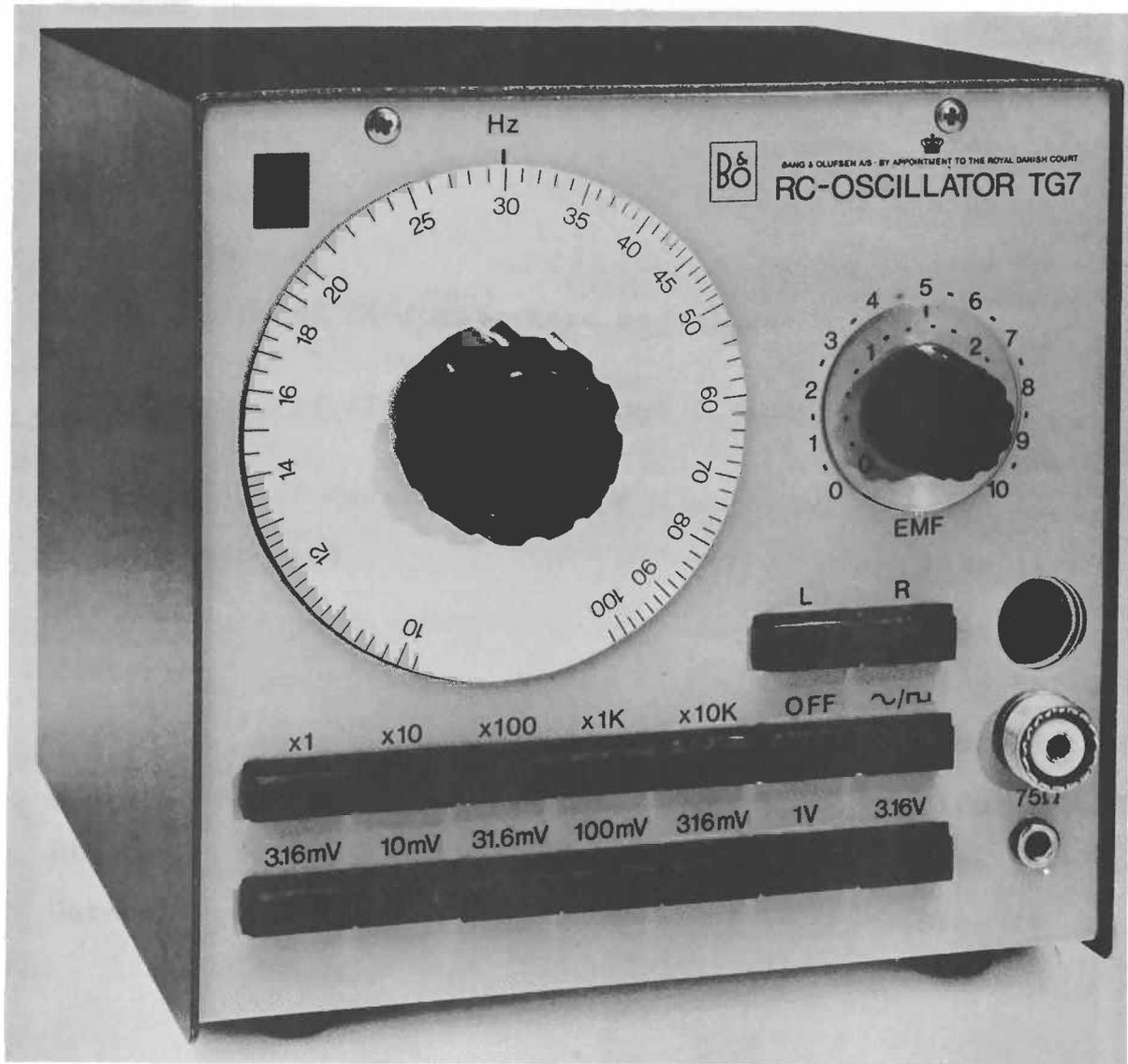


RC-OSCILLATOR TG7

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INSTRUKTIONSBOG FOR RC-OSCILLATOR TG7
 INSTRUCTION MANUAL FOR RC-OSCILLATOR TG7

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TEKNISKE DATA

Frekvens:

Område:	10Hz-1MHz i 5 områder: 10Hz-100Hz, 100Hz-1KHz, 1KHz-10KHz, 10KHz-100 KHz og 100 KHz-1MHz
Skala:	10-100Hz
Nøjagtighed:	+/- 2%
Stabilitet:	+/- 0,02%/°C +/- 0,01% ved +/- 10% ændring af netspændingen, $f \leq 200\text{KHz}$

Udgangsspænding:

Kurveform:	Sinus eller firkant
Område:	0-3,16V _{eff} (EMK) i 7 områder: 0-3,16mV, 0-10mV, 0-31,6mV, 0-100mV, 0-316mV, 0-1V og 0-3,16V
Skala:	0-3,16 og 0-10
Nøjagtighed:	
Trykknop-attenuator:	+/- 0,2dB
Variabel attenuator:	+/- 0,5dB
Frekvenskarakteristik:	+/- 0,05dB fra 20Hz til 200KHz +/- 0,1dB fra 10Hz til 1MHz
Stabilitet (sinus):	+/- 0,05%/°C +/- 0,01% ved +/- 10% ændring af netspændingen
DC-offset:	max. 100mV (reduceres proportionalt med trykknop-attenuator-område)
Forvrængning (sinus):	Mindre end 0,05% ved 1KHz, mindre end 0,1% fra 20Hz til 200KHz, mindre end 0,15% fra 10Hz til 500 KHz og mindre end 0,2% fra 10Hz til 1MHz
Stigetid (firkant):	Max. 50 ns
Symmetri (firkant):	Bedre end 3%
<u>Udgangsimpedans:</u>	75Ω

Synk. udgang:

Kurveform: Sinus eller firkant

Udgangsspænding: $1V_{\text{eff}}$ (EMK)

Udgangsimpedans: 600Ω

Nettilslutning: 110V, 130V, 220V eller 240V AC,
50-400Hz. Forbrug 5W

Temperatur-område: 0-50°C

Dimensioner (kabinet): Bredde: 163 mm
Dybde: 210 mm
Højde: 160 mm

Vægt: 4 kg

Finish: Sølvgrå og blå hammerlak

Tilbehør: 1 instruktionsbog
1 kabel UHF/2×banan
1 kabel 5-pol.DIN/5-pol.DIN
2 krokodillenæb

INTRODUKTION

B&O RC-oscillator type TG7 er en fuldtransistoriseret sinus/firkant-generator med lav forvrængning til anvendelse på laboratorier, skoler, serviceværksteder, fabrikker m.m. Den dækker et stort frekvensområde, 10Hz....1MHz, og er meget stabil overfor temperatur- og netspændingsvariationer. Udgangsspændingen (0...3,16V) kan varieres kontinuerlig i syv områder.

Generatoren kan med fordel anvendes ved undersøgelse og reparation af stereoforstærker-udstyr, idet der på instrumentet findes en speciel 5-pol. DIN-udgang, kombineret med en venstre/højre-kanalomskifter.

Udgangsimpedansen er lav (75Ω), hvorved man i de fleste tilfælde kan se bort fra den capacitive belastning i målekabler og -ledninger.

ANVENDELSE

RC-oscillator TG7 kan tilsluttes følgende netspændinger: 110V, 130V, 220V eller 240V. Spændingsomskifteren (15) bag på instrumentet stilles til den korrekte netspænding (14) før tilslutning til nettet. Instrumentet tændes ved at indtrykke een af frekvensområde-knapperne (11), og slukkes ved tryk på netafbryderen (10).

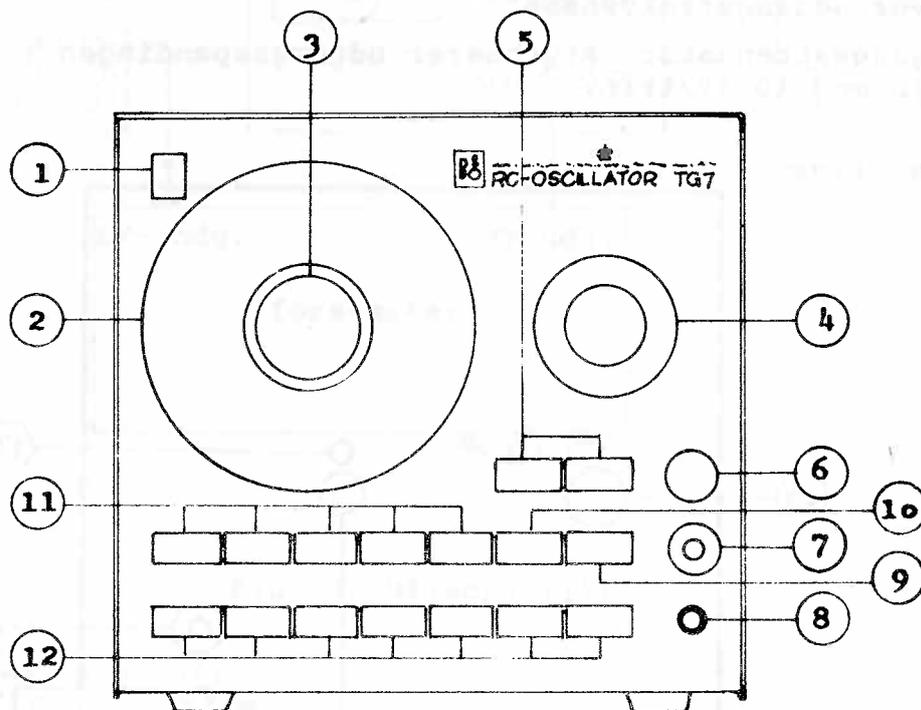


Fig.1. RC-oscillator TG7 set forfra

Instrumentets betjening fremgår af fig. 1/2.

1. Indikatorlampe: Lyser op, når generatoren er tændt.
2. Frekvensskala: Varierer frekvensen inden for hvert område.
3. Mikrodrev: Ændrer frekvensskalaens udveksling i forholdet 5:1.
4. Variabel attenuator: Varierer udgangsspændingen inden for hvert område af udgangsattenuatoren (12).
5. Kanalomskifter: Skifter signalet på stereo-udgangsbøsningen (6), mellem venstre (L), højre (R) eller venstre + højre (L+R) kanal. Ved 4-kanal-stereo er der signal på begge venstre-kanaler samtidig og begge højre-kanaler samtidig.
6. Stereo-udgang, 5-pol. DIN.
7. Udgang for koaksial-tilslutning.
8. Stel-bøsning.
9. Funktionsomskifter: Skifter mellem sinus- og firkantkurveform.
10. Netafbryder.
11. Frekvensområde-omskifter: Skifter mellem 5 områder. Af-læsning af området multipliceret med skalaaf-læsning (2) giver udgangsfrekvensen.
12. Udgangsattenuator: Attenuerer udgangsspændingen i 6 trin med 10 dB/trin.

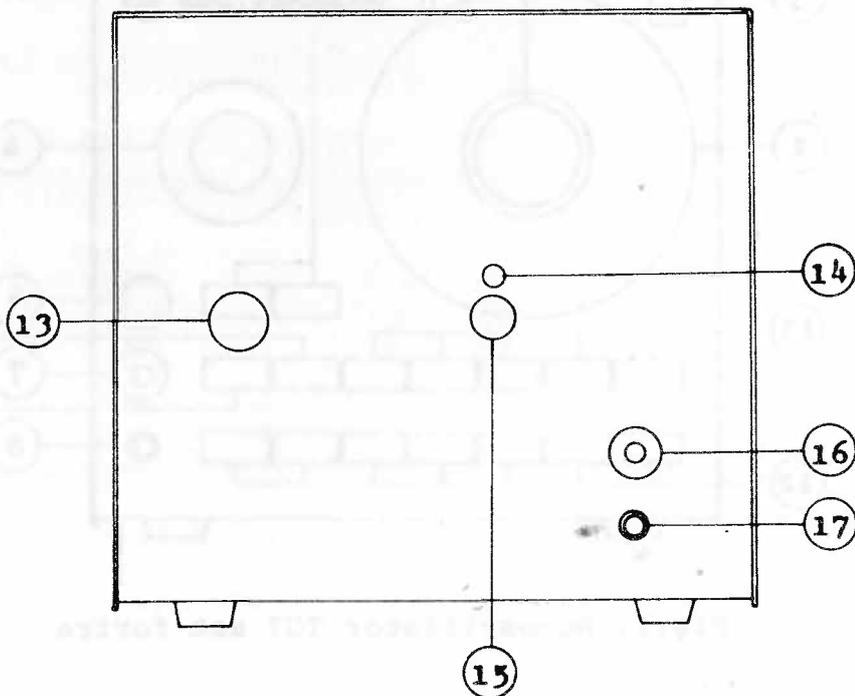


Fig. 2. RC-oscillator TG7 set bagfra.

13. Netsikring.
14. Netspændingsindikering: Angiver den netspænding, instrumentet må tilsluttes.
15. Netspændingsomskifter: Skifter mellem 4 forskellige netspændinger, 110V, 130V, 220V og 240V.
16. Synk.udgang: Afgiver 1V (konstant) i tomgang eller 0,5V ved en belastning på 600Ω. Kurveformen er den samme som på udgang (6) og (7).

Afprøvning af LF-forstærkere med sinus-signal, efter DIN-45500 (Entwurf aug. 1971).

RC-oscillator TG7, et LF-wattmeter (f.eks. B&O Wattmeter RWM4) samt evt. et oscilloskop tilsluttes måleobjektet som vist i fig. 3. RC-oscillatorens kabinet forbindes til jord, øvrige instrumenter samt måleobjektet må ikke forbindes til jord.

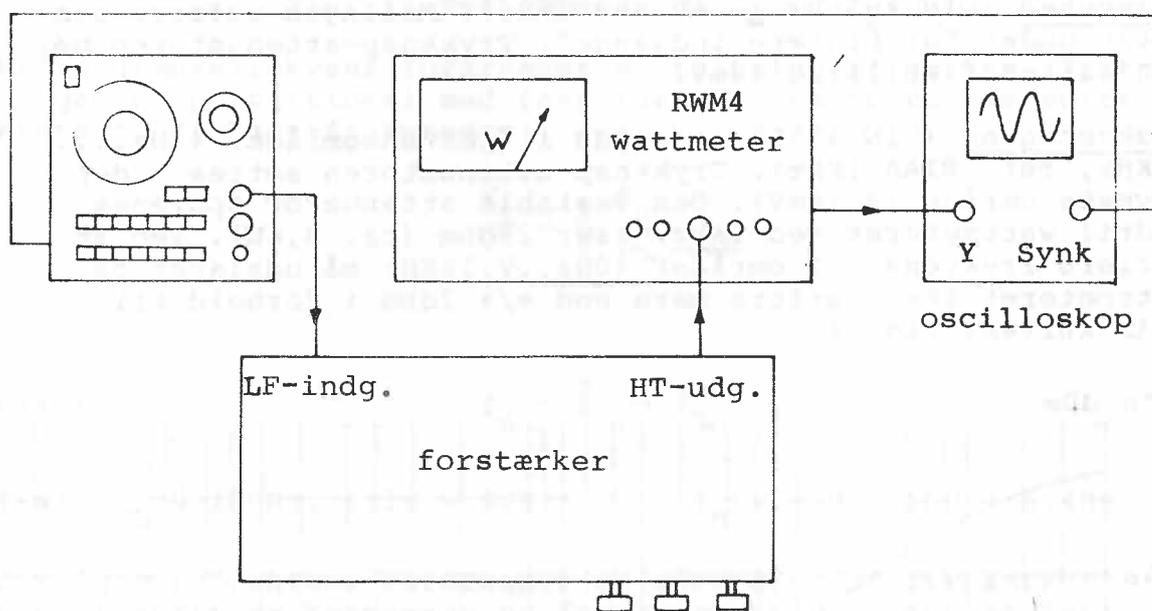


Fig. 3. Måleopstilling

a) Liniære indgange:

Følsomhed (DIN-45500: $\leq 0,5V$). Følsomheden måles normalt ved 1 kHz sinus (10Hz x 100). Trykknop-attenuatoren sættes i stilling 1V. Begge kanalomskifter-knapper indtrykkes (L+R). Wattmeteret indstilles til måling af max. udgangseffekt i.h.t. instruktionsbogen for RWM4 (side 8, pkt. 4). Den variable attenuator opdrejes, indtil wattmeteret viser den for måleobjektet angivne max. udgangseffekt. Følsomheden kan da aflæses på attenuator-skalaen. Et LF-voltmeter kan evt. tilsluttes koaksialudgangen til kontrol af udgangsspændingens amplitude.

Frekvensgang (DIN-45500: $\pm 1,5\text{dB}$ fra 40Hz til 16KHz, ref. 1KHz). Ved 1KHz opdrejes den variable attenuator, indtil wattmeteret viser 28dBm (ca. 0,6W). Trykknop-attenuatoren sættes i stilling 100mV. Ved at variere frekvensen i området 40Hz.... 16KHz må udslaget på RWM4 ikke variere mere end $\pm 1,5\text{dBm}$ i forhold til udslaget ved 1KHz (26,5....29,5dBm). Måleobjektets tonekontroller skal stå i deres neutrale stilling.

Kanalforskel, kanalbalance og krydstaleafstand måles i.h.t. instruktionsbogen for RWM4 side 9, pkt. 5a, 5b og 6a. Krydstaleafstanden fra venstre til højre kanal og omvendt skal iflg. DIN-45500 være mindst 40dB ved 1KHz og mindst 30dB i frekvensområdet 250Hz....10KHz.

Forvrængning (DIN-45500: Max. 1% i frekvensområdet 40Hz.... 12,5KHz). RC-oscillator TG7's egenforvrængning er meget lille, mindre end 0,1%, og er derfor velegnet til kontrol af forvrængningen på HiFi-udstyr. Forvrængningen måles normalt ved max. normeret udgangseffekt.

b) Indgange for magn. pick-up (RIAA):

Følsomhed (DIN 45500: $\leq 5\text{mV}$ ved 1KHz). Målingen udføres som nævnt under "a) Liniære indgange". Trykknop-attenuatoren bør dog sættes i stilling 10mV.

Frekvensgang (DIN 45500: $\pm 2\text{dB}$ i frekvensområdet 40Hz.... 16KHz, ref. RIAA/1KHz). Trykknop-attenuatoren sættes i det laveste område (3,16mV). Den variable attenuator opdrejes, indtil wattmeteret ved 1KHz viser 28dBm (ca. 0,6W). Ved at variere frekvensen i området 40Hz....16KHz må udslaget på wattmeteret ikke variere mere end $\pm 2\text{dBm}$ i forhold til RIAA-kurven, fig. 4.

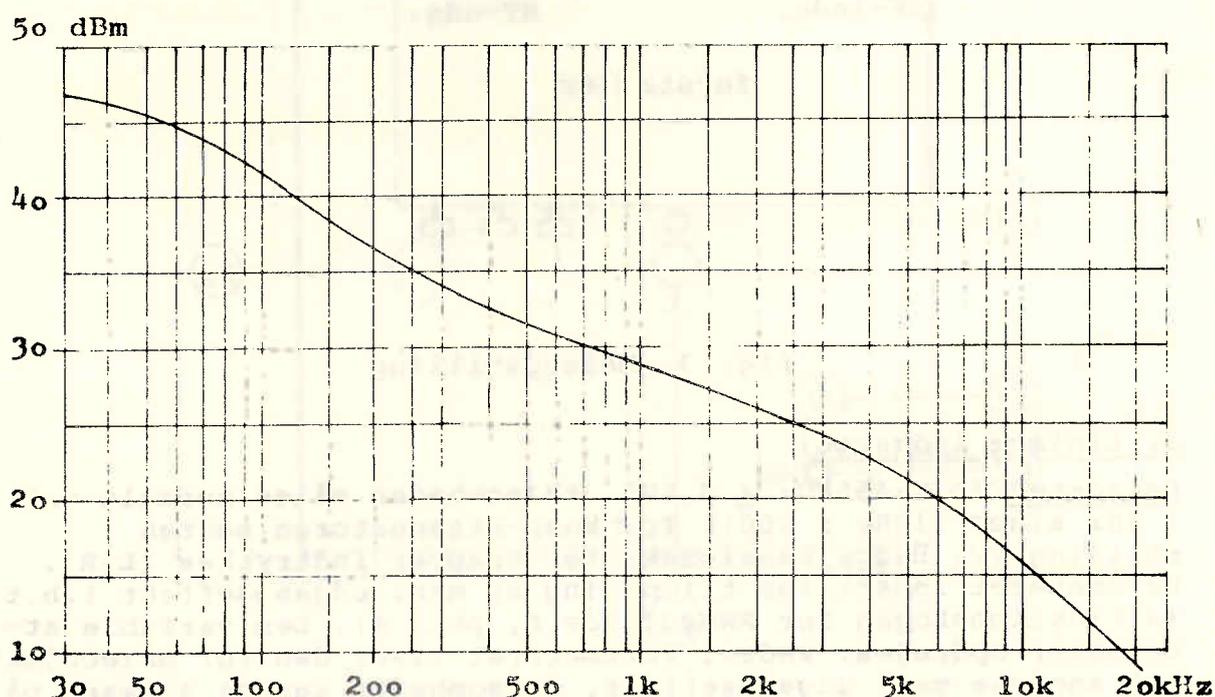


Fig. 4. RIAA-frekvenskarakteristik

Afprøvning af LF-forstærkere med firkant-signal

a) Liniære indgange:

Frekvensgang. Anvender man et firkantsignal i stedet for et sinus-signal, som beskrevet i det foregående, sker der en deformation af kurveformen i nærheden af den nedre og den øvre grænsefrekvens. Ud fra en relativ måling af kurvens fæ-
con på et oscilloskop, kan disse grænsefrekvenser let bereg-
nes. Som målefrekvens benyttes normalt 100Hz og 10kHz (ved
nyere forstærkere dog op til 50kHz). Forstærkerens bas- og
diskantregulering skal stå i neutral stilling.

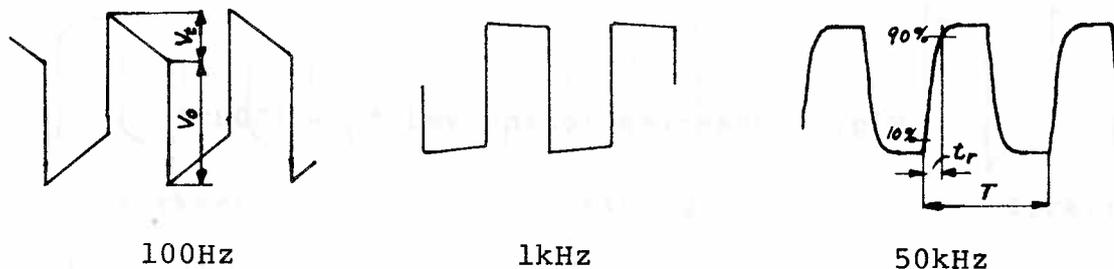


Fig. 5. Bestemmelse af f_n og f_ϕ .

Nedre grænsefrekvens forårsager en tiltning af kurven. Tilt-
ningen er proportional med forholdet mellem nedre grænsefre-
kvens og firkant-frekvensen:

$$\frac{V_t}{V_0} = \frac{1}{2} \cdot \frac{f_n}{f_{\square}}$$

eller

$$f_n = \frac{2}{1} \cdot \frac{V_t}{V_0} \cdot f_{\square}$$

Eks: $f_{\square} = 100\text{Hz}$, tilt = 10%: $f_n = \frac{2}{1} \cdot 0,1 \cdot 100 = 6,4\text{Hz}$

Øvre grænsefrekvens forårsager en afrunding af firkantkur-
vens flanker og bestemmes ud fra en relativ måling af "sti-
getiden":

$$f_\phi = \frac{0,35}{t_r} = 0,35 \cdot f_{\square} \cdot \frac{T}{t_r}$$

Eks.: $\frac{T}{t_r} = 6$ og $f_{\square} = 10\text{kHz}$: $f_\phi = 0,35 \cdot 10 \cdot 6 = 21\text{kHz}$

NB: Ovenstående formler for nedre og øvre grænsefrekvens er
kun gældende, såfremt forstærkerens afskærings-asymptoter
er -6dB/oktav, svarende til eet RC-led.

Bas- og diskant-regulering. En firkant-spænding indeholder
foruden grundfrekvensen en del harmoniske af denne. De høje-
re harmoniske er indeholdt i kurvens flanker, hvorimod de
lavere harmoniske danner kurvens "vandrette" dele. Dette for-
hold kan benyttes til kontrol af en forstærkers bas- og dis-
kant-regulering, fig. 6/7.

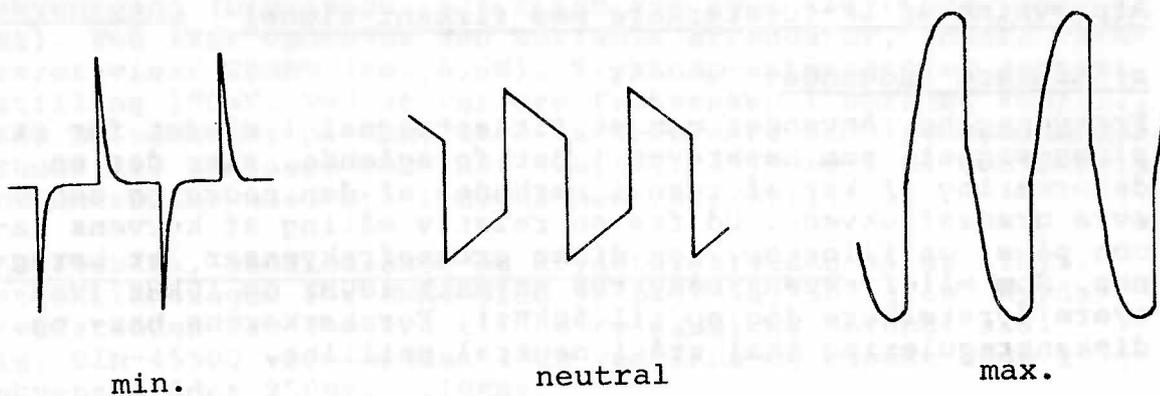


Fig. 6. Bas-regulering ved $f_L = 100\text{Hz}$

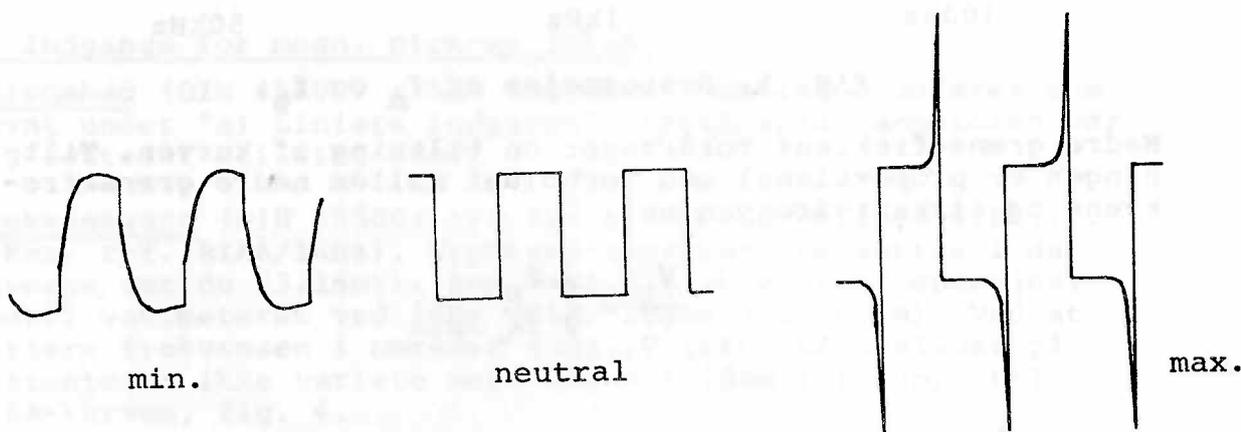


Fig. 7. Diskant-regulering ved $f_L = 1\text{kHz}$

b) Uliniære indgange ("RIAA"):

Frekvensgang. Frekvensgangen for en forstærker med "RIAA"-karakteristik (fig. 4) minder en del om frekvensgangen for en linier forstærker med max. bas- og min. diskant-regulering. Firkantspændingens kurveform vil derfor blive deformeret i lighed med fig. 6 (max.) og fig. 7 (min.)

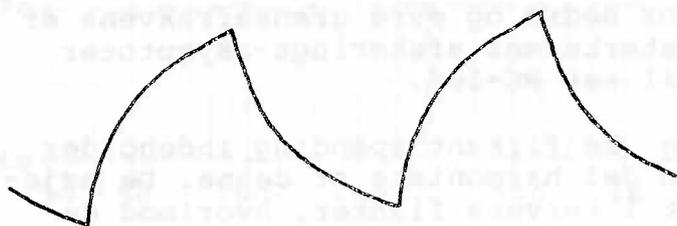


Fig. 8. "RIAA"-frekvensgang ved $f_L = 1\text{kHz}$. (Bas- og diskant-regulering i neutral stilling).

Justering af oscilloskop-probe

Et oscilloskop er normalt forsynet med en speciel udgang til justering af den tilhørende probe's frekvensgang, men man er ikke altid i stand til at udføre denne justering korrekt, fordi test-spændingens kurveform ofte er for dårlig.

LF-oscillator TG7 kan udmærket anvendes til dette. Som målefrekvens benyttes $f_{\Omega} = 1\text{KHz}$. Probens trimmekondensator justeres således, at firkant-spændingens kurveform bliver korrekt (fig. 9).

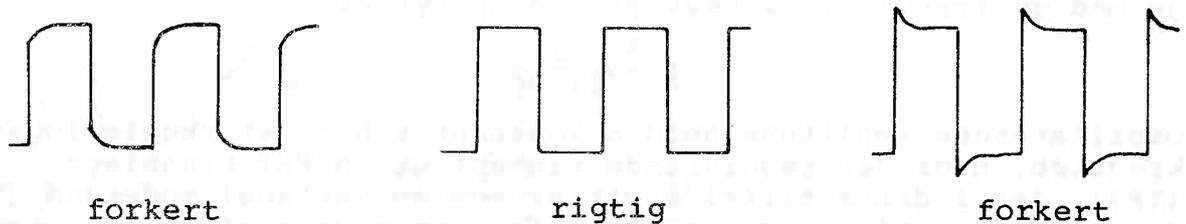


Fig. 9. Justering af oscilloskop-probe

Signal-tracing

LF-oscillator TG7 kan udmærket anvendes som signal-tracer. En kort "stigetid" på firkantspændingen er ensbetydende med et stort indhold af harmoniske.

Da oscillatoren er DC-koblet, skal test-ledningen forsynes med en seriekondensator, idet udgangs-attenuatoren ellers let ødelægges. Denne kondensator bør være $0,1\mu\text{F}/400\text{V}$ ved undersøgelse af LF-kredsløb og $1\text{nF}/400\text{V}$ ved undersøgelse af HF-kredsløb.

Ved signal-tracing på denne måde er det muligt at undersøge, om der er "hul" gennem alle kredsløb i LF-forstærkere, AM- og FM-modtagere, tunere m.m. ved $f_{\Omega} = 1\text{KHz}$. Ved FM-ant./osc.kredse kan det dog være nødvendigt at anvende en højere målefrekvens, f.eks. $f_{\Omega} = 1\text{MHz}$.

VIRKEMÅDE (FIG. 10)

TG7 er en såkaldt "Wien-bro" oscillator med ens modstands- og kapacitetsværdier i den frekvensbestemmende brogren. Kondensatorerne er kontinuert variable (frekvensskala), mens modstandene kan varieres i spring v.h.a. en trykknappomskifter (frekvensområde). Svingningsbetingelsen for oscillatoren er, at sløjfeforstærkningen, fra punktet "a" gennem forstærkeren A1 og tilbage til punktet "a", er lig med 1 og at fasedrejningen igennem sløjfen samtidig er nul. For en "Wien-bro" oscillator medfører nævnte betingelse, at forstærkeren A1 skal have en forstærkning på nøjagtig $3/Q$. Er dette tilfældet, vil oscillatoren svinge med en frekvens, f , bestemt ved udtrykket

$$f = \frac{1}{2\pi RC}$$

Oscillatorens amplitude holdes konstant v.h.a. et reguleringskredsløb, hvor det regulerende element er en FET-transistor (TR7), der i dette tilfælde virker som en variabel modstand (i det lineære område under pinch-off). Den styres af en komparator, som afgiver en fejlspænding, såfremt oscillatorens udgangsspænding, p.g.a. en forstyrrelse (støjimpuls, temperaturændring m.m.), ændrer amplitude. Eksempelvis vil et fald i amplituden have følgende virkning: DC-spændingen på udgangen af ensretteren mindskes, hvilket udstyrer komparatoren i positiv retning. Spændingen på gate'n af TR7 bliver mindre negativ. Dette medfører, at den ækvivalente seriemodstand, og dermed modkoblingen i oscillatorforstærkeren, bliver mindre. Resultatet bliver således at forstærkningen, og dermed udgangsspændingen, bliver større. - Med en Field-effekt transistor som variabel modstand (fremfor en glødelampe eller termistor) kan der opereres med korte reguleringstider, og da reguleringsløjfen samtidig er kritisk dæmpet, opnås en meget stabil sinusspænding.

Amplituden bestemmes af referencespændingen V_{ref} , der frembringes v.h.a. en zenerdiode på 5,6V. Arbejdspunktet for denne er valgt således, at temperaturkoefficienten bliver nul. Dette medfører, at amplituden bliver praktisk taget uafhængig af temperaturændringer.

Komparatoren virker også som integrator, der udglatter den ensrettede spænding, således at ripple'n på styrespændingen til TR7 bliver forsvindende. Dette har betydning for oscillatorens harmoniske forvrængning.

For at opnå en god nøjagtighed på frekvensskalaen er det en betingelse, at frekvensen kun er afhængig af Wien-bro'ens RC-led. Forstærkeren A1 må således ikke ændre fasen og skal derfor have en amplitudekarakteristik, som er ret en dekade højere end oscillatorens frekvensområde. Dette medfører, at der må anvendes en udgangsforstærker, som "buffer" overfor kapacitive belastninger.

Oscillatorens firkantsspænding frembringes ved at lede sinusspændingen gennem en Schmitt-trigger med tilhørende komplementær-symmetrisk (push-pull) udgangstrin.

Udgangsattenuatoren er en præcisionsattenuator sammensat af 6-led, som hver giver en dæmpning på 10dB. Udgangsimpedansen er konstant 75 ohm.

Spændingen på synk.udgangen er konstant 1V og fås via en emitterfølger for at få en lav udgangsimpedans, 600 ohm. Denne udgang kan bl.a. anvendes til synkronisering af et oscilloskop.

VIRKEMÅDE (KREDSLØB)

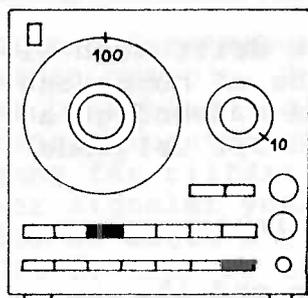
De tre forstærkere A1, A2 og A3 (fig. 10) er bygget op efter samme princip. De har alle en høj tomgangsforstærkning, $>60\text{dB}$, er DC-koblede og består af tre trin. Det 1. trin er en differentialforstærker (langhalet par), hvor den inverterende indgang får tilført det modkoblede signal. Det 2. trin forstærker signalet yderligere og ændrer samtidig DC-niveauet, således at dette i hviletilstanden er nul på forstærkerudgangen. Det 3. trin er en impedansomsætter, der giver forstærkeren en lav udgangsimpedans.

I oscillator-forstærkeren (TR1....TR6) er der anvendt field-effekt transistorer i differentialtrinnet for at opnå en høj indgangsimpedans. Dette er nødvendigt, da "R" i Wien-broen er $30\text{M}\Omega$ i det laveste frekvensområde. Udgangstrinnet i denne forstærker er en emitterfølger (TR6).

Komparator-forstærkeren (TR8....TR11) arbejder noget anderledes end A1 og A3, idet der på den ikke-inverterende indgang ligger en positiv DC-spænding, V_{ref} . Dette medfører, at forstærkeren er afbrudt (cut-off), når den tilførte spænding er mindre end referencespændingen. I denne tilstand er udgangsspændingen begrænset til $+0,6\text{V}$ v.h.a. dioden D6. Først når spændingen på den inverterende indgang overstiger V_{ref} arbejder forstærkeren lineært og som integrator. Den integrerende virkning fremkommer ved at kondensatoren C21 i modkoblingsløjfen påvirker indgangen som en kondensator, der er forstærknings gange større (den såkaldte Miller-effekt). I de to laveste frekvensområder parallelforbinderes C21 med et ekstra led a.h.t. tidskonstanten for reguleringen.

Buffer-forstærkeren (TR12....TR19) er forsynet med et komplet-symmetrisk udgangstrin, og modkoblet til en resulterende forstærkning på 1,6 gange.

I schmitt-triggeren (TR20....TR22) er den normale fælles emittermodstand, som frembringer den regenerative virkning, erstattet af en diodekoblet transistor, TR21. Dennes meget lille dynamiske modstand reducerer hysteresen. Transistoren forspændes via modstanden R85, sørger samtidig for, at triggerniveauet på indgangen er nul. Disse forhold medvirker til, at firkantspændingen på udgangen bliver symmetrisk.



dette er tilfældet.

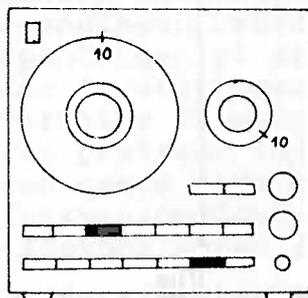
Spændingen i målepunkt $\triangle 3$ kontrolleres med et voltmeter, ca. $\pm 1,5V$.

Frekvensskalaen $\textcircled{2}$ stilles på "100". Med de to trimmere "xl00", fig. 11, justeres spændingen i målepunkt $\triangle 3$ til $\pm 1,5V$ samtidig med, at frekvensen justeres til 10KHz. Frekvensskalaen $\textcircled{2}$ stilles på "10". Frekvensen kontrolleres, og såfremt denne afviger mere end $\pm 1\%$ fra 1KHz, gentages ovennævnte justeringsprocedure.

Frekvensområde-omskifteren $\textcircled{1}$ sættes i stilling "xl0". Frekvensskalaen $\textcircled{2}$ stilles på "100". Med de to trimmere "xl0", fig. 11, justeres spændingen i målepunkt $\triangle 3$ til $\pm 1,5V$ samtidig med, at frekvensen justeres til 1KHz.

På tilsvarende måde justeres de resterende trimmere: "xl"-trimmerne justeres i "xl"-området, "xlK"-trimmerne i "xlK"-området o.s.v.

Sinus-amplitude



Koaksial-udgangen $\textcircled{7}$ tilsluttes et digital-voltmeter. Trykknop-attenuatoren $\textcircled{12}$ sættes i stilling "1V". Den variable attenuator $\textcircled{4}$ stilles på "10". Frekvensen indstilles til 1KHz (10Hz x 100).

Med potentiometeret P2, fig. 12, justeres udgangsspændingen til $1V_{\text{eff}}$.

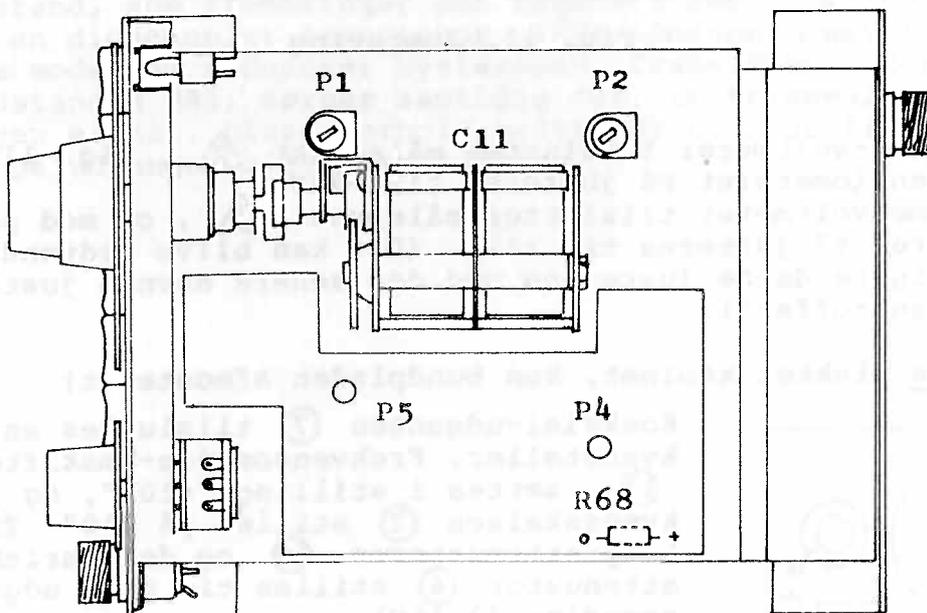
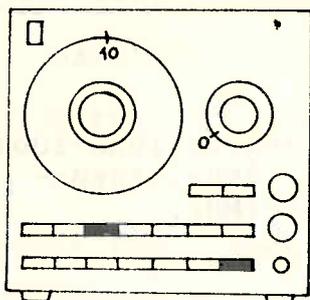


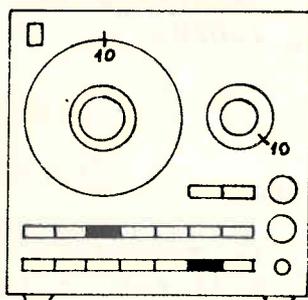
Fig. 12. Justering

Tomgangsstrøm



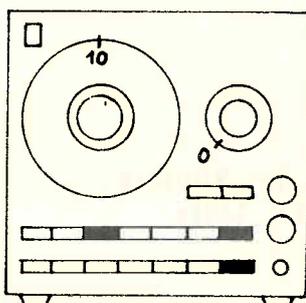
Trykknop-attenuatoren ⑫ sættes i stilling "3,16V". Den variable attenuator ④ stilles på "0". Frekvensen indstilles til 1KHz. Med potentiometeret P4 justeres spændingen over modstanden R68 til 50mV DC. Spændingen måles med et universalmeter, der tilsluttes direkte over modstanden.

Forvrængning



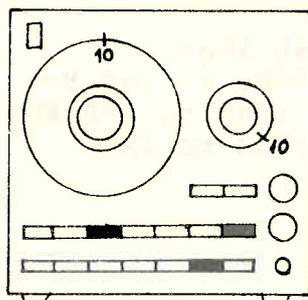
Koaksial-udgangen ⑦ tilsluttes et forvrængningsmeter, der kan måle forvrængning mindre end 0,03%. Trykknop-attenuatoren ⑫ sættes i stilling "1V". Den variable attenuator ④ stilles på "10". Frekvensen indstilles på 1KHz. Med potentiometeret P1 justeres til min. forvrængning. Med kabinettets svøb påmonteret kontrolleres, om forvrængningen stadig er mindre end 0,03%.

Firkant-offset



Koaksial-udgangen ⑦ tilsluttes et DC-voltmeter. Trykknop-attenuatoren ⑫ sættes i stilling "3,16V". Den variable attenuator ④ stilles på "0". Frekvensen indstilles til 1KHz. $\sqrt{\pi}$ -knappen indtrykkes. Med potentiometeret P7 justeres DC-offset-spændingen til 0V +/-50mV.

Firkant-amplitude



Koaksial-udgangen ⑦ tilsluttes et AC-digital-voltmeter. Trykknop-attenuatoren ⑫ sættes i stilling "1V". Den variable attenuator ④ stilles på "10". Frekvensen indstilles til 1KHz. $\sqrt{\pi}$ -knappen indtrykkes. Med potentiometeret P5 justeres udgangsspændingen til 1,11V. Et digital-voltmeter måler normalt middelværdi og er kalibreret i sinus-effektivværdi, hvorfor der må tages hensyn til formfaktoren, 1,11. Såfremt digital-voltmeteret måler effektivværdi, justeres udgangsspændingen til 1V.

TECHNICAL DATA

Frequency:

Range: 10Hz-1MHz in 5 ranges: 10Hz-100Hz,
100Hz-1KHz, 1KHz-10KHz, 10KHz-
100KHz and 100KHz-1MHz.

Scale: 10-100Hz

Accuracy: +/- 2%

Stability: +/- 0,02%/°C
+/- 0,01% at +/- 10% change in
line voltage, $f \leq 200\text{KHz}$

Output voltage:

Waveform: Sine or square wave.

Range: 0-3,16V RMS (EMF) in 7 ranges:
0-3,16mV, 0-10mV, 0-31,6mV, 0-100mV,
0-316mV, 0-1V and 0-3,16V.

Scale: 0-3,16 and 0-10.

Accuracy:

Pushbutton attenuator: +/- 0,2dB

Variable attenuator: +/- 0,5dB

Frequency response: +/- 0,05dB, 20Hz to 200KHz.
+/- 0,1dB, 10Hz to 1MHz

Stability (sine): +/- 0,05%/°C
+/- 0,01% at +/- 10% change in
line voltage

DC-Offset: Max. 100mV (reduced in proportion
to pushbutton attenuator setting).

Distortion (sine): Less than 0,05% at 1KHz,
Less than 0,1%, 20Hz to 200 KHz
Less than 0,15%, 10Hz to 500 KHz and
less than 0,2%, 10Hz to 1MHz

Rise time(square wave): Max. 50 ns

Symmetry (square wave): Within 3%

Output impedance: 75 Ω

Auxiliary output:

Waveform: Sine or square wave

Output voltage: $1V_{RMS}$ (EMF)

Output impedance: 600Ω

Power requirements: 110V, 130V, 220V or 240V AC,
50-400Hz. Consumption 5W.

Ambient temperature range: $0-50^{\circ}C$

Dimensions (cabinet): Width: 163mm
Depth: 210mm
Height: 160mm

Weight: 9 lbs. (4 kg)

Finish: Silvergrey and blue hammertone

Accessories:
1 instruction manual
1 cable UHF/2banana
1 cable 5-pol.DIN/5-pol.DIN
2 alligator clips



INTRODUCTION

The B&O RC-Oscillator Type TG7 is a solid state sine-square wave generator with low distortion, suitable for laboratories, schools, service shops, factories, etc. It has a wide frequency range, 10Hz.....1MHz, and great stability with respect to variations in temperature and line voltage. The output voltage (0...3.16V) is continuously variable over seven ranges.

This generator may advantageously be used for checking and repairing stereo amplifier equipment as the instrument includes a special 5-pole DIN output in combination with a left-right channel selector. The output impedance is low (75Ω), which makes it possible in most cases to disregard the capacitive load on measuring cables and leads.

APPLICATION

The RC-Oscillator TG7 may be connected to the following line voltages: 110V, 130V, 220V or 240V. The voltage selector (15) on the rear of the instrument is set at the correct line voltage (14) before connection to the line. The instrument is turned on by depressing one of the frequency range buttons (11) and is turned off by pushing the power switch (10).

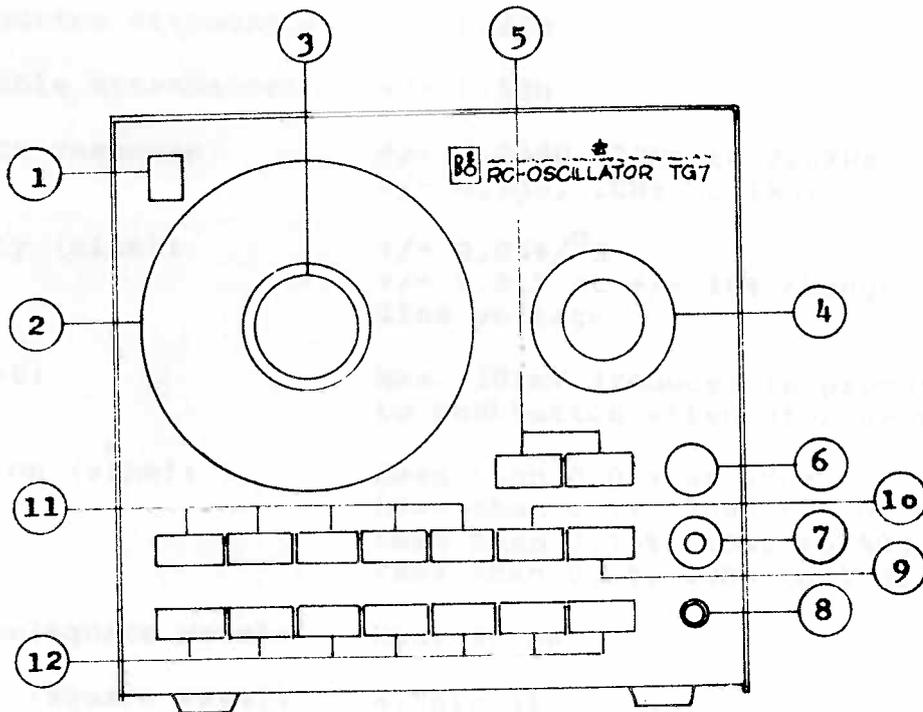


Fig. 1. RC-oscillator TG7, front view

Operating of the instrument appears from figs. 1-2

1. Indicator lamp: Lights when generator is turned on.
2. Frequency dial: Varies the frequency within each range.
3. Microdrive: Changes gearing of frequency dial in the ratio of 5:1.
4. Variable attenuator: Varies the output voltage within each range of ourput attenuator (12).
5. Channel selector: Switches signal on stereo output socked (6) between left (L), right (R) or left + right (L+R) channels. Four-channel stereo has signal on both left channels simultaneously and both right channels simultaneously.
6. Stereo output: 5-pole DIN.
7. Output for coaxial connection.
8. Ground terminal.
9. Function selector: Switches between sine and square-wave form.
10. Power switch.
11. Frequency range selector: Switches between 5 ranges. The reading of the range multiplied by dial reading (2) is the output frequency.
12. Output attenuator: Attenuates the output voltage in 6 steps of 10 dB each.

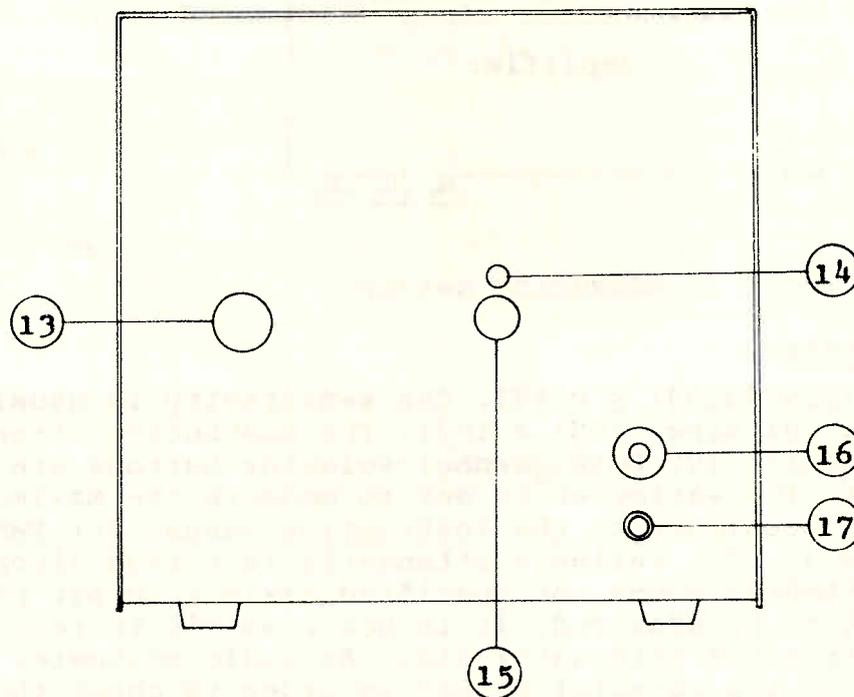


Fig. 2. RC-oscillator TG7, rear view

13. Line fuse.
14. Line voltage indicator: Indicates the line voltage to which instrument may be connected.
15. Line voltage selector: Switches between 4 different line voltages, 110V, 130V, 220V and 240V.
16. Sync. output: Open-circuit voltage is 1V (constant). The wave form is identical to outputs (6) and (7).

Testing of audio amplifier with sine-wave signal, based on DIN-45500 (Entwurf Aug. 1971)

The RC-Oscillator TG7, and audio wattmeter (e.g. B&O Wattmeter RWM4) and, if desired, an oscilloscope are connected to the object to be measured, as shown in Fig. 3. The cabinet of the RC-Oscillator is grounded; other instruments and the object under measurement must not be grounded.

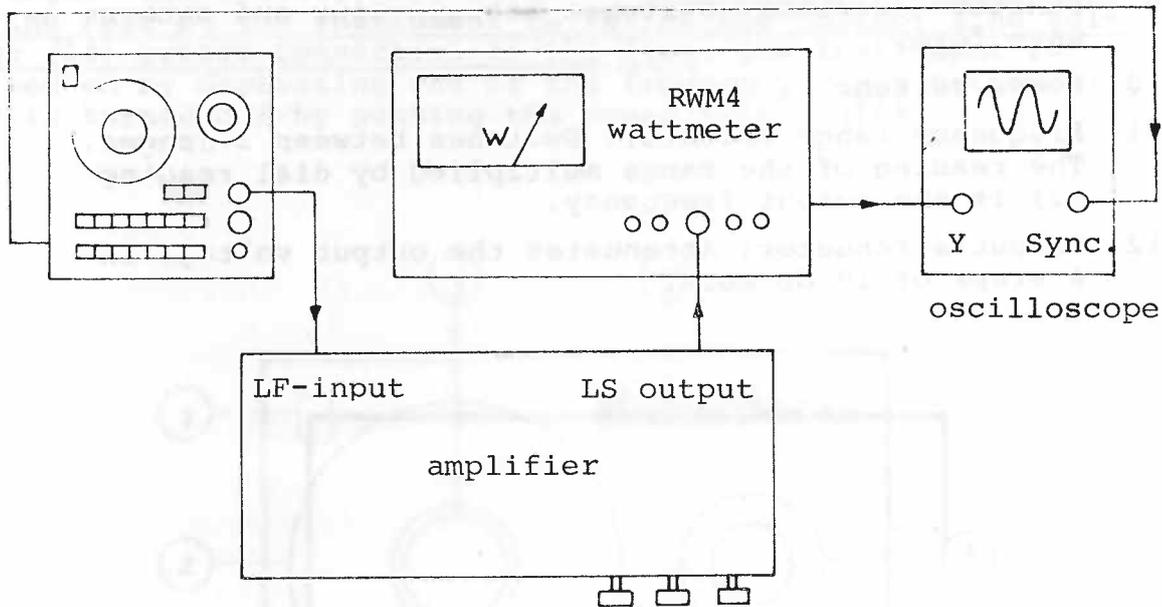


Fig. 3. Measuring set-up

a) Linear inputs:

Sensitivity (DIN-45500: $\leq 0.5V$). The sensitivity is usually measured at 1 kHz sine ($10Hz \times 100$). The pushbutton attenuator is set in position 1V. Both channel-selector buttons are depressed (L+R). The wattmeter is set to measure the maximum output power, according to the instruction manual for RWM4 (page 8, item 4). The variable attenuator is turned clockwise until the wattmeter shows the specified maximum output power of the object to be measured. It is now possible to read the sensitivity from the attenuator dial. An audio voltmeter may be connected to the co-axial output in order to check the amplitude of the output voltage.

Frequency response (DIN-45500: ± 1.5 dB from 40Hz to 16KHz, ref. 1KHz). At 1KHz the variable attenuator is turned clockwise until the wattmeter shows 28 dBm (about 0.6W). The pushbutton attenuator is set to 100mV. By varving the frequency within the range of 40Hz.....16KHz, the meter scale reading must not vary more than ± 1.5 dBm in relation to the meter scale reading at 1KHz (26.5....29.5dBm). The tone controls of the object measured should be in their neutral positions.

Channel difference, channel balance and cross-talk are measured in accordance with the instruction manual for RWM4, page 9, items 5a, 5b and 6a. The cross-talk from left to right channel and vice versa should, according to DIN-45500, be at least 40dB at 1KHz and at least 30dB within the frequency range of 250Hz.....10KHz.

Distortion (DIN-45500: max. 1% within frequency range of 40Hz.....12.5KHz). The distortion of the RC-Oscillator TG7 is very low, less than 0.1%, and is therefore suitable for checking the distortion of HiFi equipment. Distortion is usually measured at max. rated output power.

b) Inputs for magn. pick-up (RIAA):

Sensitivity (DIN-45500: ≤ 5 mV at 1KHz). The measuring is carried out as described in "a) Linear inputs". The pushbutton attenuator should, however, be set on 10mV.

Frequency response (DIN-45500: ± 2 dB within frequency range of 40Hz....16KHz, ref. RIAA/1KHz). The pushbutton attenuator is set in lowest range (3.16mV). The variable attenuator is turned clockwise until at 1KHz the wattmeter shows 28 dBm (about 0.6W). By varving the frequency within the range of 40Hz....16KHz, the meter scale reading must not vary more than ± 2 dBm in relation to the RIAA-curve, Fig. 4.

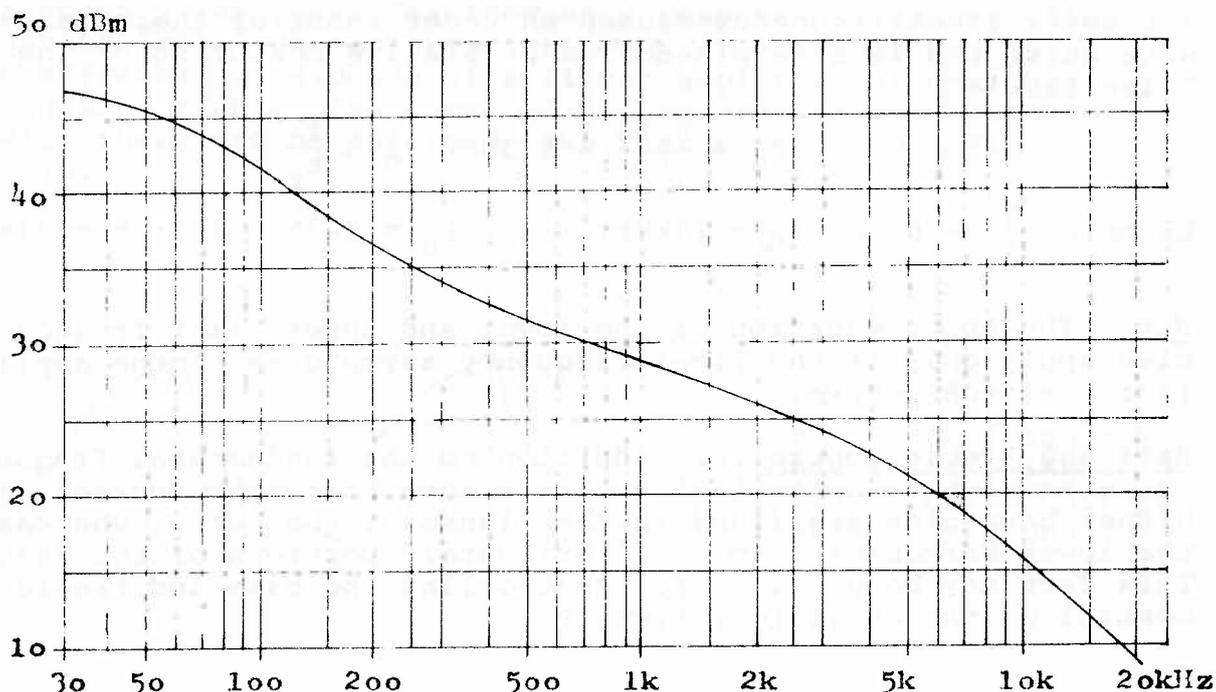


Fig. 4. RIAA frequency response

Testing of audio amplifiers with square-wave signal.

a) Linear inputs:

Frequency response. If a square-wave signal is used instead of a sine-wave signal, as described in the foregoing, the curve is deformed near the lower and upper limet frequencies. From a relative measuring on an oscilloscope of the shape of the curve, these limet frequencies are easily determined. The measuring frequencies used are normally 100Hz and 10kHz. The bass and treble controls of the amplifier should be in their neutral positions.

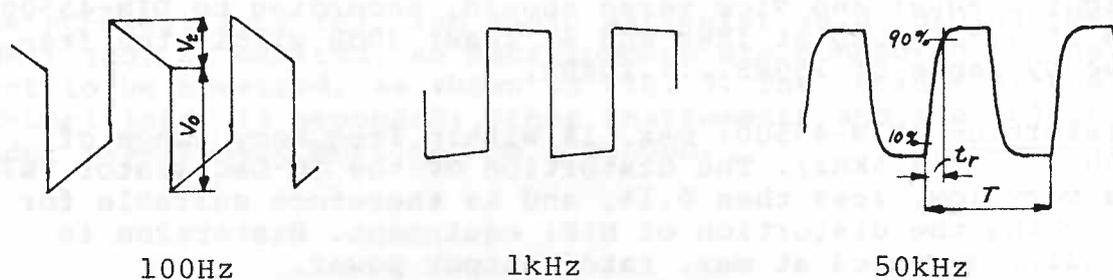


Fig. 5. Determination of f_1 and f_u

The lower limet frequency will cause a tilting of the curve. This tilting is proportional to the ratio between the lower limet frequency and the square-wave frequency:

$$\frac{V_t}{V_0} = \frac{1}{2} \cdot \frac{f_1}{f_{\square}}$$

or

$$f_1 = \frac{2}{1} \cdot \frac{V_t}{V_0} \cdot f_{\square}$$

Example: $f_{\square} = 100\text{Hz}$, tilt = 10%: $f_1 = \frac{2}{1} \cdot 0.1 \cdot 100 = 6.4\text{Hz}$

The upper limet frequency causes an under shoot of the square-wave curve and is determined from a relative measuring of the "rise time":

$$f_u = \frac{0.35}{t_r} = 0.35 \cdot f_{\square} \cdot \frac{T}{t_r}$$

Example: $\frac{T}{t_r} = 6$ and $f_{\square} = 10\text{kHz}$: $f_u = 0.35 \cdot 10 \cdot 6 = 21\text{kHz}$

Note: The above equation of the lower and upper limet frequencies apply only if the limet frequency asymptotes of the amplifier are -6dB/octave.

Bass and treble control. In addition to the fundamental frequency, a square-wave potential contains some harmonics thereof. The higher harmonics are found in the flanks of the curve, whereas the lower harmonics form the "horizontal" portions of the curve. This fact may be utilized for controlling the bass and treble control of the amplifier, Figs. 6-7.

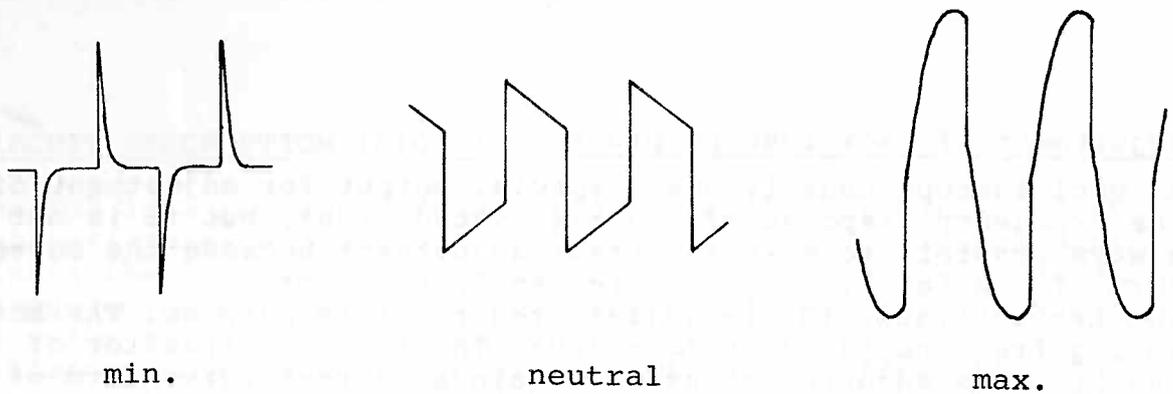


Fig. 6. Bass adjustment at $f_{\Omega} = 100\text{Hz}$

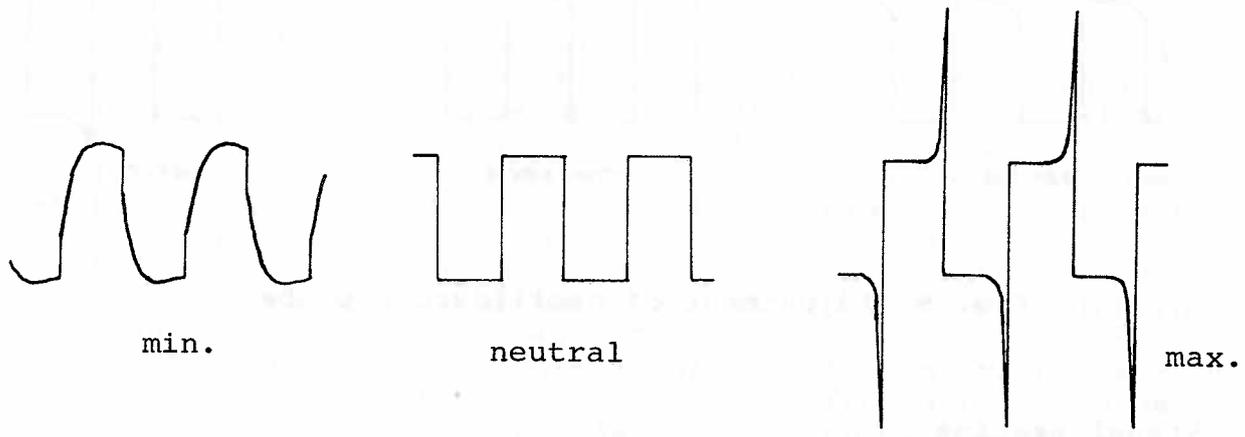


Fig. 7. Treble adjustment at $f_{\Omega} = 1\text{kHz}$

b) Non-linear inputs ("RIAA"):

Frequency response. The frequency response of an amplifier having "RIAA" characteristics (Fig. 4) somewhat resembles the frequency response of a linear amplifier at max. bass and min. treble. The curve of the square-wave potential will therefore be deformed like Fig. 6 (max.) and Fig. 7 (min.)

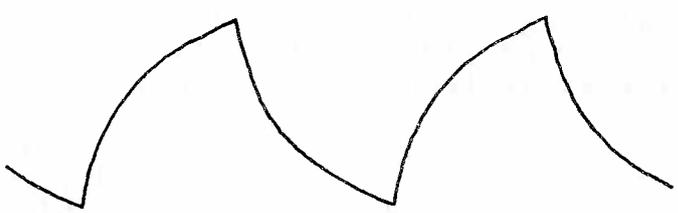


Fig. 8. "RIAA" frequency response at $f_{\Omega} = 1\text{kHz}$. (Bass and treble controls in neutral positions)

Adjustment of oscilloscope probe

An oscilloscope usually has a special output for adjustment of the frequency response of the associated probe, but it is not always possible to make a correct adjustment because the curve form of the test voltage is frequently too poor. The LF-Oscillator TG7 is well-suited for this purpose. The measuring frequency used is $f_{\text{m}} = 1\text{kHz}$. The trimmer capacitor of the probe is adjusted so as to obtain a correct curve form of the square-wave potential (Fig. 9).

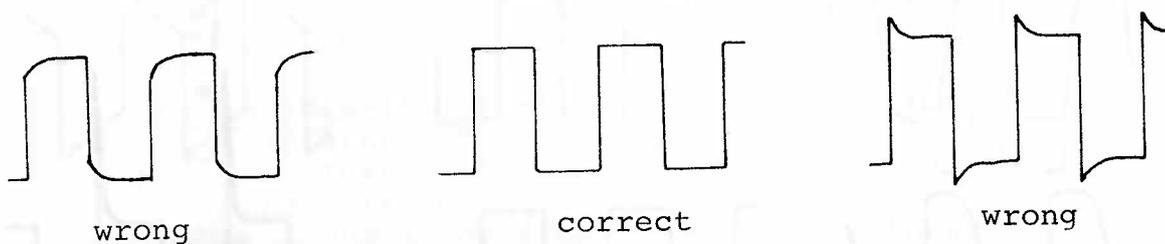


Fig. 9. Adjustment of oscilloscope probe

Signal tracing

The LF-Oscillator TG7 is excellent as signal tracer. A short "rise time" of the square-wave potential is tantamount to a substantial content of harmonics. As the oscillator is DC coupled the test cable must be provided with a series capacitor as otherwise the output attenuator is easily damaged. This capacitor should be $0.1\mu\text{F}/400\text{V}$ when testing AF circuits and $1\text{nF}/400\text{V}$ for checking HF circuits. Signal tracing in this manner makes it possible to check if there is a "hole" through all circuits of AF amplifiers, AM and FM receivers, tuners, etc., at $f_{\text{m}} = 1\text{kHz}$. In case of FM antenna and oscillating circuits it may, however, be necessary to employ a higher measuring frequency, e.g. $f_{\text{m}} = 1\text{MHz}$.

CIRCUIT DESCRIPTION (FIG. 10)

The TG7 is a so-called "Wien bridge" oscillator having identical resistance and capacity values of the bridge branch determining the frequency. The capacitors are continuously variable (frequency dial), while the resistors are variable in stages by means of a pushbutton selector (frequency range). The oscillatory condition of the oscillator is that from point "a" through the amplifier A1 and back to point "a", the loop amplification is equal to 1, and that the phase shift through the loop is zero at the same time. To a "Wien bridge" oscillator this condition involves that the amplifier A1 must have an amplification of exactly $3\sqrt{0}$. In the affirmative the oscillator will oscillate at a frequency, f , determined by the equation

$$f = \frac{1}{2\pi RC}$$

The oscillator amplitude is maintained constant by means of a control circuit where the controlling unit is an FET transistor (TR7) which in this case acts as variable resistor (within the linear range below pinch-off). It is controlled by a comparator which generates an error voltage if, owing to some disturbance (noise pulse, variation in temperature, etc.), the output voltage of the oscillator changes amplitude. A drop in amplitude could, for instance, have the following effect: The DC voltage of the output of the rectifier is reduced, which induces the comparator positively. The voltage of the TR7 gate is rendered less negative. This means that the equivalent series resistance and with that the negative feedback in the oscillator amplifier is reduced. As a consequence, the amplification and with that the output voltage is increased. - By means of a field-effect transistor as variable resistor (rather than a filament lamp or thermistor) it is possible to operate with short periods for adjustment, and as at the same time the control loop is critically damped, a very stable sine-wave voltage is obtained.

The amplitude is determined by the reference voltage V_{ref} which is obtained by means of a zener diode of 5.6V. The operational point of the latter has been selected so as to render the temperature coefficient zero. This has the effect that the amplitude will be as good as independent of changes in temperature. The comparator also acts integrator smoothing the rectified voltage such that the ripple of the control voltage for TR7 is rendered negligible. This is important to the harmonic distortion of the oscillator.

To obtain satisfactory accuracy with the frequency dial it is required that the frequency be only dependent on the Wien-bridge components. Consequently, the amplifier A1 must not change the phase and should therefore have an amplitude characteristic which is straight (one decade higher than the frequency range of the oscillator). This makes it necessary to use an output amplifier as "buffer" against capacitive loads.

The square-wave voltage of the oscillator is produced by guiding the sine-wave voltage through a Schmitt trigger with associated complementary-symmetrical (push-pull) output stage. The output attenuator is a precision attenuator composed of 6 circuits each having a damping effect of 10dB. The output impedance is 75 ohms constant.

The voltage of the sync. output is 1V constant and is obtained via an emitter follower so as to have a low output impedance, 600 ohms. This output may, for example, be used for synchronizing an oscilloscope. 27

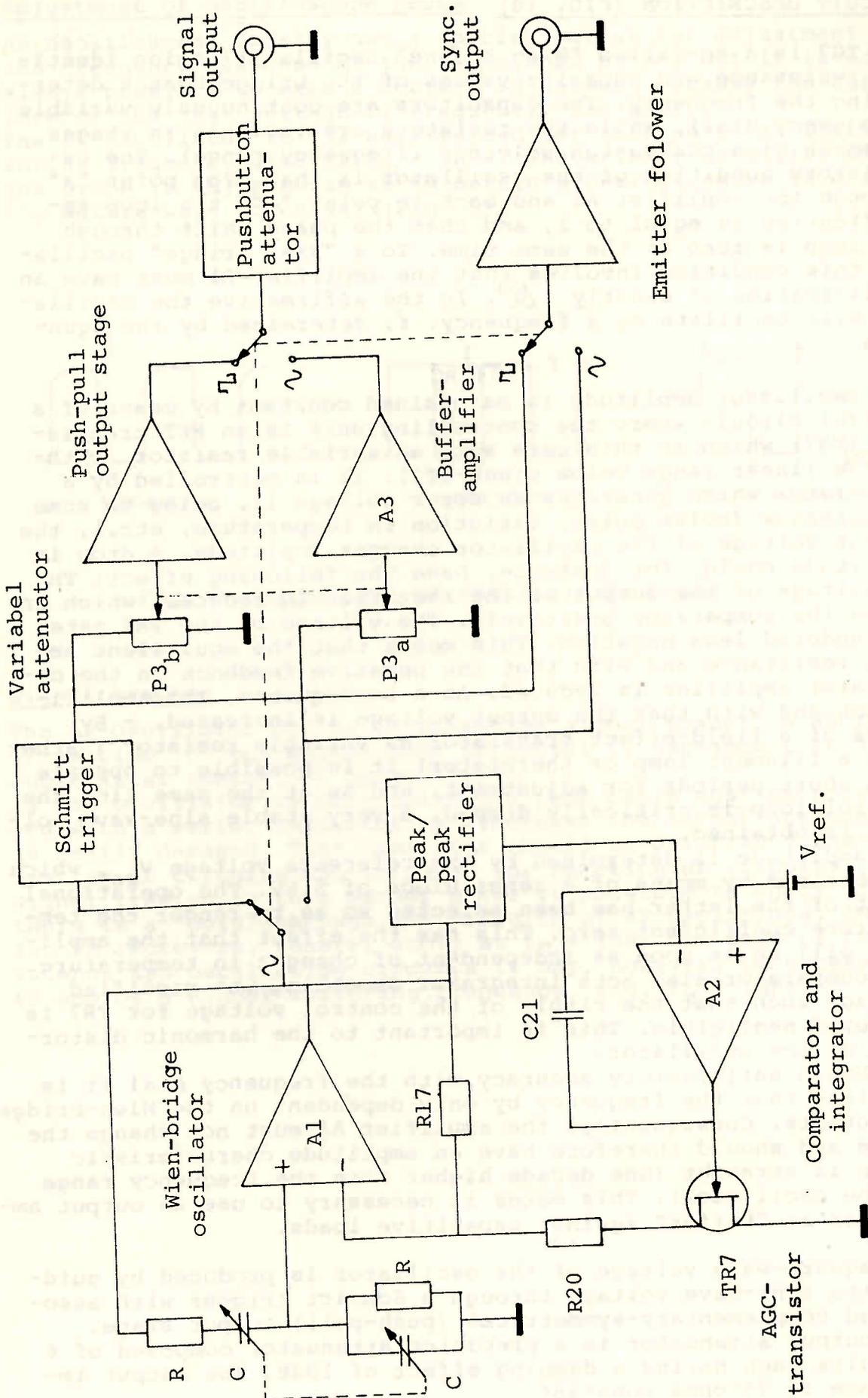


Fig. 10. Block Diagram

CIRCUIT DESCRIPTION (DIAGRAM)

The three amplifiers A1, A2 and A3 (Fig. 10) are based on the same principle. All have high open loop voltage gain >60 dB; they are DC coupled and have three stages. The first stage is a differential amplifier (long-tailed pair), where the negative feedback signal is applied to the inverted input. The second stage further amplifies the signal and changes the DC level so as to be zero on the amplifier output. The third stage is an impedance transformer imparting to the amplifier a low output impedance.

The oscillator amplifier (TR1....TR6) uses field-effect transistors in the differential stage to obtain high input impedance. This is necessary as "R" of the Wien bridge is $30M\Omega$ in the lowest frequency range. The output stage of this amplifier is an emitter follower (TR6).

The comparator amplifier (TR8....TR11) has an operation somewhat different to A1 and A3 as the non-inverted input is subject to a positive DC voltage, V_{ref} . This means that the amplifier is cut off when the induced voltage is lower than the reference voltage. In this state the output voltage is restricted to $+0.6V$ by means of the diode D6. Not until the voltage of the inverted input exceeds V_{ref} does the amplifier operate linearly and as integrator. The integrating effect is produced by the capacitor C21 of the negative feedback loop affecting the input as a capacitor multiplied by the amplification (the so-called Miller effect). In the case of the two lowest frequency ranges, C21 is connected in parallel with an extra capacitor because of the regulation time constant.

The buffer amplifier (TR12...TR19) is provided with a complementary-symmetrical output stage and has negative feedback with resultant gain of 1.6 times.

In the Schmitt trigger (TR20....TR22) the normal common emitter resistor, which produces the regenerative effect, has been replaced by a diode-connected transistor, TR21. Its very low dynamic resistance reduces the hysteresis. The transistor is biased via the resistor R85 and takes care at the same time that the input trigger level is zero. This to ensure a symmetrical square-wave voltage of the output.

ADJUSTMENT

The RC-Oscillator TG7 is designed for long-term operation without requiring adjustment and service. Only in the event of component defects will it under normal conditions be necessary to check and adjust the instrument. In that case the following procedure should be followed:

To be able to make the adjustment, the following instruments are necessary:

- 1) Digital voltmeter, AC/DC, accuracy better than 1%
- 2) Frequency counter, 10Hz....1MHz
- 3) Distortion meter capable of measuring distortion less than 0.03% over frequency range of 10Hz...200KHz.

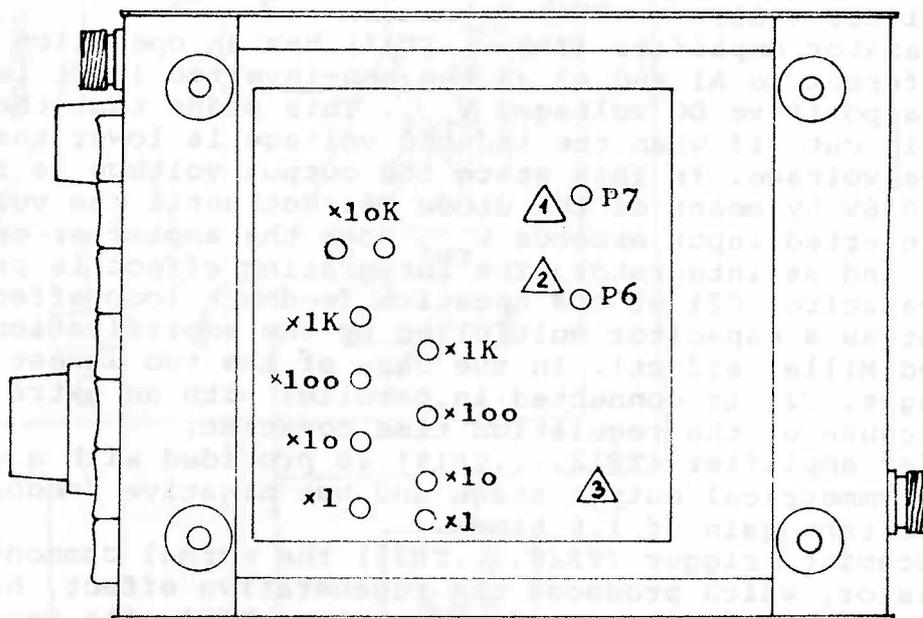
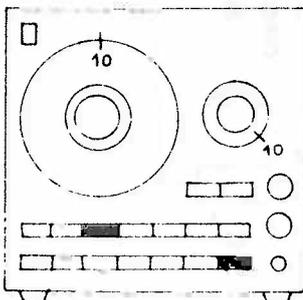


Fig. 11. Adjustment

Power supply

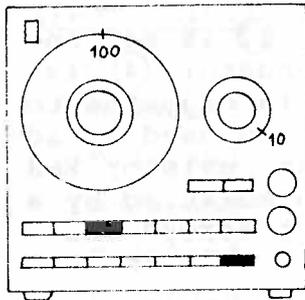
A digital voltmeter is connected to measuring point $\triangle 2$, Fig. 11, and adjustment is made to +12V by means of the potentiometer P6. The same voltmeter is connected to measuring point $\triangle 1$, and the potentiometer P7 is used to make adjustment to -12V. (It may be necessary to correct this adjustment at the square-offset adjustment mentioned later).

Frequency (Cabinet closed, only the bottom plate removed).



The co-axial output $\textcircled{7}$ is connected to a frequency counter. The frequency range selector $\textcircled{1}$ is set on "x100", and the frequency dial $\textcircled{2}$ is set on "10". The pushbutton attenuator $\textcircled{12}$ and the variable attenuator $\textcircled{4}$ are set on max. output voltage (3.16V).

If counter does not show 1KHz, the frequency dial is mechanically adjusted in relation to the spindle of the variable capacitor until

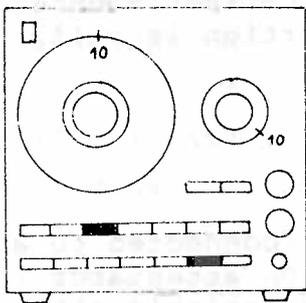


this is the case.

The voltage at measuring point $\triangle 3$ is checked by a voltmeter, about $-1.5V$. The frequency dial $\textcircled{2}$ is set on "100". The two trimmers "x100", Fig. 11, are used to adjust the voltage at measuring point $\triangle 3$ to $-1.5V$, while the frequency is adjusted to 10KHz. The frequency dial $\textcircled{2}$ is set on "10". The frequency is checked, and if it deviates more than $\pm 1\%$ from 1KHz, the above adjustment procedure is repeated.

The frequency range selector $\textcircled{1}$ is set on "x10". The frequency dial $\textcircled{2}$ is set on "100". The two trimmers "x10", Fig. 11, are used to adjust the voltage at measuring point $\triangle 3$ to $-1.5V$, while the frequency is adjusted to 1KHz. The remaining trimmers are adjusted similarly: The "x1" trimmers are adjusted within the "x1" range, the "x1K" trimmers within the "x1K" range, etc.

Sine wave amplitude



The co-axial output $\textcircled{7}$ is connected to a digital voltmeter. The pushbutton attenuator $\textcircled{12}$ is set on "1V". The variable attenuator $\textcircled{4}$ is set on "10". The frequency is adjusted to 1KHz (10Hz x 100). The potentiometer P2, Fig. 12, is used to adjust the output voltage to $1V_{\text{eff}}$.

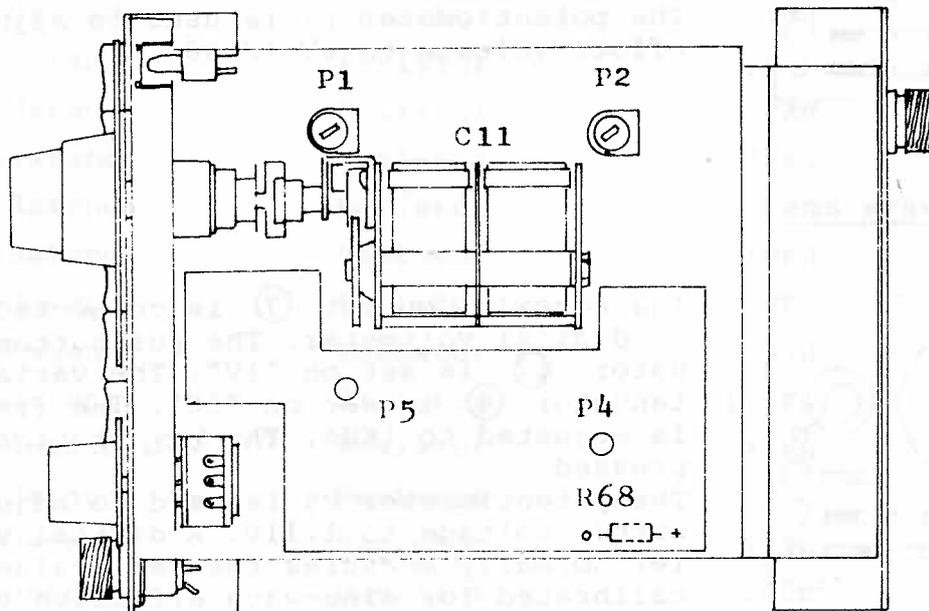
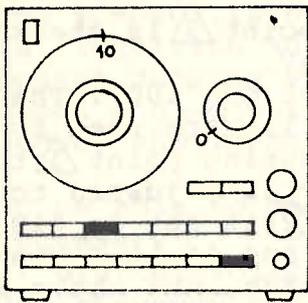


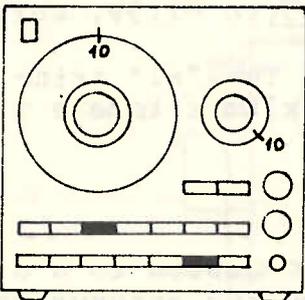
Fig. 12. Adjustment

No-signal current



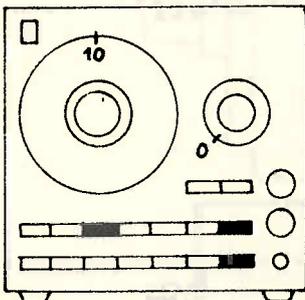
The pushbutton attenuator ⑫ is set on "3.16V". The variable attenuator ④ is set on "0". The frequency is adjusted to 1KHz. The potentiometer P4 is used to adjust the voltage across the resistor R68 to 50mV DC. The voltage is measured by a multimeter connected direct across the resistor.

Distortion



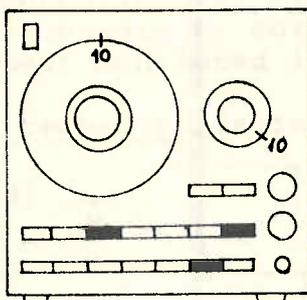
The co-axial output ⑦ is connected to a distortion meter capable of measuring distortion less than 0.03%. The pushbutton attenuator ⑫ is set on "1V". The variable attenuator ④ is set on "10". The frequency is adjusted to 1KHz. The potentiometer P1 is used to adjust to min. distortion. With the cabinet mounted it is checked if the distortion is still less than 0.03%.

Square-wave offset



The co-axial output ⑦ is connected to a DC voltmeter. The pushbutton attenuator ⑫ is set on "3.16V". The variable attenuator ④ is set on "0". The frequency is adjusted to 1KHz. The ν/η -button is depressed. The potentiometer P7 is used to adjust the offset-voltage to 0V +/-50mV.

Square-wave amplitude



The co-axial output ⑦ is connected to an AC digital voltmeter. The pushbutton attenuator ⑫ is set on "1V". The variable attenuator ④ is set on "10". The frequency is adjusted to 1KHz. The ν/η -button is depressed. The potentiometer P5 is used to adjust the output voltage to 1.11V. A digital voltmeter normally measures the mean value and is calibrated for sine-wave effective value, and therefore the shape factor of 1.11 has to be taken into consideration. In case the digital voltmeter measures the effective value, the output voltage is adjusted to 1V.

STYKLISTE (PARTS LIST)

R1		Modstand	Resistor	30,1M Ω	1%	0,5W
R2		Modstand	Resistor	30,1M Ω	1%	0,5W
R3		Modstand	Resistor	3,01M Ω	1%	0,5W
R4		Modstand	Resistor	3,01M Ω	1%	0,5W
R5		Modstand	Resistor	301K Ω	0,5%	0,25W
R6		Modstand	Resistor	301K Ω	0,5%	0,25W
R7		Modstand	Resistor	30,1K Ω	0,5%	0,125W
R8		Modstand	Resistor	30,1K Ω	0,5%	0,125W
R9		Modstand	Resistor	3,01K Ω	0,5%	0,125W
R10		Modstand	Resistor	3,01K Ω	0,5%	0,125W
R11	5001029	Modstand	Resistor	1K Ω	10%	0,5W
R12	5010041	Modstand	Resistor	5,6K Ω	5%	0,125W
R13	5010076	Modstand	Resistor	3,3K Ω	5%	0,125W
R14	5010058	Modstand	Resistor	470 Ω	5%	0,125W
R15	5010070	Modstand	Resistor	390 Ω	5%	0,125W
R16	5010070	Modstand	Resistor	390 Ω	5%	0,125W
R17		Modstand	Resistor	2K Ω	0,5%	0,25W
R18	5001029	Modstand	Resistor	1K Ω	10%	0,5W
R19	5001029	Modstand	Resistor	1K Ω	10%	0,5W
R20		Modstand	Resistor	825 Ω	0,5%	0,25W
R21	5010059	Modstand	Resistor	10K Ω	5%	0,125W
R22		Modstand	Resistor	976 Ω	0,5%	0,25W
R23	5010041	Modstand	Resistor	5,6K Ω	5%	0,125W
R24	5010153	Modstand	Resistor	1,2K Ω	5%	0,125W
R25	5010075	Modstand	Resistor	33K Ω	5%	0,125W
R30	5010061	Modstand	Resistor	56K Ω	5%	0,125W
R31	5010059	Modstand	Resistor	10K Ω	5%	0,125W
R32	5010076	Modstand	Resistor	3,3K Ω	5%	0,125W
R33	5010411	Modstand	Resistor	47 Ω	5%	0,125W
R34	5010247	Modstand	Resistor	1,5K Ω	5%	0,125W
R35	5010045	Modstand	Resistor	47K Ω	5%	0,125W
R36	5001013	Modstand	Resistor	100 Ω	10%	0,5W
R37	5010064	Modstand	Resistor	2,2K Ω	5%	0,125W
R38	5010092	Modstand	Resistor	220 Ω	5%	0,125W
R39	5010041	Modstand	Resistor	5,6K Ω	5%	0,125W
R40	5010247	Modstand	Resistor	1,5K Ω	5%	0,125W
R41	5010059	Modstand	Resistor	10K Ω	5%	0,125W

R42	5010040	Modstand	Resistor	1K Ω	5%	0,125W
R43	5010298	Modstand	Resistor	2,7K Ω	5%	0,125W
R44	5001164	Modstand	Resistor	3,3 Ω	10%	0,5W
R45	5001164	Modstand	Resistor	3,3 Ω	10%	0,5W
R46	5010065	Modstand	Resistor	100 Ω	5%	0,125W
R47	5010059	Modstand	Resistor	10K Ω	5%	0,125W
R50	5001019	Modstand	Resistor	220 Ω	10%	0,5W
R51	5010059	Modstand	Resistor	10K Ω	5%	0,125W
R52	5010247	Modstand	Resistor	1,5K Ω	5%	0,125W
R53	5010058	Modstand	Resistor	470 Ω	5%	0,125W
R54	5010411	Modstand	Resistor	47 Ω	5%	0,125W
R55	5010411	Modstand	Resistor	47 Ω	5%	0,125W
R56	5010247	Modstand	Resistor	1,5K Ω	5%	0,125W
R57	5010247	Modstand	Resistor	1,5K Ω	5%	0,125W
R58	5010058	Modstand	Resistor	470 Ω	5%	0,125W
R59	5001013	Modstand	Resistor	100 Ω	10%	0,5W
R60	5010058	Modstand	Resistor	470 Ω	5%	0,125W
R61	5010247	Modstand	Resistor	1,5K Ω	5%	0,125W
R62	5010247	Modstand	Resistor	1,5K Ω	5%	0,125W
R63	5010059	Modstand	Resistor	10K Ω	5%	0,125W
R64	5010247	Modstand	Resistor	1,5K Ω	5%	0,125W
R65	5010058	Modstand	Resistor	470 Ω	5%	0,125W
R66	5001013	Modstand	Resistor	100 Ω	10%	0,5W
R67	5001013	Modstand	Resistor	100 Ω	10%	0,5W
R68		Modstand	Resistor	10 Ω	5%	0,125W
R69		Modstand	Resistor	10 Ω	5%	0,125W
R70	5010067	Modstand	Resistor	560 Ω	5%	0,125W
R71	5010040	Modstand	Resistor	1K Ω	5%	0,125W
R72		Modstand	Resistor	75 Ω	0,5%	0,25W
R73	5001164	Modstand	Resistor	3,3 Ω	10%	0,5W
R74	5001164	Modstand	Resistor	3,3 Ω	10%	0,5W
R75	5001164	Modstand	Resistor	3,3 Ω	10%	0,5W
R76	5001164	Modstand	Resistor	3,3 Ω	10%	0,5W
R80	5001029	Modstand	Resistor	1K Ω	10%	0,5W
R81	5010068	Modstand	Resistor	820 Ω	5%	0,125W
R82	5010041	Modstand	Resistor	5,6K Ω	5%	0,125W
R83	5010153	Modstand	Resistor	1,2K Ω	5%	0,125W
R84	5010144	Modstand	Resistor	680 Ω	5%	0,125W
R85	5010064	Modstand	Resistor	2,2K Ω	5%	0,125W

R86	5010053	Modstand	Resistor	15K Ω	5%	0,125W
R87	5001013	Modstand	Resistor	100 Ω	10%	0,5W
R88	5010153	Modstand	Resistor	1,2K Ω	5%	0,125W
R89	5010064	Modstand	Resistor	2,2K Ω	5%	0,125W
R90	5010153	Modstand	Resistor	1,2K Ω	5%	0,125W
R91	5010041	Modstand	Resistor	5,6K Ω	5%	0,125W
R92	5001013	Modstand	Resistor	100 Ω	10%	0,5W
R93	5001013	Modstand	Resistor	100 Ω	10%	0,5W
R94	5010041	Modstand	Resistor	5,6K Ω	5%	0,125W
R95	5010151	Modstand	Resistor	56 Ω	5%	0,125W
R96	5010468	Modstand	Resistor	15 Ω	5%	0,125W
R97	5010468	Modstand	Resistor	15 Ω	5%	0,125W
R98	5001164	Modstand	Resistor	3,3 Ω	10%	0,5W
R99	5001164	Modstand	Resistor	3,3 Ω	10%	0,5W
R100	5001164	Modstand	Resistor	3,3 Ω	10%	0,5W
R101	5001164	Modstand	Resistor	3,3 Ω	10%	0,5W
R102	5010052	Modstand	Resistor	6,8K Ω	5%	0,125W
R110	5001013	Modstand	Resistor	100 Ω	10%	0,5W
R111	5010144	Modstand	Resistor	680 Ω	5%	0,125W
R112	5010144	Modstand	Resistor	680 Ω	5%	0,125W
R113	5010000	Modstand	Resistor	270 Ω	5%	0,125W
R114	5001029	Modstand	Resistor	1K Ω	10%	0,5W
R120	5010040	Modstand	Resistor	1K Ω	5%	0,125W
R121	5010153	Modstand	Resistor	1,2K Ω	5%	0,125W
R122	5010040	Modstand	Resistor	1K Ω	5%	0,125W
R123	5010044	Modstand	Resistor	330 Ω	5%	0,125W
R124	5010044	Modstand	Resistor	330 Ω	5%	0,125W
R125	5010040	Modstand	Resistor	1K Ω	5%	0,125W
R126	5010153	Modstand	Resistor	1,2K Ω	5%	0,125W
R127	5010040	Modstand	Resistor	1K Ω	5%	0,125W
R128	5010044	Modstand	Resistor	330 Ω	5%	0,125W
R129	5010044	Modstand	Resistor	330 Ω	5%	0,125W
R140		Modstand	Resistor	129 Ω	0,5%	0,25W
R141		Modstand	Resistor	102 Ω	0,5%	0,25W
R142		Modstand	Resistor	287 Ω	0,5%	0,25W
R143		Modstand	Resistor	215,7 Ω	0,5%	0,25W
R144		Modstand	Resistor	215,7 Ω	0,5%	0,25W
R145		Modstand	Resistor	215,7 Ω	0,5%	0,25W
R146		Modstand	Resistor	215,7 Ω	0,5%	0,25W

R147	Modstand	Resistor	215,7 Ω	0,5%	0,25W
R148	Modstand	Resistor	145 Ω	0,5%	0,25W
R149	Modstand	Resistor	145 Ω	0,5%	0,25W
R150	Modstand	Resistor	145 Ω	0,5%	0,25W
R151	Modstand	Resistor	145 Ω	0,5%	0,25W
R152	Modstand	Resistor	98,8 Ω	0,5%	0,25W
R153	5010152 Modstand	Resistor	75 Ω	5%	0,33W
P1	5370068 Potentiometer	Potentiometer	25K Ω lin.	20%	0,1W
P2	5370074 Potentiometer	Potentiometer	10K Ω lin.	20%	0,1W
P3	5310050 Potentiometer	Potentiometer	2x1K Ω lin.	0,5dB	
P4	5370006 Potentiometer	Potentiometer	2K Ω lin.	20%	0,1W
P5	5370002 Potentiometer	Potentiometer	500 Ω lin.	20%	0,1W
P6	5370002 Potentiometer	Potentiometer	500 Ω lin.	20%	0,1W
P7	5370002 Potentiometer	Potentiometer	500 Ω lin.	20%	0,1W
C1	4340002 Trimmekondensator	Capacitor, trimmer		20pF	
C2	4340002 Trimmekondensator	Capacitor, trimmer		20pF	
C3	4340002 Trimmekondensator	Capacitor, trimmer		20pF	
C4	4340002 Trimmekondensator	Capacitor, trimmer		20pF	
C5	4340002 Trimmekondensator	Capacitor, trimmer		20pF	
C6	4340002 Trimmekondensator	Capacitor, trimmer		20pF	
C7	4340002 Trimmekondensator	Capacitor, trimmer		20pF	
C8	4340002 Trimmekondensator	Capacitor, trimmer		20pF	
C9	4340002 Trimmekondensator	Capacitor, trimmer		20pF	
C10	Kondensator, keram.	Capacitor, ceramic		2,2pF	100V
C11	4310010 Drejekondensator	Capacitor, variable		2x518pF	
C12	4000008 Kondensator, keram.	Capacitor, ceramic		18pF	63V
C13	4030010 Kondensator, keram.	Capacitor, ceramic		0,1 μ F	12V
C14	4200010 Elektrolytkond.	Capacitor, electrolytic		10 μ F	16V
C15	4200035 Elektrolytkond.	Capacitor, electrolytic		100 μ F	6,4V
C16	4010060 Kondensator, keram.	Capacitor, ceramic		22nF	40V
C17	4010060 Kondensator, keram.	Capacitor, ceramic		22nF	40V
C18	4010060 Kondensator, keram.	Capacitor, ceramic		22nF	40V
C19	4030010 Kondensator, keram.	Capacitor, ceramic		0,1 μ F	12V
C20	4030010 Kondensator, keram.	Capacitor, ceramic		0,1 μ F	12V
C21	4200010 Elektrolytkond.	Capacitor, electrolytic		10 μ F	16V
C22	4200035 Elektrolytkond.	Capacitor, electrolytic		100 μ F	6,4V
C23	4201022 Elektrolytkond.	Capacitor, electrolytic		32 μ F	40V

C24	4200067	Elektrolytkond.	Capacitor, electrolytic	200 μ F	10V
C25	4201024	Elektrolytkond.	Capacitor, electrolytic	50 μ F	40V
C26	4340002	Trimmekondensator	Capacitor, trimmer	20pF	
C30	4011022	Kondensator, keram.	Capacitor, ceramic	4,7nF	40V
C31	4011022	Kondensator, keram.	Capacitor, ceramic	4,7nF	40V
C32	4130029	Kondensator	Capacitor	0,47 μ F	250V
C33	4130029	Kondensator	Capacitor	0,47 μ F	250V
C34	4003130	Kondensator, keram.	Capacitor, ceramic	47pF	63V
C40	4003130	Kondensator, keram.	Capacitor, ceramic	47pF	63V
C41	4200084	Elektrolytkond.	Capacitor, electrolytic	400 μ F	4V
C42	4130029	Kondensator	Capacitor	0,47 μ F	250V
C43	4130029	Kondensator	Capacitor	0,47 μ F	250V
C50	4200076	Elektrolytkond.	Capacitor, electrolytic	500 μ F	2,5V
C51	4200067	Elektrolytkond.	Capacitor, electrolytic	200 μ F	10V
C60	4200042	Elektrolytkond.	Capacitor, electrolytic	125 μ F	16V
C61	4201007	Elektrolytkond.	Capacitor, electrolytic	4 μ F	40V
C62	4011022	Kondensator, keram.	Capacitor, ceramic	4,7nF	40V
C63		Elektrolytkond.	Capacitor, electrolytic	1000 μ F	25V
C64	4200042	Elektrolytkond.	Capacitor, electrolytic	125 μ F	16V
C65	4011014	Kondensator, keram.	Capacitor, ceramic	4,7nF	400V
C66	4011014	Kondensator, keram.	Capacitor, ceramic	4,7nF	400V
C67	4200042	Elektrolytkond.	Capacitor, electrolytic	125 μ F	16V
C68	4201007	Elektrolytkond.	Capacitor, electrolytic	4 μ F	40V
C69	4011022	Kondensator, keram.	Capacitor, ceramic	4,7nF	40V
C70		Elektrolytkond.	Capacitor, electrolytic	1000 μ F	25V
C71	4200042	Elektrolytkond.	Capacitor, electrolytic	125 μ F	16V
C80	4010029	Kondensator, keram.	Capacitor, ceramic	180pF	100V
D1	8300058	Diode	Diode	1N4148	
D2	8300058	Diode	Diode	1N4148	
D3	8300142	Diode	Diode	AA143	
D4	8300142	Diode	Diode	AA143	
D5	8300128	Zenerdiode	Diode, zener	ZF5,6	
D6	8300058	Diode	Diode	1N4148	
D7	8300154	Zenerdiode	Diode, zener	ZF6,8	
D8	8300058	Diode	Diode	1N4148	
D9	8300058	Diode	Diode	1N4148	
D10	8300128	Zenerdiode	Diode, zener	ZF5,6	
D11	8300128	Zenerdiode	Diode, zener	ZF5,6	
D12	8310028	Ensretter	Rectifier	B30C300	

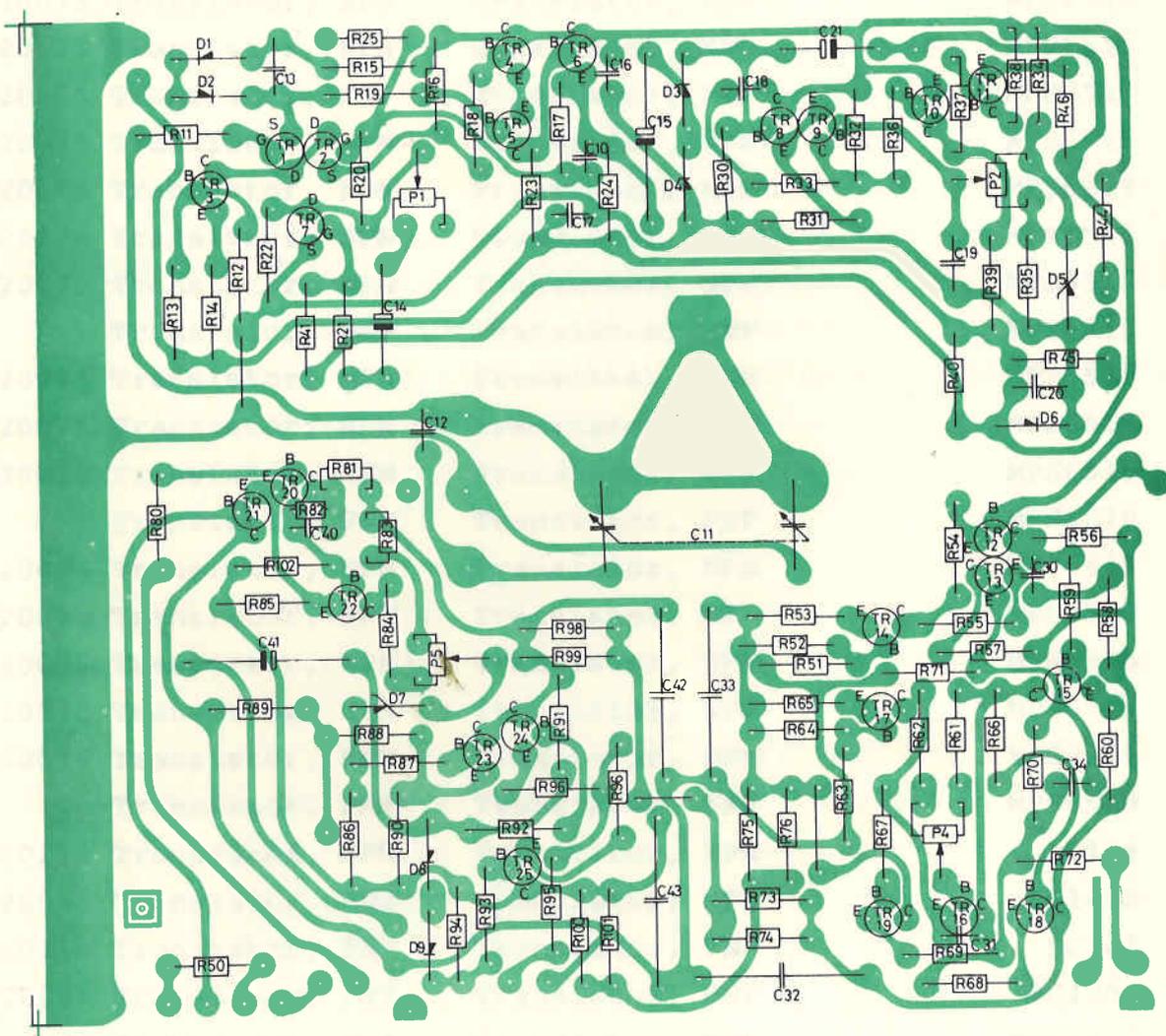
TR1	8320119	Transistor, FET	Transistor, FET	TIS88
TR2	8320119	Transistor, FET	Transistor, FET	TIS88
TR3	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR4	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR5		Transistor, PNP	Transistor, PNP	MPS6519
TR6	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR7		Transistor, FET	Transistor, FET	BF244C
TR8	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR9	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR10	8320076	Transistor, PNP	Transistor, PNP	MPS6517
TR11	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR12	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR13	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR14	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR15		Transistor, PNP	Transistor, PNP	MPS6519
TR16	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR17	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR18	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR19		Transistor, PNP	Transistor, PNP	MPS6519
TR20	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR21	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR22	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR23	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR24	8320075	Transistor, NPN	Transistor, NPN	MPS6515
TR25		Transistor, PNP	Transistor, PNP	MPS6519
TR26	8320124	Transistor, NPN	Transistor, NPN	BC119
TR27	8320095	Transistor, NPN	Transistor, NPN	BC149B
TR28	8320118	Transistor, PNP	Transistor, PNP	BC143
TR29	8320069	Transistor, PNP	Transistor, PNP	BC159B
TR30	8320075	Transistor, NPN	Transistor, NPN	MPS6515

	2755008	Mikrodrev, komplet	Micro drive, complete	
	6271086	Netledning, komplet	Power-cord, complete	
T1	8013105	Nettransformer	Power transformer	2x12,6V/0,2A
	7450014	Netafbryder	Power Switch	
F1		Sikring, træg	Fuse, slow	80mA
	7212007	Stikdåse, L/R	Socket, L/R	
	8230023	Lampe	Lamp	12V-30mA
	7201016	Lampefatning	Lamp Socket	

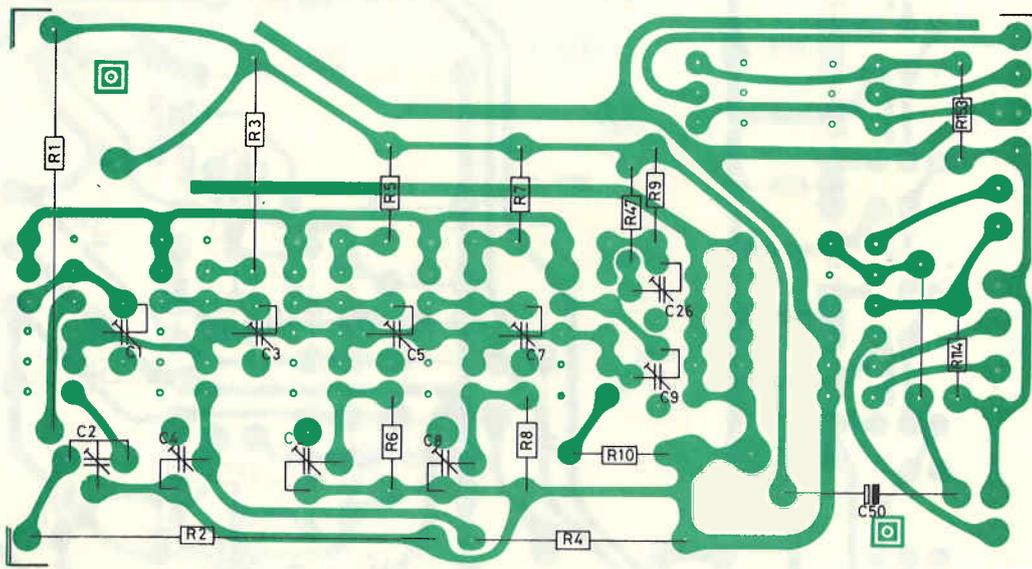
7401001	Omskifter, netspænding	Switch, mains
7400066	Omskifter,funktion	Switch, function
7400067	Omskifter, attenuator	Switch, attenuator
7400068	Omskifter, L/R	Switch, L/R
6270164	Kabel UHF/2xbanan	Cable UHF/2xbanana
0961014	Kabel 5-pol. DIN/ 5-pol.DIN	Cable 5-pol. DIN/ 5 pol. DIN



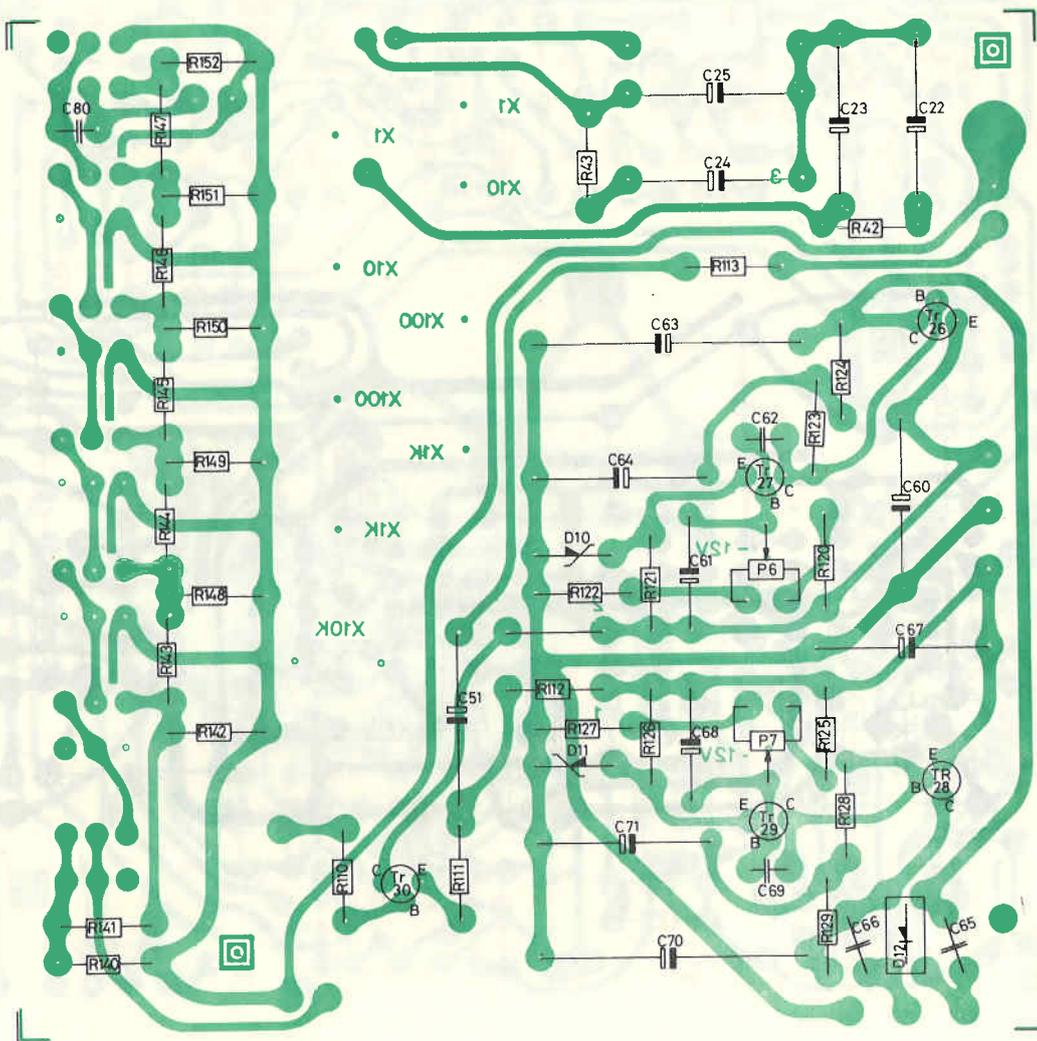
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Komponentplacering, oscillator
 Component location, oscillator

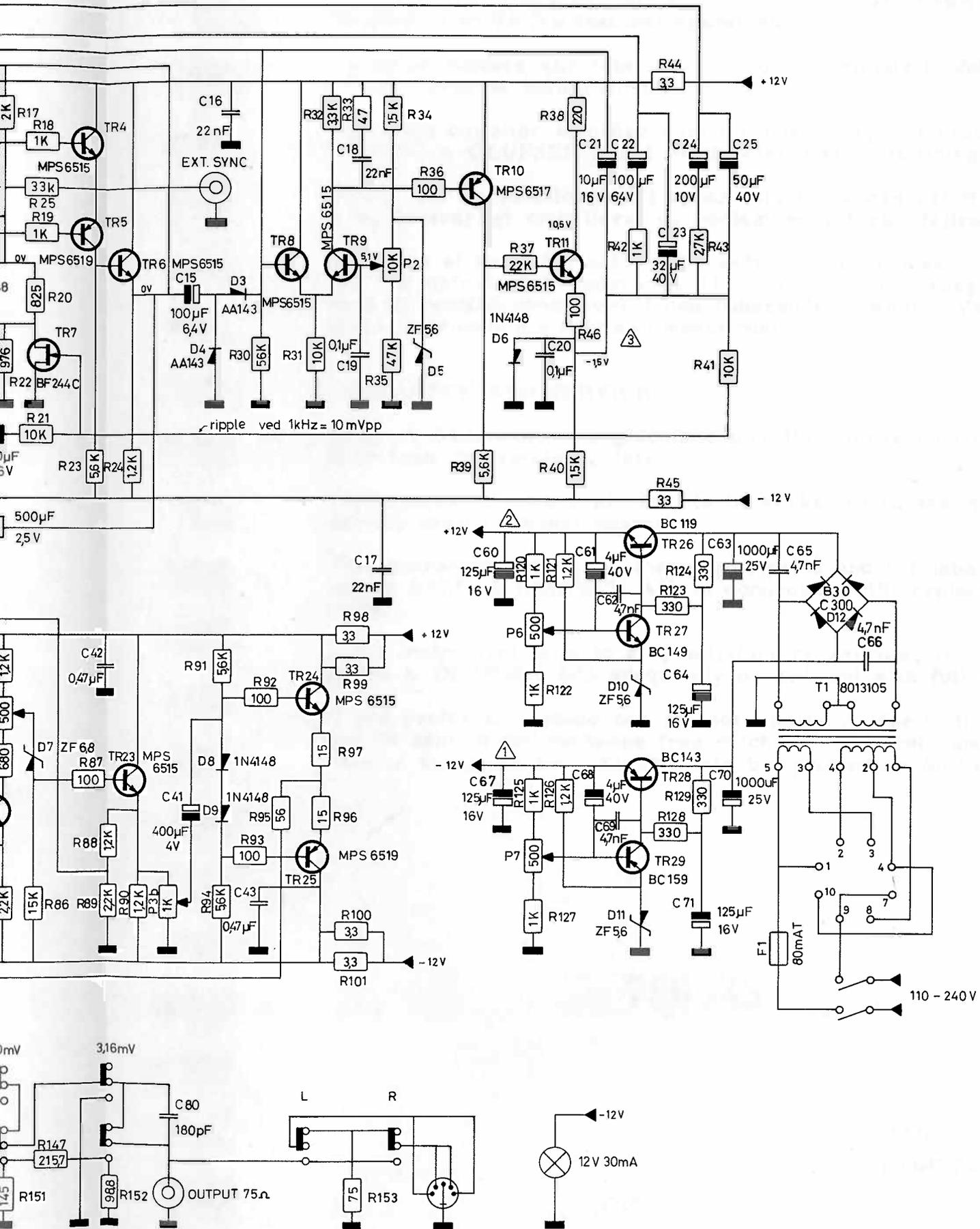


Komponentplacering, frekvensområde-omskifter
 Component Location, Frequency range selector



Komponentplacering, netdel/attenuator
 Component Location, power supply/attenuator





X1 X10 X100 X1K X10K

