EnDe-CODE

TELEVISION SIGNAL ENCODING AND DECODING

FOR

CABLE SYSTEMS

By

Abraham M. Reiter

Director of Advanced Engineering

Athena Communications Corp.

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ABSTRACT

A low cost system for encoding and decoding the picture and sound signals on CATV channels is described. A simple encoder is connected to the modulator for each encoded channel and an all-channel set top decoder can decode all channels--standard and non-standard. No modifications to the cable system are required.

The heart of the system is the patented "gray blank" method of encoding video by replacing the synchronizing and blanking components of the composite video signal with a steady voltage midway between black and white. The color reference burst is superimposed on the steady voltage. Proper synchronization on a normal television receiver is lost because the receiver attempts to lock on the blackest portions of the video signal. The sound is encoded by positioning the FM sound carrier 1 MHz below the video carrier. Pulse signals that are used to restore the video to normal are amplitude modulated on the repositioned sound carrier. Decoding is accomplished without demodulating the video or audio.

SUMMARY

EnDe-Code is a system for transforming any 6 MHz channel into a private channel that is available only to those who have decoders. The system consists of an encoder that is connected to the modulator of the channel to be encoded and a decoder that is connected to the antenna terminals of the television set.

Composite video is modified by the encoder resulting in the gray blank video waveform shown in figure 1. Horizontal sync and blanking and vertical sync (not shown) are replaced by the gray level, i.e. the level midway between black and white. In the modulator, gray blank video is modulated on a 45.75 MHz carrier and converted to the desired output channel in the usual way.

The encoder also takes the frequency modulated 41.25 MHz sound carrier from the modulator, converts it to 46.25 MHz and amplitude modulates video restoring pulses. The 46.75 MHz is sent back to the modulator to be converted to the desired output channel along with the video carrier. The 41.25 MHz is suppressed.

The encoder is provided with a switch that returns the channel to normal service without the need to make any other adjustments or change any cables.

A standard television receiver that is tuned to the encoded channel is deprived of normal sync and receives no sound.

The decoder restores the sync and blanking to the video carrier (45.75 MHz) using the pulses on the 46.75 MHz carrier, and sound is restored by repositioning 46.75 MHz to 41.25 MHz. The restored carriers are converted to a convenient standard channel and delivered to the TV set. The entire decoding process is accomplished without demodulating the sound or video information.

ENCODER

Interconnections between the modulator and the encoder are shown in a general way by figure 2. The encoder is compatible with any modulator that generates standard IF carriers (45.75 MHz video and 41.25 sound) and converts these carriers to the output channel.

Video is connected directly to the encoder but audio is connected to the modulator where it frequency modulates the sound carrier in the normal way. The FM 41.25 MHz carrier from the modulator is diverted to the encoder.

The encoder does three things:

- -it generates gray blank video
- -it converts 41.25 MHz to 46.75 MHz at the same level
- -it amplitude modulates video restoring pulses at a modulation level of 30% on the 46.75 MHz

In the encode mode the encoder delivers gray blank video and 46.75 MHz to the modulator. The 41.25 MHz carrier is suppressed. In the normal mode the encoder delivers normal video and 41.25 MHz to the modulator and 46.75 MHz is suppressed. In either mode there are just two carriers.

The method of combining carriers for conversion to the output channel depends upon the modulator design. If a single mixer is used the lines carrying 45.75 MHz, 41.25 MHz and 46.75 MHz are combined and go to the mixer. If separate mixers are used for video and sound, the 46.75 MHz line may be combined with either of the other two lines.

Manipulation of signals within the encoder is shown in the block diagram in figure 3 and waveforms that aid in understanding encoder operation appear in figure 4.

Gray Blank Video

Gray blank video is generated in a switching circuit. The input video is clamped on the back porch of blanking to provide a reference voltage to which the gray level can be referred. When suppressing pulses are applied, the switching circuit output switches to the gray level. The color reference burst is superimposed on the gray level.

Figure 4 shows several lines of normal video, suppressing pulses and gray blank video starting just before field 1 and ending just after vertical blanking. The start of field 1 is defined by a whole line between the first equalizing pulse and the preceding horizontal sync pulse. All horizontal retrace intervals and the entire six line interval at the start of the field are gray.

Restoring Signal

The restoring signal, also shown in figure 4, is slightly modified sync that is band limited to 200 KHz before it is amplitude modulated on the 46.75 MHz carrier. Aside from band limiting, the difference between the restoring signal and sync is that the three half-line equalizing pulses following vertical sync are not present in the restoring signal. These pulses are left in the video as part of the gray blank video signal.

The band limiting filter delays the restoring signal and further delay occurs in the narrow band circuits in the decoder. To compensate for these delays the encoder advances the restoring signals approximately five microseconds with respect to the suppressing signals.

Front Panel Controls

There are three adjustments to assist in setting up gray blank video. They control the suppressing pulse width, suppressing pulse position and gray level, respectively. A video gain control is provided to set the depth of modulation.

The functional mode of the encoder is controlled by a three-station pushbutton switch. One station selects the normal mode, another the encoded mode and the third switches power off. Indicator lights display the selected operating mode.

DECODER

The decoder operates on signals in the standard television IF band, 41 MHz to 47 MHz, so it is necessary to convert the encoded channel to that band before decoding. After decoding, the restored channel is converted to a standard VHF channel and delivered to the antenna terminals of the TV set. If more than one channel is encoded, the same decoding circuits are used, but a tuner is required to convert each encoded channel to the 41 MHz - 47 MHz band. The output conversion remains the same regardless of the number of encoded channels or their frequencies.

Video Restoring

Figure 5 shows a block diagram of the decoder and figure 6 shows some waveforms that aid in understanding how the video is restored.

The augmenter is a three level RF switch, i.e. a circuit that can be switched to any one of two higher gain (or lower loss) states from a given reference state. If the gain is increased by 4.7 Db, the gray level will become the blanking level and an increase of 7.2 Db results in the sync level.

Two sets of pulses are applied to the augmenter to restore the blanking and sync levels, respectively. The pulses are derived from the restoring signal that is amplitude modulated on the 46.75 MHz carrier. After demodulation the restoring signal passes through a 0-200 KHz filter. Sync is made by clipping and squaring the restoring signal and blanking is made by stretching sync.

The restored video has a front porch that remains gray. Since the front porch occurs before retrace, it is not visible. If the receiver were underscanned, it would show as a gray, rather than black, border on the right hand side of the picture. The gray front porch is just as effective as black as a guard band, preventing the video content from affecting the position of sync in the sync separator circuits.

The color burst is keyed up to the blanking level and its amplitude increases as a result of augmenting. Anticipating this, the color burst is reduced in amplitude in the encoded video.

The bandwidth of the augmenter is 4.2 MHz and there are traps for 46.75 MHz and for adjacent high channel video, 39.75 MHz.

Sound Restoring

A simple heterodyne operation with a 5.5 MHz oscillator is all that is required to move the 46.75 MHz carrier to 41.25 MHz. The 5.5 MHz oscillator is crystal controlled to provide an accuracy of 550 Hz to the repositioned carrier. Tuned circuits in the output of the sound mixer reject 46.75 MHz.

Functional Integration

The decoder shown in figure 5 may be considered as a component that can be integrated with other equipment in a subscriber's home. For example, a decoding module could be built into a converter to provide a very attractive combination. The augmenter is on at all times and functions as an amplifier. The remaining circuits are tuned on for decoding only. A program is now under way to put a decoder module in the Gamut 26 converter manufactured by Oak Electro/Netics.

Another attractive possibility is a transponder with a decoding module. In addition to its other functions, the transponder could also sense when the decoder is on.

SYSTEM CONSIDERATIONS

Security

The security of the EnDe-Code system is adequate to block a number of possible approaches to unauthorized reception:

1. No adjustment of the television receiver can possibly restore the picture or the sound.

2. No commercially available standard equipment can be purchased to decode picture or sound.

3. Although the bill of material is simple, the construction and alignment of the decoder from a kit of parts requires sophisticated equipment and considerable electronic skill.

4. The proprietary nature of the system is an effective deterrent to unauthorized manufacture and distribution of decoders.

Interference

It is essential that adjacent channel interference from an encoded channel to a normal channel, from a normal channel to an encoded channel or between encoded channels should not be greater than that between normal channels.

One general observation can be made. A carrier modulated with gray blank video has a peak power that is limited to the black level which is about 3Db less than sync. On the average it is much lower than that because video signals rarely have sustained intervals of black.

As a result, encoded video carriers will interfere much less with adjacent channels than carriers modulated with normal video. For the same reason, encoded video carriers will contribute less to intermodulation and beats.

In figure 7, the positions of the carriers in four adjacent channels are shown. Two of the channels are encoded and two are normal. The case that appears to have the greatest potential for mutual interference involves an encoded channel and a lower adjacent normal channel because the sound carriers are only 0.5 MHz apart. That case will be discussed in some detail.

Consider first the effect of the normal sound carrier on the encoded channel. In the decoder, the 46.75 MHz amplifier must reject the adjacent sound carrier which appears at 47.25 MHz. Failure to reject 47.25 MHz will result in a 0.5 MHz beat on the restoring pulses. The design of the decoder is such that if the beat is smaller than the restoring pulses, sync will not be affected because the 200 KHz band limiting filter is adequate to remove it, after detection. Since the 47.25 MHz and 46.75 MHz carriers are about equal in level on the cable, very little attenuation of 47.25 MHz is required.

A more subtle, but far more serious possibility results from an undesired output in the sound mixer. The 47.25 MHz combines with 5.5 MHz yielding 41.75 MHz. That is just 420 KHz from the color subcarrier. To insure that it will not be visible requires that it be 40 Db below the video. Since it is 15 Db lower on the cable, the decoder must provide 25 Db of attenuation, which is well within its capability.

Consider next the effect of the encoded sound carrier on the normal channel. The sound in the normal channel will not be affected because the 4.5 MHz sound IF in the TV set can easily reject a signal of equal level that is 0.5 MHz away. To be sure that a visible beat does not appear the encoded sound must be no greater than -8 Db with respect to the video carrier in the normal channel, and the encoded sound satisfies that requirement.

Compatability with Existing Systems

EnDe-Code can be applied to any television channel and all the required signals are transmitted within that channel. This is why it can be installed in any CATV system without changing any hardware from the head end to the subscriber's matching transformers.

Cost

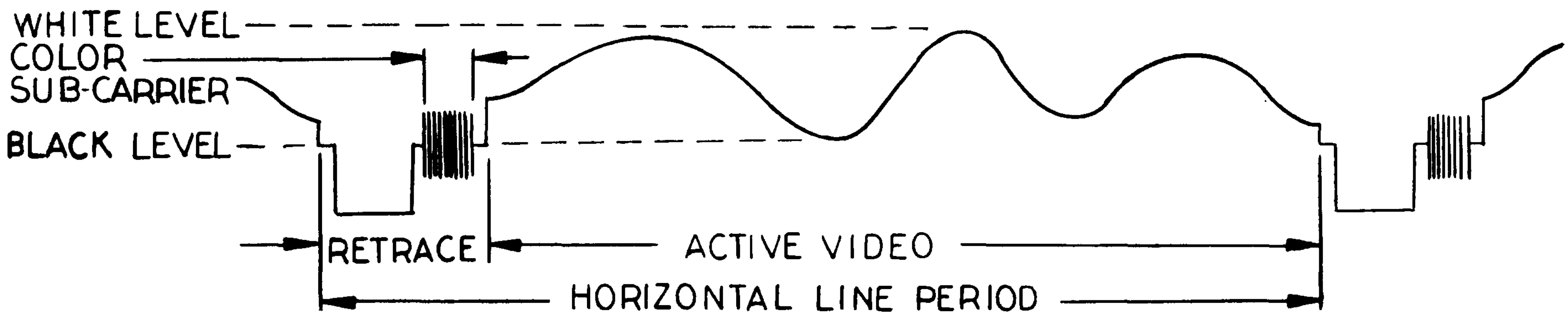
The cost of the decoder is clearly the most important element of the EnDe-Code system cost. The design was guided by the principle that manipulating video and sound signals on modulated carriers and at low level is simpler, less expensive and gives better results than manipulations that require demodulation. The decoder is low in cost because of success in adhering to that principle.

CONCLUSION

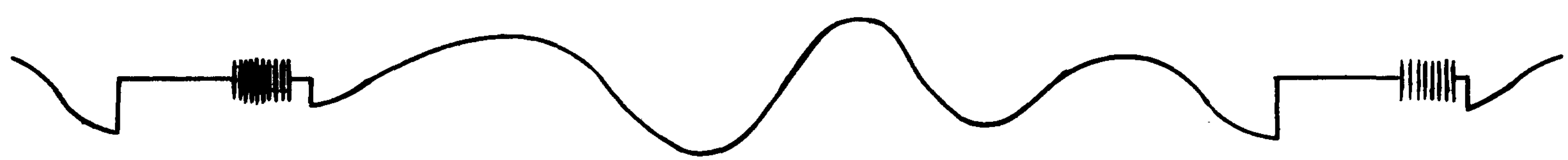
EnDe-Code, a low cost system of encoding and decoding television signals in CATV has been described.

It has been shown that it can be applied to any channel, standard or non-standard, to any number of channels and that a channel is readily switched between normal and encoded service in seconds.

It has also been shown that EnDe-Code does not interfere with normal CATV service or require any changes to the CATV system other than installation of encoders and decoders.



NORMAL VIDEO



GRAY BLANK VIDEO

FIGURE 1- VIDEO WAVEFORMS

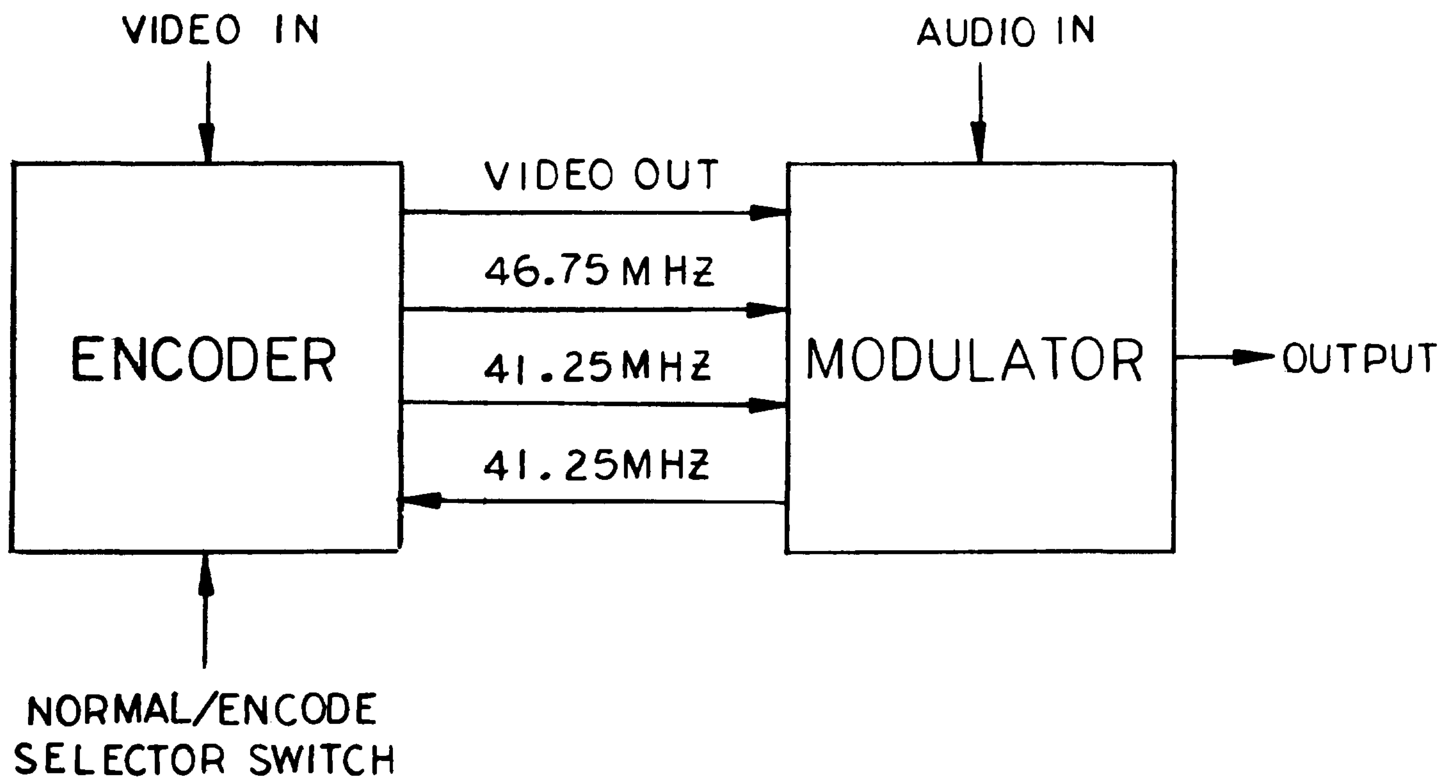


FIGURE 2-INTERCONNECTIONS BETWEEN ENCODER & MODULATOR

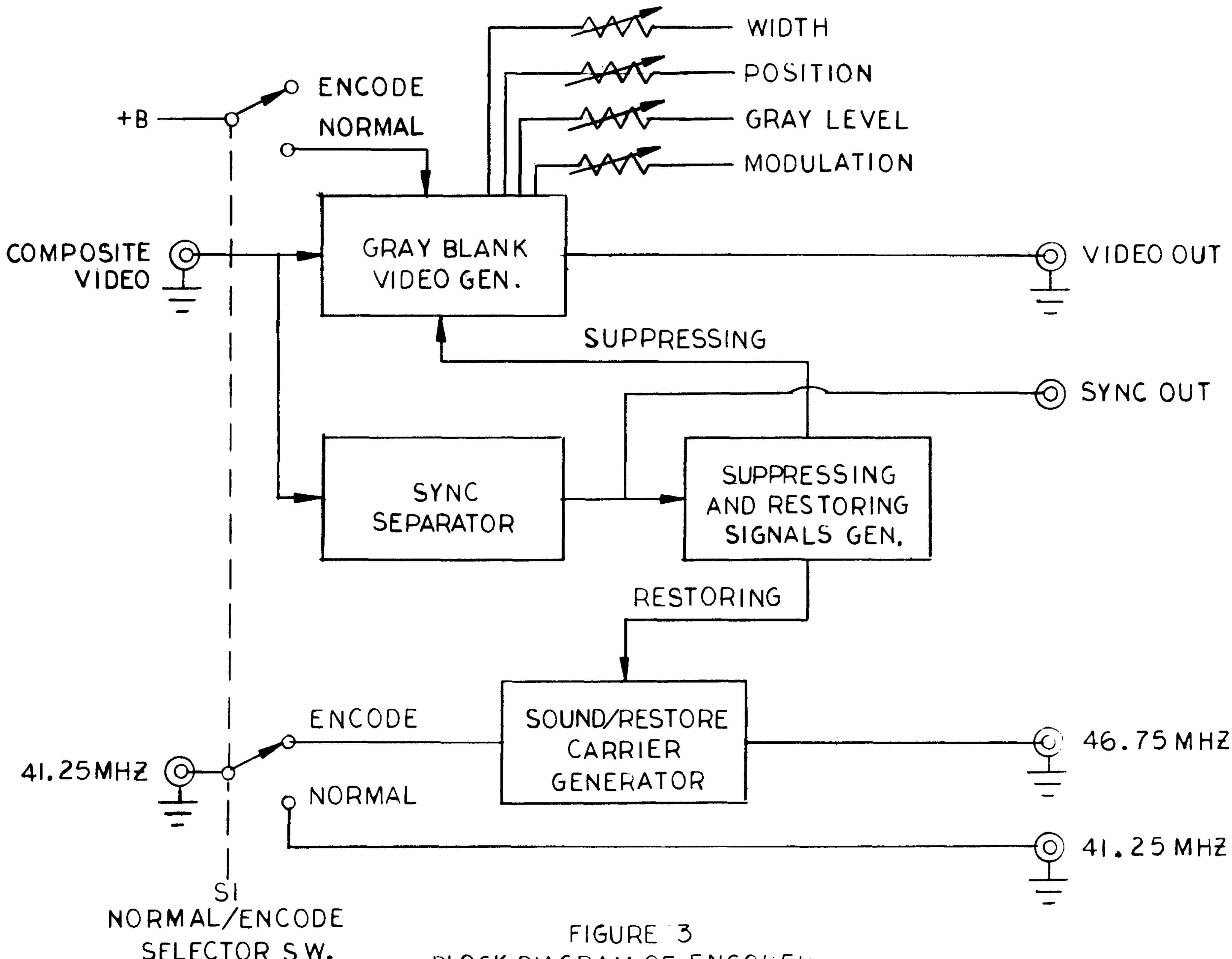


FIGURE 3
BLOCK DIAGRAM OF ENCODER

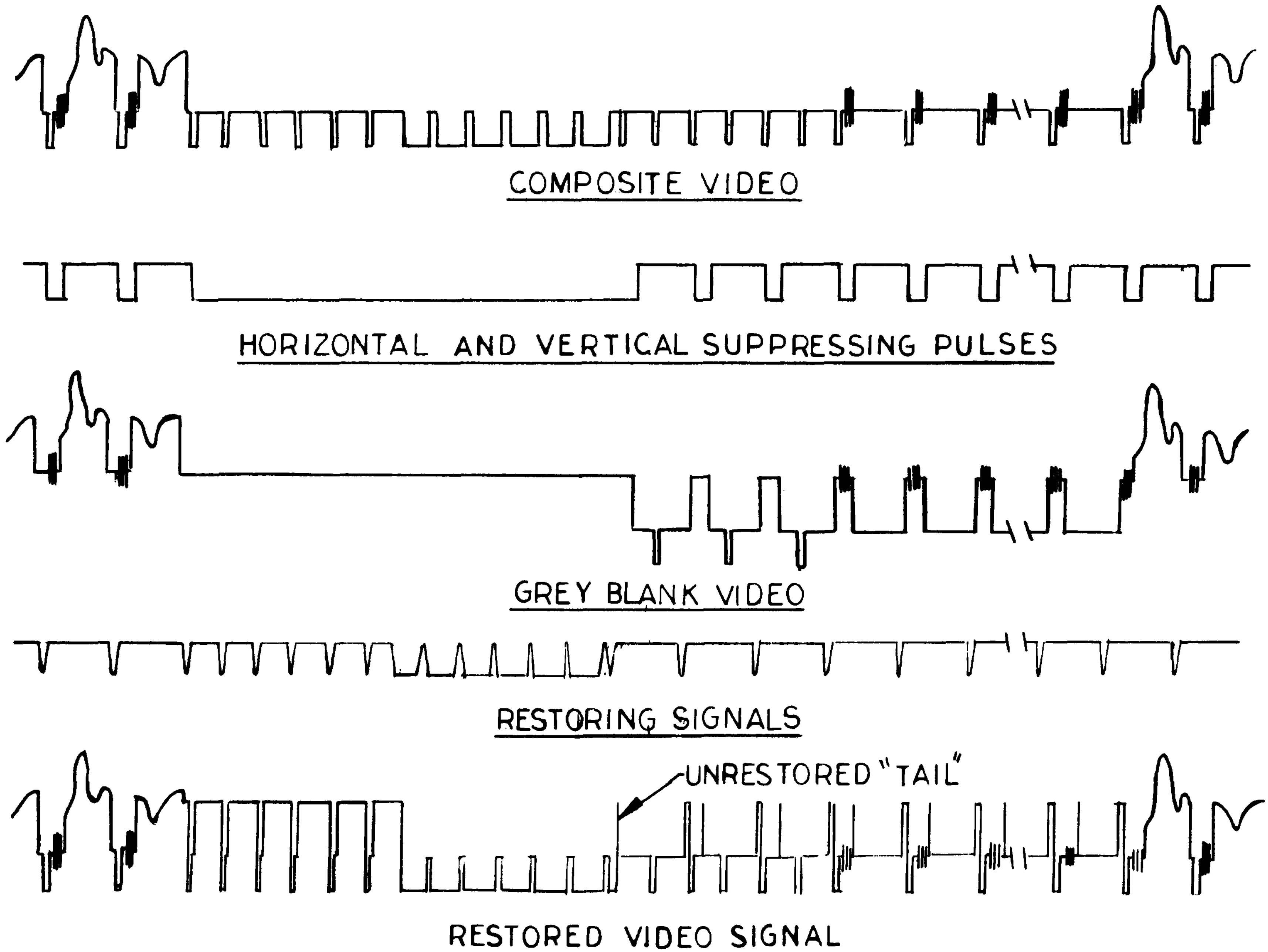


FIGURE 4 - WAVEFORMS

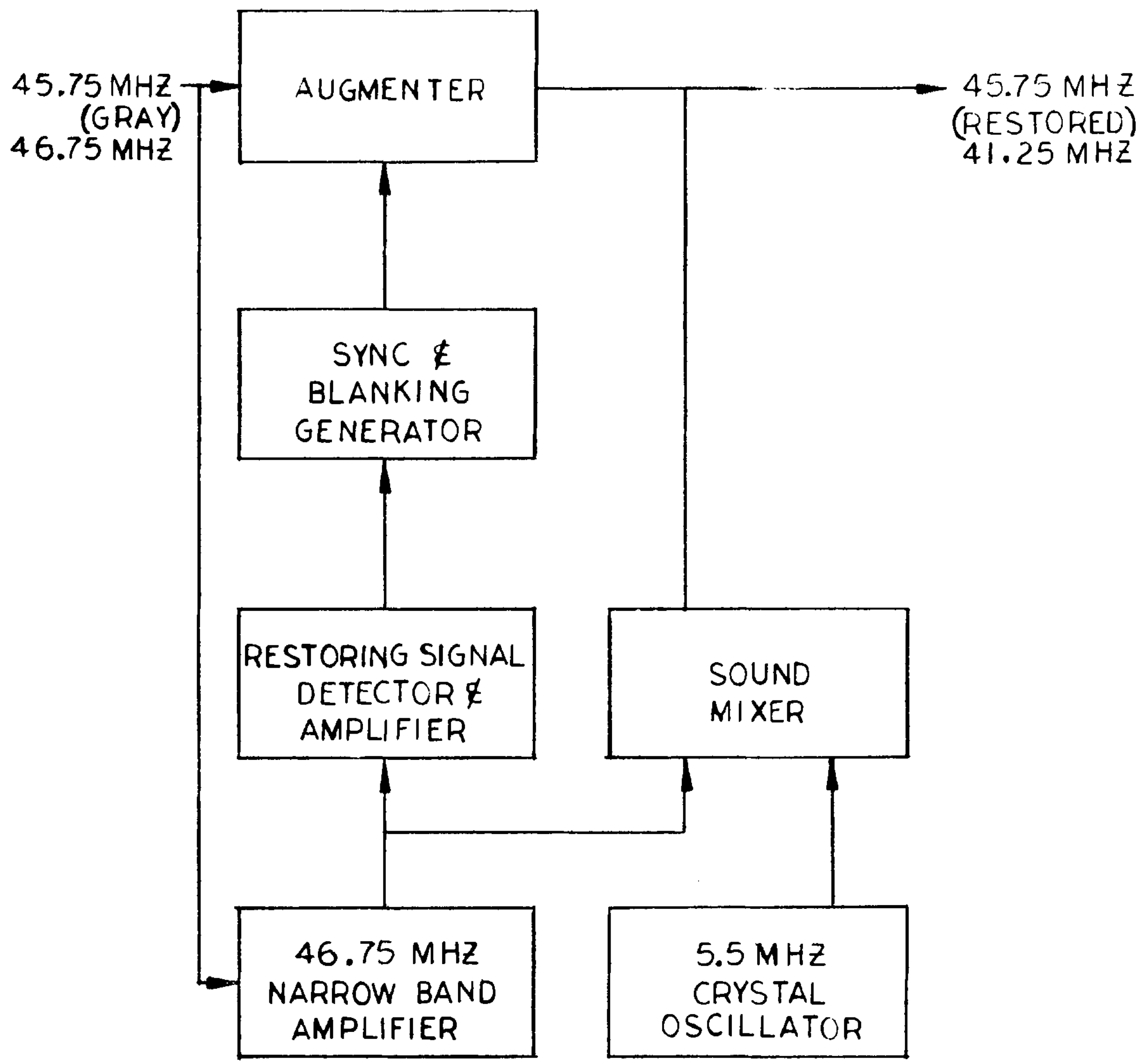
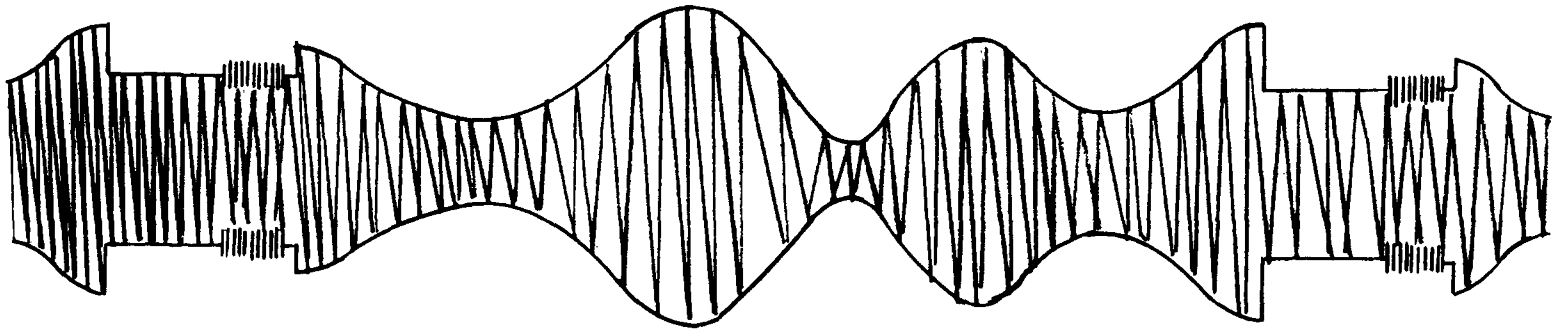
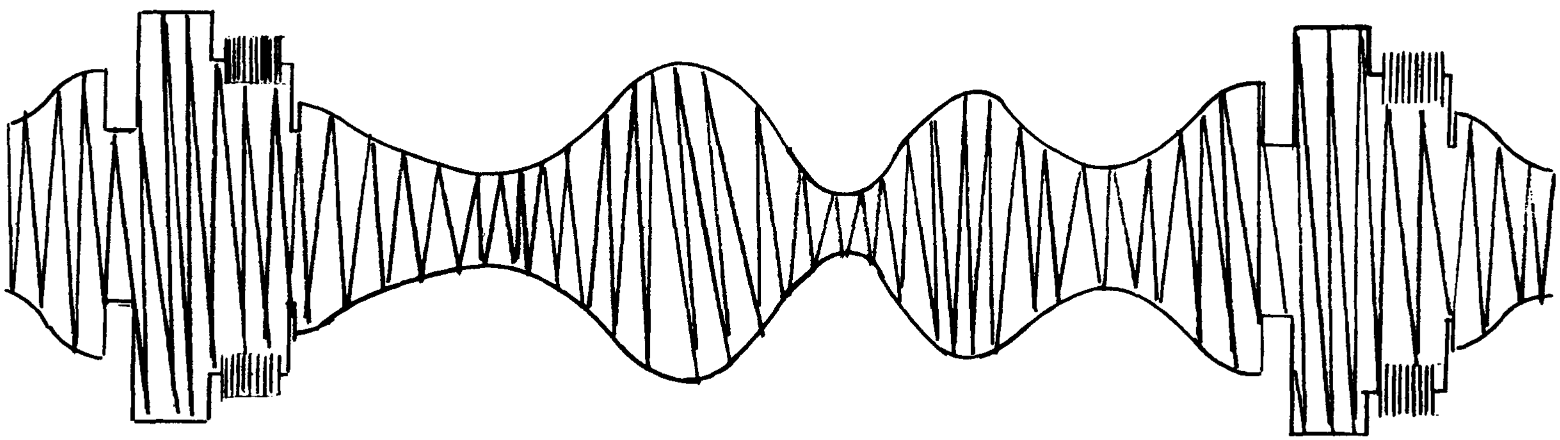


FIGURE 5
BLOCK DIAGRAM-DECODER



GREY BLANK VIDEO MODULATED ON AN IF CARRIER



RECONSTITUTED COMPOSITE VIDEO SIGNAL ON AN IF CARRIER

FIGURE 6-VIDEO WAVEFORMS

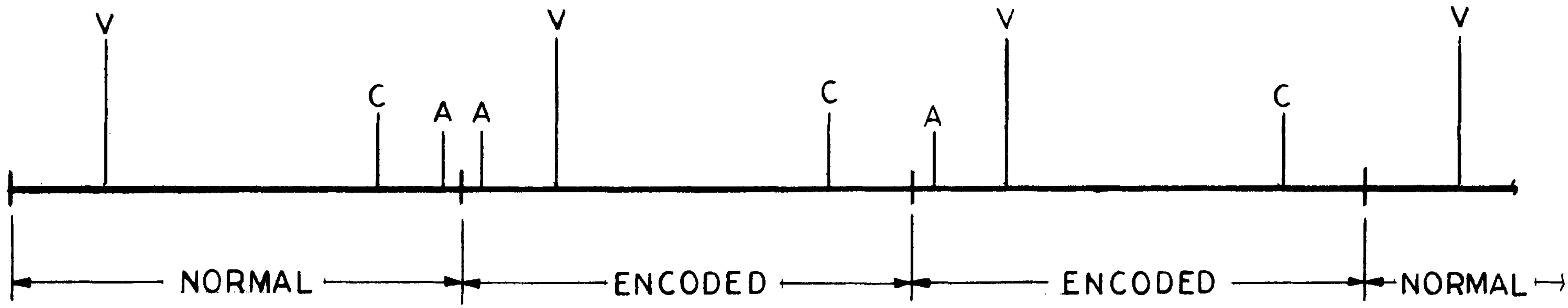


FIGURE 7-POSITION OF CARRIERS