ADAPTIVE TV GHOST SUPPRESSOR

A DISSERTATION PRESENTED TO

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BY

H. Y. NGAI (B. SC.)

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ABSTRACT

Multipath signal due to reflection causes 'ghosting' in TV receiver. In difficult sites, picture quality is so seriously degraded as to render the television set unserviceable. A method of recovering the orginal signal based on finding out the delay and the relative amplitude of the reflected signal and cancelling it in black and white television is presented. The process is self-adaptive and, even under low signal-to-noise-ratio condition,yields an improved picture quality. The feasibility of extending this method to colour television is also discussed.

CONTENTS

FIGURES

NEW TERMS USED

Blanking line selection pulse: A pulse which is generated in the system selects the reference portion from the input video signal for automatic ghost elimination.

Signal sync position pulse: It is generated in the system. The position of it is just coincides with the sync pulse of the video signal. It is used to gate the whole sync pulse without more or less out.

Ghost sync position pulse: It is generated in the system. The position of it is just coincides with the sync pulse of the reflected signal. It is used to gate the whole sync pulse of the reflected signal without more or less out.

Clamping pulse; A pulse used to operate the clamper in order to clamp the blanking level of the video signal to a preset D.C. level. It is generated in the system.

1. INTRODUCTION

Multipath signal due to reflection causes double images, or ghosts on TV screen. In some sites, a single reflected signal could impair an otherwise perfect reception. A self-adaptive ghost elimination method is proposed here to cancel the unwanted signal. Sufficient circuitry is built to establish the principle and the method under the simplified condition of one single ghost with the same polarity as the direct signal on a black and white television set. Also shown in this report is the feasibility of opposite polarity ghost cancelling and the feasibility of extending this method to colour television.

The method adopted is one of superposition of signal based on the assumption that the reflected signal causes a time delayed image on the screen with smaller amplitude but no distortion. Figure 1-1 shows a typical case of a ghost existing on a television screen and Figure 1-2 shows a picture with no ghost. The corresponding video waveforms are shown in Figure 1-3 and 1-4 respectively. The kink appears at the video waveform of Figure1-3 shows the superposition of the direct and reflected signal. A weaker image, the ghost, appears at the right hand side of the original image is indicated on Figure 1-1. By observing the ghost picture of television sets at various location in Hong Kong, the assumptions made above are valid in practice.

Figure 1-1. Picture of the GREY SCALE with ghost present.

Figure 1-2. Picture of the GREY SCALE with no ghost.

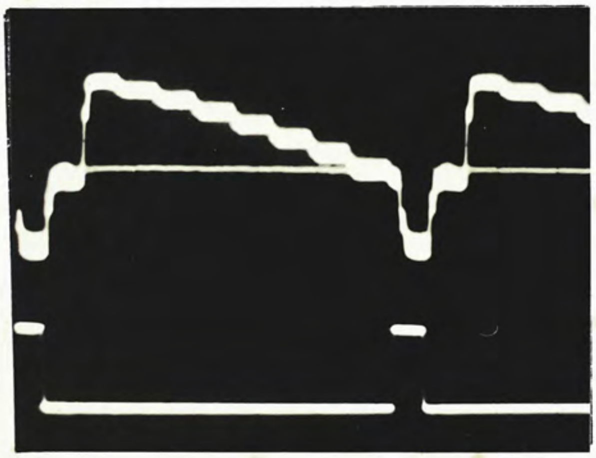


Figure 1-3. Video waveform of the GREY SCALE with ghost present.

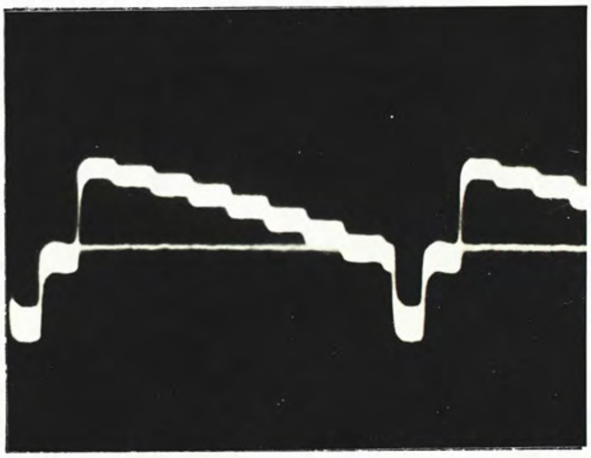


Figure 1-4. Video waveform of the GREY SCALE with no ghost.

The detected video signal is firstly splitted. For one, the signal is used to determine the time delay and the relative amplitude of the ghost. These measured parameters are used to delay and attenuate the signal. The other, on subtraction with the delayed and attenuated signal, gives the original video signal. Since the control parameters are derived from the signal itself, the system will optimize the delay and attenuation continuously. Continuous changing of the ghost condition due to the changes of reflector and propagation medium characteristics can be eliminated by this self-adaptive ghost elimination method.

Noise is present in receiver generally. Figure 1-5 shows a typical case of a ghost-existing picture with noise, Figure 1-6 shows the corresponding video waveform. The Figures show that even in a high quality received picture, noise has comparable amplitude as the ghost's. The presence of noise makes it difficult to measure the time delay and relative amplitude of the ghost. Phase-locked loop method and multichannel averaging-technique are used here to recover the time delay and amplitude of the ghost from the noisy signal.

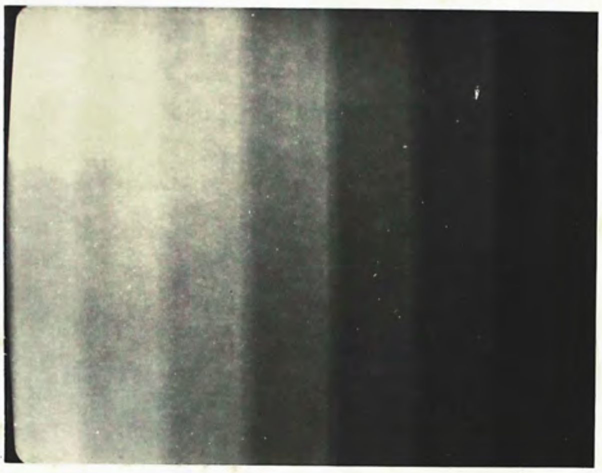


Figure 1-5. Ghost-existing picture with noise.

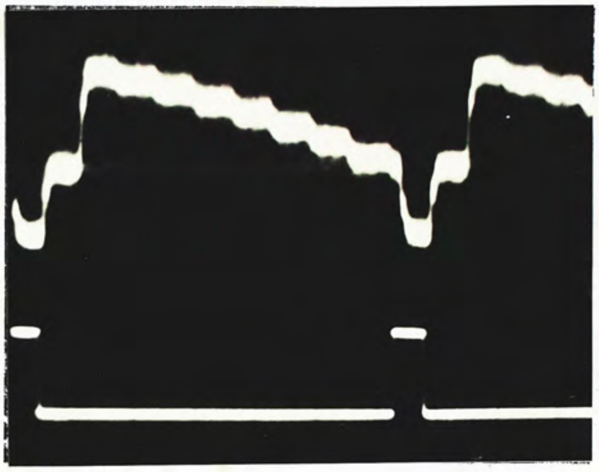


Figure 1-6. Video waveform of ghost-existing picture with noise.

2. PRINCIPLE OF GHOST ELIMINATION

2-0 SUMMARY

In this chapter, the principle of ghost cancellation and the possibility of working self-adaptively in black and white television boardcasting system are explored. Assumption for elimination of ghost under the simplifed condition of one single ghost with the same polarity as the direct signal is make in section 2-1, Section 2-2 states the method of ghost elimination which is proven experimentally in section 2-3. After showing that the method of ghost elimination can be realized in practice, possibility of working self-adaptively is discussed in section 2-5. Also, the effect of incorrect adjustments on the system are found and stated in section 2-4, it is helpful in the choice of the circuits used during circuit implementation.

2-1 ASSUMPTIONS

When the EM wave and its reflected wave are received simultaneously by the antenna, ghost is formed. Since the reflected wave is normally attenuated after reflection, having travelled a longer path, and perhaps received by a high directivity antenna, the ghost is always somewhat attenuated. Since the reflected wave has travelled a longer path, the ghost is always delayed. A reasonable assumption is made here that the ghost is an exact replica of the signal except relatively time delayed and attenuated.

2-2 METHOD OF GHOST CANCELLING

Since the reflected signal, the ghost,is only attenuated and delayed, it is possible to cancel it by using the direct signal. That is to attenuate the direct signal according to the ghost amplitude, delay it according to the time difference, and then subtract it from the signal recieved. With the correct amount of attenuation and delay, the reflected signal will be exactly cancelled out. This is illustrated in Figure 2-2-1 and Figure 2-2-2.

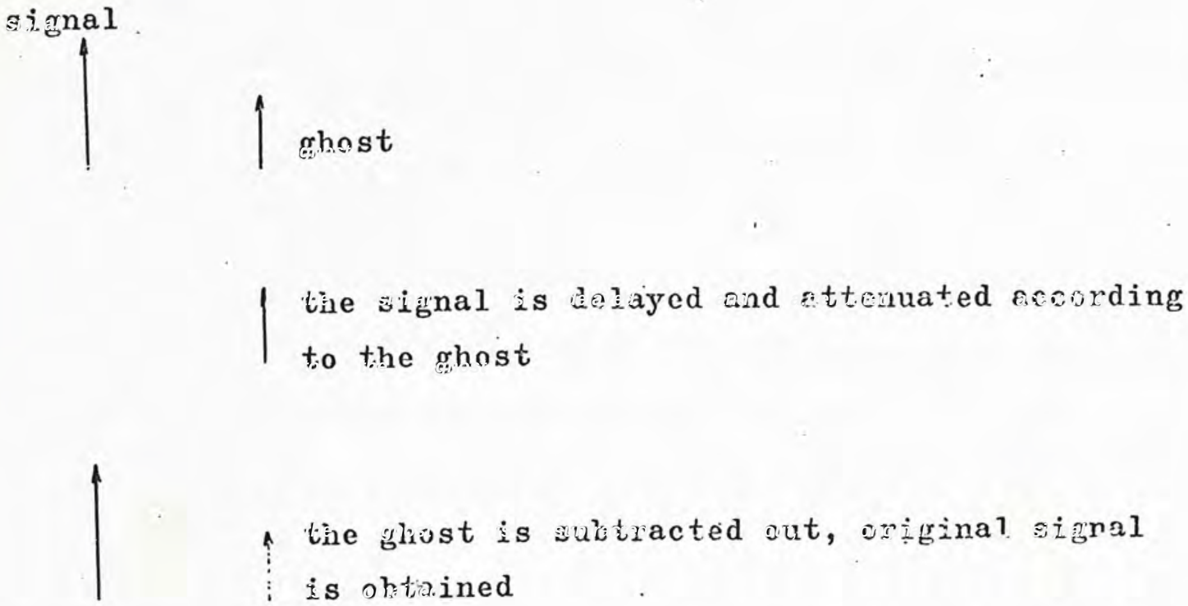


Figure 2-2-1. Recovering of original signal from the mixed signal by subtraction.

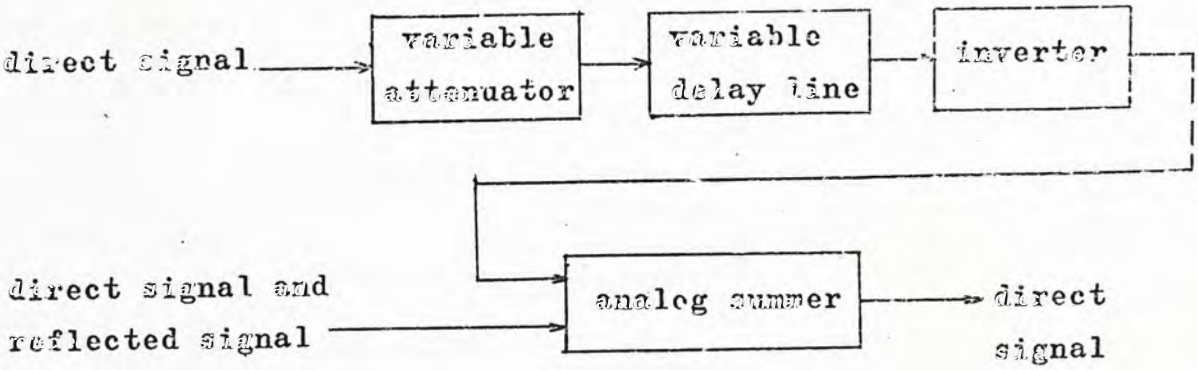


Figure 2-2-2. Circuit implementation of ghost elimination.

But when the direct signal and the reflected signal are received by the antenna simultaneously, there is no way to seperate the direct signal from the reflected signal since they are superimposed together. If the composite signal is delayed and attenuated to cancel the reflected one, new ghost with twice the time delay and a smaller opposite-polarity ghost is introduced. This illustrated in Figure 2-2-3.

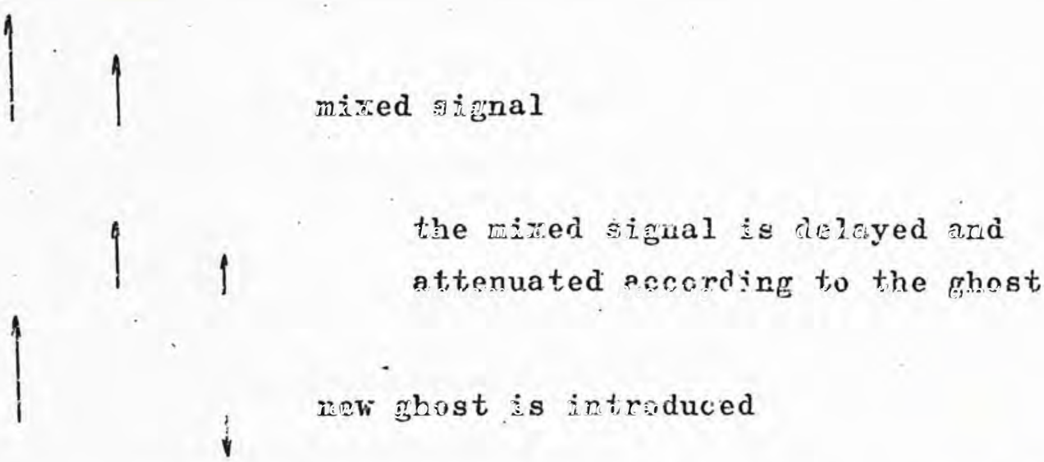


Figure 2-2-3. New ghost is generated due to using mixed signal instead of using direct signal only in subtraction.

The method of cancelling the newly generated ghost is to attenuate, delay and invert signal iteratively to cannel the ghost generated. This is illustrated in Figure 2-2-4.

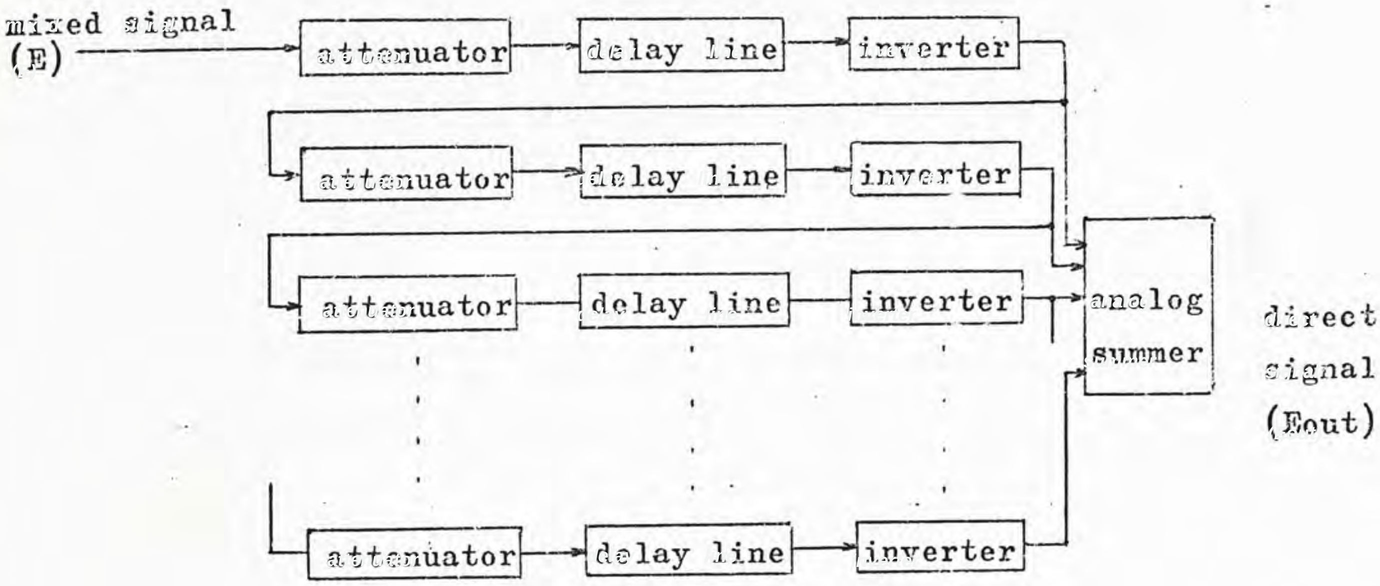


Figure 2-2-4. Direct signal is recovered from mixed signal by cancelling newly generated ghosts iteratively.

Mathematically, a sinusoidal signal with frequency $\frac{\omega}{2\pi}$ and unity amplitude, superimposed with its time delayed (T), attenuated (A) portion, can be expressed as:

$$E = (1 + A e^{-j\omega T}) \sin \omega t$$

Then,

$$E_{out} = \Big[(1 + A e^{-j\omega T}) - (1 + A e^{-j\omega T}) A e^{-j\omega T} + (1 + A e^{-j\omega T}) A^2 e^{-2j\omega T} - (1 + A e^{-j\omega T}) A^3 e^{-j3\omega T} + \cdots\cdots (-1)^n (1 + A e^{-j\omega T}) A^n e^{-jn\omega T}\Big] \sin \omega t$$

$$= \frac{1 + A e^{-j\omega T}}{1 - (-A e^{-j\omega T})} \sin \omega t$$

$$= \sin \omega t.$$

The result shows that the original signal is recovered after the ghost is cancelled iteratively. Simplification is achieved by modifying the above diagram into the form as shown below without affecting the final result.

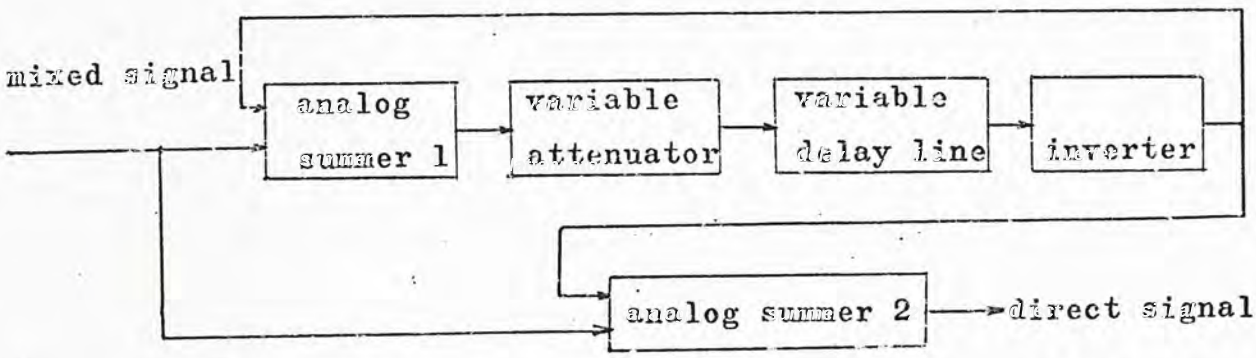


Figure 2-2-5. Simplification of Figure 2-2-4 is achieved by using the attenuator block, the delay block iteratively.

Since inputs are common at the analogy summers, further simplification can be done by discarding analog summer 2 and obtaining direct signal output from analog summer 1. This is shown in Figure 2-2-6.

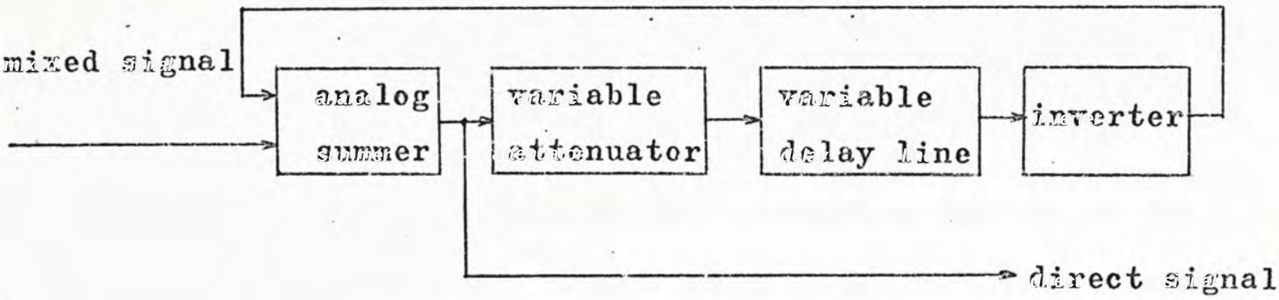


Figure 2-2-6. Final block diagram for ghost elimination after further simplification is done on Figure 2-2-5.

2-3 VERIFICATION OF THE PRINCIPLE

Theoretically, ghost under the assumption that it is an exact replica of the signal except relatively time delayed and attenuated can be eliminated by using circuit configuration as shown in Figure 2-2-6. Verification of this principle is done below.

Figure 2-3-1 shows a received picture with no ghost. This picture is obtained by careful alignment of the receiving antenna towards the transmitting tower.

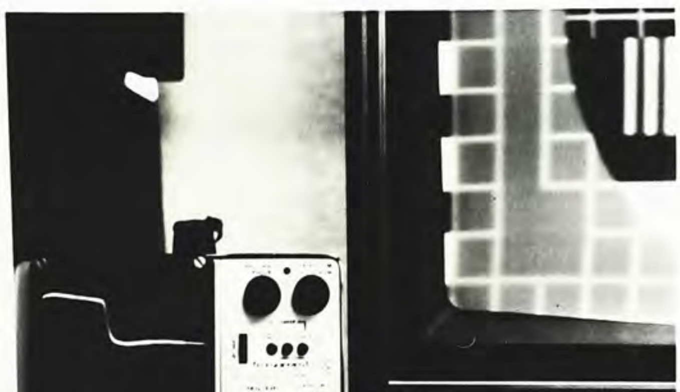


Figure 2-3-1. Picture without ghost and its video waveform emphasizing on the sync pulse.

Changing the orientation of the receiving antenna by trial and error, a ghosted picture is received. This is due to the direct signal and its reflected signal are received simultaneously by the receiving antenna. Figure 2-3-2 shows the ghosted picture and the sync pulse of its video waveform.

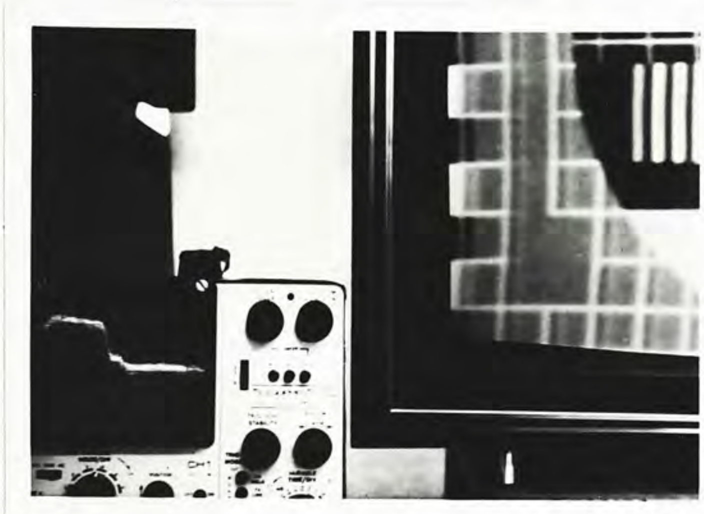


Figure 2-3-2. Ghosted picture received and its video waveform emphasizing on the sync pulse.

What Figure 2-3-2 shows is expected. The weaker image at the right hand side of the original image shows that reflected signal is superimposed on the direct signal, which is shown clearly at the sync pulse on the oscilloscope.

A manual control attenuator and a manual delay adjust video delay line which is constructed by using the Mathey video signal delay line* is use as building blocks in the circuit configuration as shown in Figure 2-2-6 is inserted into the video channel of the television receiver to eliminate the ghost. After selecting the attenuation and adjusting the time delay carefully, the original picture is recovered. The sync pulse of the video signal and its picture on the screen is shown in Figure 2-3-3. Figure 2-3-4 shows the path of signal flows after the system is inserted into the television set.

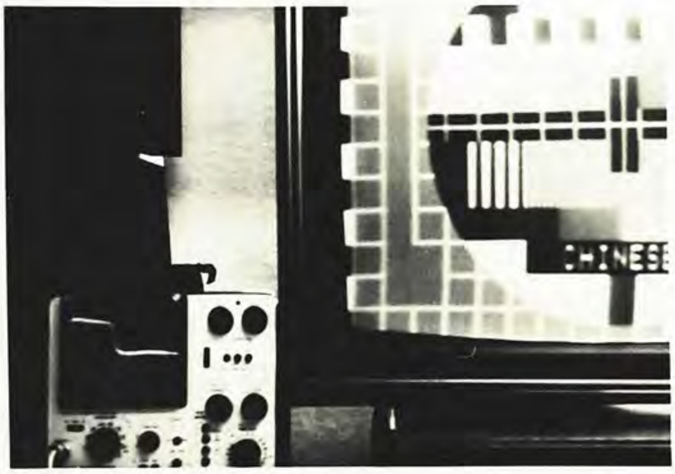


Figure 2-3-3. Picture after manual ghost eliminating and its video waveform emphasizing on the sync pulse.

* The company which produces video delay lines for television boardcasting. Address: William Clowes Street, Burslem, Stoke-on-Trent st6 3at, English.

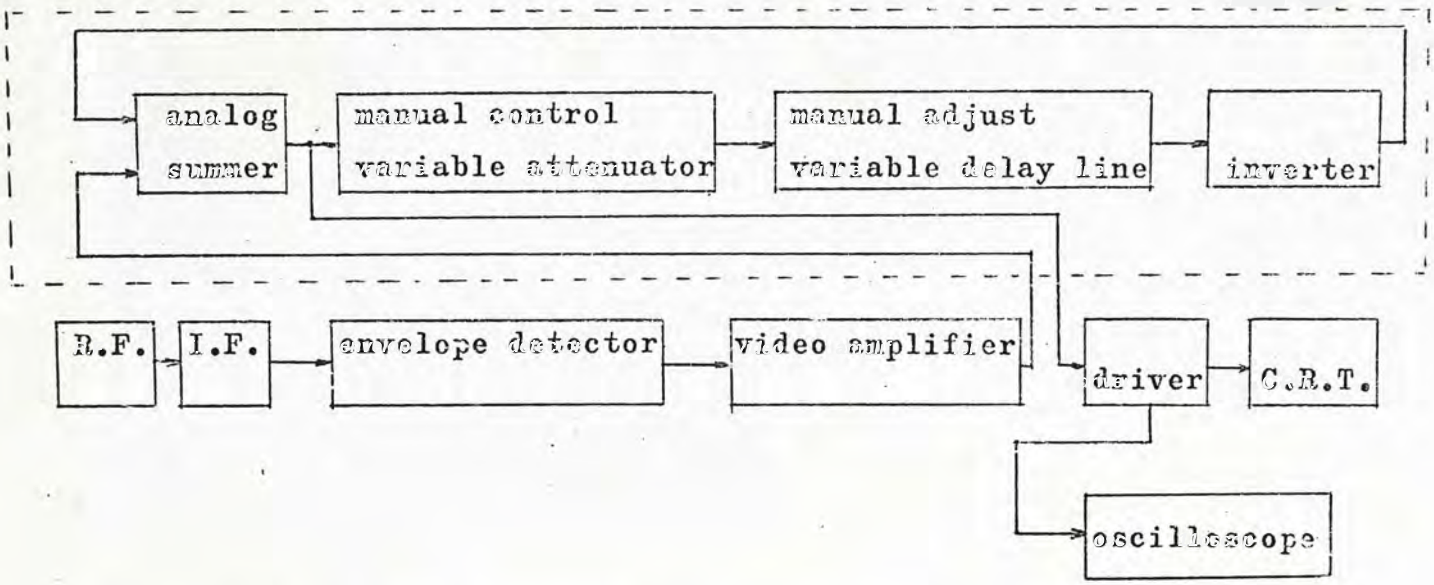


Figure 2-3-4. System inserted for ghost elimination. Blocks within the dotted line are the ghost elimination circuit inserted.

Comparing Figure 2-3-3 with Figure 2-3-1, it is shown that the ghost has been eliminated. The results indicate that the principle and the assumption made before are correct, and the method of cancellation of ghost can be realized in practice.

2-4 EFFECT OF INCORRECT COMPENSATION ON THE RECEIVING PICTURE

With incorrect attenuation and correct time delay, the system output gives an incompletely cancelled ghost picture. The waveform and the video display of this situation is shown in Figure 2-4-1.

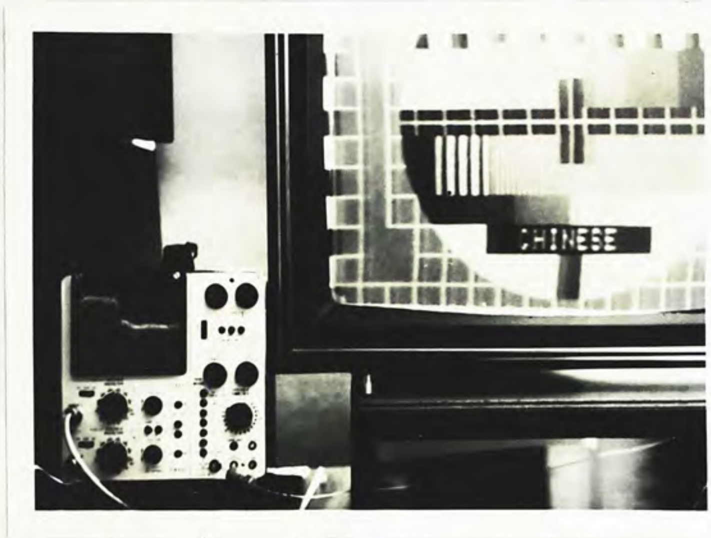


Figure 2-4-1. Picture with incomplete ghost amplitude cancellation.

With incorrect time delay, no matter whether the attenuation of the system is correct or not, the system will give a worse picture than without cancellation.

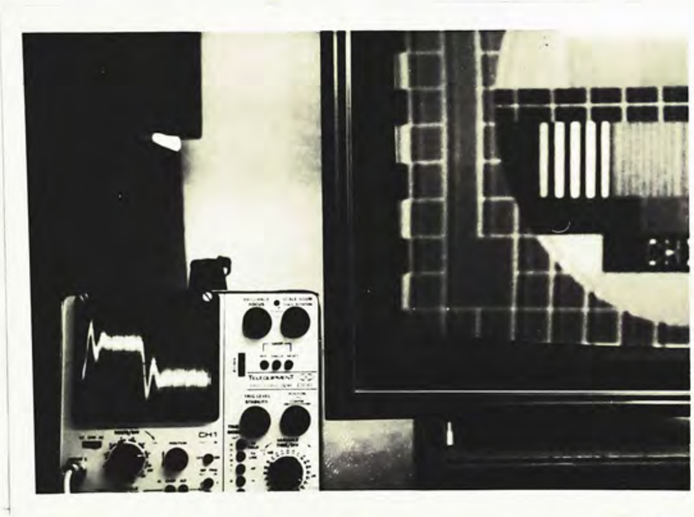


Figure 2-4-2. Picture after cancellation with incorrect time delay--shorter in time.

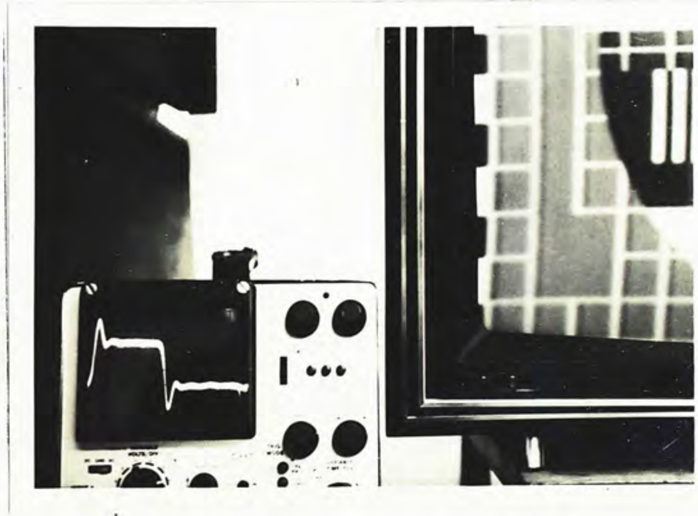


Figure 2-4-3. Picture after cancellation with non-zero delay when there is no ghost.

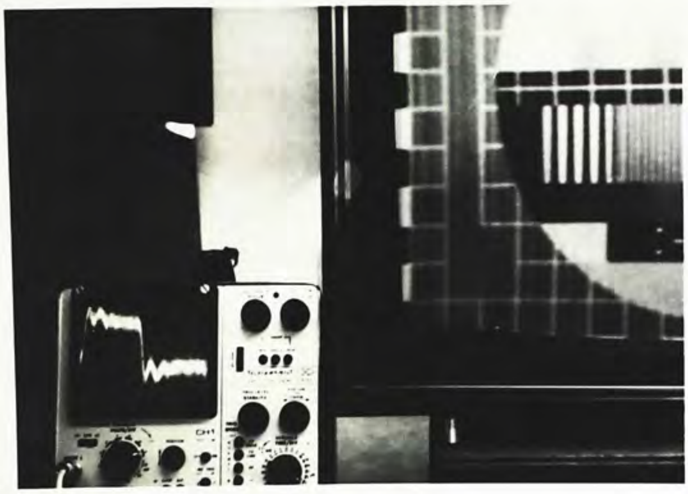


Figure 2-4-4. Picture after cancellation with incorrect time delay-longer in time.

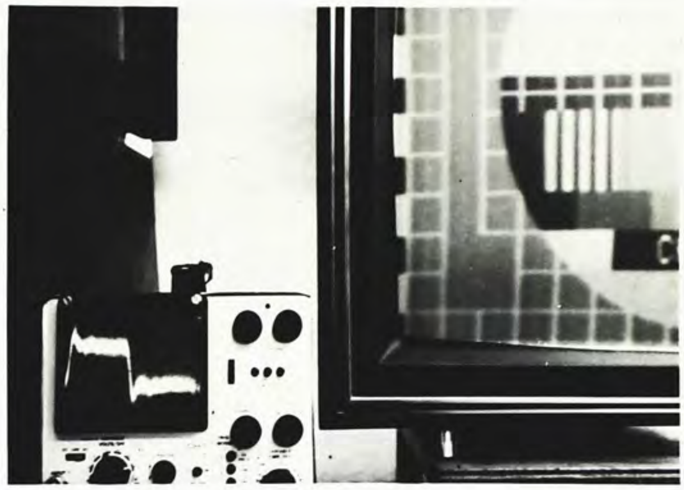


Figure 2-4-5. Same as in Figure 2-4-4 except with larger attenuation of the attenuator

The results indicate that an accurate time delay control is needed in order to yield an improved picture quality, but an incomplete ghost amplitude cancelled picture will be a better quality picture than without cancellation.

2-5 SELF-ADAPTIVE ELIMINATION OF GHOST IN TELEVISION

In order that the system works automatically, reference signal from which time delay and attenuation of ghost can be determined must be derived from the received signal. In television signal, the amplitude and timing of the sync pulse are held constant during transmission, it gives us a good reference to determine the control parameters. By comparing the amplitude and timing of the signal sync pulse and ghost sync pulse, control parameters can be obtained.

If the reflected wave has a time delay less than 5.8 μS,* the two signals are superimposed at the receiving antenna and give a video signal as shown in Figure 2-4-1. It provides a possibility that both the amplitude and time delay can be detected since the ghost sync pulse is stationary in time. But, if the reflected wave has a time delay greater than 5.8 μS, the ghost sync pulse superimposes on the video signal. Since the video content changes with time, this makes it difficult to detect both the amplitude and position of the ghost.

* Appendix I. Typical line showing synchronising pulse.

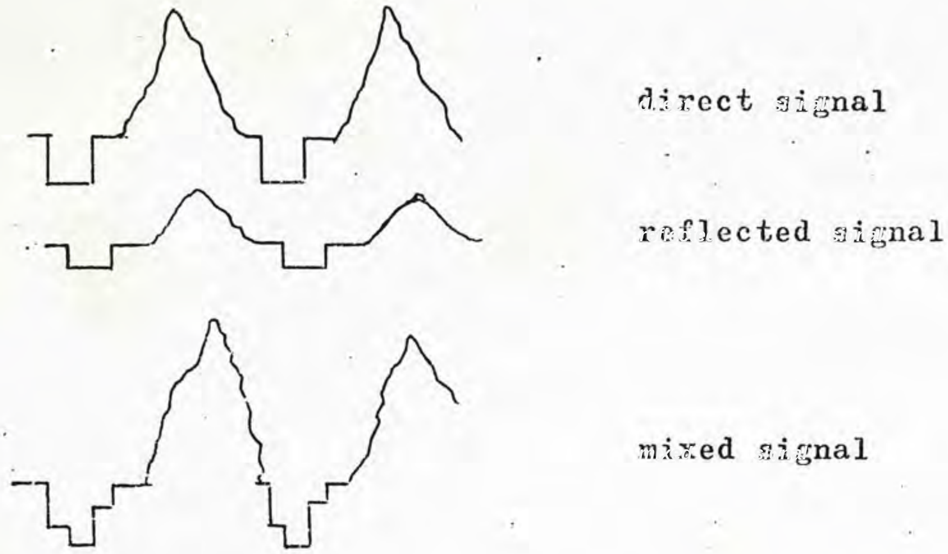


Figure 2-5-1. Video waveform of a typical line when the reflected signal with delay smaller than 5.8 µS. The ghost sync pulse superimposes on the back porch of the original signal. The time delay of the ghost can be determined by comparing the falling edges of the sync pulses. The amplitude of the ghost can be obtained by measuring the amplitude on the back porch of the original signal from the blanking level.

This condition can be avoided in the field blanking interval.* Even though the ghost has delay greater than 5.8 µS, information will not be lost. This is illustrated in Figure 2-5-2.

* Appendix II. Vertical synchronising and blanking waveform for a typical signal.

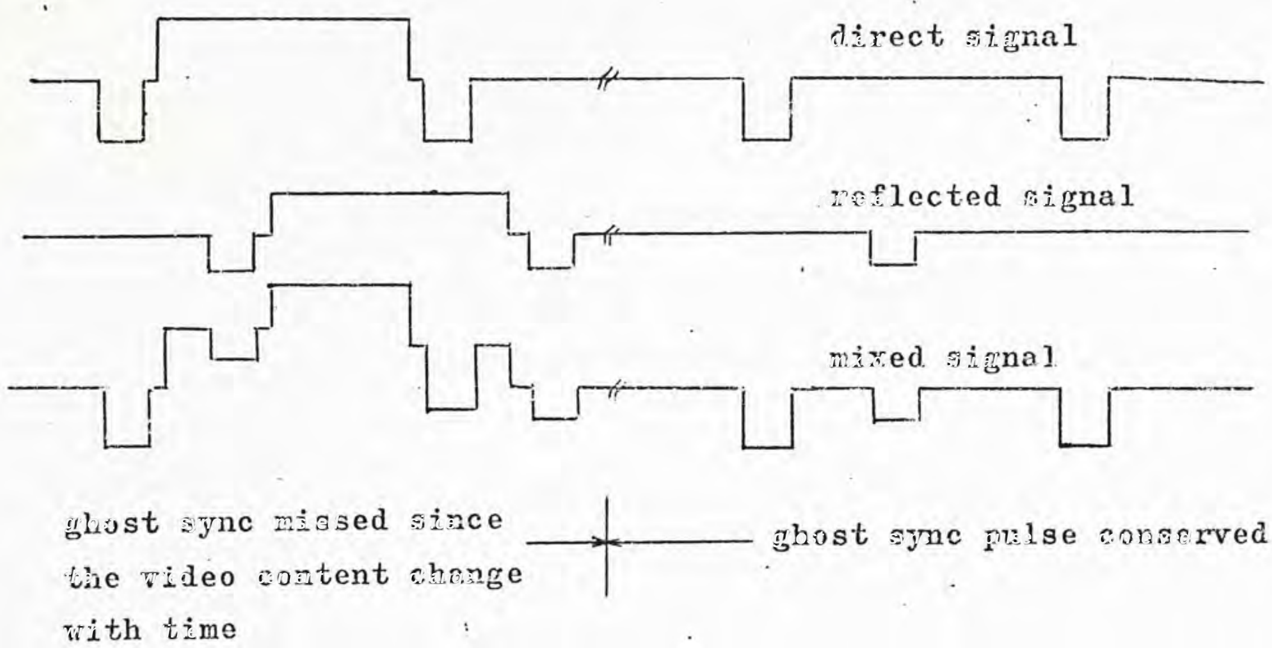


Figure 2-5-2. Amplitude and time delay of ghost is preserved in the field blanking interval.

By comparing the edges of the signal sync pulse and the ghost sync pulse on blanking lines, delay information can be obtained up to 64 μS. It is sufficient in practice. Since 1 μS delay on the television screen implies 300 meter path difference of the two signals, 64 μS delay implies there are 300x64 = 19200 meter in path different. For such a long length, the ghost will be attenuated to a negligible level compared with the direct signal when received.

It is shown that it is possible for self-adaptive cancellation of ghost in television.

2-6 CONCLUSION

The ghost elimination method is proven experimentally. It produces a ghost-free picture under actual receiving condition. It is a good evidence that the assumption make before is correct.

In black and white television system, it is found that automatic elimination of ghost is attainable. It is also shown in section 2-4 that the effects of wrong control parameters on the compensated picture. By using these results, it is a good starting point for circuit implementation for self-adaptive ghost elimination.

3. CIRCUIT IMPLEMENTATION

3-0 SUMMARY

In this chapter, circuit design of the system taking the practical requirement and previous conclusion into consideration is done. Section 3-1 states the tolerance of the time delay error accepted by visual perception. Some brief specifications of the system are also given in this section. Section 3-2 gives the block diagram of the adaptive TV ghost suppressor which will be discussed in detail on a separated block basis in section 3-3.

To measure time delay, digital circuit is used since it gives a reliable output under our situation and the output will be used to control the variable delay line directly. Closed-loop control is used in the attenuation control circuit in order that an accurate attenuation of the signal according to the ghost can be attained. Detail description of the reference signal selection circuit is given since all the control parameters will be obtained from this block.

3-1 SPECIFICATION AND SOME EXPLANATION

According to Figure 2-2-6, the final block diagram for ghost elimination, the system requires a variable attenuator, a variable time delay circuit, an inverter and an analog summer.

In practice, exact adjustment of the time delay of the variable delay line according to the ghost is hard to achieve, the following Figures show elimination of ghost with exact amplitude compensation but with incorrect time delay. It is found that 0.1 uS error has a negligible effect to visual perception.

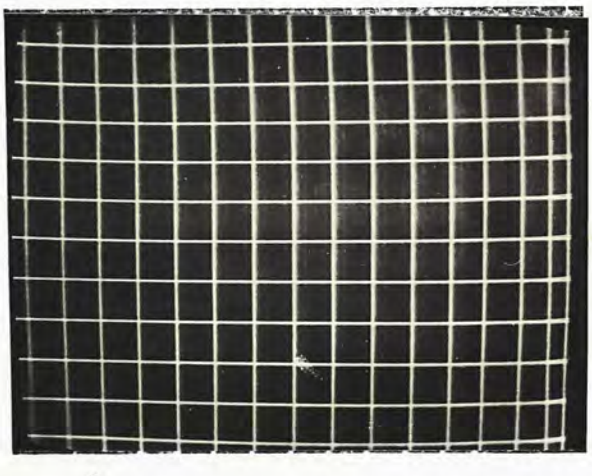


Figure 3-1-1. An exactly compensated picture for comparison purpose.

Figure 3-1-2. 1 µS delay ghosted picture with 0.9 µS time delay compensation

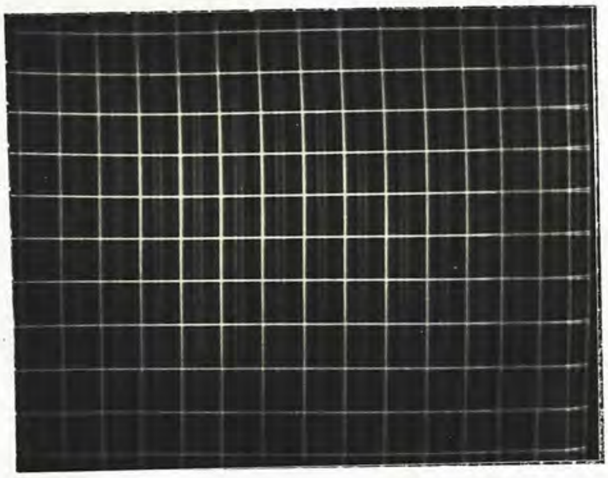


Figure 3-1-3. 1 μS delay ghosted picture with 0.8 μS time delay compensation

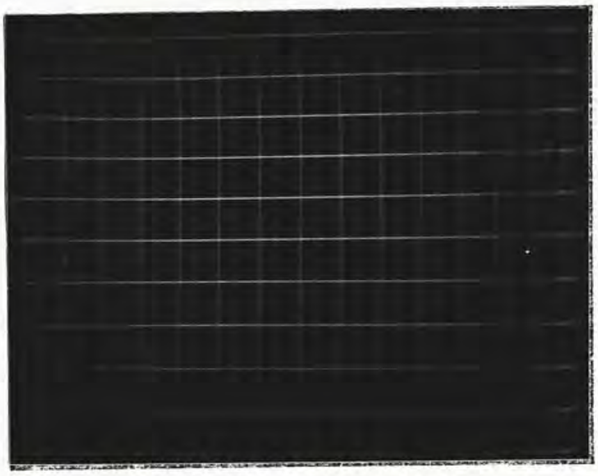


Figure 3-1-4. 1 μS delay ghosted picture with 0.7 μS time delay compensation

Although a more exact time delay adjustment in compensation will yield a better picture quality, more complex is the circuitry required. A trade off is made here that 0.1 uS step-change variable delay line is constructed for ghost elimination.

According to the results obtained in section 2-4, a correct time delay control is needed in order to yield an improved picture quality, the system must works correctly to avoid compensation with incorrect time delay. Any unreliable control parameters obtained must be discarded.

Since the video signal covers frequencies from $50H_z$-$5MH_z$. The circuits used in this system must be able to handle this frequency range.

Since the system is an adaptive one, the time delay and the relative amplitude of the ghost is determined from the signal itself. These measured parameters are used to delay and attenuate the signal in subtraction. The portion of the video signal from which this parameters can be obtained must be seperated out.

3-2 BLOCK DIAGRAM

According to the analysis and block diagram for ghost elimination stated above, the system layout is constructed as shown in Figure 3-2-1.

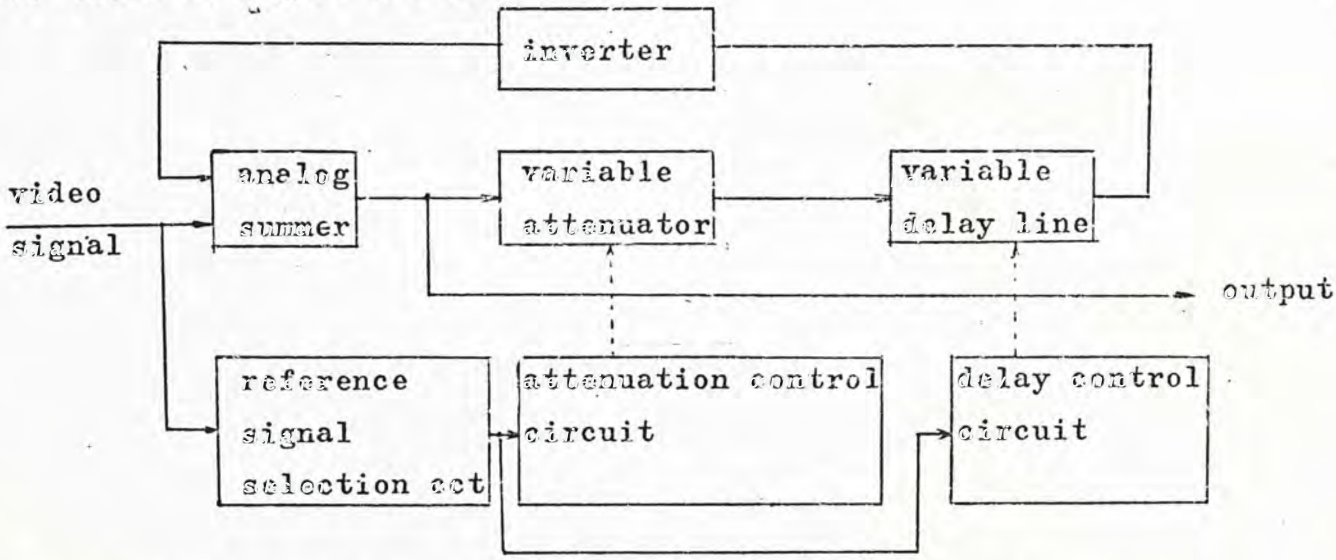
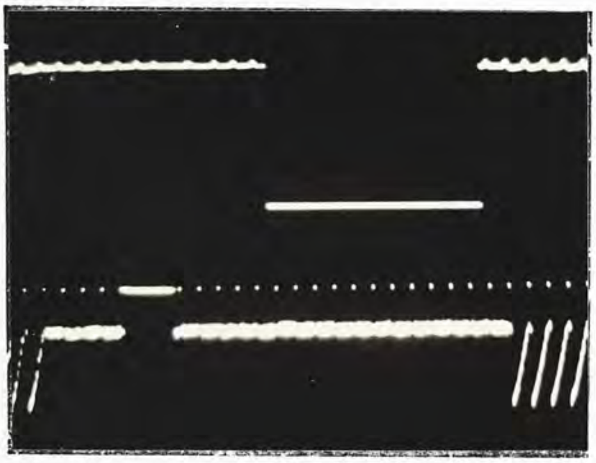


Figure 3-2-1. Block diagram of the adaptive TV ghost suppressor.

3-3 DESCRIPTION OF VARIOUS BLOCKS

3-3-1 REFERENCE SIGNAL SELECTION CIRCUIT

Since the only portion of video signal from which correct information about attenuation and time delay up to 64 uS can be obtained is the blanking lines, this portion must be seperated out. Figure 3-3-1-1 shows the blanking lines are selected by the pulse, namely, the blanking line selection pulse.

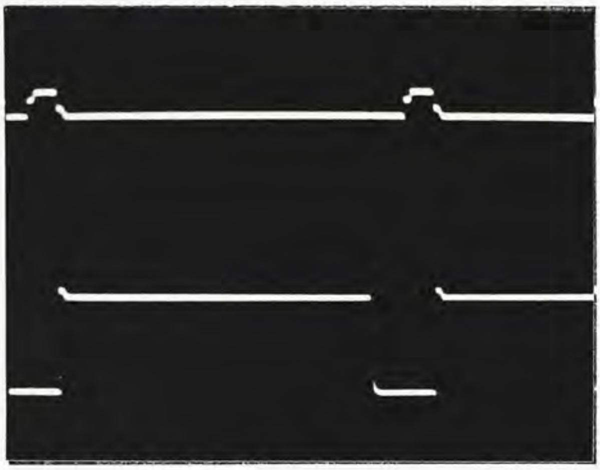


blanking line selection pulse

input video signal

Figure 3-3-1-1. The blanking lines are selected by the blanking line selection pulse.

In order that the ghost sync pulse which is smaller in amplitude than the signal sync pulse can be detected, the sync pulse of the direct signal must be gated out.

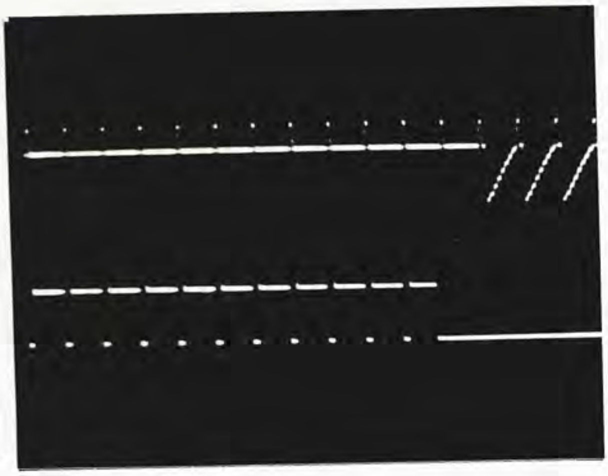


mixed sync pulse in the blanking lines

the remaining ghost sync pulse

<u>Figure 3-3-1-2</u>. The signal sync pulse is gated out in order to detect the ghost sync pulse which is smaller in amplitude than the signal sync pulse.

The pulse, namely the signal sync position pulse, which is used to gate the signal sync pulse out is derived from the separator output. Sync pulse of ghost with a few hundred nS time delay only will be lost if the sync separator output is used instead of the signal position pulse to gate the signal sync pulse out. This is due to the delay in the sync separator output caused by the switching recovery time. Figure 3-3-1-3 shows the video signal after selected by the blanking lines selection pulse and the signal sync position pulse together.



mixed video signal

blanking lines except the signal sync pulses are selected.

Figure 3-3-1-3. Signal from which control parameters are derived is selected by blanking lines selection pulse and the signal sync position pulse together.

In order to measure the relative amplitude of ghosts sync, D.C. level is reinserted to the blanking level of the composite video signal. Since the occurrence of ghost about 64 µS is rare, if at all, will have a negligible amplitude, the last 4 µS on every blanking line is used to reinsert the D.C. level. By now, the time delay of ghost can be suppressed is restricted within 64-4.7-4 uS. The timing relationship between the clamping pulse and the blanking line is shown in Figure 3-3-1-4.

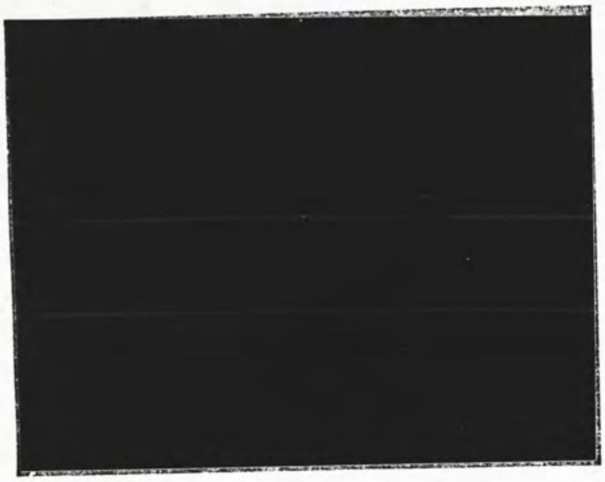


Figure 3-3-1-4. The timing relationship between the clamping pulse and the blanking line.

The block diagram for the reference signal selection circuit* is shown on the next page.

* Appendix III. Detail circuit description

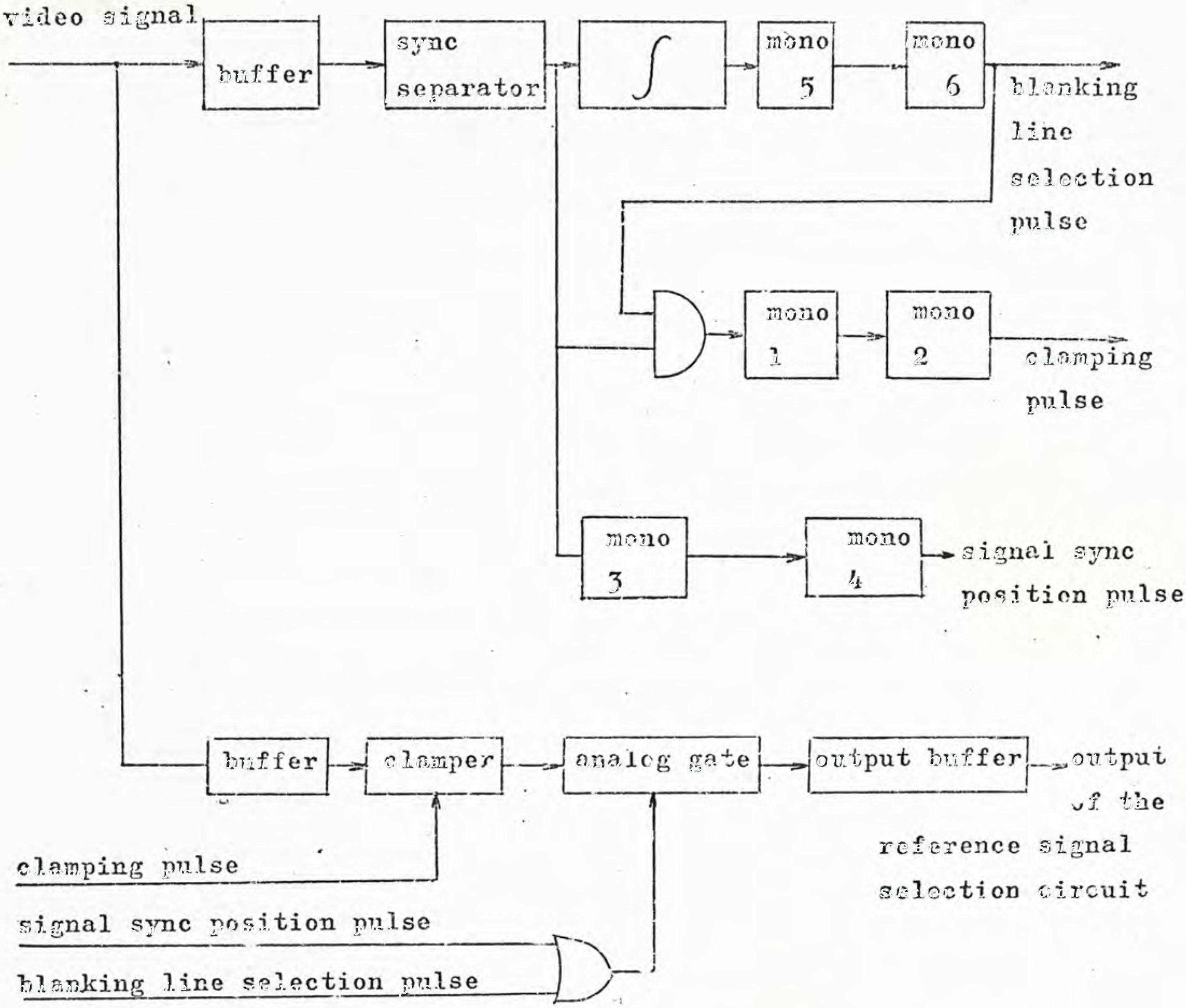
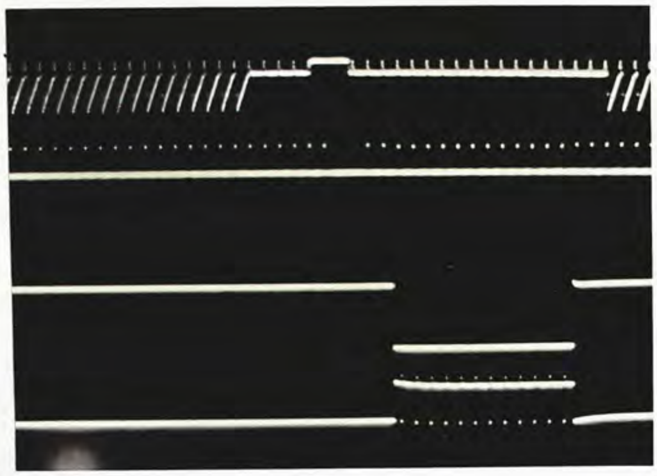


Figure 3-3-1-5. Block diagram of the reference signal selection circuit.

Monostable multivibrator 5, adjusting the location of the blanking line selection pulse, is triggered by the integrator output. Monostable multivibrator 6 adjusts the pulse width of the pulse. Monostable multivibrator 1 controls the location and monostable multivibrator 2 controls the pulse width of the clamping pulse. Monostable 3 and 4 reconstruct the sync pulse, namely, the signal sync position pulse. After OR'ing the signal sync position pulse with the blanking line selection pulse, it controls the analog gate. The output of the analog gate is fed to the attenuation control block and delay control block in which the control parameters are determined.

Figure 3-3-1-6 shows the time relationship of the video signal, control pulses, and output of the reference signal selection circuit. An enlarged picture shows the time relationship of the clamping pulse, the sync seperator output, the signal sync position pulse is shown in Figure 3-3-1-7.



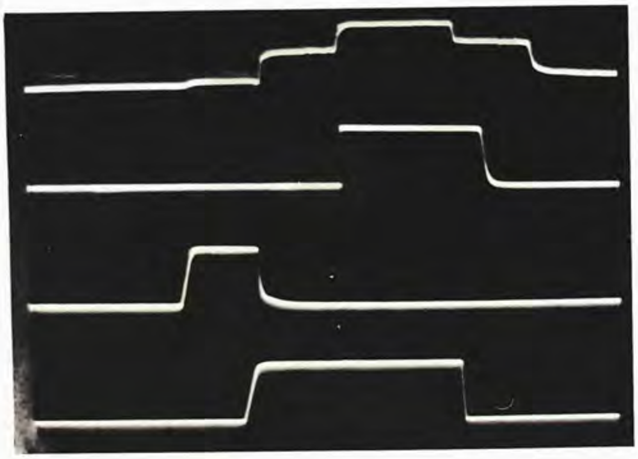
ghosted video signal

signal sync position pulse

blanking line selection pulse

output of the reference signal selection circuit

<u>Figure 3-3-1-6</u>. The timing relation between the video signal, the signal sync position pulse, the blanking line selection pulse and the output of this block.



video signal with ghost present

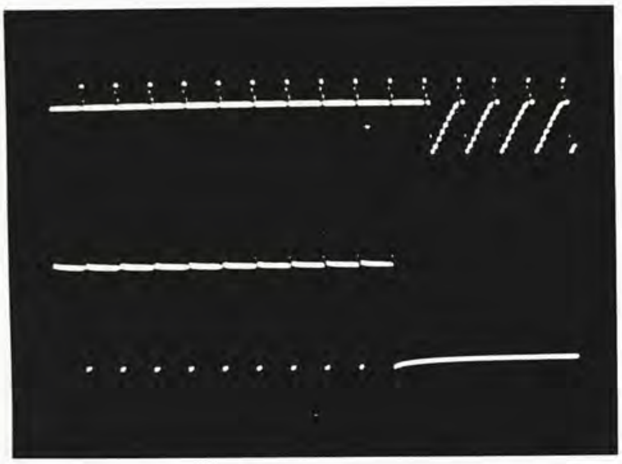
sync separator output

clamping pulse

signal sync position pulse

<u>Figure 3-3-1-7</u>. The timing relation between the video signal, the sync separator output, the clamping pulse, and the signal sync position pulse.

If ghost is present, the output signal of the circuit is as shown in Figure 3-3-1-8.



video signal with ghost present

preset D.C. level

ground level

output of the reference signal selection circuit when ghost is present

Figure 3-3-1-8. Output of the circuit when ghost is present. Only information between the sync pulse of the blanking lines is preserved.

3-3-2 VARIABLE ATTENUATOR

The band-width of the variable attenuator must cover the video band-width of the television signal which is 5 MHz. Suitable attenuator whose attenuation can be adjusted by electrical signal is used.*

* Appendix IV. Detail circuit description.

3-3-3 ATTENUATION CONTROL CIRCUIT

In order that the signal is attenuated to the amplitude of the reflected signal, a feedback controlled method is used to achieve this purpose. This is shown in Figure 3-3-3-1.

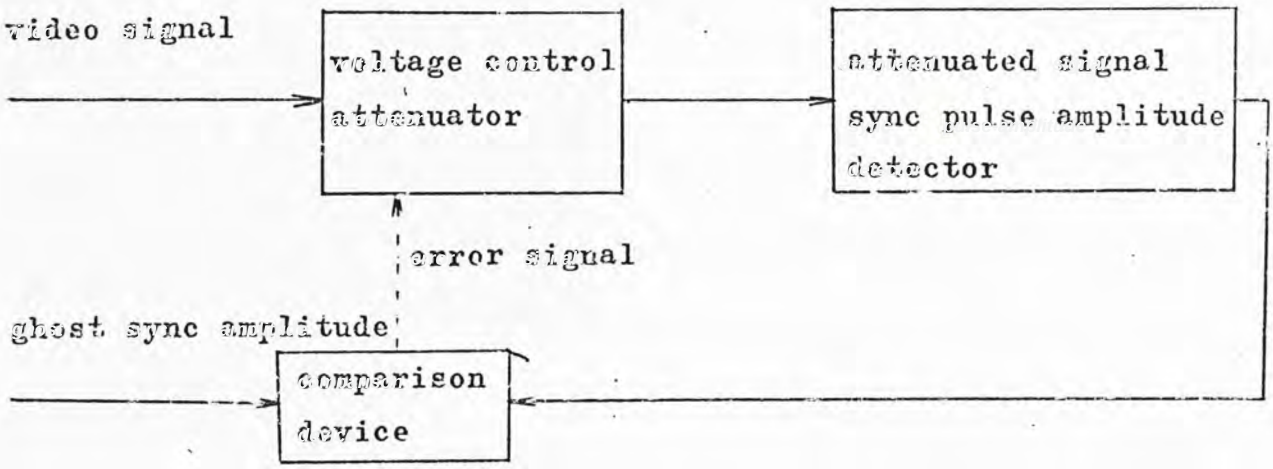
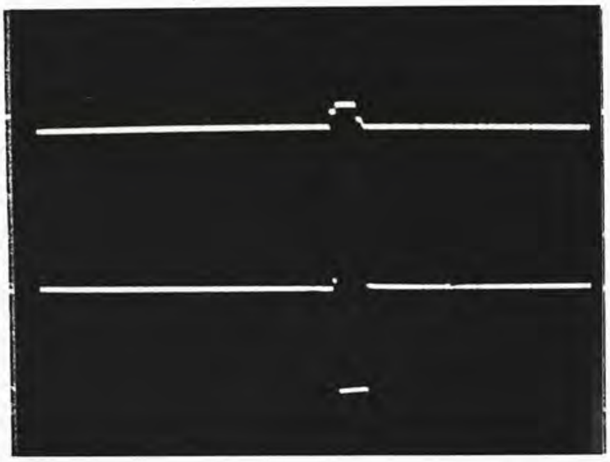


Figure 3-3-3-1. Feedback control is used in attenuation control circuit.

After attenuation, sync pulse amplitude of the attenuated signal is separated out and compared with the ghost sync pulse amplitude which can be obtained by detecting the maximun level above the preset D.C. level of the reference signal selection output.

If the ghost delay is less than 4.7 μS, the signal sync is superimposed with the ghost sync, in order to measure the sync pulse of the attenuated signal, the ghost sync pulse must be separated out.

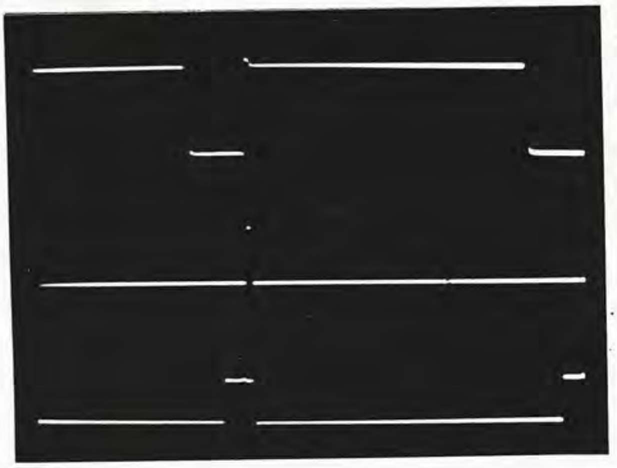


attenuated video signal

the ghost sync pulse is gated out

Figure 3-3-3-2. The ghost sync is gated out to avoid error in measuring the attenuated sync amplitude when the ghost delay is less than 4.7 μS. The amplitude of the attenuated signal sync is obtained by detecting the maximun level above the preset D.C. level as used in ghost amplitude detection.

Ghost sync position pulse, which gates out the ghost sync pulse from the attenuated signal, is derived from the output of the reference signal selection circuit. The output of the selection circuit is fed into a comparator whose threshold level is adjusted just above the preset D.C. level, the falling edge of ghost sync pulse is then enlarged. The ghost sync position pulse is obtained from a monostable multivibrator triggered by this edge. After OR'ing with the blanking line selection pulse, it is used to gate the ghost sync pulse out.



output of the reference signal selection circuit

voltage comparator output

ghost sync position pulse

Figure 3-3-3-3. The ghost sync position pulse is obtained by using a monostable multivibrator triggered by the falling edge of the comparator output with quasi-stable time = (64-4.7) uS.

The following block diagram shows the attenuation control circuit.*

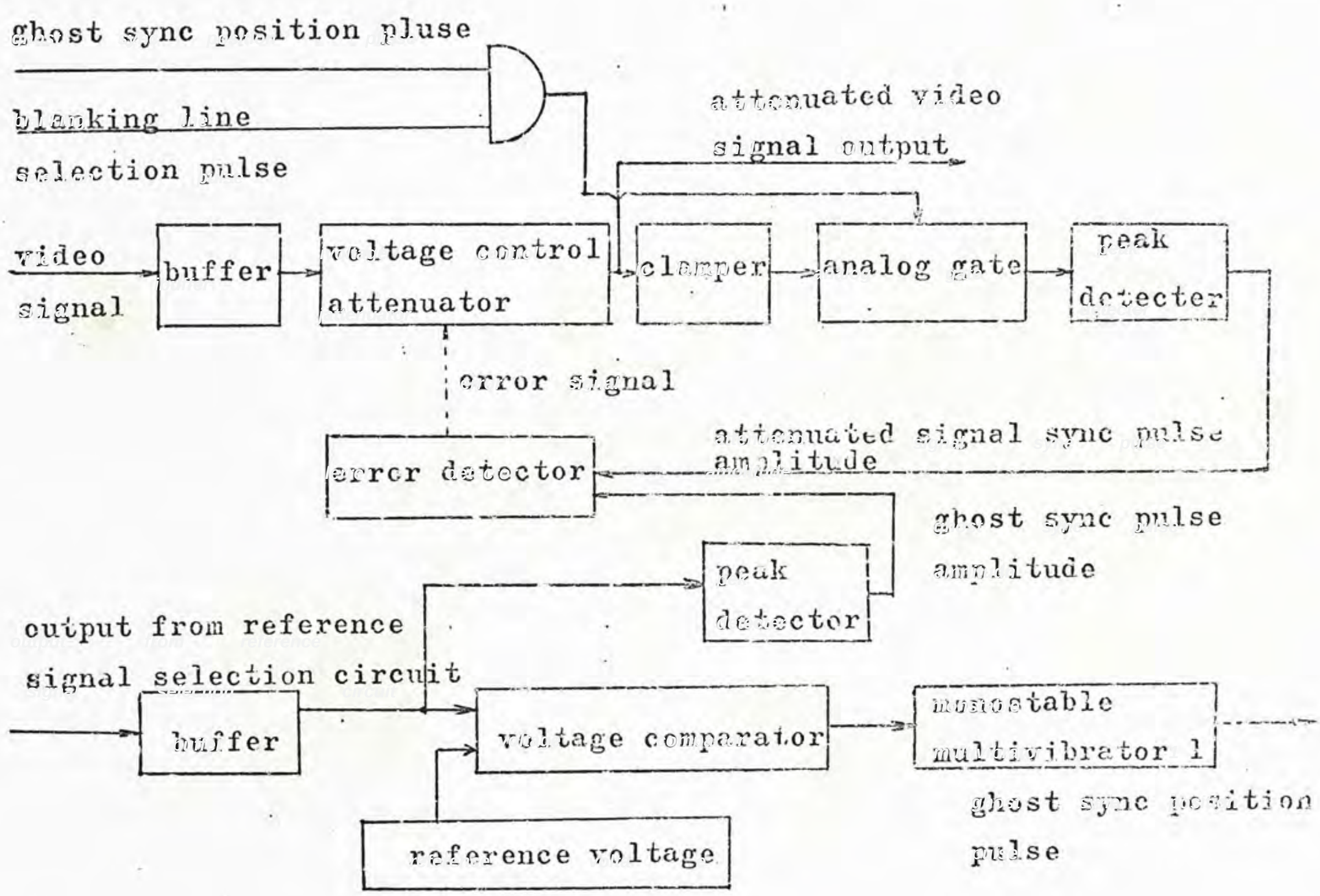


Figure 3-3-3-4. Block diagram of the attenuation control circuit.

* Appendix V. Detail circuit description.

The output of voltage comparator is used to trigger the monostable multivibrator 1 to generate the ghost sync position pulse. After OR'ing with the blanking line selection pulse, the attenuated signal sync pulse is selected. After passing through the peak detector, the D.C. voltage is compared with the ghost's one. The error signal drives the attenuator in the direction to reduce the error.

3-3-4 DELAY CONTROL CIRCUIT

The time difference between the falling edge of the signal sync pulse and ghost sync pulse can be measured by counting clock pulses between this interval.

Measurement will be wrong if the counting circuit is triggered occasionally by noise. A more reliable result will be obtained by averaging several counts.

The measured parameter will be loaded to the variable delay line just after the reference signal selecting pulse since switch process will not affect the picture in the blanking lines.

Since an exact* delay compensation is needed in this system, any wrong control signal will give a worse picture in result. Unreliable control parameter is discarded. The previous result is held until another correct control parameter is obtained.

* Exact means within 0.1 µS tolerance.

Since the ghost delay is able to change slowly, due to change of reflector and propagation medium characteristics, the previously measured parameter cannot be used indefinitely. Parameter will be cleared if no correct parameter has been received after a specified time.

In order that the signal will not be over compensated in case of no ghost, the control circuit will reset the parameter to zero immediately.

The following block diagram shows the delay control circuit.*

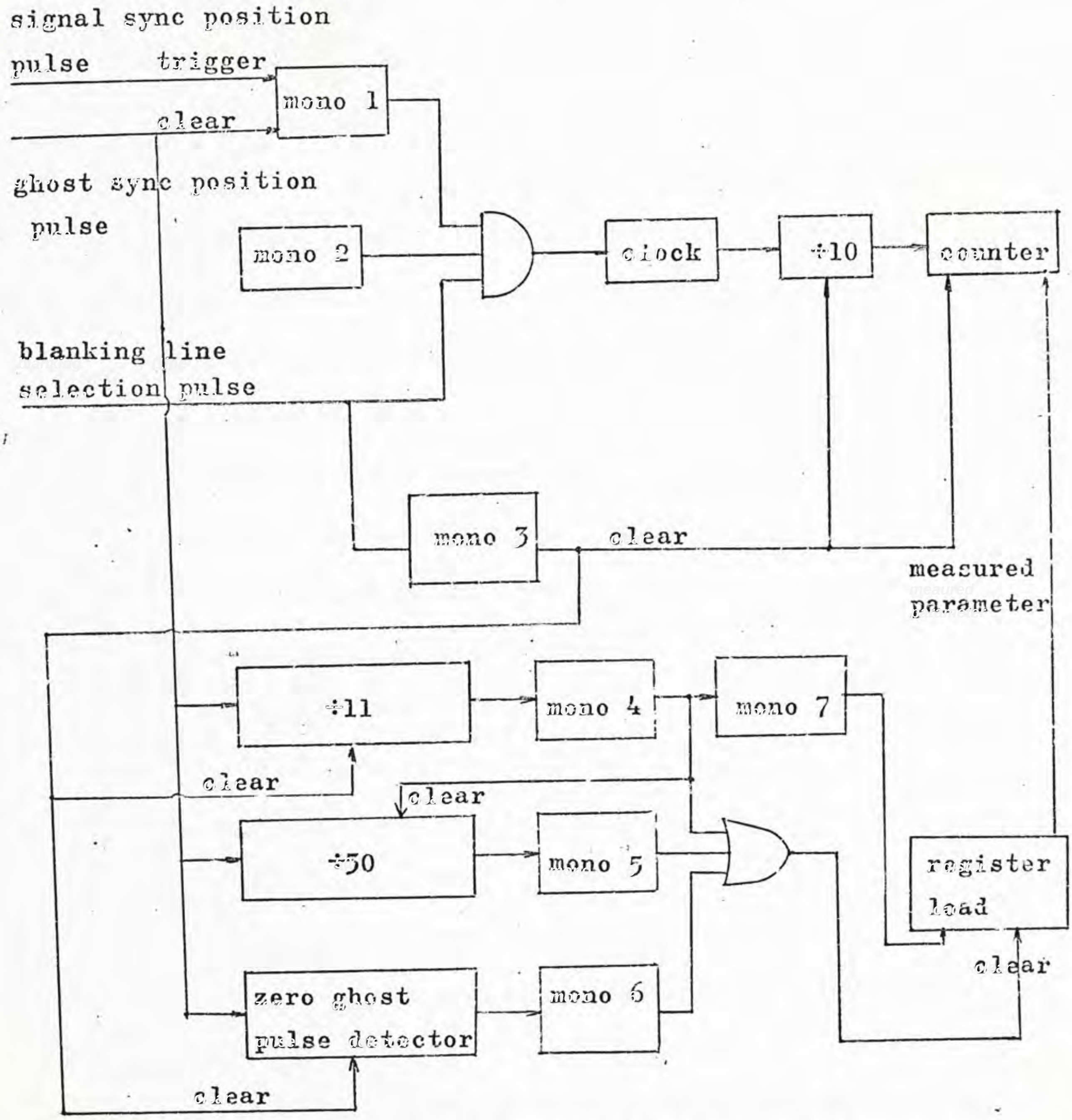


Figure 3-3-4-1. Block diagram of the delay control circuit.

* Appendix VI. Detail circuit description.

Monostable multivibrator 1, with quasi-stable time (64-4.7-4)uS is triggered by the falling edge of the signal sync position pulse, and cleared by the negative edge of the ghost sync position pulse if it is present. In order not to miscount when ghost is absent, monostable multivibrator 2 serves as ghost existance tester which inhibit the clock when ghost is absent. It is a retriggerable monostable multivibrator with quasi-stable time longer than 64 uS, it will be turned on after first ghost sync position pulse and retriggered by the following ten pulses. The reference signal selection pulse ensures that the delay control circuit operates within the chosen blanking lines. The clock pulse which is enabled by monostable 1, 2, and the blanking line selection pulse is counted by the counter after divided by ten.

If the ghost sync position pulse is counted exactly equal to eleven, this implies the measured parameter is correct, information will replace the old one in the register.

If ghost position pulse is counted exactly equal to zero. This implies no ghost is presented, information in the register will be cleared immediately.

If ghost position sync is counted not equal to zero or eleven, unreliable parameter is measured. If within 5x50 lines, that is 5 second, no correction information is obtained, the register is cleared to zero. Any output at the ÷11 counter will reset the ÷50 counter to zero for measuring of the next 5 second.

The following Figure shows the timing relationship of the pulses in the control delay circuit.

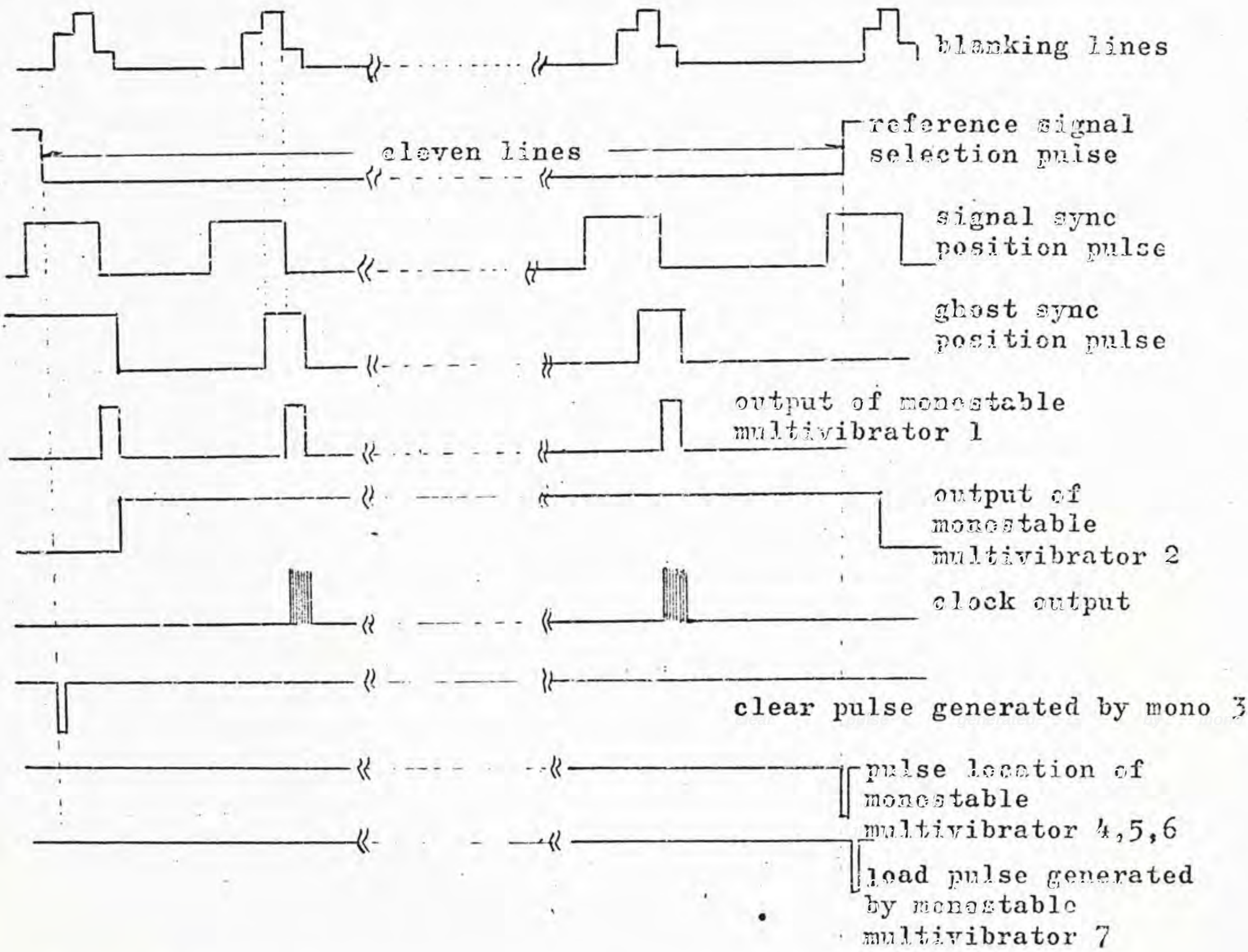


Figure 3-3-4-2. Timing relationship of the pulses in the control delay circuit.

3-3-5 VARIABLE DELAY LINE*

The variable delay line is constructed by using the Ampex 570-211 delay line. The maximun delay time of the variable delay line built is 1.2μS just for testing purpose. Frequency response of it is flat over 5MHz bandwidth. Variable delay times are obtained by tapping out in a 0.1 μS step at different available tap-points on the delay line through the analog switches which are controlled by the decoded outputs of the delay control circuit.

3-3-6 SUMMER AND THE INVERTER**

The summer and the inverter are common circuits. The only requirement of them is that the frequency response mustbe able to cover the bandwidth of video signal.

* APPENDIX VII. Detail circuit decription.

** APPENDIX VIII. Detail circuit description.

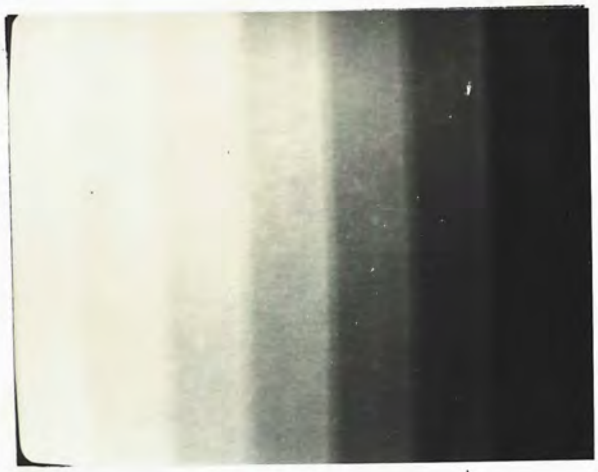
4. NOISE PROBLEM

4-0 SUMMARY

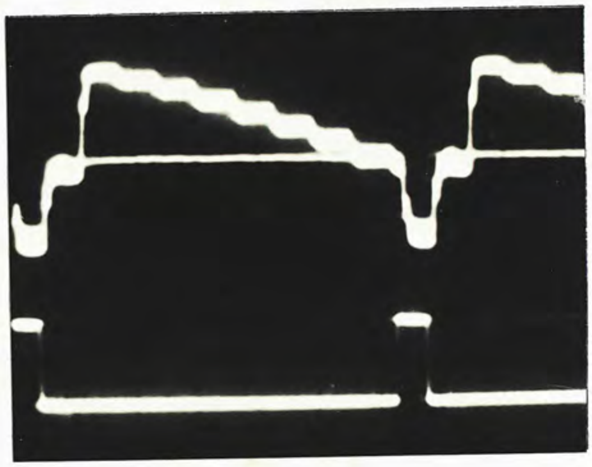
Normally, the video signal received is accompanied by noise. When the noisy ghosted signal is fed into the system for ghost elimination, incorrect operation since the control parameters are disturbed by noise. In this chapter, method of solving the noise problem is described. It is found that multichannel averaging method is suitable for noise rejection. Design for a multichannel averaging unit which is suit'ed to the purpose of control parameters recovering in the economic sense is described in paragraph 4-3-3.

4-1 NOISY TV SIGNAL

Under actual condition, the television signal received by the television receiver is accompanied by noise. Figure 4-1-1 shows picture with different amount of noise and their corresponding video waveform.

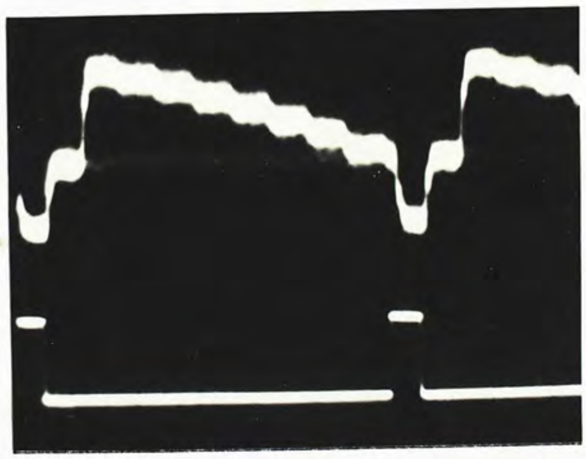


picture on the screen with lower noise



received video waveform

picture on the screen with higher noise



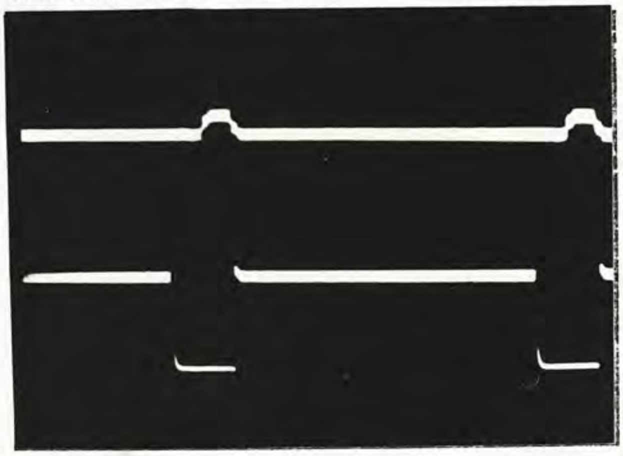
received video waveform

Figure 4-1-1. Noisy pictures and their corresponding video waveform

4-2 EFFECT OF NOISE ON THE SYSTEM

As shown in Figure 4-1-1, the noise amplitude of the video waveform of the acceptable picture is comparable with the ghost. Under noise present condition, the system described above cannot work normally.

Firstly, the system measures the ghost amplitude by peak detection of the blanking lines from the blanking level with signal sync pulses being gated out. Error will occur when noise is present since the maximum level is risen by the presence of noise. This is shown in Figure 4-1-2.

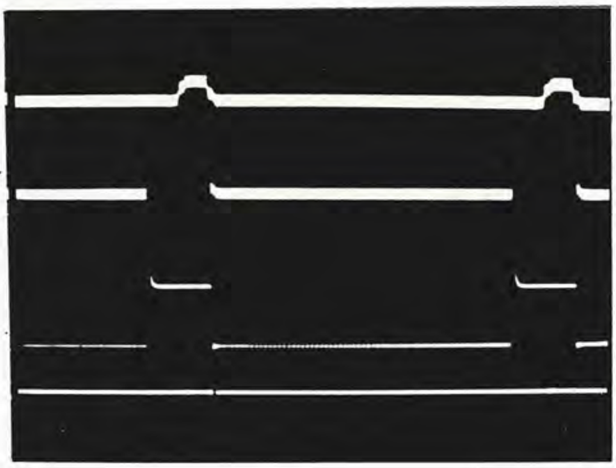


noisy input signal

reference signal selection circuit output under noisy condition

Figure 4-1-2. The output waveform of the reference signal selection circuit when the input video signal is superimposed by a 1 MH_z sinusoidal signal.

Secondly, the ghost position is determined by comparing the voltage level in the blanking lines with the preset D.C. level. Error will also occur if noise is present. Figure 4-1-3 shows additional outputs from the voltage comparator due to the present of the sinosoidal signal are obtained.



noisy input signal

reference signal selection circuit output under noisy condition

output of the voltage comparator in the attenuation control circuit as shown in Figure 3-3-3-4

Figure 4-1-3. Error occurs when the noisy reference signal selection circuit output is used to determine the ghost position.

Futhermore, the sync separator output will be disturbed by high level noise, under this situation, the system will work incorrectly since all the gate pulses, the clamping pulse, sync position pulses are derived from the sync separator output directly or indirectly.

4-3 METHOD OF SOLVING THE NOISE PROBLEM

4-3-1 PHASE-LOCKED LOOP METHOD

In television receiver, phase-locked technique is used in the horizontal sweep circuit in order to obtain a stable scanning. Figure 4-3-1-1 shows a typical circuit of phase-locked loop.

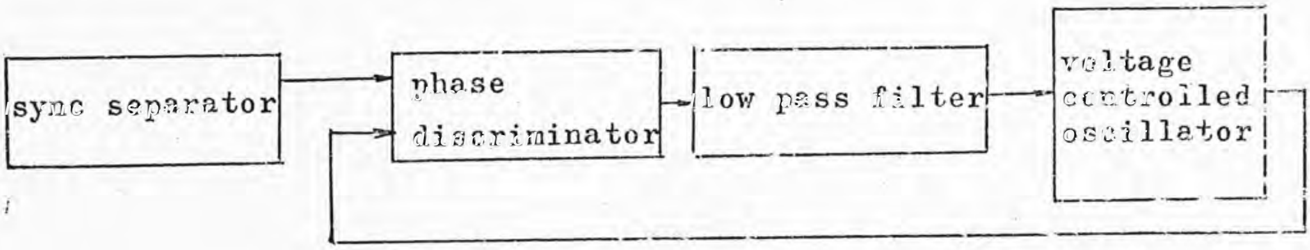


Figure 4-3-1-1. Phase-locked loop for sync pulse recovering.

The sync separator output, some of them are due to occasional spike is compared with the output of the voltage-controlled oscillator. Leading or lagging in phase will give a positive or negative voltage at the discriminator output, any short term output is rejected by the lowpass filter. The output voltage is then fed to the control terminal of the voltage control oscillator. The oscillator output, which is noise free, indicates the position of signal sync pulse reliably. A typical circuit of the phase-locked loop using in television is shown in Appendix IX.

A similar configuration can be used to recover ghost sync from noise. However, some modification must be done. Since the ghost sync position pulse occurs only eleven times per field, the control voltage must be temporary stored when the ghost sync is absent. New comparison will be continued when the next group of ghost sync pulse arrives. The following Figure shows the modified phase-locked loop for ghost position recovering.*

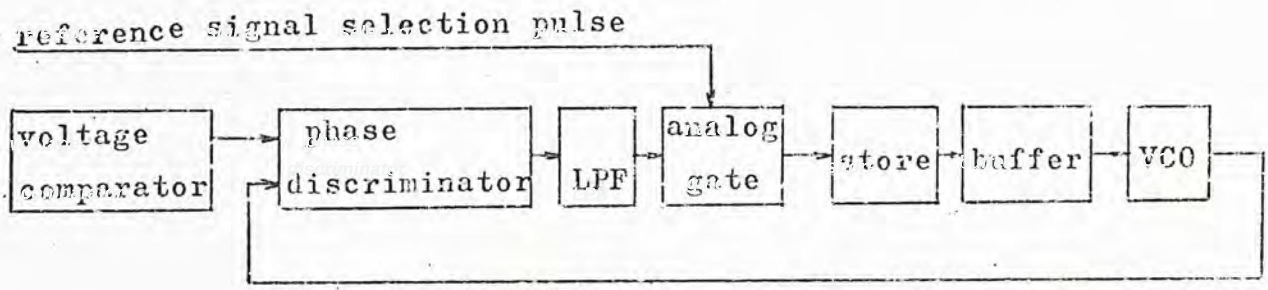


Figure 4-3-3-2. Modified phase-locked loop for ghost sync recovering.

The gate, controlled by the reference signal selecting pulse is closed when the ghost sync pulse is present. The storage element, which is a small capacitor followed by a very high input impedence voltage buffer, holds the lowpass filter output voltage when the gate is opened. The output signal is locked to the input frequency eventually.

* Appendix X. Detail circuit diagram.

After the edges of the signal sync pulse and the ghost sync pulse are recovered, time delay can be detected.

The amplitude of the signal sync pulse and the ghost sync pulse which are needed in the closed-loop control attenuation control circuit must be found. By examining the signal sync position pulse and the ghost sync position pulse, it is found that the amplitudes can be found with the help of logic circuit. Figure 4-3-1-3 and Figure 4-3-1-4 show the portions where the amplitude of the sync pulses can be obtained. Method of obtaining original amplitude of the noisy sync pulses is shown in Figure 4-3-1-5.

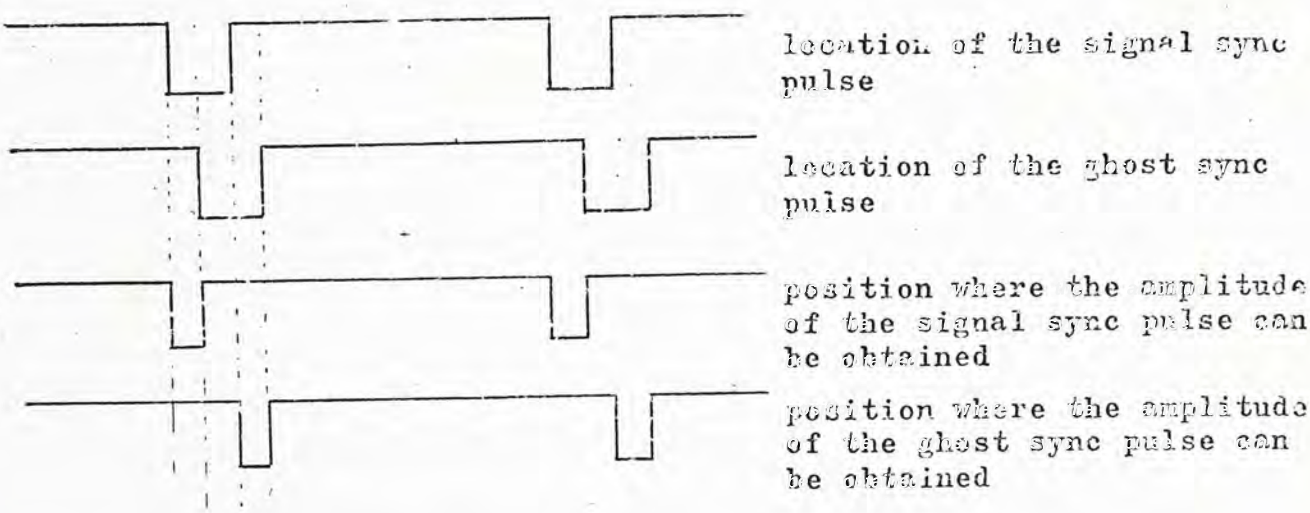


Figure 4-3-1-3. Amplitude of the signal sync pulse and the ghost sync pulse can be found with the help of logic circuit. The Figure shows the wanted portions when the time delay is less than 4.7 μS.

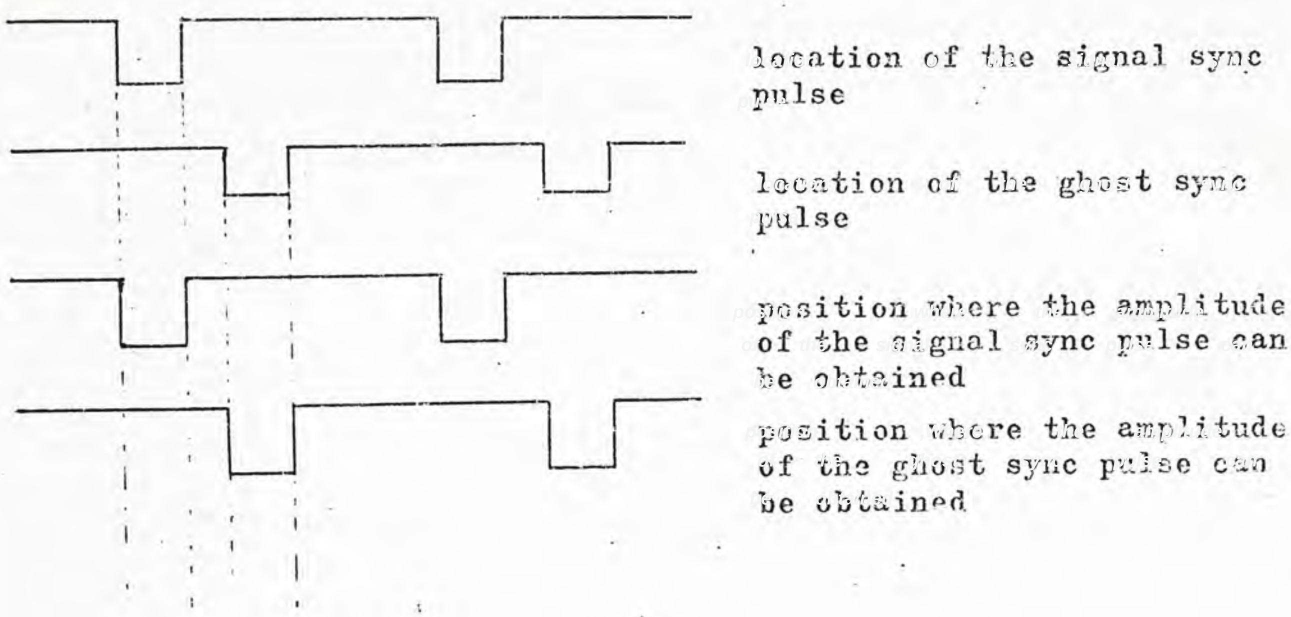


Figure 4-3-1-4. Wanted portions for amplitude recovering when the time delay is longer than 4.7 μS.

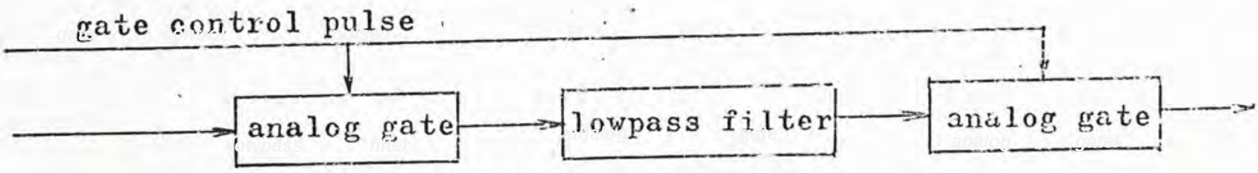


Figure 4-3-1-5. The amplitude of the noisy sync pulses can be recovered by averaging the amplitude of the wanted portion.

The averaged output of the portion of the noisy sync pulse wanted is illustrated in Figure 4-3-1-6. The detail circuit for amplitude recovering is shown in Appendix XI.

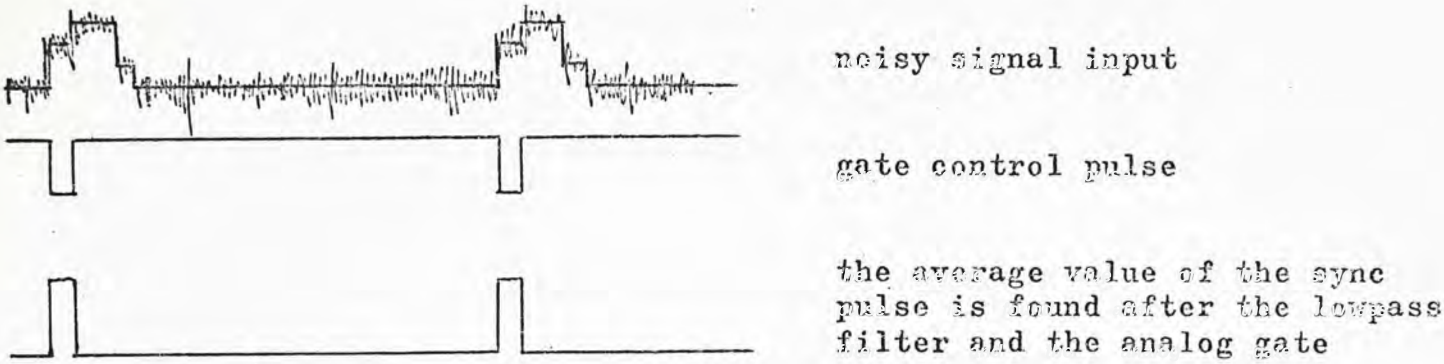


Figure 4-3-1-6. The amplitude of noisy sync pulses are recovered.

4-3-2 MULTICHANNEL AVERAGING METHOD

Figure 4-3-2-1 shows the basic idea of multichannel averaging technique. It recovers the original signal by averaging the corresponding sections of the repetitive signal and then sums it back together.

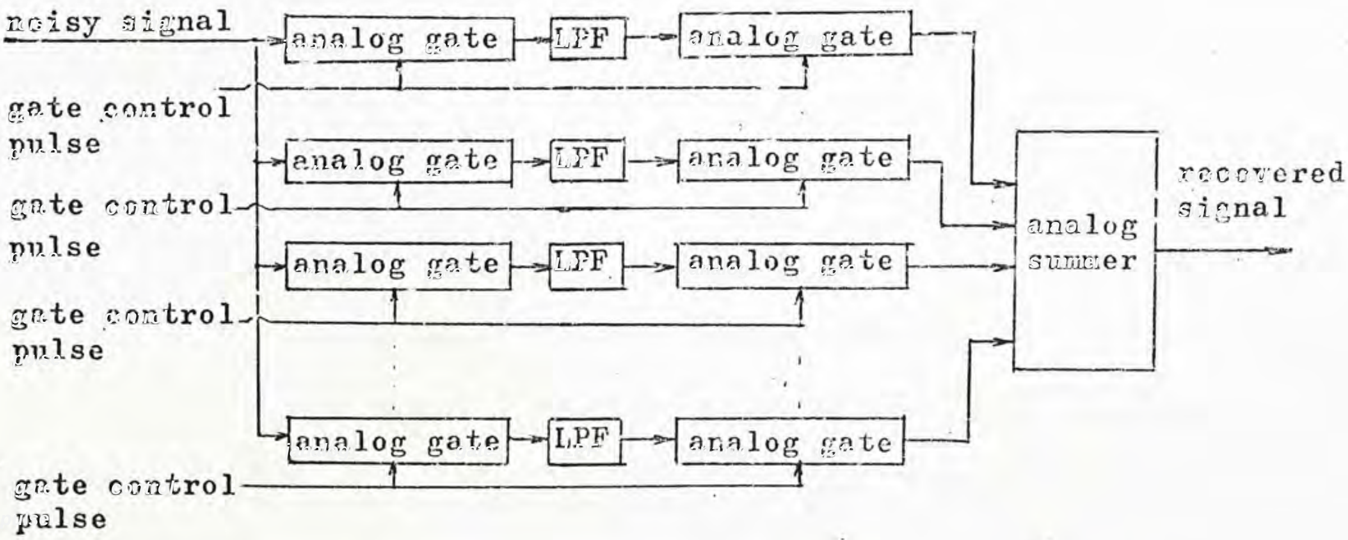


Figure 4-3-2-1. Basic idea of multichannel averaging technique.

Since the same section of the perodic signal must be gated into the specified gate, a reliable reference pulse which strictly indicates the phase of the signal must exist to supervise the gates operating sequentially.

This method can be used in recovering the sync pulse of the video signal since it is a repetitive signal. The reference signal can be derived from the voltage controlled oscillator output which provides horizontal scanning of the receiver. Reference signal will be lost at the moment when the direct signal received is too weak for satisfactory reception only.

The ability of reproduction of the original signal depends on the noise superimposed on the signal and the gate width of the sampling gate. For a longer gate time, the system will be simpler, but the output waveform will be distorted more heavily. The gate width for sync pulse recovering is chosen to be 0.1 uS since 0.1 uS resolution is needed.

Since the information on which the system makes decision is the blanking lines gated out by the reference signal selection pulse, multichannel averaging is needed to be done only on this portion. After the noise of this portion is rejected by the averaging circuit, the ghost can be eliminated self-adaptively by using the system stated before. Figure 4-3-2-2 shows multichannel averaging is done on the blanking lines only.

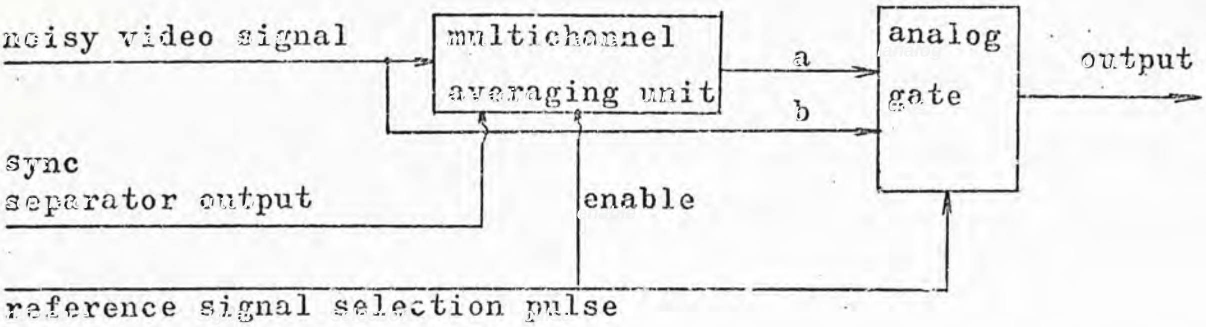


Figure 4-3-2-2. Multichannel averaging is done on the blanking lines in order to reject the noise which makes the system works incorrectly.

The gate, which is controlled by the reference signal selection pulse, switches input a or b into the output. When the reference signal selection pulse connects a to the output, it enable the multichannel averaging simultaneously. The multichannel averaging circuit must be disabled at the end of the blanking lines since video signal which is non-perodic will be present.

4-3-3 SAVING CHANNEL IN RECOVERING OF SYNC PULSE

In order to average the signal, 64x10 channels must be used in order to cover the 64 µS period. A complicated circuitry is involved.

Instead of averaging signal before being fed to the system, averaging can be done on the output of the reference signal selection circuit from which the control parameters is derived. (64-4.7-4)x10 channels are needed in order to recover the ghost sync pulse which will locate anywhere in this range. Figure 4-3-3-1 shows multichannel averaging is done on the output of the reference signal selection circuit. Figure 4-3-3-2 shows the input and output of the multichannel averaging unit using configuration as shown in Figure 4-3-3-1.

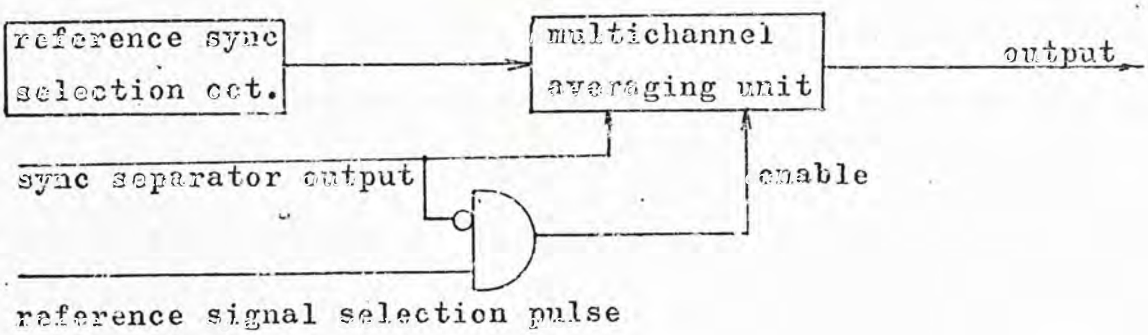
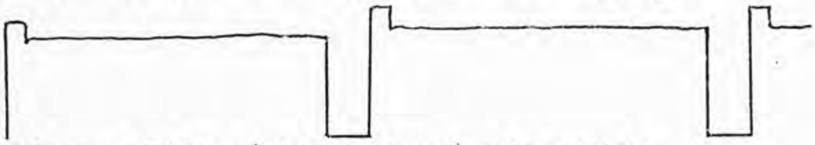


Figure 4-3-3-1. Multichannel averaging is done on the output of the reference signal selection circuit instead of what is done as shown in Figure 4-3-2-2.

waveform before multichannel averaging



waveform after multichannel averaging

Figure 4-3-3-2. The input and output of the multichannel averaging unit using configuration as shown in Figure 4-3-3-1.

Since only the ghost sync pulse carries information about time delay and relative attenuation only, averaging on the rest is a waste. It is economical to multichannel-average only around the location of the ghost, then, only 4.7x10 channels are needed.

Before averaging, the ghost location must be found at first. Sampling is taken between the signal sync pulses in the blanking lines, any sampling output has a voltage higher than the blanking level indicates that ghost is present. Under this condition, the multichannel channel averaging unit which will last for 4.7 µS after tuned on is enabled. In order not to miss any ghost sync pulse between the signal sync pulses, the seperation of the sampling pulse must less than 4.7 µS. Although the averaging unit will not garantee the complete recovery of the ghost sync pulse,it is sure that the falling edge of the ghost sync pulse will be found with a maximun error of 0.1 µS. This error, which cause delay in the falling edge of recovered ghost sync pulse will cancel the truncation error cause by the divide by ten counter in delay control circuit to some degree. Therefore the error will not accumulate to a level larger than 0.1 µS. After the edge is found, the amplitude of the sync pulses can be found as in paragraph 4-3-1. Figure 4-3-3-3 shows the circuit diagram of the averaging unit. The relevant pulse, input and output are shown in Figure 4-3-3-4. The detail circuit is shown in Appendix XII.

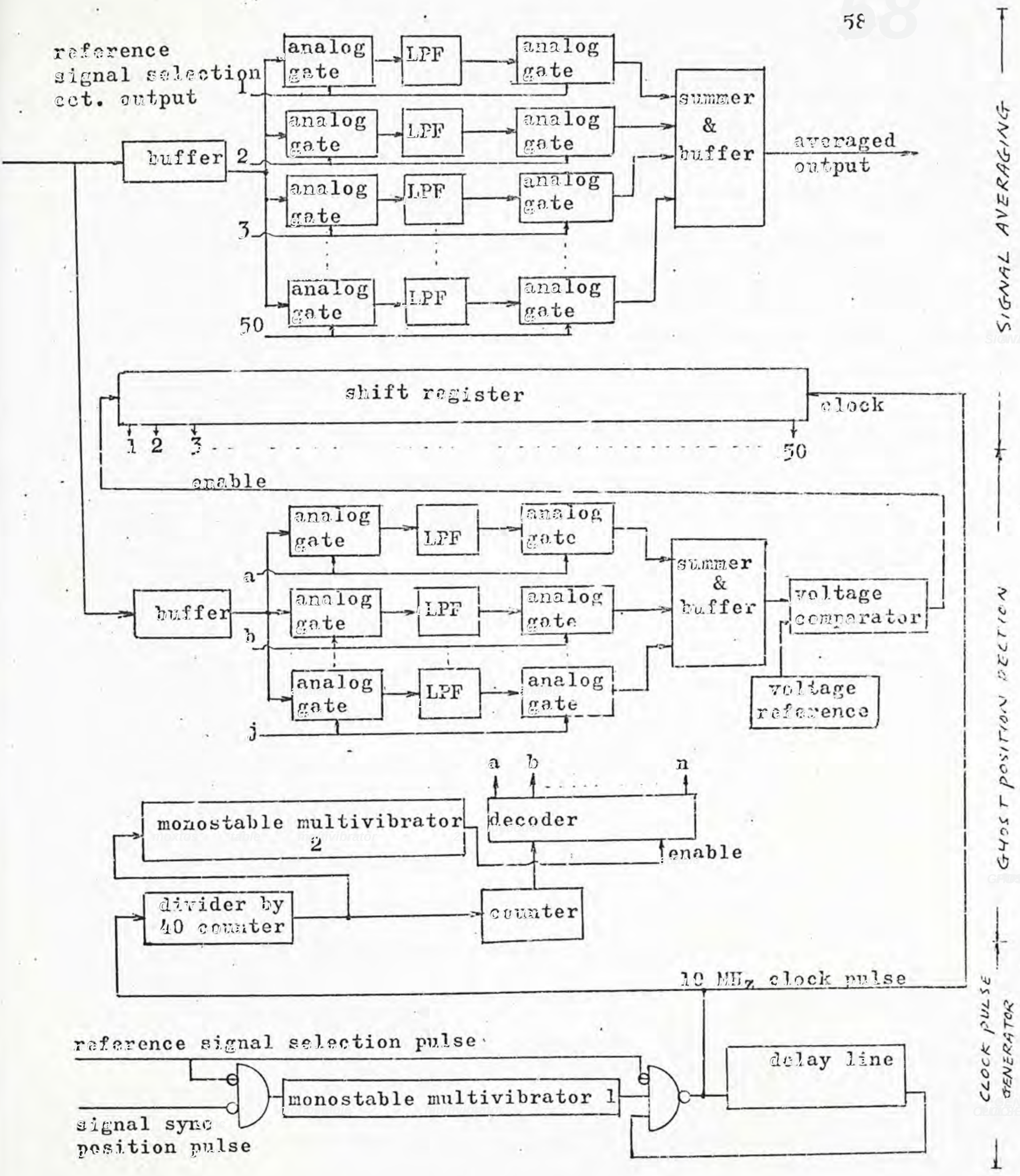


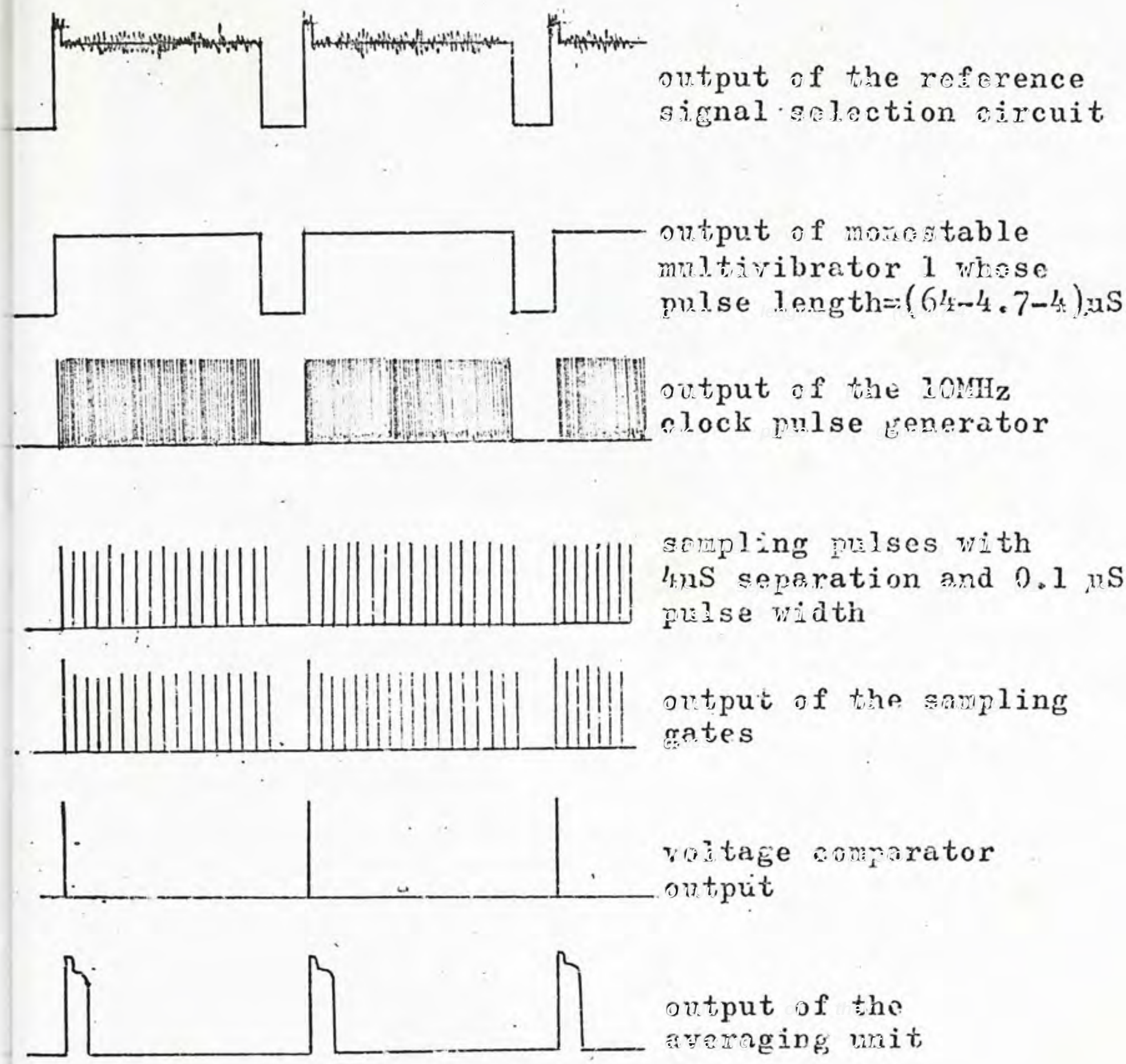
Figure 4-3-3-3. Block diagram of the averaging unit.

The clock is enabled by reference signal selection pulse which ensures that averaging process is done in this period. Monostable multivibrator 1 disablesthe clock at the signal sync pulse period. It is triggered on by the falling edge of signal sync position pulse with output pulse length equal to (64-4.7-4) µS. It possesses an additional function that it ensures the clock pulse is synchronized with signal in every line.

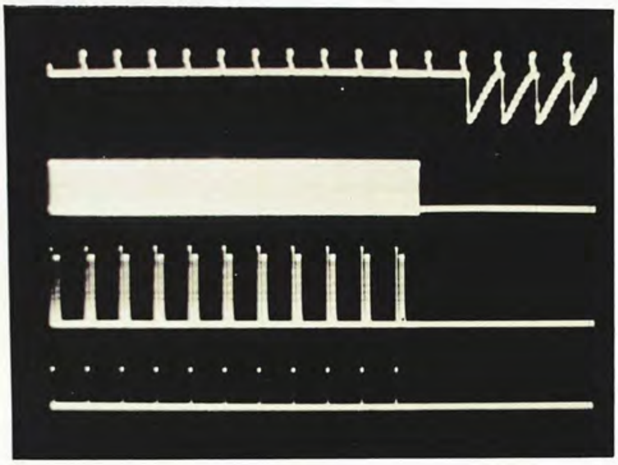
The clock pulses, divided by the ÷40 divider which determines the separation between sampling pulses, is then counted by the counter. The output is decoded by a 4-to-16 decoder whose outputs are used to drive the sampling gates. The sampling width of the sampling pulse is controlled by monostable multivibrator 2 whose output enables the decoder for 0.1 µS after each count. Any further voltage comparator output are blocked after the first one is shifted into the shift register in every blanking line.

If a positive output appeared at the output of the voltage comparator, a negative pulse shifted into the shift register which is shifted right by the clock pulse. This negative pulse energizes the gatessequentially until the pulse is shifted out.

If the averaging capacity is made to be 5 µS and the sampling pulses have a time seperation of 4 µS, only 5x10÷14=64 channels are needed.



<u>Figure 4-3-3-4</u>. Timing relationship of pulses in the averaging unit.



input video signal

output of the clock pulse generator of the unit

output of the sampling gates (only 3 pules are shown)

voltage comparator output

Figure 4-3-3-5. Timing relationship of the video signal, clock pulse, sampling gates output, voltage comparator output of the averaging unit built.

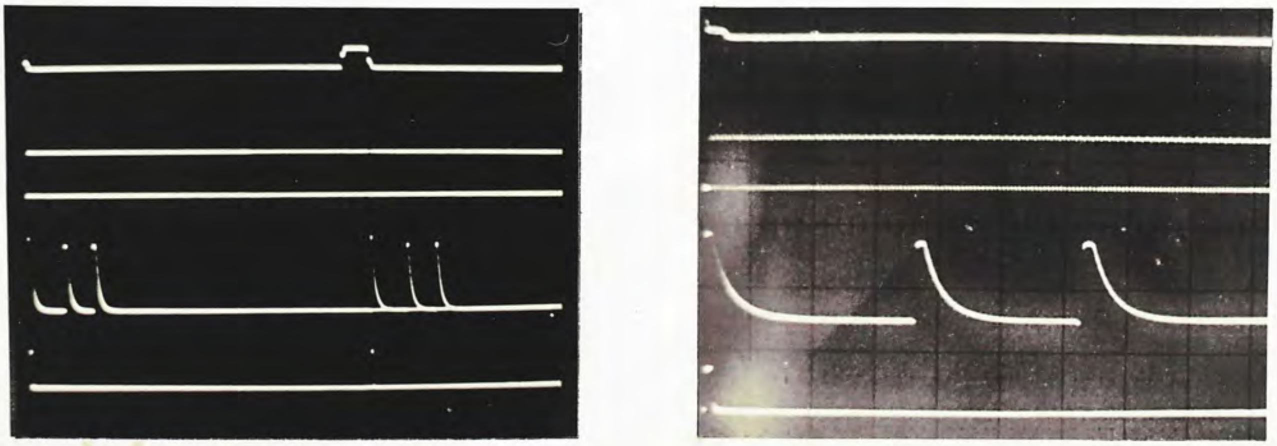
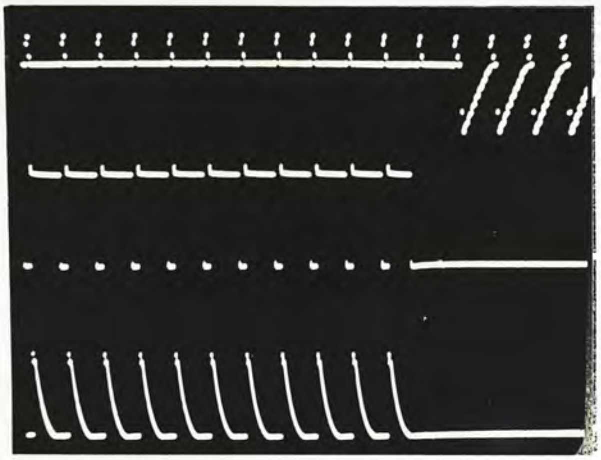


Figure 4-3-3-6. Enlarged waveform of Figure 4-3-3-5.



input video waveform

reference signal selection circuit output

output of the averaging unit

Figure 4-3-3-7. The input video waveform, the output of reference signal selection circuit and averaging unit of the circuit built is shown.

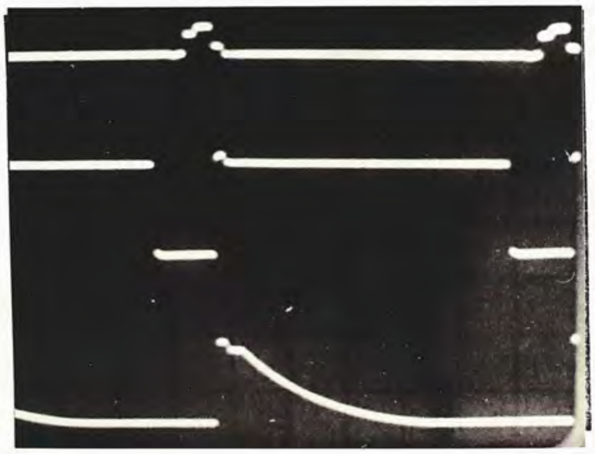
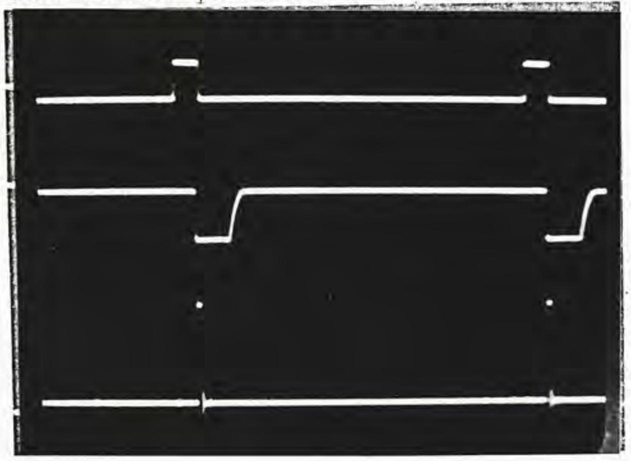


Figure 4-3-3-8. Enlarged picture of Figure 4-3-3-7 is shown. It is shown that the ghost sync of the input signal can be obtained form the averaging unit. The large fall-time at the averaging unit output is contributed by the output capacitance of the analog gate.

4-4 CONCLUSION

Both the phase-locked loop method and multichannel averaging technique can be used to recover falling edge of the ghost sync pulse, but they have their own defects.

Figure 4-4-1 shows the sync separator output and the phase-locked loop output. It is found that the phase-locked output is stable. It recovers sync pulse even when high noise as shown in the lower picture as shown in Figure 4-1-1.



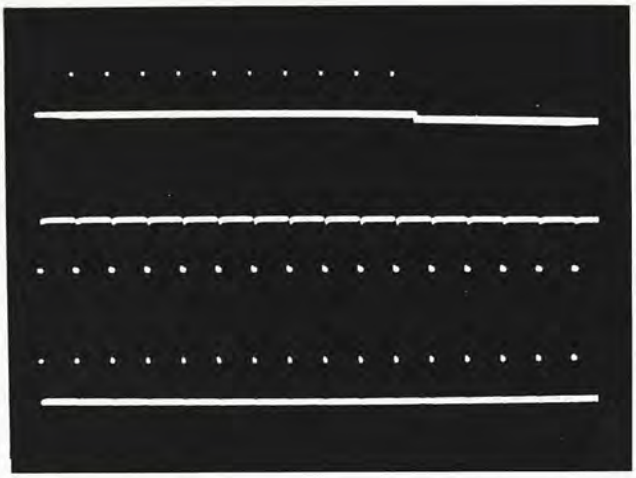
sync separator output

phase-locked loop output

a monostable multivibrator is placed after the loop to compensate the time different between the sync separator output and phase-locked loop output

Figure 4-4-1. The edge of sync is stabilized by using phase-locked technique.

Figure 4-4-2 shows the ghost sync pulse output and the modified phase-locked loop output. It is found it takes a long time for the system to lock, and is unable to lock when noise is present. It is not suitable to use for our purpose.



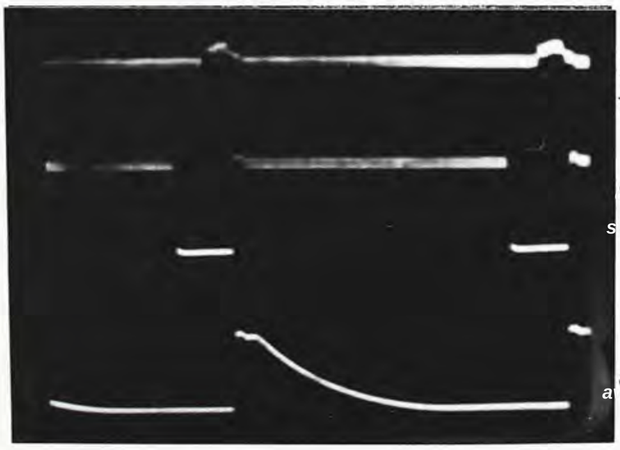
voltage comparator output when the video signal is noise-free

modified phase-locked loop output

time different compensation

Figure 4-4-2. The modified phase-locked loop output under no noise condition.

Multichannel-averaging has its defects because of its complexity, but it gives a reliable output which reproduces the signal embedded in noise. Figure 4-4-3 shows the noisy signal input and the reconstructed waveform.



1 MH_Z sinusoidal signal superimposed video signal

output of the reference signal selection circuit

averaged output

Figure 4-4-3. Noise is rejected by the averaging unit. It recovered the ghost sync pulse from noise appears at the reference signal selection circuit.

A trade-off is made here that the phase-locked loop method is used for signal sync pulse revovering, the multichannel averaging method is used in the ghost sync pulse channel. The system works satisfactorily by using this method in practical situation. Since phase-locked loop is used in the horizontal scanning circuit, it is wise to use its output instead of using the external building phase-locked loop.

4-5 SYSTEM MODIFICATION

In order to solve the noise problem, a little modification on the system is made. The ghost amplitude, instead of being detected by the peak detector directly, is first passed through the averaging unit. The attenuated signal sync pulse amplitude, instead of being gated out by the blanking line selection pulse and the ghost sync position pulse, is gated by the signal sync position pulse and the ghost sync position pulse and passing through a lowpass filter for amplitude recovering. Since all these parts of the system are located in the control attenuation circuit, modification is needed to be done only in this part. Figure 4-5-1 shows the circuit diagram of the modified control attenuation circuit.

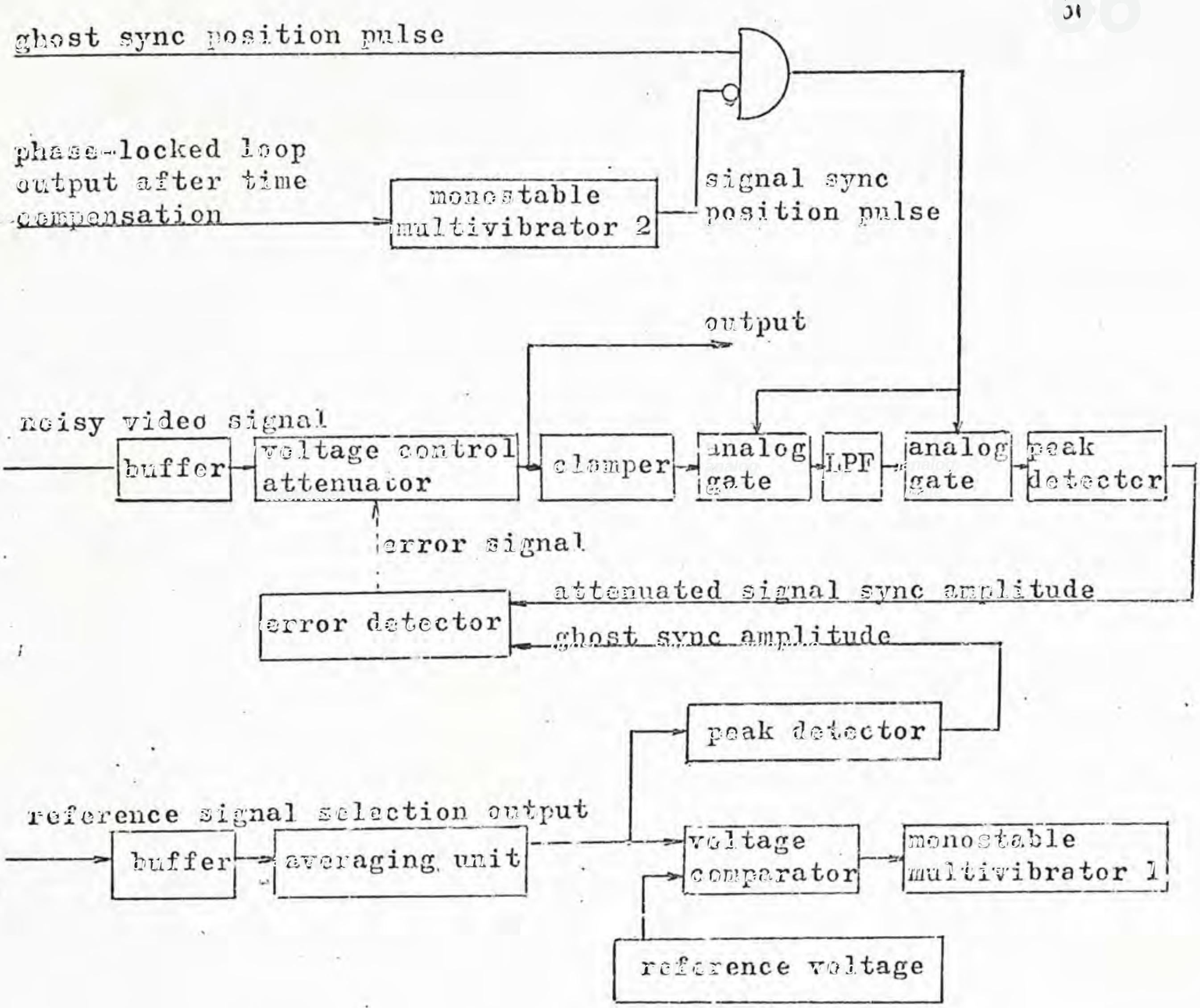


Figure 4-5-1. Block diagram of the modified attenuation control circuit. Comparing with Figure 3-3-3-4, block diagram of the attenuation control circuit, it can be found that only the method of detecting the attenuated signal sync pulse amplitude is change and the averaging unit is inserted in front of the voltage comparator.

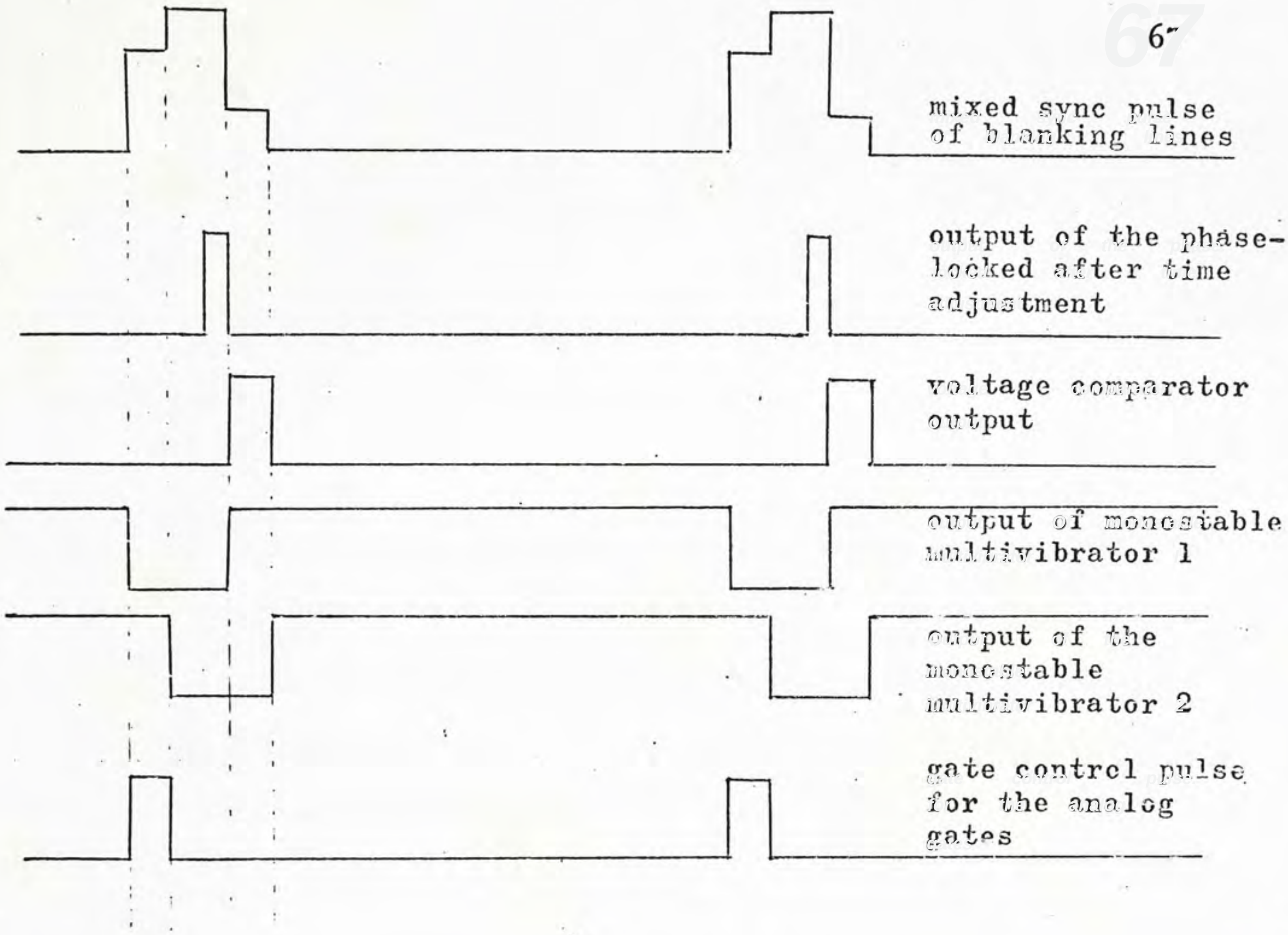


Figure 4-5-2. Timing relationship of the pulses in the modified attenuation control circuit.

5. TEST AND RESULT

5-0 SUMMARY

In this chapter, performance of the system is examined. In order to test the circuit built during circuit implementation conveniently, a ghost simulator simulating the ghost in actual condition is made. After finding that the system function properly even when noise is present by using the ghost simulator as signal source, field test is carried out. The procedure and the results of the test are stated in section 5-4.

5-1 GHOST SIMULATION

In order to work conveniently, a ghost simulator simulating the real situation is made. Figure 5-1-1 shows the layout of the ghost simulator.

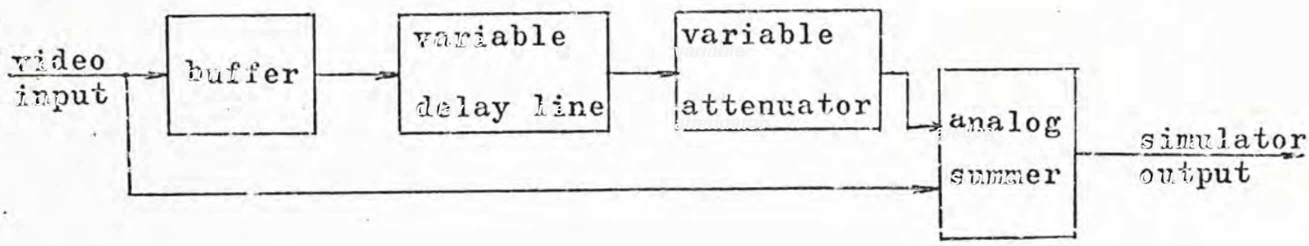


Figure 5-1-1. Construction of the ghost simulator.

Philips television pattern generator model PM5508 is used as the video signal source. Figure 5-1-2 shows the input and output waveforms of the ghost simulator. Figure 5-1-3 shows the picture on the screen of the output waveform. It does simulate the real situation as shown in the Figures in section 2-3.

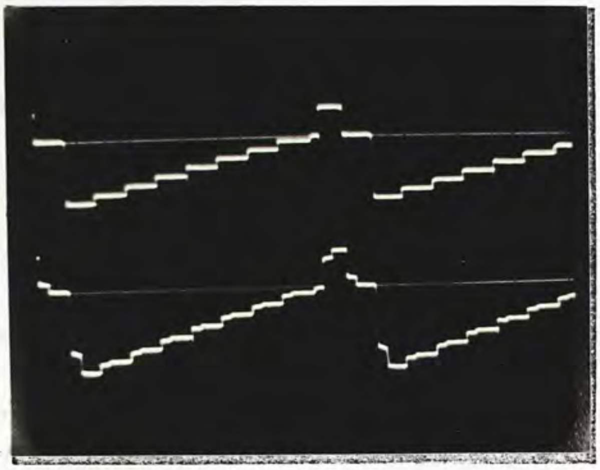
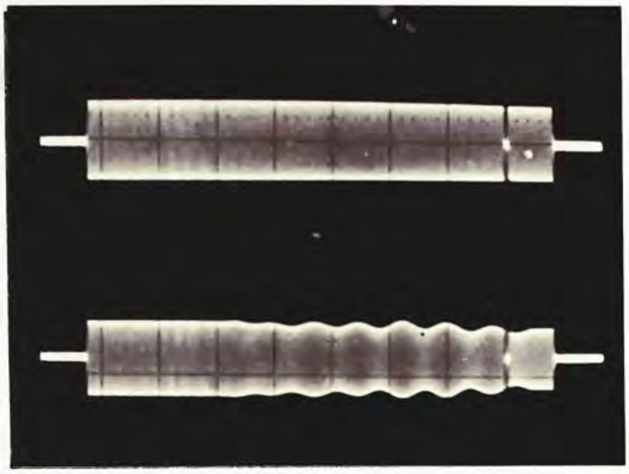


Figure 5-1-2. Input and output of the simulator.

Figure 5-1-3. Picture of the simulator output.

Under the assumption that the ghost is a replica of the signal except delayed and attenuated, the frequency response and time delay versus frequency of the delay line is measured. It is found that the time delay is independent of frequency and the attenuation is almost flat within 0-5 MH_z frequency range. Figure 5-1-4 shows the frequency response of the delay by using a 0-5 MH_z sweep signal. Detail circuit of the simulator is given in Appendix XIII.



0-5 MH_z sweep signal input to the delay line (The marker identify the 5 MH_z position)

output of the delay line

Figure 5-1-4. The frequency response of the delay line.

5-2 SYSTEM TESTED UNDER NO NOISE CONDITION

The system is tested under no noise condition by using the following apparatus:

(i) Ghost simualtor.

(ii) Philips pattern generator model PM5508.

(iii) Hewlett Packard 4 beam oscilloscope 181A.

(iv) Philips colour television set model 25K141.

Figure 5-2-1 shows the test set-up of the system under no noise condition.

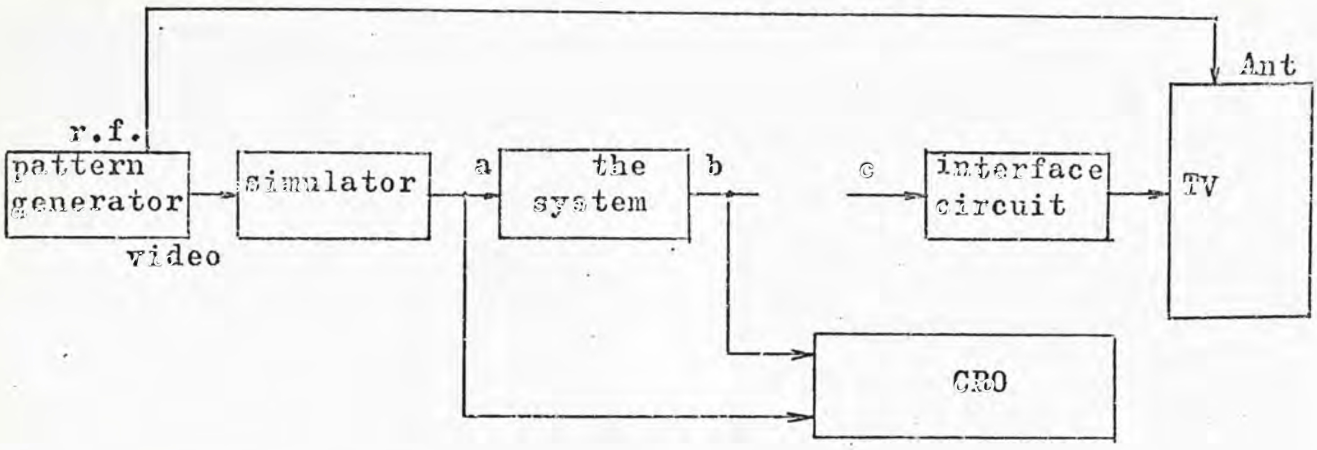


Figure 5-2-1. The test set up of the system under no noise condition.

While the R.F. output of the pattern generator is fed into the antenna input terminal, the video output of it is fed into the simulator and then fed to the system simultaneously. With synchronization of the scannings being done by the R.F. signal fed to the antenna input terminal, the video channel of the television is disconnected, and obtains signal via point a or point b by suitable adjustment of the gain of the interface circuit. Figure 5-2-2 shows the picture of the signal at the system input. Figure 5-2-3 shows the picture of the signal at the system output. Figure 5-2-4 shows the corresponding waveforms at the input and output of the system.

Figure 5-2-2. Picture of video signal at the system input.

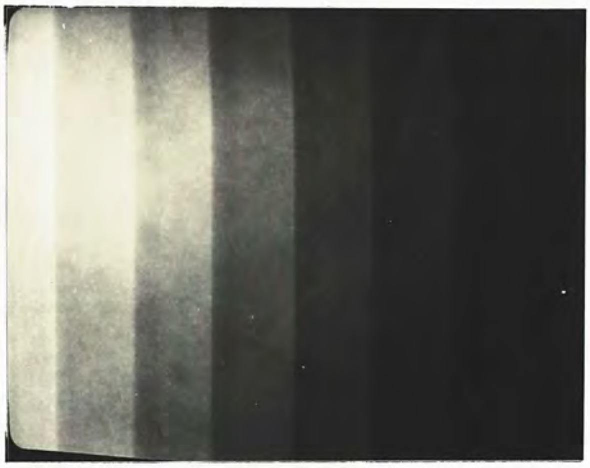
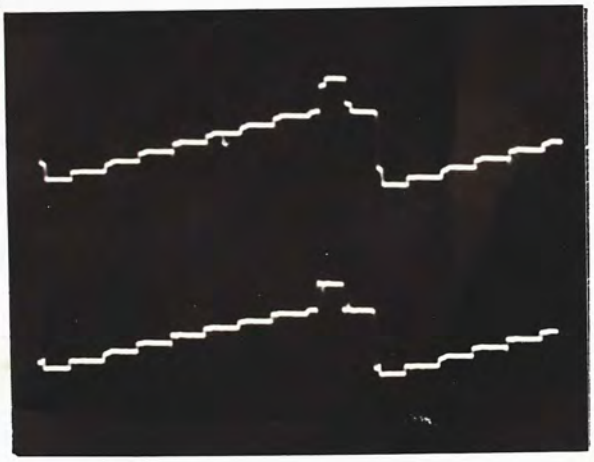


Figure 5-2-3. Picture of video signal at the system output. The ghost is eliminated by the system.



waveform at the system input

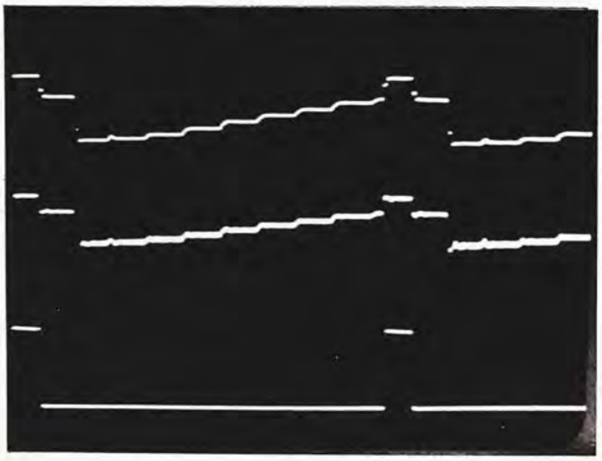
waveform at the system output

Figure 5-2-4. Corresponding waveforms at the input and output of the system.

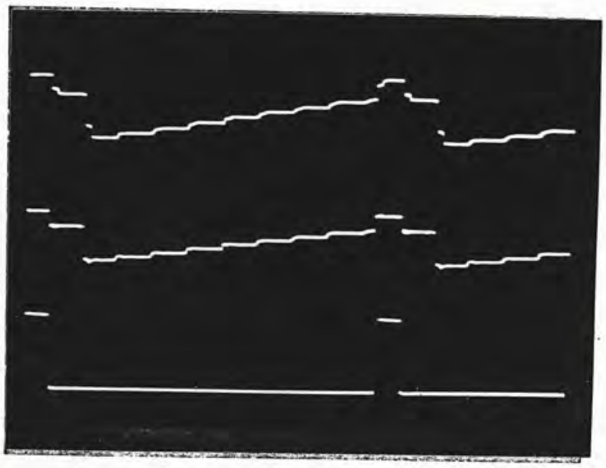
It is shown that the picture at system output is ghost eliminated.

By continuously changing the ghost amplitude slowly, the system works self-adaptively to give a ghost eliminated signal out.

By changing the time delay of the delay line in the ghost simulator, the system also works self-adaptively to give a ghost eliminated signal out. Figure 5-2-5 shows ghosts with different delay is eliminated by the system.



0.5 µS



1 µS

Figure 5-2-5. Ghosted waveform and the ghost eliminated waveform of 0.5 µS and 1 µS ghost delay. The pulse appears at the lowest part of the photoes are the sync separator output. It is used to synchronize the oscilloscope only.

5-3 SYSTEM TESTED UNDER NOISY CONDITION

The system is tested under noisy condition by the following apparatus:

(i) Ghost simulator.

(ii) Philips patten generator model PM5508.

(iii) Hewlett Packard 4 beam oscilloscope 181A.

(iv) Philips colour television set model 25K141.

(v) Audio signal generator.

Figure 5-3-1 shows the test set-up of the system under noisy condition.

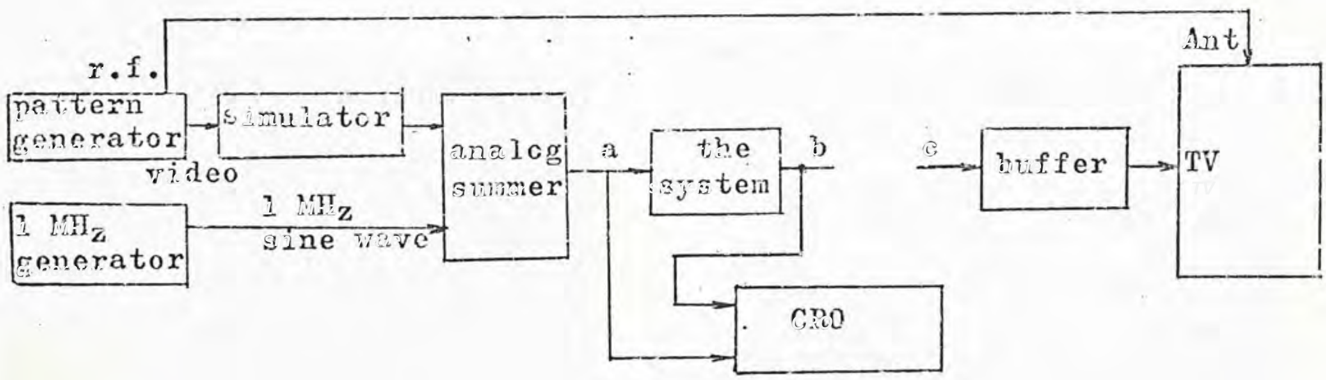
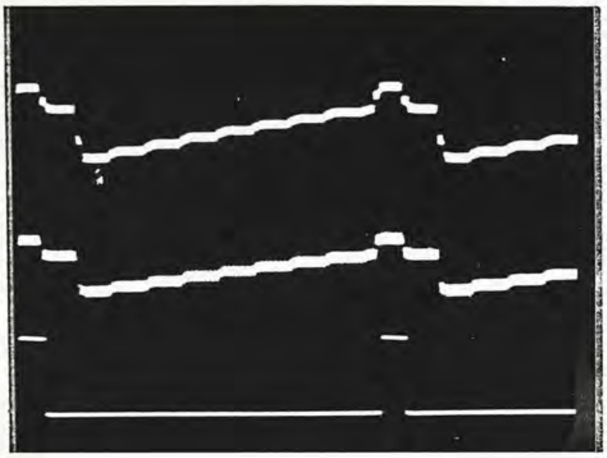


Figure 5-3-1. The test set up of the system under noisy condition.

Same configuration is used as using in the test under no noise condition except a 1 MH_z sinusoidal signal is superimposed to the output of the ghost simuator. The purpose of superimposing the 1 MH_z signal on the video signal is to examine the effect of noise on the system. Since the noise accompanied with the video signal is rejected by using the multichannel averaging unit which is sensitive to low frequency noise as lowpass filter is invloved in its circuit, the lowest dominant frequency of the noise in video channel, which is about 1 MH_z, must be injected into the system for the test on noise rejection ability. Figure 5-3-2 shows the picture of the noisy signal before this system. Figure 5-3-3 shows the picture of the system output. Figure 5-3-4 shows the waveform at the input and output of the system.

Figure 5-3-2. Picture obtained before the system.

Figure 5-3-3. Picture obtained after the system.



waveform at the system input

waveform at the system output

Figure 5-3-4. Waveform at the input and output of the system.

It is shown that the picture at the system output is ghost eliminated even under noisy condition.

With a fix time delay and amplitude of the ghost, changing the amplitude of the superimposed sinewave will not affect the system output. This condition is held until the sinusoidal signal amplitude exceeding one-third of the sync pulse amplitude of the direct signal. This will satisfy the practical requirement when the system is used to eliminate ghost occurs in actual receiving condition.

5-4 FIELD TEST

After finding that the system works as expected and functions properly even when noise is present, field test on the system is done.

The following figure shows the system is inserted into the video channel of the amplifier.

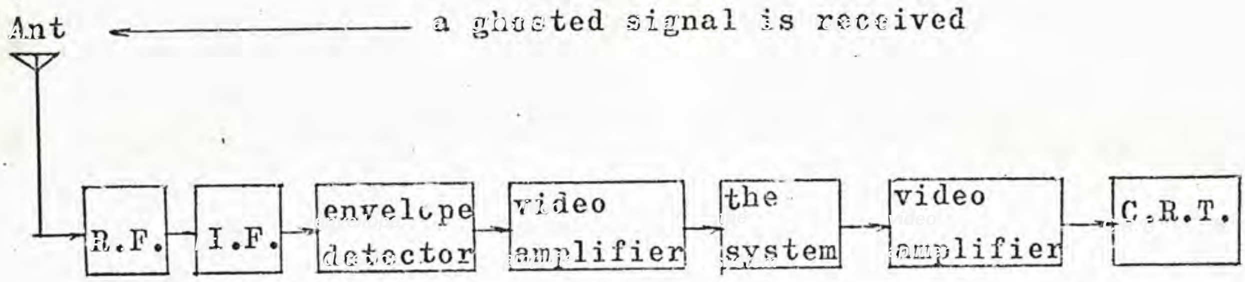


Figure 5-4-1. System field test. The system is inserted into the video channel of the television receiver.

The video signal obtained from the television receiver is normally superimposed by a 50 H_z signal. Figure 5-4-2 shows the video signal obtained from the receiver and its corresponding picture on the screen. The enlarged video waveform is shown on Figure 5-4-3.

Before the video signal from the receiver is fed into the system for adaptive ghost elimination, the top of the sync pulse from which the control parameters is derived is lined up by a champer* at first. Figure 5-4-4 shows the video waveform of GREY SCALE obtained from the receiver is lined up.

* Appendix XIV. Detail circuit.

Figure 5-4-2. The video signal obtained from the receiver is superimposed by a 50 Hz signal.

Figure 5-4-3. Enlarged picture shows the video signal obtained from the receiver.

Figure 5-4-4. The sync pulses are lined up by the clamper.

After clamping, the video signal is fed into the system. Since the sync pulse obtained from the receiver will be distorted both in duration and edge, timing readjustment on the control pulses of the system must be made. After finishing the alignment, photoes are taken from the television screen. Figure 5-4-5 shows picture before ghost elimination and Figure 5-4-6 shows picture after ghost elimination. It is shown that the ghost is eliminated.

Figure 5-4-5. Picture received without ghost elimination.

Figure 5-4-6. Picture received after ghost elimination.

5-5 CONCLUSION

The results obtained showing that the system works perfectly under laboratory test. Although only 1.2 uS delay ghost can be eliminated in this system, it can be expected that it can also eliminate ghost up to $(64-4.7-4)\mu S$ since condition of ghost with long delay time has been taken into consideration when the circuit is designed.

Although jittering occurs due to reception of the distorted sync pulse from the receiver at the system output intermittently, the workability of the method of ghost elimination is certain.

6. EXTENSION

6-0 SUMMARY

Although the system is done for ghost elimination under black and white television boardcasting under the simplied condition of one single ghost with the same polarity as the direct signal, certain extensions are discussed in this chapter.

Ghost with opposite polarity can be eliminated by the system with little modification only is given in section 6-1. In section 6-2, method of obtaining a ghost eliminated picture under colour television boardcasting is mentioned. Finally, the multighost problem which has not been solved is stated.

6-1 ELIMINATION OF GHOST WITH REVERSED POLARITY

When the R.F. carriers of the signal and the reflected signal are out of phase, superimposing of the two signals will cause a ghost with reversed polarity. That is, besides being delayed and attenuated, it is inverted. To eliminate such type of ghost, a similar method as stated before can be used.

Mathematically, a sinusoidal signal with frequency $\frac{\omega}{2\pi}$ and unity amplitude, superimposed with its time delayed (T), attenuated (A), inverted position can be expressed as :

$$E = (1 - Ae^{-j\omega T}) \sin \omega t$$

If the circuit as shown in Figure 6-1-1 is used to process the signal, the output will be:

$$Z_{out} = [(1-Ae^{-j\omega T}) + (1-Ae^{-j\omega T}) Ae^{-j\omega T} + (1-Ae^{-j\omega T}) A^2e^{-2j\omega T} + \cdots] \sin \omega t$$

$$= \sin \omega t$$

The original signal is recovered.

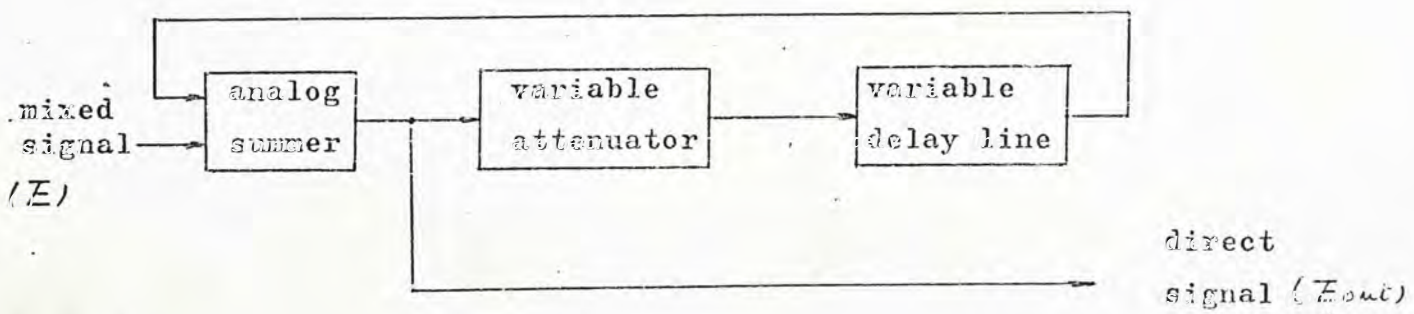


Figure 6-1-1. Block diagram for negative ghost elimination.

The system which can eliminate both the positive and negative ghost can be modified from the block diagram as shown in Figure 3-2-1. Some additional circuits which detect which type of the ghost exists must added. Figure 6-1-2 shows the modified system which can eliminate both the positive and negative ghost.

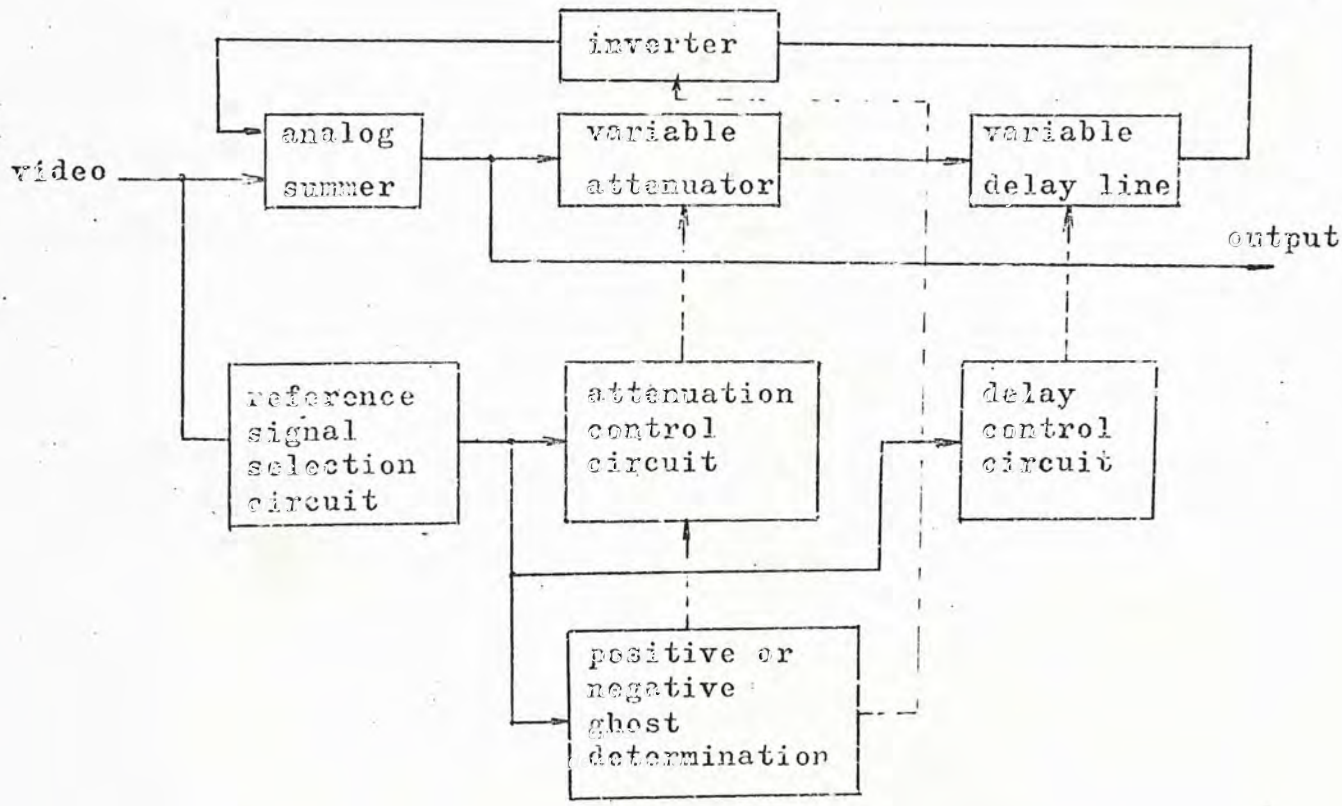


Figure 6-1-2. System which can eliminate the positive and negative ghost.

In order to detect amplitude of the negative ghost, some modification on the system must be done. Figure 6-1-3 shows the further modified attenuation control circuit. The amplitude and falling edge of the sync pulse of negative ghost can be detected.

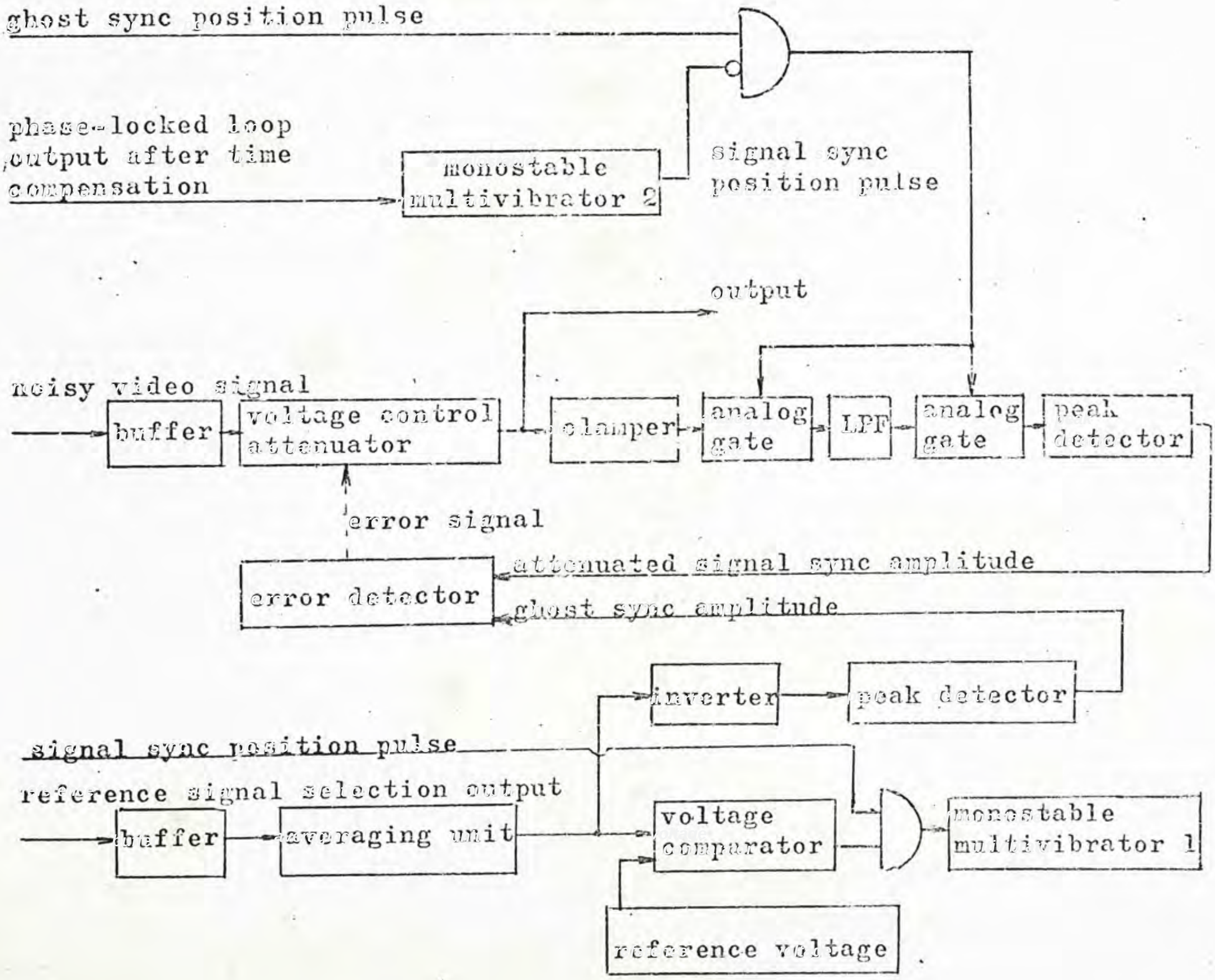


Figure 6-1-3. Further modification is done on the block diagram as shown in Figure 4-5-1 for negative ghost elimination.

The only modification on the Figure 4-5-1 is that a AND GATE and a inverter is added into the circuit. The AND GATE inhibits output from the voltage comparator at the location of signal sync pulse and the inverter inverts voltage between signal sync pulses with respect to the blanking level.

6-2 GHOST IN COUOUR TELEVISION SYSTEM

Ghosting in colour television will cause seriously degradation of the picture since the delay signal will form an image and perhaps, with colour change. This is due to the subcarrier of the colour signal possesses random phase relationship to the signal burst after delayed.

Theoretically, ghost cancelling can be apply to the colour television system, but practically it is not easily attainable. 0.1 uS delay tolerance is acceptable in black and white receiver, but it will cause colour change seriously in a colour receiver. An exact time delay compensation is therefore needed in colour television system. Figure 6-2-1 shows the idea of obtain an exact time delay compensation by the help of the burst appears at the back porch of the video signal in colour boardcasting system.

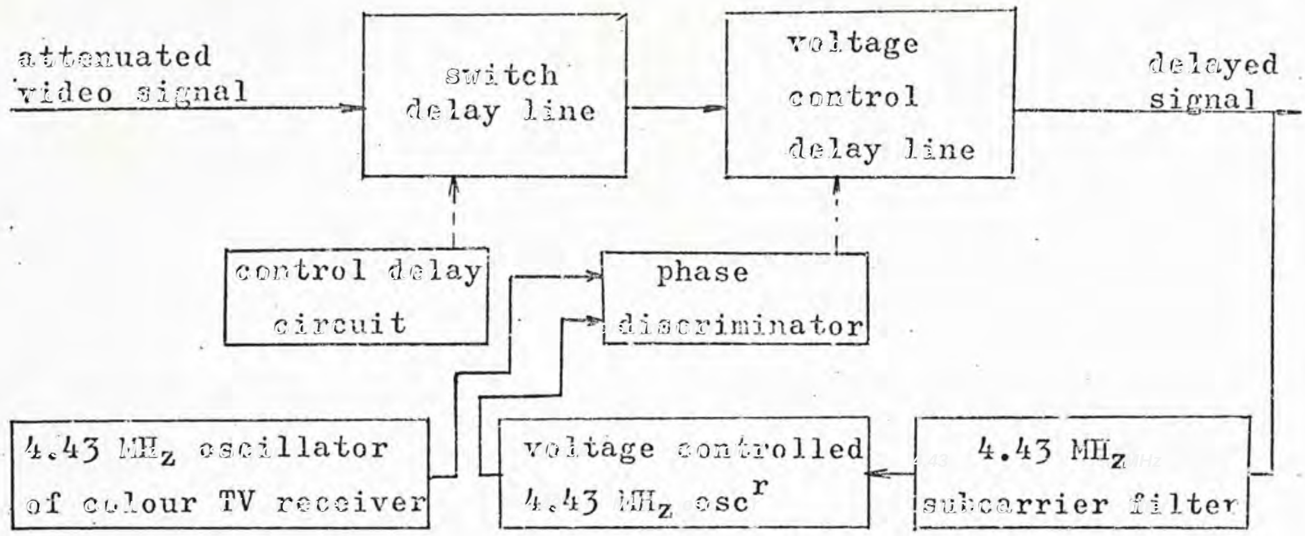


Figure 6-2-1. Fine control of the time delay.

The switch delay line, which is controlled by the delay control circuit, compensates the mixed signal with 0.1 uS delay tolerance. After delaying, the phase of the burst on the delayed signal is compared with the phase of the subcarrier oscillator in the colour television receiver,any error signal will drive the voltage control delay line in the direct to minize it. Then exact time delay compensation will be obtained.

6-3 MULTIGHOST CONDITION

Sometimes, more than one ghost is received by the television receiver. Under this condition, the principle stated aboved cannot be applied for ghost elimination since additional ghost will be generated after one ghost is eliminated. Figure 3 shows a example of double ghost, it generates infinite number of ghost after cancelling the first ghost.

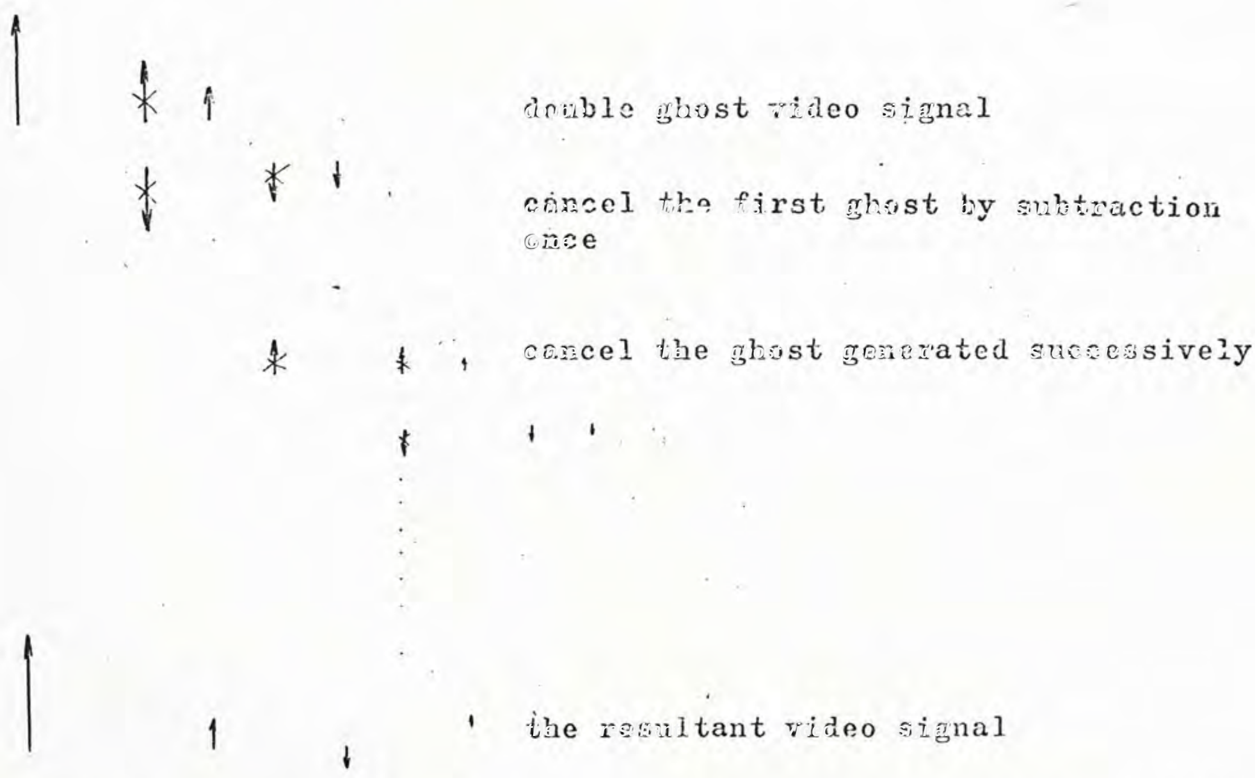


Figure 6-3-1. New ghosts are generated after one ghost is eliminated.

In general, one dominant ghost situation will be obtained by suitable choosing the orientation of the antenna with the cost of direct signal attenuated. If it is done, the new generated ghost will be negligible on the screen.

7. CONCLUSION

Method of ghost elimination on the receiver for black and white television boardcasting by subtracting the delayed signal from the mixed signal is successful, the system built for ghost elimination works self-adaptively.

In order that the self-adaptive system is immune from noise, both phase-locked loop technique and multichannel averaging technique are used in the system. The phase-locked loop using for sync pulse re-generation gives a stable re-generated sync pulse which controls the pulses in the system function properly. The multichannel averaging unit using to recover the reference signal from noise makes the control circuits of the system measure control parameters correctly.

Digital circuitry using in the delay control circuit of the system makes it subject to fast response to time delay changing and capability of measuring time delay accurately over a wide range. The closed-loop controlled method using in the attenuation control circuit makes the exact amplitude compensation become possible. System using these control circuits can eliminate ghost exactly. Since a 0.1 uS step-varying variable delay is used in the built system, the system can give ghost eliminated picture with delay different within 0.1 uS only.

Since the system works self-adaptively by using information obtaining from the sync pulses, the system will work incorrectly when the sync pulse received is distorted. For this reason, correct tuning of the R.F. tuner must be done in order to obtain a less distorted video signal. The timing of the control pulses in the system must be carefully re-adjusted if the sync pulse receives by different receiver or from different station is different in edge or duration. This makes it complicated for practical usage.

It is shown that the system can eliminate negative ghost after an inverter and an AND GATE are added to the system. For elimination of ghost in colour television, a fine adjustment on the time delay compensation is need in order to obtain a ghost eliminated picture without colour change.

It is assumed that the ghost, the delayed signal, is always smaller in amplitude than the signal, but in the case that both signals received are reflected signal, the signal with longer time delay could have larger amplitude than the shorter one. Under this situation, the shorter delayed one will be eliminated by the system by using the longer delayed one which contains information of last line. This will not cause a serious effect on the picture since two adjacent lines will not different from each other very much generally. If the ghost of delay larger than 64 uS is received,

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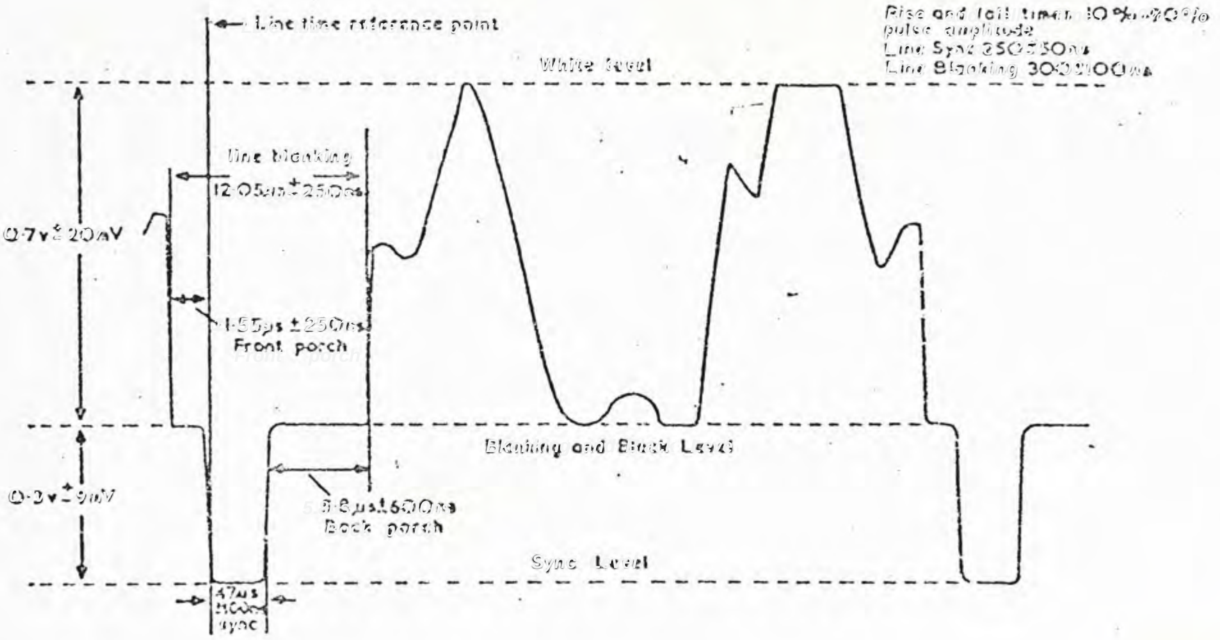
the system will treat the ghost as within 64 uS, since the circuit cannot identify sync pulses from various lines.

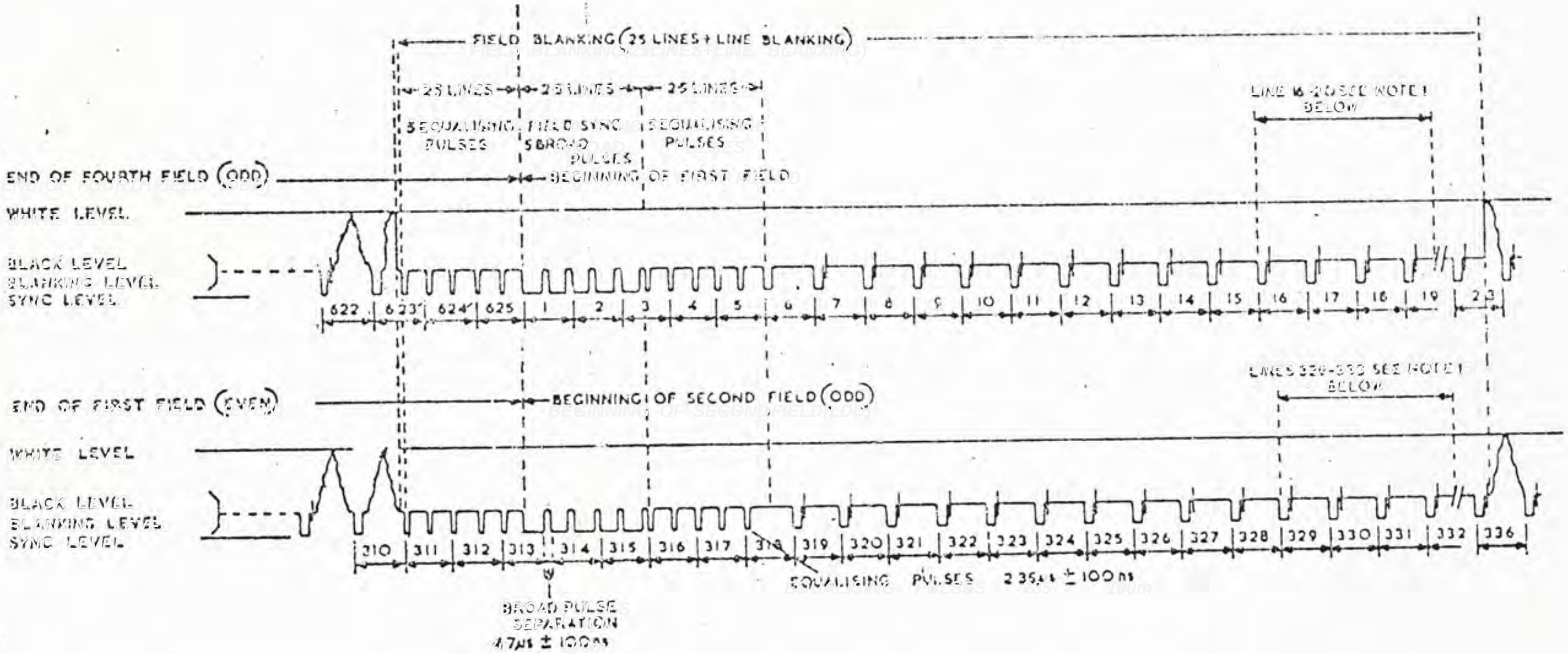
This method, cancelling reflected signal due to multipath effect adaptively, can be used in other data transmitted system provided a reference signal, such as the sync pulse, can be obtained from the signal received.

APPENDICES



NOTE: Pulse duration is measured at half amplitude points. Blanking duration is measured at half amplitude points with a white level signal of line duration

APPENDIX I. Typical line showing synchronising pulse



NOTE 1:
LINES 16 TO 20 INCLUSIVE AND 329 TO 333 INCLUSIVE MAY CONTAIN IDENTIFICATION CONTROL OR TEST SIGNALS

NOTE 2
THE FIRST & SECOND FIELDS ARE IDENTICAL WITH THE THIRD AND FOURTH IN ALL RESPECTS EXCEPT BURST BLANKING

RISE & FALL TIMES 10% - 90% PULSE AMPLITUDE
FIELD BLANKING 300 ± 100ns
FIELD SYNC PULSES 250 ± 50ns
EQUALISING PULSES 250 ± 50ns

APPENDIX II. Vertical synchronising and waveform for a typical signal

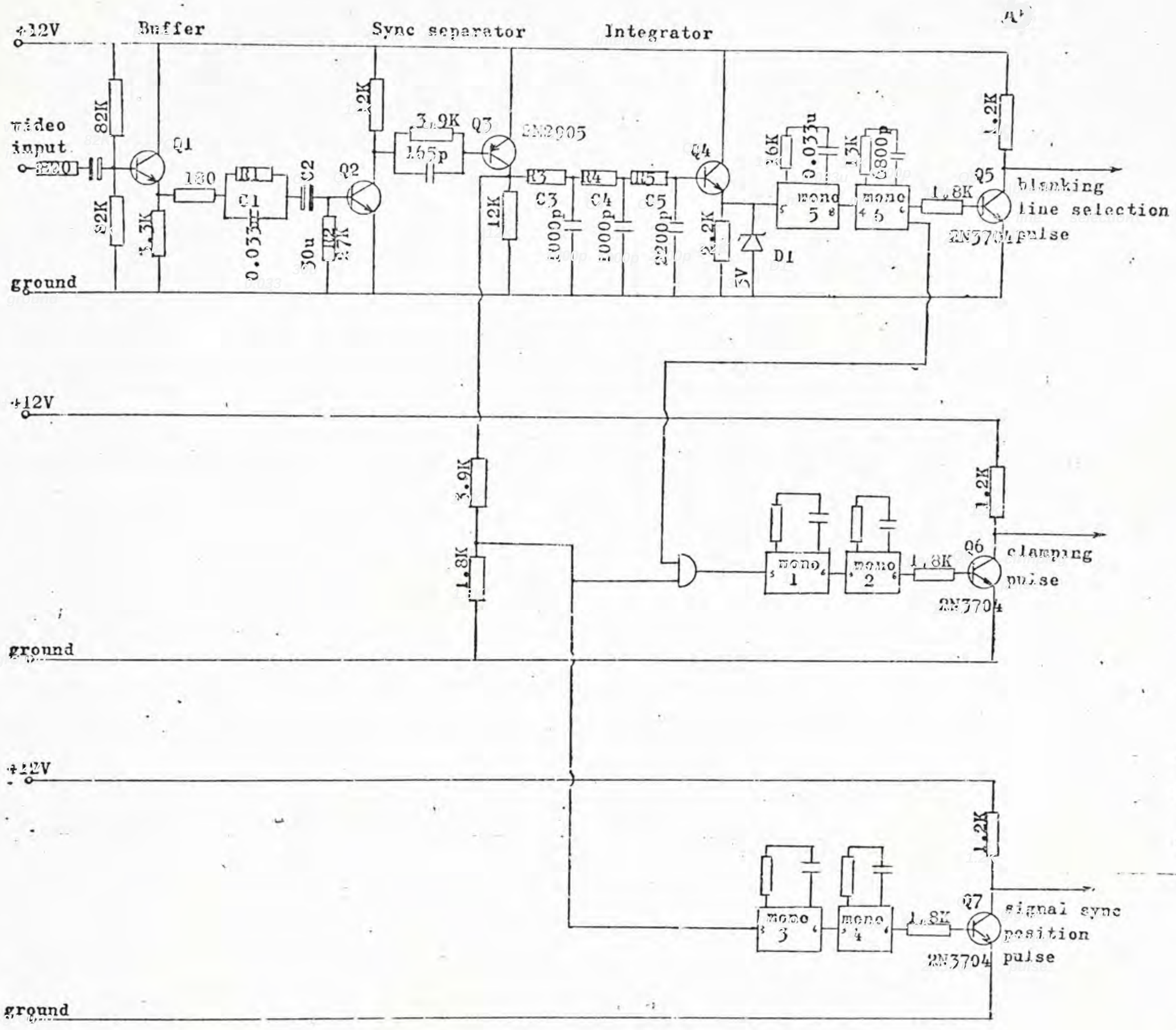
APPENDIX III

DETAIL DESCRIPTION OF THE REFERENCE SIGNAL SELECTION CIRCUIT

Q1 forms a emitter follower as a buffer. Q2, Q3 is a conventional sync seperator, R1, R2, C1, C2 from a double time constant network, any short spike due to distribance will drop across C1 and discharged through the resistor R1, and then will not appear at the output of the sync seperator. R3, R4, R5, C3, C4, C5 form a integrator which seperates the vertical sync pulse out.

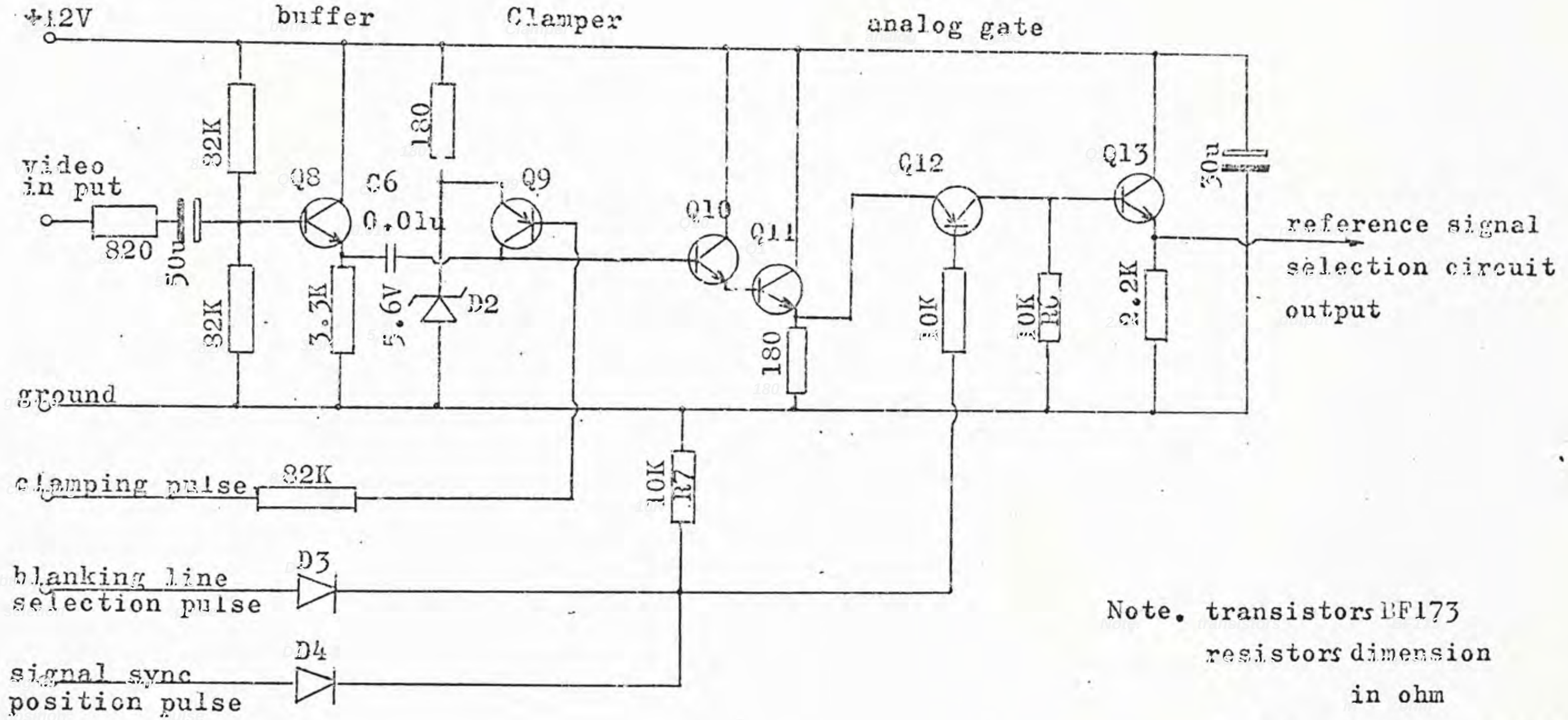
A d.c. level is re-inserted by using a keyed clamper circuit Q9, C6. The darlington pair Q10, Q11 isolates loading of the analog gate Q12 from C6. The output, which will be restored to zero by R6 when the ghost is closed is obtained from emitter follower Q13.

D3, D4, R7 form an OR GATE. The output of OR GATE control the analog gate Q12 to gate the appropiate position of the video signal out. D1 clips the input voltage fed to monostable multivibrator 1 below 5V to aviod damage. D2 determines the preset d.c. level inserted to the blanking level.



APPENDIX III. Control pulses in reference signal selection circuit

Note. transistors BF173
resistors dimension
in ohm
unless otherwise specified



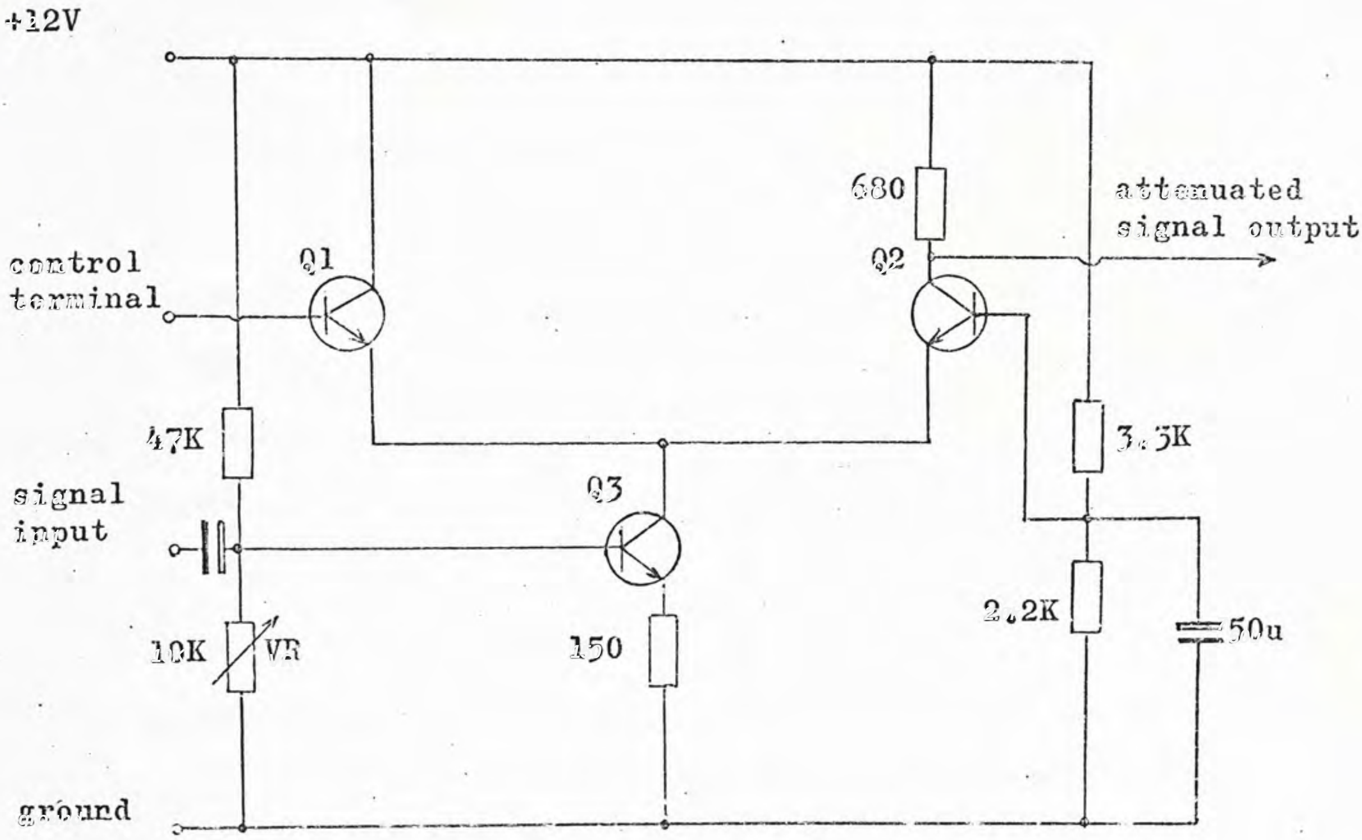
Note. transistors BF173
resistors dimension
in ohm
unless otherwise specified

APPENDIX III. Reference signal selection circuit

APPENDIX IV

VOLTAGE CONTROLLED ATTENUATOR

For symmetrical condition in two branches, the current I_E distributes evenly into two branches. For non-symmetrical condition, the current distribution ratio is controlled by the control terminal. If signal is injected into the base of Q3, the signal current will distribute into two branches according to the distribution ratio.



note. Transistors BF173
Resistors dimension
in ohm
Unless other specified

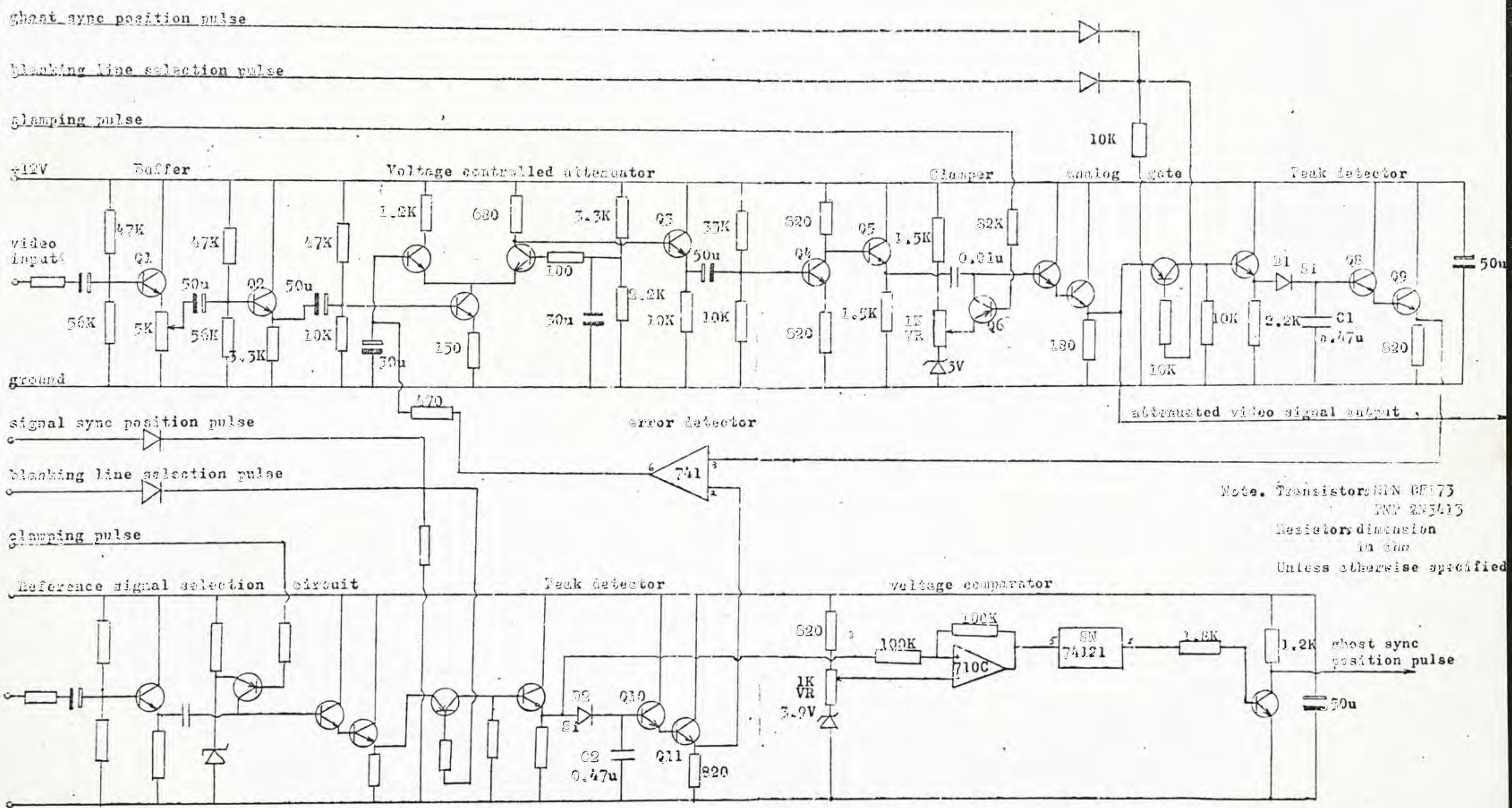
APPENDIX IV. Voltage controlled attenuator

APPENDIX V

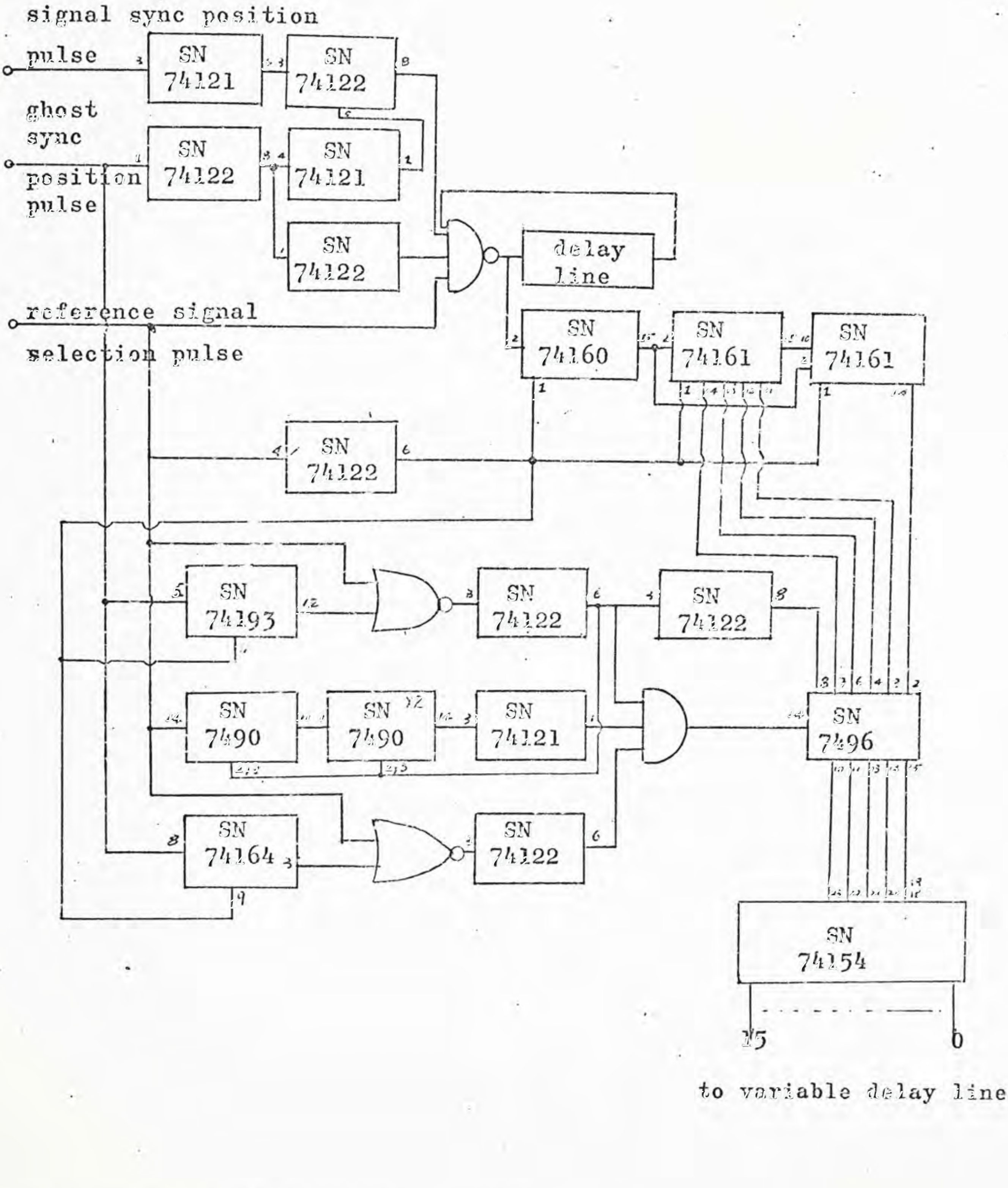
THE ATTENUATION CONTROL CIRCUIT

The amplitude of the ghost sync pulse is detected by the peak detector D2, C2, Q10, Q11.

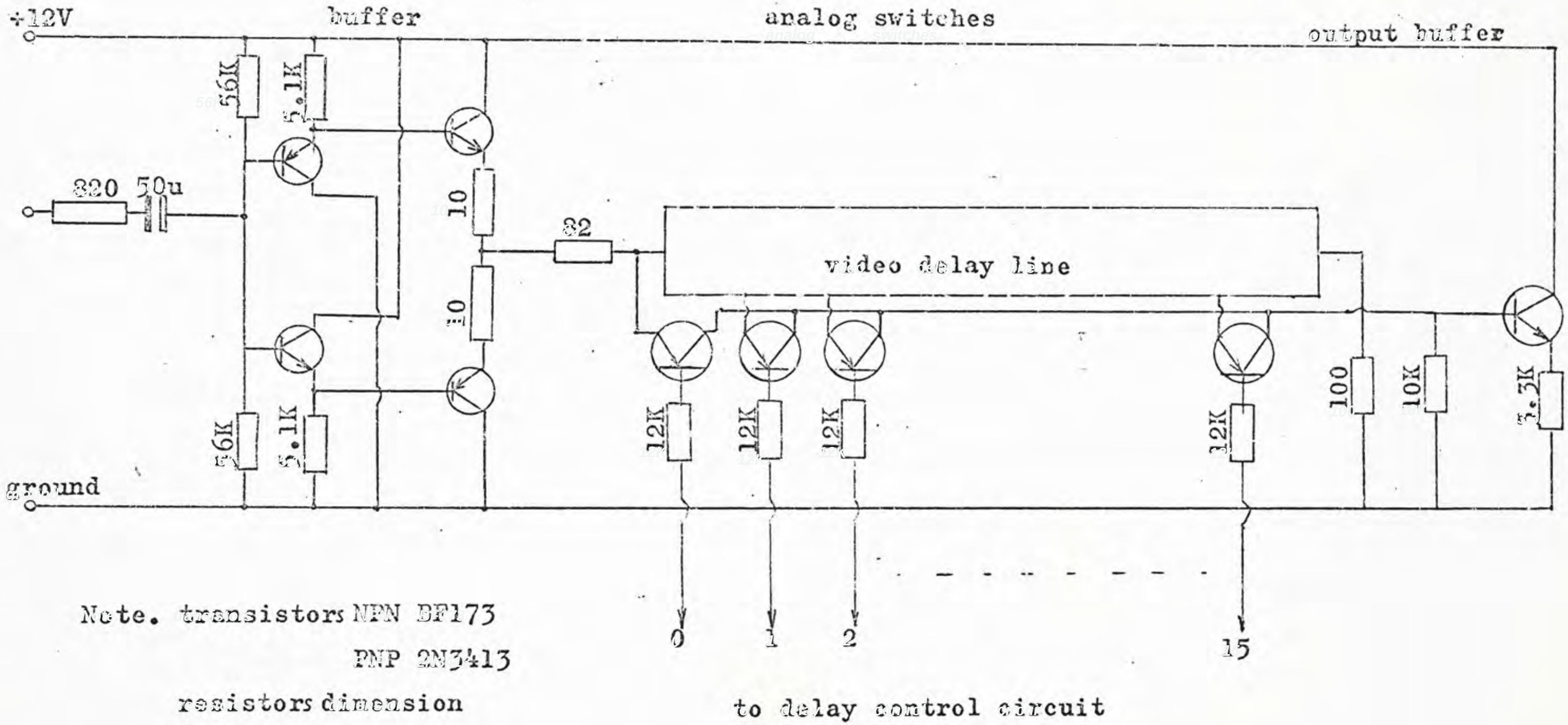
The composite video signal is fed into the voltage control attenuator via the buffer amplifier Q1 and amplitude adjusting stage Q2. The output of the attenuator is amplified by stage Q3, Q4, Q5. After the preset d.c. level is re-inserted into the blanking level by the keyed clamper stage Q6, the amplitude of the attenuated signal sync pulse is seperated by the analog gate stage Q7. The amplitude, being detected by the peak detector D1, D2, Q8, Q9, is compared with the amplitude of ghost sync pulse in operational amplifier 741. The error is then amplified by 741 whose output is used to drive the voltage controlled attenuator in the direction to minimize it. The variable resistor VRI is used to balance the different between the signal and the ghost channel.



APPENDIX V. Attenuation control circuit

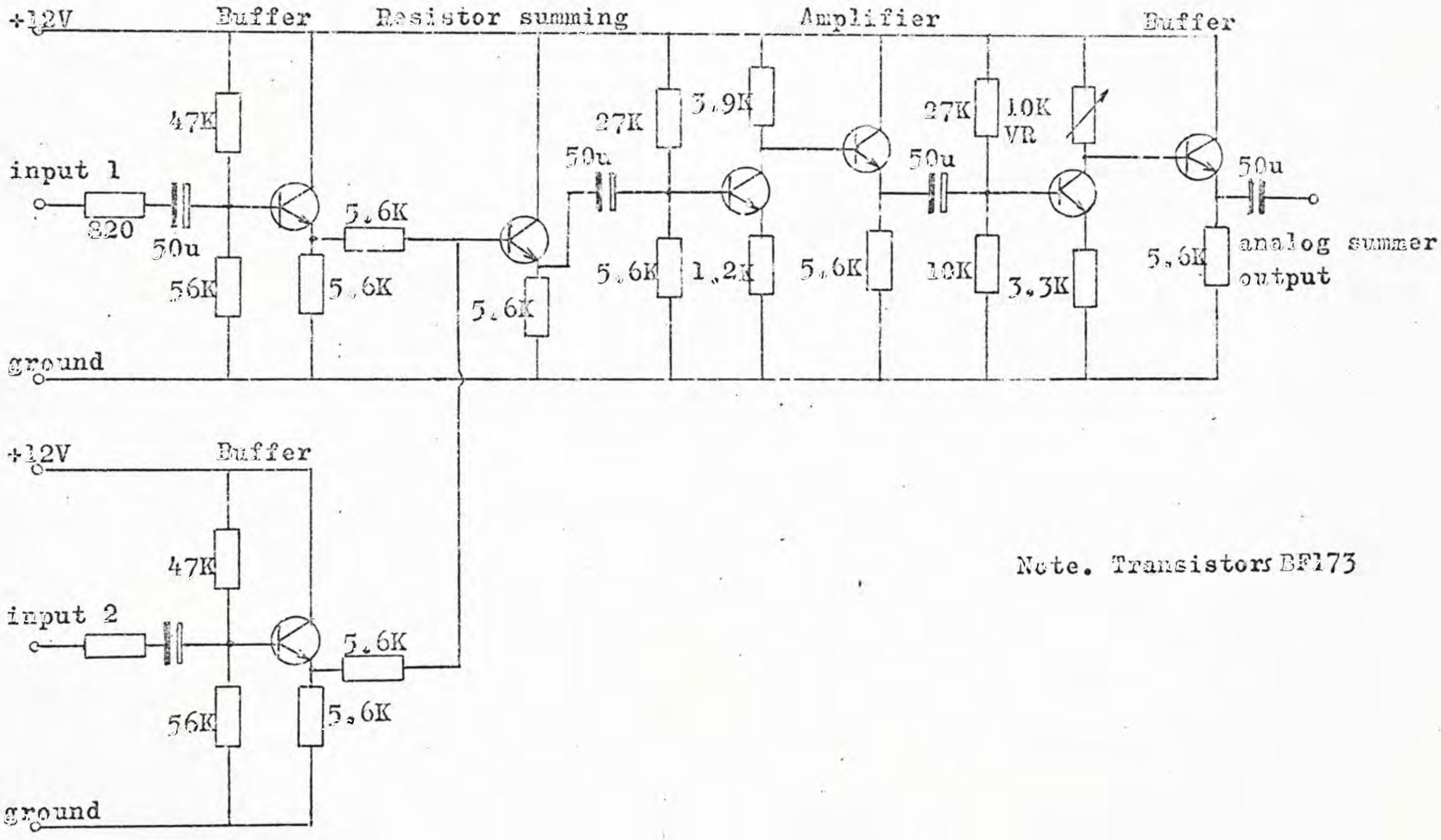


APPENDIX VI. Delay control circuit



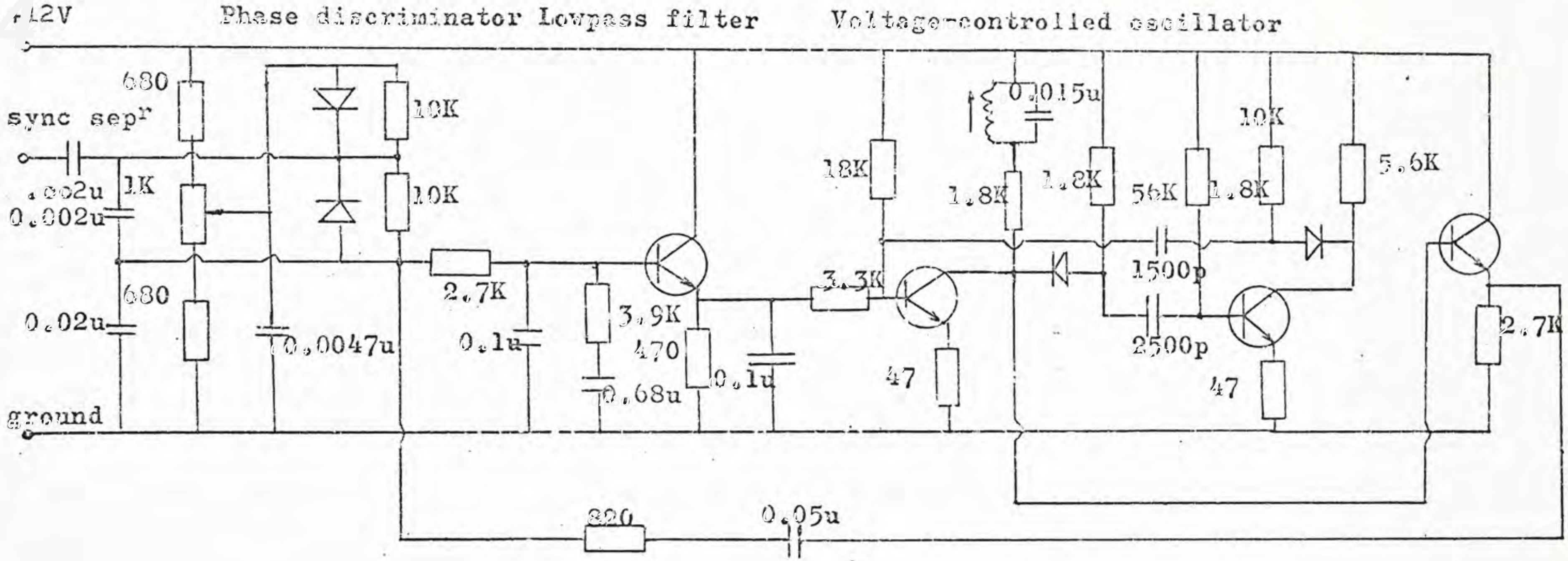
Note. transistors NPN BF173
PNP 2N3413
resistors dimension
in ohm

APPENDIX VII. Variable delay line



Note. Transistors BF173

APPENDIX VIII. Analog summer

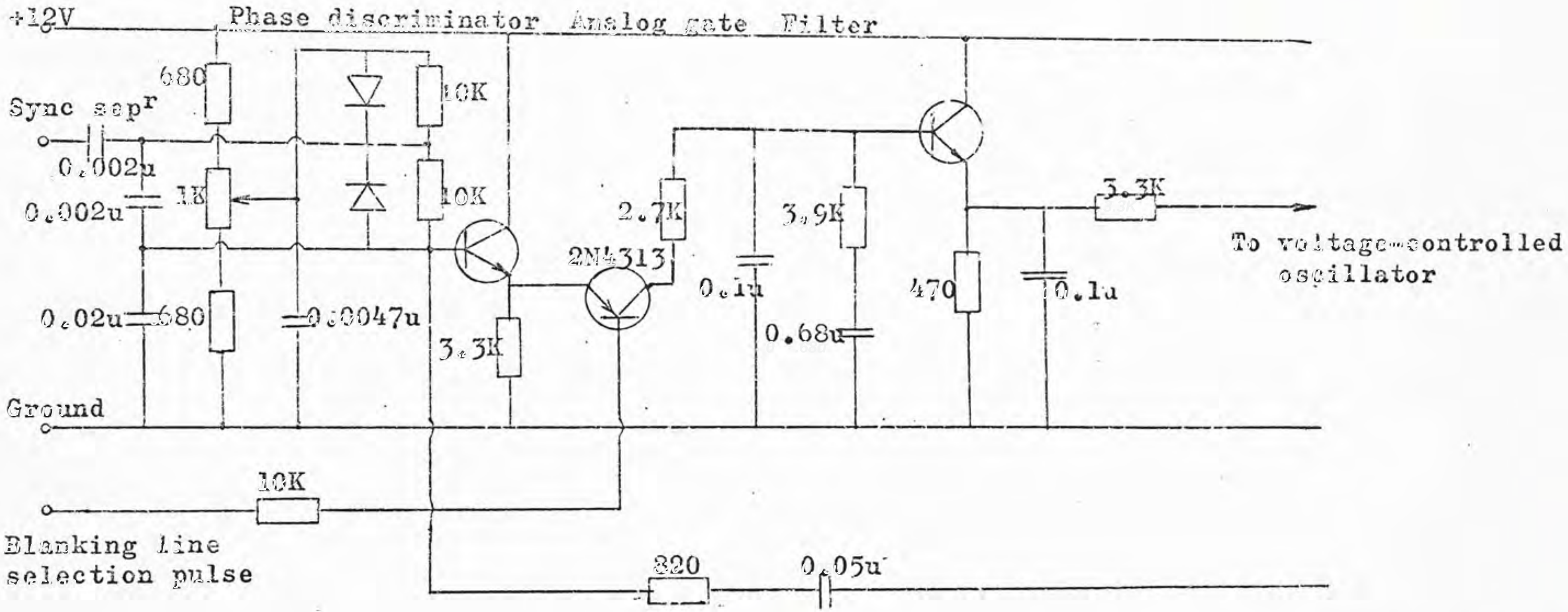


Note. Transistors CS9011

resistors dimension
in ohm

Unless otherwise specified

APPENDIX IX. Typical phase-locked loop using in horizontal scanning circuit of television receiver

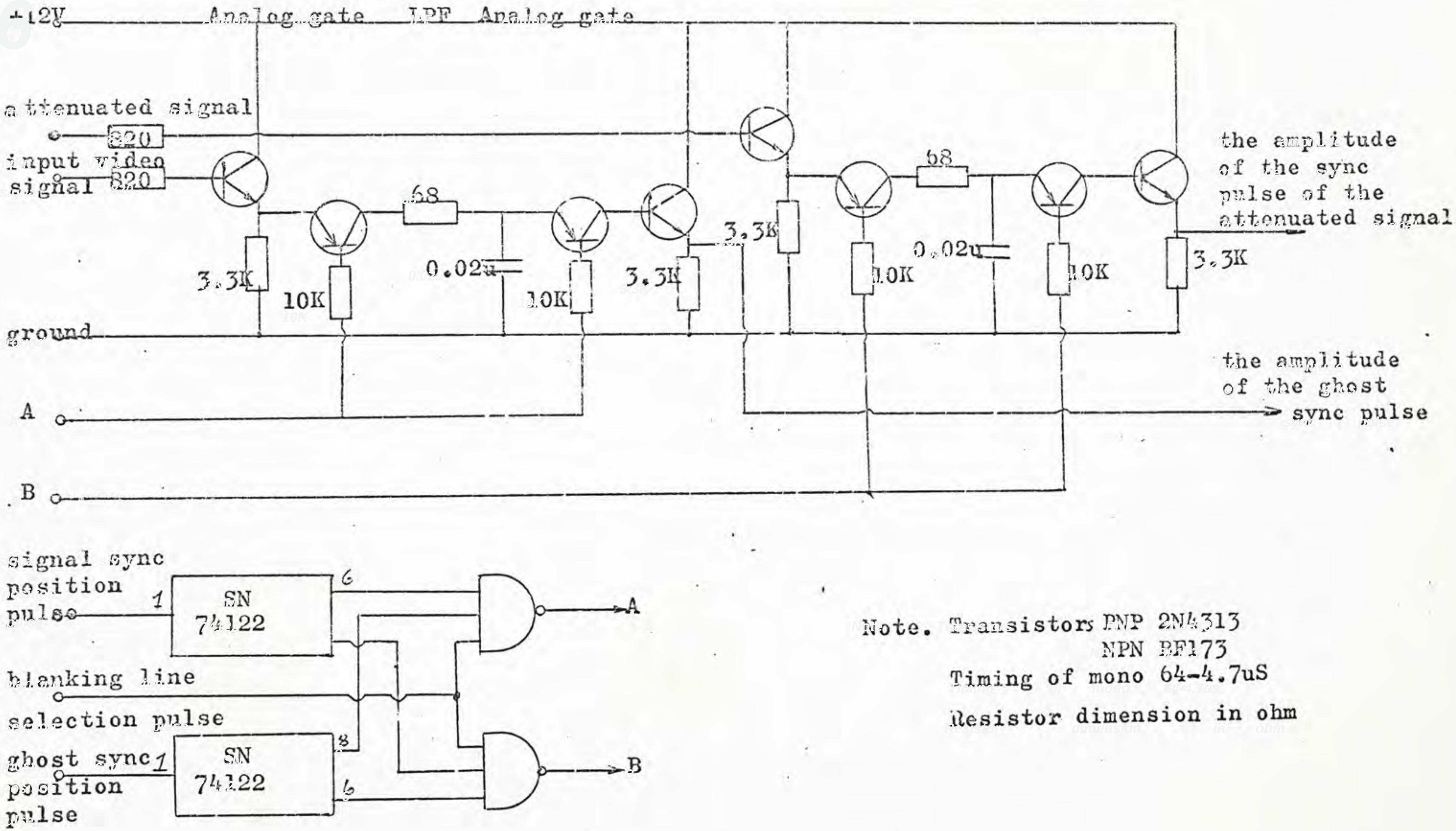


Note. Transistors CS9011

Resistors dimension in ohm

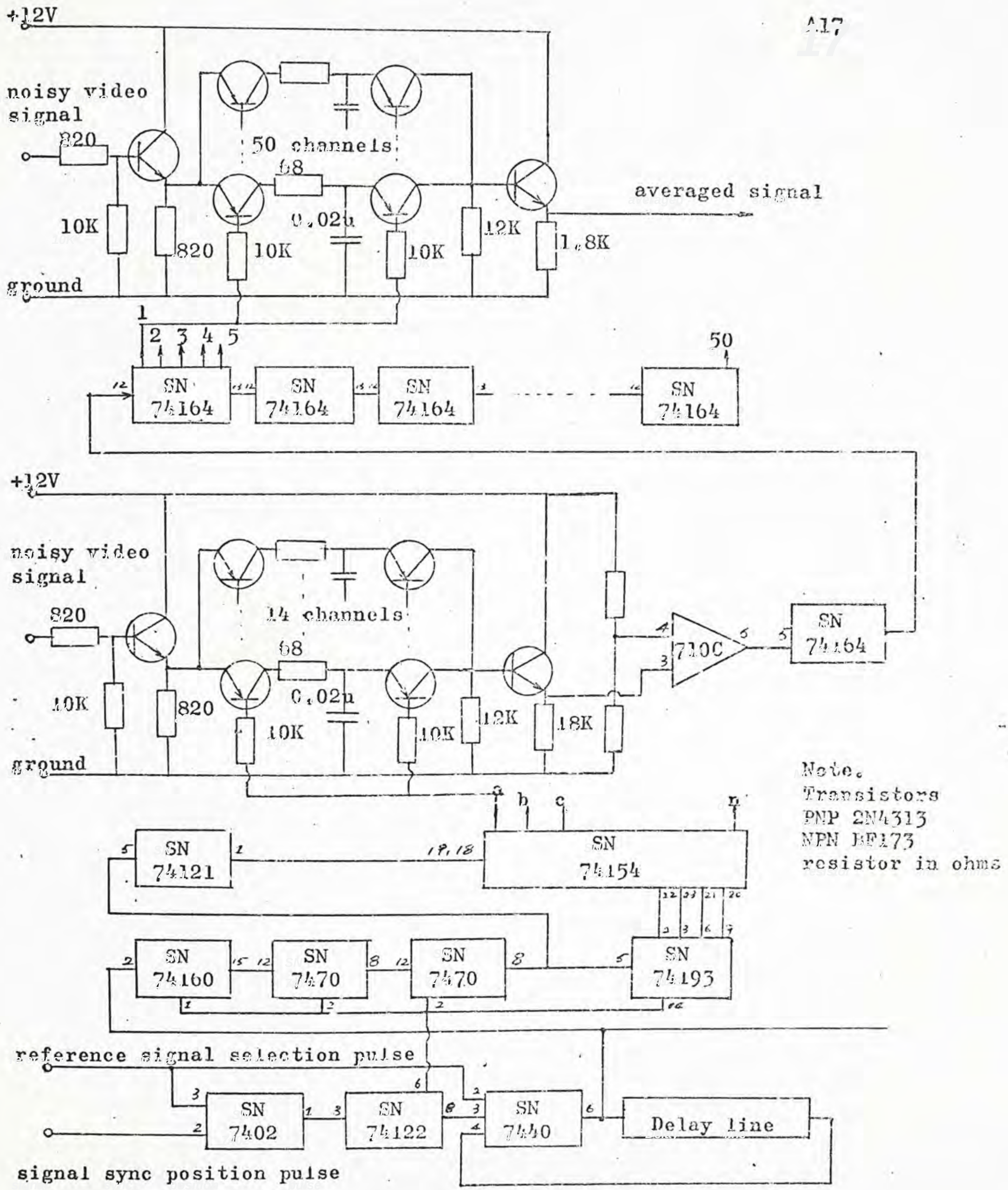
Unless otherwise specified

APPENDIX X. Modified phase-locked loop for ghost sync recovering

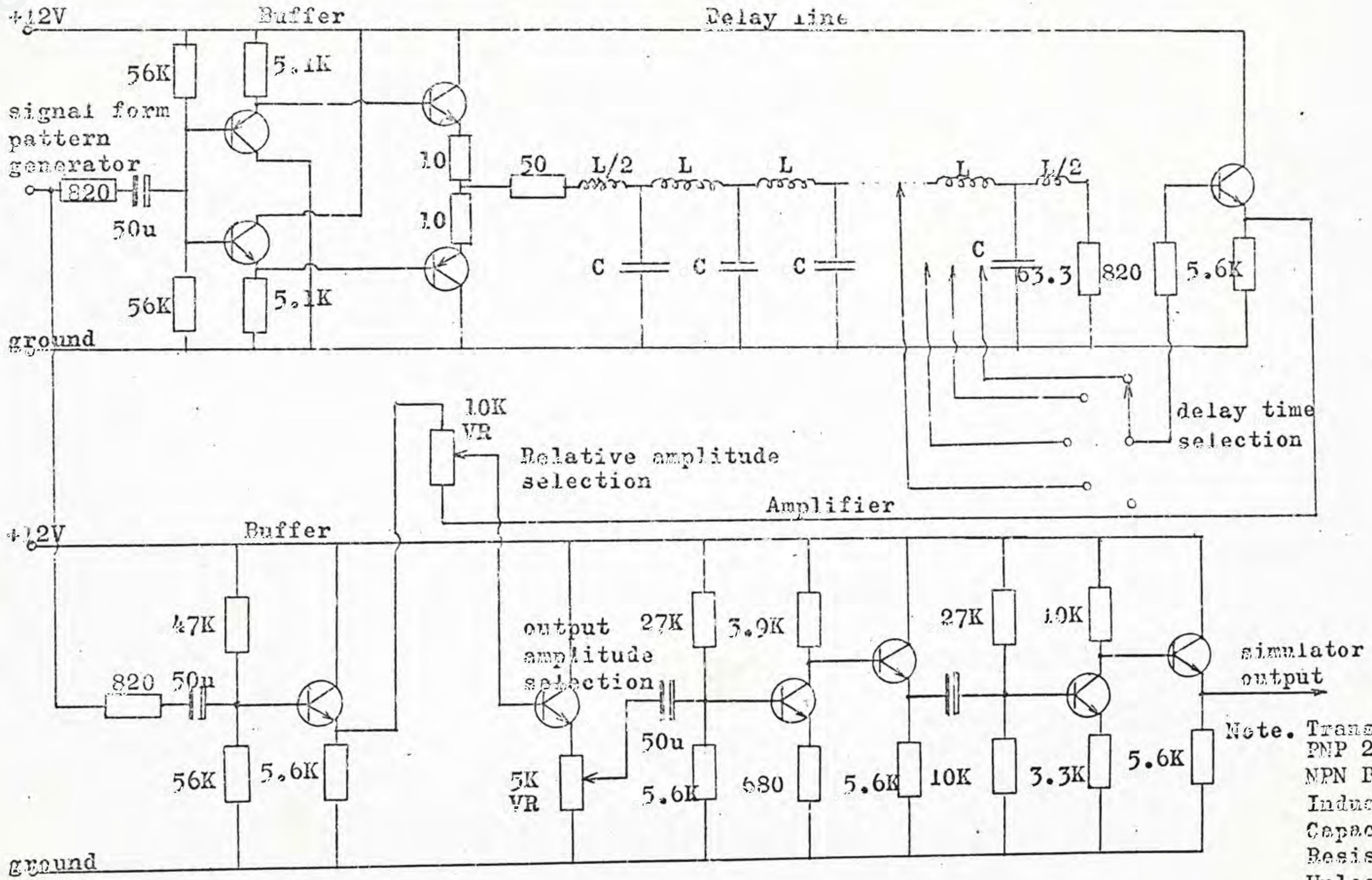


Note. Transistors PNP 2N4313
NPN BF173
Timing of mono 64-4.7uS
Resistor dimension in ohm

APPENDIX XI. Circuit for amplitude recovering

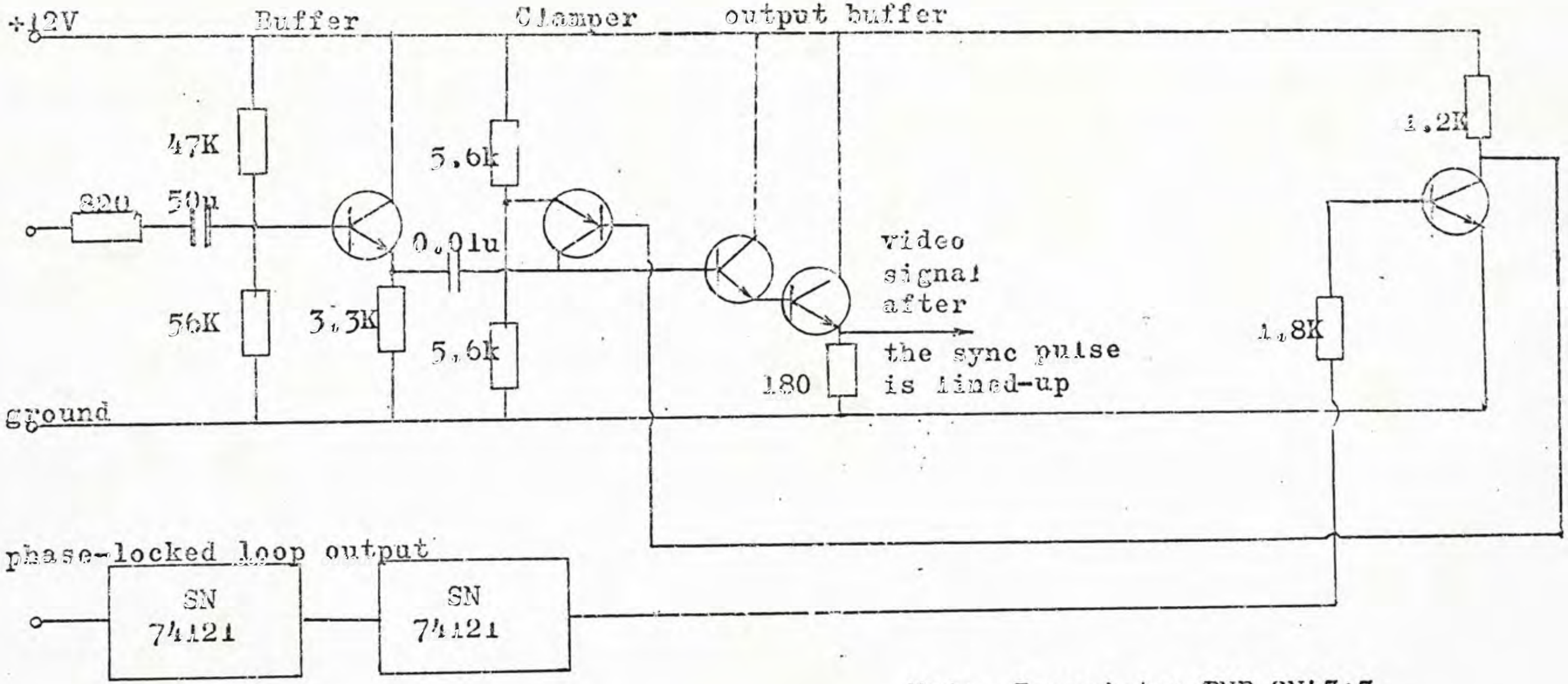


APPENDIX XII. Detail circuit diagram of the averaging unit



Note. Transistors
PNP 2N4313
NPN BF173
Inductors 0.03uH
Capacitors 75pF
Resistors in ohm
Unless otherwise
specified

APPENDIX XIII. Ghost simulator



the clamping pulse is
adjusted at the sync
pulse position

Note. Transistors PNP 2N4313
NPN BF173
Resistors in ohms
Unless otherwise specified

APPENDIX XIV. Clamper for 50Hz signal rejection

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