Users Manual

for the 9600 Baud G3RUH
Packet-Radio-Controller

TNC2H

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Preface

The use of 9600 Baud technique is widespread now. So, every radio amateur should be able to operate a 9600 Baud packet station with good results. However, the connection of the radio to the TNC respectively to the modem may be a problem. The TNC2H will make it as simple as possible to get 'on the air' with 9600 Baud by offering a complete solution for the generation and demodulation of the audio signal.

This manual describes the use of the TNC2H and its software. There is a 'FSK-Manual' available, which is a collection of fundamental articles about the FSK-techniques and a lot of descriptions how to modify your radio for 9600 Baud use.

The further development of the digital mode packet radio will depend on our efforts to increase the general transmission speed to 9600 Baud. It is important, that every development is published via the existing packet-radio mailbox network. So, your contribution will be accessible to all interested packet amateurs.

Thanks to James Miller, G3RUH, for his support and the experiments with TNC2H. The enhanced design of the G3RUH modem by Henning Rech, DF9IC made the combination of TNC and modem on a single printed circuit board possible.

The translation was done by Ulf Kumm, DK9SJ. I tried my best, but I am sure that this translation contains lots of mistakes and wrong expressions. As far as these do not affect the technical contents of the manual, this book will be useful as well. Any comments about this manual and its translation are welcome. Write, fax or eMail to info@symek.com

Thanks to James Miller, G3RUH, who checked the english version for translation errors.

The table of contents will be found at the beginning of this manual. The index on the last few pages may be useful to find the desired information.

For informations about the newest on Packet-Radio and our TNC read our internet pages: **http://symek.com**

We hope you enjoy the use of your TNC!

31.7.2000   Ulf Kumm, DK9SJ

Specifications, Technical Data of TNC2H

Power Supply:

12 Volt DC (min. 9 V, max. 16 V), typ. 160 mA (Option: 70 or 35 mA), internal supply: 5 Volt.
Regulator: standard regulator 7805 (Option low-power: MAX738)

Physical Dimensions:

Approx. B=105, T=170, H=42mm, (4 x 6.7 x 1.6 inch), weight approx. 450 gr.

Computer Interface:

RS232 (+/- 10 Volt), 25-pin Sub-D receptacle with UNC-nut bolts.
Baudrate: 150; 300; 1200; 2400; 4800; 9600; 19200; 38400 Baud
Parity: none , word length 8 Bit (may be configured by software)
outputs: data out (Pin 3), CTS (Pin 5) optional: DCD (Pin 9) and DSR (Pin 6)
inputs: data in (Pin 2), RTS (Pin 4) optional DTR (Pin 20)

Modem Interface:

CMOS -level 5 volt. TXData, TXClock, RXData, RXClock, RTS CTS, DCD, + 5 Volt, Reset, ground. The TNC2H may supply up to 200mA for a external modem, connected to the 20 pin modem-connector. Connection of additional modems to the TNC2H digital controller via 20 pin ribbon cable and connector. Assignment of the 20 pin modem connector according to the recommendation of DF9IC for high-speed-modem-disconnect connections.

LED Displays:

Power (5 Volt), STA, CON, PTT, DCD.

Microprocessor:

Z80 (Toshiba TMPZ84C00-10 CPU, 9,8 MHz clock), 8 bit data-bus

Program Storage (EPROM):

2 x   32 kbyte containing 2 softwares, selectable by DIP-switch

Data Storage (CMOS-RAM): (with battery-backup)

32 kbyte, about 24 kbyte available for data.

Real Time Clock:

Software-clock, depends on the software. Not supplied by the battery.

DIP-Switches:

9 switches for selection of software-options, terminal-baudrate and modem transmit-filter.

Reset and Watchdog:

MAX 691 reset and power supervisory circuit

Battery:

3 Volt lithium battery with automatic switch over by MAX691. Calculated lifetime: 8 years

Connection and Set-up of TNC2H on a single Page

You are already familiar with TNC and packet-radio? The information on this page will be enough for starting to operate the TNC2H.

Power Supply:

12 V (9-16 V), max. ca 200 mA. Plug 5mm NES-type connector. Plus pole inner, minus outer contact .

Computer connection, Interface:

RS232 via a 1:1 serial cable. 25-pin plug to TNC, 25-pin jack to the computer COM port. Essential are only pins 2, 3 and 7. Baudrate configuration: select the baud rate according to your computer with DIP-switches 1, 2 and 3:

SW 1	SW 2	SW 3	Baud
⇓	⇓	⇓	300
⇓	⇓	⇑	600
⇓	⇑	⇓	1200
⇓	⇑	⇑	2400

SW 1	SW 2	SW 3	kBaud
⇑	⇓	⇓	4,8
⇑	⇓	⇑	**9,6**
⇑	⇑	⇓	19,2
⇑	⇑	⇑	38,4

Software-selection (DIP-switch 4)

SW 4	Software
⇓	**TF2.6, WA8DED, Hostmode-Software**
⇑	TAPR 1.1.8 Terminal-Software

Transmit filter adjustment: (DIP-switch 5-8)

SW 5 LSB=1	SW 6 2	SW 7 4	SW 8 MSB=8	Filter characteristic
⇓	⇓	⇓	⇓	**Loop back-characteristic**
⇑	⇓	⇓	⇓	Curve No. 1 etc.

Radio connection

The radios are connected in the same way as usual with other TNC by a 5-pin DIN-plug:

Pin	Name	Function (name of the radio connection)
1	MIC	modulator, TNC-AF-output
2	GND	ground, 0 Volt, shield
3	PTT	transmit key, closes to ground when transmitting
4	SPRK	demodulator, TNC AF input

Installation:

Connect everything (radio, computer, power), start the computers program, ready. Problems? Everything should run as expected. If not, you should go on reading the following pages carefully.

Introduction

There are some thousands of TNC2H in use and are obviously working satisfactory. The printed circuit board version is called "TNC2H-G".

The 9600 baud technique is relatively young and there are almost no radios available, which are ready to plug in. But finally, amateur radio is a hobby for experiments. With the TNC2H, you own a device, which takes care of all problems concerning the generation of the audio frequency packet signals.

In principle, the coupling of a 9600 Baud modem to a radio makes problems: the audio frequency bandwidth must reach from about 30 Hz up to 5 kHz. The direct modulation of the phase-locked-loop control voltage is unfavourable, because the phase comparator tries to compensate the influence of the modulation to the transmit frequency. The cut-off frequency of the control voltage lowpass loop filter of common pll-controlled transmitters is in the range of 100 Hz. So, the modulation below this frequency is not possible without significant attenuation.

For most radios, there are instructions available on how they can be modified for 9600 baud packet use. Some of these instructions, which are published in the packet-mailbox-system are thoroughly tested, some are not. You find a collection of such instructions in our 'FSK-manual', which is updated regularly. (available in German language)

Maybe, there will appear radios on the market, which could be directly connected to the TNC2H without modifications.

Power supply of TNC2H

The TNC2H is supplied with direct current (DC). The inner contact of the power supply plug is the positive pole, the outer contact (case) is the negative pole. The current drain is about 180 mA, the TNC needs 8-9 volt minimum, maximum 16 volt. There should be no excessive ripple on the supply voltage, maybe problems will occur when using simple supplies without proper smoothing.

> **ATTENTION!** When the negative pole of the TNC supply is already grounded via the computer or radio connection, the positive pole of the power supply (inner contact of the power supply plug) must not touch the outer contact of the TNC's power supply jack. If this happens, there will be a short circuit which will cause severe damage to the pc-board traces and the semiconductors, if there is no fuse in the + supply lead.

When special 'zero-power-GAL's are used (low-power-option, e.g. the type AMD PALCE16V8Z), the current drain is reduced to about 75 mA. There is also a switch-mode step down voltage regulator available, which halves the power drain again, total consumption is then about 35 mA (400 mW) only.

Connection of the radio to TNC2H

For 9600 baud operation, the radio MUST be modified (few exceptions excluded). We have made a special "FSK-manual" which contains a large collection of instructions, how to modify the radios. Besides, there are some interesting articles about the 9600 baud FSK technique fundamentals in this book.

If you have already modified your radio, the following description on how to connect the TNC will do:

The radio is connected via a 5-pin (180 degree) DIN-plug. The five pins of the plug are attached as follows:

view to solder side of plug
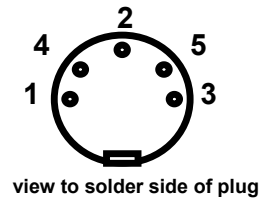
Pin 1: MODULATOR of the radio, AF output of TNC
Pin 2: GND ground
Pin 3: PTT transmit key, switched to ground
Pin 4: DEMODULATOR, AF output of the radio
Pin 5: spare (see text)

Attention: the five pins are not enumerated in turn! The numbers of the contacts are printed on the black insulating body of the plug (almost invisible figures) and on the rear panel of the TNC2H. The pins are arranged in the following order: 3 (PTT), 5 (n.c.), 2 (GND), 4 (DEM), 1 (MOD). The middle pin 2 (GND) is made as a soldering tag for attaching the screen wires of a microphone cable.

Modulator (Pin 1)

Here, the modulator of the radio is connected. The maximum output voltage of the TNC2H is up to approx. 2 Volt$_{SS}$ and could be adjusted with the only trimmer resistor (accessible when the case is opened).. The minimal output voltage, which could be set, is about 50 mV. Below this, the adjustment becomes somewhat fiddly. Turning the trimmer to more than 3 o'clock (which is about 1,5 V$_{SS}$) may cause to overdrive the last filter stage and the output signal will be clipped. If 1 volt is not enough for your radio, it would be better to activate the AF-final stage (see below). The TNC2H has a AF-output amplifier with a very low output resistance and a gain of 1. The output voltage may be magnified by changing the feedback resistors of the final amplifier up to 10 Volt$_{SS}$. It is a good idea to solder pins of a IC-socket to the pads of R22 and R23 to try and exchange some values more easily.

R22	R17	Amplifier gain	Output voltage (pot middle position)
infinite	2,2 kΩ	1	ca. 1 Vss
2,2 kΩ	2,2 kΩ	2	ca. 2 Vss
2,2 kΩ	10 kΩ	5	ca. 5 Vss

Sometimes, the radio requires much less AF-voltage, e.g. only 10 mV for sufficient modulation. For this case, the AF voltage must be reduced by a voltage divider, which should be placed in the radio. The output of the TNC2H should be about 1 Volt for good adjustment with the pot near middle position. This gives less susceptibility to hum and noise. Another fine place for the voltage divider is the DIN-plug.

The output voltage is coupled via a electrolytic capacitor. There should be no DC voltage applied to pin 1, which is less then 0 Volt, i.e. negative, because the output capacitor of TNC will be reversed in polarity. If the modulation input of your radio shows negative voltage, you should connect a 10µF capacitor in series, minus connection directed to the radio modulator. The transmit signal sounds like white noise, but on a oscilloscope you recognise pulses with a distance of about 0,1 ms.

IMPORTANT: the correct adjustment of the transmit AF is very important. As the radios are modulated directly (there is no AF-amplifier or modulation limiter), you may far overdrive the modulator by applying too much AF voltage. This gives the transmit signal an excessive bandwidth and the IF filter of the destination receiver will totally distort the signal. We advice to watch closely the eye diagram at the receiver and adjust then the proper modulation level. If the AF is too low, you may loose some signal-to-noise ratio, but you don't risk to distort the signal by overdriving.

Demodulator (Pin 4)

The demodulator-output of the radio is connected to this pin. The AF voltage should be 150 mV or more. The decoder works at voltages of 50 mV or more without errors, but the DCD-

LED will flicker and the modem is sensitive against signal distortions. If your radio offers a AF output voltage less than 150 mV, the high impedance AF-preamplifier could be made more sensitive by soldering in a additional resistor R23. As mentioned above, we recommend to solder two single pins out of a IC-socket to the R23 pads to try several different values of R23.

R23	R14	preamp-gain	AF-input sensitivity
infinite	2,2 kΩ	1	ca. 100 mV
2,2 kΩ	2,2 kΩ	2	ca. 50 mV
2,2 kΩ	10 kΩ	5	ca. 20 mV
1,2 kΩ	10 kΩ	10	ca. 10 mV

If the output of your radio produces much more signal voltage, it should be reduced by a voltage divider, which is mounted in the radio to get 1 Volt or less. The input resistance of the TNC2H is about 1 MΩ in parallel with the small input capacitance of the op amp.

PTT (Pin 3)

This pin is switched to ground when transmitting. With this, all common PTT-circuits of the usual radios may be operated. The switch in the TNC is a n-channel vertical MOS-field effect transistor (VMOS-FET), which is able to switch up to 60 Volts and up to 500 mA.

In the 'on'-state, the resistance of the FET is typically 30 Ω or less, the cut-off current when switched off is far below 1 µA. VMOS-FETs are suited well for such applications, because the voltage across the switched-on FET is low (only a few mV). Bipolar silicon npn-transistors have usually saturation voltages, which are much higher.

With this circuit, it is only possible to switch DC-voltages up to about 20 Volts to ground. You cannot pull a line up to 12 Volt when transmitting or switch a negative voltage. For this application, you should use a switching amplifier or a reed relay (with diode clamp).

At most (handy) radios, the PTT contact and microphone is connected to the same signal pin. The AF-path for the microphone signal is decoupled by a series capacitor, the PTT-signal is fed by a series resistor of 2 to 20 kΩ in order not to short-circuit the microphone. When pressing the PTT switch, DC current may flow through this resistor, keying the transmitter. As the microphone will not be used with the 9600 Baud FSK-modem, the mic-connector of the radio may be connected directly to the PTT-pin of the TNC2H. Then, the short circuit of the mic-modulation is no disadvantage.

GND (Pin 2)

Ground of the radio (case, 0 Volt)

Spare (Pin 5)

At a standard TNC2H, this pin is not connected. When you solder an additional diode 1N4148 CR5, you may feed a additional external DCD-carrier detect, e.g. for the use of combined 9600/1200 baud digipeaters. The external DCD-circuit should have an open collector, which goes low (switches to ground) when a carrier is detected. When you solder in a wire jumper instead of CR5, the DCD signal may be lead to external circuits. If R24 is soldered in (value not critical), the demodulator output is available at pin 5.

This is useful for the bit-error-test (see chapter "jumper" and "experiments with TNC2H"). You may connect a pulse counter or simply a headphone to pin 5. There will be a crack in the headphone every time the data output changes from 0 to 1 or vice versa. If the distant station has set his TNC in bit-error-test mode, this should never happen. Every time, if there is a crack in spite, there was one wrong bit received. A good link 'cracks' only every 10 seconds or less.

Standard FSK Connection Cable

for Transceivers with 9600 Baud FSK Capability

Since about 1994, the industry begun to produce amateur radio transceivers with the necessary inputs and outputs for 9600 Baud FSK. The transceivers of Kenwood, Azden Alinco, Yaesu, ICOM use the same connector and pinning and are easy to connect to a TNC2H. The radios have a 6 pin mini-DIN socket (same type as for PS/2 keyboards). You have to make a simple cable with a 6 pin jack on the one side and the 5 pin DIN jack on the other. Just connect the pins 1 to 1, 2 to 2, 3 to 3 and 4 to 4. Pins 5 (and 6) remain unconnected. As it is difficult to solder the tiny 6 pin jack it is better to buy a ready-made PS/2 keyboard extension cable, cut it into two pieces and attach the 5 pin DIN connector. Read the manual of the radio, how the FSK mode is to be enabled and how to adjust sensitivity. If the demodulator output voltage exceeds 0.5 volt, it is a good idea to reduce it to that level by soldering a voltage divider into the cable plug.

another SYMEK TNC: TNC21S 1200 Baud AFSK

Connection of the TNC2H to IBM compatible (PC)

Preparation of an interface cable

There are IBM-compatibles with 25 pin or with 9 pin plugs. You need a 25 pin (or 9 pin) Jack for the computer side, and a 25 pin sub-d-plug for the TNC. Also, you should use two suitable connector cases: we recommend metal cases with 4-40 UNC screws to lock the connectors.

Usual PC's use a 9 pin plug for COM 1 and a 25 pin plug at COM 2. When COM 1 is used for the mouse, it is best to connect the TNC to COM 2 via the 25-pin Jack cable.

In addition to the four RS232 signals TxD, RxD, RTS and CTS, the TNC will use Pin 8 (DCD) of the interface. Every time, the CON LED is on (when using TAPR software, this is the case every time you are connected to a distant station), there is a +10 Volt RS232 signal present. This signal is used by some satellite communication programs.

Here the schematics of a serial cable with 25-pin or 9-pin jack. The pin-numbers of the 9-pin version are in {Brackets}

Schematics: (Connections in (Brackets) may be omitted)

```
Plug (PC) - Jack (cable) ---------------- Plug (Cable) - Jack (TNC)

 ( Pin 8      (Pin 1} >-------(pink)--------> Pin 8 )
   Pin 3      {Pin 2} >-------(brown)-------> Pin 3
   Pin 2      {Pin 3} >-------(green)-------> Pin 2
 ( Pin 20     {Pin 4} >-------(grey)--------> Pin 20 )
   Pin 7      {Pin 5} >-------(white)-------> Pin 7
 ( Pin 6      {Pin 6} >-------(blue)--------> Pin 6 )
 ( Pin 4      {Pin 7} >-------(yellow)------> Pin 4 )
 ( Pin 5      {Pin 8} >-------(red)---------> Pin 5 )
 ( Pin 22     {Pin 9} >-------(violet)------> Pin 22 )
```

Software for your PC

For MS-DOS-computers, there is a variety of different programs for packet-radio. In principle, there are three different types of programs:

- Programs for use with TAPR-software in TNC-EPROM. These include different terminal programs like e.g. TELIX or the terminal, which is included in MS-Windows etc. Generally not specially made for use with packet-radio but simple to use and instructive for beginners.

- Programs for TheFirmware (WA8DED) in TNC-EPROM, e.g. SP-software by ESKAY. Similar is "GP" (Graphics Packet) with graphic user interface and mouse support for operation. A very friendly program for colour screen. Further, there is a program known, which runs as a windows-application (even in the background) with 386 / 486 systems. (WINPR)

- Programs for KISS-software in TNC-EPROM (KISS ON. For data transfer with TCP/IP-protocol there are programs by KA9Q or Net-PC available, which can work only with the TNC in KISS-mode.

The best is to use a simple public domain terminal program in the beginning.

If you have trouble when interfacing the PC and TNC, you should ask an OM, who is familiar with PC and serial interfaces. If the connection to your computer doesn't work on the first try, in most cases the reasons are only minor details.

Connection of TNC2H to Atari-ST-Computer

Preparation of the connection cable to the interface

You need a 25-pin sub-d jack and a 25-pin sub-d plug with cases (best with screws to lock). At least, the pins 2, 3 and 7 have to be connected, like the cable for PC mentioned above. If you like, you may connect all 25 wires or use a ribbon cable with the suitable connectors or use a ready made cable.

```
Plug (Atari) - Jack (Cable) --- Plug (Cable) - Jack (TNC)

            Pin 2 >------(green)--------> Pin 2
            Pin 3 >------(brown)--------> Pin 3
            Pin 7 >------(white)--------> Pin 7
```

When operating at 9600 baud (RS232), the length should not exceed 10 m. Avoid putting long RS232 cables in parallel with AC-power or antenna wires.

Installation with Atari (Terminal program)

Select the option "VT52-emulator" (see Atari-manual). You may now transmit and receive data via the serial port of the Atari. If the "VT52-emulator" entry is not available, you find this program on the "EMULATOR.ACC" Diskette, which is delivered with the computer. Copy this program to your system disc and reboot the computer (cycle power).

When pressing the 'HELP'-key, the "RS232-configuration menu appears on the screen".

Select the following parameters (valid also for other terminal programs on other computers!)

	TAPR-EPROM	WA8DED-EPROM
Baud-Rate:	9600	9600 (as TNC)
parity:	EVEN	NONE
Duplex:	FULL	FULL
Bits/character:	7	8
Bit 8:	OFF	OFF
Xon/Xoff:	ON	OFF
RTS/CTS:	OFF	OFF

Click 'OK' and the menu will be stored.

Connect now the TNC to the serial port and plug in the TNC-power. If everything is OK, the sign-on message will appear on the screen.

Connection of TNC2H to Apple Macintosh

```
8-pin round DIN-connector --- 25-pin sub-d connector

(HSK 0) Pin 1 >------(green)---->>----> Pin 20 (DTR)
(HSK 1) Pin 2 >------(yellow)--<<----> Pin 8 + Pin 6 (DCD+DSR)
(TxD)   Pin 3 >------(brown)---->>----> Pin 2 (TxD)
(GND) Pin 4+8 >------(white)---<>----> Pin 7 (GND)
(RxD-)  Pin 5 >------(red)-----<<----> Pin 3 (RxD)
```

Operating the TNC2 with TAPR-EPROM

The TAPR-software is included in the TNC2H EPROM and is activated when Switch 4 is in position "up". TAPR software is intended for use of the TNC with a data terminal. The task of the data terminal is to show everything on the screen received on the serial interface. All characters which are typed are sent to the TNC.

This relatively simple task is done best by a data terminal. For all computers there are terminal-programs available (terminal emulator programs) which turn the computer into a terminal, like TELIX for PC or the "VT52-Emulator" for Atari. A good terminal program has the advantage that received text may be stored or printed.

On the next pages, we describe the operation of the TNC using such a data terminal.

Preparation to use TAPR Software

First, you have to connect the data terminal to the TNC (see above). In every case, the sign-on message of the TAPR software has to appear on the screen. If you type in anything, this text has to appear (as echo) on the screen as well. The radio should be connected to the TNC, otherwise there is no possibility to try out.

Command-mode and Konvers-mode

(Konvers is written with K instead of C intentionally to distinguish it from Command-mode C)

At power-on, the TNC reports its sign-on message, ending with 'cmd:'. The TNC is in the Command-mode and waits for a command, which it understands, to execute. The TNC knows 113 different commands, ranging from 'ACKPRIOR' to 'XON', but don't worry, you will soon learn the 10 commands, which are necessary for 'normal' packet-radio operation, by heart.

In Konvers-mode you do not send commands to the TNC but text for the distant station. Normally this goes like::

```
CONNECT G9XYZ [Command: establish a connection]
```

now, the TNC changes to Konvers-mode automatically. Everything you type in now, e.g.

```
Hi Peter, how do you do today?
```

does not concern the TNC (which would have problems to find a suitable answer) but the distant station. But when the QSO is finished, you have to tell the TNC to end the connection again. Therefore you switch to Command-mode and the TNC will report

```
cmd:
```

Now type

```
DISCONNECT
```

(that's, what the TNC understands now again) and the link is disconnected.

When operating in TAPR mode, you should always know whether you are in Konvers-mode (i.e. you talk to the distant station) or 'chat' with the TNC in Command-mode.

Transparent Data transmission with TAPR Software

Transmitting binary data

The TAPR software is suited to transmit ASCII-characters. But some characters have a special function (like Return, Backspace, Ctl-C etc.). If you want to transfer program code or other binary data, it is possible and probable that this data contains such control characters. A usual and practical way is the 7-plus encoding. A file is transformed by a 7-plus program in a way, that no control characters appear in the resulting data and there is some information (like filename, checksums etc.) added to the 7 plus encoded file. This data may be transferred by all common packet programs or mailbox systems without problems. It does not matter, which TNC-software is used. You only need a computer and a 7-plus encoding / decoding program.

But if binary data has to be transferred between two TNCs, you may use the transparent mode of the TAPR software. Once in transparent mode, the TNC is capable to transmit **all** 256 possible ASCII-characters without exception. The data is received exactly as transmitted. A typical application would be to connect a remote printer, data terminal or meter to a computer via radio. A real transparent data link does not differ from a direct cable connection. (except the transfer rate of cause)

Start of Transparent mode

A packet-connection is established as usual by executing the command:

```
C G4EEG [command: establish a connection]
```

when the connection is established (in Konvers-mode), you switch to transparent mode:

first change to command-mode by typing control-c and then

```
T        [command: change to transparent mode]
```

The command works like the K-command (switching from command to konvers mode), but switches to transparent instead of konvers mode.

Everything typed-in now, (and only that), appears at the distant station without any differences. Own characters are not echoed and all control characters are transmitted unchanged.

As there is no 'return' control character in transparent mode to cause the TNC to send the packet, the data is transmitted at regular time intervals (see command "PACTIME")

Exiting the Transparent mode

As the TNC, once in transparent mode, doesn't react to any control character, it is necessary to use a 'trick' to change back to command mode. There are two possibilities:

1. The computer sends a break-signal (i.e. the RS232-interface line is keyed to +10 Volt for some ms). The TNC leaves transparent mode and reports again   cmd:

2. After a waiting time (defined using the CMDTIME command, default 1 sec.) the computer sends three times the control-c character (less than CMDTIME time between the characters) and again waits the CMDTIME-defined time. After that, the TNC reports again cmd:. If CMDTIME is set to zero, this method is no more possible and only break (method 1) may exit the transparent mode.

The essential commands for transparent mode

(see also the alphabetical listing of the TAPR-commands) : Transpar, PACTime, PARity, Paclen, TRFlow, TXFlow, CMdtime, CONMode, NEwmode, Xflow, CONPerm

Example for programming transparent mode

The following example shows how to realise a transparent wireless data connection, using 2 TNC2 with TAPR software.

1. execute the RESET command. Establishes defined start conditions.

2. define the two callsigns, using the MYcall command.

3. set both TNC2 to CONMode Transparent. So, they will switch to transparent mode after being connected.

4. depending on your application, set AWlen 8 and PARity 0. (optional) Eventually set PACTime, PACLen etc.

5. Establish the connection (execute Connect between both TNC)

6. now, the transparent data link may be tested.

Permanent connections

A connection, once established, may be stored with the CONPerm command. Continue the example above:

7. Send a BREAK-signal, the TNC will enter command mode. Then switch CONPerm ON at both TNC. With command T back to transparent mode again.

8. Cycle power (switch TNC power off and on again) at both TNC. As soon as the power is restored, the TNC will try to reconnect the interrupted connection. The green LED will light again, the transparent connection is active again like before the interruption. The interruption of the link will cause the message "`*** LINK OUT OF ORDER, possible data loss`".

TIP: When power-on, the (maybe unwanted) sign-on message of the TNCs will appear. By changing some addresses in EPROM, this interfering message may be suppressed. The addresses 0290 to 0297 in the TAPR-half of the EPROMs are $CD, xx, xx, 20, 02, 18, EF, CD. The contents of the addresses 0293 and 0294 are $20 and $02 are changed to $00 and $00. At power-on, there will appear only the stream message (e.g. `|A`) which shows, which channel is active.

Optimising the data transfer rate

When using the TNC on standard digipeaters, all parameters should be unchanged. Only then is the chance to access the channel is the same for all users. But for special data transfer applications on a dedicated frequency, the transfer rate may be optimised by adapting the TAPR-parameters. This is important, when large amount of data is to be transferred.

PACLEN: To transmit as much data per packet as possible, the packet-length is set to the maximum value of 256 bytes (PACLEN 0). If it happens frequently so that errors occur, the packet length should be reduced.

MAXFRAME: With MAXFRAME 1 every packet has to be acknowledged before the next packet is transmitted. With MAXFRAME 7 the TNC transmits 7 packets at one time and waits for the acknowledge of the 7th packet only before transmitting the next 7 packets. This reduces the number of transmit/receive switches significantly and accelerates data flow.

FRACK: When there is no acknowledge by the distant station, the TNC will wait the FRACK-time until it re transmits the unacknowledged packet again. The shorter FRACK is, the shorter the waiting time until retry. When CONPERM ON is set, the TNC tries to reconnect after a time distance of FRACK.

TXDELAY: TXDELAY has to be set to a minimum of course. The optimum value is found by trial and depends on transmitter and receiver. TXDELAYC defines the minimum number of flags, which are sent before every packet (minimum 1)

DWAIT: After a transmission, there will be always a delay of DWAIT before the TNC transmits again. If there is a link without any digipeaters used (i.e. two TNC directly connected), DWAIT may be reduced to 0.

ACKTIME: Delay until the transmission of acknowledge. May be set to minimum (try). ACKPRIOR ON gives priority to the acknowledge-packets.

DEADTIME: is adapted to the speed of the receiver's DCD. For a radio link on one frequency between 2 TNC, DEADTIME may be set to a minimum.

SLOTS: defines the probability for the channel-access. With SLOT 1, the probability is 100%, the higher the channel loading, the higher the SLOTS value should be chosen. (default 3, maximum 127, reasonable values up to 10)

RS232: The RS232-connection, of course, must be not slower than the radio link. E.g. in hostmode the TNC will send the acknowledge not before it has transferred all its buffer contents to the computer. This halves the transfer speed. The attached computer must be able to send and receive the data without delay. Some programs are consuming a lot of calculating power for drawing all the data on the screen (e.g. soft-scroll) and slow down the whole transfer rate significantly.

FULLDUP: If there is the possibility to transmit and receive simultaneously (separate transmitter and receiver required), the transfer rate may be increased again. If the transmitter is keyed continuously, TXDELAY may be set to 0.

There is a 100 page booklet available, which explains all the TAPR 1.1.8 commands. Refer to the listing at the end for addresses of TAPR.

Operating the TNC2 with ´The Firmware´ (WA8DED)

Originally, the TNC2 was developed by the TAPR group of Tucson Arizona. This software was suited for use with a data terminal. Some time later, WA8DED created a new program, which included the 'host-mode' and was therefore also suited for the use with a computer. Meanwhile, the WA8DED is wider spread as the TAPR software. In Germany, the NORD<>LINK-group developed a new program, which is compatible to the WA8DED and includes some additional features. These programs are called TheFirmware, the different versions (e.g. TF2.1 to TF2.6) are available for various numbers of channels (4 to 28 channels)

The TF-software in EPROM supports usually 10, (depending on the type 4 to 28) channels, i.e. you may have 10 connections at the same time. With TheFirmware, it is possible to assign (different) callsigns to each channel. Whereas you have to switch between command and konvers mode, the TheFirmware is always in konvers mode, the command mode is only valid for a single line, i.e. for one command.

There are some different WA8DED-like EPROMs for TNC2. Here a short list:

WA8DED 4-channel with KISS and clock

WA8DED 18-channel with KISS and clock

WA8DED 32-channel without KISS and without real-time-clock

TF23 NORD<>LINK 10-channel with KISS, with clock and with DAMA-mode

TF24 NORD<>LINK with DAMA and checksum-KISS ("**SMACK** = **S**tuttgarts **M**odified **A**mateur-**C**hecksum **K**ISS) ")

TF26 NORD<>LINK with DAMA, "**SMACK** " and //Q-disconnect

TF27b NORD<>LINK with DAMA, OPTIMA, SMACK and //Q-disconnect

With the WA8DED EPROMs, commands are entered by typing the escape <ESC>-key. The TNC reports with a simple

```
    *
```

whenever this asterisk is displayed at the beginning of a line, the TNC expects a command line. We want to have a QSO on channel 1. Therefore we switch to channel 1 and enter our callsign:

```
  <ESC> S 1            (switch to channel 1)
```

```
    <ESC> I GW3BBD          (enter the callsign)
```

Now, we can try a connect:

```
    <ESC> C GW2FTF V GW1AT       (connect)
```

When trying this, the other users on the same frequency will bother you, because (though being connected) the monitor mode is still active. Let's switch the monitor mode off:

```
    <ESC> M N     (Monitor off)
```

And now, we disconnect the link on channel 1 again:

```
    <ESC> S 1     (eventually switch to channel 1 again)
    <ESC> D       (disconnect)
```

ready. As you see at this examples, even two or three characters are effective. The WA8DED software is especially well suited, if there is not a human being operating the TNC but a computer. As it is reported, computers are taciturn, the short WA8DED commands are best for their communication with similar machines. As a part of the WA8DED software, you may switch to the hostmode by entering the JHOST command. This hostmode is not intended for manual operation, but works best with a computer. The special commands, which are effective when JHOST is set, are not covered by this manual. Some (good) programs, like SP, GP, WINPR etc. take advantage from the hostmode.

The WA8DED programs work normally without parity bit, 8 bit word length, Xon/Xoff/RTS/CTS off.

Commands of Firmware 2.6 or 2.7

All that is typed in will be sent as a data packet after return, except the line begins with Escape (<ESC>, $1B)! Note: before each of the following commands, you have to type <ESC> first. After that, the * appears and you have to type the command. You may omit the space between the command character and the parameter if you want. Entering the commands in lowercase or uppercase letters is the same.

Some commands are global valid for the TNC, others, which have to / may be defined for each channel individually, are printed in *slant* characters. Default-values (as found after power-on) are underlined.

A 0	insert a <LF> after <CR>
<u>A 1</u>	after every <CR>, a <LF> is sent to the terminal
B [<n>]	time [sec] after that the DAMA mode is cancelled. Display: start-value (actual value)
C call1 [call2 ... call9]	establish connection to call1, eventually via the digipeater call2...call9. You may also type "C call1 VIA call2...call9". When the channel 0 (monitor-channel) is active when executing the C-command, the destination call is set for all packets, which are transmitted in 'unproto'-mode (i.e. for all packets, which are sent without a connection being established)
D	finish a connection on this channel. If the disconnect-packet isn't acknowledged by the distant station, the connection is aborted after a second 'D'.
E 0 / <u>E 1</u>	entered characters are not echoed /are echoed
F n	wait time, until a unacknowledged packet is repeated. Default: 250 ms. Values below 16 are multiplied by 100 to assure compatibility with older versions.

G 0	(only valid in hostmode): status request of the channels
H	display the heard-list
H 0	disable heardlist-update
H 1	enable heardlist-update
H 2	clear heardlist
H n	set maximal number of entries of heardlist
I call	entry of the own callsign. For each channel, a separate callsign may be defined. The call, which is defined for channel 0 is used for the TNC working as a digipeater (via...)
JHOST 0 / JHOST 1	switches the TNC to terminal-mode / to hostmode. The hostmode is intended for the communication with special programs, e.g. GP, SP, AHP, WINPR..
K	show date / time stamp
K 0	disable time stamp
K 1	enable time stamp and status reports
K 2	enable time stamp, status reports and monitor mode
K TT.MM.JJ	set date (European form DD.MM.YY)
K MM/DD/YY	set date (US form MM/DD/YY)
K HH:MM:SS	set time clock / show time and date
L	shows all channels (callsign and status). The active channel is marked with a +.
L [n]	shows channel n (destination call and status)
M N	disables all monitor functions
M I	monitor-mode: only I-frames (data-packets) are shown
M U	monitor-mode: only UI-frames (unproto data-packets) are shown
M S	monitor-mode: only supervisory-frames (control-packets) are shown
M C	monitor-mode active, even when connected,
M + call1 call2 ... call 8	only these calls are monitored
M - call1 call2 ... call 8	all but these calls are monitored. Example: M UI - G4AAU G3FTZ
N n	maximum number of transmissions of a packet, if there is no acknowledge by the distant station. n=0...127, Default=10, 0 means infinite. May be defined for each channel separately. (Retry)
O n	maximum number consecutive packets, which are transmitted without acknowledgement. (MAXFRAME) n=1...7, Default=2. May be defined for each channel separately.
P n	Probability for the transmission of a packet, after the channel has become free. n=0...255, Default=32. When DAMA is active, the value is set to 255.
QRES	clears all data in RAM, reset. The TNC is restarted or returns to its operating system (TNC3 only)
QUIT	(only TNC3): exit the TF26, save the parameters in a .CFG file in RAM, return to the TNC3 operating system

R 0 / <u>R 1</u>	digipeat-function disabled / enabled
S n	switches to channel n. Channel 0 is used for unproto-calls only. Callsigns may be assigned to channels 1...10 (depends on version).
T n	wait time between transmitter keying and starting to transmit data. n=0...127 * 10ms, Default=25=250ms
U <u>0</u> text	no Ctext will be sent.
U 1 text	when getting connected, 'text' is answered as welcome for the distant station.
U 2 text	like U 2. In addition, a disconnect is caused when a **//Q** at beginning of a line is received (terminal mode only)
W n	define time slot. n=0...127, Default=10 = 10ms
X 0 / <u>X 1</u>	transmitter disabled / enabled
Y n	maximum number of connection channels n=0...10, Default: 4
Z 0	no handshake to the terminal and no handshake to the TNC
Z 1	no handshake to the terminal but software-handshake to the TNC
Z 2	software-handshake to the terminal but no handshake to the TNC
<u>Z 3</u>	software-handshake to the terminal and software-handshake to the TNC
@A1 [<n>]	SRTT calculation: define / show value for A1. Default: 7
@A2 [<n>]	SRTT calculation: define / show value for A2. Default: 15
@A3 [<n>]	SRTT calculation: define / show value for A3. Default: 3
@B	display of free memory space (Buffer)
<u>@D 0</u> / @D 1	fullduplex off / on
@I [<n>]	set value for IPOLL-frame length. Default: 60
@M [0|<u>1</u>]	terminal-mode: 0=7 Bit 1=8 Bit
@S	display status of the connection
@T2 n	timer 2 interval, n=0...65535 * 10ms, default=150. time until a received packet will be acknowledged
@T3 n	timer 3 interval, n=0...32767 * 10ms, default=18000=3 min. time, the TNC waits for the distant station to give a sign of life until a request is sent
<u>@V 0</u> / @V 1	callsign check disabled / enabled

control characters: <BS> or <DEL> will clear the last typed character. ^U or ^X clears the whole input line, ^R clears the input line and displays the received data. Again typing ^R restores the cleared line.

Construction of a TNC2H-kit

You should be familiar with soldering printed circuit boards. When working carefully, nothing will go wrong. Here are some points, which should be observed. Note: if there is a single component soldered wrong in place, the whole TNC won't work and the search for the fault may take more time than the construction itself. Further, there is a risk that a component will be damaged as it takes trouble to find out which part it is and to find a replacement for it.

Hints for construction of a kit

1. for 'home-brew' TNCs, we recommend the use of IC-sockets so, it is easier to replace unintentionally killed parts. Unsoldering of IC is very diffucult!

2. only ceramic capacitors and single resistors CANNOT be soldered the wrong way! IC, electrolytic capacitors, diodes, resistor networks and the battery have to be soldered watching their polarity

3. Load the board carefully and complete in any order. There are no wire jumpers. Have a very close look to all solder points after all, the expense will be worth. Professionals brush the resin flux away with spirit (dry well after)

4. the battery is mounted, after all tests have been successful

Set-up of a self made TNC2H

The DIP-switches are set as follows:

⇑ ⇓ ⇑ ⇑ ⇑ ⇑ ⇑ ⇑ ⇑

all up except 2=down means: 9600 Bd terminal Baudrate, TAPR-software, loop back-filter

The completely built-up TNC (with EPROM) is connected to a power supply (current limit about 200 mA). The current drain should be 130 to 160 mA (check!). The CON- and STA LED will light for about a half second and go out again. If this happens, the digital part is 99% OK. If the LED stays on, you have to find the fault in the digital parts of the TNC2.

Now, connect a data terminal (take care of baud rate etc.) and switch the TNC on again. The sign-on message has to appear on the screen, ending with the `cmd:` . You may watch the +/- 10 volt RS232 signal at the interface lines with a scope. When typing 'return', a new line with 'cmd:' will appear.

Jumper settings in the TNC2H

J1: RX-mute: near the DIP-switch. When receiving, the transmitter is muted. If you cut the trace on the solder side of the board and connect the middle pin with the pin nearer to the front panel, the transmitter is **not** muted.

J2: BERT-Data: Bit Error Test Jumper: near J1, in the corner of the board near the DIP-switch. Default is normal data mode. When you cut the BERT-jumper on the board's solder side and connect the middle pin to ground (nearer to the front panel), the TNC will transmit zeroes only (but scrambled). The distant station may suppose a transmission error, whenever a one is received. Alternatively, you may transmit a 'always zero' signal when executing the CAL-command in TAPR mode. CAUTION: When you leave the TNC in BERT-mode, all functions will seem like standard data mode, but it won't work! A frequent operator error, which may take hours to fix!

J3: WDOG: Watchdog-Disable, near the resistors, direction to the DIP-switch. Is shorted when the transmit time limiter is to be disabled (e.g. for tests)

J4: SIO-DCDB : between SIO and RAM, normally closed (to ground), may be opened for NET-ROM-applications

J5: D/A Test pin : exactly in the centre of the board, near GAL-R and RN5. Output of the D/A converter, unfiltered transmit data signal

J6: RXC Test pin : exactly in the centre of the board, near GAL-R and U15. Here you may tap the clock, which is restored from the received signal, e.g. for triggering the oscilloscope when watching the eye-diagram.

J7: RX-Eye Test pin : near Pin 1 of the crystal oscillator. Input of the decider, filtered receive-data. Here, you may watch the eye diagram of the received data. A better wave form of the eye diagram may be measured at pin 8 of U9 (LM324) (there are no disturbing influences of LM393 trigger.

J8: 19,6--9,8 MHz, located between the sub-d-jack and U19, (near the battery). If a 19,66 MHz quartz-oscillator is used (for 19200 baud operation) you may run the CPU and baud rate clocks with the half oscillator frequency, when switching to "19,6 MHz". Cut the "9,8 MHz" connection on the solder side before.

J9: Pin9, near the sub-d-jack. Connects pin 9 of the sub-d-jack with the power-supply jack if needed. The power may then applied via the 25 pin jack as well.

J10: GND, in the corner near the sub-d-jack. Ground connection, e.g. for grounding the case or as test pin for the oscilloscope.

(R22): output*, near the voltage regulator. Only used if the output amplifier must have a gain greater than 1

(R23): input*, near the voltage regulator. Only used if the input preamplifier must have a gain greater than 1

(R24): BERT, near the leads of the voltage regulator. Is only needed if the received data should be connected to pin 5 of the DIN-connector. Solder a wire or better a 100 Ohm resistor as R24 to make the bit-errors audible in a headphone, which is connected to Pin 5 (see also "experiments with TNC2H). R24 must not be soldered in, when CR5 is soldered!

(CR5): between DIN and power jack. If here a 1N4148 is soldered, a DCD-signal may be fed from a external source (e.g. from a 1200 baud modem to disable the TNC2H's transmitter). If pin 5 of the DIN jack is switched to ground, the yellow LED "DCD" lights and the TNC supposes that the radio channel is occupied. If a 1N4141 is soldered in place with reverse polarity as indicated in the circuit diagram, the DCD-signal of the TNC2H may be tapped: when a 9600-baud-signal is present, pin 5 of the DIN-jack is tied to ground. Of course, a wire jumper or a 100 Ω resistor may be used as CR5. Then you can use both and you may interlock two TNCs. Each of them is disabled until both DCD circuits release the common line. CR5 must not be soldered in, when R24 is soldered!

Bitrate and Baudrate

In this description, we talk sometimes about Bit/s, sometimes about Baud (Bd) as transmission speed. With the TNC2H, both statements are equivalent, as with every clock cycle there is only a single bit transferred. (data signalling rate) It is possible to transfer more than one bit per clock cycle (e.g. with multiple phase shift keying). Then, the data transfer rate (bit/s) may be a multiple of the baud rate (Baud)

Digital Interface (Modem-Disconnect-Connector)

The TNC2H possesses a 20 pin plug on board, where you may connect a external modem with a ribbon cable. The pin assignment corresponds to the DF9IC recommendation for high-speed modems. All even numbered pins are grounded, this gives a excellent screening effect when using flat ribbon cable. However, the cable length should not exceed 20 cm (8 inch)

Pin assignment modem-disconnect

Pin	Signal	Function	Jumper		Pin	Signal
1	+ 5 Volt	power supply of the modem from the TNC	-		2	ground
3	+ 5 Volt	power supply of the modem from the TNC	-		4	Ground
5	Reset	low-pulse after power-on	-		6	Ground
7	DCD	AF carrier detect from modem to TNC	D1		8	Ground
9	CTS	transmitter is keyed up (from modem to TNC)	D2		10	Ground
11	PTT	transmitter keying (from TNC to Modem)	D2		12	Ground
13	TxD	transmit data (from TNC to modem)	D3		14	Ground
15	RxD	receive data (from modem to TNC)	D6		16	Ground
17	TXC	transmit clock (from modem to TNC)	D5		18	Ground
19	RXC	receive clock (from modem to TNC)	D4		20	Ground

The digital signals have CMOS TTL-level (0 / 5 Volt), the modem is supplied via the digital interface pins 1 and 3 with the regulated 5 volt (ca. max. 200 mA)

Descriptions of the interface signals (modem disconnect)

Reset (Pin 5): (input tof modem) normally HI, is pulsed LO for approx. 50 ms when the TNC3 is powered on or when the MAX691 watchdog circuit goes to the reset-state. The signal is not used in the TNC2H and most modems do not use it as well. (for later enhancements, like DSP-modems)

DCD (Pin 7) Data Carrier Detect: (output of modem) HI, when the modem receives no carrier, LO, when the modem has locked on a signal (DCD).

CTS (Pin 9) Clear to Send: (output of modem) normally HI. When the transmitter is keyed up, the modem will pull this line LO. The TNC will transmit the data not before CTS is LO.

PTT (Pin 11) Push to talk, or RTS (Request to send)**:** (input to modem) normally HI. When the transmitter should be keyed, the TNC pulls this line LO. With the AFSK-1200 modem, PTT is identical to the CTS-Signal, which goes from Modem to the TNC.

TxD (Pin 13) Transmit Data: (input to modem). The data is latched at the rising edge (LO-HI-transition) of the transmit clock (TXC).

RXD (Pin 15) Receive Data: (output of modem). Data is valid at the rising edge (LO-HI-transition) of receive clock (RXC) and changes at the falling edge.

TXC (Pin 17) Transmit Clock: (output of modem) A frequency which equals the baud rate is generated by the modem and defines the data transmission speed between TNC and modem. At LO-HI-transitions of the transmit clock, the transmit data (TXD) must be valid and stable.

RXC (Pin 19) Receive Clock: (output of modem). The clock which was derived from the received data, is transferred to the TNC. At the rising edge (LO-HI-transition) of receive clock the data (RXD) is valid, it changes at the falling edge. The RXC-frequency corresponds to the transmit clock of the transmitting distant station and will slightly differ from the own transmit clock.

Connecting a external modem to TNC2H

The TNC2H has a 20-pin connector for 20 wire ribbon cable for external modems. Take care that the pin 1 (red marked wire) of both sides of the cable is oriented properly. Pin 1 of the TNC2H is situated at the edge of the board, near the corner, the SYMEK modems have the pin 1 generally in the centre of the board. The internal modem of TNC2H is disconnected by cutting the traces at the solder side of the jumper pads D1 to D6 (situated between the LED's) If there is no transmitter connected to the internal modem, it would be enough to cut D1, D2, D5 and D6. For this case, the internal modem will transmit parallel to the external modem without interference.

The TNC2 generates and requires the TX- and RX-data in NRZ-format. If a TNC3 modem (AFSK1200 etc.) should be connected, it must be modified to "NRZ" !

The DCD and PTT LED's of the external modem and of the TNC2 will light at the same time. So, it is not necessary to arrange it in a way that the modem LED's are visible.

If the modem be built-in into the TNC2H case, you may fix the board with 5mm spacers bottom up on the top panel. Orient it in a way, that the DIN-jack is situated behind the TNC2H front panel and drill (!) a 16 mm hole over the LED's to insert the radio connector (new front panels are available as spare parts). A better solution is: place the modem in the middle of the case and make the radio connection with a 30cm round 5 wire cable piece with a 5 pin jack at the end. Drill a 6mm hole in the rear panel (over the RS232 jack) and pull it through.

Use of the TNC2H internal modem

If the internal TNC2H modem should be connected to e.g. another TNC (TNC2, TNC3 etc.), the Jumpers D1...D6 have to been cut and the modem signals have to be tapped here. The assignment of the jumpers and the modem disconnect signals are found in the table above. A external TNC is connected by soldering wires to those pins of the jumpers D1-D6, which are oriented to the centre of the board. The Pins nearer to the edge go to the SIO of TNC2H.

DCD-Coupling of TNC2H and TNC2S for combined Digipeater

There exist digipeaters, which operate combined 9600/1200 Baud access modes. When using such a digipeater, it is necessary, that the TNC recognises the channel 'busy', even when there is a transmission with another Baudrate.

1. the 1200 baud user access of a combined digipeater is used with a TNCS. Cut the Jumper trace "DCD" at TNC2S on the solder side of the board and close the jumper at the "3105" side. The 'digital' squelch (XR2211 circuit) is now disabled. The TNC2S recognises the channel busy, when the squelch of the radio receiver opens. It doesn't matter if the signal is 1200 or 9600 baud.

2. if a TNC2H and TNC2S should be used simultaneously for operation with a combined digipeater, both TNC-DCD-circuits may simply combined with a wired-or-circuit. At the TNC2S you have to make the following modification: Pin 6 of XR2211 is cut directly at the IC's body and on the solder side of the pcb pins 5 and 6 of 2211 are shorted by a solder drop. Now, the DCD-function is inverted: if there is a packet-Signal, the DCD-LED goes out (instead of on) and the transmitter may be keyed, is the channel silent, the transmitter will be disabled. To turn the sense of DCD back again, cut pin 13 of 74HC86 near the boards surface and connect the pin's stump to ground (e.g. pin 7 of adjacent 74HC74) with a enamelled copper wire. Now, the TNC2S must operate exactly as before.

Now, install a wire in the TNC2S from the interconnection pin5/Pin6 of XR2211 to the jumper "DIN" (middle pin) to lead the DCD-signal via pin 5 of the DIN-jack out of the case. Pin 5 has now the following meaning:

- if pin 5 of DIN-jack is tied to ground, the TNC signals "channel busy" and doesn't transmit.

- is the channel busy, pin 5 of DIN-jack is tied to ground.

It is possible to connect some TNC2 with pin 5 of DIN-jack in parallel. The TNC will transmit only, when all connected receivers signal 'channel free'.

If a TNC2H is connected to this DCD-coupling, the optional diode CR5 (DCDE) has to be installed as a wire jumper. For this case, pin 5 has the same function as described above. (see also the manual of TNC2)

With diodes, the interlocks may be programmed in a way, that one TNC may block another but not vice versa.

Self test of TNC2H   (audio loop back)

Preparation for Self test

As equipment, you need a computer or a data terminal, a power supply for the TNC and if possible a oscilloscope. You will gain much experience with the 9600 baud FSK technique with the following steps.

Self test with TAPR-Firmware and Terminal-program

Connect the TNC2H with the data terminal / PC with terminal-emulator software and switch the DIP-switch 4 of TNC2H up for TAPR-Software. The terminal should be configured 7 Bit, even Parity so that the correct sign-on message appears after power-on

First enter your callsign:

```
mycall g3abc
```

and start the calibration routine with the command

```
cal
```

with the 'K'-key, the transmitter may be keyed and releases. Watch the signal at test pin J5 or at the cw-stop of the trimpot: You may see a mix-up of lines, but all of them intersect at certain points. This picture is called eye-diagram. It is the audio frequency signal, which is generated by the TNC. Even when there is no data transferred, the signal changes constantly and pseudo-randomly from 0 to 1 and vice versa. This random sequence is generated by the modem.

When connecting pin 1 with pin 4 of the DIN-jack (I made a special DIN-plug for that purpose), the transmit signal is fed back to the receiver's input. You may receive the data, which you produce yourself. At pin 14 of U14 (TL064) or pin 8 of U9 the received and filtered signal may be watched. If you see distortions (clipping of the curves), you have to turn the trimmer back to avoid overdriving of the sensitive input. The eye-diagram at pin 8 of U9 (LM324) has (caused by the receiver input filter) even sharper intersection points as the transmit signal itself. At J7 you can look at the input signal of the decider (comparator) stage. By means of this signal, at the sampling time, the decision is made whether the received signal was a zero or a one.

Now, you should use a oscilloscope with external trigger if possible. The trigger is derived from J6 (Rx-Clock). It makes no sense to trigger on the transmit or receive signal itself. If a dual channel oscilloscope is available, attach J6 to the second channel and trigger on this signal.

Test with a distant station

The matter becomes more interesting, when there is a uhf-transmitter and receiver used instead of a wire jumper between pin 4 and 1 of the DIN-jack. Mostly, this tests will be made with a distant station, which generates a test signal with the CAL-command. Choose a frequency, which is not occupied in order to not disturb anyone. The eye-diagram will look not as perfect as at the loop back-test. The intersection points become blurred and the eye is no more as widely open, i.e. some lines cross the region, which was dark before. The crucial thing is, that there remains a part of the eye 'open'. At the times, the lines generally intersect in the upper and lower part of the screen picture, there must be no line near the centre between the zero and the one.

Now, you should try out the four switches 5,6,7 and 8 at the transmitting TNC and watch, which combinations give the clearest intersections. This could be done during transmission, the transmitting TNC has not to be powered off. The most interesting switch positions are written down. Mostly, position 0 or 9 to 12 are best. Now, the first test has been finished successfully.

Bit-Error-Test

To find out the really optimum switch position, you have to execute the bit-error-test (BERT): The transmitting TNC has not to be modified, it will do to generate a test signal with the TAPR CAL-command and to take care, that the transmitter keeps keyed up. (Because of the transmit time limiter (Watchdog), the transmitter has to be keyed up manually) At the receiving TNC, the modem-output (pin 12 of GAL-R) is watched. You will find a DC-voltage (zero or one), which will show a short impulse every time, there was a (wrong) bit received, which the transmitter didn't send.

Connect a small loudspeaker to pin 5 of the DIN-jack and solder a 100 Ω resistor as R24 in place. The speaker will crack silently, when a wrong bit was recognised. As the link gets

worse, (signal strength), the cracks will increase. Optimise in a way, that there are no more cracks for at least some seconds. If there is a crack every other second, the link isn't good and you should search for the reasons. The reason is often that the transmitter doesn't modulate properly.

First, adjust the AF-amplitude of the transmitting TNC. This is done in the simplest way by listening to the transmitted signal. If the trimpot of the transmitting TNC is turned fully counter clockwise, there will be only the unmodulated carrier to receive. Now increase slowly the volume of the transmitter output until the noise-like signal becomes louder no more. Now decrease the AF signal until the noise becomes just a little bit quieter. But it is best to watch the received signal at the scope.

To execute the bit error test, proceed as follows: First cut the trace of the jumper J2 (in the very corner near the DIP-switch) between the middle pin and the 'data' pin. Now pull a jumper over the two pins 'BERT'. The TNC will now transmit zeroes only. The same result may be obtained when executing the CAL-command in TAPR-software, starting to transmit with K and cause the SIO to send a constant 1 or 0 with the D (='diddle')-key.

For the transmitter could be keyed up at will, the watchdog is disabled by installing the watchdog jumper J3 (WDOG). With the CAL-command, the transmitter is keyed (and released), the TNC will transmit (scrambled) zeroes now.

At the receiving TNC, you watch if there occur (error-) pulses at the BERT-output. Now try out the 16 filter curves and write down the bit error rate. Try to count the number of error occurrences by listening to the acoustic cracks. Switch positions, where the BERT-output crackles more or less are principally unusable. Only the positions with less than one bit error per second are interesting.

If the adjustment of the IF-filters and demodulator is not optimal, this could also cause a increase of bit errors due to deformation of the receive eye pattern. If the eye seems to be not symmetrical, try to turn carefully the discriminators centre frequency. But do not misalign all the IF filters if you are not used to such work.

The following table may be useful to find out the best filter curves:

No	S1	S2	S3	S4	**S5**	**S6**	**S7**	**S8**	S9	errors / 10 s	for (radio type)
0	x	x	x	x	⇓	⇓	⇓	⇓	x		Audio Loop back (AF-Test)
1	x	x	x	x	⇑	⇓	⇓	⇓	x		TR2300
2	x	x	x	x	⇓	⇑	⇓	⇓	x		TR8300
3	x	x	x	x	⇑	⇑	⇓	⇓	x		TS700
4	x	x	x	x	⇓	⇓	⇑	⇓	x		IC451
5	x	x	x	x	⇑	⇓	⇑	⇓	x		Pye Europa
6	x	x	x	x	⇓	⇑	⇑	⇓	x		Pye F460
7	x	x	x	x	⇑	⇑	⇑	⇓	x		Pye R461, DR570EP
8	x	x	x	x	⇓	⇓	⇓	⇑	x		Mobira 325
9	x	x	x	x	⇑	⇓	⇓	⇑	x		Tait 500
10	x	x	x	x	⇓	⇑	⇓	⇑	x		Salora 4624204
11	x	x	x	x	⇑	⇑	⇓	⇑	x		Storno CQM700
12	x	x	x	x	⇓	⇓	⇑	⇑	x		Storno CQM663
13	x	x	x	x	⇑	⇓	⇑	⇑	x		G4FPV-XCVR
14	x	x	x	x	⇓	⇑	⇑	⇑	x		G8ADH-XCVR
15	x	x	x	x	⇑	⇑	⇑	⇑	x		Cirkit 23cm

This test is executed in both directions until the bit error rate is small enough. It is best, if there is a event counter used and a real statistic calculation is made. Values below 10^{-4} are OK, but with a error rate of 10^{-3} there would be every 1000th bit wrong, i.e. every 4th packet would have to be repeated. At 9600 baud, 1 error per 10 seconds correspond to a bit error rate of 10^{-5}.

Most of the experiments will give results of about 20 errors per second. Better filter curves give 2 to 4 error per 10 sec, really useful are bit error rates of less than 1 error per 10 seconds.

The scrambler generates a signal, which is repeated every 2^{17} bit, thus corresponding a duration of 13,65 seconds. In the data stream, all possible 17-bit combinations occur regularly every 13,65 seconds. Certain bit combinations, e.g. 17-time zero or 17-time one may cause problems with a link. This could be recognised, if the bit errors occur regularly every 13,65 seconds, generally symmetrical, i.e. double (every 7 sec). If there are more than one pair of critical combinations, the number of bit errors doubles again, bit errors occur every 3,4 sec or possibly even more frequent. In addition, there are non systematical transmission errors, caused by noise or other sources of interfering signals.

Self connect and Test-QSO

If everything is OK so far, you may start to try a connect. Do it as described in the earlier chapters, if there is no one to connect, just connect yourself. With TAPR-software this is possible without problems. Type in e.g.

```
C G9XYZ
```

and the connection should be established at once. If you use TheFirmware, such a self connect is only possible when setting @D 1 (fullduplex on). After that, everything is like (or similar to) TAPR. Texts which are sent as info-packets, are received immediately and displayed. The real QSO with a distant station will complete the test session. Now, you should adjust the transmitter key-up delay (TX-delay) to an optimum by reducing TX-delay step by step until problems by too short transmitter pre-keying occur. Increase TX-delay by 20-30% to be on the safe side. TX-delays of 10 to 50 ms are suitable for 9600 baud operation. If the radio has as lazy receive/transmit switch and TX-delays of 200 or more ms become necessary, the transmission will slow down: A typical 9600-baud packet has a length of approx. 500-2500 bit and takes 50 to 250 milliseconds. If the transmitter needs 200 ms just for switching, the gain of speed is no more significant: almost half of the time is wasted for useless delay times. A ideal suited packet transmitter should have transmit/receive delays of 10 ms or less.

Grounding the case

The case has no direct connection with the circuit, but there is a ground trace on the printed circuit board, which has at least thermal contact to the side parts of the case to support the cooling of the voltage regulator. This ground trace gives at least a capacitive coupling of circuit ground and case.

For better screening against RF-interference and static electricity, it may be advisable to connect case and TNC ground directly. If there are static discharges (e.g. caused by synthetic carpets and dry atmosphere) it may happen that the TNC does an reset when touching with the hand, maybe forgetting its stored parameters. The high voltage of the static charge (10 - 40kV) may cause a tiny spark between case and circuit. A safe remedy is a connection to ground: solder a bare 0,5 mm wire (3 cm long) to J10 ('GND'), which is situated in the pcb's corner. Tear this wire away from the board and bend it around the right nut bolt of the sub-d jack. When closing the case again, the wire is pinched between jack and rear panel, which gives sufficient contact to ground.

RF-interference protection

By use of 11 RF-filters, there was taken great care on the RF-filtering for all outgoing signals. The filters are situated directly near the connectors and connected to a low inductance ground plane. The T-filters have a small inductor at the input and output and a 1 nF capacitor to ground. The RF-attenuation vs. frequency curve was selected with regard to the amateur frequencies

frequency range	Attenuation	Band
10 MHz	10 dB	
20 MHz	20 dB	
50 MHz	30 dB	
100 MHz	35 dB	
150 MHz	50 dB	2 m
500 MHz	30 dB	70 cm
1000 MHz	20 dB	

(Values in dB(μV/m) measured in 1 m distance with dipole in non reflecting environment

Results of the measurements in a EMI-laboratory:

meas. frequency	interferences	peaks, single spectral lines
1,5 to 50 MHz	less than 0dB	2 lines at 18 and 20 MHz ca 9 dB
50 to 70 MHz	less than 15 dB	lines at 60 and 70 MHz ca 30 dB
70 to 100 MHz	less than 5 dB	lines at 80 and 90 MHz
100 to 130 MHz	less than 20 dB	lines at 100, 110 and 120 MHz
130 to 200 MHz	less than 3 dB	lines at 130, 140, 150... (less than 10 dB)
over 200 MHz	less than 10 dB	lines every 10 MHz (less then 30 dB)

If the TNC and the receiver antenna are not sufficiently decoupled, it may happen that the reception is interfered by the clock frequencies of the TNC. If this is the case, you should ground the case first (see above) and check, if the interference has disappeared. Frequently, the interference is not caused by the TNC but by other equipment, especially the computers, which emit the unwanted signals through the computer-TNC connection to the radio receiver. Additional filtering on the computer data cable may help. All unwanted emissions of the TNC in the frequency range from 0 to 30 MHz are too weak to be measured in the EMI-laboratory!

The TNC2H had been tested to be conform with the refulations for electromagnetic compatibility (EMVG). The TNC2H meets the requirements for the CE-sign.

Meaning of the light emitting diodes (LED)

There are 5 LEDs at the front panel as operational status indicator, and 7 DIP-switches for configuring the baud rate and the software-options.

The PWR-LED (yellow)

This LED is supplied by the TNC's regulated 5 volt supply voltage and will always light, when the TNC is supplied with power

The PTT-LED (red)

The LED will lit, when the transmitter is keyed. After approx. 20s continuous transmission, the transmitting is switched off, but the LED will still light (as a effect of the watchdog circuit)

The DCD-LED (yellow)

This LED will light, when the modem recognises the radio channel busy. As long as the LED lights the TNC will not transmit

The CON-LED (green)

This LED is controlled by the TNC software and may have different meanings, dependent on the software used. With TAPR it means: You are connected to a distant station on the selected channel. With WA8DED, it means nearly the same.

The STA-LED (red)

This LED is controlled by the TNC software and may have different meanings, dependent on the software used. With TAPR it means: The TNC has outgoing data packets in its memory,

which are not acknowledged by the distant station yet. With WA8DED-hostmode, it means: There have been data packets received, but not transferred to the computer yet:

Meaning of the DIP-switches

Setting of the 9 DIP-switches of TNC2H (general)

The levers of the DIP-switch can be set up (switched off) or down (switched on) with a pointed object (do not use ballpen or pencil). As the switches close to ground, a open switch means a high level (one, + 5 volt), a closed switch means low level (zero, 0 volt). In the following description, the levers are represented by arrows, the point of them indicating the position of the switch lever.

⇑   switch up = open = hi level (1)

⇓   switch down = closed = low level (0)

×   for this setting, don't care about this switch

Switches 1, 2 and 3 : terminal-baudrate

(Switch 1 is covered by the front panel, it is used only if there are extremely low baud rates used)

⇓	⇓	⇓	×	×	×	×	×	Terminal-baudrate 150 Baud
⇓	⇓	⇑	×	×	×	×	×	Terminal-baudrate 600 Baud
⇓	⇑	⇓	×	×	×	×	×	Terminal-baudrate 1200 Baud
⇓	⇑	⇑	×	×	×	×	×	Terminal-baudrate 2400 Baud
⇑	⇓	⇓	×	×	×	×	×	Terminal-baudrate 4800 Baud
⇑	⇓	⇑	×	×	×	×	×	**Term.-baud rate 9600 Baud (Default)**
⇑	⇑	⇓	×	×	×	×	×	Terminal-baudrate 19200 Baud
⇑	⇑	⇑	×	×	×	×	×	Terminal-baudrate 38400 Baud

switch 1-3: terminal-baudrate (standard 9,8 MHz oscillator used)

Switch 4: selecting upper/lower half of EPROM

As EPROM, it is possible to use 27C256 (32 kbyte) or 27C512 (64 kbyte) types. The operating software for the TNC needs only 32 kbyte. So, in a 27C512 two complete, different softwares may be stored. The selection of one of them is done by switching the most significant address A15 (pin 1 of EPROM). The built-in EPROM is programmed in a way, that TAPR software is active when A15=1, is A15 tied to ground, the WA8DED software is selected.

For use of 27C256, Pin 1 (Vpp) has to be tied to Vcc (=1, switch op = open)

×	×	×	⇓	×	×	×	×	×	A15=0 original EPROM: <u>WA8DED /</u> <u>TheFirmware TF 2.6 or 2.7</u> (e.g. for 'SP'-program, 'GP', 'TOP'etc) or: 27C512 EPROM, lower half
×	×	×	⇑	×	×	×	×	×	A15=1 original EPROM: TAPR or: 27C512 EPROM, upper half or: 27C256 EPROM type

Switch 5 - 9: Filter

The switches 5 - 9 serve for selection of the G3RUH-transmit filter. Switch 9 is partly covered by the front panel, but the switch 9 has to be always closed. There are 32 different filter characteristics to select, but as there are only 16 different ones available now, the upper half of the EPROM is filled with $7F. If the upper half of the EPROM is selected, the transmitter will be mute.

				1	2	4	8	16	
0	×	×	×	×	⇓	⇓	⇓	⇓	⇓	loop back-curve
1	×	×	×	×	⇑	⇓	⇓	⇓	⇓	filter curve No. 1
9	×	×	×	×	⇑	⇓	⇓	⇑	⇓	filter curve No. 9
10	×	×	×	×	⇓	⇑	⇓	⇑	⇓	filter curve No. 10
11	×	×	×	×	⇑	⇑	⇓	⇑	⇓	try-out which fits best
12	×	×	×	×	⇓	⇓	⇑	⇑	⇓	(make bit error test)
15	×	×	×	×	⇑	⇑	⇑	⇑	⇓	filter curve No. 15

Modification of TNC2H for 19200 baud

General

The circuit of the TNC2H modem was designed for 9600 baud, but may be used for other baud rates in a wide range as well. The baud rate depends on the filter frequencies, which is defined only by the values of the filter capacitors C6 to C11 and C13 and the digital clock frequencies for modem transmitter and receiver. The modification for 19200 baud is already prepared, other baud rates are also possible. It would be nice, if 9600 baud would become general standard. At 4800 baud, the question arises 'why not 9600' as the expense for the radio modification is the same. At 19200 baud, there may occur difficult problems with the radio bandwidth and there will be problems with adjacent-channel interference. Further, the speed gain won't be satisfactory because of the transmit delay times, which will prevail.

For modification of TNC2H, just replace the capacitors, which determine the filter frequency by components with the half value and double the clock oscillator's frequency.

Modification of the Analogue Filters

The capacitors are unsoldered carefully, the lead is removed from the holes and the new components are soldered in place according to the following table:

	C6	C7	C8	C9	C10	C11	C13
9600 baud	1 nF	3,3 nF	1 nF	100 pF	470 pF	1 nF	220 pF
19200 baud	470 pF	1,5 nF	470 pF	47 pF	220 pF	470 pF	100 pF
buy:	new	new	new	new	ex C13	ex C10	ex C9

Changing the Baud Rate-Clock

The 9,8304 MHz oscillator is carefully unsoldered and replaced by a 19,6608 MHz oscillator. As now the CPU-clock is doubled as well, jumper J8 on the pcb solder side has to be cut and closed on the "19,6 MHz" side again.

Now, all clocks for the terminal baud rate and the SIO-timer will double. This has to be considered in any case. All programmed timer of the TNC have to be set to the double time now, i.e. TX-Delay, Frack, etc. Further, the terminal baudrate (which is set with the first four switches at the front panel) will double. Now, the following table will be valid:

1	2	3	4	5	6	7	8	9	DIP-switch
⇓	⇓	⇓	×	×	×	×	×	⇓	terminal-baudrate 300 baud
⇓	⇓	⇑	×	×	×	×	×	⇓	terminal-baudrate 1200 baud
⇓	⇑	⇓	×	×	×	×	×	⇓	terminal-baudrate 2400 baud
⇓	⇑	⇑	×	×	×	×	×	⇓	terminal-baudrate 4800 baud
⇑	⇓	⇓	×	×	×	×	×	⇓	terminal-baudrate 9600 baud
⇑	⇓	⇑	×	×	×	×	×	⇓	term.-baudrate 19200 baud (Default)
⇑	⇑	⇓	×	×	×	×	×	⇓	terminal-baudrate 38400 baud
⇑	⇑	⇑	×	×	×	×	×	⇓	(terminal-baudrate 76800 baud)

DIP-switch when using a 19,66 MHz quartz oscillator
do not use position 76800 baud.

Observe when operating 19200 baud:

It is not absolutely sure that a TNC2, running at 9,8 MHz CPU-clock, receives the signals 100% in every case with any software. With TAPR or KISSmode, there were no problems, but with hostmode and the WA8DED derived programs, sometimes problems arise, due to slow processing speed. It could happen, that a program will 'hang', but normally, the TNC will just lose single packets. This causes a retry and seems, as if the radio link was bad, but the failure was caused by the TNC itself.

A possible remedy would be, to replace the CPU and SIO by 20 MHz-types and keep the setting of J8 at "9,8 MHz". Because of the increased power drain, the dissipation of the voltage regulator has to be watched.

Low-power-version of TNC2H

Description of low power versions

Normally, the TNC is supplied by a 13,5-Volt voltage source and needs a current of 130-200 mA. With the low-power-version, the current drain may be reduced down to approx. 35 mA. Most of the power is needed for the GALs, but there are (more costly) GALs available, which need almost no power, thus reducing the total TNC2H current from typically 180 to 70 mA. As the TNC uses internally only 5 Volt, it is possible to replace the 7805 linear voltage regulator by a switchmode step down converter, which converts the input voltage of 6 to 16 Volt down to 5 Volt. The efficiency of this circuit is 80-90%, this reduces the current at 12 Volt to the half with respect to the 5 volt side. The total supply current of the low-power-TNC2H is then approx. 35 mA, this corresponds to a power of 0,5 Watt (instead of 2 Watt at the standard model). A later modification is easy: As the GALs are mounted in sockets, they have just to be exchanged into zero-power types. The 7805 regulator has to be unsoldered and replaced by the switchmode regulator.
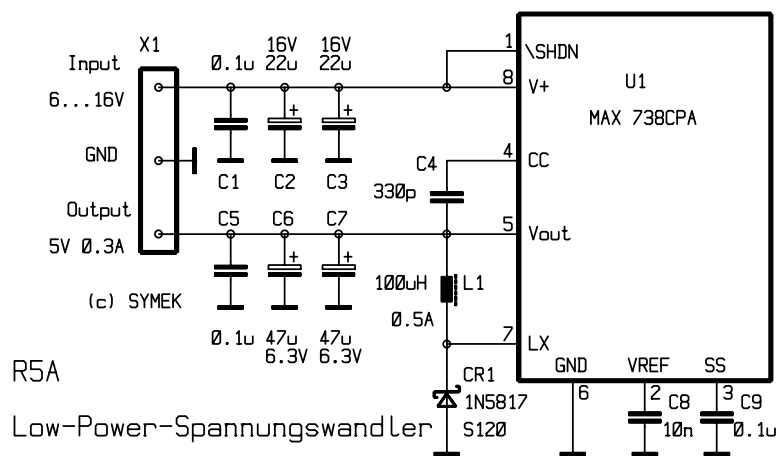
Switchmode regulator

Tip: if you make sure, not to reverse the supply polarity, the reverse-polarity protection diode CR 3 may be omitted (i.e. shorted). This will reduce the current again about 2 mA.

The normal supply-voltage range of TNC2H is 8 to 16 volt DC. With the power-saving regulator and the shorted diode CR 3, the device will work in a range of 6 to 16 Volt. The higher the input voltage, the lower the current. But do not exceed the 16 volt limit!

The power-saving voltage converter replaces the 7805 regulator. It converts an input voltage of 6 up to maximal 16 Volt to 5 Volt, the efficiency is 90%. The higher the input voltage, the lower the current.

Parts list TNC2H-G

BATT1	lithium-battery 3V 180 mAh		R8	R 2,2 MΩ (2,20 MΩ)
C1, 2, 3, 4	multilayer cap-C 0,1µF		R9	R 18 kΩ (18,2 kΩ)
C5	tantal- 4,7µF 16V		R10	R 27 kΩ (27,4 kΩ)
C6	WIMA film 1000pF 5%		R11	R 47 kΩ (47,5 kΩ)
C7	WIMA film 3300pF 5%		R12	R 100 kΩ (100 kΩ)
C8	WIMA film 1000pF 5%		R13	R 6,8 kΩ (6,81 kΩ)
C9	WIMA film 100pF		R14	R 2,2 kΩ (2,21 kΩ)
C10	WIMA film 470pF		R15	R 39 kΩ (40,2 kΩ)
C11	WIMA film 1000pF 5%		R16	R 82 kΩ (82,5 kΩ)
C12	multilayer 0,1µF		R17	R 2,2 kΩ (2,21 kΩ)
C13	WIMA film 220pF 5%		R18	R 330 kΩ (332 kΩ)
C14	WIMA film 470nF		R19	R 8,2 kΩ (8,25 kΩ)
C15, 16, 17	multilayer 0,1µF		R20	R 2,2 MΩ (2,20 MΩ)
C18 - 22	tantal 4,7µF 16V		R21	R 2,2kΩ (2,21 kΩ)
C23, 24	multilayer 0,1µF		(R22)	n.c. (s. table output voltage)
C25	tantal 4,7µF 16V		(R23)	n.c. (s. table Input sensitivity)
C26, 27	multilayer 0,1µF		(R24)	n.c. (s. BERT-mode)
(C28)	n.c.		R25	R 2,2 MΩ (2,20 MΩ)
C29 - 31	tantal 4,7µF 16V		R26	R 220 Ω
C32	ceramic 33 pF		RN1	RN10-1-10K 10-pin, 9 resistors
CR1	diode 1N4148		RN2	RN10-3-1K5 10-pin, 5 resistors
CR2	zener ZPD18		RN3	RN10-1-10K 10-pin, 9 resistors
CR3	diode 1N4002		RN4	RN10-1-10K 10-pin, 9 resistors
CR4	diode 1N4148		RN5	RN10-3-10K 10-pin, 5 resistors
(CR5)	(for DCD outp. only): 1N4148		ST1	(n.c.) 20-pin male connector
F1-6	EMI-T-filter 1nF L-C-L		ST2	SUBD25 connector
F7, 8	EMI-T-filter 100pF L-C-L		ST3	DIN5-connector
F9-11	EMI-T-filter 1nF L-C-L		ST4	STV-connector for NES-J
J1	jumper 3-pin RX-mute		SW1	9-pin Piano-DIP-switch
J2	jumper 3-pin BERT-Data		U1	TMPZ84C00-10 Z80 CPU 10 MHz
J3	jumper 2-pin WDOG		U2	TMPZ84C40-8 Z80 SIO-0
J4	jumper 2-pin DCDB		U3	74HC14 hex trigger
J5	test pin D/A out		U4	GAL16V8_T (socket)
J6	test pin RXClock		U5	27C256 G3RUH-filter EPROM (socket)
J7	test pin RX-Eye		U6	ZN429 D/A converter
J8	jumper 3-pin 9,8-19,6 MHz		U7	CD4006 shift reg. (TX)
J9	jumper Pin 9 power supply		U8	GAL16V8_C (socket)
J10	ground pin		U9	LM324 opamp
LED1	LED 3mm yellow PWR		U10	27C256/512 TNC-EPROM (socket)
LED2	LED 3mm red PTT		U11	55256-10LP 32kByte RAM
LED3	LED 3mm yellow DCD		U12	GAL16V8_R (socket)
LED4	LED 3mm green CON		U13	LM393 comparator
LED5	LED 3mm red STA		U14	TL064 opamp
P1	R-trim 10K 10x5 mm output		U15	CD4006 shift reg. (RX)
Q1	VMOS-FET BS170		U16	74HC139 decoder
R1	R 100 kΩ (all: metal film resistors)		U17	MAX232 RS232-interface
R2	R 56 kΩ (56,2 kΩ)		U18	MAX691 reset +RAM-control
R3	R 2,2 kΩ (2,21 kΩ)		U19	74HC151 multiplexer
R4	R 2,2 kΩ (2,21 kΩ)		U20	74HC4020 binary counter
R5	R 12 kΩ (12,1 kΩ)		U21	XTAL oscillator 9,8304 MHz
R6	R 100 kΩ (100 kΩ)		U22	7805 5-volt-regulator
R7	R 2,2 kΩ (2,21 kΩ)			

Schematic diagram TNC2H-G (digital)
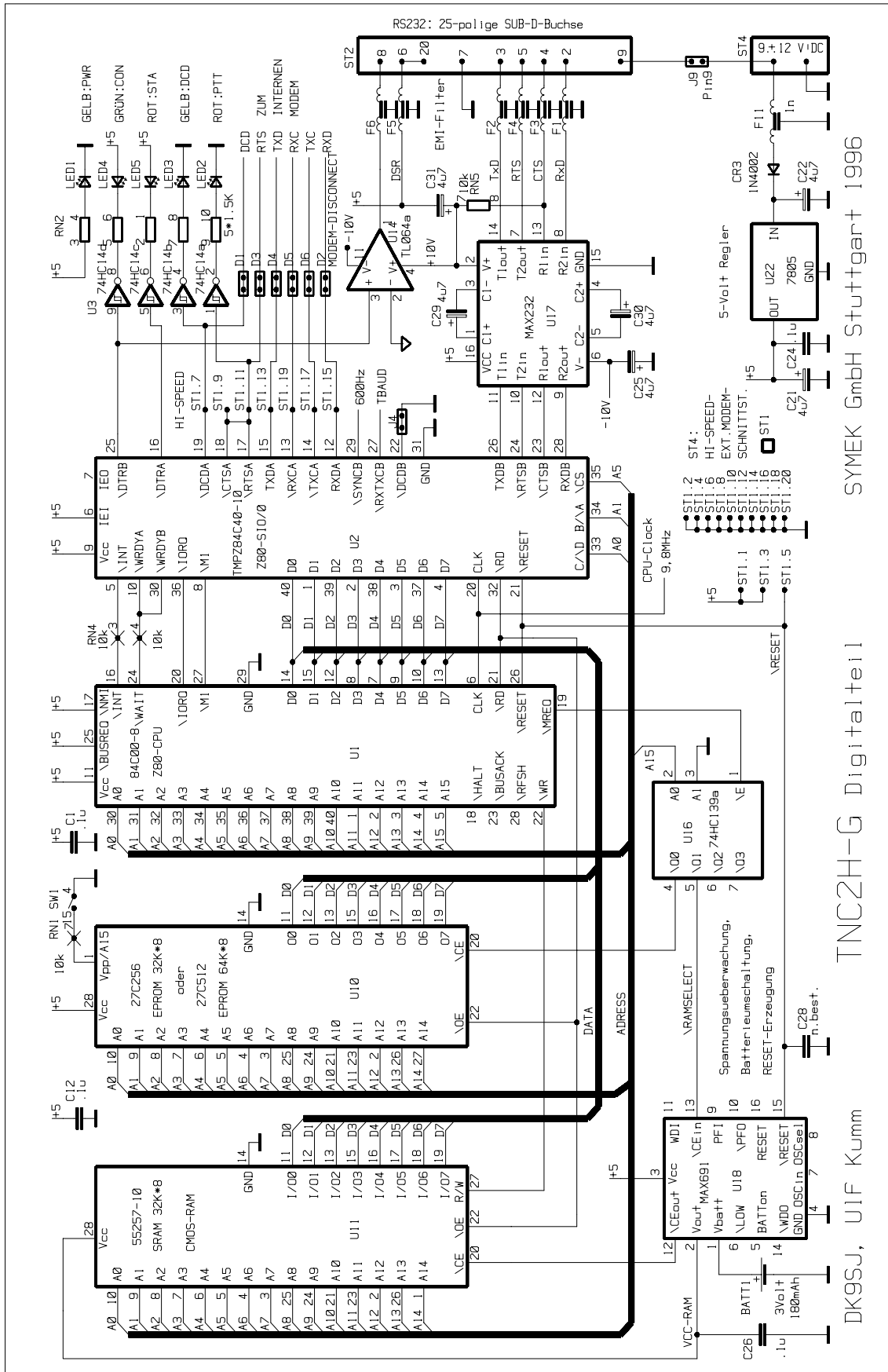
Schematic diagram TNC2H-G (modem)
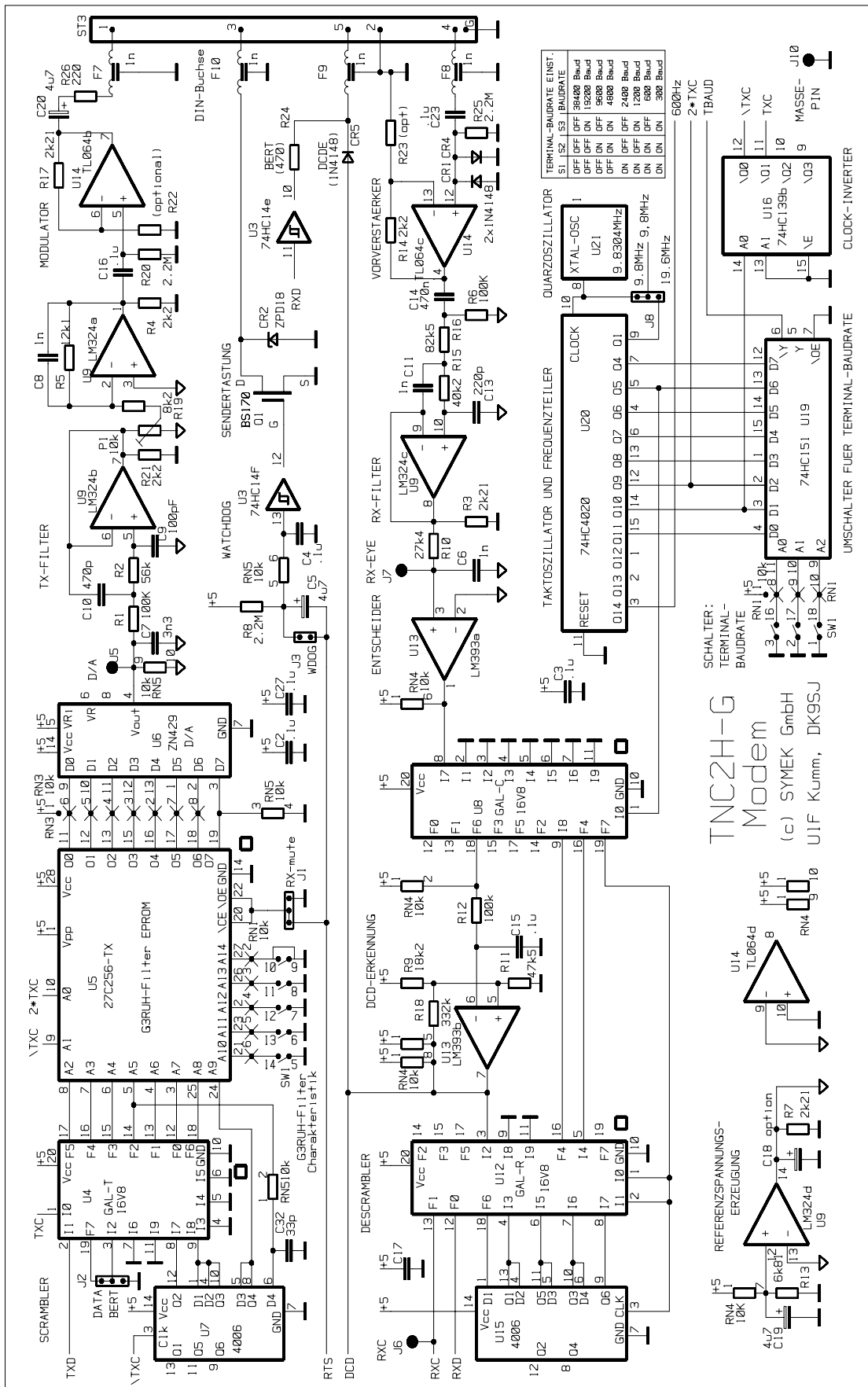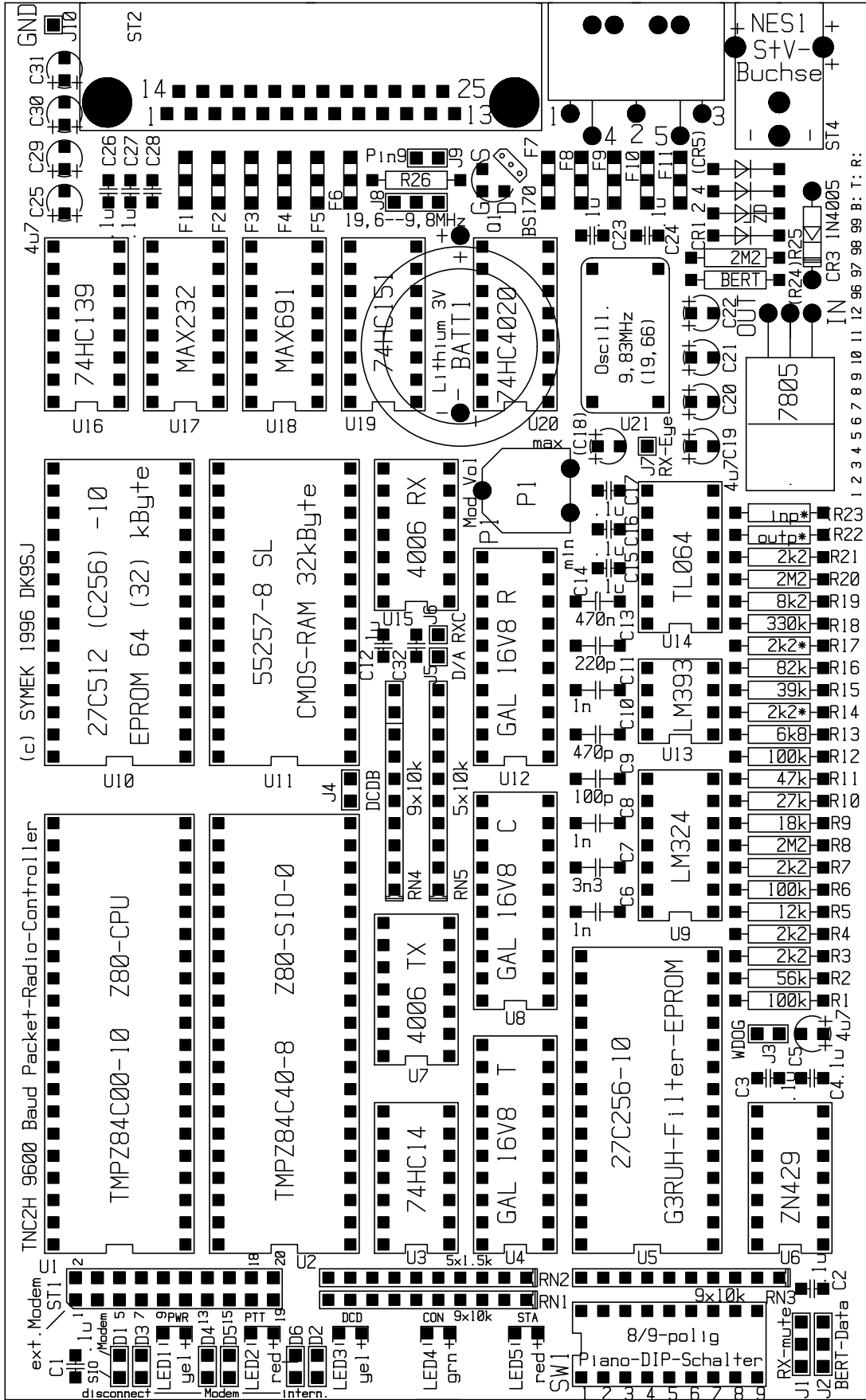
What to do if the TNC doesn't work?

The circuit of the TNC is well tested. The component quality is industry standard, the printed circuit board quality is outstanding and the devices are thoroughly tested before shipment. Nevertheless, it may happen, that the TNC fails.

Mostly, the apparent fault is are the parameters, which are set to wrong values. Reset the TNC totally to its new state and try again.

If you modified your TNC in any way (e.g. another EPROM), try first if this may cause the malfunction and cancel the modifications.

Here some hints, how to damage the TNC. (please do not try, the faults are not covered by our warranty):

- Overload of the power supply by over voltage or short circuit in the ground connection (potential difference between computer ground, supply ground and radio ground). Do never apply a voltage to the power supply jack, which is more negative than the ground (of computer or radio). It is a good idea to connect the grounds of radio, computer and power supply directly and not via the connection inside the TNC. In case of lightning, the radio ground may be lifted to high voltages, causing a excessive current flow through the TNC to power or computer and severe damages to all equipment.

- Destruction of the RS232 interface: the RS232-interface is robust, but there should be no external voltage be applied to the pins. The interface connector may be removed while the TNC is powered on without damage. In case of trouble with the interface, if the computer communicates with the TNC no more, check the MAX232 first.

As the case is not grounded, occasionally resets may occur if there are static discharges. Connect the case to ground as described earlier.

If your TNC won't operate in spite of all efforts, you should try to borrow another TNC and make sure that there are no malfunctions in the other equipment, but really in the TNC itself. If the TNC seems to be defective, connect your dealer or the manufacturer for repair. The manufacturer warranty period is 1 year from date of invoice.

If you prefer to repair the TNC by yourself, we can supply the special parts. Call for availability.

The manufacturer will repair the devices as soon as possible. If the TNC was modified, these modifications eventually have to be cancelled.

In any case, please give us a **precise, written description of the fault**, even when you called us by phone before. Maybe you could describe, how your TNC was operated and which incident has lead to the failure. You make it easier for us to find the fault and the TNC will be returned sooner.

We wish you much joy when using the device!

55 & 73 ! Ulf Kumm, DK9SJ

License terms for TNC2 hard and software

The TNC contains two programs in EPROM: the NORD×LINK software (e.g. TF26, a WA8DED-like software with hostmode and KISS/SMACK) and the TAPR software (e.g. TAPR 1.1.8). The NORD×LINK software is free for non-commercial use, but it is not allowed to sell this software as a commercial product. If someone enhances the NORD×LINK software he has to offer his results to the general public as the original software was. In a case of doubt, refer to the license conditions if NORD×LINK, which was published in the packet mailbox net (called "ALAS").

The copyright of the TAPR-software is owned by Tucson Amateur Packet Radio. The EPROMs used in the TNC2, containing TAPR-software are licensed by TAPR, the sign on message shows SYMEK as owner of a license to copy the program. We have paid the unique fees for the right to use the software as well as the royalties for each EPROM.

The copyright of the FIR-filters with EPROM and modem-designs is owned by James Miller, G3RUH. There exists a contract between the parties about using and copying the G3RUH design.

The improved design of the G3RUH modems has been made by Dr. Henning Rech, DF9IC. There are agreements between SYMEK and DF9IC about the use of the design.

The printed circuit board artwork has been done by SYMEK GmbH. It is not allowed to copy this without written permission.

Parts of this handbook may be published and spread for non commercial purpose, if the source is mentioned (e.g. 'from: SYMEK manual for TNC2H'). We share the interest of all packet amateurs to make our contribution for this fascinating technique. We are happy if packet radio finds as much friends as possible.

Your comments are welcome by Internet: eMail: info@symek.com

For informations about the newest on Packet-Radio and our TNC read our internet pages: **http://symek.com**

Addresses and suppliers

SYMEK GmbH (production and distribution of TNC3S, TNC2S, TNC2H, TNC2M etc.) DK9SJ, Ulf Kumm Johannes-Krämer-Straße 34, D-70597 Stuttgart (Sonnenberg) Phone: +49-711-7618923, Hotline: +49-711-7654911, Fax: xx49-711-7678924, Email: info@symek.com, homepage: http://symek.com

Other SYMEK products

TNC21S "the proven"

The TNC21S is the standard packet controller for 1200 baud packet-radio. Inclusing ist predecessor, the TNC2S, there are many thousand installations in many countries. It is a good choice for packet operation at 1200 baud AFSK for amateur or cb radio. Z80 CMOS processor with 5 MHz clock, 32 kByte RAM, standard EPROM with TheFirmware. 110x35x85 mm perfectly screened case to avoid any rf emissions, reliable reset-circuit, battery backup RAM, detailed, comprehensive manual with much information for the packet-beginner (available now in German and French language - check for availability in English).

TNC2H "the fast"

The TNC2H has a built-in 9600 baud G3RUH-modem. TNC digital part and modem are on a single printed circuit board. The TNC is not connected to microphone and speaker jack of the radio but directly to the modulator and demodulator. Suited ideally for amateur-packet-satellites. Current drain: approx. 150 mA, with optional low power circuits 35 mA only. Aluminium case like TNC2S. Very detailed manual in English or German language.

TNC3S "16-bit 2 port" the high end packet controller

The TNC3 utilises a 16-Bit processor MC68302 and allows packet-operation with **two** modems simultaneously. The packet-baud rate may be up to 1 Mbaud per port, the plug-in

modems are included in the case. Up to 2 MByte CMOS RAM and EPROM, battery buffered real time clock. RS232 interface as TNC2, max. 115 kBaud. Low power drain. Optional: Software-development package, add-on memory. The TNC3S may be used as a high-speed TheNet Node (NET-ROM-type), FlexNet node and TCP/IP node simultaneously and can be used as TNC (TheFirmware compatible) with a powerful mailbox at the same time. Several TNC3 may be linked via a 1 Mbit/s serial bus for bigger nodes with up to 10 outgoing links.

Modem AFSK 1200

1200 baud AFSK-modem for TNC3S (suited for TNC2H too) 40x120 mm modem-board with separate tone decoder as squelch circuit and possibility to combine the DCD-signals.

Modem FSK-9600

Modem for 9600 baud G3RUH FSK-modulation, for TNC3S (as well as for TNC2H and other TNC2 or RMNC) 80x120 mm modem board. Filter, bit-error-test, watchdog and PTT accessible from the rear panel. Connection for combining the DCD-signals. With some modifications, this modem type could be used for baudrates up to 614 kBaud!

Ask your dealer for information and availability of the mentioned products.

TNC2H, rear view

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