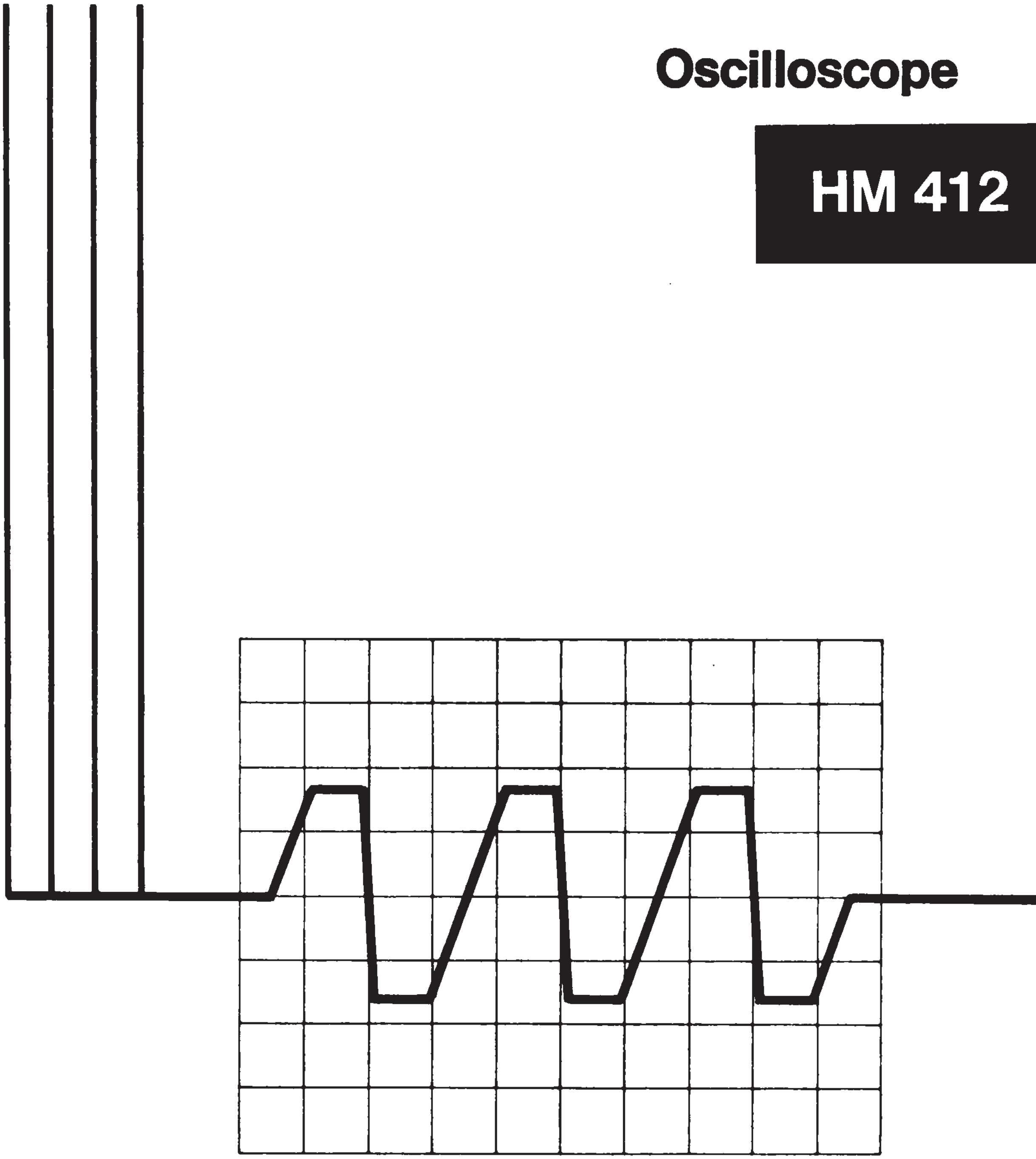
MANUAL



Oscilloscope

HM 412

HAMEG MESSTECHNIK

HAMEG

OSCILLOSCOPE HM 412-5

- **Overscan Indication**
- **Bandwidth DC-20MHz**
- **Delayed Sweep**
- **Triggering to 40MHz**

The Model **HM412** demonstrates the exceptionally high standard of quality and operating comfort achieved by **HAMEG**. The rectangular flat-faced CRT with quick heating cathode has a **8x10cm internal graticule** to eleminate parallax errors. **Regulated power supplies** ensure that line fluctuations do not adversely affect the display and specified measuring accuracy The **multitude of operating modes** is very impressive. The vertical sensitivity of both channels can be increased to **2mV/cm**. Fully matched X-Y operation is available, also the channels can be **added** or **subtracted**. Special features of the HM412 are the vertical **overscanning** facility, automatic **peak value triggering to 40MHz**, and **sweep delay** for the expansion of relatively small signal portions across the full screen area. The **alternate triggering** of two asynchronous signals, **variable hold-off time**, TV and line triggering, **single sweep**, raster illumination, trace rotation, **Z-modulation**, ramp output, built-in calibrator, and a burn-in resistant CRT phosphor make the HM412 a most versatile oscilloscope at a competitive price.

Accessories optional
Attenuator Probes x1, x10, and x100, Demodulating Probe, various Test Cables, Component Tester, Four-Channel Unit, Viewing Hood, Trolley, Carrying Case, ect.

Specification

Vertical Deflection (Y)
Bandwidth of both channels:
DC-20MHz (-3dB), DC-28MHz (-6dB).
Risetime: 17.5ns (approx.).
Overshoot: 1% (maximum).
Deflection coefficients: 12 calibr. steps, 5mV/cm-20V/cm (1-2-5 sequence), variable gain control uncalibr. to 2mV/cm, accuracy better than ±3% (in cal. position).
Input impedance: 1MΩ II 25pF.
Input coupling: DC-AC-GND.
Max. Input voltage: 500V (DC + peak AC).
Polarity: normal or inverted on Channel I.
Overscanning: indicated by 2 LED's.

Operating modes
Channel I, Channel II, Channel I and II, alternate or chopped (approx. 1MHz).
Addition: Channel I + II.
Difference: with Channel I inverted.
X-Y operation: sensitivity ratio 1:1

Timebase
Time coefficients: 21 calibrated steps, 0.5µs/cm-2s/cm (1-2-5 sequence), with variable control uncalibr. to 0.2µs/cm, with magnifier x5 uncalibrated to 40ns/cm, accuracy better than ±3% (in cal. position).
Variable hold-off-time: 10:1 (min.).
Ramp output: 5V (approx.).

Trigger System
Modes: automatic (peak value) or variable trigger level.
Source: Ch. I or II, altern. Ch. I/II, line, ext.
Slope: positive or negative.
Coupling: DC, AC, TV frame.
Sensitivity: int. 5mm, ext. 1V (approx.).
Bandwidth: DC-40MHz.
Trigger action: indicated by LED.
Single sweep: Single-Reset buttons with LED.

Sweep Delay
Ranges: 7 decade steps, 100ns-1s with fine control, ratio 10:1
Modes: Normal, Search, Delay; mode indicated by LED.

Horizontal Deflection (X)
Bandwidth: DC-2MHz (-3dB).
(X-Y mode: phase shift <3° at 100kHz).
Other values see Vertical Deflection.
Input via channel II.

Miscellaneous
Cathode-ray tube: D14-252, intern. graticule, rectangular flat-faced, quick heating cathode.
Accelerating potential: 2000V
Calibrator: square-wave generator 1kHz, 0.2V ±1%, for probe compensation.
Z-Modulation input: TTL-level.
Trace rotation: adjustable on front panel.
Graticule illumination: three-position switch.
Regulated DC power supplies: all operating voltages including the EHT
Line voltages: 110, 125, 220, 240V AC.
Line fluctuation: ±10% (maximum).
Line frequency range: 50-60Hz.
Power consumption: 38W (approx.).
Weight: 7.5kg (approx.).
Dimensons (mm): **W** 212, **H** 237, **D** 380.
Finish: dark grey. With handle and tilt stand.

Subject to change.

General

The mechanical construction of the HM412 is both **stable and functional**. Internally the printed circuit boards are easily accessible to facilitate **ease of maintenance**, should this be required. However, the design of the HM412 is such that every component is operated well within its specified limits to ensure **long term reliability**. The manual supplied with each instrument covers the operating procedure, circuit diagrams, PCB layouts, test and service instructions are also included. For the investigation of low frequency phenomena the HM412 with P7 long persistence phosphor CRT is recommended.

Operating Modes

The HM412 may be operated as either a **single or dual trace** oscilloscope. In the dual trace mode two waveforms differing in time and amplitude can be displayed consecutively **(Alternate Mode)** or by multiple switching of the channels during one sweep period **(Chop Mode)**. Normally the alternate mode is employed when displaying high frequency signals. The sum of the two channels is displayed in the **Add Mode**, if Channel I is then inverted a **differential display** is obtained. It is significant to note that all these modes can be selected on just four pushbuttons. In the **X-Y mode**, the horizontal signal is derived from Channel II so that both the horizontal and vertical channels have the same input impedance and sensitivity range.

Vertical Deflection

Each channel contains a **diode protected FET input** preamplifier. The preamplifiers are electronically switched to the final vertical amplifier in either alternate or chop mode. The electronic switch operates with bistable controlled diode gates. In the alternate mode, the unblanking pulse from the sweep generator is used as the control signal, while a **1 MHz signal** is used in the **chop mode**. To minimize drift, the input stages of the preamplifiers are **monolithic integrated circuits**. The sensitivity of each vertical amplifier is selected on a 12 position frequency compensated attenuator, calibrated in V/cm. For reliable triggering at high frequencies the **bandwidth of the preamplifiers** is in the order of **50 MHz**. The bandwidth of the complete vertical system is dependent on the final output amplifier, the quoted value refers to the -3dB point **(70% of 60mm)**. If a smaller display is acceptable it is possible to investigate signals **up to about 40 MHz**. The final vertical amplifier incorporates the **Overscanning** facility. This technique is superior to the more common beam finder, as it will also indicate if a large repetitive "spike" of more than **100 ns width** is present on either channel. In the case of complete overscan, both LED's are illuminated. A built-in 1 kHz square-wave generator can be used to check amplifier calibration and probe compensation.

Timebase

The HM412 timebase incorporates an **LPS trigger circuit**, a new technique developed by HAMEG. The complete triggering process is carried out by a monolithic integrated circuit voltage comparator with TTL output. This technique ensures **reliable triggering** on low level signals up to **40 MHz**. When automatic mode is selected the timebase will free run, also in the absence of a trigger signal, always displaying a time axis. The **automatic mode** is supported by a fast **Peak Value Triggering**. In the **normal trigger mode**, the amplitude point on the trigger signal, at which the sweep is triggered, is manually adjustable on signal's rising or trailing edge. The trigger performance on aperiodic signals (e. g. complex digital words) is enhanced by using the **variable hold-off time**. For investigating single events, or for photography, the **single-shot** mode can be used. The HM412 can be triggered from either Channel I or II, from the line or external. In the **alternate trigger mode**, the source is taken alternatively from Channel I and II, this enables signals which are **not frequency related** to be triggered. Trigger coupling can be either AC, DC or TV lowpass filter. The **Sweep Delay** enables a short time interval of a waveform to be expanded and investigated at higher resolution, for example a sweep rate of 10 µs/cm can be expanded by a factor of **250 times**. At slower speeds far greater magnification is possible. Operation of the sweep delay is relatively easy, as only three controls need to be used, an **LED indicates the operating mode**. With the delay mode switch in the **"Norm."** position the total waveform under investigation is triggered as a normal display. The mode switch should then be set to **"Search"** position, in this mode the LED indicator will flash. By adjusting the **seven position delay range switch** and **twenty turn precision fine control** the commencement of the trace can be set just prior to the short time interval to be investigated. When this point is achieved the mode switch should be set to **"Delay"**. In this condition the LED is permanently illuminated, and the time interval under test will be displayed. If the main timebase sweep speed is increased, then the time interval under test will be **further expanded**. Again the delay fine control can be used to enable the exact point of interest to be displayed. The sweep delay facility is particularly useful for the analysis of complex waveforms, for instance the **colour burst** in a composite video signal can be expanded to **cover the full screen width**. Two BNC sockets for **Z modulation input** and **ramp output** are located on the rear panel of the instrument.

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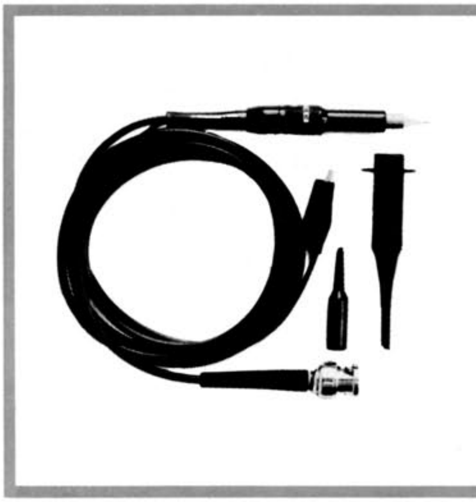
This frequency compensated attenuator probe should be used when the circuit under test is a high impedance source or the signal voltage exceeds 100 Vpp. It should be noted that the probe reduces the input voltage by a factor of 10. The probe can be connected to the test circuit by a removable sprung hook, and an integral ground lead with an insulated crocodile clip.

Specification

Attenuation x10. Bandwidth DC-100 MHz. Risetime 3.5 ns. Max. input voltage 600 V (DC + peak AC) Input impedance 10 Megohm. Input capacitance 10.3 13.6 pF Compensation range 10 60 pF Cable length 1.5 m.

Accessories supplied: Sprung Hook, Trimming Tool.



HZ 30 Oscilloscope Probe x 10

The HZ 35 is a straight through probe without attenuation and therefore allows the full sensitivity of the oscilloscope to be used Due to the probe capacity it is only recommended for use with relatively low impedance and low frequency sources. This probe is connected to the test circuit by a sprung hook and integral ground lead with an insulated crocodile clip.

Specification

Bandwidth DC-10 MHz. Max. input voltage 600 V (DC + peak AC) Input resistance equal to the oscilloscope resistance. Input capacitance 47 pF + oscilloscope input capacitance. Cable length 1.5 m.

Accessories supplied: Sprung Hook, BNC Adapter

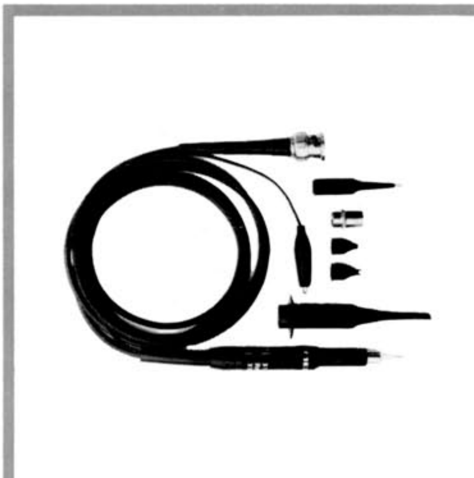
HZ 35 Oscilloscope Probe x 1

The HZ 36 is a switchable probe offering both x10 and x1 operation. n the x10 mode the characteristics are the same as the HZ 30. n the x1 position the cable capacity will act as a load on a high impedance source, however the maximum sensitivity of the oscilloscope can be fully uti ized The reference position enables a ground reference level to be set. n this mode the oscilloscope input is grounded

Specification

Attenuation x10 same as HZ 30 spec. x1 operation: Bandwidth DC-10 MHz. Max. input voltage 600 V (DC + peak AC) Input resistance equal to the oscilloscope resistance. Input capacitance is 40 pF + oscilloscope input capacitance. Reference position: probe tip grounded via 9 Megohm, oscilloscope input grounded. Cable length 1.5 m.

Accessories supplied: Sprung Hook, Trimming Tool BNC Adapter Insulating Tip IC Tip.



HZ 36 Switchable Probe x 10/x 1

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For the measurement of voltages between 500 V and 1500 V it is essential to use the HZ 37 x 100 attenuator probe. It should be noted that if voltages greater than 600 V are applied to the HZ 30, HZ 36 and HZ 38 probes then serious damage to the probes and the oscilloscope input will occur When using the HZ 37 the input voltage to the oscilloscope is reduced by a factor of 100.

Specification

Attenuation x 100. Bandwidth DC 50 MHz. Risetime 7 ns. Max. input voltage 1500 V (DC + peak AC) Input resistance 9.1 Megohm. Input capacitance approx. 4.6 pF Compensation range 12 48 pF Cable length 1.5 m.

Accessories supplied: Sprung Hook, Trimming Tool BNC Adapter Insulating Tip, IC Tip.

HZ 37 Oscilloscope Probe x 100

The HZ 38 is a x 10 attenuator probe which has been specially designed for the investigation of relatively high frequency signals. As the risetime of the probe is added geometrically to that of the oscilloscope it should not be greater than 20% of the oscilloscope risetime. The HZ 38 is recommended for use with instruments quoting a bandwidth of 40 MHz or more, as the effective bandwidth of the oscilloscope wil not suffer reduction by the probe.

Specification

Attenuation x 10. Bandwidth DC 200 MHz. Risetime 1 7 ns. Max. input voltage 500 V (DC + peak AC) Input resistance 10 Megohm. Input capacitance approx. 13 pF. Compensation range 12 - 48 pF. Cable length 1.5 m.

Accessories supplied: Sprunk Hook, BNC Adapter 2 Ground Leads.

HZ 38 Oscilloscope Probe x 10

The HZ 39 Demodulator Probe is particularly suitable for the display of the AM content of RF signals, and as a detector for swept-frequency voltages. The main circuit component is a peak to peak rectifier with a capacitor input. For RF suppression the output signal is derived via a low-pass filter For correct operation the probe must be terminated by 1 Megohm (oscilloscope input resistance with DC coupling) f AC coupling has to be used then a separate 1 Megohm resistor will be required to achieve the neccessary DC bias voltage for the diodes.

Specification

Bandwidth approx. 35 kHz to 250 MHz. RF input voltage range 0.25 Vrms to 40 Vrms. Max. input voltage 200 V (DC + peak AC). Output polarity positive. Cable length 1.5 m.

Accessories supplied: Sprung Hook, BNC Adapter

HZ 39 Demodulator Probe

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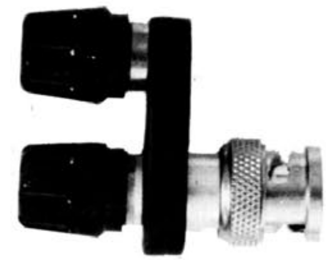
This adapter is designed to meet applications where it is neccessary to connect 4 mm plugs to an instrument with a BNC input socket. The HZ 20 is solidly constructed and versatile incorporating a BNC male plug to dual 4 mm binding post. The binding post mounting can be rotated so that the adapter can be positioned to avoid obstructing front panel controls.

Specification

Dimensions (mm) length 42, width 35, depth 18. Standard BNC male plug. Two 4 mm binding posts 19 mm between centres. Maximum input voltage 500 V (DC + peak AC)



HZ 20 Adapter Binding Posts to BNC

The HZ 22 is a 50 ohm through termination with a BNC female socket to receive the test cable and a BNC male plug for connection to the osci loscope. This termination should be used to terminate signal generators and koax-cables which have a 50 ohm characteristic impedance. For correct operation the termination must be connected directly to the osci loscope input, otherwise the test signals, irrespective of its fundamental shape, will be deformed The termination should also be used for the accurate measurement of high frequency sine wave signals (to avoid standing waves) The HZ 22 should not be employed when a compensated attenuator probe is used

Specification

Dimensions (mm) 14 x 20 x 62. Max. load 2 W Max. voltage 10 Vrms.

HZ 22 50 ohm Through-Termination

When setting the frequency compensation of an oscilloscope input attenuator with a 1 Megohm input resistance a screened x2 input attenuator must be used The HZ 23 is a compact attenuator with a BNC male plug for connection to the oscilloscope vertical input, and a BNC female socket for connection to the coaxial cable from the osci loscope calibrator In series with the centre connections of the plug and socket is a 1 Megohm resistor paralled by a ceramic trimmer capacitor The trimmer can be adjusted to equal the input capacitance of the oscilloscope, then the impedance of the HZ 23 is equal to the specified input impedance of the oscilloscope under test.

Specification

Dimensions (mm) 62 x 21 x 15. Fixed resistor 1 Megohm. Capacitance compensating range 12 - 48 pF Max. voltage 250 V (DC + peak AC).

HZ 23 Input Attenuator x2

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The HZ 32 coaxial test cable is designed to facilitate connection between an oscilloscope and instruments with 4 mm sockets. However, this combination of BNC- 4 mm can be used for many other applications. For example when investigating AF signals from a high impedance source the possibility of hum pick-up and crosstalk is greatly reduced as the signal input 4 mm plug is completely screened Both the BNC and 4 mm signal plug have anti-kink mouldings while the 4 mm earth lead is fine stranded wire, to minimize the risk of the cable breaking.

Specification

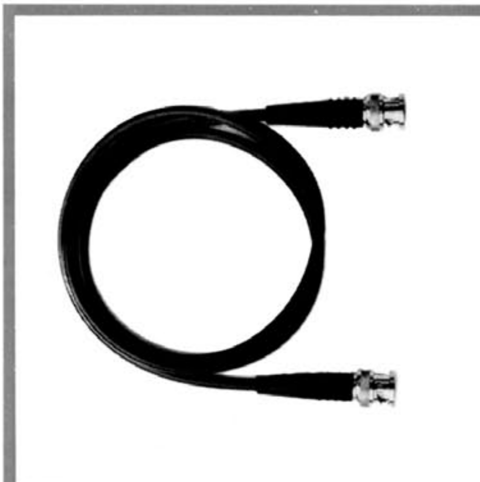
Cable length 1 15 m. Cable capacitance 120 pF Characteristic impedance 50 ohm. Max. voltage 500 V (DC + peak AC).

HZ 32 Test Cable BNC- 4 mm

The HZ 34 is a coaxial test cable terminated with BNC male plugs at each end. Today the BNC connection system is the most widely used type in the commercial electronics field, and the HZ 34 gives the user a test cable with specified characteristics. To minimize the possibility of cable breakage both BNC plugs are protected by anti-kink mouldings.

Specification

Cable length 1.2 m. Cable capacitance 126 pF Characteristic impedance 50 ohm. Max. voltage 500 V (DC + peak AC).



HZ 34 Test Cable BNC - BNC

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When the osci loscope is used for field service applications the HZ 43 carrying case wil prove to be invaluable, as it has been designed to protect the instrument and provide storage for accessories and tools. The carrying case is manufactured from hard wearing material, the base of the case has a thick shock absorbing lining which protects the instrument against rough hand ing. One side of the case has a compartment which can be used to carry accessories, tools and spares. Dimensions for the carrying case are 260 x 210 x 460 mm, while the compartments measurements are 260 x 210 x 50 mm. The instrument handle is used for carrying minimizing the stresses applied to the carrying case.

Suitable for HM 312, HM 412 and HM 512 oscilloscopes. Special model for HM 812 oscilloscope on request.

HZ 43 Carrying Case

The HZ 44 Carrying Case has been specially designed for the smaller instruments in the HAMEG range, though of course it may be used for other instruments of a similar size. t also contains a compartment which can be used for accessories and tools. The case is manufactured from a hard wearing material. A leather shoulder strap, with a protective pad, is fixed to the case, this is particularly advantageous if other equipment has to be carried. Ventilation holes are provided in the case so that instruments with a maximum consumption of 30 Watts can be operated in the case. Overall dimensions are approx. 300 x 125 x 300 mm, accessory compartment approx. 120 x 40 x 280 mm.

Suitable for HM 307 HZ 62 and HZ 64 instruments.

HZ 44 Carrying Case

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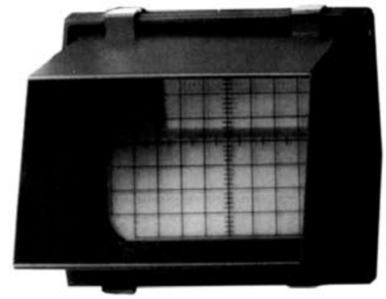
Under high ambient ight conditions it may be found that the contrast of the display is diminished, also problems can sometimes be caused by unwanted reflections on the graticule. In most cases the HZ 47 Viewing Hood will overcome these problems as it shields the display area, substantially increasing the contrast, and decreasing the possibility of reflections. The HZ 47 has four sprung clips which easily locate into slots on the oscilloscope bezel

Suitable for HM 312, HM 412, HM 512 and HM 812 oscilloscopes.



HZ 47 Viewing Hood

General Information

The new HM412 is as easy to use as its predecessors. Technologically it represents the latest state of engineering in this price range. This is particularly illustrated by the increased use of monolithic integrated circuits. The logical arrangement of the controls and connectors on the front panel ensures that the user will quickly become familiar with the operation of the instrument. However, even experienced operators are advised to read the following instructions thoroughly, as they include important information relating to the use of the HM412.

This instrument is designed and tested according to international safety standards (e. g. **VDE 0411 part 1 and 1a:** Safety requirements for electronic measuring apparatus). The instrument has left the factory in perfect safety condition. To preserve this state and to ensure operation without danger, the user must observe all advice and warning remarks in these Operating, Test, and Service Instructions. **The case, chassis, and all measuring terminals are connected to the Safety Earth conductor.** The instrument corresponds to the specification for the **Safety Classification I** (three-conductor AC power cable). The grounded accessible metal parts (case, sockets, jacks) and the power line circuit of the HM412 are tested against one another with 1500V 50Hz. Under certain conditions, 50Hz or 60Hz hum voltages can occur in the measuring circuit due to interconnection with other line powered instruments or devices. This can be avoided by using a protective isolating transformer between the line outlet and power plug of the HM412. Without an isolating transformer, the instrument's power cable must be plugged into an approved three-contact electrical outlet, which meets International Electrotechnical Commission (IEC) safety standards. The disconnection of the Safety Earth conductor is inadmissible.

As with most electron tubes, the cathode-ray tube develops X-rays. With the HM412-5 **the dose equivalent rate falls far below the maximum permissible value of 36pA/kg** (0.5mR/h).

If a protective isolating transformer is used for the display of signals with high zero potential, it should be noted that these voltages are also connected to the oscilloscope's case and other accessible metal parts. Voltages up to 42V are not dangerous. Higher voltages, however, involve a shock hazard. In this case, special safety measures must be taken and must be supervised by qualified personnel.

To obtain the maximum life from the cathode-ray tube, the minimum intensity setting necessary for the measurement in hand and the ambient light conditions should be used. **Particular care is required when a single spot is displayed**, as a very high intensity setting may cause damage to the fluorescent screen of the CRT. In addition, switching the oscilloscope off and on at short intervals stresses the cathode of the CRT and should therefore be avoided.

In spite of Mumetal-screening of the CRT, effects of the earth's magnetic field on the horizontal trace position cannot be completely avoided. This is dependent upon the setting up direction of the oscilloscope on the place of work. Then a centred trace will not align exactly with the horizontal center line of the graticule. A few degrees of misalignment can be corrected by a potentiometer accessible through an opening on the front panel marked *TR*.

As with all HAMEG oscilloscopes, the front panel is subdivided into sections according to the various functions. Located on the upper right, next to the CRT, is the power switch and indicating lamp; the intensity, focus, horizontal position and trace rotation controls together with the graticule illumination slide switch and the calibrator output are also in this section. The Sweep Delay controls are located immediately below this section. The controls for the two deflection systems are located below the CRT. The left-hand section contains the controls for both vertical measuring amplifiers. The controls for the timebase and trigger selection are contained in the right-hand section.

The instrument is designed so that even incorrect operation will not cause serious damage. The pushbuttons control only minor functions, and it is recommended that before the commencement of operation that all pushbuttons are in the "out" position. After this the pushbuttons can be operated depending upon the mode of operation required. For a better understanding of these Operating Instructions the front panel picture at the end of these instructions can be unfolded for reference alongside the text.

The HM412 accepts all signals from DC (direct voltage) up to a frequency of at least 20MHz (-3dB). For sine-wave voltages the upper frequency limit will be 30-35MHz. However, in this higher frequency range the vertical display height on the screen is limited to approx. 3-4cm. In addition, problems of time resolution also arise, i.e. with 25MHz and the fastest adjustable sweep rate (40ns/cm), one cycle will be displayed every 1cm. The tolerance on indicated values amounts to ±3% in both deflection directions. All values to be measured can therefore be determined relatively accurately. However, it should be remembered that from approximately 6MHz upwards the measuring error will increase as a result of loss of gain. At 12MHz this reduction is about 10%. Thus, approximately 11% should be added to the measured voltage at this frequency. As the bandwidth of the amplifiers differ (normally between 20 and 25MHz), the measured values in the upper limit range cannot be defined exactly. Additionally, as already mentioned, for frequencies above 20MHz the dynamic range of the display height steadily decreases. The vertical amplifiers are designed so that the transmission performance is not affected by its own overshoot.

Warranty

Before being shipped each instrument must pass a 10 hour quality control test. Almost every early failure can be detected by means of intermittent operation during this test. Nevertheless, a component may only fail after a longer period of operation. Therefore, all HAMEG instruments are under warranty for a period of one year, provided that no modifications have been made to the instrument. HAMEG will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. HAMEG is not liable for consequential damages. It is recommended that the instrument be repackaged in the original manner for maximum protection. We regret that transportation damage due to poor packaging is not covered by this warranty. In case of any complaint, attach a tag to the instrument with a description of the fault observed. Please supply name and department, address and telephone number to ensure rapid service.

Operating Conditions

Admissible ambient temperature range during operation: +10°C...+40°C. Admissible ambient temperature range for storage or transportation: −40°C ...+70°C. If condensed water exists in the instrument it should not be turned on before acclimatization is achieved. In some cases (an extremely cold oscilloscope) about two hours should be allowed before putting the instrument into operation. The instrument should be placed in a clean and dry room. In other words, the instrument may not be put into operation in explosive, corrosive, dusty, or moist environments. The instrument may be operated in any position, however, the convection cooling must not be impaired. Therefore, when the instrument is in continuous operation it should be used in the horizontal position preferably on its tilt stand.

The instrument must be disconnected and secured against unintentional operation if there is any presumption that safe operation is not possible. This supposition is qualified

- if the instrument has visible damage,
- if the instrument has loose parts,
- if the instrument does not function,
- after a long storage under unfavourable circumstances (e. g. out of doors or in moist environments),
- after hard transportation stress (e. g. in a poor packaging).

First Time Operation

On delivery, the instrument is set to AC 240V ±10% (50-60Hz) mains/line voltage. The power plug-in unit at the rear contains the three-pin power connector. For this a three wire power cord with triple-contact connector and three-pole power plug is required. The unit also contains the power fuse, which is interchangeable for the different mains/line voltages. The fuse holder with its square top plate can be pulled out, and **changing of the mains/line voltage** is possible by turning this plate 90 degrees for each of the four voltages marked on the plate (see triangle below the fuse holder). The fuse holder should then be plugged in again in the selected position. The power fuse must correspond to the voltage selected and when necessary should be replaced. The type and rated current are given on the rear panel and in the Service Instructions.

To obtain a display the following procedure should be adopted. All pushbuttons should be in the *out* position. All variable control knobs with arrows should be in the fully counterclockwise (*Cal.*) position, while those with marker lines should be set to their mid-range (marker lines pointing approximately vertically). It should be noted that the slide switch in the *DELAY* section is set to the *Norm.* position. Furthermore, both slide switches in the *TIMEBASE* section should be set to their uppermost position.

The instrument is switched on by depressing the **POWER** pushbutton located on the right of the CRT; an LED indicates that the instrument is on. If the trace is not visible, after a short warm-up period of 10 seconds (quick heating cathode), it is possible that the **INTENS.** control needs to be increased (rotate clockwise), or the sweep generator is not triggered. Also, the **POS.** controls might be incorrectly set, in this case the overscan LED's will indicate. All knobs and switches should again be checked to ensure that the correct positions have been selected. Particular attention should be paid to the **Peak/Norm.** pushbutton. In the absence of an input signal the baseline will only be displayed if this pushbutton is in the "out" position (automatic peak value triggering). If only a dot appears (Caution! CRT phosphor could be damaged under this condition), probably the pushbutton for the **Hor. ext.** is depressed. If this is so, it should be released. Now, the baseline should appear and the **INTENS.** control should be adjusted for average brightness, while optimum sharpness is obtained by adjusting the **FOCUS** control. At the same time both input coupling switches **DC-AC-GD** should be in the **GD** position. Thus, the inputs to the Y-amplifiers are shorted preventing the introduction of unwanted signals. In the **GD** position, any signal applied to the vertical inputs is not shorted, therefore preventing damage to the circuit under investigation.

DC-Balance Adjustment

Each vertical amplifier contains an FET input preamplifier, it is possible that over a long period of time the characteristics of the FET may change. This can on occasions change the DC-Balance of the vertical amplifier. This is recognized, ***if the vertical trace position changes considerably when the fine control on the input attenuator is rotated***. It should be noted that if the change is less than 1mm after a 20 minute warm-up period then the instrument is within specification. Larger changes than this can be corrected by adjusting the potentiometer which is located behind the opening marked **Bal.** which is located above the sensitivity switch for each amplifier. As the potentiometer is a helical type, it may require a number of turns to obtain correct setting. To obtain correction the fine control should be continuously rotated while the potentiometer is adjusted (deflection coefficient **5mV/cm**; input coupling slide switch to **GD**). Correct DC-Balance is obtained when the vertical trace position remains steady while the fine control is varied. It should be noted that for correction of Channel II the pushbutton marked **CH I/CH II** must be depressed.

Type of Signal

All types of signals whose frequency spectrum is below 20MHz can be displayed on the HM412. The display of simple electrical processes such as sinusoidal RF and AF signals or ripple voltage poses no problems. However, when square or pulse-shaped signals are displayed it must be remembered that their ***harmonic content*** must also be transmitted. In this case, the bandwidth on the vertical amplifier must be considerably higher than the repetition frequency of the signal. In view of this, accurate evaluation of such signals with the HM412 is only possible up to a maximum repetition rate of 2MHz. Operating problems can sometimes occur when composite signals are to be displayed, especially if they do not contain any suitable level components and repetition frequency which can be used for triggering. This occurs, for example, with burst signals. To obtain a stably triggered display in these cases, it may be necessary to use the timebase variable control or the sweep delay facility. ***Television video signals are relatively easy to trigger***. However, when investigating signals at frame rate, the upper **Trigger-Selector** switch has to be set in **LF** position (low-pass filter). In this mode, the more rapid line pulses are attenuated so that, with appropriate level adjustment, triggering can easily be carried out on the leading or trailing edge of the frame synchronizing pulse.

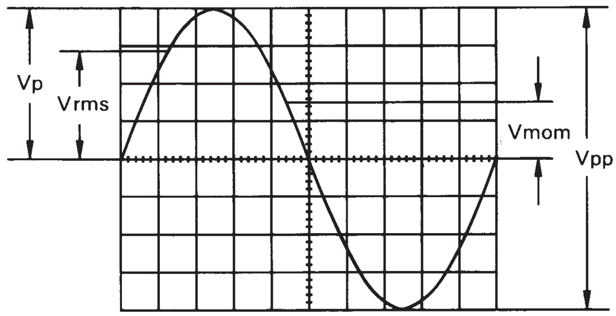
For optional operation as an DC or AC voltage amplifier, each channel is provided with an **DC-AC** switch. The **DC** position should only be used with an attenuator probe or at very low frequencies or if the acquisition of the DC voltage content of the signal is absolutely necessary.

However, when investigating very low-frequency pulses, disturbing ramp-offs may occur with AC coupling. In this case, DC operation is to be preferred if the signal voltage is not superimposed on a high DC voltage level. Otherwise, a capacitor of adequate capacitance must be connected before the input of the vertical amplifier (with DC coupling). It should be remembered that this capacitor must have a sufficiently high breakdown voltage. DC operation is also recommended for the display of logic and pulse signals, particularly if their pulse duty factor changes permanently during operation. Otherwise, the display will move up and down with any change. DC voltages can only be measured in the **DC** position.

Amplitude Measurements

In general electrical engineering, alternating voltage data normally refers to effective values (rms = root-mean-square value). However, for signal magnitudes and voltage designations in oscilloscope measurements, the peak-to-peak voltage (Vpp) value is applied. The latter corresponds to the real potential difference between the most positive and most negative points of a signal waveform.

If a sinusoidal waveform, displayed on the oscilloscope screen, is to be converted into an effective (rms) value, the resulting peak-to-peak value must be divided by $2x\sqrt{2} = 2.83$. Conversely, it should be observed that sinusoidal voltages indicated in Veff (Vrms) have 2.83 times the potential difference in Vpp. The relationship between the different voltage magnitudes can be seen from the following figure.



Voltage values of a sine curve
Vrms = effective value; Vp = simple peak or crest value;
Vpp = peak-to-peak value; Vmom = momentary value.

The minimum signal voltage required at the vertical amplifier input for a display of 1 cm is approximately ***2mVpp***. This is achieved with the attenuator control set at **5mV/cm** and the ***fine control in the fully clockwise position***. However, smaller signals than this may also be displayed. The ***deflection coefficients*** on the input attenuators, designated by **AMPL.** are indicated in **mV/cm** or **V/cm**. The magnitude of the applied voltage is ascertained by multiplying the selected deflection coefficient by the vertical display amplitude in cm.

If an attenuator probe X10 is used, it should be remembered that a further multiplication by a factor of 10 is required to ascertain the correct voltage value. ***For exact amplitude measurements the fine control on the*** **AMPL.** ***switch must be set to its calibrated detent*** (fully counterclockwise = arrow horizontal and pointing to the left).

With direct connection to the vertical input, signals up to 160Vpp may be displayed. If the applied signal is superimposed on a DC (direct voltage) level the total value (DC + peak value of the alternating voltage) of the signal on the input must not exceed ±500V. This same limit applies to normal attenuator probes X10, the attenuation ratio of which allows signal voltages up to approximately 1,000Vpp to be evaluated. Voltages of up to approximately

3,000Vpp may be measured by using the HZ37 high voltage probe which has an attenuation ratio of 100:1. It should be noted that its Vrms value is derated at higher frequencies (see page M6: Connection of Test Signal). If a normal X10 probe is used to measure high voltages there is the risk that the compensation trimmer bridging the attenuator series resistor will break down causing damage to the input of the oscilloscope. However, if for example only the residual ripple of a high voltage is to be displayed on the oscilloscope, a normal X10 probe is sufficient. In this case, an appropriate high voltage capacitor (approx. 22-68nF) must be connected in series with the input tip of the probe.

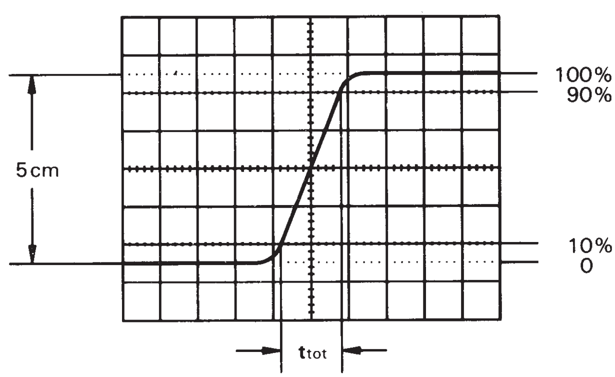
It is very important that the oscilloscope input coupling is set to **DC**, if an attenuator probe is used for voltages higher than 500V (see page M6: Connection of Test Signal).

Time Measurements

As a rule, all signals to be displayed are periodically repeating processes and can also be designated as periods. The number of periods per second is the recurring frequency or repetition rate. One or more signal periods or even part of a period may be shown as a function of the adjustment of the **TIMEBASE** switch. The time coefficients on the **TIMEBASE** switch are indicated in **s/cm**, **ms/cm** and **µs/cm**. Accordingly, the dial is subdivided into three sectors. The duration of a signal period or a portion of the waveform is ascertained by multiplying the relevant time (horizontal distance in cm) by the time coefficient selected on the **TIMEBASE** switch. ***The time fine control marked* VAR. *must be in its calibrated detent (*Cal.*) for accurate measurement*** (arrow horizontal and pointing to the left).

If the time is relatively short as compared with the complete signal period, an expanded time scale (**X-MAGN. x5**) should be applied. In this case, the ascertained time values have to be divided by 5. Very small time intervals at optional points of the signal can be measured more exactly with the aid of the sweep delay. With it, the display and measurement of time intervals, which are smaller than 1% of the full signal period, are possible. The smallest measurable time interval is, on the whole, dependent on the obtainable brightness of the CRT. The limit is an expansion of approximately 200-250 times. Using a Viewing Hood HZ47, an expansion of 1000 times is possible, provided that the time coefficient set on the **TIMEBASE** switch is greater than ***50µs/cm*** for the signal's basic period. Otherwise, the fastest sweep speed determines the greatest possible expansion.

When investigating pulse or square waveforms the critical feature is the risetime of the voltage step. To ensure that transients, ramp-offs, and bandwidth limits do not unduly influence the measuring accuracy, the risetime is generally measured between 10% and 90% of the vertical pulse height. For signal peak-to-peak amplitudes of ***5cm*** height, which are symmetrically adjusted to the horizontal center line, the internal graticule of the CRT has two horizontal dotted lines with ±2.5cm center distance. Adjust the amplifier by means of the **AMPL.** switch with fine control and **Y-POS.** control so that the pulse is precisely aligned with these subsidiary lines for 0 and 100%. The 10% and 90% points of the signal will now coincide with the two horizontal graticule lines, which have a distance of ±2cm from the horizontal center line. The risetime is given by the product of the horizontal distance in cm between these points of intersection and the time coefficient setting. If magnification is used, this product must be divided by 5. The fall time of a pulse can also be measured by using this method. The following figure shows correct positioning of the oscilloscope trace for accurate risetime measurement.



When very fast risetimes are being measured, the risetime of the oscilloscope amplifier has to be deducted from the measured time value. The risetime of the signal can be calculated using the following formula.

$$t_r = \sqrt{t_{tot}^2 - t_{osc}^2}$$

In this the t_{tot} is the total measured risetime and t_{osc} is the risetime of the oscilloscope amplifier (approx. 17.5ns with HM412-5). If t_{tot} is greater than 100ns, then this can be taken as the risetime of the pulse, and calculation is unnecessary.

Connection of Test Signal

The signal to be displayed should be fed to the vertical input of the oscilloscope by means of a screened test cable, e.g. the HZ32 or HZ34, or by a X10 or X100 attenuator probe. The use of these screened cables with high impedance circuits is only recommended for relatively low frequencies (up to approx. 50kHz). For higher frequencies, and when the signal source is of low impedance, a cable of matched characteristic impedance (usually 50Ω) is recommended. In addition, and especially when investigating square or pulse waveforms, a resistor equal to the characteristic impedance of the cable must also be connected to the cable at the input of the oscilloscope. When using a 50Ω cable, such as the HZ34, a 50Ω through-termination type HZ22 is available from HAMEG. When investigating square or pulse waveforms with fast risetimes, transient phenomena on both the edge and top of the signal may become visible if the correct termination is not used. It must be remembered that the 50Ω through-termination will only dissipate a maximum of 2 watts. This power consumption is reached with 10Vrms or with 28Vpp sine signal. If a X10 attenuator probe (e.g. HZ30) is used, no termination is necessary. In this case, the connecting cable is matched directly to the high impedance input of the oscilloscope. When using attenuator probes even high internal impedance sources are only slightly loaded (by approximately 10MΩ// 11pF). Therefore, when the voltage loss due to the attenuation of the probe can be compensated by a higher sensitivity setting on the HM412, the probe should always be used, also it should be remembered that the series impedance of the probe provides a certain amount of protection for the input of the oscilloscope amplifier. It should be noted that all attenuator probes must be compensated in conjunction with the oscilloscope (see: Probe Adjustment).

If a X10 or X100 attenuator probe is used, always the **DC** input coupling must be set. With **AC** coupling, the attenuation is frequency-dependent, the pulses displayed can exhibit ramp-off, DC-voltage contents are suppressed — but load the concerning input coupling capacitor of the oscilloscope. The electric strength of which is maximum 500V (DC + peak AC). For the suppression of disturbing DC voltages, a ***capacitor*** of adequate capacitance and electric strength ***may be connected before the input tip of the probe*** (e. g. for ripple measurements).
With the X100 probe the permissible AC input voltage is frequency-dependent limited:
underneath 20kHz (TV line frequency!) up to

max. 1.500 Vp ≙ 3.000 Vpp ≙ 1.061 Vrms;

above 20kHz (with f in MHz) up to

$$\text{max.}\ \frac{212}{\sqrt{f}}\,\text{Vp} \triangleq \frac{424}{\sqrt{f}}\,\text{Vpp} \triangleq \frac{150}{\sqrt{f}}\,\text{Vrms.}$$

It is important to remember that when low voltage signals are being investigated the position of the ground point on the test circuit can be critical. This ground point should always be located as close as possible to the measuring point. If this is not done, serious signal deformation may result from any spurious currents through the ground leads or test chassis parts. This comment also applies to the ground leads on attenuator probes which ideally should be as short and as thick as possible.

For the representation of two signals in the differential-mode, two attenuator probes are required, which are absolutely equal in impedance and attenuation. Only with such probes is it possible to take signals from the test circuit. In the differential-mode, the measurement of a signal voltage between two circuit points, which are isolated from ground, is possible. As a fall in voltage across a known resistance, the current between two circuit parts is also measurable. For many differential measurements it is advantageous **not** to connect both the probe ground leads to the test circuit. Any hum or common-mode interference may be thereby avoided.

Hum or interference voltage appearing in the measuring circuit (especially with a small deflection coefficient) is possibly caused by multiple grounding, because through it equalizing currents can flow in the screenings of the measuring cables (fall in voltage between the non-fused earthed conductors of other line powered devices, which are connected to the oscilloscope or test object, e. g. signal generators).

Caution: When connecting unknown signals to the oscilloscope input, always set the **DC-AC** input coupling switch to **AC** and the **AMPL.** switch should initially be set to ***20 V/cm***. Pay attention to the Overscanning indication (see next paragraph).

Sometimes the trace will disappear after an input signal has been applied (see below: Y Overscanning Indication). Then the **AMPL.** switch must be turned back to the left, until the vertical signal height is only 3-6cm. With a signal amplitude greater than 160Vpp, an attenuator probe must be inserted before the oscilloscope's vertical input. If after applying the signal the trace is blanked, the period of the signal is probably substantially longer than the set value on the **TIMEBASE** switch. It should be turned to the left on an adequately greater time coefficient.

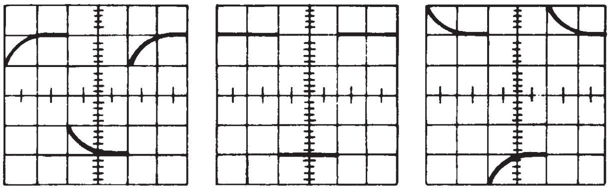
Y Overscanning Indication

This indicating facility shows any overscanning of the usable screen dimensions ***in the vertical direction***, if the baseline or signal portions with more than 100ns length of time (e. g. needle pulses) are not within the graticule. The indication is achieved by two light-emitting diodes, marked **Overscan**, which are located between both input attenuators. Should one LED illuminate without an input signal, this means that the respective vertical positioning control has been adjusted improperly. Because each LED correlates with one of both possible directions, it can be seen, in which direction the trace has left the screen. With dual channel operation, misadjustment of both **Y-POS.** controls can occur. If both traces lie in the same direction, one LED illuminates likewise. If one trace is positioned above and the other underneath the graticule, both LED's are illuminated. The indication of the Y position after crossing the graticule area occurs **in each operating mode**, also when, due to missing time deflection, no baseline is displayed, or when the oscilloscope is in the X-Y mode. As previously written in the paragraph "First Time Operation", the **Peak/Norm.** pushbutton should not be pressed if possible, as a baseline is then permanently displayed, also without any input signal. The trace disappears at times after applying an input signal. The LED indication shows, in which direction the trace has left the screen, above or below the graticule. Illumination of both LED's at the same time after applying a signal means that the vertical deflection has overscanned the graticule edges in both directions. With **DC** input coupling and an applied signal with a relatively high DC offset, smaller sizes also of displayed signals can overscan the raster edges, because the DC voltage causes a vertical position shift of the display height, which seemed correctly adjusted. In this case, a smaller display height must be accepted, or **AC** input coupling has to be selected. Lighting of the overscan LED's does not imply that the signal's shape is always distorted in the setting just selected. The vertical amplifier has a certain overdriving reserve. However, it is better to check that the maximum output voltage swing is not exceeded. This can be done by turning the **AMPL.** switch one step to the left. If the overscanning indication is extinguished thereby, the foregoing setting can be used for checking e. g. the tops of square pulses with vertical expansion. Of course, this is not valid for frequency spectra beyond 10MHz, because in this case the overdriving reserve naturally diminishes.

Probe Adjustment

To achieve the undistorted display of signals when using an X10 or X100 attenuator probe the probe must be compensated to match the input impedance of the vertical amplifier. This can be easily achieved as the HM412 has a built-in square-wave generator with a repetition frequency of approx. 1kHz and an **output voltage of 0.2Vpp ±1%**.

The method employed is as follows. The probe tip with its sprung hook is connected to the output eye designated by a square-wave on the front panel of the instrument. The probe trimmer is then adjusted by using the trimming tool supplied. The correct display is shown in the following figure.



incorrect correct incorrect

The **TIMEBASE** switch should be in the **0.2ms/cm** position. The input coupling is set to **DC**. If the attenuator sensitivity is set to **5mV/cm**, the display will have a height of ***4cm*** when an X10 probe is being compensated. As an attenuator probe is constantly subjected to considerable stresses the compensation should be frequently checked.

It should be noted that the frequency of the square-wave generator is unsuitable for the time calibration. Furthermore, the pulse duty factor has not the 1:1 value. Finally, the rise and fall times of the square signal are so fast that the edges — even with maximum intensity — are visible only with difficulty. This is not a flaw, but actually the precondition for a simple and exact probe compensation (or a deflection coefficient check) like horizontal pulse tops, calibrated pulse amplitude, and zero potential on the negative pulse top.

Operating Modes

The required operating modes are selected on 4 pushbuttons located in the vertical amplifier section. For **Mono** operation all pushbuttons should be in the "out" position, the instrument is then operating on ***Channel I*** only. For **Mono** operation with ***Channel II***, the **CH II** pushbutton has to be pressed; then the lower **Trigger Selector** switch should be set to **II**. When the **Mono/Dual** button is depressed, the HM412 is in **Dual** channel operation. In this mode, the channels are displayed consecutively (alternate mode). This mode is not suitable for the display of very low frequency signals, as the trace will appear to flicker or jump. Under these conditions, the **Alt./Chop.** button should be depressed selecting chopped mode. In this position, both channels then share the trace during each sweep period. For the display of high frequency signals the type of channel switching selected is less important.

To select the ***add mode*** only the **Alt./Chop. (I+II)** button should be depressed. The signals on both channels are then added together. If in this mode Channel I is ***inverted*** (pushbutton **Invert I** depressed), then the ***difference*** between the two channels is displayed. For both of these operating modes the vertical position of the trace depends on the setting of the **Y-POS.** control of both channels.

For ***X-Y operation*** the pushbutton marked **Hor. ext.** must be depressed. The X signal is then derived from ***Channel II. The calibration of the X signal during X-Y operation is determined by the setting of the Channel II input attenuator and fine control***. This means that the sensitivity range and input impedance are identical for both the X and Y axes. However, the **Y-POS. II** control is disconnected in this mode. Its function is taken over by the **X-POS.** control. It is important to note that the **x5 MAGN.** switch, incorporated in the **X-POS.** control and normally used for expanding the sweep, should not be operated in the X-Y mode. It should also be noted that the bandwidth of the X amplifier is approximately 2MHz (-3dB), and therefore an increase in phase difference between both axes is noticeable from 50kHz upwards.

Trigger and Timebase

In order to obtain a stable display, the timebase must be triggered synchronously with the test signal. The trigger signal can be derived from the test signal itself, when internal triggering is selected, or from a frequency related signal applied to the external trigger input. The required trigger source and coupling mode are selected on both slide switches, marked **Trigger Selector**, located in the **TIMEBASE** section.

To achieve a perfectly stable display the correct settings of the timebase and trigger controls is most important. When the **Peak/Norm.** button is not pressed, the sweep generator will be ***triggered automatically***. In this trigger mode, a baseline will be present also in the absence of an input test signal. In this condition virtually all uncomplicated, periodically repeating signals above 30Hz will be displayed in a stably locked condition. Operation of the timebase is then limited to selecting a convenient time setting. The trigger point on the signal curve is selected with the **LEVEL** control. Its capture range is balanced automatically always to the peak-to-peak amplitude of the signal just applied. The advantage of this trigger mode is that the trigger point shift is more independent of the display height just selected and of the signal's shape. For instance, the pulse duty factor of a square signal may change from 1:1 to 100:1 without triggering failure. However, it may happen during the course of a foregoing measurement that the **LEVEL** control was adjusted nearly to its stop. The triggering then fails possibly during the following measurement as a result of a change in display height and/or signal shape. A small turning of the **LEVEL** control towards midrange is enough, however, for a stable display. This ***Automatic Peak Value Triggering*** operates in principle also with external triggering via the **TRIG. EXT.** socket. However, the (synchronous) trigger voltage required for it should be approximately in the 1-10Vpp range.

With ***Normal Triggering*** (**Peak/Norm.** button depressed) and **LEVEL** adjustment, triggering of the sweep is possible at any point of a signal edge, also with very complex signal shapes. With Normal Triggering, the trigger range, which is determined by the **LEVEL** control, is strongly dependent on the display height. If it is smaller than 1cm, the **LEVEL** adjustment needs to be operated with a sensitive touch.

Triggering can be selected on either the leading or trailing edge of the trigger signal depending on whether the +/− ***slope*** pushbutton is in the out or depressed position.

With internal triggering in the mono operation mode, the lower **Trigger Selector** switch in the TIMEBASE section must be set to **I** or **II**, corresponding to the selected vertical input. On dual channel operation, the internal trigger signal may be selected from either Channel **I** or Channel **II**. However, it is preferable to trigger from the less complicated signal. When the trigger switch is in the **I/II** position and the vertical amplifiers are in the alternate mode, triggering is derived then ***alternately from Channel I and Channel II***. This mode is particularly useful, when ***asynchronous signals*** are being investigated. The Normal Triggering should be prefered in this mode. The representation of one signal only is not possible on the alternate mode. On all other modes, only Channel I is connected through in the **I/II** position. In the **Line** position of the upper trigger switch, the ***line/mains frequency*** serves as a trigger signal.

For external triggering the lower trigger switch must be set to **Ext.** The sinc. signal (1-10Vpp) must then be fed to the **EXT. TRIG.** socket. On mono channel operation with Channel I an external triggering is possible via the input of Channel II (with the lower Trigger Selector switch in **II** position). This method is particularly advisable, if the amplitude of the trigger signal does not lie between 1 and 10Vpp or if it is of unknown value. In this case, the trigger amplitude can be adjusted by means of the **AMPL. II** switch in a range from 5mVpp up to approximately 150Vpp, matching the trigger input requirements of the timebase in an optimum manner. It is advantageous, when first the external trigger signal is displayed and adjusted to a height of 2-6cm. For this, the **CH II** button has to be pressed. After this, the **CH II** button can be released to **CH I** operation. However, the Trigger Selector switch remains in the **II** position.

Trigger coupling is selected on the upper **Trigger Selector** switch marked **AC** and **DC**, which operates on either internal or external triggering. The **AC** position can be used for the investigation of most uncomplicated waveforms, while **DC** coupling is recommended, when very low frequency signals are being investigated. If **DC** coupling is selected, it is advisable to obtain triggering by using the **LEVEL** control in the ***Normal Triggering mode*** (**Peak/Norm.** button depressed), as there is a possibility that, in the **Peak** position, triggering may not achieved on signals without zero-axis crossing point (DC offset). DC coupling in the Normal Triggering mode is also recommended for the investigation of pulse-shaped signals with duty cycles, which change strongly during the measurements. However, ***Peak Value Triggering*** is not impossible with DC trigger coupling, but it needs a precise adjustment of the ***DC input balance*** (see: DC-Balance Adjustment, page M3).

If the video signal of a television receiver is to be displayed at frame frequency, synchronization is generally difficult due to the presence of the higher line frequency pulses contained in the signal. The line pulses can be attenuated by switching the upper Trigger Selector switch to **LF**. In this position, a low-pass filter is switched into the trigger input circuit. It will now be found that the trigger **LEVEL** control can be adjusted to trigger from either the positive or negative edge of the frame pulse. This setting is also advantageous for triggering from other signals that have a repetition frequency of 800Hz or less, as high frequency harmonics or noise in the signal are suppressed by the presence of the low-pass filter. However, ***TV triggering at line frequency*** needs **AC** trigger coupling (or **DC** coupling if necessary).

As already mentioned, simple signals may be triggered automatically in the **Peak** trigger mode. The repetition rate may also vary in such cases. However, if the pulse duty factor on square-wave or pulse signals changes drastically or deforms to a needle pulse, then the **Normal** trigger mode with **LEVEL** adjustment may well become necessary. With composite signals, the trigger facility is dependent on the occurence of certain periodically recurring levels. The **LEVEL** adjustment of these signals will require some care.

If it is found that a triggering point cannot be located on complex signals even after repeated and careful adjustment of the **LEVEL** control in the **Normal** trigger mode, it may be possible to obtain one by adjusting the **VAR.** control. On occasions it may be found advantageous to leave the trigger mode button in the **Peak** position and to use only the **VAR.** fine control. Another method to obtain a stable display for ***aperiodic signals*** (such as complex digital words) is the use of the **HOLD-OFF** control. This device controls the holdoff time between two sweeps. During this time no triggering is possible. The adjustment of the **HOLD-OFF** control allows an increase in holdoff time by the factor 10. Pulses or other waveforms, appearing during this off period, cannot trigger the timebase. Particularly with aperiodic pulse trains of the same amplitude, the start of the sweep can be shifted to the interesting pulse, e. g. the second with double pulses. This is also valid for burst signals. The start of the trigger sequence can be adjusted in each case to the optimum or required moment. After termination of the measuring task, the **HOLD-OFF** control should be re-set into its calibration detent **x1**, because the brightness of the display is reduced drastically under these circumstances.

Single processes or events, e. g. individual interference pulses or the display of the dying out of a resonant circuit after impulse excitation, can be represented with single sweep. For this the **Single** button has to be depressed. The LED on the left, next to the **Reset** button, shows the readiness of the sweep. If the **Ready** lamp is not illuminated, the **Reset** pushbutton must be pressed likewise. Indeed, it is possible in some cases to operate with Peak Value Triggering. The trace starts then approximately on the base line level. This trigger mode is very sensitive; however, already small and accidentally appearing interference pulses can trigger a premature single sweep. For the triggering at higher or lower level values or with very slow frequencies the Normal Triggering is much more advantageous.

It is favorable to determine previously the adequate setting of the **LEVEL** control in normal timebase operation using a similar signal voltage. If it is correctly adjusted, the next following trigger pulse starts the single sweep. After its run the **Ready** lamp goes out. For a repetition of the action, the **Reset** button must be pressed once more. With single shot, only relatively slow processes can be observed visually. Mostly a photographic registration is more advantageous.

The time coefficient settings on the **TIMEBASE** switch are calibrated when the variable time fine control marked **VAR.** is set in the **Cal.** position. When the **VAR.** control is set fully clockwise, then the sweep speed is increased by a factor of at least 2.5. This factor is not precisely calibrated. When the X5 expansion of the sweep (**X-MAGN.**) is also operated in conjunction with the **VAR.** control, a maximum sweep speed of approximately 40ns/cm is obtained (**TIMEBASE** to **0.5μs/cm**). The choice of the optimum time coefficient depends on the repetition rate of the signal being measured. The number of cycles displayed will increase with the time coefficient (by turning the **TIMEBASE** switch counterclockwise).

HAMEG

Trigger Indicator

An LED on condition indicates that the timebase is triggered and will produce a stable display. This is valid as well with automatic as with normal triggering. The LED marked **Trig.** is located above the **TIMEBASE** switch to the right. Especially with very slow signals the trigger indicator can assist you to adjust the **LEVEL** control, which sometimes needs sensitive adjustment. The pulses, which control the trigger indicator, are stored for approximately 100ms only. With signals with an extremely slow repetition rate the action of the LED is more or less flashing.

Sweep Delay

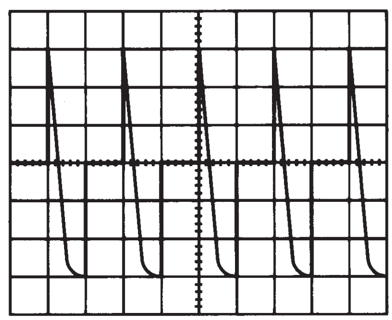
With the sweep delay the start of the sweep can be delayed from the trigger instant at a selectable time (100ns to maximum 1s). It is therefore possible to start the sweep at practically any point of a waveform. The interval, which follows the start of the sweep, can be greatly expanded by the increase of the sweep speed. From the **10μs/cm TIMEBASE** range downwards to slower sweep speeds, an expansion of at least 20 times, with the aid of the **VAR.** control 50 times, and including the **X-MAGN. x5** expansion even 250 times, is possible. With time coefficients higher than 10μs/cm, the maximum expansion increases proportionally. However, with increasing the expansion, the display brightness decreases. Under very high ambient light conditions a Viewing Hood like HZ47 can overcome this problem. It should be noted that there are some difficulties with higher expansions, if the test signal has inherent jitter.

Operation of the sweep delay is relatively easy, as only 3 controls in the **DELAY** section need to be used: the **MODE** slide switch (operating mode), the **DELAY** rotary switch (delay time range), and the **VARIABLE** control (delay time fine control). The latter, a twenty-turn precision potentiometer with overwind protection, can increase the delay time range tenfold. An LED near the **MODE** switch indicates the operating mode.

For reliable operation of the sweep delay, it is recommended that the following procedure always be adopted; also reference to the accompanying figures will be of assistance.

Initially, the sweep delay **MODE** slide switch should be set in the **Norm.** position. In this mode, the complete waveform under investigation will be displayed as for normal oscilloscope operation. The LED in the delay section is not illuminated in this mode. The time coefficient on the **TIMEBASE** switch is selected so that ***1 to 3 basic periods of the signal*** are displayed. In doing so, the **x5** ***expansion must be switched off temporarily*** (**X-MAGN.** knob depressed). The **HOLD-OFF** control should be set to **x1** and the **VAR.** control to **Cal.** The **LEVEL** control is adjusted so that a stable triggering is ensured (**Trig.** LED is illuminated).

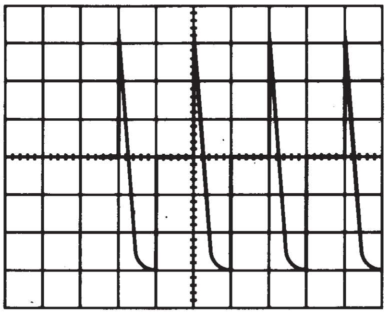
Figure 1



MODE : **Norm.**
TIMEBASE : **0.5ms/cm**
LED : **off**

The **MODE** switch should now be set to the **Search** position; it will be seen that the start of the display will shift to the right. The amount of shift indicates the exact delay time. If a display is not obtained in this mode, then a lower delay time range should be selected. For example, when investigating the waveform shown in the figures, a display could not be obtained with a delay time setting of **10ms**, as the display is completely blanked. However, as a result of setting the **DELAY** rotary switch to **0.1μs**, the shifting is also not visible. The **DELAY** range switch should then be rotated clockwise until the display starts just prior to the short time interval to be investigated. The precise adjustment to this start is done with the **VARIABLE x1-x10** fine control. The rotating range of the latter has no stop. On the range limits a certain snapping noise is audible. Initially, this control should be set at the left start position. In the **Search** mode, the LED indicator will flash.

Figure 2

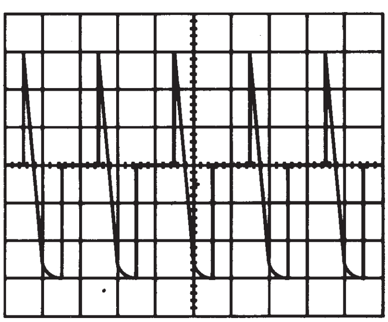


MODE : **Search**
DELAY range : **1 ms**
TIMEBASE : **0.5 ms/cm**
LED : flashing
Delay time = 2.5 cm · 0.5 ms/cm = 1.25 ms

In figure 2 it can be seen that the delay time is also measurable. It is identical with the adjusted shifting of the start of the trace. This time can be determined on multiplication of the horizontal shifting in cm by the time coefficient set on the **TIMEBASE** switch.

Now the **MODE** switch can be set to **Delay**. In this mode, the LED is permanently illuminated. The display will now shift to the left and the trace will commence in the same position as for a normal display; however, the short time interval under investigation is now on the left side at the start of the display.

Figure 3

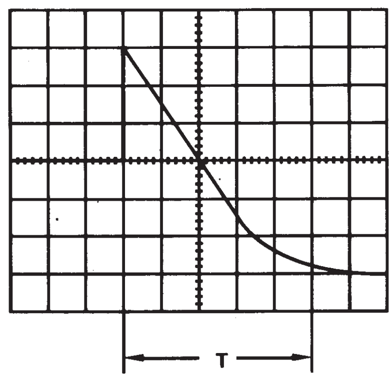


MODE : **Delay**
DELAY range : **1 ms**
TIMEBASE : **0.5 ms/cm**
LED : illuminated

If the **TIMEBASE** sweep speed is increased (rotate **TIMEBASE** switch clockwise), then the short time interval will be expanded. It may be found that, as the amount of expansion is increased, the trace will tend to shift. If this happens, the **VARIABLE** fine control can be readjusted — also subsequently at any time — to enable the exact point of interest to be displayed.

In the example shown in figure 4, it can be seen that an expansion of X10 was obtained by increasing the timebase sweep speed from 0.5 ms/cm to **50µs/cm**. Also the precise measurement for the delayed portion of the waveform is possible. In the example, this was found to be 250µs on multiplication of the horizontal length in cm (of an optional signal section) by the time coefficient just adjusted.

Figure 4



MODE : **Delay**
DELAY range : **1 ms**
TIMEBASE : **50µs/cm**
LED : illuminated
Expansion : $0.5 \cdot 10^{-3} : 50 \cdot 10^{-6} = 10$
T = 5 cm · 50µs/cm = 250µs

Essential for unobjectionable operation with the sweep delay is a preserved trigger point. All signals, which have a constant phase shift between the expanded section and trigger point, pose no problems. This means all electrical signal shapes, which contain signal edges of the same polarity and with triggerable level values, which are constantly repeated with the recurring frequency. Is there no constant phase shift, the triggering may fail after switching from the **Search** to **Delay** position or with changing of the time coefficient. It is then better already in the normal operation mode (display of the signal's basic period) to attempt to find a trigger point, which has a constant phase shift up to the signal section to be expanded. With complicated composite signals, the display of the basic period could become superimposed by other signal portions. These disappear as a rule when the sweep speed is increased. Otherwise, a stable display of the expanded display is obtained by adjusting the **LEVEL** and **VAR.** control.

Using the **X-MAGN.** switch, a ***fivefold expansion*** of the desired signal section is possible without any change of triggering and timebase. This can be of assistance with complicated or difficult to trigger signals.

Operation of the sweep delay needs some experience, particularly with composite signals. However, the display of sections from simple signal waveforms is easily possible. It is recommended to operate only in the sequence **Norm.-Search-Delay**, because otherwise location of the short time interval to be investigated will be relatively difficult. The sweep delay facility can be used with the HM412 in either single or dual trace operating mode.

Delay Mode Indication

Both operating modes of the sweep delay are indicated with an LED, located to the right of the DELAY **MODE** slide switch. In **Search** position, the LED will flash. This is a particular indication of the temporary operating state. The **Delay** position, is indicated by constant lighting of the LED. However, should this be noted in the normal operating mode, then the change-over of the slide switch to its **Norm.** position has been overlooked. Maybe there are errors in displaying a signal by complete or partial blanking. This indication, therefore, should be closely observed.

Miscellaneous

The ramp output voltage of the sweep generator can be derived from a BNC connector mounted on the rear panel of the instrument. The load resistance should not be less than 10kΩ. If the DC potential of the ramp output voltage is not required, a capacitor should be connected in series with the output connector.

Blanking or modulation of the trace is possible with low level TTL voltage which can be applied to a BNC connector mounted on the rear panel of the instrument. It should be noted that damage to the instrument will occur, if higher voltages than TTL (5Vpp) are applied to this input.

Especially for the photographic recording of displays, the HM412 has a raster illumination. Normally, the raster, which is necessary for the measurement, is not visible without illumination. Variation of the brightness is possible with a three-step slide switch marked **ILLUM.**, which is mounted above the power on/off pushbutton. In the uppermost position, the illumination is switched off. The optimum setting is dependent on the camera used. Possibly some test pictures are necessary for a good representation of the graticule.

Maintenance

Within the context of maintenance, it is recommended that the important characteristics of the HM412 be periodically checked. The following Test Instructions indicate only those tests, which can be performed without the use of expensive ancillary instruments. For more exacting tests the HAMEG Oscilloscope Calibrator HZ62 is recommended. It should be noted that the HZ62 may be used to calibrate oscilloscopes manufactured by other companies.

Accessories

Each HAMEG oscilloscope is supplied with an Instruction Manual only. However, a wide range of accessories, which include test cables and probes, are available and should be ordered according to the particular application.

SHORT INSTRUCTIONS FOR HM 412-5

First Time Operation

Connect the instrument to power outlet. Switch on **POWER** (pushbutton to the right of the CRT). LED indicates operating condition. ***Case, chassis and all measuring terminals are connected to the Safety Earth conductor (Safety Classification I).***
All other pushbuttons, in particular **Peak/Norm.** button, are in out position.
DELAY **MODE** slide switch in **Norm.** position. **HOLD-OFF** control to left stop (**x1**).
Adjust **INTENS.** control for average brightness.
Center trace on CRT using **X-POS.** and **Y-POS.** controls, then focus trace.

Operating Modes of Vertical System

Channel I: All pushbuttons in out position.
Channel II: **CH II** button depressed.
Channel I and channel II: **Mono/Dual** button depressed.
Channel switching mode alternate or chopped selected by **Alt./Chop.** button.
Signals < 1 kHz with **Chop.**
Add Mode: **I + II** (**Alt./Chop.**) pushbutton only depressed (sum I + II).
Differential Mode: **I + II** and **Invert I** pushbuttons depressed (difference —I + II).

Trigger Modes

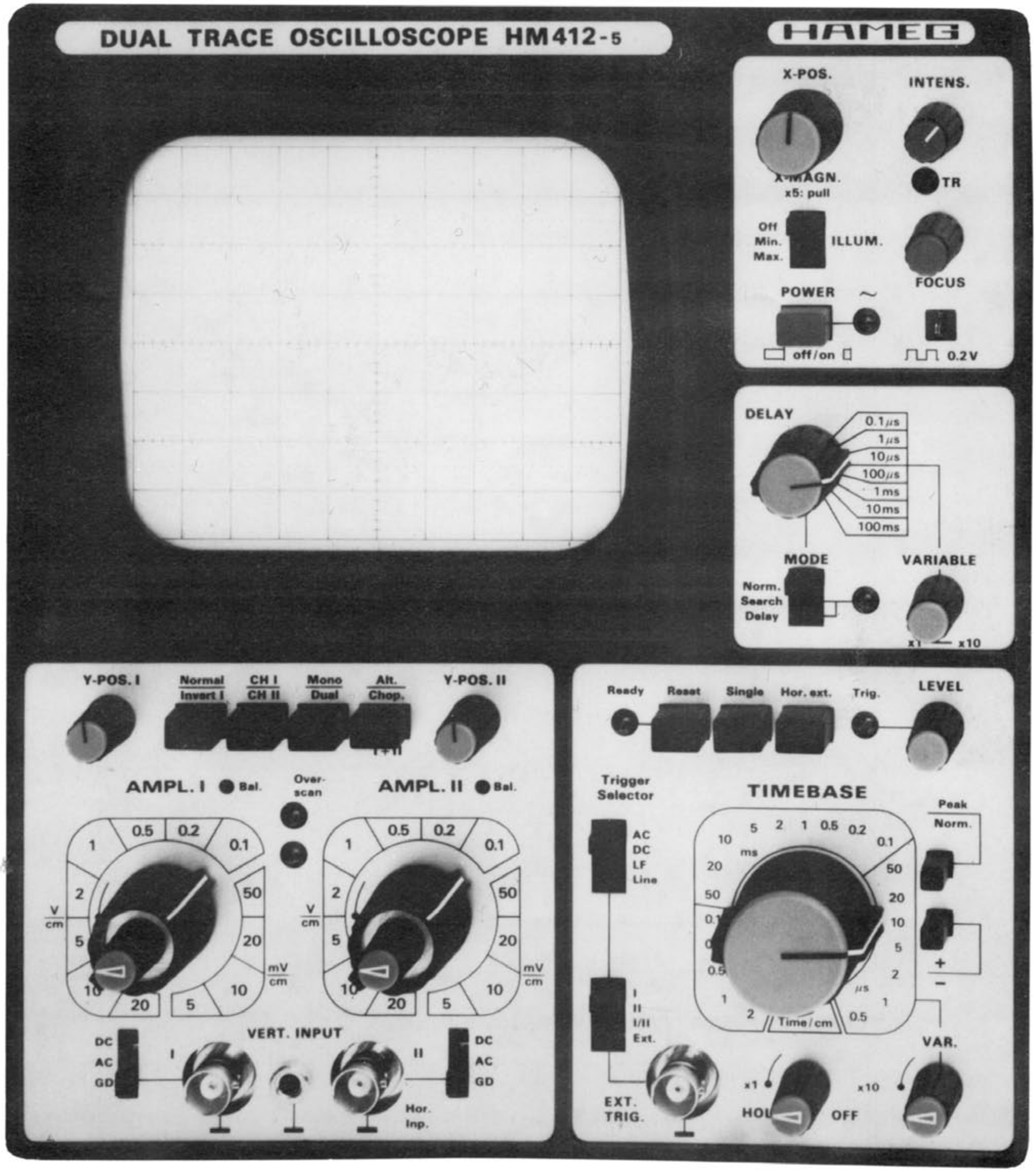
Trigger source selection with slide switch marked **I-II-I/II-Ext.**
Alternate triggering from Channel I/Channel II in **I/II** position.
Ext. position: Sinc. signal (1-10Vpp) on **EXT. TRIG.** connector.
Trigger slope selected on **+/—** pushbutton.
Trigger coupling selection with **AC-DC-LF-Line** slide switch.
LF position: Low-pass filter (DC) coupling.
Line position: Line/mains frequency triggering with DC coupling.
Trigger Mode selected on **Peak/Norm.** button. Pay attention to **Trig.** LED.
  Peak = Automatic Peak-Value Triggering.
  Norm. = Normal Triggering.
Single sweep: **Single** and **Reset** button depressed. Pay attention to **Ready** LED.

Measuring

Connect test signal to **VERT. INPUT** connector Channel **I** and/or Channel **II**.
Compensate attenuator probe with built-in square-wave generator.
Select **AC** or **DC** input coupling.
Adjust required display height of signal with **AMPL.** switch and Y fine control.
Pay attention to **Overscan** indication.
Calibrated amplitude measurement with Y fine control fully counterclockwise (**C**).
Select sweep speed with **TIMEBASE** switch and **VAR.** control.
Calibrated time measurement with **VAR.** control fully counterclockwise (**Cal.**).
x5 expansion with **X-MAGN.** knob pulled out.
Adjust trigger point with **LEVEL** control.
To trigger at TV frame frequency select **LF** trigger coupling.
To trigger aperiodic signals (such as digital words or pulse trains) use **HOLD-OFF** control.
X-Y Operation with **Hor. ext.** pushbutton depressed; X input via Channel **II**.
Section expansion with Sweep Delay Operation:

- **Norm.** position: Normal oscilloscope operation without sweep delay.
- **Search** position: Use **DELAY** range switch and **VARIABLE x1 - x10** control to select point of interest on displayed signal. LED flashing.
- **Delay** position: Delayed signal now displayed. Expansion obtained by rotating **TIMEBASE** switch clockwise. LED illuminated.

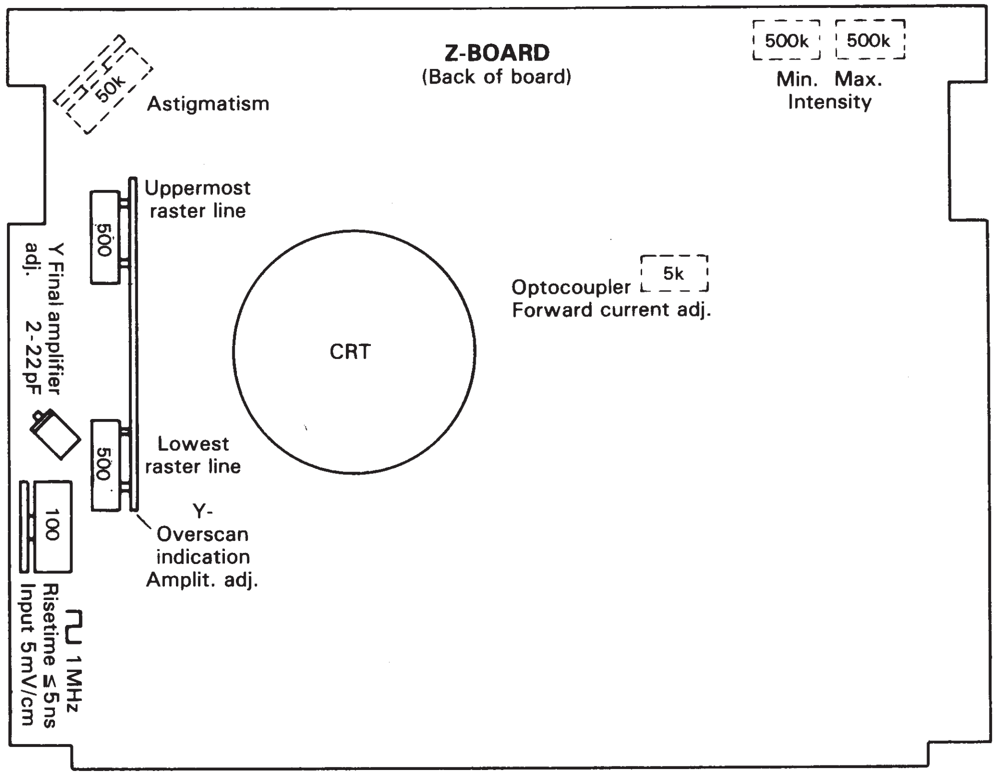
FRONT VIEW



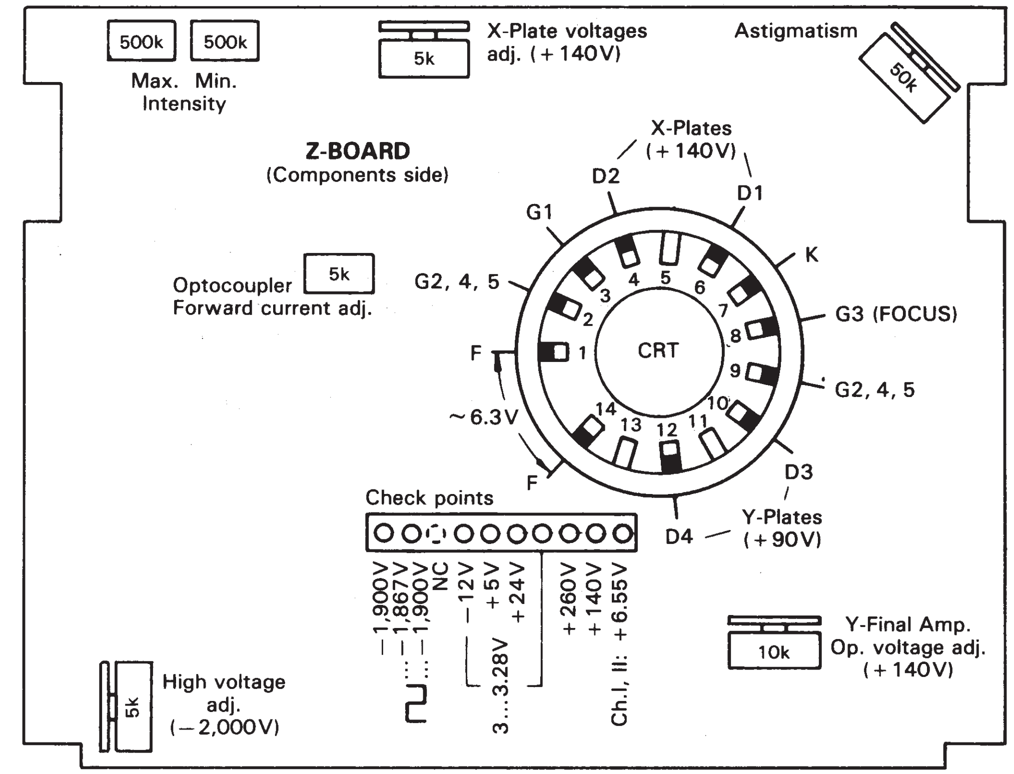
DUAL TRACE OSCILLOSCOPE HM412-5
HAMEG
X-POS.
INTENS.
X-MAGN.
x5: pull
TR
Off
Min.
Max.
ILLUM.
FOCUS
POWER
off/on
0.2V
DELAY
0.1μs
1μs
10μs
100μs
1ms
10ms
100ms
MODE
VARIABLE
Norm.
Search
Delay
x1
x10
Y-POS. I
Normal
Invert I
CH I
CH II
Mono
Dual
Alt.
Chop.
I+II
Y-POS. II
AMPL. I
Bal.
Over-
scan
AMPL. II
Bal.
V
cm
mV
cm
VERT. INPUT
DC
AC
GD
Hor.
Inp.
Ready
Reset
Single
Hor. ext.
Trig.
LEVEL
Trigger
Selector
TIMEBASE
AC
DC
LF
Line
ms
μs
Time/cm
Peak
Norm.
EXT.
TRIG.
x1
x10
OFF
VAR.

HM 412-5
ADJUSTING PLAN
PLAN D'AJUSTAGE
ABGLEICHPLAN
PLAN DE AJUSTES

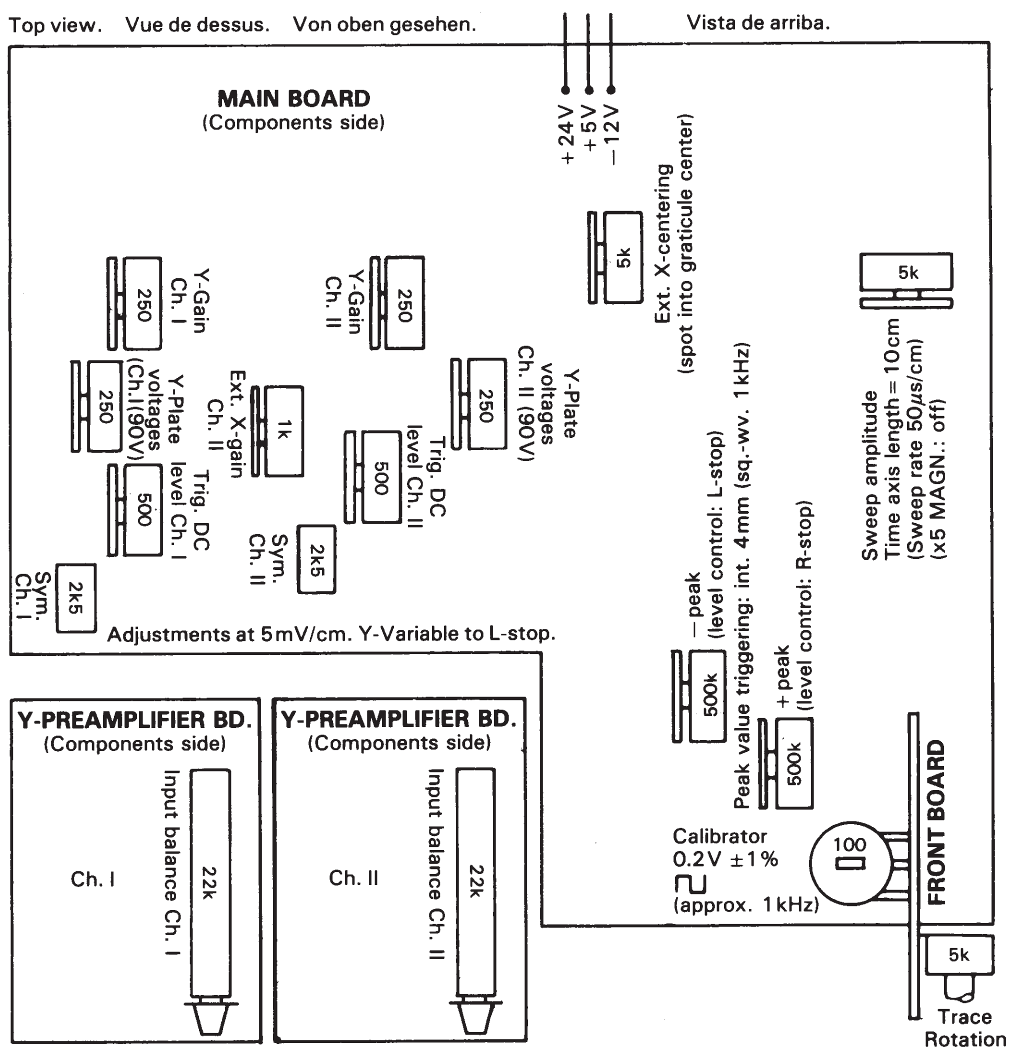
See from front. Vue d'avant. Von vorn gesehen. Vista de adelante.



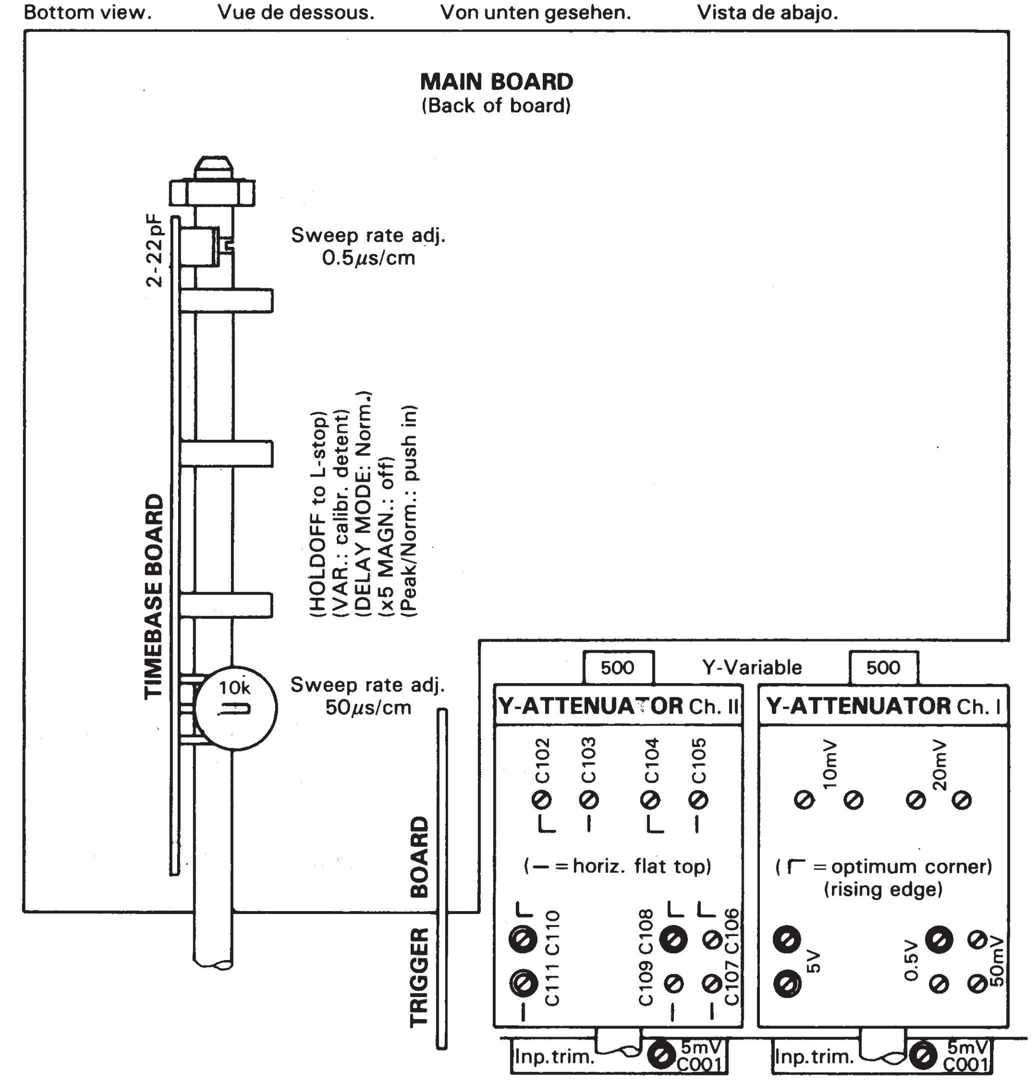
See from the rear. Vue de l'arrière. Von hinten gesehen. Vista de atrás.



Top view. Vue de dessus. Von oben gesehen. Vista de arriba.



Bottom view. Vue de dessous. Von unten gesehen. Vista de abajo.



General

These Test Instructions are intended as an aid for checking the most important characteristics of the HM412-5 at regular intervals without the need for expensive test equipment. For more exacting tests the HAMEG Oscilloscope Calibrator HZ62 is recommended. It should be noted that the HZ62 may be used to check and calibrate oscilloscopes manufactured by other companies. It is also suitable for checking large numbers of oscilloscopes on a regular routine basis. Resulting corrections and readjustments inside the instrument, detected by the following tests, are described in the Service Instructions. They should only be undertaken by qualified personnel.

As with the First Time Operation instructions, care should be taken that all knobs with arrows are set to the calibrated positions, and that the DELAY **MODE** switch is set to **Norm.** None of the pushbuttons, in particular the **Peak/Norm.** button, should be depressed. It is recommended to switch on the instrument for about 15 minutes prior to the commencement of any check.

Cathode-Ray Tube: Brightness and Focus, Linearity, Raster Distortions

Normally the CRT of the HM412 has good brightness. Any reduction of this brightness can only be judged visually. However, decreased brightness may be the result of reduced high voltage. This is easily recognized by the greatly increased sensitivity of the vertical amplifier. The control range for maximum and minimum brightness (intensity) must be such that the beam just disappears before reaching the left hand stop of the **INTENS.** control, while with the control at the right hand stop the focus is just acceptable. The timebase fly-back must on no account be visible. It should be noted that with wide variations in brightness, refocusing is always necessary. Moreover, with maximum brightness, no "pumping" of the display must occur. If pumping does occur, it is normally due to a fault in the stabilization circuit for the high voltage supply. The presetting pots for the high voltage circuit, minimum and maximum intensity, are only accessible inside the instrument (see Adjusting Plan and Service Instructions).

A certain out-of-focus condition in the edge zone of the screen must be accepted. It is limited by standards of the CRT manufacturer. The same is valid for the non-linearity and raster distortion in the edge zone of the CRT in accordance with international standards (see CRT data book). These limit values are strictly supervised by HAMEG. The selection of a cathode-ray tube without any tolerances is practically impossible (too many parameters).

Astigmatism Check

It should be checked whether the horizontal and vertical sharpness of the display are equal. This is best seen by displaying a square-wave signal with the repetition rate of approximately 1 MHz. Focus the horizontal tops of the square-wave signal at normal intensity, then check the sharpness of the vertical edges. If it is possible to improve this vertical sharpness by turning the **Focus** control, then an adjustment of the astigmatism control is necessary. An alternative method is to check the shape of the spot with both vertical inputs switched to the **GD** position (and the **Hor. ext.** pushbutton depressed); the **FOCUS** control is then repeatedly varied around the optimum focusing point. The shape of the spot, whether round or oval or rectangular, must stay the same to the right and left of the optimum focusing point. A potentiometer of 50kΩ (see Adjusting Plan) is provided inside the instrument for the correction of astigmatism (see Service Instructions). A certain loss of marginal sharpness of the CRT is unavoidable; this is due to the manufacturing process of the CRT.

Symmetry and Drift of the Vertical Amplifier

Both of these characteristics are substantially determined by the input stages of the amplifiers. The checking and correction of the DC balance for the amplifiers should be carried out as already described in the Operating Instructions. The symmetry of Channel I and the final vertical amplifier can be checked by inverting Channel I (depress **Invert I** pushbutton).

The vertical position of the trace should not change by more than 5mm for good symmetrical alignment. However, a change of 1cm is just permissible. Larger deviations indicate that changes have occurred in the amplifier.

A further check of the vertical amplifier symmetry is possible by checking the control range of the **Y-POS.** controls. A sine-wave signal of 10-100kHz is applied to the amplifier input. When the **Y-POS.** control is then turned fully in both directions from stop to stop with a display height of approximately 8cm, the upper and lower portions of the trace that are visible should be approximately of the same height. Differences of up to 1cm are permissible (input coupling should be set to **AC**). Checking the drift is relatively simple. **Ten minutes after switching on the instrument**, set the trace exactly on the horizontal center line of the graticule. The beam position must not change by more than 5mm during the following hour. Larger deviations generally result from different characteristics of the two FET's in the input to the Y amplifier. To some extent, fluctuations in drift are caused by offset current on the gate. The drift is too high, if the vertical trace position drifts by more than 0.5mm on turning the appropriate **Y-AMPL.** switch through all 12 steps. Sometimes such effects occur after long periods of operation.

Calibration of the Vertical Amplifier

A square-wave voltage of ***200mVpp*** is present at the output eyelet marked with a square-wave. This has a tolerance of ±***1%***. If a direct connection is made between this eyelet and the input of the vertical amplifier, the displayed signal in the **50mV/cm** position should be ***4cm*** high. Maximum deviations of 1.2mm (3%) are permissible. If a ***X10 probe*** is connected between the output eyelet and Y input, the same display height should result in the **5mV/cm** position. With higher tolerances it should first be investigated whether the cause lies, within the amplifier or in the amplitude of the square-wave signal. On occasions it is possible that the probe is faulty or incorrectly compensated. If necessary, the measuring amplifier can be calibrated with an accurately known DC voltage (**DC** input coupling). The trace position should then vary in accordance with the deflection coefficient set. Adjustment of the vertical amplification or the calibrator voltage is only possible from within the instrument (see Adjusting Plan and Service Instructions). According to experience, this is rarely necessary.

Transmission Performance of the Vertical Amplifier

The transient response and the phase compensation can only be checked with the aid of a square-wave generator with a fast risetime (***max. 5ns***). The signal coaxial cable (e. g. HZ34) must be terminated at the vertical input of the oscilloscope with a resistor equal to the characteristic impedance of the cable (e. g. with HZ22). Checks should be made at 50Hz, 500Hz, 5kHz, 50kHz, 500kHz and 1MHz, the deflection coefficient should be set at **5mV/cm** with **DC** input coupling (Y fine control in **C**al. position). In so doing, the square pulses must have a flat top without ramp-off, spikes and glitches; no overshoot is permitted, especially at 1MHz and a display height of ***4-5cm***. At the same time, the top corner of the pulse must not be rounded. In general, no great changes occur after the instrument has left the factory, and it is left to the operator's descretion whether this test is undertaken or not.

Certainly the quality of the transmission performance is not only dependent on the measuring amplifier. ***The input attenuators***, located in the front of the amplifier, ***are frequency-compensated in each position***. Even small capacitive changes can reduce the transmission performance. Faults of this kind are as a rule most easily detected with a square-wave signal with a low repetition rate (e. g. 1kHz). If a suitable generator with max. output of 40Vpp is available, it is advisable to check at regular intervals the deflection coefficients on all positions of the input attenuators and readjust them as necessary. A compensated ***2:1 series attenuator*** is also necessary, and this must be matched to the input impedance of the oscilloscope. This attenuator can be made up locally or ordered from HAMEG under the type designation HZ23. It is important that this attenuator is screened. For local manufacture, the electrical components required are a 1MΩ ±1% resistor and, in parallel with it, a trimmer 3-15pF in parallel with approx. 20pF. One side of this parallel circuit is connected directly to the input connector of the vertical amplifier and the other side is connected to the generator, if possible via a low-capacitance coaxial cable. The series attenuator must be matched to the input impedance of the oscilloscope in the **5mV/cm** position (**DC** input coupling; square tops exactly horizontal; no ramp-off is permitted). This is achieved by adjusting the trimmer located in the 2:1 attenuator. The shape of the square-wave should be the same in each input attenuator position.

Operating Modes: Mono/Dual, Alt./Chop., I+II, X-Y Operation

On depressing the **Mono/Dual** pushbutton, two traces must appear immediately. On actuation of the **Y-POS.** control, the trace positions should have no affect on each other. Nevertheless, this cannot be entirely avoided, even in fully serviceable instruments. When one trace is shifted vertically across the entire screen, the position of the other trace must not vary by more than 0.5mm. A criterion in chopped operation is trace widening and shadowing around and within the two traces in the upper or lower region of the screen. Set **TIMEBASE** switch to **1µs/cm**, depress the **Mono/Dual** and **Alt./Chop.** pushbuttons, set input coupling of both channels to **GD** and advance the **INTENS.** control fully clockwise. Adjust **FOCUS** for a sharp display. With the **Y-POS.** controls shift one of the traces to a +2cm, the other to a —2cm vertical position from the horizontal center line of the graticule. Do not try to synchronize the chop frequency (1MHz) by means of the time fine control! Then alternately release and depress the **Alt./Chop.** pushbutton. Check for a negligible trace widening and periodic shadowing in the chopped mode.

It is important to note that in the **I+II** add mode or the **—I+II** difference mode (**Invert I** button depressed in addition) the vertical position of the trace can be adjusted by using both the Channel I and Channel II **Y-POS.** controls. If a trace is not visible in either of these modes, the overscanning LED's will indicate the position of the trace.

In X-Y Operation (**Hor. ext.** pushbutton depressed), the sensitivity in both deflection directions will be the same. When the signal from the built-in square-wave generator is applied to the input of Channel II, then, as with Channel I in the vertical direction, there must be a horizontal deflection of ***4cm*** when the deflection coefficient is set to **50mV/cm** position (fine control set to its **C**al. position, **X-MAGN.** knob depressed). The check of the Mono channel display with the **CHI/CHII** button is unnecessary; it is contained indirectly in the tests above stated.

Triggering Checks

The internal triggering threshold is important as it determines the display height from which a signal will be stably displayed. It should be approx. 3-5mm (frequency-dependent) for the HM412. An increased trigger sensitivity creates the risk of response to the noise level in the trigger circuit. This can produce double-triggering with two out-of-phase traces. Alteration of the trigger threshold is only possible internally. Checks can be made with any sine-wave voltage between 50Hz and 1MHz in both trigger modes: **Peak** value and **Norm.** triggering. In both trigger modes, a **LEVEL** adjustment is necessary. The checks should show the same trigger sensitivity with the same frequency. On depressing the **+/—** button, the trigger polarity changes from the positive-going to the negative-going edge of the trigger signal. The HM412 should trigger internally on sinusoidal signals up to 40MHz perfectly at a display height of approx. 5mm.

For external triggering (**Trigger Selector** switch to **Ext.**), the **EXT. TRIG.** input connector requires a signal voltage of 0.2-3Vpp, which is in synchronism with the Y input signal. The voltage value is dependent on the frequency and the trigger coupling mode (**AC-DC-LF**).

Checking of the internal TV triggering is possible with a video signal of any given polarity. In the **LF** position only, reliable triggering on ***frame*** frequency is possible. However, triggering on ***line*** (horizontal-scanning) frequency requires **AC** (possibly **DC**) trigger coupling. If no video signal is available, the function of the **LF** position (low-pass filter) can be checked using line/mains frequency or the built-in calibrator signal. With a line/mains frequency signal

(50-60Hz), switching from **AC** to **LF** trigger coupling should have no effect. In contrast, the minimum signal voltage required for reliable triggering should be at least double, when the 1kHz calibration signal is applied.

The display should not shift horizontally during a change of the trigger coupling from **AC** to **DC** with a sine-wave signal without DC offset. The basic requirement for this is a correct ***DC Balance Adjustment*** on the input of the vertical amplifier (see Operating Instructions, page M3).

If both vertical inputs are **AC** coupled to the same signal and both traces are brought to coincide exactly on the screen, when working in the **Alt*ernate* Dual *channel mode***, then no change in display should be noticeable, when the **Trigger Selector** switch is set to the **I** or **II** or **I/II** position. In the **Alt*ernate* Dual *channel mode***, two non-frequency related signals (i. e. line/mains frequency and calibration signal) can be reliably triggered internally, when the **Trigger Selector** switch is set to the **I/II** position (alternate triggering). With the **Chop*ped* Dual *channel mode*** in the **I/II** position, triggering from Channel I only is possible. Periodical signal blanks (due to the chopper frequency 1MHz) may not be visible in the **Chop** mode.

Timebase

Before checking the timebase it should be ascertained that the ***trace length is approx. 10cm***. If not, it can be corrected with the potentiometer for sweep amplitude (see Adjusting Plan). This adjustment should be made with the **TIMEBASE** switch in a middle position (i. e. **50μs/cm**) and with the **VAR.** control in **Cal.** position.

If a precise marker signal is not available for checking the timebase deflection coefficients, then an accurate sine-wave generator may be used. Its frequency tolerance should not be greater than ±1%. The timebase accuracy of the HM412 is given as ±3%, but as a rule it is considerably better than this. For the simultaneous checking of timebase linearity and accuracy at least 10 oscillations, i. e. ***1 cycle every cm***, should always be displayed. For precise determination, set the peak of the first marker or cycle peak exactly behind the first vertical graticule line using the **X-POS.** control. Deviation tendencies can be noted after some of the marker or cycle peaks.

The following table shows which frequencies are required for the particular ranges.

2s/cm	0.5Hz	0.5ms/cm	2kHz
1s/cm	1Hz	0.2ms/cm	5kHz
0.5s/cm	2Hz	0.1ms/cm	10kHz
0.2s/cm	5Hz	50μs/cm	20kHz
0.1s/cm	10Hz	20μs/cm	50kHz
50ms/cm	20Hz	10μs/cm	100kHz
20ms/cm	50Hz	5μs/cm	200kHz
10ms/cm	100Hz	2μs/cm	500kHz
5ms/cm	200Hz	1μs/cm	1MHz
2ms/cm	500Hz	0.5μs/cm	2MHz
1ms/cm	1kHz		

The **VAR.** control range can also be checked. The sweep speed becomes faster by turning the **VAR.** control clockwise to its right stop. One cycle at least every 2.5cm should be displayed (with **X-MAGN.** knob depressed; measurement in the **50μs/cm** range).

When the **X-MAGN.** control is actuated, a marker or cycle peak will be displayed every 5cm (with **VAR.** control in **Cal.** position; measurement in the **50μs/cm** range).

The 20 and 10ms/cm ranges can be checked very precisely with mains frequency (***50Hz*** only). On the 20ms/cm range a cycle will be displayed every cm, while on the 10ms/cm range it will be every 2cm.

The use of an Oscilloscope Calibrator (HAMEG Type HZ62) is recommended, if the timebase is to be checked on a number of oscilloscopes on a regular routine basis. This instrument employs a quartz marker, providing peak pulses at 1cm intervals for each time range. It should be noted that on triggering such pulses the **Peak/Norm.** button must be depressed (Normal Triggering).

Sweep Delay

When the Sweep **DELAY MODE** slide switch is set to the **Norm.** mode, the delay should have no effect on the display of the ***1kHz calibration signal***. When the Sweep Delay is set in the **Search** mode (refer to Sweep Delay Operating Instructions), it is possible to check the delay time by means of a distance measurement of the blanked baseline. For this, the **DELAY VARIABLE** control **x1-x10** must be set to **x1** (rotate counterclockwise until a snap noise is audible). When **Delay** is selected, the trace reverts to the full 10cm display without any blanking.

In the full range of adjustment of the **DELAY VARIABLE** control, the displayed waveform of the calibration signal should be shifted without any jitter, jumping or intermittent blanking. Control settings: Connect calibrator eyelet with **VERT. INPUT** Channel **I**, **DC** input coupling, deflection coefficient **50mV/cm**, **Trigger Selector** switch to **AC** and Channel **I**, time coefficient **1ms/cm**, no pushbutton depressed, all controls in calibrated position, **DELAY MODE** switch in **Norm.** position. Now the calibrator signal is displayed with a display height of 4cm and approx. 1 cycle per cm. After switching to **Search**, the **MODE** indication lamp blinks. Set the **DELAY** range switch to **1ms**. Rotate the **DELAY VARIABLE** control until the left half of the display is blanked. The delay time is now ***5ms***. After switching to **Delay**, the display is again fully visible. The **DELAY MODE** indication shows continously. The signal displayed can be expanded now. To this purpose turn the **TIMEBASE** switch clockwise to **5µs/cm**. The expansion is now x200. With the **DELAY VARIABLE** control, the nearest edge of the calibration signal can be brought into the screen center and checked on the above-mentioned criteria. With x200 expansion, the display brightness normally needs increasing (with **INTENS.** and **FOCUS** control). However, larger expansion than x200 is quite possible, but the jitter restricts the evaluation.

Correction of the Trace Alignment

The CRT has an admissible angular deviation ±5° between the X deflection plane D1-D2 and the horizontal center line of the internal graticule. This deviation, due to tube production tolerances, and also the influence of the earth's magnetic field, which is dependent on the instrument's North orientation, are corrected by means of the **TR** potentiometer. In general, the trace rotation range is asymmetric. It should be checked, whether the baseline can be adjusted somewhat sloping ***to both sides*** round about the center line of the graticule. With the HM412-5 in its closed case, an angle of rotation ±0.57° (1mm difference in elevation per 10cm graticule length) is sufficient for the compensation of the earth's magnetic field.

Miscellaneous

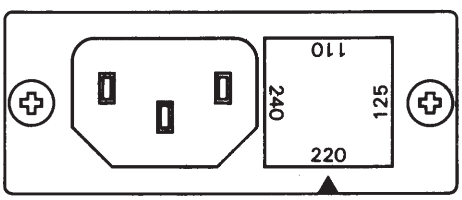
If a variable line/mains transformer is available, the characteristics of the HM412 on power voltage fluctuations of ±10% should be checked. Under these conditions no variations should be detected on the display in either the vertical or horizontal axis.

General

The following instructions are intended as an aid for the electronic technician, who is carrying out re-adjustments on the HM412, if the nominal values do not meet the specifications. These instructions primarily refer to those faults, which were found after using the Test Instructions. However, this work should only be carried out by properly qualified personnel. For any further technical information call or write to HAMEG. Addresses are provided at the back of the manual. It is recommended to use only the original packing material, should the instrument be shipped to HAMEG for service or repair (see also Warranty, page M2).

Line/Mains Voltage Change

The instrument has a power plug-in unit at the rear. This unit contains the power fuse, which is interchangeable for the different line/mains voltages. The fuse holder with its square top plate can be pulled out by means of a small screwdriver, and changing of the power voltage is possible by turning this plate 90 degrees for each of the four power voltages marked on the plate (see triangle below the fuse holder). The fuse holder should then be plugged in again in the selected position.



Required power fuse-link:
5x20mm, time lag (slow-blow), **250V~, C,**
to IEC 127/III; DIN 41662.

Line/mains voltage	**Rated current**
110V~ ±10%	**T 0.5A**
125V~ ±10%	**T 0.5A**
220V~ ±10%	**T 0.25A**
240V~ ±10%	**T 0.25A**

The power fuse has to match the set line/mains voltage and must be changed if necessary. It should be checked that only fuses of the specified type and current are used in this case. The use of patched fuses or short circuit of the fuse holder is inadmissible.

Instrument Case Removal

The rear cover can be taken off after three domed cap nuts on it have been removed and after unplugging of the power cord's triple-contact connector. While the instrument case is firmly held, the entire chassis with its front panel can be withdrawn forward. When the chassis is inserted into the case later on, it should be noticed that the case has to fit under the flange of the front panel. The same applies for the rear of the case, on which the rear cover is put.

Caution
The instrument must be disconnected from all power sources during opening or closing of the case, for maintenance work or a change of parts or components. If a measurement, trouble-shooting, or an adjustment on the opened instrument is unavoidable, this work must be done by a specialist, who is familiar with the risk involved.

When the instrument is set into operation after the case has been removed, attention must be paid to the accelerating voltage for the CRT, which is 2000V. These high voltage potentials are on the CRT socket as well as on the vertical positioned PCB around this socket.They are highly dangerous and therefore precautions must be taken. It is noticed furthermore that shorts occuring on different points of the CRT high voltage and unblanking circuitry will definitely damage some semiconductors and the opto-coupler. For the same reason it is very risky to connect capacitors to these points while the instrument is on.

Capacitors in the instrument may still be charged, even when the instrument is disconnected from all voltage sources. Normally the capacitors are discharged 6 seconds after switching off. However, with a defective instrument, an interruption of the load is not impossible. Therefore, after switching off, it is recommended to connect one after the other all 8 terminals of the check strip on Z-board across 1kΩ to ground (chassis) for a period of 1 second.

Pay ATTENTION to change information on page K2.

Use caution when exposing or handling the CRT. Handling of the CRT shall be done only by qualified maintenance personnel (implosion danger).

Operating Voltages

Besides the two AC voltages for the CRT heating and for graticule illumination (and line/mains triggering) there are seven electronically stabilized DC operating voltages generated (+24V, +5V, −12V, +140V, +260V, −1900V, and 33V for the unblanking circuit). These different operating voltages are fixed voltages, except the +140V (vertical final stage) and the high voltage, which can be adjusted. The variation of the fixed voltages greater than ±5% from the nominal value indicates a fault. Both adjustable voltages have to be set exactly for +140V respectively −1900V by the adjustments of two variable resistors (10kΩ and 5kΩ), which are located on the Z-board. These voltages are measured on the Check Socket with reference to ground (see Adjusting Plan). Measurements of the high voltage may only be accomplished by the use of a sufficient highly resistive voltmeter (≥10MΩ). You must make absolutely sure that the electric strength of the voltmeter is sufficiently high. It is recommended to check the ripple and also the interaction from other possible sources. Excessive values might be very often the reason for incomprehensible faults. The maximum ratings are specified on the circuit diagrams. For the measurement of the high voltage ripple you need a probe capable to withstand 2000V (e.g. X100 probe HZ37). But also a normal probe X10 is sufficient with a capacitor (10... 20nF 2000V) connected in series to the probe tip.

Maximum and Minimum Brightness

Two variable resistors of 500kΩ each, located on the upper edge of the vertical positioned Z-board, are used for these adjustments (see Adjusting Plan). They may only be touched by a properly insulating screwdriver (Caution! High voltage.). The adjustments must possibly be repeated, because the functions of both variable resistors are dependent on each other. Correct adjustment is achieved, when the trace can be blanked while **Hor. ext.** pushbutton is depressed and, in addition, the requirements described in the Test Instructions are met.

Astigmatism Correction

The ratio of vertical and horizontal sharpness can be adjusted by the variable resistor of 50kΩ, located near to the upper edge of the Z-board (see Adjusting Plan). As a precaution however, the voltage for the vertical deflecting plates (approx. +90V) should be checked before, because this voltage will affect the astigmatism control. While the adjustment is accomplished (with depressed **Hor. ext.** button), the **FOCUS** control knob has to be repeatly turned to and fro until the shape of the luminous spot, whether round or oval or rectangular, stays the same to the right and left of the optimum focusing. The interaction of focus adjustment and astigmatism correction should be noted. After this adjustment, a square-wave signal should be displayed and be verified once more in accordance with the Test Instructions. The final adjustment has always to be the **FOCUS** control.

Trouble-Shooting the Instrument

For this job, there will be needed at least an isolating variable line/mains transformer (protection classification II), a signal generator, an adequate precise multimeter, and, if possible, an oscilloscope. This last item is required for complex faults, which can be traced by the display of signal or ripple voltages. As noted before, the stabilized high voltage and the supply voltage for the final stages (approx. 300V) are highly dangerous. Therefore it is recommended to use **totally insulated extended probe tips**, when trouble-shooting the instrument. Incidental touches with dangerous voltage potentials are then unlikely. Of course, these instructions can not thoroughly cover all kinds of faults. Some common-sense will certainly be required, when a complex fault has to be investigated.

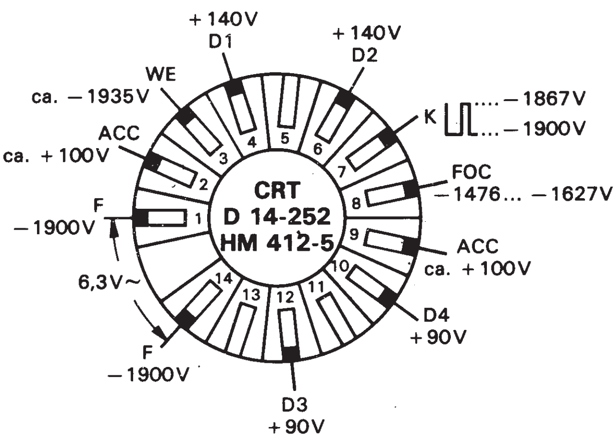
If the instrument fails completely, the first and most important step will be to measure the deflecting plate voltages of the CRT. In almost any case, the faulty

Pay ATTENTION to change information on page K2.

section can be located. The sections represent:

1. Vertical deflection. 2. Horizontal deflection.
3. CRT circuit. 4. Power supply.

While the measurement takes place, the position controls of both deflection devices must be in mid-position. When the deflection devices are operating properly, the separate voltages of each plate pair are almost equal then (Y = 85-95V and X = 133-147V). If the separate voltages of a plate pair are very different, the associated circuit must be faulty. An absent trace in spite of correct plate voltages means a fault in the CRT circuit. Missing deflecting plate voltages is probably caused by a defect in the power supply.



Voltages at the CRT socket

If trouble is suspected, visually inspect the instrument. Look for loose or burned components that might suggest a source of trouble. Check to see that all circuit board connections are making good contact and are not shorting to an adjacent circuit. Prior to any extensive troubleshooting, also check the external power source.

Replacement of Components and Parts

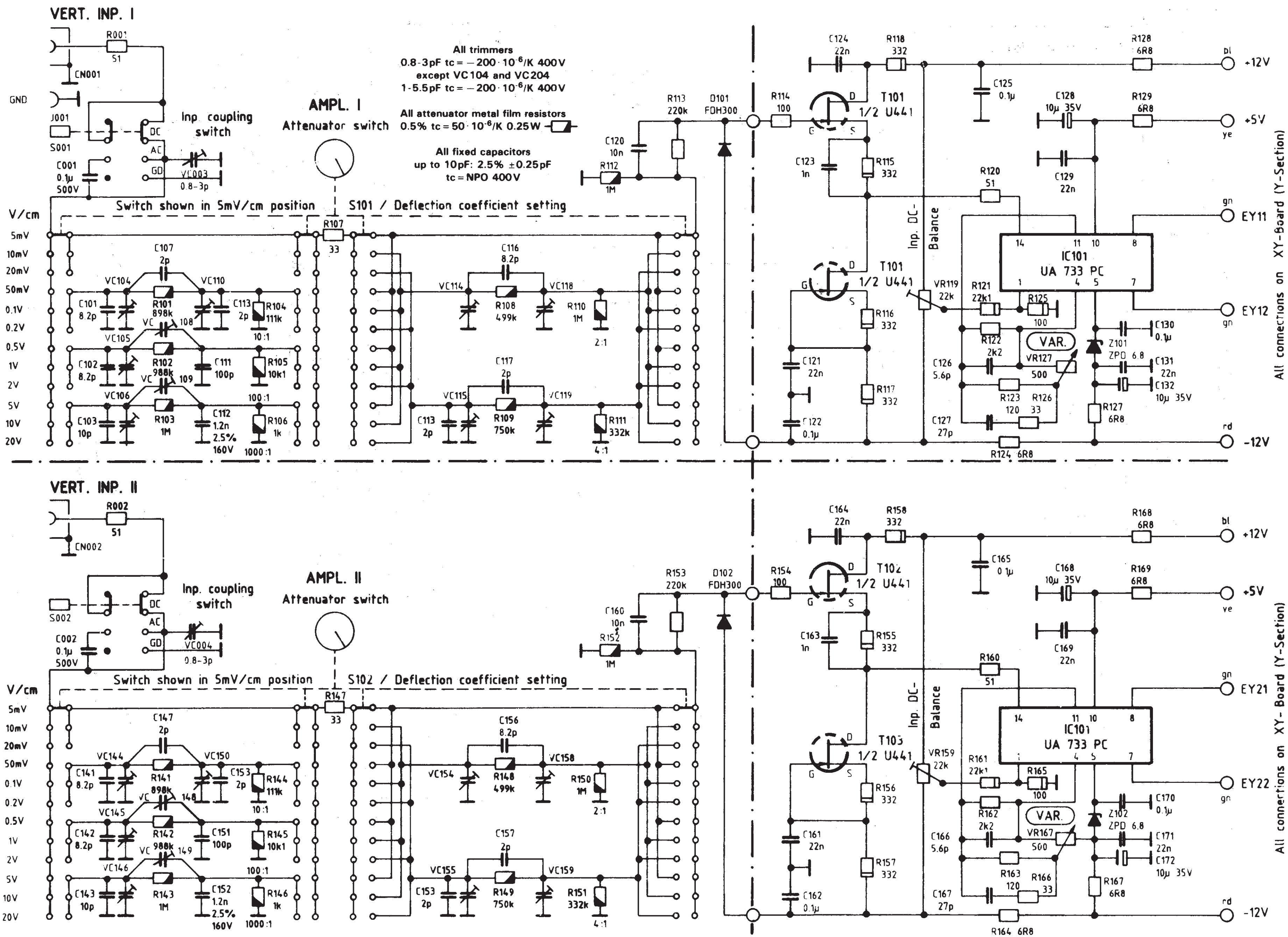
For the replacement of parts and components use only parts of the same or equivalent type. Resistors without specific data in the diagrams have a power dissipation of 1/3 Watt and a tolerance of 2%. Resistors in the high voltage circuit must have sufficient electric strength. Capacitors without a voltage value must be rated for an operating voltage of 63V. The capacitance tolerance should not exceed 20%. Many semiconductors are selected, especially the gate-diodes 1N4154, and all amplifier transistors, which are contained in push-pull circuits (including the FET's). If a selected semiconductor is defective, all gate-diodes or both push-pull transistors of a stage should be replaced by selected components, because otherwise there are possibly deviations of the specified data or functions. The HAMEG Service Department can give you advice for troubleshooting and replaceable parts. Replacement parts can be ordered by letter or telephone from the nearest HAMEG Service Office. Please supply the following information: Instrument type and serial number, description of the part (including function and location in the instrument), quantity desired.

Adjustments

Indeed, as advised in the Operating, Test and Service Instructions, small corrections and adjustments are easily carried out with the aid of the Circuit Diagrams and ***Adjusting Plan***. However, a complete recalibration of the oscilloscope should not be attempted by an inexperienced operator, but only someone with sufficient expertise. Several precision measuring instruments with cables and adapters are required, and only then should the pot's and trimmers be readjusted provided that the result of each adjustment can be exactly determined. Thus for each operating mode and switch position, a signal with the appropriate sine or square waveform, frequency, amplitude, risetime and duty cycle is required.

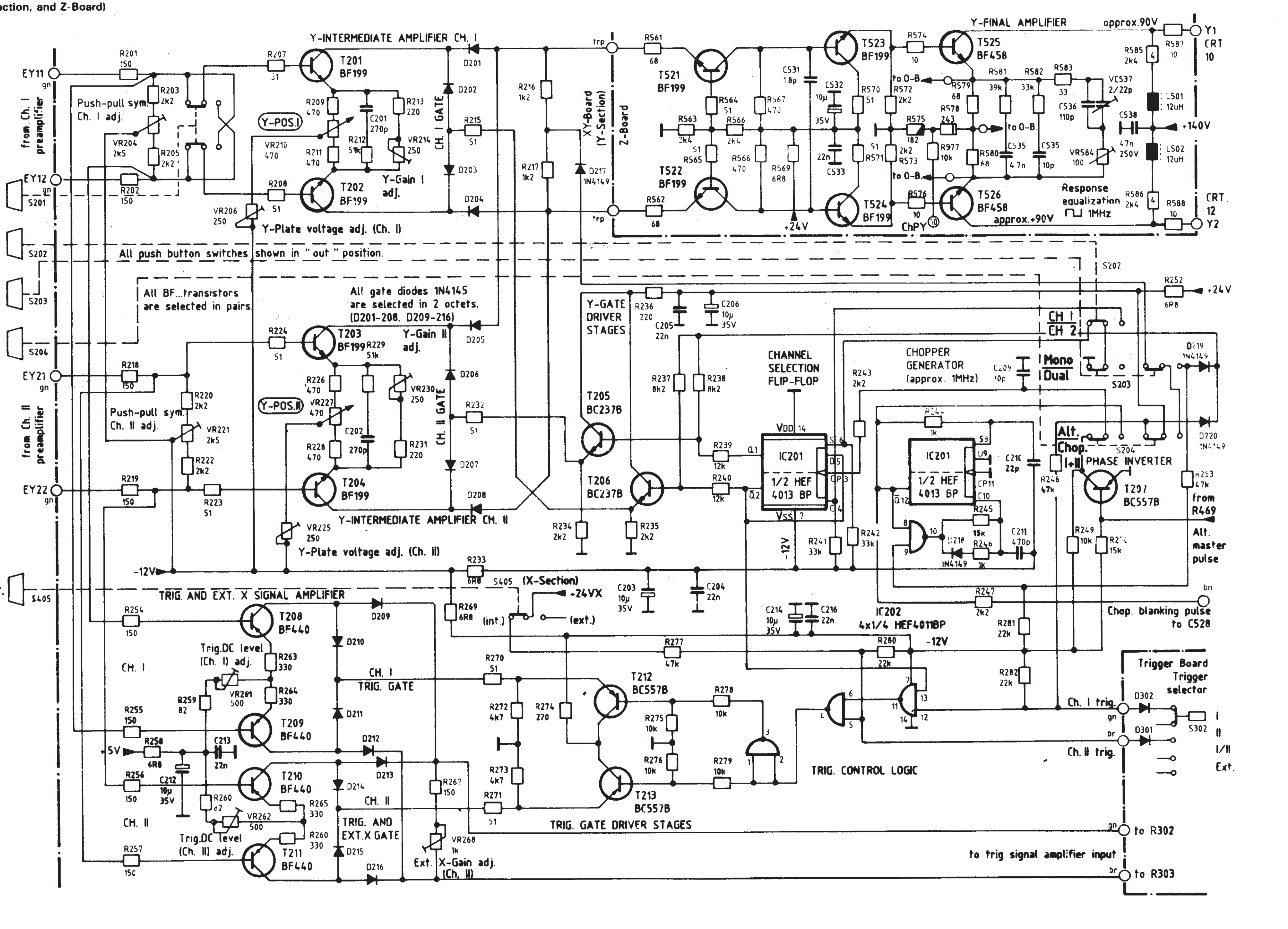
Y-INPUT, ATTENUATOR, AND PRE-AMPLIFIER CHANNEL I AND CHANNEL II   HM 412-5

(EY-Board I+II, Chassis)



Y-AMPLIFIER WITH FINAL STAGE, CHANNEL SWITCHING; TRIGGER AND EXT. X-SIGNAL PRE-AMPLIFIER WITH CONTROL LOGIC HM 412-5

(XY-Board: Y-Section, and Z-Board)



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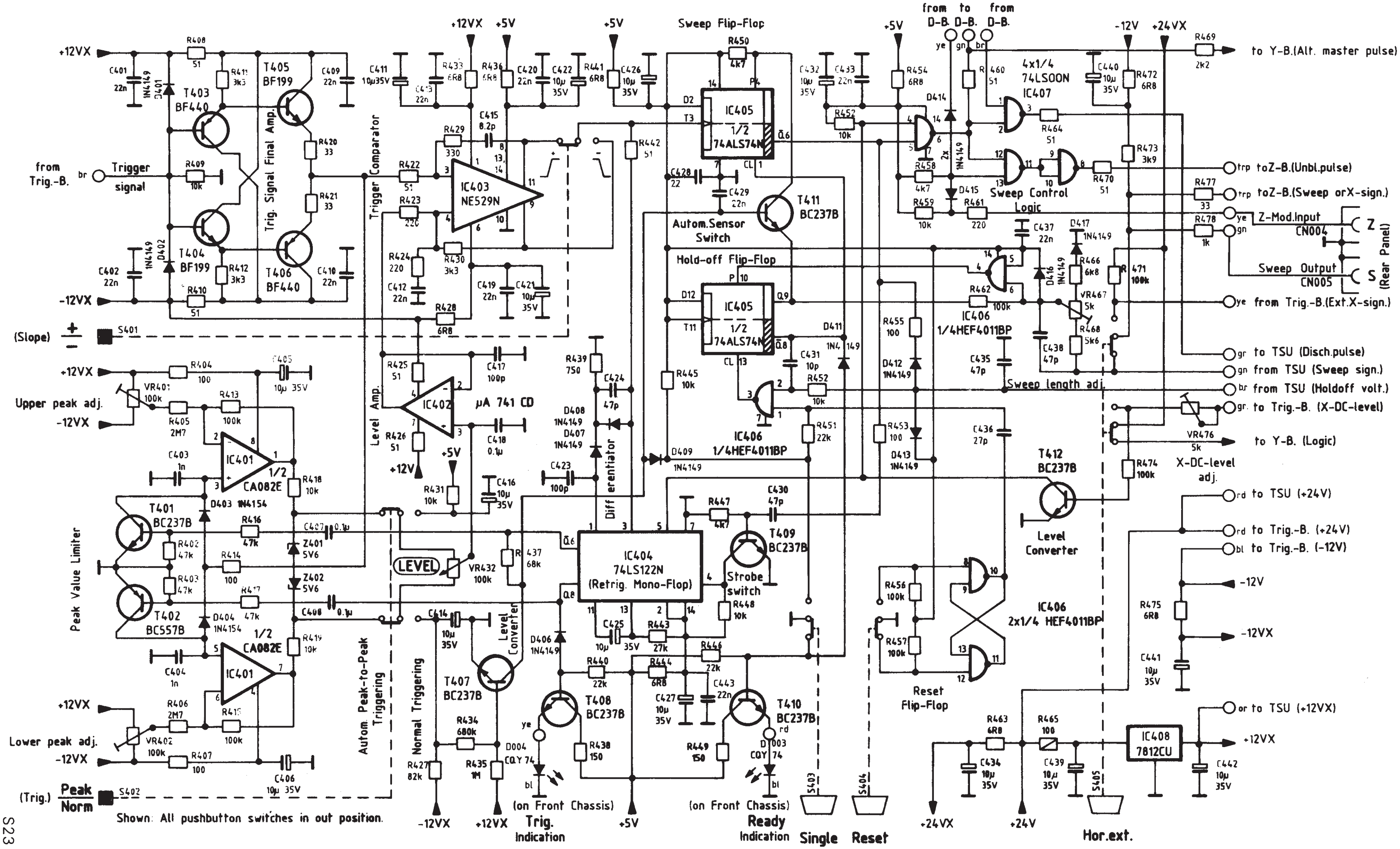
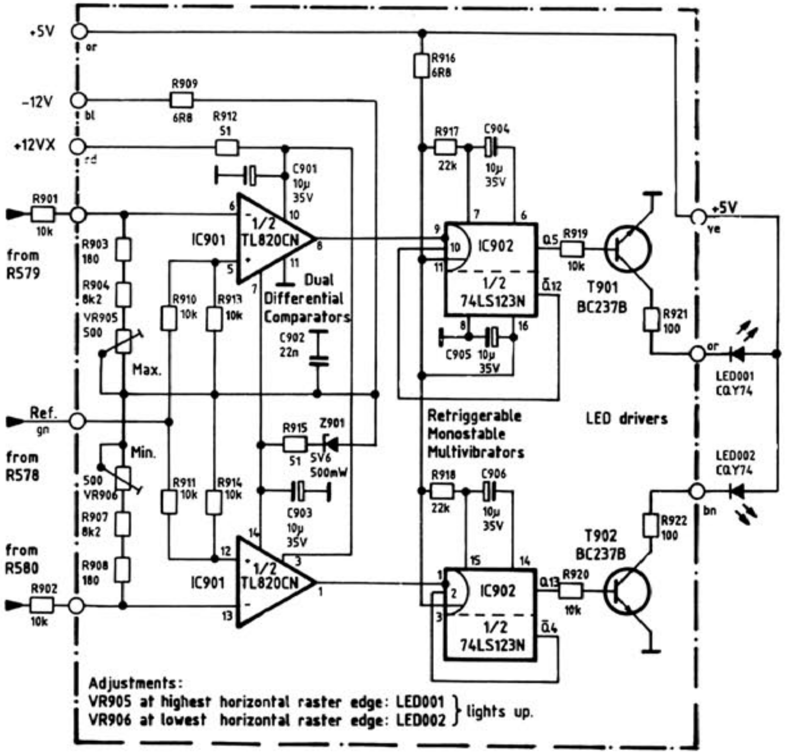
TRIGGER FINAL AMPLIFIER WITH PEAK VALUE LIMITER AND COMPARATOR; TIMEBASE CONTROL CIRCUIT HM 412-5

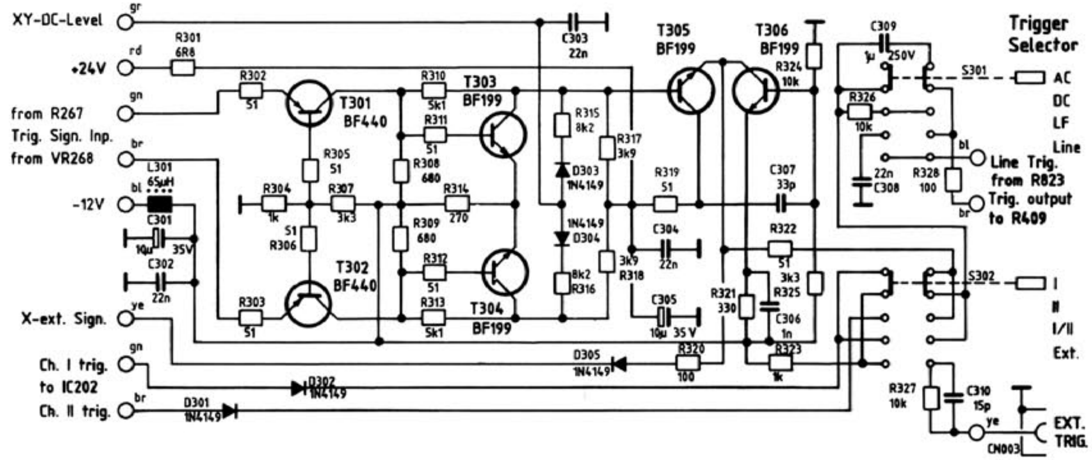
(XY-Board: X-Section, partial Front Chassis)



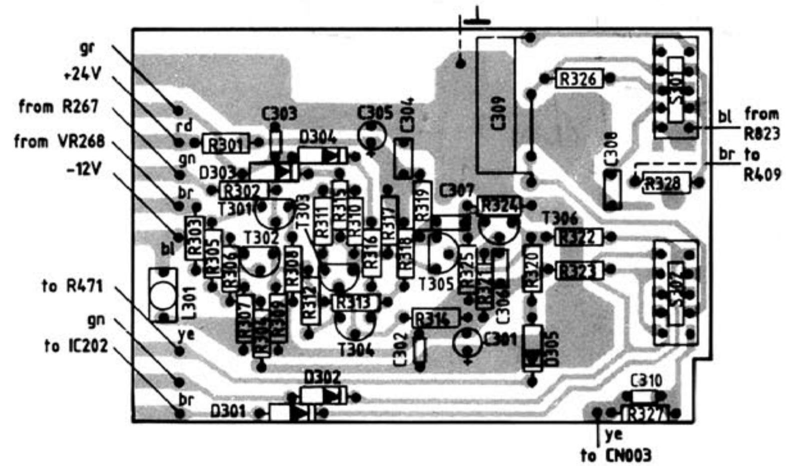
OVERSCANNING INDICATION CIRCUIT HM 412-5
(OS-Board)



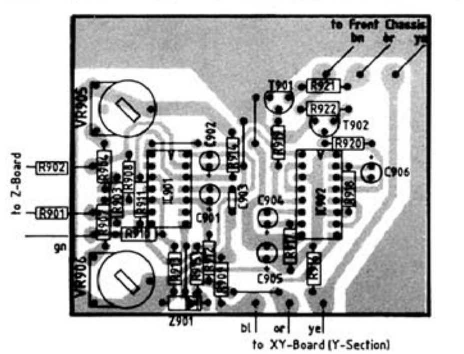
TRIGGER AND EXT. X SIGNAL (AMPLIFIER, SELECTOR SWITCHES) HM 412-5
(Trigger Board on Front Chassis)



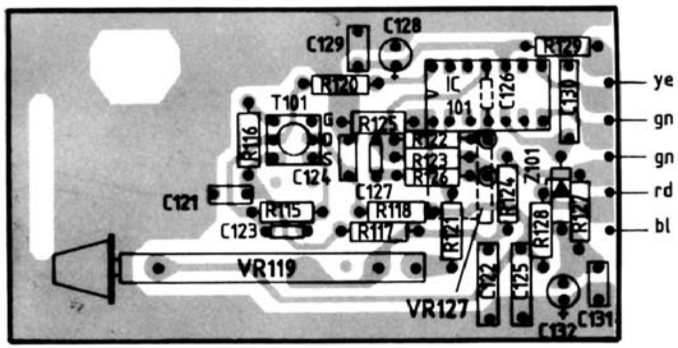
COMPONENT LOCATIONS TRIGGER-BOARD HM 412-5



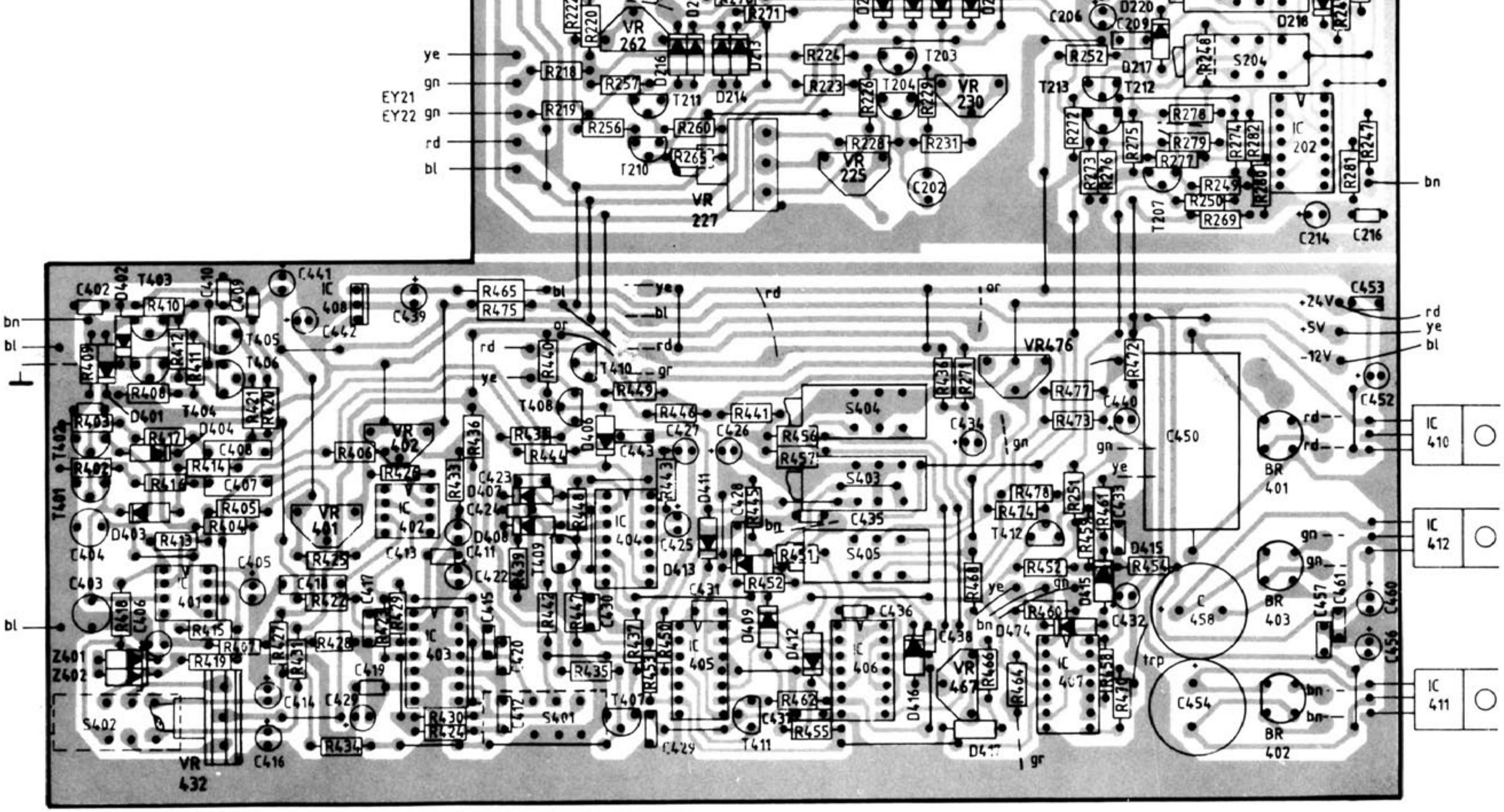
COMPONENT LOCATIONS OS-BOARD HM 412-5



COMPONENT LOCATIONS EY-BOARD HM 412-5

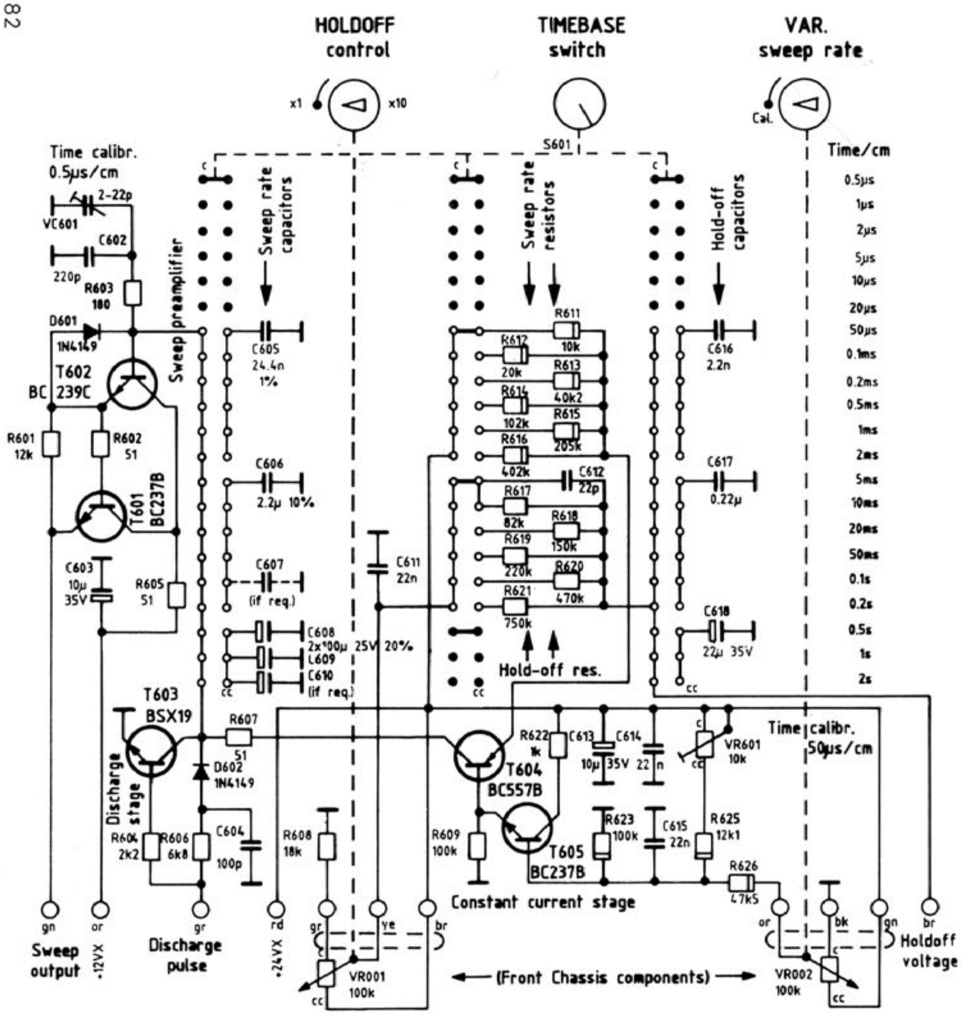


COMPONENT LOCATIONS XY-BOARD HM 412-5

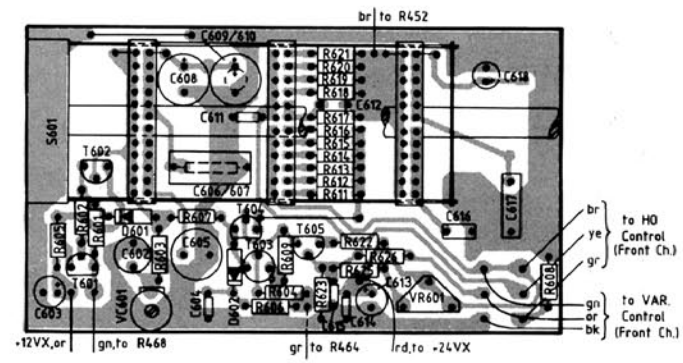


TIMEBASE SWITCH UNIT HM412-5

(TSU-Board, partial Front Chassis)

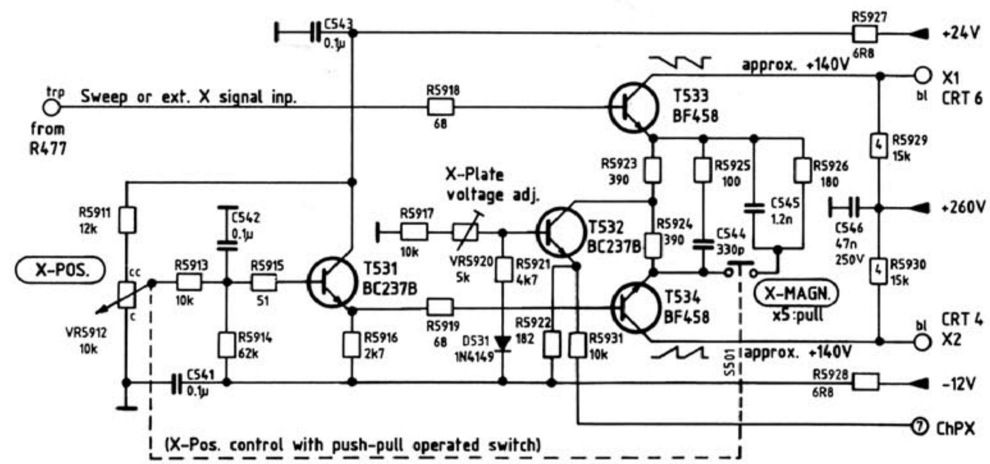


COMPONENT LOCATIONS TSU-BOARD HM 412-5

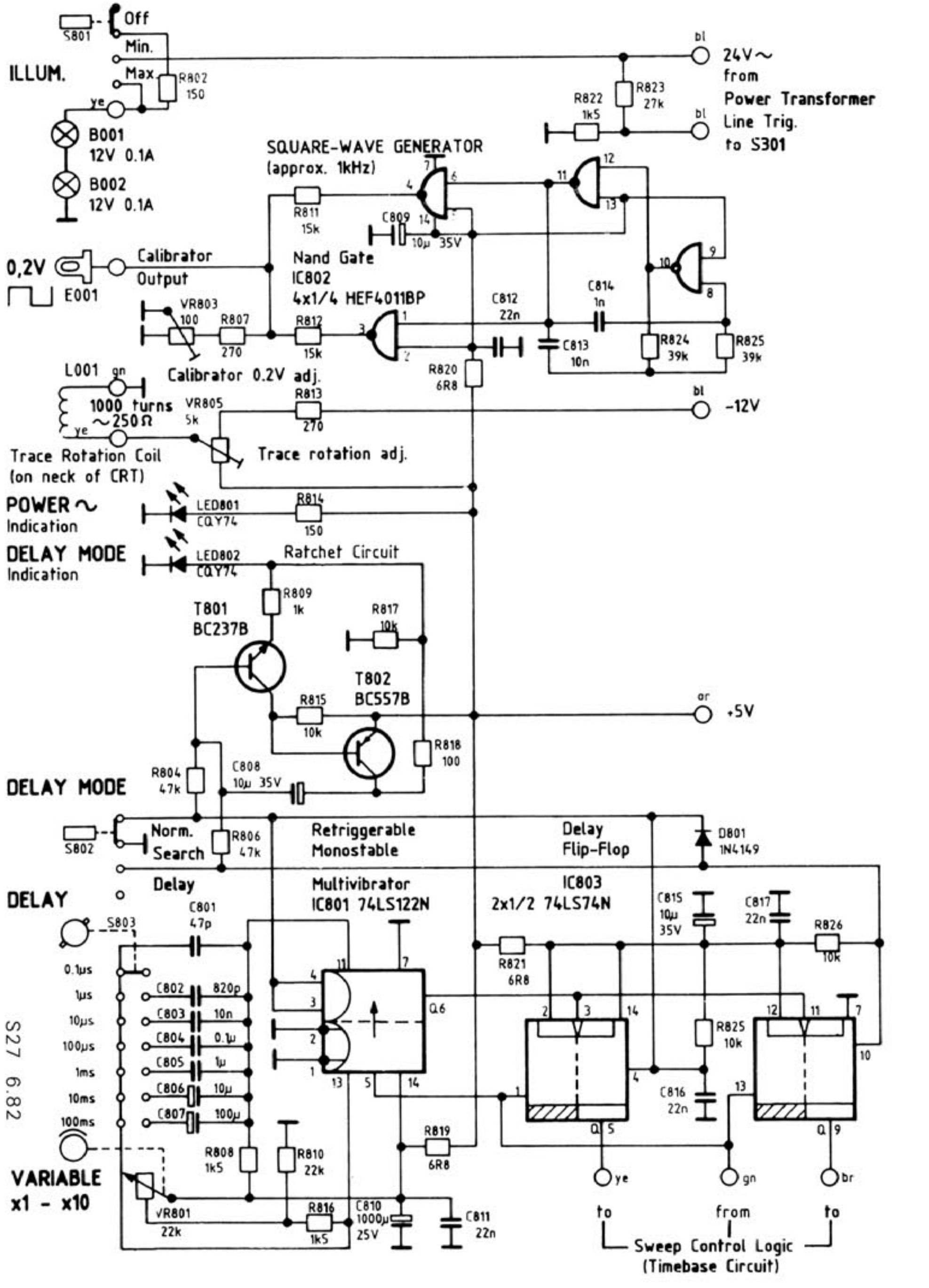


X-FINAL AMPLIFIER (POSITIONING, x5 MAGN.) HM 412-5

(Z-Board)



GRATICULE ILLUMINATION, CALIBRATOR, TRACE ROTATION, SWEEP DELAY CIRCUIT (Delay-Board) HM 412-5



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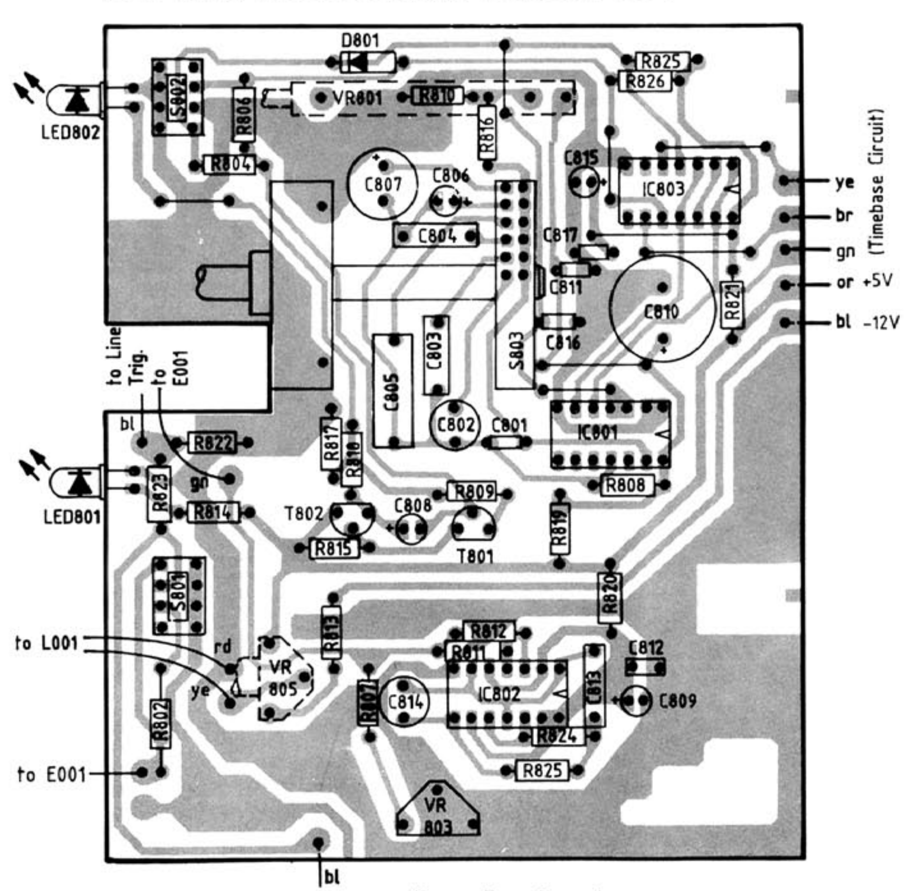
COMPONENT LOCATIONS DELAY-BOARD HM 412-5



Identification of Electrical Components

Electrical components on certain parts of the HM 412-5 are marked such that the first numeral is on:

Chassis — **0..**
Y-Inputs, ext. Trig. Input, Trig. and Ready LED, Overscan LEDs, Variable Sweep Rate and Holdoff Controls, Graticule Illumination Bulbs, Trace Rotation Coil, Rear Panel Connectors, Power Switch, Power Transformer, Power Plugs + Fuse-Attachment, CRT

EY-Board I + II — **1..**
Attenuator and Preamplifier Ch.I + II

XY-Board: Y-Section — **2..**
Y-Amplifier, Channel Switching, Trig. and ext. X-Preamplifier with Control Logic

Trigger Board — **3..**
Trigger and ext. X-Signal Amplifier

XY-Board: X-Section — **4..**
Trigger Final Amplifier, Limiter, Comparator, Timebase Control Circuit, LV-Power Supply

Z-Board — **5..**
X- and Y-Final Amplifiers, HV-Power Supply, Unblanking and CRT Circuit

TSU-Board — **6..**
Timebase Switch Unit

Delay Board — **8..**
Graticule Illumination, Calibrator, Trace Rotation, Sweep Delay Circuit

OS-Board — **9..**
Overscanning Indication Circuit

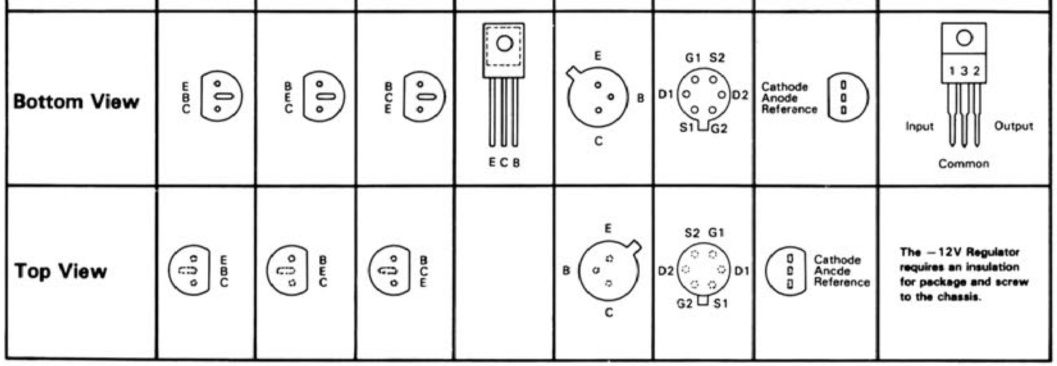
Abbreviations

B... Incandescent bulb (Illum.)
BR... Bridge rectifier (Silicium)
C... Capacitor (fixed)
ChP... Check point
CN... Connector
CRT... Cathode-ray tube
D... Diode (Silicium)
E... Eyelet (Calibrator)
F... Fuse
IC... Integrated Circuit
L... Inductor, Coil
LED... Light emitting diode
PPF... Power Plugs + Fuse-Attachm.
R... Resistor (fixed)
S... Switch
T... Transistor (Silicium)
TR... Transformer
VC... Variable capacitor
VR... Variable resistor
Z... Z-Diode

Resistor Identification

Resistor 0.25W 2% (carbon film)
Resistor 0.25W 1% tc = $50 \cdot 10^{-6}$/K (metal film)
Resistor 0.25W 0.5% tc = $50 \cdot 10^{-6}$/K (metal film)
Resistor 0.5W 2% (or for HV) (carbon film)
4 Resistor 4W 2% tc = $400 \cdot 10^{-6}$/K (metal oxide film)

Types and Terminals of Transistors and some ICs	BC237B BC239C BC557B BF297	BF199 BF440	BF423	BF458 BF459 BUX86/87 BD232	BSX19	U441	TL430C	78XXCU



Check strip on Z-Board
(seen from rear of instrument)

1	2	3	4	5	6	7	8	9	10
CRT cathode	−1.9kV	(NC)	−12V	+5V	+24V	ChP X	+260V	+140V	ChP Y

(1) Unblanking square pulse: 33Vpp ±5% added to −1.9kV

(2) HV −1.9kV VR507 adj.

(7) 3.0... 3.28V between (7) and (4). VR5920 adj.
The exact voltage value is dependent upon the measured operating voltage of the X final stage (see following table):

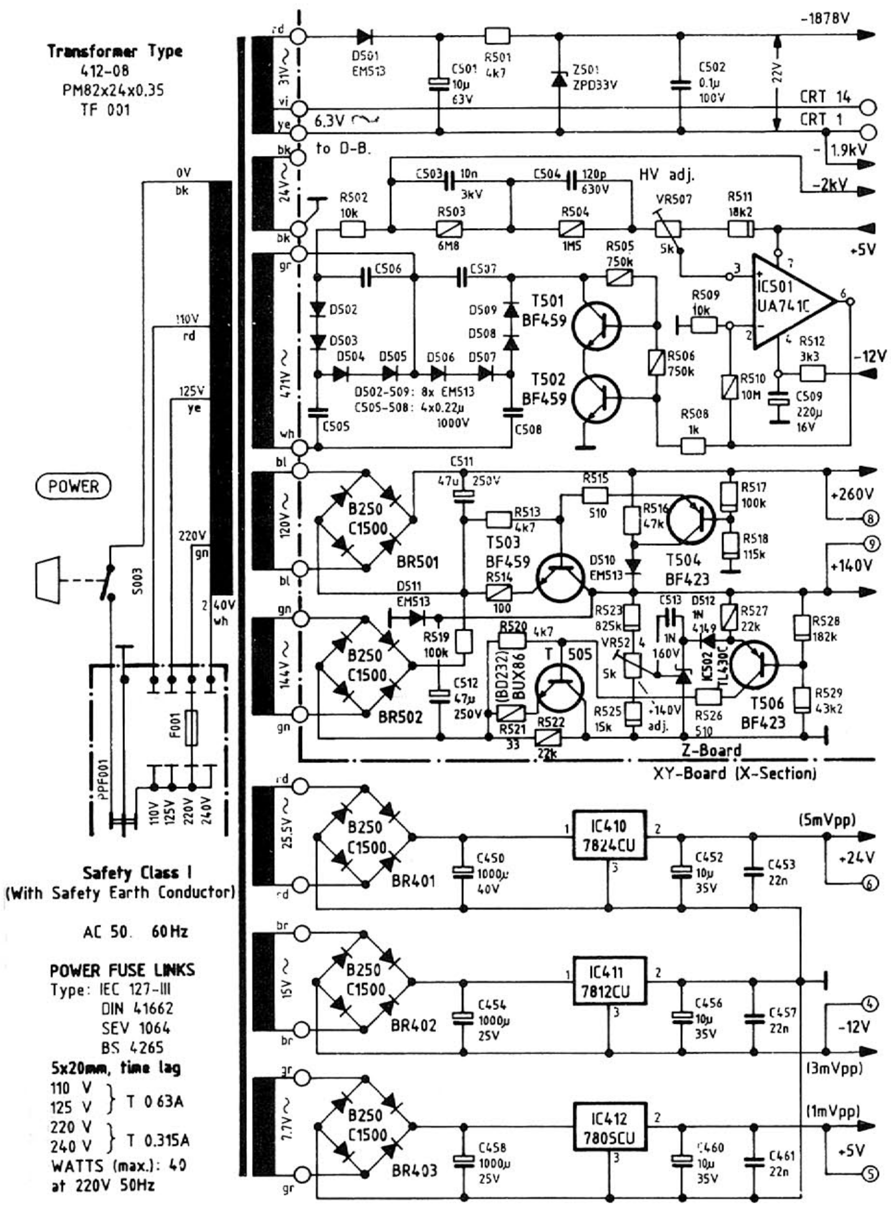
258V → 3.00V	264V → 3.18V
260V → 3.08V	266V → 3.24V
262V → 3.14V	268V → 3.28V

(10) +6.55V between (10) and ground.
Ch. I: VR206 adj.
Ch. II: VR225 adj.

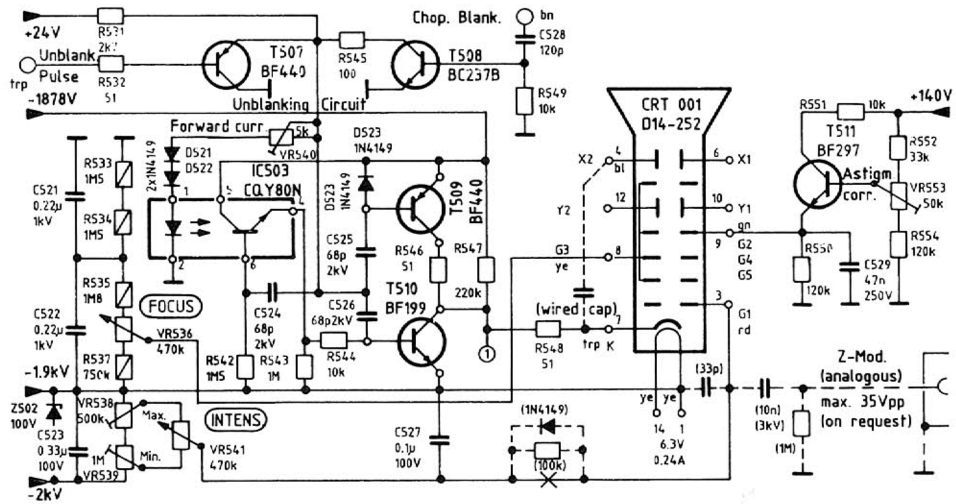
Check of the Unblanking Pulse on ChP1

Pulse amplitude ***33Vpp*** ±5% added with ***−1.9kV*** **(Caution!)**. Check with Control Oscilloscope by means of a X10 attenuator probe with 10nF ***3kV*** capacitor between ChP1 and probe input tip.
Test Scope settings: Input coupling to GND (no input signal), 50µs/cm, intern. automatic triggering (free running).
Control Scope settings: 1V/cm (DC), 0.2ms/cm, intern. automatic triggering.
Display on Control Scope:
Negative pulse tops exactly horizontal (forward sweep = bright trace on Test Scope). Positive pulse tops approx. horizontal (flyback = dark trace).
Adjustment of VR540:
Adjust the forward current of the optocoupler diode in the middle of the following points:
a) glitch in the positive top (bright trailing edge),
b) shortening of the negative top or reaching the right stop of VR540 respectively. Between these two points is a wide range (needed for int. temperature variation). With correct adjustment the edges of the square-wave should not be visible on the Control Scope. Then change both TIMEBASE settings to 0.5µs/cm and 2µs/cm resp. Now steep square-wave edges must be visible.

POWER SUPPLY (Z-Board, partial X-Section of XY-Board and Chasis)



CRT-CIRCUIT (Z-Board) HM 412-5



COMPONENT LOCATIONS Z-BOARD HM 412-5