FEATURES OF THE VADCG TNC+

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Abstract

This paper describes the features and design philosophy of the new VADCG TNC+ (TNC plus) terminal node controller which is the second TNC produced by the Vancouver Amateur Digital Communications Group (VADCG). The TNC+ has many unique features not found on the current TNCs being marketed. These features facilitate Amateur packet radio software development and dissemination and permit the interested user to learn about the detailed operation of the TNC and various protocols. The VADCG TNC+ is an 'open' system as opposed to a 'black box' system.

Background

Members of the VADCG designed the first Amateur packet radio board in 1979 and after some discussion one evening in the living room of my house over possible names to give the device, we decided to call it a 'terminal node controller' (TNC). Although there were a lot of other proposals that evening, this terminology is now used world-wide to describe this commonplace piece of equipment. The same term is now also used to describe equipment with both a controller and modem although at the time the term was coined, it was considered that the modem and controller functions were separate. The original board used an external modem.

When the first VADCG TNC was designed in 1979, 2716s cost $80 each and they were hard to find even at that price. So the first TNC was designed with the less expensive 2708 EPROMs. Time has passed and memory prices and technology have substantially improved. Although the original TNC's lifetime has been extended through a slight modification allowing the use of 2732 EPROMs or by the use of add-on or 'daughter' boards, the time has finally come to replace the board with one with more memory and some new features such as long-term battery backed up RAM which were not possible when the original board was designed.

The original TNC has now been around for over six years and the original purchasers have certainly seen a long lifetime for a pioneer project. Software development is still being done on the original board and software developers using it usually have made available all the source code freely and free of charge for the various programs developed for the board. The tradition of supplying software source free of charge for Amateur packet radio use started with the original software for the first TNC which was written by myself in the spirit of cooperative development. This tradition of free sharing of information is dying out now that Amateur packet radio has been turned over to commercial interests.

Protocols such as V-l, V-2, AX.25 and V-3 as well as various types of repeater and digipeater programs, monitors and debuggers and user interfaces have been provided free of charge to users of the original VADCG TNC. These programs were usually developed on CP/M systems. There is even a system which allows three of these protocols to be resident in the TNC at the same time.

When the original TNC was designed, it was intended to be used as a common development system so that software developers could exchange their programs and sharetheirwork for the commongoalof Amateur packet radio development. It was designed so that developers could use the most common development system available to thematthetime- theCP/M system. It was intended that it would meet the needs of Amateur packet radio developers long into the future. It was designed to operate at speeds up to 64,000 Baud which at the time were thought to be necessary for a useful Amateur packet radio network. It is somewhat of a surprise and a disappointment to the original developers of the TNC to see that almost seven years later, in 1986 that almost all packet radio operation is done at speeds no higher than 1200 Baud. The high speed capability of this board has never been used.

In the intervening years since the VADCG pioneer TNC development, Amateur TNCs have degenerated into mass-produced 'black boxes with canned programs with unavailable source code and little or no information on the internal workings of the software. Some have been stripped of the common development tools such as the ability to display and alter memory. This has presumably been done to keep the inner workings of the software a secret. It is the author's opinion that these closed systems and an almost paranoid tendency to standardize at any cost suppress the further development of Amateur packet radio and in fact are significant enough that they make it doubtful that the full potential of Amateur packet radio will ever be realized.

In spite of these somewhat gloomy expectations, the VADCG has produced its second TNC - the TNC+. This work has been done in order to encourage more technical development of Amateur packet radio hardware and software by providing a TNC that is easy to develop and exchange programs for and has the capability of high speed operation. But note that the TNC+ is not just intended for developers. It is intended to be used by both developers and end users alike. It is hoped that the end users will realize the importance of using equipment and software that can be upgraded by local developers and not simply opt for the cheapest TNC available at the time.

SYSTEM DESIGN

Although many people helped to bring the TNC+ into existence, the design of the system was done mainly by two individuals - John Spraggs, VE7ADE and myself. It is important to understand the design philosophy behind the VADCG TNC+ as it is not the same as most of the TNCs on the market. Factors which went into the design of this TNC are:

We wanted to modernize the TNC while still keeping faith with the purchasers of the original VADCG TNC designed in 1979. We did not want to negate the original purchaser's investment in hardware or the time spent in getting the system operational,

We also wanted to avoid negating all the effort by many people developing software for the original board.

We wanted to provide a more 'open' system than most of the other TNC manufacturers. The source for most of the software running on the board is available.

We wanted more and better ways to upgrade and distribute new software for the TNC than by replacement of EPROMs. The large battery backed up RAM space combined with selectable write protected areas allows programs to be distributed in five different ways with appropriate software:

1. Programs may be loaded from a 'HEX' file from a computer.
2. Programs may be loaded from a remote computer using a packet radio link,
3. Programs may be transferred directly from one TNC to another using a packet radio link without the aid of a computer.
4. Programs may be loaded over a telephone connection with simple interface hardware.
5. Programs can still be provided in burned in EPROMs as has been done in the past.

We wanted to provide a system that software developers could easily use. With this TNC, the software developer does not have to own an EPROM programmer and eraser. New programs can be loaded quickly from a serial port on the development system. In addition, an operating system using a version of FORTH called STOIC and an assembler is already operating and available which runs on the TNC+ itself. With these tools, a knowledgable developer can program directly on the TNC in either assembly language or higher level Forth type words. This in fact, allows the TNC to operate as an independent microcomputer development system.

We wanted to increase the flexibility and function of the TNC rather than strip it to bare essentials as is being done by others. The parallel port allows use of a printer and terminal simultaneously or provides signals for remote control applications. The serial port supports automatic speed and format selection (Autobaud) over a wide range. The Baud rates are not just the binary rates between 300 and 9600 but go up to 38,400 Baud and down to DC including all standard speeds in this range as well as many non-standard speeds. For example, speeds of 45.45, 110, 400 and 134.5 are supported by the hardware.

Instead of an ion-board modem providing only low speeds of 300 or 1200 Baud, the TNC+ has an industry standard connector to an off-board modem and supports synchronous modems at Baud rates up to 64,000 Baud and asynchronous moderns up to 9600 Baud and both NRZ and NRZI encoding is supported at all Baud rates. In the author's opinion,, the future of Amateur packet radio urgently requires a move to higher Baud rates for both the end-user and backbone links. The TNC+ can use almost all existing standard modems such as Bell 202, 212A, 103, etc. as well as many others which have not seen common use in Amateur radio as yet. (An off-board radio modem is available from the VADCG which supports changes from 300 to 1200 Baud with switch selection and requires no tuning up and is powered directly from the TNC+.)

Compare this for example, to the off-board modem connector in many other TNCs. They frequently do not use a standard connector or standard voltage levels (TTL instead of RS-232), and only support the more expensive synchronous modems and require special signals which are not supplied by standard modems.

We wanted to ensure that the TNC+ had sufficient capacity for expansion. The full 64kB memory support should provide adequate memory for many future packet radio software developments.

HARDWARE SPECIFICATIONS

Timing
The 8085A Microprocessor uses a 4.9152 MHz. crystal to provide a master system clock of 2.4576 MHz. A binary dividing chain provides frequencies from 307.2 kHz. down to 4.6875 Hz. for HDLC controller data rates and software clocking. The timing chain may also be used for interrupting the microprocessor at selected regular intervals.

Memory
The full 64k addressing space is supported and the following combinations of RAM/EPROM are supported by jumper selection:

8k EPROM - 56k RAM
16k EPROM - 48k RAM
32k EPROM - 32k RAM

The RAM below 8000 (Hexadecimal) in the address space may be selectively write protected by jumper selection. All RAM is backed up by a Lithium battery expected to last about 5 years if the TNC+ is powered off. If the TNC is powered on, it should last for the shelf life of the battery which is greater than10 years. 8 sockets for 2764 type EPROMs and 6264LP RAM chips are provided. A Voltage comparator automatically disables memory and resets the microprocessor when the supply voltage drops into an out of specification range. This prevents the microprocessor from writing garbage data into random memory locations during power brown-outs.

Serial Port
Uses an 8250 UART with internal Baud rate generator using industry standard 1488 and 1489 RS-232 drivers to a standard female DB-25S connector. The connector may be configured as either a DCE or DTE(or non-standard connections) with a jumper plug provided. The RS-232 signals supported are:

Transmit Data	TD	*
Received Data	RD	*
Request to Send	RTS	
Clear to Send	CTS	*
Data Set Ready	DSR	*
Carrier Detect	CD	*
Data Terminal Ready	DTR	
Ring Indicator	RI	

The serial port can be used in polled mode or interrupt driven mode by the software. Changes in status of the lines marked with an '*' can generate interrupts. The serial Baud rate, data format, stop bits, etc. are under complete software control allowing for automatic selection of data speed and format (Autobaud). Standard Baud rates supported are: 38,400, 19,200, 9600, 4800, 2400, 1200, 600, 400, 300, 150, 134.5, 110, 75, 45.45. Many other non-standard speeds are also supported by the hardware.

Modem port
An Intel 8273 HDLC/SDLC protocol controller chip is used with 1488 and 1489 RS-232 drivers and an industry standard DB-25S (female) connector supporting the following signals:

Transmit Data	TD	*
Received Data	RD	
Request to Send	RTS	*
Clear to Send	CTS	
Data Set Ready	DSR	
Carrier Detect	CD	
Transmit Clock	TC	
Receive Clock	RC	
Data Terminal Ready	DTR	*
Signal Quality	SQ	
Ring Indicator	RI	
Data Speed Select	DSS	*

The output signals are indicated by an '*'. In addition, +12 and -12 voltages are supplied on pins 9 and 10 of the DB-25S connector to supply power to the modem. The on-board switching power supply has excess capacity to power a modem. A separate header connector provides the above signals at TTL levels along with +5, +12 and -12 voltage levels for an internal modem (inside the same cabinet). Both full duplex and half duplex, synchronous and asynchronous modems are supported by means of on-board jumpers. Asynchronous modem speeds at the following Baud rates are supported by means of on board jumpers: 9600, 4800, 2400, 1200, 600, 300, 150, 75. Other asynchronous modem speeds (such as 400 Baud) are possible up to 9600 Baud if clocks are provided on RC and TC by the modem, Synchronous modems are supported at any Baud rate up to 64,000 Baud. (Baud rate is controlled by the modem.) Note that the Baud rate may be limited by the software being used.

The 8273 transmit and receive functions are completely independent allowing for full duplex operation. Separate receive and transmit interrupts are provided allowing for interrupt driven software.

Parallel Port
An 8255A Programmable Parallel Interface provides 24 I/O lines of TTL level signals on a DB-25S connector. These lines may be programmed under software control in several different modes of operation such as input or output, handshaking, bidirectional and interrupt control. They may be programmed to drive a printer with a Centronics parallel interface or provide control lines for specialized equipment. The parallel port may be operated under interrupt control.

Configuration Switches
An 8-position DIP switch is provided which can be read by software.

Indicator **LEDs**
There are 4 on-board LEDs which can be turned on and off by software. A header is provided for mountfng the LEDs off board if desired,

Trap Switch
Circuitry and a connector is provided to allow for an off-board Trap interrupt switch. (Non-maskable interrupt) This is very useful for a software developer to analyse software failures.

Reset Switch
Circuitry and a connector is provided to allow for an off--board Reset switch or pushbutton. A reset function is automatically performed when the TNC+ is powered on.

Power supply
An on board switching power supply and regulation is provided to supply all voltages needed by the board as well as Power for off board circuitry such as modems. Nominal DC power of +10 to +15 Volts is required but typical operation is between +7 Volts and +18 Volts. A connector is provided to operate the TNC directly from regulated +5, +12 and -12 Volts without the need of the switching power supply components. When the board is not supplying off-board power the measured current consumption without CMOS components is:

290 mA at 17 Volts
340 mA at12 Volts
480 mA at 7 Volts

The on board switching power supply supplies regulated power at the following currents for off-board devices.

5 Volts at 2 Amperes
-12 Volts at approximately 120 mA.

The input power Voltage (+10 to +15 Volts) is also available.

PC Board
7.75 X 8.5 inches (197 X 216 mm.) Double--sided G-10 Glass Epoxy with plated through holes. The board is silk-screened and solder masked.

Upgrade
Users with the original VADCG TNC board should note that this board is exactly the same size as the original board with mounting holes and edge connectors in the same position as the original board. The major components from the original board such as the 8273, 8255, 8250, 8085, 1488s, 1489s, 4024, 74LS373, 74LS132s, 74LS00 and 4.9152 MHz. crystal can be removed and installed on the new board and the old power supply can be used to power it instead of using the on-board switching power supply components. This will significantly reduce the cost of upgrading to the new board. A special parts kit will be available for those who already have the original VADCG TNC and are upgrading to the TNC+.

Documentation
Since the TNC+ is being supplied as a kit, the documentation includes step-by-step assembly instructions, parts lists and circuit diagram as well as hardware configuration instructions. Because many different types of software are available to run on the TNC+, separate documentation packages are provided for each software package or protocol and for the firmware.

FIRMWARE

The TNC+ parts kit will come with a single programmed 2764 EPROM containing code which will allow bootstrap loading of the battery backed up RAM through the serial port or by a radio link to another TNC+. It contains the Autobaud routines and memory file system as well as drivers for the serial, parallel and HDLC ports. The firmware contains buffer and queue management routines and common routines which can be used by programs in RAM and a monitor program which allows for the displaying of registers and status, the displaying and changing of memory, and the display of the directory of memory files and programs. The firmware allows for all but the Trap and Restart interrupts to be vectored to RAM addresses. The firmware provides for the disabling of the AutoBaud function if desired and allows for selection of the program (protocol) to be entered after a hardware reset of the TNC+. These features are useful when the TNC is connected to a host computer.

SOFTWARE

All I/O port addresses remain the same as in the original TNC board so the many programs written for the original board still run in the new board usually with no modifications required. Much time and effort has been made developing these programs and that effort should not have been wasted.

The following programs are expected to be available at the time this paper is published. Most are available now. Note that several of these programs (protocols) may be installed in the TNC+ at the same time. New programs will become available as they are developed.

STOIC - This is a Forth-like operating system for the TNC+. It contains an integrated 8085 assembler as well as additionallow-level communication words for use of the HDLC/SDLC communications interface on the TNC+. This allows the TNC+to be used as a personal computer and allows the knowledgable user to develop communications programs directly on the TNC+. Although this is not a normal TNC function, the structure and addressing capability of the TNC+ made it easy to provide this operating system.

V-l - Also called the original "Vancouver" link level protocol. This was the first protocol in widespread use for packet radio in the U.S. and Canada.

Although superceded by the more generalized V-2, V-3 and AX.25 protocols nowadays, it is nevertheless the most efficient protocol in terms of overhead and may well be the best choice for point to point half duplex links and for the current type of satellite communications.

V-2 - An efficient link level protocol also developed in Vancouver and used in several countries. The specifications for this protocol were published in the proceedings of the third ARRL Amateur Radio Computer Networking Conference in the paper titled, "A New Vancouver Protocol." This implementation supports the International Standard X.3 and X.28 user interface protocols as well.

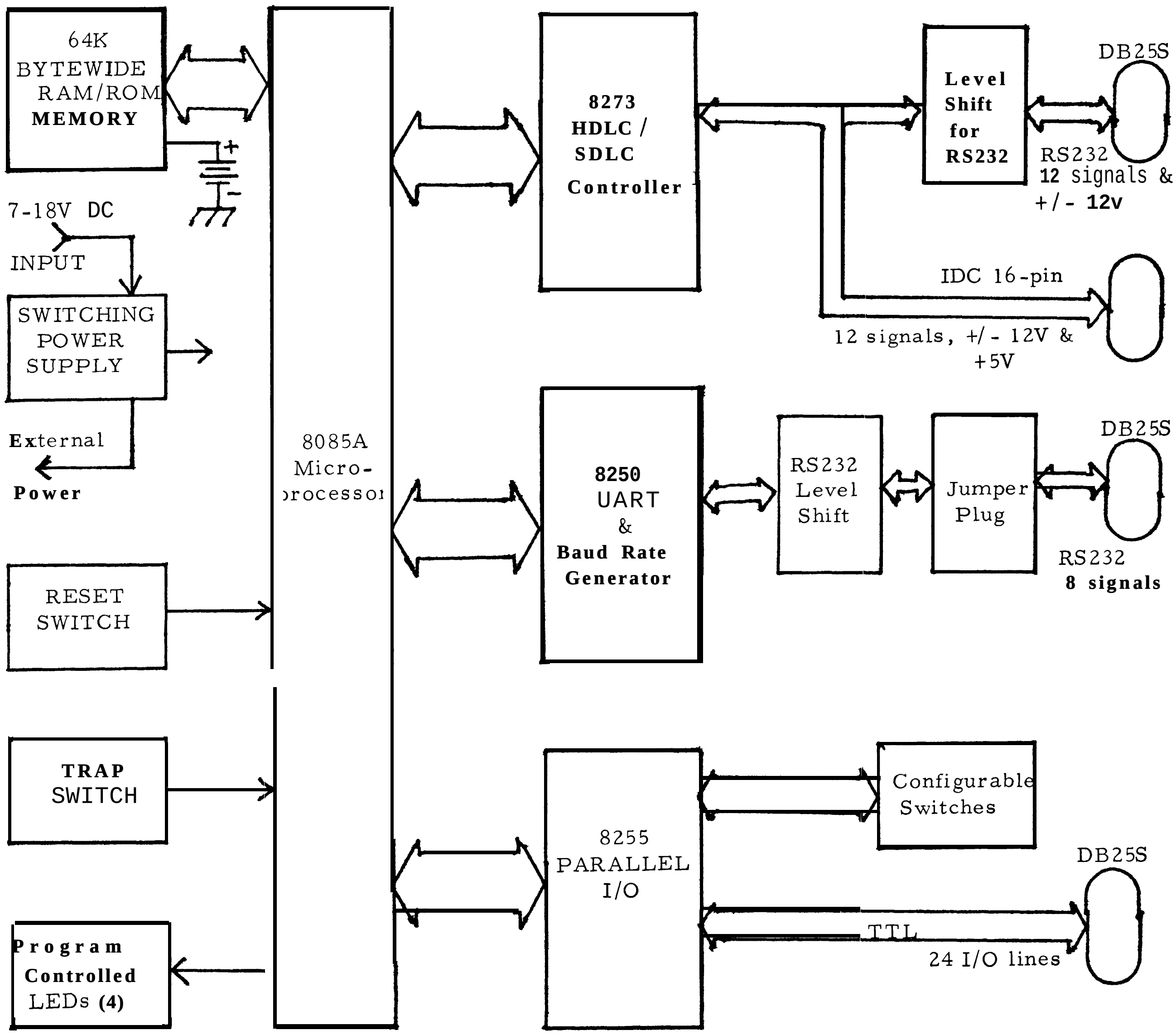
V-3 - This is a experimental new state-exchange link level protocol capable of supporting multiple links simultaneously. Like V-2, it uses the X.3 and X.28 protocols as well.

AX.25 - This is currently the most popular protocol in use. This version supports multiple repeaters.

Note that the source code for most of these programs will be made available on diskette.

SUMMARY

The author is grateful to those volunteers whose efforts have made the TNC+ available. It is hoped that the availability of this board and its software will accelerate the technical development of Arnateur packet radio and give interested Amateurs a tool which can be used to learn the details of packet radio communication.



TNC+ BLOCK DIAGRAM