Reduction of Dynamic False Contour in PDP using Equalizing Pulses

Ki Ho Seo[**] and Ki Woong Whang[*]

Abstract

In this paper, we report relatively simple equalizing pulse method for reducing dynamic false contour in PDP. Calculation cost is reduced by limiting pixels to add equalizing pulse and using look-up-table(LUT) for given subfield pattern. Pixels to be modified are determined after comparing selected number of most significant bits(MSB) with those of adjacent pixels. The equalizing pulse amount is determined by consulting LUT, which is for a fixed velocity of 1 pixel/tv field. Even though the suggested scheme does not cover every luminance combination of neighboring pixels, it is expected to work well after appropriate modifications are made according to the velocity.

Keywords : plasma display panel, dynamic false contour

1. Introduction

The subfield method is used to express gray scales in plasma display panels(PDPs). It is good for still images, but it experiences serious disturbance in expressing moving images which is referred to as 'dynamic false contour(DFC)'[1]. DFC occurs in the area in which the luminance changes smoothly with abrupt subfield state change. The state of the most significant bit(MSB) is usually changed in that area. Among the proposed remedy techniques so far, the equalizing pulse technique[2] was reported to be one of the effective methods to achieve DFC reduction.

Serious DFC occurs when the state of MSBs is changed. In the Fig. 1(a), image velocity is 1 pixel/tv field to the right and left. The original luminance is 127 and 128. There is one level difference in luminance, but the eye integrates stimuli along the arrows such that the viewer see bright or dark disturbance between two pixels. DFC changes according to the image velocity, movement direction, etc. DFC becomes broader as image moves faster as shown in Fig. 2. And it has opposite appearance when the image moves to the opposite direction. Bright DFC occurs when the image moves to the right, and dark DFC occurs when the image moves to left as in Fig. 1(a).

In Fig. 1(b), the pixel, 127, is modified to be 111. Bright DFC(143) occurs at the side of the dark DFC(111). But it is less visible than that of Fig. 1(a). If the image is viewed from sufficiently far distance, it will be look like 127, the average value of 111 and 143 because the human eyes have limit to spatial contrast sensitivity[6]. Equalizing pulse technique modifies pixels to give the same or similar integration result with the original luminance. This involves tedious calculation in order to modify all the pixels and subfields properly in spite of its good result. Thus, we suggest a simple technique for determining the amount and the position of equalizing pulse. It needs the motion vector and look-up-table(LUT) and does not deal with all the pixels.

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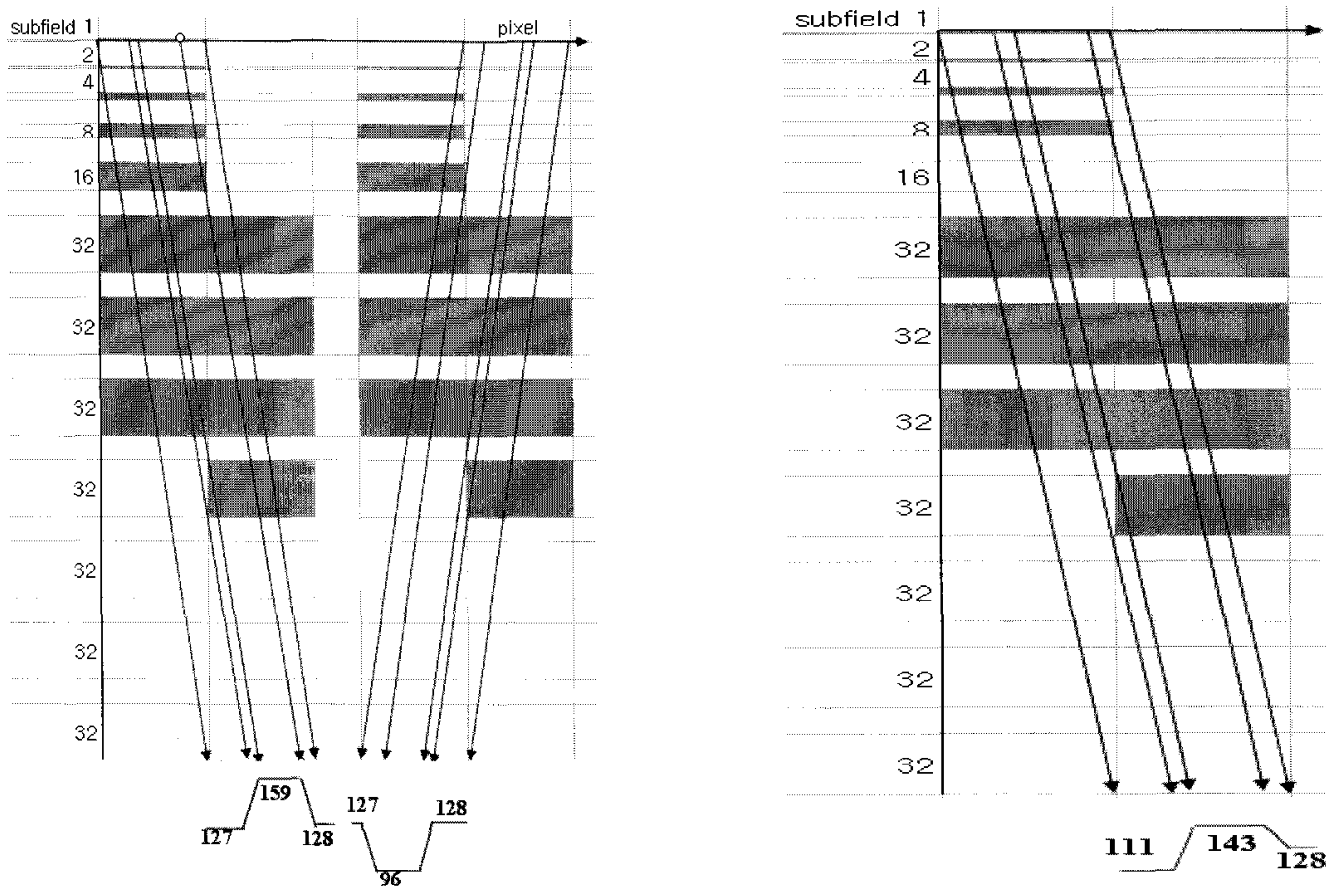
[*] Member, KIDS; [**] Student Member, KIDS.
Corresponding Author : Ki Ho Seo
School of Electrical Engineering & Computer Science, Seoul National University #053 San 56-1, Shinlim-dong, Kwanak-gu, Seoul 151-744, Korea.
E-mail : kihoss@pllab.snu.ac.kr **Tel** : +2 880-7253 **Fax** : +2 880-1792



(a) (b)

Fig. 1. (a) Example of a dynamic false contour. Subfield pattern is (1 2 4 8 16 32 32 32 32 32 32 32) (b) Example of dynamic false contour after modification.

2. Proposed Technique

2.1 Preparation for the process

Serious DFC occurs when the subfield state changes abruptly and the luminance change slightly. Thus position can be predicted in advance. For example, if a big subfield is newly turned on, other small subfields should be turned off even if the luminance differs slightly. In Fig 1(a), some small subfields(1 2 4 8 16) are turned off and one big subfield(32) is turned on in the right-hand side pixel. Although DFC occurs whenever there is a difference in the subfield state among adjacent pixels, we concentrate on the pixels that show major subfield difference with neighboring pixels to reduce calculation cost. Serious DFC position can be predicted by checking the difference of the number of MSB turned on. If the MSB difference with left or right pixel is one, the spot will be assumed to be a pixel having DFC. If the MSB difference is more than one, the spot will be assumed to be the real edge rather than a DFC pixel. The pixel with the level 127 is checked to be modified in the above example. Equalizing pulse is then added to the checked pixels and their adjacent pixels. Modification is limited so as not to change the state of MSB to increase the stability of the algorithm. Changing MSB may induce additional disturbance especially when the information is false on which the modification is based.

2.2 Making look-up-table

Used subfield pattern is (1 2 4 8 16 32 32 32 32 32 32 32). If the image moves to the right, equalizing pulse is added only to the left pixels for calculation convenience. If the image moves to the left, equalizing pulse is added only to the right pixels. The LUT has three columns as shown in Fig 3. The first two columns are the original luminance of neighboring two pixels. There is one difference of MSB(32) between these pixels. For example, even though a pair like (31 33) exists, there is no a pair like (30 31) because they have the same MSB number(0). The third column is a modified luminance of left pixel that makes the least mean square error in the simulation result. The assumed moving velocity is 1 pixel/tv field to the right only. Because the opposite moving direction produces an opposite DFC, the LUT can be used for moving to the left with only slight modification. For instance, (127 128 111) can be used a pixel pair (128 127) moves to left. The right pixel, 127, will be modified in this case.

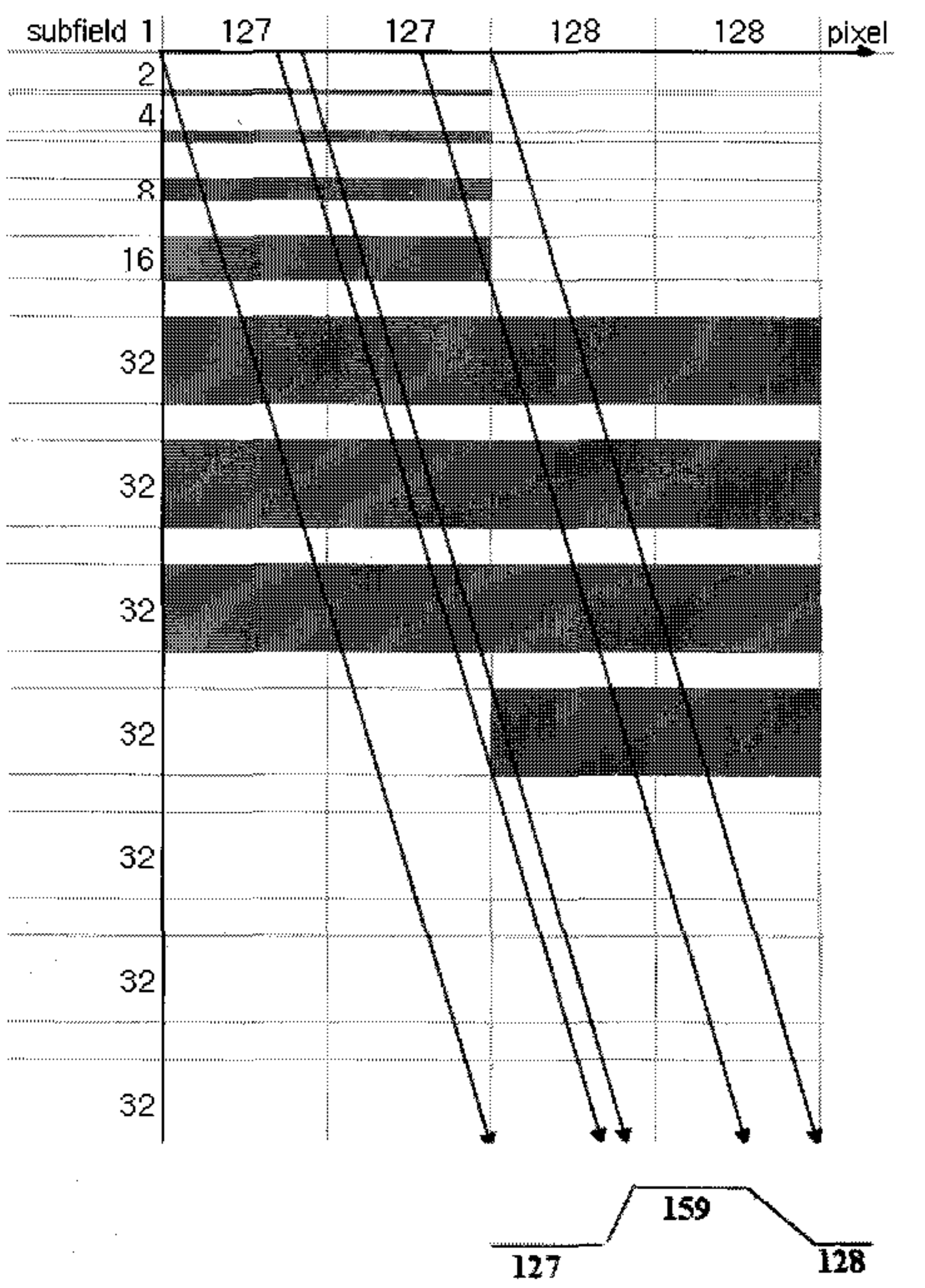


Fig. 2. Dynamic false contour of velocity 2 pixel/tv field.

2.3 Adding equalizing pulses and additional modification

If the image moving velocity is 1 pixel/tv field to the left or right, it is sufficient to modify checked pixels after consulting LUT. But it is insufficient when the image moves faster. DFC becomes broader as the image moves faster as shown in Fig. 2, so modifying one pixel is insufficient. In the case where the image moves faster, additional equalizing pulses are needed in the modified pixel's direction. Namely, if the image moves to the right, additional equalizing pulses need to be added to the left pixels. The amount of additional equalizing pulses is determined mainly by using the amount of pulses of 1 pixel/tv field.

The amount of equalizing pulse is the multiplication of the velocity and the modification amount of 1 pixel/tv field. Since faster velocity produces broader DFC as shown in Fig. 2, multiplication reflects necessary modification almost. Additional modification amount is added to adjacent pixels to reduce DFC as shown in Fig. 4. Additional modification is different depending on the motion direction and the change of the number of MSB turned on. In Fig. 4, X and Y pixels have only one different MSB number that is turned on. If the moving velocity is 2 pixel/tv field to right, twice the amount of modification of velocity 1 pixel/tv field case is applied to X pixel. If the moving velocity is 3 pixel/tv field, the same modification made as in the case of 2 pixel/tv field is applied to the pixel X and the same modification amount of 1 pixel/tv field is applied to pixel Z. Modification amount and range differ according to the change of the number of MSB turned on. Modification is limited so as to limit changes not to modify the state of the MSB, because the change of MSB state may induce another noise there.

Left pixel	Right pixel	Modified left pixel
127	128	111
127	129	111
...	...	...

Fig. 3. Part of the look-up-table.

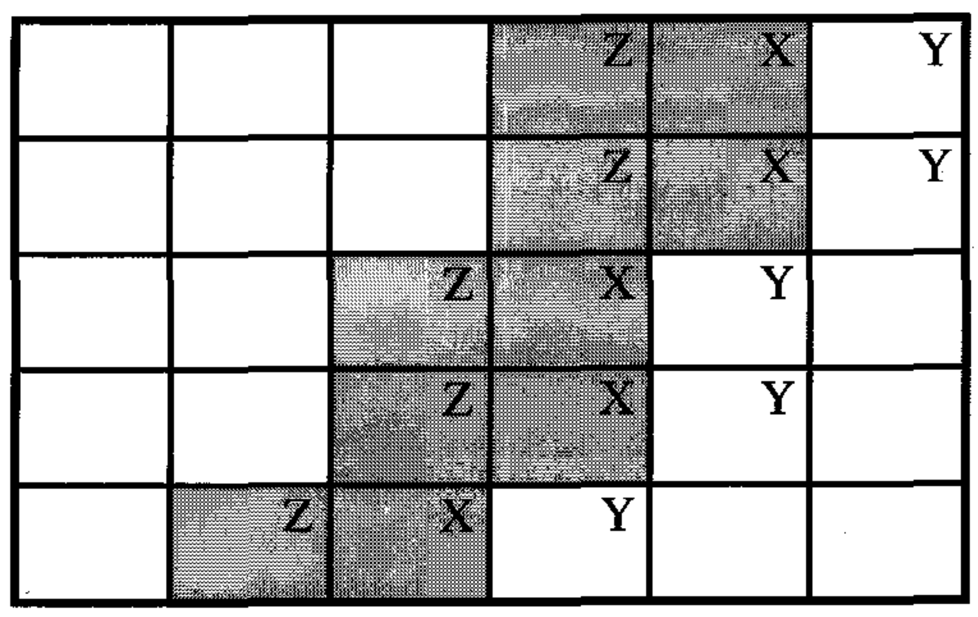
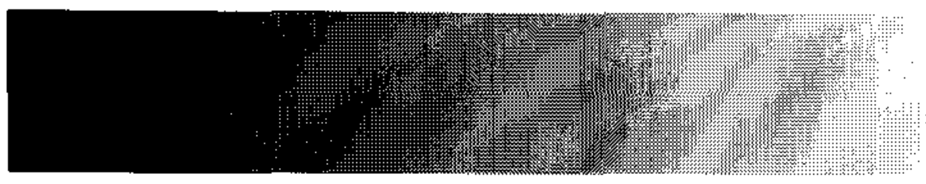


Fig. 4. Range of modification.

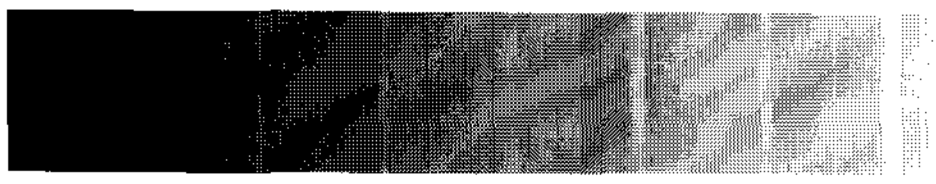
Because subfields to be modified(small subfields) are in the beginning of the given tv field, one-directional modification can reduce DFC without inducing another noise. The result of this process may not be the most optimal solution, and there have been other solutions are reported[3][4][5]. The merit to this process is that it only needs a simple LUT and relatively simple calculation.

3. Result

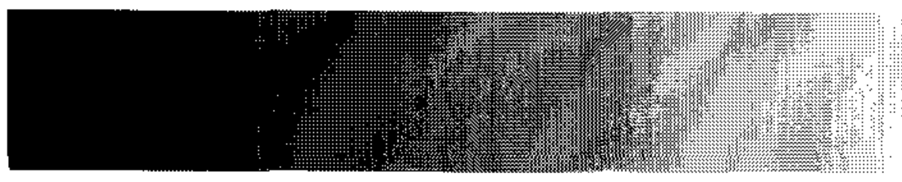
Fig. 5(a) shows the original image and fig. 5(b) the simulation result without any process. Fig. 5(c) show the result of the connected image with the above processes. The assumed velocity was 4 pixel/tv field to the right. We can see that there is more DFC in the bright area, which means we can give more equalizing pulses in that area.



(a)



(b)



(c)

Fig. 5. (a) Original image, (b) Result without any process, (c) Result after above process.

Fig. 6. Original image.

Fig. 7. Checked pixels to which equalizing pulse is added.

Fig. 8. Simulation result without any process.

Fig. 9. Result after the completion of the whole process.

Figs. 6~9 show the entire processes. The original image is shown in Fig. 6. The pixels to add equalizing pulse are determined after checking the number of MSB which is turned on. Calculation for getting motion vector is applied to those black pixels in Fig. 7. If it is confirmed that the checked pixels are stationary, no modification is made to those pixels.

Checked pixels can be seen to reflect DFC well in Fig. 7, 8. Equalizing pulse is given to the position of black pixels and adjacent pixels in Fig. 7 by using LUT and motion vector. Fig. 9 shows the result after the completion of the whole process. From this figure, we can see that the visibility of DFC is significantly reduced.

4. Summary

The principle of using equalizing pulse for the reduction of DFC had been well known but it rarely had been adopted in the real products because of its complexity. A simple equalizing pulse technique which uses a look-up-table for specific subfield pattern for the reduction of the dynamic false contour has been suggested and proved to be an effective method which does not require a large memory space.

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