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54 **Electronic colour signal generator and colour image display system provided therewith.**

57 A colour signal generator has a colour memory (CLUT) and an address generator. The memory is divided in a number ($N \geq 2$) of sections, and each section comprises either colour reference data for a particular intensity of the colours or colour reference data for different intensities of a particular colour. The address generator is provided for generating address words which comprises a first part generated upon a receipt digital signal representing a pixel to be displayed on a display device and a second part generated upon a receipt intensity value indicating the pixel display intensity. A memory section being selectable by one said address parts and a location within the selected memory section being selectable by the other address part.

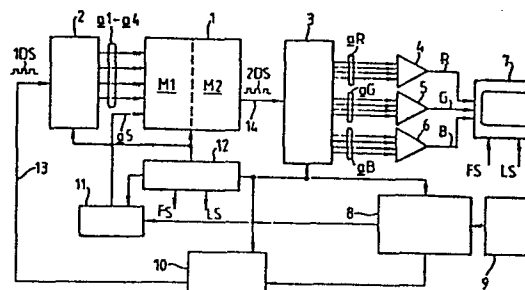


Fig.1.

Electronic colour signal generator and colour image display system provided therewith.

The invention relates to an electronic colour signal generator for a colour image display system, which generator comprises a memory having addressable memory locations for storing colour reference data, an address generator connected to an address input of the memory
5 and having a signal input for receiving digital signals representing pixels to be displayed, said address generator being provided for generating address words for selectively addressing the memory locations, a generated address word comprising a first part determined upon a receipt digital signal, reading means connected to a data output
10 of the memory for outputting the colour reference data from the selected memory locations.

Such an electronic colour signal generator is known from the GB patent specification GB 2 032 740A. The colour reference data stored in the memory identifies different colours of varying hue,
15 saturation and intensity. These three terms as used in this prior patent specification, and as will be so used in the present specification, have their standard dictionary means. Thus, "hue" means the attribute of colours that permits them to be classified as red, green, blue, or an intermediate between any contiguous pair of these three colours, and
20 relates to the dominant wavelength of a colour. "Saturation" characterises the purity of a colour, that is, the extent to which it is mixed with white. "Intensity" relates to the brightness or luminosity of a colour. For any particular colour, the stored colour reference data is in three separate parts which relate respectively to linear proportions
25 of the three primary colours, red, green and blue that are to be combined to produce that particular colour of appropriate hue, saturation and intensity on a display unit of a colour image system. When a pixel has to be displayed in a particular colour, a digital signal representing that pixel colour is supplied to a signal input of
30 the address generator. Upon a receipt digital signal the address generator generates an address word for selecting a memory location in the memory. At that selected memory location there is stored colour

reference data for that particular colour which colour reference data is then outputted via the reading means, and supplied to a display unit for displaying that particular pixel in that particular colour.

A drawback of the known electronic colour signal generator is that for different intensity values of a same colour, either the same colour reference data have to be used, or it is necessary to reprogram the memory, which is a roundabout way of operating the system. However, the colour characteristics of hue, saturation and intensity are not simple functions of the red, green and blue colour proportions, but are extremely inter-dependent and are inter-related by complex mathematical formulae. These relationships are further complicated by the non-linear response or "gamma" of a cathode ray tube. Therefore, it has been found that the intensity of many colours is unlikely to be altered by a linear change in the proportions of red, green and blue colours which are used additively to produce them, without also changing the hue and saturation of these colours.

This inability to alter independently the intensity of a colour without also affecting its hue and saturation poses a problem in image display on the screen of a display device. For instances, where a coloured portion of a displayed image is increased in intensity to highlight that portion, undesirable change in the hue and/or saturation of the coloured portion can result. Also, where a coloured portion of a displayed image is reduced in intensity (e.g. to provide a window for the display of sub-titles), undesirable change in the hue and/or saturation of that coloured portion can again result.

It is an object of the present invention to provide an electronic colour signal generator which permits modifications of the intensity of a displayed colour without affecting the hue and saturation of that colour and without the necessity to reprogram the memory.

According to the present invention, a colour signal generator of the type set forth above is characterized in that said address generator comprises an intensity signal input for receiving an intensity value indicating the pixel display intensity, said address generator being further provided for generating an exclusive second address part for each received intensity value and for forming address words by combining for each pixel their respective first and second address part, and wherein said memory comprises a number ($N \geq 2$) of memory

sections, each memory section being assigned for the storage of exclusive colour reference data, a memory section being selectable by one of said address parts and a location within the selected memory section being selectable by the other address part.

5 The division of the memory in a number of memory sections, wherein each section comprises exclusive colour reference data permits the colour reference data for a standard range of colours to be stored in one section of the memory, and colour reference data for higher and/or lower intensity versions of the standard range of colours
10 to be stored in another section or sections of the memory. It is thus no longer necessary to reprogram the memory to obtain another set of colour reference data. Further upon receipt of an intensity value on his intensity signal input, the address generator generates an exclusive second address part for this intensity value. An address word for a
15 pixel is then formed by combining the first and the second address part. Thus for a particular combination of colour and intensity there is formed an exclusive address word, which addresses an exclusive colour reference data. One of said address parts then selects a memory section while the other address part then selects a colour reference data in
20 that selected memory section. That exclusive colour reference data then permits to display the pixel in the desired combination of colour and intensity without affecting the hue and saturation.

By this means, not only will the non-linearities of a colour cathode ray tube and the complex relationships between the colour
25 characteristics of hue, saturation and intensity be taken into account, but also the human perception to colour can be taken into account.

It should be noted that prior USA patent specification
4 183 046 describes a colour signal generator in which the words of the first digital signal are in three separate groups of data bits which
30 define the colours of elements of an image to be displayed in terms of intensity, hue and saturation. The data bit groups corresponding to hue and saturation are employed for simultaneously addressing the memory which contains colour reference data representing the dimensions of hue and saturation only. This data is read out as a second digital signal
35 for conversion by digital-to-analogue conversion means into analogue signals which serve as red, green and blue video signals for driving a 3-gun colour cathode ray tube to form on the screen thereof the image

represented by the first digital signal. The data bit group which corresponds to intensity is applied to the digital-to-analogue conversion means to modulate the magnitude of the red, green and blue video signals. This permits intensity to be altered without also
5 altering hue and/or saturation.

A first preferred embodiment of a colour image display apparatus comprising a colour signal generator according to the invention is characterized in that each of said memory sections having at least a predetermined number of memory locations, each of said memory
10 sections being assigned for the storage of colour reference data belonging to a particular intensity value, a memory section being selectable by said second address part while a location within a selected memory section being selectable by said first address part. The predetermined number of memory locations of each memory section is
15 given by the minimum number of different colour available in the colour image display system. In this particular embodiment there is one memory section per intensity level. A simple realization of the division of the memory in sections and of the selection of the different sections is thus obtained.

20 A second preferred embodiment of a colour image display apparatus comprising a colour signal generator according to the invention is characterized in that each of said memory sections having at least a predetermined number of memory locations, each of said memory sections being assigned for the storage of colour reference data of
25 different intensities belonging to a particular colour, a memory section being selectable by said first address part while a location within a selected memory section being selectable by said second address part. In this particular embodiment there is one memory section per colour available in the system. An alternative and also simple realization of
30 the division of the memory in sections is thus obtained.

In order that the invention may be more fully understood reference will now be made by way of example to the accompanying drawing, in which:

Figure 1 shows a block schematic diagram of a colour
35 signal generator conforming to the invention; and

Figure 2 shows a modification of the colour signal generator shown in Figure 1.

Referring to the drawing, the image display system shown in Figure 1 comprises a colour signal generator which is formed by a colour memory 1, a memory addressing circuit 2, a memory read-out circuit 3, and a select circuit 11. The image display system further
5 comprises three digital-to-analogue converters 4, 5 and 6, a colour cathode ray tube display device 7, a processor 8, an input device 9, a display memory 10, and a timing control circuit 12.

For the operation of the colour signal generator, data representing an image for display is received from the input device 9
10 and fed into the display memory 10 for storage therein under the control of the processor 8. The input device 9 can be, for instance, an electronic writing tablet for creating static colour pictures and other graphics displays on the screen of the display device 7. The created display is in bit-map form and may be composed, for instance, of a
15 matrix of 512 x 512 picture elements (pixels). The colour of each pixel of an image display is stored as a multi-bit word in the display memory 10, which is a random access memory. It is assumed for the purpose of discussion that each pixel can have any one of sixteen different colours, so that each pixel is then represented by a respective 4-bit
20 word in the display memory 10.

The display device 7 is controlled by means of line and field synchronizing signals LS and FS to effect conventional refresh raster scanning (with or without field interlacing) for producing the image display. In synchronism with the raster scan, the 4-bit words
25 which define the colours for the pixels of the image display are read out from the display memory 10. The four bits of each word are read out serially on a lead 13 for application to the memory addressing circuit 2 as a first digital signal 1DS. The circuit 2 latches the four bits of each received word in turn and applies them in parallel to the first
30 four leads a1 to a4 of a group of five memory address leads a1 to a5. The remaining address lead a5 receives a logic "0" or "1" bit from the select circuit 11, as will be described.

The colour memory 1 is a read only memory or a random access memory and serves as a colour look-up table (CLUT). The colour
35 memory 1 has a first section M1 which comprises sixteen memory locations which can be addressed selectively by respective "0" and "1" bit combinations of the 4-bit words on the address leads a1 to a4, in

conjunction with a bit of value "0" on the address lead a5. The colour memory 1 also has a second section M2 which comprises sixteen memory locations which can be addressed selectively by the same respective "0" and "1" bit combinations of the 4-bit words on the address leads a1 to a4, in conjunction with a bit of value "1" on the address lead a5. Each of the memory locations of each section is assumed to have a storage capacity for a 12-bit word which represents colour reference data. Thus, a selection of sixteen different 12-bit words from a possible total of 4096 (~4K) 12-bit words can be stored in each memory section. When a memory location is addressed, the bits of the 12-bit word stored therein are read-out serially on a lead 14 as a second digital signal 2DS and latched into the memory read-out circuit 3. The bits of the latched word are then applied in three 4-bit groups to the digital-to-analogue converters 4, 5 and 6, respectively, over three groups of address leads aR, aG and aB. These converters convert the 4-bit groups applied them into respective red, green and blue video signals on leads R,G,B, for driving the colour cathode ray tube display device 7.

The colour reference data stored in the sixteen memory locations of the memory section M1 represents a standard range of 16 different colours. These locations can be addressed by the appropriate 4-bit word on the address leads a1 to a4, as aforesaid. In accordance with the present invention, the colour reference data stored in the sixteen memory locations of the memory section m2 represent different (e.g. low) intensity versions of the 16 colours which form the standard range of colours. Each 4-bit word on the leads a1 to a4 also addresses in the memory sections M2 the particular memory location containing the different intensity version of the standard colour that is contained in the memory location which it addressed in the memory section M1. Under the control of the processor 8, the select circuit 11 produces either a "0" bit or a "1" bit on the address lead a5, to select either the memory location in the memory section M1 or the memory location in the memory section M2, that are both being addressed by the 4-bit word on the address leads a1 to a4. The colour reference data is read out from the selected memory location to provide the standard or different colour version, as the case may be, for the pixel concerned in the image display.

The selection among standard or different intensity versions of the colours can be realized either under request of an operator by application of a select signal at said input device 9, or under request of an executed program. The processor 8 supplies the
5 coordinates of a display area together with an intensity value indicating the pixel display intensity (standard or different intensity) to the select circuit 11. This select circuit which also receives clock signals from the timing control circuit 12 scans with the displayed picture and applies either a "0" bit or a "1" bit on the
10 address lead a5 in accordance with the received intensity indication when said colour memory is addressed for the display of said display area.

A picture displayed on said display device 7 can be divided into, for example, 16 rectangular display areas numbered from
15 0-15. In this case the processor 8 supplies the number (4 bits) of the display area and the associated intensity indication (1 bit) to the selection circuit.

In another embodiment of the select circuit a content addressable memory is used which is loaded by the processor 8.

20 When setting-up the generator, the colour reference data in the colour memory 1 would be edited visually on the display device 7 using the processor 8 with an inter-active software program. With this program, the bit values of the three 4-bit groups for each colour forming the standard range of colours would first be settled by the user
25 and then stored in the memory locations in the memory sections M1. Following this operation, the different intensity version of each colour would be settled subjectively by the user by altering the bit values of the three 4-bit groups for the colour until a satisfactory result was obtained. The altered bit values of the 4-bit groups for each colour
30 would then be stored in the memory locations in the memory section M2. With this subjective determination of the different intensity versions of the colours the human perception of the eye can be taken into account, along with the non-linearities or "gamma" of the colour cathode ray tube and the complex relationships between the colour dimensions of
35 hue, saturation and intensity.

The timing of the operation of the colour signal generator is under the control of the timing control circuit 12. As

aforesaid, the timing control assumes serial read-out from both of the memories 1 and 10. However, data read-out in parallel from these memories would, of course, be possible by suitably altering the timing control.

- 5 The colour memory 1 can have a number ($N \geq 2$) of sections. For instance, three memory sections may be provided, the additional memory section containing colour reference data for high intensity versions of the standard range of colours. Where three memory sections of the colour memory 1 are provided, one additional address lead such as
10 lead a5 would be required to provide a 2-bit select code from the select circuit 11.

- In the modification shown in Figure 2, the colour memory 1 comprises three separate sections, M_a, M_b and M_c to which the four address leads a1 to a4 are connected in common. Each of these
15 separate sections contains sixteen memory locations and colour reference data for standard, high and low intensity versions of a range of 16 colours are stored in corresponding memory locations of the three memory sections. Thus, when a 4-bit word is applied to the address leads a1 to a4 from the addressing circuit 2, all three memory locations which
20 contain colour reference data for the colour concerned are addressed concurrently. The select circuit 11 now has separate select leads S1 to S3 which are connected respectively to the separate sections M_a, M_b and M_c. When one of these select leads is energized by the select circuit 11, the relevant memory section is activated and colour
25 reference data can only be read out from an addressed memory location of that memory section. The read-out colour reference data is latched via an OR-gate 15 into the read-out circuit 3 for utilization, as before.

- In the described embodiment, each memory section comprises all the colour reference data for a particular intensity. It
30 will be clear that other divisions of the memory 1 are also possible, such as for example a division wherein there is assigned a particular colour to each memory section. At the memory location of such a section there are then stored the colour reference data for the different intensities of that colour. In this embodiment, the first part of the
35 address word formed by the bits a1 to a4 then selects a memory section, while the second part (a5, or S1 to S3) selects a memory location within the selected memory section.

CLAIMS

1. An electronic colour signal generator for a colour image display system, which generator comprises a memory having addressable memory locations for storing colour reference data, an address generator connected to an address input of the memory and having a signal input
5 for receiving digital signals representing pixels to be displayed, said address generator being provided for generating address words for selectively addressing the memory locations, a generated address word comprising a first part determined upon a receipt digital signal, reading means connected to a data output of the memory for outputting
10 the colour reference data from the selected memory locations, characterized in that said address generator comprises an intensity signal input for receiving an intensity value indicating the pixel display intensity, said address generator being further provided for generating an exclusive second address part for each received intensity
5 value and for forming address words by combining for each pixel their respective first and second address part, and wherein said memory comprises a number ($N \geq 2$) of memory sections, each memory section being assigned for the storage of exclusive colour reference data, a memory section being selectable by one of said address parts and a location
0 within the selected memory section being selectable by the other address part.

2. A colour image display apparatus comprising a colour signal generator as claimed in Claim 1, wherein said reading means are connected to a colour display device, characterized in that each of said
5 memory sections having at least a predetermined number of memory locations, each of said memory sections being assigned for the storage of colour reference data belonging to a particular intensity value, a memory section being selectable by said second address part while a location within a selected memory section being selectable by said first
0 address part.

3. A colour image display apparatus comprising a colour signal generator as claimed in Claim 1, wherein said reading means are

connected to a colour device, characterized in that each of said memory sections having at least a predetermined number of memory locations, each of said memory sections being assigned for the storage of colour reference data of different intensities belonging to a particular

5 colour, a memory section being selectable by said first address part while a location within a selected memory section being selectable by said second address part.

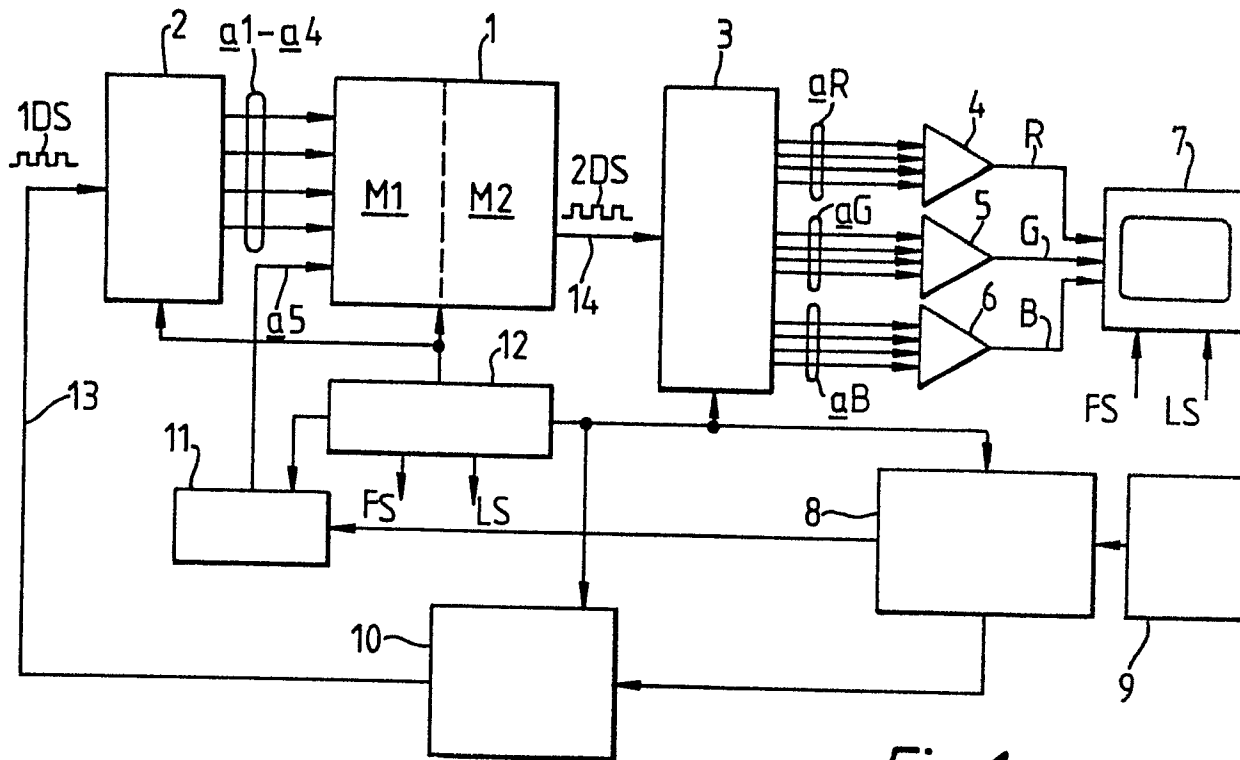


Fig. 1.

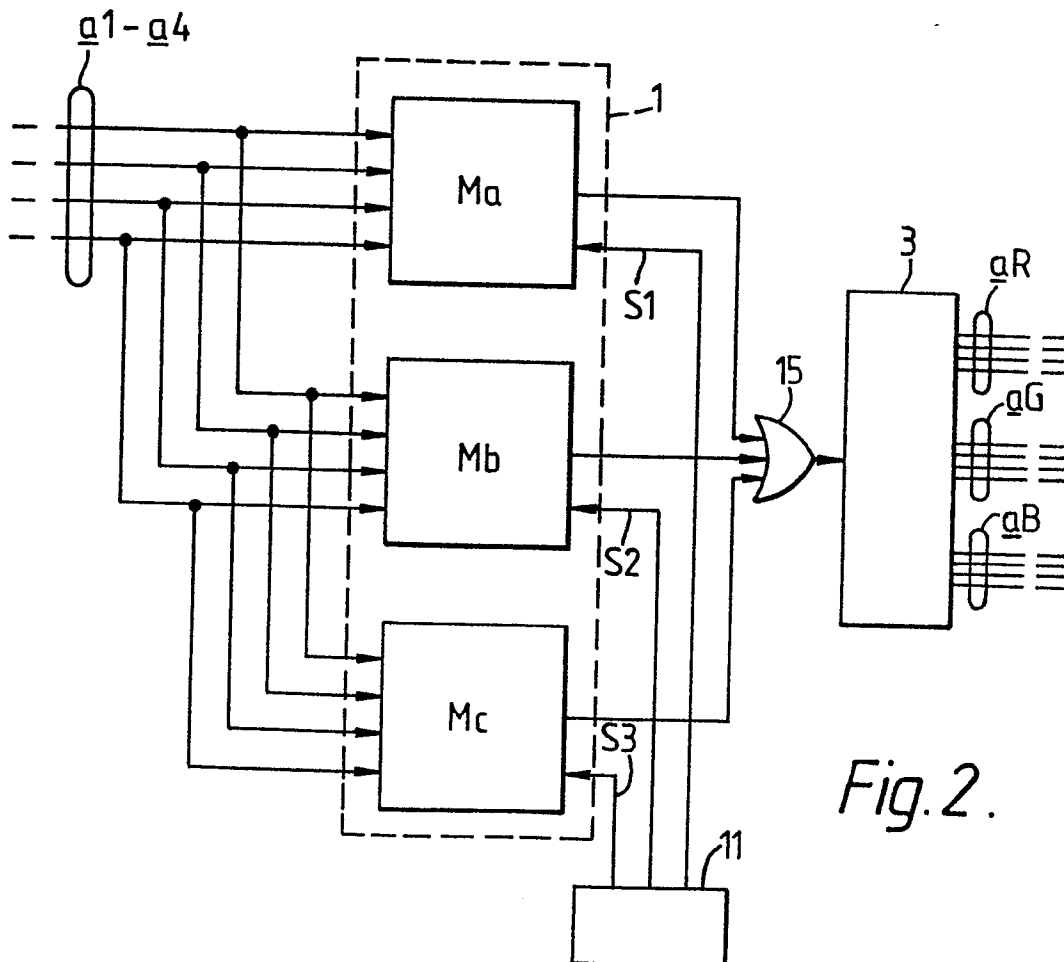


Fig. 2.