ELECTRON TUBES

RCA Application Note

AN - 146
December 1, 1950

Minimizing Pulse Voltages in Television Vertical-Deflection Amplifiers

This Note describes principles and methods for minimizing the amplitude of the pulse voltages generated in the output of vertical-deflection amplifiers for magnetic-deflection kinescopes. These pulse voltages, which are developed by the rapid change of current in the vertical-deflecting coils during vertical retrace, should be kept small in order to minimize the possibility of failure in the vertical-output transformer, the vertical-output tube, and the tube socket. The design principles described in this note are simple to apply and usually lead to reductions of about 50 per cent in the pulse voltages.

Theoretical Limitations

The minimum theoretical pulse voltage developed in a yoke during retrace is a function of retrace time; a longer retrace period permits a lower pulse voltage. There are, however, several successive factors imposing a maximum limit on the duration of vertical retrace. The fundamental limitation is that retrace must be completed during vertical blanking or the picture will be folded at the top. Television standards specify that vertical blanking last between five and eight per cent of the field period, which is 16,667 microseconds. A further limitation arises from the fact that conventional vertical oscillators do not permit retrace to begin before the arrival of the vertical synchronizing pulse, which follows the beginning of blanking by an interval approximately equal to one per cent of the field period. A receiver, therefore, must have a retrace time of less than four per cent of the field period (665 microseconds). Finally, provision must be made for an even shorter retrace because tube and component variations will cause production variations. Fortunately, pulse voltage may be limited to a reasonable value without a retrace period of three per cent of the field period (500 microseconds) being exceeded.

The magnitude of pulse voltage is determined not only by duration of retrace but also by the waveshape of the voltage in the vertical-deflecting

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

Photolithographed in U.S.A.

coils. If linear trace and retrace are assumed and if the yoke is considered to be an inductance and resistance in series, the coil current and voltage will be of the form shown in Fig.1a. In contrast, the minimum pulse amplitude is obtained if the coil voltage pulse is made rectangular as depicted in Fig.1b. The rectangular pulse is achieved when the retrace is slightly faster at the start. The values of theoretical minimum pulse voltage obtained with this ideal rectangular waveform are most conveniently used when expressed as a function of peak-to-peak sawtooth voltage and retrace time. This relationship enables the data to be applied universally to any vertical-deflection circuit and permits quick comparison between the ideal and the practical circuit. The corresponding ratio of pulse to sawtooth voltage in an actual circuit is easily measured for comparison purposes with an oscilloscope, either at the vertical-deflecting winding or at the plate of the vertical-output tube.

Table 1 shows the ratio of theoretical minimum pulse voltage to sawtooth voltage for various retrace times. These values can be closely approached in practice. For this table, a vertical-deflecting winding with an inductance of 41 millihenries and a resistance of 48 ohms and operating without damping resistance was assumed. Because all conventional yokes have approximately the same ratio of inductance to resistance, the table is generally applicable to deflecting yokes operated at a field frequency of 60 cycles per second. In addition, the theoretical minimum for peak plate-voltage in the circuit of the vertical-output tube may be approximated from this table. The peak-to-peak sawtooth voltage at the plate of the vertical-output tube will usually be of the order of 1.2 times the average plate voltage. The approximate peak voltage, therefore, is (1.6 + 1.2r) times the plate voltage, where r is the ratio given in Table 1.

Table 1

Retrace Time in Per Cent of Field Period	0.5	1	1.5	2	2.5	3	4
Ratio of Pulse Voltage to Sawtooth Voltage	9.8	4.68	2.98	2.12	1.6	1.26	0.83

Adjustment of Retrace Time

The minimum retrace time is determined by the resonant frequency of the deflecting winding and its associated components. The retrace time may be made longer than this minimum by proper adjustment of the damping resistance applied during retrace. When triodes are used as vertical-output amplifiers, the tube itself is used as the damping resistance and the damping is adjusted by the "peaking" portion of the grid signal to the vertical-output tube. The best method of adjusting the retrace time is to make the duration of the peaking pulse equal to the desired retrace time.

The duration of the peaking pulse depends solely upon the conduction period of the discharge device in the sawtooth-generating circuit. Generally, the conduction period, in turn, depends upon the duration of the pulse on the grid of the tube in the discharge circuit. In the blocking-oscillator discharge circuit, the duration of the grid pulse is a function of the resonant frequency of the blocking-oscillator transformer. This resonant frequency may be lowered by adding external capacitance across the transformer, although redesign of the transformer would be desirable to maintain

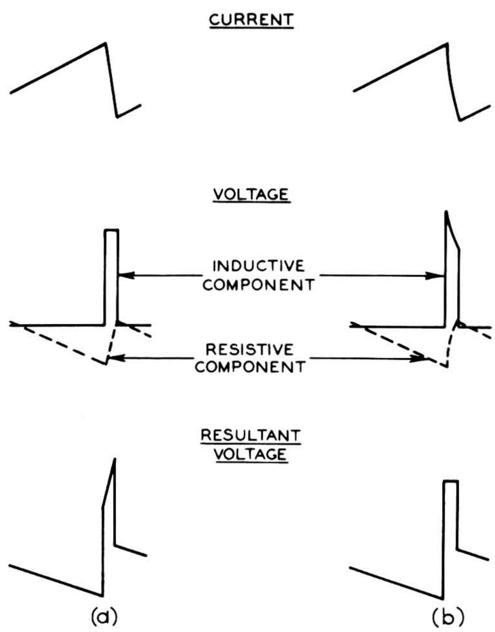

Fig. 1-Current-voltage relationships in vertical deflecting windings. Retrace period shown disproportionately large for clarity.

a high L to C ratio. If capacitance is added, some shunting resistance may be required to lower the Q of the coil so as to prevent "double triggering" of the blocking oscillator.

Adjustment of Peaking Amplitude

The theoretical value for minimum retrace pulse can be approached only if the duration of the peaking pulse equals the desired retrace time, as described above, and if the amplitude of peaking is properly adjusted. The amplitude should be varied to obtain a waveform of coil voltage similar to that of Fig.2b. Amplitude variation should not be used to adjust retrace time. The amplitude of the peaking has some effect upon retrace duration, as shown in Fig.2, but when the amplitude is varied to obtain a desired retrace time, the minimum theoretical voltage corresponding to that retrace time can not be approximated. For example, Fig.2a shows the underdamped condition resulting from too much peaking, as evidenced by the damped oscillation after retrace. In Fig.2b, which shows the proper amount of peaking, the peaking amplitude is just sufficient to complete retrace at the instant the peaking pulse is completed. Fig.2c shows the overdamped condition resulting from insufficient peaking amplitude. The peaking interval is completed before retrace is

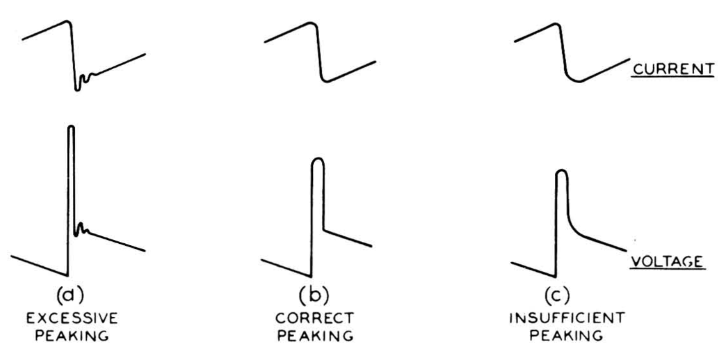

Fig. 2 - Dependence of retrace period and pulse voltage on peaking amplitude, as evidenced by waveforms of current and voltage in vertical-deflecting coil.

ended; the remainder of retrace is then much slower because of the still greater damping of the tube without peaking. If peaking is insufficient, retrace time is increased greatly without much reduction of the pulse voltage.

The shape of the waveform at the yoke or plate of the vertical-output tube is a good criterion for the adjustment of peaking amplitude. Alternatively, the point of correct adjustment may be judged through observation of the kinescope raster. When the peaking is properly adjusted, the spacing of the first few lines at the top of the raster is practically equal to the spacing of the next few lines below. Wider spacing indicates too much peaking; cramping or fold-over at the top of the raster indicates too little peaking.

Effect of Peaking Waveform

As is illustrated in Fig.1, the ideal condition for minimizing the pulse voltage is to make the retrace slightly faster at the beginning than near the end. Most conventional circuits tend to cause this type of nonlinearity. Blocking oscillators, in fact, normally cause the retrace to be too nonlinear. The waveforms obtained with a conventional blocking oscillator, Fig.3a, show that the peaking pulse has a greater amplitude at the beginning of peaking. This greater amplitude reduces the damping on the vertical-output transformer and permits the retrace to be very fast at the beginning with the result that the retrace pulse is much larger than it should be. The shape of the peaking pulse in a circuit containing a blocking oscillator results from the fact that, during conduction, the "resistance" of the blocking-oscillator tube is varying. The variation is caused by the excessive slope of the voltage waveform at the grid. This slope may be reduced by inserting a resistor of approximately 100,000 ohms in series with the grid of the tube. It may be desirable to insert this resistor at the tube socket to minimize electrostatic coupling to the grid circuit and possible loss of interlace. Fig.3b shows the effect of this resistance on the waveforms of Fig.3a.

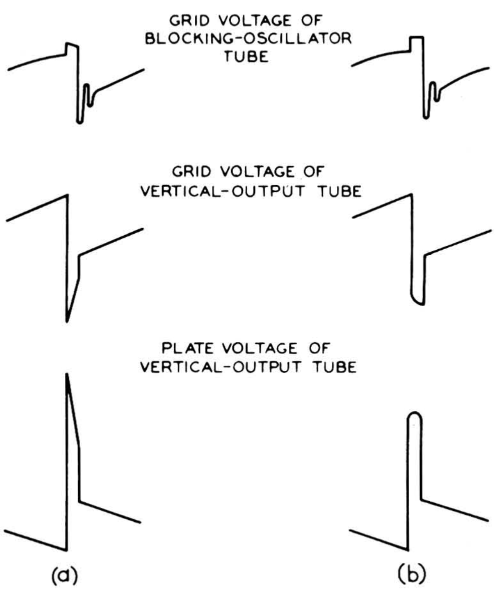

Fig.3 - Effect on pulse voltage when waveform of blocking oscillator grid voltage is varied. (a) result of uncorrected grid-waveform; (b) pulse reduction when grid resistor is added.

Kinescope Picture as Aid to Adjustment

Observation of the vertical-retrace lines in the picture can be useful in circuit design in a number of ways. For instance, the retrace time can be accurately measured by counting the retrace lines. Because each line represents one horizontal-scanning period, the number of retrace lines divided by 525 and multiplied by 100 yields the retrace time in per cent of the vertical-scanning period. The raster should be interlaced for this measurement. In addition, the relative spacing of the retrace lines is a good indication of the linearity of vertical retrace. The retrace should appear quite linear. The degree of nonlinearity requisite for minimum pulse voltage is not sufficient to be readily visible to the eye on the kinescope picture.