S P E C T R U M O F F M A T V

By G8MNY

Most people are familiar with FM modulation and the sidebands it produces, but Colour ATV with inter-carriers is more complex and it is very difficult to see and understand what is going on.

ATV COMPONENT PARTS

SOUND SUBCARRIER

The signal feed to the FM modulator has many components, the simplest of which is the 6MHz FM sub-carrier sound. This has a peak deviation of +/-50KHz. The audio pre-emphasis network should give 50uS pre-emphasized (+15dB @ 15KHz Treble lifted) audio, to obtain best Signal to noise from the FM process. Audio Bandwidth 30-15KHz @-3dB is easily possible.

LUMINANCE and SYNCS

The Luminance and Syncs signal has a bandwidth from near DC (10Hz) to 5.25MHz. A flat gain, phase, and group delay, over this frequency range is essential if the picture is to remain intact. Frame sync are at 50Hz and Line is at 15.625KHz, and all the picture information is repeated at these rates.

COLOUR SUBCARRIER

To the luminance is added the complex 4.43MHz PAL colour signal. It is a double sideband signal made with a Phase & Amplitude modulator driven from the colour difference signals. It produces a colour signal bandwidth of 1.3MHz.

FM TELEVISION

PRE-EMPHASIS

As with the FM audio, the TV signal to noise ratio, is much improved when Pre-emphasis & de-emphasis is used. This is because the FM modulation and demodulation process suffer from high levels of HF noise.

With the Video signal frequency range, simple CR time constant pre-emphasis, will not work due to the number of octaves it contains. The emphasis standard used for all FM Video is the CCIR 405, that describes a 14dB HF lifting curve, made from 5 components. This gives lift only to the picture detail like, edges and colour information, above 2MHz that suffer the most from noise, leaving the bulk of the signal unchanged. It is applied to the composite video signal before modulation, but not the sound sub-carrier!

FM MODULATION PROCESS

Rather than attempting to explain the complexity of all these signals applied to an FM modulator, lets go back a step and consider what happens when we FM modulate with a simple square wave.

With a square wave you get two CW carriers switched on and off at the square wave frequency both with sets of AM sidebands. The depth of deviation only separates the two CW frequencies. So high deviation separates these signals, low brings them together so there sidebands overlap. Increasing the Square wave frequency, just increases each of the CW sideband widths.

Now you know what is going on, lets take a look at simple video signal consisting of 8 levels of Luminance and syncs (standard grey scale) this gives 9 CW carriers all pulsing on and off in sequence at line rate.

However if we use 6MHz sound sub-carrier with no video, we generate 2 main Sub-carriers 12Mhz apart, at a level dependent on the injection level similar to AM.

Put back the grey scale video with the sub-carriers and we have not 9, but 27 CW signals. Consisting of the 9 instantaneous carrier frequencies each with a pair of lower power sound sub-carrier sidebands at +/-6MHz. From this you can see there are repetitions of all the Video information on the sound sub-carriers.

BANDWIDTH
Without taking the higher order of FM sidebands into account, it can be shown the full channel needed is 19MHz wide. If we look at the above example the two sound sub-carrier are 12MHz apart. When the recommended +/-3.5MHz peak deviation of video is applied, each sub-carrier frequencies are also moved over the same +/-3.5 MHz, making

12MHz + 7MHz = 19MHz total sub-carrier displacement.

FM SIDEBANDS
Go on forever! Yes its is true, unfortunately with FM not only the first order of sidebands are generated. The levels of the other orders (Fm x 2,3,4,5,6,7,8,9,...) depending on the Modulation index (Dev/Fm), but they are always present at some level!

However the video signal varying in intensity, pre-emphasis, and sub-carriers, the use of Modulation Index to try to describe what levels of higher order products you actually get is just not possible. In practice these higher orders products decrease depending on their fundamental injection level.

FM ATV DEVIATION
To limit bandwidth used (unlike satellite TV where MI=1.5 with 6 or more Sub-carriers) ATV uses only a peak deviation of +/-3.5MHz (MI=0.7). However with CCIR pre-emphasis the low frequency (<2MHz) deviation is practice -14dB below the +/-3.5MHz peak deviation which gives;-

0.2 x +/-3.5 MHz = +/-0.7MHz.

So most of the signal energy is near the carrier, only the colour & sub-carriers are spread.

When using a Satellite Rx for ATV, this narrow deviation causes problems of low video gain and high noise (& adjacent channel RADAR).

SUBCARRIER LEVEL
The ATV recommended sub-carrier levels are -18dBc. In the receiver this level of Sub-carrier just about provides FM limiting for the sound demodulator, when the picture is about P4 grade. But as the Picture grades reduce the sound will be totally lost at a P2 while a noisy colour picture remains.

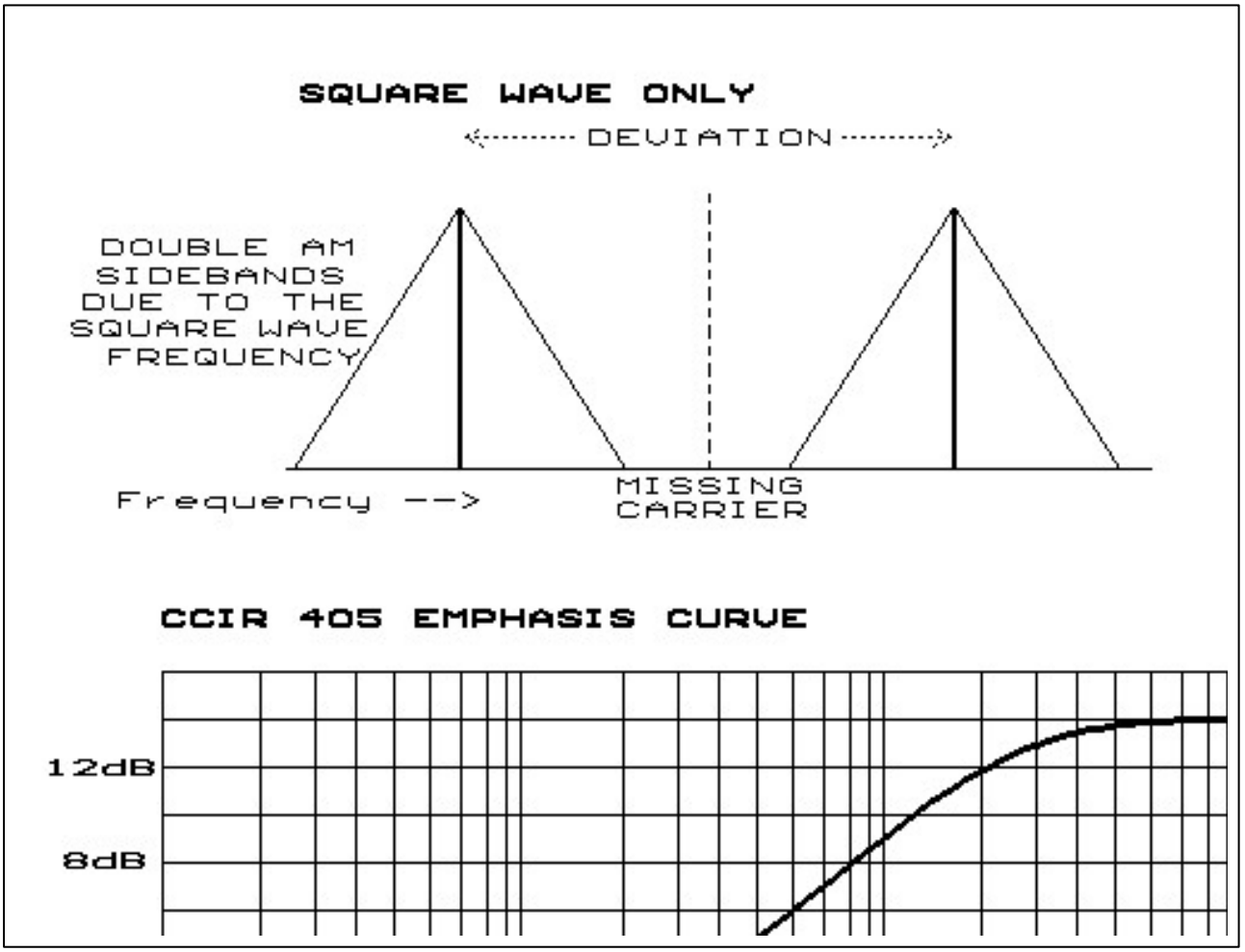
The result of this sub-carrier level however is to make the ATV signals 19MHz edges -51dBc with successive 6Mhz products falling off at a rate of 18dB/6MHz.

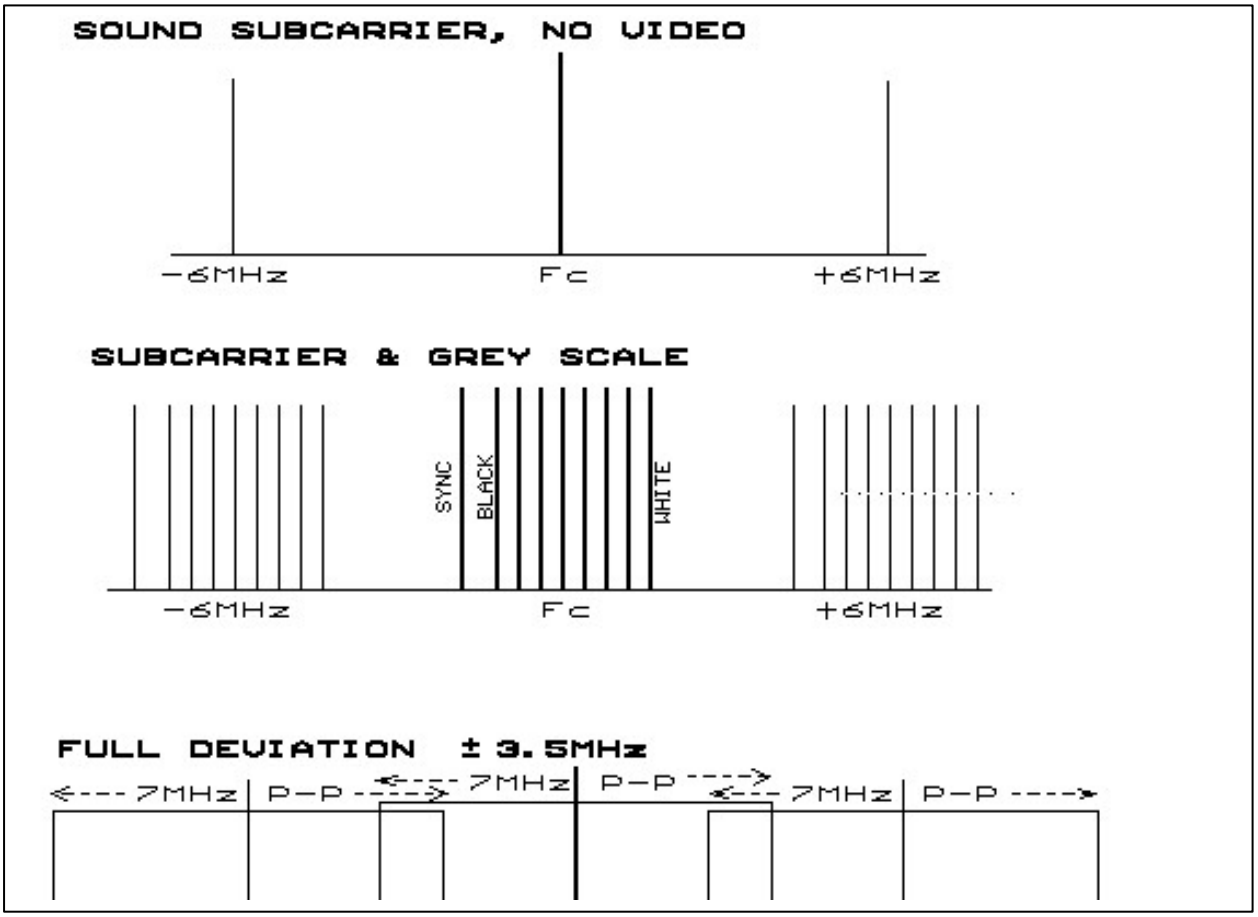
FILTERING
Although narrow Rx is effective on FM for weak signal, the effect on good signals when the weaker parts of the spectrum are lost due to over filtering causes all sorts of video distortions like;-

Sparkly edges,
Colour problems,
Video on sound buzz,
Poor syncs.

For Transmitters as well as the above problems, tight filters cause SWR increases as modulation is applied, introducing AM modulation mixing problems in the PA.

Filtering below 19MHz flat bandwidth will cause some of the above on good P5 signals, but will not be noticed on weaker ones. Filtering below 12MHz on weak signals is very useful where sound & quality are not wanted.




SOUND SUBCARRIER, NO VIDEO
-6MHz
Fc
+6MHz
SUBCARRIER & GREY SCALE
SYNC
BLACK
WHITE
-6MHz
Fc
+6MHz
FULL DEVIATION ± 3.5MHz
7MHz
P-P
7MHz
P-P
7MHz
P-P