

A Full-Duplex 56kb/s CSMA/CD Packet Radio Repeater System

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ABSTRACT

There are no **true** Carrier Sense, Multiple Access with Collision Detect (**CSMA/CD**) systems operational in amateur radio. **Full-duplex** systems **currently** in use are actually **CSMA/CA** - that is, CSMA with Collision Avoidance. We describe here a system that accomplishes full collision detection with little additional system complexity compared with an ordinary full-duplex system.

1. Overview

The idea of a full-duplex **bit**-regenerative packet repeater is not new. [1-5] Because of the **well**-known disadvantages of **CSMA**, schemes like full-duplex repeaters are suggested because they eliminate the hidden transmitter problem. Although there are other ways to eliminate hidden terminals, for example, busy tone and polling schemes [6-7], full-duplex provides the capability for the transmitting station to *listen while transmitting*. This allows the station to determine if the bytes being sent are the same as the bytes being received. If so, then all is well. If not, then a collision is occurring, and transmission should immediately cease.

By taking advantage of this capability to quickly detect collisions, an extremely high performance packet radio system can be constructed, with little additional system complexity compared with an ordinary full-duplex repeater.

2. Our Approach

We have used off-the-shelf hardware to augment a simple digital regenerative scheme with some intelligence. This scheme not only allows repeater operation, and all of the benefits of full duplex, but also permits trivial **connection** with other **KA9Q TCP/IP** networks.

The code that runs in the user node is the same as the code that runs in the repeater. We did this to reduce the coding effort, but also it is a nice fallout of this scheme. Basically, the code is the same as that for a KISS TNC [8], with a few straightforward extensions. These extensions are:

- A function to store the AX.25 link layer id (callsign + SSID) inside the digital hardware.
- A function that compares **byte-for-byte** in real-time the incoming (or repeated, in the case of the repeater) packet with the outgoing packet, and **interrupts** transmission in case the bytes don't match.

- A function to compare the incoming packet's link layer ID to the stored link layer ID, and to insert that packet at the head of a priority queue, thereby ensuring that the connected computer gets important packets, and avoids overload of the connected computer.

End user TCP/IP routing is accomplished by first an "arp add" like **this**:

```
arp add ax25 aa6iw.ampr.org aa6iw-0
```

What this tells the end user's TCP/IP setup is that all packets for the IP name "aa6iw.ampr.org" are to be addressed using a link address of "aa6iw-0".

An end user that wishes to be connected to the rest of the local internet would need the following "route add" statement:

```
route add default rp0 aa6iw.ampr.org
```

which would cause all IP datagrams that are not explicitly routed to go via the aa6iw.ampr.org gateway.

For each station that would use this repeater, a separate "route add" statement would be required. So, for example, if hs.k3mc.ampr.org uses the repeater, and he knows that aa4cg.ampr.org also uses the repeater, hs.k3mc.ampr.org needs:

```
route add aa4cg.ampr.org rp0
```

¹Note that aa6iw.ampr.org is in fact the gateway computer that is attached to our repeater node. It is connected via an ordinary RS-232 cable with KISS protocol.

in his KA9Q NET.EXE initialization². Similarly, aa4cg.ampr.org needs the following line for his NET.EXE initialization:

```
route add hs.k3mc.ampr.org rp0
```

Additional repeater users need to have individual "route add" statements for every user of the repeater. Users on the other networks that are accessed via the gateway computer, however, are handled by the default routing.

3. Hardware

The heart of the repeater is, of course, the Dale Heatherington, WA4DSY 56 kilobit modem^[9]. This truly beautiful design is serving as the workhorse for many advanced packet systems. The Georgia Radio Amateur Packet Enthusiasts Society (GRAPES) makes this board set and a parts kits available to amateurs at nominal cost³.

The digital portion uses the standard Kantronics Data Engine. This V40-based controller has all the power needed to handle this application. In particular, the Data Engine has a Zilog 8530 SCC dual-channel serial controller chip. In our implementation, one channel (the over-the-air one) is DMA-driven, and

²"rp0" is just an arbitrary designator that associates a NET.EXE interface with a name: for this example, it means "Repeater 0".

³Doug Drye, KD4NC, and a band of other enthusiasts makes the distribution of Dale's radio possible.

the other is the high-speed KISS link back to a host **computer**⁴.

The end user stations and the repeater naturally differ on RF requirements.

The end user stations use a simple MMIC-based 906.65 to 29.05 MHz downconverter. The transmitting upconverter is a Hamtronics XV-4. The user antennas are on a single boom: The 430 antenna is vertically polarized, and the 900 MHz antenna is horizontally polarized. These two antennas are in a "**cross**" configuration, similar to typical satellite antennas. The number of elements can be varied; the particular user station configuration depends upon required BER for satisfactory repeater system performance. See Figure 1. The single-boom dual-band antenna is fed with a single cable, and split inside the shack.

The repeater site uses a simple downconverter on receive, and an MMIC-based upconverter for transmit. A Power Amplifier boosts output to 10 to 50 watts. Omnidirectional antennas are used at the repeater site, and are fed with a single feedline, like the user case.

As you can see **from** Figure 2, the repeater needs a simple AND/OR gate addition. The functions of these parts **is** simple. The OR gate merely allows the digital card to hear what it is transmitting (remember, we are

⁴**Please** note that our design **decision** to use a standard **KISS** serial link means that **we** do not depend on a particular implementation of NET.EXE on a particular machine; IBM PCs, Macintoshes, **Amigas**, etc., can all use KISS Interfaces.

running identical code in the user nodes and the repeater node)? When we are doing this, we must ignore what would normally be received, and this is the function of the AND gate. Note that when the repeater wants to talk, everybody else listens!

4. Conclusion

This scheme reduces the "**window** of vulnerability" of ordinary **CSMA** and **CSMA/CA** systems to very low levels. It eliminates both hidden and exposed terminals. Since collisions don't cost much in lost channel time, we can send larger packets and reduce per-packet overhead to quite low levels.

We look forward to continuing to work on this system, and to gather quantitative data to assess the **CSMA/CD** performance.

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⁵**This** would happen when the RS-232 network connection requires the repeater to originate a **message onto the repeater system**.

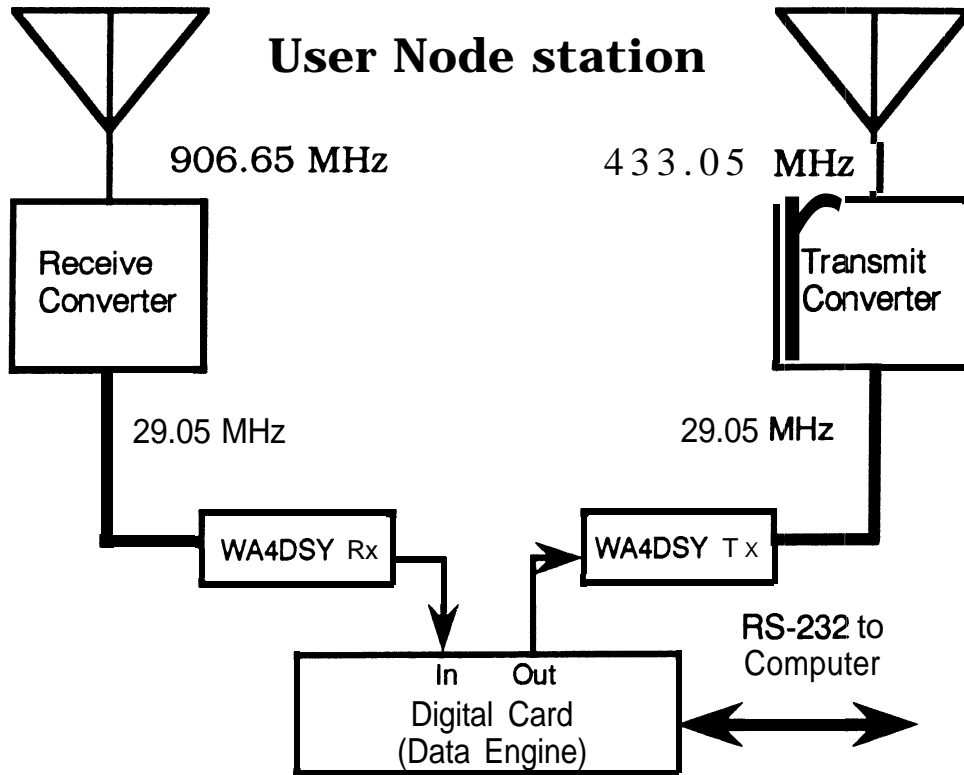


Figure 1

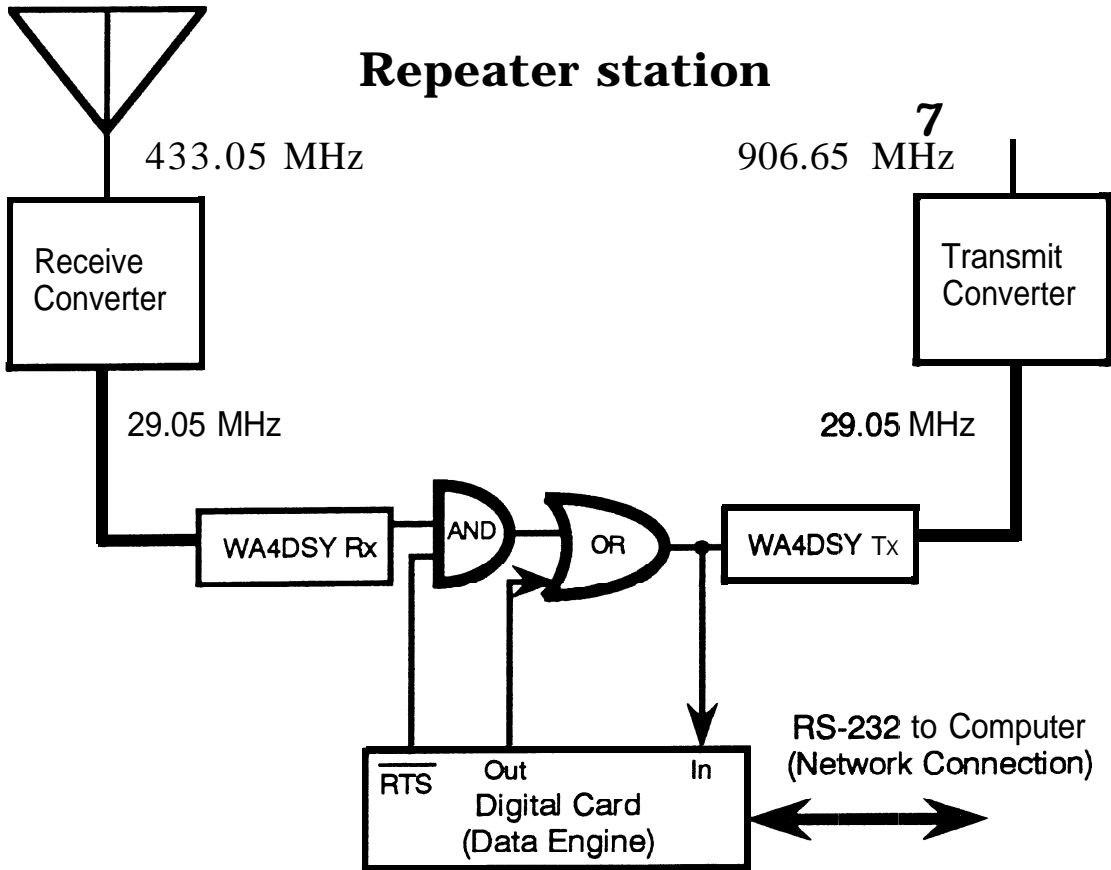


Figure 2

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