RCA

LB-836

TELEVISION RECEIVER SIGNAL CIRCUIT AND AGC CONSIDERATIONS FOR IMPULSE NOISE IMMUNITY

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Television Receiver Signal Circuit and AGC Considerations for Impulse Noise Immunity

Approved Stuart Wm Seeley

Introduction

The performance of a television receiver in the presence of impulse noise is one of its important characteristics. By proper design receivers may be built which will produce accurately synchronized usable pictures when the amplitude of the interference is *several thousand times* the signal amplitude. On the other hand a poorly designed receiver will not only lose synchronization but may be biased off and lose the picture entirely if the amplitude of the noise is only a few times greater than that of the signal. Other receivers may synchronize well in the presence of impulse noise but will produce white flashes or streaks on the kinescope.

If good performance in the presence of impulse noise is to be realized, the problems involved in the receiver fall into two categories. The first problem is to avoid mutilation of the composite video signal by the noise as it passes through the signal circuits of the receiver so that none of the information in the composite video signal is lost and no erroneous information is added. The output of the signal circuits will then consist of the desired video signal plus the impulse noise. This bulletin discusses the factors which must be considered to minimize the effects of impulse noise in the r-f, i-f, video and a-g-c circuits. Other bulletins (LB-813, *Improved Sync Separation in Television Receivers in the Presence of Impulse Noise* and LB-823, *A Noise Inversion Circuit for Improved Noise Immunity in Television Receivers*) have discussed the problems involved in improving sync separator performance.

General Discussion

In a receiver which has inadequate immunity to impulse noise interference, this interference may cause loss of synchronization; it may bias the amplifier off and cause more or less complete loss of picture; or it may cause white flashes or streaks (so-called white noise) on the kinescope. The potential causes of these troubles are principally in the r-f and i-f amplifiers, the a-g-c system, and the video amplifier. If these circuits are properly designed, relatively simple well-designed sync circuitry will operate in the presence of large amounts of impulse noise. On the other hand, if these circuits are not properly designed the signal reaching the sync circuits may be so mutilated that even the finest sync system could not operate properly.

Some general statements can be made regarding the causes of each of the symptoms described above. If a receiver loses synchronization in the presence of impulse noise, the signal-to-noise ratio at the input to the sync circuits is too poor. A cure may be effected by improving the signal-to-noise ratio at the input to the sync circuits or by improving the performance of the sync circuits, or both.

If a receiver tends to bias itself off so that the amplitude of the video signal at the second detector drops when impulse noise is applied, the a-g-c system is usually deficient. In modern receivers the video stage is not likely to cause loss of picture, but many pre-war receivers were built with sync-positive output from the video detector and with capacitance coupling to the video stage. Noise pluses could then develop bias by grid-circuit rectification to reduce the gain of that stage. The performance of this combination is so poor that it has been used very infrequently in recent years.

Modern receivers generally use the video amplifier as a noise clipper to improve the signal-to-noise ratio at the input to the sync system. Receivers with the best noise immunity have also derived the a-g-c voltage from a detector following the video amplifier to take advantage of the superior signal-to-noise ratio obtainable at the plate of the video amplifier stage.

If a receiver reproduces the noise pulses as white flashes on the screen of the kinescope, the cause of the difficulty will usually be found in the grid circuits of any or all of the following: the r-f stage, the mixer, or the video i-f amplifier. It results from time constants which charge up on noise peaks strong enough to cause grid current to flow. The bias resulting from the grid current reduces the gain of the receiver until the capacitor involved in the time constant has discharged. Relatively short white noise flashes following otherwise black noise pulses can be caused by incorrect r-f, i-f, or video peaking if the response is such as to produce overshoots.

AGC Considerations

To provide optimum performance in the presence of impulse noise a television receiver a-g-c system should fulfill two principal requirements.

(1) It should operate to maintain the tips of the sync signal at some chosen reference level independent of video content in the signal or the presence of impulse noise.

(2) It should have low output impedance.

If the video signal is held at some reference level independent of modulation or signal strength the noise can be clipped at a level just above the sync pulses. If no such reference is established and maintained, the clipping level must be set so that the largest video signal will not be stripped of sync information. Therefore, when the video signal falls below this amplitude, the signal-to-noise ratio will deteriorate.

In the type of circuitry used to date which most accurately holds the reference level and thus provides best noise clipping as the modulation and signal strength are varied, the sync negative output of the video detector is d-c coupled to the first video stage. The a-g-c detector is then d-c coupled to the output of the video stage. Since the video stage functions as a clipper to remove the noise, two advantages accrue. One is that the clipping level remains essentially constant above the a-g-c threshold and the other is that the a-g-c detector has much less noise applied to it. Two successful applications of this principle are the a-g-c system used in RCA television receiver 8T241 and later versions of the same basic chassis, and keyed a-g-c system described in LB-769, *A Simple Keyed AGC System for Television Receivers*. Incidentically, both of these systems reference on the sync signals but the keyed system is responsive to the applied signal only when the keying pulse is present (about 10 per cent of the total time) so that only about 1/10 of the noise can influence the a-g-c operation. This is an advantage over systems which are sensitive to all noise pulses.

If either of these a-g-c systems is set up so that the sync tips are nearly at cutoff of the video amplifier, the noise at the output of the video stage will be of only slightly greater amplitude than that of the signal even though the noise amplitude may have been many times greater than the signal amplitude at the second detector. Fig. 1 is a photograph of the signal and noise at the second detector and Fig. 2 shows how the noise has been clipped at the output of the video stage in a typical receiver. It is difficult to make either a sync separator or peak a-g-c system operate satisfactorily with as adverse a signal-to-noise ratio as that shown in Fig. 1. However, even relatively simple sync circuits will function well if the signal-to-noise ratio is no worse than that shown in Fig. 2.

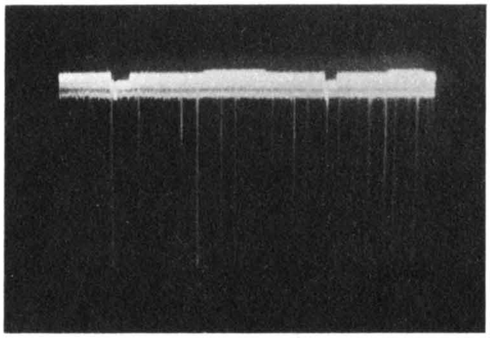

Fig. 1 - Signal plus noise at second detector.

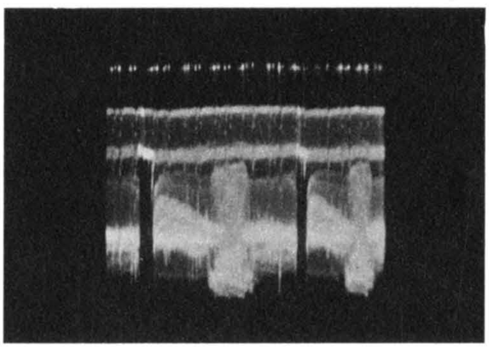

Fig. 2 - Signal plus noise at output of video.

Best noise clipping in the video amplifier may be obtained only if its input is of sufficient amplitude. It will deteriorate if the product of received signal strength and receiver gain to the second detector produces less signal than the value required to produce a-g-c voltage. Therefore, it is desirable to provide enough gain ahead of the video stage to produce clipping on the weakest signal to be received, particularly if the receiver sync clipper circuitry requires a relatively good signal-to-noise ratio for acceptable performance. LB-813 and LB-823 describe sync circuitry which has improved performance with degraded signal-to-impulse-noise ratio at the sync input. The designer may evaluate the relative cost of and problems inherent in high receiver gain to obtain good noise clipping in the video amplifier for all signals versus the cost of improved noise immunity in the sync circuits.

Other a-g-c systems which rectify the r-f carrier at the second detector are commonly used. They may be divided into two categories, the peak detector and the average detector, although there may not be a clear line of demarcation between them. Ideally, in a television receiver a peak detector is required. Only the sync and black levels are independent of picture content, but because the black level is not usable in a simple device a peak detector operating to maintain the sync level constant is often used. However, an ordinary peak detector is not practical because of its susceptibility to impulse noise. A simple circuit which performed a great deal better than previously-used peak detectors was described in LB-731, *A Transformerless 7-Inch Television Receiver* and LB-761, *A Novel Ten-Inch Television Receiver*. This double-time-constant arrangement used as short an input-time constant as possible consistent with making the a-g-c output voltage substantially independent of picture content. Only a relatively small amount of energy from each noise pulse can be stored in the input capacitor so its performance is reasonably good and it has been widely used. However, the adverse signal-to-noise ratio existing at the second detector is applied to it and so its performance is inferior to the systems which benefit from the noise clipping in the video amplifier.

The use of the d.c. at the video second detector for a-g-c voltage requires few components and consequently appears attractive. Both advantages and disadvantages accrue. The advantage other than reduced cost is that since the voltage is the average value of the signal, it is relatively immune to impulse noise because the noise usually has low average value even though its peak value is high. The disadvantages are that the operation of the receiver is no longer in accordance with system standards because the gain of the receiver varies as a function of picture content and that insufficient a-g-c voltage is developed, particularly on a white picture. Because insufficient a-g-c voltage is developed, overload on strong signals is usually a serious problem.

These simple a-g-c circuits appear to be economical but in evaluating their cost it is necessary to consider the standard of performance to be achieved. If that standard is high the a.g.c. may set a ceiling on the performance because it is not protected by noise clipping. In addition, the clipping level in the video amplifier cannot be accurately maintained so that an extra burden is placed on the sync clipper circuits which may involve additional cost in that portion of the receiver.

As mentioned previously, the second of two principal requirements of an a-g-c system which operates well in the presence of impulse noise is low output impedance. The importance of low output impedance is apparent only if the a-g-c detector is relatively insensitive to noise, but if this condition is achieved, its value is largely lost if the output impedance is high. Fig. 3 is a simplified schematic of a portion of a receiver. V1, V2, and V3 are controlled tubes, whose bias is determined by the a-g-c detector which develops a current I which flows through resistor R and charges capacitor C. If the a-g-c detector is sensitive to noise and I increases in the presence of noise, it is necessary to change to a-g-c circuitry which is less sensitive to noise to realize an improvement in receiver performance. With an a.g.c. which is insensitive to noise so that I does not increase appreciably in the presence of noise another factor becomes important. Strong noise will cause grid current to flow in the controlled tubes and generate a current I_N. which will increase the bias on the controlled tubes and reduce the receiver gain.

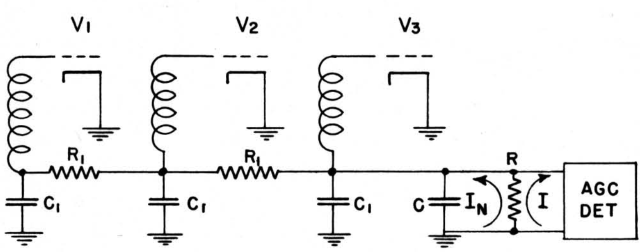

Fig. 3 - Simplified schematic of a portion of a receiver.

Capacitor C must be large enough to filter out the a-c component of the noise currents and resistor R must discharge capacitor C at a rate faster than it is charged by those currents so that the current from the a-g-c detector is the principal factor in determining the a-g-c bias. Capacitor C also filters the output of the a-g-c detector to remove the 60-cycle component resulting from the vertical pedestal in the video signal and any a-c component in the a-g-c detector caused by noise.

It is difficult to generalize on permissible minimum values of C and maximum values of R because so many variables depending upon the design of the particular receiver are involved. But it is helpful to know the order of magnitude of values which may be expected to provide reasonable performance. It has been the experience of this laboratory that with an a-g-c detector of the keyed type, C should be a minimum of 0.5 uf. At this capacitance value the performance is compromised somewhat in the presence of impulse noise. The performance improves as capacitance is added but no noticeable improvement is realized above about 3 µf. R should probably not exceed 100,000 ohms. In a typical receiver it was easy to demonstrate that the performance in the presence of impulse noise deteriorated as R was increased above 100,000 ohms but it was difficult to demonstrate any great improvement as it was reduced below that value.

"White Noise"

Large noise pulses should cut the kinescope off and so should produce black streaks in the picture. A relatively large amount of this black noise may be present without detracting materially from the entertainment value. However, the white flashes or streaks often seen on improperly designed receivers are far more annoying to the observer. This white noise may result from relatively short-time constant circuits which are charged as a result of noise pulses of sufficient amplitude to draw grid current in the r-f, mixer, or i-f stages. If the time constant involved were long as in the case of the a-g-c system the receiver would become biased off and the signal would disappear. However, when the time constants are short, the gain of the receiver is reduced for only a short time following each noise pulse. This is the equivalent of modulating the picture signal in the white direction. Fig. 2 is a photograph of the signal at the plate of the video stage in a receiver in which the reproduced noise is predominantly black. Fig. 4 is a photograph of a video signal in the same receiver but with one time constant introduced in the i-f amplifier so that white noise is produced. The effects of the time constant can be readily seen in Fig. 4, a pulse extending in the negative direction following each noise pulse which extends in the positive direction at the video amplifier plate. It is difficult to observe the white noise pulses at the output of the video detector because the amplitude of the video signal is so small compared with that of the noise pulses.

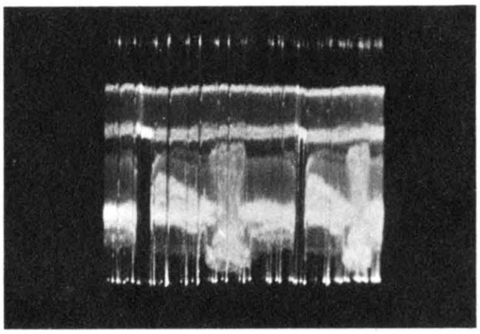

Fig. 4 - Same receiver and conditions as Fig. 2 except one time constant added in i.f. to produce white noise.

The time constants which can cause white noise are usually found in the grid circuits of r-f, mixer or i-f stages. For example, in Fig. 3 the filter resistors labeled R_1 in combination with the by-pass capacitors C_2 can be troublesome. If R_1 is large the capacitor C_1 can become charged and will reduce the gain of the associated tube until it has discharged. It has become common practice in television receivers to use values of the order of 100 to 330 ohms for R_1 for this reason.

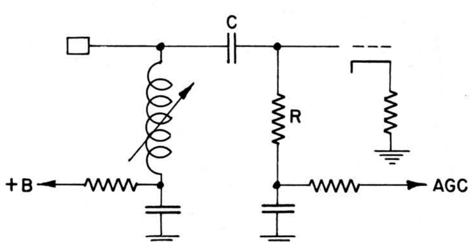

Fig. 5 - Type of circuitry which can produce white noise.

A common cause of white noise is the use of circuitry of the type shown in Fig. 5. If a noise pulse causes grid current to flow, capacitor C becomes charged and the gain of the stage does not become normal until it has discharged through R. One cure is to shunt R with an r-f choke. Another is to use transformer coupling as in Fig. 6. The transformer may be double-tuned or it may be a bifilar winding to obtain the electrical equivalent of Fig. 5 but without the time constant. The components of Fig. 5 may be rearranged as in Fig. 7. This removes the time constant from the grid circuit but the circuit is usable only if the B supply voltage is sufficiently high that the IR drop in the damping resistor does not result in too low plate voltage.

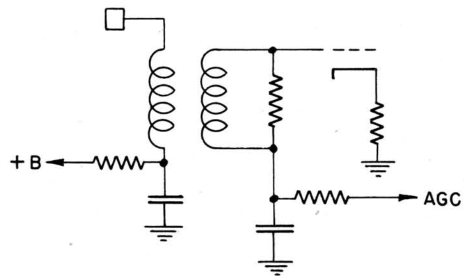

Fig. 6 - Transformer coupling to eliminate the time constant of Fig. 5 which can cause white noise.

An expedient which is helpful because it makes the white noise pulses shorter but which is not a cure is to make the coupling capacitor C of Fig. 5 as small as possible. The length of the streaks of white noise will be approximately proportional to the coupling capacitor value for a given value of damping resistor.

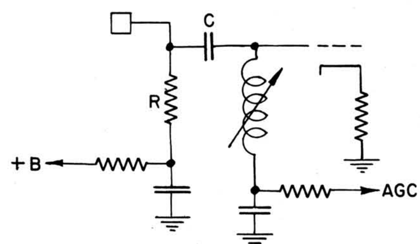

Fig. 7 - Circuit of Fig. 5 rearranged to eliminate the time constant.

It is obvious that if a receiver has troublesome time constants in each of the stages from the r-f to the last i-f that as the noise amplitude is increased, the last i-f stage will be the first to draw grid current and cause white noise. If this circuit is corrected and the noise amplitude increased the next to last stage will do the same, etc., until if enough noise is introduced the white streaking can be caused by time constants in the grid of the r-f stage.

White noise difficulties may also result from overall response characteristics which are such as to produce overshoots. The effect could be produced in r-f or i-f circuits which have excessive response for the high video modulation frequencies but in practice have most often been found to be due to the second detector peaking circuits. In some receiver designs the response is made other than flat to introduce overshoots in the video content to produce a subjectively crisper picture. Serious white noise difficulties have been experienced in receivers where this overshoot is introduced in the video detector peaking. However, the same amount of overshoot in the video amplifier is much less likely to cause trouble because the signal-to-noise ratio is usually improved at the output of the video amplifier.

Overshoots from the noise pulses may be obnoxious even though the overshoots in the video content may be subjectively pleasing. The amplitude of the noise pulses at the video detector may be many times the amplitude of the video signal at the detector and the noise overshoot is therefore proportionately greater. For example, in a typical receiver the video level at the second detector might be of the order of 3 volts peak-to-peak amplitude, approximately 1 volt of sync and 2 volts of video content. The noise pulse amplitude might be 20 volts peak to peak. If the peaking overshoot were 10 per cent it may be seen that the overshoot in the white direction of an otherwise black noise pulse would be equal to 2 volts. Since the overshoot amplitude in the example chosen is equal to the peak-to-peak amplitude of the video content of the picture signal, it follows that if the noise pulse occurs in a black portion of the picture, the noise pulse itself will not be seen but the overshoot will produce a white spot on the kinescope whose brightness will be equal to the brightest highlight. If the noise pulse occurs in a white portion of the picture, the overshoot will be brighter than the brightest highlight. It may cause the kinescope to bloom and produce a very large bright spot on the kinescope screen.

The same percentage of overshoot in the video amplifier circuits will produce much lower amplitude white noise if the video amplifier clips the noise because the noise and signal amplitudes will be more nearly the same. Therefore, if the receiver is designed to produce an overshoot in the video information, the circuit which produces the overshoot should follow the noise clipping to minimize the amount of white noise resulting from the overshoot.

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