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VIDEO SIGNAL PROCESSING FOR TV BROADCASTING

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A modern television broadcasting plant provides facilities for the pick-up and broadcast of entertainment, news, and cultural and educational subject matter in both visual and sound. The purpose of such a plant is to provide an adequate and satisfactory audio-visual services, and this requires a flexible and well-coordinated installation. A functional subdivision of equipment and facilities is the following:

(a) Studio and control facilities (Video and audio)

(b) Field pick-up and relay facilities (video and audio)

(c) Visual and aural broadcast transmitters.

Typical studio and control facilities consist of one or more live-talent studios, a film pick-up studio, a video effect studio, one or more announcers' booths, and a master control room having switching and monitoring (audio-video) facilities for various studio outputs or remote pick-up outputs to the transmitter, as required. The master timing or synchronizing generator, various video line amplifiers, power supply rectifiers, computer controled graphic and animation. equipment, electronic effect aparatus, intercommunication system, and other equipment common to the studio facilities system are usually grouped in a main equipment room.

Filed pick-up facilities include portable television cameras such as electronic news gathering (ENG) and electronic field production (EFP) cameras with their associated control, monitoring, and synchronizing equipment and portable sound mixer and other equipment. Either radio relay circuits (radio-link equipments), coaxial cables, or equialized telephone lines are used to transmit the video signals back to the master control room of the broadcast station. The sound signal of the program is generally transmitted back by wire line, though radio-link circuits are used where wire facilities are not available. Field pick-ups also include the use of mobile equipment where the ENG and EFP television cameras, along with their synchronizing, control and monitoring equipment, are mounted in a moving truck, boat, aircraft etc.

The need for maximum height of the transmitting antenna to provide line-of-sight (LOS) reception for as many receivers as possible usually requires that the main visual and aural transmitters be located remote from the television studios. The visual link between the master control switching point (usually main studio) and the main transmitter equipment with the antenna system may be a microwave radio relay circuit, a coaxial cable transmission line or equilized telephone line. The audio link between the master control point and the transmitter is usually a wire line depending on the distance.

In order to coordinate operations and to assure program continuity, the television plant must be provided with an adequate and flexible intercommunication and wire system seperately and apart from the sound program pick-up, control, and transmission equipment.

Overall Video System Response

In a television studio the video signals pass through a relatively large number of amplifier stages in cascade in traveling from the camera to the transmitter. The transient response of the overall system must therefore be given careful consideration. A small phase or amplitude distortion in each individual stage has a cumulative effect when a large number of stages is operated in cascade. The overall effect of such distortion when not compensated is to cause changings in brightness.

A practical engineering approach to the problem is the following:

(a) When designing a studio, an accurate estimate can be made of the number of stages likely to be connected in cascade. This estimate can be used in conjuction with data and desing parameters of individual stages.
(b) The desing parameters for high-frequency video compensation.

This can be accomplished by choosing a top video frequency some what higher than the nominal top frequency handled by the tansmitter. Thus, the studio equipment amplifiers might be designed and compensated for a top frequency to assure uniform overall amplitude characteristics required by present standards.

The video signal in the transmission medium is the electromagnetic form, and it may be detected when it is transduced into a sensible form. A video signal that contains information varies with time in an unpredictable manner. (When we sense how it is varying we have received information.) Information is encoded in the signal in a manner that suits the communications medium. In telecommunications the medium will be a cable or radio-link, probably carrying many communication channels, in which the signal gets becomes distorted.

The Composite Video Signal

In the desing of television systems provision must be made for the transmission of these four signals: a) Video signal, b) Horizontal synchronizing signal, c) Vertical synchronizing signal, and d) Sound signal.

The system may be designed to transmit all four of these from seperate transmitters. Alternatively, two or more may be combined and transmitted by a single transmitter. The combination of the video signal and the two synchronizing signals in a single transmission has been recognized as particularly suitable, since it simplifies both receiving and transmitting equipments and also removes delay problems between these components.

The construction of a composite signal containing these three individual signals requires the synchronizing and video signals to occupy different ranges of amplitude, since these two kind of signals can not be distinguished from one another by a frequency seperation. They must also occupy different time intervals. These requirements are satisfied by assigning a range of potentials beyond black (therefore called infra-black) to the synchronizing signals and by inserting synchronizing signals in the time intervals provided for scannig lines.

That means two lines of a composite signal showing line synchronizing pulses are properly located in the retrace intervals. The position of the leading edge of the pulse in the retrace interval is set a short time after the beginning of the interval so that even receiver circuits of somewhat restricted band width will have time to reach blacklevel before the synchronizing pulse begins.

The portion of the transmission amplitude range not occupied by synchronizing signals is reserved for the picture information.

The Radio-Frequency (RF) Signal

The composite video signal may be applied to an r-f carrier as amplitude modulation (AM), frequency modulation (FM) or phase modulation (PM). In television broadcasting, multipath transmission is frequently observed; picture distortions caused by multipath transmission when phase or frequency modulation is used are so serious that these methods of modulation have not seemed practical. Television broadcasting, therefore, makes use of amplitude modulation (AM).

Polarity of modulation may be either positive (an increase of image brightness represented by an increase of radiated signal) or negative. A positive modulation polarity signal includes at all times the synchronizing level (Zero carrier) and the black level. It does not indicate the level of peak white unless elements of this intensity are present in the picture. Negative modulation polarity, on the other hand, includes the synchronizing level (maximum carrier intensity), the black level, and peak white (zero carrier) at all times.

Automatic gain control circuits for receivers require the presence in the received signal of some characteristics which is independent of modulation. In sound transmissions, the average value of the carrier has the required characteristics, but in television signals, the average value is dependent on avarage picture brightness. White level, black level, or synchronizing level must be used instead. Preferably, the peaks of the signal envelope should be used, so that a simple peak detector may serve as the source of automatic gain control information. It is found, therefore, that negative modulation polarity simplifies very much the provision of automatic gain control in receivers.

The effects of impulse noise interference on signals of the two polarities are quite different. (With positive modulation impulse noise usually produces bright spots in the reproduced picture and has little effect on synchronizing signals.) With negative modulation impulse noise produces primarily black spots on the picture, but has a greater tendency to interfere with synchronizing signals. Since it is found possible to minimize the effect of impulse noise on synchronizing sufficiently by careful circuit design in the receiver and (since) automatic gain control is believed desirable.

The sound accompanying a television video signal is transmitted on a seperate carrier whose frequency is located, with respect to the picture carrier and its sidebands. The pre-emphasis practice standardized for frequency-modulated sound broadcasting is also used for television sound.

American standards for television have chosen negative modulation polarity. European standards for television have been set positive modulation polarity.

Synchronizing

In television practice the video information is generated in an orderly sequence. The monitor must display this information in the same sequence if the original picture is to be reproduced. It is necessary, therefore, that information to synchronize the scanning operation of the monitor be furnished with the video information and that this information be subject to delays in transmission identical to those experienced by the video information. Synchronizing signals are, therefore, included with the video signals.

There are two ways in which scanning devices may be synchronized. In the simple way, the synchronizing signal has essentially a pulse form and is applied to the scanning device in such fashion as to terminate the scanning trace and initiate the retrace. This action takes place at speed limited only by the transient response of the scanning oscillator itself. This method of operation has the advantage of simplicity but the disadvantage that the scanning cycle may be mistimed and the picture consequently distorted by:

1) A noise impulse

2) Loss of a synchronizing pulse due to a temporary blocking of the signal channel by noise,

3) The combination of random noise components with the synchronizing pulse to produce random phase variation of the leading edge of the pulse.

The alternative synchronizing method is to apply the synchronizing signal and a signal derived from the scanning device to a phase comparison circuit whose output voltage controls the frequency of the scanning device. If the synchronizing pulses are uniformly spaced and the scanning device is itself stable in frequency, the phase control may be made slow acting.

Sperate synchronizing signals are required for the two directions of scanning. With interlaced scanning it is essential that these signals be separable one from the other in a receiver.

It is a characteristic of an integrating circuit that it "rememembers". For this reason the interval immediately preceding the vertical synchronizing signal contains horizontal synchronizing signals at twice the normal repetition rate. The time intervals immediately preceding the vertical synchronizing pulses in the two fields are made identical. The line synchronizing pulses are reduced to half their normal duration during this period so that their integrated value will be no greater than that of line pulses of normal duration and normal repetition rate. These equalizing pulses also appear for a short interval following the vertical synchronizing signal to insure that during the entire interval in which the vertical scanning device is sensitive to synchronizing signals those signals will be alike in both fields.

The Video Signal

The video signal is generated by a pick-up tube or CCD circuit. The purpose of the television pick-up tube or CCD circuit is to convert an optical image of the scene to be transmitted into an electrical signal of the light distribution in the image. The signal is obtained by scanning in sequance a rectangular image area along a fixed number of adjoining horizontal scanning lines; with an ideal transmission system and viewing device the instantaneous signal output of the pick-up tube or CCD circuit determines the brightness of a particular picture element.

A satisfactory CCD circuit must be capable of furnishing a signal that can be converted into an image with adequate detail. Similar requirements regarding resolution, signal-to-noise ratio, uniformity, and sensitivity must also be fulfilled by the 35-mm negative film employed in commercial motion-picture production, whose properties may reasonably be taken as a standard. This is all the more appropriate since the comparison of television with motion picture appears inescapable.

35-mm film is generally capable of resolving 1000-1500 lines per picture height; on the other hand, at this level the photographic grain or noise interferes seriously with the picture detail. For a ratio of the signal to the root-mean-spuare (RMS) noise amplitude of 30-40, the resolution must be redused to about 600 lines. It should be noted that the RMS noise amplitude employed throughout in the present discussion is only about 1/6 as great as the peak-to-peak noise amplitude, which may be observed directly on an oscilloscope screen. The signal-to-noise ratio for film remains approximately constant throughout the useful exposure range. The more sensitive television pick-up tubes, for which the noise is constant and the signal-to-noise ratio, hense, is lower in the low lights than in the high lights.

Some pick-up tubes exhibit higher sensitivity and signal-to-noise ratio for equal resolution than film. They enable television cameras to function more favorably than studio and motion-picture cameras.

Transmission of the DC Component

The output of the pick-up tube or CCD circuit usually requires amplification to raise it to usable level and may require processing to remove from the signal components which are not properly a part of the signal. Its direct component must (either) be transmitted faithfully (fidelity) with the same gain as other components.

It is theoretically possible to transmit and amplify the d-c component along with the other components of the video signal. But, in practice, this is found to be inconvenient. A satisfactory alternative, known as " d-c reinsertion ", may be followed once the black-level of the signal has been established. In this alternative practice the black intervals are used to provide an a-c carrier of the d-c component.

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