

In the May 1984 issue of *Elektor* we mentioned that connecting the digital cassette recorder described in January of this year to the output of a ZX81 can cause problems. Since then we have worked day and night (in spirit at least) to find a solution to help owners of this computer. This article deals with what we came up with.

digital cassette recorder  
with the ZX81  
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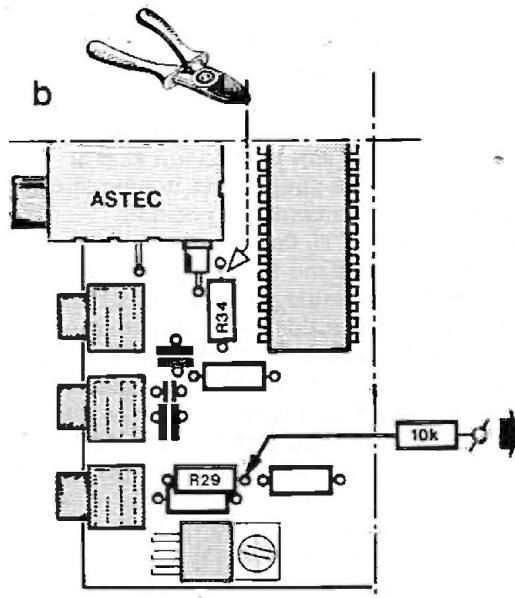
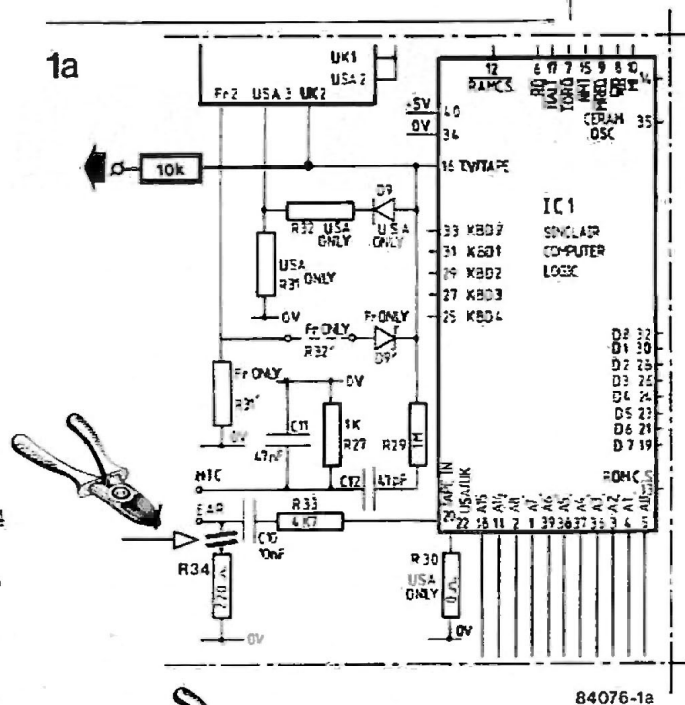
# digital cassette recorder with the ZX81

A few changes are needed both to the cassette recorder board and the ZX81 board and we will begin with the latter. Part of the circuit of the ZX81 is shown in figure 1. The computer's output signal must be amplified by making a new cassette output. This is done by connecting a 10 k resistor to the TV/TAPE output (pin 16) of IC1. All this means is soldering the resistor to R29 on the printed circuit board, as indicated by figure 1b. The output signal then has an amplitude of 150 mV<sub>pp</sub>. The digital cassette recorder operates by driving the tape into saturation but the ZX cannot do this very easily as the impedance of its EAR input is too high. All that is required to lower the impedance is to cut the connection of R34 to EAR.

Moving on to the cassette recorder board, the hysteresis of A1 must be reduced by increasing the value of resistor R6 to 82 k. The amplification of the playback section is reduced by increasing the value of R20 to 10 k. The pause-level is improved by giving C8 a value of 10 n. The pair of relays, Rel and Re2, can better be operated by hand. In normal use the video signal is present at the cassette output of the Sinclair with the result that the circuit will always select recording. The easiest way to solve this problem is to cut the copper track close to pin 6 of Re2 and link pin 6 to +12 V via a switch. For those who want the ultimate, a band-pass filter (with a centre frequency of about 5 kHz) can be added in the playback section. In this case C6 = 10 n, C8 = 2n2, C9 = 100 n and R20 remains 1 k. All that remains then is to connect a 560 p capacitor parallel to R21.

To enable the circuit to be calibrated a short program with a large loop must be written into the computer and the **SAVE** command is then given. The preset at the input, P1, must now be trimmed so that LED D11 lights properly. The analogue output, AN, is used when playing a recorded program back to the ZX81. For playback preset P3 must be set so that the program is read into the computer correctly. This can be seen by looking at the width of the black bars on the screen. There should be slightly more black than white visible.

When reading in a program it is important that preset P1 should be turned completely to ground or that the plug be removed from the input of the recorder



makes the  
storing of  
programs more  
reliable for  
Sinclair's  
smallest

circuit. Under no circumstances may LED D11 light during playback. This is essential to prevent cross-talk between the recording and playback sections. Probably the best solution is to short-circuit the input by using a 3.5 mm socket with a built-in switch. As soon as the plug is removed from the socket the input is then grounded.

When the modifications given here are carried out there will be joy in the hearts of Sinclair ZX81 users as this computer can finally be used with the Elektor digital cassette recorder.

The ZX81 is one of the most popular personal computers but it does leave a lot to be desired in certain respects, one of the most notable of which being its cassette interface. Any ZX81 user who has had to type in a complete program again because it could no longer be loaded from cassette will confirm this. The pulse cleaner described here is designed to make such problems a thing of the past. This makes it a must not only for ZX81 users but also for any other computer that uses a similar type of pulse/pause system for the cassette connection.

# ZX81 cassette pulse cleaner

The Sinclair ZX81's cassette interface uses frequency shift keying (FSK) with a single frequency. The signal is built up of a number of pulses, a pause, a number of pulses again, another pause, and so on (see figure 1a). The number of pulses between two pauses indicates the logic level: four pulses represent a logic zero and eight pulses are used to indicate a logic one. If this signal is stored on a cassette tape the 'digital' shape cannot be properly processed due to limitations in the recorder's electronics and the qualities of the tape itself. When the data is read from the tape it will enter the computer as a signal that looks something like that shown in figure 1b. The oscillation on the last pulse before a pause could cause the computer to falsely consider this as an extra pulse, with dire consequences. In order for the computer to be able to process it properly this signal should really be made into a digital signal with all the interference removed.

## The layout

The various parts of the circuit are seen in the block diagram of figure 2. The incoming signal from the cassette recorder is first passed through an adjustable attenuator before being amplified and

passed through a band-pass filter. This is followed by another amplifier and a high-pass filter. All this is necessary to remove any low frequency oscillations from the signal as the computer could interpret them as extra pulses. The filtered signal is then fed through a negative and positive peak rectifier. A Schmitt trigger compares these output signals with the signal from the high-pass filter to ensure that short noise pulses are also removed. The result is a clean digital cassette signal at the output. The output signal from the positive peak rectifier, incidentally, is also used to control the attenuator at the input.

a cassette output signal cleaner for computers with single-frequency FSK

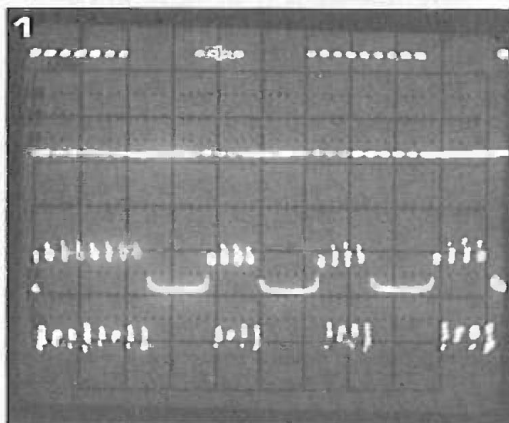


Figure 1. These are the sort of pulses that appear at the ZX81's cassette output (top). After processing by the cassette recorder the signal (bottom) does not look quite so 'clean'.

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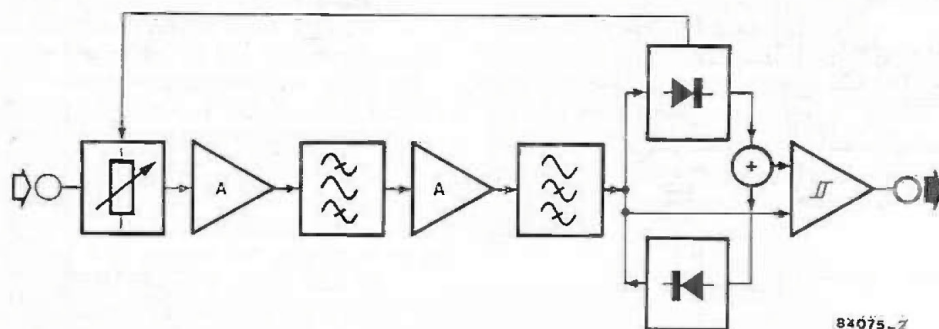


Figure 2. The circuit for the pulse cleaner, as the block diagram here shows, consists of some amplifiers and filters, a pair of peak rectifiers, a comparator section and an attenuator.



## The circuit

The circuit diagram for the pulse cleaner is shown in figure 3. The input signal is first of all attenuated by preset P1 and then passes to the adjustable attenuator. The output of positive peak rectifier A2 determines the d.c. voltage at the base of transistor T1, which, in turn, decides the current passed through diodes D1 and D2 and therefore the impedance (or, strictly speaking, the differential resistance) of the diodes. When the output voltage of A2 is high the attenuation of the input signal will be correspondingly high. The moving coil meter in the collector line of T1 gives a visual indication of the strength of the signal.

The attenuator is followed by op-amp IC1 which amplifies the signal by a factor of eleven and then feeds it to the band-pass filter consisting of R4...R9 and C3...C8. The filtered signal is amplified by a factor of 100, by A1, to compensate for the attenuation introduced by the band-pass filter. The low frequency part of the signal

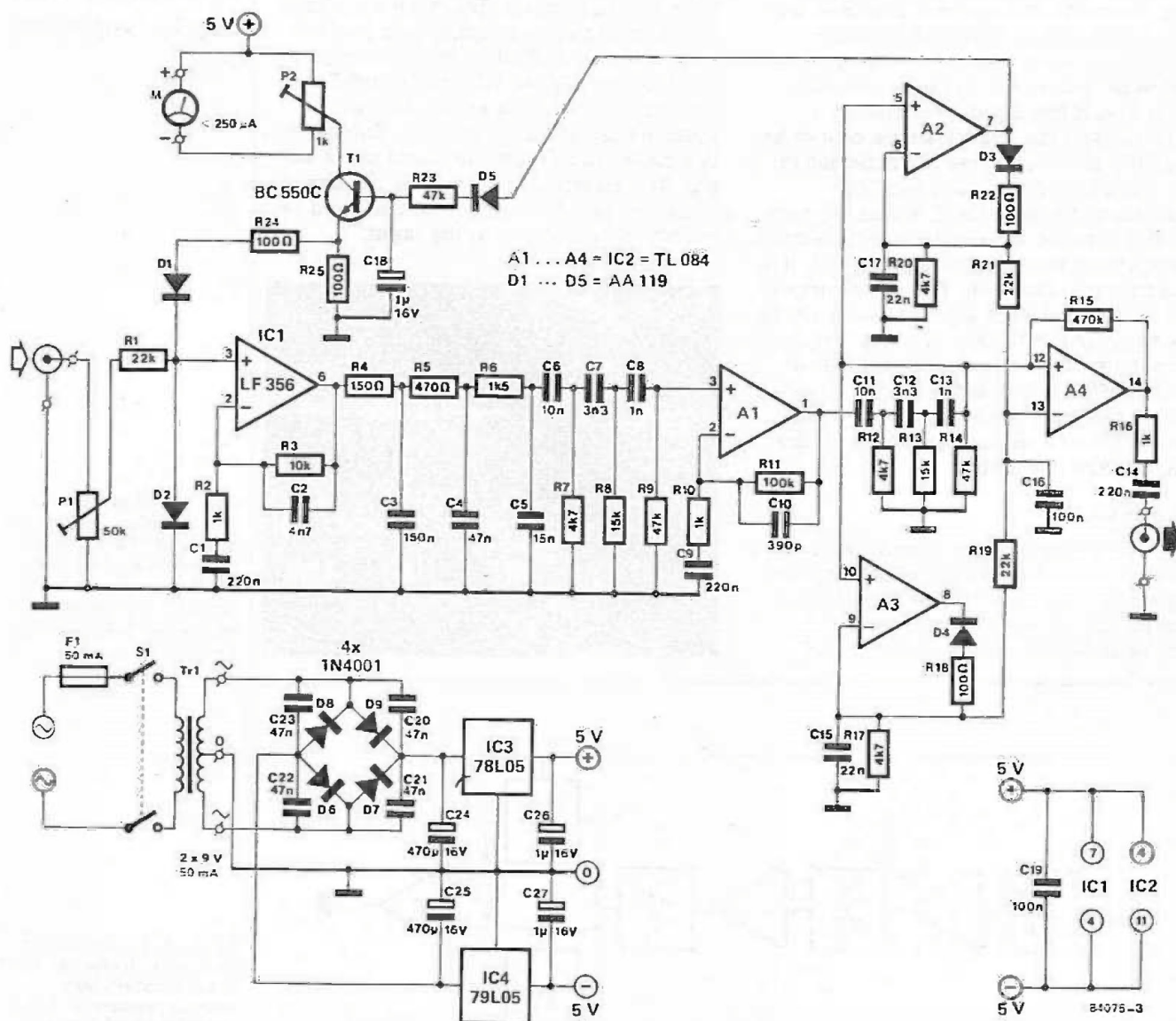
is then removed by high-pass filter R12...R14/C11...C13 whose cut-off point is at about 9 kHz.

The treated signal is fed to the inputs of the two peak rectifiers, A2 and A3, and the non-inverting input of Schmitt trigger A4. Each rectifier consists of an op-amp with a diode at the output. A 22 nF capacitor (C15 or C17) is charged to the maximum value of the input voltage via the diode, which is part of the op-amp's feedback loop. The 100  $\Omega$  resistors are needed to limit the charging current that the op-amps provide.

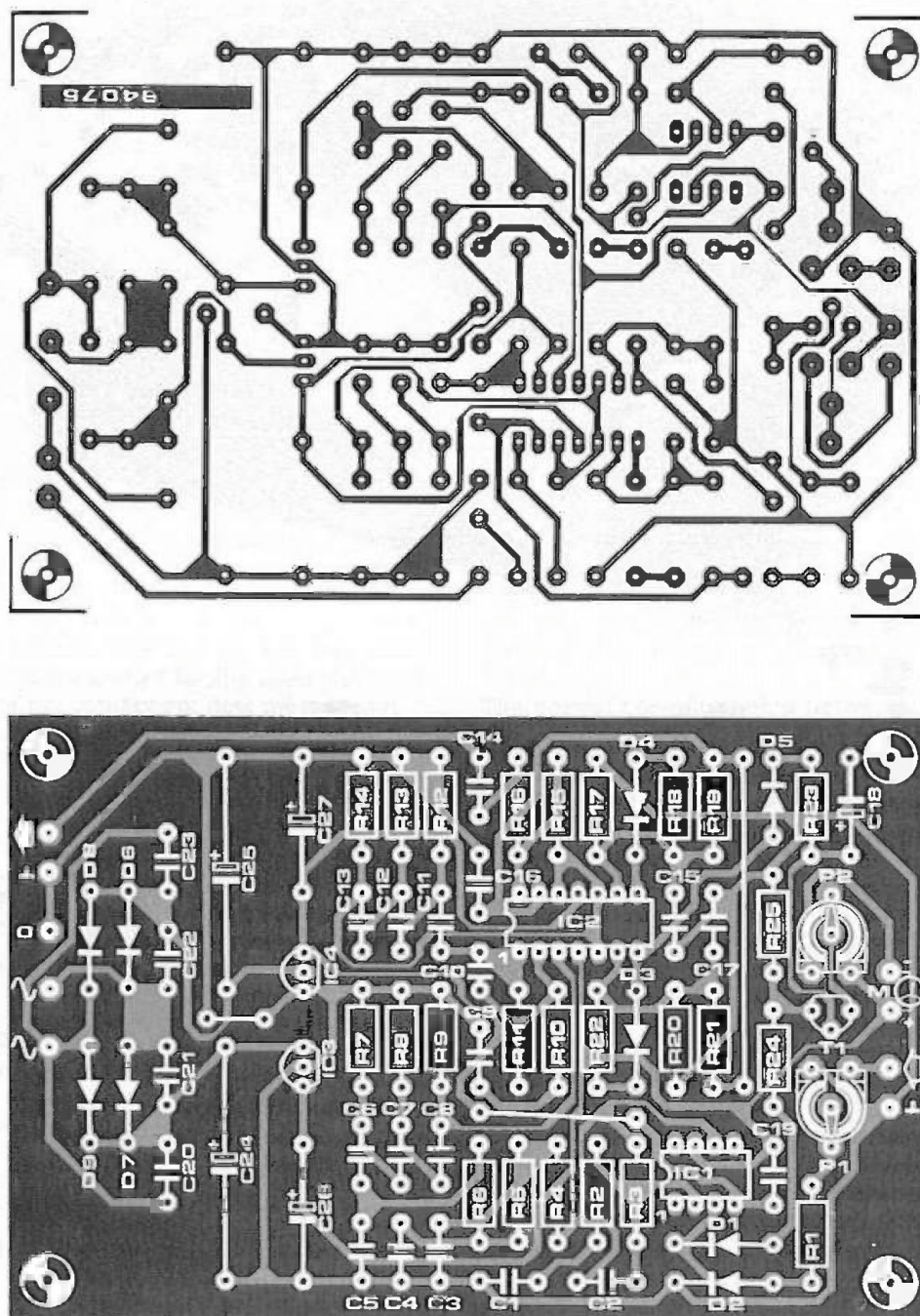
The output signals from the two rectifiers are added via resistors R19 and R21 and then go to the inverting input of A4. The other input of the Schmitt trigger, as we have already noted, is connected to the output of the high-pass filter so that A4 compares the rectifier signals with the differentiated cassette pulses provided by the filter. The output of the circuit is a clean rectangular waveform that can be fed directly to the ZX81 cassette input.

Figure 3. The circuit diagram for the pulse cleaner. As the circuit is quite straightforward all the sections from the block diagram can easily be found here.

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## Parts list

## Resistors:

R1, R19, R21 = 22 k  
 R2, R10, R16 = 1 k  
 R3 = 10 k  
 R4 = 150  $\Omega$   
 R5 = 470  $\Omega$   
 R6 = 1k5  
 R7, R12, R17, 20 = 4k7  
 R8, R13 = 15 k  
 R9, R14, R23 = 47 k  
 R11 = 100 k  
 R15 = 470 k  
 R18, R22, R24, R25 = 100  $\Omega$   
 P1 = 50 k preset  
 P2 = 1 k preset

## Capacitors:

C1, C9, C14 = 220 n  
 C2 = 4n7  
 C3 = 150 n  
 C4, C20 ... C23 = 47 n  
 C5 = 15 n  
 C6, C11 = 10 n  
 C7, C12 = 3n3  
 C8, C13 = 1 n  
 C10 = 390 p  
 C15, C17 = 22 n  
 C16, C19 = 100 n  
 C18, C26, C27 = 1  $\mu$ /16 V  
 C24, C25 = 470  $\mu$ /16 V

## Semiconductors:

D1 ... D5 = AA 119  
 D6 ... D9 = 1N4001  
 T1 = BC 550C  
 IC1 = LF 355  
 IC2 = TL 094  
 IC3 = 78L05  
 IC4 = 79L05

## Miscellaneous:

F1 = fuse, 50 mA slow blow  
 M1 = moving coil meter,  $\leq 250 \mu$ A f.s.d.  
 S1 = double pole mains switch  
 Tr1 = mains transformer, 2  $\times$  9 V, 50 mA

## In practice

Small though this circuit is we thought it worthy of a printed circuit board design. This is shown in figure 4. As the power supply is included on the printed circuit board the only external components are the transformer and, of course, the meter. The various connection points, input, output, meter and power, are all clearly marked. When everything is connected and mounted the two presets must be set. Calibrating and testing the circuit is done with the pulse cleaner connected between ZX81 and cassette recorder. Now, while trying to load some (well recorded) programs from the cassette, trim preset P1 until all programs are received correctly.

When this is done set P2 so that the needle of the meter is in mid scale while programs are being loaded.

The meter reading can be used as a reference point when loading programs. If the needle does not indicate mid scale P1 should be trimmed until the reference position is again indicated. In this way even programs that have been difficult to load in the past can now be loaded properly.

Figure 4. The printed circuit board for the FSK pulse cleaner can be fitted into its own case or there may be room for it within either the computer or the cassette recorder.