SECTION 3

NON-LINEAR AMPLIFIER AM19/503

Introduction

The AM19/503 accepts a non-composite positive-going video signal at 0·7 volt p-p which is applied to a network of diodes and resistors so that the output signal, at 0·25 volt p-p, is distorted according to a pre-determined non-linear characteristic. The equipment requires also a feed of negative-going mixed syncs at 2 volts p-p.

The AM19/503 comprises three units known as Unit 1, Unit 2 and Unit 3 which, in normal use, plug into a PN3/23 chassis together with an extra unit-3 module (if required), an AM5/507 and a power supplier PS2/13M (Instruction G.2) to form a Non-linear Amplifier AM19/504. Index peg positions for the three sub-units are:

Unit 1	4 and 21
Unit 2	8 and 20
Unit 3	8 and 22

In addition to the three units mentioned above a Unit 4 is available for test purposes. This is used to determine the component values necessary to construct a non-linear circuit (Unit 3) having any particular transfer characteristic within the range of the equipment. Unit 4 is similar to Unit 3 and has the same index peg positions.

General Specification

Unit 1

Non-composite video input

Amplitude	0·7 V p-p
Impedance	75 ohms

Mixed sync pulse input

Amplitude	2 V p-p ± 3 dB
Impedance	about 2 kilohm

Non-composite video output

Amplitude	about 10 V
Impedance	about 30 ohms (not to be terminated)

D.C. supplies

Positive relative to chassis	18 V, 30 mA 36 V, 60 mA
(With white-level pulse generator not operating)	36 V, 45 mA

Unit 2

Non-composite video input

(Via relay contacts RLA-2, RLB-1 and RLB-2)

Amplitude	about 0·25 V p-p
Impedance	1 kilohm

Non-composite video output

Amplitude (across 75 ohms)	about 0·125 V
Impedance	75 ohms

D.C. supply 18 V, 25 mA
(Positive relative to chassis)

Unit 3

Non-composite video input

(via contacts RLA-1 in Unit 2)

Amplitude	10 V (approx)
Impedance	1·5 kilohms (approx)

Non-composite video output

Amplitude	0·25 V (approx)
Impedance	75 ohms

D.C. supply 18 V, 25 mA
(positive relative to chassis)

All units operate over the temperature range 20—45 degrees C.

Circuit Description

The three units of the AM19/503 are constructed on separate printed wiring boards and each is mounted on a CH1/12A chassis.

Unit 1 contains a 23-dB amplifier which is associated with a relatively complex feedback clamp circuit of the synchronous detector type. The clamp establishes the potential of the video signal during the back-porch period. Blanking-level must be held within close limits because the action of a non-linear network which follows the clamp (in Unit 3) would tend to exaggerate any level variations which occur in the region of black level. A subsidiary circuit in Unit 1 can be used to add white-level pulses to the non-composite video output signal. Each pulse, which is timed to occur during a line-sync period, provides a clamping potential which is required for use in associated equipment under certain conditions of operation of the AM19/503.

Unit 2 provides a low-impedance source of modified video signals for an external circuit and contains also a 0-dB amplifier which can be switched into the circuit by a relay so that the output signal is inverted. A second relay in Unit 2 enables the signal to be routed to either of two non-linear networks which may be incorporated in the complete assembly.

Unit 3 contains the non-linear (diode and resistor) network together with an emitter-follower output stage.

Unit 1

Fig. 3.1 is the circuit diagram of this unit. The non-composite video input signal is applied to a feedback amplifier, comprising transistors TR1 to TR3, which has a gain of 23 dB. The feedback path includes a frequency-conscious circuit which ensures optimum stability and maintains the gain of the amplifier substantially constant to 8 MHz.

Transistors TR24 and TR25 generate a white-level pulse from a feed of mixed syncs when pins 10 and 13 of the module socket are connected. Capacitor C35 and the bias chain form a differentiating circuit. TR24 is normally conducting but is cut off for about 4 µs by the negative-going spikes which are coincident with the leading edges of line-frequency pulses. The time-constant of the differentiating circuit is chosen to prevent operation by twice-line-frequency pulses contained in the mixed-sync signal.

When TR24 is cut off TR25 is bottomed and the potential on the base of TR4 rises to about +18 volts. The resultant 4-µs pulses thus added to the video signal at TR4 emitter occurs during that part of the blanking period normally allotted to the line-sync pulse. The tip of this pulse is at white level and provides a reference level which is used for clamping purposes, when the non-composite video signal is inverted by use of Unit 2, and for aligning the non-linear amplifier. If the voltage of a white-level signal at TR4 emitter is arranged to be the same as that of the pulse, then the amplitude of the signal applied to the following non-linear circuit (in Unit 3) is correct.

The non-composite video signal from TR4 is fed also to a bridge circuit formed by diodes D9—D12 where it is compared, during the line-blanking period, with the d.c. reference voltage established by zener diode ZD4. Diodes D2 and D3 serve to limit excursions of the signal applied to the bridge, and to reduce spurious signals present as a result of the clamping action.

Mixed sync pulses are applied to TR12 and are differentiated in the collector circuit. Diode D7 removes the resultant positive-going spikes; the negative-going spikes, each coincident with the trailing edge of a line sync pulse, are amplified by TR13 and TR14.

Two outputs are taken from the emitter of TR14; one is routed to the base of the demodulator transistor TR20 and the other drives the sampling bridge via a phase-splitting transformer.

Any difference between the reference potential and the blanking level of the video-signal produces an output from the bridge during the time the diodes are forward biased. The pulses resulting from repeated comparison of the two signals form an error signal which is amplified and fed from the low-impedance source created by TR18 and TR19 to the base of TR20. This transistor conducts only when a pulse from TR14 is present and thus it extracts the error information from the amplitude-modulated pulse waveform. During the sampling period C32 is charged to about the peak value of the pulse from TR18 and TR19. The demodulated error signal, represented by the varying potential on C32, is smoothed by R65 and C33 and amplified by TR21, TR22 and TR23. The time constant of the filter circuit determines the time taken for the clamp to restore correct d.c. conditions of the signal output subsequent to an error being detected by the bridge. In practice, the duration is about 300 µs; this is the maximum speed of response possible. The output from TR23 is fed to the emitter of TR1 so that the d.c. shift which caused the error is reduced.

Unit 2

Fig. 3.2 shows the circuit of this module.

The non-composite video signal output from Unit 1 is routed through contacts RLA1 in Unit 2 to the non-linear network in Unit 3. The resultant distorted signal is returned from Unit 3 to contacts RLA-2 (in Unit 2), and thence via contacts of a second relay, RLB, to an emitter-follower, TR9. Alternatively, when RLB is energised, the signal is first applied to transistor TR8 (connected as a

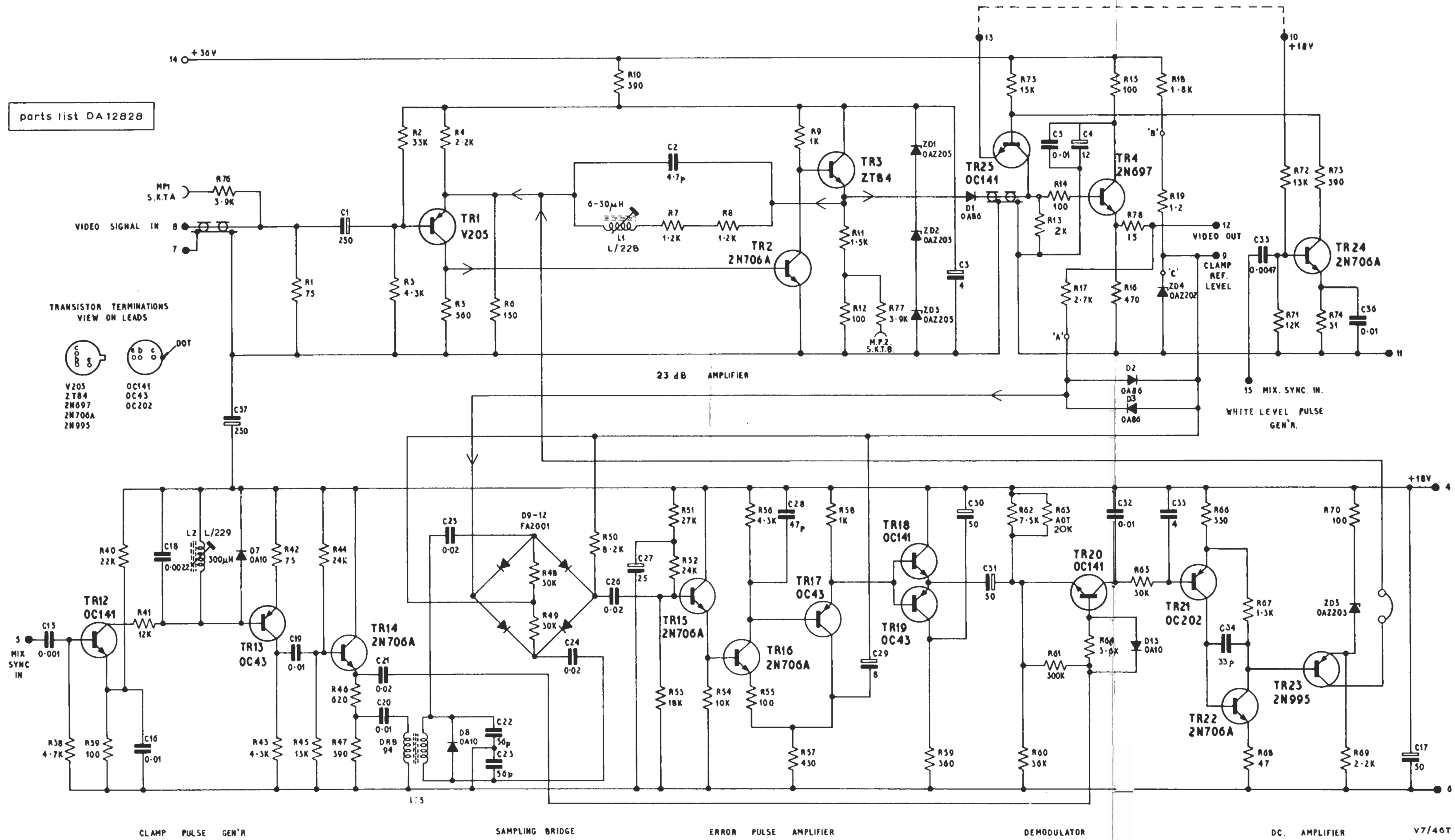


Fig. 3.1 Circuit of the AM19/503, Unit 1

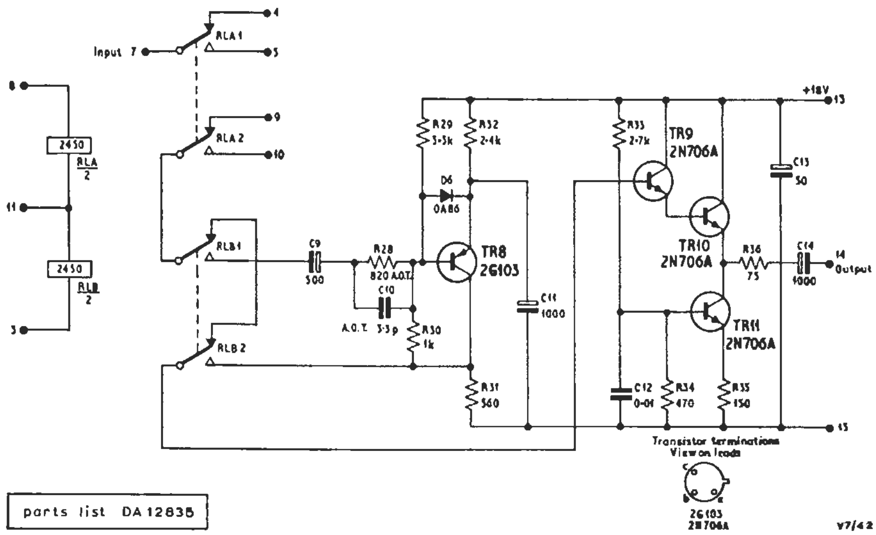


Fig. 3.2 Circuit of the AM19/503, Unit 2

0-dB gain amplifier), and the signal is thus inverted before being fed to TR9.

TR10 and TR11 form a low impedance source supplying a non-composite video signal to the external circuit. The output-impedance is raised to 75 ohms by the series resistor R36.

Relay RLA can be remotely operated so that the video signal is routed to one of two non-linear networks (assuming two Unit-3 modules are incorporated in the complete assembly; see AM19/504).

Unit 3

The circuit of this unit is given in Fig. 3.3 and shows a number of diode and resistor chains, each of which is arranged to distort the input signal to a different degree, the variously-modified signals being subsequently mixed to produce a combined output signal distorted according to the required non-linear transfer characteristic.

Fig. 3.4 shows a single chain having a similar circuit to each of those employed in Unit 3.

The instantaneous potential of a linear sawtooth signal applied between A and B is limited in Unit 1 to an excursion of +6 to +18 volts; the practical limits in Unit 3 are typically +6·3 and +17 volts.

Diode D1 is cut-off when the signal reaches a potential determined by the dividing action of R1, R2 and R3. The output from C is therefore a low-level, truncated sawtooth signal, as indicated in Fig. 3.4. The potential at which the sawtooth departs from its linear shape is referred to as the breakaway point.

Resistor R4 determines the proportion of the modified signal developed by the chain which is mixed with signals from other chains. D2 is included to provide a voltage which compensates for that due to the impedance of the clipping diode, D1.

Fig. 3.3 shows that three chains (numbered 1, 2 and 3) are provided, each being similar to that shown in Fig. 3.4. Each chain can be adjusted to produce different degrees of attenuation to the more negative parts of the input signal, and also to have different breakaway points. Thus, the slope of the combined transfer characteristic changes by discrete amounts, the most negative part being the steepest as indicated by the output waveform shown in Fig. 3.3. This effect is known as black stretch.

A fourth chain (number 4) is connected in a different manner although the circuit action is similar to that described for the other three. In this instance, however, the lower part of a linear sawtooth applied across D404 and R421 is removed. The result of adding the modified signal from this chain is to increase the slope of the more positive part of the combined transfer characteristic. The effect of this action is known as white stretching and is shown in the waveforms of Fig. 3.3 by the sharp tip of the distorted sawtooth

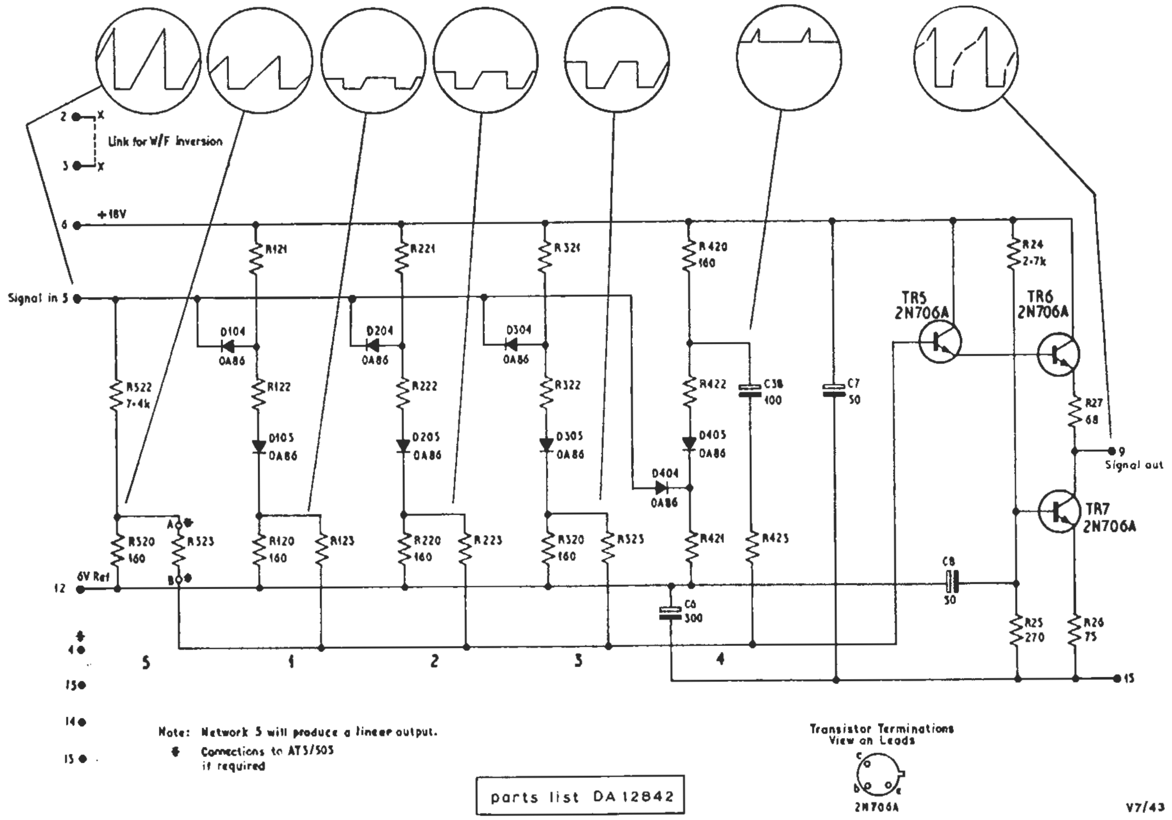


Fig. 3.3 Circuit of the AM19/503, Unit 3

output signal.

A proportion of the unmodified input signal can also be added to the output by resistors R522, R520 and R523, which comprise chain number 5.

The combined signal produced by mixing various proportions of the signals from each chain is fed to an output circuit which is similar to that used in Unit 2. C6 is included to reduce spurious signals present in the feed of the 6-volt reference potential from Unit 1. Further reduction of these unwanted signals is arranged by applying them in reverse phase through C8 to TR7.

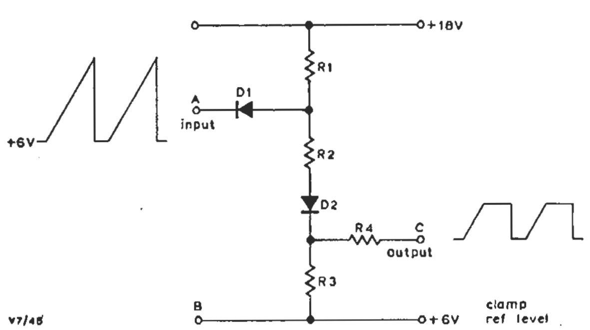


Fig. 3.4 Single Diode-resistor Chain from Unit 3

Unit 4

The circuit of Unit 4, which is normally used only for test purposes, is shown in Fig. 3.5. A network of diodes and resistors form a number of chains as in the Unit-3 circuit, except that some of the resistors are variable, and that extra resistors can also be switched into the circuit if required.

Two chains which clip the positive parts of the incoming signal (as in chains 1, 2 and 3 of Unit 3; see Fig. 3.3) are provided. A third chain can be switched (by SA) to provide a similar positive-clipping action or, alternatively, can produce negative clipping in the manner of chain 4 of Unit 3 (Fig. 3.3). A variable proportion of the unmodified input signal is introduced into the total output signal by resistor chain 5.

The output amplifiers of Unit 4 and Unit 3 are identical.

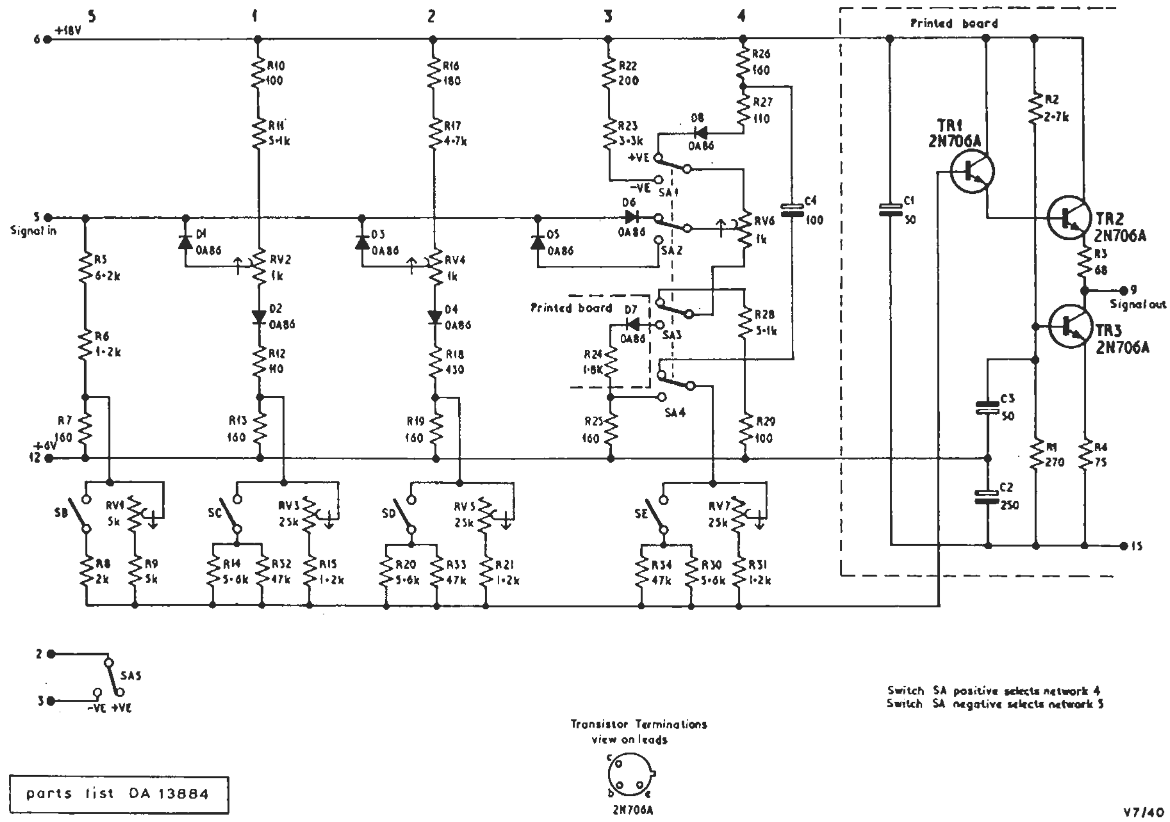


Fig. 3.5 Circuit of the AM19/503, Unit 4

Determination of component values for Unit 3 using Unit 4

The following description outlines the procedure for using a Unit-4 module to derive the component values necessary to construct a non-linear circuit (Unit 3) having a particular transfer characteristic.

Test apparatus required

Oscilloscope, such as Tektronix 535
Unit 4 module
Type CH1A/1 chassis extender

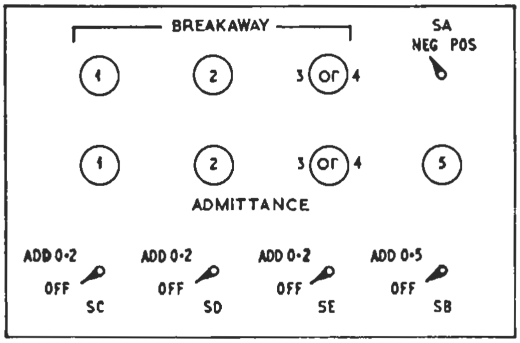
Note. The various units comprising the AM19/503 are normally assembled with other units to form a non-linear amplifier type AM19/504. The following procedure is detailed in relation to the equipment in this form.

Fig. 3.6 shows the number and positions of the various controls provided on the Unit 4 chassis. A conversion chart, to be used in conjunction with control-dial readings obtained from Unit 4, is also shown.

Procedure

1. Connect the Unit 4 module to the chassis extender and plug this assembly into one of the Unit-3 positions of the combined equipment (AM19/504).
2. Draw the required characteristic to suitable scales on the oscilloscope graticule. This drawing will have the form of a distorted sawtooth composed of straight lines of differing slope similar to that shown as the output waveform in Fig. 3.3.
3. Apply a linear sawtooth waveform signal to the input of the AM19/503.
4. Obtain a trace on the oscilloscope screen showing the nonlinear amplifier output signal waveform. Adjust the level of the applied signal so that the output signal shows correct correspondence between the tip of the sawtooth and the white-level pulse (see circuit description of Unit 1). Adjust the oscilloscope gain and time-base controls so that the shape

R421 breakaway 4	5·2K	5·3K	5·4K	5·5K	5·6K	5·7K	5·8K	5·9K	6·0K	6·1K	6·2K
R321 breakaway 3	4·5K	4·4K	4·3K	4·2K	4·1K	4·0K	3·9K	3·8K	3·7K	3·6K	3·5K
R221 breakaway 2	5·88K	5·78K	5·68K	5·58K	5·48K	5·38K	5·28K	5·18K	5·08K	4·98K	4·88K
R121 breakaway 1	6·2K	6·1K	6·0K	5·9K	5·8K	5·7K	5·6K	5·5K	5·4K	5·3K	5·2K
breakaway reading	0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	1·0
R122 breakaway 1	110	210	310	410	510	610	710	810	910	1·01K	1·11K
R222 breakaway 2	430	530	630	730	830	930	1·03K	1·13K	1·23K	1·33K	1·43K
R322 breakaway 3	1·8K	1·9K	2·0K	2·1K	2·2K	2·3K	2·4K	2·5K	2·6K	2·7K	2·8K
R422 breakaway 4	1·11K	1·01K	910	810	710	610	510	410	310	210	110



Operating notes

1. Switch SA
   in negative position network 3 selected
   in positive position network 4 selected
2. To obtain the values of the following resistors in KΩ :–

   $$K\Omega = \frac{1}{\text{admittance value}} \quad \text{(see below)}$$

   For R123 admittance value = ① + SC
   " R223 " " = ② + SD
   " R323 " " = ③ + SE
   " R423 " " = ④ + SE
   " R523 " " = ⑤ + SB
3. Values of resistors R121, 221, 321, 421 & R122, 222, 322, 422. as required to be obtained from table

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Fig. 3.6 The Controls and Conversion Chart for Unit 4

of one cycle of the displayed signal can be compared with the superimposed diagram.

5. Set each of the breakaway controls (upper row) until the angles in the displayed sawtooth slope and those shown in the drawing of the required characteristic lie on the same vertical lines.
6. Adjust the admittance controls (using, if necessary the extra admittance values available by operating the switches mounted immediately below the variable controls) until the displayed waveform corresponds as nearly as possible with the required characteristic.

Note that, when making the adjustments described in 6, above, the total admittance (i.e. the addition of the figures shown on all the variable and switched controls) must be 1·0 ± 0·2. The satisfaction of this requirement ensures that the correct source impedance for the Unit-3 output emitter follower is obtained; it is an additional requirement to the simple one of making the two shapes coincide.

7. Obtain the required resistor values by comparing the breakaway figures given by the upper control-dial readings with the chart shown in Fig. 3.6.

The remaining resistor values can be obtained by using the admittance readings and the formula given in Fig. 3.6.

Note that the reading given by the breakaway control adjacent to switch SA is used to derive a resistor value from the chart for R321 (breakaway 3) or R421 (breakaway 4). The value to be chosen is indicated by note 1 of Fig. 3.6, and depends on whether the resultant non-linear characteristic is required to produce an effect of white stretch (SA set to NEG) or to have an additional stage of black stretch (SA set to POS).

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