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Design Examples of Semiconductor Circuits 1978/79

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Discrete Semiconductors · Integrated Circuits

Design Examples of Semiconductor Circuits

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SIEMENS AKTIENGESELLSCHAFT

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1. RF Circuits

1.1 Combination Tuner with VHF-MOS-Mixer Offering Excellent Large Signal Characteristics

The UHF- and VHF-circuits of the combination tuner shown in **fig. 1.1** exactly correspond to those already described in "Design Examples of Semiconductor Circuits Edition 1977/78". To improve the large signal characteristics of the VHF-Tuner the MOS-tetrode BF 961 is used. Thus the crossmodulation factor is increased by a factor of two.

PIN-diode attenuator

For the PIN-diode attenuator a common circuit is chosen and the diodes are mounted on the board to achieve a sufficient control range without any screening between input and output. The control characteristics are determined by resistors R_1, R_2, R_3 and R_5 and the downwards control starts at 7 V. It reaches its maximum at 1.5 V.

UHF-prestage

The high-pass filter at the front end of the UHF-circuit consists of components C_9, C_{14} and L_6. It suppresses frequencies of stations which do not belong to the UHF-range. Good broad-band matching and neutralization are obtained by base capacitor C_{19} and series coil L_{33}. The latter also improves the noise figure in the upper frequency range. The choosen operating point (8 mA at 8 V) guarantees a distortion minimum of the prestage transistor. The choke L_{13}, the capacitor C_{21}, the internal transistor capacitance and the circuit capacitance react as a broad-band parallel-resonant-circuit the resonant frequency of which is just below the UHF-range.

By the high L/C-ratio of this resonant circuit a very high matching impedance of the transistor is guaranteed within the lower frequency range. Thus a high gain of this stage is obtained and the gain loss occurring usually at $\lambda/4$-tuned circuits is compensated. By this measure the gain is nearly constant in the total UHF-range. The resistance of the different resonant circuits has to be high to achieve a good selectivity at a fixed quality factor and initial capacitance of the capacitance diode. Therefore a series capacitor with a low capacitance is used assuming the effective parallel capacitance of the resonant circuit is very low. This measure means that even in the UHF-range discrete coils are used. The low quality factor of these coils is well compensated by the high resistance of the resonant circuits. As the capacitance diodes and the coils of the resonant circuits are vertically mounted, the connections to the resonant circuits are not made on the pc-board. By this measure and by the low capacitance of the coupling capacitor C_{21} the parallel capacitances are additionally reduced.

The coupling of the band-pass filter is obtained by the stray field of the coils. Besides that an additional coupling is realized in the lower frequency range by the coil L_{15}.

Self-oscillating mixer stage

The oscillator circuit is also operated with high impedances and in conjunction with a very weak reverse feedback via C_{34} and R_{22} a constant oscillating behaviour is achieved in the total frequency range. In the lower frequency range the oscillation is supported by the low-pass choke L_{25}, which shows an effect similar to the coil L_{13} of the prestage. By the resistor R_{22} a too strong resonance increase of the feedback circuit is avoided.

The resistance of R_{32} attenuates the resonant circuit consisting of L_{25} and adjacent capacitors. The mixing stage is coupled to the second RF band-pass filter via capacitor C_{29}. On the primary side of the band-pass filter a load decrease is obtained by the frequency-dependent voltage divider consisting of the capacitance diode D_5 and the series capacitor C_{27}. It is then easier to realize constant gain and selectivity.

The transistor AF 279S operates at 10.2 V and 1.8 mA to achieve a low temperature drift of the oscillator-frequency.

The series resonant circuit consisting of L_{18} and C_{32} keeps the resistance of the emitter circuit low and thus an optimum of the conversion transconductance is obtained. The IF signal is coupled to the first gate of the VHF mixer via the loaded band-pass filter, the switching diode D_{15} and the capacitor C_{50}. In the UHF-range the tetrode BF 961 operates as an IF amplifier. In the VHF-range the switching diode is negatively biased by the resistors R_{40} and R_{41}, to reduce the harmfull influence of the capacitors at gate 1.

VHF prestage

The front end low-pass filter consisting of L_3 and C_{10} decouples the VHF- and the UHF-prestage. L_4 and C_8 act as an IF band-stop filter. Additional band-pass filters with excellent selection characteristics eliminate stations from other frequency bands. The dynamic of the prestage is improved by resistor R_{12} connected to the emitter of the prestage transistor. The noise factor of the prestage is then increased by 1 dB. Undesired oscillations are suppressed by means of the capacitor C_{26} and the ferrite bead L_{17}. The prestage transistor operates at 8 V and 8 mA.

The tuned RF band-pass filter is dimensioned in that a slightly flattened curve is realized. As the band-pass filter is only marginally influenced by the high input impedance of the mixing stage the primary side is attenuated by the resistor R_{16}. An additional attenuation is obtained by the current-limiting resistors R_{20} and R_{27} during operation of band I. By this measure the gain of the stages infront of the mixer is kept relatively low to obtain good crossmodulation characteristics.

The coupling of the band-pass filter is realized in band III by utilizing the stray field of L_{19} and L_{22} or of L_{21} in band I.

VHF mixing stage

The VHF mixing stage includes an additive mixing circuit using the MOS tetrode BF 961. Contrary to common mixers with bipolar transistors the following advantages are provided:

- excellent crossmodulation characteristics,
- simple coupling to the band-pass filter by using the capacitor C_{43} with a low capacitance,
- a low noise figure of 6 dB, therefore only a low gain of the prestage is required, thus the dynamic range of the tuner is increased,
- because of the high input impedance a very good selectivity of the RF band-pass filter is obtainable and the influence of adjacent stations is eliminated,
- improved interference suppression by reducing the generation of harmonics,
- unwanted modulations are not transferred to the oscillator circuit as the mixer impedance depends only marginally on the driving signal.

VHF oscillator

The oscillator circuit operates with the PNP-Si-transistor BF 606. Because of its epitaxial construction the BF 606 is well favoured for driving MOS-mixers. The circuit is dimensioned in that an oscillator voltage greater than 500 mV is applied at gate 1 of the MOS-tetrode in band I and III. In band I the capacitor C_{55} additionally supports the reverse feedback and C_{65} connected in series to C_{45} assures an optimum of static and dynamic tracking.

The transistor of the oscillator circuit operates at 4.6 V and 1.9 mA.

Technical data

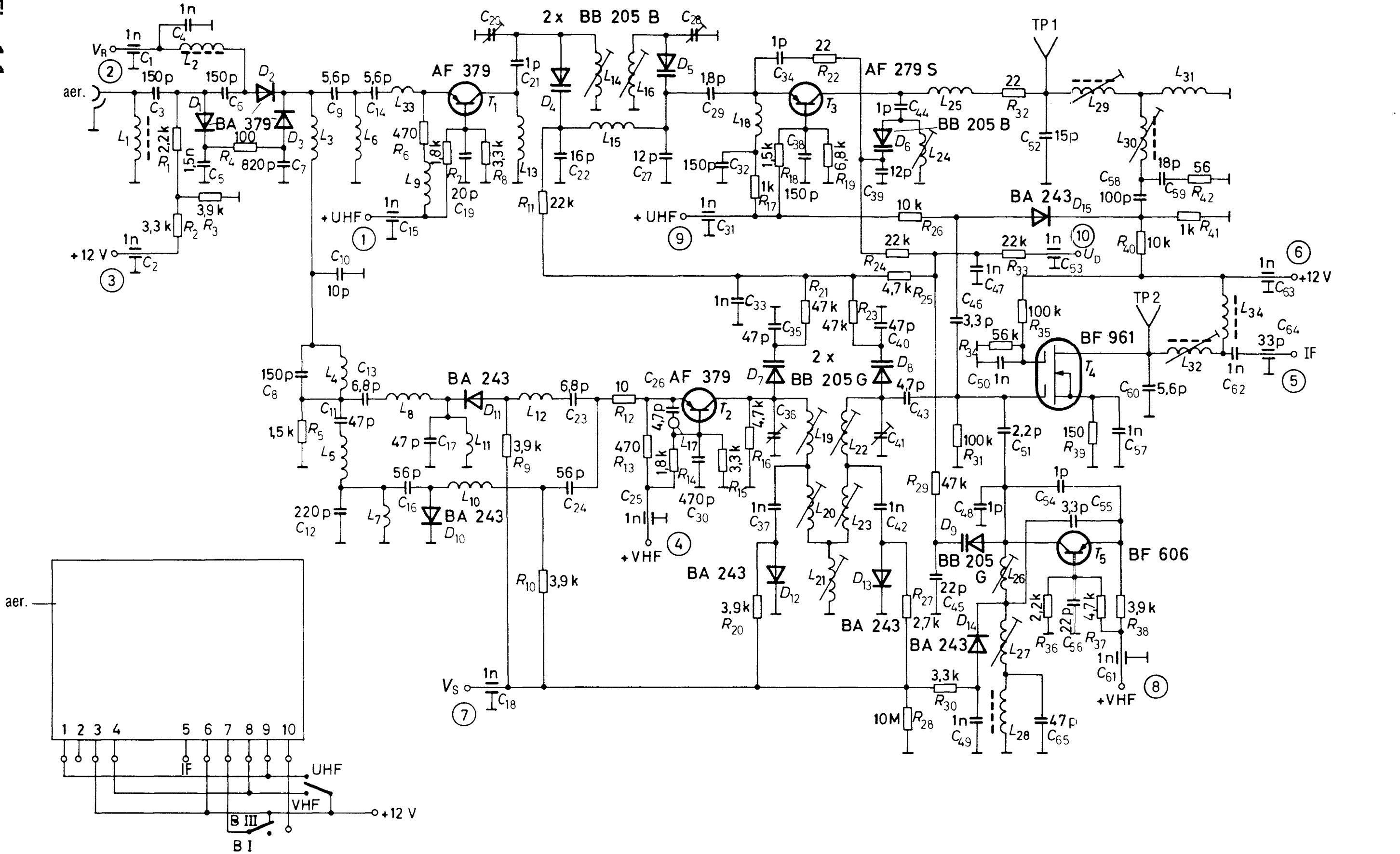
	Band I	Band III	UHF	
Frequency range (f)	51–65	178–227	470–860	MHz
Supply voltage (V_s)	12	12	12	V
Supply current (I_s)	25	40	23.5	mA
Tuning voltage (V_R)	2.5–23	5–24	1.2–24	V
Power gain (G)	23–25	23–26	26–29	dB
RF bandwidth (B_{RF})	8.5–9.5	9.5–11.5	12–16	MHz
IF bandwidth (B_{IF})	5	5	5	
Noise factor (NF)	<7.5	<7.5	<8	dB
Image frequency attenuation				
Interference voltage for 1% crossmodulation in channel (N)	16	16	10	mV
$N\pm1$	50	30	20	mV
$N\pm2$	–	85	55	mV
$N\pm3$	–	120	110	mV
Oscillator frequency drift for $\Delta T_{amb}=15$ K	$<\pm150$	$<\pm200$	$<\pm500$	KHz

Components for circuit 1.1

		Ordering code	SCS stock number
2 Transistors	AF379	Q62701-F72	7018
1 Transistor	AF279S	Q62701-F87	70589
1 Transistor	BF961	Q62702-F518	71218
1 Transistor	BF606	Q62702-F492	71217
3 Pin-diodes	BA379	Q62702-A485	7013
3 Capacitance diodes	BB205B	Q60201-B61-E1	71504
3 Capacitance diodes	BB205G	Q60201-B62-E3	71505
6 Switching diodes	BA243	Q62702-A521	71082
3 Bead-type capacitors	1 pF $\pm$0.1 pF N750		–
1 Bead-type capacitor	1.8 pF $\pm$0.25 pF N470	B38185-J5010-C800	–
1 Bead-type capacitor	2.2 pF $\pm$0.5 pF N750	B38186-J5020-D200	–
1 Bead-type capacitor	3.3 pF $\pm$0.25 pF N750	B38186-J5030-C300	–
2 Tube-type capacitors	1 pF $\pm$0.1 pF N1500		–
1 Trapezium capacitor	1.5 nF $\pm^{80}_{20}$%	B37296-B5152-Z2	–
1 Trapezium capacitor	820 pF $\pm^{50}_{20}$%	B37292-B5821-S2	–
1 Trapezium capacitor	470 pF $\pm^{50}_{20}$%	B37291-B5471-S2	–
2 Trapezium capacitors	150 pF $\pm$10%	B37290-B5151-K2	–
2 Trapezium capacitors	12 pF $\pm$0.5 pF N470	B38285-J5120-J2	–

			Ordering code	SCS stock number
1	Trapezium capacitor	16 pF ± 0.5 pF		–
1	Trapezium capacitor	20 pF ± 5%	B38286-J5200-J2	–
1	Disc-type capacitor	3.3 pF ± 0.5 pF	B38112-A5030-D1	–
2	Disc-type capacitors	4.7 pF ± 0.5 pF	B38112-A5040-D701	–
3	Disc-type capacitors	5.6 pF ± 0.5 pF	B38112-A5050-D601	–
2	Disc-type capacitors	6.8 pF ± 0.5 pF	B38112-A5060-D801	–
1	Disc-type capacitor	10 pF ± 5%	B38116-J5100-J1	1787B
1	Disc-type capacitor	15 pF ± 5%	B38116-J5150-J1	1789
1	Disc-type capacitor	18 pF ± 5%	B38116-J5180-J1	1777
2	Disc-type capacitors	22 pF ± 5%N750	B38116-J5220-J1	1778
5	Disc-type capacitors	47 pF ± 5%N750	B38116-J5470-J1	–
2	Disc-type capacitors	56 pF ± 5%	B38116-J5560-J1	–
1	Disc-type capacitor	100 pF ± 10%	B37215-B5101-K1	–
3	Disc-type capacitors	150 pF ± 10%	B37215-B5151-K1	–
1	Disc-type capacitor	220 pF ± 10%	B37205-A5221-K1	–
9	Disc-type capacitors	1 nF $\pm^{50}_{20}$%	B37235-J5102-S1	1726
1	Feed-through capacitor	33 pF ± 10%	B37810-A3330-K2	–
9	Feed-through capacitors	1 nF $\pm^{50}_{20}$%	B37810-A3102-S2	

Fig. 1.1.



aer.
V_R
+12 V
+UHF
+VHF
V_S
AF 379
AF 279 S
2 x BB 205 B
2 x BB 205 G
BA 379
BA 243
BB 205 G
BF 961
BF 606
TP 1
TP 2
IF
U_D
UHF
VHF
B III
B I
1 2 3 4 5 6 7 8 9 10

1.2 UHF Tuner with Preamplifier Using an MOS Transistor

Most of the UHF-tuners use aperiodic input circuits. The input transistor operates with a high-pass filter connected infront of it to reduce the influence of unwanted stations. If, however, an interfering station is located in the UHF-range, the undesired signals are processed by the first transistor, the crossmodulation characteristics of which are responsible for the maximum of the admissible interfering voltage. The crossmodulation characteristics can be improved by using a MOS-tetrode and a selective circuit at the front end (see **fig. 1.2**). The aerial is coupled to gate 1 via the coil L_1 and thus a better edge steepness of the input filter curve is obtained. To keep the bandwidth constant over the total frequency range the MOS transistor BF 960 is coupled to the front end circuit via capacitance diode D_2. The BF 960 offers high conductance as well as low input and output impedances. The stability is much better than that obtained with bipolar transistors. The control characteristic is determined by resistors R_1 to R_4. If the tetrode is not controlled the voltage at gate 1 should be 0.5 V higher than the source level.

The band-pass between the prestage and the self-oscillating mixer is dimensioned in that good selectivity is attained. The mixing circuit is similar to that shown in **fig. 1.1**.

Technical data

Supply voltage	$V_S = 12$ V
Tuning voltage	$V_D = 1$ V to 25 V
Power gain	$G > 20$ dB
Noise figure	$NF < 7$ dB

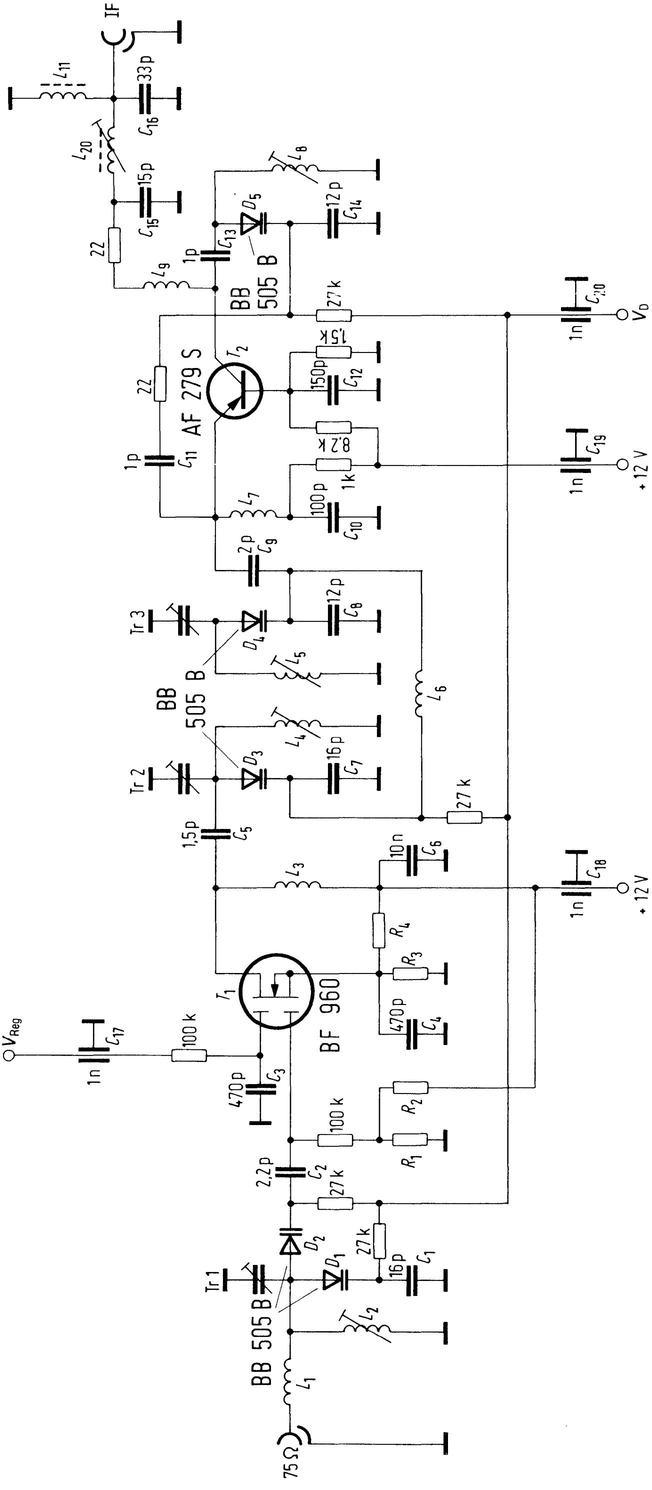

IF
L_{11}
33p
C_{16}
L_{20}
15p
C_{15}
22
L_9
1p
C_{13}
D_5
BB 505 B
L_8
12p
C_{14}
27 k
1n
C_{20}
V_D
AF 279 S
T_2
22
1p
C_{11}
1,5 k
150p
C_{12}
8,2 k
1k
100p
C_{10}
L_7
1n
C_{19}
+ 12 V
2p
C_9
Tr 3
D_4
12p
C_8
BB 505 B
L_5
L_6
Tr 2
D_3
L_4
16p
C_7
27 k
1,5p
C_5
L_3
10n
C_6
1n
C_{18}
+ 12 V
R_4
R_3
T_1
BF 960
470p
C_4
V_{Reg}
1n
C_{17}
100 k
470p
C_3
R_2
100 k
R_1
2,2p
C_2
27 k
27 k
D_2
D_1
16p
C_1
Tr 1
BB 505 B
L_2
L_1
75 Ω

Fig. 1.2.

Components for circuit of 1.2

			Ordering code	SCS stock number
1	Transistor	BF960	Q62702-F0499	71443
1	Transistor	AF279S	Q62701-F87	70589
5	Capacitance diodes	BB505B	Q62702-B113	71511
1	Bead-type capacitor	2.2 pF ± 0.25 pF	B38186-J5020-C20	–
1	Bead-type capacitor	1.5 pF ± 0.1 pF	B38185-J5010-B5	–
1	Bead-type capacitor	2 pF ± 0.25 pF	B38186-J5020-C0	–
2	Bead-type capacitors	1 pF ± 0.1 pF N750	–	–
1	Disc-type capacitor	10 nF $\pm^{50}_{20}$%	Q37449-D6103-S1	17332
2	Trapezium capacitors	12 pF ± 0.5 pF N470	B38285-J5120-J2	–
2	Trapezium capacitors	16 pF ± 0.5 pF	–	–
1	Trapezium capacitor	150 pF ± 10%	B37290-B5151-K2	–
2	Trapezium capacitors	470 pF $\pm^{50}_{20}$%	B37291-B5471-S	–
1	Disc-type capacitor	15 pF ± 5%	B38116-J5150-J1	1789
1	Disc-type capacitor	33 pF ± 5%	B38117-J5330-J1	1757
1	Disc-type capacitor	100 pF ± 10%	B37215-B5101-S1	1721
4	Feed-through capacitors	1 nF $\pm^{50}_{20}$%	B37810-A3102-S2	–

1.3. Broadband VHF Amplifier Using 2 × BFR 96 with Band-Pass-Filters for Band I and Band III

Fig. 1.3 shows the circuit of an aerial amplifier for the TV bands I and III. The band-pass filters at the front end function as a diplexer and reduce signals of undesired stations. The transistor BFR 96 offers extremely linear transmission characteristics as well as a high cutoff frequency ($f_T = 5$ GHz).

The gain of every stage is about 8 dB. It is determined by an inverse current feedback of the emitter and by an inverse voltage feedback from collector to base. The output stage operates at a collector current of 60 mA to obtain a high output voltage whereas the prestage operates at 40 mA. These two operating points have been chosen for compensating the distortions generated in the prestage and in the output circuit. Two 39 Ω-resistors are connected in parallel to keep the emitter inductance low.

Technical data

Supply voltage	V_S	= 24 V
Supply current	I_S	approx. 110 mA
Input impedance	R_I	= 75 Ω
Output impedance	R_O	= 75 Ω
Power gain	G	= 15 dB
Noise figure	N	= 7.3 dB
Input reflection factor	$\|r\|$	= 0.2 to 0.3
Output reflection factor	$\|r\|$	= 0.1
Output voltage (DIN 45004 IMA = 66 dB)	V_O	= 350 mV

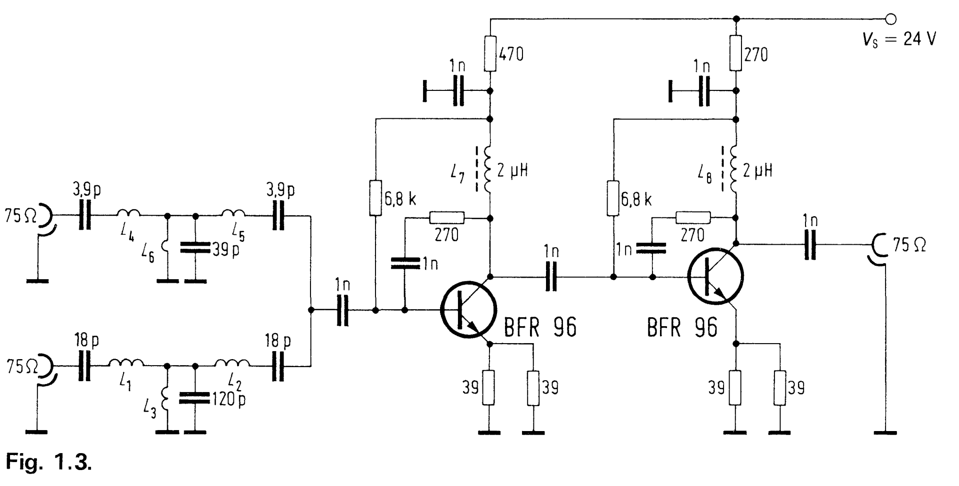


Fig. 1.3.

Components for circuit 1.3

		Ordering-code	SCS stock number
2 Transistors	BFR 96	Q62702-F516	71322
2 Disc-type capacitors	3.9 pF	B38112-A5030-D901	–
2 Disc-type capacitors	18 pF	B38116-J5180-J1	1777
1 Disc-type capacitor	39 pF	B38062-A6390-G9	–
1 Disc-type capacitor	120 pF	B38066-J6121-G9	–
7 Disc-type capacitors	1 nF	B37235-J5102-S1	1726
2 Cylindrical cores for UHF-chokes (2 μH) U 17, 1.5 mm × 10 coarsely wound with 25 turns of Cu L, ∅ 0.25 mm		B61110-A2050-X17	–

1.4 FM Tuner Using two MOSFETs BF961

Fig. 1.4 shows the circuit of a FM tuner using two MOS tetrodes in the prestage as well as in the output stage. The circuit is characterized by good input sensitivity and extremely good large-signal behaviour. The front end circuit is optimally coupled to gate 1 with reference to the noise figure. The prestage is controllable by a transistor in that V_R is connected to ground level. The source potential is determined by resistors R_7 and R_8 connected to V_S to avoid a negative control voltage. Besides that the potential of gate 1 has to be positive. This is achieved by the voltage devider consisting of R_2 and R_4. If V_R has no connection to ground the prestage operates at gain maximum.

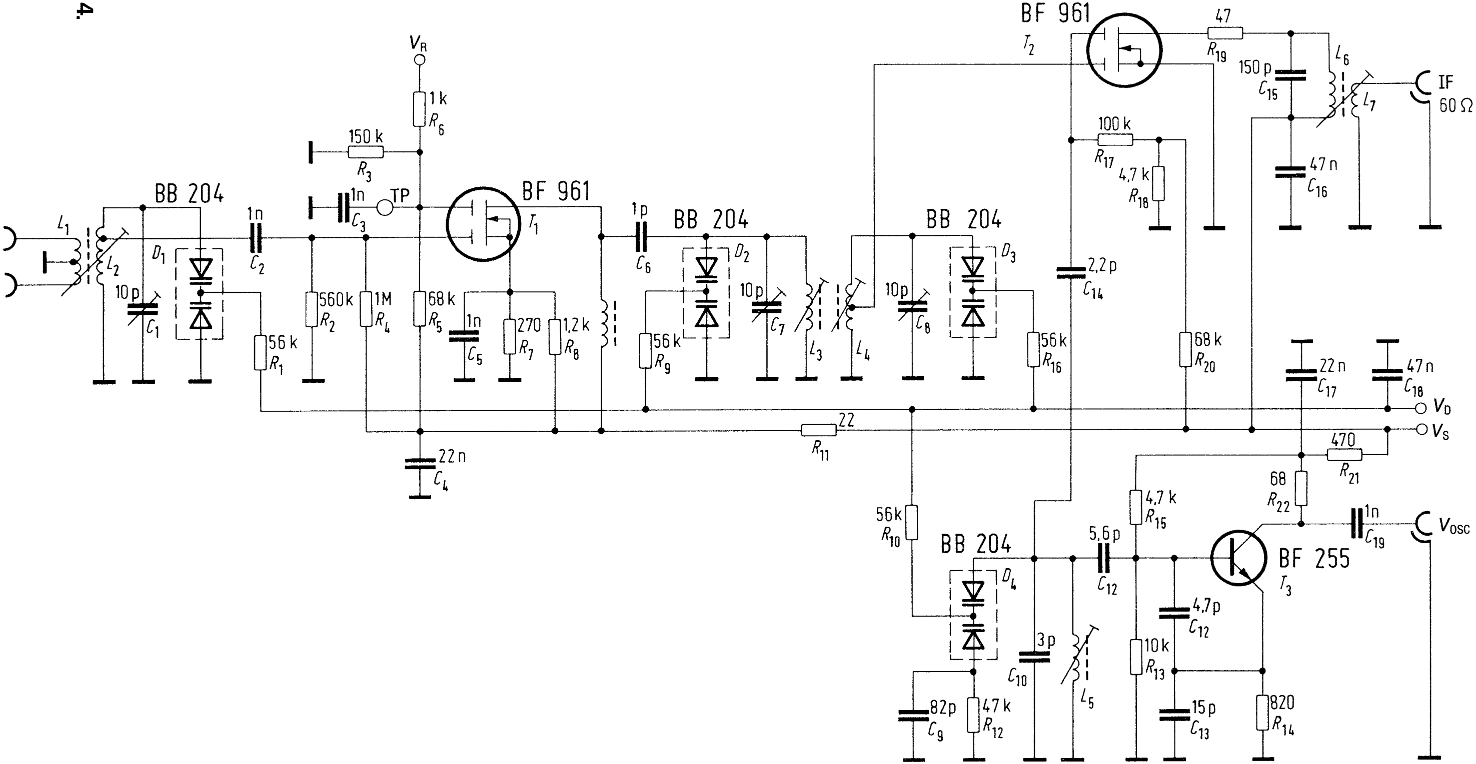
The RF band-pass filter is very weakly coupled to the drain via a 1 pF-capacitor. It offers practically a no-load quality factor as the coupling to the mixing stage is also very weak.

The mixer operates multiplicatively and an operating point has been chosen in that a very good crossmodulation characteristic is obtained.

The oscillator using the transistor BF255 operates in a common-collector circuit, guaranteeing few harmonics. If frequency indicator or synthesizer are to be driven the oscillator signal can be picked up at point V_{osc}, whereby the internal impedance is very low.

Technical data

Supply voltage	V_s	$=12$ V
Supply current	I_s	~ 30 mA
Tuning voltage	V_D	$=4.5$ to 28 V
Power gain	G	>20 dB
Noise figure	NF	<5 dB
RF bandwidth	B	<1 MHz
Input reflection factor	r	<0.35
Control voltage	V_R	9 to 0.5 V
Control range	ΔG	>50 dB
Drift of oscillator		
Frequency with respect to temperature		3 kHz/K



BB 204
BB 204
BB 204
BB 204
BF 961
BF 961
BF 255
V_R
V_D
V_S
V_{osc}
IF
60 Ω
TP
L_1
L_2
L_3
L_4
L_5
L_6
L_7
D_1
D_2
D_3
D_4
T_1
T_2
T_3
10 p C_1
1n C_2
1n C_3
22 n C_4
1n C_5
1 p C_6
10 p C_7
10 p C_8
82p C_9
3 p C_{10}
5,6 p C_{12}
4,7 p C_{12}
15 p C_{13}
2,2 p C_{14}
150 p C_{15}
47 n C_{16}
22 n C_{17}
47 n C_{18}
1n C_{19}
56 k R_1
560k R_2
150 k R_3
1M R_4
68 k R_5
1 k R_6
270 R_7
1,2 k R_8
56 k R_9
56k R_{10}
22 R_{11}
47 k R_{12}
10 k R_{13}
820 R_{14}
4,7 k R_{15}
56 k R_{16}
100 k R_{17}
4,7 k R_{18}
47 R_{19}
68 k R_{20}
470 R_{21}
68 R_{22}

Fig. 1.4.

Components for circuit 1.4

		Ordering code	SCS stock number
2 Transistors	BF961	Q62702-F518	71218
1 Transistor	BF255	Q62702-F202	8748
4 Capacitance diodes	BB204 green	Q60201-B58-X5	70732
1 Disc-type capacitor	82 pF $\pm$2%	B38066-J6820-G6	17254
1 dito	3 pF $\pm$0.25 pF	B38115-J5030-C301	–
1 dito	5.6 pF $\pm$0.25 pF	B38112-A5050-C601	–
1 dito	4.7 pF $\pm$0.25 pF	B38112-A5040-C701	–
1 dito	15 pF $\pm$5%	B38116-J5150-J1	1789
1 dito	2.2 pF $\pm$0.25 pF	B38115-J5020-C201	–
1 Disc-type capacitor	1 pF $\pm$0.25 pF	B38060-A6010-C9	–
1 Styroflex capacitor	150 pF $\pm$2,5%	B31310-A1151-H	1112
2 Disc-type capacitors	47 nF $\pm^{50}_{20}$%	B37449-A6473-S2	17233
2 Disc-type capacitors	22 nF $\pm^{50}_{20}$%	B37449-D6223-S1	17333
4 Disc-type capacitors	1 nF $\pm^{50}_{20}$%	B37235-J5102-S1	1726
3 Ceramic disc-type capacitors, variable	10 pF 5 mm distance		
1 Choke core		B69310-A0001-X101	–
1 Ferrite bead		B62110-A3011-25	–
4 Screw cores		B63310-B3021-X017	–

Coil data

L_1	2×1 turn	0.5 mm ∅ CuL
L_2	5 turns	0.8 mm ∅ CuAg tap at 3rd turn
L_3	5 turns	0.8 mm ∅ CuAg
L_4	5 turns	0.8 mm ∅ CuAg tap at 2.5 turns
L_5	8.5 turns	0.8 mm ∅ CuAg
L_6	12 turns	0.2 mm ∅ CuL
L_7	2 turns	0.2 mm ∅ CuL

L_1 to L_5 on coil formers 4.3 mm ∅
L_1 to L_4 on screw cores B63310-B3021-X017
L_5 with screw core 3.5×0.5×10 (brass)
L_6 and L_7 on Vogt coil formers D41-2520

Choke	6.8 µH choke core	B69310-A0001-X101
Ferrite bead		B62110-A3011-25

1.5 Car-Superhet Using an IC Maximum

Fig. 1.5.1 shows the circuit of a car superheterodyne receiver. It operates with a maximum quantity of integrated circuits and a minimum of mechanical parts and switches.

FM tuner

Fig. 1.5.2 shows the circuit of the FM tuner using the MOS FET BF961. It offers extremely low noise figure and good interference suppression. With an optimal relation between the bandwidth of the front end circuit, the prestage gain of approx. 6 dB and the mixing gain of the S042P a total noise figure of 4 to 5 dB is realized.

As the symmetrical mixer is characterized by a very low noise figure the S042P can be very weakly coupled to the RF band-pass filter (bandwidth approx. 1 MHz). Thus a high interference immunity is achieved. The internal transistors of the S042P operate with an impressed current and therefore the feed back influence of the RF input to the oscillator circuit is strongly reduced and aerial voltages of up to 3 V can be operated without causing any essential detuning of the oscillator (less than 10 kHz).

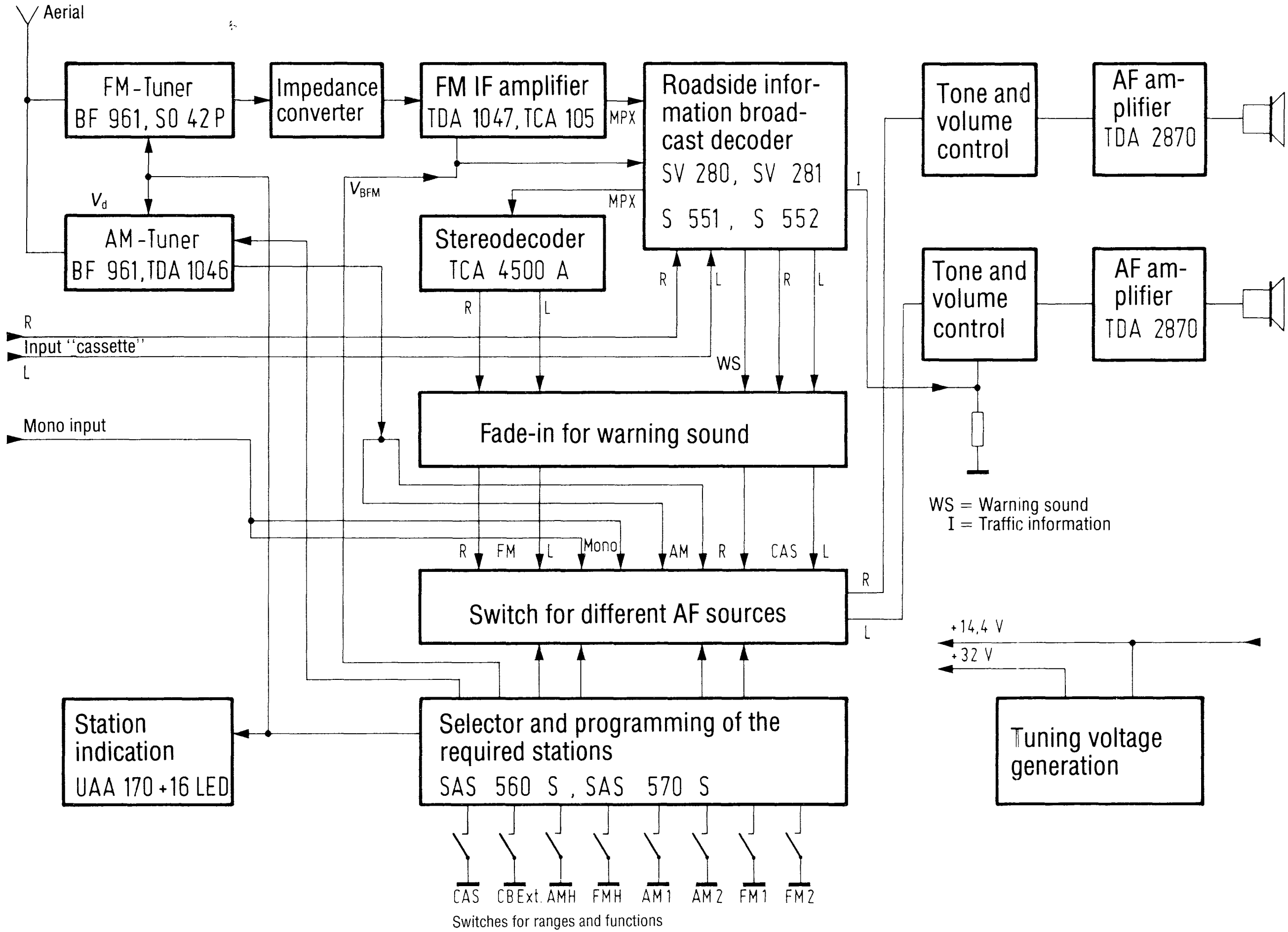
An impedance transmitter using the transistor BF241 with a gain of approx. 1.4 dB is connected to the IF circuit as shown in **fig. 1.5.3**. The in- and outputs of the following ceramic filter are matched with 330 Ω-resistors to obtain good filter characteristics and optimum phase linearity. The filter offers a 300 kHz-selectivity of more than 20 dB and the spurious responses are sufficiently suppressed by the IF circuit connected to the mixer output.

The FM signal is demodulated by the symmetrical coincidence demodulator of the TDA1047, incorporating an 8-stage limiting amplifier. Its external phase shifting circuit consists of one or two sections according to the required distortion factor.

The incorporated adjustable squelch is effective over an input signal range of more than 40 dB. It assures an easy operation as well as the possibility to switch off the AF signal depending on the detuning. This muting occurs from $\Delta f = \pm 80$ kHz.

The AFT push-pull current output of the TDA1047 influences via the PNP-transistor BC258B and the *z*-diode ZTK27 the potential at the potentiometer (Preomat) with reference to the AFT-current. The voltage divider is dimensioned in that a voltage shift of ± 1 V occurs at the detuning maximum and thus an AFT-range of ± 250 kHz is realized.

A LED indicates as to whether a station with a sufficiently high input signal is received. It is turned off by the TCA105 if a voltage of more than 400 mV is applied to the input of the TCA105. This positive switching-off voltage is supplied from the TDA1047 and reduced by a voltage divider.



Aerial
FM-Tuner
BF 961, SO 42 P
Impedance converter
FM IF amplifier
TDA 1047, TCA 105
MPX
Roadside information broadcast decoder
SV 280, SV 281
S 551, S 552
Tone and volume control
AF amplifier
TDA 2870
Tone and volume control
AF amplifier
TDA 2870
V_d
V_{BFM}
MPX
I
AM-Tuner
BF 961, TDA 1046
Stereodecoder
TCA 4500 A
R
L
R
L
R
L
R
Input "cassette"
L
WS
Fade-in for warning sound
Mono input
WS = Warning sound
I = Traffic information
R
FM
L
Mono
AM
R
CAS
L
R
Switch for different AF sources
L
+14,4 V
+32 V
Station indication
UAA 170 + 16 LED
Selector and programming of the required stations
SAS 560 S, SAS 570 S
Tuning voltage generation
CAS
CBExt.
AMH
FMH
AM 1
AM 2
FM 1
FM 2
Switches for ranges and functions

Fig. 1.5.1.

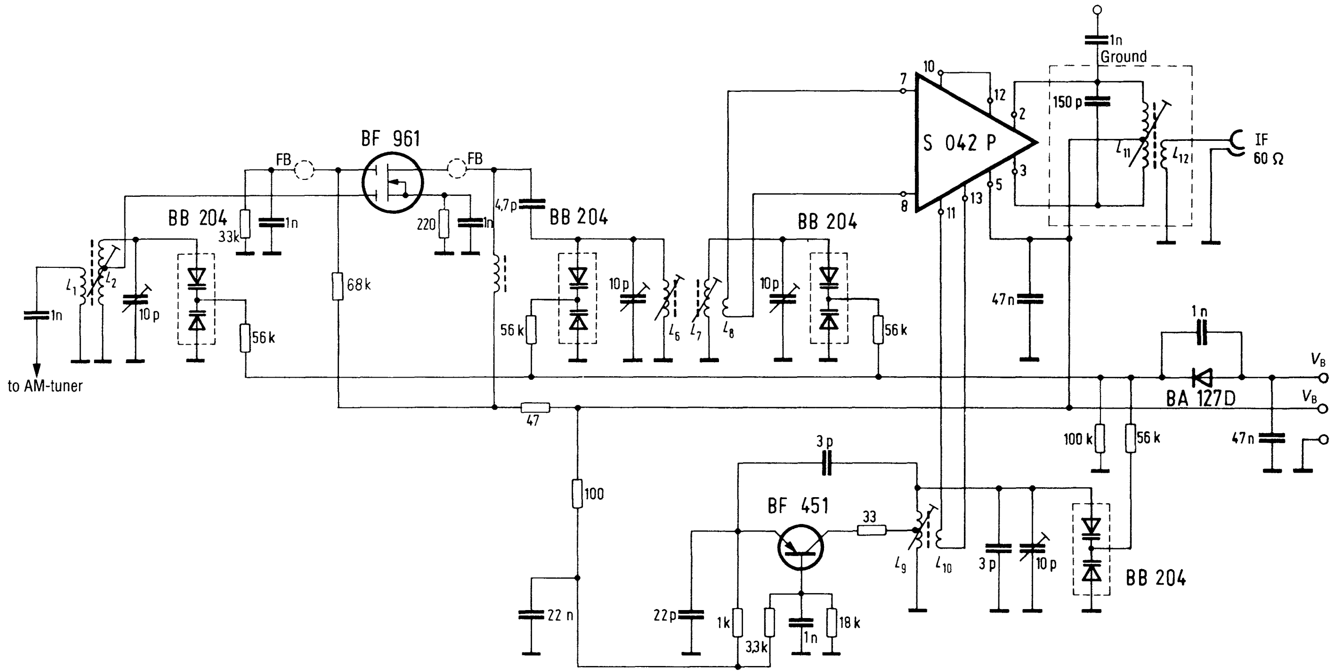

BF 961
FB
FB
BB 204
BB 204
BB 204
BB 204
33k
1n
220
1n
4,7p
68k
L1
L2
10 p
1n
56k
to AM-tuner
56 k
10p
L6
L7
L8
10p
56k
S 042 P
10
7
12
2
3
5
8
11
13
1n
Ground
150 p
L11
L12
IF
60 Ω
47n
1 n
VB
VB
BA 127D
47
100 k
56 k
47n
100
3 p
BF 451
33
L9
L10
3 p
10 p
22 n
22p
1k
3,3k
1n
18 k

Fig. 1.5.2.

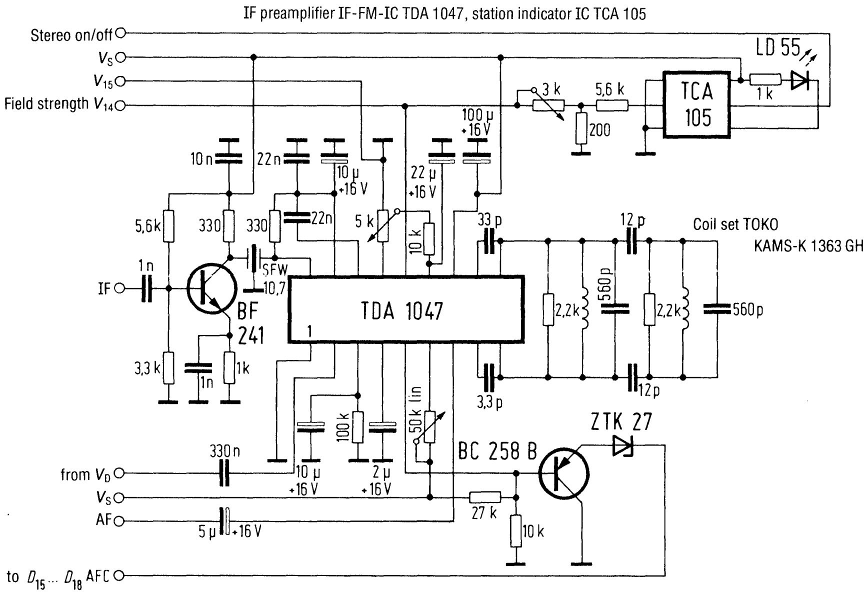


Fig. 1.5.3.

The threshold for the LED is adjustable by a dc voltage which is supplied from the TDA1047 and which depends on the input level of the FM signal. This dc voltage may also be utilized as positive switching voltage for stereo operation. The LED should be turned on, when the signal-to-noise ratio of the input signal is 26 dB.

AM tuner

The circuit of the AM tuner shown in **fig. 1.5.4** uses the IC TDA1046. The electronic tuning of the front end circuit and of the oscillator circuit is achieved by the capacitance diode BB413. Because of the amplitude-controlled oscillator the TDA1046 is especially favoured for applications with capacitance diodes operating in a tuning voltage range of up to 30 V.

It has to be considered that relatively high input signals (some volts) are often applied to the aerial of a car radio when the car passes stations at a minimum distance. Therefore an aperiodically-operating control circuit attenuates high input signals to a maximum value of 800 mV_{pp}. Up to this voltage the capacitance diode can be operated without generating undesired distortions of the AF signal. The MOS FET BF 961 is used as control transistor. In opposite to common circuits the control voltage is applied to gate 1 and the AM signal to gate 2. The tuner offers distortion factors of less than 1% at input voltages of approx. 1 V_{rms}. The

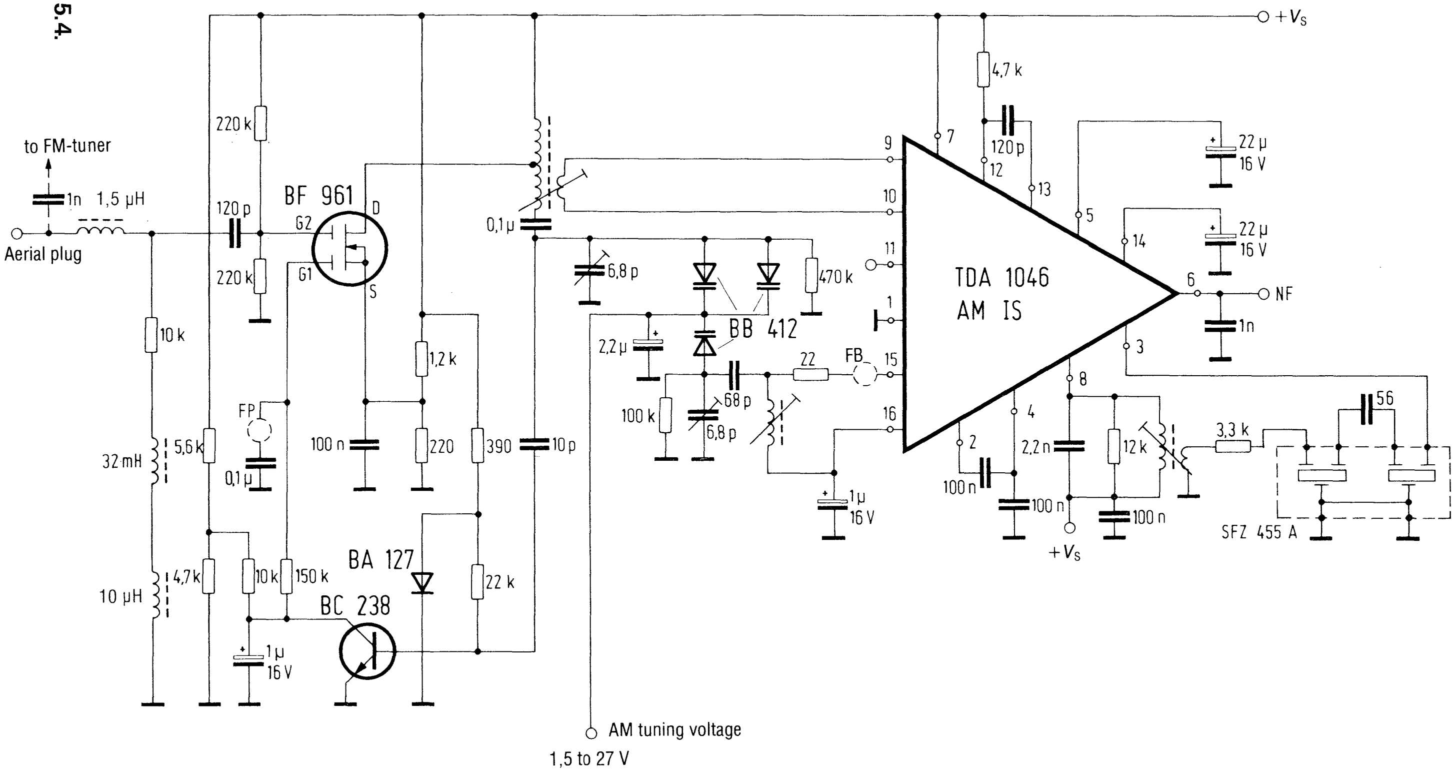

to FM-tuner
1n
1,5 µH
Aerial plug
220 k
120 p
220 k
BF 961
G2
G1
D
S
10 k
32 mH
10 µH
5,6 k
4,7 k
10 k
150 k
FP
0,1 µ
1 µ
16 V
BC 238
BA 127
100 n
1,2 k
220
390
22 k
0,1 µ
10 p
6,8 p
BB 412
470 k
2,2 µ
100 k
68 p
6,8 p
22
FB
1 µ
16 V
AM tuning voltage
1,5 to 27 V
TDA 1046
AM IS
9
10
11
1
15
16
7
12
13
5
14
6
3
8
4
2
4,7 k
120 p
22 µ
16 V
22 µ
16 V
NF
1n
100 n
2,2 n
100 n
12 k
100 n
+V_S
3,3 k
56
SFZ 455 A
+V_S

Fig. 1.5.4.

signal level at the capacitance diode of the oscillator circuit is kept constant to a value of approx. 800 mV_{pp} by means of the internally controlled oscillator.

The control voltage for the aperiodically-operating control circuit is supplied to transistor BC 238 via the 10 pF-capacitor. The transistor operates as rectifier. The filtered signal is applied to gate 1 and thus the FET is controlled. The tuned circuit is tapped off to reduce influences of the front end circuit to the FET-output and its connected loads. As the FET and the capacitance diode operate with different polarities of the supply voltage a galvanically-decoupled input circuit has to be used.

Decoder for roadside information broadcast

As it is very important that car drivers are promptly informed of traffic situation a decoder for roadside information broadcast is installed in the described car radio. It operates with the Siemens ICs S 0280, S 0281, S 551 and S 552. By that the station identification (SI), the announcement identification (AI) as well as the region identification (RI) can be utilized (see **fig. 1.5.5**).

By the station identification all stations transmitting a roadside information are detected. The announcement identification is broadcasted additionally during the period of the special announcement for the traffic and can be utilized for switching purposes, e.g. interrupting the cassette playback or increasing volume if it had been turned down for some reasons. The region identification identifies the station broadcasting in a certain region. In this case the IC S 552 decodes an auxiliary frequency, which is modulated upon the station frequency. The IC S 0280 incorporates a circuit which regenerates from the MPX-signal the 57 kHz-signal and its modulation products. As the master generator of the system oscillates with a frequency of 455 kHz interferences in the AM-frequency range are possible. Therefore the oscillator circuit is turned off via a diode and a voltage divider when an AM-signal is received. In the IC S 0280 the electronic switch for the MPX-signal is closed, if a switching signal is supplied from the IC S 551 after the identification of a VFR station or if the programming allows all stations to pass. From the regenerated 57 kHz-signal the identification for region as well as for announcement is filtered by two active filters and supplied to the ICs S 551 and S 552 for further processing.

The IC S 0281 contains additionally three electronic switches which interrupt the cassette programme if a traffic announcement is made. The traffic information is passed on to the AF-stage. The IC S 552 is suited for selecting the station of a defined district.

The stereo decoder

For stereo the PLL-stereo-decoding IC TCA 4500 A operating without coils is utilized as demonstrated in **fig. 1.5.6.**

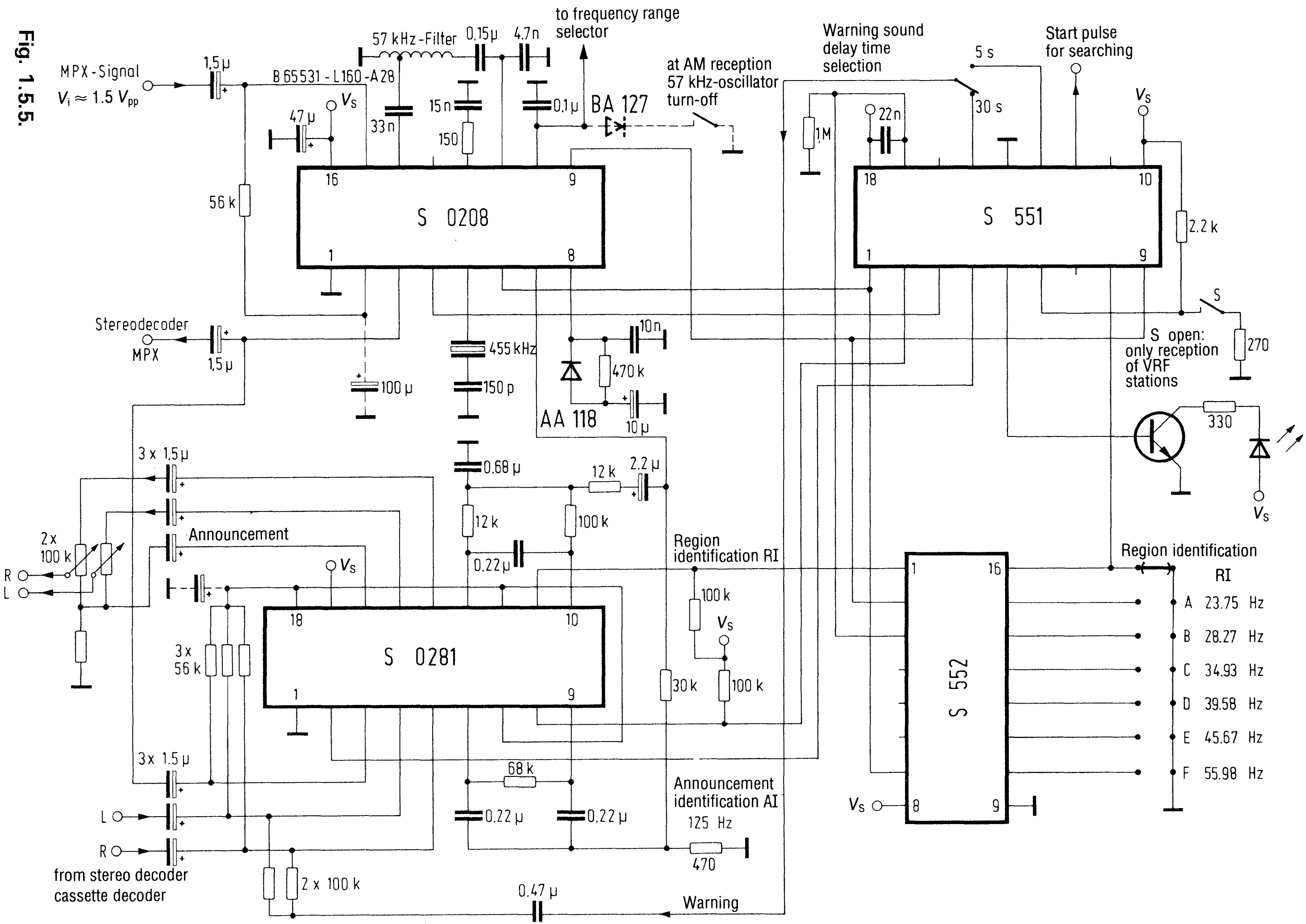

MPX-Signal
$V_i \approx 1.5\ V_{pp}$
1,5 µ
B 65531 - L160 - A28
57 kHz-Filter
0,15 µ
4.7 n
to frequency range selector
at AM reception 57 kHz-oscillator turn-off
Warning sound delay time selection
5 s
30 s
Start pulse for searching
47 µ
V_S
33 n
15 n
150
0,1 µ
BA 127
1M
22 n
56 k
S 0208
16
9
1
8
S 551
18
10
1
9
2.2 k
S
270
S open: only reception of VRF stations
Stereodecoder MPX
1,5 µ
100 µ
455 kHz
150 p
10 n
470 k
AA 118
10 µ
330
3 x 1,5 µ
0.68 µ
12 k
2.2 µ
12 k
100 k
Announcement
2 x 100 k
R
L
0.22 µ
Region identification RI
100 k
100 k
30 k
S 0281
18
10
1
9
3 x 56 k
S 552
1
16
8
9
Region identification RI
A 23.75 Hz
B 28.27 Hz
C 34.93 Hz
D 39.58 Hz
E 45.67 Hz
F 55.98 Hz
3 x 1.5 µ
68 k
0.22 µ
0.22 µ
Announcement identification AI 125 Hz
470
L
R
from stereo decoder cassette decoder
2 x 100 k
0.47 µ
Warning

Fig. 1.5.5.

AF stage

The AF circuit is shown in **fig. 1.5.7.** It comprises the electronic switches for the different signals, the tone control and the output amplifiers. The AF signals from the tuner or other sources, e.g. cassette playback (stereo) and CB-receiver (mono), are supplied via diodes to the base of a common-emitter circuit. The switching signal is utilized as base voltage for the transistors. RC-circuits with relatively long time constants guarantee that the switching is achieved with a smooth cross fade. As switching diode the type BA243 is used. Generally this diode is applied in VHF tuners to obtain a good cross-talk attenuation.

If an announcement identifier is transmitted the traffic message can be faded in by the roadside information broadcast decoder. This happens even if the volume control is turned down. In this case the message is audible with standard or with preset volume.

For the output circuit two TDA2870 are used. This amplifier IC is especially suited for applications in car radios. It operates in a push-pull mode and has an output power maximum of 12 W. By its internal protection circuit the TDA2870 is well protected against short-circuits and thermal overloads. The load maximum is 2 Ω.

Operating instructions

The different functions of the device are selected by the switching amplifier ICs - SAS560S and SAS570S. They are driven by push buttons as touch sensors do not work reliably when the operator wears gloves or when the air humidity is high. These ICs store the push button signals and supply the tuning voltage to the tuner (see **fig. 1.5.8**). The lamp power-output (I_{out}=approx. 50 mA) drives not only the indication LEDs but is also responsible for different switching operations,

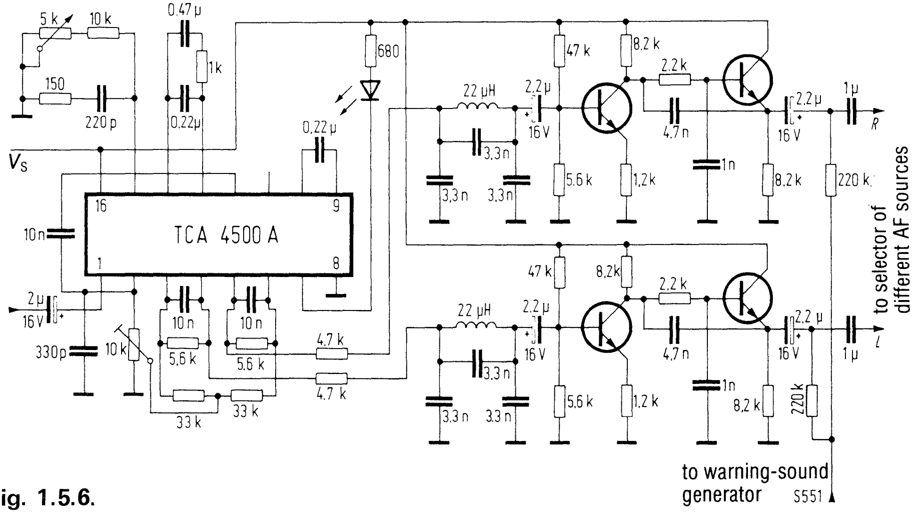
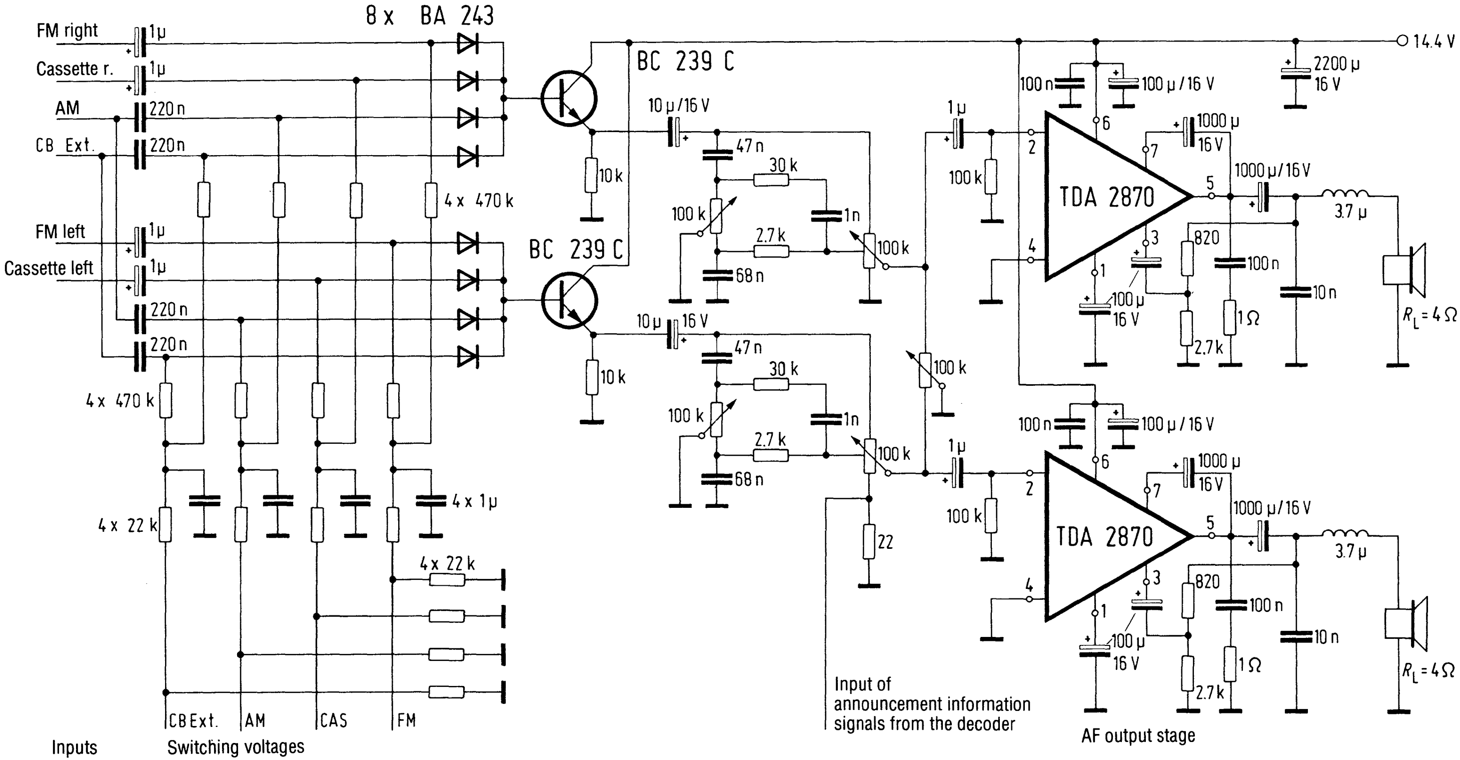


Fig. 1.5.6.

Fig. 1.5.7.



FM right
Cassette r.
AM
CB Ext.
FM left
Cassette left
1µ
220 n
8 x BA 243
4 x 470 k
4 x 22 k
4 x 1µ
BC 239 C
10 k
10 µ/16 V
47 n
30 k
100 k
1 n
2.7 k
68 n
22
14.4 V
100 n
100 µ / 16 V
2200 µ
16 V
1000 µ
TDA 2870
1000 µ/16 V
3.7 µ
820
10 n
1 Ω
$R_L = 4\,\Omega$
CB Ext.
AM
CAS
FM
Inputs
Switching voltages
Input of announcement information signals from the decoder
AF output stage

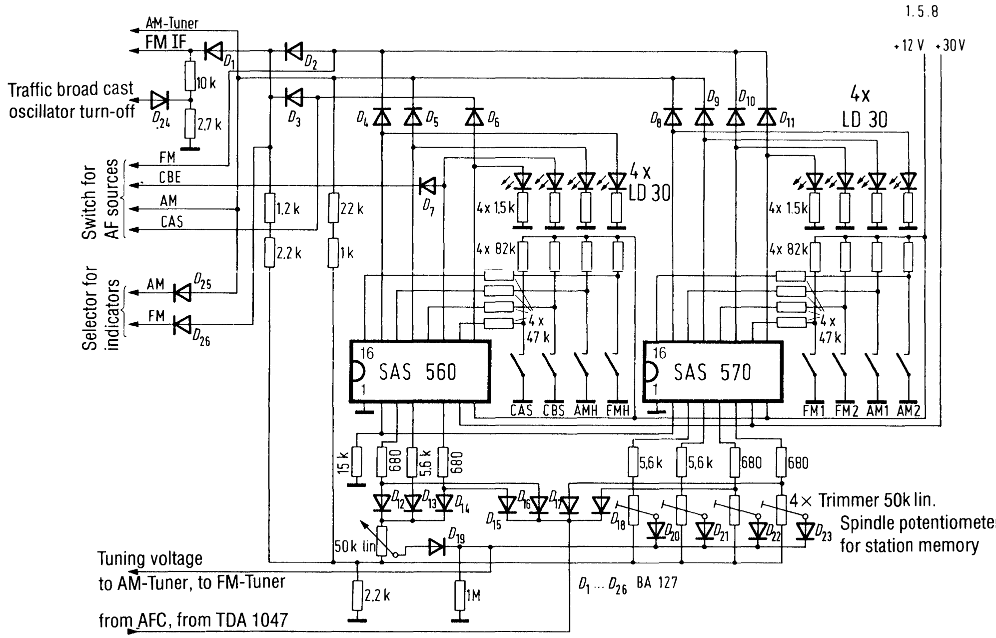


Fig. 1.5.8.

e.g. turn-off of the roadside information broadcast decoder, selecting the different AF-signal sources, switching on one of the two tuners for the desired frequency range (D_1 to D_{11}). To assure that a traffic information is reproduced, even if the cassette programme is running, i.e. the push button "cassette" is pressed, the FM tuner and the traffic broadcast decoding system are turned on. In this case a station, broadcasting a traffic message, can be manually selected.

The diodes D_{15}, D_{16}, D_{17} and D_{18} as well as the four 680 Ω-resistors belong to the AFC circuit of the FM tuner. A current, which is controlled by the TDA1047 is applied via the transistor BC258B to these resistors. The value of the current depends on the difference between the oscillator frequency and the station carrier frequency. With reference to this difference this current increases or decreases and different voltage drops across the 680 Ω-resistors are generated. Thus the tuning voltage is influenced.

Frequency indication

The IC UAA170 drives LEDs which indicate the received stations (see **fig. 1.5.9**). The tuning voltage is matched to the circuit by means of a FET.

In the described concept the tuners operate with two different tuning voltages (FM = 4.5 to 27 V and AM = 1.5 V to 27 V). Therefore a switching of the reference

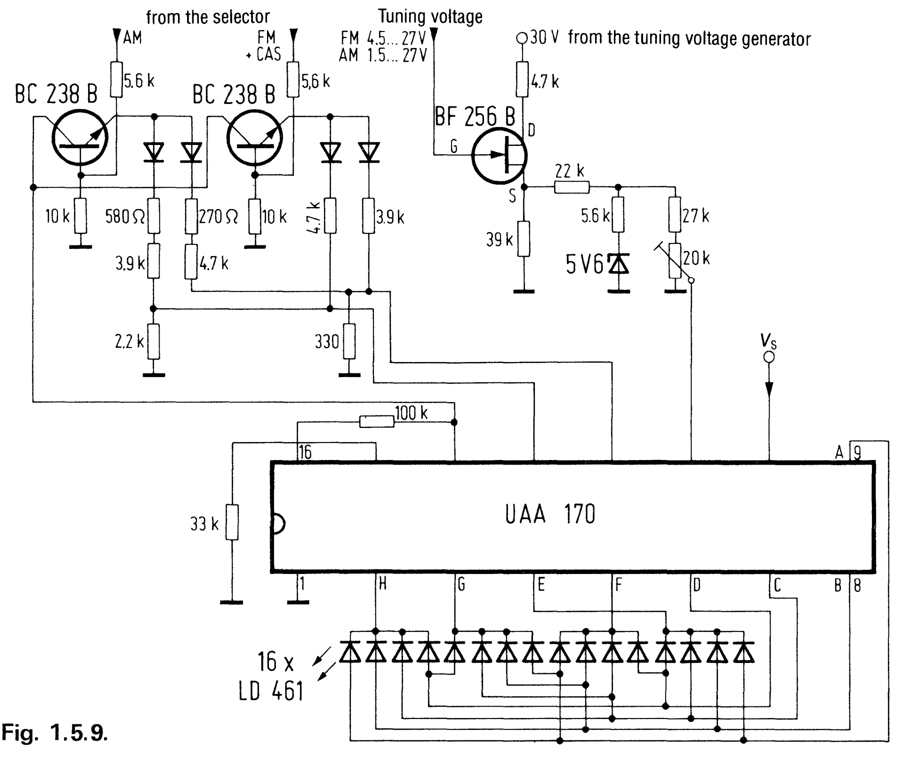


Fig. 1.5.9.

voltages for the UAA 170 is necessary. This is realized by the two voltage dividers and the two transistors type BC 238 B.

Components for the car superhet

			Ordering code	SCS stock number
1	IC	TDA 1046	Q67000-A1092	71092
1	IC	TDA 1047	Q67000-A1091	71093
1	IC	SO 42 P	Q67000-A0335	7252
1	IC	SAS 560 S	Q67000-S30	70346
1	IC	SAS 570 S	Q67000-S31	70347
1	IC	S 0280	Q67000-A1264	
1	IC	S 0281	Q67000-A1265	
1	IC	S 551	Q67000-Z109	
1	IC	S 552	Q67000-Z110	
2	Transistors	BC 239 C	Q62700-C282	8832
1	Transistor	BC 258 B	Q62702-C188	8602
4	Transistors	BC 414 C	Q62702-C376-V2	7032
1	Transistor	BF 241	Q62702-F303	8484

			Ordering code	SCS stock number
1	Transistor	BF 256 B	–	–
1	Transistor	BF 451	Q62702-F313	7039
1	Capacitance diode	BB 413	Q62702-B86	71302
4	Capacitance diodes	BB 204 green	Q62702-B57-X5	70732
36	Diodes	BA 127 D	Q60201-X127-D9	70044
8	Switching diodes	BA 243	Q62702-A521	71082
1	Z-diode	ZTK 27	–	–
3	Sibatit®-capacitors	10 n/63 V	B37448-A6103-S2	17224
4	Sibatit®-capacitors	22 n/63 V	B37448-A6223-S2	17225
3	Sibatit®-capacitors	47 n/63 V	B37448-A6473-S2	17227
1	Sibatit®-capacitor	100 n/63 V	B37449-A6104-S2	17235
1	Styroflex®-capacitor	330 pF/25 V	B31310-A3331-H	1367
2	Styroflex®-capacitors	33 pF/63 V	B31310-A5330-F	2477
2	Styroflex®-capacitors	12 pF/63 V	B31310-A5120-F	
2	Styroflex®-capacitors	560 pF/25 V	B31310-A3561-H	1371
6	Styroflex®-capacitors	3300 pF	B31310-A3332-H	1383
2	Styroflex®-capacitors	680 pF	B31310-A3681-H	1373
1	Styroflex®-capacitor	150 pF	B31310-A3151-H	1363
2	Styroflex®-capacitors	1000 pF	B31310-A3102-H	1377
1	Styroflex®-capacitor	2200 pF	B31310-A3222-H	1381
5	MKT capacitors	10 n/63 V	B32509-A0130-M	
3	MKT capacitors	15 n/63 V	B32509-A0153-M	
1	MKH capacitor	22 n/63 V	B32509-A0223-M	29945
1	MKH capacitor	33 n/63 V	B32509-A0333-M	29946
3	MKH capacitors	47 n/63 V	B32509-A0473-M	29947
15	MKH capacitors	100 n/63 V	B32509-A0104-M	29949
10	MKH capacitors	220 n/63 V	B32509-A0224-M	29951
1	MKH capacitor	330 n/63 V	B32509-A0334-M	29952
1	MKH capacitor	470 n/63 V	B32509-A0474-M	29953
2	MKH capacitors	680 n/100 V	B32510-D1684-K	29959
1	MKH capacitor	1 µ/100 V	B2510-D1105-K	
1	MKH capacitor	150 n/63 V	B32509-A0154-M	
1	Electrolytic capacitor	2200/16 V	B41012-E4228-T	7865
2	Electrolytic capacitors	1000/16 V	B41012-B4108-T	7864
11	Electrolytic capacitors	100 µ/16 V	B41286-B4107-T	
5	Tantalum capacitors	1 µ/40 V	B45181-B4105-M	7943
10	Tantalum capacitors	1.5 µ/25 V	B45181-B3155-M	7944
8	Tantalum capacitors	2.2 µ/20 V	B45181-A3225-M	
1	Tantalum capacitor	4.7 µ/40 V	B45181-B4475-M	7947
1	Tantalum capacitor	10 µ/25 V	B45181-B3106-M	7939
4	Tantalum capacitors	10 µ/40 V	B45181-B4106-M	7949
3	Tantalum capacitors	22 µ/16 V	B45181-A2226-M	7933
1	Tantalum capacitor	47 µ/16 V	B45181-A2476-M	7934
2	Tantalum capacitors	47 µ/40 V	B45181-B4476-M	7953
1	Ceramic capacitor	3 pF	B38112-A5030-C3	
1	Disc-type capacitor	3.3 pF	B38062-A6030-C306	17240

1 Disc-type capacitor	10 pF	B38062-J6100-G6	17246
1 Disc-type capacitor	27 pF	B38062-J6270-G6	17249
2 Disc-type capacitors	100 pF	B38066-J6101-G6	17255
1 Disc-type capacitor	120 pF	B37370-A1121-S	
2 Disc-type capacitors	220 pF	B38066-J6221-G6	17257
1 Disc-type capacitor	330 pF	B37370-A1331-S	
1 Disc-type capacitor	1000 nF	B37062-A6102-K6	17262
2 Disc-type capacitors	2200 nF	B37066-A6222-K6	17263
1 Disc-type capacitor	4700 nF	B37062-A6472-K6	17264
1 AM ceramic filter	SFZ455B	Fa. Stettner	
1 FM ceramic filter	SFE10.7MS	Fa. Stettner	
2 Coils KANS		K1363GH Fa. Componex	
1 Coilspule YXNS		30931X Fa. Componex	
2 Coils		D41-2519 Fa. Vogt-coil set	
1 Coil		D41-2520 Fa. Vogt-coil set	
4 Ferrite beads		62110-A5028-X022	
1 Ferrite bead		B62110-MII3.5 × 1.2 × 5.2	
2 Coils 22 mH	TOKO	10RA146LY223J Fa. Componex	
1 Pot-core		B65517-A0000-R030	2814
1 Pot-core		B65531-L0160-A028	2817
2 Chokes		B82114-R-A2	28326

1.6 AM Receiver Circuits Using New Types of AM Capacitance Diodes BB 413 and BB 312 and IC TDA 1046

Circuits of AM receivers very often operate with switching diodes for selecting the frequency range. In this case very high parallel capacitances influence the resonant circuits of the medium and long wave ranges. Therefore the MW range has to be split into two sections. To avoid this disadvantage two new types of capacitance diodes have been developed by the Siemens AG, the BB 413 and the BB 312. Both offer a higher capacitance and thus, even under the forementioned conditions, the total MW range can be covered.

Circuits using the AM receiver IC with demodulator, type TDA 1046, have already been described in "Design Examples of Semiconductor Circuits, Edition 1977/78". This IC includes a controlled RF prestage, a multiplicatively-operating push-pull mixer with separate oscillator, a controlled IF amplifier with integrated two-path demodulator, an active low-pass filter and an AF preamplifier. For improving the selectivity, i.e. the crossmodulation characteristics, the TDA 1046 can also be utilized to realize receivers with 3 tuned circuits as they are mainly used in car radios.

The capacitance diode BB 312 is a double-diode with a capacitance of 2 × 485 pF at $V_R = 1$ V and approx. 21 pF at $V_R = 30$ V.

The BB 413 is a triple-diode similar to the BB 113 with a capacitance of 360 pF at 1 V and approx. 15 pF at 30 V. It is mounted in the same type of case as the BB 113. By means of the BB 413 receivers with three tuned circuits can be realized with a common prestage gain of 10 to 15 dB. For devices operating with two circuits, two systems of the capacitance diode are connected in parallel and utilized in the front end circuit. The circuit of the receiver is shown in **fig. 1.6.1.** The front end is dimensioned in that the optimal matching source-impedance is 60 Ω. The circuit offers a low-pass filter characteristic and therefore the sensitivity is nearly constant over the frequency range. Because of its controlled oscillator the TDA 1046 is especially favoured for receivers with capacitance diodes. By that the amplitude of the oscillator voltage is kept to a constant value of approx. 700 mV_{pp}. The voltage across the capacitance diode is 500 mV_{pp} at 975 kHz and approx. 700 mV_{pp} at 2075 kHz. The corresponding frequencies of the received signal are 520 kHz and 1640 kHz. Usually the non-linearity of the capacitance diode characteristic $C_C = f(V_R)$ causes tracking errors. But with the relatively low voltages mentioned above the influence is kept to a minimum. The resistance of R is dimensioned in that on one hand it does not excessively damp the oscillator circuit but on the other hand the voltage dropping across it due to the reverse current does not noticeably influence the oscillator frequency. A value between 47 and 68 kΩ meets these requirements.

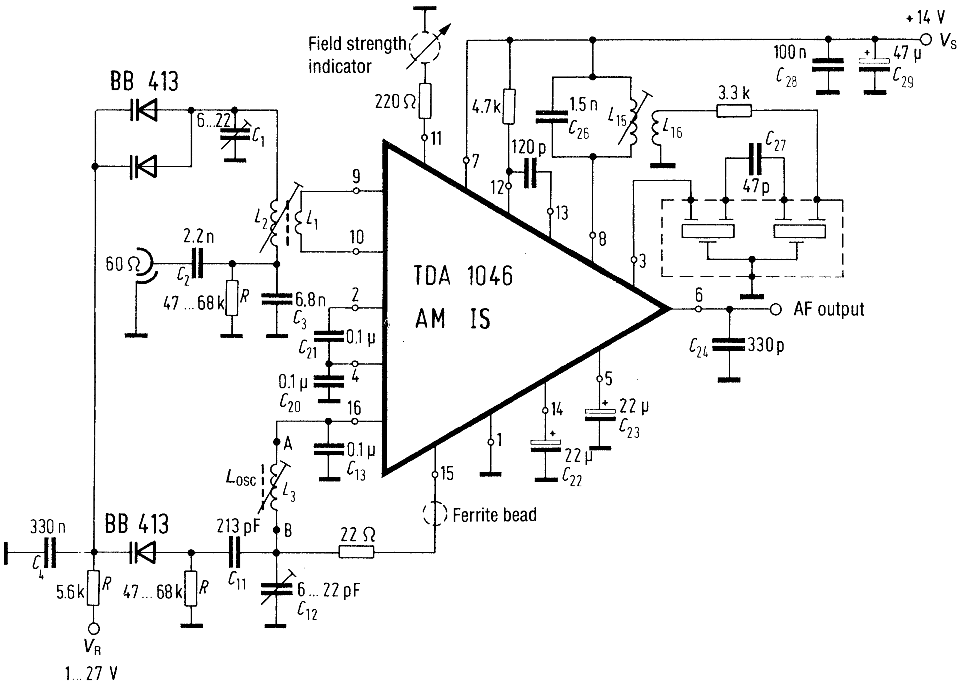


Fig. 1.6.1.

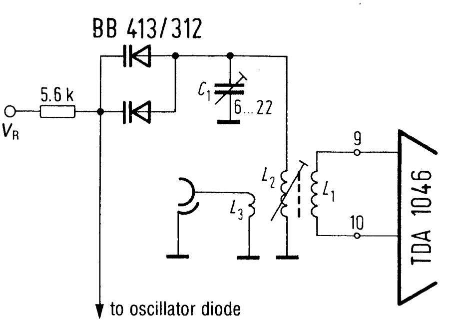


Fig. 1.6.2.

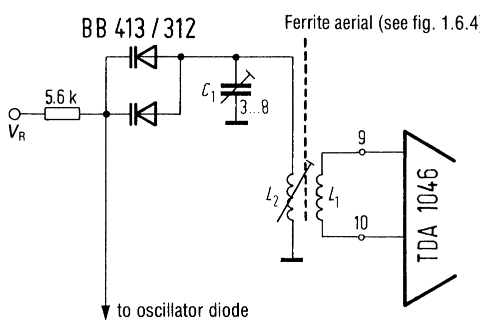


Fig. 1.6 3.

Fig. 1.6.2 shows the receiver circuit with inductive coupling to the transmitter ($R_i = 60\ \Omega$).

Fig. 1.6.3 demonstrates the front end circuit using a ferrite aerial the construction of which can be understood from **fig. 1.6.4.**

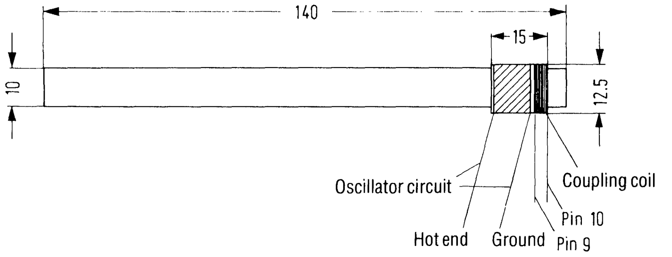


Fig. 1.6.4.

Table 1 indicates the coil data for all receiver circuits.

Technical data

Frequency	f	=520 to 1640 kHz
Tuning voltage	V_D	=1.5 to 27 V
IF bandwidth	B_{IF}	=4 kHz at 6 dB, 7 kHz at 10 dB
Supply voltage	V_s	=9 V (8 to 18 V)
AF output voltage (at a signal-to-noise ratio of 26 dB)	V_o	=280 mV at R_L=10 kΩ
Signal-to-noise ratio maximum		51 dB

Technical data of the receivers with capacitive coupling in accordance to fig. 1.6.1

a) **with BB 413:**

Frequency	600 kHz	900 kHz	1500 kHz
Input voltage in µV at a signal-to-noise ratio of			
S/N = 6 dB	1.7	1.8	2.8
S/N = 10 dB	3.0	3.2	4.5
S/N = 20 dB	11.0	11.0	16.0
S/N = 26 dB	21.0	22.0	32.0
S/N = 40 dB	120.0	140.0	180.0
Tuning voltage	1.5 to 27 V		
Front-end circuit bandwidth	9 to 40 kHz (f_{in}=520 to 1640 kHz)		

b) **with BB 312:**

Frequency	600 kHz	900 kHz	1500 kHz
Input voltage in µV at a signal-to-noise ratio of			
S/N = 6 dB	2.0	2.0	3.8
S/N = 10 dB	3.25	3.5	6.5
S/N = 20 dB	11.5	13.0	21.0
S/N = 26 dB	23.0	27.0	42.0
S/N = 40 dB	150.0	140.0	270.0
Tuning voltage	1.5 to 27 V		
Front-end circuit bandwidth	8 to 40 kHz (f_{in}=520 to 1640 kHz)		

Technical data of the receivers with inductive coupling (source impedance 60 Ω)

a) **with BB 413:**

Frequency	600 kHz	900 kHz	1500 kHz
Input voltage in µV at a signal-to-noise ratio of			
S/N = 6 dB	3.0	1.8	1.4
S/N = 10 dB	4.8	3.0	2.2
S/N = 20 dB	15.0	10.0	7.4
S/N = 26 dB	30.0	20.0	15.0
S/N = 40 dB	180.0	110.0	85.0
Tuning voltage	1.5 to 27 V		
Front-end circuit bandwidth	8 to 32 kHz (f_{in} = 520 to 1640 kHz)		

b) **with BB 312:**

Frequency	600 kHz	900 kHz	1500 kHz
Input voltage in µV at a signal-to-noise ratio of			
S/N = 6 dB	4.5	2.4	2.2
S/N = 10 dB	7.2	4.0	3.4
S/N = 20 dB	22.0	13.0	12.0
S/N = 26 dB	48.0	27.0	23.0
S/N = 40 dB	280.0	170.0	130.0
Tuning voltage	1.5 to 27 V		
Front-end circuit bandwidth	8.5 to 40 kHz (f_{in} = 520 to 1640 kHz)		

Technical data of the receivers with ferrite aerial

a) **with BB 413:**

Frequency	600 kHz	900 kHz	1500 kHz
Input voltage in mV at a signal-to-noise ratio of			
S/N = 10 dB	0.16	0.19	0.1
S/N = 20 dB	0.520	0.57	0.525
S/N = 26 dB	1.0	1.2	0.650
S/N = 40 dB	6.4	7.0	3.75
Tuning voltage	1.5 to 27 V		
Front-end circuit bandwidth	13 to 35 kHz (f_{in} = 520 to 1640 kHz)		

b) **with BB 312:**

Frequency	600 kHz	900 kHz	1500 kHz
Input voltage in mV at a signal-to-noise ratio of			
S/N = 10 dB	0.12	0.10	0.10
S/N = 20 dB	0.38	0.44	0.38
S/N = 26 dB	0.8	0.9	0.8
S/N = 40 dB	4.2	5.0	4.8
Tuning voltage	1.5 to 27 V		
Front-end circuit bandwidth	8 to 40 kHz (f_{in} = 520 to 1640 kHz)		

Table 1

TDA 1046	Front-end coil	Oscillator coil	Coupling coil (primary winding)	Coupling coil (secondary winding)
with ferrite aerial				
BB 312	49 turns	90 turns		10 turns
BB 413	49 turns	90 turns		10 turns
with source impedance of 60 Ω				
BB 312	115 turns	90 turns		15 turns
BB 413	90 turns	90 turns		15 turns
with inductive coupling of 60 Ω				
BB 312	115 turns	90 turns	2 turns	15 turns
BB 413	90 turns	90 turns	2 turns	15 turns

Ferrite aerial: cross-wise wound coil 09234-117-06 on ferrite aerial rod B61610-J1017-X025

Components for circuit 1.6

		Ordering code	SCS stock number
1 IC	TDA 1046	Q67000-A1092	71092
1 Capacitance diode	BB 413	Q62702-B86	71302
1 Ceramic capacitor	47 pF	B37370-A1470-S	–
1 Ceramic capacitor	120 pF	B37370-A1121-S	–
1 Styroflex-capacitor	213 pF		
combination of	180 pF	B31110-A1181-H	–
and	33 pF	B31110-A1330-H	–
1 Ceramic capacitor	330 pF	B37370-A1331-S	–
1 Styroflex-capacitor	1.5 nF	B31063-A5152-H	–
1 MKH-layer capacitor	2.2 nF	B32560-A3222-K	–
1 MKH-layer capacitor	6.8 nF	B32560-A3682-K	–
4 MKH-layer capacitors	0.1 µF	B32560-D1104-J	27548
1 MKH-layer capacitor	0.33 µF	B32560-D1334-J	27552
2 Electrolytic capacitors	22 µF/40 V	B41286-A7226-T	7833
1 Ferrite bead	N 22	B62110-A3007-X022	

1.7 IF LC-Filter for TCA 440 and TDA 1046

In some applications the use of ceramic filters for IF selection is accompanied by problems, e.g. the employment of these filters in aeroplane models where high vibrations occur. Therefore it is advantageous to use a compact LC-filter as shown in **fig. 1.7.1.** The IF-selection is totally accomplished by it. The input circuit is dimensioned meeting all requirements of the TCA 440 with respect to the supply voltage. The bandwidth is easily and reproducibly adjustable by means of the coupling capacitors.

The insertion loss of 11 dB corresponds to the values of a ceramic filter. The measured selections at different coupling capacitors are documented in **table 1.7** and shown in **fig. 1.7.2.**

Table 1.7

C_K	Insertion loss	Bandwidth				Curve
		3 dB	6 dB	10 dB	50 dB	
5.6 pF	11 dB	4.1 KHz	6.0 KHz	7.0 KHz	13.6 KHz	1
6.8 pF	8.5 dB	5.2 KHz	7.2 KHz	8.6 KHz	15.7 KHz	2
8.2 pF	8.0 dB	6.0 KHz	8.2 KHz	10.0 KHz	17.3 KHz	3
10.0 pF	7.0 dB	7.0 KHz	9.4 KHz	11.2 KHz	19.6 KHz	4

Coil data

L1:	85 turns	6 × 0.04 ESSCu
L2:	15 turns	(L1, L2)
L3:	100 turns	6 × 0.04 ESSCu
L4:	88 turns	6 × 0.04 ESSCu
L5:	12 turns	(L4, L5)

wound on Vogt coil former D71-2498.1

Note: ESSCu = enamelled silk screened copper wire

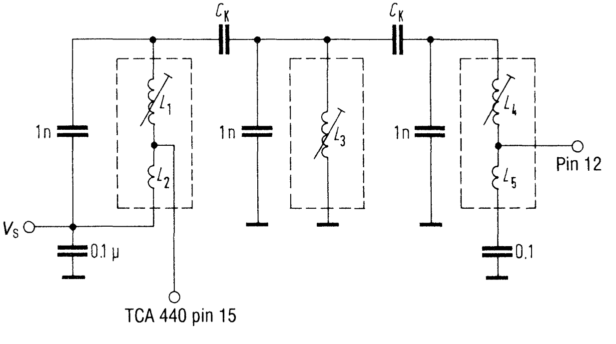


Fig. 1.7.1.

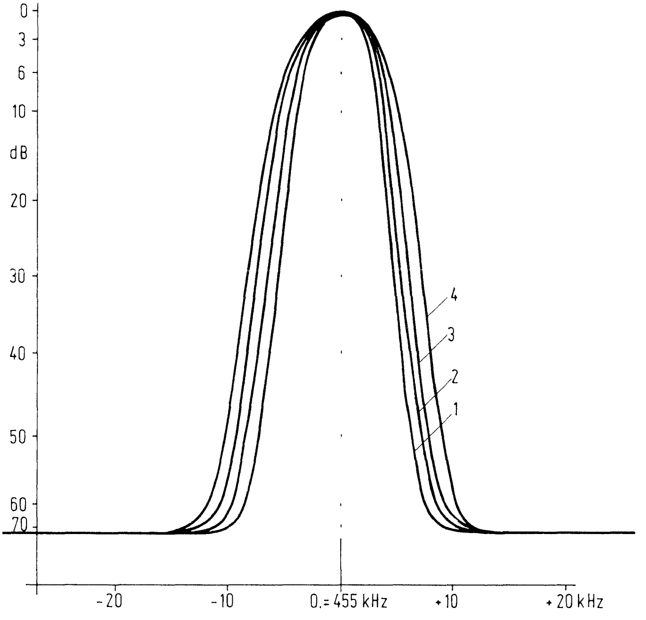


Fig. 1.7.2.

Components for circuit 1.7

			Ordering code	SCS stock number
3	Polypropylene capacitors	1 nF/160 V	B33063-A1102-H	27828
1	MKH-layer capacitor	0.1 µF/100 V	B32560-D1104-J	27548
3	Vogt coil formers D71-2498.1 (coil data according to table)			

1.8 Transposer with BF 960/961 Transposing 432 to 434 MHz into 28 to 30 MHz

Fig. 1.8 shows a circuit which transposes a section of the 70 cm-band into the 10 m-band. It uses the MOS tetrodes BF 960 and BF 961 recently developed by the Siemens AG. The circuit consists of the prestage with the BF 960 and the mixer. The operating point of the BF 960 is adjusted by potentiometer P_1. No additional negative bias is necessary as a positive voltage is supplied via the 1.2 kΩ/270 Ω-divider to the source terminal of the MOS tetrode. The following RF band-pass filter is constructed according to principles of line techniques. The multiplicatively operating mixing circuit uses the VHF MOS-FET BF 961. The output resonant circuit consisting of L_3 and C_{12} is tuned to 29 MHz. The IF is coupled out via L_4. The oscillator signal with a frequency of 404 MHz and an amplitude between 0.9 and 1.5 V_{rms} at 60 Ω can be generated by multiplying a crystal-frequency or by frequency synthesis. It is applied to gate 2 of the BF 961.

The coupling of the oscillator signal is not critical as gate 2 operates with a 68 Ω-resistor and a series 1 nF-capacitor connected to ground. Thus a low impedance for the IF signal and a good mixing gain are realized.

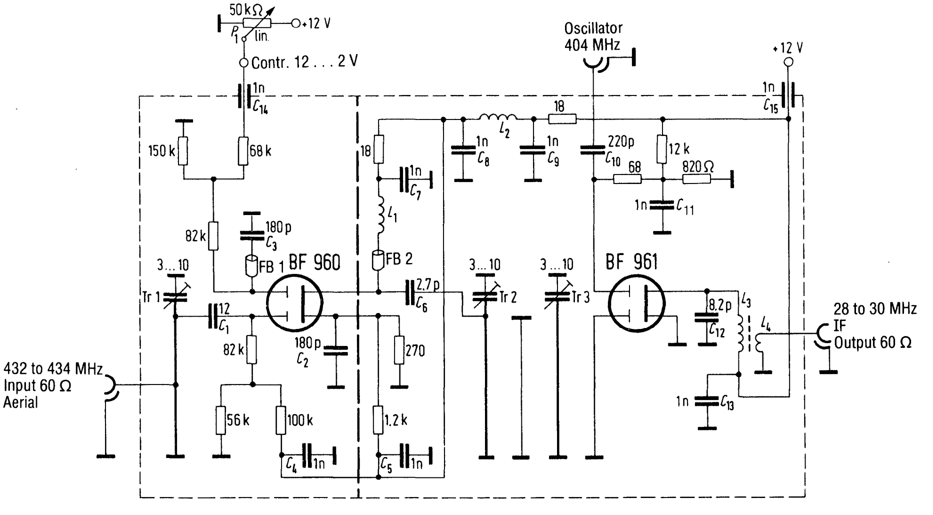


Fig. 1.8.

Technical data

Power gain	G_p	27 dB
Noise figure	NF	3 to 3.5 dB
Front end circuit bandwidth	$B_{(-3\ dB)}$	30 MHz
RF bandwidth	$B_{(-3\ dB)}$	16 MHz
Image frequency rejection		40 dB
Input reflexion coefficient		$\|r\|=0.3$
Dynamic range		$\Delta G_p=45$ dB
Crossmodulation characteristics		
$V_{interf.}$*) in the range between 430 and 440 MHz		3 mV
in the range at 20 dB downward control		100 mV
from ±50 MHz		100 mV

*) $V_{interf.}$ is the R.M.S.-value at 60 Ω of the interference voltage of an undesired station frequency which is 100% modulated by a sine signal and which generates an amplitude modulation of 1% upon the actual carrier.

Coil data

L_1 8 turns, 3 mm ∅, 0.5 mm ECu
L_2 11 turns, 3 mm ∅, 0.5 mm ECu
L_3 25 turns, ECu 0.3 mm ∅ } on coil former
L_4 4 turns, ECu 0.3 mm ∅ } Sp 3.5/18.5-core U17
distance L_3/L_4
L_4 wound on top of L_3

Note: ECu = enamelled copper wire

Components for circuit 1.8

			Ordering code	SCS stock number
1	MOS-Transistor	BF960	Q62702-F499	71743
1	MOS-Transistor	BF961	Q62702-F518	71218
1	Disc-type capacitor	2.7 pF	B38112-A5020-D701	–
1	Disc-type capacitor	8.2 pF	B38112-A5080-D201	–
3	Ceramic trimmers (tube-type)	10 pF		–
1	Disc-type capacitor	12 pF	B38116-J5120-J5	1788
1	Trapezium capacitor	180 pF	B37290-B5181-M002	–
1	Disc-type capacitor	180 pF	B38066-J6181-G1	–
1	Disc-type capacitor	220 pF	B37205-A5221-M1	–
7	Disc-type capacitors	1 nF	B37235-J5102-S1	1726
2	Feed-through capacitors	1 nF	B37810-A3102-S2	–
2	Ferrite beads		B62110-A3011-25	–
1	Screw core		B63310-B3021-X017	–

1.9 RF Circuit of a Small SSB Receiver for the 80 m-Band Using TCA 440 and S 042 P

Fig. 1.9 shows a very simple circuit of a receiver which is suited for receiving single-sideband (SSB)-transmissions. The AM receiver-IC TCA 440 comprises a RF prestage with AGC, a balanced mixer, an oscillator and an IF amplifier with AGC.

The RF band-pass filter of the prestage selects the required frequency range of 3.5 to 3.8 MHz. It assures a sufficient image frequency rejection at a used IF of 455 kHZ. The prestage circuit cannot be tuned. Only the oscillator circuit is tunable by a variable capacitor. Therefore the amount of required components is reduced to a minimum.

The oscillator operates below the receiving frequency.

For the SSB-operation the bandwidth of the ceramic filter should not exceed 3 kHz. The gain of the IF circuit is automatically controlled and the control of the RF prestage is obtained by a potentiometer. It is possible to drive an indicator for the relative field-strength of the input signal via pin 10 of the TCA 440. For this application a moving-coil instrument is recommended.

Usually double-sideband (DSB)-transmissions are demodulated by the diode AA 118.

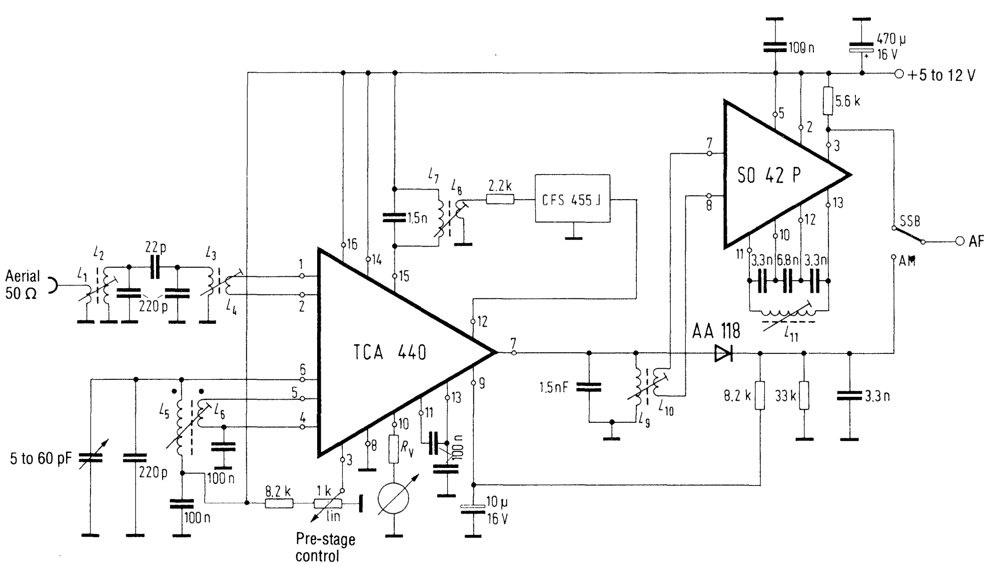


Fig. 1.9.

At SSB-operations the IF-signal is supplied via L_{10} to the pins 7 and 8 of the S 042 P, which offers the function of a product-demodulator with heterodyning oscillator.

As the lower sideband is not usually transmitted a switching of the heterodyning oscillator is not provided for.

If the described circuit is completed with an AF amplifier a portable receiver is realized.

With a sample device an input sensitivity of less than 1 µV at a signal-to-noise ratio of 10 dB across 60 Ω has been measured.

Coil data

	Turns	Wire diameter	Coil former	Screw core
L_1	3	12×0.4 ESSCu	Sp 3.5/18.5	K1
L_2	33	12×0.4 ESSCu		
L_3	33	12×0.4 ESSCu	Sp 3.5/18.5	K1
L_4	15	12×0.4 ESSCu		
L_5	40	0.15 ECu	Vogt filter set	
L_6	15	0.15 ECu	D41-2519 or cube core	
L_7	70	12×0.04 ESSCu	D41-2519 complete	
L_8	12	12×0.04 ESSCu		
L_9	70	12×0.04 ESSCu	D41-2519 complete	
L_{10}	5	12×0.04 ESSCu		
L_{11}	70	0.1 ECu	D41-2519 complete	

Notes: ECu = enamelled copper wire; ESSCu = enamelled silk screened copper wire

List of components

		Ordering code	SCS stock number
1 IC	TCA 440	Q67000-A669	7469
1 IC	S 042 P	Q67000-A335	7252
1 Diode	AA 118	Q60101-X118	8010
1 Disc-type capacitor	22 pF	B38116-J5220-J1	1778
2 Disc-type capacitors	220 pF	B37205-A5221-M1	–
1 Styroflex-capacitor	220 pF	B31310-A3221-H	1365
2 Styroflex-capacitors	1.5 nF	B31310-A3152-H	1379
3 MKH layer capacitors	3.3 nF	B32560-D6332-J	27622
1 MKH layer capacitor	6.8 nF	B32560-D6682-J	27624
5 Sibatit®-capacitors	100 nF	B37449-A6104-S2	17235
1 Electrolytic capacitor	10 µF	B41286-A8106-T	7836
1 Electrolytic capacitor	470 µF	B41286-A4477-T	7889

2. AF Circuits

2.1 AF Amplifier for 5.5 Watt Output Power Using TDA 1037 D

Circuits of AF amplifiers using TDA 1037 have already been described in section 2.1 of "Design Examples of Semiconductor Circuits, Edition 1977/78". The TDA 1037 is encapsulated in a single-in-line package, whereas the TDA 1037 D has a dual-in-line case with eighteen pins. Therefore AF amplifiers can be realized very economically. Pins 10 to 18 perform the thermal contact of the IC to the chassis. An internal electronic circuit reacts like a fuse and protects the TDA 1037 D against thermal overload.

Fig. 2.1 shows a circuit as generally used in TV sound-amplifiers. The gain is controlled by the resistor connected via an electrolytic capacitor to pin 6, whereas the 1.5 nF- and 3.3 nF-capacitors are responsible for the deemphasis. If the described AF amplifier is used for other applications the capacitances have to be varied. The output power stage is controlled by an internal bootstrap circuit via the 470 µF-capacitor. Thus a higher efficiency is realized.

The dc current flows through the loudspeaker coil.

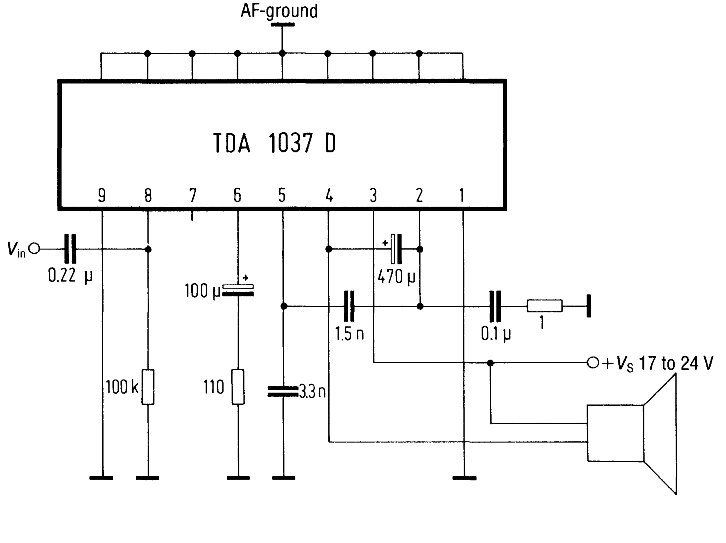


Fig. 2.1.

Technical data

Supply voltage	V_S	17	17	18	18	19	19	20	20	24	V
Output voltage	V_o	6.3	6.6	6.6	7	7	7.4	7.3	7.8	8.5	V
Output power (f=1 KHz, K=10%)	P_o	5	2.7	5.4	3	6.1	3.5	6.7	3.8	4.6	W
Load	R_L	8	16	8	16	8	16	8	16	16	Ω
Ambient temperature	T_{amb}	55	55	55	55	55	55	55	55	55	°C

Components for circuit 2.1

		Ordering code	SCS stock number
1 IC	TDA 1037 D	Q67000-A1229	
1 Ceramic capacitor	1.5 nF	B37981-J5152-K	17311
1 Ceramic capacitor	3.3 nF	B37981-J5332-K	17313
1 Ceramic capacitor	100 nF	B37988-J5104-M	17326
1 MKT capacitor	220 nF	B32509-A0224-M	29951
1 Electrolytic capacitor	100 µF/25 V	B41286-B5107-T	7891
1 Electrolytic capacitor	470 µF/25 V	B41012-A5477-T	7911
1 Resistor	1 Ω/0.3 W	B54311-Z5010-G001	28572
1 Resistor	110 Ω/0.3 W	B54311-Z5111-G001	28570
1 Resistor	100 kΩ/0.3 W	B54311-Z5104-G001	28598

2.2 AF Amplifier for an Output Power of 10 Watt Using TDA 2870

The TDA 2870 is an IC which was especially designed for applications in car radios. Its output power stage is controlled by an internal circuit in that the IC is protected against thermal overload and short-circuits. The total output power is 10 Watt at a load of 2 Ω.

The gain is adjustable by the two resistors of 1.2 kΩ and 10 Ω. If an application with a minimum of components is required the former resistor can be eliminated. In this case the other resistor has to be increased to a value of 82 Ω.

The circuit shown in **fig. 2.2** operates in a supply voltage range between 5 and 18 Volts, whereas the output power stage is controlled by an internal bootstrap circuit in order to increase the efficiency. For realizing this feature a 100 µF-capacitor is connected from pin 5 to 7 of the TDA 2870.

Components for circuit 2.2

		Ordering code	SCS stock number
1 IC	TDA 2870		
2 Ceramic capacitors	100 nF	B37988-J5104-M	17326
1 Ceramic capacitor	680 pF	B37986-J5681-J	17289
1 MKT capacitor	1000 nF	B32561-D1105-J	27574
1 Electrolytic capacitor	22 µF/25 V	B41315-A7226-V	–
2 Electrolytic capacitors	100 µF/25 V	B41286-A5107-T	7891
1 Electrolytic capacitor	2200 µF/16 V	B41010-E4229-T	7850
1 Resistor	1 Ω/0.3 W	B54311-Z5010-G001	25572
1 Resistor	10 Ω/0.3 W	B54311-Z5100-G001	79860
1 Resistor	1.2 kΩ/0.3 W	B54311-Z5122-G001	28510

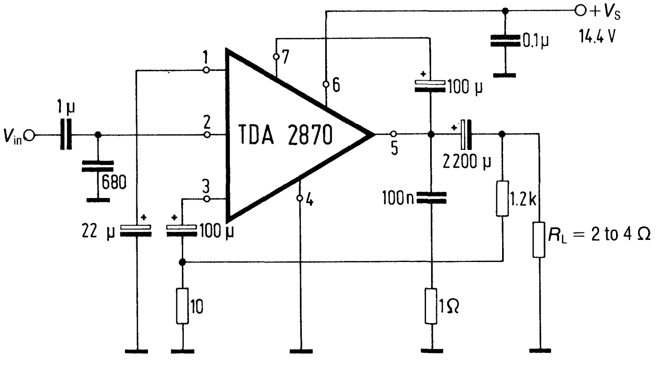
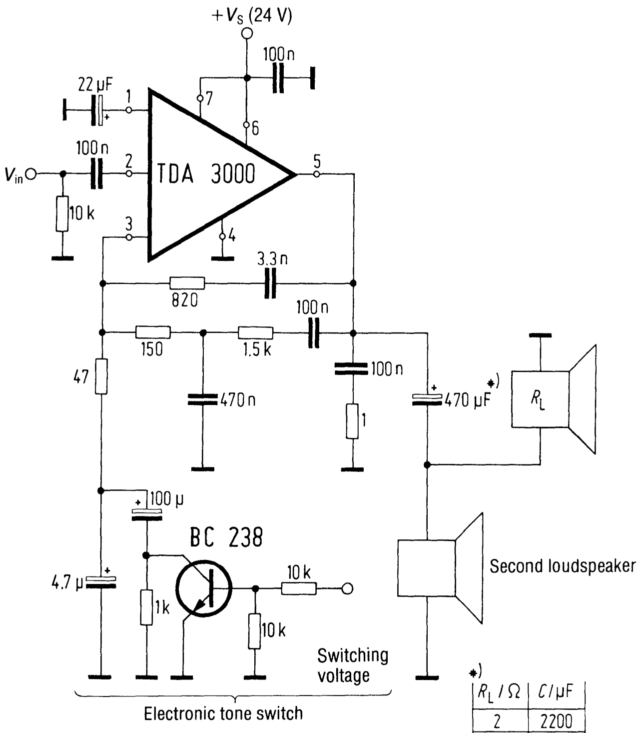


Fig. 2.2.

2.3 AF Amplifier for an Output Power of 15 Watt Using TDA 3000

Fig. 2.3 shows a circuit for an AF amplifier for an output power of 15 Watt using the IC TDA 3000. By an internal electronic fuse the IC is protected against thermal overloads and short-circuits. Treble and bass are controlled by 10 dB referred to the value at about 1 kHz. This feature is achieved by a specially dimensioned reverse feedback circuit. The transistor BC 238 operates as an electronic switch by which the tone control can be turned off. If no switching voltage is applied to the base of the transistor the control circuit is ineffective. As the TDA 3000 supplies high output currents a second loudspeaker can be used.

For supply voltages equal or higher than 20 V an internal bootstrap circuit increases the efficiency. In this case an electrolytic capacitor has to be connected from pin 5 to 7 as already described for circuit 2.2.



*)

R_L / Ω	C / µF
2	2200
4	1000
8	470
16	220

Fig. 2.3.

Technical data

Supply voltage	V_S	20	20	20	24	V
Output power (f=1 Hz, K=10%)	P_o	8	9	13.5	15	W
Load	R_L	8	4	2	4	Ω

Components for circuit 2.3

		Ordering code	SCS stock number
1 IC	TDA 3000	Q67000-A1332	–
1 Transistor	BC 238	Q62702-C698	70091
1 Ceramic capacitor	3.3 nF	B37981-J5332-K	17313
4 Ceramic capacitors	100 nF	B37987-J5104-K	17322
1 Ceramic capacitor	470 nF	B37985-J5474-M	17328
1 Electrolytic capacitor	4.7 µF/25 V	B41315-A8475-V	–
1 Electrolytic capacitor	22 µF/25 V	B41315-A7226-V	–
1 Electrolytic capacitor	100 µF/25 V	B41286-B5107-T	7891
1 Electrolytic capacitor	470 µF/25 V	B41012-A5477-T	7911
or	220 µF/25 V	B41286-B5227-T	7892
	1000 µF/25 V	B41012-C5108-T	7912
	2200 µF/25 V	B41012-B5228-T	7913
1 Resistor	1 Ω/0.3 W	B54311-Z5010-G001	28572
1 Resistor	47 Ω/0.3 W	B54313-Z5470-G001	28390
1 Resistor	150 Ω/0.3 W	B54311-Z5151-G001	28545
1 Resistor	820 Ω/0.3 W	B54311-Z5821-G001	28560
1 Resistor	1 kΩ/0.3 W	B54311-Z5102-G001	28509
1 Resistor	1.5 kΩ/0.3 W	B54311-Z5152-G001	28512
3 Resistors	10 kΩ/0.3 W	B54311-Z5103-G001	28532

2.4 Tone Control Using TDA 4290

The IC TDA 4290 is favoured for tone, treble and bass control. A selection between a linear and a physiological characteristic is possible, whereby the control is achieved by means of a dc voltage.

Treble emphasis and deemphasis depend on the dc voltage supplied to pin 14 and a linear characteristic is achieved at $V_{14} = 0.5 \times V_2$. The capacitance at pin 13 determines the start of the emphasis.

Pre- and deemphasis of the bass are realized by the voltage at pin 8 and by the capacitor connected from pin 10 to 11, whereas a linear characteristic is achieved at $V_8 = 0.5 \times V_2$.

The volume is adjustable by the voltage at pin 5 and under the condition of $V_5 = 0.5 \times V_2$ the output level at pins 3 and 6 is nearly the same as the input level at pin 9. The voltage at these two outputs is decreased by 80 dB, if the voltage is zero at pin 5 and if there is no connection to pin 4.

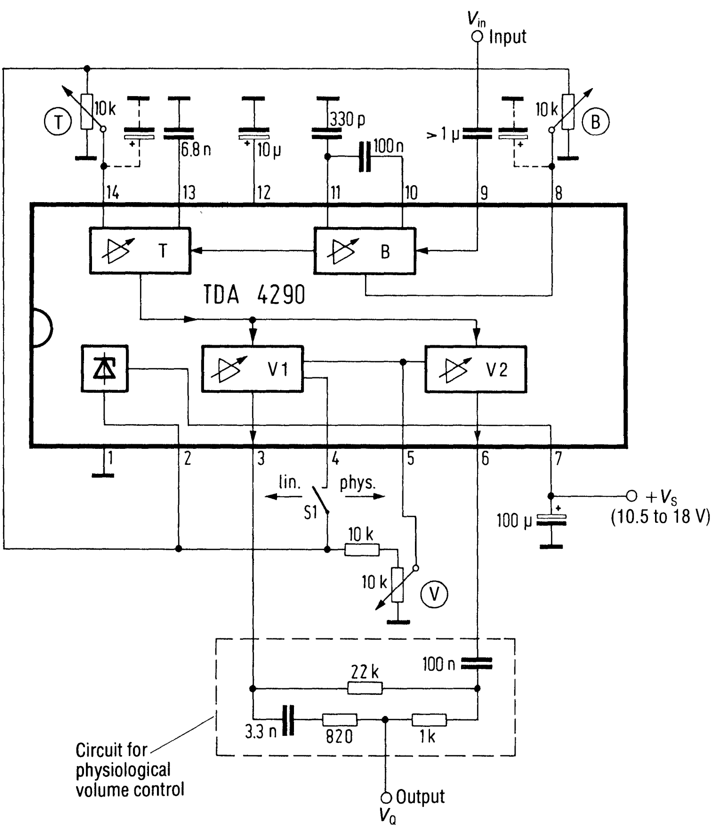


Fig. 2.4.

For realizing the volume control a reference voltage V_2 is applied to pin 4. The deemphasis obtained at pin 3 differs from that at pin 6. If the voltage V_5 is 1 Volt, e.g., a decrease of 30 dB occurs at pin 3 and of 60 dB at pin 6. If, however, a frequency-dependent circuit is connected to pin 3 and 6 as shown in **fig. 2.4**, the output signal depends on the frequency as well as on the adjusted volume, i.e. the levels at pin 3 and 6. As the voltage at pin 3 is equal to that at pin 6 under the condition of maximum volume, the frequency-dependent circuit has no influence to the voltage V_Q. If the deemphasis increases the output voltage at pin 6 decreases faster than at pin 3. Therefore the circuit connected to pin 6 reacts as a frequency-dependent shunt for the signal path from pin 3 to the output.

Components for circuit 2.4

		Ordering code	SCS stock number
1 IC	TDA 4290	Q67000-A1359	–
1 Ceramic capacitor	330 pF	B37979-J5331-J	17285
1 Ceramic capacitor	3.3 nF	B37981-J5332-K	17313
1 Ceramic capacitor	6.8 nF	B37981-J5682-K	17315
2 Ceramic capacitors	100 nF	B37987-J5104-K	17322
1 MKT capacitor	>1 µF e.g.	B32234-A1155-K	2683
1 Electrolytic capacitor	10 µF/63 V	B41315-A5106-T	–
1 Electrolytic capacitor	100 µF/25 V	B41286-A5107-T	7891
1 Resistor	820 Ω/0.3 W	B54311-Z5821-G001	28560
1 Resistor	1 kΩ/0.3 W	B54311-Z5102-G001	28509
1 Resistor	10 kΩ/0.3 W	B54311-Z5103-G001	28532
1 Resistor	22 kΩ/0.3 W	B54311-Z5223-G001	28540
3 Potentiometers	10 kΩ/lin.		–

2.5 Hearing-Aid Preamplifier Using TAB 1031 K

Fig. 2.5.1 to 2.5.4 show circuits for hearing-aid preamplifiers without automatical gain control. The circuit of **fig. 2.5.1** is favoured by a minimum of components required. For guaranteeing a stable operation the impedance of the driving voltage source has to be less than 3 kΩ. The gain depends on the load R_{13} and amounts 55 to 80 dB at resistances of 150 to 3.3 kΩ. The coupling capacitor at the input should have a low leakage current.

For increasing the dynamic characteristics and the gain a resistor can be connected from pin 14 to ground. Thus the emitter resistance of the output stage is decreased (100 Ω). This measure is recommended especially for load currents of $R_{13}<300$ Ω.

If the impedance of the voltage source is high an additional filtering is advantageous. This is achieved by the combination of the internal resistance of 100 Ω between pin 8 and 11 and the capacitor C_{11} connected to pin 11 (pls. refer to **fig. 2.5.3**).

In the circuit of **fig. 2.5.4** an additional capacitor is connected from pin 5 to ground as the driving voltage source has a high impedance. The capacitor C_5 improves the characteristics at low frequencies. With reference to the circuit of fig. 2.5.1 an improved noise factor is realized but the dynamic becomes worse.

If an external gain adjustment is required, a 100 kΩ-potentiometer has to be connected from pin 1 to pin 14 as demonstrated in **fig. 2.5.5**. Besides that a 2.2 nF-capacitor is connected from pin 12 to 13 to achieve a better frequency compensation and to influence the high frequency cutoff.

Fig. 2.5.6 shows a circuit with earphone. Because of the inductive part of the phase impedance, the compensating capacitor C_f is connected from pin 12 to pin 11 or to ground.

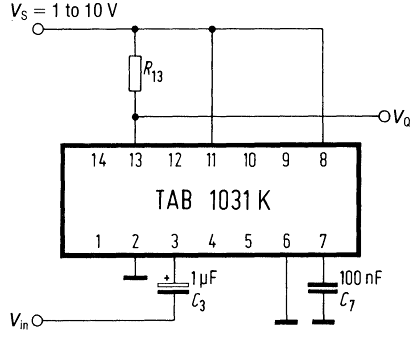


Fig. 2.5.1.

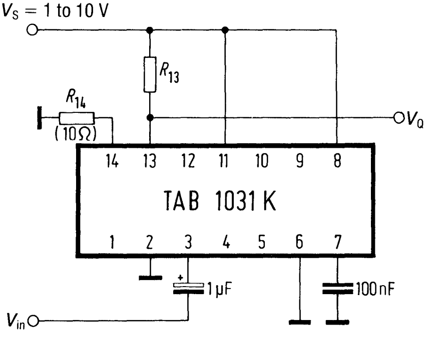


Fig. 2.5.2.

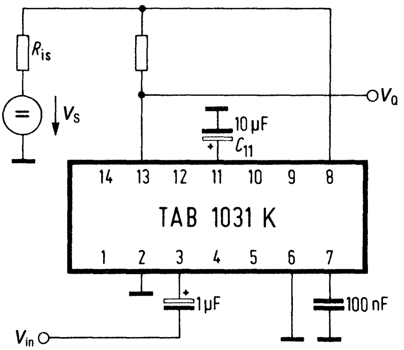


Fig. 2.5.3.

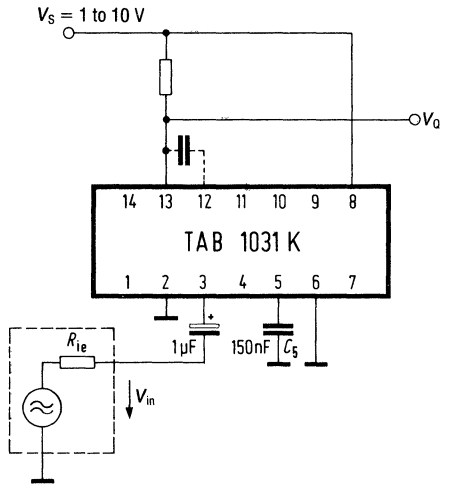


Fig. 2.5.4.

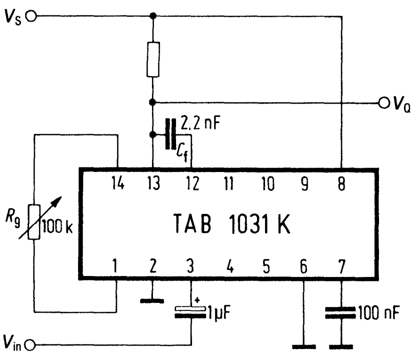


Fig. 2.5.5.

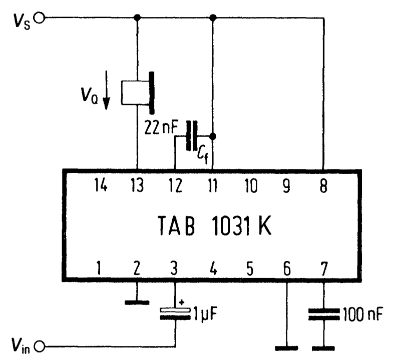


Fig. 2.5.6.

Fig. 2.5.7 shows a circuit with earphone as well as with microphone. The dc operating point is adjustable by the potentiometer P_{10} and the gain is set by the resistor R_9.

A circuit using TDA 1031 K with automatic gain control is demonstrated in fig. 2.5.8 to 2.5.10. The difference being that pin 6 is not connected to ground but to an RC-circuit consisting of a 1 MΩ-resistor R_6 and a 2.2 µF-capacitor C_6. The latter component should have a low leakage current.

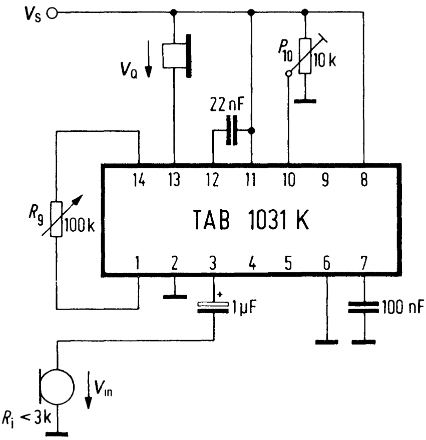


Fig. 2.5.7.

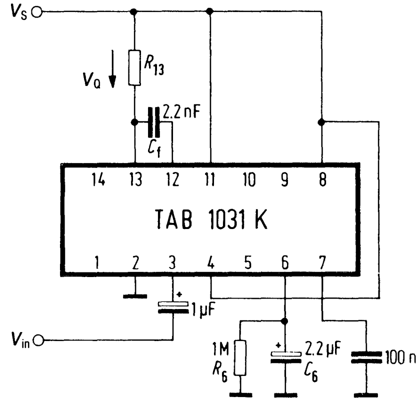


Fig. 2.5.8.

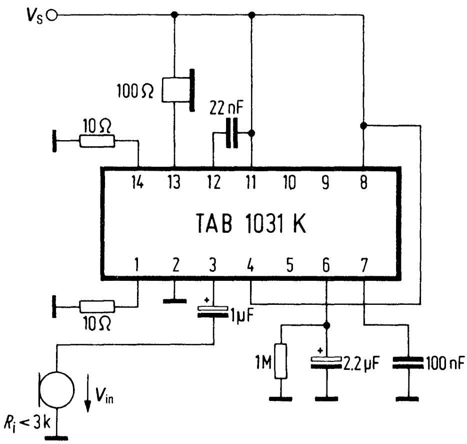


Fig. 2.5.9.

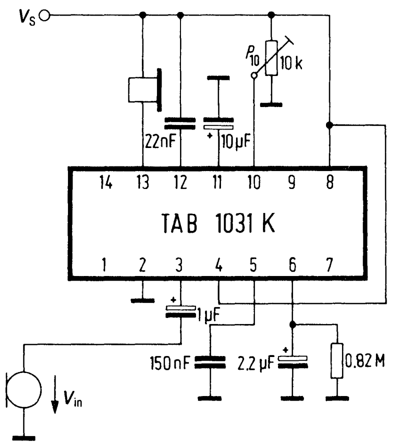


Fig. 2.5.10.

The earphone of the circuit shown in **fig. 2.5.9** has a low impedance. The source impedance of the microphone should not exceed 3 kΩ.

In the amplifier circuit of **fig. 2.5.10** the impedance of the earphone as well as of the driving voltage source is high. The operating point is adjustable by the potentiometer P_{10} to keep the dc current low.

Components for circuits 2.5.1 and 2.5.2

		Ordering code	SCS stock number
1 Hearing-aid preamplifier	TAB 1031 K	Q67000-A1314	–
1 Ceramic capacitor (flat type)	0.1 µF	B37449-A6104-S2	–
1 Tantalum electrolytic capacitor	1 µF/40 V	B45178-E6105-M	–

Components for circuit 2.5.3		Ordering code	SCS stock number
As for circuit 2.5.1 and			
1 Tantalum electrolytic capacitor	10 μF	B45178-A5106-M	29806

Components for circuit 2.5.4

1 Hearing-aid preamplifier	TAB 1031 K	Q67000-A1314	–
1 MKH layer capacitor	0.15 μF	B32560-D1154-J	27549
1 Tantalum electrolytic capacitor	1 μF/40 V	B45178-E6105-M	29818

Components for circuit 2.5.5

As for circuit 2.5.1 and			
1 Polypropylene capacitor	2.2 nF	B33063-A1222-H	27833

Components for circuits 2.5.6 and 2.5.7

As for circuit 2.5.1 and			
1 MKH layer capacitor	22 nF	B32560-D3223-J	27564

Components for circuit 2.5.8

As for circuit 2.5.5 and			
1 Tantalum electrolytic capacitor	2.2 μF	B45178-A4225-M	29797

Components for circuit 2.5.9

As for circuit 2.5.7 and			
1 Tantalum electrolytic capacitor	2.2 μF	B45178-A4225-M	29797

Components for circuit 2.5.10

1 Hearing-aid preamplifier	TAB 1031 K	Q67000-A1314	–
1 MKH layer capacitor	22 nF	B32560-D3223-J	27564
1 MKH layer capacitor	0.15 μF	B32560-D1154-J	27549
1 Tantalum electrolytic capacitor	1 μF/40 V	B45178-A6105-M	29818
1 Tantalum electrolytic capacitor	2.2 μF	B45178-A4225-M	29797
1 Tantalum electrolytic capacitor	10 μF	B45178-A5106-M	29806

2.6 Push-pull Output Amplifier for Hearing-Aids Using TAB 1041

The TAB 1041 is available in a miniature package (TAB 1041W) and as micropack. The latter package is especially favoured for application in film circuits.

Fig. 2.6.1 shows an amplifier circuit for operation of hearing-aids with a minimum of external components. The two symmetrical coils of the earphone are represented by the resistors R_1 and R_4. The centre tap of the coil is connected to V_S. If a gain adjustment is required, an additional resistor R_6 has to be connected from ground to pin 6 as shown in **fig. 2.6.2**. Besides that a reverse feedback from pin 3 to 6, consisting of the series resistor R_3 and the 68 nF-capacitor is recommended.

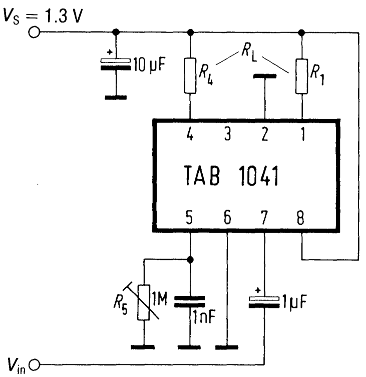


Fig. 2.6.1.

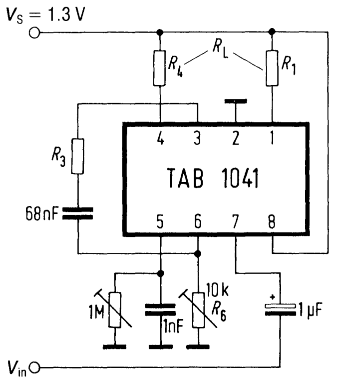


Fig. 2.6.2.

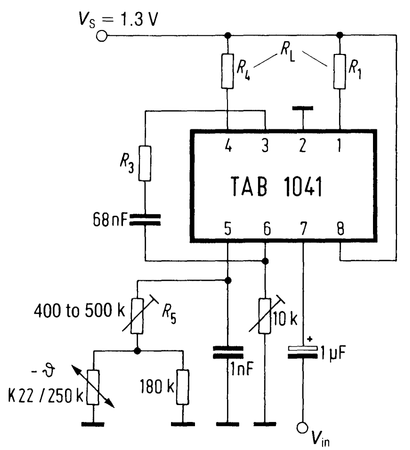


Fig. 2.6.3.

A NTC resistor compensates the temperature dependence on the operating point. In **fig. 2.6.3** a shunt of 180 kΩ is connected in parallel to the NTC resistor. The series resistor adjusts the dc current.

Components for circuit 2.6.1		Ordering code	SCS stock number
1 Push-pull output amplifier	TAB 1041 K	Q67000-A1315	–
or	TAB 1041 W	Q67000-A1315W	–
1 MKH layer capacitor	1 nF	B32560-D6102-J	27618
1 Tantalum electrolytic capacitor	1 µF/40 V	B45178-E6105-M	2324
1 Tantalum electrolytic capacitor	10 µF/25 V	B45178-A3106-M	2316

Components for circuit 2.6.2

As for circuit 2.6.1 and			
1 MKH layer capacitor	68 nF	B32560-D1683-J	27547

Components for circuit 2.6.3

As for circuit 2.6.2 and			
1 NTC resistor	K22/250 k	Q63022-K254-M	8423

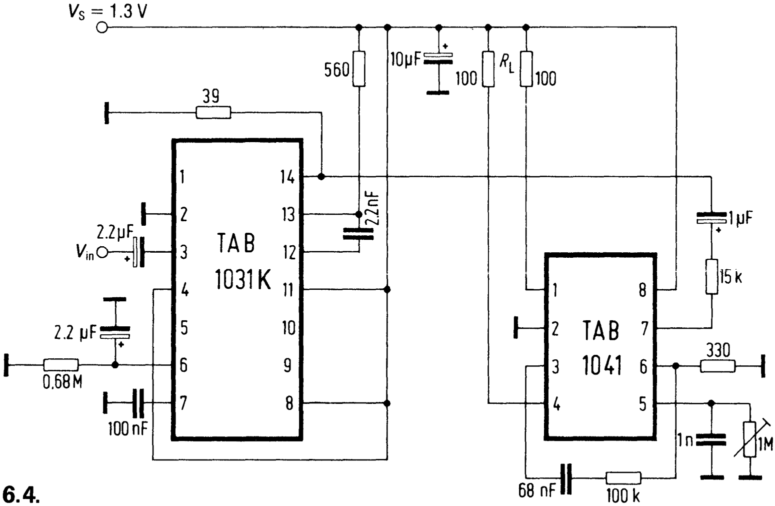


Fig. 2.6.4.

Fig. 2.6.4 demonstrates the combination of the hearing-aid preamplifier TAB 1031 K and the push-pull output amplifier TAB 1041. The circuit operates with a mono cell battery.

Components for circuit 2.6.4		Ordering code	SCS stock number
1 Hearing-aid preamplifier	TAB 1031 K	Q67000-A1314	–
1 Hearing-aid push-pull-amplifier	TAB 1041 K	Q67000-A1315	–
1 MKH layer capacitor	1 nF	B32560-D6102-J	27618
1 MKH layer capacitor	22 nF	B32560-D3223-J	27564
1 MKH layer capacitor	68 nF	B32560-D1683-J	27547
1 Ceramic capacitor (flat type)	0.1 µF	B37449-A6104-S2	17235
1 Tantalum electrolytic capacitor	1 µF/40 V	B45178-E6105-M	29818
2 Tantalum electrolytic capacitors	2.2 µF/20 V	B45178-A4225-M	29797
1 Tantalum electrolytic capacitor	10 µF/25 V	B45178-A5106-M	29806

3. TV Circuits

3.1 Digital Tuning System SDA 100

Fig. 3.1.1 shows a block diagram of the digital tuning system SDA 100, developed by Siemens AG. It essentially comprises three groups of functions:

frequency processing
controlling and displaying
station storing.

The required frequencies are produced by a frequency synthesis generator accordingly to the phase-locked-loop principle (PLL). This generator consists of a voltage-controlled oscillator (the actual tuner oscillator), a frequency divider type S 0436 with a constant ratio of 1 : 64, a programmable divider IC S 0437, a phase detector and an integrator using the IC TBB 1331 A. The reference frequency for the phase detector is produced by a 4 MHz-crystal-oscillator with 2048 : 1-divider.

The fast-operating ECL-divider S 0436 covers a frequency range between 60 and 1 GHz. For a reliable operation a sine-wave signal with an r.m.s.-value of ≧200 mV in the forementioned frequency range should be applied to its input. This divider is suitably mounted also in the tuner case. A broadband amplifier offering a voltage gain of approx. 20 dB is connected between the divider and the oscillator to avoid influences of the oscillator frequency. The push-pull outputs of the S 0436 offer a good immunity to noise and interferences from the output signal being 1 V_{pp}.

The PLL-IC S 0437 includes a 13 bit-programmable synchroneous divider. Its input frequency maximum is 15 MHz.

The dividing factor is serially set to a 13 bit-shift-register. Its clock frequency is generated by a crystal divider and is available for the IC SM 564 at the collector output. The repetition period of the clock CL is 16 µs and the pulse duration is 4 µs. Shifting is processed at the low-high transition of the shifting cycle. The S 0437 also supplies a synchroneous pulse SYC with a repetition time of 512 µs and a pulse duration of 8 µs.

The push-pull output at pin 4 operates as a current source at "too high" input frequencies and as current drain at "too low". If the input frequency is correct the output has a high impedance.

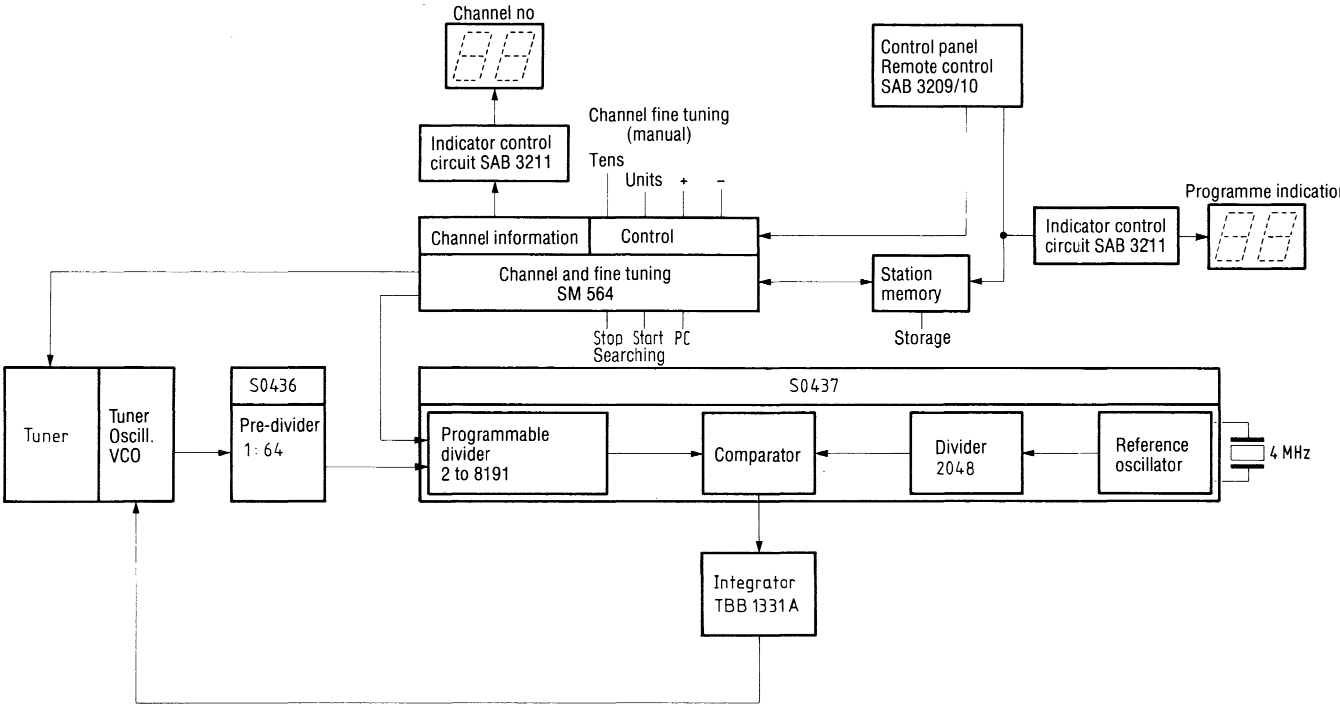
For tuning voltages of $V_D \leqq 12.5$ V an integrating network has to be connected directly to the output. If higher voltages are required, e.g. for TV-tuners, an external operational amplifier is necessary.

In the described circuit the op amp. TBB 1331 is used. It operates as integrator and boosts the tuning voltage to $V_D = 0.5$ to 30 V.

The MOS IC SM 564 is located between the programmable divider and the station memory, which stores the channel number and the corresponding tuning information.

Fig. 3.1.1.

SDA 100



It is electrically programmable and converts the tuning information to a frequency information which determines the dividing factor of the PLL-divider and which is serially transfered to the PLL-circuit. The total channel numbers are stored in the station memory, i.e., each address of the memory corresponds to a TV station.

When the push button of the TV channel-selector is operated the control circuit receives a programme change instruction from the remote control receiver. By this instruction a tuning information is serially transfered from the station memory to the PLL-circuit and the TV set is tuned with the accuracy of a crystal to the frequency of the required station.

Fig. 3.1.2 shows the wiring for the different ICs of the SDA100. The initial programming of a TV station, the frequency of which has not yet been stored, is realized by the control push buttons "channel units" and "channel tens". By each push button operation the relevant channel number is increased by one, i.e. the channel information is converted in a frequency and passed on to the PLL-circuit. Then it is audible on the TV-screen that the next channel has been selected.

Besides that the SM564 offers a "search-tuning". When this function is started by pressing the push button "search-tuning start", the frequency information is transfered from the ROM to the PLL-circuit by means of the control circuit. This process is stopped automatically when a frequency of a station is received. Then the control circuit receives an input signal which completes the searching.

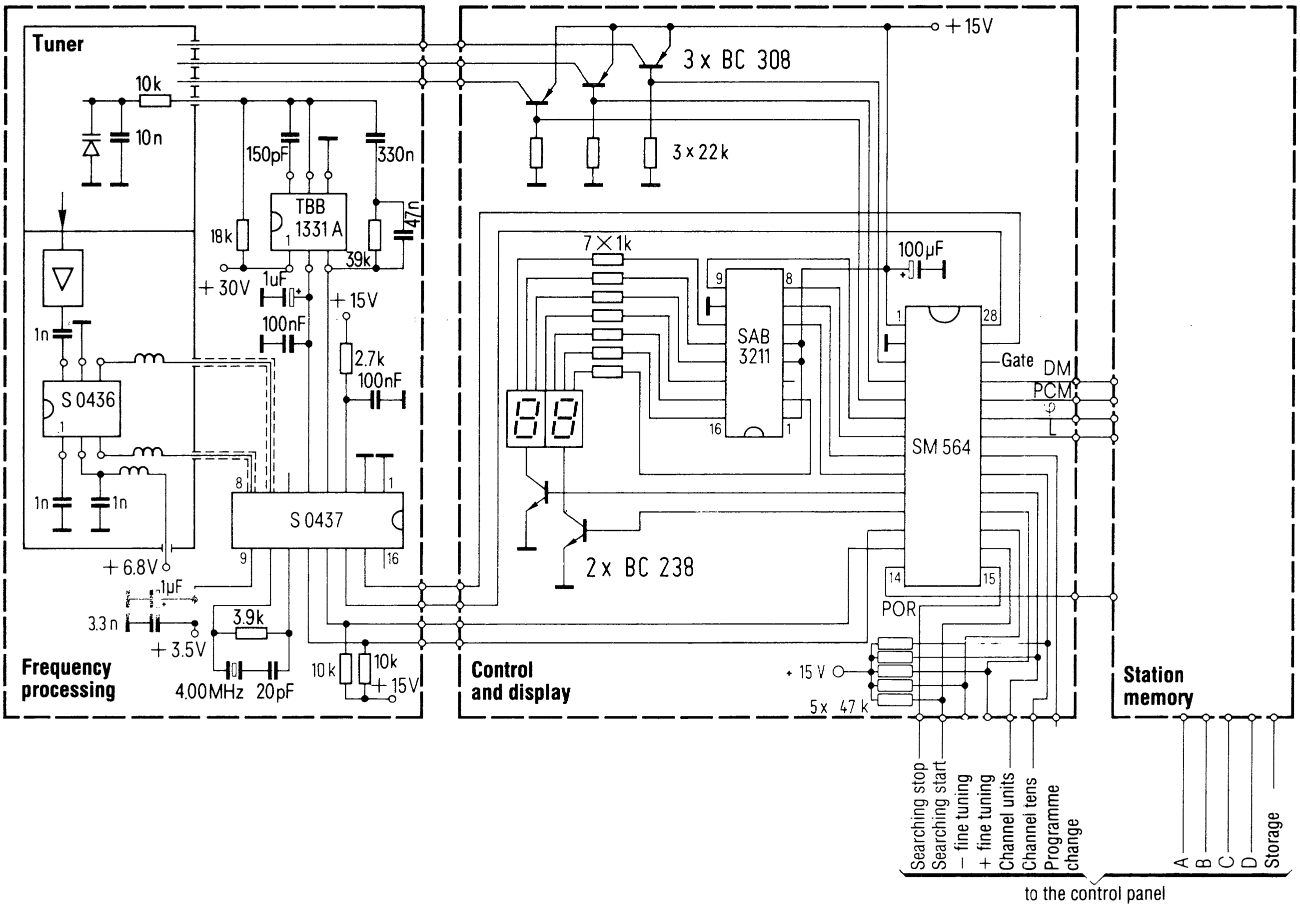
By using the push buttons "fine tuning plus" and "fine tuning minus" frequency deviations can be compensated with an accuracy of +3.875 MHz and −4 MHz in steps of 125 kHz. The frequency tuning automatically is in operation every 250 ms, when the push button is pressed. It stops when one of the range limits is reached (automatical overflow limitation).

In this case the channel indication lamp blinks as long as the push button is pressed. For every frequency information, being stored in the memory, the corresponding tuning information as well as fine tuning information can also be placed into the tuning memory.

The SM564 comprises a mask programmable ROM with the capability of storing a frequency information for 100 TV channels. For every frequency information the corresponding instructions for band selection (VHF-band I, III and UHF) are also stored in the ROM and processed by the control circuit.

Between the SM564 and the tuning memory the data are transfered as a pulse train, incorporating the shift clock φ, the data and an enable signal PCM. The data word contains the information of the channel number and of the fine tuning. The former is BCD-coded (4 bits for each figure) whereas the latter exists as a dual figure of 6 bit. The information for the channel number indication is available at the outputs 6 to 9 as a BCD-coded word of 4 bit. The outputs 10 and 11 are responsible for the assignment of units and tens. The frequency of these multiplex signals is approx. 60 Hz.

Fig. 3.1.2.


Tuner
10k
10n
150pF
330n
TBB 1331 A
47n
18k
39k
+ 30V
1uF
+ 15V
100nF
2.7k
100nF
1n
S 0436
1n
1n
S 0437
8
1
9
16
+ 6.8V
1μF
3.3 n
+ 3.5V
3.9k
4.00MHz
20pF
10 k
10k
+ 15V
Frequency processing
+ 15V
3 x BC 308
3 x 22 k
7 × 1k
SAB 3211
9
8
16
1
100μF
SM 564
1
28
14
15
Gate
DM
PCM
L
POR
2 x BC 238
+ 15 V
5 x 47 k
Control and display
Station memory
Searching stop
Searching start
– fine tuning
+ fine tuning
Channel units
Channel tens
Programme change
A
B
C
D
Storage
to the control panel

Components for circuit 3.1.2

		Ordering code	SCS stock number
1 High frequency divider	S 0436	Q67000-A1339	–
1 PLL-IC	S 0437	Q67000-A1347	–
1 Operational amplifier	TBB 1331 A	Q67000-A1348	–
1 Control circuit	SM 564	Q67100-Z123	–
2 Transistors	BC 238	Q62702-C698	70091
3 Transistors	BC 308	Q62702-C704	70097
1 Ceramic capacitor	22 pF	B37979-J5220-J	17273
1 Polypropylene capacitor	150 pF	B33063-B6151-H	27871
3 Disc type ceramic capacitors	1 nF	B37062-A6102-K6	17262
1 Disc type capacitor	3.3 nF	B37232-J5332-S1	1718
1 MKH layer capacitor	47 nF	B32560-D3473-J	27566
2 Ceramic capacitors	0.1 µF	B37449-A6104-S2	17235
1 MKH layer capacitor	0.33 µF	B32560-D1334-S2	27552
2 Tantalum electrolytic capacitors	1 µF/40 V	B45178-A6105-M	29818
1 Electrolytic capacitor	100 µF	B41316-A5107-V	2344

3.2 Video-IF Amplifier with AFT Using a Surface Wave Filter

The circuit shown in **fig. 3.2** is characterized by the following sections

preamplifier with BF199
surface wave filter OFW361-G
video-IF amplifier using TBA1440G or TBA1441
AFT-circuit with TDA4260

Because of the low input impedance of the preamplifier the coupling to the tuner is not critical. Its gain of approx. 28 dB compensates the loss of the surface wave filter.

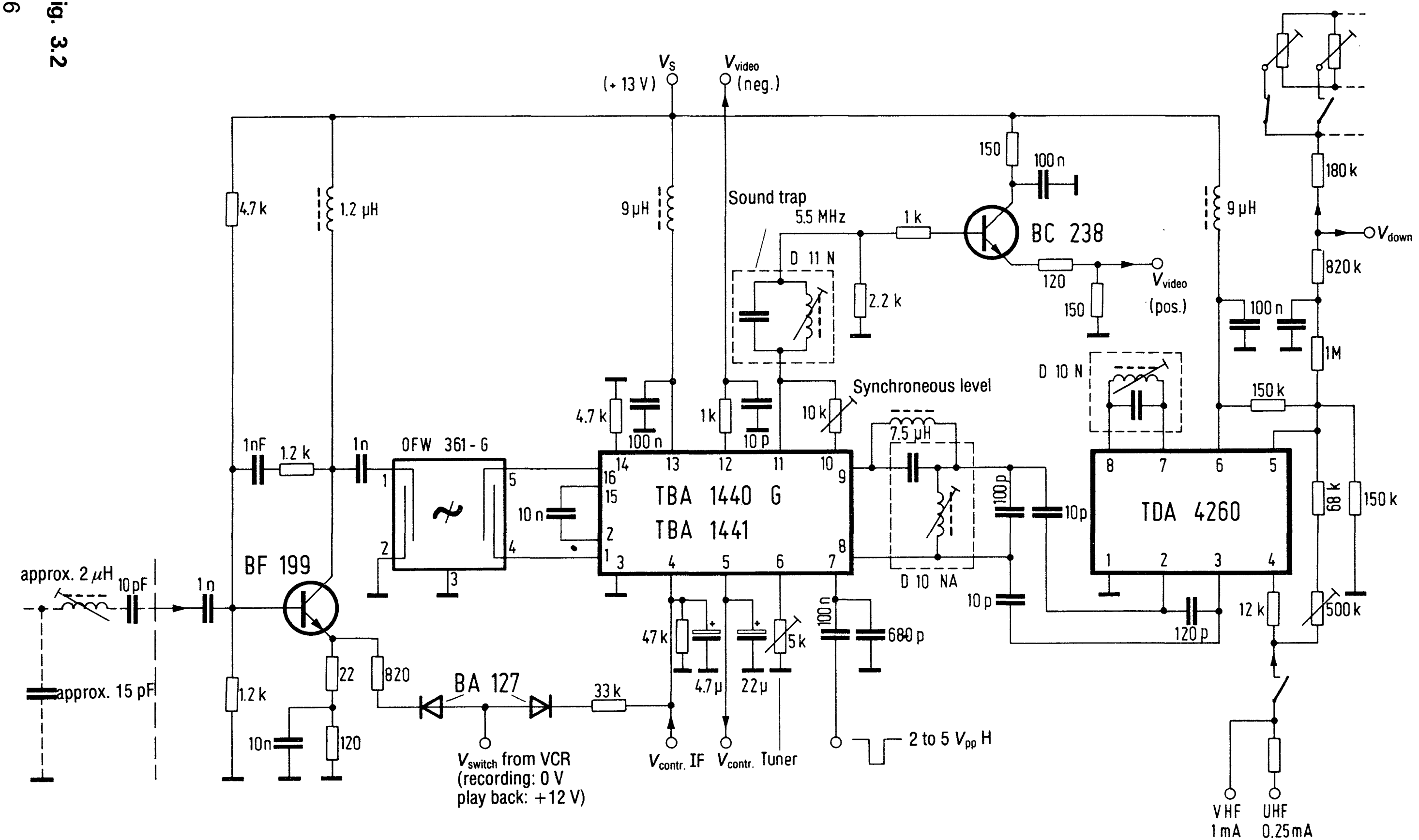
If the tuner is directly coupled to the front end, a high attenuation for its output circuit is necessary. But an operation with a second resonant circuit (as drawn with intermittent lines) connected to the output is also possible. In this case a two-circuit filter with nearly critical coupling is realized.

The collector current of the BF199 is 14 mA. The transistor operates in a range of low crossmodulation to achieve good crossmodulation characteristics. Besides that a revers current feedback is realized by the 22 Ω-resistor connected to the emitter. A reverse voltage feedback is effective between collector and base, and therefore the input impedance is low. For VCR play back the prestages can be turned off by the diode BA127. In this case a voltage of 12 V has to be applied to the diode, which switches off the BF199 by increasing its emitter-voltage.

The BF199 is connected to the TBA1440G via a surface wave filter made of lithium niobad. Its standardized transmission characteristic, the phase response and the traps are determined by the construction of the different sections.

The video-IF IC TBA1440G (or TBA1441) contains a controllable video-IF amplifier with high gain, a controlled demodulator and two video output stages supplying positive and negative signals, keyed control as well as delayed tuner-control. The demodulator circuit connected to pins 8 and 9 is tuned to a frequency of 38.9 MHz. It is responsible for the image carrier regeneration and supplies the voltage for the integrated demodulator. This resonant circuit is dimensioned in that video interferences are effectively suppressed. Therefore a 12 pF-capacitor is connected in series to the demodulator circuit (Hartley oscillator). At pin 12 a negative video signal of approx. 4 V_{pp} is available. The positive video signal at pin 11 is supplied to the transistor BC238. At its emitter a voltage of 1 V_{pp} across 75 Ω is available. This standardized signal is utilized for operations of VCR-devices. A 5.5 MHz-stop-band filter is connected to the base of the BC238. It suppresses the sound carrier by 20 dB. The synchroneous signal, i.e. the level of the video signal, is adjusted by the 10 kΩ-potentiometer connected to pins 10 and 11. The tuner control-start is determined by the resistance of the 5 kΩ-potentiometer at pin 6. Pin 5 supplies enough current that PIN-diode circuits can be operated without using additional transistors.

For video-recorder play back the video-IF amplifier has to be switched off. This is achieved by turning-off the transistor BF199 and by downward-controlling the



VS
(+13 V)
Vvideo
(neg.)
4.7 k
1.2 μH
9 μH
Sound trap
5.5 MHz
1 k
BC 238
150
100 n
D 11 N
2.2 k
120
150
Vvideo
(pos.)
9 μH
180 k
Vdown
820 k
100 n
1M
150 k
D 10 N
Synchroneous level
10 k
4.7 k
100 n
1 k
10 p
7.5 μH
1nF
1.2 k
1n
OFW 361 - G
TBA 1440 G
TBA 1441
10 n
TDA 4260
100 p
10p
68 k
150 k
D 10 NA
10 p
120 p
12 k
500 k
approx. 2 μH
10pF
1 n
BF 199
approx. 15 pF
1.2 k
22
820
10n
120
BA 127
33 k
47 k
4.7μ
22μ
5k
100 n
680 p
2 to 5 Vpp H
Vswitch from VCR
(recording: 0 V
play back: +12 V)
Vcontr. IF
Vcontr. Tuner
VHF
1 mA
UHF
0.25mA

Fig. 3.2

TBA1440 to a gain minimum by an impressed IF control-voltage of approx. 3 V. Because of the internal control amplifier the tuner is also downward-controlled.

The IC TDA4260 is utilized for the AFT-circuit. It comprises a limiting amplifier with a coincidence demodulator and an AFT-amplifier with a controllable current-source output. A resonant circuit is connected to pins 7 and 8. It is tuned to a frequency of 38.9 MHz and in conjunction with the TDA4260 it operates as a frequency discriminator. As a function of the frequency deviation at the input a negative or positive current is available at pin 5. This correcting signal is superimposed to the tuning voltage via a resistor network. The current variation can be advantageously programmed. Thus a matching optimum of the conductance is possible over a wide range. The described circuit operates with a programming current of 1 mA in the VHF-range and with approx. 0.25 mA in the UHF-range. The offset-current of the TDA4260 is compensated by the influence of the 500 kΩ-potentiometer. It is set that without RF signal the same dc voltage is available at the AFT-output independently of the programming current.

The TDA4260 is weakly coupled to the demodulator circuit. Thus a relatively small and symmetrical capture range is realized and a faultless change from one channel to the other is guaranteed even if the AFT is switched on.

Components for circuit 3.2		Ordering code	SCS stock number
1 IC	TBA1440G	Q67000-A1022	71042
1 IC	TDA4260	Q67000-A1300	71330
1 Surface wave filter	OFW361	B39936-A1	–
1 Transistor	BF199	Q62702-F355	7072
1 Transistor	BC238C	Q62702-C280	8830
2 Diodes	BA127	Q60201-X127	8019
3 Ceramic disc type capacitors	10 pF/63 V	B38062-J6100-G6	17246
1 Disc type ceramic capacitor	100 pF/63 V	B38066-J6101-G6	17255
1 Disc type ceramic capacitor	120 pF/63 V	B38062-J6121-G	–
1 Disc type ceramic capacitor	680 pF/63 V	B37062-A6681-K6	17261
2 Disc type ceramic capacitors	1 nF/63 V	B37062-A6102-K6	17262
1 Disc type ceramic capacitor	2.2 nF/63 V	B37062-A6222-K6	17263
2 Sibatit® capacitors	10 nF/63 V	B37449-D6103-S1	17332
6 Sibatit® capacitors	100 nF/63 V	B37449-A6104-S2	17235
1 Electrolytic capacitor	4.7 µF/16 V	B41313-A4475-V	1933
1 Electrolytic capacitor	22 µF/40 V	B41316-A7226-V	2343

Filter coils LD10N, LD10NA, LD11N=type 10K of Toko Elektronik, Düsseldorf (required circuit capacitors are included to the filter kit)

3.3 RGB-Circuit Using TDA 2530

The RGB-matrix preamplifier TDA 2530 is an improved version of the TBA 530. It offers the following features

internal clamping
so-called electronical potentiometer for gain adjustment
excellent transmission characteristics
capacitively coupled colour difference-signal inputs.

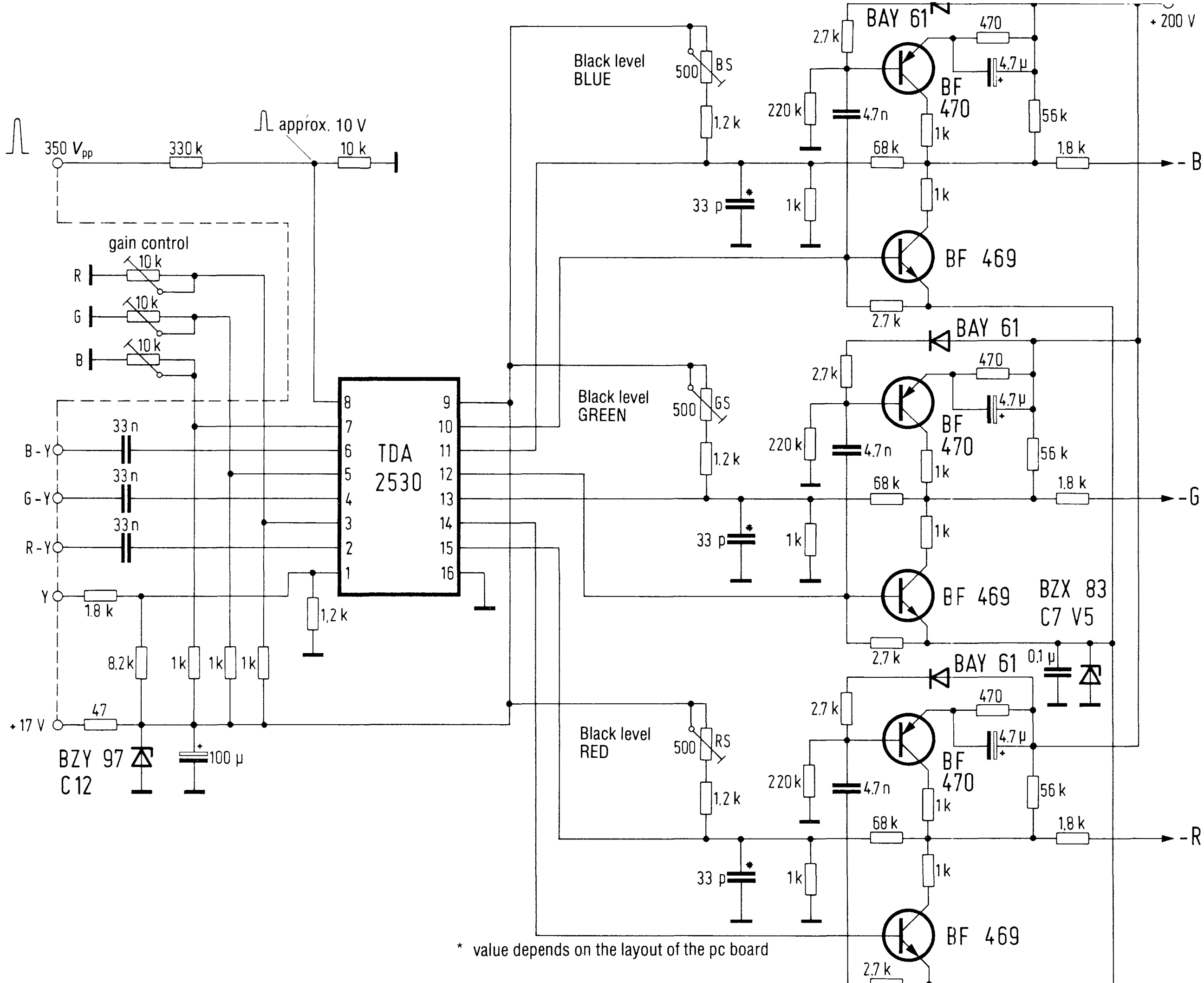
Fig. 3.3 shows the combination of the TDA 2530 and two complementary output stages. The colour difference-signals are applied to the inputs of the TDA 2530 via the 33 nF-coupling-capacitors. The Y-signal has a dc-level of 1.5 V and is supplied to pin 1. After the RGB-matrixing and the clamping the colour signals are available at pins 10, 12 and 14 of the TDA 2530 to drive the output stages, using the transistors BF 469 and BF 470. Because of the excellent thermal characteristic of the SOT-32-package a high reliability of the output stages is achieved. The emitters of the BF 469 are biased via a z-diode to a level of 7.5 V, because the outputs of the TDA 2530 offer a dc level of 8.2 V. The bases of the NPN-transistors are directly controlled whereas the bases of the PNP-transistors are driven via a 4.7 nF-capacitor. The 470 Ω-emitter-resistors have the effect of a reverse dc feedback. The operating point, i.e. the dc current for the BF 470, is determined by the voltage divider connected to the base. This dc current is necessary to avoid distortions.

Because of the high-pass filter characteristic of the base circuits only a very small video signal is applied to the transistor bases at low video frequencies. In this case the transistor operates as a constant-current source and by its dc current a positive potential is applied to the picture tube.

The signals of the output stages are supplied to the corresponding picture tube cathodes via 1.8 kΩ-resistors. Besides that the output signal is reduced by the voltage divider consisting of the 68 kΩ- and 1 kΩ-resistors. It is supplied to the feedback inputs at pins 11, 13 and 15 of the TDA 2530. This feedback signal can be superimposed by a dc current for adjusting the black level with a value of approx. 50 V.

The output signal is clamped by a positive line-fly-back pulse, which is supplied via a voltage divider to pin 8 of the TDA 2530. At this test point the pulse amplitude should be approx. 10 V. For adjusting the gain a dc voltage between 0 and 12 V is applied to pins 3, 5 and 8. The gain can be varied approx. 6 dB by means of the potentiometer.

Fig. 3.3.



350 V_{pp}
330 k
approx. 10 V
10 k
gain control
R
G
B
10 k
10 k
10 k
B - Y
G - Y
R - Y
Y
+17 V
33 n
33 n
33 n
1.8 k
8.2 k
1 k
1 k
1 k
47
BZY 97
C 12
100 µ
1,2 k
TDA
2530
Black level
BLUE
Black level
GREEN
Black level
RED
500
BS
GS
RS
1,2 k
33 p
220 k
4.7 n
68 k
2.7 k
BAY 61
BF
470
BF 469
470
4.7 µ
56 k
1.8 k
+200 V
- B
- G
- R
BZX 83
C7 V5
0.1 µ
* value depends on the layout of the pc board

Components for circuit 3.3

			Ordering code	SCS stock number
1	IC	TDA 2530	Q67000-A1295	–
3	Transistors	BF469	Q62702-F497	71074
3	Transistors	BF470	Q62702-F498	71075
3	Diodes	BAY61	Q62702-A389	8579
1	z-diode	BZX83C7V5	Q62702-Z1074-F82	7314
1	z-diode	BZY97C12	Q68000-A955-F82	70152
3	Ceramic capacitors	33 pF	B38066-J6330-G1	–
3	MKH layer capacitors	4.7 nF/250 V	B32560-A3472-K	–
3	MKH layer capacitors	33 nF/250 V	B32560-A3333-J	–
1	MKH layer capacitor	0.1 µF/250 V	B32560-A3104-J	–
3	Electrolytic capacitors	4.7 µF/63 V	B41016-A8475-V	–
1	Electrolytic capacitor	100 µF/16 V	B41316-A4107-V	2341
1	Resistor	47 Ω 0.25 W	B51260-Z4470-J1	36674
3	Resistors	470 Ω 0.25 W	B51260-Z4471-J1	36683
12	Resistors	1 kΩ 0.25 W	B51260-Z4102-J1	36688
4	Resistors	1.2 kΩ 0.25 W	B51260-Z4122-J1	36689
3	Resistors	1.8 kΩ 0.25 W	B51260-Z4182-J1	36691
6	Resistors	2.7 kΩ 0.25 W	B51260-Z4272-J1	36693
1	Resistor	82 kΩ 0.25 W	B51260-Z4823-J1	37281
1	Resistor	10 kΩ 0.25 W	B51260-Z4103-J1	37270
3	Resistors	56 kΩ 0.25 W	B51260-Z4563-J1	37279
3	Resistors	220 kΩ 0.25 W	B51260-Z4224-J1	37283
1	Resistor	330 kΩ 0.5 W	B51261-Z4334-J1	37951
3	Resistors	1.8 kΩ 0.5 W	B51261-Z4182-J1	37675
3	Resistors	68 kΩ 2 W	B51266-A2683-G	28812
3	Potentiometers (vertically mounted)	470 Ω	B58655-Z0471-M401	79928

3.4 FM-Receiver with TBA120U and TDA1037D for TV Sets

Complete FM receivers for processing the sound frequency in TV sets are economically developed by using the TBA120U and TDA1037D. As these ICs operate with a wide supply-voltage range of 4 to 28 V they can generally be utilized for many applications. The circuit shown in **fig. 3.4** comprises an electronic volume control for manual and remote operation, an adjustment for a standard value of the volume as well as an AF-switch for selecting an operation either with tape recorder or with video signals.

The sound-IF of 5.5 MHz is supplied via a RC-circuit to the ceramic filter SFE 5.5 MA and then applied to pin 14 of the TBA120U. The internal limiting amplifier eliminates the residual AM of the FM signal being supplied to the coincidence demodulator. The coincidence circuit consisting of coil E_2 and capacitor C_9 is connected to pins 7 and 9 of the IC. The coupling capacitors for realizing the phase shift are integrated to the TBA120U. The capacitor C_8 is connected between pins 8 and 11. Together with the internal impedance of the output stage and the tone control circuit a deemphasis is realized. The volume control is achieved by applying a variable dc-voltage between 0 and +12 V. Manual as well as remote control is possible. The AF signal being processed by the electronic volume control is available at pin 8 of TBA120U. It is supplied via a 1 kΩ-resistor and the coupling capacitor C_{11} to pin 8 of the TDA1037D. A deemphasis is realized by the capacitor C_{10} in conjunction with the tone control potentiometer of 2.5 kΩ.

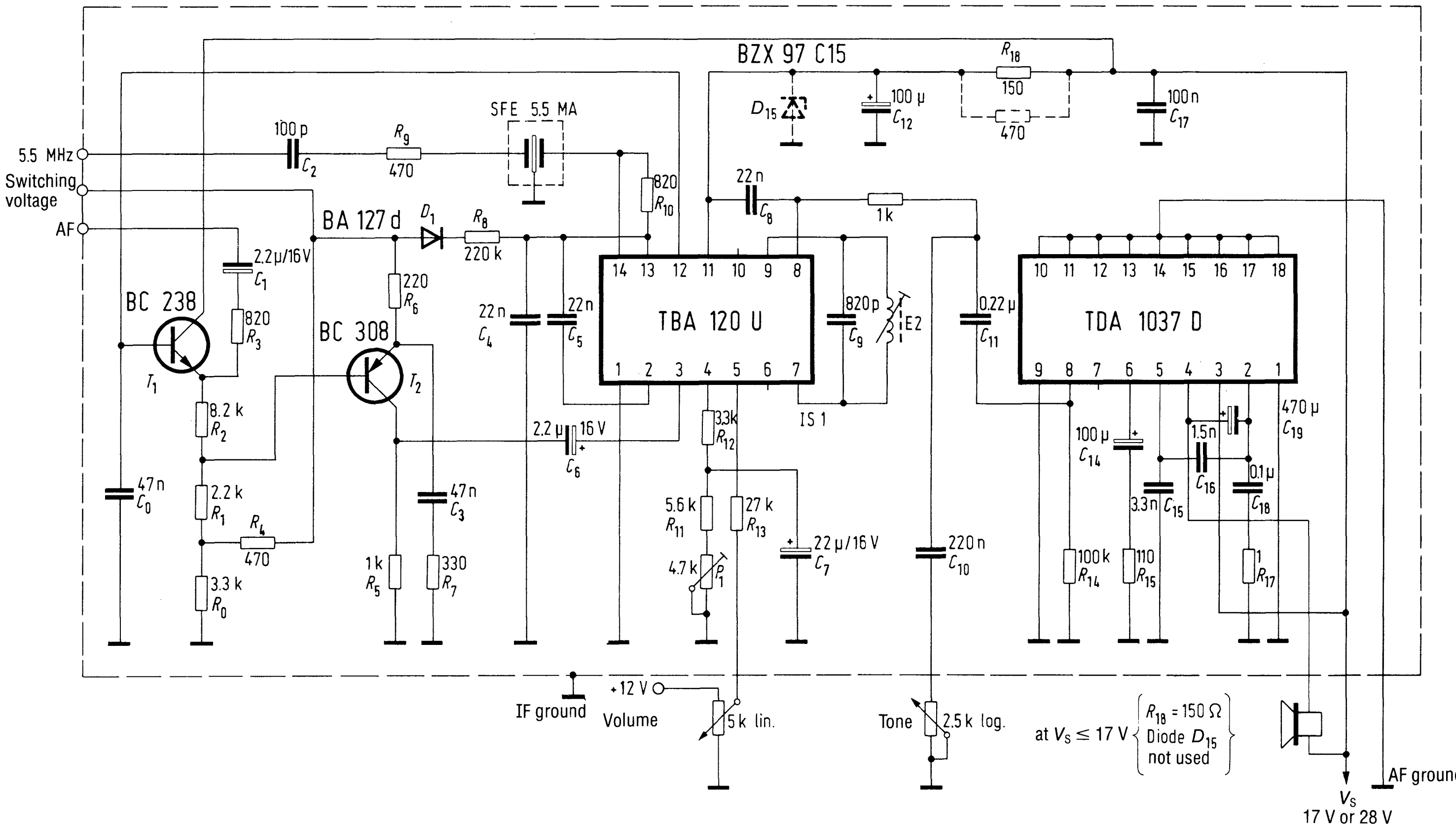
AF-signal switch

For sound reproduction a switching voltage of +12 V is supplied from the VCR-recorder to the sound frequency processor. Therefore transistor T_1 is switched off.

A positive voltage is applied to the emitter of T_1 via resistor R_4. It is higher than the base voltage at pin 12. Therefore the AF signal is supplied via the capacitor C_1 and the two resistors R_2 and R_3 to the base of transistor T_2. This AF signal is amplified and available at the collector of T_2. It is applied via the capacitor C_6 to pin 3 of the IC. When the operation of reproduction is selected the switching voltage is also applied via the diode D_1 and the resistor R_8 to pin 13 of the TBA120U. Therefore the limiting amplifier for the sound-IF signal is switched off.

When an operation of recording is selected no switching voltage is supplied from the VCR recorder. The uncontrolled AF signal is available at pin 12 and is applied via the transistor T_1, resistor R_3 and capacitor C_1 to the output.

The circuit of the AF amplifier is described in chapter 2.1. If greater output powers are required the circuits of fig. 2.2 and fig. 2.3 can be used.



5.5 MHz
Switching voltage
AF
BC 238
T_1
BC 308
T_2
BA 127 d
D_1
R_8 220 k
100 p C_2
R_9 470
SFE 5.5 MA
820 R_{10}
2.2 µ/16 V C_1
820 R_3
8.2 k R_2
2.2 k R_1
R_4 470
3.3 k R_0
47 n C_0
220 R_6
47 n C_3
1 k R_5
330 R_7
22 n C_4
22 n C_5
2.2 µ 16 V C_6
TBA 120 U
IS 1
BZX 97 C15
D_{15}
100 µ C_{12}
R_{18} 150
470
100 n C_{17}
22 n C_8
1 k
820 p C_9
E2
3.3 k R_{12}
5.6 k R_{11}
27 k R_{13}
4.7 k P_1
22 µ/16 V C_7
0.22 µ C_{11}
220 n C_{10}
TDA 1037 D
100 µ C_{14}
3.3 n C_{15}
1.5 n C_{16}
470 µ C_{19}
0.1 µ C_{18}
100 k R_{14}
110 R_{15}
1 R_{17}
IF ground
+12 V
Volume
5 k lin.
Tone
2.5 k log.
at $V_S \leq 17$ V { $R_{18} = 150\ \Omega$ Diode D_{15} not used }
AF ground
V_S
17 V or 28 V

Fig. 3.4.

Components for circuit 3.4

		Ordering code	SCS stock number
1 IC	TBA 120 U (Siemens)	Q67000-A920	70351
1 IC	TDA 1037 D (Siemens)	Q67000-A1229	71041
1 Transistor	BC 238 A	Q62702-C278	8828
1 Transistor	BC 308 A	Q62702-C285	8797
1 Diode	BA 127 D	Q60201-X127-D9	70044
1 Ceramic or MKM capacitor	1.5 nF 25 V	B37981-J5152-K	17311
1 Ceramic or MKM capacitor	10 nF 25 V	B37981-J5103-K	17316
3 Ceramic or MKM capacitors	22 nF 25 V	B37987-J5223-K	17318
2 Ceramic or MKM capacitors	100 nF 25 V	B37987-J5104-K	17322
1 Ceramic or MKM capacitor	220 nF 25 V	B37988-J5224-M	17327
1 Styroflex or Ceramic capacitor	100 pF 25 V	B38066-J6101-G6	17255
1 Styroflex or Ceramic capacitor	820 pF 25 V	B37986-J5821-J	17290
1 Electrolytic capacitor	22 µF 16 V	B41316-A7226-V	2343
3 Electr. cap. (vertical)	100 µF 25 V	B41316-A5107-V	2344
1 Electr. cap. (vertical)	470 µF 10 V	B41316-A3477-V	2339
1 Electr. cap. (vertical)	470 µF 25 V	B41316-A5477-V	7918
1 Resistor	1 Ω 0.4 W	B54311-Z5010-G001	28572
1 Resistor	100 Ω 0.4 W	B54311-Z5101-G001	28569
1 Resistor	110 Ω 0.4 W	B54311-Z5111-G001	28570
1 Resistor	150 Ω 0.4 W	B54311-Z5151-G001	28545
1 Resistor	330 Ω 0.4 W	B54311-Z5331-G001	28552
1 Resistor	820 Ω 0.4 W	B54311-Z5821-G001	28560
1 Resistor	3.3 kΩ 0.4 W	B54311-Z5332-G001	28520
1 Resistor	6.8 kΩ 0.4 W	B54311-Z5682-G001	28528
1 Resistor	100 kΩ 0.4 W	B54311-Z5104-G001	28598
1 Ceramic filter	SFE 5.5 MA	Firma Murata	
1 Coil filter	E 2	Firma Toko	

3.5 Pulse Generator with LSI MOS-IC S 178 Used for Video Systems

The core of the circuit shown in **fig. 3.5** is the LSI MOS-IC S178. This generator supplies all the pulses required for video operation. It operates with reference to a crystal-controlled clock frequency f_T. As the S178 processes also one half of the clock cycle a symmetrical signal with a pulse duty factor of 2:1 is required. The used integrated crystal-oscillator Q052 supplies such a signal.

The video pulse generator S178 comprises two counters. The first one (named horizontal counter) divides the clock frequency to a value of twice the line frequency, whereas the second one (named vertical counter) operates as an 11-bit-asynchroneous-counter. It can externally be set to a defined line number by a 10-bit-dual-code. Pins 11 to 2 are the programming inputs for the figures from 2^0 to 2^{10}. The two last bits, 2^9 and 2^{10}, are commonly applied to pin 2. The set line number is compared with the content of the vertical counter. If both are indicating the same value the counter is reset and started again by the next 2H-pulse-edge. The set line number is refered to the picture frequency. However, since the counter is driven by a signal with twice the line frequency, vertical pulses are generated for every field.

The position of the horizontal and vertical pulses is determined by an external 3-bit-code. Pins 25 to 23 are the programming inputs N_A to N_C.

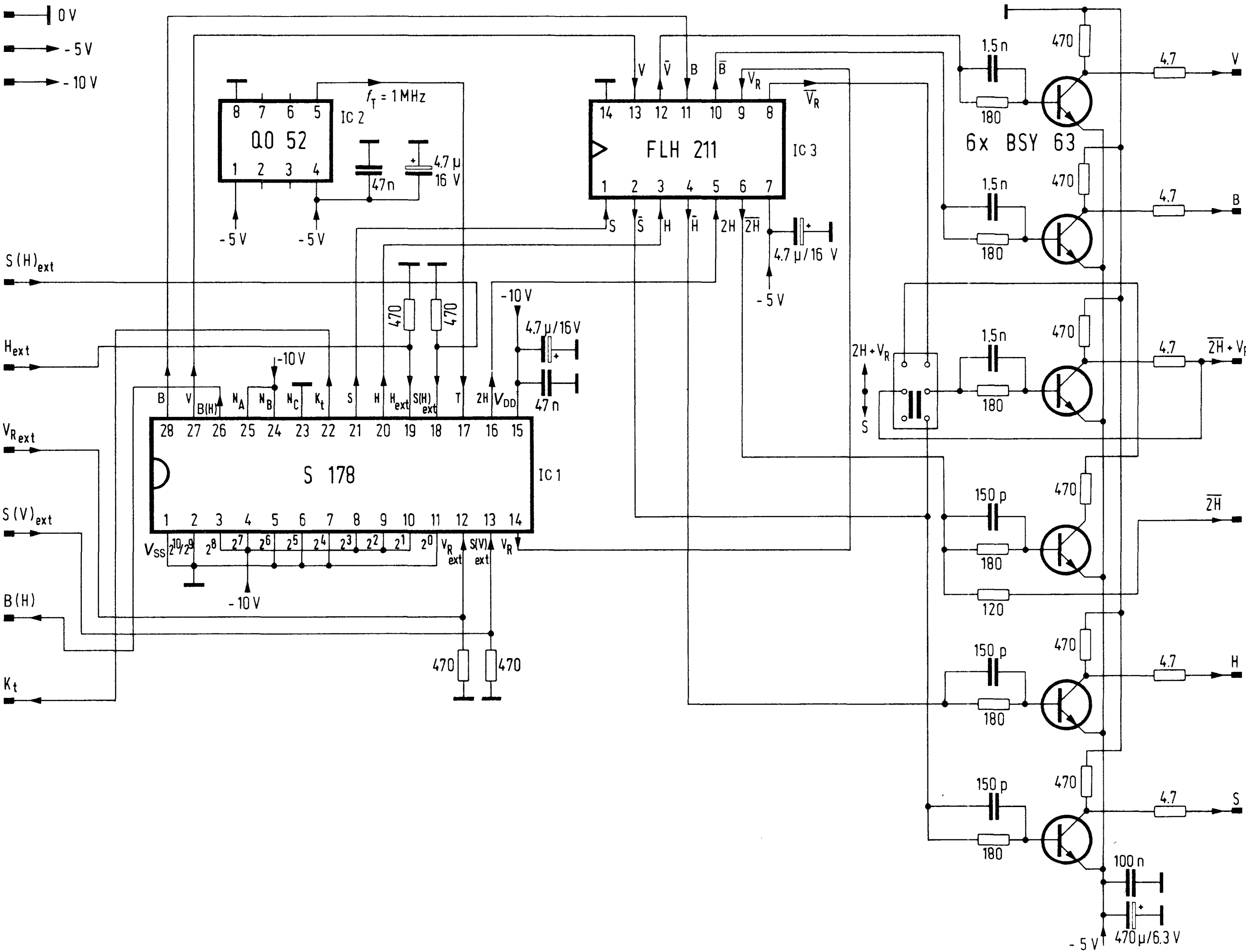
Line number	Field frequency	Required clock frequency	3-bit-code			10-bit-code										
	(Hz)	(MHz)	N_A	N_B	N_C	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
525	60	1.00800	L	L	L	L	H	L	L	L	L	L	H	H	L	H
625	50	1.00000	L	L	H	L	H	L	L	H	H	H	L	L	L	H
735	60	1.41120	L	H	L	L	H	L	H	H	L	H	H	H	H	H
875	50	1.40000	L	H	H	L	H	H	L	H	H	L	H	L	H	H
1023	60	1.96416	H	L	L	L	H	H	H	H	H	H	H	H	H	H

By means of the 3-bit-coding and the line-code various pulse diagrams can be set. In this case, different clock frequencies are also obtained. The following table demonstrates that five pulse diagrams are possible.

Theoretically every other line number can be set, but as the bits 2^9 and 2^{10} are commonly applied to pin 2 a range of 512 to 1535 lines is only possible. If an even line number is set the pulse diagram has no intermediate line.

The circuit shown in fig. 3.5 operates with a pulse diagram of 625 lines/50 Hz.

Fig. 3.5.


0 V
- 5 V
- 10 V
S (H)ext
Hext
VRext
S (V)ext
B (H)
Kt
Q0 52
IC 2
fT = 1 MHz
47n
4,7 µ 16 V
FLH 211
IC 3
4,7 µ / 16 V
S 178
IC 1
-10 V
4,7 µ/16 V
47 n
470
6x BSY 63
1,5 n
150 p
180
120
4,7
100 n
470 µ/6,3 V
V
B
2H + VR
2H
H
S

All important pulses are generated either as pulse composition (synchroneous pulse composition S, blanking pulse composition B) or as separate pulses (V, H, $\overline{2H}$, $2H+V_R$). They are available at transistor output stages driven by the TTL-IC FLH 211. Besides that the horizontal blanking pulses B (H) and the clamping pulses K_t are generated. The fan out for the output stage of these two pulses is one TTL-input each.

The pulse generator can be externally synchronized. In this case external pulses $S\ (H)_{ext}$ and $S\ (V)_{ext}$ or H_{ext} and $V_{R\,ext}$ are supplied to the S 178. H_{ext} and $V_{R\,ext}$ are used if a synchronization with the $2H+V_R$-signal is necessary, e.g., for mixing of various video signals.

A synchroneous-pulse composition S[S(H)+S(V)] or a $2H+V_R$-signal is available at the output and can be selected by a switch. The $(2H+V_R)$-pulses and the $(2H+V_R)$-signal are mixed in the output stage.

Components for circuit 3.5		Ordering code	SCS stock number
1 LSI-MOS Video pulse generator	S 178	Q67100-Z84	71054
1 Hexinverter	FLH 211	Q67000-H153	8757
1 Integrated crystal oscillator	QO 52	–	–
6 Transistors	BSY 63	Q60218-Y63	8321
3 Styroflex® capacitors	150 pF	B31310-A3151-H	1363
3 Styroflex® capacitors	1.5 nF	B31310-A3152-H	1379
2 Ceramic capacitors	47 nF	B37443-B0473-S3	17052
1 Ceramic capacitor	100 nF	B37443-B0104-S3	17054
3 Electrolytic capacitors	4.7 µF/16 V	B41313-A4475-V	1933
1 Electrolytic capacitor	470 µF/6.3 V	B41286-A2477-T	2336

4. Optoelectronic Circuits and Remote Control Systems

4.1 Preamplifier for IR Remote Control Systems

Infrared remote control receivers with MOS-ICs usually require a digital input signal with TTL-levels. Therefore a preamplifier has to be connected between the photodiode and the MOS-circuit. Such a preamplifier has already been described in "Design Examples of Semiconductor Circuits, Edition 77/78, Chapter 4.2". In the following a circuit, using the IC TDA 4050 is commented. The TDA 4050 was especially developed for applications of IR remote control systems. It comprises a controlled prestage, an amplifier and a threshold amplifier. This IC offers excellent large-signal characteristics, an output with short-circuit protection and a simple driver circuit for active band-pass filters. Although solutions without coils are cheaper, an LC-network is connected to the input of the circuit shown in **fig. 4.1.1** to obtain a higher selectivity. The photodiode SFH 205 is connected directly to the resonant circuit. It is reversely operated and biased with 11 to 14 Volt. The signal from the resonant circuit is supplied to the input of the IC via transistor BC 414 C. Thus the signal-to-noise ratio is improved. An active filter is connected to pins 4 and 5. It is part of the reverse feedback circuit of the operational amplifier. The output signal is available at pin 3, offering a protection against short-circuits to ground ($R_i = 10$ kΩ). At L-level the output has a low impedance.

Fig. 4.1.2 shows a circuit without coils. The large-signal characteristics and noise immunity are improved by a network consisting of resistors and diodes.

Both circuits should advantageously be mounted in a double-screened case.

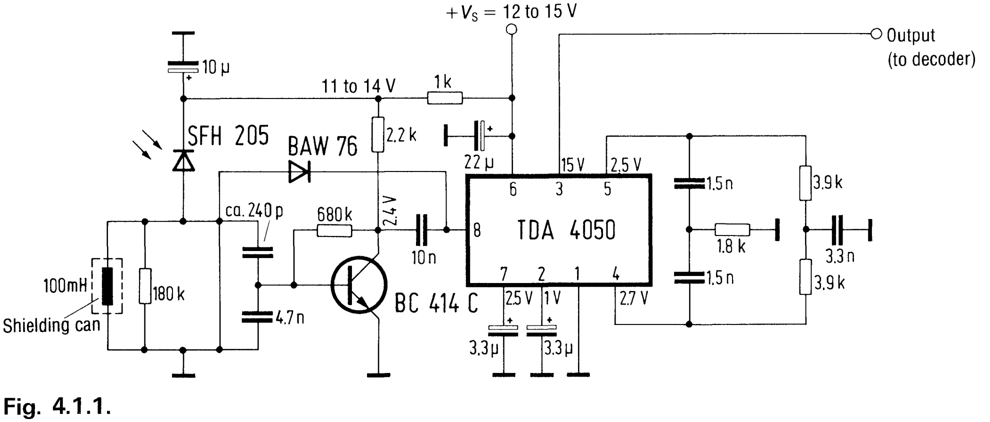


Fig. 4.1.1.

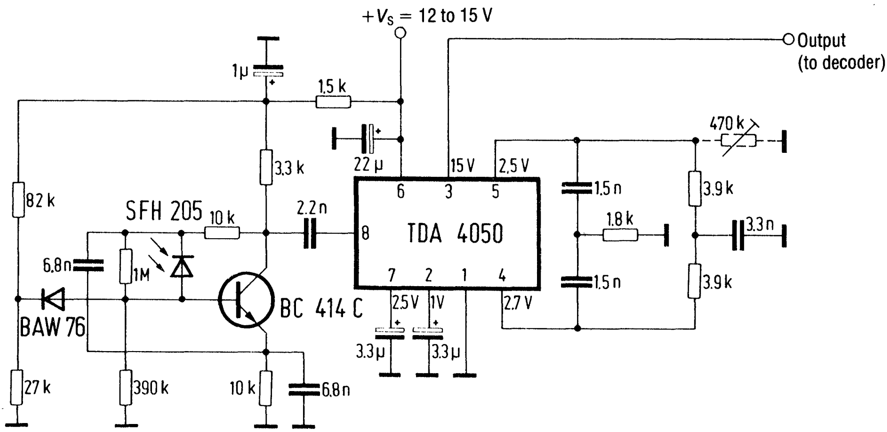


Fig. 4.1.2.

Without any influence of extraneous light a distance of 25 to 30 m between transmitter and receiver can be easily realized, whereas the distance is much higher if the circuit with LC-network is used.

The described preamplifier circuit is also applicable for IR remote control systems used in TV sets. In this case only a range of 15 to 18 m is covered because of the wire-netting protection and the stray influences of the TV defection coils.

Components for circuit 4.1.1		Ordering code	SCS stock number
1 Infrared preamplifier	TDA4050	Q67000-A1373	71792
1 Transistor	BC414C	Q62702-C376-V2	7032
1 Photodiode	SFH205	Q62702-P102	–
1 Diode	BAW76	Q62702-A397	8646
1 Polypropylen capacitor	ca. 240 pF		
combination of	220 pF	B33063-B6221-H	27873
and	22 pF	B33063-B6220-F	27859
2 MKH layer capacitors	1.5 nF	B32560-D6152-J	27619
1 MKH layer capacitor	3.3 nF	B32560-D6332-J	27622
1 MKH layer capacitor	4.7 nF	B32560-D6472-J	27623
1 MKH layer capacitor	10 nF	B32560-D6103-J	27625
2 Tantalum electrolytic capacitors	3.3 µF/16 V	B45178-A3335-M	29792
1 Electrolytic capacitor	10 µF/63 V	B41286-A8106-T	7836
1 Electrolytic capacitor	22 µF/40 V	B41286-A7226-T	7833
1 Coil	100 mH	Fa. Toko	

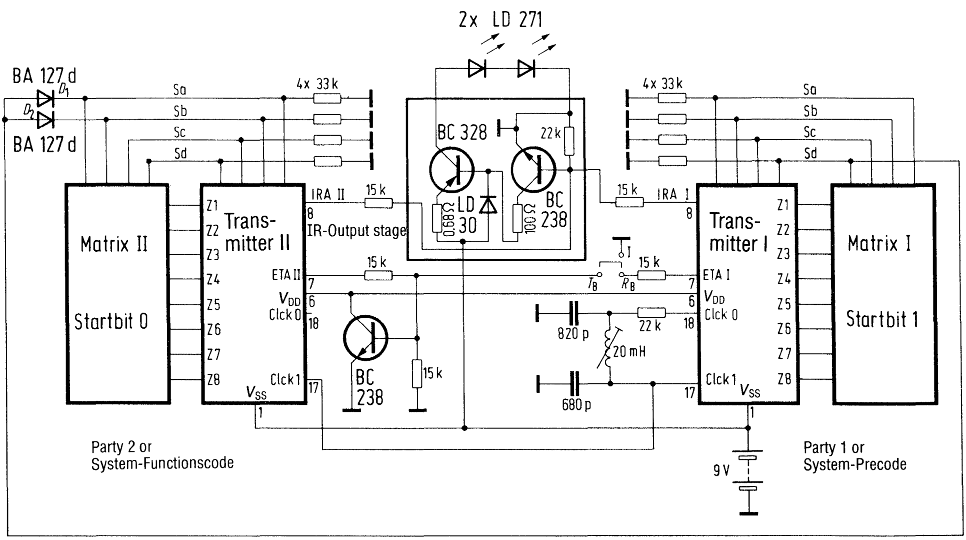
Components for circuit 4.1.2

		Ordering code	SCS stock number
1 Infrared preamplifier	TDA 4050	Q67000-A1373	71792
1 Transistor	BC 414 C	Q62702-C376-V2	7032
1 Photodiode	SFH 205	Q62702-P102	–
1 Diode	BAW 76	Q62702-A397	8646
2 MKH layer capacitors	1.5 nF	B32560-D6152-J	27619
1 MKH layer capacitor	2.2 nF	B32560-D6222-J	27621
1 MKH layer capacitor	3.3 nF	B32560-D6332-J	27622
2 MKH layer capacitors	6.8 nF	B32560-D6682-J	27624
1 Tantalum electrolytic capacitor	1 µF/40 V	B45178-A6105-M	29818
2 Tantalum electrolytic capacitors	3.3 µF/16 V	B45178-A3335-M	29792
1 Electrolytic capacitor	22 µF/40 V	B41286-A7226-T	7833

4.2 IR Transmitter Using Two SAB 3210 in Multiplex Operation

The use of two multiplex-operating SAB 3210 offers many additional applications for the remote control system IR 60. By transmitter I as well as by transmitter II one of the 60 instructions can be transmitted. The first instruction may be utilized to transmit a coded address in order to select a defined device and the second one may include the actual information. Another application is thinkable in that with TV games the transmitter I is used by one party and transmitter II by another. Besides that it is possible to start the transmitter I with the Ø-bit and transmitter II with the 1-bit.

The two transmitter ICs are commonly controlled by one oscillator and connected together at pin 17. During the no-operation state the transmitters are turned off. When an instruction is set via the matrix keys both transmitters are switched on. But a transmitting signal is produced only by the SAB 3210, the matrix of which released an instruction. If both matrixes are operated the instructions are successively processed. The transmitters are switched on via the transistor BC 238, which receives its turn-on signal via the line ETA I or ETA II. When both transmitters are connected via 15 kΩ-resistors to the base of the BC 238, they have the same priority. If only the transmitter II is connected to the transistor, it operates as a slave of transmitter I, since the oscillator of transmitter I leads by half of the clock cycle.



(Instruction sequence: Signal transmitter II, signal transmitter I) System precode

with R_B/T_B both transmitters have same priority (games)
with $R/\perp$ transmitter I has priority

Fig. 4.2.1.

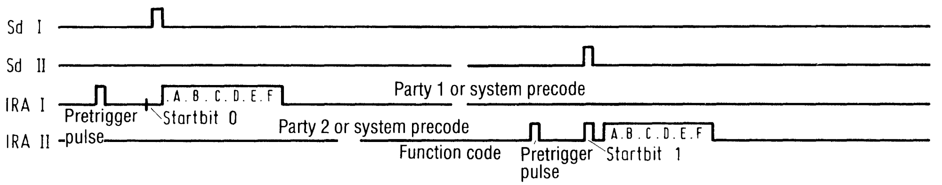


Fig. 4.2.2.

The sequential processing of the signals from transmitter I and II is accomplished by resetting the internal timing circuit by means of short pulses being applied to the column inputs Sa+Sb and having H-levels. The scan line Sd of transmitter I is connected via the diodes D_1 and D_2 to the column inputs Sa and S_b of transmitter II. By the mentioned resetting the coded information of transmitter II is delayed by 20 ms with reference to the one of transmitter I **(see fig. 4.2.2).**

Transmitters I and II may operate with the same or with different start bits. In this case one or two receiver ICs SAB 3209 or one SAB 3271 have to be used.

Components for circuit 4.2		Ordering code	SCS stock number
2 ICs	SAB 3210	Q67100-Y396	71790
2 Transistors	BC 238 B	Q62702-C279	8829
1 Transistor	BC 328	Q62702-C312	70100
2 Diodes	BA 127 D	Q60201-X127-D9	70044
2 LEDs	LD 271	Q62703-Q148	71058
1 LED	LD 30 C	Q62705-P22-F39	7368
1 Styroflex® capacitor	680 pF	B31310-A3681-H	1373
1 Styroflex® capacitor	820 pF	B31310-A3821-H	1375
1 Coil	20 mH	Fa. Toko	–
1 Resistor	0.68 Ω	–	–
1 Resistor	100 Ω 0.5 W	B51261-Z4101-J1	37659
5 Resistors	15 kΩ 0.5 W	B51261-Z4153-J1	37691
2 Resistors	22 kΩ	B51261-Z4223-J1	37694
8 Resistors	33 kΩ	B51261-Z4333-J1	37697

4.3 Remote Control Receiver-IC SAB 3209 Operating with 4-fold Analog Memory SAB 1013

The analog functions of the remote control system IR 60 can be extended by using the SAB 1013. In this case the instructions 8 to 15 are utilized for the SAB 1013. The instructions 40 to 47 are responsible for coding the SAB 3209.

The circuit shown in **fig. 4.3** operates with a power supply of 10 V. The ports for data and enable signals are connected together via 1 kΩ-resistors. The clock is available at pin 2 of the SAB 3209. It is applied to the z-diode BZX 83 C9 via a resistor. The z-diode limits the amplitude to 9 V_{pp}. For the muting during programme selection a signal is supplied via a 1 kΩ-resistor from pin 8 of SAB 3209 to pin 6 of SAB 1013.

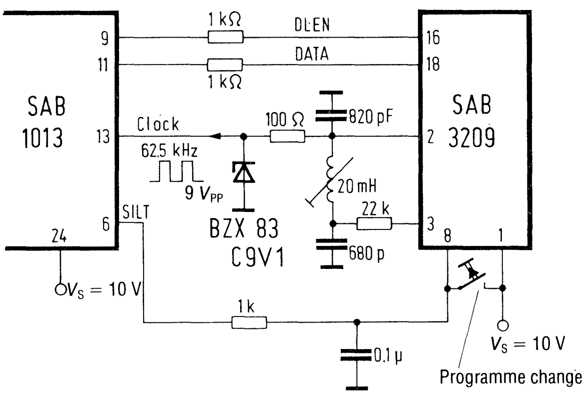


Fig. 4.3.

Components for circuit 4.3		Ordering code	SCS stock number
1 4-fold analog memory IC	SAB 1013	–	–
1 IR60 receiver IC	SAB 3209	Q67100-Y395	71789
1 Z-diode	BZX 83 C9 V1	Q62702-Z1076-F82	7316
1 Styroflex capacitor	680 pF	B31310-A3681-H	1373
1 Styroflex capacitor	820 pF	B31310-A3821-H	1375
1 MKH layer capacitor	0.1 μF	B32560-D1104-J	27548
1 Coil	20 mH	Fa. Toko	–

4.4 System IR 60 Utilized for Remote Control of Radio Sets, Tape and Cassette Recorders

In this chapter the principle of IR remote control for Hi-Fi-devices is explained. The following functions are remotely controlled:

Tuner:	6 stations mono/stereo-selector
Amplifier:	AF-signal-source selector, tuner, tape recorder, volume, treble, bass, quicktone, normal position of volume, treble and bass
Tape recorder:	on, off, start, stop, break, recording.

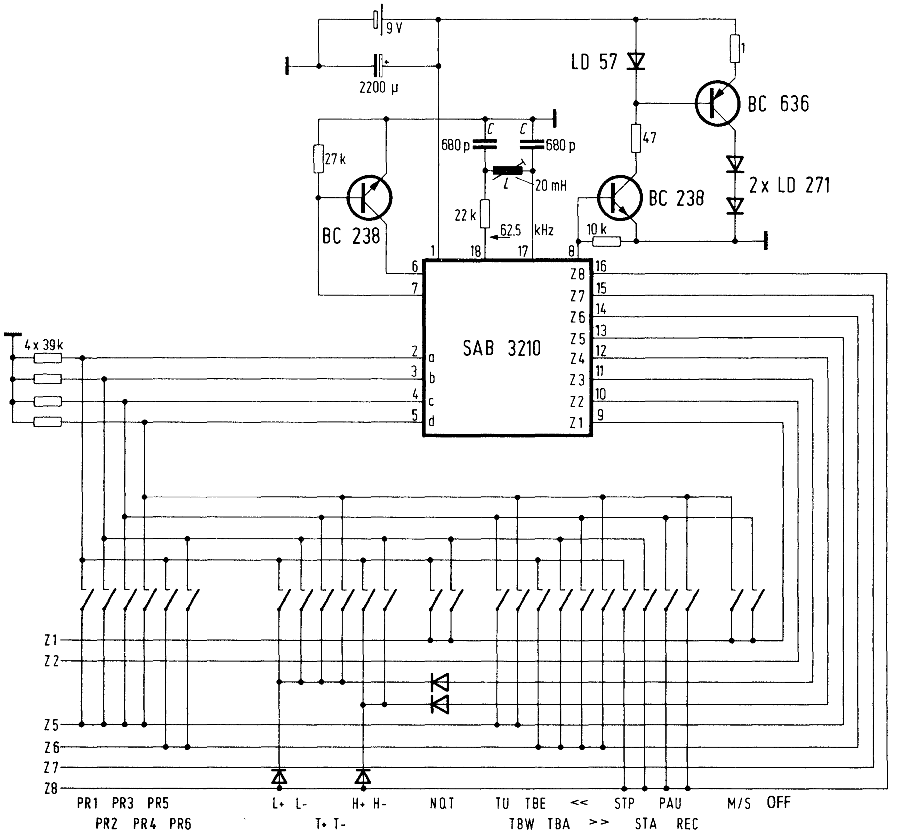


Fig. 4.4.1.

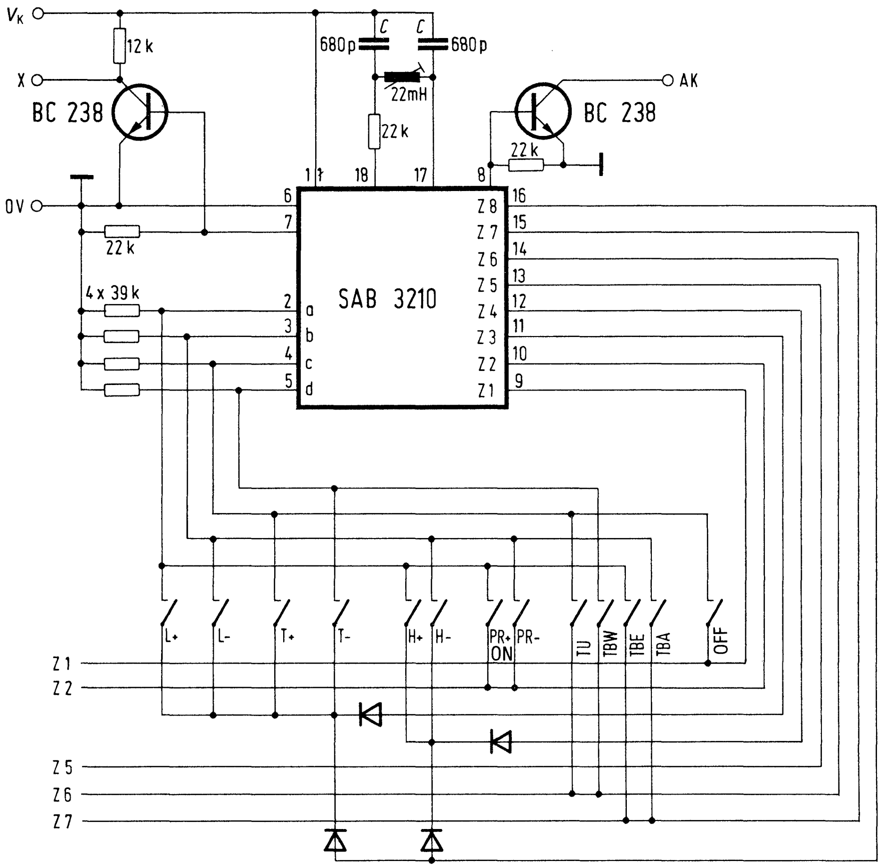


Fig. 4.4.2.

For tape recorder operation it is presumed that the motor is electronically controlled. The following circuit is only one example representing a manifold of other applications. It is absolutely possible to control more devices than used in the described circuit. In this case the remote control instructions have to be extended.

Fig. 4.4.1 shows the circuit of the transmitter, mounted in a very small box. The basic operation of the transmitter has already been described in "Design Examples of Semiconductor Circuits, Edition 1977/1978", chapter 4.8. The touch keys for the various instructions are connected to the matrix input of the transmitter-IC SAB 3210. If the corresponding row "Z" is connected to one of the columns "a to d" a serial-coded information is available at pin 8. The two light emitting diodes, type LD 271, convert the pulse current of transistors T_1 and T_2 to modulated infrared light. The diode LD 57 limits the current and is utilized for operation indication. T_3 operates as switching-on transistor, which turns on the SAB 3209 only if one of the touch keys is pressed. During the stand-by operation this transistor is turned off and the supply current of the IC is only a few μA.

If use of only manual controls is desired, a second SAB 3210 is utilized as shown in **fig. 4.4.2.** Its output AK is directly connected to the series input of the receiver IC (see **fig. 4.4.3**). For manual control the connection between preamplifier and SAB 3210 is interrupted by a signal being applied to input X. If this turn-off is not made the noise of the preamplifier would interfere the received signal. In opposite to the remote control the programmes are selected in the stepping mode by PR+ or PR−. At the same time the device is connected to the mains by PR+.

The circuit already described in chapter 4.1 can be used for the preamplifier.

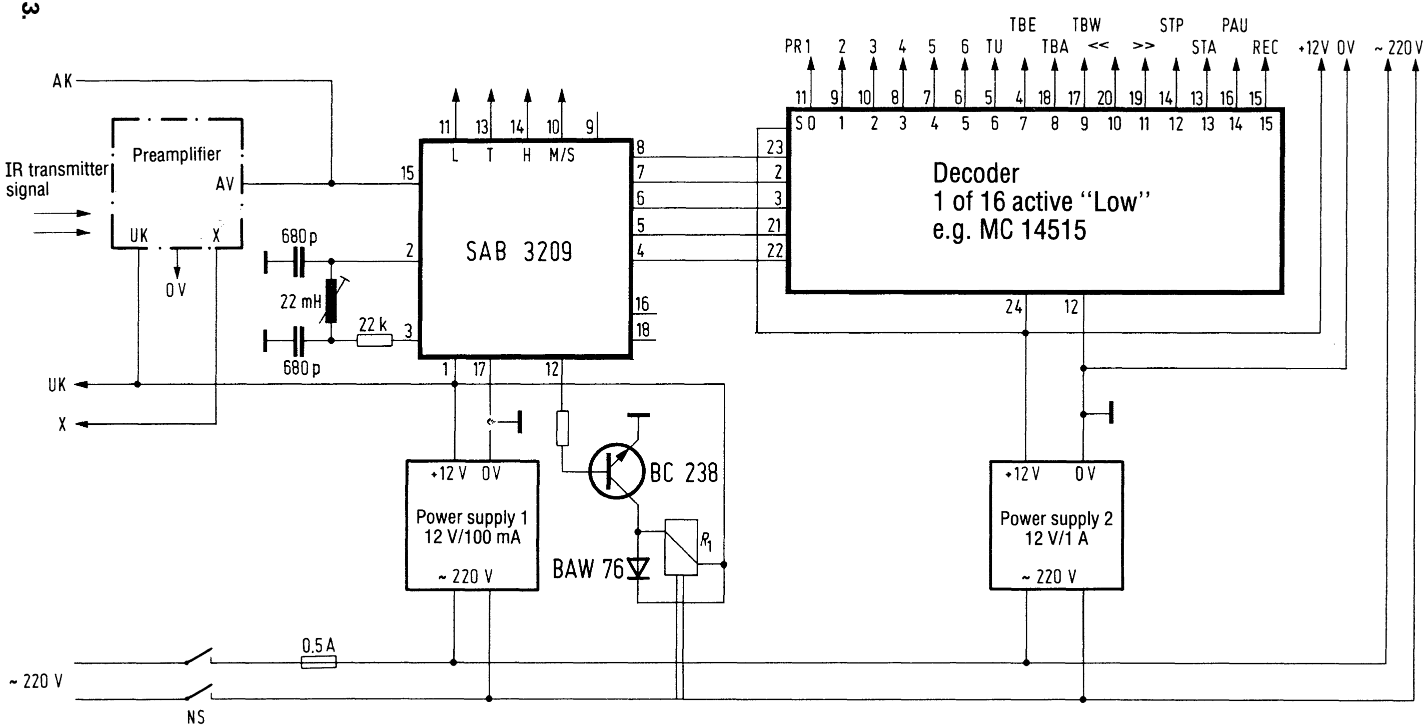
The SAB 3209 receives its information either from the preamplifier or via the line AK from the transmitter IC for manual control (see **fig. 4.4.3**).

The SAB 3209 contains three memories for the analog functions L (volume), H (treble control), T (bass control). Each of these functions is supplied as pulse-width-modulated signal and by an integrating network a dc voltage is generated. At the outputs for the programme control PRGA to PRGD the binary-coded instructions are available. They are decoded by the 1 of 16-decoder. If the information at the programme control outputs changes a strobe pulse for the auxiliar memories of the decoder is available at pin 8. The instruction for selecting mono or stereo-operation is supplied directly from the SAB 3209.

Preamplifier, receiver IC and the second transmitter IC for manual control are connected to the power supply 1. During stand-by, i.e. when the remote control is turned off, the idle-current relay R_1 is pulled up. Therefore the power supply to the other circuits is interrupted. The relay drops out when the keys PR1 to PR6 are touched or when PR+ is applied. In this case the other circuits are turned on via the break contact of R_1.

Fig. 4.4.4 shows the interconnection of the various devices. When the power supply is connected to the mains the flip-flops FF1 to FF3 are set to a privileged state by means of capacitors. If this state is not forced it may occur that the AF-signal source switch is in the position of tape play back whilst a radio station is selected. Six stations can be chosen by the lines PR1 to PR6, whereas the rest of the lines correspond to the other functions of the circuit. For stereo operation two TDA 4290 (so-called electronic potentiometer) are required. The tape recorder can be switched on or off via the control lines TBE and TBA.

Fig. 4.4.3.



AK
IR transmitter signal
Preamplifier
AV
UK
X
0 V
680 p
22 mH
22 k
680 p
UK
X
SAB 3209
L T H M/S
11 13 14 10 9
15
2
3
8 7 6 5 4
16
18
1 17 12
BC 238
BAW 76
R1
Power supply 1
12 V/100 mA
+12 V 0 V
~ 220 V
0.5 A
~ 220 V
NS
Decoder
1 of 16 active "Low"
e.g. MC 14515
S0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
23 2 3 21 22
24 12
PR1 2 3 4 5 6 TU TBE TBA TBW << >> STP STA PAU REC
+12V 0V ~ 220 V
Power supply 2
12 V/1 A
+12 V 0 V
~ 220 V

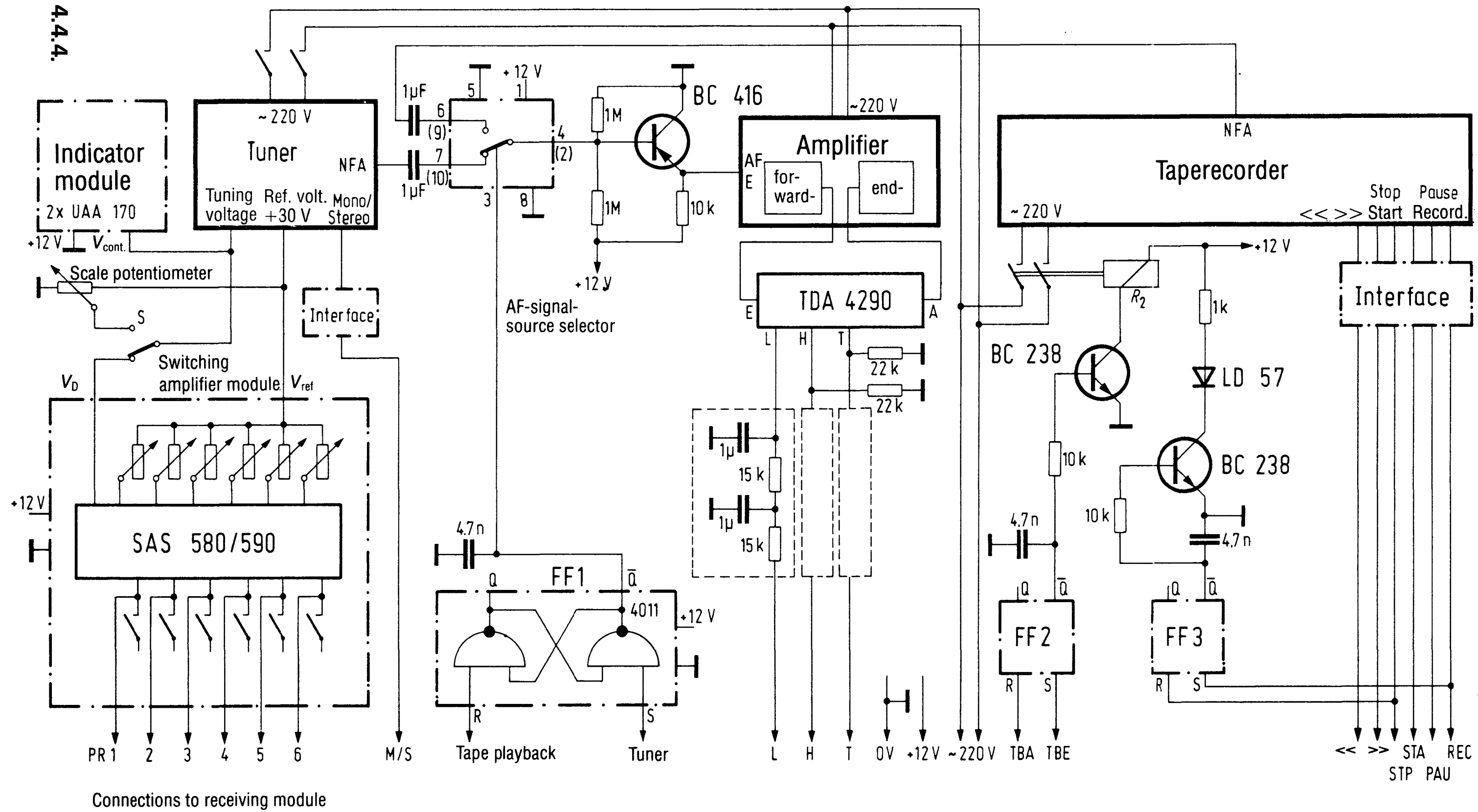

Indicator module
2x UAA 170
+12 V
$V_{cont.}$
~220 V
Tuner
NFA
Tuning voltage
Ref. volt. +30 V
Mono/ Stereo
Scale potentiometer
S
Interface
Switching amplifier module
V_D
V_{ref}
+12 V
SAS 580/590
PR 1
2
3
4
5
6
M/S
1μF
1μF
+12 V
5
1
6
(9)
7
(10)
4
(2)
3
8
AF-signal-source selector
BC 416
1M
1M
10 k
+12 V
4,7n
FF1
Q
$\bar{Q}$
4011
+12 V
R
S
Tape playback
Tuner
~220 V
Amplifier
AF
E
for-ward-
end-
TDA 4290
E
A
L
H
T
22 k
22 k
1μ
15 k
1μ
15 k
L
H
T
0V
+12 V
~220 V
NFA
Taperecorder
~220 V
Stop Start
Pause Record.
<< >>
+12 V
R_2
1k
BC 238
LD 57
10 k
BC 238
10 k
4,7n
4,7n
Q
$\bar{Q}$
FF2
R
S
Q
$\bar{Q}$
FF3
R
S
Interface
TBA
TBE
<<
>>
STA
REC
STP
PAU
Connections to receiving module

Fig. 4.4.4.

Components for circuit 4.4.1		Ordering code	SBS stock number
1 IR remote control transmitter	SAB 3210	Q67100-Y396	71790
2 Transistors	BC238	Q62702-C314	70102
1 Transistor	BC636	Q68000-A3365	70893
2 LEDs	LD 271	Q62703-Q148	71058
1 LED	LD 57/II	Q62703-Q100-S3	70635
4 Diodes	BA 127 D	Q60201-X127-D9	70044
2 Styroflex® capacitors	680 pF	B31310-A3681-H	1373
1 Electrolytic capacitor	2200 µF	B41012-E4228-T	7865
1 Coil	20 mH	Fa. Toko	–

Components for circuit 4.4.2

1 IR remote control transmitter	SAB 3210	Q67100-Y396	71790
2 Transistors	BC238	Q62702-C314	70102
4 Diodes	BA 127 D	Q60201-X127-D9	70044
2 Styroflex® capacitors	680 pF	B31310-A3681-H	1373
1 Coil	22 mH	Fa. Toko	–

Components for circuit 4.4.3

1 IR remote control transmitter	SAB 3209	Q67100-Y395	71789
1 Decoder 1 of 16	e.g. MC14515 (Fa. Motorola)	–	–
1 Transistor	BC238	Q62702-C314	70102
1 Diode	BAW76	Q62702-A397	8646
2 Styroflex® capacitors	680 pF	B31310-A3681-H	1373
1 Coil	22 mH	Fa. Toko	–

Components for circuit 4.4.4		Ordering code	SCS stock number
1 IC	TDA 4290	Q67000-A1359	–
1 IC	SAS 580	Q67000-S28	–
	or 590	Q67000-S29	–
1 IC	HEF 4011	–	–
2 Transistors	BC238	Q62702-C314	70102
1 Transistor	BC416	Q62702-C378	70106
1 LED	LD 57/II	Q62703-Q100-S3	70635
3 MKH layer capacitors	4.7 nF	B32560-D6472-J	27623
3 MKH layer capacitors	1 µF	B32561-D1105-J	27574

4.5 Remote Control of Various Hi-Fi-Devices via a Common Data Bus with Optoelectronic Couplers and Application of the IR 60-System

Nowadays the application of an IR remote control system for a TV set is self-evident. But it can also be efficiently utilized for Hi-Fi-devices. Therefore a circuit based on the Siemens remote control system IR60 and using the ICs SAB3210, SAB3209/4209 and SAB3271 is described in the following. It is obvious that the influence of single instructions on various devices has to be considered when the instructions for each device are assigned. Each device, e.g., tuner, amplifier, recordplayer and tapedeck has to be controlled separately.

The preamplifier for the infrared signals (see chapter 4.1) is advantageously placed in an optimal position to obtain a good reception. The remote control signal supplied from this preamplifier is applied to every Hi-Fi-device via a loop-through connection. To avoid hum influences each device is coupled to the preamplifier by optoelectronic couplers as shown in **fig. 4.5.1.**

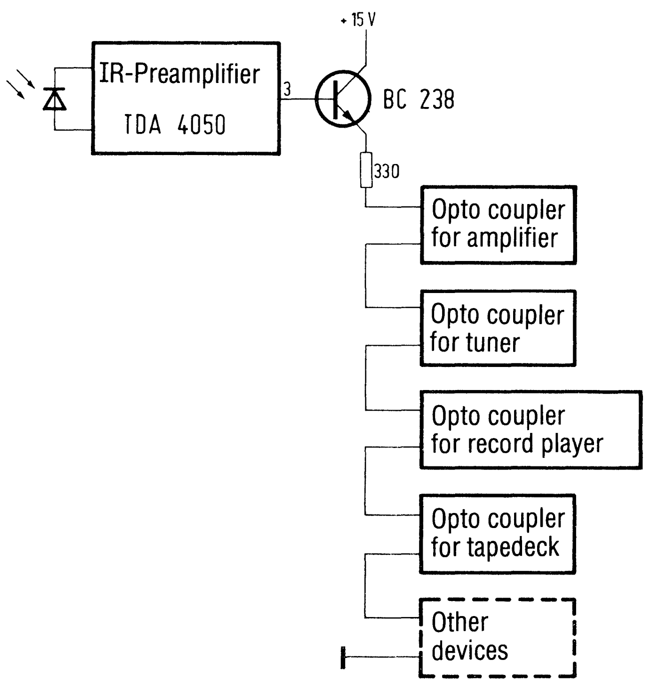


Fig. 4.5.1.

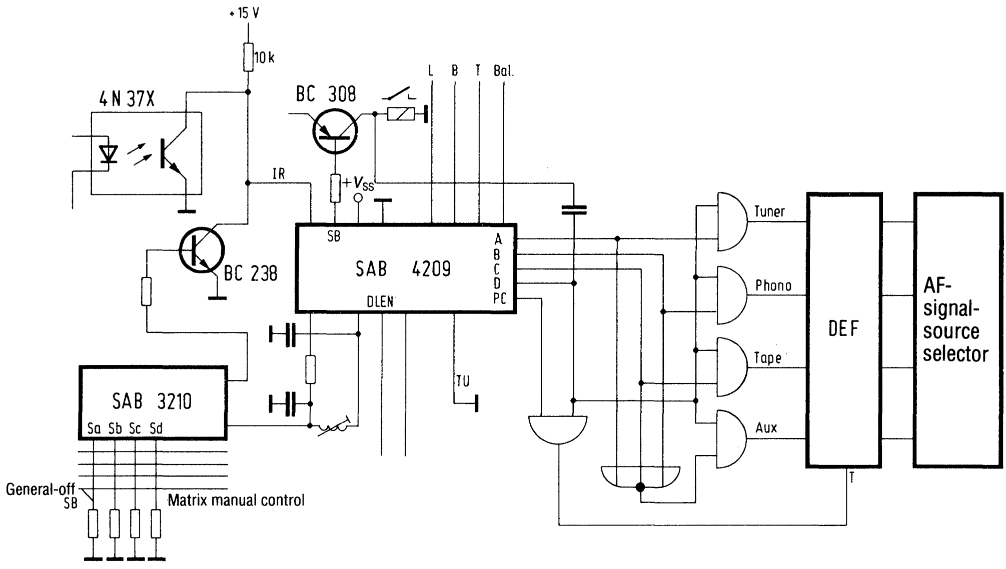


Fig. 4.5.2.

Fig. 4.5.2 shows the decoding circuit of the amplifier using SAB 4209 and memories for four analog functions. The circuit for selecting the AF-signal source is characterized by a logic operation circuit and by a slave memory. For the decoding 4 of the 16 possible instructions have been utilized. Their D-bit is characterized by H-level. At three combinations one of the outputs A, B or C supplies a signal with H-level, whereas at the fourth combination the outputs A to C offer a signal with L-level. This bit-combination is shifted into the D-flip-flop by the PC-signal which happens as positive pulse at every change.

The clock for this shifting is generated by adding the D- and PC-signal. By the D-bit the operation for AF-signal-source switching and for station selecting is unambiguously separated. The amplifier is switched on by the AF-signal-source switching as well as by the station selecting. As privileged status the amplifier is connected to the tuner, the programme 1 is selected for the tuner and the stereo operation is chosen when the on-instruction occurs. Besides that the tuner is switched on when another AF-signal source is selected.

For the manual control of the Hi-Fi-devices an additional transmitter IC SAB 3210 is used.

Fig. 4.5.3 shows the receiver decoder SAB 3209 of the tuner. As already described for the AF-signal-source selection the instructions 17 to 23 influence the station selection of the tuner. Instruction 16 activates the manual tuning. Tuner and amplifier are automatically turned on when the station touch-keys of the remote control are operated during stand-by. Since the D-bit of the 8 station touch-keys has

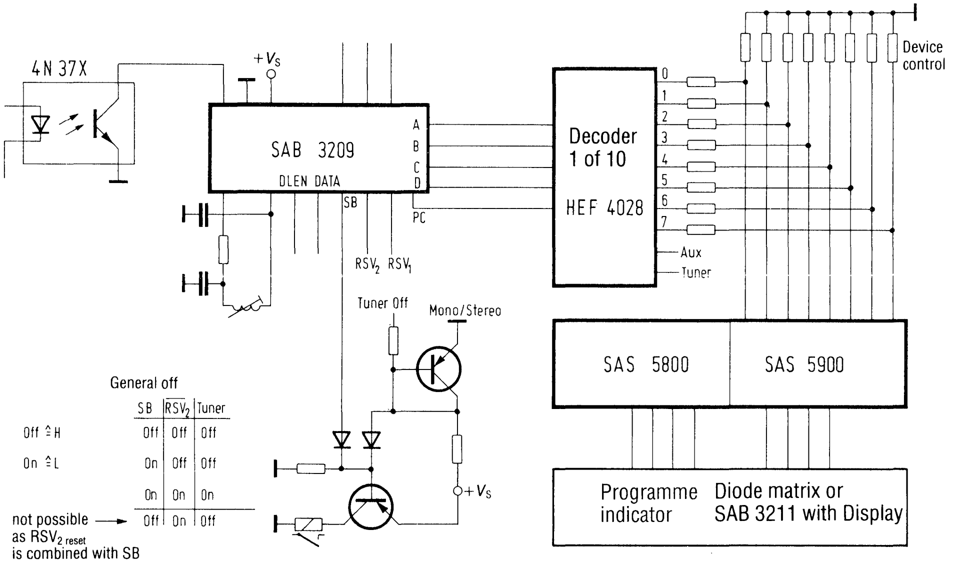


Fig. 4.5.3.

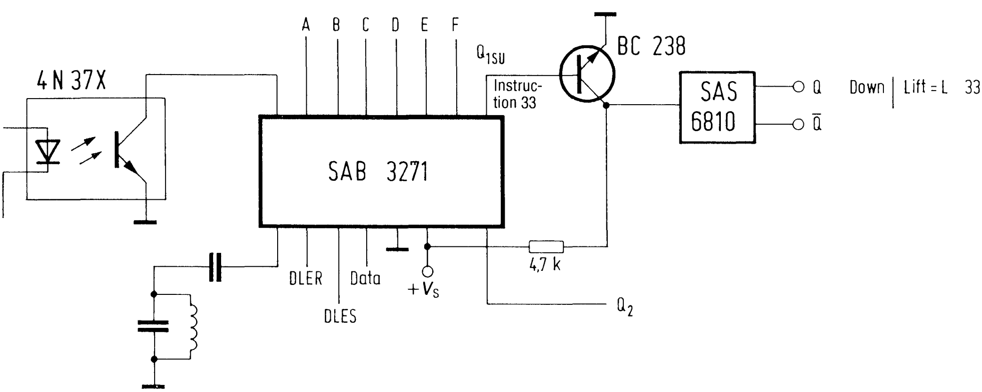


Fig. 4.5.4.

an L-level, the 1 of 10 decoder decodes only the instructions for station 1 to 7 for manual tuning, for auxiliary and for tuner.

If the AF-signal-source selector of the amplifier is set to the position "tuner" by the remote control, the same instruction is decoded again by the tuner and interpreted as tuner-turn-on instruction. The auxiliary flip flop 1 of the SAB 3209 is an alternating one. It is utilized for selecting mono or stereo operation, whereas "stereo" is the privileged position, which occurs when the power supply is turned on during the "stand-by" and when the instruction "normal" is set.

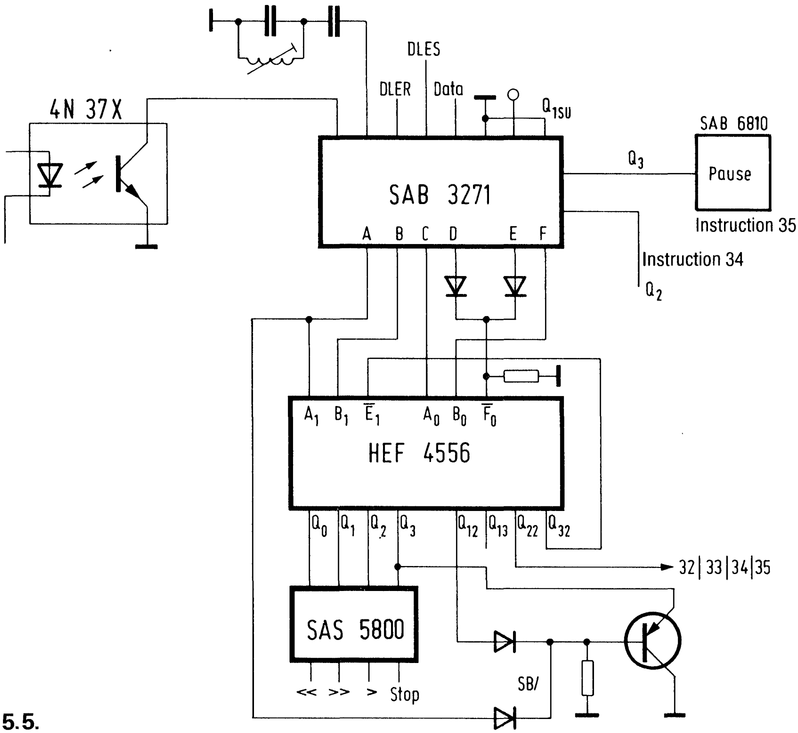


Fig. 4.5.5.

The auxiliary flip flop 2 is also alternate. It turns the tuner on or off. The turn-on occurs only when the SB flip flop is set by a station selection or by an AF-signal-source selecting. The privileged position is "low" and corresponds to "tuner-off".

Four instructions are assigned to the record player (see **fig. 4.5.4**). These are received and processed from the IC SAB 3271. The instructions "down" and "lift" are stored by the SAS 6810, whereby the opposite position can be achieved by instruction 33.

The receiver decoder SAB 3271 also processes the five control instructions for the cassette recorder as shown in **fig. 4.5.5**. Wind, rewind and playback are oppositely released. The brake-instruction has the function of an alternate flip flop. By the stop instruction all recorder functions are set to stand-by and the turn-off occurs. Wind, rewind and playback have switching-on functions at the same time.

If a system extension is required an instruction-set to two additional devices is possible as shown in **fig. 4.5.6.**

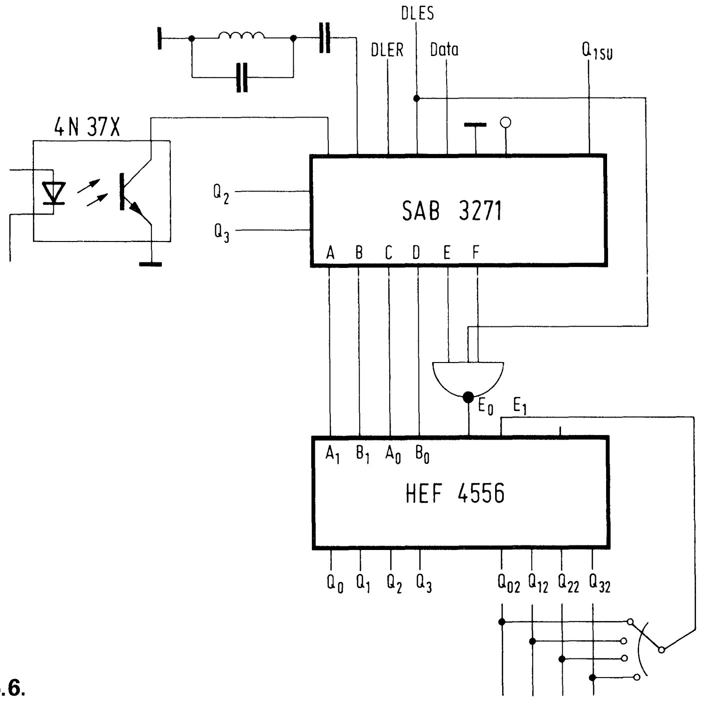


Fig. 4.5.6.

The above mentioned solutions are typical applications for a remote control of Hi-Fi-devices. The **table 4.5.7** indicates the features of the used ICs SAB 3209, SAB 3210, SAB 4209 and SAB 3271. They supplement each other without showing a great redundance. The operating comfort is extremely high since some instructions are used for some functions to influence several devices.

Table 4.5.7. Important features of the IR 60-receiver ICs

SAB 3209	SAB 4209	SAB 3271
4-bit-programme memory	4-bit-programme memory	–
3 Analog functions	4 Analog functions	–
2 Auxiliary flip flops	1 Touch key selector	–
Quicktone set, volume and reset	Quicktone, A-FF, volume and reset	–
Repeat PC-pulse	Single PC-pulse	–
Static DLEN	31 kHz clock burst	–
Analog functions instructions 40 to 45	Analog functions instructions 8 to 15	–
2 Pin LC oscillator	2 Pin LC oscillator	1 Pin LC oscillator
–	–	6 bit-parallel outputs
–	–	Start-bit switch
–	–	Single DLEN
–	–	Repeat DLEN (clock burst 31 kHz)
–	–	1 RS-FF-output
–	–	1 Altern. flip flop output
–	–	Selectable pulse, flip flop or time-analog outputs

Components for circuit 4.5.1		Ordering code	SCS stock number
1 IR preamplifier	TDA 4050	Q67000-A1373	–
1 Transistor	BC 238	Q62702-C698	70091
1 Photodiode	SFH 205	Q62702-P102	–

Components for circuit 4.5.2

1 IR remote control transmitter IC	SAB 3210	Q67100-Y396	–
1 IR remote control receiver IC	SAB 3209	Q67100-Y395	–
1 Optoelectronic coupler	4 N 37 X	Q68000-A4897-F72	71488
1 Transistor	BC 238	Q62702-C698	70091
1 Transistor	BC 308	Q62702-C704	70097
1 Styroflex capacitor	680 pF	B31310-A3681-H	1373
1 Coil	30 mH	Fa. Toko	–

Components for circuit 4.5.3		Ordering code	SCS stock number
1 IR remote control receiver IC	SAB 3209	Q67100-Y395	–
1 Decoder 1 of 10	HEF 4028	–	–
1 Switching amplifier	SAS 5800	Q67000-S62	–
1 Switching amplifier	SAS 5900	Q67000-S63	–
1 Optoelectronic coupler	4 N 37 X	Q68000-A4897-F72	71488
2 Transistors	BC 308	Q62702-C704	70097
2 Diodes	BA 127 D	Q60201-Y127-D9	70044
2 Styroflex capacitors	680 pF	B31310-A3681-H	1373
1 Coil	22 mH	Fa. Toko	–

Components for circuit of 4.5.4

1 IR receiver IC with parallel outputs	SAB 3271	Q67100-Y461	–
1 Switch-IC	SAS 6810	Q67000-S61	–
1 Optoelectronic coupler	4 N 37 X	Q68000-A4897-F72	71488
2 Styroflex capacitors	680 pF	B31310-A3681-H	1373
1 MKH layer capacitor	0.1 µF	B32560-D1104-J	27548
1 Coil	22 mH	Fa. Toko	–

Components for circuit 4.5.5

1 IR remote control receiver IC with parallel outputs	SAB 3271	Q67100-Y461	–
1 IC	HEF 4556	–	–
1 Switching amplifier	SAS 5800	Q67000-S62	–
1 Switching IC	SAS 6810	Q67000-S61	–
1 Optoelectronic coupler	4 N 37 X	Q68000-A4897-F72	71488
1 Transistor	BC 308	Q62702-C704	70097
4 Diodes	BA 127 D	Q60201-X127-D9	70044
1 Styroflex capacitor	680 pF	B31310-A3681-H	1373
1 MKH layer capacitor	0.1 µF	B32560-D1104-J	27548
1 Coil	22 mH	Fa. Toko	–

Components for circuit 4.5.6

1 IR remote control receiver IC with parallel outputs	SAB 3271	Q67100-Y461	–
1 IC	HEF 4556	–	–
1 Optoelectronic coupler	4 N 37 X	Q68000-A4897-F72	71488
1 Styroflex capacitor	680 pF	B31310-A3681-H	1373
1 MKH layer capacitor	0.1 µF	B32560-D1104-J	27548
1 Coil	22 mH	Fa. Toko	–

4.6 IR Remote Control System Using SAB 3209 and SAB 3210 and Operating at a Carrier Frequency of 455 kHz

The described IR remote control system operates at a carrier frequency of 455 kHz, which had been chosen as there are cheap electronic components available for this frequency range. Besides that the electro-magnetic influences are insignificant and therefore only simple screening measures are necessary.

Transmitter (Fig. 4.6.1)

The carrier frequency of 455 kHz is generated by a Meissner oscillator, whereby a ceramic filter is used to obtain a very constant frequency of the feedback circuit.

The carrier frequency signal is combined with the 7-bit-biphase code of the transmitter IC SAB 3210 by the gate IC HEF 4011. It is supplied to the output stage of the transmitter IC (see **fig. 4.6.2**). The carrier frequency of 30 kHz is suppressed by an RC-network operating as a low-pass filter.

The output stage of the transmitter operates with an impressed current and the diode peak-current of approx. $1 A_{pp}$ is kept constant in a power supply range of 7 to 9 V. The radiant intensity maximum of the two emitting diodes LD 271 is 150 mW/sr.

Technical Data

V_S = 9 V
I_S = 17 mA
I_e = 150 mW/sr

Receiver (Fig. 4.6.3)

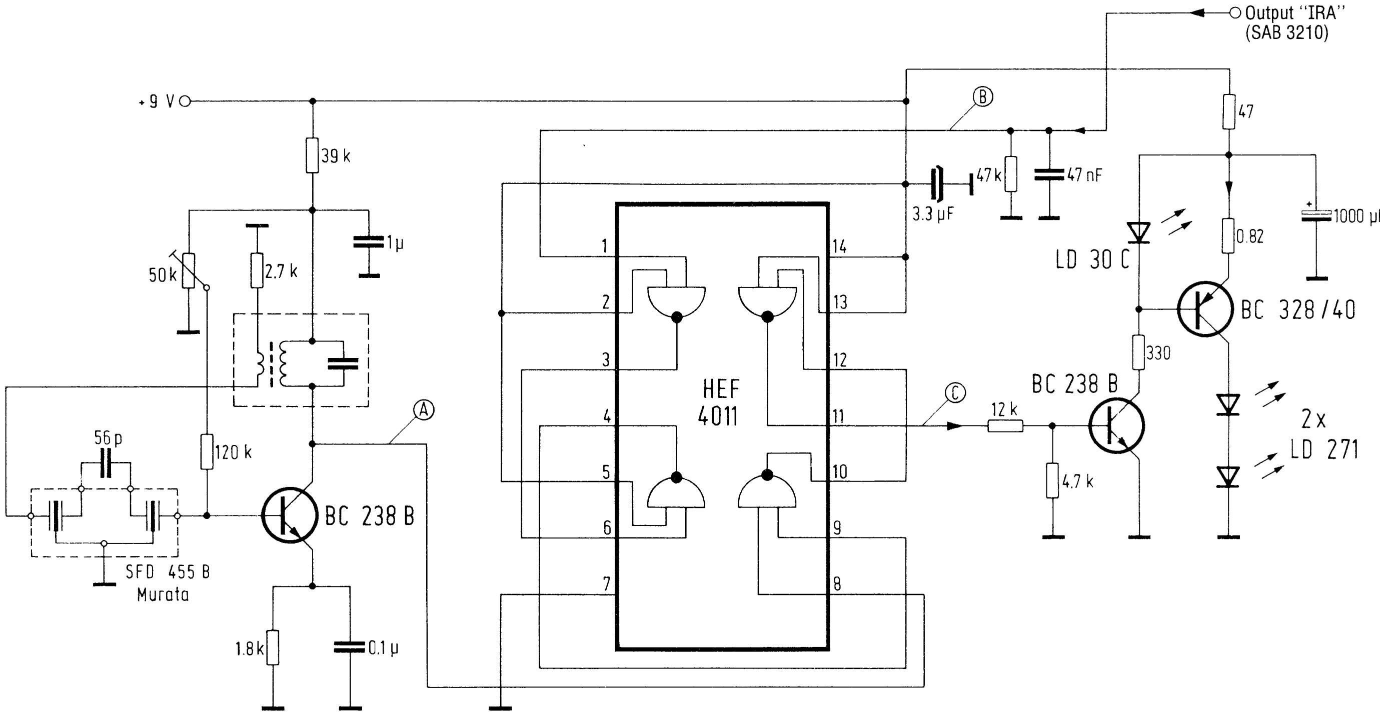
The receiver essentially corresponds to the circuit already described as preamplifier for the remote control system IR 60 in "Design Examples of Semiconductor Circuits, Edition 77/78, page 46". The RF input circuit of the TCA 440 has a very low impedance. Therefore it is coupled to the receiving diode BP 104 via a commonly used TOKO-filter. A TOKO coil is also utilized for the output circuit.

Technical Data

V_S = 15 V
I_S = 12 mA
Distance = 0 to 15 m

A criterion for the sensitivity of remote control system IR 60 is the distance between transmitter and receiver, at which all instructions without any faults are received. With the described system a distance of 15 m was realized, whereas at a carrier frequency of 30 kHz about 23 meters are possible.

Fig. 4.6.1.



Output "IRA"
(SAB 3210)
+9 V
39 k
1µ
50 k
2.7 k
56 p
120 k
BC 238 B
SFD 455 B
Murata
1.8 k
0.1 µ
A
B
C
3.3 µF
47 k
47 nF
47
0.82
1000 µF
LD 30 C
BC 328/40
330
BC 238 B
12 k
4.7 k
2 x
LD 271
HEF
4011
1
2
3
4
5
6
7
8
9
10
11
12
13
14

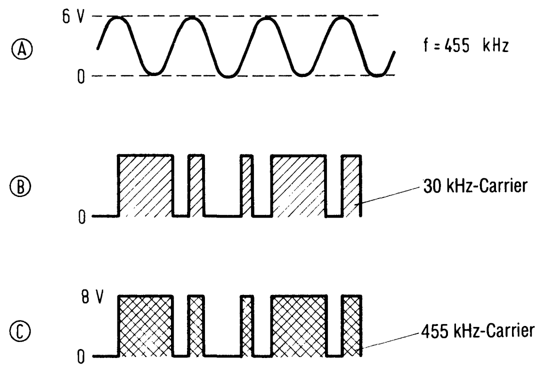


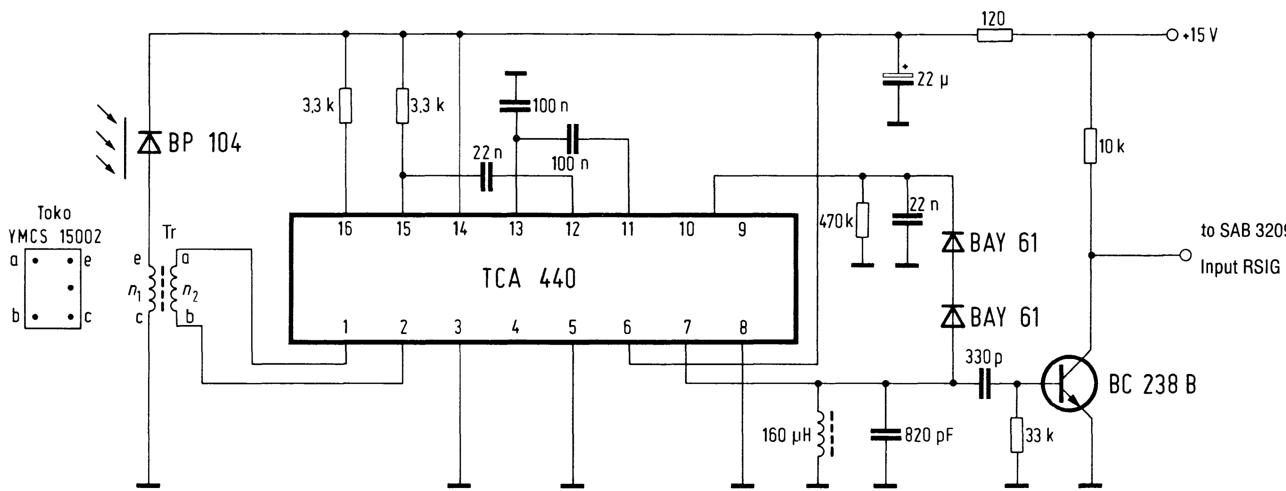
Fig. 4.6.2.

Components for circuit 4.6.1		Ordering code	SCS stock number
1 IC	HEF 4011	–	–
2 Transistors	BC 238 B	Q62702-C279	8829
1 Transistor	BC 328/40	Q62702-C312-V2	8806
2 Diodes (infra red)	LD 271	Q62703-Q148	71058
1 Diode (red)	LD 30 C	Q62705-P22-F39	7368
1 MKH capacitor	47 nF	B32234-B3473-M	1681
1 Ceramic capacitor	0.1 µF	B37449-A6104-S3	17042
1 Electrolytic capacitor	1 µF/40 V	B41313-A7105-V	1915
1 Electrolytic capacitor	4.7 µF	B41313-A2106-V	–
1 Electrolytic capacitor	1000 µF/10 V	B41010-A3108-T	7846
1 Ceramic filter	SFD 455 B	Murata	–
1 IF filter	455 k 47	Toko	–

Components for circuit 4.6.3

1 Receiver IC	TCA 440	Q67000-A669-S2	7469
1 Transistor	BC 238 B	Q62702-C279	8829
1 Photodiode	BP 104	Q62702-P84	71262
2 Diodes	BAY 61	Q62702-A389	8579
1 Styroflex capacitor	330 pF	B31310-A3331-H	1367
1 Styroflex capacitor	820 PF	B31310-A3821-H	1375
1 MKH layer capacitor	22 nF	B32560-B3223-J	–
2 Ceramic capacitors	100 nF	B37449-A6104-S3	17042
1 Ceramic capacitor	22 nF	B37449-A6223-S3	17335
1 Electrolytic capacitor	22 µF 16 V	B45181-A2226-M	7933
1 Transformer	YMCS 1500 W	Fa. Toko	–
1 Coil	160 µH	Fa. Toko	–

Fig. 4.6.3.



120
+15 V
22 µ
3,3 k
3,3 k
100 n
100 n
22 n
BP 104
10 k
Toko
YMCS 15002
a
e
b
c
Tr
e
a
n_1
n_2
c
b
16
15
14
13
12
11
10
9
TCA 440
1
2
3
4
5
6
7
8
470 k
22 n
BAY 61
BAY 61
to SAB 3209
Input RSIG
330 p
BC 238 B
160 µH
820 pF
33 k

4.7 Driving a 16 × 31-LED-Matrix by Three UAA170

Only one in-line-array of LEDs can usually be driven by the IC UAA170, whereby every light point of the array corresponds to a defined voltage.

With three ICs UAA170, however, a two-dimensional 16 × 31-LED-matrix can be operated. One IC controls the horizontal lines (voltage V_x) and the two others the columns (voltage V_y). Every of the 496 light dots of the matrix are determined by a defined value of V_x and V_y.

There exists a manifold of applications for such a LED-matrix, e.g.,
two-dimensional position indication
step-and-repeat manufacturing processes
phase compensation by means of Lissajous figures,
whereby the achievable accuracy is 1 degree with a 5 × 5-matrix
dynamic control.

The principle of operation is explained at a reduced matrix of 5 × 5 LEDs (see **fig. 4.7.1**).

The columns are driven by one UAA170 and via optoelectronic couplers, type CNY17, i.e. the IC controls the infrared light emitting diodes of the coupler. The collectors of the optoelectronic coupler-transistors are connected to the power supply $+V_S$, the emitters drive directly the columns of the matrix. The transistor is turned on when infrared light is emitted by the corresponding diode. The horizontal lines can also be operated by optoelectronic couplers. In this case their emitters have to be connected to ground via a resistor. The optoelectronic couplers, however, are replaced by the cheaper circuit A, consisting of a diode, a transistor and two resistors.

Fig. 4.7.2 shows a circuit for driving a 16 × 31-LED-matrix.

Special measures have been taken for achieving exactly the same increase of switch-on voltage for the horizontal line diodes as well as for the vertical ones. Thus an equal light change-over (smooth to abrupt) from one LED to another is realized in horizontal as well as in vertical direction of the matrix.

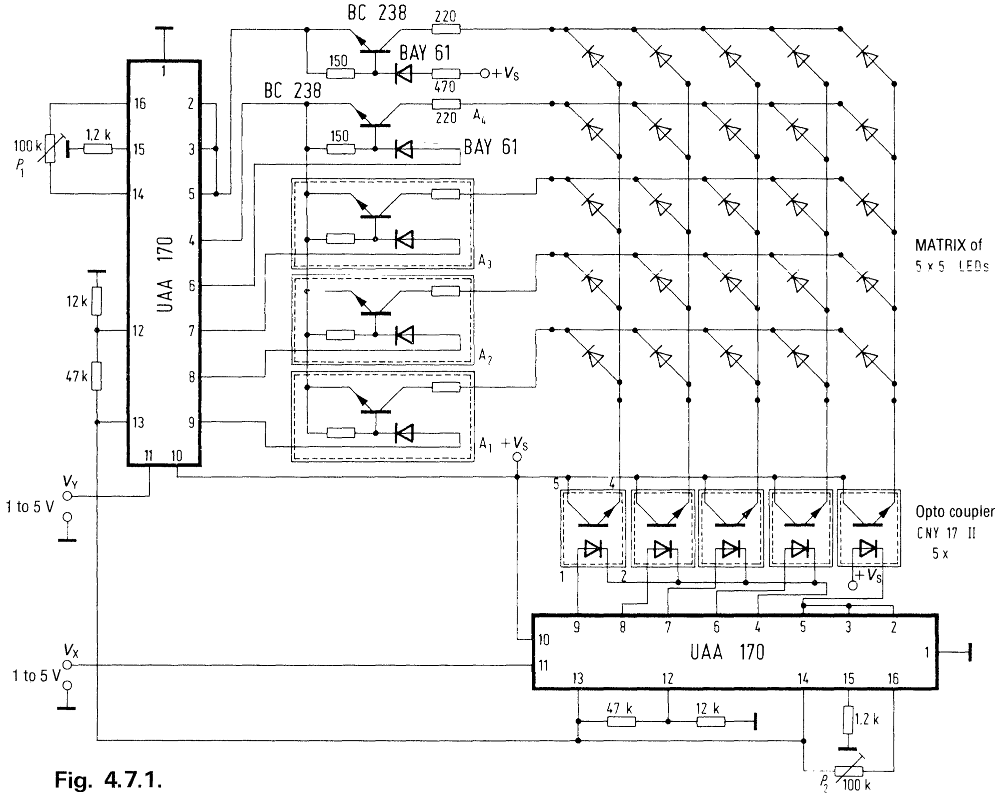


Fig. 4.7.1.

Components for circuit 4.7.2

			Ordering code	SCS stock number
3	Control ICs for LED-arrays	UAA170	Q67000-A940	70353
31	Optoelectronic couplers	CNY17II	Q62703-N1-S2	70838
496	GaP LEDs or a corresponding number of LED-arrays	LD471	Q62703-Q102	70131
16	Transistors	BC238	Q62702-C698	70091
1	Transistor	BC308	Q62702-C704	70097
17	Diodes	BAY61	Q62702-A389	8579
1	Resistor	100 Ohm	B51261-Z4101-J1	37695
16	Resistors	150 Ohm	B51261-Z4151-J1	37661
16	Resistors	220 Ohm	B51261-Z4221-J1	37663
1	Resistor	470 Ohm	B51261-Z4471-J1	37667
3	Resistors	1 kOhm	B51261-Z4102-J1	37672
1	Resistor	39 kOhm	B51261-Z4393-J1	37698
1	Resistor	56 kOhm	B51261-Z4563-J1	37941

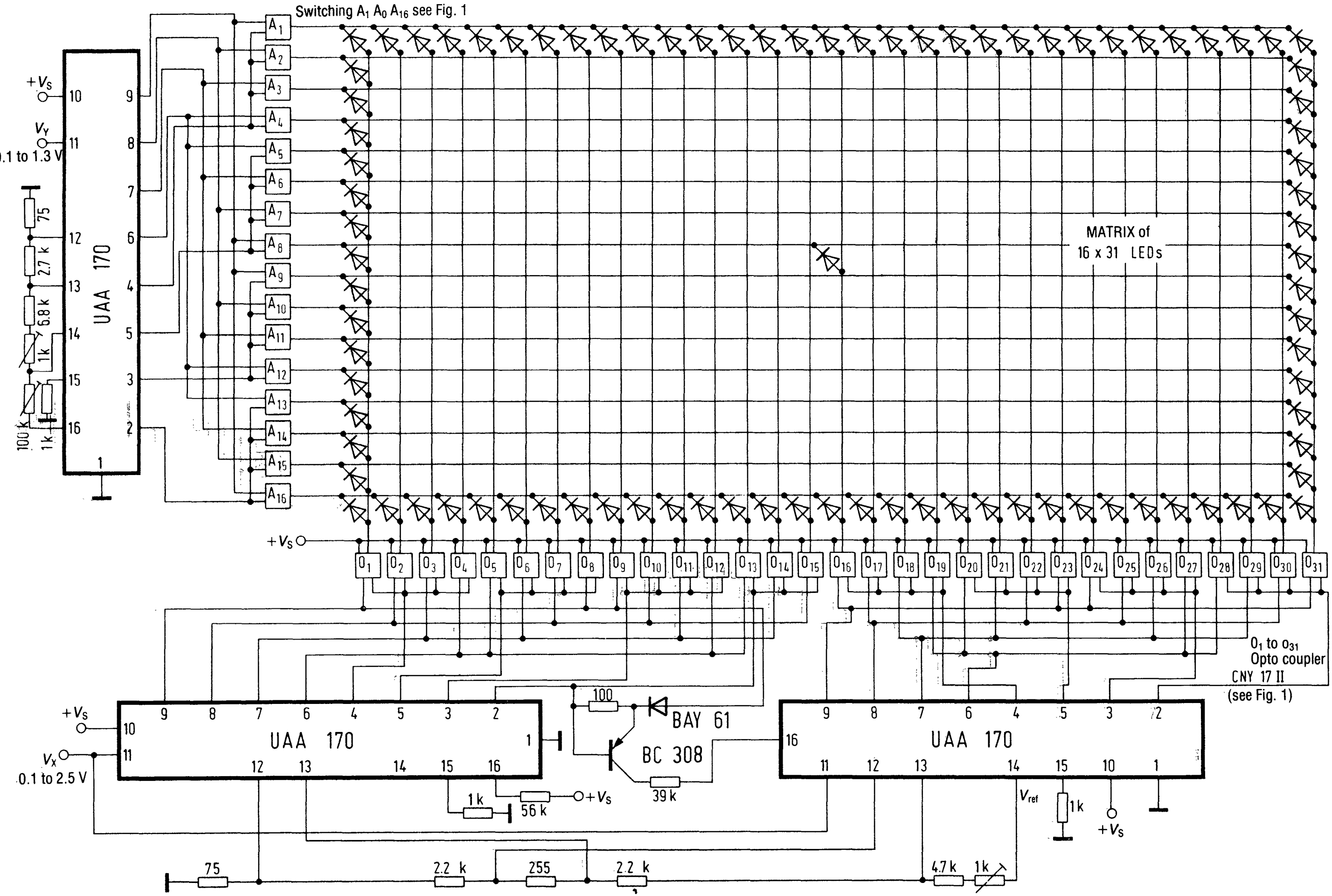

Switching A1 A0 A16 see Fig. 1
MATRIX of
16 x 31 LEDs
UAA 170
+VS
VY
0.1 to 1.3 V
75
2.7 k
6.8 k
1 k
100 k
1 k
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
A15
A16
O1
O2
O3
O4
O5
O6
O7
O8
O9
O10
O11
O12
O13
O14
O15
O16
O17
O18
O19
O20
O21
O22
O23
O24
O25
O26
O27
O28
O29
O30
O31
O1 to O31
Opto coupler
CNY 17 II
(see Fig. 1)
UAA 170
+VS
VX
0.1 to 2.5 V
1 k
56 k
100
BAY 61
BC 308
39 k
UAA 170
Vref
1 k
75
2.2 k
255
2.2 k
4.7 k
1 k

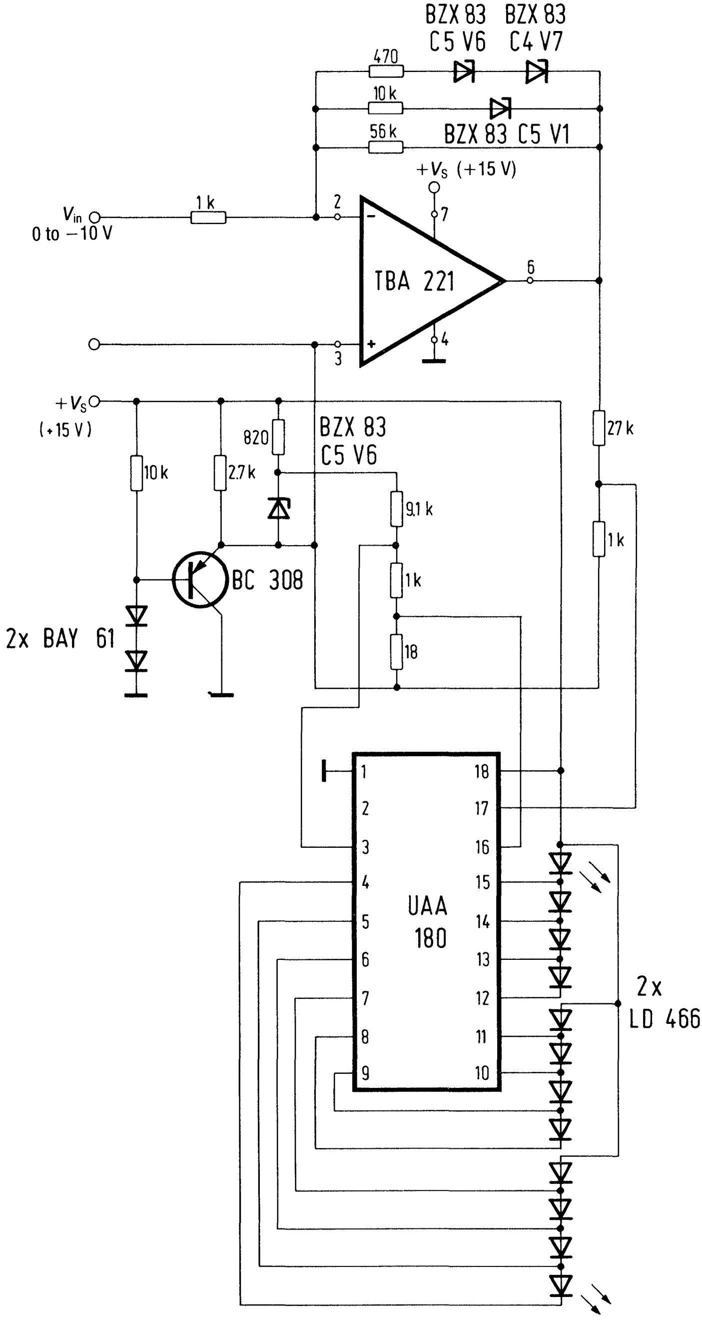
Fig. 4.7.2.

4.8 Level Meter with Logarithmic Scale Using UAA 180

Fig. 4.8 shows a circuit of a level meter with an LED-array for indication. The input signal is applied via a pre-resistor to the operational amplifier TBA 221. The logarithmic characteristic is realized by 3 resistors and 3 z-diodes being part of the reverse feedback circuit. Contrary to the common circuits already described in "Design Examples for Semiconductor Circuits, Edition 76/77, Section 4.10.1" this one operates with only one power supply. A network consisting of the two diodes BAY 61 and the transistor BC 308 sets a bias of approx. 2 V to the non-inverting input of the operational amplifier. This voltage is also the reference for the UAA 180 and for the 27 k/1 kΩ-divider connected to the output of the operational amplifier. This reference voltage is slightly increased by a 18 Ω-resistor to decrease the threshold for the first light spot. The upper level of the reference voltage is generated by the 9.1 k/1 kΩ-divider and the voltage of 5.6 V being stabilized by the z-diode BZX 83 C5V6.

With the described circuit a good conformity to a logarithmic characteristic is achieved and the indicated level increases by 5 dB from one light spot to another.

Components for circuit 4.8		Ordering code	SCS stock number
1 IC	UAA 180	Q67000-A1104	70757
1 Operational amplifier	TBA 221	Q67000-A134	8783
1 Transistor	BC 308	Q62702-C704	70097
2 LED-arrays	LD 466	Q62703-Q84	70129
2 Z-diodes	BZX 83 C5 V6	Q62702-Z1071-F82	7312
1 Z-diode	BZX 83 C5 V1	Q62702-Z1070-F82	7311
1 Z-diode	BZX 83 C4 V7	Q62702-Z1069-F82	7310
2 Diodes	BAY 61	Q62702-A389	8579



BZX 83
C5 V6
BZX 83
C4 V7
470
10 k
56 k
BZX 83 C5 V1
$+V_S$ (+15 V)
V_{in}
0 to −10 V
1 k
2
7
TBA 221
6
4
3
$+V_S$
(+15 V)
820
BZX 83
C5 V6
27 k
10 k
2.7 k
9.1 k
1 k
BC 308
1k
2x BAY 61
18
UAA
180
2x
LD 466

Fig. 4.8.

4.9 Light Barrier Indicating the Direction of Interruption

It is generally important to know not only that a light barrier has been passed but also from which direction the passing occurred. These requirements can be met by using the window discriminator TCA 965 with RS memory function (refer to "Design Examples of Semiconductor Circuits, Edition 77/78, Section 5.4"). Two receiver diodes are necessary to indicate the passing direction (see **fig. 4.9.1**).

The LED CQY 77 operates as transmitter diode. It is supplied with short current pulses of approx. 1A peak value and a repetition period of 30 ms. These pulses are generated by the programmable unijunction transistor BRY 56. The emitted light pulses are received by the diodes BP 104. They are connected to two transistors operating as emitter followers. The transistors are connected to a differential amplifier via a 15 nF-capacitor each. The output signal of the TCA 971 is supplied to pin 8 of the window discriminator.

No signal is available from the differential amplifier if both receiver diodes are covered and when both receive light. If the diode A is not met by the light beam the voltage V_8 at pin 8 is greater than that at pin 7. If the diode B is not met by the light beam V_8 is lower than V_6 (see **fig. 4.9.2**).

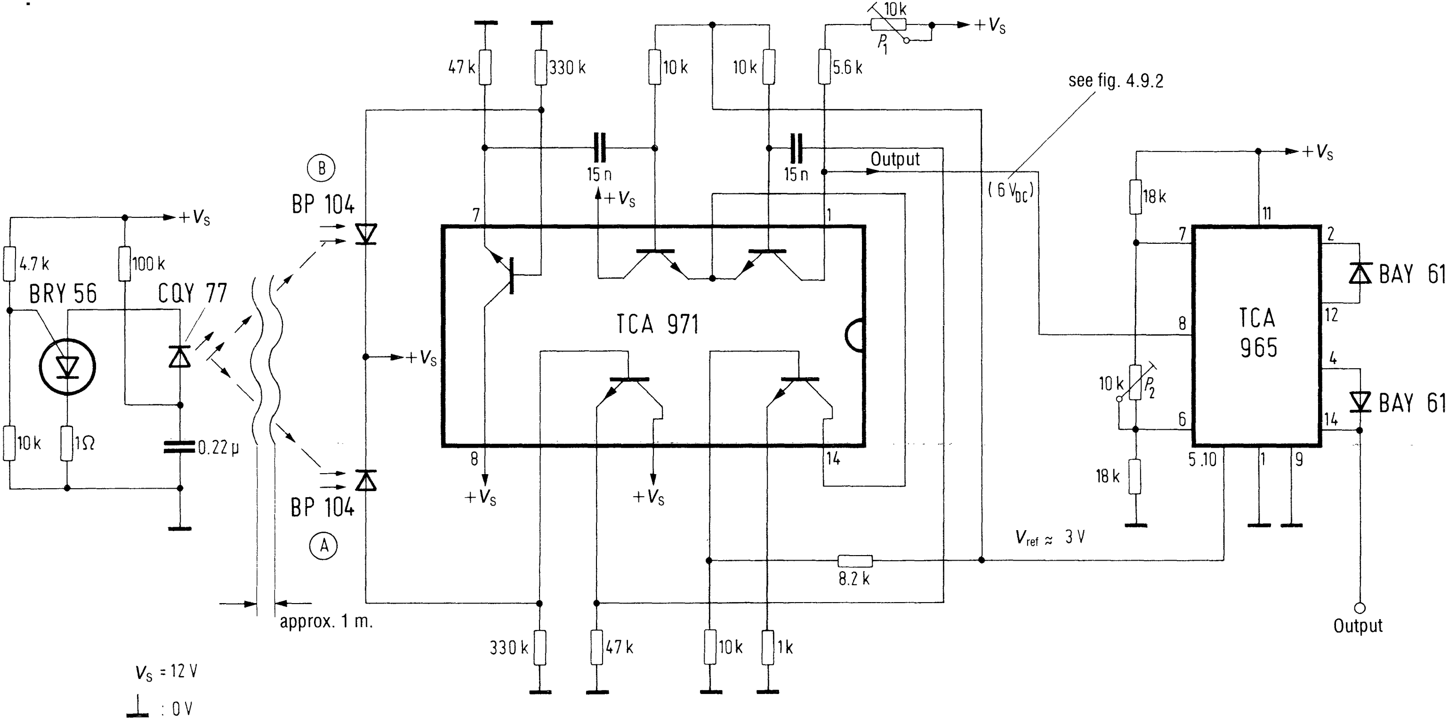
If the light barrier is passed from A to B an L-level is available at pin 14 (curve I). But if it is passed from B to A, pin 14 shows an H-level (curve II).

The sensitivity of the circuit is adjustable by potentiometer P_2. Potentiometer P_1 sets the dc level of the output symmetrically to V_6 and V_7. The five transistors are combined in the transistor-array TCA 971.

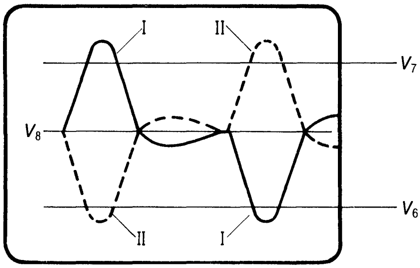
Thus a very good temperature behaviour of the differential amplifier is obtained. The reference voltage V_{10} at pin 10 of the TCA 965 is also utilized by the constant-current source of the TCA 971.

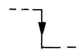
Components for circuit 4.9.1		Ordering code	SCS stock number
1 Window discriminator	TCA 965	Q67000-A982	70754
1 Transistor-Array	TCA 971	Q67000-T11	70755
1 Unijunctiontransistor	BRY 56	Q68000-A803-F1	–
2 Photodiodes	BP 104/blue	Q62702-B58-X6	70731
1 LED	CQY 77/I	Q62703-Q121-S1	70844
2 Diodes	BAY 61	Q62702-A389	8579
2 MKH layer capacitors	15 nF	B32560-D6153-J	27626
1 MKH layer capacitor	0.22 µF	B32560-D1224-J	27551

Fig. 4.9.1.



+V_S
4.7 k
100 k
BRY 56
CQY 77
10 k
1Ω
0.22 μ
B
BP 104
BP 104
A
approx. 1 m.
V_S = 12 V
: 0 V
47 k
330 k
10 k
10 k
5.6 k
10 k
P_1
15 n
15 n
Output
see fig. 4.9.2
(6 V_{DC})
7
1
8
14
TCA 971
330 k
47 k
10 k
1k
8.2 k
V_{ref} ≈ 3 V
18 k
18 k
10 k
P_2
TCA 965
11
7
8
6
5.10
1
9
2
12
4
14
BAY 61
BAY 61
Output



Curve I for passing direction (A) → (B) 

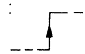
Curve II for passing direction (B) → (A) 

Fig. 4.9.2.

4.10 Power Supply Using the Photovoltaic Cell BPY 64 for Low-Consumption-Devices

In the following a circuit using the photovoltaic cell BPY 64 and a blocking oscillator is described. It is utilized for supplying energy to small electronic devices of low power consumption, e.g., transmitter of infrared remote control systems. Generally a buffer accumulator is connected in parallel to this circuit and thus an operation without any batteries or other power supplies is realized.

On sunny days transmitted energy of approx. 1 mWh can be generated by a Silicon-diode area of 2 cm^2 (corresp. to 6 × BPY 64) even in standard-size living rooms. But on cloudy or winterdays a maximum value of only 0.2 mWh can be expected.

Assuming a current of 10 mA for the short operation period of a IR remote control transmitter a power of 60 mW at a battery voltage of 6 V is necessary. As the sum of all operations for remote control of a TV set does not exceed one minute per day, an electric energy of 1 mWh per day is required.

Under ideal conditions (i.e. power matching $R_i = R_0$, meeting exactly the colour temperature for the sensitivity maximum) the photovoltaic cell BPY 64 supplies approx. 60 µW at 1000 lx and at a colour temperature of 2856 K. In practice, however, an average power generation between 15 and 16 µW can be obtained at diffused daylight and cloudy sky (E = 1000 lx).

Six photovoltaic cells, type BPY 64, connected in series as shown in **fig. 4.10.1** guarantee a safe starting of the blocking oscillator even at a low illuminance of 100 lx (daylight). The oscillator operates at 10 kHz. Its frequency strongly depends on the illuminance and the load. The basic current is adjusted by resistor R_1. A value of 82 kΩ can be considered as a good compromise especially at a low illuminance. The resistance of R_1 should be lower for higher illuminance values.

The circuit offers an efficiency of approx. 60 to 65%.

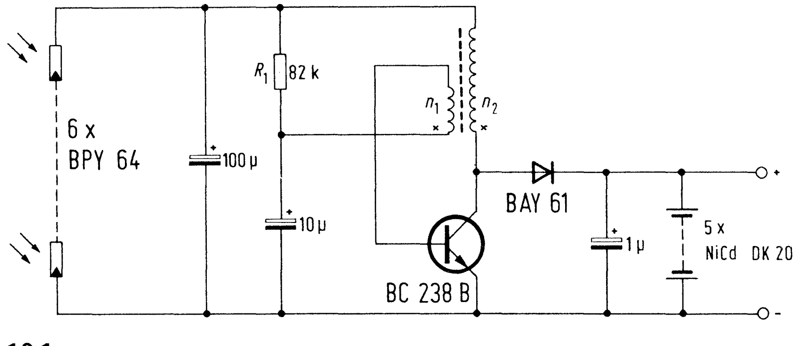


Fig. 4.10.1.

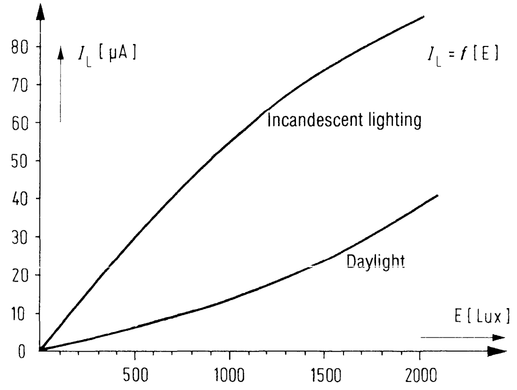


Fig. 4.10.2.

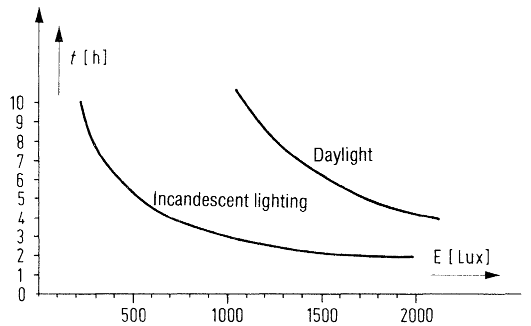


Fig. 4.10.3.

Five NiCd-cells (20 DK, Varta, ordering number 3910020001) can be suitably utilized as buffer accumulators. They supply an open-circuit voltage of approx. 6.2 V at a 100% charge. The capacity is 20 mAh.

Fig. 4.10.2 shows the accumulator current as a function of illuminance at an open-circuit voltage of 5.8 V and at a charge without load. The two curves show the dependence on incandescent lighting (60 W-bulb, matt, with white reflector) and on daylight (diffuse, near the window).

Fig. 4.10.3 shows the time necessary per day as a function of the illuminance. As reference an energy of 1000 µWh is assumed. This is required by the accumulator if the remote control transmitter is operated 60 times per day for a period of 1 s.

Coil data

n_1: 15 turns 0.07 enamelled copper wire
n_2: 340 turns 0.07 enamelled copper wire

Components for circuit 4.10.1

		Ordering code	SCS stock number
1 Transistor	BC238B	Q62702-C279	8829
6 Si photovoltaic cells	BPY64	Q60215-Y64	71497
1 Si switching diode	BAY61	Q62702-A389	8579
1 Alu electrolytic capacitor	1 µF 40 V	B41313-A7105-V	1915
1 Alu electrolytic capacitor	10 µF 25 V	B41313-A5106-V	1935
1 Alu electrolytic capacitor	100 µF 10 V	B41283-B3107-T	7806
1 Pot core	∅ 9 × 5 mm, N30	B65517-A0000-R030	2814
1 Coil former		B65522-A0000-R001	3004
1 Assembly		B65518-A2001-X000	–
1 Resistor	82 kOhm, 0.25 W	B51260-Z4823-J1	37281
5 NiCd cells	20DK, Fa. Varta	3910020001	–

5. Control, Regulating and Switching Amplifier Circuits

5.1 Reducing the Hysteresis of Window Discriminator TCA 965

In some cases the reduction of the internal hysteresis of TCA 965 is desired. This can only be realized by circuits in which pin 9 is not connected to ground. (Setting of the window is achieved by adjusting the window middle voltage and the window width voltage V_9).

Fig. 5.1.1 shows a hysteresis reduction circuit which is only applicable for voltages $V_9 > 200$ mV. For lower values of V_9 the circuit of **fig. 5.1.2** has to be utilized. It can also be used for higher voltages but with reference to the circuit 5.1.1 one additional resistor is required.

The hysteresis reduction is obtained by resistor R_H connected in parallel to R_2 (see fig. 5.1.1). The transistor at output 13 operates as a switch.

If the voltage V_9 has nearly the same value as the collector-emitter reverse voltage V_{CER} of the switching transistor (output 13), the parallel connecting of R_H to R_2 results in that no evident hysteresis reduction is obtained. This disadvantage is avoided in that a higher voltage (approx. 1 to 2 V) is applied to R_H (see fig. 5.1.2). Thus the influence of V_{CER} is essentially lower. In accordance to resistors R_2 and R_1 the resistance of R_H has to be high.

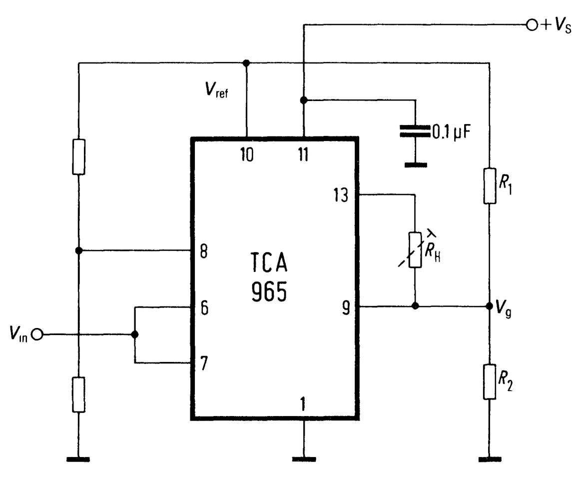


Fig. 5.1.1.

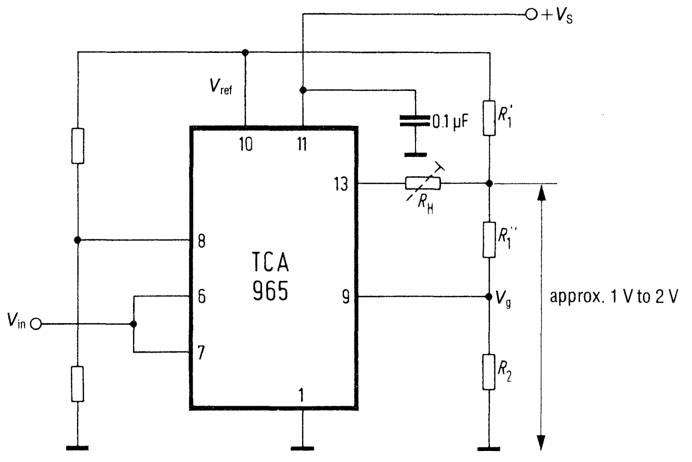


Fig. 5.1.2.

Components for circuits 5.1.1 and 5.1.2

		Ordering code	SCS stock number
1 Window discriminator	TCA 965	Q67000-A982	70754
1 MKH layer capacitor	0.1 µF	B32560-D1104-J	27548

5.2 Circuit for Reducing the Hysteresis of TCA105

For some applications it is necessary to operate the threshold switch TCA105 with a smaller hysteresis than the internal one. This can be realized by an external resistor R_H connected from the inverted output (pin 5) to the input (pin 2). The resistance of R_H depends on the fact that an additional load resistor is connected from pin 5 (output) to $+V_S$ or not.

In the latter case the feedback resistor R_H is connected to ground by the output transistor if an input voltage, being higher than the threshold, is applied. Therefore the input current is reduced to compensate the internal hysteresis (see **fig. 5.2**). If the input signal is below the threshold the output is non-conductive, i.e. the input is not loaded. This compensation operates independently of the supply voltage. The resistance of R_H is in the range of some 100 kΩ and depends on the hysteresis.

The operations are completely different if a load is connected to the inverted output. In this case the resistor R_H is connected via the load R_L to the power supply, when the output transistor is turned off. There is no additional input current.

The resistance for R_H has to be in the range of some MOhms. It depends on the power supply voltage.

In both cases the resistance of the feedback resistor R_H has to be dimensioned in that no overcompensation occurs. The input load change should not be too high during the switching. Otherwise an oscillation with a low frequency will be generated at the outputs.

Components for circuit 5.2		Ordering code	SCS stock number
1 Threshold switch	TCA105	Q67000-A572	7249

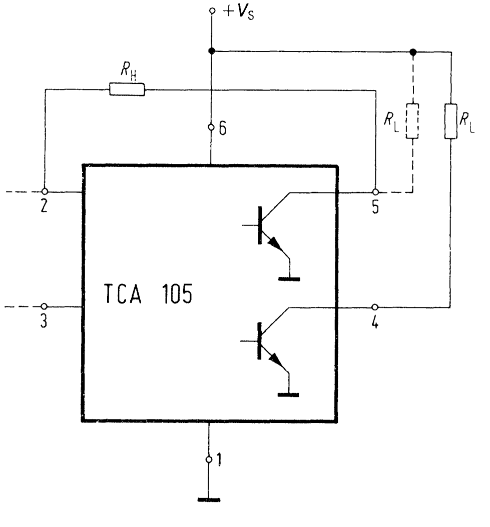


Fig. 5.2.

5.3 Integrated Circuits TCA 105 or TCA 205A Utilized as Switches for Two-Line-Connection

It is often necessary to replace a mechanical switch with an electronic one. However, this electronic device should operate without any third line for the power supply.

This requirement can be satisfied by using the threshold switches TCA 105 or TCA 205A as shown in **fig. 5.3.1** and **5.3.2.** The wide range of the power supply voltage from $V_S = 4.5$ V (TCA 105) or $V_S = 4.75$ V (TCA 205A) to 30 V is utilized to keep the on- and off-state of the IC. If the output of the threshold switch is conductive the IC is supplied with a sufficiently high voltage by means of the voltage divider consisting of the load (resistance of the relay windings) and the resistor R_Q (see **fig. 5.3.2**). If the output is non-conductive a current of approx. 3 mA flows through the load (refer to fig. 5.3.1).

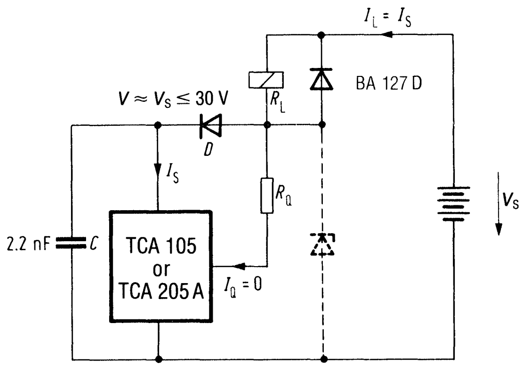


Fig. 5.3.1.

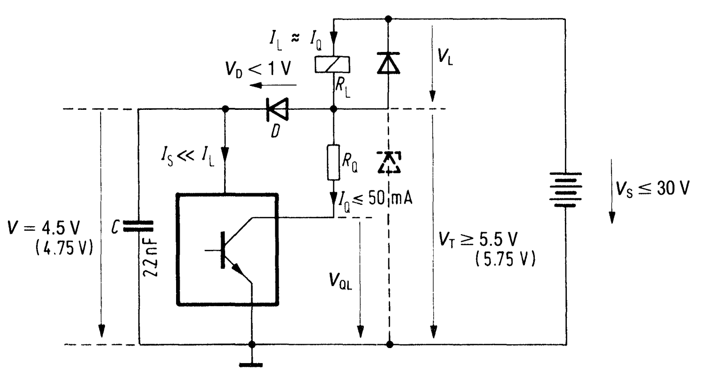


Fig. 5.3.2.

As the supply voltage for the IC changes very rapidly during the switching the internal voltage regulation circuit is not able to react, i.e. a strong oscillation will be generated at the output of the IC. Therefore the 2.2 nF-capacitor is connected in parallel to the IC to reduce the voltage increase.

If the load is inductive (e.g. a relay) either a protection diode has to be connected in parallel to the relay or a z-diode in parallel to the IC.

For the conductive state of the output the following conditions are assumed:

1. Power supply voltage $V_S \leqq 30$ V
2. Divider voltage $V_R = (V_S + V_D)$:
   $V_T = (V_S - V_L) \geqq 5.5$ V (5.75 V)
3. Load current $I_L = \frac{V_L}{R_L} \leqq 50$ mA
4. Voltage divider

$\frac{R_Q}{R_L} = \frac{V_T - V_{QL}}{V_L}$; $V_{QL} = f(I_L)$, see **Fig. 5.3.2**

Components for circuits 5.3.1 and 5.3.2

			Ordering code	SCS stock number
1 Threshold switch		TCA 105	Q67000-A527	7249
	or	TCA 205A	Q67000-A1034	70741
1 Diode		BA 127 D	Q60201-X127-D9	70044
1 Ceramic capacitor		2.2 nF	B37238-J5222-S	1728
1 Resistor in accordance to the a.m. equation			–	–

5.4 Triac-Matching-Circuit for the LSL-Family FZ 100

The following chapter describes five of the mostly used circuits for driving power switches, e.g. triacs, with components of the LSL-family FZ 100. For industrial control applications very often an isolation of the control circuit from the power switching circuitry is required. The optoelectronic coupler as shown in **fig. 5.4.1** and consisting of the LED LD 52 and the photoresistor FW 9802 is favoured for this application. When no light is applied the photoresistor has a high resistance (<800 kΩ), i.e. no current flows to the gate of the triac and therefore the triac is turned off. If the output of gate FZH 101A shows H-level a current flows via transistor BCY 58 to the LD 52. Because of the illumination the resistance of the FW 9802 decreases to approx. 2.4 kΩ. The triac is then triggered.

Fig. 5.4.2 shows a circuit for direct matching without any isolation. In this case the positive pole of the power supply is connected with the neutral line. A negative

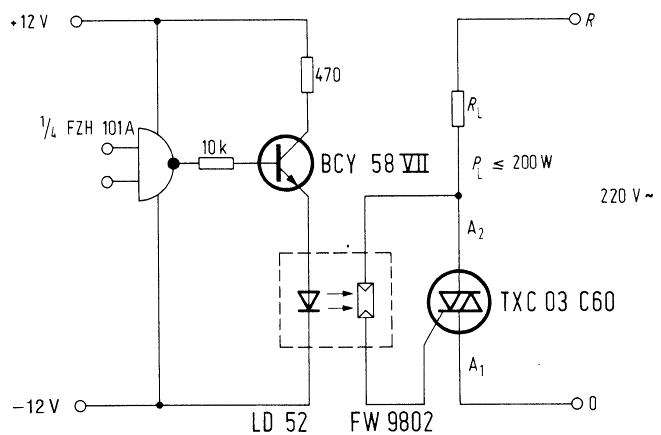


Fig. 5.4.1.

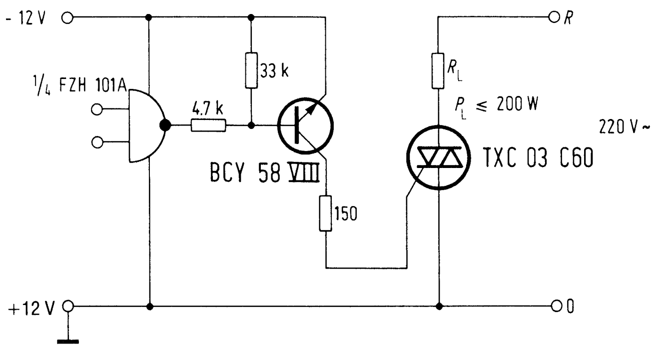


Fig. 5.4.2.

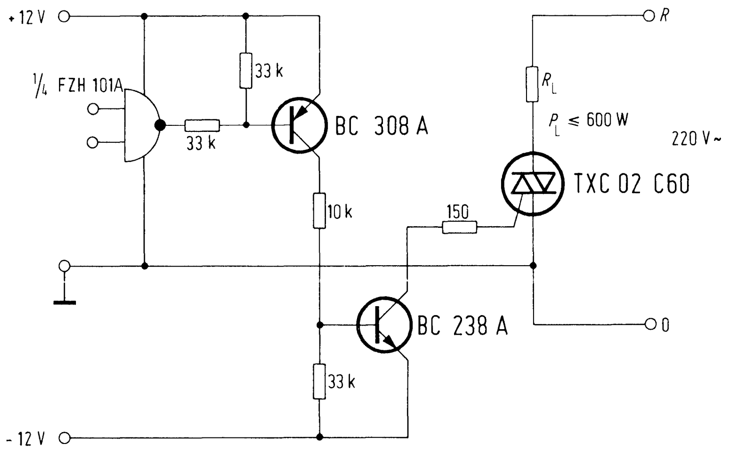


Fig. 5.4.3.

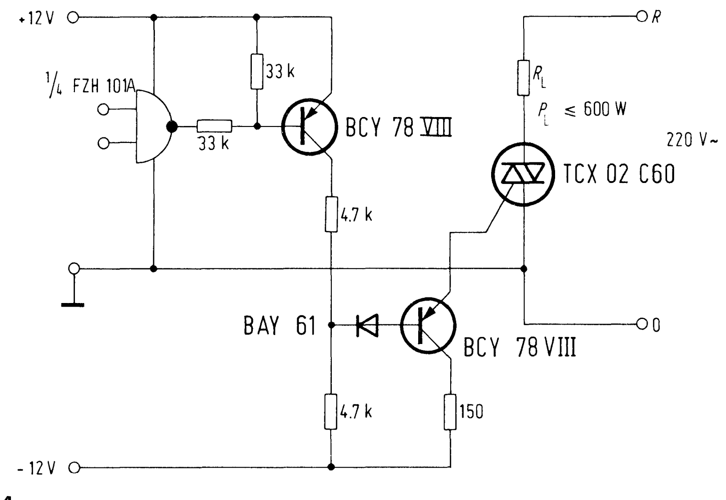


Fig. 5.4.4.

voltage is applied to the gate and the triac is triggered, if the output of the logic IC has H-level. However, it has to be assured that the logic circuit refers to a level of −12 V with regard to the neutral line. If this is not feasible a power supply with plus and minus 12 V-lines has to be used.

As shown in **fig. 5.4.3** the triac is triggered. The transistor BC308 is switched on via the base voltage divider and drives the following transistor BC238. Its collector supplies a negative trigger signal via the 150 Ω-resistor to the gate and thus the triac is turned on.

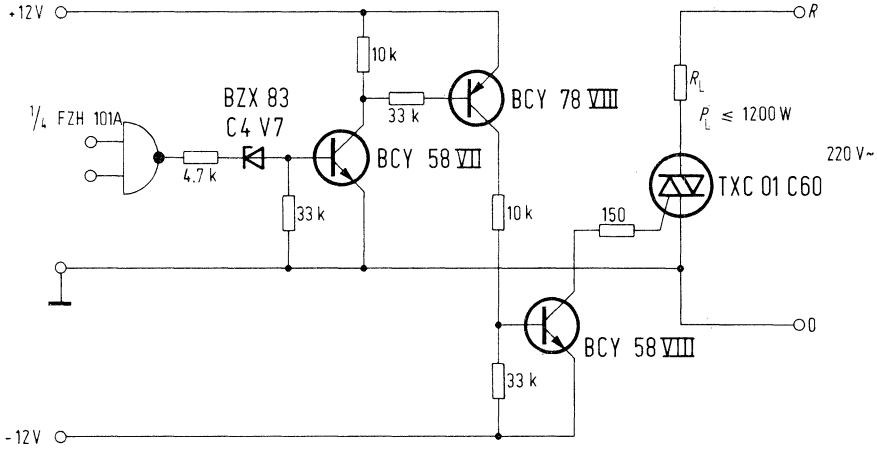


Fig. 5.4.5.

In the circuit of **fig. 5.4.4** the triac is triggered when the FZH101A has H-level at its output. In this case the upper transistor BCY78 is non-conductive and the lower transistor BCY78 is driven via a diode and a 4.7 kΩ-resistor. The emitter of the lower transistor supplies a trigger signal, which is negative with reference to the neutral line, to the gate of the triac.

Fig. 5.4.5 shows another circuit in which the triac is triggered when the FZH101A has H-level at its output. Besides that the triac TXC01C60 is used. Contrary to the types of the before mentioned circuits this one supplies a current of 6 A.

Components for circuit 5.4.1

		Ordering code	SCS stock number
1 Triac	TXC03C60	C66048-A1502-A12	–
1 NAND gate	FZH101A	Q67000-H1242	70786
1 Transistor	BCY58VII	Q60203-Y58-G	8290
1 LED	LD52/II	Q62703-Q159	71332
1 Photoresistor	FW9802	Q62705-P19-F65	–

Components for circuit 5.4.2

1 Triac	TXC03C60	C66048-A1502-A12	–
1 NAND gate	FZH101A	Q67000-H1242	70786
1 Transistor	BCY58VII	Q60203-Y58-G	8290

Components for circuit 5.4.3

1 Triac	TXC02C60	C66048-A1501-A23	–
1 NAND gate	FZH101A	Q67000-H1242	70786
1 Transistor	BC238A	Q62702-C278	8828
1 Transistor	BC308A	Q62702-C285	8797

Components for circuit 5.4.4

		Ordering code	SCS stock number
1 Triac	TXC02C60	C66048-A1501-A23	–
1 NAND gate	FZH101A	Q67000-H1242	70786
2 Transistors	BCY78VIII	Q60203-Y78-H	8613
1 Diode	BAY61	Q62702-A389	8579

Components for circuit 5.4.5

1 Triac	TXC01C60	C66048-A1500-A23	–
1 NAND gate	FZH101A	Q67000-H1242	70786
2 Transistors	BCY58VII	Q60203-Y58-G	8290
1 Transistor	BCY58VIII	Q60203-Y58-H	8291
1 Transistor	BCY78VIII	Q60203-Y78-H	8613
1 Z-diode	BZX83C4C7	Q62702-Z1069-F82	7310

5.5 Magnetic Barrier Using the Hall-IC SAS 251

Contactless electronic switches are becoming more and more popular due to their many advantages: bounce-free, no-functional disturbance due to impurities or aggressive atmosphere, high switching speed, practically unlimited operational life. New simplified switching possibilities for magnetically-operated contactless switches are given when using the IC SAS 251. It is encapsulated in a 4 pin-plastic package and includes the Hall-generator and the necessary processing circuit, i.e. amplifier, Schmitt-trigger and two in-phase output amplifiers for switching 30 mA (see **fig. 5.5.1**).

The described magnetic barrier can be used as end-switch or position-switch, as pulse generator or with a correspondingly shaped soft iron part (e.g. toothwheel) as an electronic tachometer. The large temperature range of the SAS 251 also allows the device to be applied in the automotive industry, for instance for transistor ignition systems.

Layout and function

The mechanical layout of the magnetic barrier is illustrated in **fig. 5.5.2.** It comprises the IC SAS 251, the cube-shaped permanent magnet VACOMAX® (Vakuumschmelze GmbH, Hanau), two soft iron pole shoes (FL) and an amagnetic fixation (HA) which may also be replaced by a compound.

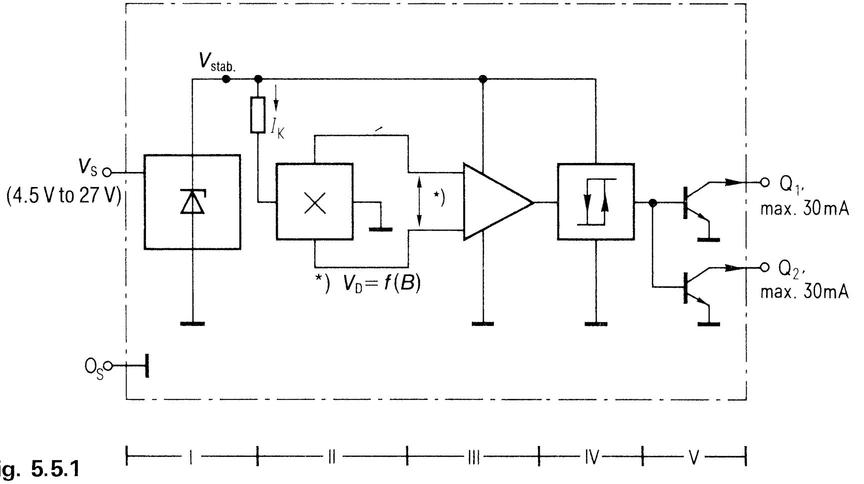


Fig. 5.5.1

I	Voltage stabilization
II	Hall generator
III	Amplifier
IV	Threshold switch
V	Output stages with open collector, in-phase
I_C	Constant supply current
V_{stab}	Internally stabilized supply voltage, derived from V_S

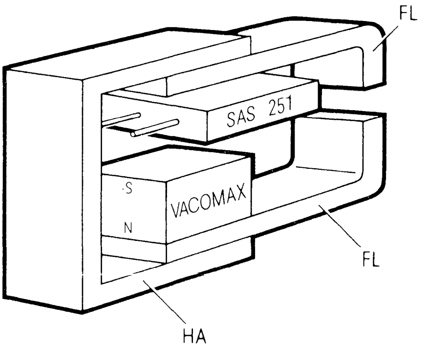


Fig. 5.5.2.

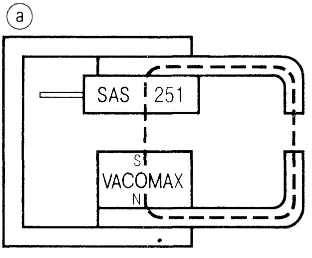


Fig. 5.5.3a.

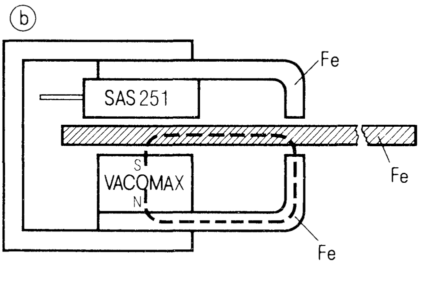


Fig. 5.5.3b.

The function is based on the principle of the magnetic short-circuit. **Fig. 5.5.3a** shows the barrier without the iron lug in the slot. The magnetic flux lines close via the upper area of the soft iron part and the Hall generator in the SAS 251 which receives a reasonable amount of induction to exceed the turn-on induction B_E. In this case the output transistors of the SAS 251 are conductive.

As soon as the iron lug is in the slot **(fig. 5.5.3b)** the magnetic flux lines are short-circuited via the iron lug. The induction in the Hall generator then decreases below the turn-off induction B_A and the SAS 251 output transistors are switched off. **Fig. 5.5.4** shows the magnetic flux density B and the signal V_Q of one IC-output transistor as a function of the path s in the soft iron sheet in the slot of the barrier. The new VACOMAX®-magnetic-material delivers at smallest dimensions high inductances as they are needed for the application.

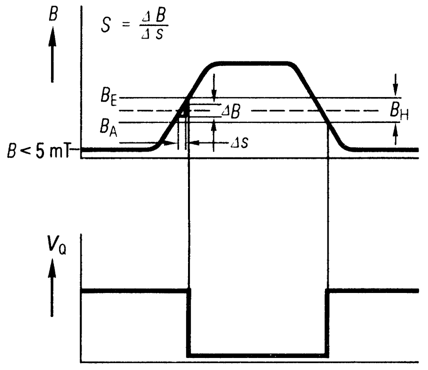


Fig. 5.5.4.

S	Steepness
B_E	Turn-on induction
B_A	Turn-off induction
B_H	Magnetic hysteresis
$V_Q \sim V_s$	
s	Path within the iron sheet

The two outputs Q_1 and Q_2 of SAS 251 have open collectors and can switch currents up to 30 mA. Thus LEDs, relays and power Darlington transistors can be directly driven.

Components for circuit 5.5.2

		Ordering code	SCS stock number
1 Hall IC	SAS 251	Q67000-S47	71355

5.6 Electronic Temperature Sensor Using a Simple 4 bit-A/D-Converter

In **fig. 5.6.1** the circuit of an electronic temperature sensor is illustrated. Temperatures between +3° and +33 °C are indicated as coded word with a length of 4 bit. This A/D converter principally may also be extended to word lengths of more than 4 bit.

Function

The NTC resistor R1 is part of an analog bridge circuit (R1 to R4). The bridge voltage is compared by a window discriminator consisting of operational amplifiers OP1 and OP2. The window discriminator distinguishes the signals inside or outside the window, i.e. whether the measurement signal is too high, too low or correct. In case the signal is too high or too low, the window discriminator will release

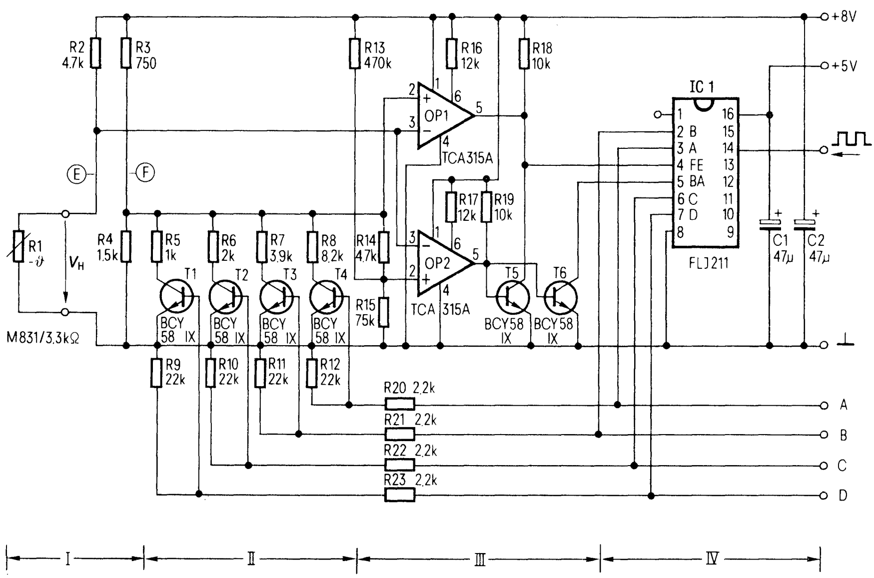


Fig. 5.6.1

I Analog test bridge using the NTC resistor R1
II Binary step divider with a ratio of 1:2:4:8
III Window discriminator (OP1 and OP2)
IV Binary counter (forward-backward counter)
If a simple forward counter is used the circuit simplifies as shown in fig. 5.6.2.

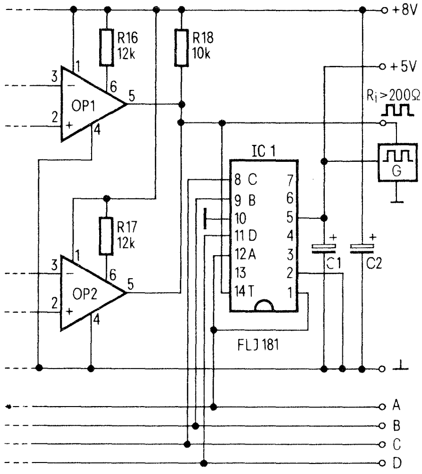


Fig. 5.6.2.

the binary counter IC1 which will continuously count the pulses of an external clock generator. The counter outputs A to D control the binary step-switches T1 to T4 which, in turn, adjust the analog bridge circuit in accordance to the count state of the binary counter. The bridge adjustment causes a stepwise modification of the bridge voltage between points E and F. As soon as the bridge voltage is in line with the inside area of the discriminator window, the counter is stopped. The count state, therefore, indicates the adjustment state of the analog bridge, i.e. the measurement value. The binary counter may be a simple forward counter or a forward-backward counter. The advantage of using a forward-backward counter is that at change of the bridge voltage the follow-up will be performed in any case in the correct direction. The intermediate values occurring during the follow-up correspond exactly to the change of the analog measurement signal.

When using a forward counter on the contrary only a continuous forward count is possible. It can occur that at the reduction of the analog signal by just one step, the counter will continue to count in the forward direction up to the overflow to begin at the start until the new adjustment is achieved. Beside the corresponding time prolongation of the adjustment procedure a control amplifier being possibly connected behind the A/D-converter, would receive incorrect instructions. If the output signal is only used for display purposes, a simple forward counter is sufficient (see **fig. 5.6.2**), because the high clock frequency up to 100 kHz is not perceivable by the human eye.

Dimensioning hints and function of the circuit shown in fig. 5.6.1

Bridge circuit with binary step switch

For the given temperature range of +3 to +33 °C the NTC resistor M831 (3.3 kΩ), an operation voltage of 8 V and a series resistor R1 with a resistance of 4.7 kΩ

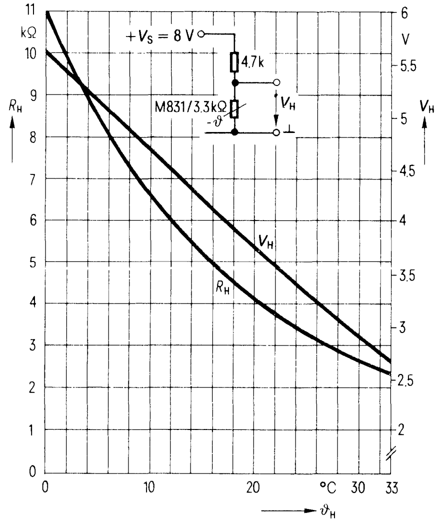


Fig. 5.6.3.

were chosen. The resistance response of the NTC resistor is given in **fig. 5.6.3** as a function of the temperature. The comparator divider of the bridge circuit is composed of R3, R4 and the binary step switch with T1 to T4 including the collector resistors R5 to R8. The values of R5 to R8 shall feature as accurately as possible the ratio 1:2:4:8 (in fig. 5.6.1 corresponding to 1 kΩ, 2 kΩ, 3.9 kΩ, 8.2 kΩ). With the 4-bit-word-output the inaccuracy of R7 and R8 is not of importance. The highest comparator voltage will occur when all transistors (T1 to T4) are blocked, and the lowest voltage happens when all transistors are conductive.

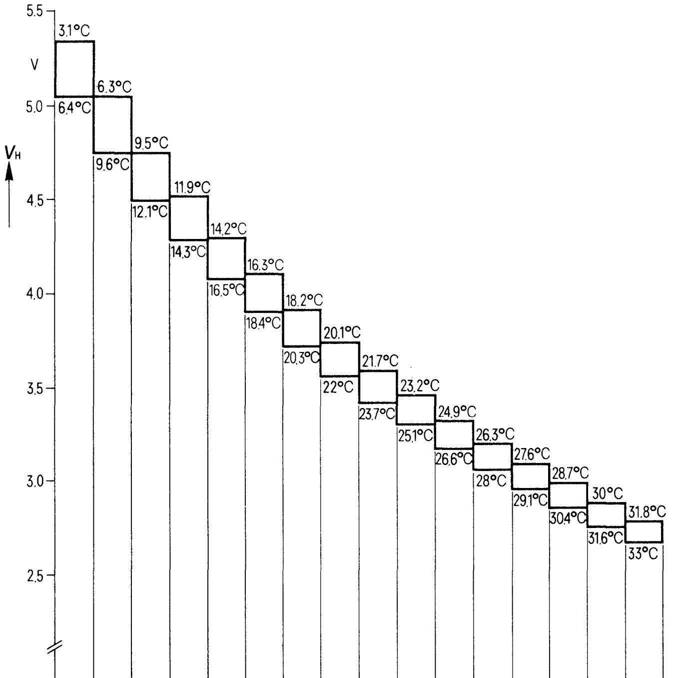
Window discriminator

The window is determined by the partial resistors R13, R14 and R15. Their optimal values were the best rated from several comparative evaluations.

Attention must be paid to the window width being at least equal or larger than the voltage jump between two counter positions, otherwise a continuous oscillation between the two counter positions would result. Furthermore, the window should not be too great in order to hinder unnecessary enlargements of the tolerance range. The window width fully corresponds to the voltage drop at resistor R14. The divider current is mainly determined by R15. Resistor R13 reduces somewhat the window width. **Fig. 5.6.4** shows the switching stages and effective window widths in the total signal range.

Binary counter

The TTL-IC FLJ 211 may be used as forward-backward counter IC1. The start-stop signal is applied to the input. The potential at BA determines the count direction. Decoupling and reversing are performed by transistors T5 and T6. The clock fre-



D	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H
C	L	L	L	L	H	H	H	H	L	L	L	L	H	H	H	H
B	L	L	H	H	L	L	H	H	L	L	H	H	L	L	H	H
A	L	H	L	H	L	H	L	H	L	H	L	H	L	H	–	H

Fig. 5.6.4.

quency is applied externally. The test circuit showed a permissible maximum clock frequency of 100 kHz. The clock frequency in any case has to be smaller than the response delay from counter output to recognition of the signal at the window discriminator output. If necessary, the clock frequency may be reduced to several pulses per second. This is, for instance, useful if filter capacitors have to be added to suppress interferences on the sensitive sensor line.

A/D converter with simple forward counter

As already mentioned, the A/D-converter may also be designed with a simple forward counter **(fig. 5.6.2).** For this purpose, the circuit is somewhat reduced. T5 and T6 may be eliminated. The counter may be, as in our example, the IC FLJ 181.

Components for circuit 5.6

		Ordering code	SCS stock number
2 Aluminium electrolytic capacitors	47 µF 25 V	B41283-B5476-T	7876
1 Binary 4 bit-forward-backward	FLJ 211	Q67000-J145	8901
counter or 4 bit-binary counter	FLJ 181	Q67000-J34	8763
2 Operational amplifiers with Darlington input	TCA 315 A	Q67000-A561	7293
6 NPN silicon transistors	BCY 58 IX	Q60203-Y-J	8292
1 NTC resistor	M 831/10%/ 3.3 kΩ/2.1[1])	Q63483-M 1003-K43	3950

[1]) NTC resistor moulded in an aluminium case, suitable for sensoring temperatures of air as well as of liquids.
Length of the PVC connection cable is 2100 mm.

5.7 Replacement of an Unijunction Transistor Used in Timing Circuits

Unijunction transistors are very often used as clock generators in photo-flash warning devices. In the circuit illustrated in **fig. 5.7** the unijunction transistor is replaced by two inexpensive transistors T_1 and T_2. The frequency of the oscillation varies only in the admissible range because RC-components with small tolerances have been used. Therefore adjustment is not necessary.

The threshold V_{th} is determined by resistors R_1 and R_2 which have a resistance tolerance of $\pm 2\%$.

$$V_{th} = V_S \times \frac{R_2 + R_3}{R_1 + R_2 + R_3} + 0.6\,V$$

The clock frequency is $(134 \pm 9.3)\,min^{-1}$, if components are used with tolerances as indicated in fig. 5.7. The switching time is:

$$t_S = R \times C \times \ln \frac{V_S}{V_S - (V_Z + 0.6\,V)}$$

If the EB-voltage of 0.6 V for the transistor BC308 is neglected the clock frequency is voltage-independent. For the voltage V_Z and thus for the power supply voltage V_S high values have to be chosen to reduce the influence of the EB-voltage. However, the admissible reverse voltage of the EB-diode has to be considered.

The following table shows the dependence of frequency on the power supply voltage V_S. The temperature coefficient is $+0.3\ min^{-1}/K$. It is linear between $-10°$ and $+50$ °C.

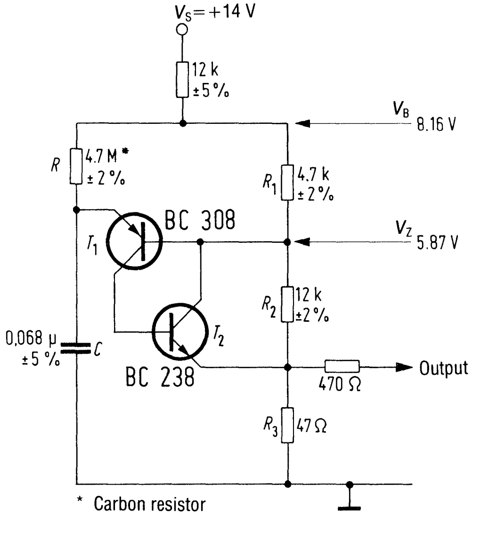


Fig. 5.7.

Table

Supply voltage V_S	−20%	−10%	Nominal value	+10%	+20%
Frequency (min^{-1})	129	132	134	136	141

Components for circuit 5.7

		Ordering code	SCS stock number
1 Transistor	BC238	Q62702-C698	70091
1 Transistor	BC308	Q62702-C704	70097
1 MKH layer capacitor	68 nF	B32560-D1683-J	27547

5.8 Control of Rotating-Direction for Small Motors with an AC Power Supply

The circuit of **fig. 5.8.1** operates with bridge-connected rectifiers consisting of two Darlington-transistor pairs. One pair is directly controlled by potentiometer P_1, the other is phase-reversely driven by an operational amplifier. The circuit operates as follows. A signal is supplied from the tap of potentiometer P_1 to the inverting input of the op. amp. The non-inverting input is connected to the power supply lines via the voltage divider consisting of R_1 and R_2. All four Darlington transistors are switched off when the tap of P_1 is in its centre position. In every other position two transistors, being in diagonal position, are always conductive. The current flows either through transistor T_1, the motor and transistor T_4 or through transistor T_2, the motor and transistor T_3. The power dissipation of the Darlington transistors reaches its maximum at half of the motor voltage. As there are two pairs of transistors it is advantageous to use two separate heat sinks, one for the npn-types and one for the pnp-transistors. No additional measures for protecting the transistors against inductive voltage peaks from the motor are necessary since the Darlington transistors BD 675/676 already incorporate an inversely-poled diode. If the motor is short-circuited a current of approx. 4 A flows through the transformer. As the Klixon reacts within 10 seconds no additional protection measures are required.

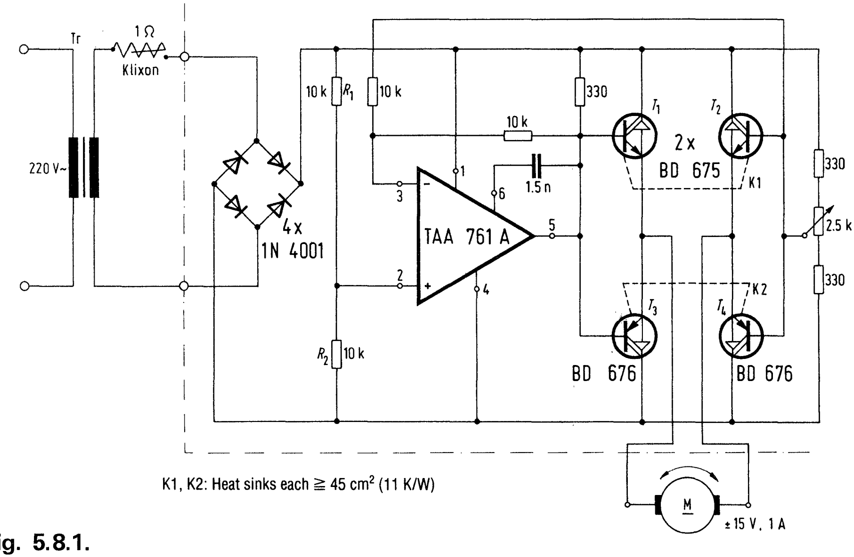


Fig. 5.8.1.

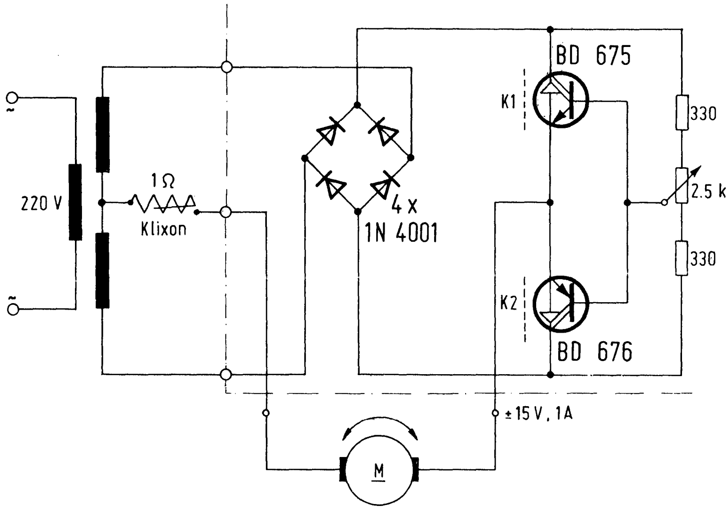


Fig. 5.8.2.

The circuit of **fig. 5.8.2** operates with two power supply voltages. For reversing the direction of rotation one of the bridge arms consisting of transistors BD675 and BD676 is utilized. The controlling is directly realized by potentiometer P_1. As the possible power dissipation maximum at half of the motor voltage is only applied to one transistor a greater area of heat sink is necessary. The transformer has to be dimensioned in that the short-circuit current does not exceed a value of 4A. Thus an overloading of the transistor between the period of short-circuit and Klixon reaction is avoided. The case temperature of each transistor has to be less than 50 °C.

Fig. 5.8.3 shows a circuit which operates only with one half-wave. Contrary to the two circuits described before a small current flows through the transistors when the tap of P_1 is in its centre position. The current of the positive half-wave flows via the upper transistor, the negative one via the lower transistor. The reaction of both half-wave currents compensates and the motor does not rotate. The value of the half-wave current depends on the resistance of P_1 and on the current gain of the transistors. Therefore a compromise between a reasonably low current of the centre tap position and a sufficiently high current for the control range, i.e. for the angle of rotation at asymmetrical positions, has to be found. The resistance of P_1 is 33 Ω when the potentiometer is in one of its final positions. This resistance determines essentially the current maximum of the transistors.

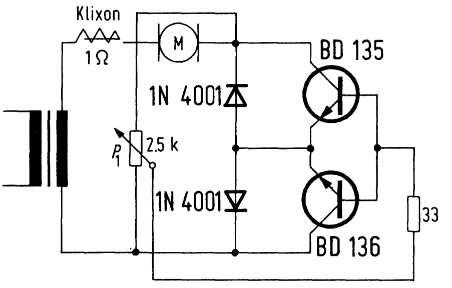


Fig. 5.8.3.

Components for circuit 5.8.1

		Ordering code	SCS stock number
1 Operational amplifier	TAA 761 A	Q67000-A522	7236
2 PNP darlington transistors	BD 676	Q62702-D239	70559
2 NPN darlington transistors	BD 675	Q62702-D238	70558
4 Diodes	1N 4001	C66047-Z1306-A21	48001
1 MKH layer capacitor	1.5 nF/400 V	B32560-D6152-J	27619
1 Potentiometer	2.5 kΩ/0.1 W	–	–
7 Resistors	1 × 330 Ω/0.5 W	B51261-Z4331-J1	37665
	2 × 330 Ω/0.1 W	B51260-Z4331-J1	36681
	4 × 10 kΩ/0.1 W	B51260-Z4103-J1	37270
2 Heat sinks	2 × 45 cm^2 ≙ 11 K/W	–	–

Components for circuit 5.8.2

1 PNP darlington transistor	BD 676	Q62702-D239	70559
1 NPN darlington transistor	BD 675	Q62702-D238	70558
4 Diodes	1N 4001	C66047-Z1306-A21	48001
1 Potentiometer	2.5 kΩ/0.1 W	–	–
2 Resistors	330 Ω/0.1 W	B51260-Z4331-J1	36681
1 Heat sink	120 cm^2 ≙ 6 K/W	–	–

Components for circuit 5.8.3

1 Transistor	BD 135	Q62702-D106	70121
1 Transistor	BD 136	Q62702-D107	70122
2 Diodes	1N 4001	C66047-Z1306-A21	48001
1 Resistor	33 Ω	–	–
1 Potentiometer	2.5 kΩ/0.1 W	–	–

5.9 Control of Rotation Direction of Small Motors with a DC Power Supply

Contrary to the before-mentioned circuits, the motor current of the circuit shown in **fig. 5.9** flows through potentiometer P_1. In the centre position of the potentiometer no current is flowing through the motor, but only a power supply current through the two arms of P_1, the two diodes and the two transistors. An automatical current limitation is realized by the resistance of the potentiometer. When the slider of P_1 is turned to the left the motor current flows through diode D_1 and transistor T_2. In this case the transistor T_1 is weakly conductive.

When the slider is turned to the right the motor current flows through diode D_2 and transistor T_1. A diode BA127D is connected to the base of each transistor to reduce the leakage current when one of the transistors is switched off.

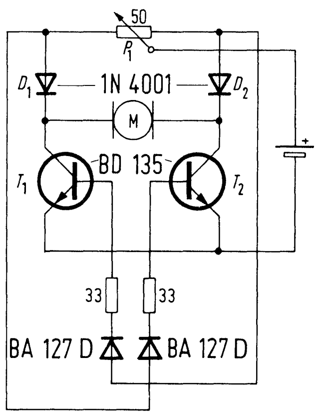


Fig. 5.9.

Components for circuit 5.9

		Ordering code	SCS stock number
2 Transistors	BD135	Q62702-D106	70121
2 Diodes	1N4001	C66047-Z1306-A21	48001
2 Diodes	BA127D	Q60201-X127-D9	70044
2 Resistors	33 Ω/0.1 W	–	–
1 Potentiometer	50 Ω/5 W	–	–

6. Electronic Circuits for Electric Power Engineering

6.1 Electronic Dimmer with Touch Keys

The new MOS IC S566B makes it possible to control all functions by a single touch key (sensor). This solution offers together with modern comfort and design a further advantage in that any number of, even physically separated, parallel controls or an electronic remote control, can be operated.

Principle of the MOS dimmer

The operation principle of a touch key (sensor) is based on the finite resistance between human body and earth. Thus the input potential of an electronic circuit may be varied and switching and control operations released. As the commands "ON", "OFF" and "phase-angle-control" is controlled by a single sensor the duration of the touch remains as the only discrimination criteria. The application of this input information, its storage and the correctly phased gate triggering of the triac is achieved by the integrated MOS IC S566B. By means of a PLL circuit the internal clocks are generated and synchronized to frequency and phase with the mains. The almost digital operation mode provides exact and stable adjustment of the desired phase angle. The triac is triggered at each half-wave by an approximately 30 µs-pulse at pin 8.

Description of the circuit

Fig. 6.1.1 shows a dimmer circuit for incandescent lamps, which can replace the ordinary mechanical switch usually connected in series with the lamp. The switching function is realized by triac T_c. In the reversed state the mains voltage is applied to the triac terminals, in the conductive state only a residual voltage is present. However, the electronic control circuit requires a dc voltage of 15 V for operation. The IC, therefore, was designed for an adjustable phase angle of approx. 30° (minimum). The voltage delivered by this angle causes capacitor C3 to be charged to the operating voltage of the IC via rectifier D2. A capacitance of an electrolytic capacitor is sufficient with regard to the very low power consumption of the circuit. R1 and C2 serve as current limiters for the z-diode D1. Capacitor C1 and choke Ch give the specified RF interference suppression.

The synchronization with the mains frequency is achieved by the ac voltage applied to the triac, and supplied via R2 to pin 4. The inherent interference signals are filtered by C6. C4 and C5 are part of the internal control circuit of the IC. A touch of the sensor surface influences the potential of the voltage divider at the control input (pin 5). The necessary touch protection is provided by resistors R8 and R9. The sensitivity of the sensor is adjustable by R7. Further touch keys are not easily connected in parallel to this input because, on long lines, the high-resistance input is too sensitive to external interference. A second inverting input is provided for this purpose. It can be terminated with low impedance. The control is achieved by short-circuiting by means of a mechanical push button or a sensor-driven transistor as shown in **fig. 6.1.1.**

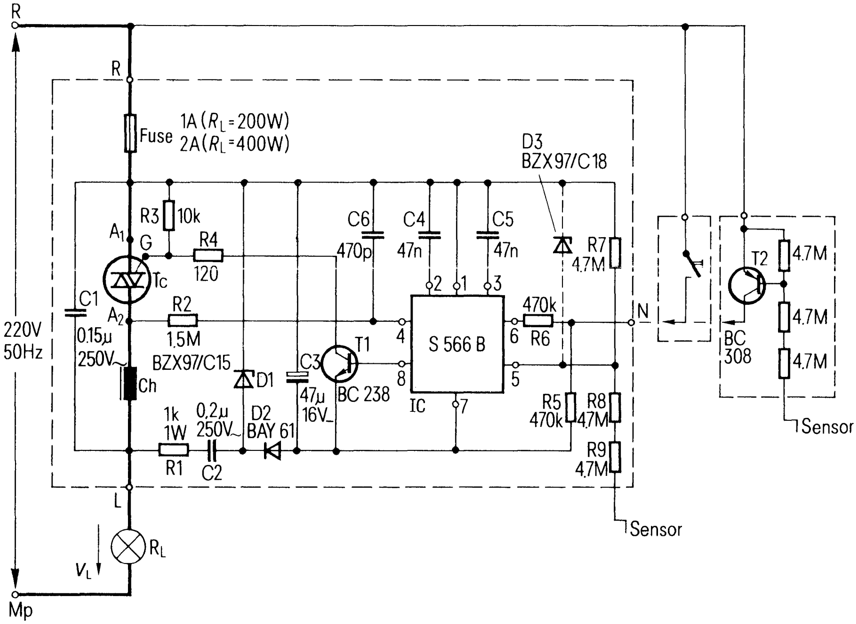


Fig. 6.1.1. Circuit of the electronic sensor dimmer using the new MOS IC type S 566 B. Attention has to be paid in that the correct connections are made, i.e. *R* to the hot lead, and *L* to the lamp.

Parallel controls or simple switches are connected to terminal *N*.

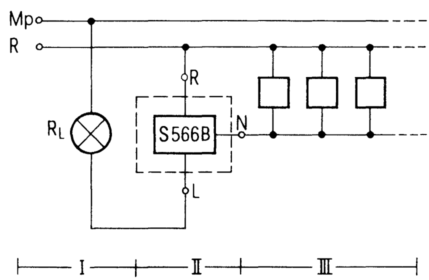


Fig. 6.1.2. Arrangement of parallel-connected control devices

I Resistive load (lamp)

II Triac control using S 566 B in accordance to fig. 6.1.1

III Parallel-connected control devices or keys of any number (see fig. 6.1.1, right)

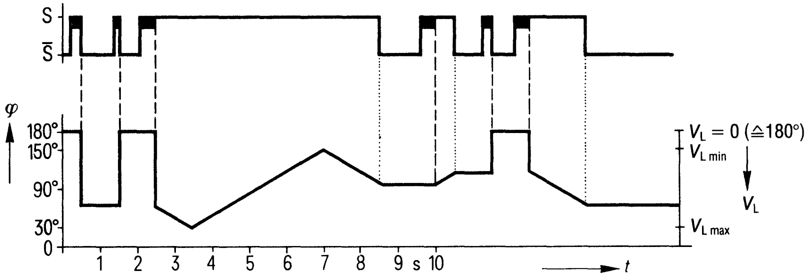


Fig. 6.1.3. Influencing the phase angle by touching the sensor

Fig. 6.1.2 illustrates the easy connection for parallel control devices. If no controls are required R5 and R6 may be eliminated. Input 6 has then to be directly connected to V_{DD} (pin 7).

For reliable operation of the sensor it is absolutely necessary that the IC is correctly connected to the mains, i.e. terminal R to the "hot" lead and L via the lamp to the neutral wire Mp. But with a mechanical contact at pin 6 the connection to the proper terminals is no longer important, i.e. mobile power consumers, for instance, floor lamps can be operated.

The triac is triggered in the 3rd and the 4th quadrant via a driver transistor (T_1) which allows also the use of triacs with higher gate currents. The maximum power of the connected load is limited by the maximum ratings of the triac. The RFI suppression has also to be selected accordingly. For incandescent lamp control the switch-on transient pulses which may reach 5 to 10 times the rated lamp current due to the low cold resistance, have to be considered.

Control behaviour

Fig. 6.1.3 shows the control behaviour. With a short touch of the sensor, i.e. less than 0.4 s but more than 60 ms (immunity period for interference suppression) the phase angle is aligned to a preliminarily fixed value for turn-on. Another short touch releases the turn-off. If the touch lasts more than 0.4 s the phase angle φ will sweep the whole control range within a period of 7 s, i.e. the output voltage is controlled from the minimum to the maximum and return as long as the finger remains on the key.

A new touch causes the control direction to reverse, e.g. first touch: φ gets larger, i.e. the lamp becomes darker; second touch: φ becomes smaller, i.e. the lamp becomes brighter, and so on. At turn-off, a short touch allows the previously set value to remain stored in the IC memory. At the next turn-on the phase angle φ adopts this last value. Hence the lamp burns at the previously set brightness or dimming begins at this initial value.

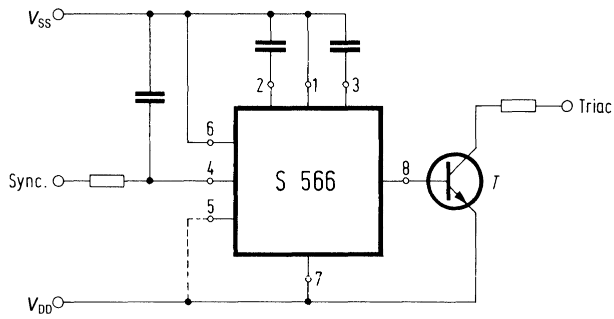


Fig. 6.1.4.

The phase angle can be adjusted between 30 to 150° of each half-wave. The smallest angle (30°) is necessary to provide the supply voltage, the largest angle (150°) still allows a significant margin between the lowest output voltage (i.e. the least brightness) and the off-position in that a clear identification of the dimmer switching state is obtained.

The control is achieved without the hysteresis which is common in conventional circuits.

Fig. 6.1.4 shows a circuit which continuously changes the phase angle. Therefore the voltage across a load is periodically controlled up- and downwards. These kinds of control are favoured for applications of illuminated advertisements, warning devices or electric sirens. In this case the sensor input (pin 5) has to be connected to V_{DD} (dashed line) or the auxiliary input (pin 6) directly to V_{SS}.

Components for circuit 6.1		Ordering code	SCS stock number
1 Electronic dimmer IC	S 566 B	Q67100-Z120	71429
1 NPN silicon transistor	BC238	Q62702-C698	70091
1 PNP silicon transistor (for parallel sensors)	BC308	Q62702-C704	70097
1 Triac			
for loads of up to max. 200 W: Triac	TXCO3A60	C66048-A1502-A2	48058
for load of up to max. 400 W: Triac (mounted on a cooling block 10 K/W)	TXCO2A60	C66048-A1501-A6	48053

			Ordering code	SCS stock number
1	RFI suppression choke (ring core)[1]	2.5 A nominal current	B82603-V-B11	35033
1	Z-Diode,	BZX97/C15 0.5 W	Q62702-Z1239-F82	7353
1	Silicon switching diode	BAY61	Q62702-A389	8579
2	MKH layer capacitors	47 nF/250 Vdc	B32560-B3473-J	27566
1	Ceramic disc type capacitors	470 pF/400 Vdc	B37205-A5471-S1	1724
1	RFI suppression capacitor	0.15 µF/250 Vac	B81111-B-B27	35008
1	RFI suppression capacitor (X)[2]	0.2 µF/250 Vac	B81111-B-B28	35009
1	Aluminium electrolytic capacitor	47 µF/25 Vdc	B41286-A-5476-T	7890
1	Carbon resistor	1 k/1 W, ±5%	B51264-Z4102-J1	39171
1	Carbon resistor	120 Ω/0.33 W±5%	B51261-Z4121-J1	37660
1	Carbon resistor	10 kΩ/0.33 W±5%	B51261-Z4103-J1	37689
2	Carbon resistors	470 kΩ/0.33 W±5%	B51261-Z4474-J1	37952
1	Carbon resistor	1.5 MΩ/0.33 W±5%	B51261-Z4155-J1	37938
6	Carbon resistors	4.7 MΩ/0.33 W±5%	B51261-Z4475-J1	37939

[1]) For a lamp load of up to 200 W a 1.6 A-choke is sufficient, ordering code B82603-V-B10 (not available from SCS-Fürth).

[2]) In the described circuit this capacitor is used as a current limiter and not for RFI suppression.

6.2 Phase Angle Control Using IC S 566 for Small Supply Voltages

The operation principle of the electronic dimmer IC S 566 has already been described in chapter 6.1. The following demonstrates an application of this IC for supply voltages between 12 and 16 V as they are used for, e.g., toy railway-trains. As shown in **fig. 6.2.1** the dc voltage supplying the S 566 is produced by rectification during a half-wave. Contrary to the operation with 220 V only a small voltage drops across the limiting resistor R_1. For direct synchronization the secondary voltage of transformer is not sufficient. Because of the slow voltage increase the threshold is only readed at defined phase angles. Therefore the control would have a wide dead zone. But by the transistor T_1 a steeper slope is produced. It can be adjusted to the required phase angle by matching the resistance of the divider resistor R_3. As this application operates with very low load currents a triac offering low holding currents has to be used. A further advantage is obtained in that a lamp with 1 to 2 W is connected in parallel to the output.

At transformers with a low output power the stray inductance corresponds to a high series resistance when the triac is turned on by a fast current increase. Therefore a short voltage breakdown will occur. It is applied to the synchronous input of the IC and causes interferences. This disadvantage can be avoided by increasing the capacitance of C_4 to approx. 0.1 µF. For the short-circuit protection a bimetal switch, type Klixon, is utilized. But the triac has to be rated for the maximum short-circuit current which will flow until the bimetal switch interrupts the power supply line.

The storage of the preset value is a certain disadvantage of the S 566 for this application. If the load, in this case the train, is switched off by a short touch of the sensor, no possibility exists for re-start with a reduced speed, as the driving

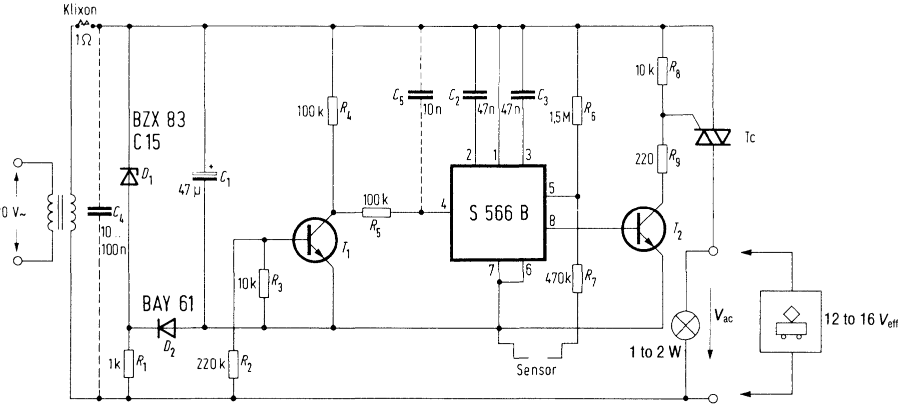


Fig. 6.2.1.

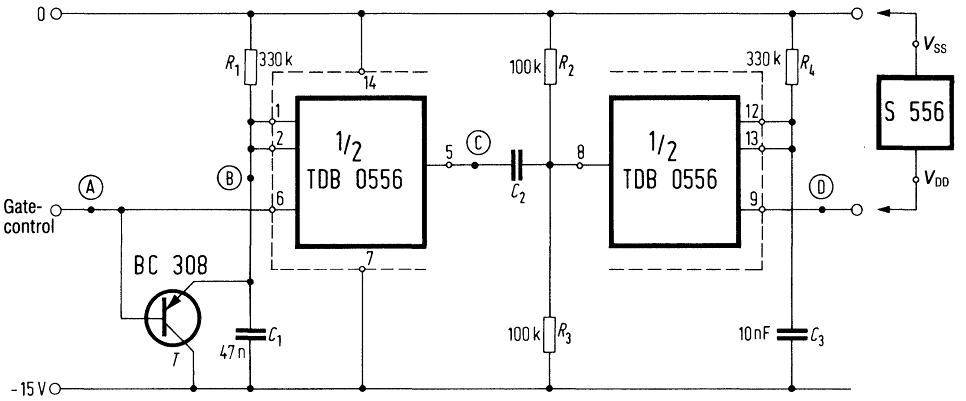


Fig. 6.2.2.

voltage jumps again to the previously adjusted value. The memory can be erased by turning off the supply voltage. **Fig. 6.2.2** shows an circuit which interrupts momentarily the voltage supply line when the dimmer circuit is switched off. Thus the above mentioned disadvantage is avoided. The first timing circuit operates as a monostable multivibrator, which is always reset again by the trigger pulses of the triac. If these trigger pulses are not applied the charging procedure continues without any interruption and the output is switched. The second monostable multivibrator is triggered by output signals from the first multivibrator, which interrupts the voltage supply line of the S 566 for a short time.

Components for circuit 6.2.1

		Ordering code	SCS stock number
1 IC	S 566 B	Q67100-Z120	71429
1 Triac	TX D10 K40 P	C66048-A1504-A4	–
2 NPN-Transistors	BC 238	Q62702-C698	70091
1 Z-Diode	BZX 83/C15	Q62702-Z1081-F82	7321
1 Diode	BAY 61	Q62702-A389	8579
2 MKH layer capacitors	10 nF	B32560-B3103-I	27562
2 MKH layer capacitors	47 nF	B32560-B3473-I	27566
1 Electrolytic capacitor	47 µF	B41286-A5476-T	7890
1 Resistor	220 Ω/0.3 W	B51261-Z4221-J1	37663
1 Resistor	1 kΩ/0.3 W	B51261-Z4102-J1	37672
2 Resistors	10 kΩ/0.3 W	B51261-Z4103-J1	37689
1 Resistor	220 kΩ/0.3 W	B51261-Z4224-J1	37948
1 Resistor	470 kΩ/0.3 W	B51261-Z4474-J1	37952
1 Resistor	1.5 MΩ/0.3 W	B51261-Z4155-J1	37938

Components for circuit 6.2.2

		Ordering code	SCS stock number
1 IC	TDB 0556 A	Q67000-A1046	70320
1 PNP-Transistor	BC 308	Q62702-C704	70097
2 MKH layer capacitors	10 nF	B32560-B3103-I	27562
1 MKH layer capacitor	47 nF	B32560-B3473-I	27566
2 Resistors	100 kΩ	B51261-Z4104-J1	37944
2 Resistors	330 kΩ	B51261-Z4334-J1	37951

6.3 Excess Temperature Protection Circuit for Dimmer IC S 566

Fig. 6.3 shows a circuit with a PTC resistor which protects the dimmer IC S566 against excess temperatures during operation. As the resistance of the PTC resistor increases when the temperature rises, the trigger current is decreased in that the triac is finally switched off. When the temperature drops again the current increases and the circuit starts automatically to operate. The advantage of switching off the triac only and not the total circuit is in that the function of the dimmer IC is not influenced, i.e. the same illumination is set with reference to the previously adjusted value.

Another possibility for excess temperature protection is given by replacing the resistor R_4 by a PTC resistor, type P350-B11. This P350 increases its resistance at 80 °C. In the temperature range below 80 °C, the resistance reaches a minimum of 200 Ω. Therefore triacs with a trigger current of ≦50 mA can be used only.

If triacs with higher trigger currents are used the circuit "b" is recommended. It interrupts the base control of transistor T_1. The PTC resistor P330-B11 is well favoured for this application. The resistor R_A is connected in parallel to the base-emitter-junction and thus a safe turn-off is assured when the PTC resistor becomes high-resistive. The resistance of R_A depends on the gain of T_1 and on the trigger-current group of the triac. It is dimensioned in that the excess temperature protection circuit becomes effective at temperatures of approx. 80 °C.

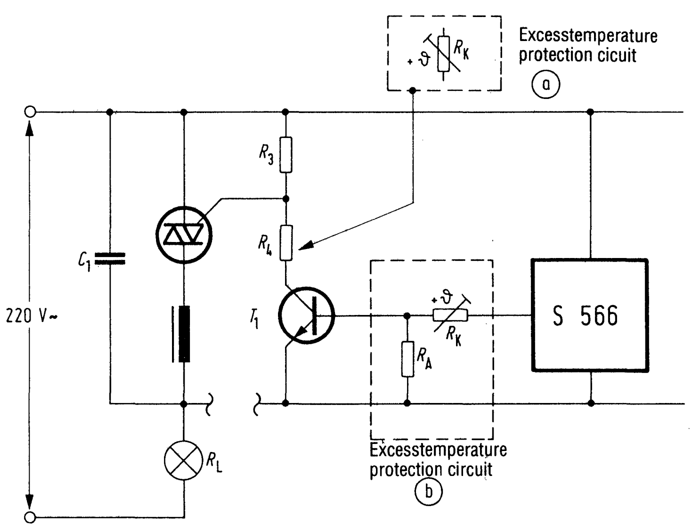


Fig. 6.3.

Since the trigger currents are slightly unsymmetrical in the 3rd and 4th quadrant a triac is triggered often at one half wave, i.e. the lamp is operated at half of its illumination.

But with the second half-wave, which is later applied, the triac and thus the lamp are completely turned off.

Components for circuit 6.3

		Ordering code	SCS stock number
1 PTC resistor	P330-B11 or	Q63100-P330-B11	–
	P350-B11	Q63100-P350-B11	–

6.4 Low-Loss DC-Control Circuit Using S 566

Fig. 6.4 shows a low-loss circuit which controls a dc voltage by using the IC S566. It operates in accordance to the principle of a keyed control. The effective output voltage is controlled by the duty cycle with which the load is turned on or off and not by a voltage drop across a series resistor as usually practised.

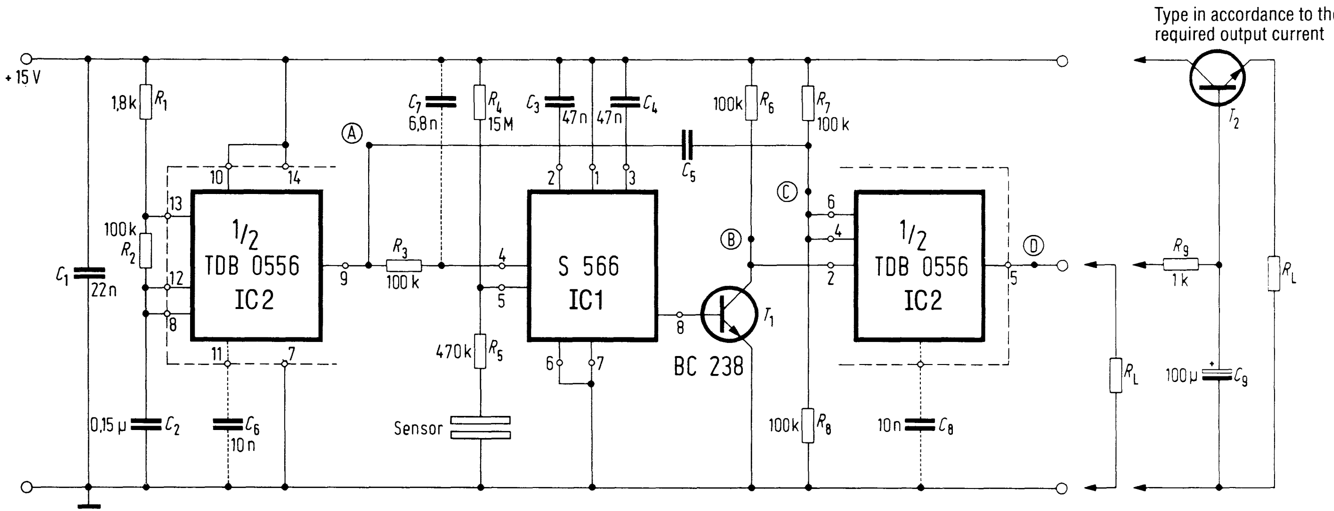
A square-wave generator produces an ac voltage which is required for the synchronization. The frequency is 50 Hz. The output pulses supplied by the S566 are phase-shifted by the required angle with reference to the basic oscillation. A bistable multivibrator is triggered by the output pulse of the S566 and reset by the following slope of the control signal. Thus a signal with a constant frequency (100 Hz) and a controllable duty cycle is available at the output.

The square-wave generator and the bistable multivibrator are realized by the dual timer IC TDB0556. One of the timers is utilized as an astable the other as a monostable multivibrator The resistance of R_1 has to be chosen essentially lower than that for R_2 to get a duty cycle of approximately 2:1 for the square-wave voltage. An accurate adjustment is not necessary, as the PLL-circuit of the S566 synchronizes automatically within a defined capture range. The output of the monostable multivibrator is set to H-level by the trigger pulses of the S0556 applied to its trigger input. The slopes of the square-wave signal are differentiated by the circuit consisting of C_5, R_7 and R_8. These pulses alternatively reset the output to *L*-level via the threshold or the reset input.

The timer offers a push-pull output which supplies a maximum current of 200 mA. If higher currents are required a power amplifier has to be used.

If an unkeyed dc voltage with an amplitude being controlled by the sensor circuit is required it can be realized by a series transistor and an RC-circuit connected to its base as shown on the right side of fig. 6.4.

Fig. 6.4.



Type in accordance to the required output current
+15 V
1,8k
R_1
100k
R_2
C_1
22n
0,15 μ
C_2
C_6
10n
1/2
TDB 0556
IC2
13
12
8
10
14
11
7
9
Ⓐ
R_3
100 k
C_7
6,8n
R_4
15M
470k
R_5
Sensor
C_3
47n
47n
C_4
C_5
S 566
IC1
2
1
3
4
5
6
7
8
BC 238
T_1
Ⓑ
100k
R_6
R_7
100 k
Ⓒ
100k
R_8
10n
C_8
1/2
TDB 0556
IC2
6
4
2
5
Ⓓ
R_L
R_9
1 k
100 μ
C_9
T_2
R_L

Components for circuit 6.4

		Ordering code	SCS stock number
1 IC	S566A/566B	Q67100-Z120	71429
1 IC	TDB0556A	Q67000-A1046	70320
1 NPN Transistor	BC238	Q62702-C698	70091
1 NPN Transistor	type is determined by load	–	–
1 MKH layer capacitor	6.8 nF	B32560-B3682-K	27561
3 MKH layer capacitors	10 nF	B32560-B3103-I	27562
1 MKH layer capacitor	22 nF	B32560-B3223-I	27564
2 MKH layer capacitors	47 nF	B32560-B3473-I	27566
1 MKH layer capacitor	0.15 µF	B32231-A1154-K	16981
1 Electrolytic capacitor	100 µF/16 V	B41316-A4107-V	2341
1 Resistor	1 kΩ/0.3 W	B51261-Z4102-J1	37672
1 Resistor	1.8 kΩ/0.3 W	B51261-Z4182-J1	37675
5 Resistors	100 kΩ/0.3 W	B51261-Z4104-J1	37944
1 Resistor	470 kΩ/0.3 W	B51261-Z4474-J1	37952
1 Resistor	15 MΩ/0.3 W	B51261-Z4156-J1	–

6.5 Triac Triggering Circuit with TCA 780

The thyristor triggering IC TCA 780 supplies output currents with a maximum of +50 mA at both half-waves. **Fig. 6.5.1** shows a circuit for control of a triac by a positive trigger current. It is suitable for types:

TXD10H60,
TXD10H60M,
TXD10H60P.

In general standard triac types are not specified for such a control in the second quadrant (positive current, negative voltage at A_2).

The above-mentioned triacs are also available for peak voltages of 700 V. In this case the type identification is TXD10H70.

Fig. 6.5.2 shows a circuit for control of a triac with a negative trigger current. The 0.22 µF-capacitor is charged via the 10 kΩ-resistor and has a polarity as shown in the figure. In this case the transistor BC238 is non-conductive. It is controlled by the trigger pulses via the two diodes, type BAY61. Thus the emitter-collector-junction becomes conductive and one plate of the capacitor is connected to ground potential. A negative trigger current is generated.

Fig. 6.5.3 shows another circuit which allows higher trigger currents of approx. 100 mA. In this case the transistor operates as an emitter follower and the trigger current is limited by resistor R_1. This circuit is applicable for selected types of standard triacs with a trigger current of +100 mA in all quadrants.

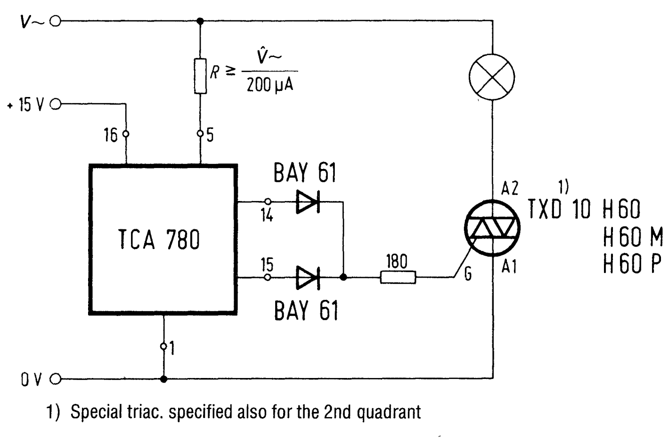


Fig. 6.5.1.

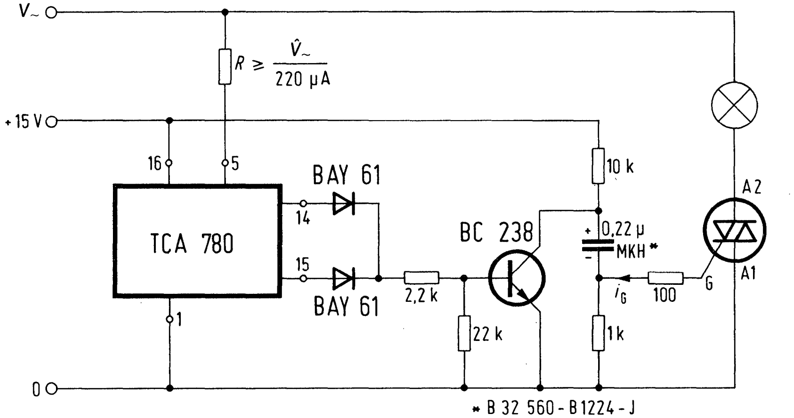


Fig. 6.5.2.

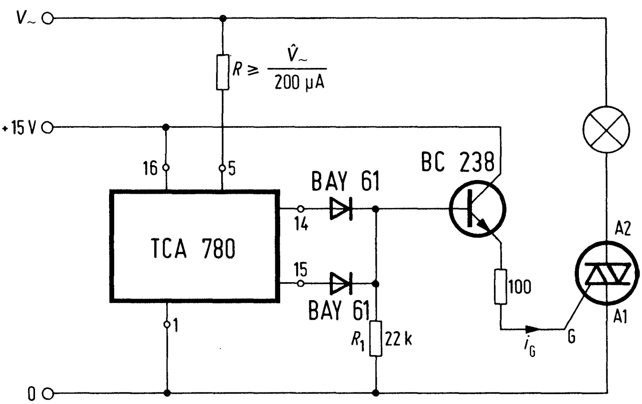


Fig. 6.5.3.

Components for circuit 6.5.1

		Ordering code	SCS stock number
1 Thyristor trigger IC	TCA 780	Q67000-A1087	71428
1 Triac	TX D10 H60	C66048-A1504-A8	–
2 Diodes	BAY 61	Q62702-A389	8579

Components for circuit 6.5.2

1 Thyristor trigger IC	TCA 780	Q67000-A1087	71428
1 Triac	type depends on the required load	–	–
1 Transistor	BC 238	Q62702-C698	70091
2 Diodes	BAY 61	Q62702-A389	8579
1 MKH layer capacitor	0.22 µF	B32560-B1224-J	–

Components for circuit 6.5.3

		Ordering code	SCS stock number
1 Thyristor trigger IC	TCA 780	Q67000-A1087	71428
1 Triac	type depends on the required load	–	–
1 Transistor	BC 238	Q62702-C698	70091
2 Diodes	BAY 61	Q62702-A389	8579

6.6 Contactless Control for Solenoid Valves with 3000 W Using a Triac

Solenoids require the total power only during the pull-up. For types with 300 to 3000 W the hold power is much lower. Therefore a remarkable power saving is possible by choosing the correct construction and the optimal power supply.

Fig. 6.6 shows a circuit in which the total dc power is supplied to the solenoid valve only during the pull-up time of 5 s. Thereafter a lower hold power is applied by means of a phase-angle control circuit. This power is sufficient to hold the solenoid.

When the circuit is connected to the mains the LED LD 52 is non-reversely poled and emits light. Thus the photoresistor FW 9802, being connected to the triac gate, is illuminated. It resistance is decreased to approx. 2.5 kΩ. The supplied gate current is sufficient to trigger the triac T_c and to operate the solenoid winding via the rectifier-bridge Gl.

After 5 s the RC-circuit turns on the transistor T_1 and therefore the transistor T_2 is non-conductive. No current flows through the LED (20 mA). The photoresistor is not illuminated and becomes high resistive (800 kΩ), i.e. no gate current and thus no full-wave-load current flow.

The triac has a second trigger circuit, which operates as a phase angle control circuit. The trigger voltages is adjusted by potentiometer *P*. When the voltage across the capacitor C_3 has reached the necessary trigger voltage level for the diac, the triac receives a short trigger pulse.

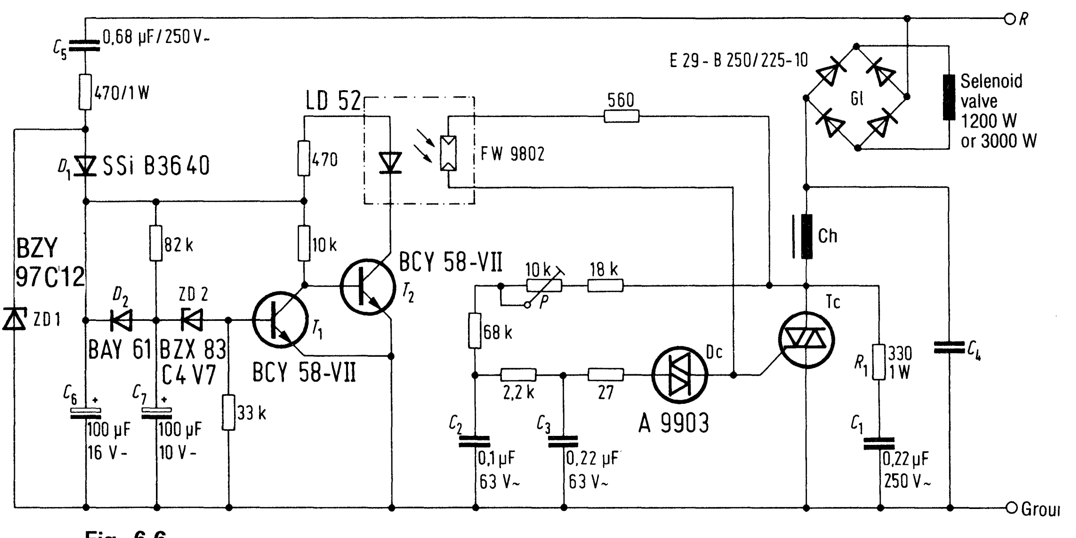


Fig. 6.6.

The load is connected to the mains during the remaining time of the positive half-wave. Assuming the triac is triggered at an angle of $\alpha = 125°$, then the dc voltage at the solenoid valve is $V_{d(AV)} = 75$ Vdc. The hold-voltage for the solenoid can be adjusted by potentiometer *P* between 60 Vdc and 90 Vdc.

Components for circuit 6.6

		Ordering code	SCS stock number
1 Triac	TXD10H70M (Tc) [1]	C66048-A1504-A20	–
	TXD98A60 (Tc) [2]	C66048-Z1651-A4	–
1 Diac	A9903	C66048-Z1304-A1	4790
1 Rectifier bridge	E29-B250/225-10	C66067-A1740-A2	4680
2 Transistors	BCY58-VII	Q60203-Y58-G	8290
1 Z-diode	BZY97C12	Q62702-Z1237-F82	7351
1 Z-diode	BZX83C4V7	Q62702-Z1069-F82	7310
1 Diode	SSi B3640	C66047-A1062-A4	48403
1 Diode	BAY61	Q62702-A389	8579
1 LED	LD52/II	Q62703-Q159	71332
1 Capacitor	0.10 µF/63 V~	B32560-B1104-J	–
1 Capacitor	0.22 µF/63 V~	B32560-B1224-J	–
1 Capacitor	0.22 µF/250 V~	B32655-A6224-M	–
1 Capacitor	0.22 µF/250 V~	B81121-C-B56 or	–
		B81121-C-B75 (C4) [1]	–
	0.47 µF/250 V~	B81121-C-B58 or	–
		B81121-C-B77 (C4) [2]	–
1 Capacitor	0.68 µF/250 V~	B32655-A6684-M	–
1 Electrolytic cap.	100 µF/10 V–	B41283-B3107-T	7806
1 Electrolytic cap.	100 µF/16 V–	B41283-B4107-T	7810
1 Photoresistor	FW9802	Q62705-P19-F65	–
1 Choke		B82603-V-B12 [1]	–
		B82603-V-B14 [2]	–

[1] For solenoid valve controls of 1200 W/198 Vdc
[2] For solenoid valve controls of 3000 W/198 Vdc

6.7 Control Circuit for Direct Triggering a Thyristor with TCA 780

Fig. 6.7 shows a phase angle control circuit using the IC TCA 780 for direct triggering of thyristors, e.g. type BStC0540. However, small thyristors with silicon dices in the size of B, C and D (fourth letter in the ordering code, e.g. BStC ...) may also be used.

The phase angle is adjustable between 0 and 180° el, the power at the load between 0 and 400 W.

The IC supply voltage (pin 16) is directly generated from the mains via a series resistor R1, rectified by the diode D1 and stabilized to 15 V by the z-diode D4.

The synchronization input (pin 5) is connected to phase R via a 1.2 MΩ-series-resistor and to ground via two antiparallelly connected diodes (D2, D3). The two diodes limit the voltage for the synchronization input to about ±0.6 V.

The frequency of the ramp generator is determined by the zero voltage detector, i.e. at each zero-crossing of the mains voltage the saw tooth wave is generated again. The steepness of the voltage rise is adjusted by the ramp capacitor

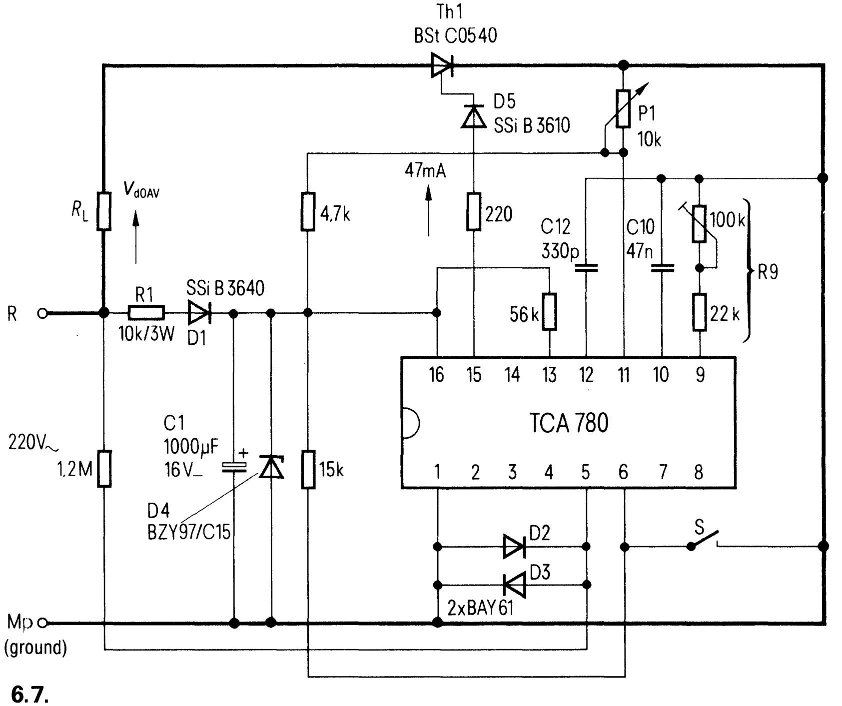


Fig. 6.7.

(C10=47 nF) and the ramp resistor (R9≈100 kΩ). In the present circuit the saw tooth amplitude is 7 V.

The control voltage V_{11} is adjustable from 0 to 8 V by potentiometer P1. This allows to set a current flow angle from 0 to 180° at the load. As in the described half-wave control circuit the thyristor is only conductive in one direction, output A2 (pin 15) is only connected with the thyristor gate. A positive trigger pulse is applied to the gate every 20 ms during the positive half-wave. The output A1 (pin 14) which supplies a positive trigger pulse during the negative half-wave, remains unconnected. The output pulse duration is determined by the capacitance of the capacitor C12 as demonstrated in **table 6.7.** In the circuit of fig. 6.7 the thyristor is triggered by a pulse with a duration of 200 µs and a gate current of 47 mA.

Turn-on and -off with inhibit signal

Positive trigger pulses will only be generated during the positive half wave of mains voltage if the potential at the inhibit input (pin 6) is higher than +3.5 V. A resistance of 15 kΩ is therefore connected to +-terminal (pin 16) of the power supply. When the voltage at the inhibit input decreases below +2 V no output pulses are supplied. Short-circuiting pin 6 to ground, for instance by a switch S or a logic circuit, disconnects the load independently from any other signal state at the TCA 780.

Table 6.7

Capacitor C12 (Extension of pulse duration)	0	100 pF	220 pF	330 pF	680 pF	1000 pF
Trigger pulse duration	30 µs	80 µs	130 µs	200 µs	370 µs	550 µs

Components for circuit 6.7

		Ordering code	SCS stock number
1 Thyristor	BSt C 0540	C66048-A1400-A5	48249
1 Thyristor control IC	TCA 780	Q67000-A1087	71428
2 Diodes	BAY 61	Q62702-A389	8579
1 Diode	SSi B 3610	C66047-A1062-A2	48401
1 Diode	SSi B 3640	C66047-A1062-A4	48403
1 Z-Diode	BZY 97/C15	Q62702-Z1239-F82	7353
1 Styroflex capacitor	330 pF/25 V–	B31310-A3331-H	1367
1 MKH layer capacitor	47 nF/250 V–	B32560-D3473-J	27566
1 Electrolytic capacitor	1000 µF/16 V–	B41010-B4108-T	7849

6.8 Phase Angle Control Circuit for Thyristors with TCA 780 and Transistorized Trigger-Pulse-Amplifier

Fig. 6.8 shows a circuit as it is used for the half-wave control with thyristors for high currents (maximum rms-current of BStF 2553 is 30 A). A separate power supply (15 V) with transformer and rectifier is required. The dc load can be controlled by potentiometer P1. As the TCA 780 is delivering only output currents of up ro 50 mA but thyristors of the type BStF 25 need a triggerr current of 1A to provide a fast and low-loss turn-on, an amplifier stage with the NPN silicon transistor BSX 45 has to be connected between the IC and the thyristor.

Components for circuit 6.8		Ordering code	SCS stock number
1 Thyristor	BStF 2553	C66048-A2458-A2	–
1 Thyristor control IC	TCA 780	Q67000-A1087	71428
1 Transistor	BSX 45-16	Q60218-X45-V16	8628
2 Diodes	BAY 61	Q62702-A389	8579
1 Styroflex capacitor	330 pF/25 V–	B31310-A3331-H	1367
2 MKH layer capacitors	10 nF/400 V–	B32560-D6103-J	27625
1 MKH layer capacitor	47 nF/250 V–	B32560-D3473-J	27566
1 TSE capacitor	0.22 µF/250 V–	B25839-A6224-M	–

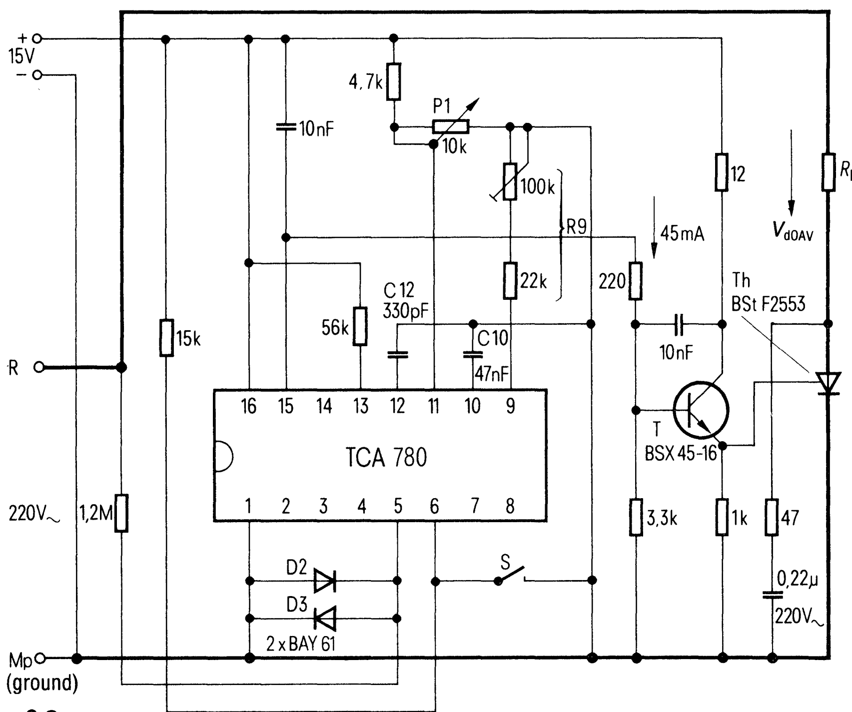


Fig. 6.8.

6.9 Thyristor Phase Angle Control Circuit with TCA 780 and Potential Separation by Using a Trigger Pulse Transformer

Fig. 6.9 shows a phase control with transistorized trigger pulse amplifier and transformer. In this control circuit the gate trigger pulses are applied to the thyristor BStF 2553 by a trigger transformer thus providing a galvanic separation of the control part from the mains.

The output pulse (45 mA) is supplied from pin 15 of TCA 780 to the trigger pulse amplifier (transistor *T*) every 20 ms. The secondary winding of the transformer delivers the trigger current of 1A during 550 µs at a gate-cathode voltage of 2 V. For the excess voltage protection of the switching transistor *T* a protective circuit comprising a z-diode and a diode is connected in parallel to the transformer winding N_1.

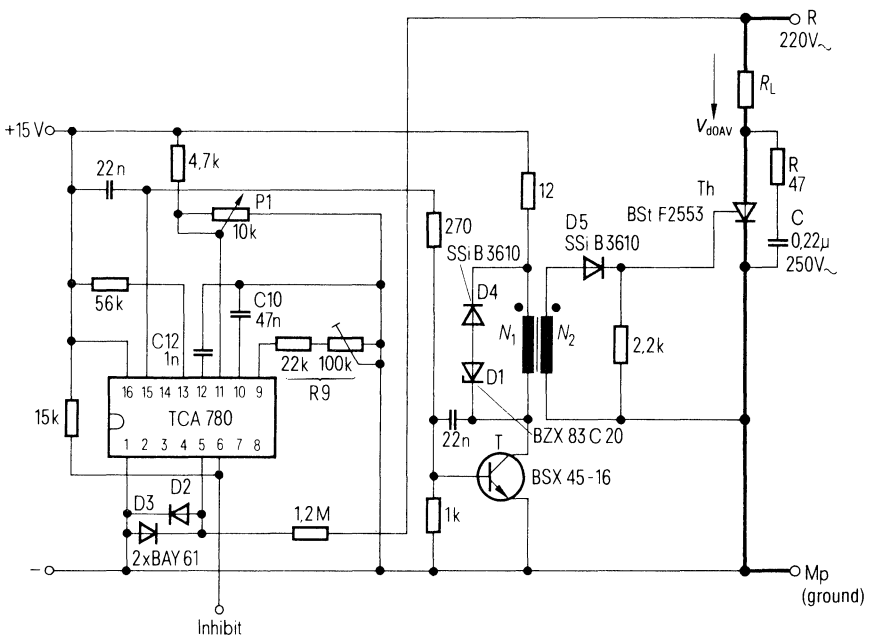


Fig. 6.9.

Components for circuit 6.9

		Ordering code	SCS stock number
1 Thyristor	BStF2553	C66048-A2458-A2	–
1 Thyristor control IC	TCA780	Q67000-A1087	71428
1 Transistor	BSX45-16	Q60218-X45-V16	8628
2 Diodes	BAY61	Q62702-A389	8579
2 Diodes	SSiB3610	C66047-A1062-A2	48401
1 Z-Diode	BZX83C20	Q62702-Z1084-F82	7324
1 MKH layer capacitor	1000 pF/250 V–	B32560-B3102-K	–
2 MKH layer capacitors	22 nF/250 V–	B32561-D3223-J	27577
1 MKH layer capacitor	47 nF/250 V–	B32560-D3473-J	27566
1 TSE capacitor	0.22 μF/250 V~	B25839-A6224-M	–
1 Trigger pulse transformer IT	produced by VAC	ZKB418/079-02-PF	28204

6.10 Control Set for Half-Controlled Three-Phase Current Bridge

Fig. 6.10.1 shows a half-controlled three-phase current bridge with thyristors connected to the positive terminal of the output voltage (common cathode) and three diodes connected to the minus. In each arm of the bridge an uncontrolled rectifier and a thyristor are connected in series.

Each phase (R, S, T) requires a control device ZB1T for one thyristor which periodically generates control pulses being synchronized to the mains frequency. These control pulses trigger the thyristors at the time given by the control device. The trigger time can be shifted synchronously for all three phases by means of potentiometer P1.

The phase angle α is measured in electrical degrees (a full cycle=360 °el). It relates to the natural trigger time of the thyristor, i.e. counts from the point at which in a rectifier circuit, consisting of diodes, the following valve processes the current, which is the crosspoint of the positive half-wave voltages **(fig. 6.10.2).** The highest possible dc voltage at the converter output is achieved by a control pulse at this point, so when rectifying we refer to "total rectifier control" and define the relevant control angle as α=0 °el.

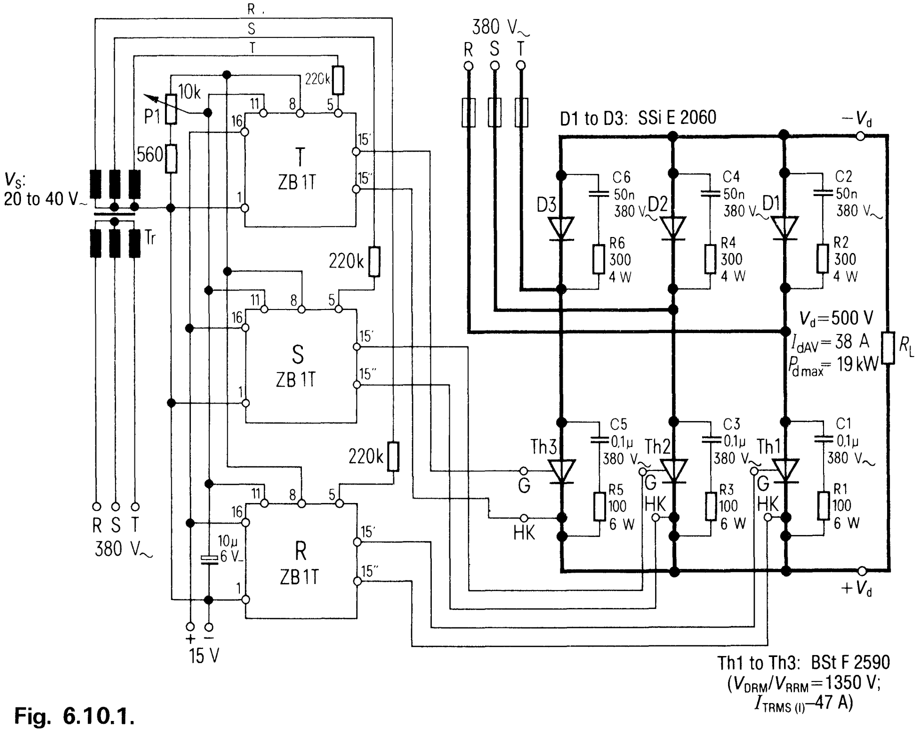


Fig. 6.10.1.

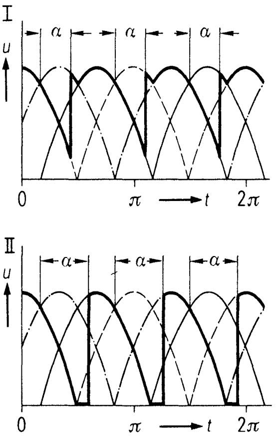


Fig. 6.10.2.

Fig. 6.10.2 shows the voltage response at a resistive load and an operation without interval (I) and with interval (II). The trigger pulses have a duration of 550 µs. They can be extended by increasing the capacitance of C12 and have to be rated such as to allow the thyristor to have a sufficiently high hold-current at the end of every pulse to remain conductive.

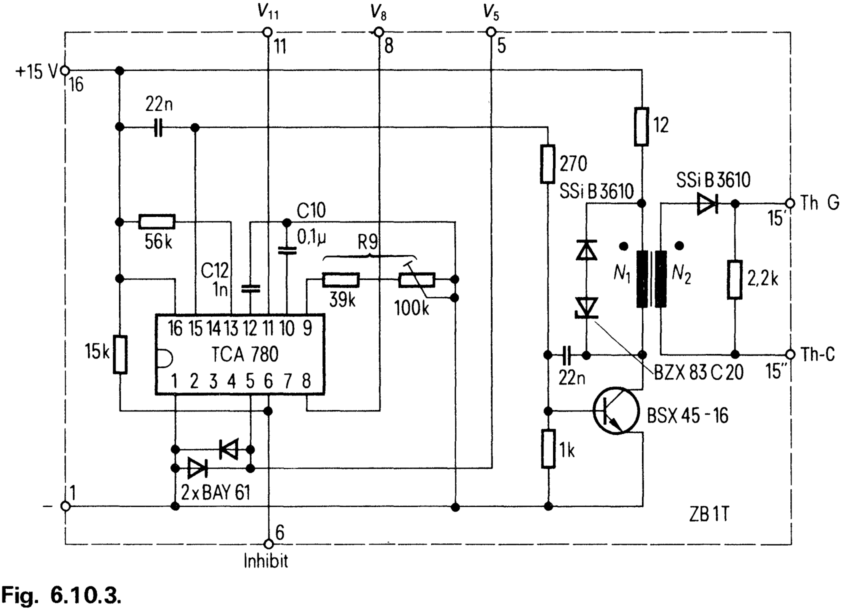


Fig. 6.10.3.

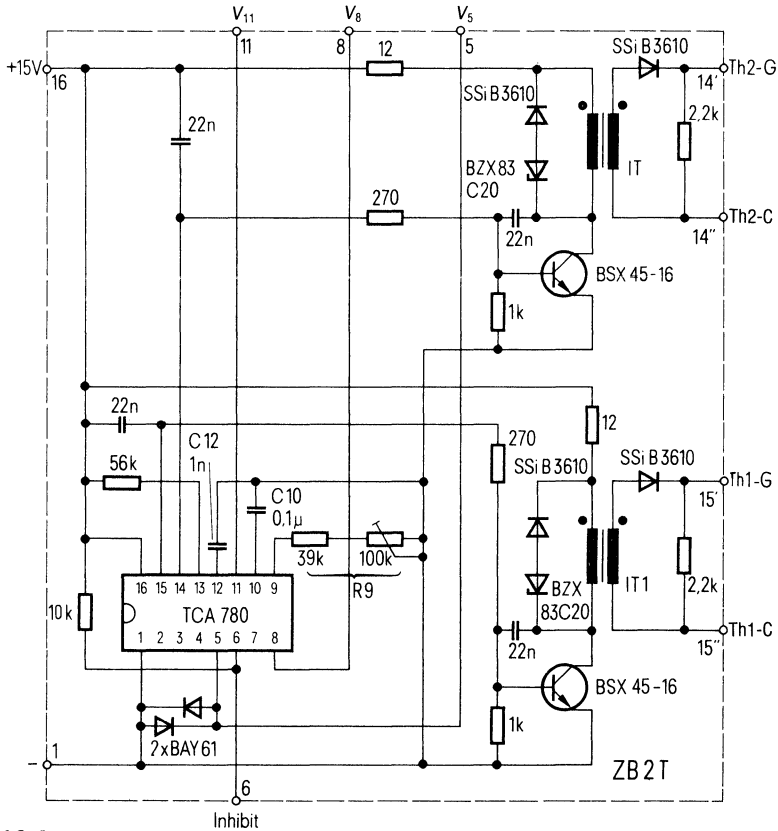


Fig. 6.10.4.

Fig. 6.10.3 and **6.10.4** show the control circuit ZB1T (for triggering one thyristor) and ZB2T (for triggering two transistors, operating in anti-parallel connection). With these two control circuits any other version of converters or control devices in the one- or three-phase mode can be realized.

The complete control set comprising three ZB1T devices requires a supply voltage of 15 V at a consumption of 15 mA per device (the power requirement of the connected trigger pulse amplifier is not included). The outputs of the control devices can be loaded up to 1A at a supply voltage of 15 V. The pulse duration is about 0.55 ms. The positive supply voltage for the IC is applied to pin 16 and pin 1 is grounded.

The synchronization inputs (pin 5) of the control device ZB1T are connected to phases R, S and T via a series resistance of 220 kΩ at each phase.

The saw tooth wave amplitude of the described circuit is 2.4 V.

The control voltage V_{11} can be varied between 0 V and 3.1 V by potentiometer P_1. V_{11} is deviated from the reference voltages V_8 which are in parallel connected for the three-phase mode. When the positively rising saw tooth voltage reaches the value of the control voltage applied to pin 11, a trigger pulse is available at pin 15′ or 15″ (see fig. 6.10.3). This pulse can be linearily shifted by V_{11} thus adjusting the current flow angle at the load.

The three control circuits are synchronized by the three-phase star voltage and allow a pulse shift over 180 °el theoretically.

In the three-phase bridge circuit the natural trigger time (total rectifier control) occurs 30 °el after zero crossing, leaving 150 °el for the maximum phase control range.

An adjustment has to be achieved at the stop of potentiometer P_1 for the trigger angle $\alpha = 0$ °el to avoid that the first pulse is not generated before the natural trigger time is reached.

Components for circuit 6.10.1		Ordering code	SCS stock number
3 Stud type thyristors	B St F 2590	C66048-A2458-A6	49054
3 Stud type diodes	SSi E 2060	C66047-A1024-A4	4917
3 Capacitors	0.05 µF/380 V~	B37819-S7503-S1	–
3 Capacitors	0.1 µF/380 V~	B25839-A6104-M	–
3 Resistors	100 Ω/6 W	–	–
3 Resistors	300 Ω/4 W	–	–

Components for circuit 6.10.3

1 Thyristor control IC	TCA 780	Q67000-A1087	71428
1 Transistor	BSX 45-16	Q60218-X45-V16	8628
2 Diodes	BAY 61	Q62702-A389	8579
2 Diodes	SSi B 3610	C66047-A1062-A2	48401
1 Z diode	BZX 83 C20	Q61702-Z1084-F82	7324
1 MKH layer capacitor	1 nF/250 V–	B32560-B3201-K	–
2 MKH layer capacitors	22 nF/250 V–	B32561-B3223-J	–
1 MKH layer capacitor	0.1 µF/100 V–	B23560-B1104-J	–
1 Trigger pulse transformer IT	produced by VAC	ZKB418/079-02-PF	28204

Components for circuit 6.10.4

1 Thyristor control IC	TCA 780	Q67000-A1087	71428
2 Transistors	BSX 45-16	Q60218-X45-V16	8628
2 Diodes	BAY 61	Q62702-A389	8579
4 Diodes	SSi B 3610	C66047-A1062-A2	48401
2 Z-diodes	BZX 83 C20	Q62702-Z1084-F82	7324
1 MKH layer capacitor	1 nF/250 V–	B32560-B3102-K	–
4 MKH layer capacitors	22 nF/250 V–	B32561-B3223-J	–
1 MKH layer capacitor	0.1 nF/100 V–	B32560-B1104-J	–
2 Trigger pulse transformers IT1, IT2	produced by VAC	ZKB418/079-02-PF	28204

6.11 Periodical Control of a Pulse Train with Continuous Adjustment Range between 1 and 99%

If a triac is to be utilized for controlling an ac load there are two possibilities: either the phase angle control which is common in the converter technology or the full wave control during which the load is switched with a certain rhythm during the zero-voltage crossing.

The phase control is only accepted where for technical reasons a pulse train control is not allowed as is the case with the brightness control of illumination fittings or the rpm control of motors.

In all other applications – for instance heaters, ovens, stove plates, electrical blankets, washing machine heatings, irons, hair driers, and soldering irons – the ac load control has to be accomplished by the periodic pulse train control with a switching device operating at no voltage. The described circuit allows the load to be continuously controlled between 1 and 99%.

Periodic wave packet control

Fig. 6.11.1 shows the circuit. The control of the load is realized by varying the duty cycle t_1/T (switch-on time t_1 referred to the switching period T) by potentiometer P. The switching time is approximately 5 s and may be varied by changing the capacitance of capacitor C1, i.e. adapting the thermal time constant to the load.

The circuit consists essentially of the adjustable timer TDB 0555B, the no-voltage switching device T1 in the diagonal branch of the diode bridge D1 to D4, and the operational amplifier TAA 861 which supplies the trigger current for the triac.

Power supply

For the power supply of IC and op amp a one-way rectifier circuit composed of line diode D5 and series resistor R9 is provided. The dc voltage is stabilized by the z-diode D6 to 9.1 V.

Timer function of TDB 0555B and influence on the op amp

Due to the input 2 (trigger) of the timer IC being connected to the input 6 (trigger threshold) the circuit triggers itself like an astable multivibrator. C1 is loaded via R1 and the potentiometer partial resistor P1 by applying the supply voltage. The capacitor voltage V_{C1} exponentially rises with the time constant:

$$\tau = (R_1 + P_1) \times C_1$$

The IC output (pin 3) has ground potential as long as the voltage at C1 is below $2/3 \times V_S$. Output 3 of the IC applies ground potential to the resistor R5 of the resistor bridge R2 to R6.

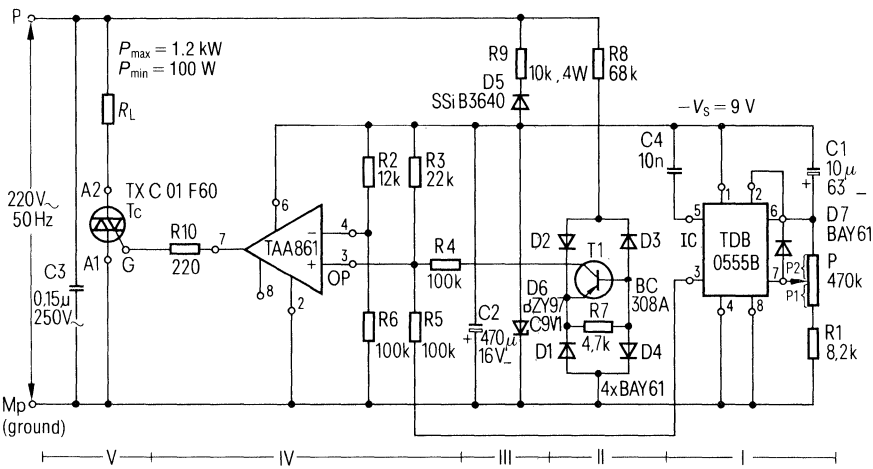
A comparison shows the non-inverting input of OP (pin 3) which is more positive than the inverting input (pin 4). Therefore, the output (pin 7) of the op amp has ground potential and the triac obtains no trigger current, i.e. it is non-conductive. As soon as the voltage at C1 will reach the value $2/3 \times V_S$ the comparator (in IC) will reset the multivibrator when C1 is discharged by an integrated transistor via P2 (partial resistor of potentiometer P). The output shows a level of -9 V (see **fig. 6.11.2**) and thus a voltage of -9 V is also applied to resistor R5.

No-voltage switching device T1

The bridge branches at the input of the op amp can now only be adjusted by transistor T1, which is located in the diagonal branch of the bridge circuit. The circuit consists of 4 diodes (D1 to D4). The ac-terminals of the rectifier bridge are connected to the line voltage via resistor R8. T1 is only blocked for about 200 μs during the positive and negative sine half-wave, i.e. during the zero crossing of the mains voltage ($V_m \leqq \pm 1.8$ V).

While T1 is blocked input 4 of the op amp is more positive than input 3. Output 7 changes to a level of -9 V and the triac receives trigger current via resistor R10. The full line voltage is applied to the load R_L by the triac being triggered.

The trigger pulse for the triac is cut off at the instant the line voltage across the bridge exceeds a level of ± 1.8 V. T1 gets conductive and ground potential is applied to resistor R4. The resistor bridge now is misaligned in that the op amp input has ground potential and no trigger current can flow. As long as output 3 of the IC shows -9 V the triac will be triggered only at zero crossing of



I Adjustable timer with TDB0555B
II No-voltage switching device in the diagonal branch of a bridge circuit
III Power supply and control circuit
IV Op amp with resistor bridge
V Triac and RFI suppression capacitor C3

Fig. 6.11.1.

the ac line voltage. The described circuit controls the triac in the third and fourth quadrant. As soon as the voltage at C1 drops to a value of $1/3 \times V_S$ the multivibrator flops by the negative edge of the positive pulse at pin 2. The discharge of C1 is stopped and output 3 of the IC has again ground potential, i.e. the triac separates the load from the line.

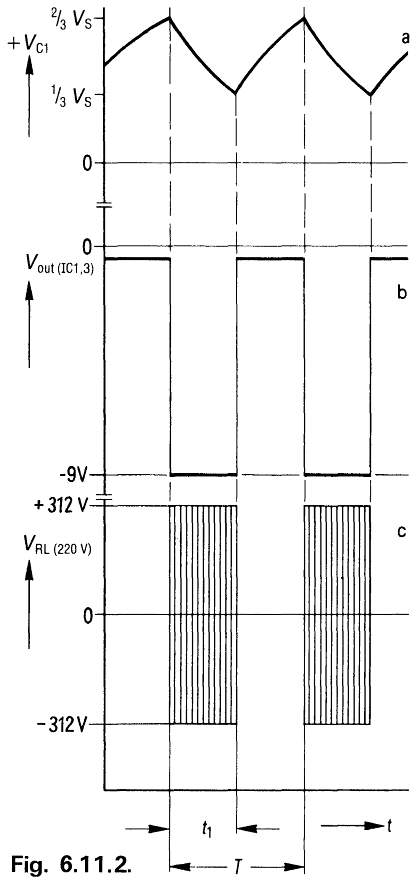


Fig. 6.11.2.

a at capacitor C1 (zero point referred to $-V_S = 9$ V)
b at output pin 3 of the integrated timer TDB 0555B (zero point referred to ground)
c at the resistive load R_L. The 50 Hz-pulse-train has the switch-on time t_1, the pulse repetition period T is about 5 s in the case of **fig. 6.11.1.** The duty cycle may be adjusted by potentiometer P

Duty cycle

The duty cycle is determined by resistor R1 as well as P1 and P2. It is normally limited to 50%. By connecting diode D7 in parallel to the partial resistor of potentiometer P2 duty cycles of less than 50% can also be obtained.

Components for circuit 6.11

			Ordering code	SCS stock number
1	Timing IC	TDB 0555B	Q67000-A1044	70139
1	Operational amplifier	TAA 861	Q67000-A89	8694
1	Triac	TX C01 F60	C66048-A1500-A38	
1	Silicon transistor	BC 308 A	Q62702-C285	8797
1	Silicon Z diode 1 W, plastic package (DO-41)	BZY 97 C9V1	Q68600-A952-F82	70149
1	Diode (V_{RRM}=600 V)	SSi B 3640	C66047-A1062-A4	48403
5	Si-switching diodes	BAY 61	Q62702-A389	8579
1	MKH layer capacitor	10 nF ± 5%, 250 Vdc	B32560-B3103-J	27562
1	RFI suppression capacitor (X)	0.15 μF, 250 Vac	B81121-C-F13	1802
1	Aluminium electrolytic capacitor	10 μF, (+50 −10%) 63 Vdc	B41286-A8106-T	7836
1	Aluminium electrolytic capacitor	470 μF, (+50 −10%) 16 Vdc	B41286-A4477-T	7889
1	Potentiometer linear	470 kΩ	B58621-Z474-M	26182
1	Carbon layer resistor	220 Ω/0.25 W, ±5%	B51261-Z4221-J1	37663
1	Carbon layer resistor	4.7 kΩ, 0.25 W, ±5%	B51261-Z4472-J	37683
1	Carbon layer resistor	8.2 kΩ, 0.25 W, ±5%	B51261-Z4822-J	37688
1	Carbon layer resistor	12 kΩ, 0.25 W, ±5%	B51261-Z4123-J	37690
1	Carbon layer resistor	22 kΩ, 0.25 W, ±5%	B51261-Z4223-J	37694
1	Carbon layer resistor	68 kΩ, 0.25 W, ±5%	B51261-Z4683-J	37942
3	Carbon layer resistors	100 kΩ, 0.25 W, ±5%	B51261-Z4104-J	37944
1	Wire resistor	10 kΩ, 4 W, ±5%	B25295-A2103-J	26272

6.12 Overload Protection for a PTC Resistor Used in a Motor Protection Circuit

PTC resistors are generally utilized to protect motors against inadmissible excess temperature caused by overloads. As the resistance of this PTC resistor is to be only dependent on the temperature of the motor the operating voltage can be low ($V \leqq 2$ to 3 V). Practically there is no self-heating.

In practice, however, it may occur that the motor-protection-PTC resistor is directly connected to the mains, e.g. during repair or during initial installation. In this case the resistor is destroyed.

To protect such a PTC resistor against mains voltages a fuse should be used, whereby a so-called "microfuse" which is very often utilized in transistor protection circuits offers a great benefit. It can be connected directly to the mains (220 V or 110 V).

If, however, voltages lower than 100 V are required for application to the PTC resistor the protection circuit has to be extended as shown in **fig. 6.12.** When an excess voltage (V_Z) occurs the PTC resistor is short-circuited by the transistor and thus the microfuse reacts.

The resistance of R_1 has to be dimensioned for high power peaks and not for a high constant-power, as the microfuse turns off after a short period of time. The turn-off time depends on the hight of the excess voltage and the resistance of the PTC resistor (temperature). In the described circuit a turn-off time of $t_{off} \leqq 2$ s is guaranteed for a rated current being twice as normal. As a transistor is used for short-circuiting the PTC resistor, the mains ac voltage has to be rectified by the diode 1N4004.

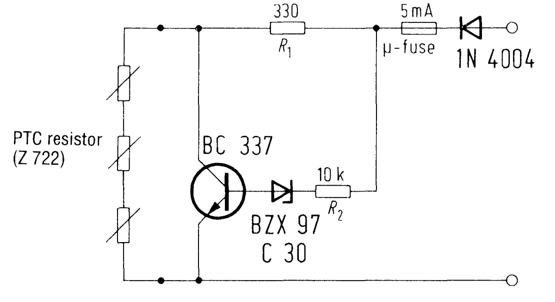


Fig. 6.12.

Components for circuit 6.12		Ordering code	SCS stock number
1 Transistor	BC337	Q62702-C313	70101
1 Z diode	BZX97C30	Q62702-Z1246-F82	7360
1 Diode	1N4004	C66047-Z1306-A24	48004
1 Fuse	5 mA microfuse	–	–

6.13 SIKAFIT, a PTC Resistor for a Smooth Quick-Start of Fluorescent Lamps

Almost every fluorescent lamp used in Western Europe is turned on by special glow starters. This results – as probably known – in a non-satisfying starting behaviour. During a time duration of seconds several fruitless trigger attempts occur before reaching the operational state. This also unfavourably influences the life of the lamps.

If an especially dimensioned PTC resistor is connected in parallel to the ballast, starting can be essentially improved (see fig. 6.13.1). The start is then fast, lamp preserving, and usually also without triggering. For the most common lamp types adequate PTC resistors, called SIKAFIT, are now available.

A typical characteristic of a PTC resistor is shown in **fig. 6.13.2.** If a voltage V is applied to such a component an initial current $i_o = V/R_o$ is flowing. The PTC resistor is heated up within a certain time ("switching time" t_s) to its characteristic

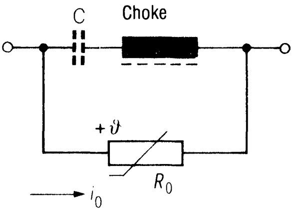
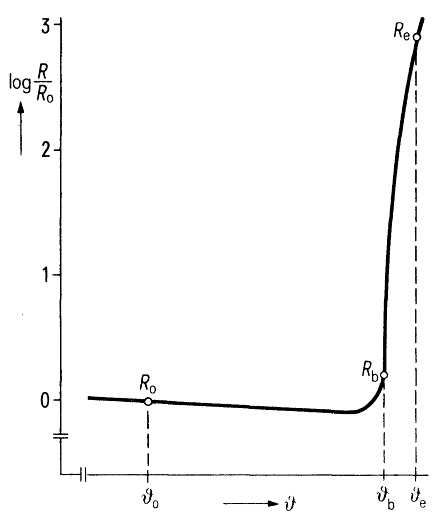


Fig. 6.13.1.



ϑ_o Ambient temperature
ϑ_b Reference temperature (beginning of the steep resistance increase at heating)
ϑ_e Final temperature
R_o Initial temperature
R_b ($\approx 2 \times R_o$) Reference resistance
R_e Final resistance at ϑ_e (depends on the thermal dissipation conditions)

Fig. 6.13.2.

reference temperature ϑ_b. Its resistance increases rapidly in that the current drops to a very small value. The final resistance R_e which will be adopted depends on the heat dissipation conditions. It is, in this case, rising at least to the power of two decades of the initial resistance R_o. The power to maintain the highly resistive balance is about 1 W.

For the required application the PTC resistor has to be dimensioned relating to the initial resistance in that the resulting current flowing through the helice will have the desired value.

The relevant nominal resistances are in **table 6.13.3.** The initial current flowing through the PTC resistor at nominal conditions is also shown. This is necessary in calculating the switching time. During this switching time the lamp is highly heated. Furthermore, the choke is shunted in such a way that no triggering, caused by a high voltage pulse, can occur. With the auxiliary device, lamps with small and medium power usually fire after the first opening of the glow starter contact just by the mains voltage amplitude as a result of favourable conditions. The initially somewhat increased operating current then causes the PTC resistor to heat further until it finally reaches the highly-resistive state and practically gets ineffective.

Such lamps which need an increased triggering voltage even with a good preheating (e.g. 65 W lamp) allow a triggering only if the PTC resistor has reached a high resistance. Thus triggering attempts within the switching time of the PTC resistor remain ineffective, i.e. harmful cold starts are avoided. At the end of the relatively short switching time the lamp is well preheated and, under normal conditions, will fire immediately at the next starting trial.

Table 6.13.3

Lamp type		20 W		40 W		65 W	
Balast		cap.	ind.	cap.	ind.	cap.	ind.
R_o	Ω	330	330	280	330	180	220
i_o	A	0.56	0.56	0.67	0.57	1.05	0.86

Investigations have shown that a switching time of 1 s is sufficient to obtain the best possible preheating. Lamps with low power have an optimal value of about 0.5 s.

The most favorable reference temperature the PTC resistor has to have depends on the application conditions. If the ambient temperature varies in a wide range (i.e. for illumination in the open air or in work-shops) the reference temperature should not be less than 100 °C. For living rooms, however, materials having lower temperatures may be considered and may even have certain advantages (simpler assembly, lower power dissipation during operation).

Naturally, the PTC resistor after turning-off the lamp needs some time to be cooled down to the ambient temperature and thus to become fully effective at the next turn-on. As the cooling is rapid in the beginning and the switching time increases correspondingly, the cooling effect which is seldomly realized is of secondary importance. But it is very essential that no disadvantages are caused by this cooling effect with reference to the normal triggering process.

In view to subsequent mounting of the quick-start auxiliary device into any lamp type a suitable plastic package has been developed for the PTC resistor. The case is electrically and thermally isolated and has self clamping terminals. The dimensions are illustrated in **table 6.13.4.** Corresponding types for other fluorescent lamps will be advised on request.

Table 6.13.4 Short characteristics of SIKAFIT

		Type 40 W[1])	Type 65 W	
Cold resistance	R_{25}	300 to 400	200 to 260	Ω
Maximum case temperature during operation (on top of case) (at $\vartheta_{amb} = +25$ °C)	ϑ_{case}	70	70	°C
Thermal cooling constant	τ_{th}	≈100	≈100	s
Turn-on time at rated conditions	t_s	≈1	≈1	s
Ordering code		Q63100-P9390-D140	Q63100-P9390-D165	
SCS stock number		72262	72263	

[1]) Can be used also for 20 W-lamps, however, the matching is not optimal.

6.14 Quick-Start Device for Fluorescent Lamps Using PTC Resistor and Series Diode

In chapter 6.13 a quick-starting method for fluorescent lamps has been described. A further decrease of the turn-on time can be realized by optimizing the pre-heating. In this case which is called "rapid start" a diode is connected in series to the PTC resistor. If an inductive balance is used a higher effective preheating current other than in the case of a direct short-circuit is achieved by dc magnetization of the choke. **Fig. 6.14.1** shows a rapid-start circuit for a tandem lamp of 2 × 20 W. For the triggering two starters connected also in series have to be used. As these starters operate independently from each other, i.e. they do not react exactly at the same time, the trigger characteristics of tandem lamps are usually disadvantageous. But the rapid-start device enables a triggering at the same time at least during the preheating period. Thus an advantageous operation of both lamps is realized.

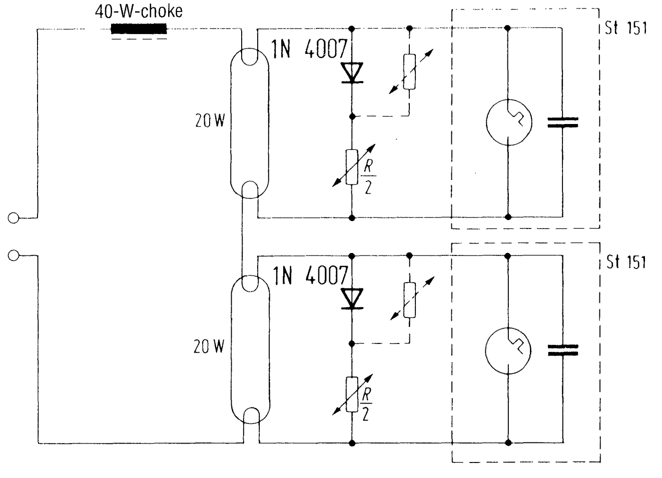


Fig. 6.14.1.

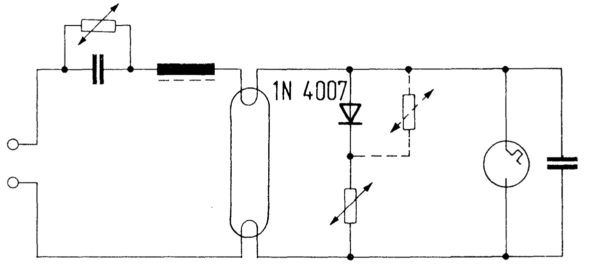


Fig. 6.14.2.

Fig. 6.14.2 shows a rapid-start circuit with a capacitive ballast. Besides the already mentioned series diode another PTC resistor is connected in parallel to the phase-shifting capacitor.

List of components for circuits 6.14.1 and 6.14.2

		Ordering code	SCS stock number
1 Diode	1N4004	C66047-Z1306-A24	48004

For suitable types of PTC resistors please contact Components Sales Department of the Siemens AG, Balanstr. 73, D-8000 Munich 80.

7. Power Supply Circuits

7.1 Power Supply Using Precision Voltage Regulator IC TDB 0723A

Fig. 7.1 shows a circuit of a power supply which may be considered as an alternation to the circuit already described in "Design Examples of Semiconductor Circuits, Edition 1977/78, Page 135".

The advantage of the following circuit is in that the collectors of the four transistors, type 2N3055, can be mounted directly on iron sheet of the chassis. Therefore the thermal resistance between transistor case and heat sink device is low. The output voltage is adjustable by potentiometer P (2.5 kΩ). The resistor R_o determines the threshold of the short-circuit current limitation ($I_{max} \approx 0.7\ V/R_o$). The TDB 0723A incorporates also an excess temperature protection circuit. Four transistors, type 2N3055, have been connected in parallel because of the high output current required.

Components for circuit 7.1

			Ordering code	SCS stock number
1	Voltage regulator IC	TDB 0723A	Q67000-A1069	70322
4	Transistors	2N3055	Q62702-U58-F14	71214
1	Transistor	BD135	Q62702-D106	70121
1	Bridge rectifier SSi4E11/12	B30/25-8	C66117-A5002-A201	48024
1	Styroflex capacitor	470 pF	B31110-A1471-K	1578
1	Electrolytic capacitor	22 µF/40 V	B41286-A7226-T	7833
1	Electrolytic capacitor	4.7 mF/40 V	B41070-B7478-T	–
1	Electrolytic capacitor	10 mF/40 V	B41070-K7109-T	–

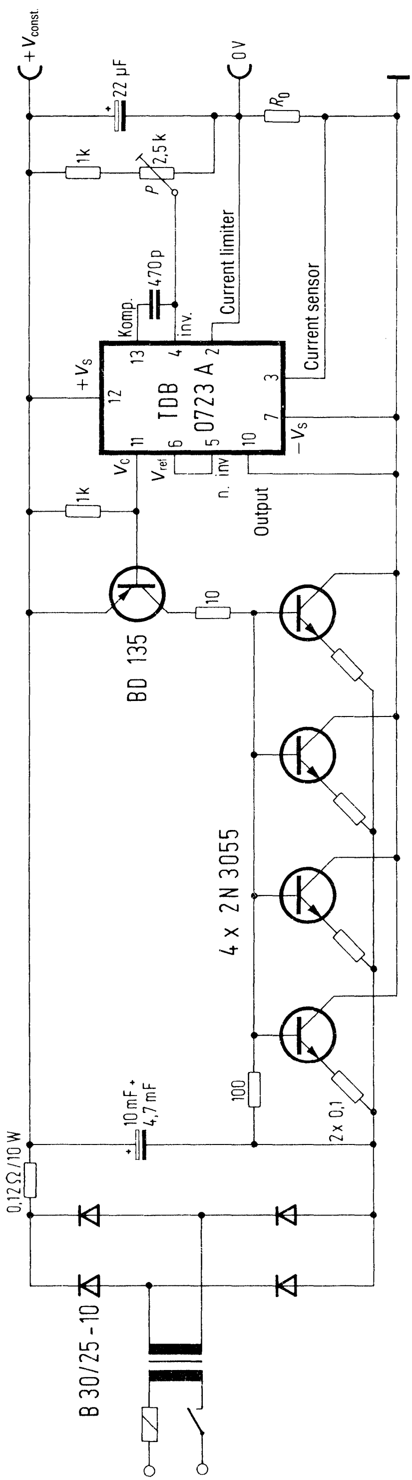

+ V_const.
22 µF
0 V
R_0
1k
2,5 k
P
470 p
Current limiter
Current sensor
Komp.
inv.
+V_S
TDB
0723 A
−V_S
V_C
V_ref
n. inv
Output
1k
BD 135
10
4 x 2N 3055
100
10 mF + 4,7 mF
2 x 0,1
0,12 Ω/10 W
B 30/25 - 10

Fig. 7.1.

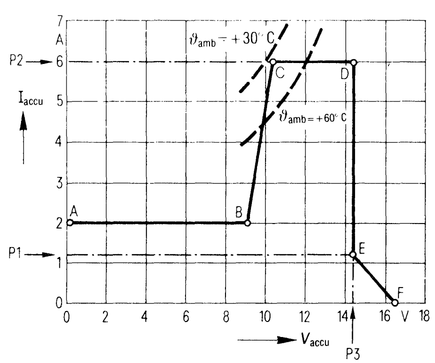
7.2 Short-Circuit Proof Charging Device for 6 A at 12 V Offering Preserving Charging and Automatical Cut-Off

The charging process has three phases as shown in **fig. 7.2.1.** During phase A-B, for instance, a charge current of only 2A is flowing in the event of a totally discharged accu. Thus the charging device is protected against overload. In the second phase C-D the charging is achieved with maximum constant current. During the third phase E-F, above the gas voltage, a strongly reduced current is used for charging. A higher voltage causes the current to drop down to cut-off.

Description of the circuit

The circuit is shown in **fig. 7.2.2.** The power control comprises two epibase transistors, type BD646 (T2, T3). In spite of the current control and the parallel connection of the two power transistors T2 and T3, no series resistor is included in the basic current-circuit. This provides small total power dissipation. As the current control must not be extremely accurate when using chargers the current-impression can be realized by the base current. If two transistors are coupled, no current distribution by resistors connected in series to the emitters is necessary. If the transistors do not have the same current-gain characteristics, different currents would arise and thus different power dissipations in the transistors. When the maximum power dissipations of two uncoupled transistors are known and the difference taken into account by inserting an adequate heat-sink, even different transistors may be connected in parallel without resistors for the current distribution.

The result is that the base current to a great extent determines the load current. The base current, however, depends on the symmetrical resistors R5 and R6, on



A–B Reduced charge current at discharged accu between 0 and 10 V.

C–D Charging with full constant current at accu voltages between 10 and 14.4 V. The current is adjusted by P2. The transition from B to C depends on the temperature.

D–E Abrupt decrease of the charging current at a threshold voltage of 14.4 V to a lower value being adjusted by P1. The threshold voltage is adjustable by P3.

E–F Further decrease of the charging current at increasing accu voltages down to the cutt-off F at 16.5 V.

Fig. 7.2.1.

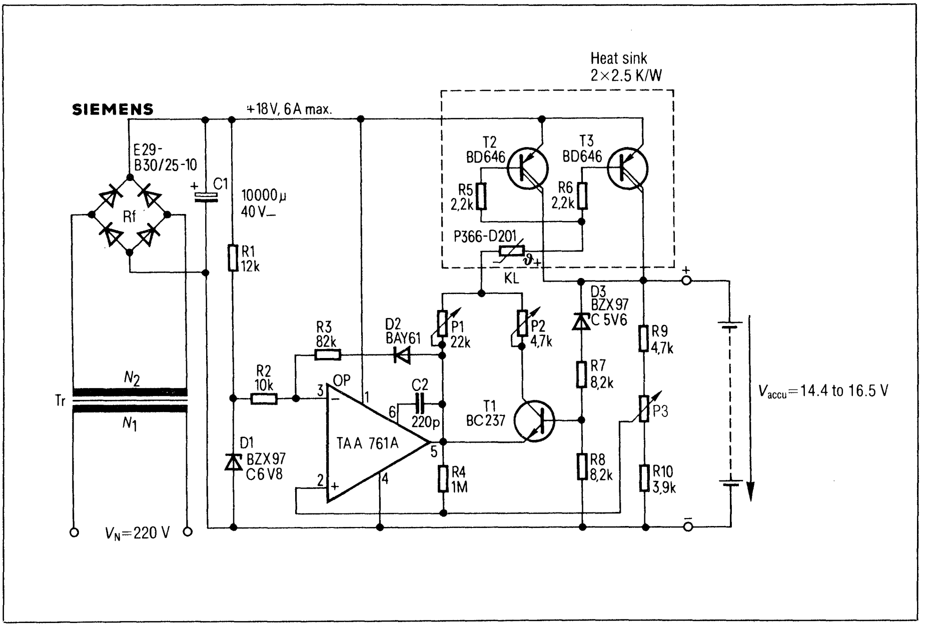


Fig. 7.2.2.

the PTC resistor KL, on the parallel connected potentiometers P1 and P2 (at conductive T1) as well as on the output voltage of the operational amplifier.

The PTC resistor KL is responsible for thermal protection. It is mounted on the common heat sink of the power transistors T2 and T3 with a good heat-conduction. If this heat sink reaches a temperature of +100 °C, for instance by overload, overvoltage or insufficient air-conditioning, the PTC resistor gets a high resistance. The base current and thus the charge current are reduced in that the power dissipation and with it the heating decrease to a permissible value.

Adjustment of the charge currents

Besides the three adjustment possibilities for the charge currents, which all interfere, the adjustment is conveniently simple. First, the switching threshold of 14.4 V is adjusted by potentiometer P3. Then with P1 the value for the residual current above the flip point (point E, fig. 7.2.1) has to be set. Finally, the charge current rating has to be adjusted by means of P2 below the flip point (phase C-D). The initial current (phase A-B) depends on the adjustment of the residual charge current and is 30 to 100% higher than the residual charge current adjusted by P1, following the transistor characteristics. The rated load current (I_{NL}) and the residual charge current (I_{RL}) have to be adjusted with reference to the Ah-capacity of the accu. Relevant approximative values are

$$I_{NL} \approx \frac{\text{Ah-capacity}}{5\,\text{h}} \quad \text{and} \quad I_{RL} \approx \frac{\text{Ah-capacity}}{20\,\text{h}}.$$

Components for circuit 7.2.2

			Ordering code	SCS stock number
1	Operational amplifier (plastic package, 6 pins)	TAA 761 A	Q67000-A522	7236
1	Silicon NPN transistor	BC 237	Q62702-C697	70090
2	Silicon PNP power Darlington transistors	BD 646	Q62702-D232	71359
1	Small rectifier set (moulded)	E29-B30/ 25-10	C66067-A1740-A5	4677
1	Silicon switching diode	BAY 61	Q62702-A389	8579
1	Z diode	BZX 97/C5V6 0.5 W	Q62702-Z1229-F82	7343
1	Z diode	BZX 97/C6V8 0.5 W	Q62702-Z1231-F82	7345
1	PTC resistor	NAT 95 °C $R_{25}=70\ \Omega$ $V_{max}=20$ V	Q63100-P366-D201	72015
1	Aluminium electrolytic capacitor	10000 µF 40 Vdc	B41111-K7109-T	2739
1	Styroflex capacitor	220 pF 63 Vdc	B31063-A5221-H	2389
2	Carbon layer resistors	2.2 kΩ 0.3 W ±5%	B51261-Z4222-J1	37677
1	Carbon layer resistor	3.9 kΩ 0.3 W ±5%	B51261-Z4392-J1	37681
1	Carbon layer resistor	4.7 kΩ 0.3 W ±5%	B51261-Z4472-J1	37683
2	Carbon layer resistors	8.2 kΩ 0.3 W ±5%	B51261-Z4822-J1	37688
1	Carbon layer resistor	10 kΩ 0.3 W ±5%	B51261-Z4103-J1	37689
1	Carbon layer resistor	12 kΩ 0.3 W ±5%	B51261-Z4123-J1	37690
1	Carbon layer resistor	82 kΩ 0.3 W ±5%	B51261-Z4823-J1	37943
1	Carbon layer resistor	1 MΩ 0.3 W +5%	B51261-Z4105-J1	37957
1	Potentiometer	22 kΩ 0.1 W	B58042-Z0223-M320	26689
1	Potentiometer	4.7 kΩ 0.1 W	B58042-Z0472-M320	26687
1	Potentiometer	2.2 kΩ 0.1 W	B58042-Z0222-M320	26686
1	Mains transformer	M102/35, Dyn. sheet IV/0.35 without air gap N_1 725 turns, 0.65 varnished copper wire N_2 50 turns, 2.0 varnished copper wire (or 4 × 0.95 varnished copper wire)		

7.3 Control Circuit with Transformer for Push-Pull Switch Mode Power Supply

Push-pull switch mode power supplies (SMPS) for higher voltages require a key-controlled operation with blanking intervals to avoid high commutating currents flowing through the switching transistors. These currents are generated since the transistors have finite charging times between 2 and 3 µs. Generally it is very difficult to transmit blanking intervals by using only one transformer because of the undesired overshoots at pulse edges. Therefore two transistors are recommended for circuits with higher output powers and higher supply voltages.

The circuit shown in **fig. 7.3.1** demonstrates a solution with only one driving transformer. It transmits the corresponding staircase voltage. The supply voltage for the driving circuit can be derived from the SMPS directly or from any other source.

The generator voltage at the input is in a range between 30 and 50 V_{pp}. If necessary the phase of the output signal can be adjusted by potentiometer R_1. The pulse symmetry is set by R_2, whereas R_3 and R_4 adjust the blanking intervals. The blanking pulses are differentiated by the 3.3 nF-capacitor and the control transistor T_{10}. They are applied to the driving transistors via T_3 to T_7.

The bases of transistors T_8 and T_9 are based by a divider to a level being half of the supply voltage. Thus an unobjectionable transmission of the blanking intervals is guaranteed. The positive blanking pulses control transistor T_8 whereas transistor T_9 is driven by the negative ones. Every inductively – generated, fly-back voltage at the two emitters is automatically attenuated by one of the corresponding transistors. Both signal paths have been crossed to achieve equal propagation times.

Diode D_1 connected to the base of T_1 is responsible for time symmetry.

A reversed current-flow via the base of each transistor T_3 and T_5 is avoided by diodes D_2 and D_3.

During the uncontrolled state the transistors T_6 and T_7 are non-conductive. Therefore half of the supply voltage V_s is applied to the base of each transistor T_8 and T_9.

It is very important that the driving transformer has a very low stray inductance.

The primary windings 1–2 and 3–4 have to be split into two sections because the secondary windings 5–6 and 7–8 have to be inserted between them (refer to **fig. 7.3.2**).

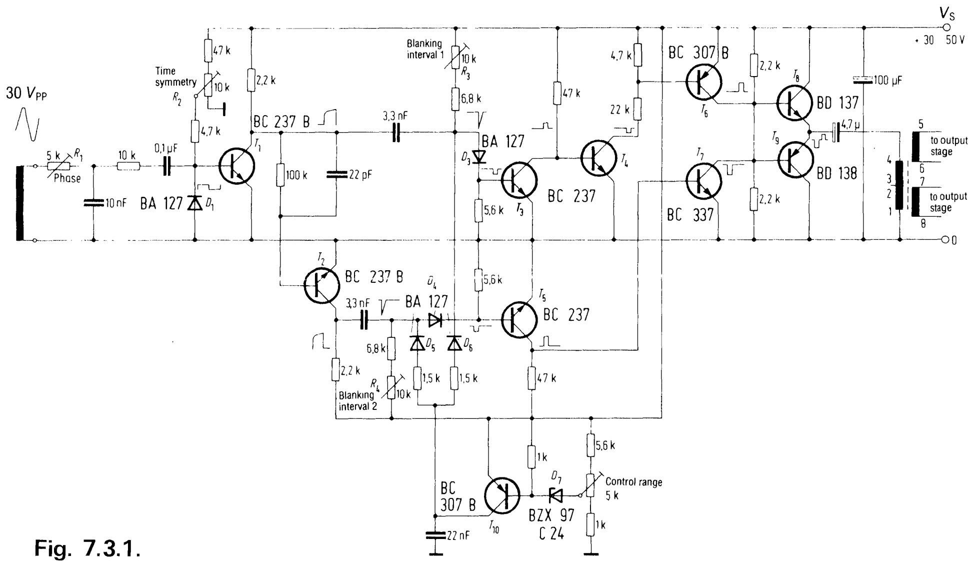
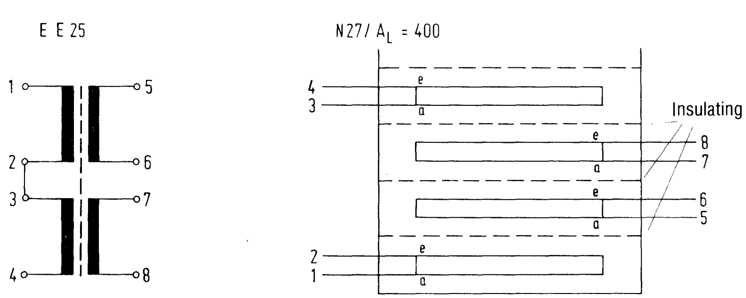


Fig. 7.3.1.



1 - 2	150 / 0,2	Turns/varnished copper wire ∅ mm
3 - 4	35 / 0,35	Turns/varnished copper wire ∅ mm
5 - 6	35 / 0,35	Turns/varnished copper wire ∅ mm
7 - 8	150 / 0,2	Turns/varnished copper wire ∅ mm

Fig. 7.3.2.

Components for circuit 7.3.1

		Ordering code	SCS stock number
5 Transistors	BC 237 B	Q62702-C277	8827
2 Transistors	BC 307 B	Q62702-C324	8879
1 Transistor	BC 337	Q62702-C313-V1	8834
1 Transistor	BD 137-10	Q62702-D108-V2	8811
1 Transistor	BD 138-10	Q62702-D109-V2	8822
5 Diodes	BA 127 D	Q60201-Y127-D9	70044
1 Z diode	BZX 97 C 24	Q62702-Z1244-F82	7358
1 Styroflex capacitor	22 pF	B31110-A1220-F	1562
2 MKT capacitors	3.3 nF	B32535-C6332-K	–
1 MKT capacitor	22 nF	B32535-C3223-K	–
1 MKT capacitor	0.1 µF	B32535-C1104-K	–
1 Electrolytic capacitor	4.7 µF	B41286-A9475-T	–
1 Siferrit core	EF 25 (Tr1)	B66207-A0000-R027	–
1 Coil former for	EF 25 (Tr1)	B66207-A1003-R001	–

7.4 Control Circuit for Push-Pull Switch Mode Power Supply with 2 × BD 647

The circuit shown in **fig. 7.4** is favoured for driving switch mode power supplies (SMPS). It operates without any control circuit. The operating voltage for the control circuit is 30 V and can be supplied from the SMPS itself or from any other source. The supply voltage for the drivers (5 V) or the resistances of the driver collector resistors can be varied with reference to the base currents of the output transistors. If higher output currents are required a circuit with driving transformers is recommended. The generator source voltage or the reverse feedback voltage at the input should range between 30 and 50 V_{pp}. The phase of the output voltage can be adjusted by resistor R1. A coarse symmetry of the signal is obtained by diode D1 connected to the base of transistor T1, whereas a fine adjustment is achieved by potentiometer R2. A square wave voltage is available at the base as well as at the collector of T1. It is differentiated by the 3.3 nF-capacitor with reference to the control current of transistor T5 (BC307B). This current is set to a determined rated value by the reference diode D6 and the potentiometer R5. In this case the output voltage is indirectly controlled. If the control should be influenced by the output signal an optoelectronic coupler or a transformer has to be used.

After the phase reversal at transistor T2 the square wave voltage is differentiated again by a 3.3 nF-capacitor. Both signal paths are separated by means of the two fast-reacting diodes D4 and D5 being components of the control circuit.

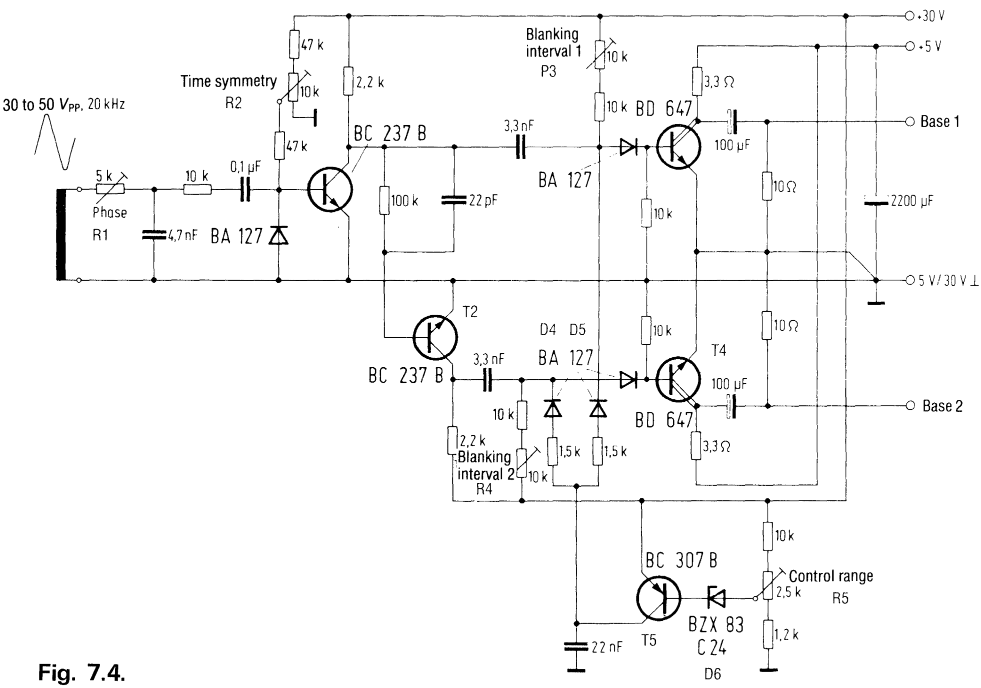


Fig. 7.4.

The blanking intervals are adjusted by potentiometers R3 and R4. The differentiated pulses are amplified by the Darlington transistors T3 and T4 and applied in push-pull to base 1 and 2 of the output-stage transistors, whereby the two 100 µF – electrolytic – capacitors transmit the control and turn-off currents.

Components for circuit 7.4

		Ordering code	SCS stock number
2 Transistors	BC 237 B	Q62702-C277	8827
1 Transistor	BC 307 B	Q62702-C324	8879
2 Transistors	BD 647	Q62702-D233	71357
5 Diodes	BA127	Q60201-X127	8019
1 Z diode	BZX83 C 24	Q62702-Z1086-F82	7326
1 Styroflex capacitor	22 pF	B31110-A1220-J	1562
2 MKT capacitors	3.3 nF	B32535-C6332-K	–
1 MKT capacitor	4.7 nF	B32535-C6472-K	–
1 MKT capacitor	22 nF	B32535-C3223-K	–
1 MKT capacitor	0.1 µF	B32535-C1104-K	–
2 Electrolytic capacitors	100 µF	B41283-B5107-T	7877
1 Electrolytic capacitor	220 µF	B41010-E9227-T	7859

7.5 Control Circuit for Push-Pull Switch Mode Power Supplies with 2 Driver Transformers

Push-pull circuits for switch mode power supplies (SMPS) with higher voltages require a key-controlled operation with blanking intervals to avoid high commutating currents flowing through the switching transistors. These currents are generated as the transistors have finite charging times (2 to 3 µs). Generally it is very difficult to transmit blanking intervals by using one transformer because undesired overshoots at pulse edges are generated.

In the circuit shown in **fig. 7.5** two driving transformers are used. They transmit the signals with a phase shift, i.e. the blanking intervals are also transmitted. The operating voltage for the control circuit can be supplied from the SMPS itself or from any other source.

The driving voltage at the input is between 30 and 50 V_{pp}. If necessary the phase of the output signal can be influenced by potentiometer R_1. The potentiometer R_2 adjusts the symmetry of the signal and the blanking intervals are set by potentiometers R_3 and R_4. The blanking pulses are differentiated by the 3.3 nF-capacitor and the control transistor T_9. They are supplied to transistors T_3 and T_4. A negative current for the base of T_3 and T_4 is avoided by two diodes, D_3 and D_4.

The two fast-reacting diodes D_5 and D_6 and the two 3.3 kΩ-resistors decouple the two signal paths and suppress common-mode interferences.

The control current is set to a defined value by reference diode D_7 and potentiometer R_5.

No additional RCD-components are required for suppressing overshoots for an unobjectionable signal transmission. The positive blanking pulses (pulse duration) control the transistor T_5 and the negative ones (pulse space) the transistor T_6. Every inductively generated flyback voltage at the two emitters is automatically attenuated by one of the corresponding transistors. If there is no control the transistors T_5 and T_6 are non-conductive. The output transistors can be arranged as shown in **fig. 7.6.1.**

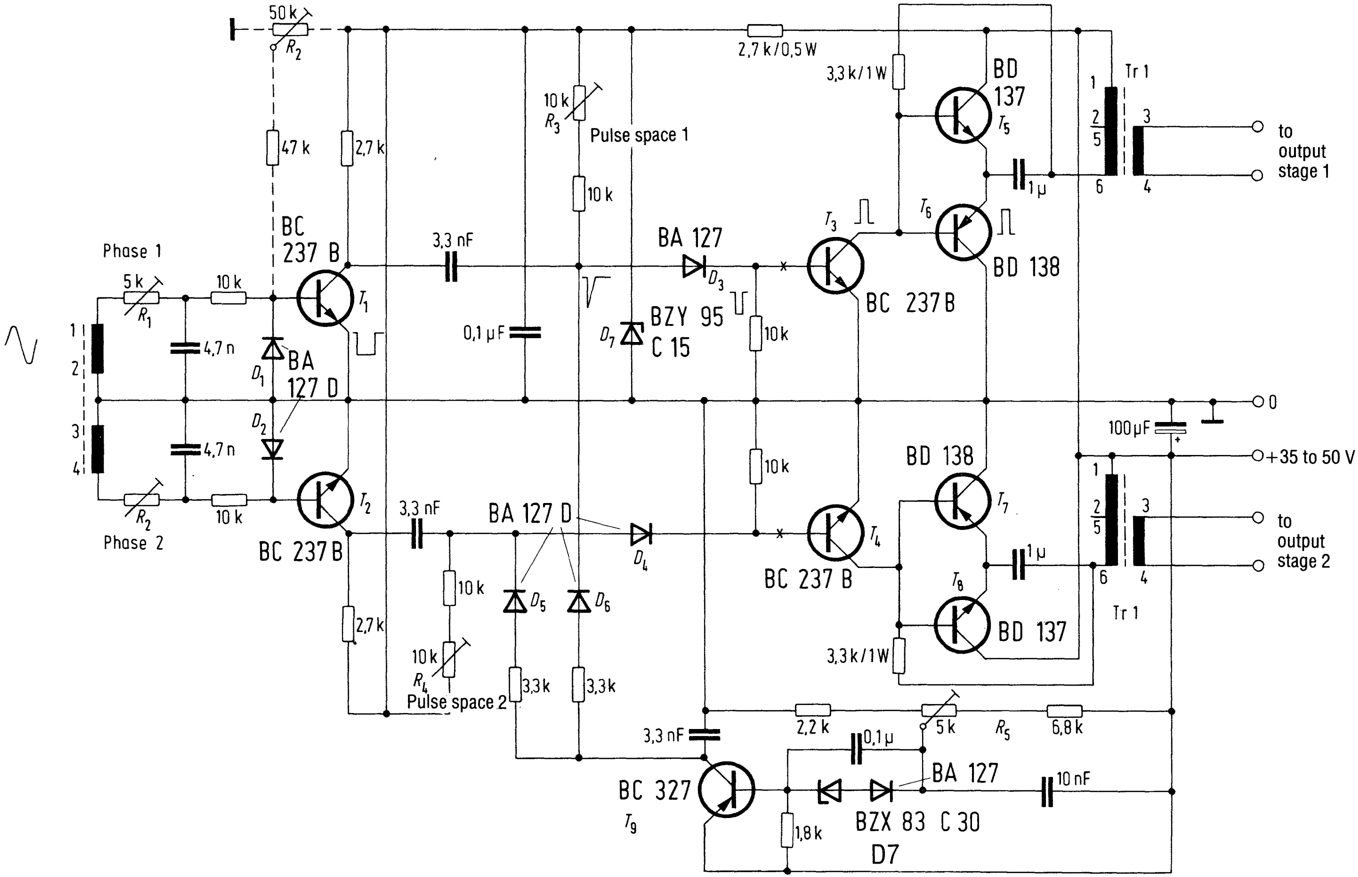

50 k
R_2
47 k
2,7 k
10 k
R_3
Pulse space 1
10 k
2,7 k/0,5 W
3,3 k/1 W
BD 137
T_5
Tr 1
1
2
5
3
6
4
1 µ
to output stage 1
T_6
BD 138
T_3
BC 237 B
BA 127
D_3
BZY 95 C 15
D_7
10 k
0,1 µF
3,3 nF
BC 237 B
T_1
Phase 1
5 k
R_1
10 k
4,7 n
D_1
BA 127 D
D_2
4,7 n
1
2
3
4
0
100 µF
+35 to 50 V
BD 138
T_7
10 k
T_2
R_2
10 k
Phase 2
BC 237 B
3,3 nF
BA 127 D
D_4
T_4
BC 237 B
1 µ
to output stage 2
Tr 1
T_8
BD 137
3,3 k/1 W
10 k
D_5
D_6
2,7 k
10 k
R_4
Pulse space 2
3,3 k
3,3 k
3,3 nF
2,2 k
5 k
R_5
6,8 k
0,1 µ
BA 127
10 nF
BC 327
T_9
1,8 k
BZX 83 C 30
D7

Fig. 7.5.

Components for circuit 7.5

		Ordering code	SCS stock number
4 Transistors	BC 237 B	Q62702-C277	8827
1 Transistor	BC 327	Q62702-C311	70099
2 Transistors	BD 137/16	Q62702-D108-V3	–
2 Transistors	BD 138/16	Q62702-D109-V3	–
6 Diodes	BA 127 D	Q60201-X127-D9	70044
1 Capacitor	2.2 nF	B32535-C6222-K	–
2 Capacitors	3.3 nF	B32535-C6332-K	–
2 Capacitors	4.7 nF	B32535-C6472-K	–
1 Capacitor	0.1 µF	B32535-C1104-K1	–
2 Capacitors	1 µF	B32535-C1105-K	–
1 Electrolytic capacitor	100 µF	B41010-B9107-T	7858
2 Transformer cores	EF 25 (Tr1)	B66207-A0400-L026	–
2 Coil formers for EF 25		B66208-A1003-R001	33605

7.6 1 kW/20 kHz-Generator with Output voltages of 500 V and 40 V at 25 A

Fig. 7.6.1 shows the circuit for a 1 kW-generator. Its principle of operation is as follows. At the base of T_1 positive pulses are generated by a feedback via windings n4 and n5 or by any other corresponding signal source. The transistors T_1 and T_3 are turned on. The maximum minus-voltage is applied via the 1 µF-capacitor to transformer Tr1. If the transistor T_1 is turned off the transistor T_2 is conductive and the maximum positive-voltage is supplied to Tr1. Thus a square wave voltage with a low source impedance is generated. It controls the power transistor T_4 and turns it on and off. The recovery currents are such high in that the transistor T_4 can be switched fast enough. Directly after the conductive period of T_4 the voltage at the collector-emitter-junction is kept in that the turn-off current can be decreased sufficiently and in that the collector voltage is not increasing inadmissibly.

The start of the oscillation is achieved by applying the operating voltage to the prestage transistors when the circuit is connected to the mains. The operating voltage is derived either from the rectified mains voltage in conjunction with a RCZ-circuit or from any other separate power supply. In some concepts it may be advantageous to apply a starting dc-current via the base divider to the transistors T_4 and T_1 to guarantee the oscillation-generation for all stages. At self-oscillating circuits the oscillation is interrupted immediately when a short-circuit happens or is increased towards higher frequencies if the transformer has a greater stray inductance. The blanking intervals are determined by the time circuit consisting of C_1 and R_1.

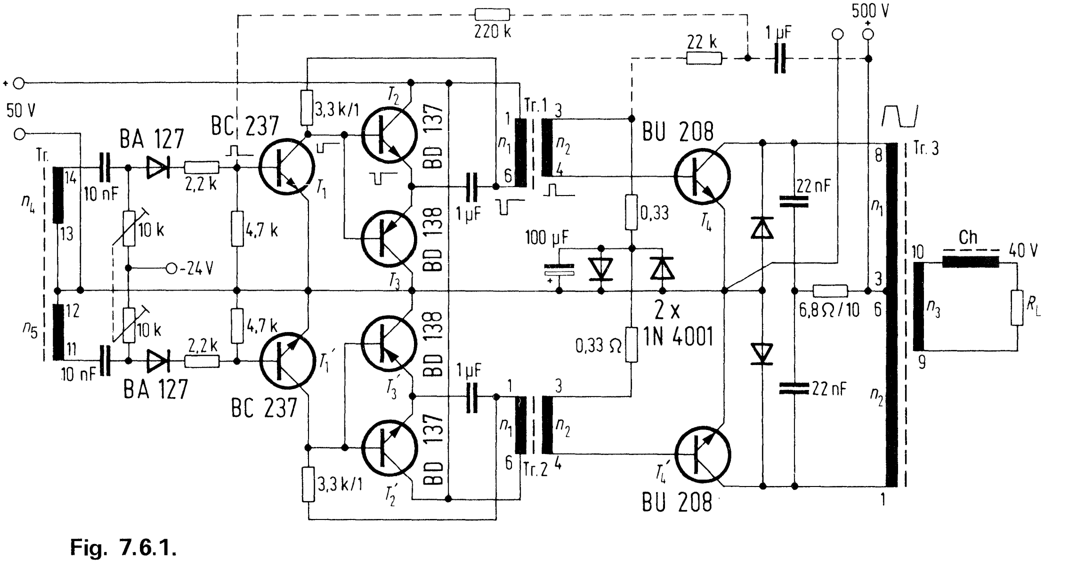


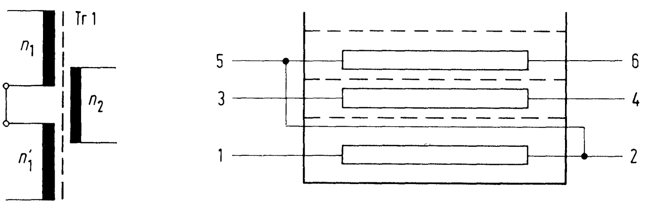
Fig. 7.6.1.

The pulse duration can be adjusted by resistor R_1 if a control voltage is applied. For variable blanking intervals the resistance of R_1 or the ± 24 V-supply-voltage has to be changed.

The explained principle of operation also applies correspondingly to the other amplifier of the push-pull circuit. For the transformer Tr3 a Siferrit core N 27 with a seize PM 87 ∅ × 70 mm and an air gap of approx. 1 mm (inside) has been used.

Components for circuit 7.6

		Ordering code	SCS stock number
2 Transistors	BU 208	Q68000-A494-F193	71326
2 Transistors	BC 237 B	Q62702-C277	8827
2 Transistors	BD 137-10	Q62702-D108-V2	8811
2 Transistors	BD 138-10	Q62702-D109-V2	8822
2 Diodes	BA 127 D	Q60201-X127-D9	70044
2 Diodes	1 N 4001	C66047-Z1306-A21	48001
2 Capacitors	10 nF/>100 V	B32510-D3103-K	28923
2 Capacitors	22 nF/100 V	B32650-J0223-K	–
2 Capacitors	1 µF/>100 V	B32511-D1105-K	–
1 Capacitor	1 µF/630 V	B32334-A8683-M	–
1 Electrolytic capacitor	100 µF	B41283-A8107-T	7880

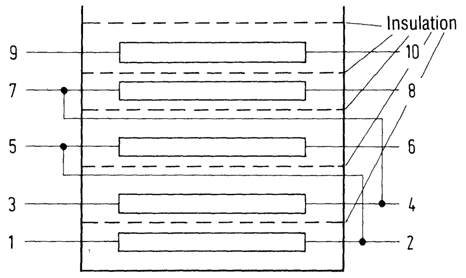


Winding schematic for transformer Tr1

Core EF 25/N 27	B 66 207 - A0000 - R027
Coil former	B 66 208 - A1003 - R001

1-2	150 turns	0.25 ∅ enamelled copper wire
3-4	30 turns	0.4 ∅ enamelled copper wire
5-6	150 turns	0.25 ∅ enamelled copper wire

Fig. 7.6.2.



Winding schematic for transformer Tr 3
Potcore: 87 mm ∅ × 70 mm, $L = 1$ mm (inside)
B 65713 - A0000 - R027
Coil former: B 65714-A1001-T001

1-2	22 turns	stranded wire 120×0.1 ∅ double enamelled copper wire
3-4	22 turns	stranded wire 120×0.1 ∅ double enamelled copper wire
5-6	22 turns	stranded wire 120×0.1 ∅ double enamelled copper wire
7-8	22 turns	stranded wire 120×0.1 ∅ double enamelled copper wire
9-10	5 turns	stranded wire 10×(120×0.1 ∅ double enamelled copper wire)

Fig. 7.6.3.

8. Digital Circuits

8.1 Reaction-Time Test Device

With the device the circuit of which is described in **fig. 8.1** it is possible to test ones typical reaction time under different physical conditions. Because of its power supply with batteries a mobile operation is feasible. The clock generator ($f = 100$ Hz) consists of two ICs, type FLK101, and the adjacent components. The two monostable multivibrators automatically trigger each other.

The output signal of the clock generator (pin 1) drives the frequency divider, consisting of three ICs FLJ181, as well as the decade counter comprising the three ICs, type FLL171.

A random time between 0.5 and 20 s is generated by the frequency divider. When the start push button is pressed only the dividers of IC_3 are reset via inverter *R*. As the clock is still running the content of the two other divider-ICs is undefined and it depends on accident when the pulse being available at pin 12 of inverter S is displayed at the beginning of the test time.

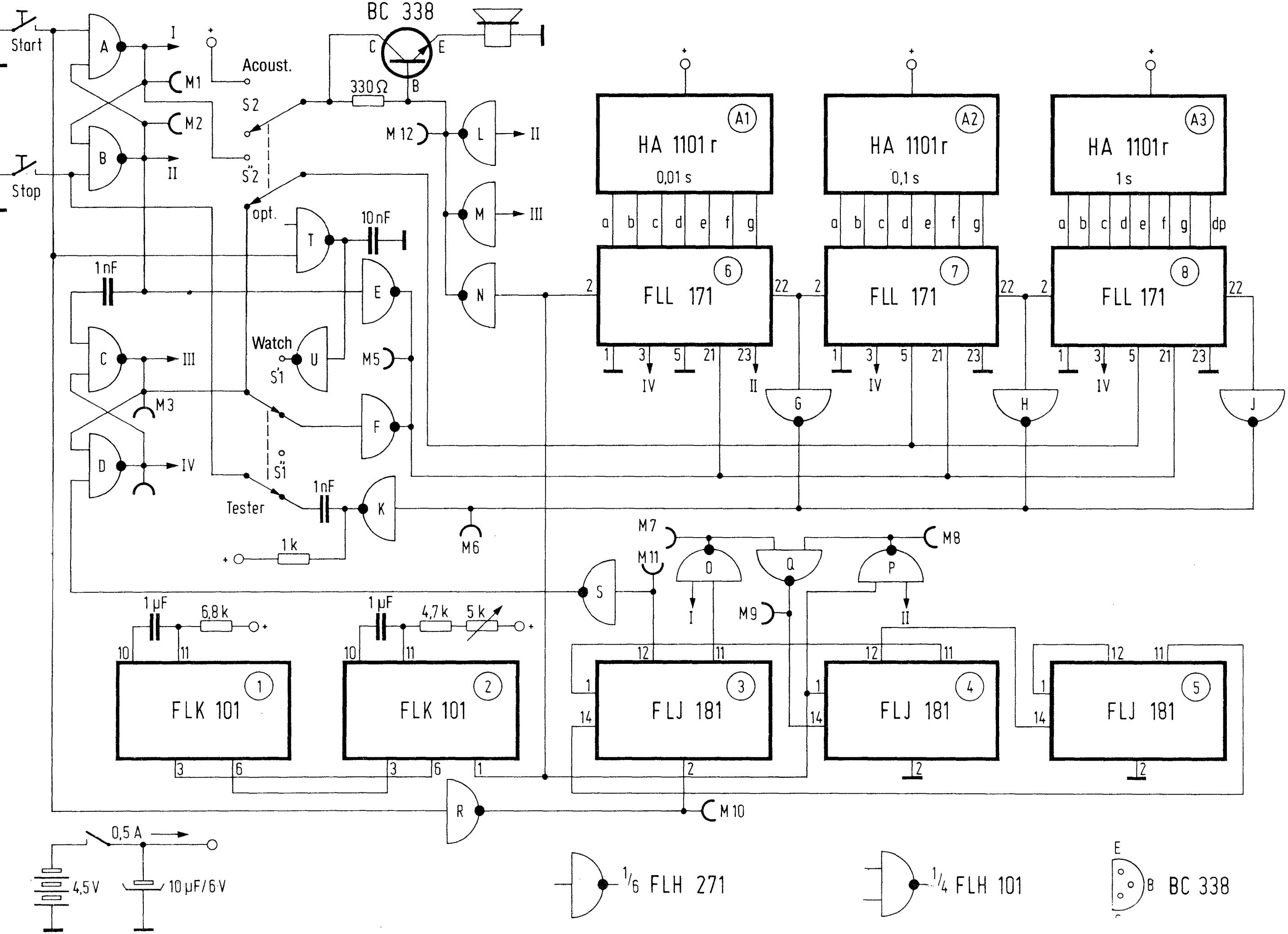
When the start push button is operated the RS-flipflop consisting of NAND-gates is set. The pulse of its output II is supplied via a 1 nF-capacitor to another RS-flipflop incorporating the NAND-gates C and D. The decade counter is reset to "ØØØ" and the first two digits are blanked in that only a "Ø" is displayed.

When the random time has passed the second flipflop is reset via inverter *S*. On the display the other two "Ø" are visible. If the switch S_2 is in its upper position "acoustical" a 100 Hz-signal is supplied via the inverters *L, M, N* to the base of transistor BC338, which drives a loudspeaker. Now the decade time-counter consisting of the three ICs, type FLL171 runs. In the first instance the count is not displayed.

The operator of the test-reaction time device should then immediately press the stop push button to reset the first flipflop and to stop via inverter *E* the time counter. Then the accumulated count is displayed or the tone is turned off.

If the stop push button is not operated within the maximum displayable time of 9.99 s an automatic stop is realized by the decade counter and the inverters *G, H, J* and *K*. In this case "9.99" is displayed.

The device can also be utilized as a stop watch. In this case the counter runs immediately after the start push button has been pressed. The count is always displayed and the automatic stop at 9.99 s is ineffective. The operation may also be used for calibrating the test time. In this case a longer clock time is compared with those of a normal watch and the 5 kΩ-potentiometer is adjusted correspondingly.



BC 338
Start
Stop
Acoust.
S2
S''2
opt.
Watch
S'1
S''1
Tester
330 Ω
C
B
E
10 nF
1 nF
1 k
M1
M2
M3
M5
M6
M7
M8
M9
M10
M11
M 12
A
B
C
D
E
F
G
H
J
K
L
M
N
O
P
Q
R
S
T
U
I
II
III
IV
HA 1101 r
0,01 s
0,1 s
1 s
A1
A2
A3
a
b
c
d
e
f
g
dp
FLL 171
FLK 101
FLJ 181
1 µF
6,8 k
4,7 k
5 k
0,5 A
4,5 V
10 µF/6 V
1/6 FLH 271
1/4 FLH 101
BC 338

Fig. 8.1.

Components for circuit 8.1

			Ordering code	SCS stock number
2	NAND-gates	FLH 101 (7400)	Q67000-H1	8658
2	Inverters	FLH 271 (7405)	Q67000-H154	8774
2	Monoflip-flops	FLK 101 (74121)	Q67000-K13	8910
3	4 bit binary counters	FLJ 181 (7493A)	Q67000-J34	8763
3	Decimal counters	FLL 171 (74143)	Q67000-L58	70723
1	Transistor	BC 338	Q62702-C314	70102
3	7-Segment-LED-Displays	HA 1101r	Q30-X313	71283
2	MKH layer capacitors	1 nF/400 V	B32560-D6102-J	–
1	MKH layer capacitor	10 nF/400 V	B32560-D6103-J	–
2	MKH layer capacitors	1 µF/100 V	B32561-D1105-J	–
1	Electrolytic capacitor	10 µF/6 V	B41313-A2106-V	1931
1	Resistor	330 Ω	B54311-Z5331-G1	28552
1	Resistor	1 kΩ	B54311-Z5102-G1	28509
1	Resistor	4.7 kΩ	B54311-Z5472-G1	28524
1	Resistor	6.8 kΩ	B54311-Z5682-G1	28528
1	Potentiometer	5 kΩ lin.	–	–
1	Mini loud-speaker	8 Ω/0.2 W; ≈60∅	–	–
3	2 pole reversing switches		–	–
2	Push buttons	Make contact (1 × red, 1 × green)	–	–
3	Batteries	1.5 V (Baby; Alkali-Mangan)	–	–

8.2 Control Circuit for Touch-Keys with S056H

Fig. 8.2 shows a circuit of a control device with touch keys for two channels. The monolithic IC S056H offers 4 output drivers, but in the described application only two of them are utilized. When the touch key "on 1" is operated the first stage is set and the output at pin 15 has the level of the power supply voltage. Thus the relay 1 pulls up. When the touch key "off 1" is operated the second stage which is not utilized in this application is set. A switching pulse is available at the corresponding output and resets stage 1. Thus the transistor BC338 is turned off and the relay drops.

The touch key pair "on 2/off 2" operates correspondingly. In this case the load is a relay. It is directly connected to the output pin 11 which supplies a maximum driving current of 55 mA. Diode BA133F protects the circuit against wrong polarity.

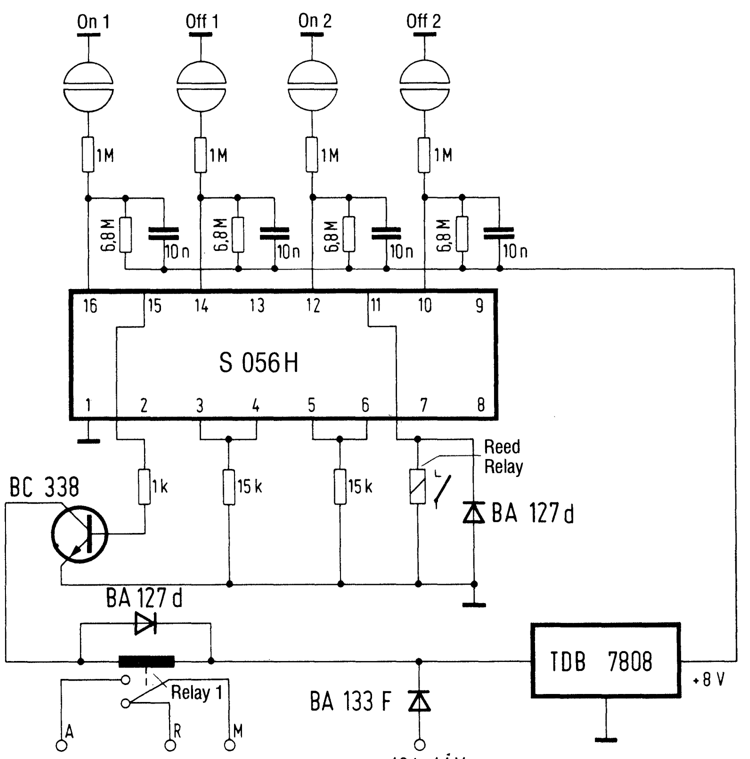


Fig. 8.2.

Components for circuit 8.2

			Ordering code	SCS stock number
1	Switching amplifier	S 056 H	Q67000-S36	–
1	Positive voltage regulator	TDB 7808	Q67000-A1053	70327
1	Transistor	BC 338	Q62702-C314	70102
2	Diodes	BA 127 D	Q60201-X127-D9	70044
1	Diode	BA 133 F	Q62702-A505	–
4	MKH layer capacitors	10 nF	B32560-D6103-J	–
1	Resistor	1 kΩ 0.3 W	B51261-Z4102-J1	37672
2	Resistors	15 kΩ 0.3 W	B51261-Z4153-J1	37691
4	Resistors	1 MΩ 0.1 W	–	–
4	Resistors	6.8 MΩ 0.1 W	–	–

9. Microcomputer Systems

9.1 Two-Position Temperature Control with the Microcomputer System Kit SIKIT-DK/8080

The two-position temperature control is frequently used in control systems. It is particularly suited for temperature control in household appliances, heating, cooling equipment and for automotive industry.

An application example of a two-position temperature control is the use with the microcomputer system kit SIKIT-DK/8080. The A/D-conversion of the actual temperature value is mainly achieved by the microcomputer in a cost effective way, and may be used also for the A/D-conversion of other physical quantities by means of suitable sensors. This principle is also adaptable for the microcomputer systems 8085 and 8048. The assembler programme described in detail eases the use of control as a subprogramme.

Fig. 9.1.1 shows the control characteristic with different on- and off-values which are typical for this kind of control. In this example, the temperature rating is $T_{rated} = 60$ °C and the hysteresis amounts ± 2 °C.

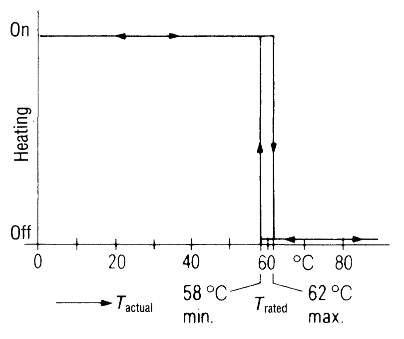


Fig. 9.1.1.

The total circuit diagram **(fig. 9.1.2)** includes the microcomputer system kit SIKIT-DK/8080 and the timer TDB 0555 B. The NTC resistor M 822 is utilized as temperature sensor.

Analog-Digital Conversion

The NTC resistor changes its resistance R_H in dependence on the temperature following the e-function:

$$R_H = R_N \times e^{B\left(\frac{1}{T} - \frac{1}{T_N}\right)}$$

whereas

R_N = nominal temperature
B = material constant
T = absolute temperature in K
T_N = nominal temperature in K

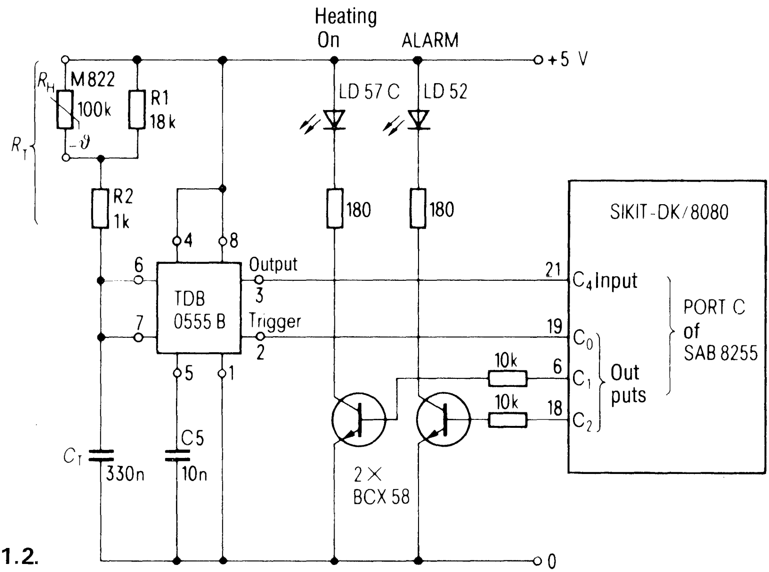


Fig. 9.1.2.

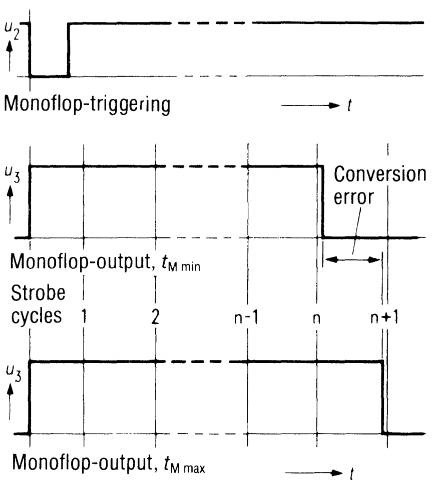


Fig. 9.1.3.

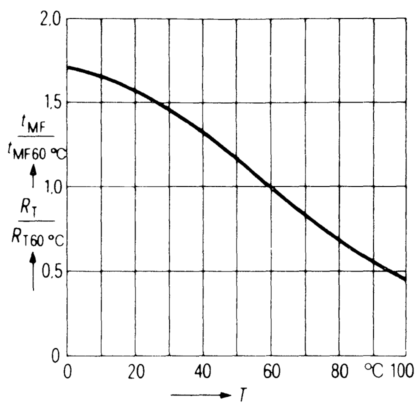


Fig. 9.1.4.

This analog value cannot be directly applied to the microcomputer. The thermistor resistance has to be converted in a proportional time period. This can be achieved by the cheap timer-IC TDB 0555 B. Then, in turn, the time is converted in a binary number by the microcomputer.

The timer acts as monostable multivibrator **(fig. 9.1.2)** whose output pulse duration t_{MF} is determined by the $R_T C_T$-circuit:

$$t_{MF} = 1.1 \times R_T \times C_T.$$

The pulse duration is dependent on the supply voltage, i.e. the +5 V voltage applied to the microcomputer system kit may be used also for the timer. The trigger and output levels of the TDB 0555 B are TTL-compatible and can be directly supplied to the programmable interface IC, SAB 8255.

Function

Fig. 9.1.3 shows the time-response of the A/D conversion. The microcomputer supplies a pulse with a duration of about 7 µs to the trigger input 2 of the timer via pin C_o of the programmable interface IC, SAB 8255. The monoflop is started, output 3 changes to positive potential. Now, a count loop is established in the microcomputer, whose run time $t_{cycle} = 21$ µs. The time is determined by the crystal of the microcomputer and the programme. It serves as a very accurate reference.

As soon as the loop is completed, output 3 is read and as long as level is "high" a 1 is added in the register pair B, C of SAB 8080 A. At "low" the counter is stopped; the register content corresponds to the actual temperature value.

Accuracy of A/D conversion

Fig. 9.1.3 illustrates the principle error of the procedure with a maximum of +1 bit. It may be seen that the accuracy increases proportionally to the number of count cycles. In the example of fig. 9.1.1 a cycle number of 190 is obtained at a rated temperature $T_{rated\ min} = 58$ °C. Hence the maximum resolution error is approximately +0.5%.

Temperature characteristic-maximum values for line cut-off, short-circuits and rated values

Fig. 9.1.4 shows the relative temperature response of the total resistor R_T and the monoflop time t_{MF}.

The lowest temperature determines the limit value for a line interruption between sensor R_H and IC. In the given example $T_{min} = 0$ °C. On account of the exponential function of the NTC resistance it would result, with respect to the rated temperature of $T_{rated} = 60$ °C, a count time which is 19 times longer and which would block the microcomputer for a long time. Consequently, resistor R_1 was connected in parallel and this limits the strobing time to $1.7 \times t_{rated}$. R_1, however, reduces the rise of the characteristic and should not have a too low resistance.

The maximum short-circuit value is determined by the highest occurring temperature. In our example $T_{max} = +100$ °C. The series resistor R_2 protects the timer against overload.

The number of loop runs of the A/D converter can be calculated as

$$n = \frac{1.1 \times R_T \times C_T}{t_{cycle}}.$$

Our example leads to the following values:

a) Normal operation:

$T_{rated\ max} = +62\ °C$
$R_T = 10.30\ k\Omega,\ n_{rated\ max} = 178$
$T_{rated\ min} = +58\ °C$
$R_T = 11.01\ k,\ n_{rated\ min} = 190$

b) Line cut-off:

$T_{LCO} < 0\ °C$
$18.21\ k\Omega < R_T < 19\ k\Omega,\ 315 < n < 328.$

c) Line short-circuit:

$T_{LSC} > 100\ °C$
$1\ k\Omega < R_T < 4.89\ k\Omega,\ 17 < n < 85.$

Total control error

With the circuit as shown in **fig. 9.1.5** the tolerances of components as R_H, R1, R2 and C_T, the SIKIT quartz frequency and the timer switching point can be adjusted in that only the TC of the mentioned components and the quantization error of the A/D converter will have influence.

At the rated temperature of +60 °C the monoflop characteristic as shown in **fig. 9.1.4** has a rising edge of 63 µs/°C which corresponds to 3 count cycles of the A/D converter. Thus the quantization causes an error of 0.33 °C.

Flow chart

The subroutine "TEMP" for the temperature control **(fig. 9.1.6)** begins with the triggering of the monoflop via output C_o of the programmable interface IC. Then

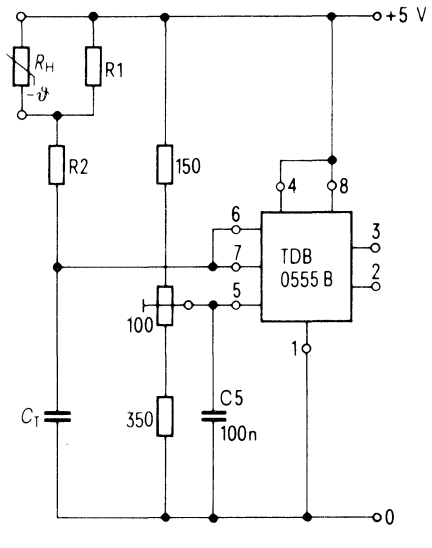


Fig. 9.1.5.

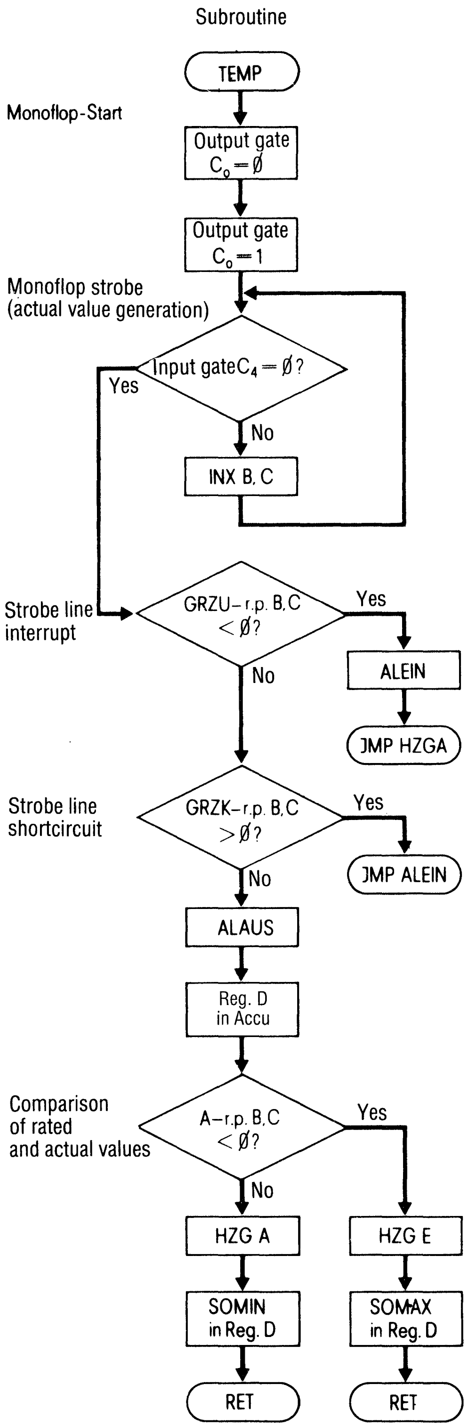

Subroutine
TEMP
Monoflop-Start
Output gate C0 = Ø
Output gate C0 = 1
Monoflop strobe (actual value generation)
Input gate C4 = Ø ?
Yes
No
INX B, C
Strobe line interrupt
GRZU – r.p. B, C < Ø?
Yes
No
ALEIN
JMP HZGA
Strobe line shortcircuit
GRZK – r.p. B, C > Ø?
Yes
No
JMP ALEIN
ALAUS
Reg. D in Accu
Comparison of rated and actual values
A – r.p. B, C < Ø?
Yes
No
HZG A
HZG E
SOMIN in Reg. D
SOMAX in Reg. D
RET
RET

Fig. 9.1.6.

a count loop is provided which is necessary for the A/D conversion of the actual temperature value described above. It follows the checking of line interrupt and short-circuiting with the limit values of GRU and GRK. Disturbances produce in both cases alarm and disconnect the heating. If the actual value is between the limits of GRU and GRK a possibly preset alarm command is reset by ALAUS. The comparison of the actual and rated value follows. For that purpose the microprocessor compares the rated value data allocated in the RAM with the actual one. To realize the required two-position temperature characteristic, SOMIN and SOMAX are stored alternatively in one section of the RAM. When the temperature is higher than the rated value (actual value < rated value) the heating is cut-off and with SOMIN the minimum rated value is stored in the RAM. If the temperature gets too low, the heating turns on and the maximum rating is allocated in the RAM with SOMAX.

The storage of the minimum and maximum ratings offers the advantage in that the rated values can be varied by other subroutines. Besides that these ratings can also be stored in one of the MP-registers. But this register has not to be changed by any other subroutine.

After the device is turned on an undefined rated value is stored in the RAM during the first programme run. This will result in an undefined state for the heating. Only after the second run, which happens normally after a few seconds, the heating is switched on in a defined way.

Assembler programme (subroutine)

The EQU-pseudo-instructions determine the control word for the selected I/O interface devices, for the limits of the line interruption, for the limits of the short-circuit and for the rated value. The subroutine "TEMP" needs a ROM-capacity of 79 × 8 bit.

Label	Op. Code	Operand	Time µs	Comment
CWR	EQU	ØF7H		Address of control word register of SAB 8255
PORTC	EQU	ØF6H		Select a SAB 8255 and its port C
NGRU	EQU	3AH		} Limit value of line interrupt
HGRU	EQU	Ø1H		
NGRK	EQU	54H		} Limit value of line shortcircuit
HGRK	EQU	ØØ		
SOMIN	EQU	ØBDH		Rated value T_{min}
SOMAX	EQU	ØB1H		Rated value T_{max}
MERK	EQU	1***H		Address for special location in the RAM
TEMP:	MVI	A, 8AH	3.5	Determine operation mode "Ø" of the SAB 8255 (control word No. 6)
	OUT	CWR	8.5	
	LXI	B, Ø	13.5	Set registers B, C to Ø
STAMF:	MVI	A, Ø	3.5	Set output C_0 of SAB 8255 to Ø and
	OUT	CWR	8.5	start monoflop
	MVI	A, Ø1	12	Set output C_0 to 1 and
	OUT	CWR	17	reset monoflop trigger

Label	Op. Code	Operand	Time µs	Comment
ABFMF:	IN	PORTC	5	Count loop: Strobe monoflop output
	ANI	1ØH	8.5	
	JZ	LTGU	13.5	mask for input C_4
	INX	B	16	increment register B, C
	JPM	ABFMF	21	Jump
LTGU:	XRA	A	2	Line interrupt, carry to Ø
	MVI	A, NGRU	5.5	Load accu with least significant byte of GRU
	SBB	C	7.5	NGRU-NIST with carry
	MVI	A, HGRU	11	Load accu with most significant byte of GRU
	SBB	B	13	HGRU-HIST with carry
	JNC	LTGK	18	At carry=Ø→jump to line shortcircuit
ALEIN:	MVI	A, Ø5H	3.5	Output C_2 to 1
	OUT	CWR	8.5	
	JMP	HZGA	13.5	Jump to heat OFF
LTGK:	XRA	A	2	Line shortcircuit, carry to Ø
	MVI	A, NGRK	5.5	Load accu with least significant byte of GRK
	SBB	C	7.5	NGRK-NIST with carry
	MVI	A, HGRK	11	
	SBB	B	13	HGRK-HIST with carry
	JNC	ALEIN	18	At carry=1→jump to alarm ON
ALAUS:	MVI	A, Ø4H	3.5	Output C_2 to Ø
	OUT	CWR	8.5	
SIV:	XRA	A	2	Comparison of rated and actual value, carry to Ø
	LDA	MERK	8.5	Load accu with content of special RAM location=rated value
	SBB	C	10.5	SOLL-NIST with carry
	MVI	A, Ø	14	Load accu with Ø
	SBB	B	16	Ø-HIST with carry
	JNC	HZGA	21	At carry=Ø→jump to heating OFF
HZGE:	MVI	A, Ø3H	3.5	Output C_1 to 1→heating ON
	OUT	CWR	8.5	
	MVI	D, SOMAX	12	Maximum rated value into accu
	STA	MERK	18.5	into special RAM location
	RET		23.5	
HZGA:	MVI	A, Ø2H	3.5	Output C_1 to Ø→heating OFF
	OUT	CWR	8.5	
	MVI	A, SOMIN	12	minimum rated value into accu
	STA	MERK	18.5	into special RAM location
	RET		23.5	

Auxiliary programme

If the subroutine "TEMP" shall be tested in the SIKIT without a main programme the auxiliary routine is needed.

Label	Op. Code	Operand	Time µs	Comments
	ORG	1***H		YY start address
STACK:	EQU	1***H		ZZ RAM address for stack pointer
	LXI	SP, STACK		Load stack pointer with ZZ address
HPROG:	CALL	TEMP		Call subroutine TEMP
ZVERZ:	MVI	A, ØFH		Time delay, load accu with 16D
ZSCHL:	DCR	A	2.5	Decrement accu
	JNZ	ZSCHL	7.5	Result$\neq$Ø→jump time loop
	JMP	HPROG		Result=Ø→jump main program

Here the "CALL" instruction is followed by a time delay on account of a time loop into which the subroutine "TEMP" will jump on the "RETURN" instruction. This time delay of 16×7.5 µs is required for the complete discharge of capacitor C_T in the monoflop before the next start. In case of a line interrupt the monoflop would start again after 85 µs.

If there is a main programme a subroutine is called after time intervals of more than 200 µs, so that a time loop is not required.

Real time consideration

The run of the routines is entered into the programme list. The total duration is

at line interrupt: 6.97 ms with $n=328$,
at line short-circuit: 0.46 ms with $n=17$ and
at normal operation: 4.12 ms with $n=190$ (at $T_{rated\ max}$).

At normal operation the programme time depends on the number of count cycles n of the A/D conversion. At $T_{actual}=T_{rated}=60$ °C, which is the steady state of the controller, the time period for the programme is:

$(184 \times 21\ \mu s) + 120\ \mu s = 3984\ \mu s$.

When a lower resolution of the A/D converter is selected the programme time is reduced respectively.

Note! If the programme development and test is achieved with the RAM of the SIKIT, SAB 8111 A-4-D with an access time of <450 ns have to be used. This is the same when employing ROMs or EPROMs. In case memories with a longer access times are used, a wait cycle has to be added. The microcomputer adopts the waiting state after receiving the instruction address. In this case the A/D conversion has to be accordingly dimensioned.

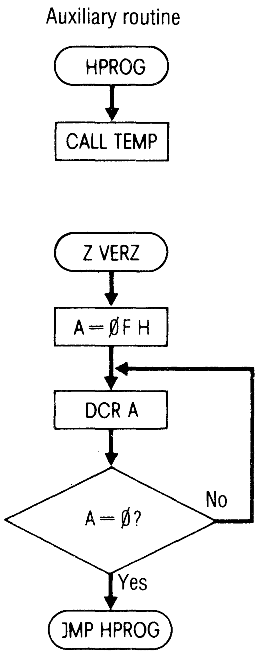


Fig. 9.1.7.

Components for circuit 9.1.2

		Ordering code	SCS stock number
1 System Kit	SIKIT-DK/8080	Q67201-C5	–
1 Timer IC	TDB 0555 B	Q67000-A1044	70319
2 Transistors	BCX 58/VIII	Q62702-C619	71173
1 LED	LD 52 C	Q62703-Q160	71333
1 LED	LD 57 C	Q62703-Q100-S4	70859
1 NTC resistor	M 822 100 k	Q63082-M2104-k	72126
1 MKH layer capacitor	10 nF	B32560-D6103-J	–
1 MKH layer capacitor	0.33 µF	B32560-D1334-J	–

9.2 Multiplex Operation of Key Boards and LED-Displays with the Microprocessor SAB 8080A

For the realization of equipment controls by means of microcomputer systems there exists often the problem that the provided input/output lines do not suffice. This concerns in particular single-chip microcomputers with 24 to 32 I/O lines.

One possibility to reduce the necessary number of I/O lines consists in operating the keys and displays in multiplex. The keys and displays are arranged in a matrix with lines and columns. The time-multiplex means that the different lines of the matrix are activated periodically, one after the other. The switching frequency is chosen so high in that the impression for the human eye is that of a static display. If we want to get the same visual brightness as in the static operation also in the multiplex operation, higher LED currents are necessary.

At microcomputer controlled devices the multiplex function is realized by software together with a periodic interrupt, i.e. the programme is interrupted by influence of external hardware.

The principle is explained by circuit of **fig. 9.2.1.** The difference between circuit **9.2.2** will be explained later on.

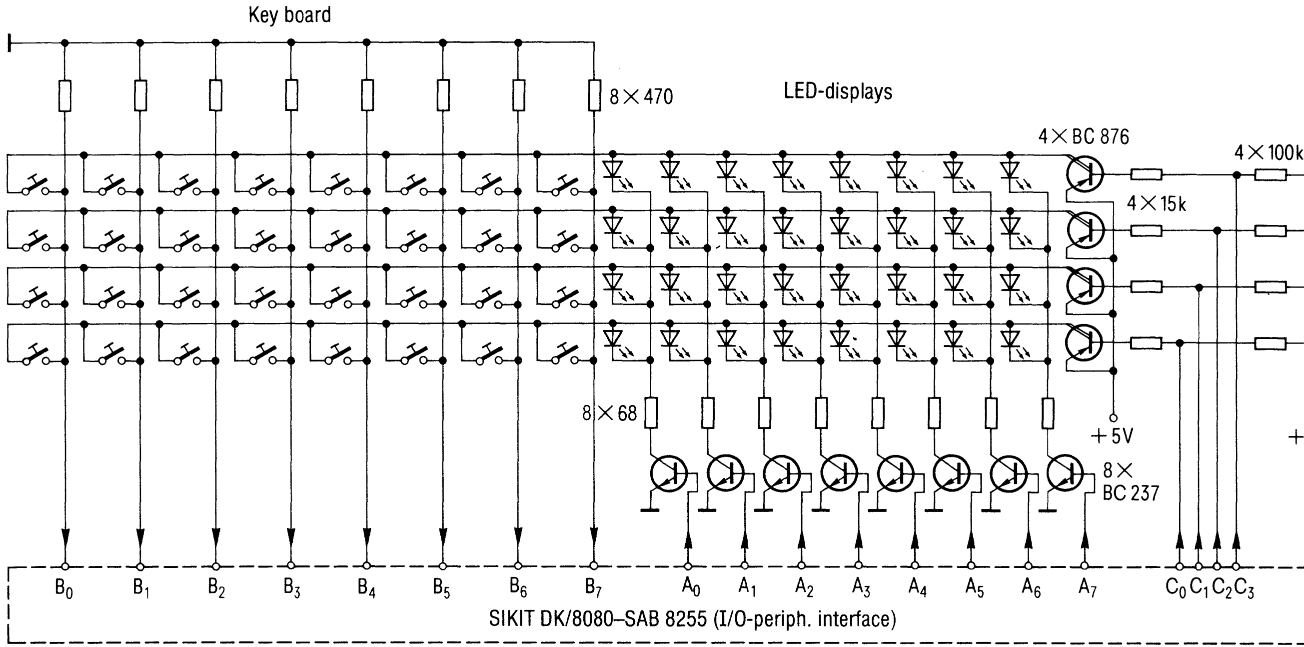
The total circuit comprises:
Microcomputer system kit SIKIT-DK/8080 **fig. 9.2.3**
Interrupt oscillator TDB 0555
Key matrix
LED matrix

The function of the key and LED matrices is determined by the user specified software of the microcomputer system (stored in the SIKIT either in a RAM or in an EPROM). Keyboard and LED display are composed of two matrices with four lines and eight columns each. The lines of two matrices are identical. They can be activated via Darlington transistors (BC 876).

Function of the LED matrix

The lines are turned on sequentially via Darlington transistors with a frequency of 200 Hz. Each line gets positive potential for 5 ms (5 V minus V_{CE}-leakage voltage of the BC 876). After 20 ms each line was activated at least one time (see pulse diagram of **fig. 9.2.4**). The columns of the LED matrix are switched by NPN transistors (BC 237). A LED is placed in every cross point of line and column. It only luminates if the respective line and column are activated. The current flows from the supply voltage +5 V via the Darlington transistor BC 876, the LED, the 68 Ω-limiter and the transistor BC 237 to ground. If a line is activated, a bit combination corresponding to the LED state of the relevant line, is applied simultaneously to the base of the column transistors. The drive of the next line switches also the information at the columns in that the actual column information is applied to each line (LED state of the corresponding line). Due to the high switching speed (5 ms per line) one gets the impression of a static image (static display).

Fig. 9.2.1.



Key board
8 × 470
LED-displays
4 × BC 876
4 × 100k
4 × 15k
8 × 68
+5V
+5V
8 × BC 237
B0
B1
B2
B3
B4
B5
B6
B7
A0
A1
A2
A3
A4
A5
A6
A7
C0 C1 C2 C3
SIKIT DK/8080–SAB 8255 (I/O-periph. interface)

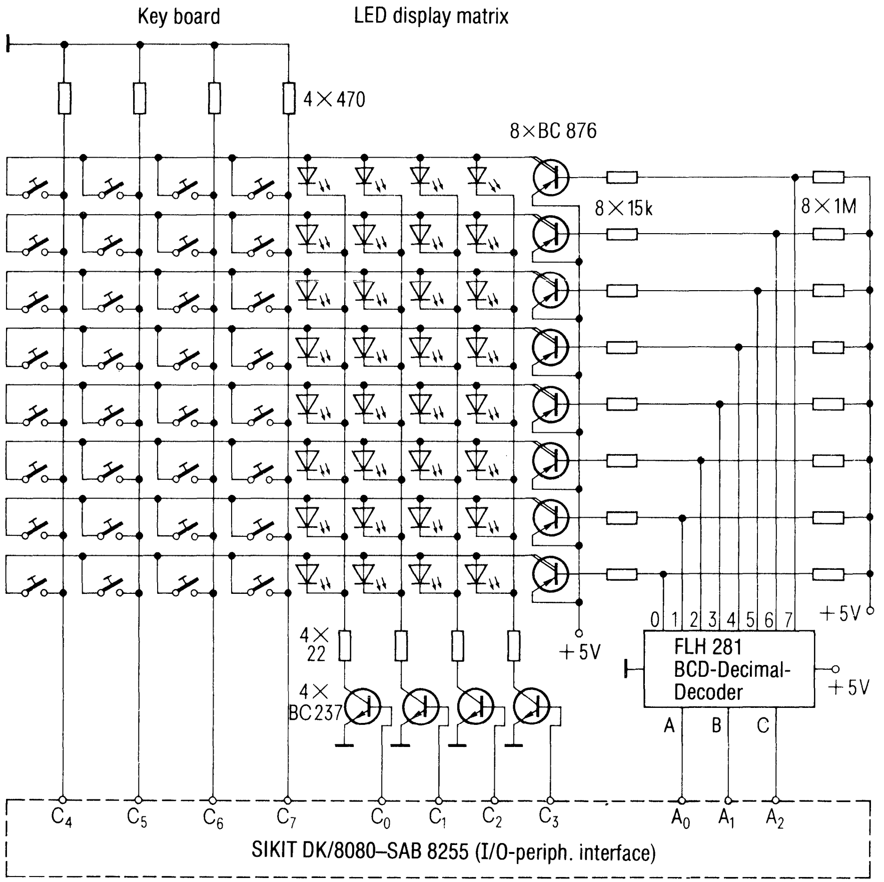


Fig. 9.2.2.

As the single LEDs are switched with a pulse duty cycle of 1 : 3 a correspondingly higher pulse current is necessary to obtain the same visual impression of brightness as with a static display.

Function of the key matrix

As LED and key lines are identical a new key line is activated every 5 ms (via Darlington transistors BC876). The columns of the key matrix are directly connected with port B of the programmable I/O-interface SAB8255. Port B is defined by the programme as an input in that the information at the columns can be read by the microprocessor (L or H signal). Lines and columns are connected by a key in the respective cross point. If a line is activated and a key of this line is pushed, the corresponding column will have H signal. A current flows from +5 V terminal via Darlington transistor BC876, the key, the 470 Ω-resistor towards ground.

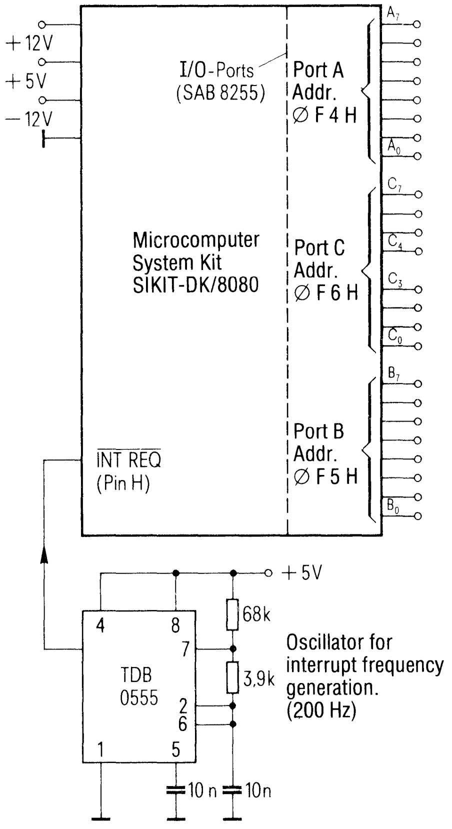
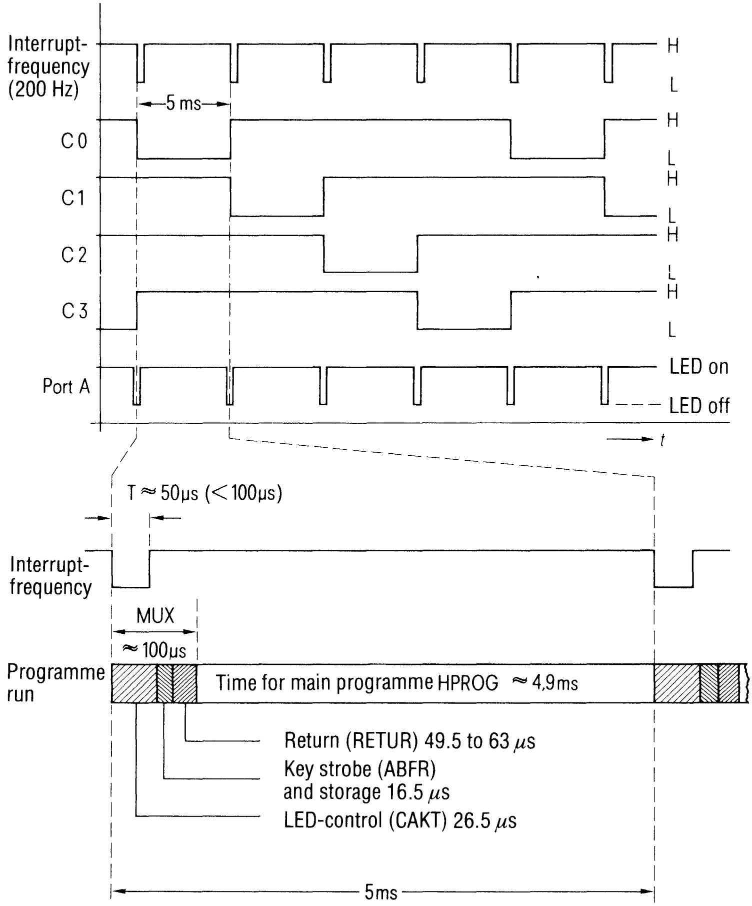


Fig. 9.2.3.

During the activation time of a line the information is read by the microprocessor at the columns of the key matrix and stores them. Each line has an own memory place. Each of the 32 keys is read at least once within 20 ms to ensure that a key action is gathered in any case, even if it is caused by a very short manual touch.

The same functions of circuit 9.2.2 differ from circuit 9.2.1 by the following items:

- Line-column distribution: eight lines (identical for display and keyboard) and four columns each.
- The line switching is not caused by the microprocessor directly with the help of the line Darlington transistors but by the BCD-decimal decoder FLH 281. Every BCD combination at inputs A, B, C of decoder FLH 281 (numbers Ø to 7) exactly corresponds to an activated output (L signal) of Ø to 7 at the FLH 281 and thus to one activated line (out of eight lines).
- The advantage of circuit 9.2.2 consists of a very small number of necessary I/O lines (11). This is achieved by the line-column distribution as well as by the use of the BCD-decimal decoder FLH 281.



Timing for different programme parts

Fig. 9.2.4.

- The higher pulse duty cycle of the LED current in the order of 1 : 7 (8 lines!) has to be considered as an inconvenience. To obtain the same brightness as in circuit 9.2.1 higher pulse currents are necessary.
- Circuit 9.2.2 can be extended by doubling the column number to 64 keys and 64 LEDs. There is no need to change the software.

Application possibilities of electronic switches for the keyboard

The function (see **fig. 9.2.5**) is very similar to that of the keyboards of the circuits 1 and 2. The keys are replaced by NPN transistors BC 237 accommodated in the cross points of lines and columns.

If a line is activated and a transistor of this same line is switched on, the relevant column reaches H-signal which can be read by the microprocessor. The current flows from +5 V terminal via the line Darlington transistors, the switching transistor and the 470 Ω-resistor to ground.

The transistors in the key matrix can be switched by corresponding signals, generated, e.g., by electronic sensors.

One example is the temperature monitoring with the help of an NTC resistor. The arrangement illustrates a two-position regulator with hysteresis.

When the rated temperature, which is fixed by a voltage divider, is reached, C_3 will feature H-signal as soon as the corresponding line is activated. If the microprocessor has read this information, it will for instance cut off the heating. If the temperature lies below the rated value, C_3 has an L-signal (heating turned on).

Software

As the functional mode (time multiplex) requires a time pattern (continuous line switching frequency = 200 Hz, T = 5 ms) a periodical subroutine call is needed. Each call controls one line. The subroutine controls the correct timing of lines and columns.

A periodic subroutine call is enabled by applying a periodic interrupt request (see also pulse level diagram, fig. 9.2.4) by means of the interrupt oscillator (timer TDB 0555, fig. 9.2.3). The timer output is connected to the interrupt-request-pin of the SIKIT. Each time the output of the interrupt oscillator changes from H to L the main programme is interrupted and the subroutine is activated for the control of keys and displays. An automatic return to the main programme follows.

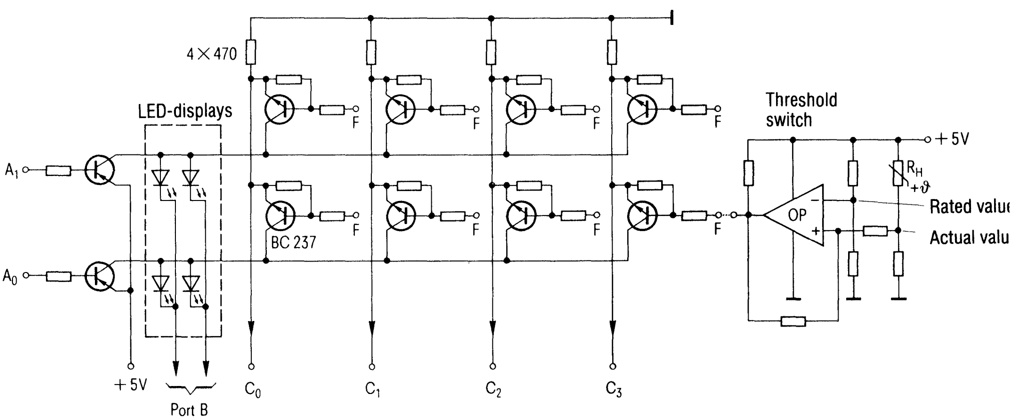


Fig. 9.2.5.

Principally, a subroutine can also be enabled by a CALL instruction. In this case a software counter has to follow the routine, which executes a call every 5 ms.

As the 200 Hz-clock-frequency is continuously needed, the microprocessor otherwise could not fulfill its tasks.

If the microprocessor includes an internal timer (e.g. SAB 8048) the external interrupt oscillator can be eliminated. An internal clock increments the time register (8 bit). An overflow of the timer register releases a so-called timer interrupt which, in turn, calls a subroutine, for instance keyboard and display subroutine. A preadjustment of the time register allows realization of different times. Here it is important that the counting in the timer register is independent of the currently running programme.

In view of an application of the programme as universal as possible for the different tasks of a key- and display matrix, no special functions were introduced into the programme.

The storage of a line key state and the strobe of the keys are executed separately. The storage is done by the subroutine, the strobe is realized by the main programme. It corresponds, for instance, one key line to eight different programmes of which one programme can be selected and started by pushing a key. The state of one of the pushed programme keys is stored accordingly in the subroutine. The main programme evaluates then the identity of the key and starts the corresponding programme. If the strobe was made by the subroutine, the latter had to be adapted to the application (loss of flexibility). The strobe routines within the programme require only a short time and a few ROM capacity.

The subroutine is divided into clearly defined functional blocks, so that an adaption to different tasks is easy. Consequently, the software of circuit 9.2.1 distinguishes from circuit 9.2.2 only by some constant values.

The programme can also be used, for instance, for a multi 7-segment display in multiplex mode. The lines correspond to the different digits of the display. The 7-segment code of the correspondingly displayed figure is applied to the columns.

The following tested programme has several functions:

- A LED is affected to each key for the acknowledgement (to state that the key action was recognized by the microprocessor).
- The corresponding LED luminates if the key is activated.
- Every key push is stored and can be read by the main programme.
- If a LED shall luminate without a key being pushed, the main programme just has to write the bit assigned to the desired LED into the corresponding register.
- The LED is turned off in the same way, i.e. by erasing the corresponding bit in the register.

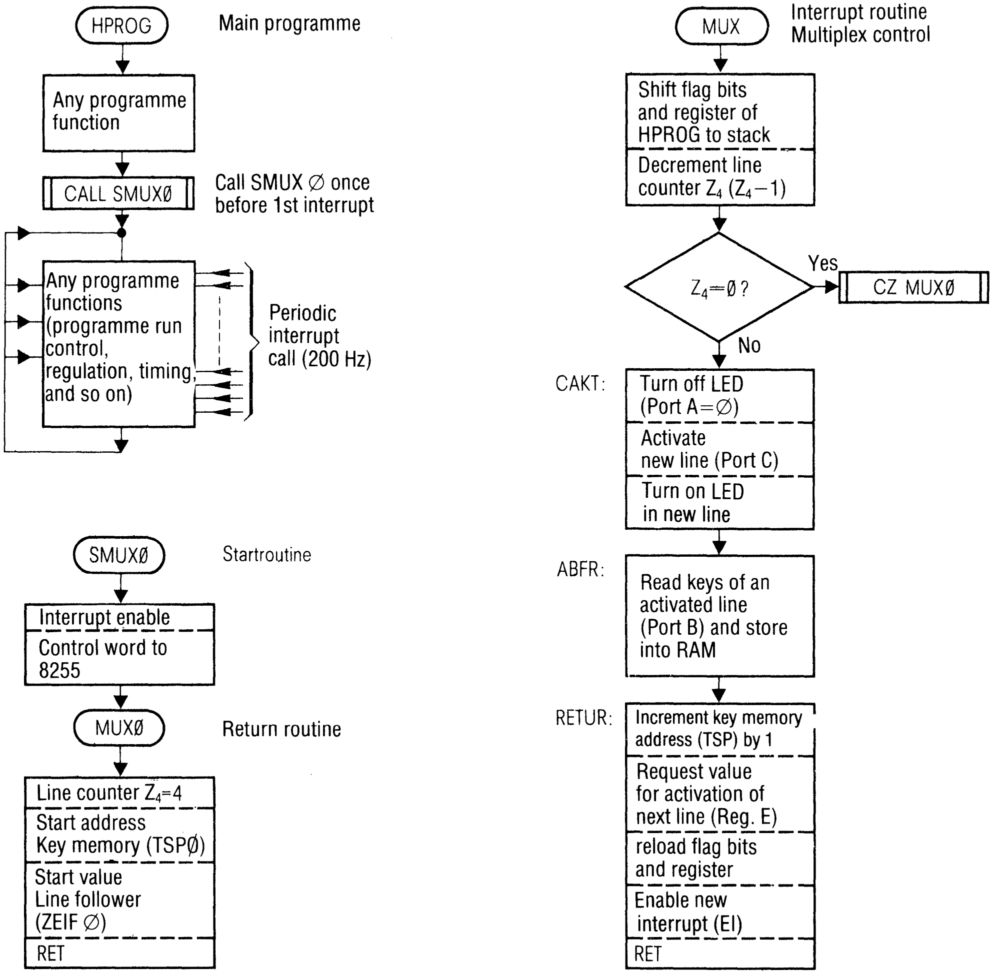


Fig. 9.2.6.

Flow chart

The flow chart shown in **fig. 9.2.6** comprises the logic structure of the subroutine as well as the relations to the main programme. It does not concern a certain microcomputer system. Beside some special 8080 designations (8255, register E) given with regard to the assembler programme, the chart can generally be used. The main programme is labled HPROG. Before the multiplex routine MUX for control of key and display matrices is first started by an interrupt, a unique call with the start routine SMUXØ has to be executed.

SMUXØ carries out the following:

- Interrupt is enabled.
- The inputs and outputs of 8255 are defined by the control word.
- Line counter Z_4 is set to the initial value 4.
- The key storage address is set to the initial value TSPØ. This is the RAM address which stores the key and LED state of the first line.
- The initial value for the activation of the first line is set (ZEIFØ).

As soon as HPROG is interrupted by the first interrupt request, the jump to the multiplex control MUX follows. Now the interrupt status of the flag bit and the registers of HPROG are stored in the stack. The line counter Z_4 is decremented.

The following inquiry requests as to whether Z_4 has Ø. This will by the case as soon as all lines of the matrix have been activated, i.e. at least after four MUX calls. If $Z_4 = Ø$, the reset routine MUXØ is called. This event reestablishes the conditions as they are necessary for the activation of the first line. If the result of the Z_4 request is unequal to zero, the programme executes the routine CAKT (activation of a line at port C).

CAKT controls the line commutation as well as affects the correct column information. As the microprocessor cannot execute at a time the line switching and the switching of the column information (lines and columns are connected to different I/O ports), the following procedure is necessary to avoid errors:

1. Turn off all LEDs of the previously activated line.
2. Line switch-over.
3. Set the column information corresponding to the newly activated line (from key memory TSP in the RAM). See also port A in the pulse diagram of fig. 9.2.4.

This method prevents that the wrong column information is shortly put on the activated line. Now, in the request routine ABFR the keys of the activated line are read and stored in the RAM under the key memory address TSP. The return routine RETUR prepares along with the return to the main programme, the activation of the next line:

- increment the key memory address,
- for the activation of the next line shift bit pattern into E,
- enable a new interrupt. If one interrupt is accepted, automatically any other interrupt is disabled.

Before the return is achieved, the stored values from the stack have to be reloaded. Every new interrupt causes the same procedure as described. Thus, the two matrices (keys and display) are automatically controlled in the multiplex mode by the periodic subroutine call with interrupt.

Assembler programme (see listing)

Circuit 9.2.1 for SIKIT-DK/8080

The programme is written in the 8080-Assembler language. For the use of hardwares other than SIKIT the programme constants (stack, RAM range, I/O addresses) and the interrupt transfer routine have to be changed.

The symbolic addresses (MUX, MUXØ, and so on) are in accordance with the descriptions in the flow-chart. To make the subroutine MUX run on the SIKIT, the given main programme HPROG can be used. The latter executes the unique call of the start routine SMUXØ and establishes a loop without apparent function. In the real user programme, HPROG executes the corresponding control functions.

Interrupt transfer routine

When an interrupt is executed with the SIKIT-DK/8080 the command RST 7 causes the programme to jump to address 38 H. This address lies in the ROM range of the SIKIT monitor programme and is inaccessible to the user. This is why a jump instruction (JMP) to the RAM address 13 FDH is marked under the address 38 H. In this RAM address the user can now write his special jump instruction for the interrupt routine, for instance JMP MUX.

If no SIKIT is used as hardware, the interrupt treatment has to be adapted accordingly.

Changes of the Assembler Programme for circuit 9.2.2

- New programme constants:
  ```
  MODE    EQU   88H
  ZEILE   EQU   Ø8H
  ZEIFØ   EQU   ØH
  ```
- Affect lines and columns anew to the I/O-ports by the routines CAKT and ABFR.
- Within the RETUR routine, RLC is replaced by INR E.

Proposition for reading routines within the HPROG (see listing)

ABFR1 finds the pushed key out of a row of eight keys and executes the jump to the corresponding programme.

Inquiry criterion is the carry bit.

ABFR2 monitors a switch (also an electronic one). Here, the corresponding bit is masked.

Time requirement for MUX

Requirements on the interrupt signal (fig. 9.2.4)

The interrupt oscillator releases an interrupt every 5 ms. The multiplex routine MUX requires about 100 µs. That means at the disposal of the main programme HPROG there are 4.9 ms between the two calls (98% referred to 5 ms).

The L-phase of the interrupt signal has to be shorter than the execution time of MUX (<100 µs). If this is not the case, HPROG would be interrupted twice within 5 ms. If the interrupt call is still present after the return of the first reading (L-phase>100 µs), a new interrupt would immediately be released.

The interrupt frequency can be increased if the structural timing of the main programme permits same.

Main programme and Multiplex routine

Label	Op. Code	Operand	Comment
	ORG	1000 H	PROGRAM CONSTANTS:
TSP0	EQU	1310 H	START ADDRESS OF KEY MEMORY
COUNT	EQU	1309 H	COUNT REGISTER
PORTA	EQU	0F4 H	I/0 PORT 8255 ADDRESSES
PORTB	EQU	0F5 H	
PORTC	EQU	0F6 H	
CWR	EQU	0F7 H	CONTROL WORD REGISTER 8255
MODE	EQU	82 H	CONTROL WORD 8255
ZEILE	EQU	04 H	LINE NUMBER
ZEIF0	EQU	0EE H	START VALUE LINE FOLLOWER
STAC	EQU	1390 H	STACK POINTER
			START ROUTINE SMUX0 AND
			RETURN ROUTINE MUX0
			HPROG CALLS SMUX0 BY CALL SMUX0
			MUX CALLS MUX0 BY CZ MUX0
SMUX0	EI		ENABLE INTERRUPT
	MVI	A, MODE	8255 INITIALIZE
	OUT	CWR	
	LXI	H, COUNT	LOAD REGISTER AND RAM
MUX0	MVI	M, ZEILE	WITH START VALUES
	LXI	B, TSP0	
	MVI	E, ZEIF0	
	RET		
			MULTIPLEX ROUTINE MUX
			CALL MULTIPLEX ROUTINE MUX
			BY PERIODIC INTERRUPT (RST 7)
MUX	PUSH	PSW	STATUS WORD AND ACCU IN THE STACK
	PUSH	H	H, L INTO STACK
	LXI	H, COUNT	COUNT ADDRESS TO H, L
	DCR	M	DECREMENT COUNTER CONTENTS
	CZ	MUX0	JUMP TO MUX0 FOR Z=0
			ACTIVATION OF THE DIFFERENT LINES (PORTC)
CAKT	XRA	A	ACCU=0
	OUT	PORTA	TURN OFF LED
	MOV	A, E	ACTIVATE
	OUT	PORTC	CORRESPONDING LINE
	LDAX	B	ACTUAL DATA (STATE OF LED)
	OUT	PORTA	TO PORT A
			KEY STORAGE
ABFR	IN	PORTB	PORT B INTO ACCU
	MOV	D, A	MASK ACTUAL DATA
	LDAX	B	OF PORT B WITH STORED DATA
	ORA	D	
	STAX	B	STORAGE

Label	Op. Code	Operand	Comment
			RETURN INTO MAIN PROGRAM
RETUR	INX	B	INCREMENT CONTENTS OF B, C,
	MOV	A, E	REQUEST LINE FOLLOWER VALUE FOR
	RLC		ACTIVATION OF
	MOV	E, A	NEXT LINE
	POP	H	POP STACK INTO H, L
	POP	PSW	SHIFT ACCU AND STATE WORD
	EI		ENABLE INTERRUPT
	RET		
			MAIN PROGRAM HPROG
			HERE ONLY AUXILIARY PROGRAM TO ENABLE
			RUN AND TEST OF MUX WITH SIKIT
HPROG	LXI	SP, STAC	LOAD STACK POINTER
	NOP		
	CALL	SMUXØ	SINGLE CALL OF START ROUTINE
SCHL	NOP		SIMULATE A PROGRAM LOOP
	JMP	SCHL	AS MAIN PROGRAM
	END		
	ORG	13FDH	INTERRUPT TRANSFER ROUTINE
	JMP	MUX	
	END		

Subroutines

Label	Op. Code	Operand	Comment
			SUBROUTINES ABFR1 AND ABFR2
			SUBROUTINE ABFR1 WITHIN HPROG
			FINDS A PUSHED KEY OUT OF
			8 IN ONE LINE WITH JUMP TO
			THE CORRESPONDING PROGRAM
ABFR1	XRA	A	ERASE CARRY BIT
	LDA	TSP	LOAD ACCU WITH CONTENTS OF TSP
	RRC		ROTATE ACCU CONTENTS RIGHT
			WITH BRANCH CARRY
	JC	ADRØ	IF CARRY=1, JUMP TO ADRØ
	RRC		
	JC	ADR1	
	RRC		
	JC	ADR2	
	RRC		
	JC	ADR3	
	RRC		
	JC	ADR4	
	RRC		
	JC	ADR5	
	RRC		
	JC	ADR6	
	RRC		
	JC	ADR7	
	JMP	HPROG	CONTINUE IN MAIN PROGRAM

```
                                  REQUEST ROUTINE ABFR2 WITHIN HPROG
                                  EXECUTES MONITORING OF A SWITCH
ABFR2     LDA       TSP           LOAD ACCU WITH CONTENTS OF TSP
          ANI       XXH           MASK SWITCH
          JNZ       ADRX          SWITCH CLOSED, JUMP TO ADRX
          JMP       HPRO2         SWITCH OPEN, CONTINUE IN HPROG
```

Components for circuit 9.2.1

		Ordering code	SCS stock number
1 MC system kit	SIKIT-DK/8080	Q67201-C5	–
8 Transistors	BC 237	Q62701-C697	70090
4 Transistors	BC 876	Q62702-D908	71720
32 LEDs	LD 57 C	Q62703-Q100-S4	70859

Components for circuit 9.2.2

1 MC system kit	SIKIT-DK/8080	Q67201-C5	–
1 BCD-Decimal-Decoder	FLH 281	Q67000-L3	8761
4 Transistors	BC 237	Q62702-C697	70090
8 Transistors	BC 876	Q62702-D908	71720
32 LEDs	LD 57 C	Q62703-Q100-S4	70859

Components for circuit 9.2.3

1 Timer IC	TDB 0555 B	Q67000-A1044	70319
2 MKH layer capacitors	10 nF	B32535-D6103-J	–

Components for circuit 9.2.5

1 Operational amplifier	TAA 861 A	Q67000-A278	7239
8 Transistors	BC 237	Q62702-C697	70090
2 Transistors	BC 308	Q62702-C704	70097
4 LEDs	LD 57 C	Q62703-Q100-S4	70859

9.3 16-Digit-Display for the Microcomputer System SAB 8080A Using the Alphanumeric LED-Display HA 4041

The LED-display-IC, type HA 4041, incorporates a memory and a decoder. It is favoured for applications in microcomputer systems. The HA 4041 contains 4 displays, therefore 4 ICs are required for displaying 16 digits.

The circuit shown in **fig. 9.3.1** is especially suited for the Mikroset 8080, but it can also be applied to other microcomputer systems offering DMA-facilities.

Function

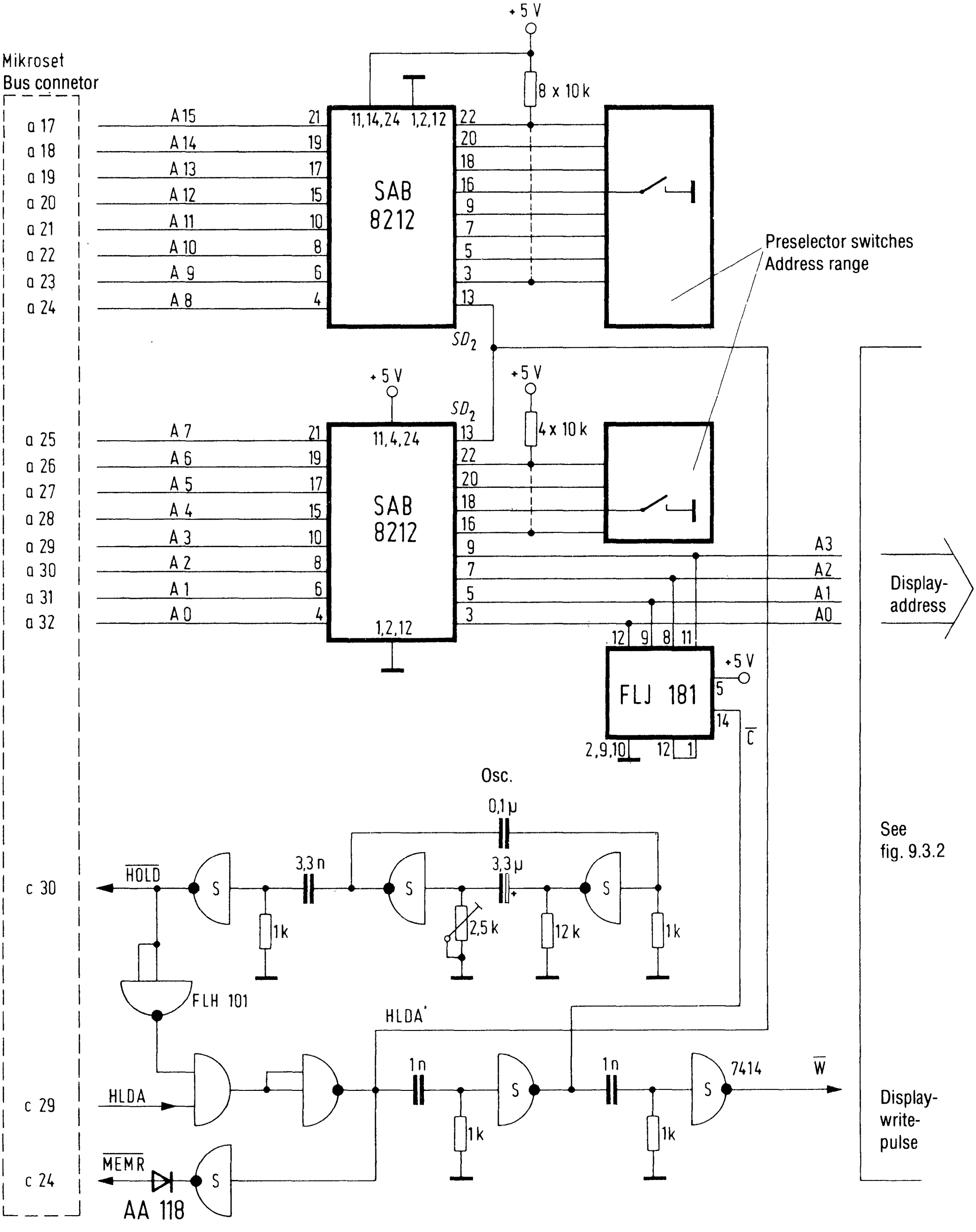
An additional circuit supplies a HOLD-instruction every 6 ms and after acknowledgement by HLDA an ASCII-data-word is loaded into the internal memory of the HA 4041. In this case the microprocessor programme has to be interrupted for 6 µs. After 16 HOLD-instructions the information for all 16 digits has been written into the display memory of the HA 4041 and is displayed. The total loading requires 16×6 ms $= 96$ ms and during this period the microprocessor does not operate for a time period of 96 µs. No additional software is required for reading and displaying. The ASCII-data-words, however, have to be defined and stored at corresponding places of the memory.

Circuit description

An oscillator consisting of 2 inverters supplies a signal with a frequency of approx. 150 Hz. Periodical HOLD-pulses with a duration of 8 µs are generated by a differentiation-circuit comprising 3.3 nF-capacitor and 1 kΩ-resistor. The pulse repetition period is 6 ms. The microprocessor SAB 8080 supplies a HLDA-signal approx. 2 µs after receiving the leading edge of the HOLD-pulse. By adding this signal with the HOLD-signal a pulse with a duration of 6 µs is generated, the trailing edge of which coincides with the one of the HOLD-pulse. During the HLDA-pulse the address of the memory-place, which has just been read, is supplied to the address-bus of the MC-system via two latches SAB 8212. The 12 most significant address-bits are determined by preselector switches, the 4 least significant ones are supplied by a 16 bit-counter, which is incremented by one at each HLDA-pulse. Since there are to be data on the data-bus after receiving the display writing pulse $\overline{W}$, this pulse is generated from the $\overline{MEMR}$-pulse by a double-differentiation and by means of two Schmitt-triggers. **Fig. 9.3.3** shows the timing of the described pulses.

Display

Buffers are connected between the data bus and the HA 4041 as shown in **fig. 9.3.2.** The IC FLL 101 operates as 1 of 4-decoder for selecting one of the 4 display-ICs.



Mikroset
Bus connetor
a 17
a 18
a 19
a 20
a 21
a 22
a 23
a 24
a 25
a 26
a 27
a 28
a 29
a 30
a 31
a 32
c 30
c 29
c 24
A 15
A 14
A 13
A 12
A 11
A 10
A 9
A 8
A 7
A 6
A 5
A 4
A 3
A 2
A 1
A 0
+5 V
8 x 10 k
4 x 10 k
11,14,24 1,2,12
SAB 8212
11,4,24
1,2,12
SD2
Preselector switches
Address range
A3
A2
A1
A0
Display-address
FLJ 181
2,9,10
Osc.
0,1 µ
3,3 n
3,3 µ
2,5 k
12 k
1k
HOLD
FLH 101
HLDA'
HLDA
MEMR
AA 118
1 n
7414
W
See fig. 9.3.2
Display-write-pulse

Fig. 9.3.1.

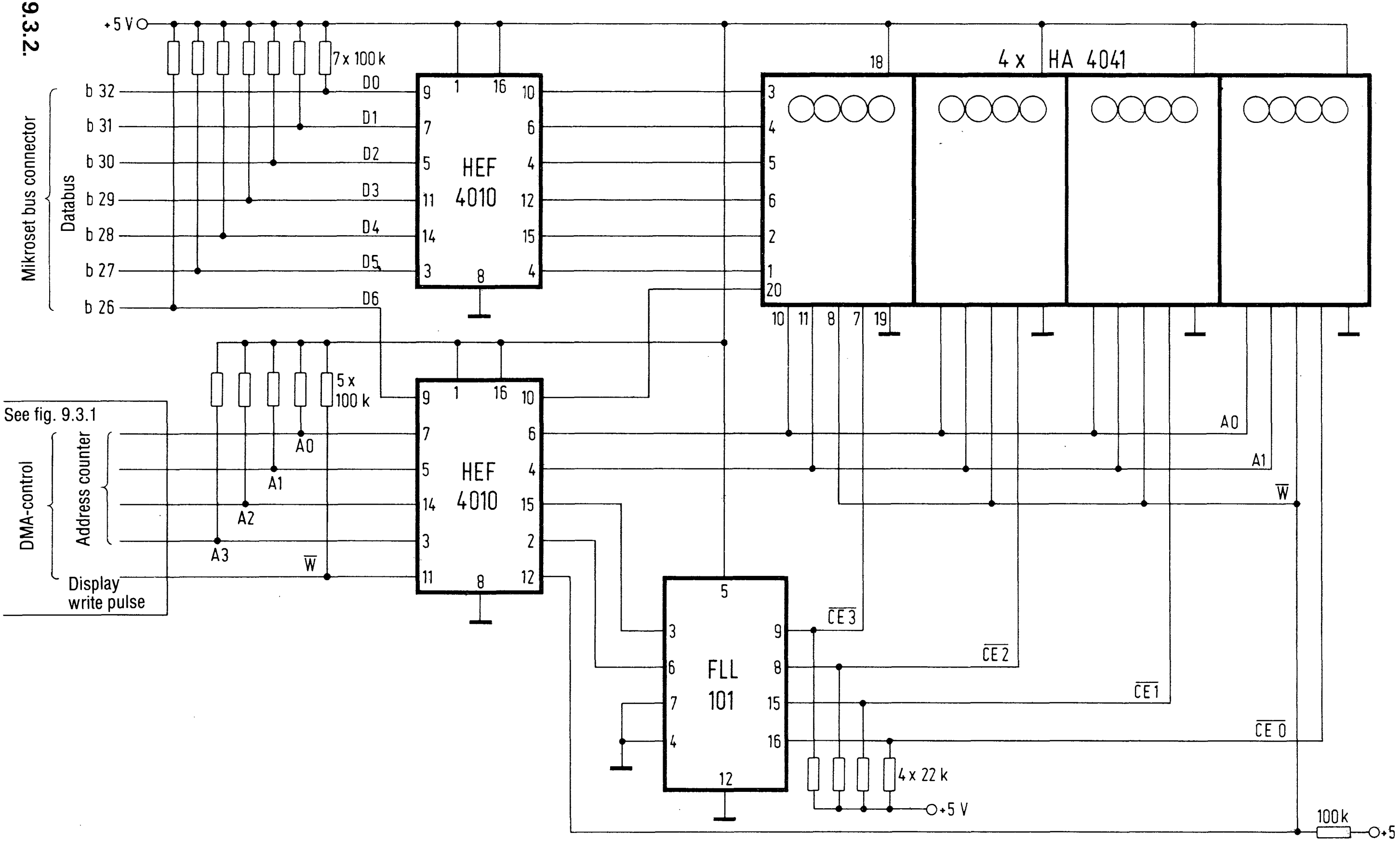

+5 V
7 x 100 k
Mikroset bus connector
Databus
b 32
b 31
b 30
b 29
b 28
b 27
b 26
D0
D1
D2
D3
D4
D5
D6
HEF 4010
4 x HA 4041
5 x 100 k
See fig. 9.3.1
DMA-control
Address counter
A0
A1
A2
A3
W̄
Display write pulse
FLL 101
C̄Ē 3
C̄Ē 2
C̄Ē 1
C̄Ē 0
4 x 22 k
100 k

Fig. 9.3.2.

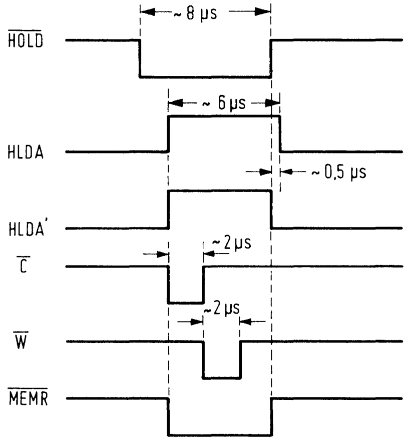


Fig. 9.3.3.

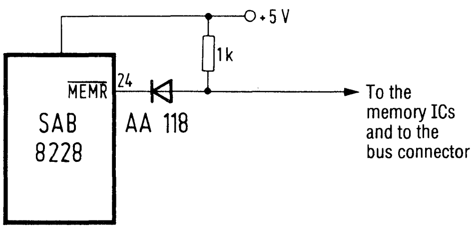


Fig. 9.3.4.

Modification of the Mikroset 8080

As shown in **fig. 9.3.4** a diode AA118 and a pull-up resistor are connected between the IC SAB8228 and the memories avoiding that the $\overline{\text{MEMR}}$-line of the Mikroset 8080 is influenced by two different sources.

Expansion possibilities

The described principle of operation is applicable to an infinite number of digits. The address counter, however, has to be adapted to the requirement and the strobe frequency probably has to be increased to avoid too long cycle-times. Besides that it is possible to drive display-lines for letters. If the total text is stored at successive memory places, single text lines can be displayed with a chosen rhythm by means of the microcomputer system. In this case the most significant address bits have to be incremented by one at corresponding times. Moving-news-panel is also possible, if the address range is periodically shifted within the memory of the microcomputer system.

Components for circuit 9.3.1

		Ordering code	SCS stock number
2 8-Bit-I/O-ports	SAB 8212-P	Q67020-P3-F88	70964
1 NAND-gate	FLH 101	Q67000-H1	8658
1 Schmitt-Trigger-Hex-Inverter	7414	Q67000-L109	–
1 4-Bit-binary counter	FLJ 181	Q67000-J34	8763
1 Diode	AA 118	Q60101-X118	8010
2 MKH layer capacitors	1 nF	B32560-D6102-J	27618
1 MKH layer capacitor	3.3 nF	B32560-D6332-J	27622
1 MKH layer capacitor	0.1 µF	B32560-D1104-J	27548
1 Tantalum electr. capacitor	3.3 µF	B45178-A5335-M	29803

Components for circuit 9.3.2

4 LED-displays red	HA 4041 r	Q68000-A4825	71784
2 C-MOS-drivers	HEF 4010	–	–
1 BCD-decimal-Decoder	FLL 101	Q67000-L1	8776

Components for circuit 9.3.4

1 Diode	AA 118	Q60101-X118	8010

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