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Improved Performance Analysis of PAL Television Error Value Correction using Inverse Matrix Generator Model

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ABSTRACT: *Improved performance analysis of PAL television error value correction using inverse matrix generator model focuses to improve variable colour saturation, lower signal-to-noise ratio, loss of colour editing accuracy, utilize a procedure on television interlaced scanning techniques. Correct saturation error values to unity introduced to the system with event of better colour stability. Differential phase error is a problem of PAL television system which lead to whiteness of colour on a picture. When this value is distorted, it cannot give transmitted picture information to receivers. PAL achieves accurate colour through cancelling out phase difference between the two signals, the act of cancelling out errors can reduce the colour saturation while holding the hue stable. The performance characteristics shared by PAL led to its ability to convert picture from one colour scheme to other, enable it perform on receiver makes it fascinating of field of research. The model provides a detailed mathematical analysis of using inverse matrix generator with zero-window comparators and low-pass filter which ensure that output is never a zero value.*

KEYWORDS:*Hue; Saturation;Error value; PAL;Inverse matrix*

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I. INTRODUCTION

The introduction of colour television in the 1950's was a great achievement. The world of television would not be the same as it is today with just two colours (black and white) [1] and [10]. Even though they were considerably hard to make, history evolved over a time through many inventors around the world strive to create such device, and enable millions of people to see wireless broadcasts that were reproduced in life like colours. The invention of a chroma which refer as colour signal processing scheme called National Television Committee (NTSC) standard demonstrated several perceived deficiencies and weakness, Europe waited for the solidification of American standard solution for all their early technical problems, finally another colour invented called Phase Alteration Line (PAL), which adopted in some parts of Europe and Africa.

Saturation is the purity or vividness of the colour, expressed as the absence of white [5]. Saturation is the amount of whiteness of a hue or colour[3] and [4]. This, lead to unwanted picture darkening. Therefore, when this value is distorted, it cannot give the true colour information to the receiver as it is transmitted [1], [2]. Thus, this study analyzing the effects of saturation error value and the various method that could be adapted to reduce the error in PAL system.

The model utilized an inverse matrix generator to ensure that saturation error value is eliminated. Reducing the saturation drains the colour away, leaving just the grayscale component. That to say variation in the saturation if the high-frequency amplitude is not transmitted correctly: phase errors and differential phase have the effect only of reducing the saturation to 1-COSβ, where β is the phase error. To correct wrong hue resulting from static phase errors in the transmission path [8]. PAL achieves accurate hue through cancelling out phase difference between the two signals. The act of cancelling out errors can reduce the colour saturation while holding the hue stable. The disadvantages of these techniques were lack of separability of signals the receiver, resulting in signal crossing-effects and loss of picture quality. Moreover, our design approach using simulink provides a unique method that ensure saturation error of PAL television system is eliminated or to zero error value as target of amplitude equal to unity.

II. LITERATURE REVIEW

[2] discussing the disadvantages of PAL noted that in the process of holding a stable hue through its line inversion technique, the saturation become variable. He acknowledges that while the variable saturation effect cannot be ignored, the eye can more readily accommodate it to hue variation.

[4] established a model for hue correction using saturation control. This model is achieved by a colour space value adjusted based on a hue angle and a saturation value, and a second colour space value adjusted based on the defined hue angle and the saturation value. The second colour space values are processed to obtain a hue-adjusted colour space values. This model works perfectly for NTSC colour system that can treat each horizontal scan lines uniquely to obtain the individual colour make-up unlike PAL. It is difficult to obtain the individual hue until after demodulation in PAL the demodulated colours are already distorted as after demodulation in PAL. Also, it would lead to reduction of vertical saturation by half.

[6] proposed a model of TV encoding with a function of adjusting hue. This model has a function for adjusting hue for receiving a first and second colour mixture signals comprising a first and second multiplexer which is representative of a hue angle and its inverse or negative, a Sin-Co generator, a first and second multiplier circuit and an adder. While a patent can work perfectly for NTSC as it requires a minimum interface to incorporate the model, for PAL, it will require a great deal of overhauling of the standard procedures for PAL or could add huge deal of cost and interface materials to effect. Also, this model deals with individual hues while PAL deals with colour differences. Thus, the power dissipation will be higher and power/current inefficient.

[7] proposed a model for digital colour signal processing to include a multiplier which multiplies two demodulated digital colour difference signals by a digital colour-saturation signal to provide three-time division-multiplexed signal pairs, each of which is added to the digital luminance signal by an adder. The colour-saturation-signal input of the multiplier is preceded by a second multiplier to which the colour-saturation signal and multiplier factors stored in a memory are applied. These multiplier factors are permanently stored by the manufacturer of the colour television receiver or can be adjusted during the operation of the receiver. The three adders are followed by three digital-to-analog converters which provide analog colour signals. The disadvantage of this model is that it does not maximize the saturation but increases it to a defined level.

III. MATERIALS AND METHOD

3.1 Materials

The basic materials used for this research are CAD software, proteus, simulink

- Signal generator
- Low-pass filter
- Zero window detector
- Inverse matrix generator
- Multiplier

3.2 Methods

The method employed for the research of this paper are inverse matrix method, while Simulink and proteus CAD software were employed for simulation of the design. In order to achieve the set objective of this research, the following sequence of steps were taken:

- A sinusoidal signal was employed as the input, to represent the PAL signal
- An envelope detection circuit (low-pass filter)
- Zero-window detector/comparator circuit that will ensure that the input signal amplitude is never zero.
- An inverse matrix generator
- A multiplier/correction circuit to produce the best output signal.

Using the above sequence of design approach will ensure that the saturation error will be reduced. Hence a model can be developed.

3.3 Analysis of Mathematical Model of Inverse Matrix Generator

In reducing the saturation error of PAL television signal, the following formulas are employed;

Given that $F(t) = A\sin n\omega t$ (1)

Where; F(t) = the input signal of PAL TV

A = signal amplitude.

'n' can be any number from 1

The gain/transfer function of our low pass filter is given as;

$$\text{Gain }\{G(t)\} = \frac{\text{output }\{X(t)\}}{\text{input }\{F(t)\}} \quad (2)$$

In the s-domain $\text{Gain }\{G(s)\} = \frac{\text{output }\{X(s)\}}{\text{input }\{F(s)\}}$ (3)

The Laplace transform of a low pass filter is given as

$G(s) = \frac{1}{s+1}$ (4)

Equating Equations (3) and (4)

$G(s) = \frac{X(s)}{F(s)} = \frac{1}{s+1}$ (5)

Cross multiplying gives;

$SX(s) + X(s) = F(s)$ (6)

Applying the inverse Laplace transform to equation (6) from the standard inverse Laplace transform table, the equation in the time domain will be;

$F(t)= \frac{dx(t)}{dt} + cx(t)$ (7)

Where c = constant

Applying the power square law to the input signal, we will have;

$Y(t)= F(t)^2$ (8)

Resolving equation (7) using the relevant integration techniques gives

Integrating factorI. $F = e^{\int cdt}$ (9)

1f c = 1

$e^{\int cdt} = e^{\int dt} = e^t$ (10)

Multiplying equation (7) with I.F, gives

$Y(t) \times e^t = \frac{dx(t)}{dt} \times e^t + x(t) \times e^t$ (11)

Rearranging gives

$\frac{d}{dt}\{x(t)e^t\} = Y(t) \times e^t$ (12)

$x(t) = \frac{1}{e^t}\int\{Y(t) \times e^t\}_{dt}$ (13)

Substituting equation (1) and (8) into (13) gives

$x(t) = \frac{1}{e^t}\int\{(A \sin \omega t)^2 e^t dt = \frac{1}{e^t}\int\{(A^2 \sin^2 wt) e^t$ (14)

from the half angle formula, we know that;

$\sin^2 \omega = \frac{1-\cos 2\omega}{2}$ (15)

From the standard table of integration, we have;

$$\int e^{au} \cos bu\, du = \frac{e^{au}}{a^2 + b^2}(a \cos bu + b \sin bu) + C$$ (16)

Integrating equation (14) and simplifying gives

$x(t) = \frac{A^2}{2}\{\left(1 - \frac{\cos 2\omega t - 2\omega \sin 2\omega t}{1+4\omega^2}\right) - [e^{-1}\left(1 - \frac{1}{1+4\omega^2}\right)]$ (17)

Making A the subject of the formular, gives;

$A = \sqrt{\frac{2x(t)}{\left(1-\frac{\cos 2\omega t-2\omega \sin 2\omega t}{1+4\omega^2}\right)-[e^{-1}\left(1-\frac{1}{1+4\omega^2}\right)]}}$ (18)

Let $K = \{\left(1 - \frac{\cos 2\omega t - 2\omega \sin 2\omega t}{1+4\omega^2}\right) - [e^{-1}\left(1 - \frac{1}{1+4\omega^2}\right)]$ (19)

$A = \sqrt{\frac{2x(t)}{K}}$ (20)

3.4 Simulated Design of The Inverse Matrix Generator

The analysis of mathematical model developed, the block diagram model of saturation Amplitude Extractor in figure 1,

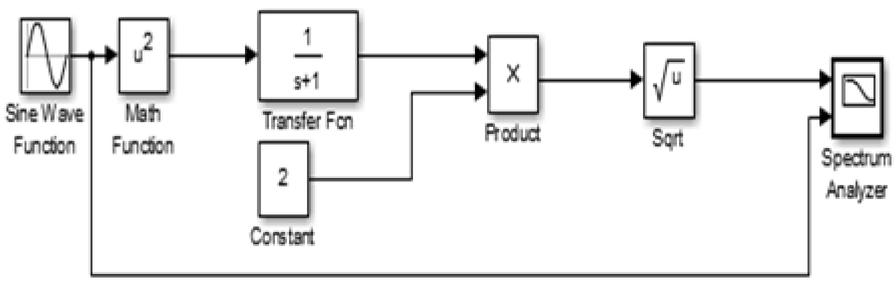

Figure 1: Block Diagram Model of Saturation Amplitude Extractor

We employed the square law which gave us a total value that will be passed into the low-pass filter to completely block the sinusoidal components, leaving the only with a Dc value. We know that F(t) = Asinnωt be the saturation obtained after PAL correction $(\text{Asinn}\omega t)^2 = A^2 \sin^2 wt$

Then, $A^2\sin^2\omega t = ½ A^2 (1-\cos2\omega t) = ½ A^2 - ½ A^2\cos2\omega t$

The result of squaring above is to passed into a low pass filter, which will block the sinusoidal component (time varying signal and its harmonies), allowing only the non-sinusoid of ½ A^2 to pass through. The low-pass filter that will be employed in the simulation will be a transfer function, whose cut-off frequency is 1 rad/sec, equivalent to 0.0255Hz. to obtain A from the filter output, have to double (multiply by 2) and finally take the square root.

3.5Inverse Matrix Generator Model and Error Correction

From the equation of matrixes, we developed in line with inverse matrix:

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \text{and } A^{-1} = \begin{bmatrix} w & x \\ y & z \end{bmatrix}, \text{ and } A^{-1} = \frac{1}{ad - bc} \text{ X } \begin{bmatrix} a & -b \\ -c & d \end{bmatrix}$$

$$W = \frac{d}{ad - bc}, \ x = \frac{-b}{ad - bc}, \ y = \frac{-c}{ad - bc}, \text{ and } z = \frac{a}{ad - bc}$$

This mathematical model will be implemented in the simulink as shown in figure 2.

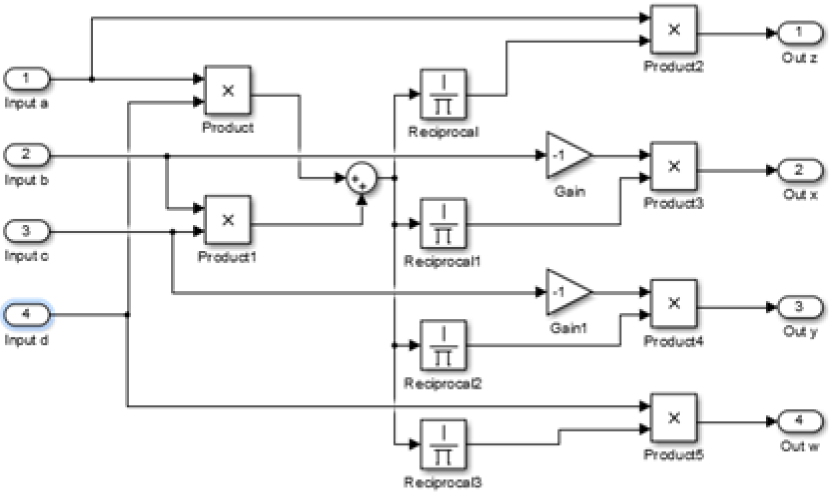

Figure 2: Simulink Model of Inverse Matix Generator

The four input;a,b,c, and d of inverse matrix generator if a is allocated value 1 and c = 0, b to be the output moderator a value choosen, which standard value is mostly 0.7V or 100IRE. While d will be saturation input amplitude. Its outputs are; w,x,y and z with w and y as 0 and 1, x will become –b/d and z is 1/a. with these obtained result, one can choose x or z as the final output point. The output x is choosenas 1volt or 140IRE is super-saturated amplitude, so that b can moderate it by taking its product. By considering the amplitude of lvolt, z will be a preferred output point.

To correct the inverse saturation amplitude from output point z, the signal will be multiplied with the original saturation signal, to obtain a 1V saturation amplitude signal as shown in the equation below; original signal =Asinωt

Error correction = Asinωt X 1/A = 1.sinwt output point the reciprocal of A, which is passed into a multiplier with the original saturated signal to produce a corrected saturation. From the mathematical model developed so far, the implementation of the saturation value can be generated as shown in Figure 2.

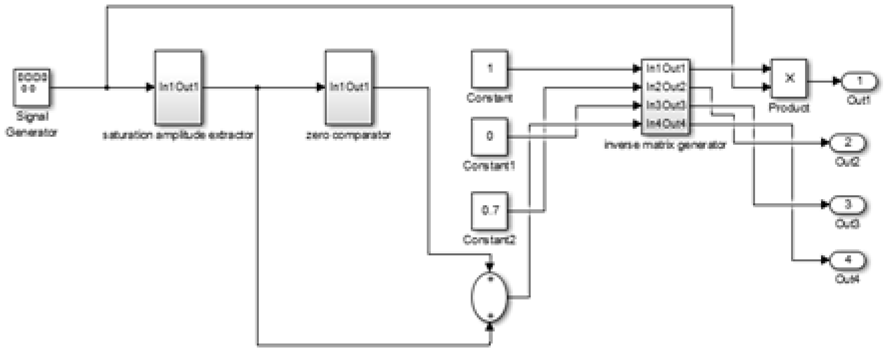

Figure 3: The Complete Sauration Error Correction Block Diagram

IV. RESULTS AND DISCUSSION

The software simulation tools employed in this research are; simulink (from matlab) whose subsystem blocks/models where instrumental in carrying out the designs and proteus 8.6 CAD tools.

The input signal is a sinusoidal (sinwave) signal, which is used to represent the saturation value that is generated by PAL colour television system with a time varying frequency and amplitude values. In carrying out the simulation, we employed different steady-state value of amplitude and frequency and checked the corresponding output, which confirmed our model was able to achieve its stated aim.

The following values were chosen for the sine wave generated by PAL colour television as it corrects a given differential phase error.

Frequency (F) = 50Hertz

Amplitude (A) = 0.5

Input signal = $0.5\sin(2\pi \times 50t) = 0.5\sin(314.2t)$, $\omega = 314.2$ rad/sec

For a properly saturated signal for a colour television, the amplitude must be 1. This means that for the stated signal above, the properly saturated signal should be; sin (314.2t).

4.2Saturation Amplitude Extractor Evaluation

The error saturation sine wave is passed through a low-pass filter network as shown in Figure 3 earlier, here it can be seen that sinusoid of our input signal has been filtered out leaving us with the dc components only, whose value change from zero to 0.5 in 2 seconds (which the human eye can comfortably ignore as starting transient) which represent the amplitude of the error saturation sinusoidal signal as shown in Figure 4.

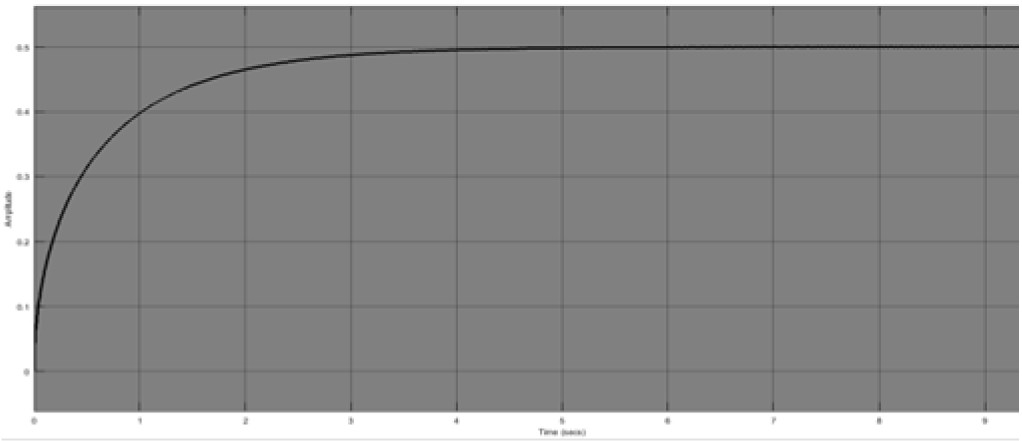

Figure 4: Saturation Amplitude Etractor Output

That can be attributed to the low-pass filter present at this stage of the model. this implies that no matter the sinusoidal signal that is presented at the input; be it dynamic or static, the sinusoid is filtered out and the amplitude extracted, which is then passed as input into the next stage.

4.3Zero-Window Comparator Stage Evaluation

The zero-window comparator receives its input from the amplitude extraction stage, its function ensures that no value zero goes into the inverse matrix network. The graph of Figure 5 shows that amplitude at its input is a non-zero number hence its output drops from 1 to 0, meaning that the system is very sensitive and can switch from 0 to 1 or vice-versa, depending on what the input feeds into the zero-window comparator as shown in Figure 5.

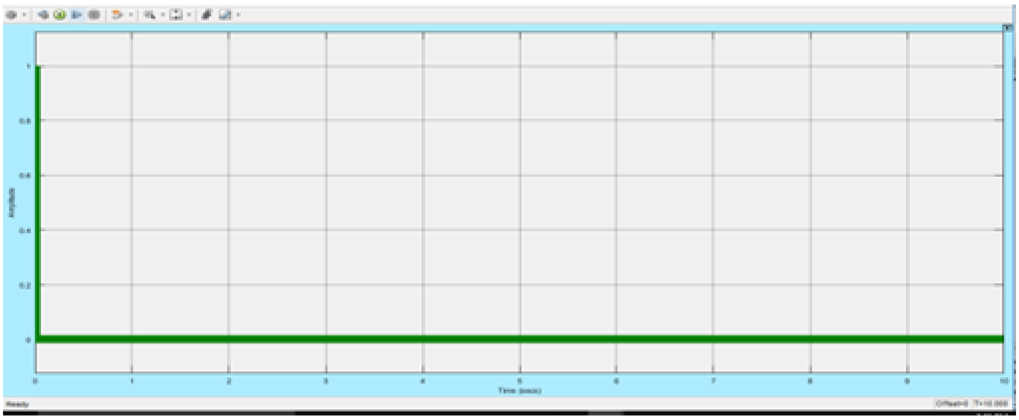

Figure 5: Zero Window Comparator Output

4.4The Inverse Matrix Generator Stage

The inverse matrix generator that was model in this research is a 2 x 2 matrix with 4 parameters as inverse output. Three of these inputs are fixed with A_{11} being 1, $A_{21} = 0$, $A_{12} = 0$, A_{12} is a modifier whose value is 0.7 which is the equivalent saturation safe limit for colour television output. And A_{22} being the dynamic time varying saturation amplitude whose value is a function of the dynamic amplitude of the input sinusoid.

From the mathematical modeling of the inverse matrix generator as shown in Figure 2, if A_{22} (or “d”) is zero, the system will become unstable due to the equation being divided by zero, which is not the desire. The inverse matrix, outputs w = 1, y = 0 as fixed output when x varies as a multiple of b and z is the reciprocal of input d.

4.5Correction Saturation Output Signal from Point Z

This is the corrected saturation sinusoid, that was obtained by multiplying the out-point z, of the inverse matrix generator with the original to obtain an output with maximum amplitude of 1. Figure 6 shows a signal with an initial transient that dies out in 2 seconds which can be clips off automatically. But it can also be noted that the output follows the input in phase.However, the effect of the super-saturation is resolved by the eye because the super-saturation amplitude is not too large from the unity and duration is about 2 seconds.

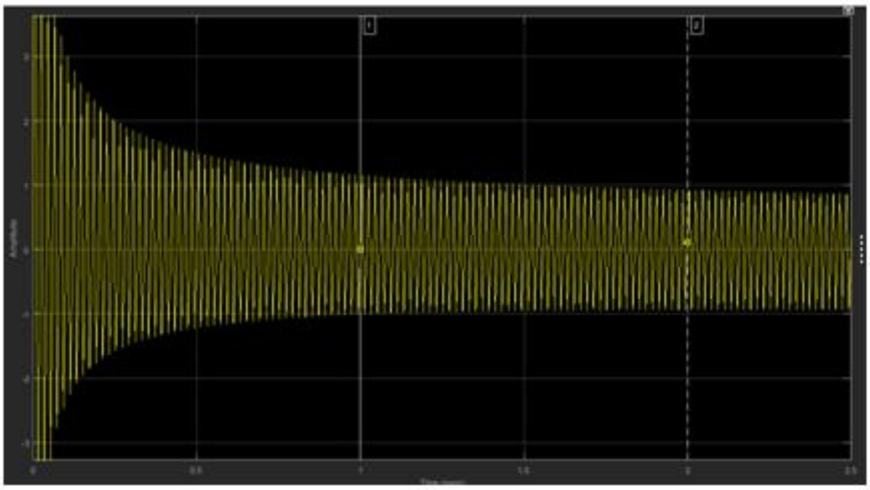

Figure6: Output Signal From Point Z

VII. CONCLUSION

From the research work so far, the problem of differential phase errors has been successfully overcome in the PAL system. The model provided a method of reducing the saturation error value of PAL colour television system. If this is not implemented, the phase error will be sufficient to affect the transmitted picture hue or colour information to the receiver which leads to unwanted picture darkening of the frame. It has a modified model that uses well known equation and internal circuitry embedded in the system. The output stage will automatically clip the over saturated signal without total overhaul of the PAL television system. What is required is possibly an extension port with a power source and signal source.

Thus, a manual hue control becomes unnecessary. However, the delay line technique of reception also involves a reduction in the vertical resolution of the chrominance signal but the effect is less pronounced because the two chrominance signals are radiated continuously and the receiver interpolates between the signals of two consecutive lines.

In the series of simulation, the inverse matrix generator acts as a stabilizer to the saturation of colour signal, which ensure that zero is not given as an input into our inverse matrix generator. The zero-window comparator circuit create maximum and minimum point of zero, ensure that our model reacts any non-zero input whether negative or positive.

Combining the inverse matrix generator output to the original signal gives us a desired amplitude of 1v. to correct the saturation amplitude from 0.5V to 1V. despite the perfect theoretical error connection in practice may not have such high values. It is also worthy to note that perfect error correction was achieved by over saturation that lasted about 2 seconds, since this time is not much to the human eye may not observe it. Taking a television sets that are produced now, the problem of over-saturation has been achieved by automatically clipping saturated signal to 1V at start up.

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