RCA

LB-820

A LABORATORY APPROACH TO THE REDUCTION OF TELEVISION RECEIVER CHASSIS RADIATION FROM THE LOCAL OSCILLATOR

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Approved

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Introduction

Investigation of several television receivers at the Industry Service Laboratory has revealed that they have in common several factors which appear to cause excessive direct chassis oscillator radiation. The open-field measurement setup described in LB-802, *Open-Field Test Facilities For Measurement of Incidental Receiver Radiation,* is the only means for determining the absolute magnitude of this radiation from a receiver but the instrumentation and technique to be described here has been found useful in the laboratory for isolating and determining the qualitative effect of corrective measures.

Obviously, if all of the oscillator energy is confined within the tuner, none of it will be radiated. Therefore, the technique involves measurement of oscillator voltages external to the tuner before and after changes intended to confine the oscillator energy. Because open-field measurement of many television receivers has shown that chassis radiation on the high channels is the worst source of radiation with modern tuners, this bulletin deals only with that phase of the problem. However, the instrumentation used is also useful for measuring the voltage appearing at the antenna terminals.

The several receivers which have been investigated have all responded to the same measures. These include adequate shielding of the tuner and filtering of the power, a-g-c and i-f leads.

General Discussion

In general, the problem of reducing chassis oscillator radiation is one of confining the oscillator energy to the tuner enclosure. In planning the approach to this problem it was felt that if the presence of oscillator energy outside the tuner could be detected it would be possible to find the coupling path and take steps to minimize it.

It is possible to utilize a loop for detecting the presence of oscillator energy currents or a voltmeter to measure the voltages developed by these currents. The voltmeter approach was selected for the initial work and was found to provide suitable indications. The current detector has not been investigated. The two terminals of the voltmeter are connected between points at which a difference in potential of oscillator voltage might be expected, for example; i-f grid to chassis; +B, a-g-c, or heater leads to chassis, or between two points on the chassis itself. Qualitative results of various filtering or shielding measures can be readily detected.

In application best results are obtained if the measurement of oscillator energy by this method is used to complement the open-field measurements. It provides an excellent tool for the engineer working in the laboratory because it indicates whether or not a change he has made is likely to be helpful or harmful. The final determination of the radiation propensities of a receiver, however, must be made in an open-field measurement setup.

Measurement Equipment

The oscillator voltage detector consists of a crystal diode, the output of which is applied to a vibrator-type chopper. This is followed by a high gain audio amplifier and the "modulated" d-c signal is viewed on an oscilloscope. Calibration is obtained by comparison with an r-f signal generator.

A number of d-c amplifiers which can be used with a crystal probe are commercially available. One particular unit that has been found to give satisfactory results is the Leeds and Northrup Model 9835. The circuit diagram of an amplifier that was built in this laboratory with which voltage levels down to about 0.5 millivolts can be detected is shown in Fig. 1.

Two probes that were built for use with this unit are also shown. One has a balanced 300-ohm input and is used for the measurement of oscillator energy at the antenna terminals. The other is an unbalanced high-impedance probe that is used for detecting energy about the chassis.

Since the crystal detector efficiency at the levels encountered in this work is low it is necessary to keep hum, noise, and microphonics in the input circuits to a minimum in order to realize best sensitivity. A double shielded two-conductor cable is utilized between the probe and the amplifier with the ground for the diode circuit being made at the first stage of the amplifier.

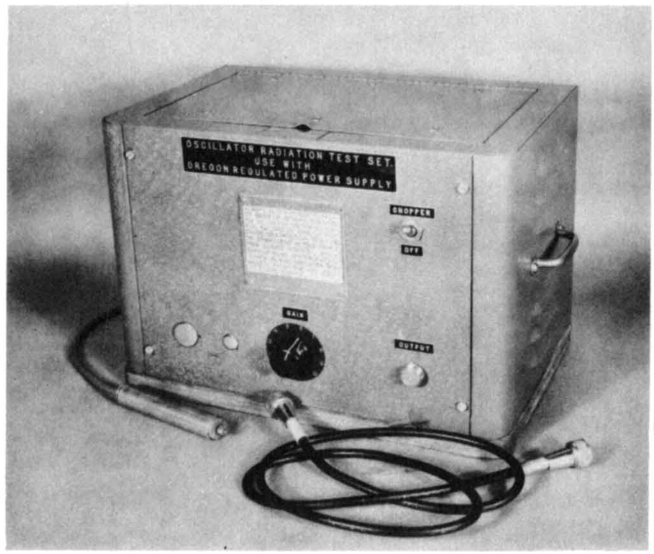


Fig. 2 - Complete view of oscillator radiation test set.

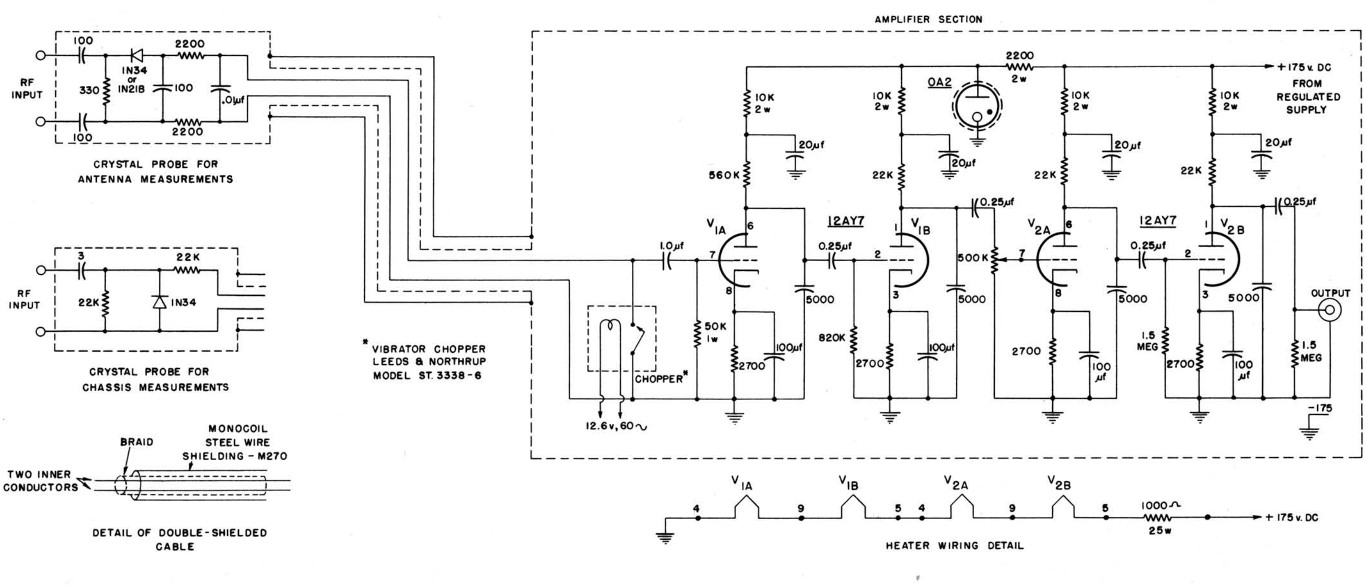


Fig. 1 - Circuit diagram of equipment for the detection of oscillator energy.

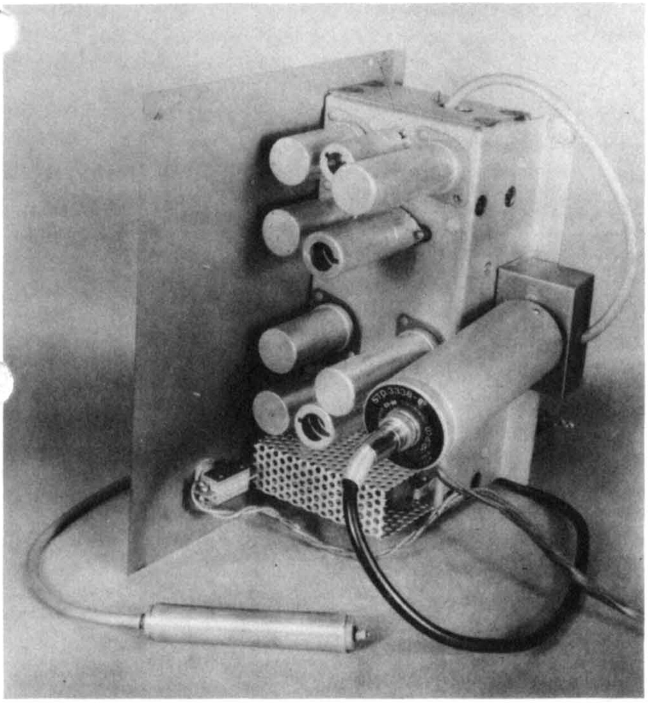
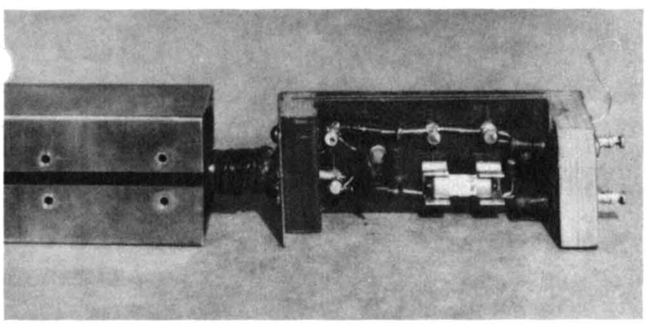
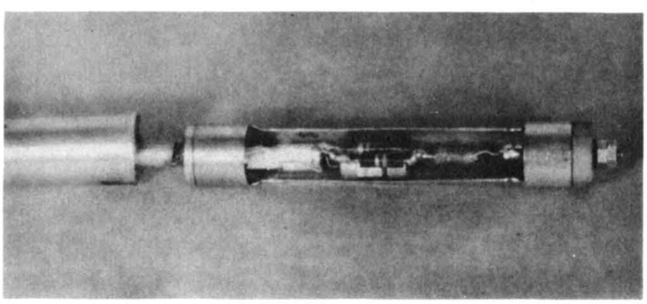


Fig. 3 - Inside view of oscillator radiation test set.



(a) 300-ohm balanced probe



(b) High-impedance unbalanced probe

Fig. 4 - Probes for detecting oscillator energy.

Sensitivities in the order of 0.5 millivolts have been obtained with the use of selected 1N34 crystals. At higher frequencies, near 1000 Mc, type 1N21B crystals were found to have slightly greater sensitivity but because of difficulty with crystal failure these were not used. In working with this equipment care should be taken not to apply heat to the crystal as this results in false readings.

Several photographic views of the amplifier are shown in Fig. 2 and Fig. 3 while Fig. 4 shows the details of the probe construction.

Measurements in a Typical Receiver

The chassis radiation of several receivers representing current design was measured in the open field setup. These receivers were then brought into the laboratory where measurements were made of the level of oscillator voltage at various points within chassis. It was possible in this way to ascertain the location of possible sources of radiation. Then by the expeditious use of shielding and filtering and by some modifications in circuit design the level of energy at these points was reduced.

A second set of open-field measurements was used to determine the effect of the laboratory changes on the absolute radiation. Table I gives the results of the measurements on one

Table I

RECEIVER CHASSIS RADIATION AS MEASURED AT 100 FEET ON CHANNEL 8	
Conditions of Measurement	Microvolts per Meter at 100 Feet
A. Total chassis radiation from the receiver in its original condition.	1500
B. Same as A with shield added to both the tuner and the sound i-f trap.	200
C. Same as B with tuner power leads filtered and with line cord oriented away from the tuner.	80
D. Same as C with i-f coupling removed.	50
E. Same as D with tuner double shielded (single ground between shields).	Not Detectable (Under 5 µv/M)

receiver on Channel 8 before modification and also shows the effect of the various corrective measures. If the chassis radiation on Channels 7 to 13 is reduced to a reasonable level the chassis radiation on Channels 2 to 6 has been found to be undetectable or very close to the minimum measurable level of the open-field test equipment.

Shielding and Filtering

By far the most important single factor in the reduction of chassis radiation was the use of a well grounded shield which covered the complete underside of the tuner circuit. Without this shield hundreds of millivolts of oscillator energy could be measured at almost any point on the chassis, i.e., video leads, a-c power lead, tube mount, etc. It was necessary to ground the shield securely at many points particularly near the oscillator section.

After a shield was added it was possible to locate energy escaping from the tuner via the power and a-g-c leads. It was necessary to filter these leads at the point that they entered the tuner chassis. The relative amplitude of the signal on these leads is a function of the particular chassis and tuner but in one specific chassis the heater lead was the major offender and measured about 55 millivolts. Approximately 10 millivolts was present on the +B and a-g-c leads.

With the addition of the filtering the level on the heater lead was under 3 millivolts and on the a-g-c and +B under 1 millivolt.

Another source of radiation was found to be an unshielded sound i-f trap which was coupled into the mixer plate circuit. It was necessary either to shield this coil, or to eliminate it entirely and obtain the required rejection elsewhere in the i-f amplifier.

The routing of leads such as the a-c line or +B close to the tuner can contribute substantially to the total radiation.

IF Coupling Circuit

A considerable amount of oscillator energy was coupled into the receiver circuits through the coupling network between the mixer plate and the first video i-f amplifier grid. In dual i-f receivers, in which the sound takeoff is at the mixer plate, oscillator energy feedthrough to the first sound i-f stage is also a problem.

Several video i-f coupling circuits in common use were investigated and in general were poor in this respect. Fig. 5 shows several circuit configurations and the approximate level of oscillator energy appearing at the first i-f amplifier grid. All of the circuits were used with a 6J6 double-triode mixer oscillator. The values shown were measured on one typical receiver which was equipped with a satisfactory shield.

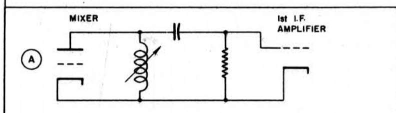
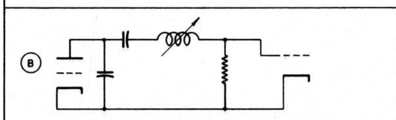
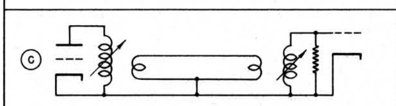
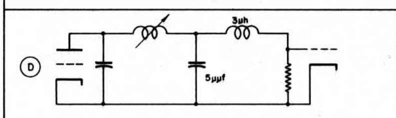
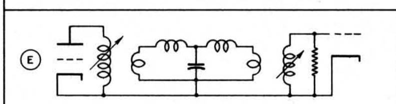
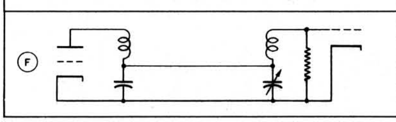
CIRCUIT	MILLIVOLTS OF OSCILLATOR ENERGY ON GRID OF FIRST VIDEO I.F. AMPLIFIER — HIGH CHANNELS	LOW CHANNELS
	GREATLY EXCEEDS CAPACITY OF MEASURING EQUIPMENT (>200 mv.)	>200 mv.
	12 mv. max.	8 mv. max.
	18 mv. max.	8 mv. max.
	2.5 mv. max.	5 mv. max.
	3 mv. max.	Under 3 mv.
	Under 2 mv.	Under 2 mv.

Fig. 5 - Effect of various i-f coupling on the magnitude of oscillator energy at i-f grid.

As can be seen the parallel single-tuned circuit, (Fig. 5A) which is very rarely used in receivers of recent design, is particularly bad. The level of energy at the i-f grid in circuits of this type may be a volt or more. The use of a series coil coupling circuit (Fig. 5B) is a great improvement but the level, on the high channels, has been observed to exceed 12 millivolts. The double-tuned link-coupled circuit (Fig. 5C) is somewhat poorer than the series coil circuit.

Several modifications have been found in which the level of energy at the i-f grid is considerably below the above mentioned values. Circuit D in Fig. 5 shows a modification of the series coil arrangement in which the tuning inductance is split into two parts. With this circuit the oscillator level measured about 2 millivolts on the high channels. No appreciable loss of gain was apparent.

The addition of a low pass filter in the link of the link-coupled double-tuned arrangement (Fig. 5E) is effective in cutting down the oscillator feedthrough with this circuit. Care should be taken that the filter does not effect the overall gain or the frequency response to i-f signals.

Circuit F which is a double-tuned arrangement using low side capacitive coupling has proven to be effective if the coupling capacitor is divided into two approximately equal parts with one half inside the tuner chassis and the other half near the i-f grid. If necessary an inductance could be added between the two parts of the coupling capacitor for additional attenuation of oscillator energy.

Several precautions are worth noting in the matter of physical placement of parts in the coupling circuit. In a double-tuned network it is preferrable to position one coil inside the tuner and the other at the i-f grid. Any filtering or bypassing in the coupling lead should be close to the opening in the shield with the oscillator energy being bypassed back to the tuner chassis. With the series coil best results were obtained with the coil inside the tuner shield if the i-f lead was kept to a minimum length. In the construction of i-f coils the leads and terminals should be positioned to produce minimum capacitance across the coil.

Since it is conceivable that coupling networks following the first i-f stage may have spurious responses at frequencies in the oscillator range the existance of substantial amounts of oscillator energy in stages following the first i.f. is possible and should not be overlooked.

Conclusion

By applying the method described in this bulletin the chassis component of radiation has been substantially reduced in several different receivers. Correlation of results has shown that, in general, the same troubles have been present in all chassis tested, i.e., inadequate shielding, lack of filtering on power and a-g-c leads, and feedthrough to the i-f grid.

Even though it provides only qualitative indications, the approach described in conjunction with an open-field measurement setup provided a good laboratory tool for reduction of chassis radiation.

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