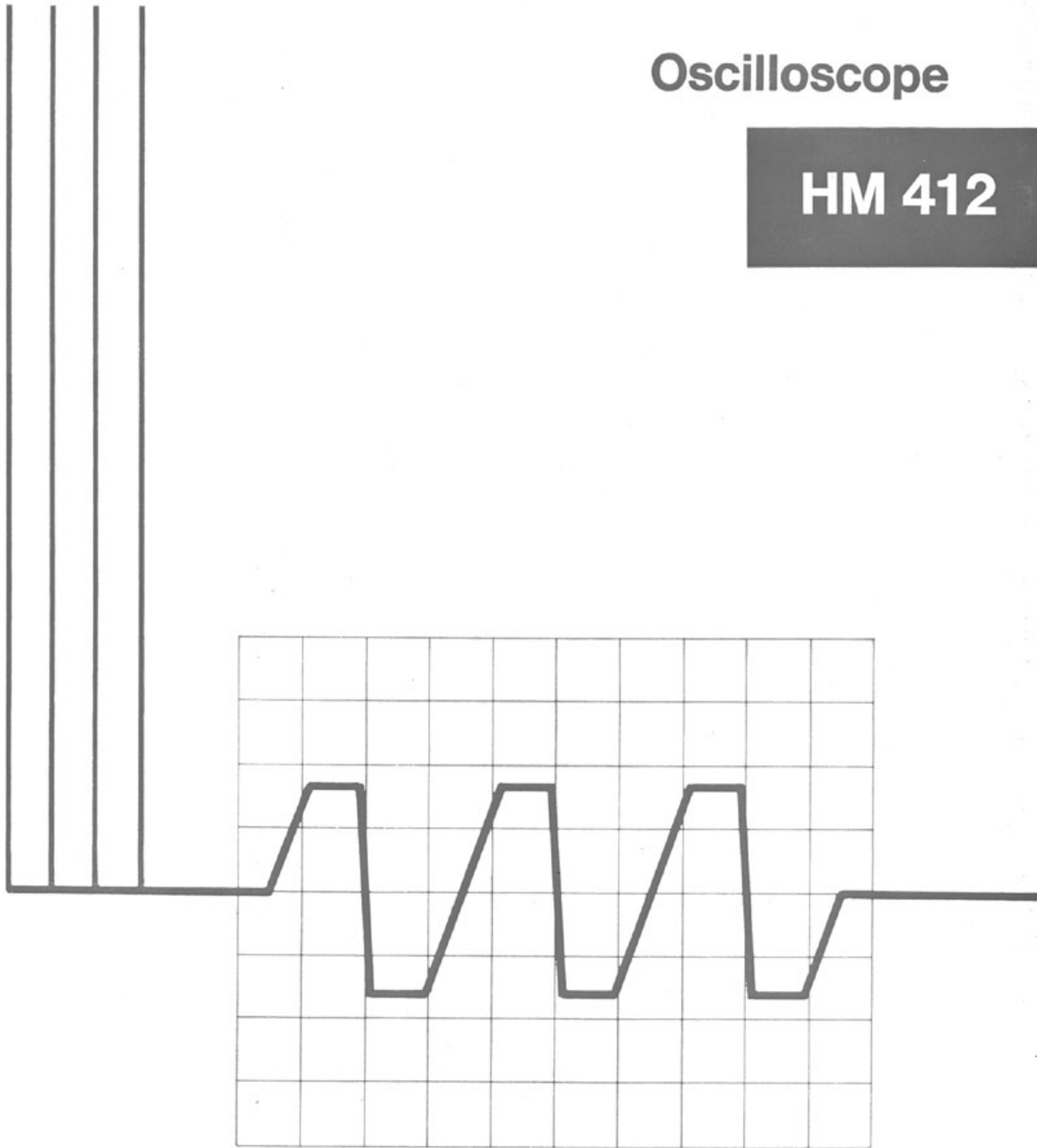


MANUAL

Oscilloscope

HM 412



HAMEG MESSTECHNIK

Specification

Vertical Deflection (Y)

Bandwidth: of both channels

DC - 20 MHz (-3dB), DC - 28 MHz (-6dB).

Risetime: 17.5 ns (approx.).

Overshoot: 1% (maximum).

Deflection coefficients: 12 calibr. steps, 5 mV/cm - 20 V/cm (1-2-5 sequence), variable gain control uncalibr. to 2 mV/cm, accuracy better than $\pm 3\%$ (in cal. position).

Input impedance: 1 Megohm // 25 pF.

Input coupling: DC - AC - GND.

Max. Input voltage: 500 V (DC + peak AC).

Polarity: normal or inverted on channel I.

Overscanning: indicated by 2 LED's.

Operating modes

Channel I, channel II and II,

alternate or chopped (approx. 1 MHz).

Addition: channel I + II.

Difference: with channel I inverted.

X-Y operation: ratio 1 : 1 (input via ch. II).

Timebase

Time coefficients: 21 calibrated steps,

0.5 μ s/cm - 2 s/cm (1-2-5 sequence),

with magnifier x5 to 100 ns/cm,

with variable control uncalibr. to 40 ns/cm,

accuracy better than $\pm 3\%$ (in cal. position).

Ramp output: 5 V (approx.).

Trigger System

Modes: automatic or variable trigger level.

Source: ch. I or II, altern. I/II, line, ext.

Slope: positive or negative.

Coupling: DC, AC, TV frame.

Sensitivity: int. 5 mm, ext. 0.5V (approx.).

Bandwidth: DC - 40 MHz.

Trig. action: indicated by LED.

Sweep Delay

Ranges: 7 decade steps, 100 ns - 1 s

with fine control, ratio 10 : 1.

Modes: normal, search, delayed;

modes indicated by LED.

Horizontal Deflection (X)

Bandwidth: DC - 2.3MHz (-3dB).

(X-Y mode: phase shift $\leq 3^\circ$ at 110 kHz).

Deflection coefficients: 12 calibr. steps, 5 mV/cm - 20 V/cm (1-2-5 sequence), variable gain control uncalibr. to 2 mV/cm.

Input impedance: 1 Megohm // 25 pF.

Miscellaneous

Cathode-ray tube: 130 BXB 31, 13 cm ϕ .

Accelerating potential: 2000 V.

Calibrator: square-wave generator 1 kHz,

0.2 V $\pm 1\%$, for probe compensation.

Z-Modulation input: TTL - level.

Trace rotation: adjustable on front panel.

Graticule illumination: four-position switch.

Stabilized power supply: all operating voltages including the EHT.

Mains voltages: 110, 127, 220, 240 V AC.

Mains fluctuation: $\pm 10\%$ (maximum).

Mains frequency range: 50 - 60 Hz.

Power consumption: 36 W (approx.).

Weight: 8.6 kg (approx.).

Dimensions (mm): 212 x 237 x 380.

Finish: dark grey. With handle and tilt stand.

Subject to change.



- Overscanning
- Delayed Sweep

- Bandwidth DC - 20 MHz
- LPS Triggering to 40 MHz

The **HM 412** demonstrates the exceptionally high standard of quality and performance achieved by **HAMEG**. Full use has been made of the **Latest Technology** with integrated circuits and discrete semiconductors being combined for optimum performance. Internal **Stabilized Power Supplies** ensure that mains fluctuations do not adversely affect the HM 412. Both vertical channels incorporate a variable gain control which increases the gain to **2 mV/cm**. Fully matched X-Y operation is available, also the channels can be **Added or Subtracted**. A special feature of the HM 412 is the vertical **Overscanning** facility, location of a "lost" trace is indicated on two LED's. An **LPS Trigger Circuit** ensures reliable triggering up to 40 MHz. The **Sweep Delay** enables a relatively small time interval of a waveform to be expanded and investigated. Both the trigger and delayed conditions are indicated by LED's. These facilities coupled with graticule illumination, **Z Modulation**, and a square-wave calibrator make the HM 412 a very versatile instrument.

Accessories optional

Attenuator Probes x 10 and x 100, Demodulating Probe, various Test Cables, Component Tester, Four-Channel Unit, Viewing Hood, Trolley, Carrying Case, etc.

General

The mechanical construction of the HM412 is both **rugged 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 are selectable on just three push buttons. 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** pre-amplifier. The pre-amplifiers 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 pre-amplifiers 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 pre-amplifiers** 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 (70% of 60 mm)** point. 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 alignment.

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 in the absence of a trigger signal. The blanking of the CRT is controlled by an **opto-coupler**. The HM412 can be triggered from either channel I or II. In the alternate trigger mode the source is taken alternatively from channels I and II, this enables signals which are **not frequency related** to be triggered. Trigger coupling can be either AC, DC or TV. 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 $10\mu\text{s}/\text{cm}$ 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 for 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 display area**. Two BNC sockets for **Z modulation input** and **ramp output** are mounted on the rear panel of the instrument.

HAMEG

This frequency compensated attenuator probe should be used when the circuit under test is a high impedance source or the signal voltage exceeds 100Vpp. 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-100MHz. Risetime 3.5ns. Max. input voltage 600V (DC + peak AC). Input impedance 10 Megohm. Input capacitance 10.3-13.6pF. Compensation range 10-60pF. Cable length 1.5m.

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

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. In the x10 mode the characteristics are the same as the HZ 30. In 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 utilized. The reference position enables a ground reference level to be set. In this mode the oscilloscope input is grounded.

Specification

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

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



HZ 36 Switchable Probe x 10/x 1

For the measurement of voltages between 500 V and 1500 V it is essential to use the HZ 37 x100 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 x100. 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 x10 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 will not suffer reduction by the probe.

Specification

Attenuation x10. 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: Sprung 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). If AC coupling has to be used then a separate 1 Megohm resistor will be required to achieve the necessary 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

This adapter is designed to meet applications where it is necessary 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 oscilloscope. This termination should be used to terminate signal generators and coax-cables which have a 50 ohm characteristic impedance. For correct operation the termination must be connected directly to the oscilloscope 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): 14x20x62. 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 oscilloscope calibrator. In series with the centre connections of the plug and socket is a 1 Megohm resistor paralalled 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

HAMEG

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

HAMEG

When the oscilloscope is used for field service applications the HZ 43 carrying case will 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 handling. 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. It 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

Under high ambient light 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

OPERATING INSTRUCTIONS

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.

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 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. As the HM412 is a fully transistorized oscilloscope the heat generation of the instrument is very low, thus ensuring long term reliable operation. However, in common with all technically advanced instruments the main functions of the HM412 should be periodically checked using the Test Instructions at the end of this manual.

The instrument is designed so that even incorrect operation will not cause serious damage. The push-buttons 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. For

sine-wave voltages the upper frequency limit will be 30-40MHz. However, in this higher frequency range the vertical display height on the screen is limited to approx. 2-3cm. 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 $\pm 3\%$ 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 instrument has a plug-in unit at the rear. This unit contains the three-pin power connector. For this a three wire power cord with triple-contact connector and three-pole power plug is required. Because the earthing contact is isolated, the chassis, case, and all measuring connectors of the instrument are **not** connected to the earthed wire of the power outlet (corresponding to IEC 348: Safety Class I). This earthed wire is only connected to the first protective winding of the power transformer. The mutual isolation between the touchable metallic parts, the earthed contact, and the power contacts is tested at 1500V 50Hz. The appearance of a 50 or 60Hz hum signal on the screen due to connection with other mains/line operated equipment is therefore impossible. In accordance with standard safety regulations, the earth wire must not be disconnected. As with most electron tubes, the cathode-ray tube develops X-rays. With the HM412-4 the dose equivalent rate falls far below the maximum permissible value of 36pA/kg (0.5mR/h).

When displaying signals with high zero potential, it should be noted that these voltages are also connected to the oscilloscope case. Voltages up to 40V 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.

Caution

In spite of Mumetal-screening of the CRT, effects of the earth's magnetic field on the horizontal trace position cannot be completely avoided. Sometimes, however, the CRT itself may be rotated slightly, due to hard shocks during shipment. In both cases, a centred trace will not align exactly with the horizontal centre line of the graticule. A few degrees of misalignment can be corrected by a preset resistor accessible through an opening on the front panel marked "TR". If repositioning of the CRT is required the procedure described in the Service Instructions should be followed.

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. It is strongly recommended that when the instrument needs to be returned that the original packing should be used to avoid possible transport damage. We regret that transportation damage due to poor packaging is not covered by this warranty.

Operating Conditions

Admissible ambient temperature range during opera-

tion: + 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 instruments is in continuous operation it should be used in the horizontal position preferably on its tilt stand.

First Time Operation

On delivery, the instrument is set to 240V AC mains voltage. The power plug-in unit at the rear contains the mains fuse, which is interchangeable for the different mains voltages. The fuse holder with its square top plate can be pulled out, and **changing of the mains voltage** is possible by turning this plate 90 degrees for each of the four mains voltages marked on the plate (see triangle beside the fuse holder). The fuse holder should then be plugged in again in the selected position. The mains fuse must correspond to the mains voltage selected and when necessary should be replaced (see "Power Supply" diagram or Service Instructions).

To obtain a display the following procedure should be adopted. All push buttons should be in the "out" position. All variable control knobs with arrows should be in the fully anti-clockwise ("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 sweep delay section is set to the "norm." position. Furthermore, both slide switches in the timebase section should be set to their uppermost position. The "LEVEL" control should be set in the "AT" 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 one minute, 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 "LEVEL" control. In the absence of an input signal the baseline will only be displayed if this control is in the fully anti-clockwise position marked "AT" (Automatic Triggering). If only a dot appears (Caution! CRT phosphor could be damaged under this condition), probably the push-button 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 pre-amplifier, 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 trimmer which is located behind the opening marked "Bal." which is located above the sensitivity switch for each amplifier; as the trimmer is a helical pot it may require a number of turns to obtain correct setting. To obtain correction the fine control should be continuously rotated while the trimmer is adjusted. 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 "Mono/Dual" must be depressed.

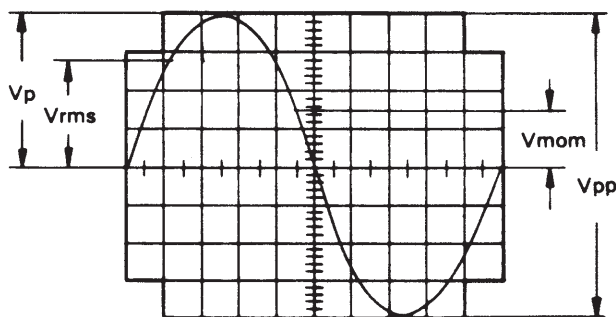
Type of Signal

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 50Hz ripple voltage poses no problems. However, when square or pulse-shaped signals are displayed it must be remembered that their harmonic content will 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 "TV" pushbutton must be depressed. 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 AC or DC voltage amplifier, each channel is provided with an "AC-DC" switch. The DC range should only be used 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.

Amplitude Measurements

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 with the display amplitude in cm. It should be remembered that in general 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 value is applied. The latter corresponds to the real potential difference between the most positive and most negative points of a signal waveform. If the sinusoidal value displayed on the oscilloscope's screen is to be converted into an effective (rms) value, the resulting peak-to-peak value must be divided by $2\sqrt{2} = 2.83$. Conversely, it should be observed that sinusoidal voltages indicated in V_{eff} (V_{rms}) have 2.83 times the potential difference in V_{pp} .



Voltage values of a sine curve

V_{rms} = effective value; V_p = simple peak or crest value;
 V_{pp} = peak-to-peak value; V_{mom} = momentary value.

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. 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 ex-

ceed $\pm 500V$. 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 this value is reduced at higher frequencies. 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.

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 $\mu\text{s/cm}$. 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 (in cm) by the time coefficient selected on the "TIMEBASE" switch. The time fine control marked "VARIABLE" must be in its calibrated position (arrow horizontal and pointing to the left).

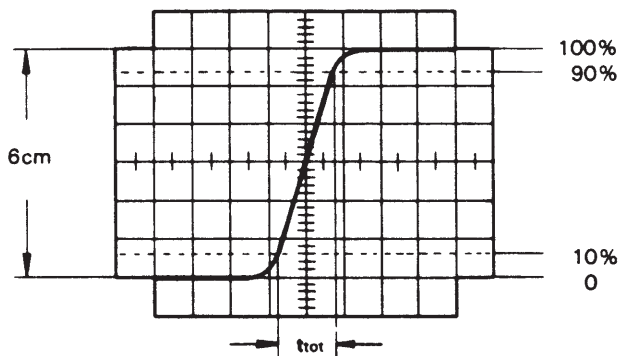
If the time is relatively short as compared with the complete signal period, an expanded time scale ("X-MAG" x5) should be applied. In this case, the ascertained time values have to be divided by 5.

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. Both

these values are marked on the CRT graticule by horizontal dotted lines along with the 0 and 100% values for signal peak-to-peak amplitudes of 6cm height and are symmetrical about the horizontal centre line. Adjust the amplifier controls so that the pulse is precisely aligned with the 0 and 100% graticule lines. The 10% and 90% points of the signal will now coincide with the dotted lines. The risetime is given by the product of the horizontal distance in cm between these two points 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. 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 HM412-4). If t_{tot} is greater than 100ns, then this can be taken as the risetime of the pulse, and calculation is unnecessary. The following figure shows correct positioning of the oscilloscope trace for accurate risetime measurement.



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 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. 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.

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, you require two attenuator probes which are absolutely equal in impedance and attenuation. Only with such probes is it possible to take signals from the test circuit. 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.

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 20V/cm. Pay attention to the Overscanning Indication (see next paragraph).

Y Overscanning Indication

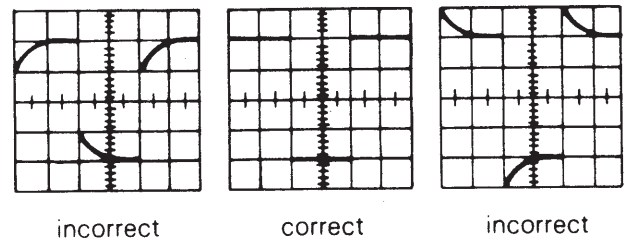
Two light-emitting diodes, located above the vertical input attenuators, show any overscanning of the usable screen dimensions in the vertical direction. Because each LED is correlated with one of both possible directions the beam position is known even if the beam is not visible, or the horizontal deflection is missing, or the vertical positioning control have been adjusted improperly. This is also true with any input signal. Displayed signals, with a pulse duration greater than 100ns, which exceed the uppermost and/or lowermost horizontal graticule line are indicated by lighting of the upper and/or lower LED. With dual mode it is the same. Only one LED will be on, if both traces are in the same area out of the raster. However, both LED's will be on, if one trace is above and the other one is below the usable screen area. Sometimes the trace will disappear after an input signal has been applied. The indication, however, shows in what direction the trace has left the screen area. With an input signal applied and both LED's on, that means an overdriven vertical deflection in both directions. Then the associated attenuator switch has to be set to a greater deflection coefficient. With DC input coupling and an applied signal with DC offset also smaller sizes of displayed signals can overscan the screen area when the position control is out of the midrange. In this case, the vertical input coupling should be set to "AC".

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.

The method employed is as follows. The probe tip is connected to the mini-socket designated with 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.



The "TIMEBASE" switch should be in the "0.2ms/cm" position. The signal has an amplitude of 0.2Vpp \pm 1%. 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.

Operating Modes

The required operating modes are selected on 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. When the "Mono/Dual" button is depressed the HM412 is in dual channel operation. In this mode, the channels are displayed consecutively (alternating 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.

quency, 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 depressing the "TV" pushbutton which switches a low-pass filter 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 1 kHz or less, as high frequency harmonics or noise in the signal are suppressed by the presence of the low-pass filter.

If it is found that a triggering point cannot be located on complex signals even after repeated and careful adjustment of the "LEVEL" control it may be possible to obtain one by adjusting the "VARIABLE" control. On occasions it may be found advantageous to leave the "LEVEL" control in the "AT" position and to use only the "VARIABLE" control.

The deflection coefficient settings on the "TIMEBASE" switch are calibrated when the "VARIABLE" control is set in the "Cal." position. When the "VARIABLE" 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 "VARIABLE" a maximum sweep speed of approximately 40ns/cm is obtained when the "TIMEBASE" switch is set at 0.5 μ s/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.

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 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.

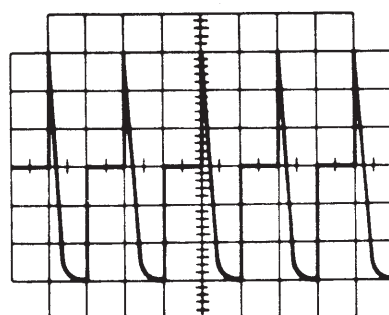
Sweep Delay

The sweep delay facility enables a short time interval of a waveform to be expanded and investigated at a higher resolution, for example, a sweep rate of 10 μ s/cm can be expanded by a factor of 250 times. At lower sweep speeds far greater magnification is possible. Operation of the sweep delay is relatively easy, as only 3 controls need to be used: the sweep delay range switch which selects a delay time from 0.1 μ s to 100ms, a twenty-turn precision potentiometer fine control which can increase the delay time tenfold, and the delay mode slide switch. An LED indicates the operating mode. These controls together with the LED are located in a section to the right of the CRT.

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

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, the amount of shift indicates the exact delay time. If a display is not obtained in this mode then a lower "DELAY" time should be selected. For example, when investigating the waveform shown in the figures a display could not be obtained with a

To select the add mode only the "Alt/Chop" 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. Therefore, 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. It is important to note that the x5 magnifier incorporated in the "X-POS." control and normally used for expanding the sweep should not be operated in the X-Y mode. It is also important to note that the bandwidth of the X-amplifier is approximately 2.3MHz (-3dB), and therefore an increase in phase difference between both axes is noticeable at higher frequencies. The phase shift is 3 degrees at 100kHz.

Trigger and Timebase

To achieve a perfectly stable display the correct settings of the timebase and trigger controls is most important. When the "LEVEL" control is in the "AT" position the sweep generator will be triggered automatically. In this mode a baseline will be present in the absence of a 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.

In order to obtain a stable display the timebase must be triggered synchronously with the test signal. The trigger 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 is selected on the lower slide switch located in the timebase section and can be either internal-line-external. Normally the internal position is used.

In the "line" position the mains frequency serves as a trigger signal, this position is particularly useful when signals that are synchronized to the mains are being investigated.

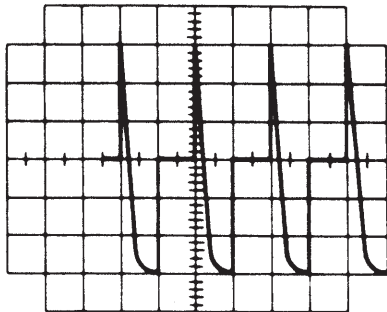
When triggering externally a signal of at least 0.5Vpp (20MHz) resp. 2Vpp (30Hz) is necessary while on internal triggering a display height of 5mm is required. Trigger coupling is selected on the pushbutton marked "AC/DC", which operates on either internal or external triggering. The "AC" position can be used for the investigation of most uncomplicated waveforms, while "DC" coupling (pushbutton depressed) is recommended when very low frequency signals are being investigated. When "DC" coupling is selected it is advisable to obtain triggering by using the "LEVEL" control in manual operation, as there is a possibility that in the "AT" position triggering may not be achieved on signals without a zero-axis crossing point (DC offset; missing DC-balance). Triggering can be selected on either the leading or trailing edge of the trigger signal depending on whether the "+/-" pushbutton is in the out or depressed position.

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. The internal trigger source is selected on the upper slide switch located to the left of the main timebase control. When this switch is in the "I/II" position and the vertical amplifiers are in the alternate mode then triggering is derived alternately from Channel I and Channel II. This mode is particularly useful when asynchronous signals are being investigated.

As already mentioned simple signals may be triggered automatically i.e. without manual operation of the "LEVEL" control, 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 operation of the "LEVEL" control may well become necessary. With composite signals, the trigger facility is dependent on the occurrence of certain periodically recurring levels. The "LEVEL" adjustment of these signals will require care. If, for example, the complex video signal of a television receiver is to be displayed at frame fre-

delay setting of 10ms. The delay fine control should now be adjusted so that the display starts just prior to the short time interval to be investigated. In the "search" mode the LED indicator will flash.

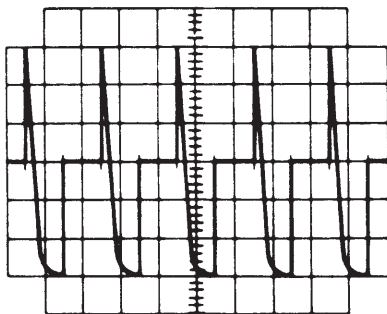
Figure 2



Mode : "search"
 Timebase : 0.5ms/cm
 LED : flashing
 Delay = 2.5cm · 0.5ms/cm = 1.25ms

When this point has been achieved the mode switch should be set to "delay" mode, 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 at the start of the display.

Figure 3

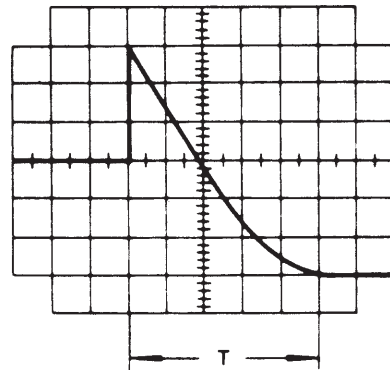


Mode : "delay"
 Timebase : 0.5ms/cm
 LED : illuminated

If the main timebase sweep speed is increased (rotate "TIMEBASE" control clockwise) then the short time interval will be expanded. It may be found that as the amount of expansion is increased that the trace will tend to shift, if this happens the delay fine control can be readjusted to enable the exact point of interest to be displayed. In the example shown it can

be seen that an expansion of X10 was obtained by increasing the timebase sweep speed from 0.5ms/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.

Figure 4



Mode : "delay"
 Timebase : 50μs/cm
 LED : illuminated
 Expansion: X10
 T = 5cm · 50μs/cm = 250μs

It should be noted that on signals which contain inherent jitter an exact time measurement in delay mode may be difficult due to the jitter.

Using the "X-MAGN." switch, you can expand the desired signal section fivefold without any change of triggering and timebase. This can be helpful 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 left of the delay mode slide switch. In "search" position, the LED will blink. 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 you have forgotten to change-over the slide switch to its "norm." position. Maybe, there are errors in displaying a signal by partially blanking. Pay attention, therefore, to this indication.

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 $10k\Omega$. If the DC potential of the ramp output voltage is not required then a capacitor should be connected in series with the output connector.

Blanking or modulation of the trace is possible with low level TTL voltages 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 four-step slide switch marked with "ILLUM.", which is mounted above the power on/off pushbutton. In the first 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

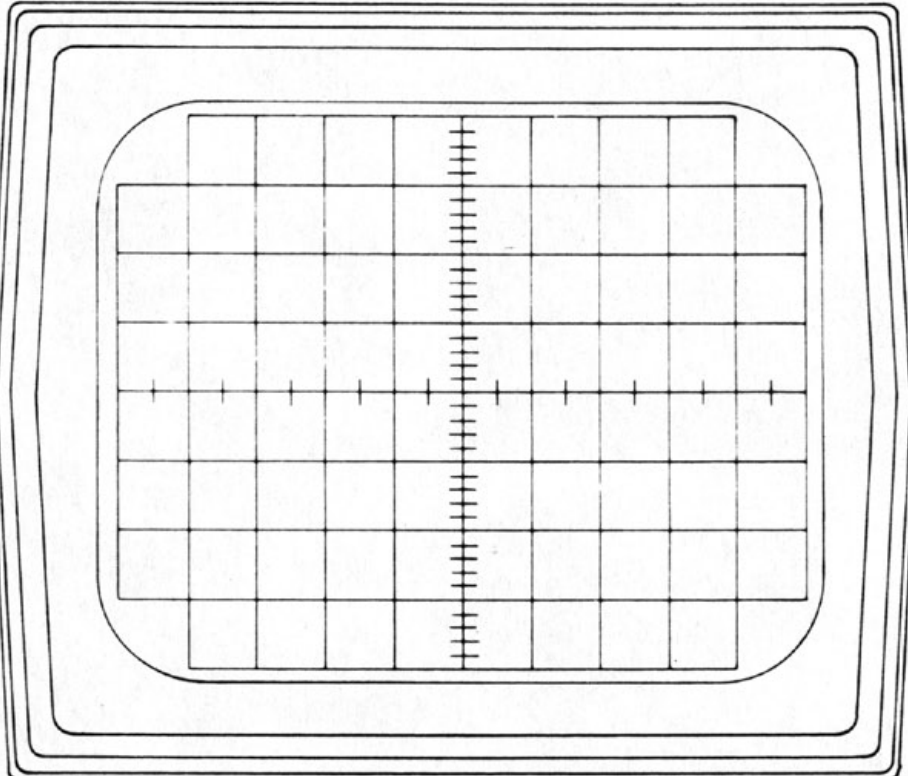
Within the context of maintenance, it is recommended that the important characteristics of the HM412 are periodically checked. The following Test Instructions indicate only those tests which can be performed without the use of expensive ancillary instruments. For more exacting tests the HAMEG oscilloscope 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.

OSCILLOSCOPE HM 412

HAMEG



X-POS.

INTENS.

X-MAGN.
x5 pull

ILLUM.

POWER

off / on

DELAY

0.1 μ s
1 μ s
10 μ s
100 μ s
1 ms
10 ms
100 ms

norm search delay

V-POS. I **V-POS. II**

Invert I Mono/Dual Alt/Chop I + II

AMPL. I Bal. Over drive **AMPL. II** Bal.

VERT. INPUT

DC AC GD $1M\Omega$ $25pF$ DC AC GD

Hor Inp

V cm 1 0.5 0.2 0.1 2 5 10 20 50 **mV cm**

AC/DC TV +/- Hor ext. XY

TIMEBASE Trig.

Trigger Source

10 5 2 1 0.5 0.2 0.1 **ms** 50 20 10 5 2 1 **μ s** 1 0.5 **Time/cm**

LEVEL AT

VARIABLE Cal

Calibrator 0.2V

TRIG. EXT.

General

These Test Instructions are intended as an aid for checking the most important characteristics of the HM412-4 at regular intervals without the need for expensive test equipment. It is recommended that any adjustments that have to be carried out inside the instrument are undertaken by qualified personnel. As with the First Time Operation Instructions care should be taken that all knobs with arrows are set to their calibrated position ("LEVEL" control to "AT"), and that the delay mode switch is set to "norm.". None of the push buttons should be depressed. Please note that the operating voltage of the cathode-ray tube is approx. 2kV. This high voltage is on both the CRT socket and the vertically positioned PC-board surrounding the socket. It is recommended that the instrument is switched on for about 15 minutes prior to the commencement of any check.

Cathode-Ray Tube: Brightness and Focus

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 trimming pots for the high voltage circuit, minimum and maximum intensity are only accessible inside the instrument (see Adjusting Plan).

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 1MHz. 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." push button 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 trimming pot of 50k Ω (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 push button "Invert I"). The vertical position of the trace should not change by more than 5mm for good symmetrical alignment. However, a change of 1 cm 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." control. 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 1 cm are permissible (input coupling should be set to "AC"). Checking the drift is relatively simple. **Fifteen minutes after switching on the instrument**, set the trace exactly

on the horizontal centre 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 mini-socket marked with a square-wave. This has a tolerance of $\pm 1\%$. If a direct connection is made between the mini-socket 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 mini-socket 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 amplifier or the calibrator voltage is only possible from within the instrument. 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. 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 discretion 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 $1\text{M}\Omega \pm 1\%$ 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" push button, two traces must appear immediately. On actuation of the

"Y-POS." control, the trace positions should have no effect 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 $1\mu\text{s}/\text{cm}$, depress the "Mono/Dual" and "Alt/Chop" push buttons, 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 centre line of the graticule. Do not try to trigger the chop frequency (1MHz). Then alternately release and depress the "Alt/Chop" push button. Check for a negligible trace widening and periodic shadowing in the chopped mode.

It is important to note that in the add mode (I+II) or the difference mode (-I+II) 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." push button 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 controls set to their calibrated positions).

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. 4mm 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 traces separated by 180° . Alteration of the trigger threshold is only possible internally. Checks can be made with any sine-wave voltage between 50Hz and

1MHz. The "LEVEL" control should be in the "AT" position. Following this it should be ascertained whether the same trigger sensitivity is also present with the manual "LEVEL" control.

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 in the "DC" coupling mode, signal voltages of approx. 0.5Vpp are necessary. In "AC" position, a 30Hz signal requires a trigger voltage of approx. 2Vpp.

Checking of the internal TV-triggering is possible with a video signal of any given polarity. With "AC/DC" coupling you can trigger on line frequency; with "TV" coupling triggering on frame frequency is possible. If no video signal is available, the function of the "TV" button can be checked using mains or the built-in calibrator signal. When triggering at mains frequency, actuation of the "TV" push button 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 may 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 alignment on the input of the vertical amplifier (see Operating Instructions).

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 alternate dual channel mode, then no change in display should be noticeable when the trigger source selector is set to the "I" or "II" or "I/II" position. In the alternate dual channel mode two non-frequency related signals (i. e. mains frequency and calibration signal) can be reliably triggered internally when the trigger source selector is set to the "I/II" position (alternate triggering). With the chopped dual channel mode in the "I/II" position triggering from Channel I only is possible. Periodical signal blanks (with 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 must be corrected with the trimming pot for sweep amplitude (see Adjusting Plan). This adjustment should be made with the "TIMEBASE" switch in a middle position (i. e. $50\mu\text{s}/\text{cm}$) and with the "VARIABLE" 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 $\pm 1\%$. The timebase accuracy of the HM412 is given as $\pm 3\%$, 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	$50\mu\text{s}/\text{cm}$ — 20kHz
0.1s/cm — 10Hz	$20\mu\text{s}/\text{cm}$ — 50kHz
50ms/cm — 20Hz	$10\mu\text{s}/\text{cm}$ — 100kHz
20ms/cm — 50Hz	$5\mu\text{s}/\text{cm}$ — 200kHz
10ms/cm — 100Hz	$2\mu\text{s}/\text{cm}$ — 500kHz
5ms/cm — 200Hz	$1\mu\text{s}/\text{cm}$ — 1MHz
2ms/cm — 500Hz	$0.5\mu\text{s}/\text{cm}$ — 2MHz
1ms/cm — 1kHz	

When the "X-MAGN." control is actuated a marker or cycle peak will be displayed every 5cm.

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

It is recommended that an oscilloscope calibrator (HAMEG Type HZ62) is required, 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 "LEVEL" control must be actuated.

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 time fine control "x1-x10" must be set to x1 (rotate anti-clockwise until a snap noise is audible). When "delay" is selected the trace reverts to the full 10cm display without any blanking. In this mode the delay fine control can be operated and a displayed waveform should be shifted without any jitter, jumping or intermittent blanking. In this mode the delay time, as set on the "DELAY" range switch and fine control, should not exceed the value of the unblanked display by more than 250 times.

Testing is possible with the calibration signal. Settings: Connect calibrator mini-socket with Channel I input connector, input coupling to "DC", deflection coefficient $50\text{mV}/\text{cm}$, trigger mode "AC" and channel "I", "LEVEL" control in the Timebase section to "AT", "TIMEBASE" switch to $1\text{ms}/\text{cm}$, no push button depressed. In the "norm." mode you can see the calibration square signal with a display height of 4cm and approx. one cycle per cm. In "search" position the delay mode indicator is flashing. The "DELAY" time switch has to be set to the 1ms range. Then the DELAY fine control can be rotated until half of the display is blanked. The delay time now amounts to 5ms. After switching to "delay" the display is fully visible; the delay mode indication shows continuously. The signal displayed can be expanded now. To this purpose turn the "TIMEBASE" switch clockwise to $5\mu\text{s}/\text{cm}$. The expansion is now 200-fold. With the fine control "x1-x10", the nearest edge of the calibration signal can be brought into the screen centre and checked on the criteria

above-mentioned. With 200-fold expansion the display brightness normally needs increasing (with "INTENS." and "FOCUS" control).

Miscellaneous

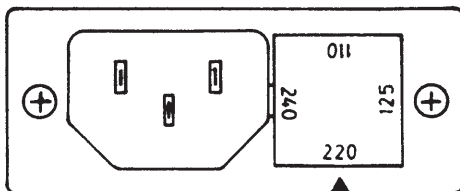
If a variable mains transformer is available, the characteristics of the HM412 on mains voltage fluctuations of $\pm 10\%$ should be checked. Under these conditions no variations should be detected on the display in either the vertical or horizontal axis.

General

The following instructions are intended as an aid for the electronic technician who is accomplishing readjustments on the HM412, if the nominal values do not meet the specifications. These instructions primarily refer to those faults which were recognized guided by 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 when the instrument will be shipped to HAMEG for service or repair.

AC 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 mains/line voltages. The fuse holder with its square top plate can be pulled out, and changing of the voltage is possible by turning this plate 90 degrees for each of the four AC 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 **slow-blow** fuse:

110 V ~ ±10%
Fuse **0.4 A**

220 V ~ ±10%
Fuse **0.2 A**

125 V ~ ±10%
Fuse **0.4 A**

240 V ~ ±10%
Fuse **0.2 A**

The power fuse has to match the set mains/line voltage and must be replaced if necessary.

Instrument Case Removal

The rear cover can be taken off after both 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 later on will be inserted into the case 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 on.

Caution

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 occurring 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.

Trace Alignment

If the trace on the screen is not exactly parallel with the horizontal centre line of the graticule, it may be mostly caused by the influence of the earth's magnetic field. Such small misalignments depending on the oscilloscope's position in the workroom can be easily corrected by the adjustment of the variable resistor for trace rotation. This is performed by a screwdriver which will be inserted in the opening of the front panel marked "TR" (Trace Rotation) located underneath of the "FOCUS" knob. Greater misalignments can only be corrected when the instrument is open and the TR-pot is set in midrange. The clamp on the CRT neck has to be loosened. Because the area around the CRT is relatively small, a tenacious adhesive tape will be a good help for tube rotation. The middle of the tape should be pressed onto the top of the exposed CRT area which is accessible between the graticule plate and the front cover. Now, either the left or the right end of the adhesive tape can be drawn effecting the CRT rotation in both directions. After this alignment is performed, both screw nuts on the clamp must be altered.

nately tightened turn by turn, otherwise the CRT might be misaligned again.

Operating Voltages

Besides the AC voltages for the CRT heating and for mains triggering there are seven electronically stabilized DC operating voltages generated (+24V, +5V, -12V, +140V, +260V, -2000V, 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 $\pm 5\%$ from the nominal value indicates a fault. Both adjustable voltages have to be set exactly for +140V respectively -2000V by the adjustments of two variable resistors each of 25k Ω 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 ($\geq 10\text{M}\Omega$). 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 500k Ω 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 performed when the trace can be blanked while "Hor. ext." pushbutton is depressed and, in addition, the requirements described in the Test Instructions will be met.

Astigmatism Correction

The ratio of vertical and horizontal sharpness can be adjusted by the variable resistor of 50k Ω , 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 repeatedly turned to and fro until the shape of the luminous spot, whether round or oval or rectangular, will stay 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.

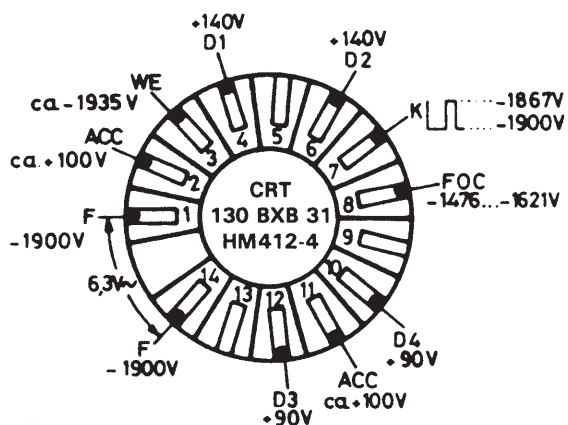
Trouble-Shooting the Instrument

For this job, there will be needed at least an isolating variable 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 noise 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 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.

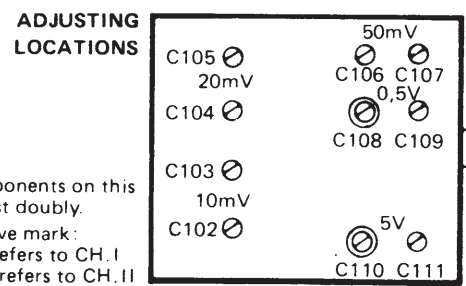
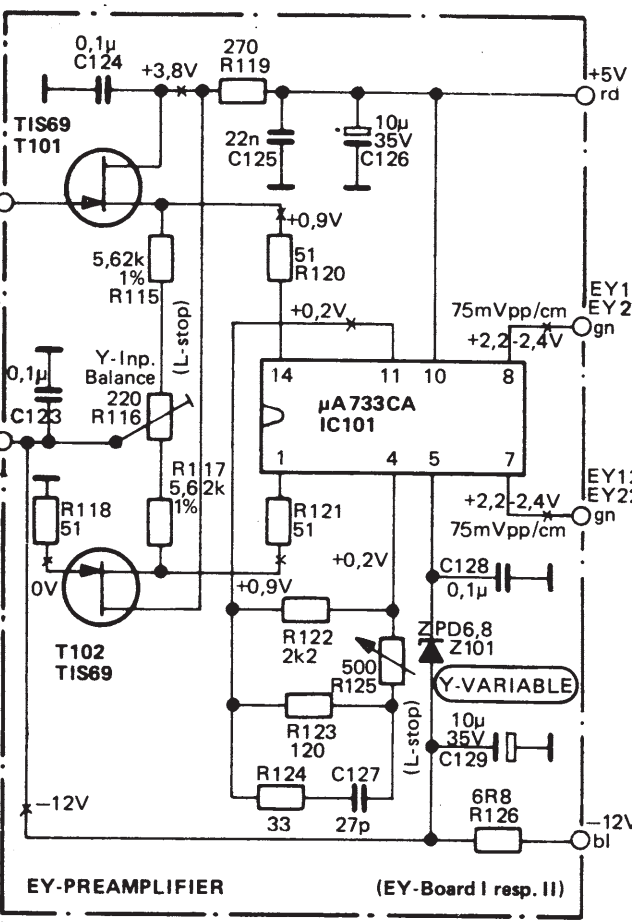
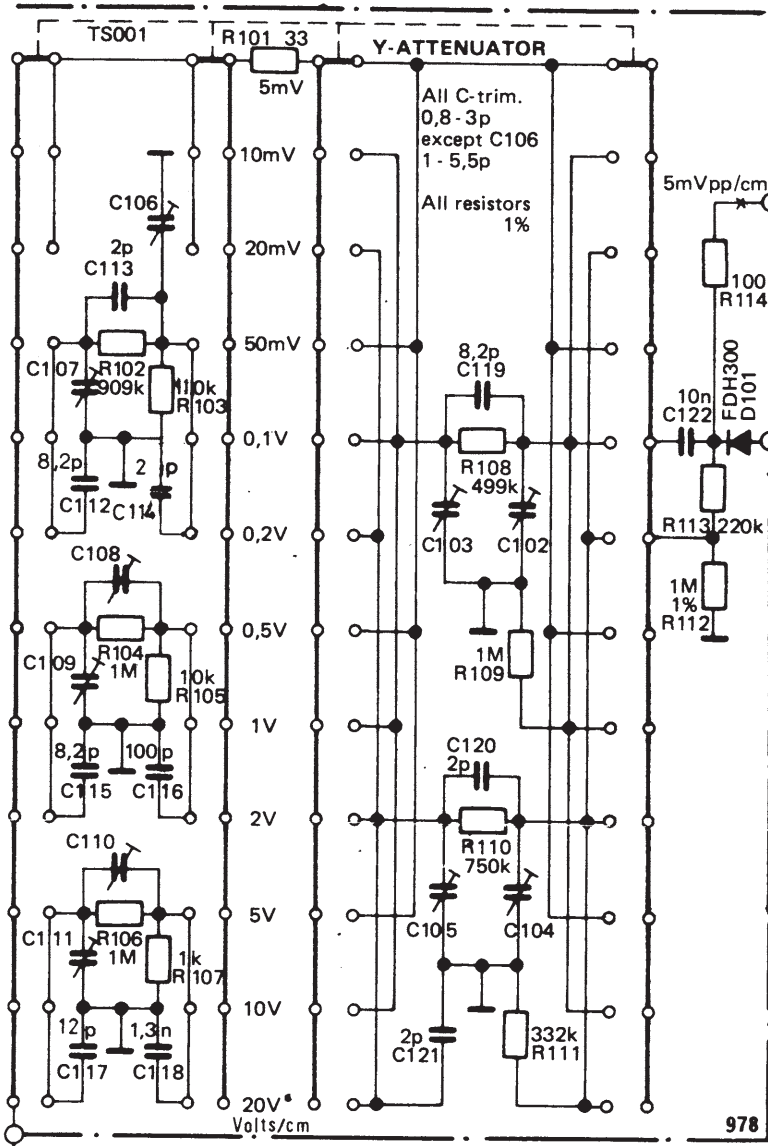


Voltages at the CRT socket

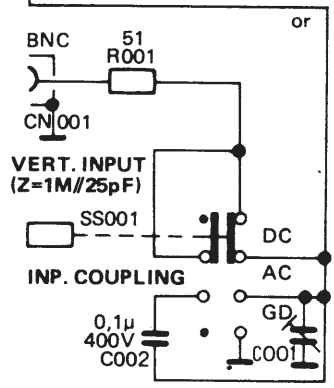
Indeed, as advised in the Operating, Test and Service Instructions, small corrections and adjustments are easily carried out with the aid of the Circuit Diagrams and Adjusting Plan. However, a complete recalibration of the oscilloscope should not be attempted by an inexperienced operator, but only someone 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 Y-PREAMPLIFIER HM 412-4

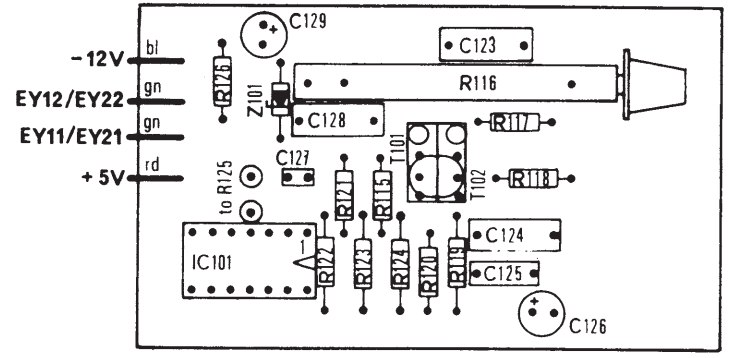
Channel I resp. II



All components on this page exist doubly.
Distinctive mark:
T101-I refers to CH. I
T101-II refers to CH. II

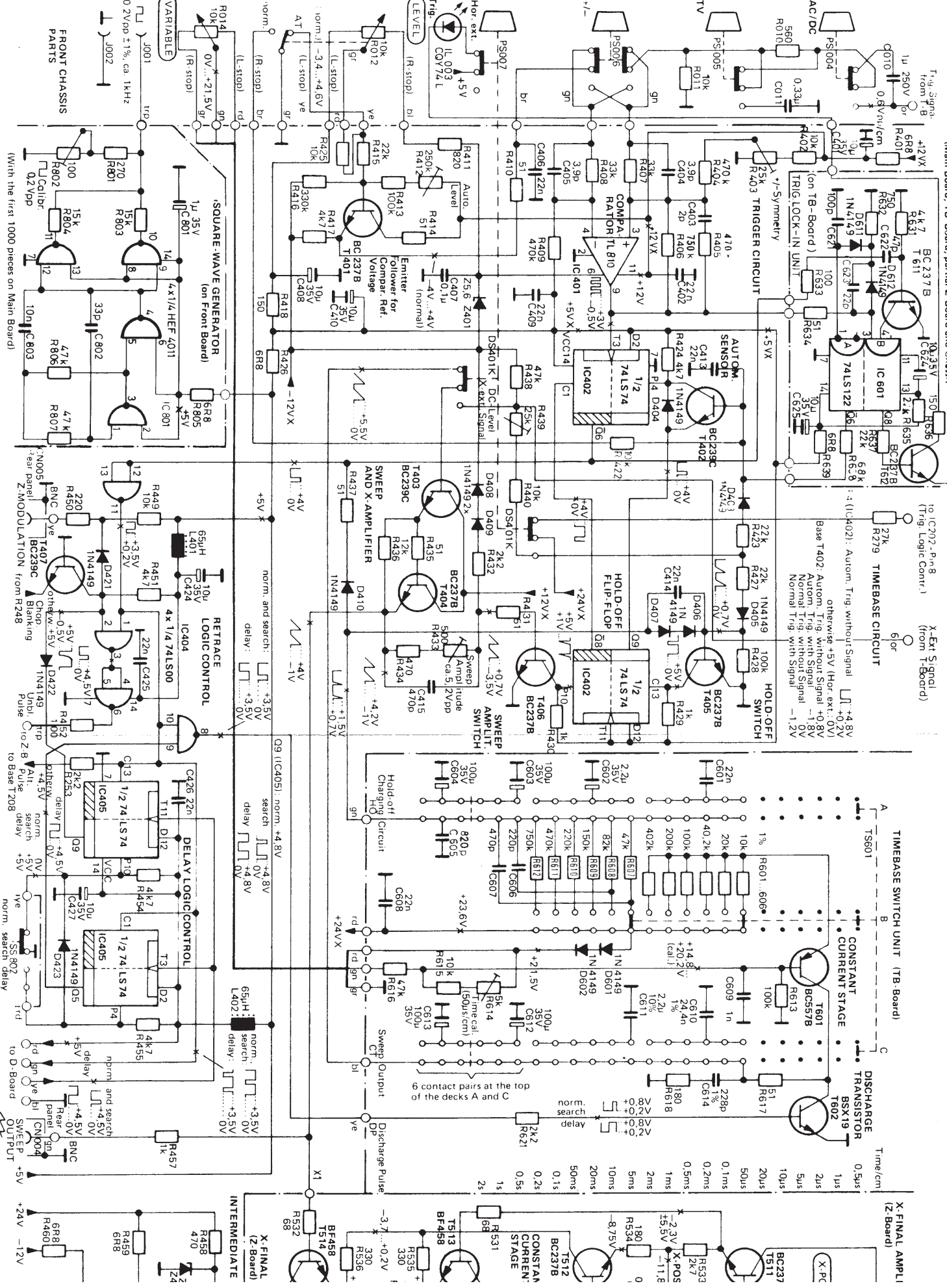


COMPONENT LOCATIONS EY-BOARD



TIMBASE AND TRIGGER CIRCUITS, SWEEP AND X-AMPLIFIER, RETRACE AND DELAY LOGIC CONTROL, SQUARE-WAVE GENERATOR HM412-4

(Main Board, TB-Board, partial Z-Board and Chassis)



IC202, Pin 8 (Trig. Logic Contr.)

X-Ext. Signal (from TB-Board)

IC402: Autom. Trig. without Signal +4.8V
 otherwise +5V (Hor. ext. 0V)
 Base T402: Autom. Trig. without Signal +0.8V
 Autom. Trig. with Signal -1.8V
 Normal Trig. without Signal 0V
 Normal Trig. with Signal -1.2V

TIMEBASE SWITCH UNIT (TB-Board)

CONSTANT CURRENT STAGE

DISCHARGE TRANSISTOR

X-FINAL AMPLI (Z-Board)

6 contact pairs at the top of the decks A and C

Time/cm
 0.5µs
 1µs
 2µs
 5µs
 10µs
 20µs
 50µs
 0.1ms
 0.2ms
 0.5ms
 1ms
 2ms
 5ms
 10ms
 20ms
 50ms
 0.1s
 0.2s
 0.5s
 1s
 2s

norm. search delay

norm. search delay

norm. search delay

norm. search delay

norm. search delay

norm. search delay

norm. search delay

norm. search delay

norm. search delay

norm. search delay

norm. search delay

norm. search delay

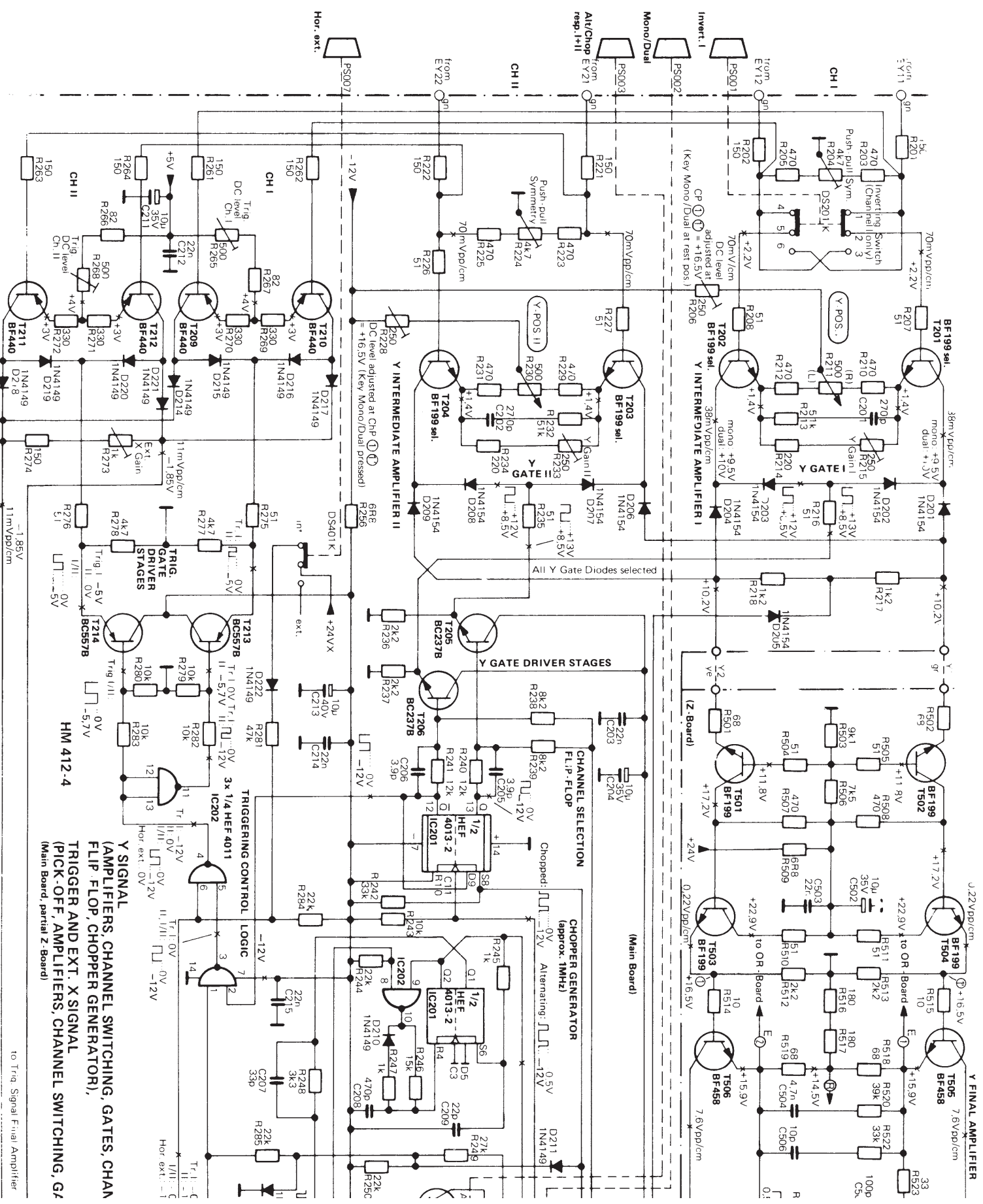
norm. search delay

norm. search delay

norm. search delay

norm. search delay

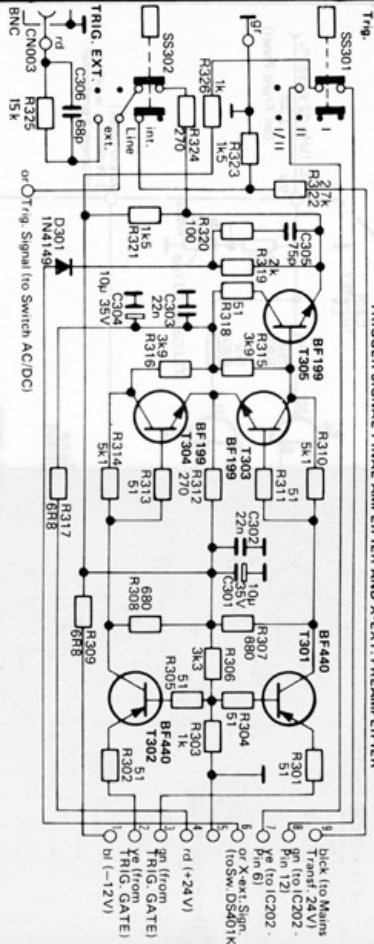
norm. search delay



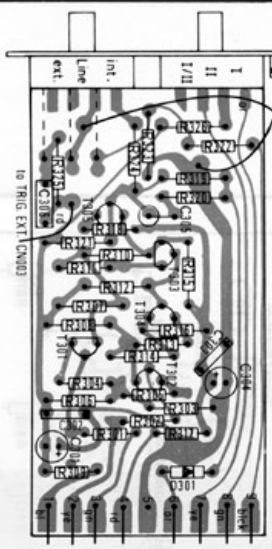
TRIGGER AND X-EXT. SIGNAL (SWITCHING, AMPLIFIER)
(Trigger Board on Front Chassis)

HM 412-4

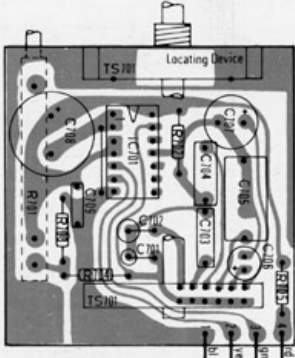
TRIGGER SIGNAL FINAL AMPLIFIER AND X-EXT. PREAMPLIFIER



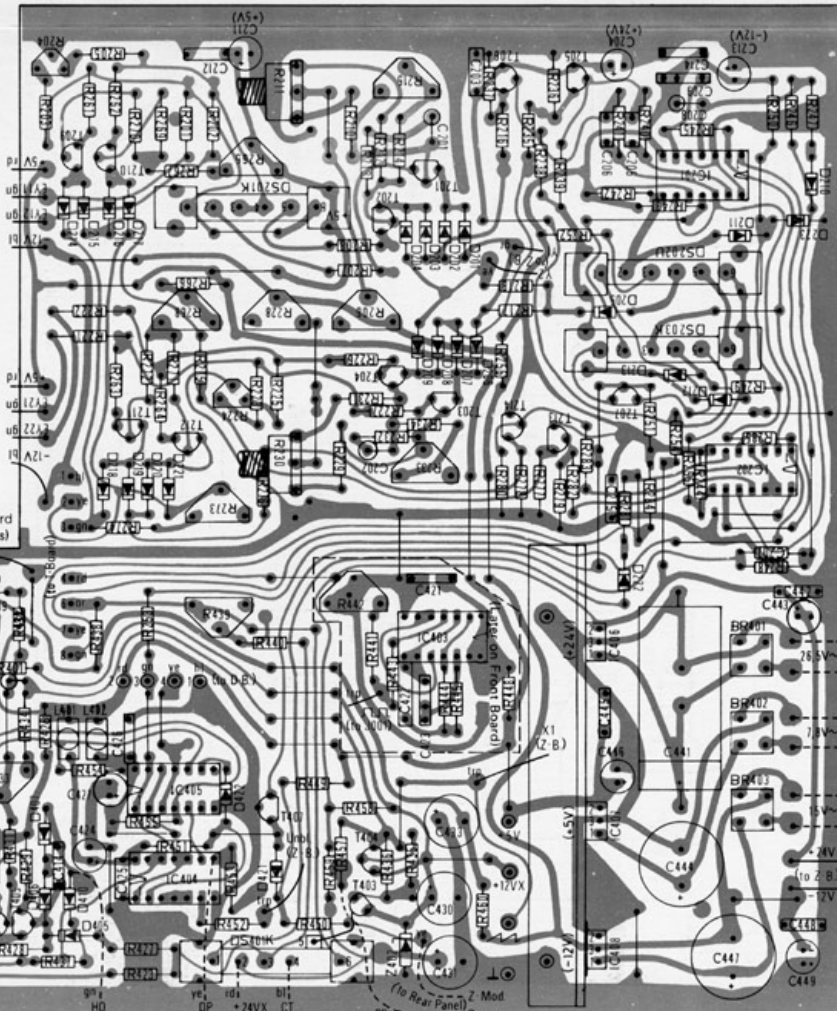
COMPONENT LOCATIONS TRIGGER BOARD



COMPONENT LOCATIONS DELAY BOARD

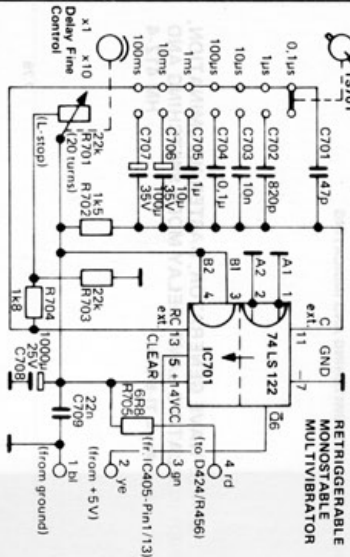


COMPONENT LOCATIONS MAIN BOARD

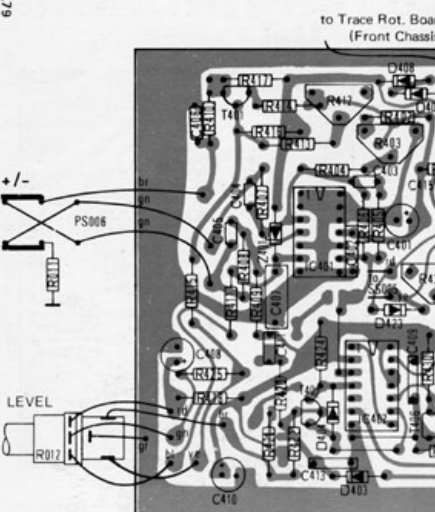
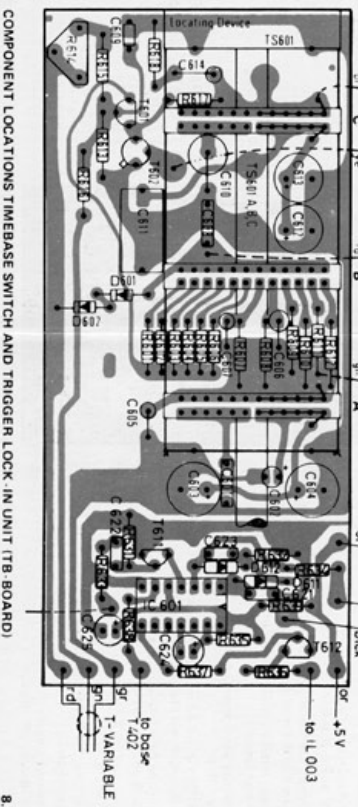


DELAY UNIT (STEPPING SWITCH, FINE CONTROL, MONOSTABLE MULTIVIBRATOR)
(Delay Board on Front Chassis)

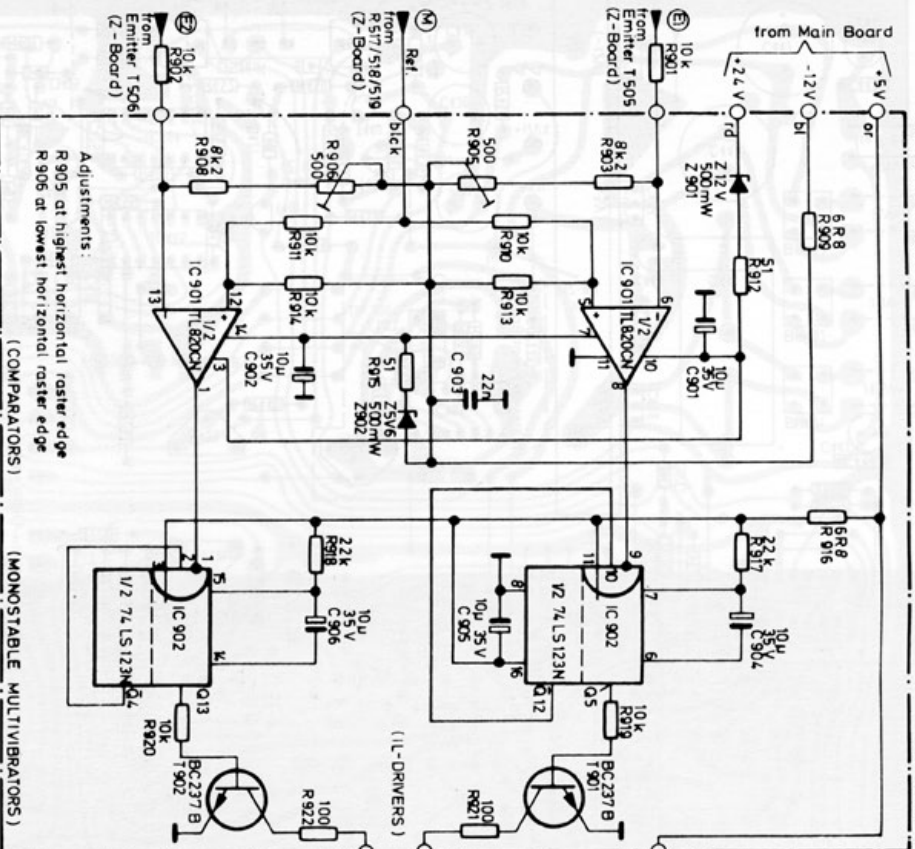
Delay Stepping Switch



RETRIGGERABLE MONOSTABLE MULTIVIBRATOR

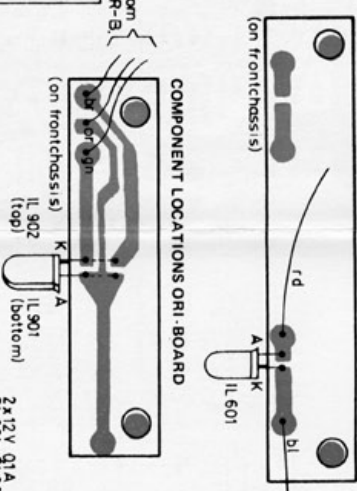


OVERRANGE CIRCUIT

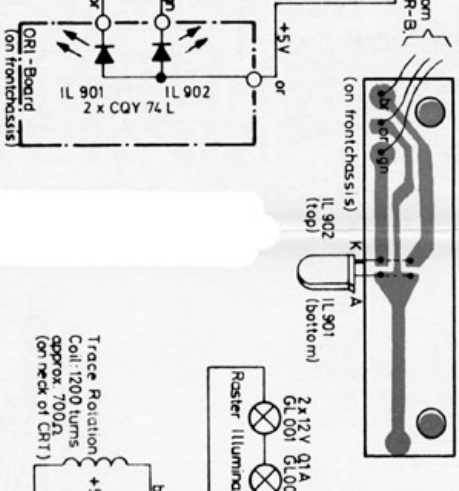


(OR-Board)

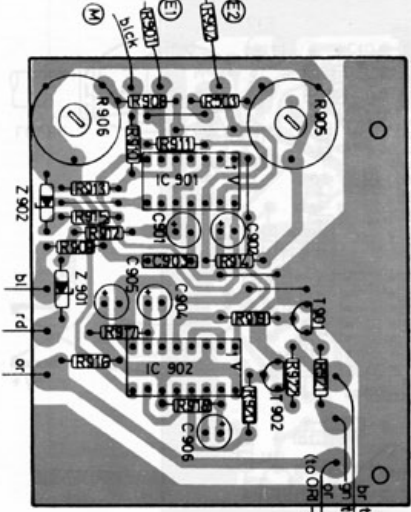
COMPONENT LOCATIONS TI-BOARD



COMPONENT LOCATIONS ORI-BOARD



COMPONENT LOCATIONS OR-BOARD



Adjustments:
R905 at highest horizontal raster edge
R906 at lowest horizontal raster edge

(COMPARATORS)

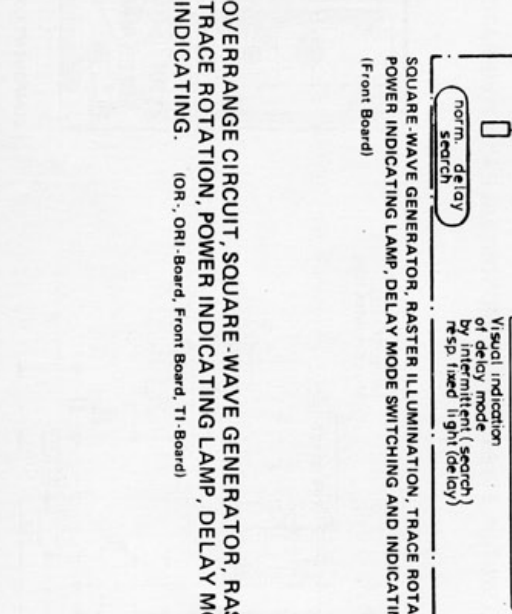
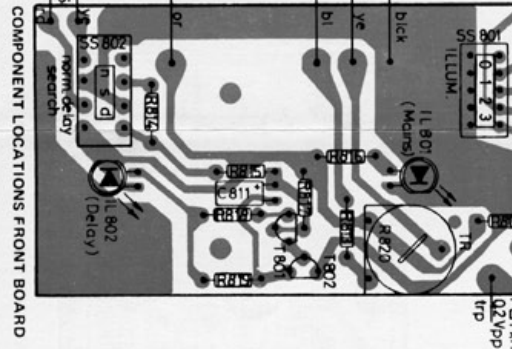
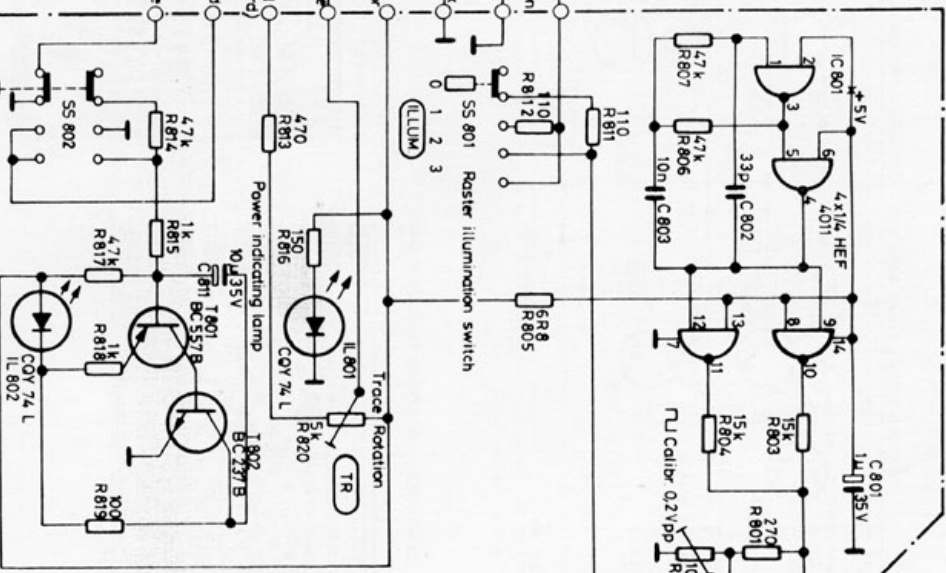
(MONOSTABLE MULTIVIBRATORS)

(IL-DRIVERS)

Electrical components on certain parts are marked such that the first numeral is at:

- Chassis = 0...
- EY-Preamplifier Unit = 1...
- EY-Board, Attenuator = 2...
- Y-Ampl., Ch-Switching, Trig. Pick-Off (Main Board, partial Z-Board) = 3...
- Trigger and Ext. X-Signal Amplifier (Trigger Board) = 4...
- Timebase and Trigger Circuit (Main Board) = 5...
- CRT, X-Y, Final Ampl., Power Supply (Z-Board, partial Main Board and Chassis) = 6...
- Timebase Switch Unit, Trig. Lock-in Unit (TB-Board, TI-Board) = 7...
- Delay Unit (D-Board) = 8...
- SqW, Gen, TR, Raster Lp's, Delay Sw. + Ind. (Front Board) = 9...
- Overrange Circuit (OR-Board, ORI-Board) = 9...

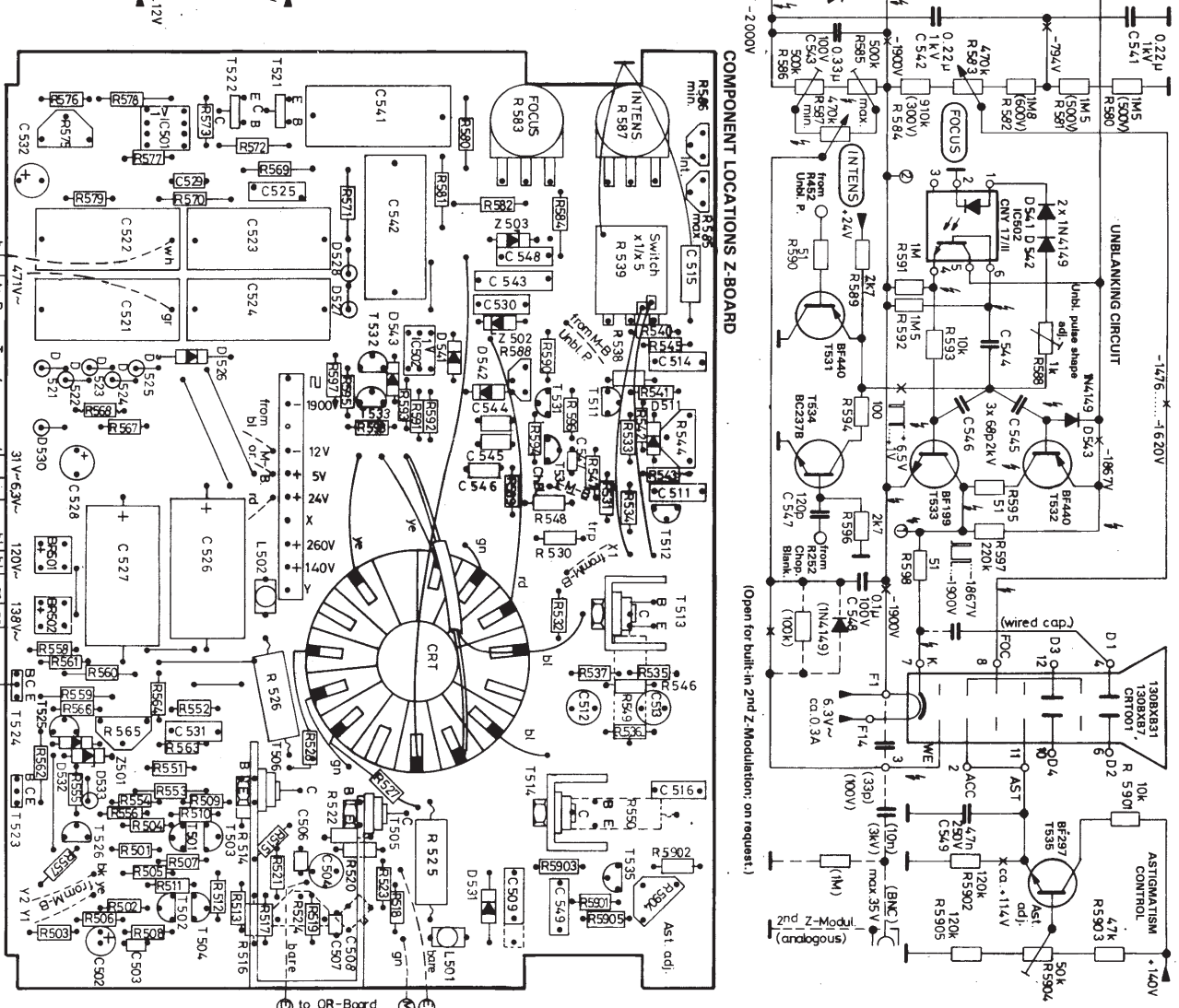
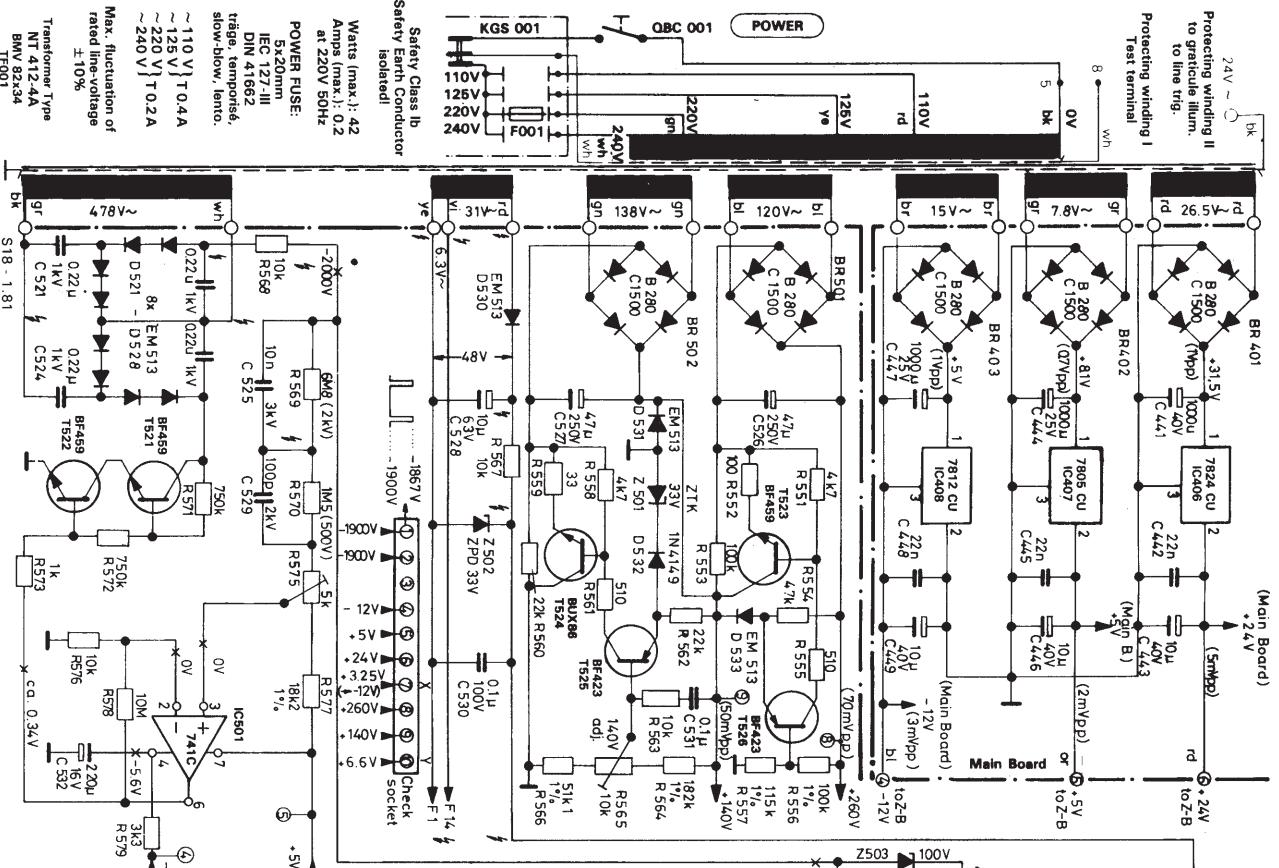
COMPONENT LOCATIONS FRONT BOARD



OVERRANGE CIRCUIT, SQUARE-WAVE GENERATOR, RASTER ILLUMINATION, TRACE ROTATION, POWER INDICATING LAMP, DELAY MODE SWITCHING AND INDICATING.

(OR-Board, ORI-Board, Front Board, TI-Board)

POWER SUPPLY AND CRT CIRCUIT HM 412-4A
(Z-Board, partial Main Board and Chassis)



to OR-Board

HAMEG

West Germany **G.m.b.H.**
Kelsterbacher Str. 15-19 — 6 FRANKFURT/M. 71
Tel. (0611) 676017-19 — Telex 0413866

HAMEG

France **S.A.R.L.**
5-9, Avenue de la République - 94800 VILLEJUIF
(Region Paris) - Tél. 678.09.98 - Télex 270705

HAMEG

España **IBERICA S.A.**
Villaroel 172-174 - Tel. 230.15.97 - BARCELONA-36

HAMEG

United Kingdom **LTD.**
74-78 Collingdon Street — LU1 1RX LUTON
Tel. (0582) 413174 — Telex 825484

HAMEG

USA **INC.**
Office: 191 Main Street — Tel. 516-883-3837
Factory: 88-90 Harbor Road — Tel. 516-883-6428
TWX 510 223-0889 — PORT WASHINGTON
N. Y. 11050