CATHODE RAY TUBE DRIVER WITH INPUT BLACK TRACKING PROVISIONS

The invention concerns a driver for a cathode ray tube (CRT) as may be employed in a television receiver or other video display system ~~with~~ provisions for inhibiting performance degradation due to CRT power supply loading. In video display systems utilizing a cathode ray tube (CRT) as the display device, a video output or driver stage is employed to amplify relatively low level video signals so as to produce relatively high level video signals suitable for direct application to the CRT. The high level video output signals typically are representative of red, green and blue components of the reproduced image, and are coupled to respective cathodes of the CRT. High supply voltages are coupled to the anode and various grids of the CRT from respective high voltage power supplies. As the average level of the reproduced image tends toward white, the currents drawn from the high voltage supplies increase, and in extreme cases may cause one or more of the high voltages to decrease in amplitude or "slump". The latter may cause the cut-off level of the CRT to increase resulting in the loss of detail in dark portions of the image.

A solution to the above described problem is to employ high voltage power supplies with sufficient current handling capabilities. However, such supplies are expensive. A more cost effective solution is illustrated in Figure 1.

The final stages of the red (R), green (G) and blue (B) channels of a video display system are shown in Figure 1. Since the three channels are substantially identical, only the red channel will be described in detail. The relatively low level red video signal which is developed at the output of pre-amplifier 10R, is amplified by driver 12R, and the resultant relatively high level red video signal is coupled through a resistor 14R to a respective cathode 16R of a CRT 18. A common first grid G1 of cathode 18 receives a supply voltage from a G1 voltage supply 20. A common second or screen grid G2, a common first focus grid F1, and a common second focus grid F2 receive respective relatively higher voltages from respective outputs of a high voltage section

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22. A very high voltage is coupled to anode A of CRT 18 from another output of high voltage section 22.

Driver 12R comprises NPN transistors Q1 and Q2 connected in a cascode amplifier configuration. The output of pre-amplifier 10R is coupled to the base of transistor Q1. A reference voltage VREF is coupled to the emitter of transistor through an emitter resistor RE. A bias voltage +VCC is coupled to the base of transistor Q2. The collector of transistor Q2 is coupled to a source of supply voltage B+ through a load, shown simply as a resistor RL, and a resistor RS, the purpose of which will be described below. The collector of transistor Q2 is also coupled through a resistor 14R to cathode 16R. A filter capacitor CS is coupled between the junction of load RL and resistor RS and signal ground. The cutoff level of CRT 18 is a function of reference voltage VREF and bias voltage VCC. The network including resistor RS and capacitor CS is provided to reduce the possibility of the loss of details in dark portions of the image during high average picture level images, as will now be explained.

Decreasing cathode voltage corresponds to increasing the "whiteness" of the image and increasing cathode voltage corresponds to increasing the "blackness" of the image. The beam current drawn by CRT 18 from high voltage section 22 increases as the average picture level increases toward white. The voltages supplied to anode and various grids of CRT 18 by high voltage network 22 tend to decrease at relatively high beam currents. If the cathode voltage were to remain constant, this would cause the cutoff level of CRT 18 to increase and cause dark areas of the image to get darker, with a resulting loss of detail. However, resistor RS produces a voltage drop which decreases the cathode voltage as the beam current increases. The voltage drop developed across resistor RS compensates for the reduction in amplitude (or "slump") of the high voltages supplied by high voltage network 22 and therefore inhibits the loss of detail in dark areas as the average picture level increases. Thus, resistor RS can be thought of as providing a "black tracking" function which operates by reducing the effective supply voltage of B+ voltage supply 24 with increases of beam current. Capacitor CS is

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required to remove the AC component at the effective supply voltage terminal at the junction of resistors RS and RL.

While the network including resistor RS and capacitor CS performs its intended function satisfactorily, it does have certain drawbacks. The value of resistor RS has to be relatively large for the intended compensation function. However, as a consequence, the "head-room" of the driver , i.e., the amplitude range of the output signal of the driver, is restricted. In addition, since the B+ voltage is relatively high (e.g., +220 volts), the physical size of capacitor CS is large, even for small capacitance values.

The present invention resides, in part, in recognition of the described problem and, in part, in providing a solution to the problem. In accordance with the present invention, a black tracking arrangement is coupled to the input of the CRT driver stage rather than to its output. Specifically, the arrangement comprises a circuit for sensing at least one relatively low level video signal coupled to the an input of a CRT drive amplifier and a circuit for developing a signal representing the average level of the sensed low level video signal. The representative signal is coupled to the CRT driver and is effectively added to the output video signal of the CRT driver such that there is an increasing shift or offset of the output video signal in the white direction as the the average level of the input video signal of the CRT drive amplifier increasingly corresponds to white. Preferably, the representative signal is added to the input signal of the CTR drive amplifier.

In a preferred embodiment of the invention, a resistive element is coupled in shunt with the output of a current amplifier comprising a pre-amplifier of a CRT drive amplifier, and in series relationship with a low pass filter element. The representative signal is developed by the low pass filter element, and, by the nature of the series connection, is added to the input video signal. As a further feature of the preferred embodiment, the low pass filter element is connected in common with at least another resistive element coupled in shunt with another pre-amplifier of another CRT drive amplifier so as to develop a signal representative of the average level of the combination of the two

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video input signals. The later arrangement provides a more reliable indication of the image content than one in which only a single input signal is utilized.

These and other aspects of the invention will be described in detail with reference to the accompanying Drawing in which:

Figure 1, previously described, is a schematic diagram of a CRT drive arrangement with a black-tracking network coupled to the output of the drive amplifier, as known in the prior art; and

Figure 2 is a schematic diagram of a CRT drive arrangement with a black-tracking network coupled to the input of drive amplifier, in accordance with the present invention.

In Figures 1 and 2, the same or corresponding elements have the same reference designators. Those portions of the arrangement of Figure 2 for which there are corresponding portions in the arrangement of Figure 1 will not be described again. As with the arrangement shown in Figure 1, only the red channel will be described in detail since all three channels are substantially identical.

In the arrangement shown in Figure 2, preamplifier 10R comprises a voltage to current converter (indicated by the overlapping circles) which converts the input low level red video signal to a corresponding output current. A terminating resistor RR connected in shunt with the the output of pre-amplifier 10R is used to develop an input voltage ER for driver 12R.

Driver 12R of the arrangement shown in Figure 2 is similar to driver 12R shown in Figure 1, but is somewhat more complex since it is a practical realization. It will also be appreciated by those skilled in the art that the load of driver 12R may be more complex than a resistor and may include active devices. For example the load of driver 12R may comprise complementary transistors configured as respective emitter-follower amplifiers and connected in a "push-pull" arrangement. Low level input voltage ER is coupled to the base of transistor Q1 through a filter network including the parallel combination of a resistor RF and a capacitor CF and an emitter-follower amplifier comprising a PNP transistor Q3. A resistor REF connected between

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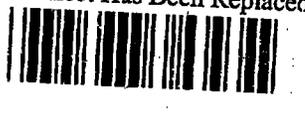

the emitter of transistor Q3 and the +VCC supply point is the load resistor of the emitter-follower amplifier. The collector of transistor Q3 is connect to a point of ground potential. A resistor RFB is connected between the collector of transistor Q2 and the base of transistor Q3 to provide negative feedback for drive amplifier 12R.

Resistor RR along with corresponding resistors RG and RB of the green and blue channels, and the parallel combination of a resistor RC and a capacitor CC connected between respective ends of resistors RR, RG and RB and a signal ground point, form a an input black tracking network for the CRT drive arrangement in accordance with the present invention. Resistor RC is a common mode terminating resistor which converts the sum of the output currents of pre-amplifiers 10R, 10G and 10B to a voltage EC. Capacitor CC is a filter capacitor which serves to filter voltage EC so that voltage EC only reflects the low frequency components of the sum of the video input currents.

Each of drive amplifier input voltages ER, EG and EB is the sum of the voltage developed across the respective one of terminating resistors RR, RG and RB and voltage EC. The voltage EC represents the average picture level (APL). In the present embodiment, in which driver amplifiers 12R, 12G and 12B are inverting amplifiers, as the APL moves toward white, the voltage EC increases. As the APL moves toward black, the voltage EC decreases. Accordingly, as the APL increases toward white, each of the driver input voltages ER, EG and EB is increasingly shifted or offset in the white-going direction, i.e., is increasingly shifted higher. Correspondingly, each of the driver output voltages at respective Q2 collectors is increasingly shifted in the white-going direction, i.e., is increasingly shifted lower. This has the effect of compensating for the "slump" of the high voltages coupled to CRT 18 as the APL moves toward white. Conversely, as the APL moves toward black, each input voltage is decreasingly shifted lower and each output voltage is decreasingly shifted higher. Thus, with the arrangement shown in Figure 2, a "black tracking" voltage is added to each driver input voltage. The magnitude of the "black tracking" voltage is determined by the ratio of the

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value of resistors RR, RG and RB (which are assumed to to be of equal value in this embodiment) and the value of resistor RC.

Compared with the black tracking arrangement shown in Figure 1, the black tracking arrangement shown in Figure 2 does not restrict the head room of the CRT drive signals. In addition, it does not require a physically large filter capacitor such as capacitor CS of the arrangement shown in Figure 1 because the voltage developed across capacitor CC is relatively low.

While it is desirable that all three low level video signals be summed to form the black tracking voltage to obtain a relatively accurate representation of the image content, it is possible to use less than all in some applications. This and other modifications are intended to be within the scope of the present invention defined by the following claims.

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Claims

1. In a video display system including a cathode ray tube (CRT 18) for reproducing an image; apparatus comprising:

means (10R; 10G; 10B) for providing a video input signal; and characterized by

means (CC, RC) responsive to said video input signal for generating an offset component (EC) representative of the average picture level of said image;

means (RR; RG; RB) for combining said offset component and said input signal to generate a combined signal (ER; EG; EB); and

means (12R; 12G; 12B) for amplifying said combined signal to produce a relatively high level video signal output suitable for application to said CRT.

2. The apparatus recited in claim 1, further characterized in that:

said means (10R; 10G; 10B) for providing said video input signal includes a voltage to current converter for providing said video input signal as a current;

said means for generating said offset signal includes a low pass filter element (CC);

said means for combining said offset component and said video input signal includes means for coupling a series combination of a DC impedance element (RR; RG; RB) and said low pass filter element (CC) in shunt with the output of said voltage to current converter.

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3. The apparatus recited in claim 1, further characterized in that

said means for providing said input video signal comprises means (10R) for providing a first video input signal, and means (10G) for providing a second video input signal;

said offset component generating means (CC, RC) is responsive to said first and second video input signals for generating said offset component (EC) representative of the average picture level of said image;

said combining means (RR, RG) combines said offset component individually with each of said first and second input signals to generate first and second combined signals (ER, EG); and

said amplifying means (12R; 12G; 12B) comprises means (12R) for amplifying said first combined signal to produce a first relatively high level video output signal suitable for application to CRT; and means (12G) for amplifying said second combined signal to produce a second relatively high level video output signal suitable for application to CRT.

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4. The apparatus recited in claim 3, further characterized in that:

said means for providing said first video input signal includes a first voltage to current converter for providing said first video input signal as a first current;

said means for providing said second video input signal includes a second voltage to current converter for providing said second video input signal as a second current;

said means for generating said offset signal includes a low pass filter element (CC);

said means (RR: RG; RB) for combining said offset component and said first video input signal includes means for coupling a series combination of a first DC impedance element (RR) and said low pass filter element (CC) in shunt with the output of said first voltage to current converter; and

said means for combining said offset component and said second video input signal includes means for coupling a series combination of a second DC impedance element (RG) and said low pass filter element (CC) in shunt with the output of said second voltage to current converter.

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