B.N.

RCA

LB-863

A CRYSTAL RINGING CIRCUIT FOR COLOR SYNCHRONIZATION

RADIO CORPORATION OF AMERICA

RCA LABORATORIES DIVISION

INDUSTRY SERVICE LABORATORY

RADIO CORPORATION OF AMERICA

RCA LABORATORIES DIVISION

INDUSTRY SERVICE LABORATORY

LB-863

A Crystal Ringing Circuit for Color Synchronization

Approved

Stuart Wm Seeley

A Crystal Ringing Circuit for Color Synchronization

Introduction

This bulletin describes a receiver color synchronization circuit which uses the ringing of a quartz crystal to produce the required color reference frequency from the separated color synchronization burst. This circuit has both advantages and disadvantages as compared with other circuitry and complete evaluation must depend on field experience. Alternative methods of providing color synchronization have been described in earlier bulletins including LB-843, *AFC Color Synchronization Circuits*.

The circuit described in this bulletin is similar in principle to that in LB-838, with a quartz crystal rather than a coil-condenser combination being used as the ringing circuit. The crystal provides improved long-term stability and less susceptibility to noise because of its higher Q.

Circuit

The basic circuit is shown in Fig. 1 which gives the electrical equivalent circuit for the crystal and shows the crystal being driven by a generator of impedance Z_G into a load of impedance Z_L. It is assumed that the burst has been separated from the composite video signal so that the driving voltage is zero except for the 10 cycles of burst (2.5 µseconds) during each line interval.

It was observed early in this investigation that under certain conditions the output voltage across Z_L contained oscillations at two frequencies, corresponding to the two circuit meshes. These frequencies are separated by a few kilocycles and correspond to the so-called series and parallel resonant frequencies of the crystal. The presence of the two frequencies was readily observed by the resulting beat envelope of the output voltage. Under conditions of high values of terminal resistance, the parallel resonant mode predominated; with low terminal resistances the shunt capacitance of the crystal was effectively shorted and only the series oscillatory mode was effective.

The parallel mode was investigated initially. As might be expected from the relatively high terminal resistances (10K ohms or higher), this mode of operation resulted in an output frequency and phase which were affected by the terminal reactances as well as by the crystal shunt capacitance. There was also a tendency toward ringing of the input coil (the effect of which could be neutralized). Because of these undesirable characteristics, the series mode of operation was investigated and found to offer substantial improvement in circuit stability and ease of alignment.

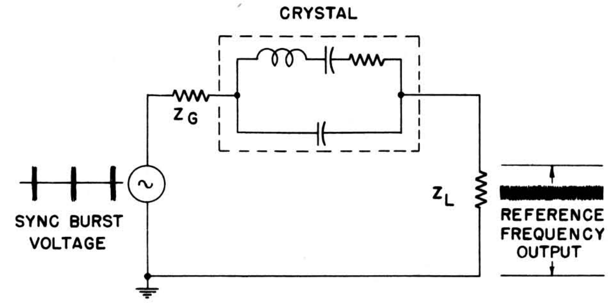
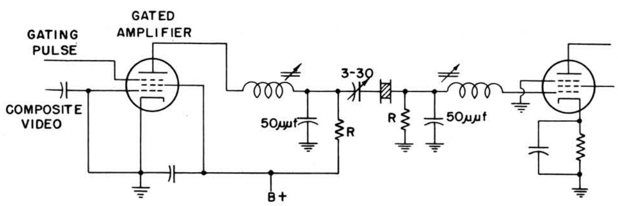


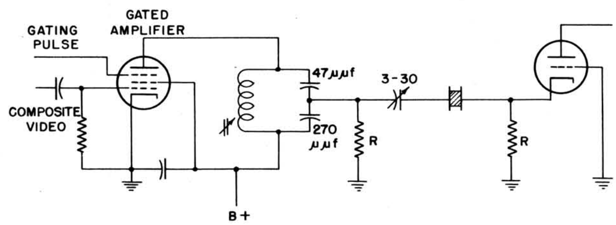
Fig. 1 - Electrical equivalent of crystal ringing circuit.

Series Operation

In order to achieve series operation, it is necessary to work the crystal out of, and into, relatively low resistances in the order of 100 to 2000 ohms. In the circuits shown in Fig. 2, a crossover in the mode of operation appears when the source and load impedances are in the region of 4000 ohms.



(a)



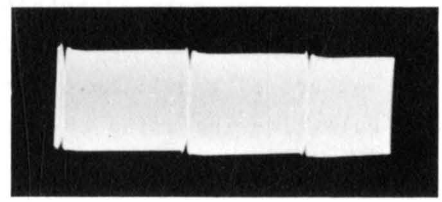
(b)

Fig. 2 - Two forms of the crystal ringing circuit. The effect of varying R is shown in Fig. 4. The series trimmer enables tuning the crystal frequency over a range of a few kilocycles.

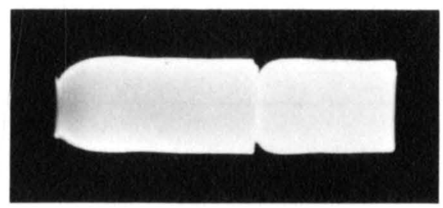
A series arrangement used is shown in Fig. 2a. The crystal is driven from the 6AS6 gated burst amplifier through an impedance transforming π network. An alternate method of driving the crystal is shown in Fig. 2b. This lends itself for use with a grounded-grid triode amplifier. The Q of the impedance matching networks in these circuits is relatively low and their effect on the phase of the output is negligible.

In both these circuits, an adjustable trimmer condenser is placed in series with the crystal to vary the resonant frequency of the crystal circuit. This provides a relatively wide range of adjustment so that the accuracy requirement on the crystal is greatly eased.

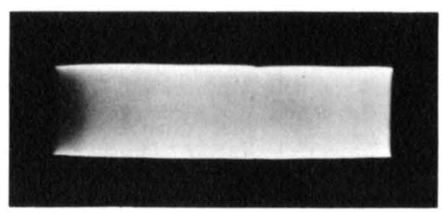
The output of the crystal ringing circuit is shown in Fig. 3 with line and field rate sweeps. The appearance of the waveforms during the burst intervals is influenced by the tuning of the crystal circuit and in general proper tuning is accompanied by maximum output and minimum discontinuity. The decay of the output voltage during the vertical interval is of course the result of absence of burst during this interval, in accordance with the present NTSC standards. The amount of decay as well as the discontinuity during the line interval are related to the circuit Q. Generally, higher circuit Q's, i.e., lower values of R, will result in more uniform output.



(a) - Output of crystal ringing circuit - horizontal sweep.



(b) - Output of crystal ringing circuit - vertical sweep.



(c) - Output of limiter - vertical sweep.

Fig. 3 - Output of crystal ringing circuit.

Phase Stability and Noise Immunity

The operating characteristics of this circuit are shown in Fig. 4 which displays the phase variation of the output as a function of the frequency separation between the transmitted color sync burst and the receiver crystal circuit resonance. Curves are given for several values of load resistance R. These curves show that, for a given frequency separation, the phase shift decreases for increasing values of series resistance, i.e., for lower values of circuit Q.

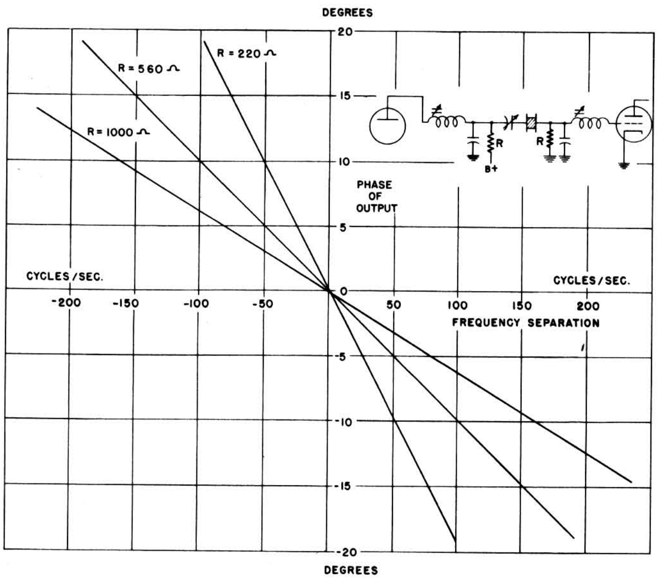


Fig. 4 - Variation in phase of output with frequency separation between burst and crystal circuit. The higher the load resistance, the lower the phase shift for a given frequency separation.

Pictures were observed under weak signal conditions using the circuits of Fig. 2 incorporated in a complete television receiver operating on NTSC standards. It was found that random noise enabled a more critical evaluation of color sync performance and was preferable to impulse noise in this respect. In general, the noise immunity was found to improve with increasing circuit Q, as is to be expected. The phase stability, with 1000-ohm terminating resistors, was such that a frequency change of ±80 cycles in the color subcarrier frequency produced a phase shift of ±5 degrees in the receiver sampling frequency. In addition to producing phase shift, detuning of the receiver crystal circuits also resulted in degradation of the picture in the form of streaking when the separation exceeded approximately ±100 cycles. With 220-ohm terminating resistors, this streaking became noticeable for a detuning of approximately ±60 cycles. Because of the greater phase stability and reduction in streaking under weak signal conditions with the crystal circuit detuned from the color sync burst, operation with 1000-ohm load resistors appeared preferable.

The crystal ringing circuit differs from AFC or locked-in oscillators in that the latter exhibit only phase variations under noise conditions. In order to eliminate amplitude variations resulting from noise and changes in signal level, it has been found essential to provide limiting so that a color sync signal of substantially constant amplitude is fed to the color demodulators. The degree of limiting required will depend on the sensitivity of the color demodulators to amplitude changes in the sampling (color reference) frequency.

Crystal Frequency

In general, it has been possible to use crystals interchangeably in the transmitter and receiver color reference frequency circuits. This comes about since in both circuits frequency is determined by the crystal in series with an adjustable capacitance of the same order of magnitude.

The color sync circuit is aligned by peaking all tuned circuits (including the crystal) for maximum output. When the series crystal trimmer is properly adjusted, minimum discontinuity will result during the sync interval. Optimum adjustment of the crystal tuning is most readily made with a weak signal input to the antenna terminals, by adjusting for minimum noise streaking.

The requirement on the accuracy of the crystal frequency is considerably less stringent than Fig. 4 would indicate. Although the crystal circuit must be tuned accurately by the associated series trimmer, the crystal itself may be ground to limits of the order of ±1000 cycles of the design center.

Jack Avins