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ASO PLUS / TEA5750

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### I - INTRODUCTION

The purpose of this note is to present the TEA5750 integrated circuit which implements the ASO plus technology (ASO : Active Sideband Optimization). This technique does not only intend to replace the FM equalizer circuit (commonly used between the head amplifier and the FM demodulator) but also to bring the following advantages and functions :

- Picture sharpness improvement : Frequency response as wide as 3MHz can be realized in VHS standard.
- Decrease of the sensitivity to the tearing effect (black fishes)
- Monitoring of the overall quality of the FM playback signal. In doing so, the TEA5750 automatically and continuously adapts the frequency spectrum of the FM signal delivered to the demodulator in such a way that the S/N ratio is improved. This function is particularly active in case of old and aged tapes.

### II - GENERAL

In video recording systems where the luma signal is carried by frequency modulated signal ; a high picture sharpness is performed when the FM playback signal features fast frequency changes. In practice, the picture sharpness is far lower than expected because the necessary fast frequency transients are slowed down by the limited bandwidth of the FM playback front end (tape, heads, rotary transformers, H-Amps). Thus it is necessary to process the FM playback signal before demodulation.

So far the commonly used solution is the FM equalizer circuitry. The main purpose of this solution is to improve the balance between the sidebands (upper and lower) and the FM carrier. This technique leads to a picture quality improvement but its efficiency is greatly limited by the following compromise : higher picture sharpness against sensitivity to noise and "black fishes" (tearing effect) :

- Amplifying the upper sideband improves the picture sharpness but decreases the S/N ratio (S/N ratio of tapes greatly decreases for high frequencies).
- Amplifying the lower side bands improves the picture sharpness but leads to higher sensitivity to the tearing effect (black fishes).

From this compromise, it results :

- A frequency response of the demodulated signal which starts decreasing for frequencies higher than 1.8 to 2MHz and attenuation at 3MHz is about 8 to 10dB.
- The sensitivity to black fishes (tearing) remains quite high when playing back aged tapes or in still picture mode.

#### ASO plus solution

In its principle the ASO plus solution is based on an active phase shifting of the FM carrier. This technique intends to compensate the phase errors and delays induced in the FM playback signal delivered by the H-Amps. In doing so, the luma transients of the demodulated signal are sharpened.

Its totally different principle makes the ASO plus solution almost independant from the above described compromise ; here the high picture sharpness is not traded off against the sensitivity to noise and tearing effects (black fishes).

Typically, in VHS recording system, the ASO plus solution gives the following results :

- The bandwidth of the demodulated signal can exceed 3MHz (at -3dB) and very often reaches the limits of the low pass filter used after the demodulator (see Figure 1).
- Signal to noise ratio S/N is not decreased by an additional amplification of the upper sideband.
- Sensitivity to tearing effects (black fishes) is greatly reduced compared with the FM equalizer case. This improvement is easily noticed when playing back old and aged records and when video heads are getting aged.

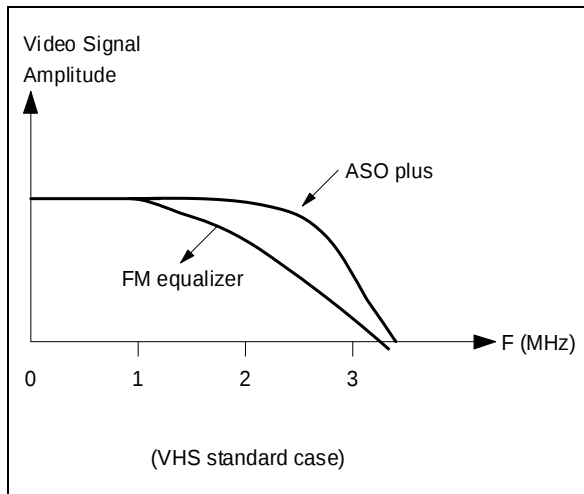
Monitoring the overall quality of the FM playback signal is an additional function of the TEA5750 in comparison with the FM equalizer solution.

In the conventional solutions (FM equalizer) the bandwidth of the playback channel remains the same whatever the quality of the playback signal. Then the playback of old and aged tapes produces noisy picture because of the constant video bandwidth.

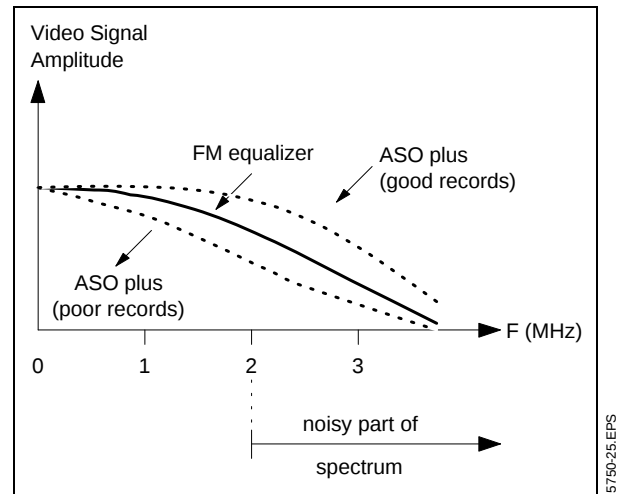
In the case of the TEA5750, the video bandwidth is automatically adjusted versus the quality of the FM signal. A wide bandwidth is maintained when playing back good records, and significantly decreased in case of poor records, in doing so the effect of noise on the picture is attenuated (see Figure 2).

The signal is decreased but the overall S/N ratio is improved.

**Figure 1 :** Extended Picture Sharpness



**Figure 2 :** Video Bandwidth Adjusted versus Playback Signal Quality



### III - ASO PLUS PRINCIPLE

For clarity this chapter has been divided in three parts corresponding to the three main benefits of the TEA5750 :

- picture sharpness improvement by active phase shifting,
- high immunity to tearing effects (black fishes),
- monitoring the overall quality of the playback signal.

#### III.1 - Active Phase Shifting

The amplitude of the signal delivered by the heads decreases when the frequency of the carrier increases. In combination with an external LC filter, the TEA5750 transforms this natural amplitude modulation into phase shifting which compensates

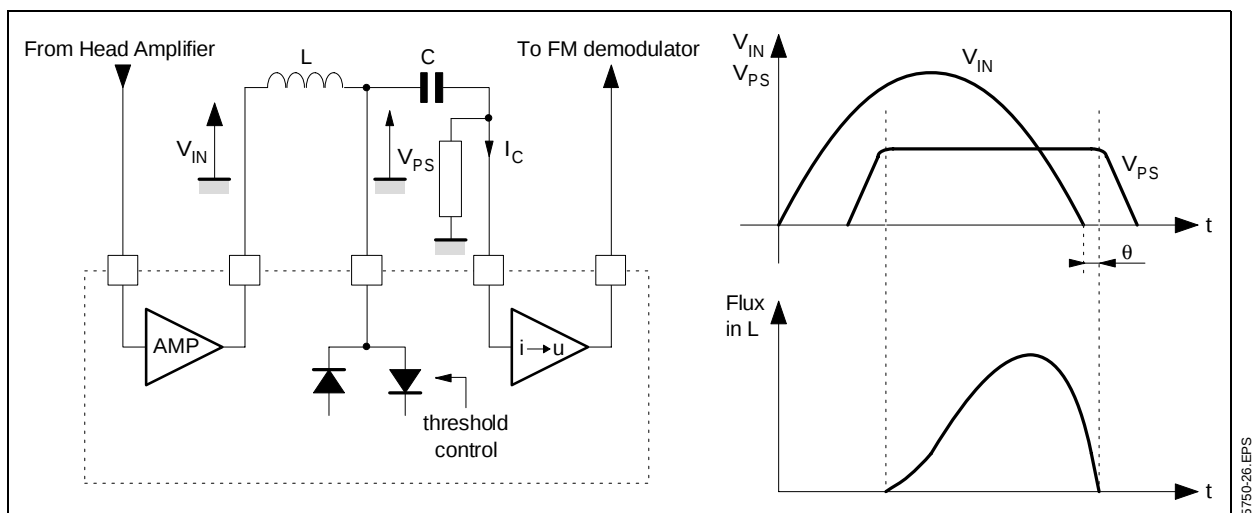
the delays (or phase errors) induced during the fast frequency deviations.

##### III.1.a - Phase Shift Generation

The core of the phase shifting function is given in Figure 3. Under normal conditions, the  $V_{PS}$  voltage at the phase shift input reaches the threshold of the diodes. Then for each half cycle, as long as the diodes conduct, a magnetic flux is stored in the inductance  $L$ . At the phase shift input pin, the next zero crossing time is delayed respect to the input signal  $V_{IN}$  for a duration  $\theta$  which is proportional to the energy  $W_L$  stored in the inductance  $L$ .

The energy  $W_L$  increases versus input amplitude and period, consequently  $\theta$  increases when the input frequency decreases.

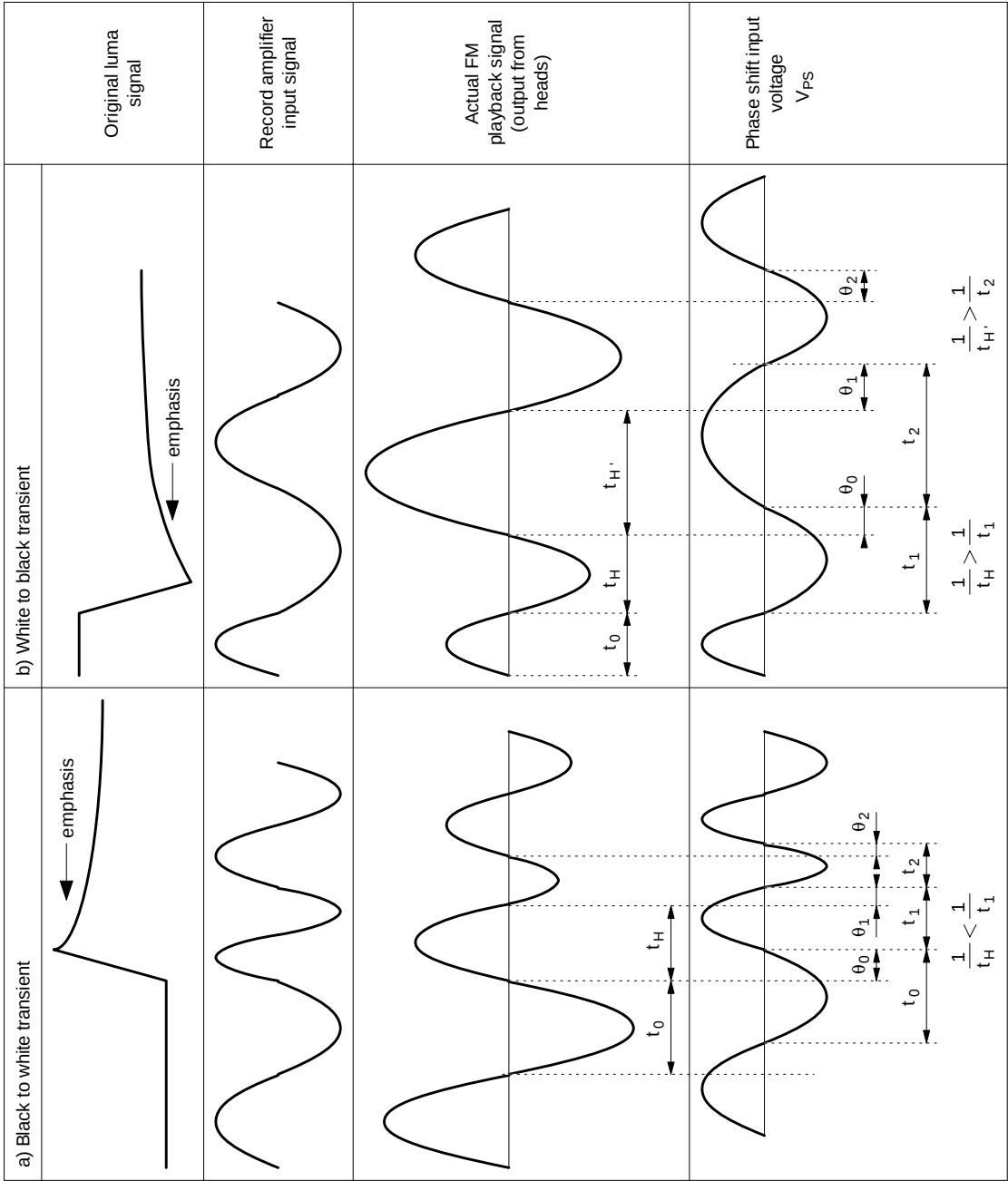
**Figure 3 :** Core of the Phase Shift Function



**III.1.b - Black to White Transients (Figure 4a)**  
(Fast increases of the FM carrier frequency)  
In this case, the input FM signal changes from large amplitude and long period to small amplitude and short period. Consequently the delay produced by the phase shifting circuit changes from large values to small values. At the instance of a black to white transient, the phase shifting induces a long period  $t_0$  followed by a short period  $t_1$ . This results in a faster frequency shift and in shorter rise times at the output of the FM demodulator.

**III.1.c - White to Black Transients (Figure 4b)**  
(Fast decreases of the FM carrier frequency)  
In this opposite case, the input FM signal changes from small amplitudes and short periods to large amplitudes and long periods. The corresponding delays will increase. So during white to black transients, the period  $t_1$  will be increased respect to the input period  $t_H$ . This results in a faster frequency change and shorter fall times at the output of the FM demodulator.

Figure 4 : Phase Shift Effect on the FM Playback Signal



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In other words, the instantaneous delays produced by the ASO core speed up the luma transients compensating the effect of the limited bandwidth of the playback front end.

### III.2 - High Immunity to Tearing Effects (black fishes)

The ASO plus core is a level dependant gain circuit (Figure 5).

- When the input voltage amplitude is low the ASO core behaves as a resonant LC circuit damped by the resistor R. The input voltage is amplified by resonance (typically  $Q \cong 2$  to 6).
- When the input voltage amplitude increases the diodes start conducting and clamp the signal.

The resulting gain  $\frac{V_{OUT}}{V_{IN}}$  decreases.

Thanks to this characteristics, the ASO plus core is able to better regenerate the playback signal when

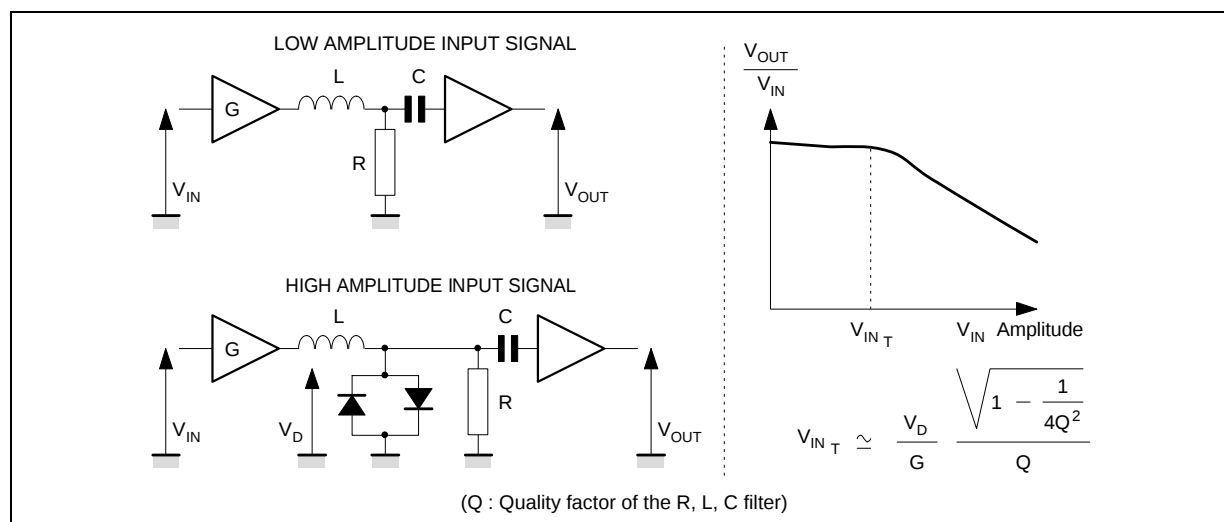
drop-outs and missing zero crossing appear. It results from this a high immunity to tearing effects (black fishes) (Figure 6).

In this field, ASO plus core has two benefits compared with the conventional FM equalizer solutions.

- Immunity to black fishes is higher.
- The signal to noise ratio is not decreased because there is no need to permanently amplify the upper side band. The high gain requested to regenerate the signal, is instantaneously provided when necessary and disappears as soon as the signal recovers a normal amplitude.

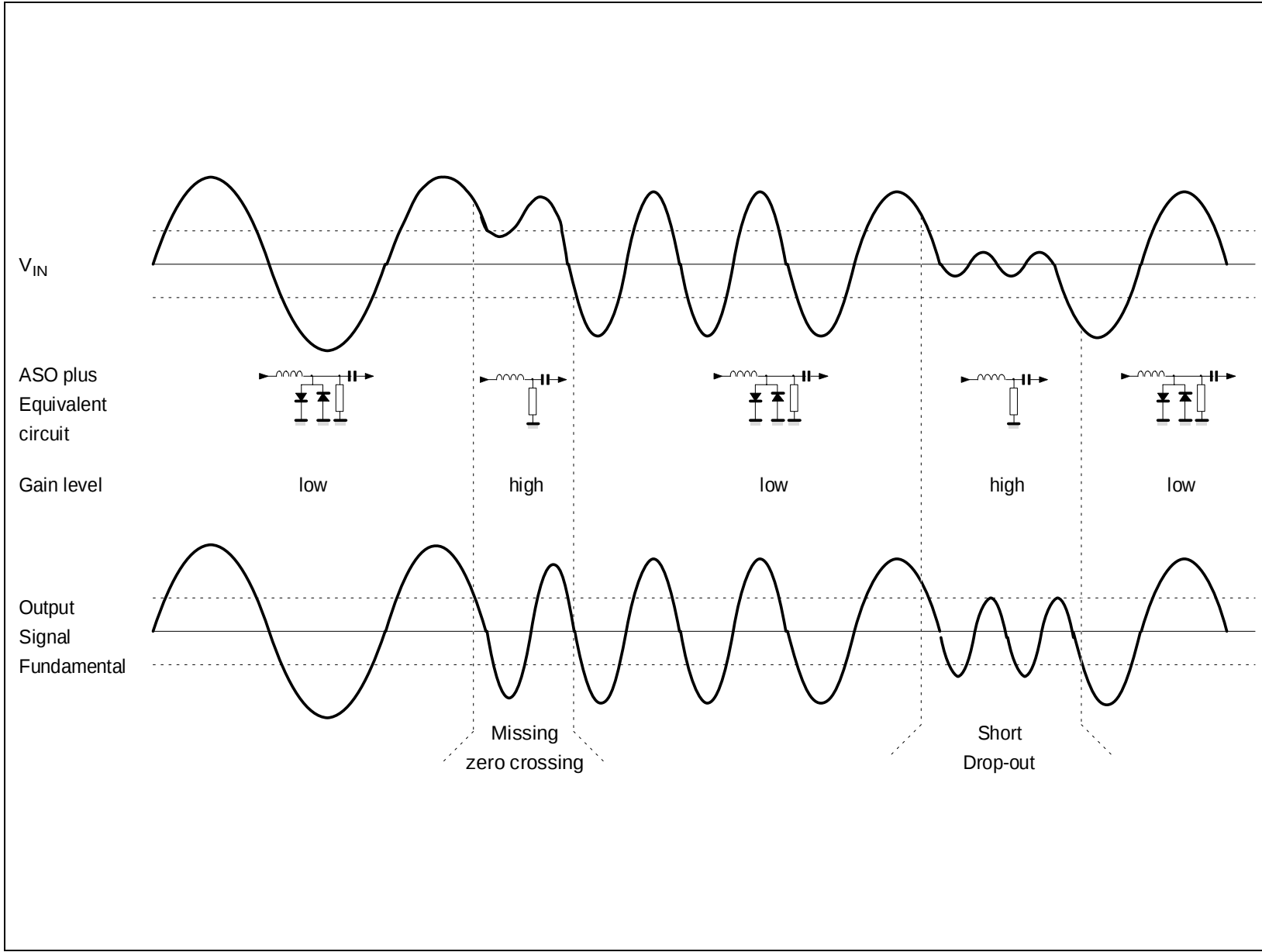
Remark : ASO plus core also rejects the "white fishe effects" : the band pass characteristics of the LC filter reject the high parasitic frequencies that could generate ultra white signals in the demodulated signal.

**Figure 5 :** The ASO plus core is a level dependant gain circuit.



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Figure 6 : ASO Plus Core under Disturbed FM Signals



### III.3 - Monitoring the Overall Quality of the Playback Signal

This is an extra function compared with the FM equalizer. Purpose is to adjust the video bandwidth versus the quality of the FM signal.

The quality is measured as following :

- The signal is poor quality when the frequency of missing zero crossings and drop-outs is high.
- Quality is judged as good in the opposite case.

The TEA5750 detects the two types of errors (missing zero crossing and drops-out) as following :

- a missing zero crossing is detected when no zero crossing is detected for a period longer than TL. TL is the longest normal halfwave.

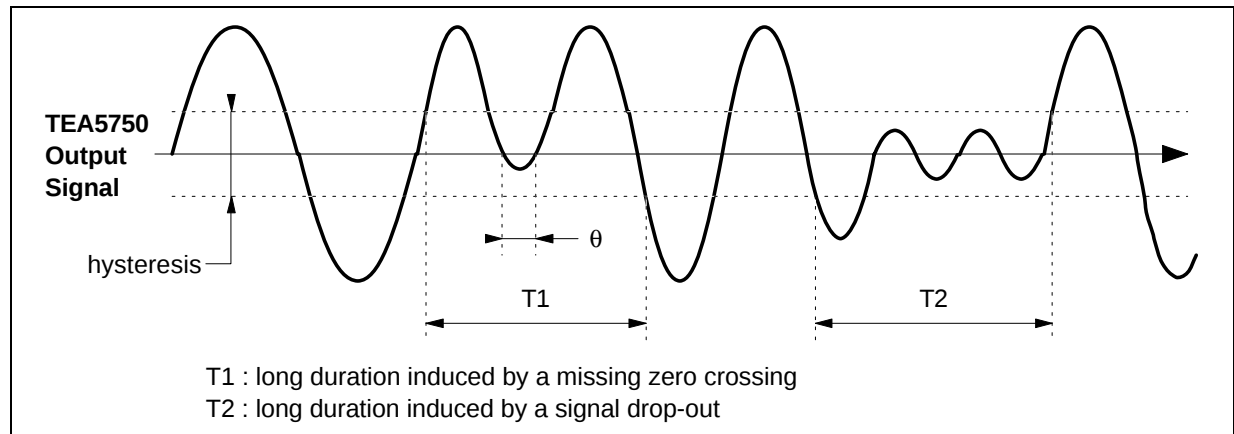
$$\text{In VHS case } TL = \frac{1}{2} \left( \frac{1}{3\text{MHz}} \right) \cong 160\text{ns}$$

An hysteresis level is introduced in the zero crossing detection, in order to consider as an error the waveforms which barely cross the 0V level. Those waveforms generates parasitics high frequencies  $\left( \frac{1}{\theta} \right)$  in the FM demodulator (see Figure 7).

- A signal drop-out is detected when the signal could not reach the above mentioned hysteresis level for a duration longer than the expected longest halfwave. Same as above (see Figure 7).

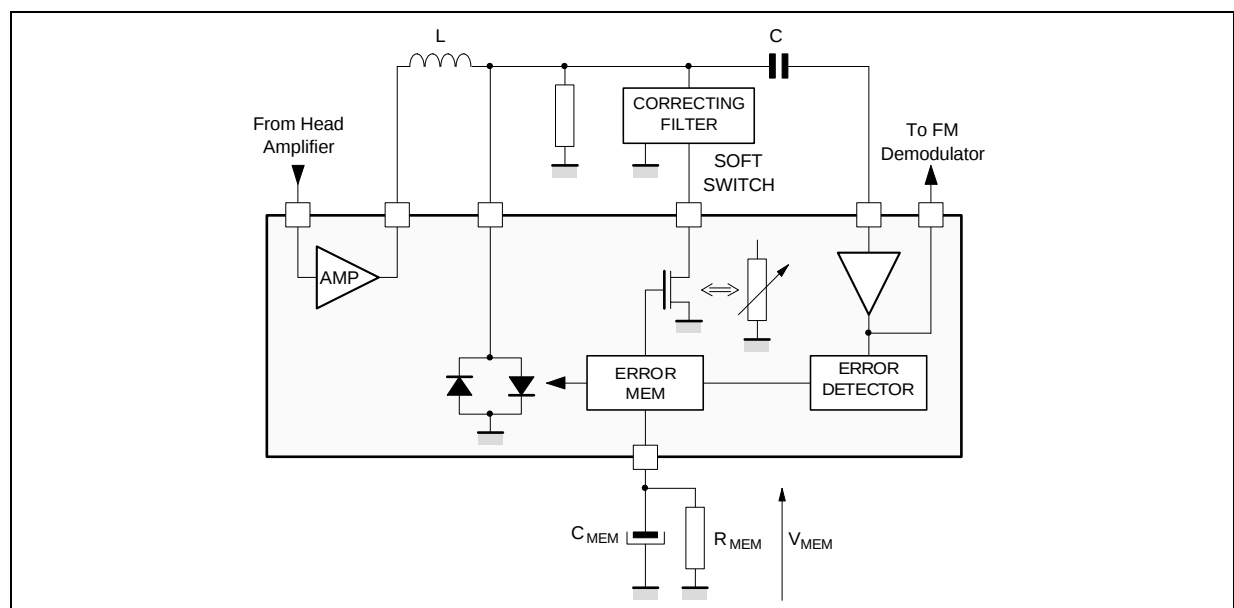
With this detection system and in combination with an external  $R_{MEM}C_{MEM}$  filter, the TEA5750 produces a DC voltage  $V_{MEM}$  proportionnal to the average error rate (Figure 8).

**Figure 7 : FM Playback Signal Errors detected by the TEA5750 Application**



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**Figure 8 : Playback Signal Quality Monitoring**



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In case of good records :

The DC voltage  $V_{MEM}$  remains lower than 1V, there is no action ; it results a demodulated video signal with a full bandwidth.

In case of poor records :

The DC voltage  $V_{MEM}$  increases, and the TEA5750 corrects the playback signal in two steps :

- in a first step, when  $V_{MEM}$  exceeds an internal threshold, by means of a softswitch the ASO<sup>+</sup> circuit change the characteristics of the correcting filter. This first correction is intended to reduce the demodulated signal bandwidth in the frequency range where noise is supposed to be present and disturbing : 2.7 to 3.2MHz (see

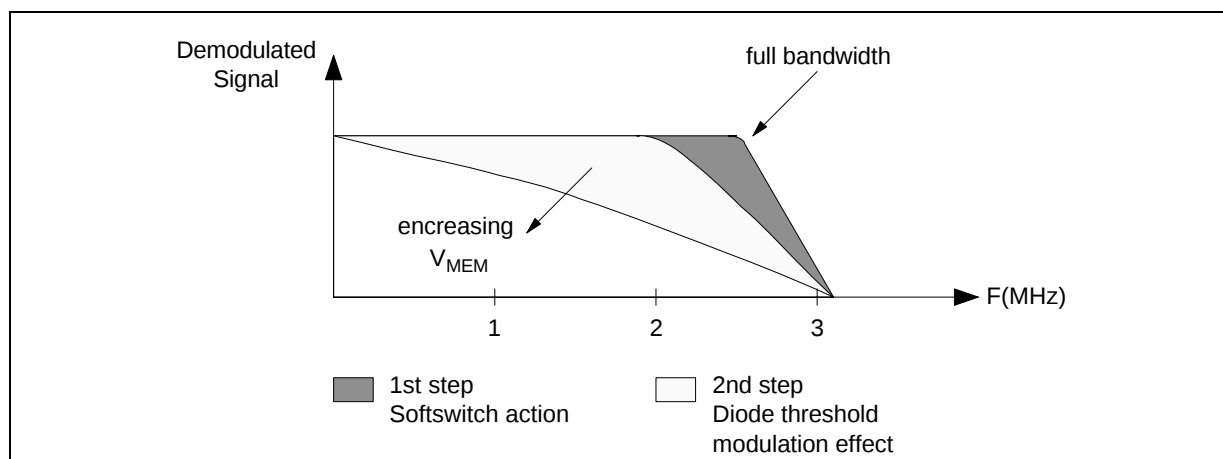
Figure 9).

- in a second step : if  $V_{MEM}$  continues to increase, the threshold of the diodes of the phase shifting circuit is increased. First consequence, the phase shifting is less effective (less flux in inductance L) and this tends to decrease the demodulated video bandwidth. Second consequence, the equivalent impedance of the node at the junction of L, C and diodes is going to increase, providing so a higher efficiency to the correcting filter. The combined effects of those two consequences produce a high attenuation of the video bandwidth. The displayed picture becomes soft (Figure 9).

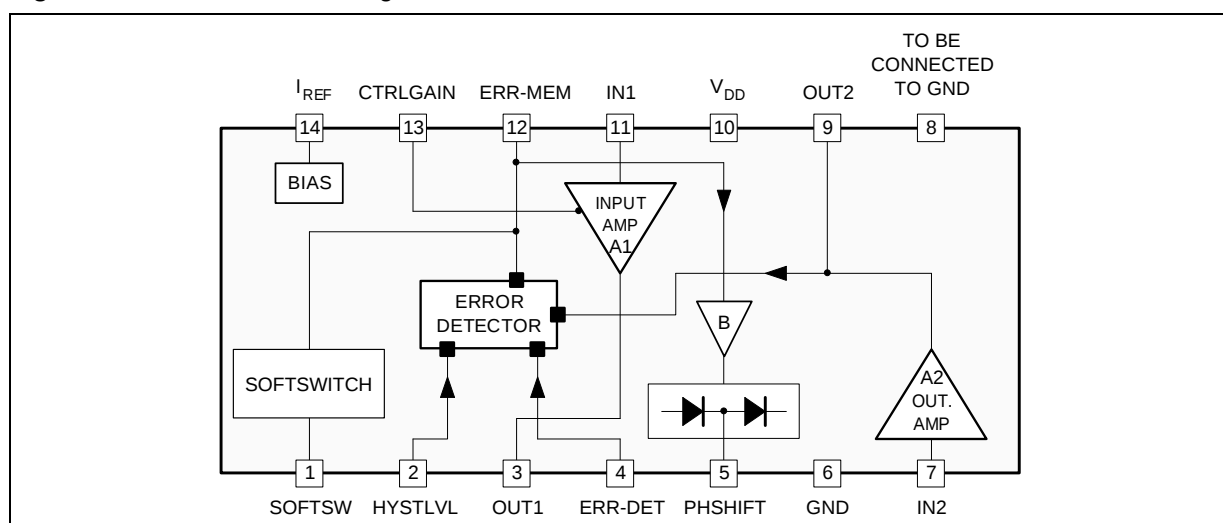
#### IV - TEA5750 FUNCTIONAL DESCRIPTION

To better understand the herebelow explanations the block diagram of the TEA5750 is given in Figure 10.

**Figure 9 :** Automatic Video Bandwidth Adjustment



**Figure 10 :** TEA5750 Block Diagram



#### IV.1 - Biasing

A Precise and stable 1.25V voltage is delivered at Pin 14. Using an accurate resistor allows to precisely biased the internal functions of the TEA5750

$$I_{REF} = \frac{1.25V}{R_{14}}$$

$R_{14}$  : 1.1k $\Omega$ /1% is recommended.

#### IV.2 - Phase Shifting Circuit

This function is made of :

- the gain controlled input amplifier,
- the clamping diodes,
- the output amplifier.
- The input amplifier A1 features a low input impedance (typ. 28 $\Omega$ ) and amplifies the input current into voltage. The gain can be externally control-

led at Pin 13 (Figure 11).

Control can be done either by a resistor connected between Pin 13 and ground (typical application) or by a voltage  $V_{13}$

$$V_{OUT1} = K \cdot [V_{13}] \cdot I_{IN}$$

$$V_{OUT1} = K [R_{13} \times I] \cdot I_{IN}$$

- Clamping diodes  
According to the principle of the ASO plus function the threshold of the diodes is modulated versus the error memory voltage  $V_{MEM}$  (or  $V_{12}$ ). Characteristics are given in Figure 12.
- The output amplifier A2 also features a low input impedance (typ. 13 $\Omega$ ) and then amplifies the input current (issued from the capacitor of the ASO core filter) into an output voltage.

Figure 11 : Phase Shifting Circuitry

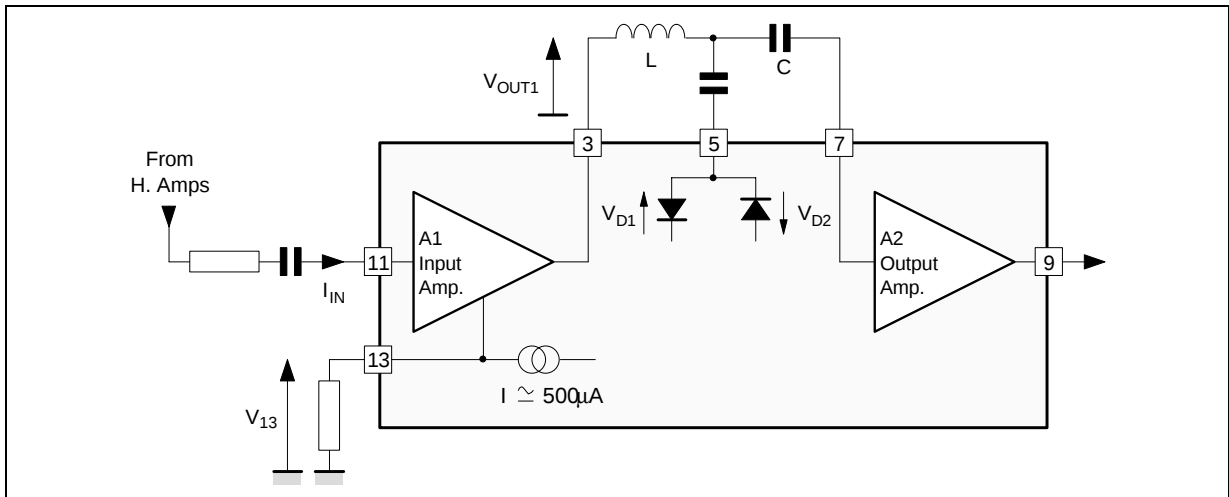
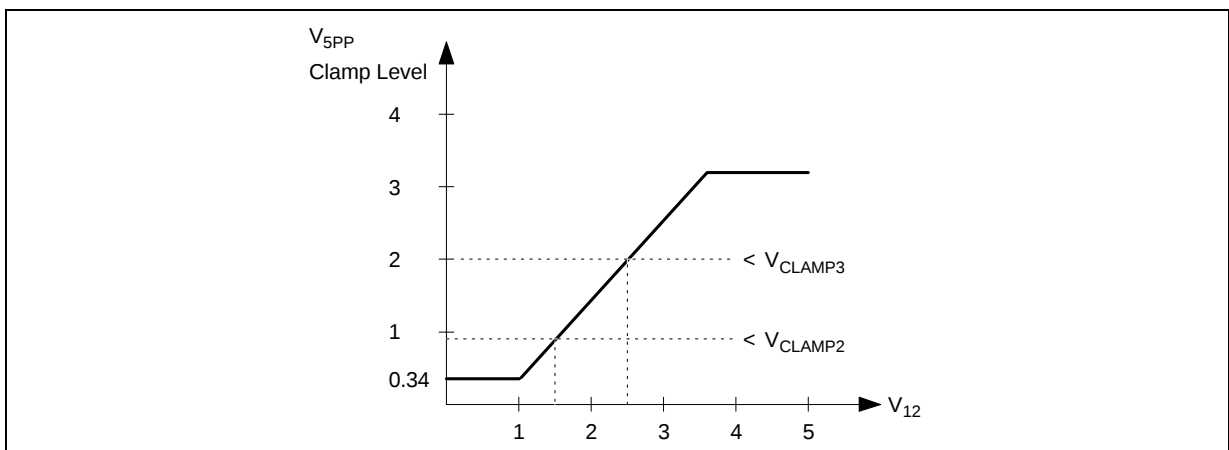


Figure 12 : Diode Threshold versus  $V_{MEM}$  on Pin 12



#### IV.3.a - Error Detector

tains the slope of the ramp compatible with the frequency of the FM carrier.

The comparison generates an "up/down" signal which increases or decreases the charging current of ramp capacitor. In doing so, the rising time of the ramp (from 0V to 1V) is maintained compatible with the halfwave duration of the FM carrier whatever the recording system (VHS, S-VHS, Video 8, HI-8).

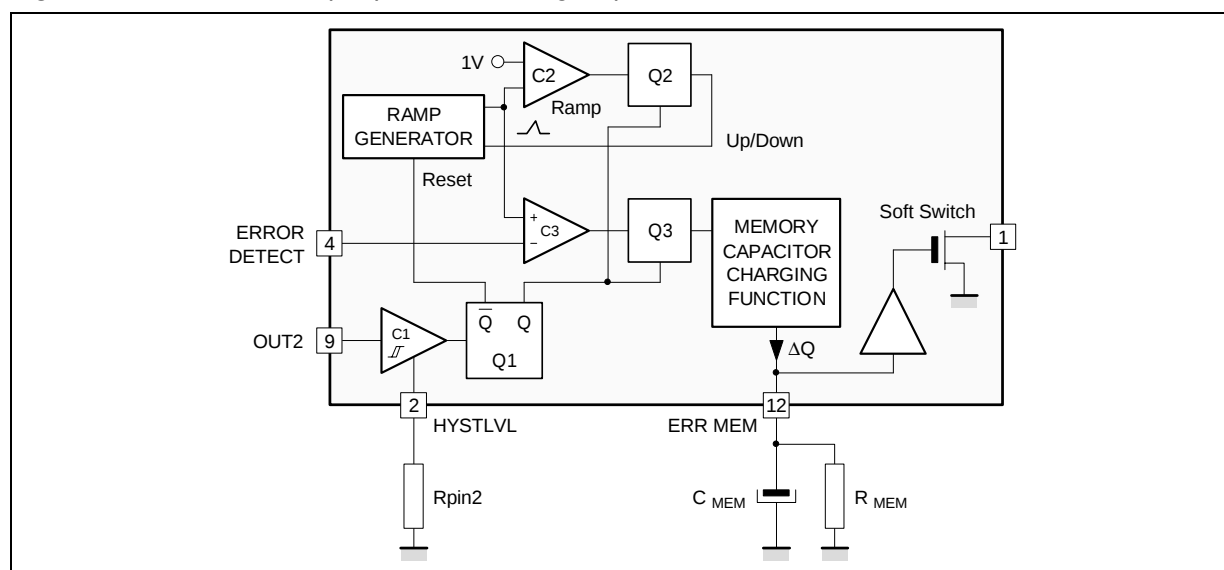
In the case of VHS standards, the rising time to 1V is kept between 104ns and 134ns

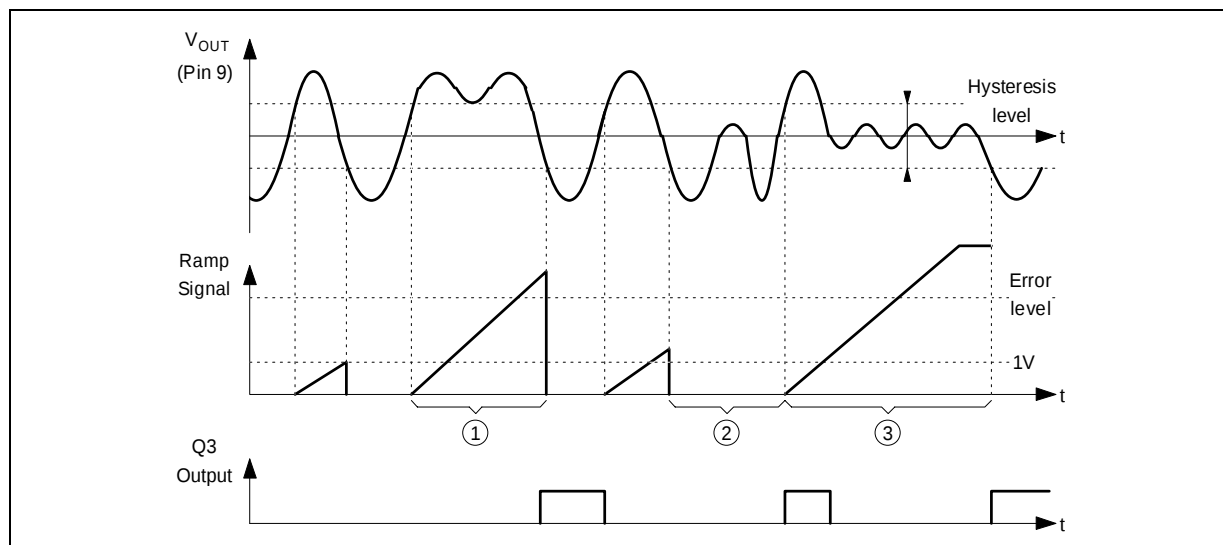
- $$(104 \text{ ns} \cong \frac{1}{2} \frac{1}{4.8 \text{ MHz}}; 134 \text{ ns} \cong \frac{1}{2} \frac{1}{3.8 \text{ MHz}}).$$

Remark : the speed of this control loop is slow, because the loop is not intended to dynamically follow the carrier frequency.

- An error is detected when the ramp signal exceeds the threshold of the comparator C3. The threshold is externally adjusted at Pin 4 and typically adjusted at about 3V.

**Figure 13 : Error Detector (simplified block diagram)**



**Figure 14 : Error Detection waveforms****Comments about Figure 14 :**

- ① Missing zero crossing
- ② A missing zero crossing happening on the negative halfwaves. This type of errors is also detected by the TEA5750.
- ③ Signal drop-out.

Remark : the hysteresis level of comparator C1 is externally adjustable at Pin 2.

$$\text{HSYT}_{\text{level}} = R_{12} \times 10 \mu\text{A}$$

$$0 \leq R_{12} \leq 10 \text{ k}\Omega$$

**IV.3.b - Error Memory (Figure 13)**

Each time, an error is detected at the output of Q3, the memory capacitor charging circuit sends a fixed amount of charges  $\Delta Q$  to  $C_{\text{MEM}}$  capacitor ( $\Delta Q$

remains the same whatever the error shape, length ;  $\Delta Q \approx 32 \text{ nc}$ ).

The capacitor  $C_{\text{MEM}}$  is discharged by the resistor  $R_{\text{MEM}}$ .

In average :  $V_{\text{MEM}} = I_{\text{moy}} \cdot R_{\text{MEM}}$   
 $V_{\text{MEM}} = \Delta Q \cdot f_{\text{err}} \cdot R_{\text{MEM}}$   
 $f_{\text{err}}$  : Error Frequency

**IV.3.c - Softswitch**

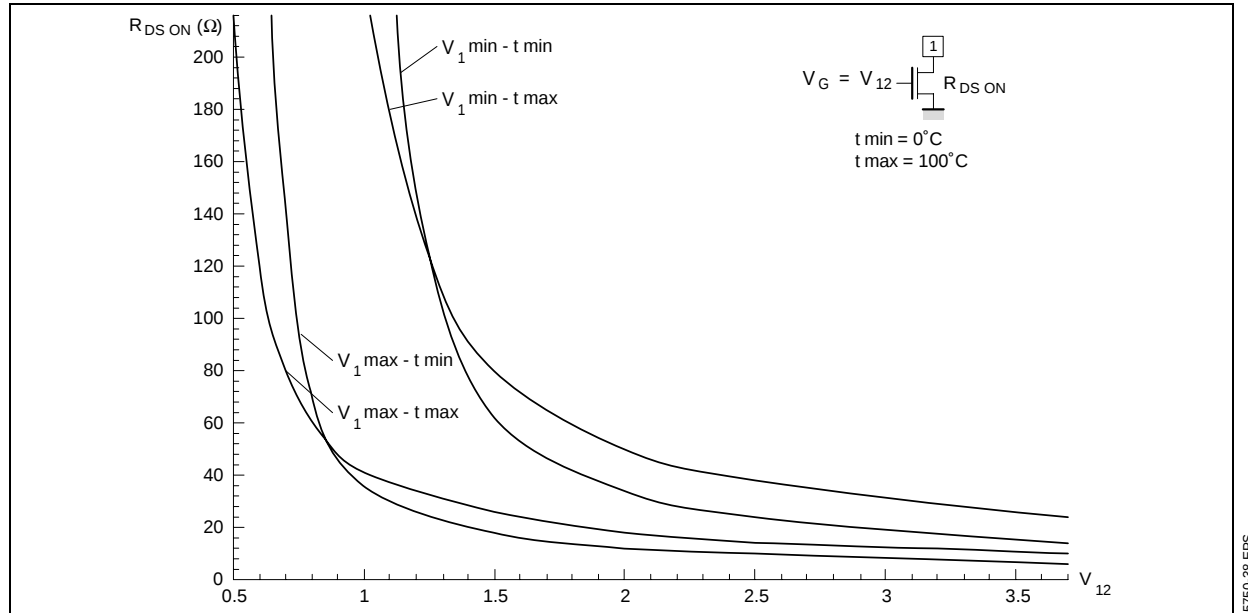
The voltage level  $V_{\text{MEM}}$  generated by the error detection drives a softswitch : a MOS transistor which is used in its variable  $R_{\text{DS ON}}$  area (Figure 15).

With this softswitch, the TEA5750 can gradually attenuate the FM signal lower side band.

More details are given in chapter V.1.e.

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Figure 15 :  $R_{DS\ ON}$  versus  $V_{ERR-MEM}$  on Pin 12



## V - IMPLEMENTATION OF THE TEA5750 IN A VHS-VTR APPLICATION

### V.1 - Typical Application Description

In this chapter, is described only the direct environment of the TEA5750. The interface circuits with the head amplifiers and the FM demodulator are decrbed in V.2 and V.3 parts.

Figure 16 illustrates a typical application diagram.

#### V.1.a - Input Filter ( $R_4$ , $C_2$ )

The input filter has 2 purposes :

- to provide the input stage with a suitable signal : referring to chapter IV.2, the input stage A1 requires a current as input signal. Consequently the  $R_4C_2$  input filter is the impedance which changes the input voltage signal (coming from the H-amps) into the required input current. In order to limit the harmonic distortion to less than -40dB, the input current must be less than (0.5mA<sub>p-pk</sub>) in the frequency deviation range.

(1) for :  $3.8\text{MHz} \leq f \leq 5\text{MHz}$

$$\frac{V_{IN\ max}\ (p-pk)}{\sqrt{R_4^2 + \frac{1}{C_2^2 \omega^2}}} \leq 0.5\text{mA}_{p-pk}$$

Additionally  $C_2$  performs a necessary capacitive coupling.

- to provide the ASO core with a FM signal featuring a more appropriate balance between the

lower and upper side bands.

Looking at the frequency response of a tape (Figure 17) it can be noticed that the high frequencies are greatly attenuated compared with the low frequencies (the attenuation between 3MHz and 6MHz is in the range of -12dB/octave for VHS tape).

This imbalance leads to important amplitude changes during luma transients (Figure 17). Those very important changes in the amplitude of the playback signal would induce a too high efficiency of the phase shifting circuit. So the inherent high pass characteristics of the  $R_4C_2$  input filter are used to decrease this imbalance.  $R_4C_2$  cut-off frequency  $f_c$  is choosen to attenuate the lower side band versus the higher side band. But the cut-off frequency should not be to high in order not to decrease the S/N ratio. In case of VHS standard  $f_c$  is choosen in the range of 6 to 8MHz. Taking into account the previous point  $R_4C_2$  is sized as following : (Figure 17).

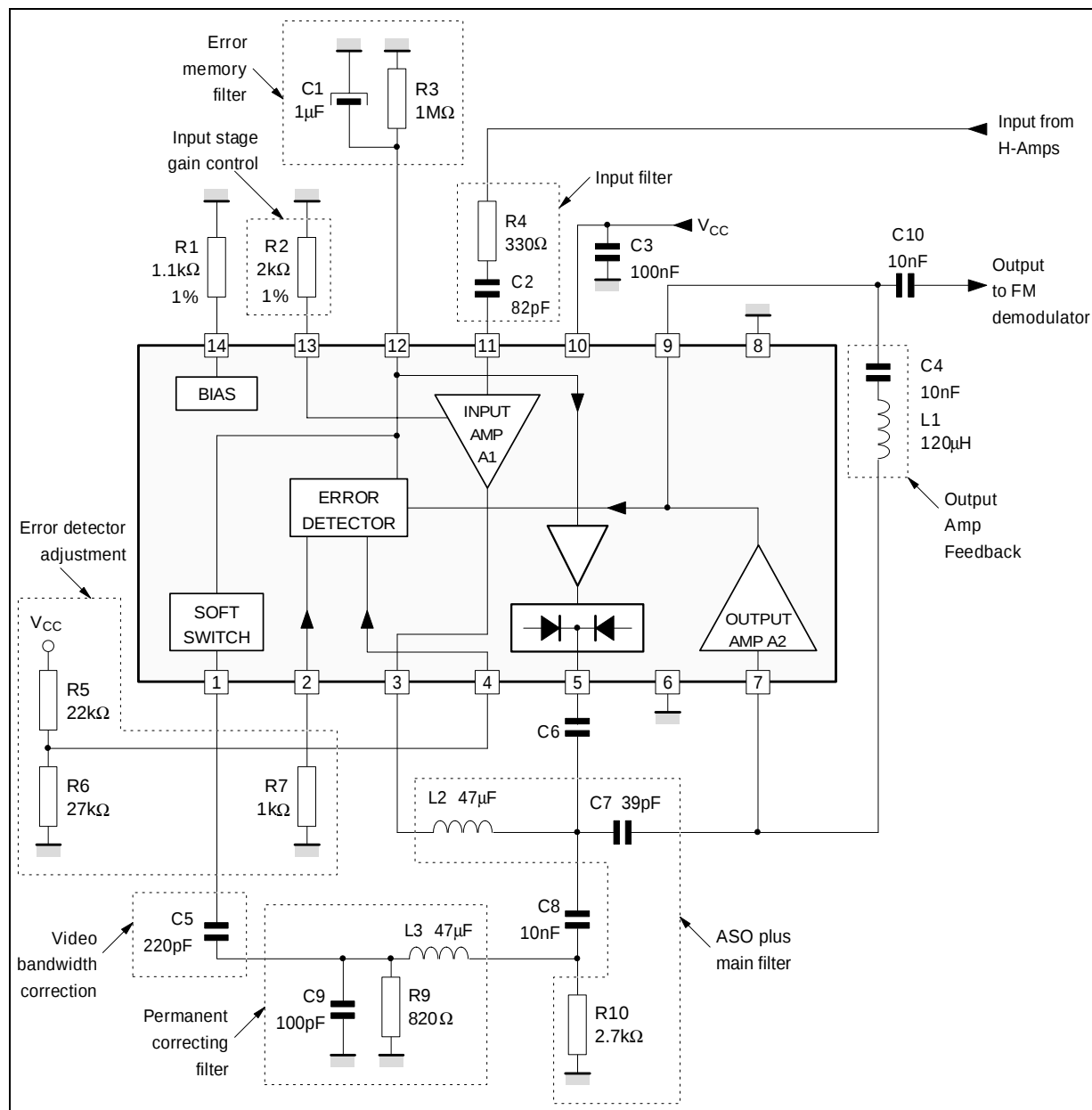
$$(1) \quad \frac{V_{IN\ max}\ (p-pk)}{\sqrt{R_4^2 + \frac{1}{C_2^2 \omega^2}}} \leq 0.5\text{mA}_{p-pk}$$

$$3.8\text{MHz} < f < 5\text{MHz}$$

$$(2) \quad 6\text{MHz} < \frac{1}{2\pi R_4 C_2} < 8\text{MHz}$$

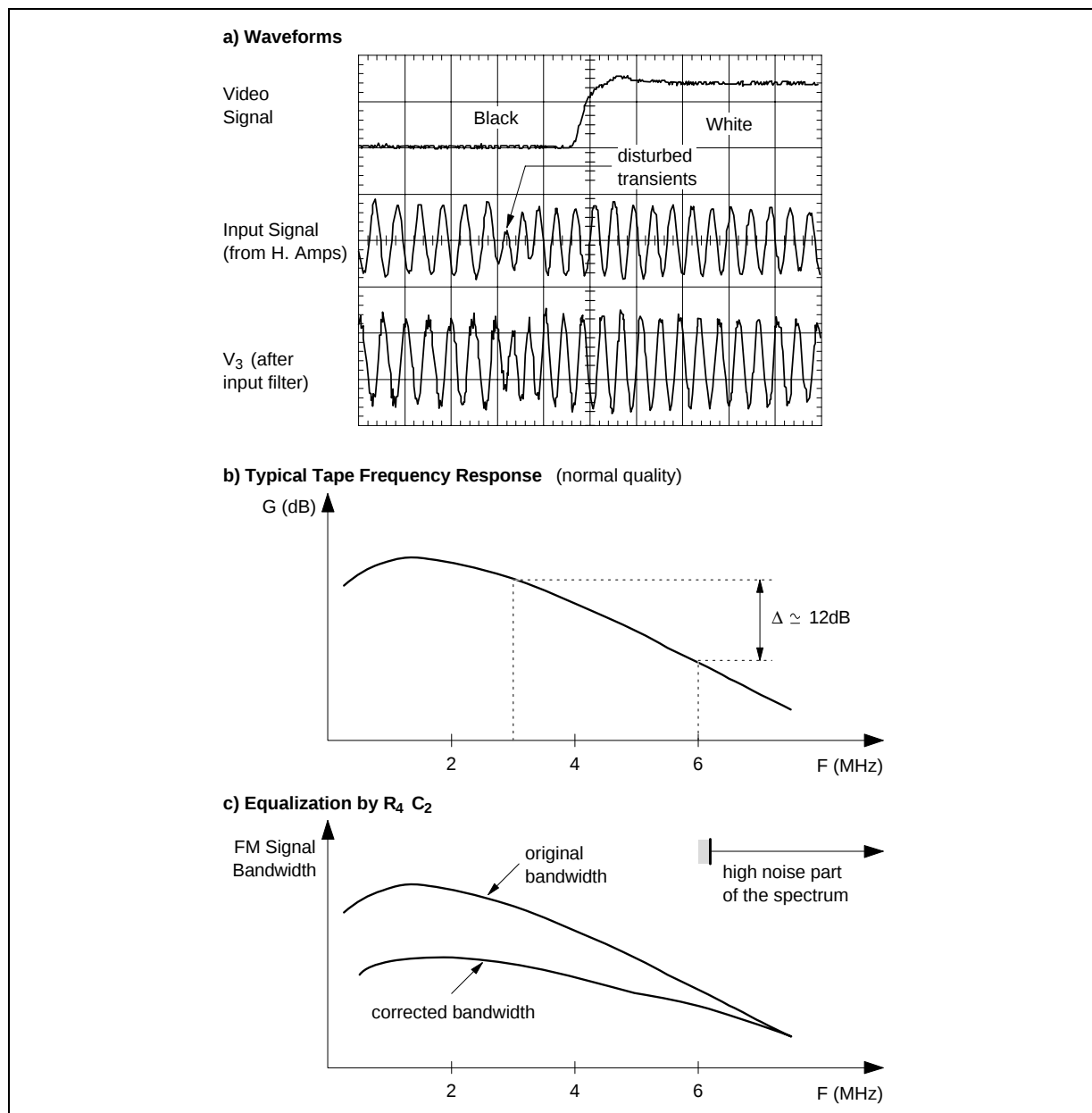
Typically :  $R_4 \cong 330\Omega$ ,  $C_2 \cong 68\text{pF}$   
( $V_{IN\ max.} \cong 0.25\text{V}_{p-pk}$ )

Figure 16 : TEA5750 Typical Application



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Figure 17 : Input Filter Equalizing Effect



### V.1.b - ASO Main Filter (L<sub>2</sub>, C<sub>7</sub>, R<sub>10</sub>)

The function of the filter L<sub>2</sub> C<sub>7</sub> R<sub>10</sub> has been already explained in details in chapter III.

Basically, under normal playback conditions, the L<sub>2</sub> inductance performs a flux storage (phase shifting), the L<sub>2</sub> C<sub>7</sub> resonant circuit performs an amplification of low amplitude waveforms (tearing effect suppression). R<sub>10</sub> provides damping.

In the typical application, the frequency characteristics of the ASO main filter are influenced by the correcting filter (chapter V.1.c) (see Figure 18).

For an appropriate operation in the application, the

total filter (main filter + correcting filter) is normally dimensionned as following.

- Resonance frequency is typically chosen at the center of the frequency deviation of the carrier.

In VHS case :  $f_{\text{resonance}} \approx 4.3\text{MHz}$ .

Remark : in some applications,  $f_{\text{resonance}}$  can be slightly under this typical value in order to better protect the synchro signal against tearing effects. Looking at Figure 18 it can be seen that the resonance frequency of the total filter (main filter + correcting filter) is about 4.3MHz (L<sub>2</sub>C<sub>7</sub> resonance frequency is about 3.5MHz).

- Q factor of the filter is chosen in order to cover properly the carrier frequency swing range (3.8MHz to 4.8MHz).

$$\frac{F_{\text{resonance}}}{F_{\text{deviation}}} \approx \frac{4.3\text{MHz}}{1\text{MHz}} \approx 4.3$$

$$Q \leq 4.3$$

In practice in order to provide margin, Q factor is in the following range :  $2 \leq Q \leq 3.5$

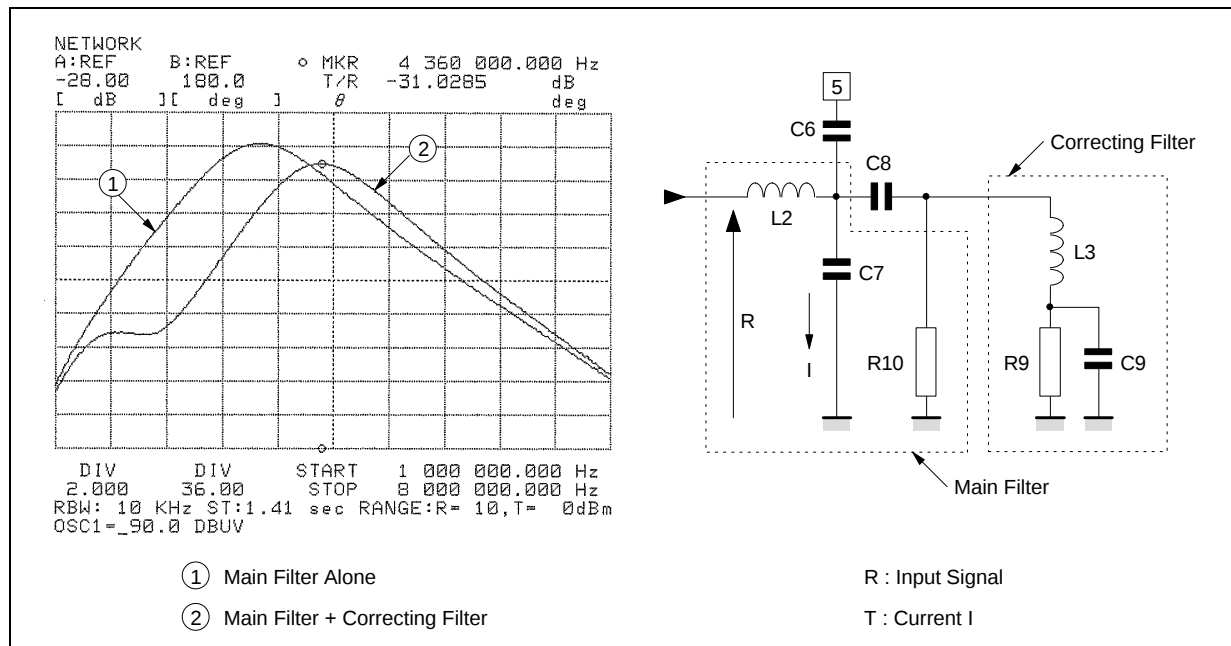
$$Q \approx \frac{R_{10}}{L_2 \omega_{\text{res}}}$$

- Free transient response of the complete filter :

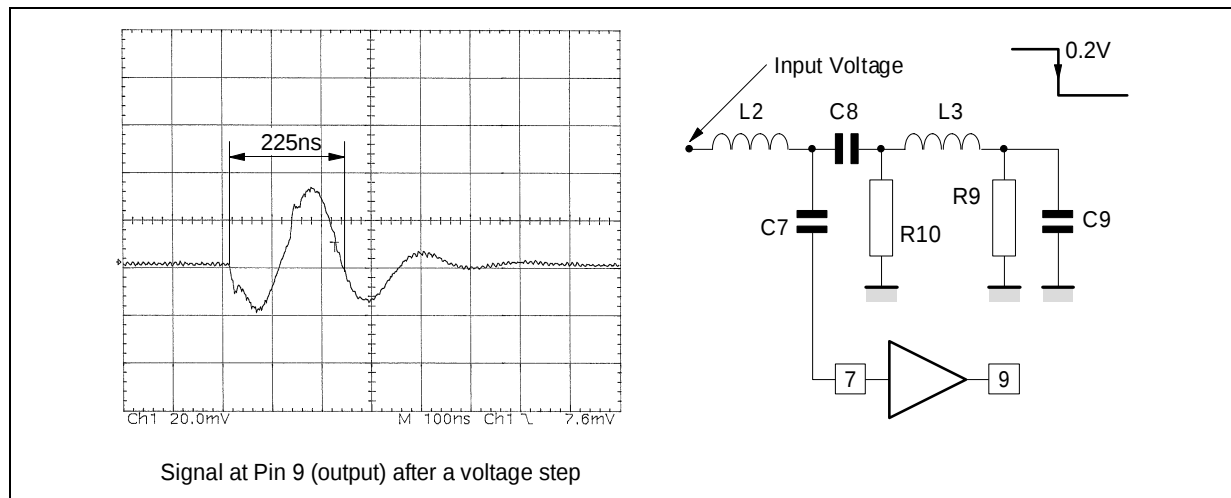
In case of signal drop outs, there is no signal at the input of the filter which consequently generates its own free transient response (Figure 19). Effect of this transient response on the picture are minimized when :

- The transient response is strongly damped : short duration.
- Damping is normally enough when  $2 \leq Q \leq 3.5$ .
- The free frequency of the filter is in the range of 4.3MHz producing then a medium grey spot less disturbing than an ultra black or ultra white spot.

**Figure 18 : Main Filter + Correcting Filter Typical Frequency Response**



**Figure 19 : Main Filter + Correcting Filter Free Transient Response**



**Remark :** It is possible to locate the correcting filter outside the TEA5750 environment.

In this case  $L_2$   $C_7$   $R_{10}$  values are simply calculated as following

$$- f_{\text{resonance}} = \frac{1}{2\pi\sqrt{L_2 C_7}}$$

$$- Q = \frac{R_{10}}{L_2 \omega_{\text{res}}}$$

#### V.1.c - Correcting filter ( $L_3$ , $R_9$ , $C_9$ ) (Figure 18)

$L_3$   $C_9$   $R_9$  filter simply performs a spectrum equalization of the playback signal ; it attenuates the spectrum in the range of 1.5MHz to 3MHz (center frequency  $\approx 2.2$ MHz) where VHS tape have a high efficiency. Results is a better balance between the upper and lower side band.

This filter is often located in the environment of the TEA5750 (like in Figure 16) because ASO plus replaces the conventional FM equalizer. However it can be located in an other part of the FM signal path.

The filter is dimensioned to compensate the soft peaking which appears in the demodulated signal frequency response (Figure 20). Consequently the requested Q factor has a low value (about 1.5).

#### V.1.d - Output Filter Feedback ( $L_1$ $C_4$ ) (Figure 21)

The output amplifier converts the current  $I_C$  of the main ASO filter into the output voltage. The typical waveforms of the current  $I_C$  show a slow slope of

the signal in the area of the zero crossing. This induces a high sensitivity to phase noise.

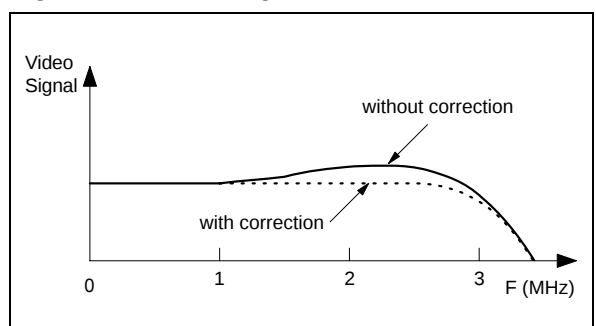
In order to avoid this problem, the feedback network of the output amplifier is an inductance. Consequently the output contains a component of input signal derivate.

$V_{\text{OUT}}$  crosses zero with a higher slope, therefore the sensitivity to jitter is reduced.

In Figure 22, is given the output voltage waveforms when the feedback is made by a resistor, this waveforms would lead to high sensitivity to phase noise (to be avoided).

$C_4$  capacitor only provides capacitive coupling, the resonance frequency of  $L_1$   $C_4$  is chosen in low frequencies ( $\approx 150$ kHz) so that the filter is almost equivalent to  $L_1$  in the FM playback spectrum (1MHz to 10MHz). Typical values are  $C_4$  : 10nF,  $L_1$  : 120 $\mu$ H.

**Figure 20 : Correcting Filter Effect**



**Figure 21 : Inductive Feedback of the Output Amplifier**

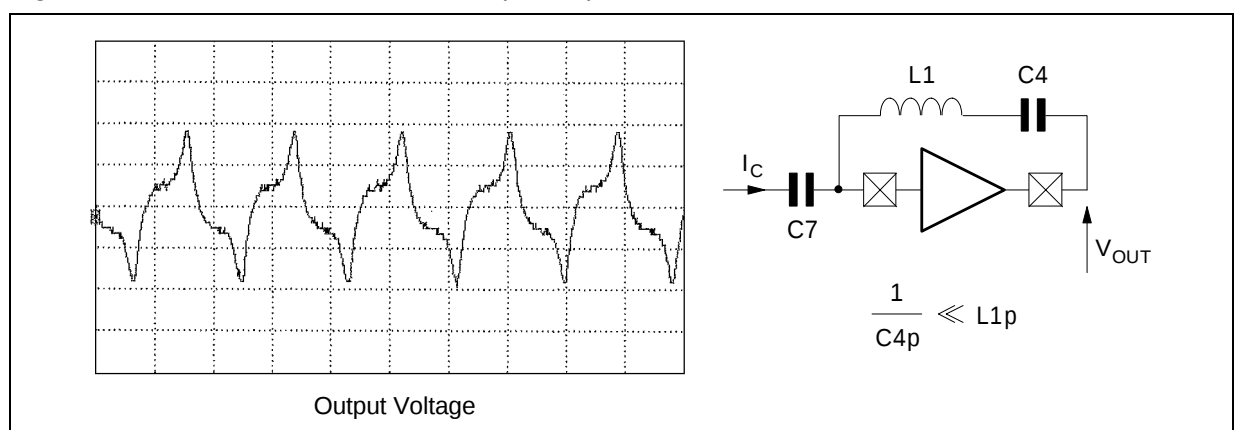
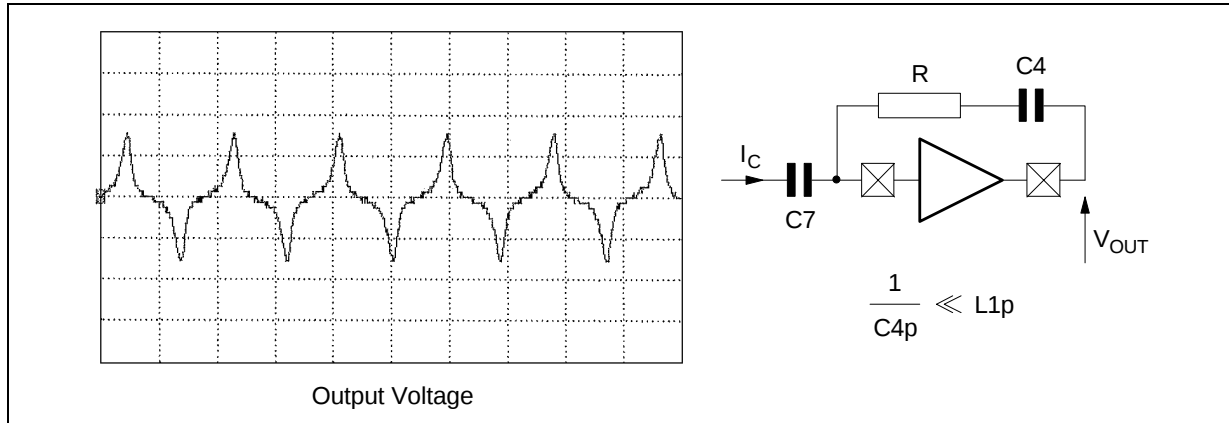


Figure 22 : Resistive Feedback of the Output Amplifier



### V.1.e - Error Memory Filter (C<sub>1</sub> R<sub>3</sub>)

Each time an error is detected in the playback signal, the error detector generates a fixed amount of charge  $\Delta Q$  (32nC : 40 $\mu$ A x 800 $\mu$ s). So by means of the parallel (C<sub>1</sub> R<sub>3</sub>) filter, a DC voltage proportional to the error rate will appear at Pin 12.

$$V_{12} = R_3 (I_{12})_{\text{average}} = R_3 \cdot \left( \frac{1}{T} \int_0^T \Delta Q \right)$$

During the playback of normal quality,  $V_{12}$  must be kept below the triggering threshold of the softswitch (typ. 0.8V). Under those conditions, errors are normally in the range of 25 per second.

$$R_3 \leq 1M\Omega$$

C<sub>1</sub> value influences the charge and discharge times of the filter. A compromise has to be found between low time constants which lead to fast fluctuations of the picture resolution (unstable sharpness) and long time constants which induce long delays before picture sharpness is definitively stabilized. Typically a 1 seconde time constant is used :  $R_3 C_1 \cong 1s$

### V.1.f - Video Bandwidth Correction (C<sub>5</sub>) (Figure 23)

In case of medium error rate ( $0.8 < V_{12} < 1.2V$ ) softswitch is turned on and then C<sub>5</sub> is added to the L<sub>3</sub> R<sub>9</sub> C<sub>9</sub> correcting filter. The resulting filter is chosen to produce an attenuation of the lower sideband of the FM playback signal in the range of 1 to 1.6MHz.

Center frequency  $f_C \cong 1.3MHz$

$$2\pi f_C = \frac{1}{\sqrt{L_3 (C_9 + C_5)}}$$

This correction corresponds to an attenuation of the upper spectrum (above 2.5MHz) of the demodulated video signal. In doing so, the expected noisiest part of the spectrum is reduced. The signal spectral density is reduced but S/N is improved.

When the error rates increases to high values  $V_{12} > 1.2V$ , the correction performed by the L<sub>3</sub>, R<sub>9</sub>, C<sub>9</sub> + C<sub>5</sub> filter is not enough. The video bandwidth is again adjusted by decreasing the phase shifting, this is performed by increasing the threshold of the diodes.

### V.1.g - Error Detector Adjustment (R<sub>5</sub>, R<sub>6</sub>, R<sub>7</sub>) (Figure 16)

Referring to the detailed description of the error detector (chapter IV.3.) :

-  $V_4$  is the threshold voltage of the error detector and selected as following :

$$\frac{V_4}{1V} \geq \frac{\text{Expected longest hardware duration}}{\text{Average halfwave duration}}$$

$$V_4 \geq 1V \times \frac{166ns}{116ns}$$

In practice at least a double margin is taken

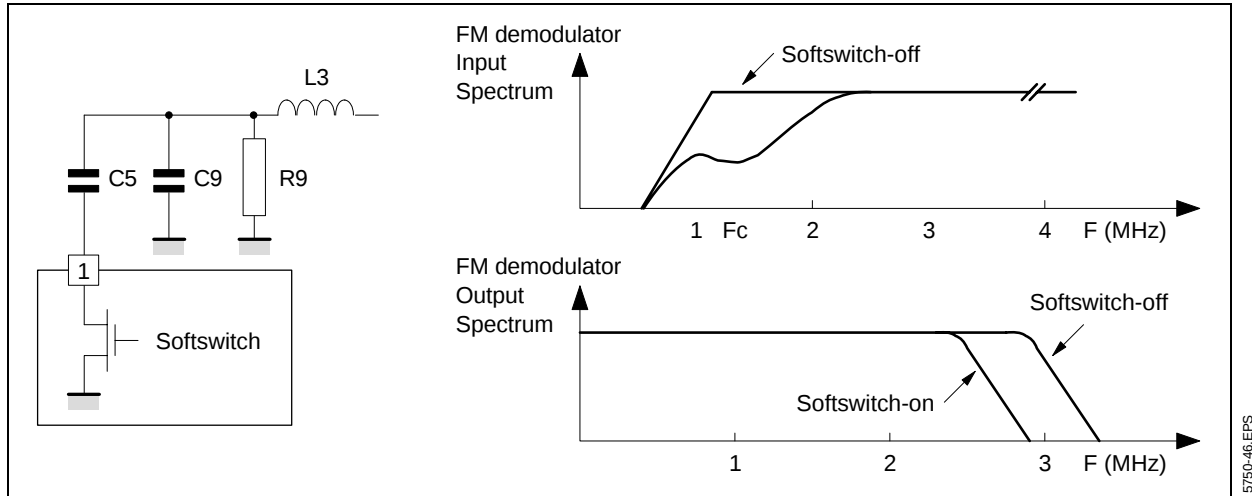
$$V_4 \cong V_{CC} \frac{R_6}{R_6 + R_5} \cong 3V$$

-  $V_2$  gives the hysteresis of the comparator

$$\text{Hyst} = R_7 \times 10\mu A$$

$$0 \leq \text{Hyst typ} \leq 300mV$$

Figure 23 : Video Bandwidth Adjustment



#### V.1.h - Input Stage Gain Control (R<sub>2</sub>)

R<sub>2</sub> is intended to control the gain of the input stage. Gain is usually adjusted in order to get about 1.2Vp-pk at Pin 3 during the synchro (3.8MHz).

#### V.1.i - Other Components

C<sub>6</sub>, C<sub>8</sub>, C<sub>10</sub> are coupling capacitors ; their value are

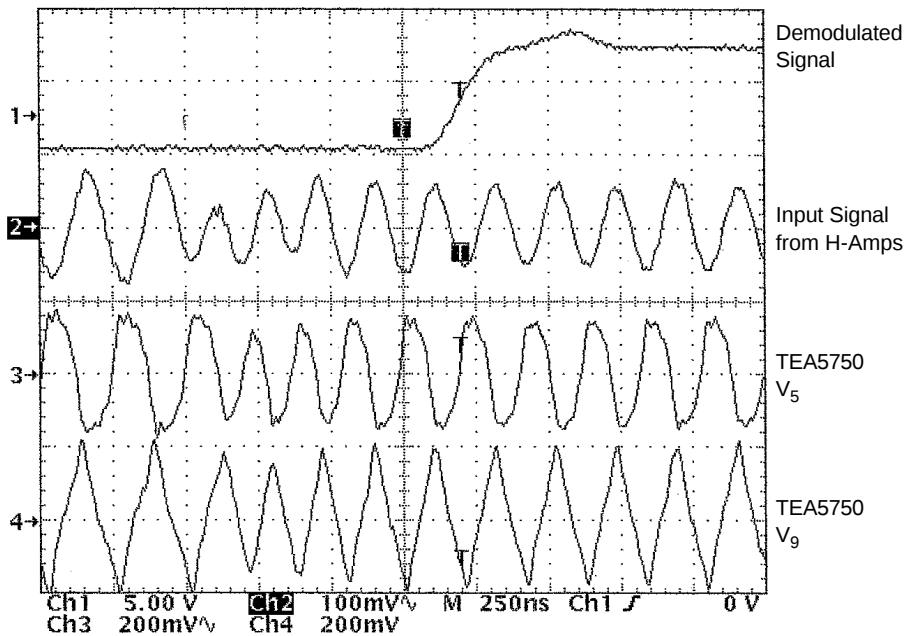
not critical (10nF to 100nF are typical values).

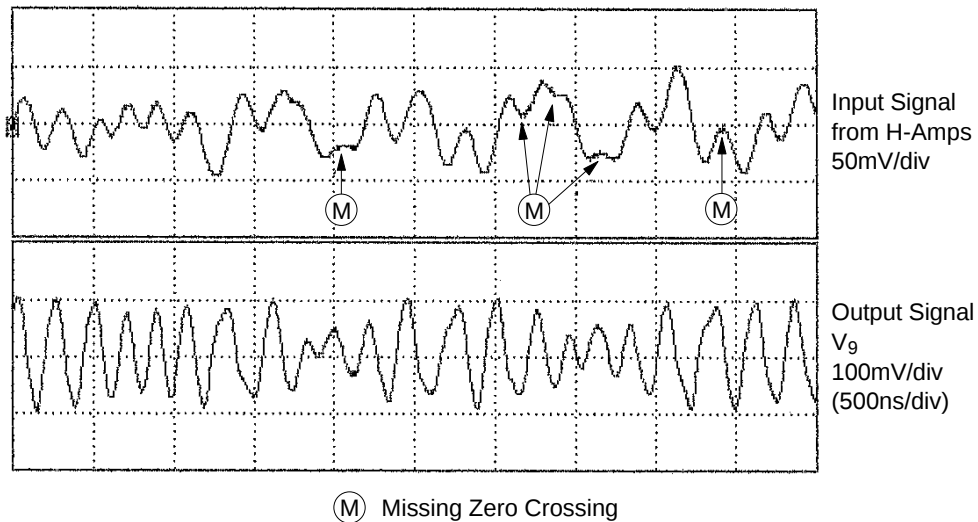
C<sub>3</sub> filters the V<sub>CC</sub> line.

#### V.1.k - Typical Waveforms and Results

The following results and waveforms have been checked in a VHS set and with the typical application circuit of the TEA5750 (see Figure 16).

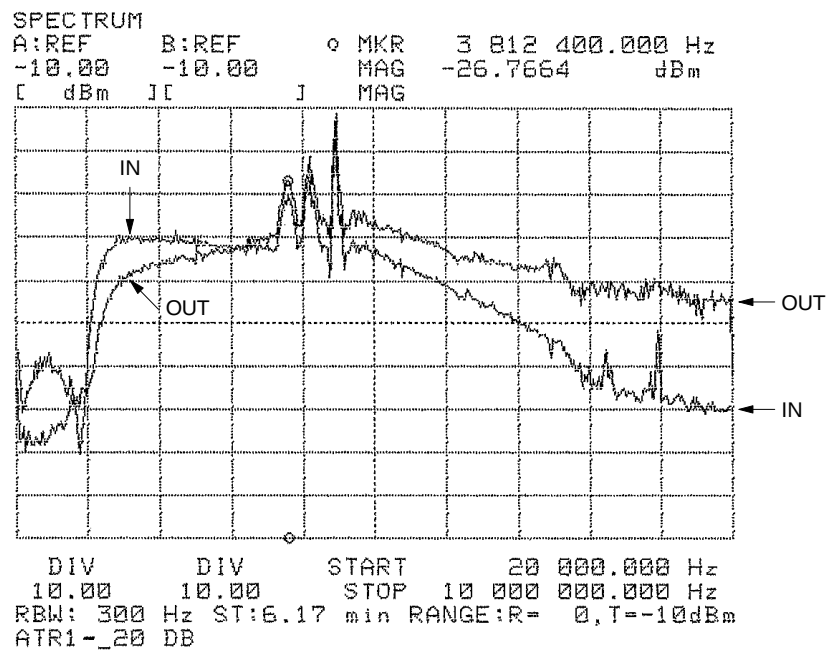
Figure 24 : Waveforms in case of medium and good quality tape. Case of a black to white transient.



**Figure 25 :** Waveforms in case of badly disturbed playback signal (ex : still picture mode of an aged tape)

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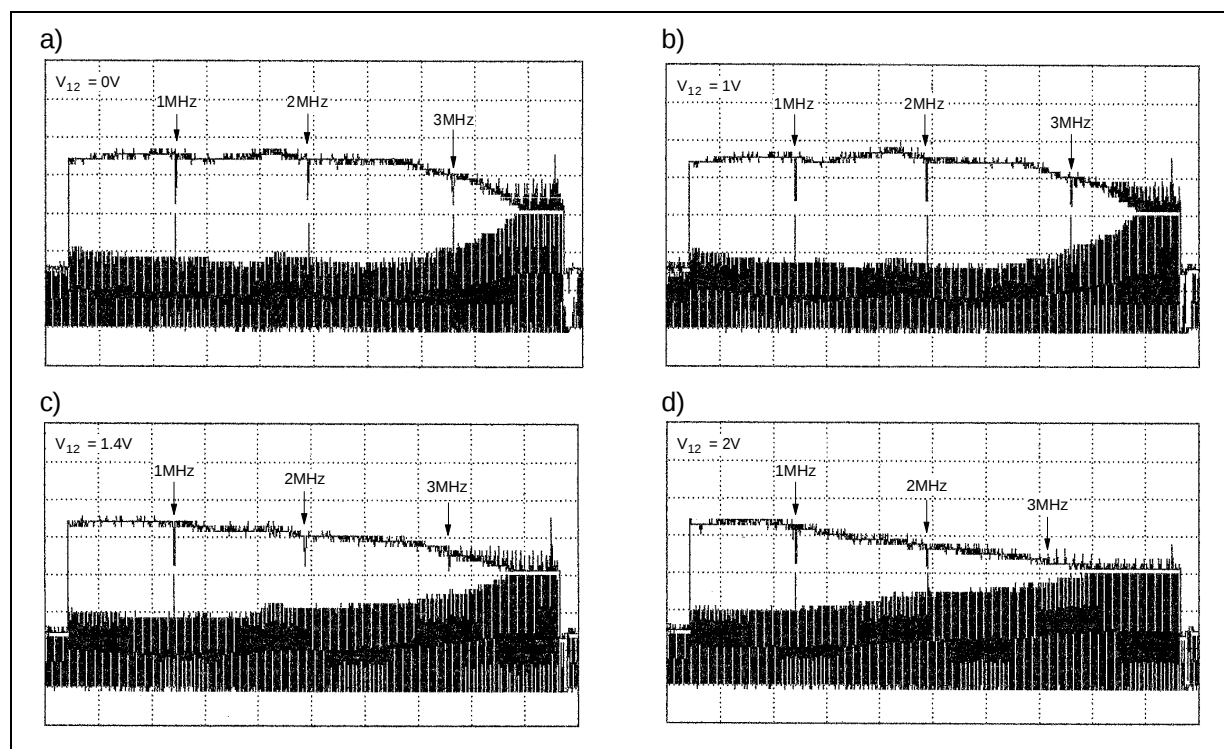
Most of the missing zero crossing are recovered. The picture features a far low rate of black fishes (tearing effect).

**Figure 26 :** Upper Side Band Recovery. Input and output signals spectrum of the ASO plus function.

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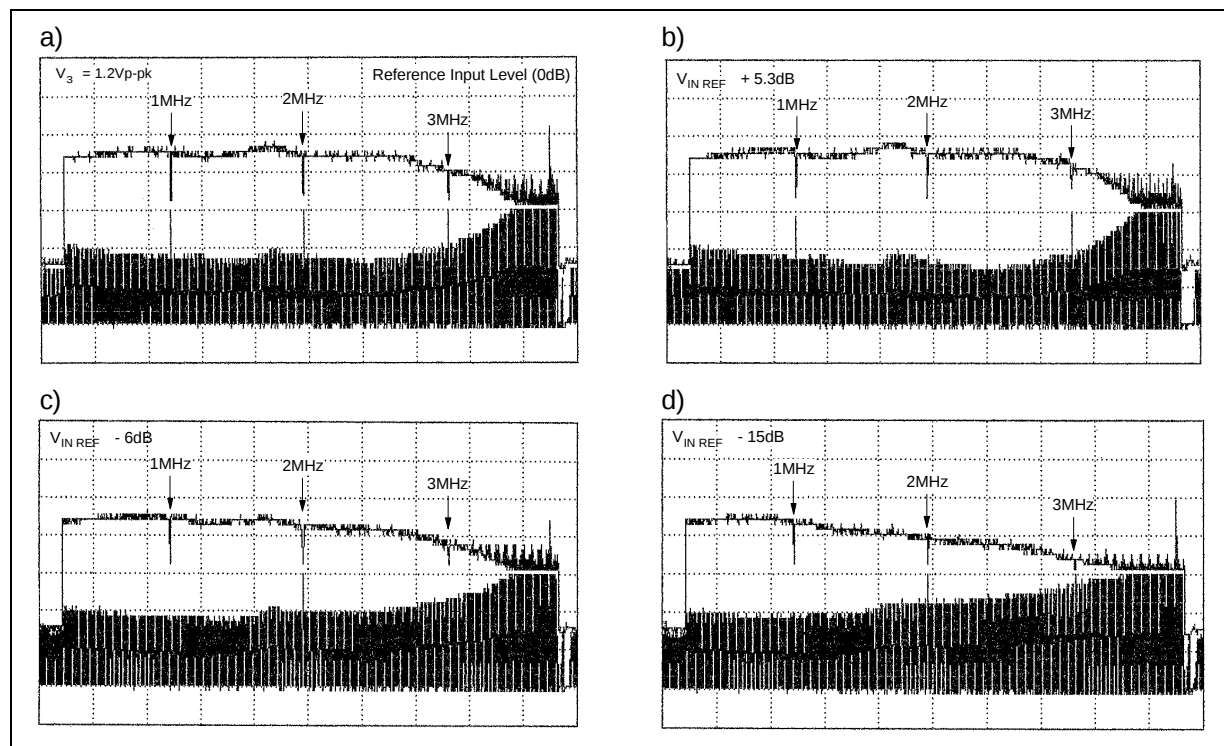
(Video pattern is a vertical black to white transient in the middle of the line)

**Figure 27 :** Demodulated Video Signal Bandwidth versus Voltage at Pin 12 (envelope signal)



Recorded signal is : video sweep with 1, 2, 3MHz markers.

**Figure 28 :** Demodulated Video Signal Bandwidth versus the Input Signal Amplitude



Reference level (0dB) corresponds to 28a) : 1.2Vp-pk at Pin 3 during synchro.  
Results : the video bandwidth is not very sensitive to the playback signal amplitude.

## V.2 - Interfacing with the Head Amplifier Part

In its principle, the ASO plus function is sensitive to the amplitude changes of the playback signal. For this reason, a chroma trap filter is necessary between the head amplifier part and the TEA5750 application, in order to avoid parasitic phase shifts induced by the chrominance signal.

In PAL application, the trap center frequency is 637kHz and an attenuation higher than 30dB is recommended (Figure 29).

Figure 30 shows an example of an interface circuit used between the head amplifier part and the TEA5750 application.

Remark : The group delay compensation circuit (Q102, C104, L102, R107) is very often inserted in the interface circuit but is not specially requested by the ASO plus circuit.

Very often the head amplifier section provides two types of playback signal : with and without AGC. When available it is generally recommended to use the output without gain control because of the two following reasons :

- This signal offers a higher S/N ratio,

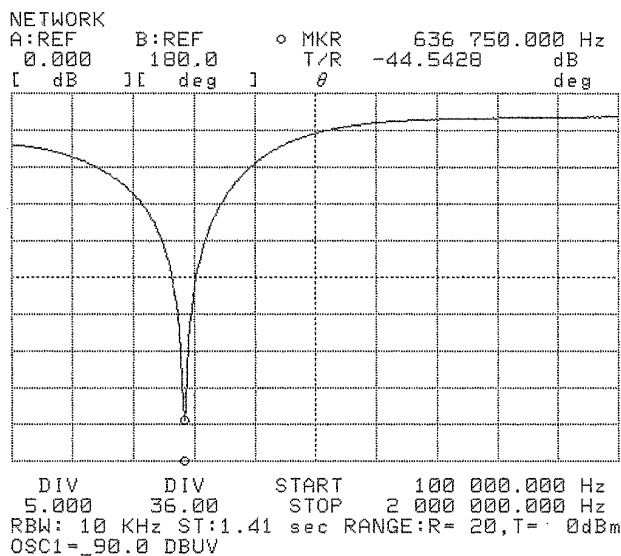
- a gain control is recommended between the ASO plus function and the FM demodulator (see chapter V.3.). In this case, the total gain would become too high if the gain controlled output of the head amplifier is used. A high gain of the channel is not suitable for stability, sensitivity to parasitics.

Remark : Generally, between 2 and 7MHz the frequency response of the interface circuit is flat, however in some application, a small peaking effect helps to better shape the playback signal (especially for applications without peaking with the head impedance).

## V.3 - Interfacing with the FM Demodulator

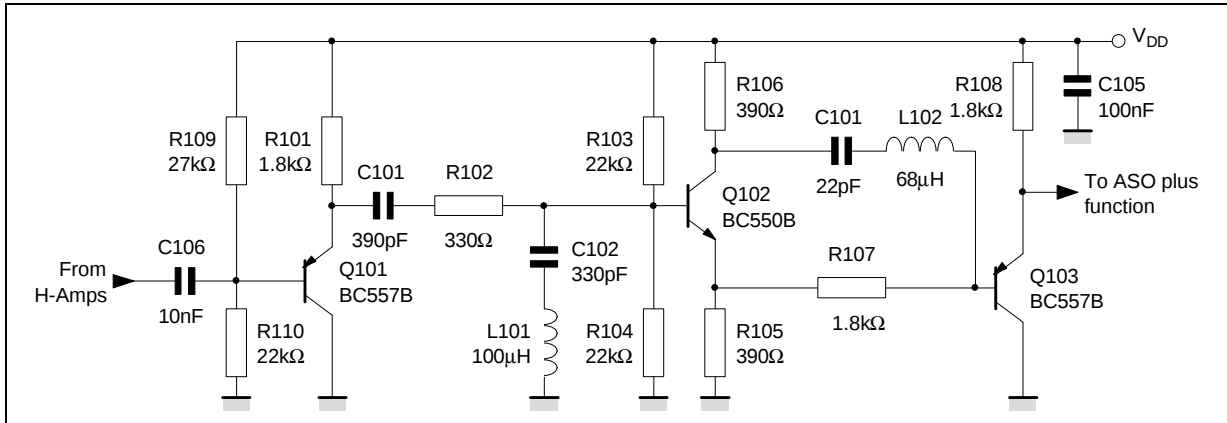
In case of disturbed playback signal, the clamping diode threshold level changes (see chapter IV.2). Consequently the output signal amplitude is modulated by the error rate, to compensate this very low frequency modulation an AGC function can be used between the ASO plus circuit and the FM demodulator (see Figure 31).

**Figure 29 :** Chroma Trap Filter Typical Characteristics in case of PAL Standard

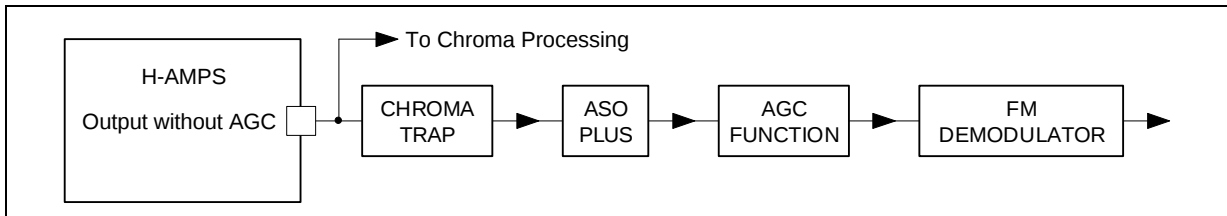


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**Figure 30 :** Example of Interface Circuit between the Head Amplifier Section and the ASO<sup>+</sup>



**Figure 31 :** FM Playback Channel Structure



Maximum theoretical output level increase is :

$$\Delta \text{dB} = 20 \log \frac{Q}{\sqrt{1 - \frac{1}{4Q^2}}}$$

Q = Quality factor of ASO main filter  
2 < Q < 3.5

⇒ ΔdB<sub>max.</sub> = 10dB

In practice this modulation does not exceed 6dB.

#### V.4 - Application Circuit Options

The TEA5750 application provides a high flexibility, and the following part is just intended to give some suggestions.

Remark : Those suggestions are just small improvements of the typical application (see Figure 16), and are not really requested.

##### V.4.a - Input Stage Gain Adjustment versus the Playback Signal Envelop Signal

As described in chapter IV.2. The input stage gain can be controlled by the voltage at Pin 13.

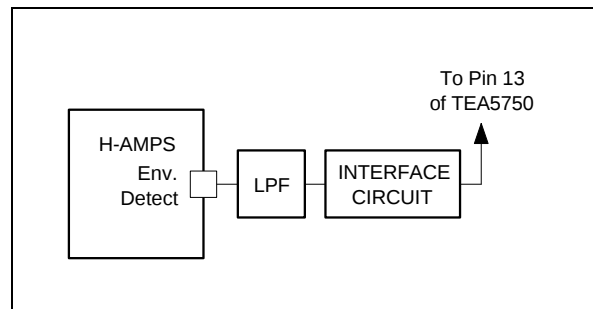
$$V_{\text{OUT}} \cong K [V_{13}] \times I_{\text{IN}}$$

$$V_{\text{OUT}} = V_3 \text{ and } I_{\text{IN}} = I_{11}$$

Then it is possible to adjust the gain of the input stage with the envelope detection signal (very often provided by the H-Amps) (see Figure 32).

A very low pass filter is normally requested in the interface circuit in order to avoid frame frequency modulation, time constant of the filter is in the range of 1s.

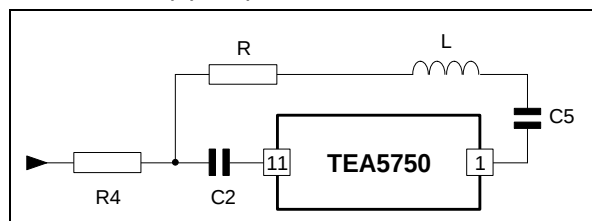
**Figure 32 :** Adapting the Input Stage Gain versus Playback Signal Amplitude



#### V.4.b - Video Bandwidth Correcting Filter

In the typical application, C5 is directly connected to the permanent correcting filter (L3, R9, C9) (see chapter V.1.f). It may happen that the correction requested cannot be easily realized with this typical solution. In this case it is possible to use a RLC<sub>5</sub> filter connected to the filter (Figure 33). With this configuration the correction becomes independent from the characteristics of the permanent correcting filter.

**Figure 33 :** Video Bandwidth Correction Filter (option)



#### V.5 - Using the TEA5750 without the Error Detector

This type of application is no longer typical, but can be useful in the following case :

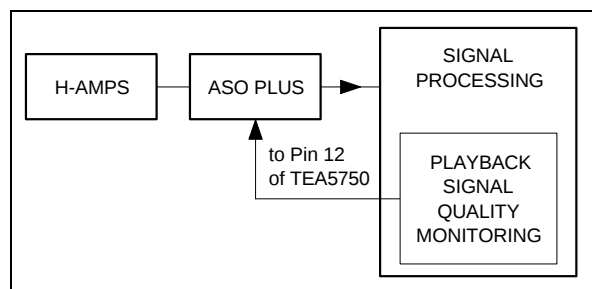
- The VTR system already features a function which monitors the quality of playback signals.
- There is a need to change the picture sharpness versus the quality of the playback signal.
- To keep a high immunity to tearing effects (black fishes).

For this type of application, the TEA5750 offers a simple and smart solution. By driving the voltage at Pin 12, it is possible to easily control the video bandwidth while keeping a high immunity to tearing effect, without degrading S/N and inducing parasitic group delay (see Figure 34).

In this case, the error detector of the TEA5750 must have the lowest sensitivity as possible. To do so :

- Pin 4 must be connected to V<sub>CC</sub>
- Pin 2 must be grounded.

**Figure 34 :** Architecture with External Playback Signal Quality Monitoring



#### V.6 - ASO Plus Implementation : Problems and Solutions

This chapter does not claim to be comprehensive. This part only claims to describe four common problems with their solutions.

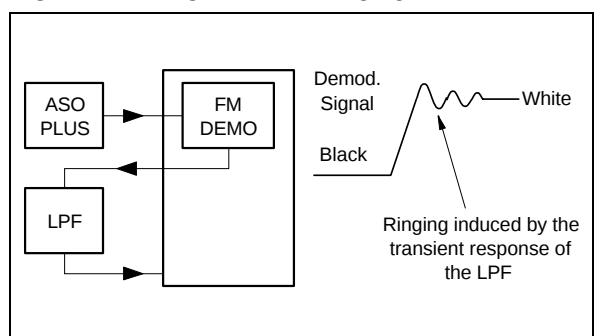
##### V.6.a - Ringing Effect after Luma Transients

Because of the wide video bandwidth provided by the ASO plus, some parasitic effects of the luma channel may be displayed. For instance the transient response of the low pass filter used in the FM demodulation; in some applications the transient response of this filter generates signal components in the range of 3 to 3.2MHz (inside the maximum bandwidth achievable with the ASO plus) (see Figure 35).

Solutions :

- Either the user wants to keep a very wide bandwidth, in such a case, the low pass filter transients characteristics have to be improved.
- Or to cut the video bandwidth with external filter so that the attenuation is high enough above 3MHz.

**Figure 35 :** Origine of the Ringing Effect



##### V.6.b - Unstable Picture Sharpness

This effect may be described as following : the picture sharpness easily changes versus the time and tape quality.

This effect likely happens when the error detector is adjusted in a too sensitive way ; so that small changes in the quality of the FM playback signal induces variations of the error voltage (Pin 12).

To correct this effect, the error detector sensitivity has to be adjusted in the way it has been primarily intended :

- V<sub>12</sub> < 0.6V for medium and good quality tape (normal)

To do so :

- V<sub>4</sub> is adjusted in the range of 3 to 3.5V,
- V<sub>2</sub> is adjusted in the range of 0 to 250mV (typ.).

### V.6.c - Pumping Effect and Long Settling Time

This effect can be described as following :

**Pumping effect :** The picture sharpness widely changes from soft to sharp (especially in still picture mode).

**Long settling time :** It takes a few seconds (1 to 5s) before the Picture sharpness reaches its final state. This specially occurs : at the beginning of a playback sequence occurring after stop conditions or after a fast search sequence.

Root cause of the effect is :

In the typical application,  $V_{12}$  voltage can have a large swing : 0 to 5V, and the time constant  $C_1R_3$  is large ( $\cong 1s$ ) ; the combined effect of those parameters induce slow and large changes of the phase shift circuits.

Solution :

When such an effect is not acceptable for the user. It is possible to greatly limit it by clamping the voltage at Pin 12 (see Figures 36 and 37). It is usually recommended to clamp  $V_{12}$  in the range of 1.6 to 2V. This value is high enough to control the bandwidth (enough control of the internal clamping diodes) and to limit the time constant so that it is no

longer noticeable.

### V.6.d. High Influence of the Playback Level on the Video Bandwidth

Description of the effect :

When the playback level widely changes (case of signal delivered by the non-gain controlled output of the head amplifier part) the bandwidth of the demodulated signal may be influenced : low playback level induces low bandwidth, high playback level induces wide bandwidth and some peaking in the range 2MHz to 2.5MHz.

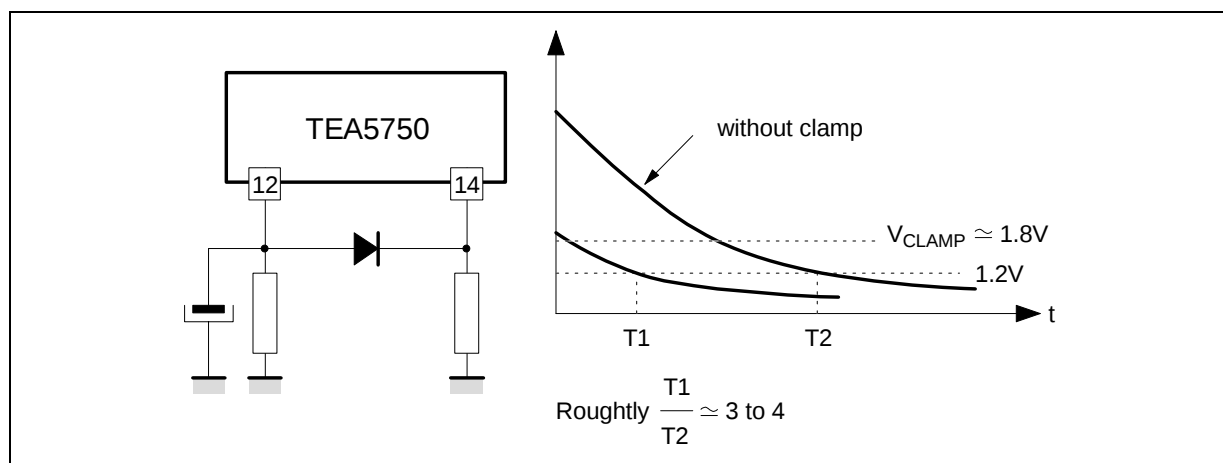
Origin of the effect :

In the typical application the permanent correcting filter  $L_3R_9C_9$  is directly connected to the ASO plus main filter  $L_2C_7$ , so the efficiency of the correction in a large extent depends on the amount of the phase shift (so depends on the playback signal amplitude).

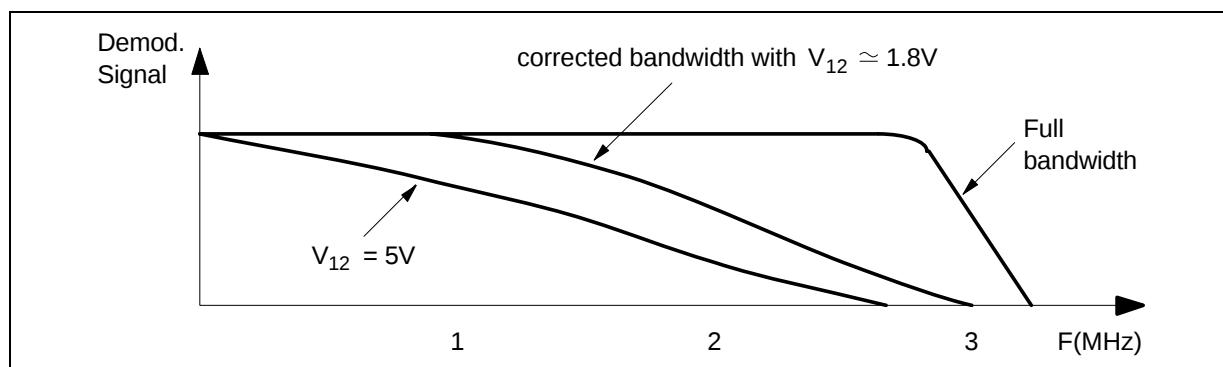
Solution :

Since the location of the permanent correcting filter is not critical, the above described effect can be greatly attenuated by moving  $L_3R_9C_9$  filter. Figure 38 gives an example of solution.

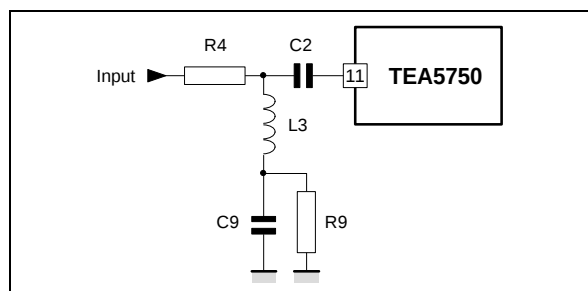
**Figure 36 :** Time Constant induced in the error signal. Effect of clamping.



**Figure 37 :** Excessive Sharpness Variation with  $V_{12} = 5V$



**Figure 38 :** Permanent correcting filter in the input section for a better rejection of the playback influence



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## VI - COMMENTS AND CONCLUSION

The ASO plus is a new function, and then a lot of detailed explanations have been given in this note, but in practice, the ASO plus function is quite easy to implement.

All the examples given in this note are relevant to VHS PAL applications, but obviously can be extended to NTSC ones and to S-VHS applications where wide bandwidth with high immunity to tearing effects is even more attractive.

## VII - REFERENCES

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