

INNER RASTER DISTORTION CORRECTION CIRCUIT

Large screen CRT displays may require a high amount of inner raster distortion correction for adequate raster linearity. The commonly used east-west pincushion distortion correction circuit using a diode modulator can correct some inner pincushion distortion. It has been found, however, that the correction of larger inner raster distortion errors is difficult. Furthermore, because prior art correction of inner raster distortion is difficult or impossible to be adjusted, the results are often unsatisfactory.

Horizontal deflection circuits commonly employ resonant trace and retrace principles. During retrace, the deflection circuit forms a high frequency parallel resonant circuit: energy is supplied to the deflection circuit from the flyback transformer primary winding. During the trace interval, a deflection switch provides a low frequency series resonant circuit formed by the deflection yoke winding and the S-shaping capacitor. As a result, energy circulates from the yoke to the S-capacitor and back to the yoke in one trace period. This produces a sinewave shaped deflection current with a conduction angle of approx. 130° , starting at about 115° and ending at about 245° . The retrace provides a fast return of the deflection current from the nominal 245° position at the end of trace to the nominal 130° position at the start of trace.

The value of the S-capacitor determines the conduction angle or the S-shaping of the deflection current. Thus, the S-capacitor is selected for best horizontal linearity. The voltage across the S-capacitor is cosine shaped. The amplitude is highest at the center of trace, when the deflection current is zero. The correction of inner raster distortion requires modulation of the S-shaping as a function of the distance along the vertical axis of the raster display, i.e. from top to the center and from the center to the bottom of the raster. This is achieved by modulation of the voltage across the S-capacitor. The modulated voltage appears also across the horizontal yoke and causes a modulation of the deflection current.



The invention provides an inner raster correction circuit allowing adjustment of correction amplitude and of overall S-shaping. A deflection winding is coupled in series with an S-correcting trace capacitor. A deflection switch is coupled to the deflection winding and responsive to a source of an input signal at a first frequency related to a deflection rate, for generating in the deflection winding a trace current during a trace interval and a retrace voltage during a retrace interval. An inside raster distortion correction circuit is coupled across the trace capacitor, for varying the amount of S-correction provided by the trace capacitor. The inside raster distortion correction circuit comprises a distortion correction switch, which is conductive and non-conductive as a function of the value of a source of modulating signal at a second frequency.

Figures 1a to 1f show raster displays with different raster distortions, and the variation of the S-correction which is necessary to correct such distortions.

Figure 2 shows a diagram in block and schematic form of a deflection circuit of a preferred embodiment of the invention.

Figures 3a to 3o show current and voltage waveforms at several points in the circuit of Figure 2, and

Figure 4 shows an alternate embodiment of the invention.

Fig. 1 shows raster displays with different inner raster distortions. Also shown are waveforms of the voltage across the S-capacitor and the modulation envelope. It is assumed that outside pincushion distortion is corrected by amplitude modulation of the deflection current. This is illustrated by the straight vertical lines at the extreme left and right hand side of the shown raster displays.

Fig. 1a shows an inner pincushion distortion error. The correction, shown in Fig. 1d, requires more S-shaping in the center than at top and bottom.

Fig. 1b shows an inner barrel error. As shown in Fig. 1e, more S-shaping is required at top and bottom than in the center.

Fig. 1c shows a second order inner pincushion error. The average space differs between the vertical lines at center and top/bottom. As shown in Fig. 1f, the correction requires less



pincushion and a flatter waveform shape at top and bottom. This is obtained by a modulation frequency higher than line frequency.

Fig. 2 shows a circuit diagram of a horizontal deflection circuit with outside pincushion correction and with the inventive circuit for the correction of the inner raster distortion such as inner pincushion distortion. The circuit has been used to generate deflection current for a SONY Trinitron picture tube Type A68JYL61X.

Figs. 3a to 3h shows waveforms at the horizontal rate, and Figs. 3i to 3o show waveforms at the vertical rate, from the circuit of Fig. 2.

The primary winding of flyback transformer T₂₀ supplies energy via E-W switching transistor Q₂₀ to the horizontal deflection circuit consisting of switching transistor Q₂₁, retrace capacitor C₂₂, linearity coil L_{LN}, horizontal yoke winding L_H and S-shaping capacitor C₂₃. Transistor Q₂₁ is driven in conventional manner by the horizontal oscillator and driver. The E-W control circuit turns off Q₂₀ at controllable instants during the first half of the retrace interval to amplitude modulate the retrace voltage V₂ across C₂₂ and in turn the deflection current i₁ flowing through L_H. Capacitor C₂₀ acts as retrace capacitor for the primary winding of T₂₀. Capacitor C₂₁ couples the transformer retrace circuit T₂₀, C₂₀ to the deflection retrace circuit C₂₂, L_H and C₂₃. The retrace voltage V₂ is divided by C₂₄, C₂₅ to obtain a low voltage retrace pulse V₆ across clamping diode D₂₀.

Waveform 3a shows the flyback transformer retrace voltage V₁ non modulated because of stabilized supply voltage +135V.

Waveform 3b shows the deflection circuit retrace voltage V₂ modulated by the action of Q₂₀.

Waveform 3c illustrates the amplitude modulated deflection current i₁ for the correction of the outside pincushion distortion. The waveforms on the right side show the parabolically shaped envelopes at the vertical rate.

The inside pincushion correction circuit consists of L₁, C₁, retrace capacitor C₃, switching transistor Q₁, D₁, D₂ and C₂. Transistors Q₄ to Q₇ generate the gate pulses for Q₁. Transistors Q₂, and Q₃ provide feedback for linear operation. Correction current i₂ flows through Q₁, C₁, L₁ and C₂₃ during the trace



interval. Q_1 is turned off at modulated instants during the first half of the retrace interval t_1 - t_2 , and turns on during interval t_2 - t_3 when the integrated anti parallel diode of Q_1 becomes forward biased. When Q_1 is turned off, current i_2 flows through C_3 and produces a retrace voltage V_4 , shown in Fig. 3g. Deflection energy is fed via C_2 and D_2 into C_3 during the modulated interval t_1 - t_2 to enhance the amplitude modulation of i_2 .

Waveform 3e shows the envelope of the modulated current i_2 . The low amplitude of i_2 is obtained when Q_1 does not turn off, or when it turns off just before t_2 . The sine wave shaped i_2 with peak amplitudes at t_a and t_a' is generated by V_3 across C_{23} . The amplitude of i_2 increases when the turn off instant of Q_1 is advanced toward t_1 . During the retrace interval t_1 - t_3 , the current path of i_2 is switched to a higher frequency by the insertion of C_3 . The rapid current change between t_1 - t_3 results in a frequency decrease of i_2 between t_3 - t_1' indicated by the shift of the amplitude peaks from t_a to t_b and from t_a' to t_b' .

The i_2 current waveform with peaks at t_b and t_b' is nearer to the resonant frequency of the i_2 current path, resulting in a higher amplitude than the waveform with the peaks at t_a and t_a' . Thus L_1 is adjusted to a resonant frequency slightly lower than the envelope of i_2 , i.e. $2(t_4 - t_0)^{-1}$. A further increase of the i_2 amplitude modulation is obtained by deflection retrace current i_3 . During interval t_0 - t_1 , down-ramping current i_3 flows through Q_1 . When Q_1 opens at t_1 , i_3 decreases because of the impedance formed by C_3 , C_1 , L_1 and C_{23} . Between t_1 - t_2 , i_3 charges C_3 , producing an increase of V_4 and in turn of i_2 . When the turn-off instant of Q_1 is retarded toward t_2 , i_3 charges C_3 during a shorter time interval, resulting in less V_4 amplitude. Diode D_2 is non-conductive during interval t_2 - t_3 . Capacitor C_2 discharges via D_1 during this time.

The turn-off instant of Q_1 is advanced in a parabolic manner from t_2 at the top of the raster to t_1 at the center of the raster, and retarded to t_2 at the bottom of the raster to produce the current i_2 envelope of waveform 3e and the retrace voltage V_4 envelope of waveform 3g. The waveforms at vertical rate on the right hand side illustrate the parabolic modulation similar to the



input voltage at the base of Q7. Currents i_1 and i_2 are added in the S-shaping capacitor C23 to modulate voltage V_3 of waveform 3d.

As a result, deflection current i_1 , waveform 3c, shows S-shaping modulated at the vertical rate. Current i_1 is more S-shaped at the center of the raster (high amplitude) than at top and bottom of the raster (low amplitude).

Deflection retrace voltage V_6 , dashed line waveform 3h, enables, via R9, the gate turn off circuit Q6, Q5 and Q4 during interval $t_0 - t_4$. Voltage V_6 charges capacitor C7 via D4. The leading edge of the charge current pulse turns on Q5 and Q4 to turn off Q1. Q4 and Q5 are held conductive by positive feedback until t_4 when Q6 is turned off. The parabolically shaped collector current of Q7 discharges C7 in a way that D4, Q5 and Q4 become conductive at modulated instants during interval $t_1 - t_2$, as shown by voltage V_5 , solid waveform 3h. Voltage V_6 , dotted waveform, is amplitude modulated due to the outside pincushion correction circuit. Transistor Q7 discharges C7 more rapidly at the center of the raster than at top and bottom, illustrated by the downramping voltage V_5 , solid waveform. The amplitude of V_5 at the end of trace determines the turn-on instant of D4, Q5 and Q4. The feedback path R1, smoothing capacitor C4 and R3 linearizes the operation of the inside pincushion correction circuit. The correction amplitude is adjustable by variable resistor R12. The working point of Q7 is controlled by Q2 and Q3 in a manner that voltage V_4 is minimum at the top and bottom of the raster to obtain a current i_2 envelope as illustrated by waveform 3e. Transistor Q2 discharges capacitor C5, via D3, to the lowest voltage of the vertical rate envelope of V_4 across C4. The voltage across C5 is fed via emitter follower Q3 and R4 to the emitter of Q7 to reduce the collector current and to minimize voltage V_4 at the top and bottom of the raster.

The overall S-shaping of the horizontal deflection circuit can be optimized by fine tuning of L_1 . This slightly changes the amplitudes of the waveform envelopes of Fig. 3d and 3e. The limits of L_1 tuning are:

If L_1 is too small, it will cause deflection compression at the end of trace.

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If L_1 is too large, it will produce inadequate inner pincushion correction.

It is to be noted that the direction of the correction current in the S-capacitor may be the same or opposite to the deflection current, resulting in additive or subtractive correction. In this way, correction may be provided for either inner pincushion or inner barrel distortion.

Fig. 4 shows a an alternative embodiment of the invention which employs a transformer T_1 to obtain a negative voltage V_4' across C_3 . The envelope of ~~the~~ modulated current i_2 decreases to zero and increases in the opposite phase from that shown in Fig. 3e. Thus, in capacitor C_{23} , current i_2 subtracts from i_1 . Accordingly, the component values of C_{23} , L_1 , C_1 and C_3 are smaller at the cost of providing transformer T_1 .

The amount of inner raster correction is adjustable independent of the outside raster correction. Furthermore, since the inner raster correction circuit is independent of the flyback transformer, the inner raster correction is not affected by changes in flyback transformer loading, such as by changes in display screen brightness.

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CLAIMS

1. A deflection apparatus with inside raster distortion correction, comprising:
 - a) a deflection winding (L_H) coupled in series with an S-correcting trace capacitor (C_{23});
 - b) a source of an input signal (synch) at a first frequency related to a deflection rate;
 - c) a deflection switch (Q_{21}) coupled to said deflection winding (L_H) and responsive to said source of input signal, for generating in said deflection winding a trace current (i_1) during a trace interval and a retrace voltage (V_2) during a retrace interval;
 - d) a source of modulating signal (vert parabola) at a second frequency; characterized by
 - e) a switch (Q_1) coupled to said trace capacitor (C_{23}), for varying the amount of S-correction provided by said trace capacitor, said switch being responsive to said modulation signal.
2. A deflection apparatus according to Claim 1, further characterized by a resonant circuit (L_1, C_1) coupled to said trace capacitor (C_{23}).
3. A deflection apparatus according to Claim 2, characterized in that said switch (Q_1) couples a distortion correction retrace capacitor in series with said resonant circuit (C_3).
4. A deflection apparatus according to Claim 3, characterized in that said distortion correction switch (Q_1) is coupled across said distortion correction retrace capacitor (C_3).
5. A deflection apparatus according to Claim 3, characterized in that said switch (Q_1) is transformer coupled (via T_1) across said distortion correction retrace capacitor (C_3).





6. A deflection apparatus according to Claim 1, characterized in that said deflection switch (Q₂₁) supplies additional current (i₃) to said trace capacitor (C₂₃).
7. A deflection apparatus according to Claim 6, characterized in that said additional current (i₃) flows in a path comprising a capacitance (C₂) and a unidirectional current conducting means (D₂), for charging said capacitance.
8. A deflection apparatus according to Claim 7, comprising a second unidirectional current conducting means (D₁) for discharging said capacitance (C₂).
9. A deflection apparatus according to Claim 1, characterized by feedback means (Q₂, Q₃, Q₄, Q₅, Q₇) coupled from a main current conducting terminal of said distortion correction switch (Q₁) to a control terminal of said distortion correction switch (Q₁).
10. A deflection apparatus according to Claim 9, in which said feedback means comprises a transistor amplifier.
11. A deflection apparatus according to Claim 1, characterized by means (Q₂₀) for correcting for outside raster distortion.
12. A deflection apparatus according to Claim 11, characterized by a deflection transformer (T₂₀), said means for correcting for outside raster distortion being coupled between said deflection switch (Q₂₁) and a source of supply power (+135V) through said deflection transformer .
13. A deflection apparatus according to Claim 12, in which said deflection rate is a horizontal deflection frequency, and said means for correcting outside raster distortion comprises a switch (Q₂₀) controlled as a function of vertical deflection.





14. A deflection apparatus according to Claim 1, in which said deflection rate is a horizontal deflection frequency and said second frequency is related to a vertical deflection frequency.

15. A deflection apparatus according to Claim 1, characterized by a capacitance (C_3) coupled across said distortion correction switch (Q_1).

16. A deflection apparatus according to Claim 1, in which said switch (Q_1) is conductive during said trace interval, and becomes non-conductive during said retrace interval.

17. A deflection apparatus according to Claim 16, in which said switch becomes non-conductive at a variable point in time during the first half of said trace interval.

18. A deflection apparatus, comprising:

a deflection circuit (Q_{21}) operable at a first deflection rate and having a deflection winding (L_H) and an S-shaping trace capacitance (C_{23}) coupled in series at a junction, a deflection current (i_1) flowing through said S-shaping capacitance;

a source (vert. parabola) of a modulating signal at a second deflection rate; and,

a modulating circuit comprising a switch (Q_1) coupled to said junction and responsive to said modulating signal for injecting a correction current (i_2) into said S-shaping trace capacitance (C_{23}), said correction current being varied in polarity and amplitude responsive to said modulating signal to correct inside raster distortion.

19. A deflection apparatus according to Claim 18, characterized in that said modulation circuit is energized by deflection energy.

20. A deflection apparatus according to Claim 19, characterized in that said deflection circuit comprises a flyback transformer (T_{20}), said modulation circuit operating independently of said flyback transformer (T_{20}).





21. A deflection apparatus, comprising:
a deflection circuit operable at a first deflection rate and having a deflection winding (L_H) and an S-shaping trace capacitance (C_{23}) coupled in series at a junction, a voltage (V_3) being defined across said S-shaping capacitance;
a source (vert. parabola) of a modulating signal at a second deflection rate; and,
a switch (Q_1) coupled to said junction and responsive to said modulating signal for varying said voltage to correct inside raster distortion.

22. A deflection apparatus according to Claim 21, characterized in that said switch (Q_1) varies said voltage (V_3) by injecting a correction current (i_2) into said S-shaping trace capacitance (C_{23}), said correction current being varied in polarity and amplitude responsive to said modulating signal.

23. A deflection apparatus according to Claim 22, characterized in that said correction current (i_2) increases or decreases a deflection current (i_1) flowing in said S-shaping capacitance (C_{23}).

24. A deflection apparatus according to Claim 21, characterized in that said source of modulating signal is energized by deflection energy.

25. A deflection apparatus according to Claim 21, characterized in that said deflection circuit comprises a flyback transformer (T_{20}), said modulation circuit operating independently of said flyback transformer.

