ROHDE&SCHWARZ
BROADCASTING DIVISION

APPLICATION NOTE

Time Delay Measurement in the Digital Studio

Products:

CCVS+COMPONENT GENERATOR	*SAF*
CCVS GENERATOR	*SFF*
VIDEO ANALYZER	*VTA 71*
DIGITAL VIDEO ANALYZER	*VCA*

7BM20_0E

Time Delay Measurement in the Digital Studio

In analog studios, where the delay equalization between the various video signals poses a measurement problem, time delays in the order of a few lines are to be expected, unless frame stores are being used for technical reasons. In these studios, for instance the SC/H phase of the various CCVS is thus correctly matched at the input of the crossbars. The delay equalization for audio is ensured too, even if the delay times are relatively short.

In digital studios with fully digital signal processing the delay times are of quite a different order of magnitude. Delay times of a few frames between video and audio may well occur quite frequently. Although studios with minimum delays are of course planned, the exact delay times must be precisely measureable:

For this kind of measurement R&S has the right instruments in their product line:

as a signal generator the	CCVS + COMPONENT GENERATOR SAF
or the	CCVS GENERATOR SFF
each with	OPTION "CCIR 601" as a digital interface
as an (digital) oscilloscope the	VIDEO MEASUREMENT SYSTEM VSA
as a digital analyzer the	DIGITAL VIDEO COMPONENT ANALYZER VCA.

Fig. 1 CCVS + COMPONENT GENERATOR SAF

Fig. 2 DIGITAL VIDEO COMPONENT ANALYZER VCA	Fig. 3 VIDEO MEASUREMENT SYSTEM VSA

Basically, there are three different delay measurements:

1. Time delay between the individual digital signal sources in the studio
2. Switching time at a digital crossbar
3. Time delays between the three signal components Y, C_b and C_r

1. Time delays between the individual digital signal sources in the studio

The first method determines the time delays between the individual digital signal sources which in the digital studio may well amount to some frames. RBT of Nuremberg proposed a method for simple and precise measurement of such long delays. The test method was used to measure the delays in the digital studios of ARD in Kassel, Frankfurt/Main and Munich. The only measuring instruments required are the

	CCVS + COMPONENT GENERATOR SAF
or the	CCVS GENERATOR SFF
each with the	OPTION CCIR601 as a digital interface and
a standard	dual-trace oscilloscope with minimum 20 ms/div
	or for measuring the time delay with line resolution the
	VIDEO MEASUREMENT SYSTEM VSA or similar.

The measurement is based on a comparison of the undelayed first SAF or SFF (digital) output signal with the second SAF or SFF output signal which has passed through the equipment under test - for instance the entire studio - with the aid of an oscilloscope. Measurement is performed after D/A conversion of the two digital signals.

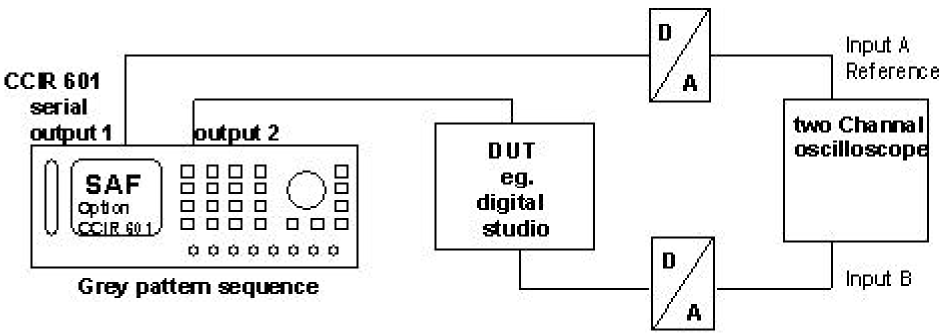

Fig. 4 Test setup for measuring the total studio delay time

The simple and fast frame sequence generation of the SAF/SFF in the SIGNAL EDIT mode is made use of. First, in the SIGNAL EDIT mode frames are edited with a grey level increased by 100mV per field. The grey level starts at 10.5 µs and ends a 62.5µs after the sync pulse leading edge. Four frames are obtained which are edited by SIGNAL EDIT to form a sequence with steadily increasing grey level. This signal can be used to measure delays of up to 8 fields (four frames).
The undelayed frame sequence of the first digital generator output is compared with the sequence of the second output after D/A conversions.

To do this, the undelayed signal is used to trigger the dual-trace oscilloscope. In the chop mode, the undelayed and the delayed signal are displayed each with 8 fields. The grey levels of the fields shown one below the other are measured. The level difference expressed in n x 100 mV gives the time delay of n fields. If for example the undelayed signal has a grey level of 300 mV and the delayed signal a grey level of 700 mV, this means a delay of 4 fields.

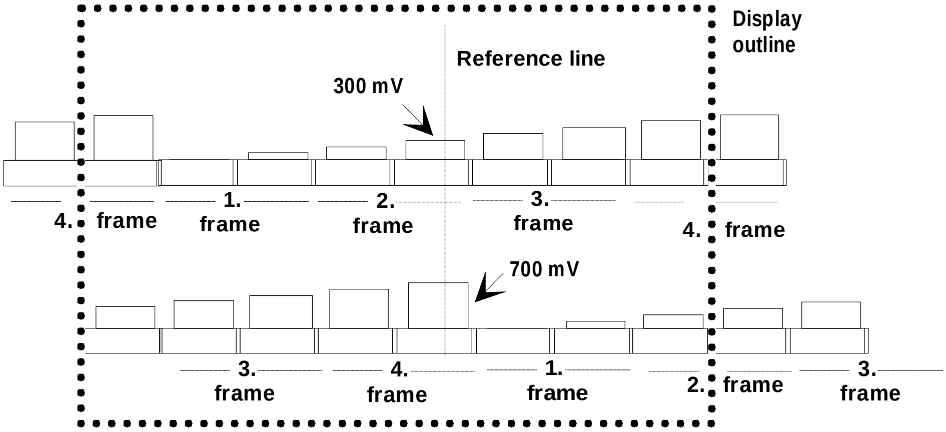

Fig. 5 Field delay measurement

The time delay can however be measured more precisely using VIDEO MEASUREMENT SYSTEM VSA. The LINE SELECT function allows the delay time to be determined to within a fraction of a line with a resolution of ns.

Again the undelayed signal triggers the VSA, which in the LINE SELECT mode displays the undelayed signal of input A and the delayed signal of input B. The inputs A and B are displayed in Two Display mode.

Let us select for instance line 336 of input signal A in the second field. This is the first active line of the field and the grey level starts at 10.5 µs as defined by signal editing.

This line is overlaid by the signal of input B. By switching through the fields in the LINE SELECT mode the field with the same grey level as that in line 336 of input signal A is found. The difference between the fields determines the field delay. The next step is to find the first active line of the delayed signal with the aid of the line selector. The difference between the lines determines the additional line delay. If the positive edges of the grey levels are also shifted in time, this delay can be accurately measured with a resolution of ns using the CURSOR function, since the grey levels in both lines have been defined to start at 10.5µs. For highest accuracy, the horizontal sweep magnification 1µs/Div should be activated.

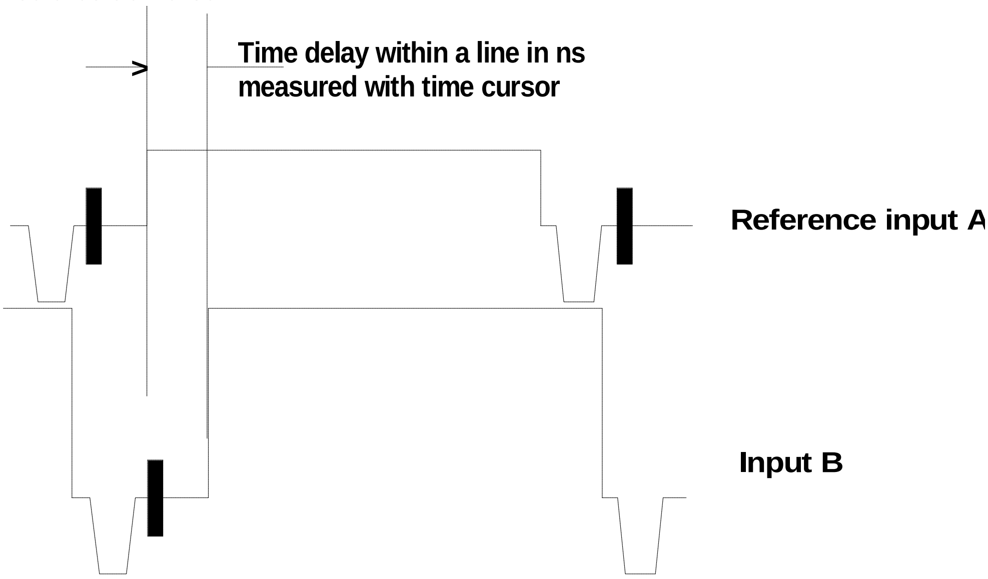

Fig. 6 VSA display for delay measurement within a line

2. Switching time at a digital crossbar

The second method concerns the determination of the switching time at a digital cross bar. The signal switchover from the input to the output must be made in line 6 of a frame. The RBT again made use of a special function of the SAF/SFF: These generators can be used to insert test signals into the vertical blanking interval (VBI) starting from line 6 in the first field and from line 319 in the second field. These insertion test signals now form an integral part of the digital ITU-R BT. 601/656 signal. For the measurement, a signal without insertion test signals in the VBI and a SAF/SFF signal with white-line test pulses inserted in the VBI is required. The signal without insertion test signals is generated via a mixer, which sets the entire picture contents including insertion test signal to zero, or with the aid of devices that are non transparent in the VBI. Such devices are always available in digital studios. The time delay between a signal with inserted white-line test pulses and a signal with black-line test signals in the entire VBI is first measured according to the first method described above in fields, lines and delay within a line and then equalized.

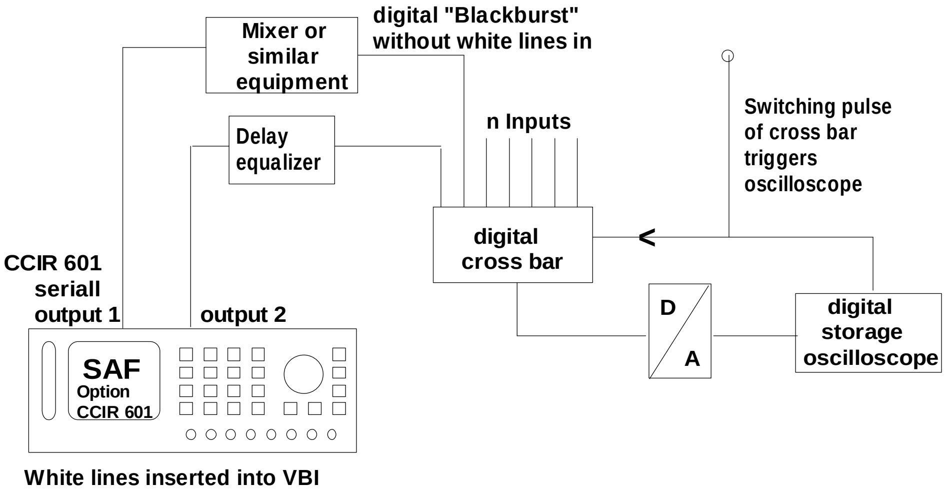

Fig. 7 Measurement of switching time at digital crossbar

Both signals are present at the inputs of a digital crossbar. The output of the crossbar is taken via a D/A converter to the input of a (digital) storage oscilloscope. The crossbar switching pulse triggers the storage oscilloscope. The oscilloscope determines the line in which the black/white switchover has taken place in the VBI. Since the digital storage oscilloscope also records the prehistory before the trigger, this method also allows precise measurement of the switchover time within the line. Transparency of the crossbar within the VBI is a prerequisite for this measurement.

3. Time delays between the three signal components Y, C_b and C_r

The third method deals with the delay between the three signal components Y, C_b and C_r. For this measurement the digital colour bars signal defined by ITU-R BT. 801 at the pixel level is required. Generator SAF or SFF fitted with option "CCIR. 601" generated this colour bars signal either in the 100/0/100/0 or 100/0/75/0 format of course also as analog components without time delay.

These component signals correspond to the analog components as for instance provided by a camera. In the digital studio, the A/D converter and the converter to the digital ITU-R BT. 601/656 format follow immediately. Delays between the now digital components may however already occur here, which means a considerable reduction of the signal quality in the studio right from the source. With the aid of the digital coulour bars, the Digital Analyzer VCA is able to measure the delay and gain errors with highest precision.
Delay and gain errors may not only arise during the analog to digital conversion, but also in digital signal processing. Such errors may occur for instance if the serial data are reclocked by a clock that

is subjected to jitter, or after serial-parallel-serial conversion of the data stream due to different clock references within component processing, or as a result of any other faulty processing steps that are not recognizable as being incorrect.

The colour bars are fed to the equipment to be tested in ITU-R BT. 601 format so that there are no errors due to A/D conversion and after digital processing in the DUT the inherent error of the latter is indicated as the test result.

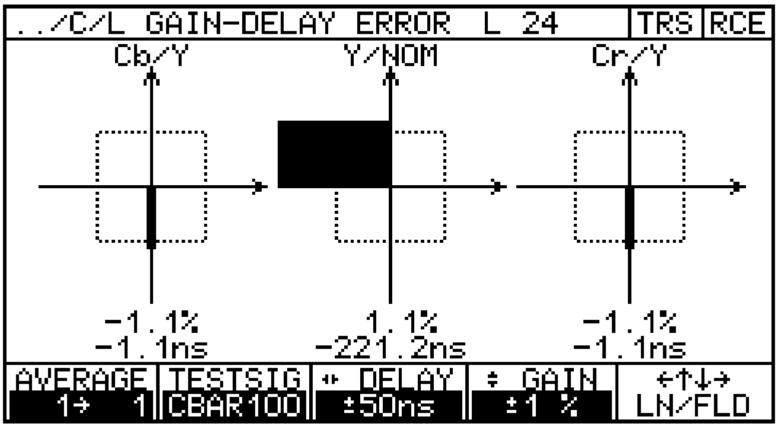

Fig. 8 Measurement of gain and delay errors on digital colour bars signal 100/0/100/0 using the DIGITAL VIDEO COMPONENT ANALYZER VCA

This menu shows the luminance Y with -221 ns time delay or +1% gain error referred to the definition in line with ITU-R BT. 801, while the two chrominance components C_r and C_b exhibit only a slight delay of -1.1 ns as against Y and an additional gain error