarding the actual amplitude distribution. In many cases, the stated multitude n_{max} is not sufficient for this, thus $k_{max} = z/n_{max}$ measured values have to be recorded to attain the required measuring accuracy. To do this, a ring memory structure of the length k_{max} is used according to Figure 2. First the relevant absolute frequency $AH(F)$ is ascertained for each amplitude window F for a first multitude n_{max} of measured values according to the processing scheme according to Figure 1 and entered in the first memory cell row $k = 1$ of the ring structure, to be precise together with the reference value likewise calculated according to Figure 1 and also together with the crest factor. Then the absolute frequency is again ascertained for each amplitude window according to the scheme according to Figure 1 for the second multitude n_{max} of measured values and entered in the second memory cell row $k = 2$ etc. until the entire ring structure is fully described by k_{max} elements. Following each entry in a memory cell row k , the measurement is shown on the display, taking the measured values processed up to now into account. Following entry in k_{max} , the first row $k = 1$ of the ring structure is overwritten again, so that only the most up-to-date measured values are always processed. From the absolute frequency values stored thus

in the ring structure, the cumulative frequency is calculated for each amplitude window and from this finally the relative frequency for each amplitude window, which frequency is then finally displayed according to Figure 3.

- 5 The ring structure can consist for example of $k = 100$ individual memory cell rows. The relative amplitude frequency for each amplitude window that is finally displayed according to Figure 3 is calculated here from the added absolute amplitude frequency for each amplitude
- 10 window divided by the number of measured values that have occurred so far, as indicated by the formulae according to Figure 2.

- The crest factor can also be determined from the maximum of
- 15 the crest factors calculated hitherto and displayed, as likewise indicated by the formula in Figure 2.

- Finally, the current percentage of the number of recorded measured values required in all for a statistically
- 20 significant statement can be displayed and corresponds to the number of entries k currently present in the ring structure divided by $k_{\max}$ according to the formula likewise indicated in Figure' 2.

- 25 In order to compare the amplitude distribution measured, as represented in Figure 3 by the vertical bars, with the theoretically given known amplitude distribution of the measurement signal used, the latter can also be faded in in the display image, as indicated in Figure 3 by the
- 30 horizontal short dashes for each amplitude window.

Any signal with a known amplitude distribution is suitable as a measurement signal; preferably a signal that is also transmitted in operation via the transmission channel to be

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measured is used, for example a digital television signal processed according to the DVB-T standard.

1. Method for displaying the amplitude distortions of a
transmission channel, characterized in that a
5 measurement signal of a known amplitude distribution is
transmitted via the transmission channel, the amplitude
values are measured at the output of the transmission
channel, these successive amplitude measured values are
converted into digital values, the amplitude values
10 measuring range is divided into adjacently connected
amplitude windows, from a given multitude of the
successively formed amplitude digital values the
frequency of their occurrence in the adjacently
connected amplitude windows is determined, and the
15 amplitude frequency values thus ascertained for each
amplitude window are displayed by means of a display
device.
2. Method according to claim 1, characterized in that a
20 reference value, in particular the root-mean-square
value, is ascertained from the amplitude frequency
values determined in all, and only the amplitude
frequency values of the amplitude windows occurring
above this reference value are displayed.
- 25 3. Method according to claim 2, characterized in that the
quadratically weighted average (root-mean-square value)
is calculated from the sum of the amplitude frequency
values as the reference value.
- 30 4. Method according to one of the preceding claims,
characterized in that first the frequency of occurrence
of the respectively different integer amplitude measured
values of the given multitude are determined, then the

reference value is calculated and the amplitude frequency values determined above this reference value are combined and added to form groups respectively, and these totals of the respectively combined groups of amplitude frequency values are displayed in the adjacently connected amplitude windows.

5. Method according to one of the preceding claims, characterized in that the crest factor is calculated from the greatest amplitude frequency value ascertained and from the reference value.
6. Method according to one of the preceding claims, characterized in that the amplitude frequency is ascertained for each amplitude window respectively according to claim 1 for several successive given multitudes $n_{\max}$ of amplitude measured values and the cumulative frequency is ascertained therefrom and then the relative amplitude frequency for each amplitude window is calculated and displayed.
7. Method according to claim 5 or 6, characterized in that the crest factor' is also determined for several successive given multitudes of amplitude measured values and the relative crest factor is calculated via the cumulative frequency ascertained therefrom and displayed.
8. Method according to one of the preceding claims, characterized in that the ideal amplitude frequency of the measurement signal is also displayed in the amplitude windows at the same time.

9. Method according to one of the preceding claims, characterized in that the current percentage of the momentarily evaluated number of given multitudes is also displayed at the same time.