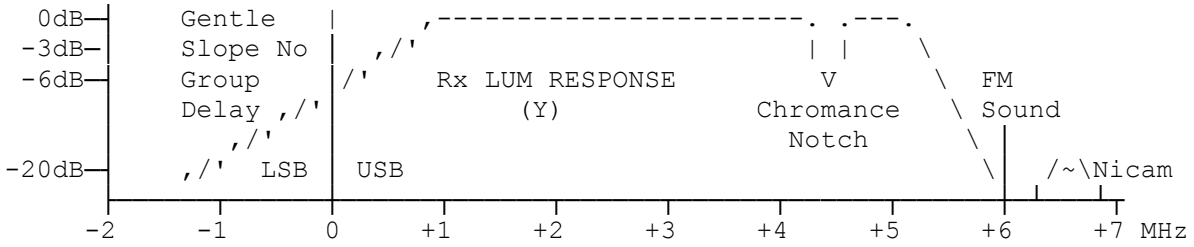
625 Line PAL Spec v Digital

By G8MNY (Updated Dec 07)
(8 Bit ASCII graphics use code page 437 or 850)
With all this who ha on DTV. I thought some Analogue facts might be relevant relating to System I. (UK)

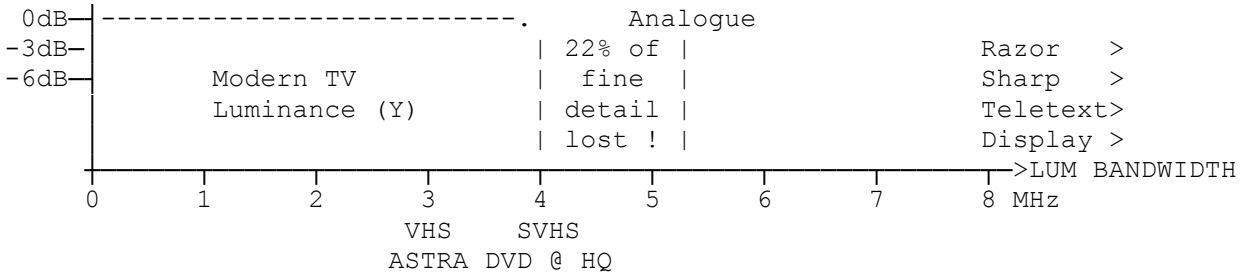
VSB PAL (UK)

The Rx IF is what makes the narrower SSB channel width possible, it is setup on a balanced DSB AM signal such that the carrier is at -6dB on the LSB gentle filter slope. The missing USB this causes, exactly equals the gained LSB fraction to produce a flat phase response DC - 5.25MHz so important for a really good TV picture.



The recommended -6dB 400kHz wide Colour notch, used to be applied in the video stage to reduce fine chrominance patterning in strong colours, enabling the otherwise full luminance bandwidth to be used. Because there is some delay in extracting & processing the PAL colour signal a luminance delay line is needed.

But in modern Rx design (cheaper) they use a video wall filter IC (bucket delay line) to do both the time delay & colour removal, but at a cost of the LOSS OF ALL luminance information above 4MHz! Unless you have a more expensive comb video filter TV design.



So the reduced 4MHz standard has been used for most digital system as the upper limit needed, except when 16:9 is selected.

DETAIL

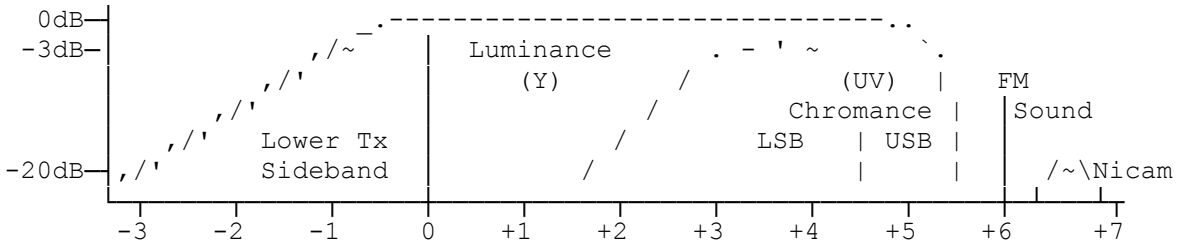
625 Line 4:3 picture due to frame syncs, & blanking/teletext has 575 lines of picture area vertical detail or 575 vertical pixels.

The 64uS lines less syncs, colour burst & porch time, have 52uS of picture area detail that is not pixelize but limited by bandwidth of 5.2MHz. That is 270 black/white cycles of information per line or 540 baud at any phase. Broadcasters insist on > 720 pixels per line for cameras & any digital stores to reduce the horizontal pixelization artifacts being too visible. (e.g. a distant boat mast being 1,2,1,2,1,2,1,2, pixels wide as a camera pans.)

For 4:3 picture you need to handle 575 x 720 pixels 25 frames per second, or better still 287.5 x 720 pixels 50 fields per second for fast action.

So for a 16:9 picture you SHOULD need 575 x 959 pixels! 1/3 more info per line, or an Analogue video bandwidth of 6.9MHz, hence the E-PAL system where detail above 4MHz was to be put above 6MHz, but that was before NICAM.

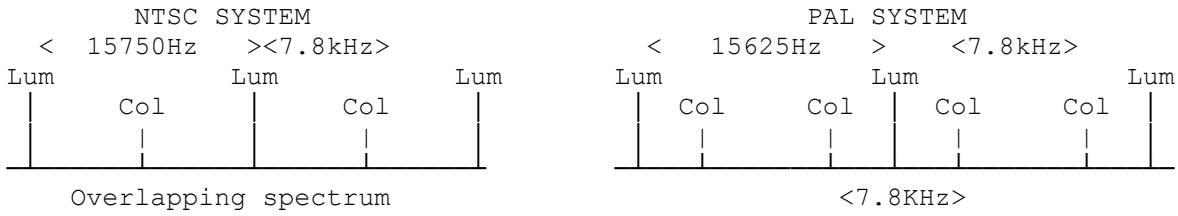
TX PAL (UK)
At the Tx, NO LSB filtering is done until -1.3MHz.



As you can see the luminance (Y) bandwidth 5.25MHz @ -3dB which at 52uS per visible line gives a 500 lines of infinite precision analogue horizontal definition. e.g. A vertical line edge (pixel) can in any position.

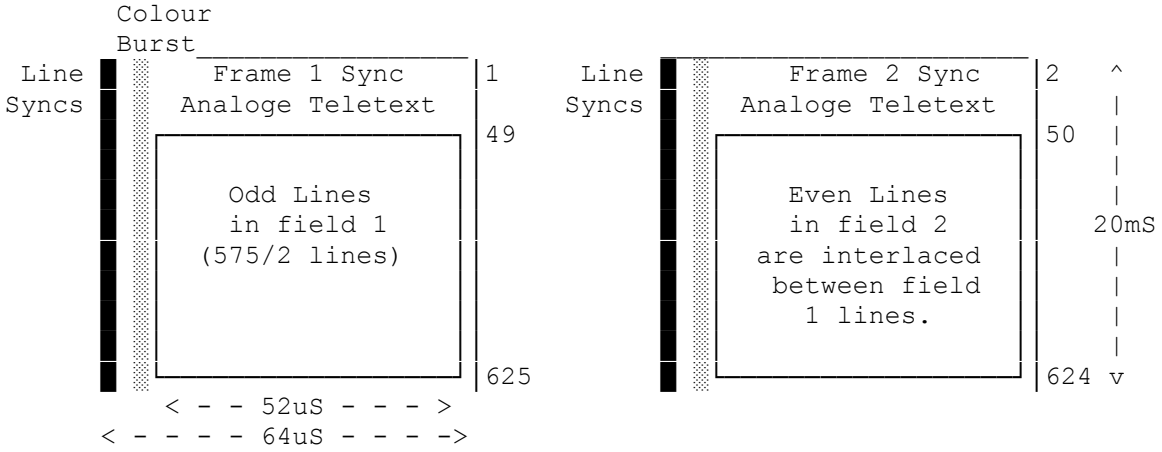
CHROMANCE (Colour)
The colour is not simple as the eye can't see colour detail well. (try Purple Blue background lettering with similar light level on a PC). So the TV systems all modified their B/W system to sprinkle some low definition colour on it. This is typically at 1/3 the bandwidth horizontally (1.4MHz) & 1/4 the bandwidth vertically, averaged out in the Rx over 2 lines in the same field. (e.g. even line 100 & 102 & odd line 101 & 103). (this much worse in VHS).

The chromance signal has been more cleverly fitted in using a quadrature carrier system to carry both blue & red difference signals (U & V), like the USA NTSC system the subcarrier frequency used makes the colour sidebands exactly interleave between the luminance sidebands.



But the PAL alternate line inversion (7.8kHz) of the (V) colour vector, ensures there is NO phase error (colour hue) seen in the signal. Like NTSC there is also minimum, but some interference to the luminance especially on fine diagonal patterns when the sidebands will clash.

FRAMES



The 625 line interlaced system actually has only 575 lines of picture. 50 lines is take up with the frame Equalising pulse, frame pulse, teletext & or blanking lines.

The 2 fields the are independent in time & effectively give smooth motion at 50 frames per second of 287.5 lines. However films are @ 24 or 25 frames per sec & the motion is worse, so also is some digital systems (e.g. frame store mixers) that only do picture calculations on a full frame of 575 lines, thus loosing time difference information needed for good smooth motion.

```
Line
 EQ   ------__------
 FP   ______________
 EQ   ------__------
 TT   xxxxxxxxxxxxx
 TT   **************
Blank ==============
 51   -------------- ODD  Field
 52   ============== EVEN Field
 53   --------------
 54   ==============
 55   --------------
 56   ==============

624   -------         Half line
625   ==============
```

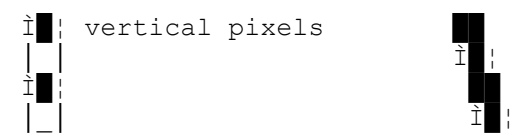
SPEED

The 4:3 Analogue system is capable of 50 (1 field) pictures per second giving really good smooth motion, twice that of 25/24 f.p.s. film.

As far as I know the broadcast MPEG we see only works at processing 25 f.p.s. (2 fields at once) & due to commercial bandwidth restrictions is not capable of sending 25 I frames/S needed for full field motion so is not the same as film.

PIXELIZATION

The 575 lines does pixelize the vertical content of the analogue picture. Until the advent of digital processing the horizontal has not.



For 4:3 aspect ratio the number of horizontal pixels expected bye the eye to match 575 vertical ones is (4/3) x 575 = 766. This equates to a video bandwidth of approx 8 MHz. But only 5.25 MHz is used, the difference is due to the advantage of the above as seen by the eye, where the position rather then the size if the pixel is more important.

For 16:9 therefore using just digital matrix of pixels, a 575 line picture will need (16/9) x 575 = 1022 pixels per line. If you just stretch the picture & do not add more pixels you end up with wider pixels that looks like a smudgy picture! ■■

PICTURE LEVELS
The analogue signal is in theory capable of an infinite number of steps. In practice the broadcasters work to a S/N ratio (weighted).

Lum	Colour	Where
48dB	42dB	Studio
56dB	52dB	Link Network
52dB	52dB	Main Tx
51dB	51dB	Off air Repeater
48dB	48dB	A transposer
45dB	41dB	Total Tx noise
40dB	35dB	New VHS tape best quality

With modern 280MB/S digital links to Tx sites S/N ratio of 70dB are the norm.

DOING THE DIGITAL SUMS
If we now take a look at what is needed to digital to do the equivalent to analogue but 16:9, then just taking the Luminance part...

Pixels per second = 575 x 1022 x 25 = 14.7MP/S

If each pixel is only sampled to 256, 8 bit quantisation level that at best can yield 46dB S/N. Then the data rate needs be 14.7 x 8 = 117 MB/S.

Now doing a simple 3x for colour you get, 357 MB/S, but adding in just 50% more for the colour (assuming it is processed as for PAL) & a bit for the stereo sound, you get a more sensible 180MB/S.

TX FEEDS
Most TV source are digital, but digital link feeds to Main Analogue + digital Tx sites are very wide bandwidth for widescreen, speed up to 280MB/S per channel are used to ensure the quality with NO DIGITAL ARTIFACTS.
The difference between these digital feeds & what is actually broadcast digitally in the UK is enormous.

COMPRESSION
Now if you use very efficient but corrupting digital compression (not like zipping where no data is lost) such as MEG2, you can have 100:1 compression with only a few noticeable artifacts that hardly show up, unless there is lots of motion or detail in the picture. But of course there is processing delay penalty of about 0.75s for it, as it needs to have lots of frames in hand to do the best data compression comparisons with.

MPEG
You now see what is need from a Digital system to get up to the old Analogue standard. Well they did not do that, they limited the pixels per line to a max of 400 on 4:3 picture.
The no of "I" frames (new frames) is severely limited by MUX bandwidth allocated per ch, so most of the frames are made up from updated of modified previous frames. If many channels on a MUX need "I" frames then some will have to wait, this is the reason for freezing the picture with no errors occasionally when a camera shot change is due.

Things that MPEG does well..
1/ Compress a full spec pictures down to about 4MB/S for a reasonable picture.
2/ Vertical movement of whole picture.
3/ Sideways movement of whole picture.
4/ Fade to Black.
5/ Change contrast.
6/ Colour registration, etc.

Things that MPEG can't do well, if at all..
A/ Zoom in of whole picture.
B/ Fast movement of any detail in part of the picture. (e.g. flames)
C/ Rotation of whole picture, e.g. a shaky camera/helicam.
D/ Cross fade to new camera shot.
E/ Provide > 256 video levels (= 47dB S/N weighted).

ENERGY
Remember every Set Top Box is about 20W watts more (10w if in a TV), Also 10W standby mode is needed, as it must be left on 24/7 to catch early hours system & software updates.

So DTV is not very green!

CONCLUSION
Using digital TV for still pictures, the definition with no PAL colour filter using RGB Scart option, looks as good as the old analogue used to be on most TVs (but not ones with Comb/6dB filters), but with no added noise, no ghosts, no ringy edges.

But Motion is a lot worse than the old Analogue, especially detailed pictures. In fact you can just see this affect on the digital fed Tx on analogue TVs, where very fine detail on a busy picture appears only a few frames later!

Despite all the hype on improved digital pictures etc, errors/noise spikes in digital signal are very badly handled. Causing the heavily compressed picture to break into large still pixels or freeze with the break up of the sound into loud squeaks.

There is a very real hidden cost of course for going digital, at least 20W per Rx/Set Top Box etc. which is not GREEN. Even though modern kit is generally more power efficient this is in addition to that.

One last point, all Computer kit crashes, STB are no exception, & power offs to reset the box after a mains brown out are normal!

Why Don't U send an interesting bul?

73 De John, G8MNY @ GB7CIP