LB-823

A NOISE-INVERSION CIRCUIT FOR IMPROVED NOISE IMMUNITY IN TELEVISION RECEIVERS

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Approved

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Introduction

This bulletin describes a circuit which provides a degree of impulse noise immunity in the synchronizing and a-g-c circuits of television receivers which up to now has required relatively complex circuitry. The new circuit requires only one-half of a double triode connected directly between the video detector output and the sync separator input. This triode constitutes a parallel channel for noise pulses which inverts the polarity of the noise normally present at the sync separator input and prevents it from appearing in the sync region of the composite video signal fed to the sync separator. Even where a high degree of noise clipping is employed in the video amplifier, the noise inversion circuit effects an improvement in signal-noise ratio at the output of the vertical integrating circuit and a consequent reduction in the amount of vertical jitter in the picture. When the input to the a-g-c circuit is taken from the noise-immune input to the sync separator, a significant reduction in vulnerability to a-g-c setup is observed under conditions of interference having high average energy content.

General Discussion

Noise immunity in the synchronizing and a-g-c circuits of modern television receivers is obtained for the most part from noise clipping in the video amplifier. This noise immunity is derived by using the a-g-c circuit to hold the sync peaks at a specified level and clipping the noise which extends beyond this level in the video or sync amplifier. Other methods of improving the noise immunity include establishing a reference level at sync peak height and the use of appropriate clipping circuits to keep the noise from extending above this height.

These methods all fail when the noise is sufficiently intense so that it becomes indistinguishable from the sync information, and the a-g-c or other reference level therefore "sets up" on the noise. In the method described in this bulletin, the signal is distinguished from the noise by inverting all noise components which extend above a fixed level corresponding to the highest signal level normally present at the video detector. The resulting noise immunity does not depend on maintenance of any reference level other than the a.g.c., and the circuit lends itself to a design which prevents the a.g.c. setting up on noise.

Basic Circuit

One form of the noise inverter is shown in Fig. 1. In this particular circuit arrangement, the video detector provides a sync negative signal which is applied to a single stage video amplifier having a cathode contrast control. The sync separator is fed sync positive composite video from the plate of the video amplifier through a 27K series resistor. This resistor also serves as the plate load for the noise inverter triode which has its cathode fed directly from the grid of the video amplifier.

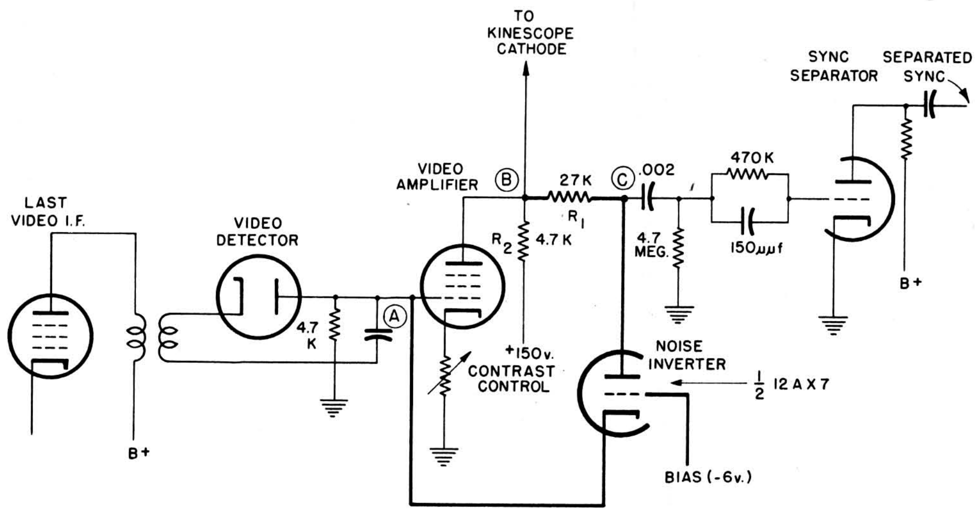

Fig. 1 - Application of noise inverter to video-sync circuit.

When noise is present at the video detector, it causes the noise inverter to conduct and to cancel the noise which would otherwise be present at the input to the sync separator. The operation of the circuit will be clear from the following considerations:

(a) The bias on the grid of the noise inverter is adjusted so that plate current flows only when the noise plus signal at the video detector exceeds (in a negative direction) the sync peak voltage at the video detector.

(b) When the noise inverter conducts, it produces a negative polarity noise pulse across the sync separator input resistor R1 which is out-of-phase with the positive noise pulse reaching this point through the video amplifier. This out-of-phase component will subtract from the component which reaches this point through the video amplifier so as to eliminate noise in the sync region of the composite video signal at the plate of the noise inverter tube. In this way conduction of the sync separator on impulse noise is prevented and a major improvement in signal-noise ratio is obtained for both horizontal and vertical synchronization.

(c) This action requires no critical balance in that the negative noise impulse developed by the noise inverter at its plate due to its conduction will in general exceed the positive noise impulse produced at the same point by the video amplifier. This momentarily drives the sync separator grid more negative than is necessary to obtain noise immunity but this has no harmful effect.

Since impulse noise in general is random in amplitude, there will be noise components present at the video detector (Fig. 2) which

(a) are smaller in amplitude than the cut-off bias on the noise inverter tube,

(b) exceed the cut-off bias but do not come up to the level corresponding to zero bias, i.e., full conduction in the noise inverter tube,

(c) and finally those which exceed the zero bias condition for the noise inverter tube.

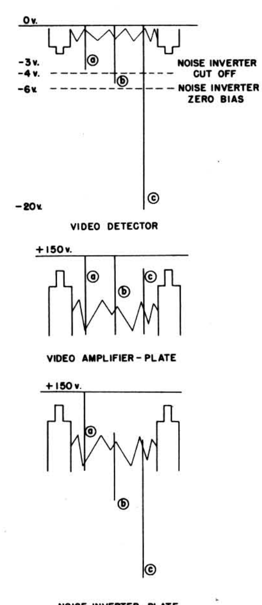

Fig. 2 - Signal plus noise at the video detector, video amplifier, noise inverter. The noise does not appear in the sync region at the noise inverter plate for noise components which are strong enough to make the noise inverter conduct.

The noise inverter circuit is not operative for noise components in the (a) category (Fig. 2). Fortunately, these components have relatively low energy content and therefore their effect on the signal-noise ratio of the sync signal is relatively small. To reduce the number of noise components which fall within this category, the bias used on the noise inverter tube should exceed the sync peak height by the smallest margin compatible with preventing conduction of this tube on the sync peaks.

To obtain maximum effectiveness for noise components falling in the (b) category, a high-mu tube should preferably be used for the noise inverter. This will reduce the number of noise components which are unable to cause adequate conduction of the noise inverter triode.

As shown in Fig. 2, the signal at the plate of the noise inverter tube has no noise in the sync region for noise pulses (b) and (c) which were strong enough to cause conduction of the noise inverter tube. For noise pulse (a) which was not strong enough to cause conduction, the noise inverter of course has no effect. A fast time constant (Fig.1) is included in the grid circuit of the sync separator to minimize the effect of these noise pulses.[1]

Oscillograms

The action of the noise inverter circuit can be seen with the aid of the oscillograms in Fig. 3 which show waveforms at the video detector, the video amplifier plate, the noise inverter plate, the sync separator grid, and the output of the vertical integrating circuit. The waveforms are shown (a) with the noise inverter tube removed, and (b) with the noise inverter operating normally. The oscillograms were photographed in a receiver using the circuit of Fig. 1. An electric shaver was the source of noise.

The results in Fig. 3 are very similar to those in the idealized waveforms of Fig. 2. With the noise inverter operating at normal bias it is evident that the sync region of the composite video signal at the noise inverter plate is free of noise. The few noise pulses which remain are the relatively low amplitude noise pulses which, as shown in the idealized waveforms of Fig. 2, are not sufficiently strong to cause the noise inverter to conduct. The removal of the noise pulses from the sync region shows up very clearly in the output of the vertical integrating circuit; with the noise inverter circuit operating, the signal-noise ratio at the output of the vertical integrating circuit is considerably improved.

1. LB-813, *Improved Sync Separation in Television Receivers in the Presence of Impulse Noise.*

Effect of Noise-Inverter Bias

The oscillograms in Fig. 4 show how the effectiveness of the noise inverter circuit depends upon the fixed bias which is placed on the grid of the noise inverter tube. In (a) the noise inverter is biased sufficiently so that it is effectively out of the circuit. In (b) reduction of the bias on the noise-inverter tube to 10 volts results in less noise in and above the sync region and a corresponding improvement in the signal-noise ratio at the output of the vertical integrating circuit. At 6 volts bias (c) there is a marked improvement; when the bias is reduced to the point where the noise inverter tube just conducts at sync peak level (d), the most favorable signal-noise ratio at the output of the vertical integrating circuit is produced.

The series of oscillograms indicates that a considerable improvement in noise immunity is obtained even when a much larger than optimum bias is used for the noise inverter tube. However, ideal performance can be approached by designing the receiver so that it has delayed a.g.c. and a flat characteristic for signal levels above the a-g-c threshold. Under these conditions, one bias setting will give optimum results for all signal levels above a-g-c threshold. As far as signals below a-g-c threshold are concerned, the noise inverter still provides a substantial improvement in performance, but the improvement is not so great as it would be if a manual bias control were provided.

The possibility of designing the noise inverter bias circuit so that the bias varies with signal level has been considered. For example, the bias may be composed of a fixed component plus an additional component which is

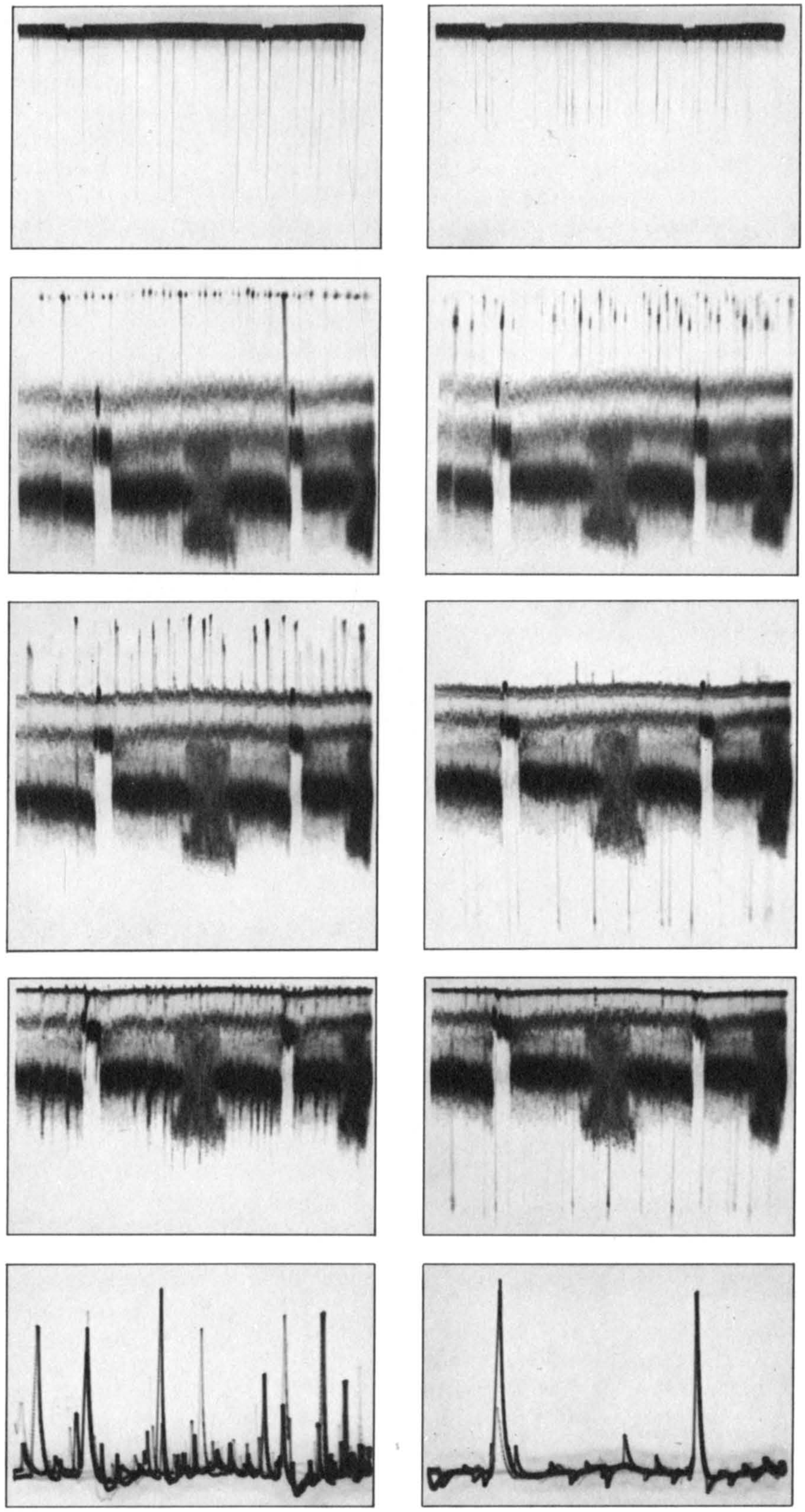

Fig. 3 – Effect of noise inverter on circuit waveforms.

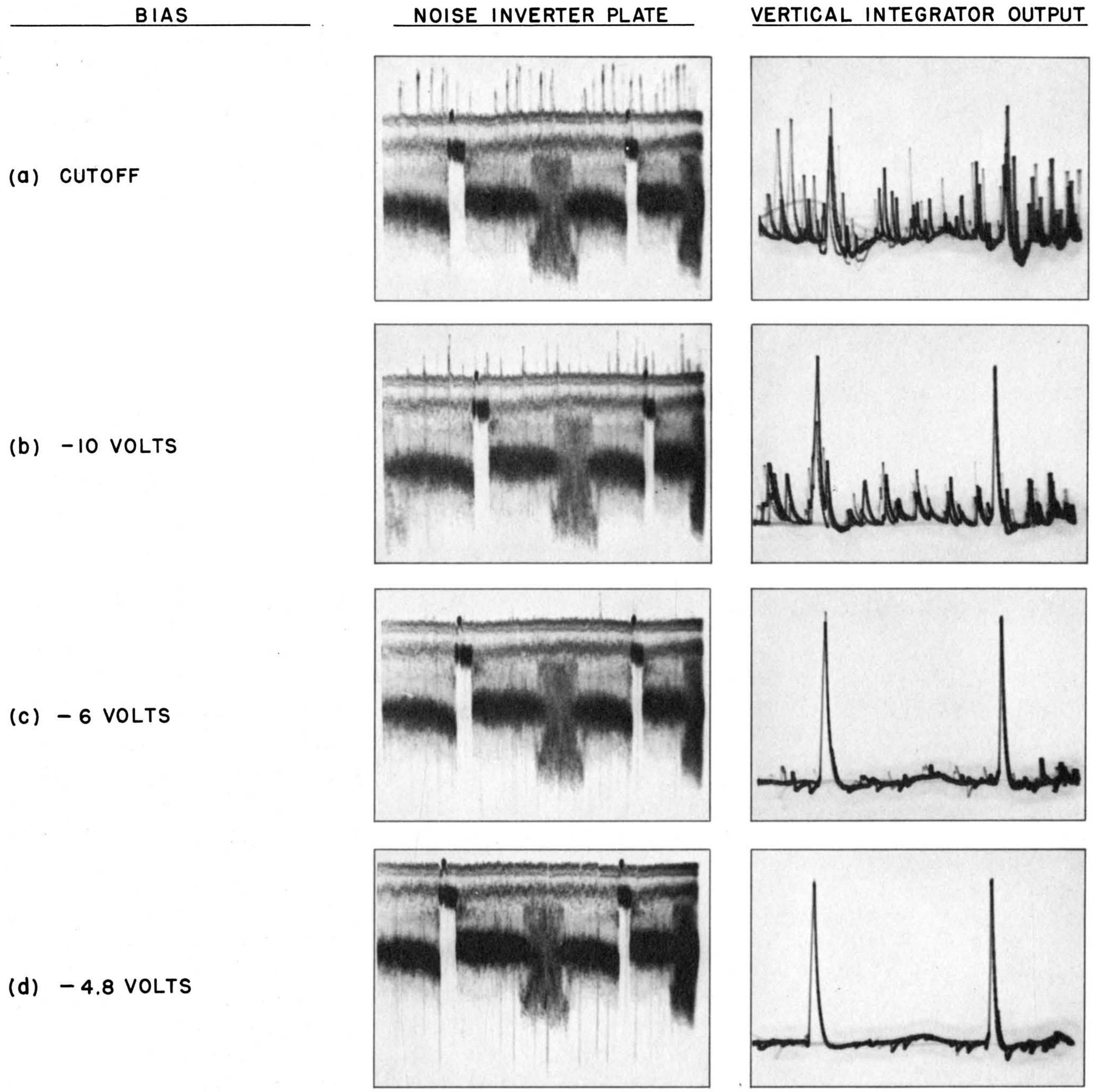

Fig. 4 - Waveforms at noise inverter plate and vertical sync integrator as a function of noise inverter bias.

derived from the a-g-c voltage. This procedure does not appear attractive when the receiver has a flat a-g-c characteristic.

Bias Circuit

The maximum amount of inverted pulse voltage will depend, among other factors, on the stiffness of the bias circuit. This effect is illustrated in Fig. 5b which shows the reduction in amplitude when a 27K resistor is placed in series with the grid of the noise-inverter tube. This resistor is necessary when the bias is obtained from a high-impedance source (such as the grid circuit of the horizontal output tube) in order to prevent setup of the bias circuit on noise.

(a) LOW-IMPEDANCE SOURCE

(b) 27K-OHM SOURCE

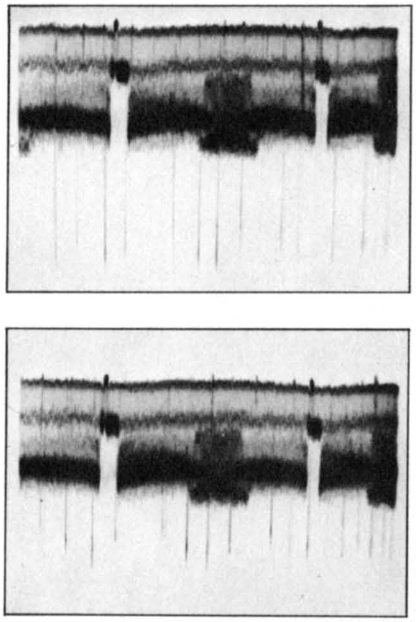

Fig. 5 - Effect of variation in noise inverter grid impedance.

Attenuation of White Noise

Although the action of the noise-inverter tube introduces white impulse noise at its plate, these impulses are attenuated sufficiently when they reach the plate of the video amplifier so that white noise is not observed in the picture when the noise inverter conducts on noise peaks. The amount of attenuation provided increases as the ratio R_1/R_2 (Fig. 1) increases. This factor plus the desirability of providing a high load resistance for the noise inverter tube implies that R_1 should be as large as is consistent with acceptable sync compression at the grid of the sync separator.

Preventing AGC Setup on Noise

The plate of the noise inverter tube in Fig. 1 provides a noise immune point which can be used to directly-couple signal level information into the grid of a keyed a-g-c tube. This arrangement provides additional noise immunity over and above that resulting from the keying action since the signal at this point is essentially free of noise in the sync region. The combined effect is to eliminate a-g-c setup (in the a-g-c tube grid circuit) as a factor in receiver noise immunity. A-g-c setup may still occur, however, in the grid circuits of the controlled tubes if the impedance level is too high.

When the grid of the keyed a-g-c tube is direct coupled to the noise inverter plate, the a-g-c system shows significantly reduced vulnerability to set up on noise. However, the receiver exhibits a strong tendency toward overload when it is switched from a weak to a strong signal. This comes about in the following manner: when the signal increases suddenly the level at the second detector increases before the a-g-c voltage can change. This causes the noise inverter tube to conduct and to cut off the keyed a-g-c tube. The receiver remains in this locked-out condition until the input signal is reduced.

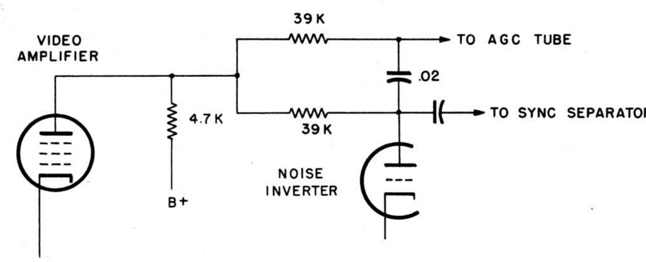

Fig. 6 - Circuit to prevent set-up of AGC by inverting the noise in the input to the AGC tube.

To prevent this action, the circuit was modified as shown in Fig. 6. The grid of the keyed a-g-c tube is returned to the plate of the video amplifier through a resistor rather than to the noise-inverter plate. The enhanced a-g-c noise immunity is retained by adding a coupling condenser between the grid of the keyed a-g-c tube and the plate of the noise-inverter tube. This was found to eliminate the tendency toward lock-out when switching from a weak to a strong signal, without impairing the noise immunity of the sync circuits.

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