In this paper, a method of U-matic VCR video output signal extraction is investigated with the aim of improving the replay image quality. The author feels that separation of luminance and chrominance signals can substantially enhance the replayed video signal, prior to its digital transfer.

In the European CCIR-PAL (B,G) version of U-matic VCR format, the luminance part of composite video signal is recorded as a frequency-modulated carrier. The principal FM sidebands are limited at relatively low deviation of 1.6MHz (4.8MHz – 6.4MHz).

In the later U-matic-variant, the SP, luminance carrier deviation is unchanged, but modulation limits are set at higher frequencies as follows: 5.6MHz (sync tip) and 7.2MHz (peak white level).

The original chrominance signal is formed as a combination of two amplitude- and phase-modulated colour difference signals (u, v), centered at 4.43MHz. This signal is also phase-rotated at each horizontal line period, furnished with short segments of colour burst signals, and finally mixed with the luminance (monochrome) signal.

The chrominance signal, together with luminance signal, forms a complex time- and frequency-interleaved composite video signal. The U-matic video recording process down-converts the original ‘chroma’ signal onto 0.686MHz (low-band), or 0.984MHz (high-band, SP) sub-carrier.
The problem of non-standard component video

Most U-matic recorders and players are fitted with two types of video output terminals: standard single-lead composite (BNC) The component output, termed ‘DUB’ terminal, delivers video as discrete Y/C signals (luminance and chrominance), via special 7-pin connector. At DUB terminal, the Y component is in standard CCIR format, while C component is always a down-converted (0.686/0.984MHz) version of the original PAL chrominance sub-carrier.

The DUB connector was originally provided for analogue tape-to-tape transfers, rendering intermediate chroma up/down/up-conversion unnecessary. However, such non-standard format is unsupported by most video capture devices. The problem has been circumvented by using an external converter, which supports only NTSC chroma signal (0.688/3.57MHz) conversion.
Fig. 2. PAL versions of U-matic video recording format (above). The separation of Y and C signals should yield potentially cleaner video output.

Composite video signal is sub-optimal
Composite video can of course be used in video digitization work as such. However, in the case of U-matic VCR, composite signal extraction is sub-optimal for serious digital archival applications.

In setting up feasible PAL Y/C component video interface between analogue VCR and capture devices, the C component must be brought back onto the original sub-carrier frequency (4.43MHz). Since the up-conversion is necessary to facilitate composite video output, the PAL C signal will be available at the machine’s internal circuitry.

Naturally, the C signal should be extracted before the VCR’s Y/C mixer stage. Also, the C signal must be removed from the machine’s composite output. In summary; the suggested Y/C interface can be set up by taking Y signal from the composite video output terminal, and C signal from the machine’s video process circuit.
Advantages of the Y/C output

In fact, the complex spectral/temporal interleaving of a luminance and chrominance signals make it practically impossible to perform lossless separation of Y and C components once they are recombined for composite output. Even if high-precision digital comb filters are employed in capturing the composite signal, time-base errors, signal delay/gain inequalities, and other instabilities pose almost insurmountable challenge in separating Y and C signals from each other.

Therefore, it seems that an early extraction of the C component of Y/C signal separation, from the replay signal chain should bring about visibly improved image quality, particularly, in the case of U-matic recordings.

Practical video measurements

In order to assess the merits of the early C signal extraction, a Sony recorder (VO-9800P) was measured using following test instruments:

*Rohde & Schwarz VSA Video Measurement System/R&S SAF CCVS+Component Video Signal Generator*

Measurements were made from both the regular composite output, and the modified Y/C output. The replay luminance resolution was measured by way of an FFT analysis, using sinx/x impulse as signal stimulus. The luminance replay noise spectrum was also measured via FFT analysis, using a 30-percent grey-field pattern as test signal.
Fig. 4. Actual video measurements from Sony VO-9800P. The Y/C component output shows visibly higher resolution as compared to composite output. Also, the luminance noise level between 2.8 and 5MHz, is considerably lower via Y/C output.

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