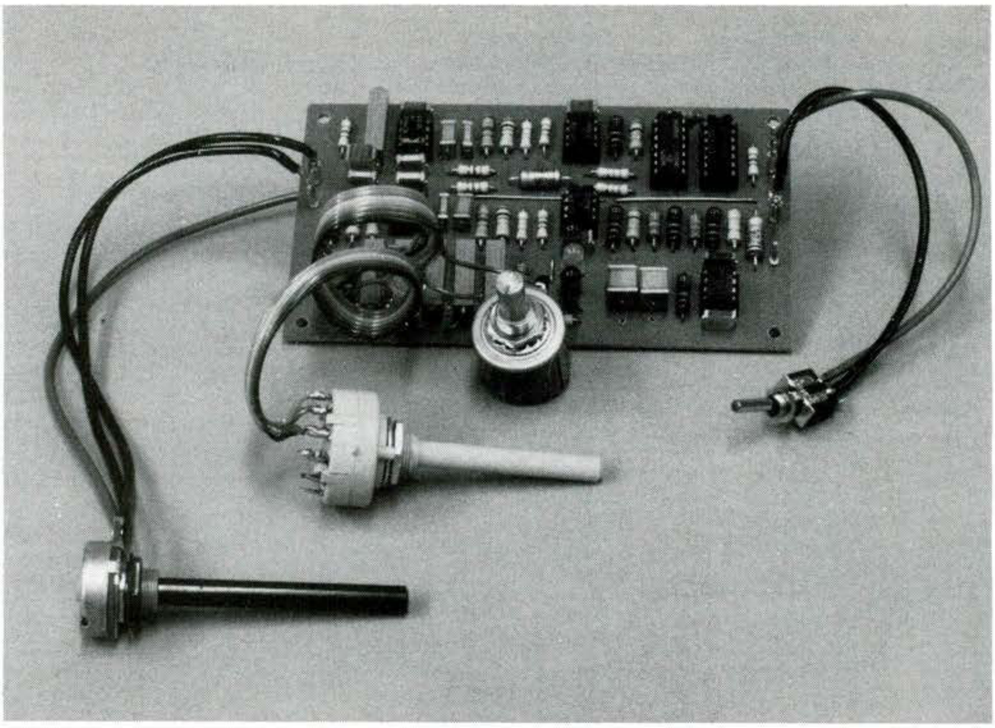


RTTY decoder

Interest in Radio Teletype (RTTY) traffic has grown appreciably over the past few years. One of the reasons for this is that micro-computers, such as the Elektor Junior Computer, which find their way into more and more homes, lend themselves readily to this absorbing hobby. Such a computer can become an effective RTTY Decoder by the addition of a small electronic circuit and a suitable program.

teletype reception by computer

Our last issue contained articles on the decoding of morse signals by means of the Junior Computer and the Elektor Z80A card. In this issue it is the turn of teletype enthusiasts.

Owners of an expanded Junior Computer can save themselves the purchase of a costly teleprinter and RTTY converter. A simple interface and an EPROM with the right program will translate the teletype gibberish on short waves into a clear text on the screen.

The principle of transmission and decoding in teletype is not much different from that in morse. Digital coded information is transmitted by interrupting a radio carrier wave: this is called CW (keyed Continuous Waves). In morse transmissions, the interruptions are in accordance with the by today's standards somewhat cumbersome morse code; in teletype, with the logically constructed 5-unit CCITT Code No. 2, better known as the Baudot code. A more detailed treatment of this subject can be found elsewhere in this issue.

Apart from the codes, there is another fundamental difference between morse and teletype operation. In morse, only one carrier is transmitted which is interrupted in the rhythm of the dots and dashes of the morse code. In teletype operation two carriers are used, of which one is used for the transmission of the logic 1s and the other for the 0s. It is as if two transmitters are operating side by side, but each working on a different frequency. When the transmitted bit is 1, one of the transmitters is switched on, while the other is off; when the transmitted bit is 0, the first transmitter is off and the second is on. In reality only one transmitter is used of which the output frequency is shifted, according to whether a 1 or a 0 is transmitted. This method of operation is therefore called Frequency Shift Keying (FSK).

In teletype, logic 1 is called 'mark' and logic 0, 'space'. The transmission containing all the bits 1 is called the 'mark signal' and that containing only 0's, the 'space signal'. The mark and space signals are very close to one another: the frequency separation is called the 'shift'.

The output of the receiver therefore contains two different audio frequencies: one represents logic 1 (mark), the other logic 0 (space). When both are present simultaneously, there is a fault in the transmission.

The RTTY interface

The signals emanating from the short-wave receiver are not suitable for driving the computer as this, as a norm, requires square-wave inputs. To modify the receiver output signals to the required shape, an interface is needed. This interface must be capable of differentiating between the two received frequencies and of transforming them into a digital signal. For this purpose use is made of a tone decoder followed by an integrator and Schmitt trigger. Two such set-ups are required in the RTTY interface because it has to cope with two different audio signals. With reference to figure 2, the level of the incoming audio signals is set as required by means of potentiometer P7 at the input of the circuit. Then follows a level indicator stage consisting of transistor T1 and a red LED, D1. The input signal is fed to two decoders, IC1 and IC2. Whereas tone decoder IC1 is aligned to one audio frequency, by means of potentiometer P8, decoder IC2 can be aligned to six different frequencies. This enables it to be switched to teletype transmissions with differing frequency shifts. Tone decoder IC1 is aligned to a nominal frequency of 1275 Hz. The frequency of decoder IC2 is then 1275 Hz ± the shift frequency. Table 1 gives the shift- and audio-frequencies normally encountered in RTTY traffic.

Table 1. Most frequently used audio and shift frequencies in RTTY traffic.

signal	set with:	frequency (audio) Hz	shift-frequency (Hz)
mark	P8	1275	0
space 1	P1	var.	var.
space 2	P2	1445	170
space 3	P3	1575	300
space 4	P4	1700	425
space 5	P5	2125	850
space 6	P6	2275	1000

The output circuit of the tone decoders contains three indicator LEDs: D2 (green) for the mark signal (IC1), D3 (red) for the space signal (IC2) and D4 (yellow) for the situation when a mark and space occur simultaneously. Because the frequency is shifted between mark and space, the overlap between the two signals during good reception is very small and D4 therefore lights rarely if at all. Bright lighting of D4 indicates a faulty adjustment or bad reception.

1

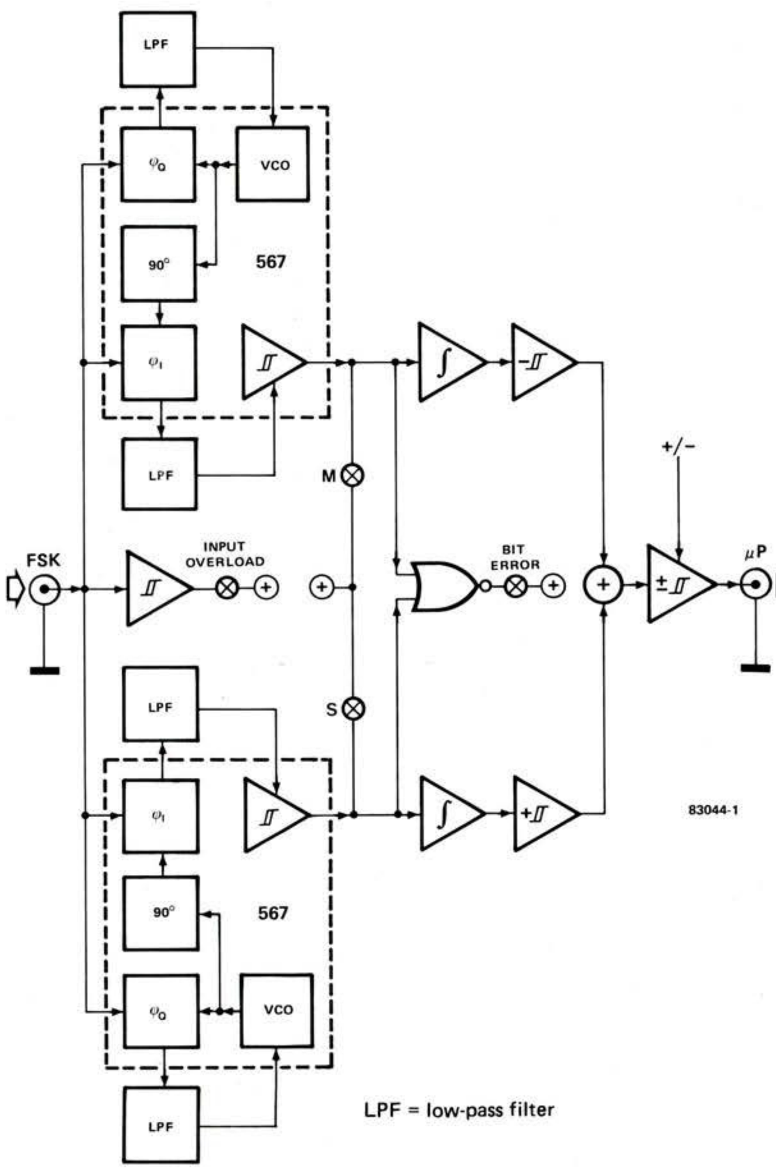


Figure 1. Block diagram of the RTTY interface. The interface consists of two tone decoders with follow-on integrators and triggers for noise and interference suppression. Its output contains an adder circuit which will deliver a usable signal even when one of the two audio signals (mark or space) is missing. The NOR connection of the tone decoder signals ensures an indication of transmission failure. With correct settings, the LED indicators for mark and space light alternately at maximum brightness, whereas the error LED lights only dimly.

2

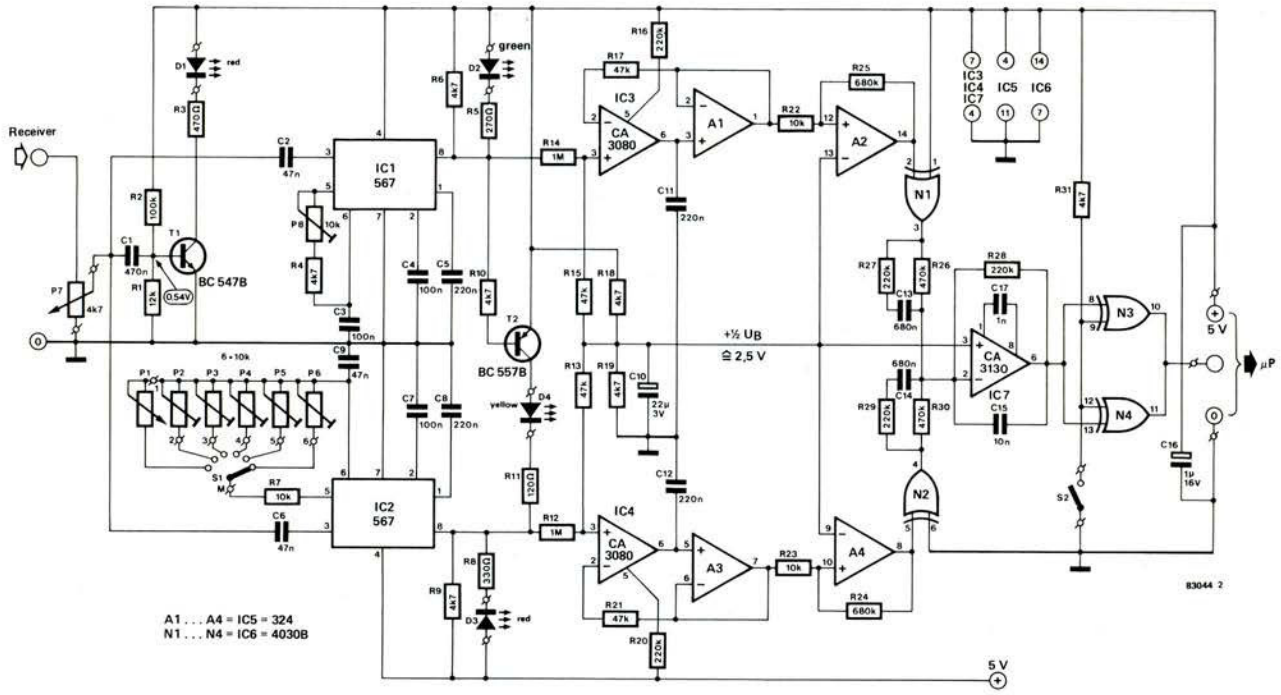


Figure 2. The interface circuit for teletype reception via the Junior Computer. It contains two tone decoders because in teletype operation two audio frequencies are keyed.

Both tone decoders are followed by OTA integrators IC3 and IC4, buffers A1 and A3, and triggers A2 and A4. The high-impedance buffers prevent the overloading of capacitors C11 and C12. The integrator and trigger section is identical to that of the morse interface described in our May issue.

Gate N1 is connected as an inverter; N2 does not invert because pin 6 has a 0 input. This is important in respect of operational amplifier IC7. This stage makes use of the fact that when one of the two signals, mark or space, is missing, the required teletype information in still fully available in the other signal. The space signal is out of phase with the mark signal but otherwise identical to it. If mark is logic 1, space is logic 0. Because N1 inverts the mark signal, whereas N2 passes the space signal unchanged, the output of the two gates contains two in-phase signals.

IC7 combines these signals in its inverting input circuit. If one of the signals is missing because of interference, the other will still be sufficient to drive the op-amp. Capacitor C15 in the negative feedback loop of IC7 ensures further integration of the audio signal by suppressing any residual unwanted signals. Gates N3 and N4 improve the slope of the square-wave output of IC7 so that a TTL compatible signal is available at the output of the interface. These gates also enable reversal of the polarity of the output signal. When S2 is open, both gates function as inverters, while when S2 is closed, they operate as non-inverting buffer stages. The setting of S2 is dependent on the teletype signal being received.

Presetting and adjustment

Once the RTTY decoder has been constructed on the printed circuit board shown in figure 3, it can be preset and adjusted by means of an audio generator and frequency meter. Both these instruments should be connected to the input (P7) of the interface.

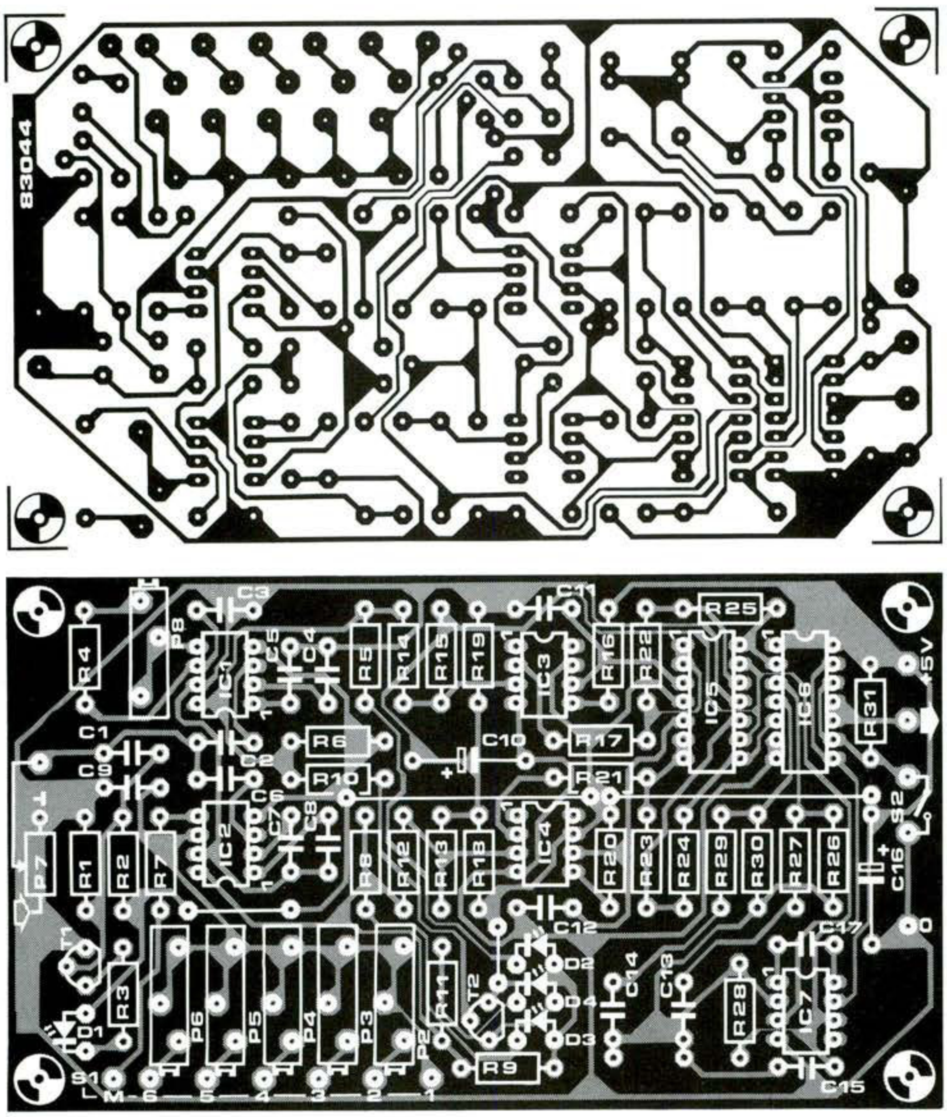
Set P7 to its mid-position, tune the generator to 1275 Hz (as indicated by the frequency meter) and adjust the generator output voltage until D1 just lights. It should now be possible to find a small range of travel of potentiometer P8 at which D2 lights. The correct position of P8 is in the centre of that range. It is also possible to reduce the generator output further and further while searching for a position of P8 where D2 lights. The position so found is the correct one.

Next, the adjustment of tone decoder IC2. Adjust potentiometers P2 . . . P6 in the same way as described for P8 above, but with the generator tuned to frequencies in accordance with table 1 (space frequency = 1275 Hz ± shift frequency).

Adjusting and presetting without using an audio generator and frequency meter is fairly difficult. When attempting to do so, it is best to set P7 to its mid-position and determine the shift-frequency of each transmission experimentally by adjusting potentiometer P1 with switch S1 set to position 1.

Once the above operations have been carried out, the interface can be connected to the audio output of a short-wave receiver. Search for a teletype transmission and adjust P7 so that LED D1 just lights. Then tune the receiver so that D2 lights as brightly as possible in rhythm with the incoming signal. Then select the correct frequency shift with switch S1. If the shift is not known, try all positions of S1 until one is found where D3 lights as brightly, and D4 as dimly, as possible. If such a position cannot be found, the shift is non-standard. In that case, set S1 to position 1 and adjust P1 to the shift of the incoming signal. When

3



Parts list

Resistors:

R1 = 12 k
R2 = 100 k
R3 = 470 Ω
R4,R5,R9,R10,R18,
R19,R31 = 4k7
R5 = 270 Ω
R7,R22,R23 = 10 k
R8 = 330 Ω
R11 = 120 Ω
R12,R14 = 1 M
R13,R15,R17,R21 = 47 k
R16, R20,
R27 . . . R29 = 220 k
R24,R25 = 680 k
R26,R30 = 470 k
P1 = 10 k 10-turn
potentiometer
P2 . . . P6,P8 = 10 k
10-turn preset potentiometer
P7 = 4k7 (5 k)
potentiometer

Capacitors:

C1 = 470 n
C2,C6,C9 = 47 n
C3,C4,C7 = 100 n
C5,C8,C11,C12 = 220 n
C10 = 22 μ/3 V
C13,C14 = 680 n
C15 = 10 n
C16 = 1 μ/6 V
C17 = 1 n

Semiconductors:

D1,D3 = LED red
D2 = LED green
D4 = LED yellow
T1 = BC 547B
T2 = BC 557B
IC1,IC2 = LM 567
IC3,IC4 = CA 3080
IC5 = LM 324
IC6 = 4030B
IC7 = CA 3130

Miscellaneous:

S1 = rotary switch,
1 pole, 6 way
S2 = single-pole switch
toggle

Figure 3. The RTTY interface is constructed on this printed circuit board. The preset potentiometers are used for the setting of the various audio frequencies.

4

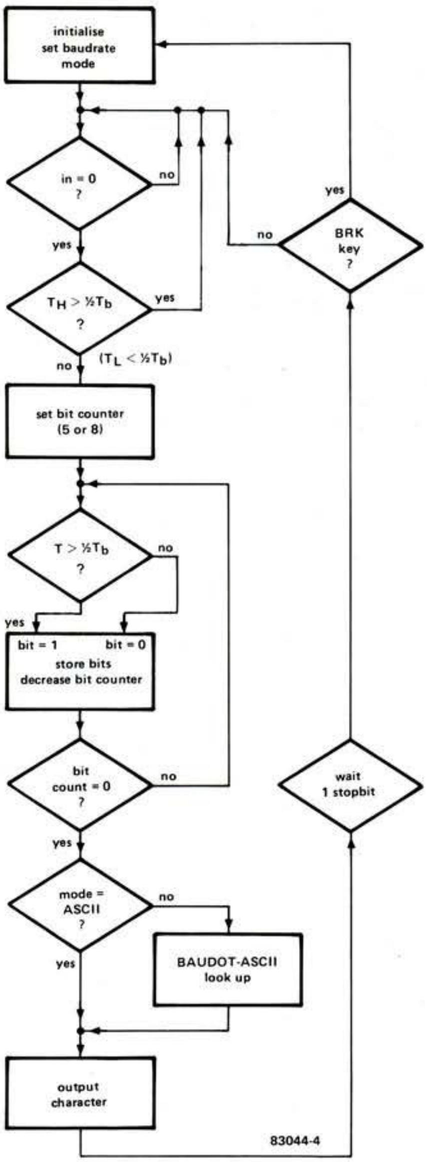


Figure 4. Simplified flow chart of the RTTY program. The 'heart' of the program is the bit counter. In contrast to an UAR/T which only scans the (calculated) centre of a pulse (unit of teletype signal), the counter determines whether the input signal during the pulse is longer than half the pulse duration for logic 1. If that is the case, it is taken to be 1, otherwise as 0. This system gives an appreciably lower susceptibility to interference, and therefore error rate, than is the case with UAR/T's.

Table 2. Print-out after starting the RTTY-program

```
BAUDRATE:

Ø=45.45 BAUD
1=5Ø
2=57
3=75
4=1ØØ
5=11Ø
DO YOU LIKE TO CHANGE IT? <Y/N>Y
SELECT THE BAUDRATE: 1
ASCII RECEIVER? <Y/N>N
FILE BUFFER? <Y/N>Y
AUTO LETTER MODE? <Y/N>
LIST THE FILE BUFFER? <Y/N>
::
```

Table 3. Starting addresses for the copy procedures.

junior versions	starting address	copied from	to address
expanded	ØE88	Ø8ØØ	4ØØØ
DOS	EE72	E8ØØ	4ØØØ

reception is satisfactory and the interface is working correctly, the LEDs will flicker in rhythm with the incoming signal.
All that remains is the presetting of the baud rate (at the computer) and the polarity of the incoming signal (set by S2). Both are a matter of trial and error as firm rules cannot be given.

The RTTY decoder program

The program of the RTTY decoder can be contained in an EPROM type 2716. This EPROM is then suitable for use with the expanded Junior Computer as well as the DOS Junior.
The RTTY interface is connected to pin PB7 of the Junior Computer. The RTTY program is so arranged that both 5-unit Baudot and 7-unit ASCII codes can be received. Moreover, the program allows up to six baud-rates.
The received data are stored in a file buffer. When the buffer is full, an error signal is given. The contents of the buffer can, of course, be read out.
A further useful feature is the Auto-Letter-Mode: when receiving Baudot code, the letter sign is often lost. This results in letters being erroneously translated as numerals. In the Auto-Letter-Mode, the decoder automatically switches back to the letter mode when a blank space is received.
Figure 4 shows the program structure in a flow chart.
When the program has been started with the address 4ØØØ, possible baud rates are displayed as shown in table 2. The computer will ask some questions which should be answered by Y (Yes) or N (No = Return). The baud-rate setting is effected by the keying in of a number between 0 and 5.
On reception of an ASCII transmission, the question 'ASCII Receiver?' must be answered by Y, because if the answer N is given, the decoder will be set to Baudot code.
After questions as to file buffer, Auto-Letter-Mode, and file buffer print out have been answered, the computer is ready to receive a serial signal across PB7; this is indicated by the display ': :'.
If the first question 'Do you like to change it?' is answered by N, the start procedure will be shortened. The decoder will then proceed in the Baudot mode with a baud rate of 50, indicated by the disappearance of the symbol ': :' from the screen.
If you want to find out the mode of operation after the program has started, simply press the Break key on the ASCII keyboard. Reset or Change of Mode of Operation is effected with the NMI key.

Operating instructions for the RTTY program

The program requires a storage capacity from 4ØØØ up to 7FFF (RAM). A (dynamic) 16K RAM card on the Junior bus will be suitable.
The starting address is 4ØØØ.
As the DOS Junior has a storage capacity which differs from that of the expanded Junior, the program for it has been put

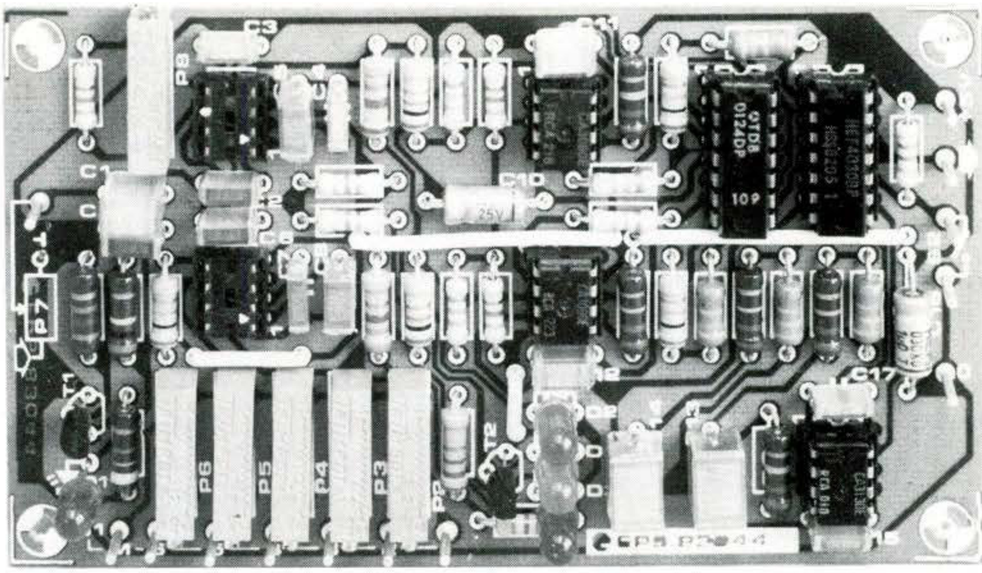


Table 4. Amendments for the DOS junior.

Address	Data
4038	A3
4039	FE

Table 5. Amendments for the expanded junior.

Address	Data
40C2. . .	EA, EA, EA
4038	34
4039	13
4041	1A
4057	AE
4058	12
44DA	1A
44DB	1A
44E4	1A
44E7	1A
44EC	1A
44F1	1A
44F6	1A
4581	1A
4589	1A
459B	18
45BE	18
45C8. . .	EA, EA, EA
45D1	1A
45CF	1A
45E0	18
4606	18
460D	18
4640	18
4646	18

Table 6. The hexdump of the RTTY decoding program.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
800	4C	BD	42	42	01	80	80	00	00	00	00	00	00	00	05	00
810	48	FF	7F	01	00	00	00	00	00	3F	35	00	0B	F0	55	20
820	4E	88	44	15	34	10	27	83	23	4C	3C	40	8D	63	23	48
830	C9	00	F0	06	20	F8	44	20	43	23	68	60	AD	06	40	2D
840	80	FA	F0	F8	A2	FF	9A	20	EB	41	4C	19	44	AD	14	40
850	48	A9	00	8D	14	40	20	1B	FE	20	2C	40	AA	68	8D	14
860	40	8A	60	68	85	F8	68	85	F9	AD	14	40	48	A9	00	8D
870	14	40	E6	F8	D0	02	E6	F9	A0	00	B1	F8	C9	00	F0	06
880	20	2C	40	4C	72	40	68	8D	14	40	A5	F9	48	A5	F8	48
890	60	20	63	40	0D	0A	42	41	55	44	4F	54	20	00	60	20
8A0	63	40	0D	0A	41	53	43	49	49	20	00	60	20	63	40	52
8B0	45	43	45	49	56	45	52	0D	0A	00	60	20	63	40	20	42
8C0	41	55	44	0D	0A	00	60	20	63	40	34	35	2E	34	35	00
8D0	60	20	63	40	35	30	00	60	20	63	40	35	37	00	60	20
8E0	63	40	37	35	00	60	20	63	40	31	30	30	00	60	20	63
8F0	40	31	31	30	00	60	20	63	40	4E	4F	20	00	60	20	63
900	40	0D	0A	52	45	43	45	49	56	45	44	20	43	48	41	52
910	41	43	54	45	52	53	20	41	52	45	0D	0A	53	54	4F	52
920	45	44	20	49	4E	20	42	55	46	46	45	52	0D	0A	00	60
930	20	63	40	41	55	54	4F	20	4C	45	54	54	45	52	20	4D
940	4F	44	45	00	60	20	63	40	0D	0A	00	60	AD	14	40	8D
950	16	40	A9	00	8D	14	40	AD	0F	40	AE	10	40	C5	FA	D0
960	1D	E4	FB	D0	19	20	63	40	0D	0A	46	49	4C	45	20	45
970	4D	50	54	59	0D	0A	00	AD	16	40	8D	14	40	60	85	FA
980	86	FB	20	45	41	A9	00	8D	1B	40	A0	00	B1	FA	C9	FF
990	F0	E5	48	20	2C	40	20	E4	41	38	A5	FA	ED	11	40	A5
9A0	FB	ED	12	40	68	90	16	20	63	40	0D	0A	46	49	4C	45
9B0	20	4F	56	45	52	46	4C	4F	57	0D	0A	00	60	C9	0D	D0
9C0	C9	20	2C	40	EE	1B	40	AE	1B	40	EC	1C	40	90	09	20
9D0	4D	40	C9	45	F0	A1	D0	AD	A9	0A	D1	FA	F0	AC	20	2C
9E0	40	4C	8A	41	E6	FA	D0	02	E6	FB	60	20	45	41	20	45
9F0	41	AD	03	40	C9	42	D0	06	20	91	40	4C	01	42	20	9F
A00	40	20	AC	40	AD	04	40	D0	06	20	C7	40	4C	3A	42	C9
A10	01	D0	06	20	D1	40	4C	3A	42	C9	02	D0	06	20	D8	40
A20	4C	3A	42	C9	03	D0	06	20	DF	40	4C	3A	42	C9	04	D0
A30	06	20	E6	40	4C	3A	42	20	EE	40	20	BB	40	AD	14	40
A40	F0	0C	20	FE	40	AD	17	40	F0	0A	20	30	41	60	20	F6
A50	40	4C	42	42	20	F6	40	4C	4A	42	C9	1F	F0	19	C9	1B
A60	F0	0F	AE	13	40	F0	05	AA	BD	7D	42	60	AA	BD	9D	42
A70	60	A9	00	8D	13	40	60	8D	13	40	A9	00	60	00	45	0A
A80	41	20	53	49	55	0D	44	52	4A	4E	46	43	4B	54	5A	4C
A90	57	48	59	50	51	4F	42	47	00	4D	58	56	00	00	33	0A
AA0	2D	20	27	38	37	0D	24	34	07	2C	00	3A	28	35	2B	29
AB0	32	00	36	30	31	39	3F	00	00	4D	58	56	00	20	A0	44
AC0	A2	FF	9A	A9	05	8D	0E	40	A9	42	8D	03	40	A2	01	8E
AD0	04	40	8E	13	40	CA	8E	14	40	8E	17	40	20	63	40	0D
AE0	0A	45	4C	45	4B	54	4F	52	20	52	54	54	59	20	44	45
AF0	43	4F	44	45	52	0D	0A	0A	42	41	55	44	52	41	54	45
B00	3A	0D	0A	0A	30	3D	34	35	2E	34	35	20	42	41	55	44
B10	0D	0A	31	3D	35	30	0D	0A	32	3D	35	37	0D	0A	33	3D
B20	37	35	0D	0A	34	3D	31	30	30	0D	0A	35	3D	31	31	30
B30	0D	0A	44	4F	20	59	4F	55	20	4C	49	4B	45	20	54	4F
B40	20	43	48	41	4E	47	45	20	49	54	3F	20	3C	59	2F	4E
B50	3E	00	20	4D	40	C9	59	D0	5A	20	63	40	0D	0A	53	45
B60	4C	45	43	54	20	54	48	45	20	42	41	55	44	52	41	54
B70	45	3A	20	00	20	4D	40	C9	30	90	DE	C9	36	B0	DA	29
B80	0F	8D	04	40	20	63	40	0D	0A	41	53	43	49	49	20	52
B90	45	43	45	49	56	45	52	3F	20	3C	59	2F	4E	3E	00	20
BA0	4D	40	C9	59	D0	10	A9	07	8D	0E	40	A9	41	8D	03	40
BB0	4C	C0	43	4C	74	44	A9	05	8D	0E	40	A9	42	8D	03	40
BC0	20	63	40	0D	0A	46	49	4C	45	20	42	55	46	46	45	52
BD0	3F	20	3C	59	2F	4E	3E	00	20	4D	40	C9	59	D0	06	8D
BE0	14	40	4C	EA	43	29	00	8D	14	40	20	63	40	0D	0A	41
BF0	55	54	4F	20	4C	45	54	54	45	52	20	4D	4F	44	45	3F
C00	20	3C	59	2F	4E	3E	00	20	4D	40	C9	59	D0	06	8D	17
C10	40	4C	19	44	29	00	8D	17	40	20	63	40	0D	0A	4C	49
C20	53	54	20	54	48	45	20	46	49	4C	45	20	42	55	46	46
C30	45	52	3F	20	3C	59	2F	4E	3E	00	20	4D	40	C9	59	D0
C40	03	20	4C	41	20	63	40	0D	0A	3A	3A	0D	0A	00	4C	74
C50	44	A9	00	8D	18	40	20	75	45	AE	03	40	E0	42	D0	03
C60	20	5A	42	AE	18	40	EC	19	40	B0	09	EC	1A	40	90	11
C70	C9	20	D0	0D	A9	0D	20	2C	40	A9	0A	20	2C	40	4C	51
C80	44	C9	0A	F0	0C	C9	0D	D0	02	A9	20	20	2C	40	EE	18
C90	40	AE	17	40	F0	07	C9	20	D0	03	8D	13	40	4C	56	44
CA0	78	AD	0F	40	AE	10	40	85	FA	86	FB	A0	FF	98	C8	91
CB0	FA	20	E4	41	AE	11	40	E4	FA	D0	F4	AE	12	40	E4	FB
CC0	D0	ED	91	FA	8C	15	40	8C	14	40	AD	0F	40	AE	10	40
CD0	85	FA	86	FB	A9	3C	A2	40	8D	7C	FA	8E	7D	FA	A9	BD
CE0	A2	42	8D	7A	FA	8E	7B	FA	A9	07	8D	82	FA	A9	3F	8D
CF0	83	FA	A9	00	8D	81	FA	60	AC	15	40	D0	1E	C9	00	F0
D00	1A	AC	14	40	F0	15	A4	FA	CC	11	40	D0	07	A4	FB	CC
D10	12	40	F0	08	A0	00	91	FA	20	E4	41	60	A0	01	8C	15
D20	40	20	A7	41	20	63	40	0D	0A	42	55	46	46	45	52	20
D30	4F	55	54	50	55	54	3F	20	3C	59	2F	4E	3E	00	20	4D
D40	40	C9	59	D0	09	20	45	41	20	45	41	20	4C	41	20	63
D50	40	0D	0A	53	59	53	54	45	4D	20	52	45	53	45	54	3F
D60	20	3C	59	2F	4E	3E	00	20	4D	40	C9	59	F0	01	60	4C
D70	BD	42	4C	3C	40	8A	48	98	48	AE	0E	40	AD	06	40	2D
D80	80	FA	F0	EE	AD	05	40	2D	82	FA	D0	F0	20	4A	46	20
D90	CC	45	B0	E8	20	4A	46	A9	40	2D	0D	F8	F0	F9	20	FC
DA0	45	20	CC	45	6E	0D	40	CA	D0	F4	38	A9	08	ED	0E	40
DB0	AA	4E	0D	40	CA	D0	FA	20	1D	46	A9	40	2D	0D	F8	F0
DC0	F9	68	A8	68	AA	AD	0D	40	8D	63	23	60	AD	05	40	2D
DD0	82	FA	F0	1D	EE	0B	40	D0	03	EE	0C	40	A9	40	2D	0D
DE0	F8	F0	E9	38	AD	0B	40	ED	09	40	AD	0C	40	ED	0A	40
DF0	60	EE	09	40	D0	03	EE	0A	40	4C	DC	45	AD	04	40	0A
E00	A8	B9	1D	40	8D	04	F8	C8	B9	1D	40	8D	05	F8	A9	00
E10	8D	09	40	8D	0B	40	8D	0A	40	8D	0C	40	60	AD	04	40
E20	0A	A8	B9	1D	40	8D	07	40	C8	B9	1D	40	8D	08	40	4E
E30	08	40	6E	07	40	4E	08	40	6E	07	40	AD	07	40	8D	04
E40	F8	AD	08	40	8D	05	F8	4C	0E	46	AD	04	40	0A	A8	B9
E50	1D	40	8D	07	40	C8	B9	1D	40	8D	08	40	4C	35	46	A2
E60	08	A0	00	B1	00	91	02	88	D0	F9	E6	01	E6	03	CA	D0
E70	F0	60	A9	00	A2	E8	85	00	86	01	A9	00	A2	40	85	02
E80	86	03	20	5F	EE	4C	00	FC	A9	08	A2	00	85	00	86	01
E90	A9	00	A2	40	85	02	86	03	20	9E	0E	4C	1D	1C	A2	08
EA0	A0	00	B1	00	91	02	88	D0	F9	E6	01	E6	03	CA	D0	F0
EB0	60															

into an EPROM which should be plugged into socket IC4 on the Junior expansion card.

As the DOS Junior has a storage capacity which differs from that of the expanded Junior, the program for it has been put into an EPROM which should be plugged into socket IC4 on the Junior expansion card.

In the expanded Junior the program is stored from 0800 to 0FFF; in the DOS Junior, between E800 and EFFF. Before the program can be started, it must be transferred from the EPROM to the RAM. The required transfer procedure are already contained in the EPROM. The addresses for the various transfer procedures are given in table 3.

After transfer of the program, some bytes have to be changed by hand as shown in detail in table 4 (DOS Junior) or table 5 (expanded Junior).

After these amendments, the program can be started: it is possible to copy it from the RAM onto an audio cassette or floppy-disc (DOS Junior) for simpler re-use at a later date.

Readers who want to program the EPROM themselves will find the Hexdump listing in table 6.