LB-838

A COLOR SYNCHRONIZATION CIRCUIT FOR RCA COLOR SYSTEM TELEVISION RECEIVERS

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Approved

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Introduction

This bulletin describes a color synchronization circuit in which the high-frequency sampling voltage is extracted from the composite color video signal by means of a high-Q resonant circuit driven by the transmitted 3.58-Mc burst. The damped oscillations thus obtained are amplified and smoothed to provide a source of 3.58 Mc for the color sampler.

This circuit has been incorporated in a complete color television receiver and its performance compared with other methods of producing the synchronized sampling voltage, including a locked-in crystal oscillator and an afc-controlled oscillator. The ringing circuit method is simple, easy to adjust and provides excellent phase stability.

General Discussion

Proper color synchronization requires that a high-frequency sampling voltage of correct phase be generated within the receiver. Present practice is to transmit a burst of 9 cycles of 3.58 Mc along with the composite color-video signal in order to provide a reference phase for the local 3.58-Mc generator. The main problem in color synchronization is accurately to lock this generator in phase with the burst and to make the action immune to interference.

Two previously used methods of generating the local sampling voltage utilize the transmitted burst as a means of providing phase and frequency information. These methods employ locked-in oscillators and afc-controlled oscillators. The first method consists of a crystal or self-excited oscillator operating at a nominal frequency of 3.58 Mc and a burst separating amplifier. The burst amplifier gates the burst and applies it directly to the frequency-controlling element of the oscillator. The burst tends to correct the phase of the oscillator at the start of each line interval, even though the free running frequency of the oscillator may differ slightly from the burst frequency. A locked-in crystal oscillator of this type has been described in LB-811, *Developmental Tri-Color Kinescope Receivers for the RCA Color Television System.*

An example of the afc oscillator method may be found in LB-799, *Circuit Diagrams and Description of a Receiver Sampler for Dot-Sequential Color Television.* In this circuit the output of the "green" and "blue" sampler tubes were combined in a differential detector to provide an afc voltage which corrected the phase of a 3.58-Mc self-excited oscillator.

In the ringing circuit method described in this bulletin, the oscillator has been replaced by a passive network consisting of a parallel tuned circuit resonant at the burst frequency. A damped train of oscillations is produced by ringing this high-Q tuned circuit with the burst. These oscillations are then passed through a smoothing amplifier to provide constant 3.58-Mc output for application to the color sampler.

Circuit Description

In the schematic diagram of Fig. 1 are shown the ringing circuit and smoothing amplifiers. The 6AS6 burst amplifier is keyed on during the burst period so that a damped wave train appears across the ringing circuit which is resonant at the burst frequency. Two amplifiers follow the ringing circuit in order to level the damped oscillations appearing across the ringing circuit to a constant amplitude output. Photographs of these waveforms are shown in Fig. 2 and 3.

The Q of the ringing circuit is 150 (including tube loading). In order to reduce the number of stages required for constant amplitude output, this value is increased to an operating Q of approximately 400 by adding positive feedback. Relatively high tuning C (450 uuf) was used in the ringing circuit in order to swamp variations in tube and wiring capacitance and to reduce tube loading. Other precautions taken in the design of the ringing resonant circuit were those that would usually be considered in the design of a tank circuit for a stable self-excited oscillator operating in the 3-4 Mc region.

All interstage coupling elements following the ringing circuit were heavily damped in order to minimize phase shifts in any stages other than the ringing amplifier. It was found desirable to tune the ringing circuit L_oC_o so that the voltage across it was in phase with the burst. This implies that any additional phase shifts in the smoothing amplifiers and other parts of the circuit should be corrected without having to tune the ringing circuit away from the burst frequency. This assures a substantially zero phase between the output voltage and the burst throughout the line interval.

Since color fidelity is determined by the accuracy with which the 3.58-Mc generator will lock in and remain in phase with the burst, the performance of the ringing circuit in terms of phase lock accuracy is of interest. In this connection it can be shown that it is not necessary for the local sampling signal to operate at precisely the same frequency as the sampler oscillator at the transmitter. This is because the phase of the sampling signal is corrected at the end of each line or every 1/15750 of a second. If the maximum allowable phase shift is specified, and it is assumed that the phase is zero immediately after the burst, then the phase difference ($\Delta\theta$) at the end of the line interval is:

$$\Delta\theta = \frac{\Delta F}{15,750} \times 360 \text{ degrees}$$

$\Delta\theta$ = Phase shift at end of line interval

ΔF = Difference between transmitter and receiver sampler frequencies.

If a phase difference of ± 10 degrees may

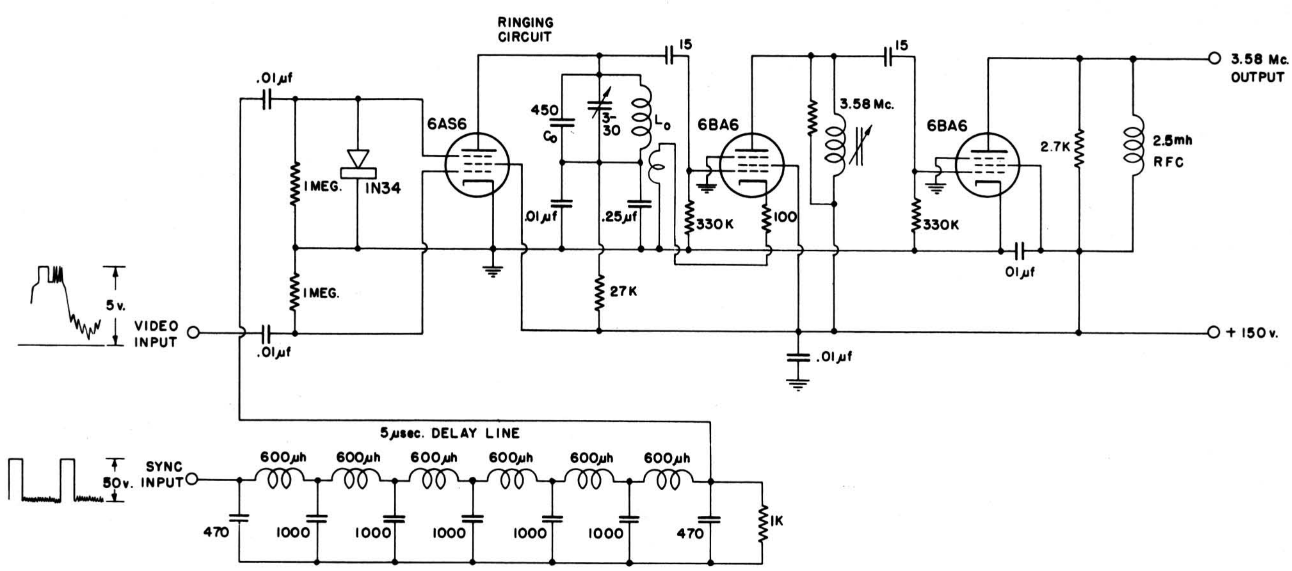

Fig. 1 – Diagram of the color synchronizing circuit.

be tolerated without significant loss in color fidelity, then the frequency of the sampling voltage may differ by approximately ±450 cycles per second.

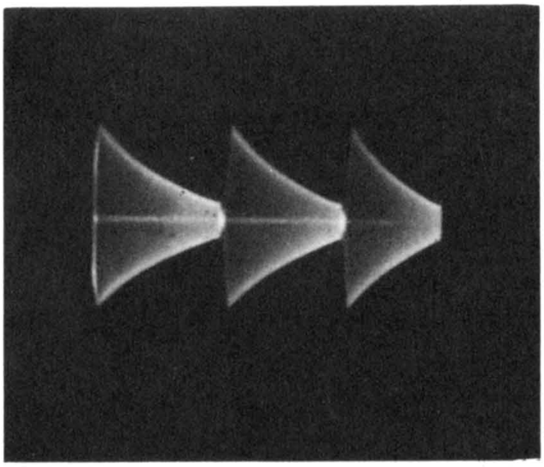

Fig. 2 – Voltage across the ringing circuit.

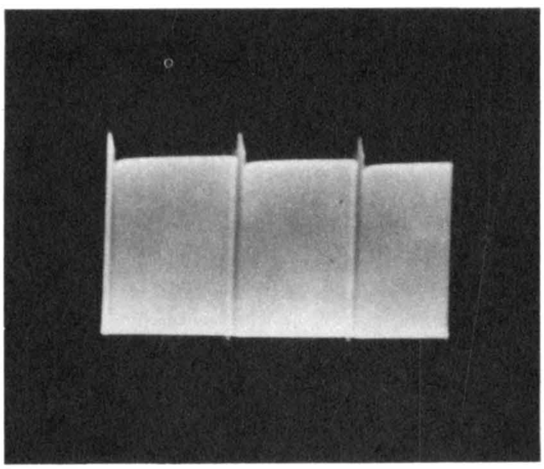

Fig. 3 – Output of the smoothing amplifier.

Since the ringing circuit is driven from a constant current source, the oscillation voltage across the tuned circuit will be in phase with the burst only when the ringing circuit is exactly resonant at the burst frequency. This implies that there will be an initial phase shift which reduces the actual frequency tolerance of the system. The total phase shift of the system is therefore:

$$\Delta\theta = \tan^{-1} 2Q \frac{\Delta F}{F} + \frac{\Delta F}{15{,}750} \times 360 \text{ degrees}$$

which occurs at the end of the line interval.

With an operating Q of 400, as in the circuit of Fig. 1, these two terms make approximately equal contributions to the phase error at the end of each line.

The Q of the ringing circuit should be high in order to restore the damped oscillations to constant amplitude in a minimum number of stages. For a decay during a line interval to 20 per cent of the initial amplitude, it was found that a Q of 400 was required. In general, the Q of the ringing circuit is related to the ratio of the initial and final amplitudes by:

$$Q = \frac{\pi n}{\text{Log}_e \frac{E_o}{E_n}}$$

n = number of complete cycles = 227 for a line interval, and sampling frequency of 3.58 Mc.

$$\frac{E_o}{E_n} = \frac{\text{Initial amplitude across } L_oC_o}{\text{Amplitude at end of line interval}}$$

In order to study the performance of the color synchronization circuit, an experimental setup was used that would allow observation of Lissajous patterns showing the instantaneous phase of the 3.58-Mc output compared with the burst. To observe the performance at any time during the line interval two cascaded driven multivibrators were used to provide a variable-phase--constant-width pulse which was applied to the control grid of the oscilloscope. This made it possible to illuminate the trace at any part of the line interval. This procedure was found useful in observing the degree of drift, performance in presence of noise, effect of supply voltage variation, etc.

Results

Stability of the color sync circuit in the presence of noise was observed to be excellent. This was demonstrated by adding random noise and impulse noise to the antenna input of the color receiver. The phase and general appearance of the sampling voltage seemed to be unaffected even under severe noise conditions. Observation of a color picture during severe noise interference showed that the video information was degraded before the color fidelity was significantly affected.

The circuit of Fig. 1 was found to be relatively free from drift in phase due to variations in supply voltages, video level or variation in circuit constants due to norma temperature and humidity changes.

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