Department of Physics, Vidyasagar University

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Topic : Television Systems

Lecture No. 01 : Block diagram of B/W TV Transmitter

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BLOCK DIAGRAM OF BW TELEVISION TRANSMITTER :

A simplified functional block diagram of a television transmitter is shown in Fig. 1.1. Necessary details of video signal modulation with picture carrier of allotted channel are shown in picture transmitter section of the diagram. Note the inclusion of a dc restorer circuit (DC clamp) before the modulator. Also note that because of modulation at a relatively low power level, an amplifier is used after the modulated RF amplifier to raise the power level. Accordingly this amplifier must be a class-B push-pull linear RF amplifier. Both the modulator and power amplifier sections of the transmitter employ specially designed VHF triodes for VHF channels and klystrons in transmitters that operate in UHF channels.

Vestigial Sideband Filter

The modulated output is fed to a filter designed to filter out part of the lower sideband frequencies. As already explained this results in saving of band space.

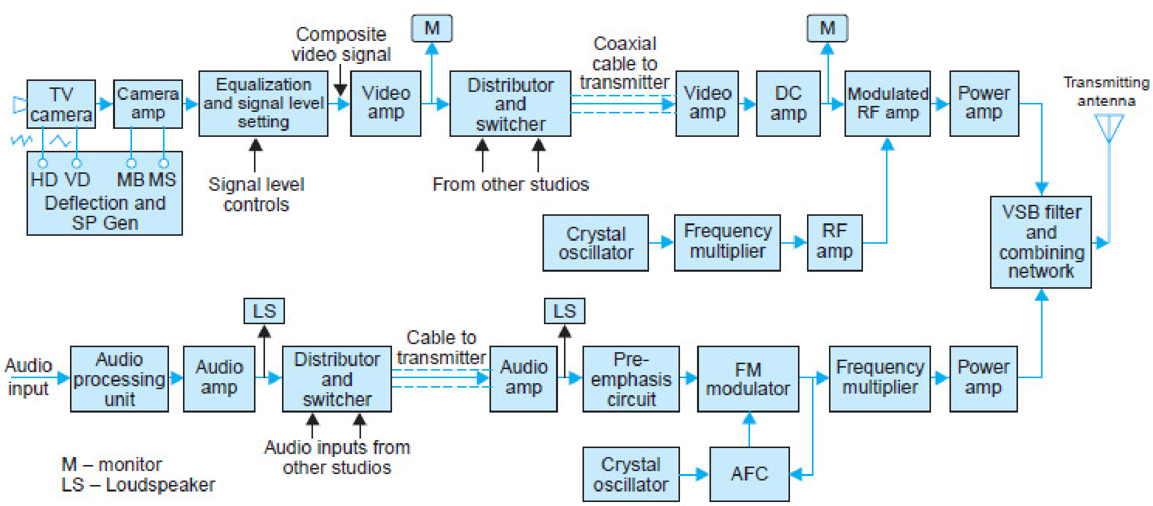

Fig. 1.1 Simplified block diagram of a BW TV transmitter

Antenna

The filter output feeds into a combining network where the output from the FM sound transmitter is added to it. This network is designed in such a way that while combining, either signal does not interfere with the working of the other transmitter. A coaxial cable connects the combined output to the antenna system mounted on a high tower situated close to the transmitter. A turnstile antenna array is used to radiate equal power in all directions. The antenna is mounted horizontally for better signal to noise ratio.

IDEA OF POSITIVE AND NEGATIVE MODULATION :

When the intensity of picture brightness causes increase in amplitude of the modulated envelope, it is called 'positive' modulation. When the polarity of modulating video signal is so chosen that sync tips lie at the 100 per cent level of carrier amplitude and increasing brightness produces decrease in the modulation envelope, it is called 'negative modulation'. The two polarities of modulation are illustrated in Fig. 1.2.

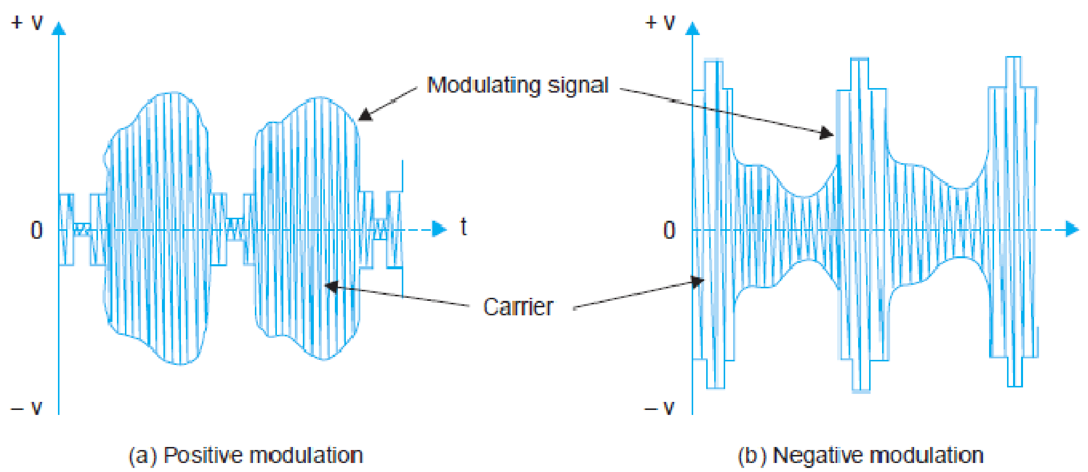

Fig. 1.2 RF waveforms of an amplitude modulated composite video signal.

Comparison of Positive and Negative Modulation

(a) Effect of Noise Interference on Picture Signal : Noise pulses created by automobile ignition systems are most troublesome. The RF energy contained in such pulses is spread more or less uniformly over a wide frequency range and has a random distribution of phase and amplitude. When such RF pulses are added to sidebands of the desired signal, and sum of signal and noise is demodulated, the demodulated video signal contains pulses corresponding

to RF noise peaks, which extend principally in the direction of increasing envelope amplitude. This is shown in Fig. 1.3. Thus in negative system of modulation, noise pulse extends in black direction of the signal when they occur during the active scanning intervals. They extend in the direction of sync pulses when they occur during blanking intervals. In the positive system, the noise extends in the direction of the white during active scanning, *i.e.,* in the opposite direction from the sync pulse during blanking.

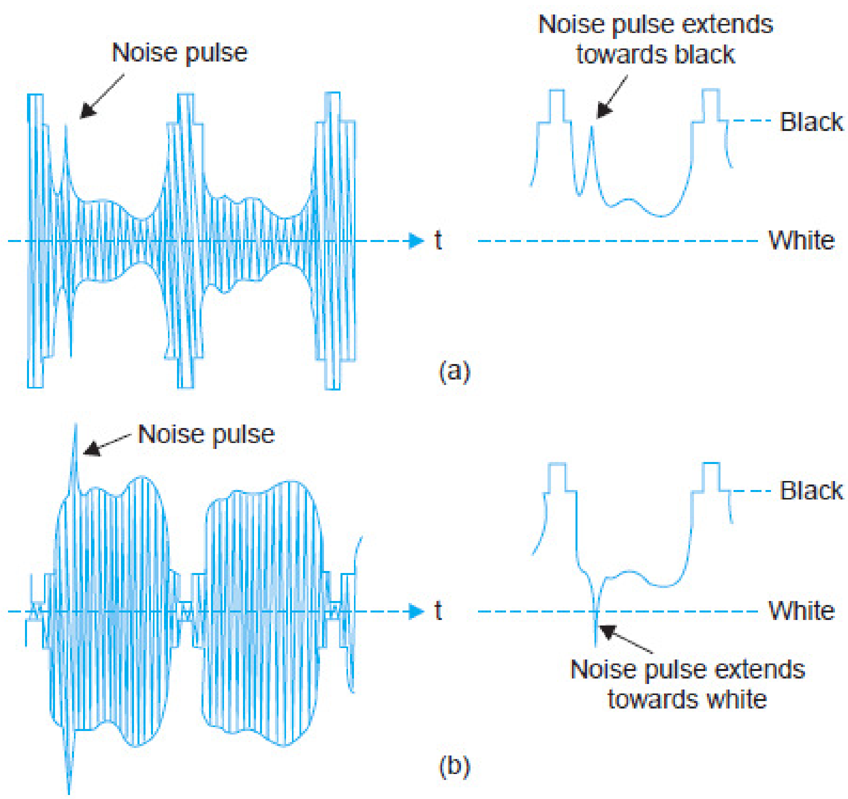

Fig. 1.3. Effect of noise pulses (a) with negative modulation, (b) with positive modulation.

Obviously the effect of noise on the picture itself is less pronounced when negative modulation is used. With positive modulation noise pulses will produce white blobs on the screen whereas in negative modulation the noise pulses would tend to produce black spots, which are less noticeable against a grey background. This merit of lesser noise interference on picture information with negative modulation has led to its use in most TV systems.

(b) Effect of Noise Interference on Synchronization : Sync pulses with positive modulation being at a lesser level of the modulated carrier envelope are not much affected by noise pulses. However, in the case of negatively modulated signal, it is sync pulses which exist at

maximum carrier amplitude, and the effect of interference is both to mutilate some of these, and to produce lot of spurious random pulses. This can completely upset the synchronization of the receiver time bases unless something is done about it. Because of almost universal use of negative modulation, special horizontal stabilizing circuits have been developed for use in receivers to overcome the adverse effect of noise on synchronization.

(c) Peak Power Available from the Transmitter : With positive modulation, signal corresponding to white has maximum carrier amplitude. The RF modulator cannot be driven harder to extract more power because the non-linear distortion thus introduced would affect the amplitude scale of the picture signal and introduce brightness distortion in very bright areas of the picture. In negative modulation, the transmitter may be over-modulated during the sync pulses without adverse effects, since the non-linear distortion thereby introduced, does not very much affect the shape of sync pulses. Consequently, the negative polarity of modulation permits a large increase in peak power output and for a given setup in the final transmitter stage the output increases by about 40%.

(d) Use of AGC (Automatic Gain Control) Circuits in the Receiver : Most AGC circuits in receivers measure the peak level of the incoming carrier signal and adjust the gain of the RF and IF amplifiers accordingly. To perform this measurement simply, a stable reference level must be available in the signal. In negative system of modulation, such a level is the peak of sync pulses which remains fixed at 100 per cent of signal amplitude and is not affected by picture details. This level may be selected simply by passing the composite video signal through a peak detector. In the positive system of modulation the corresponding stable level is zero amplitude at the carrier and obviously zero is no reference, and it has no relation to the signal strength. The maximum carrier amplitude in this case depends not only on the strength of the signal but also on the nature of picture modulation and hence cannot be utilized to develop true AGC voltage. Accordingly AGC circuits for positive modulation must select some other level (blanking level) and this being at low amplitude needs elaborate circuitry in the receiver. Thus negative modulation has a definite advantage over positive modulation in this respect.

The merits of negative modulation over positive modulation, so far as picture signal distortion and AGC voltage source are concerned, have led to the use of negative modulation in almost all TV systems now in use.

SOUND SIGNAL TRANSMISSION :

The outputs of all the microphones are terminated in sockets on the sound panel in the production control room. The audio signal is accorded enough amplification before feeding it to switchers and mixers for selecting and mixing outputs from different microphones. The sound engineer in the control room does so in consultation with the programme director. Some prerecorded music and special sound effects are also available on tapes and are mixed with sound output from the studio at the discretion of programme director. All this needs prior planning and a lot of rehearsing otherwise the desired effects cannot be produced. As in the case of picture transmission, audio monitors are provided at several stages along the audio channel to keep a check over the quality and volume of sound.

Preference of FM over AM for Sound Transmission

Contrary to popular belief both FM and AM are capable of giving the same fidelity if the desired bandwidth is allotted. Because of crowding in the medium and short wave bands in radio transmission, the highest modulating audio frequency used in 5 kHz and not the full audio range which extends up to about 15 kHz. This limit of the highest modulating frequency results in channel bandwidth saving and only a bandwidth of 10 kHz is needed per channel. Thus, it becomes possible to accommodate a large number of radio broadcast stations in the limited broadcast band. Since most of the sound signal energy is limited to lower audio frequencies, the sound reproduction is quite satisfactory.

Frequency modulation, that is capable of providing almost noise free and high fidelity output needs a wider swing in frequency on either side of the carrier. This can be easily allowed in a TV channel, where, because of very high video frequencies a channel bandwidth of 7 MHz is allotted. In FM, where highest audio frequency allowed is 15 kHz, the sideband frequencies do not extend too far and can be easily accommodated around the sound carrier that lies 5.5 MHz away from the picture carrier. The bandwidth assigned to the FM sound signal is about 200 kHz of which not more than 100 kHz is occupied by sidebands of significant amplitude. The latter figure is only 1.4 per cent of the total channel bandwidth of 7 MHz. Thus, without encroaching much, in a relative sense, on the available band space for television transmission all the advantages of FM can be availed.

MERITS OF FREQUENCY MODULATION :

Frequency modulation has the following advantages over amplitude modulation.

(a) Noise Reduction

The greatest advantage of FM is its ability to eliminate noise interference and thus increase the signal to noise ratio. This important advantage stems from the fact that in FM, amplitude variations of the modulating signal cause frequency deviations and not a change in the amplitude of the carrier. Noise interference results in amplitude variations of the carrier and thus can be easily removed by the use of amplitude limiters.

It is also possible to reduce noise in FM by increasing frequency deviation. This deviation can be made as large as required without increasing the transmitter power. Higher audio frequencies are mostly harmonics of the lower audio range. They have low amplitudes and so cause a small deviation of the carrier frequency. Noise power interference is also generally low in amplitude and so results in frequency deviation similar to that caused by higher audio frequencies. Thus higher audio frequencies are most susceptible to noise effects. If these frequencies were artificially boosted in amplitude at the transmitter and correspondingly reduced at the receiver, improvement in noise immunity could be expected. This in fact is the standard practice in all FM transmission and reception. In AM on the other hand, the signal modulation can be increased relative to noise modulation only by increasing the transmitter output power. A 20 db improvement in signal-to-noise voltage ratio requires ten-times increase in frequency deviation in FM but an increase of 100 times in AM power output. Evidently an AM system in this respect reaches an economical limit long before the FM system, provided additional bandwidth is available for FM transmission.

In an FM receiver, if two signals are being received simultaneously, the weaker signal will be eliminated almost entirely if it possesses less than half the amplitude of the other stronger signal. However, in AM the interfering signal or station can be heard or received even when a 100 : 1 relationship exists between their amplitudes.

Pre-emphasis and De-emphasis :

The boosting of higher audio modulating frequencies, in accordance with a prearranged response curve is termed pre-emphasis, and the compensation at the receiver is called de-emphasis. Examples of circuits used for each function are shown in Fig. 1.4. As is obvious from these configurations, the pre-emphasis and de-emphasis networks are high-pass and low-pass filters respectively. The time constant of the filter for pre-emphasis at transmitter and later de-emphasis at receiver has been standardized at 50 μ*s* in all the CCIR systems. However, in systems employing American FM and TV standards, networks having a time constant of 75 μs are used. A 50 μs (= *RC*) de-emphasis corresponds to a frequency response curve that is 3 db down at the frequency given by 1/(2πRC), which comes to 3180 Hz. Figure 1.5 shows pre-emphasis and de-emphasis curves corresponding to a time constant of 50 μsec.

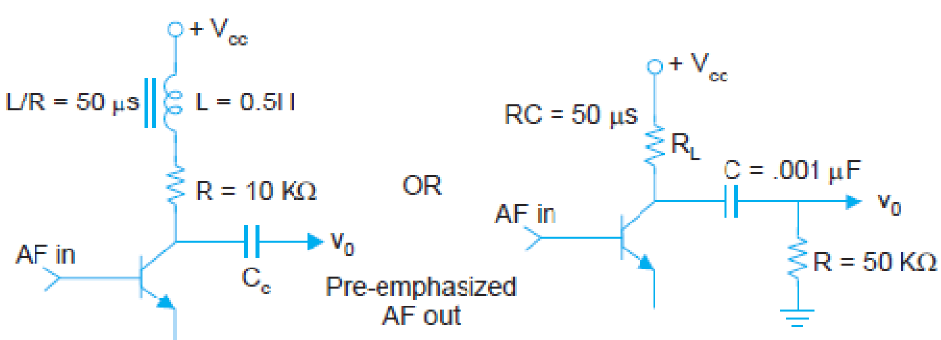

Figure 1.5 (a) Pre-Emphasis circuits for 50μs.

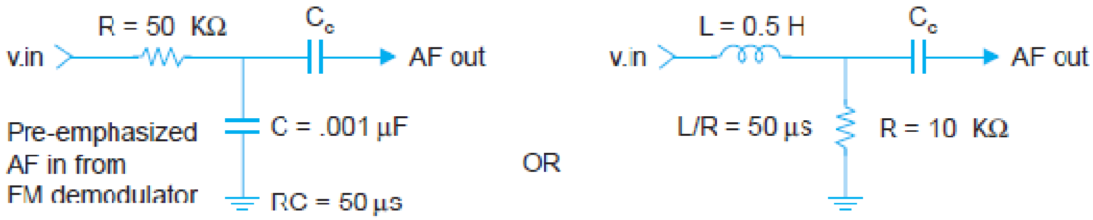

Fig. 7.14(b). De-emphasis circuits.

Figure 1.5 (b) De-Emphasis circuits for 50µs.

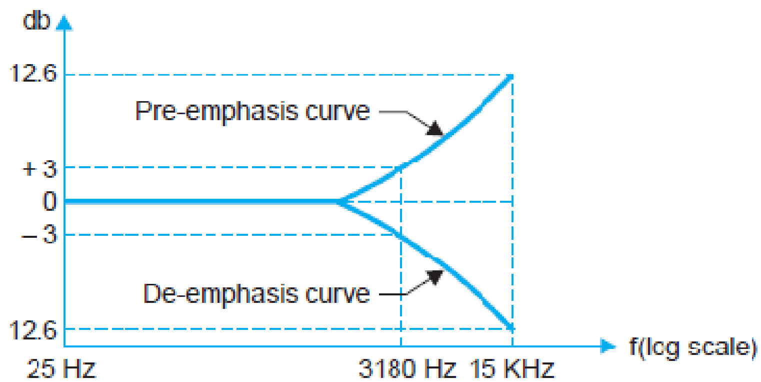

Figure 1.5 50µs emphasis curves.

(b) Transmitter Efficiency

The amplitude of the FM wave is independent of the depth of modulation, whereas in AM it is dependent on this parameter. This means that low level modulation can be used in FM and all succeeding amplifiers can be class ‘C’ which are more efficient. Thus, unlike AM, all amplifiers handle constant power and this results in more economical FM transmitters.

(c) Adjacent Channel Interference

Because of the provision of a guard band in between any two TV channels, there is less interference than in conventional AM broadcasts.

(d) Co-channel Interference

The amplitude limiter in the FM section of the receiver works on the principle of passing the stronger signal and eliminating the weaker. In this manner, a relatively weak interfering signal or any pick-up from a co-channel station (a station operating at the same carrier frequency) gets eliminated in a FM system. It may be noted that from general broadcast point of view FM needs much wider bandwidth than AM. It is 7 to 15 times as large as that needed for AM. Besides, FM transmitters and receivers tend to be more complex and hence are expensive. However, in TV transmission and reception, where handling of the picture signal is equally complex, FM sound does not add very much to the cost of equipment.

Ref: Monochrome and Colour Television, by R.R. Gulathi, New Age International Publ.