Orange binder

Book two – Tubes

CONTENTS

General section

ELECTRONIC TUBES

1. GENERAL

When properly used and handled, electronic tubes do not constitute a risk to health or to the environment.
However, certain hazards may arise and it is important that the following recommendations are observed. Care should be taken to ensure that all personnel who may handle, use or dispose of these products are aware of the necessary safety precautions.
Individual product data sheets may indicate if any of the specific hazards given in sections 2 to 9 are likely to be present.

1.1 Breakage

If a tube is broken or otherwise damaged, precautions must be taken against the following hazards which may arise:

- Broken glass or ceramics (see section 4). Protective clothing such as gloves should be worn.
- Contamination by toxic materials and vapours. In particular skin contact and inhalation should be avoided.

1.2 Disposal ←

These products should be disposed of in accordance with relevant legislation; in the United Kingdom the Deposit of Poisonous Waste Act 1972 and the Control of Pollution Act 1974 apply. Most electronic tubes contain toxic materials, therefore, particularly when disposing of large quantities, the advice of the manufacturer's service department should be sought.

orange binder, tab 1

1.3 Fire

Electronic tubes themselves do not present a fire hazard.
However, since most packaging materials are flammable, care should be taken in the disposal of such materials; some of which will emit toxic fumes if burned.
If packaged tubes are involved in a fire, implosion may occur (see section 7), together with the consequent release of toxic vapours and materials.

2. X-RADIATION

All high voltage electronic tubes produce progressively more dangerous X-rays as the operating voltage is increased. The tube envelope usually provides limited protection; however, further shielding may be required in the equipment if the voltage exceeds 10 kV. Should such shielding be required to reduce the X-ray dose rate to below the permitted limit of 0.5 mR/h, this will be indicated on the individual data sheets.
Under some equipment fault conditions, the X-ray hazard may be considerably increased.
This hazard may be present only when the tube is energized.

3. RADIO FREQUENCY (R.F.) AND MICROWAVE RADIATION ←

Exposure to r.f. fields may be a hazard even at relatively low frequencies. Absorbtion of r.f. energy by the human body is dependent on frequency. Although at frequencies below 30 MHz most energy passes straight through the body with little heating effect it may still represent a hazard. At microwave frequencies a power density above 1 mW/sq cm may comprise a definite hazard, particularly to the eyes.

3. RADIO FREQUENCY (R.F.) AND MICROWAVE RADIATION (Continued)

For this reason care should be exercised when using r.f. and microwave tubes. All r.f. connectors and cavities must be correctly fitted before operation so that no leakage of energy may occur and the r.f. energy must be coupled efficiently to the load. It is particularly dangerous to look into open waveguide, coaxial feeders or transmitter antennae while the tube is energized.
Power klystrons must not be operated without a suitable load at the output and at any intermediate cavities.
Screening of terminal insulators on some high power tubes may be necessary.
This hazard may be present only when the tube is energized.

4. BERYLLIUM OXIDE CERAMICS

The insulators of some microwave power tubes are made of beryllium oxide. Beryllium oxide dust is toxic if inhaled or if particles enter a cut or an abrasion. Avoid handling beryllium oxide ceramics; if they are touched the hands must be thoroughly washed with soap and water. Do nothing to beryllium oxide ceramics which may produce dust or fumes.
All tubes containing beryllium oxide are marked as such. Care should be taken upon eventual disposal that they are not thrown out with general industrial waste. Devices requiring disposal may be handled by the manufacturer's service department. Users seeking disposal of tubes incorporating beryllium oxide ceramics should first take advice from the manufacturer's service department.
This hazard is present at all times from receipt to disposal of tubes.

5. CADMIUM COMPOUNDS

Cadmium compounds are toxic. In the event of accidental breakage, cadmium dust may be released. Gloves should be worn and the dust should be mopped up with a damp cloth. On disposal the cloth should be sealed in a plastic bag and the hands thoroughly washed with soap and water.
Controlled disposal of tubes containing cadmium compounds should be conducted in the open air or in a well ventilated area.
Inhalation of cadmium dust must be avoided.
This hazard is present, if breakage occurs, at all times from receipt to disposal of tubes.

6. MERCURY

Mercury is a toxic substance, especially in the vapour phase. Should breakage occur, gloves should be worn and all droplets brushed up as soon as possible and placed in an airtight container for disposal. Afterwards the hands must be thoroughly washed with soap and water. Direct contact with the skin should be avoided.
This hazard is present, if breakage occurs, at all times from receipt to disposal of tubes.

7. IMPLOSION – HANDLING OF TELEVISION PICTURE AND CATHODE RAY TUBES

All vacuum tubes store potential energy by virtue of their vacuum. The energy level is low in small tubes but represents a hazard in the larger sizes of tubes.
Some modern tubes are provided with integral implosion protection which conforms to IEC65, clause 18. With these tubes, no additional protection is needed. For those tubes without integral implosion protection, precautions taken during manufacture reduce the possibility of spontaneous implosion to a minimum. However, additional stresses due to mishandling may considerably increase the risk of implosion. Implosions may occur immediately or may be delayed.
The strength of the glass envelope will inevitably be impaired by surface damage, such as scratches or bruises (localized surface cracks caused by impact). When a tube is not in its equipment or original packing, it should be placed faceplate downwards on a pad of suitable ribbed material which is kept free from abrasive substances.
Under no circumstances should any attempt be made to move the bonded faceplate or integral implosion protection band when fitted to a tube.

Stresses on the neck of the tube must be avoided. Handle by the recommended methods illustrated for those tubes which have relatively small necks with large envelopes.

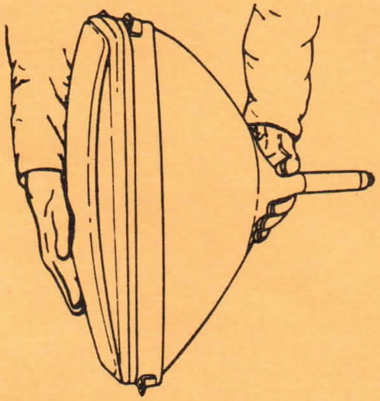


Fig.1 – Lifting tube from edge-down position.

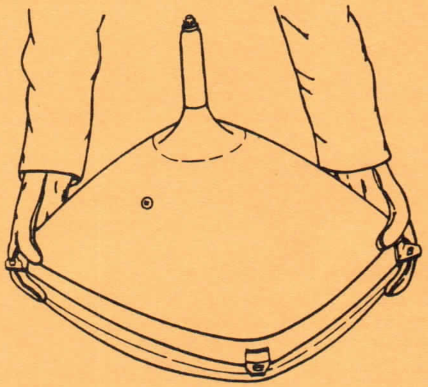


Fig.2 – Lifting tube from face-down position.

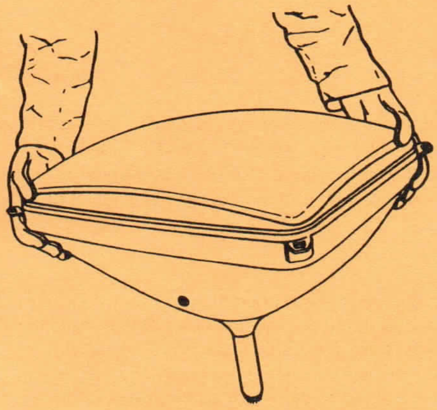


Fig.3 – Lifting tube from face-up position.

Tube on one edge

To lift a tube from the edge-down position, one hand should be placed around the parabolic section of the cone and the other hand should be placed near (slightly below) the centre of the faceplate as shown in Fig.1 **UNDER NO CIRCUMSTANCES SHOULD ANY FORCE BE APPLIED TO THE NECK OF THE TUBE.**

Tube face-down

To lift a tube from the face-down position, the hands should be placed under the areas of faceplate close to the fixing lugs (if fitted), at diagonally opposite corners of the faceplate as shown in Fig.2. The tube must not be lifted from this position by the lugs themselves. **UNDER NO CIRCUMSTANCES SHOULD ANY FORCE BE APPLIED TO THE NECK OF THE TUBE.**

Tube face-up

To lift a tube from the face-up position, the hands should be placed under the areas of the cone close to the fixing lugs (if fitted), at diagonally opposite corners of the cone as shown in Fig.3. The tube must not be lifted from this position by the lugs themselves. **UNDER NO CIRCUMSTANCES SHOULD ANY FORCE BE APPLIED TO THE NECK OF THE TUBE.**

If the handling procedures for tubes prior to insertion in the equipment are such that there is a risk of personal injury as a consequence of severe accidental damage to the tube, then it is recommended that protective clothing should be worn, particularly eye shielding.

When fitted, lugs are primarily provided for fixing in equipment and must not be subjected to excessive forces while the tube is being handled. Adequate protection must be provided if there is a possibility of the tube falling as a result of failure of a lug or lugs.

8 HIGH VOLTAGE – TELEVISION PICTURE AND CATHODE RAY TUBES

Attention is called to the fact that a high voltage may be carried by the internal coductive coating which is connected to the final anode connector and also by the external coating if not earthed, even after a tube has been removed from equipment. Anyone handling such a tube may receive an electric shock which, while generally not dangerous to the person, might cause an involuntary reaction resulting in damage to the tube which might, for example, be dropped. When it is required to discharge the tube capacitance, connection should be made via a resistor of not less than 10 kΩ which is capable of withstanding high voltages.

In equipment where the chassis can be connected directly to the mains, there is a risk of electric shock if access can be gained to the metal rimband through the aperture at the front of the equipment. In order to reduce the magnitude of the shock it is recommended that a 2 MΩ resistor, capable of withstanding peak voltages of e.h.t. values (as specified in IEC65, clause 14.1) is inserted between rimband and the braided earth contact to the external coating. This safety arrangement will provide substantial separation from the mains.

An appreciable capacitance is formed between the rimband and the internal conductive layer of the tube. In the event of flashover, high voltages of low energy will be induced on the rimband. In order to bypass these voltages, an extra-high-voltage low-inductance capacitor of a few nanofarads (in compliance with IEC65, clause 14.2) should be inserted between the rimband and the braided earth contact to the external coating.

9 STRONG MAGNETIC FIELDS

Some electronic tubes use permanent magnets in their operation. When handling or mounting such tubes, a distance of at least 5 cm should be maintained between the magnet and any piece of magnetic material to avoid mechanical shock to the magnet or to the glass or ceramic seals. For this reason it is recommended that non-magnetic tools are used during installation, such as non-magnetic stainless steel, brass, beryllium copper and aluminium. Furthermore, the user should be aware of the detrimental influence of the strong magnetic field around the magnet on compass, electrical meters, watches and

other precision instruments.
Packaged tubes must be stored in such a way as to prevent a decrease of the field strength of the magnets due to interaction with adjacent magnets. Unless otherwise stated on the data sheet, a minimum distance of 15 cm should be maintained between the tubes.
The best protection for the tube is its original packing because this ensures an adequate spacing between the tubes and ferrous objects, and moreover protects the tube against reasonable vibration and shock. Despite this controlled spacing, magnetically-sensitive instruments such as compasses, electrical meters, watches and other precision instruments should not be brought close to a bank of packaged tubes.

UNPACKED PERMANENT MAGNET TUBES SHOULD NEVER BE PLACED ON STEEL BENCHES OR SHELVES.

SAFETY RECOMMENDATIONS

SUMMARY

HAZARD:	X-radiation	Radio frequency (R.F.) and microwave radiation	Beryllium oxide ceramics	Cadmium compounds	Mercury	Implosion	High voltage	Strong magnetic fields
TELEVISION PICTURE AND CATHODE RAY TUBES	X			X		X	X	
RECTIFIERS					X			
THYRATRONS					X			
TRANSMITTING TUBES	X	X						
HIGH POWER KLYSTRONS	X	X	X					
MAGNETRONS		X						X
TRAVELLING WAVE TUBES		X						X
IGNITRONS					X			
REFER TO:	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9

Safety recommendations under the heading GENERAL (section 1) refer to all electronic tubes.

Special quality, gasfilled, and display tubes

Television and monitor tubes

BASES

SMALL-BUTTON NEO EIGHTAR BASE IEC 67-1-31
JEDEC B7-208

Dimensions in mm

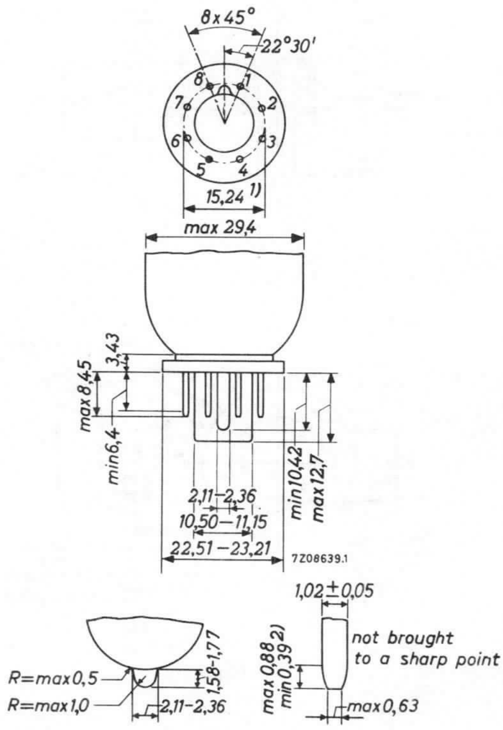


Fig. 1.

Notes
1. Base-pin positions are held to tolerances such that the base will fit a flat-plate gauge having a thickness of 9,53 and eight equally spaced holes of 1,40 ± 0,01 diameter located on a 15,24 ± 0,01 diameter circle. The gauge is also provided with a centre hole to provide 0,25 diametric clearance for the lug and key. Pin fit in the gauge shall be such that the entire length of pins will, without undue force, pass into and disengage from the gauge.
2. This dimension may vary within the limits shown around the periphery of any individual pin.

orange binder, tab 3

7-PIN MINIATURE BASE WITH PUMPING STEM

Dimensions in mm

Dimensions of this base are within the JEDEC E7-91 dimensions

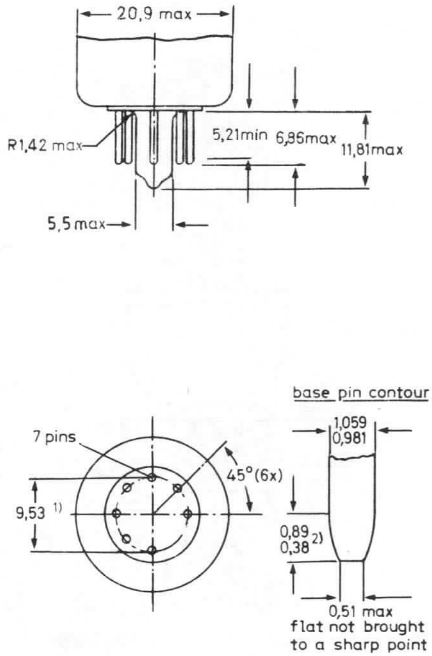


Fig. 2.

Notes
1. Base-pin and pumping stem positions are held to tolerances such that entire length of pins and stem will without undue force pass into and disengage from a flat-plate gauge having a thickness of 6,35 mm and eight holes with diameters of 1,27 ± 0,013 mm so located on a 9,525 ± 0,013 mm diameter circle that the distance along the chord between any two adjacent hole centres is 3,645 ± 0,013 mm and a centre hole of 5,97 + 0,025 mm being chamfered at the top over 1,52 mm with an angle of 45 degrees.
2. This dimension around the periphery of any individual pin may vary within the limits shown.

12-PIN BASE IEC-67-I-47a, type 2

Dimensions in mm

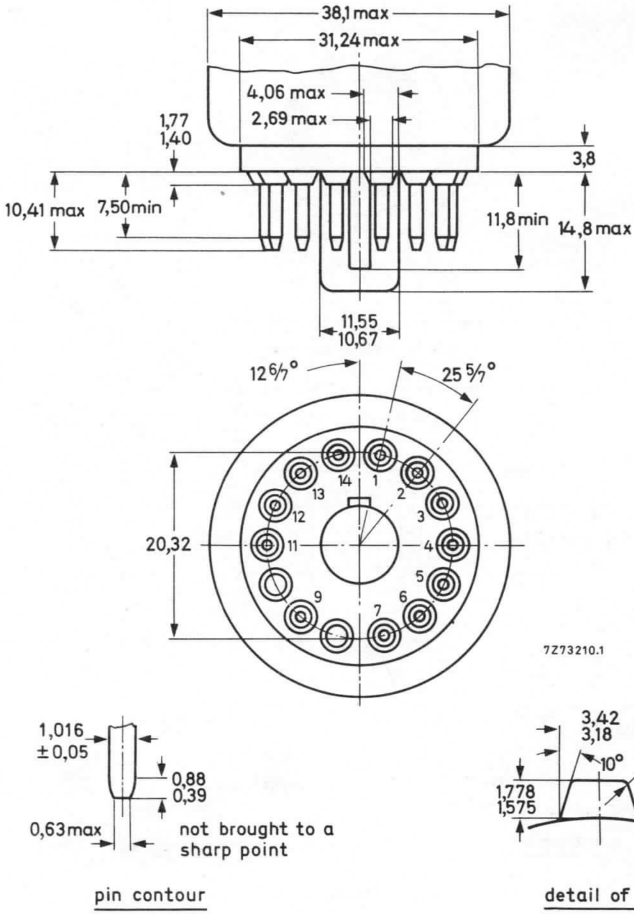


Fig. 3.

12-pin Base JEDEC B12-262

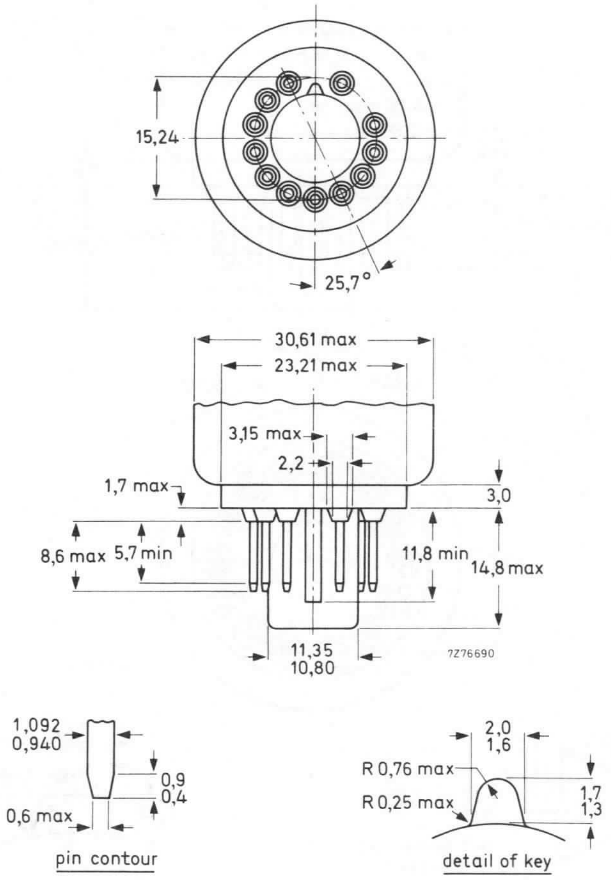


Fig. 4.

GENERAL OPERATIONAL RECOMMENDATIONS

INTRODUCTION

Equipment design should be based on the characteristics as stated in the data sheets. Where deviations from these general recommendations are permissible or necessary, statements to that effect will be made.

If applications are considered which are not referred to in the data sheets of the relevant tube type extra care should be taken with circuit design to prevent the tube being overloaded due to unfavourable operating conditions.

SPREAD IN TUBE CHARACTERISTICS

The spread in tube characteristics is the difference between maximum and minimum values. Values not qualified as maximum or minimum are nominal ones. It is evident that average or nominal values, as well as spread figures, may differ according to the number of tubes of a certain type that are being checked. No guarantee is given for values of characteristics in settings substantially differing from those specified in the data sheets.

SPREAD AND VARIATION IN OPERATING CONDITIONS

The operating conditions of a tube are subject to spread and/or variation.

Spread in an operating condition is a **permanent** deviation from an average condition due to, e.g., component value deviations. The average condition is found from such a number individual cases taken at random that an increase of the number will have a negligible influence.

Variation in an operating condition is **non-permanent** (occurs as a function of time), e.g., due to supply voltage fluctuations. The average value is calculated over a period such that a prolongation of that period will have negligible influence.

LIMITING VALUES

Limiting values are in accordance with the applicable rating system as defined by IEC publication 134. Reference may be made to one of the following 3 rating systems.

Absolute maximum rating system. Absolute maximum ratings are limiting values of operating and environmental conditions applicable to any electronic device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.
These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other electronic devices in the equipment.

The equipment manufacturer should design so that, initially and throughout life, no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment components spread and variation, equipment control adjustment, load variations, signal variation, environmental conditions, and spread or variations in characteristics of the device under considerations and of all other electronic devices in the equipment.

Design-maximum rating system. Design-maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device* of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in the characteristics of the electronic device under consideration.

The equipment manufacturer should design so that, initially and thoughout life, no design-maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, variation in characteristics of all other devices in the equipment, equipment control adjustment, load variation, signal variation and environmental conditions.

Design-centre rating system. Design-centre ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device* of a specified type as defined by its published data, and should not be exceeded under average conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply-voltage variation, equipment component spread and variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations or spread in the characteristics of all electronic devices.

The equipment manufacturer should design so that, initially, no design-centre value for the intended service is exceeded with a bogey electronic device* in equipment operating at the stated normal supply voltage.
If the tube data specify limiting values according to more than one rating system the circuit has to be designed so that none of these limiting values is exceeded under the relevant conditions.

In addition to the limiting values given in the individual data sheets the directives in the following paragraphs should be observed.

HEATER SUPPLY

For maximum cathode life it is recommended that the heater supply be stabilized at the nominal heater voltage. Any deviation from this heater voltage has a detrimental effect on tube performance and life, and should therefore be kept to a minimum. Such deviations may be caused by:

- mains voltage fluctuations;
- spread in the characteristics of components such as transformers, resistors, capacitors, etc.;
- spread in circuit adjustments;
- operational variations.

Supply from mains transformer

The maximum deviation of the heater voltage must not exceed ± 15% (Design Maximum Value). A mains transformer will generally fulfil this condition at mains voltage fluctuations not exceeding ± 10%.

Supply from line output transformer

A deviation from the nominal heater voltage due to spread in component characteristics and adjustments should not exceed ± 7,5%. Considering all other possible deviations, due to mains voltage variations, beam current variations, VCR-operation, etc., the total spread in heater voltage must not exceed ± 15%.

* A bogey tube is a tube whose characteristics have the published nominal values for the type. A bogey tube for any particular application can be obtained by considering only those characteristics which are directly related to the application.

Standby (instant-on circuits)

The majority of tubes employ quick-heating cathodes and therefore an instant-on circuit is superfluous. If used, it is recommended to that the heater voltage of the tubes be reduced during standby operation to 75% of the nominal value.

Notes: If series connection of the heater circuit has to be used, and only parallel connection is quoted in the data sheet, please contact your local supplier.

Picture tubes with quick-heating cathodes should not be used in series with receiving tubes.

CATHODE TO HEATER VOLTAGE

The voltage between cathode and heater should be as low as possible and never exceed the limiting values given in the data sheets of the individual tubes. The limiting values relate to that side of the heater where the voltage between cathode and heater is greatest. The voltage between cathode and heater may be d.c., a.c., or a combination of both. Unless otherwise stated, the maximum values quoted indicate the maximum permissible d.c. voltage. If a combination of d.c. and a.c. voltages is applied, the peak value may be twice the rated V_{kf}; however, unless otherwise stated, this peak value shall never exceed 315 V. Unless otherwise stated, the V_{kf} max. holds for both polarities of the voltage; however, a positive cathode is usually the most favourable in view of insulation during life.

In order to avoid excessive hum the a.c. component of the heater to cathode voltage should be as low as possible and never exceed 20 V r.m.s. (mains frequency). A d.c. connection should always be present between heater and cathode. Unless otherwise specified the maximum resistance should not exceed 1 MΩ; the maximum impedance at mains frequency should be less than 100 kΩ.

INTERMEDIATE ELECTRODES (between cathode and final accelerator)

In no circumstances should the tube be operated without a d.c. connection between each electrode and the cathode. The total effective impedance between each electrode and the cathode should never exceed the published maximum value. However, no electrode should be connected directly to a high energy source. When such a connection is required, it should be made via a series resistor of not less then 1 kΩ.

CUT-OFF VOLTAGE

Curves showing the limits of the cut-off voltage as a function of grid 2 voltage are generally included in the data. The brightness control should be so dimensioned that it can handle any tube within the limits shown, at the appropriate grid 2 voltage.

The published limits are determined at an ambient illumination level of 10 lux. Because the brightness of a spot is in general greater than that of a raster of the same current, the cut-off voltage determined with the aid of a focused spot will be more negative by about 5 V as compared with that of a focused raster.

FOCUSING ELECTRODE VOLTAGE

Individual tubes will have satisfactory focus over the entire screen at some value within the published range of the focusing voltage.

Due to their flat focus characteristics, black and white picture tubes can generally be operated at a fixed focusing voltage within the published range. Colour picture tubes and monitor tubes for data display should have adjustable focus.

LUMINESCENT SCREEN

To prevent permanent screen damage, care should be taken:

- not to operate the tube with a stationary picture at high beam currents for extended periods;
- not to operate the tube with a stationary or slowly moving spot except at extremely low beam currents;
- if no e.h.t. bleeder is used, to choose the time constants of the cathode, grid 1, grid 2, and deflection circuits, such that sufficient beam current is maintained to discharge the e.h.t. capacitance before deflection has ceased after equipment has been switched off.

EXTERNAL CONDUCTIVE COATING

The external conductive coating must be connected to the chassis. The capacitance of this coating to the final accelerating electrode may be used to provide smoothing for the e.h.t. supply.

The coating is not a perfect conductor and in order to reduce electromagnetic radiation caused by the line time base and the picture content it may be necessary to make multiple connections to the coating. See also 'Flashover'.

METAL RIMBAND

An appreciable capacitance exists between the metal rimband and the internal conductive coating of the tube; its value is quoted in the individual data sheets.To avoid electric shock, a d.c. connection should be provided between the metal band and the external conductive coating. In receivers where the chassis can be connected directly to the mains there is a risk of electric shock if access is made to the metal band. To reduce the shock to the safe limit, it is suggested that a 2 MΩ resistor capable of handling the peak voltages be inserted between the metal band and the point of contact with the external conductive coating. This safety arrangement will provide the necessary insulation from the mains but in the event of flashover high voltages will be induced on the metal band. It is therefore recommended that the 2 MΩ resistor be bypassed by a 4,7 nF capacitor capable of withstanding the peak voltage determined by the voltage divider formed by this capacitor and the capacitance of the metal rimband to the internal conductive coating, and the anode voltage. The 4,7 nF capacitor also serves to improve e.h.t. smoothing by adding the rimband capacitance to the capacitance of the outer conductive coating.

FLASHOVER

High electric field strengths are present between the gun electrodes of picture tubes. Voltages between gun electrodes may reach values of 20 kV over approx. 1 mm. Although the utmost precautions are taken in the design and manufacture of the tubes, there is always a chance that flashover will occur. The resulting transient currents and voltages may be of sufficient magnitude to cause damage to the tube itself and to various components on the chassis. Arcing terminates when the e.h.t. capacitor is discharged. Therefore it is of vital importance to provide protective circuits with spark gaps and series resistors, which should be connected according to Fig. 1. No other connections between the outer conductive coating and the chassis are permissible.

In picture tubes which are manufactured in Soft-Flash technology, the peak discharge currents are limited to approx. 60 A, offering higher set reliability, optimum circuit protection and component savings (see also Technical Note 039). However this limited value of 60 A is still too high for the circuitry which is directly connected to the tube socket. Therefore Soft-Flash picture tubes should also be provided with spark gaps.

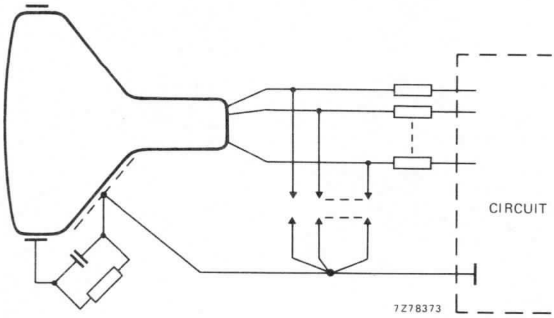


Fig. 1.

IMPLOSION PROTECTION

All picture tubes employ integral implosion protection and must be replaced with a tube of the same type number or recommended replacement to assure continued safety.

HANDLING

Although all picture tubes are provided with integral implosion protection, which meets the intrinsic safety requirements stipulated in the relevant part of IEC 65, care should be taken not to scratch or knock any part of the tube. **Stress on the tube neck must be avoided.**

When lifting a tube from the edge-down position, one hand should be placed around the parabola section of the cone and the other hand should be placed under the rim band (Fig. 2).

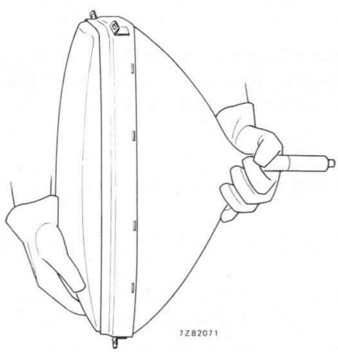


Fig. 2 Lifting picture tube from edge-down position.

When placing a tube face downwards ensure that the screen rests on a soft pad of suitable material, kept free from abrasive substances. When lifting from the face-down position the hand should be placed under the areas of the faceplate close to the mounting lugs at diagonally opposite corners of the faceplate (Fig. 3).

When lifting from the face-up position the hands should be placed under the areas of the cone close to the mounting lugs at diagonally opposite corners of the cone (Fig. 4).

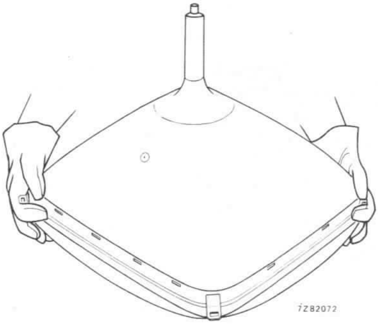


Fig. 3 Lifting picture tube from face-down position.

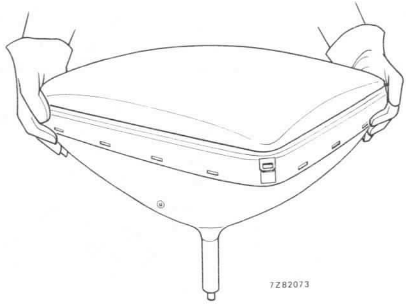


Fig. 4 Lifting tube from face-up position.

In all handling procedures prior to insertion in the receiver cabinet there is a risk of personal injury as a result of severe accidental damage to the tube. It is therefore recommended that protective clothing should be worn, **particularly eye shielding.**

If suspending the tube from the mounting lugs ensure that a **minimum of 2** are used; UNDER NO CIRCUMSTANCES HANG THE TUBE FROM ONE LUG.

The slots in the rimband of colour picture tubes are used in the mounting of the degaussing coils. It is not recommended to suspend the tube from one or more of these slots as permanent deformation to the rimband can occur.

Remember when replacing or servicing the picture tube that a residual electrical charge may be carried by the anode contact and also the external coating if not earthed. Before removing the tube from the equipment, earth the external coating and short the anode contact to the coating.

PACKING

The packing provides protection against tube damage under normal conditions of shipment or handling. Observe any instructions given on the packing and handle accordingly. The tube should under no circumstances be subjected to accelerations greater than 35 g.

MOUNTING

Unless otherwise specified on the data sheets for individual tubes there are no restrictions on the position of mounting.

The tube socket should not be rigidly mounted but should have flexible leads and be allowed to move freely.

The mass of the socket and additional circuitry should not be more than 150 g. The socket of tubes with a 7-pin miniature base may not be used for mounting components.

It is very desirable that tubes should not be exposed to strong electrostatic and magnetic fields.

DIMENSIONS

In designing the equipment the tolerances given on the dimensional drawings should be considered. Under no circumstances should the equipment be designed around dimensions taken from individual tubes.

REFERENCE LINE

Where a reference line is indicated on the tube outline drawing, it is determined by means of a gauge. Drawings of the gauges are given in this section under "Reference line gauges"

REFERENCE LINE GAUGES

REFERENCE LINE GAUGE C (JEDEC 126) (IEC67-IV-3)

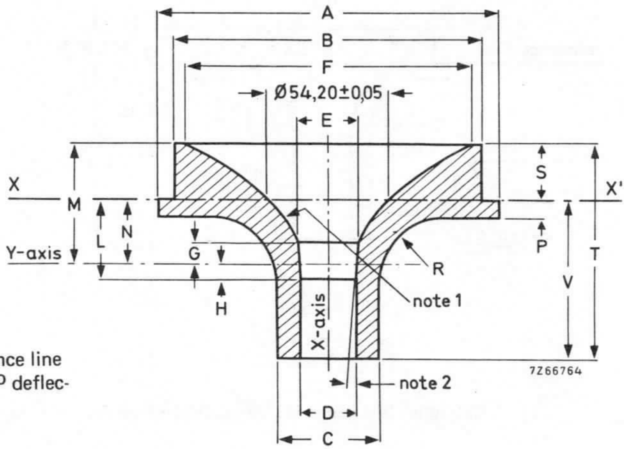


Fig. 1 Reference line gauge for 110° deflection angle.

orange binder, tab 3

The millimetre dimensions are derived from the original inch dimensions.

ref.	inches			millimetres			notes
	min.	nom.	max.	min.	nom.	max.	
A	–	5,000	–	–	127,00	–	–
B	–	4,500	–	–	114,30	–	–
C	–	2,000	–	–	50,80	–	–
D	1,168	1,168	1,171	29,668	29,668	29,743	–
E	1,241	1,242	1,243	31,522	31,547	31,572	–
F	4,248	4,250	4,252	107,900	107,950	108,000	–
G	–	0,279	–	–	7,09	–	2
H	–	0,250	–	–	6,35	–	–
L	1,165	1,170	1,175	29,60	29,72	29,84	2
M	–	1,634	–	–	41,50	–	–
N	–	0,920	–	–	23,37	–	1
P	–	0,250	–	–	6,35	–	–
R	–	1,000r	–	–	25,40r	–	–
S	0,712	0,714	0,716	18,085	18,136	18,186	–
T	–	3,214	–	–	81,64	–	–
V	2,490	2,500	2,510	63,25	63,50	63,75	–

Notes

1. $y = 0,58\,x^2 + 0,576$ inches ($0,0228\,x^2 + 14,630$ mm) 'y' values must be held to ±0,002" (0,05 mm). The Y-axis is 0,920" (23,368 mm) below the X-X' reference plane.
2. 4° ± 30' taper between planes G and L.

REFERENCE LINE GAUGE D

Dimensions in mm

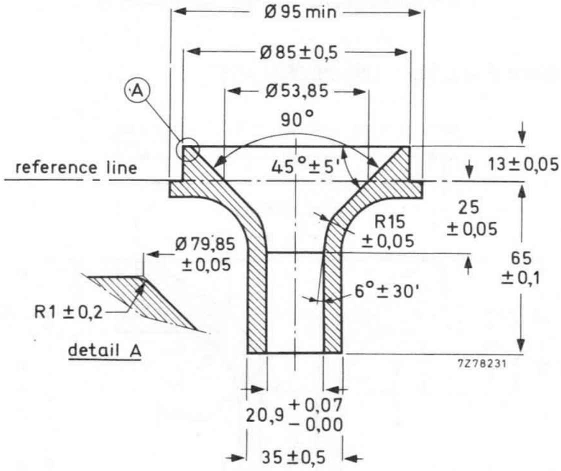


Fig. 2 Reference line gauge for 90° deflection angle.

REFERENCE LINE GAUGE G (JEDEC G148)

Dimensions in mm

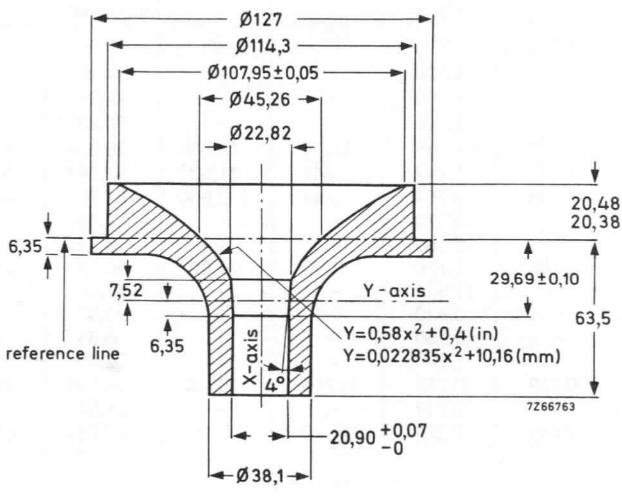


Fig. 3 Reference line gauge for 110° deflection angle.

Reference line gauge GR90CJ4

Dimensions in mm

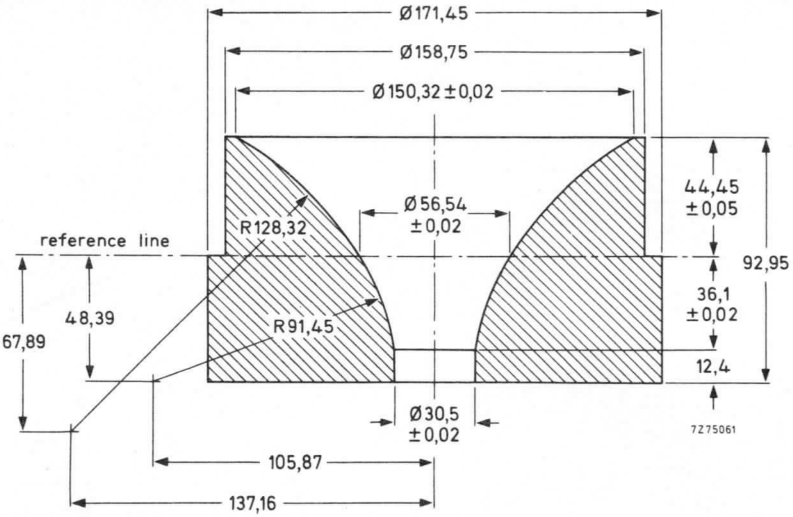


Fig. 4 Reference line gauge for 90° deflection angle.

SCREEN PHOSPHORS

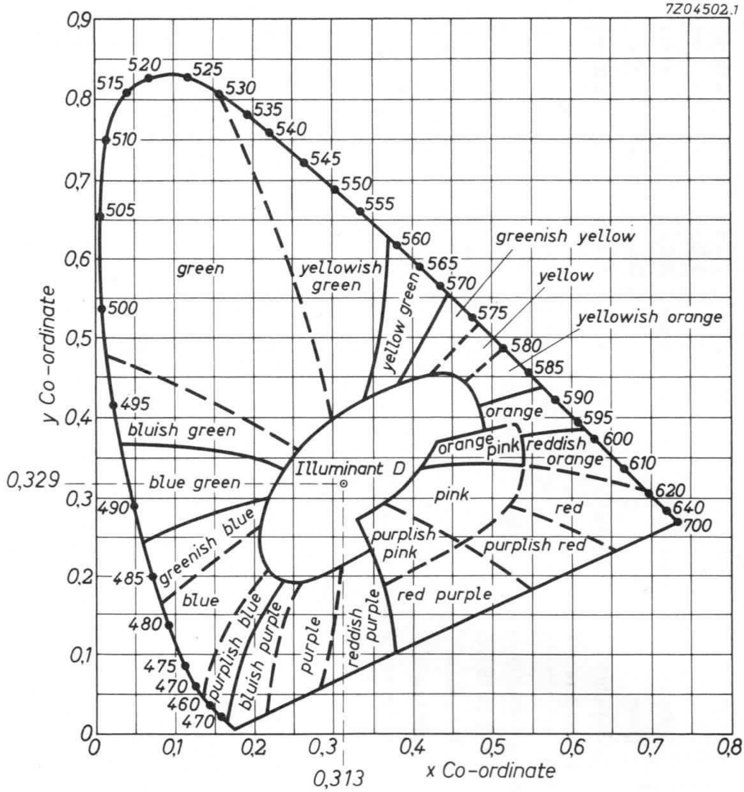


Fig. 1 Kelly chart.

Note: For screen phosphors for colour picture tubes, see the relevant data sheets.

orange binder, tab 3

Survey of screen phosphors

type	JEDEC designation	fluorescent colour	phosphorescent colour	persistence	relative level of luminance			
					10%	1%	0,1%	
W	P4	white	—	—	1,3 ms	23 ms	210 ms	(yellow component)
					1,3 ms	20 ms	180 ms	(blue component)
GH	P31	green	green	medium short	600 μs	8 ms	90 ms	
GR	P39	green	green	long	100 ms	1,4 s	9 s	
KC	—	yellow-green	yellow-green	medium short	1,3 ms	23 ms	210 ms	
X	—	colour screen	—	—	—	—	—	

The values in the table are measured under the following operation conditions.

Final accelerator voltage	10 to 18 kV
Screen current	0,1 $\mu A/cm^2$
Focusing	defocused
Excitation	sufficient for complete build-up

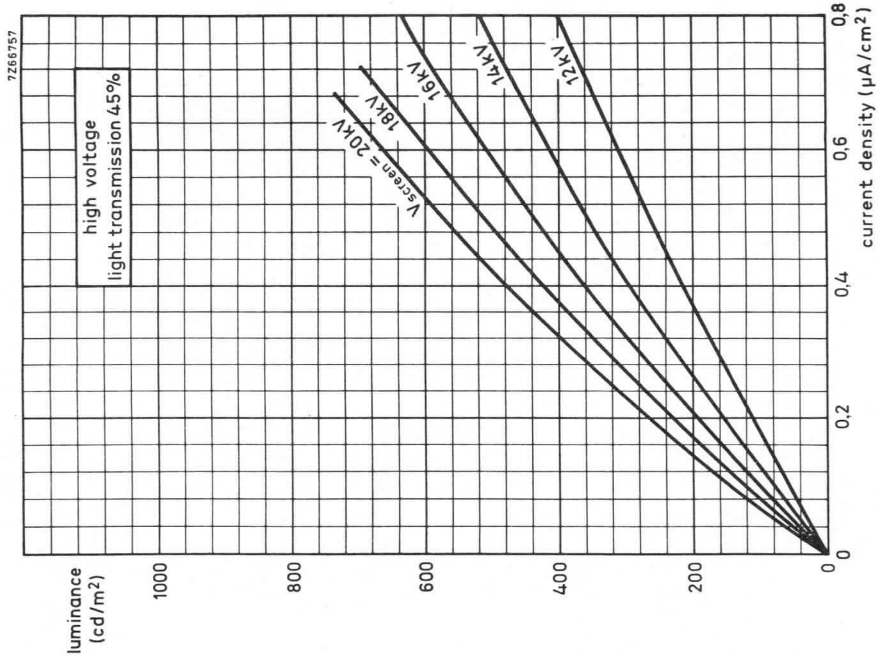


Fig. 3 Luminance as a function of current density for W phosphor.

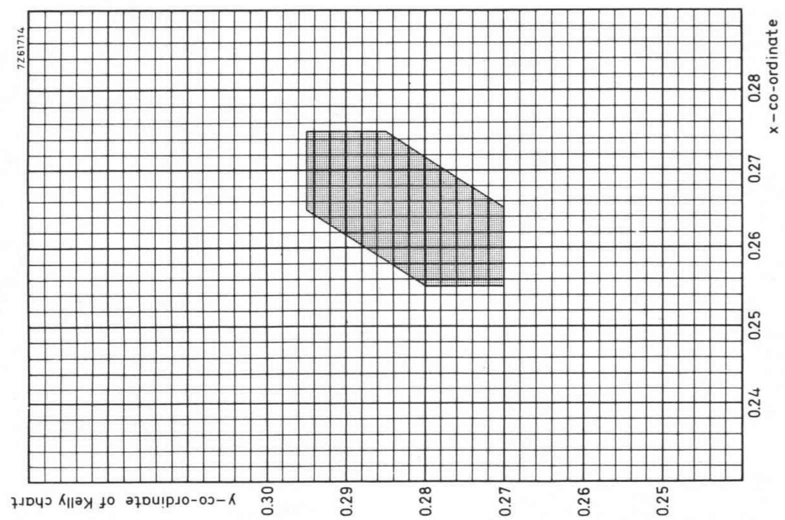


Fig. 2 Colour point tolerance area for W phosphor.

LIST OF SYMBOLS

Symbols denoting electrodes/elements and electrode/element connections

f	Heater
k	Cathode
g	Grid: Grids are distinguished by means of an additional numeral; the electrode nearest to the cathode having the lowest number.
a	Anode
m	External conductive coating
m^1	Rim band
ℓ	Fluorescent screen
i.c.	Tube pin which must not be connected externally
n.c.	Tube pin which may be connected externally

Symbols denoting voltages

Unless otherwise stated, the reference point for electrode voltages is the cathode.

V	Symbol for voltage, followed by a subscript denoting the relevant electrode/element
V_f	Heater voltage
V_{pp}	Peak-to-peak value of a voltage
V_p	Peak value of a voltage
V_{GR}	Grid 1 voltage for visual extinction of focused raster (grid drive service)
V_{KR}	Cathode voltage for visual extinction of focused raster (cathode drive service)

orange binder, tab 3

Symbols denoting currents

I	Symbol for current followed by a subscript denoting the relevant electrode
I_f	Heater current (r.m.s. value)

Note: The symbols quoted represent the average value of the current, unless otherwise stated.

Symbols denoting powers

P_ℓ	Dissipation of the fluorescent screen
P_g	Grid dissipation

Symbols denoting capacitances

See IEC publication 100

Symbols denoting resistances and impedances

R	Symbol for resistance followed by a subscript for the relevant electrode pair. When only one subscript is given the second electrode is the cathode.
Z	Symbol for impedance followed by a subscript for the relevant electrode pair. When only one subscript is given the second electrode is the cathode.

Symbols denoting various quantities

L	Luminance
f	Frequency
H	Magnetic field strength

TYPE DESIGNATION

PRO ELECTRON TYPE DESIGNATION CODE

The type number of the picture tubes consists of:
Single letter, group of figures, hyphen, group of figures, letter or letter group.

The first letter indicates the prime application of the tube:
A – Television display tube for domestic application.
M – Monitor tube for video and data display.

First group of figures: diameter or diagonal of the face in cm.

Second group of figures: design number.

Final letter or letter group: properties of the phosphor screen.
The first letter denotes the colour of the fluorescence; the second letter, if any, denotes other specific differences in screen properties.
W – White screen for television and data display tubes.
X – Three-colour screen for television display tubes.
GH – Green screen for video and data display tubes (medium-short persistence).
GR – Green screen for video and data display tubes (long persistence).

Example

A66-540X

- A: television display tube for domestic application
- 66: face diagonal (66 cm)
- 540: design number
- X: three-colour screen

orange binder, tab 3

DEFLECTION UNIT

- **Raster Correction Free**

QUICK REFERENCE DATA

Picture tube	
gun arrangement	in line
diagonal	42 cm (16 in)
neck diameter	29,1 mm
Deflection angle	90°
Line deflection current, edge to edge at 25 kV	3,04 A p-p
Inductance of line coils, parallel connected	1,89 mH
Field deflection current, edge to edge at 25 kV	0,45 A(p-p)
Resistance of field coils, series connected	55,6 Ω

APPLICATION

This deflection unit, in conjunction with devices for colour purity and static convergence is for 90° in-line colour picture tubes A42-590X and A42-591X, with a neck diameter of 29,1 mm. The unit requires no raster correction circuitry.

DESCRIPTION

The deflection unit consists of saddle-shaped line deflection coils, toroidal wound field deflection coils and metal fins, thus forming a raster correction free hybrid yoke. The unit has a metal non-magnetic clamping ring at the rear, to fix the deflection unit on the neck of the picture tube.

MECHANICAL DATA

Dimensions in mm

Outlines

The deflection unit fits a tube with a neck diameter of 29,1 $^{+0,9}_{-0,7}$ mm.

For correct fitting the tube neck should be provided with adhesive tape.

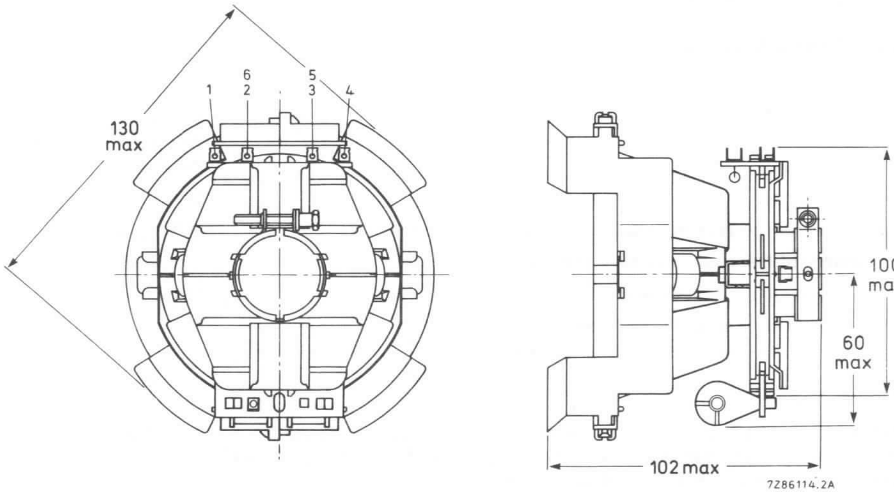


Fig. 1.

Maximum operating temperature (average copper temperature measured with resistance method)	+ 90 °C
Storage temperature range	−20 to + 90 °C
Flame retardent	according to UL 1413, category 94-V1
Torque on neck clamp screw	1,4 Nm

ENVIRONMENTAL TEST SPECIFICATIONS

Vibration	IEC 68-2-6 (test Fc)
Bump	IEC 68-2-29 (test Eb; 35g)
Cold	IEC 68-2-1 (test Ab)
Dry heat	IEC 68-2-2 (test Bb)
Damp heat, steady state	IEC 68-2-3 (test Ca)
Cyclic damp heat	IEC 68-2-30 (test Db)
Change of temperature	IEC 68-2-14 (test Nb)

ELECTRICAL DATA

Line coils	parallel connected
Inductance at 1 V (r.m.s.), 1 kHz	1,89 mH ± 5%
Resistance at 25 °C	2,6 Ω ± 10%
Line deflection current, edge to edge, at 25 kV	3,04 A (p-p)
Voltage during line scan, edge to edge, at 25 kV, scan period 52,5 μs	109 V
Field coils	series connected
Inductance at 1 V (r.m.s.), 1 kHz	116 mH ± 10%
Resistance at 25 °C	55,6 Ω ± 7%
Field deflection current, edge to edge, at 25 kV	0,45 A (p-p)
Cross-talk	a voltage of 10 V, 15625 Hz applied to the line coils causes no more than 0,2 V across the field coils (damping resistors included)
Insulation resistance at 1 kV (d.c.)	
between line and field coils	> 500 MΩ
between line coil and core clamp	> 500 MΩ
between field coil and core clamp	> 10 MΩ

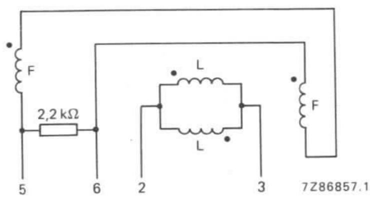


Fig. 2 Connection diagram, L = Line, F = Field.

ADJUSTMENT

- Adjust the static convergence with the four and six-pole magnets of the multipole unit AT1052 for the relative movement of the beams under influence of a four or six-pole magnet.
- Adjust colour purity by axial movement of the deflection yoke and adjustment of the two-pole magnets for centring of the beams.
- Tighten the screw of the clamping ring on the deflection yoke to secure the axial position of the unit on the picture tube.
- Readjust, if necessary, the convergence with the four and six-pole magnets.
- Tilt the unit in either horizontal or vertical direction, or in both directions so that blue, green and red lines converge at the end of the horizontal and vertical axis.
- This position of the unit has to be secured by three rubber wedges placed between the picture tube and the deflection unit. These wedges have to be cemented on to the picture tube.

DEFLECTION UNIT

- Raster Correction Free

QUICK REFERENCE DATA

Picture tube	
gun arrangement	in line
diagonal	51 cm (20 in)
neck diameter	29,1 mm
Deflection angle	90^o
Line deflection current, edge to edge at 25 kV	3,1 A p-p
Inductance of line coils, parallel connected	1,9 mH
Field deflection current, edge to edge at 25 kV	0,86 A p-p
Resistance of field coils, parallel connected	13,6 Ω

APPLICATION

This deflection unit, in conjunction which devices for colour purity and static convergence is for 90^o in-line colour picture tube A51-590X, with a neck diameter of 29,1 mm.
The unit requires no raster correction circuitry.

DESCRIPTION

The deflection unit consists of saddle-shaped line deflection coils, toroidal wound field deflection coils and metal fins, thus forming a raster correction free hybrid yoke. The unit has a metal non-magnetic clamping ring at the rear, to fix the deflection unit on the neck of the picture tube.

MECHANICAL DATA

Dimensions in mm

Outlines

The deflection unit fits a tube with a neck diameter of 29,1 $^{+0,9}_{-0,7}$ mm.

For correct fitting the tube neck should be provided with adhesive tape.

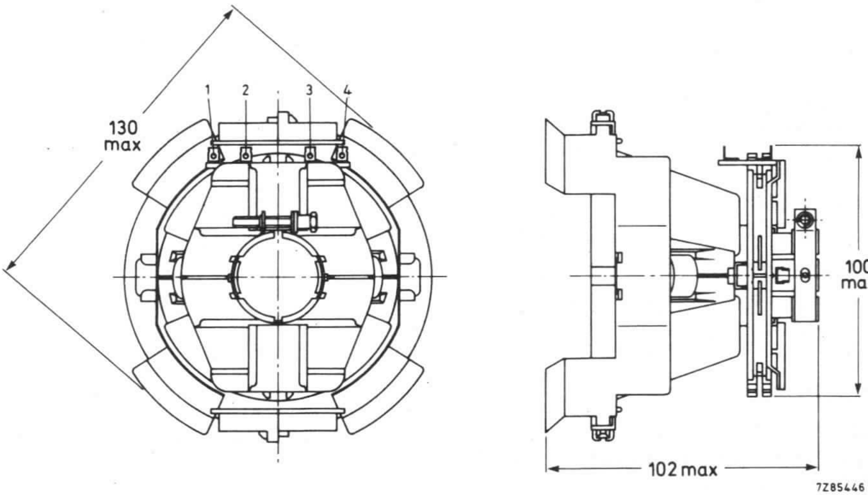


Fig. 1.

Maximum operating temperature (average copper temperature measured with resistance method)	+ 90 °C
Storage temperature range	−20 to + 90 °C
Flame retardent	according to UL 1413, category 94-V1
Torque on neck clamp screw	1,4 Nm

ENVIRONMENTAL TEST SPECIFICATIONS

Vibration	IEC 68-2-6 (test Fc)
Bump	IEC 68-2-29 (test Eb; 35g)
Cold	IEC 68-2-1 (test Ab)
Dry heat	IEC 68-2-2 (test Bb)
Damp heat, steady state	IEC 68-2-3 (test Ca)
Cyclic damp heat	IEC 68-2-30 (test Db)
Change of temperature	IEC 68-2-14 (test Nb)

ELECTRICAL DATA

Line coils	
Inductance at 1 V (r.m.s.), 1 kHz	1,9 mH ± 5%
Resistance at 25 °C	2,2 Ω ± 10%
Line deflection current, edge to edge, at 25 kV	3,1 A(p-p)
Field coils	
Inductance at 1 V (r.m.s.), 1 kHz	29 mH ± 10%
Resistance at 25 °C	13,6 Ω ± 7%
Field deflection current, edge to edge, at 25 kV	0,86 A(p-p)
Cross-talk	a voltage of 10 V, 15 625 Hz applied to the line coils causes no more than 0,2 V across the field coils (damping resistors included)
Insulation resistance at 1 kV (d.c.)	
between line and field coils	> 500 MΩ
between line coil and core clamp	> 500 MΩ
between field coil and core clamp	> 10 MΩ

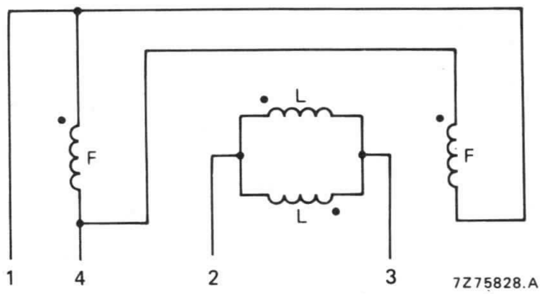


Fig. 2 Connection diagram, L = Line, F = Field.

ADJUSTMENT

- Adjust the static convergence with the four and six-pole magnets of the multipole unit AT1052 for the relative movement of the beams under influence of a four or six-pole magnet.
- Adjust colour purity by axial movement of the deflection yoke and adjustment of the two-pole magnets for centring of the beams.
- Tighten the screw of the clamping ring on the deflection yoke to secure the axial position of the unit on the picture tube.
- Readjust, if necessary, the convergence with the four and six-pole magnets.
- Tilt the unit in either horizontal or vertical direction, or in both directions so that blue, green and red lines converge at the end of the horizontal and vertical axis.
- This position of the unit has to be secured by three rubber wedges placed between the picture tube and the deflection unit. These wedges have to be cemented on to the picture tube.

HIGH RESOLUTION CRT FOR DATA DISPLAY

- 90° deflection angle
- 31 cm (12 in) face diagonal; rectangular glass
- 28,6 mm neck diameter
- white, green or yellow-green screen phosphor
- integral implosion protection

QUICK REFERENCE DATA

Deflection angle	90°
Face diagonal	31 cm (12 in)
Overall length	max. 295 mm
Neck diameter	28,6 mm
Heating	6,3 V/240 mA
Quick heating cathode	with a typical tube a legible picture will appear within 5 s
Grid 2 voltage	400 V
Anode voltage	17 kV
Resolution	approx. 1300 lines

orange binder, tab 3

APPLICATION

This high resolution CRT is for alphanumeric and graphic display applications, such as computer terminals, word processors, etc.

The CRTs can be supplied with white (W), green (GH and GR) or yellow-green (KC) phosphors.

ELECTRICAL DATA

Focusing method	electrostatic
Deflection method	magnetic
Deflection angles	
diagonal	approx. 90°
horizontal	approx. 82°
vertical	approx. 67°
Direct interelectrode capacitances	
cathode to all other electrodes	approx. 3 pF
grid 1 to all other electrodes	approx. 7 pF
Capacitance of external conductive coating to anode	max. 1050 pF min. 600 pF
Heater voltage	6,3 V
Heater current at 6,3 V	240 mA

OPTICAL DATA

Phosphor type	W (P4*), GH (P31*), GR (P39*) and KC
Light transmission at centre of screen	approx. 50%

RASTER CENTRING

The field intensity perpendicular to the tube axis should be adjustable from 0 to 800 A/m. For optimum overall sharpness it is recommended to centre the raster electrically via the deflection coils.

* According to EIA.

MECHANICAL DATA (see also the figures under Dimensional Data)

Overall length	max. 295 mm
Greatest dimensions of tube	
diagonal	321 mm
width	282 mm
height	222 mm
Minimum useful screen dimensions	
diagonal	295 mm
horizontal axis	257 mm
vertical axis	195 mm
area	501 cm^2
Implosion protection	rim band
Bulb	J99-Z1
Bulb contact designation	J99-Z1a-j121
Base designation	IEC 67-I-31a; EIA B7-208
Basing	8HR
Flashover protection	ring trap base
Mass	approx. 3,2 kg

RATINGS (Absolute Maximum System)

Unless otherwise specified voltage values are positive and measured with respect to grid 1.

Anode voltage	max. 19 kV min. 13 kV
Grid 4 (focusing electrode) voltage	−500 to +1000 V
Grid 2 voltage	max. 700 V
Anode current	
long-term average value	max. 75 μA
peak value	max. 300 μA
Cathode voltage, positive peak value	max. 400 V
Heater voltage	6,3 V ± 10% *
Cathode-to-heater voltage	max. 100 V

* For maximum cathode life it is recommended that the heater supply be stabilized at 6,3 V.

CIRCUIT DESIGN VALUES

Grid 4 current		
positive	max.	25 μA
negative	max.	25 μA
Grid 2 current		
positive	max.	5 μA
negative	max.	5 μA

MAXIMUM CIRCUIT VALUES

Resistance between cathode and heater	max.	1,0 MΩ
Impedance between cathode and heater	max.	0,1 MΩ
Grid 1 circuit resistance	max.	1,5 MΩ
Grid 1 circuit impedance	max.	0,5 MΩ

TYPICAL OPERATING CONDITIONS

Cathode drive; voltages specified with respect to grid 1

Anode voltage	17 kV
Grid 4 (focusing electrode) voltage	0 to 400 V*
Grid 2 voltage	400 V
Cathode cut-off voltage	40 to 70 V**

Grid drive; voltages specified with respect to cathode

Anode voltage	17 kV
Grid 4 (focusing electrode) voltage	0 to 400 V*
Grid 2 voltage	400 V
Grid 1 cut-off voltage	45 to 83 V**

RESOLUTION

The resolution is approx. 1300 lines. It is measured at the screen centre, with shrinking raster method, at light output = 68,5 cd/m^2 (20 foot lambert), grid 2 voltage = 700 V, anode voltage = 17 kV; raster dimensions 216 mm x 162 mm.

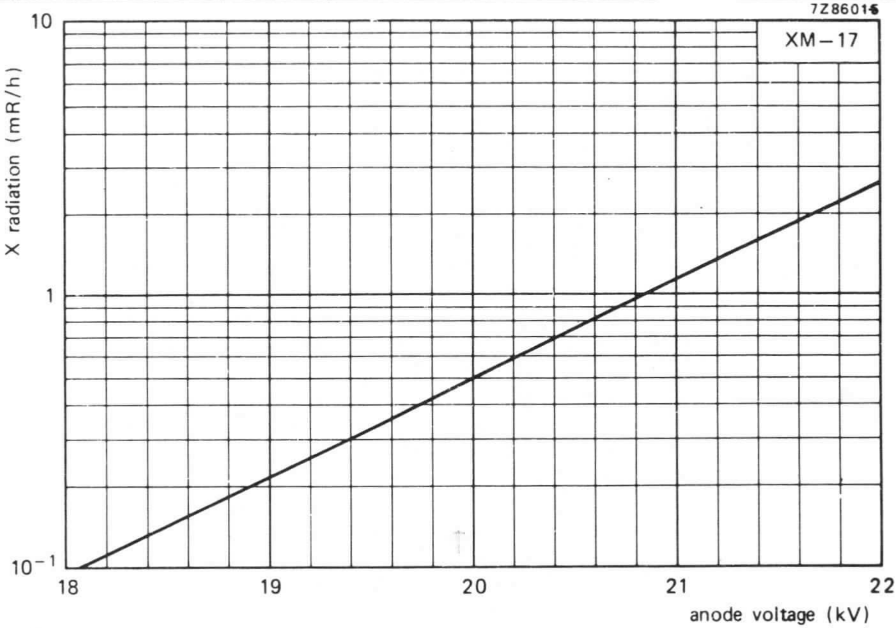
X-RADIATION CHARACTERISTIC

X-radiation emitted will not exceed 0,5 mR/h throughout the useful life of the tube, when operated within the given ratings. See also graphs on the next page.

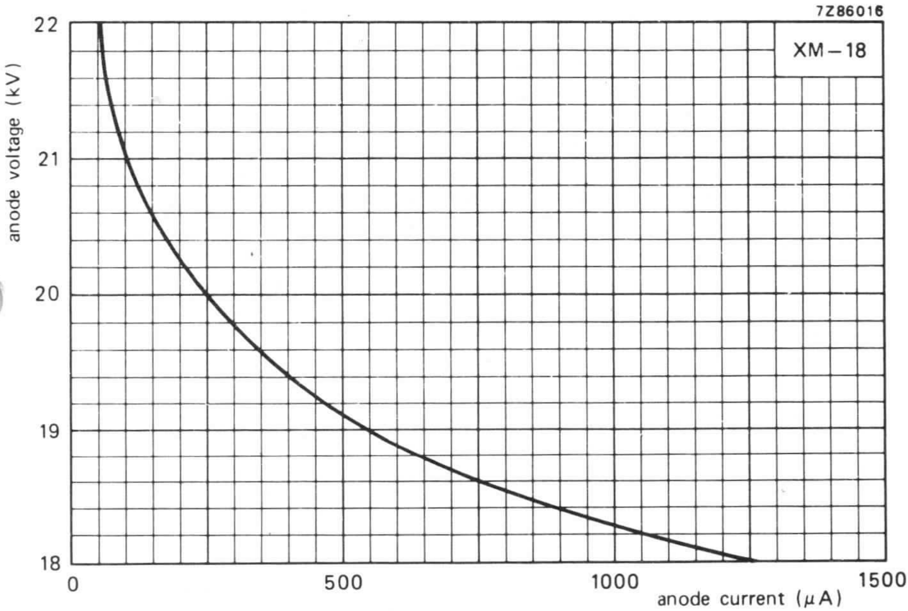
* Measured at screen centre on spot at anode current = 50 μA (peak), anode voltage = 17 kV, grid 2 voltage = 400 V. For optimum overall sharpness dynamic focusing is recommended (typ. 250 V).

** Visual extinction of focused raster.

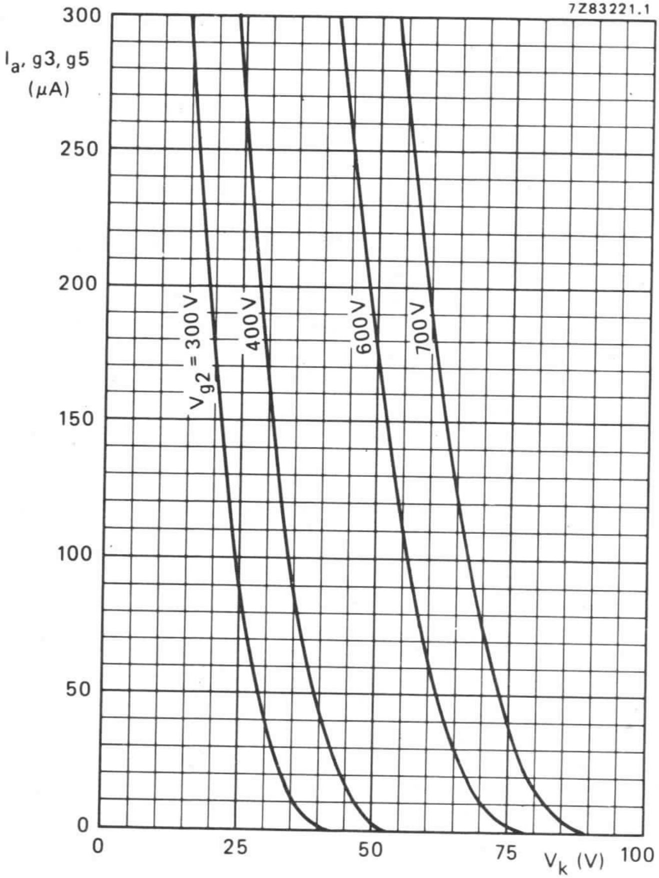
DEVELOPMENT SAMPLE DATA



X-radiation limit curve according to JEDEC94, at a constant anode current of 250 μA, measured according to JEDEC64D.

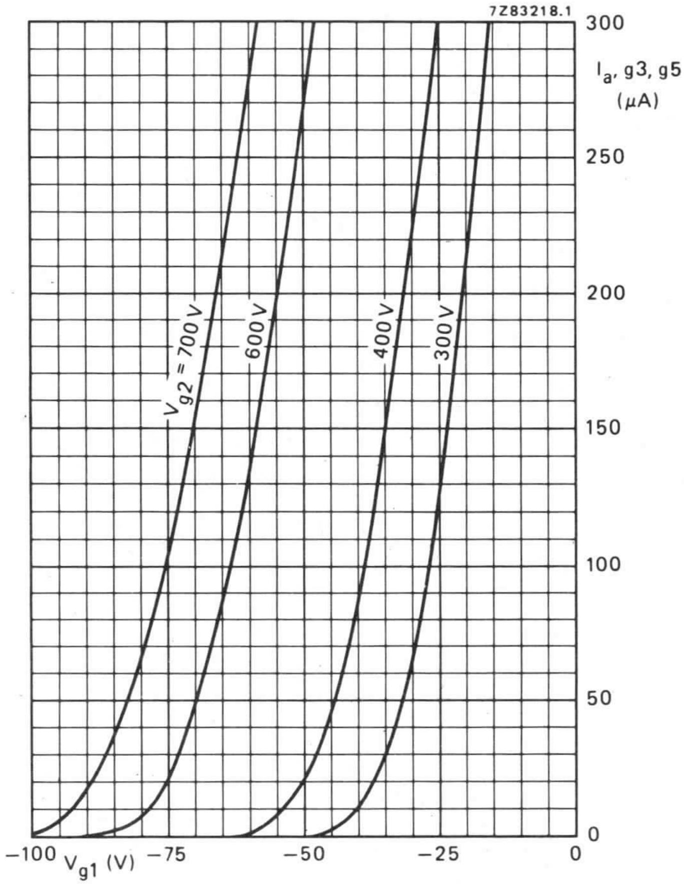


0,5 mR/h isoexposure-rate limit curve, according to JEDEC94, measured according to JEDEC64D.

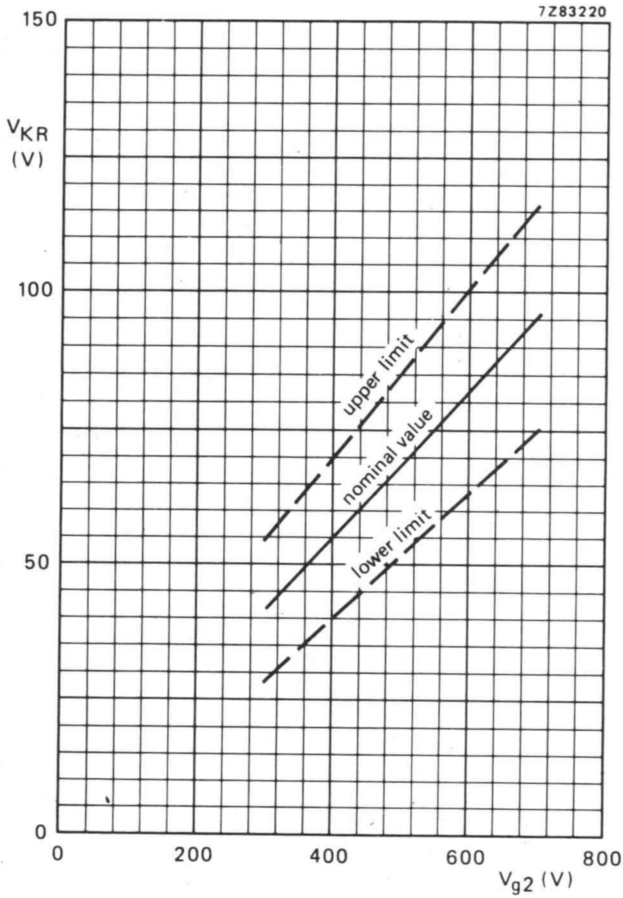


Anode current as a function of cathode voltage.
Cathode drive; $V_{a,g3,g5}$ = 17 kV.

DEVELOPMENT SAMPLE DATA

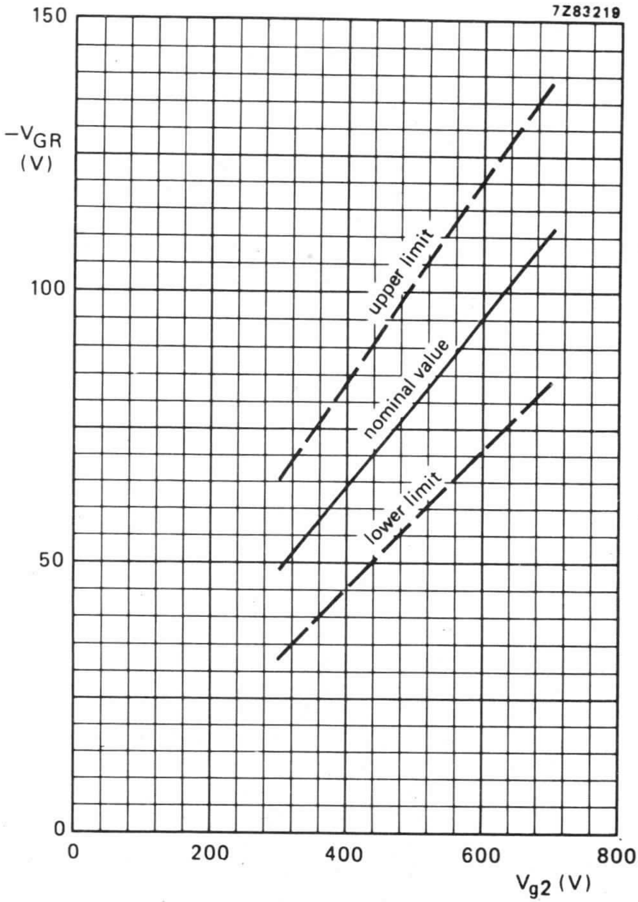


Anode current as a function of grid 1 voltage.
Grid drive; $V_{a,g3,g5}$ = 17 kV.



Limits of cathode cut-off voltage as a function of grid 2 voltage.
Cathode drive; $V_{a,g3,g5}$ = 17 kV.

$$\frac{\Delta V_{KR}}{\Delta V_{a,g3,g5}} = 0{,}15 \times 10^{-3}.$$



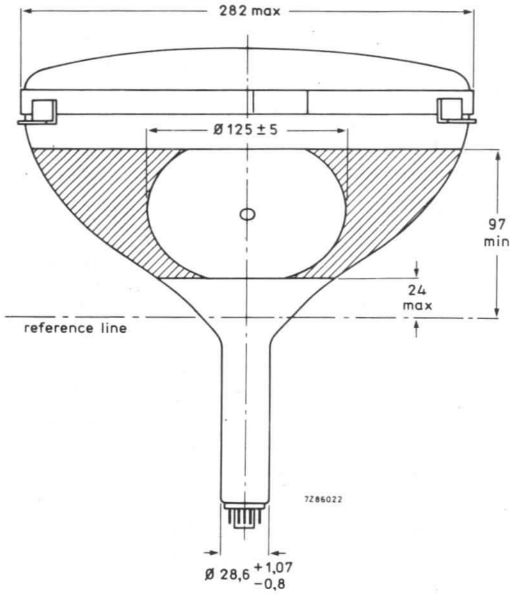
Limits of grid 1 cut-off voltage as a function of grid 2 voltage.
Grid drive; $V_{a,g3,g5}$ = 17 kV.

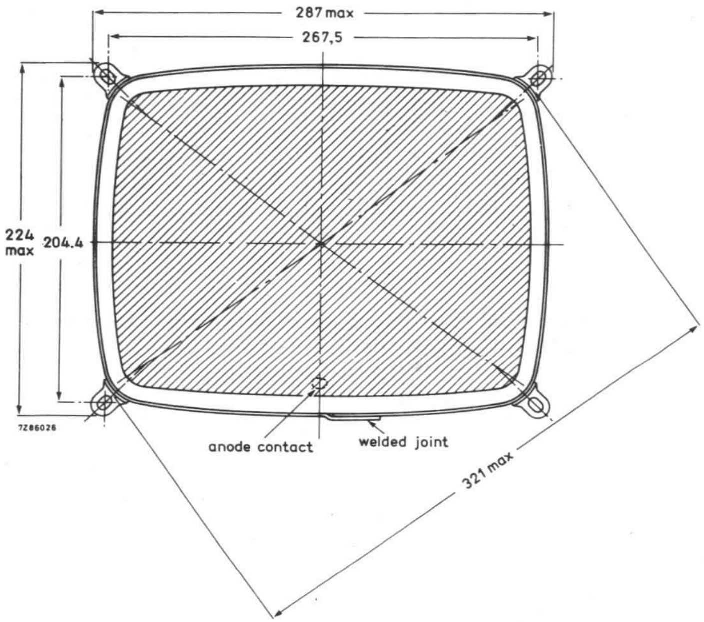
$$\frac{\Delta V_{GR}}{\Delta V_{a,g3,g5}} = 0,15 \times 10^{-3}.$$

DEVELOPMENT SAMPLE DATA

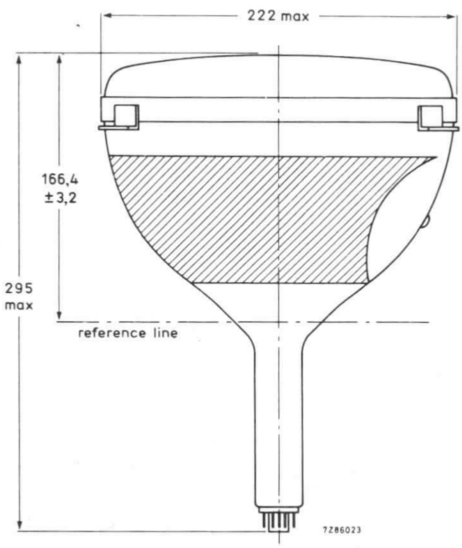
DIMENSIONAL DATA

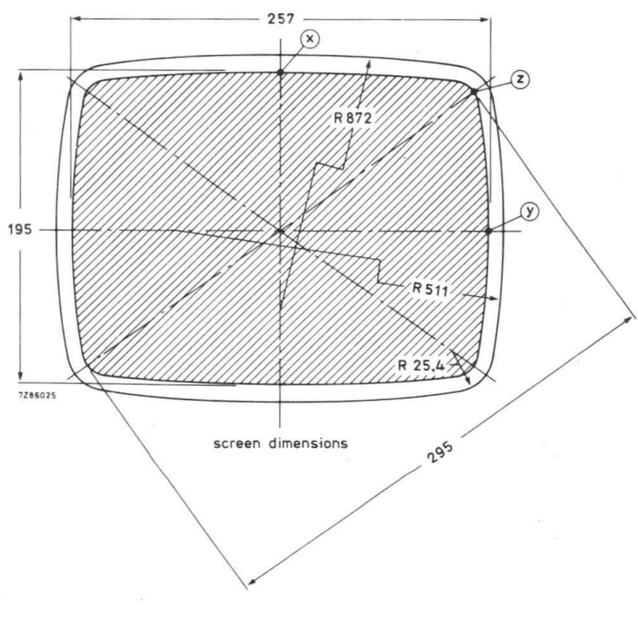
Dimensions in mm



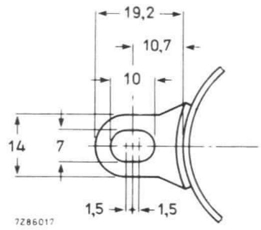


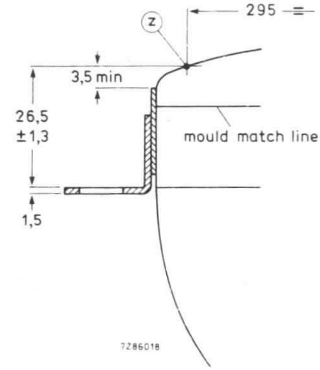
Mullard

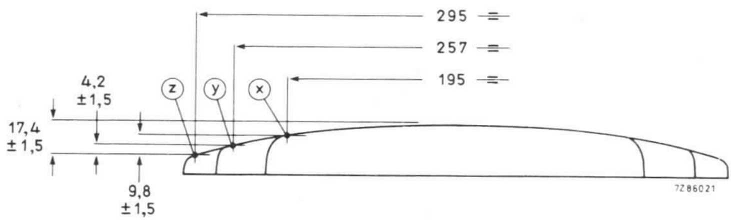


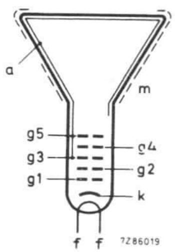


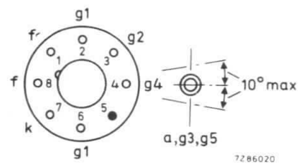
DEVELOPMENT SAMPLE DATA


19,2
10,7
10
14
7
1,5
1,5
7Z86017

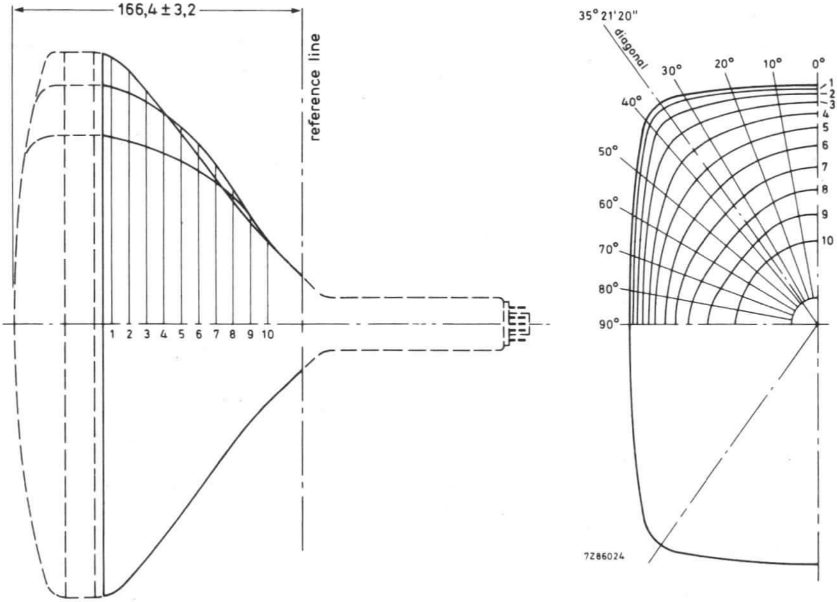

295
z
3,5 min
26,5
±1,3
mould match line
1,5
7Z86018


295
257
195
z
y
x
4,2
±1,5
17,4
±1,5
9,8
±1,5
7Z86021


a
m
g5
g4
g3
g2
g1
k
f
f
7Z86019


g1
f
g2
f
g4
k
g1
1
2
3
4
5
6
7
8
10° max
a,g3,g5
7Z86020

Maximum cone contour



DEVELOPMENT SAMPLE DATA

Section	Nom. distance from reference line	Distance from centre (max. values)										
		0°	10°	20°	30°	diag.	40°	50°	60°	70°	80°	90°
1	110	137,1	138,5	142,9	150,5	154,0	151,0	133,0	120,5	112,6	108,2	106,8
2	100	134,2	135,3	138,6	144,2	147,0	144,4	128,3	116,9	109,6	105,5	104,2
3	90	128,8	129,4	131,2	134,1	135,6	134,2	122,5	112,5	106,0	102,4	101,2
4	80	121,9	122,0	122,3	122,9	122,6	121,1	113,6	106,5	101,6	98,8	97,9
5	70	113,5	113,2	112,4	110,8	109,4	108,0	104,3	100,3	96,9	94,6	93,8
6	60	103,1	102,4	100,2	97,3	95,9	94,8	92,6	90,9	89,6	88,7	88,4
7	50	90,9	89,6	86,3	83,5	82,4	81,7	80,7	80,5	81,1	81,6	81,8
8	40	77,2	76,0	72,8	70,0	69,0	68,4	68,0	68,7	70,5	73,1	74,1
9	30	62,7	62,1	60,4	58,1	57,2	56,7	56,3	57,0	58,6	61,4	63,5
10	20	47,7	47,5	47,1	46,5	46,0	45,7	45,4	45,7	46,5	47,4	47,7

HIGH RESOLUTION MONOCHROME DISPLAY TUBES

- For Data Graphic Displays
- 90° deflection angle
- 34 cm (14 in) face diagonal; rectangular glass
- 20 mm neck diameter
- Integral implosion protection

QUICK REFERENCE DATA

Deflection angle	90°
Face diagonal	34 cm (14 in)
Overall length	max. 287 mm
Neck diameter	20 mm
Heating	12 V/130 mA
Quick heating cathode	with a typical tube a legible picture will appear within 5 s
Grid 2 voltage	400 V
Anode voltage	14 kV
Resolution	approx. 1300 lines

APPLICATION

These high resolution tubes are for alpha-numeric and graphic display applications, such as computer terminals, small business computers, etc.

The tubes can be supplied with different phosphors and anti-reflective treatments, see "High resolution monochrome display tubes, General".

AVAILABLE VERSIONS

The following versions are available:
M32EAB0 – normal glare and normal tinted face glass;
M32EAB1 – direct grind and normal tinted face glass;
M32EAB2 – direct grind and dark tinted face glass;
M32EAB3 – direct etch and dark tinted face glass;
M32EAB4 – high glare and dark tinted face glass.

ELECTRICAL DATA

Focusing method	electrostatic
Deflection method	magnetic
Deflection angles	
diagonal	approx. 90°
horizontal	approx. 82°
vertical	approx. 67°
Interelectrode capacitances	
cathode to all other electrodes	max. 4 pF
grid 1 to all other electrodes	max. 7 pF
Capacitance of external conductive coating to anode*	max. 1200 pF min. 600 pF
Capacitance of external conductive coating to anode**	max. 1050 pF min. 450 pF
Capacitance of anode to implosion protection hardware**	approx. 150 pF
Heater voltage	12 V
Heater current at 12 V	130 mA

OPTICAL DATA

Phosphor type	see "High resolution monochrome display tubes, General"
Light transmission at screen centre	
tube with normal tinted face glass	approx. 48%
tube with dark tinted face glass	approx. 34%

RASTER CENTRING

The field intensity perpendicular to the tube axis should be adjustable from 0 to 800 A/m. For optimum overall sharpness it is recommended to centre the raster electrically via the deflection coils.

* Implosion protection hardware connected to external conductive coating.
** Implosion protection hardware not connected to external conductive coating.

MECHANICAL DATA (see also the figures under Dimensional Data)

Overall length	max. 287 mm
Greatest dimensions of tube	
diagonal	350 mm
width	298 mm
height	240 mm
Minimum useful screen dimensions (projected)	
diagonal	322 mm
horizontal axis	270 mm
vertical axis	210 mm
area	554 cm^2
Implosion protection	T-band
Bulb	EIA-J340B1 or EIA-J340D1
Bulb contact designation	IEC 67-III-2, EIAJ1-21
Base designation	EIA-E7-91
Basing	7GR
Mass	approx. 3,6 kg

RATINGS (Absolute Maximum System)

Unless otherwise specified voltage values are positive and measured with respect to grid 1.

Anode voltage	max. 16 kV min. 10 kV
Grid 4 (focusing electrode) voltage	−200 to + 1000 V
Grid 2 voltage	max. 700 V
Anode current	
long-term average value	max. 130 μA
peak value	max. 600 μA
Cathode voltage, positive peak value	max. 400 V
Heater voltage	12 V ± 10%*
Cathode-to-heater voltage	max. 200 V

* For maximum cathode life it is recommended that the heater supply be regulated at 12 V.

CIRCUIT DESIGN VALUES

Grid 4 current		
positive	max.	25 μA
negative	max.	25 μA
Grid 2 current		
positive	max.	5 μA
negative	max.	5 μA

MAXIMUM CIRCUIT VALUES

Resistance between cathode and heater	max.	1 MΩ
Impedance between cathode and heater	max.	0,1 MΩ
Grid 1 circuit resistance	max.	1,5 MΩ
Grid 1 circuit impedance	max.	0,5 MΩ

TYPICAL OPERATING CONDITIONS

Cathode drive; voltages specified with respect to grid 1

Anode voltage	14 kV
Grid 4 (focusing electrode) voltage	0 to 300 V*
Grid 2 voltage	400 V
Cathode cut-off voltage	32 to 64 V**

Grid drive; voltages specified with respect to cathode

Anode voltage	14 kV
Grid 4 (focusing electrode) voltage	0 to 300 V*
Grid 2 voltage	400 V
Grid 1 cut-off voltage	35 to 70 V**

RESOLUTION

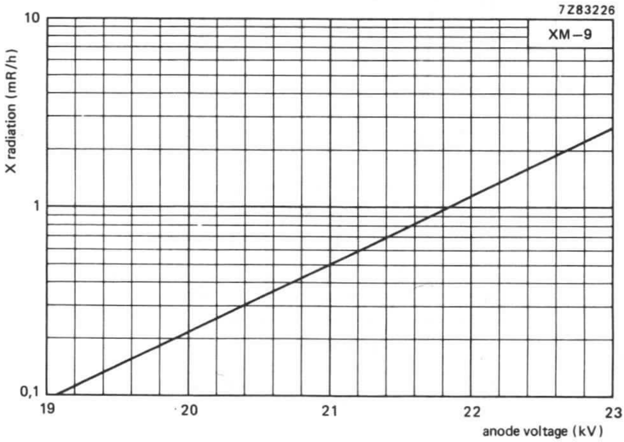
The resolution is approx. 1300 lines. It is measured at the screen centre, with shrinking raster method, at light output = 68,5 cd/m² (20 foot lambert), grid 2 voltage = 700 V, anode voltage = 14 kV; phosphor type WW, without anti-glare treatment, raster dimensions 237 mm x 178 mm.

X-RADIATION CHARACTERISTIC

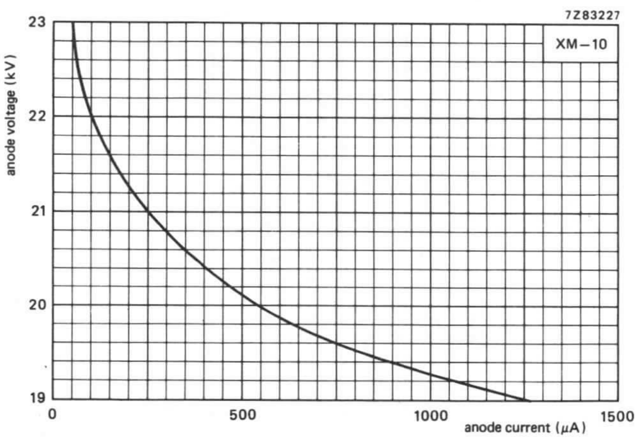
X-radiation emitted will not exceed 0,5 mR/h throughout the useful life of the tube, when operated within the given ratings.

* Measured at screen centre on spot at anode current = 250 μA (peak), anode voltage = 14 kV, grid 2 voltage = 400 V.
Dynamic focus (only for optimization): Typical correction for a video field of H x V = 237 mm x 178 mm:
line parabola 200 V,
field parabola 100 V.

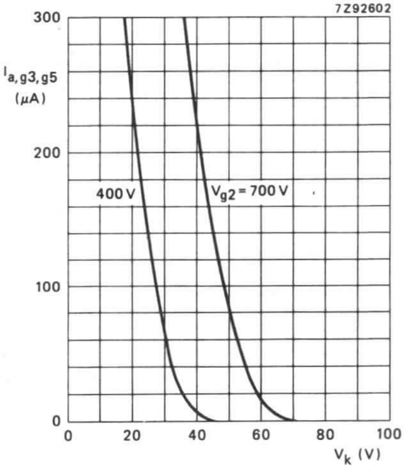
** Visual extinction of focused raster.



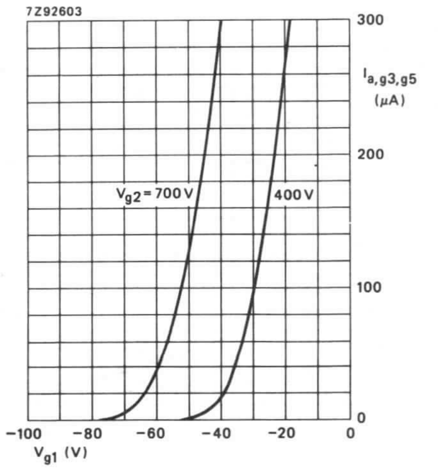
X-radiation limit curve according to JEDEC94, at a constant anode current of 250 μA, measured according to TEPAC103A.



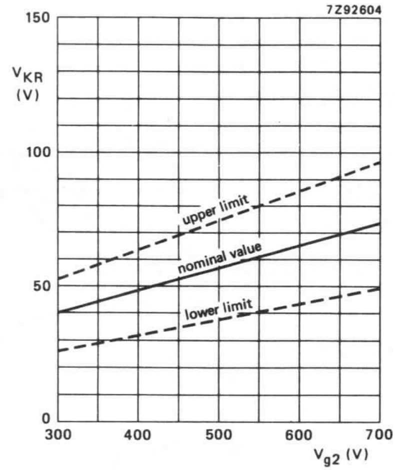
0,5 mR/h isoexposure-rate limit curve, according to JEDEC94, measured according to TEPAC103A.



Anode current as a function of cathode voltage.
Cathode drive; $V_{a,g3,g5}$ = 14 kV.

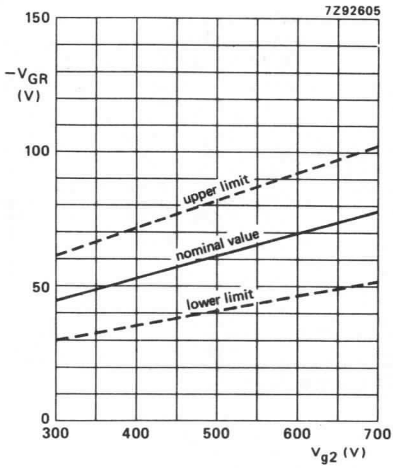


Anode current as a function of grid 1 voltage.
Grid drive; $V_{a,g3,g5}$ = 14 kV.



Limits of cathode cut-off voltage as a function of grid 2 voltage.
Cathode drive; $V_{a,g3,g5}$ = 14 kV.

$$\frac{\Delta V_{KR}}{\Delta V_{a,g3,g5}} = 0,15 \times 10^{-3}.$$

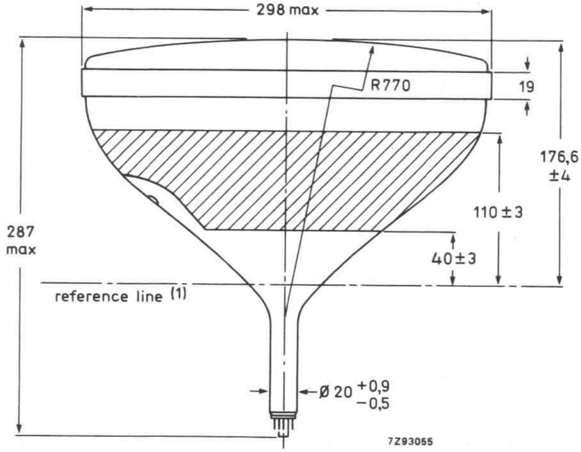


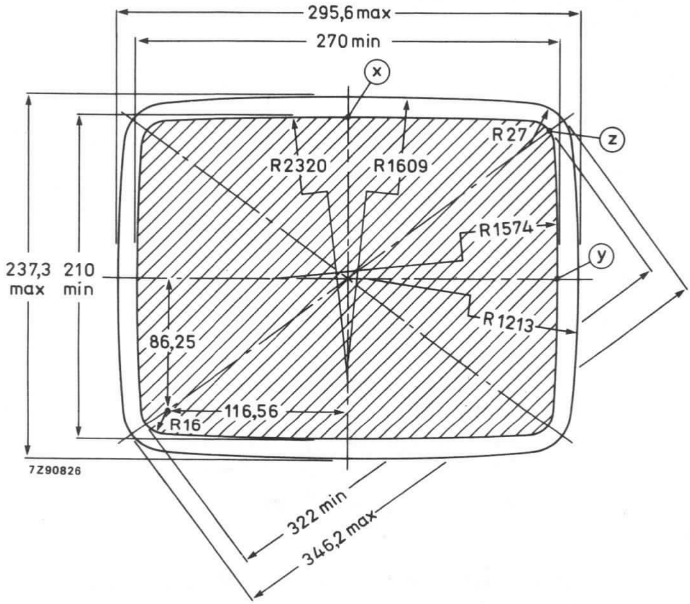
Limits of grid 1 cut-off voltage as a function of grid 2 voltage.
Grid drive; $V_{a,g3,g5}$ = 14 kV.

$$\frac{\Delta V_{GR}}{\Delta V_{a,g3,g5}} = 0,15 \times 10^{-3}.$$

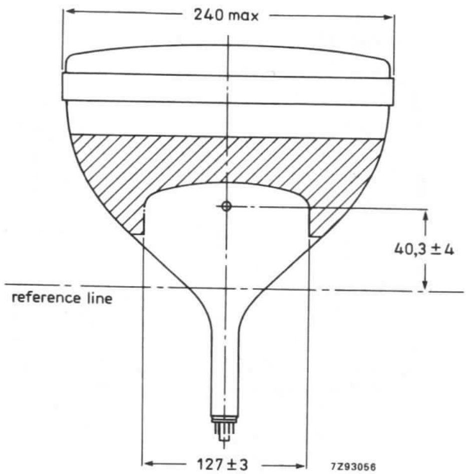
DIMENSIONAL DATA

Dimensions in mm

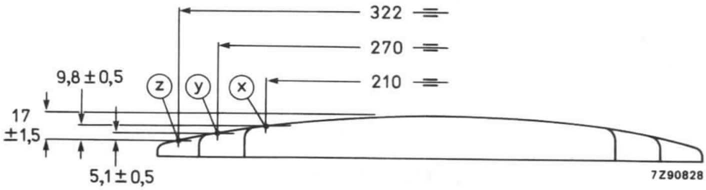




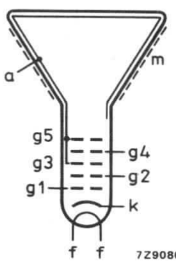
(1) The reference line is determined by the plane of the upper edge of reference line gauge D when the gauge is resting on the cone.



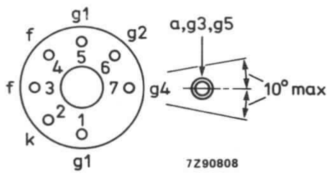
7Z93056



7Z90828

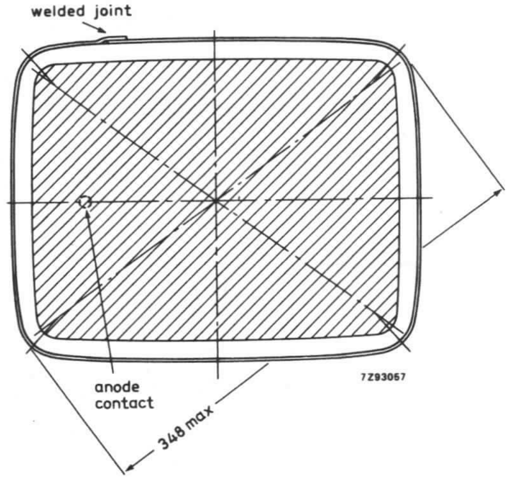


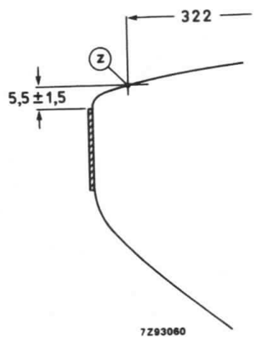
7Z90807



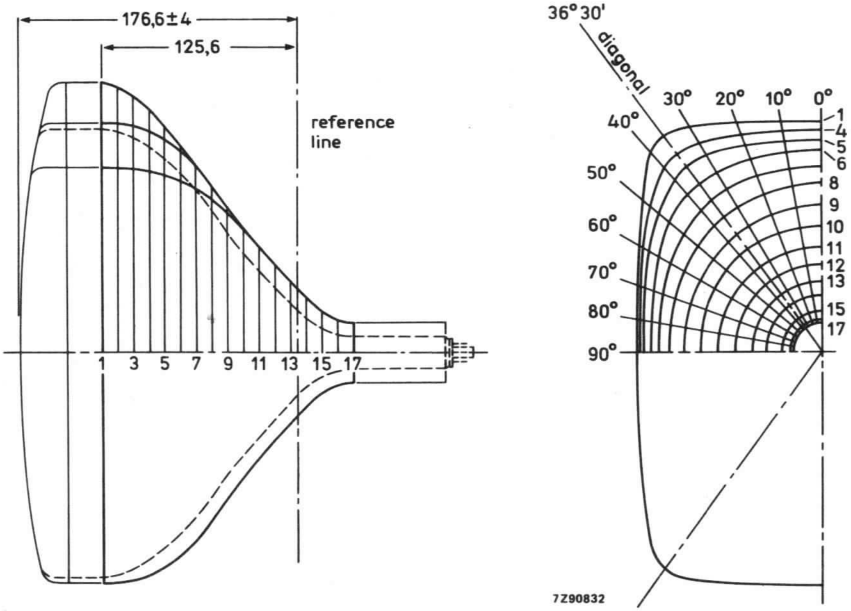
7Z90808

Front view


welded joint
anode contact
348 max
7Z93057


322
z
5,5 ± 1,5
7Z93060

Maximum cone contour



7Z90832

section	nom. distance from section 1	max. distance from centre										
		0°	10°	20°	30°	diag.	40°	50°	60°	70°	80°	90°
1	0	147,8	149,8	158,2	167,9	173,6	172,0	151,5	135,5	125,7	120,3	118,6
2	10	147,7	149,8	156,1	166,8	171,5	169,8	150,9	135,2	125,5	120,2	118,5
3	20	146,7	148,7	154,6	162,7	165,3	163,7	149,0	135,5	125,1	119,9	118,2
4	30	143,4	145,2	149,9	155,3	156,1	154,8	144,1	131,9	131,9	118,4	116,8
5	40	137,7	139,1	142,3	145,0	144,9	143,8	136,7	127,5	120,1	115,7	114,2
6	50	129,6	130,6	132,2	133,1	132,6	131,8	127,3	121,2	115,5	111,8	110,5
7	60	119,6	119,9	120,3	120,2	119,6	119,0	116,5	112,9	109,3	106,5	105,5
8	70	108,1	107,9	107,4	106,8	106,2	105,9	104,5	102,7	100,7	99,1	98,4
9	80	95,3	94,9	94,2	93,4	92,9	92,6	91,8	90,9	90,1	98,2	88,0
10	90	80,7	80,5	80,0	79,6	79,4	79,2	78,9	78,5	78,2	77,9	77,7
11	100	67,3	67,3	67,2	67,1	67,1	67,1	67,1	67,0	67,0	66,9	66,8
12	110	56,7	56,7	56,6	56,7	56,7	56,7	56,7	56,8	56,8	56,7	56,7
13	120	46,5	46,5	46,5	46,5	46,5	46,6	46,6	46,6	46,6	46,6	46,5
14	130	36,7	36,7	36,7	36,7	36,7	36,7	36,8	36,8	36,8	36,8	36,7
15	140	26,7	26,6	26,6	26,6	26,7	26,7	26,7	26,7	26,7	26,7	26,7
16	150	20,1	20,1	20,1	20,1	20,1	20,1	20,1	20,1	20,1	20,1	20,1
17	160	19,7	19,7	19,7	19,7	19,7	19,7	19,8	19,8	19,8	19,7	19,7

FLAT
HIGH RESOLUTION MONOCHROME DISPLAY TUBES

- For Data Graphic Displays
- 90° deflection angle
- 34 cm (14 in) face diagonal; rectangular glass
- 1520 mm radius of screen curvature
- 20 mm neck diameter
- Integral implosion protection

QUICK REFERENCE DATA

Deflection angle	90°
Face diagonal	34 cm (14 in)
Overall length	max. 282 mm
Neck diameter	20 mm
Heating	12 V/130 mA
Quick heating cathode	with a typical tube a legible picture will appear within 5 s
Grid 2 voltage	400 V
Anode voltage	14 kV
Resolution	approx. 1300 lines

APPLICATION

This high resolution tube is for alpha-numeric and graphic display applications, such as computer terminals, small business computers, etc.

AVAILABLE VERSIONS

The following versions are available: M32EBJ and M32EBL.

The tubes can be supplied with different phosphors and anti-reflective treatments, see "High resolution monochrome display tubes, General".

Differences between the tubes can be found under 'Dimensional data'.

ELECTRICAL DATA

Focusing method	electrostatic
Deflection method	magnetic
Deflection angles	
diagonal	approx. 90°
horizontal	approx. 79°
vertical	approx. 65°
Interelectrode capacitances	
cathode to all other electrodes	max. 4 pF
grid 1 to all other electrodes	max. 7 pF
Capacitance of external conductive coating to anode*	max. 1200 pF min. 600 pF
Capacitance of external conductive coating to anode**	max. 1050 pF min. 450 pF
Capacitance of anode to implosion protection hardware**	approx. 150 pF
Heater voltage	12 V
Heater current at 12 V	130 mA

OPTICAL DATA

Phosphor type	see "High resolution monochrome display tubes, General"
Light transmission at screen centre	
tube with normal tinted face glass	approx. 42%
tube with dark tinted face glass	approx. 30%

RASTER CENTRING

The field intensity perpendicular to the tube axis should be adjustable from 0 to 800 A/m. For optimum overall sharpness it is recommended to centre the raster electrically via the deflection coils.

* Implosion protection hardware connected to external conductive coating.
** Implosion protection hardware not connected to external conductive coating.

DEVELOPMENT DATA

MECHANICAL DATA (see also the figures under Dimensional Data)

Overall length	max. 282 mm
Greatest dimensions of tube	
diagonal	348,5 mm
width	298 mm
height	240 mm
Minimum useful screen dimensions (projected)	
diagonal	320 mm
horizontal axis	269 mm
vertical axis	210 mm
area	554 cm^2
Implosion protection	T-band/rimband
Bulb	EIAJ-JB340AH03 or EIAJ-JB340AH04
Bulb contact designation	IEC 67-III-2, EIAJ1-21
Base designation	EIA-E7-91
Basing	7GR
Mass	approx. 3,9 kg

RATINGS (Absolute Maximum System)

Unless otherwise specified voltage values are positive and measured with respect to grid 1.

Anode voltage	max. 16 kV min. 10 kV
Grid 4 (focusing electrode) voltage	−200 to + 1000 V
Grid 2 voltage	max. 700 V
Anode current	
long-term average value	max. 130 μA
peak value	max. 600 μA
Cathode voltage, positive peak value	max. 400 V
Heater voltage	12 V ± 10%*
Cathode-to-heater voltage	max. 100 V

* For maximum cathode life it is recommended that the heater supply be regulated at 12 V $^{+0\%}_{-5\%}$.

CIRCUIT DESIGN VALUES

Grid 4 current		
positive	max.	25 µA
negative	max.	25 µA
Grid 2 current		
positive	max.	5 µA
negative	max.	5 µA

MAXIMUM CIRCUIT VALUES

Resistance between cathode and heater	max.	1 MΩ
Impedance between cathode and heater	max.	0,1 MΩ
Grid 1 circuit resistance	max.	1,5 MΩ
Grid 1 circuit impedance	max.	0,5 MΩ

TYPICAL OPERATING CONDITIONS

Cathode drive; voltages specified with respect to grid 1

Anode voltage	14 kV
Grid 4 (focusing electrode) voltage	0 to 300 V*
Grid 2 voltage	400 V
Cathode cut-off voltage	32 to 64 V**

Grid drive; voltages specified with respect to cathode

Anode voltage	14 kV
Grid 4 (focusing electrode) voltage	0 to 300 V*
Grid 2 voltage	400 V
Grid 1 cut-off voltage	35 to 70 V**

RESOLUTION

The resolution is approx. 1300 lines. It is measured at the screen centre:

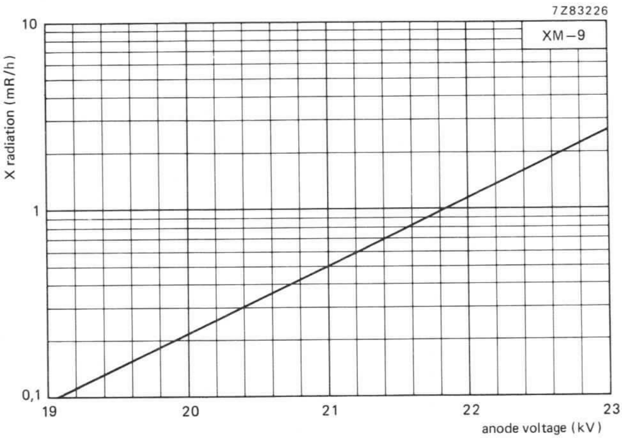
- with shrinking raster method,
- at light output 68,5 cd/m^2 (20 foot lambert) and raster dimensions 237 mm x 178 mm,
- at V_{g2} = 700 V and anode voltage = 14 kV,
- with phosphor type WW,
- with normal tinted face glass, without anti-glare treatment of screen surface.

X-RADIATION CHARACTERISTIC

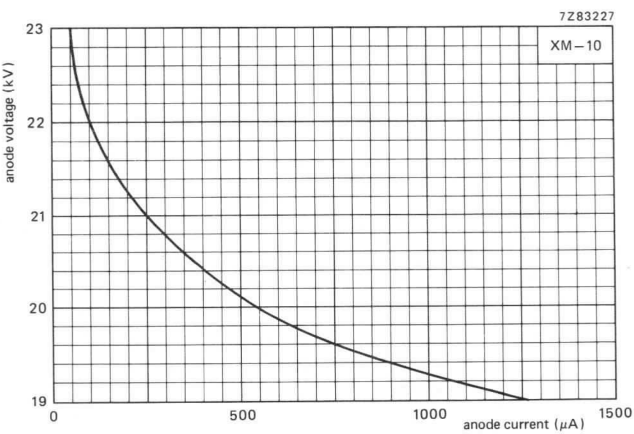
X-radiation emitted will not exceed 0,5 mR/h throughout the useful life of the tube, when operated within the given ratings.

* Measured at screen centre on spot at anode current = 250 µA (peak), anode voltage = 14 kV, grid 2 voltage = 400 V.
Dynamic focus (only for optimization): Typical correction for a video field of H x V = 237 mm x 178 mm:
line parabola 200 V,
field parabola 100 V.

** Visual extinction of focused raster.

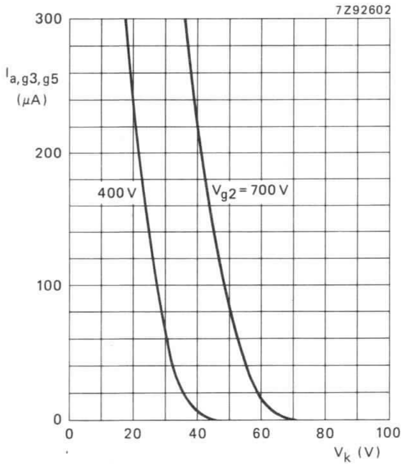


X-radiation limit curve according to JEDEC94, at a constant anode current of 250 μA, measured according to TEPAC103A.

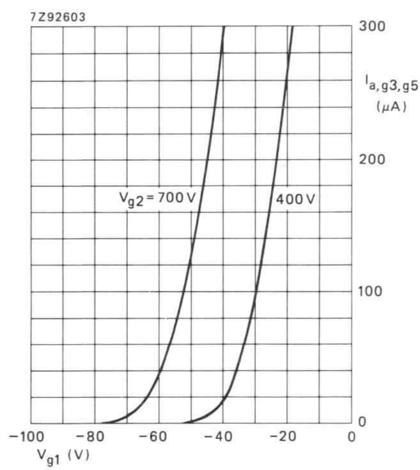


0,5 mR/h isoexposure-rate limit curve, according to JEDEC94, measured according to TEPAC103A.

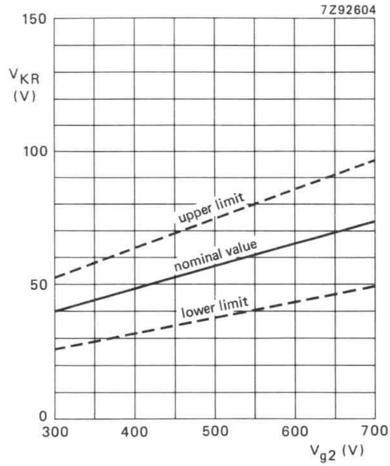
DEVELOPMENT DATA



Anode current as a function of cathode voltage.
Cathode drive; $V_{a,g3,g5}$ = 14 kV.

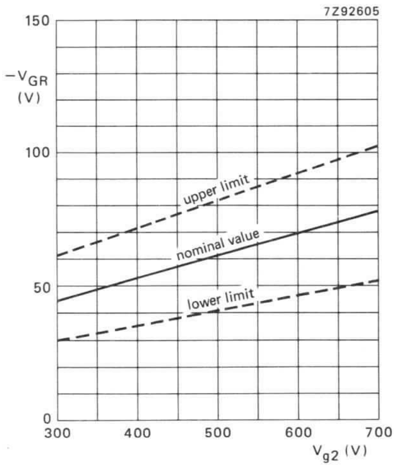


Anode current as a function of grid 1 voltage.
Grid drive; $V_{a,g3,g5}$ = 14 kV.



Limits of cathode cut-off voltage as a function of grid 2 voltage.
Cathode drive; $V_{a,g3,g5}$ = 14 kV.

$$\frac{\Delta V_{KR}}{\Delta V_{a,g3,g5}} = 0,9 \times 10^{-3}.$$



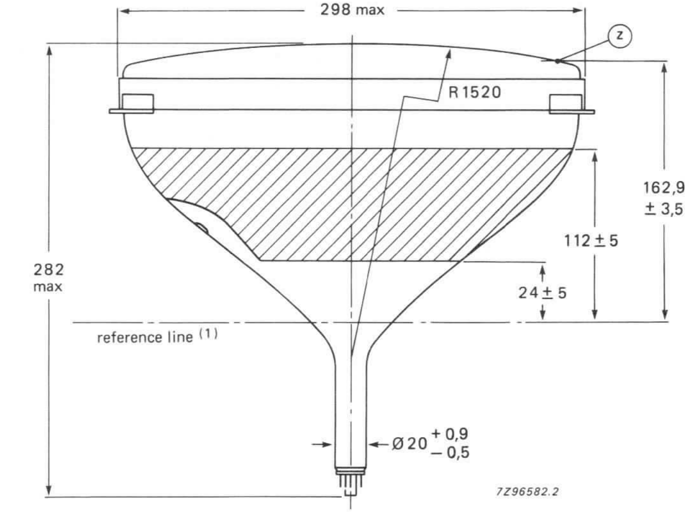
Limits of grid 1 cut-off voltage as a function of grid 2 voltage.
Grid drive; $V_{a,g3,g5}$ = 14 kV.

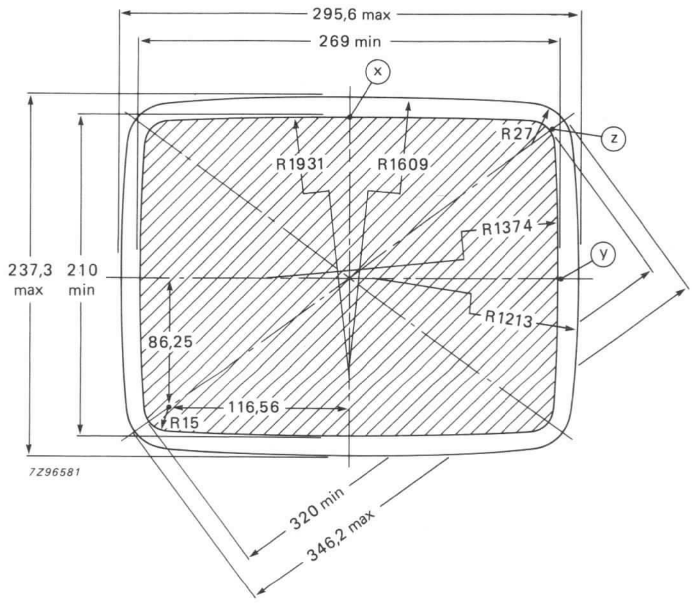
$$\frac{\Delta V_{GR}}{\Delta V_{a,g3,g5}} = 0,9 \times 10^{-3}.$$

DEVELOPMENT DATA

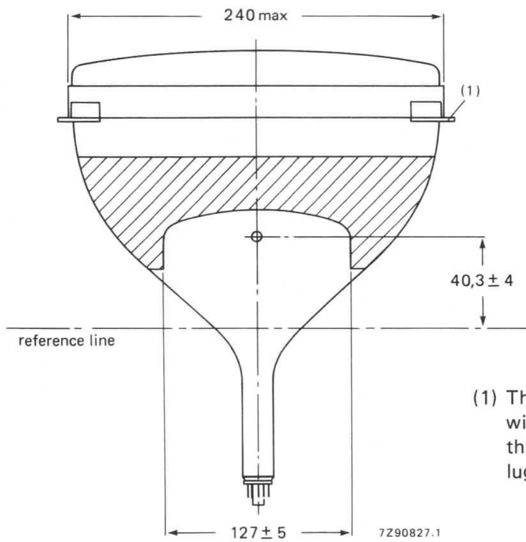
DIMENSIONAL DATA

Dimensions in mm

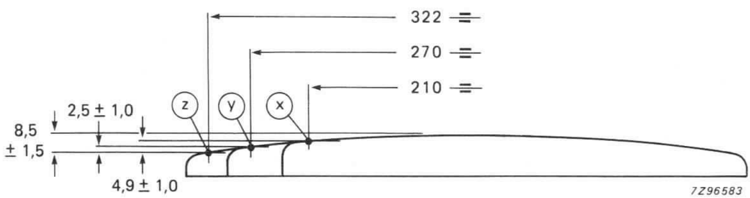


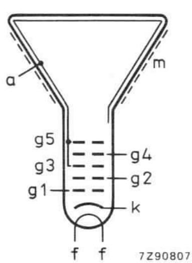


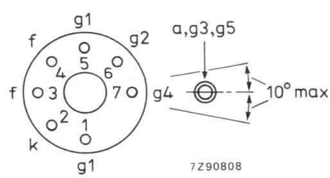
(1) The reference line is determined by the plane of the upper edge of reference line gauge D when the gauge is resting on the cone.



(1) The displacement of any lug with respect to the plane through the other three lugs is max. 1,5 mm.

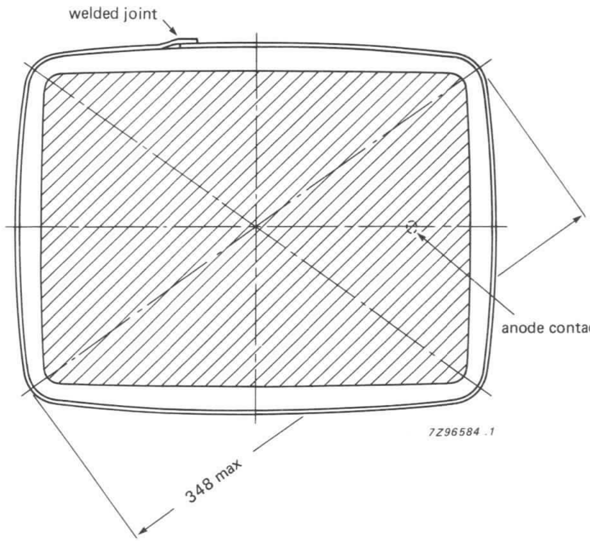


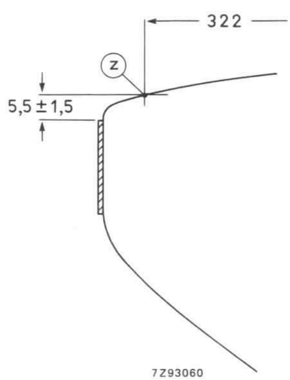




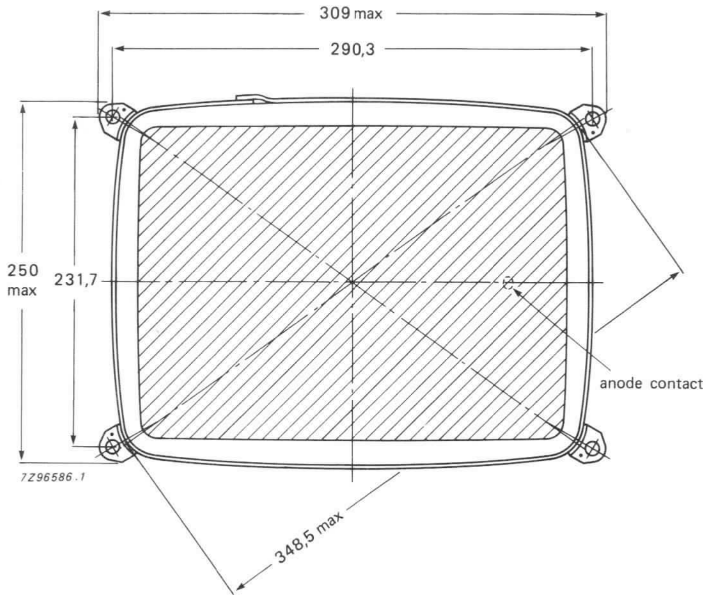
DEVELOPMENT DATA

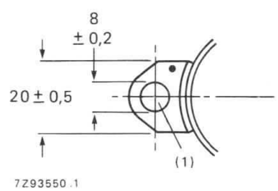
Front view of tube M32EBJ

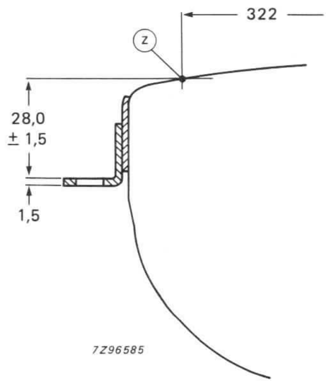




Front view and lug dimensions of tube M32EBL



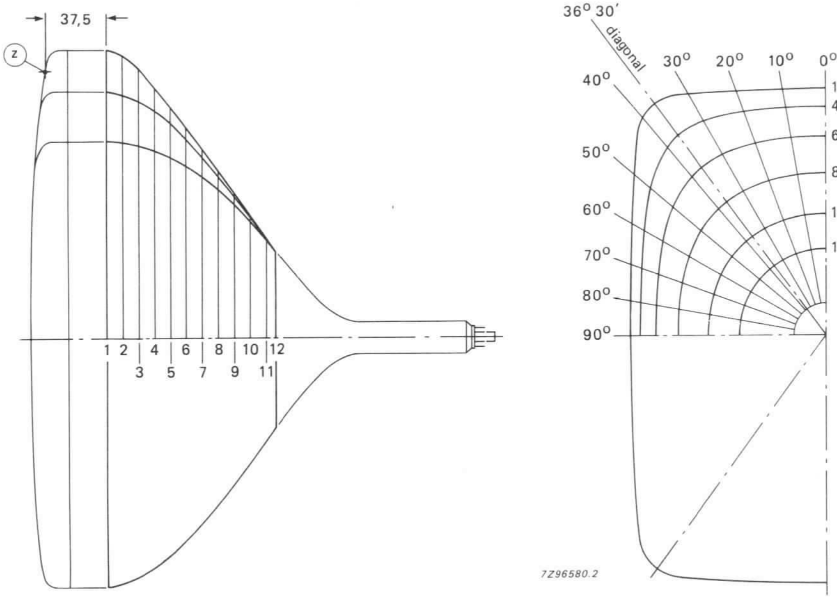




(1) The mounting screws in the cabinet must be situated inside a circle of 5 mm diameter drawn around the true geometrical positions i.e. at the corners of a rectangle of 290,3 mm x 231,7 mm.

DEVELOPMENT DATA

Maximum cone contour



section	nom. distance from section 1	max. distance from centre										
		0,00	10,00	20,00	30,00	36,50	40,00	50,00	60,00	70,00	80,00	90,00
1	0	147,75	149,80	156,19	167,63	173,43	171,77	151,39	135,49	125,67	120,31	118,60
2	10	146,15	148,17	154,42	165,14	170,27	168,65	149,73	134,26	124,62	119,34	117,66
3	20	142,36	144,25	149,91	158,20	161,07	159,63	145,28	131,24	122,14	117,11	115,50
4	30	136,49	138,18	142,87	148,45	149,74	148,65	138,71	126,91	118,58	113,89	112,39
5	40	128,75	130,16	133,72	137,36	137,91	137,07	130,27	121,08	113,85	109,61	108,23
6	50	119,35	120,49	123,12	125,56	125,86	125,30	120,77	113,97	108,01	104,28	103,05
7	60	108,70	109,58	111,51	113,24	113,50	113,19	110,37	105,66	101,04	97,92	96,84
8	70	97,64	98,27	99,58	100,70	100,90	100,74	99,10	96,11	92,85	90,43	89,53
9	80	86,29	86,69	87,45	88,06	88,14	88,04	87,11	85,36	83,31	81,62	80,93
10	90	74,00	74,26	74,72	75,09	75,14	75,10	74,60	73,64	72,44	71,37	70,90
11	100	60,59	60,78	61,12	61,41	61,51	61,52	61,35	60,93	60,34	59,78	59,50
12	110	51,89	51,97	52,09	52,20	52,23	52,24	52,19	52,07	51,90	51,73	51,64

FLAT
HIGH RESOLUTION MONOCHROME DISPLAY TUBES

- For Data Graphic Displays
- 90^{o} deflection angle
- 34 cm (14 in) face diagonal; rectangular glass
- 1520 mm radius of screen curvature
- 20 mm neck diameter
- Integral implosion protection

QUICK REFERENCE DATA

Deflection angle	90^{o}
Face diagonal	34 cm (14 in)
Overall length	max. 282 mm
Neck diameter	20 mm
Heating	12 V/75 mA
Grid 2 voltage	400 V
Anode voltage	14 kV
Resolution	approx. 1000 lines

orange binder, tab 3

APPLICATION

These high resolution tubes are for alpha-numeric and graphic display applications, such as computer terminals, small business computers, etc.

AVAILABLE VERSIONS

The following versions are available: M32EBM and M32EBN.

The tubes can be supplied with different phosphors and anti-reflective treatments, see ''High resolution monochrome display tubes, General''.

Differences between the tubes can be found under 'Dimensional Data'.

ELECTRICAL DATA

Focusing method	electrostatic
Deflection method	magnetic
Deflection angles	
diagonal	approx. 90°
horizontal	approx. 79°
vertical	approx. 65°
Interelectrode capacitances	
cathode to all other electrodes	max. 5 pF
grid 1 to all other electrodes	max. 6 pF
Capacitance of external conductive coating to anode*	max. 1200 pF min. 600 pF
Capacitance of external conductive coating to anode**	max. 1050 pF min. 450 pF
Capacitance of anode to implosion protection hardware**	approx. 150 pF
Heater voltage	12 V
Heater current at 12 V	75 mA

OPTICAL DATA

Phosphor type	see "High resolution monochrome display tubes, General"
Light transmission at screen centre	
tube with normal tinted face glass	approx. 42%
tube with dark tinted face glass	approx. 30%

RASTER CENTRING

The field intensity perpendicular to the tube axis should be adjustable from 0 to 800 A/m. For optimum overall sharpness it is recommended to centre the raster electrically via the deflection coils.

* Implosion protection hardware connected to external conductive coating.
** Implosion protection hardware not connected to external conductive coating.

MECHANICAL DATA (see also the figures under Dimensional Data)

Overall length	max. 282 mm
Greatest dimensions of tube	
diagonal	348,5 mm
width	298 mm
height	240 mm
Minimum useful screen dimensions (projected)	
diagonal	320 mm
horizontal axis	269 mm
vertical axis	210 mm
area	554 cm^2
Implosion protection	T-band/rimband
Bulb	EIAJ-JB340AH03 or EIAJ-JB340AH04
Bulb contact designation	IEC 67-III-2, EIAJ1-21
Base designation	EIA-E7-91
Basing	7GR
Mass	approx. 3,9 kg

RATINGS (Absolute Maximum System)

Unless otherwise specified voltage values are positive and measured with respect to grid 1.

Anode voltage	max. 16 kV min. 10 kV
Grid 4 (focusing electrode) voltage	−550 to + 1100 V
Grid 2 voltage	max. 550 V
Anode current	
long-term average value	max. 100 μA
peak value	max. 150 μA
Cathode voltage, positive peak value	max. 220 V
Heater voltage	12 V ± 10%*
Cathode-to-heater voltage	max. 100 V

DEVELOPMENT DATA

* For maximum cathode life it is recommended that the heater supply be regulated at 12 V $^{+0\%}_{-5\%}$.

CIRCUIT DESIGN VALUES

Grid 4 current	
positive	max. 25 μA
negative	max. 25 μA
Grid 2 current	
positive	max. 5 μA
negative	max. 5 μA

MAXIMUM CIRCUIT VALUES

Resistance between cathode and heater	max. 1 MΩ
Impedance between cathode and heater	max. 0,1 MΩ
Grid 1 circuit resistance	max. 1,5 MΩ
Grid 1 circuit impedance	max. 0,5 MΩ

TYPICAL OPERATING CONDITIONS

Cathode drive; voltages specified with respect to grid 1

Anode voltage	14 kV
Grid 4 (focusing electrode) voltage	0 to 400 V*
Grid 2 voltage	400 V
→ Cathode cut-off voltage	38 to 68 V**

Grid drive; voltages specified with respect to cathode

Anode voltage	14 kV
Grid 4 (focusing electrode) voltage	0 to 400 V*
Grid 2 voltage	400 V
→ Grid 1 cut-off voltage	41 to 75 V**

RESOLUTION

The resolution is approx. 1000 lines. It is measured at the screen centre:

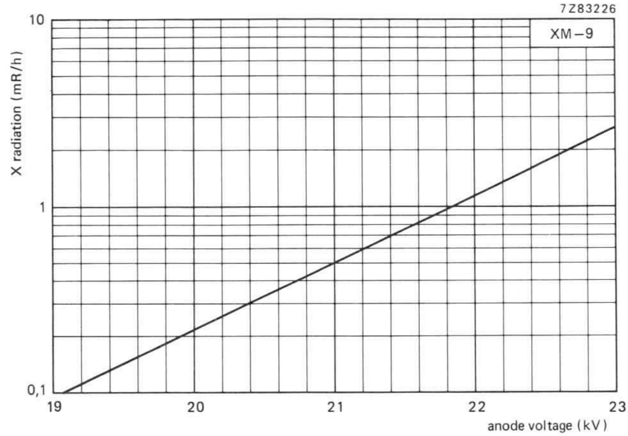
- with shrinking raster method,
- at light output 68,5 cd/m^2 (20 foot lambert) and raster dimensions 237 mm x 178 mm,
- at V_{g2} = 550 V and anode voltage = 14 kV,
- with phosphor type WW,
- with normal tinted face glass, without anti-glare treatment of screen surface.

X-RADIATION CHARACTERISTIC

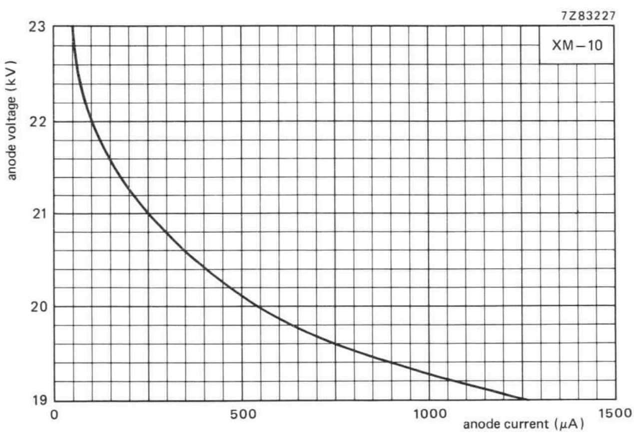
X-radiation emitted will not exceed 0,5 mR/h throughout the useful life of the tube, when operated within the given ratings.

* Measured at screen centre on spot at anode current = 50 μA (peak), anode voltage = 14 kV, grid 2 voltage = 400 V.
Dynamic focus (only for optimization): Typical correction for a video field of H x V = 237 mm x 178 mm:
line parabola 200 V,
field parabola 100 V.

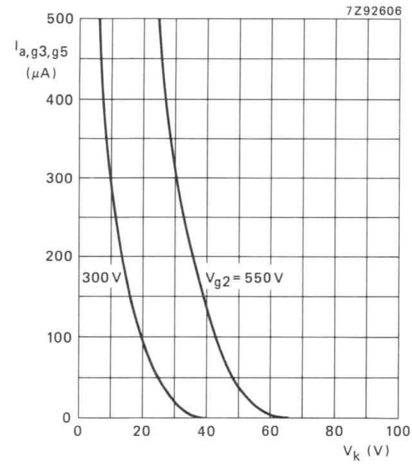
** Visual extinction of focused raster.



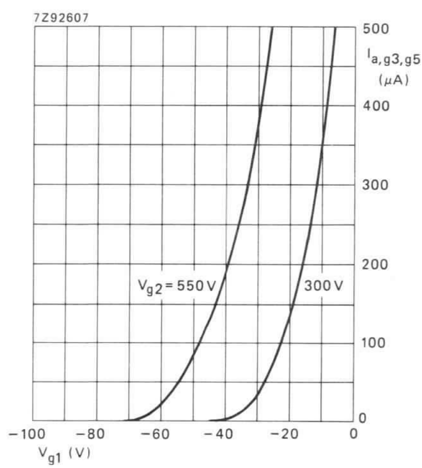
X-radiation limit curve according to JEDEC94, at a constant anode current of 250 μA, measured according to TEPAC103A.



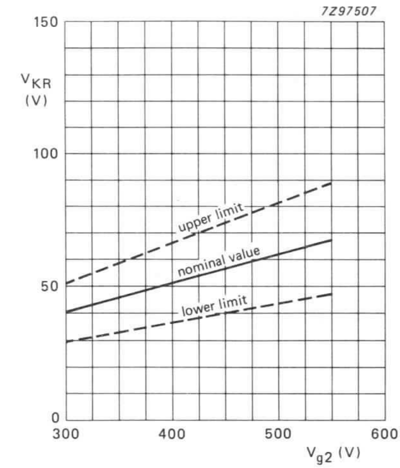
0,5 mR/h isoexposure-rate limit curve, according to JEDEC94, measured according to TEPAC103A.



Anode current as a function of cathode voltage.
Cathode drive; $V_{a,g3,g5}$ = 14 kV.

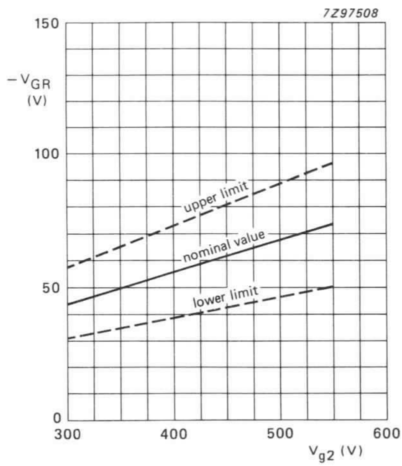


Anode current as a function of grid 1 voltage.
Grid drive; $V_{a,g3,g5}$ = 14 kV.



Limits of cathode cut-off voltage as a function of grid 2 voltage.
Cathode drive; $V_{a,g3,g5}$ = 14 kV.

$$\frac{\Delta V_{KR}}{\Delta V_{a,g3,g5}} = 0{,}15 \times 10^{-3}.$$

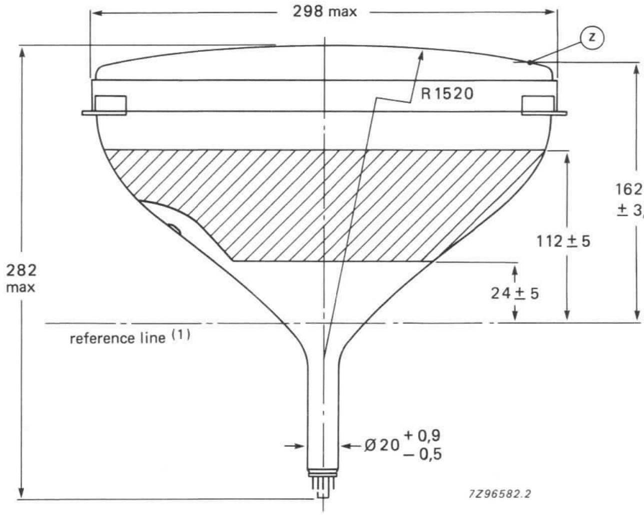


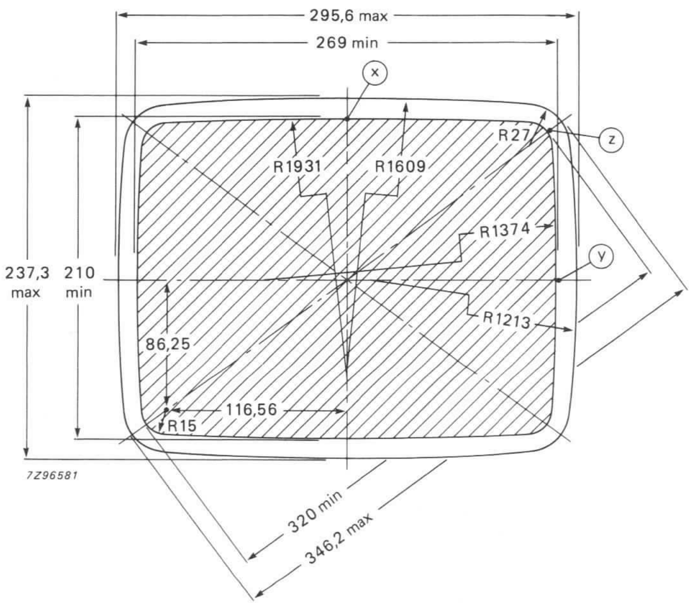
Limits of grid 1 cut-off voltage as a function of grid 2 voltage.
Grid drive; $V_{a,g3,g5}$ = 14 kV.

$$\frac{\Delta V_{GR}}{\Delta V_{a,g3,g5}} = 0{,}15 \times 10^{-3}.$$

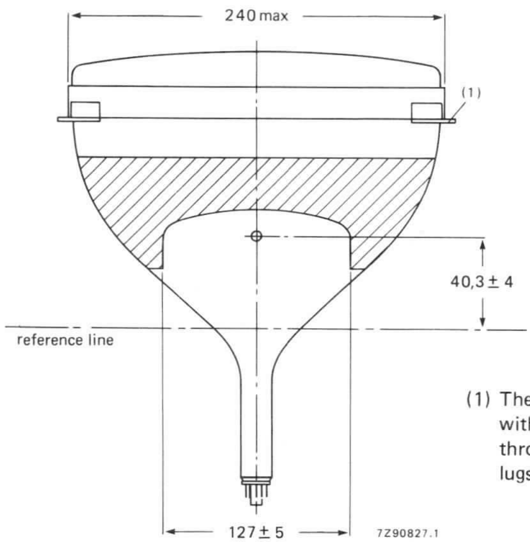
DIMENSIONAL DATA

Dimensions in mm

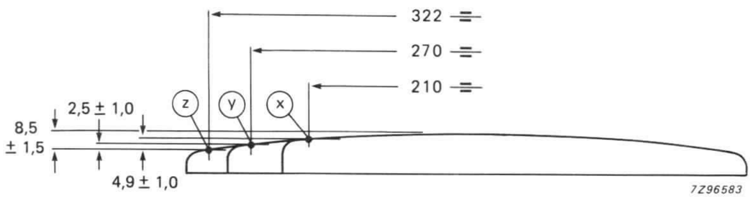


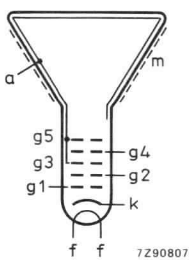


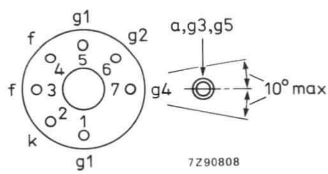
(1) The reference line is determined by the plane of the upper edge of reference line gauge D when the gauge is resting on the cone.



(1) The displacement of any lug with respect to the plane through the other three lugs is max. 1,5 mm.

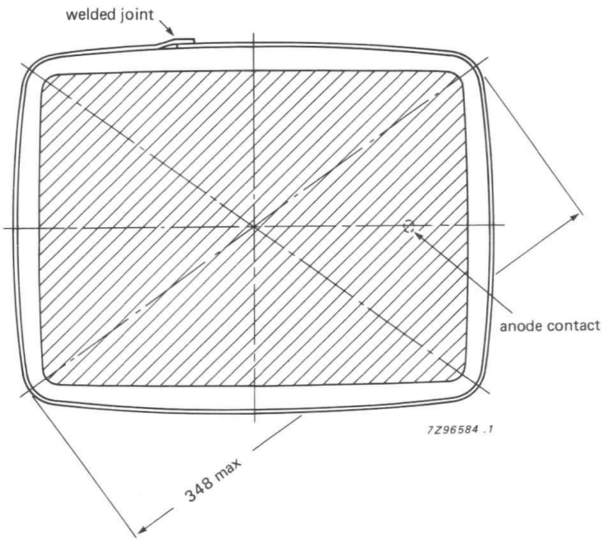


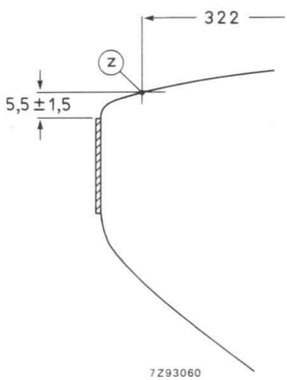




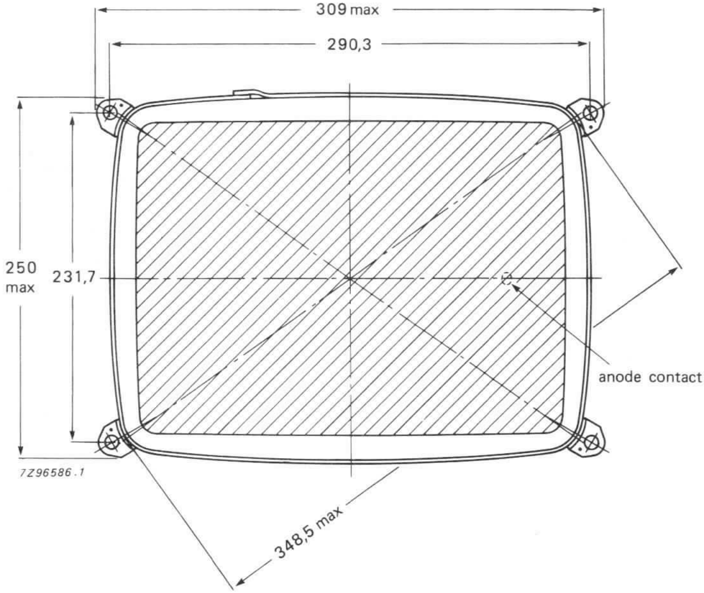
DEVELOPMENT DATA

Front view of tube M32EBM





Front view and lug dimensions of tube M32EBN



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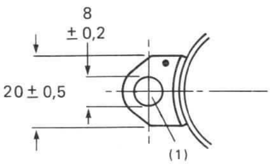

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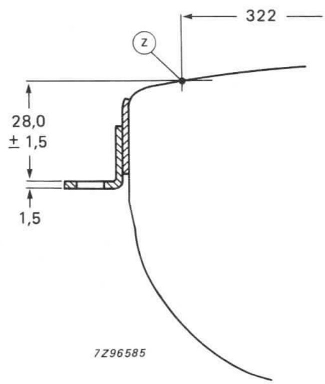
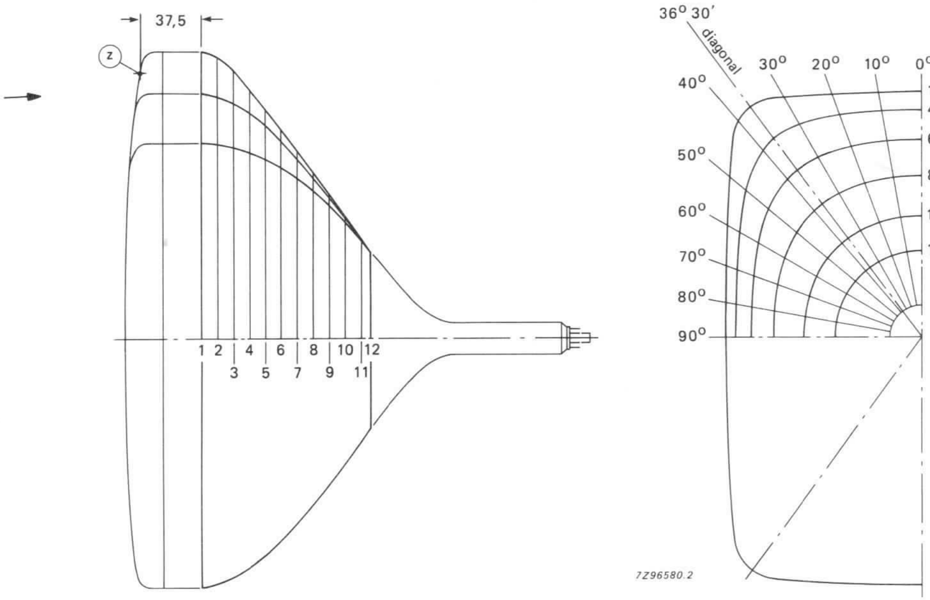


7Z96585

DEVELOPMENT DATA

(1) The mounting screws in the cabinet must be situated inside a circle of 5 mm diameter drawn around the true geometrical positions i.e. at the corners of a rectangle of 290,3 mm x 231,7 mm.

Maximum cone contour



section	nom. distance from section 1	max. distance from centre										
		0,00	10,00	20,00	30,00	36,50	40,00	50,00	60,00	70,00	80,00	90,00
1	0	147,75	149,80	156,19	167,63	173,43	171,77	151,39	135,49	125,67	120,31	118,60
2	10	146,15	148,17	154,42	165,14	170,27	168,65	149,73	134,26	124,62	119,34	117,66
3	20	142,36	144,25	149,91	158,20	161,07	159,63	145,28	131,24	122,14	117,11	115,50
4	30	136,49	138,18	142,87	148,45	149,74	148,65	138,71	126,91	118,58	113,89	112,39
5	40	128,75	130,16	133,72	137,36	137,91	137,07	130,27	121,08	113,85	109,61	108,23
6	50	119,35	120,49	123,12	125,56	125,86	125,30	120,77	113,97	108,01	104,28	103,05
7	60	108,70	109,58	111,51	113,24	113,50	113,19	110,37	105,66	101,04	97,92	96,84
8	70	97,64	98,27	99,58	100,70	100,90	100,74	99,10	96,11	92,85	90,43	89,53
9	80	86,29	86,69	87,45	88,06	88,14	88,04	87,11	85,36	83,31	81,62	80,93
10	90	74,00	74,26	74,72	75,09	75,14	75,10	74,60	73,64	72,44	71,37	70,90
11	100	60,59	60,78	61,12	61,41	61,51	61,52	61,35	60,93	60,34	59,78	59,50
12	110	51,89	51,97	52,09	52,20	52,23	52,24	52,19	52,07	51,90	51,73	51,64

HIGH RESOLUTION COLOUR DISPLAY TUBE ASSEMBLIES

- 90° deflection angle
- 37 cm (14 in) face diagonal
- 29,1 mm neck diameter
- Pigmented phosphors
- High resolution obtained by 0,29 mm dot triplet pitch and high-resolution in-line electron guns
- Hexagonal dot arrangement
- Black matrix screen for high brightness and contrast
- Internal magneto-static beam alignment
- Soft-Flash technology offering improved monitor reliability
- Internal magnetic shield
- Rimband type implosion protection (UL approved)
- Supplied as a pre-aligned, self-converging tube-coil assembly; dynamic convergence is not required

QUICK REFERENCE DATA

Deflection angle	90°
Face diagonal	37 cm (14 in)
Overall length	354 mm
Neck diameter	29,1 mm
Dot triplet pitch	0,29 mm (0,011 in)
Resolution: minimum number of resolvable pixels* at 200 μA; mod. depth −9 dB	790 x 570
Heating	6,3 V/673 mA
Focusing voltage	26% of anode voltage

Available versions

M37-. . . . / . / . . . .

Light transmission at screen centre:
103 X = 85%
108 X = 57%
118 X = 46%

deflection unit, see Table on the next page

screen surface treatment;
N = direct etch
(no indication for high gloss)

* Pixel = picture element.

ELECTRON–OPTICAL DATA

Electron gun system	unitized in-line
Focusing method	electrostatic
Focus lens	bi-potential
Convergence method	magnetic
Deflection method	magnetic
Deflection angles	
diagonal	approx. 90°
horizontal	approx. 78°
vertical	approx. 60°

ELECTRICAL DATA

Tube

Capacitances		
anode to external conductive coating including rimband	$C_{a(m + m')}$	max. 1300 pF min. 800 pF
grid 1 of any gun to all other electrodes	C_{g1}	24 pF
cathodes of all guns, connected in parallel, to all other electrodes	C_k	15 pF
cathode of any gun to all other electrodes	C_{kR}, C_{kG}, C_{kB}	5 pF
focusing electrode to all other electrodes	C_{g3}	6 pF
Heating		indirect by a.c. or d.c.
heater voltage	V_f	6,3 V
heater current	I_f	673 mA

Deflection unit

parameter	unit	M37-. . . ./. /followed by				
		1020	1030	1031*	1040	1050*
Line deflection coils, Fig. 1						
inductance	mH ± 4%	1,2	0,6	0,6	0,3	0,15
resistance	Ω ± 10%	1,5	0,8	0,8	0,4	0,2
Line deflection current, edge to edge, at 25 kV	A (p-p)	3,62	5,12	5,12	7,24	10,24
Field deflection coils, Fig. 2						
inductance	mH ± 10%	6,5	6,5	13,1	6,5	6,5
resistance	Ω ± 7%	5,7	5,7	11,5	5,7	5,7
Field deflection current, edge to edge, at 25 kV	A (p-p)	1,36	1,36	0,96	1,36	1,36

* Under development.

Maximum permissible voltage	
between line and field coils	3000 V (d.c.)
between field coils and core	300 V (d.c.)
Insulation resistance	
between line and field coils, at 1 kV (d.c.)	500 MΩ
between line coil and core clamping ring, at 500 V (d.c.)	30 MΩ
between field coil and core clamping ring, at 1000 V (d.c.)	100 MΩ
Cross-talk	a voltage of 1 V, 15625 Hz applied to the line coils causes no more than 20 mV across the field coils

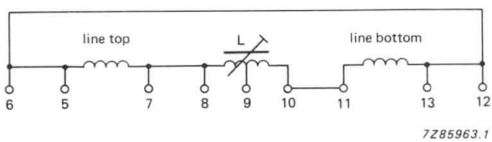


Fig. 1 Line coils.
L is factory adjusted.

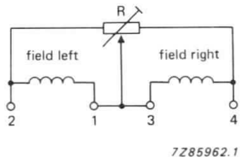


Fig. 2 Field coils.
R is factory adjusted.

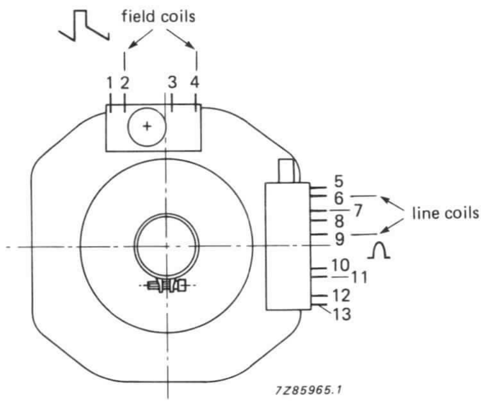


Fig. 3 Terminal location of deflection coils.

OPTICAL DATA

Screen	metal-backed phosphor dot triplets; black matrix		
Screen finish	non-glare (direct etch) or high gloss		
Useful screen dimensions			
diagonal	min. 335,4 mm		
horizontal axis	min. 280,8 mm		
vertical axis	min. 210,6 mm		
area	min. 580 cm^2		
Recommended useful screen dimensions for alphanumeric display			
diagonal	307 mm		
horizontal axis	244 mm		
vertical axis	186 mm		
Phosphor			
red	rare earth, pigmented		
green	sulphide type		
blue	sulphide type, pigmented		
Persistance	medium short		
Phosphor colour co-ordinates			
red	x = 0,635; y = 0,340		
green	x = 0,315; y = 0,600		
blue	x = 0,150; y = 0,060		
Dot arrangement	hexagonal		
Spacing between centres of adjacent dot triplets	approx. 0,29 mm (0,011 in)		
	M37-103X	M37-108X	M37-118X
Light transmission of face glass at screen centre	approx. 85%	approx. 57%	approx. 46%
Luminance at screen centre*			
red	41 cd/m^2	27 cd/m^2	22 cd/m^2
green	150 cd/m^2	100 cd/m^2	81 cd/m^2
blue	21 cd/m^2	13,5 cd/m^2	11 cd/m^2
white (x = 0,287, y = 0,292)**	212 cd/m^2	142 cd/m^2	114 cd/m^2
Reflectivity	19%	8%	5,5%

* Measuring conditions: I_{ap} per gun = 200 μA, scan duty cycle = 75%; scanned area = 244 mm x 186 mm.
** Three guns activated, ratio of anode currents = 1:1:1.

Resolution — see Table below; values shown are measured under following conditions: V_a = 25 kV, V_k = 100 V, V_{g3} adjusted for minimum width of vertical white lines at half east or half west zone; sine-wave drive voltage; horizontal raster scan of H x V = 244 mm x 186 mm

modulation depth	min. number of resolvable picture elements (n.H x n.V)		
	I_a = 100 μA per gun	I_a = 200 μA per gun	I_{ap} = 400 μA per gun
−6 dB	830 x 560	700 x 510	490 x 400
−9 dB	950 x 620	790 x 570	530 x 440
−12 dB	980 x 670	870 x 610	600 x 470
−20 dB	980 x 780	980 x 690	690 x 520

Notes

– The resolution figures in the Table are worst-case values in the display area, and include losses of modulation depth due to deflection defocusing and screen texture; the resolution at the screen centre is in general higher.
– Limitations due to moiré effects are not taken into account; the maximum resolution imposed by the Shannon limit of the phosphor screen = n.H x n.V = 980 x 1150 (signal dot rate equals phosphor dot rate).

MECHANICAL DATA (see also the figures on the following pages)

Overall length	max. 353,7 ± 5 mm
Neck diameter	29,1 mm
Greatest dimensions of tube face (excluding mounting lugs)	
diagonal	366,4 ± 1,6 mm
width	315,4 ± 1,6 mm
height	246,4 ± 1,6 mm
Implosion protection	shrink type (UL, CSA and VDE approved)
Anode contact designation	JEDEC J1-21; IEC 67-III-2
Base designation	10-pin base JEDEC B10-277
Basing designation	see Fig. 10
Mass	approx. 6,4 kg
Mounting position	anode contact on top

MECHANICAL DATA (continued) Dimensions in mm

Notes are given after the drawings.

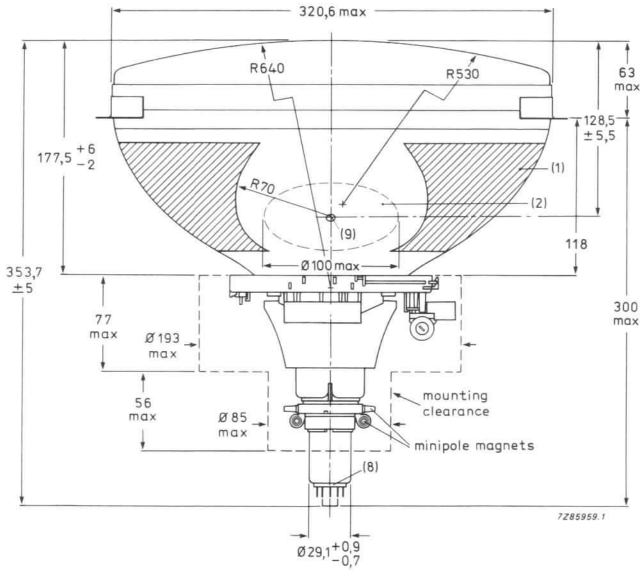


Fig. 4a.

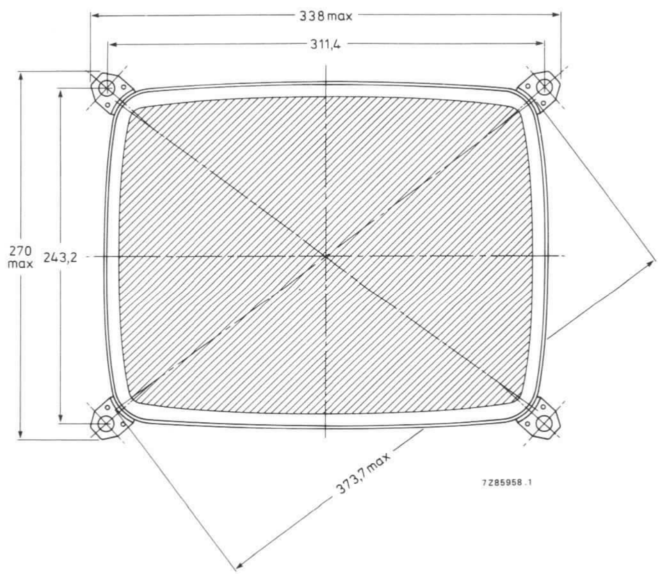


Fig. 4b.

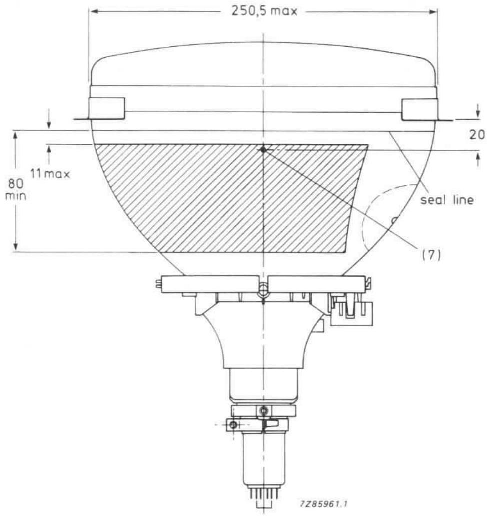

250,5 max
20
80
min
11 max
seal line
(7)
7Z85961.1

Fig. 4c.

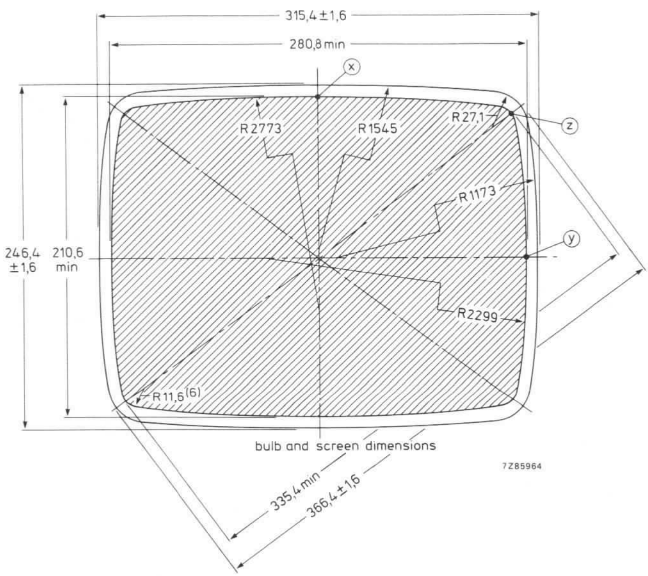

315,4 ± 1,6
280,8 min
x
z
y
R2773
R1545
R27,1
R1173
R2299
R11,6 (6)
246,4
± 1,6
210,6
min
bulb and screen dimensions
7Z85964
335,4 min
366,4 ± 1,6

Fig. 5.

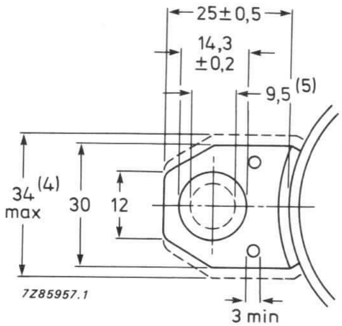


Fig. 6.

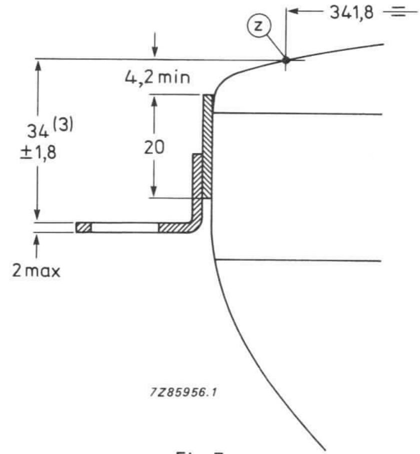


Fig. 7.

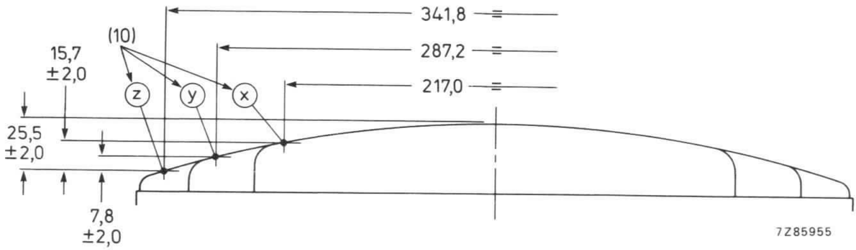


Fig. 8.

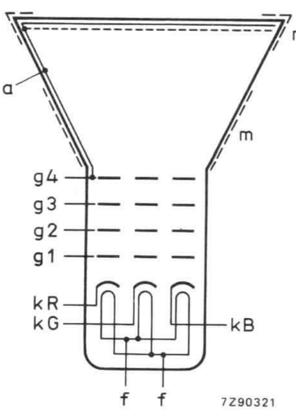


Fig. 9.

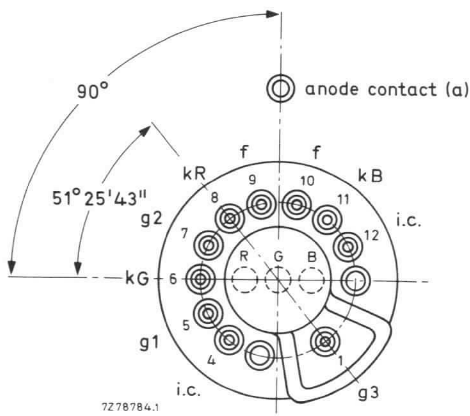


Fig. 10.

i.c. = internally connected (not to be used)

Notes to outline drawings on the preceding pages

1. Configuration of outer conductive coating may be different, but will contain the contact area as shown in the drawing.
2. To clean this area, wipe only with a soft lintless cloth.
3. The displacement of any lug with respect to the plane through the three other lugs is max. 1 mm.
4. Minimum space to be reserved for mounting lug.
5. The position of the mounting screw in the cabinet must be within a circle of 9,5 mm diameter drawn around the true geometrical positions, i.e. the corners of a rectangle of 311,4 mm x 243,2 mm.
6. Co-ordinates for radius R = 11,6 mm: x = 126,98 mm, y = 90,76 mm.
7. Centre of gravity.
8. The socket for this base should not be rigidly mounted; it should have flexible leads and be allowed to move freely. After mounting of the tube in the cabinet note that the position of the base can fall within a circle, having a diameter of max. 50 mm, concentric with an imaginary tube axis. The mass of the mating socket with circuitry should not be more than 150 g; maximum permissible torque is 40 mNm.
9. Small cavity contact J1-21, IEC 67-III-2.
10. The X, Y and Z reference points are located on the outside surface of the face plate 3,2 mm beyond the intersection of the minor, major and diagonal screen axis respectively, with the minimum published screen.

10-pin base; JEDEC B10-277

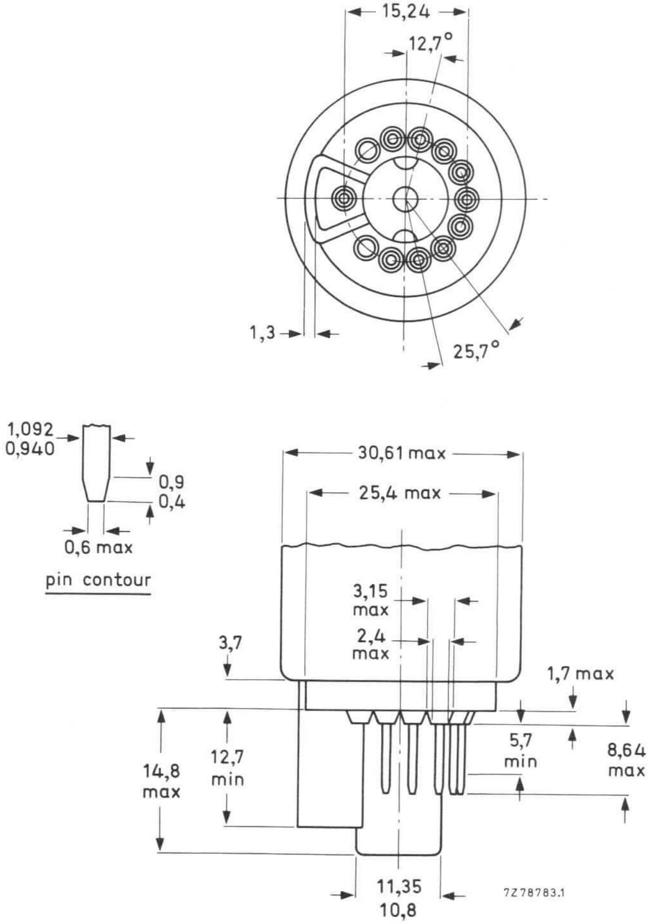


Fig. 11.

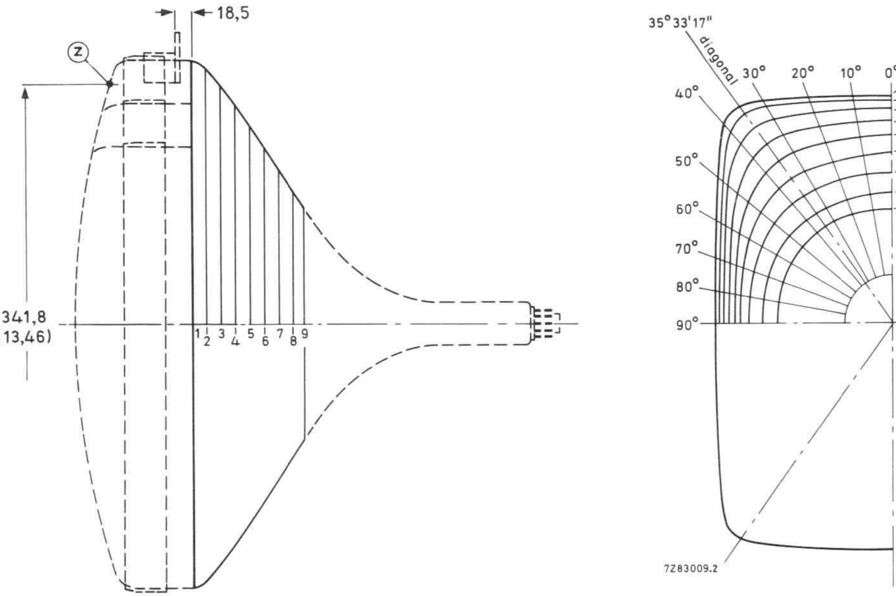


Fig. 12.

section	nom. distance from section 1	distance from centre (max. values)														
		0°	10°	20°	25°	30°	32° 30′	diag. axes	37° 30′	40°	45°	50°	60°	70°	80°	90°
1	0	157,2	159,4	166,3	171,7	178,2	181,2	183,6	183,3	180,0	167,9	156,5	140,0	129,8	124,2	122,4
2	10	154,7	156,9	163,5	168,5	174,1	176,6	178,1	177,7	174,8	164,4	153,7	137,8	127,9	122,4	120,7
3	20	148,8	150,7	156,3	160,0	163,5	164,6	165,0	164,4	162,6	156,0	147,7	133,6	124,4	119,3	117,7
4	30	140,4	142,1	146,2	148,6	150,5	151,0	151,1	150,7	149,6	145,6	140,0	128,6	120,3	115,7	114,2
5	40	130,3	131,3	134,0	135,4	136,5	136,8	136,8	136,6	136,1	134,1	130,8	122,7	115,9	111,7	110,3
6	50	118,2	118,8	120,1	120,9	121,6	121,8	122,0	122,0	121,9	121,2	119,8	115,4	110,5	107,0	105,8
7	60	104,9	104,7	105,1	105,5	106,0	106,2	106,5	106,7	106,9	107,1	107,0	105,6	103,1	100,8	99,8
8	70	90,6	89,9	89,8	90,0	90,4	90,6	90,9	91,1	91,4	91,9	92,3	92,5	91,7	90,4	89,7
9	77	79,9	79,1	79,0	79,1	79,4	79,6	79,9	80,1	80,4	80,9	81,4	81,8	81,4	80,5	79,9

RECOMMENDED OPERATING CONDITIONS (cathode drive)

The voltages are specified with respect to grid 1.

Anode voltage	$V_{a,g4}$	25 kV
Grid 3 (focusing electrode) voltage	V_{g3}	6,2 to 7,0 kV
Grid 2 voltage	V_{g2}	see Fig. 13

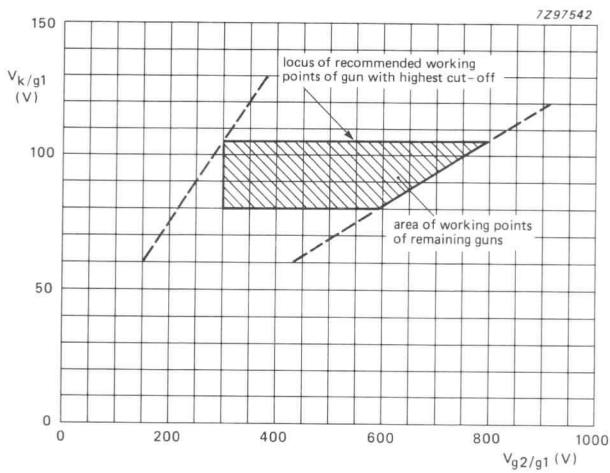


Fig. 13 Spot cut-off design chart.

Grid 2 voltage (V_{g2}) adjusted for highest gun spot cut-off voltage V_k = 105 V.

Remaining guns adjusted for spot cut-off by means of cathode voltage.

V_{g2} range 300 to 800 V

V_k range 80 to 105 V

Adjustment procedure:

Set the cathode voltage (V_k) for each gun at 105 V; increase the grid 2 voltage (V_{g2}) from approx. 300 V to the value at which one of the colours becomes just visible. Now decrease the cathode voltage of the remaining guns so that the other colours also become visible.

EQUIPMENT DESIGN VALUES (each gun if applicable)

The values are valid for anode voltages between 20 and 27,5 kV.
The voltages are specified with respect to grid 1.

Grid 3 (focusing electrode) voltage	V_{g3}	24,8 to 28% of anode voltage
Grid 2 voltage for visual extinction of focused spot (V_k = max. 105 V)	V_{g2} and V_k	see Fig. 13
Difference in cut-off voltages between guns in any tube	ΔV_k	lowest value ≥ 80% of highest value
Cathode drive characteristic		see Fig. 14
Grid 3 (focusing electrode) current	I_{g3}	−5 to + 5 μA
Grid 2 current	I_{g2}	−5 to + 5 μA
Grid 1 current at V_k = 100 V	I_{g1}	−5 to + 5 μA

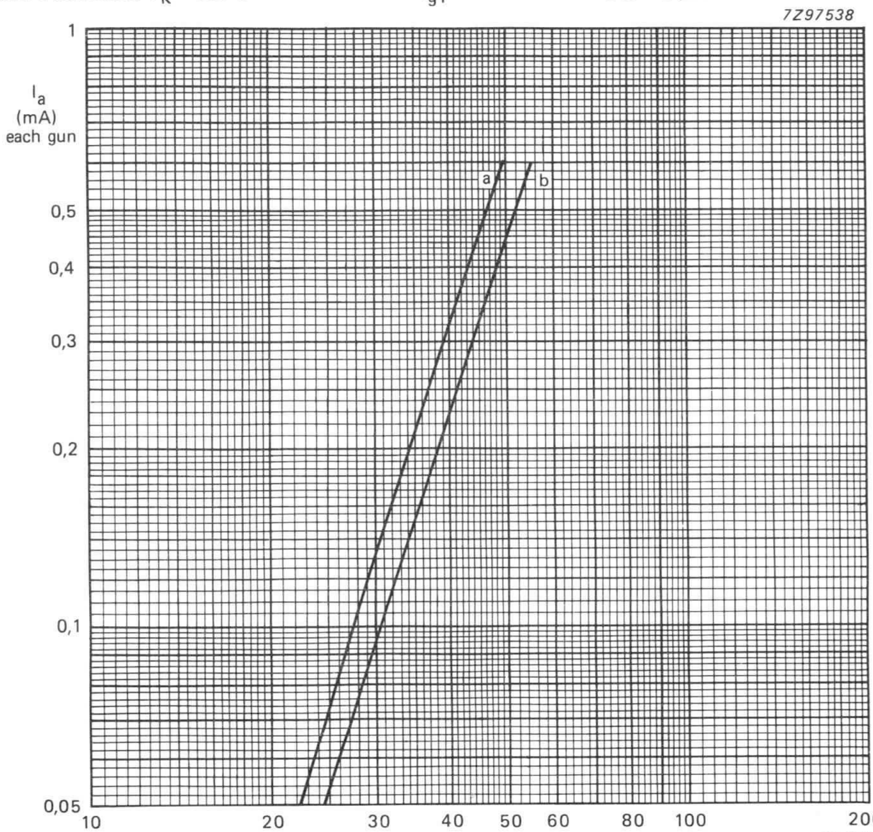


Fig. 14 Typical cathode drive characteristics at spot cut-off voltages of 80 V (curve a) and 105 V (curve b).
V_f = 6,3 V; $V_{a,g4}$ = 25 kV; V_{g3} adjusted for focus; V_{g2} adjusted to provide spot cut-off for desired V_k.

LIMITING VALUES (each gun if applicable)

Tube

Design maximum rating system unless otherwise stated.
The voltages are specified with respect to grid 1.

Anode voltage	$V_{a,g4}$	max.	27,5 kV	notes 1 and 2
		min.	20 kV	note 3
Anode current for each gun, peak value	I_{ap}	max.	400 μA	
Long term average anode current for each gun	I_a	max.	200 μA	
Long term average anode current for three guns	I_a	max.	450 μA	
Grid 3 (focusing electrode) voltage	V_{g3}	max.	10 kV	
Grid 2 voltage, peak	V_{g2p}	max.	1000 V	
Cathode voltage				
positive	V_k	max.	200 V	
positive operating cut-off	V_k	max.	130 V	
negative	$-V_k$	max.	0 V	
negative peak	$-V_{kp}$	max.	2 V	
Cathode to heater voltage				
positive	V_{kf}	max.	150 V	
positive peak	V_{kfp}	max.	200 V	note 1
negative	$-V_{kf}$	max.	0 V	
negative peak	$-V_{kfp}$	max.	100 V	note 1
Heater voltage	V_f	max.	6,6 V	note 4
		min.	5,7 V	

Deflection unit

Maximum operating copper temperature 95 °C

Temperature rise of the coils (ΔT)
M37-. . . ./ ./1020, M37-. . . ./ ./1030 and
M37-. . . ./ ./1040 see Table A
M37-. . . ./ ./1050 see Table B

Table A

line frequency/ flyback time	temperature rise (ΔT)	
	line coils	frame coils
24 kHz/8 μs	20 °C	15 °C
32 kHz/6 μs	25 °C	20 °C
48 kHz/4 μs	35 °C	30 °C

Table B

line frequency/ flyback time	temperature rise (ΔT)	
	line coils	frame coils
32 kHz/6 μs	17 °C	17 °C
48 kHz/4 μs	23 °C	23 °C
64 kHz/3 μs	32 °C	32 °C

LIMITING CIRCUIT VALUES

Grid 3 circuit resistance	R_{g3}	max.	30 MΩ
Grid 1 to cathode circuit resistance (each gun)	R_{g1k}	max.	0,75 MΩ

Notes

1. Absolute Maximum rating system.
2. During adjustment on the production line this value is likely to be surpassed considerably. It is therefore strongly recommended first to make the necessary adjustments for normal operation.
3. Operation of the tube at lower voltages impairs the luminance and resolution.
4. For maximum cathode life, it is recommended that the heater supply be regulated at 6,0 V.

FLASHOVER PROTECTION

With the high voltage used with this tube (max. 27,5 kV) internal flashovers may occur. As a result of the Soft-Flash technology these flashover currents are limited to approx. 60 A offering higher set reliability, optimum circuit protection and component savings.
Primary protective circuitry using properly grounded spark gaps and series isolation resistors (preferably carbon composition) is still necessary to prevent tube damage. The spark gaps should be connected to all picture tube electrodes at the socket according to the figure below; they are not required on the heater pins. No other connections between the outer conductive coating and the chassis are permissible.
The spark gaps should be designed for a breakdown voltage at the focusing electrode (g3) of 11 kV ($1{,}5 \times V_{g3}$ max. at $V_{a,g4} = 25$ kV), and at the other electrodes of 1,5 to 2 kV.
The values of the series isolation resistors should be as high as possible (min. 0,5 kΩ) without causing deterioration of the circuit performance. The resistors should be able to withstand an instantaneous surge of 20 kV for the focusing circuit and 12 kV for the remaining circuits without arcing.
Additional information is available on request.

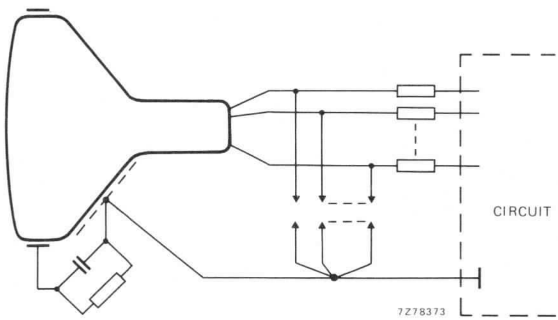


Fig. 15.

X-RADIATION LIMIT

Maximum anode voltage at which the X-radiation emitted will not exceed 0,5 mR/h at an anode current of 300 μA

entire tube	31 kV*
face-plate only	33 kV

Warning:

If the value for the tube face only is used as design criterion, adequate shielding must be provided in the monitor for the anode contact and/or certain portions of the tube funnel and panel sidewalls to insure that the X-radiation from the monitor is attenuated to a value equal to or lower than that specified for the face of the tube.

Maximum voltage difference between anode and focus electrode at which the X-radiation will not exceed 0,5 mR/h — 30 kV

Warning:

If the voltage value above can be exceeded in the monitor additional attenuation of the X-radiation through the tube neck may be required.

The X-radiation emitted from this display tube, as measured in accordance with the procedure of TEPAC Publication No. 194, will not exceed 0,5 mR/h throughout the useful tube life when operated within the 'Design maximum ratings'.

The tube should not be operated beyond its 'Design maximum ratings' stated above, but its X-radiation will not exceed 0,5 mR/h for anode voltage and current combinations given by the isoexposure-rate limits characteristics shown on the next page.

Operation above the values shown by the curve may result in failure of the monitor to comply with the Federal Performance Standard of the U.S. for Television Receivers, Section 1020. 10 of Part 1020 of Title 21, Code of Federal Regulation (PL90-602) as published in the Federal Register Volume 38, No. 198, Monday, October 15, 1973.

Maximum X-radiation as a function of anode voltage at 300 μA anode current is shown by the curve on the next page. X-radiation at a constant anode voltage varies linearly with anode current.

* This rating applies only if the anode connector used by the set maker provides the necessary attenuation to reduce the X-radiation from the anode contact by a factor equal to the difference between the anode button isoexposure-rate limit curve and the isoexposure-rate limit curve for the entire tube.

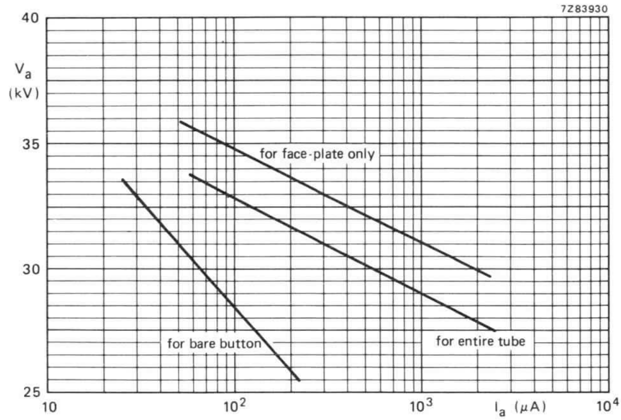


Fig. 16 0,5 mR/h isoexposure-rate limit curve.

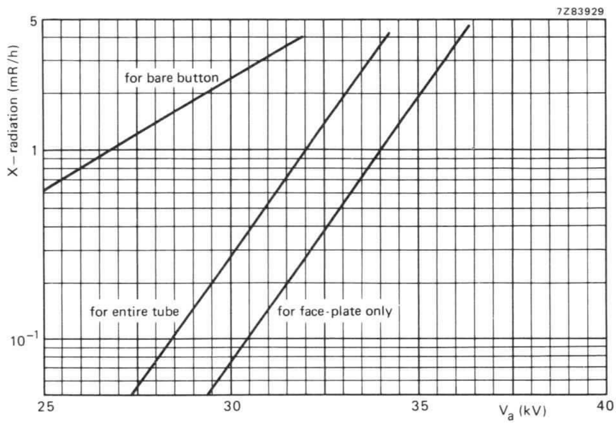


Fig. 17 X-radiation limit curve at a constant anode current of 300 μA.

WARNINGS

X-radiation

Operation of this colour display tube under abnormal conditions which exceed the 0,5 mR/h iso-dose rate curve shown on the preceding page may produce soft X-rays which may constitute a health hazard on prolonged exposure at close range unless adequate external screening is provided. Precautions must therefore be exercised during servicing of monitors using this tube to ensure that the anode voltage and other tube voltages are adjusted to the recommended values so that the 'Design maximum ratings' are not exceeded.

Tube replacement

This display tube incorporates integral X-radiation and implosion protection and must be replaced with a tube of the same type number or a recommended replacement to assure continued safety.

Shock hazard

The high voltage at which the tube is operated may be very dangerous. The monitor should include safeguards to prevent the user from coming in contact with the high voltage. Extreme care should be taken in servicing or adjustment of any high-voltage circuit.

Caution must be exercised during the replacement or servicing of the display tube since a residual electrical charge may be held by the high-voltage capacitor formed by the external and internal conductive coatings of the display tube funnel. To remove any residual charge, short the anode contact button, located in the funnel of the tube, to the external conductive coating before handling the tube. Discharging the high voltage to isolated metal parts such as cabinets and control brackets may produce a shock hazard.

Tube handling

Display tubes should be kept in the shipping box or similar protective container will just prior to installation. Wear heavy protective clothing, including gloves and safety goggles with side shields, in areas containing unpacked and unprotected tubes to prevent possible injury from flying glass in the event a tube breaks. Handle the tube with extreme care. Do not strike, scratch or subject the tube to more than moderate pressure. Particular care should be taken to prevent damage to the seal area.

The packing should incorporate sufficient cushioning so that under normal conditions of shipment or handling an impact acceleration of more than 35g is never applied to the tube.

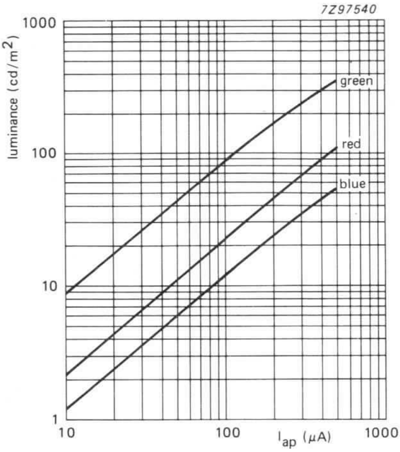


Fig. 18.

M37-103X
Luminance at the centre of the screen as a function of I_{total}.
$V_{a,g4}$ = 25 kV; V_f = 6,3 V; V_{g3} adjusted for optimum focus.
Raster size = 244 x 186 mm^2.

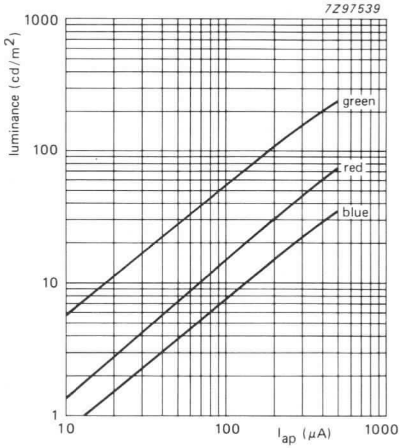


Fig. 19.

M37-108X
Luminance at the centre of the screen as a function of I_{total}.
$V_{a,g4}$ = 25 kV; V_f = 6,3 V; V_{g3} adjusted for optimum focus.
Raster size = 244 x 186 mm^2.

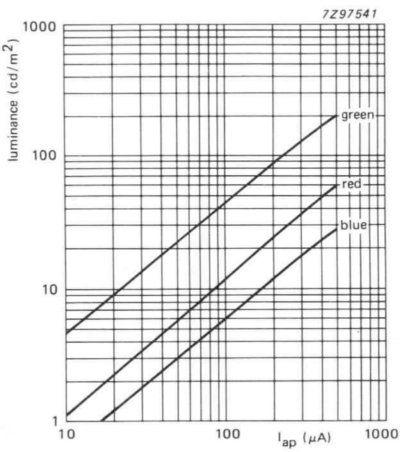


Fig. 20.

M37-118X
Luminance at the centre of the screen as a function of I_{total}.
$V_{a,g4}$ = 25 kV; V_f = 6,3 V; V_{g3} adjusted for optimum focus.
Raster size = 244 x 186 mm^2.

DEGAUSSING

The display tube has an internal magnetic shield. This shield and the shadow mask with its suspension system may be automatically degaussed by a coil mounted on the cone of the display tube as shown in Fig. 21.

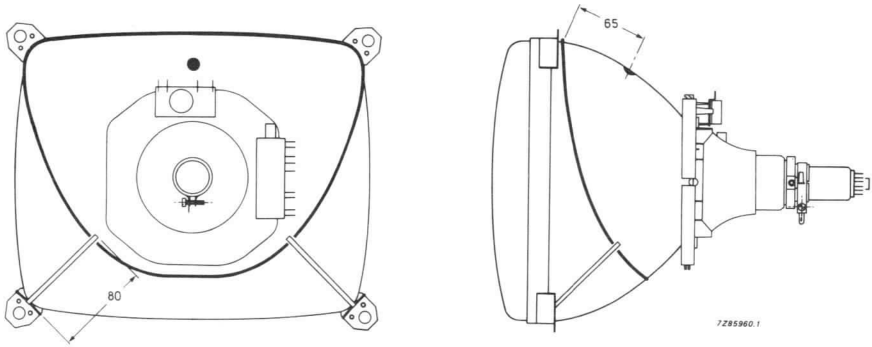


Fig. 21 Position of degaussing coil on the display tube; dimensions are given in mm.

For proper degaussing an initial magnetomotive force (m.m.f.) of 600 ampere-turns is required in the coil. This m.m.f. has to be gradually decreased. In the steady state, no significant m.m.f. should remain in the coil (≤ 0,6 ampere-turns).

If single-phase power rectification is used, provision should be included to prevent asymmetric distortion of the a.c. voltage applied to the degaussing circuit due to high d.c. inrush currents.

An example of a degaussing circuit and coil data for various mains voltage are given below.

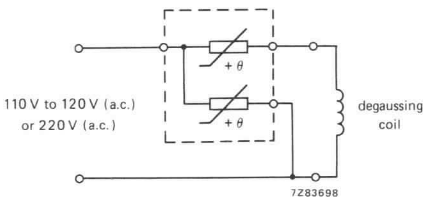


Fig. 22 Degaussing circuit using dual PTC thermistor.

Data of degaussing coil

	110 to 120 V (a.c.)	220 V (a.c.)
Circumference	90 cm	90 cm
Number of turns	70	120
Copper-wire diameter	0,45 mm	0,3 mm
Resistance	6,7 Ω	25,9 Ω
Catalogue number of dual PTC thermistor	8222 298 73091	2322 662 98009

CONVERGENCE AND RASTER SPECIFICATION

The maximum misconvergence after 20 min operation is given in Table 1 and Fig. 23.

Test conditions (all voltages are measured with respect to grid 1)

Heater voltage	V_f	6,3 V
Grid 2 voltage	V_{g2}	525 V
Grid 3 voltage	V_{g3}	to be adjusted for focus at half east or half west, using cross-hatch pattern or characters H, at anode current of 300 μA (peak) per gun
Anode voltage	V_a	25 kV
Test pattern		cross-hatch pattern
Ambient temperature	T_{amb}	25 ± 5 ^{o}C
Tube facing		East

Notes

1. Misconvergence is the distance between centres of the red, green, blue lines at the screen using rectangular co-ordinates.
2. Anode and/or focusing voltage and terrestrial magnetism affects the static confergence performance. Therefore small readjustments of the minipole magnets (see Fig. 4a) may be necessary.

Table 1 Maximum misconvergence after 20 min operation

location (see Fig. 23)	type of error	max. error between any colour
centre	red-green-blue line separation in either the horizontal or vertical direction	0,15 mm
area A		0,30 mm
area B		0,40 mm

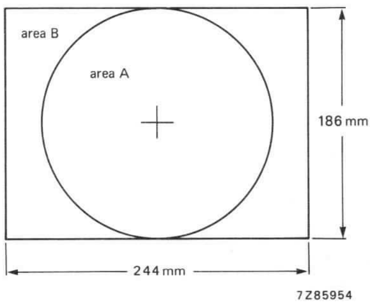


Fig. 23 Convergence test areas.

Raster centring

horizontal	max. 4 mm
vertical	max. 4 mm

Raster rotation max. 0,4° (Fig. 24)

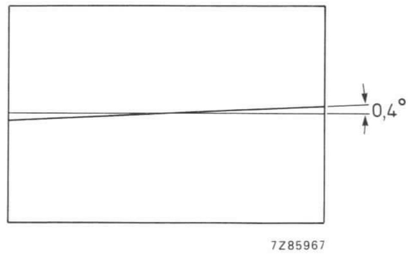


Fig. 24 Raster rotation.

Pattern distortion, measured without east-west and north-south correction

Pin cushion distortion		
east-west	$\frac{2(H1 + H2)}{B1 + B2} \times 100\%$ (Fig. 22)	max. 8,0%
north-south	$\frac{2(V1 + V2)}{A1 + A2} \times 100\%$ (Fig. 22)	max. 1,0%
Max. pin-cushion distortion at each side		
east-west	H1 or H2 (Fig. 22)	max. 6,5 mm
north-south	V1 or V2 (Fig. 22)	max. 1,5 mm
Parallelogram	P1 or P2 (Fig. 23)	max. 2,5 mm

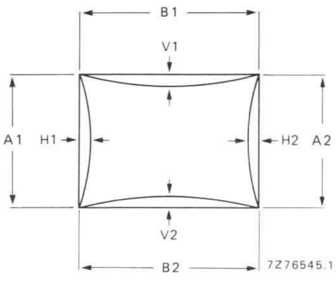


Fig. 25 A1, A2 = 186 mm; B1, B2 = 244 mm.

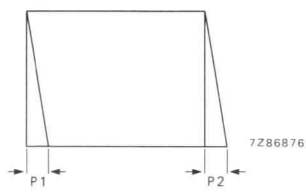


Fig. 26.

HIGH RESOLUTION COLOUR DISPLAY TUBE ASSEMBLIES

- 90^{o} deflection angle
- 37 cm (14 in) face diagonal
- 29,1 mm neck diameter
- High resolution obtained by 0,29 mm dot triplet pitch and high-resolution in-line electron guns
- Hexagonal dot arrangement
- Black matrix screen for high brightness and contrast
- Internal magneto-static beam alignment
- Non-glare faceplate
- Internal magnetic shield
- Rimband type implosion protection
- Supplied as a pre-aligned, self-converging tube-coil assembly; dynamic convergence is not required
- M37-103X/N/1000 series: assembly with display tube with clear face glass
  M37-108X/N/1000 series: assembly with display tube with tinted face glass

QUICK REFERENCE DATA

Deflection angle	90^{o}
Face diagonal	37 cm (14 in)
Overall length	342 mm
Neck diameter	29,1 mm
Dot triplet pitch	0,29 mm (0,011 in)
Resolution: minimum number of displayable pixels*	800 x 600
Heating	6,3 V/685 mA
Focusing voltage	28% of anode voltage

orange binder, tab 3

* Pixel = picture element.

ELECTRON–OPTICAL DATA

Electron gun system	unitized in-line
Focusing method	electrostatic
Focus lens	bi-potential
Convergence method	magnetic
Deflection method	magnetic
Deflection angles	
diagonal	approx. 90°
horizontal	approx. 78°
vertical	approx. 60°

ELECTRICAL DATA

Tube

Capacitances		
anode to external conductive coating including rimband	$C_{a(m+m')}$	max. 1300 pF min. 800 pF
grid 1 of any gun to all other electrodes	C_{g1}	17 pF
cathodes of all guns, connected in parallel, to all other electrodes	C_k	15 pF
cathode of any gun to all other electrodes	C_{kR}, C_{kG}, C_{kB}	5 pF
focusing electrode to all other electrodes	C_{g3}	6 pF
Heating		indirect by a.c. or d.c.
heater voltage	V_f	6,3 V
heater current	I_f	685 mA

Deflection unit

parameter	unit	M37-103X/N/followed by				
		1010	1020	1030	1040	1050
Line deflection coils, Fig. 1						
inductance	mH ± 4%	2,4	1,2	0,6	0,3	0,15
resistance	Ω ± 10%	3	1,5	0,8	0,4	0,2
Line deflection current, edge to edge, at 25 kV	A (p-p)	2,60	3,62	5,12	7,24	10,24
Field deflection coils, Fig. 2						
inductance	mH ± 10%	6,5	6,5	6,5	6,5	6,5
resistance	Ω ± 7%	6,5	6,5	6,5	6,5	6,5
Field deflection current, edge to edge, at 25 kV	A (p-p)	1,36	1,36	1,36	1,36	1,36

Maximum permissible voltage	
between line and field coils	3000 V (d.c.)
between field coils and core	300 V (d.c.)
Insulation resistance	
between line and field coils, at 1 kV (d.c.)	500 MΩ
between line coil and core clamping ring, at 500 V (d.c.)	30 MΩ
between field coil and core clamping ring, at 1000 V (d.c.)	100 MΩ
Cross-talk	a voltage of 1 V, 15625 Hz applied to the line coils causes no more than 20 mV across the field coils

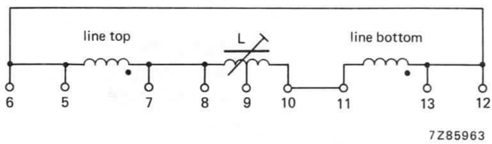


Fig. 1 Line coils.
L is factory adjusted.

See Fig. 3 for location of terminals.

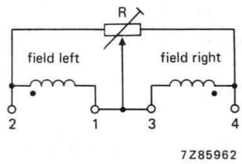


Fig. 2 Field coils.
R is factory adjusted.

See Fig. 3 for location of terminals.

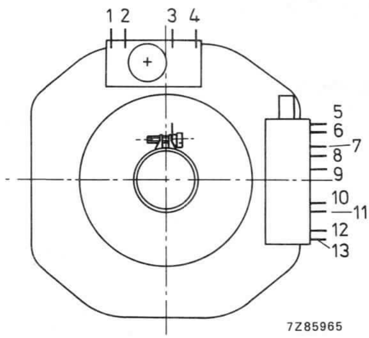


Fig. 3 Terminal location of deflection coils.

DEVELOPMENT SAMPLE DATA

OPTICAL DATA

Screen	metal-backed phosphor dot triplets; black matrix
Screen finish	non-glare (direct etch)
Useful screen dimensions	
diagonal	min. 335,4 mm
horizontal axis	min. 280,8 mm
vertical axis	min. 210,6 mm
area	min. 580 cm^2
Recommended useful screen dimensions for alphanumeric display	
diagonal	307 mm
horizontal axis	244 mm
vertical axis	186 mm
Phosphor	
red	rare earth
green	sulphide type
blue	sulphide type
Phosphor colour co-ordinates*	
red	x = 0,635; y = 0,340
green	x = 0,315; y = 0,600
blue	x = 0,150; y = 0,060
Dot arrangement	hexagonal
Spacing between centres of adjacent dot triplets	approx. 0,29 mm (0,011 in)
Light transmission of face glass at centre	
M37-103X/N/1000 series	approx. 85%
M37-108X/N/1000 series	approx. 60%
Minimum number of displayable pixels**	800 x 600

* Other phosphors available to special order.
** Measuring conditions:
anode current per gun (peak value) = 300 μA;
pulse width equal to the dot pitch;
screen area used = 244 mm x 186 mm.

MECHANICAL DATA (see also the figures on the following pages)

Overall length	max. 354 mm
Neck diameter	29,1 mm
Greatest dimensions of tube face (excluding mounting lugs)	
diagonal	366,4 ± 1,6 mm
width	315,4 ± 1,6 mm
height	246,4 ± 1,6 mm
Implosion protection	shrink type (UL, CSA and VDE approved)
Anode contact designation	JEDEC J1-21; IEC 67-III-2
Base designation	10-pin base JEDEC B10-277
Basing designation	see Fig. 10
Mass	approx. 6,4 kg
Mounting position	anode contact on top

Notes to outline drawings on the following pages

1. Configuration of outer conductive coating may be different, but will contain the contact area as shown in the drawing.
2. To clean this area, wipe only with a soft lintless cloth.
3. The displacement of any lug with respect to the plane through the three other lugs is max. 1 mm.
4. Minimum space to be reserved for mounting lug.
5. The position of the mounting screw in the cabinet must be within a circle of 9,5 mm diameter drawn around the true geometrical positions, i.e. the corners of a rectangle of 311,4 mm x 243,2 mm.
6. Co-ordinates for radius R = 11,6 mm: x = 126,98 mm, y = 90,76 mm.
7. Maximum dimensions in plane of lugs.
8. The socket for this base should not be rigidly mounted: it should have flexible leads and be allowed to move freely. The bottom circumference of base will fall within a circle concentric with the tube axis and having a diameter of 50 mm.
9. Small cavity contact J1-21, IEC 67-III-2.
10. The X, Y and Z reference points are located on the outside surface of the face plate 3,2 mm beyond the intersection of the minor, major and diagonal screen axis respectively, with the minimum published screen.

DEVELOPMENT SAMPLE DATA

MECHANICAL DATA (continued) Dimensions in mm

Notes are on the preceding page.

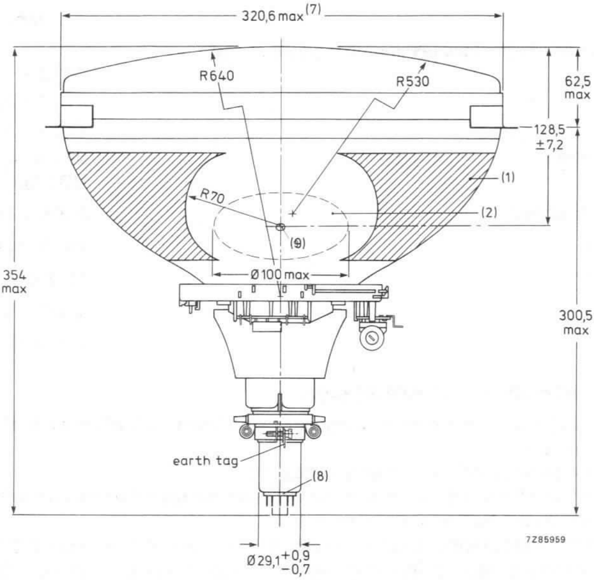


Fig. 4a.

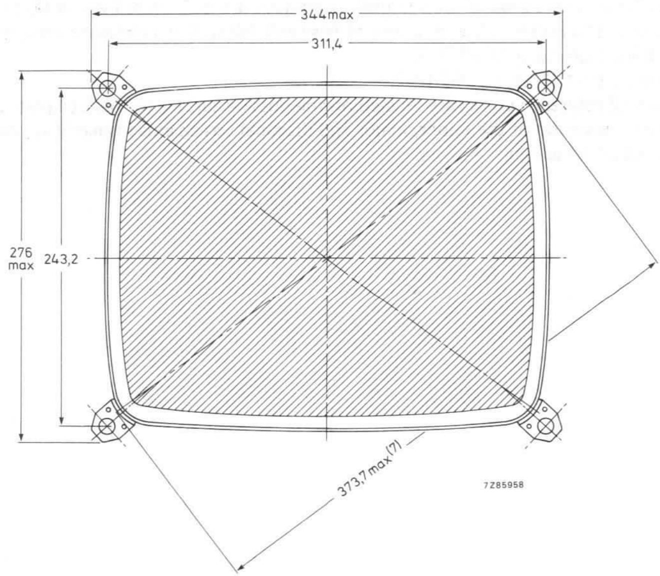


Fig. 4b.

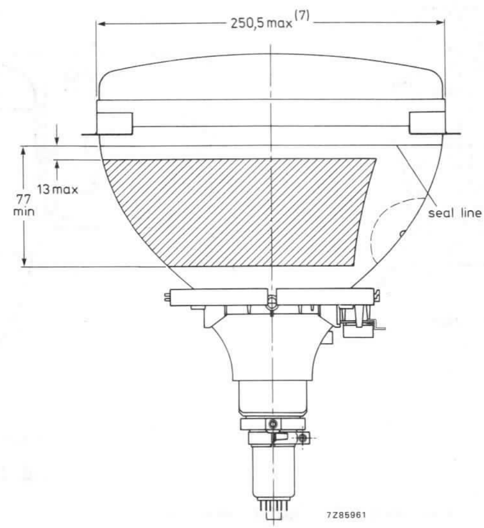

250,5 max (7)
13 max
77 min
seal line
7Z85961

Fig. 4c.

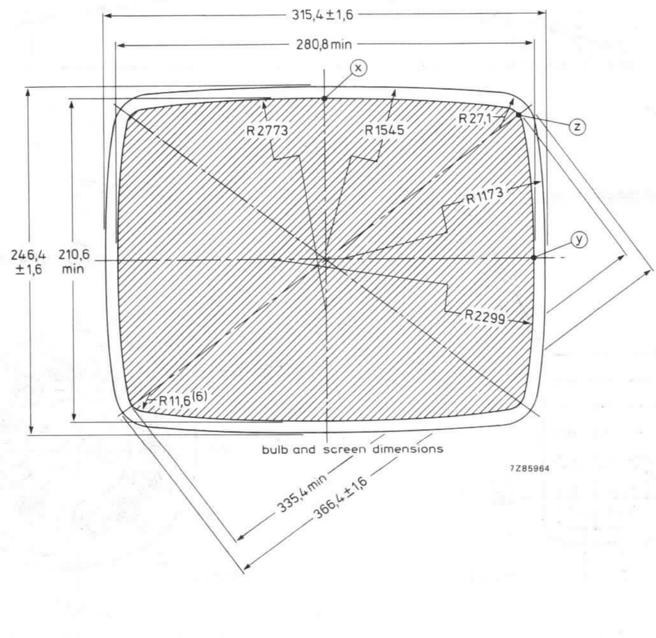

315,4 ± 1,6
280,8 min
x
R 2773
R 1545
R 27,1
z
R 1173
y
246,4 ± 1,6
210,6 min
R 2299
R 11,6 (6)
bulb and screen dimensions
7Z85964
335,4 min
366,4 ± 1,6

Fig. 5.

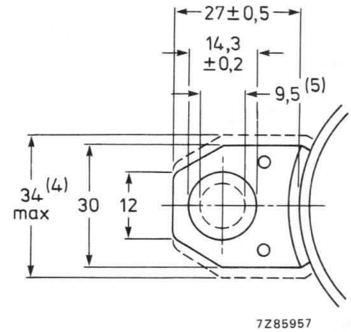


Fig. 6.

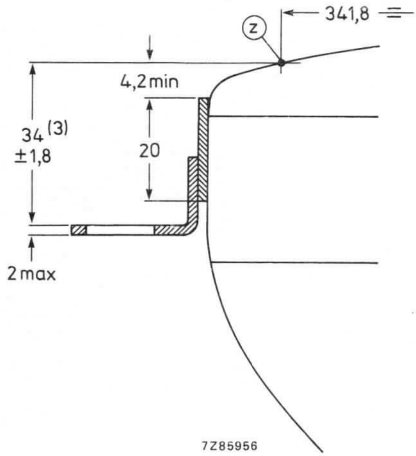


Fig. 7.

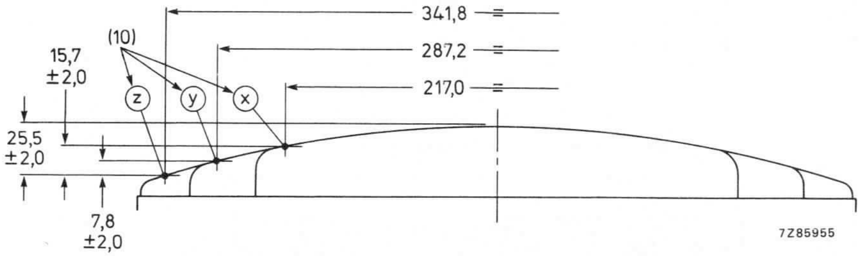


Fig. 8.

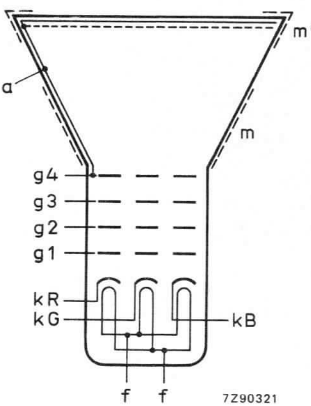


Fig. 9.

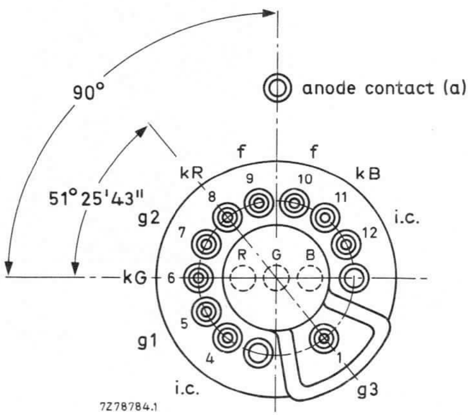


Fig. 10.

i.c. = internally connected (not to be used)

10-pin base; JEDEC B10-277

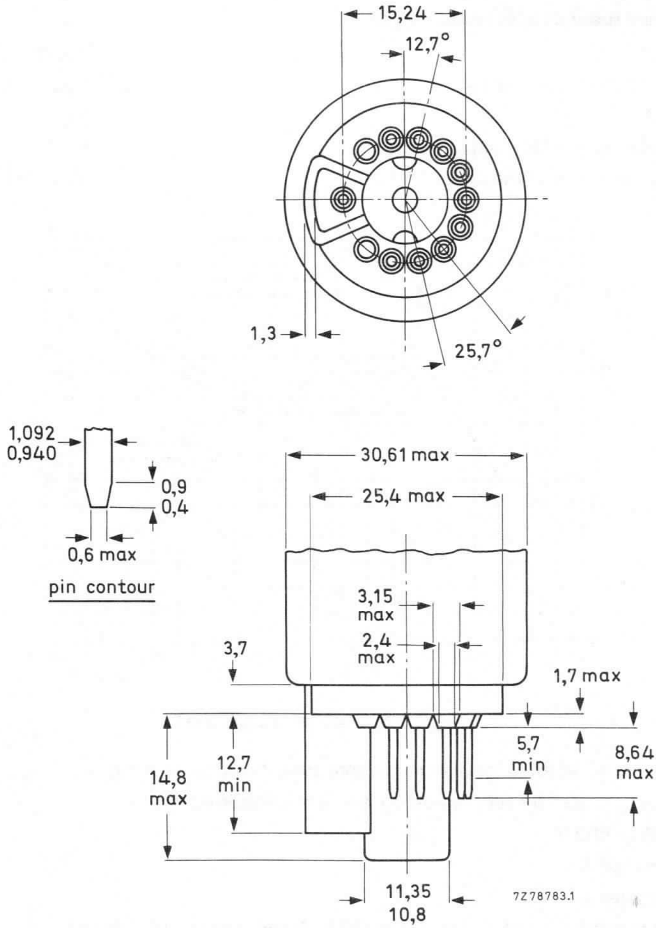


Fig. 11.

DEVELOPMENT SAMPLE DATA

RECOMMENDED OPERATING CONDITIONS (cathode drive)

The voltages are specified with respect to grid 1.

Anode voltage	$V_{a,g4}$	25 kV
Grid 3 (focusing electrode) voltage	V_{g3}	6,6 to 7,5 kV
Grid 2 voltage	V_{g2}	see Fig. 12
Anode current of each gun (peak)	I_{ap}	300 μA
Luminance at the centre of the screen L*	to be established	

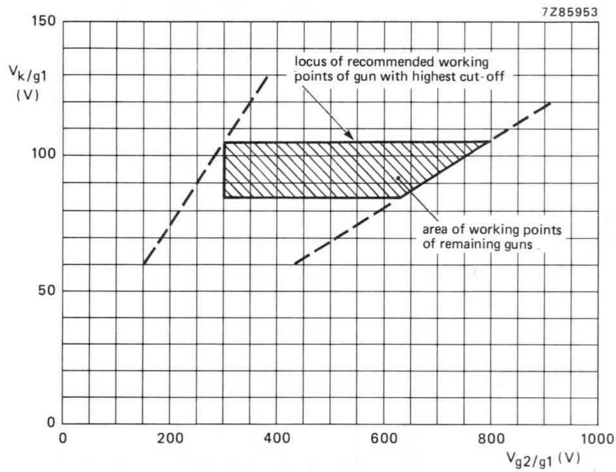


Fig. 12 Spot cut-off design chart.

Grid 2 voltage (V_{g2}) adjusted for highest gun spot cut-off voltage V_k = 105 V.

Remaining guns adjusted for spot cut-off by means of cathode voltage.

V_{g2} range 300 to 800 V

V_k range 85 to 105 V

Adjustment procedure:

Set the cathode voltage (V_k) for each gun at 105 V; increase the grid 2 voltage (V_{g2}) from approx. 300 V to the value at which one of the colours becomes just visible. Now decrease the cathode voltage of the remaining guns so that the other colours also become visible.

* Tube adjusted for a focused raster with a current density of 0,4 $\mu A/cm^2$ of the respective colour.

EQUIPMENT DESIGN VALUES (each gun if applicable)

The values are valid for anode voltages between 20 and 27,5 kV.
The voltages are specified with respect to grid 1.

Grid 3 (focusing electrode) voltage	V_{g3}	26,6 to 29,8% of anode voltage
Grid 2 voltage for visual extinction of focused spot (V_k = max. 105 V)	V_{g2} and V_k	see Fig. 12
Difference in cut-off voltages between guns in any tube	ΔV_k	lowest value ⩾ 80% of highest value
Cathode drive characteristic		see Fig. 13
Grid 3 (focusing electrode) current	I_{g3}	−5 to + 5 μA
Grid 2 current	I_{g2}	−5 to + 5 μA
Grid 1 current at V_k = 100 V	I_{g1}	−5 to + 5 μA

to produce white, CIE co-ordinates

	x = 0,313 y = 0,329			x = 0,281 y = 0,311		
Percentage of total anode current supplied by each gun (typical)						
red gun		39,0%			28,7%	
green gun		35,2%			38,6%	
blue gun		25,8%			32,7%	
Ratio of anode currents	min.	av.	max.	min.	av.	max.
red gun to green gun	0,8	1,1	1,4	0,5	0,7	0,9
red gun to blue gun	1,1	1,5	1,9	0,7	0,9	1,2
blue gun to green gun	0,5	0,7	1,0	0,6	0,8	1,1

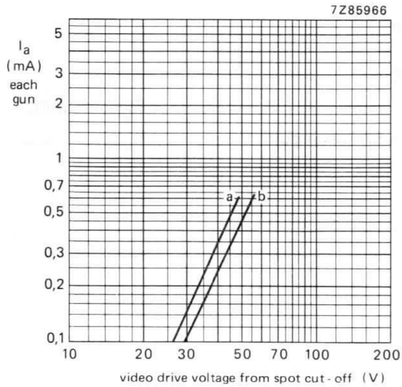


Fig. 13 Typical cathode drive characteristics at spot cut-off voltages of 85 V (curve a) and 105 V (curve b).

V_f = 6,3 V;
$V_{a,g4}$ = 25 kV;
V_{g3} adjusted for focus.

DEVELOPMENT SAMPLE DATA

LIMTING VALUES (each gun if applicable)

Tube

Design maximum rating system unless otherwise stated.
The voltages are specified with respect to grid 1.

Anode voltage	$V_{a,g4}$	max.	27,5 kV	notes 1 and 2
		min.	20 kV	note 3
Anode current for each gun				
peak	I_{ap}	max.	400 μA	
average	I_a	max.	200 μA	
Long term average anode current for three guns		to be established		
Grid 3 (focusing electrode) voltage	V_{g3}	max.	10 kV	
Grid 2 voltage, peak	V_{g2p}	max.	1000 V	
Cathode voltage				
positive	V_k	max.	400 V	
positive operating cut-off	V_k	max.	200 V	
negative	$-V_k$	max.	0 V	
negative peak	$-V_{kp}$	max.	2 V	
Cathode to heater voltage				
positive	V_{kf}	max.	275 V	
positive peak	V_{kfp}	max.	300 V	note 1
negative	$-V_{kf}$	max.	0 V	
negative peak	$-V_{kfp}$	max.	200 V	note 1
Heater voltage	V_f	max.	6,9 V	note 4
		min.	5,7 V	

Deflection unit

Maximum operating temperature	95 °C

LIMITING CIRCUIT VALUES

Grid 3 circuit resistance	R_{g3}	max.	30 MΩ
Grid 1 to cathode circuit resistance (each gun)	R_{g1k}	max.	0,75 MΩ

Notes

1. Absolute Maximum rating system.
2. During adjustment on the production line this value is likely to be surpassed considerably. It is therefore strongly recommended first to make the necessary adjustments for normal operation.
3. Operation of the tube at lower voltages impairs the luminance and resolution.
4. For maximum cathode life, it is recommended that the heater supply be regulated at 6,0 V.

FLASHOVER PROTECTION

With the high voltage used with this tube (max. 27,5 kV) internal flashovers may occur. As a result of the Soft-Flash technology these flashover currents are limited to approx. 60 A offering higher set reliability, optimum circuit protection and component savings.
Primary protective circuitry using properly grounded spark gaps and series isolation resistors (preferably carbon composition) is still necessary to prevent tube damage. The spark gaps should be connected to all picture tube electrodes at the socket according to the figure below; they are not required on the heater pins. No other connections between the outer conductive coating and the chassis are permissible.
The spark gaps should be designed for a breakdown voltage at the focusing electrode (g3) of 11 kV (1,5 x V_{g3} max. at $V_{a,g4}$ = 25 kV), and at the other electrodes of 1,5 to 2 kV.
The values of the series isolation resistors should be as high as possible (min. 1,5 kΩ without causing deterioration of the circuit performance. The resistors should be able to withstand an instantaneous surge of 20 kV for the focusing circuit and 12 kV for the remaining circuits without arcing.
Additional information is available on request.

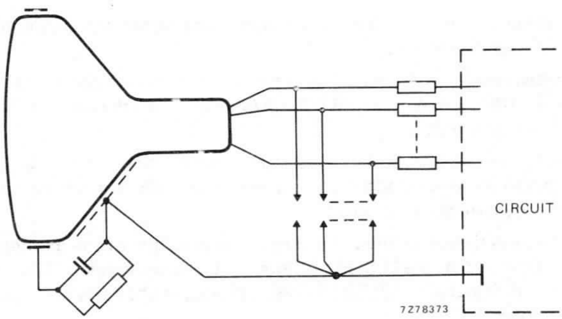


Fig. 14.

DEVELOPMENT SAMPLE DATA

X-RADIATION LIMIT

Maximum anode voltage at which the X-radiation emitted will not exceed 0,5 mR/h at an anode current of 300 μA

entire tube	31 kV*
face-plate only	33 kV

Warning:

If the value for the tube face only is used as design criterion, adequate shielding must be provided in the monitor for the anode contact and/or certain portions of the tube funnel and panel skirt to insure that the X-radiation from the monitor is attenuated to a value equal to or lower than that specified for the face of the tube.

Maximum voltage difference between anode and focus electrode at which the X-radiation will not exceed 0,5 mR/h — 30 kV

Warning:

If the voltage value above can be exceeded in the monitor additional attenuation of the X-radiation through the tube neck may be required.

The X-radiation emitted from this display tube, as measured in accordance with the procedure of JEDEC Publication No. 64D, will not exceed 0,5 mR/h throughout the useful tube life when operated within the 'Design maximum ratings'.

The tube should not be operated beyond its 'Design maximum ratings' stated above, but its X-radiation will not exceed 0,5 mR/h for anode voltage and current combinations given by the isoexposure-rate limits characteristics shown on the next page.

Operation above the values shown by the curve may result in failure of the monitor to comply with the Federal Performance Standard of the U.S. for Television Receivers, Section 1020. 10 of Part 1020 of Title 21, Code of Federal Regulation (PL90-602) as published in the Federal Register Volume 38, No. 198, Monday, October 15, 1973.

Maximum X-radiation as a function of anode voltage at 300 μA anode current is shown by the curve on the next page. X-radiation at a constant anode voltage varies linearly with anode current.

* This rating applies only if the anode connector used by the set maker provides the necessary attenuation to reduce the X-radiation from the anode contact by a factor equal to the difference between the anode button isoexposure-rate limit curve and the isoexposure-rate limit curve for the entire tube.

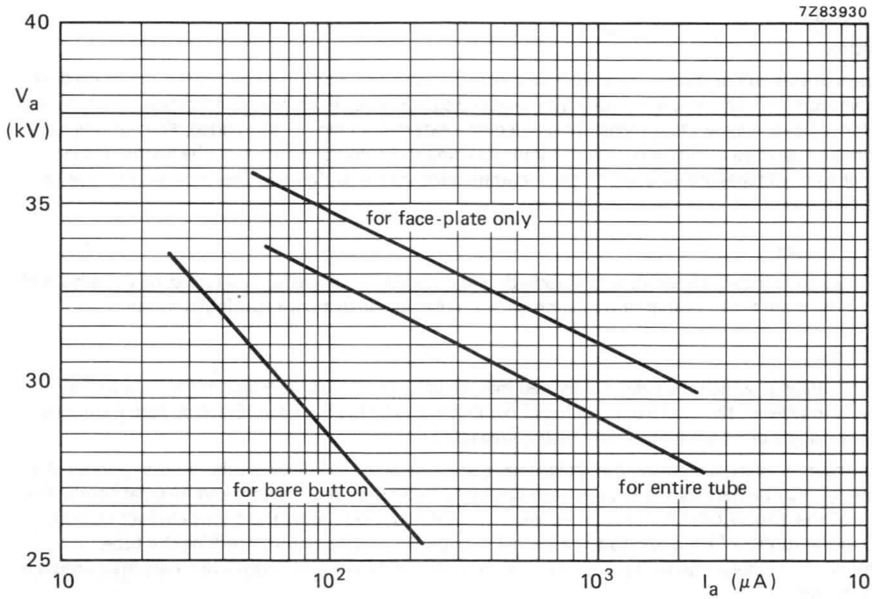


Fig. 15 0,5 mR/h isoexposure-rate limit curve.

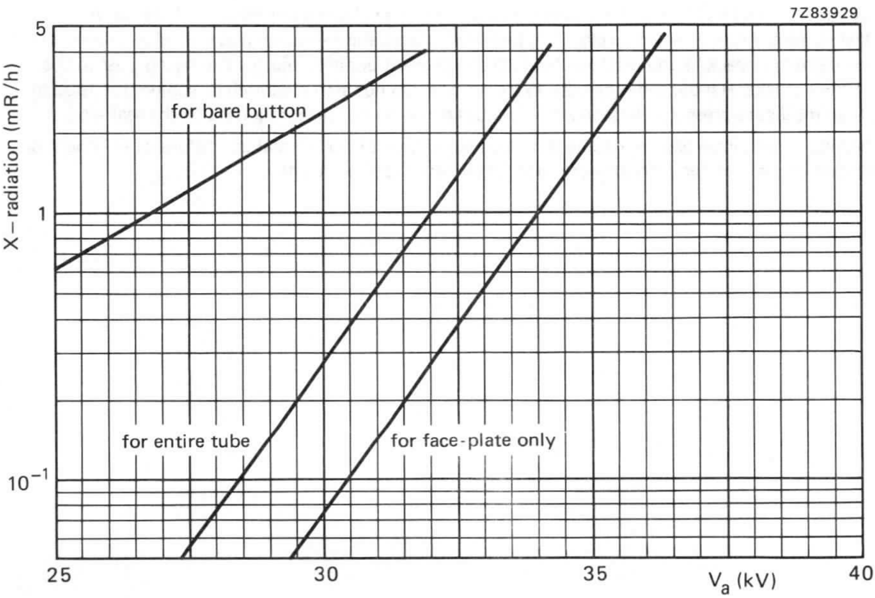


Fig. 16 X-radiation limit curve at a constant anode current of 300 μA.

DEVELOPMENT SAMPLE DATA

WARNINGS

X-radiation

Operation of this colour display tube under abnormal conditions which exceed the 0,5 mR/h iso-dose rate curve shown on the preceding page may produce soft X-rays which may constitute a health hazard on prolonged exposure at close range unless adequate external screening is provided. Precautions must therefore be exercised during servicing of monitors using this tube to ensure that the anode voltage and other tube voltages are adjusted to the recommended values so that the 'Design maximum ratings' are not exceeded.

Tube replacement

This display tube incorporates integral X-radiation and implosion protection and must be replaced with a tube of the same type number or a recommended replacement to assure continued safety.

Shock hazard

The high voltage at which the tube is operated may be very dangerous. The monitor should include safeguards to prevent the user from coming in contact with the high voltage. Extreme care should be taken in servicing or adjustment of any high-voltage circuit.

Caution must be exercised during the replacement or servicing of the display tube since a residual electrical charge may be held by the high-voltage capacitor formed by the external and internal conductive coatings of the display tube funnel. To remove any residual charge, short the anode contact button, located in the funnel of the tube, to the external conductive coating before handling the tube. Discharging the high voltage to isolated metal parts such as cabinets and control brackets may produce a shock hazard.

Tube handling

Display tubes should be kept in the shipping box or similar protective container will just prior to installation. Wear heavy protective clothing, including gloves and safety goggles with side shields, in areas containing unpacked and unprotected tubes to prevent possible injury from flying glass in the event a tube breaks. Handle the tube with extreme care. Do not strike, scratch or subject the tube to more than moderate pressure. Particular care should be taken to prevent damage to the seal area.

The packing should incorporate sufficient cushioning so that under normal conditions of shipment or handling an impact acceleration of more than 35g is never applied to the tube.

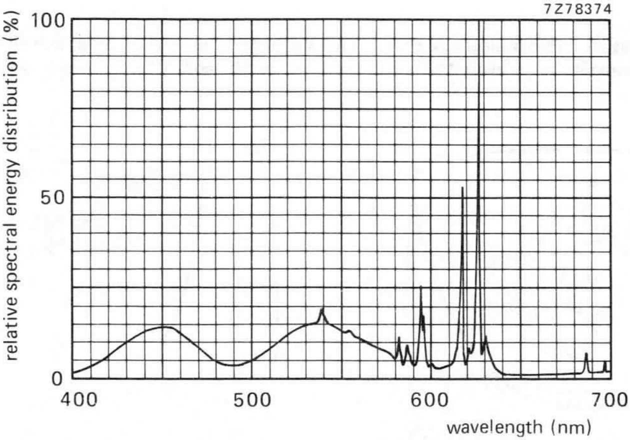


Fig. 17 Simultaneous excitation of red, green and blue phosphor, measured in a tube, to produce white of x = 0,281, y = 0,311. Exact shape of the peaks depends on the resolution of the measuring apparatus.

Colour co-ordinates:	x	y
red	0,635	0,340
green	0,315	0,600
blue	0,150	0,060

DEVELOPMENT SAMPLE DATA

DEGAUSSING

The display tube has an internal magnetic shield. This shield and the shadow mask with its suspension system may be automatically degaussed by a coil mounted on the cone of the picture tube as shown in Fig. 18.

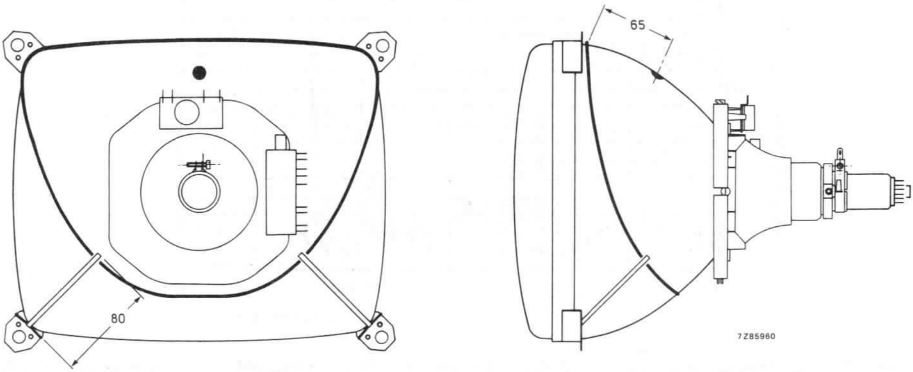


Fig. 18 Position of degaussing coil on the display tube; dimensions are given in mm.

For proper degaussing an initial magnetomotive force (m.m.f.) of 600 ampere-turns is required in the coil. This m.m.f. has to be gradually decreased. In the steady state, no significant m.m.f. should remain in the coil (⩽ 0,6 ampere-turns).

If single-phase power rectification is used, provision should be included to prevent asymmetric distortion of the a.c. voltage applied to the degaussing circuit due to high d.c. inrush currents.

An example of a degaussing circuit and coil data for various mains voltage are given below.

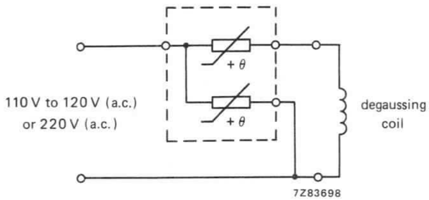


Fig. 19 Degaussing circuit using dual PTC thermistor.

Data of degaussing coil

	110 to 120 V (a.c.)	220 V (a.c.)
Circumference	95 cm	90 cm
Number of turns	70	120
Copper-wire diameter	0,45 mm	0,3 mm
Resistance	6,7 Ω	25,9 Ω
Catalogue number of dual PTC thermistor	2322 662 98013	2322 662 98009

CONVERGENCE AND RASTER SPECIFICATION

The maximum misconvergence after 15 min operation is given in Table 1 and Fig. 20

Test conditions (all voltages are measured with respect to grid 1)

Heater voltage	V_f	6,3 V
Grid 2 voltage	V_{g2}	525 V
Grid 3 voltage	V_{g3}	to be adjusted for focus at screen centre, using cross-hatch pattern or characters H, at anode current of 300 μA (peak) per gun
Anode voltage	V_a	25 kV
Test pattern		cross-hatch pattern
Ambient temperature	T_{amb}	25 ± 5 °C

Notes

1. Misconvergence is the distance between centres of the red, green, blue lines at the screen using rectangular co-ordinates.
2. Anode and/or focusing voltage and terrestrial magnetism affect the static convergence performance. Therefore small readjustments of the minipole magnets may be necessary.

Table 1 Maximum misconvergence after 15 min operation

location (see Fig. 20)	type or error	max. error between any colour
centre	red-green-blue line separation in either the horizontal or vertical direction	0,15 mm
area A		0,30 mm
area B		0,40 mm

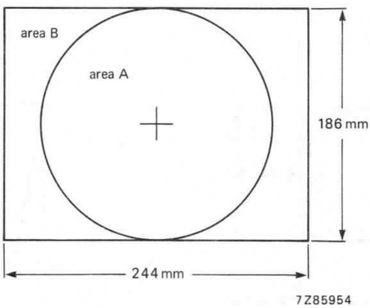


Fig. 20 Convergence test areas.

DEVELOPMENT SAMPLE DATA

Raster centring

horizontal	max. 5 mm
vertical	max. 5 mm

Raster rotation max. 0,4° (Fig. 21)

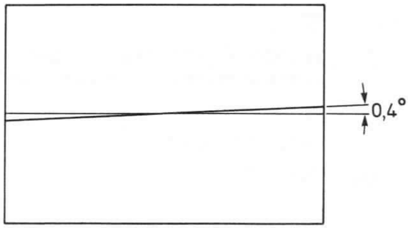


Fig. 21 Raster rotation.

Pattern distortion, measured without east-west and north-south correction

Pin cushion distortion		
east-west	$\frac{2(H1 + H2)}{B1 + B2}$ x 100% (Fig. 22)	max. 8,0%
north-south	$\frac{2(V1 + V2)}{A1 + A2}$ x 100% (Fig. 22)	max. 1,0%
Max. pin-cushion distortion at each side		
east-west	H1 or H2 (Fig. 22)	max. 6,5 mm
north-south	V1 or V2 (Fig. 22)	max. 1,5 mm
Parallelogram	P1 or P2 (Fig. 23)	max. 2,5 mm

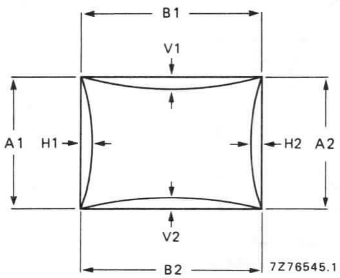


Fig. 22 A1, A2 = 186 mm; B1, B2 = 244 mm.

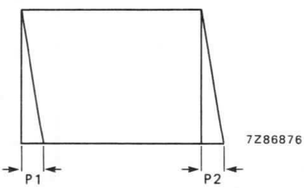


Fig. 23.

Cathode-ray tubes

4

Camera tubes

5

Supersedes June 1986 data

FRAME TRANSFER SENSOR

GENERAL DESCRIPTION

The NXA1011 frame transfer sensor is a solid state imaging device which produces two interlaced 294-line fields (including 6 lines for dark reference and testing) with an aspect ratio of 4:3.
The device is compatible with CCIR TV standards and has a 7,5 mm image diagonal matching the half-inch camera tube format.

APPLICATIONS

- ENG cameras – the high blue sensitivity and good horizontal resolution makes this sensor suitable for 3-chip ENG colour cameras
- Surveillance cameras – solid state reliability, high resolution and sensitivity provide the quality to be an ideal successor for the Newvicon® or Ultricon® pick-up element
- Character and pattern recognition – the excellent linearity and uniformity recommends this sensor as a first choice for these applications
- Robotics – the small size, light-weight and mechanical ruggedness makes this sensor extremely suitable for all types of high resolution robot-vision applications
- Visual aids – the low voltage and mechanical ruggedness of this device allows design of safe and reliable cameras for visual aids

FEATURES

- Effective number of elements: 604 (horizontal) x 576 (vertical)
- Dark reference: 1 line per field for black clamping
- 100 x anti-blooming margin
- Gamma is 1
- High sensitivity, low noise
- Freedom from lag, burn-in, geometrical distortion and microphonic noise

DEVICE ORGANIZATION

- Frame transfer charge coupled device
- Unit cell size: 10 μm (horizontal) x 15,6 μm (vertical)
- Dummy elements: the first 5 elements of the 3 output registers are dummy elements
- On-chip high sensitivity output amplifier
- Image area: 6,0 mm (horizontal) x 4,5 mm (vertical)
- Chip size: 6,95 mm (horizontal) x 9,35 mm (vertical)

FUNCTIONAL DESCRIPTION

The special electrode arrangement allows 26% of the photosensitive element to be free of polysilicon. This facilitates easy penetration of the blue light into the element to provide good blue sensitivity.

The layout of the sensor is shown in Fig. 1.
It comprises 3 functional areas:

- a matrix of photosensitive elements and integration electrodes,
- a storage section,
- three BCCD read-out registers.

Figure 2 shows the transport process in the imaging and storage regions. At time t_0, the start of the first field read-out from the imaging region, ϕ_3 is low and the charge is concentrated beneath ϕ_4 to ϕ_2. At t_1, ϕ_4 goes low and the charge in each pixel concentrates beneath ϕ_1 and ϕ_2. At t_2, ϕ_3 goes high and the charge packets advance one gate electrode, spreading out beneath ϕ_1, ϕ_2 and the following electrode ϕ_3. In the next step, at t_3, ϕ_1 goes low compressing the charge packets beneath ϕ_2 and ϕ_3, and at t_4, ϕ_4 goes high allowing the charge packets again to advance one gate electrode. This process continues in both the imaging and storage regions until all the charge packets have transferred to the storage region.

The sensor in the integration mode is shown in Fig. 3. The first field is generated when phases ϕ_4, ϕ_1 and ϕ_2 are high and ϕ_3 is low, Fig. 3(a). ϕ_3 effectively forms a potential barrier separating the pixels in the first field. The charges generated by incident light then integrate beneath ϕ_4 and ϕ_2, centred on ϕ_1. So each pixel extends vertically over four gate electrodes.
The potential distribution of the second field, and hence its position relative to the first field is shown in Fig. 3(b). The second field is always displaced by two gate electrodes relative to the first field, with its charge patterns centred on ϕ_3, and with ϕ_1 forming the barrier between pixels, thus providing a perfectly interlaced frame structure.

CAUTION

The image sensor is a MOS device which can be destroyed by static charging of the gates. Always store the device with short-circuiting clamps or on conductive foam plastic. When cleaning the glass window only use alcohol or acetone. Rub the window carefully and slowly. Dry rubbing of the window may cause static charges which can destroy the device.

orange binder, tab 5

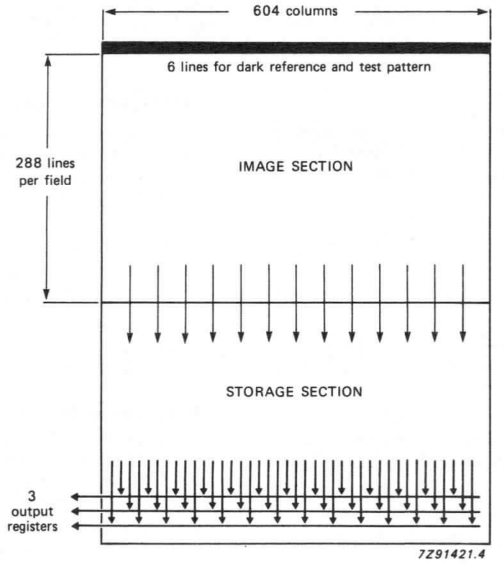


Fig. 1 Sensor layout and charge transport direction.

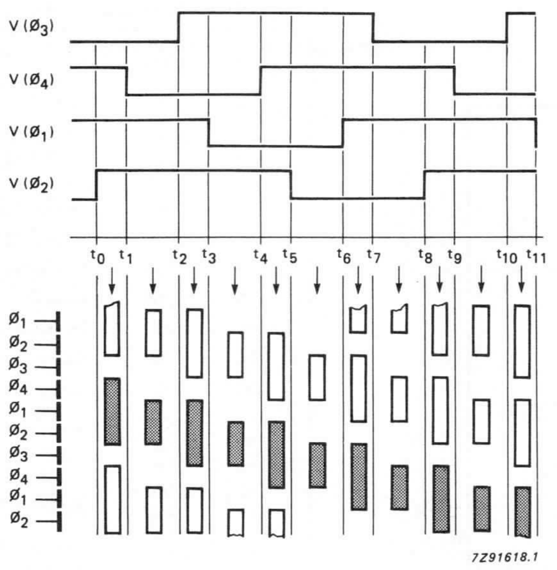


Fig. 2 Charge transport in the vertical direction.

DEVELOPMENT DATA

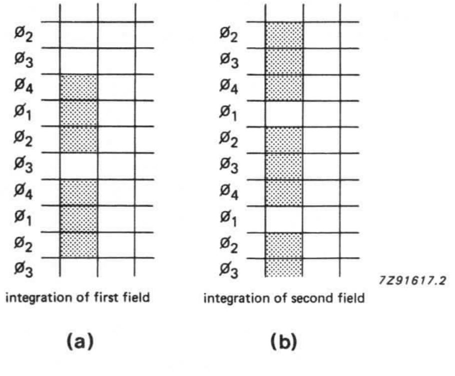


Fig. 3 Interlacing of the sensor.

(a) For integration of the first field, ϕ_4 to ϕ_2 are high, ϕ_3 is low forming a barrier between charge packets.

(b) For integration of the second field, ϕ_2 to ϕ_4 are high, ϕ_1 is low.

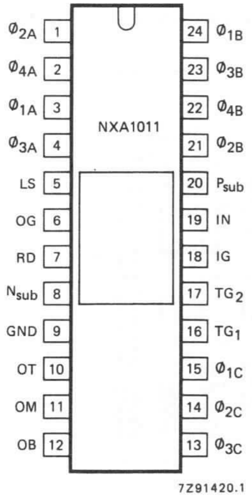


Fig. 4 Pin configuration.

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1 2 3 4	ϕ_{2A} ϕ_{4A} ϕ_{1A} ϕ_{3A}	Vertical transfer clocks for image part
5	LS	Light shield (Al. cover on storage part)
6	OG	Output gate
7	RD	Drain reset transistor
8	N_{sub}	N-substrate; supply voltage
9	GND	Ground
10	OT	Output top
11	OM	Output middle
12	OB	Output bottom
13 14 15	ϕ_{3C} ϕ_{2C} ϕ_{1C}	Horizontal transfer clock for output register
16 17	TG1 TG2	Transfer gates
18	IG	Input gate (test point for manufacturing)
19	IN	Input diffusion (test point for manufacturing)
20	P_{sub}	P-substrate
21 22 23 24	ϕ_{2B} ϕ_{4B} ϕ_{3B} ϕ_{1B}	Vertical transfer for storage part

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Voltages with respect to P_{sub}				
RD	$V_{RD\text{-}PSUB}$	–0,5	+25	V
IN	$V_{IN\text{-}PSUB}$	–0,5	+25	V
Voltages with respect to N_{sub}				
RD	$V_{RD\text{-}NSUB}$	–10	+0,5	V
IN	$V_{IN\text{-}NSUB}$	–10	+0,5	V
all other connections		–25	+0,5	V
Current from one output		–	10	mA
Storage temperature range	T_{stg}	–55	+80	°C
Operating ambient temperature range	T_{amb}	–20	+60	°C

DEVELOPMENT DATA

DC CHARACTERISTICS at T_{amb} = 25 °C

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Voltage at LS (note 1)	V_{LS}	–	V_{Nsub}	–	V
Voltage at OG (note 2)	V_{OG}	2	–	10	V
Voltage at RD; (note 2) current to sensor: I < 1 μA	V_{RD}	10	–	V_{Nsub}	V
Voltage at N_{sub}; (note 2) I < 10 mA	V_{Nsub}	15	20	22	V
Voltage difference between V_{Nsub} and V_{RD}	$V_{Nsub}-V_{RD}$	–	–	7	V
Voltage at IG	V_{IG}	–	GND	–	V
DC level of output voltage at OT, OM, OB (notes 3 and 4)	$V_{OT;\ OM;\ OB}$	6	–	15	V
Voltage at P_{sub}; (note 2) current from sensor: I < 50 μA	V_{Psub}	0	–	5	V
Voltage at IN	V_{IN}	–	V_{Nsub}	–	V
Power dissipation	P	–	80	150	mW
Leakage current of gates	I_l	–	–	10	μA

Notes

1. The lightshield should be connected to V_{Nsub} (ot to GND).
2. These values must be adjusted to the optimum operating point within the given range.
3. Measured with output buffer. See Fig. 5.
4. See Fig. 16.

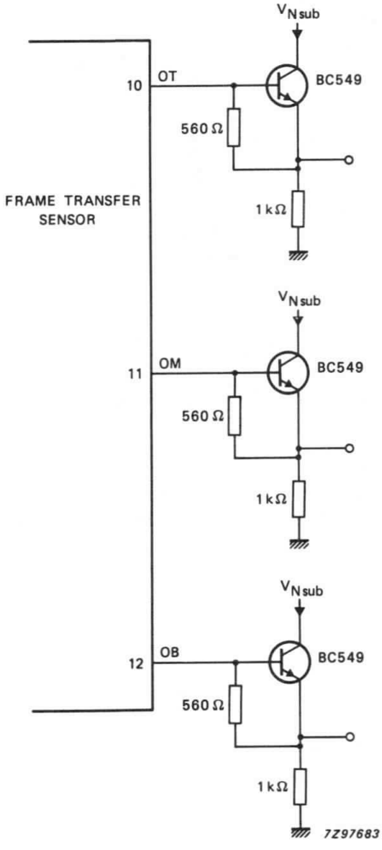


Fig. 5 Output buffer for measurements.

DEVELOPMENT DATA

CLOCK CHARACTERISTICS (note 1)

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
LOW levels					
ϕ_{nA}, ϕ_{nB}	$V_{\phi nA/B}$	–	GND	–	–
ϕ_{1C}, ϕ_{2C}, ϕ_{3C} ($\phi_{1CLOW} = \phi_{2CLOW} = \phi_{3CLOW}$) (note 2)	$V_{\phi nC}$	–	0	$V_{Nsub}-10$	V
TG1 (note 2)	V_{TG1}	0	–	$V_{Nsub}-10$	V
TG2 (note 2)	V_{TG2}	0	–	$V_{Nsub}-10$	V
Amplitudes					
ϕ_{nA}, ϕ_{nB}, ϕ_{nC}	$V_{\phi(p\text{-}p)}$	9,75	10	10,25	V
Timing (see Figs 6 and 7)					
Horizontal clocks					
clock frequency (note 3)	f_c	–	3,854	–	MHz
rise time	t_{rc}	20	–	40	ns
fall time	t_{fc}	20	–	40	ns
fall time of ϕ_{1C} during horizontal blanking (note 4)	t_{fcB}	–	200	–	ns
overlap time	t_{ihc}	10	–	–	ns
	t_{ilc}	5	–	–	ns
Vertical clocks					
clock frequency	f_{cv}	–	625	–	kHz
rise time	t_{rv}	–	70	–	ns
fall time	t_{fv}	–	100	–	ns
overlap time	t_{ihv}	100	–	–	ns
	t_{ilv}	100	–	–	ns
Transfer gates					
rise time	t_{rTG}	–	70	–	ns
fall time	t_{fTG}	–	100	–	ns
Clock capacitance					
Each clock phase ϕ_{nA}, ϕ_{nB}	$C_{\phi nA/B}$	–	–	3000	pF
ϕ_{nC}, TG1, TG2	$C_{\phi nC}$, $C_{TG1/2}$	–	–	100	pF
Leakage current of the clock connections	I_l	–	–	10	μA

Notes

1. Measured with output buffer. See Fig. 5.
2. These values must be adjusted to the optimum operating point within the given range.
3. Deviations from this frequency result in incorrect aspect ratio.
4. It is recommended to use the longer fall time of the ϕ_{1C} pulse during the horizontal blanking period to avoid irregular vertical stripes.

ADJUSTMENT OF OPERATING LEVELS

A reasonable picture may be obtained by using the settings quoted in the NXA1011 Test Sheet. For optimum performance, fine adjustment of the sensors d.c. levels is essential. When carrying out this operation the following points should be considered.

- Vertical stripes in the picture are usually the result of charges being unevenly sorted into the three output registers. This can be influenced by offsets $V_{\phi C}$, V_{TG1}, V_{TG2} and V_{OG}.
- The anti-blooming performance of a sensor is influenced by its internal vertical potential gradient. This can be optimized by adjusting V_{Nsub} and V_{Psub}.

DRIVING PULSE WAVEFORMS

The specifications of the sensor are measured when the following clock pulses are applied (Figs 6 and 7). In principle the sensor can be operated with different clock pulses, e.g. different clock frequencies (overlap conditions have to be maintained).

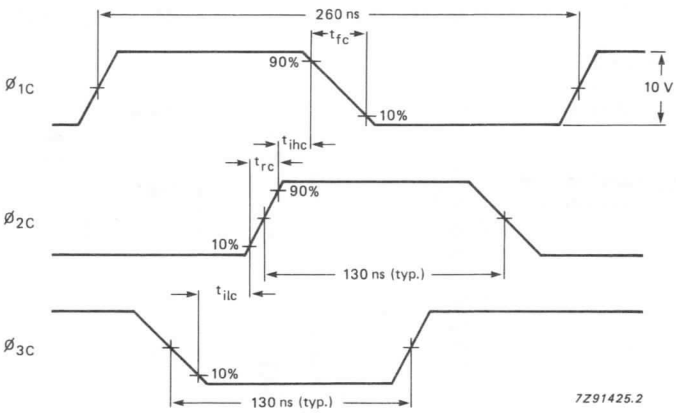


Fig. 6 Horizontal transport timing waveforms for the sensor electrodes (ϕ_{nC}); times measured at the 10% and 90% points of the amplitude.

DEVELOPMENT DATA

DRIVING PULSE WAVEFORMS (continued)

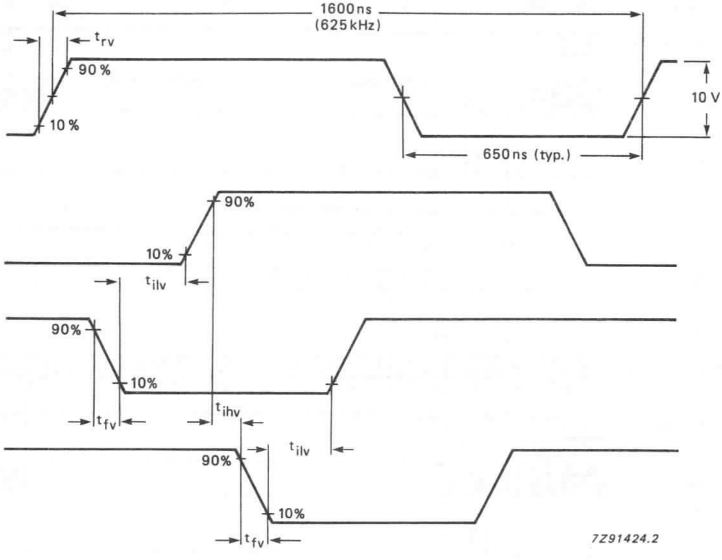


Fig. 7 Vertical transport timing waveforms for the sensor electrodes (ϕ_{nA}, ϕ_{nB}); times measured at the 10% and 90% points of the amplitude.

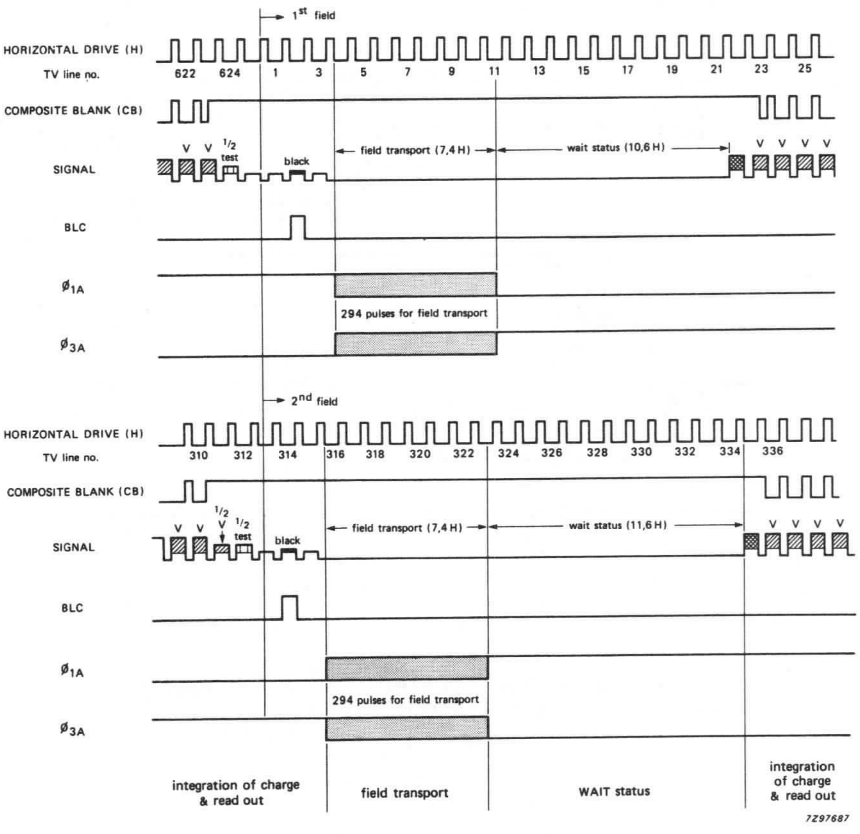


Fig. 8 Drive-pulse sequence and line numbering for field transport.

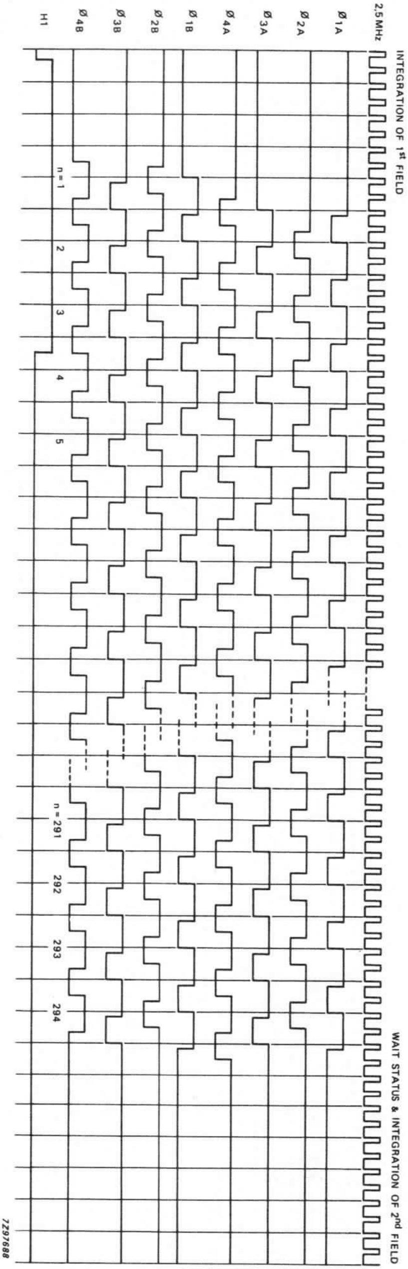


Fig. 9 Field transport pulses 1st field.

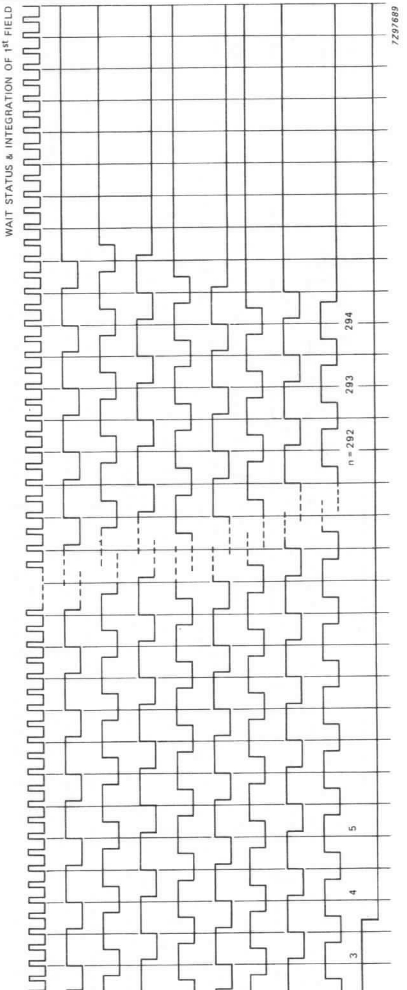


Fig. 10 Field transport pulses 2nd field.

DEVELOPMENT DATA

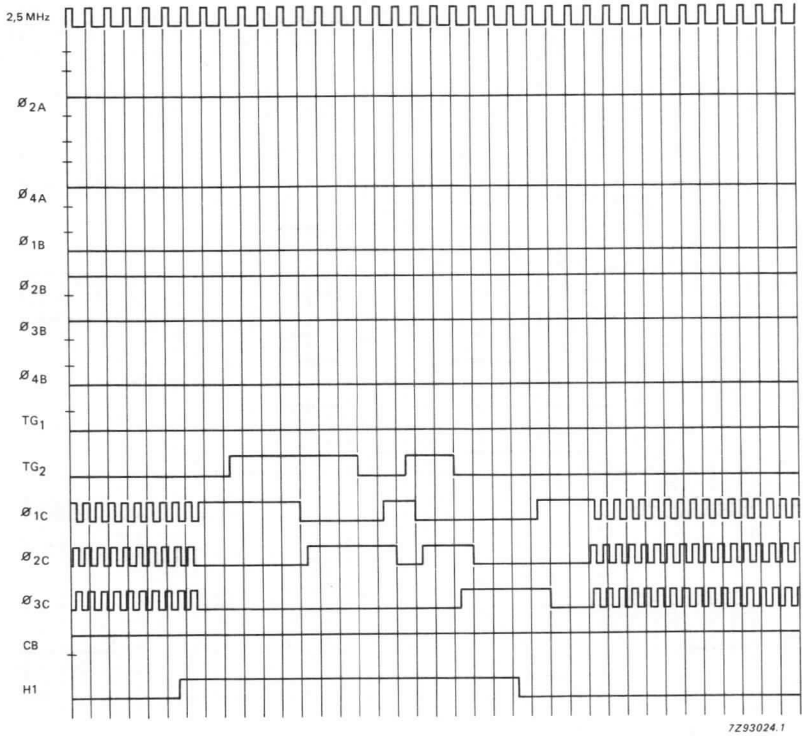


Fig. 11 Wait status.

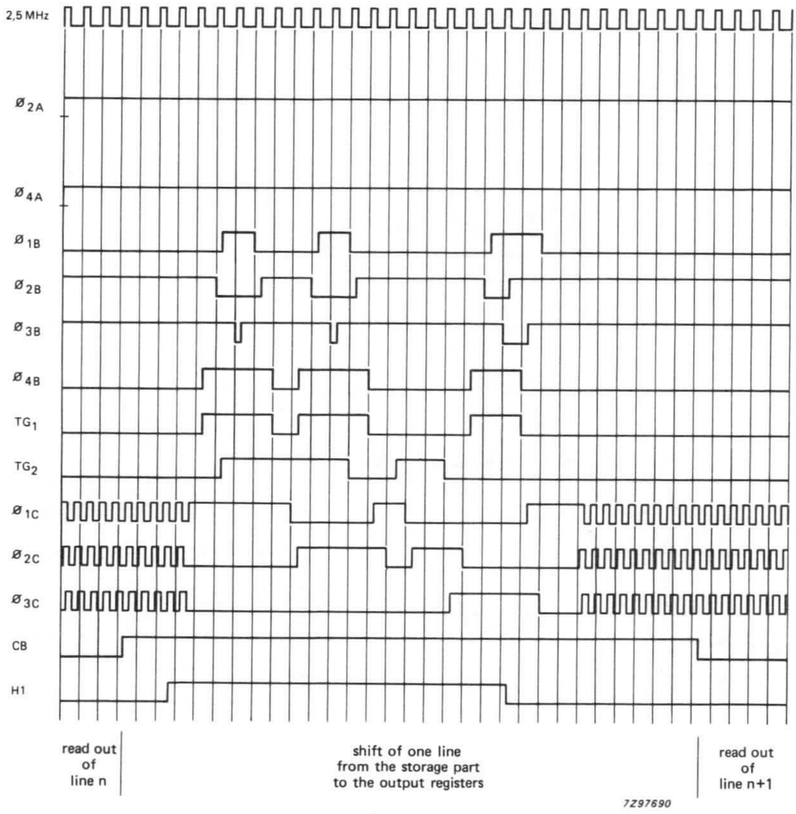


Fig. 12 Read out of the output registers and sorting of the signal into output registers.

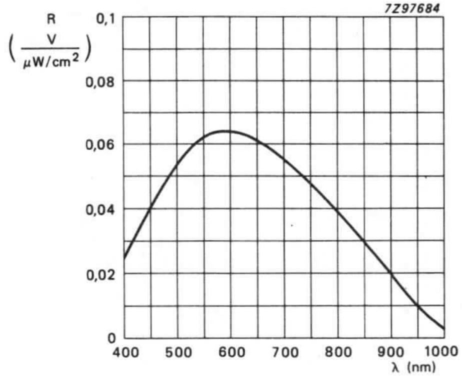


Fig. 13 Spectral response.

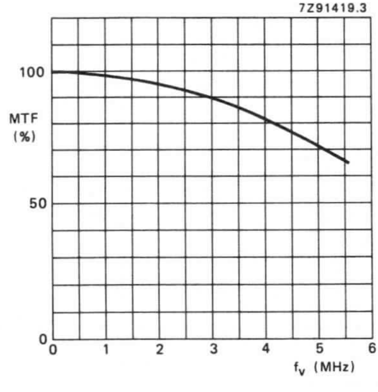


Fig. 14 Theoretical horizontal modulation transfer function; MTF as a function of the video signal frequency: three outputs correctly multiplexed.

DEVELOPMENT DATA

OUTPUT CHARACTERISTICS at T_{amb} = 60 °C

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Load capacitance	C_L	–	–	10	pF
Output signal voltage at standard illumination (peak-to-peak value) (S/N typ. 50 dB) (notes 1 and 2)	V_{OTS} V_{OMS} V_{OBS}	65	–	130	mV
Signal to noise ratio at standard illumination (notes 1, 2 and 3)	S/N	–	50	–	dB
Output signal voltage at saturation (peak-to-peak value) (notes 2 and 4)	V_{Osat}	250	400	–	mV
Clock cross-talk to output (peak-to-peak value)	V_{OCLK}	–	–	0,2	V
Maximum illumination on the sensor without blooming (note 5)	E_B	1000	–	–	lx
Transport inefficiency					
horizontal one step	ϵ_H	–	–	$8,5 \times 10^{-5}$	
vertical one step	ϵ_V	–	–	5×10^{-5}	
Dark current	I_D	–	–	5	nA
Smear (note 6)					%

Notes

1. 5 Lx on the sensor, colour temperature of light source 3200 K, Hoya-IR-filter C500S, 1 mm is used.
2. Measured with output buffer.
3. 200 kHz to 5 MHz, weighted, T_{amb} = 25 °C
4. Maximum usable range of illumination: 85% of saturation level.
5. See 'Definition of blooming'.
6. See 'Definition of smear'.

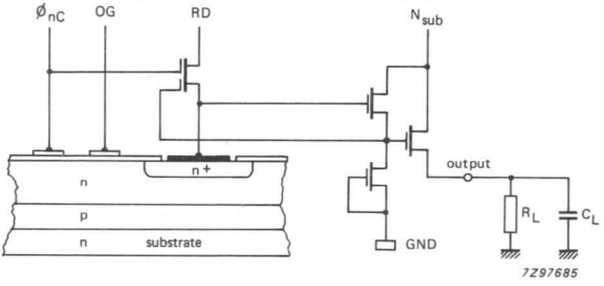


Fig. 15 Circuit diagram for one output channel.

DEFINITION OF SMEAR

During the field transport time the complete field is shifted over the image section. So each pixel of one column is illuminated by all the other pixels of the column for a short time. Therefore a bright spot makes a bright vertical stripe on the image. This effect is called smear. The brightness of the stripe depends on the height of the spot and on the illumination of the spot.

It is defined by the equation:

$$V_{smear} = \frac{t_{field\ transport}}{t_{integration}} \times \frac{h}{H} \times \frac{E}{E_{sat}} \times V_{sat}$$

Where:

V_{smear}	= Additional output voltage due to smear
$t_{field\ transport}$	= 0,47 ms
$t_{integration}$	= 19,5 ms
h	= Height of bright spot
H	= Height of the complete image
E	= Illumination of the spot
E_{sat}	= Saturation illumination
V_{sat}	= Output voltage at saturation

Example:

Spot height is 10% of the height.
Spot illumination is 100% of saturation.

$$V_{smear} = \frac{0,47}{19,5} \times 0,1 \times 1 \times V_{sat} = 0,0024 \times V_{sat}$$

DEVELOPMENT DATA

DEFINITION OF BLOOMING

When part of the image section (spot) is illuminated above saturation level and with the rest of the image dark, at a certain level of overexposure (1000 1x for the NXA1011), the area of the spot increases irregularly. This effect is called blooming.

PICTURE ELEMENT DEFECTS

picture quality at T_{amb} = 60 °C

GRADE	PIXEL DEFECTS (note 1)	CLUSTERS (note 2)	COLUMN DEFECTS (note 3)
01	0	0	0
02	2	0	0
03	10	2	0
04	35	5	2

Notes

1. A picture element is considered defect, if its signal deviates more than ±10% from the mean signal of the neighbouring picture element at standard illumination.
2. A cluster is a pair of two defect pixels at a distance of less than 3% of the picture height. The sum of pixel defects and clustered pixel defects does not exceed the number of permitted pixel defects.
3. If more than two pixel defects occur in one column, this is considered a column defect.
   Additionally the indicated number of defect pixels is allowed.

OUTPUT SIGNAL

The output signal is a pulse sequence with a d.c. offset. The HIGH level of the output pulses, dependent upon the d.c. adjustments, varies between 8 and 12 volts. The LOW levels depend upon the signal voltage, itself a function of the intensity of the light falling on the sensor, and is between 1,0 and 0,2 volts below the HIGH level. These pulses contain the video information and need further processing to be converted into a signal suitable for use in standard video circuitry.

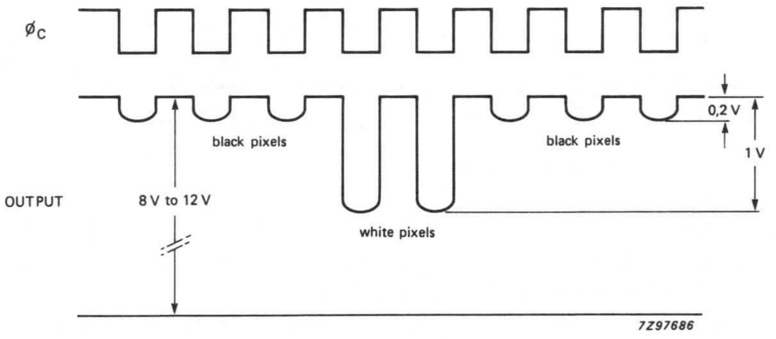


Fig. 16 Typical signal at the sensor output.

DEVELOPMENT DATA

MECHANICAL PARAMETERS

The sensor is encapsulated in a 24-lead dual in-line ceramic package with a high-quality glass viewing window on the top side for admittance of light to the sensor.

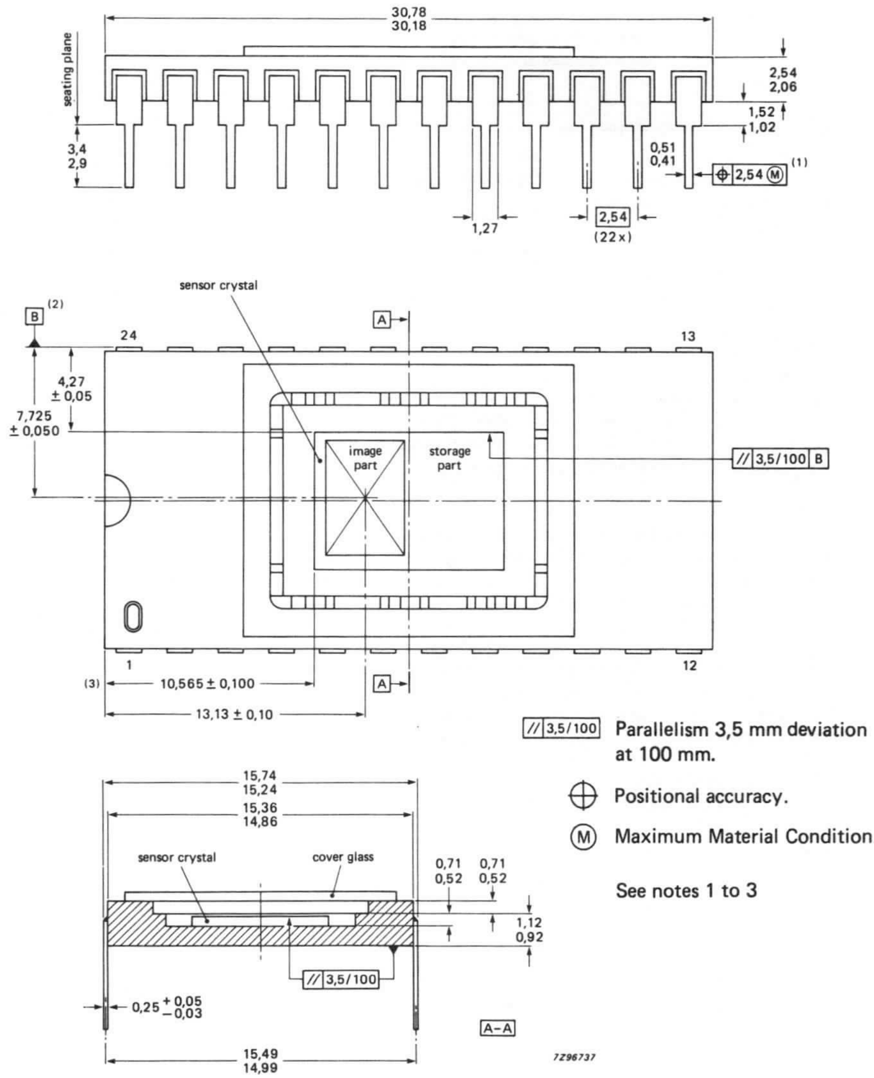


Fig. 17 Package outline; dimensions in mm (also see notes).

Notes to Fig. 17

1. Centre-lines of all leads are within ±0,127 mm of the nominal position shown; in the worst case, the spacing between any two leads may deviate from nominal by ±0,254 mm.
2. Line B is the connection line between pins 13 and 24. Pins 14 to 23 are not necessarily exactly on this line.
3. These two dimensions are measured at the centre-line of the package.

GENERAL DIMENSIONS (See Fig. 17)

Chip thickness	525 ± 15 μm
Cover glass thickness	0,55 ± 0,05 mm
Thickness of glue layer between sensor and cavity bottom	80 ± 30 μm
Refractive index	1,5
Transmission (400-700 nm)	90%

Sensor is filled with dry air.

SOLDERING

1. By hand

Apply the soldering iron below the seating plane (not more than 2 mm above it). If its temperature is below 300 °C it must not be in contact for more than 10 seconds; if between 300 °C and 400 °C, for not more than 5 seconds.

2. By dip or Wave

The maximum permissable temperature of the solder is 260 °C, this temperature must not be in contact with the joint for more than 5 seconds. The total contact time of successive solder waves must not exceed 5 seconds. The device may be mounted up to the seating plane but the temperature of the ceramic body must not exceed the specified storage maximum. If the printed circuit board has been pre-heated, forced cooling may be necessary immediately after soldering to keep the temperature within the permissible limit.

3. Repairing soldered joints

The same precautions and limits apply as in (1) above.

DEVELOPMENT DATA

APPLICATION INFORMATION

Figure 18 shows a circuit for providing the pulse sequences needed to drive the sensor. A SAA1043 sync-pulse generator provides the three TV standards, namely PAL, SECAM and NTSC. These include vertical and horizontal blanking, and black-level clamping. It also provides other signals essential for tv camera operation and can be triggered externally for operation with, for example, a VCR or computer. The sync-pulse generator drives a SAD1019 multi-norm pulse-pattern generator (MNPPG) developed specifically for the image sensors. It provides all the clock signals except the pulses for the horizontal read-out registers. Its use avoids the need to develop complex circuitry for driving the NXA1011. Fast clock pulses for the three horizontal read-out registers are generated by a pixel generator TDA4302, delivering three 3,85 MHz pulse trains with a 120° phase difference between them. The output levels from the MNPPG and the pixel generator are too low to drive the shift registers directly. Additional driver ICs are therefore needed to boost the signals i.e. for the pixel generator one TDA4305 and, for the MNPPG, two TDA4301 ICs. During horizontal blanking, the pixel generator is inhibited and slower pulses, derived from the MNPPG, are applied to the pixel generator output and, then, via the TDA4305, to the transfer gates and horizontal gate electrodes to sort the charge packets into the three horizontal read-out registers.

More detailed information is available on request.

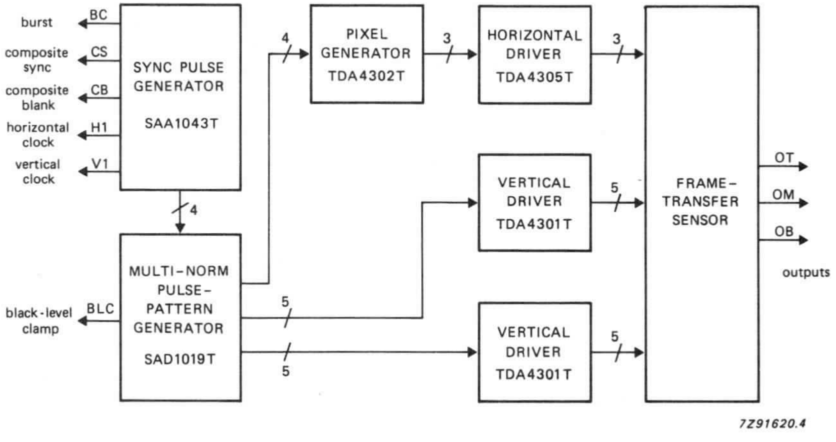


Fig. 18 Drive circuit for the NXA1011 frame transfer sensor.

Supersedes June 1986 data

FRAME TRANSFER SENSOR

FRAME TRANSFER SENSOR

GENERAL DESCRIPTION

The NXA1021 frame transfer sensor is a solid state imaging device which produces two interlaced 294-line fields (including 6 lines for dark reference and testing) with an aspect ratio of 4:3. The sensor is equipped with an on-chip colour stripe filter.

The device is compatible with PAL and SECAM TV standards and has a 7,5 mm image diagonal matching the half-inch camera tube format.

APPLICATIONS

- Consumer entertainment cameras
- Surveillance cameras – solid state reliability, high resolution and sensitivity provide the quality to be an ideal successor for your stripe filter camera tube
- Visual aids – the low voltage and mechanical ruggedness of this device allows design of safe and reliable cameras for visual aids
- Slide and film scanners for consumer applications

FEATURES

- Effective number of elements: 604 (horizontal) x 576 (vertical)
- Cyan, green, yellow and stripe filter on the chip
- Dark reference: 1 line per field for black clamping
- 100 x anti-blooming margin
- Gamma is 1
- High sensitivity, low noise
- Freedom from lag, burn-in, geometrical distortion and microphonic noise

DEVICE ORGANIZATION

- Frame transfer charge coupled device
- Unit cell size: 10 μm (horizontal) x 15,6 μm (vertical)
- Separate outputs for the cyan, green, and yellow channels
- Dummy elements: the first 5 elements of the 3 output registers are dummy elements
- On-chip high sensitivity output amplifier
- Image area: 6,0 mm (horizontal) x 4,5 mm (vertical)
- Chip size: 6,95 mm (horizontal) x 9,35 mm (vertical)

FUNCTIONAL DESCRIPTION

The special electrode arrangement allows 26% of the photosensitive element to be free of polysilicon. This facilitates easy penetration of the blue light into the element to provide good blue sensitivity.

The layout of the sensor is shown in Fig. 1.
It comprises 3 functional areas:

- a matrix of photosensitive elements and integration electrodes,
- a storage section,
- three BCCD read-out registers.

Figure 2 shows the transport process in the imaging and storage regions. At time t_0, the start of the first field read-out from the imaging region, ϕ_3 is low and the charge is concentrated beneath ϕ_4 to ϕ_2. At t_1, ϕ_4 goes low and the charge in each pixel concentrates beneath ϕ_1 and ϕ_2. At t_2, ϕ_3 goes high and the charge packets advance one gate electrode, spreading out beneath ϕ_1, ϕ_2 and the following electrode ϕ_3. In the next step, at t_3, ϕ_1 goes low compressing the charge packets beneath ϕ_2 and ϕ_3, and at t_4, ϕ_4 goes high allowing the charge packets again to advance one gate electrode. This process continues in both the imaging and storage regions until all the charge packets have transferred to the storage region.

The sensor in the integration mode is shown in Fig. 3. The first field is generated when phases ϕ_4, ϕ_1 and ϕ_2 are high and ϕ_3 is low, Fig. 3(a). ϕ_3 effectively forms a potential barrier separating the pixels in the first field. The charges generated by incident light then integrate beneath ϕ_4 and ϕ_2, centred on ϕ_1. So each pixel extends vertically over four gate electrodes.

The potential distribution of the second field, and hence its position relative to the first field is shown in Fig. 3(b). The second field is always displaced by two gate electrodes relative to the first field, with its charge patterns centred on ϕ_3, and with ϕ_1 forming the barrier between pixels, thus providing a perfectly interlaced frame structure.

CAUTION

The image sensor is a MOS device which can be destroyed by static charging of the gates. Always store the device with short-circuiting slamps or on conductive foam plastic. When cleaning the glass window only use alcohol or acetone. Rub the window carefully and slowly. Dry rubbing of the window may cause static charges which can destroy the device.

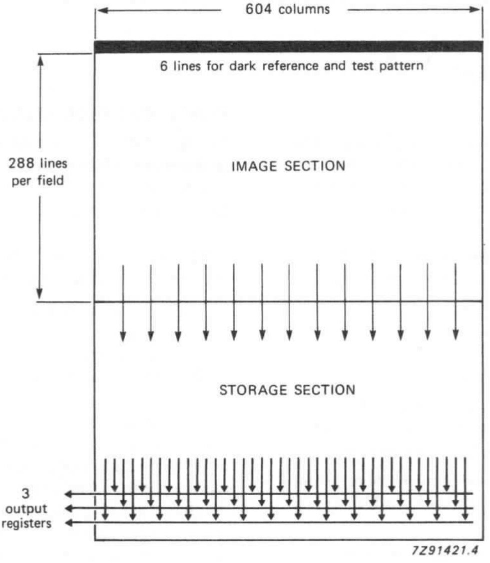


Fig. 1 Sensor layout and charge transport direction.

DEVELOPMENT DATA

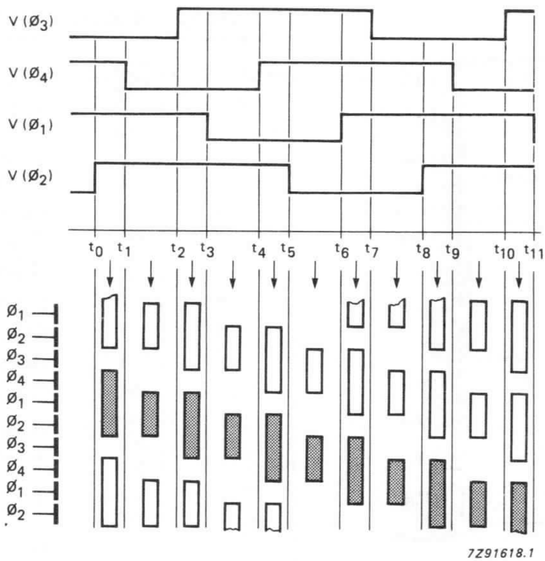


Fig. 2 Charge transport in the vertical direction.

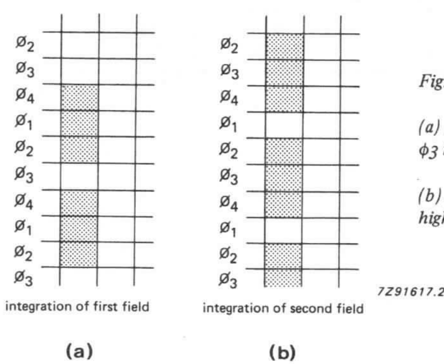


Fig. 3 Interlacing of the sensor.

(a) For integration of the first field, ϕ_4 to ϕ_2 are high, ϕ_3 is low forming a barrier between charge packets.

(b) For integration of the second field, ϕ_2 to ϕ_4 are high, ϕ_1 is low.

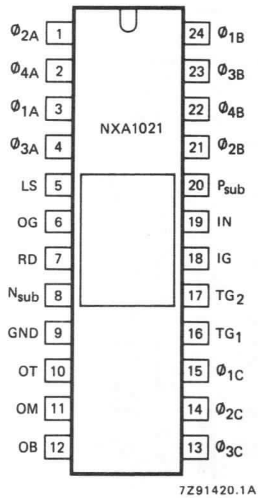


Fig. 4 Pin configuration.

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1 2 3 4	ϕ2A ϕ4A ϕ1A ϕ3A	Vertical transfer clocks for image part
5	LS	Light shield (Al. cover on storage part)
6	OG	Output gate
7	RD	Drain reset transistor
8	N_{sub}	N-substrate; supply voltage
9	GND	Ground
10	OT	Output top (cyan)
11	OM	Output middle (green)
12	OB	Output bottom (yellow)
13 14 15	ϕ3C ϕ2C ϕ1C	Horizontal transfer clock for output register
16 17	TG1 TG2	Transfer gate
18	IG	Input gate (test point for manufacturing)
19	IN	Input diffusion (test point for manufacturing)
20	P_{sub}	P-substrate
21 22 23 24	ϕ2B ϕ4B ϕ3B ϕ1B	Vertical transfer clocks for storage part

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Voltages with respect to P_{sub}				
RD	$V_{RD\text{-}PSUB}$	−0,5	+25	V
IN	$V_{IN\text{-}PSUB}$	−0,5	+25	V
Voltages with respect to N_{sub}				
RD	$V_{RD\text{-}NSUB}$	−10	+0,5	V
IN	$V_{IN\text{-}NSUB}$	−10	+0,5	V
all other connections		−25	+0,5	V
Current from one output		–	10	mA
Storage temperature range	T_{stg}	−30	+80	°C
Operating ambient temperature range	T_{amb}	−20	+60	°C

DC CHARACTERISTICS at T_{amb} = 25 °C

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Voltage at LS (note 1)	V_{LS}	–	V_{Nsub}	–	V
Voltage at OG (note 2)	V_{OG}	2	–	10	V
Voltage at RD; (note 2) current to sensor: I < 1 μA	V_{RD}	10	–	V_{Nsub}	V
Voltage at N_{sub}; (note 2) I < 10 mA	V_{Nsub}	15	20	22	V
Voltage difference between V_{Nsub} and V_{RD}	$V_{Nsub}-V_{RD}$	–	–	7	V
Voltage at IG	V_{IG}	–	GND	–	V
DC level of output voltage at OT, OM, OB (notes 3 and 4)	$V_{OT;OM;OB}$	6	–	15	V
Voltage at P_{sub}; (note 2) current from sensor: I < 50 μA	V_{Psub}	0	–	5	V
Voltage at IN	V_{IN}	–	V_{Nsub}	–	V
Power dissipation	P	–	80	150	mW
Leakage current of gates	I_l	–	–	10	μA

Notes

1. The lightshield should be connected to V_{Nsub} (or to GND).
2. These values must be adjusted to the optimum operating point within the given range.
3. Measured with output buffer. See Fig. 5.
4. See Fig. 16.

DEVELOPMENT DATA

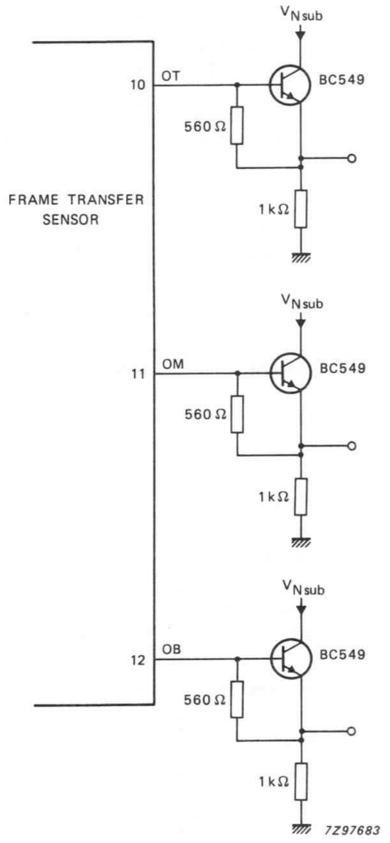


Fig. 5 Output buffer for measurements.

DEVELOPMENT DATA

CLOCK CHARACTERISTICS (note 1)

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
LOW levels					
ϕnA, ϕnB	$V_{\phi nA/B}$	–	GND	–	–
ϕ1C, ϕ2C, ϕ3C (note 2) (ϕ1CLOW = ϕ2CLOW = ϕ3CLOW)	$V_{\phi nC}$	–	0	$V_{Nsub}-10$	V
TG1 (note 2)	V_{TG1}	0	–	$V_{Nsub}-10$	V
TG2 (note 2)	V_{TG2}	0	–	$V_{Nsub}-10$	V
Amplitudes					
ϕnA, ϕnB, ϕnC	$V_{\phi(p\text{-}p)}$	9,75	10	10,25	V
Timing (See Figs 6 and 7)					
Horizontal clocks					
clock frequency (note 3)	f_c	–	3,854	–	MHz
rise time	t_{rc}	20	–	40	ns
fall time	t_{fc}	20	–	40	ns
fall time of ϕ_{1C} during horizontal blanking (note 4)	t_{fcB}	–	200	–	ns
overlap time	t_{ihc}	10	–	–	ns
	t_{ilc}	5	–	–	ns
Vertical clocks					
clock frequency	f_{cv}	–	625	–	kHz
rise time	t_{rv}	–	70	–	ns
fall time	t_{fv}	–	100	–	ns
overlap time	t_{ihv}	100	–	–	ns
	t_{ilv}	100	–	–	ns
Transfer gates					
rise time	t_{rTG}	–	70	–	ns
fall time	t_{fTG}	–	100	–	ns
Clock capacitance					
Each clock phase					
ϕnA, ϕnB	$C_{\phi nA/B}$	–	–	3000	pF
ϕnC, TG1, TG2	$C_{\phi nC}$, $C_{TG1/2}$	–	–	100	pF
Leakage current of the clock connections	I_l	–	–	10	µA

Notes

1. Measured with output buffer. See Fig. 5.
2. These values must be adjusted to the optimum operating point within the given range.
3. Deviations from this frequency result in incorrect aspect ratio.
4. It is recommended to use the longer fall time of the ϕ_{1C} pulse during the horizontal blanking period to avoid irregular vertical stripes.

ADJUSTMENT OF OPERATING LEVELS

A reasonable picture may be obtained by using the settings quoted in the NXA1021 Test Sheet. For optimum performance, fine adjustment of the sensors d.c. levels is essential. When carrying out this operation the following points should be considered.

- Vertical stripes in the picture are usually the result of charges being unevenly sorted into the three output registers. This can be influenced by $V_{\phi C}$, V_{OG}, V_{TG2} and V_{TG1}.
- The anti-blooming performance of a sensor is influenced by its internal vertical potential gradient. This can be optimized by adjusting V_{Nsub} and V_{Psub}.

DRIVING PULSE WAVEFORMS

The specifications of the sensor are measured when the following clock pulses are applied (Figs 6 and 7). In principle the sensor can be operated with different clock pulses, e.g. different clock frequencies (overlap conditions have to be maintained).

More detailed information is available on request.

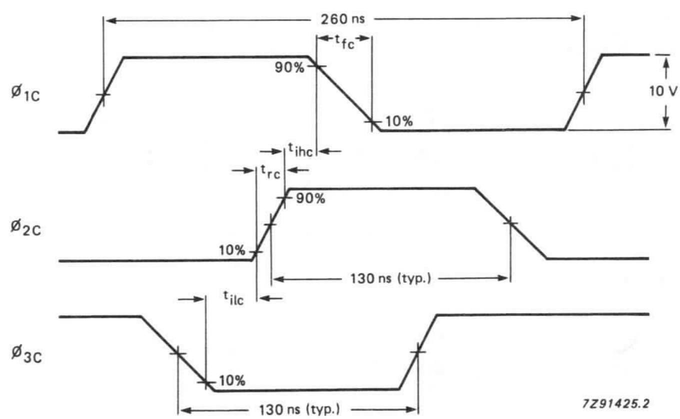


Fig. 6 Horizontal transport timing waveforms for the sensor electrodes (ϕ_{nC}); times measured at the 10% and 90% points of the amplitude.

DRIVING PULSE WAVEFORMS (continued)

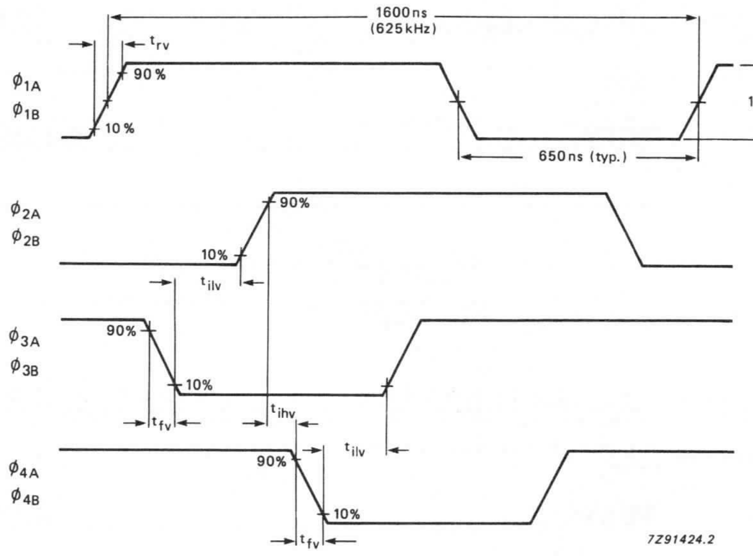


Fig. 7 Vertical transport timing waveforms for the sensor electrodes (ϕnA, ϕnB); times measured at the 10% and 90% points of the amplitude.

DEVELOPMENT DATA

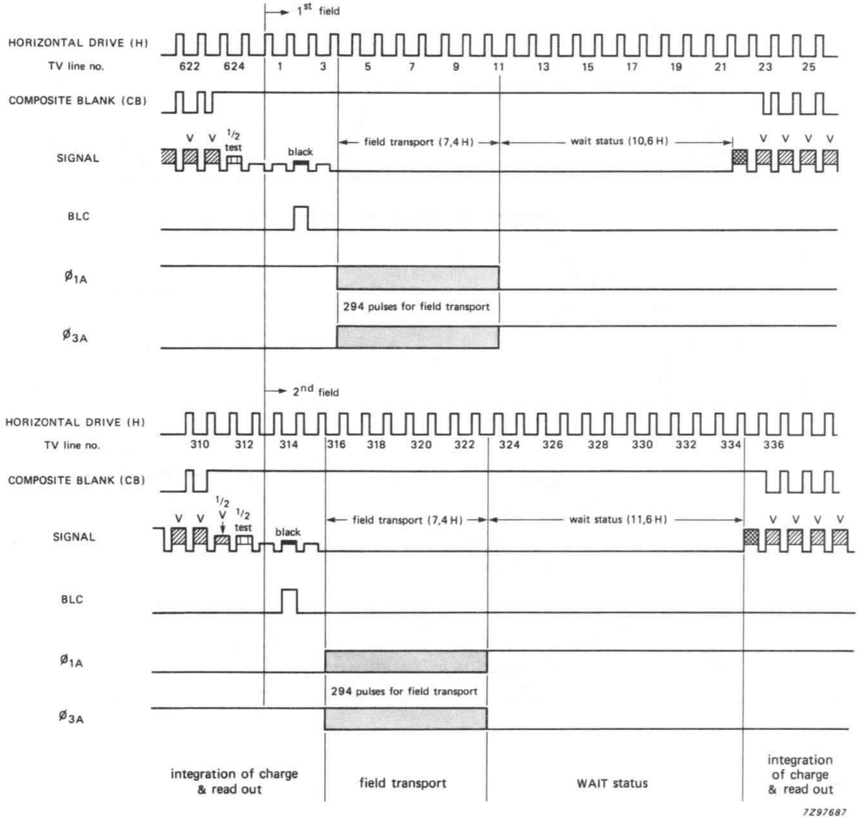


Fig. 8 Drive-pulse sequence and line numbering for field transport.

DEVELOPMENT DATA

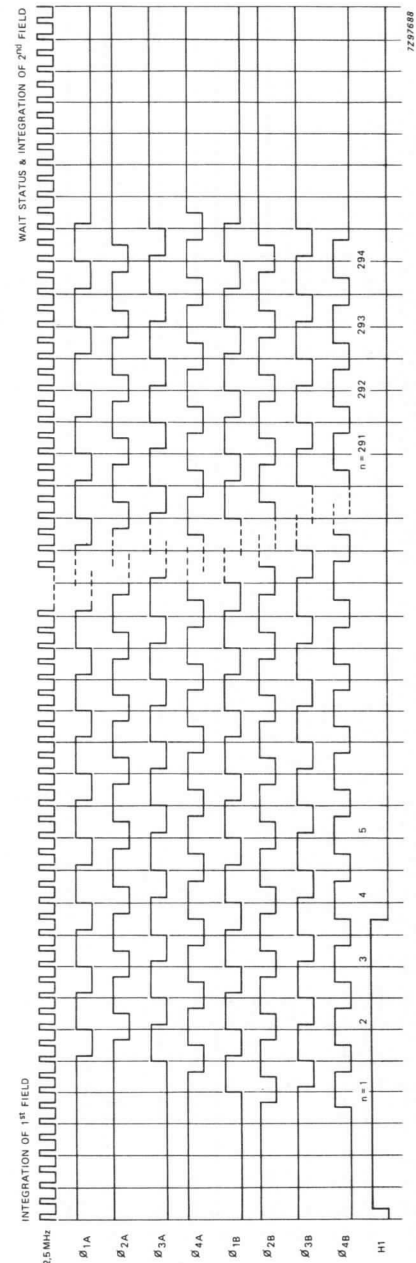


Fig. 9 Field transport pulses 1st field.

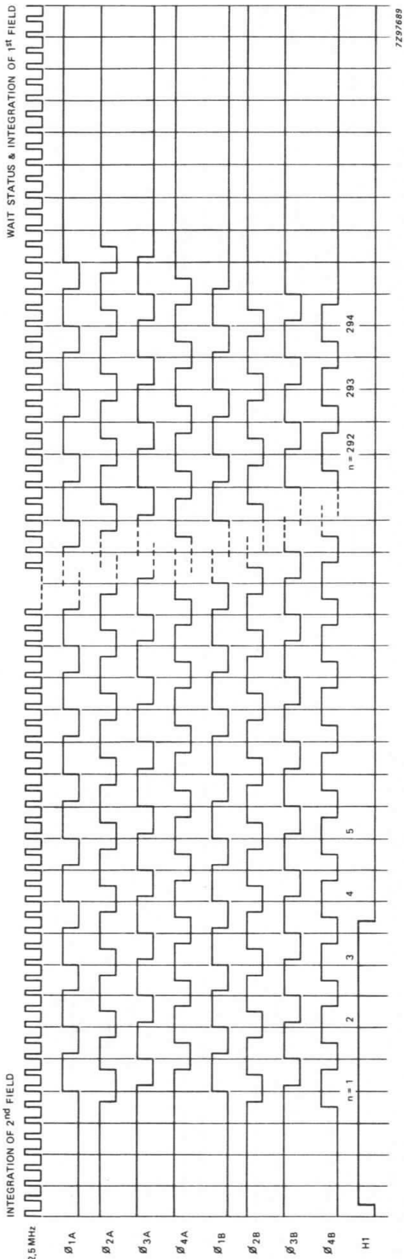


Fig. 10 Field transport pulses 2nd field.

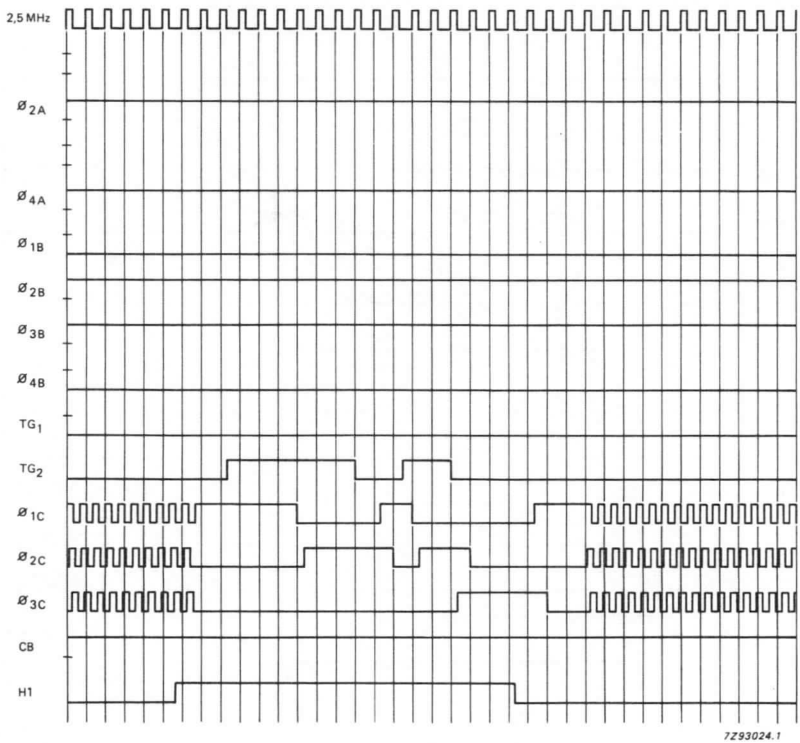


Fig. 11 Wait status.

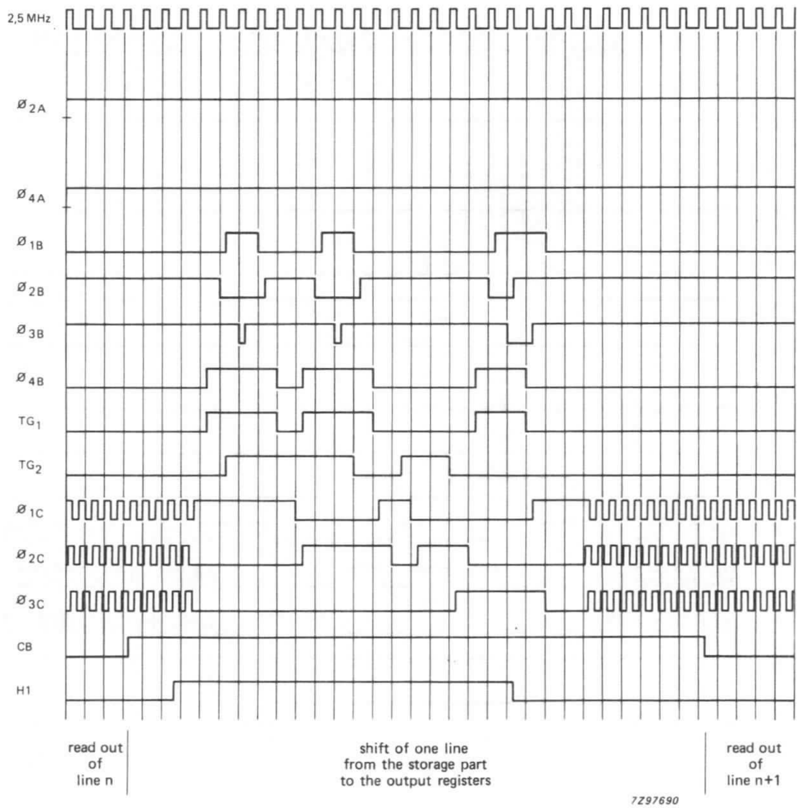


Fig. 12 Read-out of the output registers and sorting of the signal into output registers.

DEVELOPMENT DATA

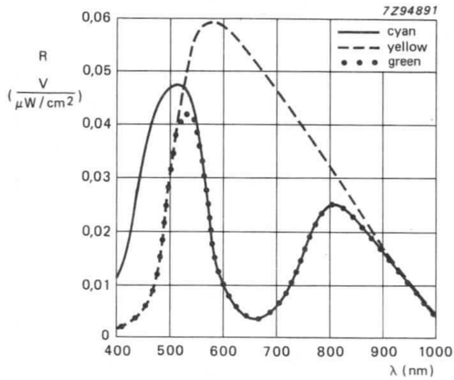


Fig. 13 Spectral response

OUTPUT CHARACTERISTICS at T_{amb} = 60 °C

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Load capacitance	C_L	–	–	10	pF
Output signal voltage at standard illumination (peak-to-peak value) (see notes 1 and 2)					
Cyan channel	V_{OT}	30	–	–	mV
Green channel	V_{OM}	27	–	–	mV
Yellow channel	V_{OB}	60	–	–	mV
Output signal voltage at saturation (peak-to-peak value) (notes 2 and 3)	V_{Osat}	250	400	–	mV
Clock cross-talk to output (peak-to-peak value)	V_{OCLK}	–	–	0,2	V
Maximum illumination on the sensor without blooming (note 4)	E_B	1000	–	–	lx
Transport inefficiency					
horizontal one step	ϵ_H	–	–	8,5x10^{-5}	
vertical one step	ϵ_V	–	–	5x10^{-5}	
Dark current	I_D	–	–	5	nA
Smear (note 5)					%

Notes

1. 5 lx on the sensor, colour temperature of light source 3200 K, Hoya-IR-Filter C500S, 1 mm is used.
2. Measured with output buffer.
3. Maximum usable range of illumination 85% of saturation level.
4. See 'Definition of blooming'.
5. See 'Definition of smear'.

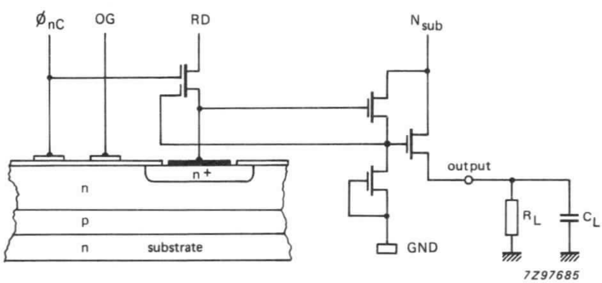


Fig. 14 Circuit diagram for one output channel.

DEVELOPMENT DATA

DEFINITION OF SMEAR

During the field transport time the complete field is shifted over the image section. So each pixel of one column is illuminated by all the other pixels of the column for a short time. Therefore a bright spot makes a bright vertical stripe on the image. This effect is called smear. The brightness of the stripe depends on the height of the spot and on the illumination of the spot.

It is defined by the equation:

$$V_{smear} = \frac{t_{field\ transport}}{t_{integration}} \times \frac{h}{H} \times \frac{E}{E_{sat}} \times V_{sat}$$

Where:

V_{smear}	=	Additional output voltage due to smear
$t_{field\ transport}$	=	0,47 ms
$t_{integration}$	=	19,5 ms
h	=	Height of bright spot
H	=	Height of the complete image
E	=	Illumination of the spot
E_{sat}	=	Saturation illumination
V_{sat}	=	Output voltage at saturation

Example: Spot height is 10% of the height
Spot illumination is 100% of saturation

$$V_{smear} = \frac{0,47}{19,50} \times 0,1 \times 1 \times V_{sat} = 0,0024 \times V_{sat}$$

DEFINITION OF BLOOMING

When part of the image section (spot) is illuminated above saturation level and with the rest of the image dark, at a certain level of overexposure (1000 lx for the NXA1021), the area of the spot increases irregularly. This effect is called blooming.

PICTURE ELEMENT DEFECTS

Picture quality at T_{amb} = 60 °C

GRADE	PIXEL DEFECTS (note 1)	CLUSTERS (note 2)	COLUMN DEFECTS (note 3)
01	0	0	0
02	2	0	0
03	10	2	0
04	35	5	2

Notes

1. A picture element is considered defect, if its signal deviates more than ± 10% from the mean signal of the neighbouring picture elements at standard illumination.
2. A cluster is a pair of two defect pixels at a distance of less than 3% of the picture height. The sum of pixel defects and clustered pixel defects does not exceed the number of permitted pixel defects.
3. If more than two pixel defects occur in one column, this is considered a column defect.
   Additionally the indicated number of defect pixels is allowed.

OUTPUT SIGNAL

The output signal is a pulse sequence with a d.c. offset. The HIGH level of the output pulses, dependent upon the d.c. adjustments, varies between 8 and 12 volts. The LOW levels depend upon the signal voltage, itself a function of the intensity of the light falling on the sensor, and is between 1,0 and 2,0 volts below the HIGH level. These pulses contain the video information and need further processing to be converted into a signal suitable for use in standard video circuitry.

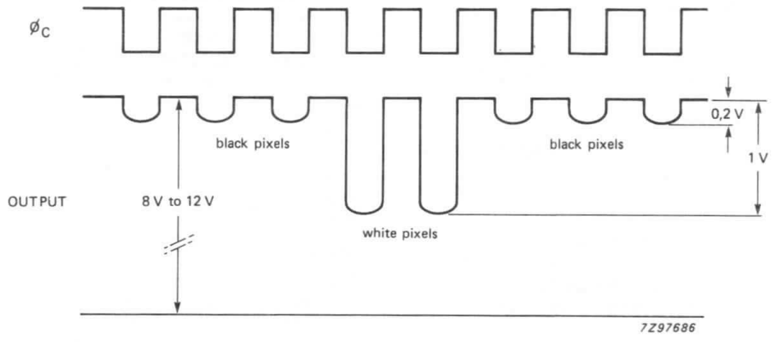


Fig. 15 Typical signal at the sensor output.

DEVELOPMENT DATA

MECHANICAL PARAMETERS

The sensor is encapsulated in a 24-lead dual in-line ceramic package with a high-quality glass viewing window on the top side for admittance of light to the sensor.

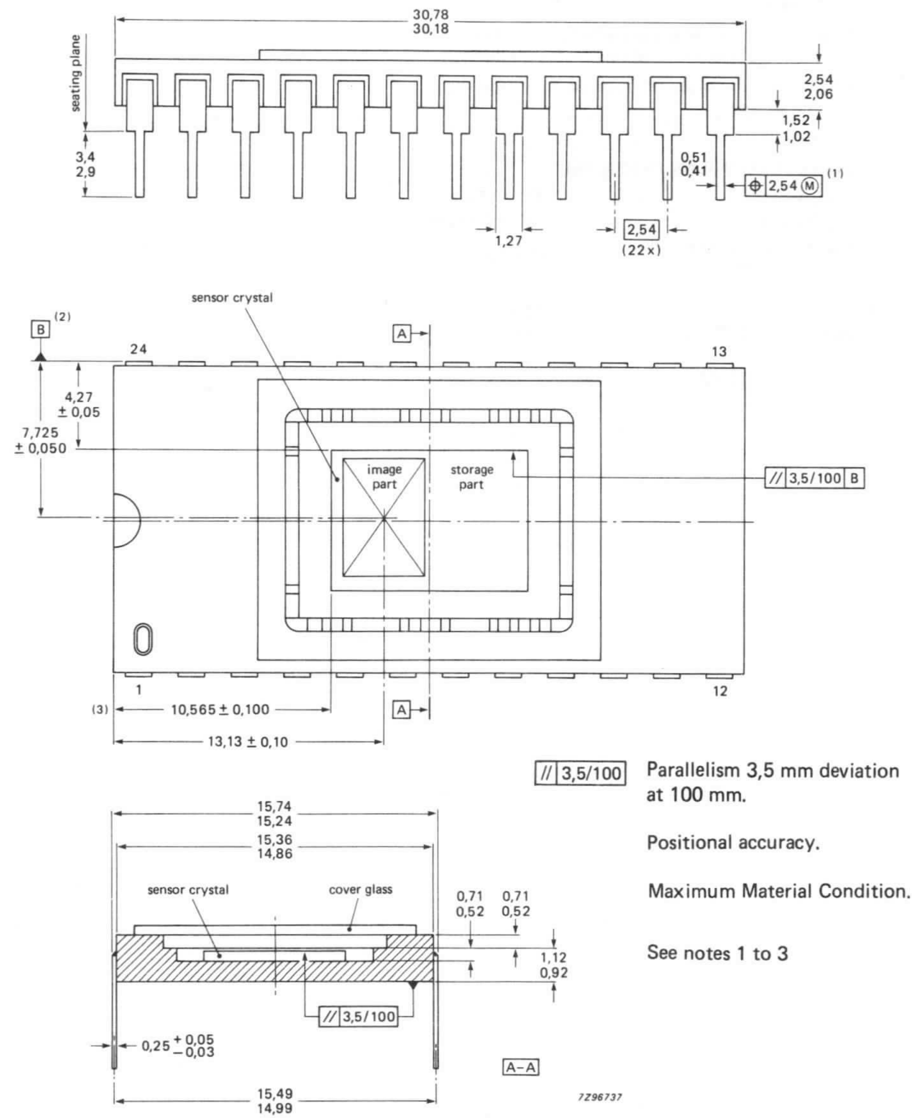


Fig. 16 Package outline; dimensions in mm (also see notes).

Notes to Fig. 16

(1) Centre-lines of all leads are within ± 0,127 mm of the nominal position shown; in the worst case, the spacing between any two leads may deviate from nominal by ± 0,254 mm.

(2) Line B is the connection line between pins 13 and 24. Pins 14 to 23 are not necessarily exactly on this line.

(3) These two dimensions are measured at the centre-line of the package.

GENERAL DIMENSIONS (See Fig. 16)

Chip thickness	525 ± 15 μm
Cover glass thickness	0,55 ± 0,05 mm
Thickness of glue layer between sensor and cavity bottom	80 ± 30 μm
Refractive index	1,5
Transmission (400-700 nm)	90%

Sensor is filled with dry air.

APPLICATION INFORMATION

Figure 17 shows a circuit for providing the pulse sequences needed to drive the sensor. A SAA1043 sync-pulse generator provides the three TV standards, PAL, SECAM and NTSC. These include vertical and horizontal blanking, plus black-level clamping. It also provides other signals essential for tv camera operation and can be triggered externally for operation with, for example, a VCR or computer. The sync-pulse generator drives a SAD1019 multi-norm pulse-pattern generator (MNPPG) developed specifically for the image sensors. It provides all the clock signals except the pulses for the horizontal read-out registers. Its use avoids the need to develop complex circuitry for driving the NXA1021. Fast clock pulses for the three horizontal read-out registers are generated by a pixel generator TDA4302, delivering three 3,85 MHz pulse trains with a 120° phase difference between them. The output levels from the MNPPG and the pixel generator are too low to drive the shift registers directly. Additional driver ICs are therefore needed to boost the signals, i.e. for the pixel generator one TDA4305 and, for the MNPPG, two TDA4301 ICs. During horizontal blanking, the pixel generator is inhibited and slower pulses, derived from the MNPPG, are applied to the pixel-generator output and, then, via the TDA4305, to the transfer gates and horizontal gate electrodes to sort the charge packets into the three horizontal read-out registers.

More detailed information is available on request.

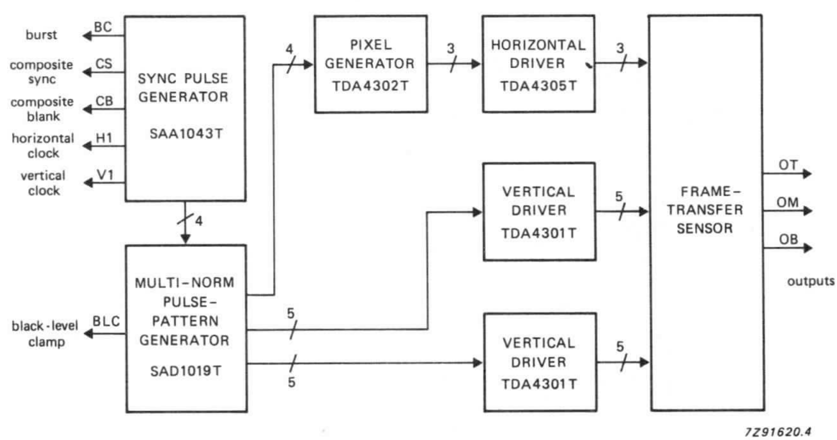


Fig. 17 Drive circuit for the NXA1021 frame transfer sensor.

Supersedes June 1986 data

FRAME TRANSFER SENSOR

GENERAL DESCRIPTION

The NXA1031 frame transfer sensor is a solid state imaging device which produces two interlaced 251-line fields (including 6 lines for dark reference and testing) with an aspect ratio of 4:3.
The device is compatible with EIA TV standards and has a 7,5 mm image diagonal matching the half-inch camera tube format.

APPLICATIONS

- ENG cameras – the high blue sensitivity and good horizontal resolution makes this sensor suiteable for 3-chip ENG colour cameras
- Surveillance cameras – solid state reliability, high resolution and sensitivity provide the quality to be an ideal successor for the Newvicon® or Ultricon® pick-up element
- Character and pattern recognition – the excellent linearity and uniformity recommends this sensor as a first choice for these applications
- Robotics – the small size, light-weight and mechanical ruggedness makes this sensor extremely suitable for all types of high resolution robot-vision applications
- Visual aids – the low voltage and mechanical ruggedness of this device allows design of safe and reliable cameras for visual aids

FEATURES

- Effective number of elements: 610 (horizontal) x 490 (vertical)
- Dark reference: 1 line per field for black clamping
- 100 x anti-blooming margin
- Gamma is 1
- High sensitivity, low noise
- Freedom from lag, burn-in, geometrical distortion and microphonic noise

DEVICE ORGANIZATION

- Frame transfer charge coupled device
- Unit cell size: 9,9 μm (horizontal) x 18,6 μm (vertical)
- Dummy elements: the first 5 elements of the 3 output registers are dummy elements
- On-chip high sensitivity output amplifier
- Image area: 6,0 mm (horizontal) x 4,5 mm (vertical)
- Chip size: 6,95 mm (horizontal) x 9,35 mm (vertical)

FUNCTIONAL DESCRIPTION

The special electrode arrangement allows 35% of the photosensitive element to be free of polysilicon. This facilitates easy penetration of the blue light into the element to provide good blue sensitivity.

The layout of the sensor is shown in Fig. 1.
It comprises 3 functional areas:

- a matrix of photosensitive space elements and integration electrodes,
- a storage section,
- three BCCD read-out registers.

Figure 2 shows the transport process in the imaging and storage regions. At time t_0, the start of the first field read-out from the imaging region, ϕ_3 is low and the charge is concentrated beneath ϕ_4 to ϕ_2. At t_1, ϕ_4 goes low and the charge in each pixel concentrates beneath ϕ_1 and ϕ_2. At t_2, ϕ_3 goes high and the charge packets advance one gate electrode, spreading out beneath ϕ_1, ϕ_2 and the following electrode ϕ_3. In the next step, at t_3, ϕ_1 goes low compressing the charge packets beneath ϕ_2 and ϕ_3, and at t_4, ϕ_4 goes high allowing the charge packets again to advance one gate electrode. This process continues in both the imaging and storage regions until all the charge packets have transferred to the storage region.

The sensor in the integration mode is shown in Fig. 3. The first field is generated when phases ϕ_4, ϕ_1 and ϕ_2 are high and ϕ_3 is low, Fig. 3(a). ϕ_3 effectively forms a potential barrier separating the pixels in the first field. The charges generated by incident light then integrate beneath ϕ_4 and ϕ_2, centred on ϕ_1. So each pixel extends vertically over four gate electrodes.
The potential distribution of the second field, and hence its position relative to the first field is shown in Fig. 3(b). The second field is always displaced by two gate electrodes relative to the first field, with its charge patterns centred on ϕ_3, and with ϕ_1 forming the barrier between pixels, thus providing a perfectly interlaced frame structure.

CAUTION

The image sensor is a MOS device which can be destroyed by static charging of the gates. Always store the device with short-circuiting clamps or on conductive foam plastic. When cleaning the glass window only use alcohol or acetone. Rub the window carefully and slowly. Dry rubbing of the window may cause static charges which can destroy the device.

orange binder, tab 5

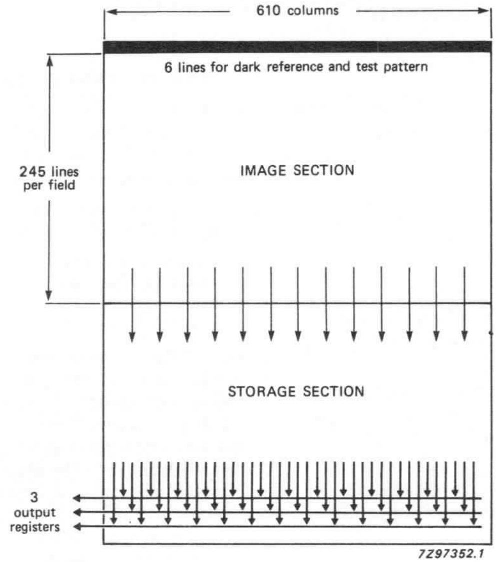


Fig. 1 Sensor layout and charge transport direction.

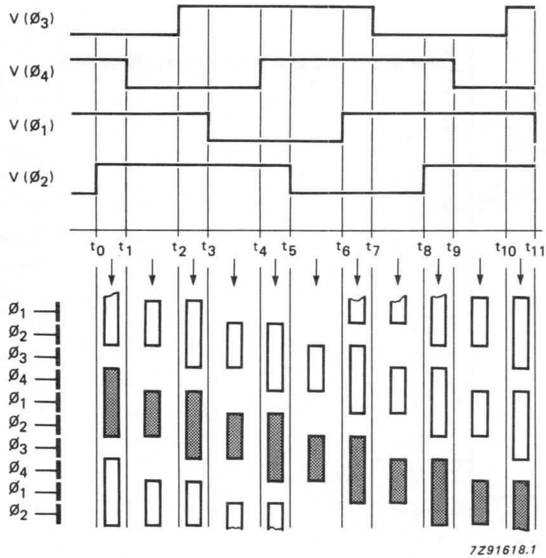


Fig. 2 Charge transport in the vertical direction.

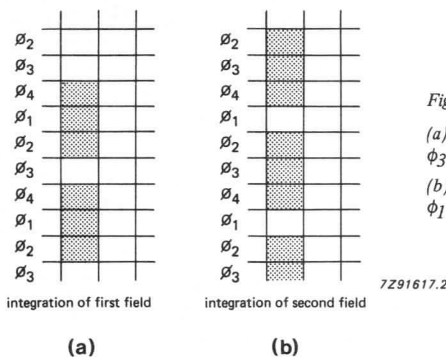


Fig. 3 Interlacing of the sensor.

(a) For integration of the first field, ϕ_4 to ϕ_2 are high, ϕ_3 is low forming a barrier between charge packets.

(b) For integration of the second field, ϕ_2 to ϕ_4 are high, ϕ_1 is low.

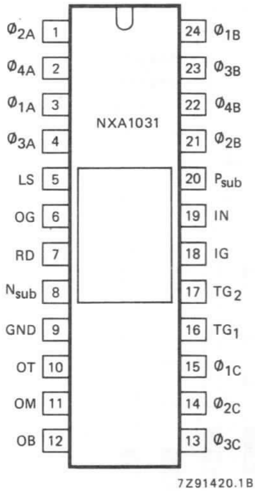


Fig. 4 Pin configuration.

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1	ϕ_{2A}	Vertical transfer clocks for image part
2	ϕ_{4A}	
3	ϕ_{1A}	
4	ϕ_{3A}	
5	LS	Light shield (A1, cover on storage part)
6	OG	Output gate
7	RD	Drain reset transistor
8	N_{sub}	N-substrate; supply voltage
9	GND	Ground
10	OT	Output top
11	OM	Output middle
12	OB	Output bottom
13	ϕ_{3C}	Horizontal transfer clock for output register
14	ϕ_{2C}	
15	ϕ_{1C}	
16	TG1	Transfer gates
17	TG2	
18	IG	Input gate (test point for manufacturing)
19	IN	Input diffusion (test point for manufacturing)
20	P_{sub}	P-substrate
21	ϕ_{2B}	Vertical transfer clocks for storage part
22	ϕ_{4B}	
23	ϕ_{3B}	
24	ϕ_{1B}	

DEVELOPMENT DATA

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Voltages with respect to P_{sub}				
RD	$V_{RD\text{-}PSUB}$	−0,5	+25	V
IN	$V_{IN\text{-}PSUB}$	−0,5	+25	V
Voltages with respect to N_{sub}				
RD	$V_{RD\text{-}NSUB}$	−10	+0,5	V
IN	$V_{IN\text{-}NSUB}$	−10	+0,5	V
all other connections		−25	+0,5	V
Current from one output		−	10	mA
Storage temperature range	T_{stg}	−55	+80	°C
Operating ambient temperature range	T_{amb}	−20	+60	°C

DC CHARACTERISTICS at T_{amb} = 25 °C

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Voltage at LS (note 1)	V_{LS}	−	V_{Nsub}	−	V
Voltage at OG (note 2)	V_{OG}	2	−	10	V
Voltage at RD; (note 2) current to sensor: I < 1 μA	V_{RD}	10	−	V_{Nsub}	V
Voltage at N_{sub}; (note 2) I < 10 mA	V_{Nsub}	15	20	22	V
Voltage difference between V_{Nsub} and V_{RD}	$V_{Nsub}-V_{RD}$	−	−	7	V
Voltage at IG	V_{IG}	−	GND	−	V
DC level of output voltage at OT, OM, OB (notes 3 and 4)	$V_{OT;OM;OB}$	6	−	15	V
Voltage at P_{sub}; (note 2) current from sensor: I < 50 μA	V_{Psub}	0	−	5	V
Voltage at IN	V_{IN}	−	V_{Nsub}	−	V
Power dissipation	P	−	80	150	mW
Leakage current of gates	I_1	−	−	10	μA

Notes

1. The lightshield should be connected to V_{Nsub} (or to GND).
2. These values must be adjusted to the optimum operating point within the given range.
3. Measured with output buffer. See Fig. 5.
4. See Fig. 16.

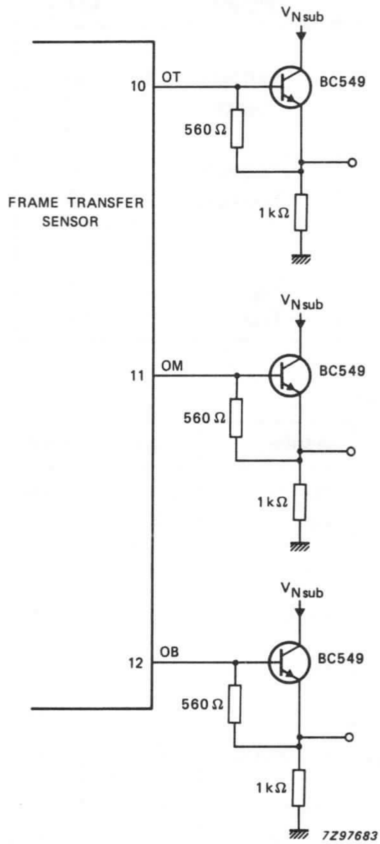


Fig. 5 Output buffer for measurements.

DEVELOPMENT DATA

CLOCK CHARACTERISTICS (note 1)

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
LOW levels					
ϕ_{nA}, ϕ_{nB}	$V_{\phi nA/B}$	–	GND	–	–
ϕ_{1C}, ϕ_{2C}, ϕ_{3C} ($\phi_{1CLOW} = \phi_{2CLOW} = \phi_{3CLOW}$) (note 2)	$V_{\phi nC}$	–	0	$V_{Nsub}-10$	V
TG1 (note 2)	V_{TG1}	0	–	$V_{Nsub}-10$	V
TG2 (note 2)	V_{TG2}	0	–	$V_{Nsub}-10$	V
Amplitudes					
ϕ_{nA}, ϕ_{nB}, ϕ_{nC}	$V_{\phi(p\text{-}p)}$	9,75	10	10,25	V
Timing (see Figs. 6 and 7)					
Horizontal clock					
clock frequency (note 3)	f_c	–	3,90	–	MHz
rise time	t_{rc}	20	–	40	ns
fall time	t_{fc}	20	–	40	ns
fall time of ϕ_{1C} during horizontal blanking (note 4)	t_{fcB}	–	200	–	ns
overlap time	t_{ihc}	10	–	–	ns
	t_{ilc}	5	–	–	ns
Vertical clocks					
clock frequency	f_{cv}	–	629	–	kHz
rise time	t_{rv}	–	70	–	ns
fall time	t_{fv}	–	100	–	ns
overlap time	t_{ihv}	100	–	–	ns
	t_{ilv}	100	–	–	ns
Transfer gates					
rise time	t_{rTG}	–	70	–	ns
fall time	t_{fTG}	–	100	–	ns
Clock capacitance					
Each clock phase					
ϕ_{nA}, ϕ_{nB}	$C_{\phi nA/B}$	–	–	3000	pF
ϕ_{nC}, TG1, TG2	$C_{\phi nC}$, $C_{TG1/2}$	–	–	100	pF
Leakage current of the clock connections	I_l	–	–	10	µA

Notes

1. Measured with output buffer. See Fig. 5.
2. These values must be adjusted to the optimum operating point within the given range.
3. Deviations from this frequency result in incorrect aspect ratio.
4. It is recommended to use the longer fall time of the ϕ_{1C} pulse during the horizontal blanking period to avoid irregular vertical stripes.

ADJUSTMENT OF OPERATING LEVELS

A reasonable picture may be obtained by using the settings quoted in the NXA1031 Test Sheet. For optimum performance, fine adjustment of the sensors d.c. levels is essential. When carrying out this operation the following points should be considered.

- Vertical stripes in the picture are usually the result of charges being unevenly sorted into the three output registers. This can be influenced by $V_{\phi C}$, V_{OG}, V_{TG2} and V_{TG1}.
- The anti-blooming performance of a sensor is influenced by its internal vertical potential gradient. This can be optimized by adjusting V_{Nsub} and V_{Psub}.

DRIVING PULSE WAVEFORMS

The specifications of the sensor are measured when the following clock pulses are applied (Figs 6 and 7). In principle the sensor can be operated with different clock pulses, e.g. different clock frequencies (overlap conditions have to be maintained).

More detailed information is available on request.

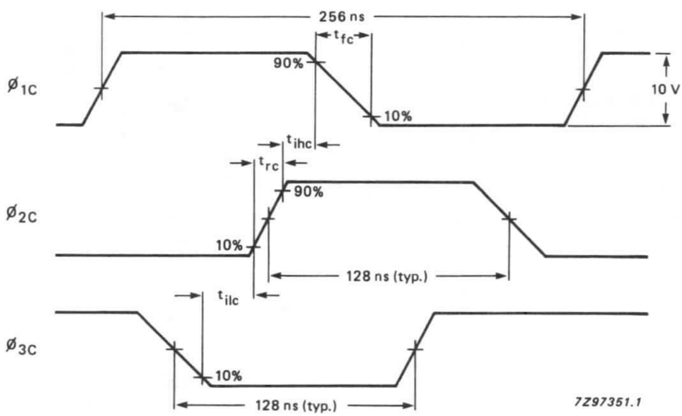


Fig. 6 Horizontal transport timing waveforms for the sensor electrodes (ϕ_{nC}); times measured at the 10% and 90% points of the amplitude.

DEVELOPMENT DATA

DRIVING PULSE WAVEFORMS (continued)

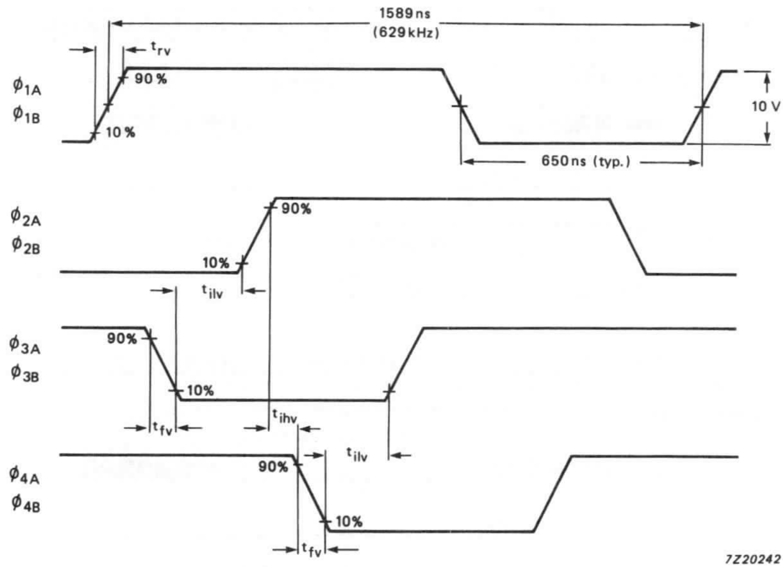


Fig. 7 Vertical transport timing waveforms for the sensor electrodes (ϕ_{nA}, ϕ_{nB}); times measured at the 10% and 90% points of the amplitude.

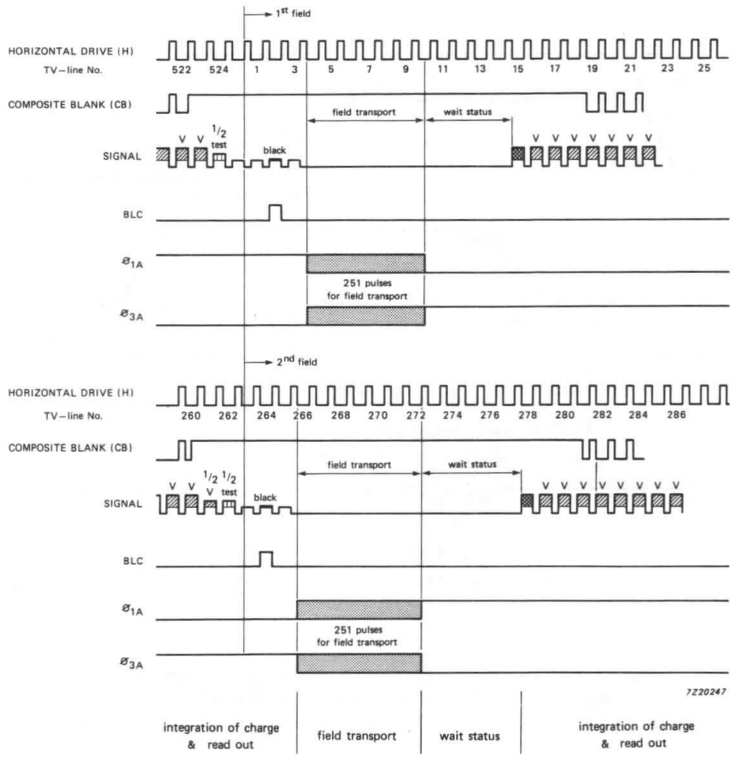


Fig. 8 Drive-pulse sequence and line numbering for field transport.

DEVELOPMENT DATA

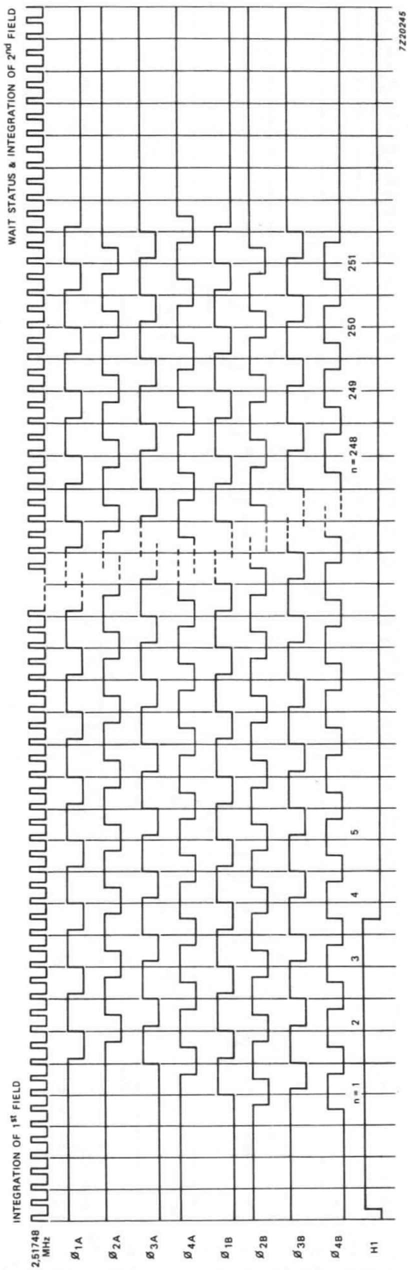


Fig. 9 Field transport pulses 1st field.

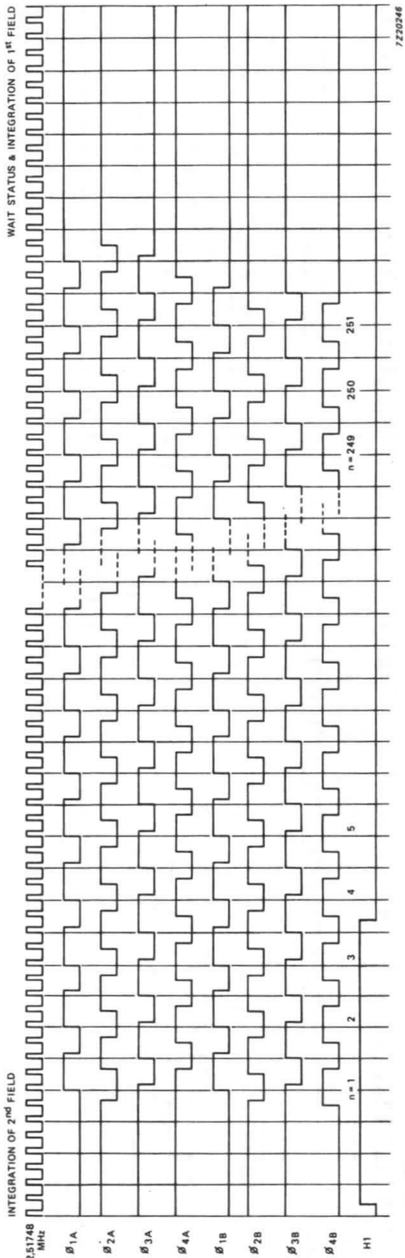


Fig. 10 Field transport pulses 2nd field.

DEVELOPMENT DATA

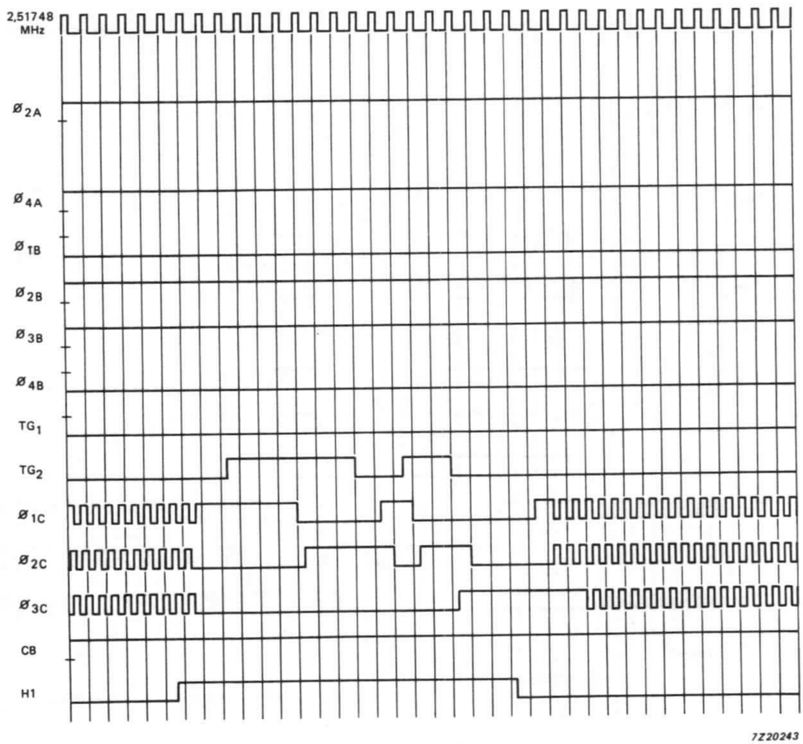


Fig. 11 Wait status.

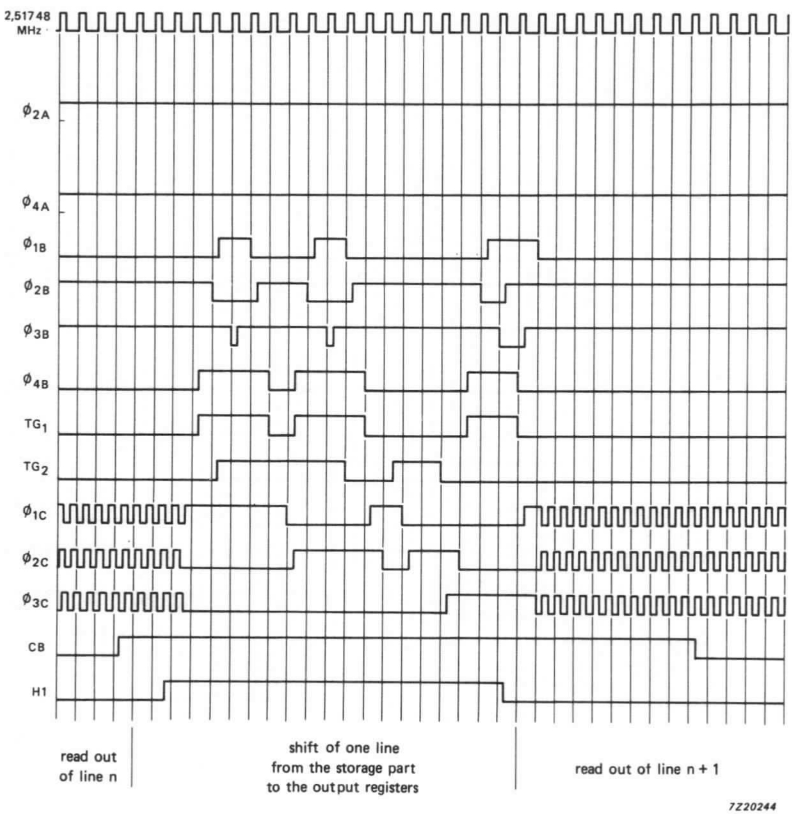


Fig. 12 Read out of the output registers and sorting of the signal into output registers.

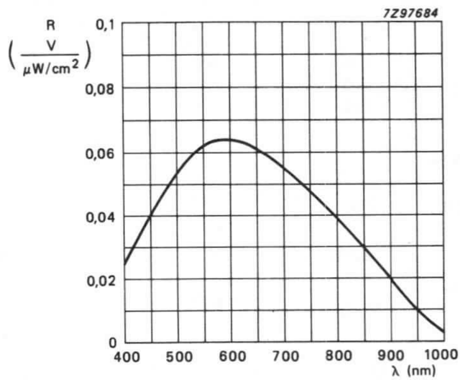


Fig. 13 Spectral response.

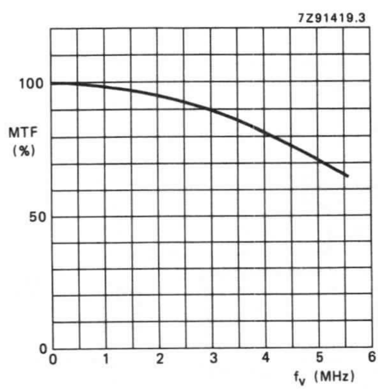


Fig. 14 Theorectical horizontal modulation transfer function; MTF as a function of the video signal frequency: three outputs correctly multiplexed.

OUTPUT CHARACTERISTICS at T_{amb} = 60 °C

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Load capacitance	C_L	–	–	10	pF
Output signal voltage at standard illumination (peak-to-peak value) (S/N typ. 50 dB) (notes 1 and 2)	V_{OTS} V_{OMS} V_{OBS}	65	–	130	mV
Signal to noise ratio at standard illumination (notes 1,2 and 3)	S/N	–	50	–	dB
Output signal voltage at saturation (peak-to-peak value) (notes 2 and 4)	V_{Osat}	250	400	–	mV
Clock cross-talk to output (peak-to-peak value)	V_{OCLK}	–	–	0,2	V
Maximum illumination on the sensor without blooming (note 5)	E_B	1000	–	–	lx
Transport inefficiency					
horizontal one step	ϵ_H	–	–	$8,5 \times 10^{-5}$	
vertical one step	ϵ_V	–	–	5×10^{-5}	
Dark current	I_D	–	–	5	nA
Smear (note 6)					%

Notes

1. 5 lx on the sensor, colour temperature of light source 3200 K, Hoya-IR-Filter C500S, 1 mm is used.
2. Measured with output buffer.
3. 200 kHz to 5 MHz, weighted, T_{amb} = 25 °C.
4. Maximum usable range of illumination 85% of saturation level.
5. See "Definition of blooming".
6. See "Definition of smear".

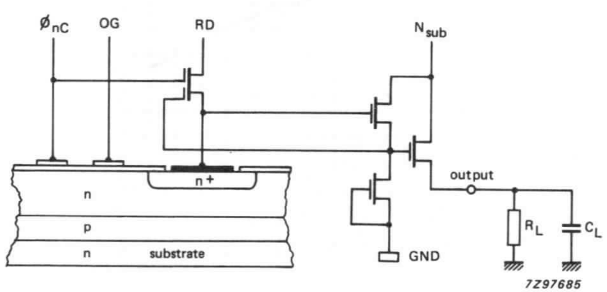


Fig. 15 Circuit diagram for one output channel.

DEVELOPMENT DATA

DEFINITION OF SMEAR

During the field transport time the complete field is shifted over the image section. So each pixel of one column is illuminated by all the other pixels of the column for a short time. Therefore a bright spot makes a bright vertical stripe on the image. This effect is called smear. The brightness of the stripe depends on the height of the spot and on the illumination of the spot.

It is defined by the equation:

$$V_{smear} = \frac{t_{field\ transport}}{t_{integration}} \times \frac{h}{H} \times \frac{E}{E_{sat}} \times V_{sat}$$

Where:

V_{smear}	=	Additional output voltage due to smear
$t_{field\ transport}$	=	0,4 ms
$t_{integration}$	=	16,2 ms
h	=	Height of bright spot
H	=	Height of the complete image
E	=	Illumination of the spot
E_{sat}	=	Saturation illumination
V_{sat}	=	Output voltage at saturation

Example:

Spot height is 10% of the height
Spot illumination is 100% of saturation

$$V_{smear} = \frac{0{,}4}{16{,}2} \times 0{,}1 \times 1 \times V_{sat} = 0{,}0024 \times V_{sat}$$

DEFINITION OF BLOOMING

When part of the image section (spot) is illuminated above saturation level and with the rest of the image dark, at a certain level of overexposure (1000 lx for the NXA1031), the area of the spot increases irregularly. This effect is called blooming.

PICTURE ELEMENT DEFECTS

picture quality at $T_{amb} = 60\ ^oC$

GRADE	PIXEL DEFECTS (note 1)	CLUSTERS (note 2)	COLUMN DEFECTS (note 3)
01	0	0	0
02	2	0	0
03	10	2	0
04	35	5	2

Notes

1. A picture element is considered defect, if its signal deviates more than ± 10% from the mean signal of the neighbouring picture elements at standard illumination.
2. A cluster is a pair of two defect pixels at a distance of less than 3% of the picture height. The sum of pixel defects and clustered pixel defects does not exceed the number of permitted pixel defects.
3. If more than two pixel defects occur in one column, this is considered a column defect.
   Additionally the indicated number of defect pixels is allowed.

OUTPUT SIGNAL

The output signal is a pulse sequence with a d.c. offset. The HIGH level of the output pulses, dependent upon the d.c. adjustments, varies between 8 and 12 volts. The LOW levels depend upon the signal voltage, itself a function of the intensity of the light falling on the sensor, and is between 1,0 and 0,2 volts below the High level. These pulses contain the video information and need further processing to be converted into a signal suitable for use in standard video circuitry.

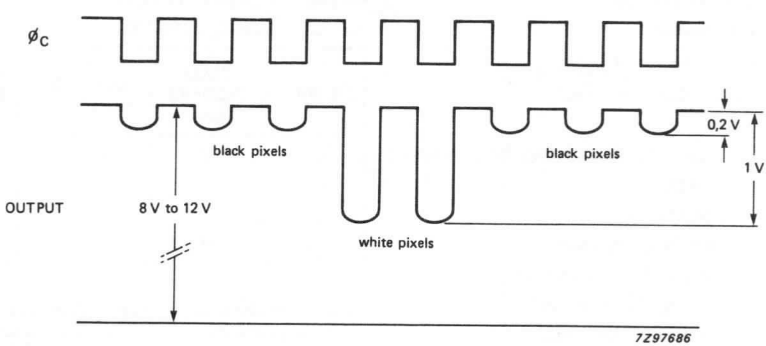


Fig. 16 Typical signal at the sensor output.

MECHANICAL PARAMETERS

The sensor is encapsulated in a 24-lead dual in-line ceramic package with a high-quality glass viewing window on the top side for admittance of light to the sensor.

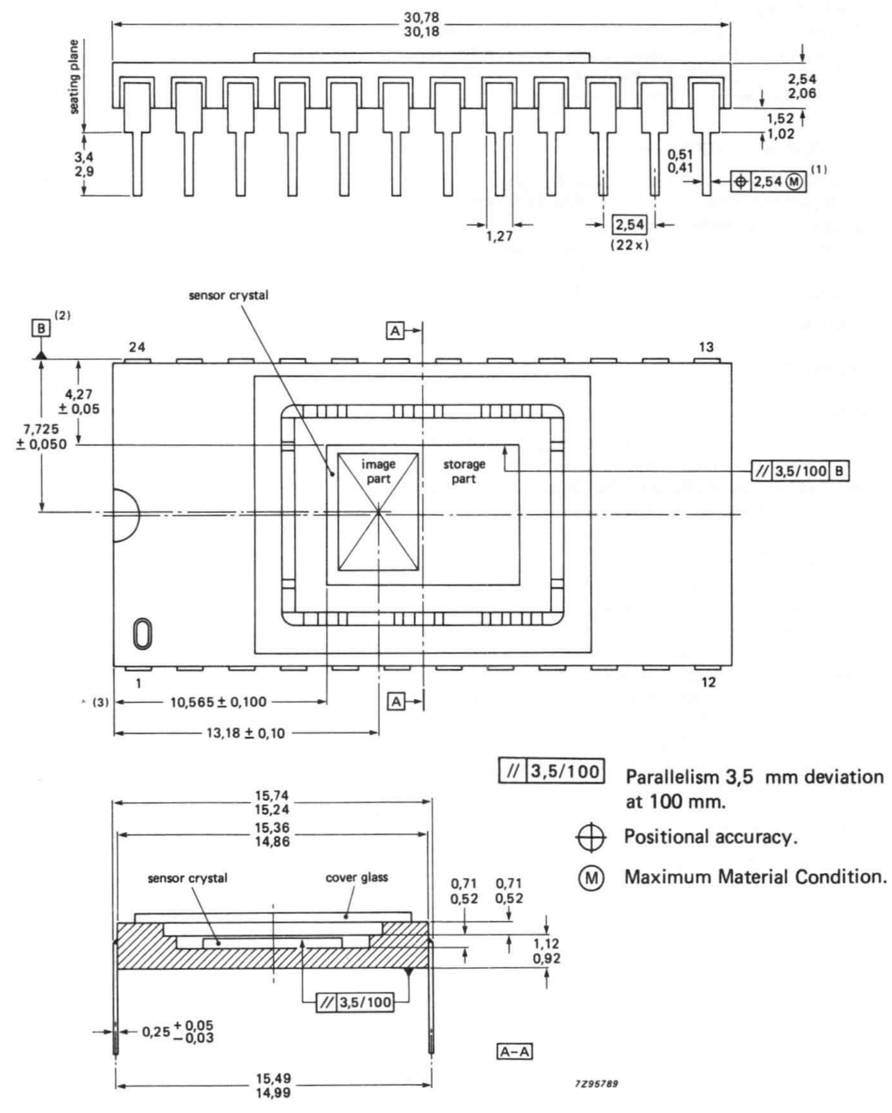


Fig. 17 Package outline; dimensions in mm.

DEVELOPMENT DATA

Notes to Fig. 17

1. Centre-lines of all leads are within ± 0,127 mm of the nominal position shown; in the worst case, the spacing between any two leads may deviate from nominal by ± 0,254 mm.
2. Line B is the connection line between pins 13 and 24. Pins 14 to 23 are not necessarily exactly on this line.
3. These two dimensions are measured at the centre-line of the package.

GENERAL DIMENSIONS (See Fig. 17)

Chip thickness	525 ± 15 μm
Cover glass thickness	0,55 ± 0,05 mm
Thickness of glue layer between sensor and cavity bottom	80 ± 30 μm
Refractive index	1,5
Transmission (400-700 nm)	90%

Sensor is filled with dry air

SOLDERING

1. By hand

Apply the soldering iron below the seating plane (not more than 2 mm above it). If its temperature is below 300 °C it must not be in contact for more than 10 seconds; if between 300 °C and 400 °C, for not more than 5 seconds.

2. By dip or Wave

The maximum permissable temperature of the solder is 260 °C, this temperature must not be in contact with the joint for more than 5 seconds. The total contact time of successive solder waves must not exceed 5 seconds. The device may be mounted up to the seating plane but the temperature of the ceramic body must not exceed the specified storage maximum. If the printed circuit board has been pre-heated, forced cooling may be necessary immediately after soldering to keep the temperature within the permissible limit.

3. Repairing soldered joints

The same precautions and limits apply in (1) above.

APPLICATION INFORMATION

Figure 18 shows a circuit for providing the pulse sequences needed to drive the sensor. A SAA1043 sync-pulse generator provides the three TV standards PAL, SECAM and NTSC. These include vertical and horizontal blanking, plus black-level clamping. It also provides other signals essential for TV camera operation and can be triggered externally for operation with, for example, a VCR or computer. The sync-pulse generator drives a SAD1019 multi-norm pulse-pattern generator (MNPPG) developed specifically for the image sensors. It provides all the clock signals except the pulses for the horizontal read-out registers. Its use avoids the need to develop complex circuitry for driving the NXA1031. Fast clock pulses for the three horizontal read-out registers are generated by a pixel generator TDA4302, delivering three 3,9 MHz pulse trains with a 120° phase difference between them. The output levels from the MNPPG and the pixel generator are too low to drive the shift registers directly. Additional driver ICs are therefore needed to boost the signals i.e. for the pixel generator one TDA4305 and, for the MNPPG, two TDA4301 ICs. During horizontal blanking, the pixel generator is inhibited and slower pulses, derived from the MNPPG, are applied to the pixel-generator output and, then, via the TDA4305, to the transfer gates and horizontal gate electrodes to sort the charge packets into the three horizontal read-out registers.

More detailed information is available on request.

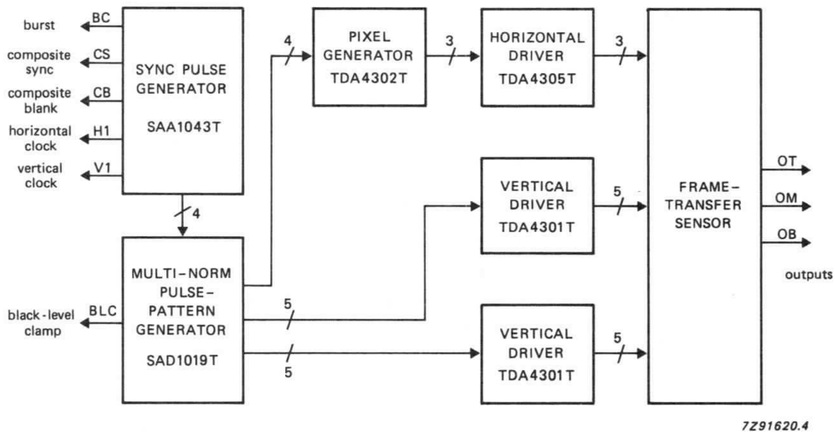


Fig. 18 Drive circuit for the NXA1031 frame transfer sensor.

Supersedes June 1986 data

FRAME TRANSFER SENSOR

GENERAL DESCRIPTION

The NXA1041 frame transfer sensor is a solid state imaging device which produces two interlaced 251-line fields (including 6 lines for dark reference and testing) with an aspect ratio of 4:3.
The sensor is equipped with an on-chip colour stripe filter. The device is compatible with NTSC TV standards and has a 7,5 mm image diagonal matching the half-inch camera tube format.

APPLICATIONS

- Consumer entertainment cameras
- Surveillance cameras – solid state reliability, high resolution and sensitivity provide the quality to be an ideal successor for your stripe camera tube
- Visual aids – the low voltage and mechanical ruggedness of this device allows design of safe and reliable cameras for visual aids
- Slide and film scanners for consumer applications

FEATURES

- Effective number of elements: 610 (horizontal) x 490 (vertical)
- Cyan, green, yellow stripe filter on the chip
- Dark reference: 1 line per field for black clamping
- 100 x anti-blooming margin
- Gamma is 1
- High sensitivity, low noise
- Freedom from lag, burn-in, geometrical distortion and microphonic noise

DEVICE ORGANIZATION

- Frame transfer charge coupled device
- Unit cell size: 9,9 μm (horizontal) x 18,6 μm (vertical)
- Separate outputs for the cyan, green, and yellow channels
- Dummy elements: the first 5 elements of the 3 output registers are dummy elements
- On-chip high sensitivity output amplifier
- Image area: 6,0 mm (horizontal) x 4,5 mm (vertical)
- Chip size: 6,95 mm (horizontal) x 9,35 mm (vertical)

FUNCTIONAL DESCRIPTION

The special electrode arrangement allows 35% of the photosensitive element to be free of polysilicon. This facilitates easy penetration of the blue light into the element to provide good blue sensitivity.

The layout of the sensor is shown in Fig. 1.
It comprises 3 functional areas:

- a matrix of photosensitive elements and integration electrodes,
- a storage section,
- three BCCD read-out registers.

Figure 2 shows the transport process in the imaging and storage regions. At time t_0, the start of the first field read-out from the imaging region, ϕ_3 is low and the charge is concentrated beneath ϕ_4 to ϕ_2. At t_1, ϕ_4 goes low and the charge in each pixel concentrates beneath ϕ_1 and ϕ_2. At t_2, ϕ_3 goes high and the charge packets advance one gate electrode, spreading out beneath ϕ_1, ϕ_2 and the following electrode ϕ_3. In the next step, at t_3, ϕ_1 goes low compressing the charge packets beneath ϕ_2 and ϕ_3, and at t_4, ϕ_4 goes high allowing the charge packets again to advance one gate electrode. This process continues in both the imaging and storage regions until all the charge packets have transferred to the storage region.

The sensor in the integration mode is shown in Fig. 3. The first field is generated when phases ϕ_4, ϕ_1 and ϕ_2 are high and ϕ_3 is low, Fig. 3(a). ϕ_3 effectively forms a potential barrier separating the pixels in the first field. The charges generated by incident light then integrate beneath ϕ_4 and ϕ_2, centred on ϕ_1. So each pixel extends vertically over four gate electrodes.
The potential distribution of the second field, and hence its position relative to the first field is shown in Fig. 3(b). The second field is always displaced by two gate electrodes relative to the first field, with its charge patterns centred on ϕ_3, and with ϕ_1 forming the barrier between pixels, thus providing a perfectly interlaced frame structure.

CAUTION

The image sensor is a MOS device which can be destroyed by static charging of the gates. Always store the device with short-circuiting clamps or on conductive foam plastic. When cleaning the glass window only use alcohol or acetone. Rub the window carefully and slowly. Dry rubbing of the window may cause static charges which can destroy the device.

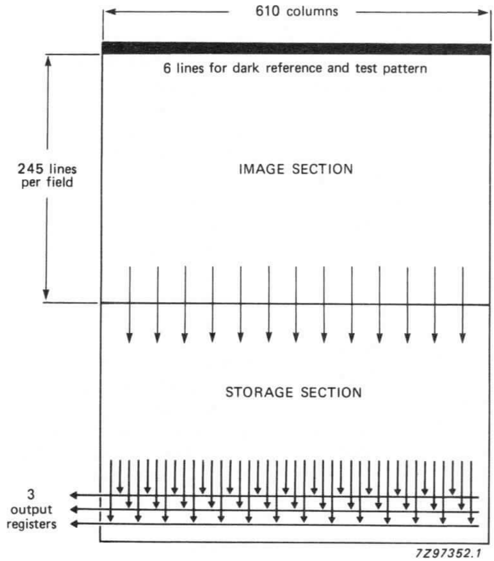


Fig. 1 Sensor layout and charge transport direction.

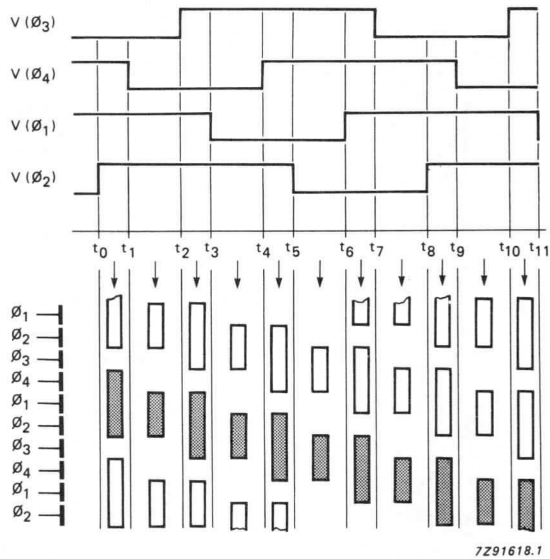


Fig. 2 Charge transport in the vertical direction.

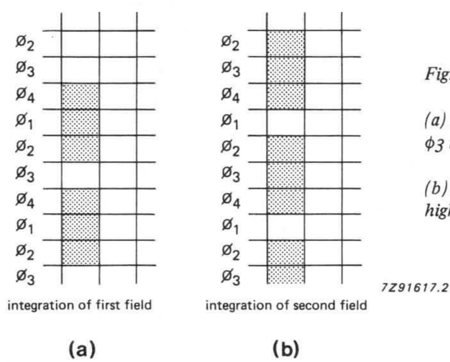


Fig. 3 Interlacing of the sensor.

(a) For integration of the first field, ϕ_4 to ϕ_2 are high, ϕ_3 is low forming a barrier between charge packets.

(b) For integration of the second field, ϕ_2 to ϕ_4 are high, ϕ_1 is low.

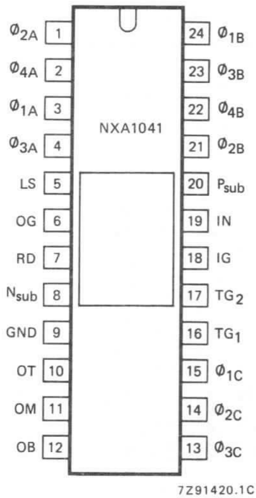


Fig. 4 Pin configuration.

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1	ϕ2A	Vertical transfer clocks for image part
2	ϕ4A	
3	ϕ1A	
4	ϕ3A	
5	LS	Light shield (Al. cover on storage part)
6	OG	Output gate
7	RD	Drain reset transistor
8	N_{sub}	N-substrate; supply voltage
9	GND	Ground
10	OT	Output top (cyan)
11	OM	Output middle (green)
12	OB	Output bottom (yellow)
13	ϕ3C	Horizontal transfer clock for output register
14	ϕ2C	
15	ϕ1C	
16	TG1	Transfer gate
17	TG2	
18	IG	Input gate (test point for manufacturing)
19	IN	Input diffusion (test point for manufacturing)
20	P_{sub}	P-substrate
21	ϕ2B	Vertical transfer clocks for storage part
22	ϕ4B	
23	ϕ3B	
24	ϕ1B	

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Voltages with respect to P_{sub}				
RD	$V_{RD\text{-}PSUB}$	−0,5	+25	V
IN	$V_{IN\text{-}PSUB}$	−0,5	+25	V
Voltages with respect to N_{sub}				
RD	$V_{RD\text{-}NSUB}$	−10	+0,5	V
IN	$V_{IN\text{-}NSUB}$	−10	+0,5	V
all other connections		−25	+0,5	V
Current from one output		−	10	mA
Storage temperature range	T_{stg}	−30	+80	°C
Operating ambient temperature range	T_{amb}	−20	+60	°C

DC CHARACTERISTICS at T_{amb} = 25 °C

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Voltage at LS (note 1)	V_{LS}	−	V_{Nsub}	−	V
Voltage at OG (note 2)	V_{OG}	2	−	10	V
Voltage at RD; (note 2) current to sensor: I < 1 μA	V_{RD}	10	−	V_{Nsub}	V
Voltage at N_{sub}; (note 2) I < 10 mA	V_{Nsub}	15	20	22	V
Voltage difference between V_{Nsub} and V_{RD}	$V_{Nsub}-V_{RD}$	−	−	7	V
Voltage at IG	V_{IG}	−	GND	−	V
DC level of output voltage at OT, OM, OB (notes 3 and 4)	$V_{OT;OM;OB}$	6	−	15	V
Voltage at P_{sub}; (note 2) current from sensor: I < 50 μA	V_{Psub}	0	−	5	V
Voltage at IN	V_{IN}	−	V_{Nsub}	−	V
Power dissipation	P	−	80	150	mW
Leakage current of gates	I_l	−	−	10	μA

Notes

1. The lightshield should be connected to V_{Nsub} (or to GND).
2. These values must be adjusted to the optimum operating point within the given range.
3. Measured with output buffer. See Fig. 5.
4. See Fig. 16.

DEVELOPMENT DATA

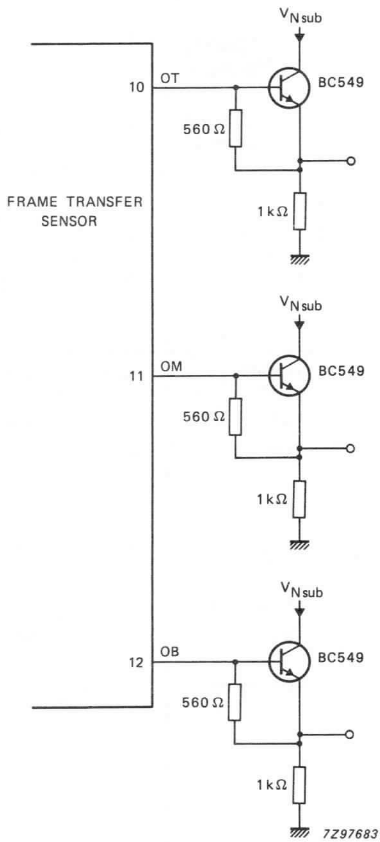


Fig. 5 Output buffer for measurements.

DEVELOPMENT DATA

CLOCK CHARACTERISTICS (note 1)

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
LOW levels					
$\phi nA, \phi nB$	$V_{\phi nA/B}$	–	GND	–	–
$\phi 1C, \phi 2C, \phi 3C$ (note 2) ($\phi 1CLOW = \phi 2CLOW = \phi 3CLOW$)	$V_{\phi nC}$	–	0	$V_{Nsub}-10$	V
TG1 (note 2)	V_{TG1}	0	–	$V_{Nsub}-10$	V
TG2 (note 2)	V_{TG2}	0	–	$V_{Nsub}-10$	V
Amplitudes					
$\phi nA, \phi nB, \phi nC$	$V_{\phi(p\text{-}p)}$	9,75	10	10,25	V
Timing (See Figs 6 and 7)					
Horizontal clock					
clock frequency (note 3)	f_c	–	3,90	–	MHz
rise time	t_{rc}	20	–	40	ns
fall time	t_{fc}	20	–	40	ns
fall time of ϕ_{1C} during horizontal blanking (note 4)	t_{fcB}	–	200	–	ns
overlap time	t_{ihc}	10	–	–	ns
	t_{ilc}	5	–	–	ns
Vertical clock					
clock frequency	f_{cv}	–	629	–	kHz
rise time	t_{rv}	–	70	–	ns
fall time	t_{fv}	–	100	–	ns
overlap time	t_{ihv}	100	–	–	ns
	t_{ilv}	100	–	–	ns
Transfer gates					
rise time	t_{rTG}	–	70	–	ns
fall time	t_{fTG}	–	100	–	ns
Clock capacitance					
Each clock phase					
$\phi nA, \phi nB$	$C_{\phi nA/B}$	–	–	3000	pF
ϕnC, TG1, TG2	$C_{\phi nC}, C_{TG1/2}$	–	–	100	pF
Leakage current of the clock connections	I_l	–	–	10	μA

Notes

1. Measured with output buffer. See Fig. 5.
2. These values must be adjusted to the optimum operating point within the given range.
3. Deviations from this frequency result in incorrect aspect ratio.
4. It is recommended to use the longer fall time of the ϕ_{1C} pulse during the horizontal blanking period to avoid irregular vertical stripes.

ADJUSTMENT OF OPERATING LEVELS

A reasonable picture may be obtained by using the settings quoted in the NXA1041 Test Sheet. For optimum performance, fine adjustment of the sensors d.c. levels is essential. When carrying out this operation the following points should be considered.

- Vertical stripes in the picture are usually the result of charges being unevenly sorted into the three output registers. This can be influenced by $V_{\phi C}$, V_{OG}, V_{TG2} and V_{TG1}.
- The anti-blooming performance of a sensor is influenced by its internal vertical potential gradient. This can be optimized by adjusting V_{Nsub} and V_{Psub}.

DRIVING PULSE WAVEFORMS

The specifications of the sensor are measured when the following clock pulses are applied (Figs 6 and 7). In principle the sensor can be operated with different clock pulses, e.g. different clock frequencies (overlap conditions have to be maintained).

More detailed information is available on request.

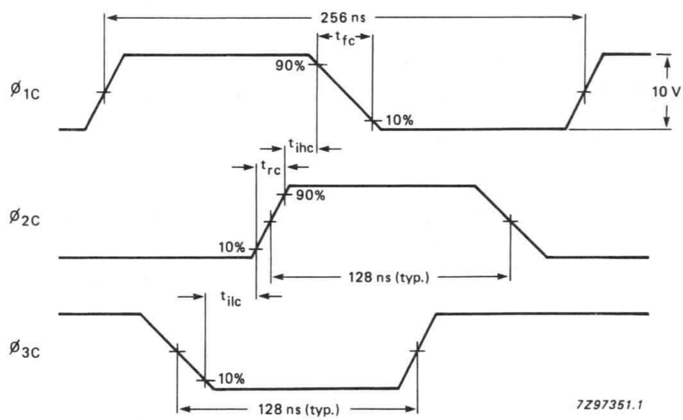


Fig. 6 Horizontal transport timing waveforms for the sensor electrodes (ϕ_{nC}); times measured at the 10% and 90% points of the amplitude.

DRIVING PULSE WAVEFORMS (continued)

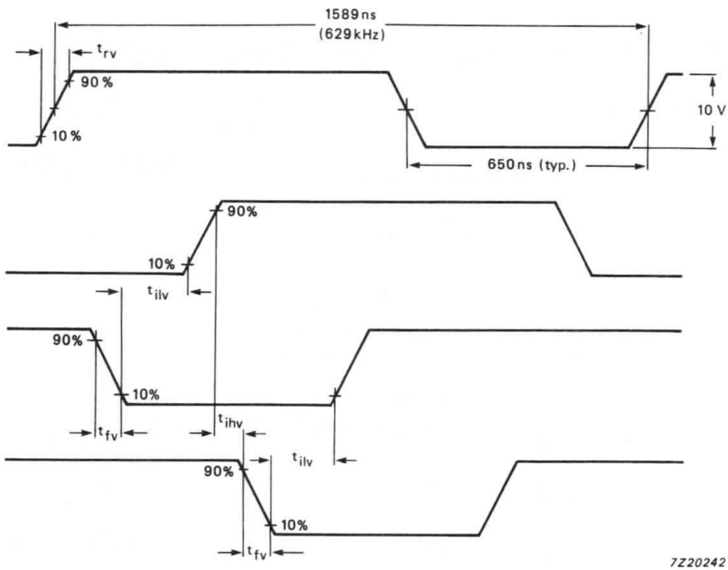


Fig. 7 Vertical transport timing waveforms for the sensor electrodes (ϕ_{nA}, ϕ_{nB}); times measured at the 10% and 90% points of the amplitude.

DEVELOPMENT DATA

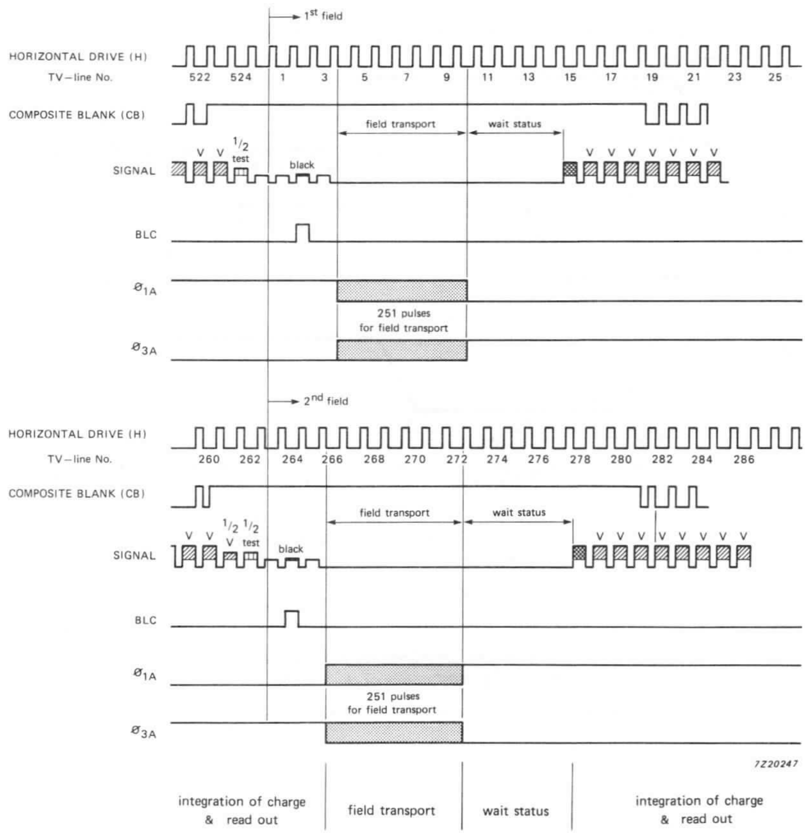


Fig. 8 Drive-pulse sequence and line numbering for field transport.

DEVELOPMENT DATA

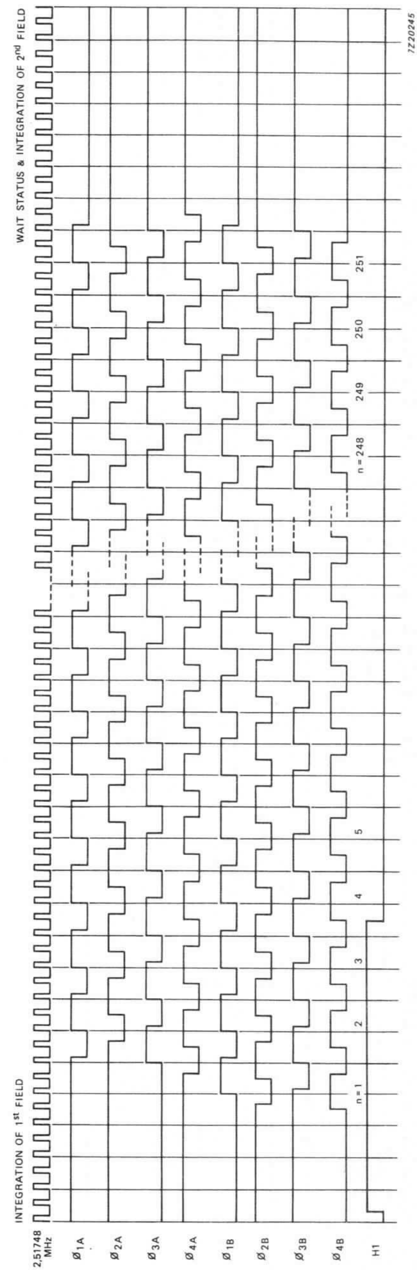


Fig. 9 Field transport pulses 1st field.

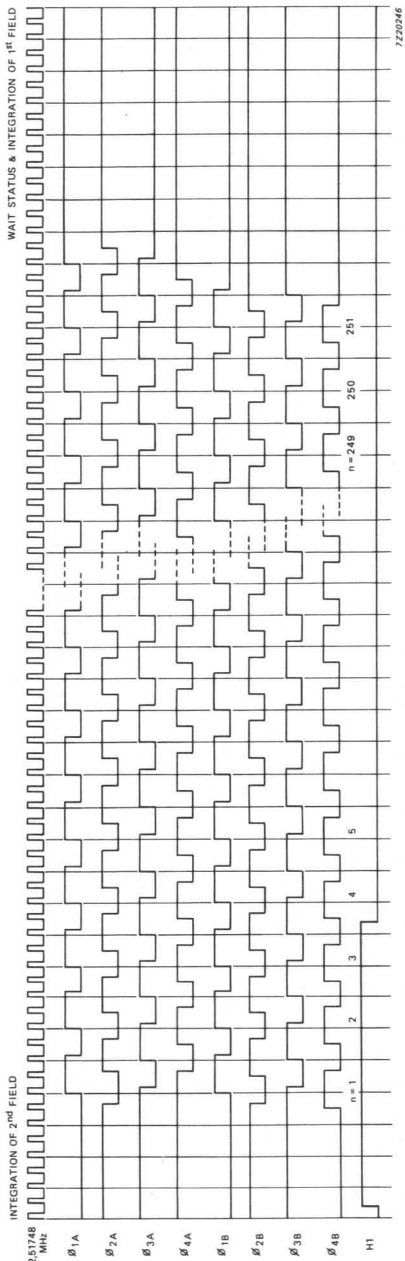


Fig. 10 Field transport pulses 2nd field.

DEVELOPMENT DATA

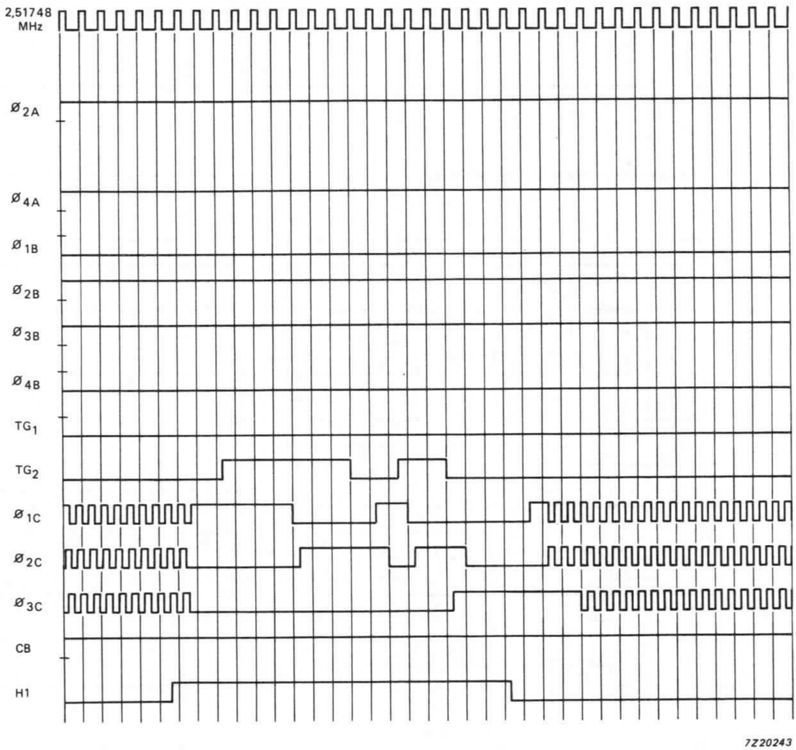


Fig. 11 Wait status.

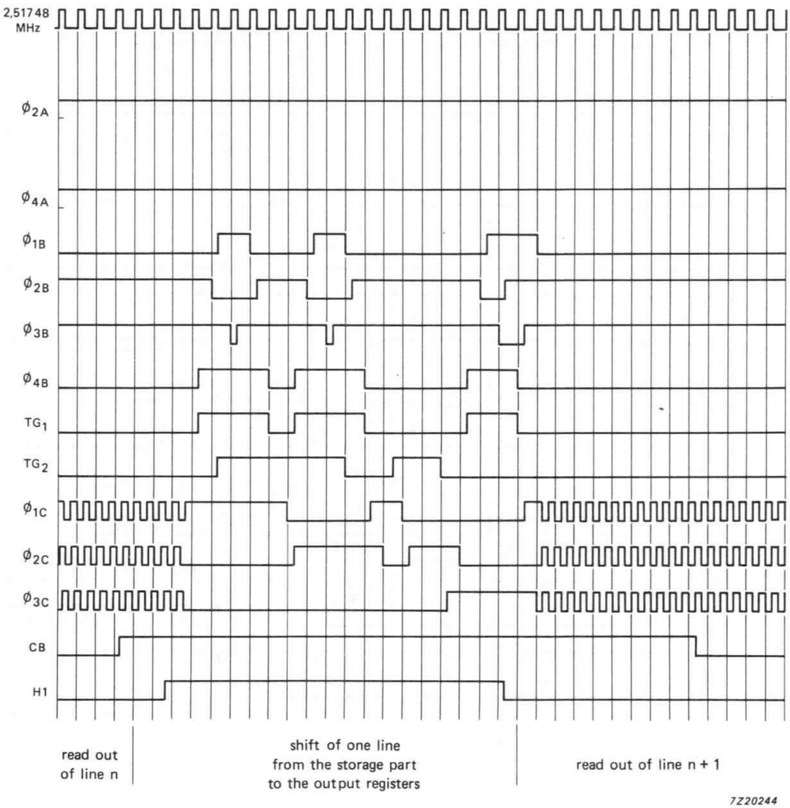


Fig. 12 Read-out of the output registers and sorting of the signal into output registers.

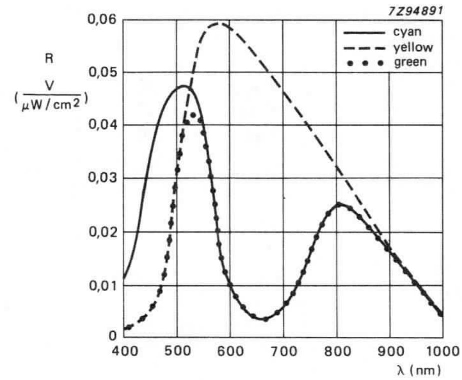


Fig. 13 Spectral response.

DEVELOPMENT DATA

OUTPUT CHARACTERISTICS at T_{amb} = 60 °C

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Load capacitance	C_L	–	–	10	pF
Output signal voltage at standard illumination (peak-to-peak value) (see notes 1 and 2)					
Cyan channel	V_{OT}	30	–	–	mV
Green channel	V_{OM}	27	–	–	mV
Yellow channel	V_{OB}	60	–	–	mV
Output signal voltage at saturation (peak-to-peak value) (notes 2 and 3)	V_{Osat}	250	400	–	mV
Clock cross-talk to output (peak-to-peak value)	V_{OCLK}	–	–	0,2	V
Maximum illumination on the sensor without blooming (note 4)	E_B	1000	–	–	lx
Transport inefficiency					
horizontal one step	ϵ_H	–	–	$8,5 \times 10^{-5}$	
vertical one step	ϵ_V	–	–	5×10^{-5}	
Dark current	I_D	–	–	5	nA
Smear (note 5)					%

Notes

1. 5 lx on the sensor, colour temperature of light source 3200 K, Hoya-IR-Filter C500S, 1 mm is used.
2. Measured with output buffer.
3. Maximum usable range of illumination 85% of saturation level.
4. See 'Definition of blooming'.
5. See 'Definition of smear'.

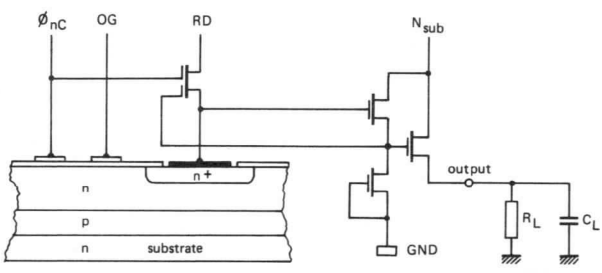


Fig. 14 Circuit diagram for one output channel.

DEFINITION OF SMEAR

During the field transport time the complete field is shifted over the image section. So each pixel of one column is illuminated by all the other pixels of the column for a short time. Therefore a bright spot makes a bright vertical stripe on the image. This effect is called smear. The brightness of the stripe depends on the height of the spot and on the illumination of the spot.

It is defined by the equation:

$$V_{smear} = \frac{t_{field\ transport}}{t_{integration}} \times \frac{h}{H} \times \frac{E}{E_{sat}} \times V_{sat}$$

Where:

V_{smear}	=	Additional output voltage due to smear
$t_{field\ transport}$	=	0,4 ms
$t_{integration}$	=	16,2 ms
h	=	Height of bright spot
H	=	Height of the complete image
E	=	Illumination of the spot
E_{sat}	=	Saturation illumination
V_{sat}	=	Output voltage at saturation

Example: Spot height is 10% of the height
Spot illumination is 100% of saturation

$$V_{smear} = \frac{0,4}{16,2} \times 0,1 \times 1 \times V_{sat} = 0,0024 \times V_{sat}$$

DEVELOPMENT DATA

DEFINITION OF BLOOMING

When part of the image section (spot) is illuminated above saturation level and with the rest of the image dark, at a certain level of overexposure (1000 lx for the NXA1041), the area of the spot increases irregularly. This effect is called blooming.

PICTURE ELEMENT DEFECTS

Picture quality at T_{amb} = 60 °C

GRADE	PIXEL DEFECTS (note 1)	CLUSTERS (note 2)	COLUMN DEFECTS (note 3)
01	0	0	0
02	2	0	0
03	10	2	0
04	35	5	2

Notes

1. A picture element is considered defect, if its signal deviates more than ± 10% from the mean signal of the neighbouring picture elements at standard illumination.
2. A cluster is a pair of two defect pixels at a distance of less than 3% of the picture height. The sum of pixel defects and clustered pixel defects does not exceed the number of permitted pixel defects.
3. If more than two pixel defects occur in one column, this is considered a column defect.
   Additionally the indicated number of defect pixels is allowed.

OUTPUT SIGNAL

The output signal is a pulse sequence with a d.c. offset. The HIGH level of the output pulses, dependent upon the d.c. adjustments, varies between 8 and 12 volts. The LOW levels depend upon the signal voltage, itself a function of the intensity of the light falling on the sensor, and is between 1,0 and 0,2 volts below the HIGH level. These pulses contain the video information and need further processing to be converted into a signal suitable for use in standard video circuitry.

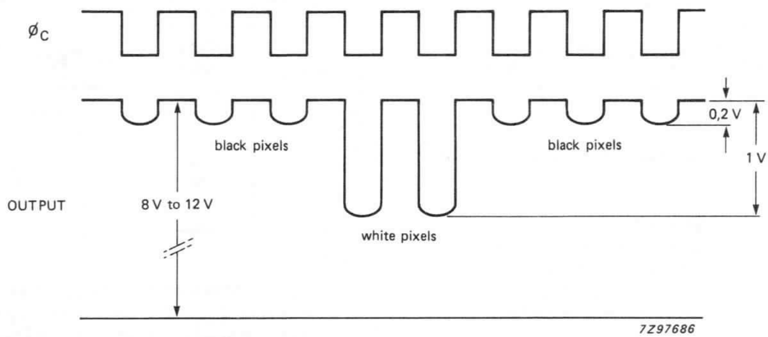


Fig. 15 Typical signal at the sensor output.

DEVELOPMENT DATA

MECHANICAL PARAMETERS

The sensor is encapsulated in a 24-lead dual in-line ceramic package with a high-quality glass viewing window on the top side for admittance of light to the sensor.

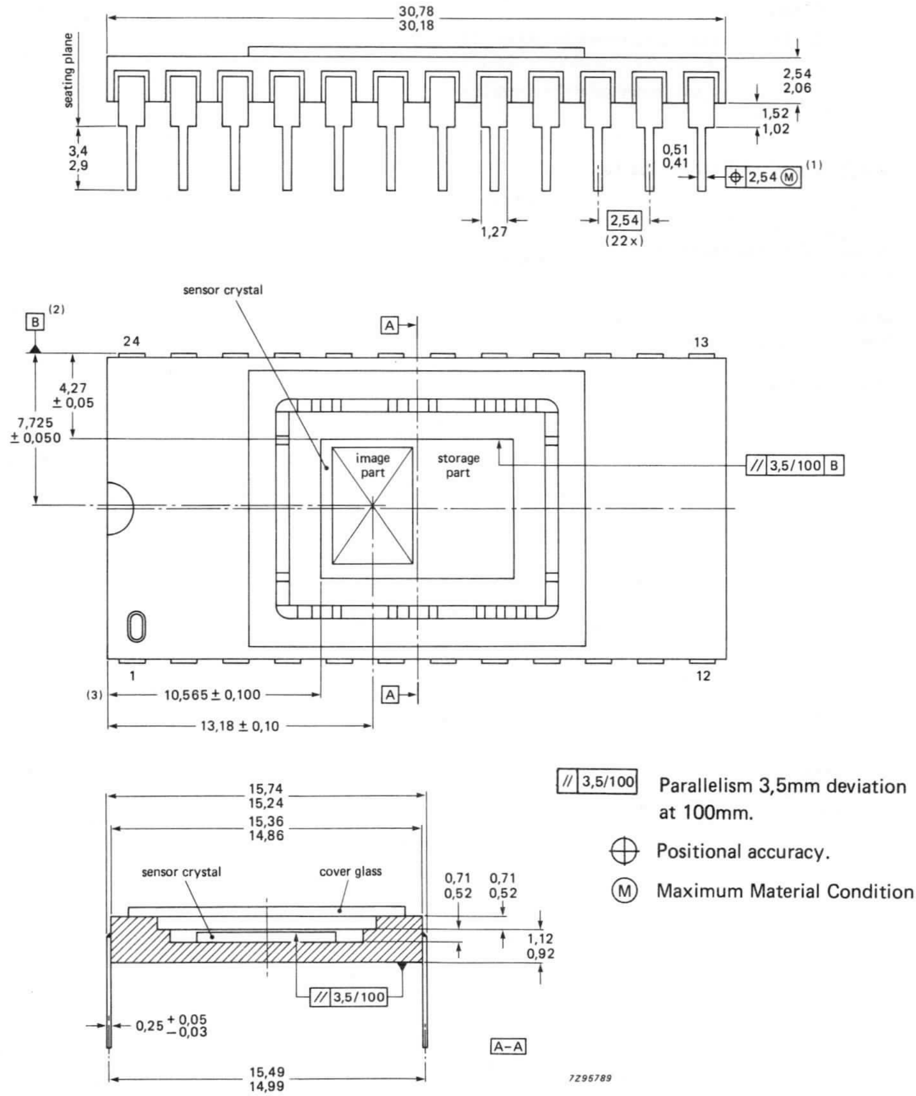


Fig. 16 Package outline; dimensions in mm (also see notes).

Notes to Fig. 16

(1) Centre-lines of all leads are within ± 0,127 mm of the nominal position shown; in the worst case, the spacing between any two leads may deviate from nominal by ± 0,254 mm.

(2) Line B is the connection line between pins 13 and 24. Pins 14 and 23 are not necessarily exactly on this line.

(3) These two dimensions are measured at the centre-line of the package.

GENERAL DIMENSIONS (See Fig. 16)

Chip thickness	525 ± 15 μm
Cover glass thickness	0,55 ± 0,05 mm
Thickness of glue layer between sensor and cavity bottom	80 ± 30 μm
Refractive index	1,5
Transmission (400-700 nm)	90%

Sensor is filled with dry air.

APPLICATION INFORMATION

Figure 17 shows a circuit for providing the pulse sequence needed to drive the sensor. A SAA1043 sync-pulse generator provides the three TV standards, PAL, SECAM and NTSC. These include vertical and horizontal blanking, plus black-level clamping. It also provides other signals essential for TV camera operation and can be triggered externally for operation with, for example, a VCR or computer. The sync-pulse generator drives a SAD1019 multi-norm pulse-pattern generator (MNPPG) developed specifically for the image sensors. It provides all the clock signals except the pulses for the horizontal read-out registers. Its use avoids the need to develop complex circuitry for driving the NXA1041. Fast clock pulses for the three horizontal read-out registers are generated by a pixel generator TDA4302, delivering three 3,9 MHz pulse trains with a 120° phase difference between them. The output levels from the MNPPG and the pixel generator are too low to drive the shift registers directly. Additional driver ICs are therefore needed to boost the signals, i.e. for the pixel generator one TDA4305 and, for the MNPPG, two TDA4301 ICs. During horizontal blanking, the pixel generator is inhibited and slower pulses, derived from the MNPPG, are applied to the pixel-generator output and, then, via the TDA4305, to the transfer gates and horizontal gate electrodes to sort the charge packets into the three horizontal read-out registers.

More detailed information is available on request.

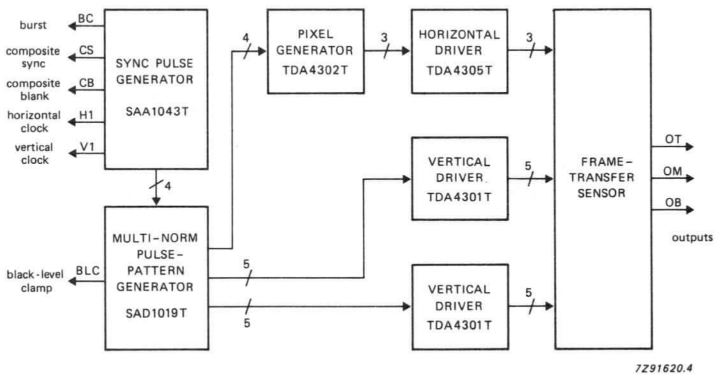


Fig. 17 Drive circuit for the NXA1041 frame transfer sensor.

Image intensifier tubes

6

Transmitting and r.f. heating tubes

7

AIR COOLED V.H.F. POWER TETRODE

Forced air cooled coaxial power tetrode in metal-ceramic construction primarily intended for use as a linear broad-band amplifier in TV transmitters in the bands I and III. This type is also very suitable for a.m. and f.m. broadcast and a.f. modulator applications, and in TV transposer service.

QUICK REFERENCE DATA

Class-AB linear amplifier (vision)				
Frequency	f		175,25	MHz
Anode voltage	V_a		8	kV
Output power in load, sync	W_ℓ		27,5	kW
Power gain, sync	G		14,5	dB
Class-B f.m. telephony				
Frequency	f		260	MHz
Anode voltage	V_a		8,5	kV
Output power in load	W_ℓ		25	kW
Power gain	G		14,9	dB
Television transposer service				
Frequency	f		175 to 225	MHz
Anode voltage	V_a		8	kV
Output power in load, sync	W_ℓ		10,5	kW
Power gain, sync	G		16,2	dB

HEATING: direct; thoriated tungsten filament, mesh type.

Filament voltage	V_f		10,4	V $^{+1\%}_{-3\%}$ ←
Filament current	I_f		115	A ←
Filament peak starting current	I_{fp}	max.	750	A
Cold filament resistance	R_{fo}		10,5	mΩ
Waiting time	t_w	min.	1	s

orange binder, tab 7

TYPICAL CHARACTERISTICS

Anode voltage	V_a	8	kV
Grid 2 voltage	V_{g2}	700	V
Anode current	I_a	2,4	A
Transconductance	S	60	mA/V
→ Amplification factor	μ_{g2g1}	8,5	

CAPACITANCES

	grounded cathode		grounded grid		
Input	C_i	135	C_i	69	pF
Output	C_o	23	C_o	23	pF
Anode to grid 1	C_{ag1}	0,85			pF
Anode to filament			C_{af}	0,25	pF

TEMPERATURE LIMITS

Absolute maximum envelope temperature	T_{env}	max.	240	°C
Recommended maximum seal temperature	T	max.	200	°C

COOLING

See cooling curves.
Direction of airflow: see outline drawing.

The air should be ducted so that sufficient air is directed to the seals to keep the seal temperature below the limit.

ACCESSORIES

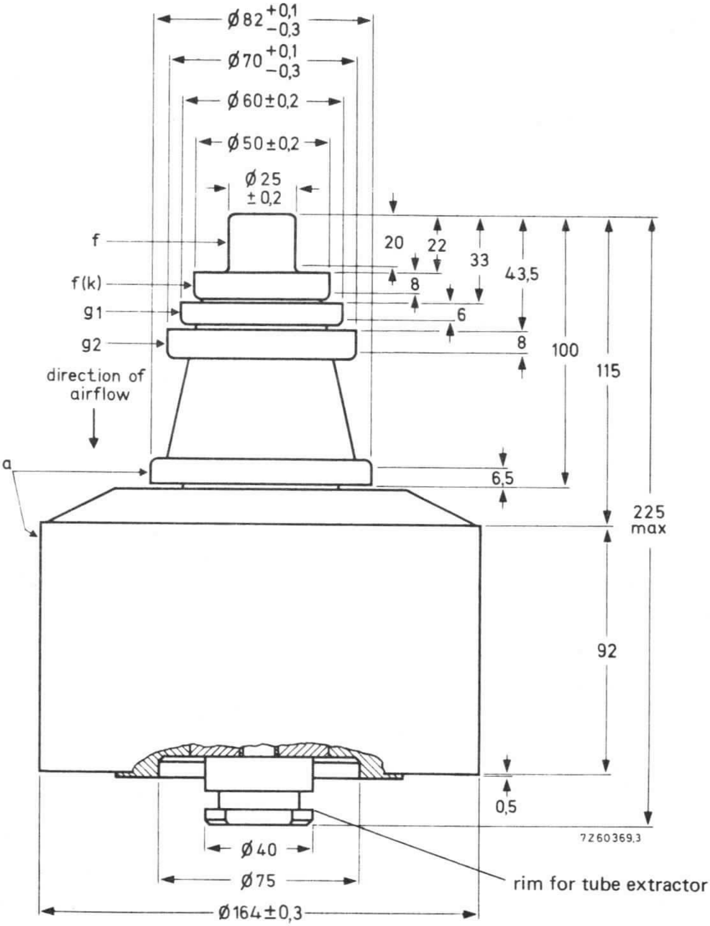
Band I amplifier circuit assembly (vision)	type 40759
Band I amplifier circuit assembly (sound)	type 40760
Band III amplifier circuit assembly (vision)	type 40768
Band III amplifier circuit assembly (sound)	type 40769

MECHANICAL DATA

Dimensions in mm

Net mass: approx. 11 kg

Mounting position: vertical with anode up or down



R.F. CLASS-AB LINEAR AMPLIFIER FOR TELEVISION SERVICE

Negative modulation, positive synchronization (C.C.I.R. system).
Unless otherwise specified the voltages are given with respect to the cathode.

LIMITING VALUES (Absolute maximum rating system)

					notes
Frequency	f	up to	260	MHz	
Anode voltage	V_a	max.	9	kV	
Grid 2 voltage	V_{g2}	max.	1	kV	
Grid 1 voltage	$-V_{g1}$	max.	500	V	
Anode current, black	$I_{a\ black}$	max.	7	A	
Anode input power, black	$W_{ia\ black}$	max.	40	kW	
Anode dissipation	W_a	max.	18	kW	
Grid 2 dissipation	W_{g2}	max.	100	W	
Grid 1 dissipation	W_{g1}	max.	50	W	
Cathode current	I_k	max.	9	A	

OPERATING CONDITIONS grounded grid

				notes
Frequency of vision carrier	f	175,25	MHz	
Bandwidth (−1 dB)	B	7,5	MHz	1
Anode voltage	V_a	8	kV	
Grid 2 voltage	V_{g2}	700	V	
Grid 1 voltage	V_{g1}	−84	V	2
Anode current, no-signal condition	I_a	900	mA	
Anode current, black	$I_{a\ black}$	3,9	A	3
Grid 2 current, black	$I_{g2\ black}$	55	mA	3
Grid 1 current, black	$I_{g1\ black}$	180	mA	3
Output power in load, sync	$W_{\ell\ sync}$	27,5	kW	
Output power in load, black	$W_{\ell\ black}$	16,5	kW	3
Anode dissipation, black	$W_{a\ black}$	14	kW	
Driving power, sync	$W_{dr\ sync}$	965	W	
Driving power, black	$W_{dr\ black}$	520	W	
Gain, sync	G_{sync}	14,5	dB	
Gain, black	G_{black}	15	dB	
Sync compression	sync in/out	30/25		4
Differential phase		<3	deg	5
Differential gain		$\geqslant 85$	%	5
L.F. linearity		$\geqslant 85$	%	5

Notes: see page 5

OPERATING CONDITIONS (continued)

					notes
Frequency of vision carrier	f	83,25	55,25	MHz	
Bandwidth (−1 dB)	B	7	7	MHz	1
Anode voltage	V_a	6,5	6,5	kV	
Grid 2 voltage	V_{g2}	700	700	V	
Grid 1 voltage	V_{g1}	−88	−88	V	2
Anode current, no signal condition	I_a	900	900	mA	
Anode current, black	$I_{a\ black}$	4,1	4,5	A	3
Grid 2 current, black	$I_{g2\ black}$	55	45	mA	3
Grid 1 current, black	$I_{g1\ black}$	160	175	mA	3
Output power in load, sync	$W_{\ell\ sync}$	20	20	kW	
Output power in load, black	$W_{\ell\ black}$	12	12	kW	3
Anode dissipation, black	$W_{a\ black}$	14,6	17,2	kW	
Driving power, sync	$W_{dr\ sync}$	835	910	W	
Driving power, black	$W_{dr\ black}$	444	520	W	
Gain, sync	G_{sync}	13,8	13,4	dB	
Gain, black	G_{black}	14,3	13,6	dB	
Sync compression	sync in/out	30/25	27/25		4
Differential phase		<3	<3	deg	5
Differential gain		$\geqslant 85$	$\geqslant 85$	%	5
L.F. linearity		$\geqslant 85$	$\geqslant 85$	%	5

NOTES

1. With double tuned circuit.
2. To be adjusted for the stated no signal anode current.
3. Black signal including line sync pulses.
4. A picture/sync ratio of 75/25 for the outgoing signal requires a ratio of max. 70/30 for the incoming signal in which case the sync compression sync in/out = 30/25.
5. Measured with 9-step staircase amplitude, running from 17% to 75% of the peak sync value, with superimposed a 4,43 MHz sine wave with a 10% peak to peak value.
6. At c.w. output power = 10,5 kW.
7. Three-tone test method (vision carrier −8 dB, sound carrier −10 dB, sideband signal −16 dB with respect to peak sync = 0 dB).

R.F. CLASS-AB AMPLIFIER FOR TELEVISION TRANSPOSER SERVICE grounded grid

LIMITING VALUES

See page 120.

OPERATING CONDITIONS grounded grid

Negative modulation, positive synchronization, combined sound and vision (CCIR standard G)

				notes
Frequency	f	175 to 225	MHz	
Bandwidth (−1 dB)	B	8	MHz	1
Anode voltage	V_a	8	kV	
Grid 2 voltage	V_{g2}	900	V	
Grid 1 coltage	V_{g1}	−95	V	2
Anode current, no signal condition	I_a	1,8	A	
Anode current	I_a	3,3	A	6
Grid 2 current	I_{g2}	35	mA	6
Grid 1 current	I_{g1}	20	mA	6
Driving power, sync	W_{dr}	250	W	
Output power in load, sync	W_ℓ	10,5	kW	
Power gain	G	16,2	dB	
Intermodulation products	d	−56	dB	7

Notes: see page 5

R.F. CLASS-B F.M. TELEPHONY

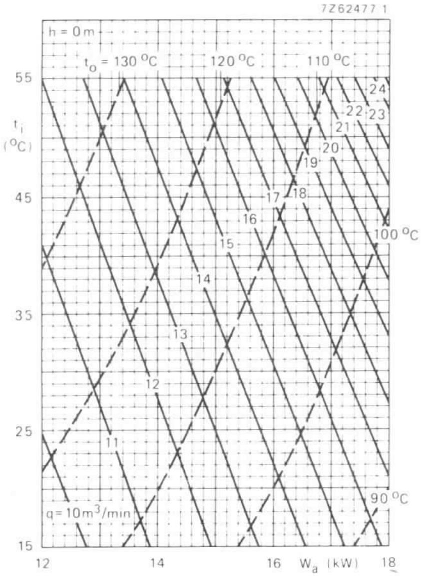
LIMITING VALUES (Absolute maximum rating system)

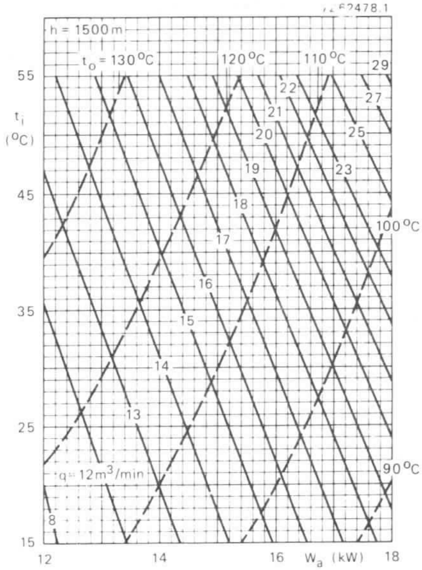
					note
Frequency	f	up to	260	MHz	
Anode voltage	V_a	max.	9,5	kV	
Grid 2 voltage	V_{g2}	max.	1	kV	
Grid 1 voltage	$-V_{g1}$	max.	500	V	
Anode current	I_a	max.	7	A	
Anode input power	W_{ia}	max.	42	kW	
Anode dissipation	W_a	max.	18	kW	
Grid 2 dissipation	W_{g2}	max.	100	W	
Grid 1 dissipation	W_{g1}	max.	50	W	
Cathode current	I_k	max.	9	A	

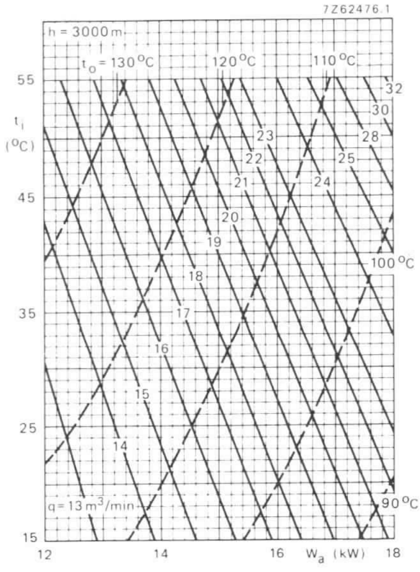
OPERATING CONDITIONS

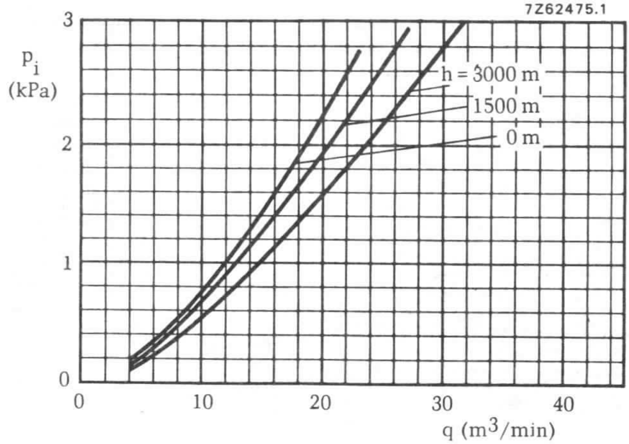
Frequency	f	260	MHz	
Anode voltage	V_a	8,5	kV	
Grid 2 voltage	V_{g2}	700	V	
Grid 1 voltage	V_{g1}	−106	V	2
Anode current, no signal condition	I_a	300	mA	
Anode current	I_a	4,6	A	
Grid 2 current	I_{g2}	100	mA	
Grid 1 current	I_{g1}	325	mA	
Anode input power	W_{ia}	39,1	kW	
Anode dissipation	W_a	14	kW	
Output power in load	W_ℓ	25	kW	
Efficiency, total		64	%	
Driving power	W_{dr}	800	W	
Power gain	G	14,9	dB	

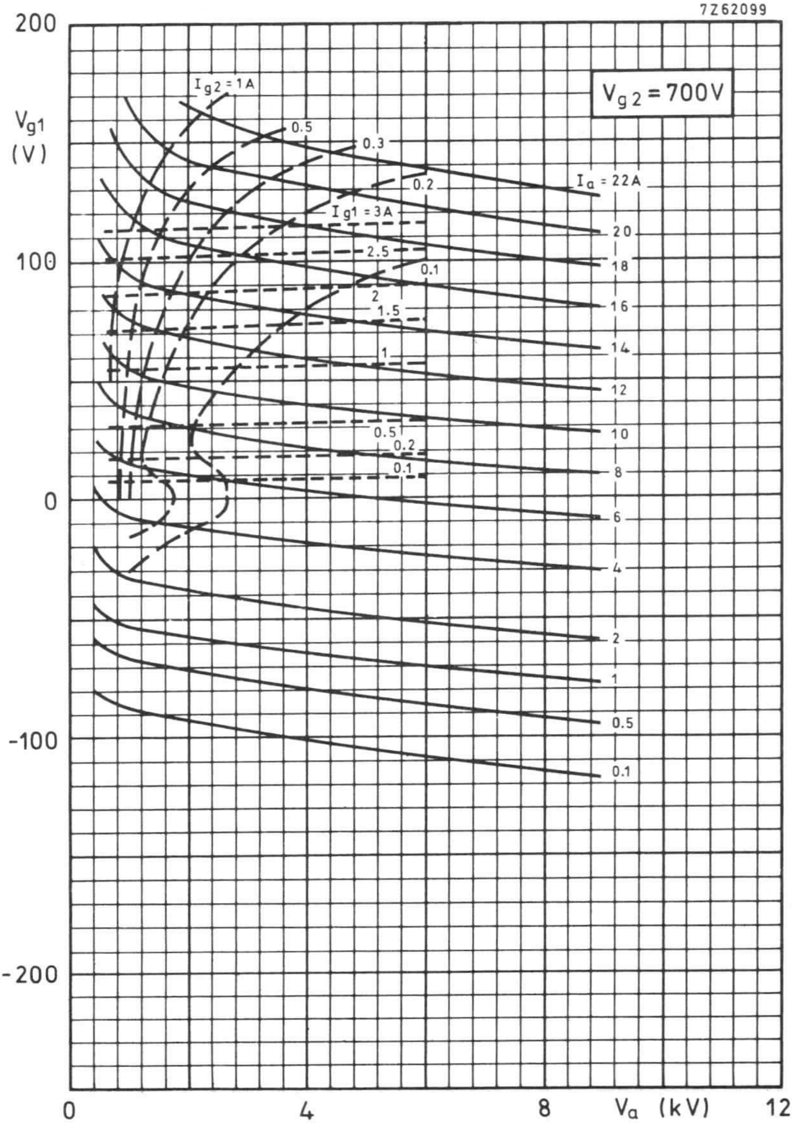
Note: see page 5


7Z62477.1
h = 0 m
t_o = 130 °C
120 °C
110 °C
100 °C
90 °C
t_i (°C)
55
45
35
25
15
24
23
22
21
20
19
18
17
16
15
14
13
12
11
q = 10 m³/min
12
14
16
W_a (kW)
18


62478.1
h = 1500 m
t_o = 130 °C
120 °C
110 °C
100 °C
90 °C
t_i (°C)
55
45
35
25
15
29
27
25
23
22
21
20
19
18
17
16
15
14
13
8
q = 12 m³/min
12
14
16
W_a (kW)
18


7Z62476.1
h = 3000 m
t_o = 130 °C
120 °C
110 °C
100 °C
90 °C
t_i (°C)
55
45
35
25
15
32
30
28
25
24
23
22
21
20
19
18
17
16
15
14
q = 13 m³/min
12
14
16
W_a (kW)
18


7Z62475.1
3
2
1
0
p_i (kPa)
h = 3000 m
1500 m
0 m
0
10
20
30
40
q (m^3/min)


7Z62099
200
100
0
-100
-200
V_{g1}
(V)
$V_{g2} = 700V$
$I_{g2} = 1A$
0.5
0.3
0.2
0.1
$I_{g1} = 3A$
2.5
2
1.5
1
0.5
0.2
0.1
$I_a = 22A$
20
18
16
14
12
10
8
6
4
2
1
0.5
0.1
0
4
8
12
V_a (kV)

AIR COOLED V.H.F. POWER TETRODE

Forced air cooled coaxial power tetrode in metal-ceramic construction primarily intended for use in R.F. power amplifier applications up to 250 MHz.

QUICK REFERENCE DATA

Class-B amplifier (C.W.)			
Frequency	f		170 - 230 MHz
Anode voltage	V_a		10 kV
Output power in load	W_ℓ		35 kW
Power gain	G		16 dB

HEATING: direct; thoriated tungsten filament, mesh type.

Filament voltage	V_f		7,5 V $^{+1\%}_{-3\%}$ ←
Filament current	I_f		180 A
Filament peak starting current	I_{fp}	max.	1000 A
Cold filament resistance	R_{fo}		4,2 mΩ
Waiting time	t_w	min.	1 s

TYPICAL CHARACTERISTICS

Anode voltage	V_a		10 kV
Grid 2 voltage	V_{g2}		900 V
Anode current	I_a		2,4 A
Transconductance	S	≈	70 mA/V
Amplification factor	μ_{g2g1}		10

orange binder, tab 7

CAPACITANCES, grounded grid

			grounded grid
Input	C_i		86 pF
Output	C_o		29 pF
Anode to filament	C_{af}	<	0,3 pF

TEMPERATURE LIMITS

Absolute maximum envelope temperature	T_{env}	max.	240 °C
Recommended maximum seal temperature	T	max.	200 °C

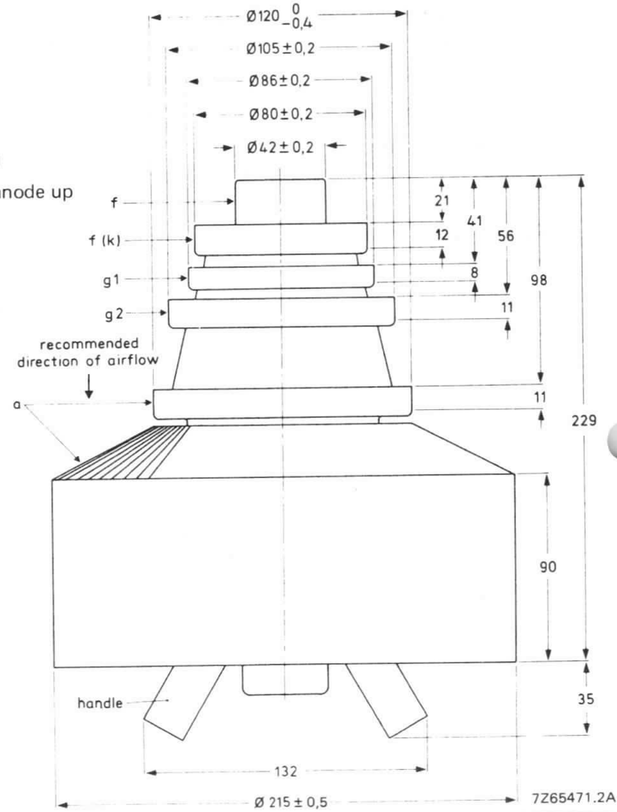
COOLING

$W_a + W_g$ kW	h m	T_i °C	q_{min} m³/min.	p_i, tube only Pa	p_i including circuit assembly Pa	max. T out °C
25	500	40	30	1000	1600	94

Direction of air flow: See outline drawing.
The air should be ducted so that sufficient air is directed to the seals to keep the seal temperature below the limit.

MECHANICAL DATA

Net mass	approx. 17 kg
Mounting position	vertical with anode up or down.



R.F. CLASS-B POWER AMPLIFIER

Unless otherwise stated, the voltages are given with respect to the cathode.

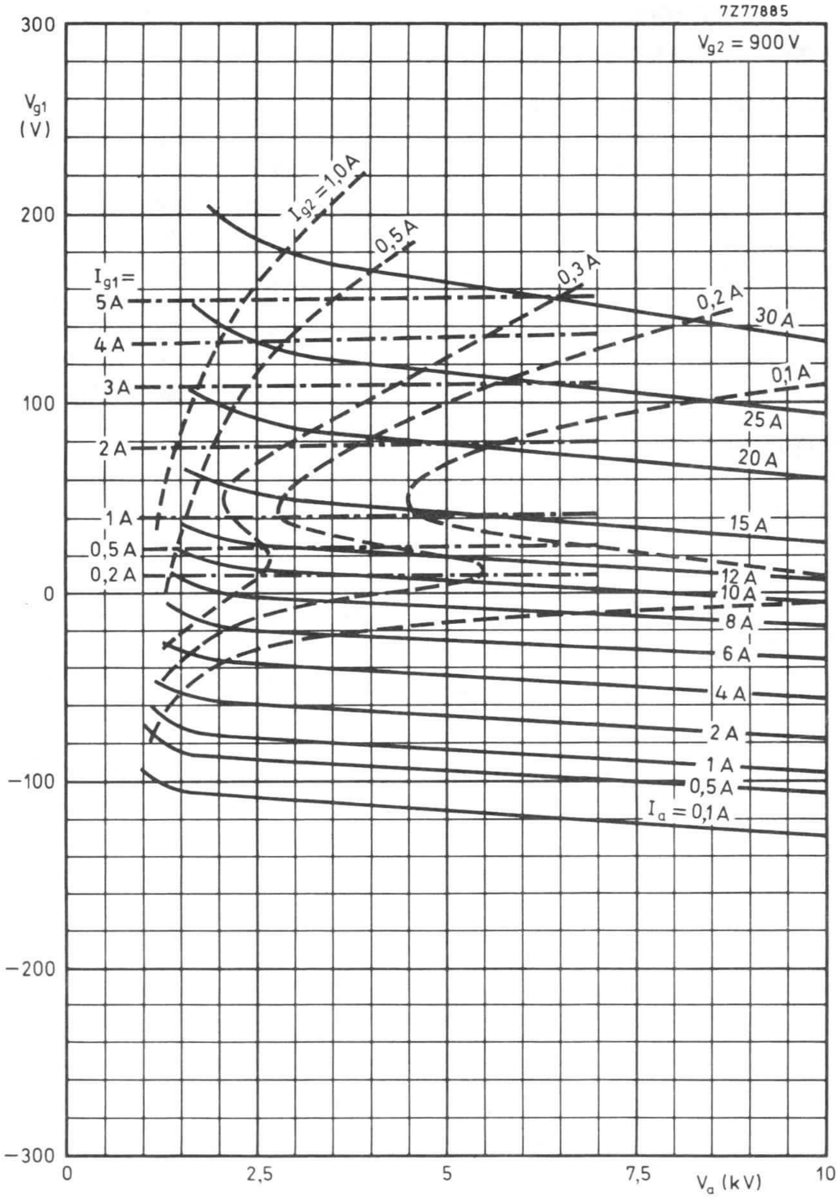
LIMITING VALUES (Absolute maximum rating system)

Frequency	f	up to	250	MHz
Anode voltage	V_a	max.	12	kV
Grid 2 voltage	V_{g2}	max.	1200	V
Grid 1 voltage	$-V_{g1}$	max.	500	V
Anode current	I_a	max.	8	A
Anode dissipation	W_a	max.	30	kW
Grid 2 dissipation	W_{g2}	max.	400	W
Grid 1 dissipation	W_{g1}	max.	300	W
Cathode current	I_k	max.	9	A

OPERATING CONDITIONS (grounded grid)

Frequency	f		200	MHz	
Anode voltage	V_a		10	kV	
Grid 2 voltage	V_{g2}		900	V	
Grid 1 voltage	V_{g1}	≈	−90	V	*
Anode current, no-signal condition	I_a		1,0	A	
Anode current	I_a		5,9	A	
Grid 2 current	I_{g2}		190	mA	
Grid 1 current	I_{g1}		370	mA	
Output power in load	W_ℓ	⩾	35	kW	
Driving power	W_{dr}		850	W	
Gain	G		16	dB	

* To be adjusted for the stated no-signal anode current.


7Z77885
V_{g2} = 900 V
V_{g1} (V)
300
200
100
0
−100
−200
−300
I_{g1} =
5 A
4 A
3 A
2 A
1 A
0,5 A
0,2 A
I_{g2} = 1,0 A
0,5 A
0,3 A
0,2 A
0,1 A
30 A
25 A
20 A
15 A
12 A
10 A
8 A
6 A
4 A
2 A
1 A
0,5 A
I_a = 0,1 A
0
2,5
5
7,5
10
V_a (kV)

WATER COOLED 50 kW POWER TETRODE

Water cooled coaxial power tetrode in metal-ceramic construction primarily intended for use in R.F. power amplifier applications up to 100 MHz.

QUICK REFERENCE DATA

Class-B amplifier (C.W.)

Frequency	f		100 MHz
Anode voltage	V_a		12 kV
Anode output power	W		50 kW
Power gain	G		16 dB

HEATING: direct; thoriated tungsten filament, mesh type.

Filament voltage	V_f		7,5 V $^{+1\%}_{-3\%}$
Filament current	I_f		180 A
Filament peak starting current	I_{fp}	max.	1000 A
Cold filament resistance	R_{fo}		4,2 mΩ
Waiting time	t_w	min.	1 s

TYPICAL CHARACTERISTICS

Anode voltage	V_a		10 kV
Grid 2 voltage	V_{g2}		900 V
Anode current	I_a		2,4 A
Transconductance	S	≈	70 mA/V
Amplification factor	μ_{g2g1}		10

CAPACITANCES, grounded grid

			grounded grid
Input	C_i		86 pF
Output	C_o		29 pF
Anode to filament	C_{af}	<	0,3 pF

TEMPERATURE LIMITS

Absolute maximum envelope temperature	T_{env}	max.	240 °C
Recommended maximum seal temperature	T	max.	200 °C

orange binder, tab 7

COOLING

W_a kW	T_i °C	q l/min	pi kPa	T_o °C
30	20	21	34	42
	50	32	71	64
20	20	14	17	43
	50	20	31	66

Absolute maximum water inlet temperature T_i 50 °C

Absolute maximum water pressure p 600 kPa

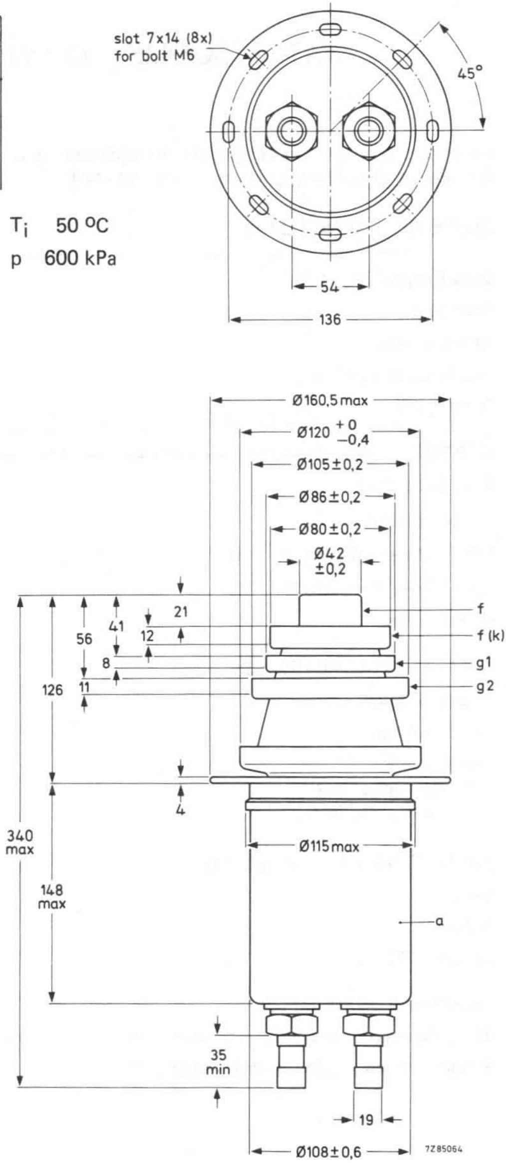
The temperature of the seals and envelope should be kept well below 200 °C.

An air flow of about 1 m^3/min must be ducted along the seals from a 30 mm diameter nozzle positioned at a distance of 200 mm from the tube header.

MECHANICAL DATA

Net mass 7 kg

Mounting position vertical with anode up or down.



R.F. CLASS-B POWER AMPLIFIER

Unless otherwise stated, the voltages are given with respect to the cathode.

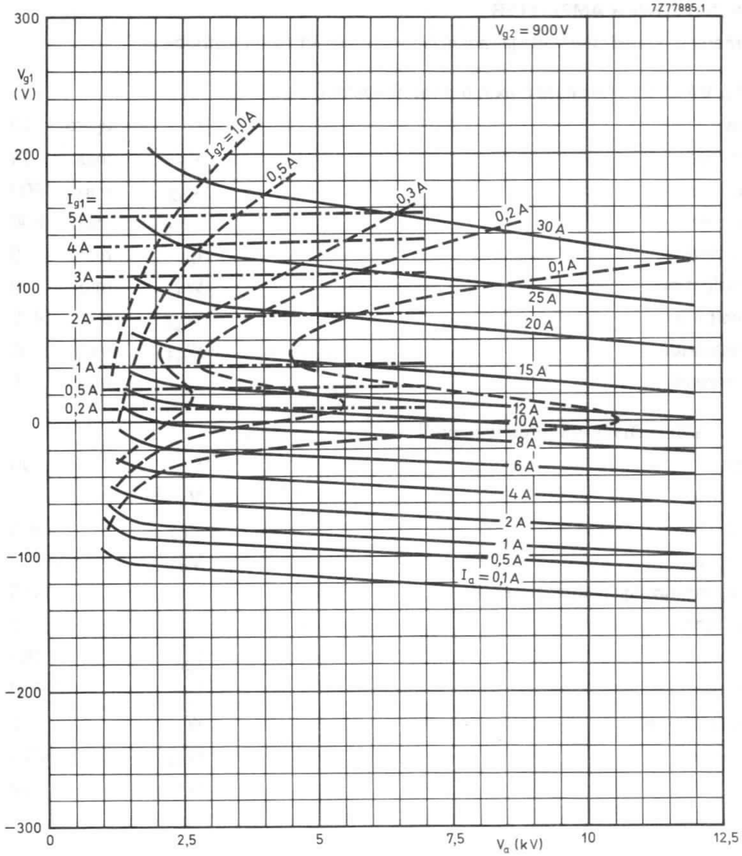
LIMITING VALUES (Absolute maximum rating system)

Frequency	f	up to	250	MHz
Anode voltage	V_a	max.	14	kV
Grid 2 voltage	V_{g2}	max.	1200	V
Grid 1 voltage	$-V_{g1}$	max.	500	V
Anode current	I_a	max.	8	A
Anode dissipation	W_a	max.	30	kW
Grid 2 dissipation	W_{g2}	max.	400	W
Grid 1 dissipation	W_{g1}	max.	300	W
Cathode current	I_k	max.	9	A

OPERATING CONDITIONS (grounded grid)

Frequency	f		100	MHz
Anode voltage	V_a		12	kV
Grid 2 voltage	V_{g2}		900	V
Grid 1 voltage	V_{g1}	≈	−110	V *
Anode current, no-signal condition	I_a		0,5	A
Anode current	I_a		6	A
Grid 2 current	I_{g2}		190	mA
Grid 1 current	I_{g1}		800	mA
Anode output power	W		50	kW
Driving power	W_{dr}		1250	W
Gain	G		16	dB

* To be adjusted for the stated no-signal anode current.


7Z77885.1
V_{g2} = 900 V
V_{g1} (V)
300
200
100
0
−100
−200
−300
I_{g1}=
5 A
4 A
3 A
2 A
1 A
0,5 A
0,2 A
I_{g2} = 1,0 A
0,5 A
0,3 A
0,2 A
0,1 A
30 A
25 A
20 A
15 A
12 A
10 A
8 A
6 A
4 A
2 A
1 A
0,5 A
I_a = 0,1 A
0
2,5
5
7,5
10
12,5
V_a (kV)

AIR COOLED V.H.F. POWER TETRODE

for grounded cathode operation

Forced air cooled coaxial power tetrode in metal-ceramic construction primarily intended for use as grid-driven linear amplifier for single sideband, suppressed carrier service and grid-driven broadband amplifier with high power gain in TV band I and III transmitters and transposers. The type is also very suitable for f.m. broadcast applications. The electrode arrangement is specially designed for grounded cathode operation.

QUICK REFERENCE DATA

Class-AB linear amplifier (vision)				
Frequency	f		175,25	MHz
Anode voltage	V_a		3	kV
Output power in load (sync)	W_ℓ		1,1	kW
Power gain	G		20	dB
Class-AB f.m. amplifier				
Frequency	f	up to	260	MHz
Anode voltage	V_a		4	kV
Output power in load	W_ℓ		2,2	kW
Power gain	G		22	dB

orange binder, tab 7

HEATING: direct; thoriated tungsten filament, mesh type

Filament voltage	V_f		4,2	$V^{+1\%}_{-3\%}$ ←
Filament current	I_f		53	A
Filament peak starting current	I_{fp}	max.	300	A
Cold filament resistance	R_{fo}		8,5	mΩ
Waiting time	t_w	min.	1	s

TYPICAL CHARACTERISTICS

Anode voltage	V_a	3	kV
Grid 2 voltage	V_{g2}	700	V
Anode current	I_a	500	mA
Transconductance	S	25	mA/V
Amplification factor	μ_{g2g1}	10	

CAPACITANCES grounded cathode

Input	C_i		54 pF
Output	C_o		8 pF
Anode to grid 1	C_{ag1}		0,1 pF

TEMPERATURE LIMITS

Absolute maximum envelope temperature	T_{env}	max.	240 °C
Recommended maximum seal temperature	T	max.	200 °C

COOLING

Direction of airflow: see drawing

$W_a + W_g$ W	h m	T_i °C	q_{min} m^3/min	p_i Pa	T_o max. °C
2000	0	35	2,00	530	92
1500	0	35	1,30	280	103
1000	0	35	0,80	140	113
2000	0	55	2,40	670	107
1500	0	55	1,55	340	118
1000	0	55	0,95	180	127
2000	1500	35	2,58	670	89
1500	1500	35	1,68	340	99
1000	1500	35	1,03	180	109
2000	3000	25	2,78	690	81
1500	3000	25	1,80	350	91
1000	3000	25	1,11	190	101

The air should be ducted so that sufficient air is directed to the seals to keep the seal temperature below the limit.

ACCESSORIES

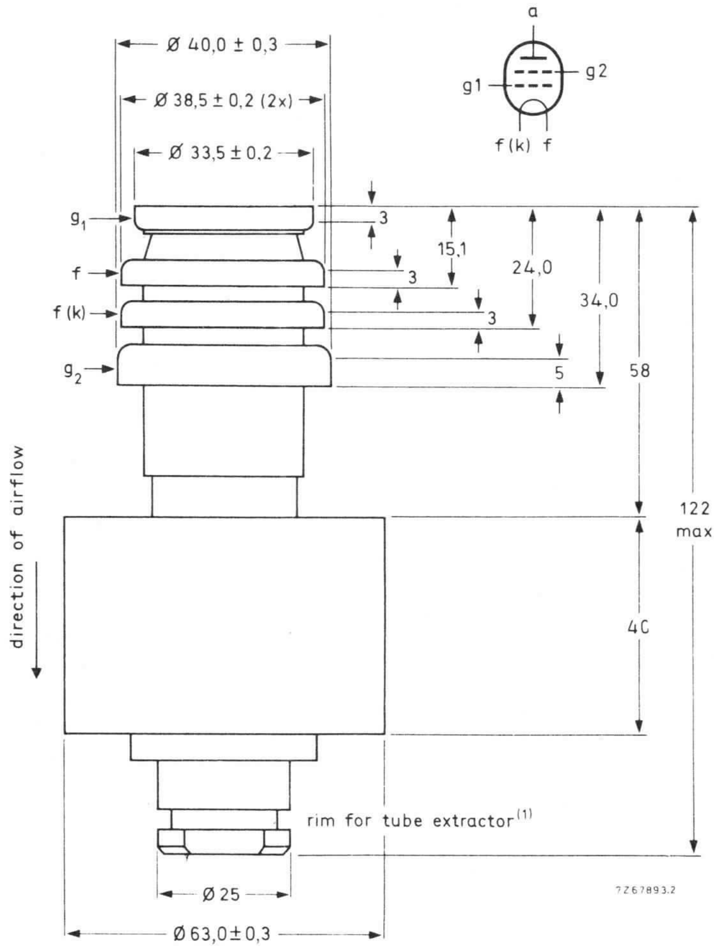
Band III amplifier circuit assembly (vision)	type 40776
Band III amplifier circuit assembly (sound)	type 40777
Band II amplifier circuit assembly (sound)	type 40778

MECHANICAL DATA

Dimensions in mm

Net mass: 0,55 kg

Mounting position: vertical with anode up or down



(1) Tube extractor type 40750; catalogue number 7322 120 02140.

RF CLASS-AB LINEAR AMPLIFIER FOR TELEVISION SERVICE

Negative modulation, positive synchronization (C.C.I.R. system).
Unless otherwise specified the voltages are given with respect to the cathode.

LIMITING VALUES (Absolute maximum rating system)					notes
Frequency	f	up to	260	MHz	
Anode voltage	V_a	max.	4,2	kV	
Grid 2 voltage	V_{g2}	max.	750	V	
Grid 1 voltage	$-V_{g1}$	max.	100	V	
Anode current, black	I_a	max.	1,2	A	
Anode input power, black	W_{ia}	max.	4	kW	
Anode dissipation	W_a	max.	2	kW	
Grid 2 dissipation	W_{g2}	max.	70	W	
Grid 1 dissipation	W_{g1}	max.	30	W	
Cathode current	I_k	max.	1,5	A	
Grid 1 circuit resistance	R_{g1}	max.	10	kΩ	

OPERATING CONDITIONS grid driven				4
Frequency of vision carrier	f	175,25	MHz	
Bandwidth (−1 dB)	B	7	MHz	1
Anode voltage	V_a	3	kV	
Grid 2 voltage	V_{g2}	700	V	
Grid 1 voltage	V_{g1}	−55	V	2
Anode current, no-signal condition	I_a	300	mA	
→ Anode current, black	$I_{a\ black}$	650	mA	3
Grid 2 current, black	$I_{g2\ black}$	20	mA	3
Grid 1 current, black	$I_{g1\ black}$	0	mA	3
Output power in load, sync	$W_{\ell\ sync}$	1100	W	
Output power in load, black	$W_{\ell\ black}$	660	W	3
Anode dissipation, black	$W_{a\ black}$	≈ 1200	W	
Gain, sync	G_{sync}	20	dB	
Gain, black	G_{black}	20	dB	
Sync compression	sync in/out	25/25		6
Differential phase		< 3	deg	7
Differential gain		⩾ 90	%	7
L.F. linearity		⩾ 90	%	7
Driving power sync	$W_{dr\ sync}$	11	W	

Notes: see page 5

CLASS-AB F.M. AMPLIFIER

LIMITING VALUES (Absolute maximum rating system)

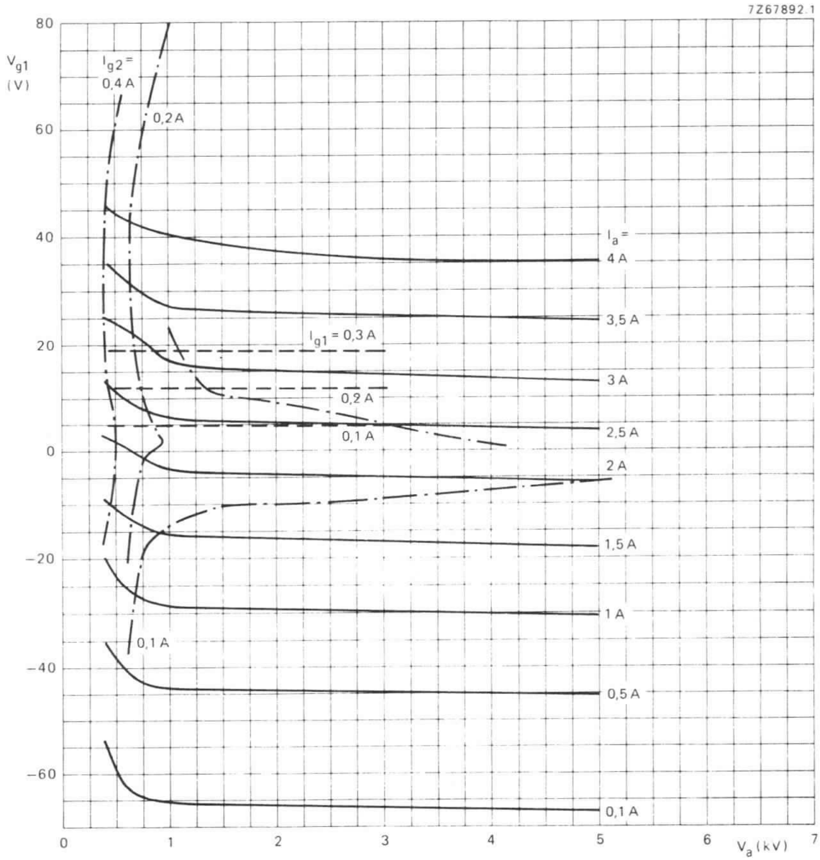
					notes
Frequency	f	up to	260	MHz	
Anode voltage	V_a	max.	4,2	kV	
Grid 2 voltage	V_{g2}	max.	750	V	
Grid 1 voltage	$-V_{g1}$	max.	100	V	
Anode current, black	I_a	max.	1,2	A	
Anode input power, black	W_{ia}	max.	4	kW	
Anode dissipation	W_a	max.	2	kW	
Grid 2 dissipation	W_{g2}	max.	70	W	
Grid 1 dissipation	W_{g1}	max.	30	W	
Cathode current	I_k	max.	1,5	A	
Grid 1 circuit resistance	R_{g1}	max.	10	kΩ	

OPERATING CONDITIONS grid driven

					notes
Frequency	f	80 to 230		MHz	5 ←
Anode voltage	V_a	3	4	kV	
Grid 2 voltage	V_{g2}	700	700	V	
Grid 1 voltage	V_{g1}	−60	−60	V	2
Anode current, no-signal condition	I_a	200	200	mA	
Anode current	I_a	700	900	mA	
Grid 2 current	I_{g2}	30	60	mA	
Grid 1 current	I_{g1}	10	20	mA	
Anode input power	W_{ia}	2,1	3,6	kW	
Anode dissipation	W_a	1,1	1,6	kW	
Output power in load	W_ℓ	1,1	2,2	kW	←
Power gain	G	22,5	22,5	dB	
Driving power	W_{dr}	6	12	W	

Notes

1. With double-tuned circuit.
2. To be adjusted for the stated no-signal anode current.
3. Black signal including line sync pulses.
4. Measured in amplifier circuit assembly type 40776.
5. Measured in amplifier circuit assembly types 40778 (band II) and 40777 band III respectively.
6. A picture/sync ratio of 75/25 for the outgoing signal requires a ratio of max. 70/30 for the incoming signal in which case the sync compression sync in/out = 30/25.
7. Measured with 10-step staircase amplitude, running from 17% to 75% of the peak sync value, with a superimposed 4,43 MHz sinewave with a 10% peak to peak value.


7Z67892.1
V_{g1} (V)
80
60
40
20
0
−20
−40
−60
I_{g2} = 0,4 A
0,2 A
0,1 A
I_a =
4 A
3,5 A
3 A
2,5 A
2 A
1,5 A
1 A
0,5 A
0,1 A
I_{g1} = 0,3 A
0,2 A
0,1 A
0
1
2
3
4
5
6
7
V_a (kV)

AIR-COOLED R.F. POWER TETRODE

Forced air-cooled coaxial power tetrode in metal-ceramic construction primarily intended for use as grid-driven linear amplifier for single sideband, suppressed carrier service.

QUICK REFERENCE DATA

Class-AB1 linear SSB amplifier

Frequency	f	1 to 30	MHz
Anode voltage	V_a	4	kV
Output power in load	W_l	2100	W
Power gain	G	23	dB

HEATING: direct; thoriated tungsten filament, mesh type

Filament voltage	V_f	4,2	V $^{+1\%}_{-3\%}$ ←
Filament current	I_f	53	A
Filament peak starting current	I_{fp} max	300	A
Cold filament resistance	R_{fo}	8,5	mΩ
Waiting time	t_w min	1	s

orange binder, tab 7

TYPICAL CHARACTERISTICS

Anode voltage	V_a	3	kV
Grid 2 voltage	V_{g2}	700	V
Anode current	I_a	500	mA
Transconductance	S	25	mA/V
Amplification factor	μ_{g2g1}	10	

CAPACITANCES

Input	C_i	54	pF
Output	C_o	8	pF
Anode to grid 1	C_{ag1}	0,1	pF

TEMPERATURE LIMITS

Absolute maximum envelope temperature T_{env} max. 240 °C

Recommended maximum seal temperature T max. 200 °C

COOLING

Direction of air flow: see drawing.

$W_a + W_g$ W	h m	T_i °C	q_{min} m³/min	p_i Pa	T_o max °C
2000	0	35	2,00	530	92
1500	0	35	1,30	280	103
1000	0	35	0,80	140	113
2000	0	55	2,40	670	107
1500	0	55	1,55	340	118
1000	0	55	0,95	180	127

The air should be ducted so that sufficient air is directed to the seals.

ACCESSORIES

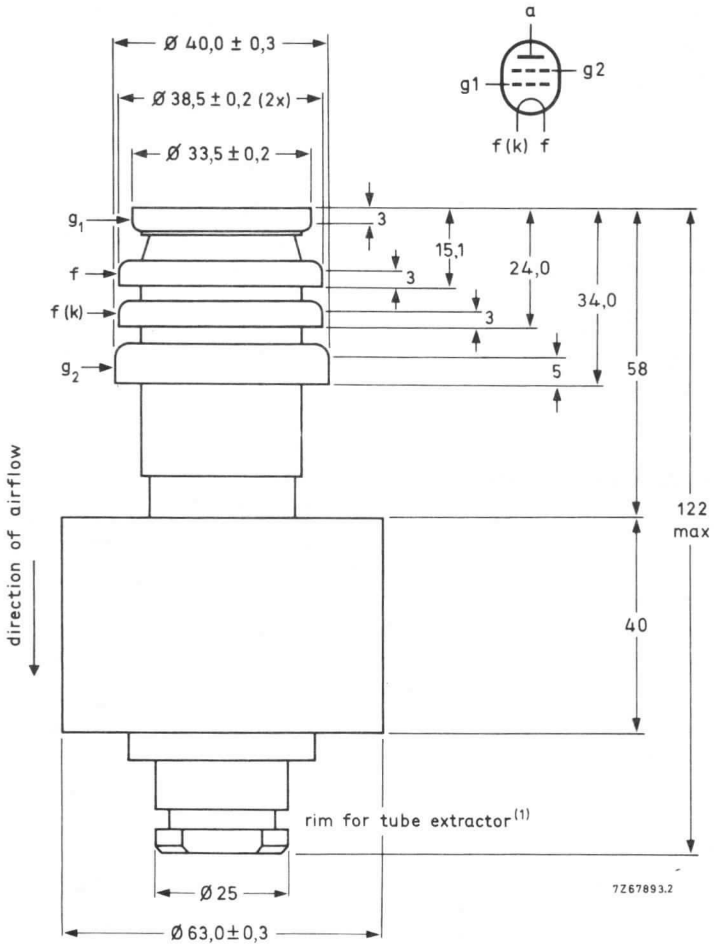
A drawing of the recommended socket construction is available on request.

MECHANICAL DATA

Dimensions in mm

Net mass: 0,55 kg

Mounting position: vertical with anode up or down



R.F. CLASS-AB LINEAR AMPLIFIER, SINGLE SIDEBAND, SUPPRESSED CARRIER

Unless otherwise specified the voltages are given with respect to the cathode.

LIMITING VALUES (Absolute maximum rating system)

					notes
Frequency	f		up to 110	MHz	
→ Anode voltage	V_a	max	4,4	kV	
Grid 2 voltage	V_{g2}	max	750	V	
Grid 1 voltage	$-V_{g1}$	max	100	V	
Anode current	I_a	max	1,2	A	
Cathode current	I_k	max	1,5	A	
Anode input power	W_{ia}	max	4	kW	
Anode dissipation	W_a	max	2	kW	
Grid 2 dissipation	W_{g2}	max	70	W	
Grid 1 dissipation	W_{g1}	max	30	W	
Grid 1 circuit resistance	R_{g1}	max	10	kΩ	

OPERATING CONDITIONS

Frequency	f	30	MHz		
Anode voltage	V_a	4	kV		
Grid 2 voltage	V_{g2}	700	V		
Grid 1 voltage	V_{g1}	~ −67	V		1
Grid 1 circuit resistance (load)	R_{g1}	1	kΩ		
Load resistance	$R_{a\sim}$	2500	Ω		

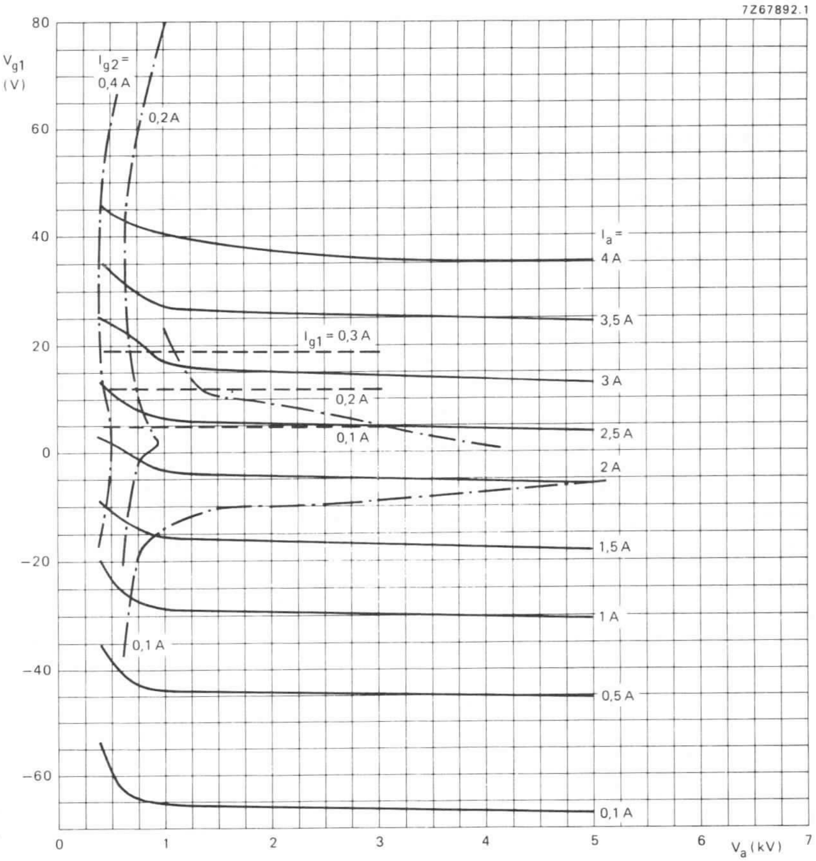
		zero signal	single tone signal	double tone signal		notes
Grid 1 driving voltage	$V_{g1\,p}$	0	80	80	V	
Anode current	I_a	200	900	550	mA	
Grid 2 current	I_{g2}	0	90	34	mA	
Grid 1 current	I_{g1}	0	20	1,5	mA	
Driving power (PEP)	W_{dr}	0	10	10	W	2
Anode input power	W_{ia}	800	3600	2200	W	
Anode dissipation	W_a	800	1500	1150	W	
Power gain	G			23	dB	
Output in load	W_l	–	2100	–	W	
Output power in load (PEP)	W_l	–	–	2100	W	
Total efficiency	η	–	58,5	48	%	
Intermodulation distortion						
3rd order	d_3	–	–	< -30	dB	3
5th order	d_5	–	–	< -35	dB	3

Notes: see page 5

						notes
Frequency	f		30		MHz	
Anode voltage	V_a		3		kV	
Grid 2 voltage	V_{g2}		700		V	
Grid 1 voltage	V_{g1}		≈ −66		V	1 ←
Grid 1 circuit resistance (load)	R_{g1}		1		kΩ	
Load resistance	$R_{a\sim}$		1500		Ω	
		zero signal	single tone signal	double tone signal		
Grid 1 driving voltage	$V_{g1\,p}$	0	75	75	V	
Anode current	I_a	200	800	500	mA	
Grid 2 current	I_{g2}	0	90	40	mA	
Grid 1 current	I_{g1}	0	10	1	mA	
Driving power (PEP)	W_{dr}	0	10	10	W	2
Anode input power	W_{ia}	600	2400	1500	W	
Anode dissipation	W_a	600	800	700	W	
Power gain	G	–	–	22	dB	
Output power in load	W_l	–	1600	–	W	
Output power in load (PEP)	W_l	–	–	1600	W	
Total efficiency	η	–	66	53	%	
Intermodulation distortion						
3rd order	d_3	–	–	−30	dB	3
5th order	d_5	–	–	−30	dB	3

Notes

1. To be adjusted for the stated no-signal anode current.
2. Design value for output power of driver stage.
3. Maximum values encountered at any level of drive voltage referred to the amplitude of either of the two equal tones at that level.


7Z67892.1
V_{g1} (V)
I_{g2} =
0,4 A
0,2 A
0,1 A
I_{g1} = 0,3 A
0,2 A
0,1 A
I_a =
4 A
3,5 A
3 A
2,5 A
2 A
1,5 A
1 A
0,5 A
0,1 A
V_a (kV)
80
60
40
20
0
−20
−40
−60
0
1
2
3
4
5
6
7

AIR COOLED U.H.F. POWER TETRODE

Forced-air cooled coaxial power tetrode in metal-ceramic construction. The tube features a high gain and a high linearity and is primarily intended for use as linear broadband amplifier in band IV/V TV transmitters and transposers.

QUICK REFERENCE DATA

Class-AB linear amplifier				
Frequency	f		860	MHz
Anode voltage	V_a		5,5	kV
Output power in load, sync	$W_{\ell(sync)}$		5,5	kW
Power gain	G		16,5	dB
TV transposer service				
Frequency	f		470 to 860	MHz
Anode voltage	V_a		5,0	kV
Output power in load, sync	$W_{\ell(sync)}$		2,2	kW
Power gain	G		16,5	dB

HEATING: direct; thoriated tungsten filament

Filament voltage	V_f		5	$V^{+1\%}_{-3\%}$ ←
Filament current	I_f		130	A
Filament peak starting current	I_{fp}	max.	800	A
Cold filament resistance	R_{fo}		4,5	mΩ
Waiting time	t_w	min.	1	s

TYPICAL CHARACTERISTICS

Anode voltage	V_a	2	kV
Grid 2 voltage	V_{g2}	700	V
Anode current	I_a	6	A
Transconductance	S	140	mA/V
Amplification factor	μ_{g2g1}	8	

CAPACITANCES, grounded-grid

Input	C_i		62 pF
Output	C_o		13 pF
Anode to filament	C_{af}	<	0,1 pF

TEMPERATURE LIMITS

Absolute maximum envelope temperature	T_{env}	240 °C
Recommended maximum seal temperature	T_s	200 °C

→ **COOLING**

$W_a + W_g$ kW	h m	T_i °C	q_{min} m³/min	p_i Pa tube only	p_i Pa tube + cavity	T_o max. °C
7	0	35	7,5	660	1240	88
5	0	35	5,0	330	620	94
7	0	55	9,3	860	1700	101
5	0	55	6,2	430	850	106
7	1500	35	9,0	800	1450	88
5	1500	35	6,0	400	730	96
7	3000	25	9,6	800	1450	83
5	3000	25	6,4	400	730	90

The air should be ducted so that sufficient air is directed to the seals to keep the seal temperature below the limit.

For direction of air flow see outline drawing. The air should be ducted so that sufficient air is directed to the seals to keep the seal temperature below the limit.

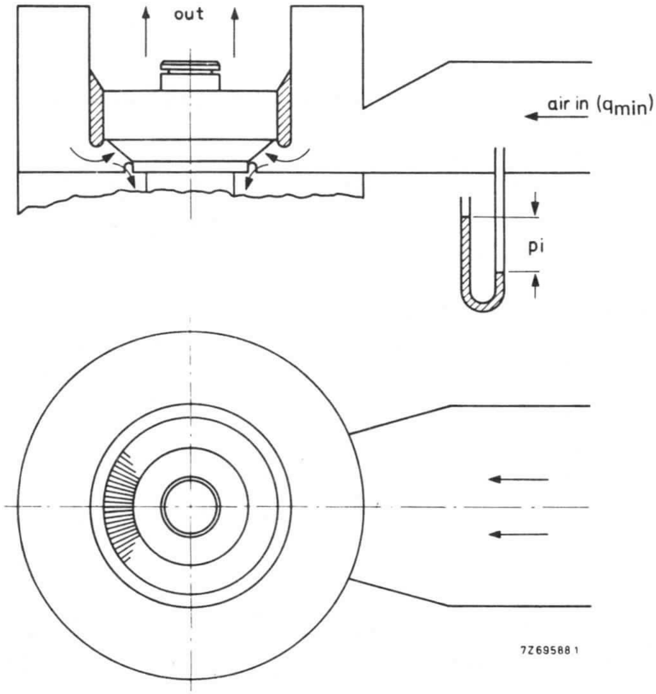


Fig. 1 Schematic of cooling air flow.

ACCESSORIES

Band IV/V amplifier circuit assembly type 40783.

MECHANICAL DATA

Dimensions in mm

Net mass: ≈ 3,5 kg

Mounting position: vertical with anode up or down

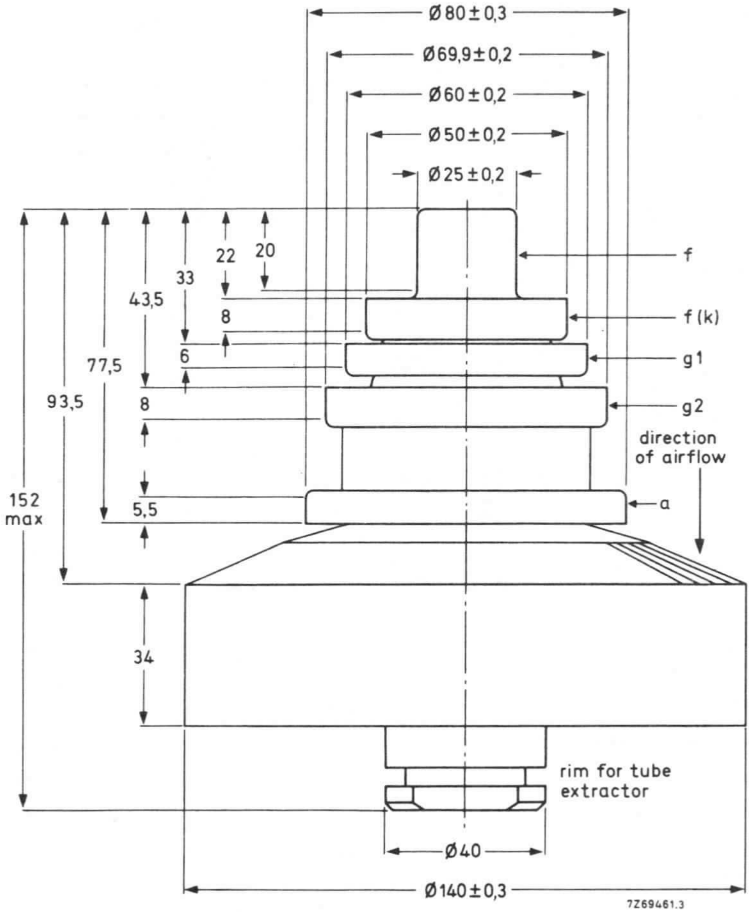


Fig. 2.

R.F. CLASS-AB LINEAR AMPLIFIER FOR TELEVISION SERVICE

(Detailed information on definitions of terms and application suggestions are available on request.)

Negative modulation, positive synchronization (CCIR system).
Unless otherwise stated, the voltages are given with respect to the cathode.

LIMITING VALUES (Absolute maximum rating system)

					notes
Frequency	f	up to	1000	MHz	
Anode voltage	V_a	max.	6	kV	
Grid 2 voltage	V_{g2}	max.	1000	V	
Grid 1 voltage	$-V_{g1}$	max.	200	V	
Anode current, black	$I_{a\,black}$	max.	2,5	A	
Anode input power, black	$W_{ia\,black}$	max.	10	kW	
Anode dissipation	W_a	max.	7	kW	
Grid 2 dissipation	W_{g2}	max.	100	W	
Grid 1 dissipation	W_{g1}	max.	50	W	←
Cathode current	I_k	max.	4	A	

OPERATING CONDITIONS, grounded grid, grounded screen grid

					notes
Frequency of vision carrier	f		470 to 860	MHz	
Bandwidth (−1 dB)	B		10	MHz	1
Anode voltage	V_a		5,5	kV	
Grid 2 voltage	V_{g2}		700	V	
Grid 1 voltage	V_{g1}		−65	V	2
Anode current, no-signal condition	I_a		1,0	A	
Anode current, black	$I_{a\,black}$		1,9	A	3
Grid 2 current, black	$I_{g2\,black}$	≈	30	mA	3
Grid 1 current, black	$I_{g1\,black}$	≈	0	mA	3
Output power in load, sync	$W_{\ell\,sync}$		5,5	kW	
Output power in load, black	$W_{\ell\,black}$		3,3	kW	3
Anode dissipation, black	$W_{a\,black}$	≈	6,8	kW	
Power gain, sync	G_{sync}		16,5	dB	
Power gain, black	G_{black}		17	dB	
Sync compression	sync in/out		30/25		4
Differential phase		≈	4	deg	5
Differential gain		⩾	92	%	5
L.F. linearity		⩾	92	%	5
Driving power, sync	$W_{dr\,sync}$		125	W	←

Notes: see page 6

R.F. CLASS-AB AMPLIFIER FOR TELEVISION TRANSPOSER SERVICE

LIMITING VALUES

Unless otherwise stated, the voltages are given with respect to the cathode.

					notes
Frequency	f	up to	1000	MHz	
Anode voltage	V_a	max.	6	kV	
Grid 2 voltage	V_{g2}	max.	1000	V	
Grid 1 voltage	$-V_{g1}$	max.	200	V	
Anode current, 0 dB	I_a	max.	2,5	A	
Anode input power, 0 dB	W_{ia}	max.	10	kW	
Anode dissipation	W_a	max.	7	kW	
Grid 2 dissipation	W_{g2}	max.	100	W	
→ Grid 1 dissipation	W_{g1}	max.	50	W	
Cathode current	I_k	max.	4	A	

OPERATING CONDITIONS

Negative modulation, positive synchronization, combined sound and vision (CCIR standard G)

					notes
Frequency	f		470 to 860	MHz	
Bandwidth (−1 dB)	B		10	MHz	1
Anode voltage	V_a		5,0	kV	
Grid 2 voltage	V_{g2}		700	V	
Grid 1 voltage	V_{g1}		−60	V	2
Anode current, no-signal condition	I_a		1,2	A	
Anode current	I_a		1,8	A	6
Grid 2 current	I_{g2}	≈	20	mA	6
Grid 1 current	I_{g1}	≈	0	mA	6
Output power in load, sync	$W_{\ell\, sync}$		2,2	kW	
Power gain	G		16,5	dB	
Intermodulation products	d		−54	dB	7

Notes
1. With double-tuned circuit.
2. To be adjusted for the stated no-signal anode current.
3. Black signal including line sync pulses.
4. A picture/sync ratio of 75/25 for the outgoing signal requires a ratio of max. 70/30 for the incoming signal, in which case the sync compression is 30/25.
5. Measured with a 9-step staircase amplitude, running from 17% to 75% of the peak sync value, with a superimposed 4,43 MHz sine-wave having a 10% peak-to-peak value.
6. At a C.W. output power = 2,2 kW.
7. Three-tone test method (vision carrier −8 dB, sound carrier −10 dB, sideband signal −16 dB with respect to peak sync = 0 dB).

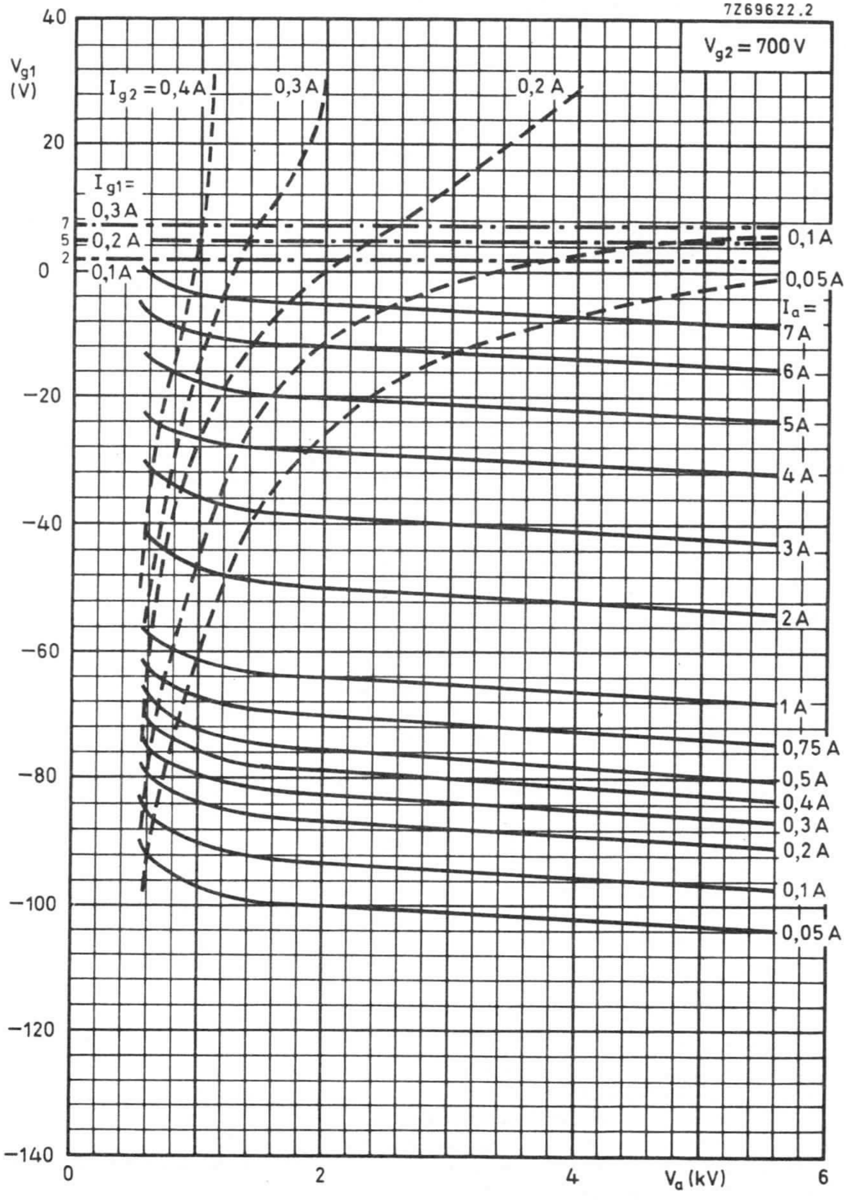

7Z69622.2
V_{g2} = 700 V
V_{g1} (V)
I_{g2} = 0,4 A
0,3 A
0,2 A
I_{g1} =
0,3 A
0,2 A
0,1 A
0,1 A
0,05 A
I_a =
7 A
6 A
5 A
4 A
3 A
2 A
1 A
0,75 A
0,5 A
0,4 A
0,3 A
0,2 A
0,1 A
0,05 A
40
20
0
−20
−40
−60
−80
−100
−120
−140
7
5
2
0
2
4
6
V_a (kV)

Fig. 3.

AIR COOLED U.H.F. POWER TETRODE

Forced-air cooled coaxial power tetrode in metal-ceramic construction. The tube features a high gain and a high linearity and is primarily intended for use as linear broadband amplifier in band IV/V TV transmitters and transposers.

QUICK REFERENCE DATA

Class-AB linear amplifier

Frequency	f		860 MHz
Anode voltage	V_a		3,5 kV
Output power in load, sync	$W_{\ell(sync)}$		600 W
Power gain	G		15,4 dB

TV transposer service

Frequency	f		860 MHz
Anode voltage	V_a		3,0 kV
Output power in load, sync	$W_{\ell(sync)}$		220 W
Power gain	G		15,6 dB

Class-AB f.m. amplifier

Frequency	f		860 MHz
Anode voltage	V_a		4,0 kV
Output power in load	W_ℓ		1,1 kW
Power gain	G		16,4 dB

HEATING: direct; thoriated tungsten filament

Filament voltage	V_f		3,9 V $^{+1\%}_{-3\%}$ ←
Filament current	I_f		52 A
Filament peak starting current	I_{fp}	max.	300 A
Cold filament resistance	R_{fo}		10 mΩ
Waiting time	t_w	min.	1 s

TYPICAL CHARACTERISTICS

Anode voltage	V_a	1 kV
Grid 2 voltage	V_{g2}	700 V
Anode current	I_a	2 A
Transconductance	S	60 mA/V
Amplification factor	μ_{g2g1}	13

orange binder, tab 7

CAPACITANCES, grounded-grid

Input	C_i		26 pF
Output	C_o		8,6 pF
Anode to filament	C_{af}	<	0,05 pF

TEMPERATURE LIMITS

Absolute maximum envelope temperature	T_{env}	240 °C
Recommended max. seal temperature	T_s	200 °C

COOLING

$W_a + W_g$ kW	h m	T_{in} °C	q_{min} m³/min see Fig. 1	p_i P_a tube only	tube + cavity	T_{out} °C
2	0	35	2,5	450	600	79
2	0	55	3,0	800	1000	86
2	1500	35	3,0	550	720	79
2	3000	25	3,3	550	720	77

For direction of air flow see outline drawing. The air should be ducted so that sufficient air is directed to the seals.

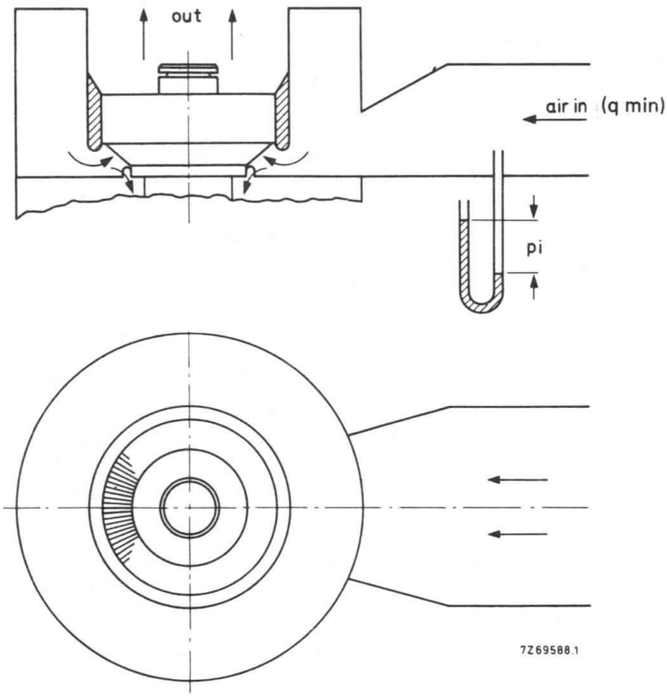


Fig. 1 Schematic of cooling air flow.

ACCESSORIES

Band IV/V amplifier circuit assembly (transposer), vision	type 40782V
Band IV/V amplifier circuit assembly, sound	type 40782S

MECHANICAL DATA

Dimensions in mm

Net mass: ≈ 0,85 kg

Mounting position: vertical with anode up or down

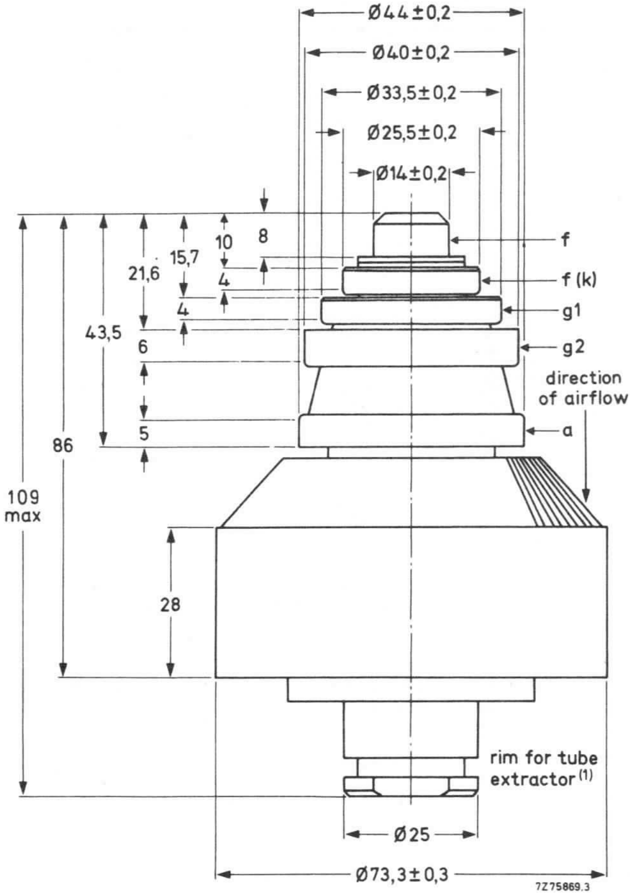


Fig. 2.

(1) Tube extractor type 40750; catalogue number 7322 120 02140.

R.F. CLASS-AB LINEAR AMPLIFIER FOR TELEVISION SERVICE

(Detailed information on definitions of terms and application suggestions are available on request.)

Negative modulation, positive synchronization (CCIR system)

Unless otherwise stated, the voltages are given with respect to the cathode.

LIMITING VALUES (Absolute maximum rating system)

					notes
Frequency	f	up to	1000	MHz	
Anode voltage	V_a	max.	4	kV	
Grid 2 voltage	V_{g2}	max.	800	V	
Grid 1 voltage	$-V_{g1}$	max.	100	V	
Anode current, black	$I_{a\ black}$	max.	700	mA	
Anode input power, black	$W_{ia\ black}$	max.	2,5	kW	
Anode dissipation	W_a	max.	2	kW	
Grid 2 dissipation	W_{g2}	max.	25	W	
Grid 1 dissipation	W_{g1}	max.	25	W	
Cathode current	I_k	max.	1	A	

OPERATING CONDITIONS, grounded grid, grounded screen grid

					notes
Frequency of vision carrier	f		470 to 860	MHz	
Bandwidth (−1 dB)	B		9	MHz	1
Anode voltage	V_a		3,5	kV	
Grid 2 voltage	V_{g2}		700	V	
Grid 1 voltage	V_{g1}	≈	−36	V	2
Anode current, no-signal condition	I_a		400	mA	
Anode current, black	$I_{a\ black}$	≈	640	mA	3
Grid 2 current, black	$I_{g2\ black}$	≈	7	mA	3
Grid 1 current, black	$I_{g1\ black}$	≈	0	mA	3
Output power in load, sync	$W_{\ell\ sync}$		600	W	
Output power in load, black	$W_{\ell\ black}$		360	W	3
Anode dissipation, black	$W_{a\ black}$	≈	1,8	kW	
Power gain, sync	G_{sync}		15,4	dB	
Power gain, black	G_{black}		15,6	dB	
Sync compression	sync in/out		28/25		4
Differential phase		⩽	3	deg	5
Differential gain		⩾	90	%	5
L.F. linearity		⩾	90	%	5
Driving power, sync	$W_{dr\ sync}$		18	W	

Notes: see page 6

R.F. CLASS-AB AMPLIFIER FOR TELEVISION TRANSPOSER SERVICE

Unless otherwise stated, the voltages are given with respect to the cathode.

LIMITING VALUES (Absolute maximum rating system)

					notes
Frequency	f	up to	1000	MHz	
Anode voltage	V_a	max.	4	kV	
Grid 2 voltage	V_{g2}	max.	800	V	
Grid 1 voltage	$-V_{g1}$	max.	100	V	
Anode current, 0 dB	I_a	max.	700	mA	
Anode input power, 0 dB	W_{ia}	max.	2,2	kW	
Anode dissipation	W_a	max.	2	kW	
Grid 2 dissipation	W_{g2}	max.	25	W	
Grid 1 dissipation	W_{g1}	max.	25	W	
Cathode current	I_k	max.	1	A	

OPERATING CONDITIONS, grounded grid, grounded screen grid

Negative modulation, positive synchronization, combined sound and vision (CCIR standard G)

Frequency	f		470 to 860	MHz	
Bandwidth (−1 dB)	B		10	MHz	1
Anode voltage	V_a		3,0	kV	
Grid 2 voltage	V_{g2}		700	V	
Grid 1 voltage	V_{g1}	≈	−32	V	2
Anode current, no-signal condition	I_a		500	mA	
Anode current	I_a	≈	620	mA	6
Grid 2 current	I_{g2}	≈	4	mA	6
Grid 1 current	I_{g1}	≈	0	mA	6
Output power in load, sync	$W_{\ell\ sync}$		220	W	
Power gain	G		15,6	dB	
Intermodulation products	d	⩽	−54	dB	7

Notes

1. With double-tuned circuit.
2. To be adjusted for the stated no-signal anode current.
3. Black signal including line sync pulses.
4. A picture/sync ratio of 75/25 for the outgoing signal requires a ratio of max. 70/30 for the incoming signal, in which case the sync compression is 30/25.
5. Measured with a 10-step staircase amplitude, running from 17% to 75% of the peak sync value, with a superimposed 4,43 MHz sine-wave having a 10% peak-to-peak value.
6. At a C.W. output power is 220 W.
7. Three-tone test method (vision carrier −8 dB, sound carrier −10 dB, sideband signal −16 dB with respect to peak sync = 0 dB).

CLASS-AB F.M. AMPLIFIER

Unless otherwise stated, the voltages are given with respect to the cathode.

LIMITING VALUES (Absolute maximum rating system)

					note
Frequency	f	up to	1000	MHz	
Anode voltage	V_a	max.	4,2	kV	
Grid 2 voltage	V_{g2}	max.	800	V	
Grid 1 voltage	$-V_{g1}$	max.	100	V	
Anode current	I_a	max.	800	mA	
Anode input power	W_{ia}	max.	3	kW	
Anode dissipation	W_a	max.	2	kW	
Grid 2 dissipation	W_{g2}	max.	25	W	
Grid 1 dissipation	W_{g1}	max.	25	W	
Cathode current	I_k	max.	1	A	

OPERATING CONDITIONS, grounded grid, grounded screen grid

Frequency	f		470 to 860	MHz	
Bandwidth (−3 dB)	B		4	MHz	
Anode voltage	V_a		4,0	kV	
Grid 2 voltage	V_{g2}		700	V	
Grid 1 voltage	V_{g1}	≈	−48	V	2
Anode current, no-signal condition	I_a		200	mA	
Anode current	I_a	≈	730	mA	
Grid 2 current	I_{g2}	≈	20	mA	
Grid 1 current	I_{g1}	≈	4	mA	
Anode input power	W_{ia}		2920	W	
Anode dissipation	W_a		1580	W	
Output power in load	W_ℓ		1,1	kW	
Power gain	G		16,4	dB	
Driving power			25	W	

Notes: see page 6

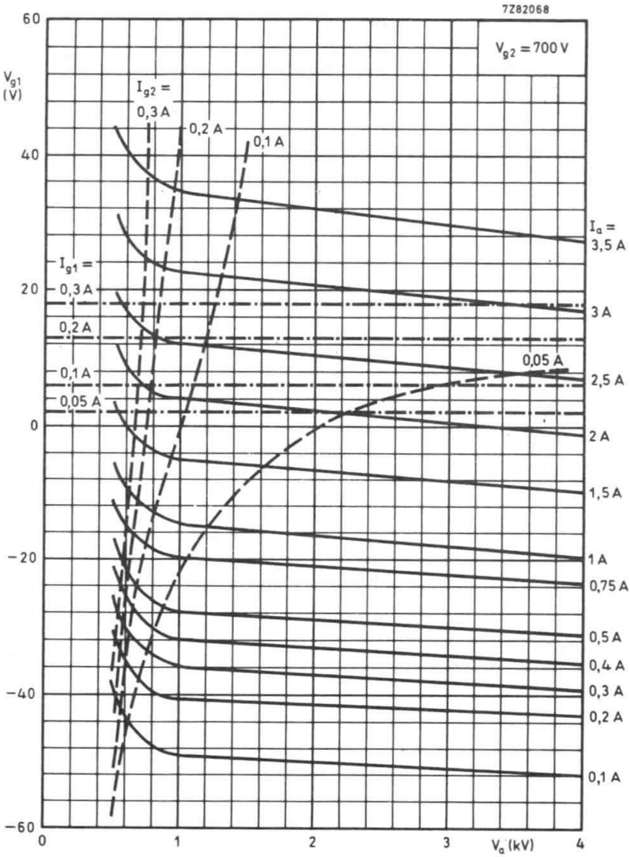

7Z82068
V_{g2} = 700 V
V_{g1} (V)
60
40
20
0
−20
−40
−60
I_{g2} =
0,3 A
0,2 A
0,1 A
I_{g1} =
0,3 A
0,2 A
0,1 A
0,05 A
0,05 A
I_a =
3,5 A
3 A
2,5 A
2 A
1,5 A
1 A
0,75 A
0,5 A
0,4 A
0,3 A
0,2 A
0,1 A
0
1
2
3
4
V_a (kV)

Fig. 3.

Supersedes December 1981 data

AIR COOLED V.H.F. POWER TETRODE

Forced air cooled coaxial power tetrode in metal-ceramic construction primarily intended for use as a high gain linear broadband amplifier in band III TV transmitters. This type is also recommended for f.m. broadcast applications.

QUICK REFERENCE DATA

Class-AB linear amplifier (vision)

Frequency	f	225	MHz ←
Anode voltage	V_a	5,5	kV
Output power in load, sync	W_ℓ	11	kW
Power gain, sync	G	17	dB

Class-AB f.m. amplifier

Frequency	f		230	MHz ←
Anode voltage	V_a	5,5	6,5	kV
Output power in load	W_ℓ	5	10	kW
Gain	G	19	19	dB

HEATING: direct; thoriated tungsten filament, mesh type.

Filament voltage	V_f	8	V^{+1}_{-3} %
Filament current	I_f	113	A
Filament peak starting current	I_{fp}	max. 560	A
Cold filament resistance	R_{fo}	7,7	mΩ

Waiting time: procedure prior to switching subsequently $-V_{g1}$, V_a and V_{g2}:

$V_f = 2$ V	t_w	30	s
then $V_f = 8$ V	t_w	5	s

TYPICAL CHARACTERISTICS

Anode voltage	V_a	5	kV
Grid 2 voltage	V_{g2}	500	V
Anode current	I_a	2	A
Transconductance	S	115	mA/V
Amplification factor	μ_{g2g1}	8	

CAPACITANCES

Input	C_i	85	pF
Output	C_o	17,5	pF

orange binder, tab 7

TEMPERATURE LIMITS

Absolute maximum envelope temperature	T_{env}	240 °C
Recommended maximum seal temperature	T_s	200 °C

COOLING

$W_a + W_g$ kW	h m	T_i °C	q_{min} m³/min	P_i P_a tube only	tube + cavity	T_o max. °C
14	0	25	12	1040	1350	100
10	0	25	8	490	600	100
14	0	55	16	1680	2650	110
10	0	55	12	990	1350	110
14	1500	25	14	1190	1550	100
10	1500	25	10	640	800	100
14	1500	40	16	1500	2200	110
10	1500	40	12	900	1200	110
14	3000	25	16	1330	1750	100
10	3000	25	12	780	1000	100

For direction of air flow see outline drawing. The air should be ducted so that sufficient air is directed to the seals to keep the seal temperature below the limit.

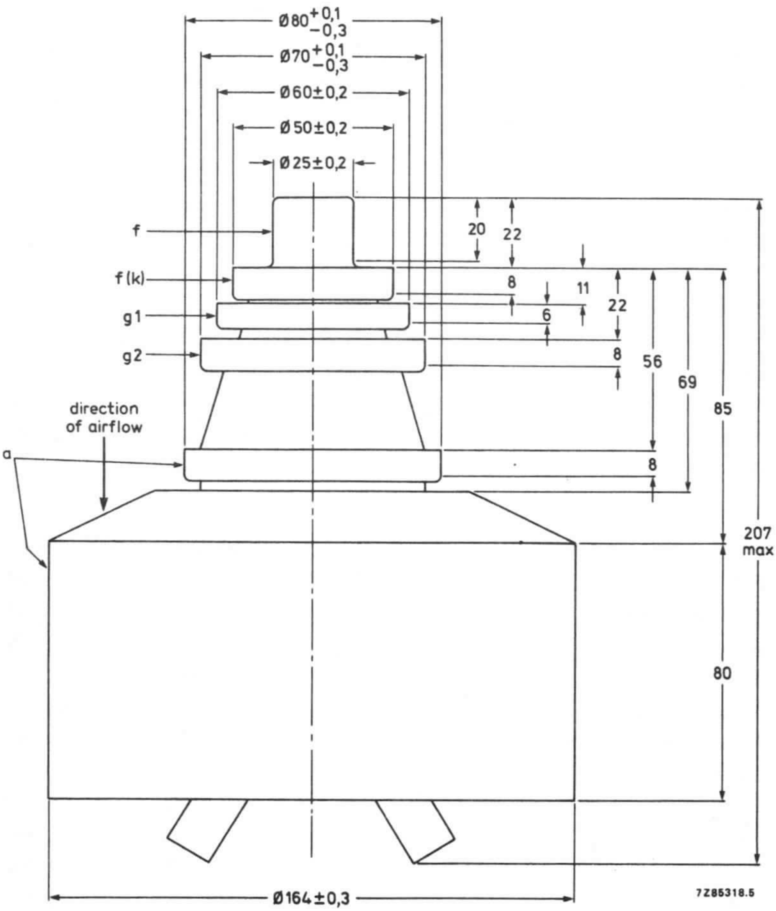
LIMITING VALUES

Frequency	f	up to	250 MHz
Anode voltage	V_a		7 kV
Grid 2 voltage	V_{g2}		800 V
Grid 1 voltage	$-V_{g1}$		250 V
Anode current, black	I_a		4 A
Anode input power, black	W_{ia}		20 kW
Anode dissipation	W_a		14 kW
Grid 2 dissipation	W_{g2}		80 W
Grid 1 dissipation	W_{g1}		80 W

MECHANICAL DATA

Net mass: approx. 9 kg

Mounting position: vertical with anode up or down.



DEVELOPMENT SAMPLE DATA

ACCESSORIES

Band II amplifier circuit assembly	type 40788
Band III amplifier circuit assembly (vision)	type 40787V
Band III amplifier circuit assembly (sound)	type 40787S

Input circuits of the cavities are broadbanded (no input tuning required)

OPERATING CONDITIONS, cathode driven

The voltages are given with respect to the cathode.

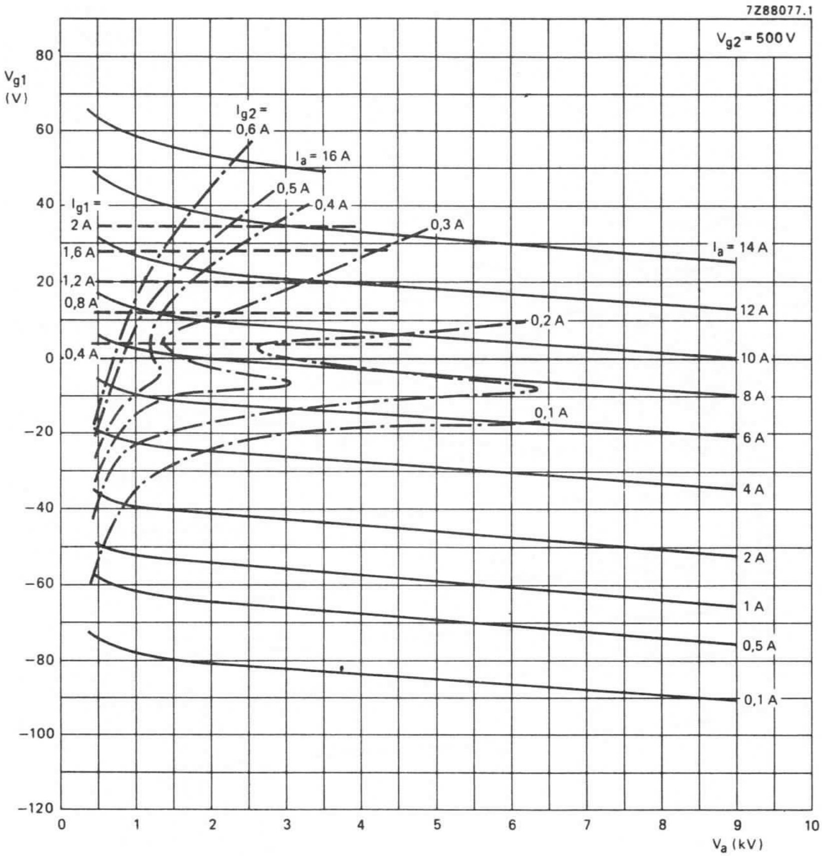
CLASS-AB AMPLIFIER FOR TELEVISION SERVICE

						notes
Frequency of vision carrier	f		175 to 225	175 to 225	MHz	
Bandwidth (−1 dB)	B		8	8	MHz	1
Anode voltage	V_a		4,5	5,5	kV	
Grid 2 voltage	V_{g2}		500	500	V	
Grid 1 voltage	$-V_{g1}$	≈	50	50	V	2
Anode current, zero signal	I_a		1,2	1,2	A	3
Anode current, black	I_a	≈	2,5	2,9	A	3
Grid 2 current, black	I_{g2}	≈	100	100	mA	3
Grid 1 current, black	I_{g1}	≈	0	20	mA	
Output power in load, sync	W_ℓ		5,5	11	kW	
Output power in load, black	W_ℓ		3,3	6,6	kW	
Gain, black	G		17	17	dB	
Sync compression	sync in/out	≤	30/25	30/25		4
Differential phase		<	3	3	deg	6
Differential gain		≥	90	90	%	6
L.F. linearity		≥	90	90	%	5

CLASS-AB F.M. AMPLIFIER

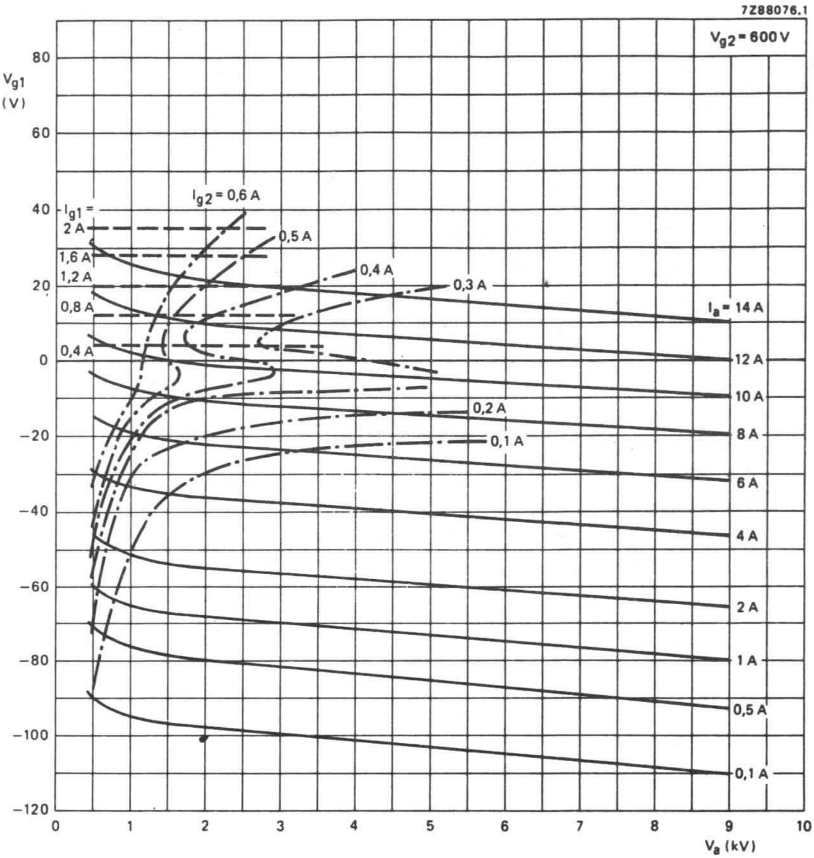
						notes
Frequency	f		80 - 230	80 - 230	MHz	
Bandwidth (−3 dB) 80 MHz	B	≈	1,5	1,5	MHz	
Bandwidth (−3 dB) 230 MHz	B	≈	4	4	MHz	
Anode voltage	V_a		5,5	6,5	kV	
Grid 2 voltage	V_{g2}		500	500	V	
Grid 1 voltage	$-V_{g1}$	≈	60	60	V	2
Anode current, no-signal condition	I_a		1	1	A	
Anode current	I_a	≈	2,2	2,7	A	
Grid 2 current	I_{g2}	≈	100	125	mA	
Grid 1 current	I_{g1}	≈	0	20	mA	
Anode input power	W_{ia}		12	18	kW	
Output power in load	W_ℓ		5	10	kW	
Driving power	W_{dr}		65	100	W	
Power gain	G		19	20	dB	

Notes: see page 5



Notes

1. With double-tuned anode circuit.
2. To be adjusted for the stated zero signal anode current.
3. Black signal, including line sync pulses.
4. A picture/sync ratio of 75/25 for the outgoing signal requires a ratio of max. 70/30 for the incoming signal, in which case the sync. compression in 30/25.
5. Measured with a 10 step staircase, running from 17% to 75% of the peak sync value.
6. As 5 but with a superimposed 4,43 MHz sine-wave heaving a 10% peak-to-peak value.


7Z88076.1
V_{g2} = 600 V
V_{g1} (V)
80
60
40
20
0
−20
−40
−60
−80
−100
−120
I_{g1} =
2 A
1,6 A
1,2 A
0,8 A
0,4 A
I_{g2} = 0,6 A
0,5 A
0,4 A
0,3 A
0,2 A
0,1 A
I_a = 14 A
12 A
10 A
8 A
6 A
4 A
2 A
1 A
0,5 A
0,1 A
0
1
2
3
4
5
6
7
8
9
10
V_a (kV)

Supersedes December 1981 data

AIR COOLED V.H.F. POWER TETRODE

Forced air cooled coaxial power tetrode in metal-ceramic construction primarily intended for use as linear broadband amplifier in band III TV transmitters for vision.

QUICK REFERENCE DATA

Class-AB linear amplifier (vision)

Frequency	f		250 MHz
Anode voltage	V_a		7 kV
Output power in load (sync)	W_ℓ		30 kW
Power gain (sync)	G		18 dB

HEATING: direct; thoriated tungsten filament, mesh type.

Filament voltage	V_f		8 V $^{+1}_{-3}$ %
Filament current	I_f		185 A
Filament peak starting current	I_{fp}	max.	800 A
Cold filament resistance	R_{fo}		4,2 mΩ

Waiting time; procedure prior to switching on subsequently $-V_{g1}$, V_a and V_{g2}:

$V_f = 2$ V	t_w		30 s
then $V_f = 8$ V	t_w		5 s

orange binder, tab 7

TYPICAL CHARACTERISTICS

Anode voltage	V_a		6	kV
Grid 2 voltage	V_{g2}		500	V
Anode current	I_a		4	A
Transconductance	S	≈	160	mA/V
Amplification factor	μ_{g2g1}	≈	8	

CAPACITANCES, grounded grid

Input	C_i	≈	125	pF
Output	C_o	≈	28	pF

TEMPERATURE LIMITS

Absolute maximum envelope temperature	T_{env}	max.	240	°C
Recommended maximum seal temperature	T_s	max.	200	°C

COOLING

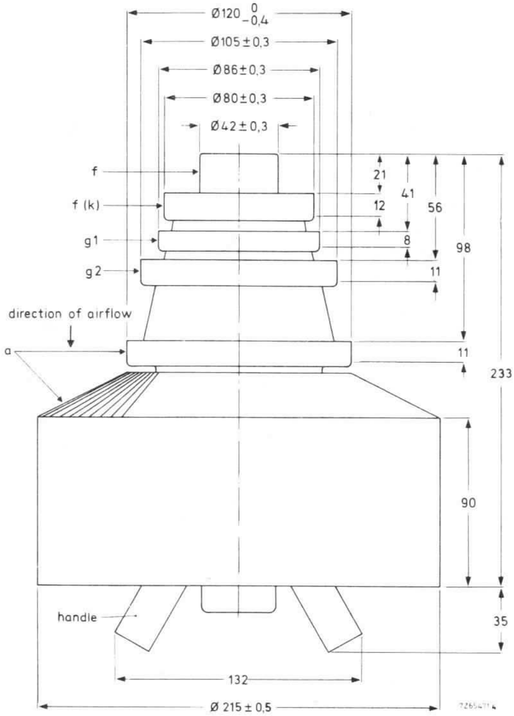
$W_a + W_g$ kW	h m	T_i °C	q_{min} m^3/min	P_i Pa tube only	P_i Pa tube + cavity	T_o max. °C
26	0	25	24	1320	2040	90
23	0	25	21	1030	1600	90
26	0	55	28	1660	2700	110
23	0	55	25	1340	2200	110
26	1500	25	24	1130	1700	100
23	1500	25	21	880	1250	100
26	3000	25	28	1300	2000	100
23	3000	25	25	1000	1500	100

For direction of air flow see outline drawing. The air should be ducted so that sufficient air is directed to the seals to keep the seal temperature below the limit.

DEVELOPMENT SAMPLE DATA

MECHANICAL DATA

Net mass	approx. 17 kg
Mounting position	vertical with anode up or down.



ACCESSORIES

Band III amplifier circuit assembly (vision)	type 40786V
Band III amplifier circuit assembly (sound)	type 40786S

Input circuits of cavities are broadbanded (no input tuning required)

LIMITING VALUES (Absolute maximum rating system)

Frequency	f	up to	250	MHz
Anode voltage	V_a		8,5	kV
Grid 2 voltage	V_{g2}		800	V
Grid 1 voltage	$-V_{g1}$		250	V
Anode current	I_a		8	A
Anode input power, black	W_{ia}		50	kW
Anode dissipation	W_a		26	kW
Grid 2 dissipation	W_{g2}		200	W
Grid 1 dissipation	W_{g1}		200	W

OPERATING CONDITIONS, cathode driven

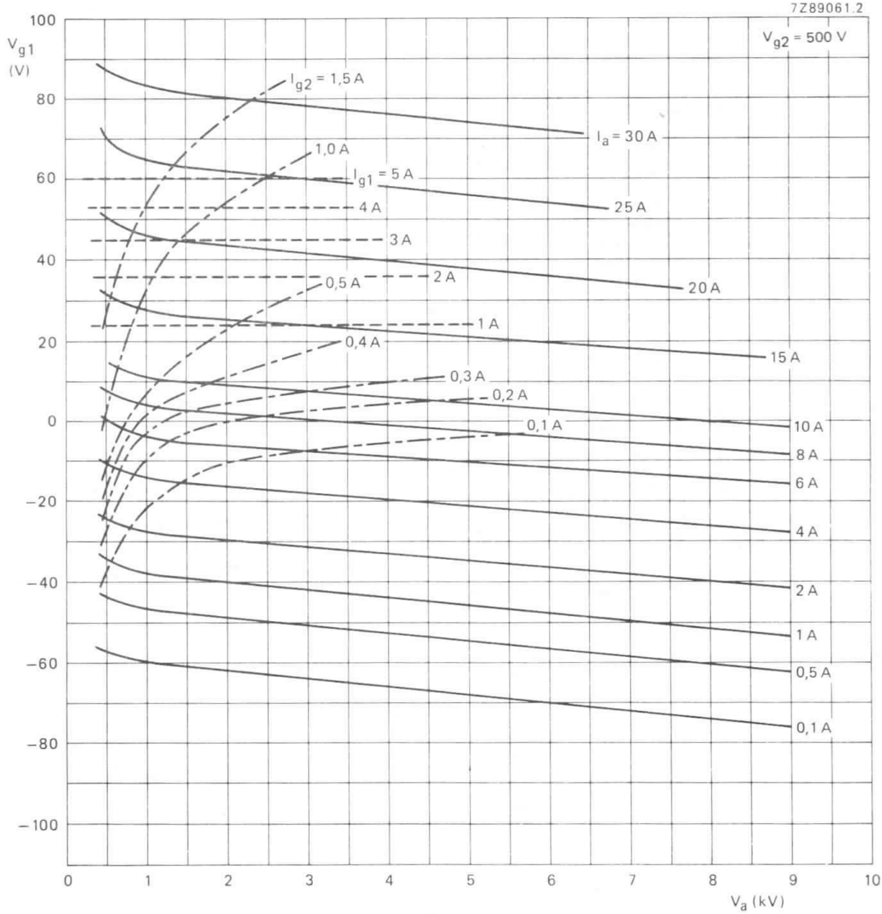
The voltages are given with respect to the cathode.

CLASS-AB AMPLIFIER FOR TELEVISION SERVICE

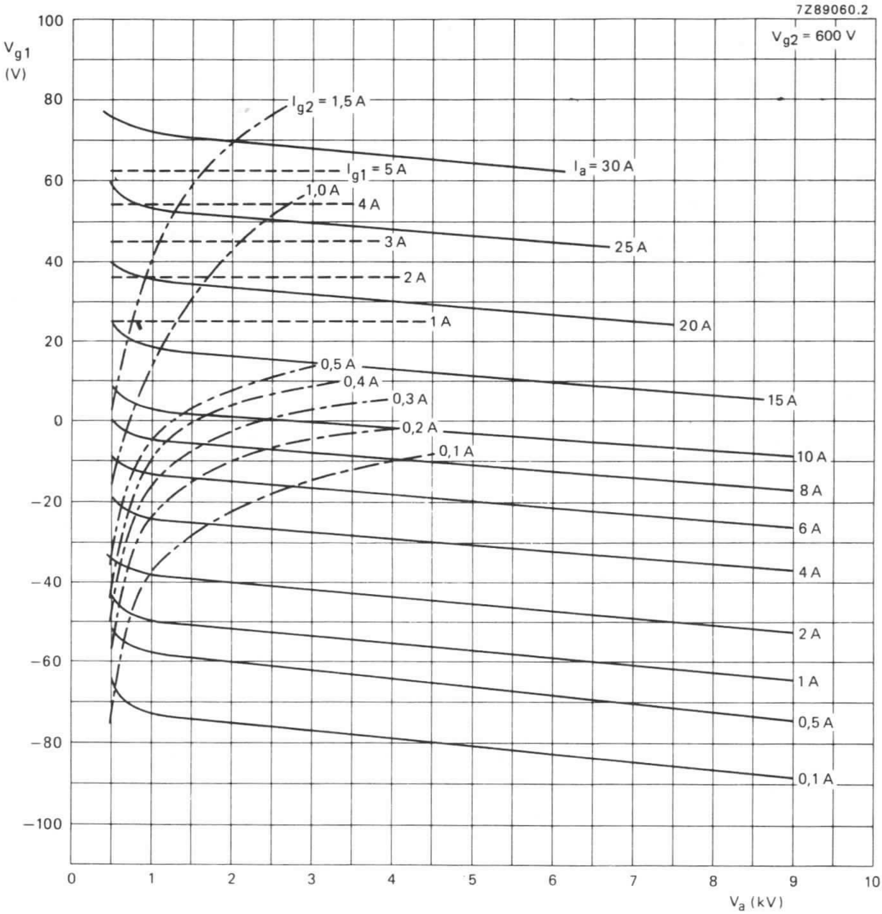
									notes
Frequency of vision carrier	f				175 to 225			MHz	
Bandwidth (−1 dB)	B		8	8	8	8	7,5	MHz	1
Anode voltage	V_a		5	5,5	6	6,5	7	kV	
Grid 2 voltage	V_{g2}		500	500	500	500	500	V	
Grid 1 voltage	$-V_{g1}$	≈	50	50	50	50	50	V	2
Anode current (zero signal)	I_a		1,2	1,2	1,2	1,2	1,2	A	
Anode current (black)	I_a	≈	3,5	4,0	4,6	5,2	5,7	A	
Grid 2 current (black)	I_{g2}	≈	100	120	150	150	150	mA	
Grid 1 current (black)	I_{g1}	≈	0	15	55	120	180	mA	
Output power in load, sync	W_ℓ		11	15	20	25	30	kW	
Output power in load, black	W_ℓ		6,6	9	12	15	18	kW	
Gain	G				18			dB	
Sync compression	sync in/out	<			30/25				
Diffferential phase		<			5			deg	
Differential gain		⩾			90			%	
L.F. linearity		⩾			90			%	

Notes

1. With double tuned anode circuit.
2. To be adjusted for the stated zero signal anode current.



DEVELOPMENT SAMPLE DATA


7Z89060.2
V_{g2} = 600 V
V_{g1} (V)
100
80
60
40
20
0
−20
−40
−60
−80
−100
I_{g2} = 1,5 A
1,0 A
0,5 A
0,4 A
0,3 A
0,2 A
0,1 A
I_{g1} = 5 A
4 A
3 A
2 A
1 A
I_a = 30 A
25 A
20 A
15 A
10 A
8 A
6 A
4 A
2 A
1 A
0,5 A
0,1 A
0
1
2
3
4
5
6
7
8
9
10
V_a (kV)

AIR COOLED V.H.F. POWER TETRODE

Forced air cooled coaxial power tetrode in metal-ceramic construction for use in:
- linear broad band amplifiers for T.V. band III, vision and sound combined
- linear broad band amplifiers for T.V. band III, vision only
- F.M. broadcast applications in band II

QUICK REFERENCE DATA

Class-AB linear amplifier (vision and sound combined)

Frequency	f	225		MHz
Anode voltage	V_a	5,5	7	kV
Output power in load, sync	W_ℓ	5	10	kW
Power gain	G	16	16	dB

Class-AB linear amplifier (vision)

Frequency	f	225		MHz
Anode voltage	V_a	6	7,5	kV
Output power in load, sync	W_ℓ	11	21	kW
Power gain	G	15,5	15,5	dB

Class-AB f.m. amplifier

Frequency	f	110		MHz
Anode voltage	V_a	7,5	9	kV
Output power in load	W_ℓ	10,5	20	kW
Gain	G	17	17	dB

HEATING: direct: thoriated tungsten filament, mesh type.

Filament voltage	V_f		10,4	$V^{+1}_{-3}\%$
Filament current	I_f		112	A
Filament peak starting current	I_{fp}	max.	750	A
Cold filament resistance	R_{fo}		10,5	mΩ

Waiting time: procedure prior to switching subsequently $-V_{g1}$, V_a and V_{g2}:

V_f = 2 V	t_w	30	s
then V_f = 10,4 V	t_w	5	s

orange binder, tab 7

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TYPICAL CHARACTERISTICS

Anode voltage	V_a	6	kV
Grid 2 voltage	V_{g2}	900	V
Anode current	I_a	3	A
Transconductance	S	70	mA/V
Amplification factor	μ_{g2g1}	8,5	

CAPACITANCES, grounded grid

Input	C_i	≈ 70	pF
Output	C_o	≈ 25	pF

TEMPERATURE LIMITS

Maximum envelope temperature	T_{env}	240	°C
Maximum seal temperature	T_s	200	°C

COOLING

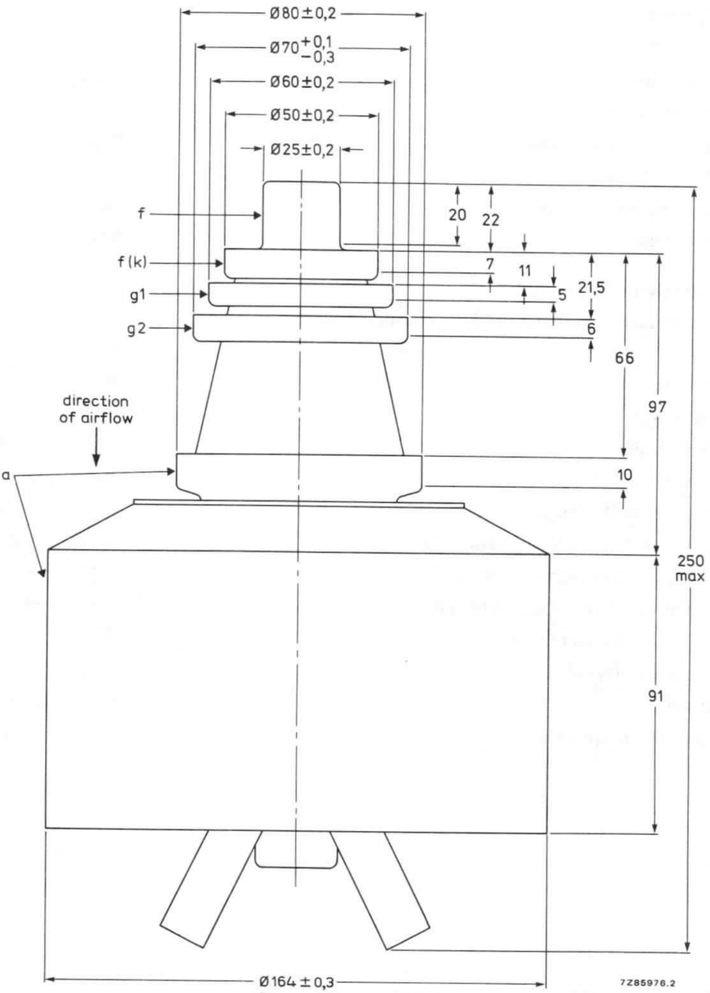
$W_a + W_g$ kW	h m	T_i °C	q_{min} m³/min	Δp Pa tube only	Δp Pa tube + cavity	T_o max °C
17	0	25	15	1400	1600	100
14	0	25	12	1000	1100	100
17	0	55	19	2100	2400	110
14	0	55	16	1600	1800	110
17	1500	25	17	1550	1700	100
14	1500	25	14	1100	1200	100
17	3000	25	19	1450	1700	100
14	3000	25	16	1150	1300	100

For direction of air flow see outline drawing. The air should be ducted so that sufficient air is directed to the seals to keep the seal temperature below the limit.

MECHANICAL DATA

Net mass approx. 11 kg

Mounting position vertical with anode up or down.



ACCESSORIES

Band II amplifier circuit assembly type 40788

Band III amplifier circuit assembly type 40786A

Input circuit of cavity is broadbanded (no input tuning required).

R.F. CLASS-AB LINEAR AMPLIFIER FOR TELEVISION SERVICE

LIMITING VALUES (Absolute maximum rating system)

Frequency	f	up to	250 MHz
Anode voltage	V_a		10 kV
Grid 2 voltage	V_{g2}		1 kV
Grid 1 voltage	$-V_{g1}$		500 V
Anode current, black	I_a		7 A
Anode input power, black	W_{ia}		30 kW
Anode dissipation	W_a		17 kW
Grid 2 dissipation	W_{g2}		150 W
Grid 1 dissipation	W_{g1}		50 W

OPERATING CONDITIONS

Vision and sound combined (10 : 1) cathode driven

Frequency	f	175 to 225		MHz
Bandwidth (−1 dB)	B	8	8	MHz
Anode voltage	V_a	5,5	7	kV
Grid 2 voltage	V_{g2}	900	900	V
Grid 1 voltage*	V_{g1}	≈ 95	≈ 100	V
Anode current (zero signal)	I_a	1,8	1,8	A
Anode current, black + line sync pulse	I_a	≈ 2,45	≈ 2,9	A
Grid 2 current, black + line sync pulse	I_{g2}	≈ 30	≈ 50	mA
Grid 1 current, black + line sync pulse	I_{g1}	≈ 0	≈ 0	mA
Output power in load (sync)	W_ℓ	5	10	kW
Driving power (sync)	W_{dr}	⩽ 125	⩽ 250	W
Power gain	G	⩾ 16	⩾ 16	dB
Intermodulation products**	d	⩽ −54	⩽ −54	dB

* To be adjusted for the stated zero signal anode current.

** Measured with:
sync. = 0 dB
black = −2,2 dB
grey = −8 dB
sound = −10 dB
side band = −16 dB
Intermodulation products of driver ⩽ −70 dB.

OPERATING CONDITIONS

Vision only

					notes
Frequency	f	175 to 225		MHz	
Bandwidth (−1 dB)	B	7	7	MHz	1
Anode voltage	V_a	6	7,5	kV	
Grid 2 voltage	V_{g2}	800	800	V	
Grid 1 voltage	$-V_{g1}$	95	100	V	2
Anode current (zero signal)	I_a	1,2	1	A	
Anode current, black	I_a	2,75	3,6	A	3
Grid 2 current, black	I_{g2}	75	75	mA	3
Grid 1 current, black	I_{g1}	10	100	mA	3
Output power in load, black	W_ℓ	6,6	12,6	kW	
Output power in load, sync	W_ℓ	11	21	kW	
Gain, black	G	15,5	15,5	dB	
Sync compression		$\leq$ 27/25	$\leq$ 27/25		4
Differential phase		$\leq$ 3	$\leq$ 3	deg	6
Differential gain		$\geq$ 90	$\geq$ 90	%	6
L.F. linearity		$\geq$ 90	$\geq$ 90	%	5

Notes

1. With double-tuned circuit.
2. To be adjusted for the stated zero signal anode current.
3. Black signal, including line sync pulses.
4. A picture/sync ratio of 75/25 for the outgoing signal requires a ratio of max. 70/30 for the incoming signal, in which case the sync compression is 30/25.
5. Measured with a step staircase, running from 17% to 75% of the peak sync value.
6. As 5 but with a superimposed 4,43 MHz sine-waye having a 10% peak-to-peak value.

CLASS-AB F.M. AMPLIFIER

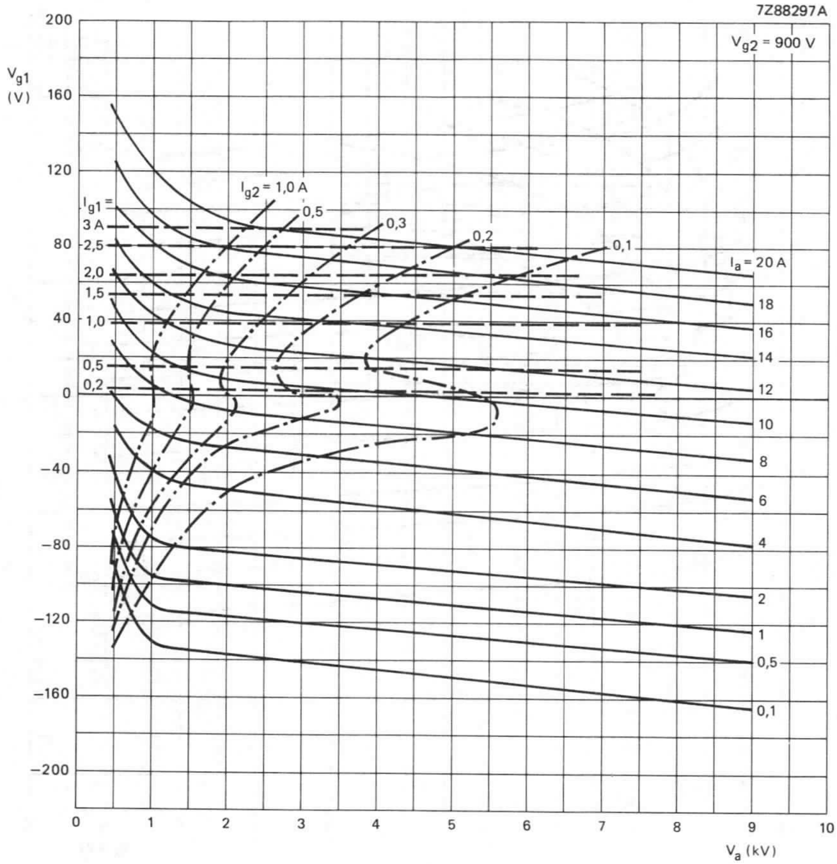
LIMITING VALUES (Absolute maximum rating system)

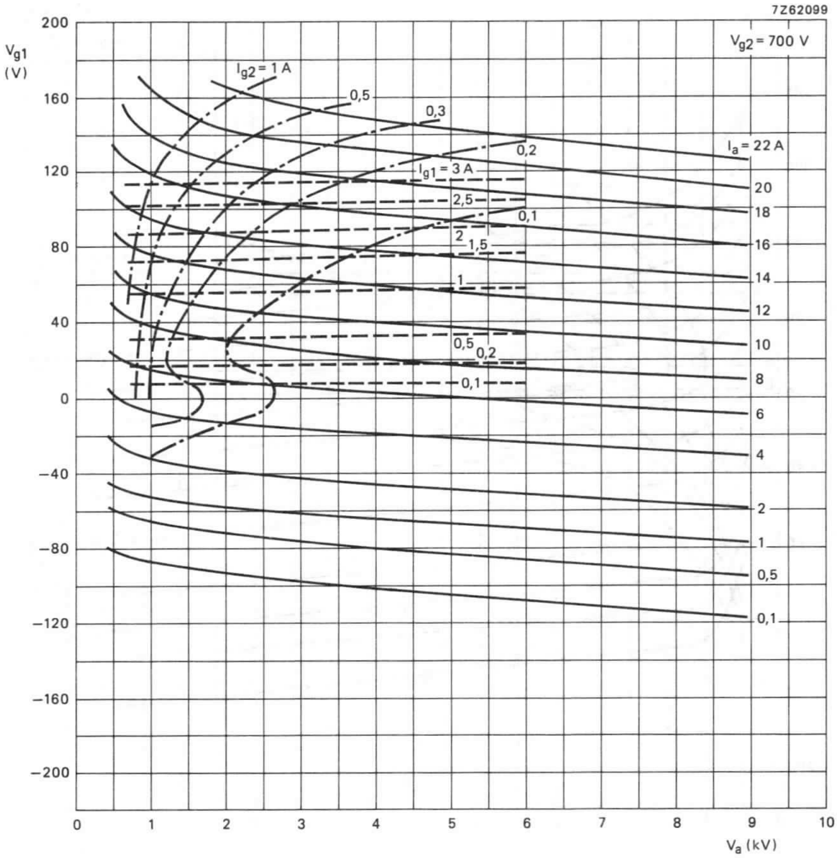
Frequency	f	up to	250	MHz
Anode voltage	V_a		10	kV
Grid 2 voltage	V_{g2}		1	kV
Grid 1 voltage	$-V_{g1}$		500	V
Anode current, black	I_a		7	A
Anode dissipation	W_a		17	kW
Grid 2 dissipation	W_{g2}		150	W
Grid 1 dissipation	W_{g1}		50	W

OPERATING CONDITIONS

Frequency	f	88 to 110		MHz
Bandwidth (−3 dB)	B	≈ 1,5	≈ 1,5	MHz
Anode voltage	V_a	7,5	9	kV
Grid 2 voltage	V_{g2}	700	700	V
Grid 1 voltage*	$-V_{g1}$	110	90	V
Anode current (zero signal)	I_a	0,5	1	A
Anode current	I_a	≈ 2,15	≈ 3,4	A
Grid 2 current	I_{g2}	≈ 120	≈ 150	mA
Grid 1 current	I_{g1}	≈ 20	≈ 150	mA
Output power in load	W_ℓ	⩾ 10,5	⩾ 20	kW
Driving power (sync)	W_{dr}	⩽ 200	⩽ 400	W
Power gain	G	⩾ 17	⩾ 17	dB

* To be adjusted for the stated zero signal anode current.


7Z88297A
V_{g2} = 900 V
V_{g1} (V)
V_a (kV)
I_{g1} =
3 A
2,5
2,0
1,5
1,0
0,5
0,2
I_{g2} = 1,0 A
0,5
0,3
0,2
0,1
I_a = 20 A
18
16
14
12
10
8
6
4
2
1
0,5
0,1
200
160
120
80
40
0
−40
−80
−120
−160
−200
0
1
2
3
4
5
6
7
8
9
10


7Z62099
V_{g1} (V)
200
160
120
80
40
0
−40
−80
−120
−160
−200
V_{g2} = 700 V
I_{g2} = 1 A
0,5
0,3
0,2
0,1
I_a = 22 A
20
18
16
14
12
10
8
6
4
2
1
0,5
0,1
I_{g1} = 3 A
2,5
2
1,5
1
0,5
0,2
0,1
0
1
2
3
4
5
6
7
8
9
10
V_a (kV)

Supersedes December 1981 data

WATER COOLED 100 kW POWER TETRODE

Water cooled power tetrode in metal-ceramic coaxial construction for use as r.f. and a.f. amplifier in a.m. broadcast transmitters and scientific applications.

QUICK REFERENCE DATA

Class-C			
Frequency	f		30 MHz
Anode voltage	V_a		11 kV
Output power	W_o		125 kW
Class B			
Anode voltage	V_a		11 kV
Output power in load	W_ℓ		2 x 75 kW

HEATING: direct; thoriated tungsten filament, mesh type.

Filament voltage	V_f		10 V $^{+1\%}_{-3\%}$
Filament current	I_f		280 A
Filament peak starting current	I_{fp}	max.	1600 A
Cold filament resistance	R_{fo}		4,0 mΩ
Waiting time	t_w		10 s

TYPICAL CHARACTERISTICS

Anode voltage	V_a	3 kV
Grid 2 voltage	V_{g2}	1 kV
Anode current	I_a	25 A
Transconductance	S	140 mA/V
Amplification factor	μ_{g2g1}	5

CAPACITANCES

Cathode to grid 1	C_{kg1}	≈	180 pF
Cathode to grid 2	C_{kg2}	≈	13 pF
Cathode to anode	C_{ka}	≈	0,3 pF
Grid 1 to grid 2	C_{g1g2}	≈	300 pF
Grid 1 to anode	C_{g1a}	≈	2,3 pF
Grid 2 to anode	C_{g2a}	≈	47 pF

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TEMPERATURE LIMITS

Absolute maximum envelope temperature	T_{env}	max.	240 °C
Recommended maximum seal temperature	T	max.	200 °C

Low velocity air flow of at least 1 m^3/min should be directed to the grid and filament seals in order to keep the temperature below 200 °C.

COOLING

Maximum anode dissipation (water cooling, 80 l/min)	W_a	150 kW
Water cooling with 60 l/min	W_a	120 kW
Absolute maximum outlet temperature	T_o	100 °C
Pressure drop in the anode cooler		20 kPa
Absolute maximum water pressure		500 kPa

MECHANICAL DATA

Net mass	approx. 35 kg
Mounting position	vertical with anode up

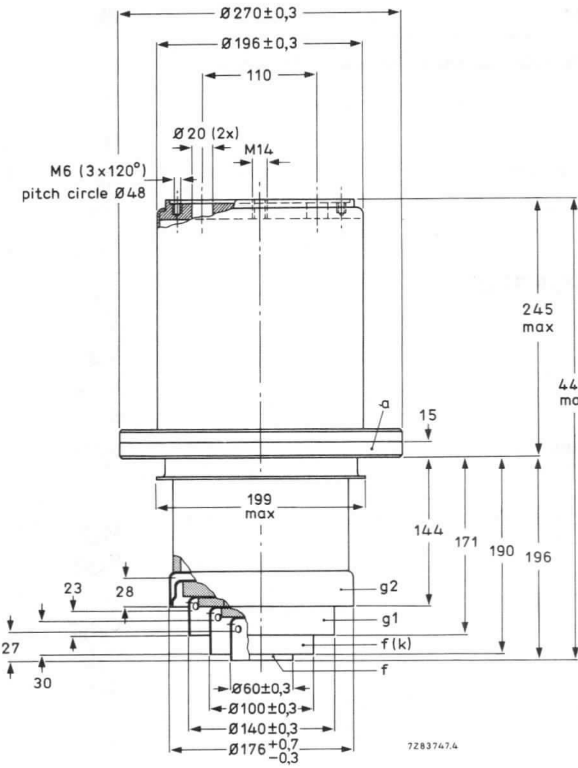


Fig. 1.

R.F. CLASS-C ANODE AND SCREEN GRID MODULATION (CARRIER CONDITIONS)

LIMITING VALUES (Absolute maximum rating system)

Frequency	f	up to	30	MHz
Anode voltage	V_a	max.	13	kV
Grid 2 voltage	V_{g2}	max.	1200	V
Grid 1 voltage	V_{g1}	max.	−800	V
Cathode current	I_k		17	A
Cathode current (peak)	I_k		160	A
Anode input power	W_{ia}	max.	200	kW
Anode dissipation	W_a	max.	150	kW
Grid 2 dissipation	W_{g2}	max.	2,2	kW
Grid 1 dissipation	W_{g1}	max.	1	kW

OPERATING CONDITIONS

Frequency	f		30	MHz
Anode voltage	V_a	≈	11	kV
Grid 2 voltage (modulation 80%)	V_{g2}	≈	1	kV
Grid 1 voltage	V_{g1}	≈	−550	V
Grid driving voltage peak	V_p		700	V
Anode current	I_a	≈	15	A
Grid 2 current	I_{g2}	≈	0,5	A
Grid 1 current	I_{g1}	≈	0,8	A
Driving power	W_{dr}		1	kW
Grid 2 dissipation	W_{g2}		500	W
Grid 1 dissipation	W_{g1}		120	W
Anode input power	W_{ia}		165	kW
Anode output power	W_{oa}		125	kW
Anode dissipation	W_a		40	kW
Efficiency	η		76	%

A.F. CLASS-B POWER AMPLIFIER AND MODULATOR

LIMITING VALUES, per tube (Absolute maximum rating system)

Anode voltage	V_a		15 kV
Grid 2 voltage	V_{g2}		1,6 kV
Grid 1 voltage	V_{g1}		−800 V
Anode input power	W_{ia}		200 kW
Anode dissipation	W_a		150 kW
Cathode current (peak)	I_k		160 A
Cathode current	I_k		20 A
Grid 2 dissipation	W_{g2}		2,2 kW
Grid 1 dissipation	W_{g1}		1 kW

OPERATING CONDITIONS, two tubes in push-pull

Anode voltage	V_a	≈	11 kV
Grid 2 voltage	V_{g2}	≈	1,6 kV
Grid 1 voltage, I_{ao} = 1 A	V_{g1}	≈	−350 V
Anode current	I_a		2 x 10 A
Grid 2 current	I_{g2}		2 x 0,3 A
Grid 1 current	I_{g1}	≈	0 A
Anode input power	W_{ia}		2 x 110 kW
Anode output power	W_{oa}		2 x 75 kW
Anode dissipation	W_a		2 x 35 kW
Efficiency	η		68 %

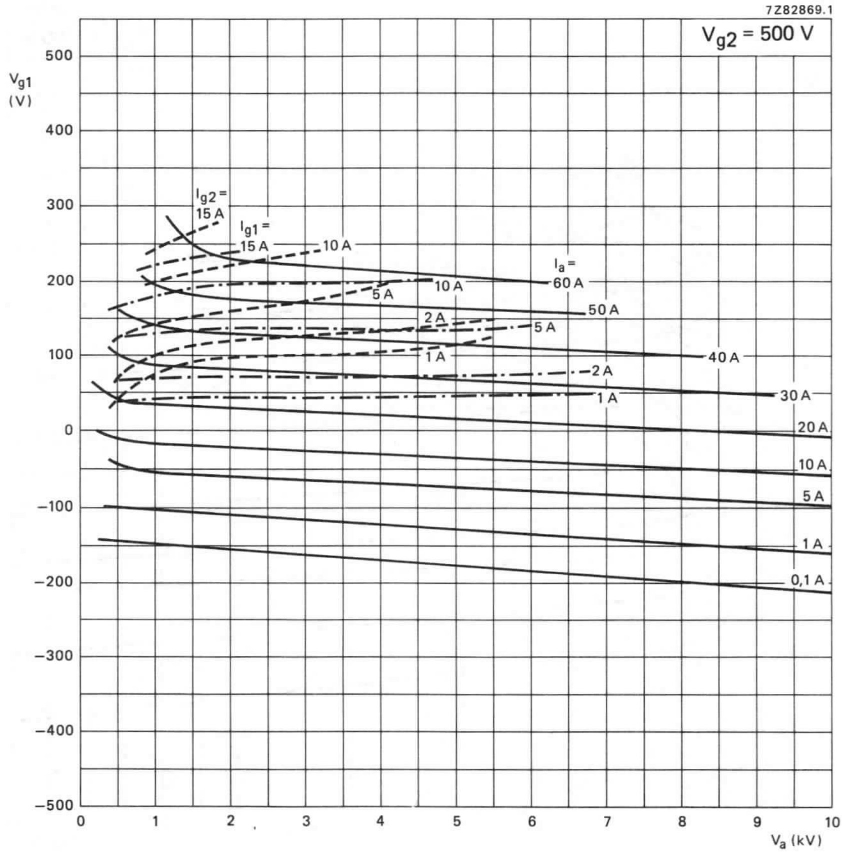

7Z82869.1
V_{g2} = 500 V
V_{g1} (V)
500
400
300
200
100
0
−100
−200
−300
−400
−500
0
1
2
3
4
5
6
7
8
9
10
V_a (kV)
I_{g2} = 15 A
I_{g1} = 15 A
10 A
I_a = 60 A
10 A
5 A
50 A
2 A
5 A
1 A
40 A
2 A
30 A
1 A
20 A
10 A
5 A
1 A
0,1 A

Fig. 2.

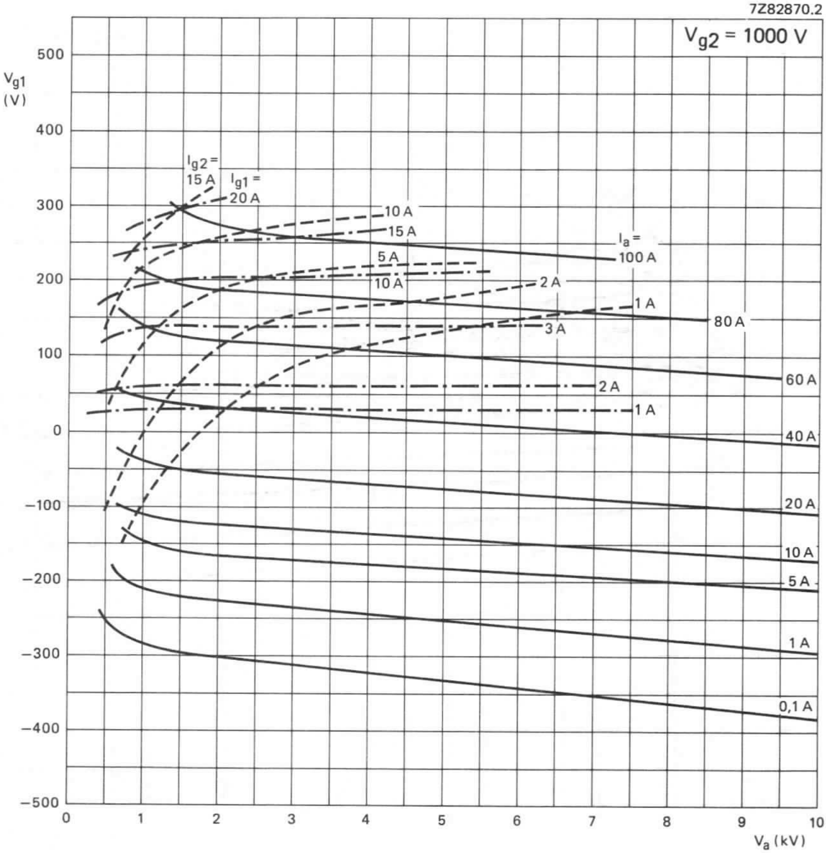

7Z82870.2
V_{g2} = 1000 V
V_{g1} (V)
500
400
300
200
100
0
−100
−200
−300
−400
−500
I_{g2} = 15 A
I_{g1} = 20 A
10 A
15 A
5 A
10 A
2 A
1 A
3 A
2 A
1 A
I_a = 100 A
80 A
60 A
40 A
20 A
10 A
5 A
1 A
0,1 A
0
1
2
3
4
5
6
7
8
9
10
V_a (kV)

Fig. 3.

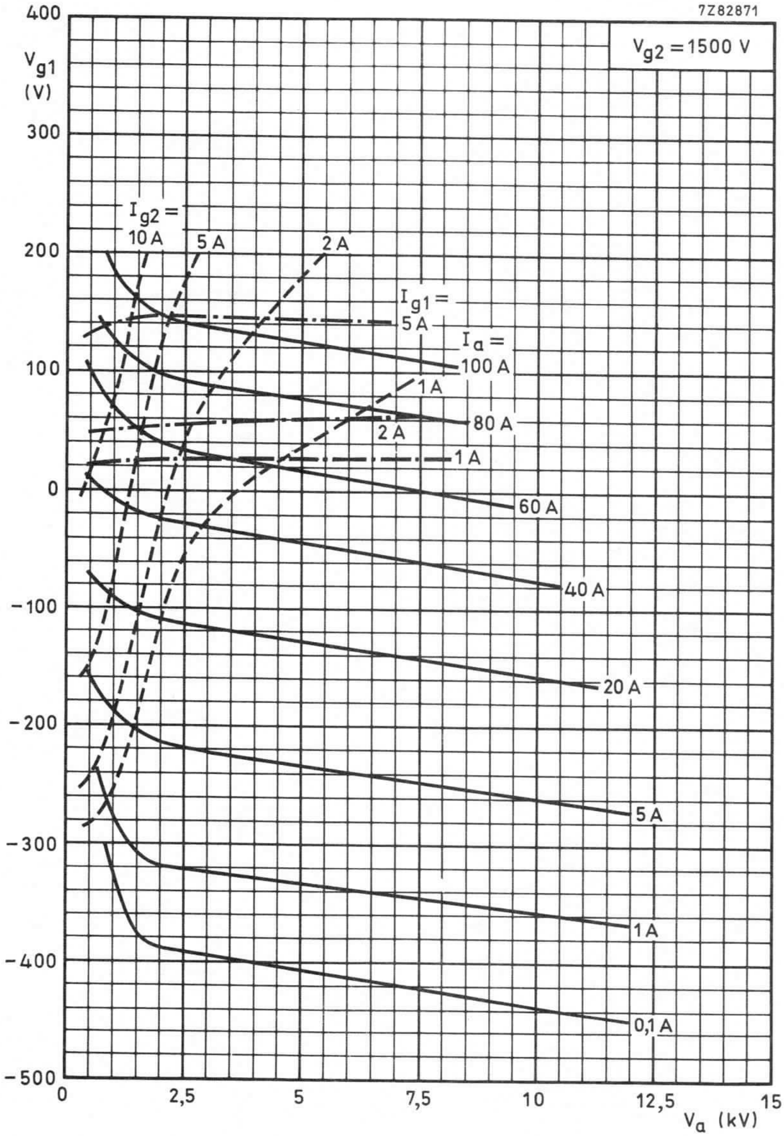

7Z82871
V_{g2} = 1500 V
V_{g1} (V)
400
300
200
100
0
−100
−200
−300
−400
−500
I_{g2} =
10 A
5 A
2 A
I_{g1} =
5 A
1 A
2 A
1 A
I_a =
100 A
80 A
60 A
40 A
20 A
5 A
1 A
0,1 A
0
2,5
5
7,5
10
12,5
15
V_a (kV)

Fig. 4.

WATER COOLED 500 kW POWER TETRODE

Water cooled power tetrode in metal-ceramic coaxial construction for use as r.f. and a.f. amplifier in a.m. broadcast transmitters and scientific applications.

QUICK REFERENCE DATA

Class-C				
Frequency	f		30	MHz
Anode voltage	V_a		12	kV
Output power	W_o		520	kW
Class B				
Anode voltage	V_a		12	kV
Output power in load	W_ℓ		2 x 330	kW

HEATING: direct; thoriated tungsten filament, mesh type.

Filament voltage	V_f		23	V
Filament current	I_f		500	A
Filament peak starting current	I_{fp}	max.	1500	A
Cold filament resistance	R_{fo}		4,5	mΩ
Waiting time	T_w	min.	10	s

Recommended switching procedure: 8 s at 8 V: 2 s at 23 V

TYPICAL CHARACTERISTICS

Anode voltage	V_a	3	kV
Grid 2 voltage	V_{g2}	1	kV
Anode current	I_a	35	A
Transconductance	S	500	mA/V
Amplification factor	μ_{g2g1}	4,4	

CAPACITANCES

Cathode to grid 1	C_{kg1}	≈	425	pF
Cathode to grid 2	C_{kg2}	≈	40	pF
Cathode to anode	C_{ka}	≈	0,6	pF
Grid 1 to grid 2	C_{g1g2}	≈	750	pF
Grid 1 to anode	C_{g1a}	≈	4,2	pF
Grid 2 to anode	C_{g2a}	≈	100	pF

TEMPERATURE LIMITS

Absolute maximum envelope temperature	T_{env}	max.	240 °C
Recommended maximum seal temperature	T	max.	200 °C

Low velocity air flow should be directed to the grid and filament seals in order to keep the temperature below 200 °C.

COOLING

Maximum anode dissipation	W_a	500 kW
Water cooling with 200 ℓ/min		
Absolute maximum output temperature	T_o	100 °C

MECHANICAL DATA

Net mass	approx. 65 kg
Mounting position	vertical with anode up

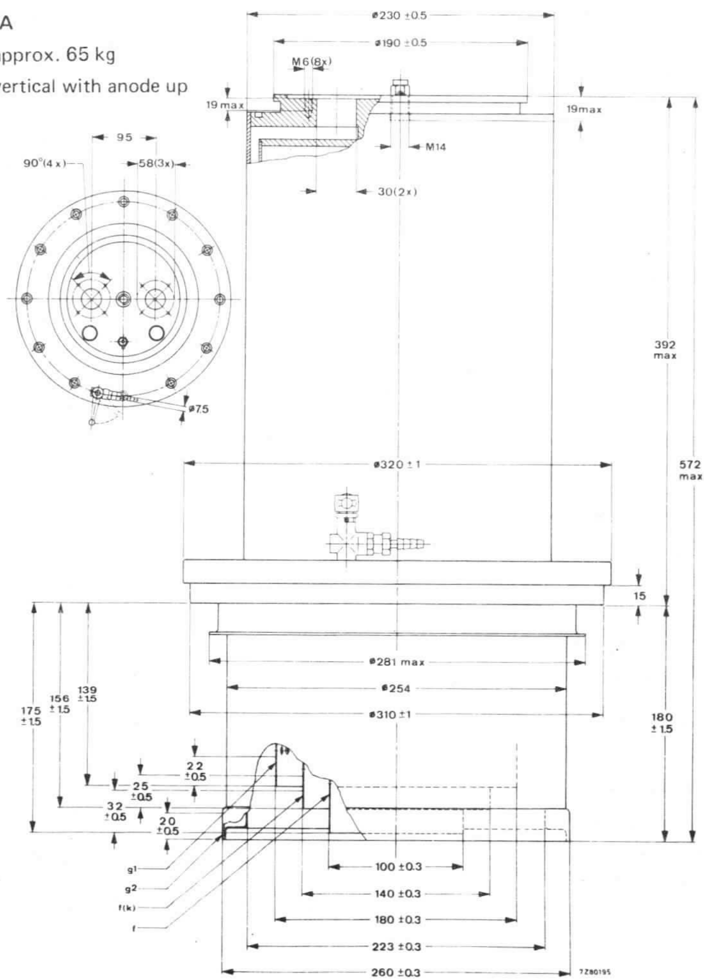


Fig. 1.

R.F. CLASS-C ANODE AND SCREEN GRID MODULATION (CARRIER CONDITIONS)

LIMITING VALUES (Absolute maximum rating system)

Frequency	f		30	MHz
Anode voltage	V_a	max.	13,5	kV
Grid 2 voltage	V_{g2}	max.	1250	V
Grid 1 voltage	V_{g1}	max.	−800	V
Anode input power	W_{ia}	max.	700	kW
Anode dissipation	W_a	max.	500	kW
Cathode current	I_k		65	A
Cathode current (peak)	I_k		600	A
Grid 2 dissipation	W_{g2}	max.	8	kW
Grid 1 dissipation	W_{g1}	max.	4	kW

OPERATING CONDITIONS

Frequency	f		30	MHz
Anode voltage	V_a	≈	12	kV
Grid 2 voltage (modulation 80%)	V_{g2}	≈	1,1	kV
Grid 1 voltage	V_{g1}	≈	−600	V
Grid driving voltage peak	V_p		750	V
Anode current	I_a	≈	54	A
Grid 2 current	I_{g2}	≈	4	A
Grid 1 current	I_{g1}	≈	2,5	A
Driving power	W_{dr}		4	kW
Grid 2 dissipation	W_{g2}		4,4	kW
Grid 1 dissipation	W_{g1}		400	W
Anode input power	W_{ia}		648	kW
Anode output power	W_{oa}		520	kW
Anode dissipation	W_a		128	kW
Efficiency	η		80	%

DEVELOPMENT SAMPLE DATA

A.F. CLASS-B POWER AMPLIFIER AND MODULATOR

LIMITING VALUES, per tube (Absolute maximum rating system)

Anode voltage	V_a		15	kV
Grid 2 voltage	V_{g2}		1,5	kV
Grid 1 voltage	V_{g1}		−800	V
Anode input power	W_{ia}		600	kW
Anode dissipation	W_a		500	kW
Cathode current	I_k		50	A
Cathode current (peak)	I_k		600	A
Grid 2 dissipation	W_{g2}		9	kW
Grid 1 dissipation	W_{g1}		3	kW

OPERATING CONDITIONS, two tubes in push-pull

Anode voltage	V_a	≈	12	kV
Grid 2 voltage	V_{g2}	≈	1250	V
Grid 1 voltage, I_{ao} = 1 A	V_{g1}	≈	−350	V
Anode current	I_a		2 x 39	A
Grid 2 current	I_{g2}		2 x 2	A
Grid 1 current	I_{g1}	≈	0	mA
Anode input power	W_{ia}		2 x 468	kW
Anode output power	W_{oa}		2 x 330	kW
Anode dissipation	W_a		2 x 138	kW
Efficiency	η		70,5	%

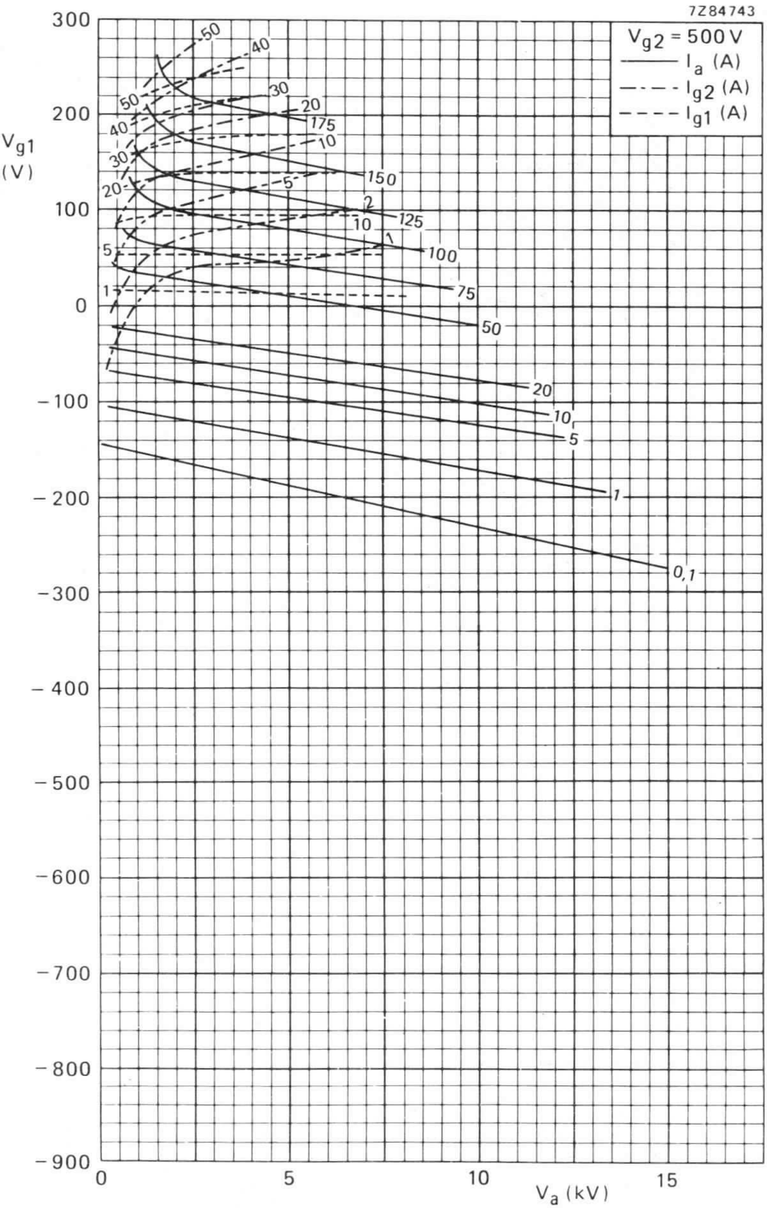


Fig. 2.

DEVELOPMENT SAMPLE DATA

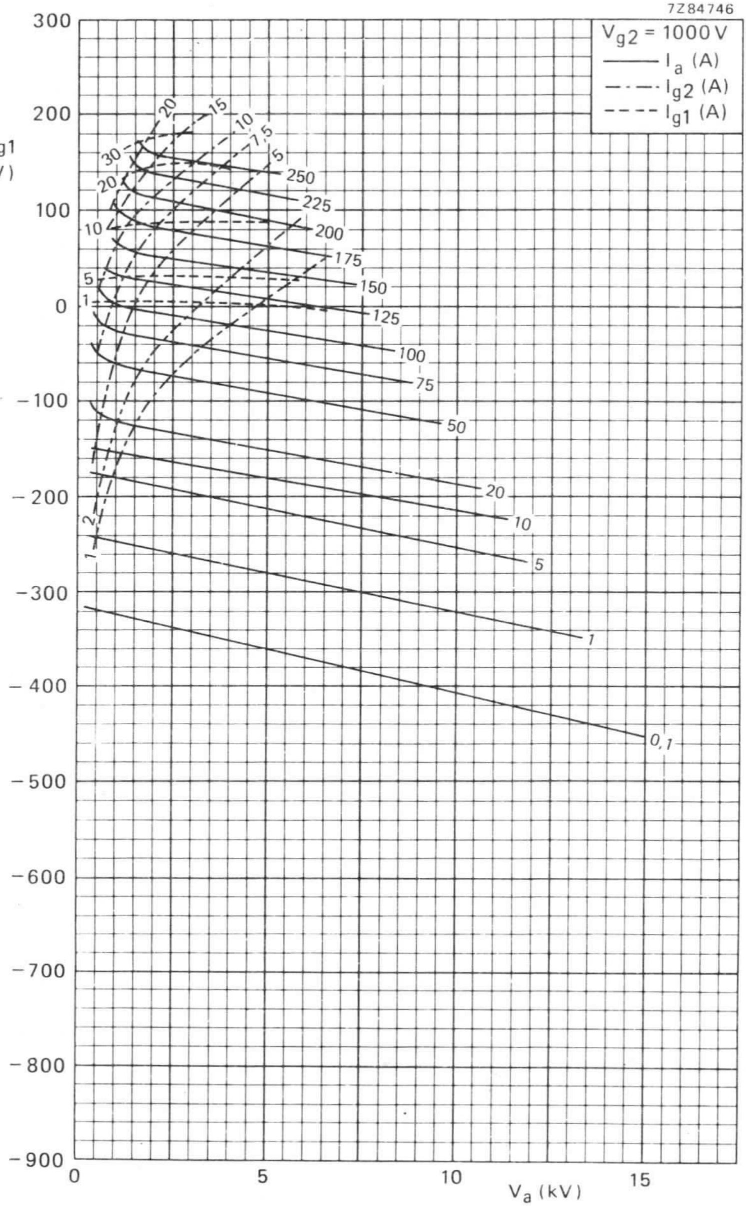

7Z84746
V_{g2} = 1000 V
I_a (A)
I_{g2} (A)
I_{g1} (A)
V_{g1} (V)
V_a (kV)
300
200
100
0
−100
−200
−300
−400
−500
−600
−700
−800
−900
5
10
15
250
225
200
175
150
125
100
75
50
20
10
5
1
0,1
30
20
10
5
1
2
20
15
10
7,5
5

Fig. 3.

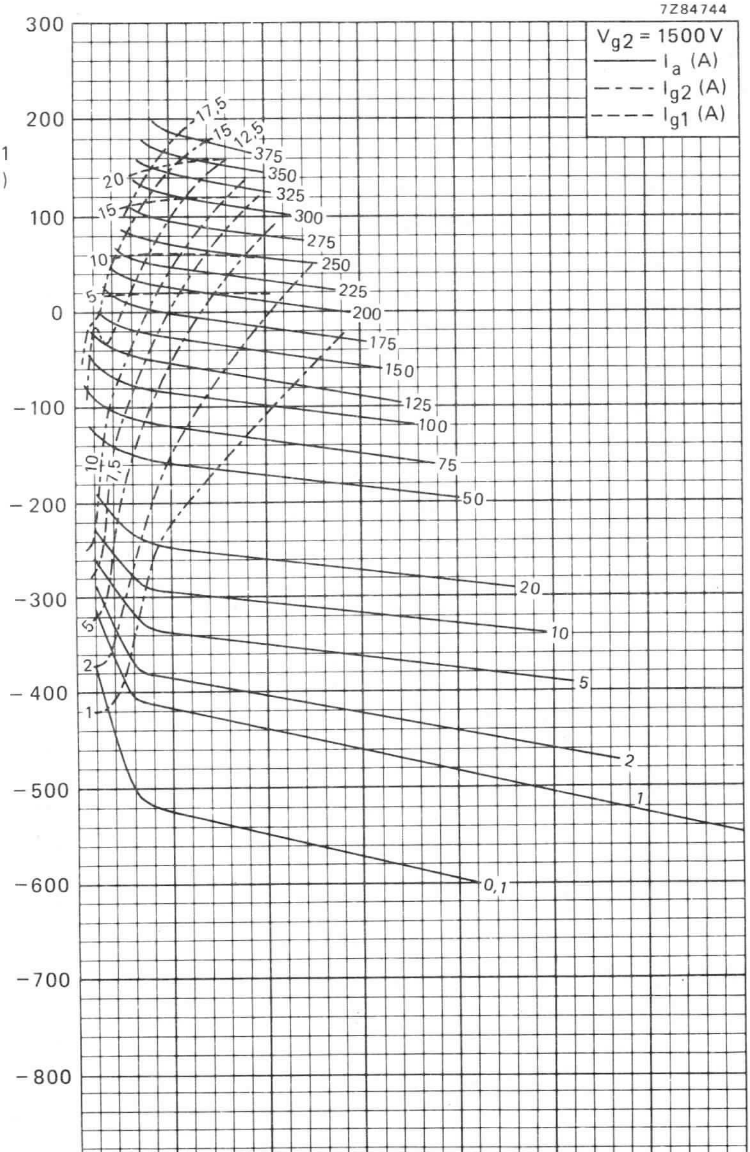


Fig. 4.

DEVELOPMENT SAMPLE DATA

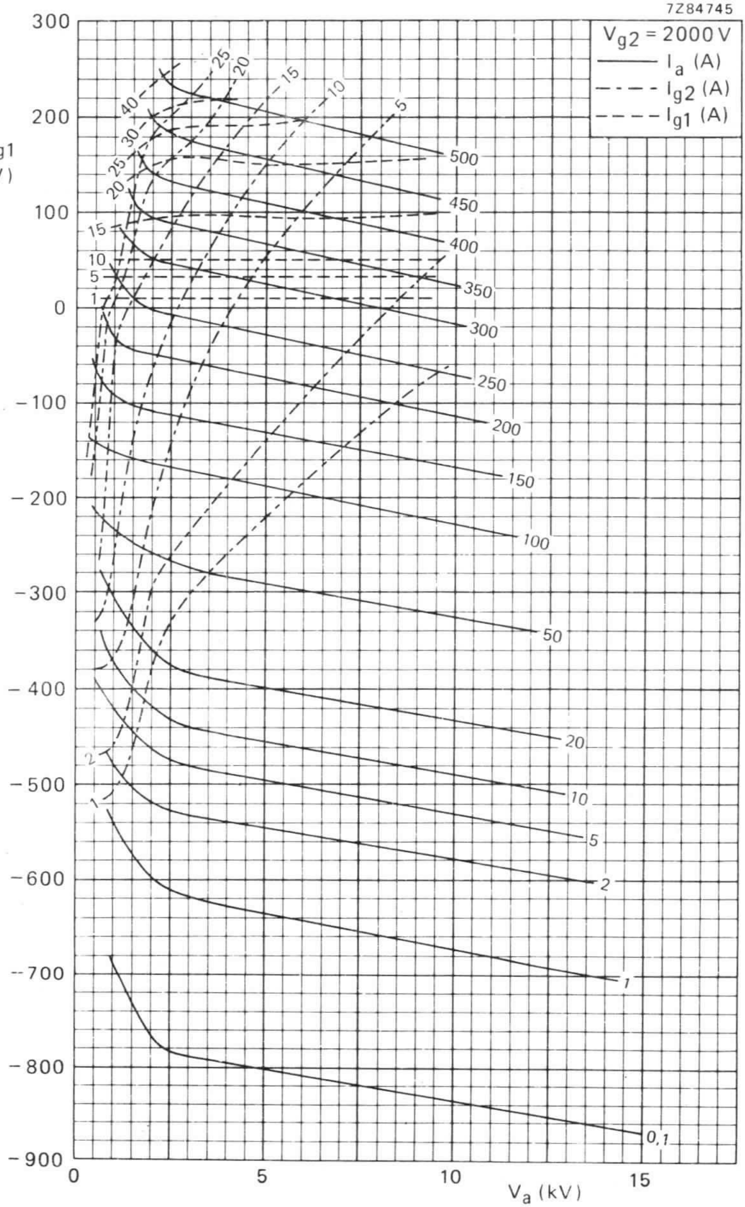

7Z84745
V_{g2} = 2000 V
I_a (A)
I_{g2} (A)
I_{g1} (A)
V_{g1} (V)
V_a (kV)
300
200
100
0
−100
−200
−300
−400
−500
−600
−700
−800
−900
0
5
10
15
500
450
400
350
300
250
200
150
100
50
20
10
5
2
1
0,1
40
30
25
20
15
10
5
1
2
1
25
20
15
10
5

Fig. 5.

WATER COOLED R.F. POWER TETRODE

Water cooled coaxial power tetrode in metal-ceramic construction primarily intended for use in r.f. power amplifier applications up to 250 MHz.

QUICK REFERENCE DATA

Class-AB amplifier

Frequency	f	200	30	MHz
Anode voltage	V_a	10	10	kV
Output power in load	W_ℓ	65	120	kW

HEATING: direct; thoriated tungsten filament, mesh type.

Filament voltage	V_f		$12^{+1\%}_{-3\%}$	V ←
Filament current	I_f		265	A
Filament peak starting current	I_{fp}	max.	1500	A
Cold filament resistance	R_{fo}		4,6	mΩ
Waiting time	t_w		10	s

The filament is designed to accept temporary fluctuations of ± 5%

TYPICAL CHARACTERISTICS

Anode voltage	V_a		10	kV
Grid 2 voltage	V_{g2}		900	V
Anode current	I_a		10	A
Transconductance	S	≈	120	mA/V
Amplification factor	μ_{g2g1}		4,5	

CAPACITANCES

		grounded cathode	grounded grid	
Input	C_i	347	160	pF
Output	C_o	45	45	pF
Anode to grid 1	C_{ag1}	3,2	–	pF ←
Anode to filament	C_{ak}	–	0,8	pF

TEMPERATURE LIMITS

Absolute maximum envelope temperature	T_{env}	max.	240	°C
Recommended maximum seal temperature	T	max.	200	°C

orange binder, tab 7

COOLING

$W_a + W_g$ kW	T_i °C	q ℓ/min.	p_i kPa	max. T_{out} °C
100	20	50	65	50
	50	80	120	70
80	20	34	30	54
	50	54	55	72
40	20	15	7	60
	50	24	13	75

Absolute maximum water inlet temperature	T_i	50 °C
Absolute maximum water pressure	p_i	600 kPa

An air flow of at least 2 m^3/min should be ducted to the seals to keep the seal temperature below 200 °C.

R.F. CLASS-AB POWER AMPLIFIER

Unless otherwise stated, the vo'tages are given with respect to the cathode.

LIMITING VALUES (Absolute maximum rating system)

Frequency	f	up to	250 MHz
Anode voltage	V_a	max.	14 kV
Grid 2 voltage	V_{g2}	max.	1200 V
Grid 1 voltage	$-V_{g1}$	max.	600 V
Anode dissipation	W_a	max.	100 kW
Grid 2 dissipation	W_{g2}	max.	1,8 kW
Grid 1 dissipation	W_{g1}	max.	0,8 kW
Cathode current	I_k	max.	22 A

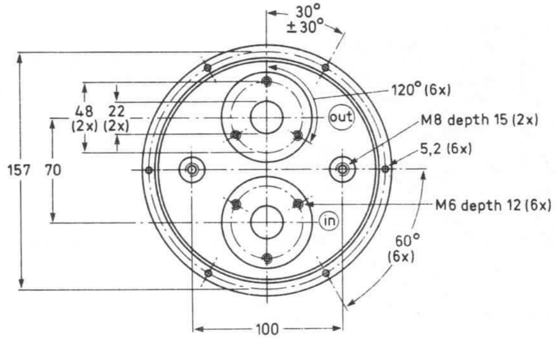
OPERATING CONDITIONS		grounded cathode	grounded grid
Frequency	f	⩽ 30	200 MHz
Anode voltage	V_a	10	10 kV
Grid 2 voltage	V_{g2}	900	900 V
Grid 1 voltage	$-V_{g1}$*	330	400 V
Anode current, no-signal condition	I_a	1,0	0,5 A
Anode current	I_a	17	12 A
Grid 2 current	I_{g2}	0,9	0,5 A
Grid 1 current	I_{g1}	1,75	0,5 A
Output power in load	W_ℓ	⩾ 120	65 kW
Driving power	W_{dr}	≈ 1	3,5 kW

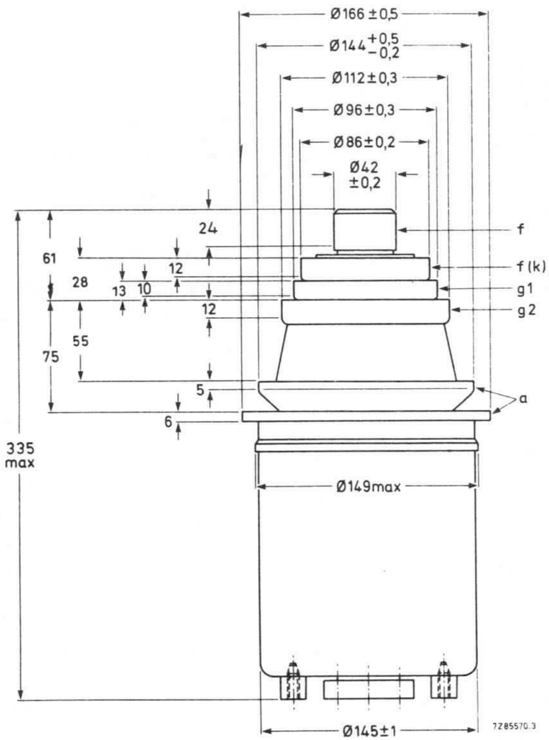
* To be adjusted for the stated no signal anode current.

MECHANICAL DATA

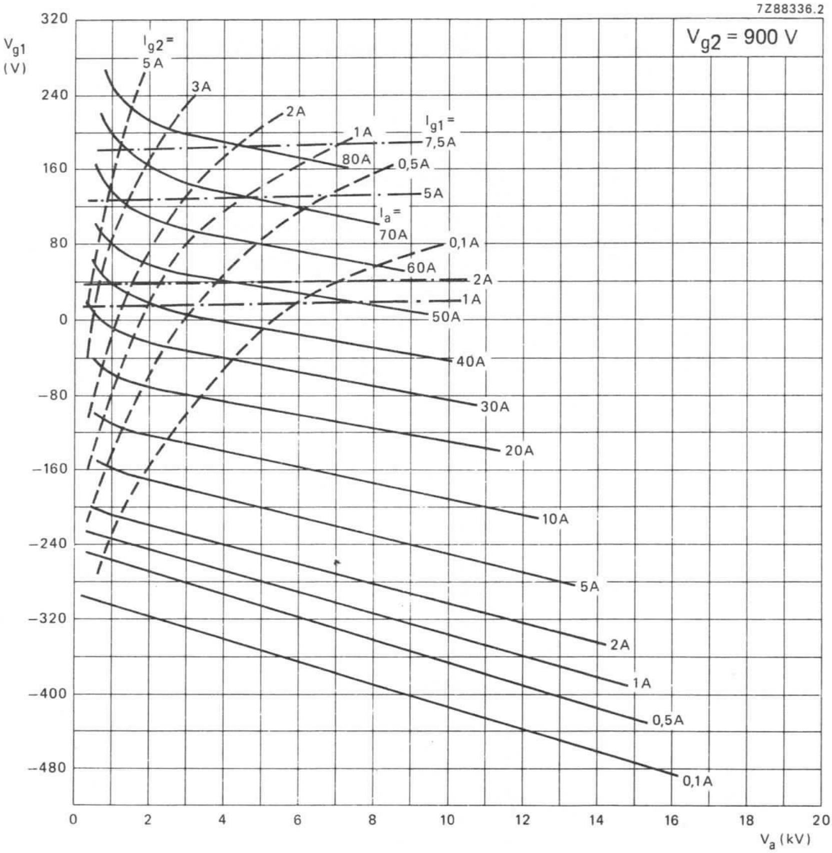
Net mass approx. 12 kg

Mounting position vertical with anode up (normal position) or anode down with reversed direction of water flow.





DEVELOPMENT SAMPLE DATA


7Z88336.2
V_{g2} = 900 V
V_{g1} (V)
320
240
160
80
0
−80
−160
−240
−320
−400
−480
I_{g2} =
5 A
3A
2 A
1 A
0,5 A
0,1 A
I_{g1} =
7,5 A
5 A
2 A
1 A
I_a =
80 A
70 A
60 A
50 A
40 A
30 A
20 A
10 A
5 A
2 A
1 A
0,5 A
0,1 A
0
2
4
6
8
10
12
14
16
18
20
V_a (kV)

AIR-COOLED R.F. POWER TETRODE

for grounded cathode operation

Forced air-cooled coaxial power tetrode in metal-ceramic construction primarily intended for use as grid-driven linear amplifier for single sideband, suppressed carrier service. This type is also recommended for f.m. broadcast applications. The electrode arrangement is specially designed for grounded cathode operation.

QUICK REFERENCE DATA

Class-AB linear SSB amplifier

Frequency	f	1,5 to 30	MHz
Anode voltage	V_a	8	kV
Output power in load	W_l	10	kW
Power gain	G	23	dB

Class-AB FM amplifier

Frequency	f	110		MHz
Anode voltage	V_a	6,5	7,5	kV
Output power in load	W_l	10	20	kW
Power gain	G	23	22	dB

HEATING: direct; thoriated tungsten filament, mesh type

Filament voltage	V_f	10,4	$V^{+1\%}_{-3\%}$
Filament current	I_f	115	A
Filament peak starting current	I_{fp} max.	750	A
Cold filament resistance	R_{fo}	10,5	mΩ
Waiting time	t_w min.	1	s

TYPICAL CHARACTERISTICS

Anode voltage	V_a	8	kV
Grid 2 voltage	V_{g2}	700	V
Anode current	I_a	2,4	A
Transconductance	S	60	mA/V
Amplification factor	μ_{g2g1}	8,5	

CAPACITANCES, grounded cathode

Input	C_i	135	pF
Output	C_o	23	pF
Anode to grid 1	C_{ag1}	0,85	pF

orange binder, tab 7

TEMPERATURE LIMITS

Absolute maximum envelope temperature	T_{env}	max.	240 °C
Recommended maximum seal temperature	T	max.	200 °C

→ COOLING

$W_a + W_g$ kW	h m	T_i °C	q_{min} m³/min	p_a p_i tube only	tube + cavity	T_o max °C
16	0	25	14	1300	1950	100
10	0	25	8	550	750	100
16	0	55	18	1900	2900	110
10	0	55	12	1000	1500	110
16	1500	25	16	1500	2200	100
10	1500	25	10	700	1000	100
16	3000	25	18	1500	2200	100
10	3000	25	12	800	1200	100

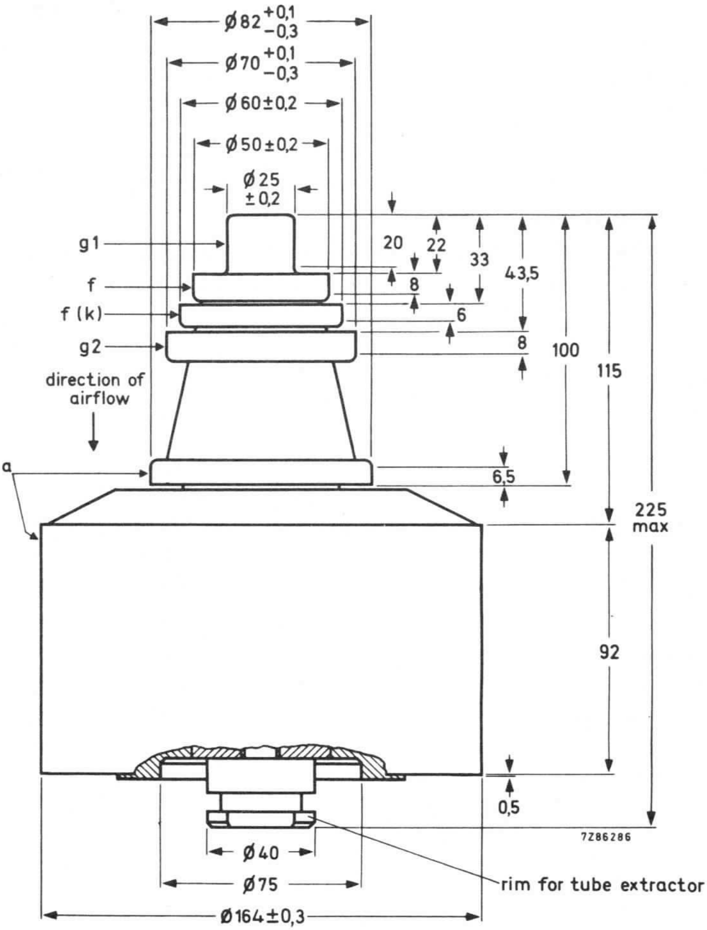
For direction of air flow see outline drawing. The air should be ducted so that sufficient air is directed to the seals to keep the seal temperature below the limit.

MECHANICAL DATA

Dimensions in mm

Net weight: approx. 11 kg

Mounting position: vertical with anode up or down



DEVELOPMENT SAMPLE DATA

ACCESSORIES

Band II amplifier circuit assembly — type 40788A ←

The electrode connection arrangement allows easy grounded cathode operation. ←

LIMITING VALUES (Absolute maximum rating system)

			notes
Frequency	f	up to 120 MHz	
Anode voltage	V_a	9 kV	
Grid 2 voltage	V_{g2}	1 kV	
Grid 1 voltage	$-V_{g1}$	500 V	
Anode current	I_a	7 A	
Anode input power	W_{ia}	40 kW	
Anode dissipation	W_a	18 kW	
Grid 2 dissipation	W_{g2}	100 W	
→ Grid 1 dissipation	W_{g1}	50 W	

OPERATING CONDITIONS, grid driven

R.F. CLASS-AB LINEAR AMPLIFIER, SINGLE SIDEBAND, SUPPRESSED CARRIER

Unless otherwise specified the voltages are given with respect to the cathode.

					notes
Frequency	f		30	MHz	
Anode voltage	V_a		8	kV	
Grid 2 voltage	V_{g2}		900	V	
→ Grid 1 voltage	$-V_{g1}$	≈	100	V	1

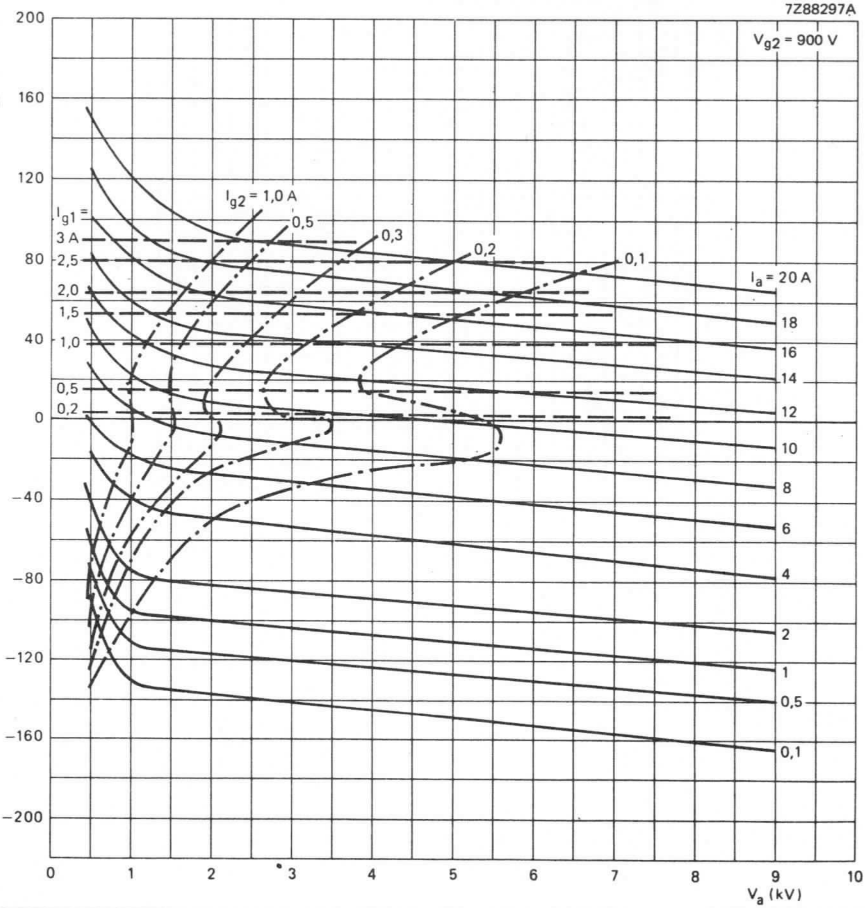
			zero signal	single tone signal	double tone signal		notes
Grid 1 driving voltage, peak	V_{g1p}		0	< 100	< 100	V	
Anode current	I_a		1,2	2,5	1,9	A	
Grid 2 current	I_{g2}	≈	10	50	15	mA	
Grid 1 current	I_{g1}	≈	0	0	0	mA	
Anode input power	W_{ia}		9,6	20	15,2	kW	
Anode dissipation	W_a		9,6	9,8	10	kW	
Output power in load (PEP)	W_ℓ		–	> 10	10	kW	
Total efficiency	η		–	50	33	%	
Intermodulation distortion							
3rd order	d_3		–	–	< –40	dB	2
5th order	d_5		–	–	< –60	dB	2

Notes

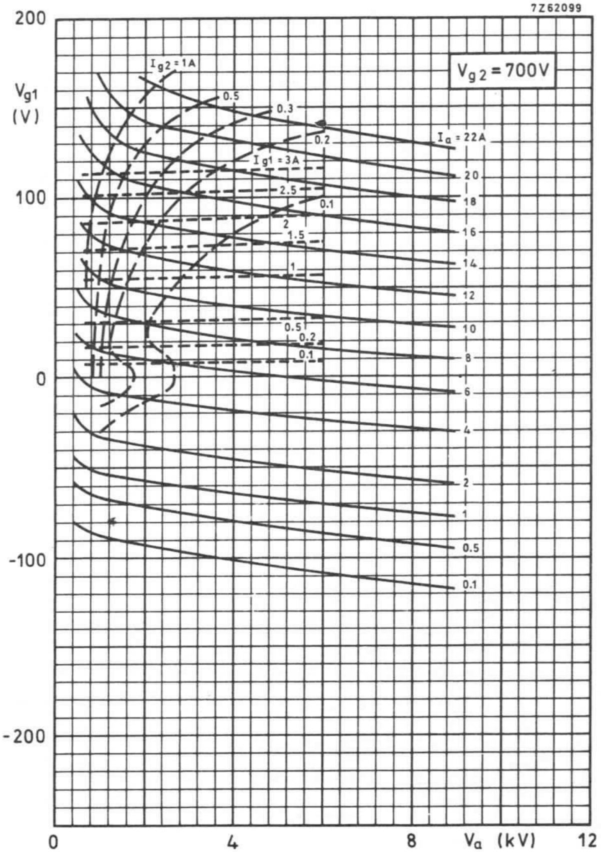
1. To be adjusted to zero signal current.
2. With reference to zero dB level.

CLASS-AB FM AMPLIFIER

Frequency	f		87-110		MHz
Anode voltage	V_a		6,5	7,5	kV
Grid 2 voltage	V_{g2}		700	900	V
Grid 1 voltage	$-V_{g1}$	≈	110	135	V (note 1)
Anode current, no signal conditions	I_a	≈	0,5	0,5	A
Anode current	I_a		2,4	4,1	A
Grid 2 current	I_{g2}	≈	100	100	mA
Grid 1 current	I_{g1}	≈	100	200	mA
Output power in load	W_ℓ		10	20	kW
Driving power	W_{dr}		50	130	W
Power gain	G		23	21	dB



DEVELOPMENT SAMPLE DATA



Mullard M84-1830/RC

Microwave tubes

8

Photomultiplier and photo tubes

9

Radiation detectors

10

GEIGER-MÜLLER TUBE

Halogen quenched γ and β ($>$ 0.25 MeV) radiation counter tube.

QUICK REFERENCE DATA

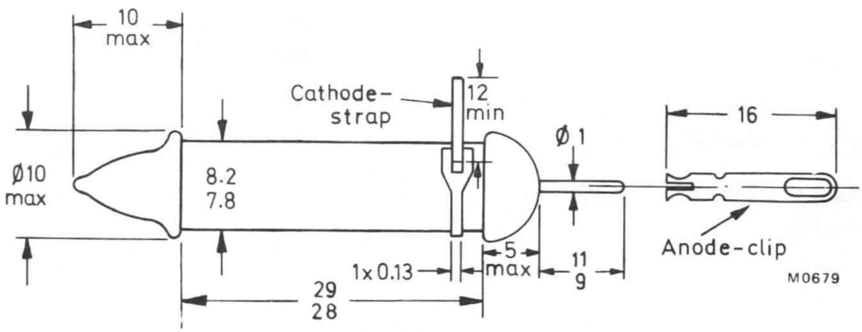
Dose rate range	10^{-3} to 10^{2}	mGy/h
Plateau threshold voltage	500	V
Plateau length	150	V
Recommended supply voltage	575	V
Chrome-iron cathode	32 to 40	mg/cm²

This data must be read in conjunction with General Information Geiger-Müller tubes.

MECHANICAL DATA

Dimensions in mm

Fig. 1



orange binder, tab 10

CATHODE

Thickness	32 to 40	mg/cm²
Sensitive length	28	mm
Material	chrome-iron	

FILLING

neon, argon, halogen

CAPACITANCE

Anode to cathode	1.1	pF

OPERATING CHARACTERISTICS (Ambient temperature ≈ 25 °C)

Measured in circuit of Fig.2

Starting voltage	max.	380	V
Plateau threshold voltage	max.	500	V
Plateau length		150	V
Recommended supply voltage		575	V
Plateau slope	max.	0.08	%/V
Background (shielded with 50 mm Pb with an inner liner of 3 mm Al), at recommended supply voltage	max.	12	count/min
Dead time. at recommended supply voltage	max.	45	μs

LIMITING VALUES (Absolute max. rating system)

Anode resistor	min.	2.2	MΩ
Anode voltage	max.	650	V
Ambient temperature continuous operating	max.	+70	°C
	min.	−40	°C
storage	max.	+75	°C

LIFE EXPECTANCY

Life expectancy at ≈ 25 °C	5×10^{10}	count

MEASURING CIRCUIT

$R_1 = 4.7\ M\Omega$

$R_2 = 100\ k\Omega$

$C_1 = 1\ pF$

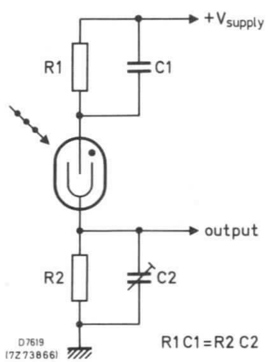
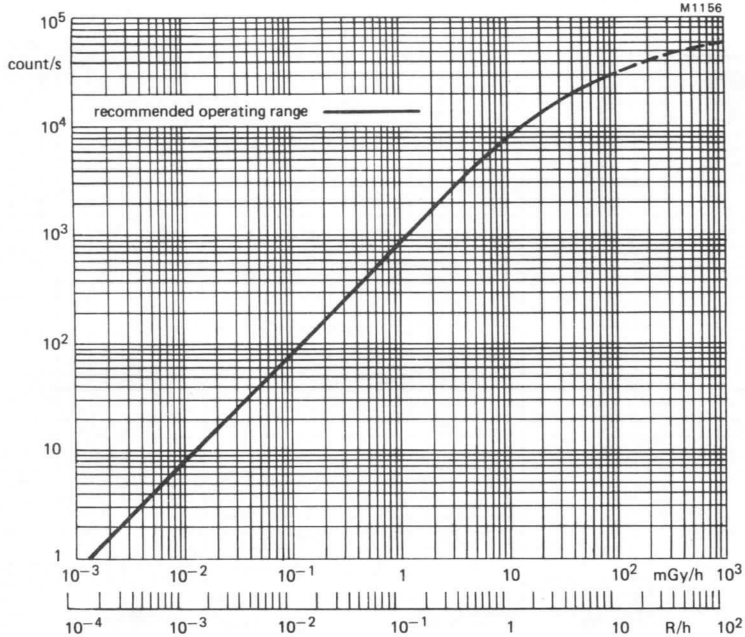
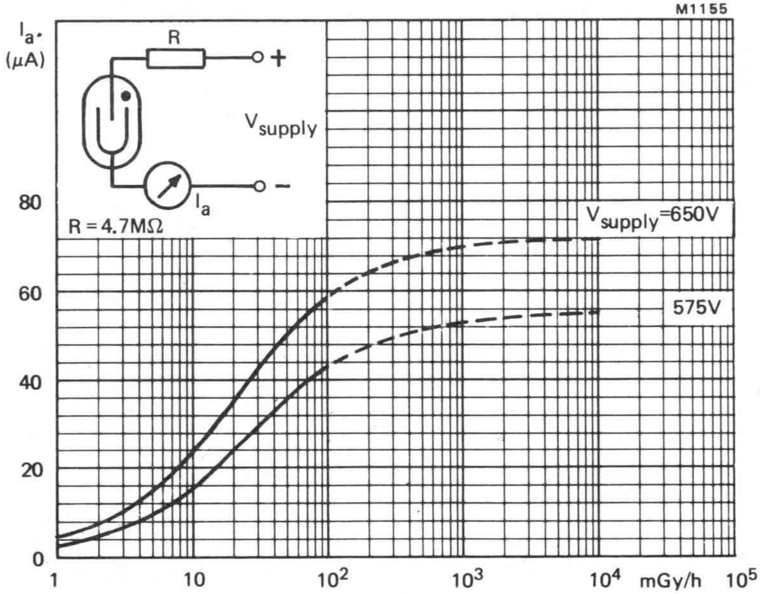


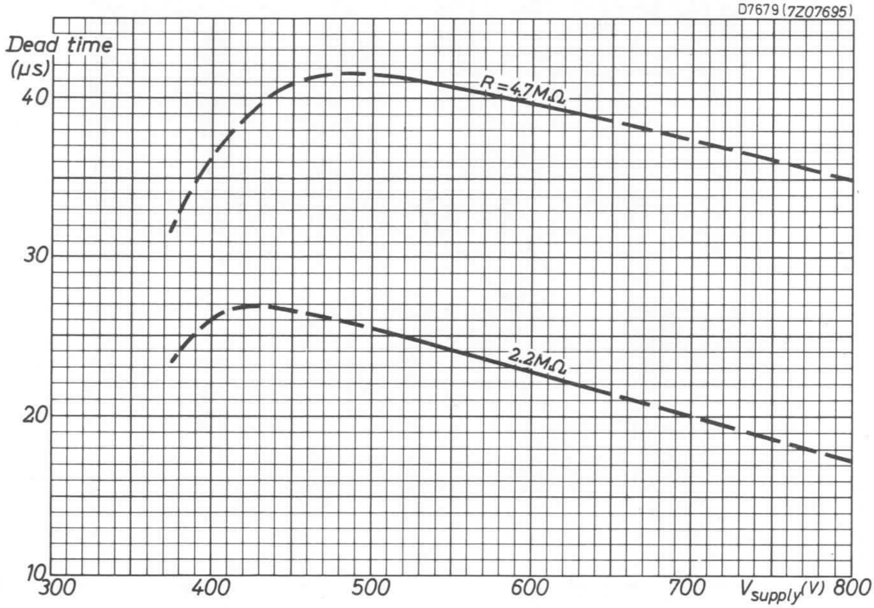
Fig.2



Typical counting rate as a function of dose rate (^{137}Cs)



Typical current as a function of dose rate (^{137}Cs)



Typical dead time as a function of supply voltage

Accessories

Miscellaneous devices

SUPERSEDES JANUARY 1982 DATA

DRY REED SWITCH

Micro dry reed switch hermetically sealed in a gas-filled glass capsule. Single-pole, single-throw type, having normally open contacts, and containing two magnetically actuated reeds. The contact switch is of the double-ended type and may be actuated by means of either an electromagnet or a permanent magnet or combinations of both. The device is intended for use in relays for switching main loads.

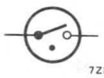
QUICK REFERENCE DATA

Contact	S.P.S.T. normally open	
Switched power	max.	40 W
Switched voltage, a.c. (r.m.s.)	max.	250 V
Switched current, resistive a.c. (r.m.s.)	max.	1 A
Contact resistance (initial)	max.	90 mΩ
Basic magnetic characteristics, measured with the Standard coil		
Operate range		30 to 65 At
Release range		10 to 25 At

MECHANICAL DATA

Contact arrangement	normally open
Lead finish	tinned
Resonant frequency of single reed	approx. 3200 Hz
Net mass	approx. 0,26 g
Mounting position	any

Dimensions in mm



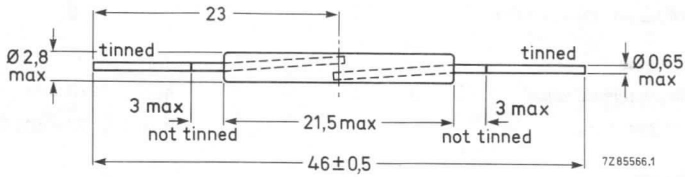


Fig. 1.

Mechanical strength

The robustness of terminations is tested according to IEC publication 68-2-21, test Ua (load 10N).

Mounting

The leads should not be bent nearer than 1 mm to the glass-to-metal seals. Stress on the seals should be avoided. Care must be taken to prevent stray magnetic fields from influencing the operating and measuring conditions. The switches can also be supplied with cropped and formed leads to customer specification.

orange binder, tab 12
9397 032 70422

Soldering

The contact unit may be soldered direct into the circuit but heat conducted to the glass-to-metal seals should be kept to a minimum by the use of a thermal shunt. Dip-soldering is permitted to a minimum of 6 mm from the seals at a solder temperature of 240 °C during maximum 10 s.

Solderability

Solderability is tested according to IEC 68-2-20, test T, solder globule method.

Weldability

The leads are weldable.

→ CHARACTERISTICS

Not-operate

Breakdown voltage	min.	750	V
Insulation resistance, initial	min.	10^6	MΩ (note 1)
Capacitance, without test coil	max.	0,20	pF

		coil I	coil II	
Must-not-operate value	max.	30	25	At
Operate				
Must-operate value	max.	65	51	At
Operate time, including bounce	typ.	0,35 (note 2)		ms
	max.	0,5 (note 2)		ms
Bounce time	typ.	0,15 (note 2)		ms
	max.	0,3 (note 2)		ms
Contact resistance, initial	typ.	60 (note 3)		mΩ
	max.	90 (note 3)		mΩ
Not-release				
Must-not-release value	min.	25	22	At
Release				
Must-release value	max.	10	9,5	At
Release time	max.	30 (note 2)		μs

Notes

1. Measured at a relative humidity of max. 45%.
2. Measured with 80 At.
3. Measured with 40 At, distance between measuring points: 41 mm, wire resistance: typ. 1 MΩ/mm.
4. Switching higher currents is possible depending on the signature of the load.

LIMITING VALUES

Absolute maximum rating systems

Switched power	max.	40 W
Switched voltage, a.c. (r.m.s.)	max.	250 V
Switched current, resistive a.c. (r.m.s.)	max.	1 A (note 4)
Current through closed contacts	max.	3,0 A
Temperature, storage and operating	max.	125 °C
	min.	−55 °C

LIFE EXPECTANCY AND RELIABILITY

Inductive loads

A. 220 V a.c. (r.m.s.); L = 3,95 H; R = 662 Ω; operating freq. 2 Hz; min. 10^4 operations. (No sticking allowed.) With a failure rate of max. 2.10^{-5} at 90% confidence level.
B. 220 V a.c. (r.m.s.); L = 5,5 H; R = 2230 Ω; operating freq. 2 Hz; min. 10^5 operations. (No sticking allowed.) With a failure rate of max. 2.10^{-6} at 90% confidence level.
C. 220 V a.c. (r.m.s.); L = 0,28 H; R = 106 Ω; switching on only; operating freq. 0,6 Hz min. 2.10^4 operations. (No sticking allowed.) With a failure rate of max. 2.10^{-5} at 90% confidence level.

Resistive load

A. 250 V a.c. (r.m.s.); R = 1 MΩ; operating freq. 20 Hz; min. 2.10^6 operations. Contact resistance max. 100 Ω and no sticking allowed. With a failure rate of 10^{-7} at 90% confidence level.

Note

Switching other loads involves different life expectancy and reliability. Consult us beforehand.

SHOCK AND VIBRATION

Impact

The units are tested according to IEC Publication 68-2-27, test Ea (peak acceleration 500 g, half sine-wave). Such an impact will not cause an open contact (no magnetic field present) to close, nor a contact kept closed by an 80 At coil to open.

Vibration

The units are tested according to IEC Publication 68-2-6 test Fc, acceleration 10 g, below cross-over, frequency amplitude 0,75 mm, frequency range 10-2000 Hz, duration 90 min). Such a vibration will not cause an open contact (no magnetic field present) to close, nor a contact kept closed by an 80 At coil to open.

COILS

Coil I: Standard coil

5000 turns of 42 SWG single enamelled copper wire on a coil former of 25,4 mm winding length and a core diameter of 8,75 mm.

Coil II: Miniature coil A according to MIL-S-55433B

10 000 turns of 48 SWG single enamelled copper wire on a coil former of 19,05 mm winding length and a core diameter of 4,32 mm.

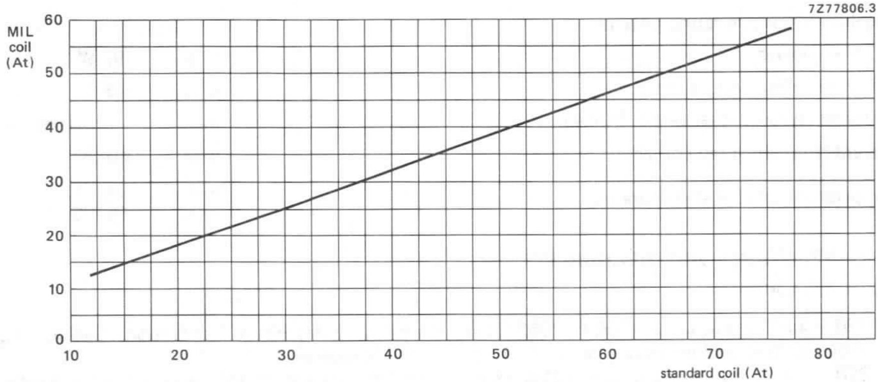


Fig. 2 Correlation at At operate in standard coil and MIL coil.

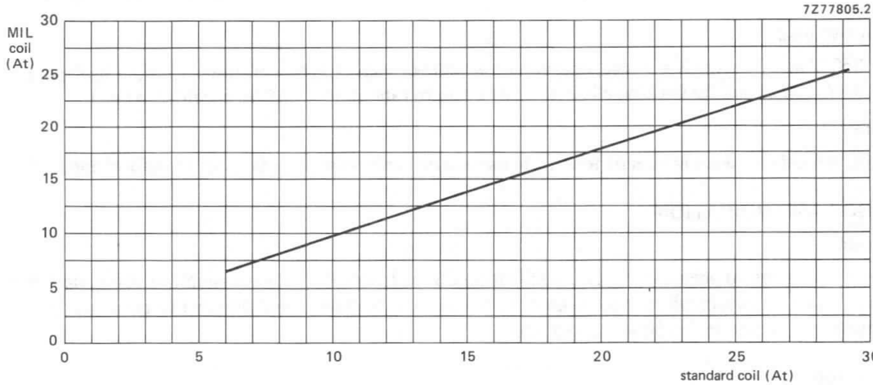


Fig. 3 Correlation of At release in standard coil and MIL coil.

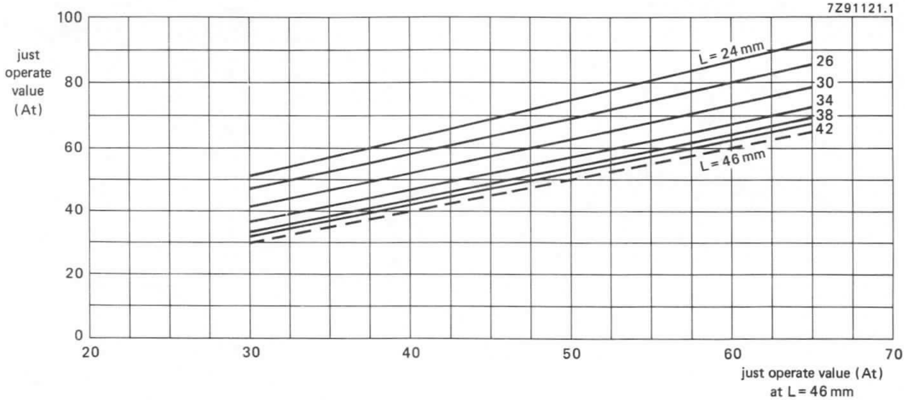


Fig. 4 Just operate values at various overall lenght compared with standard lenght of 46 mm.

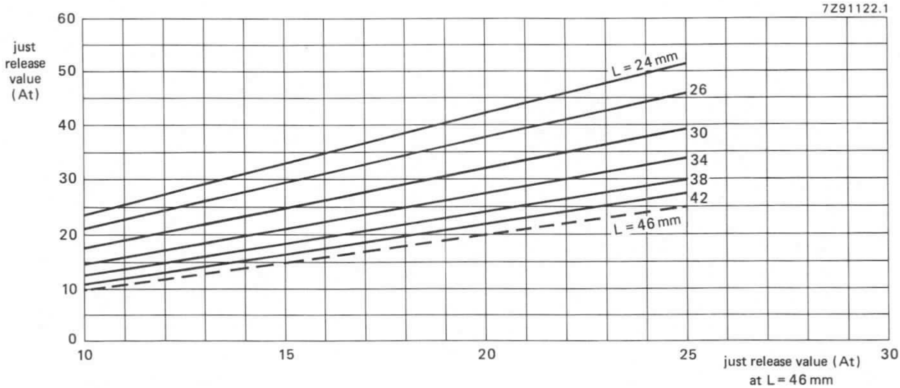


Fig. 5 Just release values at various overall lenght compared with standard lenght of 46 mm.

Supersedes Development Sample Data of October 1983

DRY REED SWITCHES

Micro dry reed switch hermetically sealed in a gas-filled glass capsule. Single-pole, single-throw type, having normally open contacts, and containing two magnetically actuated reeds. The switch is of the double-ended type and may be actuated by means of either an electromagnet or a permanent magnet or combinations of both. The device is intended for use in relays for switching power loads and high stand-off voltage applications.

QUICK REFERENCE DATA

Contact		S.P.S.T. normally open
Switched power		
types RI-46AA and RI-46A	max.	30 W
types RI-46B and RI-46C	max.	40 W
Switched voltage		
d.c.	max.	200 V
a.c. (r.m.s.)	max.	250 V
Switched current, resistive d.c. or a.c. (r.m.s.)	max.	1 A
Contact resistance (initial)	typ.	90 mΩ

The RI-46 series comprises the types RI-46AA, RI-46A, RI-46B and RI-46C with the following basic magnetic characteristics, measured with the Standard coil.

		RI-46AA	RI-46A	RI-46B	RI-46C
Operate range	(At)	12 to 21	17 to 31	27 to 56	51 to 77
Release range	(At)	5 to 14,5	6,5 to 19	9,5 to 24	14,5 to 26,5

MECHANICAL DATA

Contact arrangement	normally open
Lead finish	tinned
Resonant frequency of single reed	approx. 3200 Hz
Net mass	approx. 0,26 g
Mounting position	any

Dimensions in mm

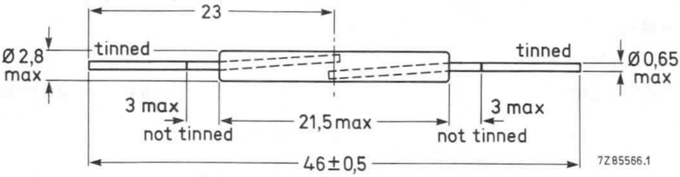


Fig. 1.

Mechanical strength

The robustness of terminations is tested according to IEC publication 68-2-21, test Ua (load 10N).

Mounting

The leads should not be bent nearer than 1 mm to the glass-to-metal seals. Stress on the seals should be avoided. Care must be taken to prevent stray magnetic fields from influencing the operating and measuring conditions. The switches can also be supplied with cropped and formed leads to customer specification.

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Soldering

The switch may be soldered direct into the circuit but heat conducted to the glass-to-metal seals should be kept to a minimum by the use of a thermal shunt. Dip-soldering is permitted to a minimum of 3 mm from the seals at a solder temperature of 240 °C during maximum 10 s.

Solderability

Solderability is tested according to IEC publication 68-2-20, test T, solder globule method.

Weldability

The leads are weldable.

→ The RI-46 series comprises four types: RI-46AA, RI-46A, RI-46B and RI-46C.

→ CHARACTERISTICS RI-46AA

		coil I	coil II	
Not-operate				
Breakdown voltage		see relevant graph		
Insulation resistance, initial	min.	10^6		MΩ (note 1)
Capacitance, without test coil	max.	0,25		pF
Must-not-operate value	max.	12	13	At
Operate				
Must-operate value	max.	21	19	At
Operate time, including bounce	typ.	0,35 (note 2)		ms
	max.	0,5 (note 2)		ms
Bounce time	typ.	0,15 (note 2)		ms
	max.	0,3 (note 2)		ms
Contact resistance, initial	typ.	60 (note 3)		mΩ
	max.	90 (note 3)		mΩ
Not-release				
Must-not-release value	min.	14,5	13	At
Release				
Must-release value	max.	5	6,5	At
Release time	max.	30 (note 2)		μs

Notes
1. Measured at a relative humidity of max. 45%.
2. Measured with 1,25 times the max. must-operate value per group.
3. Measured with 30 At, distance between measuring points: 41 mm. Wire resistance typ. 1,0 mΩ/mm.
4. Measured with 40 At, distance between measuring points: 41 mm. Wire resistance typ. 1,0 mΩ/mm.

CHARACTERISTICS RI-46A

Not-operate

Breakdown voltage		see relevant graph		
Insulation resistance, initial	min.	10^6		MΩ (note 1)
Capacitance, without test coil	max.	0,20		pF
		coil I	coil II	
Must-not-operate value	max.	17	16	At
Operate				
Must-operate value	max.	31	26	At
Operate time, including bounce	typ.	0,35 (note 2)		ms
	max.	0,5 (note 2)		ms
Bounce time	typ.	0,15 (note 2)		ms
	max.	0,3 (note 2)		ms
Contact resistance, initial	typ.	60 (note 3)		mΩ
	max.	90 (note 3)		mΩ
Not-release				
Must-not-release value	min.	19	17	At
Release				
Must-release value	max.	6,5	7,5	At
Release time	max.	30 (note 2)		μs

CHARACTERISTICS RI-46B

Not-operate

Breakdown voltage		see relevant graph		
Insulation resistance	min.	10^6		MΩ (note 1)
Capacitance, without test coil	max.	0,20		pF
		coil I	coil II	
Must-not-operate value	max.	27	23	At
Operate				
Must-operate value	max.	56	44	At
Operate time, including bounce	typ.	0,35 (note 2)		ms
	max.	0,5 (note 2)		ms
Bounce time	typ.	0,15 (note 2)		ms
	max.	0,3 (note 2)		ms
Contact resistance, initial	typ.	60 (note 4)		mΩ
	max.	90 (note 4)		mΩ
Not-release				
Must-not-release value	min.	24	20,5	At
Release				
Must-release value	max.	9,5	9,5	At
Release time	max.	30 (note 2)		μs

→ CHARACTERISTICS RI-46C

Not-operate

		coil I	coil II	
Breakdown voltage		see relevant graph		
Insulation resistance, initial	min.	10^6		MΩ (note 1)
Capacitance, without test coil	max.	0,20		pF
Must-not-operate value	max.	51	40	At
Operate				
Must-operate value	max.	77	58	At
Operate time, including bounce	typ.	0,35 (note 2)		ms
	max.	0,5 (note 2)		ms
Bounce time	typ.	0,15 (note 2)		ms
	max.	0,3 (note 2)		ms
Contact resistance, initial	typ.	60 (note 4)		mΩ
	max.	90 (note 4)		mΩ
Not-release				
Must-not-release value	min.	26,5	22,5	At
Release				
Must-release value	max.	14,5	13,0	At
Release time	max.	30 (note 2)		μs

→ LIMITING VALUES

Absolute maximum rating system

Switched power			
types RI-46AA and RI-46A	max.	30	W
types RI-46B and RI-46C	max.	40	W
Switched voltage			
d.c.	max.	200	V
a.c. (r.m.s.)	max.	250	V
Switched current, resistive d.c. or a.c. (r.m.s.)	max.	1	A (note 5)
Current through closed contacts			
type RI-46AA	max.	2,0	A
type RI-46A	max.	2,5	A
type RI-46B	max.	3,0	A
type RI-46C	max.	3,0	A
Temperature, storage and operating	max.	125	°C
	min.	−55	°C

Excursions up to 150 °C may be permissible. Consult us.

Notes
1. Measured at a relative humidity of max. 45%.
2. Measured with 100 At.
3. Measured with 30 At, distance between measuring points: 41 mm. Wire resistance typ. 1,0 mΩ/mm.
4. Measured with 40 At, distance between measuring points: 41 mm; Wire resistance typ. 1,0 mΩ/mm.
5. Switching higher currents is possible depending on the signature of the load.

LIFE EXPECTANCY AND RELIABILITY

The life expectancy data mentioned below are given at a coil energization of 1,5 x the published must-operate value for each group. Coil energization above 1,5 x will result in better life performance.

For life expectancy data end of life is defined as being reached when either:

(a) the contact resistance exceeds either 1 Ω for no-load conditions or 2 Ω for loaded conditions, measured 3 ms after energizing coil; or

(b) the release time exceeds 3 ms after de-energizing the coil (latching or contact sticking).

No-load conditions (operating frequency 100 Hz)

Life expectancy min. 10^7 operations with a failure rate of less than 10^{-9} with a confidence level of 90%. After each operation (a) and (b) are tested.

Loaded conditions (resistive load: 20 V –500 mA, operating frequency 125 Hz

Life expectancy min. 2,5 x 10^7 operations with a failure rate of less than 10^{-8} with a confidence level of 90%. After each operation points (a) and (b) are tested.

Note
Switching other loads involves different life expectancy and reliability. Consult us beforehand. Currents between 50 and 200 mA may result in a reduced life expectancy.

SHOCK AND VIBRATION

Impact

The units are tested according to IEC Publication 68-2-27, test Ea (peak acceleration 500 g, half sine-wave). Such an impact will not cause an open contact (no magnetic field present) to close, nor a contact kept closed by an 80 At coil to open.

Vibration

The units are tested according to IEC Publication 68-2-6 test Fc, acceleration 10 g, below cross-over, frequency amplitude 0,75 mm, frequency range 10-2000 Hz, duration 90 min). Such a vibration will not cause an open contact (no magnetic field present) to close, nor a contact kept closed by an 80 At coil to open.

COILS

Coil I: Standard coil

5000 turns of 42 SWG single enamelled copper wire on a coil former of 25,4 mm winding length and a core diameter of 8,75 mm.

Coil II: Miniature coil A according to MIL-S-55433B

10 000 turns of 48 SWG single enamelled copper wire on a coil former of 19,05 mm winding length and a core diameter of 4,32 mm.

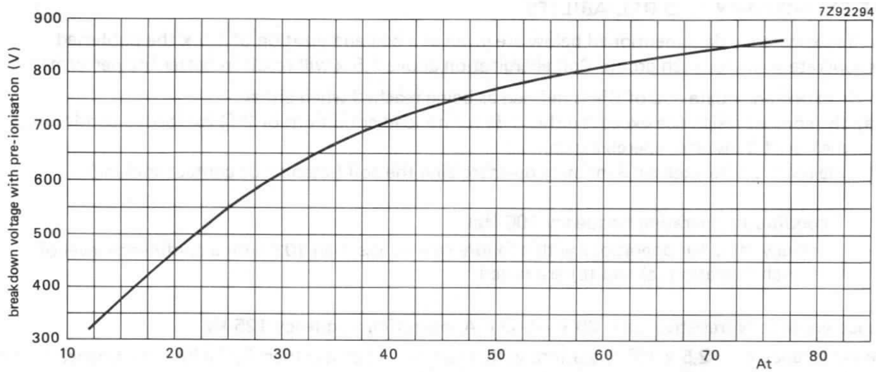

Fig. 2 Minimum breakdown voltage with pre-ionisation as a function of ampere-turns.

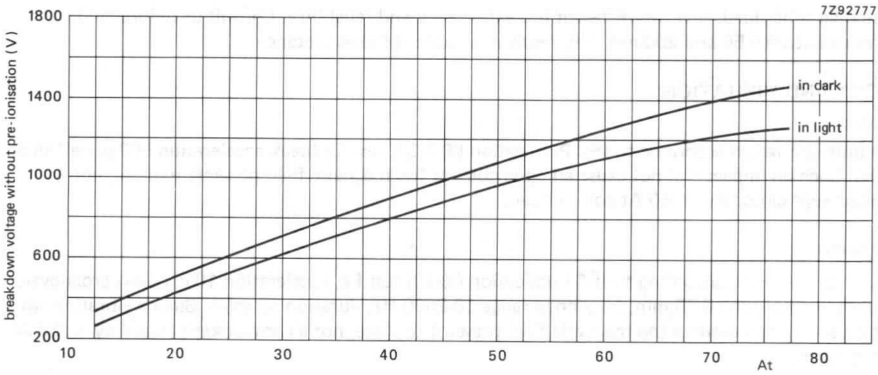

Fig. 3 Minimum breakdown voltage without pre-ionisation as a function of ampere-turns.

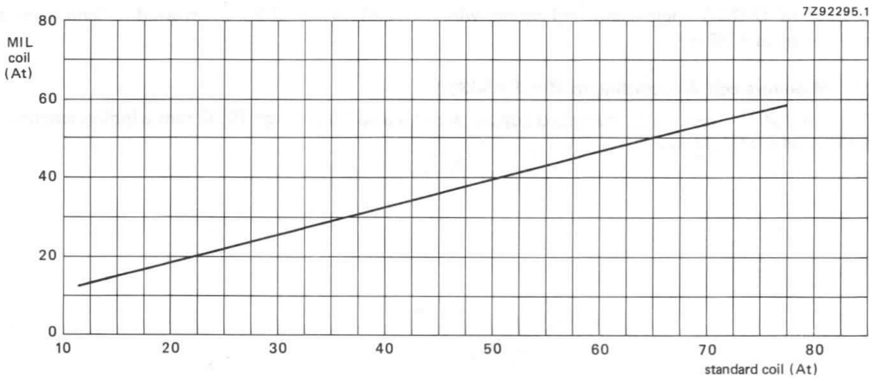

Fig. 4 Correlation of At operate in standard coil and MIL coil.

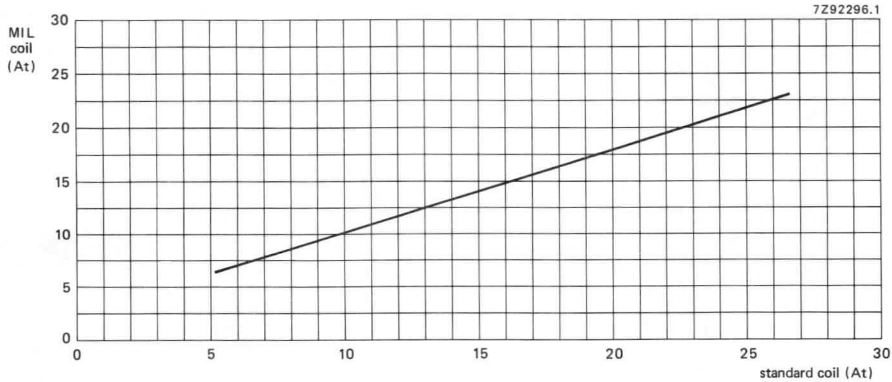

Fig. 5 Correlation of At release in standard coil and MIL coil.

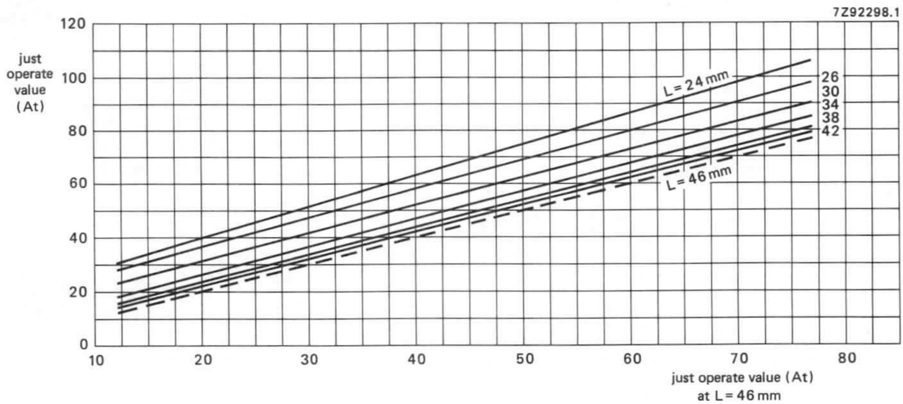

Fig. 6 Just operate values at various overall lenghts compared with standard lenght of 46 mm.

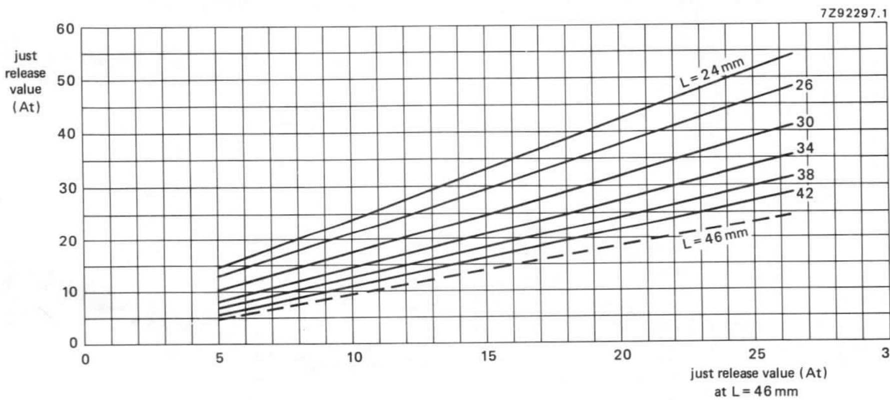

Fig. 7 Just release values at various overall lenghts compared with standard lenght of 46 mm.

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