Application Note

# Fluke PM5420 TV Signal Generator

# Motion Adaptive Color Plus (MACP)

**Introduction:**

Motion Adaptive Color Plus is designed to eliminate the cross-color effect between luminance and chrominance. Cross-color is the effect when the frequency of the luminance signals becomes almost equal to the color subcarrier frequency. In a standard multi-burst signal this effect is visible in the 3.8 to 4.8 MHz parts. On a TV screen cross-color is the anoying visible color interference, e.g. in striped shirts or dresses.

In a TV signal, the color information between two successive lines on the TV screen normally does not change very much. That means that in the PAL system a point on a line in field A has almost exactly the opposite subcarrier phase with respect to a point on a line in field B.

Consider a line "n" in the first field and a line "n+312" in the second field. If these two lines carry the same luminance and chrominance information, the luminance and the chrominance can be separated by adding (which results in the luminance signal) and subtracting (which results in the modulated chrominance signal). The color difference signals $C_R$ and $C_B$, free from cross effects,may alternatively be recovered by intra-frame averaging following chrominance demodulation. For this procedure a frame memory is required.

The procedure described above (called "Fixed" Color Plus) is in practice only used for luminance signals with high horizontal frequencies (above 3 MHz) because only this part of the signal shares spectrum with the chrominance signals. "Fixed" Color Plus works well in film mode (there is no motion between the fields; just like displaying a picture). In camera mode, this procedure causes artefacts if there are moving colored areas between two successive fields.

A practical problem can occur in fast moving colored areas. Since all of the chrominance signal is averaged, motion artefacts are sometimes visible in the form of color judder (smear). Motion Adaptive Color Plus is therefore selected for camera mode. Both in the encoder and the decoder, motion in the color signal is detected and the MACP process is applied.

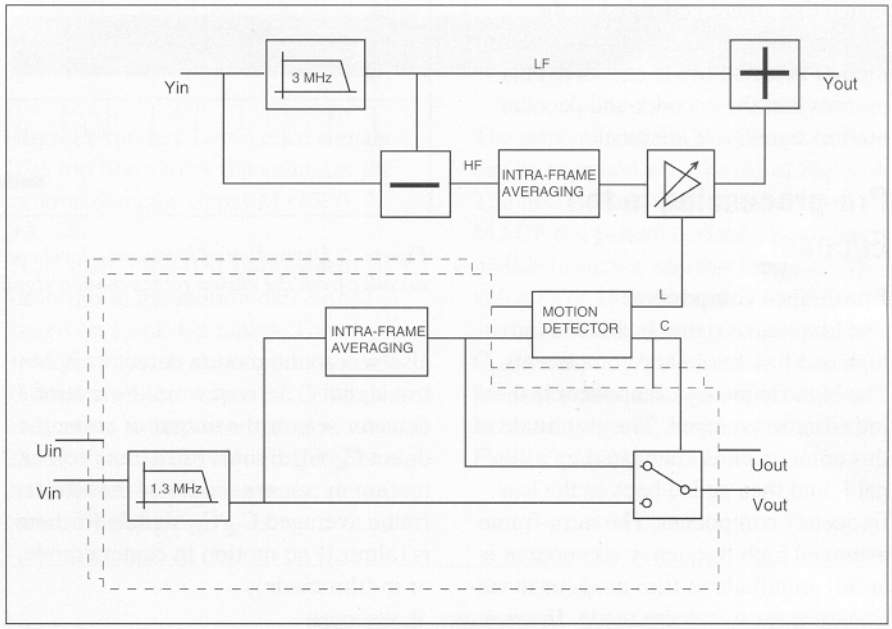


*Figure 1: MACP principle*

FLUKE®

The output of the motion detector is a control signal which selects between "Fixed" Color Plus encoding and decoding, and conventional color encoding and decoding using only low-frequency luminance (up to 3 MHz). In areas of saturated moving color, the spectrum of the encoded PALplus signal above 3 MHz is occupied solely by chrominance, with no vertical or temporal constraints. The motion detector in the decoder must track the motion detector in the encoder, and must therefore use the same form of input signal. This is chosen to be an **intra-frame-averaged** chrominance signal (between two fields in one frame), as such a signal can be generated in the decoder to match this signal generated in the encoder, independent of the amount of motion detected in the encoder. This ensures that the encoder and decoder motion signals are identical.

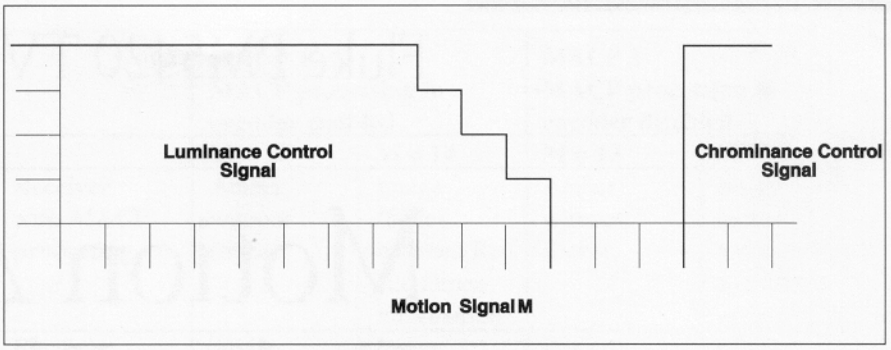


*Figure 2: Derivation of luminance level control and chrominance switching signals in the encoder from the chrominance motion signal M (example)*

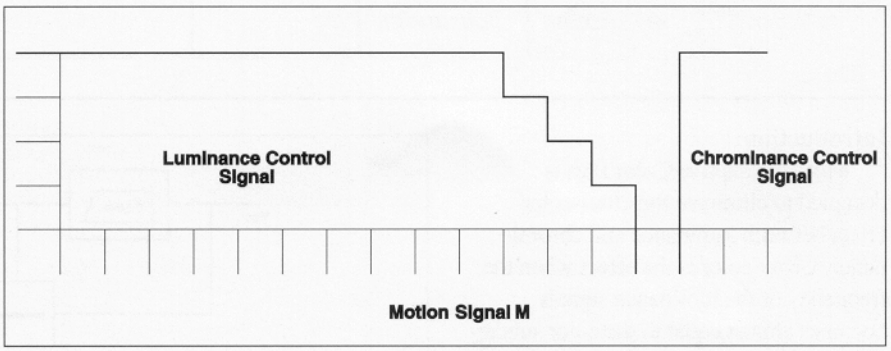


*Figure 3: Derivation of luminance level control and chrominance switching signals in the decoder from the chrominance motion signal M (example)*

## Pre-processing in the Encoder:

**Luminance component:**
The luminance signal is divided into high and low frequency components. The high frequency component is then intra-frame averaged. The amplitude of this component is attenuated by a signal L and then added back to the low frequency component. The intra-frame averaged high frequency component is at full amplitude in film mode or in stationary areas in camera mode. In areas with color motion in camera mode the signal is reduced in amplitude.

**Chrominance component:**
The chrominance signal is pre-filtered in order to provide sufficient attenuation of color difference frequencies higher than 1.4 MHz. The bandwidth is as wide as possible without introducing unacceptable levels of cross-luminance (frequencies below 3 MHz).

The $C_R/C_B$ signals are divided into two paths: a direct path (with compensating delay) and an intra-frame averaged signal. This intra-frame averaged signal is also sent to the motion detector. A control signal C derived from the motion detector selects the output of either the direct $C_R/C_B$ signals (if there is colour motion in camera mode) or the intra-frame averaged $C_R/C_B$ signals (if there is (almost) no motion in camera mode, or in film mode).

## Post-processing in the Decoder:

In the decoder a similar process takes place for both the luminance component as well as the chrominance component.

## Motion Detector Operation:

The motion detector provides control signals L and C to determine whether the spectrum above 3 MHz carries both intra-frame averaged high frequency luminance and intra-frame averaged chrominance, or non-intra-frame average chrominance.

It is important that the same motion signal is generated in both the encoder and the decoder. This means that the encoder must not use information that is not available to the decoder. The motion detector therefore operates on intra-frame averaged chrominance (the high frequency part of the luminance signal can already be attenuated in the encoder!).

The intra-frame averaged chrominance components $C_R/C_B$ are first low-pass filtered to ensure that the motion detector operates on signals with comparable bandwidths in both the encoder and the decoder.

## PALplus Test Patterns:

The Fluke PM5420 TV Signal Generator provides 4 specific test patterns for testing PALplus in manufacturing, research and development, and for servicing PALplus TV receivers. Standard test patterns are a modified "Philips" pattern (PALplus Universal pattern) in PALplus format and a PALplus zone-plate. Both patterns are available in both film mode and camera mode formats.

The PALplus Universal pattern contains information to determine whether the PALplus decoding process is done properly. If PALplus decoding took place then in the white horizontal bar below the PALplus logo strip the abbreviation DEC (from decoded) appears. The visibility however is not very clear but quite noticeable. A patent is also pending for both these test patterns.

For MACP testing two additional test patterns are available. One pattern is made with MACP pre-processing in the encoder and the second one is without MACP pre-processing. For both test patterns also a patent is pending.

Table 1 can be divided into two portions. One part is used for checking the selection between Intra-Frame-Averaged Color ($C_{IFA}$) and Direct Color information ($C_{DIR}$), the other part is used for checking the attenuation of High-Frequency Luminance signals. The top line shows the value for the motion detector signal M (13, 0, 7,..., 13, 14).

*Table 1*

| 13 | 0 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|
| $C_{IFA}$ | -(R-Y) | -(R-Y) | -(R-Y) | -(R-Y) | -(R-Y) | -(R-Y) | -(R-Y) | -(R-Y) | $C_{DIR}$ |
| | (R-Y) | (R-Y) | (R-Y) | (R-Y) | (R-Y) | (R-Y) | (R-Y) | (R-Y) | |
| | -(B-Y) | -(B-Y) | -(B-Y) | -(B-Y) | -(B-Y) | -(B-Y) | -(B-Y) | -(B-Y) | |
| | (B-Y) | (B-Y) | (B-Y) | (B-Y) | (B-Y) | (B-Y) | (B-Y) | (B-Y) | |

Note that in the PALplus system description the motion detector M is based on Look-Up tables. The PALplus system description is confidential until December 31, 1995. No indication is therefore given of what the changes in the color difference signals should be to achieve the stated values for M.

The principles of the MACP test pattern can be expained with the aid of Figure 4: The first and last vertical bars of the MACP test pattern contain color information in such a way that either the M value 13 or 14 is derived. Two frames are Intra-Frame-Averaged resulting in $C_{IFA}1$ and $C_{IFA}2$. If M equals 14 then the direct color information is transmitted (or displayed), so the sequence is Field1; Field2; Field3 and Field4.

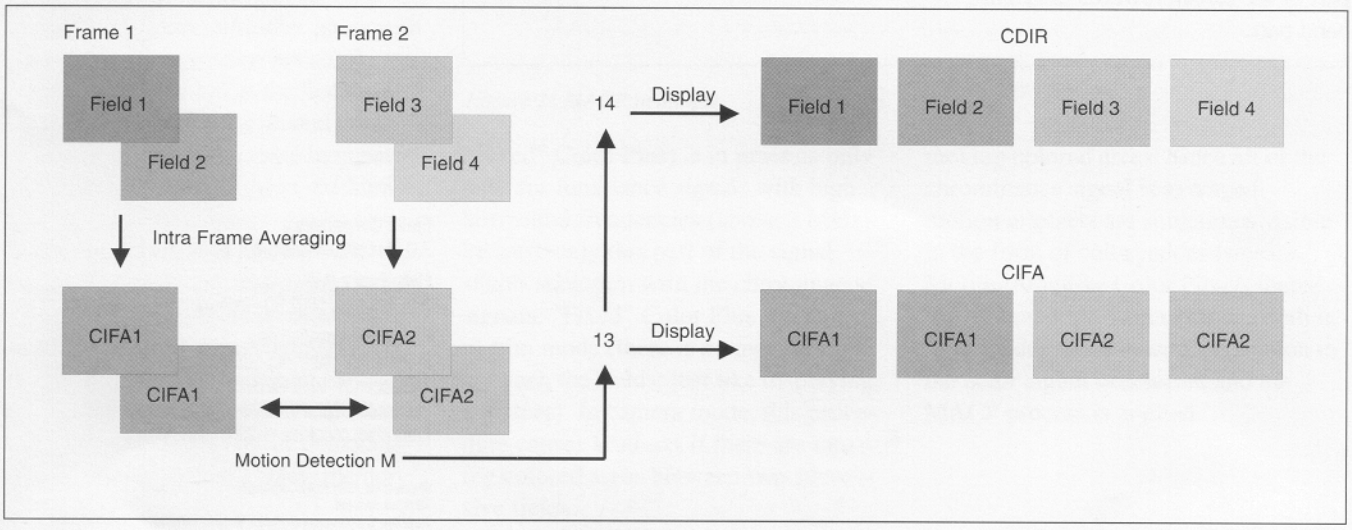


*Figure 4: Detection of Motion and order of displaying the successive fields*

If M equals 13 then the Intra-Frame-Averaged colour information is transmitted, so the sequence is $C_{IFA}1$; $C_{IFA}1$; $C_{IFA}2$; $C_{IFA}2$.
In Table 2 you will find the results that should be visible when the two MACP test patterns are selected and displayed on a TV receiver with or without MACP processing.
In the middle vertical bars the high frequency part of the luminance signal is controlled. For this, a multiburst of 3.8 MHz is present on a colored background. In the vertical direction this part is divided into 4 lines each containing different color information, see Table 1. In the vertical bar with M=0 the color information does not change and the multiburst is thus at a 100% level. In the next vertical bar the multiburst is still at 100% level, but there are color changes between two successive fields although these are just not sufficient. From the next bar onwards the multiburst amplitude is attenuated.
In test pattern MACP1 the influence of the preprocessing in the encoder is present. The MACP2 test pattern does not have this preprocessed information and is therefore better usable for a quick visual check whether the MACP process of the decoder works properly.

In this visual check the multiburst will gradually disappear from the left-hand part of the screen towards the right-hand part.

*Table 2*

| | **MACP 1 MACP processing in encoder enabled** | | **MACP 2 MACP processing in encoder disabled** | |
|---|---|---|---|---|
| | **M = 13** | **M = 14** | **M = 13** | **M = 14** |
| **Receiver with MACP processing** | Amber without flicker | Image flicker between Red and Green information | Amber without flicker | Image flicker between Red and Green information |
| **Receiver without MACP processing** | Amber without flicker | Image flicker between Red and Green information | Image flicker between Red and Green information | Image flicker between Red and Green information |

**Fluke Corporation**
P.O. Box 9090, Everett, WA USA

Fluke Europe B.V.
P.O. Box 1186, 5602 BD Eindhoven, the Netherlands

For more information call:
In the U.S.A. (800) 443-5853 or fax (206) 356 5116
In Europe (31-40) 644200 or fax (31-40) 644222
In Canada (905) 890-7600 or fax (905) 890 6866
From other countries +1(206) 356-5500


Printed in the Netherlands
B0290A-16U9509/NL EN

FLUKE®