It is conductive if the signal received from a transmitting station is low. At high signal levels, however, the diode is reverse biased by the IF-control voltage (reversing of the switching voltage). By this measure the antenna signal is stepped down by a voltage divider consisting of the 560 Ω-resistor and the transformed input impedance at L_2. Thus the permissible r.f.-levels at the antenna input are in order of some V_{pp}. The oscillator is tuned by the third system of the BB113. The 100 pF-capacitor, required for the tuning range as well as for the tracking, takes positive effect to the stability of the tuning voltage due to the fact that the characteristic curve of the BB113 becomes less steep. In addition to that higher input signal levels are permissible at low frequencies, because of the capacitive division at the high-impedance end of the circuit. The oscillator transistor is run with grounded emitter connection and is overdriven in the way that a voltage with a limited, nearly rectangled amplitude is available at its collector. At the tuned circuit, however, the amplitude is sinusoidal, since it is weakly coupled to the collector by a RC-circuit. The oscillator voltage for the mixer is coupled out at the non-bridged part of the emitter resistor and a sinusoidal oscillation with nearly constant amplitude and low internal impedance is achieved (inverse feedback for the mixer).

The frequency range of 5.8 to 10.5 MHz includes the 49-m-band (6 to 6.2 MHz), the 41-m-band (7.2 to 7.3 MHz) and the 31-m-band (9.5 to 9.7 MHz).

Due to the wide tuning range it is recomended to use an electronic magnifier with an additional potentiometer of, e.g., 500 Ω, connected to the tuning potentiometer of 50 kΩ (at the upper end)

The table below indicates the results of a test with a sample board.

f_{in} MHz	R_{in} Ω	G_p db	V_{in} max (m=30%) for k_{AF}=10% mV_{pp} D1 conductive	D1 non conductive	V_{osc} mV_{pp} (base mixer)	$-V_{tuning}$ V	$-V_{tuning}$ for Δf_{osc} = 1 kHz mV	stability of tuning voltage refered to 30 V in ‰
6	45	10	170	3700	300	1.54	5.1	3.3
8	67	11.1	170	4400	350	12.58	9.4	0.75
10	85	12.3	160	2500	300	22.76	29.2	1.28

Technical data:

Supply voltage V_S = 30 V
Total supply current I_{tot} = 20 mA
Tuning voltage V_{tun} = 0.5 to 30 V
Switching voltage for BA182 V_{switch} = ±30 V

Coil data:

L_1 = antenna coupling 60 Ω
8 turns, CuL, 0.12 m ⌀
L_1/L_2-distance = 5 mm
L_2 = r.f.-circuit, 26 turns, 12×0.05 Cu LS
L_2/L_3-distance = 3 mm
L_3 = r.f.-coupling, 2 turns, CuL, 0.25 mm ⌀

Coil formers:

⌀ 5 mm, core 20 K 12, 10 to 20 mm long
L_4 = oscillator circuit, 25 turns, 15×0.05 Cu LS
L_5 = oscillator feedback, 5 turns, Cu L, 0.12 mm ⌀
1×Vogt filter kit D 41-2520
L_7 = 1st. band-pass circuit, 85 turns, 12×0.04 Cu LS
L_8 = 2nd band-pass circuit, 85 turns, 12×0.04 Cu LS
2× Vogt filter kit D 41-2519

1.3 Antenna-amplifier with BFT 12 for FM-range

The only way to improve the reception of FM-signals or particularly of stereo FM-signals under disadvantageous receiving conditions is to amplify the antenna signal. This should be made directly at the antenna, since the loss is increased meter by meter of any cable. In most cases higher line attenuations can be expected than usually calculated. Even receivers with an additional noise figure of zero do not show any improvements of the signal-to-noise ratio becomes too low because of a long transmission line. Therefore it is practically useless to require extremely low noise figures only for the receivers.

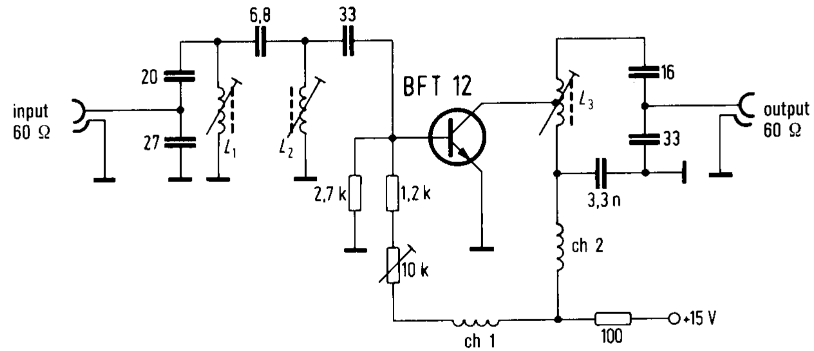


Fig. 1.3

To avoid interferences of signals received from stations of other bands it is propitious to amplify the FM-band only. The band amplifier shown in **Fig. 1.3** is connected directly to the 60-Ω-output of the FM-antenna, i.e. it is placed at the top of the antenna pole. The matching is achieved by the input band-pass connected to the base of transistor BFT12, being a typically linear silicon transistor for broadband amplifiers. The output filter matched accordingly to a 60-Ω-coaxial line is connected to the collector. The operating voltage of 15 V can be supplied by the coaxial line.

Technical data:

Power gain G_p = 22 db
Noise figure F = 3.5–4.0 db or 2.2–2.5 KT_o
Input and output reflexion coefficient $|r_i|$ and $|r_o| \leqq 0.3$
$d_{im\ (60\ db)}$ at V_{out} = 680 mV
$d_{im\ (50\ db)}$ at V_{out} = 1000 mV

Optimum operating point of minimum intermodulation
$I_C \approx 80$ mA $V_{CE} \approx 7$–7.5 V
Supply voltage 15 V

Coil data:

Vogt coil former, ordering code: Sp 3.5/16.6–2048C
Core: U17

L_1: 5 turns Cu 0.6 mm ⌀
L_2: 3 turns Cu 0.6 mm ⌀
L_3: 3+2 turns Cu 0.6 mm ⌀
Choke Ch_1 = Ch_2: 20 turns Cu L 0.3 mm ⌀, cross section of winding = 4 mm

1.4 Three-stage broadband antenna amplifier with BFT 12

Fig. 1.4 shows a design example of a three-stage broadband amplifier using the latest UHF-broadband-transistor BFT 12, offering a high gain. Intermodulation and noise figure conclude from the wide dynamic range of this output-stage transistor, which is linear already at power dissipations of 0.5 W. The special T-plastic-case meets all requirements according to r.f.-parameters, heat abstraction and economy. With the sample board a thermal resistance of R_{th} = 120 K/W is achieved. With respect to the special measures taken to guarantee a high reliability this transistor BFT 12 applies also to all requirements of professional circuits.

All three stages of the broadband amplifier are equipped with the BFT 12 and are similar in design on principle. The circuit consisting of transistor T_4 and T_5 controls the operating point of the first stage with T_1. The base of transistor T_1 is connected to the emitter of the common-emitter circuit T_4 via the choke ch_1. The source impedance of the common-emitter circuit is 3 to 4 Ω. The combination of the capacitor C_2 and the choke ch_2 connected to the emitter of T_1 has the response of a low-pass filter with a low impedance for the video-frequency range. Both measures reduce the beginning of unwanted mixing frequencies, increase the obtainable output voltage V_{out} with reference to a given intermodulation distance and improve the dynamic range of the amplifier.

If a composition of different signals is amplified, non-linear components (e.g. transistors) will generate interferences like cross modulation and intermodulation. In general these interferences are derived from the third-power part of a mathematical series expansion for the transfer characteristic. However, it has been experienced that interferences created by the part of second power are superimposed to the above mentioned ones. Interferences appear at common-emitter circuits. They are generated the base and collector by the second-power part of the characteristic and they can be reduced by low-ohmic impedances in the total video range. Thus the modulation of signals by these interferences is diminished and the cross modulation as well as the intermodulation behaviour is improved.

At relatively low power dissipation, but high power gain and linearity, the new r.f. broadband transistor BFT 12 can be used without any problems. Besides that if offers an optimum economy.

Electrical characteristics of the UHF-broadband-amplifier

Supply voltage	V_S = 13.5 V
Supply current	I = 205 mA
Number of amplifier stages	n = 3
Frequency range	20 to 860 MHz
Power gain (at R_g = R_L = 60 Ω and f = 800 MHz)	G_p = 24 db
Noise figure (at R_g = R_L = 60 Ω and f = 800 MHz)	F = 7.5 db
Output voltage (at R_g = R_L = 60 Ω and f = 800 MHz, d_{im} = 60 db, according to method of two transmitters)	V_{out} = 400 mV

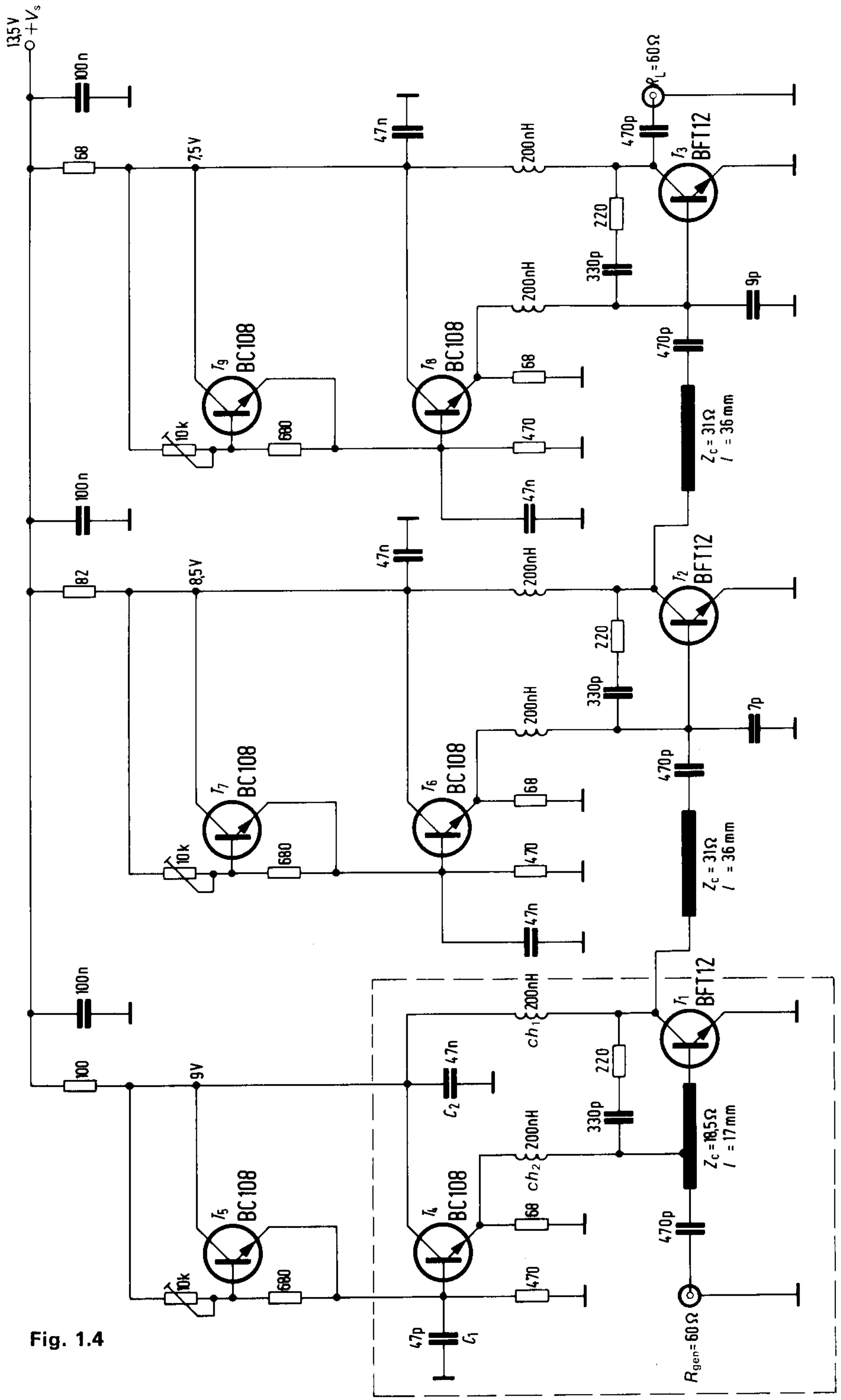


Fig. 1.4

1.5 Two-stage broadband amplifier from 1 to 1000 MHz using BFT 65

The excellent high frequency characteristics of the UHF-silicon-transistor BFT65 as low-distortion, low noise figure and high stage gain are demonstrated by the following application example of a two-stage broadband amplifier (**fig. 1.5**).

The broadband amplifier consisting of two BFT65 is mounted on a copper-faced pc board with the dimensions of 50×50 mm. In the frequency range of 1 to 1000 MHz a gain of 20 db is attained at a noise figure of 5 db. The output voltage is 130 mV at an intermodulation loss of 60 db. The first transistor T_1 operates with a collector current of 8 mA and the second one with 20 mA.

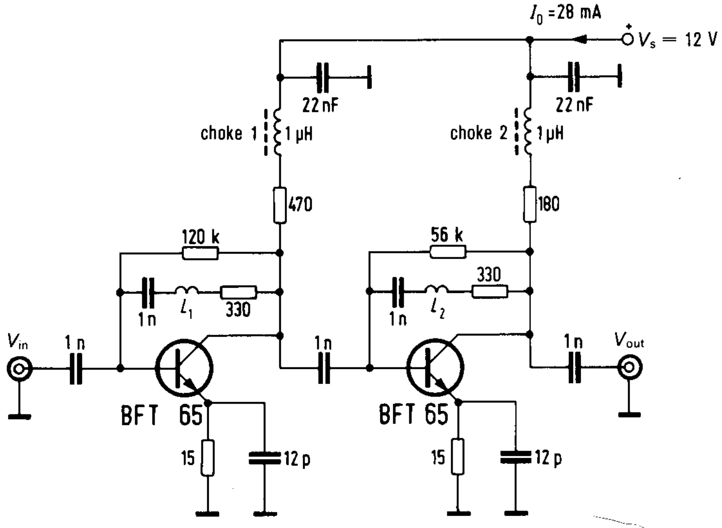


Fig. 1.5

The broadband gain response is achieved by the emitter resistor of 15 Ω.

To avoid an additional decrease of gain by inverse feedback of the emitter inductance in the upper frequency range, the inverse feedback combination consisting of 15 Ω ‖ 12 pF must have a low inductance. Therefore the emitter capacitors are proportioned so that the increasing influence of the emitter inductance is compensated at frequencies higher than 500 MHz.

The impedance matching of the input and output of each stage is achieved by a parallel feedback resistor of 300 Ω. The inductances L_1 and L_2 compensate the phase response of the resulting feedback in the frequency range >600 MHz in such a manner that the impedances are matched even if the input conductances of the transistors increase.

Characteristics

Supply voltage	V_S = 12 V
Supply current	I_S = about 28 mA
Power gain (1 to 1000 MHz, $R_g = R_L$ = 60 Ω)	G_p > 20 db
Noise figure (1 to 1000 MHz, $R_g = R_L$ = 60 Ω)	F < 5 db

Standing wave ratio (1 to 1000 MHz, $R_g = R_L$ = 60 Ω)	S<2
Output voltage (f = 800 MHz, $R_g = R_L$ = 60 Ω)	V_{out} = 130 mV
Attenuation of intermodulation	d_{im}> 60 db

T_1, T_2	BFT 65
Ch_1, Ch_2	Choke, 2 turns, CuL 0.25 mm ⌀, on double aperture core, B62152-A0007-X001
L_1, L_2	the terminal wires of resistors R_2, R_6 are wound to coils with about three turns having a cross section of 25 mm ⌀
1 nF	30 V disc capacitor
22 nF	30 V disc capacitor
12 pF	trapezoidal disc capacitor
15 Ω	low-inductance resistor (metal film)

1.6 Three-stage broadband amplifier for a frequency range of 30 to 900 MHz with BFR 34 and BFS 55

The ability of modern silicon r.f.-transistors is demonstrated in the following application of a broadband amplifier using a standard circuit.

The following electrical data were achieved:

Gain	32 db
Noise figure	5 db
Output voltage	105 mV
$d_{IM\ II}$	60 db

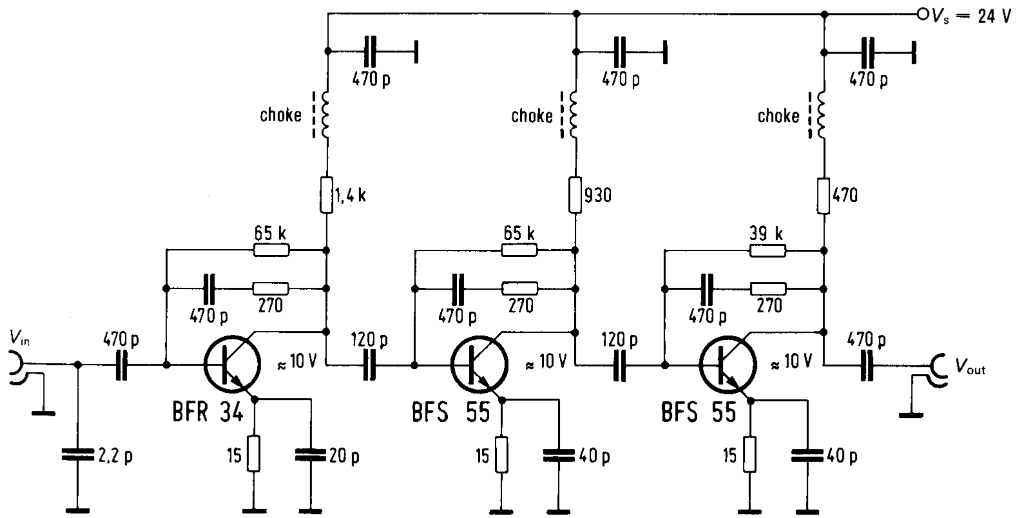


Fig. 1.6

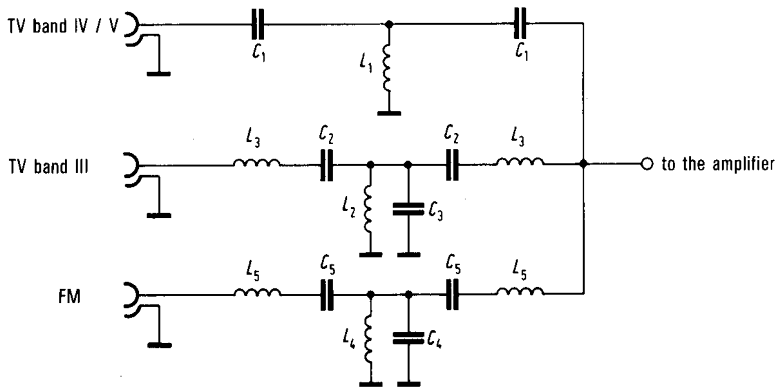
The amplifier is mounted on a pc board (glassfiber reinforced epoxy) with the dimensions of 60×80 mm and uses the transistors BFR 34 and 2× BFS 55. The supply voltage is 24 V. The amplifier consists of RC-coupled common-emitter circuits and has a negative feedback. The series and parallel feedback circuit has to perform two functions.

a) nearly to linearize the gain response over the frequency range and

b) to match the input and output impedances of the amplifier to the ones of the signal source respectively of the load.

The circuit is dimensioned in such a manner that its influence is reduced at higher frequencies. The transistor BFR 34 operates at V_{CE} = 5 V and I_C = 10 mA.

The average gain is about 32 db, whereat the one of the prestage is about 11 db. A noise figure of < 5 db is achieved at a frequency f = 800 MHz. Another performance of the BFR 34 is that the basic noise is independent of the current. Particularly at large signal operation this feature is of noticeable advantage, since the maximum distortions take place in the range of higher collector currents. An output voltage of 105 mV is attainable for the three-stage amplifier at 800 MHz and at an intermodulation loss of 60 db (simulated SSB test method). Additional frequency separating networks obtain the decoupling of the inputs required for antenna amplifiers with different ranges. The network shown in **fig. 1.6.1** is dimensioned for the FM-range, the TV-band III and the TV-band IV/V.



C_1 = 3.3 pF	L_1 = 3 turns	
C_2 = 8.2 pF	L_2 = 4 turns	
C_3 = 22 pF	L_3 = 8.5 turns	core ⌀ 2.5 mm, 0.7 mm ⌀ CuL
C_4 = 90 pF	L_4 = 12 turns	
C_5 = 47 pF	L_5 = 13 turns	

Fig. 1.6.1

1.7 Interference-immune FM- tuner

The following FM-tuner shown in **fig. 1.7** has been designed with special respect to interference immunity, narrow bandwidth, sufficiently low noise factor and good oscillator stability.

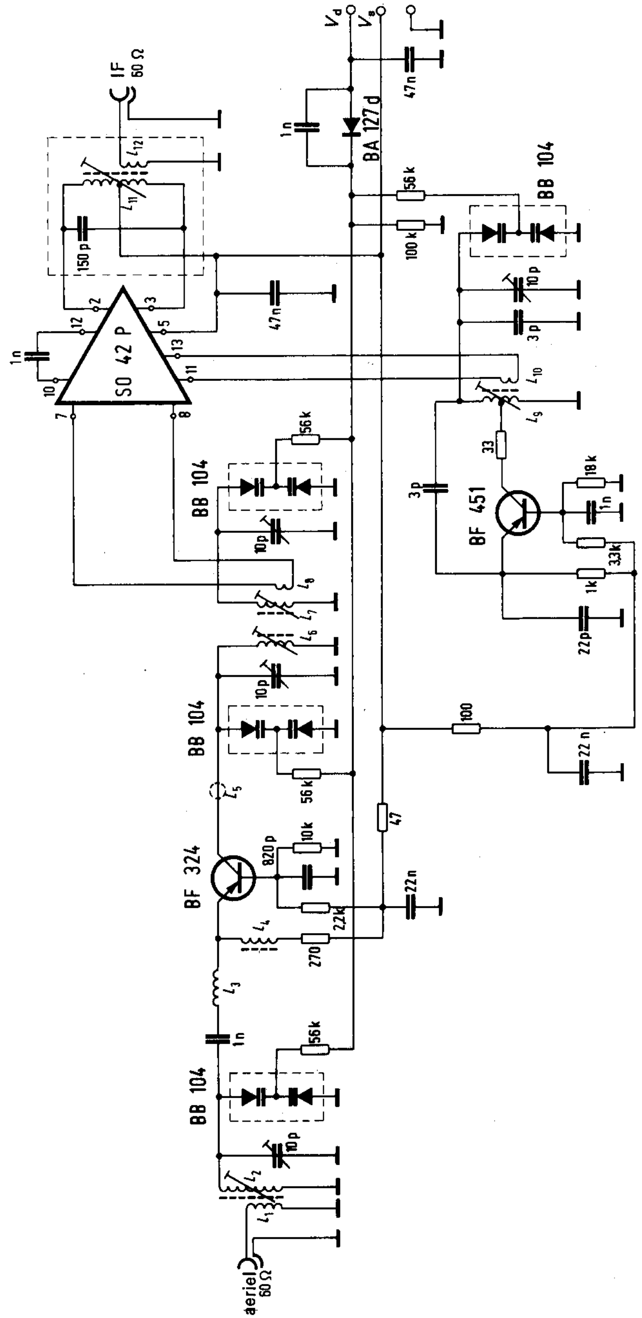


Fig. 1.7

The RF-input circuit is tuned by the double-capacitance diode BB 104, being in push-pull operation. With special respect to optimum noise figure it is matched to the pre-stage transistor BF 324 by L_3. The bandwidth of the r.f.-band-pass is adjusted in the way that the total noise figure does not exceed 5 db. The operating point chosen for the BF 324 achieves a good interference immunity at a sufficiently low noise figure of the transistor. Possible UHF-oscillations of the front end are suppressed by a ferrite bead and an accurate grounding of the base.

The ring mixer S 042 P can be coupled very weakly to the r.f.-band-pass filter due to its extremely low noise figure. Thus a very good selectivity of the mixing stage is achieved. Besides that the level at the mixer input is kept low, whereby the generation of interference mixing products is reduced.

A 33-Ω-resistor is connected to the collector of the oscillator transistor BF 451. Thus UHF-oscillations are prevented and the content of harmonics is minimized.

On account of the symmetrical wiring of the S 042 P and the separating stages with transistors operating at impressed currents the feedback of the RF-input signal to the oscillator is negligible. The oscillator frequency-detuning is less than 10 kHz at RF-input signals up to 3 V.

Characteristics

Supply voltage	12 V
Supply current	9.5 mA
Tuning voltage	4 to 25 V
Input impedance	60 Ω
Output impedance	60 Ω
Power gain	27 db
RF-bandwidth	1.1 to 1.2 MHz
IF-bandwidth	400 kHz
Noise figure	5 db
Temperature drift of oscillator	< 1.5 kHz/K
Oscillator frequency-detuning over RF-input voltage	< 10 kHz to V_{in} = 3 V

Coil data:

L_1	2 turns	0.5 mm ⌀ CuL	
L_2	6 turns	0.8 mm ⌀ CuAg	
L_3	12 turns	0.2 mm ⌀ CuL	
L_4	18 turns	0.2 mm ⌀ CuL	
L_5	ferrite bead	B62110 K12 3.5×1.6×6	
L_6	5 turns	0.8 mm ⌀ CuAg	
L_7	5 turns	0.8 mm ⌀ CuAg	
L_8	2 turns	0.5 mm ⌀ CuL	
L_9	7 turns tap at 5.5 turns	0.8 mm ⌀ CuAg	
L_{10}	2 turns	0.5 mm ⌀ CuL	
$L_{1, 2, 6, 7, 8, 9, 10}$		on coil former 4.3 mm ⌀	
$L_{1, 2, 6, 7, 8}$		threaded core B63310-B3021-x017	
$L_{9, 10}$		threaded core 3.5×0.5×10 of brass	
L_3		on Vogt coil former Sp 4/9 – 2053 A	
L_4		cylinder core B61110 U17 2×6	
L_{11}		6 turns ea.	0.2 mm ⌀ CuL
L_{12}		2 turns	0.2 mm ⌀ CuL
$L_{11, 12}$		on Vogt filter kit D41-2520	

1,8 4-GHz-oscillator with BFR 34 A

The mechanical construction of a 4-GHz-oscillator, designed with the transistor BFR 34 A, is shown in **fig. 1.8.**

An output power of 12 mW ist achievable at an operating point of V_{CE} = 12 V and I_C = 17 mA.

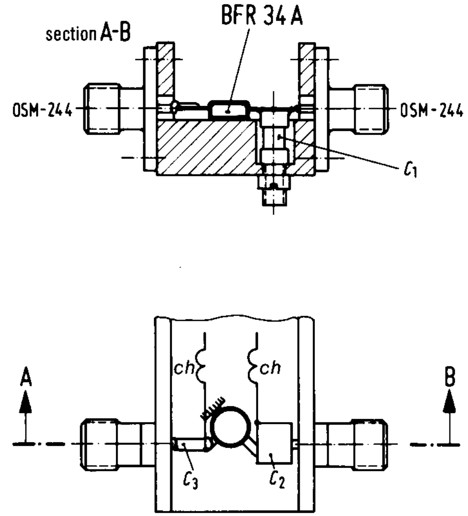


Fig. 1.8

The oscillator operates as a common-base circuit. The collector is connected to ground in order to improve the cooling of the transistor chip mounted in a plastic case. The optimum phase condition of the feedback between emitter and collector is adjusted by a coaxial line-stretcher. The coupling capacitor C_2 to the output is formed by a metal plate with the dimensions of about 5×5 mm.

The d.c. is supplied via lead-through filters and chokes using ferrite beads (1 turn).

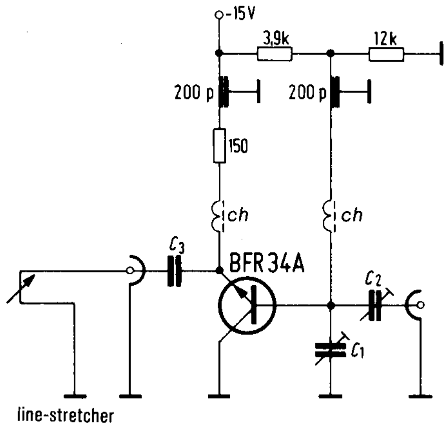


Fig. 1.8.1

The resonant circuit which actually determines the frequency include the collector capacity of the transistor and the inductors of the surrounding circuit. At 4 GHz the inductance of this resonant circuit has to be very low and has to present a high Q. Besides that a good separation between base and collector terminal has to be enabled. This requirement can be realized by an air trimmer capacitor (C_1) with low inductance and high Q. If this capacitor is operated at series resonant frequency, it takes the effect of a variable inductor. Its series inductance is reduced in addition, if the trimmer is placed in a bore-hole.

The maximum of the output power and of the transition frequency f_T is attained at a current in the range of 15 to 20 mA. At $V = 12$ V an average value of 12 mV into 50 Ω has been measured for the max. output power.

By a test with a spectrum analizer it had been demonstrated that the difference between the spectral line of the oscillator frequency and the noise was greater than 50 db; the difference to the first harmonic at 8 GHz was 30 db.

The BFR 34 A is suitable as r.f. pre-stage transistor offering low noise figure and as oscillator transistor up to 4 GHz. According to the available r.f.-power this transistor is favoured for a variety of applications: general test purposes, microwave generator for short-range radar, diode mixers, and parametric converters or amplifiers).

1.9 UHF-tuner using the high-current transistor AF 379 in prestage and mixer

With increasing numbers of broadcasting stations TV-tuners have to be able to handle higher r.f.-input signals more than in the past, especially if they are used in colour TV-sets. The developement of the UHF high-current-transistor AF 379 and the PIN-diode BA 379 turned out to be one of the solutions to this problem. Due to the wide dynamic range of the AF 379 and the high signal level handling capability of the BA 379 a considerable improvement of the cross modulation behaviour has been obtained.

Interferences generated by too high antenna signal levels occures especially in the front end, as the following two-circuit bandpass filter prevents the mixer from r.f.-input signals with wider frequency spacing. For this reason the transistor AF 379 is used only in the front end. With increasing numbers of transmitting stations it happens that the spacing between the signals received is only 2 or 3 chanels.

In this case the selection of the intermediate band-pass filter is no longer sufficient to suppress satisfactorily the antenna signal, amplified by the pre-stage. Therefore the cross-modulation immunity of this frequency range is determined by the mixer stage and it is essentially lower than for other frequencies being far away.

Thus it is necessary to improve the large signal characteristics also of the mixer. This can be obtained by replacing the usual mixer transistor by the high-current transistor AF 379 with its excellent capability to handle high signal levels. As this feature of the AF 379 takes an effect only at current higher than 4 mA the mixer has to be driven by a separated oscillator stage.

According to the different requirements the mixer and the oscillator can be dimensioñed distinctly, so that the increased number of components is in relation to the adequate improvement of quality.

With a sample tuner the following results had been experienced in the frequency range of 470 to 800 MHz. The circuit is shown in **fig. 1.9.**

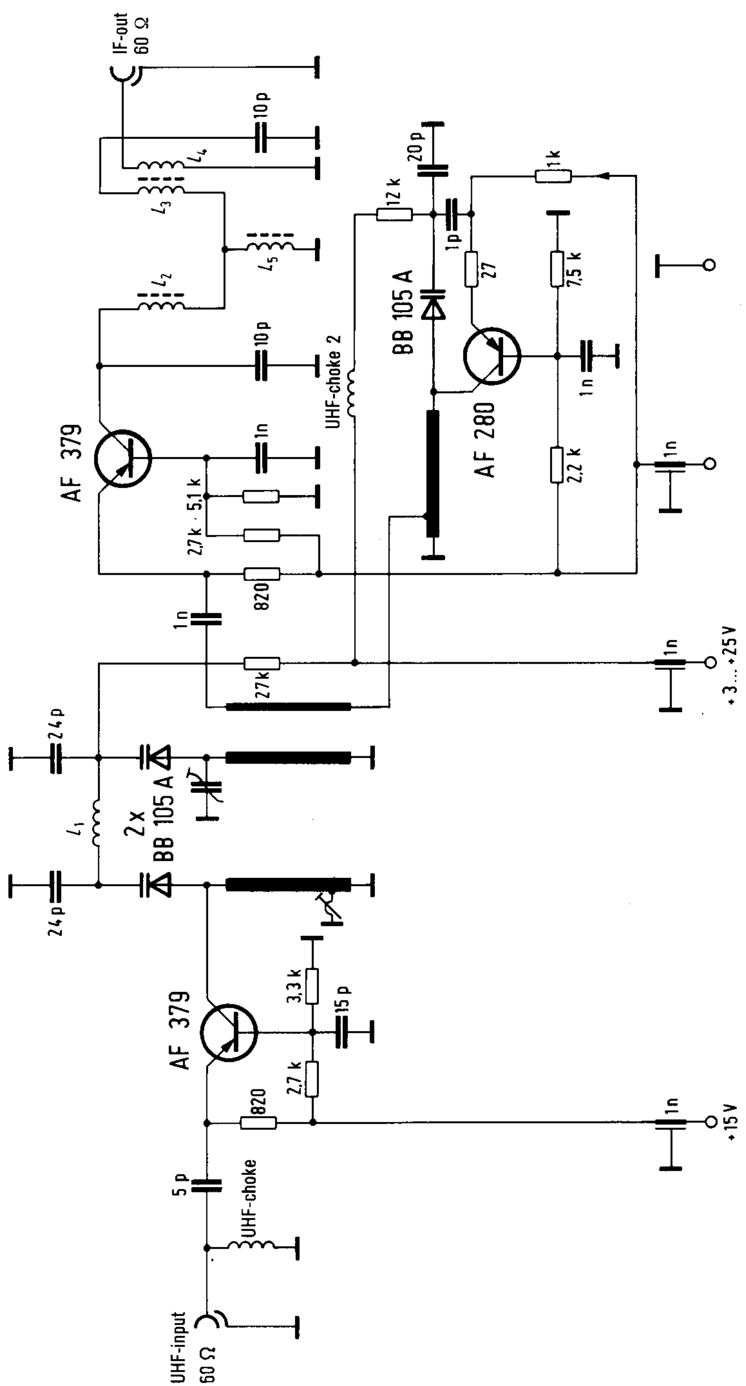


Fig. 1.9

Power gain	G_p = 18 to 23 db
Noise figure	F = 6–7.2 db
Input reflexion	r = 0.4 to 0.7
UHF bandwidth	B = 15 to 22 MHz
IF-band-pass filter	B_{IF} = 10.5 MHz
IF-band-pass filter ripple	w = 1 db
Image rejection	a_{im} > 40 db

If the signal-to-image ratio is to be improved, e.g., to a value of greater than 60 db, then only two solutions are practicable, either an additional pre-stage is connected infront of the first transistor, or the IF is shifted into a range which is higher than that of band 1.

As the cross-modulation immunity is especially of interest, fig. 1.9 1 shows the curves of cross modulation for adjacent channels at effective frequencies of 500 MHz and 790 MHz (tuner no. 3). In comparison there are also shown the test results of two other tuners with different but commonly used circuit-concepts. The effective frequency is 650 MHz.

Tuner no. 1: Using high-current prestage transistor AF 379, broadband UHF-input and self-oscillating mixer,

Tuner no. 2: Selective input band-pass filter, silicon-UHF-prestage-transistor and diode-mixer

Tuner no. 3: Three-transistor-concept with high-current mixer and high-current prestage as described above.

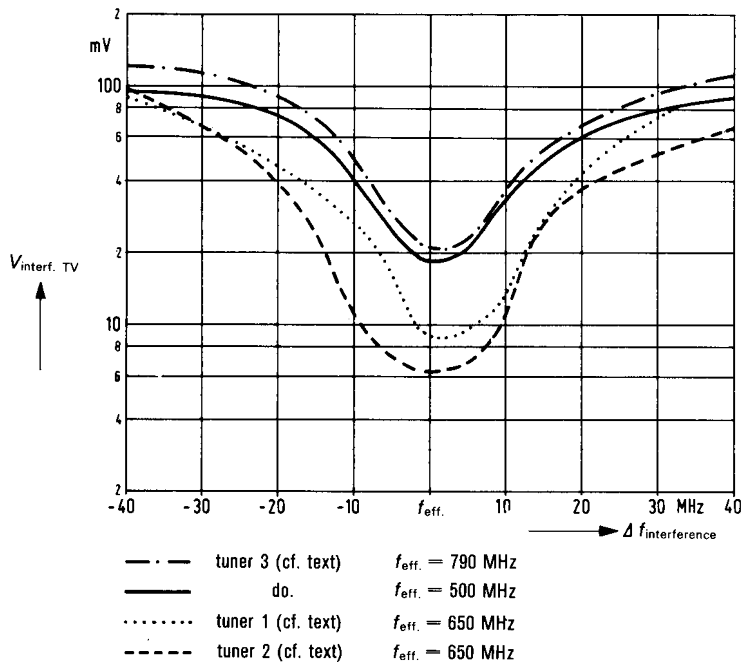


Fig. 1.9.1

Coil data:

L_1:	8	turns	0.42 CuLL	Air coil 3 mm ⌀
L_2:	12	turns	0.32 CuLL	Coil former 4.3 mm ⌀
L_3:	14	turns	0.32 CuLL	Siferrit-core U17*)
L_4:	3	turns	0.32 CuLL	10 mm long, 3.5 mm ⌀
L_5:	6.5	turns	0.42 CuLL	wound on Siferrit-core*)

*) Ordering code: B63310-B3021-X017

1.10 FM-tuning indicator with light emitting diodes

For FM-IF-amplifiers using the limiting and demodulating IC TBA 120 a zero-axis-crossing indicator with three light emitting diodes has been designed (cf. **fig. 1.10**).

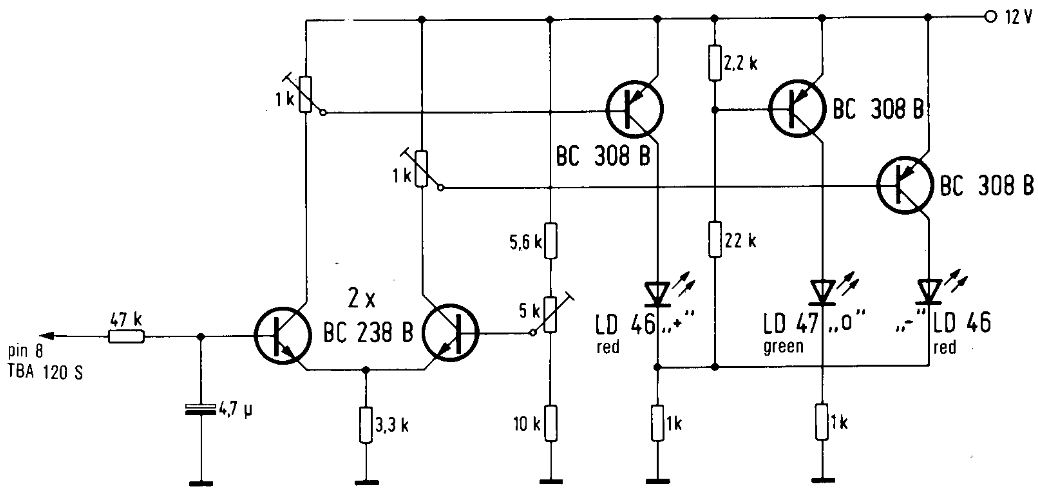


Fig. 1.10

The output voltage available at pin 8 of the TBA 120 is integrated by a RC-circuit and amplified by a differential amplifier. If a detuning occurs with reference to higher frequencies the output level of the TBA 120 increases, i.e. the left transistor (BC 238 B) of the differential amplifier is turned on, the BC 308 B becomes conductive and switches on the red "+"-LED, type LD 46. With regard to lower frequencies the "–"-diode is turned on. In both cases there exists a voltage drop at the cathode resistor being common for both red LEDs and the switching transistor for the green LED is turned off. On account of this NAND-operation the "0"-diode emits light only if none of the red diodes is switched on.

The differential amplifier is symmetrically adjusted by the 5-kΩ-potentiometer at nominal value of the IF. The threshold of the red light emitting diodes is adjusted by the 1-kΩ-potentiometer.