APPLICATION NOTE

Vertical power booster TDA4863AJ/TDA4863J

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Author(s):

J. Moors
Philips Semiconductors Systems Laboratory Eindhoven,
The Netherlands

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Summary

This report describes the application of the TDA4863AJ / TDA4863J vertical power boosters in a monitor chassis. These boosters can be used for frame frequencies up to 200 Hz. The TDA4863J uses a separate flyback supply voltage, the TDA4863AJ has a supply voltage doubler.

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1. INTRODUCTION

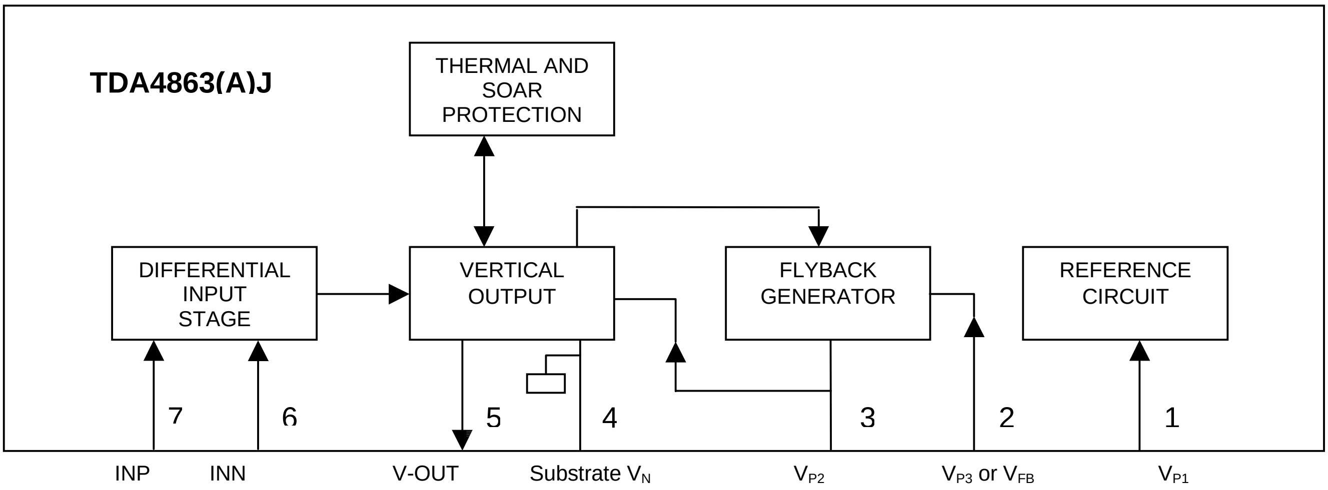
The TDA4863J / TDA4863AJ are successors of TDA4861 vertical booster for use in vertical deflection systems for frame frequencies up to 200 Hz. The TDA4863J needs a separate flyback supply voltage with the advantage that the supply voltages are independently adjustable to optimise power consumption and flyback time. For the TDA4863AJ the flyback supply voltage will be generated internally by doubling the supply voltage and therefore a separate flyback supply voltage is not needed. Both circuits provide differential input stages and fit well with the TDA485X / TDA484X monitor deflection controller family.

1.1 Features

- Power amplifier with differential voltage inputs,
- Powerless vertical shift (DC coupling),
- Output current up to 3 A (peak-to-peak value),
- Output stage with thermal and SOAR protection,
- Deflection frequency up to 200 Hz,
- Excellent linearity,
- Smaller package,
- Reduced pin count.

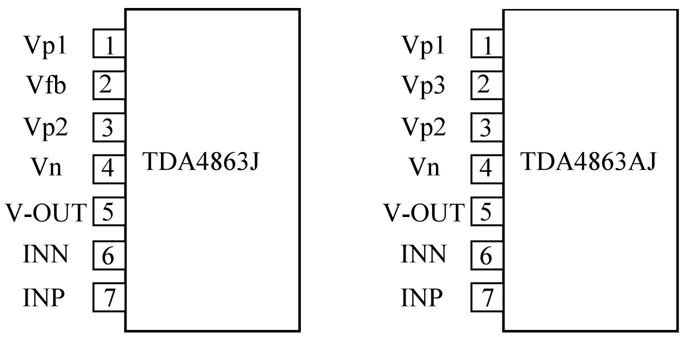
2. GENERAL DESCRIPTION

Block diagram



2.1 Pinning

symbol	pin		Description
	TDA4863J	TDA4863AJ	
V_{P1}	1	1	Positive supply voltage
V_{FB}	2	-	Flyback supply voltage
V_{P3}	-	2	Flyback generator output
V_{P2}	3	3	Supply voltage for vertical output
Substrate V_N	4	4	Substrate / negative supply voltage
V-OUT	5	5	Vertical output
INN	6	6	Inverting input of differential input stage
INP	7	7	Non-inverting input of differential input stage



2.2 Quick reference data

Measurements referenced to substrate Vn (pin 4).

symbol	parameter	conditions	Min.	Typ.	Max.	Unit
Vp1	Supply voltage (pin 1)		9	-	30	V
Vp2	Supply voltage (pin 3)		V_{p1}-1	-	60	V
Vfb	Flyback supply voltage (pin 2)	TDA4863J	V_{p1}-1	-	60	V
Vp3	Flyback generator output voltage (pin 2)	TDA4863AJ; I_{defl}=-1.5A	0	-	V_{p1}+2.2	V
Ip1	Supply current (pin 1)	During scan	-	-	10	mA
Ip2	Quiescent supply current (pin 3)	No load; no signal	-	9	-	mA
Vinp	Input voltage (pin 7)		1.6	-	V_{p1}-0.5	V
Vinn	Input voltage (pin 6)		1.6	-	V_{p1}-0.5	V
$I_{5(p-p)}$	Deflection output current (pin 5) (peak-to-peak value)		-	-	3	A
Tamb	Operating ambient temperature		-20	-	+75	°C

2.3 General device description

The following blocks are explained in this chapter:

- -the vertical amplifier,
- -the protection circuits,
- -the flyback generator,
- -the damping resistor.

2.3.1 Vertical amplifier

The input signal (e.g. coming from the deflection controller family TDA485X / TDA484X) is connected to the voltage inputs of the TDA4863(A)J. In the case of current outputs the current to voltage conversion has to be done by external resistors (R_{S1} and R_{S2}). The output current is fed back to the inverting input pin 6 (see Figure 2-1).
When a single-ended voltage sawtooth generator is used, the application is as in Figure 2-2.
The minimum input voltage on pins 6 and 7 is 1.6 V, while the maximum input voltage is V_{P1}-0.5 V (both referenced to substrate Vn (pin 4)).

The vertical output stage is a quasi-complementary class-B amplifier (half bridge concept) with a high linearity.
The maximum peak output current is 1.5 A, the gain of the amplifier can be adjusted with R_{S1}, R_{S2} and R_1.

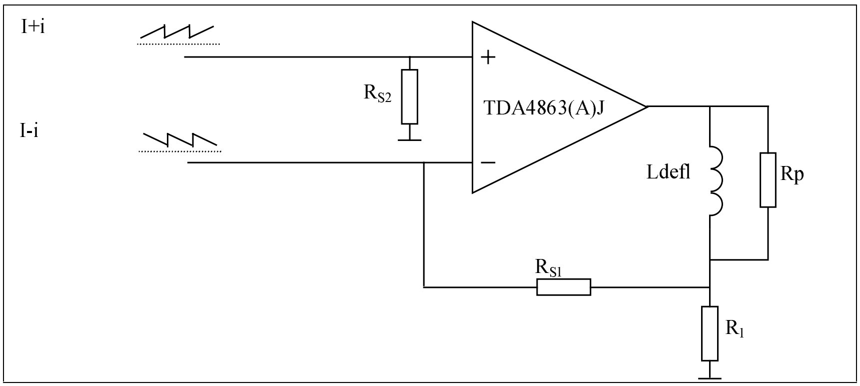


Figure 2-1: current to voltage conversion in case of differential input currents

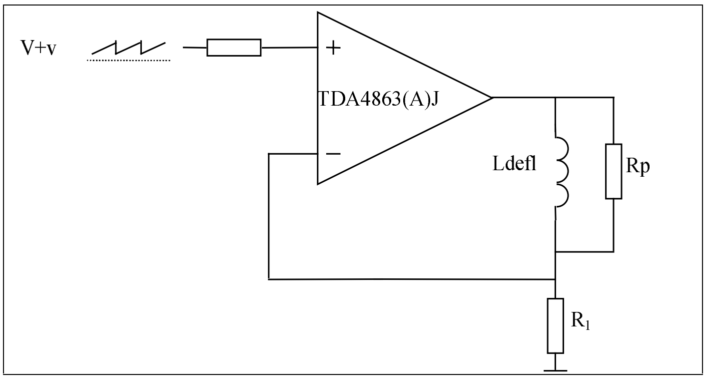


Figure 2-2: application with single-ended voltage input

2.3.2 Protection circuits

The output stage contains SOAR and thermal protection. The thermal protection will be active if the junction temperature (Tj) exceeds 160 °C. The output current on pin 5 will be until Tj has reached the thermal protection switch-off temperature (<150 °C).
The SOAR limits the maximum power dissipation in the output transistors and protects for excessive output currents.

2.3.3 Flyback generator

The flyback generator supplies the output stage during flyback. The TDA4863J is used with a separate flyback supply to achieve a short flyback time with minimised power dissipation. The TDA4863AJ needs a capacitor C_F between pins 2 and 3 which is charged to $V_{P1} – V_N$ during scan, using the external diode D_1 and the resistor R_5 (see Figure 3-3). The positive electrode of the capacitor C_F is connected to the positive supply during flyback, so the supply voltage of the output stage is then $V_{P1} + V_{P1} - V_N$.

2.3.4 Damping resistor

In parallel with the deflection coil a damping resistor is needed. This resistor has to be tuned, so that no under- or overshoot will occur after flyback. The tuning of this resistor will be treated in more detail in paragraph 3.4.

3. APPLICATION INFORMATION

3.1 Simplified pinning description

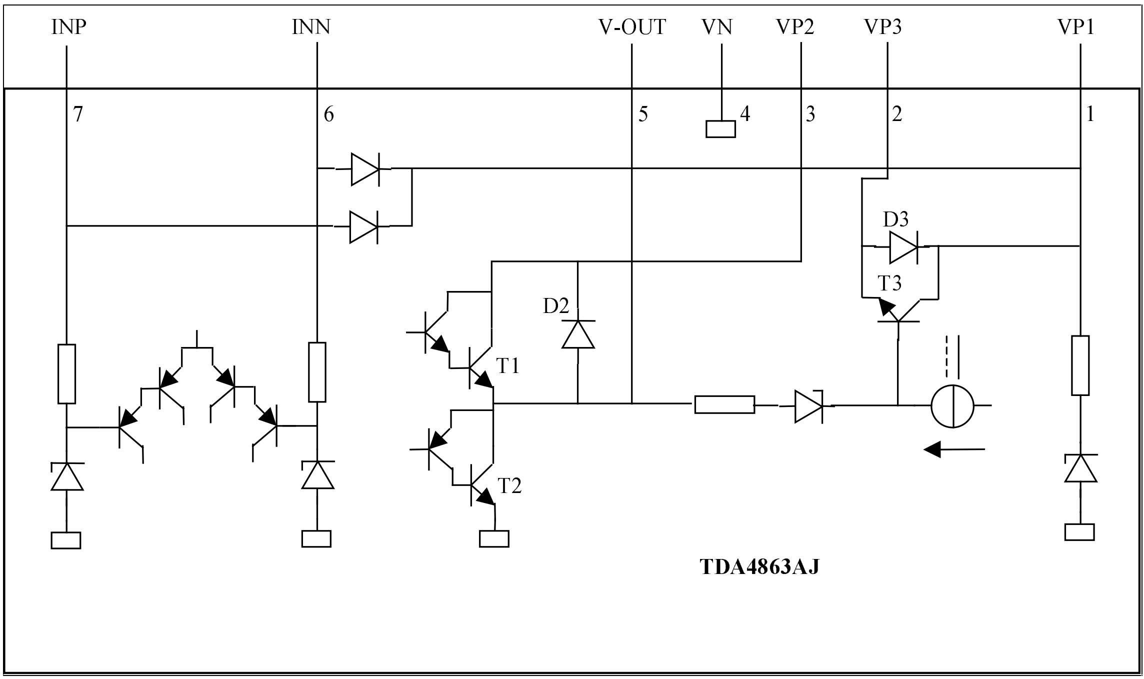


Figure 3-1: internal circuit configuration of TDA4863AJ

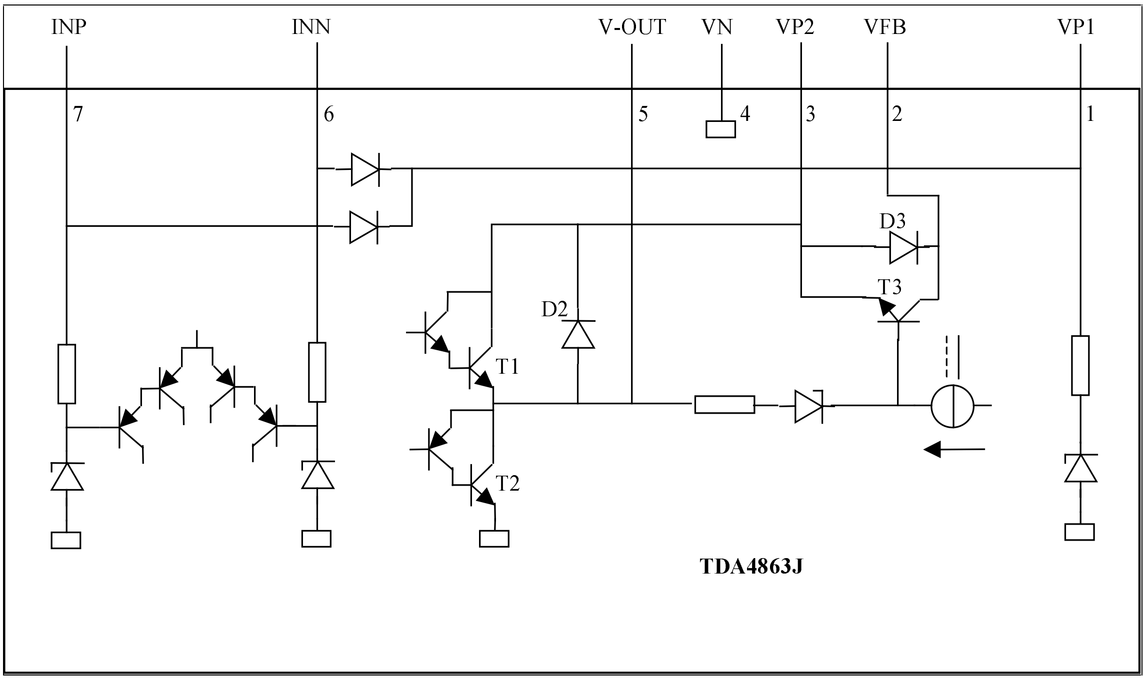


Figure 3-2: internal circuit configuration of TDA4863J

3.2 General application

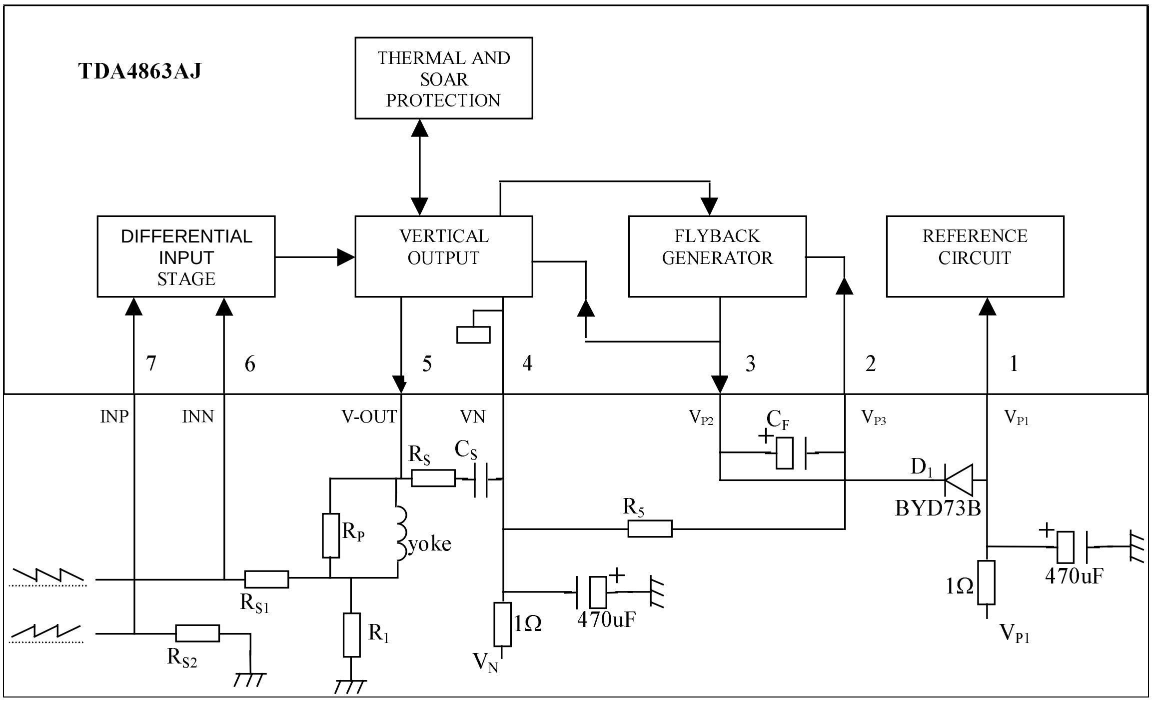


Figure 3-3: application circuit with TDA4863AJ

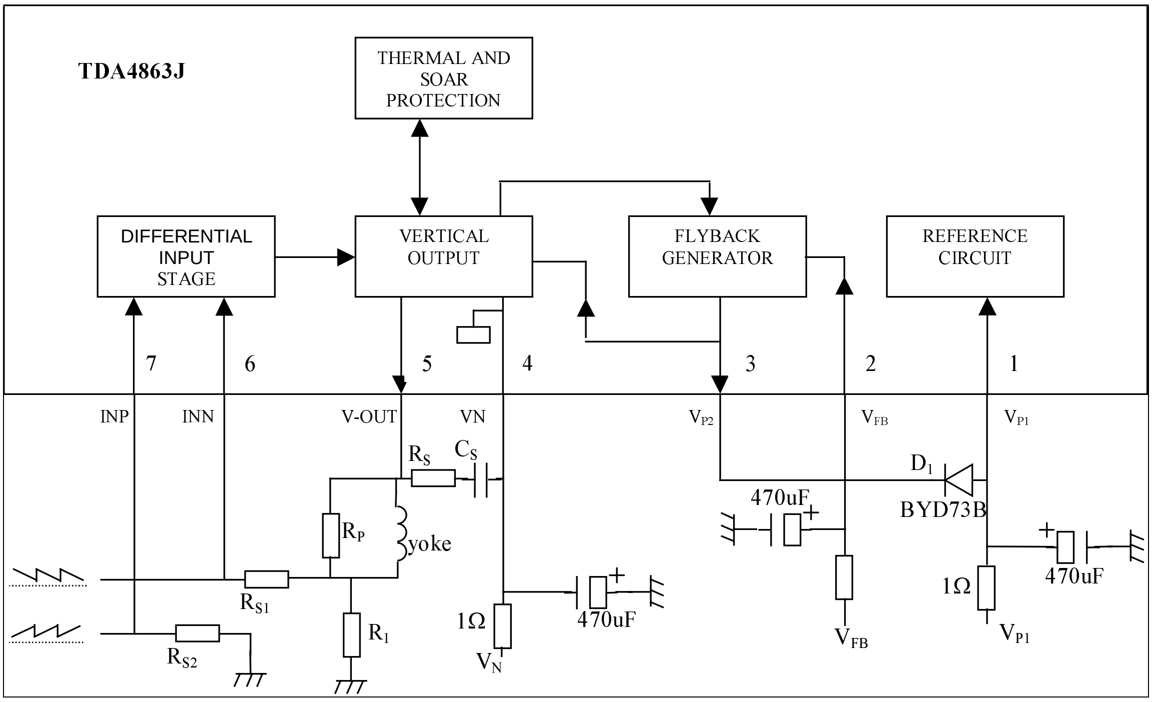


Figure 3-4: application circuit with TDA4863J

3.3 Device description per functional block / external pin.

3.3.1 Supply voltage calculation

Pin 1 and 4:
To calculate the minimum required supply voltage, certain values from the application have to be known. These values are the maximum required deflection current, the coil impedance and the measuring resistor. The coil resistance should be multiplied with a correction factor of 1.2 for hot conditions.

The IC's internal voltage losses must be taken into account. These losses are given in Table 3-1 and Table 3-2:

Table 3-1: internal IC supply voltage losses

Symbol	Parameter	Conditions	Min.	Typ.	Max.	unit
$V_{5,4\ sat}$	Output saturation voltage to Vn	I_5= 1.5 A	-	1.7	-	V
		I_5= 1 A	-	1.5	1.7	
$V_{5,3\ sat}$	Output saturation voltage to Vp2	I_5= 1.5 A	-	2.3	-	V
		I_5= 1 A	2.3	2.0	-	V

The voltage drop across the coil consists of an inductive part and a resistive part. In the first part of the scan the inductive part subtracts from the resistive part, while in the second part of the scan the inductive part adds to the resistive part.

So the voltage needed for Vp1 is:

$$V_{P1} = I_{defl(peak)} \times (1.2 \times R_{coil} + R_1) + V_{5,3sat} - 2 \times I_{defl(peak)} \times L_{coil} \times f_{\min} + V_{D1}$$

The current during the first part of the scan flows from Vp1 through diode D_1 into Vp2, through T_1 into the deflection coil and measuring resistor R_1 (see Figure 3-6 and Figure 3-7).

During the second part of the scan the voltage needed for Vn is:

$$V_N = -\left(I_{defl(peak)} \times (1.2 \times R_{coil} + R_1) + V_{5,4sat} + 2 \times I_{defl(peak)} \times L_{coil} \times f_{\max}\right)$$

In this part the current flows from earth through R_1 and the deflection coil into T_2, and back to earth via V_N (see Figure 3-6 and Figure 3-7).

where $I_{defl(peak)}$ = coil peak current
R_{coil} = coil resistance (cold condition)
f_{max} = maximum vertical (=frame) frequency
f_{min} = minimum vertical (=frame) frequency
$V_{5,3\ sat}$ = internal output saturation voltage to Vp2
$V_{5,4\ sat}$ = internal output saturation voltage to substrate ground
V_{D1} = voltage drop across diode D_1

In practise the supply voltages should be chosen somewhat higher to minimise distortion at the top and bottom of the screen.

3.3.2 Flyback supply voltage calculation

Pin 2/3:

For the calculation of the flyback supply voltage the required flyback time is needed.
The flyback voltage is approximately constant during the whole flyback time, the calculation of this voltage is:

$V_{fb} = \frac{I_{defl(peak-peak)} * (1.2 \times R_{coil} + R_1)}{1 - e^{\frac{-t_{fb} * (1.2 \times R_{coil} + R_1)}{L_{coil}}}}$. A simplified approximation is $V_{fb} = \frac{I_{defl(peak-peak)} * L_{coil}}{t_{fb}}$

Table 3-2 : internal IC flyback voltage losses

Symbol	Parameter	Conditions	Min.	Typ.	Max.	unit
$V_{2,3}$ (TDA4863J)	Voltage drop during flyback					
	Reverse	I_5=-1.5 A	-	-2.2	-	V
		I_5=-1.0 A	-	-1.5	-	V
	Forward	I_5= 1.5 A	-	3.2	-	V
		I_5= 1.0 A	-	2.2	-	V
$V_{1,2}$ (TDA4863AJ)	Voltage drop during flyback					
	Reverse	I_5=-1.5A	-	-2.2	-	V
		I_5= 1.0 A	-	-1.5	-	V
	Forward	I_5= 1.5A	-	3.2	-	V
		I_5= 1.0 A	-	2.2	-	V

In practise the flyback voltage is not constant during the flyback time.
In the case of the TDA4863J the current flows from R_1 and the coil via D_2 and D_3 into V_{FB} during the first part of the flyback, so the voltage across the coil is two diode drops higher than V_{FB} (see reverse voltage drop during flyback in Table 3-2). When the coil current passes through zero, the current reverses direction and flows through T_3 and T_1, so the voltage is somewhat lower than V_{FB} (see forward voltage drop during flyback in Table 3-2).
In the case of the TDA4863AJ the current flows from R_1 and the coil via D_2 into V_{P2} during the first part of the flyback, so the voltage is about one diode drop higher than V_{P2} (see reverse voltage drop during flyback in Table 3-2). When the coil current passes through zero, the current flows from V_{P2} through T_1 (see forward voltage drop during flyback in Table 3-2).
However, the approximation with the constant voltage is quite good.

3.3.3 Input circuit

Pin 6 and 7:

The input circuit of the TDA4863(A)J is a differential amplifier with voltage inputs. The output current signals of e.g. the TDA485X / TDA484X deflection controller family are as in Figure 3-5.

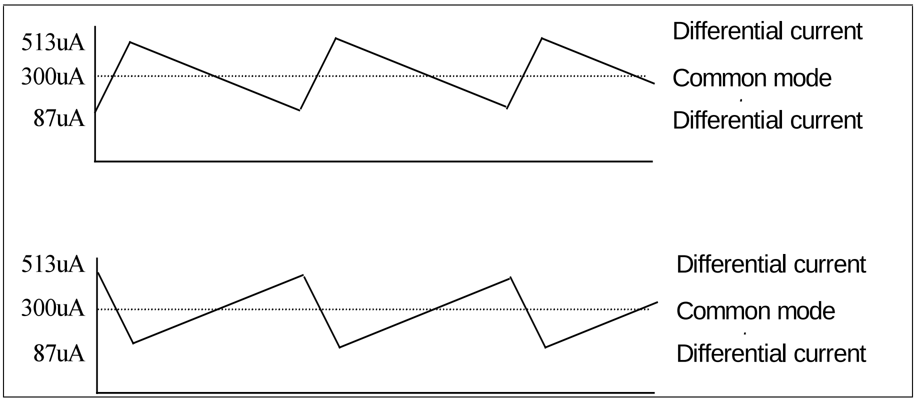


Figure 3-5: output currents from TDA485X

The common mode current is about 300 uA, while the differential mode peak-to-peak output current is about 850 uA. The output voltage of the TDA485X deflection controller family must be between 0 and 4.2 Volts, while the input voltages of the TDA4863(A)J must be between V_N+1.6 and V_{p1}-1 Volts. This means that the voltage must be between 0 and 4.2 Volts.
The maximum output current (with VGA350 vertical overscan) from the TDA485X deflection controller family is 660 uA. At this current the voltage must remain below 4.2 Volts, so R_{S1} and R_{S2} must be smaller than 4.2 V/ 660 uA= 6360 Ω. A typical value is 1800 Ω. With the minimum current of 87 uA the voltage will remain well above the 0 Volts.
Now the value of the conversion resistors R_{S1} and R_{S2} is known, R1 can be calculated:

$$I_{defl(peak-peak)} = \frac{I_{diff\_in(peak-peak)} * R_{S1,2}}{R_1}$$

so $R_1 = \dfrac{I_{diff\_in(peak-peak)} * R_{S1,2}}{I_{defl(peak-peak)}}$

If the peak-peak deflection current is 1.5 A, then the value of R_1 should be 1 Ohm.
The rms current through this resistor is:

$$I_{RMS} = \frac{1}{3} * \sqrt{3} * I_{defl(peak)} = \frac{1}{3} * \sqrt{3} * 0.75 = 433mA$$

This means that the power dissipation in R_1 is: $I_{RMS}{}^2 * R_1 = 188mW$

If we make R_{S1} and R_{S2} bigger, also the power dissipation in R_1 becomes bigger, so it is better to keep them like this.
It is also possible to work the other way around. For example if a certain supply voltage is available, then by subtracting the saturation voltage and voltage across the coil at the peak deflection current, the maximum voltage across R_1 is what is left. So the value of R_1 is this remaining voltage divided by the peak deflection current. When R_1 is known, resistors $R_{S1,2}$ can be calculated by the above formulas.

3.3.4 Vertical output stage

The Philips TDA4863(A)J vertical output stage uses a half bridge concept, which is very suitable for DC coupling of the vertical deflection coil. The deflection coil is connected between pin 5 and resistor R_1, which is connected to ground. The resistor R_1 converts the current through the coil into a voltage, which is fed back to the inverting input of the amplifier via resistor R_{S1}.

The output stage consists of transistors T_1 and T_2. During the scan T_1 is connected to the supply voltage V_{p2}, while T_2 is connected to the negative supply voltage V_N. T_1 delivers the positive coil current during the first part of the scan, while T_2 sinks the negative coil current during the second part of the scan (see Figure 3-6 and Figure 3-7).

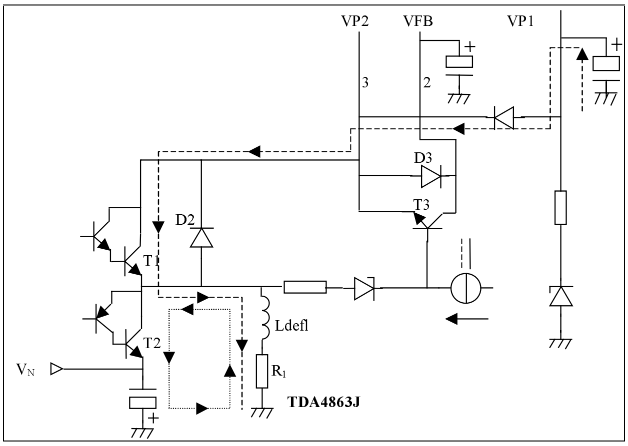


Figure 3-6: scan current flow in TDA4863J

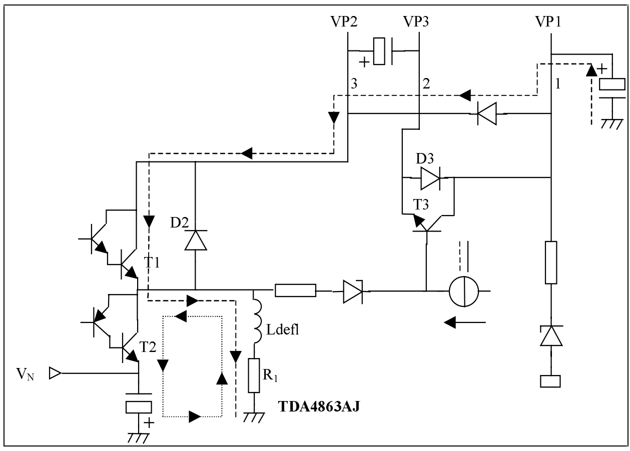


Figure 3-7: scan current flow in TDA4863AJ

In Figure 3-8 real measurement results are given.

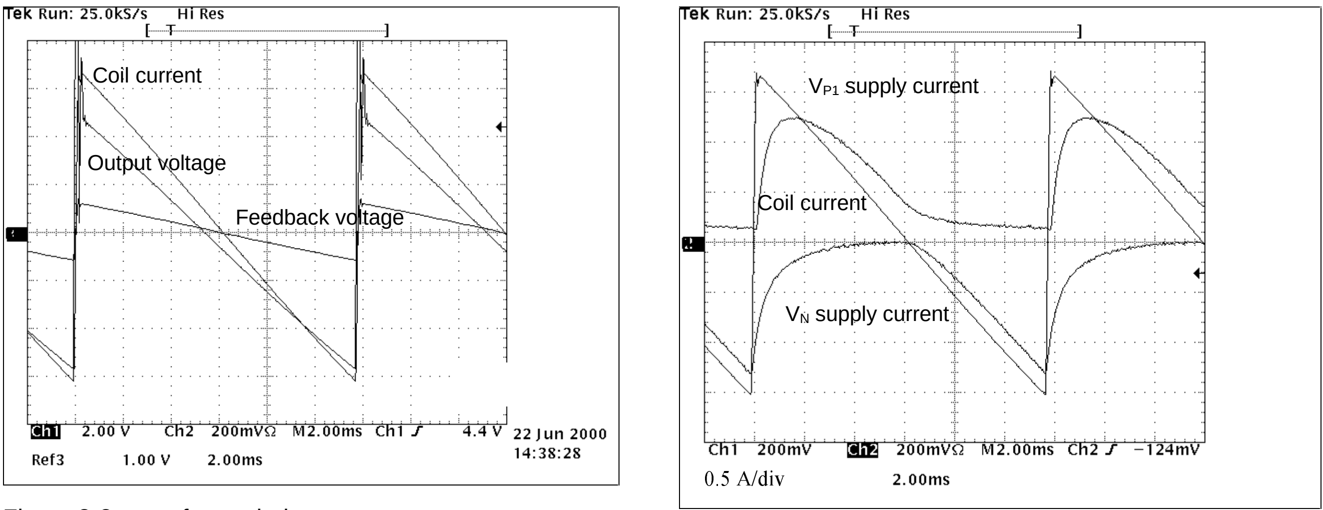


Figure 3-8: waveforms during scan

3.3.5 Flyback switch

During flyback the input currents / voltages rapidly change polarity. The output of the amplifier will try to follow this quick change, but its output voltage range is limited to V_{FB}. This limits the maximum di/dt in the coil, which in turn can be insufficient to follow the input signal. As a result of this the amplifier comes into an open-loop condition. The normal supply voltage is rather low, therefor it will take quite a long time for the current to reverse direction and follow the input again. With a higher supply voltage the flyback time will certainly decrease. That is why we apply a higher flyback supply voltage. In the TDA4863J this is done by adding an external flyback supply voltage, in the TDA4863AJ the normal positive supply voltage is doubled. But only during the flyback these voltages are applied to the coil, otherwise the power dissipation would increase too much.

At the start of flyback the input signal reverses polarity very rapidly. The circuit tries to follow this and turns off transistor T_2. However, the coil current keeps flowing in the negative direction, but now through diodes D_2 and D_3. The voltage at V_{P2} becomes higher than V_{P1}, so the external diode becomes non-conducting. In the TDA4863J the current flows via D_2 and D_3 into the external coupling capacitor at V_{FB} (see Figure 3-9). The voltage across the coil becomes two diode drops higher than V_{FB} (reverse voltage drop during flyback in Table 3-2). In the TDA4863AJ the current flows via D_2 through the external capacitor C_F (which was charged to V_{P1}-V_N during the scan) via D_3 into the decoupling capacitor at V_{P1}. So the voltage during this part of the flyback is $2 * V_{P1}$-V_N (V_{Cf}) plus two diode drops (reverse voltage drop during flyback in Table 3-2), see Figure 3-9.

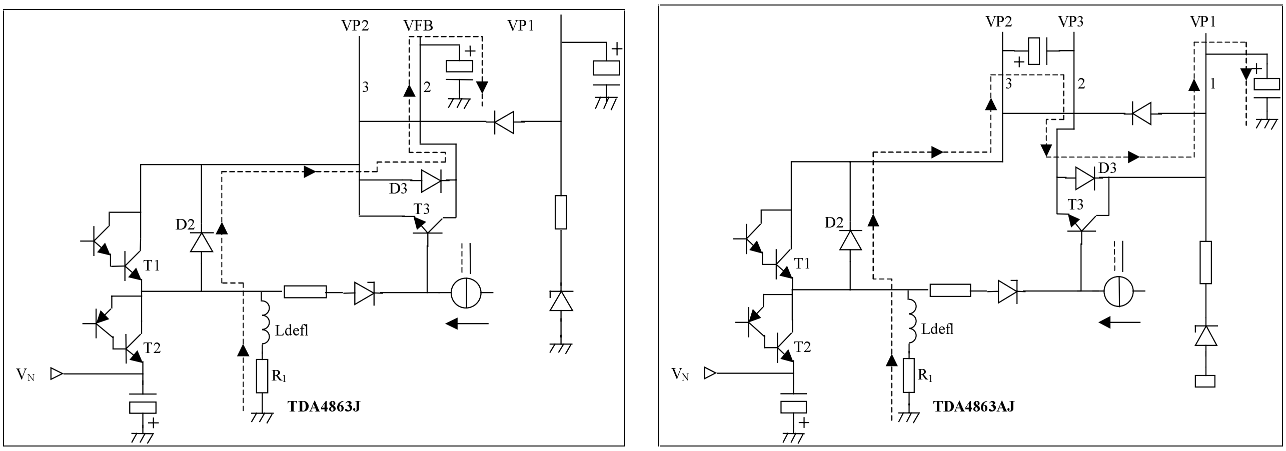


Figure 3-9: current flow first part of flyback TDA4863J/ TDA4863AJ

When the coil current passes zero transistors T_3 is “opened” by the amplifier. Now the current starts flowing in the positive direction, so diodes D_2 and D_3 become non-conducting. The voltage at V_{P2} is still higher than V_{P1}, so the external diode is still non-conducting. In the TDA4863J the current flows from V_{FB} via T_3 and T_1 through the deflection coil and resistor R_1. The voltage across the coil now becomes two $V_{CE(sat)}$ lower than V_{FB} (forward voltage drop during flyback in Table 3-1). In the TDA4863AJ the current flows from V_{P1} via the external transistor T_3, capacitor C_F and transistors T_1 through the deflection coil and resistor R_1. So the voltage during this part of the flyback is $2{*}V_{P1}\text{-}V_N$ (V_{CF}) minus two $V_{CE(sat)}$ (forward voltage drop during flyback in Table 3-1), see Figure 3-10. When the coil current reaches the input-related value, the loop is closed again and normal scan continues.

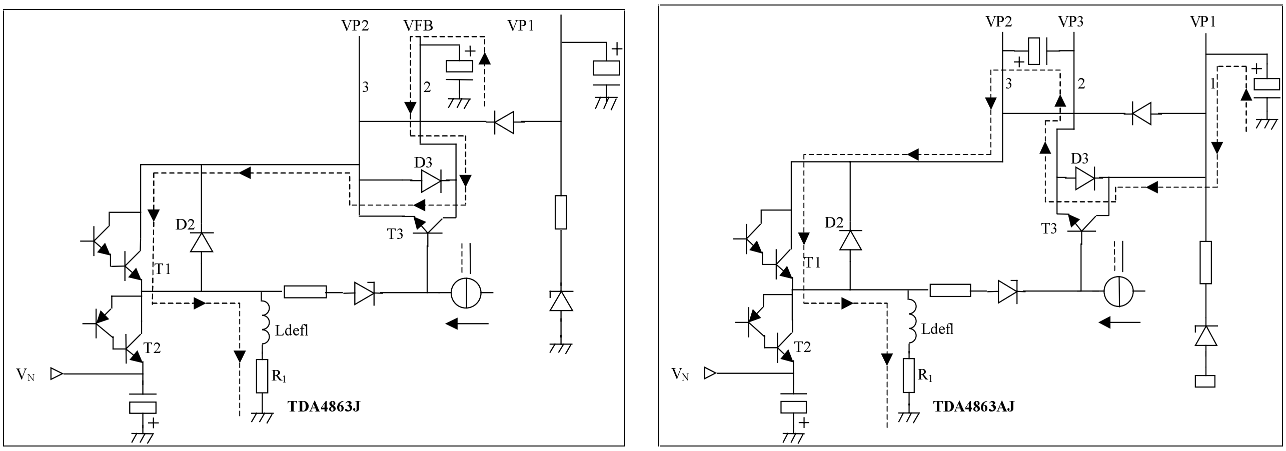


Figure 3-10: current flow second part of flyback TDA4863J / TDA4863AJ

In Figure 3-11 measurements results are shown.

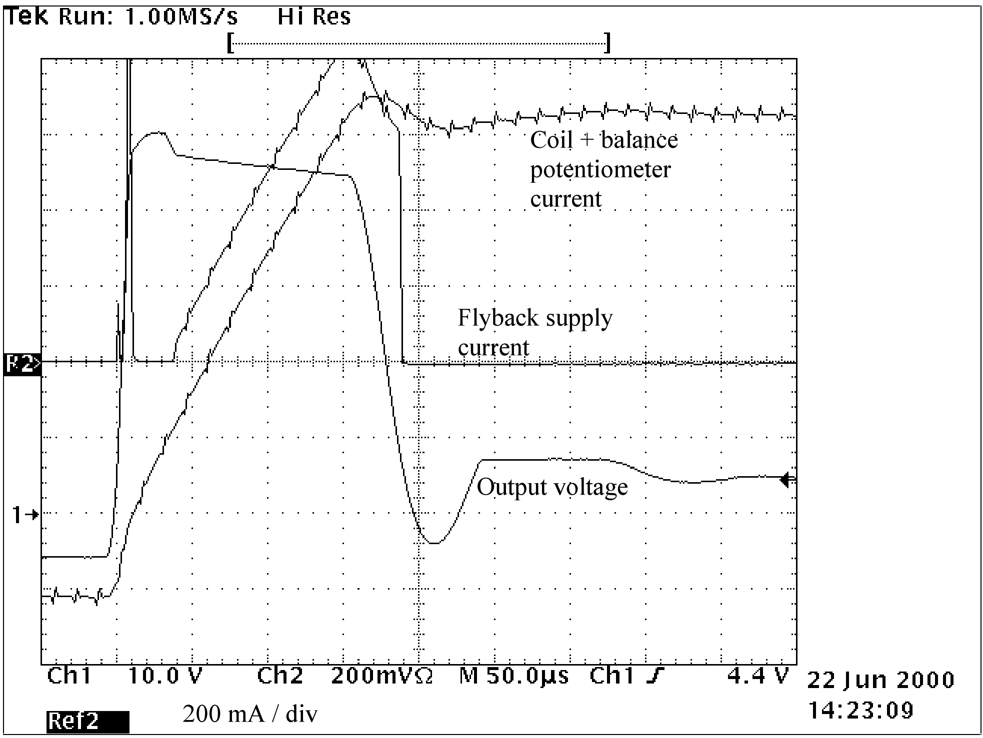


Figure 3-11: waveforms during flyback

3.3.6 Power dissipation in the output stage

The power dissipation in the output stage including the deflection coil can be calculated with the following method:

- the current through the coil and measuring resistor as a function of time during scan is given by

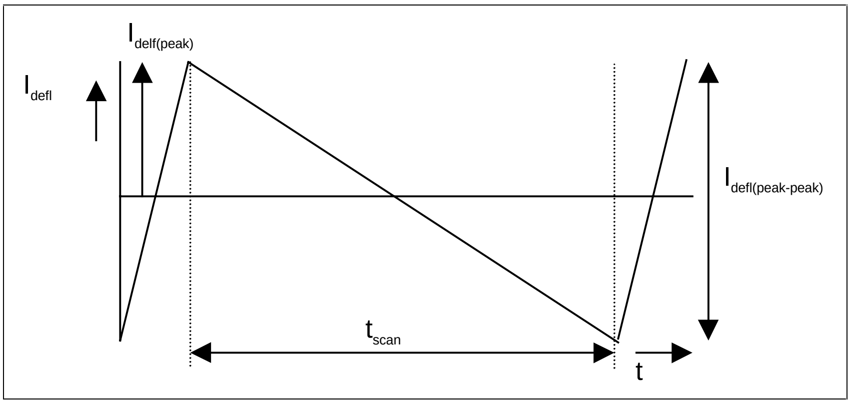


Figure 3-12: deflection current

$$I_{defl}(t) = I_{defl(peak)} - 2 * I_{defl(peak)} * \frac{t}{t_{scan}} = I_{defl(peak)} * \left(1 - 2 * \frac{t}{t_{scan}}\right)$$

and the root-mean-square value of this sawtooth coil current (during scan) is:

$$Irms_{defl} = \frac{1}{3} * \sqrt{3} * I_{defl(peak)}$$

The average power dissipation in the load during scan is:

$$P_{load} = Irms_{defl}{}^{2} * (1.2 \times R_{coil} + R_1)$$

If we assume that the deflection current is symmetrical around zero (no DC current), then the power distribution is equally divided between the positive (V_{P1}) and negative (V_N) supply. The current delivered by the positive supply is:

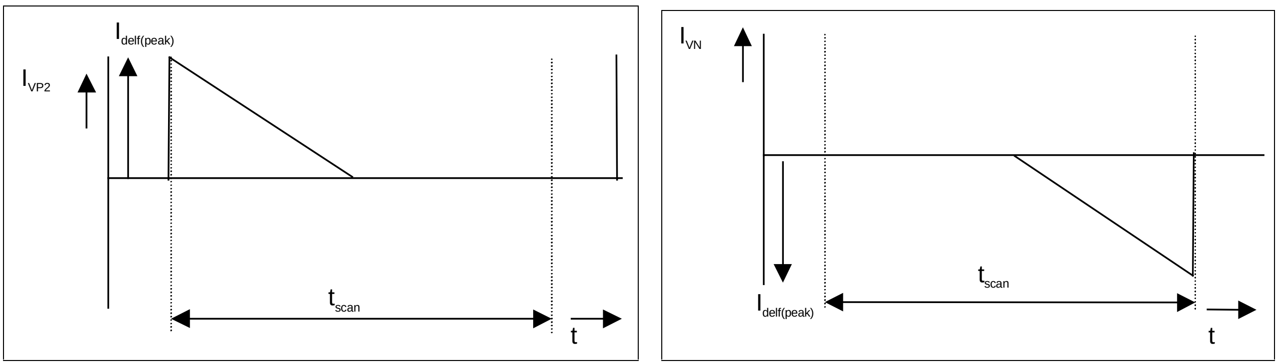


Figure 3-13: left:Vp2 supply current during scan; right:: Vn supply current during scan

$I_{VP2}(t) = I_{defl(peak)} * (1 - 2 * \frac{t}{t_{scan}})$ for $0 \le t \le 0.5 t_{scan}$

$I_{VP2}(t) = 0$ for $0.5\ t_{scan} \le t \le t_{scan}$

The average current delivered by the positive supply is then:

$$I_{VP2} = I_{defl(peak)} / 4$$

Because of the assumed symmetry the current delivered by the negative supply is the same. The voltage at V_{P2} is V_{P1}-U_{D1}, so the power delivered to the IC output transistors during the whole scan period is:

$$P_{tot(scan)} = (V_{P1} - V_{D1}) * I_{defl(peak)} / 4 - V_N * I_{defl(peak)} / 4$$

In the TDA4863J the current delivered by the flyback voltage is about 4 to 5 mA (depending on the system losses), so with a certain flyback supply voltage the power dissipation is:

$$P_{flyback} = I_{flb} * V_{flb}$$

Also the rest of the circuitry (e.g. input circuit) consumes some energy. The current flowing into pin 1 (V_{P1}) and coming out again at pin 4 (V_N) is about 10 mA, so the power dissipation in this part of the circuit is:

$$P_{qsct} = I_{qsct} * (V_{P1} - V_N)$$

This means that the total power delivered to the IC is:

$$P_{tot} = (V_{P1} - V_{D1}) \times \frac{I_{defl(peak)}}{4} - V_N \times \frac{I_{defl(peak)}}{4} + I_{flb} \times V_{flb} + I_{qsct} \times (V_{P1} - V_N)$$

The power delivered to the deflection was:

$$P_{load} = Irms_{defl}{}^2 * (1.2 \times R_{coil} + R_1) ,$$

so the power dissipation of the IC is:

$$P_{IC} = P_{tot} - P_{load}$$

3.3.7 External guard circuit

An external guard circuit can be build to prevent the picture tube from spot burn-in when vertical deflection is absent. The output generates a blanking signal.
In Figure 3-14 the circuit is drawn.

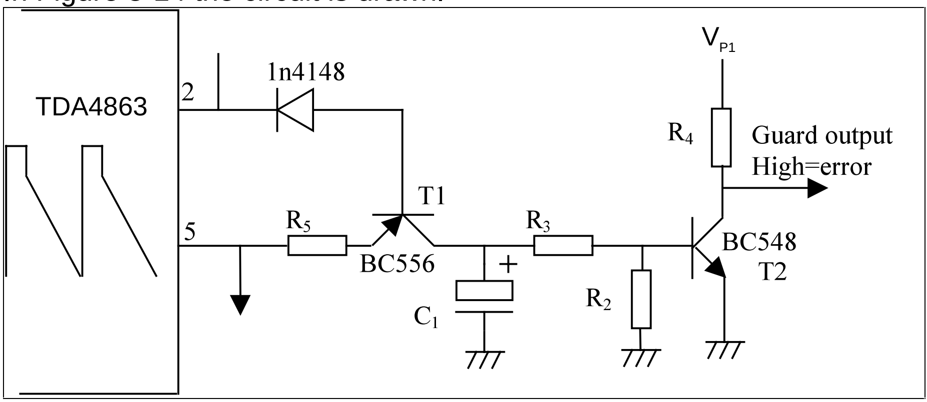


Figure 3-14: guard circuit TDA4863J

During normal operation in the first part of the flyback the voltage at pin 5 (output voltage) becomes higher than the flyback supply voltage at pin 2. During this time transistor T_1 and the diode are conducting, so the capacitor is charged to a value of about V_{fb}+"reverse voltage drop during flyback". Transistor T_2 is constantly conducting, so the guard output is low. When there is something wrong, for example one of the output transistors is broken, then the voltage at pin 5 does not become higher than pin 2 anymore. This means that transistor T_1 does not conduct, and the capacitor is discharged. So transistor T_2 becomes non-conducting and the guard output becomes high. Note: this guard output becomes high only in a fault-condition, and is not used for vertical blanking (the TDA485X / TDA484X deflection controller family already delivers a signal for vertical blanking: CLBL).

3.4 Dynamic behaviour of the amplifier

The open-loop frequency response of the vertical amplifier is like any other amplifier not flat over the entire frequency band. It has the following properties:

1 it has a certain DC-gain (A_0), which is about 18000 (85 dB),
2 it has an output resistance of about R_{out} of about 50 Ohm,
3 it has two dominant frequency poles at about 200 Hz and 200 kHz.
4 it will oscillate when driving pure inductive loads.

To prevent the amplifier from oscillating when driving an inductive load an additional RC combination (R_S;C_S) from the output to the negative supply voltage is needed. Without this RC-combination the amplifier will oscillate at a frequency of about 7MHz, causing the open-loop gain to drop also at low frequencies. R_S is fixed (5.6 Ω), while the value of C_S must be small enough, so that it does not disturb the normal functioning. This value has to be about 100nF. When C_S is too large the flyback time will increase. In Figure 3-15 and Figure 3-16 the frequency response as a function of the load impedance is given.

Open-loop frequency response of TDA4863(A)J:

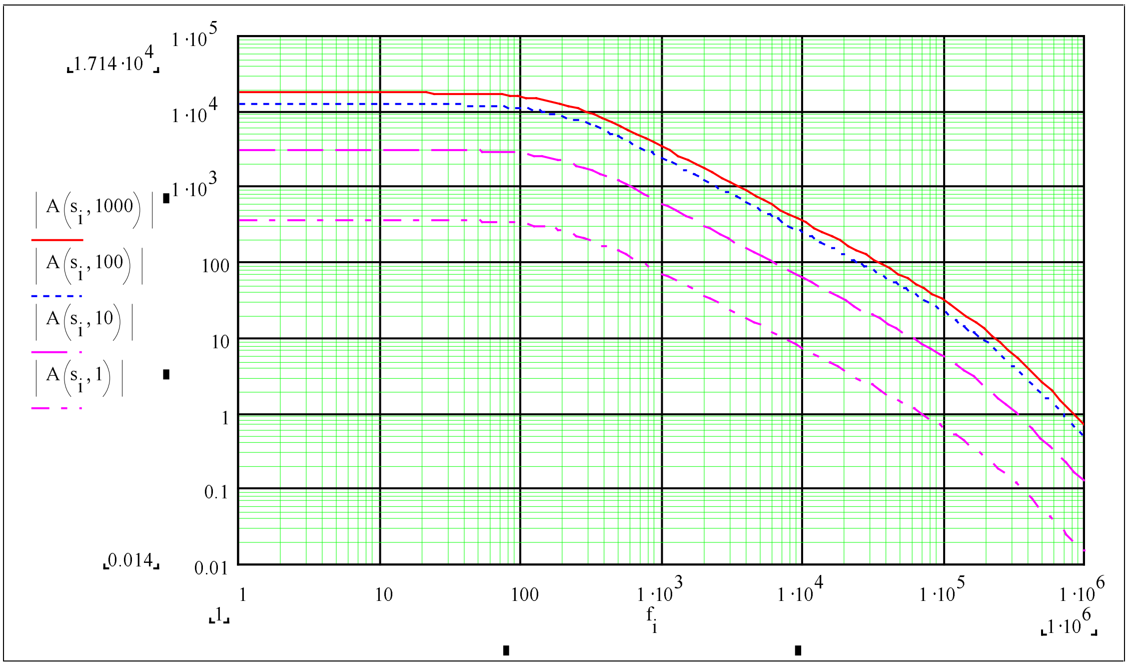


Figure 3-15: open-loop gain amplitude response of the TDA4863(A)J; Rl = 1, 10, 100 and 1000 Ohm

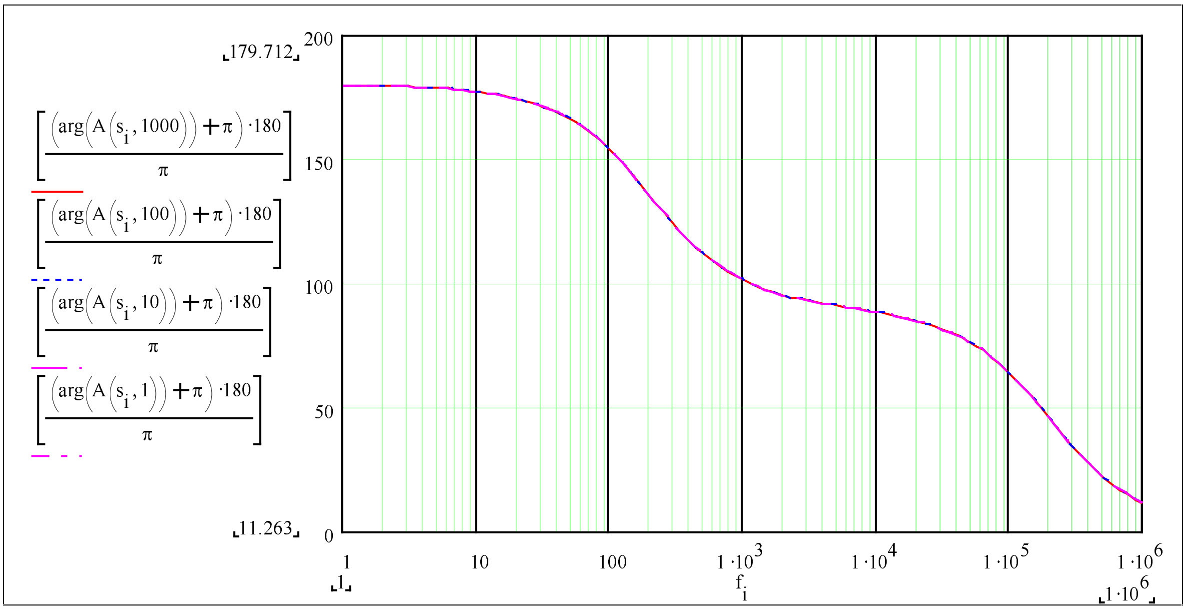


Figure 3-16: open-loop phase response of the TDA4863(A)J; Rl = 1, 10, 100 and 1000 Ohm

With the deflection coil and measuring resistor in series as a load, R_l is about 8 Ohms. In Figure 3-17 and Figure 3-18 the amplifier response is given for this condition, together with the deflection coil impedance, the voltage feedback factor and the total loop-gain of the whole system.

Loop gain stability of the amplifier system:

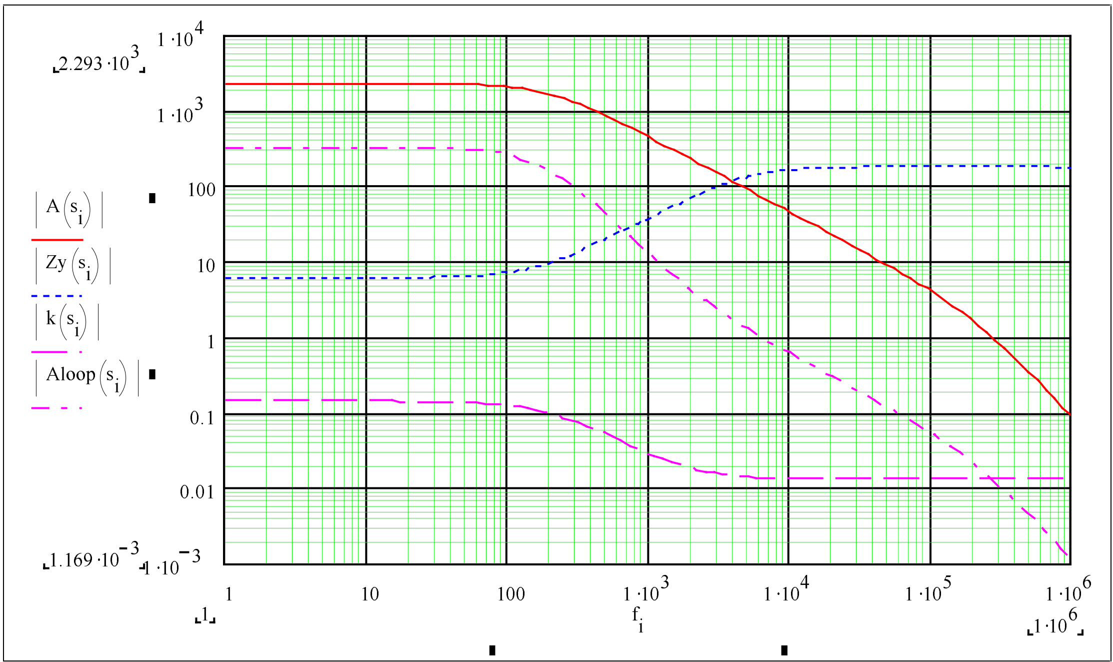


Figure 3-17: amplitude response of loop-gain of the amplifier system

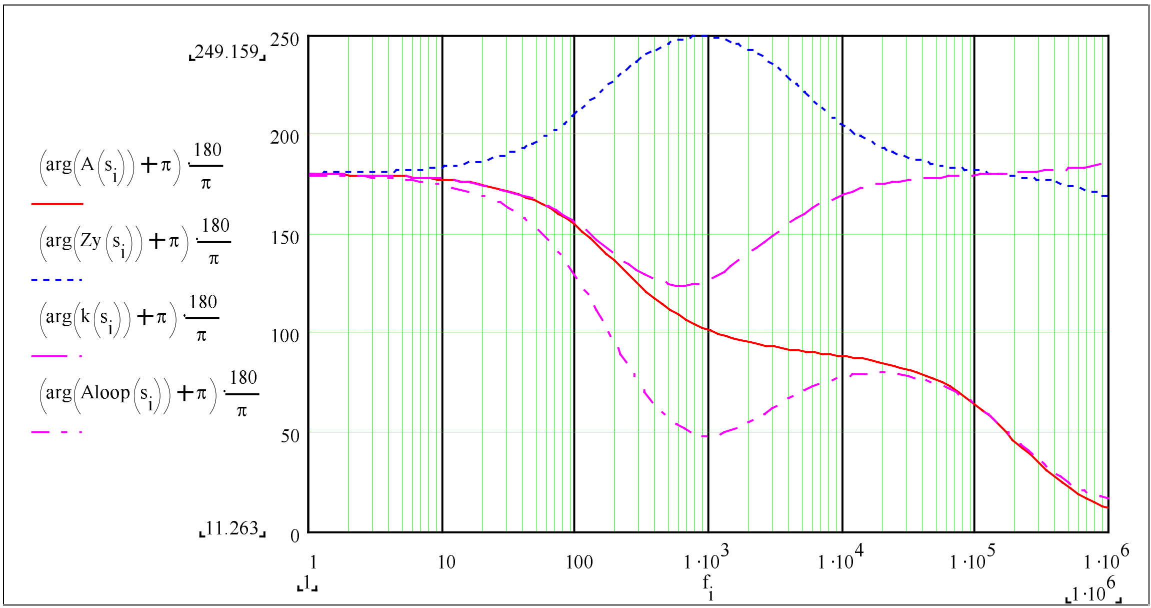


Figure 3-18: phase response of loop-gain of the amplifier system

The phase-margin (a measure of stability) is determined by looking at the phase of the loop-gain w.r.t. zero, at the frequency where the amplitude of the loop-gain goes through 1 (0 dB). This turns out to be at a frequency of 4600 Hz. The phase-margin is about 48 degrees. When the phase-margin is more than 45 degrees, the system is said to be stable (in theory this value can be lower, but then a small noise signal can still cause the system to oscillate).

The transfer-function of the input to output current is drawn in Figure 3-19. In this picture the parallel resistor of the deflection coil is varied. In Philips tubes the deflection coil has a parallel balance potentiometer of 180 Ohm. You can see that with this value the overshoot is quite large. This overshoot also causes an overshoot in the transient response, which can be measured after flyback. When we place an extra resistor parallel to the deflection coil, this overshoot is decreased, as can be seen in the picture. If we make this resistor too small, undershoot on the transient response will appear. So the value of this resistor has to be tuned to the right value (about 220 Ohm, so the total equivalent resistance is about 100 Ohm). Of course, again we must check the loop-gain stability. In fact, the phase-margin has even become bigger, about 68 degrees w.r.t. zero.

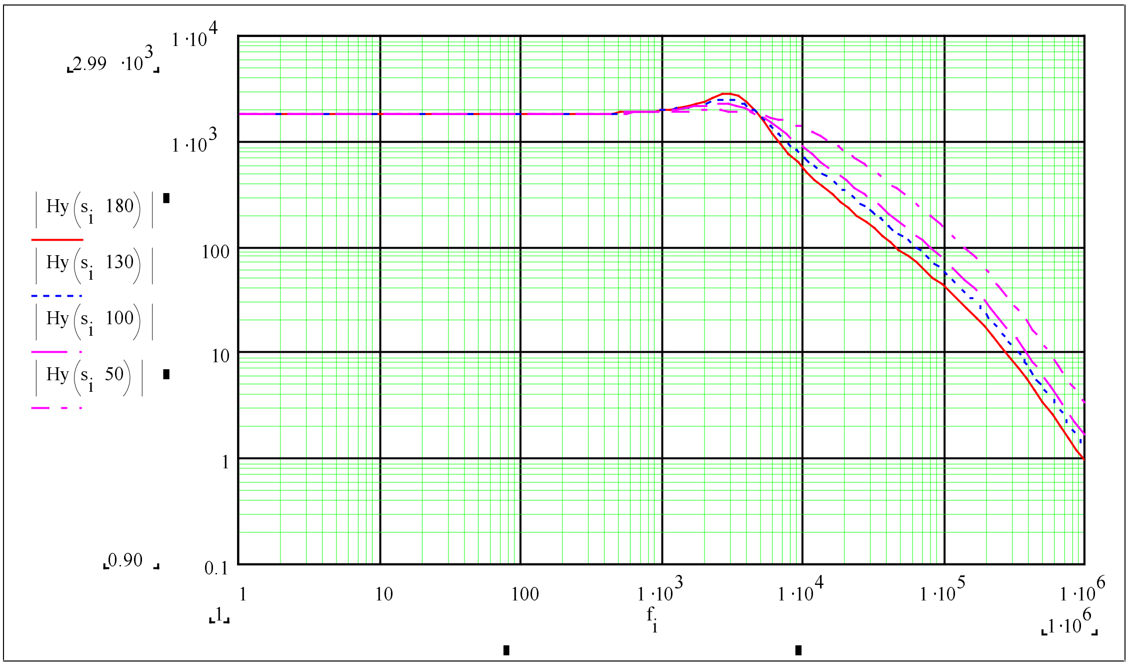


Figure 3-19: closed-loop current gain; Rb = 180, 130, 100 and 50 Ohm

3.5 Thermal considerations

When designing the vertical output stage in a real application, you have to make sure that the junction temperature of the device is below the maximum value during operation. So the power dissipation of the device has to be calculated or measured. When the maximum ambient temperature (often approximated at 65 °C) is known, the right value for the thermal resistance of the heatsink can be calculated, resulting in the right dimensions for this heatsink.

The maximum junction temperature of the device is 168 °C, but the thermal protection will already be activated, so the output current is reduced until the junction temperature is below 150 °C (switch-off temperature). But to yield a longer lifetime it is much better to keep the junction temperature below 110 °C. With a dissipation of 3 Watt this will certainly mean that a heatsink is necessary.

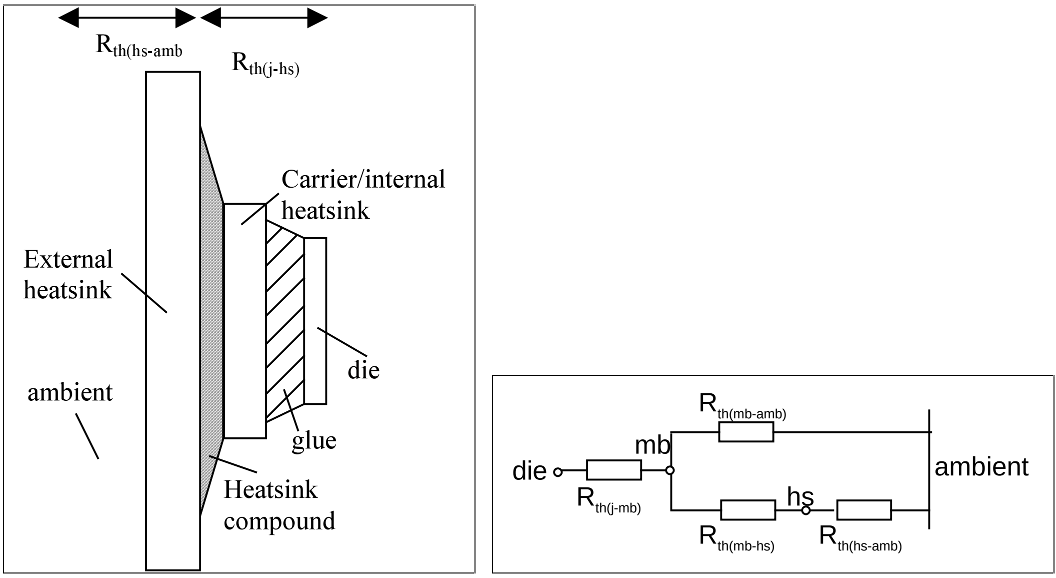


Figure 3-20: IC construction and thermal resistances and the electrical equivalent of the thermal circuit

The thermal resistance from mounting base to ambient ($R_{th(mb\text{-}amb)}$) is so large compared to the thermal resistance from mounting base to heatsink plus heatsink to ambient ($R_{th(mb\text{-}hs)}$+ $R_{th(hs\text{-}amb)}$), that $R_{th(mb\text{-}amb)}$ can be neglected.

The maximum allowed thermal resistance of the heatsink can be calculated by:

$$R_{th(hs-amb)} = \frac{T_{j(\max)} - T_{amb}}{P_{IC}} - \left(R_{th(j-mb)} + R_{th(mb-hs)}\right)$$

4. APPLICATION EXAMPLE

Below a design procedure is given along with an example. The values that are used in the example are:

- $I_{defl(peak\text{-}to\text{-}peak)}$ =1.5 A,
- L_{coil} =6.3 mH,
- R_{coil} =6.3 Ω (cold condition),
- $t_{flyback}$ =300 usec.
- f_{max} =150 Hz

The following steps should be made:

1 Read the minimum, typical and maximum peak vertical deflection current from the picture tube coil specification. The circuit should be designed in such a way that this maximum peak current is not exceeded.
In this example the maximum peak coil current is half the $I_{defl(peak\text{-}to\text{-}peak)}$, so 0.75 A.

2 Calculate the value of the conversion resistors R_{S1} and R_{S2} and the measuring resistor R_1.
Be aware that the output current from the TDA485X deflection controller family has a common mode and a maximum differential mode current, and that the input voltage is maintained between V_N+1.6 and 4.2 Volts (see paragraph 3.3.3). For the conversion resistors we take 1800 Ω, then the measuring resistor is:

$$R_1 = \frac{I_{diff\_in(peak-peak)} \times R_{S1,2}}{I_{defl(peak-peak)}}$$

$$R_1 = \frac{850 \cdot 10^{-6} \times 1800}{1.5}$$

$R_1 = 1.02\Omega$. So take a value of 1 Ω.

3 Calculate the main- and flyback supply voltages. They should be as low as possible to minimise the power dissipation.
For the positive supply:

$$V_{P1} = I_{defl(peak)} \times (1.2 \times R_{coil} + R_1) + V_{5,3sat} - 2 \times I_{defl(peak)} \times L_{coil} \times f_{\min} + V_{D1}$$

$$V_{P1} = 0.75 \times (1.2 \times 6.3 + 1) + 2.3 - 2 \times 0.75 \times 6.3 \cdot 10^{-3} \times 50 + 1$$

$V_{P1} = 9.3Volts$. So take a supply voltage from 10 Volts.

For the negative supply we have:

$$V_N = -\left(I_{defl(peak)} \times (1.2 \times R_{coil} + R_1) + V_{5,4sat} + 2 \times I_{defl(peak)} \times L_{coil} \times f_{\max}\right)$$

$$V_N = -\left(0.75 \times (1.2 \times 6.3 + 1) + 1.7 + 2 \times 0.75 \times 6.3 \cdot 10^{-3} \times 150\right)$$

$V_N = -9.5Volts$. So take a supply voltage of -10 Volts.

For the flyback voltage we have:

$$V_{fb} = \frac{I_{defl(peak-peak)} * (1.2 \times R_{coil} + R_1)}{1 - e^{\frac{-t_{fb} * (1.2 \times R_{coil} + R_1)}{L_{coil}}}}$$

$$V_{fb} = \frac{1.5 \times (1.2 \times 6.3 + 1)}{1 - e^{\frac{-300 \cdot 10^{-6} \times (1.2 \times 6.3 + 1)}{6.3 \cdot 10^{-3}}}}$$

$V_{flb} = 38.4 Volts$. So take a supply voltage of 40 Volts. This automatically means that we cannot use the TDA4863AJ for this application, because doubling the supply voltage will not give us the necessary flyback supply voltage for such a short flyback time.

4 Choose the value of damping resistor R_P about 220 Ohm. This value is depends on the picture tube coil and should be as high as possible. A wrong value for R_P results in an under- or overshoot on the coil current. So the actual value must be determined in the final circuit.

5 The value for R_S is a fixed value of 5.6 Ohm, C_S can be varied to optimise the flyback time. The value of C_S should be around 100 nF.

5 Calculate the power dissipation in the IC following the steps below:
The total power dissipated in the IC+load is:

$$P_{tot} = (V_{P1} - V_{D1}) \times \frac{I_{defl(peak)}}{4} - V_N \times \frac{I_{defl(peak)}}{4} + I_{fb} \times V_{fb} + I_{qsct} \times (V_{P1} - V_N)$$

$$P_{tot} = (10-1) \times \frac{0.75}{4} - (-10) \times \frac{0.75}{4} + 4.5 \cdot 10^{-3} \times 40 + 10 \cdot 10^{-3} \times (10 - (-10))$$

$$P_{tot} = 3.94 Watt$$

The power dissipated in the load is:

$$P_{load} = Irms_{defl}{}^2 * (1.2 \times R_{coil} + R_1)$$

$$P_{load} = \left(\frac{1}{3} \times \sqrt{3} \times 0.75\right)^2 \times (1.2 \times 6.3 + 1)$$

$$P_{load} = 1.61 Watt$$

So the power dissipation of the IC is:

$$P_{IC} = P_{tot} - P_{load}$$

$$P_{IC} = 3.94 - 1.61 = 2.33 Watt$$

6 Calculate the maximum thermal resistance of the heatsink:

$$R_{th(hs-amb)} = \frac{T_{j(\max)} - T_{amb}}{P_{IC}} - (R_{th(j-mb)} + R_{th(mb-hs)})$$

$$R_{th(hs-amb)} = \frac{110 - 65}{2.33} - (6) = 13.3 K/W$$

7 Calculate the values of the components in the guard circuit:
Suppose $I_{C(T2)}$ is 1 mA, then

$R_4 = \frac{V_{P1} - V_{CE(sat)T2}}{I_{C(T2)}} = \frac{9 - 0.2}{1 \cdot 10^{-3}} = 8800\Omega$, so take R_4=8200.

If the base current is 0.1 x $I_{C(T2)}$, and the current through R_2 is 0.05 x $I_{C(T2)}$, then

$R_2 = \frac{V_{BE(T2)}}{0.05 \times I_{C(T2)}} = \frac{0.7}{0.05 \times 1 \cdot 10^{-3}} = 14k\Omega$, so take a value of 15 kΩ. The current through R_3 is the sum of the base current of T_2 and the current through R_2, so

$$R_3 = \frac{V_{fb} + V_{rev(flyback)} - V_{CE(sat)T1} - V_{BE(T2)} - 0.15 \times I_{C(T2)} \times R_5}{0.15 \times I_{C(T2)}} \approx \frac{V_{fb}}{0.15 \times I_{C(T2)}}$$

$$R_3 = \frac{40}{0.15 \times 1 \cdot 10^{-3}} = 270k\Omega .$$

If the time constant is about 5 frames, then C_1 should be:

$C_1 = \dfrac{5 \times \dfrac{1}{f_{\min}}}{R_2 + R_3} = \dfrac{5 \times \dfrac{1}{50}}{14000 + 270000} \approx 330nF$. Within one frame the voltage across C_1 will drop about 10 Volts now, but is still high enough to keep transistor T_2 in saturation.

For the value of R_5 a value of 2.2 Ohm is chosen, its purpose is only to limit the current during start-up.

5. EMC LAYOUT RECOMMENDATIONS

In the layout and circuit diagram take care that the vertical amplifier with its external components will not disturb other electronic circuits (radiation). Also the circuit must not be disturbed by radiation coming from other electronic circuits (susceptibility/ immunity). There are three kinds of measures to improve the circuits immunity and radiation:

- limit the bandwidth of the system,
- keep current loops physically as small as possible to reduce magnetic field pick-up and radiation,
- keep PCB tracks as short as possible to reduce electric field pick-up and radiation.

Not always all three measures can and must be taken.

The following recommendations are applicable to the vertical deflection circuit:

1. Bandwidth: do not make the bandwidth larger as needed. Not only will this reduce disturbances from other electronic circuits, but also noise is reduced.
2. Input tracks: keep the input tracks as short as possible. This measure is sometimes hard to implement, but keep it in mind. Anyhow, it is also very important to keep them close together to minimise the loop area.
3. Input decoupling: place decoupling capacitors of 10 nF at the inputs of the TDA4863(A)J. This filters the inputs from high frequency disturbance.
4. Power supply: place decoupling capacitors from all supply pins to ground. Combine the grounds of all decoupling capacitors to one ground return track to the SMPS of the monitor. Do not use this ground return track for other circuits in the monitor. This makes sure that there are no high frequency disturbances on the supply voltages.
5. Heatsink: make sure that the heatsink is electrically connected to PCB ground, so it is not floating. However, the heatsink must be isolated from the back of the TDA4863(A)J, because the back of the IC is not at ground potential. The isolation must have a small thermal resistance, so heat is transferred easily through the isolation.

6. REFERENCES

-AN99009, Application information for TDA8358J deflection output circuit and East-West, July 1999, Dick v.d. Brul, Bas Kasman, Pieter v. Oosten

-AN00038, EMC of Monitors, February 2000, G. Tent, H. Verhees