APPLICATION NOTE

Application of the TDA6120 wideband video output amplifier AN96073

Philips Semiconductors

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Abstract

This report gives a description of the TDA6120Q wideband video output amplifier together with application aspects

Application of the TDA6120Q wideband Video output amplifier AN96073

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Summary

This note gives the device description of the TDA6120Q RGB wideband video output amplifier and provides the user with basic hints to obtain an optimal performance in the application.
The TDA6120Q includes one video output amplifier (30MHz/125Vpp) in a plastic DIL-bent -SIL power package DBS13P, using high-voltage DMOS technology, and is intended to drive the cathodes of a CRT in a high demanding market of High Resolution TVs and monitors. The device is provided with a black current measurement output for automatic black current stabilisation (ABS).

The following application aspects will be described:
- External components calculation.
- Circuit application & Application hints.
- Flash-over protection.

Furthermore two wideband concepts are described within this report.

- One video concept for typical TV applications, using the combination TDA4780 (monolithic RGB processor) and the TDA6120Q.
This combination has a total bandwidth of 22MHz and is suitable for High Resolution TV,MUSE and VGA (SVGA with limites bandwidth performance).
It features gamma and blue stretch and has automatic black current stabilisation(ABS).

- The other concept is designed for monitor applications, using the combination of TDA4882 monitor pre-amplifier and the TDA6120Q .
This combination has a total bandwidth of 30-60 MHz (depending on the cathode output swing requirement and is suitable for VGA, SVGA and XGA applications.

By means of this application note one is able to decide which components can be changed and what the consequences will be. This is important because the component choice is often a compromise and depends on the requirements defined by the customer.

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1.0 **INTRODUCTION**
The aim of this application note is to describe the basic operation of the TDA6120Q Wideband RGB video output amplifier and provide the user with basic hints to realise an optimal performance in the application.
The TDA6120Q includes one video output amplifiers in a plastic DIL-bent -SIL power package DBS13P, using high-voltage DMOS technology, and is intended to drive of a CRT in a high demanding market of High Resolution TVs and monitors.
The device is provided with a black current measurement output for automatic black current stabilisation (ABS).
The TDA6120Q does not include flash protection diodes, therefore it is necessary to apply an external flash diode for each channel.

Two video output concepts are described in this report.
• One video concept concept for typical TV applications, using the combination TDA4780 [(monolithic RGB processor) add-on board] and the TDA6120Q [main board]. This combination has a total bandwidth of 22MHz and is suitable for TV,MUSE and VGA (SVGA with limited bandwidth performance) .
It features gamma and blue stretch and has automatic black current stabilisation (ABS).
With this concept there are no alignments any more on the CRT panel, because of the automatic black current stabilisation and because the white point adjustment can be done in the TDA4780 via I^2C bus.

• The other concept is designed for monitor applications, using the combination TDA4882 monitor pre-amplifier (add-on board) and the TDA6120Q (mainCRT board).
This combination has a total RGB bandwidth of 30-60 MHz (depending on the cathode output swing requirement and is suitable for VGA, SVGA and XGA applications.

The main features are:

- High large signal bandwidth : 40 MHz typ at 100Vpp, [1)]
- High slewrate : 10V / ns,
- differential voltage input,
- Black-current measurement output for automatic black current stabilization,
- Bandwidth indepent of voltage gain,
- High power supply rejection ratio,
- Protection against ESD,
- Low static power dissipation,
- Controllable switch-off behaviour.

1) Measured in application set-up, with Rfl =220Ω and Cl= Ctube+ Cpcb=10pF.

2.0 QUICK REFERENCE PRODUCT DATA

Vdd	High voltage supply	180-210 V
Vcc	Low voltage	10.8-13.2V
Idd	Quiescent H.V current	typ. 10mA
Icc	Quiescent L.V current	typ. 31mA
Vin--	inverting input voltage	1.5-5V
Vin-+	ref. input voltage	1.5-5V
Voutc-max	max. output voltage	typ. Vdd - 6V
Voutc-min.	min. output voltage	typ. 4V
Aint.	Internal amplification	typ. 1.87
BWs @ 60Vpp	Small signal bandwidth	typ. 47 MHz. 2)
BWl @ 125Vpp	Large signal bandwidth	typ. 32 MHz. 2)
t_r @ 125Vpp	Cathode output rise time	typ. 14 nSec. 2)
t_f @ 125Vpp	Cathode output fall time	typ. 12.5 nSec. 2)
Rth,j-c	Thermal resistance from junction to case	typ. 3K/W

2) with Rfl=150Ω , Cl=10pF.

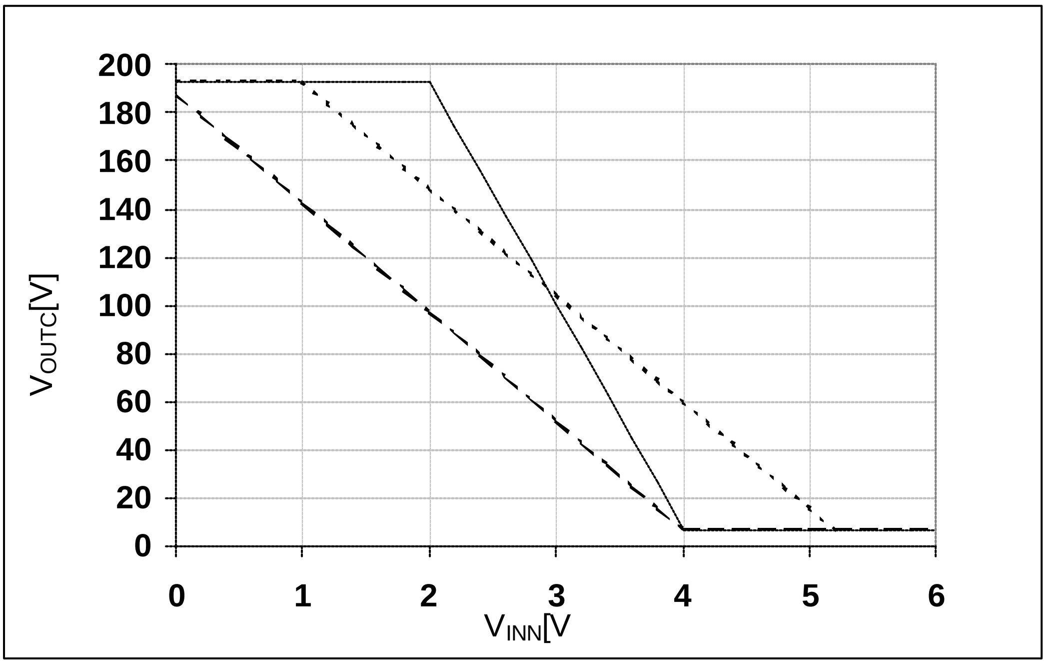


Fig.1 DC to DC transfer from input (Vin-) to output (Voutc)

SYMBOL	PIN	DESCRIPTION
RC-	1	Inverting input pre-emphasis network
VIN-	2	Inverting voltage input
RC+	3	Non-inverting input pre- emphasis network
VIN+	4	Non-inverting voltage input
IIN	5	Feedback current input
V_{CC}	6	Low supply voltage (12V)
OUTM	7	Cathode current measurement output
GND	8	Power ground
n.c.	9	Not connected
V_{DD}	10	High supply voltage (200V)
n.c.	11	Not connected
OUTC	12	Cathode output
OUT	13	Feedback output

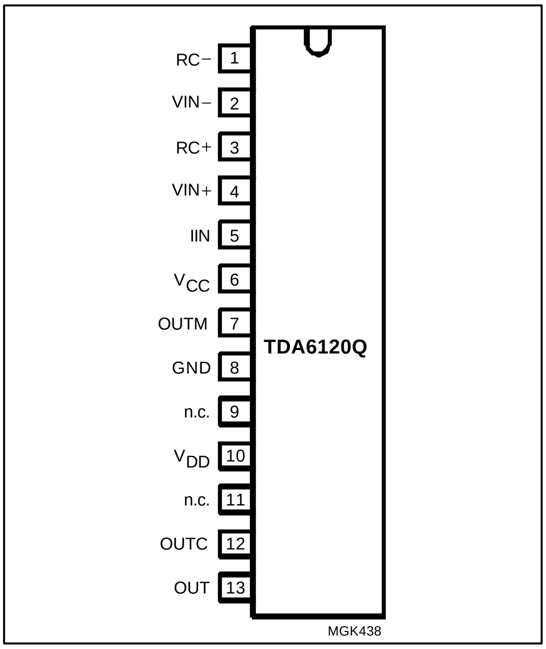


Fig.2 Pinconfiguration

3.0 CIRCUIT DESCRIPTION.

3.1 BLOCK DIAGRAM DESCRIPTION.
The complete block diagram of the TDA6120Q is shown in Fig. 3.

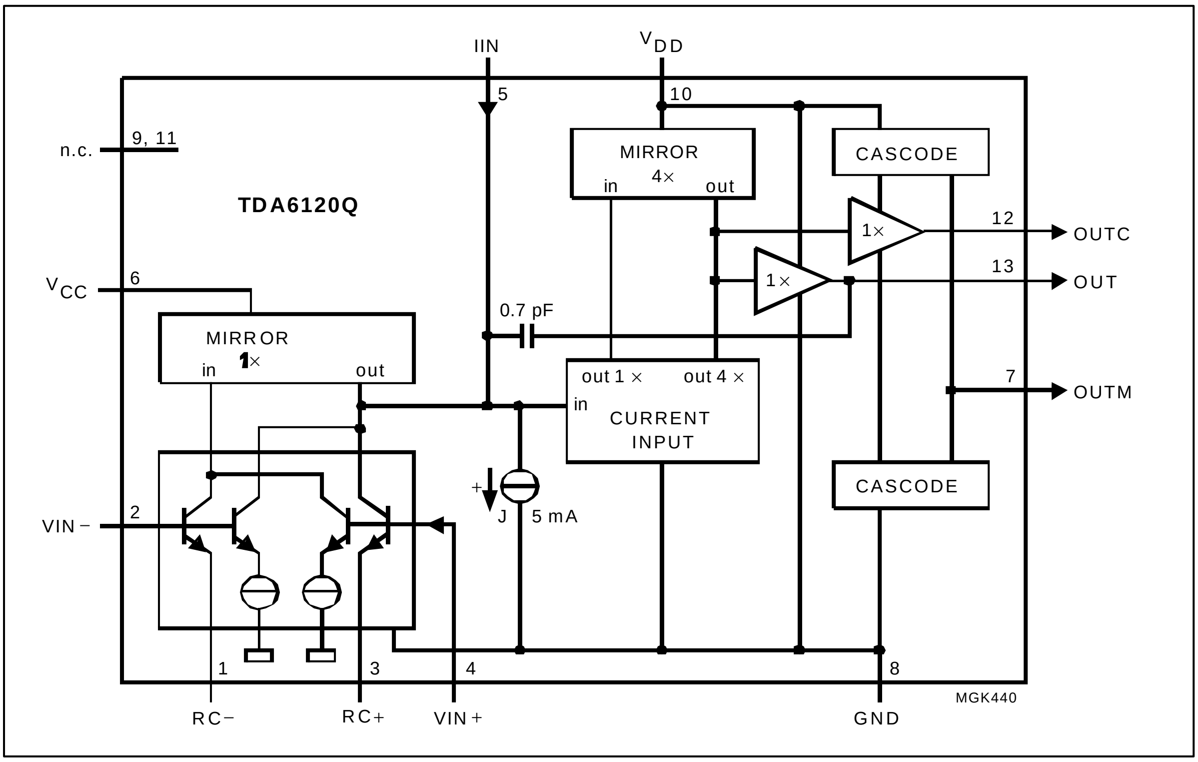


Fig.3 Block diagram of the TDA6120Q.

The TDA6120Q consists of one monolithic video output amplifier.
The amplifier can be split-up in two amplifier stages in series. The first one is a voltage to current stage (transadmittance stage), the second one is a current to voltage stage(transimpedance stage).
This gives rise to the term transadmittance - transimpedance amplifier.
At the second stage voltage to current feedback is applied by a resistor connected from OUT(pin13) to Iin(pin5). The transadmittance of the first stage can be chosen by means of a resistor between pin1 and pin3.
The advantage of this amplifier configuration is that a higher bandwidth performance can be realised w.r.t the well known operational amplifier with voltage feedback.
Furthermore, the amplifier has a differential input, which makes the amplifier less sensitive for injection from noise sources and flexible regarding DC to DC transfer.
The TDA6120Q does not include flash protection diodes that clamp the cathode output to the high voltage supply pin during a CTR flashover discharge.
Therefore an external flash diode combined with flash resistor and sparkgap has to protect the amplifiers against flash over in the picture tube.
Furthermore, the device needs two supply voltages, a low supply voltage(Vcc) of 12V and a high supply voltage(Vdd) of 200V.

The TDA6120Q is provided with a black current data pin. When using TDA4780 as drive device no adjustments are required for gain and black setting, as the TDA4780 has I²C white point adjustment and black current input pin.
The simplified basic application diagram of theTDA6120Q is given below in Fig.4
The complete application diagram of theTDA6120Q is given in Fig.18 on page 38.

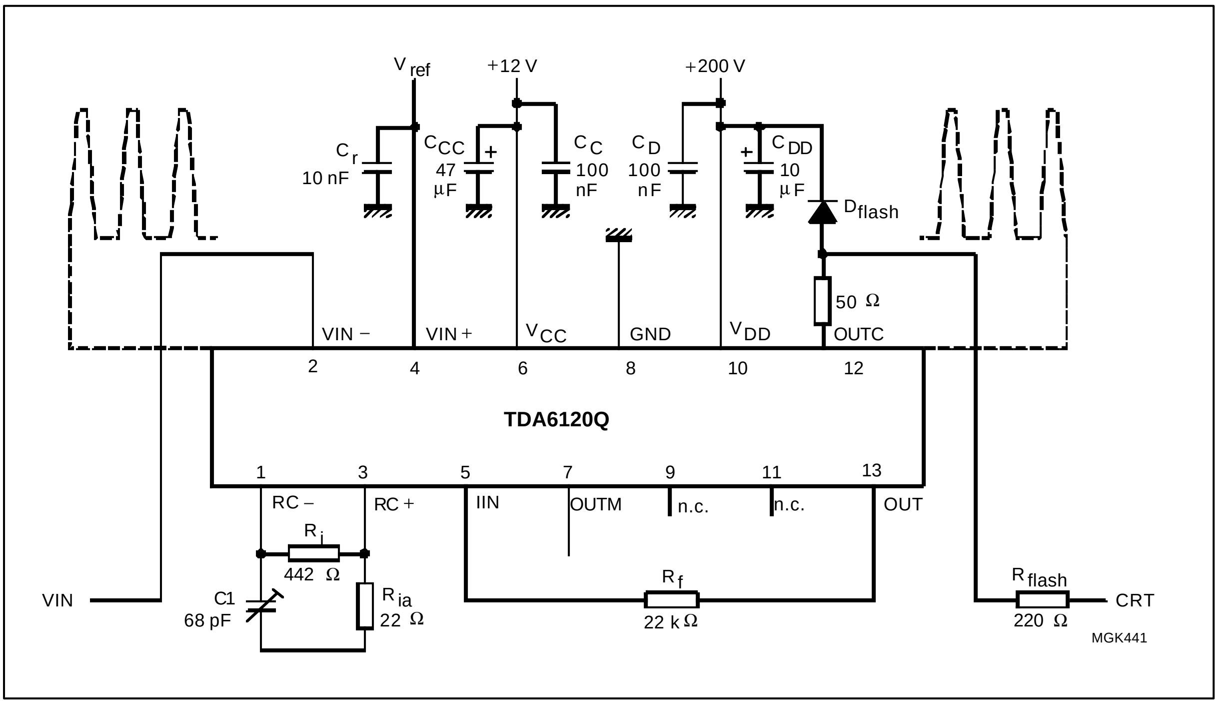


Fig. 4 Simplified basic application of the TDA6120Q.

3.2 FUNCTIONAL PIN DESCRIPTION.
A functional pin description is given in this chapter.
Pin1,3 . These are the inverting and non-inverting pre-emphasis pins.
A resistor/capacitor network has to be connected between these pins for gain and pre- emphasis setting.

Pin 2. This is the inverting voltage input. The input configuration consist of a bipolar npn transistor in a long tailed pair configuration. The input current amounts to 30 µA.typ.
The input voltage range amounts to 1.5<Vin-<5V.

Pin 4. This is the non-inverting (ref.) voltage input. The input configuration consist of a bipolar npn transistor in a long tailed pair configuration. The input current amounts to 30µA.typ. The input voltage range amounts to 1.5<Vin-<5V.

Pin 5. Feedback current input.
A feedback resistor (Rf) has to be connected from the feedback output (pin13) to this pin.
The DC level at this pin is defined by 2Vbe.

Pin6. Low voltage supply.
This pin has to be decoupled by a h.f and l.f decoupling capacitor.

Pin 7. This is the black current measurement output for automatic black current stabilisation (ABS). The voltage on pin 7 of the TDA6120Q is limited by an internal built in zener diode of 20 volts. The off-set current of pin5 amounts to +20 µA typ. at 4V< Vom< 20V. When not using ABS, this pin can be grounded via a capacitor.

Pin8. Ground

Pin9,11. Not connected

Pin 10. High-voltage supply Vdd.
This is the high voltage supply pin of the device(typ.200V) and has to be decoupled .

Pin 12. Cathode output.
The video output current is delivered by a quasi complementary class-A/B push-pull stage, designed in DMOS technology and can source and sink a current of 100 mA, for video output voltages of 125Vp-p with rise and fall times of 12.5 nSec .
A feature of this output stage is the low saturation voltage (typ. 4V) and the low voltage drop at high level (typ.Vdd-6V).
This output pin has to be connected to the cathode of the CRT via a standard resistor of 50Ω and a high-voltage flash-over protection resistor.
A high surge clamping diode has to be applied externally between this OUTC pin and the Vdd pin, so that the cathode output voltage clamps to Vdd+Vdiode.

pin13. Feedback output.
This output is used for feedback to the current input (pin5) by means of resistor (Rf) .

3.3 INTERNAL PIN CONFIGURATION
The internal pin configuration of the TDA6120Q is given in Fig 5.

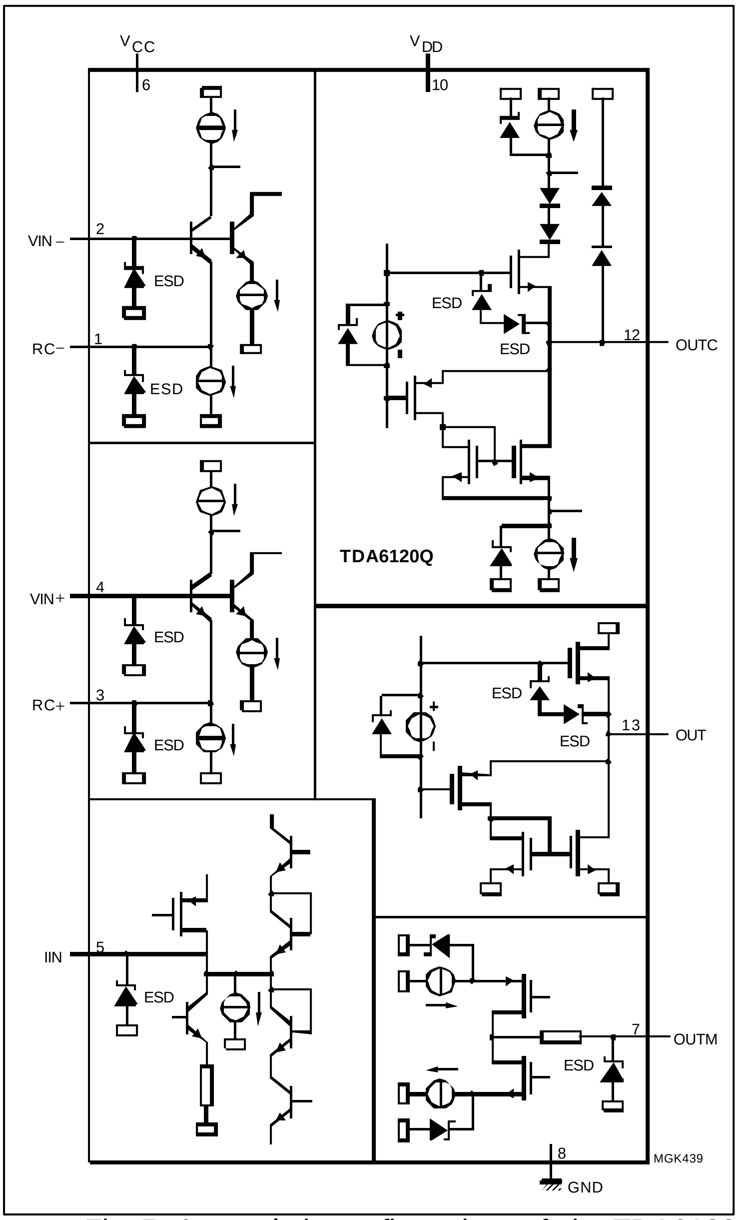


Fig. 5 Internal pin configurations of the TDA6120Q

3.4 PROTECTION CIRCUITS.
The TDA6120Q has a lot of protection circuits built-in, in order to comply with requirements of reliability.

• Protection against electrostatic discharges.
All pins have an energy protection for positive and negative voltages.

4.0 DESIGN CONSIDERATIONS.

4.1 AMPLIFIER PART.
The applied video output amplifier in the TDA6120Q is a transadmittance-transimpedance amplifier, the basic characteristics of this operational amplifier will be explained shortly.

The general transadmittance-transimpedance topology is depicted in Fig.6.

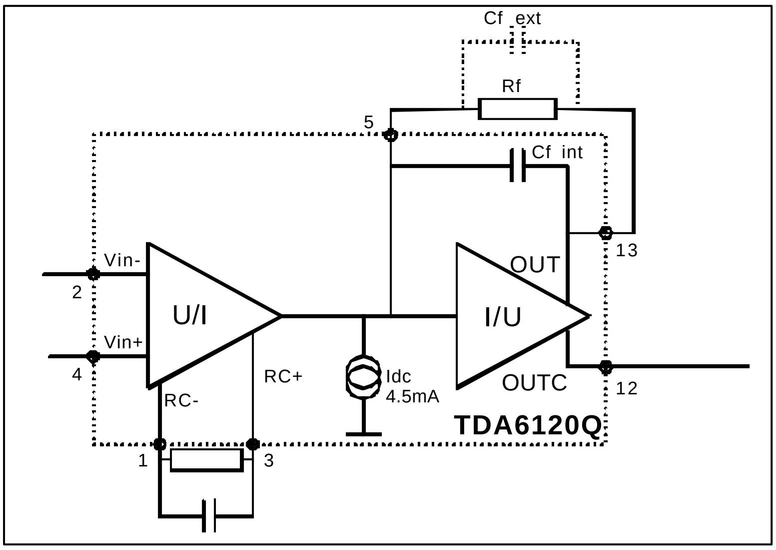


Fig.6 Basic configuration of the video amplifier.

The amplifier can be spit-up in two amplifier stages in series. The first one is a voltage to current stage (transadmittance stage), the second one is a current to voltage stage(transimpedance stage).
The advantages of this amplifier configuration are:
• high bandwidth performance,
• high input impedance, no load of drive device.
The overall amplifier has a differential input (Vin-+ and Vin--) and a single ended voltage output. The input of the overall amplifier is Vin--, Vin-+ has to be connected to an external reference voltage (Vref), which can be common for three channels (R,G and B). The reference voltage (Vref) must be stable regarding temperature drift.
The transadmittance of the first stage can be chosen by means of a resistor Ri between pin1 and pin3.
At the second stage, voltage to current feedback is appied by a feedback resistor(Rf) connected from OUT(pin13) to Iin(pin5).
At low frequencies, the overall voltage gain is determined by the ratio Rf, Ri and Aint.

4.2Voltage gain.

The overall voltage gain is defined by:

$$G = \frac{\Delta Voutc}{\Delta Vi} = \frac{\Delta Voutc}{(Vin+) - (Vin-)} = Aint . Rf/Ri.$$

With
Voutc = output cathode voltage (pin12)
ΔVi = (Vin+) - (Vin-)
Vin+ , Vin- = input voltages (pin2 and 4)
Aint = internal gain of the amplifier, typical 1.87
Rf = Feedback resistor
Ri = resistor between pin1 and 3.

For most of the applications a voltage gain of 50-100 is sufficient to get 100Vp-p video output signals.

4.3 DC toDC transfer.

The DC voltage Voutc(dc) is determined externally by Ra, Rf ,Ri , and the level of Vin+ and Vin- and internally by Aint and Idc.
From equation:

$$Voutc(dc) = [Idc.Rf + 2Vbe] + [(Vin+ - Vin-) . Rf/Ri. Aint]$$

with:
Idc= internal current source, 4.5mA typ.

Hence, Vout(dc) >>2Vbe, we can approximate the equation:

$$Voutc(dc) = Rf (Idc + \Delta Vi/Ri .Aint) = Rf (4.5 + \Delta Vi /Ri . 1.87)$$

If Vin+ =Vin-, Voutc(dc) = Idc. Rf= 4.5 .Rf.

At Vin+=Vin- and Rf=22kΩ ===> Vout(dc) =100V.

Due to the differential input stage in combination with Rf and Ri, the TDA6120Q is very flexible to fit with a lot of pre-amplifiers and CRTs.

From equation Vout(dc) = Rf (Idc + ΔVi/Ri .Aint) the DC to DC transfer can be plotted at Vin+=3V. This shown in Fig.1 of the product data on page 9.

4.4 Pole zero cancellation.
The feedback resistor Rf and the parasitic capacitor Cf cause a pole in the transfer .
For a value of Rf is >22kΩ this pole will cause a premature roll-off in the Bode plot and therefore a reduced overall small signal bandwidth.
The value of Rf is a compromise between dynamic performance and dissipation.
The bandwidth of the video amplifier can be improved by cancelling this pole by a zero. This so called pole-zero cancellation can be done by placing a capacitor Ci

across the resistor Ri. The value of this capacitance is equal to:

$$Ci=Cf.Rf/Ri$$

When the Cf = Cf_{int} + Cf_{ext} =0.7+0.1= 0.8pF and G =Rf/Ri=50, the capacitor Ci equals 40 pF. To make extra speed-up, Ci can be chosen larger, dependent on the total amount (5% to 10%) of overshoot required in the step-response. Speed-up can also partly compensate the roll-off in the input signal.

4.5 Stability.

The stability of the TDA6120Q is in principle guaranteed by the design.
In practice, the stability of the RGB board can be checked by :
- measuring the frequency response of the system, the amplitude must be as flat as possible (within a few dB),
- measuring the overshoot of a square wave signal.

4.6 Black current measurement output.

The TDA6120Q is provided with a black current data pin.
The benefits to apply ABS are to compensate the differences in the gun characteristics during warming-up and ageing of the picture tube in order to have the correct colour balance in the10µA region.
The black current stabilisation loop is an automatic control loop which stabilises the black current of each channel sequentially and independently.
To prevent that high video currents will flow in the black current input of the control processor, the voltage on pin 7 of the TDA6120Q can be limited by an external zener diode.

4.7 Flash-over protection.

The TDA6120Q needs an external protection diode (BAV21) combined with a 50Ω resistor to protect the video amplifier against CRT flash-over discharges.
This diode clamps the cathode output voltage to Vdd+Vdiode. To limit the diode current, an external 220Ω carbon high-voltage resistor (Rfl) in series with the cathode output and a 2kV spark gap is recommended. The value of this carbon resistor is a compromise between video bandwidth and flash immunity.

More details about flash protection are given in chapter 7 -"Circuit application & application hints" and in the appendix of application note AN95064 (see Reference).

5.0 EXTERNAL COMPONENTS CALCULATION.

The implementation of the TDA6120Q in an application requires the determination of external component values. These components are Rf, Ri,Ci and values of decoupling capacitors. In addition the dissipation of the IC and the feedback resistor Rf must be calculated in order to obtain the kappa of the heatsink and the size of the feedback resistor respectively.

From equation : $$\text{Voutc (dc)} = \text{Rf} (\text{Idc} + \Delta\text{Vi/Ri} .\text{Aint}) \qquad (5\text{-}1)$$

and: $$G= \frac{\Delta\text{Voutc.}}{(\text{Vin+}) - (\text{Vin-})} = \text{Aint} . \text{Rf/Ri.} \qquad (5\text{-}2)$$

it can be seen that the value of the DC output voltage as well as the voltage gain depends directly on the feedback resistor Rf. Hence Rf must be determined before calculating the value of Ri in order to obtain the correct gain and DC output voltage.

5.1 Feedback resistor Rf [R9,R12 and R15]

The value of Rf is a compromise between:
- Dynamic performance: Rf must be as low as possible in order to obtain the optimum dynamic performance.
- Minimum dissipation: Rf must be as high as possible in order to obtain the minimum static dissipation , so a low cost resistor.

A typical value of Rf is 22kΩ.
Furthermore at this value of Rf holds Vout =100V , at Vin+=Vin-.
In that case, the max. dissipation will be 1.8 Watt. (at Vdd=200V)

5.2 Input resistor Ri [R7,R10 and R13]

The input resistor can be calculated from the following formula:

$$\text{Ri} = \frac{\text{Rf. Aint.}}{G} \qquad (5\text{-}3)$$

The board described in this report is designed to handle signals from TDA4780 and TDA4882 and here a voltage gain of 100 is sufficient to get 100Vp-p video output signals. For a gain of 100 ==> Ri= 430Ω.

5.3 Speed-up capacitor Ci [C5,C10 andC15]

The value of this capacitor can be calculated with : $Ci = Cf \cdot \frac{Rf}{Ri}$ (5-4)

At $Cf = Cf_{int} + Cf_{ext}$ =0.7 +0.1 = 0.8 pF , ===>Ci = 39 pF.

As the layout of the chosen PCB is fixed, Ci can be determined for each channel.
Depending on the layout of the PCB, Ci can be different for each channel.
To avoid oscillations at very high frequencies, a stop resistor (R8,R11,R14=22Ω)has to be added in series with this speed-up capacitor.
At the evaluation board the speed-up capacitor consist of a fixed and a trimmer capacitor in parallel.
Transient improvement can be obtained by increasing the speed-up capacitor by some pF, dependent on the amount of overshoot that is desired (5-10 %).
To obtain a low inductance overall speed-up network, all components (except the trimmer) are in SMD technology.

5.4 Reference voltage Vin+.

Vin+ must be chosen in such a way that the typical blacklevel output voltage $Vo_{(black)}$ is close to to the cut-off voltage (Vco) of the picture tube.
The black level voltage Voutc(black) is determined by Rf and the level of Vin+ and Vin-(black). Vin- (black) is the typical value of the DC black level at the input and so the typical value of the brightness control range of the video processor.
Because Rf is fixed, Vin+ can be derived from the formula:

$$Voutc\ (dc) = Rf\ (Idc + \Delta Vi/Ri\ .Aint\ )$$

so that $$Vin+ = \frac{Voutc.Ri/Rf - (Idc.Ri) + (Vin- . Aint.)}{Aint} = \frac{Voutc - Rf.Idc}{G} + Vin- \quad (5\text{-}5)$$

If Vin-(black) = Vin+, Voutc(dc) = Rf.Idc

For a cut-off level of 160V ,Vi(black)= 3V , Rf=22kΩ and Ri= 430Ω ==> Vin+ = 3.6V

5.5 Vdd & Vcc decoupling (C2,C3,C7,C8,C12,C13)

The low voltage supply pin (Vcc) as well as the high voltage suppy pin must be decoupled with a capacitor of 100nF with short leads and with good HF characteristics, placed as close as possible between the supply pins and GND.
To obtain optimal decoupling and low inductance leads, SMD components are applied for this on the evaluation board.

5.6 Decoupling regarding flash [C21,C22,C23 and C16)]

To protect the video amplifiers against picture tube flash-over discharges the high supply voltage (Vdd) must be decoupled by a capacitor >20nF/250V (e.g. a film capacitor of 100nF/250V with short leads and with good HF characteristics), placed as close as possible to the Vdd supply line and GND of each TDA6120Q and definitely within 5mm. This capacitor limits voltage excursions of Vdd during the first part (T_{rise}=10 nsec) of a low resistance flash.

$$\Delta U = I(flash) . \frac{T}{C} . = \frac{Vspark\ (max.)}{Rfl} . \frac{T\ rise}{Ch.f} = \frac{4\ kV}{1k5} . \frac{10\ nsec}{20\ nF} = 1.3\ V$$

at Ch.f. = 100nF , Δ U= 0.25V.

with: V(spark(max.) = maximum ignition voltage of the sparkgap,
Trise = rise time of the cathode voltage to exceed the Vspark(max.),
Rfl= flash resistor,
Ch.f= high frequency decoupling capacitor.

The high supply voltage (Vdd) must also be decoupled with a capacitor >10uF/250V on the CRT board . This capacitor limits the voltage excursion during a high resistance flash. For the calculation of this voltage excursion it is supposed that there is no ignition of the spark gap and that the picture tube discharges completely through the external flash diode. In that case the maximal voltage excursion will be:

$$\Delta U = \frac{Ctube\ .\ Veht}{Cl.f} = \frac{2n7\ .\ 28\ kV}{10\mu F} = 7.5\ V$$

with: Ctube = capacitance of the picture tube,
Veht = voltage of extra high tension,
Cl.f = low frequency decoupling capacitor.

This capacitor is common for the three channels, the position is less critical but must be located on the CRT board.

5.7 Flash diodes [D1,D2 andD3]

An external high voltage reverse biased diode has to be connected between the OUTC of the TDA6120Q and the Vdd line, with short leads.
The diode must be able to surge high flash currents. A BAV21 diode has been chosen for this. The position on the board and lead length in conjuction with the flash capacitors (C21,22 ,23) is very important.

For more detailed information about these capacitors and flash diode see chapter 7.6 flash-over protection .

5.8 Additional components on the main CRT board.

5.8.1 Voltage /Current feedback.

When using TDA4882 or TDA4780 voltage or current feedback (ABS) can be applied . Therefor the main CRT board is provided with the X2 connector,which can deliver the required voltages (FbR, FbG ,FbB) and current (Ioutm).

5.8.2 Current feedback (Switch S4).

A zener diode D4 of 12V is applied to prevent that high video currents will flow into the black current input of the pre-amplifier. In this case the voltage is limited to 12V. Because the supply voltage of the TDA4780 is 8V, a 6V8 zener is added on the TD4780 add-on board.
When dark current feedback is applied, switch S4 must open.
If not using the ABS function, switch S4 can be closed , in that case the Iom outputs are short circuit to ground with capacitor C4 via the switch and there will be no cross-talk from the Iom outputs to the inputs. See for more details chapter7.7 .

5.8.3 Voltage feedback (switch S1,S2,S3).

In combination with the TDA4882 add-on board , the resistors R25,R27 and R29 are used for voltage feedback.

5.8.4 Stop resistors regarding h.f stability.

To avoid possible high frequency oscillations in the input leads, stop resistors of 100Ω are applied in the Vin+ and Vin- leads.

6.0 DISSIPATION & HEATSINK CALCULATION.

6.1 Static and dynamic dissipation.
The components dissipating power are the TDA6120Q and the feedback resistors.
The dissipation of the TDA6120Q consists mainly of the static contribution of the quiescent current and the dynamic dissipation caused by high frequency drive (proportional to frequency)

The static dissipation of the TDA6106Q is due to the voltage supply current and the load currents in the feedback resistors and CRT.
The static dissipation equals:

Pstat = Vcc.Icc + Vdd. Idd - [Voutc.(Voutc/Rf - Ioutc)] + Vcc.Icc (6-1)

Ioutc = DC value of the cathode current.
Voutc = DC value of the cathode voltage.
With Vdd=200V, Vcc=12V, Voutc=100V , Icc_{max} =39 mA and Idd_{max}=12 mA the static dissipation equals : Pstat= 2.9 W.

The dynamic dissipation equals:
Pdyn = Vdd . (Cl + Cint) . f . Vo p-p . b. (6-2)

Cl = load capacitance (Ctube, Csocket, Cspakgap, Cdiode, Cpar)
Cint = internal load capacitance (7 pF)
f = input frequency
Vo p-p = output voltage (peak to peak)
b = non blanking duty cycle.

Regarding the dynamic dissipation, we have to distinguish two application areas.
- High resolution TV applications
- Monitor applications.

6.1.1 High resolution TV.
The input bandwidth is defined by the control processor.
When using the TDA4780, the bandwidth is 22MHz and the output signal of 100Vp-p at the cathode of the CRT.

With Vo p-p=100V, f=22MHz (sine wave), Cl=10 pF, Cint=7 pF and b=0.8, the dynamic dissipation Pdyn. equals: 6.6 W.

The total dissipation Ptot=Pstat+Pdyn under given conditions is 9.2 W.

6.1.2 Monitor application.
To obtain well focused pictures, the max. output voltage at the cathode of the CRT will be 75Vp-p.
For the bandwidth 30MHz has been chosen, this means an input step responce of about 10nS, which is a rather practical value.

With Voutc p-p=75V, f=30MHz (sine wave), Cl=10 pF, Cint=7 pF and b=0.8, the dynamic dissipation Pdyn. equals: 6.4 W.

The total dissipation Ptot=Pstat+Pdyn under given conditions is 9.3 W.

6.2 HEATSINK CALCULATION

Thermal parameters of the TDA6120Q:
Rth,j-mb = 3 K/W (typ).
The Rth,mb-heatsink = 0.5 K/W depends on mounting method of the heatsink.
Tj,max= 150 ^{o}C
Tamb,tv= 65 ^{o}C
If the max. operating temperature in a TV set is about 65 ^{o}C, with a power dissipation of W and a thermal resistance Rth,j-mb of 3K/W, a heatsink has to be applied with a thermal resistance of:

$$Rth,heatsink = \frac{(Tj-Tamb)}{Ptot} - Rth,j\text{-}mb - Rth,(mb\text{-}heatsink) \quad [K/W] \quad (6\text{-}3)$$

$$Rth,heatsink = \frac{(Ths-Tamb)}{Ptot} \quad (6\text{-}4)$$

For High resolution TV, Rth,heatsink$\leq$ 5.74 K/W

For monitor applications, Rth,heatsink$\leq$ 5.64 K/W

On the main RGB board described in this report, a standard heatsink is used.
This heatsink has an Rth,hs of 5.6 K/W
With this heatsink , under normal maximum dissipation as calculated (9.3W) the heatsink temperature will rise to 117 ^{o}C and the junction temperature to 145 ^{o}C which is just within the limits of the IC.
This means that the use of better PC board material for the main CRT board is desired.

6.3 Absolute worst case conditions.

At absolute worst case conditions ,125Vp-p @ 30MHz , Tamb,tv =65 ^{o}C and Rth,heatsinh=5.6K/W, the heatsink temperature will rise to 140 ^{o}C and the junction temperature to 169 ^{o}C which is outside the limits of the TDA6120Q.

6.4 A more practical approach regarding dissipation

In the previous part, the dissipation has been calculated for the TDA6120Q.
However, this is a rather theoretical approach and in practice it differs from this, in particular the dynamic dissipation. This will be explained now.
In a TV set the worst case of dissipation occurs with :

- a noise signal (from the tuner) in TV mode,
- a multi-burst pattern (1-30MHz) in AV mode.

Furthermore, it is not realistic that there will be a continuous picture containing a full screen of 30 MHz sine wave signals .
Measurements in a TV set show a lower dynamic dissipation in TV and AV mode compared with the calculated values given in the previous part.
Therefore, a correction factor (Cth) can be applied for the dynamic dissipation.
However, when a smaller heatsink is used as calculated in the previous part, the TDA6120Q must be protected by a thermal protection circuit .
The basic circuit diagram for this is shown in Fig.7.

Dissipation @ Rth,hs=5.6K/w	conditions	Pstat [W]	Pdyn [W]	Ptotal [W]	Theatsink [oC]	Tjunction [oC]
absolute max.		2.9	10.6	13.5	140	169
normal max.		2.9	6.4	9.3	117	145
practical	Cth=0.6	2.9	3.8	6.7	102	122

Table 1 Overview of dissipation

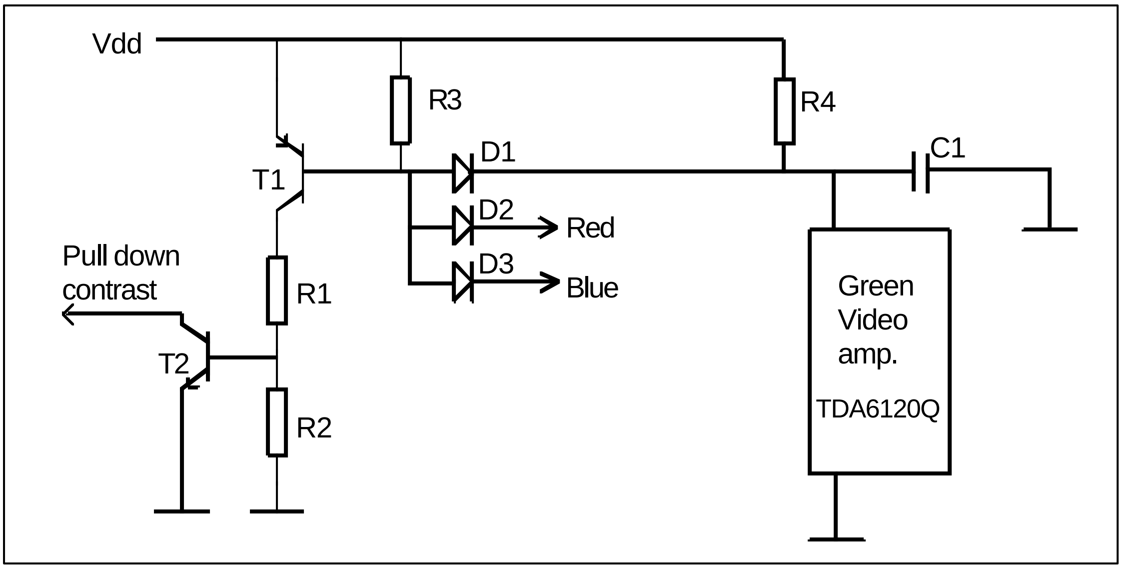


Fig.7 Thermal protection for the TDA6120Q

7.0 CIRCUIT APPLICATION & APPLICATION HINTS

In this chapter information is given concerning the application of the TDA6120Q as video output stage. The circuit diagram of a complete video output stage for use in a TV-set is given in Fig. 18 on page 38. The circuit application is optimised for handling the output signals from the video processor TDA4780 and TDA4882 in order to drive a flat square black-line CRT, with an EHT of 28kV and a cut-off voltage of 160V.
The signal gain is 40 dB and the output swing is 100Vp-p.
To obtain max. performance, TDA6120Q as well as the pre-amplifier (e.g. TDA4882 or TDA4780) should be mounted on the CRT panel.

7.1 DESIGN-IN SEQUENCE of the TDA6120Q .

To simplify the design-in of the TD6120Q, the design is summarized below:
- determine the cut-off voltage of the CRT (Tube Handbook),
- determine the required video drive for the CRT and the available drive from the colour processor and calculate the signal gain .
- determine the value of the feedback resistor Rf, see section 5.1
- calculate Ri with equation 5-3 given in section 5.2
- calculate Ci with equation 5-4 given in section 5.3
- determine the nominal value of black level of the colour processor,
- calculate reference voltage with equation 5-5, given in section 5.4
- calculate the power dissipation with equation 6-1 and 6-2 , given in section 6.0
- calculate the thermal resistance of the required heatsink with equation 6-3, given in section 6.2

7.2 Printed Circuit Board.

The PCB shown in this report on page 30 is meant for evaluation purposes.
The CRT base socket is JEDEC B10-277. The connectors X1(R,G,B,Vin+,GND) and X2(FbB, FbR, FbG.Iom)) are pin alligned with the connectors of the add-on boards.
The main CRT board of the TDA6120 is constructed with single-sided copper.

To get the optimal signal performance, special attention has to be payed on the following points of the PCB layout.
- keep h.f. current loops as short as possible,
- seperate large and small signal current paths,
- minimize parasitic capacitance, keep hf-signal tracks as narrow as possible,
- use star point grounding, make ground and supply tracks as wide as possible.

- Concerning supply decoupling & Ri/Ci network.
  Because of the very high bandwidth, use low inductance components (SMD) for h.f supply decoupling and the Ci/Ri network.

- Concerning flash-over protection :
The most important thing is that h.f. flash decoupling capacitor (C21,C22,C23=100nF) has to be placed as close as possible between the Vdd line and GND of each TDA6120 and an external high voltage reverse biased diode has to be connected between the OUTC of the TDA6120Q and the Vdd line, with very short leads.
The total current path (diode & capacitor) must be as short as possible, in order to avoid high L.di/dt voltages. See also the position of flash diodes and capacitors given at the PCB layout in Fig.19 .
A detailed example of a correct and incorrect layout regarding flash protection is given in Fig.8a and Fig.9.
The electrolytic capacitor (C16 =10 µF) has to be mounted on the CRT panel, the position on the board is not critical .

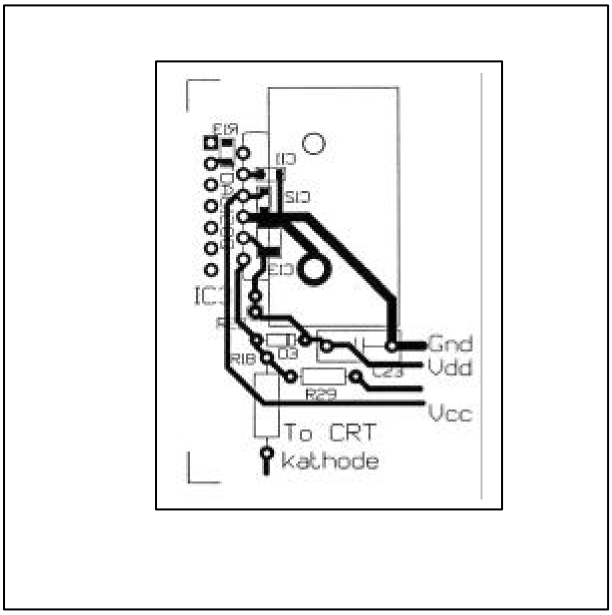


Fig.8a Correct

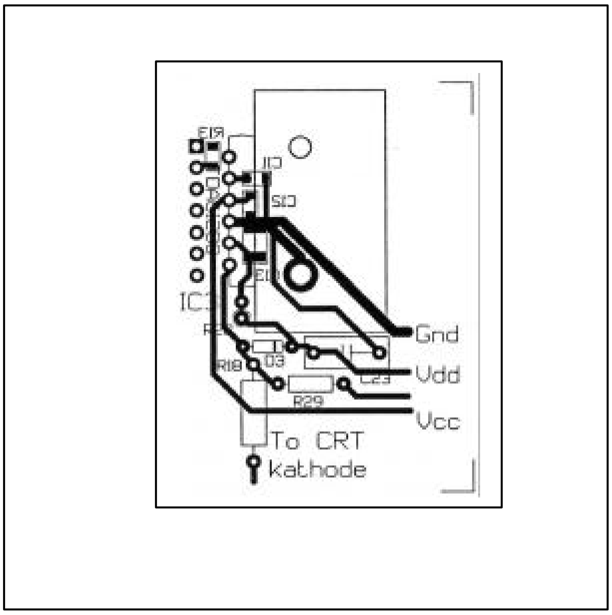


Fig.9 Not correct.

7.3 Crosstalk.

The different parasitic links which induce cross-talk are shown in Fig.10 (2 ampl.)
The parasitic coupling is caused by parasitic capacitances.

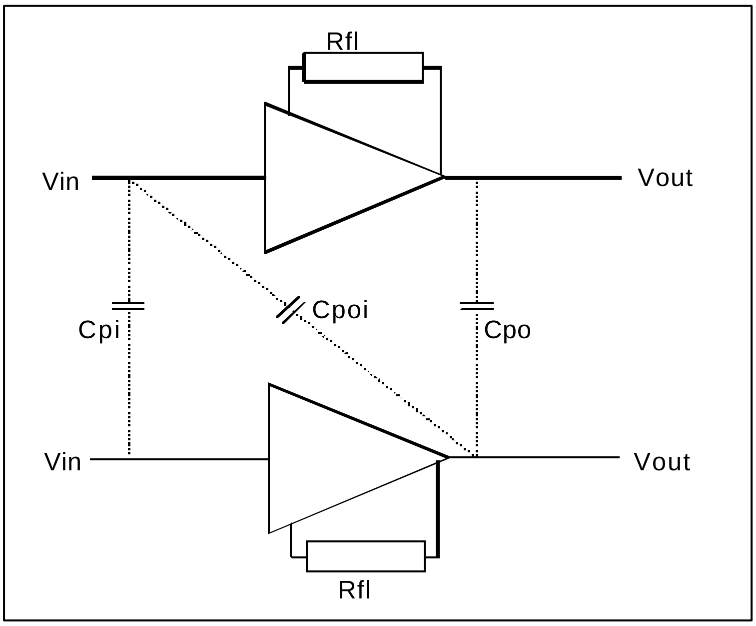


Fig. 10 Parasitic Capacitors.

The cross-talk can be caused by:
- parasitic coupling between the inputs.(Cpi),
- parasitic coupling between the outputs (Cpo),
- parasitic coupling between an output and an input of another channel (Cpoi).

The third type of parasitic coupling is dominant since it involves the coupling of relatively high level output signals with relatively low level input signals.
The parasitic coupling between inputs and outputs must be minimized to achieve an acceptable crosstalk of better than 20dB at 10 MHz.
This can be done by crossing only the input wires and separating the input and output leads.
Large signal components and wires must be laid out as far as possible from small signal wires.
High frequency radiation from the feedback resistors must not induce a voltage signal at the input of another channel. This can be achieved by:
• put enough space between the feedback resistors,
• mount these resistors in the same direction and strictly align one next to the other,
• using ground shields to isolate the input wires.

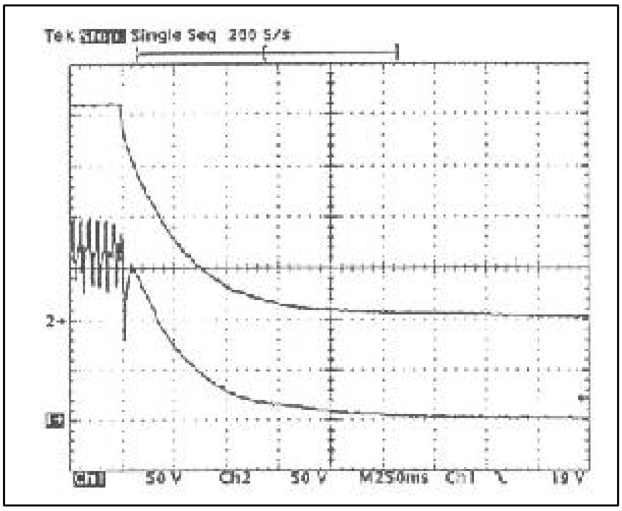
7.4 Switch-off behaviour.

When a TV receiver is being switched-off , several voltages become low.
The cathode output voltage of the TDA6120Q is dependent on the input condition of Vin+ & Vin- , Vcc and Vdd.
The switch-off behaviour of the TDA6120Q is defined and controllable.

There are two types of switch-off behaviour:

7.41 Voutc follows Vdd, after switch off, -Type A-
Voutc=f(t) is shown in fig.11
This kind of switch-off is most generaly used.
The fall time of Voutc is determined by the fall time of Vdd and can be adapted by the value of the decoupling capacitor on Vdd. The minimum value (10µF) is limited by flash over behaviour.

7.42 Voutc is switched to zero, after switch off while Vdd = high, -Type B-.
Voutc=f(t) is shown in fig.12
In this case the Ceht of the CRT will be discharged directly after switch off. This can be a safety requirement of the setmaker for service/repair.



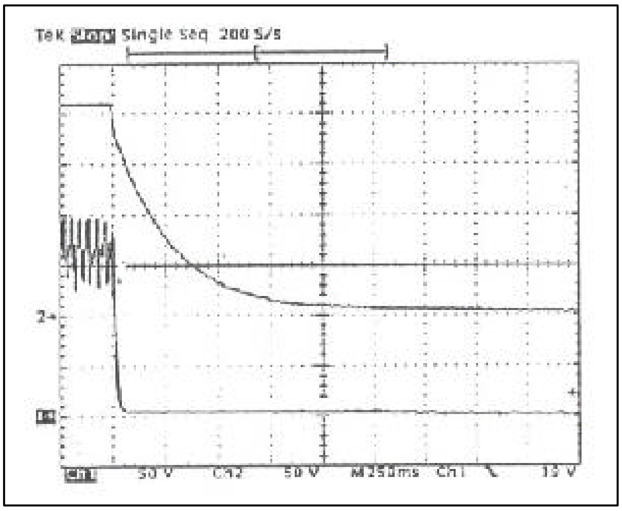


Fig.11
Upper: Vdd= f(t) ,50V/div, 250mS/div.
Lower: Voutc= f(t) ,50V/div, 250mS/div.
Vdd decoupling C16=10µF

Fig.12
Upper: Vdd= f(t) ,50V/div, 250mS/div.
Lower: Voutc= f(t) ,50V/div, 250mS/div.
Vdd decoupling C16=10µF

The 1-> and 2-> markers show the ground level.
1-> for the lower trace and 2-> for the upper trace.

7.5 How to perform the desired (TypA or TypeB) switch-off behaviour with the TDA6120Q

7.5.1 Voutc is switched to zero, after switch off while Vdd = high, -Type B-.
During switch-off, normally, the timing of the low supply voltage (Vcc) is faster than the high voltage supply (Vdd). So, Vdd has a delay w.r.t Vcc.
When Vcc is faster, the switch-off behaviour of the TDA6120Q will show the type B behaviour. This is shown below in Fig.13.
Internally, the current source Idc connected at pin 5(see block diagram Fig.5) is switched-off when Vcc goes down. This current source is derived from Vcc.

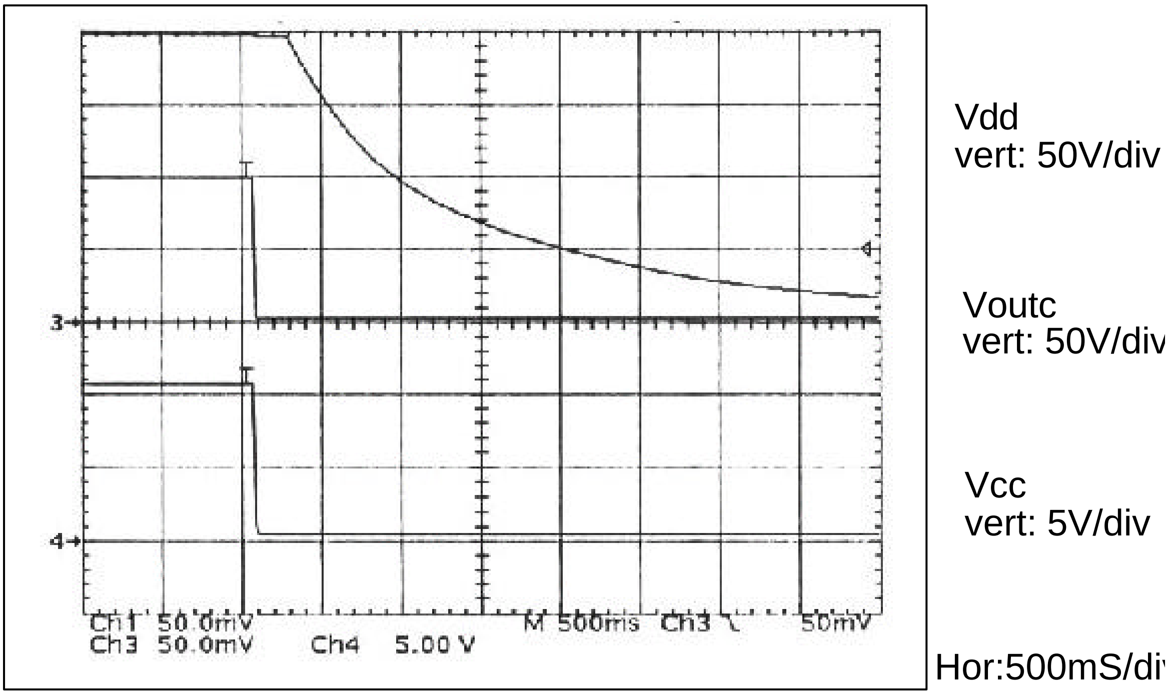


Fig.13 Voutc is switched to zero

7.5.2 Voutc follows Vdd ,after switch off, -Type A-

Type A switch-off behaviour can be obtained if Vcc goes down after Vdd and Vin+>Vin-.
This is shown in Fig.14 .
As can be seen from the curves, the timing of Vdd and Vcc will define the kind of swich-off behaviour.
At the moment Vcc goes down to zero, the switch-off behaviour of type B will be there.
So, at typeA switch-off behaviour, the timing of Vdd and Vcc is very important.

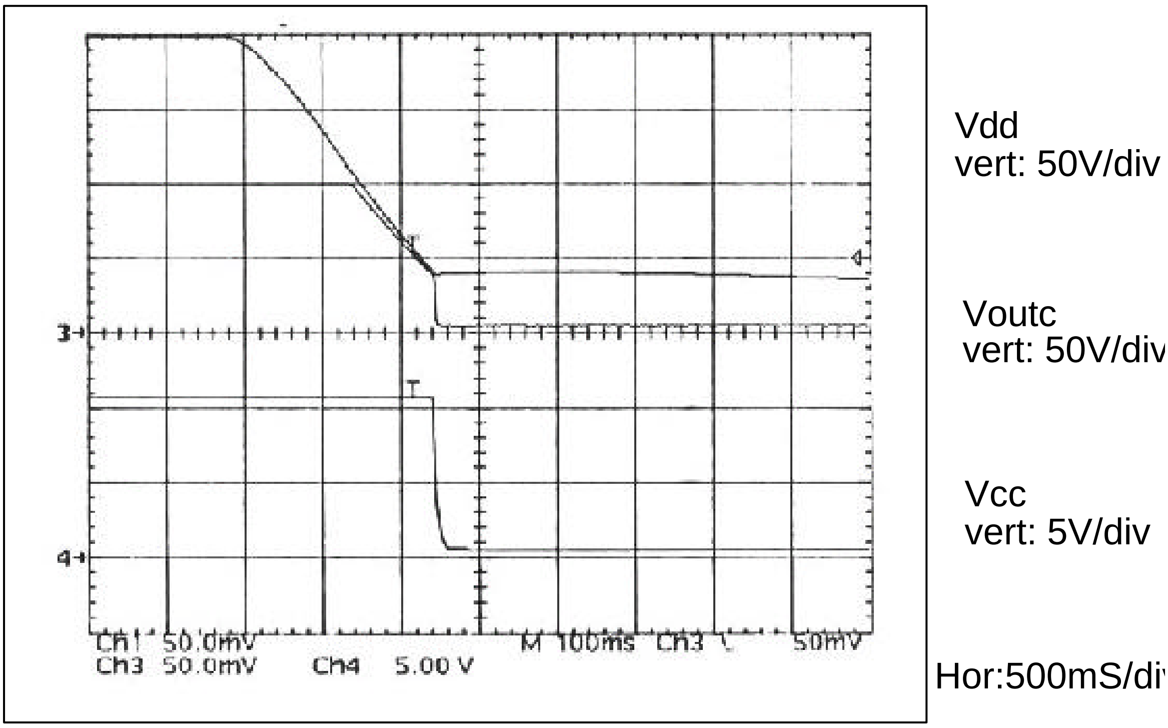


Fig.14 Voutc follows Vdd ,after switch off,

7.6 Flash-over protection.

A picture tube has generally several high voltage discharges in its life time.
During the discharge (flash), an overvoltage can occur on the cathodes. This overvoltage can damage the RGB video amplifier, since it is directly connected to the CRT.
The TDA6120Q needs an external flash protection diode combined with a 50Ω resistor to protect the video amplifier against CRT flash-over discharges. The diode clamps the cathode output voltage to Vdd+Vdiode. To limit the diode current, an external 220Ω carbon high-voltage resistor (Rfl) in series with the cathode output and a 2kV spark gap is recommended. The value of this carbon resistor is a compromise between video bandwidth and flash immunity.

Essential for flash-over protection is the connection between aquadag and main PCB(deflection/supply board). In our concept the aquadag is connected to the sparkgap on the CRT board and from here a connection to the main board. See fig.15.
Furthermore a separate earth wire must be connected from the ground of the CRT board to the line/supply main board.

The max. allowed peak supply voltage during a flash may not exceed 220V.
As the max. operating voltage is 210V, the delta voltage caused by a flash may not exceed 10 volts.
To prevent that the supply peak voltage never exceeds 220V, the value and position of decoupling capacitors is very important.

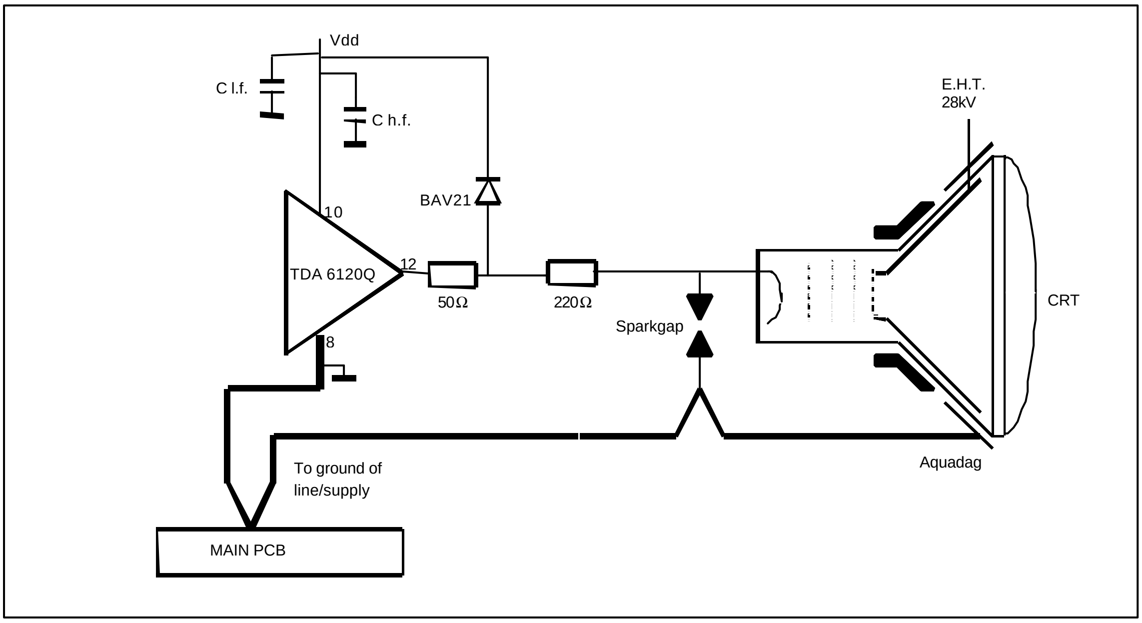


Fig.15 Grounding of aquadag & RGB board.

The following remarks are very important w.r.t. flash protection.

•To protect the TDA6120Q against fast voltage peaks during a low-ohmic flash Vdd must be decoupled with a capacitor >20nF/250V with good h.f properties and placed as close as possible between Vdd and GND, but definitely within 5mm.
This is necessary, otherwise a voltage peak can occur due to the inductance of the long wires between the TDA6120Q pins and the capacitor (V= L di/dt) and this voltage peak can damage the IC.

• For the discharge of the CRT during a high-resistance flash an electrolitic capacitor of ≤10µF/250V is necessary, mounted on the CRT board.

• For the TDA6120Q, external flash diodes have to be applied at each output
The leads of the diodes must be kept as short as possible.

• Ignition level of the sparkgap must be typical 2kV and worst case <4kV.

• Flash resistors must be high voltage carbon composite types (e.g. Allen Bradley)

• To have a short primary flash loop, earth connections of aquadag and sparkgaps are very important.
Connect the aquadag ground via a short wire (and low inductance) to the earth of the sparkgap, and from here with a wire to the ground of the line transformer on the main PCB. The inductance can be made small, e.q. by keeping it close to the surface of the picture tube. The ground of the TDA6120Q must be connected via a separate wire to the ground of the line transformer on the main board. The wire diagram is shown in Fig. 15 .

• Grid G1 connection.
In a lot of applications, grid G1 can be directly connected to aquadag ground.
In that case the flash resistor can be omitted in the G1 connection to create a permanent low impedance path for the flash current and thus better protect the cathodes , with the video output amplifiers.
The direct aquadag grounding of G1 can't be applied when measuring the EHT info, this will be discussed in the next part.

7.6.1 Flash -protection for alternative aquadag grounding.

The basic application described in this report is designed for an application in which the beam current of the EHT is measured by using a "beam current " capacitor C_{bc} in the line output stage.
In that case, the lower side of the EHT transformer is not connected to ground (for instance the TDA837X & supply demonstration kit of PS-SLE).
Therefore, special attention has to be given to flash-over behaviour.
The simplified circuit diagram is given in Fig.16.

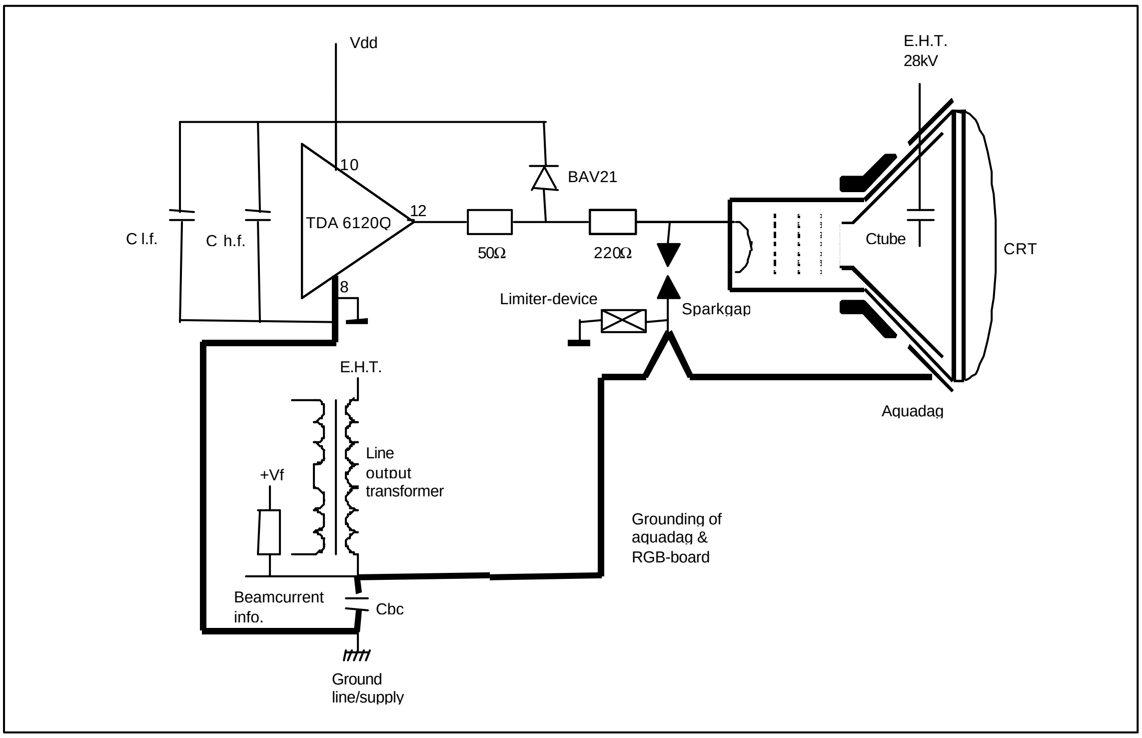


Fig.16 Alternative aqua grounding.

In case of a high resistance flash the current is low and the sparkgap does not ignite. During that flash the aquadag capacitor C_{tube} is discharged and the charge will transfer via Rfl and the internal flash diode to the capacitors Cl.f. // Ch.f. and Cbc.
The available charge of Ctube will be distributed across these capacitors.
When C_{tube}= 4 nF, Cbc=22nF and Cl.f.=10 µF the capacitor Cbc is charged at a level of several kilo Volts with a negative polarity w.r.t supply ground.
At a level of 2kV the sparkgap ignites and the voltage over Cbc will be present on the output of the TDA6120Q, resulting in a damaged IC.
To prevent this, a suppression/limiter device (zenerdiode + a series diode) or VDR has to be placed from the aquadag wire (lower side of the sparkgap) on the CRT board to supply ground. This is shown in Fig.16 (limiter device).
The suppression device must be a medium power type to handle the flash currents.

More detailed information about flash protection is given in the Appendix of the application note AN95064(see reference) .

7.7 Black current stabilisation.

The most simple application of the TDA6120Q in an automatic black current set-up in conjunction with the video processor TDA4780 is shown in Fig. 17 .
The black current stabilisation loop is an automatic control loop which stabilises the black current of each channel sequentially and independently every field.
The loop is active for a four line period , immediately after the end of the field blanking. During field scan (outside the 4L black current measuring time) , the normal video current flows in the ABS feedback path.
To prevent that high video currents will flow in the TDA4780 black current input, the voltage on pin 7 of the TDA6120Q is limited by an internal built in zener diode of 20V.
The TDA4780 has I^2C bus adjustments for the white point, the gain and colour balance in the 10µA region, therefore no adjustments are required for gain and black setting at the TDA6120Q application.
The black current input of the TDA4780 is a low impedance current driven input with leak current compensation.

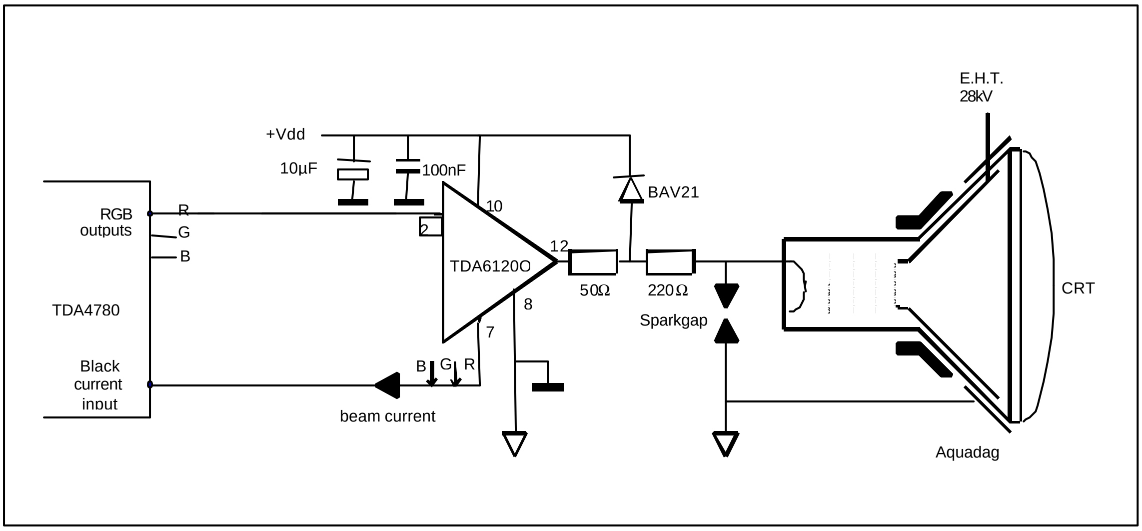


Fig.17 Basic ABS application with the TDA6120Q and TDA4780.

8.0 PERFORMANCE EVALUATION.

The evaluation board has been designed to obtain the best results.
To evaluate the h.f performance , the best way is to measure outside the TV set by driVin-g the amplifier by an h.f. generator or network analyzer.
The "passive' add-on board (see appendix) can been used as interface between the generator and the TDA6120 main board.
The flash behaviour has to be examined in a TV set. In this situation the TDA6120Q as well as the application are tested.

Measurement conditions for h.f. :

The schematic diagram of the h.f measurement set-up is shown in Fig 20 on page 41.
- High voltage supply Vdd=200V
- Biasing: Voutc(DC)=100V
- AC Gain: 40 dB
- Ioutm(pin7) is decoupled with a capacitor of 100nF to ground.
- Loading: see curves
- All measurement results include a flash resistor of 220Ω and Ct=5pF
  Ct is the cathode capacitance of the CRT.
  The total load capacitance Cl_{total}, including Csocket, Csparkgap, Cdiode and the parasitic capacitances of the PCB , will be about 10pF.
  The value of the flash resistor is a compromise between flash-over behaviour and bandwidth.

Measurement Results:

8.1 Bandwidth.

The measurement set-up is given in Fig.20 on page 41.
The curves in Fig.23 and 24, on page 43, show the frequency response with 60Vp-p and 100Vp-p output voltages at optimal Ci.
Rfl=220Ω and Ctube 5pF (total load capacitance about 10pF.
Bandwidth at 60Vp-p, amounts to 41.5 MHz. (-3dB)
Bandwidth at 100Vp-p, amounts to 40 MHz. (-3dB)
In Fig.25 the small- signal bandwidth is shown at different values of Ci.

8.2 Multi-burst performance.

In Fig.26 the multi-burst performance of the TDA6120Q is shown at Vout = 60Vp-p.
The multi- burst frequencies are 2,5,10,15,20 and 25MHz.

8.3 Cross-talk.

The measurement set-up is given in Fig.21 on page 41.
A sine wave input signal is injected in one channel and the output signal of one of the other channels is measured.

$$\text{Cross-talk} = 20 \log \frac{\text{Voutc (drive channel)}}{\text{Voutc (one of the other channels)}} \quad \text{[dB]}$$

The curves given in Fig.27, 28 and 29 on page 45 and 46 show the cross-talk of this application board at which Voutc= 60Vp-p .The worst value at 20 MHz is 26dB.
The cross-talk is not the same for the six different combinations of the three channels.
In table 2 on page 46 the cross-talk is given of the six combinations at f=20 MHz.

8.4 Rise and fall time.

The curves Fig.31 and 32 on page 47 and 48 respectively show the rise and fall time at 100Vp-p output signal of the red channel.
Typ. value Tf= 12.1 nSec. at 100Vp-p, with Rfl=220Ω, Cl=10pF and Ci=39pF
Typ. value Tr= 10.8 nSec. at 100Vp-p, with Rfl=220Ω, Cl=10pF and Ci=39pF
The fall/rise time of the input signal is 10nSec.
In Fig.30 the pulse response and overshoot is shown at the same conditions.
Table on page 48 shows the fall and rise time at 100Vpp and different values of Ci.
Table on page 48 shows the fall and rise time at 125Vpp and different values of Ci.

8.5 Flash test.

Fig. 22 on page 42 shows the test set-up applied for flash-over tests by Philips.
With this test, the TDA6120Q as well as the application are tested.

Test conditions:
TV set with 33 inch soft flash picture tube, Veht=28 kV.
So the total available charge will be Q= Ctube.Veht = 3.5nF. 28kV= 100 µC.
Number of flashes: 50

8.5.1 High-resistance flash.

During high resistance flashes , the sparkgap does not ignite and the total charge transfers via the flash resistor Rm, Rfl and the flash diode into the electrolytic decoupling capacitor of Vdd.
Where Rm is the simulation of the arc resistance in the CRT between g4 and the cathode.
In practice , the minimum value of Rm at which the sparkgap does not ignite is :

$$Rm = \frac{Rfl(Veht - V(spark)}{V(spark)} = \frac{220\Omega.\ (28-4)kV}{4k\Omega} = 1k3$$

with:
Vign of the sparkgap is worst case (4kV), Veht=28kV and Rfl=220Ω.

Under given conditions, the peak current amounts to Veht / (Rm+ Rfl)=
28kV / (1k3+220Ω)= 18.6 A.
At the high resistance flash-test, switch S1 is closed (Rfl=0 Ω), which means that the sparkgap can not ignite.
To test at various values of flash currents, the value of Rm has to be adapted.

8.5.2 Low -resistance flash.

During low-resistance flashes , S1 is open, the sparkgap ignites and only a little charge (during the first part of the flash) tranfers via the flash resistor Rfl and the flash diode into the h.f decoupling capacitor of Vdd.
Very fast peak voltages can occur on the Vdd pin of the TDA6120Q , the h.f. capacitor has to prevent the device for these peak voltages.
At a low-resistance flash , the resistor Rm (equivalent of the arc of the CRT) is typical 400Ω and worst case 200Ω for a soft flash picture tube.

9.0 ACKNOWLEDGMENT.

This project was done with help of students of Technical College Ede during the practice period.
The students involved are:

G.J. v. Holland	PCB layout, schematics and demo board assembly
L. v. Zanten	Measurements, schematics and demo board assembly

10. REFERENCES.

1) DATA SHEET TDA6120Q.
2) DATA SHEET TDA4780
3) DATA SHEET TDA4882
4) Soft-flash colour tubes, PHILIPS COMPONENTS Technical publication 253
5) Flashover in picture tubes and methods of protection. - By A. Ciuciura.- The Radio and Electronic Engineer, Vol.37, No3, March 1969.
6) Application and product description of the TDA6106Q video output amplifier. -AN 95064- By: E.H Schutte.
7) 22 Mhz Video amplifier for large jumbo picture tubes . -AN95008- By: J.J Hekker.
8) Video amplifier for HR monitor with TDA4882 and TDA6120. -AN9507- By: J.J Hekker.
9) Video amplifiers for VGA/XGA monitors. -ETV93001- By: H.J.S. Aben.

11 APPENDIX

1) Imperfections of the TDA6120Q.

2) "Passive" interface add-on board.

3) Application TDA4882 add-on board.

4) Application TDA4780 add-on board.

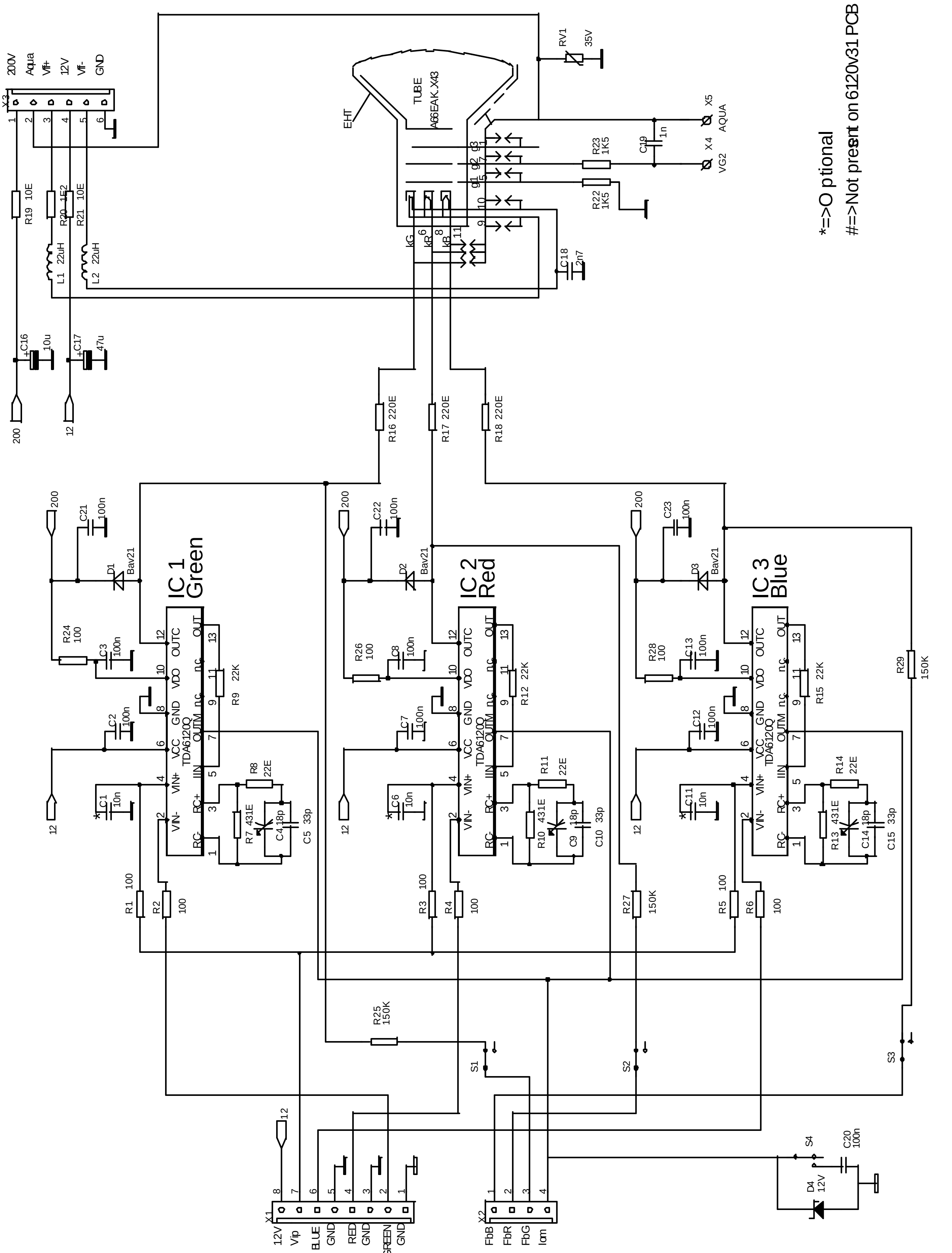
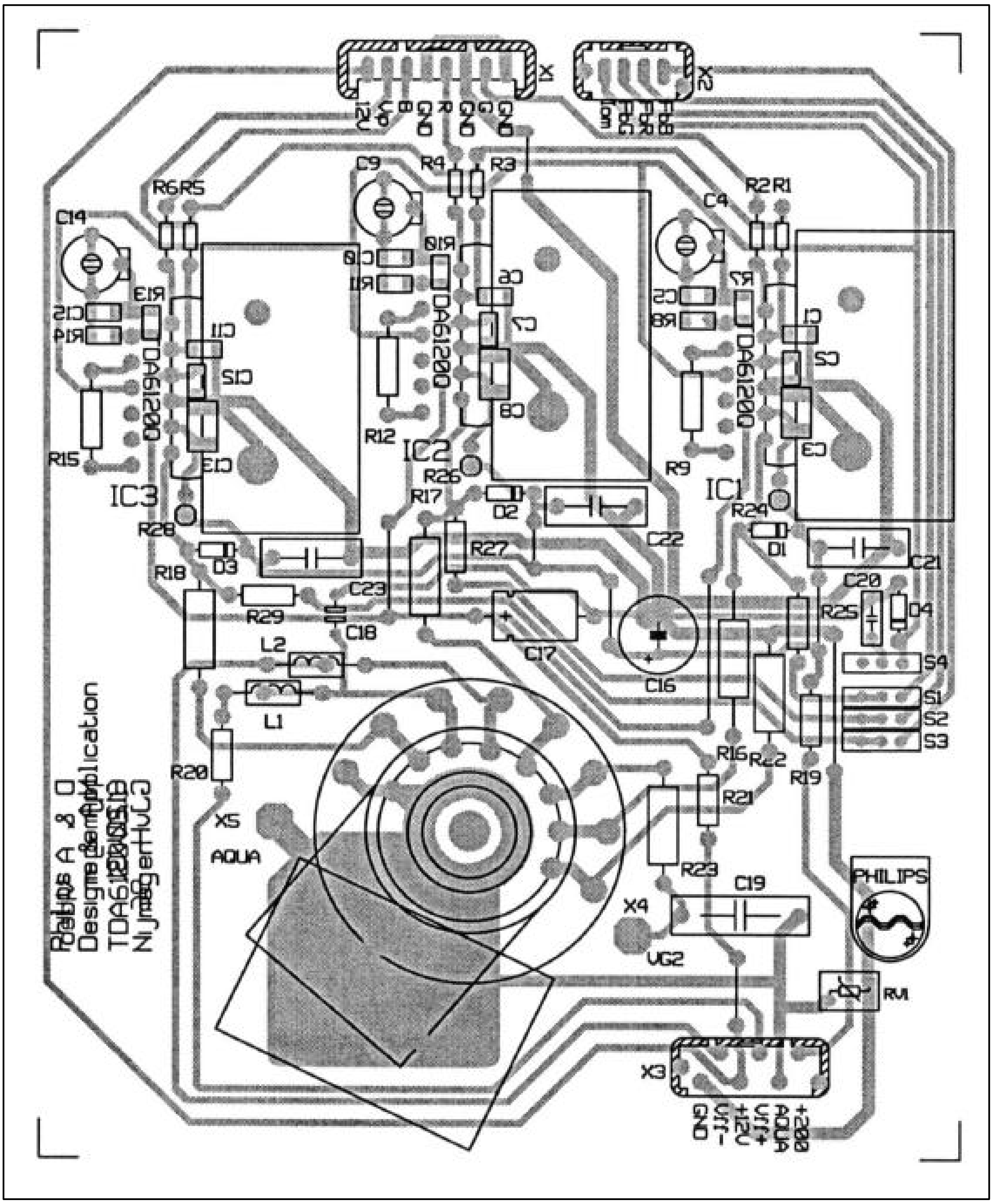


Fig. 18 Application diagram of the TDA6120Q.

PART LIST.

Position no.	VALUE	RATING	TYPE
Integrated Circuit(s)			TDA6120Q
Capacitors			
C1,C6,C11	10nF		SMD
C2,C7,C12	100nF		SMD
C3,C8,C13	100nF		SMD
C5,C10,C15	33pF		SMD
C4,C9,C14	18pF		Adjustable capacitor
C16	10µF	250V	Electrolytic
C17	47µF	16V	Electrolytic
C18	2n7	500V	Ceramic plate
C19	1nF	2000V	MKT
C20	100nF	64V	MKT
C21,C22,C23	100nF	250V	MKT
Resistors.			
R1,R2,R3,R4,R5,R6	100Ω		SFR16T
R7,R10,R13	430Ω		SMD
R8,R11,R14	22Ω		SMD
R9,R12,R15	22kΩ		2W- PR02
R16, R17,R18	220Ω		High V. Allen Bradley -1/2 W
R19,R21	10Ω		NFR25
R20	1.2Ω		NFR25
R22,R23	1k5		High V. Allen Bradley -1/2 W
R24,R26,R28	100Ω		NFR25
R25,R27,R29	150kΩ		SFR16T
R30,R31,R32	50Ω		SFR16
Diodes			
D1,D2,D3			BAV21
D4	12V		BZX79C12
VDR			
RV1(Varistor)	35V		
Special parts			
X1			8-pole connector
X2			4-pole connector
X3			6-pole connector
Picture tube socket, with integrated sparkgaps			EDEC B10-277



Scale: 1:1

Fig.19 TDA6120Q Evaluation board layout & components view.

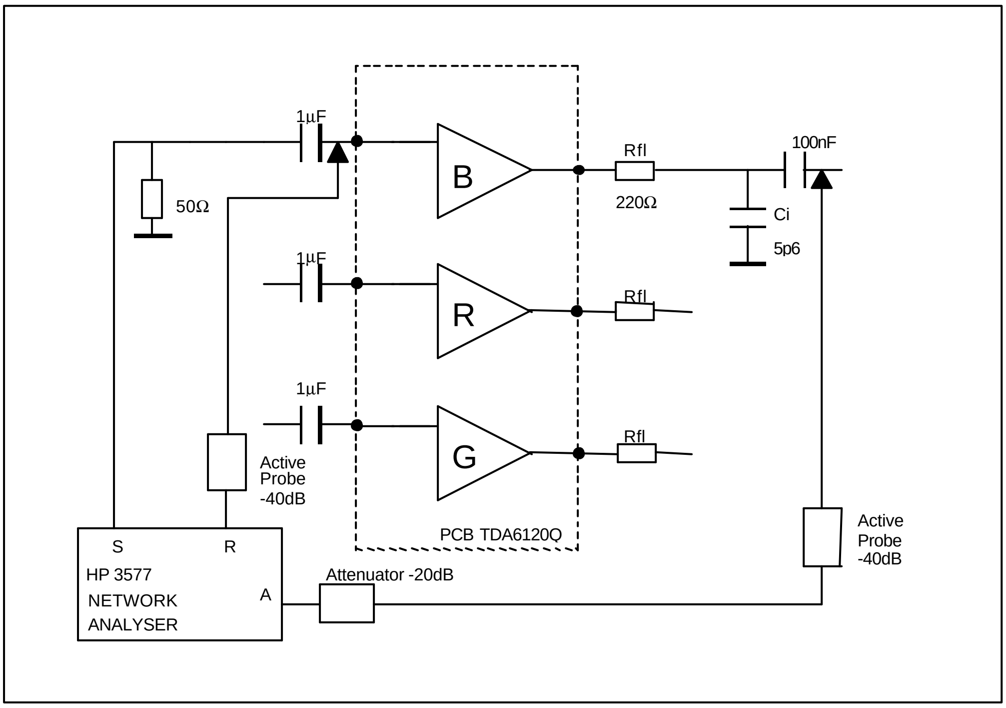


Fig.20 Bandwidth measurement set-up

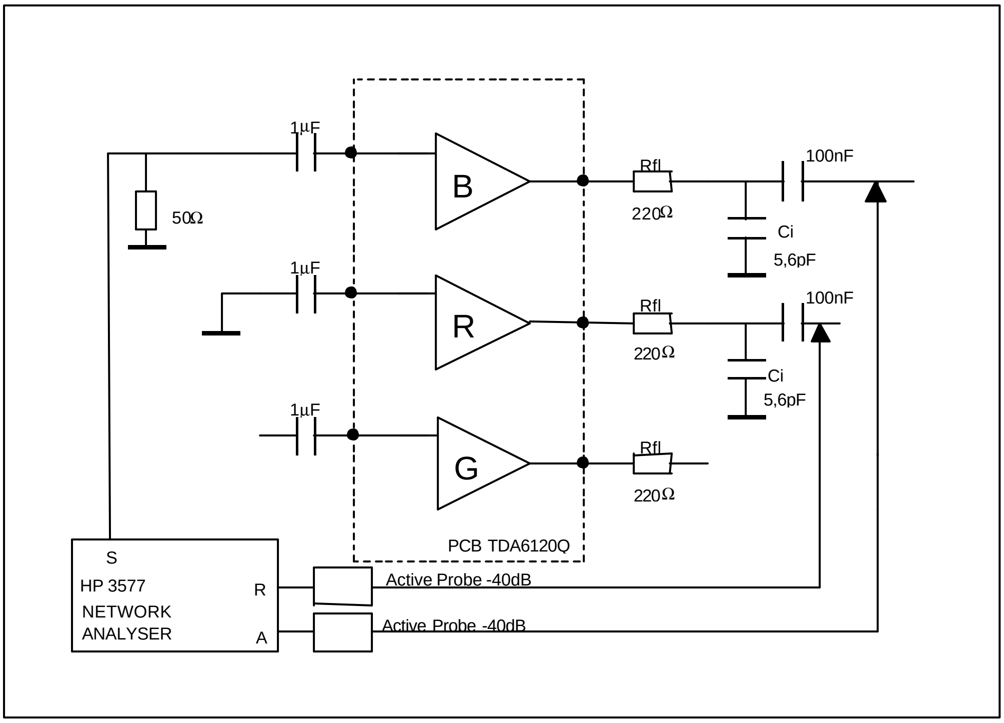


Fig. 21 Crosstalk measurement set-up

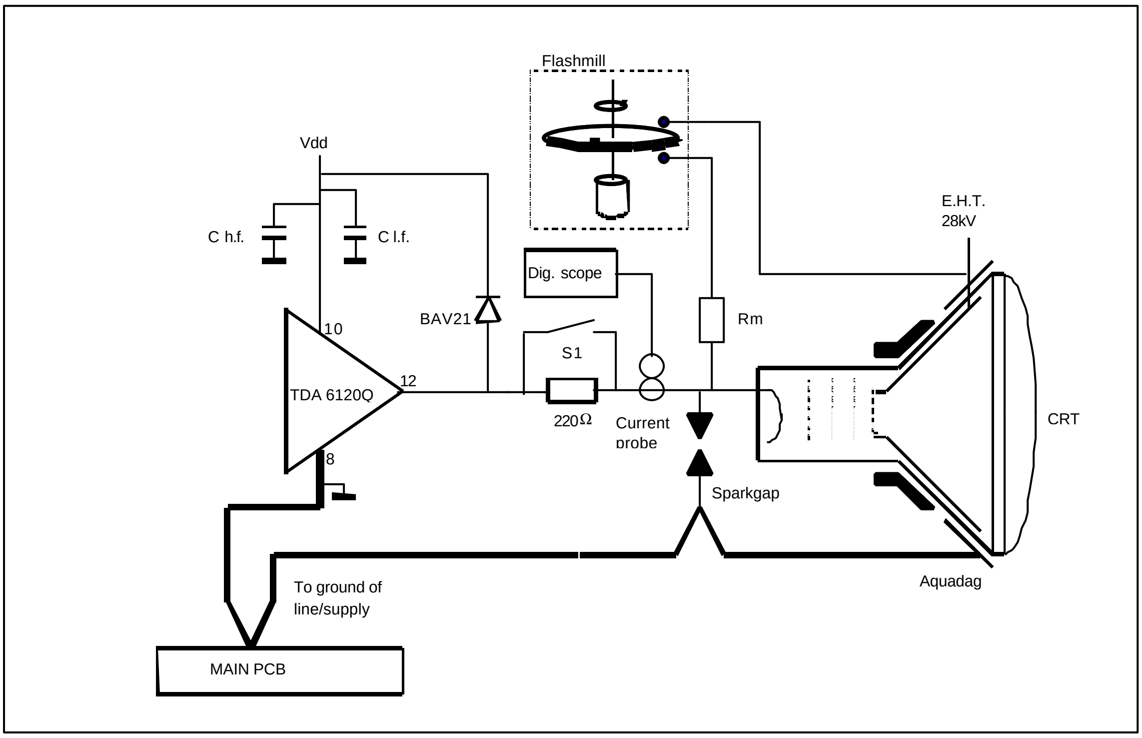


Fig.22 Flash-over test set-up.

Rfl = 220Ω

The value of Rm depends on type of test (200Ω -10kΩ) and is built with resistors in series.
Type: Allen Bradley - high voltage.
Rm is the simulation of the arc resistance in the picture tube between the EHT and the cathode.

vert. : 3dB/div
Gain[dB]

Measuremnt
after Rfl

Rfl=220Ω
Cload=10pF
Ci=39pF

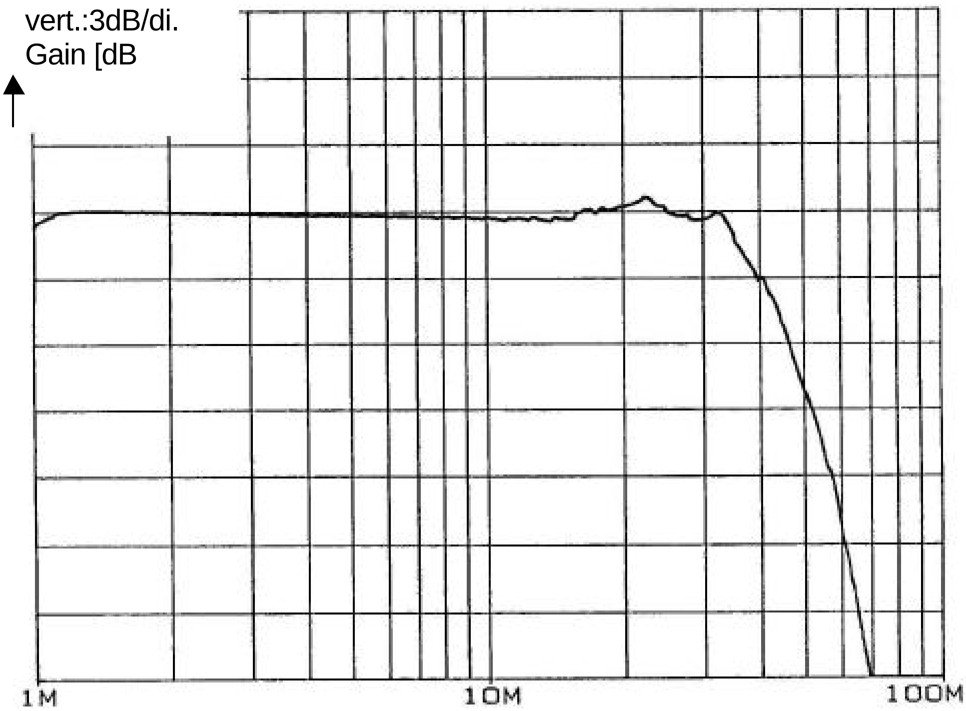
Vdd=200V
Voutc-dc=100V

Voutc-ac=60V

------->
f [Hz]

Fig.23 Small signal bandwidth of the TDA6120Q

vert.:3dB/di.
Gain [dB



Measurement
after Rfl

Rfl=220Ω
Cload=10pF
Ci=33pF

Vdd=200V
Voutc-dc=100V
Voutcac=100V

-------->
f [Hz]

Fig.24 Large signal bandwidth of the TDA6120Q.

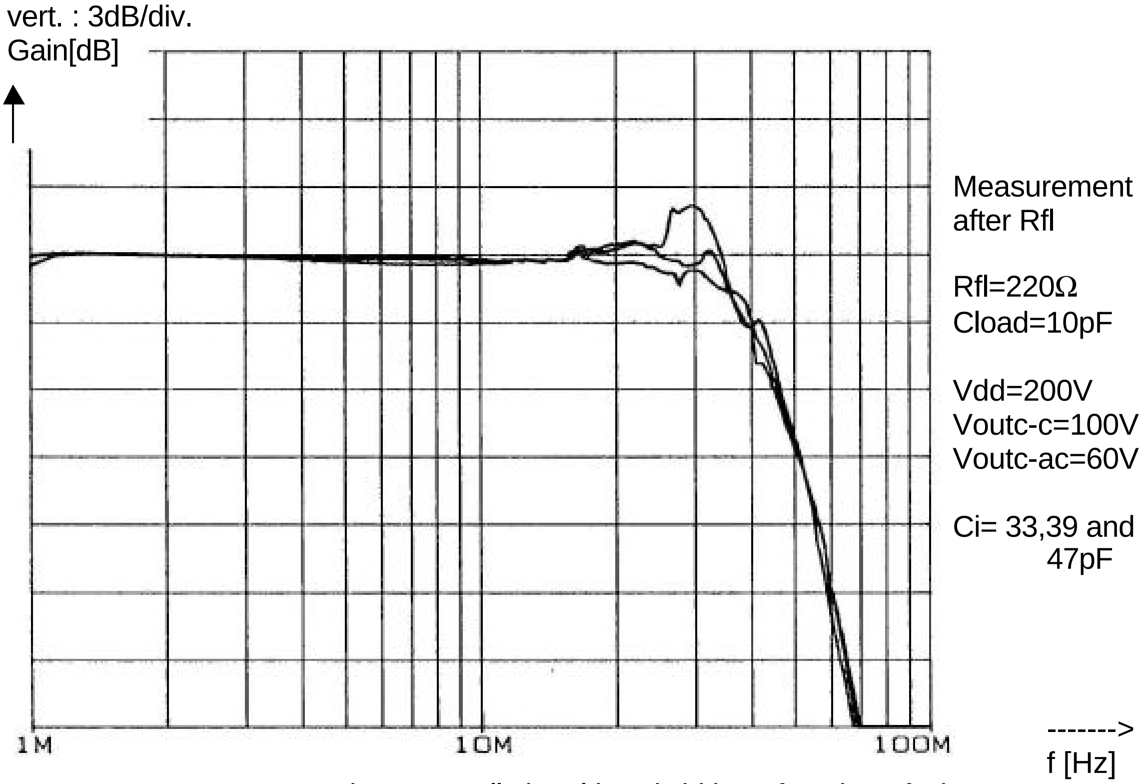


Fig.25 Small signal bandwidth as function of Ci .

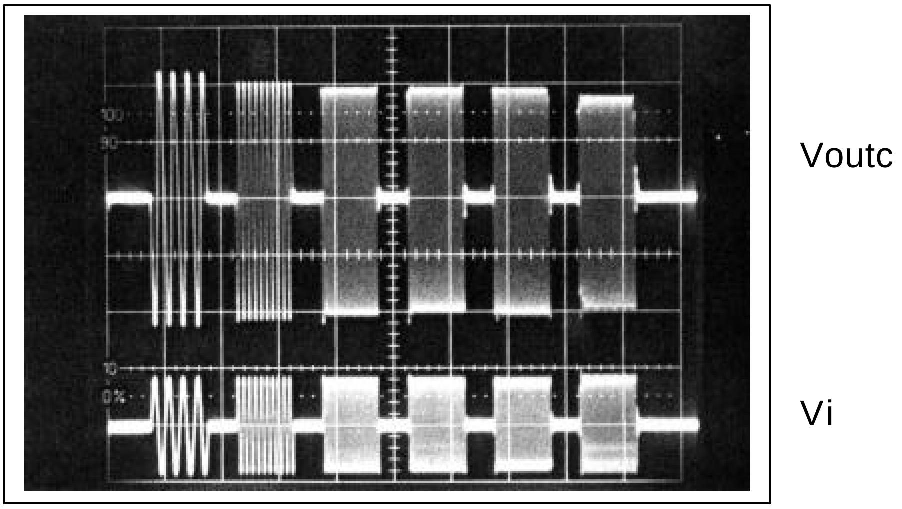


Fig.26 Multi-burst performance of the TDA6120Q.
Voutc-dc=100V, Voutc-ac=100Vpp, Ci=optimal=33pF
f= 2,5,10,15,20 and 25MHz

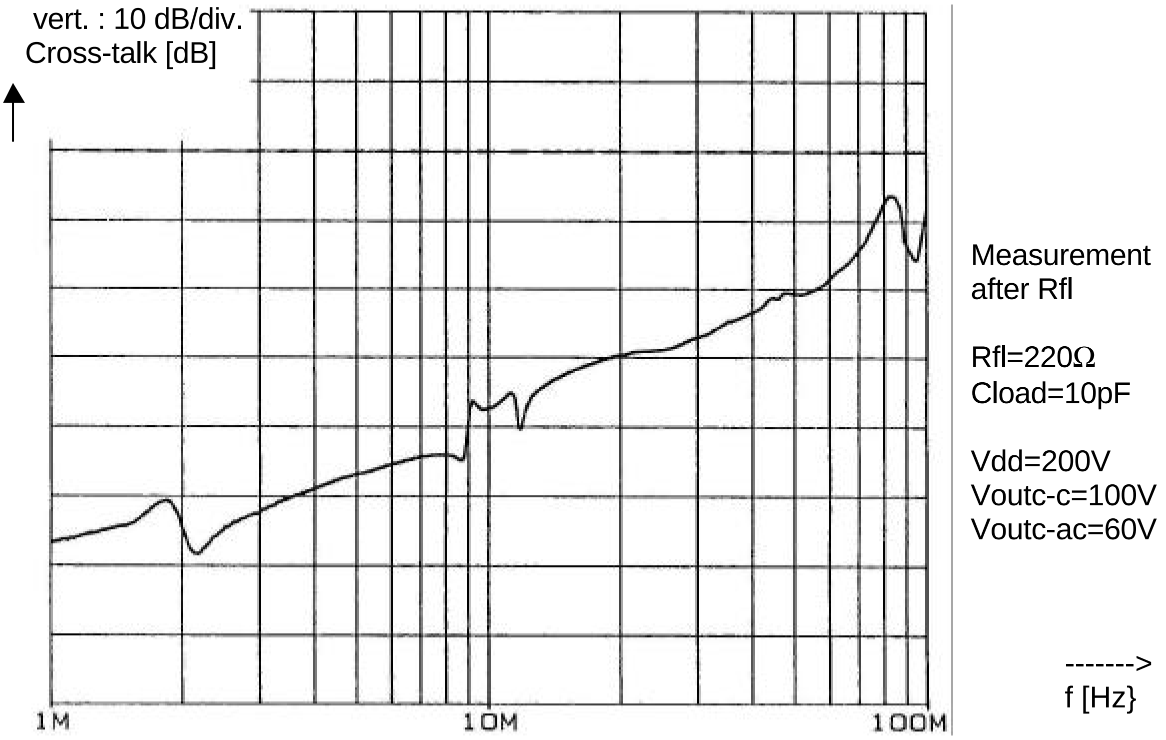


Fig.27 Crosstalk behaviour of the TDA6120Q - source= R, crosstalk=B

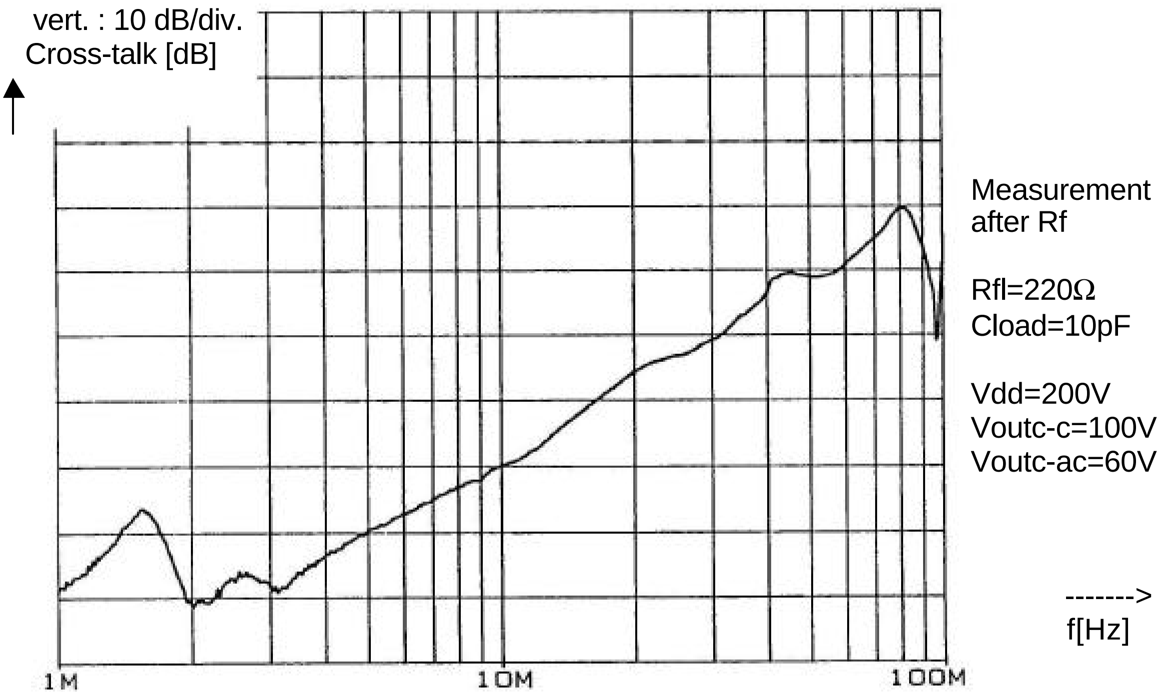


Fig.28 Crosstalk behaviour of the TDA6120Q - source= G, crosstalk=B

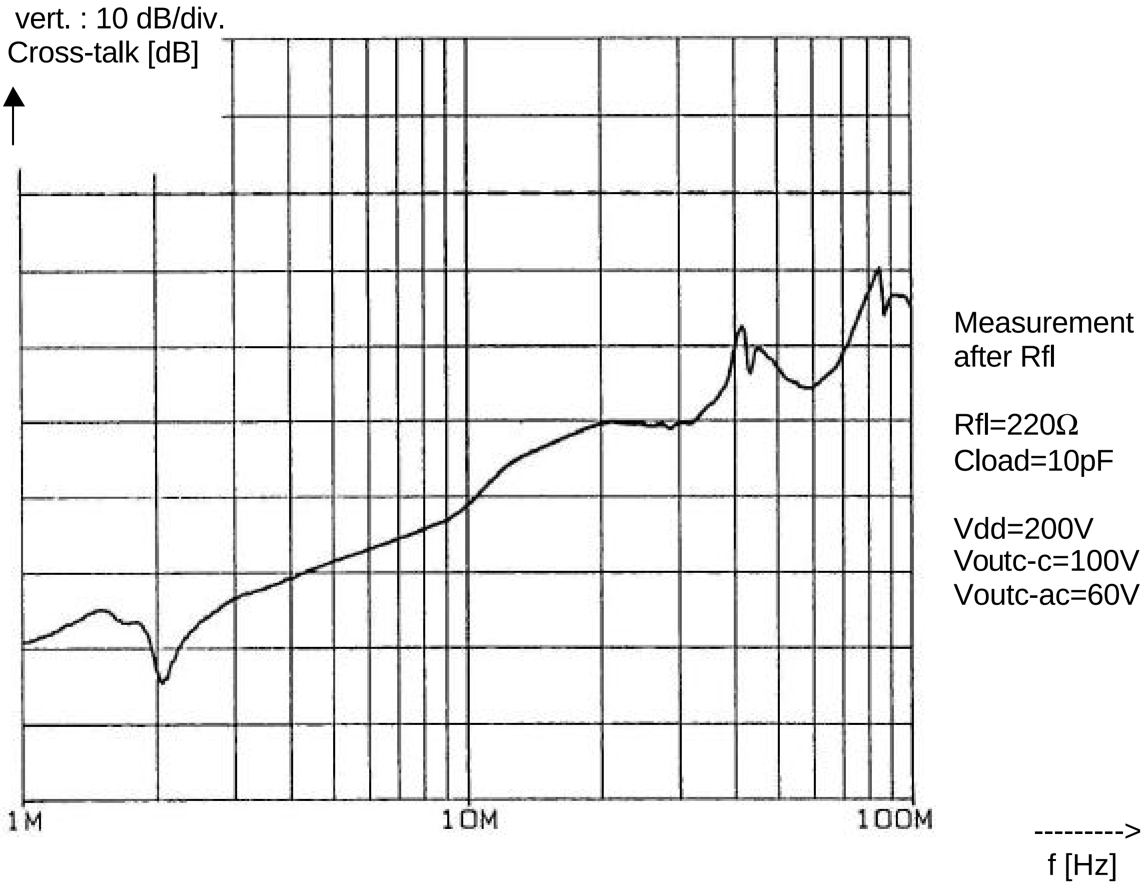


Fig.29 Crosstalk behaviour of the TDA6120Q - source= G, crosstalk=R

	Crosstalk Blue	Crosstalk Red	Crosstalk Green
Signal Blue	X	26dB	27dB
Signal Red	30dB	X	28dB
Signal Green	35dB	30dB	X

Table 2 Crosstalk at a frequency of 20 MHz.

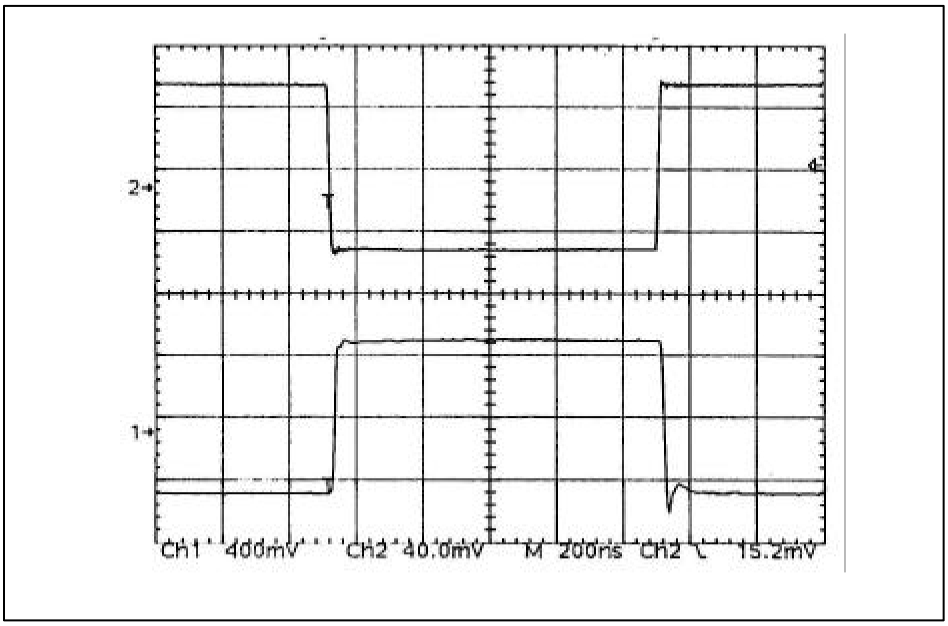


Fig.30 Pulse response of the TDA6120Q at Voutc= 100Vp-p
Measured with Rflash = 220Ω , Cl=10pF, Ci=39pF
Hor: 200nS/div Vert: upper Vi=0.4V/div , lower Voutc=40V/div.

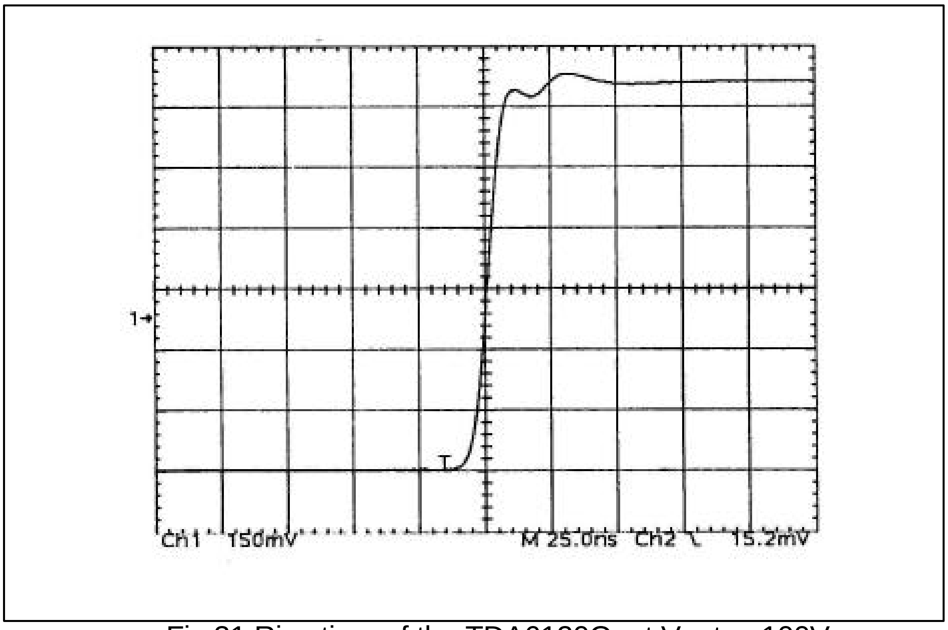


Fig.31 Rise time of the TDA6120Q at Voutc= 100Vp-p
Measured with Rflash = 220Ω , Cl=10pF, Ci=39pF
Hor: 25 nS/div Vert: 15V/div

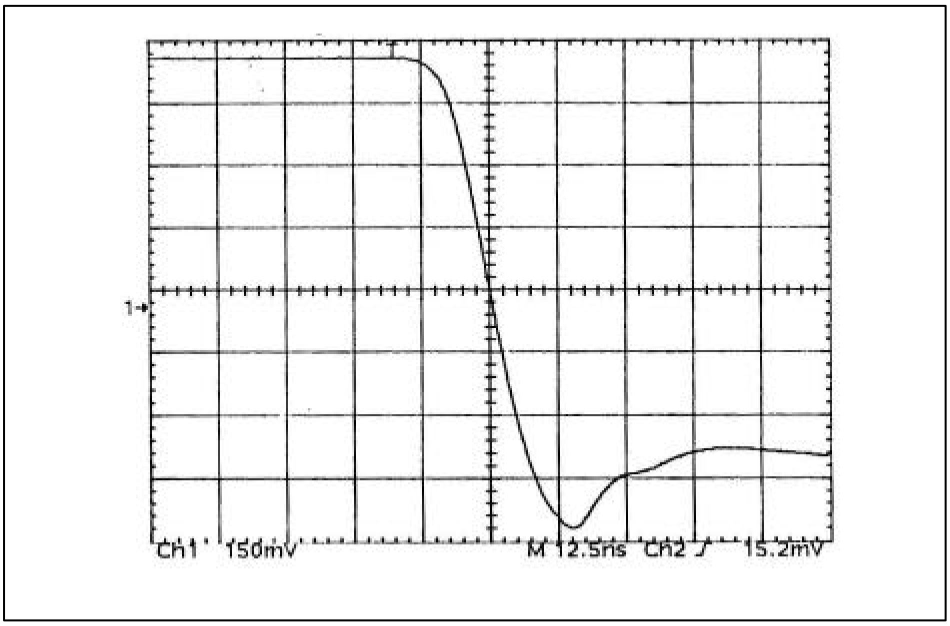


Fig.32 Fall time of the TDA6120Q at Voutc= 100Vp-p
Measured with Rflash = 220Ω , Cl=10pF, Ci=39pF
Hor: 12.5nS/div Vert: 15V/div

Voutc=100Vpp	Trise [nSec]	Tfall [nSec]
Ci=33pF	12.9	12.3
Ci=39pF	10.8	12.1
Ci=47pF	9.8	12.2

Table 3. Rise/Fall time=f(Ci) of the TDA6120Q at Voutc= 100Vp-p
Measured with Rflash = 220Ω , Cl=10pF

Voutc=125Vpp	Trise [nSec]	Tfall [nSec]
Ci=33pF	13.4	14.3
Ci=39pF	11.8	14.6
Ci=47pF	12.6	14.9

Table 4. Rise/Fall time=f(Ci) of the TDA6120Q at Voutc= 125Vp-p
Measured with Rflash = 220Ω , Cl=10pF

APPENDIX 1

IMPERFECTIONS OF TDA6120Q.

• Flash performance.
To obtain sufficient flash performance, the TDA6120Q/N1 needs a small series resistor of 50Ω in the output (pin12).
In that case, it is allowed to apply a maximum operating voltage of 210V.
For that resistor a low cost 0.5 watt resistor (SFR16) can be applied.

Note.
These resistors are not present on the evaluation PCB.

• Current measurement output.
The measurement output IOUTM is fully functional up to a junction temperature of 125^{o}C i.s.o 150^{o}C.
Furthermore the offset current is too high.
The nominal value is 20µA with a minimum value of -40µA and a maximum value of +120µA (see DATA sheet).
For three amplifiers in parallel this becomes a high value.
This offset current is constant, so if the dynamic range of of the Automatic Black-current Stabilisation (ABS) is large enough, this offset current will be seen as a large leakage current , so if the offset current can be compensated, the ABS loop will work satisfactory.
Furthermore , the lower side of the operating window is rather high, 4V>Voutm>20V, and does not fit optimal with the TDA4780.

• ESD
The maximum allowable ESD voltage for the N1 is 2000V HBM and 300V MM, except for pin 5.
For pin5 holds: HBM, 1250V and for MM 300V.

• Distortion.
A sinusoidal signal shows distorsion at frequencies above 8MHz.

APPENDIX 2

• INTERFACE - add-on board •

This board can be applied to drive the TDA6120 directly from a testpattern generator or a waveform generator.
In that case the real TDA6120Q performance can be tested.
The board fits with the CRT main board and can be used as plug-in board.
This add-on board is constructed with double-sided copper.
The schematic diagram is given in Fig.A2-1
The layout and components view is shown in Fig.A2-2

Two modes are available:
• wave signal mode
• testpattern mode.

Wave signal mode.

Switch settings:
- Set S1,S2,S3 in 50Ω position,
- Set S7 in on position (voltage divider R17,R17 active)
- Set S4,S5,S6 in 2k2 position.

In this mode the input impedance is 50Ω.
The input signals from connector X2,X3 and X4 will be set to a dc level of about 4V, which are availabe at pin 2,4,6 of connector X1.
By means of the potentiometer R13 the dc level of Vin+ (Vref) can be adjusted and is available at pin 7 of connector X1.

Testpattern mode.

Switch settings:
- Set S1,S2,S3 in 75Ω in position,
- Set S7 in off position,
- Set S4,S5,S6 in diode position,
- Apply a positve keying pulse of >6.5V to connector X5.

In this mode the input impedance is 75Ω.
During the active keying pulse the input signals from connector X2,X3 and X4 will be clamped to a dc level of about 4V,(during the back porch of the line sync. pulse).
The clamped RGB signals are availabe at pin 2,4,6 of connector X1.
By means of the potentiometer R13 the dc level of Vin+ (Vref) can be adjusted and is available at pin 7 of connector X1.

APPENDIX 2

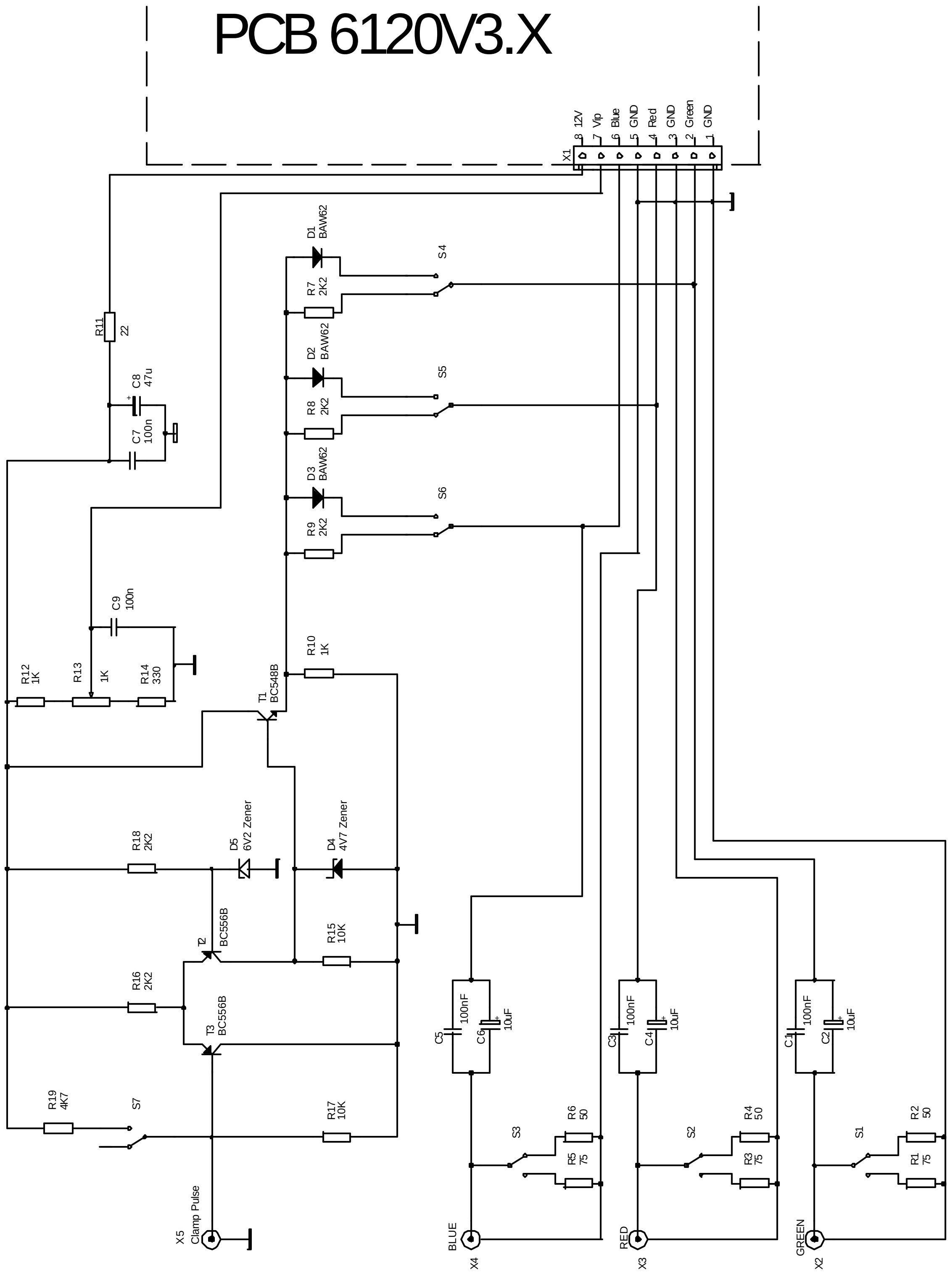
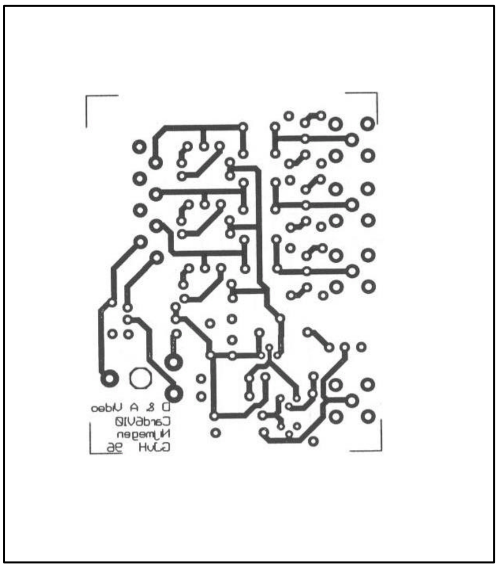
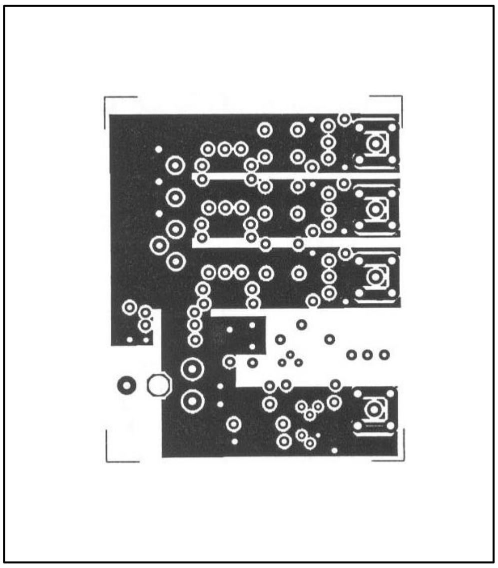
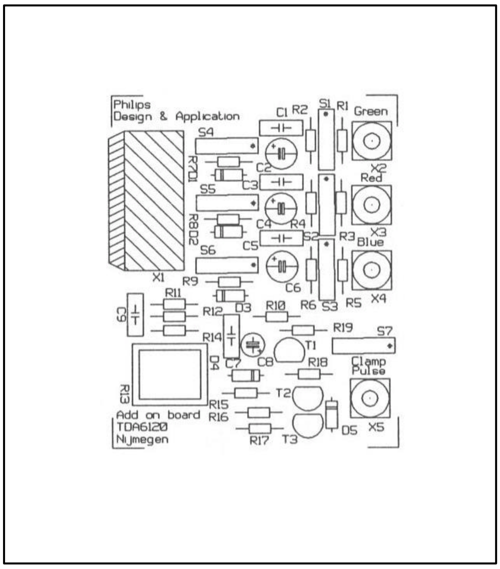


Fig. A2-1 schematic diagram " passive interface card"

APPENDIX 2







scale: 1: 1

Fig.A2-2 •Interface card - layout & components view •

APPENDIX 2

-PART LIST-
-PASSIVE INTERFACE CARD-

Component	Value	Type
Resistors.		
R1,R3,R5	75Ω	SFR16
R2,R4,R6	50Ω	SFR16
R7,R8,R9,R16,R18	2k2	SFR16
R10,R12	1kΩ	SFR16
R11	22Ω	SFR16
R13	1kΩ	potm.
R14	330Ω	SFR16
R15,R17	10kΩ	SFR16
R19	4k7	SFR16
Capacitors.		
C1,C3,C5,C7,C9	100nF	MKT
C2,C4,C6	10µF/16V	elco
C8	47µF	
Diodes.		
D1,D2,D3		BAW62
D4	2V4	BZX79/2V4
Transistors		
T1		BC548
T2,T3		BC556

APPENDIX 3

•TDA4882 ADD-ON BOARD •

CONTENTS.

INTRODUCTION.

This board equipped with the TDA4882 can be applied as pre-amplifier to drive the TDA6120Q.
The TDA 4882 is a RGB pre-amplifier for colour monitor systems with super VGA performance. A complete product description is given in the DATA sheet.
By using this combination , the concept is suitable for monitor applications.
The combination has a total bandwidth of 30-60 MHz , depending on the cathode output swing requirement and is suitable for VGA, SVGA and XGA applications.
The schematic appication diagram is given in Fig.A3-2
The PCB layout is shown in Fig.A3-3
This add-on board fits with the TDA6120Q CRT main board and can be used as plug-in board , the connectors are pin aligned.
During the application evaluation period of this project, the TDA4885 be came available.
All funtions are the same as the TDA4882. Redarding the interface between the TDA4885 and TDA6120Q the output levels of the TDA4885 fits much better.

Note.

For more details of the TDA4882 , see DATA sheet TDA4882 and application note ETV93001 (see reference).

ADDITIONAL APPLICATION INFORMATION.

Layout of the Printed Circuit Board.

The layout of the TDA4882 is critical, special attention should be given to the grounding tracks around the IC.
In general it can be said that the layout must be made such, that current loops do not overlap in order to separate large and small signal currents.
The grounding tracks and loops must be kept as small as possible .
Because of the very high bandwidth, this printed circuit board is constructed with double sided copper.

APPENDIX 3

The interface between pre-amplifier TDA4882 and output amplifier TDA6120Q.

The voltage output of the TDA4882 does not fit with the operating range of the differential input of the TDA6120Q regarding DC level.
This problem is solved by a DC level shift from GND for the TDA4882.
In that case , the output voltages of the TDA4882 are shifted with about 3.4 V.
The interface is shown in Fig.A3-1.

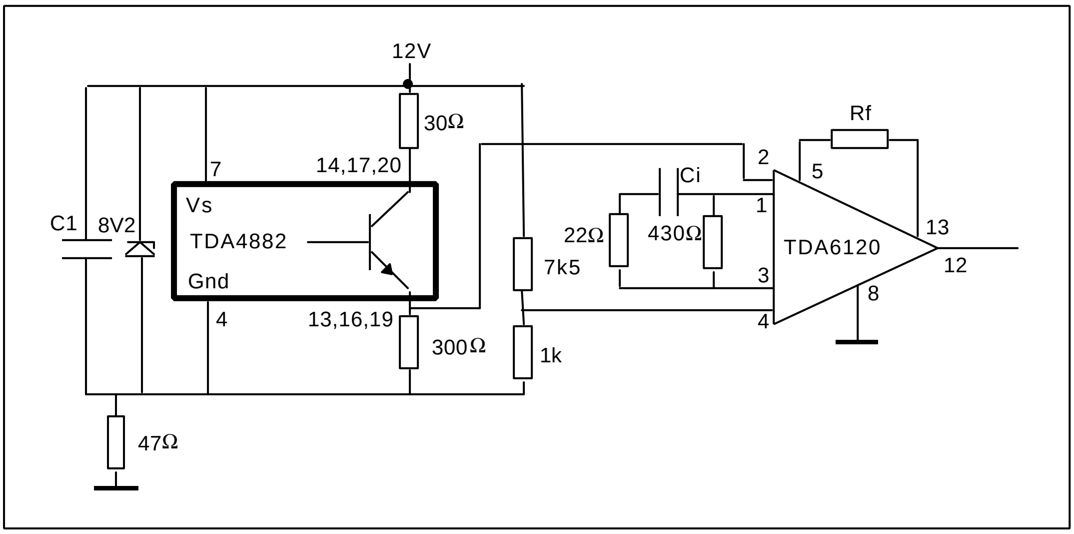


Fig.A3-1. Combination TDA4882 and TDA6120Q

The TDA4882 video pre amplifier input circuit. (connector X1,X2,X3)

All the video input signals are terminated with 75Ω to ground.
The video signal is AC coupled to the input of the TDA4882.
The inputs of the TDA4882 are terminated to ground with a 10MΩ resistor to prevent black level drift when no clamp pulse is present.
The input voltage (black to white value) is typical 0.7V and max.1V.

Available output voltage (connector X5)

The nominal signal output (black to white value) at pin 2,4,6 of connector X5 amounts to 0.8V at nominal contrast and nominal gain setting.
The gain of the red channel is fixed, the blue and green gain can be controlled by the pot. meters R4 and R35.

APPENDIX 3

The timings signals at pin 9 and pin10 of the TDA4882. (connector X4)

Pin 10.
Two timing signals:
- the horizontal clamping pulse
- the vertical blanking pulse.

pin10 (threshold)	Min.	Typ.	Max.	Unit
Vertical Blanking - Blanking -No input clamping	1.2	1.4	1.6	V
Clamping - Input clamping - No blanking	2.6	3.0	3.5	V

Pin 9.
Two timing signals:
- the blanking puse
- the switch-off signal

pin10 (threshold)	Min.	Typ.	Max.	Unit
Blanking - Blanking - Output clamping clamping	1.2	1.4	1.6	V
Switch off - Min. black level -No output clamping	5.8	6.5	6.8	V

Alternatives for blanking & clamping pulses.

Using the TDA4851.
The combination of TDA4851(Advanced Monitor Deflection Processor) and the TDA4882 is the most optimal solution to generate/use the timing needed for clamping and blanking.

Cut-off voltage stabilization. (Connector X6 and switches S1,S2 and S3)

For cut-off stabilization the video signal at the output of the TDA6120Q is divided by an adjustable voltage divider to the feedback inputs (pin18,15,12) of the TDA4882.
During the horizontal blanking time this signal is compared with an internal DC voltage. The black level voltage Voutc(black) of the TDA6120Q can be adjusted by means of potentiometers R20,R23 and R26, present on the TDA4882 add-on board.

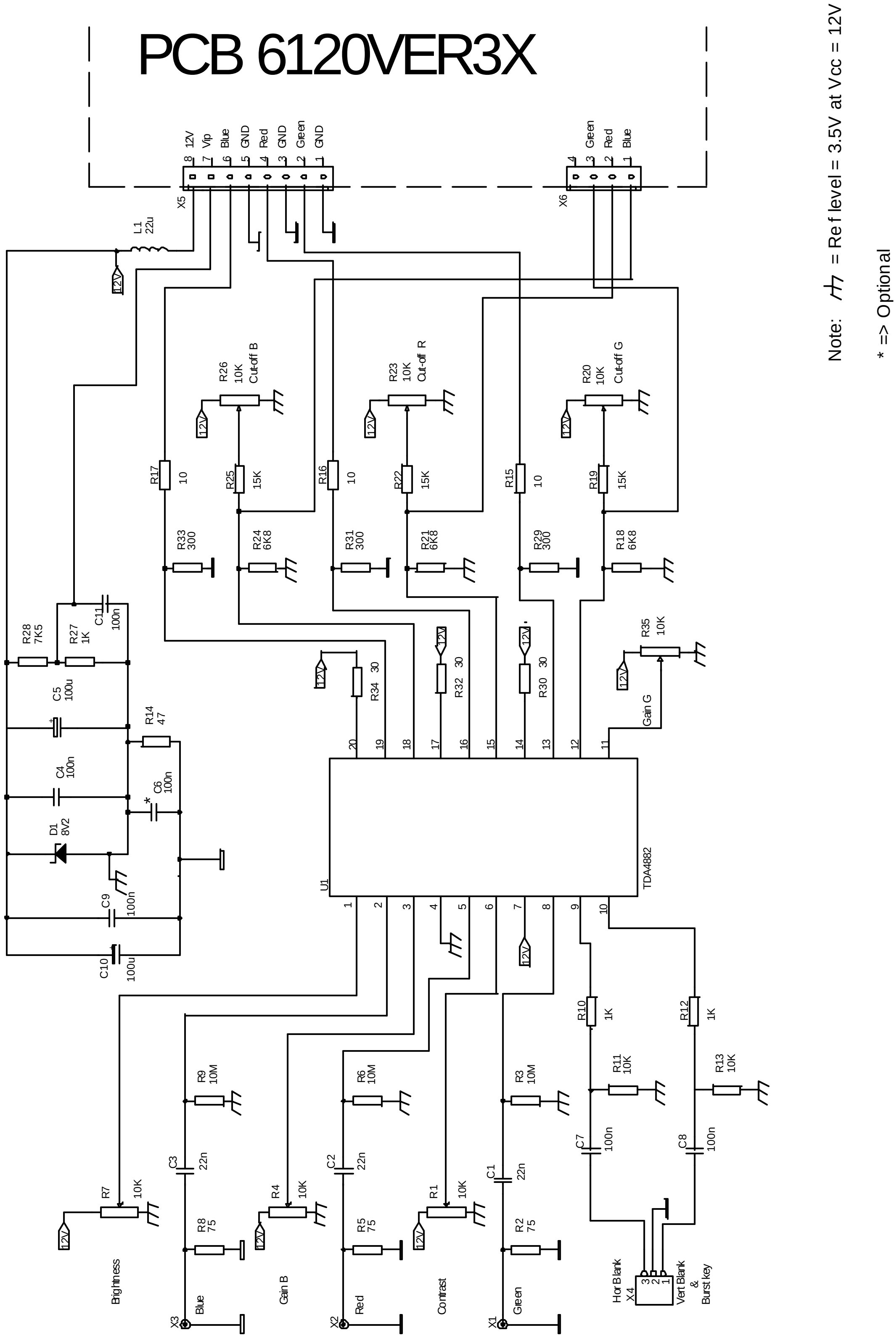


Fig.A3-2 Application diagram of theTDA4882 add-0n board

APPENDIX 3

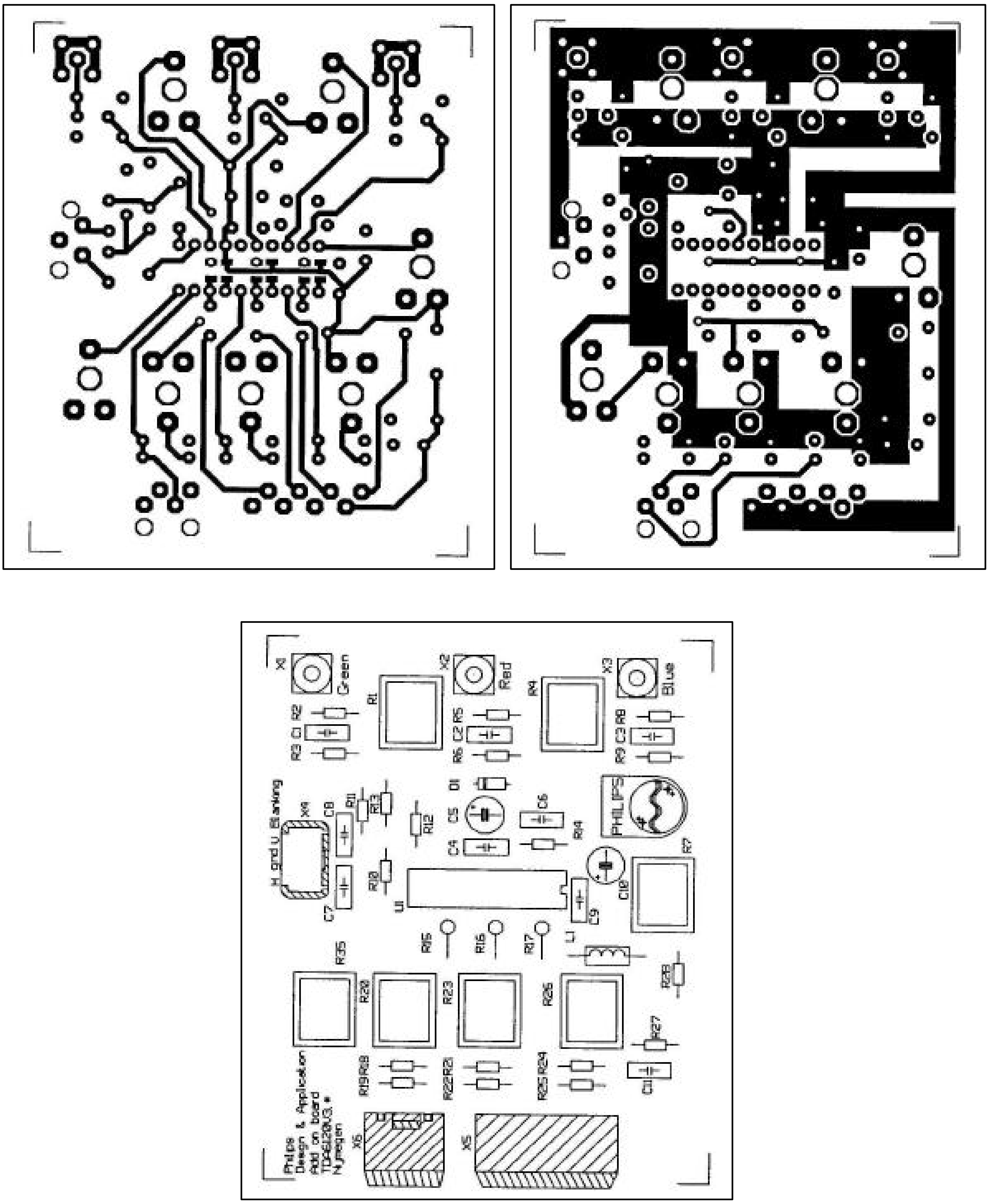


Fig.A3-3 PCB layout & Components view

APPENDIX 3

-PART LIST-
- TDA4882 ADD-ON BOARD-

Component	Value	Type
IC		TDA4882
Resistors.		
R1,R4,R7	10kΩ	potm.
R2,R5,R8	75Ω	SFR16
R3,R6,R9,R11	10MΩ	SFR16
R10,R12,R27	1kΩ	SFR16
R11,R13	10kΩ	SFR16
R14	47Ω	SFR16
R15,R16,R17	10Ω	SFR16
R18	6k8	SFR16
R19,R22,R25	15kΩ	SFR16
R20,R23,R26,R35	10kΩ	potm.
R28	7k5	SFR16
R29,R31,R33	30Ω	SFR16
R30,R32,R34	300Ω	SFR16
Capacitors.		
C1,C2,C3	22n	MKT
C4,C6,C7,C8,C9,C11100nF		MKT
C5,C10	100µF/16	Elco
Diodes.		
D1	8V2	BZX79/8V2

APPENDIX 3

PERFORMANCE OF THE TDA4882 & TDA6120Q COMBINATION

The pulse reponse performance was tested of the TDA4882 & TDA6120 combination.
The pulse response and rise& fall times are shown in Fig. A3-4,A3-5 and A3-6.

Measurement conditions :
- High voltage supply Vdd=200V
- Low voltage supply Vcc=12V
- Biasing: Voutc(DC)=100V
- AC Gain TDA6120 : 40 dB
- Voltage feedback: active (switch S1,S2,S3).
- Ioutm(pin7) is decoupled with a capacitor of 100nF to ground (switch S4).
- Rise & fall time of the square wave input signal is 10nS.
- Loading: see curves
- All measurement results include a flash resistor of 220Ω and Ct=5pF
  Ct is the cathode capacitance of the CRT.
  The total load capacitance Cl_{total}, including Csocket, Csparkgap, Cdiode and the parasitic capacitances of the PCB , will be about 10pF.

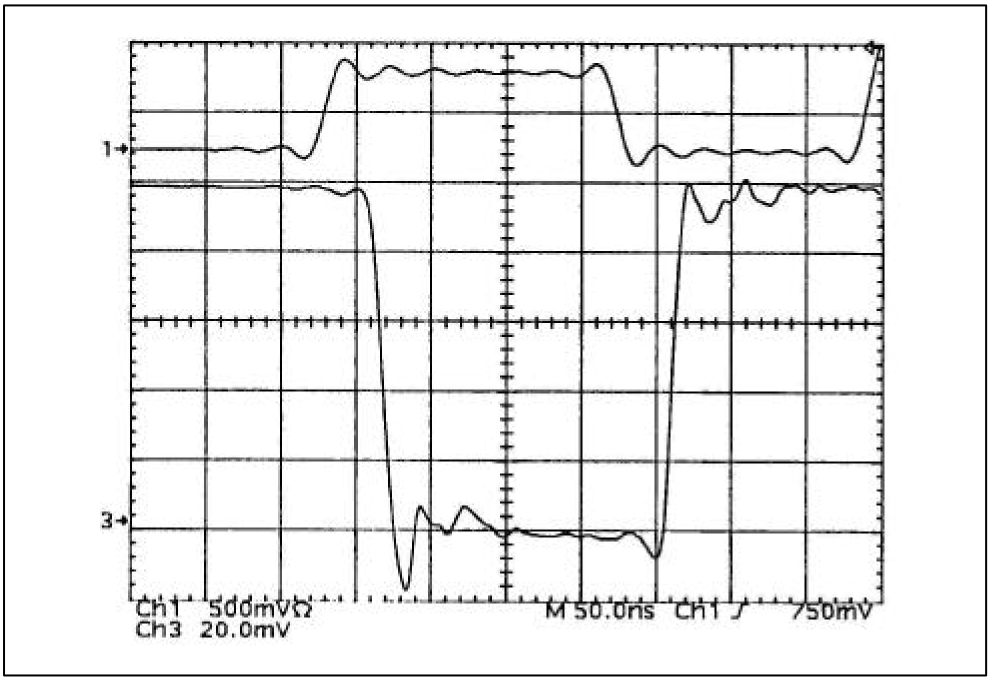


Fig.A3-4 Pulse response of the TDA4882 & TDA6120Q combination.
Voutc =100Vp-p. Measured with Rflash = 220Ω , Cl=10pF, Ci=39pF
Hor: 50nS/div Vert: upper Vi=0.5V/div , lower Voutc=20V/div

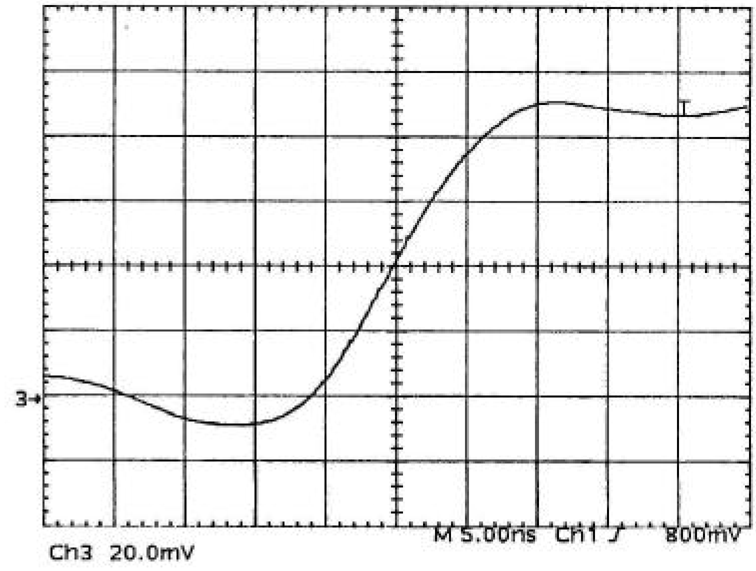


Fig.A3-5 Rise time of the TDA4882&TDA6120Q combination .
Voutc= 100Vp-p . Meaured with Rflash = 220Ω , Cl=10pF, Ci=39pF
Hor: 25 nS/div Vert: 20V/div

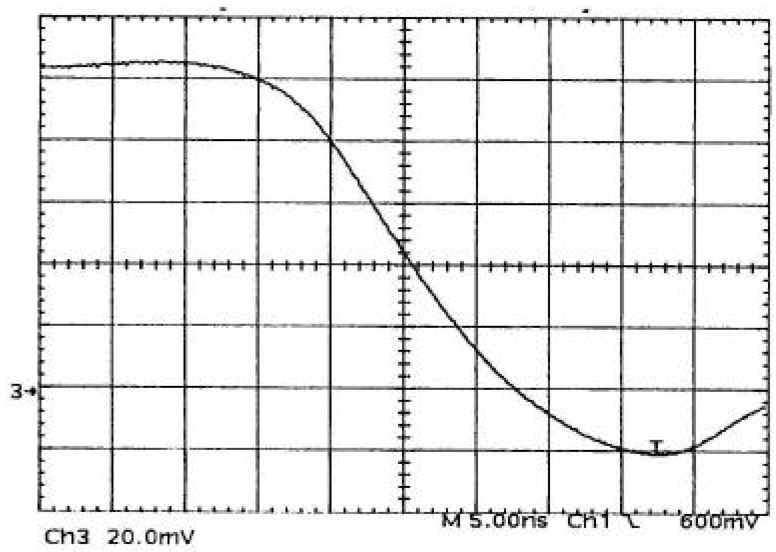


Fig.A3-6 Fall time of the TDA4882 & TDA6120Q combination .
Voutc= 100Vp-p. Measured with Rflash = 220Ω , Cl=10pF, Ci=39pF
Hor: 5nS/div Vert: 20V/div

APPENDIX 4

•TDA4780 ADD-ON BOARD •

CONTENTS.

INTRODUCTION.

This board equipped with the TDA4780 can be applied as pre-amplifier to drive the TDA6120Q.
The TDA 4780 is a RGB processor with automatic cut-off control for TV systems with High Resolution performance. A complete product description is given in the DATA sheet.
By using this combination, the concept is suitable for High Resolution TV applications.
The combination has a total bandwidth of 22MHz .
With this concept there are no alignments any more, because of the automatic black current stabilisation and because the white point adjustment can be done in the TDA4780 via I^2C bus.
The principle of automatic black current stabilisation (ABS) was given in chapter 7.7 .
The schematic application diagram of the TDA4780 is given in Fig.A4-2
The PCB layout is shown in Fig.A4-3
This add-on board fits with the TDA6120Q CRT main board and can be used as plug-in board , the connectors are pin aligned.

ADDITIONAL APPLICATION INFORMATION.

Layout of the Printed Circuit Board.

In general it can be said that the layout must be made such, that current loops do not overlap in order to separate large and small signal currents.
The layout of the TDA4882 is critical, special attention should be given to the grounding tracks around the IC.
The grounding tracks and loops must be kept as small as possible .
Because of the high bandwidth, this printed circuit board is constructed with double sided copper.

The interface between TDA4780 & TDA6120Q.
The interface between the TDA4780 and TDA6120Q is shown below in Fig. A4-1
The DC & AC output levels of the TDA4780 fit with the input levels of the TDA6120Q.

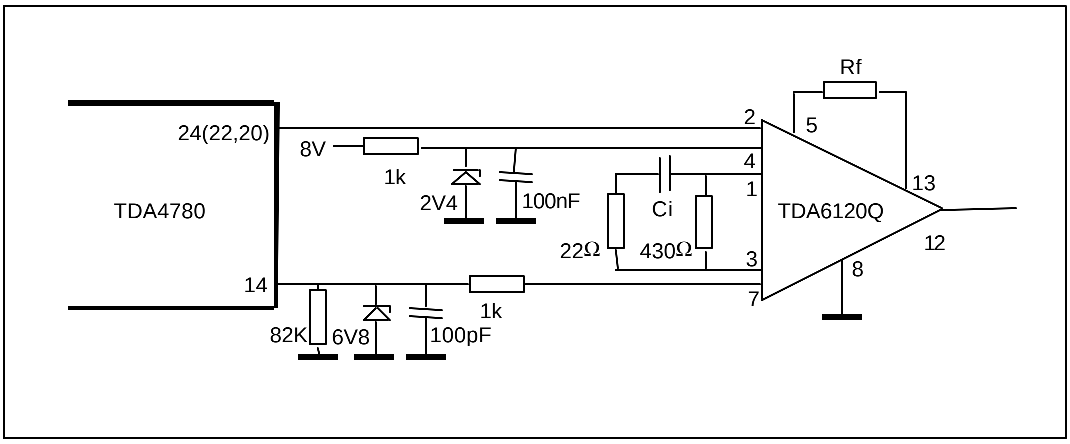


Fig.A4-1 Combining the TDA4780 and TDA6120Q.

The TDA4780 video processor input circuit. (connector X5,X2,X7)
By using these inputs , the TDA4780 has to be set in R1,G1,B1 mode via I^2C bus.
All the video (R,G,B) input connectors are terminated with 75Ω to ground .
The video signals are AC coupled to the inputs of the TDA4780.
The R,G,B input voltage (black to white value) is typical 0.7V.

Sandcastle input (connector X4)

The TDA4780 must have a two- or three-level (selected through I^2C) sandcastle signal for operation.

I2C bus signals (connector X3)

The TDA4780 needs I2C data.

Note.
For more details about the TDA4870, see DATA sheet TDA4870

APPENDIX 4

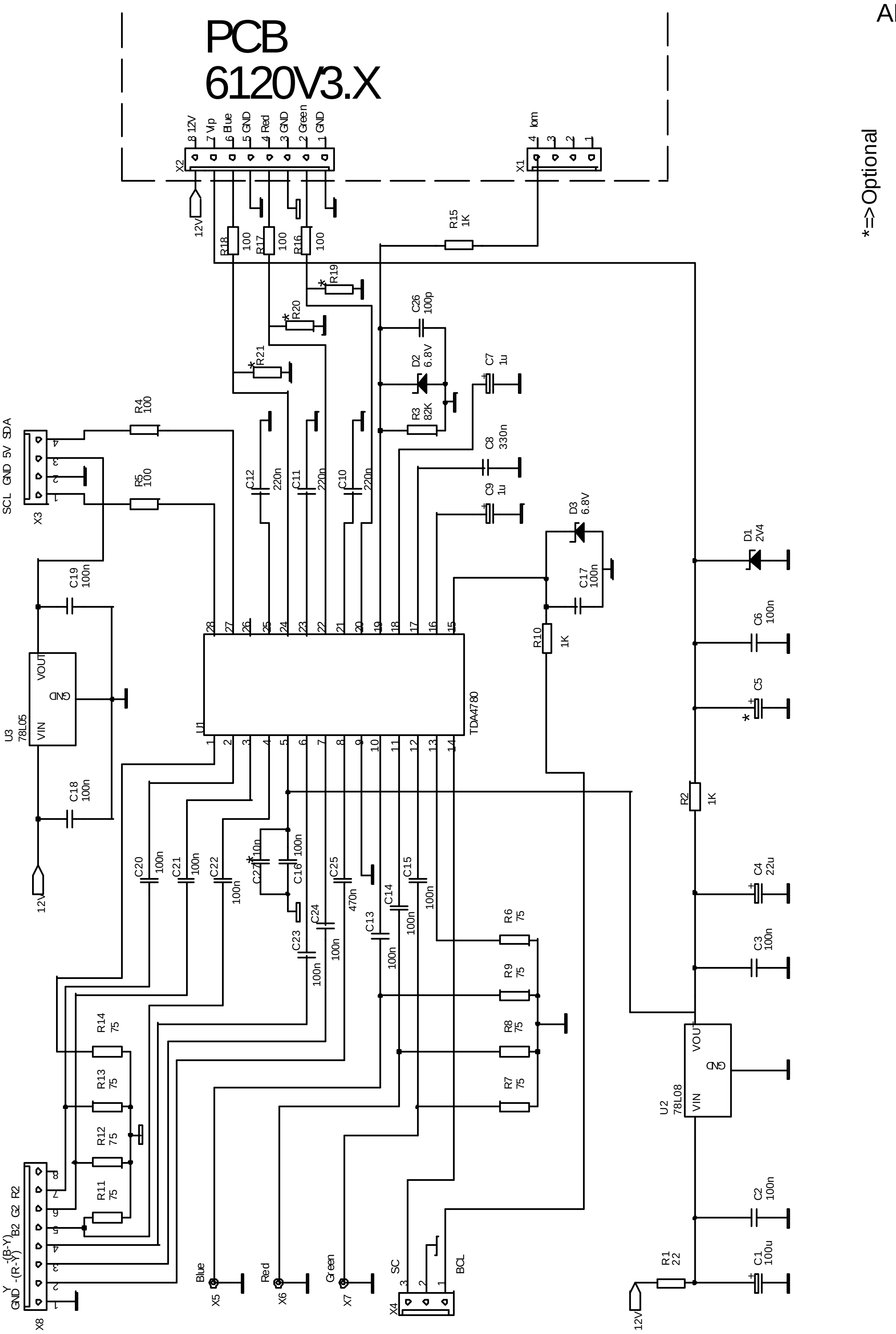


Fig. A4-2 Application diagram of the TDA4780 add-on board

APPENDIX 4

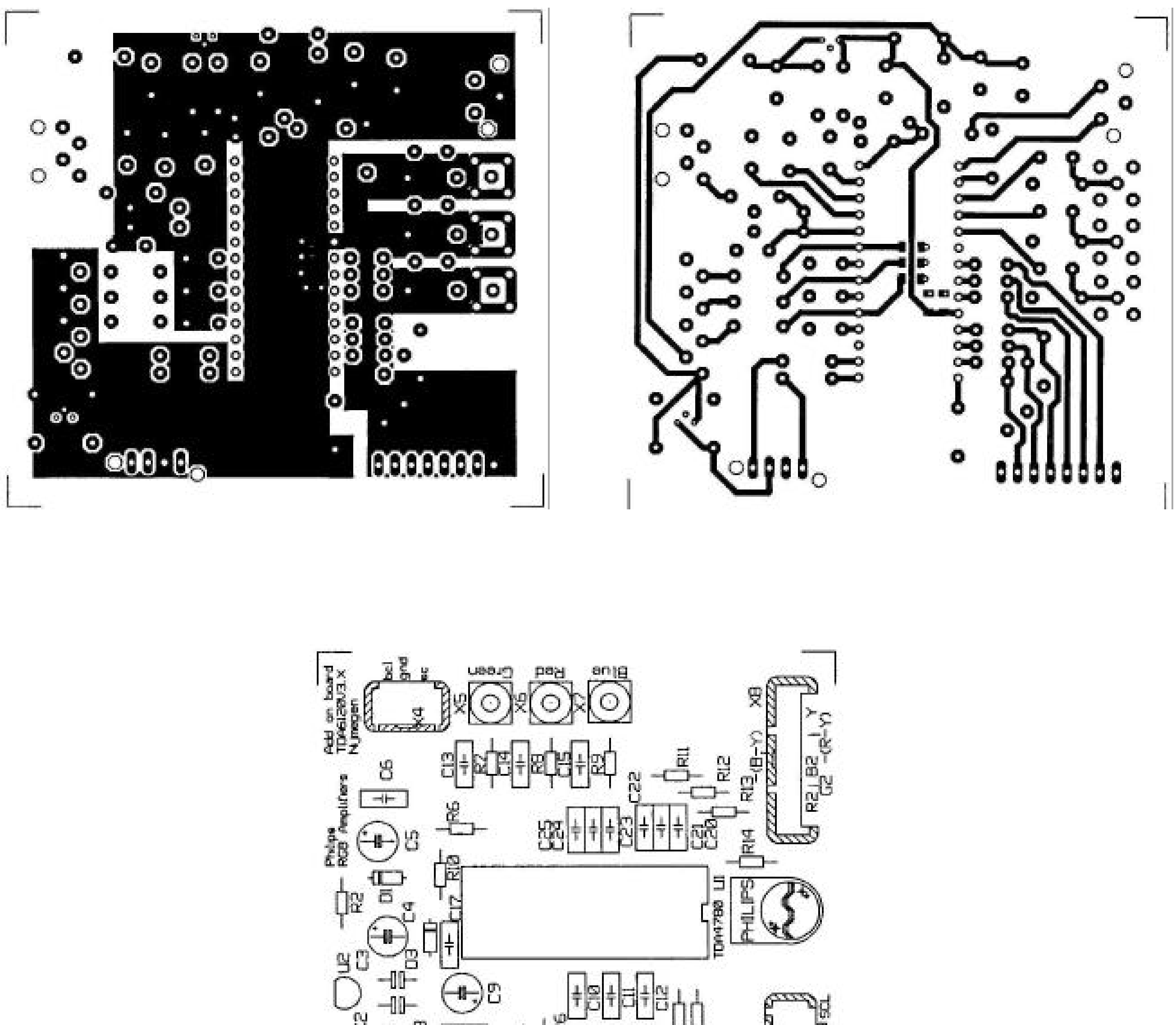


Fig.A4-3 PCB layout & Components view of the TDA4780 add-on board

APPENDIX 4

-PART LIST-
- TDA4780 ADD-ON BOARD-

Component	Value	Type
IC		TDA4780
<u>Resistors.</u>		
R1	22Ω	SFR16
R2,R10,R15	1kΩ	SFR16
R3	82kΩ	SFR16
R4,R5	100Ω	SFR16
R6,R7,R8,R9,R10,	75Ω	SFR16
R11,R12,R13,R14	75Ω	SFR16
R16,R17,R18	100Ω	SFR16
<u>Capacitors.</u>		
C1	100µF/16V	Elco
C2,C3,C6	100nF	MKT
C4	22µF/16V	Elco
C7,C9	1µF/16V	Elco
C8	330nF	MKT
C10,C11,C12	220nF	MKT
C13,C14,C15,C16,C17	100nF	MKT
C18,C19,C20,C21,C22	100nF	MKT
<u>Diodes.</u>		
D1	2V2	BZX79/2V4
D2,D3	6V8	BZX79/6V8

APPENDIX 4

PERFORMANCE OF THE TDA4780 & TDA6120Q COMBINATION

The pulse reponse performance is measured of the TDA4882 & TDA6120 combination.
The results are shown inFig.A4-4, A4-5 and A4-6.
Furthermore the multi-burst performance is measured , this is shown in Fig.A4-7, A4-8, A4-9 and A4-10.

Measurement conditions :

- High voltage supply Vdd=200V
- Low voltage supply Vcc=12V
- Biasing: Voutc(DC)=100V
- AC Gain TDA6120 : 40 dB
- Voltage feedback: not active (switch S1,S2,S3).
- Ioutm(pin7) : active (Switch S4
- Loading: see curves
- All measurement results include a flash resistor of 220Ω and Ct=5pF
  Ct is the cathode capacitance of the CRT.
  The total load capacitance Cl_{total}, including Csocket, Csparkgap, Cdiode and the parasitic capacitances of the PCB , will be about 10pF.

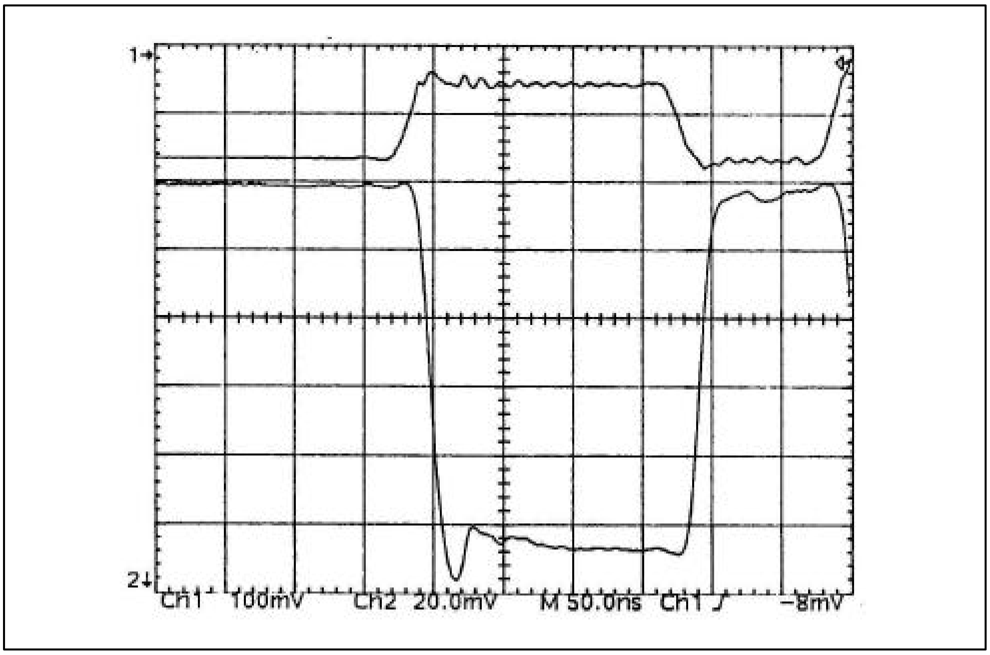


Fig.A4-4 Pulse response of the TDA4780 & TDA6120Q combination
Voutc= 100Vp-p. Measured with Rflash = 220Ω , Cl=10pF, Ci=39pF
Hor: 50nS/div Vert: upper Vi=1V/div , lower Voutc=20V/div.

APPENDIX 4

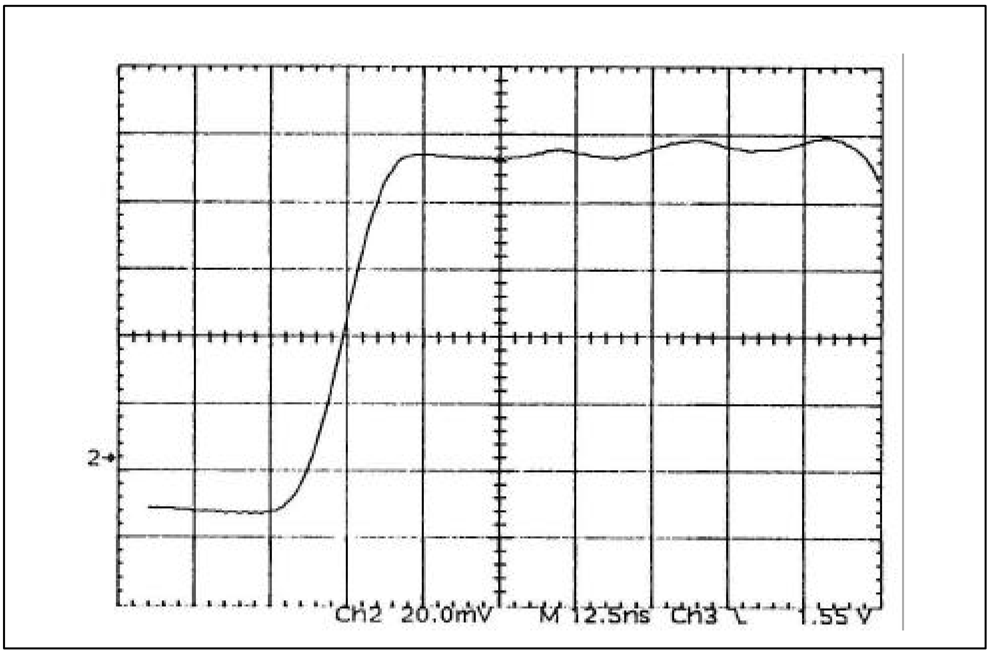


Fig.A4-5 Rise time of the TDA4780 & TDA6120Q combination .
Voutc= 100Vp-p. Measured with Rflash = 220Ω , Cl=10pF, Ci=39pF
Hor: 12.5 nS/div Vert: 20V/div

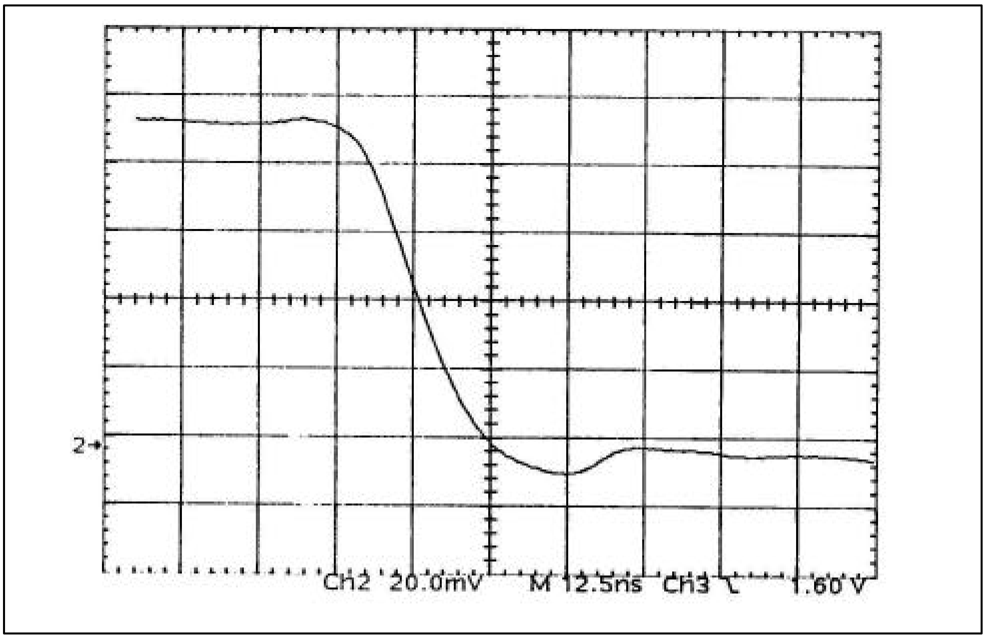
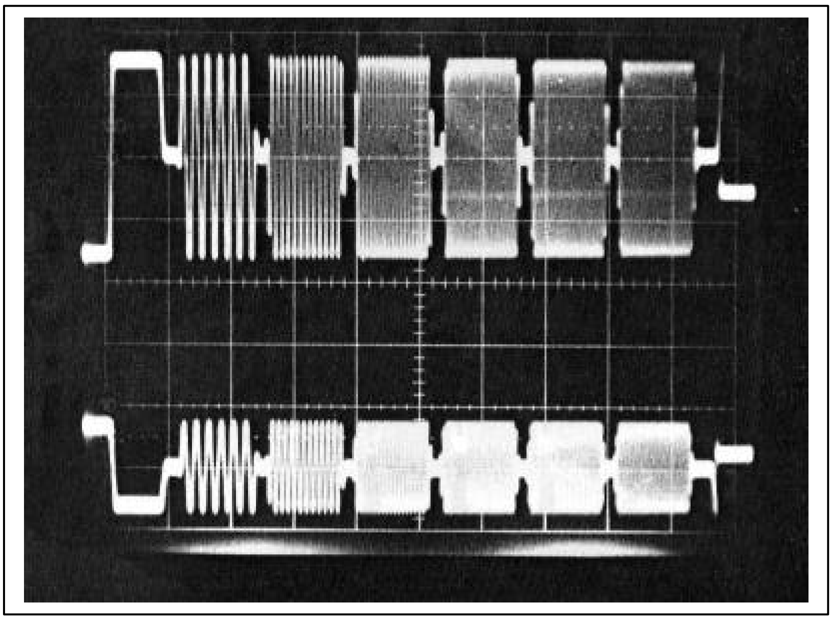


Fig.A4-6 Fall time of the TDA4780 & TDA6120Q combination.
Voutc= 100Vp-p. Measured with Rflash = 220Ω , Cl=10pF, Ci=39pF
Hor: 12.5nS/div Vert: 20V/div.

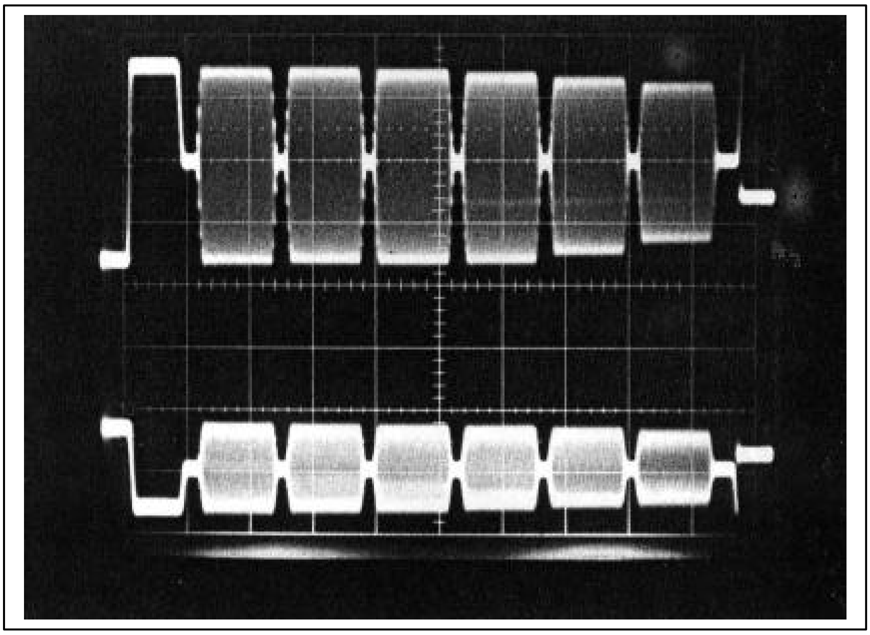
Small signal Multi - burst performance APPENDIX 4



Voutc
20V/div

Vi
0.5V/div

Fig.A4-7 Multi-burst performance of the TDA4780 &TDA6120Q.
Voutc-dc=100V, Voutc-ac=60Vpp, Ci=optimal=33pF
f= 1,2,3,4,5 and 6 MHz

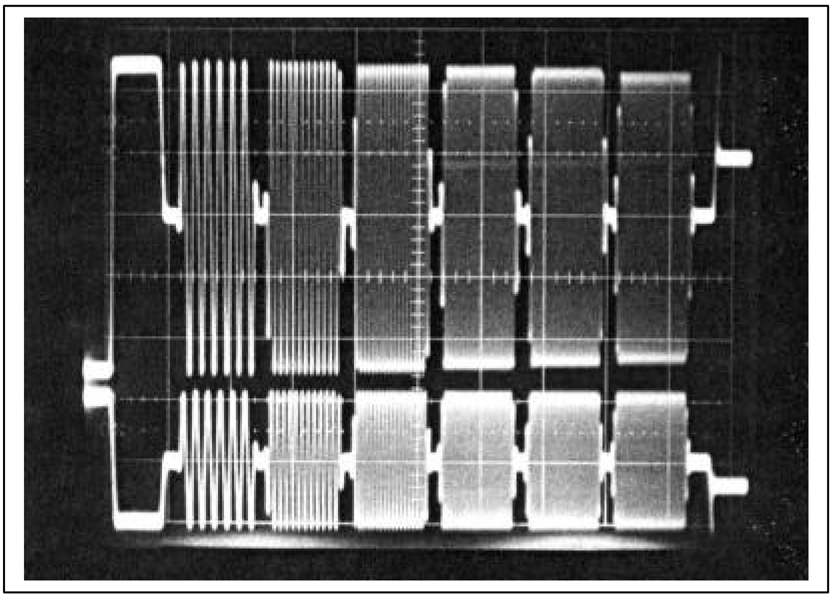


Voutc
20V/div

Vi
0.5V/div

Fig.A4-8 Multi-burst performance of theTDA4780&TDA6120Q.
Voutc-dc=100V, Voutc-ac=60Vpp, Ci=optimal=33pF
f= 10,12,14,16,18 and 20MHz

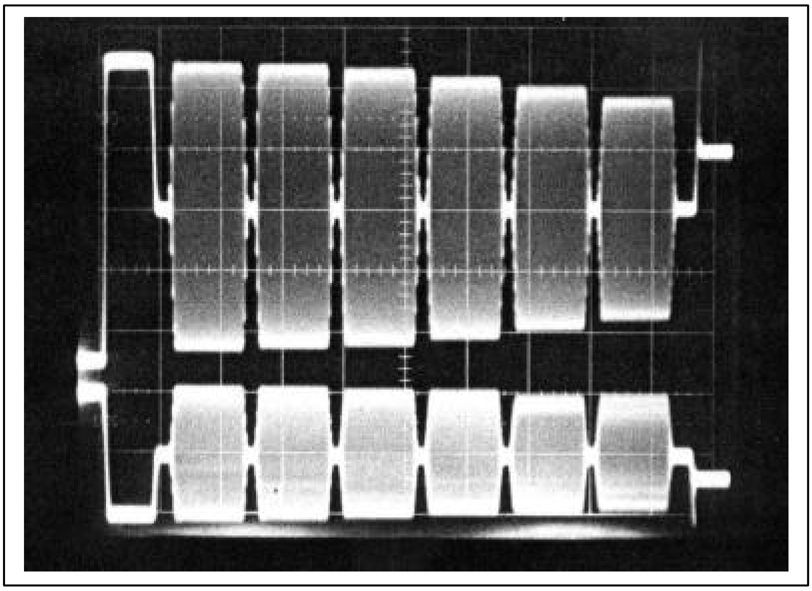
Large signal Multi- burst performance APPENDIX 4



Voutc
20V/div

Vi
0.5V/div

Fig.A4-9 Multi-burst performance of the TDA4780 & TDA6120Q.
Voutc-dc=100V, Voutc-ac=100Vpp, Ci=optimal=33pF
f= 1,2,3,4,5 and 6 MHz



Voutc
20V/div

Vi
0.5V/div

Fig.A4-10 Multi-burst performance of the TDA4780 &TDA6120Q.
Voutc-dc=100V, Voutc-ac=100Vpp, Ci=optimal=33pF
f= 10,12,14,16,18 and 20MHz