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APPLICATION NOTE

Delay measurements in digital TV studios with Digital Video Component Analyzer VCA

Products:

DIGITAL VIDEO ANALYZER   *VCA*

7BM13_0E

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The requirements for measuring the new signal components of the digital TV studio are completely different from those for analog PAL or NTSC. Many adjustments made during commissioning and acceptance of a studio are no longer required but a number of new measurements has to be carried out particularly with a view to signal delay. For this reason the Digital Video Component Analyzer VCA from Rohde & Schwarz includes measurements for determining the signal delays in a digital studio - in addition to measurements of data frame and physical measurements of serial-digital transmission:

- delay between individual digital video signals,
- absolute delay of digital video signals on different signal paths,
- delay of frame as against the sync word (picture location),
- delay between video signal components.

To avoid poor signal quality or even failures, all these parameters have to be carefully determined during the initial measurements in the studio. Up to now this was only possible with the aid of analog test equipment after a D/A conversion of the signals with the disadvantage that much time was required for interconnecting instruments and measurement results were not very accurate. As all these measurements can now be carried out with VCA at the digital level, these disadvantages can be overcome.

Description of measurements performed:

Signals should arrive simultaneously at the position where they are cut, mixed or otherwise processed. Normally this is the mixer or a routing switcher. While in the case of analog measurements the studio engineer had to make accurate adjustments to within nanoseconds, in digital studios this work is carried out by so-called "autophasers". However, signal delays are multiples of the values occurring in the analog studio because of digital signal storing so, when planning a studio, care has to be taken that the control ranges of the autophasers are not exceeded. In practice this can be checked by measuring the SIGNAL DELAY. With the aid of this measurement the delay between two video signals is determined so that the difference can be set to 0 by means of a clock (GENLOCK GENERATOR) with adjustable time levels.

Provided GENLOCK GENERATOR and ROUTING SWITCHER can be remote controlled, this adjustment (see Fig. 1) can also be carried out automatically.
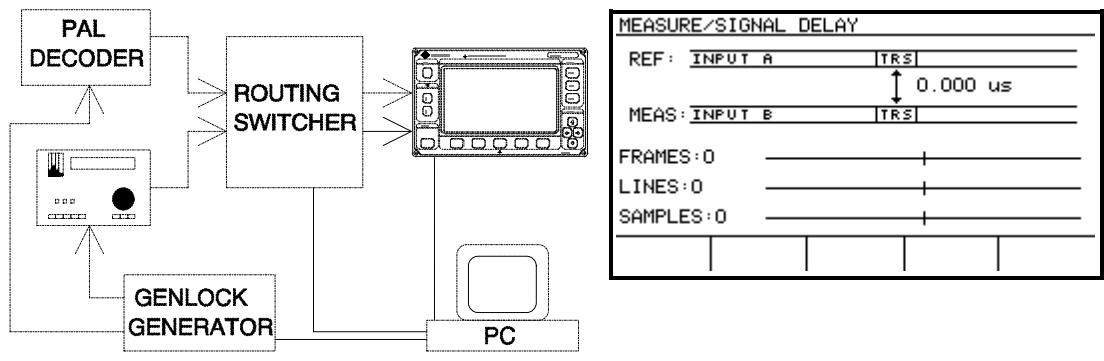

Fig. 1: Automatic GENLOCK adjustment for equal signal delays

Delays shorter than one frame period (40 ms or 33 ms) can be measured with any video signal considering that the time information is contained in the sync word (TRS). Longer delays are measured by the VCA automatically when the test signal is an all-black picture comprising a white bar that is not available in each frame. For instance, when the 8V PAL identification pulse is used (= 1 white bar in every 4th frame), a measurement range of +/-2 frame periods is obtained. For delays longer than 2 frames a longer test sequence (max. 16 frames) can be generated with a corresponding measurement range of +/-8 frames (Fig. 2).
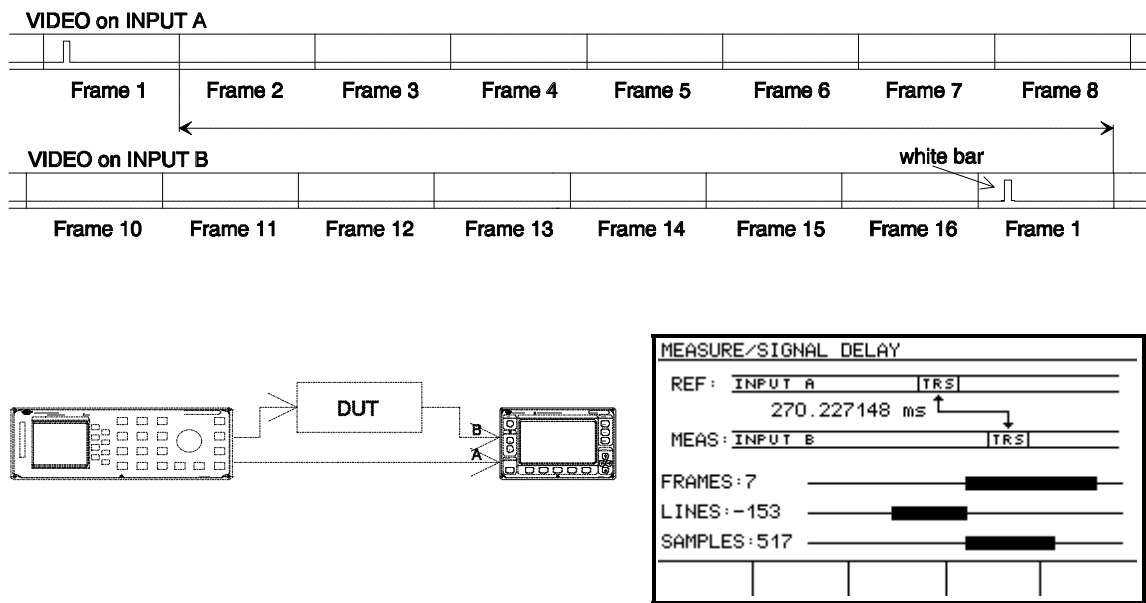

Fig. 2: Test signal, test setup and VCA display when a long absolute delay is measured

These test signals are provided by the CCVS Generators SAF and SFF from Rohde & Schwarz, which comprise the 8V pulse as standard test line while the 16-frame signal sequence can be created with CREATE PATTERN and CREATE SEQUENCE in the SIGNAL EDIT menu.

The absolute delay of digital video signals has to be measured for instance when the signal delay caused by studio equipment and signal paths is not known. In this case only a complete delay schedule of the studio with all required GENLOCK time levels can be determined. If no such schedule is available, the total delay of the video signal through the studio has to be determined and matched to the total delay of associated audio signal through the sound studio. Thus video and audio signals will also match at the studio output.

The absolute signal delay is determined in the same measurement but in this case 2 synchronized video signal outputs are required: one is connected to VCA input B via the signal path to be measured, the other directly to VCA input A (Fig. 2). Since the directly connected signal only incurs the delay caused by the connecting cable (approx. 4 ns/m) the measured delay difference equals the absolute delay of the measured signal path; in the example more than 270 milliseconds.

The third problem is the delay between the frame and the sync word. This parameter is called PICTURE LOCATION. It means that a point in the center of the frame will be in the center again after several processing procedures such as A/D and D/A conversion. A shift of the point can occur both in the vertical and horizontal direction. A shift of the vertical picture location causes a delay of at least one line. Such a delay is present when the line information in the frame changes and the line numbers of the change are known. In this case the correct line numbers and therefore the vertical picture location can be determined with the aid of any WAVEFORM monitor using a LINE SELECTOR (provided in the VCA). For instance, in the SPLITFIELD test pattern of the 625-line system generated by the SAF the change occurs between lines 214 and 215 in the first field and line 527 and 528 in the second field (Fig. 3).
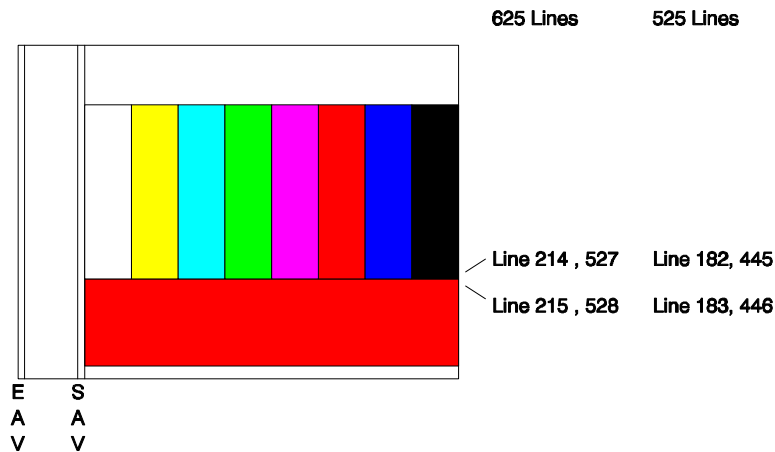
Fig. 3: Lines of signal change in the splitfield generated by the SAF

Measuring the horizontal picture location with the WAVEFORM monitor yields inaccurate results. In this case an automatic measurement is required like that carried out by the VCA. For measuring the chrominance/luminance gain delay error, the edge positions of the colour bars in the digital video signal are evaluated. ITU-R 801 prescribes colour bars of 100% and 75% saturation accurately to the point. If the middle of the luminance signal (Y) edge is not at sample Y360, a deviation from the horizontal picture location occurs. It is specified as delay error of Y/NOM in nanoseconds.

When testing A/D converters it should be ensured beforehand that the position of the ITU-R 801 colour bars as against the analog sync pulse at the analog side is to standard. ITU-R 801 does not explicitly specify this time relation but the nominal times result from the standard position of the SAV and from the determined position of the analog sync pulse referred to the EAV as specified by ITU-R 656 .

The example in Fig. 4 shows a picture location shifted by 148.1 ns to the left which means that the colour bars were digitized two clocks (13.5 MHz) too early, ie the sync frame triggered 2 clocks too late.

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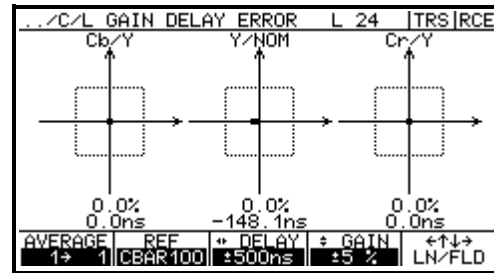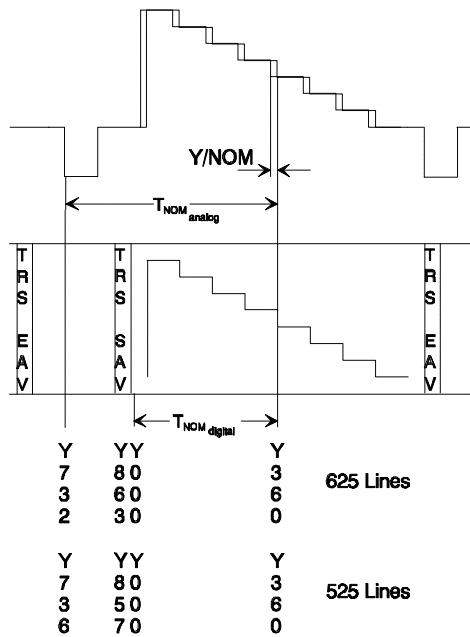
625 lines

$T_{NOM_{analog}}$ = 492 samples = 36.444 µs

$T_{NOM_{digital}}$ = 360 samples = 26.666 µs

525 lines:

$T_{NOM_{analog}}$ = 482 samples = 35.704 µs

$T_{NOM_{digital}}$ = 360 samples = 26.666 µs

Fig. 4: Horizontal picture location as measured on ITU-R 801 colour bars

Unfortunately the SPLITFIELD test signal used for determining the vertical picture location comes from analog measurements so that its position is not exactly defined in the standard. The result is that in practical applications it is not possible to determine the total picture location with only one test signal. However, when a reference A/D converter is used which has been checked or adjusted once by means of the ITU-R 801 colour bars, the SPLITFIELD can be applied via this A/D converter and then the horizontal position of the colour bars be determined and stored as nominal position in the VCA MEMORY. After that the SPLITFIELD test signal can be used for measuring both directions of the picture location.

We now come to the fourth problem: The different components of a video signal may arrive with different delays. In the TV picture this is noticed by colour effects at the vertical edges, non-specialists would describe them as colour shadows. In the digital system a shift of the edges hardly ever occurs unless band limiting has been carried out which causes different distortions (rounding) at the signal edges (picture edges). The main error source in this case is the analog/digital conversion but which cannot be completely done away with since 40 years of television left us with plenty of analog recorded video material. In addition, the change from analog to digital studios will not take place overnight so that digital and analog sources will have to be used simultaneously for quite some time.

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In these A/D converters the three components are converted in separate paths and because of the different sampling rates (13.5 MHz for Y and 6.75 MHz for Cb and Cr) the delay of the different band-limiting filters has to be compensated for.
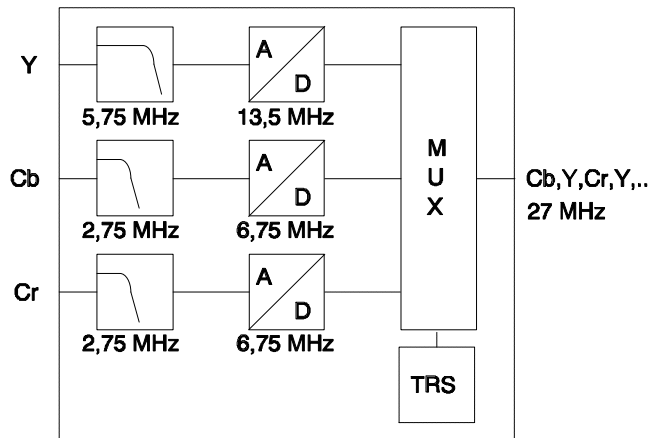
Fig. 5: Block diagram of A/D converter

Different band-limiting filters can cause different delays - eg in the case of inadequate group-delay equalization. Same as with analog measurements these delays cannot be completely avoided and here even show a temperature response. These delay errors too are determined in a chrominance/luminance gain delay measurement. The delay of Cb and Cr component edges are displayed with reference to the edges of the luminance signal (Cb/Y or Cr/Y).

Also in this case the ITU-R 801 colour bars are used as reference signal. However, colour bars determined and stored in a previous reference measurement may be used as well. The example in Fig. 6 shows a leading Cb and a lagging Cr signal. As this measurement also includes a level check, A/D conversion can be adjusted with the aid of a single screen display.
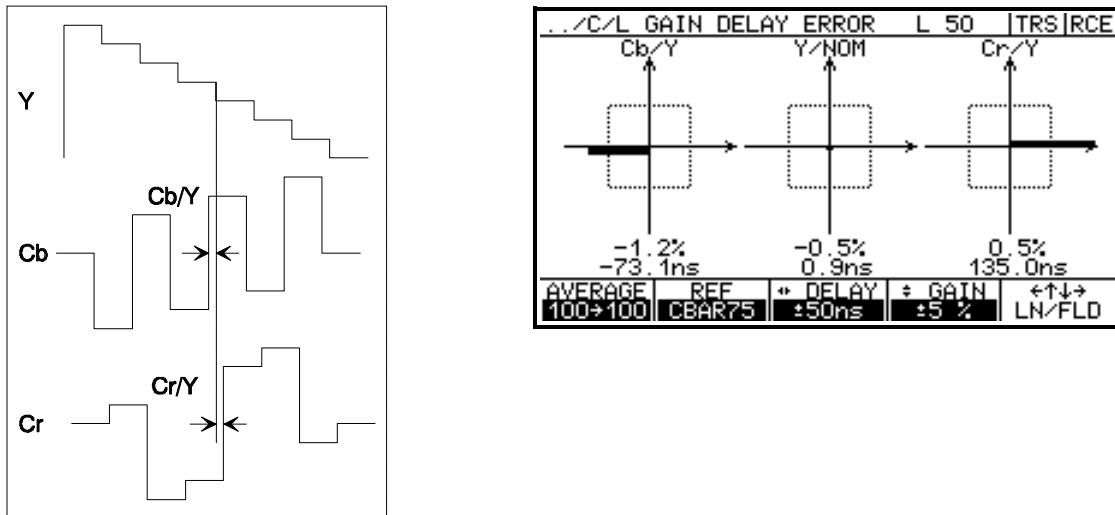
Fig. 6: Measuring the delay between components of a digital video signal

Thus almost all video signal paths of a digital TV studio can be tested and monitored with the aid of two VCA displays. The hardware handling these parameters is shown in the block diagram of Fig. 7. The video signals are applied to the DATA & DELAY MEASUREMENT block via the signal inputs A and B. The time measurements are carried out by highly integrated gate arrays that can be reloaded during operation, while measurement results are evaluated and displayed by a high-performance 32-bit signal processor (DSP). The RS232/RS422 interface allows complete remote control of all functions, hardcopies on a printer or storage in a PCX file. For performing the described measurements, a VCA with option B11 is required which permits also other important measurements in the digital signal components studio such as data jitter, amplitude spectrum and return loss to be carried out. The "picture location" and "delay errors within components" measurements are included in the basic unit
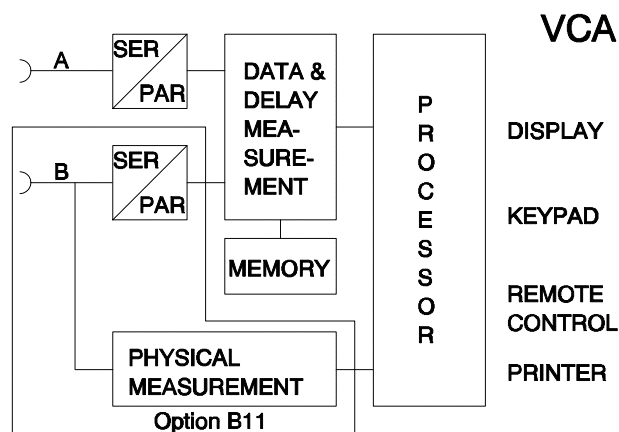

Fig. 7: VCA block diagram