Application Note

PWM East-West correction

AN10294_1

Philips Semiconductors

Abstract

The East-West correction circuit is an essential part of the horizontal deflection electronics in a CRT TV with a 110 degrees CRT. One part of the EW correction circuit is the EW amplifier. The linear amplifier, which is traditionally used for this purpose, still causes substantial power loss in the TV chassis. A PWM amplifier overcomes this problem, while simultaneaously employing a smaller (cheaper) power semiconductor component.

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Summary

The East-West correction circuit is an essential part of the horizontal deflection electronics in a CRT TV with a 110 degrees CRT. One part of the EW correction circuit is the EW amplifier. The linear amplifier, which is traditionally used for this purpose, still causes substantial power loss in the TV chassis. A PWM amplifier overcomes this problem, while simultaneaously employing a smaller (cheaper) power semiconductor component.

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1. Introduction

The market for TV's is forecast to grow by 6.5 percent to 171M units by 2007, during the forecast period CRT TV is predicted to account for over 85% of these units. In Western Europe and the US, where the market is saturated, sales will be either replacement sales or value propositions for new technologies such as plasma screens and LCD TV. Consequently, there will be a shift in volume sales from the West to Asia Pacific, and in particular China. In these markets CRT TV will be the dominant technology and whilst this is a mature technology it continues to be refined to provide an ever better product to the consumer. This article addresses the design and optimization of one of the critical circuits within a CRT TV – the East-West correction amplifier.

2. Displaying a picture on a CRT

In order to display a picture on a Cathode Ray Tube screen, an electron beam originating from an electron gun (in a color CRT it's actually three beams) scans the screen surface in both vertical and horizontal direction. To achieve this the beam is deflected by two independent magnetic fields: one for making the beam move from the top to the bottom of the screen (vertical deflection; 50 times per second – assuming PAL mode of operation) and the second for making the beam move from left to right (horizontal deflection; for PAL: 15625 Hz). Both magnetic fields are realized by making use of coils (so-called deflection coils) that are respectively driven with the vertical and the horizontal deflection current.

Generally, vertical deflection is the "easy part", but horizontal deflection is more cumbersome. Certainly when a screen is flat and when the tube is shallow (110 degrees tube) geometry errors will occur that distort the picture.

3. East-West correction

In such CRT display systems using 110 degrees display tubes, EW correction is needed to compensate for one of the geometry errors. Without East-West correction serious distortion in the corners of the displayed picture would become visible.

Figure 1a PM5544 test card properly displayed on a 110 degrees CRT using East-West correction

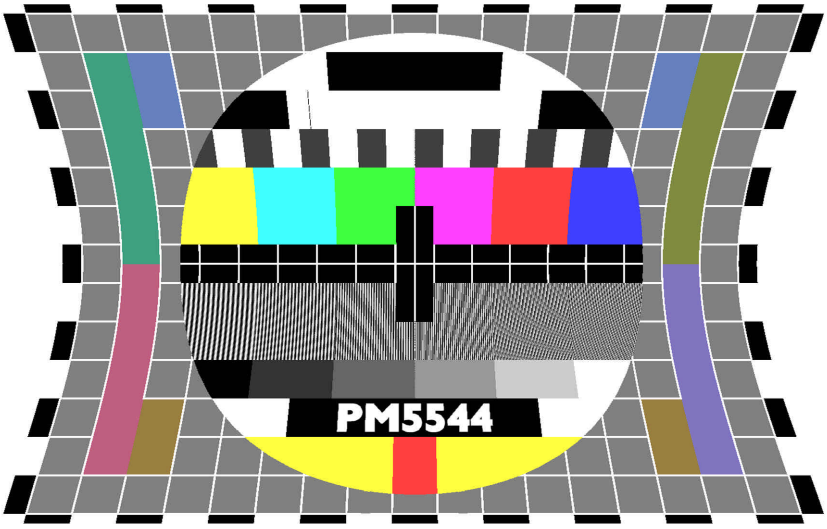

Figure 1b Distorted PM5544 test card displayed on a 110 degrees CRT screen without East-West correction

To overcome picture distortion a correction signal is used to adapt the deflection current. This EW correction signal is provided by the deflection processor and must be amplified by an EW amplifier. The amplified correction signal is usually summed to the junction node of the damper and the modulator diode.

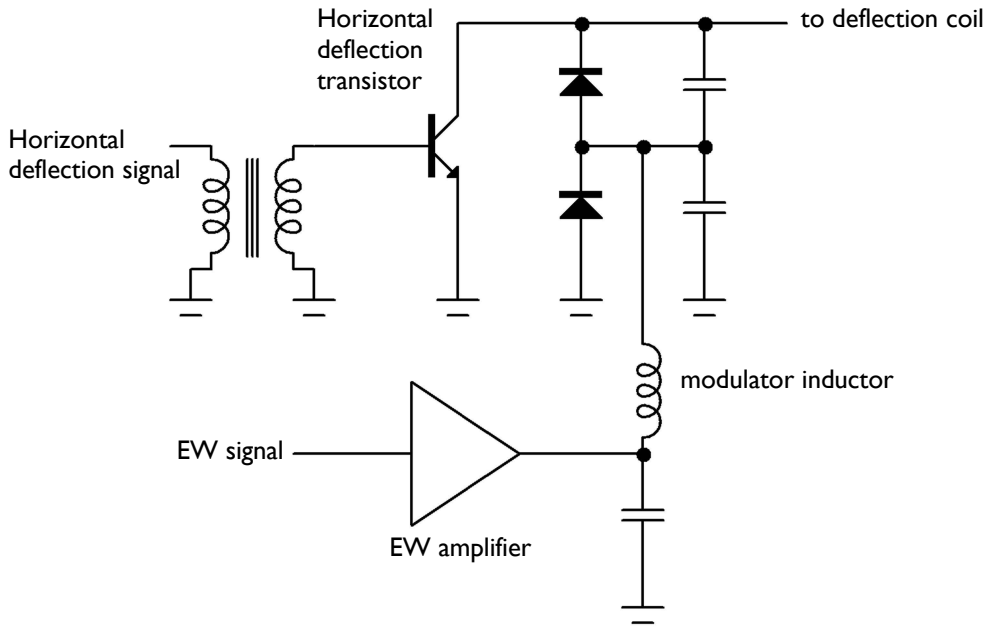

Figure 2 Simplified 110 degrees CRT deflection circuit including East-West correction

The East-West correction signal manifests itself as a parabola which is repeated at frame frequency (see figure 2). For single scan PAL and SECAM displays this means a repetition rate of 50Hz, for NTSC it will be 60Hz, for dual scan PAL/SECAM 100Hz and for dual scan NTSC 120Hz.

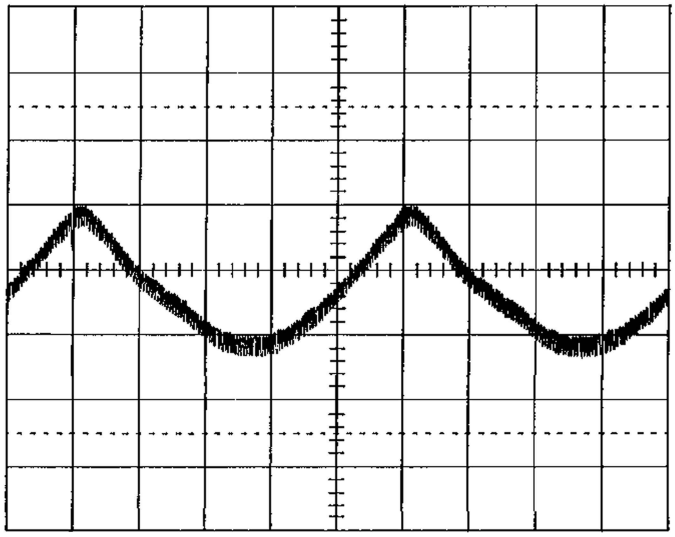

Figure 3 Typical East-West correction signal at the output of the EW amplifier (recorded by an oscilloscope)

4. Linear East-West amplifier

In the conventional solution the analog EW signal, generated by the deflection processor, is amplified by a linear amplifier. A simplified version of such an amplifier is shown in figure 4.

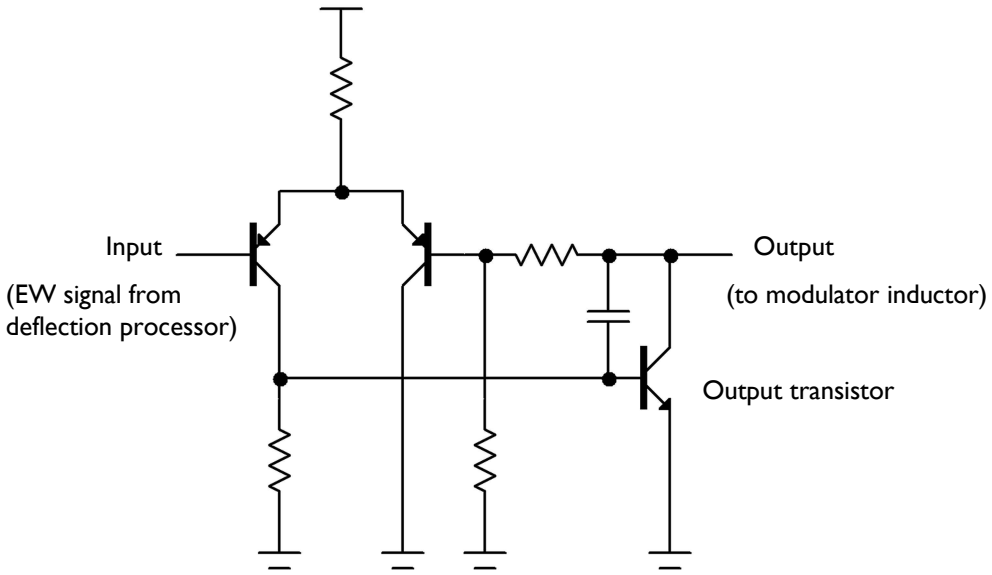

Figure 4 Simplified linear East-West amplifier

In the EW amplifier shown in figure 4, the (power) output transistor is a bipolar transistor. In many commercial CRT display system implementations a MOSFET is used instead of a bipolar transistor. For the principle of operation this does not make a difference.

The output transistor – which can either be MOSFET or bipolar – in the above type of EW amplifier is operating in linear mode, which causes substantial heat generation in the transistor. Power dissipation in the range from at least 1 to 2 Watt must be tolerated. A device in a TO220-like package (with or without heatsink) is the common component encountered in this position.

5. PWM East-West amplifier

In order to circumvent power dissipation originating from linear operation, a PWM amplifier can be used to take care of EW correction. The principle of this type amplifier is similar to the Class D audio amplifier. By using a PWM modulator the analog input signal from the deflection processor is translated into a sequence of width modulated pulses. The pulse sequence is applied to the gate of a

MOSFET. In this way the MOSFET is operating purely as a switch, thus avoiding power dissipation due to linear mode. The drain node of the MOSFET is now also producing a sequence of pulses that can be "averaged" by an LC filter. At the output of the LC filter the amplified (analog) EW correction signal is produced.

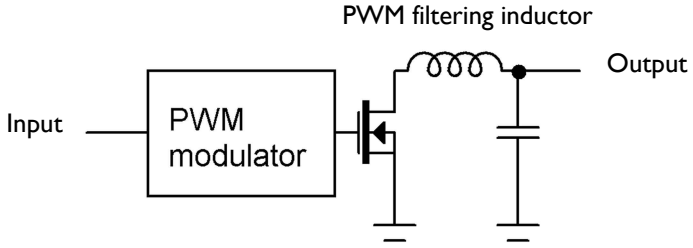

Figure 5 Principle of the PWM East-West amplifier

The frequency of these pulses must at least be an order of magnitude higher than the frequency content of the signal to be modulated. In order to keep the filtering components small, it is also advisable to use a high switching frequency. In a carefully designed circuit one may be able to combine the PWM filtering inductor and the modulator inductor.

One disadvantage of PWM amplifiers is that the switching frequency may cause interference with other frequencies occurring in a system. Depending on the actual implementation of the PWM, it may therefore be wise to synchronize the PWM with the CRT line frequency or even to use the line frequency as the switching frequency.

A basic block diagram of a PWM is shown in figure 6.

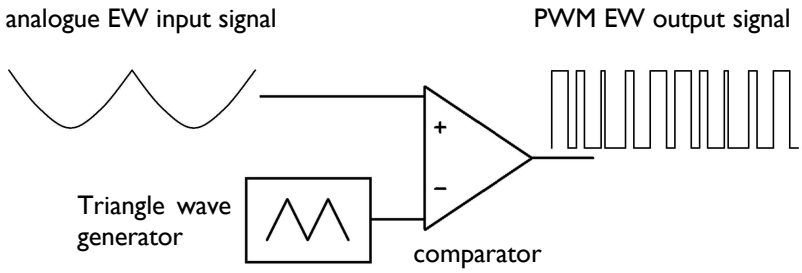

Figure 6 Block diagram of a fixed frequency PWM

Nowadays MOSFETs with very low R_{DSON} are available in extremely small (surface mount) packages. In this application low R_{DSON} is key to keep modulation loss low. Additionally, the high pulse frequency requires the power MOSFET to be a low gate charge (Q_{GD}) type in order to prevent excessive switching loss. Because of the low power loss, the small (SMD) MOSFET can easily be mounted on the PCB while no heat sinking will be needed. Philips now has a wide range of MOSFETs available for this type of application.

Type number	V_{DS} [V]	I_D [A]	R_{DSON} [mΩ]	Q_{GD} [nC]	Gate drive	Package
PHT6N06LT	55	5.5	150	-	Logic level	SOT223
PHT8N06LT	55	7.5	80	-	Logic level	SOT223
PMV80EN	60	3.8	78	-	Standard	SOT23
PHT4NQ10T	100	3.5	250	-	Standard	SOT223
PHT4NQ10LT	100	3.5	250	-	Logic level	SOT223
PHT6NQ10T	100	6.0	100	8.2	Standard	SOT223
PSMN038-100K	100	5.2	38	14	Standard	SO8
PHK5NQ10T	100	5.0	51	11	Standard	SO8
PHK12NQ10T	100	11.5	30	7	Standard	SO8
PHK4NQ10T	100	4.0	70	10	Standard	SO8
PSMN085-150K	150	3.5	85	14	Standard	SO8
PHK5NQ15T	150	5.5	75	12	Standard	SO8
PHK4NQ20T	200	4.0	130	8.7	Standard	SO8

Table 1 Philips MOSFET devices for PWM EW amplifiers