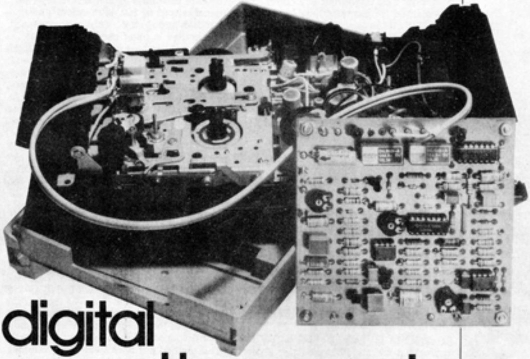

digital cassette recorder

Cassette recordings are still the most popular memory for home computers because they offer the cheapest method available. Unfortunately, it is not the most reliable method because a cassette recorder is, after all, intended for processing audio rather than digital signals. The present circuit converts a normal cassette recorder into a digital one with vastly improved data transfer capability without the loss of the audio facility.

. . . ensures your bits stay on the tape

Most home computers have a cassette recorder interface which usually obeys a simple rule: the cheaper and simpler the computer, the worse the data transfer to the recorder. This only becomes evident, of course, when you 'read' a newly loaded program and find that all is not what it's supposed to be. Why is that? And can anything be done about it?
In most computers, a signal is delivered to the interface which is not really suitable for an audio cassette recorder. The amplitude of the signal is normally limited to prevent the overloading of the recorder, while a transfer speed is chosen which, according to the computer manufacturers, is 'safe'. In other words, the computer is adapted to the cassette recorder without too much thought to the fact that the recorder was designed for a different purpose.
We have tackled the problem from the opposite direction by matching the recorder to the computer. A 'read' (playback) and a 'write' (recording) amplifier are added which improves the data transfer to the extent that baud rates of 4800 may be used! When you consider that the baud rate in most, if not all, home computers cannot exceed a three-figure number, you realize what a considerable improvement our circuit offers.

Analogue and digital recording

The (analogue) recording of audio signals onto magnetic tape requires special circuits to ensure that the playback signal is a faithful reproduction of the original. After all, Dolby and DBX did not come about by accident! One of the important design considerations, for instance, is to prevent saturation of the magnetic tape (as saturation would cause distortion).
A square-wave pulse, as generated by most computers, consists of a large number of sinusoidal voltages. As the recording/playback amplifier of a recorder is optimized for audio signals, it will suppress a number of constituents of such a pulse. The result is that what's recorded is no longer a square-wave signal. Further disintegration of the pulse takes place during playback, there is the tape noise, and . . . The consequence of it all is that the Schmitt trigger normally found in the input stages of a cassette interface is not presented with one proper pulse, but several distorted ones.

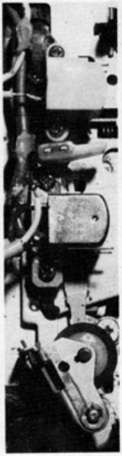

Figure 1. The only modification to the recorder is in the cable to the tape head. The existing amplifier remains untouched and fully usable for audio operation.

The process in a digital recorder is much simpler: the magnetic tape is driven into saturation. This is, without any doubt, the best method for recording data onto tape, particularly if the tape is positively magnetized during logic 'high' signals and negatively during 'low' signals.
Before we analyze the circuit diagram, a reassurance about the cassette recorder: it needs only one modification. The screened cable to the tape head needs to be cut and the digital read/write amplifier inserted between the cut ends as shown in figure 2. The audio recording/playback amplifier is not touched at all so that the recorder remains fully usable for normal audio operation.

The circuit

The write/read (recording/playback) amplifier consists of two functional units separated by the switch-over unit (see figure 1). The read amplifier is constructed in two parts to which we'll come back in the circuit description. Other items shown in figure 1 are the write and read indicator LEDs.

Write (recording) amplifier

As explained in 'switching' below, we'll assume that ES1 and ES2 (see figure 2) are closed and that contacts Re1 and Re2 are open.
The square-wave pulses from the computer are applied across preset P1 and from there fed to the inverting input of opamp IC1 via R1 and C1. Diodes D1 and D2 limit the signal to ± 0.7 V. The gain of IC1 is fixed at about 100 by voltage divider R2/R3. Anti-parallel connected diodes D3 and D4 in the feedback loop limit the output of the opamp to ± 0.7 V. Plus or minus? you may ask. Surely the supply voltage is +12 V only? True, but the non-inverting input of IC1 does not lie at earth potential but at +6 V because of voltage divider R12/R13. The signal output of IC1 is therefore superimposed onto +6 V. This arrangement is also used in other parts of the circuit. Figure 3 shows how a sinusoidal (FSK) input signal is converted by this method: the frequency remains unchanged, but the waveform becomes rectangular. You can well imagine that if a sine wave is so converted, a distorted rectangular pulse will certainly be fully resorted to its original shape. We have taken an FSK signal as an example because that shows the operation of the circuit most clearly. In general, our digital recorder is not required with computers which have an FSK output, but as this example shows: you never know . . .
The rectangular output of IC1 is inverted again by trigger A1 and increased to the maximum possible level of 12 V_{pp} (wave shape 4, figure 3).
The output of A1 is split: one part is applied to terminal 'A' of the tape head via R32 and ES1; a second is again inverted by trigger A2 and then fed to the earth terminal 'B' of the tape head via R33 and ES2. The signal at the tape head is therefore the difference in outputs of the two opamps A1 and A2: note that the tape head is not connected to earth. This method not only saves some coupling capacitors (which might distort the signal slightly) but, what's far more important, the tape magnetization for a logic low signal is the opposite of that for a high signal.

Switching

A third part of the output of A1 is applied to the electronic switching circuit via C3. This circuit consists of electronic switches ES1 and ES2, relays Re1 and Re2, diodes D7 and D8, and a few resistors and capacitors.

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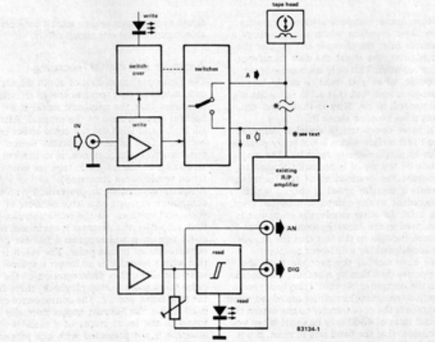

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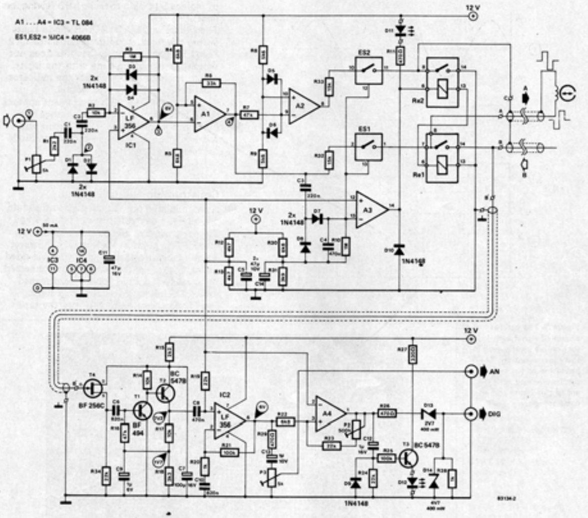

Figure 2. The new amplifier consists of three parts: a recording (write) and playback (read) amplifier and a switching circuit which separates the two amplifiers.

The non-inverting input of comparator A3 is at a level of about +6 V via voltage divider R12/R13. Under no-signal conditions, the inverting input is at about +4.4 V via voltage divider R30/R31. The output of A3 is therefore at +12 V and relays Re1 and Re2 are actuated. The voltage at the inverting input also exists at the inputs of electronic switches ES1 and ES2, but is not sufficient to close the switches: a voltage close to the supply voltage is required to do that. Summarizing: under no-signal conditions, ES1 and ES2 are open and the contacts of Re1 and Re2 closed. The circuit is then in the 'read' condition.

When a signal arrives from the computer, the output of A1 is applied to the control inputs of ES1 and ES2, and to the inverting input of A3 via C3 and D7. The output of A3 goes low, the relays open, and ES1 and ES2 close. The circuit is then in the 'write' condition. Capacitor C4 charges and continues to do so as long as there is a signal coming in from the computer. As the input current of A3, ES1, and ES2 is very small, the charge on C4 is sufficient to keep the switching circuits in the same state even during the pauses between the pulses. When the computer signal ceases, C4 discharges through R10 and the circuit reverts to the 'read' condition.

Read (playback) amplifier

In the 'read' condition, Re2 connects the earth terminal of the tape head to the circuit earth (0 V). The tape signal is connected via Re1 to the gate of FET T4. This small-signal amplifier is followed by a second consisting of T1 and T2, and a third formed by IC2. To ensure that the maximum signal is available at the output of IC2, its input is 'raised' to about 6 V, derived from the voltage divider R12/R13. The total gain of the three stages is around 80 dB, of which half is contributed by IC2. This is ample for many computers and the output of IC2 is therefore available at terminal 'AN'. The output level can be matched to the computer input requirement by preset P3.

For those situations where more gain is required, a fourth amplifier, A4, has been provided. The gain of this amplifier can be

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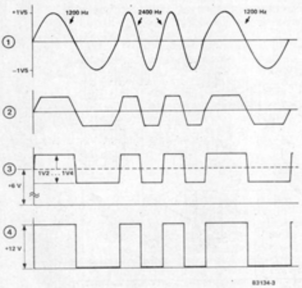

Figure 3. The various phases of signal conversion are clearly seen in this representation. The operation of the circuit can be checked with the aid of this figure and an oscilloscope.

condition. It is possible that it continues to light faintly during the 'read' condition; if you find this disturbing, the only solution is to replace D11 by a cheaper LED (giving less light).

Then there is LED D12. This diode lights during the 'read' condition. Capacitor C12 keeps T3 conducting so that this does not switch on and off in time with the input signal. Resistor R25 prevents the indicator circuit affecting the output signal.

Finally, diode D10. This component appears to be located in a somewhat strange position, but a good look at the circuit will show that it functions as a protection diode for relays Re1 and Re2.

Construction and calibration

Assembling the printed circuit board should not present any difficulties: figure 4 and the parts list give all the information required. One point needs watching, however. Although we are dealing with a double-sided board, the two points 'B' must be connected by means of a short length of screened cable. The reason for this is that during 'read' operation the signal from the tape

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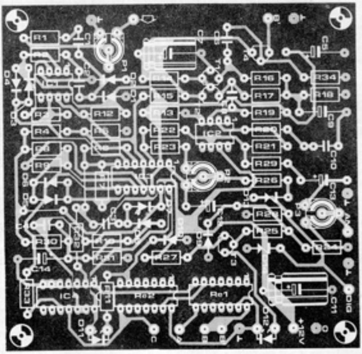


Figure 4. The printed-circuit board is double-sided, and the component layout side takes the form of an earth-plane.

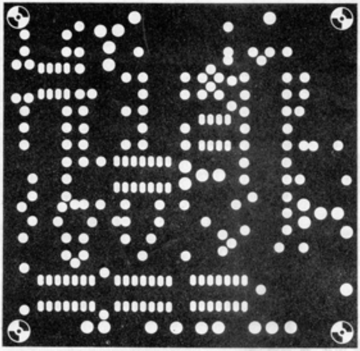
set between 17 dB and 37 dB by preset P2. As A4 is driven into saturation, its output is virtually identical with signal 4 in figure 3. The output is raised to TTL-level via voltage divider R26/D13/D14 and made available at terminal 'DIG'.

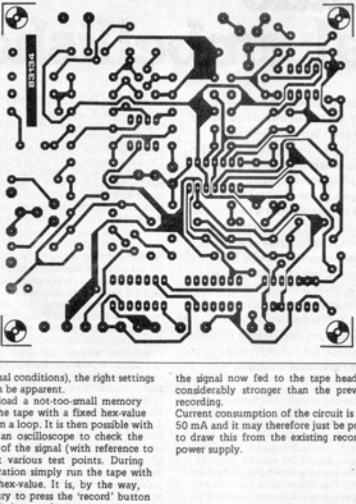
A few further points

To avoid confusion, some aspects of the circuit have been ignored so far. To start with: LED D11. This lights when the output of A3 is low, that is, during the 'write'

head is very small (remember the 80 dB gain!). For the same reason, the screened cable between 'A' and the head must be kept as short as possible. In contrast to audio circuits, there is no central earth point here, so that the earths at both sides of the cable must be connected with one another.

The circuit is very simple to set up. The correct positions of P1 . . . P3 are dependent upon the type of computer and on the baud rate. If you start at the centre position of these presets and have checked that the d.c. levels shown in the circuit diagram are





Parts list

Resistors:
R1,R15 = 2k2
R2,R14,R17 = 10 k
R3,R10 = 1 M
R4,R5,R22,R30 = 6k8
R6 = 33 k
R7 = 47 k
R8,R9 = 5k6
R11,R26,R29 = 470 kΩ
R12,R13 = 4k7
R16 = 47 k or 47k5, metal film, 1%
R18 = 3k3
R19,R23,R24,R34 = 22 k
R20,R28 = 1 k
R21,R25 = 100 k
R27 = 330 kΩ
R31 = 3k9
R32,R33 = 15 k
P1,P3 = 5 k preset
P2 = 500 k preset

Capacitors:
C1,C2,C3 = 220 n ceramic
C4,C8 = 470 n ceramic
C5,C14 = 47 μ/10 V electrolytic
C6,C10 = 820 n ceramic
C7 = 100 μ/16 V electrolytic
C9 = 1 μ/6 V electrolytic
C11 = 47 μ/16 V electrolytic
C12,C13 = 1 μ/10 V electrolytic

Semiconductors:
D1 . . . D10 = 1N4148
D11,D12 = LED
D13 = zener diode 2V7, 400 mW
D14 = zener diode 4V7, 400 mW
T1 = BF 494
T2,T3 = BC 547B
T4 = BF 256C
IC1,IC2 = LF 356
IC3 = TL 084
IC4 = 4066B

Miscellaneous:
Re1,Re2 = DIL relay, e.g. ERNI 10L34 (4.5 . . . 5.0 V/1 A)
PC Board 83134

OK (no-signal conditions), the right settings should soon be apparent.

Final tip: load a not-too-small memory region of the tape with a fixed hex-value and program a loop. It is then possible with the aid of an oscilloscope to check the conversion of the signal (with reference to figure 3) at various test points. During 'write' operation simply run the tape with this fixed hex-value. It is, by the way, not necessary to press the 'record' button during 'write' operations to erase any material already present on the tape because the signal now fed to the tape head is considerably stronger than the previous recording.

Current consumption of the circuit is around 50 mA and it may therefore just be possible to draw this from the existing recorder power supply. ◾