Tucson Amateur Packet Radio
packetRADIO Project

TAPR packetRADIO Development Team

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Abstract

This paper will discuss the Tucson Amateur Packet Radio packetRADIO project. Technical and design considerations will be explained and discussed. Beta-testing of the radio project will be outlined.

Introduction

It wasn't long after amateurs started beta testing the TAPR TNC-1 that it became apparent to many that there was trouble looming on the horizon. Even in the earliest days, visionary amateurs could see that 1200 baud packet would not accommodate the large numbers of packeteers operating in heavily populated areas. Within a very short time the larger metropolitan areas of the country were, in fact, experiencing crowded packet channels.

The adaptation of radios designed for voice use in the earlier packet radio days was acceptable. As the packet channels have become more crowded, the inefficiencies and economics of these voice radios have become a significant negative factor in packet radios growth. However, designing a better radio for packet use was far down the list of projects for TAPR to pursue. A glance through the Table of Contents of papers of earlier ARRL Networking Conferences' will refresh memories of what, in those years, were the more pressing issues.

During 1987 and 1988 the packet radio problem surfaced again and was discussed in earnest within TAPR. Finally, in hotel rooms at the 7th Networking Conference, a decision was made to go ahead with a program to develop a radio designed specifically for digital use. This paper will outline the project to date.

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Desian Goals

The purpose behind the packetRADIO project is to design a low cost, high speed rf box for the average Amateur. There were a number of design criteria set forth as goals from the start of the project. Figure A outlines the current specifications of the radio.

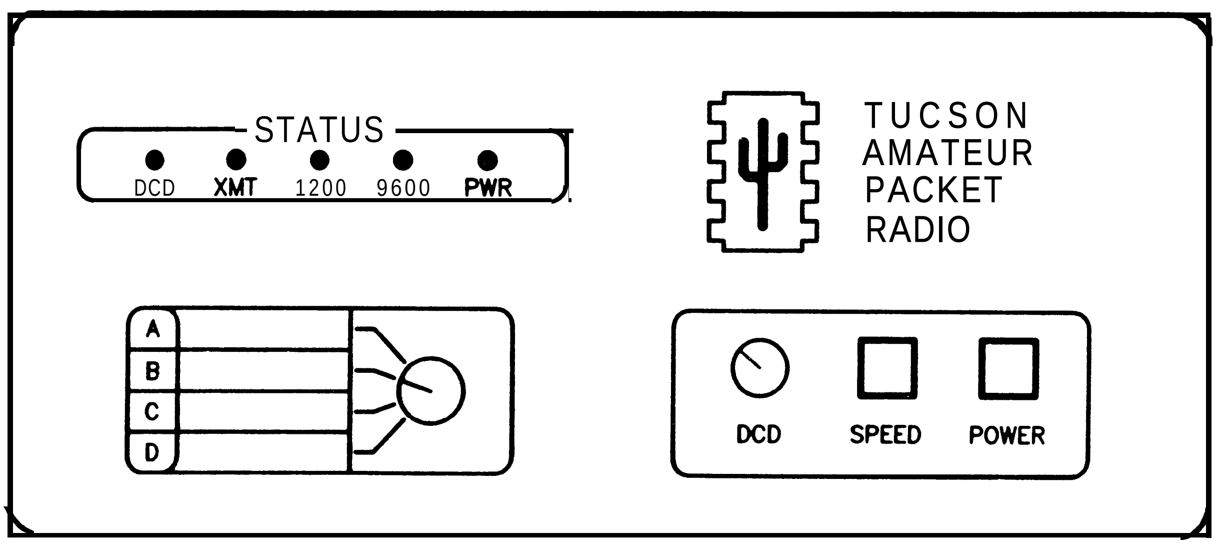
- Design a 9600+ high speed packet radio. Amateurs need faster local access than 1200 baud AFSK. While many will want to put the packetRADIO to work on their backbone links, it is the feeling of the development team that future network linking will be done at much higher speeds. By moving local network access to 9600 bit/s, our local packet frequencies will be better utilized.

- Low cost. The design should be simple and easy to reproduce. By using simple FSK techniques that are already in use,

Figure A : Specifications

General	Power :	+10 to +17 VDC
	Number of Channels :	1 to 4
	Frequency of Range :	144-148 MHz
Transmitter	Power Output :	25 watts into 50Ω
	Mismatch :	Stable into a VSWR of 3:1
	Modulation :	1200bps - 3 kHz deviation of 2200 Hz tone 9600 bps - filtered FSK, +/- 3 kHz deviation
	Spurious output :	-60 dBc
	Keyup time :	Less than 1 millisecond
	Lineup :	Modulated 45 MHz offset crystal oscillator mixed with receiver L.O. to produce output operating frequency.
Receiver	Sensitivity :	-113 dBm (0.5 µV) into 50Ω for 10^{-3} BER
	Intermodulation :	-70 dB
	Spurious response :	-80 dB
	Time to carrier detect :	3 millisecond (9600 bps) 15 millisecond (1200 bps)
	Lineup :	FET preamp One Crystal-controlled L.O. per channel (for enhanced frequency stability). 45 MHz 1st I.F. 10.7 MHz 2nd I.F. Linear phase response multi-pole filtering.

Figure B : Front Panel (not to size)



such a radio will be compatible with other designs (TAPR [1], TPRS TexNet [2], G3RUH [3]). This also translated to less complexity than current commercial radios (i.e. no touch-tone, PLL, scanners, voice synthesizers, etc.) Figure B shows the front panel.

- Fast turn around time between transmit and receive. This would allow the modem to operate as closely to 9600 bit/s as possible. The design now accommodates a one millisecond (mSec) turnaround compared to the average 150 mSec to 400 mSec of commercial voice radios. To maintain this fast turnaround time, the team felt that the radio needed a 25 watt output to be acceptable for the widest variety of applications. Having an amplifier outside of the unit would again increase the turnaround time, which is the critical factor for better performance.

- Include a 1200 baud AFSK modem to encourage the average Amateur to make the switch to the new design. This also allows compatibility with the existing standard.

- The design should allow for easy modifications to obtain different bands and speeds (i.e. 220 MHz and 19.2 Kbit/s). The design should also allow full-duplex operation.

- A number of items were included on the wish list :
  - Enhanced TNC built into the design which could also control the radio.
  - 220 MHz capability in the initial test units.

Radio Technical Information

The TAPR packetRADIO is a crystal controlled, 2-meter four frequency radio designed specifically for 1200 and 9600 bit/s packet operation. The TAPR radio employs pin diode switching and an offset transmitter oscillator to provide fast turn-around between transmit and receive. A block diagram of the radio is shown in Figure C.

Starting at the antenna :

The antenna is connected to a lowpass filter which attenuates the harmonics of the transmitter and provides high frequency selectivity for the receiver. The output of the lowpass filter is connected to the pin diode switch. This switch provides the transmit/receive RF switching in the transceiver. A pin switch allows fast switching between transmit and receive.

Following the receive path:

The received signal from the pin switch is connected to a 2-pole LC filter providing RF selectivity for the receiver.

A FET preamp follows the LC filter providing a nominal 10 dB of gain and a 3 dB noise figure with a +30 dBm third order intercept point. The FET preamp output is fed to a 3-pole helical resonator which provides additional RF selectivity. The helical resonator output is fed to a FET mixer which provides a nominal 15 dB of gain with a +30 dBm intercept point.

The 45 MHz IF output of the first mixer is fed to a 2-pole Piezo technology model 2844 crystal filter. The crystal filter provides selectivity to protect the backend of the receiver. By using a crystal filter at this point in the receiver, the intercept point of the overall receiver is set by the preamp and mixer intercept points. The overall intercept point of the front end to the mixer output was measured to be -2 dBm. This intercept point provides better than 70 dB IM protection to the receiver.

The output of the 45 MHz crystal filter is fed to a Signetics NE605 IC which provides the second mixer, second local oscillator, 10.7 MHz IF amplifier and discriminator. The first 10.7 MHz crystal filter is a 4-pole Piezo Technology model 5182. The second 10.7 MHz filter is a 2-

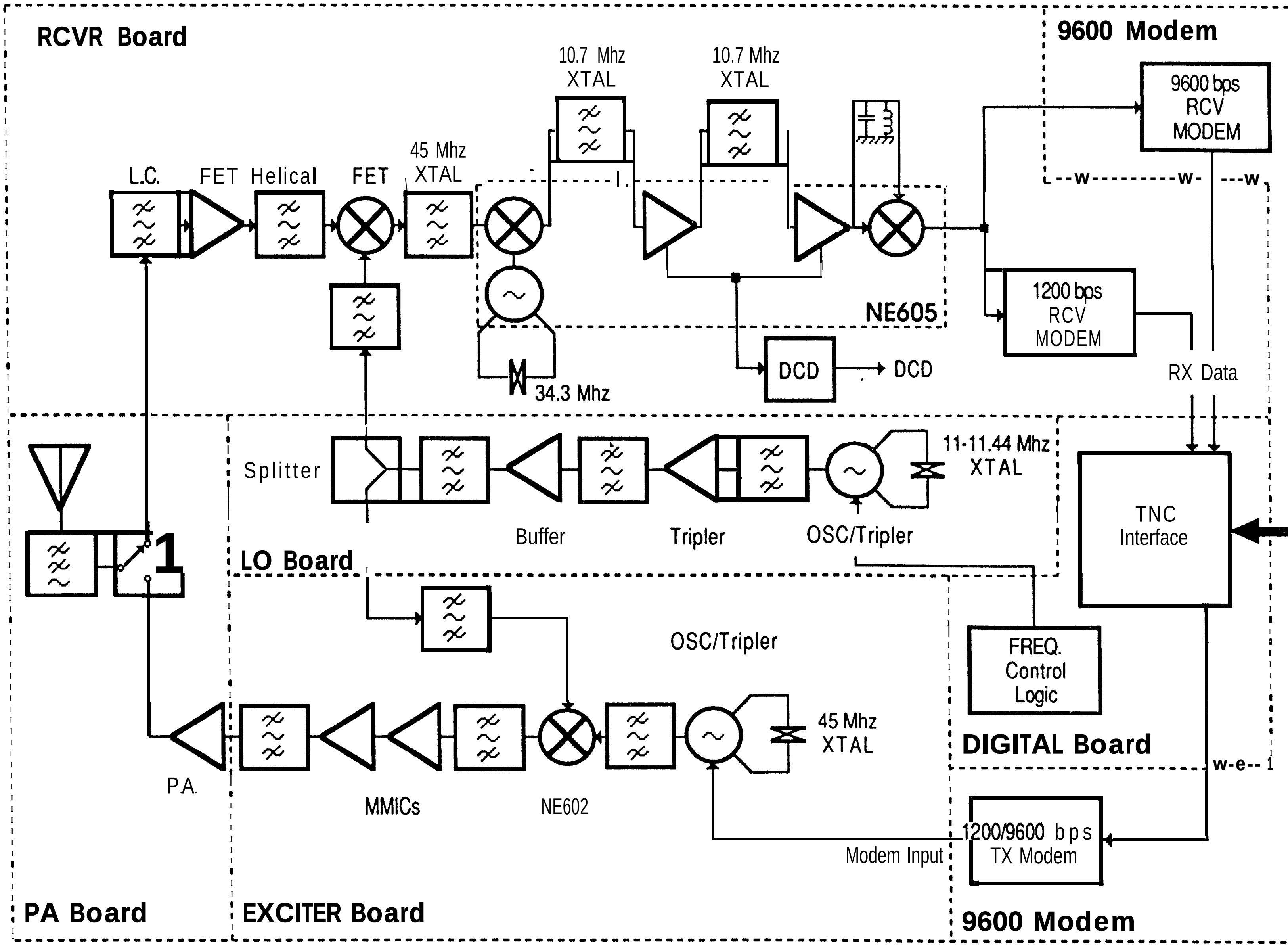


Figure C : packetRADIO Block Diagram

pole Piezo Technology model 2195. The combination of the 45 MHz and 10.7 MHz crystals provide tight selectivity for good adjacent channel protection with a flat group delay response.

Data carrier detect is provided from the RF level circuits of the NE605. A front panel control is provided for the operator to set the sensitivity level for the DCD.

The discriminator output of the NE605 is connected to the 1200 and 9600 bit/s modems. Each modem then provides the appropriate received data stream to the TNC interface.

Local Oscillator:
The local oscillator board provides a local oscillator signal to the receiver and the transmitter. Four crystal oscillators are provided for up to four channel operation. The oscillator also acts as a tripler providing a 33 to 34.333 MHz drive signal to the tripler. The tripler takes the oscillator/tripler signal and multiplies it to the 99 to 103 MHz range.

The buffer amplifier provides gain to the 99-103 MHz signal to provide a nominal +10 dBm signal out of the LO board. The power splitter divides the RF output of the lo board equally between the receiver and the transmitter.

Exciter:
The exciter board contains a frequency modulated crystal controlled 45 MHz offset oscillator. The modulation input for the oscillator is provided from the digital board transmit modem. The transmit modem contains a FIR filter to filter the 9600 bit/s transmit data. In the 1200 bit/s mode, the transmit modem uses the same ROM containing the 9600 bit/s FIR filter to generate the 1200 and 2200 Hz tones. The output of the 45 MHz oscillator is mixed with the output of the lo board in a NE602 mixer IC.

The 144-148 MHz signal out of the mixer is filtered in a 2-pole LC filter and then amplified using two MMIC amplifiers. The output of the MMIC amplifiers is then filtered in a 2-pole LC filter and sent to the PA board.

The exciter output is amplified by a Toshiba S-AV7 power amplifier on the PA board and then routed to the pin switch.

Modem Technical Information

The 1200 and 9600 bit/s modems designed for the TAPR packetRADIO are a culmination of years of experiments with 1200 and 9600 bit/s amateur packet operation. The 1200 bit/s modem incorporates all the information obtained from the TAPR TNC-1 and TNC-2 EXAR 2211 receive modem tests [4]. The 9600 bit/s receive modem incorporates experience from the TAPR [1], TPRS TexNet [2; 5], G3RUH [3], and GRAPES [6] modems into a low cost, high performance FSK receiver. The selection of flat group delay filters in the IF of the packetRADIO simplifies the design of the 9600 bit/s modem by not distorting the data signal in the receiver IF filters.

In the 9600 bit/s receive mode, the radio discriminator output is sent to post detection filters and a limiter. In the 1200 bit/s mode, the discriminator output is de-emphasized and detected in an EXAR 2211 IC. The limited data from each modem is then sent to the digital board where clock is recovered from the received data stream. The reclocked data is then sent from the digital board to the TNC. The digital board also provides selectable rf or digital DCD.

The transmit modem incorporates digital signal processing (DSP) techniques to generate the filtered FSK signal for the 9600 bit/s modem and to generate the tones for the 1200 bit/s modem. This creates a modem which only requires setting the deviation in the transmitter.

The digital board contains the TNC interfacing circuitry. It also provides the transmit time-out function, data and control lines to and from the TNC and radio, and clock generation circuits used by both the radio and transmit modem. A 16 and 1 times clock is sent to the transmit modem along with the transmit data to operate the transmit ROM. The transmit ROM contains a finite impulse response (FIR) filter which filters the transmit data in the 9600 bit/s mode. The transmit ROM also contains a 1200 and 2200 Hz tone generator for use in the 1200 bit/s mode.

Beta-Testing.

As with previous TAPR projects, Beta testing will be an important part of the development process. Local Beta test coordinators will act as spokespersons for their test group. This procedure was used in the 1983 Beta test of TAPR's first packet controller. The end result was the TNC-1 design. To help facilitate communications, a special section will be made available to the coordinators on Compuserve's HamNet. This private area will help us detect problems and possible solutions much quicker than by mail. It will also allow information to be disseminated to local packet networks quickly.

Initially the design team had hoped to have a 2 meter and 220 MHz radio available for testing, but due to time constraints, beta testing will only be done with 2 meter radios. Many groups have voiced interest in experimenting with higher frequencies and speeds during the testing period and the design team hopes that these groups can further add to the design of the packetRADIO.

This project is the most complex TAPR has ever undertaken, so to help speed up the testing period the units will be wired and tested. There are no plans to produce kits. By doing this, we hope to shorten the time it will take for manufacturers to have units available in the market place. If in the end, this allows the average packet enthusiast to enjoy true high speed digital communication at reasonable cost, then Amateur Radio will once again have contributed to advancing the state of the radio art.

:Notes

1. Conference proceedings are available from the ARRL 225 Newington CT 06111.

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