

The invention relates to a method for improving the resolution of digital signals in accordance with the first part of claim 1.

In order to reduce the bulk of data during the digital transmission of television signals, it is known to initially transform the television signals, in blocks, from the original range into a frequency range, of these, on the basis of the spectral coefficients obtained by the transformation, to transmit only the essential coefficients and to set the inessential ones equal to zero and thereafter, to inversely transform the transformed values back into the original range. The transformation is effected by multiplication of the signal values with a transformation function whereby the number of places increases as a result of the transformation. For e.g. a two dimensional transformation of the block size 8×8 , an integer division of the coefficient blocks and hence a rounding of the transformation values is effected twice in order to reduce the number of places to the value laid down for an adequate resolution of the steps of the luminance and/or chrominance signal values e.g. 8 bits plus sign.

It has been found, that, with small ac components of the transformed coefficients i.e. for smooth structures in the original picture, coarse structures appear after the inverse transformation. This is due to the fact that items of information are lost by reason of the rounding of the transformed values and are then missing during the inverse transformation and hence there is visible distortion since there is no masking available from higher frequency signal components.

The object of the invention is, while limiting the number of places in the frequency range, to obtain a better reproduction of small signal variations in the original range after the inverse transformation.

This object is achieved in a method in accordance with the first part of claim 1 by the features defined in the characterising part.

The coefficients for the dc component calculated after the transformation of the sampling values on the one hand and the ac components on the other hand occupy different numerical ranges. The dc component encompasses only positive values, the ac components encompass positive and negative values whereby however, their amount can only be at most half as large as that of the dc component. Consequently, the span between the smallest and the largest possible value is the same for the dc component and for the ac components. This circumstance is made use of in

the invention in order to create uniform ranges for the values of the dc component and of the ac components by displacement of one of the numerical ranges. Thereby, the available places of the data words can be optimally utilised for the quantisation of the coefficients.

The invention further relates to a circuit arrangement for the improvement of the resolution of television signals in accordance with the first part of claim 4.

In this respect, the object is, while limiting the number of places in the frequency range, to create a circuit arrangement which enables a better reproduction of small signal variations in the original range after the inverse transformation.

This object is achieved in a circuit arrangement in accordance with the first part of claim 4 by the features defined in the characterising part.

Developments and advantageous embodiments of the invention are apparent from the further claims, the description and the drawing with the help of which an embodiment of the invention will be explained hereinafter.

In the drawing,

Fig. 1 shows a circuit arrangement for the transformation of digital signals from the original range into a frequency range having a limitation of the number of places and a subsequent inverse transformation into the original range ;

Fig. 2 a circuit arrangement corresponding to Fig. 1, with however, additional range displacement circuits.

The transformation circuit illustrated in Fig. 1 is suitable for the processing of television signals in which the television picture is resolved into square blocks of 8×8 pixels and the sampling values corresponding to the luminance and/or chrominance values having a quantisation of 256 quantisation steps are available as eight place data words. Due to the two dimensional extent of the blocks, a two dimensional transformation is effected whereby initially, a horizontal first dimension and thereafter a vertical second dimension is transformed.

For the implementation of this transformation, the circuit arrangement comprises a first transformation circuit 1, a buffer store and transposition circuit 2, a second transformation

circuit 3 and, following a transmission path 4 or a bulk store, a circuit for the inverse transformation consisting of a third transformation circuit 5, a second buffer store and transposition circuit 6 and a fourth transformation circuit 7. The four transformation circuits 1, 3, 5 and 7 may be constructed for example as stores in whose storage locations all of the occurring transformed values which were calculated with the transformation function are contained and which, upon addressing their inputs, are applied to the outputs. The buffer store and transposition circuits 2, 6 may be constructed as stores in which the sequence of the stored values is regrouped in such a way that the values previously present in the rows are now transposed into the columns and vice versa. In other words, the matrix formed by the coefficients is rotated through 90° .

The value range which the sampling values, or, after the transformation, the dc components and ac components adopt, is indicated below the respective function blocks in the decadic numbering system.

The sampling values queuing up on the input 8 occupy a value range of 0 to 255. On the assumption that eight pixels of an 8×8 matrix are transformed in the first dimension, the number of places at the output 9 of the transformation circuit 1 increases by the factor eight. Consequently, the value range at the output 9 comprises the numerical values from 0 to 2,040 for the dc component and from -1,020 to +1,020 for the ac components. By not taking into account the three places of least significance (LSB), there results a division of the coefficients by eight. This number of places is also the basis for the values at the input 10 of the second transformation circuit 3, whereupon the transformed coefficients at the output 11 are increased once more by the factor eight and, by not taking into account the three places of least significance (LSB), are limited to the previously mentioned range of the dc component and of the ac component.

Thus, at the input 12 of a transmission path 4 or of a bulk store, there are indeed values having 256 steps available for the dc component but for the ac components however, there are only 128 steps. The values for the ac components are thus more coarsely quantised and it is possible that quantisation errors will make themselves disturbingly apparent during the reproduction in that step structures become visible for gradual brightness or colour transitions.

After the storage and transmission, the transformed values available at the output 13 are inversely transformed back into

the picture range and this in the opposite manner to the forward transformation. The inverse transformation initially occurs unidimensionally for the columns. From the data words present at the input 14, data words are calculated at the output 15 after the inverse transformation whose value range lies respectively between -1,020 and +1,020 for the dc components and for the ac components whereby the actually occupied value range only extends from +255 and -255 however since the higher binary places are equal to zero. The three most significant places (MSB) therefore do not need to be taken into account. From the said value range, a dc component occupies between 0 and 255 and ac components between -127 and +127. After the rows and columns were interchanged in the buffer store and transposition circuit 6, the data words from this value range reach the input 16 of the fourth transformation circuit 7. After inverse transformation, there again appears at the output 17 of the fourth transformation circuit 7 data words of which the most significant places (MSB) are not taken into account. The value range of the sampling values again amounts to between 0 and 255.

In the circuit arrangement in Fig. 2, which is constructed similarly to Fig. 1, there are arranged additional range displacement circuits 18 and 19, which may be formed for example as adding circuits of a variable value and a constant value. During the processing of the dc component in the still unlimited number of places, the relevant value of the dc component present at the input 20 is subtracted by the half of its maximum numerical range i.e. for 2,040 by 1,020 so that the new value range at the output 21 now comes to lie between -1,020 and +1,020. Thereby, the value range of the dc component coincides with that of the ac component. Instead of the division by eight by leaving out the three places of least significant value (LSB), here now, only a division by four is undertaken. The now, possibly negative numerical range of the dc component is denoted in a similar way as for the ac components by a prefix sign.

This measure is of benefit for the ac components which can now be processed with a resolution of -255 to +255 in the transformation circuit 3. In the following stages, the further forward transformation and the inverse transformation correspond to those of Fig. 1. However, after the inverse transformation, the second dimension is necessary to produce the original range. This happens by means of the further range displacement circuit 19 in which the numerical value 255 is added to the data words present at the input 22 and the result is divided by two. A data word is then derivable at the output 23 whose value range extends from 0 to 255. With the measures described, the ac components can be stored or transmitted with a resolution which

is higher by the factor 2 without increasing the number of places. During the reproduction of the values into the original range, this leads to a gradation of the luminance and chrominance values which is less conspicuous.



Claims

1. Method for improving the resolution of digital signals, in particular luminance and/or chrominance television signals, whose sampling values are transformed (1, 3) as blocks e.g. by discrete cosine transformation so that a positive coefficient representing a dc component (G1) and a plurality of negative or positive coefficients representing ac components (We) occur for each two dimensional block and in which the number of places required for the representation of the coefficients is limited when calculating the coefficients and in which the thus obtained coefficients are inversely transformed (5, 7) after a transmission and/or storage (4), characterised in that, a two dimensional transformation consisting of two unidimensional transformations occurs for each of the blocks, wherein, between the first (1) and second (2) unidimensional transformations, the numerical values of the coefficients representing the dc component are displaced (18) into the numerical range which the coefficients representing the ac components occupy and are provided with a corresponding sign (VZ) and wherein, after the conclusion of the inverse transformation, the numerical values of the blocks are transferred back (19) into the original numerical range.

2. Method in accordance with Claim 1, characterised in that, for the displacement (18) of the numerical values of the dc components, a value is subtracted from each dc component which is such as corresponds to the half of the numerical range available to the dc components after the first transformation (MSB...LSB to 20).

3. Method in accordance with Claim 1 or 2, characterised in that, for the reverse transfer (19), a value is added to each of the numerical values of the blocks which is such as corresponds to the half of the numerical range available to the numerical values after the concluded inverse transformation.

4. Circuit arrangement for improving the resolution of digital signals, in particular luminance and/or chrominance television signals, whose sampling values are transformed as blocks e.g. by discrete cosine transformation, by means of a transformation circuit (1, 3) so that a positive coefficient representing a dc component (G1) and a plurality of negative or positive coefficients representing ac components (We) occur for each two dimensional block and in which the number of places required for the representation of the coefficients is limited when calculating the coefficients or the correspondingly transformed coefficients are inversely transformed by means of an inverse



transformation circuit (5, 7), characterised by the following transformation section:

- a first unidimensional transformation circuit (1) for the digital signals;
- a first range displacement circuit (18), which displaces the numerical values of the coefficients representing the dc component into the numerical range which the coefficients representing the ac components occupy, located after the first unidimensional transformation circuit;
- a second unidimensional transformation circuit (3) which is located after the first range displacement circuit and emits the two dimensional transformed blocks of coefficients,

and by the following inverse transformation section:

- a first unidimensional inverse transformation circuit (5) following which there is located a second unidimensional inverse transformation circuit (7);
- a second range displacement circuit (19) which transfers the numerical values of the blocks back into the original numerical range after the conclusion of the inverse transformation.

5. Circuit arrangement in accordance with Claim 4, characterised in that, the first range displacement circuit (18) subtracts a value from each dc component which is such as corresponds to the half of the numerical range available to the dc components after the first transformation (MSB...LSB to 20).

6. Circuit arrangement in accordance with Claim 4 or 5, characterised in that, the second range displacement circuit (19) adds a value to each of the numerical values of the blocks which is such as corresponds to the half of the numerical range available to the numerical values at the output (17) of the second inverse transformation circuit.