Transistor Amplifier DESIGN

3 FOUR CIRCUITS USING 2N2926

By A. Foord

Now that high gain *npn* silicon transistors are readily available at low cost, they can be used in place of germanium types, even at audio frequencies. The 2N2926 is a typical example of a planar silicon transistor intended for general purpose applications, and can be obtained in five categories of current gain, each with a spread of two to one. Its ratings are given in Table 3.1.

This article outlines four simple audio circuits which are sometimes used in association with those described earlier in this series.

EMITTER FOLLOWER

Fig. 3.1 shows a common emitter amplifier, followed by an emitter follower. The emitter follower stage is generally used for two reasons: to prevent the output loading the collector of the amplifier stage and to enable loads as low as 1 kilohm to be fed. The maximum output of this circuit is 1V r.m.s. into 1 kilohm.

The three possible positions for connecting the emitter decoupling capacitor enables different degrees of local negative feedback to be applied to the first stage, to reduce the gain if required.

In position A the emitter is completely decoupled (no feedback) and the amplifier has an input impedance of 6 kilohms for a typical gain of 300 times, depending on current gain of the particular transistor used. Without the 220pF capacitor (C3) in circuit the upper 3dB down point is 90kHz; with the 220pF capacitor the bandwidth is reduced to 27kHz. The lower 3dB down point is at 25Hz.

In position B the emitter is only partially decoupled and negative feedback through R4 reduces the gain to 75 times at an input impedance of 10 kilohms.

In position C the gain is 10 times, feedback being nearly 100 per cent through both R4 and R5. The input

Table 3.1. CHARACTERISTICS OF 2N2926 TRANSISTOR

Maximum collector-emitter voltage	18V
Maximum reverse base-emitter voltage	5V
Maximum mean collector current	100mA
Power dissipation in free air at 25°C ambient temperature	200mW
Gain bandwidth product (typical)	120MHz

Colour Code	A.C. current gain at 10V 2mA 1kHz	D.C. current gain at 4·5V 2mA (typical)
Brown	35 to 70	36
Red	55 to 110	62
Orange	90 to 180	115
Yellow	150 to 300	155
Green	235 to 470	215

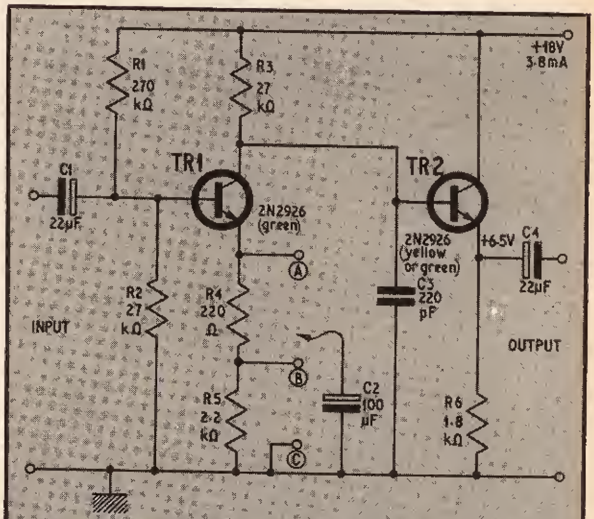

Fig. 3.1: Simple amplifier using a common emitter and emitter follower stage. Capacitor C2 has three alternative connections for setting the degree of a.c. feedback. Position C is equivalent to having no capacitor at all, maximum feedback. Position B gives a small amount of feedback. Position A gives minimum feedback

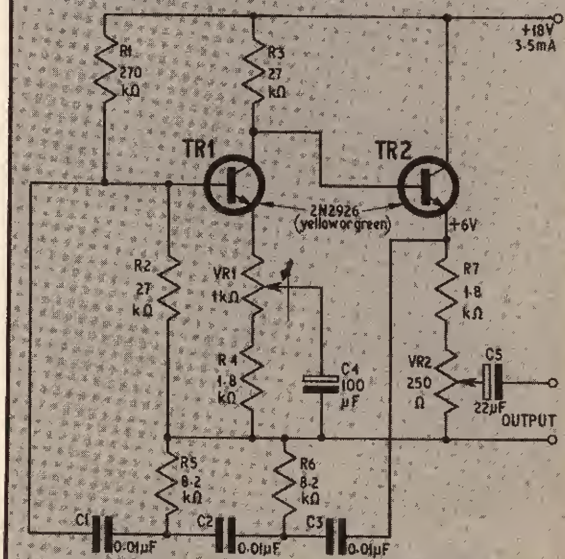

Fig. 3.2: Phase shift oscillator at 400Hz when 360 degrees phase shift is achieved between network and amplifier

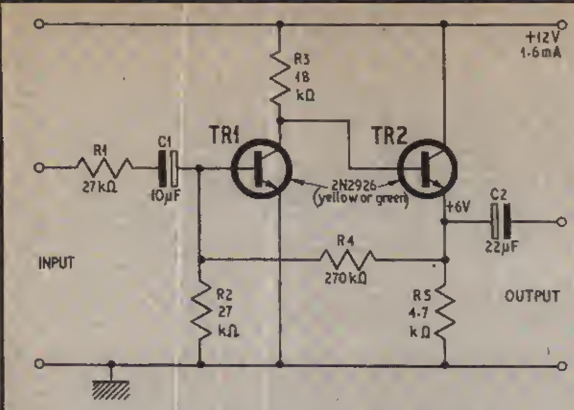

Fig. 3.3. Times ten fixed gain amplifier

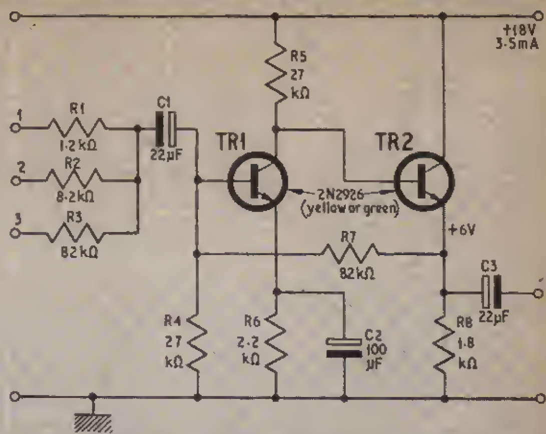

Fig. 3.4. Amplifier providing three fixed gains through the input resistors

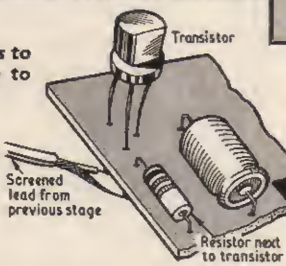

Fig. 3.6b. The correct method is to position the input resistor close to the transistor

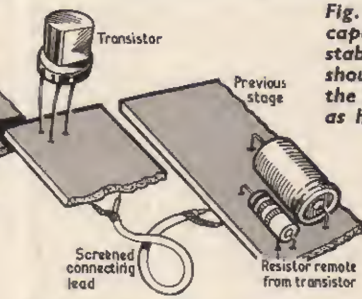

Fig. 3.6a. To avoid stray capacitance affecting a.c. stability the input resistor should not be remote from the base of the transistor as here

impedance is also 10 kilohms. The output impedance is less than 50 ohms in each case.

The frequency response of this circuit is +0 −3dB, 25Hz to 27kHz with C3 connected. If C3 is disconnected, the frequency response is modified to +0 −3dB, 25Hz to 90kHz.

Since this type of circuit has a high input impedance and a low output impedance, several can be cascaded without interaction.

PHASE SHIFT OSCILLATOR

A very similar amplifier circuit can be modified to provide a phase shift oscillator (Fig. 3.2). There is a 180 degree shift in the amplifier and another 180 degree phase shift in the ladder network (C1, C2, C3, R5, R6) so that the complete circuit oscillates at about 400Hz. VR1 should be increased from minimum gain until the circuit just oscillates.

Output is from 0 to 1V peak-to-peak set by VR2. The output is tapped from the emitter chain (R7, VR2) of the second transistor to avoid loading the amplifier and because 1V output is usually enough for most audio testing purposes.

TIMES TEN AMPLIFIER

The common emitter, emitter follower arrangement in Fig. 3.1 has series local feedback applied to the first stage to reduce its gain if required. Negative feedback can also be applied in a different manner (see Fig. 3.3). Here feedback is applied from the emitter of the second transistor to the base of the first. For this arrangement, performance details are:

Gain 10 times.
Maximum output 1V r.m.s. into 2·2kΩ load.
Output impedance less than 50Ω.
Input impedance 27kΩ.
Frequency response +0 −3dB, 20Hz to 80kHz.

FIXED GAINS AMPLIFIER

A more elaborate arrangement, capable of giving various fixed gains and a higher output current is shown in Fig. 3.4. Characteristics here are:

Maximum output 1V r.m.s. into 1kΩ load.
Output impedance less than 50Ω.
Frequency response +0 −3dB, 20Hz to 100kHz.
Input 1—gain 60 times, input impedance 1·2kΩ.
Input 2—gain 10 times, input impedance 8·2kΩ.
Input 3—gain 1 times, input impedance 82kΩ.

In each case the *source* impedance must be less than the value of the input series resistor if the full gain of the circuit is to be realised, so this circuit must be fed from an emitter follower. It can be made to have a gain variable from 1·6 times to 60 times by replacing the input resistor by a series variable resistance of 50 kilohms and a fixed resistor of 1 kilohm.

Construction of all these circuits can follow normal audio practice; printed circuit boards are ideal. For the circuits in Figs. 3.3, 3.4, and 3.5 it is particularly important to keep the leads on the base of the first transistor short. When connecting one of these amplifiers up the resistor should be at the end near the first stage, any stray capacitance up to 20pF or so from TR1 base to earth could cause unwanted oscillations. When using screened input leads, follow the preferred method of connection (Fig. 3.6) with the input series resistor close to the TR1 base to minimise stray capacitance effects between screen and core.

Part 4 next month is the beginning of a deeper investigation into the properties and effects of negative feedback in audio amplifiers. Some examples of practical circuits are included to illustrate this.